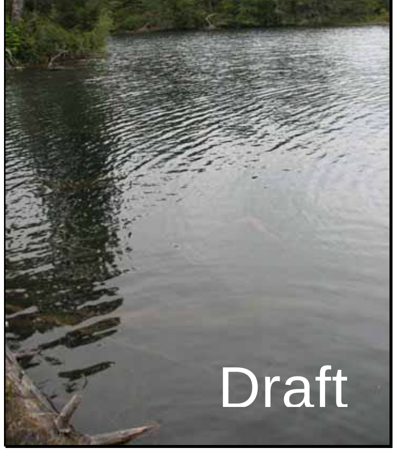
DUNES CITY



STORMWATER MANAGEMENT MANUAL

August 2007

Dunes City Draft Chapter 99 Stormwater Pollution Reduction   a/o 7/1/07

99.05 PURPOSE. The purpose of this chapter is to establish requirements for protecting and safeguarding the general health and safety of the public by reducing stormwater-related impacts on the quality of the city's water resources including drinking water.   Standards are provided for the capture and treatment of stormwater runoff from impervious surface areas and for reducing the introduction of pollutants into stormwater.

99.10 APPLICABILITY. The improvement of both public and private stormwater management facilities through or adjacent to a new development shall be the responsibility of the developer. Said improvements shall comply with all applicable city ordinances, policies and standards. Except as exempt under DCC 99.15, the standards in this chapter apply to all applications for development submitted after the effective date of this ordinance requesting approval of one or more of the following:

(A) Land use application: Partition tentative plan; subdivision tentative plan; planned unit development tentative plan; or site review.

(B) Development/Building Permit Application.

(C) Excavation, Grading, Driveway, or Access Permit Applications.

99.15 EXEMPTIONS. The requirements and standards of this chapter do not apply to:

(A) An application that will result in the construction or creation of less than five-hundred square feet of new or replaced impervious surface area at full buildout of the development.

(B) A development/building permit application for any of the following:

(1) Development of a lot or parcel included in a land use application that was determined by the city to comply with the standards in DCC 99.25, Pollution Reduction Standards. The approved land use application shall control development.

(2) Development of a lot or parcel that was not included in an application that was determined by the city to comply with the standards in DCC 99.25 and will result in less than five-hundred square feet of new or replaced impervious surface within a 12 month period.

99.20 STORMWATER CONTAINMENT AND DESTINATION STANDARDS. The purpose of these standards is to protect life and property from flood and drainage hazards through the establishment of containment and destination regulations for stormwater runoff from development.

(A) Stormwater Containment and Destination requirements apply to all new development, except as exempted under 99.15.

(B) All Stormwater facilities shall be designed and constructed in accordance with the flood control design standards of this code and the facility design requirements set forth in the Stormwater Management Manual.

(C) An applicant proposing new development must submit documentation to the City showing stormwater runoff generated by the new development at the flood control design storm level will be either:

(1) Contained on-site in accordance with the flood control design storm and Stormwater Management Manual, or

(2) Discharged off-site in accordance with the flood control design storm and Stormwater Management Manual into an existing stormwater drainage facility that has the capacity to accommodate the runoff from the proposed development. In demonstrating facility capacity, the evaluation shall include the runoff from all current uses to the stormwater facility and runoff from new development proposals that have already been approved by the City as of the date the applicant submits a complete application. Prior approvals shall include, but are not limited to, tentative plans and final plats. Where off-site destination includes the direct discharge of runoff into an open waterway, the proposal must comply with the Flow Control requirements of DCC 99.30.

(3) If the applicant cannot demonstrate that existing stormwater drainage facilities have adequate capacity to accommodate the proposed runoff from the new development, the applicant must construct storm drainage facilities with adequate capacity to accommodate the runoff from the proposed development, or construct on-site containment facilities per (A) above.

(D) Stormwater runoff disposed of in underground systems may also be regulated through the federal Underground Injection Control (UIC) program under Part C of the Safe Drinking Water Act (42 U.S.C 300, Chapter 6A, Subchapter XII) and Oregon Administrative Rule Chapter 340, Section 044.

99.25 POLLUTION REDUCTION STANDARDS. The purpose of DCC 99.25 is to protect public health by reducing the introduction of pollution into the waters of the city.

(A) Land use and development applications shall include pollution reduction facilities selected from the Stormwater Management Manual as follows:

(1) For undeveloped land applications listed in DCC 99.10(A), the selected pollution reduction facilities shall treat all the stormwater runoff from the development site that will result from the water quality design storm.

(2) For applications listed in DCC 99.10(A) or DCC 99.10(B) that change or add development, the selected pollution reduction facilities shall treat the stormwater runoff from all added and replaced impervious surfaces that will result from the water quality design storm.

(3) Development/building permit applications shall select pollution reduction facilities that treat all stormwater runoff from all new or replaced impervious surface area, or an equivalent on-site area, that will result from the water quality design storm.

(B) All pollution reduction facilities shall be sited, designed, constructed, and maintained according to the pollution reduction provisions and the facility design requirements set forth in the Stormwater Management Manual.

(C) The standards in DCC 99.25 may be adjusted pursuant to the Stormwater Management Manual.

99.30 FLOW CONTROL STANDARDS. The purpose of DCC 99.30 is to protect waterways from the erosive affects of increases in stormwater runoff peak flow rates and volumes that result from the effects of impervious surfaces and land disturbances.

(A) All proposed improvements that may create stormwater flows which drain into a stream, pipe, or conduit shall demonstrate using methodology in the Stormwater Management Manual that peak rates of flow delivered to an existing open waterway will not increase during storms larger than the water quality design storm and smaller than the flood control design storm as a result of the proposed development.

(B) For purposes of designing the system as required by the standards in this section the amount of impervious surface per lot is assumed to be the maximum allowed lot coverage by structures plus all additional impervious surface coverage.

(C) All facilities to control the rate of stormwater runoff shall be sited, designed and constructed according to the flow control provisions and the facility design requirements set forth in the Stormwater Management Manual. Flow control facilities must be designed using one of the methodologies outlined in the Stormwater Management Manual.

(D) The standards in DCC 99.30 may be adjusted pursuant to the Stormwater Management Manual.

99.35 STORMWATER SOURCE CONTROLS. All source controls shall be designed and constructed according to the source control provisions set forth in the Stormwater Management Manual, except when the source control would duplicate controls required by a state or federal permit obtained by the applicant. Source control standards set forth in DCC 99.35 apply to all improvements that result in any of the defined site uses or characteristics listed in DCC 99.40 (A) - (D).

(A) Fuel dispensing facilities and surrounding traffic areas where vehicles, equipment or tanks are refueled on the premises. A fuel dispensing facility is the area where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers. Exempt from these controls are propane tanks.

(B) Exterior storage of liquid materials, for example chemicals, food products, waste oils, solvents or petroleum products in above ground containers, in quantities of fifty gallons or more, including permanent and temporary storage areas. Exempt from this subsection are underground storage tanks or installations requiring a Water Pollution Control Facility (WPCF) permit and containers with internal protections.

(C) All facilities that store solid waste. A solid waste storage area is a place where solid waste containers, including compactors, dumpsters, and garbage cans, are collectively stored. Solid waste storage areas include areas used to collect and store refuse or recyclable materials collection areas.

(D) All development that stockpiles or stores high-risk or low-risk bulk materials in outdoor containers, as the terms “high-risk” and “low-risk” are used in the Stormwater Management Manual. Exempt from this subsection are:

(1) Materials that have no measurable solubility or mobility in water and no hazardous, toxic or flammable properties;

(2) Materials that exist in gaseous form at ambient temperature;

(3) Materials, except for pesticides and fertilizers, which are contained in a manner that prevents contact with stormwater.

(E) All development with a designated equipment or vehicle washing or steam cleaning area.

(F) All development projects that disturb property suspected or known to contain contaminants in the soil or groundwater.

99.40 STORMWATER OPERATIONS AND MAINTENANCE STANDARDS. The purpose of this section is to ensure that through adequate operation and maintenance, stormwater facilities protect life and property from flood and drainage hazards and provide protection for waterways from the erosive effects of runoff.

(A) Operation and maintenance standards apply to all facilities designed and constructed in accordance with this Section and the Stormwater Management Manual.

(B) Unless otherwise agreed, stormwater management facilities shall be privately owned and shall be operated and maintained in accordance with this ordinance and the Stormwater Management Manual.

(C) The city shall maintain public stormwater management facilities located on city-owned property, city rights-of-way and city easements.

(D) To ensure that any city maintained stormwater management facility can be accessed by the city for routine and/or emergency maintenance the applicant of an applicable land use request or development permit must dedicate easements approved by and to the city.

99.45 INSPECTION. The City Council shall designate a Health and Safety Inspector qualified in stormwater control measures with responsibility for evaluating proposed and completed stormwater measures and facilities. This includes evaluation and approval of all stormwater standards and controls required by this ordinance at stages of completion as specified in the Stormwater Manual. The Inspector shall report to the City Council on the implementation of the requirements of this ordinance.

99.50 ADJUSTMENT REVIEW – APPROVAL CRITERIA. The Health and Safety Inspector shall approve, conditionally approve, or deny an adjustment review application for Stormwater Containment and Destination, Pollution Reduction, Flow Control and Source Control Standards. Approval or conditional approval shall be based on compliance with the following applicable criteria.

(A) The requirement in DCC 99.25 (A)(1) - (3) that selected pollution reduction facilities shall treat all the stormwater runoff that will result from the water quality design storm may be adjusted upon a finding that the selected pollution reduction facility will treat as much of the runoff as possible and one of the following applies:

(1) The area generating untreated runoff is less than five-hundred square feet of impervious surface and is isolated from the pollution reduction facility;

(2) The area generating untreated runoff is less than five-hundred square feet of impervious surface and it is not technically feasible to drain the untreated runoff to the pollution reduction facility;

(3) Constructing pollution reduction facilities to treat the runoff from the area at issue would require removal of trees or damage to other natural resources; or

(4) The area generating untreated runoff is less than five-hundred square feet of impervious surface and limited access to the area would prevent regular maintenance of the pollution reduction facility.

(B) The requirement in DCC 99.25 (B) that all pollution reduction facilities be sited, designed, and constructed according to the pollution reduction provisions and the facility design requirements set for in the Stormwater Management Manual and that pollution reduction facilities must be designed using one of the methodologies outlined in the Stormwater Management Manual may be adjusted upon finding that all of the following requirements are met:

(1) The proposed alternative design will achieve equal, or superior, results for pollution reduction function, maintainability and safety, and the proposed siting does not adversely affect structures or other properties.

(2) The applicant's written description of the proposed alternative design has been reviewed and approved the City Engineer. The description of the proposed design submitted for review must include all of the following information for each component of the proposed alternative design:

(a) Size, technical description, capacity, capital cost, design life, construction process and costs, consequences of improper construction, operation and maintenance requirements and costs;

(b) Data on the effectiveness of proposed alternative technologies, if available, including data from laboratory testing and pilot / full-scale operations, and information regarding the operations of any full-scale installations;

(c) Any other available information about the proposed design, including peer reviewed articles, scientific or engineering journals, and approvals from other jurisdictions.

(3) The applicant has submitted a method and schedule for monitoring the effectiveness of the proposed design once constructed, and a schedule for its maintenance.

(4) The applicant has submitted a signed statement that the applicant will replace the alternative pollution reduction facility if it does not function as proposed.

(C) The requirements in DCC 99.30 that Flow Control Standards and in DCC 99.35 Source Control Standards be sited, designed and constructed according to the provisions and the facility design requirements set forth in the Stormwater Management Manual may be adjusted if the applicant can demonstrate that the selected flow control facility will achieve the same result as those listed in the Stormwater Management Manual.

(D) The requirement in DCC 99.40 that source controls be sited, designed and constructed according to source control provisions set forth in the Stormwater Management Manual may be adjusted if the applicant can demonstrate that the selected source control will achieve the same result as those listed in the Stormwater Management Manual.

99.55 STORMWATER MANAGEMENT MANUAL. In order to implement DCC 99.05 through 99.50, the City Council shall adopt a Stormwater Management Manual that is consistent with the following goals:

(A) Reduce runoff pollution from development by reducing the overall amount of impervious surface area and extent of connectedness to downstream drainages.

(B) Emphasize stormwater management facilities that, to the maximum extent practicable, retain and treat stormwater utilizing on-site controls.

(C) Emphasize stormwater management facilities that incorporate vegetation as key element, and include design and construction requirements that ensure landscape plant survival and overall stormwater facility function success.

(D) Operate and maintain stormwater management facilities in accordance with facility-specific Operation and Maintenance Plans.

(E) Reduce pollutants of concern that are generated by identified site uses and site characteristics that are not addressed solely through the pollution reduction measure by implementing additional specific source control methods including reducing or eliminating pathways that may introduce pollutants into stormwater and avoiding preventable discharges to surface waters or groundwater.

99.60 DEFINITIONS. As used in this Chapter, unless the context requires otherwise, the following words and phrases mean:

Development: All improvements on a site, including buildings, other structures, parking and loading areas, landscaping, paved or graveled areas, grading and areas devoted to exterior display, storage, or activities, Development includes improved open areas such as plazas and walkways, but does not include natural geologic forms or landscapes.

Flow control facility. Any structure or drainage device that is designed, constructed, and maintained to collect, retain, infiltrate, or detain surface water runoff during and after a storm event for the purpose of controlling flow rate and volume leaving the site.

Impervious Surface / Area. Any surface area that causes water to runoff the surface in greater quantities or at an increase rate of flow from conditions preexisting to development. Types of impervious surface include, but are not limited to, rooftops, asphalt and concrete parking lots, driveways, roads, and sidewalks. Note: Slatted decks are considered pervious surface. Gravel surfaces are considered pervious surfaces unless they cover impervious surfaces or are compacted to a degree that causes their runoff coefficient to exceed eighty percent.

Nonpoint Source Pollution: Discharge from a diffuse pollution source, that is without a single point of origin.

Pollution Reduction Facility. Any structure or drainage device that is designed, constructed, and maintained to collect and filter, retain, or detain surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality.

Property suspected or known to contain contaminants in the soil or groundwater. Any real property where the presence of any hazardous substance or petroleum product indicates an existing release, past release, or threatened release of a hazardous substance or petroleum product into the ground, groundwater, or surface water of the property.

Runoff. Water from rainfall, snow melt, or otherwise discharged that flows across the ground surface instead of infiltrating the ground.

Source Control. Any structure, device, or design that is used to eliminate or reduce stormwater pollution from a known source.

Stormwater. Water derived from a storm event.

Stormwater Management Manual. The Dunes City Stormwater Management Manual as adopted by the city.

Stormwater Management Facility. Any structure or configuration of the ground that is used or, by its location, becomes a place where stormwater flows or is accumulated, including but not limited to pipes, curbs, gutters, catch basins, ponds, open drainage ways, runoff control facilities, wetlands and their accessories.

Water Quality Design Storm. A theoretical storm for estimating the amount of stormwater runoff to be treated. Facilities designed to store and treat a volume of stormwater shall be sized in accordance with the Stormwater Management Manual.

99.65 ENFORCEMENT. Failure to construct, operate and maintain source controls as set forth in this Chapter shall be unlawful and a civil infraction subject to the enforcement provisions of Chapter 36 of the Dunes City Code.

(A) If Dunes City determines that maintenance or repair work is required to be done to stormwater management facilities located in the development, the city shall give the owner notice of the specific maintenance and / or repair required. The city shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and / or repair is not completed within the time set by the city, written notice will be sent to the owner stating that the city's intention is to perform such maintenance and bill the owner for all incurred expenses.

(B) If, at any time Dunes City determines that the existing facility creates any imminent threat to public health, safety, or welfare, Dunes City ay take immediate measures to remedy said threat. No notice to the persons as listed in (A) above shall be required under such circumstances. All other owner responsibilities remain in effect.

STORMWATER MANAGEMENT MANUAL
TABLE OF CONTENTS

Chapter			Page

2.0 Stormwater Management Facility Design

Chapter		Page

Chapter	Page

4.0 Source Controls

Appendices

LIST OF EXHIBITS

Chapter 1.0
GENERAL POLICIES

Summary of Chapter 1.0

This chapter outlines Dunes City's stormwater management requirements and identifies who is required to conform to these requirements. It includes:

1.1 PURPOSE OF MANUAL

Stormwater management is a key element in maintaining and enhancing the City's water quality and livability. There is a direct link between stormwater and the City's surface and ground waters. As the City is developed, the impervious surfaces that are created increase the amount of runoff during rainfall events, disrupting the natural hydrologic cycle. Without control, these conditions erode stream channels and prevent groundwater recharge. Parking lots, roadways, and rooftops increase the pollution levels and temperature of stormwater runoff that is transported to surface and groundwater resources. Protecting these waters is vital for a great number of uses, including fish and wildlife habitat, recreation, and drinking water.

The purpose of this manual is to provide stormwater management principles and techniques that help preserve or mimic the natural hydrologic cycle and achieve water quality goals. This *Stormwater Management Manual* provides contractors, developers and design professionals with specific requirements for reducing the impacts of stormwater runoff quantity and pollution resulting from new development.

This manual is for development subject to the stormwater development standards adopted by City ordinance (See **Appendix A**).

1.2 SUMMARY OF MANUAL CONTENTS

Chapter 1.0: General Policies, outlines the purpose and use of this manual and defines terms. It outlines pollution reduction, flow control, and destination design standards, explains the rules for connecting to existing systems, and differentiates public and private stormwater management systems. This chapter also identifies special circumstances on a proposed development site that may make it impractical to implement on-site pollution reduction or flow control to the standards specified in this manual.

Chapter 2.0: Stormwater Management Facility Design, provides methods for selecting and designing stormwater management facilities that accomplish pollution reduction, flow control, and/or destination goals. The "simplified," "presumptive," and "performance" approaches are presented.

Chapter 3.0: Operations & Maintenance, presents operations and maintenance (O&M) submittal requirements and provides templates for stormwater management facility O&M plans.

Chapter 4.0: Source Controls, addresses site activities and characteristics with the potential to generate pollutants that may not be addressed solely through the pollution reduction facilities presented in Chapter 3.0.

Appendix A: Dunes City City Code Section 99.05 – 99.65 includes the section of City Code that addresses stormwater management policies and standards and that officially recognizes the City's *Stormwater Management Manual*.

Appendix B: Reserved

Appendix C: Santa Barbara Urban Hydrograph Method describes the Santa Barbara Urban Hydrograph method of computing stormwater runoff hydrographs.

Appendix D: Simplified Approach Sizing Calculations, provides a sample of the method used to calculate the simplified approach sizing factors.

Appendix E: Water Quality & Flood Control Design Storm Development, outlines the rational behind the development of Dunes City's pollution reduction storm rate and volume, and associated goal of treating ninety percent of the average annual rainfall, and the city's drainage/flood control storm for addressing on-site containment and area flow controls.

1.3 DEFINITIONS

Note: Definitions are intended to be consistent with Dunes City Codes.

Applicant: Any person, company, or agency that applies for a permit through Dunes City.

***Bulk Material Transportation Route*:** Any path routinely used to transport materials regulated in Section 4.5 onto, off of, or within a site. Bulk material transportation routes shall be constructed with impervious surfaces and shall provide spill containment.

Capacity: The capacity of a stormwater drainage system is the flow volume or rate that a facility (e.g., pipe, pond, vault, swale, ditch, drywell, etc.) is designed to safely contain, receive, convey, reduce pollutants from or infiltrate stormwater that meets a specific performance standard. There are different performance standards for pollution reduction, detention, conveyance, and destination, depending on location.

Catch Basin: A structural facility located just below the ground surface, used to collect stormwater runoff for conveyance purposes. Generally located in streets and parking lots, catch basins have grated lids, allowing stormwater from the surface to pass through for collection. Catch basins also include a sump bottom and submerged outlet pipe (down-turned 90 degree elbow, hood, or baffle board) to trap coarse sediment and oils.

Constructed Treatment Wetlands: A facility that exhibits wetland characteristics but was constructed for the express purpose to perform a utility need, such as a sedimentation pond, and is not subject to the jurisdictional requirements of federal and state wetland law. See **Chapter 2.0** for information regarding the design of constructed treatment wetlands.

***Containment – drainage/flood control*:** Retaining potential post-development runoff on-site for either infiltration or release as runoff to downstream drainages at pre-development flow rates.

Control Structure: A device used to hold back or direct a calculated amount of stormwater to or from a stormwater management facility. Typical control structures include vaults or manholes fitted with baffles, weirs, or orifices. See **Chapter 2.0** for information regarding the design of control structures.

Conveyance: The transport of stormwater from one point to another.

Destination: The ultimate discharge point for the stormwater runoff from a particular site, also known as stormwater disposal. Destination can include on-site infiltration such as surface infiltration facilities, drywells and sumps, and soakage trenches, and off-site flow to ditches, drainage ways, rivers and streams, and off-site storm pipes.

Detention Facility: A facility designed to receive and hold stormwater and release it at a slower rate, usually over a number of hours. The full volume of stormwater that enters the facility is eventually released.

Detention Tank, Vault, or Oversized Pipe: A structural subsurface facility used to provide flow control for a particular drainage basin. See **Chapter 2.0** for information regarding the design of detention tanks, vaults, and oversized pipes.

Development: Any human-induced change to improved or unimproved real estate, whether public or private, for which a permit is required, including but not limited to construction, installation, or expansion of a building or other structure, land division, street construction, drilling, and site alteration such as dredging, grading, paving, parking or storage facilities, excavation, filling, or clearing.

Development Permit: A permit authorized or required by the Oregon Structural Specialty Code and Oregon One and Two Family Dwelling Code, including but not limited to permits for:

1. New buildings.
2. Additional square footage added to a building.
3. Building demolition.
4. Foundations.
5. Change of occupancy.
6. Grading / Fill.
7. Site improvements.

Development Footprint: The new or redeveloped area covered by buildings or other roof structures and other impervious surface areas, such as roads, parking lots, and sidewalks.

Disposal: See definition of *Destination*.

Drainage Basin: A specific area that contributes stormwater runoff to a particular point of interest, such as a stormwater management facility, stream, wetland, or pipe.

Drainage way: An open linear depression, whether constructed or natural, which functions for the collection and drainage of surface water. It may permanently or temporarily contain runoff.

Driveway: The area that provides vehicular access to a site. A driveway begins at the property line and extends into the site. In parking areas, the driveway does not include vehicular parking, maneuvering, or circulation areas.

Dry Detention Pond: A surface vegetated basin used to provide flow control for a particular drainage basin. Stormwater temporarily fills the dry detention pond during large storm events and is slowly released over a number of hours, reducing peak flow rates. See **Chapter 2.0** for information regarding the design of dry detention ponds.

Drywell: A structural subsurface facility with perforated sides or bottom, used to infiltrate stormwater into the ground. See **Chapter 2.0** for information regarding the design and use of drywells.

Equipment and/or Vehicle Washing Facilities (**Section 4.7**): Designated equipment and/or vehicle washing or steam cleaning areas. This includes smaller activity areas such as wheel washing stations.

Extended Wet Detention Pond: A surface vegetated basin with a permanent pool of water and additional storage volume, used to provide pollution reduction and flow control for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. During large storm events, stormwater temporarily fills the additional storage volume and is slowly released over a number of hours, reducing peak flow rates. See **Chapter 2.0** for information regarding the design of extended wet detention ponds.

Exterior Materials Storage Area: Any exterior materials storage location that is not completely enclosed by a roof and sidewalls.

Exterior Storage of Bulk Materials (**Section 4.5**): Outdoor areas used to stockpile erodible materials.

Flood Control: The practice of managing stormwater drainage and flood protection.

Flow Control: The practice of limiting the peak flow rates and volumes. Flow control is intended to protect downstream properties, infrastructure, and resources from the increased stormwater runoff peak flow rates and volumes resulting from development.

Flow Control Facility: Any structure or drainage device that is designed, constructed, and maintained to collect, retain, infiltrate, or detain surface water runoff during and after a storm event for the purpose of controlling post-development water quantity leaving the development site.

Flow-Through Planter Box: A structural facility filled with topsoil and gravel and planted with vegetation. The planter is completely sealed, and a perforated collection pipe is placed under the soil and gravel, along with an overflow provision, and directed to an acceptable destination point. The stormwater planter receives runoff from impervious surfaces, where it is filtered and retained for a period of time. See **Chapter 2.0** for information regarding the design of flow-through planter boxes.

Fuel Dispensing Facilities (**Section 4.2**): Areas where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above ground fuel tanks, fuel pumps, and the surrounding pad). This definition applies to large-sized gas stations as well as single-pump fueling operations.

Grassy Swale: A long, narrow, trapezoidal or semicircular-shaped channel, planted with a dense grass mix. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out. See **Chapter 2.0** for information regarding the design of grassy swales.

***Hazardous Material*:** Any material or combination of materials that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or that may pose a present or potential hazard to human health, safety, or welfare, or to animal or aquatic life or the environment when improperly used, stored, transported or disposed of, or otherwise managed. For purposes of chemical regulation by this manual, moderate to high toxicity and confirmed human carcinogenicity are the criteria used to identify hazardous substances.
(Note: This manual does not use the Resource Conservation and Recovery Act (RCRA) definition of hazardous. For the purpose of this manual, hazardous material is intended to include hazardous, toxic, and other harmful substances.)

***Hazardous Material Containment Zone (HMC Zone)*:** An area where a specific individual activity involving use of a hazardous material takes place, and where chemical quantities at that location are expected to exceed defined thresholds. HMCs may include (but are not limited to) storage and / or process areas, transportation routes, work areas, and loading / unloading facilities.

High-Risk Site: A site with characteristics and / or activities that have the potential to generate pollutants that may not be addressed solely through the pollution reduction facilities presented in Chapter 2.0. High-risk site characteristics and activities are listed in **Section 4.1.1**.

Impervious Surface/ Area: Any surface area that causes water to run off the surface in greater quantities or at an increased rate of flow from conditions pre-existing to development. Types of impervious surface include, but are not limited to, rooftops, asphalt and concrete parking lots, driveways, roads, sidewalks, and pedestrian plazas. *Note:* Slatted decks are considered pervious. Gravel surfaces are considered pervious unless they cover impervious surfaces or are compacted to a degree that causes their runoff coefficient to exceed 80%.

Infiltration: The percolation of water into the ground.

Infiltration Planter Box: A structural facility filled with topsoil and gravel and planted with vegetation. The planter has on open bottom, allowing water to infiltrate into the ground. Stormwater runoff from impervious surfaces is directed into the planter box, where it is filtered and infiltrated into the surrounding soil. See **Chapter 2.0** for information regarding the design of infiltration planter boxes.

Inlet: A structural facility located just below the ground surface, used to collect stormwater runoff for conveyance purposes. Generally located in streets and parking lots, inlets have grated lids, allowing stormwater from the surface to pass through for collection. The term "inlet" can also be used in reference to the point at which stormwater from impervious surfaces or conveyance piping enters a stormwater management facility.

Manufactured Stormwater Treatment Technology: A proprietary structural facility or device used to remove pollutants from stormwater. Refer to **Chapter 2.0** for approval criteria related to manufactured stormwater treatment technologies.

Maximum Extent Practicable (MEP): See definition of *Practicable.*

Off-site stormwater facility: Any stormwater management facility located outside the property boundaries of a specific development, but designed to reduce pollutants from and/or control stormwater flows from that development.

On-site stormwater facility: Any stormwater management facility necessary to control stormwater within an individual development project and located within the project property boundaries.

Operations and Maintenance (O&M): The continuing activities required to keep stormwater management facilities and their components functioning in accordance with design objectives. See **Chapter 3.0** regarding operations and maintenance requirements for stormwater management facilities.

Outfall: A location where collected and concentrated water is discharged. Outfalls include discharge from stormwater management facilities, drainage pipe systems, and constructed open channels. See **Chapter 2.0** for information regarding the design of outfalls.

***Parking Area*:** Any area which can be used by motor vehicles, recreational vehicles, trailers, and boats for parking, including driveways and access aisles providing access to the parking stalls.

Permeable Pavement: See definition of *Pervious Pavement*.

Pervious Pavement: The numerous types of pavement systems that allow stormwater to percolate through them and into subsurface drainage systems or the ground. See **Chapter 2.0** for design requirements related to pervious pavement. Also referred to as porous or permeable pavement.

Pollutant: An elemental or physical product that can be mobilized by water or air and creates a negative impact on the environment. Pollutants include suspended solids (sediment), heavy metals (such as lead, copper, zinc, and cadmium), nutrients (such as nitrogen and phosphorus), bacteria and viruses, organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers), floatable debris, and increased temperature.

Pollutants of Concern: Watershed-specific parameters identified by the Oregon Department of Environmental Quality (DEQ) as having a negative impact on the receiving water body. Pollutants of concern can include suspended solids, heavy metals, nutrients, bacteria and viruses, organics, floatable debris, and increased temperature.

Pollution Reduction Facility: Any structure or drainage device that is designed, constructed, and maintained to collect and filter, retain, or detain surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality.

Porous Pavement: See definition of *Pervious Pavement*.

Post-Developed Condition: As related to new development: A site's ground cover after development.

Practicable: Available and capable of being done as determined by the City, after taking into consideration cost, existing technology, and logistics in light of overall project purpose.

Pre-Developed Condition: As related to new development: A site's ground cover prior to the proposed development.

Public facility: A street, right-of-way, sewer, drainage, stormwater management, or other facility that is either currently owned by the City or will be conveyed to the City for maintenance responsibility after construction.

Rainwater Harvesting: The practice of collecting and using stormwater for purposes such as irrigation and toilet flushing. See **Chapter 2.0** for information regarding rainwater harvesting.

Redevelopment: Any development that requires demolition or complete removal of existing structures or impervious surfaces at a site and replacement with new impervious surfaces.

Retention Facility: A facility designed to receive and hold stormwater runoff. Rather than storing and releasing the entire runoff volume, retention facilities permanently retain a portion of the water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation. In this way, the full volume of stormwater that enters the facility is not released off-site.

Roadway: Any paved surface used to carry vehicular traffic (cars/trucks, forklifts, farm machinery, or any other large machinery).

Runoff: Stormwater flows across the ground surface during and after a rainfall event.

Sand Filter: A structural facility with a layer of sand, used to filter pollutants from stormwater. See **Chapter 2.0** for information regarding the design of sand filters.

Santa Barbara Urban Hydrograph (SBUH): A hydrologic method used to calculate runoff hydrographs. See **Appendix C** for information regarding the use of the Santa Barbara Urban Hydrograph method.

Soakage Trench: A long linear excavation backfilled with sand and gravel, used to filter pollutants from and infiltrate stormwater into the ground. See **Chapter 2.0** for information regarding the design of soakage trenches.

Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 4.4**): Outdoor areas with one or more facilities that store solid waste (both food and non-food waste). Single- and two-family residential solid waste storage areas, containers, and trash compactors are exempt.

Stormwater: Water runoff that originates as precipitation on a particular site, basin, or watershed.

Stormwater Facility Landscaping: The vegetation (plantings), topsoil, drain rock, and other surface elements associated with stormwater management facility design.

Stormwater Management: The overall culmination of techniques used to reduce pollutants from, detain and/or retain, and provide a destination for stormwater to best preserve or mimic the natural hydrologic cycle on a development site. Public health and safety, aesthetics, maintainability, capacity of existing infrastructure and sustainability are important characteristics of a site's stormwater management plan.

Stormwater Management Facility: Any structure or configuration of the ground that is used, or by its location, becomes a place where stormwater flows or is accumulated, including but not limited to, pipes, sewers, curbs, gutters, manholes, catch basins, ponds, open drainage ways, runoff control facilities, wetlands, and their accessories.

Stormwater Re-use: See definition of *Rainwater Harvesting*.

Street Swale: A vegetated or grassy swale located next to a public or private street for the purpose of managing stormwater. See **Chapter 2.0** for information regarding the design of street swales.

Sump: As used in this manual: A large drywell used to infiltrate stormwater from streets. Sumps are generally 48 inches in diameter and 30 feet deep. The term "sump" can also be used to reference to any volume of a facility below the point of outlet, in which water can accumulate. See **Chapter 2.0** for information regarding the use and design of sumps.

Surface Conveyance: The transport of stormwater on the ground surface from one point to another.

Surface Infiltration Facility: A facility designed to receive and infiltrate stormwater runoff at the ground surface to meet stormwater destination requirements.

Surface Retention Facility: A facility designed to receive and hold stormwater runoff at the ground surface. Rather than storing and releasing the entire runoff volume, surface retention facilities permanently retain a portion of the water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation.

Time of Concentration (Tc_c): The amount of time it takes stormwater runoff to travel from the most distant point (measured by travel time) on a particular site or drainage basin to a particular point of interest. See **Appendix C** for calculations related to time of concentration.

Total Suspended Solids (TSS): Matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter.

Underground Injection Control (UIC): A federal program under the Safe Drinking Water Act, delegated to the Oregon Department of Environmental Quality (DEQ), which regulates the injection of water below ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. See **Section 1.4.3** for information regarding the UIC program.

Vegetated Facilities: As used in this manual: Stormwater management facilities that rely on plantings to enhance their performance. Plantings can enhance many facility functions, including infiltration, pollutant removal, water cooling, flow calming, and prevention of erosion.

Vegetated Filter Strip: A gently sloping, densely vegetated area used to filter, slow, and infiltrate stormwater. See **Chapter 2.0** for information regarding the design of vegetated filter strips.

Vegetated Infiltration Basin: A vegetated surface facility that temporarily holds and infiltrates stormwater into the ground. See **Chapter 2.0** for information regarding the design of vegetated infiltration basins.

Vegetated Swale: A long, narrow, trapezoidal or semicircular channel, planted with a variety of trees, shrubs, and grasses. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out. Check dams are used to create small ponded areas to facilitate infiltration. See **Chapter 2.0** for information regarding the design of vegetated swales.

Water Body: Water bodies include rivers, streams, sloughs, drainages including intermittent streams and seeps, ponds, lakes, aquifers, wetlands, and coastal waters.

Watercourse: A channel in which a flow of water occurs, either continuously or intermittently, with some degree of regularity. Watercourses may be either natural of artificial.

Water Quality: A term used to describe the chemical, physical, and biological characteristics of stormwater. Pollution reduction and flow control are two components of water quality management in stormwater runoff.

Water Quality Design Storm: A theoretical storm for estimating the amount of stormwater runoff to be treated. Facilities designed to store and treat a volume of stormwater shall be sized in accordance with Section 1.5.2 of this *Stormwater Management Manual*.

Wet Pond: A surface vegetated basin with a permanent pool of water, used to provide pollution reduction for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. See **Chapter 2.0** for information regarding the design of wet ponds.

Wetland: An area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas except those constructed as water quality or quantity control facilities. Specific wetland designations shall be made by the Corps of Engineers and the Division of State Lands.

1.4 STORMWATER DESTINATION

1.4.1 The Purpose of Stormwater Destination

Stormwater destination refers to the ultimate discharge point for stormwater generated by large, intense rainfall events from a particular development site. While many of the stormwater management facilities from Chapter 2.0 are designed to provide pollution reduction, flow control, or both, most of them do not infiltrate stormwater from large, intense rainfall events sufficiently enough to be considered the only stormwater destination for the site. In addition to water quality measures, destination measures from Chapter 2.0 are required and must be approved by the City (for off-site flow or infiltration within the public right-of-way and for infiltration on private property). It should be noted that the destination method might have an impact on the pollution reduction and flow control requirements for a site. Therefore, it is advantageous to determine the method of destination first.

Destinations can be grouped into two general categories: on-site infiltration and off-site flow. On-site infiltration methods include surface infiltration techniques, soakage trenches, drywells, and infiltration sumps. Off-site flow methods include discharge to drainage ways (including roadside ditches and natural drainages and streams), rivers, and off-site stormwater facilities. The appropriate destination point is site-specific and depends on a number of factors, including soil type, slopes, and availability of public and private infrastructure.

1.4.2 Destination Standards

ON-SITE INFILTRATION

Where complete on-site infiltration is used for the destination of stormwater, the following standards shall apply:

Surface Infiltration Facilities: Surface infiltration facilities must demonstrate the ability to store and infiltrate the Flood Control Design Storm. See **Section 2.2.2** for detailed surface infiltration facility sizing and design procedures, including safety factors.

Drywell, Infiltration Sump, and Soakage Trench Systems: The peak flow rate from the Flood Control Design Storm must be calculated using the Rational Method

(Q=C*I*A), and a safety factor of 2 shall be applied. The intensity shall correspond to the calculated time of concentration (5-minute minimum).

OFF-SITE DISCHARGE TO SURFACE FLOW

Where stormwater is discharged to an off-site surface flow conveyance facility, such as a ditch, drainage way, stream, or river, the following standards shall apply:

Beginning at the point of discharge from the site, the surface conveyance facility must have the capacity to convey flows from the Flood Control Design Storm from all contributing upstream drainage areas. The Flood Control Design Storm peak flow rate shall be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance.

OFF-SITE DISCHARGE TO PIPED FLOW

Where stormwater is discharged to an off-site piped conveyance facility the following standards shall apply:

For development with an increase in net impervious area: Beginning at the point of discharge from the site, the piped conveyance facility must have the capacity to convey flows from the Flood Control Design Storm from all contributing upstream drainage areas without surcharge. If no other stormwater options are available, the existing piped conveyance facility may surcharge, but the hydraulic grade line must remain 6" below gutter elevation where water could surcharge into the street, catch basins, manholes, curb inlets. The Flood Control Design Storm flow rates shall be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance.

100-YEAR ESCAPE ROUTE

All projects must demonstrate where stormwater from the 100-year storm event will go, and that public safety concerns and property damage will be avoided. This may include storage in parking lot, street, or landscaping areas.

1.4.3 Underground Injection Control Structures (UICs)

This section provides general information only. Complete regulations and requirements are available on the Oregon Department of Environmental Quality (DEQ) website:
http://www.deq.state.or.us/wq/groundwa/uichome.htm

The federal Underground Injection Control (UIC) Program (under the Safe Drinking Water Act) regulates the injection of water below the ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. DEQ administers the UIC Program in Oregon.

DEQ defines a UIC as any system, structure, or activity that discharges fluid below the ground or subsurface. UICs can pollute groundwater and surface water if not properly designed, sited, and operated. Stormwater systems such as sumps, drywells, and soakage trenches are examples of UICs subject to DEQ regulation.

Owners or operators of new and existing UICs are required to register and provide inventory data to DEQ. This information helps DEQ determine if the UIC is eligible for “rule authorization.” Rule authorization allows the owner or operator to operate the UIC without a permit from DEQ. UICs that do not qualify for rule authorization must either be closed, modified to meet requirements for rule authorization, or the owner must submit a water pollution control facility permit application to DEQ and obtain a permit.

CRITERIA FOR RULE AUTHORIZATION

UICs must be registered and approved by DEQ before construction. DEQ has set minimum criteria for rule authorization (OAR 340-044-0018), identified below:

? No other waste is mixed with stormwater.
? Site development, design, construction, and management practices have minimized stormwater runoff.
? No other method of stormwater disposal, including construction or use of surface discharging storm drains or surface infiltration designs, is appropriate.
? No domestic drinking water wells are present within 500 feet.
? No public drinking water supply wells are present within 500 feet or a two-year time of travel.
? No soil or groundwater contamination is present.
? The UIC is not deeper than 100 feet and does not discharge within 10 feet of the highest seasonal groundwater level.
? A confinement barrier or filtration medium is present, or best management practices (BMPs) are used to prevent or treat stormwater contamination. Stormwater management efforts should focus on maximizing source controls, use of vegetated pollution controls, and infiltration through surface infiltration or shallow subsurface facilities.
? Design and operation prevents accidental or illicit spills and allows for temporary blocking.

Compliance with these criteria must be demonstrated during the registration process. Compliance can generally be more readily accomplished if stormwater management efforts focus on maximizing source controls, using surface vegetated pollution control options such as swales and planters, and disposing of stormwater through surface infiltration or shallow subsurface facilities.

RULE AUTHORIZATION PROCESS

Registration and inventory information for UICs proposed to serve private property should be submitted directly to DEQ, (503) 229-5945.

Registration and inventory data should be submitted at least 60 days in advance of potential start of work. In some cases, DEQ and the City will need additional information from the applicant in order to make a determination on the potential for use of a UIC.

The registration, rule authorization and permit process is explained in more detail on DEQ's permit webpage: **http://www.deq.state.or.us** For technical questions, call the DEQ UIC Program at 503-229-5945. For copies of UIC registration applications or forms, call 1-800-452-4011.

1.5 POLLUTION REDUCTION

1.5.1 The Purpose of Pollution Reduction

Urbanization is recognized as having a serious impact on Dunes City's waters. As land is developed, impervious area and surface runoff increase. This runoff collects and transports pollutants to downstream receiving waters. Pollutants of concern include:

? Suspended solids (sediment)
? Heavy metals (dissolved and particulate, such as lead, copper, zinc, and cadmium)
? Nutrients (such as nitrogen and phosphorus)
? Bacteria and viruses
? Organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers)
? Floatable debris
? Increased thermal load (temperature)

Dunes City's design standards for source control devices as well as best management practices designed to improve stormwater quality. This *Stormwater Management Manual* is part of Dunes City's water quality management program to improve the quality of water within Dunes City.

1.5.2 Pollution Reduction Design Methodologies

Pollution reduction facilities shall be designed using the Water Quality Design Storm (see definition of Water Quality Design Storm). Pollution reduction facilities are sized using two different methods. Vegetated filters, oil / water separators, and some proprietary treatment systems are sized to treat a rate of flow draining through them. Other pollution reduction facilities are sized to treat a volume of runoff.

Flow rate-based pollution reduction facilities (such as swales and filters) designed to treat runoff generated by a rainfall intensity of **xxxx** inches per hour for off-line flow-through type facilities and **yyy** inches per hour for on-line flow-through type facilities, and flow volume-based facilities (such as wet ponds) designed to treat runoff generated by 1.4 inches of rainfall over 24 hours (with NRCS Type 1A rainfall distribution) will treat approximately ninety percent of the average annual rainfall. Facilities that must be sized by routing a hydrograph through the facility (rate-based facilities with a storage volume component) may utilize a continuous simulation program or single-storm hydrograph-based analysis method, such as SBUH (with 1.4 inches of rainfall over 24 hours and NRCS Type 1A rainfall distribution) to demonstrate capture and treatment ninety percent of the average annual rainfall volume. See **Appendix E** for more detailed information regarding the formulation of Dunes City's pollution reduction standards and Water Quality Design Storm.

One of the three design methodologies from **Chapter 2.0** must be used to design pollution reduction facilities to meet these requirements. The above rainfall intensities are to be used in the Rational Method (Q=CIA) equation to calculate pollution reduction runoff rates for flow rate based facilities. The above 24-hour storm is to be used in the Soil Conservation Service (SCS, now Natural Resources conservation Service) methodology to design volume based facilities. These Water Quality Design Storms are used to size rate-based pollution reduction facilities unless the **Simplified Approach** from Chapter 2.0 is used.

Exhibit 1-1: Pollution Reduction Facility Removal Capabilities

○ (white)	The facility can likely remove the parameter
◐ (grey)	The facility can potentially remove the parameter, depending on design
● (black)	The facility cannot likely remove the parameter

Pollution Control Facility Type	**Bacteria**	**Temperature**	**Nutrients**	**Pesticides (DDT, Dieldrin, Aldrin)**	**PCB**	**PCB FW**	**PCB NT**	**PCB**	**2,3,7,8 TCDD (Dioxin)**	**PAH**	**Trace Metals (Pb, As, Fe, Mn)**
Pervious pavement	○	○	◐	◐	◐	○	●	◐	◐	◐	◐
Tree credit	●	○	●	●	●	◐	●	●	●	●	●
Infiltration planter box	○	○	○	◐	○	○	◐	○	○	○	○
Flow-through planter box	○	○	○	◐	○	○	◐	○	○	○	○
Vegetated swale	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Grassy swale	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Street swale / planter	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Vegetated filter strip	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Vegetated infiltration basin	○	○	○	◐	○	○	◐	○	○	○	○
Wet pond	◐	◐	◐	◐	○	○	●	○	○	○	○
Extended wet detention pond	◐	◐	◐	◐	○	○	◐	○	○	○	○
Constructed treatment wetland	◐	○	○	◐	○	○	◐	○	○	○	○
Sand filter	○	○	○	◐	○	○	◐	○	○	○	○
Manufactured filtration device	○	◐	○	◐	○	○	◐	○	○	○	○
Rainwater harvesting	○	○	○	◐	○	○	○	○	○	○	◐
	○	○	○	◐	○	○	○	○	○	○	◐
	○	○	○	◐	○	○	○	○	○	○	◐
	○	○	○	◐	○	○	○	○	○	○	◐

Note: This table is for guidance only. Actual pollutant removal capabilities are based on specific facility design and site parameters.

OIL CONTROL FOR HIGH-RISK VEHICLE AND EQUIPMENT TRAFFIC AREAS

Oil controls can include either (1) spill control manholes (**Exhibit 2-25**) or (2) the incorporation of Lynch-type catch basins within the parking lot or at the outlet to swales or other pollution reduction facilities. The discharge of stormwater with a visible sheen off-site or into on-site UICs is prohibited.

FLOW CONTROL

1.6.1 The Purpose of Flow Control

Prior to development, rainfall appears as stream flow, evaporates into the atmosphere, or infiltrates into the ground where it recharges groundwater aquifers or surface water bodies. Urbanization results in the loss of forest, agricultural land, and open space and increases the amount of impervious area. As a result, development can have the following hydrologic impacts:

? Increased stormwater flow rates
? Increased stormwater runoff volumes
? Decreased groundwater recharge and base flows into streams
? Seasonal flow volume shifts

Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increases in stormwater runoff peak flow rates and volumes resulting from development.

The City’s policy is to ensure that runoff leaving the post-development site:
? does not exceed the capacity of the receiving conveyance facility or water body.
? does not increase the potential for stream bank and stream channel erosion.
? does not create or increase any upstream or downstream flooding problems.

The basic design concept for flow control (detention and retention) is simple: water from developed areas is managed with a variety of flow control techniques and released to downstream conveyance systems at a slower rate (detention) and lower volume (retention). Managing flows in this way attempts to mimic the site’s natural rainfall runoff response prior to development (See **Exhibit 1-2**).

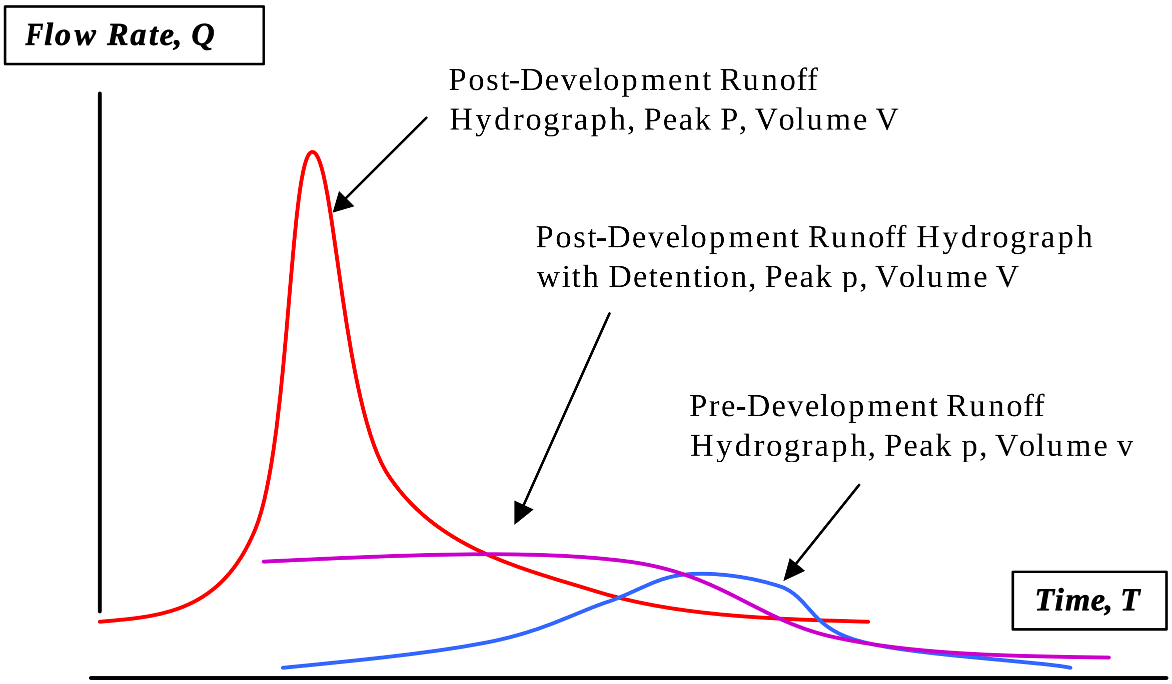
Detention facilities temporarily store stormwater runoff in a pond, tank, vault, or pipe. The water is slowly released from the facility, typically over a number of hours.

Retention facilities also store stormwater runoff. Rather than storing and releasing the entire runoff volume, however, the facility permanently retains a portion of the water on-site, where it infiltrates and recharges the groundwater aquifer, and in the case of surface retention facilities, evaporates or is absorbed and used by surrounding vegetation. In this way, retention facilities reduce the total volume of water released downstream. Surface treatments (such as pervious pavements) that cover or replace traditional impervious surfaces and vegetated facilities such as swales, filters, ponds, and planter boxes are all examples of retention facilities.

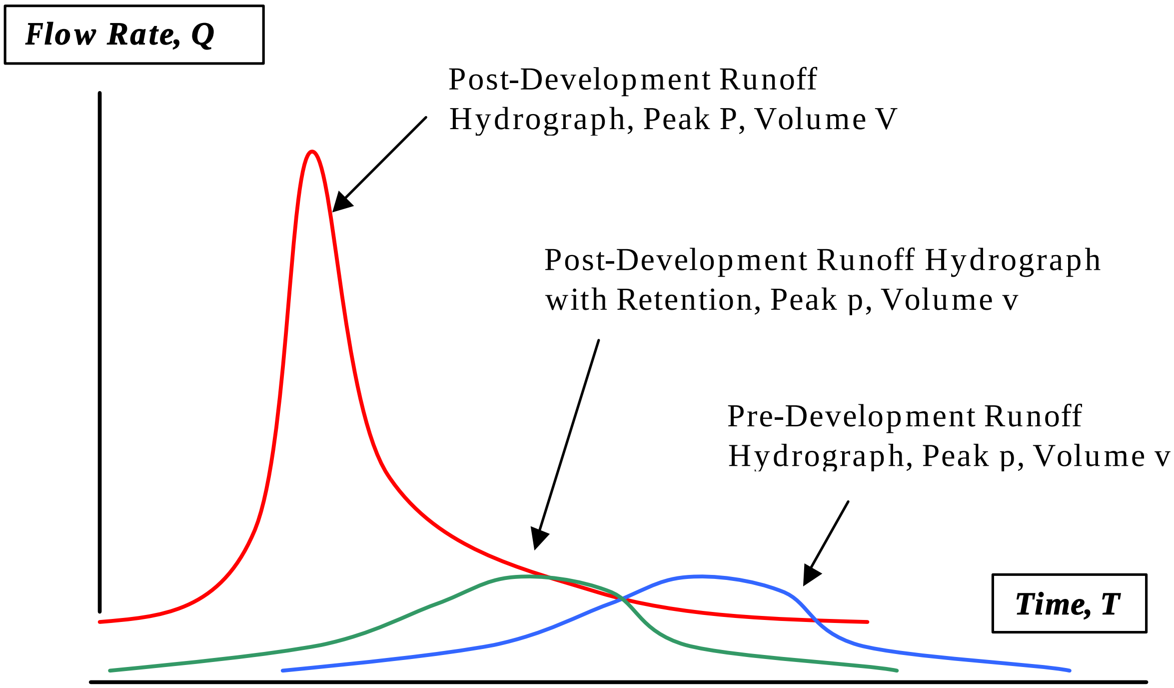
In the past, flow control plans often relied solely on detention facilities. Facilities that control only peak flow rates, however, allow the duration of high flows to increase, causing the potential for increased erosion downstream. For example, after development with detention, the magnitude of the 2-year peak flow rate may not increase, but the amount of time that the flow rate occurs will increase. Retention systems, on the other hand, are particularly effective at lowering the overall runoff volume, reducing the amount of time that the peak flow rate occurs. In addition, by infiltrating stormwater, retention systems recharge groundwater that serves as the base flow for streams during the dry season. Therefore, stream systems and lakes that require erosion protection, including salmonid habitat streams, warrant the use of retention systems. Where retention systems cannot be used, detention systems that control the duration of the geomorphically significant flow (i.e., flow capable of moving sediment) shall be used. Such detention systems employ lower release rates and are therefore larger in volume.

Time of concentration, or the time it takes rainfall to accumulate and run off a site, is another important factor in determining downstream hydrologic impacts created by development. Flow rates from individual sites may be controlled, but when they are combined quickly in fast-flowing conveyance pipes, the downstream effect will still be increased in-stream flow rates and volumes. Breaking flow patterns up into surface retention systems helps increase a site's time of concentration and lessons downstream impacts.

Exhibit 1-2: Illustration of the effect of detention and retention facilities on post-developed hydrographs (large storm events)



General Relationship Between Pre-Development Hydrograph, Post-Development Hydrograph, and Post-Development Hydrograph with Detention Facility in Place.



General Relationship Between Pre-Development Hydrograph, Post-Development Hydrograph, and Post-Development Hydrograph with Retention Facilities in Place.

1.6.2 Flow Control Strategies

Background:
Urban development can cause excessive stream bank and channel erosion. Any development that discharges stormwater runoff off-site shall be designed to control and minimize increases in flows to reduce the potential for further aggravation of in-stream erosion problems.

The added controls are based on the geomorphically significant flow, which is the flow that initiates sediment movement in the channels. The erosion-causing flow varies from channel to channel. Unless more specific data are available, the City assumes that the erosion-causing flow is equivalent to the Water Quality Design Storm, and the requirements of this manual are based on that assumption. Specifically, the more restrictive control requirement is to limit the post-development peak flow rate from the Water Quality Design Storm to the pre-development peak flow rate from the Water Quality Design Storm. The facilities shall also control the post-development flows from the Flood Control Design Storm peak flows to the pre-development levels.

General Requirement:
For new development in this area, on-site infiltration or on-site retention (such as pervious pavement, planters, swales, and other surface vegetated facilities) is preferred to control stormwater volumes and flow rates. Regardless of the method used, flow control shall be sufficient to maintain peak flow rates at their pre-development levels for storms larger than

the Water Quality Design Storm and smaller than the Flood Control Design Storm. (See definition of pre-developed condition in **Section 1.3**)

Circumstances when more restrictive flow control is required:
Development projects proposing to discharge stormwater off-site must evaluate the capacity of the off-site receiving system (i.e. storm sewer, ditch, drainageway, etc.) against the standards presented in **Section 1.4**. Additional flow control may be required on-site if off-site receiving systems do not have sufficient capacity to accept the additional flows.

IMPORTANT NOTES:

? Pollution reduction requirements still apply if a development site is exempt from flow control requirements.

? Development must still properly dispose of stormwater using approved methods in accordance with **Section 1.4** of this manual.

SUMMARY OF THE CITY'S FLOW CONTROL REQUIREMENTS:

1) Flow Control requirements apply to a development that drains directly to a stream or drains into a pipe that discharges into a stream. ?
2) On-site infiltration is required to the maximum extent practicable.
3) Where complete on-site infiltration is not practicable, on-site retention (flow volume control) facilities should be used.
4) Piping systems that provide conveyance from a site to an ultimate discharge point must have adequate capacity per City's standard, or additional flow control on-site may be required.

1.7 OPEN DRAINAGE

A drainage way is an open linear depression, whether constructed or natural, which functions for the collection and drainage of surface water. It may be permanently or temporarily inundated. Open drainage provides many important functions to both our stormwater conveyance system and the environment. Drainage ways provide both flow management (regulation of stream flow, retention and detention of water, flood control, contribution to seasonal base flows, and groundwater recharge) and water quality protection (filtration of pollutants and reduction of stormwater temperatures). Open drainage ways may either be privately or publicly maintained, but maintenance operations should not hinder the functionality of the public use of the facility.

1.7.1 Interlot Drainage

Interlot drainage refers to overland drainage without a defined channel (sheet drainage) and some French drain systems. This may include minor open channels and enclosed storm drain pipe systems, upon private properties that serves only to collect and remove stormwater runoff generated within the boundaries of private properties. All maintenance of interlot drainage systems is the responsibility of the property owner.

If water from an interlot system exits a private property onto an adjacent private property, the maintenance system is the joint responsibility of the private property owners involved.

1.7.2 Maintenance Guidelines

Cleaning operations may be done only as needed to maintain the conveyance capacity of the drainage way.

Cleaning operations should be done during the drier months when equipment can gain access to the channel banks without damage. Upon completion of the work, the banks shall not be left rutted or torn up or in a condition which would encourage rain water erosion. After cleaning operations, the banks along the channel shall be repaired of all damage caused by the maintenance activities in order to prevent accelerated erosion of the banks.

Unless a drainage way is publicly owned or covered by a recorded maintenance agreement that states otherwise; private property owners are responsible for vegetation management and debris removal. No mowing shall be performed on the banks of channels.

1.7.3 Easement Guidelines

Drainage easements are to assure that the current flow rate and pattern of the drainage way continues to be adequately conveyed through the development site. Current flow volumes and/or drainage way capacities will be determined by reviewing existing data, which may include available hydrologic records, drainage basin hydrology, historical data, high water marks, soil inundation records, photographs of past flooding, and other similar information.

Public drainage easements may be accepted by the City when all of the following criteria are met:

1) The storm drainage conveys water from public rights of way or is part of an identified public drainage system.
2) Capacity of the drainage facility is approved by the City as to meeting expected future development needs.
3) Existing systems are inspected by City staff prior to acceptance and all deficiencies discovered during the inspection are removed.
4) Maintenance access is provided.

1.8 OTHER REGULATORY STORMWATER PROGRAMS

Conformance with this manual's requirements does not relieve the applicant of other applicable local, state, or federal regulatory or permit requirements. This chapter is intended to complement any additional regulation, and is not expected to conflict with, exclude, or replace those regulations. In case of a conflict, the most stringent local, state, or federal regulations apply. Some of the more common additional regulations that may apply are summarized below.

1.8.1 Illicit Discharge Program

The City expects spill response supplies, such as absorbent material and protective clothing, to be available at all potential spill areas. Employees should be familiar with the site's operations and maintenance plan and/or proper spill cleanup procedures.

1.8.2 Industrial Pretreatment Program

Some facilities may be required to obtain a State of Oregon NPDES stormwater permit before discharging to the City's storm sewer system or to waters of the state. Applicants may also be required to obtain an industrial wastewater permit for discharges to the wastewater system. Facilities subject to these requirements are generally commercial or industrial facilities. Typical discharges include process wastewater, cooling water, or other discharges generated by some of the sources in this chapter that drain to the City stormwater or wastewater systems.

An evaluation will be done during the building permit review process to determine if an industrial discharge permit is required. If a permit is required, the industrial permit application process will be independent of the building permit review/issuance process. However, building permit applications may have to be revised to accommodate industrial permitting compliance requirements (*i.e.* sampling points, pretreatment facilities, *etc.*).

1.8.3 Oregon DEQ Underground Injection Control (UIC) Program

The Oregon Department of Environmental Quality (DEQ) identifies drywells, sumps, and piped soakage trenches as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. Because the UIC Program states that these types of wells may have a direct impact on groundwater, registration or permitting with DEQ is required. See **Section 1.4.3** for additional information.

1.8.4 Other Local, State, and Federal Programs

The requirements presented in this chapter do not exclude or replace the requirements of other applicable codes or regulations, such as the hazardous substances storage requirements of articles 79 and 80 of the Oregon State Fire Code; the spill prevention control and containment (SPCC) regulations of 40 CFR 112 (EPA); the Resource Conservation and Recovery Act (RCRA); or any other applicable local, state, or federal regulations or permit requirements.

Additional Dunes City and Oregon Department of Environmental Quality (DEQ) permit requirements may apply. Contact City staff at 541-997-3338 for additional information about stormwater discharges to City-owned stormwater systems.

Chapter 2.0
STORMWATER MANAGEMENT FACILITY DESIGN

Summary of Chapter 2.0

This chapter provides procedures for selecting and designing facilities that provide stormwater pollution reduction, flow control, and/or destination benefits. It includes:

To Use This Chapter:
1) Use the ordinance in **Appendix A** and **Chapter 1.0** to determine the pollution reduction, flow control, and destination requirements for the project.
2) Select stormwater management facilities from **Section 2.9: Facility Selection and Design** to meet pollution reduction, flow control, and/or destination requirements for the project.
3) Size facilities using the **simplified approach**, **presumptive approach**, or **performance approach** presented in this chapter. For simplified approach facilities, use **Form SIM** for sizing. For presumptive or performance approach facilities, use specific sizing criteria presented with each facility type and hydrologic analysis methods listed in **Section 2.3**. Integrate the facilities into the project's overall site plan.
4) Prepare drawings and specifications for each stormwater management facility in accordance with the design criteria in **Section 2.9: Facility Selection and Design**.
5) Consult **Chapter 3.0** for the operations and maintenance guidelines for each stormwater management facility.

2.1 INTRODUCTION

Three methodologies are included in this chapter for the sizing and design of stormwater management facilities: the simplified, presumptive, and performance approach. Each design approach has limitations on applicability. See **Exhibit 2-1** for a list of the facility types, their applicable design methodologies.

Exhibit 2-1: Stormwater Management Facility Application Table

Stormwater Management Facility Type	**Associated Design Approach**		
	Pollution Reduction	**Flow Control**	**Destination**
Pervious pavement	Simplified	Simplified	Performance
Tree credit	Simplified	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[3]
Flow-through planter	Simplified[1]	Simplified	NA
Swales < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[3]
Swales > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[3]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[3]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[3]
Sand filter	Simplified[1]	Simplified	Presumptive[3]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Spill control manhole	Presumptive[2]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Soakage trench	NA	Presumptive	Presumptive
Infiltration sump	NA	Presumptive	Presumptive
Drywell	NA	Presumptive	Presumptive

Exhibit 2-1 Notes:

[1]The performance approach may be used to downsize these simplified approach facilities when flow control is not required.

[3]The **Surface Infiltration Facility** design criteria must be used.

[4]Vegetated or grassy swales must be integrated into the bottom of dry detention ponds.

2.2 DESIGN METHODOLOGIES

2.2.1 Simplified Approach

The simplified approach is a relatively easy process for selecting and designing combined pollution reduction and flow control facilities, intended to save the project developer and the City time and expense. Combination facilities can be more practical to build than separate pollution reduction and flow control facilities. Simplified approaches facilitate the surface retention of stormwater, which provides a number of benefits, including pollution reduction, groundwater recharge and protection, peak flow reduction, and volume reduction. Rather than detaining stormwater and releasing it off-site at increased post-developed volumes, these facilities help infiltrate or retain water on-site. In areas with surface drainage ways and streams, on-site retention lessens the “flashy” high- and low-flow impacts created by development in watershed basins. Stream erosion and temperature impacts are also decreased. Overall, these facilities help mimic the natural hydrologic cycle by slowing and infiltrating stormwater.

Simplified Approach Sizing

Facilities designed in accordance with the simplified approach are presumed to comply with the City’s pollution reduction and flow control requirements. As sized with **Form SIM** sizing factors, the simplified approach facilities do not sufficiently dispose of large storm events. Additional facilities, designed using the presumptive or performance approach, are required that meet the destination requirements.

Sizing factors for the simplified approaches (shown on **Form SIM** below) were developed as an effective, simple, and quick tool to use for site planning and to accelerate permit review and approval. Generalized assumptions were used that may result in conservative sizing for some development sites. Manual users have the option to use the sizing factors as given on Form SIM, or follow the performance approach and submit an alternative facility size, along with supporting engineering calculations for City review for compliance with the performance criteria. The performance approach may be used to downsize facilities in circumstances when flow control is not required.

Appendix D: *Simplified Approach Sizing Calculations* provides information about how facility sizing factors were developed, and guidance on how the same methodology can be used to develop alternative facility sizes. An approved hydrologic analysis method (**Section 2.3**), such as a Santa Barbara Urban Hydrograph (SBUH) based approach or continuous simulation model, must be used to generate flow rates and volumes for design analysis. When facilities are downsized to meet pollution reduction requirements only, flows above the pollution reduction design flow must be routed around the facility with an approved diversion structure (**Section 2.5**).

The first four simplified approaches on Form SIM (pervious pavements and tree credits) are impervious area reduction or mitigation techniques to reduce the overall square-footage of impervious area that requires stormwater management. These facilities intercept rainfall, and are not generally designed to receive stormwater runoff. The second group of simplified approaches on Form SIM (infiltration and flow-through planter boxes, vegetated and grassy swales, vegetated filter strips and infiltration basins, and sand filters) is designed to receive stormwater runoff from impervious surfaces.

Simplified Approach Applications

Applicants using the simplified approach shall submit **Form SIM** as part of their permit application, along with construction drawings and details. **Page 2 of Form SIM** can be used to claim credit for planting new trees and retaining existing tree canopy on-site.

A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report is required by the City to evaluate the suitability of the proposed facility location. Projects that utilize simplified approach facilities must also fulfill Stormwater Destination requirements.

Form SIM: Simplified Approach for Stormwater Management

The city has produced this form to assist with a quick and simple approach to manage stormwater on-site.
Facilities sized w ith this form are presumed to comply with pollution reduction and flow control requirements.

New or Replaced Impervious Site Area ____ **Box 1**

(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)

INSTRUCTIONS

1. Enter square footage of new or redeveloped impervious site area in Box 1 at the top of this form.

2. Select impervious area reduction techniques from rows 1 & 2 to reduce the site's resulting stormwater management requirement. Tree credit can be calculated using the tree credit worksheet on the next page. Sum square footage of rows 1 & 2 and enter Total Impervious Area Reduction in Box 2

3. Subtract Box 2 from Box 1 and enter number in Box 3. This is development area that is required to provide treatment facilities for its stormwater runoff.

4. Select desired stormwater management facilities from rows 3-9. In Column 1, enter the square footage of impervious area that each facility will manage.

5. Multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the facility surface area needed to manage runoff from the impervious area.

6. Total Column 1 (Rows 3-9) and enter the resulting "Impervious Area Managed" in Box 4.

7. Subtract Box 4 from Box 3 and enter the result in Box 5. When this number reaches 0, pollution reduction and flow control requirements have been met. Submit this form with the application for permit.

8. If Box 3 is greater than 0 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from Chapter 2.0 of the Stormwater Management Manual to manage stormwater from these remaining surfaces.

Impervious Area Reduction Technique	Column 1 Impervious Area Managed = Facility Surface Area	Column 2	Column 3
1) Pervious Pavement(s)	____ sf		
2) Tree Credit (Next Page)	____ sf		
	____		
	____		
Total Impervious Area Reduction (Sum 1 and 2)	____ **Box 2**		

New Impervious Management Area (Box 1 - Box 2) ____ **Box 3**

Stormwater Management Facility	Impervious Area Managed			Sizing Factor		Facility Surface Area	Unit
3) Infiltration Planter	____	sf	x	0.07	=	____	sf
4) Flow -Through Planter	____	sf	x	0.07	=	____	sf
5) Vegetated Swale	____	sf	x	0.09	=	____	sf
6) Grassy Swale	____	sf	x	0.1	=	____	sf
7) Vegetated Filter Strip	____	sf	x	0.2	=	____	sf
8) Vegetated Infil. Basin	____	sf	x	0.11	=	____	sf
9) Sand Filter		sf	x	0.06	=	____	sf

Total Impervious Area Managed (Sum 3 thru 9) ____ **Box 4**

See Chapter 2.0: drywell and soakage trench sizing and design requirements.

Box 3 - Box 4 ____ **Box 5**

Development Site (Information):

Tax Map/Lot ____

Street Address ____

Total Sq. ftg. ____

Soil Type ____

Perc Rate ____

Form SIM (Page 2): Tree Credit Worksheet

See **Tree Credits** section for more information regarding the use of trees to meet stormwater management requirements.

New Evergreen Trees

To receive stormwater management credit, new evergreen trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree height (at the time of planting) to receive credit is 6 feet.

Enter number of new evergreen trees that meet qualification requirements in Box A		**Box A**
Multiply Box A by 200 and enter result in Box B		**Box B**

New Deciduous Trees

To receive stormwater management credit, new deciduous trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree caliper (at the time of planting) to receive credit is 2 inches.

Enter number of new deciduous trees that meet qualification requirements in Box C		**Box C**
Multiply Box C by 100 and enter result in Box D		**Box D**

Existing Tree Canopy

To receive stormwater management credit, existing tree canopy must be preserved during and after construction. Existing tree canopy must be within 25 feet of ground-level impervious surfaces. Existing trees cannot be credited against rooftop surfaces. Minimum tree caliper to receive credit is 4 inches.

Enter square-footage of existing tree canopy that meets qualification requirements in Box E		**Box E**
Multiply Box E by 0.5 and enter the result in Box F		**Box F**

Total Tree Credit

Add boxes B, D, and F and enter the result in Box G		**Box G**

For sites with less than 1,000 square-feet of new or redeveloped impervious area:
The amount in Box G is to be entered as "Tree Credit" on Form SIM. ** Stop Here **

For sites with more than 1,000 square-feet of new or redeveloped impervious area:

Multiply Box 1 of Form SIM by 0.1 and enter the result in Box H		**Box H**
Enter the lesser of Box G and H in Box I.		**Box I**

This is the amount to be entered as "Tree Credit" on Form SIM. **Stop Here**

2.2.2 Presumptive Approach

Facilities that utilize this design approach are classified as "presumptive," *i.e.*, facilities that are *presumed* to be in compliance with the City's pollution reduction, flow control, and/or destination requirements if the presented sizing and design requirements are followed.

There are a few key differences between the presumptive and simplified approach sizing methodologies. Stormwater management goals that require the presumptive approach to be used for a particular facility type do not lend themselves well to simplified sizing. More detailed hydrologic calculations must be performed to adequately design the facility to achieve the desired goal. Another difference is that the presumptive approach presents sizing methodologies that meet the requirements of one particular goal (pollution reduction, flow control, or destination), rather than multiple goals. See **Exhibit 2-1** for the table that specifies the design approaches that are applicable to each management goal, for each facility type.

Presumptive Approach Application

In addition to detailed construction drawings and details shown on permit drawings, all applicants using the presumptive approach for stormwater management are required to submit a detailed stormwater report. This report shall include a general description of the stormwater facility and how it is intended to function. It shall include detailed hydraulic calculations, as summarized in **Exhibit 2-2**. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be provided. In addition, a geotechnical report is required by the City to evaluate the suitability of the proposed facility location. Projects using facilities designed under the presumptive approach must also fulfill Stormwater Destination requirements.

Exhibit 2-2:
Checklist of Calculations to be Included in Stormwater Report

Stormwater Facility Type

A= Grassy Swale, and Subsurface Infiltration Facilities
B= Wet Pond
C= Extended Wet Detention Pond, and Surface Infiltration Facilities
D= Dry Detention Pond
E= Constructed Treatment Wetland
F= Detention Tank, Vault, or Pipe
G= Manufactured Treatment Technology or Spill Control Manhole

Parameter or Calculated Value to be Included in the Stormwater Report	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Site Variables:							
Site soil type (A, B, C, or D)	x	x	x	x	x	x	x
Contributing area (acres)	x	x	x	x	x	x	x
Pre-developed curve number CN			x	x	x	x	
Pre-developed time of concentration T of C (minutes)			x	x	x	x	
Post-developed curve number CN	x	x	x	x	x	x	x
Post-developed time of concentration T of C (minutes)	x	x	x	x	x	x	x
Distance from ground surface to max. height of seasonal groundwater (feet)	x	x	x	x	x	x	x
Hydrographs:							
Pre-developed hydrographs for the water quality and flood control storms, including peak rates & total volumes			x	x	x	x	
Post-developed hydrographs for the water quality and flood control storms, including peak rates & total volumes (only if routed through the facility)			x	x	x	x	
Post-developed hydrographs for the water quality and flood control storms after being routed through the facility, including peak rates & total volumes			x	x	x	x	
Facility Geometry:							
Table showing area and volume of the facility every 6” in elevation		x	x	x	x	x	
Side slopes (h: v or %)	x	x	x	x	x		
Longitudinal slope (h: v or %)	x				x		
Bottom width and length (feet)	x	x	x	x	x		
Overall width and length (feet)	x	x	x	x	x		
Hydraulic Controls:							
Orifice or weir descriptions, sizes, and elevations, including by-pass facilities			x	x	x	x	
Elevation, size, and type of overflow spillway or pipe	x	x	x	x	x	x	x

Calculated Values:							
Pollution reduction flow rate	x						x
Pollution reduction permanent pool volume and elevation		x	x		x		
Forebay volume and elevation		x	x	x	x		
Hydraulic residence time for the pollution control storm	x				x		
Storm routing data showing the peak water surface elevation in the facility for the 2 water quality & flood control storms (only if routed through the facility)	x	x					x
Detailed storm routing data for the water quality and flood control storms, showing inflow rate, outflow rate, and water surface elevation in the facility every 10 minutes throughout the storm.			x	x	x	x	

PRESUMPTIVE SURFACE INFILTRATION DESTINATION DESIGN APPROACH

Where soil conditions allow for percolation near the ground surface, surface infiltration facilities can be used to dispose of stormwater from large storm events to meet destination standards. The infiltration of stormwater near the ground surface helps increase the separation to groundwater, providing a greater filtration layer and decreasing the risk of groundwater contamination. It also serves to mimic the predevelopment hydrologic cycle, decreasing downstream impacts and recharging groundwater and increasing evapotranspiration.

Examples of surface infiltration facilities that can be designed under this approach include vegetated, grassy, and street swales, infiltration planters, and vegetated infiltration basins. While the design procedure in this section accounts for complete on-site infiltration of stormwater, facilities sized per the simplified approach are not sized adequately to meet destination standards and must include an overflow to an acceptable destination point. Surface infiltration facilities are not classified as underground injection controls (UICs) by DEQ, and therefore do not need to be registered.

Surface Infiltration Facility Design Approach to Meet Destination Standards

1) Determine the preliminary facility size by calculating the runoff volume generated by the 5-year storm (3.6 inches of rainfall over 24 hours, NRCS Type 1A rainfall distribution-from Table C-1). The SBUH method can be used to determine this volume, or the volume can be approximated by the following formula:

   Runoff Volume (cubic feet) = 0.3 feet * Impervious Area (square-feet)

   The facility will need to be capable of containing this volume of runoff through a combination of above ground storage and below ground storage within voids in a subsurface rock trench.

2) Surface infiltration facilities require infiltration tests during the design phase of the project. For public facilities, double-ring infiltrometer tests shall be conducted, in accordance with ASTM D3385-94 and City review for compliance with testing methods. For private facilities, the falling head infiltration test procedure specified in **Section 2.4.2** shall be used. The minimum acceptable infiltration rate for surface infiltration facilities to meet destination standards is 0.5 inches per hour. A clogging factor of 4 is then applied to the resulting infiltration rate to be used in the design of the facility.

3) The design infiltration rate (measured infiltration rate divided by 4) is then used to check the facility drawdown time. When full, the facility drawdown time shall not exceed 30 hours.

4) The wet seasonal high water table must be determined, and a minimum 4-foot clearance to bottom of facility must be maintained.

5) The 100-year base flood elevation shall be determined and must show that structures will not be flooded and that property damage and safety risks will be avoided.

6) Minimum setbacks from surface infiltration facilities to structures are shown in **Exhibit 2-4**.

7) All areas to be used as surface infiltration facilities shall be back-filled with a suitable sandy loam planting and filtration medium. Minimum depth shall correspond to each facility type's specification. The borrow source of this medium, which may be the same or a different location from the facility area itself, must be tested as follows:

   If the borrow area is undisturbed soil one test is required per 200 square-feet of borrow area. The test consists of "grab" samples at 1-foot depth intervals to the bottom of the borrow area. All samples at the testing location are then mixed, and the resulting sample is laboratory tested to meet the following criteria:

   USDA minimum textural analysis requirements: A textural analysis is required from the site-stockpiled topsoil. If topsoil is imported, a textural analysis shall be performed for each location where the topsoil was excavated.

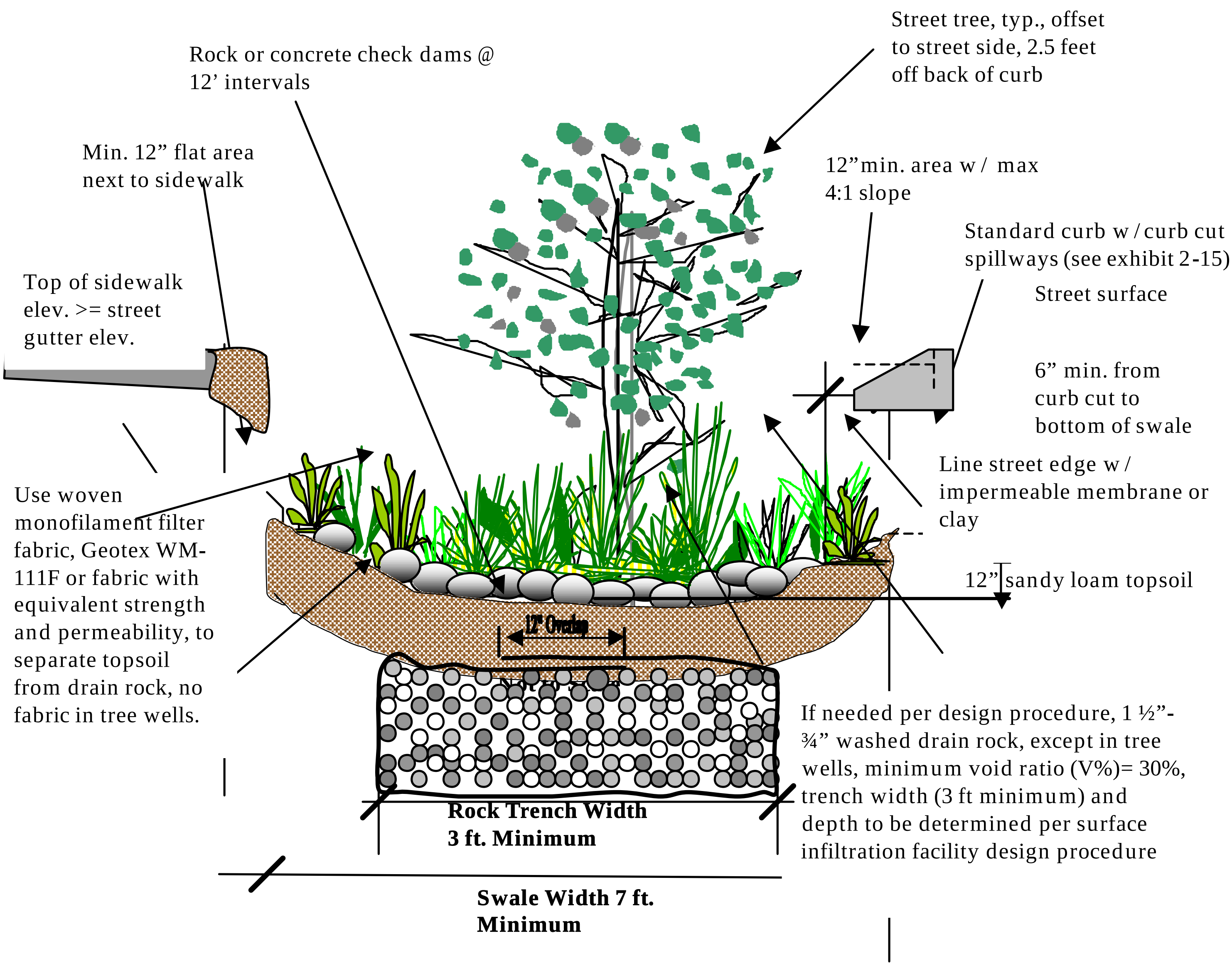
   Requirements:
   Sand 35 – 60%
   Silt 30 – 55% (Loam)
   Clay 10 – 25%

   The soil shall be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches.

8) Surface infiltration facility areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of surface infiltration facility areas.

9) For surface infiltration facilities, post-construction field infiltration testing will be required. Methods consistent with those used during design of the facilities shall be used. The resulting infiltration rate must show that the facility drawdown time will not exceed 30 hours.

Exhibit 2-3: Example Cross-Section of Vegetated Street Swale.



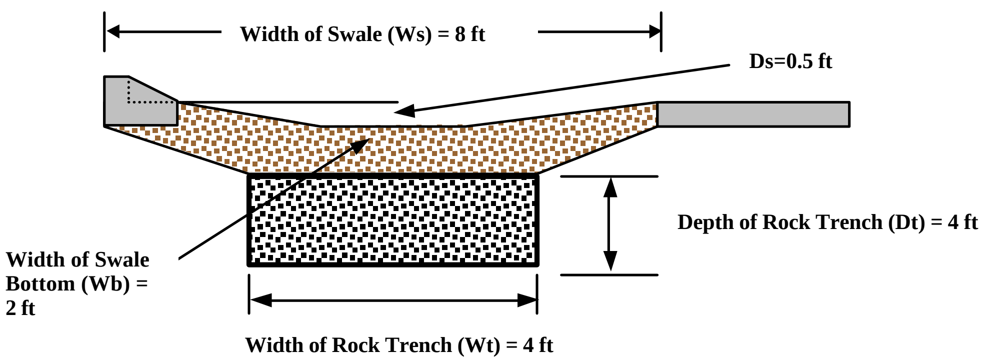
SURFACE INFILTRATION FACILITY SIZING EXAMPLE

Facility Type: Vegetated Street Swale

Objective: Find swale dimensions needed to meet destination standards.

Givens: Design Storm (P) = 5 year, 24 hour storm = 3.6 total inches = **0.3 feet**
Maximum Drawdown Time (Td) = **30 hours**
Infiltration Rate Safety Factor = **4**

Site Characteristics:
Impervious Area (Ai) = 200' x 28' = **5,600 square feet**
Measured Infiltration Rate (Im), using Double-Ring Infiltrometer Test = 12"/hr = **1'/hr**
Swale width (Ws) = **8 feet**
Swale bottom width (Wb) = **2 feet**
Swale depth (Ds) = **0.5 feet**
Rock trench width (Wt) = **4 feet**
Rock trench depth (Dt) = **4 feet**
Void Ratio of Rock Trench (VR) dimensionless = **0.30**



Calculations:
Runoff Volume (Vr) cubic feet = P * Ai = 0.3 * Ai = 0.3 * 5,600 = **1,680 cubic feet**
Design Infiltration Rate (Id) feet per hour = Im / 4 = **0.25 ft/hr**
Swale Storage Volume (Vs) = L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

Check #1: Runoff Volume (Vr) must be less than or equal to Swale Storage Volume (Vs)

Vr <= Vs

(0.3 * Ai) <= L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

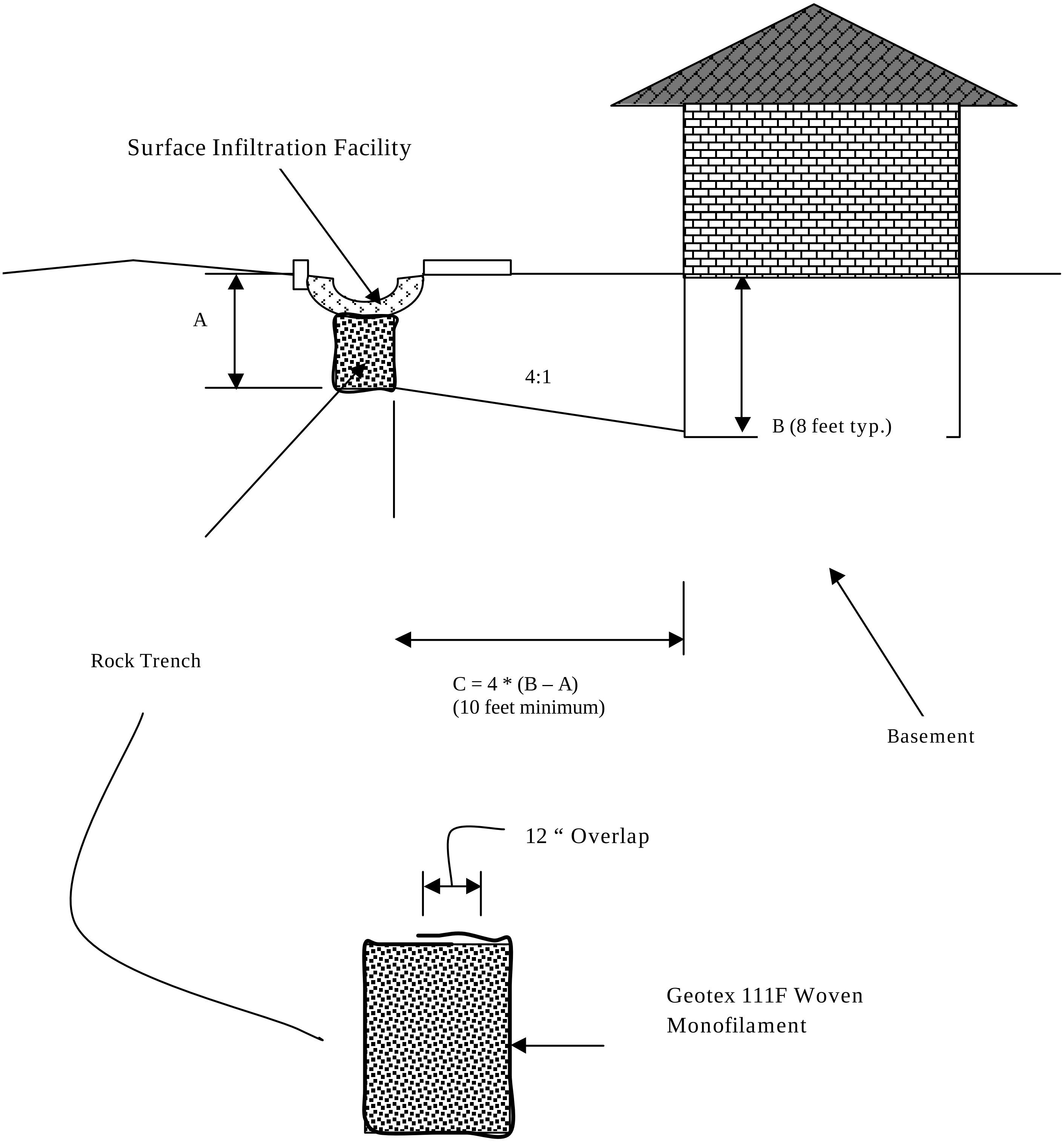
To find L: L = (0.3 * Ai) / [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]
L = (0.3 * 5,600) / [(0.5 * 0.5 * (8 + 2)) + (0.30 * 4 * 4)] = <u>230 feet</u>

Check #2: Swale drawdown time must not exceed maximum allowable (Td) = 30 hours

(0.3 * Ai) / (Id * Wt * L) <= 30 hours

(0.3 * 5,600) / (0.25 * 4 * 230) = <u>7.3 hours</u> < 30 hours, therefore OK

Exhibit 2-4: Surface Infiltration Facility Setback Detail



2.2.3 Performance Approach

The list of accepted stormwater management facilities is continually changing as new products are developed and more is learned about the performance of facilities already in use. Design professionals may propose facilities other than those included in this manual by using the performance approach.

The performance approach requires detailed engineering design and calculations, as well as documented evidence of the proposed design's performance. The City will accept the proposed design for meeting pollution reduction requirements if the design professional demonstrates that it:

?? Will perform at the required efficiency and capture and treat ninety percent of the average annual rainfall. Documented performance is required and shall include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.
?? Can be maintained to perform at the maintenance level set forth in **Chapter 3** of this Manual.

Performance Approach Application

In addition to detailed construction drawings and details to be shown on permit drawings, all applicants using the performance approach for stormwater management are required to submit a detailed stormwater report. This report shall include a description of the stormwater facility, how it is intended to function, and documented evidence of the proposed design's performance. It shall include detailed hydraulic calculations as summarized in **Exhibit 2-2** and must demonstrate the performance criteria listed above. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report is required by the City to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill Stormwater Destination requirements.

2.3 HYDROLOGIC ANALYSIS

With the exception of pollution reduction and flow control facilities designed using the simplified approach, stormwater management facilities should be designed using hydrologic analysis methods described below. If one of the hydrologic analysis methods discussed below is not used, City staff must pre-approve the alternative method before the plans and calculations are submitted. Regardless of how the hydrologic calculations are performed, all hydrologic submittals shall include data necessary to facilitate the City's review. This data is summarized in **Exhibit 2-2**.

2.3.1 Pollution Reduction

Flow Rate-Based Facilities: With the exception of facilities sized using the simplified approach, City staff will use the Rational Method with rainfall intensities presented in **Section 1.5.2** to verify flow rates used to size rate-based pollution reduction facilities. The design professional may, in addition to the Rational Method, use SBUH, NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of ninety percent of the average annual rainfall.

Flow Volume-Based Facilities: Volume-based pollution reduction facilities included in this manual (wet ponds and extended wet detention ponds) are required to use the pre-determined volume of 1.4 inches over 24 hours with a Vb/Vr ratio of 2 to be in presumptive compliance.

Combination Rate/Volume Facilities: When using SBUH, a 1.4 inch, 24-hour storm with NRCS type 1A rainfall distribution shall be used. The design professional may also use NRCS TR-55, HEC-1, or SWMM.

2.3.2 Flow Control

With the exception of facilities sized using the simplified approach the design professional may, in addition to the SBUH, use the Rational Method, NRCS TR-55, HEC-1, or SWMM to demonstrate compliance with flow control standards.

2.3.3 Destination

The Rational Method must be used to design the infiltration flow rate for infiltration sumps, drywells, and soakage trenches. If surface infiltration facilities, such as vegetated, grassy, or street swales, vegetated infiltration basins, and infiltration planters are proposed to meet destination requirements, the **Surface Infiltration Facility** sizing methodology must be used to meet presumptive compliance. The surface infiltration facility sizing methodology relies on the determination of the 5-year storm runoff volume, which can be calculated using the simple approximation formula provided, SBUH, NRCS TR-55, HEC-1, or SWMM.

2.3.4 Conveyance

The Rational Method will be used to verify design calculations for pipe or surface conveyance facility sizing. HEC-1 or SWMM may be used for projects greater than 40 acres in size.

2.3.5 Hydrologic Analysis Method Resources

The **Santa Barbara Urban Hydrograph (SBUH) Method** (**See Appendix C**) may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the simplified approach.

The **SCS TR-55 Method** may be applied to small, medium, and large projects. This is also one of the recommended methods for completing hydrologic analysis necessary for designing flow control facilities when not using the simplified approach. (Refer to SCS Publication 210-VI-TR-55, Second Edition, June 1986.)

The **HEC-1 Method** may be used on medium and large projects. (Refer to the HEC User’s Manual.)

The **SWMM Method** may be used on medium and large projects. (Refer to the SWMM User's Manual.)

2.4 INFILTRATION TESTING

To size stormwater management facilities, it is often necessary to know the infiltration rate of the soil at the actual facility location. The following general criteria apply to all proposed infiltration facilities:

1) For all infiltration facilities, a minimum infiltration rate of 0.5 inches per hour is required. Infiltration rates shall be determined by performing either infiltration testing in compliance with this section.
2) Testing can be classified into three categories, (1) initial feasibility testing, (2) design testing, and (3) post-construction testing. (see **Exhibit 2-5**)
3) Testing shall be conducted or observed by a qualified professional. This professional shall either be a registered professional engineer in the State of Oregon, or a soils scientist or geologist licensed in the State of Oregon.
4) All field-testing must be done in the proposed area of the facility.
5) Testing data shall be documented, including a description of the infiltration testing method.

2.4.1 Initial Feasibility Testing

Initial feasibility testing is conducted to determine whether full-scale testing is necessary, and is meant to screen unsuitable sites and reduce testing costs. It involves either one field test per facility (regardless of type or size) or previous testing data, such as the following:

? Septic percolation testing on-site, within 200 feet of the proposed facility location and on the same contour; or
? Previous written geotechnical reporting on the site location as prepared by a qualified geotechnical expert; or
? NRCS Lane County Soil Mapping showing unfeasible conditions such as a hydrologic group "D" soil in a low-lying area.

If the results of initial feasibility testing as determined by a qualified professional (registered professional engineer, landscape architect, or geologist) show that an infiltration rate of greater than 0.5 inches per hour is probable, then the design and post-construction testing shall be in accordance with **Exhibit 2-5**. PW will waive design-testing if existing testing data is on file with the City for the site. In the case of infiltration testing, an encased soil boring may be substituted for a test pit, if desired.

Exhibit 2-5: Infiltration Testing Summary Table

Type of Facility	Initial Feasibility Testing (Section 2.4.1)	Design Testing (Section 2.4.2)	Post-Construction Testing (Section 2.4.3)
Drywell System	Required	One test pit and one falling head test per drywell.	(see **drywell** section for procedure)
Soakage Trench	Required	One test pit and one falling head test per soakage trench.	Not applicable.
Infiltration Sump System	Required	Testing of an existing sump in the vicinity, or construction and testing of one sump.	All infiltration sumps must be field-tested after construction. (see **infiltration sump** section for procedure)
Surface Infiltration Facility	Required	One double-ring infiltrometer test (for public facilities) or one falling head test (for private facilities) per facility area	All surface infiltration facilities must be field tested after construction.

2.4.2 Design Testing

The following **test pit** procedure shall be followed:

1) Excavate a test pit or dig a standard soil boring to a minimum depth of 4 feet below the proposed facility bottom elevation. Also conduct Standard Penetration Testing (SPT) every 2 feet to a depth of 4 feet below the facility bottom.
2) Determine depth to highest seasonal groundwater table (if within 4 feet of proposed bottom) upon initial digging or drilling.
3) Determine USDA or Unified Soil Classification System textures at the proposed bottom and 4 feet below the bottom of the facility.
4) Determine depth to bedrock (if within 4 feet of proposed bottom).
5) The soil description should include all soil horizons.
6) The location of the test pit or boring shall correspond to the facility location; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such.

The following **falling head infiltration test** procedure shall be followed:

1) Install casing (solid 5-inch diameter, 30-inch length) to 24 inches below proposed facility bottom (see **Exhibit 2-6**).
2) Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing. Upon the tester's discretion, a 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill casing with clean water to a depth of 24 inches and allow to pre soak for 24 hours.
3) 24 hours later, refill casing with another 24 inches of clean water and monitor water level (measured drop from the top of the casing) for 1 hour. Repeat this procedure (filling the casing each time) three additional times, for a total of four observations. Upon the tester's discretion, the final field rate may either be the average of the four observations or the value of the last observation. The final rate shall be reported in inches per hour.
4) Testing may be done through a boring or open excavation.
5) The location of the test shall correspond to the facility location.
6) Upon completion of the testing, the casings shall be immediately pulled, and the test pit shall be back-filled.

Where required, the **double-ring infiltrometer test** procedure must follow ASTM D3385-94, standard test method for infiltration rate of soils in field using double-ring infiltrometer.

Note: For soils types known as Cascade silt loams (soils with a fragipan that causes a perched water table in winter months), testing must be done between June 1 and October 1.

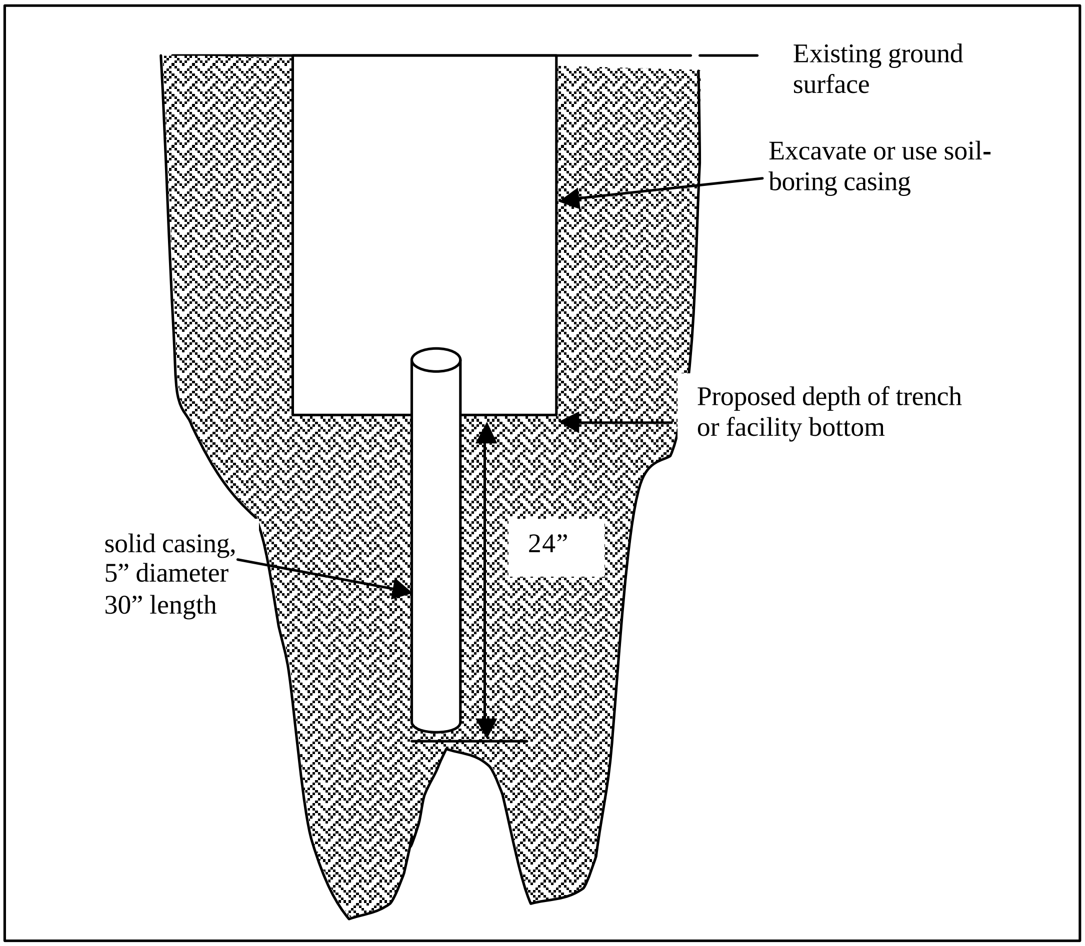
2.4.3 Post-Construction Testing

See surface infiltration facility, sump, and drywell design sections for post-construction infiltration testing procedures.

2.4.4 Laboratory Testing

Grain-size sieve analysis and hydrometer tests where appropriate may be used to determine USDA soils classification and textural analysis. Visual field inspection by a qualified professional may also be used, provided it is documented. The use of laboratory testing to establish infiltration rates is prohibited.

Exhibit 2-6: Falling Head Test



2.5 CONTROL STRUCTURES FOR DETENTION SYSTEMS

This section presents the methods and equations for the design of flow restricting control structures, for use with extended wet detention ponds, dry detention ponds, and structural detention facilities. It includes details and equations for the design of orifices, and equations for rectangular sharp crested weirs and v-notch weirs.

Detention control structures shall be either weir structures or orifice structures. Weir structures may be enclosed in a catch basin, manhole, or vault, or may be installed in the open, provided they are accessible for maintenance and are not exposed to damage. Riser type restrictor devices also provide some incidental oil/water separation and spill control. Weir structures provide some oil/water separation when fitted with a baffle plate located upstream of the weir.

2.5.1 Design Methodologies

The following criteria apply to control structure design.

? The control structure shall be designed to pass the 100-year storm event as overflow without causing flooding of the contributing drainage area.

Orifices

? Orifices may be constructed on a “tee” riser section (see **Exhibit 2-7**) or on a baffle (see **Exhibit 2-8**).

? Multiple orifices may be necessary to meet the flood control design storm performance for a detention system. However, extremely low flow rates may result in small orifices (< 2 inches) that are prone to clogging. In these cases, retention facilities that do not rely on orifice structures shall be used to the maximum extent practicable to meet flow control requirements. Large projects may also result in high flow rates that necessitate excessively large orifice sizes that are impractical to construct. In such cases, several orifices may be located at the same elevation to reduce the size of each individual orifice.

Orifice Sizing Equation:

$$Q = C A \sqrt{2gh}$$

where:

Q = Orifice discharge rate, cfs
C = Coefficient of discharge, feet (suggested value = 0.60 for plate orifices)
A = Area of orifice, square feet
h = hydraulic head, feet
g = 32.2 ft/sec^2

The diameter of plate orifices is typically calculated from the given flow. The orifice equation is often useful when expressed as an equivalent orifice diameter in inches.

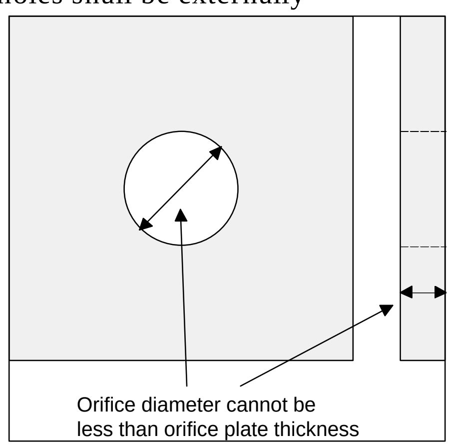
$$d = \sqrt{\frac{36.88\, Q}{\sqrt{h}}}$$

where:

Q = flow, cfs
d = orifice diameter, inches
h = hydraulic head, feet

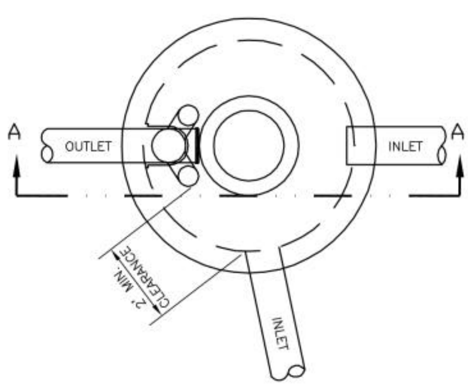
? Orifices shall be protected within a manhole structure, or by a minimum 18-inch-thick layer of 1½" to 3" evenly graded, washed rock. Orifice holes shall be externally protected by stainless steel or galvanized wire screen (hardware cloth) with a mesh of 3/4" or less. Chicken wire shall not be used for this application.

? Orifice diameter shall be greater than or equal to the thickness of the orifice plate (see diagram).



? If less than 3", the orifice shall not be made of concrete. A thin material (e.g., stainless steel, HDPE or PVC) shall be used to make the orifice plate; the plate shall be attached to the concrete or structure**.**

PLAN VIEW



NOTES:

1. EXCEPT AS SHOWN OR NOTED, UNITS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGER PRECAST CONCRETE MANHOLE PER STANDARD PLAN.

2. FOR DETAILS SHOWING GRADE RING, MANHOLES, AND TOP SLABS, SEE STANDARD PLAN.

3. PIPE SUPPORTS SHALL ANCHORED AT 3' MAX. SPACING BY 3/8 DIA. STAINLESS STEEL EXPANSION BOLTS EMBEDDED 2" IN WALL.

4. THE RESTRICTOR/SEPARATOR SHALL BE FABRICATED FROM SOLID WALL HDPE PIPE, OR APPROVED EQUAL.

5. OUTLET SHALL BE CONNECTED TO RESTRICTOR PIPE WITH A FLEXIBLE COUPLING.

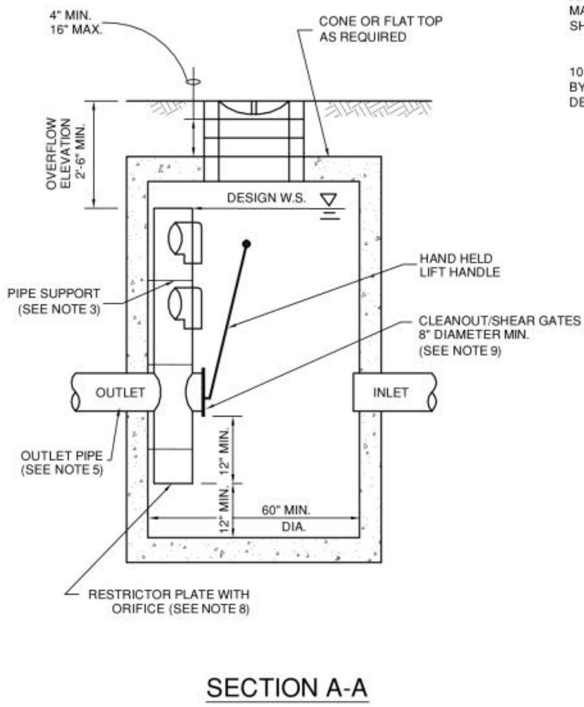
6. THE VERTICAL RISER STEM OF THE RESTRICTOR/ SEPARATOR SHALL BE THE SAME DIAMETER AS THE HORIZONTAL OUTLET PIPE, WITH A 10" MINIMUM DIAMETER.

7. MULTI-ORIFICE ELBOWS MAY BE LOCATED AS SHOWN OR ALL ON ONE SIDE OF RISER. SIZE OF ELBOWS AND PLACEMENT TO BE CLEARLY LABELED ON PLANS.

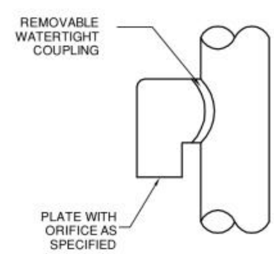
8. RESTRICTOR PLATE WITH ORIFICE AS SPECIFIED ON PLANS. SPECIFIED OPENING TO BE CUT ROUND AND SMOOTH.

9. CLEANOUT/SHEAR GATE:
ALUMINUM ALLOY PER B-26-26-32E OR CAST IRON ASTM A48 CLASS 308 AS REQUIRED. LIFT HANDLE EITHER SOLID OR TUBING WITH ADJUSTABLE HOOK AS REQUIRED. NEOPRENE RUBBER GASKET REQUIRED BETWEEN RISER MOUNTING FLANGE AND GATE FLANGE. MATING SURFACES OF LID AND BODY TO BE MACHINED FOR PROPER FIT. FLANGE MOUNTING BOLTS SHALL BE 3/4" DIA. STAINLESS STEEL.

10. GATE SHALL NOT OPEN BEYOND THE CLEAR OPENING BY LIMITED HINGE MOVEMENT, STOP TABS, OR SOME OTHER DEVICE.



SECTION A-A



ELBOW DETAIL

Dunes City Exhibit Drawing

ORIFICE LOCATION TEE RISER

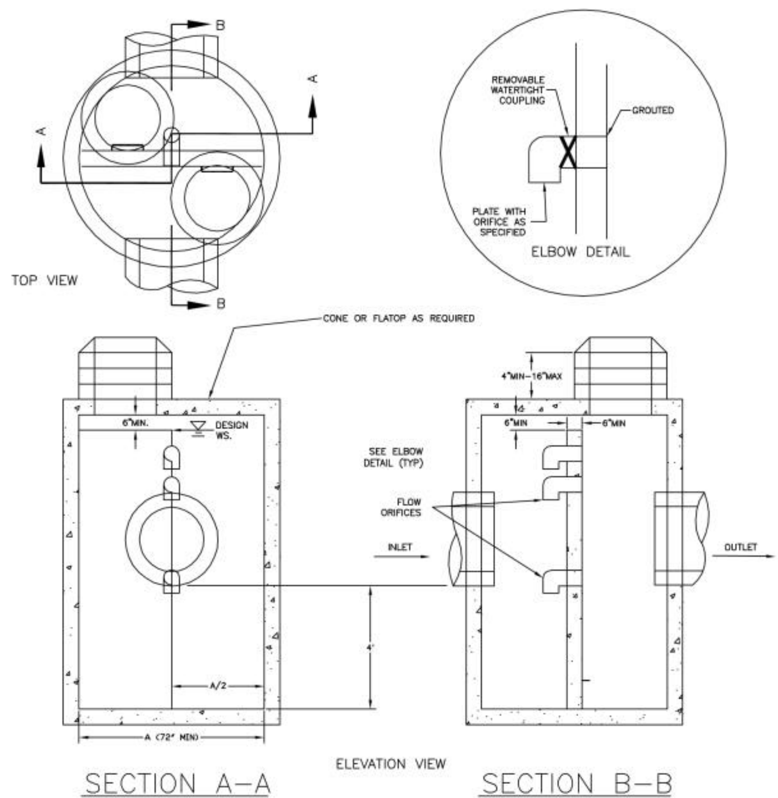
REVISIONS	
DATE	DESCRIPTION

6/06

EXHIBIT 2-7

NOTES

1. EXCEPT AS SHOWN OR NOTED, UNIT SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGE PRE CAST CONCRETE MANHOLES.
2. SEE PROJECT PLANS FOR SIZE AND LOCATION OF ORIFICES.
3. PIPE SIZES, SLOPES AND ALL ELEVATIONS AS SHOWN IN THE PLANS.
4. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
5. PRE CAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
6. ORIFICE PLATES TO BE 1/4" THICK MIN. HDPE OR APPROVED EQUAL AND ATTACHED WITH 1/2" STAINLESS STEEL BOLTS.

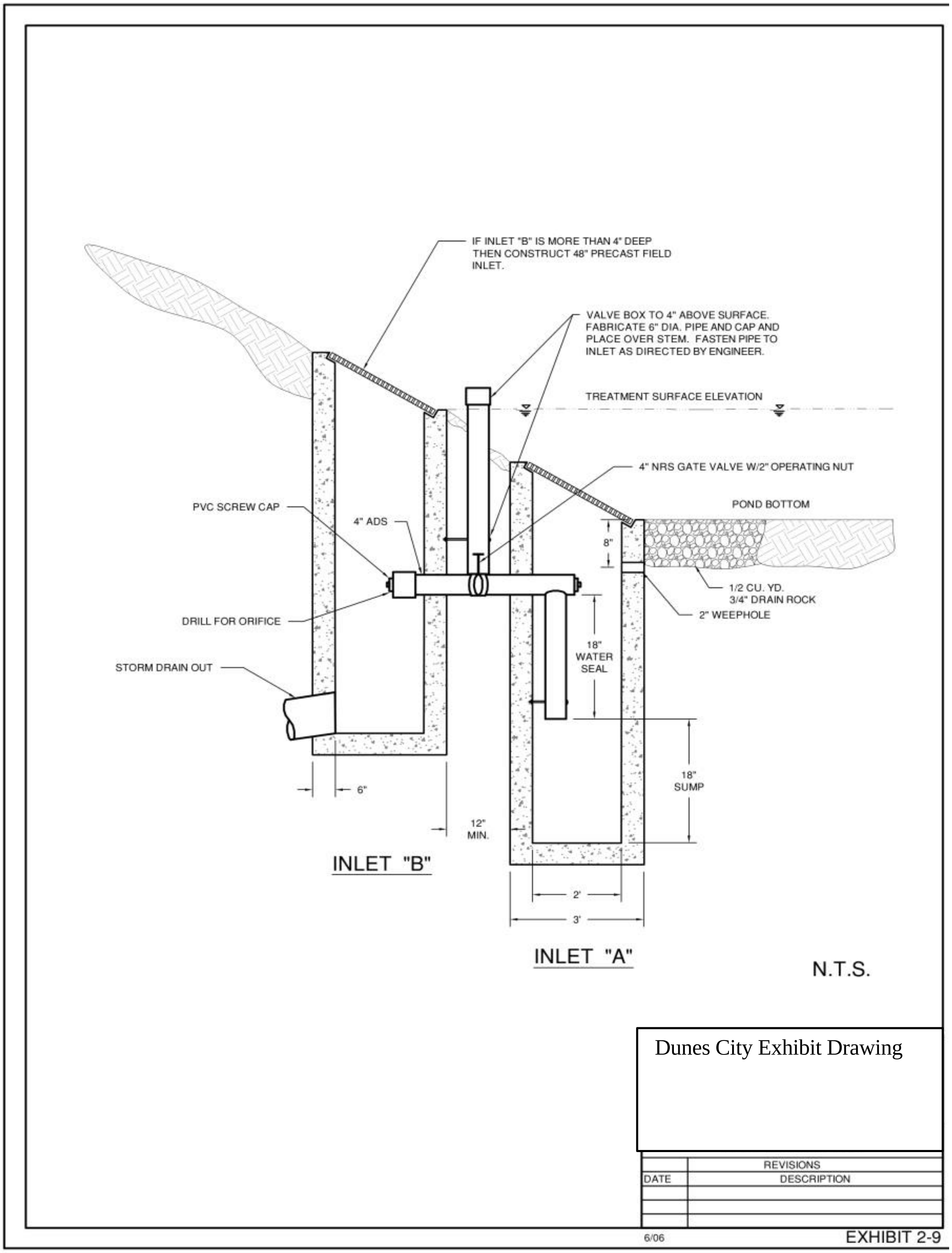


Dunes City Exhibit Drawing

ORIFICE LOCATION BAFFLE RISER

DATE	REVISIONS DESCRIPTION

6/06 EXHIBIT 2-8


IF INLET "B" IS MORE THAN 4' DEEP THEN CONSTRUCT 48" PRECAST FIELD INLET.
VALVE BOX TO 4" ABOVE SURFACE. FABRICATE 6" DIA. PIPE AND CAP AND PLACE OVER STEM. FASTEN PIPE TO INLET AS DIRECTED BY ENGINEER.
TREATMENT SURFACE ELEVATION
4" NRS GATE VALVE W/2" OPERATING NUT
POND BOTTOM
PVC SCREW CAP
4" ADS
8"
1/2 CU. YD. 3/4" DRAIN ROCK
2" WEEPHOLE
DRILL FOR ORIFICE
18" WATER SEAL
STORM DRAIN OUT
18" SUMP
6"
12" MIN.
INLET "B"
2'
3'
INLET "A"
N.T.S.
Dunes City Exhibit Drawing
REVISIONS
DATE
DESCRIPTION
6/06
EXHIBIT 2-9

Rectangular Notched Sharp Crested Weir

$$Q = C(L - 0.2H) * H^{1.5}$$

where:

Q= Weir discharge, cubic feet per second (cfs)
C = 3.27 + 0.40*H/P, feet
P = Height of weir bottom above downstream water surface, feet
H = Height from weir bottom to crest, feet
L = Length of weir, feet*

* For weirs notched out of circular risers, length is the portion of the riser circumference not to exceed 50 percent of the circumference.

V-Notched Sharp Crested Weir

$$Q = C_d \left(\text{Tan}\ \frac{?}{2}\right) H^{\frac{5}{2}}$$

where:

Q = Weir discharge, cfs
C_d = Contraction coefficient, feet (suggested value = 2.5 for 90 degree weir)
? = Internal angle of notch, degrees
H = Height from weir bottom to crest, feet

2.6 ACCESS FOR OPERATIONS AND MAINTENANCE

Adequate access for operations and maintenance must be provided to all stormwater management facilities and their components. Public facilities shall have access routes at least 10 feet wide, not to exceed 10 percent in slope, and shall be located adjacent to public rights-of-way wherever feasible. Access routes greater than 100 feet in length shall provide a vehicle turn-around for the maintenance vehicles. Where structural surfaces are needed to support maintenance vehicles, access routes shall be constructed of gravel or other permeable paving surface where possible

2.7 LANDSCAPING

2.7.1 Landscaping Applications

The design must include elements that ensure landscape plant survival and overall stormwater facility functional success. Construction specifications and/or drawings need to include the following elements:

?? Stormwater management facilities shall be designed so permanent long-term irrigation systems are not needed.

?? Landscape plan showing the location of landscape elements, including size and species of all proposed plantings, and existing plants and trees to be preserved.

?? Plant list.

2.7.2 Landscaping Design and Management

Vegetation is a key element in the performance of many stormwater management facilities. Facility-specific planting practices are shown in **Section 2.9**. These practices are based on experience and/or standard landscape industry methods for design and construction.

All plants that do not survive must be replaced. Establishment procedures, such as control of invasive weeds, animal and vandal damage, mulching, re-staking, watering, and mesh protection shall be implemented to the extent needed to ensure plant survival.

It is critical that selected plant materials are appropriate for soil, hydrologic, and other facility and site conditions. For City-maintained facilities located outside of the public right-of-way, all plants within the facility area shall be appropriate native species.

The design for plantings shall minimize the need for herbicides, fertilizers, pesticides, or soil amendments at any time before, during, and after construction and on a long-term basis. Plantings shall be designed to minimize the need for mowing, pruning, and irrigation.

If plant establishment cannot be achieved with seeding by the time of substantial completion of the stormwater facility portion of the project, the contractor shall plant the area with wildflower sod, plugs, container plants, or some other means to complete the specified plantings and protect against erosion before water is allowed to enter the facility.

2.8 OUTFALL DESIGN

Outfalls should be located above the downstream mean low water level, unless a pipe velocity of 3' per second can be maintained with the pipe outfall located below the water surface level. **Exhibit 2-10** shows a typical outfall layout. Publicly accessible outfalls greater than 15 inches in diameter shall include grated protection in accordance with **Exhibit 2-14**. All outfalls shall be provided with a rock splash pad or other approved erosion control/energy dissipation measures. Rock protection at outfalls from small diameter pipes shall be as follows:

RIP-RAP PAD DIMENSIONS FOR SMALL OUTFALLS

2" Pipe: 12" wide x 24" long x 2" deep, Average Stone Size = 1"
4" Pipe: 24" wide x 36" long x 4" deep, Average Stone Size = 2"
6" Pipe: 36" wide x 48" long x 6" deep, Average Stone Size = 4"

Rock protection at outfalls from pipes greater than 6 inches shall be designed in accordance with **Exhibit 2-11,** unless otherwise approved by the City. **Exhibit 2-12** shows riprap class selection.

Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 feet per second (fps). These shall be designed by a professional engineer using published references such as *Hydraulic Design of Energy Dissipaters for Culverts and Channels* (U.S. Department of Transportation, Federal Highway Administration) and other references. The construction plan submittal shall identify the design reference.

Drainage ways and rivers may have steep slopes or banks and may have unstable landforms (i.e. slump). Geotechnical investigation and analysis to determine the stability of the stream or river bank shall be provided with the stormwater study.

Exhibit 2-10: Typical Outfall Layout With Energy Dissipation

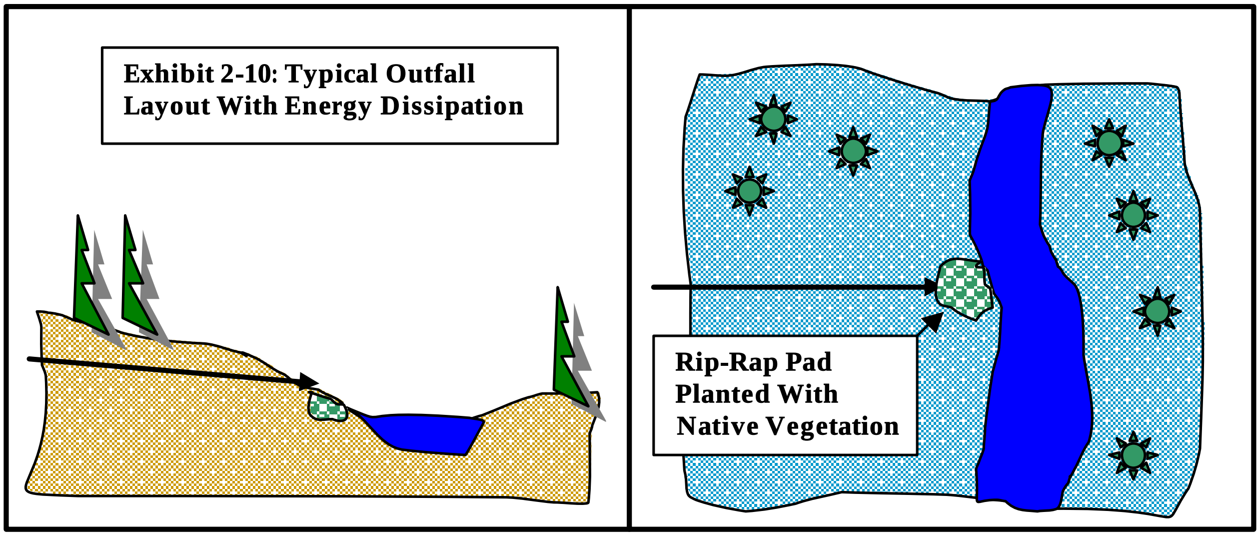


Exhibit 2-11
ROCK PROTECTION AT OUTFALLS FOR PIPES GREATER THAN 6 INCHES IN DIAMETER

Discharge Velocity at Design Flow (fps)			REQUIRED PROTECTION Minimum Dimensions				
			Type	Depth*	Width	Length**	Height
0	To	5	Riprap*	2 x (max stone size)	Diameter + 6 ft.	As calculated	Crown + 1 ft.
6	To	10	Riprap*	2 x (max stone size)	Diameter + 6 ft. or 3x dia. which-ever is greater	As calculated	Crown + 1 ft.
11	To	20	Gabion or Riprap*	2 x (max stone size)	Diameter + 6 ft. or 4x dia. which-ever is greater	As calculated	Crown +1 ft.
Over 20			Engineered Energy Dissipater Required				

* Riprap size shall be determined using the following formulae*** and the City's *Standard Construction Specifications*

V = Average velocity (ft/s)
Do = Pipe diameter (ft)
ds = Riprap diameter (ft)
Lsp = Apron length (ft)
depth = Thickness (ft)
Fo = V/(g*Do)$^{0.5}$

*Riprap size ds=0.25*Do*Fo (6" minimum)
Depth=2*ds (1 foot minimum)
**Apron length Lsp= Do(8+17*Log Fo)

g = 32.2 ft/s^2

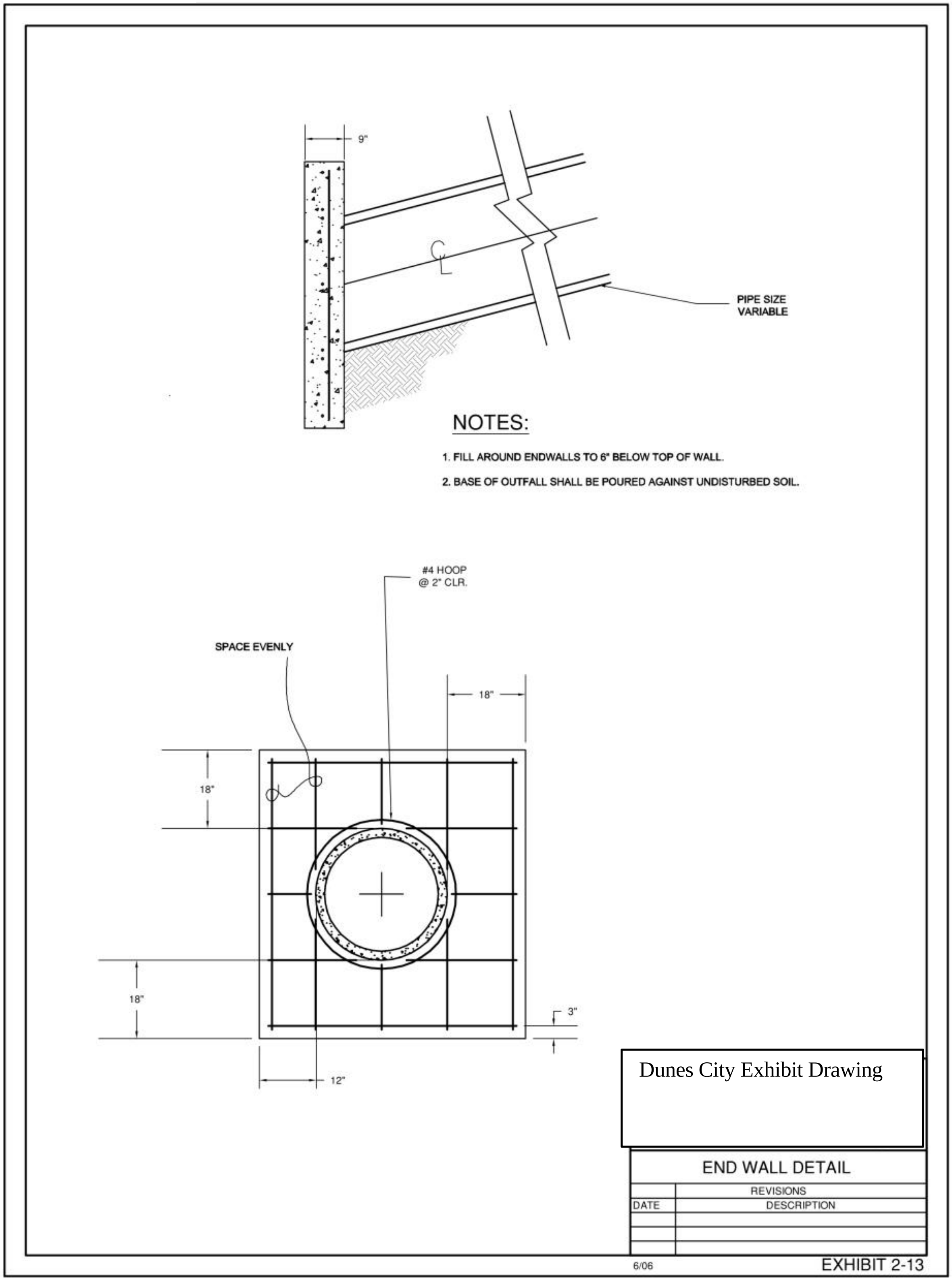
***US Army Corps of Engineers design formulas from *Erosion and Riprap Requirements at Culvert and Storm Outlets*, January 1970

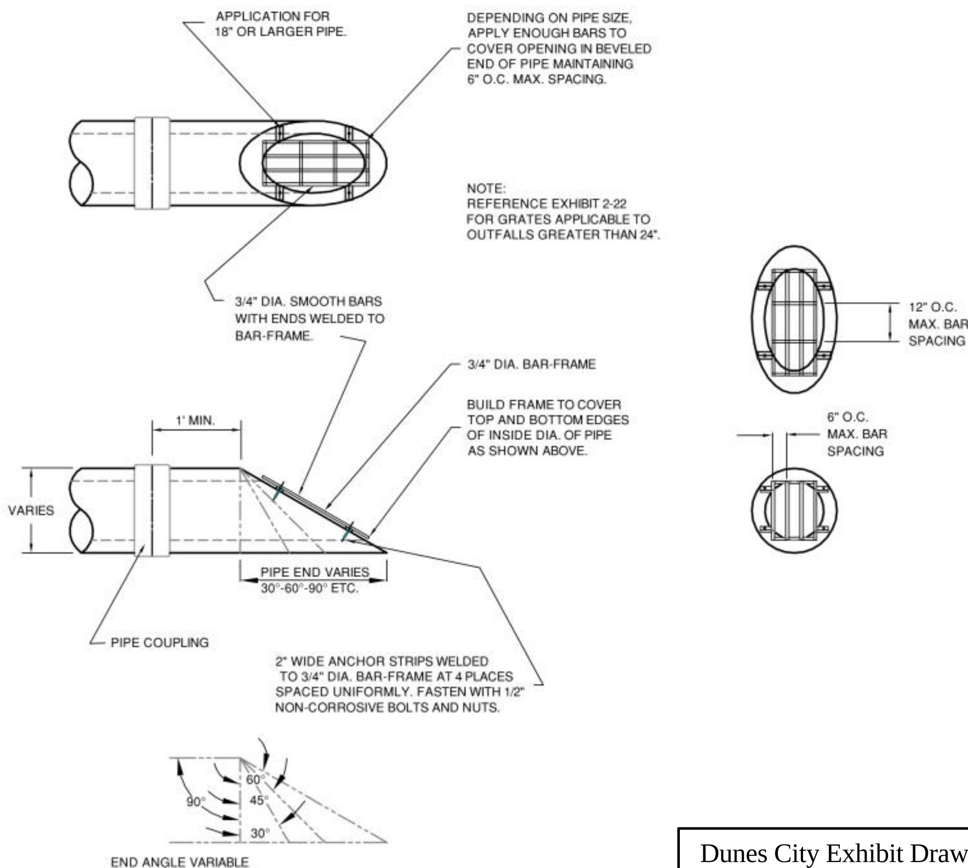
Exhibit 2-12: RIPRAP CLASS SELECTION

Weight (lbs)	Spherical Size (inches)	% by Weight	Average Stone Size (inches)
Class 50			6.3
30 – 50	8.5 – 10	20	
15 – 30	6.7 – 8.5	30	
2 – 15	3.5 – 6.7	40	
0 – 2	0 – 3.5	10	
Class 100			7.6
60 – 100	10.6 – 12.8	20	
25 – 60	8.0 – 10.6	30	
2 – 25	3.5 – 8.0	40	
0 – 2	0 – 3.5	10	
Class 250			11.3
200 – 250	15.0 – 18.0	20	
100 – 200	12.0 – 15.0	30	
10 – 100	6.0 – 12.0	40	
0 – 10	0 – 6.0	10	
Class 700			15.2
500 – 700	21.5 – 24.0	20	
200 – 500	15.9 – 21.5	30	
20 – 200	7.4 – 15.9	40	
0 – 20	0 – 7.4	10	
Class 2000			21.7
1400 – 2000	30.4 – 34.0	20	
700 – 1400	24.0 – 30.4	30	
40 – 700	9.3 – 24.0	40	
0 – 40	0 – 9.3	10	

Reference: Erosion and Riprap Requirements at Culverts and Storm-Drain Outlets
U.S. Army Engineers, Jan 1970

Exhibit 2-13


9"
PIPE SIZE
VARIABLE
NOTES:
1. FILL AROUND ENDWALLS TO 6" BELOW TOP OF WALL.
2. BASE OF OUTFALL SHALL BE POURED AGAINST UNDISTURBED SOIL.
#4 HOOP
@ 2" CLR.
SPACE EVENLY
18"
18"
18"
3"
12"
Dunes City Exhibit Drawing
END WALL DETAIL
REVISIONS
DATE
DESCRIPTION
6/06
EXHIBIT 2-13



Dunes City Exhibit Drawing

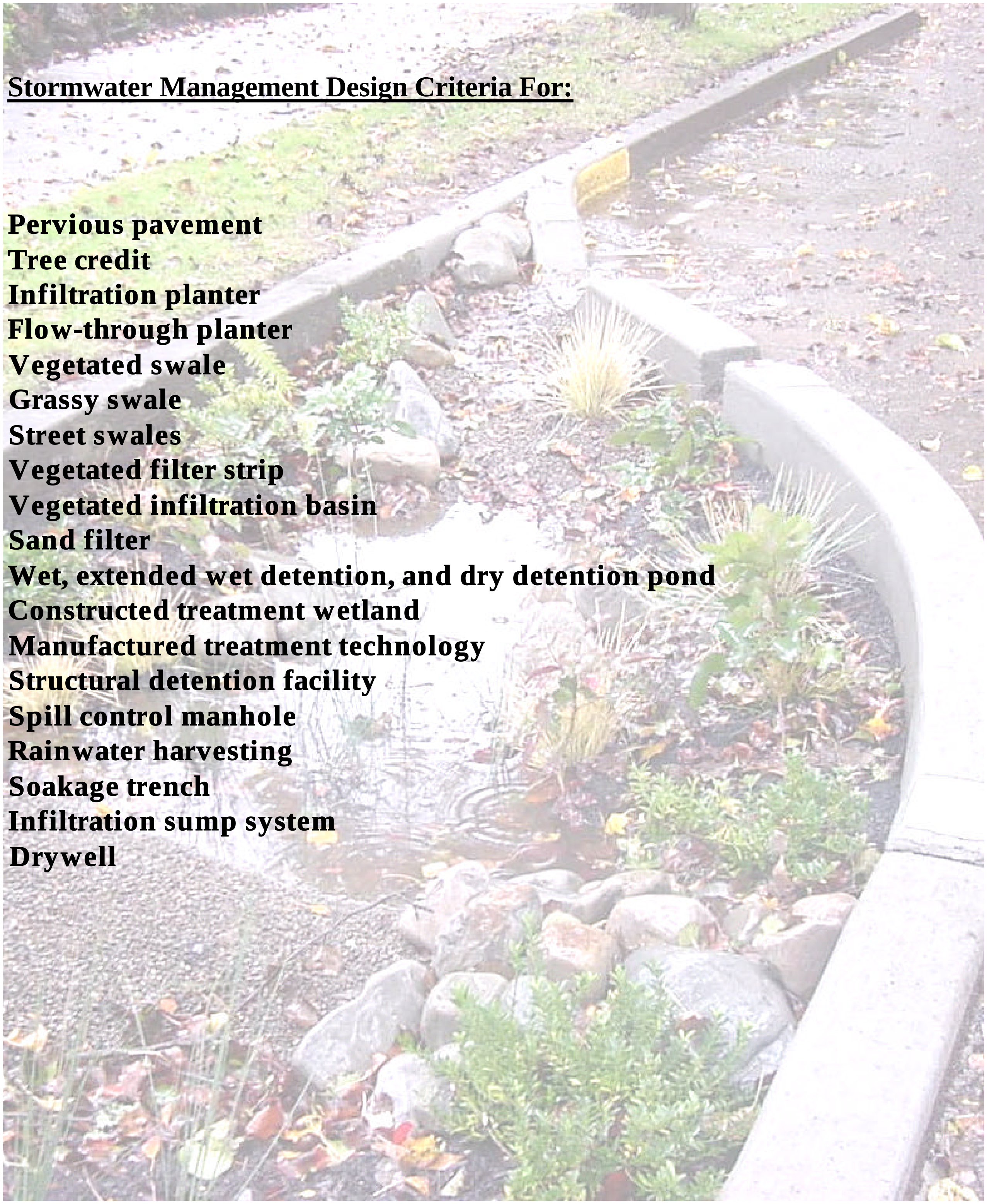
OUTFALL PIPE GRATED PROTECTION

DATE	REVISIONS DESCRIPTION

6/06

EXHIBIT 2-14

2.9 FACILITY SELECTION AND DESIGN

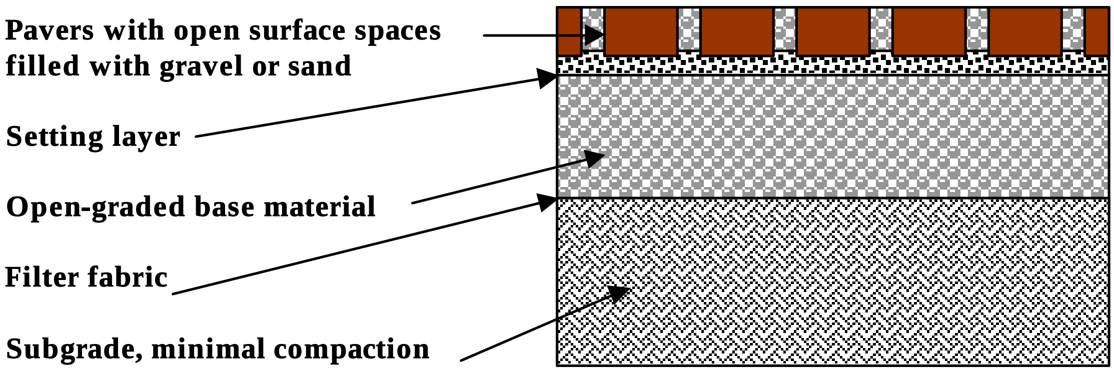


Stormwater Management Design Criteria For:

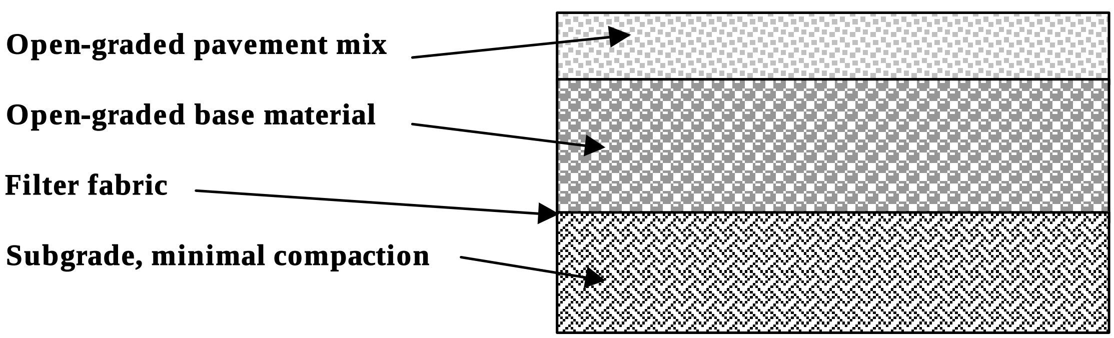
Pervious pavement
Tree credit
Infiltration planter
Flow-through planter
Vegetated swale
Grassy swale
Street swales
Vegetated filter strip
Vegetated infiltration basin
Sand filter
Wet, extended wet detention, and dry detention pond
Constructed treatment wetland
Manufactured treatment technology
Structural detention facility
Spill control manhole
Rainwater harvesting
Soakage trench
Infiltration sump system
Drywell

Pervious Pavement: Detention/Retention Facility

Pervious Concrete Block or "Paver" Systems



Pervious (Open Graded) Concrete and Asphalt Mixes



Stormwater Management Goals Achieved Acceptable Sizing Methodologies

? Impervious Area Reduction
? Pollution Reduction………………………... SIM
? Flow Control………………………………. SIM
? Destination…………………………………. PERF

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility is an impervious surface reduction technique. It is applicable for use in parking lots, driveways, and in some cases streets.

Pervious Pavement: Detention/Retention Facility

Description: There are many types of pervious pavement on the market today. Numerous products and design approaches are available, including special asphalt paving; manufactured products of concrete, plastic, and gravel; paving stones; and brick. It may be used for walkways, patios, plazas, driveways, parking lots, and some portions of streets, subject to compliance with building codes. To receive credit, the material must be installed and maintained to manufacturer's specifications. Pervious pavement accepts only precipitation, not stormwater runoff. These materials may not be allowed in certain areas (see **Chapter 4.0** for restrictions). A professional engineer, registered in the state of Oregon must design pervious pavement systems that will be supporting vehicular traffic. For EPA's "Porous Pavement Phase I Design and Operational Criteria" (EPA-600/2-80-135), go to: **http://www.epa.gov/ednnmrl/repository/abstrac2/abstra2.htm.** For Portland's Bureau of Environmental Service's report on pervious pavement demonstration projects, vendors, and other resources, go to: **http://www.cleanrivers-pdx.org/pdf/alternative_paving.pdf**.

Design Considerations: When designing pervious pavement systems, the infiltration rate of the native soil is a key element in determining the depth of base rock for the storage of stormwater, or for determining whether an underdrain system is appropriate. Traffic loading and design speed are important considerations in determining which type of pervious pavement is applicable. Pedestrian ADA accessibility, aesthetics, and maintainability are also important considerations, depending on pavement use.

Construction Considerations: Installation procedures can be detrimental to the success of pervious pavement projects, particularly pervious asphalt and concrete pavement mixes. The subgrade and base rock cannot be overly compacted with the inclusion of fine particulates or the void ratio critical to providing storage for large storm events will be lost. Weather conditions at the time of installation can affect the final product, as in the case of high or low temperatures with pervious asphalt and excessive rainfall with pervious concrete. Pavement infiltration rates shall be verified prior to final acceptance.

Design Requirements:

Soil Suitability: Pervious pavement systems are appropriate for all soil types, but will require underdrain systems to an approved stormwater destination (per **Section 1.4**) for soils that do not infiltrate well (less than 0.5 inches per hour, generally NRCS soil type D). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the base rock and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.), unless an underdrain system is used.

Dimensions and Slopes: Minimum / maximum dimensions and other specifications are product-specific and shall comply with manufacturer's recommendations. Slopes shall be less than 10% in all cases.

Setbacks: Not applicable.

Sizing: Pervious pavement systems are not considered to be impervious surfaces, and therefore do not trigger pollution reduction and flow control requirements. A high-flow overflow or underdrain system must be provided to an approved destination point per **Section 1.4**.

Limitations: Pervious pavements shall not be used on sites with a likelihood of high oil and grease concentrations. These site uses include vehicle wrecking or impound yards, fast food establishments, automotive repair and sales, and parking lots that receive a high number of average daily trips (> 1,000).

Checklist of minimal information to be shown on the permit drawings:

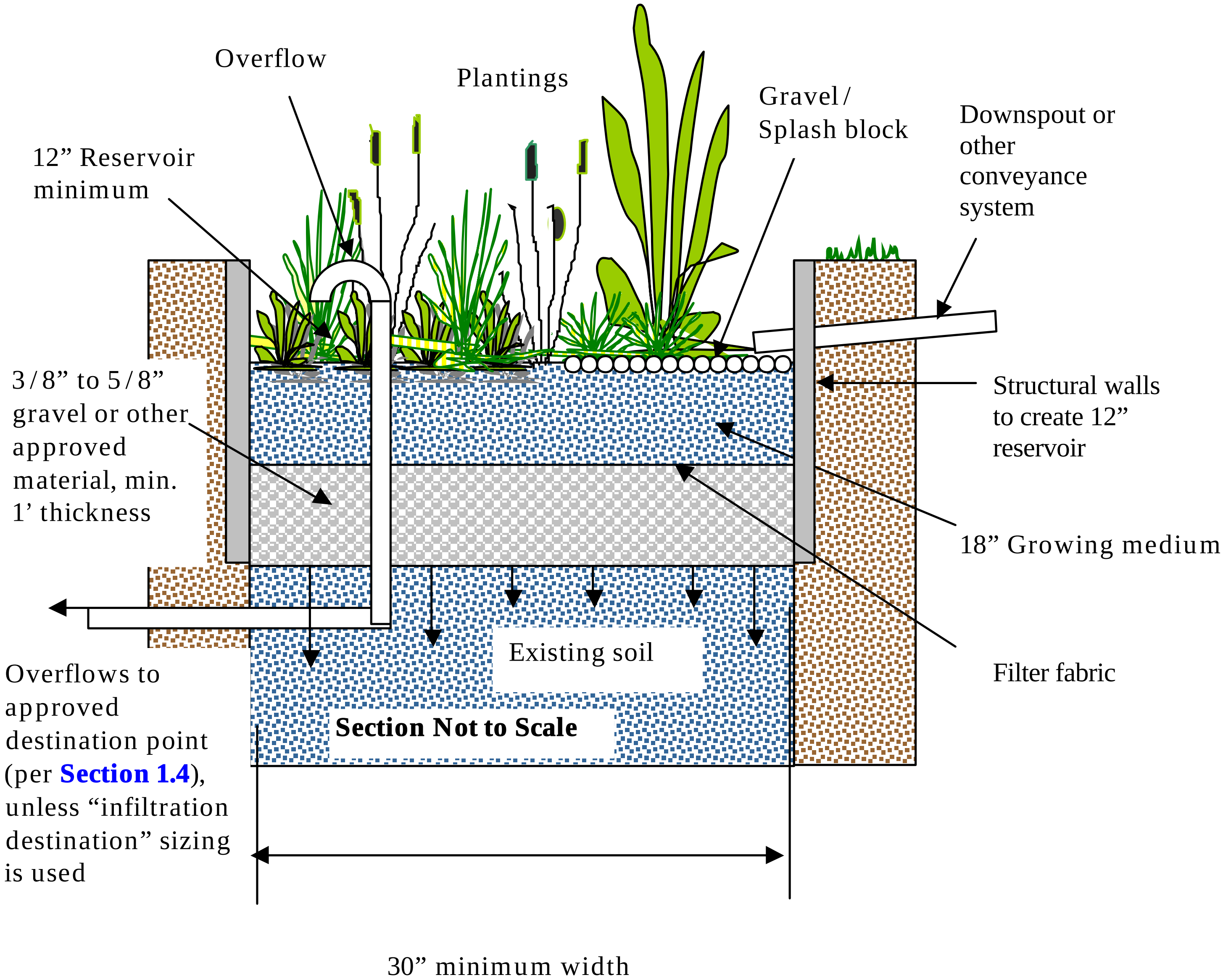
1) Facility dimensions, grades, grade breaks, and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Pervious pavement materials and installation procedure specifications
4) Subgrade and base course specifications
5) Filter fabric specification (if applicable)
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Subgrade	
Filter fabric (if applicable)	
Underdrain piping (if applicable)	Call for inspection
Base rock	
Pervious pavement installation	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Infiltration Planter: Detention/Retention Facility



Description: Infiltration planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil and infiltrates into the ground. In addition to providing pollution reduction, flow rates and volumes can also be managed with infiltration planters. Planters can be used to help fulfill a site's required landscaping area requirement and should be integrated into the overall site design. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. An overflow to an approved conveyance/ destination method per **Section 1.4** will be required, unless the facility is sized per **Surface Infiltration Facility** guidelines presented in this chapter.

Design Considerations: When designing infiltration planters, the infiltration rate of the native soil is a key element in determining size and viability.

Construction Considerations: Infiltration planter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of planter areas. Infiltration rates shall be verified prior to construction.

Design Requirements:

Soil Suitability: Infiltration planters are appropriate for soils with a minimum infiltration rate of 0.5 inches per hour (NRCS soil types A, B, & C). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.) Topsoil shall be used within the top 18 inches of the facility.

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 30 inches. Planters shall be constructed without slope.

Setbacks: Required setback from property lines is 5 feet, and 10 feet from structures.

Planter Walls: Planter walls shall be made of stone, concrete, brick, wood, or other durable material. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Individual infiltration planters sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.07 may be used. Planters shall be designed to pond water for less than 12 hours after each storm event.

Landscaping: Plantings shall be designed at the following quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

4 - Large shrubs / small trees	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants	1-gallon containers or equivalent

Infiltration Planter: Detention/Retention Facility

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Note: Tree planting is not required in planters, but is encouraged where practical. Tree planting is also encouraged near planters.

Checklist of minimal information to be shown on the permit drawings:

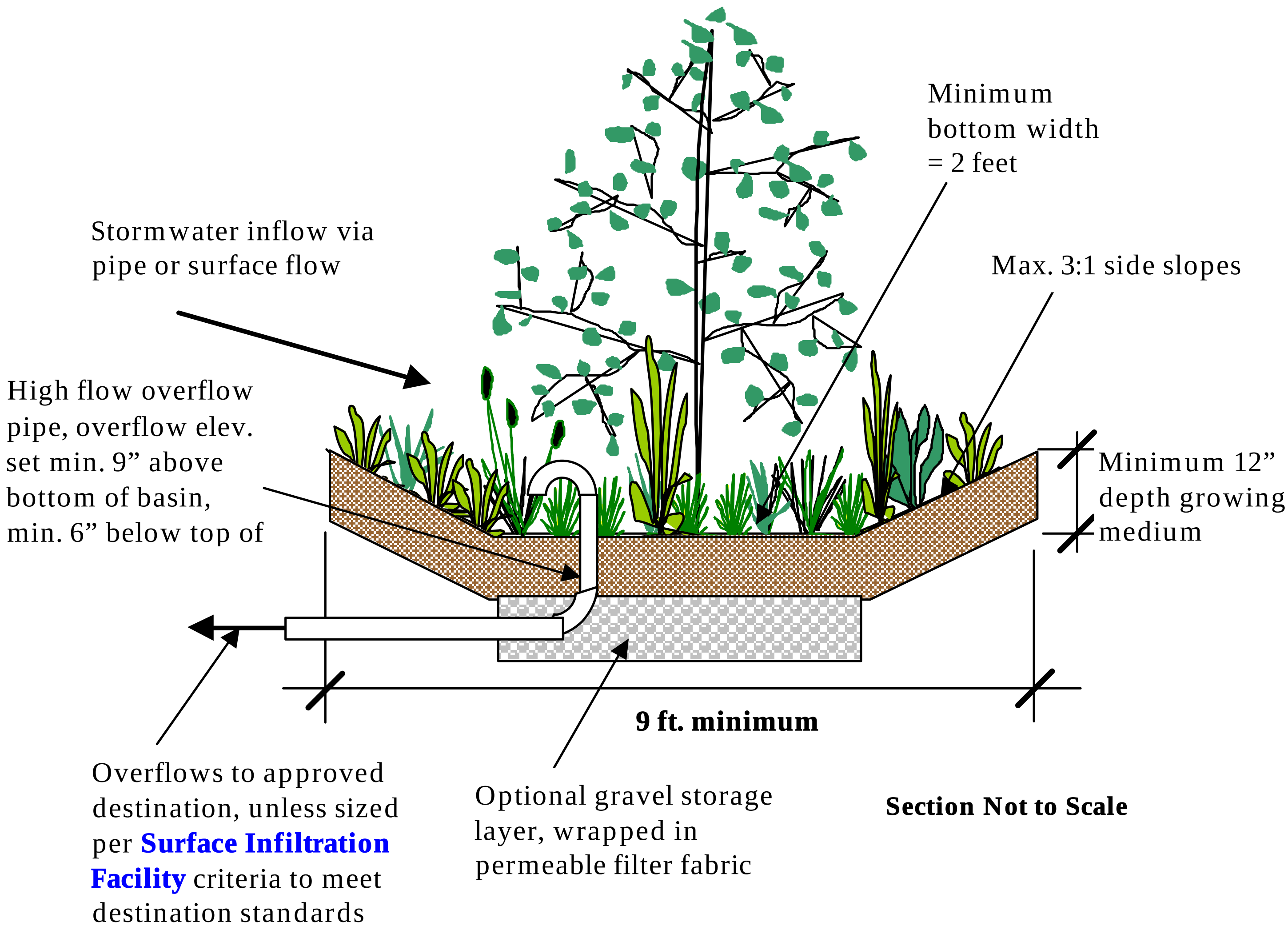
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification
5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Planter grading / excavation	
Structural components / liner	
Piping	Call for inspection
Drain rock	
Filter fabric	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Vegetated Infiltration Basin: Detention/Retention Facility



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction…………………………..	SIM, PERF[1]
? Flow Control………..…………………….	SIM
? Destination…………………………………	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution control. **2)** The **Surface Infiltration Facility** sizing methodology from this chapter may be used to achieve stormwater destination. Vegetated infiltration basins can be used to manage stormwater from all impervious surface types, and must be located on private property.

Vegetated Infiltration Basin: Detention/Retention Facility

Description: Vegetated infiltration basins are shallow landscaped depressions used to collect and hold stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated infiltration basins. They should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. As shown in the example photos, the design can be formal or informal in character and planting scheme. An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required, unless the basin is designed per "infiltration swale" guidelines presented in the chapter.

Design Considerations: When designing vegetated infiltration basins, the infiltration rate of the native soil is a key element in determining size and viability. Slopes and depth should be kept as mild as possible to avoid safety risks.

Construction Considerations: Infiltration basin areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration basin areas.

Design Requirements:

Soil Suitability: Vegetated infiltration basins are appropriate for soils with a minimum infiltration rate of 0.5 inches per hour (NRCS soil types A, B, & C). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended to support plant growth.

Dimensions: Facility storage depth may vary from 9 to 18 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum bottom width is 2 feet.

Setbacks: Required setback is 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; 200-foot setback for slopes of 30%; infiltration trenches shall not be used where slopes exceed 30%.

Sizing: Vegetated infiltration basins sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.11 may be used. Drawdown time (time for the basin to empty water from the water quality design storm) shall not exceed 24 hours.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the basin, including bottom and side slopes, plus a 10-foot buffer around the basin. Minimum plant material quantities per 300 square feet of facility area are as follows:

1 - Evergreen or deciduous tree (planted around the perimeter of the basin):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs / small trees:	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants:	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for City-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions will require City approval.

For vegetated infiltration basins, the following additional design criteria shall apply:

1) Two staff gauges shall be installed at opposite ends of the bottom of the basin, to enable maintenance staff to measure the depth of accumulated silts.

2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for infiltration.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures

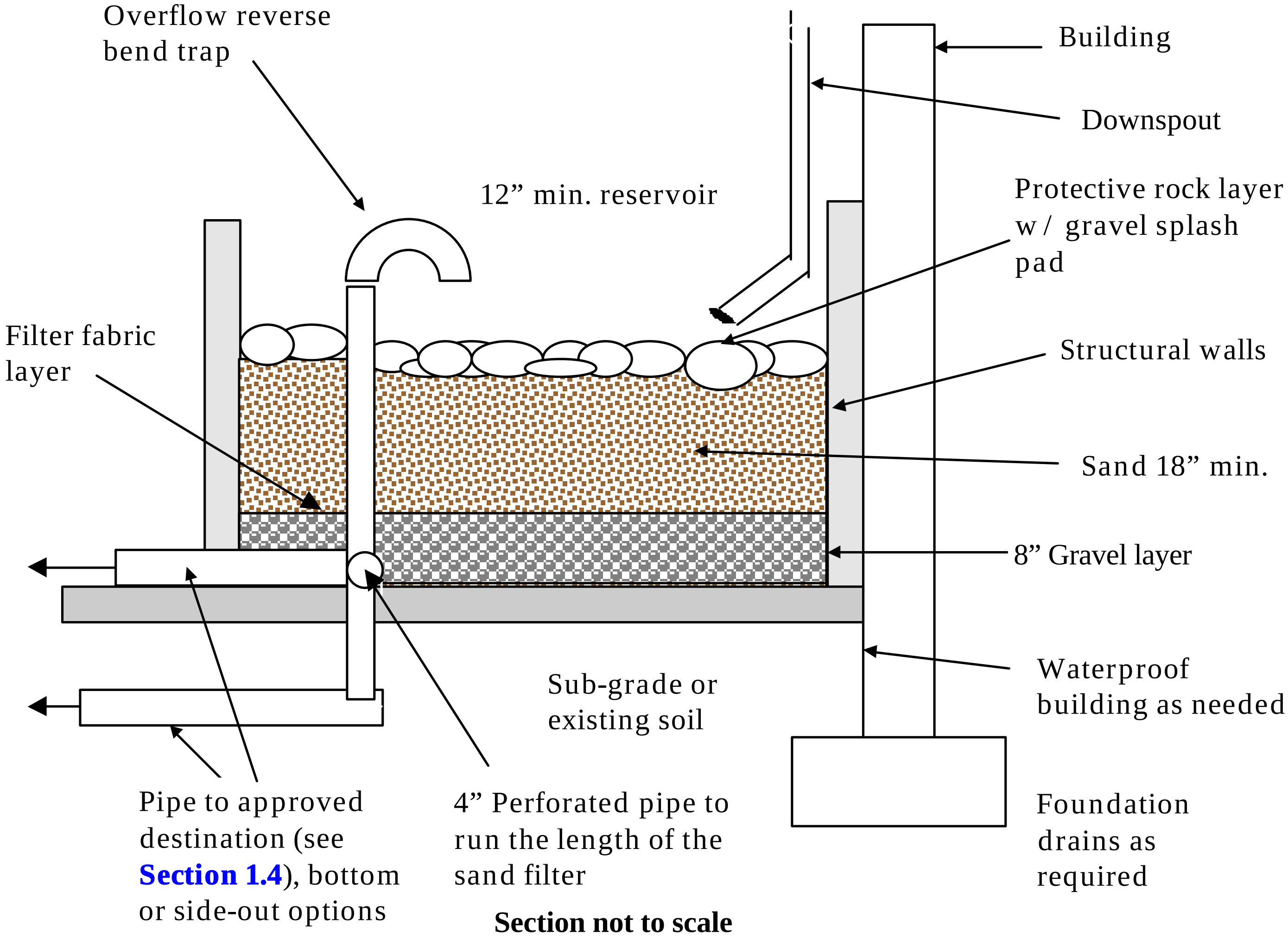
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Basin grading	
Piping	Call for inspection
Filter fabric	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Sand Filter: Optional Detention/Flow-Through Facility



Stormwater Management Goals Achieved Acceptable Sizing Methodologies

? Pollution Reduction………………………….. SIM, PERF[1]

? Flow Control……………………..………… SIM

? Destination…………………………………. PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Note: The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Sand filters can be used to manage stormwater from any impervious surface, and must be located on private property.

Sand Filter: Optional Detention/Flow-Through Facility

Description: There are two sand filter options. One is designed with an impervious bottom or is placed on an impervious surface. It can be used for all soil types. The other option, for native soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B), allows filtered water to infiltrate into the ground. For both options, pollutant reduction is achieved as the water filters through the sand; flow control is obtained by slowing the discharge rate as the water filters through the sand. Filters may be constructed in-ground or above grade. Because they can include a waterproof lining, sand filters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance/ destination method per **Section 1.4** will be required.

Design Considerations: When designing sand filters, the structural walls can often times be incorporated with building foundation plans.

Construction Considerations: Special attention needs to be paid to the filter waterproofing if constructed adjacent to building structures.

Design Requirements:

Soil Suitability: Lined sand filters are appropriate for all soil types. Filters designed to infiltrate into native soils are appropriate in soils with a minimum infiltration rate of 0.5 inches per hour (NRCS soil types A, B, & C).

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum sand filter width is 18 inches. Filter slopes shall be less than 0.5%.

Setbacks: Required setback from property lines is 5 feet, unless the sand filter height is less than 30 inches. Required setback from building structures is 10 feet, unless the sand filter is properly lined.

Structural Walls: Sand filter walls shall be made of stone, concrete, brick, or wood. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

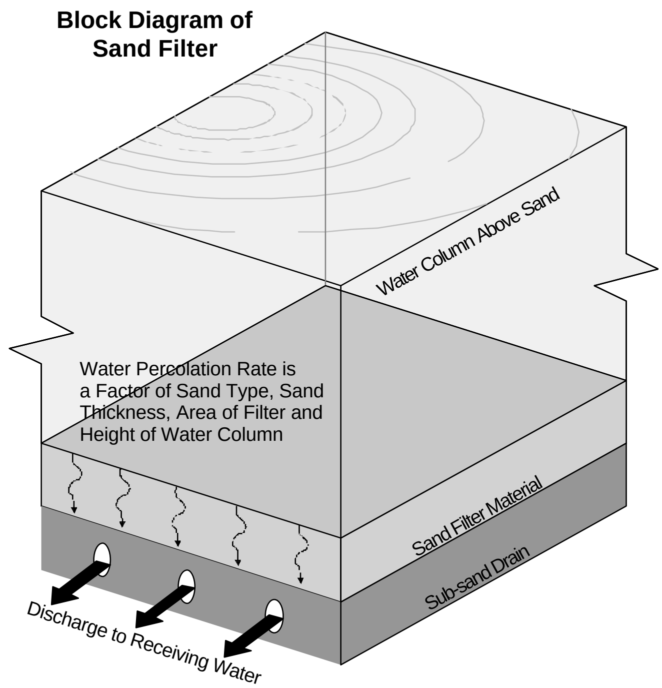
Sizing: Sand filters sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.06 may be used. Sand filters shall be designed to pond water for less than 4 hours after each storm event.

Sand Filter: Optional Detention/Flow-Through Facility

Vegetation: Plantings are optional in sand filters. For aesthetic purposes, potted plants may be submerged in the sand filter.

For public sand filters, the following additional criteria shall apply:

The sand filter consists of an inlet structure, sand bed, underdrain piping, and basin liner. Criteria for these components are provided below.



Inlet Structure

1) The inlet structure shall spread the flow of incoming water uniformly across the surface of the filter medium during all anticipated flow conditions. This flow shall be spread in a manner that prevents roiling or otherwise disturbing the filter medium.

Sand Bed/ Filter Medium

1) The length-to-width ratio shall be 2:1 or greater.

2) The sand bed configuration may be either of the two configurations shown in **Exhibit 2-16**. All depths shown are final depths. The effects of consolidation and/or compaction must be taken into account when placing medium materials. The surface of the filter medium shall be level.

3) Sand used as filter medium shall be certified by a testing laboratory as meeting or exceeding the specifications presented below:

The filter bed medium shall consist of clean medium to fine sand with no organic material, or other deleterious materials and meeting the following gradation:

Sieve Size	Percent Passing
3/8”	100
#4	95-100
#8	80-100
#16	45-85

#30	15-60
#50	3-15
#100	< 4

Sand Bed with Gravel Filter (**Exhibit 2-16:A**)

1) The top layer shall be a minimum of 18 inches of approved sand.

2) The sand shall be placed over an acceptable geofabric material covering a layer of ½- to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) No gravel is required below the underdrain piping system.

Sand Bed Using Trench Design (**Exhibit 2-16:B**)

1) The top layer shall be a minimum of 12 inches of approved sand.

2) The sand shall be placed over an acceptable geotextile fabric material covering a layer of ½ to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) The piping and gravel shall be underlain with geotextile fabric.

Underdrain Piping

1) The underdrain piping system shall consist of appropriately sized (minimum 4-inch diameter) collector manifold with perforated lateral branch lines. The pipe used in this conveyance system shall be schedule 40 polyvinyl chloride (PVC) material or an approved equal. Lateral spacing shall not exceed 10 feet.

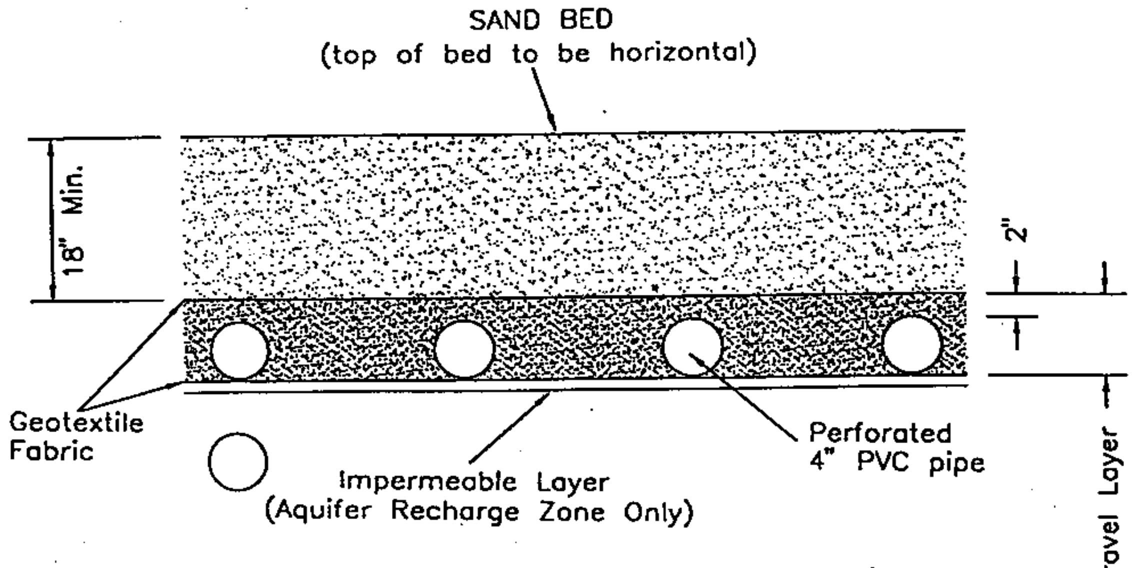
2) The underdrain laterals shall be placed with positive gravity drainage to the collector manifold.

3) The collector manifold shall have a minimum 1 percent grade toward the discharge point.

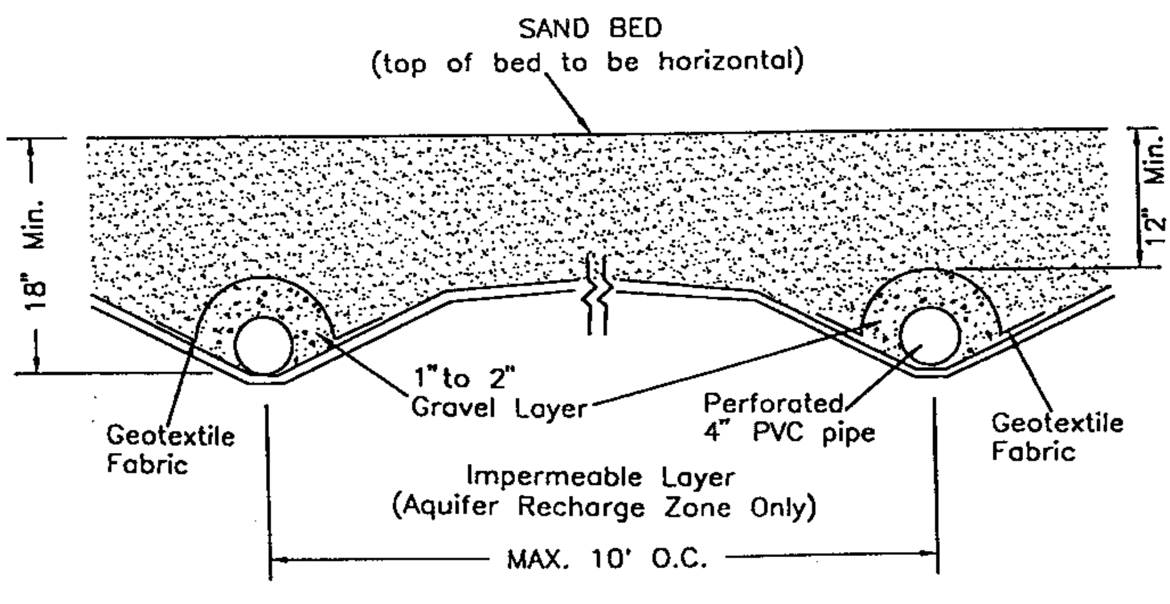
4) All laterals and collector manifolds shall have cleanouts installed, accessible from the surface without removing or disturbing filter media.

Sand Filter: Optional Detention/Flow-Through Facility

Exhibit 2-16



A. SAND BED PROFILE (with gravel filter)



B. SAND BED PROFILE (trench design)

Sand Filter: Optional Detention/Flow-Through Facility

Checklist of minimal information to be shown on the permit drawings:

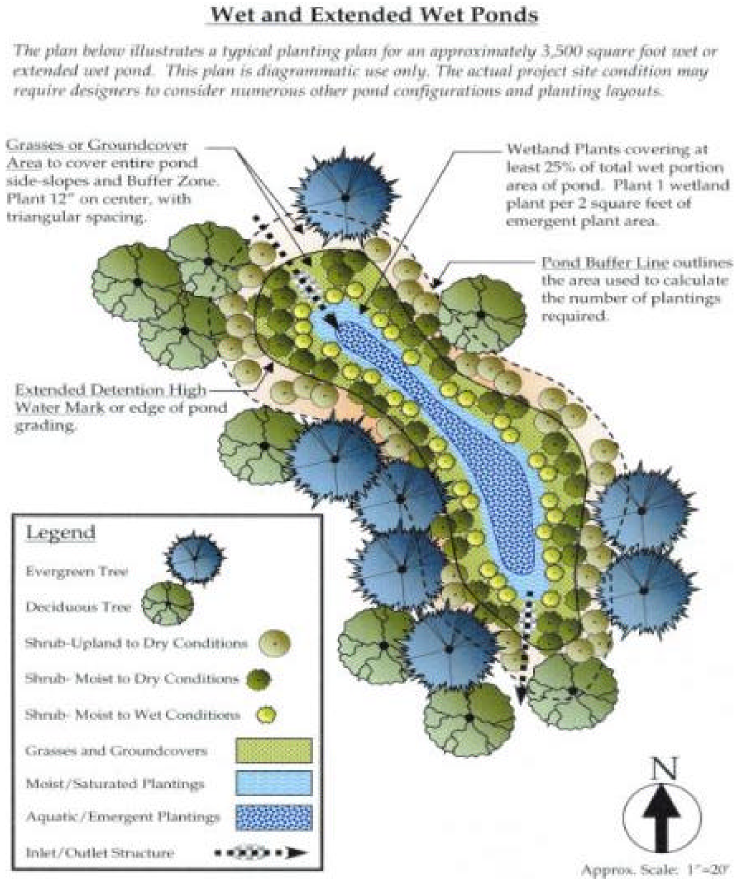
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Structural wall material specification
4) Sand specification
5) Filter fabric specification
6) Rock surface layer specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Sand filter grading	
Structural walls	Call for inspection
Piping	Call for inspection
Sand	
Filter fabric	
Rock layer	
Plantings (if applicable)	

Operations and Maintenance requirements: See Chapter 3.0.

Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction…………………………….	PRES[1]
? Flow Control……………….…………………	PRES[2]
Destination……………………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The bottom flow path of the pond must be designed as a vegetated or grassy swale, with sizing and design in accordance with criteria presented in this chapter. **2)** All ponds must overflow to an acceptable stormwater destination per **Section 1.4**. Wet and extended wet detention ponds can be used to provide pollution reduction for any impervious surfaces, and must be located outside of public rights-of-way.

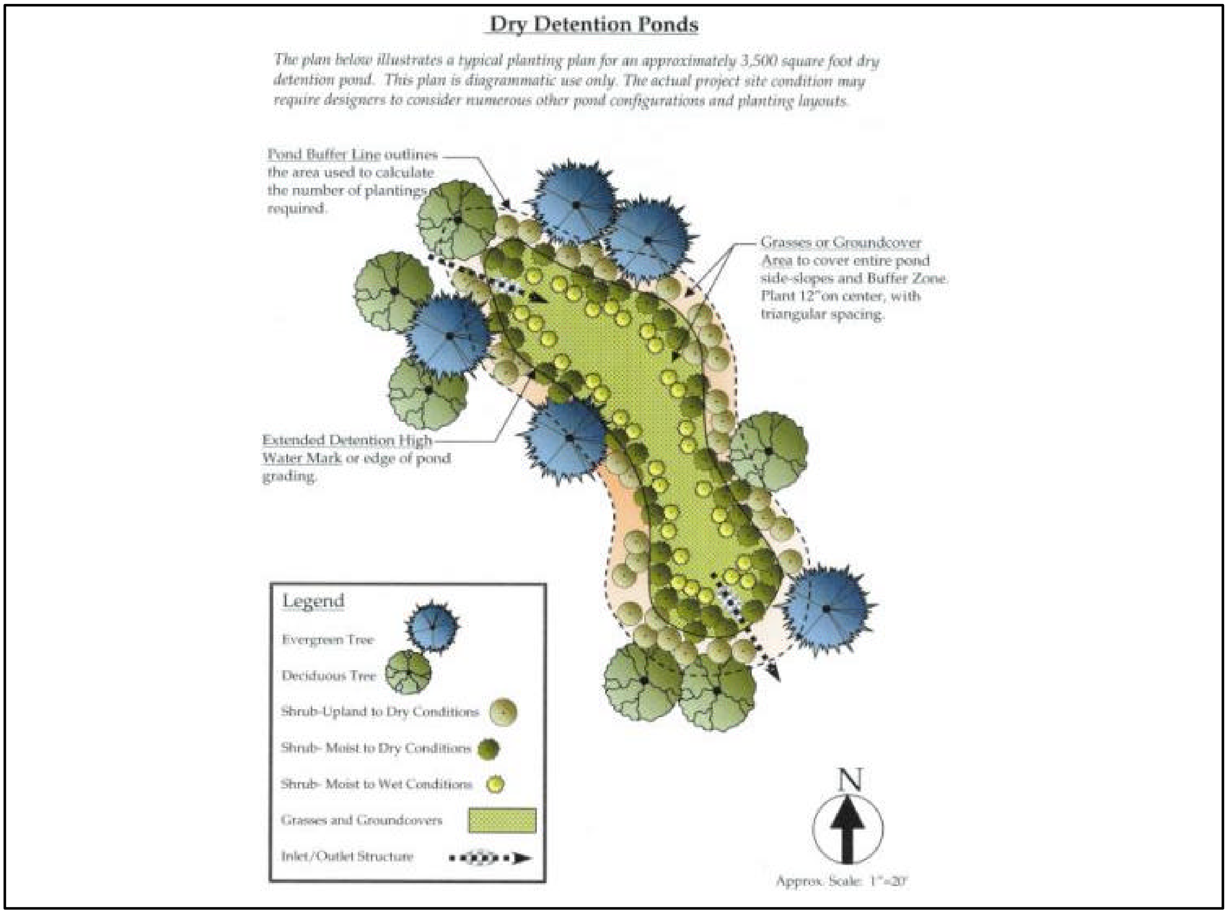
Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

Wet Pond Description: Wet ponds are constructed with a permanent pool of water (called pool storage or dead storage). Stormwater runoff enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. Additional facilities will be required to meet flow control requirements, as applicable. An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

Extended Wet Detention Pond Description: Extended wet detention ponds are constructed with a permanent pool of water (called pool storage or dead storage) and additional storage above, which fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to provide pollution reduction, and the additional storage above (extended detention area) is sized to meet flow control requirements. Pollutants are removed from stormwater through gravitational settling and biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. The extended detention portion of this facility must be designed using acceptable hydrologic modeling techniques (see **Section 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**). An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

Dry Detention Pond Description: Dry detention ponds are vegetated basins designed to fill during storm events and slowly release the water over a number of hours. Dry detention ponds must be designed using acceptable hydrologic modeling techniques (see **Section 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**. Additional facilities are required to meet pollution reduction requirements, unless the bottom flow path of the pond is designed as a vegetated or grassy swale, per swale sizing and design criteria. An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

Design Considerations: Slopes and depth should be kept as mild as possible to avoid safety risks. Wet and extended wet detention ponds should be designed for large drainage areas (5 to 150 acres) to help avoid problems associated with long periods of stagnant water. The City encourages applicants to design ponds to function as multi-purpose facilities (e.g., parks, open space, recreation facilities, or parking lots), provided that any alternative uses are compatible with the primary stormwater functions and maintenance standards. Instream ponds are not encouraged. If used, they require special approvals from the National Marine Fisheries Service, Oregon Department of Fish and Wildlife, Oregon Division of State Lands, and Dunes City, in addition to water rights from the Oregon Division of Water Resources.

Construction Considerations: As pond grading generally requires the topsoil to be removed to form the basin shape of the pond, the resulting top layers of soil must to be amended, or topsoil must be brought back in to ready the soil for planting.

Location and Ownership:

?? All open ponds to be city-maintained shall be located in a separate open space tract with public drainage easements dedicated to the City.

?? Open ponds serving more than one tax lot, or designed to function as multi-use / recreational facilities, shall be located in a separate tract (e.g., Tract A), defined easement, or designated open space.

Setbacks: Ponds shall be constructed to maintain the following setback distances from structures and other facilities. (All distances are measured from the edge of the maximum water surface elevation. The setback limit applies to ponds near the top of slope, not the bottom.)

?? Minimum distance from the edge of the pond water surface to property lines and structures: 20 feet, unless an easement with adjacent property owner is provided.

?? Distance from the toe of the pond berm embankment to the nearest property line: one-half of the berm height (minimum distance of 5 feet).

?? Minimum distance from the edge of the pond water surface to septic tank, distribution box, or septic tank drain field: 50 feet.

?? Surrounding slopes shall not exceed 10%. Minimum distance from the edge of the pond water surface to the top of a slope greater than 15 percent: 200 feet, unless a geotechnical report is submitted and approved by the City (**Exhibit 2-17**).

?? Minimum distance from the edge of the pond water surface to a well: 100 feet (**Exhibit 2-17**).

Geometry/ Design Requirements:

?? Slopes within the pond shall not exceed 3 horizontal to 1 vertical.

Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

?? The distance between all inlets and the outlet shall be maximized to facilitate sedimentation. The minimum length-to-width ratio is 3:1, at the maximum water surface elevation. This ratio is critical to prevent “short-circuiting,” where water passes directly through the facility without being detained for any length of time. If area constraints make this ratio unworkable, baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short-circuiting.

?? The maximum water depth of the pond shall not exceed 4 feet. The 0 to 2-foot depth shall be distributed evenly around the perimeter of the pond.

?? Minimum freeboard shall be 1 foot above the highest potential water surface elevation (one foot above the emergency overflow structure or spillway elevation).

?? Wet and extended wet detention ponds are applicable in NRCS Type C and D soils (A and B soils with impermeable liner). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended to support plant growth.

?? Dry detention ponds are applicable in NRCS type B, C, and D soils (the pond should most likely be designed as an infiltration basin in type A soils). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended to support plant growth.

?? Unless designed with a pollution reduction swale in the bottom flow path, dry detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area, and shall provide at least 0.5 feet of dead storage for sediment accumulation.

?? Wet and extended wet detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area, and shall provide at least 0.5 feet of dead storage for sediment accumulation.

?? Public ponds shall be designed with an upstream sedimentation manhole with downturned elbow or tee riser outflow pipe (See **Exhibit 2-18**) to trap oils and reduce the likelihood of a visible sheen on the pond surface.

?? Access routes to the pond for maintenance purposes must be shown on the plans. Public ponds will need to provide a minimum 10-foot wide access route, not to exceed 10 percent in slope. A minimum 30 foot inside turning radius shall be provided.

?? Where possible, a dewatering outlet with shut-off valve shall be provided to aid in the maintenance of the permanent pool.

?? For wet and extended wet detention ponds, a water budget shall be submitted for review. The water budget must demonstrate that the baseflow to the pond is sufficient such that water stagnation / alga matting will not become a problem.

Outlet/ Overflow:

?? If a riser pipe outlet is used, it shall be protected by a trash rack and anti-vortex plate. If an orifice plate is used, it shall be protected with a trash rack with at least

10 square feet of open surface area. In both cases, the rack must be hinged or easily removable to allow for cleaning. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.

?? All ponds shall have an emergency overflow spillway or structure designed to convey the 100- year, 24-hour design storm for post-development site conditions, assuming the pond is full to the overflow spillway or structure crest. The overflow shall be designed to convey these extreme event peak flows around the berm structure for discharge into the downstream conveyance system. The overflow shall be designed and sited to protect the structural integrity of the berm. This will assure that catastrophic failure of the berm is avoided, property damage is avoided, and water quality of downstream receiving water bodies is protected (see **Exhibit 2-19**).

?? The subgrade of the spillway shall be set at or above the 100-year overflow elevation of the control structure. The spillway shall be located to direct overflows safely into the downstream conveyance system and shall be located in existing soil wherever feasible. The emergency overflow spillway shall be armored with riprap or other flow-resistant material that will protect the embankment and minimize erosion. Riprap shall be designed in conformance with **Section 2.8** and shall extend to the toe of each face of the berm embankment. The emergency overflow spillway weir section shall be designed for the maximum design storm event for post-development conditions, using the following formula:

$$L = \frac{Q_{100}}{3.21H^{1.5}} - 2.4\,H$$

where: L = Length of bottom of weir, feet

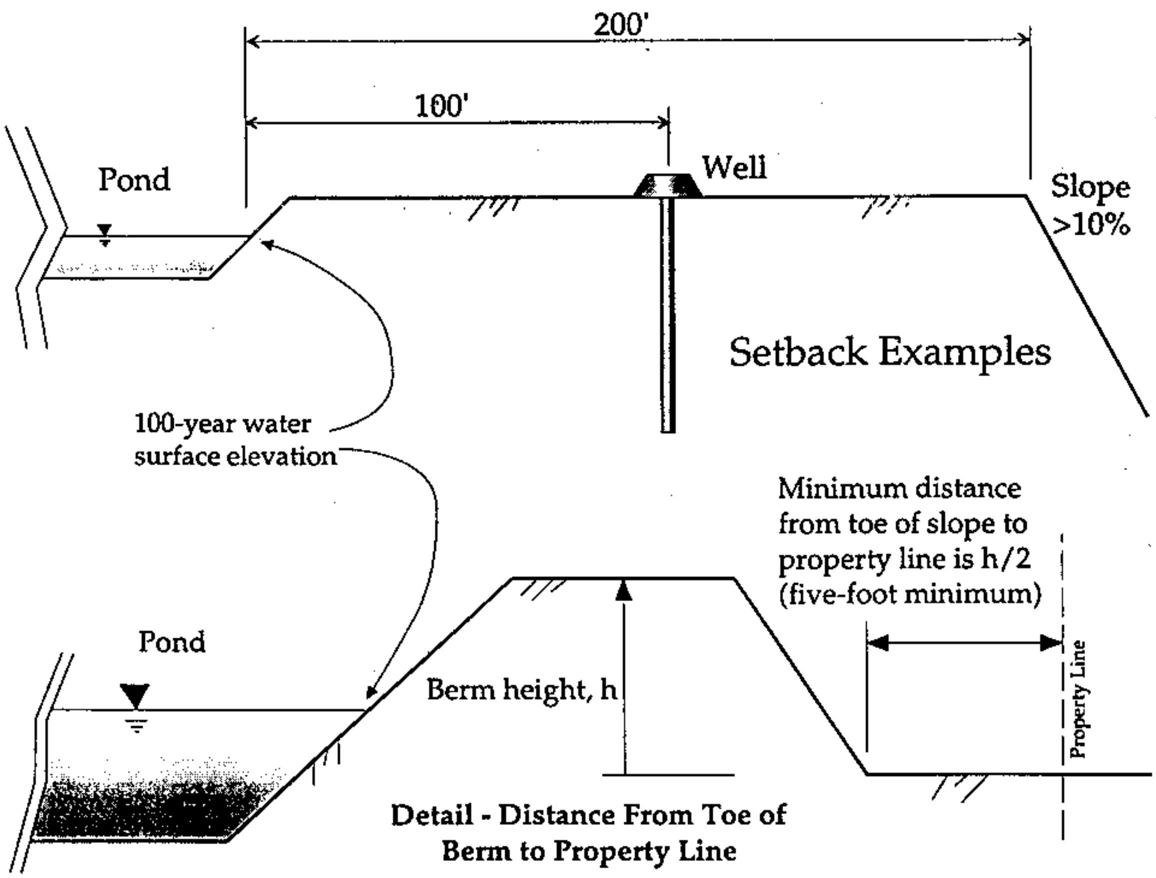
Q_{100} = 100-year post-development flow rate, cfs

H = Height of emergency overflow water surface, feet

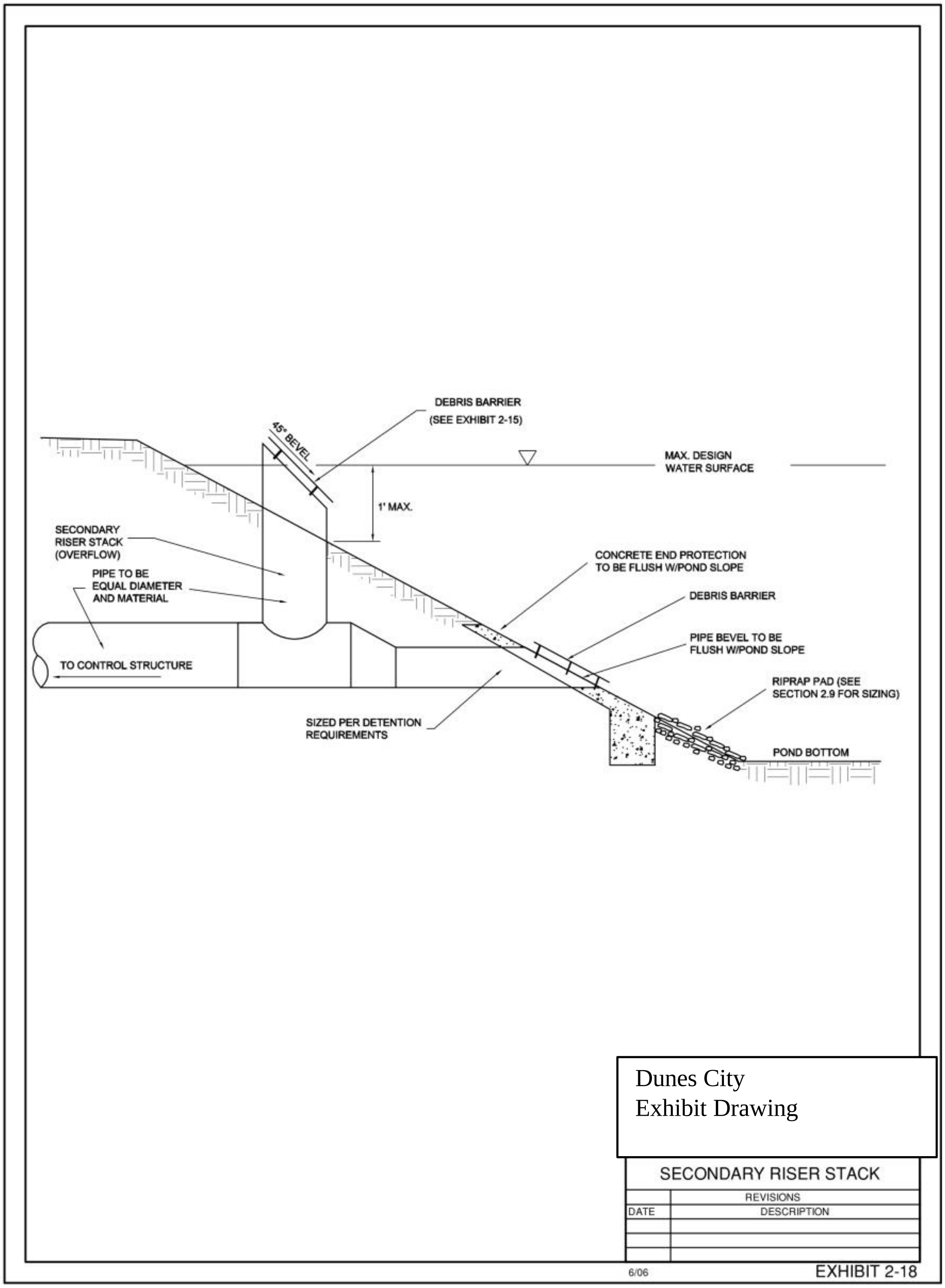
Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

EXHIBIT 2-17

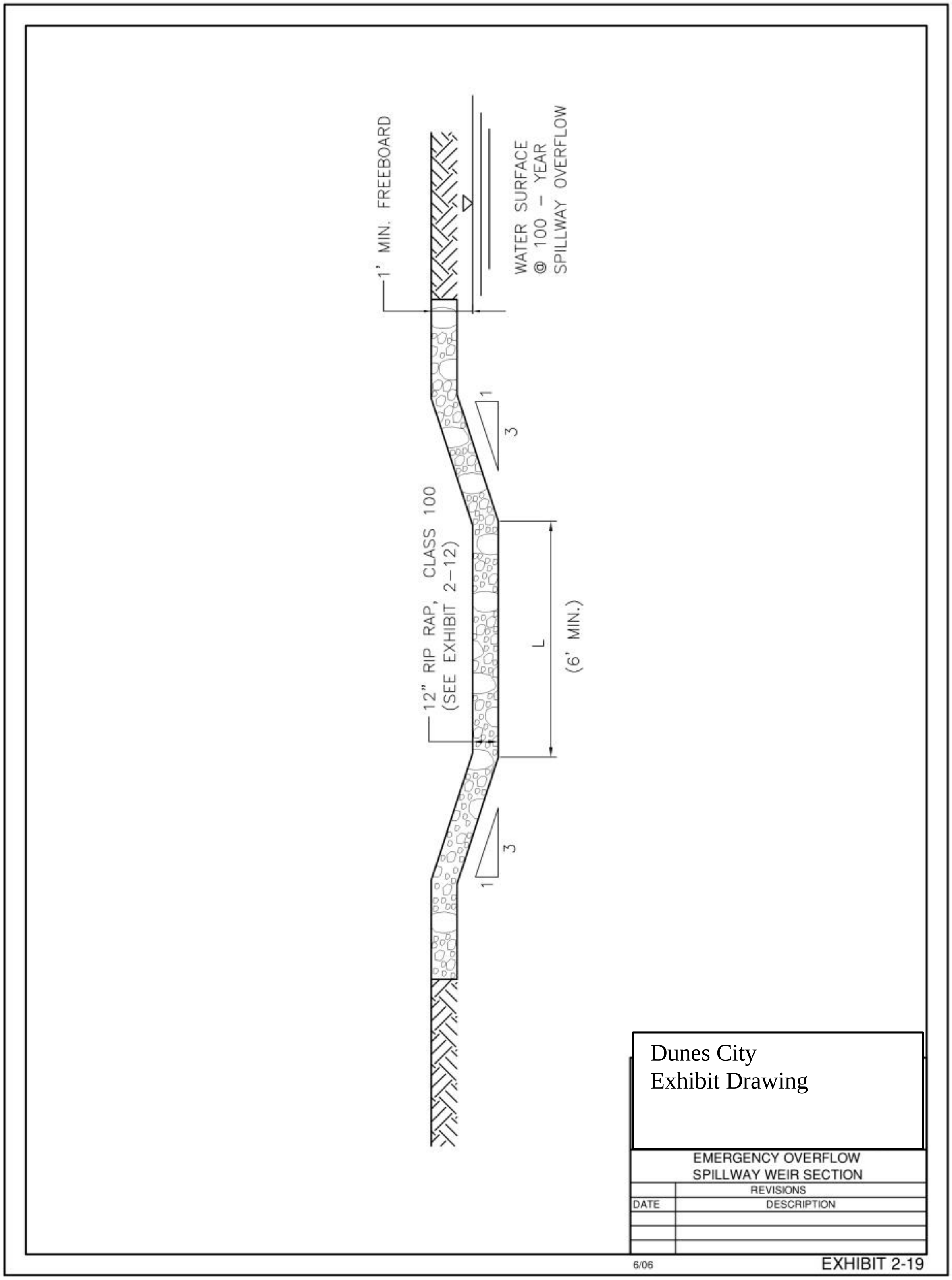
Setback Details



Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

Berm Embankment/Soil Stabilization:

?? Pond berm embankments shall be designed by a civil engineer licensed in the State of Oregon.

?? Pond berm embankments shall be constructed on native consolidated soil (or compacted and stable fill soil) that is free of loose surface soil materials, roots, and other organic debris. Topsoil will be required over the consolidated soil to support required plantings.

?? Pond berm embankments shall be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width measured through the center of the berm. (Note: A key in a berm is an excavated trench below the berm filled with soil material used to make the berm. It acts to "key" the berm into the native soil to prevent it from sliding.)

?? The berm embankment shall be constructed of compacted soil (95 percent maximum dry density, Modified Proctor Method per ASTM D1557) placed in 6- to 8-inch lifts with hand-held equipment, or 10- to 12-inch lifts with heavy equipment.

?? Anti-seepage collars shall be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth **(**see **Exhibit 2-20).**

?? During construction, exposed earth on the pond side slopes shall be sodden or seeded with appropriate seed mixture. Establishment of protective vegetative cover shall be ensured with appropriate surface-protection best management practices (BMPs) and reseeded as necessary

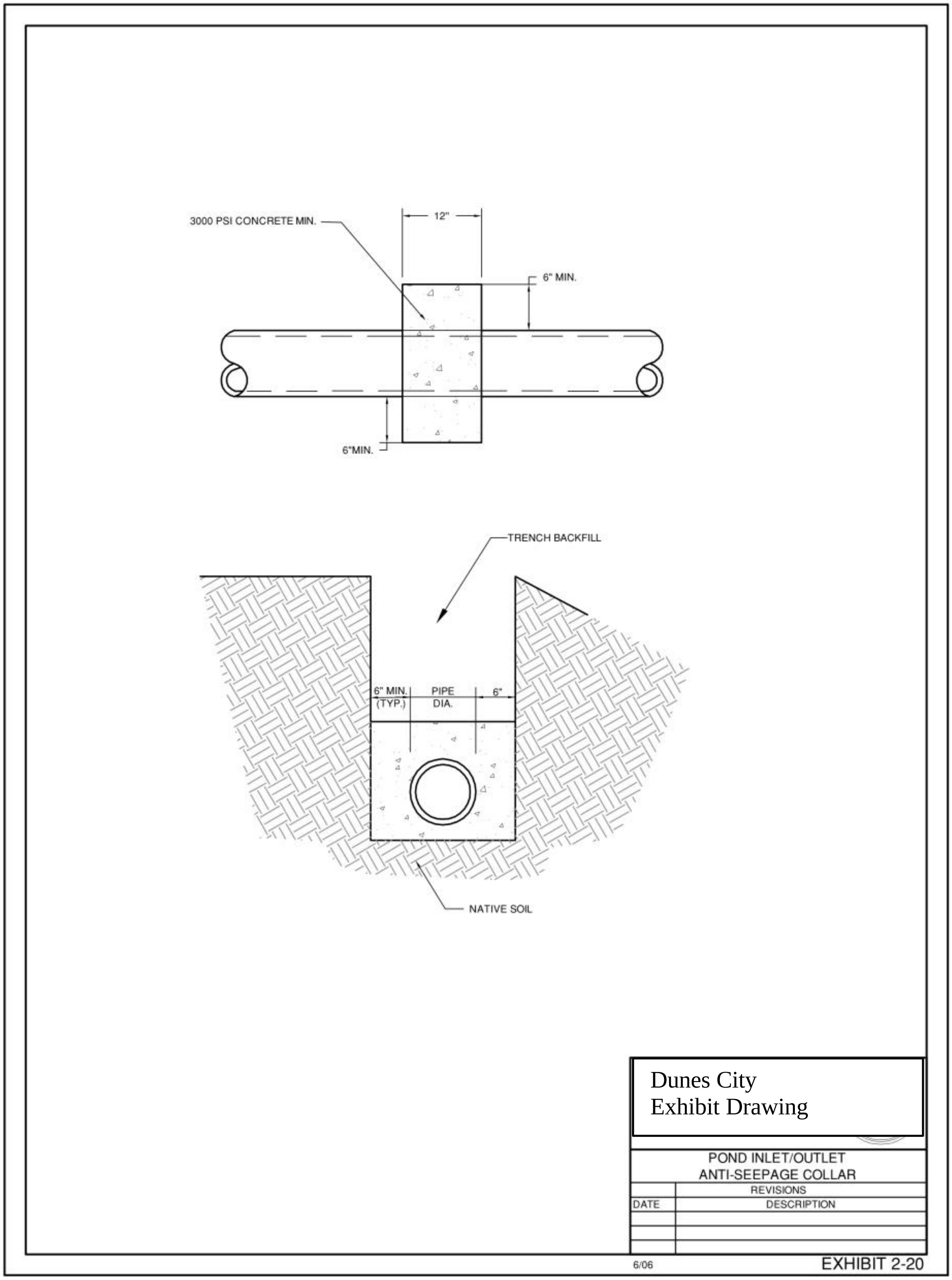
?? Pond embankments shall be constructed with a maximum (i.e. steepest) slope of 3H: 1V on the upstream and downstream face. Side slopes **within** the pond shall be sloped no steeper than 3H: 1V. The use of retaining walls in ponds requires pre-approval from the City. Retaining walls shall not exceed one-third of the circumference of the pond. Detailed structural design calculations must be submitted with every retaining wall proposal.

?? Pond berm embankments 6 feet or less in height including freeboard, measured through the center of the berm, shall have a minimum top width of 6 feet, or as recommended by a geotechnical engineer.

?? Where maintenance access is provided along the top of berm, the minimum width of the top of berm shall be at least 15 feet.

?? Two staff gauges shall be installed at opposite ends of the bottom of the pond, to enable maintenance staff to measure the depth of accumulated silts.

Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility

Wet and Extended Wet Detention Permanent Pool Sizing: The permanent pool (or "dead") storage volume, V_{pond}, is equivalent to twice the runoff volume generated by the pollution reduction storm of 1.4 inches over 24 hours (NRCS Type 1A rainfall distribution). This volume can be approximated using the following formula:

Volume = 2 * 1.4 inches * (1 foot / 12 inches) * Impervious Surface

Volume = permanent pool volume, cubic feet
Impervious Surface = area of impervious surfaces to manage, square feet

EXAMPLE

A 20-acre site is to be developed. After development, the site will be 60 percent impervious. What is the required volume for a wet pond to meet pollution reduction requirements?

For the post-development condition, the total area is 20 acres and the impervious area has increased to 60 percent, or 12 acres:

Permanent Pool Volume = 2 * 1.4 / 12 * (43560 * 12) = 121,968 cubic feet

Flow Control for Extended Wet Detention and Dry Detention Ponds: To restrict flow rates exiting the pond to those required by **Section 1.6.2**, a control structure designed in accordance with **Section 2.5** must be used. For extended wet detention ponds, this control structure must be located above the permanent pool elevation. The outlet orifice shall be designed to minimize clogging (see **Section 2.5: Control Structures**).

Landscaping: Shrubs and wetland plantings shall be designed to minimize solar exposure of open water areas. Trees or other appropriate vegetation shall be located around the east, south, and west sides of a facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, and it helps maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop.

Facility area is equivalent to the area of the pond, including bottom and side slopes, plus a 10-foot buffer around the pond. Minimum plant material quantities per **250** square feet of the facility area are as follows:

1 - Evergreen or deciduous tree:
- Evergreen trees: Minimum height: 6 feet
- Deciduous trees: Minimum caliper: 1 ½ inches at 6 inches above base.

4 - Large shrubs / small trees 3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants 1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.
Wetland plants:	1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area.

Wildflowers, native grasses, and ground covers used for City-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions will require City approval.

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Checklist of minimal information to be shown on the permit drawings:

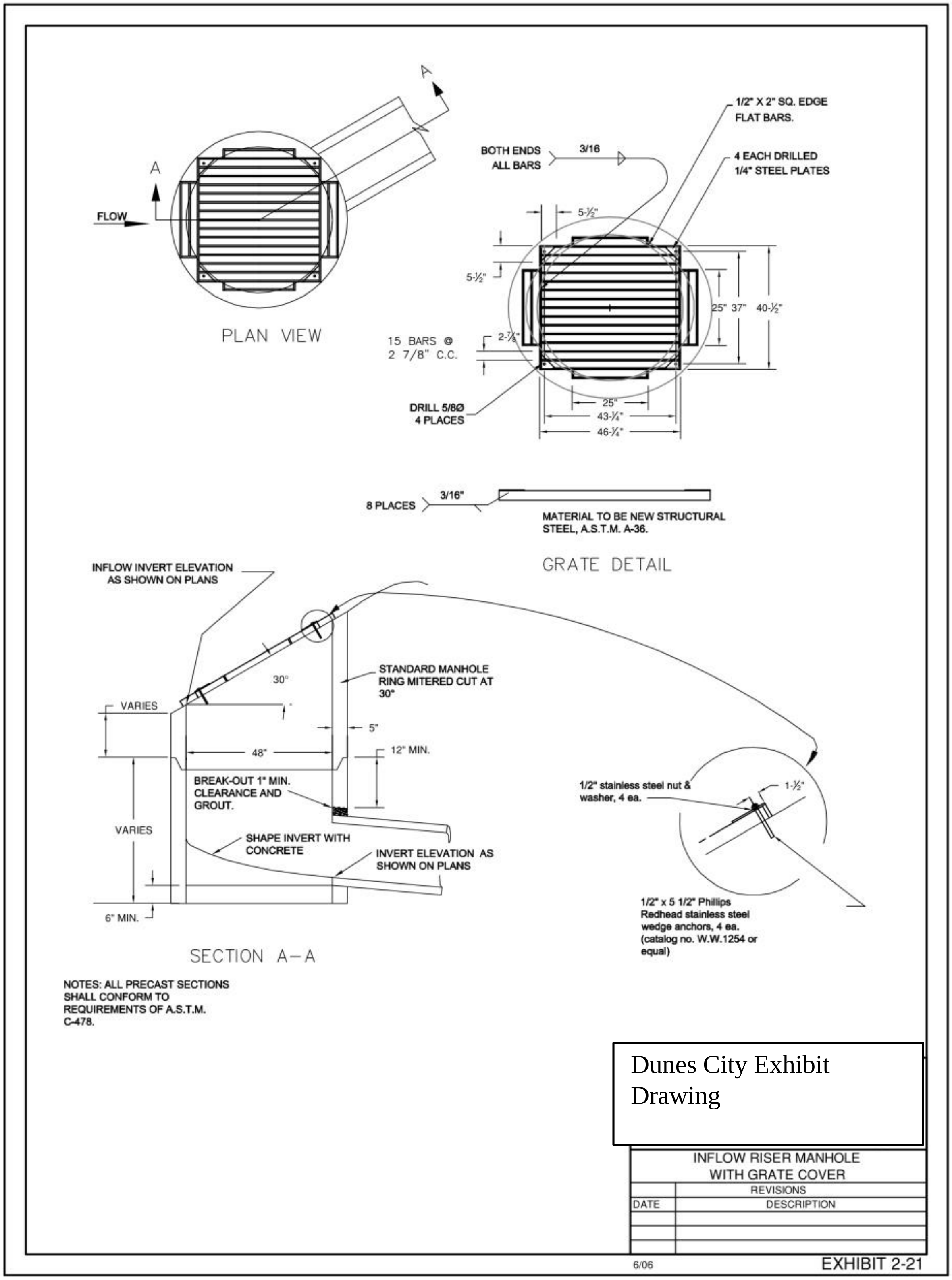
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Pond grading	
Piping	Call for inspection
Control (orifice) structure for extended wet detention and dry detention ponds	Call for inspection
Filter fabric or lining (if applicable)	
Growing medium	
Plantings	

Operations and Maintenance requirements: See **Chapter 3.0**.

Wet, Extended Wet, & Dry Detention Pond: Detention/Retention Facility



Constructed Treatment Wetland: Detention/Retention Facility

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
? Pollution Reduction…………………………….	PRES
? Flow Control…………………..…………………	PRES
Destination……………………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Wetlands can be used to manage stormwater from any type of impervious surface.

Description: A wetland is an area inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas **except those constructed as pollution reduction or flow control facilities**. The Corps of Engineers and Division of State Lands make specific wetland designations. Constructed treatment wetlands are wetlands designed and constructed for the specific purpose of providing stormwater management. Unlike natural wetlands, constructed treatment wetlands are not regulated by the Corps of Engineers and the Division of State Lands.

Wetlands remove pollutants through several processes, including sedimentation, filtration, and biological uptake. When enough volume is provided, constructed treatment wetlands can also provide a significant level of flow control.

Design Criteria: The wet portion or permanent pool of the wetland shall be equal to that required for wet ponds, or the residence time of the stormwater volume (calculated as the pollution reduction design storm volume divided by the average facility outflow rate) shall be no less than 36 hours. A design team with experience in hydrology, wetland plants, and engineering will be needed to develop a successful wetland pollution reduction facility. A water budget analysis shall be performed with the design of the facility.

Sizing: Drainage area to be served shall be no less than 10 acres. To meet pollution reduction requirements, dead storage within the wetland must equal or exceed wet pond dead storage criteria. To meet flow control requirements, a detailed hydraulic analysis must be performed by a Professional Engineer, showing compliance with flow control standards presented in **Section 1.6.2**.

Constructed Treatment Wetland: Detention/Retention Facility

Geometry: The configuration of a constructed wetland shall be tailored to each site, rather than limited to one design. Major elements of a wetland can include channels or trenches, shallow marshes, and deeper ponded areas. These elements shall be combined to take advantage of the site topography. Maximum slopes within the wetland area shall be 20%, and maximum slopes of surrounding land shall not exceed 10%. All wetland design shall address habitat, planting, and aesthetic issues.

1) The volume of water to be treated shall be allocated over the treatment area of the facility as follows:

Component	**Percent of Design Volume** (approx.)	**Percent of Facility Surface Area** (approx.)
Forebay	10	5
Micropool	10	5
Deep water (> 18”)	50	40
Deep wetland (6”-18”)	20	25
Shallow wetland (<6”)	10	25

Definitions:

Forebay: A relatively deep zone placed where influent water discharges to a stormwater wetland. It traps coarse sediments, reduces incoming velocity, and helps distribute runoff evenly over the wetland.

Micropool: A deep (4 to 6 feet) pool placed at the outlet of a stormwater wetland forebay.

Deep-water: The area within a stormwater wetland that has a water depth greater than 18 inches.

Deep wetland: The area within a stormwater wetland that has a water depth between 6 and 18 inches.

Shallow wetland: The area within a stormwater wetland that has a water depth less than 6 inches.

2) The minimum length-to-width ratio shall be 3:1, unless otherwise approved by the City. If area constraints make this ratio unworkable,

baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short-circuiting.

3) Where wetland vegetation is to be planted, side slopes shall be no steeper than 5:1. Wetland plant selection shall be consistent with anticipated hydrology.

4) Access routes to the wetland for maintenance purposes must be shown on the plans. Public wetlands will need to provide a minimum 10-foot wide access route, not to exceed 10 percent in slope. A minimum 30 foot turning radius shall be provided.

Flow:

1) Flow velocity through the wetland shall average less than 0.01 feet per second for the water quality design storm event (1.4 inches in 24 hours). If natural slope does not allow for this velocity, berms shall be used to create ponded benches.

2) Flow through the wetland shall be distributed as uniformly as possible across the marsh and ponded section.

Forebay:

1) The forebay area shall be established along the wetland inflow points to capture sediment. The forebay shall have a water depth of about 3 feet and have at least 10 percent and up to 25 percent of the total treatment wetland volume.

An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

Soil Suitability: Constructed treatment wetlands are appropriate for NRCS type C and D soils. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended to support plant growth.

Setbacks: Required setback from the top of the bank to property lines is 5 feet, and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; 200-foot setback for slopes of 30%; infiltration trenches shall not be used where slopes exceed 30%.

Landscaping: Shrubs and wetland plantings shall be designed to minimize solar exposure of open water areas. Trees or other appropriate vegetation shall be located around the east, south, and west sides of a facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, and it helps maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop.

Facility area is equivalent to the area of the wetland, including bottom and side slopes, plus a 10-foot buffer around the wetland. Minimum plant material quantities per **200** square feet of the facility area are as follows:

1 - Evergreen or deciduous tree:	
Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs / small trees	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.
Wetland plants:	1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area.

Wildflowers, native grasses, and ground covers used for city-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for city-maintained facilities; any exceptions will require City approval.

1) Two staff gauges shall be installed at opposite ends of the bottom of the wetland, to enable maintenance staff to measure the depth of accumulated silts.

2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for planting.

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Wetland grading	
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Structural Detention Facility: Detention/Retention Facility

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
Pollution Reduction……….………………..	NA
? Flow Control………………..………………	PRES
Destination………………………………….	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) See Report requirements, **Exhibit 2-2,** for hydrologic and hydraulic calculations that must be submitted with structural detention design. Structural detention facilities may be used to provide flow control for any impervious surface type, and may be located on private property or within the public right-of-way.

Description: Structural detention facilities such as tanks, vaults, and oversized pipes provide underground storage of stormwater as part of a runoff flow control system. As with any underground structure, they must be designed not only for their function as runoff flow control facilities, but also to withstand an environment of periodic inundation, potentially corrosive chemical or electrochemical soil conditions, and heavy ground and surface loadings. They must also be accessible for maintenance. Facilities in this section must be designed using acceptable hydrologic modeling techniques (See **Section 2.3**) to meet applicable flow control requirements. Additional facilities will be required to meet applicable pollution reduction requirements.

Tanks and vaults typically do not have a built-in design feature for containing sediment, as do multi-cell ponds. When tanks or vaults are used for detention storage, therefore, either a surface sediment containment pond shall be placed upstream of the tank or vault, or the tank / vault shall be oversized to allow for the temporary accumulation of sediment. Where the tank or vault is designed to provide sediment containment, a minimum of ½ foot of dead storage shall be provided, and the tank or vault shall be designed and constructed with 0% (flat) bottom slope.

Tanks and vaults can be used in conjunction with other detention storage facilities, such as ponds or parking lot ponds, to provide initial or supplemental storage.

Because of minimum orifice size specifications, structural flow control facilities (such as detention tanks, vaults, and oversized pipes) for projects with less than 15,000 square feet of impervious surface are not effective and will not be permitted. Projects with less than 15,000 square feet of impervious surface are required to use surface retention facilities to control flows.

Design Requirements:
The following criteria apply to detention tank, vault, and oversized pipe design.

?? All areas of a tank or vault shall be within 50 feet of a minimum 36-inch diameter access entry cover. All access openings shall have round, solid locking lids.
?? All privately owned and maintained facilities shall be located to allow easy maintenance and access. (**See Chapter 3.0**: Operation and Maintenance)
?? All tanks and vaults shall be designed as flow-through systems, unless separate sediment containment is provided.
?? Minimum size for a public detention pipe shall be 36 inches. If the collection system piping is designed also to provide storage, the resulting maximum water surface elevation shall maintain a minimum 1-foot of freeboard in any catch basin below the catch basin grate. Pipe capacity shall be verified using an accepted methodology approved by the City

?? The minimum internal height of a vault or tank shall be 3 feet, and the minimum width shall be 3 feet. The maximum depth of the vault or tank invert shall be 20 feet. Pipe material and surface treatment shall conform to the standards for detention tanks and vaults (see **Exhibits 2-22 and 2-24).**
?? Detention tanks and vaults shall have a minimum of ½ foot of dead storage, unless upstream sedimentation is provided (see **Exhibits 2-22 and 2-24**).

Flow Control:
?? To restrict flow rates exiting the pond to those required by **Section 1.6.2**, a control structure per **Section 2.5** must be used.

Materials and Structural Stability:
? Pipe material shall conform to the Unified Plumbing Code.
? All tanks, vaults, and pipes shall meet structural requirements for overburden support and traffic loadings, if appropriate. H-20 live loads shall be accommodated for tanks and vaults under roadways and parking areas. End caps shall be designed for structural stability at maximum hydrostatic loading conditions.
? Detention vaults shall be constructed of structural reinforced concrete (3000 psi, ASTM 405). All construction joints shall be provided with water stops.
? In soils where groundwater may induce flotation and buoyancy, measures shall be taken to counteract these forces. Ballasting with concrete or earth backfill, providing concrete anchors or other counteractive measures shall be required. Calculations shall be required to demonstrate stability.

Structural Detention Facility: Detention/Retention Facility

? Tanks and vaults shall be placed on stable, consolidated native soil with suitable bedding. Tanks and vaults shall not be allowed in fill slopes, unless a geotechnical analysis is performed for stability and construction practices.

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Checklist of minimal information to be shown on the permit drawings:

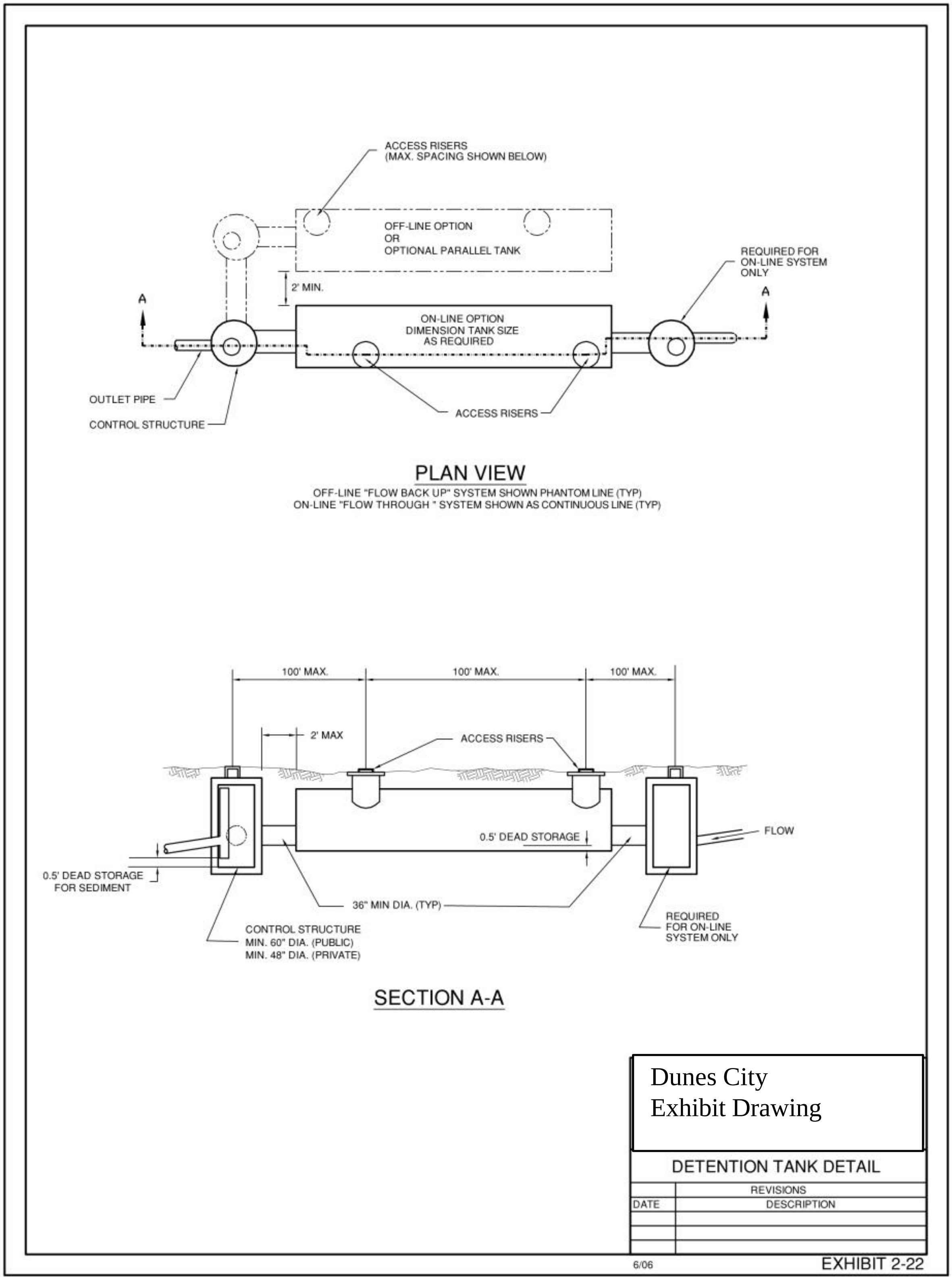
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

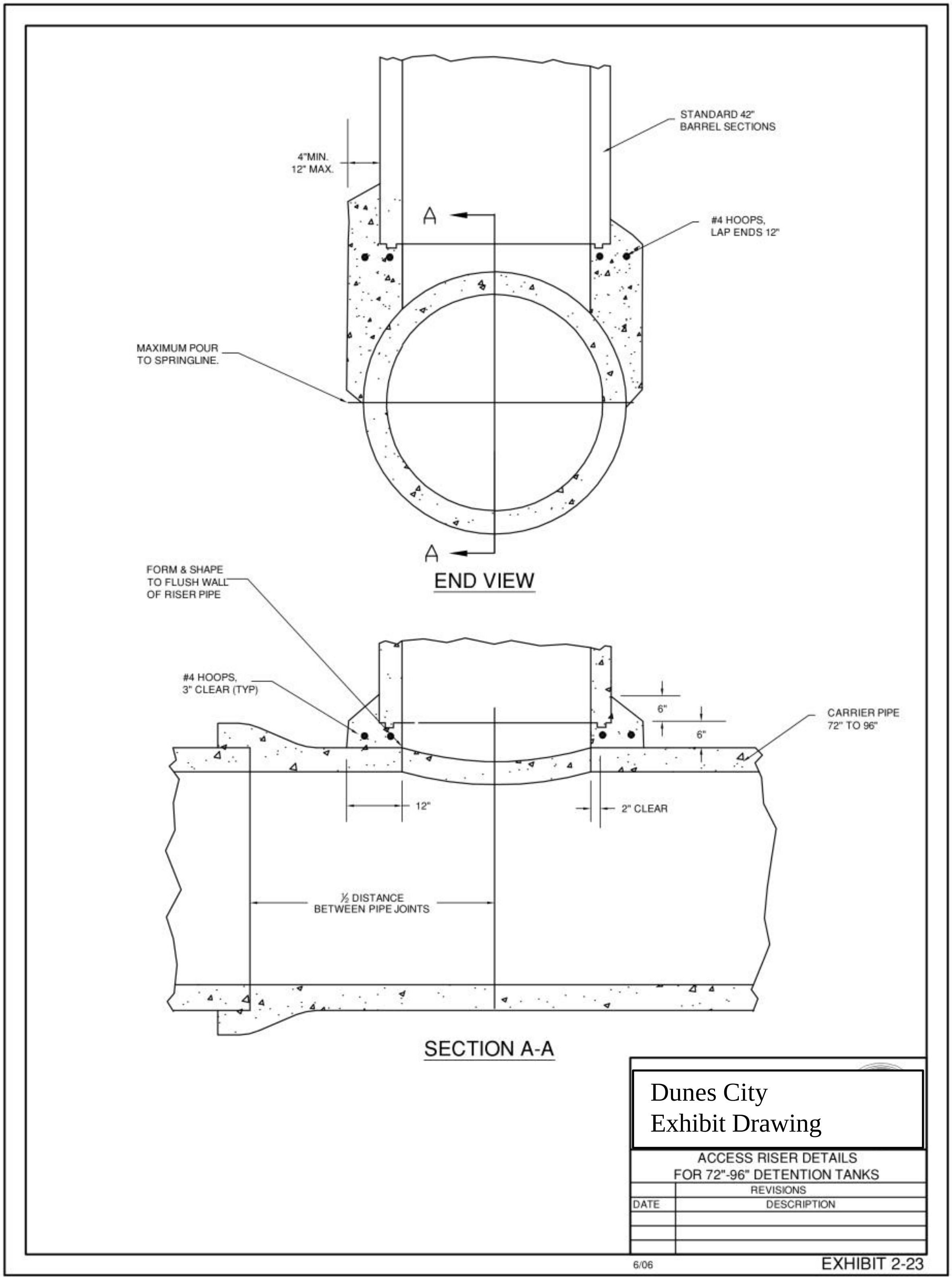
Facility Component	Inspection Requirement
Vault excavation	
Piping	Call for inspection
Vault installation	Call for inspection
Control structure (orifice structure)	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

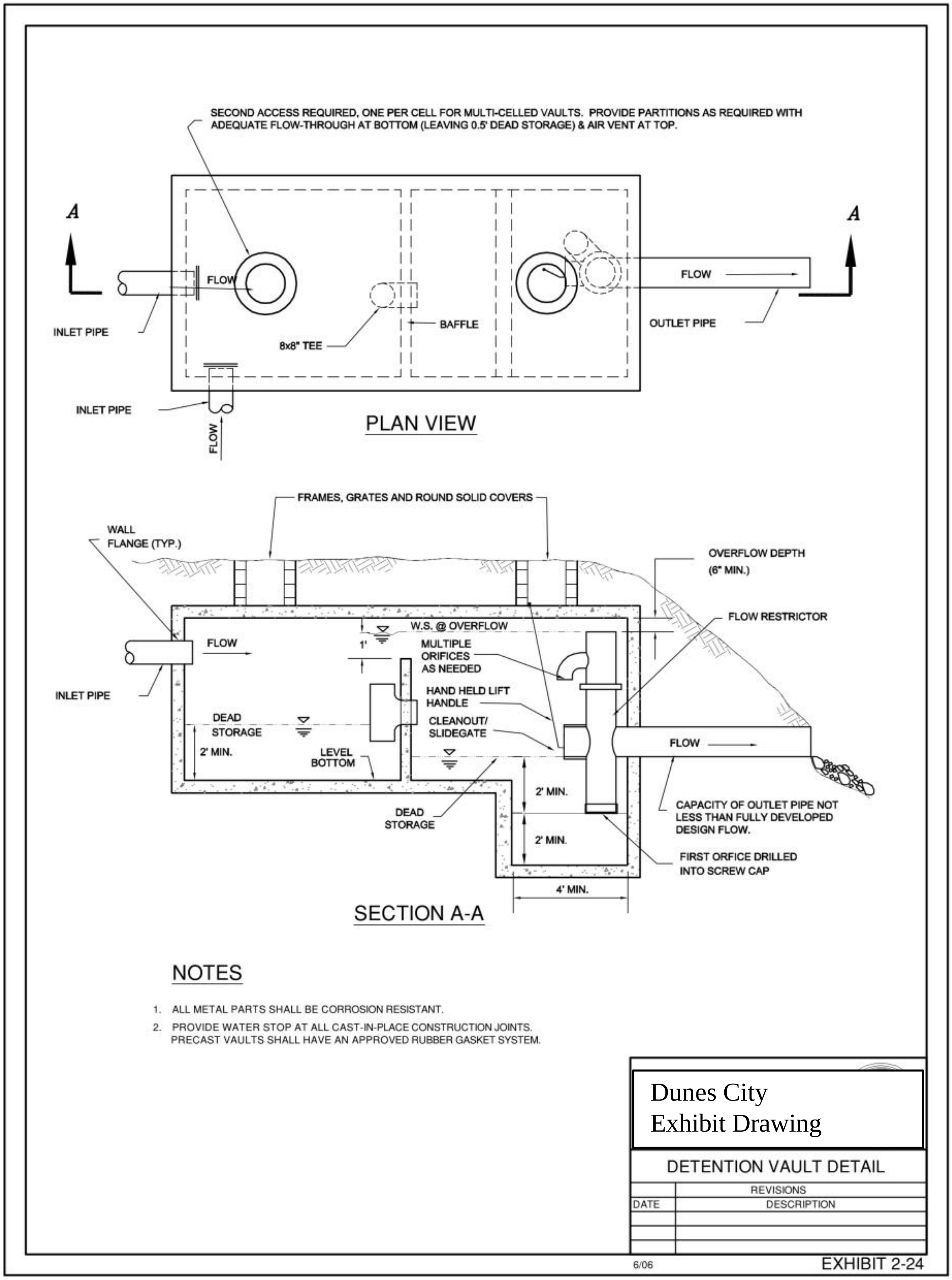
Structural Detention Facility: Detention/Retention Facility



Structural Detention Facility: Detention/Retention Facility



Structural Detention Facility: Detention/Retention Facility



Rainwater Harvesting: Detention Type Facility

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction…………………………..	PERF[1]
? Flow Control………..………………………	PERF[1]
Destination……………………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The required water storage volume is a function of drainage area, rate of water usage, and stormwater management goal. Rainwater harvesting systems may be used to manage stormwater from rooftops and depending on the water use, other impervious surfaces, and must be located on private property.

Description: Stormwater may be collected and reused for non-potable water uses within a house or building, or for landscape irrigation purposes. Uses can include reusing water in toilets and at hose bibs. Plumbing approval must be obtained with any such system.

Rainwater harvesting can provide several stormwater management benefits:

?? Flow control: Rainwater harvesting can provide significant flow-reduction benefits. Depending on the size of the water storage facility and the rate of use, a significant percentage of the annual runoff volume can be reused. Where it isn't feasible to meet a development site's full flow control obligation, rainwater harvesting can be used to manage a portion of the flow and lessen the overall flow control requirement.

?? Pollution reduction: As a result of the significant reduction in off-site flow volume that can be achieved, a significant reduction in the discharge of pollutants associated with stormwater can also be accomplished. Where it isn't feasible to meet a development site's full pollution reduction obligation, rainwater harvesting can be used to manage a portion of the flow and lessen the overall pollution reduction requirement.

Checklist of minimal information to be shown on the permit drawings, or included with the permit submittal package:

1) Water storage facility details and specifications
2) Pump and associated electrical details and specifications
3) Piping size, material, and placement details and specifications

Rainwater Harvesting: Detention Type Facility

4) Average daily water use documentation
5) Hydraulic calculations demonstrating compliance with stormwater management requirements (pollution and flow control)
6) Approximate setbacks from property lines and structures shall be shown
7) Overflow connection to approved stormwater destination per **Section 1.4**

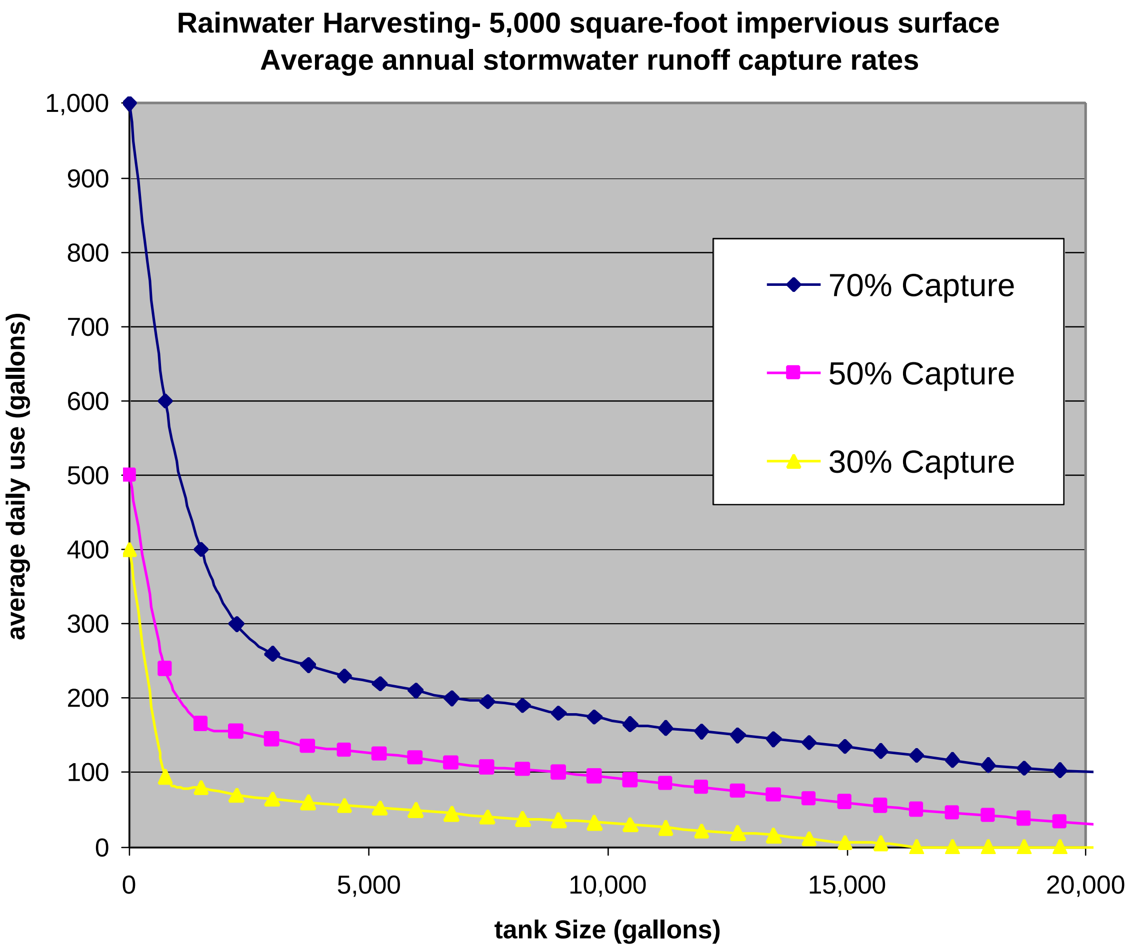
Operations and Maintenance requirements: See **Chapter 3.0**.

The following chart represents an analysis done on a 5,000 square-foot project site with 100% impervious surface. 8.5 months of 5-minute rainfall intensity data from the Fernwood rain gage in Portland was used in the analysis, which shows the relationship between water storage volume and average daily water use rate for average annual runoff capture goals of 30%, 50%, and 70%.

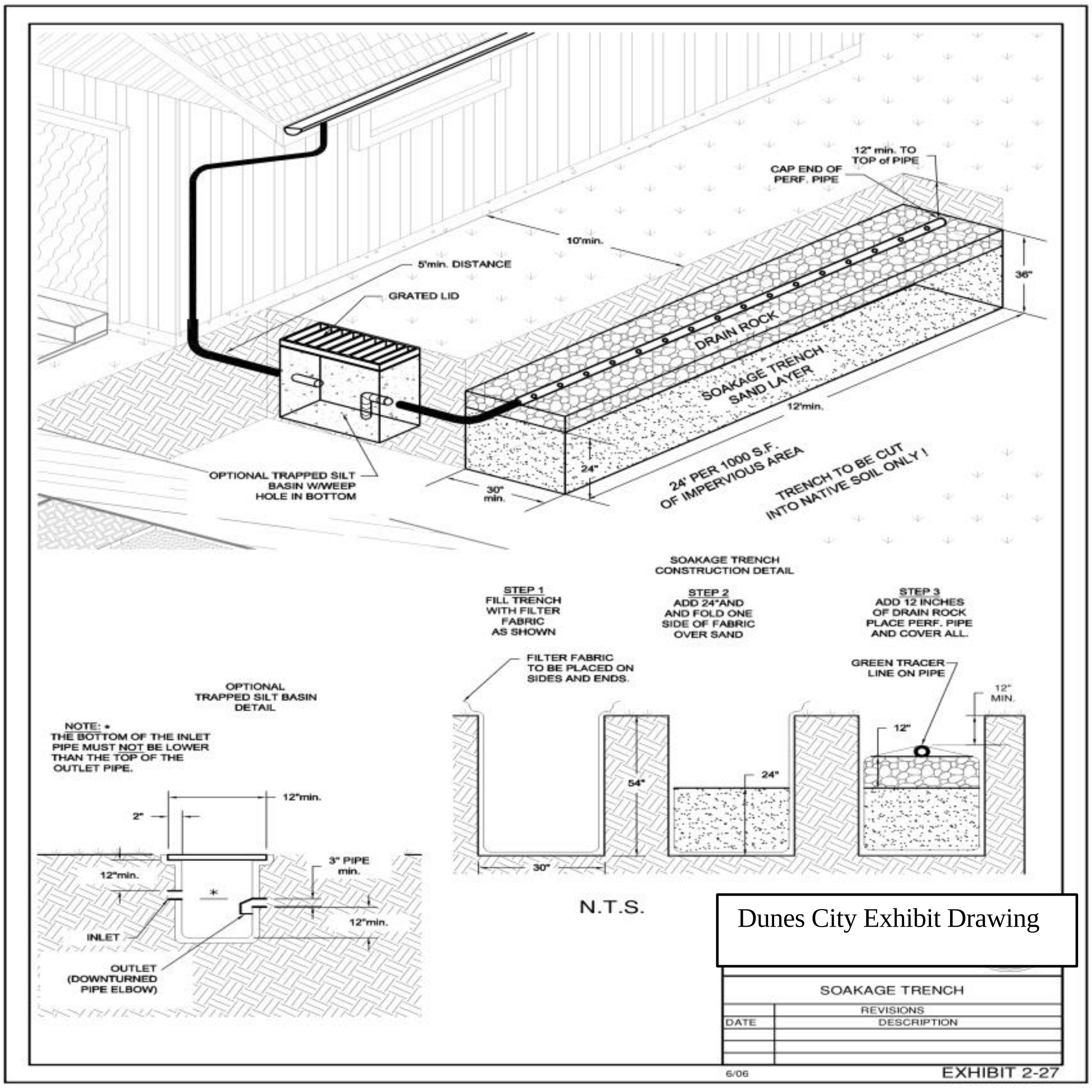
For example, if the stormwater management goal is 50% reduction of the annual release volume, the pink line is used to show that if a 2,000-gallon tank were used, the average daily use would need to be approximately 160 gallons per day. A larger tank would necessitate a smaller average daily use rate to achieve the same stormwater management goal of 50% annual volume reduction.

Rainwater Harvesting: Detention Type Facility

Exhibit 2-26



Soakage Trench: Detention/Retention Type Facility



Stormwater Management Goals Achieved Acceptable Sizing Methodologies

Pollution Reduction………..……………….. NA[1]

? Flow Control………………………………… PRES

? Destination…………………………………… PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Soakage trenches can be used to manage stormwater runoff, and with a sufficient layer of sand or soil for filtration, may be used to meet pollution reduction requirements.

2.7 SOAKAGE TRENCHES

A soakage or "infiltration" trench is a shallow trench in permeable soil that is backfilled with sand and coarse stone and lined with filter fabric. The trench surface may be covered with grating, stone, sand, or a grassed cover with a surface inlet.

Soakage trenches can be used to provide a stormwater destination by collecting and recharging stormwater runoff into the ground. The use of soakage trenches is highly dependent on soil type and height of the groundwater table.

Note: DEQ has identified soakage trenches as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of soakage trenches that serve rooftops only. All soakage trenches, with the exception of those that drain residential rooftops only, must be registered with DEQ.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call DEQ- UIC Program at 503-229-5945. For copies of applications or forms, call 1-800-452-4011.

Soakage trenches are recognized as a stormwater destination, and with a sufficient layer of sand or soil for filtration, may be used to meet pollution reduction requirements. **Exhibit 2-28** provides detailed drawing of a standard soakage trench.

Soakage Trench Design and Sizing Method

Soil conditions are critical to the success of soakage trenches. Because of this, the use of soakage trenches must be pre-approved by the City. Supporting geotechnical evidence and a documented infiltration test may be required to demonstrate that soakage trenches will work in the project area. Soakage trenches shall be sized in accordance with **Exhibit 2-28**, once City approval has been given for on-site infiltration.

Soakage Trench: Detention/Retention Type Facility

General Requirements:

Maximum area to be served:	15,000 square-feet per trench
Soils requirements: (NRCS classification)	A or B; C soils may be used if drawdown times are met
Maximum ground slopes	20 percent
Soil test requirement	ASTM D 3385-88 or City approval

1) If designed as the only stormwater destination, the soakage trench shall infiltrate the entire flood control design storm without overflow.

2) Soakage trenches shall not be accepted in soils with a tested infiltration rate of less than 0.5 inches per hour.

3) There shall be no less than 4 feet of undisturbed depth of infiltration medium between the bottom of the facility and any impervious layer (hardpan, solid rock, etc.) or seasonal high groundwater levels.

4) Drawdown time when full shall not exceed 10 hours.

5) Soakage trenches shall meet the following setback requirements for downstream slopes: minimum of 100 feet from slopes of 20%; add 5 feet of setback for each additional percent of slope up to 30%; infiltration trenches shall not be used within 200 feet of where slopes exceed 30%.

6) The bottom of the soakage trench shall be flat, or clay check-dams may be used to prevent water from collecting near the downstream end.

7) Drain medium shall have filter fabric between the medium and native soils or backfill.

8) Soakage trench areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of soakage trench areas.

9) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional engineer, shall inspect the soil after the system is excavated, before trenches are filled with drain medium, to

confirm that soils remain in suitable condition to perform at anticipated

Facility Component	Inspection Requirement
Trench grading	
Piping	Call for inspection
Filter fabric	
Sand layer	
Drain rock	

infiltration rates.

10) Soakage trenches should be located down slope of structures, and are required to be setback at least 10 feet from structures, 5 feet from property lines, and 5 feet from public utility lines.

Checklist of minimal information to be shown on the permit drawings:

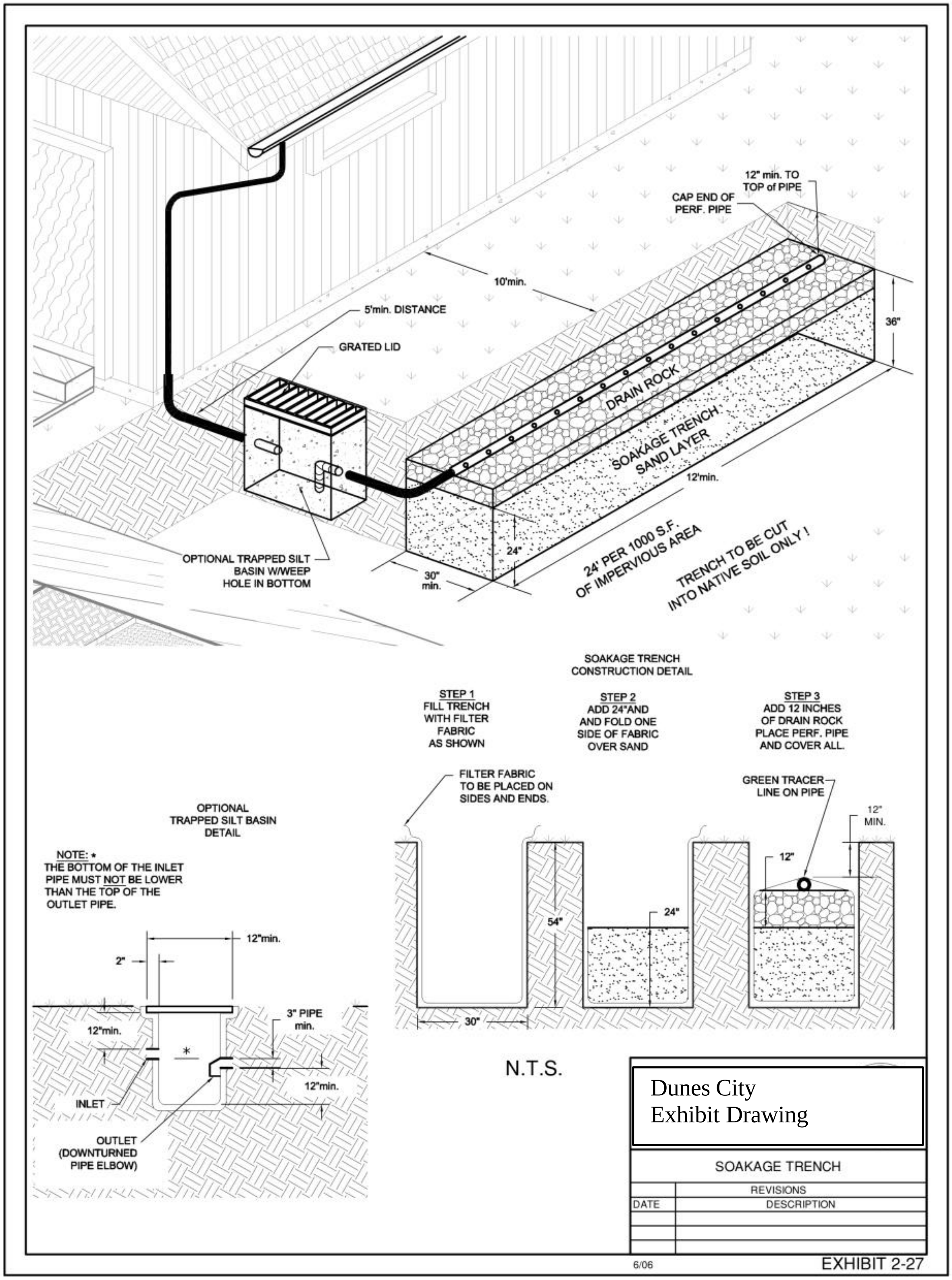
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Drain rock specification
4) Sand specification
5) Filter fabric specification
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection Requirements and Schedule:

The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Operations and Maintenance requirements: See **Chapter 3.0**.

Soakage Trench: Detention/Retention Type Facility



Soakage Trench: Detention/Retention Type Facility

Soakage Trench Sizing

?? Hydraulic calculations shall be performed using the Rational Method?
?? Soakage trenches shall be designed for the Flood Control Design Storm, with a safety factor of 2.
? The time of concentration for a soakage trench design shall be 5 minutes.

Trench

? Soakage trench and perforated pipe must be installed level and parallel to contour of finish grade.
? Soakage trench shall be located no closer than 10 feet to any building structure and not closer than 5 feet from property line.
? Unless a separate pollution reduction facility is used upstream of the trench, the sand filter portion of soakage trench must be filled with a minimum of 24” medium sand meeting OAR 340-71-295 (3)(e).
? Minimum 12” of ¾” – 2 ½” round or crushed rock to cover sand separated by one layer of filter fabric.
? The pipe shall be laid on top of this gravel and covered with filter fabric.
? At least 12” minimum of backfill shall be placed over the trench.
? All trenches shall be constructed on native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.
? Slope shall not exceed 20% without a stamped and signed geotechnical report addressing slope stability.
? Trench shall not be constructed under current or future impervious surface.

Sand

Medium sand meeting OAR 340-71-295 (3)(e) will be required. Sieve analysis of the medium sand is required to be made by a qualified party and a report provided to City of Portland plumbing inspector at the time of inspection. Analysis to comply with ASTM C136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregate and in conjunction and accordance with ASTM C-117, Standard Test Method for Materials Finer than No.200 Sieve in Mineral Aggregates by Washing.

Sieve #	% Passing
3/8	100%
#4	95-100%
#8	80-100%
#16	45-85%
#30	15-60%
#50	3-15%
#100	4% or less

Pipe

? The solid pipe from building or other source to connection with perforated pipe must be installed at a ¼” per foot slope.
? All piping within 10 feet of building must be sch. 40 ABS, sch. 40 PVC, cast iron, sch. 40 ABS, 3” sch. 40 PVC or 3” cast iron pipe may be used for rain drain piping serving not more than 1500 sf of roof or surface area. Use 4” pipe if area is greater than 1500 sf.
? Pipe must have a minimum cover of 12” measured from top of pipe to finished grade.
? The pipe within the trench shall either be PVC D2729 or HDPE Leach field pipe.
? The silt trap shall be installed between the dwelling and the sand filter, a minimum of 5’ from the dwelling.

Filter Fabric must be one of the following types/brands: LINQ 125EX; LINQ TYPAR3201; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL.

? At least 12” minimum of backfill shall be placed over this trench.

Infiltration Sump System: Detention/Retention Facility

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
Pollution Reduction………..………………..	NA
? Flow Control……………..…………………	PRES
? Destination……………………………………	PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Infiltration sump systems are used to manage stormwater from street surfaces.

INFILTRATION SUMP SYSTEMS

Infiltration sump systems can be used to provide street drainage by collecting and recharging stormwater runoff into the ground. The use of sumps is highly dependent on soil type and height of the groundwater table.

Note: The Oregon Department of Environmental Quality (DEQ) has identified sumps as “Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be either authorized by rule or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, site controls and pollution reduction facilities are required prior to disposing stormwater into them.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call DEQ- UIC Program at 503-229-5945, and for copies of applications or forms call 1-800-452-4011.

Sumps are recognized as a destination method for managing stormwater runoff, but are not intended to be used to meet pollution reduction requirements. Sump systems are excluded from use within the following specific areas and land-use types within the City:

? Within 500 feet of municipal or domestic drinking water wells, or a two-year time of travel zone, whichever is greater.

? In areas with permanent or seasonally-shallow groundwater (< 10 feet below the ground surface).

Infiltration Sump System: Detention/Retention Facility

A "sump system" (see **Exhibit 2-28**) is the total of all sump components at a single location (e.g., an intersection) and consists of inlets, piping, a sedimentation manhole, and one or more sumps. If one sump lacks adequate capacity to handle the design flow, a second sump may be placed in series with the first to provide additional capacity.

Sedimentation manholes with oil traps receive runoff from inlets before stormwater enters the sumps. The sedimentation manholes settle out most of the large particulate material that can clog sumps' drainage holes, decreasing maintenance needs and increasing long-term effectiveness.

Detailed drawings of a standard sump and standard sedimentation manhole can be found as **Exhibits 2-29** and **2-30** of this manual.

When constructed according to the standard design procedures, sump system achieves both flow control and destination benefits. A sedimentation manhole reduces pollution through removal of sediment, oils, and grease. Additional pollution reduction facilities, such as street swales, planters or filters, must be used in non-residential streets, or streets with over 1,000 average daily trips.

Sump System Method of Analysis

? Hydraulic calculations for public sumps shall be performed using the Rational Method.

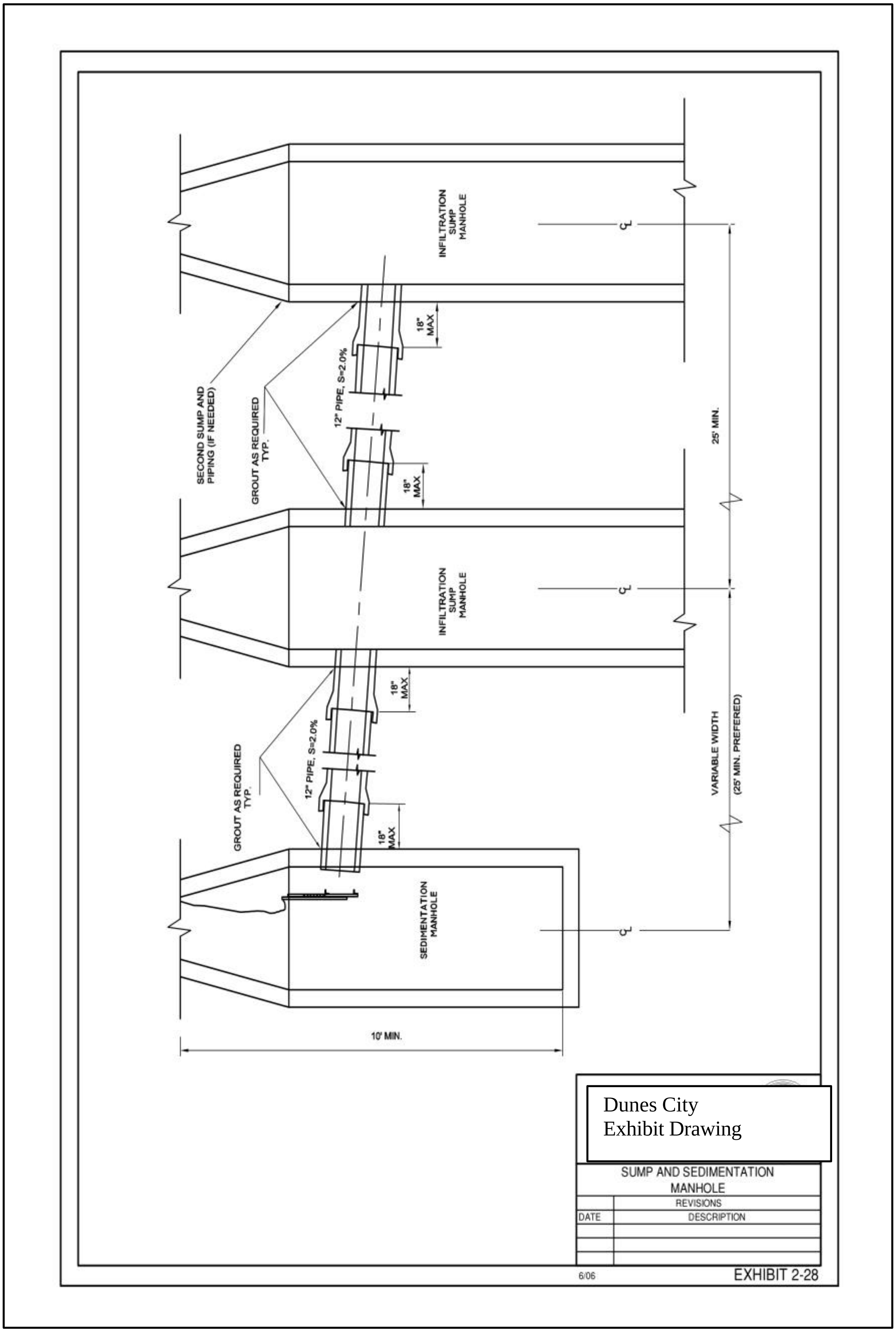
? Sumps shall be designed for the Flood Control Design Storm, with a safety factor of 2.

? The time of concentration for sump design shall be 5 minutes.

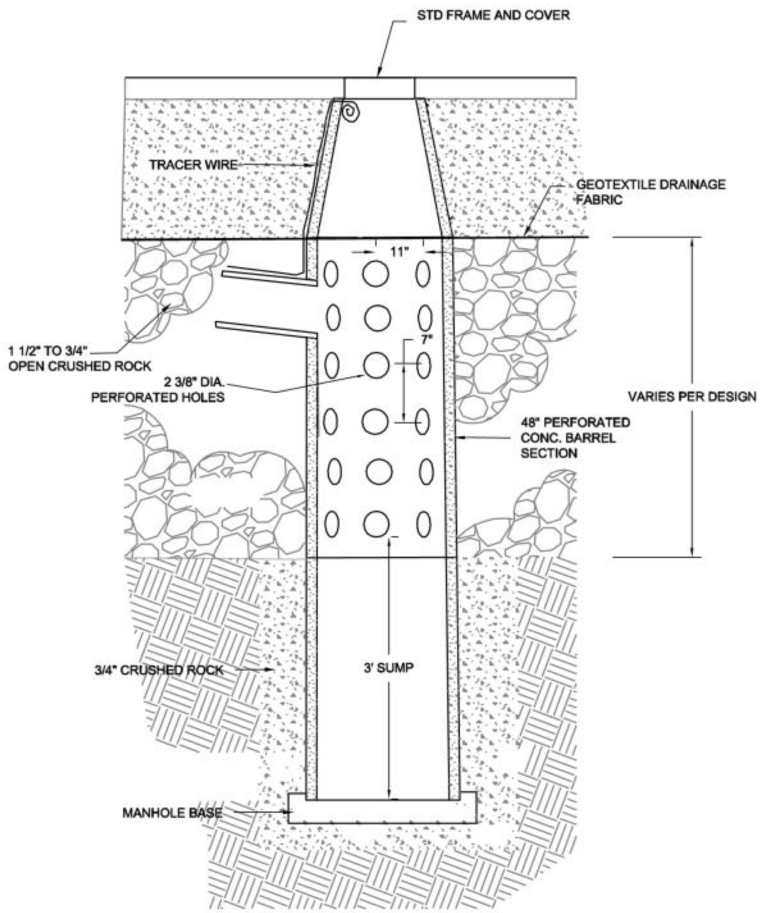
Example: What is the design percolation rate that a sump system must achieve to adequately dispose of runoff from 10,000 square-feet of paved street area?

Rational Formula:	Q=C*I*A
Assume:	Time of concentration = 5 minutes for the street area
Where:	Q= Flow in cubic feet per second C= Runoff Coefficient (0.9 for paved surfaces) I= Intensity (3.1 inches per hour for a 10-year storm event and a time of concentration of 5 minutes) A= Area in acres (10,000 square-feet = 0.23 acres)
	Q= (0.9) * (3.1) * (0.23) = 0.64 cfs
Apply safety factor of 2:	Q= 2 * 0.64 cfs = **1.28 cfs or 574.5 gallons per minute**

Infiltration Sump System: Detention/Retention Facility



Infiltration Sump System: Detention/Retention Facility



48" INFILTRATION SUMP

Dunes City
Exhibit Drawing

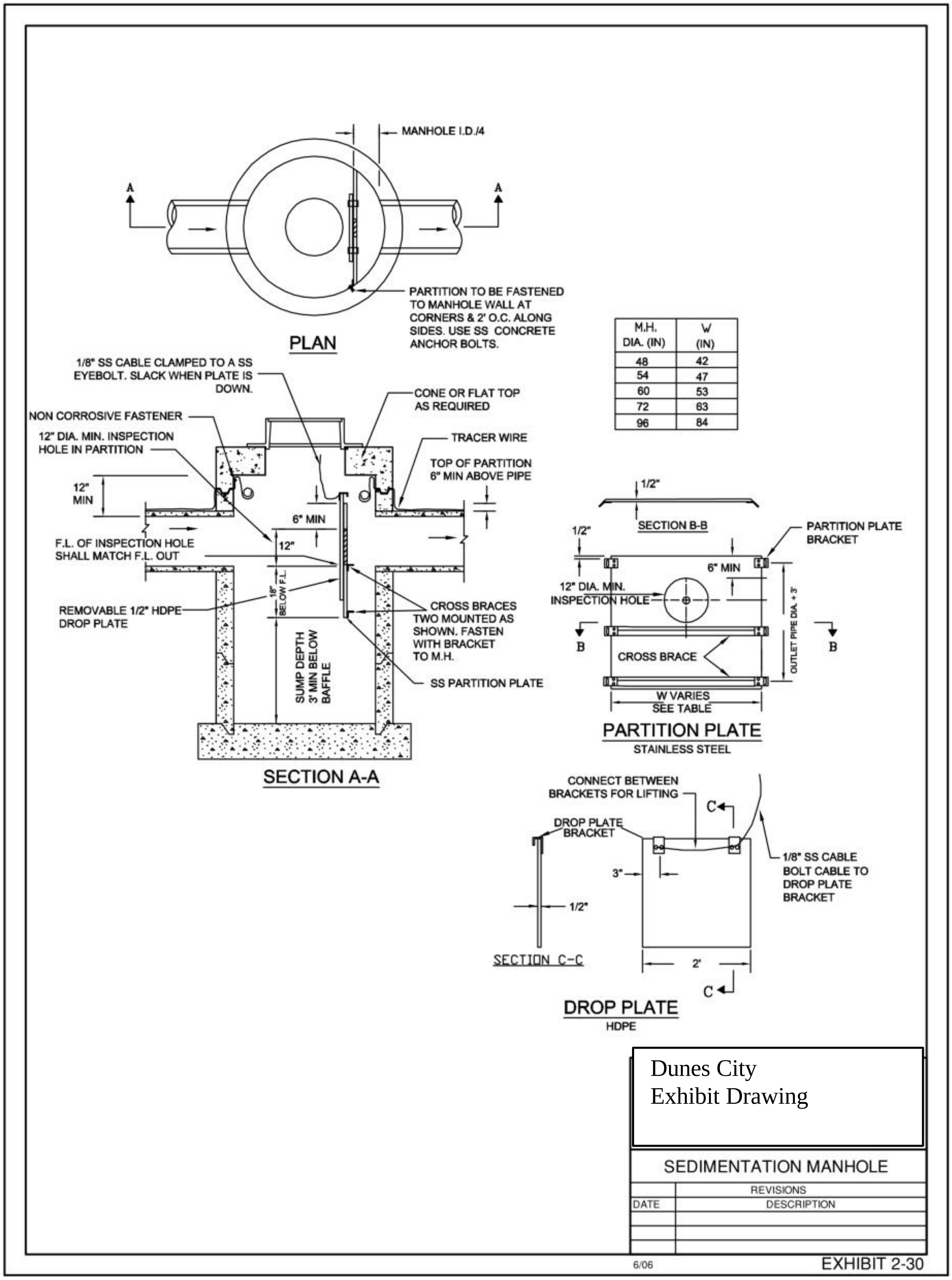
PRECAST INFILTRATION SUMP

DATE	REVISIONS DESCRIPTION

6/06

EXHIBIT 2-29

Infiltration Sump System: Detention/Retention Facility



Infiltration Sump System: Detention/Retention Facility

Sump System Design Requirements

?? Sump systems shall be designed to handle **twice** the flow from the calculated design storm.

?? A maximum of two sumps shall be used in series.

?? The minimum distance between sumps shall be 25 feet.

?? The desired distance between the sump and sedimentation manhole is 25 feet. This figure is a guideline and depends on site conditions.

?? Sumps shall not be located within 200 feet from the tops of slopes more than 10 feet high and steeper than 2h: 1v.

?? The diameter of pipe between the sump and sedimentation manhole shall be 12 inches.

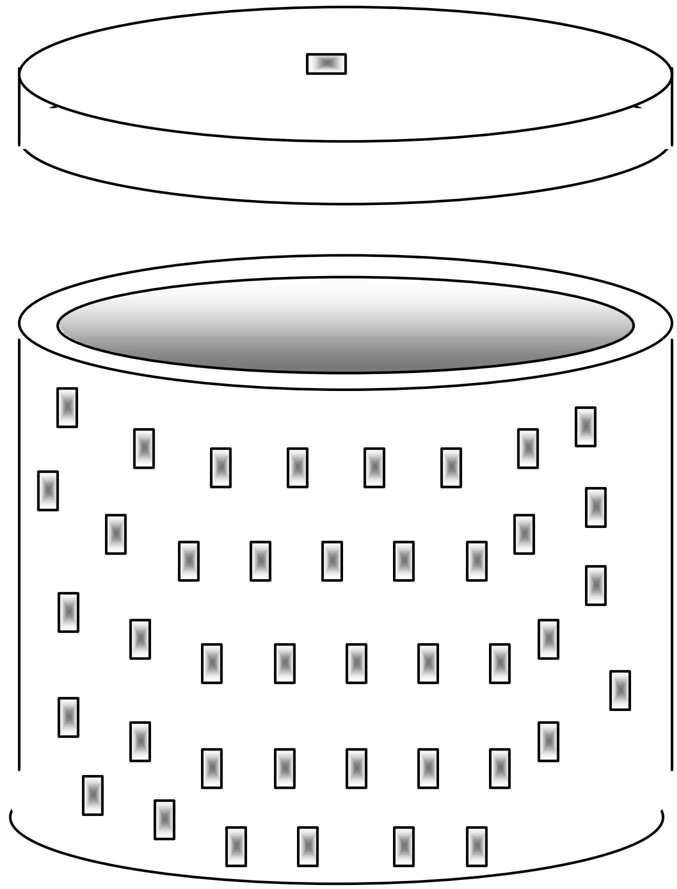
?? Sumps shall not be located in areas with a constant or seasonally high groundwater table, or shallow bedrock. The bottom of the sump shall be at least 10 feet above the seasonal high water table, and at least 3 feet above bedrock.

Checklist of minimal information to be shown on the permit drawings:

1) Sump and sedimentation manhole location with setbacks to curb, right-of-way lines, and other existing and proposed utilities.
2) Rim and bottom elevation.
3) The sump and sedimentation manhole shall reference the City standard plan numbers.
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Operations and Maintenance requirements: Turbid runoff from construction sites shall not be allowed to enter the system at any time. One year after construction is completed and prior to Final Acceptance, the contractor shall verify the design capacity of the sump using the above sump testing procedures. For Public Sump Systems, the sedimentation manhole shall be cleaned prior to City acceptance of ownership and maintenance.

Drywell: Detention/Retention Type Facility



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
Pollution Reduction………..………………..	NA
? Flow Control…………………………………	PRES
? Destination……………………………………	PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Drywells can be used to manage stormwater runoff.

Drywell: Detention/Retention Type Facility

Description: Drywells can be used as a stormwater destination by collecting and recharging stormwater runoff into the ground. The use of drywells is highly dependent on soil type and height of the groundwater table.

Note: DEQ identifies drywells as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of drywells that serve rooftops only. All drywells, with the exception of those that drain residential rooftops only, must be registered with DEQ prior to City permit issuance.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call the DEQ UIC Program at 503-229-5945. For copies of applications or forms call 1-800-452-4011.

Drywells are recognized as a stormwater destination, but they are not intended to be used to meet pollution reduction requirements. Unless a drywell used exclusively for roof runoff, pollution reduction facilities must be used to receive runoff before it enters the drywell.

Drywell systems are prohibited where permanent or seasonally shallow groundwater will exist within 10 feet of the bottom of the drywell.

Drywell Design and Sizing Method

Soil conditions are critical to the success of drywells. Because of this, the use of drywells must be pre-approved by the City. Supporting geotechnical evidence and a documented drywell test may be required to demonstrate that drywells will work in the project area. Drywells shall not be located in areas with a constant or seasonally high groundwater table.

Drywell: Detention/Retention Type Facility

Note: Developers should refer to OAR 340, Division 44, "Construction and Use of Waste Disposal Wells or Other Underground Injection Activities" for additional design and regulatory requirements.

Drywell Sizing:

?? Hydraulic calculations shall be performed using the Rational Method.
? Drywells shall be designed for the Flood Control Design Storm, with a safety factor of 2.
? The time of concentration for a Drywell design shall be 5 minutes.

General Requirements:

Soils requirements: (NRCS classification)	A or B; C soils may be used if drawdown times are met
Maximum ground slopes	20 percent
Soil test requirement	ASTM D 3385-88 or City approval

1) If designed as the only stormwater destination, the drywell shall infiltrate the entire flood control design storm without overflow.

2) Drywells shall not be accepted in soils with a tested infiltration rate of less than 0.5 inches per hour.

3) There shall be no less than 4 feet of undisturbed depth of infiltration medium between the bottom of the facility and any impervious layer (hardpan, solid rock, etc.) or seasonal high groundwater levels.

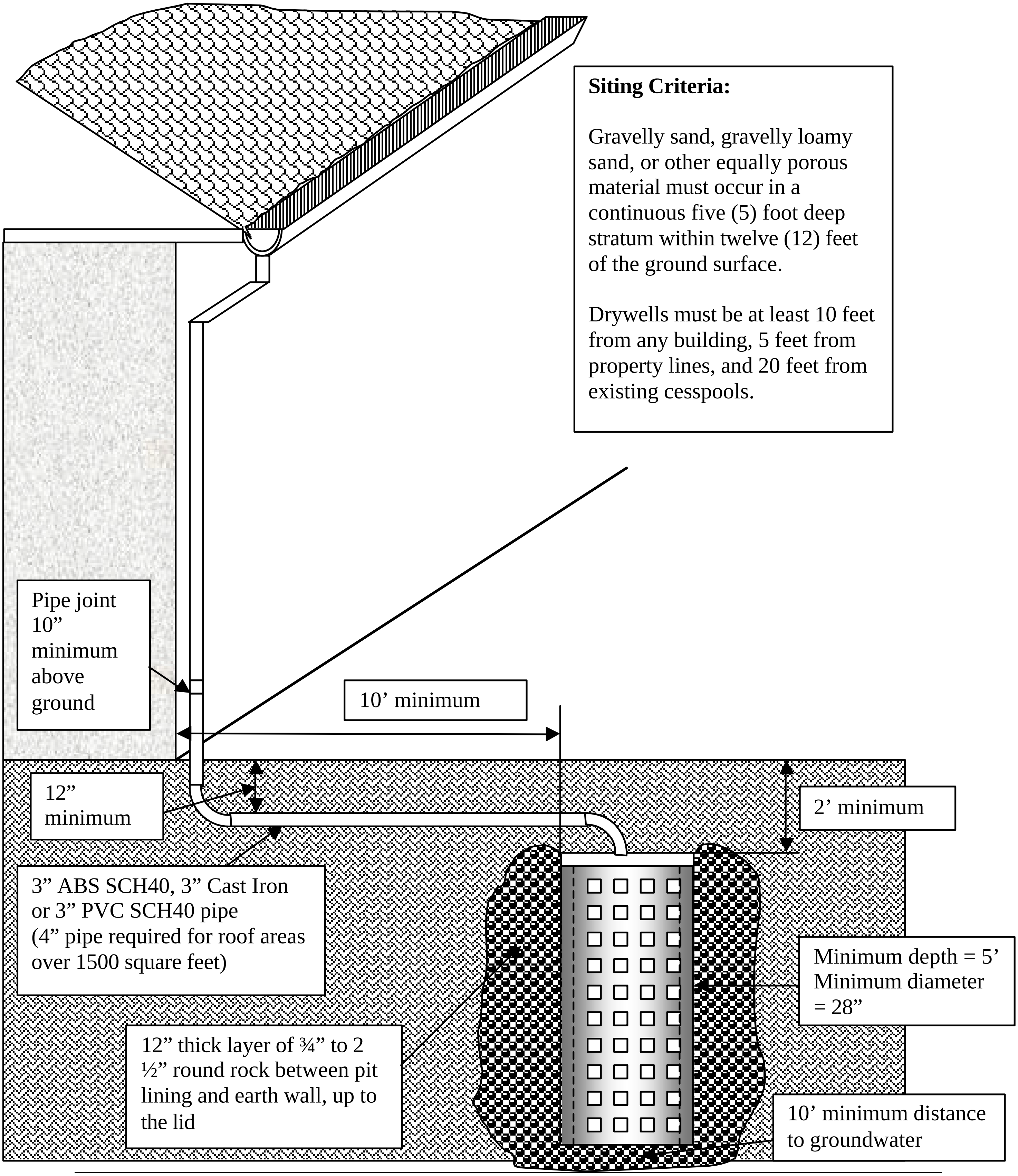
4) Drawdown time when full shall not exceed 10 hours.

5) Drywells shall meet the following setback requirements for downstream slopes: minimum of 100 feet from slopes of 20%; add 5 feet of setback for each additional percent of slope up to 30%; drywells shall not be used within 200 feet of where slopes exceed 30%.

6) Drywells should be located down slope of structures, and are required to be setback at least 10 feet from structures, 5 feet from property lines, and 5 feet from public utility lines.

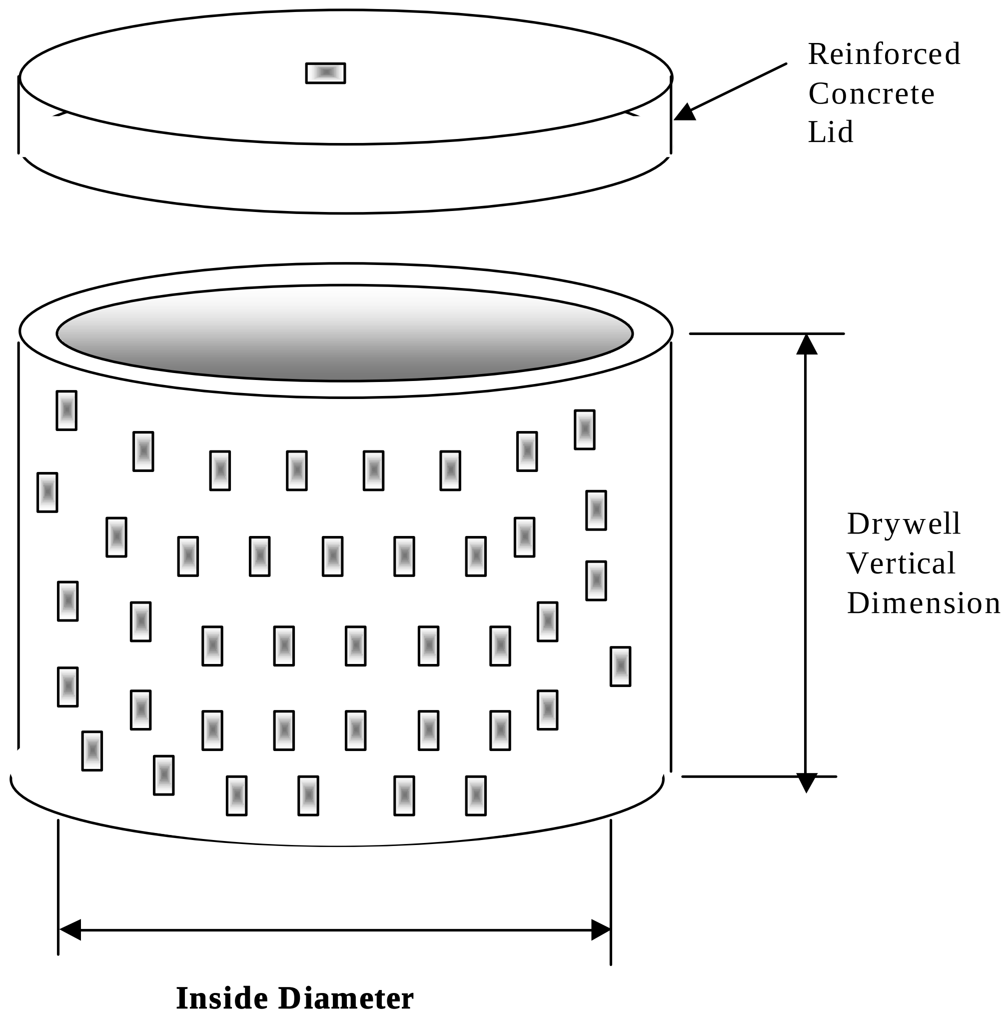
Drywell: Detention/Retention Type Facility

Exhibit 2-31: Reinforced Concrete Drywell Typical Configuration



Drywell

Exhibit 2-32: Typical Drywell:



Drywell

Checklist of minimal information to be shown on the permit drawings:

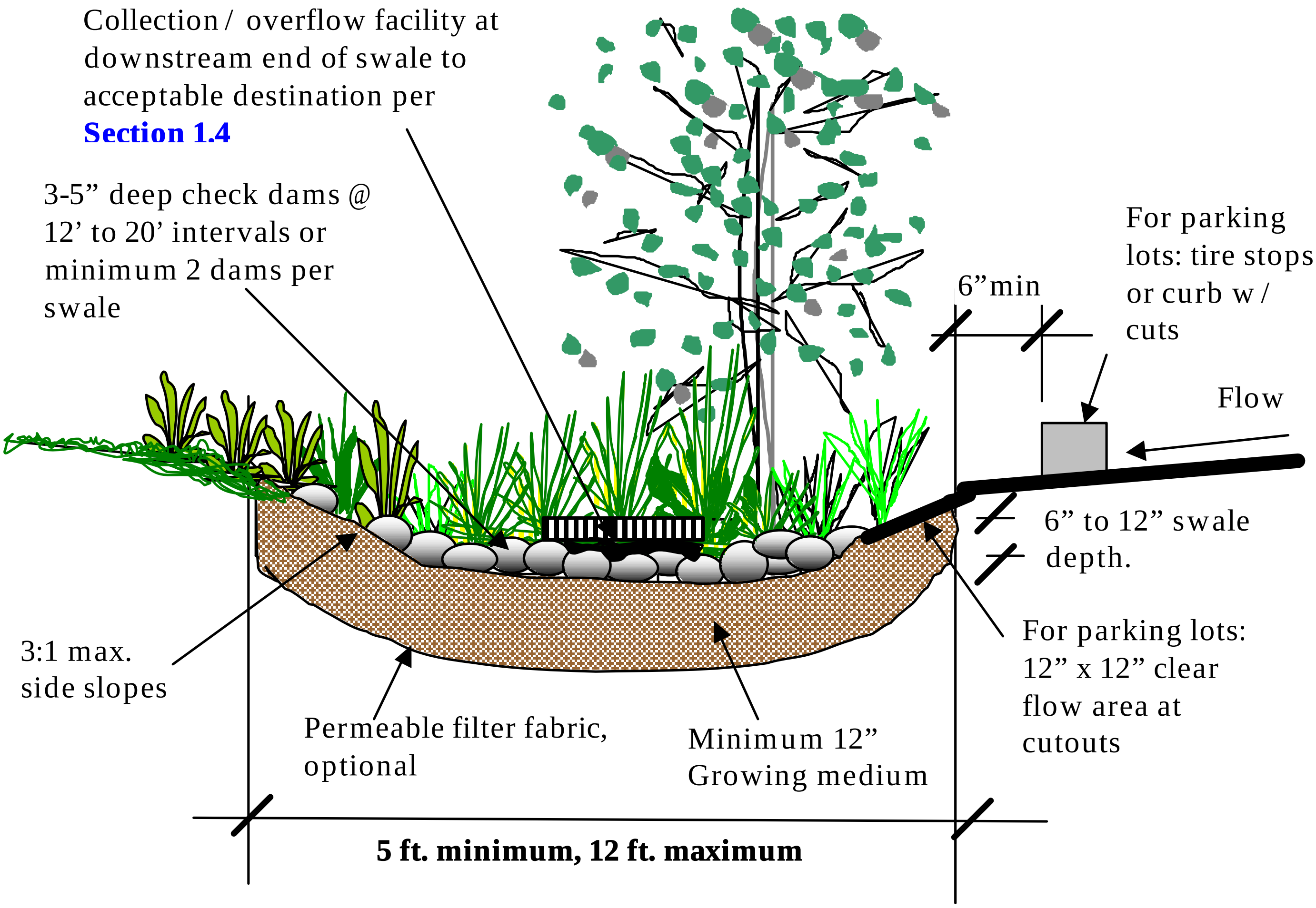
1) Facility location with setbacks from property lines and structures.
2) Depth and diameter of drywell.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Drywell excavation	
Piping	Call for inspection
Drywell installation & backfill	Cal for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Vegetated Swale: Optional Detention/Flow-Through Facility



Section Not to Scale

<u>**Stormwater Management Goals Achieved Acceptable Sizing Methodologies**</u>

? Pollution Reduction…………………………….. SIM, PERF[1], PRES[2]
? Flow Control……………………………………. SIM
? Destination……………………………………. PRES[3]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Vegetated swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **2)** For projects with more than 15,000 square-feet of impervious area to manage, the presumptive approach may be used to size the swale for pollution reduction, and additional facilities may be required to meet flow control requirements.

Vegetated Swale: Optional Detention/Flow-Through Facility

Description: Vegetated swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance/ destination method per **Section 1.4** will be required at the end of the swale.

Design Considerations: When designing vegetated swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility.

Construction Considerations: Vegetated swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Vegetated swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix E** to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Maximum longitudinal slope is 6% (temporary erosion control measures will be required on slopes greater than 2%, to stabilize soils until sufficient vegetative growth is established).

Setbacks: Required setback from top of bank of swale is 10 feet from structures unless lined with impermeable fabric or approved by City.

Sizing: Vegetated swales sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.09 may be used to. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved destination point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the Performance Approach may be used in conjunction with a measured infiltration rate to downsize the Simplified Approach sizing factor.

Presumptive Approach Sizing Criteria:

1) The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity (0.22 inches / hour) at:

   ?? Maximum design velocity of 0.9 feet per second.
   ?? Minimum hydraulic residence time (time for Q_{design} to pass through the swale) of 9 minutes.
   ?? Minimum longitudinal slope of 0.5 percent, maximum slope of 6 percent .
   ?? Designed using a Manning "n" value of 0.35.
   ?? 3:1 (or flatter) side slopes in the treatment area.

   A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute intensity = 3.5 inches per hour).

   Velocity through the facility shall not exceed 3 feet per second (fps) during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

2) Maximum bottom width shall be 8 feet.

3) Vegetation shall be established as soon as possible after the swale is completed, and before water is allowed to enter the facility.

4) Unless vegetation is established, biodegradable erosion control matting appropriate for low-velocity flows (approximately 1 foot per second) shall be installed in the flow area of the swale before allowing water to flow through the swale.

5) Access routes to the swale for maintenance purposes must be shown on the plans. Public swales will need to provide a minimum 10-foot wide access route, not to exceed 10 percent in slope.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrating them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 6 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Minimum plant material quantities per 100 square feet of facility area are as follows:

1 - Evergreen or deciduous tree (planted around the perimeter of the swale):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs / small trees:	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants:	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for City-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions will require City approval.

Stormwater Report Requirements For Presumptive Approach: See Exhibit 2-2.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

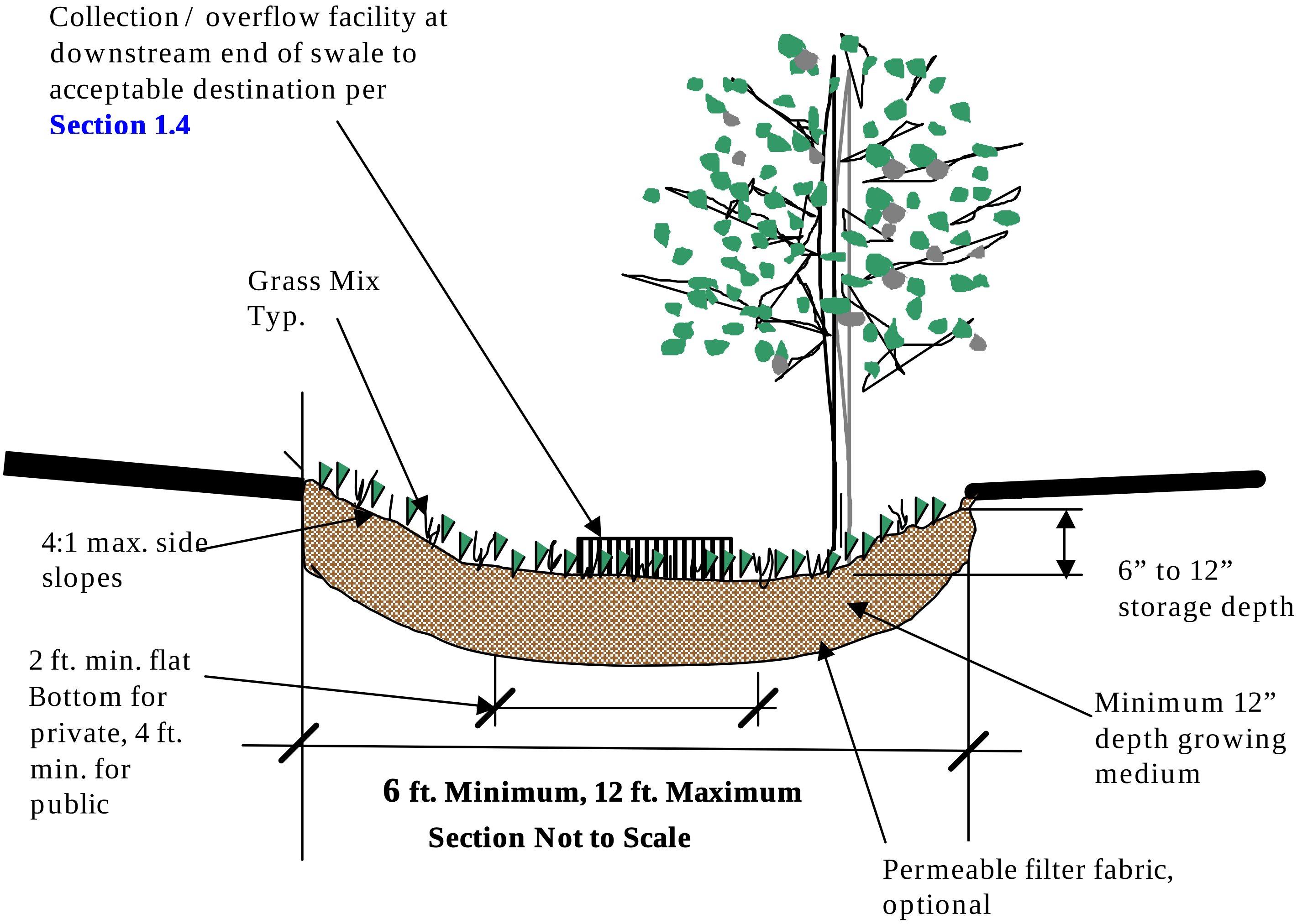
Vegetated Swale: Optional Detention/Flow-Through Facility

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Grassy Swale: Optional Detention/Flow-Through Facility



Stormwater Management Goals Achieved   Acceptable Sizing Methodologies

- ? Pollution Reduction…………………………….. SIM, PERF[1], PRES[2]
- ? Flow Control………………….……………… SIM
- ? Destination…………………………………… PRES[3]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Grassy swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **2)** For projects with more than 15,000 square-feet of impervious area to manage, the presumptive approach may be used to size the swale for pollution reduction, and additional facilities may be required to meet flow control requirements.

Grassy Swale: Optional Detention/Flow-Through Facility

Description: Grassy swales are long narrow grassy depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed for small projects (<15,000 square feet of impervious surface) with grassy swales. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance / destination method per **Section 1.4** will be required at the end of the swale.

Design Considerations: When designing grassy swales, slopes and depth should be kept as mild as possible to avoid safety risks and prevent erosion within the facility.

Construction Considerations: Grassy swale areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Grassy swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix G** to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 4 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Minimum length is 100 feet. Maximum longitudinal slope is 5%, while minimum slope is 0.5%. Maximum surrounding ground slopes shall be 10%.

Setbacks: Required setback from is 10 feet from building foundations unless lined with impermeable fabric.

Sizing: Grassy swales sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.1 may be used. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved destination point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, or there is more than 15,000 square feet of impervious area to manage, the Presumptive Approach must be used size the swale for pollution reduction, and additional facilities will be required to meet flow control requirements, where applicable.

Presumptive Approach Sizing Criteria:

1) The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity (0.22 inches / hour) at:

?? Maximum design depth of 0.33 feet.
?? Maximum design velocity of 0.9 feet per second.
?? Minimum hydraulic residence time (time for Q_{design} to pass through the swale) of 9 minutes.
?? Minimum longitudinal slope of 0.5 percent, maximum slope of 5 percent. For slopes greater than 2 percent, check dams shall be used (one 3 to 5-inch high dam every 12 feet).
?? Designed using a Manning "n" value of 0.25.
?? 4:1 (or flatter) side slopes in the treatment area.

A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute intensity = 3.5 inches per hour).

Velocity through the facility shall not exceed 3 feet per second (fps) during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

2) The swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than 6 feet, a flow spreader shall be installed at least every 50 feet.

3) To minimize flow channelization, the swale bottom shall be smooth, with uniform longitudinal slope, and with a minimum bottom width of 2 feet for private facilities and 4 feet for public facilities. Maximum bottom width shall be 8 feet.

4) Grasses or sod shall be established as soon as possible after the swale is completed, and before water is allowed to enter the facility.

5) Unless vegetation is established, biodegradable erosion control matting appropriate for low-velocity flows (approximately 1 foot per second) shall be installed in the flow area of the swale before allowing water to flow through the swale.

6) Access routes to the swale for maintenance purposes must be shown on the plans. Public swales will need to provide a minimum 10-foot wide access route, not to exceed 10 percent in slope.

Landscaping: Plantings shall be designed at the following quantities per **200** square feet of facility area. Facility area is equivalent to the area of the swale calculated from Form SIM. (Note: Facilities smaller than 200 square feet shall have a minimum of one tree per facility.):

1 Evergreen or Deciduous tree:

Evergreen trees:	Minimum height: 6 feet.
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.

Grass: Seed or sod is required to completely cover the grassy swale bottom and side slopes. (Shrubs are optional)

For the swale flow path, approved native grass mixes are preferable and may be substituted for standard swale seed mix. Seed shall be applied at the rates specified by the supplier. The applicant shall have plants established at the time of facility completion (at least 3 months after seeding). No runoff shall be allowed to flow in the swale until grass is established. Trees and shrubs may be allowed in the flow path within swales if the swale exceeds the minimum length and widths specified.

Native wildflowers, grasses, and ground covers used for City-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions will require City approval.

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification

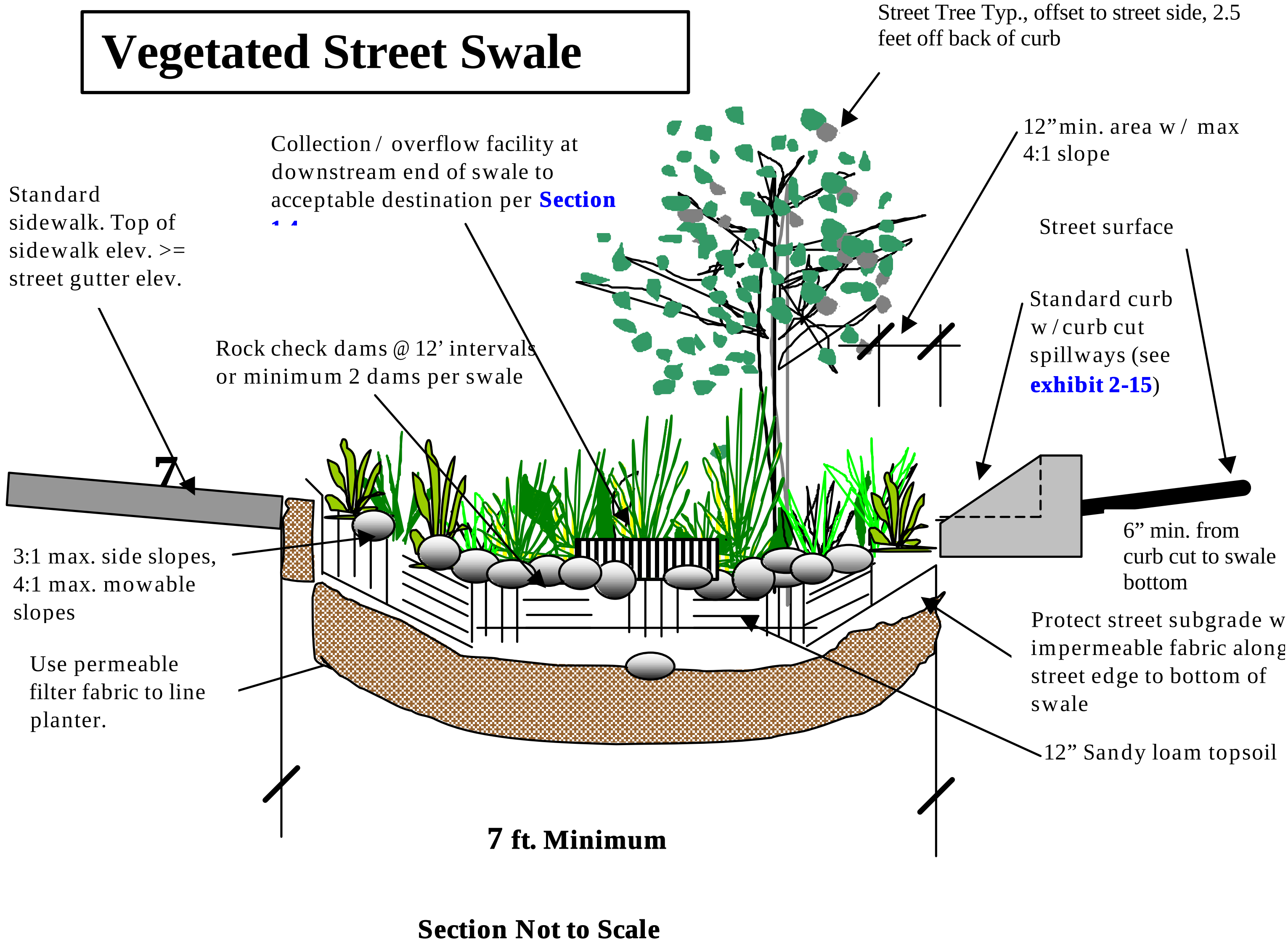
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings / seeding / sod	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Street Swales: Optional Detention/Flow-Through



Stormwater Management Goals Achieved Acceptable Sizing Methodologies

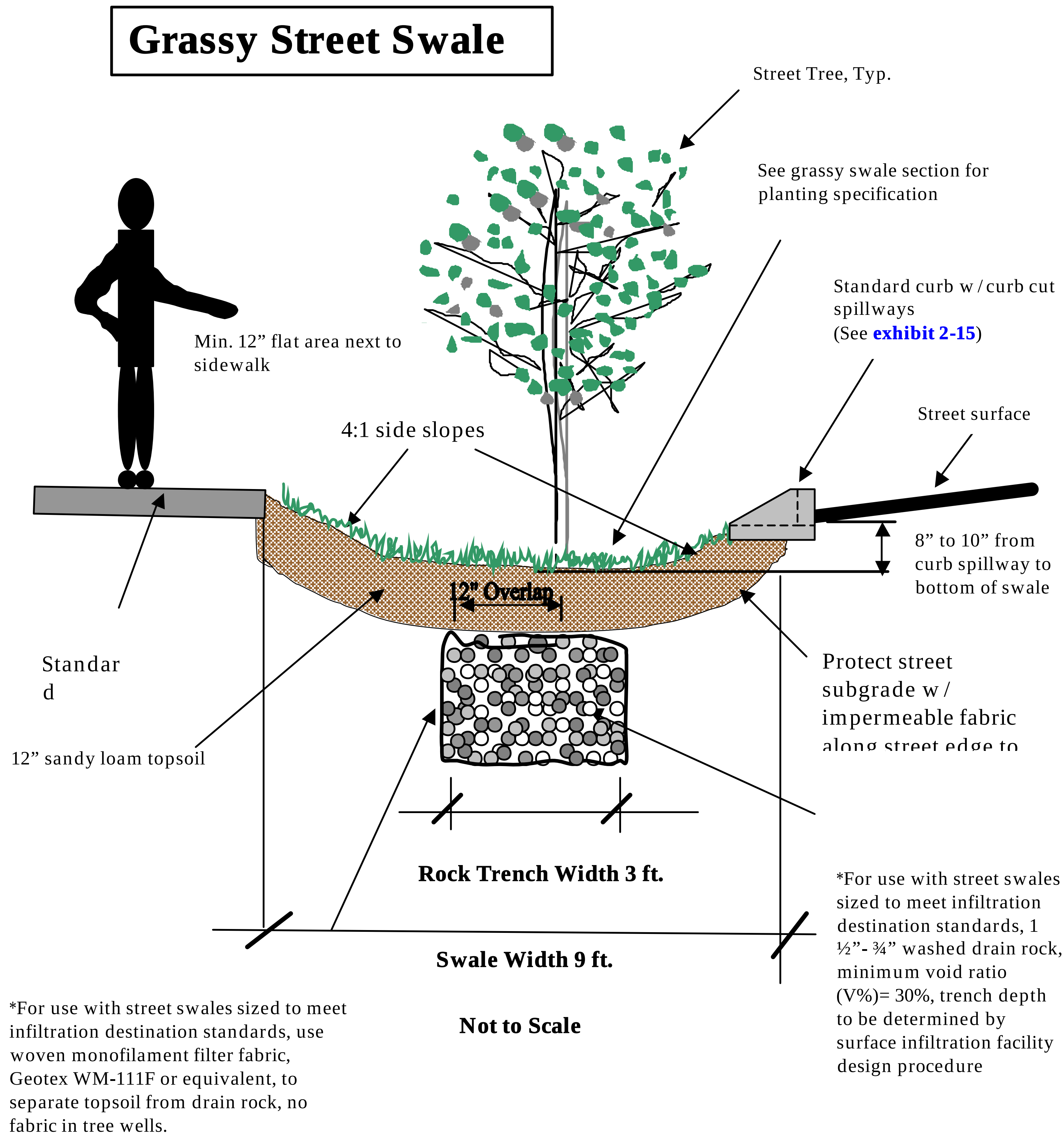
?	Pollution Reduction…………………………..	SIM, PERF[1], PRES[2]
?	Flow Control……………….…………………	SIM
?	Destination……………………………………	PRES[3]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Street swales can be used to manage runoff from parking lots, rooftops, and private streets. **2)** For projects with more than 15,000 square-feet of impervious area to manage, the presumptive approach may be used to size the swale for pollution reduction, and additional facilities may be required to meet flow control requirements

Street Swales: Optional Detention/Flow-Through



***Note:** Overflow to an approved destination point is required, unless swale is sized in accordance with **Surface Infiltration Facility** design procedure.

Street Swales: Optional Detention/Flow-Through

Description: Street construction poses particular challenges related to stormwater management design. Lack of available space is often the most difficult hurdle in locating stormwater pollution reduction and flow control facilities in or near allocated rights-of-way. Specific street swale designs that incorporate pollution reduction, flow control, and volume control into the cross-section of the street have been developed.

Street swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with street swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance/ destination method per **Section 1.4** will be required at the end of the swale, unless the swale is designed per the surface infiltration facility criteria presented in this chapter.

Design Considerations: When designing street swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility. All applicable City requirements for other street elements (curbs, sidewalks, trees, etc.) must be met.

Construction Considerations: Street swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Street swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical for vegetated swales, and 4 horizontal to 1 vertical for grassy swales (to accommodate for mowing). Minimum flat bottom width is 2 feet. Maximum longitudinal slope is 6% (temporary erosion control measures will be required on slopes greater than 2%, to stabilize soils until sufficient vegetative growth is established).

Setbacks: Required setback from building foundations is 10 feet unless lined with impermeable fabric.

Street Swales: Optional Detention/Flow-Through

Sizing: To meet pollution reduction and flow control requirements, the square-footage of street swales is to be determined using vegetated or grassy swale sizing criteria (shown on **Form SIM**), depending on which surface treatment is being used. The minimum width for street swales is 7 feet for vegetated, and 9 feet for grassy. Street swales sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.09 for vegetated swales and 0.10 for grassy swales may be used. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved destination point, per **Section 1.4**.

Presumptive Approach Sizing Criteria:

1) The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity (0.22 inches / hour) at:

   ?? Maximum design velocity of 0.9 feet per second.
   ?? Minimum hydraulic residence time (time for Q_{design} to pass through the swale) of 9 minutes.
   ?? Minimum longitudinal slope of 0.5 percent, maximum slope of 6 percent. For slopes greater than 2 percent, check dams shall be used (one dam every 12 feet).
   ?? Designed using a Manning "n" value of 0.25 for grassy swales and 0.35 for vegetated swales.

   A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute intensity = 3.5 inches per hour).

   Velocity through the facility shall not exceed 3 feet per second (fps) during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

2) The swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than 6 feet, a flow spreader shall be installed at least every 50 feet.

3) Minimize flow channelization, with uniform longitudinal slopes, and with a minimum bottom width of 2 feet for private facilities and 4 feet for public facilities. Maximum bottom width shall be 8 feet.

4) Vegetation shall be established as soon as possible after the swale is completed, and before water is allowed to enter the facility.

5) Unless vegetation is established, biodegradable erosion control matting appropriate for low-velocity flows (approximately 1 foot per second) shall be installed in the flow area of the swale before allowing water to flow through the swale.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrated them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 5 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The “facility area” is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Turf grass may be used to cover the entire swale surface area. If plantings are chosen to landscape the swale, the minimum plant material quantities per 100 square feet of facility area shall be as follows:

4 - Large shrubs / small trees:	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants:	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Ground covers used for City-maintained facilities shall be designed not to require mowing.

Street Swales: Optional Detention/Flow-Through

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All curb cut details and stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

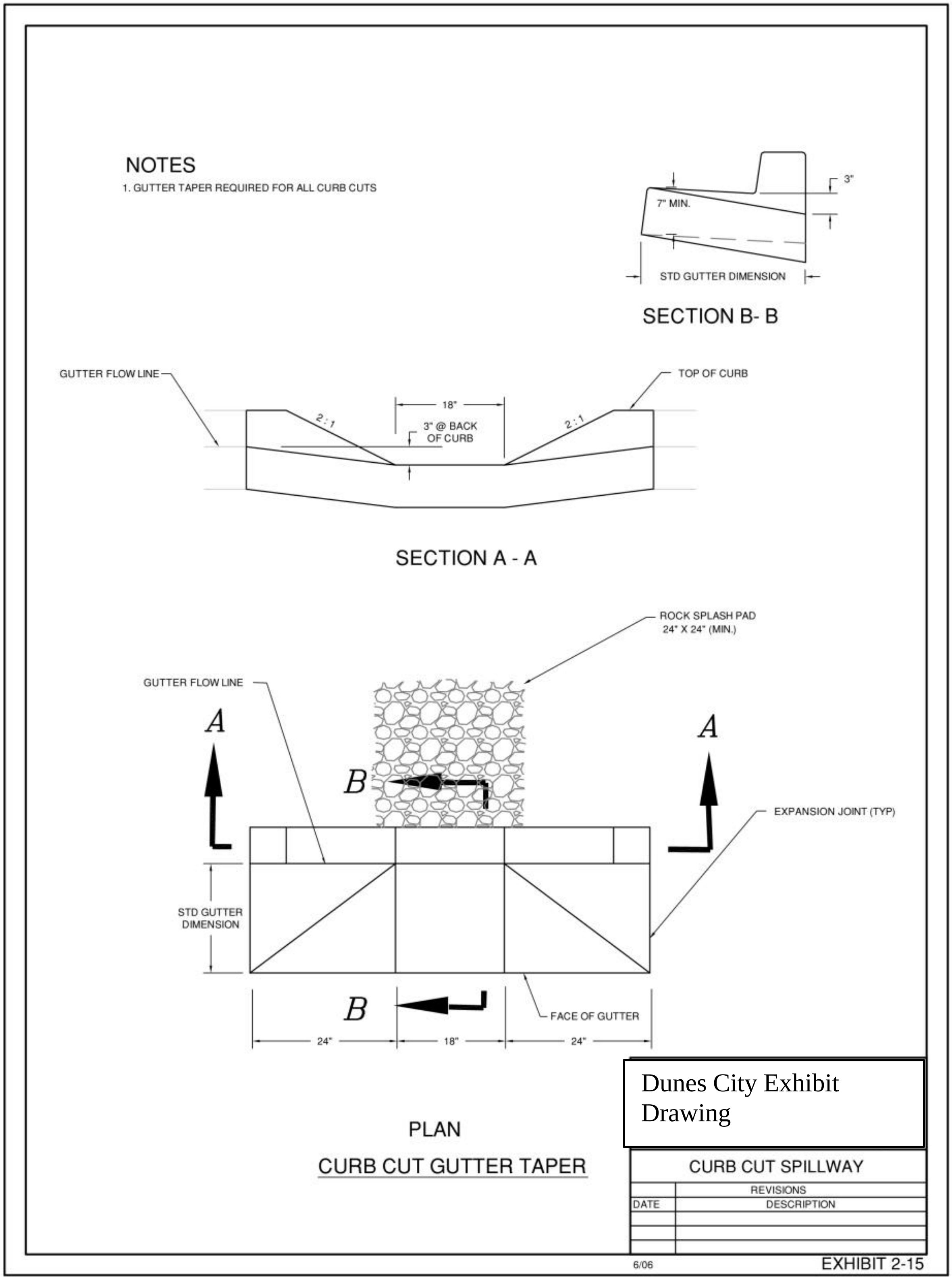
Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	
Curbs / curb cuts	Call for inspection
Piping (if applicable)	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

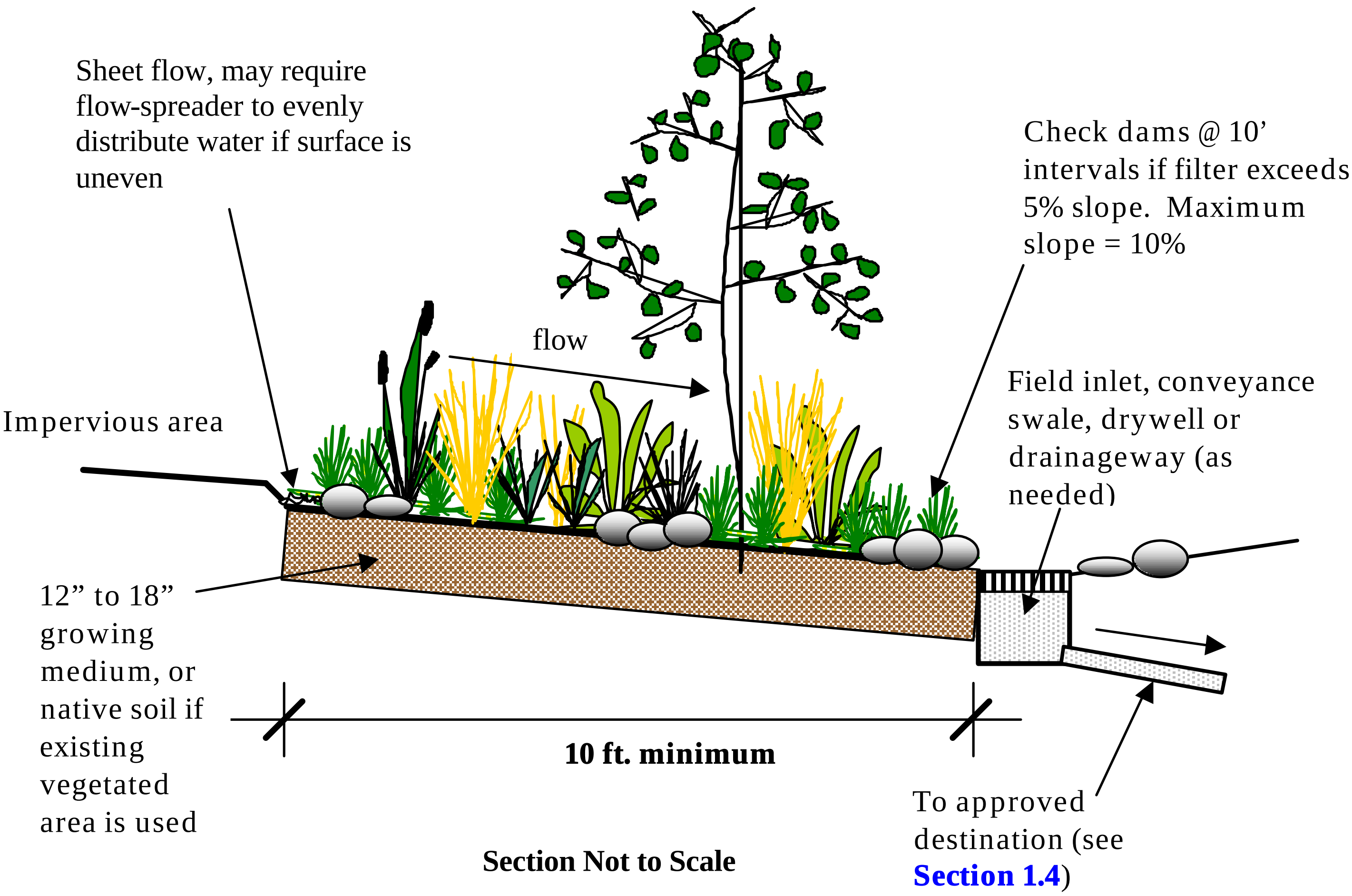
Operations and Maintenance requirements: See **Chapter 3.0**.

Street Swales: Optional Detention/Flow-Through

Exhibit 2-15: Curb Cut Spillway



Vegetated Filter Strip: Optional Detention/Flow-Through Facility



Section Not to Scale

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction…………………………..	SIM, PERF[1]
? Flow Control……………..………………….	SIM
? Destination[2]………...……………………….	SIM[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Note: The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Vegetated filters can be used to manage stormwater from rooftops, pathways, parking lots, and potentially streets (with flow spreaders or if the runoff is left as unconcentrated sheet flow).

Vegetated Filter Strip: Optional Detention/Flow-Through Facility

Description: Vegetated filter strips, or vegetated filters, are gently sloping areas used to filter, slow, and infiltrate stormwater flows. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Flow control is achieved using the relatively large surface area and for slopes greater than 5%, a generous proportion of check dams or terraces. Pollutants are removed through filtration and sedimentation. Filters can be planted with a variety of trees, shrubs, and ground covers, including grasses. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. There are an infinite number of ways to fit this concept into site designs and designers are encouraged to use the site landscape areas for this purpose. An approved conveyance/ destination method per **Section 1.4** will be required at the end of the filter.

Design Considerations: When designing vegetated filters, slopes should be kept as flat as possible to prevent erosion. Spreading the flow evenly across the filter is also important in ensuring that the facility functions correctly and avoids flow channeling.

Construction Considerations: Vegetated filter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of filter areas. Flow spreaders must be constructed perfectly level to distribute flows evenly across the filter, and for public facilities must be surveyed after construction.

Design Requirements:

Soil Suitability: Vegetated filters are appropriate for all soil types. Unless existing vegetated areas are used for the filter, topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix G** to support plant growth.

Dimensions and Slopes: Maximum allowable vegetated filter slopes are 10%. Terraces may be used to decrease ground slopes. Minimum slopes are 0.5%.

Setbacks: Required setback is 10 feet from structures unless lined with impermeable fabric.

Sizing: Unless used for very long, narrow projects such as pathways and trails, vegetated filters cannot be used to manage flow from more than 2,000 square-feet of impervious area. Filters shall be a minimum of 10 feet wide x 10 feet long. A Simplified Approach sizing factor of 0.2 may be used. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the filter to an approved destination point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the Performance Approach may be used in conjunction with a measured infiltration rate to downsize the Simplified Approach sizing factor.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete. Check dams shall be 12 inches in length, by the width of the filter, by 3 to 5 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. For other projects, minimum plant material quantities per **100** square feet of facility area are as follows. The "facility area" is equivalent to the area of the filter, as calculated from Form SIM.

1 - Evergreen or deciduous tree (planted around the perimeter of the swale):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs / small trees:	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants:	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for City-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions will require City approval.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification (if applicable)
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

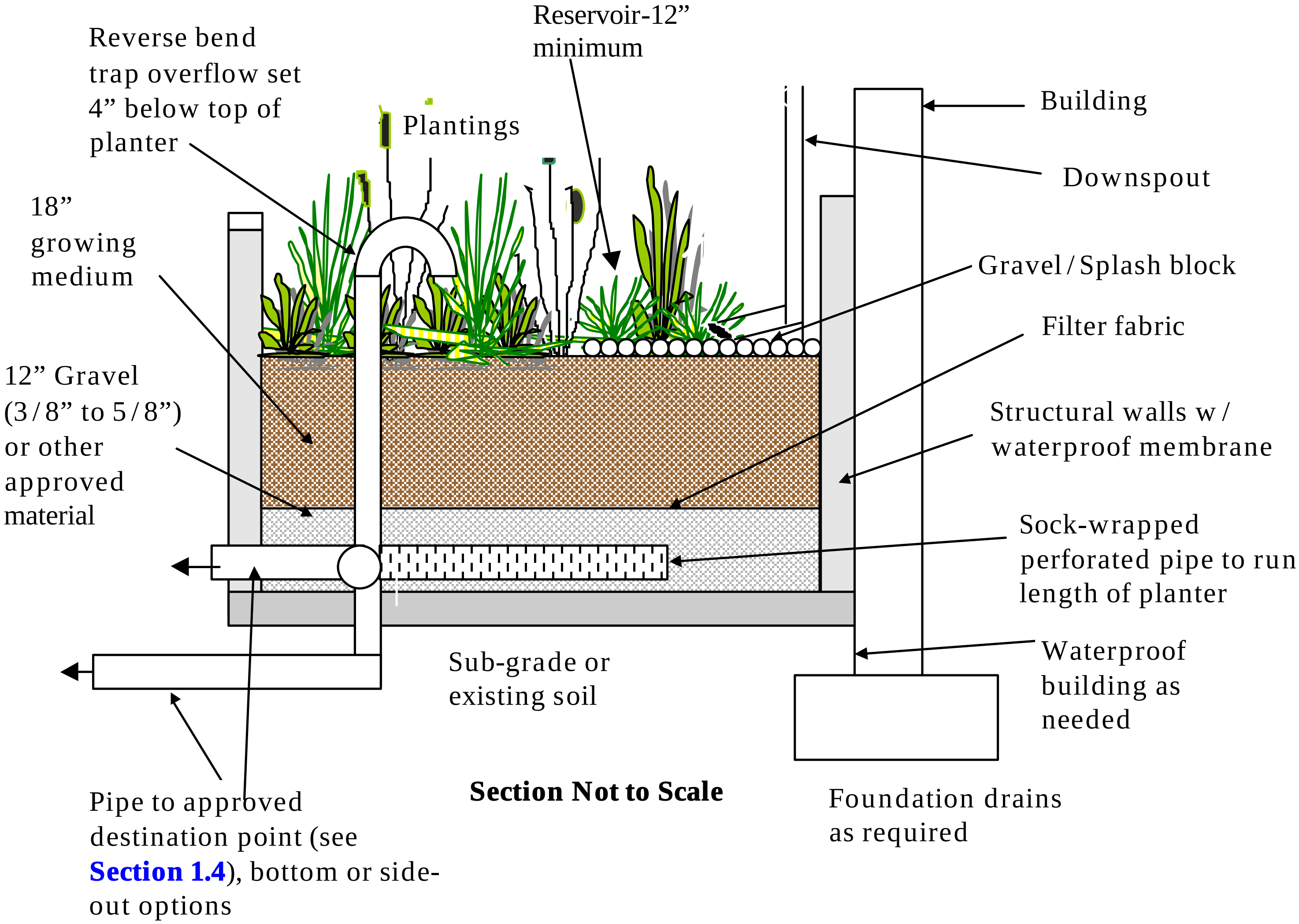
5) Landscaping plan
6) Flow spreader details and specifications
7) Check dam or terrace details and specifications

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Filter grading (if applicable)	
Flow spreaders/Terraces (if applicable)	
Piping (if applicable)	Call for inspection
Growing medium (if applicable)	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

Flow-Through Planter: Flow-Through Type Facility



Section Not to Scale

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction…………………………….	SIM, PERF[1]
? Flow Control……………………..………….	SIM
Destination…………………………………….	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Note: The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution reduction. Flow-through planters may be designed to manage runoff from rooftops, and if submerged into the ground, parking lots and streets in some cases.

Flow-Through Planter: Flow-Through Type Facility

Description: Flow-through planters are structural landscaped reservoirs used to collect and filter stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil. In addition to providing pollution reduction, flow rates and volumes can also be managed with flow-through planters. Planters should be integrated into the overall site design. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. Because they include a waterproof lining, flow-through planters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance/ destination method per **Section 1.4** will be required.

Design Considerations: When designing flow-through planters, the structural walls can often times be incorporated with building foundation plans.

Construction Considerations: Special attention needs to be paid to the planter waterproofing if constructed adjacent to building structures.

Design Requirements:

Soil Suitability: Flow-through planters are appropriate for all soil types. Topsoil shall be used within the top 18 inches of the facility.

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 18 inches. Planter slopes shall be less than 0.5%.

Setbacks: Not applicable.

Planter Walls: Planter walls shall be made of stone, concrete, brick, or wood. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Individual flow-through planters sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a Simplified Approach sizing factor of 0.06 may be used. A high-flow overflow must be provided to an approved destination point per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used to downsize the simplified approach sizing factor. Planters shall be designed to pond water for less than 12 hours after each storm event.

Flow-Through Planter: Flow-Through Type Facility

Landscaping: Plantings shall be designed at the following minimum quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

4 - Large shrubs / small trees	3-gallon containers or equivalent.
6 - Shrubs / large grass-like plants	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Note: Tree planting is not required in planters, but is encouraged where practical. Tree planting is also encouraged near planters.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification
5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Stormwater destination
9) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Planter grading / excavation	
Structural components / liner	
Piping	Call for inspection
Drain rock	
Filter fabric	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See Chapter 3.0.

Tree Credits: Impervious Surface Reduction Credit

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
? Impervious Area Reduction………………..	SIM
? Pollution Reduction……..…………………..	SIM
? Flow Control……………..……………………	SIM
Destination……………………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility intercepts rainfall and provides shade for impervious surfaces. Trees may only receive credit against the construction of ground-level impervious surfaces.

Description: Trees intercept precipitation and provide several stormwater management benefits:

?? Flow control: Trees hold water on the leaves and branches and allow it to evaporate, retaining flow and dissipating the energy of runoff. These functions are most measurable for storms of less than 0.5 inches over 24 hours. While deciduous trees are not as effective during winter months, evergreen trees are effective year round for these smaller storms and portions of larger storms. Generally, large trees with small leaves are the most efficient rainfall interceptors. Trees also facilitate stormwater infiltration and groundwater recharge.

?? Pollution reduction / stormwater cooling: Trees can provide shade over large areas of impervious surface. This provides two direct benefits. First, the hard surface is protected from direct solar exposure, which reduces heat gain. The less heat gain there is in pavement, the less heat is absorbed by stormwater as it flows over the surface. Second, by shading pavement, the trees help reduce or minimize air temperature increases caused by the hot pavement. Cooler air may help prevent stream temperature increases associated with air temperatures.

New trees planted within twenty-five feet of ground-level impervious surfaces are eligible for credit. One hundred square feet of credit is given for new deciduous trees, and two hundred square feet of credit is given for new evergreen trees. Credits also apply to existing trees kept on a site if the trees' canopies are within twenty-five feet of ground-level impervious surfaces. The credit is the square-footage equal to one-half of the existing tree canopy. No more than 10% can be mitigated through the use of trees. Trees used for credit shall be clearly labeled on permit drawings.

Tree Credits: Impervious Surface Reduction Credit

NEW EVERGREEN AND DECIDUOUS TREES:

Trees shall be maintained and protected on the site after construction and for the life of the development (50-100 years or until any approved redevelopment occurs in the future). During the life of the development, trees approved for credit shall not be removed without approval from the City. Trees that are removed or die shall be replaced within 6 months with like species.

The trees selected shall be suitable species for the site conditions and the design intent. Trees should be relatively self-sustaining and long-lived. Temporary irrigation shall be provided for native plantings. Long-term irrigation is not required. New deciduous trees must be at least 2 caliper inches and new evergreen trees must be at least 6 feet tall to receive simplified approach credit. Trees planted to meet stormwater facility planting requirements cannot also receive simplified approach credit.

Approved Trees see Comprehensive plan

EXISTING TREES:

Mature evergreen and deciduous trees can have significant benefits in addition to stormwater management. They already provide habitat for urban wildlife, energy and cost conservation, aesthetics, visual screens, heritage value, windbreaks, and recreation.

The credit applies to existing trees of 4-inch caliper or larger. Credit is based on one-half of the square footage of the tree canopy, measured within the drip-line.

Protection during construction shall be in the conformance with the City's tree preservation standards. The applicant will have to provide documentation required by the City to ensure the tree will remain healthy after construction and during the life of the project. During the life of the development, trees approved for credit shall not be removed without approval from the City.

Checklist of minimal information to be shown on the permit drawings:

1) Trees to be given credit shall be clearly labeled as such, with the size and species included.
2) Approximate setbacks from property lines and structures shall be shown.
3) Temporary irrigation measures shall be shown, if applicable.
4) Form SIM must be submitted, clearly showing that less than 10% of the impervious area is being mitigated with tree credits.

Operations and Maintenance requirements: See **Chapter 3.0**.

Manufactured Treatment Technology

Manufactured stormwater treatment technologies must be designed and constructed in accordance with the manufacturer's recommendations. Dunes City may also place special design conditions on the acceptance of the technology, such as sizing requirements that go beyond the manufacturer's recommendations, which must also be followed to obtain plan approval.

In addition to design calculations shown in the report requirements of **Exhibit 2-2**, the following must be submitted with each manufactured stormwater treatment technology project:

1) Pollution reduction capacity of the facility
2) Flow-through conveyance capacity (i.e., how much flow can be passed through the facility without stirring up and releasing trapped pollutants)

An operations and maintenance manual must also be submitted for City review. See **Chapter 3.0** for O&M plan guidance.

Manufactured stormwater treatment technologies for general use may not be capable of meeting specific TMDL requirements for certain watersheds. In that case, the treatment technology will not be accepted as a stand-alone pollution reduction facility. Rather, a pollution reduction facility that is presumed by DEQ to meet the TMDL requirement must be used.

Checklist of minimal information to be shown on the permit drawings:

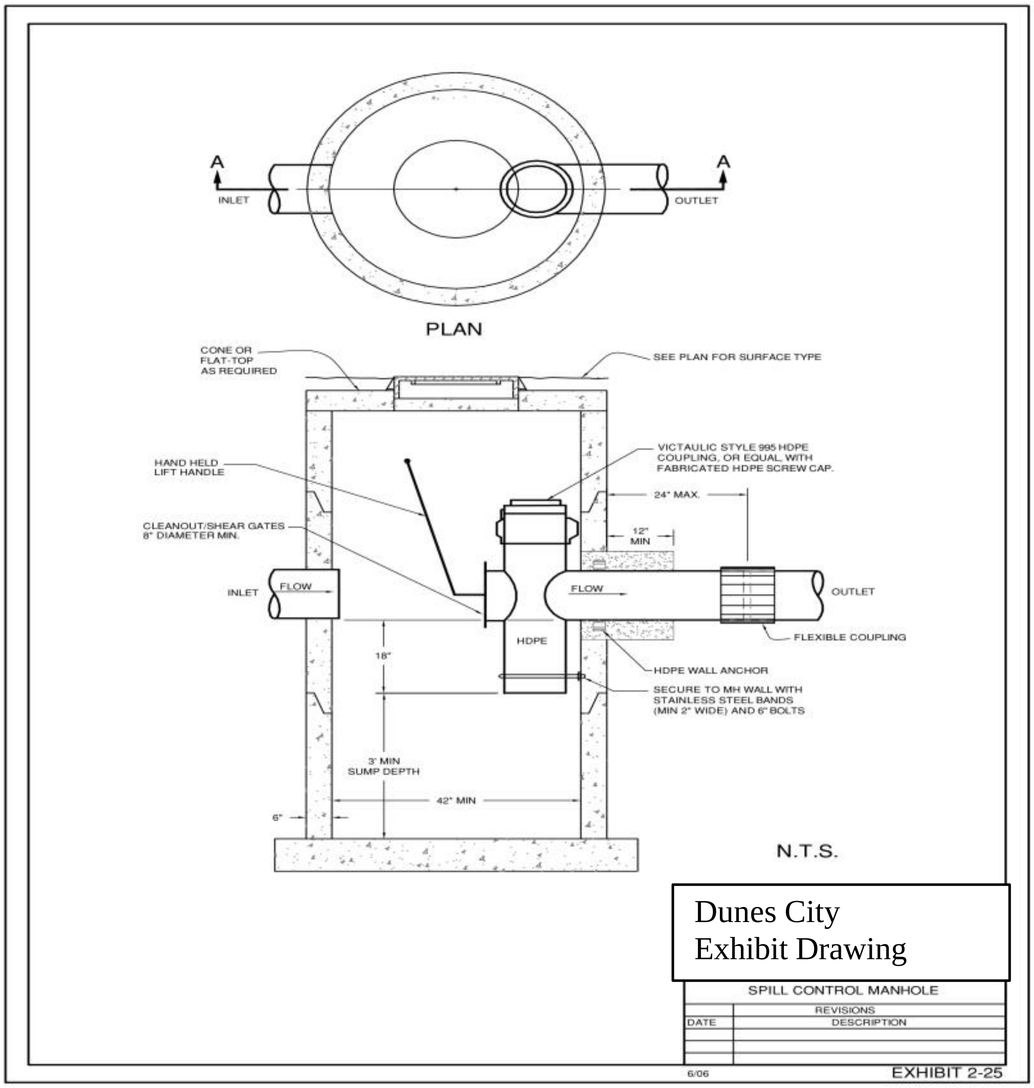
1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Vault excavation	
Piping	Call for inspection
Vault installation	Cal for inspection

Operations and Maintenance requirements: An operations and maintenance plan will be required, including information from the manufacturer, as per **Chapter 3.0**.

Spill Control Manhole



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
? Pollution Reduction[1] (Oil Only)……………..	PRES[1]
Flow Control………………..………………….	NA
Destination…………………………………….	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Description: Spill control manholes rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. They consist of a simple underground manhole with a "T" outlet designed to trap small spills. Spill control manholes must be used in conjunction with other pollution reduction systems from this chapter to meet oil control and pollution reduction requirements.

Other Options: There may be other acceptable oil controls not listed above. Applicants may propose an alternative oil control option under the performance approach. However, proposal of a new oil control will require an additional review process for approval, which may delay issuance of related building permits.

Design and Sizing Criteria:

?? Spill control manholes shall be used in conjunction with an appropriately sized pollution reduction facility. The spill control sump volume shall be 60 cubic feet *or* 20 cubic feet of sump capacity for each cubic feet per second (cfs) of peak pollution reduction design flow, whichever is greater.

?? To maintain efficiencies and reduce size, all roof drainage shall enter the stormwater system downstream of the spill control manhole, unless sized accordingly.

?? Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification in stormwater.

?? Engineered calculations are required, using the Rational Method (Q=C*I*A).

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Checklist of minimal information to be shown on the permit drawings:

1) Facility dimensions and location.
2) Profile view of facility, including typical cross-section details with dimensions. These details shall match manufacturer specifications and details.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested.

Facility Component	Inspection Requirement
Manhole excavation	
Piping	Call for inspection

Chapter 3.0
OPERATIONS & MAINTENANCE

Summary of Chapter 3.0

This chapter presents operation and maintenance (O&M) requirements for the stormwater management facilities in this manual. It includes:

To Use This Chapter:

1) After using **Chapters 1.0** and **2.0** to complete a stormwater management design for the project, fill out **Form O&M**.
2) Form O&M includes a blank section to insert a **site plan**, or attach a separate site plan sheet showing the location of the stormwater management facilities on the site, sources of stormwater runoff, and ultimate stormwater destination
3) Submit a copy of these sheets, along with the **facility-specific O&M plan** for each stormwater management facility used on-site, with the permit application. The O&M activities listed on the facility-specific O&M forms, which will be on file with the City, may later be revised with City approval
4) For **public** facilities, a copy of an O&M plan shall be submitted to the city.

3.1 INTRODUCTION O & M

This chapter provides a **facility-specific O&M plan** that identifies the O&M requirements for each type of facility included in this manual. If a stormwater facility that is not included in this manual is used (such as a manufactured stormwater treatment technology) an O&M plan prepared by the proprietor, and facility-specific O&M activities that comply with the requirements of this chapter must still be submitted.

?? The operations and maintenance (O& M) strategies in this chapter apply to all stormwater management facilities and related facility components identified in **Chapter 2.0**.

3.2 O&M APPLICATION SUBMITTALS

3.2.1 Privately Maintained Facilities

Form O&M: Operations & Maintenance Plan. The completed form must identify the owner's name, address, and phone number, the site address, financial method used to cover future operation and maintenance, and parties responsible for inspecting and maintaining the facility. It also provides a space to insert a site plan to identify the location of the facility on the site, sources of runoff entering the facility, and ultimate stormwater destination. This form must be included with every private stormwater management facility permit application, and must be recorded with the applicable county before permit issuance.

Facility-specific O&M plans (see page 3-14 through 3-41) The plans identify the specific O&M activities that are required for each type of stormwater management facility. The appropriate plans must be attached to **Form O&M** and submitted as part of the stormwater management facility permit application. The facility-specific O&M plans do not have to be recorded with the county. This allows the future stormwater management facility owner to submit O&M activity revisions, to the City, without the need to re-record the O&M plan with the county.

The facility-specific O&M activities for private facilities may be modified any time after permit issuance. Modifying the O & M activities is optional, and is intended to give the owner an opportunity to adjust maintenance needs according to site-specific history and conditions. Proposed modifications to the O&M plan must be submitted to the City for review and approval.

3.2.2 City-Maintained Facilities

A stormwater management facility that receives stormwater runoff from a public right-of-way shall become a public (City-maintained) facility. Facilities that will become City-maintained shall be constructed in compliance with City Code.

A preliminary O&M plan shall be submitted as part of the applicant's permit application package. **Form O&M** and **facility-specific O&M plans** may be used to serve as the O&M plan. In addition, the applicant shall demonstrate on the construction plans that the City can achieve the specified O&M activities. Construction of maintenance access roads shall be part of the construction plans and the dedication of public access easements must be affirmed before the construction permit is issued.

The applicant is responsible for maintaining all site stormwater management features, including their associated vegetative components, during a two-year maintenance warranty period. The applicant shall demonstrate vegetation cover planted, after the initial planting, has one full growth establishment season during the maintenance warranty period or the maintenance warranty period will be extended for one year.

At the end of this period a modified O&M plan for all site features, based on experience with the site over the two years, shall be filed with the City. Final facility sign-off will not be given until the modified O&M plan has been submitted.

3.3 O&M PLAN ENFORCEMENT

Stormwater management facilities, constructed to comply with the requirements of this manual, must be properly operated and maintained for the life of the facility. The facility owner is responsible for all aspects of facility maintenance unless otherwise agreed.

City staff has the right and responsibility to inspect private facilities to assure they are being properly operated and maintained. It is the intent of the City to use education and technical assistance to ensure the proper O&M of private facilities.

FORM O&M: OPERATIONS & MAINTENANCE PLAN INSTRUCTIONS
The following are instructions to prepare and file Form O&M: Operations & Maintenance Plan for a stormwater management facility. Failure to properly operate or maintain the water quality or quantity control facility according to the operation and maintenance plan may result in a civil penalty. A copy of the operation and maintenance plan shall be filed with Dunes City

FORM O&M: OPERATIONS & MAINTENANCE PLAN

INSTRUCTIONS

Fill out Form O&M

Project building application number: City staff will insert this number.

Owner: Print the name of the property owner.

Phone no.: Print the area code and 7-digit phone number of the property owner.

Mailing address: Print the property owner's mailing address, including zip code. After the plan is recorded with the county recorder's office, a copy of the recorded O&M Plan will be mailed to this address. The City will also use this address if further correspondence is required.

Site address: Print the address of the property where the stormwater management facility is located.

Site legal description: Print the property's legal description. Property legal descriptions may be obtained from the county assessor's office.

Signature: Sign the O&M plan form under "filer."

Site plan: **I**nclude a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), the sources of runoff entering the stormwater facility, where stormwater will be discharged to after leaving the facility, and the maintenance access location. The site plan can be inserted on Form O&M or included as a separate sheet.

Description of the financial method used to cover future operations and maintenance:
Check the appropriate box.

Party (ies) responsible for maintenance:
Provide the name, address, and phone number (both daytime and after-hours numbers) for the person or company who shall be responsible for maintaining or directly supervising the maintenance of the stormwater facilities described in the O&M Plan.

Maintenance practices and schedule for the stormwater management facility:
Provide the date the O&M Plan was prepared, the date the plan was revised (if applicable), and the month and year of the stormwater management facility installation. Provide the name, firm (if applicable), and address of the person who prepared the O&M Plan.

FORM O&M: OPERATIONS & MAINTENANCE PLAN

REQUIRED IN ACCORDANCE WITH CITY CODE

Project Building Application No.	*For official use only*
Owner's Name	
Phone No. (area code required) **(_______) _______ -**	
Mailing Address (RETURN ADDRESS FOR RECORDER**)**	
Site Address	
Site Legal Description	

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

____

Filer Signature

O&M PLAN REQUIRED INFORMATION:

1) Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility. **The stormwater management facility located on this site plan is a required condition of building permit approval for the identified property. The owner of the identified property is required to operate and maintain this facility in accordance with the O&M plan on file with the City. The requirement to operate and maintain this facility in accordance with the on-file O&M plan is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the City. The O&M plan for this facility is available at City Hall**	**Site Plan (insert here or include separate sheet):**

2) Description of the financial method used to cover future operations and maintenance. ***Check One:***

✍ Homeowner Association ✍ Property Owner Account ✍ Other (d*escribe)*____

3) Party (ies) responsible for maintenance (only if other than owner).

Daytime Phone No. (area code required)(_____) ______ -	Emergency / After-Hours Contact Phone No. (_____) _____ -
Maintenance Contact & Address	

4) Maintenance practices and schedule for the stormwater facility is included in the facility-specific O&M plan filed with Dunes City. The operation and maintenance practices are based on the publication date of the Dunes City's Stormwater Management Manual.

Preparation Date _______________	Revision Date _______________	Estimated Date of Installation _______________

Prepared By_______________________________________ Date ________

FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)

REQUIRED IN ACCORDANCE WITH CITY CODE

Project Building Application No.

For official use only

Owner's Name John Doe

Phone No. (area code required) (_541_) _555_ - _5555__

Mailing Address (RETURN ADDRESS FOR RECORDER)
XXX NW XXX Street, XXXXX, OR XXXXX

Site Address
XXX NW XXX Street, XXXXX, OR XXXXX

Site Legal Description
Section XX, Township XX, Range XX, Tax Lot XX

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

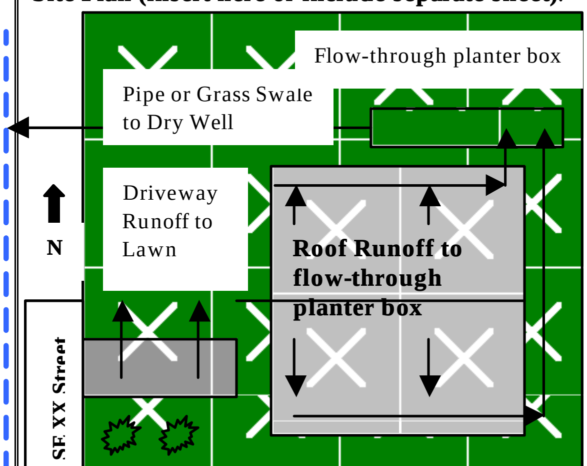
John Doe
Filer Signature

O&M PLAN REQUIRED INFORMATION:

1) **Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility.**

The stormwater management facility located on this site plan is a required condition of building permit approval for the identified property. The owner of the identified property is required to operate and maintain this facility in accordance with the O&M plan on file with the City. The requirement to operate and maintain this facility in accordance with the on-file O&M plan is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the City. The O&M plan for this facility is available at City Hall.

Site Plan (insert here or include separate sheet):



2) **Description of the financial method used to cover future operations and maintenance.** ***Check One:***

✍ Homeowner Association X Property Owner Account ✍ Other *(describe)*________________________

3) **Party (ies) responsible for maintenance (only if other than owner).** Owner Responsible

Daytime Phone No. (area code required) (541) xxx--xxxx | Emergency / After-Hours Contact Phone No. (541) xxx-xxxx

Maintenance Contact & Address Garden Guy Landscaping XXX NE XX Street XXXXXX, OR 97XXX

4) **Maintenance practices and schedule for the stormwater facility is included in the facility-specific O&M plan filed with Dunes City. The operation and maintenance practices are based on the publication date of the Dunes City's Stormwater Management Manual.**

Preparation Date _____xx-xx-xx______ | Revision Date _____xx-xx-xx______ | Estimated Date of Installation ___xx-xx-xx______

Prepared By John Doe________________________________ Date______________

FACILITY-SPECIFIC OPERATIONS AND MAINTENANCE PLANS

FACILITY PAGE

Pervious Pavement **Operations & Maintenance Plan**
Pervious pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil or being collected in underlying drain pipes and being discharged off-site. There are many types of pervious pavement including plastic rings planted with grass, stone or concrete blocks with pore spaces backfilled with gravel or sand, porous asphalt, and porous concrete. Pervious pavement accepts only precipitation, not stormwater runoff. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:
Surface: In most pervious pavement design, the pavement itself acts as pretreatment to the stone reservoir below. The surface shall be kept clean and free of leaves, debris, and sediment. The surface shall not be overlaid with an impermeable paving surface.
Overflows or Emergency Spillways are used in the event that the facility's infiltration capacity is exceeded. Overflow devices shall be inspected for obstructions or debris, which shall be removed upon discovery Overflow or emergency spillways shall be capable of transporting high flows of stormwater to an approved stormwater receiving system.
Vegetation (where applicable) shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Vegetation, such as trees and shrubs, should not be located in or around the pervious pavement because roots from trees can penetrate the pavement, and leaves from deciduous trees and shrubs can increase the risk of clogging the surface.
Source Control measures prevent pollutants from mixing with stormwater. Typical non-structural control measures include raking and removing leaves, street sweeping, vacuum sweeping, limited and controlled application of pesticides and fertilizers, and other good house keeping practices.
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater. A spill prevention plan shall be implemented at all non-residential sites and in areas where there is likelihood of spills from hazardous materials. However, virtually all sites, including residential and commercial, present potential danger from spills. All homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, solvents, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles. Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Vegetated, Grassy, and Street Swales
Operations & Maintenance Plan

Swales are planted or grassed open channels that trap pollutants by filtering and slowing flows, allowing particles to settle out. The swale should drain within 48 hours of a storm event. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Swale Inlet (such as curb cuts or pipes) shall maintain a calm flow of water entering the swale.

?? Source of erosion shall be identified and controlled when native soil is exposed or erosion channels are forming.
?? Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4" thick or so thick as to damage or kill vegetation.
?? Inlet shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
?? Rock splash pads shall be replenished to prevent erosion.

Side Slopes shall be maintained to prevent erosion that introduces sediment into the swale.

?? Slopes shall be stabilized and planted using appropriate erosion control measures when native soil is exposed or erosion channels are forming.

Swale Media shall allow stormwater to percolate uniformly through the landscape swale. If the swale does not drain within 48 hours, it shall be tilled and replanted according to design specifications.

?? Annual or semi-annual tilling shall be implemented if compaction or clogging continues.
?? Debris in quantities that inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.

Swale Outlet shall maintain sheet flow of water exiting swale unless a collection drain is used. Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming.

?? Outlets such as drains and overland flow paths shall be cleared when 50% of the conveyance capacity is plugged.
?? Sources of sediment and debris shall be identified and corrected.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Mulch shall be replenished as needed to ensure survival of vegetation.

?? Vegetation, large shrubs or trees that interfere with landscape swale operation shall be pruned.
?? Fallen leaves and debris from deciduous plant foliage shall be removed.
?? Grassy swales shall be mowed to keep grass 4” to 9” in height. Clippings shall be removed to remove pollutants absorbed in grasses.
?? Nuisance vegetation such as blackberries, scotch broom and English Ivy shall be removed when discovered.
?? Dead vegetation and woody material shall be removed to maintain less than 10% of area coverage or when swale function is impaired. Vegetation shall be replaced within four months.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles.

?? Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

If used at this site, the following will be applicable:

Check Dams shall control and distribute flow.

?? Causes for altered water flow shall be identified, and obstructions cleared upon discovery.
?? Causes for channelization shall be identified and repaired.

Vegetated Filter Strips

Operations & Maintenance Plan

Vegetated filter strips are gently sloped vegetated areas that stormwater runoff is directed to flow and filter through. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Flow control is achieved using the relatively large surface area and check dams. Pollutants are removed through infiltration and sedimentation. The vegetative filter should drain within 48 hours of storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Flow Spreader shall allow runoff to enter the vegetative filter as predominantly sheet flow.

- ?? Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming.
- ?? Sediment build-up near or exceeding 2" in depth shall be removed.

Filter Inlet shall assure unrestricted stormwater flow to the vegetative filter.

- ?? Sources of erosion shall be identified and controlled when native soil is exposed or erosion channels are present.
- ?? Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- ?? Inlet shall be cleared when conveyance capacity is plugged.
- ?? Rock splash pads shall be replenished to prevent erosion.

Filter Media shall allow stormwater to percolate uniformly through the vegetative filter.

- ?? If the vegetative filter does not drain within 48 hours, it shall be regraded and replanted according to design specifications. Established trees shall not be removed or harmed in this process.
- ?? Debris in quantities more than 2" deep or sufficient to inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.

Check Dams shall direct and control flow.

- ?? Causes for altered water flow and channelization shall be identified, and obstructions cleared upon discovery.
- ?? Cracks, rot, and structural damage shall be repaired.

Filter Outlet shall allow water to exit the vegetative filter as sheet flow, unless a collection drainpipe is used.

- ?? Sources of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are deeper than 2 inches.
- ?? Outlet shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- ?? Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- ?? Nuisance vegetation such as blackberries, scotch broom and English Ivy shall be removed when discovered.
- ?? Dead vegetation shall be removed to maintain less than 10% of area coverage or when vegetative filter function is impaired. Vegetation shall be replaced within four months.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Access: Egress and ingress routes shall be maintained to design standards.
Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Infiltration and Flow-Through Planters

Operations & Maintenance Plan

Planters are designed to allow runoff to filter through layers of topsoil (thus capturing pollutants) and then either infiltrate into the native soils (infiltration planter) or be collected in a pipe to be discharged off-site (flow-through planter). The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil. The flow-through planter is designed with an impervious bottom or is placed on an impervious surface. Water should drain through the planter within 3-4 hours after a storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Downspout from rooftop or sheet flow from paving allows unimpeded stormwater flow to the planter.

- Debris shall be removed routinely (e.g., no less than every 6 months) and upon discovery.
- Damaged pipe shall be repaired upon discovery.

Splash Blocks prevent splashing against adjacent structures and convey water without disrupting media.

- Any deficiencies in structure such as cracking, rotting, and failure shall be repaired.

Planter Reservoir receives and detains storm water prior to infiltration. Water should drain from reservoir within 3-4 hours of storm event.

- Sources of clogging shall be identified and corrected.
- Topsoil may need to be amended with sand or replaced all together.

Filter Media consisting of sand, gravel, and topsoil shall allow stormwater to percolate uniformly through the planter. The planter shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates.

- Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged.
- Sediment accumulation shall be hand removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Litter and debris shall be removed routinely (e.g., no less than quarterly) and upon discovery.

Planter shall contain filter media and vegetation.

- Structural deficiencies in the planter including rot, cracks, and failure shall be repaired.

Overflow Pipe safely conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow pipe shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged.
- Damaged pipe shall be repaired or replaced upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- Mulch shall be replenished at least annually.
- Vegetation, large shrubs or trees that limit access or interfere with planter operation shall be pruned or removed.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance vegetation shall be removed when discovered.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within a specific timeframe, e.g., 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles.

- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Vegetated Infiltration Basins

Operations & Maintenance Plan

A **vegetated Infiltration Basin** is a vegetated depression created by excavation, berms, or small dams to provide for short-term ponding of surface water until it percolates into the soil. The basin shall infiltrate stormwater within 24 hours. All facility components and vegetation shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Basin Inlet shall assure unrestricted stormwater flow to the vegetated basin.

?? Sources of erosion shall be identified and controlled when native soil is exposed or erosion channels are present.
?? Inlet shall be cleared when conveyance capacity is plugged.
?? Rock splash pads shall be replenished to prevent erosion.

Embankment, Dikes, Berms & Side Slopes retain water in the infiltration basin.

?? Structural deficiencies shall be corrected upon discovery:
?? Slopes shall be stabilized using appropriate erosion control measures when soil is exposed/ flow channels are forming.
?? Sources of erosion damage shall be identified and controlled.

Overflow or Emergency Spillway conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

?? Overflow shall be cleared when 25% of the conveyance capacity is plugged.
?? Sources of erosion damage shall be identified and controlled when soil is exposed.
?? Rocks or other armament shall be replaced when only one layer of rock exists.

Filter Media shall allow stormwater to percolate uniformly through the infiltration basin. If water remains 36-48 hours after storm, sources of possible clogging shall be identified and corrected.

?? Basin shall be raked and, if necessary, soil shall be excavated, and cleaned or replaced.

Sediment/ Debris Management shall prevent loss of infiltration basin volume caused by sedimentation. Gauges located at the opposite ends of the basin shall be maintained to monitor sedimentation.

?? Sediment and debris exceeding 4” in depth shall be removed every 2-5 years or sooner if performance is affected.
?? Restricted sources of sediment and debris, such as discarded lawn clippings, shall be identified and prevented.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

?? Mulch shall be replenished as needed to ensure healthy plant growth.
?? Vegetation, large shrubs or trees that limit access or interfere with basin operation shall be pruned or removed.
?? Grass shall be mowed to 4”-9” high and grass clippings shall be removed no less than 2 times per year.
?? Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
?? Nuisance vegetation such as blackberries, scotch broom or English Ivy shall be removed when discovered.
?? Dead vegetation shall be removed to maintain less than 10% of area coverage or when infiltration basin function is impaired. Vegetation shall be replaced within four months.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles.

?? Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

If used at this site, the following will be applicable:

Fences shall be maintained to preserve their functionality and appearance.

?? Collapsed fences shall be restored to an upright position.
?? Jagged edges and damaged fences shall be repaired or replaced.

Sand Filters

Operations & Maintenance Plan

Sand filters consist of a layer of sand in a structural box used to trap pollutants. The water filters through the sand and then flows into the surrounding soils or an underdrain system that conveys the filtered stormwater to a discharge point. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Filter Inlet shall allow water to uniformly enter the sand filter as calm flow, in a manner that prevents erosion.

- Inlet shall be cleared of sediment and debris when 40% of the conveyance capacity is plugged.
- Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming.
- Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Rock splash pads shall be replenished to prevent erosion.

Reservoir receives and detains stormwater prior to infiltration. If water does not drain within 2-3 hours of storm event, sources of clogging shall be identified and correction action taken.

- Debris in quantities more than 1 cu ft or sufficient to inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.
- Structural deficiencies in the sand filter box including rot, cracks, and failure shall be repaired upon discovery.

Filter Media shall allow to stormwater to percolate uniformly through the sand filter. If water remains 36-48 hours after storm, sources of possible clogging shall be identified and corrected.

- Sand filter shall be raked and if necessary, the sand/gravel shall be excavated, and cleaned or replaced.
- Sources of restricted sediment or debris (such as discarded lawn clippings) shall be identified and prevented.
- Debris in quantities sufficient to inhibit operation shall be removed no less than quarterly, or upon discovery.
- Holes that are not consistent with the design structure and allow water to flow directly through the sand filter to the ground shall be filled.

Underdrain Piping (where applicable) shall provide drainage from the sand filter, and **Cleanouts** (where applicable) located on laterals and manifolds shall be free of obstruction, and accessible from the surface.

- Underdrain piping shall be cleared of sediment and debris when conveyance capacity is plugged. Cleanouts may have been constructed for this purpose.
- Obstructions shall be removed from cleanouts without disturbing the filter media.

Overflow or Emergency Spillway conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow spillway shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged.
- Source of erosion damage shall be identified and controlled when erosion channels are forming.
- Rocks or other armament shall be replaced when sand is exposed and eroding from wind or rain.

Vegetation

- Vegetation, large shrubs or trees that limit access or interfere with sand filter operation shall be pruned.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance vegetation such as blackberries, scotch broom or English Ivy shall be removed when discovered.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles.

- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Soakage Trenches

Operations & Maintenance Plan

Soakage Trenches consist of drain rock and sand, and receive stormwater from roof downspouts and/or area drains. There are various components within the system – piping, silt basin and the trench itself. The **Conveyance Piping** consists of an inlet pipe (downspout or area drain), an outlet pipe located between the silt basin and the soakage trench, and a perforated pipe, located on top of the aggregate bed of the soakage trench. The **Silt Basin** is a structure receiving runoff from an inlet pipe and conveying it to the soakage trench. The silt basin serves as the pre-treatment system for the soakage trench, removing sediments and other debris that can impact its proper functioning. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, then two times per year afterwards, or within 48 hours after each major storm. The following items shall be inspected and maintained as stated:

Soakage trench infiltration: If water is noticed on top of the trench within 48 hours of a major storm, the soakage trench may be clogged.

- Check for debris/sediment accumulation, rake and remove and evaluate upland causes (erosion, surface or roof debris, etc
- Assess the condition of the aggregate and the filter fabric in the trench. If there is sediment in the aggregate, excavate and replace.
- If there is a tear in the filter fabric, repair or replace.

Conveyance Piping: If water ponds over the trench for more than 48 hours after a major storm and no other cause if identified, it may be necessary to remove the filter fabric to determine if the perforated pipe is clogged with sediment or debris.

- Any debris or algae growth located on top of the soakage trench should be removed and disposed of properly.
- If the piping has settled more than 1-inch, add fill material. If there are cracks or releases, replace or repair the pipe. If there are signs of erosion around the pipe, this may be an indication of water seeping due to a crack or break.

Silt Basin: If water remains in the soakage trench for 36-48 hours after storm, check for sediment accumulation in the silt basin

- If less than 50% capacity remains in the basin or 6" of sediment has accumulated, remove and dispose the sediment.

Spill Prevention: Virtually all sites, including residential and commercial, present dangers from spills. All homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect groundwater if spilled. It is important to exercise caution when handling substances that can contaminate stormwater.

- Activities that pose the chance of hazardous material spills shall not take place near soakage trenches.

A **Shut-Off Valve or Flow-Blocking Mechanism** may have been required with the construction of the soakage trench to temporarily prevent stormwater from flowing into it, in the event of an accidental toxic material spill. This may also involve mats kept on-site that can be used to cover inlet drains in parking lots. The shut-off valve shall remain in good working order, or if mats or other flow-blocking mechanisms are used, they shall be kept in stock on-site.

Access: Egress and ingress routes will be maintained to design standards at inspection.

Wet, Extended Wet Detention, and Dry Detention Ponds **Operations & Maintenance Plan**
Wet Ponds are constructed ponds with a permanent pool of water. Pollutants are removed from stormwater through gravitational settling and biologic processes. **Extended Wet Ponds** are constructed ponds with a permanent pool of water and open storage space above for short-term detention of large storm events. Pollutants are removed from stormwater through gravitational settling and biologic processes. **Dry Detention Ponds** are constructed ponds with temporary storage for the detention of large storm events. The stormwater is stored and released slowly over a matter of hours. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:
Pond Inlet shall assure unrestricted stormwater flow to the wet pond. ?? Inlet pipe shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected. ?? Determine if pipe is in good condition: o If more than 1 inch of settlement, add fill material and compact soils. o If alignment is faulty, correct alignment. o If cracks or openings exist indicated by evidence of erosion at leaks, repair or replace pipe as needed.
Forebay traps coarse sediments, reduces incoming velocity, and distributes runoff evenly over the wet pond. A minimum 1-foot freeboard shall be maintained. ?? Sediment buildup exceeding 50% of the facility capacity shall be removed every 2-5 years, or sooner if performance is being affected.
Embankment, Dikes, Berms & Side Slopes retain water in the wet pond. ?? Slopes shall be stabilized using appropriate erosion control measures when native soil is exposed or erosion channels are forming. ?? Structural deficiencies shall be corrected upon discovery: o If cracks exist, repair or replace structure. o If erosion channels deeper than 2 inches exist, stabilize surface. Sources of erosion damage shall be identified and controlled.
Control Devices (e.g., weirs, baffles, etc.) shall direct and reduce flow velocity. Structural deficiencies shall be corrected upon discovery: ?? If cracks exist, repair or replace structure.
Overflow Structure conveys flow exceeding reservoir capacity to an approved stormwater receiving system. ?? Overflow structure shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected. ?? Sources of erosion damage shall be identified and controlled when native soil is exposed at the top of overflow structure or erosion channels are forming. ?? Rocks or other armoring shall be replaced when only one layer of rock exists above native soil.
Sediment & Debris Management shall prevent loss of wet pond volume caused by sedimentation. ?? Wet ponds shall be dredged when 1 foot of sediment accumulates in the pond. ?? Gauges located at the opposite ends of the wet pond shall be maintained to monitor sedimentation. Gauges shall be checked 2 times per year. ?? Sources of restricted sediment or debris, such as discarded lawn clippings, shall be identified and prevented. ?? Debris in quantities sufficient to inhibit operation shall be removed routinely, e.g. no less than quarterly, or upon discovery.

Wet, Extended Wet Detention, and Dry Detention Ponds Operations & Maintenance Plan
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion and minimizing solar exposure of open water areas. ?? Mulch shall be replenished at least annually. ?? Vegetation, large shrubs or trees that limit access or interfere with wet pond operation shall be pruned or removed. ?? Grass (where applicable) shall be mowed to 4"-9" high and grass clippings shall be removed. ?? Fallen leaves and debris from deciduous plant foliage shall be raked and removed. ?? Nuisance vegetation such as blackberries, scotch broom or English Ivy shall be removed when discovered. ?? Dead vegetation shall be removed to maintain less than 10% of area coverage or when wet pond function is impaired. Vegetation shall be replaced within four months. ?? Vegetation producing foul odors shall be eliminated.
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater Releases of pollutants shall be corrected as soon as identified.
Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles. ?? Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
If used at this site, the following will be applicable:
Fences shall be maintained to preserve their functionality and appearance. ?? Collapsed fences shall be restored to an upright position. ?? Jagged edges and damaged fences and shall be repaired or replaced.

Constructed Treatment Wetlands

Operations & Maintenance Plan

Constructed Treatment Wetlands remove pollutants through several processes: sedimentation, filtration, and biological processes. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Wetland Inlet shall assure unrestricted stormwater flow to the wetland.

?? Inlet pipe shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.

?? Determine if pipe is in good condition:

- o If more than 1 inch of settlement, add fill material and compact soils.
- o If alignment is faulty, correct alignment.
- o If cracks or openings exist indicated by evidence of erosion at leaks, repair or replace pipe as needed.

Forebay traps coarse sediments, reduces incoming velocity, and distributes runoff evenly over the wetland. A minimum 1-foot freeboard shall be maintained.

?? Sediment buildup exceeding 50% of the facility capacity shall be removed every 2-5 years, or sooner if performance is being affected.

Embankment, Dikes, Berms & Side Slopes retain water in the wetland.

?? Slopes shall be stabilized using appropriate erosion control measures when native soil is exposed or erosion channels are forming.

?? Structural deficiencies shall be corrected upon discovery:

- o If cracks exist, repair or replace structure.
- o If erosion channels deeper than 2 inches exist, stabilize surface. Sources of erosion damage shall be identified and controlled.

Control Devices (e.g., weirs, baffles, etc.) shall direct and reduce flow velocity.

?? Structural deficiencies shall be corrected upon discovery:

?? If cracks exist, repair or replace structure.

Overflow Structure conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

?? Overflow structure shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.

?? Sources of erosion damage shall be identified and controlled when native soil is exposed at the top of overflow structure or erosion channels are forming.

?? Rocks or other armament shall be replaced when only one layer of rock exists above native soil.

Sediment & Debris Management shall prevent loss of wetland volume caused by sedimentation.

?? Wetlands shall be dredged when 1 foot of sediment accumulates.

?? Gauges located at the opposite ends of the wetland shall be maintained to monitor sedimentation. Gauges shall be checked 2 times per year.

?? Sources of restricted sediment or debris, such as discarded lawn clippings, shall be identified and prevented.

?? Debris in quantities sufficient to inhibit operation shall be removed routinely, e.g. no less than quarterly, or upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion and minimizing solar exposure of open water areas.

?? Mulch shall be replenished when needed.

?? Vegetation, large shrubs or trees that limit access or interfere with wetland operation shall be pruned.

?? Fallen leaves and debris from deciduous plant foliage shall be raked and removed.

?? Nuisance vegetation such as blackberries, scotch broom or English Ivy shall be removed when discovered.

Dead vegetation shall be removed to maintain less than 10% of area coverage or when wetland function is impaired. Vegetation shall be replaced within four months.

Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater Releases of pollutants shall be corrected as soon as identified.

Constructed Treatment Wetlands Operations & Maintenance Plan
Access: Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles. ?? Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
If used at this site, the following will be applicable:
Fences shall be maintained to preserve their functionality and appearance. ?? Collapsed fences shall be restored to an upright position. ?? Jagged edges and damaged fences and shall be repaired or replaced.

Underground Detention Tanks, Vaults, and Pipes Operations & Maintenance Plan
Underground detention tanks, vaults, and pipes are designed to fill with stormwater during large storm events, slowly releasing it over a number of hours. There are numerous components to each system. **Drain Inlet Pipes** convey stormwater into the detention facility. The **detention Chamber** is the structure in which stormwater accumulates during a storm event. **Orifice Structure/ Outlet Drain Pipe** restricts the flow out of the detention chamber, allowing it to fill up and slowly drain out. The orifice structure is located at the downstream end of the detention chamber. Underground facilities shall be inspected quarterly and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:
Drain Inlet Pipes shall be inspected for clogging or leaks where it enters the vault or basin during every inspection and cleanout. ?? Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.
Detention Chamber shall be inspected for cracks or damage during each inspection. ?? The detention chamber shall be cleaned out yearly or after an inch of sediment has accumulated. If there is a valve on the outlet pipe it shall be closed otherwise the outlet shall be plugged prior to cleanout. Grit and sediment that has settled to the bottom of the chamber shall be removed during each cleaning. ?? Water and sediment in the detention chamber shall be removed, tested, and disposed of in accordance with regulations. ?? Cleaning shall be done without use of detergents or surfactants. A pressure washer may be used if necessary.
Orifice Structure/ Outlet Drain Pipe shall be inspected for clogging during unit inspections/cleanouts. ?? Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.
Vegetation such as trees should not be located in or around the detention facility because roots from trees can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging the intake pipe. ?? Large shrubs or trees that are likely to interfere with detention facility operation shall be identified at each inspection then removed.
Source Control measures typically include structural and non-structural controls. Non-structural controls can include street sweeping and other good house keeping practices. It is often easier to prevent pollutants from entering stormwater than to remove them. ?? Source control measures shall be inspected and maintained (where applicable).
Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important for everyone to exercise caution when handling substances that can contaminate stormwater. Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

Underground Detention Tanks, Vaults, and Pipes
Operations & Maintenance Plan

Access: Egress and ingress routes shall be open and maintained to design standards.

Drywells
Operations & Maintenance Plan

Drywells are designed to infiltrate stormwater into the ground. Stormwater is piped to drywells from roof downspouts or pollution control facilities such as swales or planters. The pollution control facility is designed to settle out sediments and separate oils and greases from the water before releasing it through a pipe to the drywell. This prolongs the life of the drywell and helps to prevent the contamination of soils and groundwater. The drywell is a concrete or plastic manhole section with many small holes in the sides to allow stormwater to infiltrate into the surrounding soil. The drywell system shall be inspected and cleaned quarterly and within 48 hours after each major storm event. The following items shall be inspected and maintained as stated:

Stormwater Drain Pipe shall be inspected for clogging or leaks where it enters the drywell.

?? Debris/sediment that is found to clog the pipe shall be removed and disposed of in accordance with applicable federal and state requirements.

Drywell shall be inspected during each cleanout. Ponding around the catch basins or sedimentation manhole or drywell lids may indicate that the drywell is failing due to siltation, or the clogging of the sediment pores surrounding the drywell. Clogged drywells must be replaced.

Vegetation such as trees should not be located in or around the drywell because roots from trees can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging the intake pipe.

?? Large shrubs or trees that are likely to interfere with operation will be identified at each inspection and removed.

Source Control measures typically include structural and non-structural controls. Non-structural controls can include parking lot or street sweeping and other good house keeping practices. It is often easier to prevent pollutants from entering stormwater than to remove them.

?? Source control measures shall be inspected and maintained (where applicable).

Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, solvents, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater. Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

A **Shut-Off Valve or Flow-Blocking Mechanism** may have been required with the construction of the drywell to temporarily prevent stormwater from flowing into it, in the event of an accidental toxic material spill. This may also involve mats kept on-site that can be used to cover inlet drains in parking lots. The shut-off valve shall remain in good working order, or if mats or other flow-blocking mechanisms are used, they shall be kept in stock on-site.

Access: Egress and ingress routes shall be open and maintained to design standards.

Spill Control Manholes

Operations & Maintenance Plan

Spill Control Manholes operate using the principal that oil and water are immiscible (do not mix) and have different densities. Oil, being less dense than water, floats to the surface. The spill control manhole shall be inspected and cleaned quarterly. The following items shall be inspected and maintained as stated:

- **Stormwater Drain Inlet Pipe** shall be inspected for clogging or leaks where it enters the manhole during every inspection and cleanout. Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Manhole Chamber shall be inspected for cracks or damage during each inspection.

- The manhole shall be cleaned out quarterly. Cleanout shall be done in a manner to minimize the amount of trapped oil entering the outlet pipe. If there is a valve on the outlet pipe it shall be closed otherwise the outlet will be plugged prior to cleanout.
- Water and oil shall be removed, tested, and disposed of in accordance with regulations. Grit and sediment that has settled to the bottom of the chamber shall be removed during each cleaning
- Cleaning shall be done without use of detergents or surfactants. A pressure washer may be used if necessary.

Absorbent Pillows and Pads (where applicable) absorb oil from the separation chamber.

- Replacement shall occur at least twice a year, in the spring and fall, or as necessary to retain oil-absorbing function.

Stormwater Drain Outlet Pipe shall be inspected for clogging or leaks where it exits the manhole. Particular attention shall be paid to ensure that the joint where the tee joins the outlet pipe is watertight.

- Debris/sediment that is found to clog the outlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Vegetation such as trees should not be located in or around the spill control manhole because roots can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging.

- Large shrubs or trees that are likely to interfere with manhole operation shall be identified at each inspection and removed.

Source Control measures typically include structural and non-structural controls. Non-structural controls can include street sweeping and other good house keeping practices.

- Source control measures shall be inspected and maintained.

Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater.

Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

Access: Egress and ingress routes shall be open and maintained to design standards.

New Evergreen and Deciduous Trees - Operations & Maintenance Plan
Trees intercept rainfall and therefore provide a level of pollution reduction and flow control. They also provide shade, helping to cool stormwater runoff. Trees used to meet stormwater management requirements shall be kept on a site and maintained properly to ensure continued stormwater benefits. Trees shall be inspected 2 times a year and within 48 hours of a major wind or storm event. The following items shall be inspected and maintained as stated:
Leaves and Debris from the tree shall be regularly raked and disposed of. ?? Fallen leaves and debris from deciduous plant foliage shall be raked and removed. ?? Poisonous and nuisance vegetation around the tree shall be removed when discovered. ?? Dead vegetation shall be pruned from the tree on a regular basis.
Irrigation shall be implemented during the establishment period to ensure tree survival. Hand watering is preferred, but a drip-irrigation system may be used.
Protection of the tree trunk and roots shall ensure tree survival. Care should be taken when digging near tree roots. **Replacement** of dead trees shall be with a comparable species if it dies or must be removed for any another reason. The replacement tree shall be a minimum of 6' tall.

Chapter 4.0
SOURCE CONTROLS

Summary of Chapter 4.0

This chapter presents storm source controls required for site uses and characteristics that generate, or have the potential to generate, specific pollutants of concern.

To Use This Chapter:

1) Determine which characteristics and/or site uses listed in **Section 4.1.1** are included in the project.
2) Follow the design methodologies to design source controls for the project.
3) The site use may require a Discharge Authorization Request **(DAR) Form** to be submitted with the permit application.

4.1 INTRODUCTION

Some site characteristics and uses may generate specific pollutants of concern or levels that are not addressed solely through implementation of the pollution reduction measures identified in Chapter 2.0. The site characteristics and uses in this chapter have been identified as potential sources for chronic loadings or acute releases of pollutants such as oil and grease, toxic hydrocarbons, heavy metals, toxic compounds, solvents, abnormal pH levels, nutrients, organics, bacteria, chemicals, and suspended solids. This chapter presents source controls for managing these pollutants at their source.

Stormwater discharge benchmarks for pollutants exist in NPDES Industrial Stormwater General Permits issued by the State of Oregon for facilities with industrial activities that are exposed to rainfall and stormwater runoff. The state also has water quality standards listed in Oregon Administrative Rules (OAR) 340 Division 041 for discharges to surface waters.

Section 4.1.1 lists the site uses and characteristics subject to the design methodologies of this chapter, and will therefore be subject to City review. Sections 4.2 through 4.5 then provide detailed information about the required source controls.

The implementation of this chapter is <u>in addition to</u> the applicable pollution reduction, flow control, and destination requirements.

All structural source controls require a Discharge Authorization Request (DAR) form, located at the end of this chapter, to be submitted as part of the development permit application packet. For more details on structural controls, please refer to the DAR form. Applicants may propose alternatives to the source controls identified in this chapter. To request an alternative source control the applicant must complete the Special Requests section of the DAR form. Proposal of an alternative source control or alternative design element will require an additional review process and may delay issuance of related building or permits.

4.1.1 Site Uses and Characteristics That Trigger Source Controls

Projects with the following site uses and characteristics are subject to the design methodologies of this chapter:

?? Fuel Dispensing Facilities and Surrounding Traffic Areas (**Section 4.2**)
?? Above-Ground Storage of Liquid Materials (**Section 4.3**)
?? Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 4.4**)
?? Exterior Storage of Bulk Materials (**Section 4.5**)

Detailed descriptions of these site uses and characteristics can be found in each applicable section. Definitions of terms used in Sections 4.2 through 4.5 are provided in **Section 1.3**.

Applicants are required to address all of the site characteristics and uses listed in Sections 4.2 through 4.5. For example, if a development includes both a fuel dispensing area and a vehicle washing facility, the source controls in both Sections 4.2 will apply.

4.1.2 Source Control Goals and Objectives

The specific source control standards are based on the following goals and objectives:

1) Prevent stormwater pollution by eliminating pathways that may introduce pollutants into stormwater.

2) Protect soil, groundwater and surface water by capturing acute releases and reducing chronic contamination of the environment.

3) Direct wastewater discharges and areas with the potential for relatively consistent wastewater discharges (such as vehicle washing facilities) to the wastewater system.

4) Direct areas that have the potential for acute releases or accidental spills, and are not expected to regularly receive flow or require water use (such as covered fuel islands or covered containment areas), to an approved method of containment or destination.

6) Safely contain spills on-site, avoiding preventable discharges to wastewater facilities, surface water bodies, or underground injection control structures (UICs).

7) Emphasize structural controls over operational procedures. Structural controls are not operator dependent and are considered to provide more permanent and reliable source control. Any proposals for operation-based source controls need to describe the long-term viability of the maintenance program.

4.1.3 Request for Alternative Design Method of Source Control

Applicants must notify the City of their request in writing, specifying the reason for the request and supporting it with technical and factual data. The Discharge Authorization Request **(DAR) Form**, located at the end of this chapter, should be used when requesting an alternative design to the source control design methodologies.

Staff will check the DAR Form and supporting information submittal for completeness prior to review and decision.

If the request cannot be satisfied with this process, the adjustment review process, as described in **Appendix A**, will be implemented.

4.2 FUEL DISPENSING FACILITIES AND SURROUNDING TRAFFIC AREAS

4.2.1 Design

1) COVER

The fuel dispensing area shall be covered with a permanent canopy, roof, or awning so precipitation cannot come in contact with the fueling activity area. Rainfall shall be directed from the cover to an approved stormwater destination.

?? **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

?? **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

2) PAVEMENT

A paved fueling pad shall be placed under and around the fueling activity area with asphalt or concrete and shall meet all applicable building code requirements. Sizing of the paved areas shall be adequate to cover the activity area, including placement and number of the vehicles or pieces of equipment to be fueled by each pump. Fuel pumps shall be located a minimum of seven feet from the edge of the fueling pad.

3) DRAINAGE

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains. This will prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City wastewater system, or authorized pretreatment facility. Surrounding runoff shall be directed away from the hydraulically isolated fueling pad to a stormwater destination that meet all stormwater management practices of this manual and other applicable code requirements.

4) SIGNAGE

Signage shall be provided at the fuel dispensing area and shall be plainly visible from all fueling activity areas. Detailed information about signage is located in **Section 4.1.4**, and examples have been provided.

5) SPILL CONTROL MANHOLE

A spill control manhole shall be installed on the discharge line of the fueling pad (before the domestic waste line tie-in). The tee section shall extend 18 inches below the outlet elevation, with an additional 3 feet of dead storage volume below the tee to provide storage for oil and grease. The manhole shall be located on private property. For more information about spill control manholes, see **Exhibit 2-25**.

6) SHUT-OFF VALVES

A. **Shut off valves** are required to protect the City sewer systems or onsite infiltration facilities of spill risks from chemicals and other constituents that provide a danger for wide spread contamination, system damages or risk to the public health. Manual shut off valves shall not be permitted unless a "Special Request" for an adjustment is approved by the City.

Shut off valves will be required under the following situations:

?? Site or activity areas are corrosives or oxidizers are used or stored (for example, concentrated acids are corrosives having a pH of less than or equal to 2.0 and bases such as sodium or ammonium hydroxide having a pH of greater than or equal to 12.5, common oxidizers are hydrogen peroxide and bleach); or

?? Substances which are water soluble or float on water. These substances can spread rapidly into downstream conveyance and destination systems causing wide spread impacts, and difficult clean up situations (for example, oil and grease); or

?? Substances such as solvents and petroleum products that are known to infiltrate through soils and contaminate groundwater.

B. **Traffic pathways that surround the fueling pad, also designated as high-use/high-risk areas, will require a shut-off valve on the storm drainage system**. Valves installed on storm drainage systems shall be installed downstream of all private pollution reduction facilities to accommodate spill containment. These valves should be left open to facilitate stormwater flows during normal conditions, and immediately closed in the event of a spill.

C. **Fueling pads will require a shut-off valve downstream of the spill control manhole.** Valves installed on wastewater systems shall be installed before the domestic waste line tie-in. These valves must be kept closed, and only opened to allow incidental drainage activities that do not pose to be a threat or risk to the destination system. Immediately close the valve when drainage activities are completed.

Shut-off valves shall be located on private property and downstream of the exposed area's collection system. All valves shall be installed and maintained as per manufacturers recommendations. For more information about shut-off valves and associated valve boxes, contact Building & Permit Services at 541-682-5086.

7) ADDITIONAL REQUIREMENTS

A) **Installation, alterations, or removal of above-ground fuel tanks larger than 55 gallons, and any related equipment,** are subject to additional permitting requirements.

B) Bulk fuel terminals, also known as tank farms, will require the following:

- ?? Secondary containment equal to 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.
- ?? A separate containment area for all valves, pumps and coupling areas with sub-bermed areas either in front of or inside the main containment areas. These sub-bermed areas are required to have rain shields and be directed to a City wastewater system for disposal. If no City wastewater facility is available, drainage shall be directed to a temporary holding facility for proper disposal and may require a DEQ permit from the Underground Injection Control (UIC) program.
- ?? An impervious floor within all containment areas. Floors must be sealed to prevent spills from contaminating the groundwater.
- ?? Truck loading and off-loading areas. These areas shall follow cover, pavement, drainage, spill control, and shut-off valve requirements identified for fuel dispensing facilities.
- ?? Shut-off valves installed for the drainage of the tank yard, shall be installed downstream of the drainage system of the primary containment area, and kept closed. Valves installed for the drainage of the truck pad and sub-bermed containment areas shall be installed on the wastewater line downstream of the spill control manhole.
- ?? A batch discharge authorization before draining a containment area. This authorization will determine appropriate disposal methods, identify pretreatment requirements (if applicable), and authorize the discharge. Pretreatment may be required for oil and grease removal, and testing may be required to establish the specific characteristics of the discharge.

Underground fuel tanks less than 4,000 gallons in size are subject to additional permitting requirements by Oregon's Department of Environmental Quality (DEQ) and tanks larger than 4,000 gallons are referred to the Federal Environmental Protection Agency (EPA). For technical questions and permitting, call DEQ's NW Region main office at 1-800-844-8467 and ask for the Underground Storage Tank Permitting Department.

4.3 ABOVE-GROUND STORAGE OF LIQUID MATERIALS

4.3.1 Design

1) CONTAINMENT

Liquid materials shall be stored and contained in such a manner that if the container(s) is ruptured, the contents will not discharge, flow, or be washed into a receiving system. A containment device and / or structure for accidental spills shall have enough capacity to capture a minimum of 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

Containers, such as double-walled containers, with internal protection are exempt from these spill containment requirements.

2) COVER

Storage containers (other than tanks) shall be completely covered so rainfall cannot come in contact with them. Runoff shall be directed from the cover to a stormwater destination that meets all applicable code requirements.

- ?? **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.
- ?? **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

3) PAVEMENT

A paved storage area is required. The storage area shall be paved with asphalt or concrete and shall meet all applicable building code requirements. Sizing of the paved areas shall be adequate to cover the area intended for storage.

The applicant shall clearly identify any alternative method by submitting a **DAR Form**, located at the end of this chapter.

4) DRAINAGE

All paved storage areas shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater run-on to a storage area.

Covered storage areas: Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the contained area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to an approved City wastewater facility or authorized pretreatment facility.

Uncovered storage areas with containment: Water will accumulate in uncovered storage areas during and after rain. Any *contaminated* water cannot simply be drained from the area. It must be collected, inspected, and tested at the expense of the property owner before proper disposal can be determined. Some type of monitoring may also be needed to determine the characteristics and level of contamination of the stormwater.

All discharges to the wastewater system shall be considered batch discharges and shall require approval and pretreatment prior to discharge. Pretreatment requirements shall be set as part of the discharge approval process, based on the types and quantities of material to be discharged. A discharge evaluation shall be performed before connection to a wastewater facility. Testing may be required to establish characteristics of the wastewater or contaminated stormwater and to verify that local discharge limits are not exceeded.

5) SIGNAGE

Signage shall be provided at the liquid storage area and shall be plainly visible from all surrounding activity areas. Detailed information and examples are located in **Section 4.1.4.**

6) ADDITIONAL REQUIREMENTS

A) **Covered storage areas:** If the applicant elects to install drainage facilities to an approved City wastewater facility**, a shut-off valve** may be required for the covered storage area. The city will make this determination based on the type of material stored and the proposed system receiving the discharge.

Uncovered storage areas: A shut-off valve shall be installed in the storage area so excess stormwater can be drained out of the activity area and directed either to the storm drainage facilities (*if clean*) or into the City wastewater system or authorized pretreatment facility (*if contaminated*). Except when excess stormwater is being discharged, the valve shall always be kept closed so any spills within the activity area can be effectively contained.

B) **Storage of hazardous materials** located in designated groundwater resource protection areas may be subject to additional requirements.

Tank farms **shall follow the criteria established for Bulk Fuel Terminals, under** Section 4.2**.**

C) **Storage of reactive, ignitable, or flammable liquids** shall comply with the Uniform Fire Code as adopted by the State of Oregon. Source controls presented in this section are intended to complement, not conflict with, current fire code requirements. None of these requirements shall exclude or supersede any other requirements in this manual, other City permit requirements, or state and federal laws pertaining to water quality.

4.4 SOLID WASTE STORAGE AREAS, CONTAINERS, AND TRASH COMPACTORS

4.4.1 Design

For approval of solid waste storage and handling activity areas in Dunes City, the following design requirements will apply. See below for a clarification of each requirement.

ACTIVITY/ USE	REQUIREMENTS			
	(1) Cover	(2) Pavement	(3) Isolated	(4) Wastewater Drain
Multi-residential (with shared trash areas)	X	X	X	X*
Commercial	X	X	X	X
Industrial	X	X	X	X
Compactors (regardless of use)	X	X	X	X
Can and bottle return stations	X	X	X	X

***** Multi-residential ONLY. In the event gravity service to the wastewater lines cannot be obtained, a "Special Request" can be made to direct the drainage from the hydraulically isolated activity area to the development's stormwater pollution reduction facility. For more information, refer to **Additional Requirements** below.

1) COVER

A permanent canopy, roof, or awning must be provided to cover the solid waste storage activity area and shall be constructed to cover the activity area so rainfall cannot come in contact with the waste materials being stored. The cover shall be sized relative to the perimeter of the hydraulically isolated activity area it is to cover. Runoff shall be directed from the cover to a stormwater destination that meets all applicable code requirements.

2) PAVEMENT

A paved waste storage area is required when a structural cover or trash compactor is used. The area shall be paved with asphalt or concrete and meet all applicable building code requirements. Sizing of the paved area shall adequately cover the activity area intended for refuse storage, or the trash compactor(s) and associated equipment.

3) ISOLATION

Hydraulic isolation must be provided for the solid waste storage activity areas and shall be designed to prevent uncontaminated stormwater runoff from entering the area and carrying pollutants away. Runoff occurring outside the hydraulically isolated area shall be directed to a stormwater destination that meets all applicable code requirements. This can be achieved by reverse grading at the perimeter of an activity area, perimeter curbing or berming, or by the use of area drains to collect and divert runoff.

4) DRAINAGE

Drainage must be provided for the hydraulically isolated solid waste storage area and directed to the city's <u>wastewater facility</u> or authorized pretreatment facility. A wastewater drain is required for those areas that may be subject to refuse or suspected pollutants that pose a risk if the structural integrity of the trash receptacle is damaged or if its contents are exposed to rainfall.

Non-gravity Option

Activity areas that do not have gravity wastewater service can install a pressurized system. These types of installations will require the following to be provided at the time of building permit application:

1) Verification or evidence that gravity service cannot be obtained; and,
2) Details of an electronic sump pump system equipped with a float switch; and,
3) A completed DAR form.

Pressurized system installations are considered “permanent equipment” and deemed the property owner’s liability in the event of system failure or if the property becomes vacated.

Building & Permit Services will review all sump pump or sewage ejector installations for compliance with Uniform Plumbing Code and Oregon State Plumbing Specialty Code. The City staff will review for compliance with this chapter of the Stormwater Management Manual.

5) ADDITIONAL REQUIREMENTS

Multi-residential developments with shared trash areas may be allowed an alternative to the wastewater drain for the hydraulically isolated solid waste storage area. This activity area can drain to the site’s privately owned and operated stormwater pollution reduction facility if gravity service to the wastewater pipe of the development cannot be obtained. In order to be considered for the alternative, information showing that gravity service cannot be obtained and a completed **DAR form** that has both the General Information and Special Request sections completed must be submitted. All requirements previously outlined for multi-residential uses will apply.

4.5 EXTERIOR STORAGE OF BULK MATERIALS

4.5.1 Bulk Materials Categories

The materials are separated into three categories based on risk assessments for each material stored: high-risk, low-risk, and exempt.

High-Risk Materials	Low-Risk Materials	Exempt Materials
?? Recycling materials with potential effluent ?? Corrosive materials (*i.e.* lead-acid batteries) ?? Storage and processing of food items ?? Chalk / gypsum products ?? Feedstock / grain ?? Material by-products with potential effluent ?? Asphalt ?? Fertilizer ?? Pesticides ?? Lime / lye / soda ash ?? Animal / human wastes	?? Recycling materials without potential effluent ?? Scrap or salvage goods ?? Metal ?? Sawdust / bark chips ?? Sand / dirt / soil (including contaminated soil piles) ?? Material by-products without potential effluent ?? Unwashed gravel / rock ?? Compost	?? Washed gravel / rock ?? Finished lumber ?? Rubber and plastic products (hoses, gaskets, pipe, *etc.*) ?? Clean concrete products (blocks, pipe, *etc.*) ?? Glass products (new, non-recycled) ?? Inert products

4.5.2 Design

1) COVER

Low-risk materials must be covered with a temporary plastic film or sheeting at a minimum.

High-risk materials are required to be permanently covered with a canopy or roof to prevent stormwater contact and minimize the quantity of rainfall entering the storage area. Runoff shall be directed from the cover to a stormwater destination that meets all applicable code requirements.

?? **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

?? **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

2) PAVEMENT

Low-risk material storage areas are not required to be paved.

High-risk material storage areas shall be paved beneath the structural cover.

3) DRAINAGE

Low-risk material storage areas are allowed in areas served by standard stormwater management systems. However, all erodible materials being stored must be protected from rainfall.

If materials are erodible, a structural containment barrier shall be placed on at least three sides of every stockpile to act as a barrier to prevent uncontaminated stormwater from running onto the storage area and carrying pollutants away. If the area under the stockpile is paved, the barrier can be constructed of asphalt berms, concrete curbing, or retaining walls. If the area under the stockpile is unpaved, sunken retaining walls or ecology blocks can be used. The applicant shall clearly identify the method of containment on the building plans, and on the **DAR form**, located at the end of this chapter.

For **high-risk** material storage areas, the paved area beneath the structural cover shall be hydraulically isolated through grading, structural containment berms or walls, or perimeter drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the containment area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to the City's wastewater facility or authorized pretreatment facility.

4) ADDITIONAL REQUIREMENTS

A) **Storage of pesticides and fertilizers** may need to comply with specific regulations outlined by the Oregon Department of Environmental Quality (DEQ). For answers to technical questions, call DEQ's NW Region main office at 1-800-844-8467.

B) **A sampling manhole** or other suitable stormwater monitoring access point may be required to monitor stormwater runoff from the storage area. This may apply to certain types of storage activities and materials or if an alternative source control is proposed. This requirement complies with Dunes City Code, which requires appropriate stormwater destination. City staff will review for applicability of this requirement.

C) Signage shall be provided at the storage area if hazardous materials or other materials of concern are stored. Signage shall be located so it is plainly visible from all storage activity areas. More than one sign may be needed to accommodate large storage areas. Detailed information and examples are provided in Section 4.1.3.

DISCHARGE AUTHORIZATION REQUEST
for
Source Control(s)

Discharge Authorizations are required for source controls in areas that have site characteristics and facility uses that have activities at risk for source point pollutant releases that are regulated or prohibited by local, state and federal regulations.

NOTE: *A separate Authorization shall be filled out for each activity area, and Special Requests are available on the second page of this form.*

GENERAL INFORMATION (*to be completed for all Discharge Authorization Requests*)

Applicant's Name: ____________________ Date: __________

Facility Name: __________ Owner/Operator Name: __________

Facility Address: ____________________

Business Mailing Address: ____________________

Phone No.: __________ Type of business/facility: __________

Building Permit No. (*if applicable*): ____________________

SOURCE CONTROL INFORMATION

Installation of Source Control(s) are a result of:

- ✍ Tenant Improvements to an existing facility and/or building.
- ✍ New Development of a site or property that was unimproved.
- ✍ Re-Development of a site or property that had prior uses.
- ✍ Code Compliance in response to local, state or federal notification.
- ✍ Other: ____________________

____

Proposed Source Control(s) (*check all that apply*):

- ✍ Oil/Water Separator
- ✍ Collection Device/ Structure
- ✍ Containment Area
- ✍ Sedimentation Manhole with Retrofit
- ✍ Other: __________

Describe the site activity (ies) the source control(s) apply to:

____

____

____

(DISCHARGE AUTHORIZATION REQUEST FORM CONT.)

Attach a site plan with the location of the Source Control. Be sure to identify the location in reference to a permanent structure, for assistance in field verification. *(A hand-drawn sketch, not to scale, is acceptable as long as it is legible.)*

SPECIAL REQUEST (*check only if applicable*)

✍ Request to *remove* or *abandon* existing source control(s).

✍ Request to propose *alternative* source control(s).

✍ Request to *ADJUST* source control requirement(s).

✍ Request for review of *ADJUSTMENT* qualifications.

Please provide a brief explanation (*Use additional pages if necessary*.): ____________________

____

____

____

TO BE COMPLETED BY CITY:

✍ Approved ✍ Denied

Date: __________ Signature: ____________________________ Dept.: ______________

Comments: ____

____

____

Appendix C
SANTA BARBARA URBAN HYDROGRAPH METHOD

INTRODUCTION

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District to determine a runoff hydrograph for an urbanized area. It is a simpler method than some other approaches, as it computes a hydrograph directly without going through intermediate steps (i.e., a unit hydrograph) to determine the runoff hydrograph.

The SBUH method is a popular method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the method approved by Dunes City for determining runoff when doing flow control calculations.

ELEMENTS OF THE SBUH METHOD

The SBUH method depends on several variables:

- Pervious (A_p) and impervious (A_{imp}) land areas
- Time of concentration (T_c) calculations
- Runoff curve numbers (CN) applicable to the site
- Design storm

These elements shall all be presented as part of the submittal process for review by staff. In addition, maps showing the pre-development and post-development conditions shall be presented to help in the review.

Land Area

The total area, including the pervious and impervious areas within a drainage basin, shall be quantified in order to evaluate critical contributing areas and the resulting site runoff. Each area within a basin shall be analyzed separately and their hydrographs combined to determine the total basin hydrograph. Areas shall be selected to represent homogenous land use / development units.

Time of Concentration

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed. (In this case, T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration.) T_c depends on several factors, including ground slope, ground roughness, and distance of flow. The following formula for determining T_c is:

Formulas

$T_c = T_{t1} + T_{c2} + T_{c3} + \ldots + T_{cn}$

$T_t = L/60V$ (Conversion of velocity to travel time)

$T_t = \frac{0.42\,(nL)^{0.8}}{1.58(s)^{0.4}}$ (Manning's kinematic solution for sheet flow less than 300 feet)

(Shallow concentrated flow for slopes less than 0.005 ft/ft.):

$V = 16.1345(s)^{0.5}$ (Unpaved surfaces)

$V = 20.3282(s)^{0.5}$ (Paved surfaces)

Where,

T_t = travel time, minutes
T_c = total time of concentration, minutes (minimum T_c = 5 minutes)
L = flow length, feet
V = average velocity of flow, feet per second
n = Manning's roughness coefficient for various surfaces
s = slope of the hydraulic grade line (land or watercourse slope), feet per foot

When calculating T_c, the following limitations apply:

- Overland sheet flow (flow across flat areas that does not form into channels or rivulets) shall not extend for more than 300 feet.
- For flow paths through closed conveyance facilities such as pipes and culverts, standard hydraulic formulas shall be used for establishing velocity and travel time.
- Flow paths through lakes or wetlands may be assumed to be zero (i.e. $T_c = 0$).

Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to reduce diverse characteristics such as soil type, land usage, and vegetation into a single variable for doing runoff calculations. The runoff curve numbers approved for water quantity / quality calculations are included as Table C-2 of this appendix.

The curve numbers presented in Table C-2 are for *wet* antecedent moisture conditions. Wet conditions assume previous rainstorms have reduced the capacity of soil to absorb water. Given the frequency of rainstorms in this area, wet conditions are most likely, and give conservative hydrographic values.

Design Storm

The SBUH method also requires a design storm to perform the runoff calculations. For flow control calculations, use NRCS Type 1A 24-hour storm distribution. This storm is shown in Figure C-1 and Table C-4. The depth of rainfall for the 2 through 100-year storm events is shown below in Table C-1.

Table C-1
24-HOUR RAINFALL DEPTHS

Recurrence Interval, Years	2	5	10	25	100
Flood Control, Destination: 24-Hour Depths, Inches	3.12	3.6	4.46	5.18	6.48

Pollution Reduction: 24-Hour Depths, 1.4 Inches

Table C-2
RUNOFF CURVE NUMBERS

Runoff curve numbers for urban areas*

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Runoff curve numbers for other agricultural lands*

Cover description		Curve numbers for hydrologic soil grou			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range-continuous forage for grazing					
<50% ground cover or heavily grazed with no mulch	Poor	68	79	86	89
50 to 75% ground cover and not heavily grazed	Fair	49	69	79	84
>75% ground cover and lightly or only occasionally grazed	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay	-	30	58	71	78
Brush--weed-grass mixture with brush as the major element					
<50% ground cover	Poor	48	67	77	83
50 to 75% ground cover	Fair	35	56	70	77
>75% ground cover	Good	30	48	65	73
Woods-grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79

Runoff curve numbers for other agricultural lands*

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Woods					
Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.	Poor	45	66	77	83
Woods are grazed but not burned, and some forest litter covers the soil.	Fair	36	60	73	79
Woods are protected from grazing, and litter and brush adequately cover the soil.	Good	30	55	70	77

Runoff curve numbers for Simplified Approaches**

Cover description		Curve numbers for hydrologic soil group			
Simplified Approaches	Hydrologic condition	A	B	C	D
Roof Garden	Good	n/a	48	n/a	n/a
Infiltration & Flow-Through Planter Box	Good	n/a	48	n/a	n/a
Pervious Pavement	-	76	85	89	n/a
Trees					
	New and/or Existing Evergreen	-	36	60	73
	New and/or Existing Deciduous	-	36	60	73

n/a - Does not apply, as design criteria for the relevant mitigation measures do not include the use of this soil type.
*Soil Conservation Service, *Urban Hydrology for Small Watersheds*, Technical Release 55, pp. 2.5-2.8, June 1986.
**CNs of various cover types were assigned to the Proposed Simplified Approaches with similar cover types as follows:

Infiltration & Flow-Through Planter Box – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Pervious Pavement – assumed gravel.
Trees – assumed woods with fair hydrologic conditions.

Note: To determine hydrologic soil type, consult local USDA Soil Conservation Service Soil Survey.

TABLE C-3
NRCS HYDROLOGIC SOIL GROUP DESCRIPTIONS

NRCS Hydrologic Soil Group	Description
Group A	Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.
Group B	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
Group C	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.
Group D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a fragipan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Figure C-1 - NRCS 24-Hour Type 1A Hyetograph

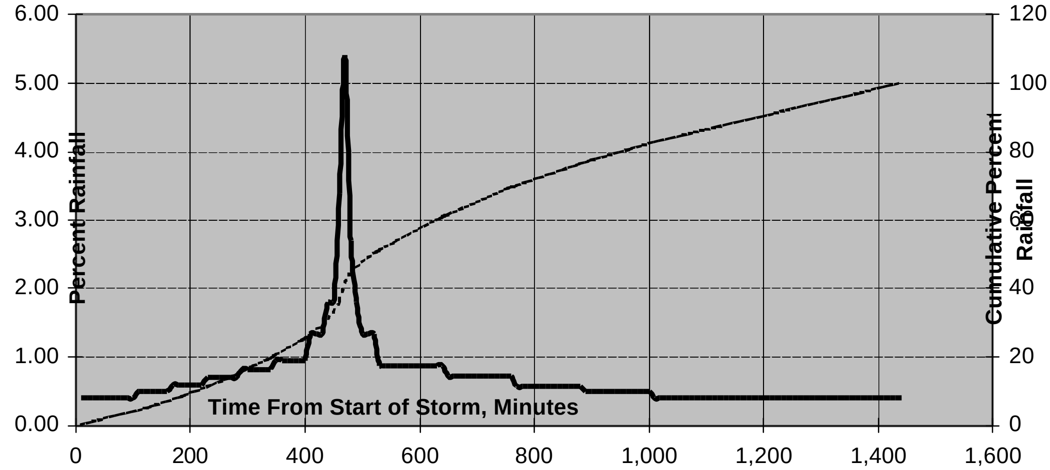


Table C-3 - NRCS Type 1A Hyetographic Distrubution - For Use In Water Quality/Quantity Design

Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall
0 - 10	0.40	0.40	360 - 370	0.95	22.57	720 - 730	0.72	67.40	1080 - 1090	0.40	86.00
10 - 20	0.40	0.80	370 - 380	0.95	23.52	730 - 740	0.72	68.12	1090 - 1100	0.40	86.40
20 - 30	0.40	1.20	380 - 390	0.95	24.47	740 - 750	0.72	68.84	1100 - 1110	0.40	86.80
30 - 40	0.40	1.60	390 - 400	0.95	25.42	750 - 760	0.72	69.56	1110 - 1120	0.40	87.20
40 - 50	0.40	2.00	400 - 410	1.34	26.76	760 - 770	0.57	70.13	1120 - 1130	0.40	87.60
50 - 60	0.40	2.40	410 - 420	1.34	28.10	770 - 780	0.57	70.70	1130 - 1140	0.40	88.00
60 - 70	0.40	2.80	420 - 430	1.34	29.44	780 - 790	0.57	71.27	1140 - 1150	0.40	88.40
70 - 80	0.40	3.20	430 - 440	1.80	31.24	790 - 800	0.57	71.84	1150 - 1160	0.40	88.80
80 - 90	0.40	3.60	440 - 450	1.80	33.04	800 - 810	0.57	72.41	1160 - 1170	0.40	89.20
90 - 100	0.40	4.00	450 - 460	3.40	36.44	810 - 820	0.57	72.98	1170 - 1180	0.40	89.60
100 - 110	0.50	4.50	460 - 470	5.40	41.84	820 - 830	0.57	73.55	1180 - 1190	0.40	90.00
110 - 120	0.50	5.00	470 - 480	2.70	44.54	830 - 840	0.57	74.12	1190 - 1200	0.40	90.40
120 - 130	0.50	5.50	480 - 490	1.80	46.34	840 - 850	0.57	74.69	1200 - 1210	0.40	90.80
130 - 140	0.50	6.00	490 - 500	1.34	47.68	850 - 860	0.57	75.26	1210 - 1220	0.40	91.20
140 - 150	0.50	6.50	500 - 510	1.34	49.02	860 - 870	0.57	75.83	1220 - 1230	0.40	91.60
150 - 160	0.50	7.00	510 - 520	1.34	50.36	870 - 880	0.57	76.40	1230 - 1240	0.40	92.00
160 - 170	0.60	7.60	520 - 530	0.88	51.24	880 - 890	0.50	76.90	1240 - 1250	0.40	92.40
170 - 180	0.60	8.20	530 - 540	0.88	52.12	890 - 900	0.50	77.40	1250 - 1260	0.40	92.80
180 - 190	0.60	8.80	540 - 550	0.88	53.00	900 - 910	0.50	77.90	1260 - 1270	0.40	93.20
190 - 200	0.60	9.40	550 - 560	0.88	53.88	910 - 920	0.50	78.40	1270 - 1280	0.40	93.60
200 - 210	0.60	10.00	560 - 570	0.88	54.76	920 - 930	0.50	78.90	1280 - 1290	0.40	94.00
210 - 220	0.60	10.60	570 - 580	0.88	55.64	930 - 940	0.50	79.40	1290 - 1300	0.40	94.40
220 - 230	0.70	11.30	580 - 590	0.88	56.52	940 - 950	0.50	79.90	1300 - 1310	0.40	94.80
230 - 240	0.70	12.00	590 - 600	0.88	57.40	950 - 960	0.50	80.40	1310 - 1320	0.40	95.20
240 - 250	0.70	12.70	600 - 610	0.88	58.28	960 - 970	0.50	80.90	1320 - 1330	0.40	95.60
250 - 260	0.70	13.40	610 - 620	0.88	59.16	970 - 980	0.50	81.40	1330 - 1340	0.40	96.00
260 - 270	0.70	14.10	620 - 630	0.88	60.04	980 - 990	0.50	81.90	1340 - 1350	0.40	96.40
270 - 280	0.70	14.80	630 - 640	0.88	60.92	990 - 1000	0.50	82.40	1350 - 1360	0.40	96.80
280 - 290	0.82	15.62	640 - 650	0.72	61.64	1000 - 1010	0.40	82.80	1360 - 1370	0.40	97.20
290 - 300	0.82	16.44	650 - 660	0.72	62.36	1010 - 1020	0.40	83.20	1370 - 1380	0.40	97.60
300 - 310	0.82	17.26	660 - 670	0.72	63.08	1020 - 1030	0.40	83.60	1380 - 1390	0.40	98.00
310 - 320	0.82	18.08	670 - 680	0.72	63.80	1030 - 1040	0.40	84.00	1390 - 1400	0.40	98.40
320 - 330	0.82	18.90	680 - 690	0.72	64.52	1040 - 1050	0.40	84.40	1400 - 1410	0.40	98.80
330 - 340	0.82	19.72	690 - 700	0.72	65.24	1050 - 1060	0.40	84.80	1410 - 1420	0.40	99.20
340 - 350	0.95	20.67	700 - 710	0.72	65.96	1060 - 1070	0.40	85.20	1420 - 1430	0.40	99.60
350 - 360	0.95	21.62	710 - 720	0.72	66.68	1070 - 1080	0.40	85.60	1430 - 1440	0.40	100.00

Appendix D
SIMPLIFIED APPROACH SIZING CALCULATIONS

The spreadsheet columns are described below:

Column (1)	Time in Minutes
Column (2)	Inflow for Storm Event (25-Year Detention Storm 3.9”/24 hours) and Contributing Impervious Area (1 acre)
Column (3)	Inflow (cf) = Inflow (cfs) x 60 x 10
Column (4)	Inflow (in) = Inflow (cf) x 12 / 43,560
Column (5)	Cumulative Inflow (in) = inflow (in) + Cumulative inflow (in) of previous step
Column (6)	Max Outflow (cfs) = Facility Area (sf) x Infiltration Rate (ft/s) **Note: Infiltration rate is assumed to be 2.5”/hr in this case. Also, for simplicity head is not taken into account.**
Column (7)	Cumulative Outflow (cf) = outflow (cfs) x 10 x 60 + cumulative outflow (cf) of previous step
Column (8)	Inflow – Outflow (cfs) = Column 2 inflow (cfs) – Column 6 outflow (cfs)
Column (9)	Incremental inflow – outflow (cf) = inflow – outflow (cfs) x 10 x 60
Column (10)	Cumulative inflow – outflow (cf) = If incremental inflow – outflow (cf) + cumulative inflow – outflow (cf) of previous step is less than 0, 0; else = incremental inflow – outflow (cf) + cumulative inflow – outflow (cf) of previous time step
Column (11)	Cumulative depth (in) = cumulative inflow – outflow (cf) x 12 / Facility Area (sf) **Note that cumulative depth does not exceed 6 inches in this case, which would result in an overflow condition. When modeling for detention purposes, overflow is allowed, but only at pre-developed peak rates. When modeling for pollution reduction, the entire post-developed runoff rate from the pollution reduction storm must be infiltrated without overflow.** **Resulting swale square-footage is 3,940, which when divided by the 43,560 square-foot impervious surface equals the 0.09 sizing factor.**

Spreadsheet Illustrating Vegetated Swale Sizing: 43,560 sq-ft imp. 25 yr storm **Swale Square Footage=** **3940**

B Soil Infiltration Rate=2.5"/hr= .21 ft/hr= **0.00006 ft/s**

(1) Time (min)	(2) Inflow (cfs)	(3) Inflow Volume (cf)	(4) Inflow Volume (in)	(5) Cumulative Inflow (in)	(6) Max Outflow (cfs)	(7) Cumulative Outflow Vol. (cf)	(8) Inflow - Outflow (cfs)	(9) Incremental Inflow - Outflow (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Cumulative Depth (in)
0	0	0	0.00	0.00	0.2364	0	-0.2364	-141.84	0	0
10	0	0	0.00	0.00	0.2364	141.84	-0.2364	-141.84	0	0
20	0	0	0.00	0.00	0.2364	283.68	-0.2364	-141.84	0	0
30	0	0	0.00	0.00	0.2364	425.52	-0.2364	-141.84	0	0
40	0.01	6	0.00	0.00	0.2364	567.36	-0.2264	-135.84	0	0
50	0.02	12	0.00	0.00	0.2364	709.2	-0.2164	-129.84	0	0
60	0.03	18	0.00	0.01	0.2364	851.04	-0.2064	-123.84	0	0
70	0.03	18	0.00	0.01	0.2364	992.88	-0.2064	-123.84	0	0
80	0.04	24	0.01	0.02	0.2364	1134.72	-0.1964	-117.84	0	0
90	0.05	30	0.01	0.03	0.2364	1276.56	-0.1864	-111.84	0	0
100	0.05	30	0.01	0.04	0.2364	1418.4	-0.1864	-111.84	0	0
110	0.06	36	0.01	0.05	0.2364	1560.24	-0.1764	-105.84	0	0
120	0.08	48	0.01	0.06	0.2364	1702.08	-0.1564	-93.84	0	0
130	0.08	48	0.01	0.07	0.2364	1843.92	-0.1564	-93.84	0	0
140	0.08	48	0.01	0.09	0.2364	1985.76	-0.1564	-93.84	0	0
150	0.09	54	0.01	0.10	0.2364	2127.6	-0.1464	-87.84	0	0
160	0.09	54	0.01	0.12	0.2364	2269.44	-0.1464	-87.84	0	0
170	0.1	60	0.02	0.13	0.2364	2411.28	-0.1364	-81.84	0	0
180	0.11	66	0.02	0.15	0.2364	2553.12	-0.1264	-75.84	0	0
190	0.12	72	0.02	0.17	0.2364	2694.96	-0.1164	-69.84	0	0
200	0.12	72	0.02	0.19	0.2364	2836.8	-0.1164	-69.84	0	0
210	0.12	72	0.02	0.21	0.2364	2978.64	-0.1164	-69.84	0	0
220	0.12	72	0.02	0.23	0.2364	3120.48	-0.1164	-69.84	0	0
230	0.13	78	0.02	0.25	0.2364	3262.32	-0.1064	-63.84	0	0
240	0.15	90	0.02	0.28	0.2364	3404.16	-0.0864	-51.84	0	0
250	0.15	90	0.02	0.30	0.2364	3546	-0.0864	-51.84	0	0
260	0.15	90	0.02	0.33	0.2364	3687.84	-0.0864	-51.84	0	0
270	0.15	90	0.02	0.35	0.2364	3829.68	-0.0864	-51.84	0	0
280	0.15	90	0.02	0.38	0.2364	3971.52	-0.0864	-51.84	0	0
290	0.17	102	0.03	0.40	0.2364	4113.36	-0.0664	-39.84	0	0
300	0.18	108	0.03	0.43	0.2364	4255.2	-0.0564	-33.84	0	0
310	0.18	108	0.03	0.46	0.2364	4397.04	-0.0564	-33.84	0	0
320	0.18	108	0.03	0.49	0.2364	4538.88	-0.0564	-33.84	0	0
330	0.18	108	0.03	0.52	0.2364	4680.72	-0.0564	-33.84	0	0
340	0.18	108	0.03	0.55	0.2364	4822.56	-0.0564	-33.84	0	0
350	0.2	120	0.03	0.59	0.2364	4964.4	-0.0364	-21.84	0	0
360	0.21	126	0.03	0.62	0.2364	5106.24	-0.0264	-15.84	0	0
370	0.21	126	0.03	0.66	0.2364	5248.08	-0.0264	-15.84	0	0
380	0.22	132	0.04	0.69	0.2364	5389.92	-0.0164	-9.84	0	0
390	0.22	132	0.04	0.73	0.2364	5531.76	-0.0164	-9.84	0	0
400	0.22	132	0.04	0.77	0.2364	5673.6	-0.0164	-9.84	0	0
410	0.26	156	0.04	0.81	0.2364	5815.44	0.0236	14.16	14.16	0.04830213
420	0.31	186	0.05	0.86	0.2364	5957.28	0.0736	44.16	58.32	0.19893928
430	0.31	186	0.05	0.91	0.2364	6099.12	0.0736	44.16	102.48	0.34957644
440	0.36	216	0.06	0.97	0.2364	6240.96	0.1236	74.16	176.64	0.60254862
450	0.42	252	0.07	1.04	0.2364	6382.8	0.1836	110.16	286.8	0.97832284
460	0.6	360	0.10	1.14	0.2364	6524.64	0.3636	218.16	504.96	1.72250314
470	1.02	612	0.17	1.31	0.2364	6666.48	0.7836	470.16	975.12	3.32629766
480	0.94	564	0.16	1.46	0.2364	6808.32	0.7036	422.16	1397.28	4.76635614
490	0.52	312	0.09	1.55	0.2364	6950.16	0.2836	170.16	1567.44	5.34680040
500	0.37	222	0.06	1.61	0.2364	7092	0.1336	80.16	1647.6	5.62023959
510	0.31	186	0.05	1.66	0.2364	7233.84	0.0736	44.16	1691.76	5.77087675
520	0.31	186	0.05	1.71	0.2364	7375.68	0.0736	44.16	1735.92	5.92151390
530	0.26	156	0.04	1.76	0.2364	7517.52	0.0236	14.16	1750.08	5.96981604
540	0.21	126	0.03	1.79	0.2364	7659.36	-0.0264	-15.84	1734.24	5.91578314
550	0.21	126	0.03	1.82	0.2364	7801.2	-0.0264	-15.84	1718.4	5.86175025
560	0.21	126	0.03	1.86	0.2364	7943.04	-0.0264	-15.84	1702.56	5.80771736
570	0.21	126	0.03	1.89	0.2364	8084.88	-0.0264	-15.84	1686.72	5.75368446
580	0.21	126	0.03	1.93	0.2364	8226.72	-0.0264	-15.84	1670.88	5.69965157
590	0.21	126	0.03	1.96	0.2364	8368.56	-0.0264	-15.84	1655.04	5.64561868

Spreadsheet Illustrating Vegetated Swale Sizing: 43,560 sq-ft imp. 25 yr storm Swale Square Footage= **3940**

B Soil Infiltration Rate=2.5"/hr= .21 ft/hr= **0.00006 ft/s**

600	0.21	126	0.03	2.00	0.2364	8510.4	-0.0264	-15.84	1639.2	5.59158578
610	0.21	126	0.03	2.03	0.2364	8652.24	-0.0264	-15.84	1623.36	5.53755289
620	0.21	126	0.03	2.07	0.2364	8794.08	-0.0264	-15.84	1607.52	5.48352
630	0.21	126	0.03	2.10	0.2364	8935.92	-0.0264	-15.84	1591.68	5.42948710
640	0.21	126	0.03	2.14	0.2364	9077.76	-0.0264	-15.84	1575.84	5.37545421
650	0.19	114	0.03	2.17	0.2364	9219.6	-0.0464	-27.84	1548	5.28048731
660	0.17	102	0.03	2.20	0.2364	9361.44	-0.0664	-39.84	1508.16	5.14458639
670	0.17	102	0.03	2.22	0.2364	9503.28	-0.0664	-39.84	1468.32	5.00868548
680	0.17	102	0.03	2.25	0.2364	9645.12	-0.0664	-39.84	1428.48	4.87278456
690	0.17	102	0.03	2.28	0.2364	9786.96	-0.0664	-39.84	1388.64	4.73688365
700	0.17	102	0.03	2.31	0.2364	9928.8	-0.0664	-39.84	1348.8	4.60098274
710	0.17	102	0.03	2.34	0.2364	10070.64	-0.0664	-39.84	1308.96	4.46508182
720	0.17	102	0.03	2.37	0.2364	10212.48	-0.0664	-39.84	1269.12	4.32918091
730	0.17	102	0.03	2.39	0.2364	10354.32	-0.0664	-39.84	1229.28	4.19328
740	0.17	102	0.03	2.42	0.2364	10496.16	-0.0664	-39.84	1189.44	4.05737908
750	0.17	102	0.03	2.45	0.2364	10638	-0.0664	-39.84	1149.6	3.92147817
760	0.17	102	0.03	2.48	0.2364	10779.84	-0.0664	-39.84	1109.76	3.78557725
770	0.15	90	0.02	2.50	0.2364	10921.68	-0.0864	-51.84	1057.92	3.60874233
780	0.13	78	0.02	2.52	0.2364	11063.52	-0.1064	-63.84	994.08	3.39097340
790	0.13	78	0.02	2.55	0.2364	11205.36	-0.1064	-63.84	930.24	3.17320446
800	0.13	78	0.02	2.57	0.2364	11347.2	-0.1064	-63.84	866.4	2.95543553
810	0.13	78	0.02	2.59	0.2364	11489.04	-0.1064	-63.84	802.56	2.73766659
820	0.13	78	0.02	2.61	0.2364	11630.88	-0.1064	-63.84	738.72	2.51989766
830	0.13	78	0.02	2.63	0.2364	11772.72	-0.1064	-63.84	674.88	2.30212873
840	0.13	78	0.02	2.65	0.2364	11914.56	-0.1064	-63.84	611.04	2.08435979
850	0.13	78	0.02	2.67	0.2364	12056.4	-0.1064	-63.84	547.2	1.86659086
860	0.13	78	0.02	2.70	0.2364	12198.24	-0.1064	-63.84	483.36	1.64882192
870	0.13	78	0.02	2.72	0.2364	12340.08	-0.1064	-63.84	419.52	1.43105299
880	0.13	78	0.02	2.74	0.2364	12481.92	-0.1064	-63.84	355.68	1.21328406
890	0.13	78	0.02	2.76	0.2364	12623.76	-0.1064	-63.84	291.84	0.99551512
900	0.12	72	0.02	2.78	0.2364	12765.6	-0.1164	-69.84	222	0.75727918
910	0.12	72	0.02	2.80	0.2364	12907.44	-0.1164	-69.84	152.16	0.51904324
920	0.12	72	0.02	2.82	0.2364	13049.28	-0.1164	-69.84	82.32	0.28080731
930	0.12	72	0.02	2.84	0.2364	13191.12	-0.1164	-69.84	12.48	0.04257137
940	0.12	72	0.02	2.86	0.2364	13332.96	-0.1164	-69.84	0	0
950	0.12	72	0.02	2.88	0.2364	13474.8	-0.1164	-69.84	0	0
960	0.12	72	0.02	2.90	0.2364	13616.64	-0.1164	-69.84	0	0
970	0.12	72	0.02	2.92	0.2364	13758.48	-0.1164	-69.84	0	0
980	0.12	72	0.02	2.94	0.2364	13900.32	-0.1164	-69.84	0	0
990	0.12	72	0.02	2.96	0.2364	14042.16	-0.1164	-69.84	0	0
1000	0.12	72	0.02	2.98	0.2364	14184	-0.1164	-69.84	0	0
1010	0.11	66	0.02	3.00	0.2364	14325.84	-0.1264	-75.84	0	0
1020	0.09	54	0.01	3.01	0.2364	14467.68	-0.1464	-87.84	0	0
1030	0.09	54	0.01	3.03	0.2364	14609.52	-0.1464	-87.84	0	0
1040	0.09	54	0.01	3.04	0.2364	14751.36	-0.1464	-87.84	0	0
1050	0.09	54	0.01	3.06	0.2364	14893.2	-0.1464	-87.84	0	0
1060	0.09	54	0.01	3.07	0.2364	15035.04	-0.1464	-87.84	0	0
1070	0.09	54	0.01	3.09	0.2364	15176.88	-0.1464	-87.84	0	0
1080	0.09	54	0.01	3.10	0.2364	15318.72	-0.1464	-87.84	0	0
1090	0.09	54	0.01	3.12	0.2364	15460.56	-0.1464	-87.84	0	0
1100	0.09	54	0.01	3.13	0.2364	15602.4	-0.1464	-87.84	0	0
1110	0.09	54	0.01	3.15	0.2364	15744.24	-0.1464	-87.84	0	0
1120	0.09	54	0.01	3.16	0.2364	15886.08	-0.1464	-87.84	0	0
1130	0.09	54	0.01	3.18	0.2364	16027.92	-0.1464	-87.84	0	0
1140	0.09	54	0.01	3.19	0.2364	16169.76	-0.1464	-87.84	0	0
1150	0.09	54	0.01	3.20	0.2364	16311.6	-0.1464	-87.84	0	0
1160	0.09	54	0.01	3.22	0.2364	16453.44	-0.1464	-87.84	0	0
1170	0.09	54	0.01	3.23	0.2364	16595.28	-0.1464	-87.84	0	0
1180	0.09	54	0.01	3.25	0.2364	16737.12	-0.1464	-87.84	0	0
1190	0.09	54	0.01	3.26	0.2364	16878.96	-0.1464	-87.84	0	0
1200	0.09	54	0.01	3.28	0.2364	17020.8	-0.1464	-87.84	0	0
1210	0.09	54	0.01	3.29	0.2364	17162.64	-0.1464	-87.84	0	0
1220	0.09	54	0.01	3.31	0.2364	17304.48	-0.1464	-87.84	0	0
1230	0.09	54	0.01	3.32	0.2364	17446.32	-0.1464	-87.84	0	0
1240	0.09	54	0.01	3.34	0.2364	17588.16	-0.1464	-87.84	0	0
1250	0.09	54	0.01	3.35	0.2364	17730	-0.1464	-87.84	0	0
1260	0.09	54	0.01	3.37	0.2364	17871.84	-0.1464	-87.84	0	0

Spreadsheet Illustrating Vegetated Swale Sizing: 43,560 sq-ft imp. 25 yr storm **Swale Square Footage=** **3940**

B Soil Infiltration Rate=2.5"/hr= .21 ft/hr= **0.00006 ft/s**

1270	0.09	54	0.01	3.38	0.2364	18013.68	-0.1464	-87.84	0	0
1280	0.09	54	0.01	3.40	0.2364	18155.52	-0.1464	-87.84	0	0
1290	0.09	54	0.01	3.41	0.2364	18297.36	-0.1464	-87.84	0	0
1300	0.09	54	0.01	3.43	0.2364	18439.2	-0.1464	-87.84	0	0
1310	0.09	54	0.01	3.44	0.2364	18581.04	-0.1464	-87.84	0	0
1320	0.09	54	0.01	3.46	0.2364	18722.88	-0.1464	-87.84	0	0
1330	0.09	54	0.01	3.47	0.2364	18864.72	-0.1464	-87.84	0	0
1340	0.09	54	0.01	3.49	0.2364	19006.56	-0.1464	-87.84	0	0
1350	0.09	54	0.01	3.50	0.2364	19148.4	-0.1464	-87.84	0	0
1360	0.09	54	0.01	3.52	0.2364	19290.24	-0.1464	-87.84	0	0
1370	0.09	54	0.01	3.53	0.2364	19432.08	-0.1464	-87.84	0	0
1380	0.09	54	0.01	3.55	0.2364	19573.92	-0.1464	-87.84	0	0
1390	0.09	54	0.01	3.56	0.2364	19715.76	-0.1464	-87.84	0	0
1400	0.09	54	0.01	3.58	0.2364	19857.6	-0.1464	-87.84	0	0
1410	0.09	54	0.01	3.59	0.2364	19999.44	-0.1464	-87.84	0	0
1420	0.09	54	0.01	3.61	0.2364	20141.28	-0.1464	-87.84	0	0
1430	0.09	54	0.01	3.62	0.2364	20283.12	-0.1464	-87.84	0	0
1440	0.09	54	0.01	3.64	0.2364	20424.96	-0.1464	-87.84	0	0
1450	0.05	30	0.01	3.64	0.2364	20566.8	-0.1864	-111.84	0	0
1460	0	0	0.00	3.64	0.2364	20566.8	-0.2364	-141.84	0	0

APPENDIX E
Dunes City - Water Quality and Flood Control Design Storms

Purpose
To identify water quality and flood control design storms for sizing water quality treatment and drainage/flood control facilities.

Water Quality Design Storm
The methodology used to develop the water quality design storm specifications for Dunes City were modeled after procedures described in the City of Eugene's "Development Standards Memorandum #4; Water Quality Design Storm Selection." Dunes City has established a water quality treatment design standard for new development where ninety percent of the average annual rainfall is captured and treated. The goal of this analysis was to identify the magnitude and duration of storm events in the Dunes City area that produce ninety percent of the average annual rainfall. It should be noted that because only hourly rainfall data are available for the area, analysis focused on total rainfall for storm events. Rainfall intensity, measured in inches per hour, could not be analyzed from local data. Total rainfall can be used to design retention/detention type stormwater facilities.

Detention/Retention Versus Flow-Through Water Quality Facilities
Detention/Retention facilities are used to treat rainfall and then either infiltrate it on-site or release it downstream at the flow velocities equal to pre-development conditions. For these facilities, hourly rainfall data is needed to develop the water quality design storm. The analysis below and the charted design storms includes this data.

Flow-Through facilities receive and treat all of the rainfall of a given site as its being released to a downstream destination facility. This approach results in a much higher flow rate than detention/retention facilities. To design for these, shorter duration and higher intensity storm data is necessary. While Dunes City is likely to rely almost exclusively on detention/retention facilities, there may be a need or desire to provide for flow-through facilities in situations where there may be no options for locating detention facilities due to grade and/or space constraints, or there may be a need or desire to convey and treat runoff from its source to its destination – like to a drywell.

Options for pursuing this design storm include researching additional monitoring sources for this type of data (not likely to be successful) or to request LCOG to conduct additional analysis with the given data for interpolating theoretical design storms for these type of facilities.

Rainfall Data Sources
In order to develop parameters for a water quality design storm, local rainfall data was needed. A RAWS (Remote Activated Weather Station) site is operated by the Siuslaw National Forest near Honeyman State Park, between Dunes City and Florence (see map, Figure 1). This station records hourly weather observations, including precipitation. Data was acquired for this site from the Western Region Climate Center. The period of record available for the Dunes site was March 1995 to March 2007, with some data gaps (see below)

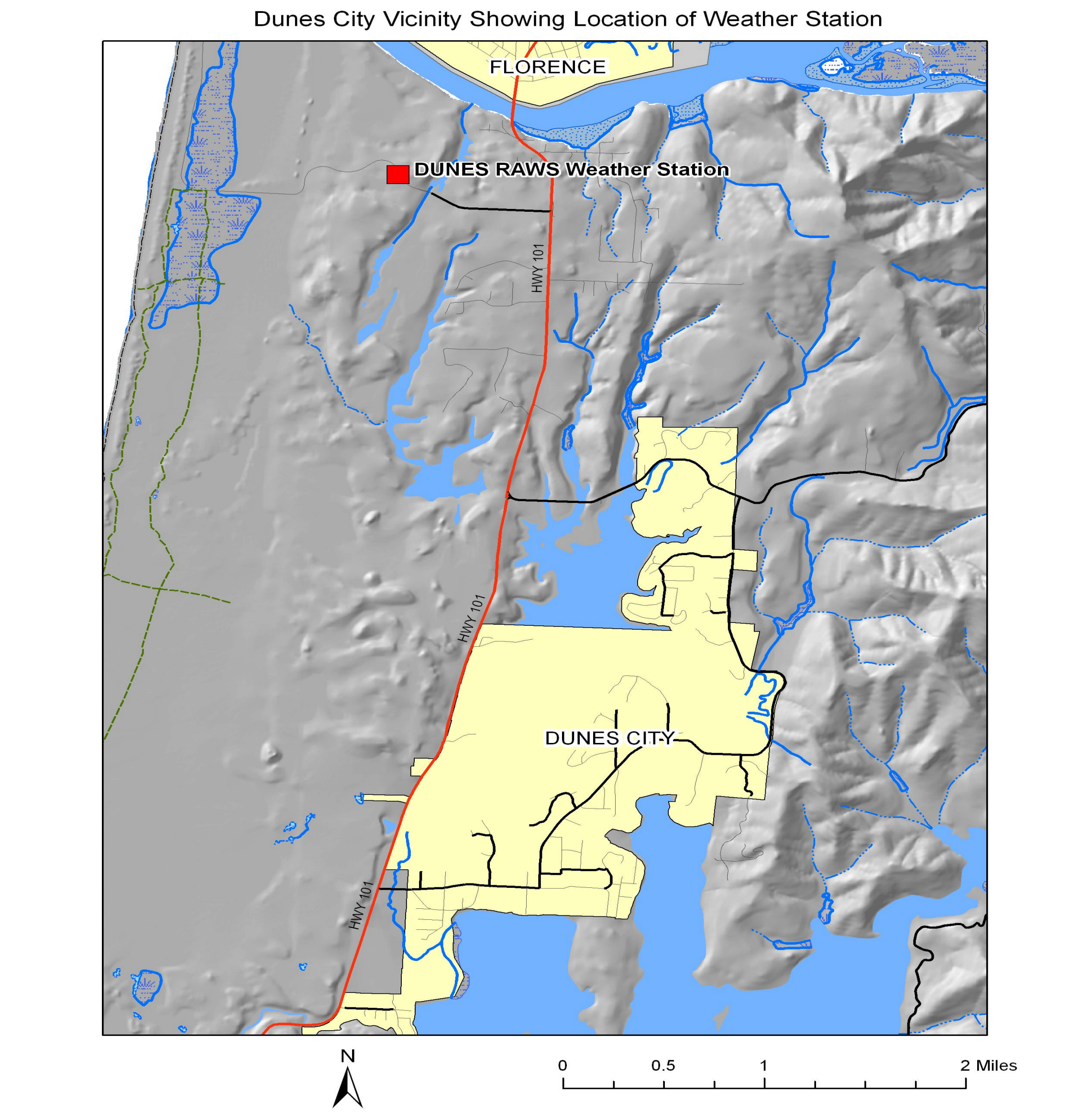
Data Availability

Hourly rainfall data for the Dunes weather station was acquired for the months available shown in **bold** in table 1 below. These data were then examined for anomalies and processed to convert hourly precipitation to step accumulated values. An output text file of hourly rainfall was created as an input to the SYNOP analysis.

Table 1: Data availability for Dunes, Oregon RAWS station

2007	**Jan**	**Feb**	**Mar**	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2005	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2004	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2003	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2002	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2001	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2000	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1999	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1998	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1997	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1996	Jan	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1995	Jan	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	Dec

Figure 1: Map of Dunes City and Dunes RAWS station



Rainfall Data Analysis Procedures

In order to analyze the rainfall data, EPA Storm Water Management Model (SWMM) version 4.4h was used. SWMM 4.4h contains the RAIN block routine that implements the Synoptic Rainfall Data Analysis Program (SYNOP). This program produces a summary and statistical analysis of storm event parameters (e.g., rainfall depths, storm intensity, storm duration) and of annual and monthly rainfall totals. Once the input data file was prepared, the SYNOP analysis was conducted using an inter-event time of 6 hours and a minimum storm depth of 0.1 inches. These parameters match those used in the Eugene water quality storm design, with the exception of minimum storm depth. Based on personal communication with Krista Reininga of URS Corporation, who performed the SYNOP analysis for the City of Eugene's stormwater planning, the minimum storm depth was misreported as 0.01 inches in the Water Quality Design Storm Design documentation. A value of 0.1 inches was chosen as a standard measure that is considered the smallest magnitude rainfall event that will produce significant runoff. The inter-event time represents the minimum length of antecedent dry period, in hours, beyond which additional rainfall measurements are considered to be separate storm events. It is used to separate the long-term rainfall record into separate, discrete storm events. It is these storm events that are analyzed to determine what rainfall amount constitutes the 80% storm event.

Water Quality Design Storm Analysis

Output files from the SYNOP analysis were brought into Excel for further analysis to determine the water quality design storm magnitude. The plot in Figure 2 shows the percentage of storm events (Y axis) that are equal or less than a specific storm rainfall depth (X axis). Based on this data, the storm event rainfall total that accounts for 80% of the rainfall events is 1.07 inches, which can be rounded up to 1.1 inches for simplification. Similarly, the 70% rainfall event (0.72 inches) as well as the 90% event (1.63 inches) can be determined. Other parameters of interest for this storm analysis include the average event duration for the 80% storm, which is 18.4 hours. The total number of storms analyzed for these results was 901. Analysis of storms with a 12 hour inter-event time period was also conducted, but as the average duration of these storms was calculated to be almost 32 hours and hence the 6 hour inter-event period was retained for the analysis. Based on the results presented in Figure 2, a design storm rainfall depth of 1.1 inches is required to capture approximately 80% of the average annual runoff from a site.

Comparison with other Jurisdictions

Several jurisdictions have adopted water quality design storm standards. The following tables present the water quality requirements for Portland, Gresham, Unified Sewerage Agency (USA), and Eugene with proposed standards for Dunes City. Note that for flow-through type facilities.

Table 2 – Water Quality Design Storm Comparisons

Jurisdiction	Average Annual Rainfall (inches)	Water Quality Design Storm			
		Detention Type Facilities		Flow-through Type Facilities	
		Total Rainfall (inches)	Storm Event Duration (hours)	Off-Line Facilities	On-Line Facilities
Portland	34	0.83	24 hour	Not Specified	Not Specified
Gresham	34	1.2	12 hour	0.11 in/hr	0.20 in/hr
USA	40	0.36	4 hour	Not Specified	Not Specified
Eugene	51	1.4*	24 hour	0.13 in/hr	0.22 in/hr
Dunes City	70	1.1*	24 hour	Not Specified	Not Specified

*To capture and treat 80% of average annual rainfall.

As shown in Table 2, if average annual rainfall is assumed to be an indicator for estimating water quality design storm, then it would be logical to assume that Dunes City's design storm would be higher than Eugene's by as much as 37%, which could bump Dunes City's design storm to 1.89 inches per hour. According to Figure 2, this volume would capture and treat 90+% of the average annual rainfall.

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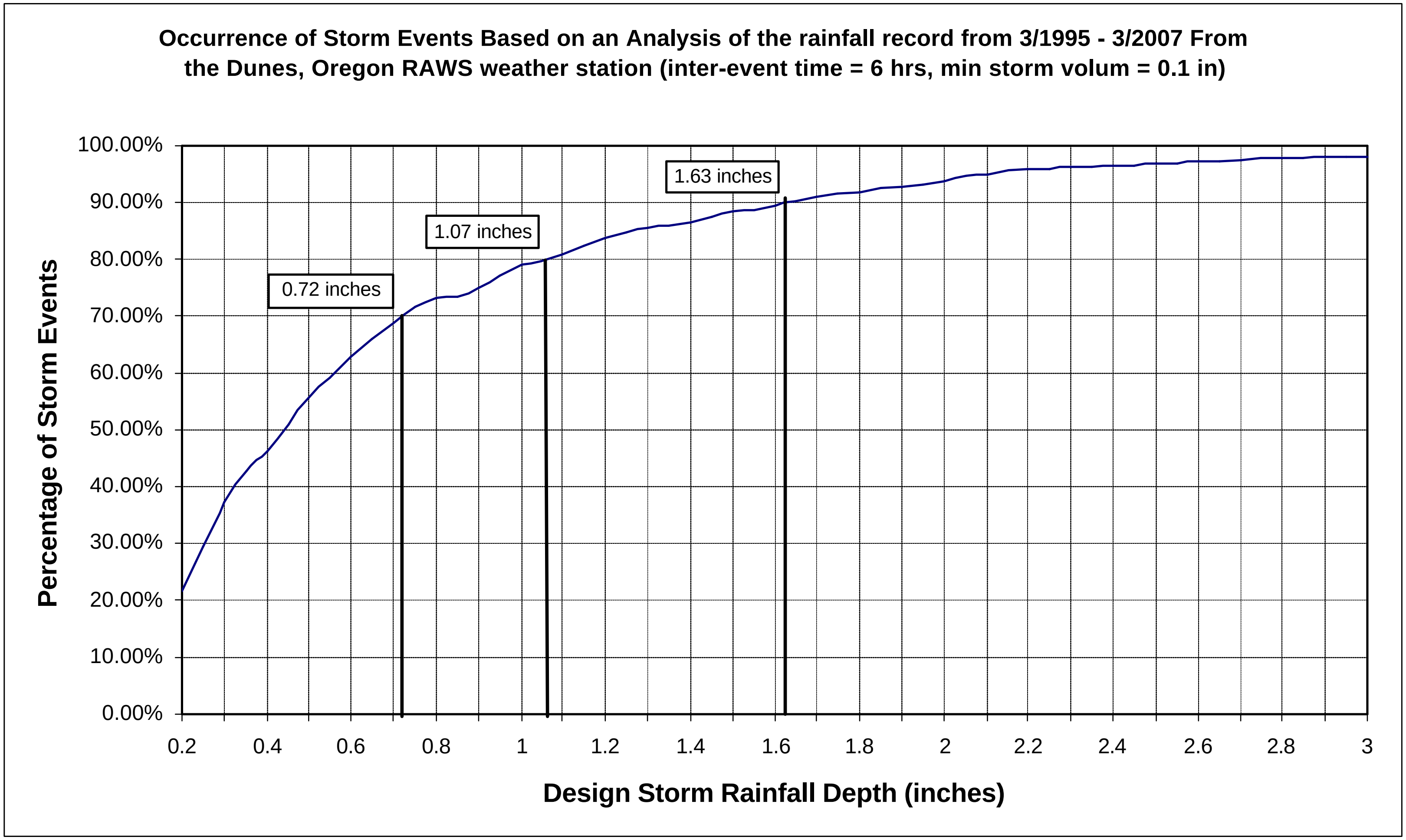
Figure 2: Storm Occurrence



FLOOD CONTROL DESIGN STORM DEVELOPMENT

Purpose
The purpose of this analysis is to provide Dunes City with an initial flood standard for containing runoff on-site in conjunction with addressing water quality design storm requirements. In addition, this standard will enable flow control requirements for addressing runoff from new streets.

For Dunes City, the estimated 5-year storm event within a 24 period would yield 4.11 inches.

Methods
In order to develop the flood control design storm characteristics, an analysis of specific recurrence interval and storm duration parameters was requested. NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published in 1973, was used to derive precipitation frequency values for Dunes City corresponding to 24 hour storms at 2, 5, 10, 25, 50, and 100 year recurrence intervals.

The Hydrometeorological Design Studies Center, part of the National Weather Service's Office of Hydrologic Development, provides a web-based means to derive a subset of precipitation frequency values, based on latitude and longitude of the location of interest. A location near the center of Dunes City was chosen, results are shown below.

Table 4
NOAA Atlas 2 - Oregon 43.9 N 124.1 W (Dunes City) ***Site-specific Estimates***

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.62	0.27
2-year 24-hour	3.46	0.14
100-year 6-hour	3.15	0.53
100-year 24-hour	6.72	0.28

In order to derive the 5 – 50 year recurrence interval 24 hour events, the NOAA Atlas 2 maps must be referred to. Results are shown in Table 5 below, and combined with the site specific estimates derived above.

Table 5 - NOAA ATLAS 2

Event	Precipitation (inches)
2-year 24-hour	3.46
5-year 24-hour	4.11
10-year 24-hour	4.53
25-year 24-hour	5.35
50-year 24-hour	5.85
100-year 24-hour	6.72

For durations other than 6 and 24 hours, a process described in the NOAA 2 Atlas was followed. First, a regression equation was used to derive the 1-hour duration storms for the 2 through 100 year recurrence intervals. Oregon is divided into five regions, for which regression equations were derived. Dunes City is located in Region 1: Coastal Plains, Puget Sound Region, and Willamette Valley below 1000 feet. The 2 and 3 hour duration events are calculated by plotting the 1 and 6 hour events. The 12 hour events are calculated by plotting the 6 and 24 hour event values. Finally, ratios of the 1 hour storm are used to calculate the storm values for the 5, 10, 15, and 30 minute rainfall events. See Table 6 below.

Table 6 – Storm Event Durations

Total Rainfall (inches)										
Recurrence	5 minute	10 minute	15 minute	30 minute	1 hour	2 hour	3 hour	6 hour	12 hour	24-hour
2-year	0.16	0.25	0.31	0.43	0.55	0.83	1.1	1.62	2.51	3.46
5-year	0.19	0.30	0.38	0.52	0.66	0.97	1.25	1.9	3.2	4.11
10-year	0.23	0.35	0.44	0.62	0.78	1.07	1.44	2.18	3.5	4.53
25-year	0.26	0.41	0.52	0.72	0.91	1.25	1.63	2.47	4	5.35
50-year	0.30	0.46	0.59	0.81	1.03	1.5	1.82	2.8	4.4	5.85
100-year	0.33	0.51	0.64	0.89	1.12	1.63	2.05	3.15	5	6.72
Rainfall Intensity (inches/hour)										
Recurrence	5 minute	10 minute	15 minute	30 minute	1 hour	2 hour	3 hour	6 hour	12 hour	24-hour
2-year	1.90	1.47	1.25	0.86	0.55	0.42	0.37	0.27	0.21	0.14
5-year	2.30	1.78	1.50	1.04	0.66	0.49	0.42	0.32	0.27	0.17
10-year	2.71	2.11	1.78	1.23	0.78	0.54	0.48	0.36	0.29	0.19
25-year	3.17	2.46	2.07	1.44	0.91	0.63	0.54	0.41	0.33	0.22
50-year	3.58	2.78	2.35	1.63	1.03	0.75	0.61	0.47	0.37	0.24
100-year	3.91	3.03	2.56	1.77	1.12	0.82	0.68	0.53	0.42	0.28

These values were then converted to rainfall intensity in inches per hour and plotted as shown in Figure 3. Actual values for both rainfall event magnitude and intensity are shown in the tables below.

Flood Control Design Storm Conclusions

Dunes City is limited at this time in establishing comprehensive flood control design standards at a broad scale.

For on-site containment for individual lot development the 5-year design storm with a total volume of 4.11 inches, as shown in Table 5.

Figure 3 - Rainfall Intensity, Duration, and Frequency Curves for Dunes City, Oregon