BLUE BTV
BASIS OF DESIGN

Design Guidance for Small-Scale Green Stormwater Infrastructure Projects in Burlington, Vermont
2023

Context

BLUE BTV is a residential green stormwater infrastructure incentive program in Burlington, VT. The program aims to educate and incentivize the implementation of green infrastructure practices that reduce the volume and improve the quality of stormwater runoff entering the City's infrastructure and natural waterways.

To ensure that design and implementation of these practices is consistent and of high quality, this document provides guidance that aligns with best practices and the City's goals and objectives.

This guide is intended for use by designers and installers of green infrastructure practices on private property in the City of Burlington. Residents may find this guide useful when preparing to implement green infrastructure where they live. This guide serves as the basis of design for all BLUE BTV certified practices. In order to receive rebates from the BLUE BTV program, these standards must be adhered to and documented throughout the process. Certain practices trigger additional review and are indicated in the practice sheets that follow.

Structural practices are only one type of intervention to improve stormwater infiltration on a site. Consider other best practices including allowing grass to stay a minimum of 3 inches or higher, adding low phosphorus (primarily leaf litter) organic matter to your gardens to improve soil health, planting trees, changing impervious surfaces to pervious options wherever possible, naturalizing lawns into meadows, and disconnecting gutters and downspouts from the storm sewer system. Learn more tips on lawn care that supports clean water at lawntolake.org.

The *Vermont Guide to Stormwater Management for Homeowners and Small Businesses* can be used as a companion to these standards. The *Vermont Guide* provides background on stormwater and green infrastructure, helpful decision trees for selecting an appropriate practice for your site, and basic instructions for sizing and implementation – including for non-structural practices. In cases where this document and the *Vermont Guide* differ on specifications, the standards outlined in this document take precedence.

The Vermont Guide to Stormwater Management can be downloaded here:
https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2018-06-14%20VT_Guide_to_Stormwater_for_Homeowners.pdf

This is a living document. As this document is the first of its kind for BLUE BTV, there may be situations that are not adequately addressed or special cases that present further questions. In these cases, please bring these questions to the attention of the BLUE BTV team (blue@uvm.edu) so that updates can be made to provide the highest quality guidance.

General Guidelines

City Priorities

Burlington stormwater contributes either to the combined sewer system (CSS, which combines sanitary and storm runoff in the same pipes), separate stormwater sewer system (conveying stormwater runoff only), or directly to the Winooski River or Lake Champlain via surface flow. Priorities for stormwater management within these different drainages differ. Where an area drains to the CSS, management decisions should prioritize reducing the quantity (volume) of water flowing to the system, whereas areas that drain to a river or lake should prioritize improving runoff water quality.

A map of the Burlington sewersheds can be found here: https://burlingtonvt.maps.arcgis.com/apps/webappviewer/index.html?id=d982d99735df4de6bd99fd3da57cba98

Impact to City Infrastructure

No stormwater runoff shall be permitted to leave a site in such a way as to impact City infrastructure. This includes unauthorized direct pipe connection to City storm sewers, or surface drainage that causes wetting of City sidewalks, or transport of surface materials onto City roadways (i.e., gravel, sand, soil). This pertains to subsurface and surface runoff and/or overflow from any stormwater management practice.

Soils testing/ evidence of toxicity

Soil testing may be requested before designing a stormwater management practice if contamination is suspected. Infiltration practices should be avoided where there is a history of toxic materials stored on site and/or identified toxicity in soils with lead, heavy metals, or hydrocarbon contaminants (such as oils and gasoline). Known underground storage tanks, previous use of a site as a gas station or garage, or known lead paint on the exterior of a house are all reasons for investigation.

Filter Fabrics

If filter fabrics are used to line an infiltration practice, they should be non-woven. Consider specifying a GeoGrid product if a filter fabric is warranted.

Infiltration testing and infiltration practice design

Burlington has a variety of soil types including sand, clay, and ledge. At a minimum, a simple soil investigation (hand auger) is recommended to verify soil texture. Infiltration testing may be necessary to determine feasibility of stormwater practice type. Any infiltration test that is sanctioned in the Vermont Stormwater Management Manual (VTSWMM) or otherwise approved by VT Agency of Natural Resources (VTANR) is acceptable. Suitability for infiltration should be verified by following VTSWMM standard methods in section 4.3.3.2.

You can find more information about the soil conditions in Burlington from a soil boring map here: https://www.arcgis.com/home/webmap/viewer.html?webmap=812393e31fca43ffad02a669259a44ad&extent=-73.2272,44.4801,-73.2019,44.491

The bottom of all infiltration practices (such as rain gardens and infiltration trenches) should be flat to distribute and infiltrate stormwater evenly. The longitudinal slope should not exceed 2.5%. Check dams can be applied at the surface or subsurface where slopes exceed 2.5%. All infiltration systems shall be designed to fully de-water the treatment volume within 48 hours after the storm event.

Pretreatment is the removal of trash, coarse sediment, debris, and organic matter prior to stormwater entering a treatment practice. It can take many forms such as conveyance through a grass channel or a settling forebay prior to the practice. In residential applications, pretreatment should be considered for any practice receiving non-rooftop runoff, particularly if the drainage area is very large, includes lots of deciduous trees or has loose material (such as exposed soil or sand) that may flow into the practice leading to premature clogging. Refer to the VTSWMM section 4.1 for further guidance on when pretreatment is necessary.

Depth to Seasonal High Groundwater Table (for infiltration practices)

The depth to the seasonal high groundwater table must be verified prior to installation of any infiltration practice. The requirements for minimum depths to seasonal high groundwater table for infiltration practices are measured from the bottom of the practice to the high-water table and are determined based on the elevation of the source of the stormwater to the practice. (For example, rooftop water is considered to be cleaner so the distance from the bottom of any infiltration practice to the high groundwater table is allowed to be shorter.) Depths between high water and the bottom of the practice for each source are as follows:

- Rooftop only ≥1 foot
- Rooftop/ driving surface mixed ≥ 3 feet
- A significant amount of water (≥1 acre) from any surface ≥ 4 feet

The link to soil boring data provided in the above section also includes depth to seasonal high groundwater information.

Compost/ Soil

Stormwater practice design should take care to avoid the addition of excess phosphorus. Compost should be used sparingly (if at all) and only applied to support the immediate growth of plants (NOT distributed throughout the soil profile of an entire practice). In many cases, additional compost is not necessary. When in doubt, test on-site soil for phosphorus prior to compost or amendment application. A soil phosphorus test ≥25 ppm indicates an adequate concentration of the nutrient for plant growth. Information for the “basic test” for soil nutrients can be found here: Agricultural and Environmental Testing Lab | UVM Extension Cultivating Healthy Communities | The University of Vermont. Where a practice is underdrained (such as bioretention) additional steps should be taken

to ensure that the practice will not add excess nutrients to waterways. Follow these guidelines for stormwater practice soil testing for any underdrained practice:
Bioretention and gravel wetland soil media testing guidance

Proximity to Infrastructure

Practices should be placed >10’ away from building foundations or, if this is not possible, practices should be lined with an impermeable liner on the side adjacent to the building and the base of the practice should be sloped away from the building. In the case of rainwater storage practices (rain barrels and cisterns) care should be taken to ensure that the overflow from the practice is directed away from the building where excess water can filter through vegetation and/or soil.

Proximity to Existing Trees

Practices should be designed and field verified to not disturb the existing root system of mature trees. For structural practices that require digging (such as rain gardens and infiltration trenches) avoiding cutting or disturbing major roots will ensure the longevity of the existing tree. Generally, such practices should be avoided under the canopy cover of mature trees to avoid the root system. If roots are encountered while digging, relocation of the proposed practice should be considered, or the depth of the practice should be slightly altered to accommodate the roots. Additional input from the BLUE BTV Team is also encouraged.

Dig Safe!

Dig Safe must be notified prior to any digging – including for infiltration testing. Call 811 to schedule a visit. The site will be staked with white pin flags or white painted stakes. A Dig Safe ticket must be submitted via the online system at least 3 days prior to digging at: https://exactix.digsafe.com/login. Mark the location where you intend to dig so Dig Safe can focus their investigation on the area of interest. Spray paint or flagging on wooden posts around the area work well. After Dig Safe visits the site, they will leave flags and/or painted lines indicating the location of underground utilities. See below for an example of how this may look.

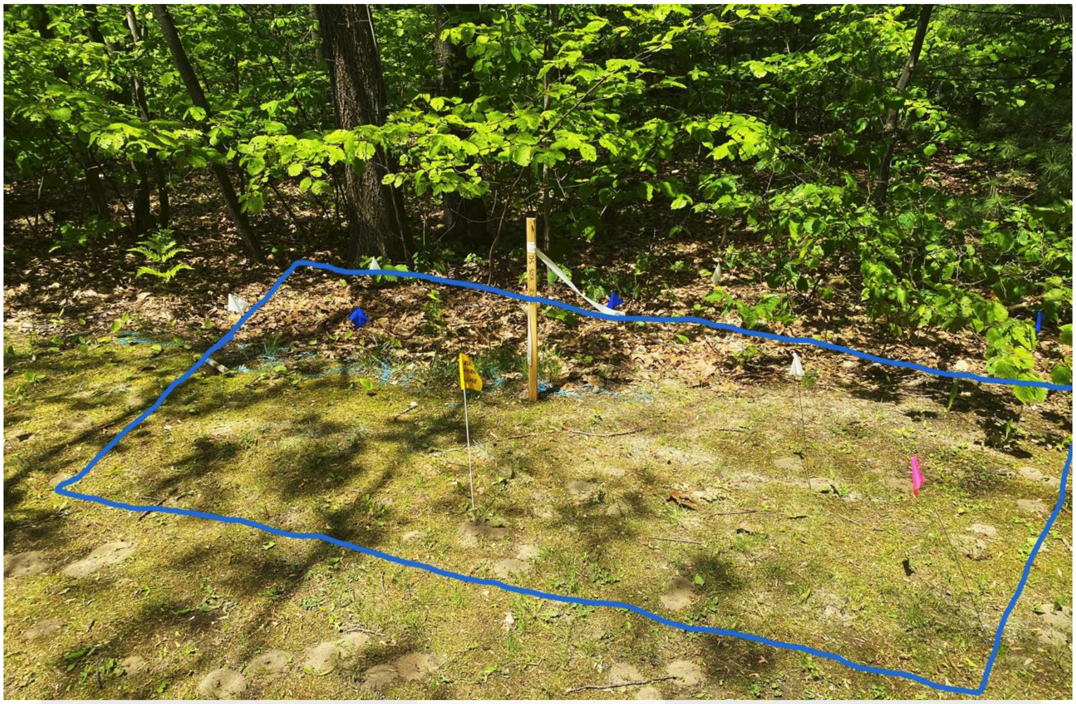


Figure 1. Dig Safe markings on a lawn. The flags indicate the location of utilities. The box outlines the area of interest.

Structural Practices

The following pages provide design guidance on these common green infrastructure practices:

Bioretention/ Rain Garden

Introduction

Bioretention or Rain Gardens are depressed areas with native plants that capture, filter, slow, and infiltrate stormwater runoff. These work best in areas with good infiltration rates, but can be modified for tighter soils or more challenging locations by increasing the size or depth and/or adding an underdrain.

Minimum Design Requirements

- Rain gardens or bioretention systems designed to infiltrate water into existing soils must be a minimum of 10 ft away from the building foundations to prevent seepage into the basement, or affixed with an impermeable liner.
- Bioretention shall not be lined unless required due to pollution hotspots, proximity to a basement, or other site-specific factors.
- Soils shall have an infiltration rate of ≥0.2 inches/hr. Slower infiltration rates require an underdrain be used as an outlet for the practice.
- Underdrain (if used) shall be a minimum 4”- diameter perforated pipe in a minimum 1-foot-deep stone layer, separated by at least 3” from the bioretention media and 2” from the bottom. Perforation should be focused on the bottom of the pipe only to avoid movement of stone and gravel into pipe from above. If a fully perforated pipe is used, woven fabric should be draped across the top of the pipe to avoid clogging from fines.
- 1-2” – diameter washed stone shall be used as bedding around a perforated pipe if used.
- Native soils can be used for shaping rain gardens. Soils added to a bioretention project shall consist of USDA sand to loamy sand classification and meet the following gradation: sand 85- 88%, silt 8-12%, clay 0-2%, and organic matter in the form of compost 3-5%.
- Bioretention systems must include an 18-36” deep planting soil bed, a hardwood mulch surface layer (or other surface treatment that suppresses weed growth and minimizes exposed soil), and a 6-12” deep ponding zone.
- The designer shall identify on the plan sheet that a soil phosphorus test using the Mehlich-3 method, or approved equivalent, is required for practices with underdrains, to ensure that bioretention soil media will not leach phosphorus. The total P concentration must be <0.2%.
- Any compost specified in a bioretention area should be from leaf litter only – no food scraps or manure.
- A bypass or an internal overflow device (e.g., elevated yard inlet) shall be used to allow larger storms to bypass the practice to a stable conveyance.

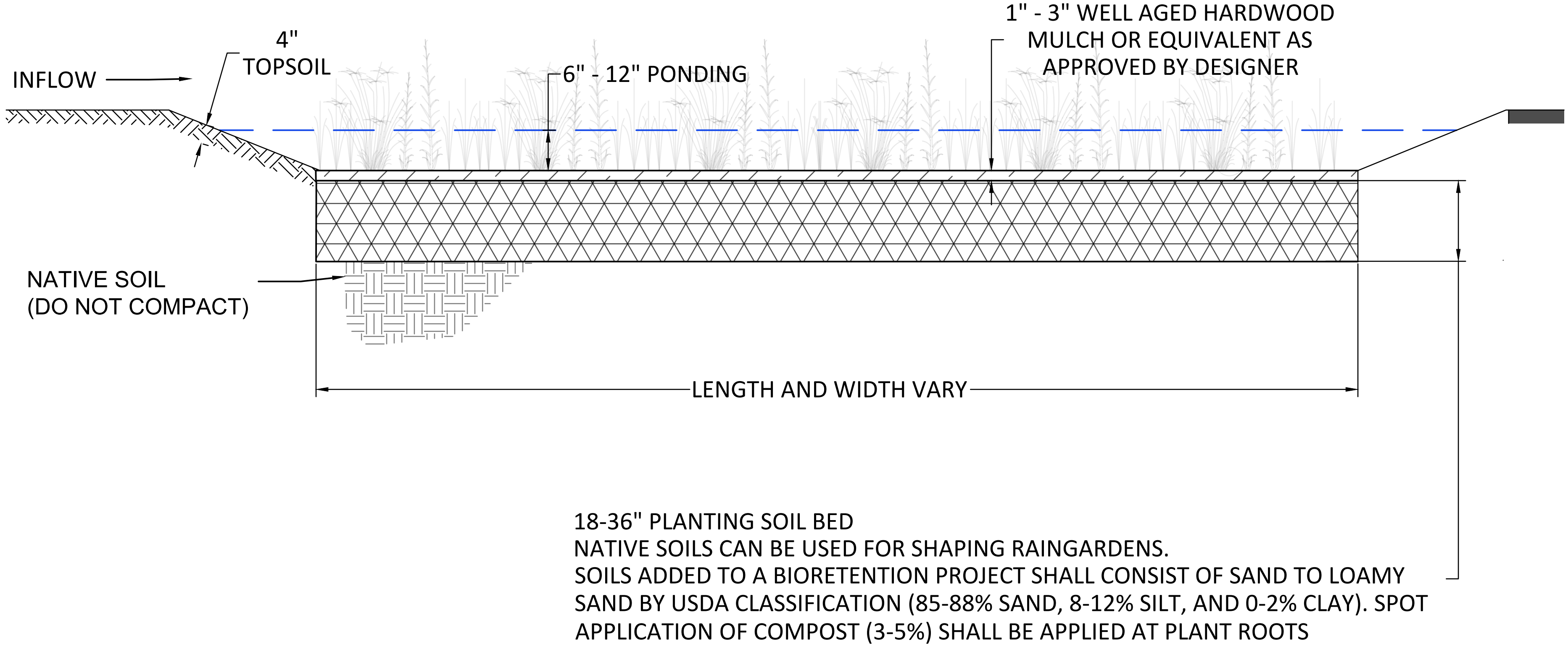
Design Guidance *(considerations for good practice)*

- Infiltration practices on 10% slopes are not recommended without review by a design professional.
- Slopes of the contributing drainage area should be <15%. If slopes are >8%, then level-spreading devices may be needed to redistribute flow prior to filtering. Filter beds within bioretention practices should be flat or slightly sloping (generally 0.5% maximum). If slopes within bioretention practice are too steep, then a series of check dams, terraces, or berms may be used to maintain sheet flow internally.
- Maximum depth of 3” of shredded hardwood mulch layer that is well aged (stockpiled for at least 6 months) should be applied. Acceptable alternatives include softwood mulch, or equivalent alternative, 3/8” rounded pea stone, or planting two or more species of tall grasses or other ground cover, allowing the whole facility to fill in with vegetation, avoiding the need for mulch.
- Select native species based on tolerance to inundation and drought and/or road salt where applicable (along walkways or driving surfaces that are salted). For more guidance on selecting appropriate vegetation, see the VT Rain Garden Manual for a plant list: https://www.uvm.edu/seagrant/rain-garden-manual
- The overflow outlet from the downstream end of the bioretention area should be non-eroding. It can consist of a stone-lined channel or an inlet grate set level with the top of the berm. If a grate is used, it should be slanted or domed to prevent clogging by leaves and debris.

Maintenance

- Inspect gutters/downspouts, inlets and pretreatment devices in the spring and after leaves drop in the fall. Remove any accumulated leaves and debris.
- Check that there is no ponding in the main treatment area after a rain event. If ponding exists, investigate the cause - clogged outlet, leaf-litter build-up, clogged surface etc.
- Regular weeding, watering (during 6-weeks of plant establishment and extended periods of heat and drought) and plant management similar to maintenance of a perennial garden is necessary.
- Revegetate bare patches and eroding areas.
- Inspect for and remove excess sediment in the pretreatment device and/or in the main treatment area.
- Remove invasive plants.
- Prune trees and shrubs yearly.
- Inspect vegetation and replace as needed (yearly).
- Inspect for and repair broken inlets or pipes (yearly).
- Fall cleanup – divide large perennial plants, weed, cut back plants at the time of senescence, remove excessive leaf litter.
- Spring cleanup – scoop out debris and sediment from inlet areas, cut back and remove last year’s organic material, add mulch, if necessary, in unplanted areas, replace plants that did not survive.

SELECT NATIVE PLANTINGS BASED ON TOLERANCE TO INUNDATION AND DROUGHT AND/OR ROAD SALT WHERE APPLICABLE

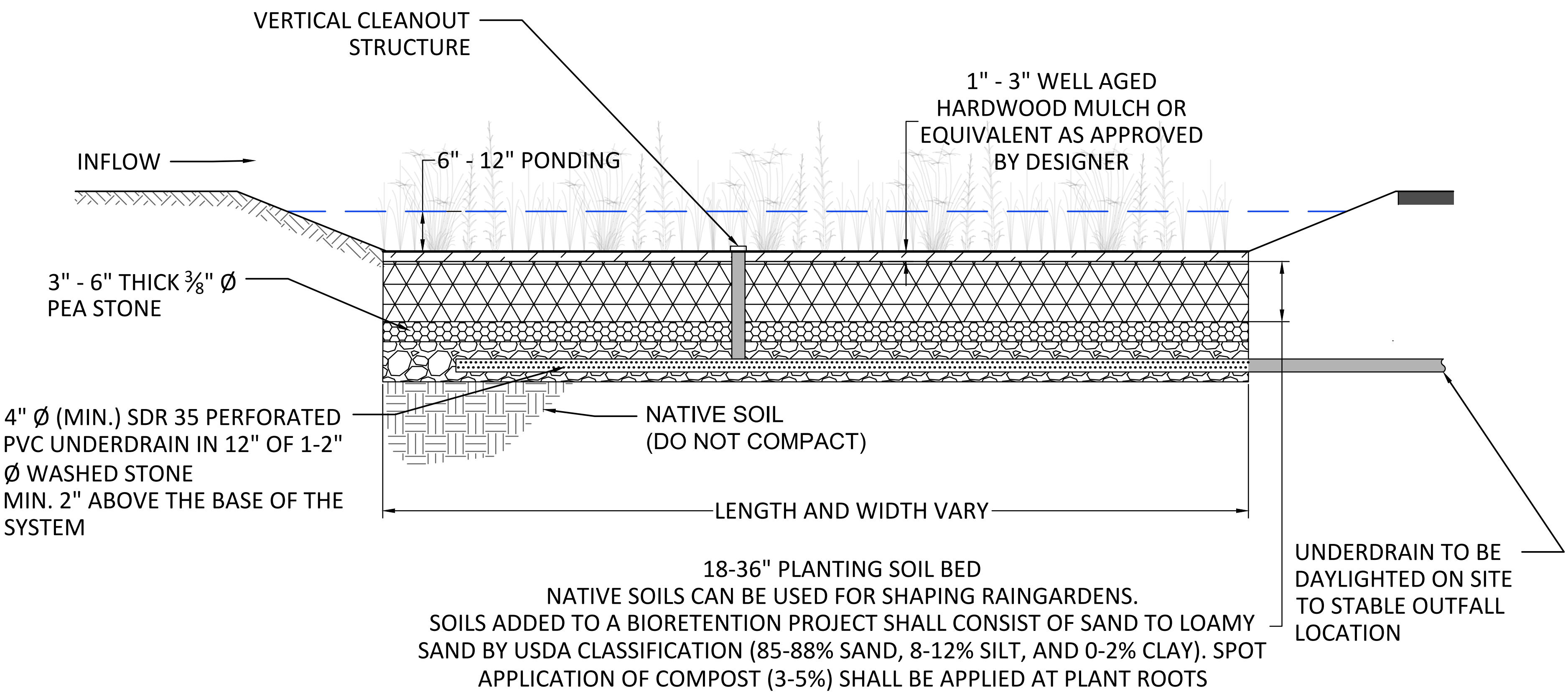


FOR USE WITH INFILTRATION RATE OF UNDERLYING SOIL ≥0.2 INCHES/HOUR

BIORETENTION BASIN / RAIN GARDEN

NOT TO SCALE

SELECT NATIVE PLANTINGS BASED ON TOLERANCE TO INUNDATION AND DROUGHT AND/OR ROAD SALT WHERE APPLICABLE



FOR USE WITH INFILTRATION RATE OF UNDERLYING SOIL <0.2 INCHES/HOUR

UNDERDRAINED BIORETENTION BASIN / RAIN GARDEN

NOT TO SCALE

Permeable Pavers

Introduction

Permeable pavers come in two main varieties: (1) interlocking stones or bricks with structural spacers that allow water to flow between the blocks to be stored and infiltrate beneath the surface and (2) "grid pavers" with larger honey-comb-like interior spaces that are integrated within the blocks themselves where gravel or soil and grass can be placed to allow infiltration. In all cases, a subbase is prepared with a larger gravel layer that will provide a stable surface for driving and adequate void space for infiltrated stormwater. "Ribbon Strips" are a type of permeable driveway option where only a hard surface (concrete, pavers, or bricks) is installed where the tire treads will be making contact with the driveway. Permeable surfaces such as a grassed area or cleaned and washed stone is installed both between and outside of the ribbon strips. Burlington's Stormwater Friendly Driveway Fact Sheets expand on the options and provide background and applications for different types:
https://www.burlingtonvt.gov/sites/default/files/DPW/Stormwater/Driveways/SW%20Friendly%20Driveways_web_v2.pdf

Minimum Design Requirements

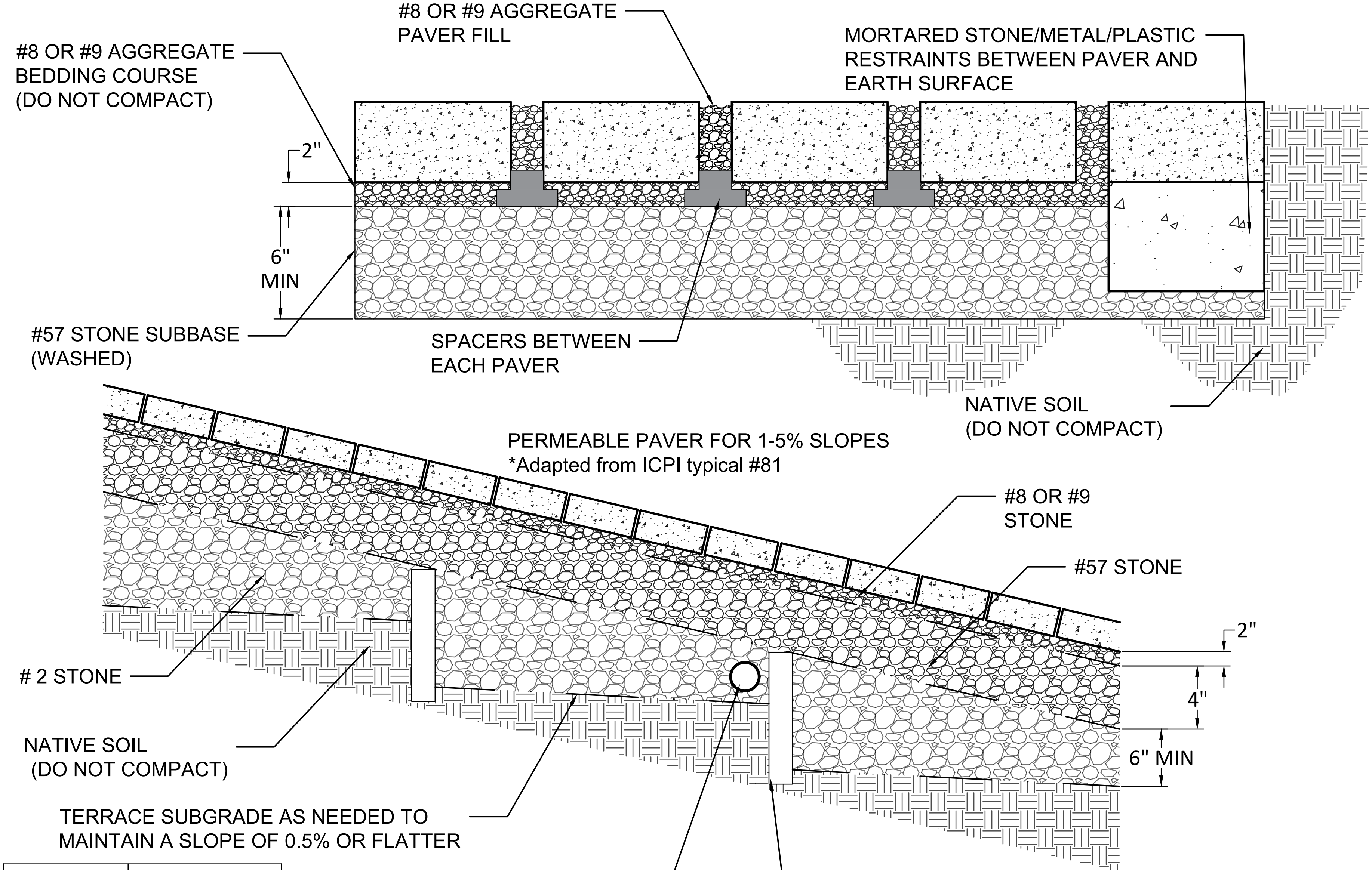
- If using permeable paver bricks, they must be "interlocking." This means that they have little nubs on their sides that will prevent them from pinching together. Regular bricks are not suitable for this purpose.
- Grid pavers for use with grass or gravel substrates must be designed for that specific application.
- The aggregate bedding course and material between paver joints shall be a #9 or #8 stone or their equivalent (1/8" – 1/2") angular fill to ensure the spaces between and areas below pavers are pervious. All aggregate must be angular; rounded aggregate is not a suitable alternative. This aggregate should not be compacted.
- There must be a subbase of gravel at least 6" in depth above the native soil. This gravel depth can vary depending on soil conditions. The subbase must be a washed #57 stone (½" – 1 ½" diameter), or equivalent.
- While rainfall can percolate between and through the pavers, "run-on" (directing flow from other surfaces to the permeable pavers) should be avoided/minimized to the maximum extent practicable. Some exceptions for small amounts of clean roof runoff are allowable.
- Slopes of greater than 5% are not appropriate for permeable pavers. If on slopes ≤5%, the paver system should slope away from structures.
- Slopes between 1 and 5% can utilize buried check dams (concrete or soil berm) and underdrains (as needed) to ensure water is being infiltrated.
- Permeable paver systems require a minimum infiltration rate of the underlying soils of 0.5 inches/hour or greater.
- Permeable pavers should not be located above an area with a water table or bedrock <2 feet below the gravel bottom, over utility lines, or above any septic system components.

Design Guidance *[considerations for good practice]*

- When using pavers, brick is strongly preferred as opposed to concrete. Concrete is easily corroded by salt and the inevitability of salt being tracked onto pavers from tires and shoes during winter months will reduce the lifespan of the paver.
- Avoid use in areas where sand and salt is expected in the winter, as this can quickly cause the system to clog and fail.
- A subbase course of minimum 6” of #57 washed stone (½” – 1 ½” diameter or equivalent) under the bedding course shall be used to provide stormwater storage capacity. Greater subbase depths can be used to store runoff from heavy storms.
- The subgrade layer is the layer of native soils below the system. The subgrade soil layer should be prepared by scarifying or tilling to a depth of 3 to 4 inches. The subgrade should be as close to flat as possible; and can be terraced as necessary to maintain a maximum slope of 0.5% or less.
- A permeable drainage fabric can be used to separate the permeable paver materials from the sides of the excavation. This ensures that side wall contamination of the courses does not occur, and prevents collapse of the sides from soil migrating into the reservoir course and undermining an adjacent sidewalk or slope.
- For ribbon strip driveways, a subbase of stone should still be installed to store water and promote infiltration.

Maintenance

- The following tasks must be avoided on all permeable pavements: sanding, re-sealing, re-surfacing, power washing, storage of snow piles containing sand, storage of mulch or soil materials, construction staging on unprotected pavement.
- Required frequency of maintenance will depend on pavement use, traffic loads, and surrounding land use.
- For the first 6 months following construction, the practice and contributing drainage area should be inspected at least twice after storm events that exceed 1/2" rainfall. Conduct any needed repairs or stabilization.
- Mow grass in grid paver applications regularly.
- Stabilize the contributing drainage area to prevent erosion.
- Remove (with industrial shop vacuum) any soil or sediment deposited on pavement as frequently as 1x/ year depending on condition of the site and presence of clogging material like leaves, grass clippings, sand, and soil.
- Replace or repair pavement surface areas that are degenerating or spalling.
- Replace aggregate paver fill (#8 or #9 stone) between the pavers if it becomes clogged.
- Attach rollers or a rubber blade to the bottoms of snowplows to prevent them from catching on the edges of pavers



STONE CATEGORY	SIZE EQUIVALENCIES
#2	$1\frac{1}{2}$" - $2\frac{1}{2}$"
#8	$\frac{3}{8}$" - $\frac{1}{2}$"
#9	$\frac{1}{8}$" - $\frac{3}{8}$"
#57	$\frac{1}{2}$" - $1\frac{1}{2}$"

INSTALL UNDERDRAIN
IF INFILTRATION RATE
IS <0.5 IN/HR

PERMEABLE PAVERS
NOT TO SCALE

BLUE BTV

Infiltration Trench/ Basin

Introduction

An infiltration trench or basin is a shallow, stone-lined channel or basin that collects and infiltrates stormwater from impervious surfaces. The surface of the practice is often stone but can also be capped with soil and grass to give a seamless look on a grassed lawn. This practice is a good choice where infiltration rates are good and gardens are not desired. They are highly flexible and can be placed at the drip line of a structure or in a location where stormwater is directed, such as a backyard.

Minimum Design Requirements

- The impervious area draining to any one infiltration trench shall not exceed 10,000 square feet.
- Underlying soils shall have an infiltration rate of ≥0.2 inches/hr. Pretreatment (i.e., swale/grass channel, vegetated filter strip, sediment forebay) for any non-rooftop runoff shall be sized to treat a minimum of 25% of the water quality volume.
- Infiltration basins shall have side slopes of 2:1 or flatter.
- Overflow (where applicable) shall be conveyed to a discharge location in non-erosive manner.
- The sides of infiltration trenches (but not the bottoms!) should be lined with filter fabric to prevent soil piping.
- Infiltration practices shall not be used for snow storage.
- If the practice is topped with soil, the soil should be well-drained. Infiltration rate should be suitable for movement of water into the practice and consistent with above infiltration standards.
- Crushed stone of a minimum size of 1” diameter should be used for the infiltration trench.
- Underdrain pipes can be designed as needed to move water through the infiltration trench (applicable at drip lines). A minimum of 4” pipe shall be used.

Design Guidance [*considerations for good practice*]

- To reduce clogging, infiltration trenches should only be used to treat water from rooftops or provide adequate pretreatment. The runoff should be pre-treated with at least one device designed to remove leaves, debris, and larger particles.
- The overall slope of the infiltration trench underdrain pipe (if used) should be between 0.5% and 6%, and it should slope away from the structure. It cannot be located on areas with natural slopes greater than 15%.
- In infiltration trench designs, a fine gravel or sand layer above the coarse stone treatment reservoir may be incorporated to serve as a filter layer.

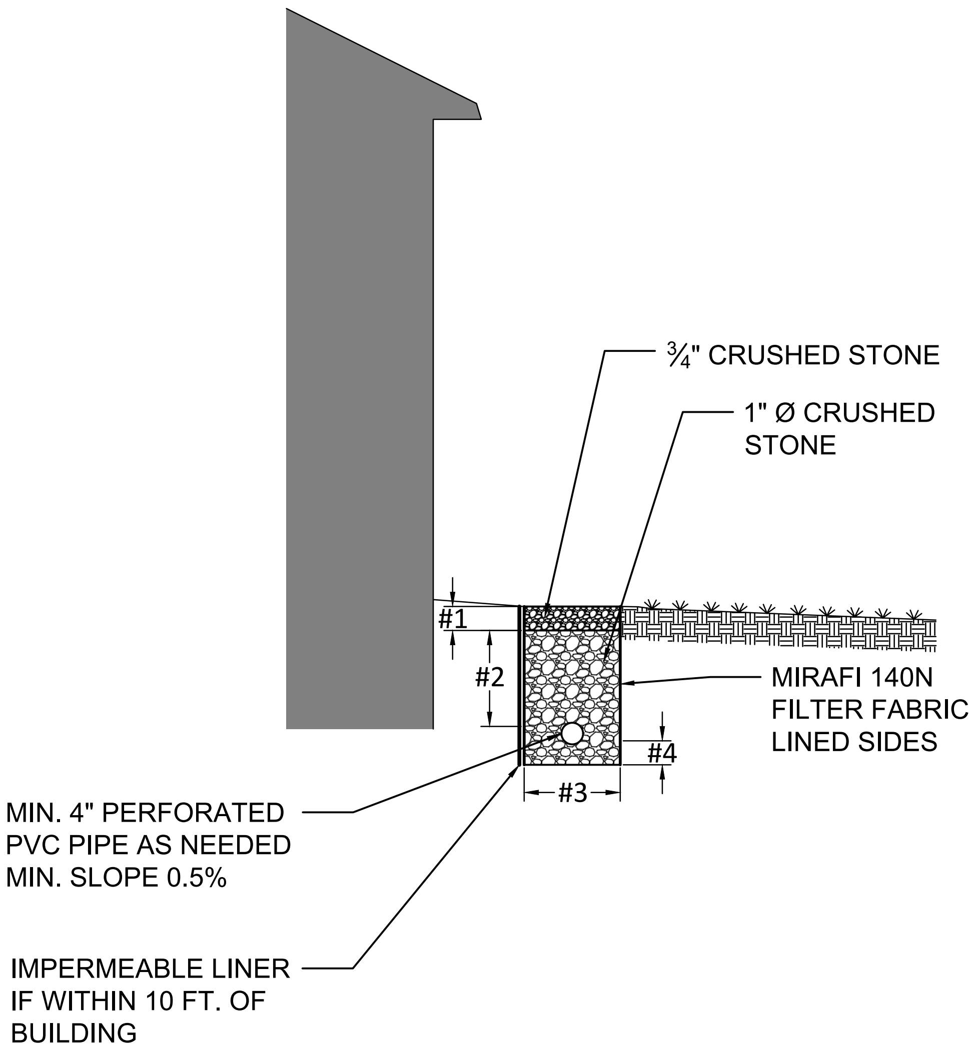
- Infiltration practices should not be hydraulically connected to structure foundations or pavement to avoid seepage and frost heave concerns.

Maintenance

- Inspect gutters/downspouts in the spring and after leaves drop in the fall. Remove any accumulated leaves and debris.
- If water fails to infiltrate 48 hours after the end of the storm as observed at the downstream pipe outlet, the gravel may need to be replaced, or clogging of the surface layer may have occurred.
- If infiltration trench / basin is vegetated with grass, regular mowing and maintenance is adequate.

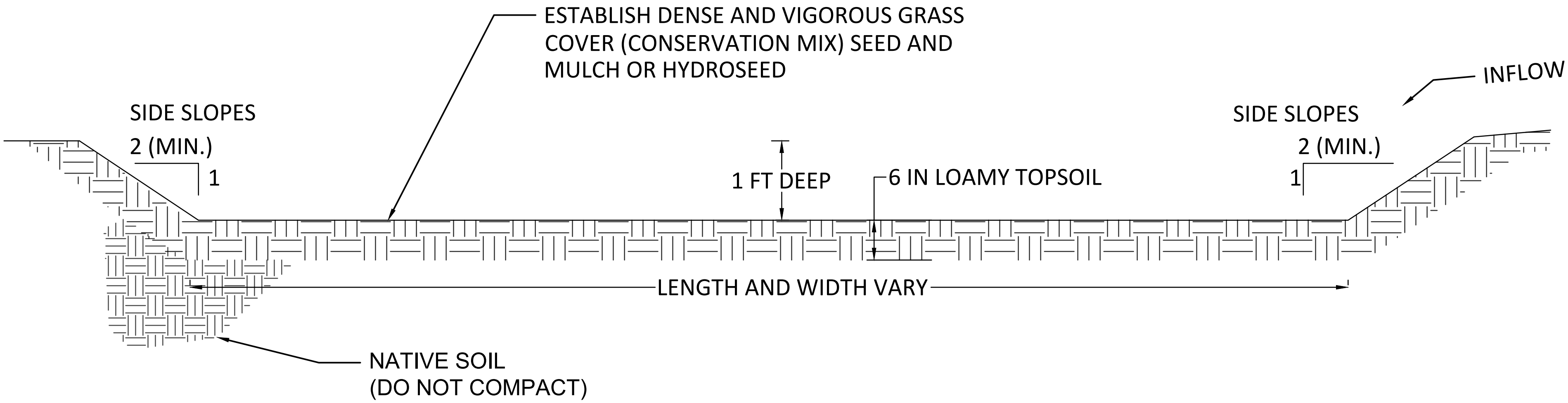
DO NOT DISTURB OR COMPACT UNDERLYING MATERIAL.

VERIFY SEASONAL HIGH WATER TABLE IS BELOW THE BOTTOM OF THE TRENCH.



DIMENSION KEY	
DIMENSION #	MEASUREMENT (IN)
#1	6"
#2	MINIMUM 24"
#3	24"
#4	6"

INFILTRATION TRENCH
NOT TO SCALE



VERIFY DEPTH TO WATER TABLE:
1-FT ROOFTOP ONLY
3-FT MIXED RUNOFF

VERIFY INFILTRATION RATE OF
UNDERLYING SOIL ≥0.2 INCHES/HOUR

PRETREATMENT REQUIRED FOR
NON-ROOFTOP RUNOFF

INFILTRATION BASIN
NOT TO SCALE

Dry Well

Introduction

Similar to infiltration trenches, dry wells collect and infiltrate stormwater runoff but in concentrated areas. They are often deeper than infiltration trenches and smaller at the surface. The idea is similar in that stormwater can easily move into the practice and then disperse throughout the soil profile surrounding the dry well. Pore space in a dry well can be achieved either by filling an excavated area with stone aggregate or using a chamber with a perforated bottom and sides to allow water to move into the surrounding soil profile.

Minimum Design Requirements

- For dry wells with ≤1,000 square feet of contributing residential rooftop runoff, vertical separation to seasonal high groundwater table shall be a minimum of 1 foot.
- Minimum field infiltration rate of 0.2 inches/hour is required.
- Dry wells must be located at least 10 feet from building foundations unless an impermeable liner is applied to prevent lateral water movement towards the structure.
- Subsurface aggregate should be 1-2" diameter clean stone with minimum dust or fines.
- Minimum height between top of practice and ground surface shall be 12".
- If water is entering the dry well from a surface inlet, a perforated vertical pipe with a yard drain attachment at the ground level should be used to ensure efficient movement into the drywell. Inlets that move water through the soil into the drywell should not be used.
- Drywells shall be designed to store and infiltrate a ½" storm (although the 1" storm capacity is preferred if space allows), and will provide a stable overflow (surcharge pipe, or equivalent).

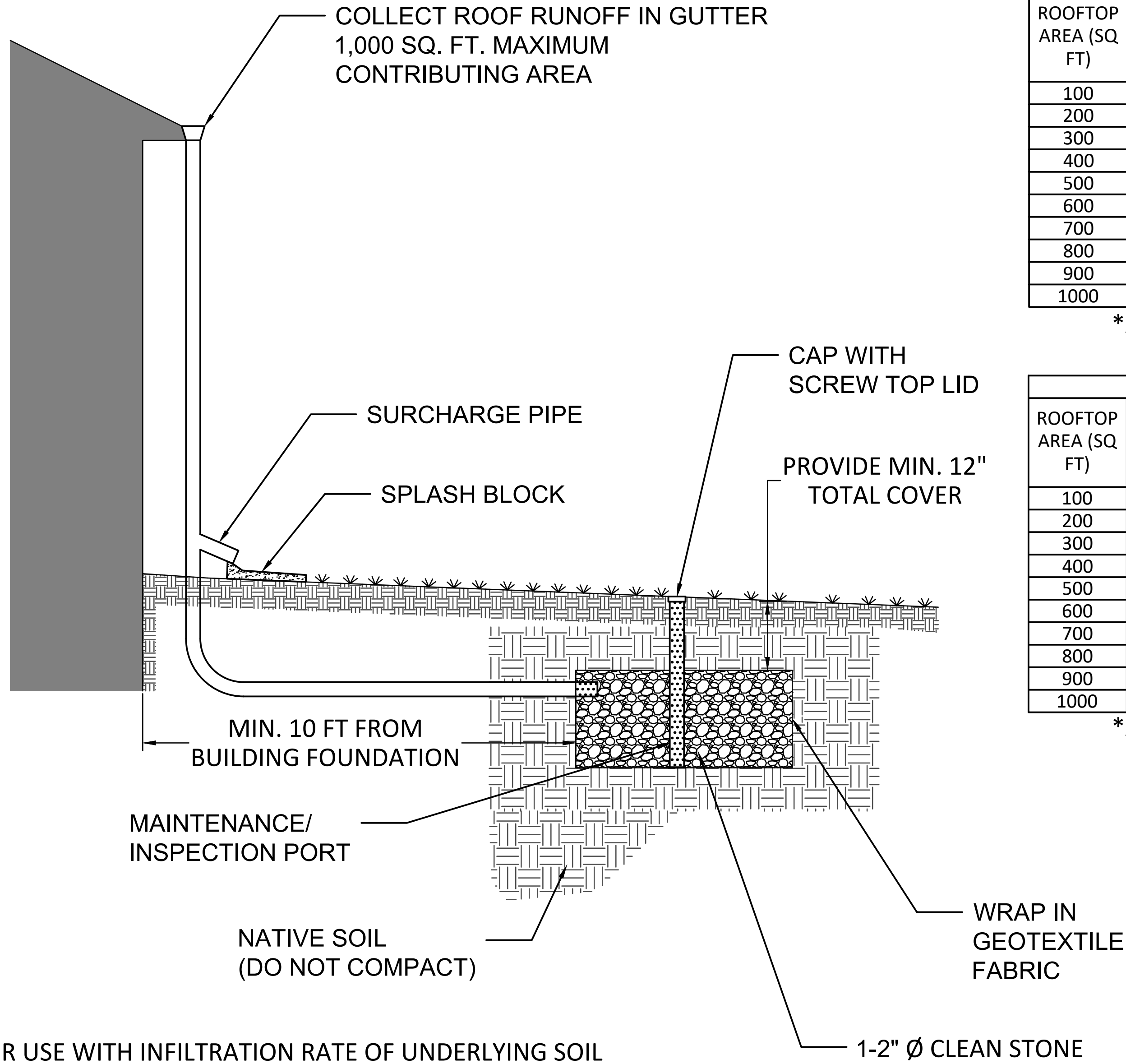
Design Guidance *[considerations for good practice]*

- The contributing area to dry wells should include rooftop runoff only unless adequate pretreatment is provided.
- As a general rule, about 25 cubic feet of stone will be needed to provide adequate storage volume for ½" of runoff from every 200 square feet of rooftop area.
- The sides and top (but not bottom) of the dry well should be lined with an acceptable filter fabric that prevents soil piping. The sides of the excavation should be trimmed of roots to ease filter fabric installation.
- Dry wells should be located in a lawn or other pervious (unpaved) area. They should not be hydraulically connected to structure foundations or pavement, to avoid seepage and frost heaving concerns.
- Proprietary infiltration chambers systems can also be used, and will decrease the overall size of the dry well due to more void space than stone fill.
- Concrete tanks can also be utilized.
- The dry well can be covered with topsoil and grass, or with pea gravel or other decorative stone as long as there is an accessible inlet.

- A 6” diameter PVC inlet pipe can be used to convey runoff from a downspout to a dry well. Perforated pipe should be used within the dry well for the horizontal and vertical pipes if the gravel-filled excavation option is chosen.

Maintenance

- Inspect gutters/downspouts in the spring and after leaves drop in the fall. Remove any accumulated leaves and debris.
- Check the dry well following large rainfall events to ensure pre-treatment is not clogged, and that the practice is not overflowing.
- Mow or trim vegetation (if any) as needed.



STONE-FILLED DRYWELL SIZING GUIDE				
ROOFTOP AREA (SQ FT)	1" STORMWATER VOLUME (CF)	1" REQUIRED TREATMENT STONE VOLUME	½" STORMWATER VOLUME (CF)	½" REQUIRED TREATMENT STONE VOLUME (CF)
100	8.33	25.25	4.17	12.63
200	16.67	50.51	8.33	25.25
300	25.00	75.76	12.50	37.88
400	33.33	101.01	16.67	50.51
500	41.67	126.26	20.83	63.13
600	50.00	151.52	25.00	75.76
700	58.33	176.77	29.17	88.38
800	66.67	202.02	33.33	101.01
900	75.00	227.27	37.50	113.64
1000	83.33	252.53	41.67	126.26

*ASSUMES A 33% VOID SPACE WITHIN STONE

CHAMBER DRYWELL SIZING GUIDE				
ROOFTOP AREA (SQ FT)	1" STORMWATER VOLUME (CF)	1" REQUIRED TREATMENT CHAMBER VOLUME	½" STORMWATER VOLUME (CF)	½" REQUIRED TREATMENT CHAMBER VOLUME (CF)
100	8.33	8.77	4.17	4.39
200	16.67	17.54	8.33	8.77
300	25.00	26.32	12.50	13.16
400	33.33	35.09	16.67	17.54
500	41.67	43.86	20.83	21.93
600	50.00	52.63	25.00	26.32
700	58.33	61.40	29.17	30.70
800	66.67	70.18	33.33	35.09
900	75.00	78.95	37.50	39.47
1000	83.33	87.72	41.67	43.86

*ASSUMES A 95% VOID SPACE FOR CHAMBERS

FOR USE WITH INFILTRATION RATE OF UNDERLYING SOIL
≥0.2 INCHES/HOUR

ROOFTOP DRYWELL (STONE-FILLED)
NOT TO SCALE

BLUE BTV

Rain Barrel or Cistern

Introduction

Rain barrels and cisterns are devices to hold roof runoff for later use. Rain barrels generally hold 50-80 gallons, but may hold up to 200 gallons. Cisterns generally hold 200-10,000 gallons, and may be above or below ground. Storing roof runoff during storms reduces the volume of contributing water to the storm sewer system and provides a usable product for watering gardens and lawns in dry periods or washing cars and outdoor furniture.

Minimum Design Requirements

- Rain barrels shall be limited to rooftop runoff and capture at least 0.2 inches of rainfall.
- Must convey overflow to a down-gradient location at least 10-ft away from buildings such as a buffer or lawn area, grass swale, gravel splash pad, or secondary treatment practice.
- An application area or water reuse purpose shall be identified that is sufficient to reuse the stormwater volume stored within a week during the irrigation period from May through September.
- Cisterns should be designed to capture the 1/2" storm but can be sized up to accommodate larger storms where feasible.
- For underground cisterns, the bottom of the tank shall be above groundwater level, and the top of the tank shall be below the frost line. Storage tanks that are above ground or not able to be buried below the frost line shall be insulated or emptied and disconnected during the winter months to protect the system from freezing.
- Underground cisterns shall be sited at least 10 feet from building foundations.
- Cisterns can be used in steep terrain, as long as the system is designed to preserve slope integrity.

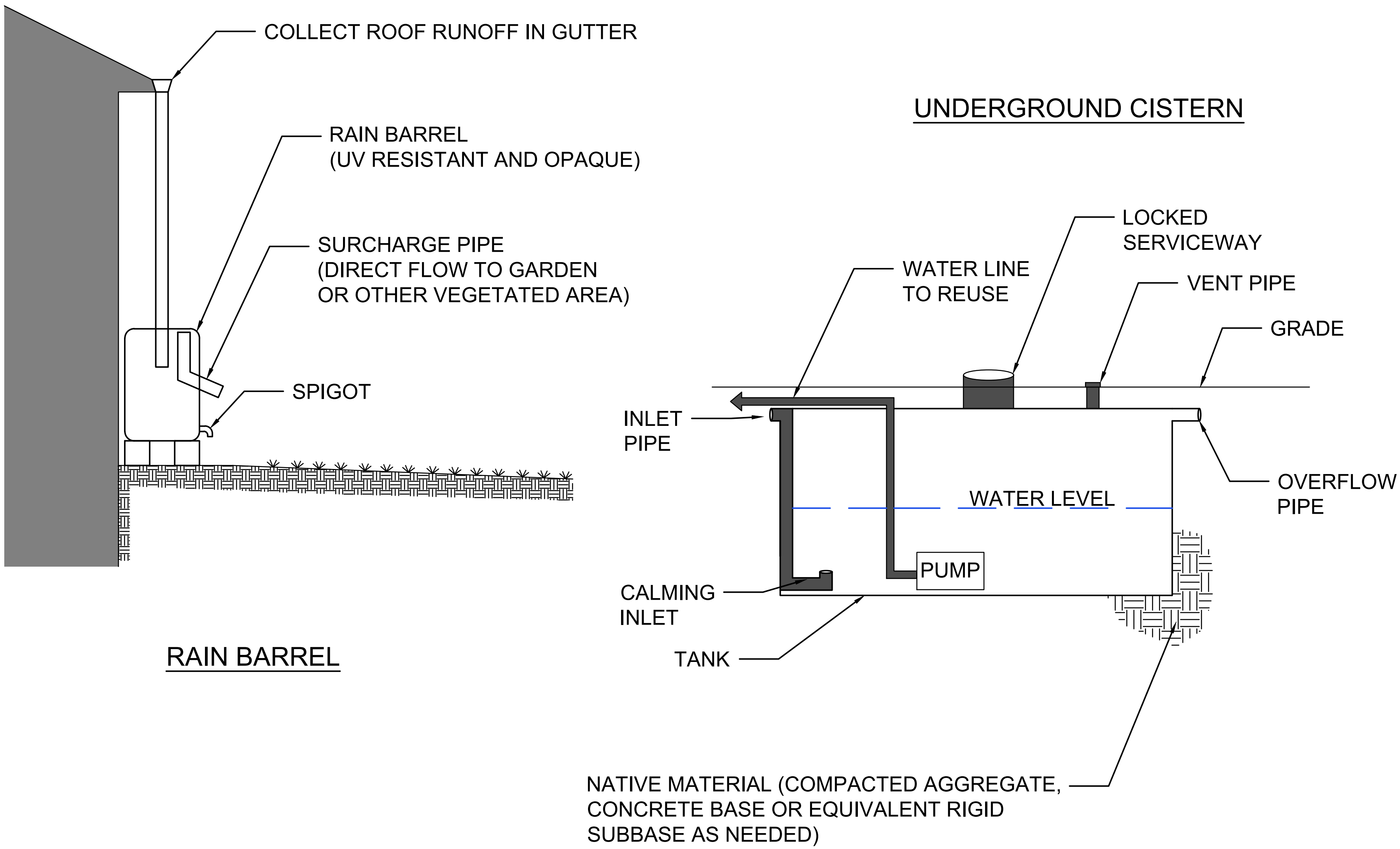
Design Guidance *[considerations for good practice]*

- Cisterns shall be designed to sit on sufficiently compacted material to bear the load of a full storage tank. May consider concrete base or aggregate beneath the cistern.
- Mosquito screening (1 mm mesh size) should be installed at openings to prevent mosquitoes from entering the storage tank.
- Above ground storage tanks should be UV resistant and opaque to prevent algae growth, and protected from sunlight where possible.
- To expand the capacity of a rain barrel or cistern, multiple units can be linked together, or the overflow can be diverted to another practice such as a rooftop disconnection area, swale, or rain garden.
- A first flush diverter may be used to ensure cleaner stored water, especially where the condition of the roof surface is poor (i.e., old or damaged asphalt shingles) or there is an active bird or mammal population on the roof. First flush diverters take the initial flow of

water off of the roof and separate it for discharge to a grassy area and away from the stored water.

Maintenance

- All rainwater harvesting system components should be inspected by the property owner at a minimum in the Spring and the Fall each year to ensure that water is flowing into the practice freely, there are no leaks, and the mosquito screen is in place and in good condition.
- Keep gutters and downspouts free of leaves and other debris.
- Inspect and clean pre-screening devices and first flush diverters (if used).
- Inspect condition of overflow pipes, overflow filter path and/or secondary runoff reduction practices and make adjustments as necessary.
- Inspect tank for sediment buildup and clean out when needed.
- Clear vegetation and trees overhanging the roof..
- Replace damaged or defective system components.
- Rain barrels and cisterns should be emptied regularly to ensure that they have adequate storage available when it rains. In between storms, use the water or allow it to empty into a stable vegetated area.
- **Empty barrel and store upside down (or capped) in winter to avoid damage from freezing. Replace lower section of downspout and diversion device to limit splashing and erosion when barrel is not connected.**



RAIN BARREL OR CISTERN

NOT TO SCALE

Water Bars

Introduction

Water bars intercept and redirect water flowing down driveways or vegetated areas. The water bars allow long sloping areas where water may move quickly and cause erosion to discharge water to stable vegetated areas prior to picking up too much speed. They are commonly used on gravel driveways but can be appropriate in other settings including paved driveways to direct water off of the driving surface to an area where it can be treated or infiltrated.

Minimum Design Requirements

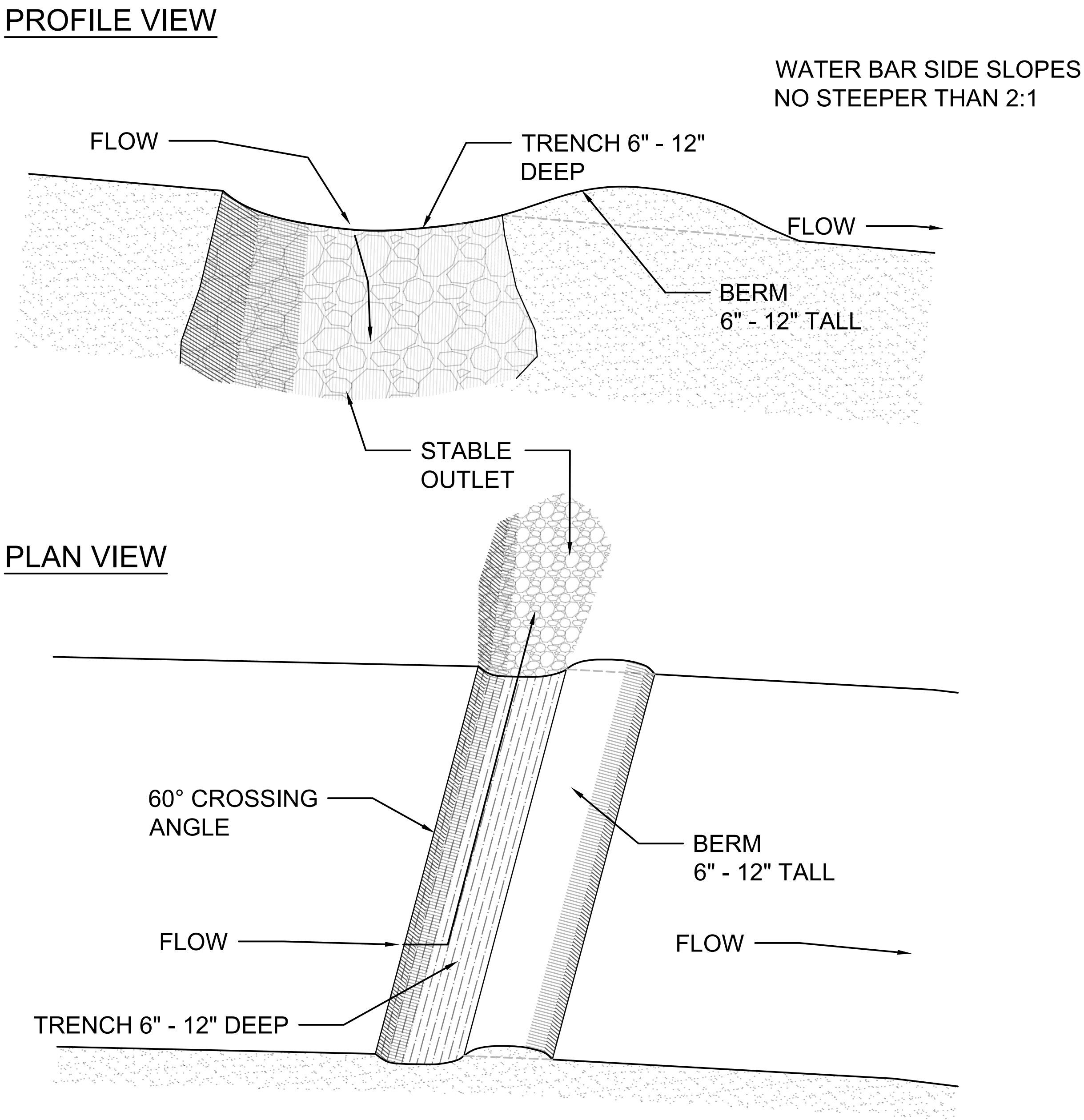
- The grade of the water bar shall not exceed 2%.
- Diverted water must be conveyed to a stable (vegetated or stone lined) area to prevent erosion.
- The side slopes shall be 2:1 or flatter.

Design Guidance: [*considerations for good practice]*

- A crossing angle of approximately 60 degrees is preferred.
- Water bars should have stable outlets, either natural or constructed. Outlet can be reinforced with a flared apron of washed drainage stone.
- For driveways: Excavate the trench 6"–12" below the road's surface. Line the bottom of the trench with fabric and reinforce with a layer of washed drainage stone. Backfill with soil and gravel along the downhill edge of the trench, creating a berm 6"–12" above the road's surface.

Maintenance

- Periodically remove accumulated debris and leaves from behind the water bar.
- Check structure after rainfall and make repairs as needed.
- Watch for erosion at the outlet and stabilize as needed.



WATER BARS
NOT TO SCALE

Vegetated Swale

Introduction

Vegetated swales are shallow open channels lined with vegetation designed to filter, slow, and convey stormwater runoff. While swales can and will infiltrate stormwater, their primary function is the conveyance of water rather than capture and treatment. As a result, a vegetated swales should have a clear location where water will flow and discharge as it reaches the end of the swale.

Minimum Design Requirements

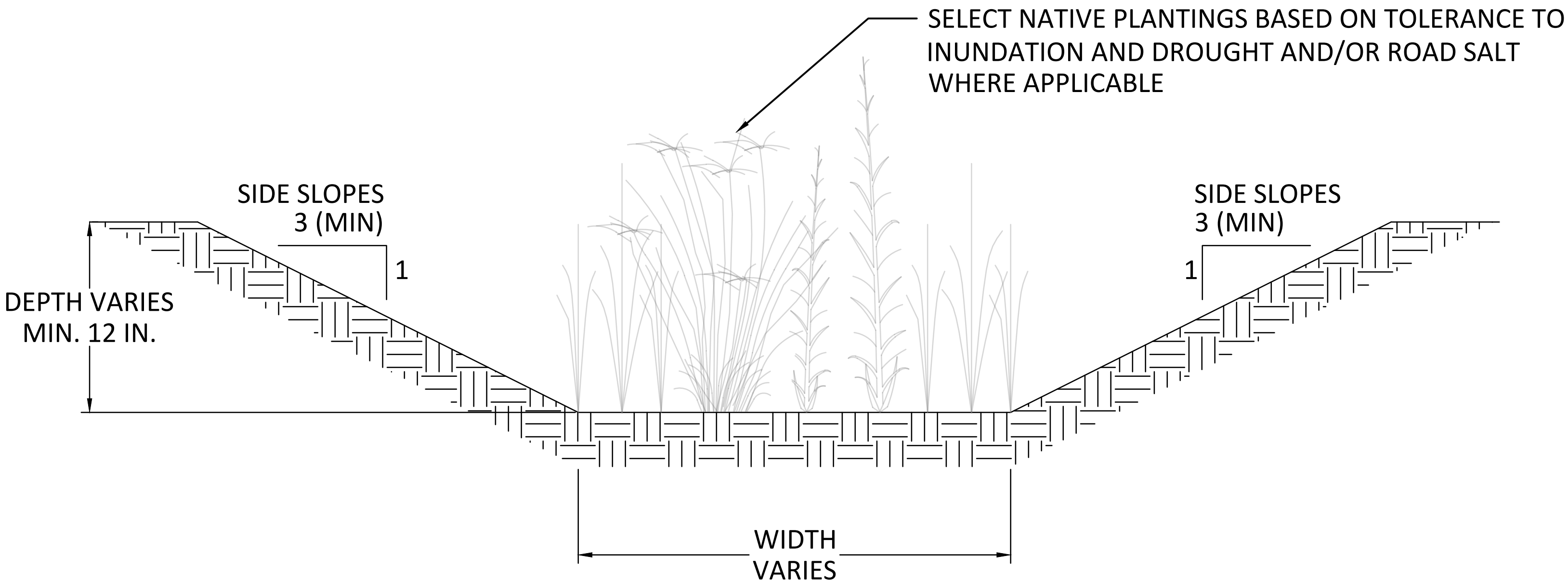
- Swales should be located where stormwater will flow – often along driveways.
- Swale slope should be no greater than 5% without the use of check dams to slow flow.
- Swale bottom should be flat with sloping sides at 3:1 or flatter.
- Swale depth should be ~1/3 the width.
- Armor the entrance to the swale with washed drainage stone to prevent erosion.
- Plant swale with native plants tolerant to wet and dry conditions.
- The outlet of the swale should allow for water to flow to a stable surface and away from infrastructure that could be damaged by excess water.

Design Guidance: [*considerations for good practice]*

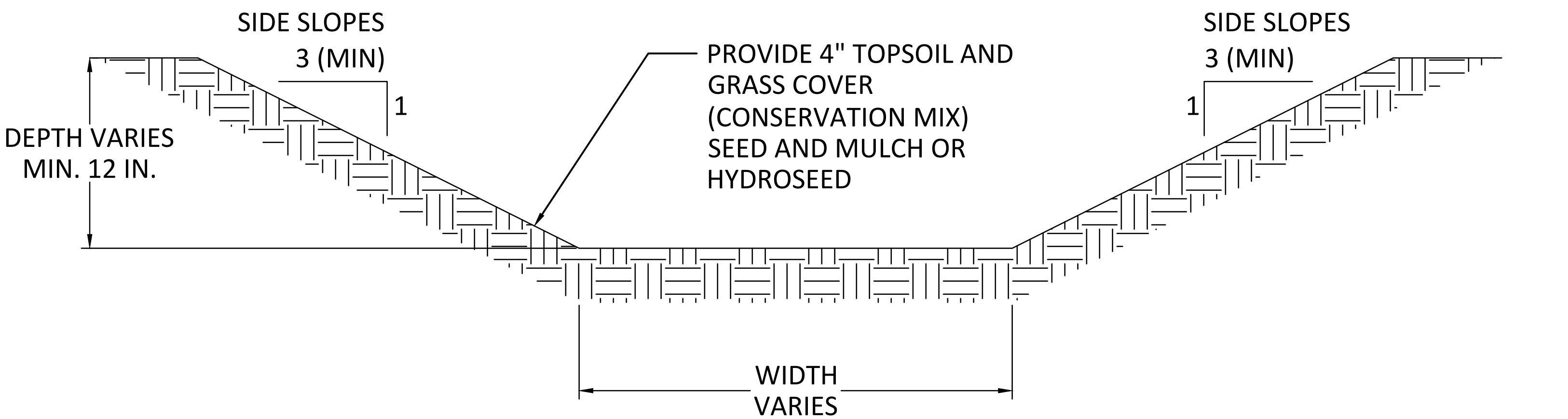
- Consider directing water away from the swale until plants are established.
- A combination of native plants and stones can be used for visual interest.

Maintenance

- Periodically remove accumulated debris.
- Maintain plants seasonally, cutting back dead vegetation, replacing plants that die, and splitting plants as growth continues over several seasons.
- Ensure that the inlet allows water to freely move into the swale.
- Watch for erosion at the outlet and stabilize as needed.



VEGETATED SWALE DETAIL



GRASS SWALE DETAIL

VEGETATED SWALE
NOT TO SCALE

Rooftop Disconnection

Introduction

A connected rooftop is one that directs water directly to a storm sewer system or a solid conveyance channel such as a driveway or roadway where no treatment is possible. Rooftop disconnection is the process of directing rooftop runoff to a vegetated area or treatment device. This often takes the form of turning out downspouts onto a lawn or other vegetated area that were directly connected to a sewer or discharged to a driveway. It is important to take precautions when disconnecting a downspout to prevent erosion or flooding of downhill infrastructure.

Minimum Design Requirements

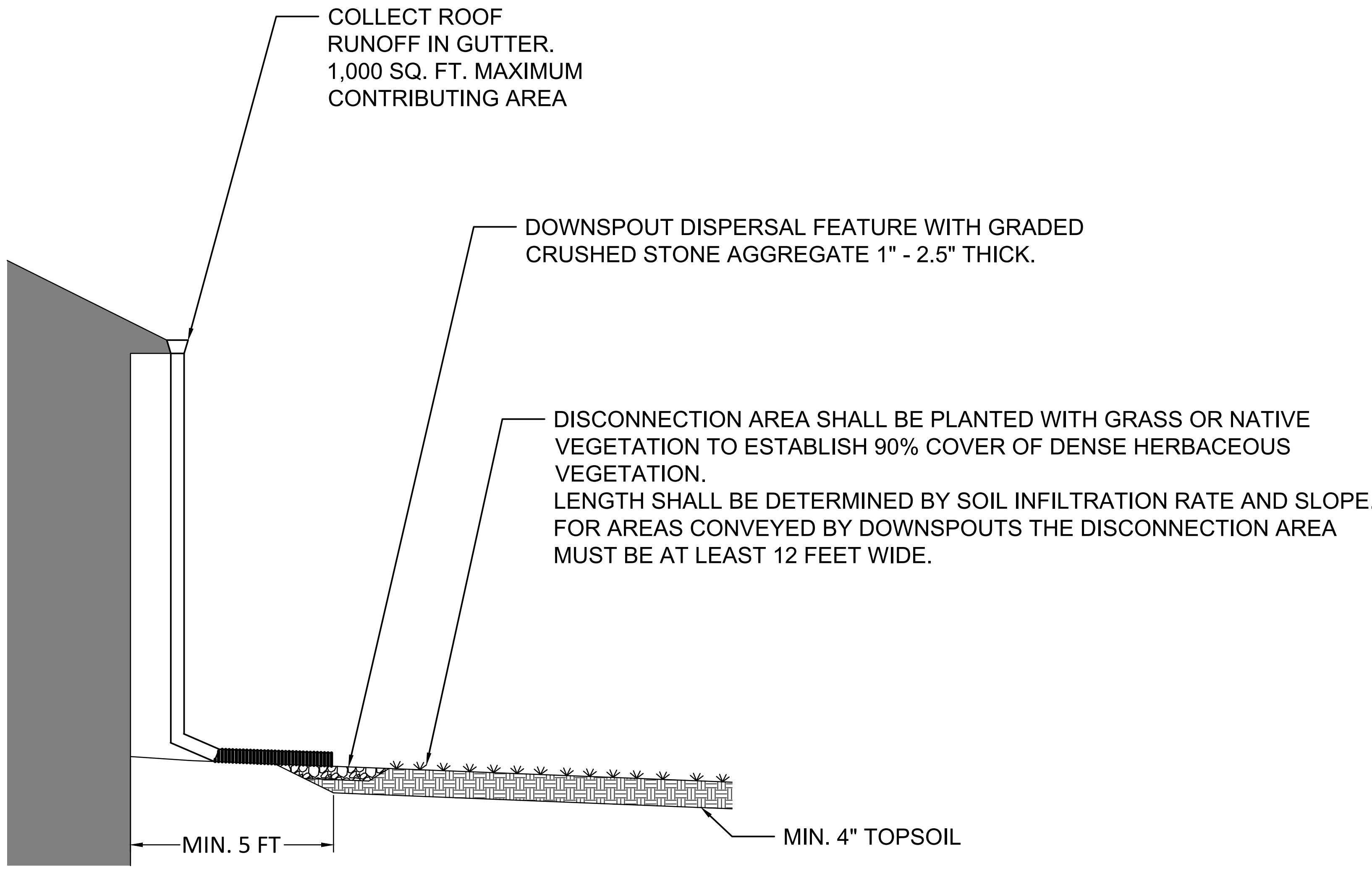
- The area to which the downspout discharges should be stable and not at risk of eroding. An angled flat stone or other splash plate can help reduce erosive force at the exit point and fan out the water.
- If the slope of the area to which the downspout is discharging is greater than 5%, water bars or other methods to slow and spread the flowing water are necessary to avoid erosion.
- If the onsite soils have an infiltration rate of <0.2 in/hour, downspout runoff should be directed to a treatment device.

Design Guidance: [*considerations for good practice]*

- Consider directing flow to mature woody vegetation – trees or shrubs - to increase infiltration.
- Consider installing a screen at the exit of the downspout to discourage rodents from entering.
- Disconnected downspouts can be coupled with infiltration practices such as a vegetated swale, infiltration trench, or dry well to increase infiltration of the runoff. Take care to encourage infiltration at a safe distance from the home foundation.

Maintenance

- Periodically remove accumulated debris and leaves from the exit of the downspout
- Ensure that the slope of the downspout and the land adjacent to it allows water to flow away from the house. Adjust if necessary.
- Clean out gutters in fall and spring to remove debris and avoid clogging.
- Monitor for erosion at outlet and stabilize as needed.



ROOFTOP DISCONNECTION

NOT TO SCALE

Trench Drain

Introduction

A trench drain is an elongated drainage system designed to capture surface water and discharge it to a stable area. Trench drains are common on driveways where sheet flow is captured and rerouted away from roadways, garages, or other structures. The drain is typically outfitted with a rigid grate at the surface over a precast concrete channel where water can flow. Debris can be removed from the drain by lifting the grate for cleaning. The area where the water is discharged should be stabilized and sloped away from structures and roadways to avoid erosion and flooding.

Minimum Design Requirements

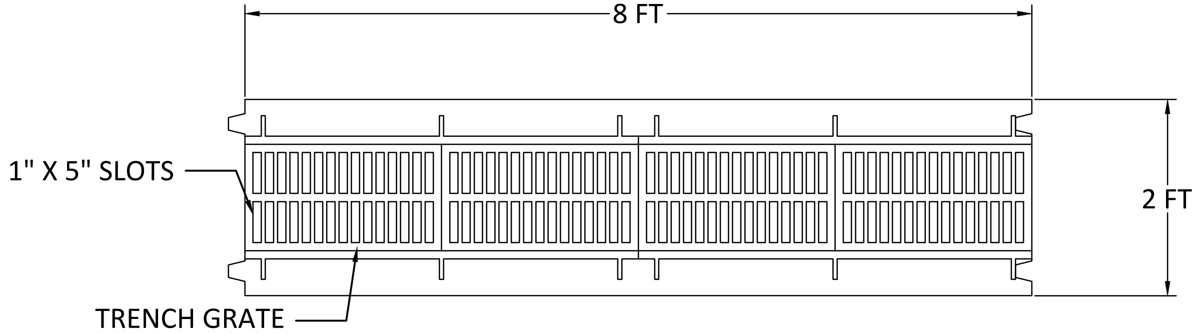
- In areas subject to vehicular traffic, the grate used at the surface must be rated to accommodate appropriate loads. If a trench drain is proposed in a landscaped or sidewalk area not intending vehicular traffic, lighter plastic products are available that would better suit the design.
- The channel should be sized to accommodate the 1” storm from the contributing drainage area to avoid flooding and washouts.

Design Guidance: [*considerations for good practice]*

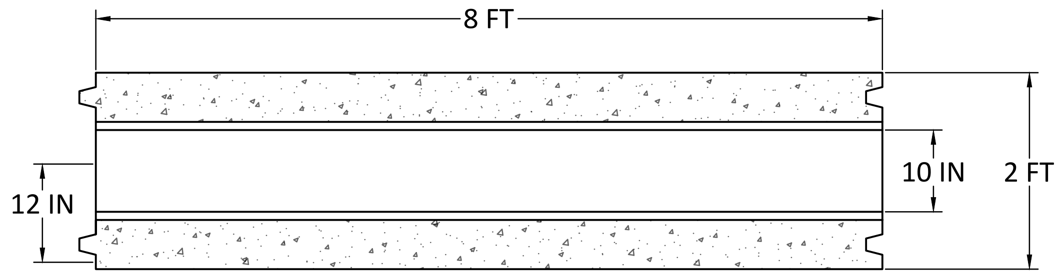
- Gravel driveways can contribute more debris and grit to a drain system. When used in conjunction with loose surface material, additional maintenance and cleaning of the drain may be necessary and should be planned for.

Maintenance

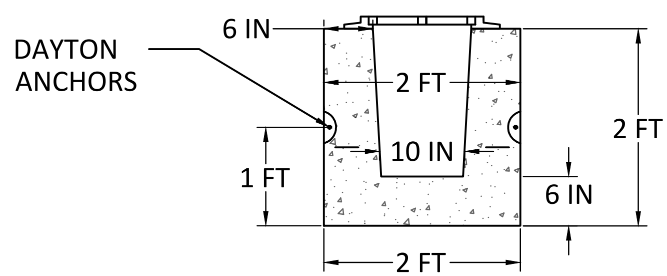
- Remove grate and clean out debris before and after rain events or as needed.
- Ensure a stabilized discharge area.
- Keep the area surrounding the trench drain graded to allow it to capture runoff.



PLAN OF TRENCH COVER



PLAN OF TRENCH BOX



SECTION

THIS SPECIFICATION IS INTENDED FOR USES IN DRIVEWAYS TO WITHSTAND VEHICULAR LOADS. LIGHTER DUTY TRENCH DRAINS MAY BE USED IN LAWNS, LANDSCAPED AREAS, OR SIDEWALKS

DETAIL ADAPTED FROM CAMP PRECAST - 2' X 2' X 8' HEAVY DUTY TRENCH DRAIN GRATE

EQUIVALENT PRODUCTS, AS APPROVED, MAY BE USED

TRENCH DRAIN
NOT TO SCALE

BLUE
BTV