PDHonline Course C316 (4 PDH)

Designing Bioretention Facilities

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Chapter 4
Construction and Inspection

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Construction and Inspection

The effectiveness of bioretention is a function of the design and the construction techniques employed. Of these two parameters, construction is far more critical in achieving quality results. Poor construction technique will cause the best-designed facility to fail prematurely, usually from sedimentation and/or clogging. To counter this problem, adequate and proper inspection is paramount. This chapter covers the basic concepts associated with bioretention construction and inspection. The ***Inspection Points*** interspersed throughout this chapter pertain to the individual section of discussion. It is envisioned that contractors and inspectors for guidance purposes would use these points.

4.1 Permitting and Processing

Typically, the installation of bioretention is a component of the grading and stormwater management permit associated with the subdivision or individual lot. Conceptual stormwater management approval and construction permits have already been obtained by this point and are not covered here. For specific permitting information, contact the Permits and Review Division, Department of Environmental Resources.

Inspection Point: *A pre-construction meeting is required for all sites with an approved stormwater management and sediment control plan. Call at least 24 hours ahead to be sure inspector is present.*

4.2 Erosion and Sediment Control Principles for Bioretention Applications

During the construction phase, sedimentation and erosion problems can be the greatest due to exposed earth, clearing and grubbing operations, and equipment soil compaction. For this reason, erosion and sediment controls are required to contain sediment on-site. For conventional stormwater management site design, this meant that the designer simply had to place a sediment control pond at the lowest point of the property under development. The sediment basin would than be used for stormwater management control after construction was completed. Sites that incorporate bioretention for stormwater control require closer attention to detail because drainage areas are reduced and massive site grading to one low point is discouraged. As a result, grading and sediment control practices are typically applied on a lot-by-lot basis to minimize the opportunity for soil transport. The following principles are identified and briefly explained for the user of this manual. For more specific information, consult the Low Impact Development National Guidelines manual.

Principle 1: Planning and Phasing- PRIOR to construction and even design, proper planning for sediment control is needed for each lot. Bioretention is a source IMP that requires placement within the lot area. Therefore, when laying out the lot, the designer must analyze the topography, existing tree cover to be preserved, the building location and associated set-backs, slope steepness and length, drainage ways, and soil types.

Finally, vertical and horizontal distances from the proposed building locations to the bioretention area must be adequate to prevent seepage problems (see Chapter 2).

Principle 2: Schedule of Operations- Expose the smallest practical area of land for the shortest possible time.

Inspection Point: *All sediment control devices must be in place prior to start of the main construction. At the end of each workday, inspect the devices to be sure of their adequacy and safeguard any trenches or excavations. Provide temporary stabilization for disturbed areas as quickly as possible or as directed by the inspector. Areas that have been disturbed and are not actively being worked, as well as areas that are on final grade, must be stabilized within 14 days.*

Fig. 4.1: Silt fence around bioretention

Principle 3: Soil Erosion Control- First line of defense against contamination of the bioretention area. This would include the installation of on-lot silt fences, diversion swales, stabilization and runoff control techniques.

Inspection Point: *Make sure that silt fencing is properly keyed into the ground to prevent undermining. See Standards and Specifications for Soil Erosion and Sediment Control for guidance.*

Principle 4: Sediment control- Even with the best erosion control techniques, sediment transport will occur. For this reason, on-lot sediment traps and/or super silt fence control practices are recommended.

Principle 5: Inspection and Maintenance- Erosion and sediment control practices must be inspected and maintained on a routine schedule. Accumulated sediment must be removed on a periodic basis, and inspected for excessive accumulation after every major storm. Particular attention should be paid to the stabilization of disturbed areas and integrity of the sediment control devices.

Inspection Point: *All sediment traps must have room for additional sediment loading capacity. Proper disposal of removed sediment is imperative to reduce the probability of downstream contamination.*

Sedimentation Rates for Bioretention- Although no specific sedimentation studies have been done on bioretention to determine the rate of accumulated sediment, estimated vertical-settling rates may be derived from Stokes Law. Sedimentation rates will vary significantly and are a function of the following factors:

- Soil particle size distribution and load of the influent (affected by land use activities)
- Retention time in the ponded area (3-4 hour downdraw time)
- Physical features of the bioretention facility surface and resulting flowpath length
- Surface area
- Water temperature affecting fluid viscosity
- Wind resuspension (minimal affect)

4.3 Construction Technique and Sequencing for Bioretention

4.3.1 Site Preparation and Planning

First and foremost, the erosion and sediment control principles itemized above must be followed to insure sediment will not affect the facility. In the planning and lot layout phase, the potential bioretention locations are identified. Two types of sediment control techniques are typically applied to bioretention facilities.

One method (most typical) is to avoid disturbing the proposed bioretention area after the initial rough grading and temporary stabilization has been performed. During the construction phase, all drainage must be directed away from the facility location to avoid excessive sedimentation. Flow can be directed away from the bioretention facility by utilizing silt fencing materials and temporary diversion swales that direct flows to small on-lot silt traps.

The other method of erosion and sediment control design applicable to bioretention is to allow the area proposed for the bioretention facility to be used for the installation of a sediment control facility. This can be done even where the in-situ soils are used without the benefit of an underdrain system. However, if a sediment control facility is to become a bioretention facility, the following conditions must be met:

- The first condition is that the proposed invert of the bioretention facility must be greater than 1 foot below the sediment control facility invert.

- The second condition is that all remnant sedimentation shall be removed.

- The third condition is that if geotechnical tests show that the in-situ soils meet or exceed the soil medium guidelines for infiltration rates, no underdrain will be required, although it is still highly recommended.

- The fourth condition is that the in-situ soils and ponded sediment materials shall be removed and the remaining surface scarified to increase the likelihood of adequate infiltration potential.

4.3.2 Minimize Lot Grading/Clearing

Bioretention facilities should be located within the development envelope, minimizing the need to clear areas unnecessarily. Bioretention areas may make use of existing wooded areas, without grading the wooded area to install the facility. Grading of any catchment area draining to the facility should be done sparingly and stabilized immediately (within 14 days).

4.3.3 Install Sediment Control Devices

Utilizing the approved sediment and erosion control plans, install necessary sediment control devices to protect the facility from contamination by sediment. Essentially, placement of silt fence material around the perimeter should be sufficient to prevent flow entering the area during construction.

4.4 Bioretention Soil Mix Preparation

4.4.1 Offsite Preparation

Soil preparation can be performed offsite and transported to the facility location when ready for installation. Prior to transport, the soil mix must be certified as meeting the criteria established for the soil medium and approved by the site inspector.

Inspection Point: *A certification of the soil shall be supplied upon request to the County Inspector.*

Soil preparation can be accomplished by thoroughly mixing soil components, amendments and additives, as needed utilizing a backhoe or front-end loader. See soils section for specific details and specifications for soils.

4.4.2 In-situ Preparation

In-situ (or in-place) soil used for bioretention must also be prepared. Scarification of soil surfaces by manually raking to aerate and reduce soil compaction is recommended. When in-situ soils are being used without underdrain systems, soils investigation/geotechnical reports are required.

Inspection Point: *A copy of the geotechnical report shall be supplied to the inspector at the preconstruction meeting. The report shall include the boring location at the bioretention facility and include USDA soil classification, boring log with penetration depths at least 2' below the proposed facility invert, depth to groundwater or impervious layer (if present), and infiltration rate of the in-situ soil.*

4.5 Timing

A bioretention facility shall not be placed in service until all of the contributing drainage area has been stabilized and approved by the inspector. Provisions for sediment control shall be in-place as specified within the sediment and erosion control plans.

4.5.1 Materials Delivery

Delivery of materials such as soil medium, plants, gravel, geotextile, and underdrains will need to be coordinated to avoid stockpiling and contamination problems. Soil materials should not be delivered until the bioretention facility location has been excavated or graded to the design elevations and geotextile fabrics and underdrain systems are in place. Planting materials should not be delivered until after the soil medium has had time to settle and trimmed to the proper grade elevation. Weather and seasonal conditions will also affect planting requirements. See Chapter 3 for specific information on planting requirements.

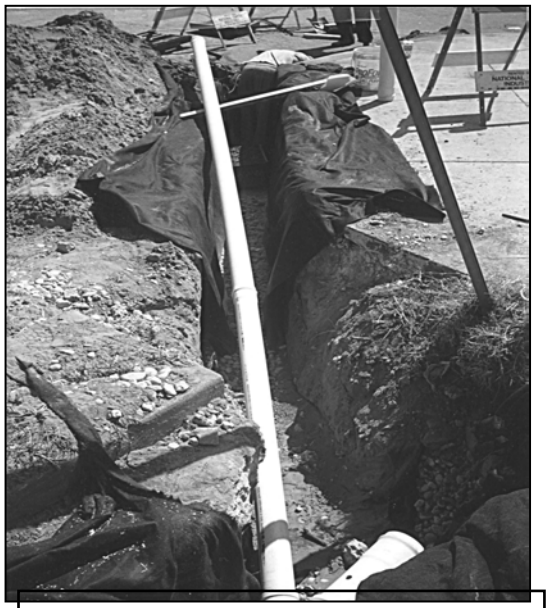

Fig. 4.2: Installation of underdrain

4.5.2 Inspection

Prior to installation of soil medium, underdrain system, geotextile fabric and planting material, the County inspector must approve that the excavation has been prepared properly.

4.6 Excavation Preparation

Excavate the facility to the design dimensions. Excavated materials shall be placed away from the facility sides to avoid contamination and possible sidewall instability. Large tree roots must be trimmed flush with the side walls in order to prevent fabric puncturing or tearing during subsequent installation procedures. The sidewalls of the trench shall be roughened where sheared and sealed by heavy equipment.

4.7 Underdrain Specification

Where underdrains are specified, the following information provides guidance for underdrain installation.

4.7.1 Underdrain Material Types

Underdrain systems may be composed of a variety of materials, with PVC pipe material being the most commonly used. PVC pipe comes in 8-12' sections. Alternative pipe

material may include flexible ADS pipe. Other pipe materials may be substituted at the designer's prerogative and with concurrence of the County.

4.7.2 Connections

Pipe joints and storm drain structure connections must be adequately sealed to avoid piping conditions (water seeping through pipe or structure joints). Pipe sections shall be coupled using suitable connection rings and flanges. Field connections to stormdrain structures and pipes shall be sealed with polymer grout material that is capable of adhering to surfaces. Underdrain pipe shall be capped (at structure) until completion of site.

4.7.3 Perforations

Perforated PVC pipe sections are available from local hardware stores. The perforation locations are not too critical for proper function, as long as the total opening area exceeds the expected flow capacity of the underdrain itself. Commonly marketed perforated PVC pipe has ¼ or ½" perforations, 6" center to center, along two or three longitudinal rows. Whether or not the perforations are placed at the invert of pipe or elsewhere, depend upon the design of the facility. Typically, the perforations are placed closest to the invert of the pipe to achieve maximum potential for draining the facility. The perforations can be placed near the top of the pipe if an anaerobic zone is intended. Water below the perforated portion of the underdrain will have a tendency to accumulate during periods of saturation. Otherwise, water will have a tendency to infiltrate into the surrounding insitu soils. See specifications table for specifics relating to underdrain perforations.

Fig. 4.3: Installed underdrain pipe

4.7.4 Location

Underdrains are typically located at the invert of the bioretention facility to intercept any filtered water that does not infiltrate into the surrounding soils. Soil and gravel cover over the underdrain shall be at least 2' in depth. Placement of 2-3" gravel bedding is recommended beneath the discharge points- Underdrains must "daylight" or connect to an existing drainage system to achieve positive flow. Suitable discharge points include:

- Grass swale areas, flush cut with sideslope areas
- Stormdrain pipe conveyance system

Inspection Point: *Prior to covering the underdrain system, the inspector must observe the underdrain itself, the connections, gravel bedding, and any filter fabric.*

Manufacturer's tickets are required for the gravel, pipe, and filter fabric material. References can be made to the County's Approved Manufacturers and Suppliers List.

4.8 Observation/Cleanout Standpipe

An observation/cleanout standpipe shall be installed in every bioretention facility that has a depth greater than 2' and/or an underdrain system. The standpipe will serve three primary functions: 1) it will indicate how quickly the bioretention facility dewaters following a storm; 2) it provides maintenance cleanout port; and 3) it will be connected to the underdrain system to facilitate cleanout.

The observation well must consist of a rigid non-perforated PVC pipe, 4 to 6 inches in diameter. It should be located in the center of the structure and be capped flush with the ground elevation of the facility. The top of the well shall be capped with a screw, or flange type cover to discourage vandalism and tampering. Lock is not necessary.

4.9 Filter Materials

4.9.1 Gravels

Gravel bed materials are sometimes used to protect an underdrain pipe to reduce clogging potential. Placement of the gravel over the underdrain must be done with care. Avoid dropping the gravel high levels from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually. The construction specifications for gravel used to protect bioretention underdrains follows:

- Gravel stone size shall be no greater than ½"-1½" in diameter. (Blue stone, double washed, #57 stone)
- The use of "pea gravel" in place of geotextile fabric is optional, but preferred
- Depth of the gravel shall not exceed 12"
- River-run, washed gravel is preferred.

Fig. 4.5: Installation of filter fabric and soil medium

4.9.2 Pea Gravel Diaphragm

Older specifications for bioretention utilized a geotextile fabric to filter water and soil before passing through to the underdrain gravel blanket. The use of a pea gravel diaphragm has gained acceptance because of the reduced likelihood of blockage. If a pea gravel diaphragm is used in this manner, it should have a minimum thickness of 3-4" and a maximum thickness of 8". Where situations permit, a greater depth may be applied.

4.9.3 Filter Fabric

Filter fabric is needed for two purposes in bioretention facilities: 1. Controlling transport of silt, and 2. Controlling the direction of flow. In some older designs, the filter fabric placed on top of the gravel bed is used to control sediment transport into the gravel bed, which otherwise may become clogged. This filter fabric must meet a minimum permittivity rate of 75 gal/min/ft^2 and shall not impede the infiltration rate of the soil medium. Filter fabric may be placed along the "walls" of the facility to help direct the water flow downward and to reduce lateral flows. Filter fabric must be placed along the sidewalls, (from the subgrade and over the stone) when installing a facility in a median strip or parking lot landscape island.

Inspection Point: *All filter fabric & liner types must be pre-approved by the inspector prior to installation. Non-woven fabric is preferred over the woven variety. Filter fabric installation requires at least 1-foot overlap at the ends and staking in-place during construction at the turned up surfaces. After soil is placed over the filter fabric, excess fabric may be removed by cutting along desired elevations. See approved suppliers list.*

4.9.4 Liners

Where bioretention is used for areas that require groundwater protection (stormwater hot spots or source water protection), a liner is employed. The minimum thickness for liners used in bioretention applications shall be 30 mil. Any underdrain systems shall be placed above the liner with a provision to cap the underdrain discharge pipe to confine drainage if needed. Care during placement of the liner is necessary to avoid puncture. Soil medium placed over the liner should be placed by hand shovel rather than construction equipment.

4.10 Soil Installation

4.10.1 Placement

Installation of soils must be done in a manner that will ensure adequate filtration. After scarifying the invert area of the proposed facility, place soil at 8"-12" lifts. Lifts are not to be compacted but are performed in order to reduce the possibility of excessive settlement. Lifts may be lightly watered to encourage natural compaction.

4.10.2 Compaction

Avoid over compaction by allowing time for natural compaction and settlement. No additional manual compaction of soil is necessary. Rake soil material as needed to level out. Overfill above the proposed surface invert to accommodate natural settlement to proper grade. Depending upon the soil material, up to 20% natural compaction may occur. For facilities designed with a liner, no scarification of the invert area is required.

Inspection Point: *Minimal compaction of soil may be performed using mechanical equipment (such as a backhoe bucket) to reduce the possibility of excessive settlement. Removing overfill is easier than adding soil when attempting bring the facility surface to the correct elevation.*

4.11 Soil Presoak

In order to speed up the natural compaction process, presoaking the placed soil may be performed. Significant settlement can occur after the first presoak, and additional settlement may occur subsequent to the initial wetting. If time and construction scheduling permits, it is preferable to allow natural settlement to occur with the help of rain events to presoak the soil medium.

Inspection Point: *The surface of the facility does not necessarily need to be uniform. A slight variance due to settling or mulching application is acceptable as long as the possible ponding depth does not exceed 6". For areas where excessive settlement occurs, apply sand to fill spots and cover with mulch as needed.*

4.12 Plant Preparation and Planting Methodology

4.12.1 Ordering

When ordering plants to be installed in a bioretention facility, adequate preparation of the bedding soils must occur prior to delivery. Timing in relation to season and readiness of the facility is paramount. Recommended ordering times are early spring or fall, depending upon the species selected.

4.12.2 Stockpiling

Often times, plant materials need to be stockpiled while the facility is being prepared. Keeping root balls wet during this period, and providing a shaded storage location will help the plants survivability.

Fig. 4.6: Natural compaction and settlement is recommended

4.12.3 Shipping

Shipping of the plant materials is typically the responsibility of the nursery or landscaping contractor. It is preferable to have the plants shipped directly to a facility site ready for planting.

4.12.4 Tags

All plant materials shall be tagged for identification in accordance with the American Standard for Nursery Stock.

Inspection Point: *Tags shall be checked by the inspector for compliance with landscaping planting list shown on the stormwater design plans. Variations of plant type, size, quantity, or quality, requires DER approval and may necessitate a plan revision submittal.*

4.12.5 Density

The initial density of the planting arrangement will be thick. This is to ensure adequate vegetative cover will quickly take hold. Once the plants continue to grow and spread out, some plants may be removed or divided by the property owner and transplanted elsewhere in the yard. For specific density information, refer to the landscaping section of this manual.

4.12.6 Timing

Transport and transplanting operations must be done at the appropriate time of the year and in sequence with construction activities to ensure survivability.

Fig 4.7: Same island- before, during and after construction

4.13 Installation of Mulching Materials

4.13.1 Placement

Mulch should be placed on the surface ponding area of the facility. The mulch material should be fresh, shredded hardwood to help retain soil moisture and maximize nutrient uptake. This type of mulch material also helps resist flotation when facility is fully ponded. If "aged" mulch is used, select the shredded type over the chip variety to minimize floatation and wash-outs.

Inspection Point: *The mulch layer should be placed after the plants and groundcover have been installed. Protect and lift groundcover vegetation to place mulch material underneath and in between plantings. The mulch layer surface should approximate the final elevation as shown on the design plans.*

4.13.2 Mulch Cover Depth

While studies have shown that the mulch layer is an important component for water quality, the layer of mulch should not exceed 3" in depth. Greater depths keep plant roots from making good contact with the soil. Mulch materials should not be mounded around the base of tree trunks as this practice encourages pests and diseases.

4.14 Maintenance and Operation

4.14.1 Fertilizing

In traditional, intensively cropped landscapes, soil fertility (and especially the level of available nitrogen) is considered the limiting factor to plant growth. As already noted, however, human actions have considerably altered the cycling of nitrogen. By design, Bioretention facilities are located in areas where nutrients (especially nitrogen) are significantly elevated above natural levels. Therefore, it is unlikely that soil fertility will be the limiting factor in plant growth, and thus fertilization would be unnecessary. Excess fertilization, (besides compromising the facility's pollutant reduction effectiveness) leads to weak plant growth, promotes disease and pest outbreaks, and inhibits soil life.

Fig 4.8: Completed Colmar Manor bioretention facility

If soil fertility is in doubt, a simple soil test can resolve the question. Homeowners may consult with their local nursery or contact the local agricultural extension office to determine fertility needs. If fertilization should become necessary, an organic fertilizer will provide nutrients as needed without disrupting soil life.

4.14.2 Harvesting

Like any garden area that includes grasses or woody plant materials, harvesting and pruning of excess growth will need to be done occasionally. Trimmed materials may be recycled back in with replenished mulch material, or land filled in the case of hot spot locations.

4.14.3 Watering

Typically, watering of the facility will not be necessary once plants have become established, except during drought conditions. Plant species for bioretention have been selected based on their hardiness and ability to survive extreme conditions. However, watering will be needed during the plant establishment stage. As with any landscaping feature, the designer should consider affects on moisture condition and the ability of the owner to apply watering as needed. Facilities susceptible to drying conditions include:

- Landscape parking lot islands
- Median areas
- Windy, exposed areas

Inspection Point: *Watering and maintenance responsibilities during different phases of a project shall generally be defined as follows, unless contractual obligations require otherwise:*

- Construction Phase: Developer/Builder
- Project Acceptance: Builder
- Property Ownership Transfer: Builder/Property Owner
- Warrantee Phase: Property Owner
- Operation Phase: Property Owner

4.14.4 Weeding

Weeding of the facilities is not absolutely necessary for the proper functioning of the bioretention facility. However, unwanted plants can be invasive, consuming the intended planting and destroying the aesthetic appeal. Therefore, weeding is encouraged to control growth of unwanted plants, especially where facilities are placed in prominent settings.

4.15 Warrantees

The landscaping work and materials shall be guaranteed for one year from the date the permit is finalized (close-out). Watering during this period is the responsibility of the property owner.

Inspection Point: *The warrantee period begins when the as-built construction plan is approved. Landscape bonds will be released upon final landscape acceptance by the inspector. It is the bondee's obligation to notify the County for a final landscape inspection request and subsequent release of landscape bond. In the case of bioretention, landscaping is bonded under the storm drain permit.*

4.16 Typical Sequence of Construction for Bioretention

The sequence of construction for bioretention areas is closely tied to the grading plans for the development. Because bioretention is a source control IMP, drainage area catchments are kept relatively small and therefore, manageable during the construction phase for

control of sediment. Basic sediment control practices are employed for each lot. For a typical bioretention sediment control plan, see Chapter 2.

A typical sequence of construction with typical construction schedule is provided at the end of this chapter (page 4-17). The sequence of construction will vary for every project but the designer may utilize this sequence of construction as a general guide. Variations to the sequence must be noted and conveyed to the County inspector. The sequence of construction shall be place on the plans.

4.17 Inspectors Checklist for Bioretention

The following checklist has been derived and modified from a checklist developed by the Community Standards Division, Site Development Inspection Section for use when evaluating a bioretention facility during different phases:

4.17.1 Bioretention Inspection Checklist

1. Pre-construction Meeting

- Approved Stormwater Management Plan
- Disseminate inspection requirements; what needs inspection
- Ticket and tag requirements & a copy of the geotechnical report (if available)

2. Excavation of Bioretention Area

- Suitable sub-grade materials
- Presence of moisture or water
- Dimensions and placement of excavation conforms with plans
- Sediment and erosion control devices in place

3. Installation Phase

- Optional sand layer placed per plan
- Backfill soil conforms with specifications and placed per details and specifications
- Correct placement of ground cover or mulch cover
- Correct placement of underdrains (size, schedule, location) where required
- Correct placement of filter fabric
- Proper placement of plant materials (type, size, quantity, tags)
- Proper grade establishment

4. Final Inspection and As-Built

- Original signed/sealed Certification Letter (for private facilities) and/or As-Built Plan (for public facilites) from a Maryland Registered Professional Engineer
- Changes in grading, facility depth, size, soil medium, plant materials, etc., shall require an As-built Plan whether private or public to reflect the changes.

- Maintenance Agreement/Covenant for bioretention facilities located on private property
- All landscaping installed/landscape warrantee documentation received
- Bioretention configuration, size and depth are in accordance with approved plans
- Landscaping certification documentation for bioretention facility(ies)
- Drainage area conforms to approved plan
- Drainage area completely stabilized

Note: Use and Occupancy Permits will not be issued by the Building Inspector for lots with bioretention without first obtaining written approval from the Site Development Inspector, with certifications from the builder.

Sequence 0f Construction For Bioretention

1. Install sediment control devices as shown on the plans.
   -Construction time: 1/2 Day

2. Grade site to elevations shown on plan. If applicable, construct curb openings, and/or remove and replace existing concrete as specified on the plan. Curb openings shall be blocked or other measures taken to prohibit drainage from entering construction area. At the end of each workday, all excavations shall be protected by construction safety fencing or temporary backfill as needed.
   -Construction time: 1 Day

3. Stabilize grading within Limit of Disturbance except for Bioretention Area. Bioretention areas may be utilized as sediment traps *if* the proposed invert of the bioretention facility is 1' lower then the sediment trap.
   -Construction time: 1/2 Day

4. Excavate bioretention area to proposed invert depth and scarify the existing soil surfaces, taking care not to compact the in-situ materials.
   -Construction time: 1/2 Day

4a. Install underdrain system and observation wells, if specified
   -Construction time: 1/2 Day

5. Backfill bioretention area with planting soil as shown in the plans and detailed in the specifications. Overfilling is recommended to account for settlement.
   -Construction time: 1/2 Day

6. Presoak the planting soil prior to planting vegetation to allow for settlement. This can be down by water truck or allowing water to enter the pit from a rain event.
   -Construction time: 1/4 Day

7. Excavate or fill to achieve proper design grade, leaving space for the upper layer of mulch and/or topsoil that will bring the surface to final grade and ready for planting.
   -Construction time: 1/4 Day

8. Plant vegetation specified in the planting plan for Bioretention Area.
   -Construction time: 1/2 Day

9. Mulch and install erosion protection at entrance points; remove sediment control practices or entrance blocks with inspector authorization.
   -Construction time: 1/2 Day

Total Estimated Construction Time – 5.0 Days

Note: The times above represent construction time only and not the full duration of the individual activities. For example, activity six (presoak) may be one month long allowing for natural settlement to occur before proceeding to activity 7.