STORM WATER MANAGEMENT GUIDE FOR DEVELOPMENT AND CONSTRUCTION

BMP MANUAL

(Appendix A - Storm Water Management Plan)

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Roy City Corporation
5051 South 1900 West
Roy , Utah 84067

801-774-1090

Prepared by

Wasatch Civil Consulting Engineering
5320 South 1950 West, Suite 1
Roy, Utah 84067
(801) 775-9191

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SECTION 1

DRAINAGE PLAN APPROVAL

1.1 PURPOSE

This document describes the approval process, design standards, and computation methods for design of storm water facilities in Roy City. Public and private drainage systems shall conform to the requirements listed in this document and to the requirements of the City's Storm Drain Master Plan.

1.2 APPROVAL PROCESS

Drainage plan review and approval by the City Engineer and the Public Works Department is required for all multi-lot developments, commercial site plans, and single-lot developments that are 1 acre or larger. Plan requirements and the review process will be conducted as part of the City's subdivision and site plan applications and approval process. Specific drainage related information and requirements are described below:

Conceptual Drainage Plan (Submit with the Concept Plan Application)

- Provide a general description of existing and proposed on-site drainage features, characteristics and facilities.
- Assess the general feasibility of LID and describe planned LID features.
- Identify the point(s) of discharge to the Roy City storm drainage system.
- Identify FEMA floodplain and floodway locations, if applicable.

Preliminary/Final Drainage Plan (Submit with Site Improvement Plans and Subdivision Application)

- Provide a Drainage Design Report prepared by a professional civil engineer registered in the State of Utah. The Drainage Design Report shall include:
  - Details, calculations, and descriptions of methodology sufficient to verify compliance with all design requirements and standards.
  - An analysis of LID feasibility based upon specific site conditions.
  - Identification of LID BMPs (best management practices) included in the design.
  - Storm Water Quality Report (see the template in Exhibit 1).
  - Existing and proposed flow patterns with subbasin boundaries and flow directions.
  - Analysis of existing, downstream storm water facilities (if required by City Engineer).
- Submit a soils report that includes the following drainage related information: soil

types and classifications; minimum depth to groundwater level; and estimated or measured soil permeability. Measured permeability is preferred for design.

- Identify existing and proposed drainage facilities including: storm drain pipes, inlets, manholes, cleanouts, swales, channels, LID features, and retention and detention basins.
- Show existing and proposed site topography (2-foot maximum contour interval). The topography information should extend beyond the site (100 feet recommended) as required to identify any potential grading problems and impacts to adjoining properties.
- Address all review comments from the preliminary drainage plan review and incorporate changes and/or additions into the final drainage plan.
- Provide drainage easements for public facilities outside the public right-of-way.
- Show engineering and design related features of the storm water pollution prevention plan (SWPPP) on the design drawings.
- Submit a SWPPP (sites 1 acre, or larger or part of a common plan of development). Complete and submit the SWPPP checklist.
- Provide a signed maintenance agreement for private storm water facilities and post-construction best management practices.
- Obtain a Storm Water Construction Activities Permit and Dust Control Permit from the Utah Division of Water Quality. Submit copies of the permits to Roy City Public Works.
- Obtain a Roy City Land Disturbance Permit.

Approvals

- Approval of site and development plans is indicated by signature blocks and initials on the approved plan set. Plan approval is required from the Roy City Planning Department, Public Works, and City Engineer.
- Approval of the drainage and LID design features (structural controls) is provided by the signature of the City Engineer on the approved plans.
- Approval of engineering related SWPPP features is indicated by the City Engineer's signature on approved plans.
- Approval of the SWPPP and construction site BMPs is indicated by Roy City Public Works issuing a Land Disturbance Permit.

A preconstruction conference is required before beginning construction. The preconstruction conference provides a final check to verify: approved construction drawings; approved SWPPP; and completion of all required permits and approvals. The Storm Water Superintendent will verify completion of all requirement prior to issuing the Land Disturbance Permit.

Any person who disagrees with the conditions or requirements for approval imposed by the City Engineer or Public Works Department can appeal to the City Manager. Appeals must be submitted in writing within 15 days of the issuance of comments or denial of approval. The City Manager or the City Manager's designee will issue a decision on the appeal.

SECTION 2

LOW IMPACT DEVELOPMENT

2.1 PERMIT COMPLIANCE

The Utah Department of Environmental Quality, Division of Water Quality authorizes Roy City to discharge storm water to the Waters of the State of Utah by a General Permit for Discharge from Small Municipal Separate Storm Sewer Systems (MS4 Permit). The State's MS4 Permit requires the following from permittees:

> *For new development or redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, the program shall include a process to evaluate and encourage a Low Impact Development (LID) approach which promotes the implementation of BMPs that infiltrate, evapotranspire or harvest and use storm water from the site to protect water quality. By March 1, 2020, the program shall include a process which requires the evaluation of an LID approach for new development or redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale. Structural controls may include green infrastructure practices such as rainwater harvesting, rain gardens, permeable pavement, and vegetated swales. If an LID approach cannot be utilized, the Permittee must document an explanation of the reasons preventing this approach and the rationale for the chosen alternative controls on a case by case basis for each project.*

2.2 LOW IMPACT DESIGN (LID) STRATEGIES AND PRINCIPLES

LID refers to engineered systems, either structural or natural, that use or mimic natural processes to promote infiltration, evapotranspiration, and/or reuse of storm water as close to its source as possible to protect water quality and aquatic habitat. LID practices at the regional and site specific level preserve, restore, and create green space using soils, vegetation, and rainwater harvesting techniques. These systems and practices are referred to as best management practices (BMPs).

LID is intended to minimize downstream storm water runoff impacts by managing runoff where it is generated. The goal of LID is to manage runoff so the post-development hydrologic conditions mimic pre-development conditions. LID features allow natural infiltration and evapotranspiration to reduce overall runoff volumes and peak flow rates. These features can also benefit water quality by treating and filtering storm water near the runoff source. By implementing LID principles and practices, water can be managed in a way that reduces negative environmental impacts often associated with developed areas and promotes the natural movement of water within the area. General LID strategies and principles include:

- Preserve and recreate natural landscape features
- Minimize directly-connected impervious area
- Comprehensive, landscape-based approached to sustainable development
- Utilize natural hydrologic functions and processes
- Focus on prevention, rather than mitigation
- Emphasize simple, low-tech, low cost methods
- Manage storm water runoff as close to the source as possible
- Minimize disturbance
- Increase drainage flow paths
- Utilize onsite filtering and treatment methods

2.3 LID STANDARDS

Implementation Requirements - Development and redevelopment projects that disturb one acre or more, including projects less than one acre that are part of a larger common plan of development, are required to evaluate feasibility of LID and include LID features where practical. Although LID standards for redevelopment projects will only be required for the increased impervious area, retrofitting existing sites is encouraged.

Determination of Feasibly - Developers/owners and their design professionals are responsible to evaluate LID feasibility and practices. Site conditions such as collapsible soils, low permeability, wetlands, drinking water source protection zones and high groundwater levels can limit the types of LID facilities that are effective. See Section 2.4 of this Design Manual for a more detailed discussion of feasibility.

If the developer and/or design professional believes that LID facilities are impractical or LID design standards cannot be achieved, they must submit documentation supporting their conclusions. The documentation must demonstrate that infiltration, evapotranspiration, and rainwater harvesting have been used to the maximum extent technically feasible and that full employment of LID facilities are not feasible due to site constraints.

Design Standards - Apply the following design standards:

- Project Volume Retention Goal - Retain the volume of runoff generated with the project's limits of disturbance over a 24-hour period during the 80th percentile storm. Based upon precipitation records from the Ogden-Hinckley Airport, the **Roy City 80th percentile storm event is 0.5 inches**.
- Consider water quality related LID practices for all projects, even if on-site retention is impractical.

2.4 BEST MANAGEMENT PRACTICES

Utah's Division of Water Quality (DWQ) has produced a guidance manual titled "A Guide to Low Impact Development in Utah" (DWQ Manual). The full document can be found here:

https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

The DWQ manual provides background and technical information on LID best management practices (BMPs), maintenance practices, selection of appropriate plant materials, methods to retain the volume generated from the design storm event, and other relevant information needed to assist developers and design professionals in making the best possible decisions for their LID design. Developers and design professionals should consult the full document for detailed design guidance.

The DWQ Manual refers to a 90th percentile design storm. The current DWQ requirement is for an 80th percentile design storm, and the 80th percentile storm is the standard applied by Roy City. The same design principles, methodologies, and calculations apply, regardless of the design storm standard.

The following sections summarize key information from the DWQ manual.

Site Considerations

Selection of appropriate LID BMPs requires consideration of the specific site conditions. Gather subsurface, geotechnical, topographical, and any other technical information about the site to incorporate into the site design. Site conditions will dictate an appropriate LID approach by revealing opportunities and limitations. The following criteria should be evaluated.

Soils - Soil characteristics will determine if certain LID approaches are feasible. Soils that are classified as Hydrologic Soil Group 'A' are generally acceptable for bioretention and infiltration BMPs. 'B' soils may be marginal for infiltration and bioretention. 'C' and 'D' soils generally have limited capacity for bioretention and infiltration. Figure 1 is a map showing hydrologic soil groups from NRCS mapping in Roy City. This map is a general guide to soil conditions, but soil variability is much more complex than indicated on the figure. It is recommended that Figure 1 be used for general planning, but site specific evaluations and measured permeability are recommended for BMP evaluation and design.

Groundwater - Infiltration BMPs should not be utilized within areas of shallow groundwater as it may lead to flooding of the BMP or introduction of pollutants into the groundwater. Measurements should be taken at each BMP location to determine the depth to the historical high groundwater. Project sites with contaminated groundwater may not be appropriate for infiltration due to the potential for mobilizing the contamination into new areas.

Drainage Patterns - Drainage patterns will be readily evident for any redevelopment project either from visual observation or from plan sets. Determine the constraints introduced by the existing storm drain network such as pipe capacity and inlet and outlet elevations. For new development projects, determine the existing drainage patterns as determined by the site's topography. It is more likely that the site's pre-development hydrology can be mirrored if the design maintains the original drainage patterns and paths.

Existing Pervious Areas and Vegetation - If existing pervious areas can support bioretention or already provide bioretention, maintain them or otherwise make them a part of the site design. Taking advantage of natural depressions or areas of vegetation is an ideal and cost-effective alternative to grading and design. Preserve existing trees and other vegetation on-site when possible.

Site Design Practices

Storm water treatment and retention is most effective when done close to its source. Site design practices accomplish this by taking advantage of approaches that are not necessarily quantifiable but are aimed at reducing the overall impact of the development.

Reduction of Impervious Surfaces - Reducing impervious surfaces, preserving pervious surfaces, or creating pervious surfaces provides multiple benefits to storm water quality. From a storm water quality standpoint, the potential for treatment is higher for runoff that lands on the pervious surface instead of on an impervious surface. Pervious surfaces with healthy soils will infiltrate more runoff from frequent storms. From a design standpoint, increasing the pervious area decreases the total runoff from the site. Pervious surfaces also provide the opportunity to add shade trees or other types of vegetation that will increase the aesthetic appeal of the site.

Disconnected Impervious Areas - The practice of connecting impervious areas to the storm drain network is ubiquitous as traditional designs encouraged the removal of runoff as quickly as possible. This practice leads to increased runoff volume from rain events and increased peak flows. Treatment of runoff is virtually nonexistent as it is conveyed from rooftop to sidewalk to parking lot to catch basin to receiving water, taking with it all the pollutants it encounters in its path. Disconnecting impervious areas by introducing pervious areas or rerouting flows from impervious surfaces (see DWQ Manual for examples) slows down flows and reduces the volume discharged to the downstream storm drain network or removes it entirely. Treatment is also provided through bioretention and biofiltration.

Curb Cuts - Curb cuts can be part of a site plan or be introduced as part of a retrofit program. Curb cuts are a simple way to convey flows from an impervious surface to a pervious surface (see DWQ Manual for examples). Roadways and parking lots are prime locations to investigate whether curb cuts can be used to divert flows from a traditional storm drain network to a pervious area or a bioswale, bioretention or infiltration area, or another type of BMP.

Additional site design practices: Additional practices that should also be consider for LID include the following:

- Preserving natural areas
- Site reforestation

- Stream and shoreline buffers
- Open space design
- Disconnecting rooftop and impervious discharges and distributing runoff
- Soil compost amendments
- Grass channels
- Storm water landscaping
- Reducing impervious cover in site design
  - Narrower/shorter driveways
  - Smaller parking lots

Acceptable BMPs for LID

As part of the subdivision, site plan, and project review process, Roy City will review LID designs to verify that the designs and practices are consistent with the City's permit requirements. The developer and design professionals are required to prepare a Drainage Design Report and a Storm Water Quality Report (see template in Exhibit 1) for documentation of design parameters, methodology, and calculations. Documentation needs to be sufficient to show compliance with City and DWQ requirements.

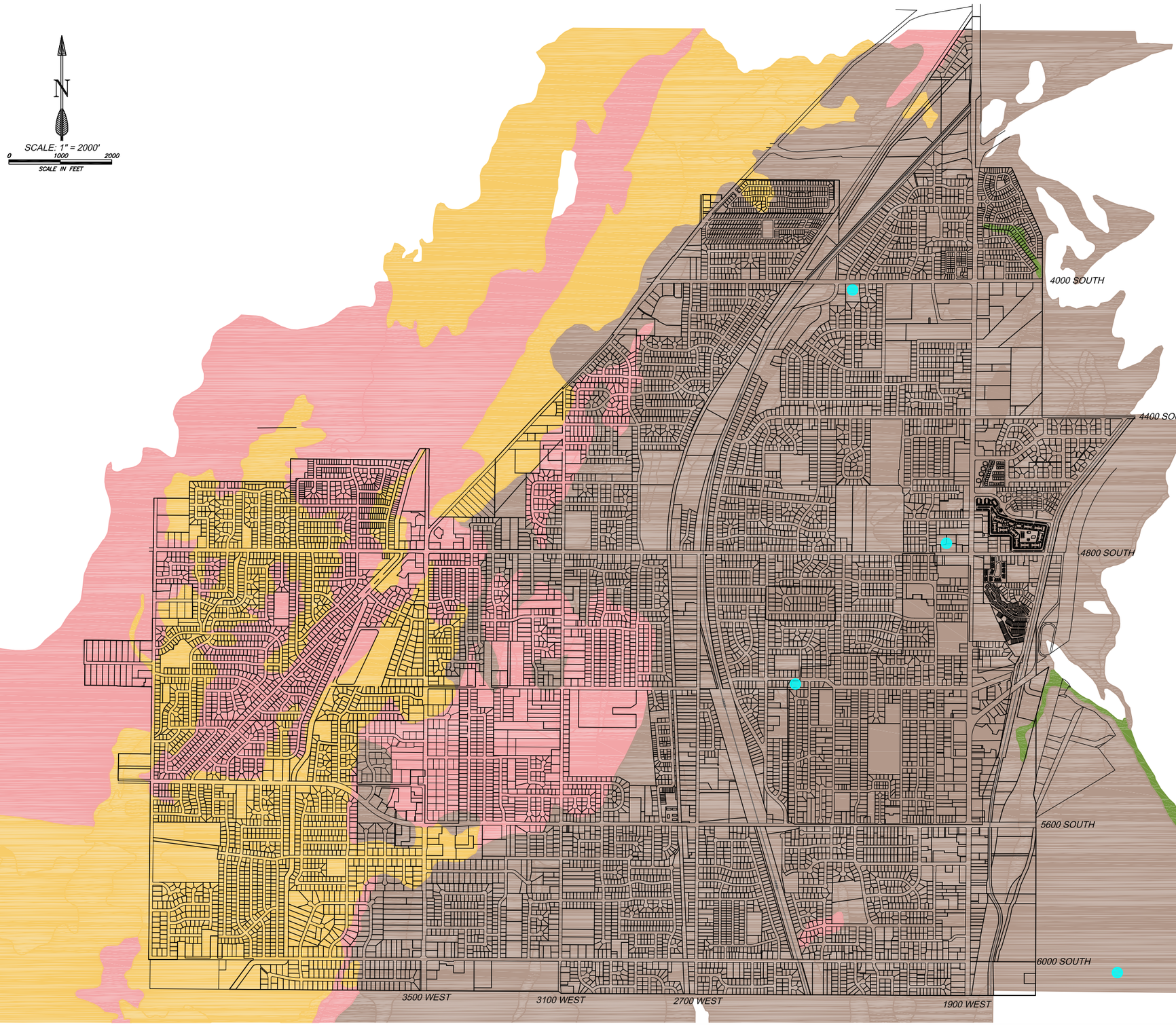
DWQ has developed fact sheets for 12 LID BMPs. These fact sheets provide guidance for the more common BMPs. However, BMP selection is not limited to those on this list. The LID BMPs recommended by the DWQ are approved for use in Roy City if they are properly designed and appropriate for site conditions. Design professionals and contractors hired by the developer/owner are responsible for the selection, design and construction of appropriate LID BMPs. DWQ fact sheets for recommended LID BMPs are included in Exhibit 2 of this document. A summary of the recommended LID BMPs is provided in the table below.

SUMMARY FOR LID BMPS

LID BMP Type	DEQ Fact Sheet ID	BMP Category	Hydrologic Soil Groups	Comments
Rain Garden	BR-1	Bioretention	A, B	May be applicable for Hydrologic Soil Groups C & D if an underdrain is used
Bioretention Cell	BR-2		A, B	
Bioswale	BR-3		A, B, C, D	
Vegetated Strip	BR-4		A, B, C, D	
Tree Box Filter	BR-5		A, B	
Green Roof	BR-6		Not Applicable	
Pervious Surfaces	PS-1	Pervious Surface	A, B	
Infiltration Basin	ID-1	Infiltration Devices (See Note 2)	A, B	Pre-treatment is required (See Note 1).
Infiltration Trench	ID-2		A, B	
Dry Well	ID-3		A, B	Pre-treatment is required (see Note 1). Dry Wells must be registered as an Underground Injection Control Class V well.
Underground Infiltration Galleries	ID-4		A, B	Pre-treatment is required (see Note 1).
Harvest and Reuse	HR-1	Harvest and Reuse	Not Applicable	Must confrom to Utah Division of Water Rights rules and regulations.

Notes:
1. Pre-treatment can be a vegetated strip (BR-4) or a manhole with a grease/oil separator (See Exhibit 4 - Pre-Treatment BMP Detail).
2. Infiltration BMPs are not be allowed within Zone 1 Drinking Water Source Protection Zones (100 foot radius around culinary water wells).

ROY CITY HYDROLOGIC SOIL GROUPS AND DWSP ZONES



HYDROLOGIC SOIL GROUP	ESTIMATED PERMEABILITY (IN/HR)
A	> 2.0
B	0.2 - 2.0
C	0.63 - 0.2
D	< 2.0

LEGEND

- HYDROLOGIC GROUP A
- HYDROLOGIC GROUP B
- HYDROLOGIC GROUP C
- HYDROLOGIC GROUP D
- DWSP ZONE 1

PREPARED BY:

FIGURE # 1. ROY CITY HYDROLOGIC SOIL GROUPS AND DWSP ZONES

WASATCH CIVIL
Consulting Engineering
1150 SOUTH DEPOT DRIVE, SUITE 225
OGDEN, UTAH 84404 (801) 775-9191

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SECTION 3

DESIGN METHODS AND CONSIDERATIONS

Roy City has established design requirements for storm drainage facilities and discharge criteria for both runoff volume and flow rates. Design criteria and methodologies are outlined in this section.

3.1 RUNOFF VOLUME CONTROL (LID)

Design Criteria

The Utah Division of Water Quality (DWQ) has established project volume retention goals for projects or redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development. The retention goal criteria and definitions are as follows:

Project Volume Retention Goal, V_{goal} – The volume of runoff generated within the project' limits of disturbance over a 24-hour period during the 80th percentile storm event.

Water Quality Volume, WQV –The volume of runoff generated within a BMP's drainage area over a 24-hour period during the 80th percentile storm event.

80th Percentile Precipitation Event = 0.5 inches over 24 hours. This precipitation depth is based upon precipitation records from the Ogden-Hinckley Airport and was calculated using the methodology outlined in the DEQ Design Manual.

Methodology

Step 1: Imperviousness

Impervious areas include all pavement, roof tops, and any other areas that prohibit infiltration into the soil. Calculate imperviousness as the ratio of the post-development impervious area to the total drainage area. Include any off-site impervious areas that are part of the BMP's drainage area.

Project imperviousness = Impervious area / Project area (area within disturbance limits)

BMP imperviousness = Impervious area within BMP drainage area / BMP drainage area

Step 2: Volumetric Runoff Coefficient

The volumetric runoff coefficient is a calculation of the fraction of rainfall that results in surface runoff. Runoff coefficients for small, frequent storms, such as for the 80th

percentile storm event, are not equivalent to runoff coefficients for large, less-frequent storms such as the 10-yr storm event. The volumetric runoff coefficient is not equivalent to the runoff coefficient used with the Rational Method. For all the equations presented below, i represents the percent of imperviousness of the drainage area in decimal format (0.0 - 1.0).

Method 1 (Reese, 2006)

$R_v = (0.91)(i) - 0.0204$ (Reese, 2006)

Where: R_v = Volumetric Runoff Coefficient
i = imperviousness (decimal value between 0.0 and 1.0)

Method 2 - Hydrologic Soil Groups

This method provides volumetric runoff coefficient equations derived from imperviousness and the NRCS hydrologic soil groups. (Guo, 2013)

NRCS Soil Group A - $R_v = (0.84)(i)^{1.302}$

NRCS Soil Group B - $R_v = (0.84)(i)^{1.169}$

NRCS Soil Group C/D - $R_v = (0.83)(i)^{1.122}$

Step 3: Retention Volume

Calculate the 80th percentile retention volume using the following equations for V_{goal} and/or WQV.

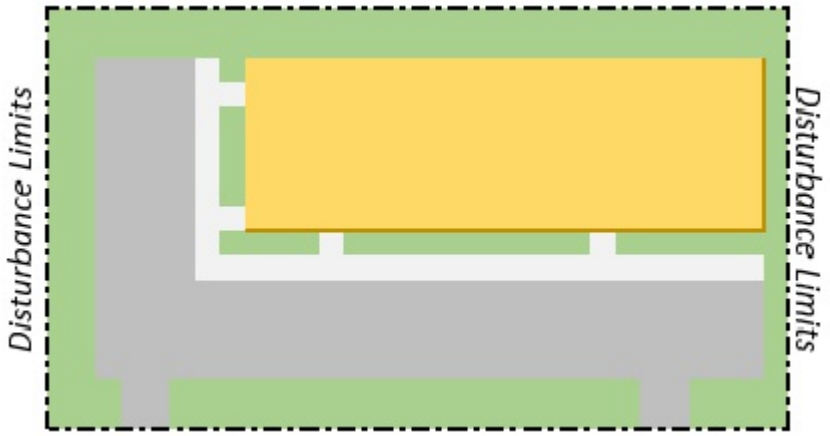
$V_{goal} = (R_v)\ (d/12)\ (A)$ or $WQV = (R_v)\ (d/12)\ (A)$

Where:

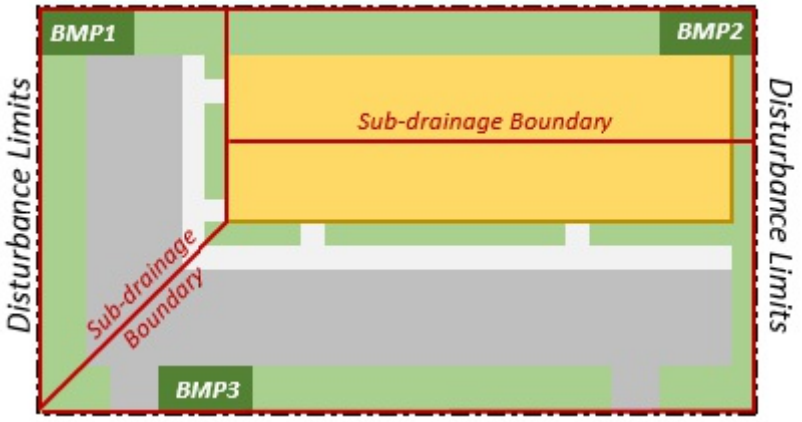
V_{goal} and WQV = 80th percentile volume (cubic feet)
R_v = volumetric runoff coefficient (unitless)
d = 80th percentile precipitation depth (0.5 inches)
A = project area or BMP drainage area, (sq. ft)

The two images on the following page show how V_{goal} and WQV are related.

V_{goal} - The project's 80th percentile volume retention requirement calculated for the entire area within the disturbance limits



WQV - The 80th percentile volume of the sub-drainage area of each BMP.



Note: If the BMP drainage areas are contained within the disturbance limits (as in the figures above), the sum of the water quality volumes for each BMP ($\sum$WQV) will equal V_{goal}.

3.2 PEAK FLOWRATE CONTROL

The hydrologic criteria used for storm drain facility planning and design shall generally follow the hydrologic criteria recommended by Weber County. These criteria are presented in *Storm Drainage Hydrologic & Hydraulic Criteria Manual* (Hansen, Allen & Luce, 2002), herein after referred to as the Weber County Manual. The following discussion summarizes the hydrologic criteria from the Weber County Manual.

Drainage Design Frequency

Selecting the drainage design frequency is dependent upon dividing the storm drainage facilities into an initial storm drainage collection system and a major storm drainage collection system. The initial system and major system are described in the *Urban Storm Drainage Criteria Manual* (Urban Drainage and Flood Control District, Denver, Colorado, June 2001) as follows:

> "Every urban area has two separate and distinct drainage systems, whether or not they are actually planned for and designed. One is the initial system, and the other is the major system. To provide for an orderly urban growth, reduce costs to future generations, and obviate loss of life and major property damage, both systems must be planned and properly engineered."

The initial storm drainage system is the facilities which provide protection against regularly recurring damage from storm runoff. Initial drainage system components include the street curb and gutter or drainage swells, and storm drain pipe systems. The initial system should be designed to safely convey the 10-year storm event without significantly restricting pedestrian or vehicle traffic. In streets with curb and gutter, the design standard is that the curb is not overtopped by runoff from the10-year storm event.

The major storm drainage system is the facilities that protect people and structures during a major storm. Major storm drainage facilities may include streets (including overtopping of the curb onto the lawn area), large conduits, open channels, and regional detention basins. The major system should generally be designed for the 100-year event with the objective of preventing major damage to homes and buildings and to prevent loss of life. This does not mean that storm drains (which are considered part of the initial storm drainage system) should be designed for the 100-year event. It means that the combination of storm drains and channelized surface flow, which may include using part of the grassed frontage area of a home as part of a 100-year channel, should be designed to accommodate the 100-year event thereby preventing damage to homes. In Roy City, the major storm drainage system includes sloughs, detention basins, and conveyance facilities across canals.

Design Rainstorm

Storm water facilities shall be designed using a design rainfall distribution appropriate for conditions and design methodology. Critical runoff events from urban areas along the Wasatch Front are caused by cloudburst type storms which are characterized by short periods of high intensity

rainfall. The Weber County Manual presents a 3-hour synthetic storm distribution that incorporates the high intensity rainfall burst typical of storms along the Wasatch Front. The rainfall distribution from the Weber County Manual is recommended for storm drain modeling and design. Design flowrates based upon the rationale method will be calculated using a storm duration determined by calculated time of concentration.

Design storm precipitation depths for Roy City were developed using the NOAA Atlas methodology as recommended in the Weber County Manual. Acceptable general values for use in Roy City are presented below.

Design Rainfall Depths (inches)

Return Period (Yrs)	Storm Duration							
	10 min	15 min	30 min	1 hr	2 hr	3 hr	6 hr	24 hr
2	0.25	0.31	0.42	0.52	0.65	0.75	1.00	1.58
10	0.43	0.53	0.71	0.88	1.02	1.11	1.40	2.14
100	0.85	1.06	1.42	1.76	1.94	1.99	2.21	3.04

Design Rainfall Intensities (inches per hour)

Return Period (Yrs)	Storm Duration							
	10 min	15min	30 min	1 hr	2 hr	3 hr	6 hr	24 hr
2	1.51	1.24	0.84	0.52	0.33	0.25	0.17	0.066
10	2.57	2.12	1.43	0.88	0.51	0.37	0.23	0.089
100	5.11	4.24	2.84	1.76	0.97	0.66	0.37	0.13

Site specific precipitation depths, as obtained from the NOAA website, are the preferred rainfall depths and intensities for facilities design.

Design Criteria for Peak Flowrates

Storm drainage facilities must be designed to safely convey runoff from the project site and from upstream tributary areas. Storm drainage facilities shall be designed based upon the storm return periods and criteria as given in the following table.

Design Criteria - Return Periods

Description	Design Storm	Specific Facilities
Initial System	10-Year	Curb & gutter, drainage swells, inlets, storm drain pipes
Major System	100-Year	Commercial and regional detention basins, large pipes, channels,
Temporary Facilities	2-Year*	Detention, berms, and drainage channels for construction sites

* A higher design standard may be required by the City Engineer if exceeding the temporary facility capacity could damage neighboring property, threaten public safety, or cause significant negative impacts to water quality.

Detention Basin Requirements and Design Criteria

Detention basins are required for the following: 1) commercial development; 2) institutional or other development with large impervious areas; 3) residential development in areas without adequate regional detention facilities; and 4) any development where the downstream storm drain system is inadequate, as determined by the City Engineer. Detention basins shall be designed to contain the 100-year storm event with a peak release rate of 0.2 cfs per tributary acre. Detention basins shall be designed with an emergency overflow designed to safely spill to the downstream major storm drain system without damaging property or threatening public safety. **The storage volume required for detention can be reduced by the water quality retention volume provided by LID design.**

Analysis Methods for Flowrate Calculations

Storm water runoff flowrates and volumes shall be calculated using methodology acceptable to the City Engineeer. Storm water modeling is required for large basins (greater than 30 acres) and for complex drainage systems with multiple detention basins. The rational method can be used for smaller basins with single detention basins for the same tributary area. The following analysis methodologies are recommended:

- Storm drainage system modeling - HEC- HMS Flood Hydrograph Package
- Runoff from Urban Areas - Kinematic Wave
- Runoff from Agricultural or undeveloped areas - SCS Unit Hydrograph
- Small Urban Basins - Rationale Method

3.3 WATER QUALITY AND BEST MANAGEMENT PRACTICES (BMPs)

The Utah Division of Water Quality mandates consideration of water quality impacts as part of the storm water facility design process. Developers/project designers are required to consider and to select appropriate permanent BMPs (LID and post construction BMPs) to minimize negative impacts of the development on water quality. LID requirements are discussed in previous sections. Post Construction BMPs that should be considered by the developer are attached. The developer must identify which BMPs are selected and indicate the justification for the selection. The Drainage Report should document the BMP selection process and should include the following water quality information:

- Expected pollutants
- Considered BMPs
- A discussion of selected BMPs and how they will improve water quality; or a discussion of why BMPs are not feasible for the project

Roy City will evaluate the selected BMPs selected and may require additional BMPs if, in the judgement of the Storm Water Superintendent or City, the proposed BMPs fail to adequately address water quality impacts. An evaluation of water quality impacts will be required as part of the plan review for a Land Use Disturbance Permit.

3.4 DRAINAGE REPORT REQUIREMENTS

Developers are required to provide a Drainage Report by a licensed professional engineer (State of Utah). The Drainage Report shall be submitted to the City Engineer for review and approval as part of the development or site approval process. At a minimum, the Drainage Report shall include the following:

LID Design

- Storm Water Quality Report (see the attached template)
- A soils report that includes the following drainage related information: soil types and classifications; minimum depth to groundwater level; and estimated or measured soil permeability. Measured permeability is preferred for design.
- Calculations of the project retention goal and water quality retention goal (for each BMP).
- Calculations of BMP retention volumes provided by the design.

Conveyance Design and Detention Design for Limiting Peak Discharge

- Identification of the methodologies and procedures
- Design storm depths/intensities
- Runoff flowrate calculations for all pipes and other key points in the system
- Required detention volume calculations with outlet hydraulics

- Calculated hydraulic capacities of pipes, ditches, channels, and structures (when appropriate)
- Calculated design detention volumes to the high water mark
- Storm water quality information and discussions as indicated above

3.5 ENVIRONMENTAL COMPLIANCE

Project design and construction must comply with Federal and State laws pertaining to threatened or endangered species, historic properties, and wetlands. Where applicable, documentation of compliance to these laws shall be submitted to Roy City for review and verification.

Threatened and Endangered Species

As of January 2021, the Utah Department of Natural Resources has identified the following threatened and endangered species as potentially being located in Weber County:

Common Name	Scientific Name	Status
Ute Ladies'-Tresses	Spiranthes diluvialis	Threatened
Monarch Butterfly	Danaus plexippus	Candidate
Greater Sage-grouse	Centrocercus urosphasianus	Resolved
Yellow-billed Cuckoo	Coccyzus americanus	Threatened
Canada Lynx	Lynx canadensis	Threatened
Gray Wolf	Canis lupis	Recovery
Least chub	lotichthys phlegethontis	Resolved

Developers should review the U.S. Fish and Wildlife Service web site for more extensive listings of threaten and endangered species and habitat descriptions. If habitat for the listed species is identified on the project site, then documentation of compliance with the Endangered Species Act should be submitted. Contact the local office of the U.S. Fish and Wildlife Service at 801-975-3330 for consultation under the Endangered Species Act.

Historic Properties

If historic properties are suspected in the project area, the developer will be required evaluate the site and receive concurrence from the appropriate State or Federal agency.

Wetlands

If known or suspected wetlands will be disturbed by the project, the developer will be required to delineate the wetlands, receive concurrence from the Army Corps of Engineers, and obtain the appropriate permit.

SECTION 4

CONSTRUCTION STORM WATER MANAGEMENT

4.1 GENERAL REQUIREMENTS

All construction projects regardless of size or extent are required to comply with Roy City Public Works Standards and appropriate construction BMPs (see attached). BMPs for construction should be selected and designed according to the attached BMP list. Variations from Roy City Public Works Standards and approved BMPs require approval by the City Engineer. Construction details associated with the BMPs are attached.

Projects that disturb 1 acre or more (or are part of a common plan that disturbs 1 acre or more) are required to obtain a Storm Water Construction Activities Permits from the Utah Division of Water Quality and a Land Disturbance Permit from Roy City prior to beginning of construction activities. A Land Disturbance Permit may be required for smaller projects or activities if, in the discretion of the Storm Water Superintendent, pose a unique threat to water quality, or public health or safety. After receiving plan approval and prior to any construction activities, a preconstruction meeting will be held with the developer and contractor. A checklist outlining key tasks in the process for construction storm water approval is attached.

4.2 SWPPP REQUIREMENTS

All construction projects that disturb 1 acre or more or are part of common plan that disturbs 1 acre or more shall prepare a storm water pollution prevention plan (SWPPP) that meets current Utah Division of Water Quality and UPDES permit requirements. SWPPP information, guidelines, and a template are available from the Utah Department of Water Quality website:

https://deq.utah.gov/water-quality/general-construction-storm-water-updes-permits

The SWPPP should be prepared by a qualified person and submitted to the City for review and approval. A SWPPP review checklist, summarizing the major required elements, is attached. The person preparing the SWPPP should include the completed checklist when submitting the SWPPP for review. The contractor is required to keep an updated copy the SWPPP at the construction site available for public review and inspection.

4.3 CONSTRUCTION INSPECTIONS AND VIOLATION PENALTIES

The contractor and developer are required to comply with Utah Division of Water Quality inspection and record keeping requirements. In addition, Roy City will inspect the construction site for compliance with the Roy City Public Works Standards, approved design drawings, SWPPP requirements, and BMP installation and maintenance requirements. A copy of the Construction Storm Water Inspection Form is attached.

Violations of SWPPP requirements, Roy City Land Disturbance Permit requirements, or State requirements can result in penalties. In general, Roy City will escalate penalties for repeated or subsequent violations according to the following scale.

- Verbal and written warnings
- Stop work orders (project red tag)
- Citation with fine (from $50 to $5,000 per day for each violation)

At the discretion of the Storm Water Superintendent, serious first time violations that represent a signficant threat to water quality, a threat to public safety, or a deliberate illicit discharge can result in a work shut down and/or a citation, even for a first offense. Citation fines amounts will be generally based upon fine amounts imposed by State of Utah for similar violations. The Storm Water Superintendent has the authority (Section 8-4-10 of Roy City Municipal Code) to issue consent orders, compliance orders, and cease and desist orders as needed to correct non-compliance.

Any person who disagrees with issuance of citation or stop work order can appeal to the City Manager. Appeals must be submitted in writing within 15 days of the issuance of the citation or order. The City Manager or the City Manager's designee will issue a decision on the appeal. The City Manager's decision may be appealed to district court. Additional appeal requirements are set forth by Section 8-4-10 of the Roy City Municipal Code.

4.4 HIGH PRIORITY SITES

Roy City will double the required inspection frequency at high priority construction sites. High priority sites are defined as those meeting one or more of the following criteria:

- Immediately adjacent to waterways (Howard Slough)
- Larger than 20 acres
- Average slope steeper than 15%
- More than 3 written violations

4.5 NOTICE OF TERMINATION PROCEDURES

The Notice of Termination formally brings to a close the Construction Activities Permit which allows the discharge storm water from construction sites. The Construction Activities Permit is issued by the Utah Division of Water Quality, and the State of Utah is the entity that grants a termination to that permit. The permit can be terminated after construction is complete and the site is stabilized, or if a new Construction Activities Permit for the site is obtained by another permitee.

When a construction site is nearing completion and the permittee is desirous of terminating their permit with the State of Utah for discharging water associated with construction activities, the contractor or developer can initiate the process to submit a notice of termination. The following steps should be taken:

1. The contractor's SWPPP coordinator for the project notifies the city storm water

inspector that they are ready for final inspection.

2. The city storm water inspector visits the site to determine if the site has reached final stabilization as determined by the UPDES Storm Water General Permit for Construction Activities. The city storm water inspector also checks to see if all temporary BMPs have been removed.

3. If there is work still to be completed, the remaining work or deficiencies are described by the city storm water inspector in the additional Comments and Corrective Actions for SWPPP Compliance section of the State's UPDES Storm Water Inspection Evaluation Form for SWPPP Compliance (inspection form). A copy of the completed inspection form will be provided to the SWPPP coordinator.

4. When the city storm water inspector is satisfied that all requirements have been met, the city storm water inspector uses the State's inspection form and completes the Notice of Termination (NOT) Inspection section of that form and sends a copy to the State for their records.

5. The permittee submits the completed NOT form to the Division of Water Quality.

6. The city storm water inspector or designated individual will make required notifications to the Division of Water Quality regarding the site and permit status. Once the State has received confirmation that the site meets all the requirements the Notice of Termination is granted.

7. The site owner/contractor will submit as-built drawings as required by Roy City Municipal Code.

4.6 PROJECT TRACKING AND ACCEPTANCE

The Storm Water Superintendent will track project status, inspections, violations and permit status. A list of current construction projects will be maintained for each fiscal year. A tracking form is included in Exhibit 1.

The City Engineer will perform inspections for conditional and final acceptance. Conditional acceptance requires completion of all site improvements, including post construction BMPs, and verification that improvements were constructed to City Standards and project design requirements. The City Engineer will provide written notice of acceptance or of any deficiencies. After a one-year guarantee period for public improvements, the City Engineer will inspect for final approval. The one-year guarantee period will not apply to private improvements.

SECTION 5

POST CONSTRUCTION STORM WATER MANAGEMENT

5.1 MAINTENANCE AGREEMENTS

Project owners are responsible to maintain of post construction storm water facilities and BMPs so these facilities will continue to function as intended. Maintenance can include repairing or replacing damaged structures, cleaning, and restoring vegetation or other erosion control measures. Maintenance responsibilities for storm water facilities and BMPs on private property will be defined by a maintenance agreement between Roy City and the property owner. A draft maintenance agreement, that can be modified as necessary to fit site specific requirements, is attached.

5.2 INSPECTION AUTHORITY AND ENFORCEMENT PROCEDURES

Roy City will conduct periodic inspections of storm water facilities and BMPs on private property. If deficiencies are found, the responsible party will be notified and corrective actions by the responsible party will be required. If corrective actions are not completed in a timely manner (as defined by the maintenance agreement or City ordinance), then Roy City may complete the corrective actions and bill the responsible party for the cost of the work. Fines or other penalties may also apply as allowed by the maintenance agreement or City ordinance.

EXHIBIT 1

FORMS

Storm Water Quality Report – Template

This is an example of how the suggested report template is completed. Text highlighted in yellow is project specific information. A blank word document of this template can be found here:
https://documents.deq.utah.gov/water-quality/stormwater/DWQ-2018-013750.docx

Date: 9/1/2019

Project Name: Garden Valley Condominiums

Project ID: 999999

Design Engineer: John Doe, PE

Is the project within a watershed that is 303(d) listed? Yes

If yes:

Name of receiving water(s): Little Cottonwood Creek-2

Listed Impairment(s): pH; Cadmium, Dissolved; Copper, Dissolved

Does the watershed have an approved TMDL? Yes

If yes:

Approved TMDL(s): Zinc

I have reviewed the storm water quality design and find this report to be complete, accurate, and current.

[stamp required at final design phase]

Project Manager

[name], Project Manager

Storm Water Coordinator

[name], Designate Storm Water Coordinator

Maintenance

[name], Head of Maintenance

Landscaping

[name], Landscape Architect or Equivalent

Project Information

Type of Project (New Development, Redevelopment): New Development

Area of Land Disturbance (ac): 3.7

Project Impervious Area (ac): 2.9

Project Imperviousness (%): 68

Project Volumetric Runoff Coefficient, R_V: 0.59

90th Storm Depth (in): 0.64

Project 90th Percentile Volume, V_{goal} (cf): 5,110

Subsurface Information

Groundwater

Depth to Groundwater (ft): 17 ft

Historical High Depth to Groundwater if known (ft): 9 ft

Source: Project groundwater monitoring

Groundwater Contamination at Site: None

Soil Information

Infiltration Rate (in/hr): 1.5 in/hr

Hydrologic Soil Group: A

Source: Project geotechnical report

Soil Contamination at Site: None

Drinking Water

Within Drinking Water Source Area Protection: No

Additional Relevant Site Information

LID Drainage Areas

Add additional rows as needed.

Contributing Drainage Area	Area (ac)	Impervious Area (ac)	Imperviousness (%)	Volumetric Runoff Coefficient, R_V	Water Quality Volume, WQV (cf)
CDA 1	0.90	0.50	0.56	0.49	1015
CDA 2	0.75	0.45	0.60	0.53	915
CDA 3	0.80	0.80	1.0	0.89	1654
CDA 4	1.25	0.75	0.60	0.53	1526
				Total WQV (cf)	**5110**

LID BMP Design

Add additional rows as needed.

Contributing Drainage Area	LID BMP Type	Water Quality Volume, WQV (cf)	Runoff Retained (cf)	Percent of Runoff Captured (%)
CDA1	Rain Garden	1015	1023	100
CDA 2	Infiltration Basin	915	920	100
CDA 3	Bioretention Cell	1654	1655	100
CDA 4	Bioretention Cell	1526	1600	100
		Total Volume Retained (cf)	5198	100

Percent of V_{goal} captured by LID BMPs: 100 %

If 100% of V_{goal} is not captured, document and provide narrative of technical infeasibilities and/or alternate compliance measures below:

Describe additional storm water quality measures incorporated into the site:

Roy City - Storm Water Approval Checklist

Project Name: _____

Submitted by: _____

Date: _____

Task Description	**Completed***	**Reviewed****
Environmental compliance (endangered species, historic properties, wetlands)	_____	_____
Storm drainage design and calculations	_____	_____
Selection of construction BMPs		
Selection of post construction BMPs	_____	_____
Maintenance agreement	_____	_____
Storm water pollution prevention plan (SWPPP)	_____	_____
Utah DEQ construction activities permit	_____	_____

* Developer or designer to initial
** Roy City reviewer to initial

Reviewed by _____ Date: _____

Reviewer Comments:

SWPPP Checklist

Project Name: _____

Review Date(s): _____

Reviewer(s): _____

Project Type: Subdivision ☐ Site Plan ☐ City Project ☐

Project Description: Are the following provided?

Project location - street address and/or latitude/longitude	☐ Yes ☐ No ☐ NA
Contact information for project owner\developer	☐ Yes ☐ No ☐ NA
Contact information for all contractors and subcontractors	☐ Yes ☐ No ☐ NA
General project and construction activities descriptions	☐ Yes ☐ No ☐ NA
Size of project (acres or sq. ft.) ==> List: _____	☐ Yes ☐ No ☐ NA
Size of disturbed area (acres or sq. ft) ==> List: _____	☐ Yes ☐ No ☐ NA
Impervious area % (before and after construction)	☐ Yes ☐ No ☐ NA
Runoff coefficients (before and after construction)	☐ Yes ☐ No ☐ NA

Site Map: Does the site map show the following?

Drainage and grading patterns	☐ Yes ☐ No ☐ NA
Limits of construction and disturbance	☐ Yes ☐ No ☐ NA
Areas to be protected (ie. wetlands, streams, vegetation)	☐ Yes ☐ No ☐ NA
Storm drain inlets	☐ Yes ☐ No ☐ NA
Structural BMP locations (sediment controls, inlet protection, perimeter controls)	☐ Yes ☐ No ☐ NA
Non structural BMP locations (sanitation, waste management, seeding, etc.)	☐ Yes ☐ No ☐ NA
Construction entrances	☐ Yes ☐ No ☐ NA
Concrete washout location	☐ Yes ☐ No ☐ NA

Pollution Sources: Are the following pollution sources identified?

Potential sources of sediment	☐ Yes ☐ No ☐ NA
Other pollution sources (concrete washouts, fuel, trash, oil, grease, etc.)	☐ Yes ☐ No ☐ NA

Best Management Practices: Are the following practices designated?

Reduce erosion (ie. minimize disturbed area, phase construction, stabilize soil promptly, and protect slopes)	☐ Yes ☐ No ☐ NA
Control sediment (ie. protect storm drain inlets, establish perimeter control, retain sediment on-site, and stabilize construction exits)	☐ Yes ☐ No ☐ NA
Good housekeeping (ie. sanitation, waste management, vehicle maintenance, chemical handling, and spill response)	☐ Yes ☐ No ☐ NA
Inspection & maintenance requirements for BMPs	☐ Yes ☐ No ☐ NA

Other: Are the following elements included?

Record keeping and training requirements	☐ Yes ☐ No ☐ NA
EPA certification statement (signed by responsible party)	☐ Yes ☐ No ☐ NA

DEFICIENCIES AND CORRECTIONS

Describe Deficiency	**Date Corrected**

SWPPP Recommended for Approval by: _____ Date: _____

EVALUATION OF IMPACTS TO WATER QUALITY

Receiving Water: _____ Distance to Receiving Water: _____

Downstream Regional Detention: ☐ Yes ☐ No

Disturbed Area Size: ☐ Small (0 to 1 acres) ☐ Medium (1 to 5 acres) ☐ Large (5 acres or larger)

Soils and Slope: ☐ Low erosion potential ☐ Medium erosion potential ☐ High erosion potential

Significant Water Quality Impact Potential: ☐ Yes ☐ No

List Post Construction BMPs Selected _____

Explanation:

Approval Signature _____ Date _____

STORM WATER FACILITIES

MAINTENANCE AGREEMENT

The following is a sample maintenance agreement for review by the reader. Actual maintenance agreements will be prepared by the City Attorney and Public Works Department as part of the subdivision and site development approval process.

IN CONSIDERATION OF Roy City ("City") approval for: <subdivision/site name>, at <subdivision/site address>, relating to real property legally described on Exhibit A, which is attached hereto and incorporated by this reference, the undersigned Grantor(s) declares that the above-described property is subject to a privately maintained storm water drainage, detention, best management practices, and/or storm water management system (the,"storm water facilities"), and also covenants and agrees as follows:

DUTIES OF GRANTOR(S):

1. Grantor(s) shall regularly inspect and maintain/repair the private storm water facilities on the said-described property in accordance with the standards specified in the City's Development Standards, Public Works Standards and the Storm Water Management Plan (City Standards), and as necessary for the storm water facilities to function as intended.

2. Grantor(s) shall inspect the storm water facilities as often as conditions require, but in any event at least once each year. Grantor(s) shall, within four weeks after each inspection, maintain/repair the storm water facilities as described in Section 1, above.

3. Grantor(s) shall inspect each element of the storm water facilities whenever the City's Public Works Director ("Director"), in his/her sole discretion, determines that unacceptable conditions exist within or adjoining to the storm water facilities. Similarly, the Director, in his/her sole discretion, may require the Grantor(s) to complete the maintenance/repair of the storm water facilities within a shorter time period than allowed in Section 2, above, if he/she determines that the deficiency poses an imminent danger.

4. Grantor(s), in effecting this maintenance/repair, shall restore the storm water facilities to like new condition, or if that is not practical, to an acceptable condition that complies with City Standards.

5. Grantor(s) is hereby required to obtain written approval from the Director prior to grading, filling, piping, cutting or removing vegetation (except for routine and minor landscape maintenance) in open vegetated drainage facilities (such as biofiltration swales, channels, ditches, ponds, etc.) or performing any alterations or modifications to the storm water facilities. Grantor(s) shall obtain all necessary permits and provide all required land surveys as required to complete maintenance and/or repairs.

6. Grantor(s) shall assume all responsibility for the implementation and cost of any maintenance and/or repairs to the storm water facilities.

RIGHTS OF THE CITY:

1. The City shall have ingress and egress rights to the said-described property for inspection and monitoring of the storm water facilities in order to determine performance, operational flows or defects in the storm water facilities.

2. If the City determines that the storm water facilities require maintenance and/or repair work, the Director shall deliver written notice to the Grantor specifically describing the required maintenance and/or repair. The notice shall also set a reasonable time in which Grantor must complete the described work. The notice shall also state that the City or its authorized agent may perform the authorized maintenance and/or repair if the Grantor(s) fails to complete the maintenance and/or repair within the time allowed. However, if the Director determines, at his or her sole discretion, that an imminent danger exists, the City's obligation to provide written notice shall be deemed waived, and the City or its authorized agent may immediately begin the required maintenance and/or repair work.

3. If the Grantor(s) does not complete the required maintenance and/or repair within the time allowed as set forth in the Director's notice, the City or its authorized agent will commence the maintenance and/or repair work described in the Director's notice.

4. If the City or its authorized agent performs the required maintenance and/or repairs to the storm water facilities, Grantor(s) shall reimburse the City all its costs incurred in completing the maintenance and/or repairs within thirty (30) calendar days of Grantor's receipt of the City's invoice for that work. Overdue payments shall accrue interest at the rate of 10 percent (10%) per annum.

5. If the Director determines, in his/her sole discretion, that the storm water facilities, if originally constructed in accordance with the City's approved design, need further modifications, Grantor(s) authorizes the City to enter the storm water facilities property in order to make these modifications.

Any notice or consent required to be given or otherwise provided for by the provisions of this agreement shall be effective either upon personal delivery or three (3) calendar days after mailing by Certified Mail, return receipt requested. This Covenant is intended to protect the value and desirability of the property described above, including the larger parcel(s), if any, benefitted by the storm water facilities. Further, this Covenant shall inure to the benefit of all the citizens of the City and shall bind Grantor(s), and its heirs, successors and assigns.

GRANTOR SIGNATURE: _____

Date: _____

ROY CITY SIGNATURE: _____

Date: _____

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

SWPPP COMPLIANCE INSPECTION FORM

Project Name:	Address:	Date:
Owner:	Contractor (Gen/Sub)	Start time:
Site Contact:	Phone:	Stop time:
Other Site Contacts:		
Other Site Contacts:		
UPDES Permit #: Expiration:	Weather: Sunny Cloudy Raining Snowing Other:	
Date of last rain event:	Duration:	Approx. Rainfall (in):
Inspected By (Print):	Local Jurisdiction or County:	
Other Inspectors:		
Other Inspectors:		
Total Project Area:	Total Disturbed Area:	
Project Type: (circle) *Subdivision* *Commercial* *Industrial* *Linear (Road/Pipe/Power)* *Land Disturbance*		
Reason for Inspection: Scheduled Complaint/Tip Random	Receiving Waters:	
Inspection Code (circle): SW sampling SW non-sampling	Inspector Code (circle): (S) State (L) Local	Type Code (circle): 1 - Municipal 2 - Industrial 3 - State

SWPPP, EROSION, SEDIMENT AND HOUSEKEEPING BMP's INFORMATION	YES	NO	N/A
1. Is the SWPPP on site and accessible, or is the SWPPP location posted in an obvious place and reasonably accessible (in a short time)?			
2. Are erosion control, sediment control, buffer controls and good housekeeping BMP's installed on the site as shown in the SWPPP?			
3. Has the SWPPP been updated to reflect the current site conditions (modifications dated & initialed on site map, new BMPs on site map, discontinued BMPs crossed off site map, new BMP details & spec's in SWPPP, SWPPP amendment Log, etc.)?			
4. Are on-site inspections being performed and recorded by a qualified person on a weekly or biweekly basis, reporting items required by permit? (Inspector name &qualifications, weather, problems/repairs, corrective action, new BMPs, removed BMPs, discharges, etc.)			
5. Have all corrective action items from previous inspections been addressed and documented within the time frame allotted ?			
6. Are SW flows entering and leaving the construction site controlled, managed, or diverted around the site? (e.g. buffer zones perimeter controls, berms, silt fence, up gradient boundary diversion, down gradient boundary sediment control, etc.)			
7. Is there evidence of sediment discharge such as mud flows or soil deposits from the construction site in downstream locations?			
8. Is there evidence of vehicles tracking soil off the construction site?			
9. Is there soil, construction material, landscaping items, or other debris piled on impervious surfaces (roads, drives) that could be washed with SW to a storm drain or water body?			
10. Is there a need to repair, maintain, or improve erosion control BMPs (temporary stabilization, erosion blankets, mulch, vegetated strips, rip rap, surface roughening, pipe slope drain, dust control, etc)?			
11. Is there a need to repair, maintain, or improve sediment control BMPs (silt fence, check dams, fiber rolls, sediment trap/basin, inlet protection, waddles, straw bails, curb cut-back, etc?			
12. Is there a need to repair, maintain, or improve good housekeeping controls (clean track out pad, sweeping, construction materials management, litter/trash control, port-o-potties staked down, fueling areas, concrete wash out area, proper curb ramps, spill prevention, etc)?			
13. Are there disturbed areas that have not had construction activities for 14 to 21 days without stabilization? (except snow or frozen ground)?			
14. Are there places where BMPs are needed and should be installed or not needed and should be removed?			

COMMENTS AND CORRECTIVE ACTIONS FOR SWPPP COMPLIANCE

Identify the problem and its location. If appropriate, describe (in general terms) what needs to be completed. However, only if qualified (e.g., you are a designer) should you be mandating specific BMPs to install. Include the date when corrections are made.

Inspector, please check all applicable SEV codes on the bottom of the next page.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Operator:

(Print Name) (Title) (Signature) (Date)

Inspector:

mod 5/16/16 (Print Name) (Title) (Signature) (Date)

(Attach additional sheets of narrative, pictures and checklists, as necessary)

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Additional Comments and Corrective Action For SWPPP Compliance

SWPPP PRE-SITE REVIEW INFORMATION	YES	NO	NA
1. Has a pre-construction review of the SWPPP been conducted by the appropriate municipal agency?			
2. Are contact names, positions, responsibilities, and telephone numbers of the Storm Water Team and all other site Operators listed in the SWPPP?			
3. Does the SWPPP include a site map showing storm drains, slopes/surface drainage patterns, stream buffer zones, SW discharge points, construction boundaries, limits of disturbance, surface waters (name of receiving water), structural controls, and does it define/explain non-structural controls?			
4. Does the SWPPP have an estimate of the area to be disturbed, a sequence of construction activities, the SW runoff coefficient for after completion, a description of the soil types, controls for discharges from (asphalt/concrete) batch plants if any, show wetland areas, and have a description of the nature of the construction activity?			
5. Does the SWPPP and site map show erosion and sediment controls placement & details (e.g. erosion blankets, mulch, slope drains, check dams, sediment basins, grass-lined channels, fiber rolls, sediment traps, silt fence, inlet protection, curb cut-back, dust control, etc?)			
6. Does the SWPPP and site map show and describe good housekeeping controls (e.g. track out pad, street sweeping, material storage, construction waste containment and removal, sanitary waste, concrete washout pits, etc)			
7. Are post-construction elements included in the SWPPP? (i.e. grass swales, detention basins, vegetated filter strips, infiltration, depression storage, landscaping/xeriscaping, discontinuous concrete or hard surface SW conveyance, etc.)			
8. Is this project in a sensitive watershed (within forest service boundaries or has a TMDL)?			X
9. Is the SWPPP signed by a responsible corporate officer with the certification statement (see permit appendix G.16.)?			
10. Are the NOI and a copy of the CGP or Common Plan permit in the SWPPP?			

EPA Form 3560-3 SEV Codes and Descriptions

D0R11		Discharge without a permit	BR19B		Failure to properly operate and maintain BMP's
D0R18		Failure to apply for a Notice of Termination	BR19A		Failure to properly install/implement BMP's
B0R12		Failure to conduct inspections	E0R16		Failure to submit required report (non-DMR)
B0C17		Failure to develop any or adequate SWPPP/SWMP	A0R22		Narrative effluent violation
B0C18		Failure to implement SWPPP/SWMP	D0R12		Failure to submit required permit information
B0R41		Failure to maintain records	A0R12		Numeric effluent violation
C0R11		Failure to monitor	B0R42		Violation of a milestone in an order
E0R14		Noncompliance with Section 308 Information Request			

EXHIBIT 2

LID FACT SHEETS

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Rain Garden

BR-1



Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Rain gardens are shallow bioretention areas with engineered or native soils. A variety of plants are used to increase infiltration and nutrient uptake including trees, shrubs, grasses, and other plants suitable for the climate. Rain gardens may be designed with various layers of soil, sand, and aggregate. They may also be designed with the existing soils at the site if the soils are expected to adequately infiltrate, support vegetation, and remove pollutants. They can be topped with a wood or rock mulch, any organic material, or other landscaping features. Performance is increased with high carbon soils. Sand and aggregate layers below the soil layers may provide filtration and storage. Rain gardens are usually well-received by the public for their aesthetic qualities.

Slopes leading to the garden bottom are gentle or steep based on site constraints, such as within urban areas. Ponding depths are typically between 1 to 18 inches. Underdrains and impermeable liners are necessary when subsurface concerns exist such as proximity to a structure, poorly infiltrating soils beneath the cross-section of the garden, or groundwater concerns. When a rain garden must be lined, its volume retention function is eliminated, pollutant removal effectiveness is diminished, and it functions primarily as a detention device; however, it still provides treatment through biofiltration. A bypass mechanism either within the rain garden or upstream of the rain garden should be considered for flood events.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No maximum	-
Side Slopes	No minimum	3H:1V	-
Ponding Depth	No minimum	18 in	-
Drawdown Time	12 hours	72 hours	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations.
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration processes to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related.
Freeboard	No minimum	No maximum	Freeboard per jurisdiction standards. For public safety, consider requiring freeboard and a minimum 6-inch embankment when ponding depth is greater than 6 inches.

Calculation Methods

Rain garden design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the geometry of the rain garden.
3. Based on the rain garden geometry and the porosity of the soil layers, determine the ponding depth and soil matrix depth required to hold the water quality volume.
4. Calculate the drawdown time.
5. Calculate the water quality outlet elevation.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A site has 1,500 sf of available open space at the downstream end of a parking lot. The parking lot and an adjacent pervious surface constitute one drainage area that is 0.75 ac in size. The total imperviousness of the drainage area is 0.80. The jurisdiction has a maximum drawdown time of 48 hours and uses a safety factor of 1.5 for water quality design.

Given

Contributing drainage area: 0.75 ac

Imperviousness: 0.80

90th percentile storm depth: 0.60 in

Design infiltration rate: 1.75 in/hr

Determine

The footprint and depth of a rain garden that can retain the water quality volume.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 0.91i - 0.0204$ (Reese method)

$R_V = 0.91(0.80) - 0.0204$

$R_V = 0.71$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

$WQV = R_V dA$

WQV = (0.71)(0.60 in)(0.75 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 1,160 cf

Minimum footprint, A_{min} (See *Minimum footprint area*)

A_{min} = (12)(Safety Factor)(WQV) / kt

A_{min} = (12)(1.50)(1,160 cf) / (1.75 in/hr)(48 hrs)

A_{min} = 250 sf

The water quality volume will infiltrate into the existing soil in 48 hours if the rain garden bottom is 250 square feet. However, this does not mean that the rain garden bottom is required to be 250 square feet. A larger footprint with a faster drawdown time may be acceptable and reduce the depth required to retain the water quality volume.

A rain garden with a bottom footprint of 1,160 sf, a 12-inch ponding depth will retain the water quality volume. If a safety factor is desired, it should be accounted for by multiplying the water quality volume by the safety factor.

Rain Garden Effectiveness

Effective rain gardens provide an aesthetically pleasing method for retaining and treating storm water. Visiting rain gardens during rain events will reveal if the garden is draining properly. Rain gardens are performing properly if they are retaining their design volume and treating runoff. Creating and following through on maintenance guidelines are critical to ensuring that a rain garden remains functional.

There are many possible indications that a rain garden has failed or is near failure, such as: ponding beyond the design ponding depth during small storm events, drawdown time exceeds design drawdown time, larger than expected sediment buildup within or upstream of the rain garden, irregular settling of the rain garden bottom creating standing water, sloughing of side slopes, excessive and unmaintained vegetation, lack of vegetation, and no maintenance or no record of maintenance. Although this is not an all-inclusive list, being aware of these items will assist in determining what steps need to be taken to remediate a failing rain garden.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the minimum separation requirement?	☐	☐
Is there available right-of-way, property, or easement?	☐	☐
Is the design infiltration rate within acceptable rates?	☐	☐
Is contaminated groundwater present?	☐	☐
Is the drainage area to the rain garden less than 5 acres? (If no, consider an infiltration basin or subdividing to create smaller drainage areas.)	☐	☐
Do utility conflicts make installation of the rain garden technically infeasible?	☐	☐
Do geotechnical conditions exist that would compromise the stability of the rain garden or surrounding structures?	☐	☐
Does the rain garden provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the rain garden if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐
Does an overflow outlet structure or bypass mechanism exist?	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Excavation

Rain gardens, like other BMPs whose functionality is dependent on infiltration, will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used within the rain garden area if infiltration is expected to occur through the rain garden bottom. Additional excavation beyond the rain garden's footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Avoid using heavy machinery within the rain garden footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Light machinery and even walking within the rain garden's footprint will also compromise infiltration. Compaction of native soils or backfill below the rain garden subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the rain garden to prevent construction site sediment from clogging soils. Scheduling installation of the rain garden shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the rain garden perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with rain garden construction.

- Excavation
- Grading
- Fine grading
- Granular borrow fill
- Landscaping and vegetation
- Top layer
- Engineered soil
- Coarse sand
- Crushed gravel
- Open graded stone
- Geotextile fabric
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Curb and gutter
- Impermeable liner (if needed)
- Underdrain system (if needed)
- Irrigation system (if needed)

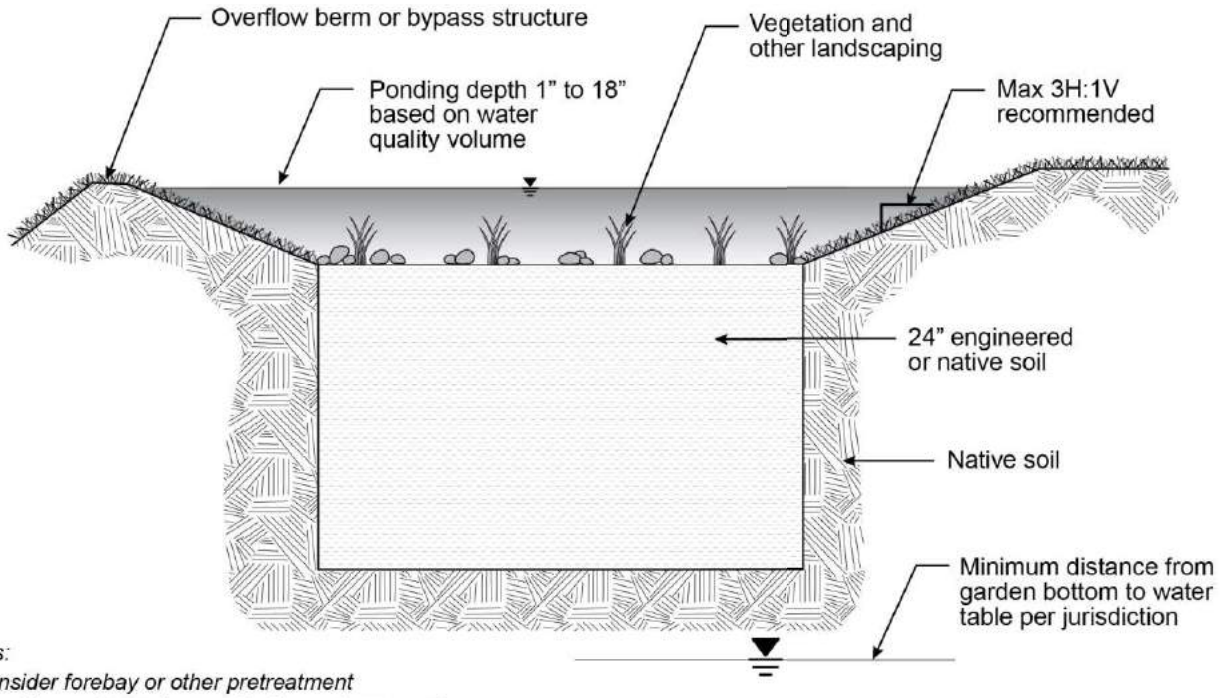
Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetative coverage, and impaired or failing vegetation.	Semiannual (Spring, Fall)	Reseed/replant barren spots. Notify the engineer if failing vegetation persists.	Low
Inspect side slopes for erosion, rilling, and sloughing.	Semiannual (Spring, Fall)	Regrade side slope if sloughing does not impact slope stability. Notify the engineer if side slope stability has been compromised and is affecting the functionality of the basin.	Low
Inspect for trash and debris within basin and at inlet and outlet structures.	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	Low
Inspect for large deposits of sediment on basin bottom indicating soil clogging.	Semiannual (Spring, Fall) or as needed	Remove and dispose of built up sediment when buildup causes reduction in size of	Low

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
		basin or if buildup results in standing water. Notify the engineer in the case of standing water as it may indicate clogging within the basin's soil layers.	
Inspect for standing water within rain garden or within observation well.	Semiannual (Spring, Fall) or as needed	Notify the engineer for further inspection.	Medium
Inspect for failure of additional features such as underdrains or irrigation systems.	Semiannual (Spring, Fall) or as needed	Repair as needed.	Medium

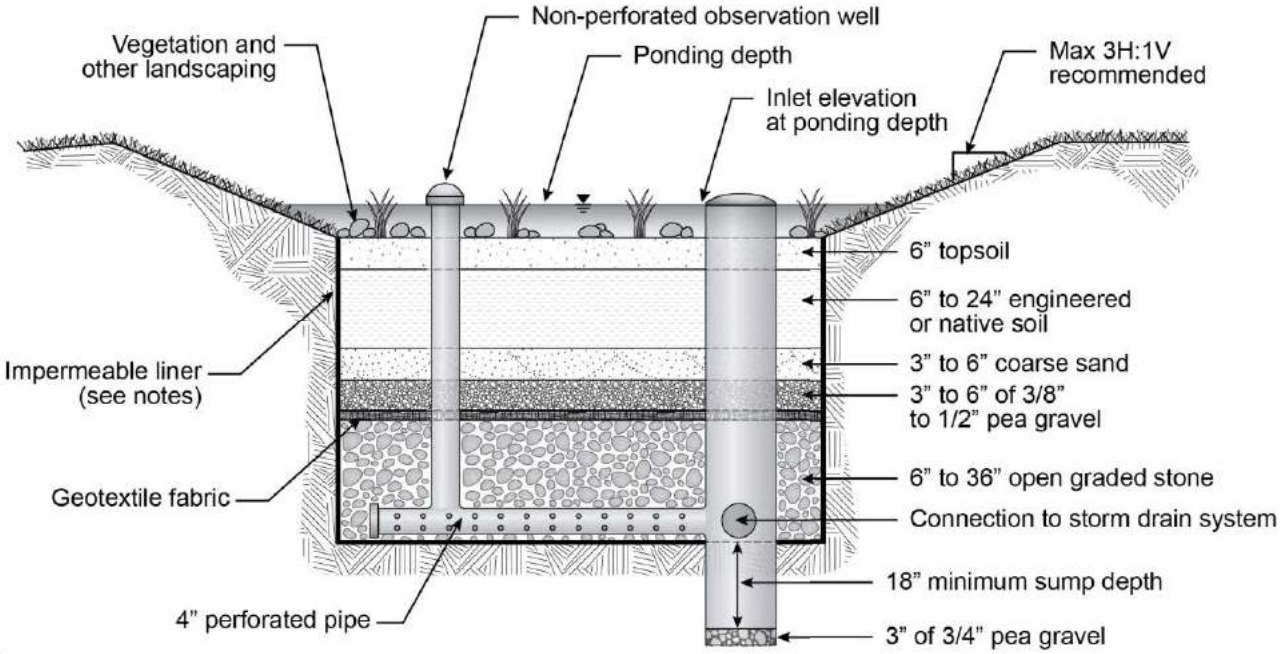


Notes:

- *Consider forebay or other pretreatment*
- *Consider upstream bypass for large storm events*

Rain Garden in Native or Engineered Soils

Not to scale



Notes:

- *Impermeable liner around all sides and bottom of rain garden if groundwater concerns exist*
- *Dimensions shown may vary based on site conditions*
- *Consider forebay or other pretreatment*

Rain Garden with Underdrain System

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Bioretention Cell

BR-2



Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Bioretention cells are shallow bioretention areas with engineered soil. They typically differ from rain gardens by having a delineation such as a curb, wall, or other distinct boundary. Similar to a rain garden, a variety of plants are used to increase infiltration and nutrient uptake including trees, shrubs, grasses, and other plants suitable for the climate. They may be designed with native soils or various layers of soil, sand, and aggregate. They can be topped with a wood or rock mulch, any organic material, or other landscaping features. Performance is increased with high carbon soils. Sand and aggregate layers below the soil layers provide filtration and storage.

Ponding depths are usually between 1 to 18 inches. In areas with high foot traffic, it may be necessary to provide a safety bench of soil within the cell and a minimum side slope leading to the cell bottom. Underdrains and impermeable liners are necessary when subsurface concerns exist such as proximity to a structure, poorly infiltrating soils, or groundwater concerns. When a bioretention cell must be lined, its volume retention function is eliminated, its pollutant removal effectiveness is diminished, and it functions primarily as a detention device; however, it still provides treatment through biofiltration. A bypass mechanism either within the bioretention cell or upstream of the cell should be considered for flood events.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No maximum	-
Ponding Depth	No minimum	18 in	-
Drawdown Time	12 hours	72 hours	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations.
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration processes to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related.
Freeboard	No minimum	No maximum	Freeboard per jurisdiction standards. For public safety, consider requiring freeboard and a minimum 6-inch embankment when ponding depth is greater than 6 inches.

Calculation Methods

Bioretention cell design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the geometry of the bioretention cell.
3. Based on the bioretention cell geometry and the porosity of the soil layers, determine the ponding depth and soil matrix depth required to hold the water quality volume.
4. Calculate the drawdown time.
5. Calculate the water quality outlet elevation.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A drainage area within a proposed roadway will be one-third of an acre with 90% imperviousness. It is proposed that three bioretention cells be placed within the drainage area creating three sub-drainage areas. Each sub-drainage area has the same imperviousness and 'A' soils are present.

Given

Contributing drainage area: 0.11 ac

Imperviousness: 0.90

Storm depth: 0.50 in

Design infiltration rate: 1.60 in/hr

Determine

The footprint and depth of the bioretention cells that can retain the water quality volume.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_{V\text{-}A} = 0.84i^{1.302}$ (R_V based on hydrologic soil group)

$R_{V\text{-}A} = 0.84(0.90)^{1.302}$

$R_V = 0.73$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.73)(0.50 in) (0.11 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 150 cf

Minimum footprint, A_{min} (See *Minimum footprint area*)

A_{min} = (12)(1.50)(150 cf) / (1.60 in/hr)(48 hrs)

A_{min} = 34 sf

The water quality volume will infiltrate into the existing soil in 48 hours if the footprint area of all bioretention cells is 34 square feet. However, this does not mean that the bioretention cell footprint is required to be 34 square feet. A larger footprint with a faster drawdown time is acceptable and will reduce the depth required to retain the water quality volume.

If the bioretention cell were to require an engineered soil layer, the design below with a bottom footprint of 200 sf will retain the water quality volume. If a safety factor is desired, it should be accounted for by multiplying the water quality volume by the safety factor.

Layer	Thickness, in	Porosity	Storage Volume, cf
Ponding	3	1.0	50
Top Soil	6	0.25	25
Engineered Soil	8	0.25	33.3
Coarse Sand	3	0.35	17.5
Pea Gravel	3	0.25	17.5
Aggregate Storage	4	0.4	26.7
Total	24 (soil layers)	0.37 (soil layers weighted)	165 (includes ponding)

Bioretention Cell Effectiveness

Effective bioretention cells provide an aesthetically pleasing method for retaining and treating storm water. Inspecting bioretention cells during rain events will reveal if the cell is draining properly. Bioretention cells are performing properly if they are retaining their design volume and treating runoff. Creating and following through on maintenance guidelines are critical to ensuring that a bioretention cell remains functional.

There are many possible indications that a bioretention cell has failed or is near failure, such as: ponding beyond the design ponding depth during small storm events, drawdown time exceeds design drawdown time, larger than expected sediment buildup within or upstream of the cell, excessive and unmaintained vegetation, lack of vegetation, obstructions at the inlet and outlet locations, and no maintenance or no record of maintenance. Although this is not an all-inclusive list, being aware of these items will assist in determining what steps need to be taken to remediate a failing bioretention cell.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the minimum separation requirement?	☐	☐
Is there available right-of-way, property, or easement?	☐	☐
Is the design infiltration rate within acceptable rates?	☐	☐
Is contaminated groundwater present?	☐	☐
Is the drainage area less than 5 acres? (If no, consider an infiltration basin or subdividing to create smaller drainage areas.)	☐	☐
Do utility conflicts make installation of the bioretention cell technically infeasible?	☐	☐
Do geotechnical conditions exist that compromise the stability of the bioretention cell or surrounding structures?	☐	☐
Does the bioretention cell provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the bioretention cell if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐
Does an overflow outlet structure or bypass mechanism exist?	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Excavation

Bioretention cells, like other BMPs whose functionality is dependent on infiltration, will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used within the excavated area if infiltration is expected to occur through the bioretention cell bottom. Additional excavation beyond the footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Avoid using heavy machinery within the bioretention cell footprint during construction as doing so will further compact the soils and diminish their infiltrating capabilities. Light machinery and even walking within the bioretention cell's footprint will also compromise infiltration. Compaction of native soils or backfill below the bioretention cell subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the bioretention cell to prevent construction site sediment from clogging soils. Scheduling installation of the bioretention cell shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the bioretention cell perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with bioretention cell construction.

- Excavation
- Landscaping and vegetation
- Top layer
- Engineered soil
- Coarse sand
- Crushed gravel
- Open graded stone
- Geotextile fabric
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Curb and gutter
- Impermeable liner (if needed)
- Underdrain system (if needed)
- Irrigation system (if needed)

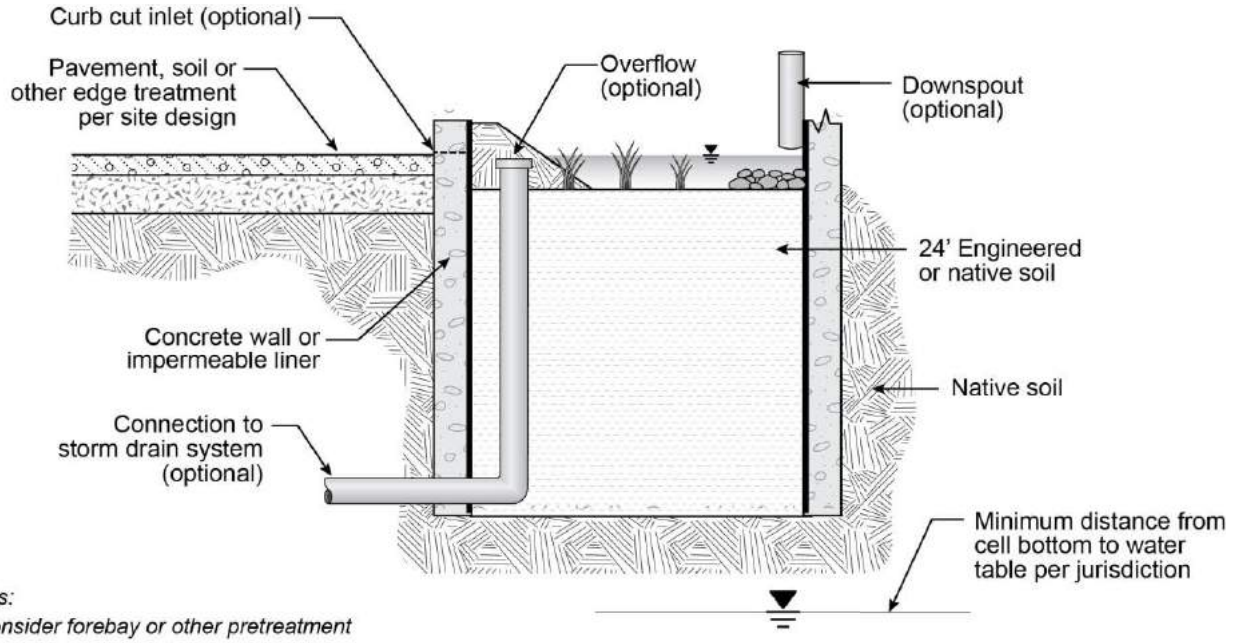
Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetative coverage, and impaired or failing vegetation.	Semiannual (Spring, Fall)	Reseed/replant barren spots. Notify the engineer if failing vegetation persists.	Low
Inspect for trash and debris within basin and at inlet and outlet structures.	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	Low
Inspect for large deposits of sediment on bottom indicating soil clogging.	Semiannual (Spring, Fall) or as needed	Remove and dispose of built up sediment when buildup causes reduction in size of basin or if buildup results in standing water. Notify the engineer in the case of standing water as it may indicate clogging within the basin's soil layers.	Low

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for standing water within bioretention cell or within observation well.	Semiannual (Spring, Fall)	Notify the engineer for further inspection.	Medium
Inspect for failure of additional features such as underdrains or irrigation systems.	Semiannual (Spring, Fall)	Repair as needed.	Medium

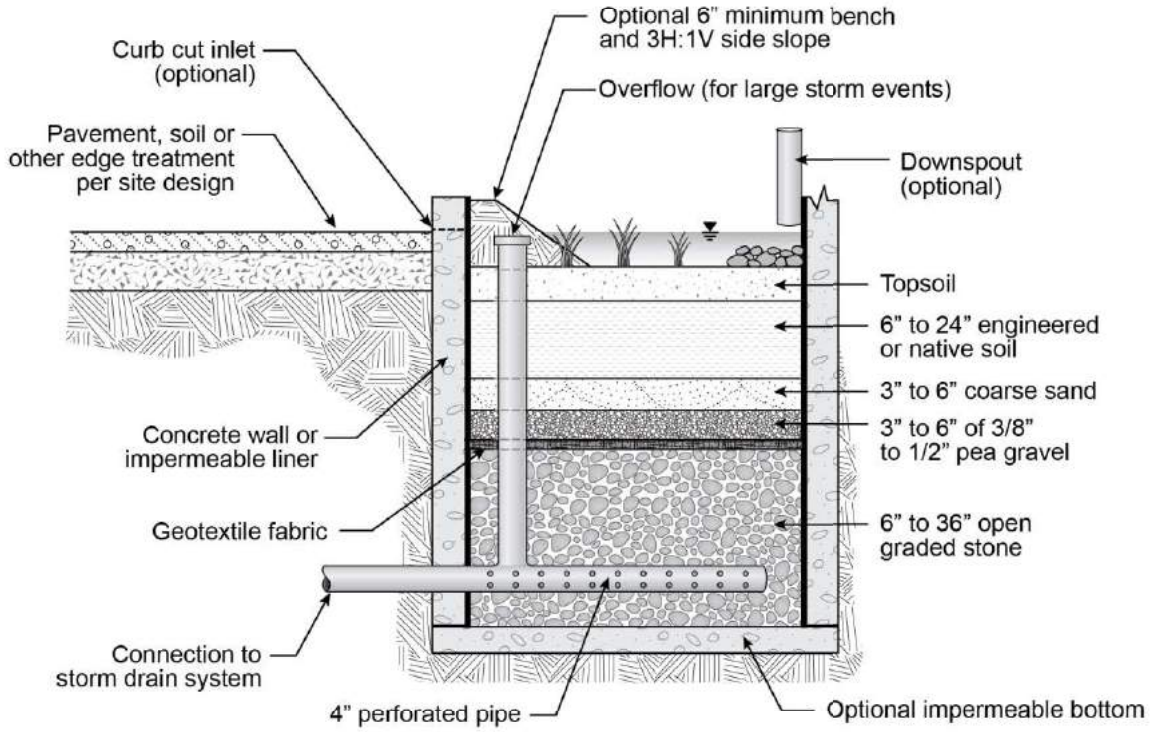


Notes:

- *Consider forebay or other pretreatment*
- *Consider upstream bypass for large storm events*

Bioretention Cell in Native or Engineered Soils

Not to scale



Notes:

- *Overflow elevation must be below elevation of inlet (curb cut, downspout, or other per site design)*
- *Dimensions shown may vary based on site conditions*
- *Consider forebay or other pretreatment*

Bioretention Cell with Underdrain System

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Bioswale

BR-3



Pollutant Removal Effectiveness

Pollutant	Effectiveness[1]
Sediment	Medium
Nutrients	Medium
Metals	Medium
Bacteria	Medium
Oil/Grease	High

[1]Removal effectiveness is increased for all pollutants as retention increases.

Bioswales are vegetated open channels designed to convey and treat storm water runoff. They are appropriate when it is desirable to convey flows away from structures or as an alternate conveyance method to pipes, concrete channels, or curbed gutters. Bioswales reduce peak flow rates, reduce flow velocities, filter storm water pollutants, and can also reduce runoff volume through infiltration.

The primary functions of bioswales are bioretention and treatment through biofiltration. Conveying runoff through bioswales allows the runoff to be filtered through two processes: bioretention through a native or engineered soil matrix and biofiltration through the above ground vegetation.

Although volume retention may be accomplished within the native soil or a subsoil matrix of engineered soil and gravel layers, retention is not its primary function. However, retention volumes may be determined by designing ponding areas within the swale or creating check dams. There is research to support the quantification of infiltration when runoff is simply conveyed through the swale (no ponding) but design parameters vary widely. Monitoring bioswales for volume reduction is the most reliable source for future estimates of expected reduction.

Primary Functions	
Bioretention	Yes
Volume Retention	Some
Biofiltration	Yes

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Length	Based on hydraulic residence time	No maximum	-
Longitudinal Slope	0.50%	5%	Underdrain recommended below minimum slope
Bottom Width	No minimum	No maximum	-
Side Slope	No minimum	3H:1V	Per jurisdiction requirements
Flow Velocity	No minimum	1.0 ft/s	Maximum permissible shear stress may also dictate maximum flow velocity
Flow Depth	No minimum	2/3 vegetation height	Flow depths greater than vegetation height will bypass the biofiltration processes
Freeboard	No minimum	No maximum	Per jurisdiction requirements
Vegetation Coverage	≥ 65%		Biofiltration is significantly reduced when vegetation coverage is less than 65%
Hydraulic Residence Time	5 min	No maximum	-

Calculation Methods

Bioswale design is governed by the water quality flow. The general design steps are:

1. Calculate the water quality flow.
2. Determine the geometry of the bioswale's cross-section.
3. Determine the flow depth.
4. Determine volume retention within bioswale, if any.
5. Check flow velocity and hydraulic residence time.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

During the planning phase of a city roadway project it has been decided to remove curbs and instead allow one acre of runoff to sheet flow into a 500 ft bioswale. There are 15 feet of available right-of-way between the edge of pavement and the project limits. A 4-foot sidewalk is also proposed to be within the right-of-way. The city has a requirement that there be no slopes greater than 6H:1V within five feet of the edge of pavement. The city's storm water requirements state that the 2-yr, 6-hr intensity must be used in determining the water quality flow rate. Per city standards, 6 inches of freeboard will be required above the water quality flow depth.

Given

Contributing drainage area: 1.0 ac

Imperviousness: 0.85

90th percentile storm depth: 0.60 in

2-yr, 6-hr storm intensity: 0.16 in/hr

Design Goals

Determine an acceptable swale bottom width and flow depth. Design a soil matrix and determine the volume of runoff that is expected to infiltrate into the bioswale.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 1.14i - 0.371$ (Granato method when $i \geq 0.55$)

$R_V = 1.14(0.85) - 0.371$

$R_V = 0.60$

Water quality flow, WQF

$WQF = R_V iA$

$WQF = (0.60)(0.16 \text{ in/hr})(1.0 \text{ ac})$

$WQF = 0.10$ cfs

Flow depth, y_d (See *Manning's Equation*)

The project team has decided that a 2-foot bottom width will be used for the bioswale. Per city standards, 6 inches of freeboard will be required above the water quality flow depth. Other design information for the bioswale includes:

Longitudinal slope: 2.0%

Side slopes: 3H:1V

Determine the flow depth during the design storm event by setting Manning's equation equal to the WQF and solving the equation for the flow depth, y_d. This calculation is made easier using a goal seek function within a spreadsheet.

$y_d = 1.8$ in

Velocity, v (See *Continuity Equation*)

The city requires that flows remain below 1 ft/s to prevent scouring of the bioswale bottom. With the flow depth known, the continuity equation can be used to determine the flow velocity. The cross-sectional area is calculated to be 0.37 sf.

$v = Q/A$

$v = (0.10 \text{ cfs}) / (0.37 \text{ sf})$

$v = 0.26$ ft/s

Minimum swale length, L_{min}

The city also requires a 5-minute minimum hydraulic residence time to achieve the maximum desired biofiltration. Using the velocity, a minimum swale length can be determined.

$L_{min} = (0.26 \text{ ft/s})(300 \text{ s})$

L_{min} = 79 ft

Any portion of the runoff that enters the swale within 79 ft of the downstream end of the swale will not receive the optimal treatment.

With 6 inches of freeboard and a side slope of 3H:1V, the top width of the bioswale is 6.00 ft. With 15 feet of available right-of-way, 6 of which are available for the swale, at the planning level there is adequate space for the bioswale. If needed, the swale's top width could be narrowed by decreasing the bottom width, which would also result in a deeper flow depth.

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.60)(0.60 in)(1.0 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 1,302 cf

Volume Reduction

The swale will also include check dams that are 6 inches high to increase the volume retention. With a longitudinal slope of 2%, a 6-inch check dam will create a triangular pool that is 25 ft long before overtopping the check dam. The volume retained behind the check dam is calculated with the bottom width, the check dam height, and the length of the check dam pool.

$V_{check\ dam}$ = (2 ft)(25 ft)(0.5 ft) / 2

$V_{check\ dam}$ = 12.50 cf

If the check dams are spaced every 50 feet, 10 check dams are possible, and the total volume retained by the check dams will be 125 cf.

Additional volume retention can be achieved in any ponding areas that are designed into the swale.

Although methodologies have been developed to determine volume retention within a bioswale, the current body of research varies widely and jurisdictions are encouraged to exercise engineering judgment (See *Volume Reduction*).

A conservative design for the soil matrix below the swale will allow for the maximum possible percentage of the water quality volume to be captured. For flood control purposes, zero infiltration may be assumed to prevent downstream piping from being undersized if the bioswale's volume reduction is overestimated. Accounting for the ten check dams, the soil matrix below will provide storage for the remaining portion of the water quality volume (1,182 cf). Whether the full remaining volume is captured can be determined by monitoring the bioswale for volume retention.

Layer	Thickness, in	Porosity	Storage Volume, cf
Engineered Soil	12	0.25	250
Coarse Sand	3	0.35	87.5
Pea Gravel	3	0.25	62.5
Aggregate Storage	20	0.4	667
Total	52 (soil layers)	0.35 (soil layers weighted)	1067 (includes ponding)

Bioswale Effectiveness

Bioswales are effective when they can accomplish their design goals of conveying flows to a downstream receiving structure, BMP, or other receiving area. Flows through the swale should be relatively steady and uniform during a rain event unless retention areas and check dams are part of the swale design. Established vegetation with adequate coverage is an indication of a healthy bioswale along with minimal sediment and lack of invasive vegetation.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
If longitudinal slope is less than minimum, can an underdrain be installed?	☐	☐
If an underdrain is needed, is sufficient hydraulic head available for proper drainage?	☐	☐
Do flows result in a shear stress greater than the maximum permissible for selected vegetation?	☐	☐
Do utility conflicts make installation of the bioswale technically infeasible?	☐	☐
Will the bioswale provide conveyance for larger storm events? (If yes, the geometry of the bioswale will need to accommodate the larger events.)	☐	☐
Is the bioswale providing pretreatment for a downstream BMP?	☐	☐
Is the bioswale connecting directly to the storm drain network? (If yes, the outlet structure elevation will need to be determined.)	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Excavation

Bioswale construction is a relatively straightforward process of excavating the swale's subsurface trench prior to backfilling with any underdrain system, open graded stone, engineered soil, and geotextile fabric. Additional excavation beyond the swale's footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Crews should avoid stepping within the trench except when necessary as doing so will compact the native soil that is expected to infiltrate runoff.

Flows During Construction

Flows during construction should be diverted away from the bioswale to prevent construction site sediment from clogging soils and to prevent erosion of the swale bed. Scheduling installation of the bioswale shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the bioswale perimeter during construction. Creating the upstream inlet or connection should be the last construction activity before flows are permitted to be conveyed as designed through the bioswale.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with bioswale construction.

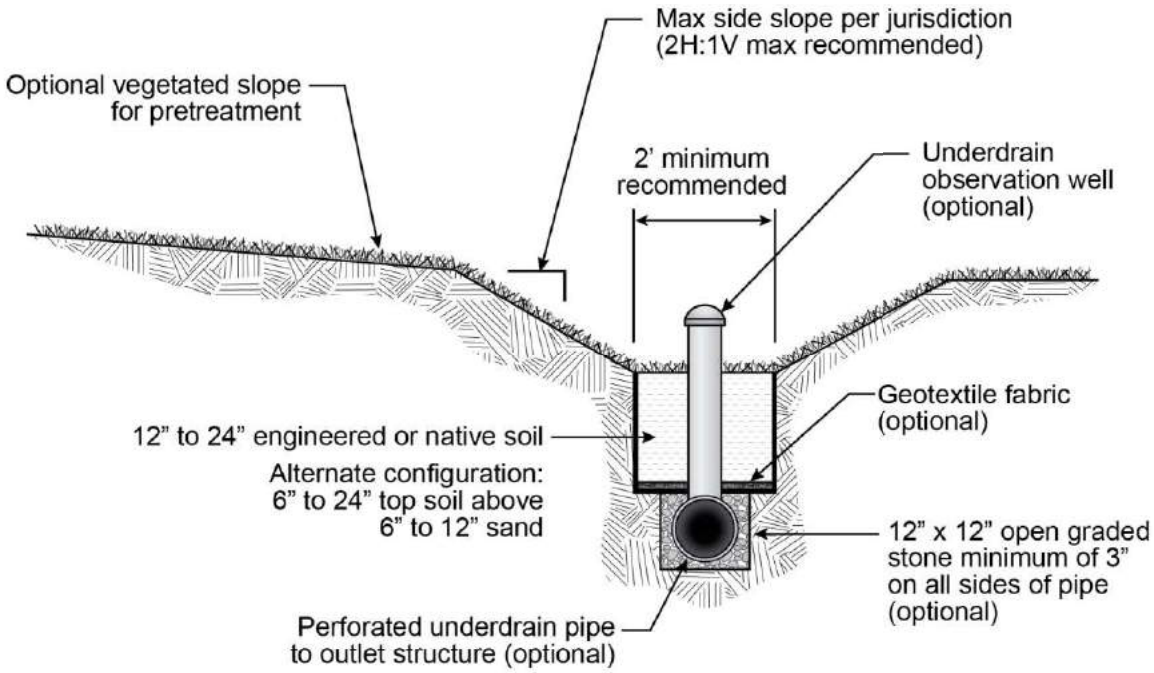
- Excavation
- Grading
- Fine grading
- Granular borrow fill
- Landscaping and vegetation
- Top layer
- Engineered soil
- Open graded stone
- Geotextile fabric
- Impermeable liner
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Underdrain system (if needed)
- Outlet protection such as riprap or other (if needed)

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetative coverage, and impaired or failing vegetation.	Semiannual (Spring, Fall)	Reseed/replant barren areas. Notify engineer if issue persists.	Low
Inspect side slopes for erosion, rilling, and sloughing.	Semiannual (Spring, Fall)	Regrade side slope if slope stability is not affected by sloughing. Notify engineer if stability is affecting basin functionality.	Low
Inspect for standing water within bioswale or within observation well.	Semiannual (Spring, Fall)	Notify engineer for further inspection.	Medium
Inspect for trash and debris at inlet and outlet structures.	Prior to mowing, at least semiannually	Remove trash and debris.	Low
Inspect vegetation height.	As needed	Mow swale as needed.	Low



Notes:

- *Engineered soil may improve filtration*
- *Underdrain recommended for longitudinal slopes < 1%*
- *Optional items shown for use of underdrain*
- *Dimensions shown may vary based on site conditions*

Bioswales

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Vegetated Strip

BR-4



Pollutant Removal Effectiveness

Pollutant	Effectiveness[1]
Sediment	High
Nutrients	Medium
Metals	Medium
Bacteria	High
Oil/Grease	High

[1]Removal effectiveness is increased for all pollutants as retention increases.

Vegetated strips are designed to receive and treat sheet flow from adjacent surfaces. This is accomplished by slowing runoff velocity to allow for pollutants and sediments to settle and by filtering out pollutants in the vegetation before entering the storm sewer system. Vegetated strips are best utilized for storm water treatment from roads, parking lots, and other impervious surfaces.

Primary Functions	
Bioretention	Yes
Volume Retention	Some
Biofiltration	Yes

The primary functions of vegetated strips are bioretention and biofiltration. Bioretention within a vegetated strip occurs as runoff enters the soil and pollutants are removed through physical, chemical, and biological processes. Similar biofiltration processes occur to provide treatment when runoff passes through the strip's vegetation. Biofiltration is significantly reduced when vegetation coverage is less than 65%. In arid locations a gravel strip may be used as a substitute for the vegetated strip. The lack of vegetation will cause biofiltration and bioretention to be greatly reduced; however, the runoff velocity will still be decreased and allow for pollutants and sediments to settle out. Volume retention through infiltration will also occur as runoff enters the gravel's void spaces.

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Length (direction of flow travel)	15 ft	No maximum	-
Longitudinal Slope	No minimum	4H:1V	Per jurisdiction requirements
Flow Velocity	No minimum	1.0 ft/s	Maximum permissible shear stress may also dictate maximum flow velocity
Flow Depth	No minimum	2/3 vegetation height	Flow depths greater than vegetation height will bypass the biofiltration processes
Freeboard	No minimum	No maximum	Per jurisdiction requirements
Vegetation Coverage	≥ 65%		Biofiltration is significantly reduced when vegetation coverage is less than 65%

Calculation Methods

Vegetated strip design is governed by the water quality flow. The general design steps are:

1. Calculate the water quality flow.
2. Determine the flow depth.
3. Check flow velocity.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A roadway project is proposing to widen a road that is near a canal. Due to high groundwater and poor soils, retention on-site is not feasible. Treatment is still an option, however, and the design team has decided to establish vegetation within the twenty feet between the edge of pavement and the canal. The city's storm water requirements state that the 2-yr, 2-hr intensity must be used in determining the water quality flow rate.

Given

Contributing drainage area: 0.25 ac

Imperviousness: 1.00

2-yr, 2-hr storm intensity: 0.318 in/hr

Design Goals

Determine that the flow depth will be less than 1 inch.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_{V\text{-}A} = 0.84i^{1.302}$ (R_V based on hydrologic soil group)

$R_V = 0.84(1.0)^{1.302}$

$R_V = 0.84$

Water Quality Flow, WQF

$WQF = R_V iA$

$WQF = (0.84)(0.318 \text{ in/hr})(0.25 \text{ ac})$

$WQF = 0.067 \text{ cfs}$

There is available right-of-way for a 300-foot long strip that is 20 feet wide. The embankment side slope is 10H:1V which corresponds to a 10% longitudinal slope for the vegetated strip.

Flow depth, y_d (See *Manning's Equation*)

Calculation of the flow depth is typically done using Manning's equation setting the equation equal to the water quality flow and solving for the flow depth.

$y_d = [(nQ)/1.49LS^{0.5}]^{0.6}$

$y_d = [(0.2)(0.071 \text{ cfs}) / (1.49)(300 \text{ ft})(0.02)^{0.5}]^{0.6}$

$y_d = 0.04 \text{ in}$

Velocity, v (See *Continuity Equation*)

The city requires that flows remain below 1 ft/s to prevent scouring of the strip bottom. With the flow depth known, the cross-sectional area is calculated to be 1.10 sf.

$v = Q/A$

$v = 0.067 \text{ cfs} / 1.10 \text{ sf}$

$v = 0.06 \text{ ft/s}$

Volume Reduction

Although methodologies have been developed to determine volume retention within a bioswale, the current body of research varies widely and jurisdictions are encouraged to exercise engineering judgment (See *Volume Reduction*).

Vegetated Strip Effectiveness

Vegetated strips are effective when they can accomplish their design goals of conveying sheet flow to the receiving area. Flows through the vegetated strip should be relatively steady and uniform during a rain event and should not create rilling or other visible signs of erosion. Established vegetation with adequate coverage is an indication of a healthy vegetated strip along with minimal sediment and lack of invasive vegetation.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Is the vegetated strip length greater than or equal to the minimum required length?	☐	☐

Do flows result in a shear stress greater than the maximum permissible for selected vegetation?	☐	☐
Is the vegetated strip providing pretreatment for a downstream BMP?	☐	☐
Is the slope in the direction of flow less than or equal to the jurisdiction's standards?	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Vegetated strips can be installed as part of normal construction activities. An appropriate grass such as turf sod should be installed per specifications. If additional vegetation such as shrubs or bushes will be used within the strip, follow landscaping guidance to ensure that vegetation establishes after installation. To maximize infiltration performance, minimize use of heavy machinery.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with bioswale construction.

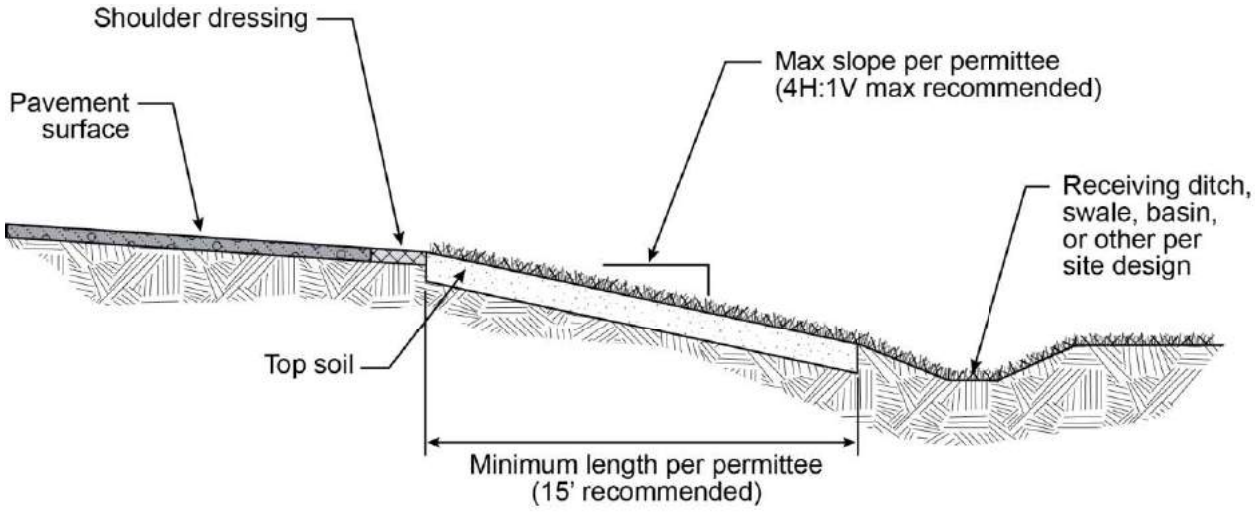
- Grading
- Landscaping and vegetation
- Topsoil
- Engineered soil
- Shoulder dressing upstream of vegetated strip

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect upstream end of vegetated strip for sediment buildup that may be impeding sheet flow.	Semiannual (Spring, Fall) or as needed	Remove and dispose of sediment buildup.	Low
Inspect grass length.	As needed	Mow strip as needed.	Low
Inspect for erosion, rilling, and sloughing.	Semiannual (Spring, Fall)	Regrade side slope if slope stability is not affected by sloughing. Notify engineer if stability is affecting basin functionality.	Low
Inspect for adequate vegetative coverage, and impaired or failing vegetation.	Semiannual (Spring, Fall) or as needed	Reseed/replant barren areas. Notify engineer if issue persists.	Low



Notes:

- *Dimensions shown may vary based on site conditions*

Vegetated Strips

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Tree Box Filter

BR-5



Source: Montgomery County, Maryland Department of Environmental Protection

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	Medium
Metals	Medium
Bacteria	High
Oil/Grease	High

Tree box filters are bioretention systems that are appropriate in urban drainage areas where space is limited. An underground concrete vault contains the soil matrix that provides bioretention and has a grated top where vegetation grows. Tree box filters are typically designed as flow-through devices, meaning that they do not retain storm water but rather allow flows to pass through them. However, a bottomless concrete vault will function as a bioretention system that provides infiltration into the native soils. Manufacturers have developed proprietary designs for tree box filters, but they may also be designed.

The primary functions of tree box filters are bioretention and treatment. Runoff from the contributing drainage area enters the tree box through an inlet where bioretention occurs. Storm water is treated by the physical, chemical, and biological processes that occur within the mulch, soil matrix, and plant roots.

Primary Functions	
Bioretention	Yes
Volume Retention	Varies[1]
Biofiltration	Yes

[1]Volume retention may be achieved with a bottomless vault.

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters. Tree box filters may be proprietary devices; follow manufacturer specifications to determine design criteria on a case-by-case basis.

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No maximum	May be less than 2 feet if tree box filter has impermeable bottom.
Ponding Depth	No minimum	12 in	-
Drawdown Time	12 hours	72 hours	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations.
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration processes to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related.

Calculation Methods

Tree box filters are typically sized based on their water quality flow but may be sized for their water quality volume when being designed for retention. Both design approaches are dependent on the contributing drainage area and imperviousness. A larger contributing drainage area will require a larger tree box filter.

Tree Box Filter Effectiveness

Tree box filters are effective when they maintain their bioretention and biofiltration capabilities. Proper inspection and maintenance of tree box filters will ensure that the chemical and biological processes that treat runoff perform optimally. Qualified inspection crews are necessary to determine if soils and vegetation are healthy.

The tree box must be able to function hydraulically. Flows must be able to pass through the filter without backing up or maintenance will be required.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Is there adequate space for a tree box filter?	☐	☐
Is there sufficient hydraulic head for tree box filter to connect to storm drain network?	☐	☐
If retention is desired, will the design infiltration rate permit a reasonable drawdown time?	☐	☐
If retention is desired, is depth to the historical high groundwater from the filter bottom greater than the jurisdiction's minimum separation requirement?	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

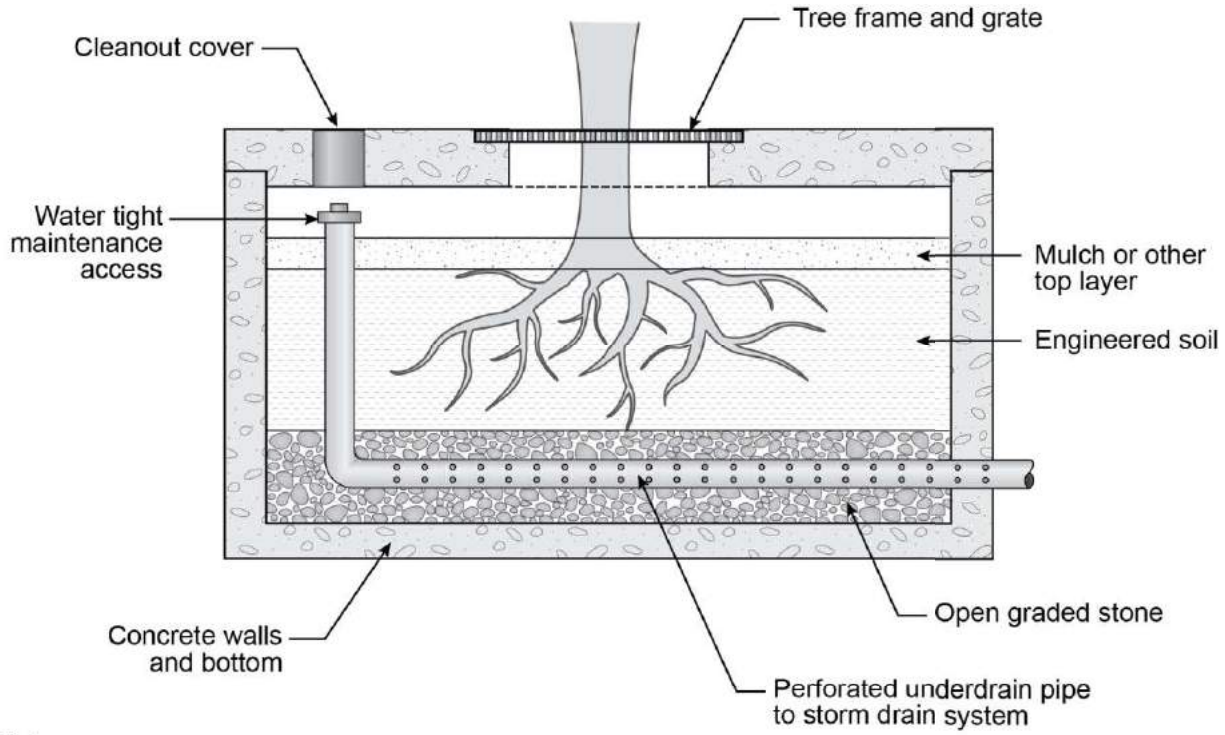
Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Proper maintenance of tree box filters will be per the manufacturer's specifications, but it typically includes the following:

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris within tree box filter and at inlet and outlet structures.	Semiannual (Spring, Fall) or as needed	Remove trash, debris and sediment.	Low
Inspect performance.	Semiannual (Spring, Fall)	Replenish media filter layer with new mulch.	Medium
Inspect for invasive species.	Semiannual (Spring, Fall)	Prune and weed filter box.	Medium



Notes:

- *Dimensions shown may vary based on site conditions*

Tree Box Filters

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Green Roof

BR-6



Pollutant Removal Effectiveness

Pollutant	Effectiveness[1]
Sediment	High
Nutrients	Medium[2]
Metals	High
Bacteria	High
Oil/Grease	-

[1]Removal effectiveness is increased for thicker soil layers.
[2]Use of organic matter to establish vegetation may increase nutrient leaching.

A green roof is a vegetated system that is designed to retain and treat rooftop runoff. The primary functions of green roofs are bioretention, volume retention, and filtration. Green roofs capture storm water within the pore space of the soil and vegetation and the moisture is then released through evapotranspiration.

Green roofs can be classified as either extensive or intensive systems. Extensive systems are those in which the soil media is up to 6 inches in depth and support smaller grasses and other vegetative species that do not have deep root systems. Intensive systems are those that support root systems greater than 6 inches such as those from trees and bushes.

The design of green roofs should be done with the coordination of qualified landscaping, structural, and maintenance teams. Vegetation selection and the proper maintenance of vegetation are critical items in the overall performance and functionality of the green roof. The integrity of the roof structure must also be accounted for as large volumes of plants, soils, water, and the weight of the green roof structure will create additional loads on the building.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Extensive	Intensive	Notes
Drawdown Time	12 hours	12 hours	-
Growth Media Depth	< 6 in	6+ in	-
Vegetation	Low growing, low water-use vegetation such as Sedum, herbs, grasses, and perennials	More complex gardens including the species listed for extensive green roofs, but also incorporating trees and shrubs.	-
Load	12-54 lb/sf	72+ lb/sf	-
Roof Slope	5:1 maximum	5:1 maximum	-
Access	Required for maintenance	Required for maintenance	-
Irrigation	Simple irrigation. Only needed during droughts and plant establishment if well designed.	Complex irrigation	-
Drainage	Simple drainage system	Complex drainage system	-

Calculation Methods

Green roof design is governed by the water quality volume; however, special consideration must also be given to vegetation selection and proper installation with the assistance of a landscape architect or other qualified person. Special consideration must also be given to the structural design of the roof, with the assistance of a structural engineer. Neither of those considerations are considered in this discussion of calculation methods. For the purposes of determining if the green roof retains the water quality volume, the general design steps are:

1. Calculate the water quality volume.
2. Determine the porosity of the engineered soil used within the green roof and the retention volume within the soil.
3. Determine the required footprint to retain the water quality volume.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

An extensive green roof system will be designed for a new building with a roof that is 0.37 acres. The entire roof will drain to the green roof. It was decided that an extensive green roof system with a 6-inch soil matrix will be used. Determine the footprint that will be needed to capture the water quality volume.

Given

Roof area: 0.37 ac

85th percentile storm depth: 0.60 in

Porosity of engineered soil: 0.25

Determine

Determine the footprint of the green roof.

Calculations

The footprint can be determined through iterative calculations. After iterative calculations, it was found that a footprint of 3,405 square feet will capture the water quality volume.

Pervious area (green roof footprint): 3,405 sf (0.078 ac)

Imperviousness of rooftop: 0.79

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 0.91i - 0.0204$ (Reese method)

$R_V = 0.91(0.79) - 0.0204$

$R_V = 0.70$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.70)(0.60 in)(16,117 sf) / (12 in/ft)

WQV = 562 cf

Determine the equivalent storage depth of the engineered soil.

$d_{equivalent}$ = (0.6 in)(0.25)

$d_{equivalent}$ = 1.5 in

Determine the required footprint of the green roof to capture the water quality volume.

Footprint = WQV / $d_{equivalent}$

Footprint = 562 cf / (1.5 in)(12 in/ft)

Footprint = 4,496 sf

Green Roof Effectiveness

Green roofs provide an aesthetically pleasing method for retaining and treating storm water runoff. Healthy plants and soils are indications that the green roof is performing as expected. Excessive drainage through the soil layer may be an indication that the soils and vegetation are not retaining runoff; consequently, the evaporation and transpiration processes are not occurring. Qualified horticulturists and/or green roof contractors should be involved in determining the health and effectiveness of the green roof.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Has a landscape architect been involved in the vegetation selection?	☐	☐
Has a structural engineer been involved in the green roof design?	☐	☐
Are maintenance crews trained and aware of maintenance responsibilities?	☐	☐

Does the green roof provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the green roof if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐
Will the green roof partially cover or fully cover the roof?	-	-
Will the green roof be extensive or intensive?	-	-

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Green roof installation should be done with proper oversight from qualified environmental or green roof specialists. Any requirements related to working on rooftops should be followed. During construction, vegetation and the growth media should be protected from erosion until vegetation has been established.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with rain garden construction.

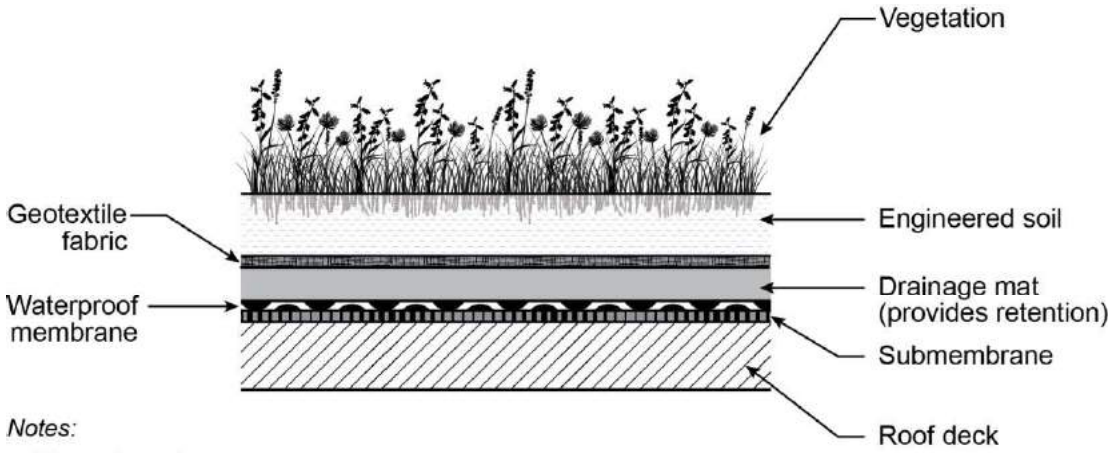
- Vegetation and landscaping expertise
- Horticulturist expertise
- Structural expertise

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of green roofs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect weed growth.	2-4 weeks during growing season	Remove weeds before they flower.	High
Inspect fertilization.	Annually	Apply fertilizer in accordance with manufacturer recommendations. Avoid hottest/driest parts of the year.	Medium
Inspect water retention.	Semiannual (Spring, Fall) or as needed	If natural precipitation is not adequate for vegetation, water plants.	High



Notes:

- *Dimensions shown may vary based on site conditions*

Green Roof

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Pervious Surfaces *PS-1*



Pollutant Removal Effectiveness

Pollutant	Effectiveness[1]
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

[1]Pollutant removal may occur in the pervious surface or the subsurface.

Pervious surfaces such as permeable pavement, concrete pavers, pervious concrete, modular open pavers, and other types of pervious surfaces provide structural support for light vehicle or pedestrian traffic while also providing open space for storm water infiltration.

The primary function of pervious surfaces is volume retention, but some filtration is possible depending on the type of paver and subsurface selected. A modular open paver that, when installed, provides a certain percentage of pervious area in the form of grass, will allow for filtration processes to occur. Another source of filtration is the choker layer directly beneath the pervious surface.

The subsections beneath the pervious surface are typically a choker layer composed of small gravel and a storage layer of larger rock beneath. Underdrains may be required if existing soils do not adequately infiltrate.

Primary Functions	
Bioretention	Yes[1]
Volume Retention	Yes
Biofiltration	Some

[1]Bioretention occurs in the subsurface and not within the pervious surface.

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Drain Time	12 hours	72 hours	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design.
Depth to Historical High Groundwater	2 ft	No maximum	-

Calculation Methods

Pervious surface design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the required thickness of the subsection layers given their porosity and the footprint of the pervious surface area.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A development in the planning phase will have a 0.90-acre parking lot. It is proposed that the parking lot be graded so that runoff is conveyed towards stalls that will be constructed with permeable asphalt.

Given

Contributing drainage area: 0.90 ac

Imperviousness: 0.95

85th percentile storm event: 0.53 in

Design infiltration rate: 0.5 in/hr

Design Goals

Determine an acceptable area size and depth of the permeable asphalt section.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 1.14i - 0.371$ (Granato method when $i \geq 0.55$)

$R_V = 1.14(0.95) - 0.371$

$R_V = 0.71$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.71)(0.53 in)(0.90 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 1,230 cf

A permeable asphalt area that is 15 ft x 140 ft (2,100 sf) with the following properties will retain the water quality volume and will have an acceptable drawdown time. See *Storage volume within a media with a known porosity* for guidance on determining storage within soils.

Layer	Thickness, in	Porosity	Storage Volume, cf
Permeable Asphalt	4	0.2	140
Choker Layer	4	0.4	280
Aggregate Storage	12	0.4	840
Total	20	0.37 (weighted)	1260

Drawdown time, t

t = Equivalent storage depth / Design infiltration rate

Weighted porosity, n_W = 0.37

Equivalent storage depth = (20 in)(0.37)

Equivalent storage depth = 7.2 in

t = (7.2 in) / (0.5 in/hr)

t = 14.40 hrs

Pervious Surface Effectiveness

Pervious surfaces are effective when runoff from the design storm depth can enter the porous spaces of the pervious surface and successfully infiltrate into the native soil or drain through an underdrain system. Visual inspection of the pervious surface can reveal reasons for failure: for example, sediment-laden sheet flows that are conveyed to the pervious surface, or a down drain might be introducing organic material. Both scenarios are likely to contribute to clogging within the porous spaces of the pervious surface or within the sublayers.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Will an underdrain system be required?	☐	☐
If an underdrain is needed, is there sufficient head for the underdrain system to drain?	☐	☐
Has the proposed pervious surface performed successfully in similar climate conditions?	☐	☐

Installation

Excavation

Pervious surfaces will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used if infiltration is expected to occur through the underlying soils beneath the pervious surface's subsection.

Activities During Construction

Avoid using heavy machinery on the revealed soil during construction. Crews should avoid unnecessarily walking on the underlying soils when possible. Compaction of native soils or backfill below the pervious surface subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the exposed underlying soil to prevent erosion. Scheduling installation of the pervious surface within a short time span after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment and storm water flows can be prevented by placing fiber rolls or silt fences around the excavated perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with construction of pervious surfaces.

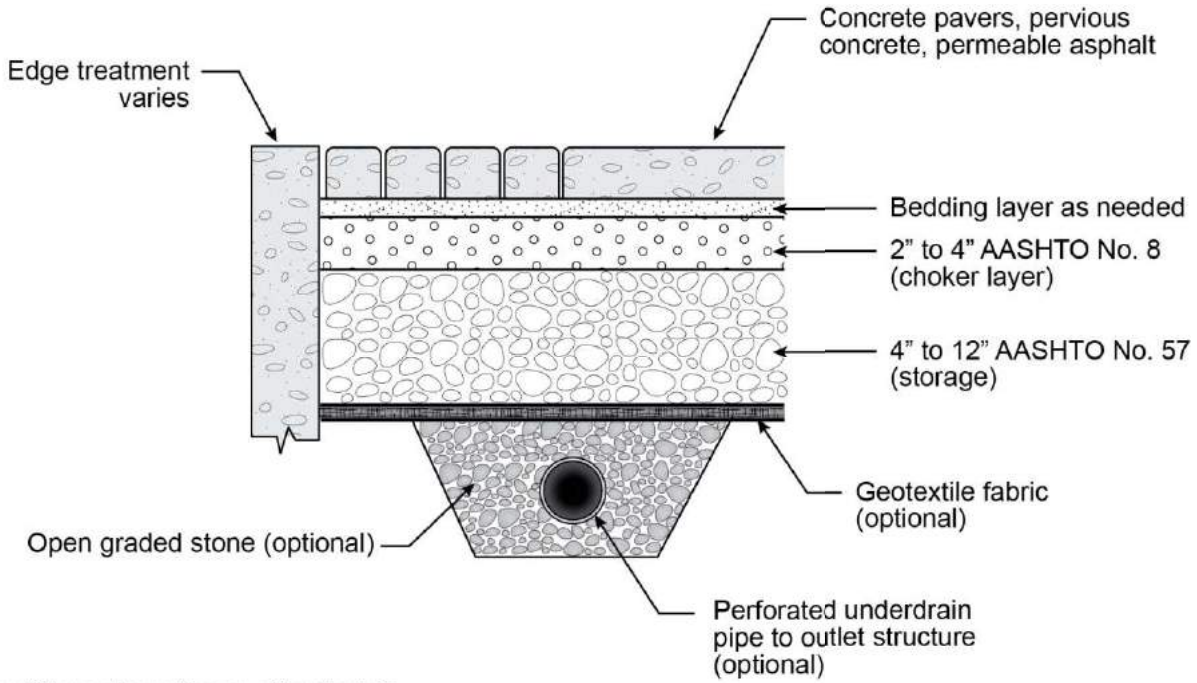
- Excavation
- Grading
- Fine grading
- Pervious surface
- Top layer
- Engineered soil
- Choker layer
- Open graded stone
- Geotextile fabric
- Impermeable liner
- Observation wells (if needed)
- Underdrain system (if needed)

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of pervious surfaces.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for sediment accumulation.	Semiannual (Spring, Fall)	Use vacuum sweeper followed by pressure washing.	Medium
Inspect for weed growth.	Semiannual (Spring, Fall)	Remove weeds.	LOW
Inspect for standing water on surface or within observation well (if used).	Semiannual (Spring, Fall)	Notify engineer for further inspection.	LOW
Inspect surface for deterioration.	Annual	Notify engineer for further inspection.	LOW
Inspect exfiltration and drainage performance.	As needed, at least annually	Notify engineer for further inspection.	Medium



Notes:

- *Optional items shown for use of underdrain*
- *Dimensions shown may vary based on site conditions*

Pervious Surfaces

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Infiltration Basin

ID-1



Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Infiltration basins are shallow depressions that use existing soils to retain and provide treatment for storm water runoff. Infiltration basins function by capturing and infiltrating runoff over a specified drawdown time.

The primary functions of infiltration basins are bioretention, volume retention, and filtration. The existing soils remove pollutants through physical, chemical, and biological processes before the storm water reaches the groundwater. Filtration occurs as runoff interacts with grass and other vegetation within the basin and as runoff infiltrates through the soil.

Infiltration basins are typically designed for larger drainage areas where it may be impractical for a BMP such as a bioretention area that requires more maintenance of specialized vegetation over a larger area.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Pretreatment of runoff may take place in a forebay that will allow for particulate settling. Forebays are typically sized for a percentage of the water quality volume; typically ranging from 10% to 25%.

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Water Quality Volume	0.1 ac-ft (4356 cf)	No maximum	-
Freeboard	1 ft		-
Overflow Spillway Length	3 ft spillway length		-
Invert Slope	0% (flat basin bottom)		-
Interior Side Slopes	No minimum	3H:1V	-
Drawdown Time	24 hours	72 hours	48 hours recommended
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design.
Depth to Historical High Groundwater	2 ft	No maximum	-

Calculation Methods

Infiltration basin design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the geometry of the infiltration basin.
3. Based on the basin geometry, determine the ponding depth required to hold the water quality volume.
4. Calculate the drawdown time.

Calculate the water quality outlet elevation.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A 13.50-acre highway development routes all of its storm water to a single infiltration basin. A safety factor of 1.50 is required for infiltration design within the jurisdiction. Adjacent soils are 'A' and are part of the drainage area.

Given

Contributing drainage area: 13.50 ac

Imperviousness: 0.65

90th percentile storm depth: 0.55 in

Soil infiltration rate: 1.35 in/hr

Design Goals

Determine the bottom footprint of the infiltration basin and the elevation of the water quality outlet above the basin bottom.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_{V\text{-}A} = 0.84i^{1.302}$ (R_V based on hydrologic soil group)

$R_{V\text{-}A} = 0.84(0.65)^{1.302}$

$R_V = 0.48$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.48)(0.55 in)(13.50 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 12,921 cf

Minimum footprint, A_{min} (See *Minimum footprint area*)

A_{min} = (12)(1.50)(12,921 cf) / (1.35 in/hr)(48 hrs)

A_{min} = 3,589 sf

The water quality volume will infiltrate into the existing soil in 48 hours if the infiltration basin bottom is 4,276 square feet. However, this does not mean that the infiltration basin bottom is limited to 4,276 square feet.

Water quality elevation, Ele_{WQ}

The elevation of a water quality outlet above the basin bottom is determined by assuming that infiltration occurs only through the bottom of the basin and not through the sides.

Ele_{WQ} = WQV / A_{min}

Ele_{WQ} = 12,921 cf / 3,589 sf

Ele_{WQ} = 3.60 ft

Infiltration Basin Effectiveness

Effective infiltration basins take advantage of open spaces for retaining and treating storm water. Established vegetation with adequate coverage is an indication of a healthy infiltration basin along with minimal sediment and lack of invasive vegetation. Side slopes should be stable and show little to no signs of erosion or rilling. Slope sloughing is an indication that geotechnical remediation is needed.

During the design storm event, infiltration basins should, at most, pond up to the water quality outlet. After the rain event, runoff within the basin should infiltrate through the bottom soils within the design drawdown time.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is there available right-of-way, property, or easement for the infiltration basin?	☐	☐
Is contaminated groundwater present at the infiltration basin location?	☐	☐
Is the water quality volume above the 4,356 cf threshold?	☐	☐

Does the infiltration basin provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the infiltration basin if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐
Do utility conflicts make installation of the infiltration basin technically infeasible?	☐	☐
Do geotechnical conditions exist that compromise the stability of the infiltration basin or surrounding structures?	☐	☐
Does an overflow outlet structure or bypass mechanism exist?	☐	☐
Is a fence required?	☐	☐

Vegetation

Refer to *Vegetation Guidance by BMP Type*.

Installation

Excavation

Installation of infiltration basins is a relatively straightforward process of excavation and grading; however, the basin will fail if proper care is not taken during construction. Excavators and heavy machinery should not be used within the basin area to avoid soil compaction.

Activities During Construction

Avoid using heavy machinery within the infiltration basin footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Installation of an outlet structure may require machinery.

Flows During Construction

Flows during construction should be diverted away from the infiltration basin to prevent construction site sediment from clogging soils. Seeding or laying turf sod should occur within a short time span after excavation to minimize the impact of unnecessary storm water flows from entering the basin area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the basin perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with infiltration basin construction.

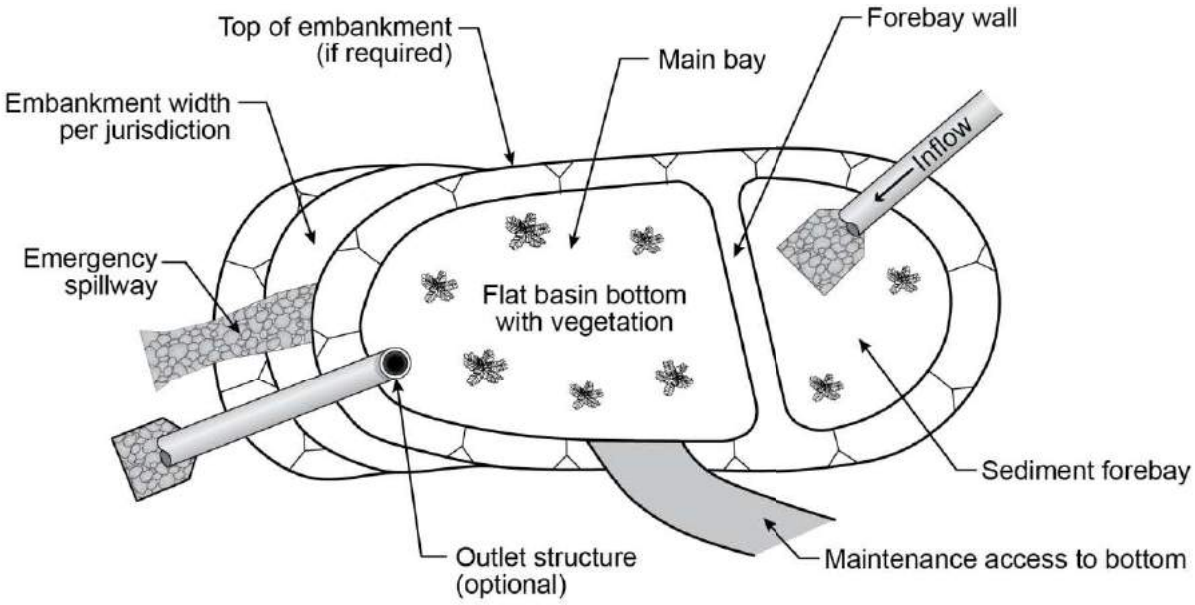
- Excavation
- Grading
- Outlet structure or upstream bypass structure (for larger storm events)
- Forebay and associated items: outlet protection, forebay wall, and connection between forebay and main bay.

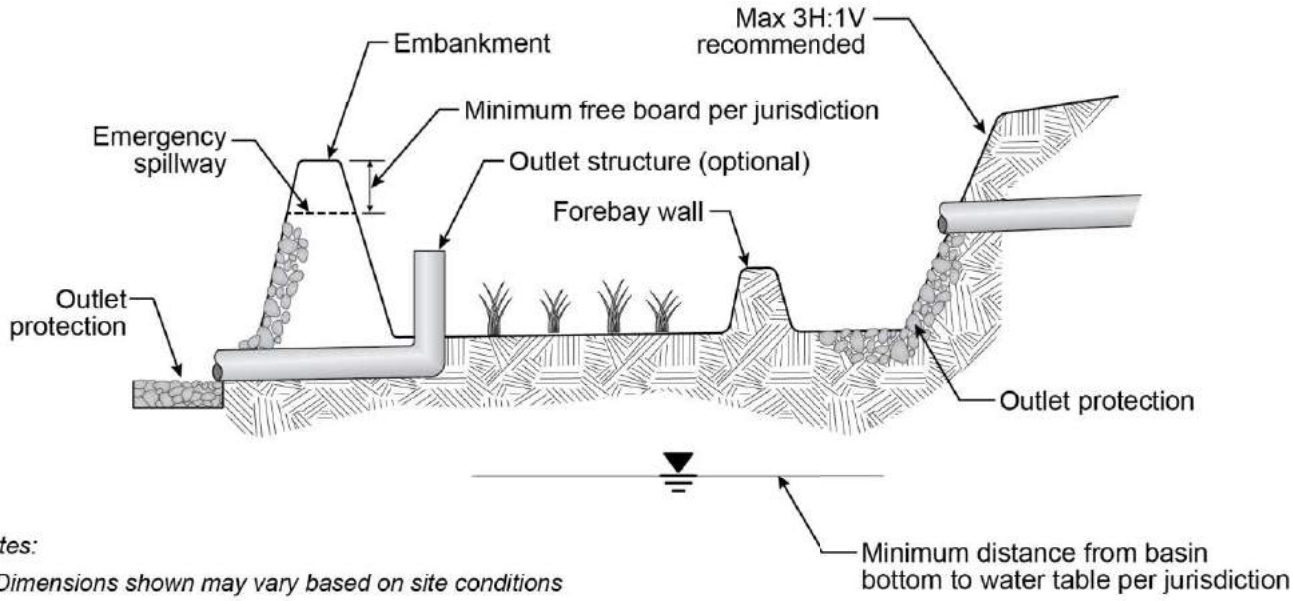
Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of infiltration BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris at inlet and outlet structures.	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	LOW
Inspect grass length.	As needed	Mow basin grass.	LOW
Inspect pre-treatment diversion structures for sediment build-up.	Semiannual (Spring, Fall)	Remove and dispose of sediment buildup.	LOW
Inspect topsoil for sediment buildup.	Semiannual (Spring, Fall) or as needed	Remove sediment.	LOW
Inspect for standing water above trench or within observation well (if used).	Semiannual (Spring, Fall)	Notify engineer for further inspection.	LOW





Notes:

- *Dimensions shown may vary based on site conditions*
- *Forebay connection type to main bay will vary: outlet pipe, gabion wall, notched concrete wall, and others are acceptable*
- *Consider upstream bypass for large storm events*

Infiltration Basin

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Infiltration Trench

ID-2



Source: NHDES Soak Up the Rain

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Infiltration trenches are linear excavations that are backfilled with a combination of gravel, open graded stone, and sand layers that provide storage within the pore space of the specified layers. Although typically linear, infiltration trenches can be any shape provided that the footprint and depth are sized to retain the water quality volume.

The primary function of infiltration trenches is volume retention. The trench is designed such that the water quality volume is retained and stored within the gravel and sand layers. Depending on the design of the trench, pollutant removal occurs via filtration as runoff passes through an initial pea gravel layer and ultimately through the bottom sand layer. A geotextile fabric is also recommended along the sidewalls of the trench and under the pea gravel layer.

Primary Functions	
Bioretention	Yes[1]
Volume Retention	Yes
Biofiltration	Some

[1]Bioretention occurs in subsurface and not within the trench.

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Depth of Trench	2 ft	No maximum	Maximum depth determined by jurisdiction.
Longitudinal Trench Slope	0%	1%	-
Width	2 ft	No maximum	-
Drawdown Time	12 hours	72 hours	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design.
Depth to Historical High Groundwater	2 ft	No maximum	-

Calculation Methods

Infiltration trench design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the trench footprint.
3. Based on the trench geometry, porosity of the trench layers, and ponding depth (if any), determine the trench depth.
4. Calculate the drawdown time.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A proposed park will have a concrete plaza that is 0.40 acres. Runoff from the plaza will flow towards a pervious area. To meet the jurisdiction's retention requirement, the design team proposes to install an infiltration trench adjacent to the plaza.

Given

Contributing drainage area: 0.40 ac

Imperviousness: 1.00

90th percentile storm depth: 0.70 in

Design Goals

Determine that the geometry of an infiltration trench that will retain the water quality volume.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 0.91i - 0.0204$ (Reese method)

$R_V = 0.91(1.0) - 0.0204$

$R_V = 0.89$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.89)(0.70 in)(0.40 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 904 cf

There are 100 linear feet adjacent to the plaza that are available for the infiltration trench. Based on the grading at the trench, ponding above the trench will not occur. A trench that is 4.5 ft wide with the following properties will be able to retain the water quality volume. See *Storage volume within a media with a known porosity* for guidance on determining storage within soils.

Layer	Thickness, in	Porosity	Storage Volume, cf
Pea Gravel	4	0.25	37.5
Open Graded Stone	56	0.4	840
Sand Layer	6	0.15	33.8
Total	66	0.36 (weighted)	911.2

The equivalent storage depth of the water quality volume within the 4,500-sf infiltration trench is:

d = 911.2 cf / 4,500 sf

d = 2 ft

d = 24 in

Drawdown time, t

The infiltration rate of the surrounding soils is 1.5 in/hr.

t = Equivalent storage depth / infiltration rate

t = 24 in / 1.5 in/hr

t = 16 hrs

Infiltration Trench Effectiveness

Effective infiltration trenches take advantage of limited or narrow spaces where bioretention areas or infiltration basins are impractical. Visible sediment buildup on the top layer of the trench could be an indication that clogging is present within the trench or that runoff is simply passing over the trench and not being captured. Although some vegetation intrusion or organic debris is likely not a concern, proper grooming and maintenance will contribute to a trench's extended life-span.

During the design storm event, runoff should be conveyed toward and enter the trench per the design plans. Recent new construction, regrading, or resurfacing within the contributing drainage area should be noted as it may impact flow paths or the introduction of new pollutants.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐
Is contaminated groundwater present at the infiltration trench location?	☐	☐
Do utility conflicts make installation of the infiltration trench technically infeasible?	☐	☐
Do geotechnical conditions exist that compromise the stability of the infiltration trench or surrounding structures?	☐	☐
Does the infiltration trench provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the infiltration trench if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐
Does an overflow outlet structure or bypass mechanism exist, if needed?	☐	☐

Vegetation

Vegetation is not typical for an infiltration trench.

Installation

Excavation

Excavation for infiltration trenches is typically linear but alternate geometries are possible. During excavation, light machinery should be used to avoid excessive compaction.

Activities During Construction

Avoid using heavy machinery within the infiltration trench footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities.

Flows During Construction

Flows during construction should be diverted away from the infiltration trench to prevent construction site sediment from clogging soils. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the trench perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with infiltration trench construction.

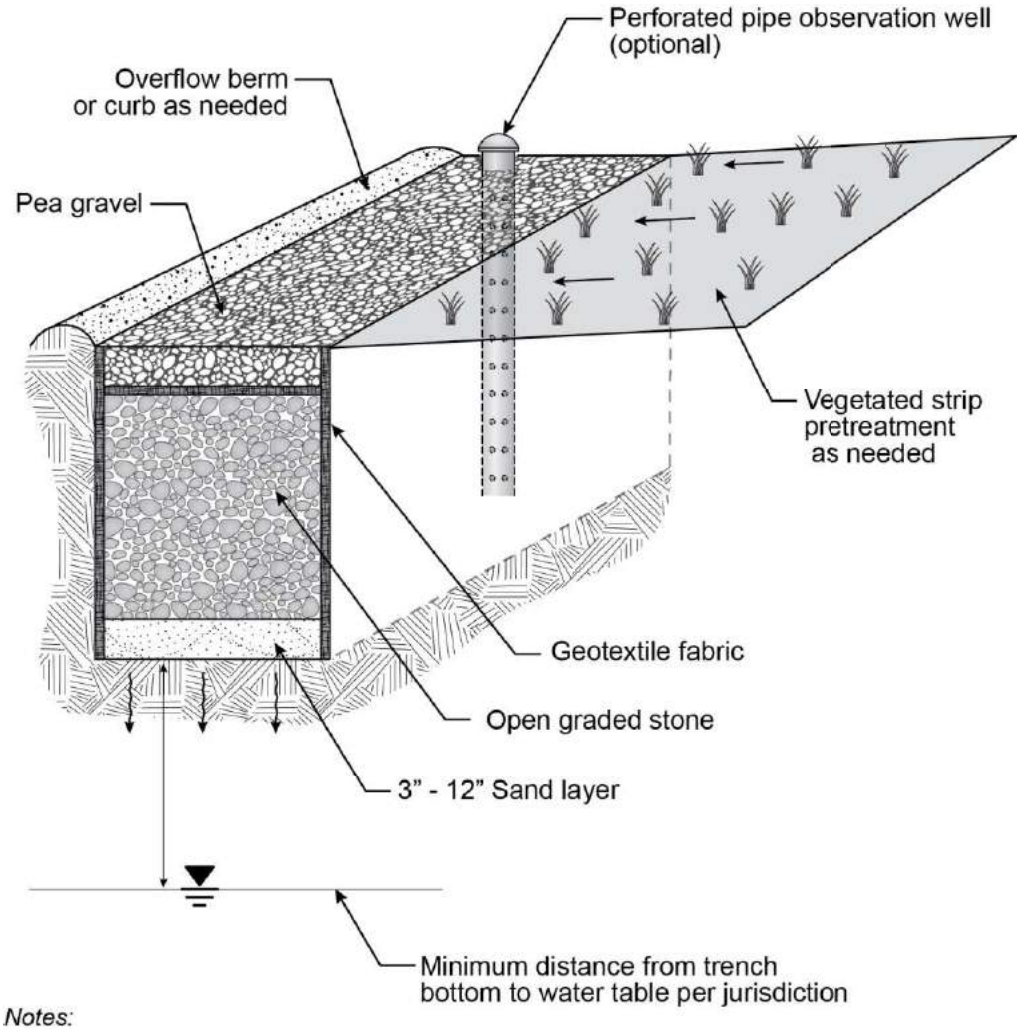
- Excavation
- Landscaping and vegetation
- Pea gravel
- Open graded stone
- Sand layer
- Geotextile separator

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of infiltration BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris at inlet and outlet structures.	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	LOW
Inspect grass length, if any, on top of trench.	As needed	Mow trench grass.	LOW
Inspect pre-treatment diversion structures for sediment buildup.	Semiannual (Spring, Fall) or as needed	Remove and dispose of sediment build up.	LOW
Inspect tree growth near trench.	Semiannual (Spring, Fall)	Remove trees in vicinity of the trench.	LOW
Inspect for standing water above trench or within observation well.	Semiannual (Spring, Fall)	Notify engineer for further inspection.	LOW



Notes:

- *Dimensions shown may vary based on site conditions*

Infiltration Trench

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Dry Well *ID-3*



Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Dry wells are underground storage areas that are sized to retain the water quality volume and infiltrate runoff into the existing soils.

The primary functions of dry wells are bioretention and volume retention. Bioretention does not occur within the dry well but occurs in the native soils immediately surrounding the dry well.

Dry wells contribute to aquifer recharge and as such classify as a subclass of Underground Injection Control (UIC) Class V wells. Refer to the DWQ website on storm water drainage wells (link below) for more information relating to the UIC Program.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	No

Storm Water Drainage Wells: https://deq.utah.gov/legacy/programs/water-quality/utah-underground-injection-control/drainage-wells/index.htm

Design Criteria

Refer to *Design Criteria* in the *Preface to Fact Sheets* for discussion of design criteria parameters.

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No maximum	-
Drawdown Time	24 hours	72 hours	-
Building Setback	10 ft	No maximum	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design.

Calculation Methods

Dry well design is governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine the dry well geometry.
3. Determine the drawdown time.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A drywell is proposed at the downstream end of a swale that is being proposed adjacent to a new road.

Given

Contributing drainage area: 0.72 ac

Imperviousness: 0.40

90th percentile storm depth: 0.59 in

Infiltration rate of surrounding soil: 3 in/hr

Design Goals

Determine the dry well geometry required to hold the water quality volume.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 0.225i + 0.05$ (Granato method when $i < 0.55$)

$R_V = 0.225(0.40) + 0.05$

$R_V = 0.14$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.14)(0.59 in)(0.72 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 220 cf

A dry well that has a 6 ft radius and is 8 ft deep will hold 226 cf.

For a conservative estimate at the planning stage, the dry well's drawdown time is based on the infiltration rate of the surrounding soil and ignores the effects of the pressure head within the dry well. A more detailed determination of the drawdown should be done for final design.

Drawdown time, t

t = Dry well depth / infiltration rate

t = (8 ft)(12 in/ft) / 3 in/hr

t = 32 hrs

Dry Well Effectiveness

Effective dry wells optimize infiltrating soils within limited space to retain storm water runoff while not introducing stability concerns to nearby development or structures. The design storm volume within a functioning dry well will drawdown within the design time and leave no standing water inside of the well. Pretreatment should be provided prior to entering the dry well and the pretreatment method should be determined based on the expected pollutants. Entry to the dry well should be unobstructed and free of debris that will restrict flows from entering.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐
Is contaminated groundwater present at the dry well location?	☐	☐
Do utility conflicts make installation of the dry well technically infeasible?	☐	☐
Do geotechnical conditions exist that compromise the stability of the dry well or surrounding structures?	☐	☐
Is pretreatment provided upstream of or within the dry well?	☐	☐

Installation

Excavation

Excavate area in which dry well will be placed.

Activities During Construction

Take proper safety measures to cover the excavated dry well area before putting the dry well in place. If the dry well is designed to infiltrate through the well bottom, place and level gravel within the excavation to provide a foundation for the well structure.

Flows During Construction

Flows during construction can enter the dry well if the grated manhole lid contains a filtering material.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Obtain a permit through the UIC Program

Installation Costs

The following cost items are typically associated with dry well construction.

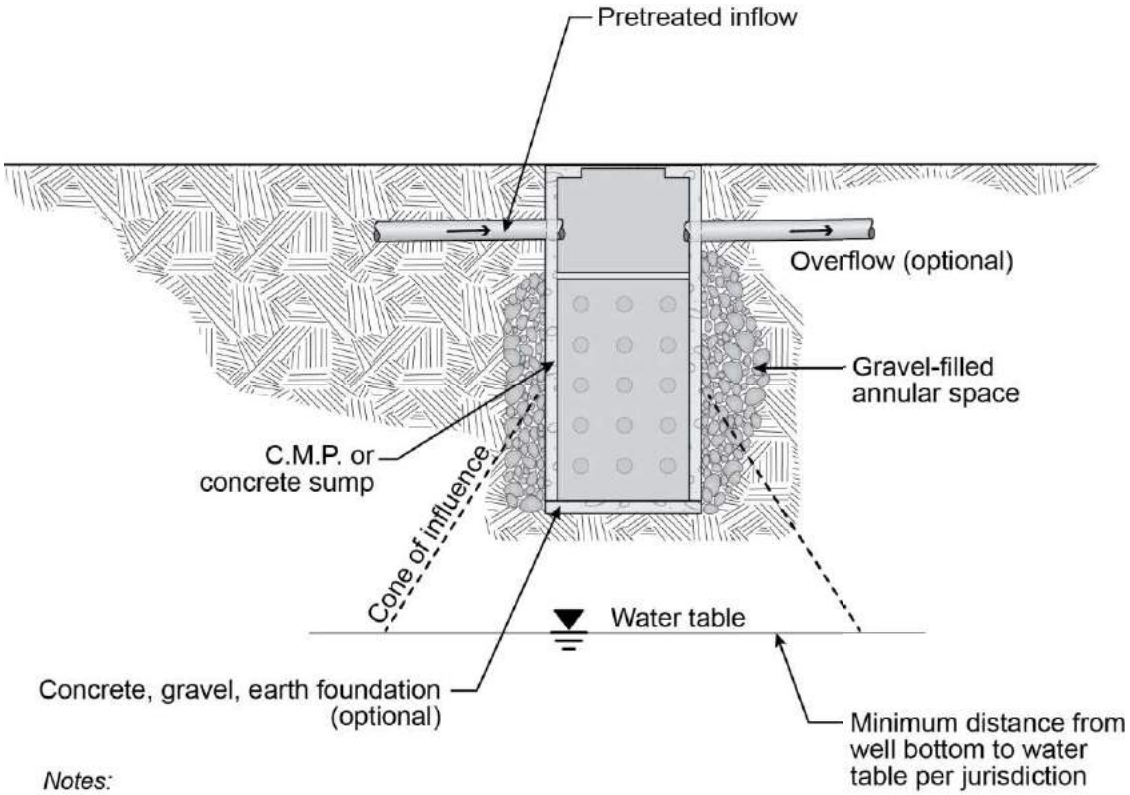
- Excavation
- Dry well
- Permit application fees for Class V Injection Wells
- Gravel-filled annular space surrounding dry well
- Pretreatment upstream of dry well
- Overflow connection to downstream system
- Gravel foundation (optional)

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of dry wells.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect water depth.	Initially after every major storm, then annually.	Remove and dispose of built up sediment when buildup causes reduction in detention capacity. Notify the engineer.	Medium
Inspect inlet for obstructions.	Semiannual (Spring, Fall) or as needed	Remove obstructions.	LOW
Inspect structural elements.	As determined by jurisdiction.	Repair or reconstruct deficient structural components.	Medium



Notes:

- *Dimensions shown may vary based on site conditions*

Dry Well

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Underground Infiltration Galleries *ID-4*



Source: StormTech

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Underground storage devices are proprietary alternatives to above ground storage when space at the project site is limited. They may be sized for the 90th percentile volume similar to how they are sized for flood control volumes. When underground storage is used for water quality, its primary functions are bioretention as runoff infiltrates into the underlying soil and volume retention. They are constrained by subsurface conditions such as depth to the historical high groundwater, soil infiltration rates, and other site-specific constraints that prevent infiltration. Designing underground storage devices is done with the assistance of the device manufacturer.

Primary Functions	
Bioretention	Yes
Volume Retention	Yes
Biofiltration	No

Pretreatment for underground systems will vary. Pretreatment removes sediment that will potentially clog elements of the underground system such as geotextile fabrics or bedding layers. If the manufacturer does not include a pretreatment system as part of the device, it may be necessary to design a separate pretreatment system such as a settling basin upstream before entering the underground system.

Underground systems are typically modular and allow for configurations that range from large areas such as would be needed underneath a parking lot to linear installations like within a park strip or underneath a bioswale.

Design Criteria

Underground storage devices are proprietary devices; follow manufacturer specifications to determine design criteria on a case-by-case basis.

Calculation Methods

Underground storage device design is governed by the water quality volume (when sizing for the water quality event). It is not uncommon for manufacturers to provide sizing tools based on the desired storage volume. The general design steps are:

1. Calculate the water quality volume.
2. Determine manufacturer's recommendations given the water quality volume and other site conditions.

Underground Infiltration Effectiveness

With regular maintenance and inspection, it can be determined if the underground system is performing as expected. As part of the design process, determine how the system will be inspected. Possible inspection methods include the use of observation wells or structural vaults at tie-in locations with the site's storm drain network. Inspect for any soil displacement or movement at the perimeter of the system and any depressions above the system.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐
Is contaminated groundwater present?	☐	☐
Do utility conflicts exist that make installation of the device technically infeasible?	☐	☐
Do geotechnical conditions exist that compromise the stability of the device or surrounding structures?	☐	☐
Is pretreatment provided upstream of or within the underground storage device?	☐	☐
Is the soil bearing capacity of the underlying soil sufficient for the system?	☐	☐
Will the underground system support the expected loads above it?	☐	☐

Installation

Excavation

Excavate the footprint of the underground system.

Activities During Construction

Avoid using heavy machinery within the excavated footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Avoid using heavy machinery on top of the underground system as well. Follow all installation guidelines from the manufacturer.

Flows During Construction

Flows during construction should be diverted away from the excavated area to prevent construction site sediment from clogging soils.

Additional Guidance

- Follow all manufacturer's requirements.

Installation Costs

The following cost items are typically associated with installation of underground storage systems.

- Excavation
- Geotextile fabric
- Underground storage devices
- Aggregate (bedding, overlay, other as needed)
- Observation wells
- Pretreatment upstream of system (if not provided)

Maintenance

Underground systems are typically designed with accessible pretreatment areas such as a manhole. Refer to manufacturer's guidelines.

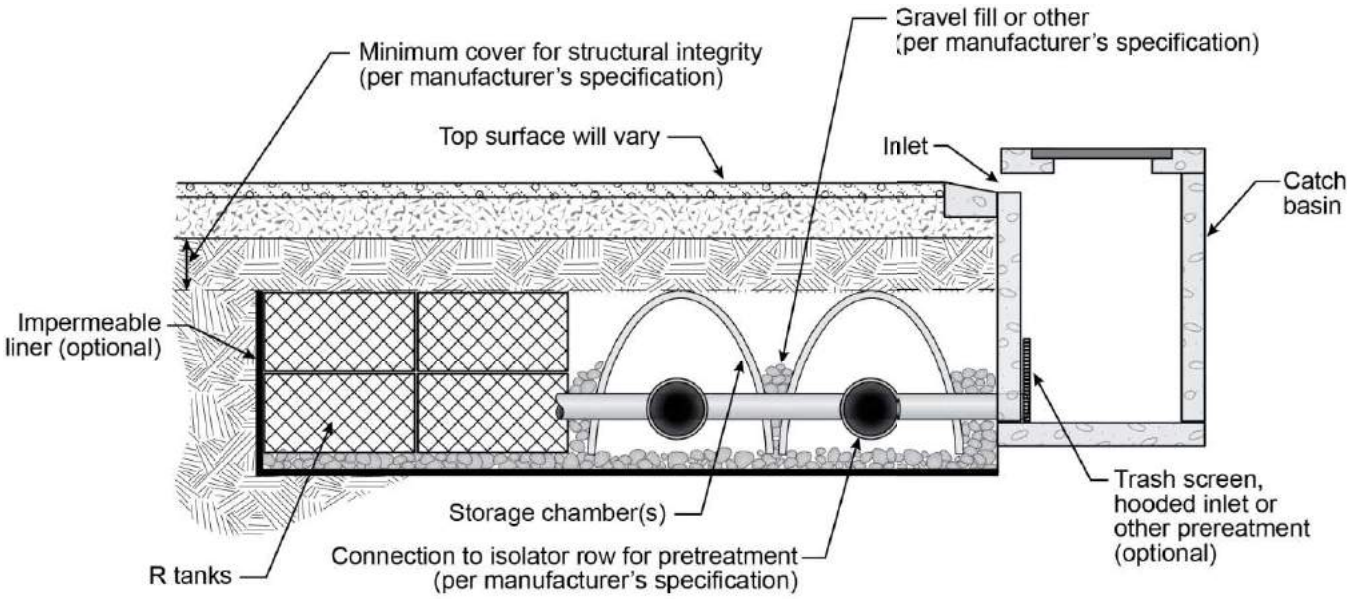
Maintenance Activities

Typical maintenance activity includes removal of sediment or debris within the pretreatment area. High pressure washing of geotextile fabrics or replacement of filter fabrics may also be needed. Refer to manufacturer's guidelines for specific activities and frequency of inspections.

Manufacturers

The following table of manufacturers is for reference only and does not constitute an endorsement.

Manufacturer	Device Type(s)	URL
StormTech	Chambers	http://www.stormtech.com/
ACF Environmental	Chambers R Tanks	https://www.acfenvironmental.com
ConTech	Chambers	https://www.conteches.com



Notes:

- *Configurations will vary*
- *Impermeable liner around undergroundsystem if groundwater concerns exist*
- *If impermeable liner is used, provide outlet to prevent standing water*

Underground Infiltration Gallery

Not to scale

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Harvest and Reuse

HR-1



Pollutant Removal Effectiveness

Pollutant removal will vary based on the ultimate use of the harvested runoff.

Harvest and reuse refers to any type of runoff collection system that captures rainfall, stores it temporarily, and reuses it for irrigation, landscaping, or other non-potable uses. Harvest and reuse systems inherently retain the volume of runoff that it captures. Depending on the subsequent use after being captured, they also provide bioretention and filtration to the released runoff.

Harvest and reuse systems may be used in lieu of directly connecting rooftop drains to storm sewer systems; where downdrains discharge to impervious surfaces and the opportunity for irrigation or landscaping exists; as part of a home owner's irrigation plan; or for any other non-potable purpose where storm water is determined to be acceptable such as vehicle or machinery washing.

Primary Functions	
Bioretention	Varies
Volume Retention	Yes
Biofiltration	Varies

As of 2010, Utah's legislative code 73-3-1.5 requires that if more than 100 gallons of rainwater (13.4 cf) are captured, it must be registered through the Utah Division of Water Rights (https://waterrights.utah.gov/forms/rainwater.asp). The code also limits the total capture to 2,500 gallons (334.2 cubic feet). See the code for additional requirements.

Design Criteria

Design criteria for harvest and reuse devices or systems will vary widely. The governing principles of harvest and reuse are based on the system's function and capacity. For example, a rain barrel that provides occasional irrigation to a flower bed should be appropriately sized for the 90th percentile volume and be able to release the volume within an appropriate time that does not flood out the flower bed. A larger harvest and reuse system, such as an underground detention vault or above ground pond will be required to meet geotechnical or structural design criteria. The applications of harvest and reuse systems are endless; specific design criteria should be determined on a case-by-case basis with site-specific consideration.

Calculation Methods

Harvest and reuse systems are governed by the water quality volume. The general design steps are:

1. Calculate the water quality volume.
2. Size device for the water quality volume.

Sample Calculations

Refer to *Calculation Methods* in the *Preface to Fact Sheets* for discussion on the equations used.

A commercial development will have two buildings with roofs that are 2,500 square feet each. Rain barrels that will release to flower beds will be included as part of the design. Each roof is considered one drainage area.

Given

Contributing drainage area: 2,500 sf

Contributing drainage area: 0.057 ac

Imperviousness: 1.00

90th percentile storm depth: 0.60 in

Design Goals

Capture all runoff from the 90th percentile storm within rain barrels.

Calculations

Volumetric runoff coefficient, R_V (See *Sample Calculations*)

$R_V = 0.91i - 0.0204$ (Reese method)

$R_V = 0.91(1.0) - 0.0204$

$R_V = 0.89$

Water quality volume, WQV (See *Developing the 90th Percentile Volume*)

WQV = (0.89)(0.60 in)(0.057 ac)(43,560 sf/ac) / (12 in/ft)

WQV = 111 cf

WQV = 832 gallons

If 55-gallon rain barrels are used, 15 rain barrels will be needed for each roof and the capture will need to be registered with the Division of Water Rights.

Harvest and Reuse Effectiveness

The effectiveness of a harvest and reuse system is dependent on its use. Detention devices should be free of standing water to prevent stagnation and vector concerns. Systems that provide irrigation or that are part of landscaping features should be inspected regularly to ensure proper performance.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Will stagnation of runoff be prevented by frequent release of the harvested runoff?	☐	☐
Does quantity of harvested runoff require registration with the Division of Water Rights?	☐	☐

Installation

Installation of harvest and reuse systems will vary depending on its use. Rain barrels can simply be connected to a down drain. More complicated systems require additional coordination.

Depending on the quantity of runoff being harvested, it will be necessary to register the detention device with the Division of Water Rights.

Installation Costs

The following cost items are typically associated with harvest and reuse systems.

-Detention device

-Upstream connection to detention device

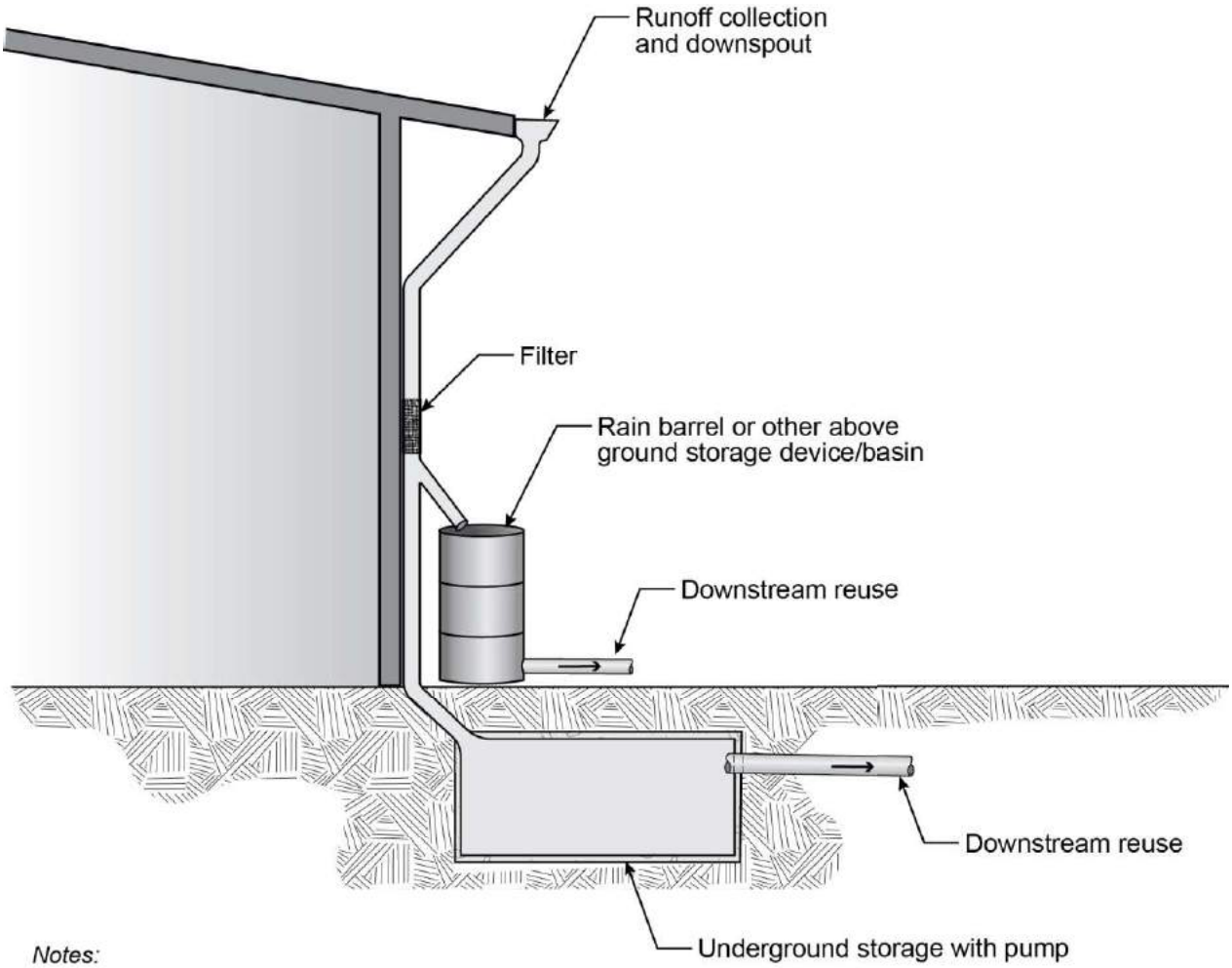
-Other items will be dependent on site-specific use

Maintenance

Refer to *Maintenance* and *Maintenance Costs* in the *Preface to Fact Sheets* for general information related to maintenance of harvest and reuse systems.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for mosquitos.	Semiannual (Spring, Fall)	Implement larvicide or other remediation.	LOW
Inspect harvesting device for leaking.	Semiannual (Spring, Fall)	Replace harvesting device.	LOW
Inspect condition of system components.	Semiannual (Spring, Fall)	Replace and repair components.	Medium



Notes:

- *Configurations and applications may vary*

Harvest and Reuse

Not to scale

EXHIBIT 3

BEST MANAGEMENT PRACTICES

STORMWATER AND CONSTRUCTION ACTIVITIES

A landowner or primary contractor who plans a construction activity which will disturb one or more acres of land, is required to obtain a permit from the Utah Division of Water Quality. The permit may be obtained on-line at www.waterquality.utah.gov/updes/stormwater. Please note that the permit is required **BEFORE** construction starts. The permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP) that identifies potential sources of stormwater pollutants and Best Management Practices (BMPs) to reduce or eliminate their impacts.

BMPs are practices that control stormwater sediment and erosion to the maximum extent practicable. These controls include a wide range of structural and non-structural options. This booklet presents BMPs that are recommended by the Utah Division of Water Quality and the Environmental Protection Agency. A Guidance Document for Stormwater Management provides information on additional BMPs and is available on-line at www.pweng.slco.org/strm/html/guide.html.

Contractors may use this booklet as general guidance related to BMPs; it is up to the contractor to select appropriate BMPs and implement and maintain these BMPs. Selection of BMPs will be site specific and deviation from those presented here may be appropriate given the conditions, contractor experience and new technology. Variations are acceptable provided implemented controls meet the intent of the BMP.

BMPs for Construction Activities

Click on the name of the BMP you would like to view

BMPs to Consider	BMP Criteria: General- for all Sites	Hazardous Wastes Used?	Excavation on Flat Surfaces?	Excavation on Slopes?	Water Bodies on Site?	Construction Temporarily Stopped?	Outside Storage Piles?	Post-Construction BMPs
Waste and Material Management								
BRRC Building, Repair, Remodeling, and Construction	X	X						
CWM Concrete Waste Management	X	X			X			
EB Earth Berm Barrier		X	X	X			X	
HWM Hazardous Waste Management	X	X						
MS Material Storage	X	X					X	
MU Material Use	X	X						X
PT Portable Toilet	X							
SCU Spill Clean-Up		X					X	X
WD Waste Disposal	X	X					X	
Vehicle and Equipment Management								
EVWA Equipment and Vehicle Washdown Area	X							
VEC Vehicle and Equipment Cleaning	X							
VEF Vehicle and Equipment Fueling	X							
Stabilization								
BIO Bioengineering				X	X			X
CM Chemical Mulch				X		X		
CP Compaction	X		X					
CR Construction Road Stabilization	X		X	X				
CESA Contaminated or Erodible Surface Areas			X	X				
DC Dust Controls	X		X	X			X	
ECB Erosion Control Blankets			X	X		X		X
FS Filter Strips	X				X			X
GM Geotextiles and Mats				X	X	X		X
HM Hydromulching			X	X				X
ML Mulching			X			X		X
PEV Preservation of Existing Vegetation	X			X	X			X
SP Seeding and Planting			X	X		X		X
SCE Stabilized Construction Entrance	X							
TPS Temporary and Permanent Seeding			X			X		X
Runoff Diversion								
BE Benching				X			X	
CD Check Dams				X	X			
DD Diversion Dike	X			X	X		X	
SD Slope Drain				X				
TDS Temporary Drains and Swales	X		X	X		X		
TSC Temporary Stream Crossing					X			
Velocity Reduction								
OP Outlet Protection					X			
SR Surface Roughening			X					
Trap/Filter Sediment								
BRF Brush or Rock Filter		X		X	X		X	
FSC Flotation Silt Curtain					X			
IP Inlet Protection - Excavated	X							
IP Inlet Protection - Gravel	X							
IP Inlet Protection - Concrete Block	X							
IP Inlet Protection - Silt Fence or Straw Bale	X							
SBB Sand Bag Barrier		X			X		X	
SB Sediment Basin	X							
ST Sediment Trap	X				X			
SF Silt Fence		X		X	X		X	
STB Straw Bale Barrier		X		X	X		X	
BMPs to Consider	**General- for all Sites**	**Hazardous Wastes Used?**	**Excavation on Flat Surfaces?**	**Excavation on Slopes?**	**Water Bodies on Site?**	**Construction Temporarily Stopped?**	**Outside Storage Piles?**	**Post-Construction BMPs**

Click on the name of the BMP you would like to view

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SELECTION OF BEST MANAGEMENT PRACTICES

Good Housekeeping & Waste Containment

- Building Repair, Remodeling, and Construction Chemical Mulch
- Concrete Waste Management
- Construction Road Stabilization
- Contaminated or Erodible Surface Areas
- Diversion Dike
- Dust Controls
- Earth Berm Barrier
- Employee Training
- Equipment & Vehicle Wash Down Area
- Floatation Silt Curtain
- Hazardous Waste Management
- Inspection & Maintenance
- Material Storage
- Material Use
- Mulching
- Portable Toilets
- Spill Cleanup
- Stabilized Construction Entrance
- Street Sweeping
- Temporary Stream Crossing
- Vehicle and Equipment Cleaning
- Vehicle and Equipment Fueling
- Waste Disposal

Minimize & Stabilize Disturbed Areas

- Benching
- Bioengineering
- Check Dams
- Chemical Mulch
- Compaction
- Construction Road Stabilization
- Construction Sequencing
- Dust Controls
- Employee Training
- Erosion Control Blankets
- Filter Strips
- Geotextiles and Mats
- Hydromulching
- Inspection & Maintenance
- Land Grading
- Mulching
- Preservation of Natural Vegetation
- Silt Fence
- Straw Bale Barrier
- Surface Roughening
- Temporary & Permanent Seeding & Planting
- Temporary Stream Crossing
- Vegetated Buffers

Protect Slope & Channels

- Benching
- Bioengineering
- Check Dams
- Chemical Mulch
- Construction Road Stabilization
- Diversion Dike
- Employee Training
- Erosion Control Blankets
- Filter Strips
- Geotextile Mats
- Hydromulching
- Inspection & Maintenance
- Land Grading
- Mulching
- Outlet Protection
- Preservation of Natural Vegetation
- Sand Bag Barrier
- Silt Fence
- Slope Drain
- Straw Bale Barrier
- Surface Roughening
- Temporary & Permanent Seeding & Planting
- Temporary Stream Crossing
- Vegetated Buffers

Control Internal Erosion & Site Perimeter

- Bioengineering
- Chemical Mulch
- Diversion Dike
- Earth Berm Barrier
- Employee Training
- Equipment & Vehicle Wash Down
- Filter Strips
- Floatation Silt Curtain
- Geotextiles and Mats
- Inlet Protection - Concrete Block
- Inlet Protection - Excavated
- Inlet Protection - Gravel
- Inlet Protection - SiltFence/Straw Bale
- Inlet Protection - Wattle
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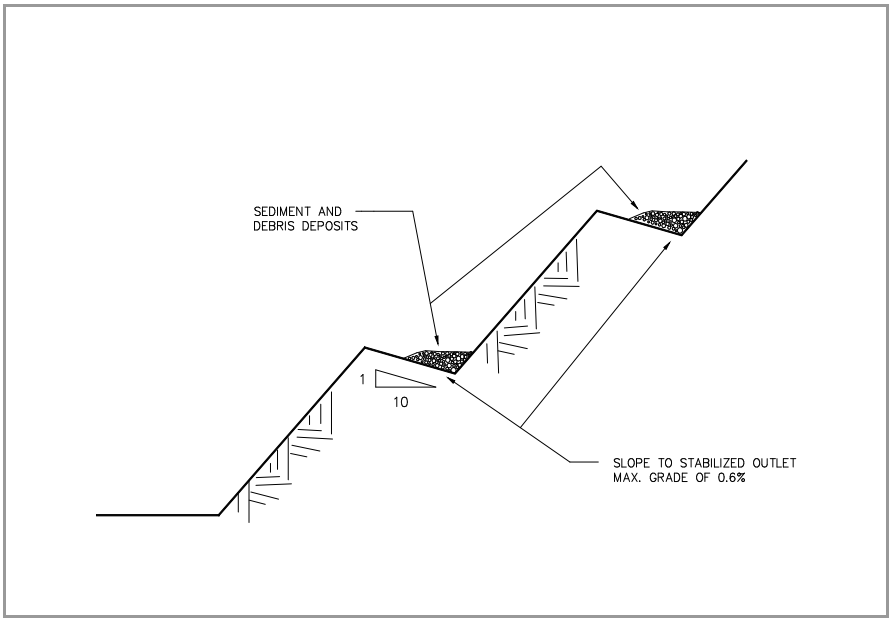
- Vehicle and Equipment Cleaning



DESCRIPTION:

Slope construction with benches spaced at regular intervals perpendicular to the slope which intercept and collect sheet flow and direct it to a stable outfall point.

APPLICATIONS:

- Unstabilized cut and fill slopes
- Large stockpiles
- Existing unstable slopes

INSTALLATION/APPLICATION CRITERIA:

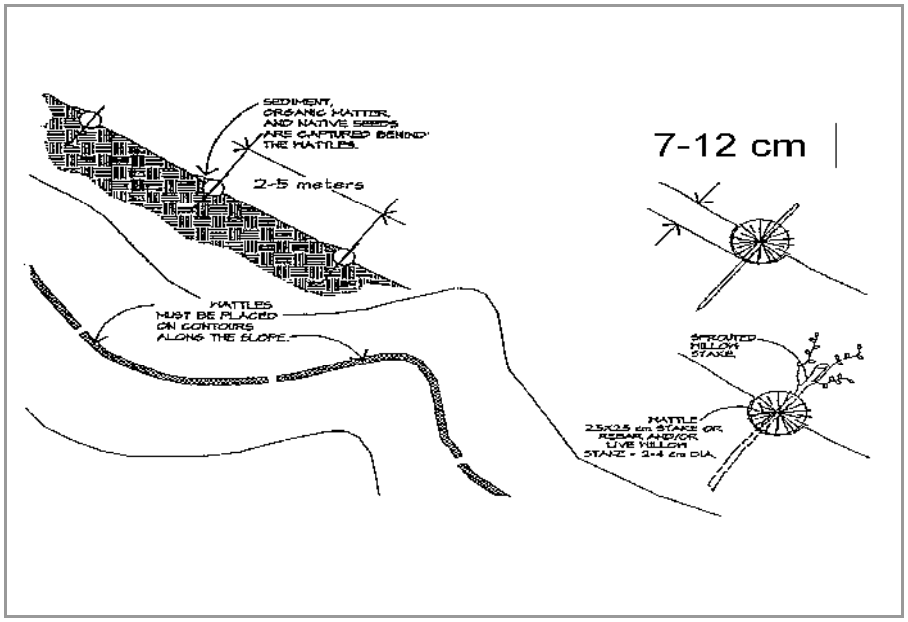
- Benches should be formed as slope is constructed and graded to the outlet point.
- Stabilized outlet with sediment controls should be in place prior to slope construction.

LIMITATIONS:

- Construction slope design must accommodate benching
- Not appropriate for sandy or rocky soil
- Only effective if suitable outlet provided

MAINTENANCE:

- Inspect after major storm events and at least biannually, repair any damaged areas.
- Remove debris blocking water flow.
- Inspect outlet, repair/replace sediment controls and remove sediment build up.



DESCRIPTION:

Bioengineering methods combine vegetative and mechanical techniques to stabilize eroding slopes. Bioengineering methods include sprigging, tubeling and wattling. Sprigging involves planting rhizomes, stolons, shoots or sprouts of a desirable species. Tubelings are forbs, shrubs, or trees commercially available in reusable plastic tubes or sleeves. Wattles are bundles of cuttings from live willows, alders, or similar plants placed and secured in trenches across a slope to aid in slope stabilization.

APPLICATIONS:

- Sprigging may be performed on cut and fill slopes or other areas needing permanent soil stability.
- Tubelings may be placed on any area needing revegetation, but are most useful on slopes or flat areas where poor topsoil conditions inhibit successful seed germination and early plant growth.
- Wattles act to reduce slope length and aid in stabilizing slopes due to surface runoff, frost heaving, needle ice, or other soil movement.

INSTALLATION/APPLICATION CRITERIA:

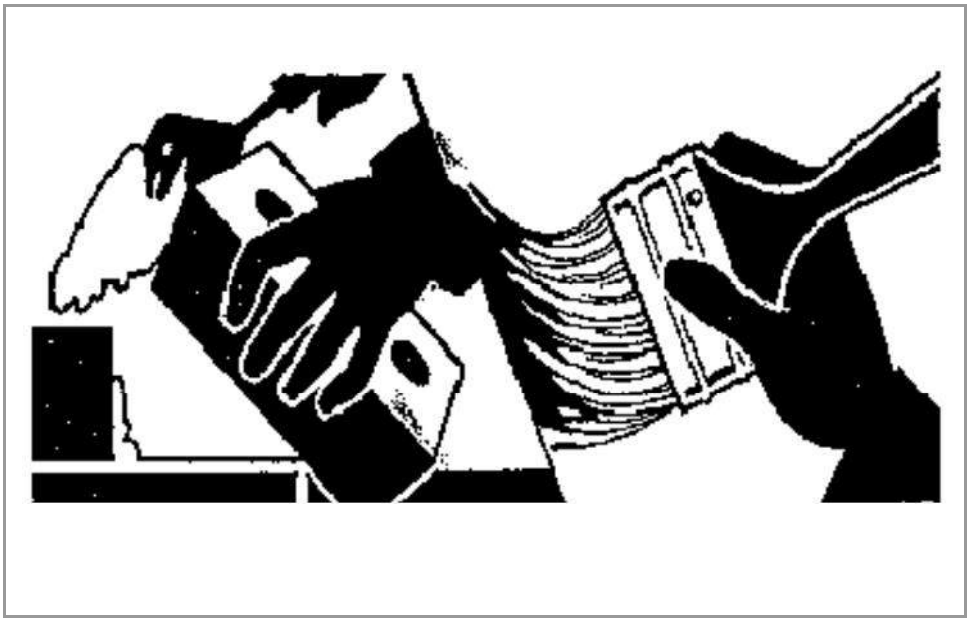
- Sprigging involves tearing sod apart; planting rhizomes or stolons, or transplanting shoots or sprouts. Sprigs are placed by broadcast, punching-in or with a special sprig planter.
- Tubelings involve drilling holes to the depth necessary to accommodate roots.
- Wattles are best applied to slopes no steeper than 2:1.

LIMITATIONS:

- Availability of plant materials may affect what species can be used.
- May be necessary to arrange for commercially grown tubelings.
- Cannot be used as a substitute for retaining walls or similar devices to stabilize over steepened slopes.

MAINTENANCE:

- Sprigging and tubeling plantings should be checked periodically until they are permanently established.
- Assess the need for replacement plantings or supplemental fertilizer.



DESCRIPTION:

Prevent or reduce the discharge of pollutants to stormwater from building repair, remodeling, and construction by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, and training employees.

APPLICATIONS:

- Use soil erosion control techniques if bare ground is temporarily exposed.
- Use permanent soil erosion control techniques if the remodeling clears buildings from an area that are not to be replaced.

INSTALLATION/APPLICATION CRITERIA:

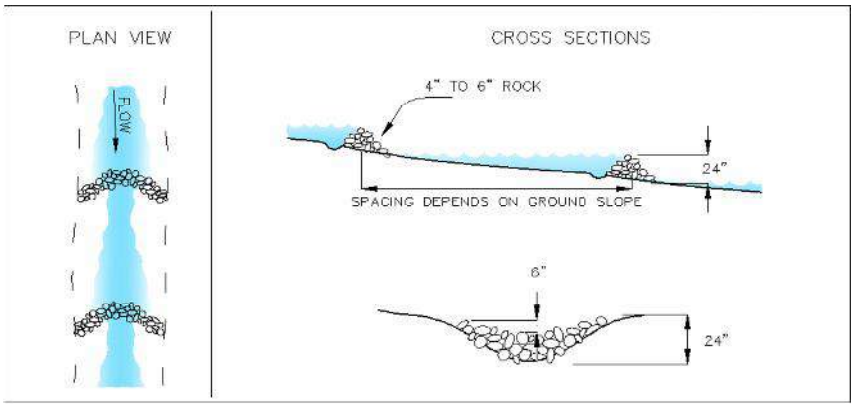
- Enclose painting operations consistent with local air quality regulations and OSHA.
- Properly store materials that are normally used in repair and remodeling such as paints and solvents.
- Properly store and dispose waste materials generated from the activity.
- Maintain good housekeeping practices while work is underway.

LIMITATIONS:

- This BMP is for minor construction only.
- A licensed hazardous waste hauler must dispose of hazardous waste that cannot be re-used or recycled.
- Safer alternative products may not be available, suitable, or effective in every case.
- Be certain that actions to help storm water quality are consistent with OSHA and air quality regulations.

MAINTENANCE:

None



DESCRIPTION:

A small, temporary dam constructed across a drainage ditch to reduce velocity of concentrated storm water flows, thereby reducing the erosion of the ditch.

APPLICATIONS:

- Temporary drainage paths
- Permanent drainage ways not yet stabilized
- Existing drainage paths receiving increased flows due to construction

INSTALLATION/APPLICATION CRITERIA:

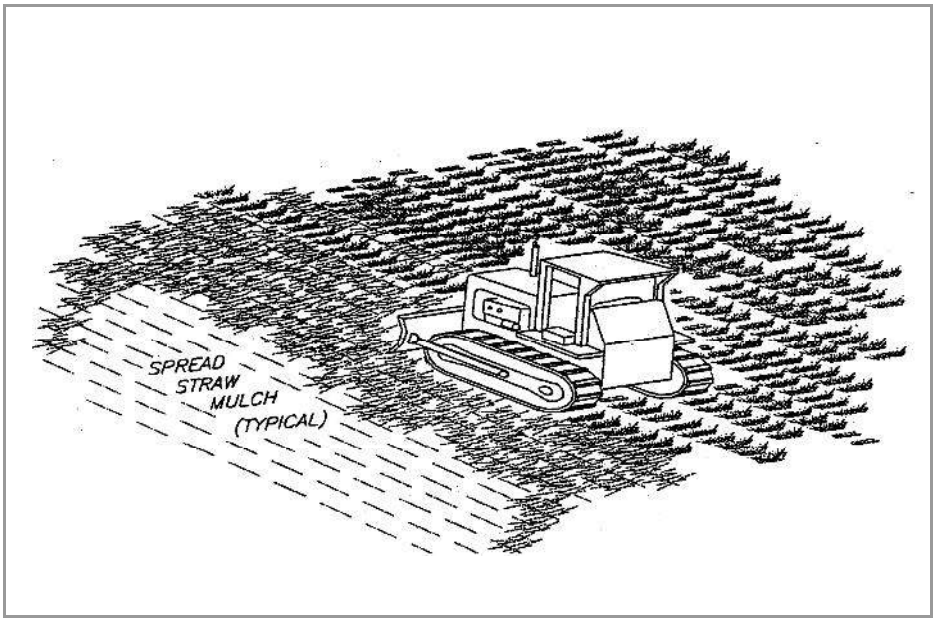
- Prepare location of dam by removing any debris and rough grading any irregularities in channel bottom
- Place rocks by hand or with appropriate machinery; do not dump
- Space dams to make the base of the upstream dam the same elevation as the top of the next lower dam
- Construct dam to pass design flows with center lower to create a weir effect
- Construct 50% side slopes on dam

LIMITATIONS:

- Maximum recommended drainage area is 10 acres
- Maximum recommended height is 24"
- Do not use in running stream

MAINTENANCE:

- Inspect dams at a minimum of twice monthly, after each major rain event, and daily during prolonged rainfall.
- Remove any large debris and repair any damage to dam, channel or sideslopes.
- Remove accumulated sediment when it reaches one half the height of the dam.



DESCRIPTION:

Applying materials such as vinyl, asphalt, plastics, or rubber on an unprotected slope to temporarily stabilize the slope.

APPLICATIONS:

- As a tacking agent to aid the stabilization of mulches (where matting is not used).
- As a short-term alternative in areas where temporary seeding practices cannot be used because of seasonal condition or climate.
- On steep and rocky slopes where neither mechanical methods or mulches and protective netting can be effectively applied.

INSTALLATION/APPLICATION CRITERIA:

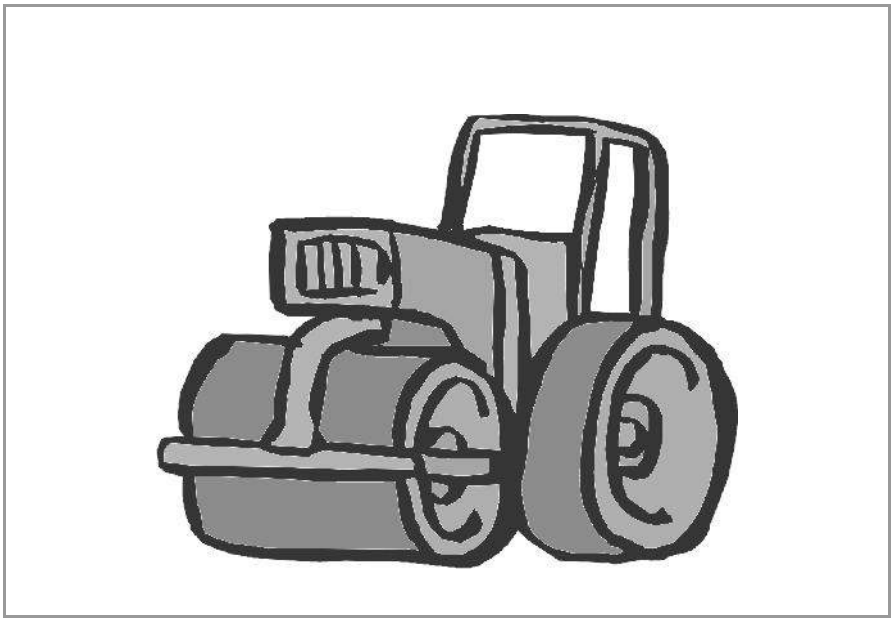
- The application rates and procedures recommended by the manufacturer of a chemical stabilization product should be followed to prevent the products from forming ponds and from creating large areas where moisture cannot get through.
- For permanent application, chemical mulches (when used with seed and mulch) should be applied over wood fiber or straw mulch.

LIMITATIONS:

- Chemical mulches can create impervious surfaces and impact water quality if not properly applied.
- Some products may not be suitable for use near live streams.

MAINTENANCE:

- Inspect at regular intervals and after each runoff-producing storm event.
- Replace chemical mulch as needed to ensure adequate level of coverage.



DESCRIPTION:

Use of rolling, tamping, or vibration to stabilize fill materials and control erosion by increasing the soil density. Increasing the density of soil improves soil strength, reduces long-term soil settlement, and provides resistance to erosion.

APPLICATIONS:

- Stabilize fill material placed around various structures.
- Improve soil in place as foundation support for roads, parking lots, and buildings.

INSTALLATION/APPLICATION CRITERIA:

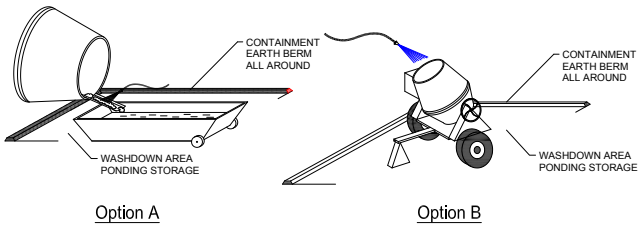
- Make sure soil moisture content is at optimum levels.
- Use proper compaction equipment.
- Install sediment control and storm water management devices below compacted areas and runon interceptor devices above these areas. Drainage from compacted areas must be carefully planned to protect adjacent uncompacted soils.
- The surface of compacted areas should be scarified and seeded or mulched and seeded to increase the effectiveness of compaction.

LIMITATIONS:

- Compaction tends to increase runoff.
- Over-compaction will hamper revegetation efforts.

MAINTENANCE:

- No maintenance required.



CONCRETE WASTE MANAGEMENT

Locate 50' from nearest inlet structure

DESCRIPTION:

Prevent or reduce the discharge of pollutants to storm water from concrete waste by conducting washout off-site, performing on-site washout in a designated area, and training employees and subcontractors.

APPLICATION:

This technique is applicable to all types of sites.

INSTALLATION/APPLICATION CRITERIA:

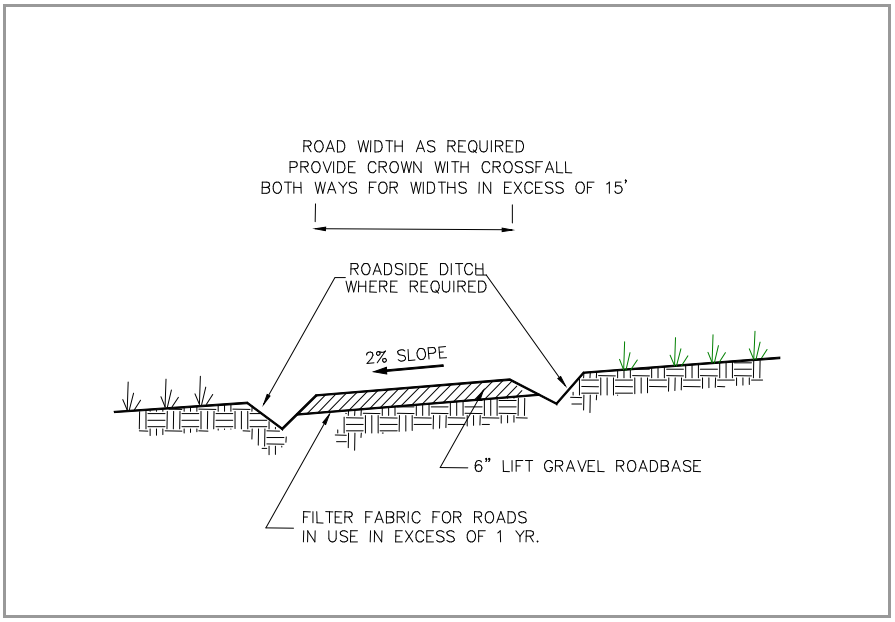
- Store dry materials under cover, away from drainage areas.
- Minimize excess mixing of fresh concrete, mortar or cement on-site.
- Perform washout of concrete trucks off-site or in designated areas only.
- Do not wash out concrete trucks into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped on-site, except in designated areas.
- When washing concrete to remove fine particles and expose the aggregate, avoid creating runoff by draining the water within a bermed or level area. (6” tall by 6” wide).
- Train employees and subcontractors in proper concrete waste management.

LIMITATIONS:

- Off-site washout of concrete wastes may not always be possible.

MAINTENANCE:

- Inspect subcontractors to ensure that concrete wastes are being properly managed.
- If using a temporary pit, dispose hardened concrete on a regular basis.



DESCRIPTION:
Temporary stabilization of on-site roadway by placement of gravel roadbase.

APPLICATION:
- On-site roadways used daily by construction traffic (may not apply to gravelly type soils).
- Parking or staging areas susceptible to erosion due to traffic use.

INSTALLATION/APPLICATION CRITERIA:
- Grade temporary access road with 2% cross fall, for two-way width provide crown.
- Provide roadside ditch and outlet controls where required.
- Place 6 inches of 2-inch to 4-inch crushed rock on driving area.

LIMITATIONS:
- May require removal of gravel roadbase at completion of activities if final cover is not impervious.
- May require controls for surface storm water runoff.

MAINTENANCE:
- Inspect after major rainfall events and at least monthly.
- Place additional gravel as needed and repair any damaged areas.
- Maintain any roadside drainage controls.



DESCRIPTION:

Construction sequencing is a specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion and sediment control measures. Construction site phasing involves disturbing only part of a site at a time to prevent erosion from dormant parts. Grading activities and construction are completed and soils are effectively stabilized on one part of the site before grading and construction commence at another part.

APPLICATIONS:

Sequencing can be used to plan earthwork and erosion and sediment control activities at sites where land disturbances might affect water quality in a receiving waterbody.

INSTALLATION/APPLICATION CRITERIA:

Sequencing schedules should include the following Design and Installation Criteria:

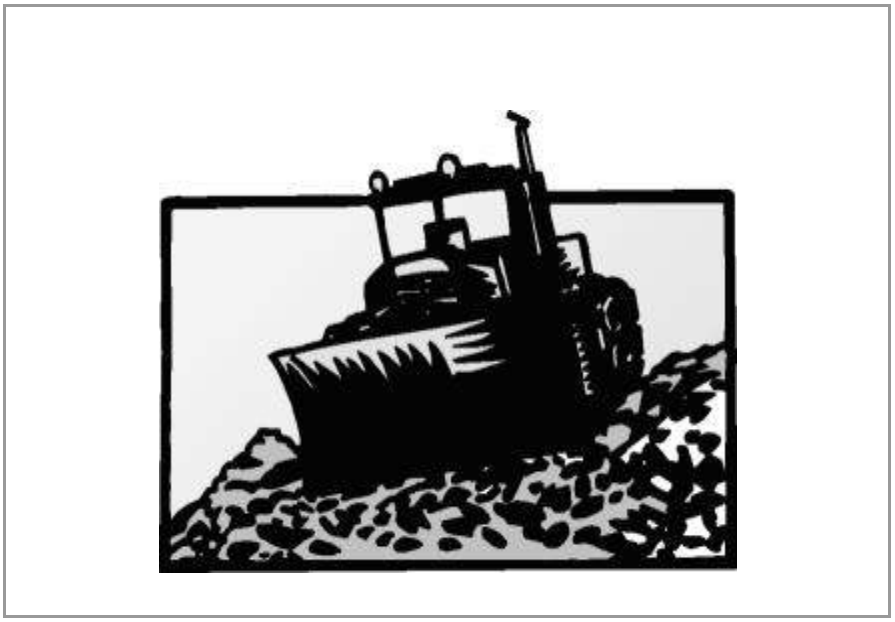
- The erosion & sediment control practices that are to be installed
- Principal development activities
  - Which measures should be installed before other activities are started
  - Compatibility with the general contract construction schedule

LIMITATIONS:

Weather and other unpredictable variables might affect sequence schedules. However, the erosion and sediment control plan should plainly state the proposed schedule and a protocol of making changes due to unforeseen problems.

MAINTENANCE:

Follow the construction sequence throughout the project and modify the written plan before any changes in construction activities are executed. Update the plan if a site inspection indicates the need for additional erosion and sediment control.



DESCRIPTION:

Prevent or reduce the discharge of pollutants to stormwater from contaminated or erodible surface areas by leaving as much vegetation on-site as possible, minimizing soil exposure time, stabilizing exposed soils, and preventing stormwater runon and runoff.

APPLICATIONS:

This BMP addresses soils which are not so contaminated as to exceed criteria but the soil is eroding and carrying pollutants off in the stormwater.

INSTALLATION/APPLICATION CRITERIA:

Contaminated or erodible surface areas can be controlled by:

- Preservation of natural vegetation, re-vegetation, chemical stabilization, removal of contaminated soils or geosynthetics.

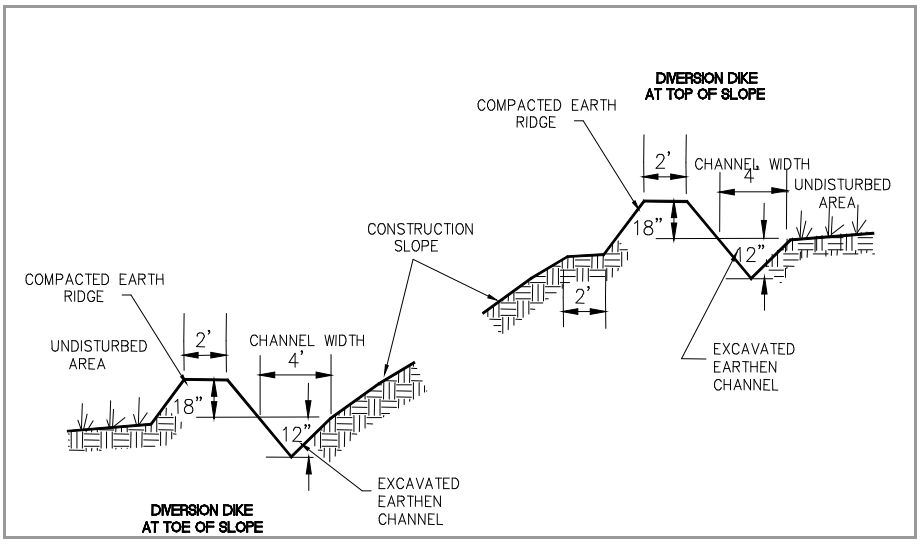
LIMITATIONS:

Disadvantages of preserving natural vegetation or re-vegetating include:

- Requires substantial planning to preserve and maintain the existing vegetation.
- May not be cost-effective with high land costs.
- Lack of rainfall and/or poor soils may limit the success of re-vegetated areas.
- Disadvantages of chemical stabilization include:
  - Creation of impervious surfaces.
  - May cause harmful effects on water quality.
  - Is usually more expensive than vegetative cover.

MAINTENANCE:

Maintenance should be minimal, except possibly if irrigation of vegetation is necessary.



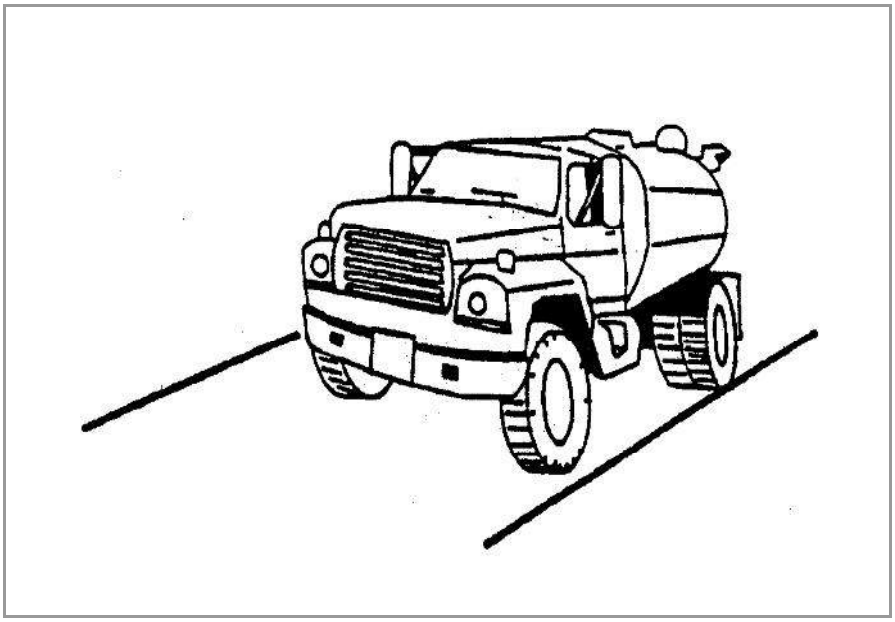
DESCRIPTION:
A temporary sediment barrier and storm runoff conveyance consisting of an excavation channel and compacted earth ridge.

APPLICATION:
- Construct along top of construction slope to intercept upgradient runoff and convey around construction site.
- Construct along toe of construction to divert sediment laden runoff.
- Construct along midpoint of construction slope to intercept runoff and channel to controlled discharge point.
- Construct around base of soil stockpiles to capture sediment.
- Construct around perimeter of disturbed areas to capture sediment.

INSTALLATION/APPLICATION CRITERIA:
- Clear and grub area for dike construction.
- Excavate channel and place soil on downgradient side.
- Shape and machine compact excavated soil to form ridge.
- Place erosion protection (riprap, mulch) at outlet.
- Stabilize channel and ridge as required with mulch, gravel, or vegetative cover.

LIMITATIONS:
- Recommended maximum drainage area of 5 acres.
- Recommended maximum sideslopes of 2h:1v (50%).
- Recommended maximum slope on channel of 1%.

MAINTENANCE:
- Inspect immediately after any rainfall and at least daily during prolonged rainfall.
- Look for runoff breaching dike or eroding channel or sideslopes.
- Check discharge point for erosion or bypassing of flows.
- Repair and stabilize as necessary.
- Inspect daily during vehicular activity on slope, check for and repair any traffic damage.



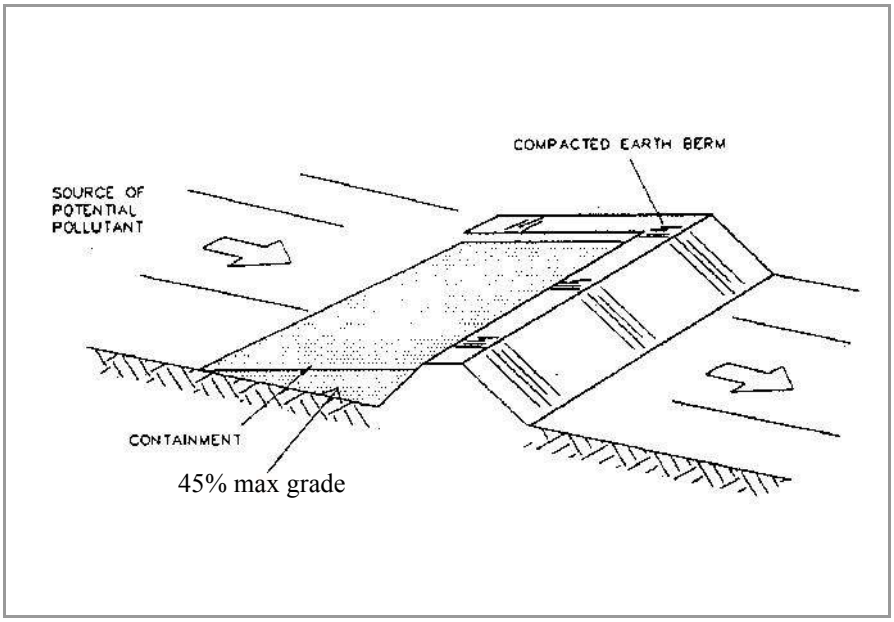
DESCRIPTION:
Dust control measures are used to stabilize soil from wind erosion, and reduce dust by construction activities.

APPLICATION:
Dust control is useful in any process area, loading and unloading area, material handling areas, and transfer areas where dust is generated. Street sweeping is limited to areas that are paved.

INSTALLATION/APPLICATION CRITERIA:
- Mechanical dust collection systems are designed according to the size of dust particles and the amount of air to be processed. Manufacturers' recommendations should be followed for installation (as well as the design of the equipment).
- Two kinds of street weepers are common: brush and vacuum. Vacuum sweepers are more efficient and work best when the area is dry.
- Mechanical equipment should be operated according to the manufacturers' recommendations and should be inspected regularly.

LIMITATIONS:
- Generally more expensive than manual systems.
- May be impossible to maintain by plant personnel (the more elaborate equipment).
- Labor and equipment intensive and may not be effective for all pollutants (street sweepers).

MAINTENANCE:
If water sprayers are used, dust-contaminated waters should be collected and taken for treatment. Areas will probably need to be resprayed to keep dust from spreading.



DESCRIPTION:
A temporary containment control constructed of compacted soil.

APPLICATION:
- Construct around waste and materials storage area.
- Construct around staging and maintenance areas.
- Construct around vehicle parking and servicing areas.

INSTALLATION/APPLICATION CRITERIA:
- Construct an earthen berm down hill of the area to be controlled. The berm should surround fueling facilities and maintenance areas on three sides to provide containment.
- Berm needs to be a minimum of 1 foot tall by 1 foot wide and be compacted by earth moving equipment.

LIMITATIONS:
- Not effective on steep slopes.
- Limits access to controlled area.
- Personnel need to quickly respond to spills with remedial actions.

MAINTENANCE:
- Observe daily for any non-stormwater discharge.
- Look for runoff bypassing ends of berms or undercutting berms.
- Repair or replace damaged areas of the berm and remove accumulated sediment.
- Recompact soil around berm as necessary to prevent piping.



DESCRIPTION:
Employee training, like equipment maintenance, is a method by which to implement BMPs. Employee training should be used in conjunction with all other BMPs as part of the facility's SWPPP.

The specific employee training aspects of each of the source controls are highlighted in the individual information sheets. The focus of this information sheet is more general, and includes the overall objectives and approach for assuring employee training in stormwater pollution prevention. Accordingly, the organization of this information sheet differs somewhat from the other information sheets in this chapter.

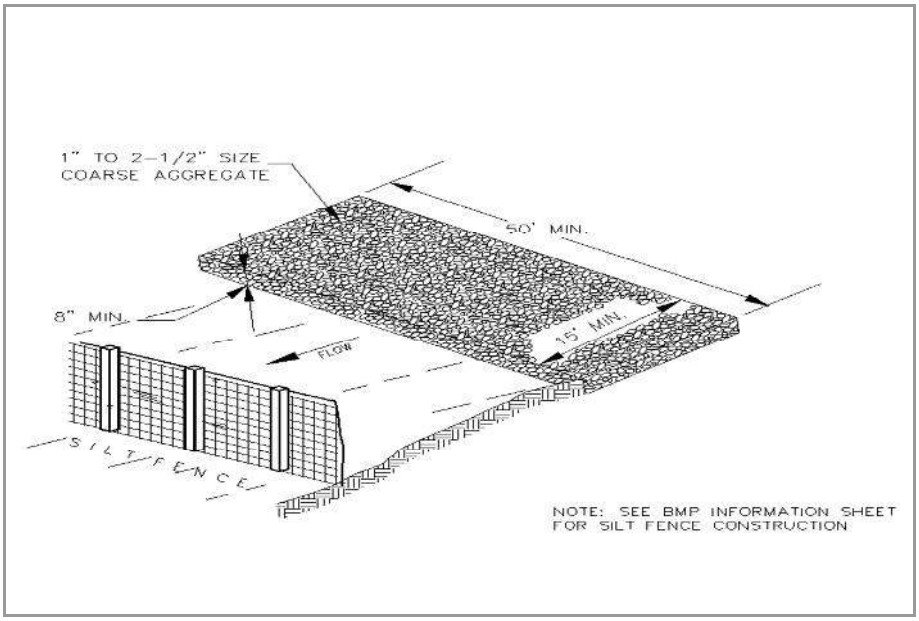
OBJECTIVES:
Employee training should be based on four objectives:

- Promote a clear identification and understanding of the problem, including activities with the potential to pollute stormwater;
- Identify solutions (BMPs);
- Promote employee ownership of the problems and the solutions; and
- Integrate employee feedback into training and BMP implementation.

APPROACH:

- Integrate training regarding stormwater quality management with existing training programs that may be required for your business by other regulations.
- Businesses that are not regulated in Federal, State, or local regulations, may use the information in this handbook to develop a training program to reduce their potential to pollute stormwater.
- Employee training is a vital component of many of the individual source control BMPs included in this manual.

BMP: Equipment and Vehicle Wash Down Area



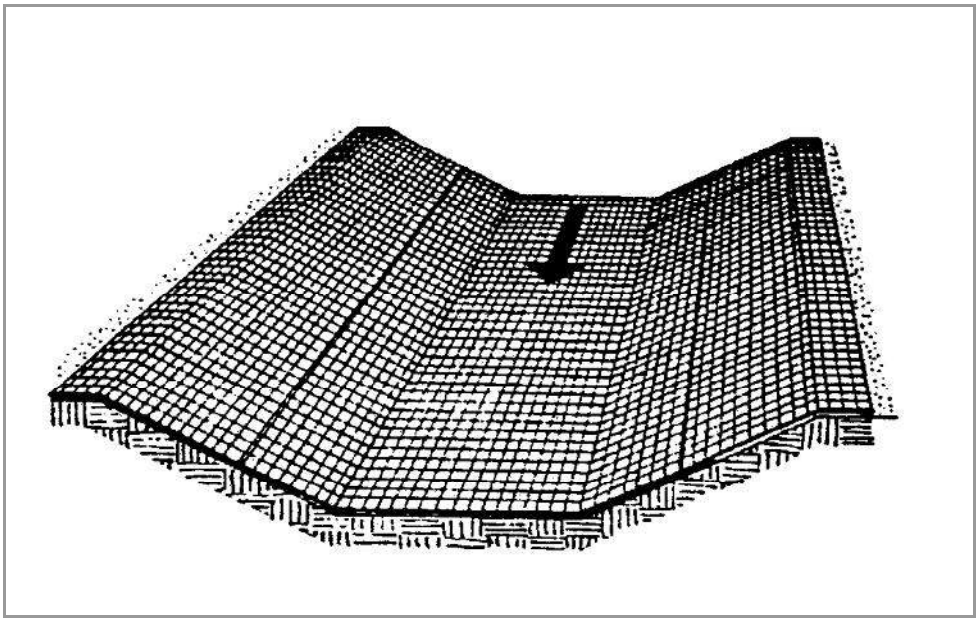
DESCRIPTION:
A stabilized pad of crushed stone for general washing of equipment and construction vehicles.

APPLICATION:
At any site where regular washing of vehicles and equipment will occur. May also be used as a filling point for water trucks limiting erosion caused by overflow or spillage of water.

INSTALLATION:
- Clear and grub area and grade to provide maximum slope of 1%.
- Compact subgrade and place filter fabric if desired (recommended for wash areas to remain in use for more than 3 months.
- Place coarse aggregate, 1 to 2-1/2 inches in size, to a minimum depth of 8-inches.
- Install silt fence downgradient (see silt fence BMP information sheet).

LIMITATIONS:
Cannot be utilized for washing equipment or vehicles that may cause contamination of runoff such as fertilizer equipment or concrete equipment. Solely used to control sediment in wash water.

MAINTENANCE:
- Inspect daily for loss of gravel or sediment buildup.
- Inspect adjacent area for sediment deposit and install additional controls as necessary.
- Repair area and replace gravel as required to maintain control in good working condition.
- Expand stabilized area as required to accommodate activities.
- Maintain silt fence as outlined in specific silt fence BMP information sheet.



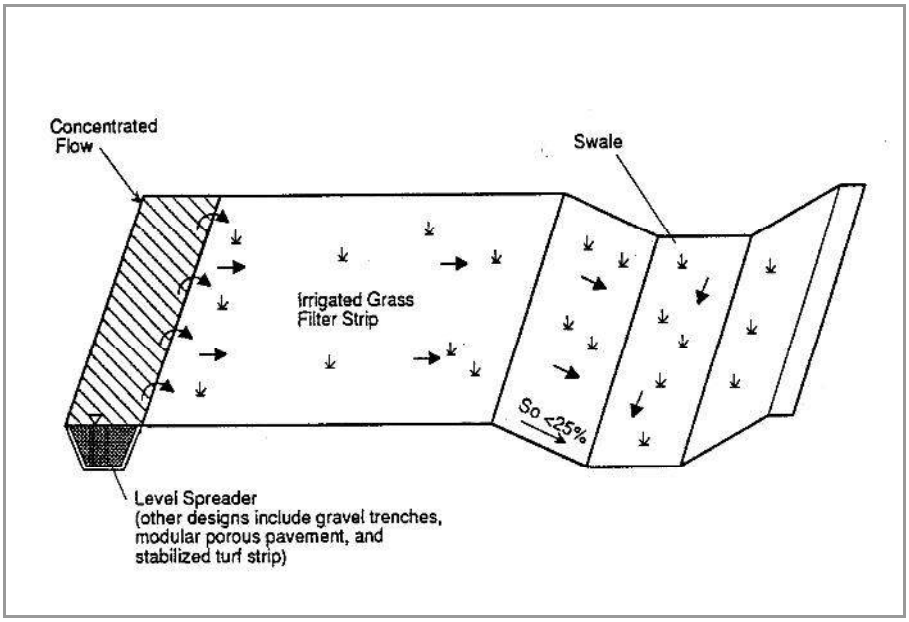
DESCRIPTION:
Erosion control blankets are used in place of mulch on areas of high velocity runoff and/or steep grade, to aid in controlling erosion on critical areas by protecting young vegetation.

APPLICATIONS:
- Where vegetation is likely to grow too slowly to provide adequate cover.
- In areas subject to high winds where mulch would not be effective.

INSTALLATION/APPLICATION CRITERIA:
- Install erosion control blankets parallel to the direction of the slope.
- In ditches, apply in direction of the flow.
- Place erosion control blankets loosely on soil - do not stretch.
- Ends of blankets should be buried no less than six inches deep.
- Staple the edges of the blanket at least every three feet.

LIMITATIONS:
Not recommended in areas which are still under construction.

MAINTENANCE:
- Check for erosion and undermining periodically, particularly after rainstorms.
- Repair dislocations or failures immediately.
- If washouts occur, reinstall after repairing slope damage.
- Monitor until permanently stabilized.



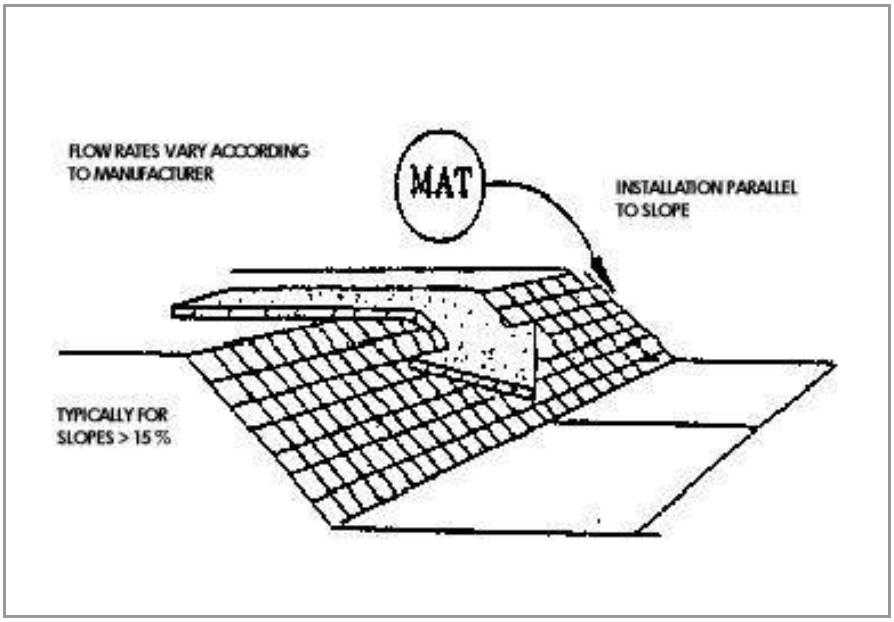
DESCRIPTION:
Filter strips are 20-foot-wide strips of natural or planted vegetation around a construction site. They are designed to cause deposition of sediments within the vegetation layer.

APPLICATIONS:
- Suited for areas where the soils are well drained or moderately well drained.
- Areas where the bedrock and the water table are well below the surface.

INSTALLATION/APPLICATION CRITERIA:
- Make sure the vegetative cover is dense enough to protect underlying soil while causing sediment to settle.
- Filter strip must be approximately 20 feet wide to function well.
- The length should be approximately 50 to 75 feet. Where slopes become steeper the length of the strip must be increased.

LIMITATIONS:
- Only applicable in areas where vegetation is previously established or where sod is added.
- Vegetated filter strips will not function well on steep slopes, in hilly areas, or in highly paved areas.
- Sites with slopes of 15 percent or more may not be suitable for filtering storm water flows.

MAINTENANCE:
- Check for channels and repair.
- Provide rock aprons to aid in slowing flow if necessary.
- Maintain vegetation at optimal height and thickness.



DESCRIPTION:
Mattings made of natural or synthetic material which are used to temporarily or permanently stabilize soil.

APPLICATION:
- Typically suited for post-construction site stabilization, but may be used for temporary stabilization of highly erosive soils.
- Channels and streams.
- Steep slopes.

INSTALLATION/APPLICATION CRITERIA:
- Mattings may be applied to disturbed soils and where existing vegetation has been removed.
- The following organic matting materials provide temporary protection until permanent vegetation is established, or when seasonal circumstances dictate the need for temporary stabilization until weather or construction delays are resolved: Jute mattings and straw mattings.
- The following synthetic mattings may be used for either temporary or post-construction stabilization, both with and without vegetation: excelsior matting, glass fiber matting, mulch matting.
- Staples are needed to anchor the matting.

LIMITATIONS:
- Mattings are more costly than other BMP practices, limiting their use to areas where other BMPs are ineffective (e.g., channels, steep slopes).
- May delay seed germination, due to reduction in soil temperature.
- Installation requires experienced contractor to ensure soil stabilization and erosion protection.

MAINTENANCE:
- Inspect monthly and after significant rainfall.
- Re-anchor loosened matting and replace missing matting and staples as required.



DESCRIPTION:
Prevent or reduce the discharge of pollutants to stormwater from hazardous waste through proper material use, waste disposal, and training of employees and subcontractors.

APPLICATION:
Many of the chemicals used on-site can be hazardous materials which become hazardous waste upon disposal. These wastes may include:

- Paints and solvents;
- Petroleum products such as oils, fuels, and grease;
- Herbicides and pesticides;
- Acids for cleaning masonry; and
- Concrete curing compounds.

In addition, sites with existing structures may contain wastes which must be disposed of in accordance with Federal, State, and local regulations, including:

- Sandblasting grit mixed with lead, cadmium, or chromium-based paints;
- Asbestos; and
- PCBs.

INSTALLATION/APPLICATION CRITERIA:
The following steps will help reduce storm water pollution from hazardous wastes:

- Use all of the product before disposing of the container.
- Do not remove the original product label, it contains important safety and disposal information.
- Do not over-apply herbicides and pesticides. Prepare only the amount needed. Follow the recommended usage instructions. Over-application is expensive and environmentally harmful. Apply surface dressings in several smaller applications, as opposed to one large application, to allow time for infiltration and to avoid excess material being carried off-site by runoff. Do not apply these chemicals just before it rains. People applying pesticides must be certified in accordance with Federal and State regulations.

LIMITATIONS:
Hazardous waste that cannot be reused or recycled must be disposed of by a licensed hazardous waste hauler.

MAINTENANCE:

- Inspect hazardous waste receptacles and area regularly.
- Arrange for regular hazardous waste collection.



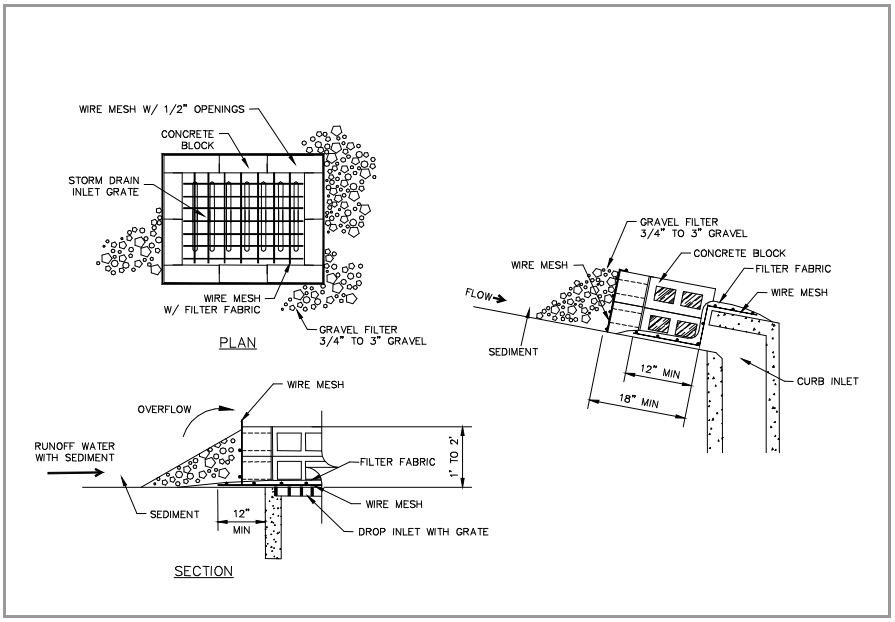
DESCRIPTION:
A combination of wood fiber mulch, processed grass, or hay or straw mulch and a tacking agent. It is made into a slurry, then applied to bare slopes or other bare areas to provide temporary stabilization.

APPLICATIONS:
- Small roadside slopes.
- Large, relatively flat areas.

Installation/Application Criteria:
- Legume seeds should be pellet inoculated with the appropriate bacteria.
- The seed should not remain in the hydromulcher tank for more than 30 minutes.
- Wood fiber may be dyed to aid in uniform application.
- Slurry should be uniformly applied until an adequate coverage is achieved.
- The applicator should not be directed at one location for a long period of time; erosion will occur.

LIMITATIONS:
- Will lose effectiveness after 1 year.
- Can use only on physically stable slopes (at natural angle of repose, or less).

MAINTENANCE:
- Periodically inspect for damage caused by wind, water, or human disturbance.
- Promptly repair damaged areas.



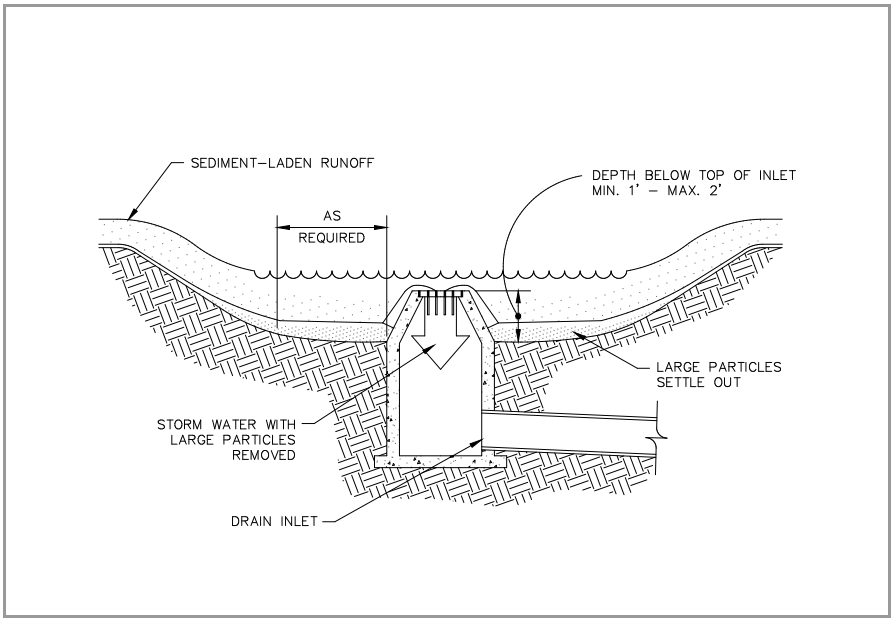
DESCRIPTION:
Concrete block and gravel filter placed over inlet to storm drain system.

APPLICATION:
Construct at inlets in paved or unpaved areas where upgradient area is to be disturbed by construction activities.

INSTALLATION/APPLICATION CRITERIA:
- Place wire mesh (with 1/2 inch openings) over the inlet grate extending one foot past the grate in all directions.
- Place concrete blocks around the inlet with openings facing outward. Stack blocks to minimum height of 12-inches and maximum height of 24-inches.
- Place wire mesh around outside of blocks.
- Place gravel (3/4" to 3") around blocks.

LIMITATIONS:
- Recommended for maximum drainage area of one acre.
- Excess flows may bypass the inlet requiring down gradient controls.
- Ponding will occur at inlet.

MAINTENANCE:
- Inspect inlet protection after every large storm event and at a minimum of once monthly.
- Remove sediment accumulated when it reaches 4-inches in depth.
- Replace filter fabric and clean or replace gravel if clogging is apparent.



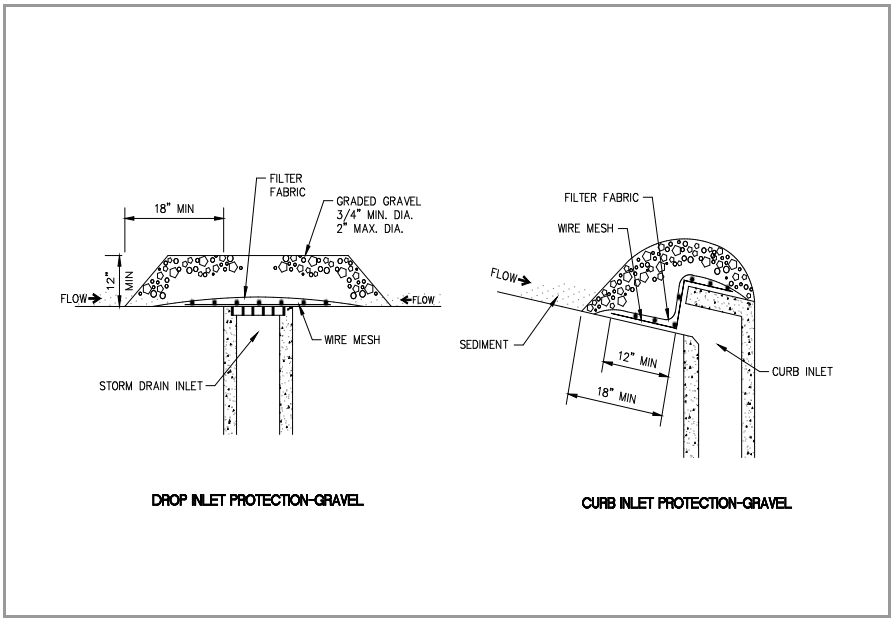
DESCRIPTION:
An area excavated around a storm drain inlet to impound water below the inlet.

APPLICATION:
Construct at storm drainage inlets located downgradient of areas to be disturbed by construction (for inlets in paved areas see other information sheets for inlet protection).

INSTALLATION/APPLICATION CRITERIA:
- Provide upgradient sediment controls, such as silt fence during construction of inlet.
- When construction of inlet is complete, excavate adjacent area 1 to 2 feet lower than the grate elevation. Size of excavated area should be based on soil type and contributing acreage.

LIMITATIONS:
- Recommended maximum contributing drainage area of one acre.
- Limited to inlets located in open unpaved areas.
- Requires flat area adjacent to inlet.

MAINTENANCE:
- Inspect inlet protection following storm event and at a minimum of once monthly.
- Remove accumulated sediment when it reaches one half of the excavated sump below the grate.
- Repair side slopes as required.



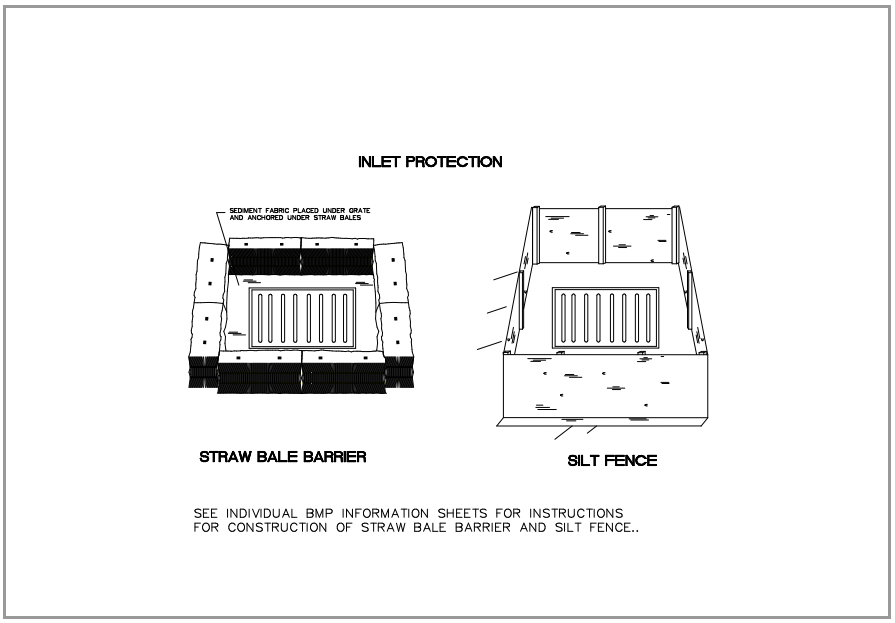
DESCRIPTION:
Placement of gravel filter over inlet to storm drain to filter storm water runoff.

APPLICATION:
Construct at inlets in paved or unpaved areas where upgradient area is to be disturbed by construction activities.

INSTALLATION/APPLICATION CRITERIA:
- Place wire mesh (with 1/2 inch openings) over the inlet grate extending one foot past the grate in all directions.
- Place filter fabric over the mesh. Filter fabric should be selected based on soil type.
- Place graded gravel, to a minimum depth of 12-inches, over the filter fabric and extending 18-inches past the grate in all directions.

LIMITATIONS:
- Recommended for maximum drainage area of one acre.
- Excess flows may bypass the inlet requiring down gradient controls.
- Ponding will occur at inlet.

MAINTENANCE:
- Inspect inlet protection after every large storm event and at a minimum of once monthly.
- Remove sediment accumulated when it reaches 4-inches in depth.
- Replace filter fabric and clean or replace gravel if clogging is apparent.



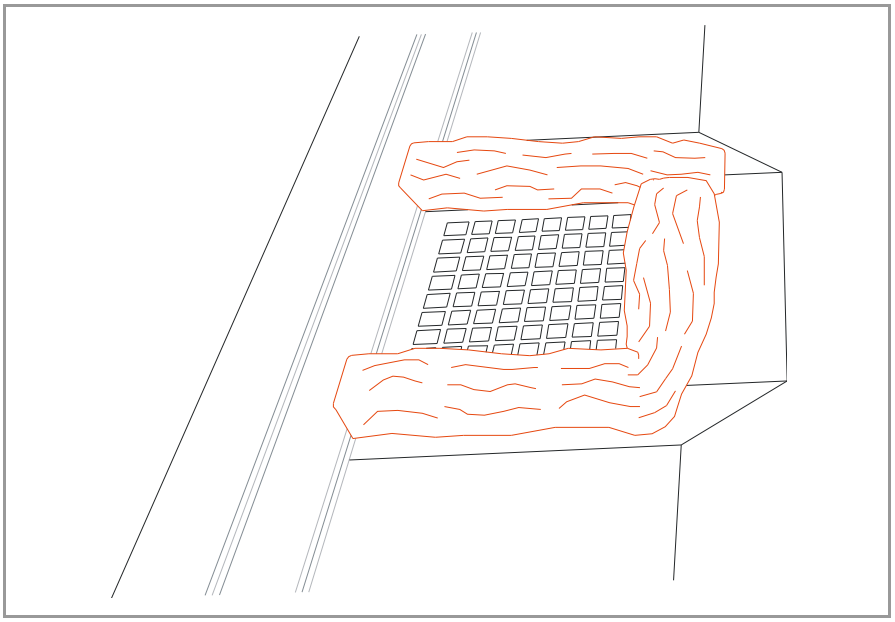
DESCRIPTION:
Sediment barrier erected around storm drain inlet.

APPLICATION:
Construct at storm drainage inlets located downgradient of areas to be disturbed by construction (for inlets in paved areas see other information sheets for inlet protection).

INSTALLATION/APPLICATION CRITERIA:
- Provide upgradient sediment controls, such as silt fence during construction of inlet.
- When construction of inlet is complete, erect straw bale barrier or silt fence surrounding perimeter of inlet. Follow instructions and guidelines on individual BMP information sheets for straw bale barrier and silt fence construction.

LIMITATIONS:
- Recommended maximum contributing drainage area of one acre.
- Limited to inlets located in open unpaved areas.
- Requires shallow slopes adjacent to inlet.

MAINTENANCE:
- Inspect inlet protection following storm event and at a minimum of once monthly.
- Remove accumulated sediment when it reaches 4-inches in depth.
- Repair or realign barrier/fence as needed.
- Look for bypassing or undercutting and recompact soil around barrier/fence as required.



DESCRIPTION:

Sediment barrier erected around storm drain inlet.

APPLICATION:

Construct at storm drainage inlets located down-gradient of areas to be disturbed by construction.

INSTALLATION/APPLICATION CRITERIA:

- Provide up-gradient sediment controls, such as silt fence during construction of inlet
- When construction of curb and gutter and roadways is complete, install gravel filled wattles around perimeter of inlet

LIMITATIONS:

- Recommended maximum contributing drainage area of one acre
- Requires shallow slopes adjacent to inlet

MAINTENANCE:

- Inspect inlet protection following storm event and at a minimum of once every 14 days.
- Remove accumulated sediment when it reaches 4 inches in depth.
- Look for bypassing or undercutting and repair or realign as needed.



DESCRIPTION:

Stormwater control BMPs need regular inspections to ensure their effectiveness, and is required by the DWQ construction permit. Routine inspections are required on a bi-weekly basis; before and after anticipated storm events. Proper maintenance is crucial to compliance with the permit and to minimize erosion.

Routine inspections help to ensure the integrity and effectiveness of BMPs; inspections prior to a rain event ensure that BMPs are cleaned out and operating properly; inspections following a rain event serve to prepare the site for the next event. Maintenance should be conducted when problems are identified.

APPLICATIONS:

Inspections and maintenance is required by the DWQ permit at all sites. Maintenance needs are best determined by a self-inspection program.

INSTALLATION/APPLICATION CRITERIA:

The person responsible for the inspections should be trained in the design and operation of the BMPS.

LIMITATIONS:

Construction site operators should allocate adequate time and resources for BMP maintenance and repair.



DESCRIPTION:

Land grading involves reshaping the ground surface to planned grades as determined by an engineering survey, evaluation, and layout. Land grading provides more suitable topography for buildings, facilities, and other land uses and helps to control surface runoff, soil erosion, and sedimentation during and after construction.

APPLICATIONS:

Land grading is applicable to sites with uneven or steep topography or easily erodible soils, because it stabilizes slopes and decreases runoff velocity. Grading activities should maintain existing drainage patterns as much as possible.

INSTALLATION/APPLICATION CRITERIA:

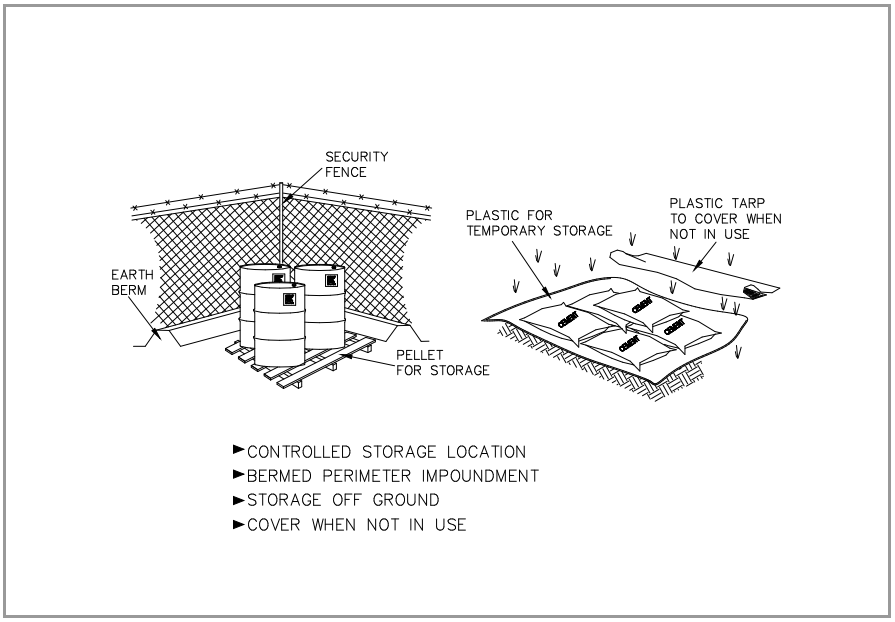
Before grading activities begin, a construction site operator must make decisions regarding the steepness of cut-and-fill slopes and how the slopes will be: Protected from runoff, stabilized and maintained.

LIMITATIONS:

Improper grading practices that disrupt natural stormwater patterns might lead to poor drainage, high-runoff velocities, and increased peak flows during storm events. Clearing and grading the entire site without vegetated buffers promotes offsite transport of sediments and other pollutants. Design the grading plan with erosion and sediment control and stormwater management goals in mind; to ensure that the plan is implemented as intended, carefully supervise grading crews.

MAINTENANCE:

- Check all graded areas and supporting erosion and sediment control practices periodically, especially after heavy rainfalls.
- Promptly remove all sediment from diversions or other stormwater conveyances, and if washouts or breaks occur, repair them immediately.
- To prevent small-scale eroded areas from becoming significant gullies, maintain them promptly.



DESCRIPTION:
Controlled storage of on-site materials.

APPLICATION:
- Storage of hazardous, toxic, and all chemical substances.
- Any construction site with outside storage of materials.

INSTALLATION/APPLICATION CRITERIA:
- Designate a secured area with limited access as the storage location. Ensure no waterways or drainage paths are nearby.
- Construct compacted earthen berm (See Earth Berm Barrier Information Sheet), or similar perimeter containment around storage location for impoundment in the case of spills.
- Ensure all on-site personnel utilize designated storage area. Do not store excessive amounts of material that will not be utilized on site.
- For active use of materials away from the storage area ensure materials are not set directly on the ground and are covered when not in use. Protect storm drainage during use.

LIMITATIONS:
- Does not prevent contamination due to mishandling of products.
- Spill Prevention and Response Plan still required.
- Only effective if materials are actively stored in controlled location.

MAINTENANCE:
- Inspect daily and repair any damage to perimeter impoundment or security fencing.
- Check materials are being correctly stored (i.e. standing upright, in labeled containers, tightly capped) and that no materials are being stored away from the designated location.



DESCRIPTION:
Prevent or reduce the discharge of pollutants to storm water from material use by using alternative products, minimizing hazardous material use on-site, and training employees and subcontractors.

APPLICATION:
The following materials are commonly used on construction sites:

- Pesticides and herbicides, fertilizers, detergents, plaster and other products, petroleum products such as fuel, oil, and grease.
- Other hazardous chemicals such as acids, lime, glues, paints, solvents, and curing compounds.

INSTALLATION/APPLICATION CRITERIA:

- Use less hazardous, alternative materials as much as possible.
- Minimize use of hazardous materials on-site.
- Use only materials where and when needed to complete the construction activity.
- Follow manufacturer's instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.
- Personnel who use pesticides should be trained in their use.
- Do not over apply fertilizers, herbicides, and pesticides. Prepare only the amount needed.
- Unless on steep slopes, till fertilizers in to the soil rather than hydroseeding.
- Do not apply these chemicals just before it rains.

LIMITATIONS:
Alternative materials may not be available, suitable, or effective in every case.

MAINTENANCE:
Maintenance of this best management practice is minimal.

DESCRIPTION:
Placement of material such as straw, grass, woodchips, woodfibers or fabricated matting over open area.

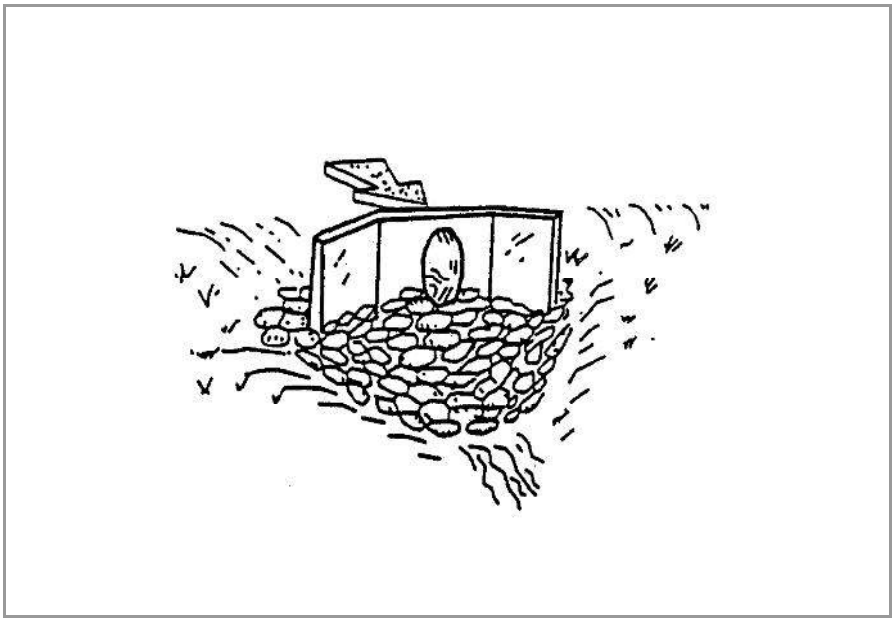
APPLICATION:
- Any exposed area to remain untouched longer than 14 days and that will be exposed less than 60 days (seed areas to be exposed in excess of 60 days).
- Areas that have been seeded.
- Stockpiled soil material.

Material	Application	Depth	Comments
Gravel: Washed 1/4" to 1-1/2"	9 cy/1000 sf	3 inches	Good for traffic areas Good for short slopes
Straw: Air-dried, free of seeds and coarse material	2-3 bales /1000 sf	2 inches min.	Subject to wind blowing Tack down or keep moist
Wood Fiber Cellulose: Free from growth inhibitors; dyed green	35 lb/1000 sf	1 inch	For critical areas, double application rate; Limit to slopes < 3% and < 150 feet

INSTALLATION/APPLICATION CRITERIA:
- Roughen area to receive mulch to create depressions that mulch material can settle into.
- Apply mulch to required thickness and anchor as necessary.
- Ensure material used is weed free and does not contain any constituents that will inhibit plant growth.

LIMITATIONS:
- Anchoring may be required to prevent migration of mulch material.
- Downgradient control may be required to prevent mulch material being transported to storm water system.

MAINTENANCE:
- Inspect mulched areas after every rainfall event and at a minimum of monthly.
- Replace mulch on any bare areas and re-anchor as necessary.
- Clean and replace downgradient controls as necessary.



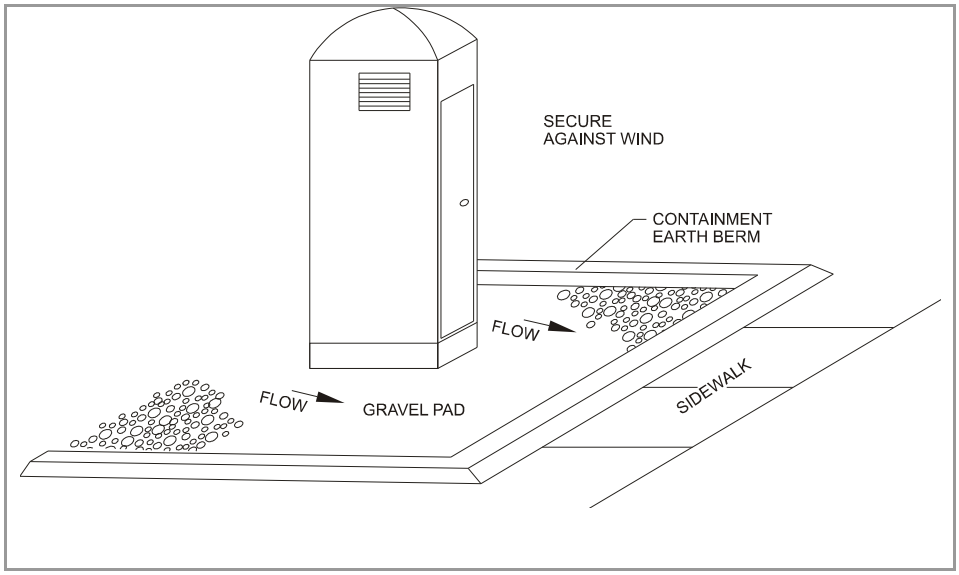
DESCRIPTION:
A rock outlet protection is a physical device composed of rock, grouted riprap, or concrete rubble which is placed at the outlet of a pipe to prevent scour of the soil caused by high pipe flow velocities, and to absorb flow energy to produce non-erosive velocities.

APPLICATIONS:
- Wherever discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach.
- Rock outlet protection is best suited for temporary use during construction because it is usually less expensive and easier to install than concrete aprons or energy dissipators.
- A sediment trap below the pipe outlet is recommended if runoff is sediment laden.
- Permanent rock riprap protection should be designed and sized by the engineer as part of the culvert, conduit or channel design.
- Grouted riprap should be avoided in areas of freeze and thaw because the grout will break up.

INSTALLATION/APPLICATION CRITERIA:
Rock outlet protection is effective when the rock is sized and placed properly. When this is accomplished, rock outlets do much to limit erosion at pipe outlets. Rock size should be increased for high velocity flows. Best results are obtained when sound, durable, angular rock is used.

LIMITATIONS:
- Large storms often wash away the rock outlet protection and leave the area susceptible to erosion.
- Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- Outlet protection may negatively impact the channel habitat.

MAINTENANCE:
- Inspect after each significant rain for erosion and/or disruption of the rock, and repair immediately.
- Grouted or wire-tied rock riprap can minimize maintenance requirements.



DESCRIPTION:

Temporary on-site sanitary facilities for construction personnel.

APPLICATION:

All sites with no permanent sanitary facilities or where permanent facility is too far from activities.

INSTALLATION/APPLICATION CRITERIA:

- Locate portable toilets in convenient locations throughout the site.
- Prepare level, gravel surface and provide clear access to the toilets for servicing and for on-site personnel.
- Construct earth berm perimeter (6” tall by 6” wide), control for spill/protection leak.

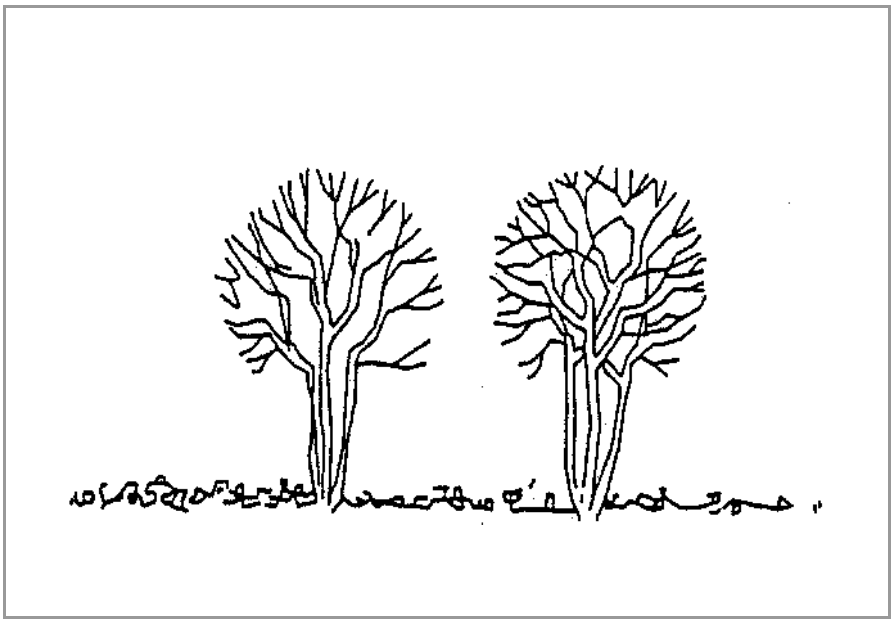
LIMITATIONS:

- No limitations.

MAINTENANCE:

- Portable toilets should be maintained in good working order by licensed service with daily observation for leak detection.
- Regular waste collection should be arranged with licensed service.
- All waste should be deposited in sanitary sewer system for treatment with appropriate agency approval.

BMP: Preservation of Existing Vegetation



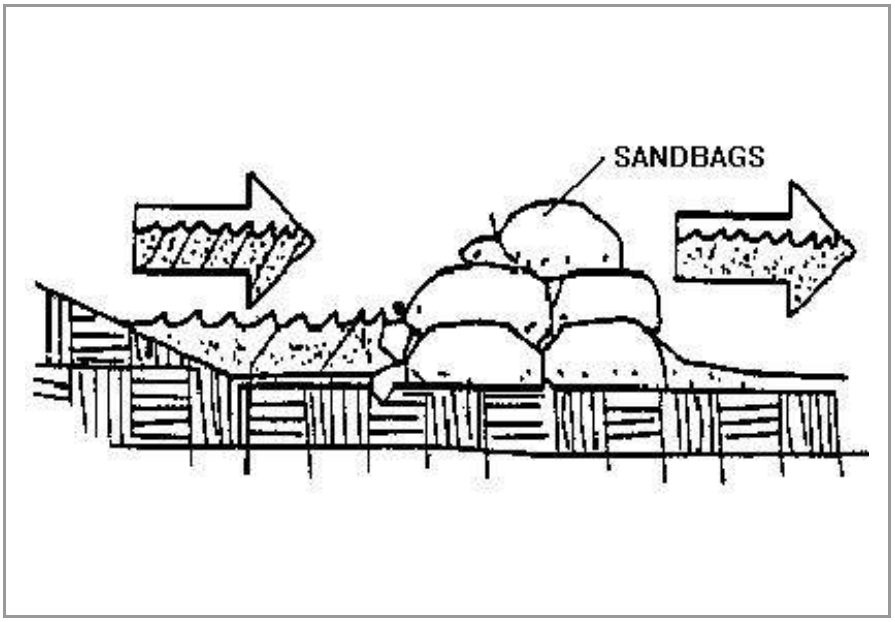
DESCRIPTION:
Carefully planned preservation of existing vegetation minimizes the potential of removing or injuring existing trees, vines, shrubs and/or grasses that serve as erosion controls.

APPLICATIONS:
This technique is applicable to all types of sites. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain.

INSTALLATION/APPLICATION CRITERIA:
- Clearly mark, flag or fence vegetation or areas where vegetation should be preserved.
- Prepare landscaping plans which include as much existing vegetation as possible and state proper care during and after construction.
- Define and protect with berms, fencing, signs, etc. a setback area from vegetation to be preserved.
- Propose landscaping plans which do not include plant species that compete with the existing vegetation.
- Do not locate construction traffic routes, spoil piles, etc. where significant adverse impact on existing vegetation may occur.

LIMITATIONS:
- Requires forward planning by the owner/developer, contractor and design staff.
- For sites with diverse topography, it is often difficult and expensive to save existing trees while grading the site satisfactorily for the planned development.
- May not be cost effective with high land costs.

MAINTENANCE:
- Inspection and maintenance requirements for protection of vegetation are low.
- Maintenance of native trees or vegetation should conform to landscape plan specifications.



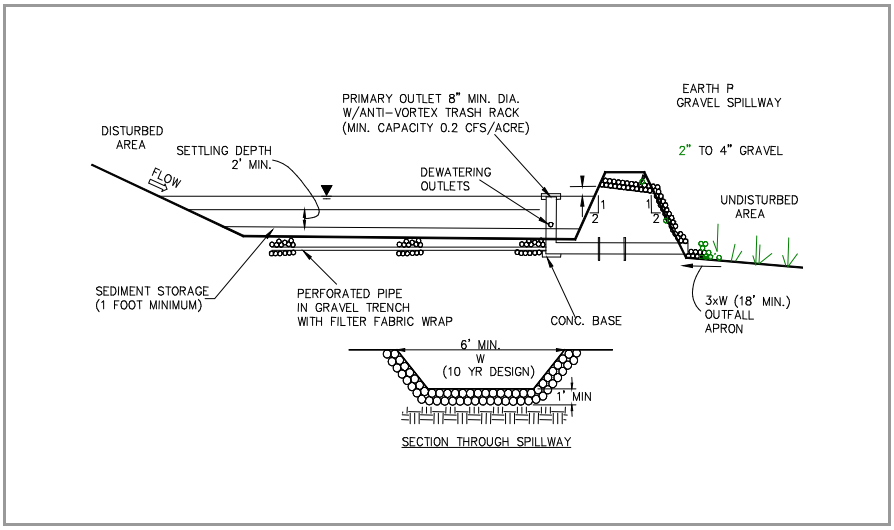
DESCRIPTION:
Stacking sandbags along a level contour creates a barrier which detains sediment-laden water, ponding water upstream of the barrier and promoting sedimentation.

APPLICATION:
- Along the perimeter of the site.
- May be used in drainage areas up to 5 acres.
- Along streams and channels
- Across swales with small catchments.
- Around temporary spoil areas.
- Below the toe of a cleared slope.

INSTALLATION/APPLICATION CRITERIA:
- Install along a level contour.
- Base of sandbag barrier should be at least 48 inches wide.
- Height of sandbag barrier should be at least 18 inches high.
- 4 inch PVC pipe may be installed between the top layer of sand bags to drain large flood flows.
- Provide area behind barrier for runoff to pond and sediment to settle.
- Place below the toe of a slope.

LIMITATIONS:
- Sandbags are more expensive than other barriers, but also more durable.
- Burlap should not be used.

MAINTENANCE:
- Inspect after each rain.
- Reshape or replace damaged sandbags immediately.
- Replace sediment when it reaches six inches in depth.



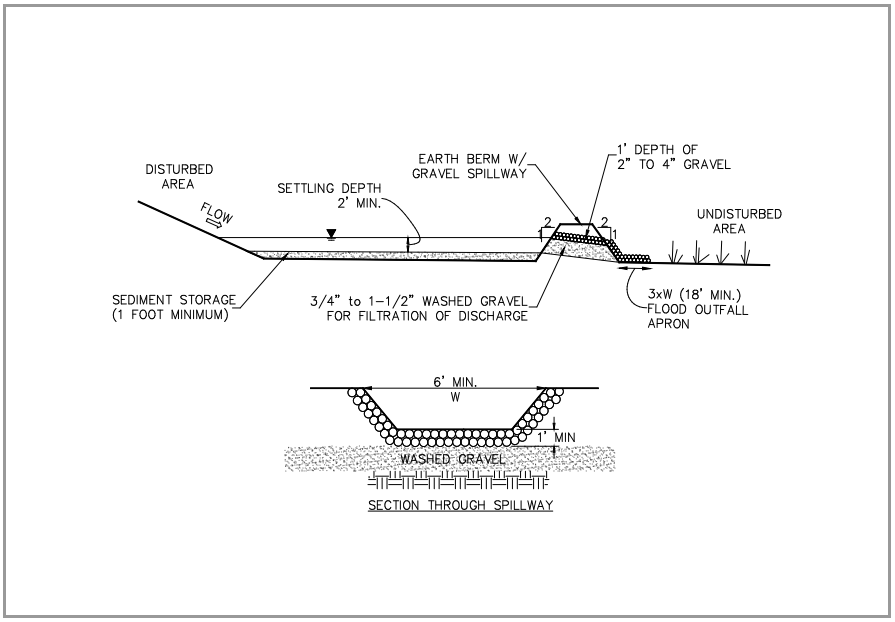
DESCRIPTION:
A pond created by excavation or construction of an embankment, and designed to retain or detain runoff sufficiently to allow excessive sediment to settle.

APPLICATION:
- At the outlet of all disturbed watersheds 10 acres or larger.
- At the outlet of smaller disturbed watersheds, as necessary.
- Where post construction detention basins will be located.

INSTALLATION/APPLICATION CRITERIA:
- Design basin for site specific location, maintain effective flow length 2 times width.
- Excavate basin or construct compacted berm containment, ensure no downgradient hazard if failure should occur. (Provide minimum of 67 cy. per acre of drainage area).
- Construct dewatering and outfall structure and emergency spillway with apron.

LIMITATIONS:
- Should be sized based on anticipated runoff, sediment loading and drainage area size.
- May require silt fence at outlet for entrapment of very fine silts and clays.
- May require safety fencing to prevent public access.
- Height restrictions for embankment may be regulated.

MAINTENANCE:
- Inspect after each rainfall event and at a minimum of monthly.
- Repair any damage to berm, spillway or sidewalls.
- Remove accumulated sediment as it reaches 2/3 height of available storage.
- Check outlet for sedimentation/erosion of downgradient area and remediate as necessary. Install silt fence if sedimentation apparent.



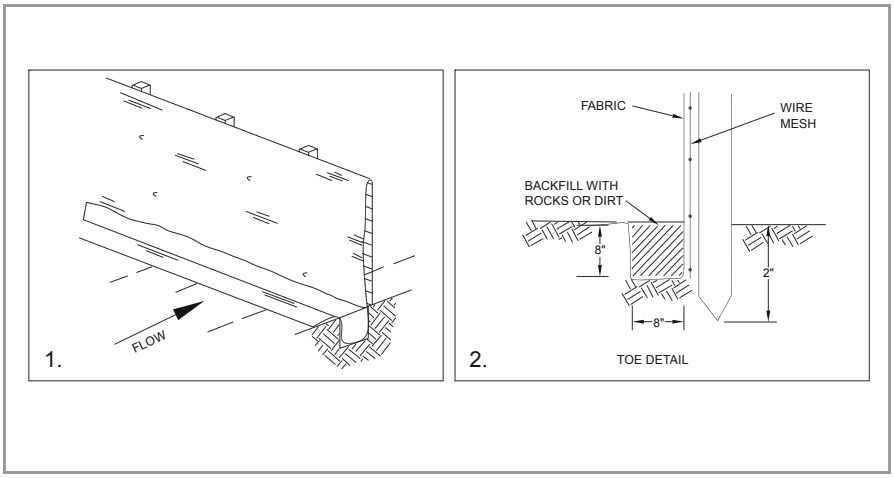
DESCRIPTION:
A sediment trap is a small excavated or bermed area where runoff from small drainage areas is detained and sediment can settle.

APPLICATION:
- Temporary control for runoff from disturbed areas of less than 3 acres.
- Temporary control for discharge from diversion dike, surface benching, or other temporary drainage measures.

INSTALLATION/APPLICATION CRITERIA:
- Design basin for site specific location.
- Excavate basin or construct compacted berm containment.
- Construct outfall spillway with apron.
- Provide downstream silt fence if necessary.

LIMITATIONS:
- Should be sized based on anticipated runoff, sediment loading and drainage area size.
- May require silt fence at outlet for entrapment of very fine silts and clays.

MAINTENANCE:
- Inspect after each rainfall event and at a minimum of monthly.
- Repair any damage to berm, spillway or sidewalls.
- Remove accumulated sediment as it reaches 2/3 height of available storage.
- Check outlet for sedimentation/erosion of downgradient area and remediate as necessary. Install silt fence if sedimentation apparent.



DESCRIPTION:

A temporary sediment barrier consisting of entrenched filter fabric stretched across and secured to supporting posts.

Application:

- Perimeter control: place barrier at down-gradient limits of disturbance
- Sediment barrier: place barrier at toe of slope or soil stockpile
- Protection of existing waterways: place barrier at top of stream bank
- Inlet protection: place fence surrounding catchbasins

INSTALLATION/APPLICATION CRITERIA:

- Place posts 6 feet apart on center along contour (or use preassembled unit) and drive 2 feet minimum into ground. Excavate an anchor trench immediately up-gradient of posts.
- Secure wire mesh (14 gage min. with 6-inch openings) to upslope side of posts. Attach with heavy duty 1 inch long wire staples, tie wires or hog rings.
- Cut fabric to required width, unroll along length of barrier and drape over barrier. Secure fabric to mesh with twine, staples, or similar, with trailing edge extending into anchor trench.
- Backfill trench over filter fabric to anchor.

LIMITATIONS:

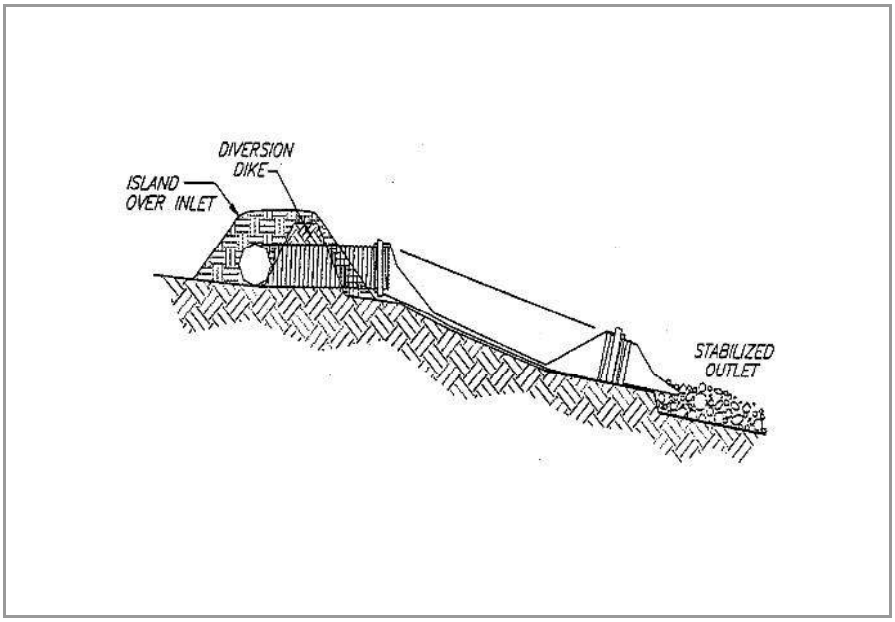
- Recommended maximum drainage area of 0.5 acre per 100 feet of fence
- Recommended maximum up-gradient slope length of 150 feet
- Recommended maximum uphill grade of 2:1 (50%)
- Recommended maximum flow rate of 0.5 cfs
- Ponding should not be allowed behind fence

MAINTENANCE:

- Inspect immediately after any rainfall and at least daily during prolonged rainfall.
- Look for runoff bypassing ends of barriers or undercutting barriers.
- Repair or replace damaged areas of the barrier and remove accumulated sediment.
- Reanchor fence as necessary to prevent shortcutting.
- Remove accumulated sediment when it reaches ½ the height of the fence.

BMP: Slope Drain

SD
Construction



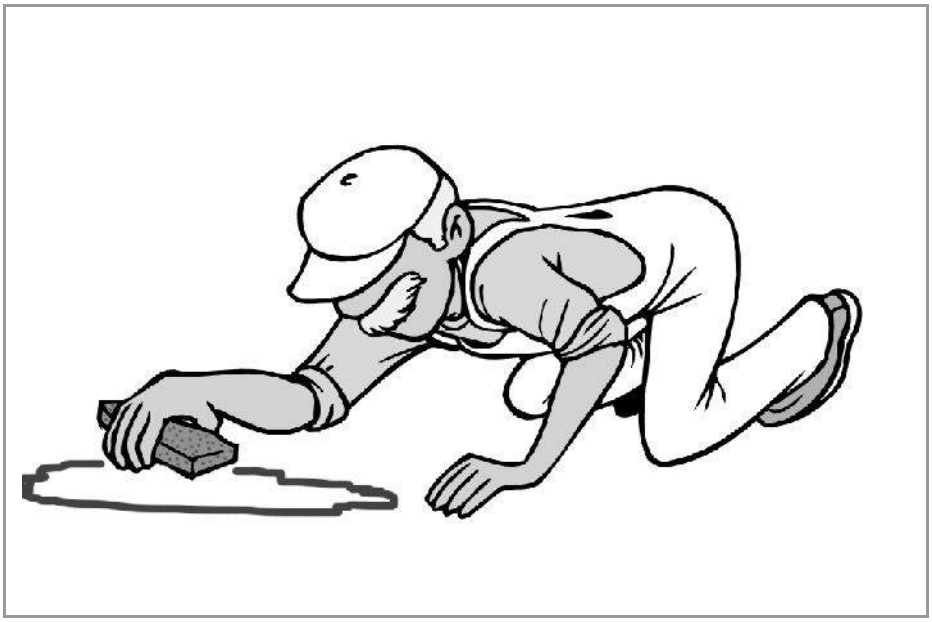
DESCRIPTION:
A temporary pipe or lined channel that drains the top of a slope to a stable discharge point at the bottom of a slope without causing erosion.

APPLICATIONS:
- Where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion.
- Drainage for top slope diversion dikes or swales.
- Emergency spillway for a sediment basin.
- Drainage for top of cut/fill slopes where water can accumulate.

INSTALLATION/APPLICATION CRITERIA:
- Secure inlet and surround with dikes to prevent gully erosion, and anchor pipe to slope.
- Size to convey at least the peak of a 10-year, storm event.
- Stabilize outlet. (See Outlet Protection BMP).

LIMITATIONS:
- Maximum drainage area per slope drain is 5 acres.
- Clogged slope drains will force water around the pipe and cause slope erosion.
- Dissipation of high flow velocities at the pipe outlet is required to avoid downstream erosion.
- Failure can result in flooding and severe erosion.

MAINTENANCE:
- Structure must be inspected weekly and after storms.
- Inlet must be free of undercutting and no water should circumvent the entry.
- Outlet should not produce erosion; velocity dissipators must be maintained.
- Pipe anchors must be checked to ensure that the pipe remains anchored to the slope.

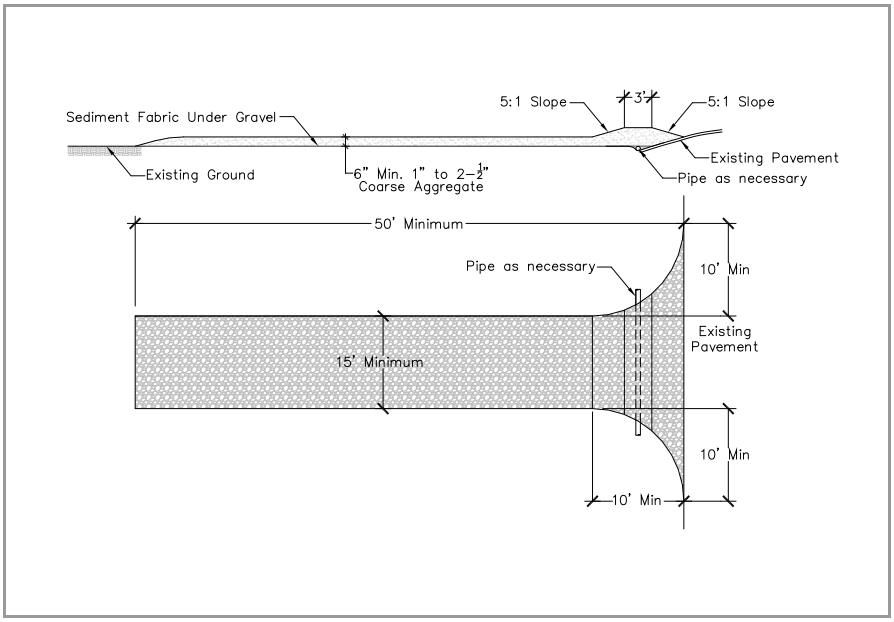


DESCRIPTION:
Practices to clean-up leakage/spillage of on-site materials that may be harmful to receiving waters.

APPLICATION:
All sites

GENERAL:
- Store controlled materials within a storage area.
- Educate personnel on prevention and clean-up techniques.
- Designate an Emergency Coordinator responsible for employing preventative practices and for providing spill response.
- Maintain a supply of clean-up equipment on-site and post a list of local response agencies with phone numbers.

METHODS:
- Clean-up spills/leaks immediately and remediate cause.
- Use as little water as possible. NEVER HOSE DOWN OR BURY SPILL CONTAMINATED MATERIAL.
- Use rags or absorbent material for clean-up. Excavate contaminated soils. Dispose of clean-up material and soil as hazardous waste.
- Document all spills with date, location, substance, volume, actions taken and other pertinent data.
- Contact the Salt Lake County Health Department (313-6700) for any spill of reportable quantity.



DESCRIPTION:

A stabilized pad of crushed stone located where construction traffic enters or leaves the site from or to paved surface.

APPLICATION:

At any point of ingress or egress at a construction site where adjacent traveled way is paved. Generally applies to sites over 2 acres unless special conditions exist.

INSTALLATION/APPLICATION CRITERIA:

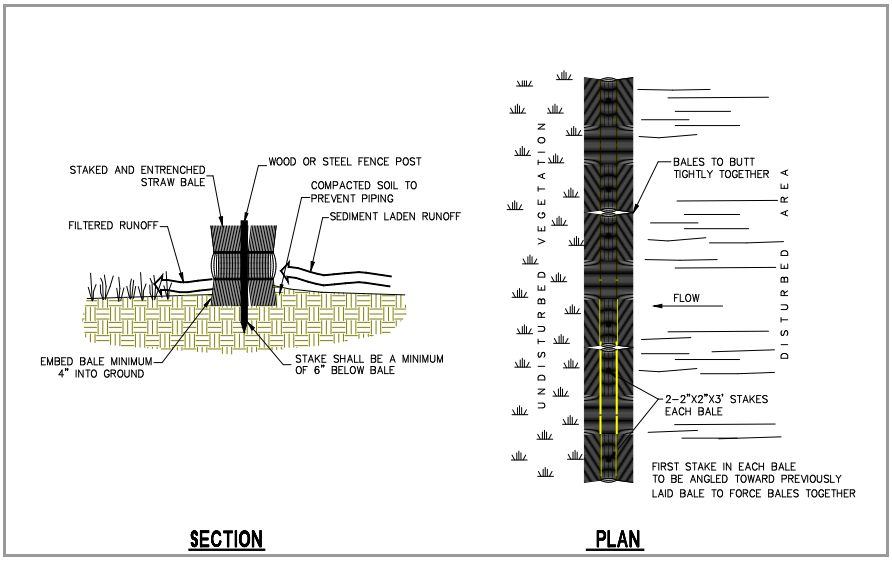
- Clear and grub area and grade to provide maximum slope of 2%.
- Compact subgrade and place filter fabric if desired (recommended for entrances to remain for more than 3 months.
- Place coarse aggregate, 1 to 2-1/2 inches in size, to a minimum depth of 8 inches.

LIMITATIONS:

- Requires periodic top dressing with additional stones.
- Should be used in conjunction with street sweeping on adjacent public right-of-way.

MAINTENANCE:

- Inspect daily for loss of gravel or sediment buildup.
- Inspect adjacent roadway for sediment deposit and clean by sweeping or shoveling.
- Repair entrance and replace gravel as required to maintain control in good working condition.
- Expand stabilized area as required to accommodate traffic and prevent erosion at driveways.



DESCRIPTION:

Temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

APPLICATIONS:

- Perimeter control: place barrier at down-gradient limits of disturbance.
- Sediment barrier: place barrier at toe of slope or soil stockpile.
- Protection of existing waterways: place barrier at top of stream bank.
- Inlet protection.

INSTALLATION/APPLICATION CRITERIA:

- Excavate a 4-inch minimum deep trench along contour line, i.e. parallel to slope, removing all grass and other material that may allow underflow.
- Place bales in trench with ends tightly abutting, fill any gaps by wedging loose straw into openings.
- Anchor each bale with 2 stakes driven flush with the top of the bale.
- Backfill around bale and compact to prevent piping, backfill on uphill side to be built up 4-inches above ground at the barrier.

LIMITATIONS:

- Recommended maximum area of 0.5 acre per 100 feet of barrier
- Recommended maximum up-gradient slope length of 150 feet
- Recommended maximum uphill grade of 2:1 (50%)

MAINTENANCE:

- Inspect immediately after any rainfall and at least daily during prolonged rainfall.
- Look for runoff bypassing ends of barriers or undercutting barriers.
- Repair or replace damaged areas of the barrier and remove accumulated sediment.
- Realign bales as necessary to provide continuous barrier and fill gaps.
- Recompact soil around barrier as necessary to prevent piping.

BMP: Street Sweeping

SS
Construction

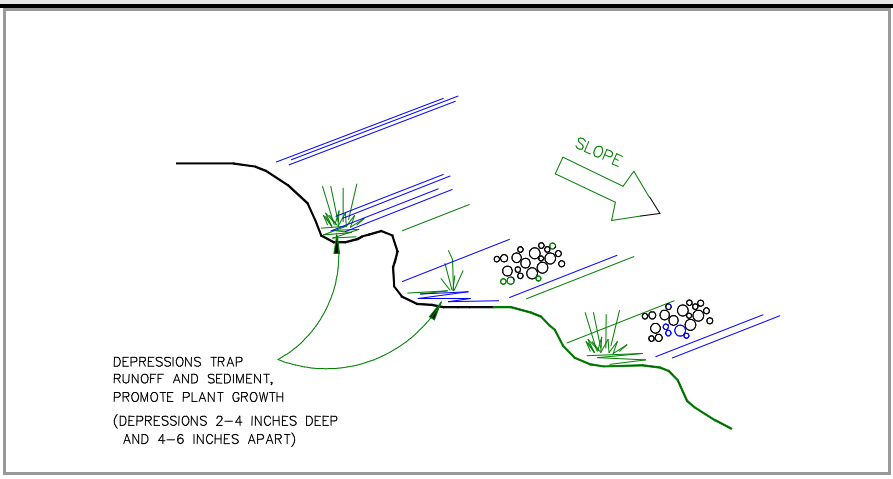


DESCRIPTION:
Reduce the discharges of pollutants to stormwater from street surfaces by conducting street cleaning on a regular basis.

APPROACH:
- Prioritize cleaning to use the most sophisticated sweepers, at the highest frequency, and in areas with the highest pollutant loading.
- Restrict street parking prior to and during sweeping.
- Increase sweeping frequency just before the rainy season.
- Proper maintenance and operation of sweepers greatly increase their efficiency.
- Keep accurate operation logs to track programs.
- Sweepers effective at removing smaller particles (less than 10 microns) may generate dust that would lead to concerns over worker and public safety.
- Equipment selection can be key for this particular BMP. There are two types used, the mechanical broom sweepers (more effective at picking up large debris and cleaning wet streets), and the vacuum sweepers (more effective at removing fine particles and associated heavy metals). Many communities find it useful to have a compliment of both types in their fleet.

LIMITATIONS:
- Conventional sweepers are not able to remove oil and grease.
- Mechanical sweepers are not effective at removing finer sediments.
- Effectiveness may also be limited by street conditions, traffic congestion, presence of construction projects, climatic conditions and condition of curbs.

MAINTENANCE:
- Replace worn parts as necessary.
- Install main and gutter brooms of the appropriate weight.



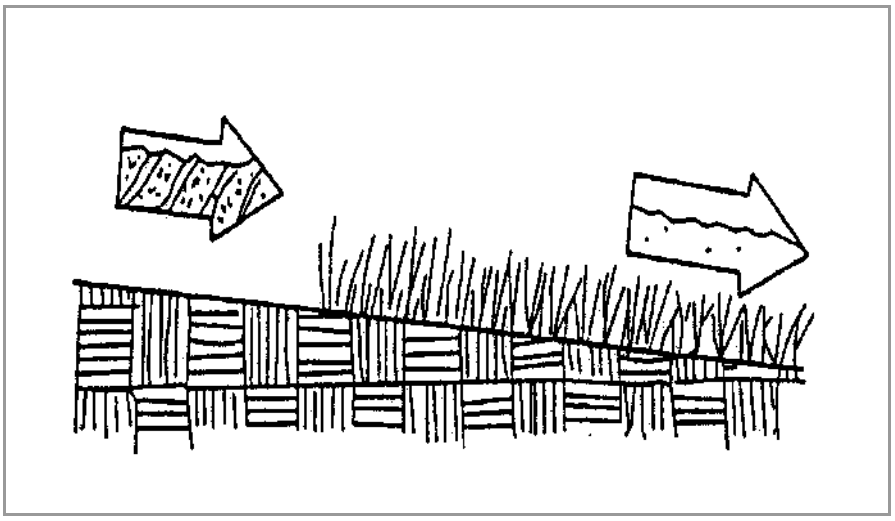
DESCRIPTION:
Rough preparation of working areas leaving depressions and uneven surface. Depressions should be done parallel to contours.

APPLICATION:
Surface roughening is appropriate for all construction that will not be receiving impervious cover within 14 days and that will be exposed less than 60 days (seed areas to be open in excess of 60 days).

INSTALLATION/APPLICATION CRITERIA:
- Surface should be left in rough condition during initial earthwork activity.
- Surfaces that have become smoothed or compacted due to equipment traffic should be roughened by use of disks, spring harrows, teeth on front end loader, or similar, operating along the contours of the slope. Tracking (by crawler tractor driving up and down slope) may also be used to provide depressions parallel to contours.
- Avoid compaction of soils during roughening as this inhibits plant growth and promotes storm water runoff. Limit tracked machinery to sandy soil.
- Seed or mulch areas to be exposed in excess of 60 days.
- Employ dust controls.

LIMITATIONS:
- Will not withstand heavy rainfall.
- Slopes steeper than 2:1 (50%) should be benched.

MAINTENANCE:
- Inspect following any storm event and at a minimum of weekly.
- If erosion in the form of rills (small waterways formed by runoff) is evident, perform machine roughening of area.
- For vegetated slopes reseed areas that are bare or have been reworked.



DESCRIPTION:
Seeding of grass and plantings of trees, shrubs, vines and ground covers provide long-term stabilization of soil. In some areas, with suitable climates, grasses can be planted for stabilization.

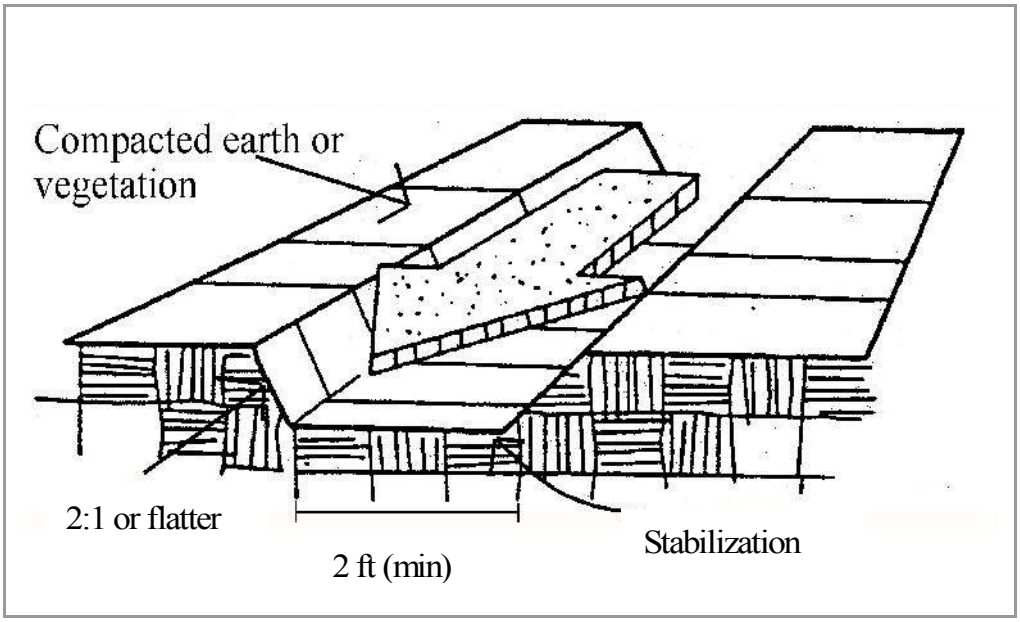
Temporary seeding - establishment of short term cover by application of rapidly germinating seed mix (alternatively hydro-seeding may be utilized).
Permanent seeding - establishment of final term cover by application of perennial seed mix (alternatively sod may be utilized).

APPLICATION:
- Appropriate for site stabilization both during construction and post-construction.
- Any graded/cleared areas where construction activities have ceased.
- Open space cut and fill areas.
- Steep slopes, spoil piles, vegetated swales, landscape corridors, stream banks.

INSTALLATION/APPLICATION CRITERIA:
Type of vegetation, site and seedbed preparation, planting time, fertilization and water requirements should be considered for each application. The recommended seed mix will be dependent on site specific information such as elevation, exposure, soils, water availability and topography. Appropriate ground preparation and fertilizer must be considered.

LIMITATIONS:
- Permanent and temporary vegetation may not be appropriate in dry periods without irrigation.
- Fertilizer requirements may have potential to create stormwater pollution.

MAINTENANCE:
- Shrubs and trees must be adequately watered and fertilized and if needed pruned.
- Grasses may need to be watered and mowed.
- Provide irrigation as required to establish growth and to maintain plant cover through duration of project.
- Reseed as necessary to provide 75% coverage
- Remediate any areas damaged by erosion or traffic.
- When 75% coverage is achieved inspect monthly for damage and remediate as necessary.



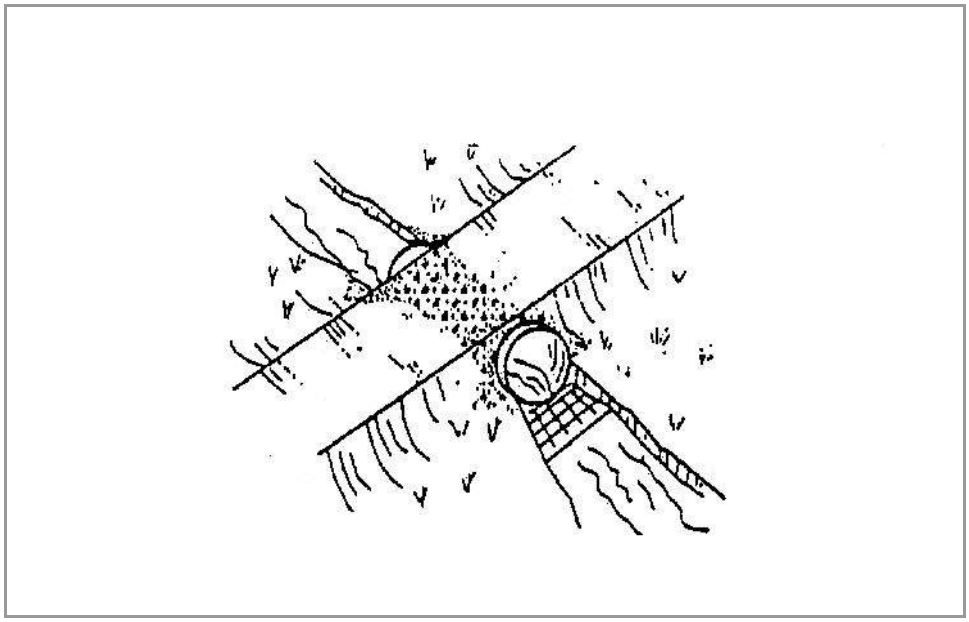
DESCRIPTION:
Temporary drains and swales are used to divert off-site runoff around the construction site, divert runoff from stabilized areas around disturbed areas, and direct runoff into sediment.

APPLICATIONS:
- Temporary drains and swales are appropriate for diverting any upslope runoff around unstabilized or disturbed areas of the construction site.
- Prevent slope failures. Prevent damage to adjacent property. Prevents erosion and transport of sediments into water ways. Increases the potential for infiltration. Diverts sediment-laden runoff into sediment basins or traps.

INSTALLATION/APPLICATION:
- Temporary drainage swales will effectively convey runoff and avoid erosion if built properly:
- Size temporary drainage swales using local drainage design criteria. A permanent drainage channel must be designed by a professional engineer (see the local drainage design criteria for proper design).
- At a minimum, the drain/swale should conform to predevelopment drainage patterns and capacities.
- Construct the drain/swale with an uninterrupted, positive grade to a stabilized outlet. Provide erosion protection or energy dissipation measures if the flow out of the drain or swale can reach an erosive velocity.

LIMITATIONS:
- Temporary drains and swales or any other diversion of runoff should not adversely impact upstream or downstream properties.
- Temporary drains and swales must conform to local floodplain management requirements.

BMP: Temporary Stream Crossing



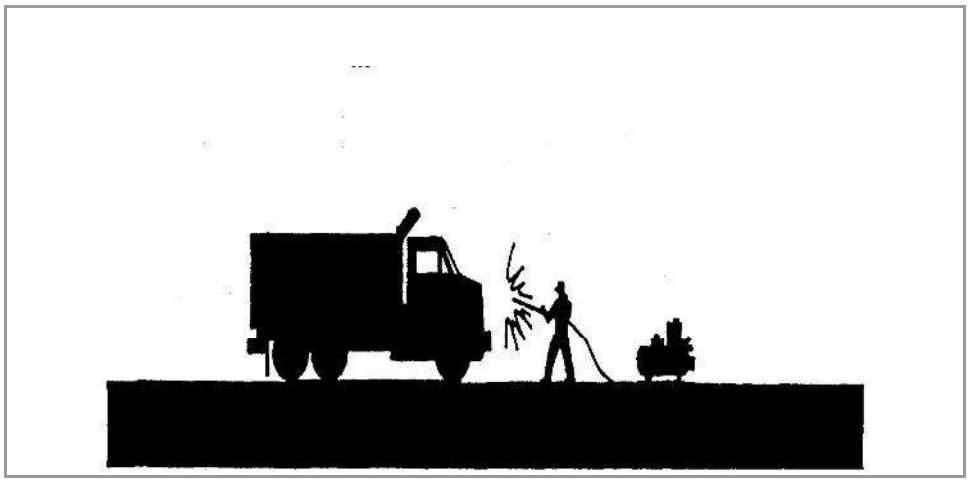
DESCRIPTION:
A temporary access stream crossing is a temporary culvert, ford or bridge placed across a waterway to provide access for construction purposes for a period of less than one year. Temporary access crossings are not intended to be used to maintain traffic for the general public.

APPLICATIONS:
Temporary stream crossings should be installed at all designated crossings of perennial and intermittent streams on the construction site, as well as for dry channels which may be significantly eroded by construction traffic.

INSTALLATION/APPLICATION:
Requires knowledge of stream flows and soil strength and should be designed under the direction of a Utah registered engineer with knowledge of both hydraulics and construction loading requirements for structures.

LIMITATIONS:
- May be an expensive for a temporary improvement.
- Requires other BMP's to minimize soil disturbance during installation and removal.
- Fords should only be used in dry weather.
- A Stream Alteration Permit may be required, contact the Utah Division of Water Rights before implementation.

MAINTENANCE:
- Inspect weekly and after each significant rainfall, including assessment of foundations.
- Periodically remove silt from crossings.
- Replace lost aggregated from inlets and outlets of culverts.

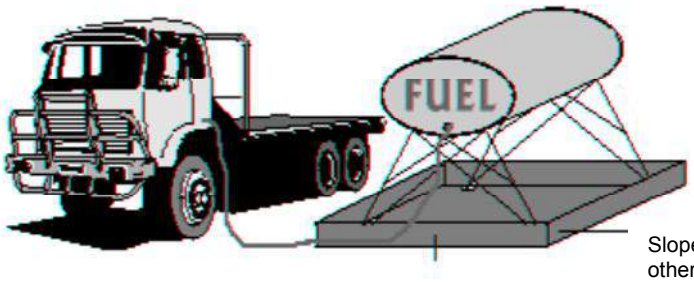


DESCRIPTION:
Prevent or reduce the discharge of pollutants to storm water from vehicle and equipment cleaning by washing in designated, contained areas only, eliminating discharges to the storm drain by infiltrating or recycling the wash water, and/or training employees and subcontractors.

INSTALLATION/APPLICATION:
- Use designated, bermed wash areas to prevent wash water contact with storm water, creeks, rivers, and other water bodies. The wash area can be sloped for wash water collection and subsequent infiltration into the ground.
- Use as little water as possible to avoid having to install erosion and sediment controls for the wash area. Use phosphate-free biodegradable soaps. Educate employees and subcontractors on pollution prevention measures. Do not permit steam cleaning on-site. Steam cleaning can generate significant pollutant concentrations.

LIMITATIONS:
- Even phosphate-free, biodegradable soaps have been shown to be toxic to fish before the soap degrades.
- Sending vehicles/equipment off-site should be done in conjunction with Stabilized Construction Entrance.

MAINTENANCE:
- Minimal, some berm repair may be necessary.



DESCRIPTION:
Prevent fuel spills and leaks, and reduce their impacts to storm water by using off-site facilities, fueling in designated areas only, enclosing or covering stored fuel, implementing spill controls, and training employees and subcontractors.

INSTALLATION/APPLICATION:
- Use off-site fueling stations as much as possible. Fueling vehicles and equipment outdoors or in areas where fuel may spill/leak onto paved surfaces or into drainage pathways can pollute storm water. If you fuel a large number of vehicles or pieces of equipment, consider using an off-site fueling station. These areas are better equipped to handle fuel and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate fueling area at your site.
- If fueling must occur on-site, use designated areas, located away from drainage courses, to prevent the runon of storm water and the runoff of spills. Discourage topping-off of fuel tanks.
- Always use secondary containment, such as a drain pan or drop cloth, when fueling to catch spills/leaks. Place a stockpile of spill cleanup materials where it will be readily accessible. Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Carry out all Federal and State requirements regarding stationary above ground storage tanks. (40 CF Sub. J) Avoid mobile fueling of mobile construction equipment around the site; rather, transport the equipment to designated fueling areas. With the exception of tracked equipment such as bulldozers and perhaps forklifts, most vehicles should be able to travel to a designated area with little lost time. Train employees and subcontractors in proper fueling and cleanup procedures.

LIMITATIONS:
Sending vehicles/equipment off-site should be done in conjunction with Stabilized Construction Entrance.

MAINTENANCE:
- Keep ample supplies of spill cleanup materials on-site.
- Inspect fueling areas and storage tanks on a regular schedule.

BMP: Vegetated Buffers



DESCRIPTION:

Vegetated buffers are areas of natural or established vegetation maintained to protect the water quality of neighboring areas. Buffer zones slow stormwater runoff, provide an area where runoff can permeate the soil, contribute to ground water recharge, and filter sediment. Slowing runoff also helps to prevent soil erosion and streambank collapse.

APPLICATIONS:

Vegetated buffers can be used in any area able to support vegetation. They are most effective and beneficial on floodplains, near wetlands, along streambanks, and on unstable slopes.

INSTALLATION/APPLICATION CRITERIA:

To establish an effective vegetative buffer, follow these guidelines:

- Make sure soils are not compacted.
- Make sure slopes are less than 5 percent unless temporary erosion control mats are also used.
- Determine buffer widths after carefully considering slope, vegetation, soils, depth to impermeable layers, runoff sediment characteristics, type and amount of pollutants, and annual rainfall.
- Make sure buffer widths increase as slope increases.
- Intermix zones of vegetation (native vegetation in particular), including grasses, deciduous and evergreen shrubs, and understory and overstory trees.
- In areas where flows are concentrated and fast, combine buffer zones with other practices such as level spreaders, infiltration areas, or diversions to prevent erosion and rilling.

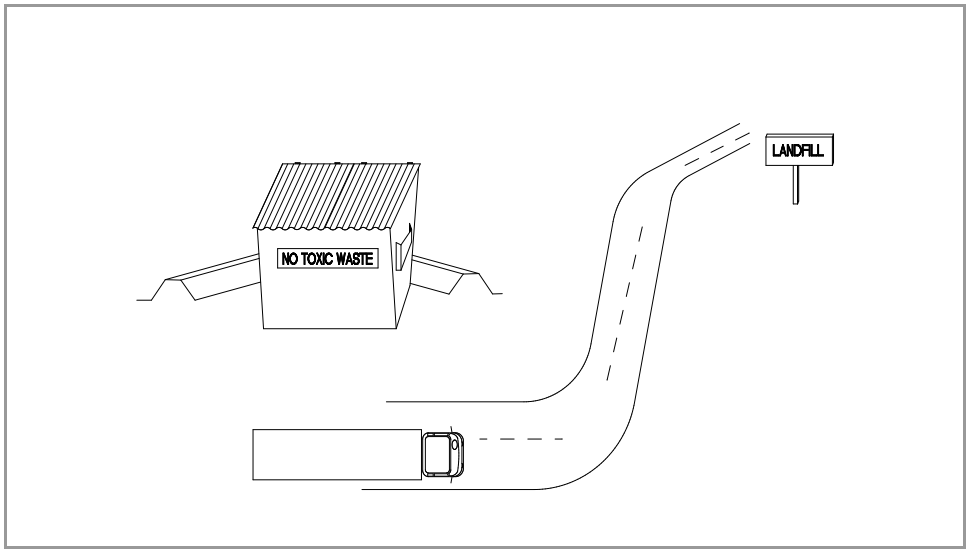
LIMITATIONS:

Adequate land must be available for a vegetated buffer. If land cost is high, buffer zones might not be cost-effective. In addition, adequate vegetative cover must be maintained in the buffer to keep it effective. Vegetated buffers work well with sheet flows, but they are not appropriate for mitigating concentrated stormwater flows.

MAINTENANCE:

Keeping vegetation healthy in vegetated buffers requires routine maintenance. Depending on species, soil types, and climatic conditions, maintenance can include weed and pest control, mowing, fertilizing, liming, irrigating, and pruning.

Adapted from EPA – Stormwater Menu of BMPs



DESCRIPTION:
Controlled storage and disposal of solid waste generated by construction activities.

APPLICATION:
All construction sites.

INSTALLATION:
- Designate one or several waste collection areas with easy access for construction vehicles and personnel. Ensure no waterways or storm drainage inlets are located near the waste collection areas.
- Construct compacted earthen berm (See Earth Berm Barrier Information Sheet), or similar perimeter containment around collection area for impoundment in the case of spills and to trap any windblown trash.
- Use watertight containers with covers to remain closed when not in use. Provide separate containers for different waste types where appropriate and label clearly.
- Ensure all on site personnel are aware of and utilize designated waste collection area properly and for intended use only (e.g. all toxic, hazardous, or recyclable materials shall be properly disposed of separately from general construction waste).
- Arrange for periodic pickup, transfer and disposal of collected waste at an authorized disposal location. Include regular Porta-potty service in waste management activities.

LIMITATIONS:
- On-site personnel are responsible for correct disposal of waste.

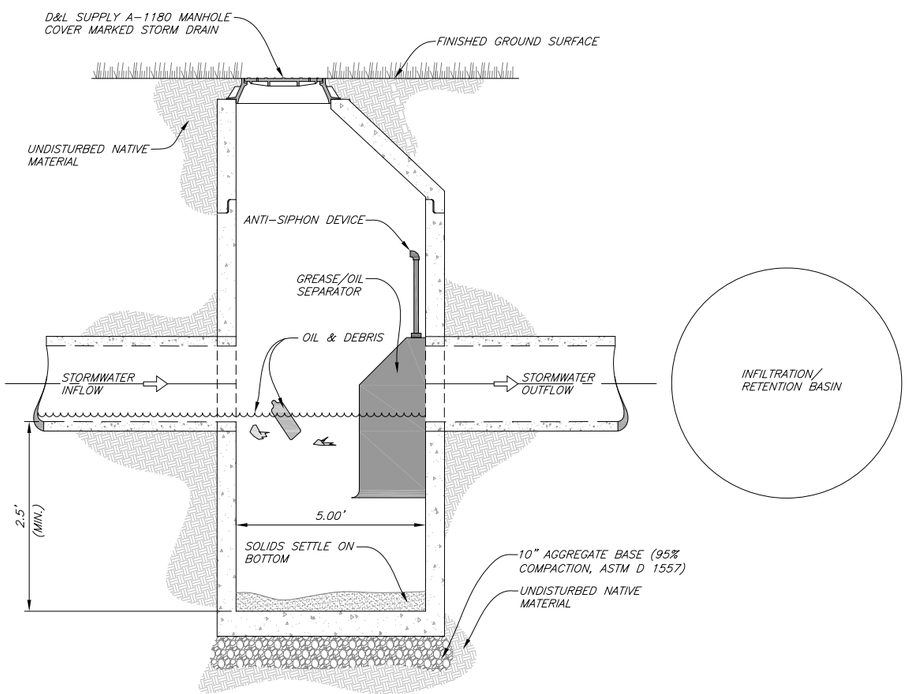
MAINTENANCE:
- Discuss waste management procedures at progress meetings.
- Collect site trash daily and deposit in covered containers at designated collection areas.
- Check containers for leakage or inadequate covers and replace as needed.
- Randomly check disposed materials for any unauthorized waste (e.g. toxic materials).
- During daily site inspections check that waste is not being incorrectly disposed of on-site (e.g. burial, burning, surface discharge, discharge to storm drain).

EXHIBIT 4

CONSTRUCTION STANDARD DETAILS FOR STORM WATER MANAGEMENT

STORMWATER PRETREATMENT FOR INFILTRATION AND RETENTION BMPS

STORM WATER PRETREATMENT FOR
BIORETENTION AND RETENTION BMPS



5' MANHOLE W/ GREASE/OIL SEPARATOR

SCALE: 1"=2'

PREPARED BY:

FIGURE # 2. ROY CITY STORMWATER PRETREATMENT FOR INFILTRATION AND RETENTION BMPS

WASATCH CIVIL
Consulting Engineering
1150 SOUTH DEPOT DRIVE, SUITE 225
OGDEN, UTAH 84404 (801) 775-9191

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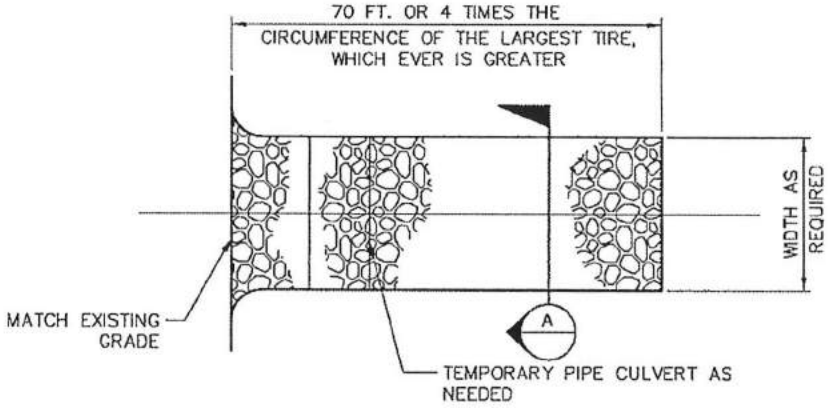
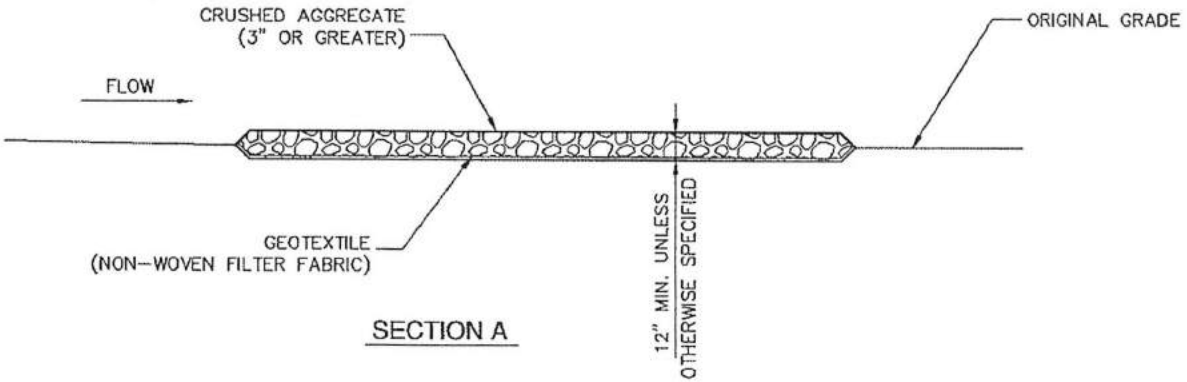


PLAN VIEW

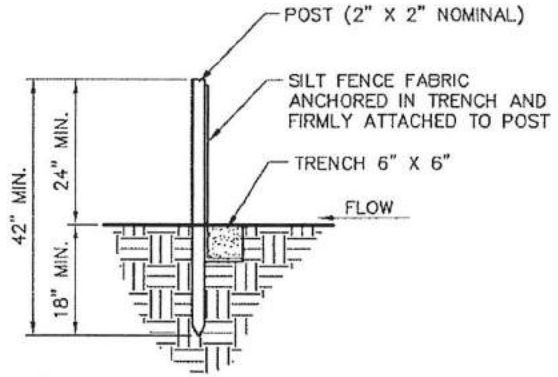


SECTION A

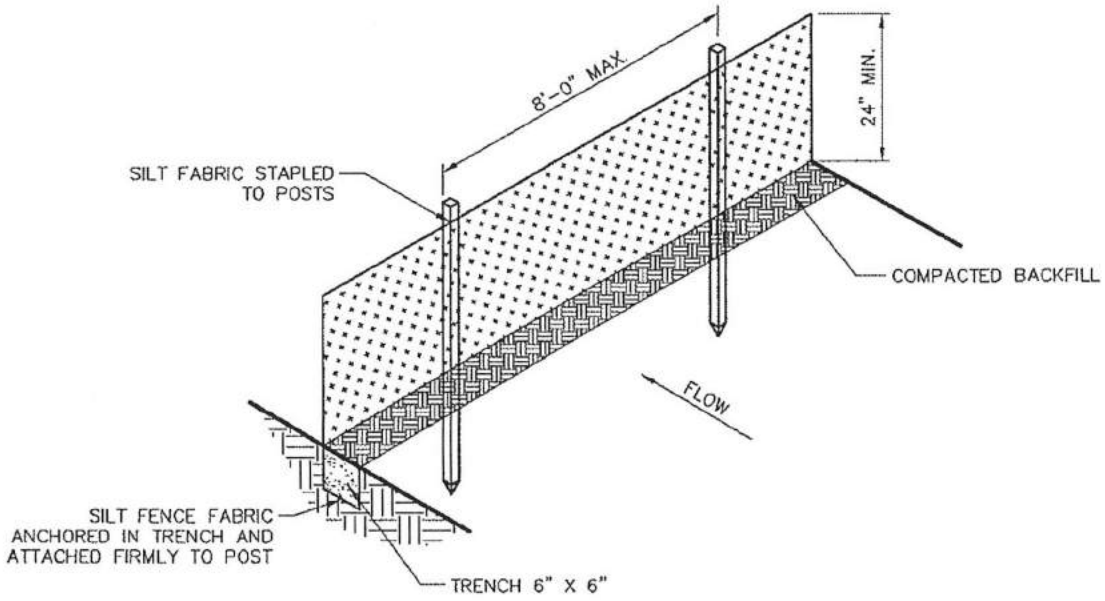
STABILIZED CONSTRUCTION ENTRANCE DETAIL (1) SCALE: N. T. S.

ROY CITY

STORM WATER MANAGEMENT
CONSTRUCTION DETAILS



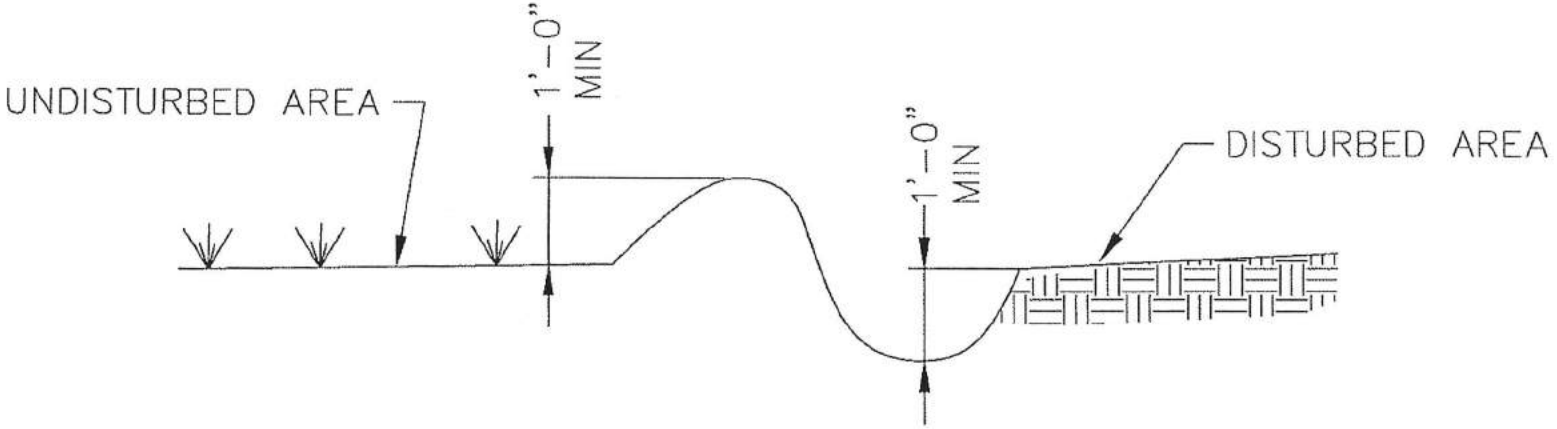
NOTES:
1. MINIMUM FILTER FABRIC HEIGHT SHALL BE 24".
2. POSTS FOR SILT FENCES SHALL BE METAL OR HARD WOOD WITH A MINIMUM LENGTH OF 36". WOOD POSTS SHALL HAVE A MINIMUM DIAMETER OR CROSS SECTION OF 2". METAL POSTS SHALL BE "STUDDED TEE" OR "U" TYPE WITH MINIMUM WEIGHT OF 1.33 LBS/FOOT.
3. DRIVE POSTS VERTICALLY INTO THE GROUND TO A MINIMUM DEPTH OF 18", AND EXCAVATE A TRENCH APPROXIMATELY 6" WIDE AND 6" DEEP ALONG THE LINE OF POSTS AND UPSLOPE FROM THE BARRIER. NO LESS THAN THE BOTTOM 1 FOOT OF THE FABRIC SHALL BE BURIED INTO THIS TRENCH.
4. THE FILTER FABRIC MATERIALS SHALL BE FASTENED SECURELY TO METAL OR WOOD POSTS USING WIRE TIES, OR TO THE WOOD POSTS WITH ¾" LONG #9 HEAVY DUTY STAPLES.
5. POSTS SHALL BE SPACED A MAXIMUM OF 8 FEET APART.



SILT FENCE DETAIL 2
SCALE: N. T. S.

ROY CITY

STORM WATER MANAGEMENT
CONSTRUCTION DETAILS

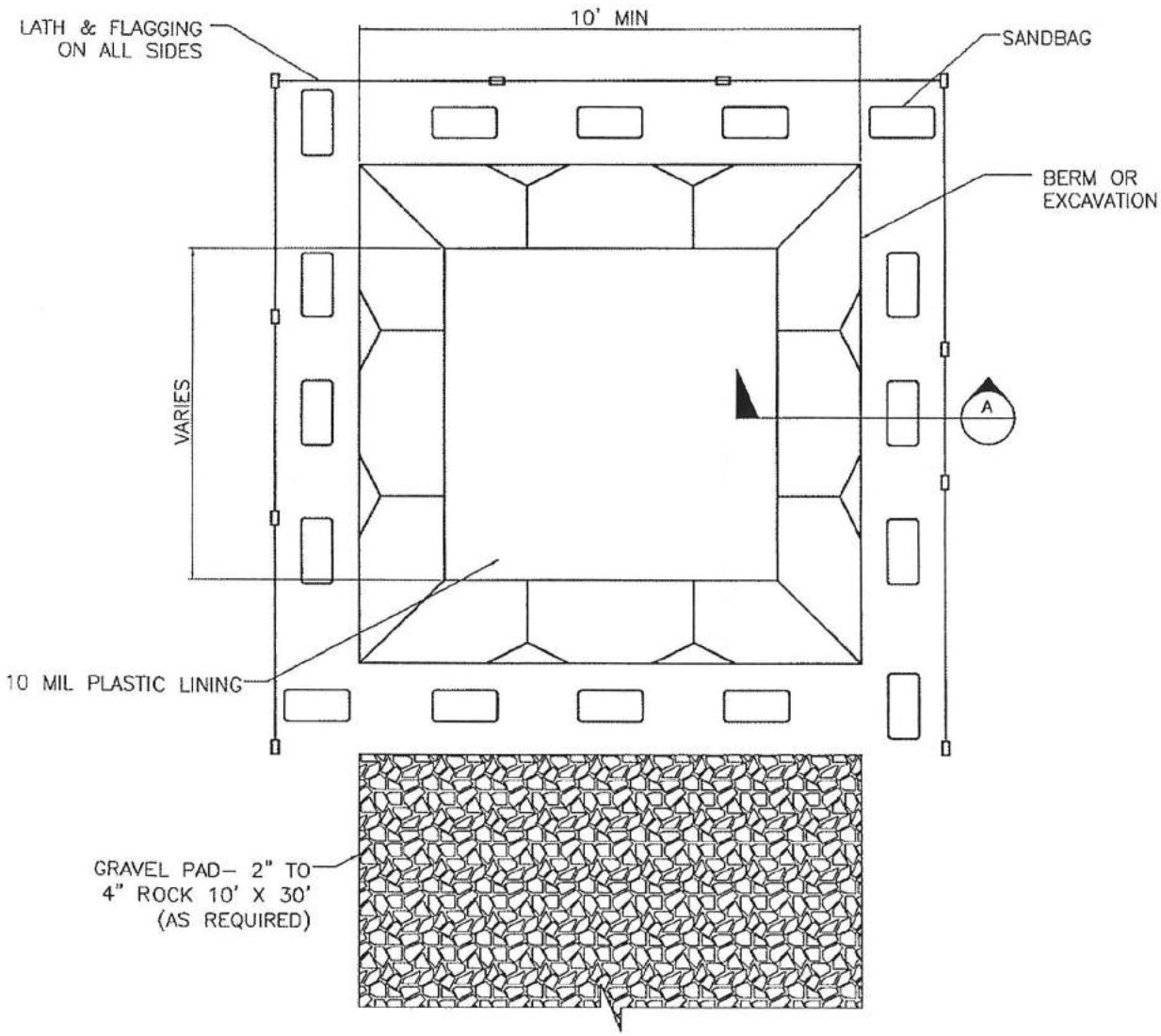


SWALE / BERM DETAIL 3

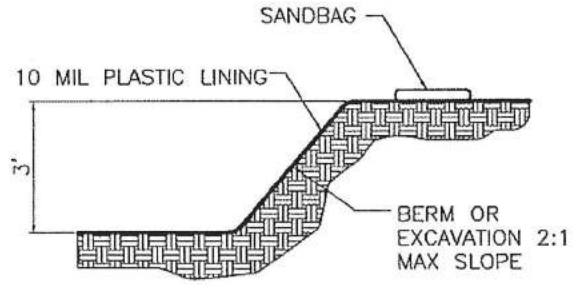
SCALE: N. T. S.

ROY CITY

STORM WATER MANAGEMENT
CONSTRUCTION DETAILS



PLAN



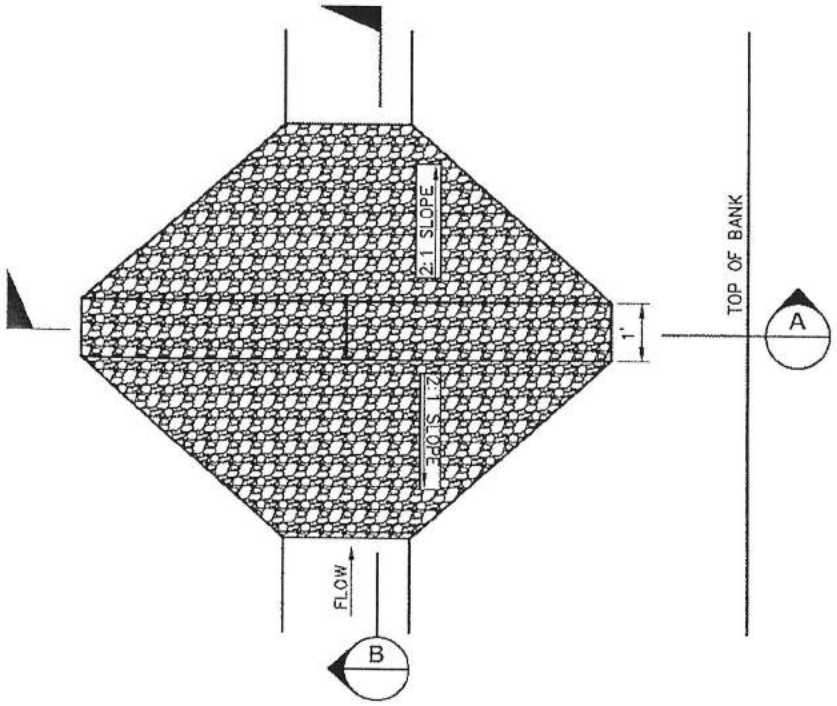
SECTION A

NOTES:
1. ACTUAL LAYOUT DETERMINED IN FIELD.
2. CONCRETE WASHOUT SIGN SHALL BE INSTALLED WITHIN 30 FT. OF THE TEMPORARY CONCRETE WASHOUT FACILITY.
3. WASHOUT NEEDS TO BE EMPTIED AND REPAIRED WHEN 75% OF STORAGE CAPACITY IS FILLED.
4. DEVELOPER/CONTRACTOR RESPONSIBLE FOR REMOVAL & PROPER DISPOSAL OF CONCRETE PRIOR TO FILING N.O.T

CONCRETE WASHOUT DETAIL 4
SCALE: N. T. S.

ROY CITY

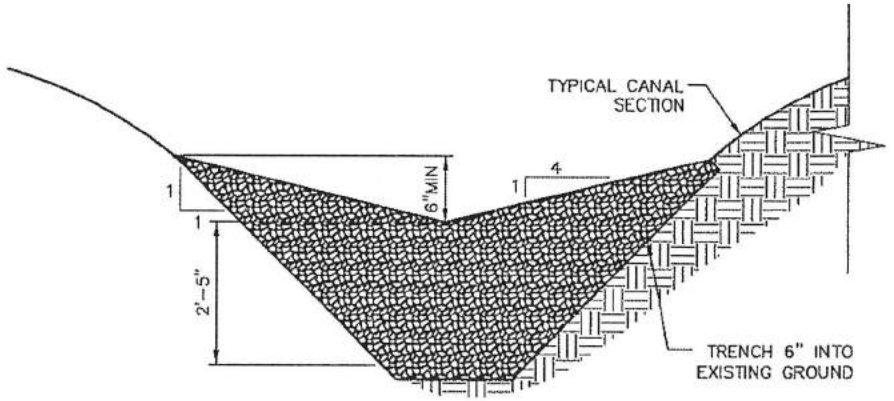
STORM WATER MANAGEMENT CONSTRUCTION DETAILS



PLAN VIEW

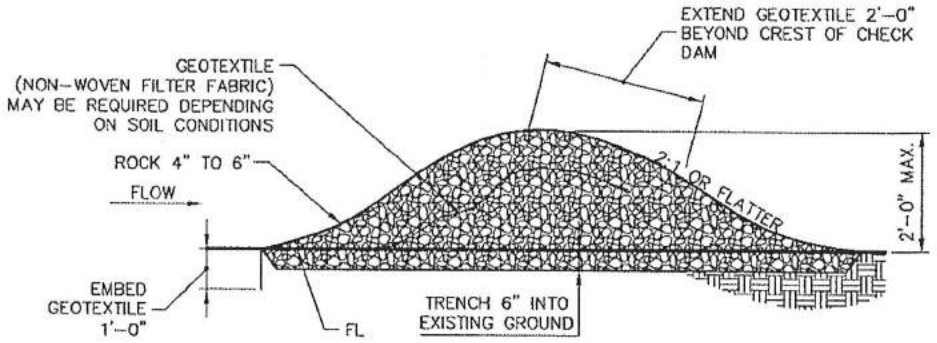
DITCH ROCK CHECK DAM 5

SCALE: N.T.S.



SECTION A

SCALE: N.T.S.

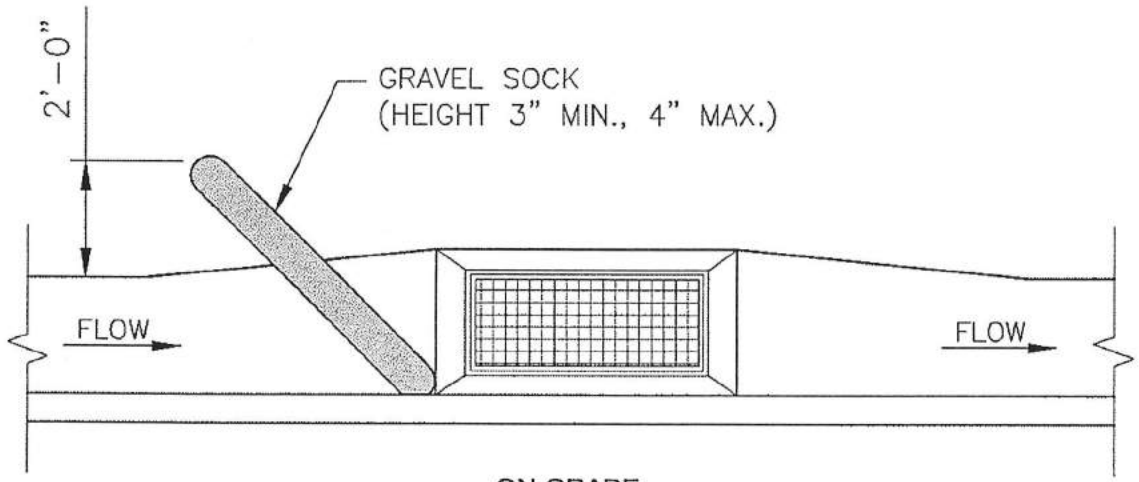


SECTION B

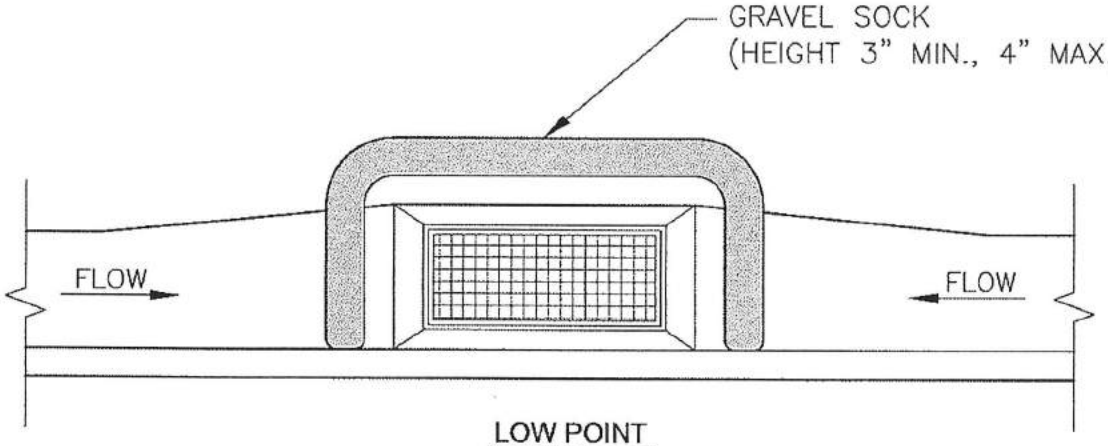
SCALE: N.T.S.

ROY CITY

STORM WATER MANAGEMENT CONSTRUCTION DETAILS



ON GRADE



LOW POINT

6 INLET PROTECTION DETAIL
SCALE: N.T.S.

ROY CITY

STORM WATER MANAGEMENT
CONSTRUCTION DETAILS