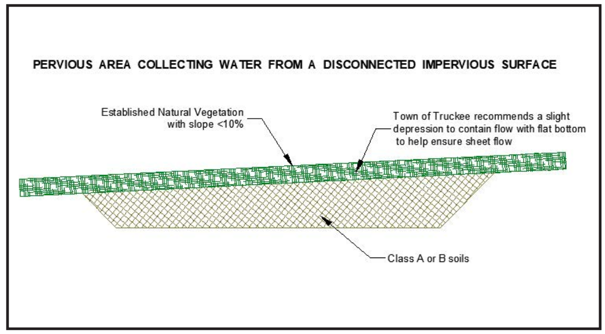
ROOFTOP & IMPERVIOUS AREA DISCONNECTION, AND SNOW STORAGE

Fact Sheet SDM-1

Including: Downspout Disconnection, Pavement Disconnection, Flowpath Disconnection.

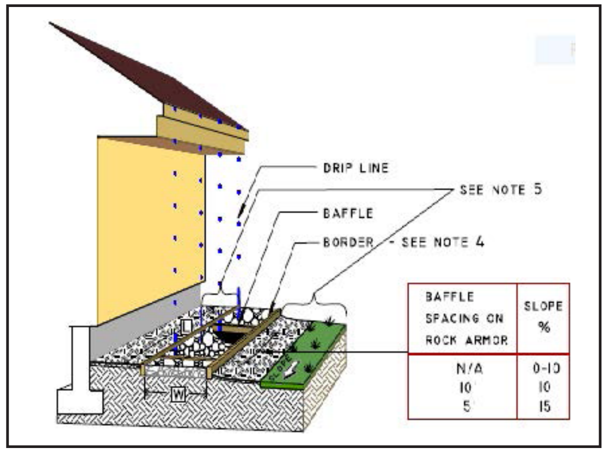
OVERVIEW

Impervious area disconnection techniques reduce the volume of storm water delivered to storm drains or receiving waters by disconnecting the runoff from these areas and redirecting it to the permeable locations that promote soil filtration and runoff infiltration. Several methods of disconnection may be utilized.



Typical vegetated area used for disconnection

The first, and most commonly used, is simple disconnection, where runoff from rooftops or residential impervious surfaces are directed to pervious vegetated areas. This is typically achieved in Truckee by allowing water to sheet flow off of a roof onto an armored dripline and then to flow to an established vegetated area.



Dripline amoring (BMP-009), NRCS 2012

The second, is when runoff is directed from a surface through a downspout or other conveyance into an established vegetated area or through these vegetated areas into an infiltration trench or basin. In this example energy dissipation devices such as splash blocks, rock armoring, bubble up emitters, or similar devices must be used to prevent erosion at the discharge point.

It is common in the Truckee area to use vegetated areas as snow storage. However, if these vegetated areas will be used as both a site design measure and for snow storage other requirements to mitigate the increased risk of pollutant transport will be required. These are integrated into the key design features.

Bubble-up emmitter, snosn.com 2017

The pervious area that will be used to receive the runoff must be located on flat slopes (<10%) with well draining soils (A,B and C). These areas must be sited away from buildings and roads to prevent moisture problems and undermining.

KEY DESIGN FEATURES

- Not appropriate on steep slopes (<10%).
- Area used for storm water reduction should exclude the areas used as dripline trenches and infiltration trenches. These retention and infiltration measures should be calculated separately as they are more efficient measures.
- A maximum impervious to pervious area ratio of 2:1 should be applied.
- All rooftop disconnections that do not use gutters and downspouts must include dripline armoring and must maintain a 2% slope away from the building for 10 feet.

- Dripline armoring shall be at a min. 18” in width and 3” in depth for 1 story. Each additional story requires 6” of additional width.
- Energy dissipation devices (level spreader, splash blocks, bubble up emitters, rock armoring) should be used if more concentrated flows are being produced i.e. gutters downspouts are used to direct rooftop runoff.
- Downspouts and extensions must extend at least 6 feet from the foundation.
- Water barriers may be required when infiltrating adjacent to paved surfaces to prevent undermining of pavement and baserock.
- If using the pervious area for residential snow storage as well as disconnection then minimum snow storage requirements as outlined in Section 18.30.130 of the Town Development Code shall be required:
  - In areas with a snow load less than 200 pounds per square foot, the required snow storage area shall equal at least 50 percent of the total parking and driveway area; and,
  - In areas with a snow load of 200 pounds per square foot or greater, the required snow storage area shall equal to at least 75 percent of the total parking and driveway area.
- Credit for rooftop and impervious area disconnection, and snow storage cannot be obtained if stream set-backs and buffers or vegetated swales are being used for credits in the same drainage management area.

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Construction Storm Water Quality Plan (SWQP) Form 2-1 should be used to calculate the retention volume (V_{ret}) associated with rooftop and impervious area disconnection. This value is then used to calculate the area of impervious surface treated, and determined if other site design measures are necessary to capture the 85th percentile, 24 hour design storm. The equation for determining V_{ret} is as follows:

$$V_{ret} = A_{imp} * V_{85} * (1/12)$$

Where:

V_{ret} = storm water retention volume (ft^3);

A_{imp} = impervious drainage area or impervious area to be kept clear of snow (ft^2); and

V_{85} = runoff volume from the 85^{th} percentile, 24-hour design storm (in)

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for all non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

- Inspect and clear debris from inflow/outflow conveyances to maintain intended drainage patterns.
- Remove debris and sediment from infiltration areas to prevent clogging
- Inspect vegetation and reseed or replant as necessary.
- Keep contributing impervious surfaces swept clean to prevent transport and accumulation of materials in the infiltration areas.
- Check for erosion and stabilize any damaged areas.

ROOFTOP & IMPERVIOUS AREA DISCONNECTION, AND SNOW STORAGE

Fact Sheet SDM-1

REFERENCES

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VEGETATED SWALE

Fact Sheet SDM-2

Also known as: Bioretention Swale, Treatment Swale, and Grassed Swale

DESCRIPTION

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey storm water runoff to downstream discharge points. They are designed to treat runoff through vegetation filtration, biological uptake, evapotranspiration, and/or infiltration into the underlying soils. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of storm water runoff.

Grassed swale. Photo Source: CDM Smith

Vegetated swales can serve as part of a storm water drainage system and can replace curbs, gutters and storm sewer systems. They are best suited to capture runoff from small impervious areas and should not be implemented in areas with highly contaminated runoff.

They can be used as part of treatment train approach and are effective at providing pretreatment for other BMPs.

KEY DESIGN FEATURES

In order to receive runoff volume reduction credits, vegetated swales must be designed in accordance with Treatment Control BMP 30 (TC-30) from the California Storm water BMP Handbook, New Development and Redevelopment. Key design elements are summarized below:

- Maximum flow velocity from the design storm event shall not exceed 1.0 foot per second.
- Vegetated swales should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, whichever is less, at the design treatment rate.
- Longitudinal slopes shall be between 0.5% and 2.5%.
- Provide sufficient length to achieve a desired treatment contact time of 10 minutes. Regardless of contact time, the swale should not be less than 100 feet in length unless used as pretreatment in conjunction with another BMP.
- Implement check dams for longitudinal slopes > 2.5% as a means to reduce slopes and promote infiltration. Space as required to maintain maximum longitudinal bottom slope < 2.5%.
- Implement entrance/outlet energy dissipation measures to limit erosion and promote retention.
- Do not compact soils beneath vegetated swales.
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing plants that thrive under the specific site, climatic, and watering conditions should be specified. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.

VEGETATED SWALE

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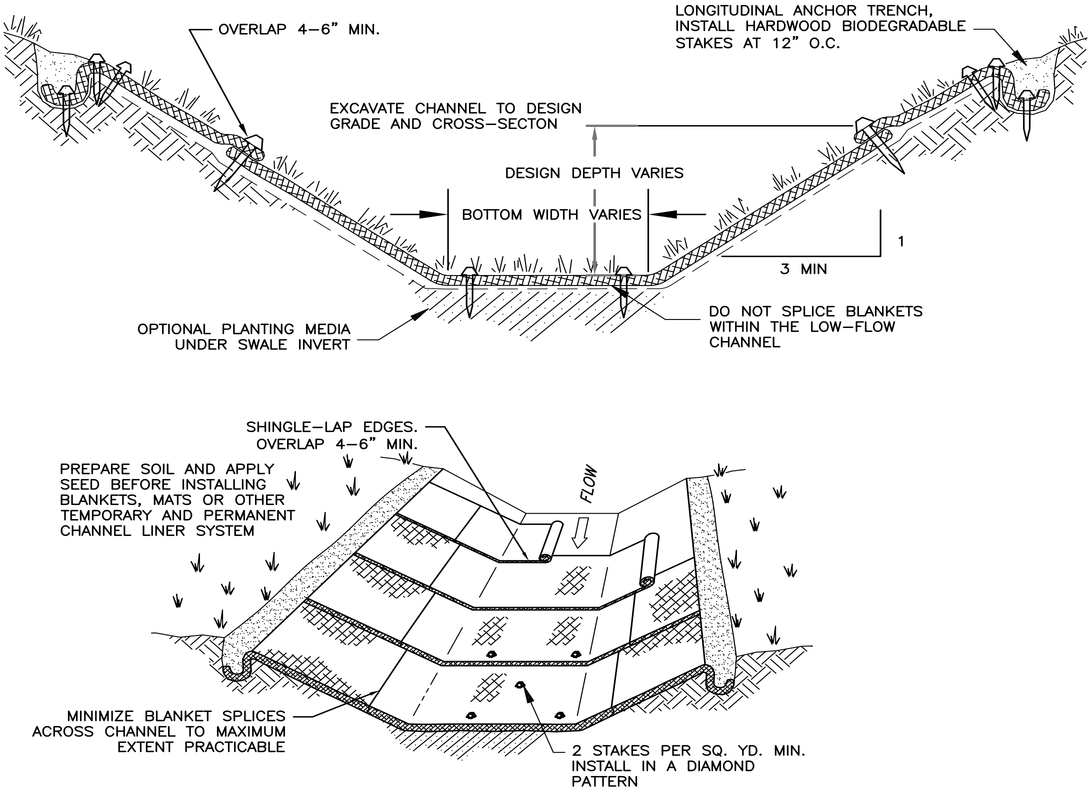

VEGETATED SWALE TYPICAL INSTALLATION

- The width of the swale should be determined using Manning's Equation, at the peak of the design storm, and a value of 0.25 for Manning's n.
- If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.
- For areas that collect road water, but are perpendicular to the road, the swale should have a pretreatment basin area near the road for easier clean out of road sand.
- Swales must be densely vegetated in order to provide adequate treatment and reduction of runoff. It is important to maximize water contact with vegetation and the soil surface.
- If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials. Diverted runoff must be managed and retained onsite to avoid violation of the Phase II MS4 Permit.
- Swales used as primary storm water conveyance facilities (i.e. without high flow bypass) must be designed according to requirements in the Town of Truckee Public Improvement Engineering Standards. These swales will not qualify for volume reduction credits unless the design criteria specified above are also satisfied.
- Temporary erosion control blankets, if used, shall be 100 percent biodegradable including materials used to hold blankets together. No plastic materials are allowed.

VEGETATED SWALE

Fact Sheet SDM-2

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Construction Storm Water Quality Plan (SWQP) Form 2-1 should be used to calculate the retention volume (V_{ret}) associated with vegetated swales. This value is then used to calculate the area of impervious surface treated, and determine if other site design measures are necessary to capture the 85th percentile, 24-hour design storm for Regulated Projects. The equation for determining V_{ret} is as follows:

$$V_{ret} = A_{imp} * V_{85} *(1/12)$$

Where:

V_{ret} = storm water retention volume (ft^3);

A_{imp} = impervious area draining to vegetated swale (ft^2); and

V_{85} = Runoff volume from 85th percentile, 24-hour design storm (in)

RUNOFF REDUCTION CREDIT REQUIREMENTS

- Vegetated swales must be designed in accordance with Treatment Control BMP 30 (TC-30 - Vegetated Swale) from the California Storm water BMP Handbook, New Development and Redevelopment (available at www.cabmphandbooks.com).
- The maximum flow velocity for runoff from the design storm event must be less than or equal to 1.0 foot per second.

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

- Inspect on a semi-annual basis to assess slope integrity, soil moisture, vegetative health, soil stability, compaction, erosion, ponding, and sedimentation.
- Mow at least once per year, but do not cut grass shorter than the design flow depth because the effectiveness of the vegetation in reducing flow velocity and pollutant removal may be reduced. Grass cuttings should be removed from the swale and composted.
- Remove accumulated sediment when it is 3” deep or higher than the turf to minimize potential concentrated flows and sediment resuspension.
- Irrigate only as necessary to prevent vegetation from dying.
- Integrated pest management should be used for pest control. The designer should ideally select vegetation that does not require fertilizers.
- Reseed periodically to maintain dense turf.
- Remove trash or obstructions that cause standing water.
- Prevent off-street parking or other activities that can cause rutting or soil compaction.

VEGETATED SWALE

Fact Sheet SDM-2

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SUBSURFACE INFILTRATION FACILITIES

Fact Sheet SDM-3

Including: Infiltration Basins, Dry Wells, Infiltration Trenches, and Infiltration Galleries

OVERVIEW

Infiltration is the most common approach to reducing storm water runoff volumes to mitigate hydro-modification and protect the quality of downstream receiving waters. The process uses the natural filtering ability of the soil to remove pollutants in storm water runoff. Infiltration facilities vary widely in type, but all generally function by storing runoff temporarily until in gradually infiltrates into the underlying soils. Infiltration has high pollutant removal efficiency and can also help recharge groundwater.

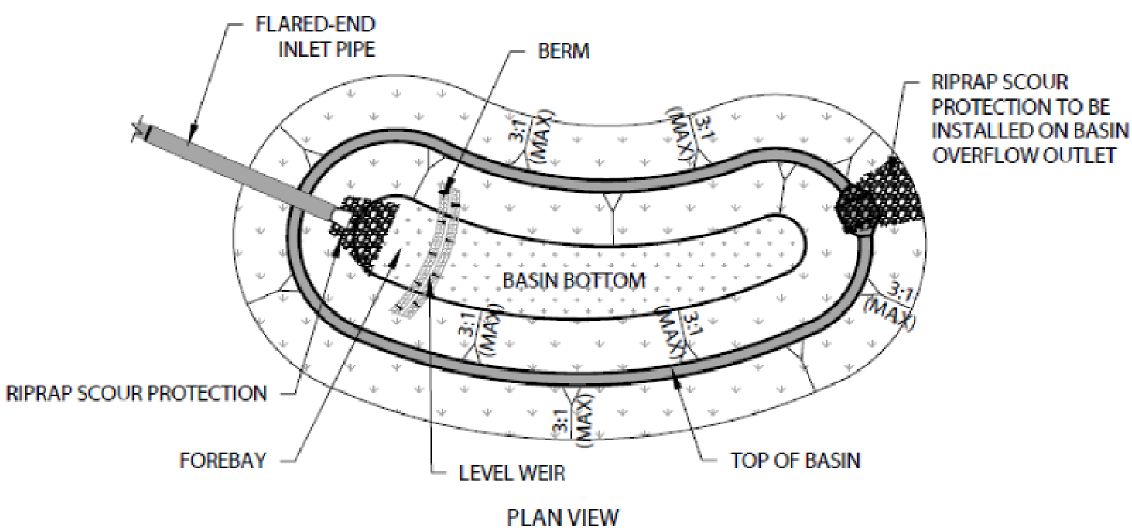
This fact sheet covers several types of surface and subsurface infiltration facilities. Shallow, excavated basins are the most common type of infiltration facility due to their relatively simple construction and high runoff storage capacity. In cold weather climates where freezing temperatures and snow accumulations can limit the effectiveness of infiltration at the ground surface, subsurface infiltration facilities can provide effective alternatives. With proper design and construction, subsurface facilities reduce freezing of runoff, thereby facilitating winter-time infiltration. Subsurface infiltration facilities can be installed beneath parking lots, or other structures, to save space and storage can be provided in underground vaults with weep holes or open bottoms, perforated piping, and a variety of commercially available products. Excavations are typically backfilled with a porous media, such as washed gravel, to further increase storage volumes.

All infiltration facilities require careful siting and design by an appropriately licensed and qualified professional. Designers must consider and evaluate many factors such as slope, soil type, groundwater, nearby structures and utilities, and other site specific characteristics to.

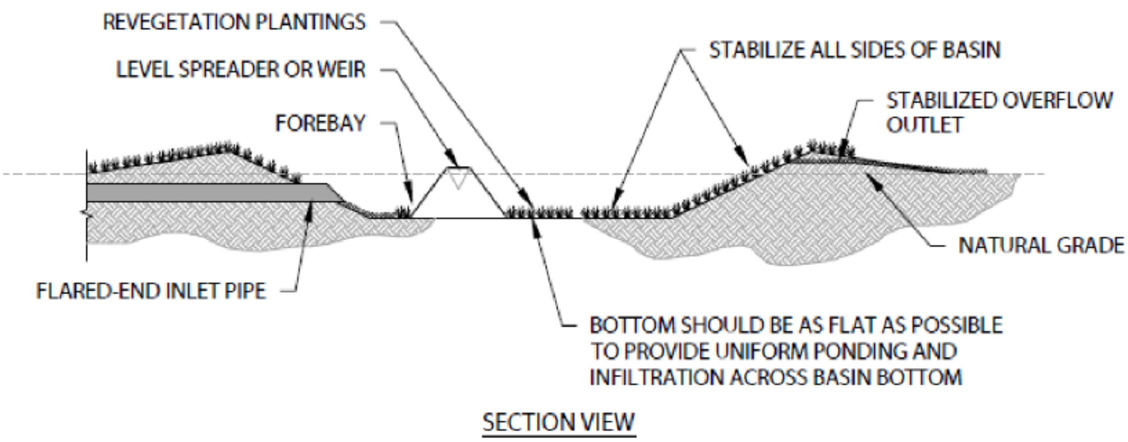
INFILTRATION BASINS

An infiltration basin is a shallow impoundment that is designed to infiltrate storm water. Infiltration basins, while similar in design to detention basins, do not include an outlet structure that is designed to slowly draw down and discharge the stored runoff. Infiltration basins designed as on-line facilities include a high-flow bypass or emergency spillway. Infiltration basins designed as off-line facilities may not have an emergency spillway, as runoff can be designed to bypass the facility based on the elevation of the water stored in the facility.

Infiltration basin functioning during typical winter time conditions, Photo: CDM Smith



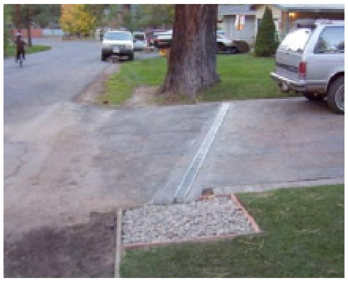
Infiltration Basin Typical Plan View, TRPA BMP Handbook, 2012



Infiltration Basin Typical Section View, TRPA BMP Handbook, 2012

DRY WELLS

A dry well is generally defined as an excavation that is deeper than it is wide, and is designed to convey non-hazardous storm water runoff to the subsurface. Dry wells can be installed to penetrate through clay, or other low-permeability soil layers, to bring the runoff into contact with more permeable underlying soils for increased infiltration. Dry wells can reduce surface runoff and flooding, recharge groundwater supplies and protect natural resources from the impacts of storm water runoff. They can be scaled to treat a wide range of flow rates and their small footprint allows for installation in space constrained locations. A schematic of a typical dry well design is provided in Figure 1.



Slotted drain discharging to dry well
Photo Source: Placer County Low Impact Development Guidebook

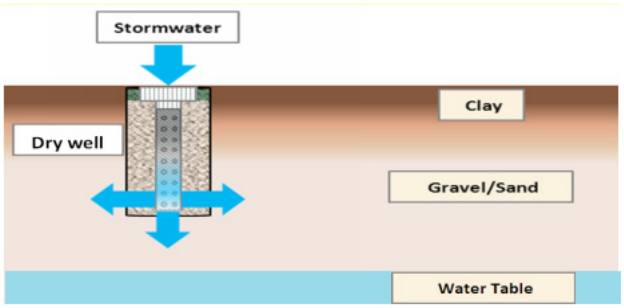


Figure 1. Typical Dry Well Schematic
Source: California Environmental Protection Agency, 2014

Due to their increased infiltration capacity, dry wells also have potential to contaminate groundwater if pollutants are allowed to enter them. For this reason, dry wells should never be installed in areas when there is potential for hazardous materials spills. Additionally, the maximum depth of a dry well should be a minimum of 10 feet above the seasonal high groundwater elevation. To prevent clogging and reduce the spread of pollutants, storm water runoff should also be pre-treated to remove sediment prior to entering a dry well.

REGULATORY INFORMATION

Dry wells receiving runoff from anything other than single-family homes must comply with the U.S. Environmental Protection Agency Underground Injection Control (UIC) regulations available at: https://www.epa.gov/uic/federal-requirements-class-v-wells

In California, Regional Water Quality Control Boards have the discretion to issue waste discharge requirements for dry wells to protect the beneficial uses of the local groundwater resources.

County environmental management departments should be consulted for additional permitting requirements prior to installing any dry well.

SUBSURFACE INFILTRATION FACILITIES

Fact Sheet SDM-3

INFILTRATION TRENCHES

Infiltration trenches are open-bottomed linear facilities that are often installed along roof driplines, or the edges of driveways, roadways, and parking lots. Their geometry promotes runoff entering via sheetflow but drain inlets and piping can also be used. Perforated piping and gravel typically provides temporary storage until the runoff can infiltrate into the soils below. To prevent clogging and reduce the spread of pollutants, storm water runoff should be appropriately pre-treated prior to entering an infiltration trench.

Infiltration trenches can be scaled to manage a large range of runoff rates and volumes to match project requirements, but their locations and sizes should be determined by an appropriately qualified and licensed professional.

Examples of large and small scale infiltration trenches are shown in the photos to the right. A schematic of a typical infiltration trench is provided in Figure 2.

Larger scale infiltration trench sized to receive roadway runoff
Photo: City of South Lake Tahoe, CA

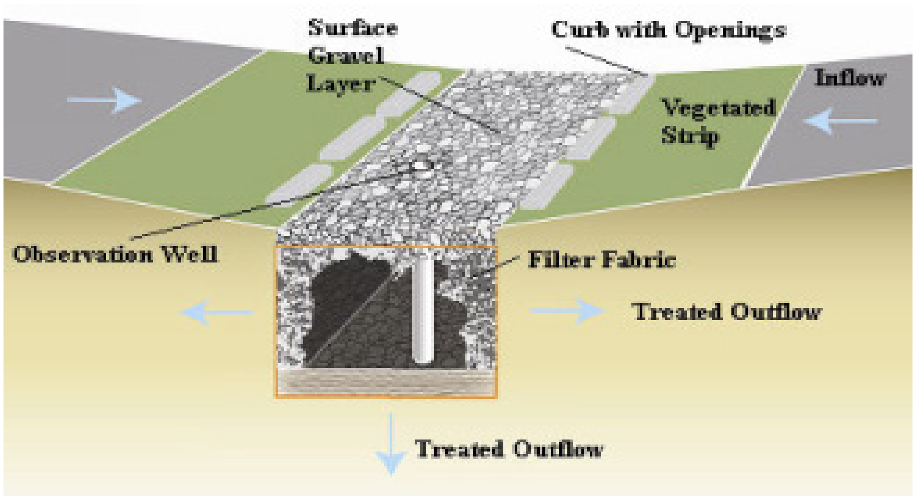


Figure 2. Typical Infiltration Trench Schematic
Source: Caltrans, 2010

An infiltration trench follows the topography to carry roof runoff safely away from the building on a multifamily residential site.
Photo: TRCA, 2010

INFILTRATION GALLERIES

Infiltration galleries typically consist of a larger scale underground structures that can include multiple rows of perforated piping, or other proprietary products to provide high storage volumes. Their design and function is similar to infiltration trenches, except infiltration galleries usually have a larger footprint and therefore greater infiltration capabilities. With proper design, infiltration galleries can be installed under impervious surfaces or near outfall locations at sites where space is limited and large volume reduction is needed. They are best suited to receive storm water discharges from larger catchments such as large driveways, roadways, parking lots, or buildings.

Large infiltration gallery consisting of perforated pipe embedded in gravel.
Photo Source: City of South Lake Tahoe, CA

SUBSURFACE INFILTRATION FACILITIES

Fact Sheet SDM-3

A schematic of a typical infiltration gallery is provided in Figure 3.

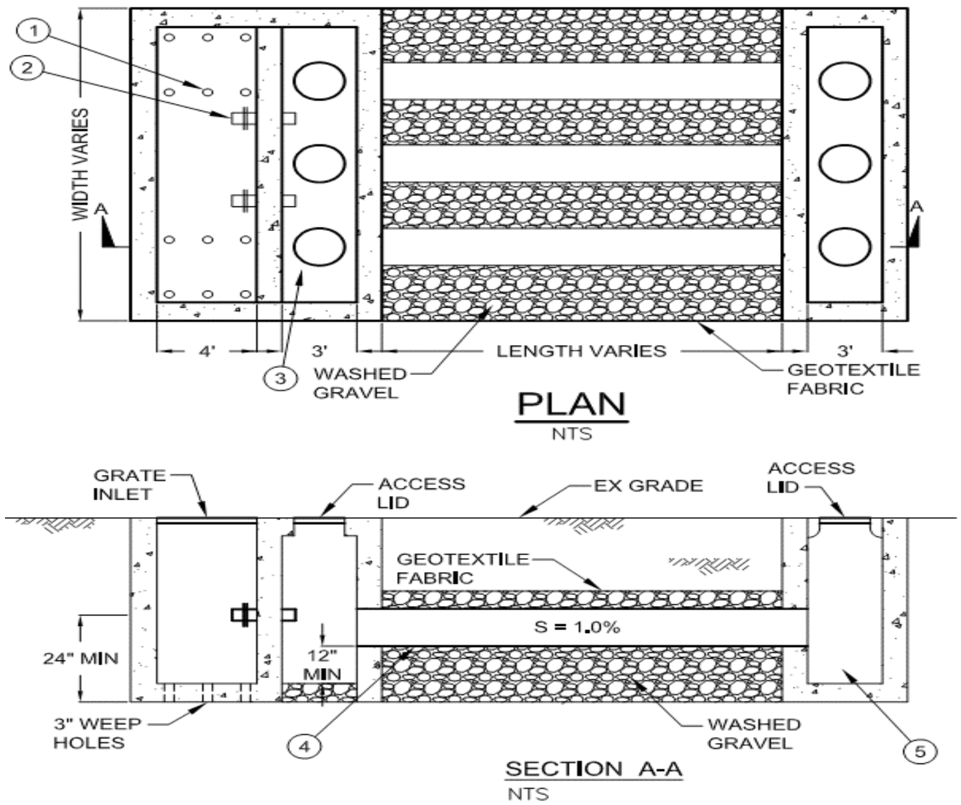


Figure 3. Typical Infiltration Gallery Schematic
Source: CDM Smith

NOTES:

1. SEDIMENTATION CHAMBER WITH OPTIONAL GRATED INLET AND 3” WEEP HOLES TO DRAIN STANDING WATER.
2. INLET PIPE WITH ORIFICE SIZED TO CONVEY PEAK FLOW RATE FROM DESIGN STORM. 6” MIN PIPE SIZE.
3. INLET CHAMBER WITH ACCESS LIDS AND GRAVEL BOTTOM.
4. PERFORATED PIPE (12” MIN) ENCASED IN WASHED GRAVEL BED. PIPE SLOPED TO INLET CHAMBER.
5. MAINTENANCE CHAMBER WITH ACCESS LIDS.

KEY DESIGN FEATURES

- The impervious area tributary to each infiltration basin must not exceed 5,000 square feet.
- Infiltration is not appropriate on fill sites or steep slopes (greater than 15%) unless the site has been evaluated and approved by an appropriately licensed and qualified professions.
- Appropriate design infiltration rates range from 0.5 in/hr minimum to 2.4 in/hr maximum.
- Water quality volume (design storm) must be infiltrated within 48 hours.
- Barriers or cutoff walls may be required when infiltrating adjacent to paved surfaces to prevent undermining of pavement and baserock.
- Infiltration systems should be sited at least 20 ft. away from building foundations.
- A minimum 5 ft. vertical separation, is required between the bottom of the infiltration facility and groundwater.
- Infiltration trenches installed on slopes greater than 3 percent require baffles, headers, or terraces to provide a level bottom for uniform infiltration. The longitudinal slope of the infiltration trench should not exceed 3%.

- Water barriers such as geomembrane or clay liners may be required when siting adjacent to utilities or structures.
- Filter fabric may be installed around the sides of subsurface infiltration systems to prevent soil intrusion into the crushed rock or gravel layer. Do not install fabric over the floor of the infiltration facility.
- Vegetation or other appropriate method of soil stabilization must be utilized on bare soils in and around infiltration basins.
- Overflow and/or high flow bypass systems must be incorporated into the design of all subsurface infiltration systems.
- Appropriate energy dissipation devices (flared end sections, rock aprons, etc.) should be used at conveyance outlets.
- Pretreatment is highly recommended to prevent the spread of pollution and prolong operational life. Pretreament is required on all non-residential projects. Pretreatment may consist of sediment traps, vegetated swales, vegetated filter strips, and/or bioretention depending on site characteristics and sediment loading rates.
- Infiltration is not appropriate at industrial sites or locations where spills can occur without pretreatment.
- Crushed rock or gravel media should be thoroughly washed prior to installation to remove fines that may result in clogging and failure.
- Perforated pipe may be installed within the gravel storage layers to provide extra void space and convey runoff horizontally and/or vertically.
- For highly compacted or low permeability soil conditions, soils underlying infiltration trenches or galleries may be over-excavated, amended by mixing in 15 to 30 percent coarse sand, and replaced uniformly without compaction.
- Upstream drainage area must be completely stabilized prior to bringing facility online.
- Maintenance cleanouts and inspection ports should be provided.
- Pipe perforation patterns should conform to applicable AASHTO specifications.
- When using a basin for residential snow storage, as well as storm water, minimum snow storage requirements, as outlined in Section 18.30.130 of the Town Development Code shall apply as follows:
  - In areas with a snow load less than 200 pounds per square foot, the required snow storage area shall equal at least 50 percent of the total parking and driveway area.
  - In areas with a snow load greater than 200 pounds per square foot, the required snow storage area shall equal at least 75 percent of the total parking and driveway area.

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Construction Storm Water Quality Plan (SWQP) template should be used to calculate the retention volume (V_{ret}) associated with subsurface infiltration. For Regulated Projects, the template uses the retention volume to calculate the area of impervious surface treated, and determine if additional control are necessary to capture the 85th percentile, 24-hour design storm. The equation for determining V_{ret} is as follows:

$$\mathbf{V_{ret} = V_{total}}$$

Where:

V_{ret} = storm water retention volume (ft^3); and

V_{total} = total volume of subsurface infiltration facility (ft^3).

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for all non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

- Inspect inflow and outflow points and remove debris to maintain unobstructed flow.
- Inspect pre-treatment sediment traps and remove accumulated sediment and other materials as needed.
- Inspect for standing water at least annually, or more frequently under high sediment loading conditions. Clogged soils may require excavation and replacement to reinstate design infiltration rates.

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BIORETENTION FACILITIES

Fact Sheet TR-1

Bioretention facilities, also known as rain gardens and storm water planters, are planted depressions that slow, treat, and infiltrate storm water to improve water quality and manage hydromodification. They can be located in a variety of settings such as along roadsides or incorporated into a site's landscaping but should be designed by a qualified professional. Bioretention facilities receive runoff from roofs and other impervious surfaces and provide treatment through settling, filtration, and biological processes as storm water ponds and percolates through planting soil media and into a subsurface gravel storage bed. Runoff volume is reduced by evapotranspiration and, if conditions are suitable, by infiltration into the underlying soils and groundwater. Bioretention facilities are effective at removing a variety of pollutants including trash, sediment, metals, nutrients, bacteria and hydrocarbons. Bioretention facilities are usually designed to allow shallow ponding, with an overflow outlet to prevent flooding during heavy storms. The overflow can be directed to a storm drain system or to another BMP.

Roadside bioretention. Source: sitephocus.com

Two general types of bioretention facilities are allowable in the Permit including infiltrating bioretention and flow-through planters. Flow-through planters are used in locations not suitable for infiltration and include impermeable liners and an underdrain pipe to collect the treated water and discharge it to the municipal storm drain or other appropriate location.

KEY DESIGN FEATURES

The design of bioretention facilities involves many considerations and planning activities should be started at the earliest possible stage of a project. It is critical that the facilities achieve the required performance standards while also protecting public health and safety, infrastructure and property. Bioretention design should begin during the site assessment and layout phase when determining building and parking locations and footprints and before the site grading plan is prepared. For infiltration type planters, consult a licensed geotechnical engineer about site suitability.

The key design features and considerations for bioretention facilities include the following:

1. Topography: In appropriate conditions and with careful design, bioretention facilities can be located on slopes by incorporating check dams, terracing, or other methods to pond the water. Infiltration on slopes can create, or increase, the potential for downgradient seepage, landslides, and other geotechnical hazards.

2. Adjacent structures: Where bioretention facilities are located next to structures such as curb and gutter, sidewalks, buildings, additional structural support may be required between the adjacent road or parking surface and bioretention soil media. Vertical cutoff walls or impervious liners should be considered to keep storm water from migrating into structural fill or road base materials. In expansive (C, D) soils, locate storm water planters far enough from structures to avoid damage to foundations (as determined by a structural or geotechnical engineer). 10 feet typical.

   Subsurface utilities should not be located within the bioretention facility and utility trenches should be isolated from the infiltrating areas to prevent the formation of preferential flow paths along trenches, migration of backfill materials, and flooding of utility vaults.

3. Inlet design: Inlets can include a variety of structures and configurations including curb cuts, open channels, and pipes. The design must provide the width and geometry needed to direct flows into the facility and its elevation must provide adequate hydraulic head for filtration and storage volume. To prevent storm water runoff from eroding the soil surface as it enters the facility, a concrete splash pad or rock energy dissipater (3”-5” -size rounded rock, 6” depth) should be placed at the inlets.

LID vegetated swale parking lot. Shellito Indoor Pool, Roseville. Photo: Greg Bates

4. Overflow: Provisions to bypass flows that exceed the design ponding depth must be included in bioretention designs. Overflow systems should be located near the entrance of the bioretention facility to prevent scouring of the system and mobilization of the mulch layer. Overflow provisions shall not impact structures. Overflow structures may consist of a raised overflow structure connected via pipe to an approved discharge point, or a surface conveyance route (e.g., curb cuts, open channel, or pipe). Overflow structures must be sized to convey peak flood flows, per Town of Truckee engineering requirements, and include provisions for clogging. Elevations must be set to provide storage of the required water quality volume.

5. Surface ponding: A minimum design depth of 6 inches is required for surface ponding to provide additional storm water storage capacity, with a maximum depth of 12 inches. Ensure that the design does not allow ponding to persist for longer than 72 hours for vector control.

6. Aggregate layer: A minimum 12-inch thick layer of ¾-inch washed aggregate below the planting media increases the facility’s water storage capacity and promotes positive drainage through the underdrain system. A 3-inch layer of smaller aggregate (washed pea gravel) between the planting media and ¾-inch aggregate layer can omit the need for filter fabric, which is known to cause clogging.

7. Bioretention soil media: A minimum 18-inch thick mixture of 60-70 percent sand meeting the specifications of the American Society for Testing and Materials (ASTM) C33 and 30-40 percent compost may be used to provide filtration of runoff while supporting healthy plant growth. It may be possible in some cases to use native soil or to amend the native soil so that it is suitable. Use of native soil will depend on the evaluation of the criteria in “Section 3 - Site Assessment” as well as consideration of structural needs and may require evaluation by a licensed Geotechnical Engineer.

8. Mulch: If the area will be mulched, initial excavation depth must anticipate the total combined media depth, to avoid having to reduce soil depth during construction to accommodate mulch at final grades. If mulch is used as a top dressing avoid wood chips or other material that will float and potentially clog overflow structures. Mulch should not be installed just before or during the rainy season.

9. Underdrain: An underdrain system should be included with the discharge elevation at the top of the aggregate layer to convey runoff not infiltrated into the native soil to the storm water system or other appropriate discharge point. The underdrain may be eliminated in areas of high groundwater, rapidly infiltrating soils or where connection of the underdrain to a surface discharge point or to a subsurface storm drain are infeasible.

The perforations in the underdrain must be directed down or else water flowing through the planting media into the gravel layer will immediately be collected and discharged through the underdrain. Maintenance access and cleanout ports should be provided so that underdrain system can be routinely inspected and cleaned as needed.

10. Liners: Facilities with documented high concentrations of pollutants in underlying soil or groundwater, facilities located where infiltration could contribute to a geotechnical hazard, and facilities located on elevated plazas or other structures may incorporate in impervious liner and may locate the underdrain discharge at the bottom of the subsurface aggregate layer.

11. Plants: A list of recommended plant species recommended is provided in the table below. Use a variety of trees, shrubs and herbaceous plant materials. Native grass meadows are especially effective at controlling and treating storm water over a large area. Choose moisture-tolerant plants for the bottom of a bioretention swale or basin. Choose plants that can tolerate both fluctuating water conditions and drought conditions for the side edges.

12. Pre-treatment: Runoff from industrial sites or locations where spills may occur or areas with excessive erosion or sediment sources should be pre-treated to address pollutants of concern prior to discharging into bioretention systems.

13. Underlying soils: Soils beneath the facility must be protected from compaction during construction activities. If soils have been compacted previously they should be ripped as deeply as necessary to loosen the soils and re-establish natural infiltration rates.

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Constructon Storm Water Quality Plan (SWQP) Form 3-2 should be used to calculate the Water Quality Volume (WQV) of bioretention facilities. This value is then used to iteratively determine the necessary bioretention area sizing to capture the remainder of the 85th percentile, 24-hour design storm not retained by Site Design Measures. The equation for determining the WQV is as follows:

$$\textbf{WQV} = \textbf{Unit WQV} * A_{imp} * R_C$$

Where:

WQV = Water Quality Volume (ft^3);
Unit WQV = design storm based on elevation and drawdown time;
A_{imp} = impervious drainage area untreated by Site Design Measures (ft^2); and
R_C = Runoff Coefficient (default 0.9).

Sites with documented high concentrations of pollutants in underlying soil or groundwater, sites located where infiltration could contribute to a geotechnical hazard, and sites located on elevated plazas or other structures may incorporate an impervious liner and may locate the underdrain discharge at the bottom of the gravel layer to create a “Flow-Through Planter.” These Flow-Through Planters must be sized according to Water Quality Flow (WQF) using Form 3-3 of the SWQP. The equation for determining the WQF for Flow-Through Planters is as follows:

$$\textbf{WQF} = A_{imp} * P_F / 43{,}200$$

Where:

WQF = Water Quality Flow (cfs);
A_{imp} = impervious drainage area untreated by Site Design Measures (ft^2); and
P_F = flow based design storm intensity (0.2 inch/hr).

Plant Selection Guidance for Low Impact Development Features in the Placer County Sierra Nevada

PLANTS[1]			Drought & Inundation Tolerance[2]			Defensible Space Considerations[3]	Origin	
Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native
Acer circinatum	Vine Maple	wet to moderately wet, shade to part sun, accent, California native	◐	●	●	◐		●
Acer ginnala	Amur Maple	moderately wet, sun to part shade	◐	●	●	Unknown		●
Acer glabrum	Rocky Mountain Maple	wet to moderately wet, part shade	◐	●	○	Unknown	●	
Alnus tenuifolia	Mountain Alder	wet, sun to part shade	●	●	○	◐	●	
Amelanchier alnifolia	Western Serviceberry	moderately wet to dry, sun to part shade	●	●	○	Unknown	●	
Arctostaphylos patula	Greenleaf Manzanita	dry, sun, rarely available	◐	○	○	●	●	
Artemisia tridentata	Sagebrush	dry, sun	○	○	○	●	●	
Betula occidentalis	Western River Birch	wet to moderately wet, sun to part shade	●	●	●	◐	●	
Ceanothus cordulatus	Mountain Whitethorn	moderately wet to dry, pale yellow sun to part shade	○	○	○	●	●	
Chrysolepis sempervirens	Chinquapin	moderately wet to dry, sun	○	○	○	●	●	
Chrysothamnus nauseosus	Rabbitbrush	dry, sun	○	○	○	●	●	
Cornus sericea	Redstem Dogwood	wet to moderately wet, sun to part shade	●	●	●	○	●	
Holodiscus discolor	Creambush	moderately wet to dry, white sun to part shade	◐	●	○	Unknown	●	
Lonicera involucrata	Twinberry	wet to moderately wet, part shade	●	●	○	Unknown	●	
Lonicera tatarica	Tatarian Honeysuckle	wet to moderately wet, full sun to part shade, poisonous berries	◐	●	●	Unknown		●
Physocarpus capitatus	Ninebark	wet to moderately wet, sun to part shade	◐	●	●	Unknown		●
Pinus mugo mugo	Dwarf Mugo Pine	moderately wet to dry, sun to part shade	◐	●	●	●		●
Potentilla fruticosa	Shrubby Cinquefoil	wet to moderately wet, sun to part shade, many cultivars	◐	●	●	Unknown	●	
Prunus cistena	Western Sandcherry	moderately wet, sun to part shade, unsuitable for upper elevation snow loads	◐	●	●	◐		●

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Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native
Prunus emarginata	Bittercherry	moderately wet, sun to part shade	●	○	○	Unknown	●	
Prunus virginiana var. demissa	Western Chokecherry	moderately wet, sun to part shade	●	●	○	Unknown	●	
Purshia tridentata	Bitterbrush	dry, sun	○	○	○	●	●	
Quercus vaccinifolia	Huckleberry Oak	moderately wet to dry, sun	○	○	○	●	●	
Rhamnus rubra	Sierra Coffeeberry	moderately wet to dry, sun	○	○	○	Unknown	●	
Rhus trilobata	Skunkbrush Sumac	moderately wet to dry, sun to part shade	○	○	○	Unknown		●
Ribes alpinum	Alpine Currant	wet to moderately wet, sun to part shade	●	●	●	◐	●	
Ribes aureum	Golden Currant	moderately wet to dry, sun to part shade	◐	●	●	Unknown		●
Ribes cereum	Wax Currant	moderately wet to dry, sun	◐	○	○	Unknown		●
Ribes nevadense	Sierra Currant (Mountain Pink Currant)	wet to moderately wet, sun part shade	●	●	○	Unknown	●	
Ribes roezlii	Sierra Gooseberry	moderately wet to dry, sun to part shade	◐	○	○	Unknown	●	
Ribes viscosissimum	Sticky Currant	moderately wet to dry, sun	◐	○	○	Unknown	●	
Rosa rubrifolia	Redleaf Rose	moderately wet, sun to part shade	◐	●	○	Unknown		●
Rosa rugosa	Tomatoe Rose	moderately wet, sun to part shade, accent	◐	●	○	◐		●
Rosa woodsii	Wood's Rose	moderately wet, pink sun to part shade	●	○	○	Unknown	●	
Salix exigua	Narrow-leaved Willow	wet, sun to part shade, SEZ, invasive	●	●	○	○	●	
Salix geyeriana	Geyer's Willow	wet, sun to part shade, SEZ	●	●	○	○	●	
Salix lemmonii	Lemmon's Willow	wet, sun to part shade, SEZ	●	●	○	○	●	
Salix purpurea 'nana'	Dwarf Arctic Willow	wet to moderately wet, sun to part shade	◐	●	●	◐		●
Salix scouleriana	Scouler's Willow	wet to moderately wet, sun to part shade	●	●	○	◐	●	
Sambucus cerulea mexicana	Blue Elderberry	wet to dry, sun to part shade	◐	○	○	Unknown	●	
Sambucus racemosa	Red Elderberry	wet to moderately wet, sun to part shade	◐	○	○	Unknown	●	
Sorbus californica	Mountain Ash	wet to moderately wet, part shade, rarely available	●	●	●	Unknown	●	

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Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native
Spiraea densiflora	Mountain Spirea	wet to moderately wet, sun to part shade	●	●	○	Unknown	●	
Spiraea spp.	Spirea species - Snowmound, Goldflame, etc	wet to moderately wet, sun to part shade, many varieties	◐	●	●	Unknown		●
Symphoricarpos albus var. laevigat	Snowberry	wet to moderately wet, sun to part shade	◐	●	○	Unknown		●
Syringa spp	Lilac Hybrids	moderately wet, sun to part shade, accent, many cultivars	◐	●	●	◐		
Syringa vulgaris	Common Lilac	moderately wet, sun to part shade, accent	◐	●	●	◐		●
Viburnum spp.	Viburnum species	moderately wet, sun to part shade, many species and cultivars	◐	●	●	Unknown		●
Aconintum napellus	Monkshood	wet to moderately wet, part shade	●	●	○	○		●
Aconitum columbianum	Columbian Monkshood	wet to moderately wet, part shade	●	●	●	○	●	
Aquilegia formosa	Crimson/Western Columbine	wet to moderately wet, sun to part shade	●	●	○	○	●	
Aquilegia spp.	Columbine	moderately wet, sun to part shade, many cultivars	●	●	●	○		
Arnica chamissonis ssp. foliosa	Arnica	moderately wet, sun	●	●	○	○	●	
Aster occidentalis	Western Mountain Aster	wet to moderately wet, sun to part shade	●	●	○	○		
Aster species	Aster	wet to moderately wet, sun to part shade, many cultivars	◐	●	●	○	●	●
Astilbe chinensis	Meadowsweet	moderately wet, shade to part shade, accent	○	●	●	○		●
Balsamorhiza sagittata	Arrowleaf Balsam Root	moderately wet to dry, sun to part shade	●	●	○	○	●	
Delphinium glaucum	Mountain Larkspur	wet to moderately wet, sun to part shade	●	●	○	○	●	
Delphinium spp.	Larkspur/Delphinium	wet to moderately wet, sun to part shade, many cultivars, accent	◐	●	●	○		●
Dianthus spp.	Sweet William, Pinks	moderately wet sun to part shade	◐	●	●	○		●
Dicentra spp.	Bleeding Heart	moderately wet, shade, accent	○	●	●	○	●	

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Digitalis spp.	Foxglove	moderately wet, sun to part shade, accent	◐	●	○	○		●
Echinacea purpurea	Purple Coneflower	moderately wet to dry, sun, accent	◐	●	○	○ I ◐		●
Epilobium angustifolium	Fireweed	wet to moderately wet, sun to part shade	●	●	○	○	●	
Epilobium canum spp latifolium	California Fuchsia	moderately wet to dry, sun	○	○	○	○	●	
Eriogonum umbellatum	Sulphur-Flower Buckwheat	sun, dry	○	○	○	○	●	●
Eschscholzia californica	California Poppy	moderately wet to dry, sun to part shade, annual	○	●	○	○	●	
Gaillardia spp.	Blanket Flower	moderately wet to dry, sun to part shade	○	●	○	○		●
Geranium richardsonii	Richardson's Cranesbill	wet to moderately wet, part shade	◐	●	●	○	●	
Geranium spp.	Hardy/Cranesbill Geranium	wet to dry, sun to part shade	●	●	○	○		●
Gilia agregata	Scarlet Gilia	moderately wet to dry, sun to part shade	○	○	○	○		●
Hemerocallis spp.	Daylily species	moderately wet, sun to part shade, many cultivars, accent	○	●	●	○		●
Hemerocallis 'Stella D'Oro'	Stella D'Oro Daylily	yellow sun to part shade, 12?14'	◐	●	●	○		●
Heracleum lanatum	Cow Parsnip	wet to moderately wet, sun to part shade	●	●	○	○	●	
Heuchera species	Coral Bells, Alumroot	wet to moderately wet, shade to part shade	◐	●	●	○		●
Iberis sempervirens	Candytuft	moderately wet to dry, sun, accent	◐	●	○	Unknown		●
Iris missouriensis	Western Blue Flag Iris	wet to moderately wet, sun to part shade	●	●	○	○	●	
Iris spp.	Bearded Iris, Siberian Iris,	wet to dry, sun to part shade, many cultivars, accent	◐	●	●	○		●
Lavandula angustifolia	English Lavander	dry, sun	◐	●	○	○		●
Leucanthemum x superbum	Shasta Daisy	moderately wet to dry, sun to part shade	●	●	○	○		●
Ligularia stenocephala	Ligularia 'The Rocket'	wet to moderately wet, shade, accent	○	●	●	○		●
Lilium pardalinum	Leopard Lily	wet, sun to part shade	●	●	○	○	●	

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Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native
Lilium parvum	Alpine Lily	wet to moderately wet, sun to part shade	●	●	○	○	●	
Lilium spp	Asiatic, Ornmental Hybrid Lily	wet to moderately wet, sun to part shade, many cultivars, accent	◐	●	●	○		●
Linum lewisii	Mountain Blue Flax	moderately wet to dry, sun	●	○	○	○	●	
Lupinus breweri	Brewer's Lupine	dry, sun	◐	○	○	○	●	
Lupinus polyphyllus	Large-leaved Lupine	wet to medium, sun to part shade	●	●	○	○	●	
Lupinus spp.	Lupine	moderately wet to dry, many species and cultivars, accent	◐	●	●	○		●
Mimulus guttatus	Yellow Monkeyflower	wet to moderately wet, shade to sun	●	●	○	○	●	
Mimulus lewisii	Lewis' Monkeyflower	wet to moderately wet, shade to part shade	◐	●	○	○		●
Monarda didyma	Bee Balm	moderately wet, part shade	◐	●	●	○		●
Monardella odoratissima	Mountain Pennyroyal	dry, sun	○	○	○	○	●	
Paeonia spp.	Peony	wet to moderately wet, sun to part shade, many cultivars, accent	◐	●	●	○		●
Papaver oriental	Oriental Poppy	moderately wet to dry, sun to part shade, accent	◐	●	○	○		●
Penstemon azureus	Azure Penstemon	moderately wet, sun	●	○	○	○	●	
Penstemon heterodoxus	Whorled Penstemon	moderately wet to dry, sun to part shade	●	●	○	○	●	
Penstemon newberryi	Mountain Pride Penstemon	moderately wet to dry, sun to part shade	○	○	○	○	●	
Penstemon rydbergii	Meadow Penstemon	wet to moderately wet, sun to part shade	●	●	○	○	●	
Penstemon strictus	Rocky Mountain Penstemon	moderately wet to dry, sun to part shade	◐	●	○	○		●
Phlox paniculata	Garden Phlox	moderately wet to dry, sun to part shade	◐	●	○	○		●
Polemonium occidentale	Jacob's Ladder	wet to moderately wet, shade to part shade	●	●	○	○		●
Potentilla glandulosa	Sticky Cinquefoil	wet to moderately wet, sun to part shade	◐	●	○	◐	●	

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Potentilla gracilis var. fastigiata	Graceful Cinquefoil	wet to moderately wet, part shade	●	●	○	○	●	
Rubus parviflorus	Thimbleberry	wet to moderately wet, sun to part shade	●	●	○	○	●	
Solidago canadensis	Canada Goldenrod	moderately wet, sun	◐	○	○	○		●
Stachys byzantia	Lamb's Ear	moderately wet to dry, sun to part shade, groundcover type habit, accent	●	○	○	○		●
Abies concolor	White Fir	moderately wet, sun to part shade, plant 5g or smaller	◐	●	○	●	●	
Abies magnifica	Red Fir	moderately wet, shade to sun, slow growing	◐	●	○	●	●	
Acer ginnala	Amur Maple	moderately wet, sun to part shade, shrub habit ⍰ prune to multi-stemmed tree	◐	●	●	Unknown		●
Betula occidentalis fonanalis	Western River Birch	wet to moderately wet, sun to part shade, shrub habit ⍰ prune to multi-stemmed tree, plant from high elevation seed source	●	●	○	○	●	
Calocedrus decurrens	California Incense Cedar	moderately wet to dry, sun to part shade	○	●	○	●	●	
Crataegus spp.	Hawthorn	moderately wet, sun to part shade, many cultivars, accent	◐	●	●	Unknown		●
Juniperus occidentalis var. occident	Western Juniper	dry, sun, slow growing	○	●	○	●	●	
Malus spp.	Crabapple species	moderately wet, sun to part shade, many cultivars, accent	◐	●	○	Unknown		●
Pinus contorta var. murrayana	Lodgepole Pine	wet to dry, sun to part shade	●	●	●	●	●	
Pinus jeffreyi	Jeffrey Pine	moderately wet to dry, sun to part shade	●	●	○	●	●	
Pinus lambertiana	Sugar Pine	moderately wet, generally	◐	●	○	●	●	
Pinus ponderosa	Ponderosa Pine	moderately wet to dry, sun to part shade	◐	●	○	●	●	
Populus tremuloides	Quaking Aspen	wet to moderately wet, sun to part shade, SEZ, invasive roots	◐	●	●	○	●	
Populus trichocarpa	Black Cottonwood	wet, sun to part shade SEZ, invasive roots	●	●	●	Unknown	●	

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Salix scouleriana	Scouler's Willow	wet to moderately wet, sun/part shade, prune to multi-stemmed tree	◐	●	○	○	●	
Sequoiadendron giganteum	Giant Sequoia	moderately wet, sun to part shade, California Native	○	●	○	Unknown		●
Sorbus aucuparia	European Mountain Ash	moderately wet, sun to part shade, accent , protect from Sap Suckers	◐	●	●	○		●
Aegopodium podagraria 'variegatu	Bishop's Weed	wet to moderately wet, shade to part shade, aggressive	◐	●	●	○	●	
Arctostphyllos nevadensis	Pinemat Manzanita	dry, sun, rarely available	○	○	○	●		
Arctostphyllos uva�ursi	Bearberry Manzanita, Kinnikinnick	moderately wet to dry, sun to part shade	◐	●	○	●		●
Asperula odorata	Sweet Woodruff	wet to moderately wet, shade to part shade, fast	○	●	●	○	●	
Bergenia spp.	Bergenia	moderately wet, shade to part shade	◐	●	●	○		●
Ceanothus prostratus	Mahala Mat (Squaw Carpet)	moderately wet to dry, sun to part shade	○	○	○	Unknown	●	
Cotoneaser dammeri	cultivars 'Eicholz', 'Coralberry', 'Bearberry'	moderately wet to dry, sun to part shade	○	●	●	Unknown	●	
Dianthus spp.	Creeping Pinks	moderately wet, sun to part shade	◐	●	●	○		●
Erigeron coulteri	Coulter's Daisy	wet to moderately wet, sun	●	●	○	○	●	
Eriongonum umbellulatum	Sulphur-Flower Buckwheat	dry, sun	○	○	○	Unknown	●	
Fragaria vesca	Wood Strawberry	wet to moderately wet, part shade	◐	●	○	○	●	
Fragaria virginiana	Mountain Strawberry	wet to moderately wet, sun to part shade	◐	●	○	○		●
Lupinus breweri	Brewer's Lupine	dry, sun	◐	○	○	○	●	
Penstemon newberryi	Mountain Pride	moderately wet to dry, sun	○	○	○	○	●	

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Groundcovers								
Phlox subulata	Creeping Phlox	moderately wet to dry, sun	○	●	○	Unknown		●
Potentilla verna	Creeping Cinquefoil	wet to moderately wet, sun to part shade, moderate traffic tolerance	◐	●	●	○		●
Rubus parviflorus	Thimbleberry	wet to moderately wet, part shade	●	●	○	○	●	
Grasses								
Sedum spp.	Stonecrop	dry, sun	○	●	○	○		●
Symphoricarpos mollis	Creeping Snowberry	moderately wet to dry, part sun	◐	●	○	Unknown	●	
Symphoricarpos sp.	Hancock Coralberry	moderately wet to dry, part sun	◐	●	○	Unknown	●	
Thymus serpyllum	Creeping Thyme	moderately wet to dry, sun to part shade	●	●	○	○		●
Veronica prostrata	Creeping Speedwell	wet to medium, sun to part shade, moderate traffic tolerance	○	●	●	○		●
Agrostis scabra	Ticklegrass	wet to dry, sun part shade	●	●	○	○	●	
Agrostis stolonifera 'Penncross'	Creeping Bentgrass	moderately wet to wet, sun, turf	○	●	●	○		●
Bromus carinatus	Mountain/California Brome	moderately wet to dry, sun to part shade	●	○	○	○	●	
Carex athrostachya	Slender Beaked Sedge	wet to dry, sun part shade	●	●	○	○	●	
Carex nebraskensis	Nebraska Sedge	wet to dry, sun part shade	●	●	○	○	●	
Deschampsia cespitosa	Tufted Hair Grass	moderately wet to wet, sun part shade	●	●	○	○	●	
Deschampsia danthonioides	Annual Hair Grass	moderately wet to wet, sun part shade	●	●	○	○	●	
Eleocharis palustrus	Spikerush	wet to dry, sun part shade	●	●	○	○	●	
Elymus elymoides ssp.californicus	Squirreltail Grass	dry, sun	●	●	○	○	●	
Elymus glaucus	Blue Wildrye	moderately wet to wet, , sun part shade, SEZ	●	●	○	○		●
Elymus triticoides	Creeping Wildrye	moderately wet, sun part shade, competitive	●	●	○	○		●
Elytrigia intermedia	Intermediate/Pubescent	dry, sun, drought tolerant,	◐	●	○	○		●
Elytrigia intermedia 'Luna'	Luna Wheatgrass	dry, sun, drought tolerant, competitive	◐	●	●	○	●	

Plant Selection Guidance for Low Impact Development Features in the Placer County Sierra Nevada								
PLANTS[1]			Drought & Inundation Tolerance[2]			Defensible Space Considerations[3]	Origin	
Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native
Grasses								
Elytrigia intermedia 'Tegmar'	Dwarf Intermediate/Pubescent Wheatgrass	dry, sun, drought tolerant, excellent erosion control	◐	●	○	○		●
Festuca arundinacea	Tall Fescue	moderately wet, sun part shade, turf types and dwarfs, not suitable for SEZ	◐	●	?	○		●
Festuca glauca	Blue Fescue	moderately wet, sun part shade, ornamental bunch grass	◐	●	?	○		●
Festuca idahoensis	Idaho Fescue	wet to dry, sun part shade	●	●	○	○		●
Festuca ovina var. duriuscala	Hard Fescue	moderately wet to dry, sun part shade, cultivars 'Durar', 'Sierra", Scaldis'	◐	●	○	●		●
Festuca rubra	Red Fescue	moderately wet to wet, shade, turf	●	●	?	○		●
Festuca rubra ssp. comutata	Chewings Fescue	moderately wet, sun part shade, turf	?	●	?	○		●
Festuca trachyphylla	Sheep Fescue	dry, sun part shade	?	?	○	○	●	
Hordeum barachyantherum	Meadow Barley	wet to dry, sun part shade	●	●	○	○	●	
Juncus articulatus	Jointleaf Rush	wet to dry, sun part shade	●	●	○	○	●	
Juncus balticus	Baltic Rush	wet to dry, sun part shade	●	●	○	○	●	
Koeleria macrantha	Prarie Junegrass	wet to dry, sun part shade	●	●	○	○	●	
Lolium perenne	Perennial Ryegrass	moderately wet to dry, turf	●	●	○	○		●
Miscanthus sinenesis	Maiden Grass	wet to moderately wet, accent	○	●	●	○		●
Poa ampala 'Canby's'	Bluegrass, big	moderately wet to dry, sun part shade	?	?	○	○	●	
Poa ampala 'Sherman's'	Bluegrass, big	moderately wet to dry, sun part shade	?	?	○	○	●	
Poa pratensis	Kentucky Bluegrass	wet to moderately wet, sun part shade, turf	●	●	●	○	●	
Poa sandbergii	Sandberg Bluegrass	wet to dry, sun part shade	●	●	○	○		●
Pseudoroegneria spicata	Bluebunch Wheatgrass	dry, sun	?	?	○	○	●	

Plant Selection Guidance for Low Impact Development Features in the Placer County Sierra Nevada

PLANTS[1]			Drought & Inundation Tolerance[2]			Defensible Space Considerations[3]	Origin	
Scientific Name	Common Name	Optimal Site Conditions Habitat/water requirements, sun, shade, part shade, special notes	Tolerant of both Wet and Dry Periods	Better with Supplemental Irrigation	Requires Supplemental Irrigation	Fire Hazard	Native	Adapted Non-Native

Acknowledgements

We would like to acknowledge the author Robie Wilson Litchfield, ASLA Principal, Certified Green Building Professional L+P DesignWorks, Landscape Architecture + Planning for her development of this document. Special thanks also to Sarah Trebilcock, Botanist and Plant Ecologist, The Villager Nursery, Truckee, California, who reviewed this document.

Disclaimer

This list is a compilation of information based upon the author's long term experience with Sierra botany and environs beginning in the early 1970's and as a Landscape Architect in the Tahoe-Truckee region since 1990. This information is supplemented and verified by the references listed below. The author acknowledges that opinions and other lists will vary as to the appropriateness of certain plant materials for the recommended uses. As experience with emerging practices in Stormwater Management and Wildfire Management evolves, recommended uses will likely change. The information contained in this list is complete and true to the best of the author's knowledge to date. No guarantee is made as to the recommendations written herein and the author and publisher shall not be held liable in connection with the use of this information.

Legend

●	Indicates good, or yes for drought and inundation tolerance; indicates high for fire hazard
◐	Indicates fair for drought and inundation tolerance; indicates medium for fire hazard
○	Indicates poor, or no for drought and inundation tolerance; indicates low for fire hazard

Footnotes

1	*Because hardiness zones vary significantly in the Sierra, it is highly recommended that your local landscape professional or nursery be consulted to verify that chosen species are appropriate for the project area. A consulting fee may be required.*
2	*Refers to established plant material*
3	*Opinions on Fire Hazard levels will vary from fire district to fire district, this list is meant as a general guide in planning LID facilities and not as a Defensible Space guide. Consult your local fire district to verify what will be allowed in your area.*

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Micki Kelly, Kelly Biological Consulting, Truckee, California

Sarah Trebilcock, Botanist and Plant Ecologist, The Villager Nursery, Truckee, California

BIORETENTION FACILITIES

Fact Sheet TR-1

CONSTRUCTION PHASE CONSIDERATIONS

Protection and Excavation

Protecting bioretention areas during all phases of construction is a top priority. In project specifications, and during pre-bid and pre-construction meetings, communicate requirements and expectations to the contractor. From the start of construction, areas should be fenced to define limits and keep heavy equipment out. Erosion and sediment control measures should be placed so that construction sediment and wastes cannot enter the facility. Excavation activities should avoid compacting the facility base and sidewalls and should not take place during wet weather. Inlets should be blocked until construction sediment sources are removed and plants are sufficiently established to hold up to storm water flows. Plant establishment times will depend on plant species. Storm water directed away from bioretention areas during plant establishment must be managed using temporary BMPs.

Structures and Materials

Structures such as curbs, inlets, checkdams, bypass and underdrain systems and containment walls are critical to facility function. During construction, verify that the elevations of these elements match the design drawings. For example, the raised overflow structures used in bioretention facilities may look like a plan error to contractors not experienced with LID. Clearly communicating design objectives will help avoid uninformed field adjustments.

The bioretention soil mix and aggregate layers are also key components to achieving the desired performance. During pre-bid and pre-construction meetings, explain the characteristics and purpose of these materials to contractors and follow up by thoroughly reviewing construction material submittals.

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for all non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

Maintenance Indicator	Required Maintenance Activity
Is litter, excess sediment or debris present in the upstream drainage or in the bioretention facility?	Remove litter, sediment/debris. Inspect the areas upstream of the bioretention facility to make sure the tributary area is properly stabilized.
Is standing water present in the facility for longer than 72 hours after a storm?	Remove any accumulated sediment and flush drainage system including underdrain. Remove and replace top few inches of soil. Remove and replace all soil, re-grade and re-plant.
Are dead plants, weeds present?	Remove dead vegetation and replace as necessary. Pull weeds and trim excess plant growth.
Is erosion occurring within the facility or drainage system?	Repair erosion and stabilize to prevent recurrence
Are holes or voids present in the facility?	Inspect underdrain and replace soil if needed.
Are unwanted rodents or other pests present?	Implement environmentally friendly pest control practices. Do not use pesticides or herbicides in the bioretention facility.

REFERENCES

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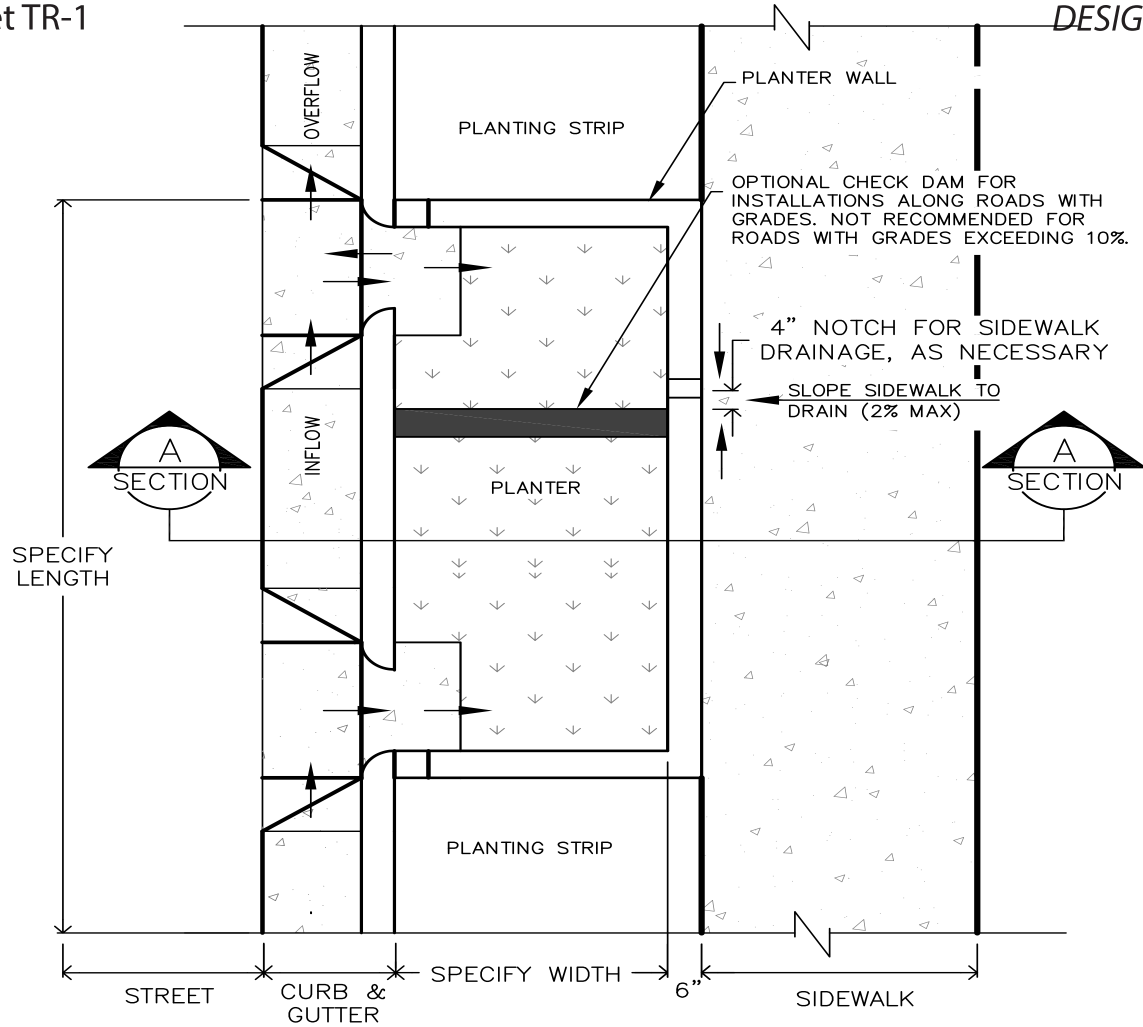
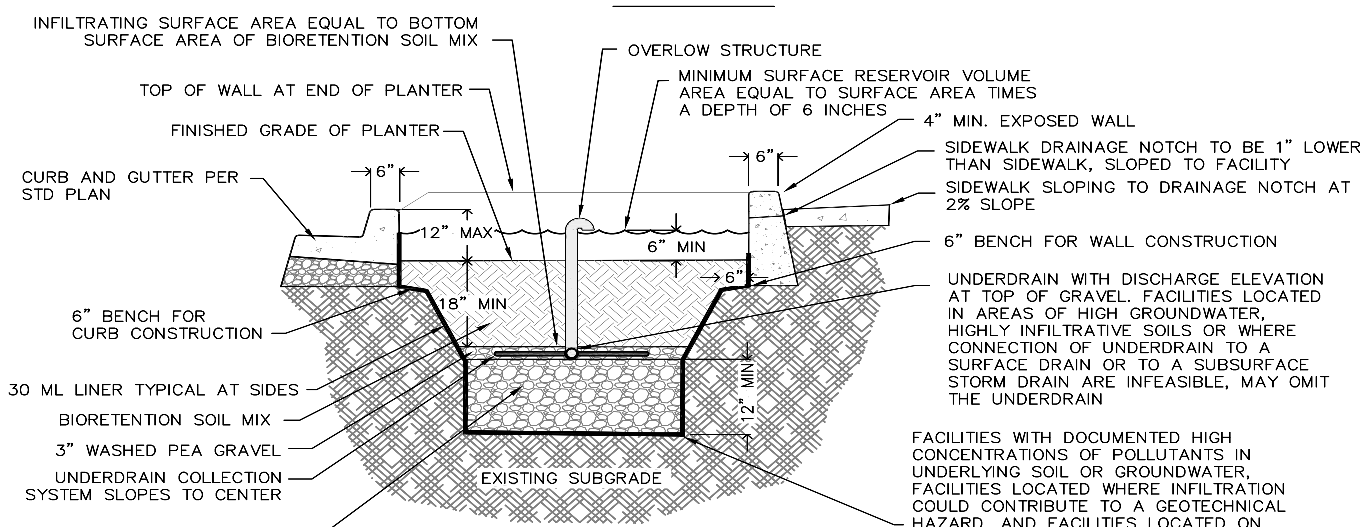


PLAN VIEW

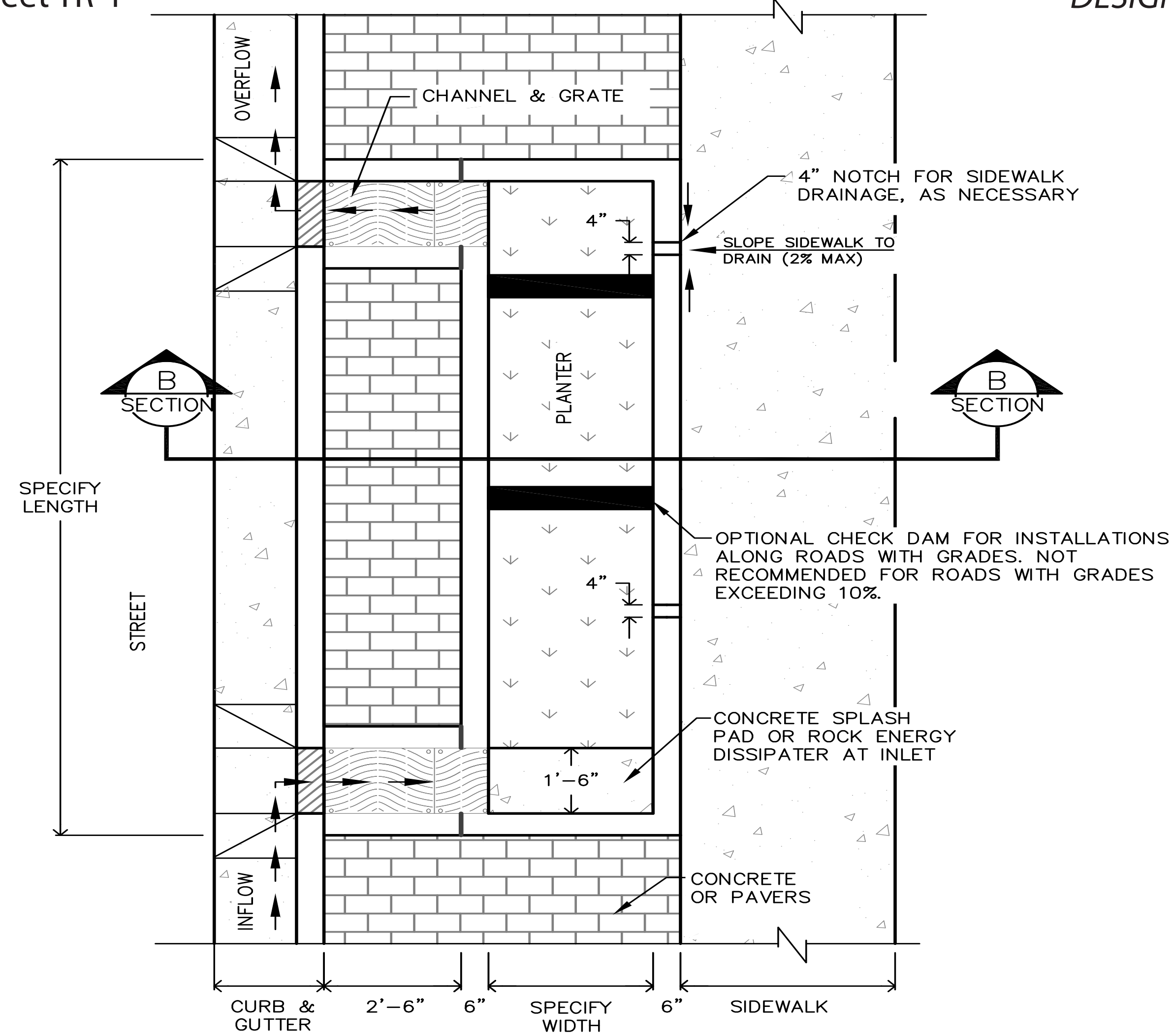


SECTION A-A

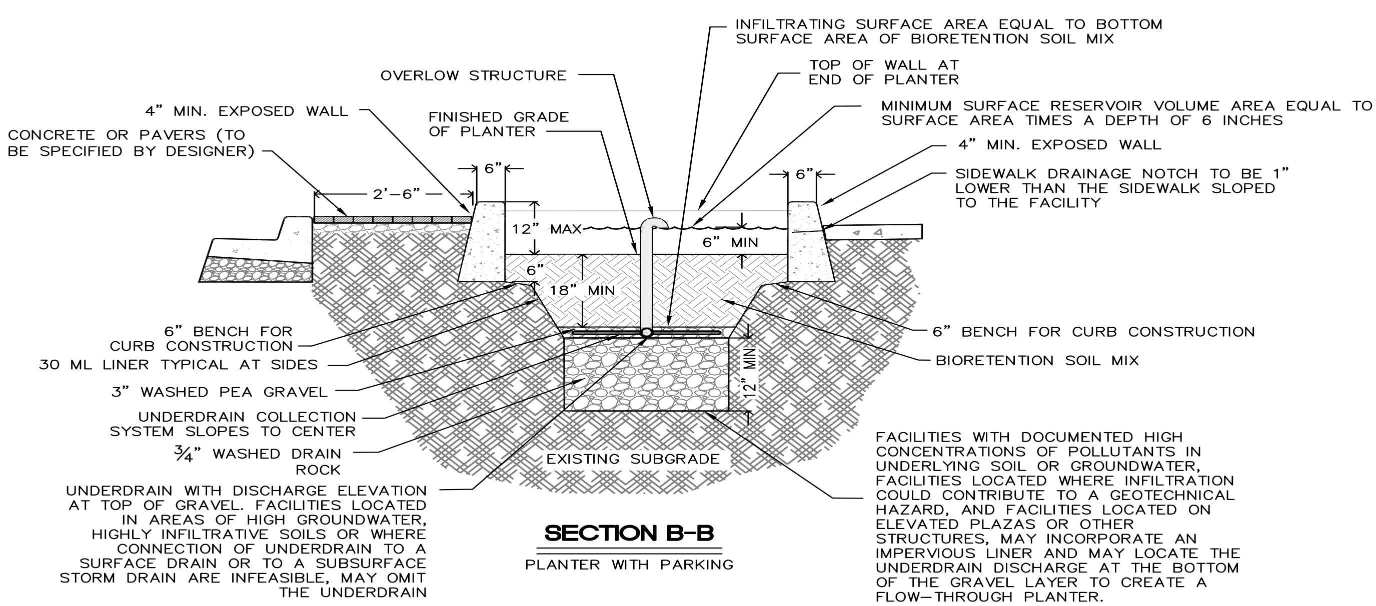
PLANTER WITHOUT PARKING

IN STREET BIORETENTION - WITHOUT PARKING
Plan & Section Views

DRAWING NOT TO SCALE
Source: Adapted from City of Salinas



PLAN VIEW

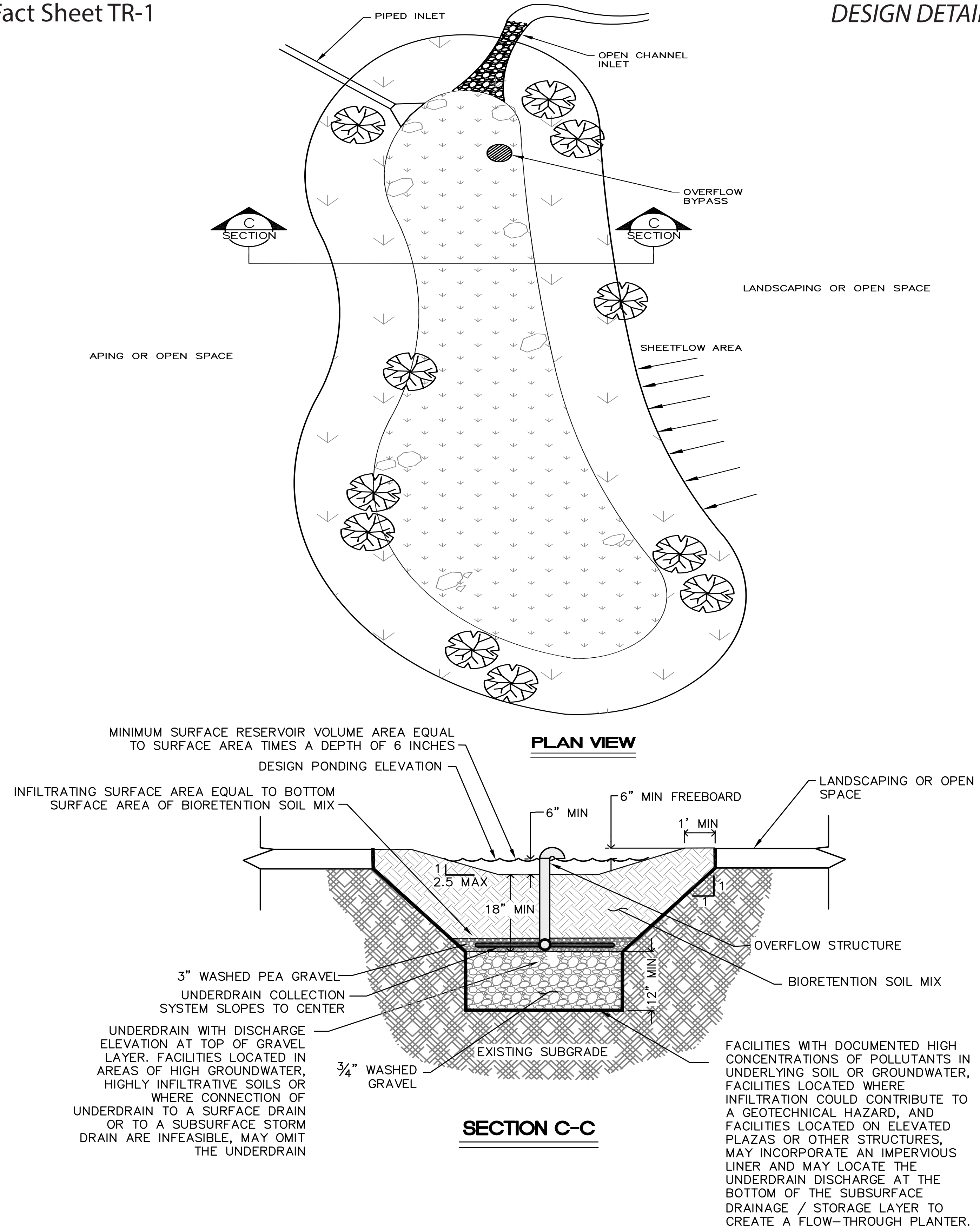


SECTION B-B

PLANTER WITH PARKING

IN STREET BIORETENTION - WITH PARKING
Plan and Section Views

DRAWING NOT TO SCALE
Source: Adapted from City of Salinas



BIORETENTION IN LANDSCAPE OR OPEN SPACE AREAS

Plan and Section Views

DRAWING NOT TO SCALE

Source: Adapted from City of Salinas

MEDIA FILTER

Fact Sheet TR-2

DESCRIPTION

Photo Source: Portland BES

Storm water media filters are typically two-chambered including a pretreatment settling basin and a filter consisting of sand, gravel, or other adsorptive filtering media. As storm water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering media in the second chamber. There are a number of design variations including the Austin sand filter, Delaware sand filter, multi-chambered treatment train (MCTT), and manufactured storm water filters. Treated storm water is collected in an effluent chamber or underdrain, and subsequently discharged to a storm water conveyance system or other appropriate location.

Manufactured storm water filters are typically underground systems that utilize membranes of various materials or cartridges filled with different types of media to filter storm water runoff. For cartridge systems, the media used can be inert, such as sand, or adsorptive, such as peat or manufactured media. The effectiveness of these systems depends on the type of membrane or media being implemented, the filter loading rate, and the characteristics of the influent storm water. For some systems, the water chemistry will also determine the effectiveness of the filter in removing dissolved constituents.

KEY DESIGN FEATURES

Media filters may only be implemented for Regulated Projects that demonstrate use of bioretention facilities to be infeasible. Regulated Projects implementing media filters must meet the following requirements:

1. Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85% of the entire project site covered by permanent structures;
2. Facilities receiving runoff solely from existing (pre-project) impervious areas; and
3. Historic sites, structures or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

The performance of any media filter is governed primarily by the following factors which should be carefully evaluated when designing the facility:

- Hydraulic Loading Rate – The application rate of untreated water to the surface of the filter media usually expressed as a flow rate per filter surface area (i.e. gpm/ft^2);
- Filter Media Gradation – A finer media gradation reduces hydraulic conductivity and increases the capture efficiency for fine particulate pollutants. Finer media also has a greater surface area which increases sorption rates for chemically active media. A more homogenous media gradation increases voids volume in a media bed. Finer media is more susceptible to surface clogging.
- Residence Time - Residence time is a function of media gradation, hydraulic loading rate and the media bed depth and configuration. A longer residence time generally improves pollutant removal performance.
- Media Chemical Properties – Filter media can be inert (i.e. sand) or can be selected to target specific pollutants of concern (i.e. activated carbon for trace organics). Chemically active options may be organic, mineral or synthetic or a combination of types. Media should be selected with consideration of the type and load of pollutants requiring removal.

- Pretreatment – Integrate adequate pretreatment facilities into media filter designs to reduce sediment loading and maintenance frequency. The level of pretreatment required is dependent on the tributary drainage area, but typical pretreatment consists of a sedimentation chambers, hydrodynamic separator, vegetated buffer strips, and vegetated swales.
- Hydraulic Head – Different media filters types have varying hydraulic head requirements that must be considered during design. Certain media filter configurations may not be suitable for flat sites.

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Construction Storm Water Quality Plan (SWQP) Form 3-3 should be used to calculate the Water Quality Flow (WQF) of media filters for Regulated Projects. This value is then used in Form 3-7 to iteratively determine the necessary media filter sizing to capture the remainder of the 85th percentile, 24-hour design storm not retained by Site Design Measures. The equation for determining the WQF for media filters is as follows:

$$\mathbf{WQF = A_{imp} * P_F / 43{,}200}$$

Where:

WQF = Water Quality Flow (cfs);
A_{imp} = impervious drainage area untreated by Site Design Measures (ft^2); and
P_F = flow based design storm intensity (0.2 inch/hr).

CONSTRUCTION PHASE CONSIDERATIONS

- Divert flow around the sand filter to protect it from sediment loads during construction. If sediment does enter the facility during construction, the sediment will require removal after the tributary area has been stabilized. Diverted flow must be managed using temporary BMPs.
- Where underdrains are used, ensure that the minimum slope of the pipe is 0.5 (1/2) percent.
- Ensure that the inverts of notches, orifices, or weirs dividing chambers correspond with design elevations to ensure proper function.
- The surface of bed filters should be completely level to promote uniform filtration.
- If precast concrete lids are used, provide lifting rings or threaded sockets to allow easy removal with standard lifting equipment.
- Once construction is complete, stabilize the entire tributary area to the media filter before allowing runoff to enter the unit.

MAINTENANCE CONSIDERATIONS

Media filters may exhibit decreased effectiveness after a single year of operation, depending on the activities occurring in the drainage area and filter loading. They clog easily when subjected to high sediment loads, and sediment reducing pretreatment practices placed upstream of the filter should be maintained properly to reduce sediment loads into the filter.

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for all non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

- Inspect for standing water at least annually, or more frequently under high sediment loading conditions.

MEDIA FILTER

Fact Sheet TR-2

- Remove sediment and debris accumulations from filter surface to prevent clogs and/or standing water.
- Inspect and maintain upstream sediment traps, or other pre-treatment BMPs, in accordance with applicable guidance.

AVAILABLE VENDOR PRODUCTS

The names of vendor products listed below are for informational purposes only. Their appearance here is not an endorsement of the products or manufacturers by Town of Truckee.

- BayFilter™
- Fabco Filter Cartridges
- Jellyfish®
- Media Filtration System (MFS)
- Perk Filter™
- Puristorm™
- Up-Flo™
- StormFilter®
- VortFilter™

Photo Source: Contech®

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TREE BOX FILTER

Fact Sheet TR-3

DESCRIPTION

Tree box filters are typically manufactured systems that provide biofiltration and media filtration to treat storm water runoff. Storm water typically flows into a pretreatment chamber to remove large sediment, debris and trash before passing into the biotreatment chamber where physical straining, and biological and chemical reactions in the mulch, root zone, and soil matrix occurs. Tree box filters are similar in concept to bioretention areas in function and application, with the major distinction that a tree box filter has been optimized for high volume/flow treatment, therefore the ratio of impervious area to treatment area is less. A tree box filter takes up little space and may be used on highly developed sites in areas such as landscaping, green space, parking lots and streetscapes.

Photo Source: Oldcastle Storm water Solutions ™

An underdrain in the tree box filter collects treated storm water to be discharged to the storm water conveyance system or other appropriate location. Manufactured tree box filters typically incorporate a high flow bypass to prevent scouring in the bioretention basin and mobilization of treated pollutants. The overflow can be directed to another treatment system or the municipal storm system.

KEY DESIGN FEATURES

Tree box filters may only be implemented for Regulated Projects that demonstrate use of bioretention facilities to be infeasible. Regulated Projects implementing tree box filters must meet the following requirements:

1. Projects creating or replacing an acre or less of impervious area, and located in a designated pedestrian-oriented commercial district (i.e., smart growth projects), and having at least 85% of the entire project site covered by permanent structures;
2. Facilities receiving runoff solely from existing (pre-project) impervious areas; and
3. Historic sites, structures or landscapes that cannot alter their original configuration in order to maintain their historic integrity.

The performance of a tree box filter is governed primarily by the following factors which should be carefully evaluated when designing the facility:

- Hydraulic Loading Rate – The application rate of untreated water to the surface of the filter media usually expressed as a flow rate per filter surface area (i.e. gpm/ft^2);
- Filter Media Gradation – A finer media gradation reduces hydraulic conductivity and increases the capture efficiency for fine particulate pollutants. Finer media also has a greater surface area which increases sorption rates for chemically active media. A more homogenous media gradation increases voids volume in a media bed. Finer media is more susceptible to surface clogging.
- Residence Time - Residence time is a function of media gradation, hydraulic loading rate and the media bed depth and configuration. A longer residence time generally improves pollutant removal performance.
- Media Chemical Properties – Filter media can be inert (i.e. sand) or can be selected to target specific pollutants of concern (i.e. activated carbon for trace organics). Chemically active options may be organic, mineral or synthetic or a combination of types. Media should be selected with consideration of the type and load of pollutants requiring removal.
- Pretreatment – Integrate adequate pretreatment facilities into media filter designs to reduce sediment loading and maintenance frequency. The level of pretreatment required is dependent on the tributary drainage area, but typical pretreatment consists of a sedimentation chambers, hydrodynamic separator, vegetated buffer strips, and vegetated swales.

- Vegetation – Choose moisture-tolerant plants that can tolerate both fluctuating water conditions and drought conditions. Refer to fact sheet TR-1 for more information on recommended plant species.

CONSTRUCTION PHASE CONSIDERATIONS

- Divert flow around the tree box filter to protect it from sediment loads during construction. If sediment does enter the facility during construction, the sediment will require removal after the tributary area has been stabilized. Diverted flow must be managed using temporary BMPs.
- Where underdrains are used, ensure that the minimum slope of the pipe is 0.5 (1/2) percent.
- Once construction is complete, stabilize the entire tributary area to the media filter before allowing runoff to enter the unit.

SIZING DESIGN GOALS AND REQUIREMENTS

The Post-Construction Storm Water Quality Plan (SWQP) Form 3-3 should be used to calculate the Water Quality Flow (WQF) of tree box filters for Regulated Projects. This value is then used in Form 3-7 to iteratively determine the necessary tree box filter sizing to capture the remainder of the 85th percentile, 24-hour design storm not retained by Site Design Measures. The equation for determining the WQF for tree box filters is as follows:

$$\mathbf{WQF = A_{imp} * P_F / 43{,}200}$$

Where:

WQF = Water Quality Flow (cfs);

A_{imp} = impervious drainage area untreated by Site Design Measures (ft^2); and

P_F = flow based design storm intensity (0.2 inch/hr).

MAINTENANCE CONSIDERATIONS

Maintenance activities and frequencies are specific to each manufactured product. Semiannual maintenance is typical and should be performed per manufacturer specifications. Maintenance agreements are available from some manufacturers.

Tree box filters may exhibit decreased effectiveness after a single year of operation, depending on the activities occurring in the drainage area and filter loading. They clog easily when subjected to high sediment loads, and sediment reducing pretreatment practices placed upstream of the filter should be maintained properly to reduce sediment loads into the filter.

INSPECTION AND MAINTENANCE REQUIREMENTS

A maintenance plan shall be provided with the SWQP for all non-residential projects. The maintenance plan shall include recommended maintenance practices, state the parties responsible for maintenance and upkeep, specify the funding source for ongoing maintenance, and provide a site specific inspection checklist. At a minimum, maintenance for all residential and commercial projects shall include the following:

- Inspect inlets and outlets and remove sediment and debris accumulations to maintain unobstructed flow paths and prevent clogging and standing water.
- Inspect trees or shrubs for general health, disease, parasites, and provide adequate supplemental irrigation. prune as needed and replace all dead plants as soon as possible.
- For deciduous species, remove shed leaves in the Fall before they enter the subsurface filtration area.

TREE BOX FILTER

Fact Sheet TR-3

AVAILABLE VENDOR PRODUCTS

The names of vendor products listed below are for informational purposes only. Their appearance here is not an endorsement of the products or manufacturers by Town of Truckee.

- DeepRoot® Silva Cell
- Filterra® Bioretention System
- TreePod® Biofilter
- UrbanGreen™ Biofilter

Photo Source: Contech®

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