4.5. Bioretention (rain gardens)

Bioretention

Bioretention areas typically are landscaping features adapted to treat storm water runoff. Bioretention systems are also known as Mesic Prairie Depressions, Rain Gardens, Infiltration Basins, Infiltration Swales, bioretention basins, bioretention channels, tree box filters, planter boxes, or streetscapes, to name a few. Bioretention areas typically consist of a flow regulating structure, a pretreatment element, an engineered soil mix planting bed, vegetation, and an outflow regulating structure. Bioretention systems provide both water quality and quantity storm water management opportunities.

Bioretention systems are flexible, adaptable and versatile storm water management facilities that are effective for new development as well as highly urban re-development situations. Bioretention can readily adapt to a site by modifying the conventional "mounded landscape" philosophy to that of a shallow landscape "cup" depression. Such landscape depression storage and treatment areas fit readily into: parking lot islands; small pockets of open areas; residential, commercial and industrial campus landscaping; and, urban and suburban green spaces and corridors.

Bioretention works by routing storm water runoff into shallow, landscaped depressions. These landscaped depressions are designed to hold and remove many of the pollutants in a manner similar to natural ecosystems. During storms, runoff ponds above the mulch and Engineered Soil Mix in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The runoff remaining in the bioretention facility filters through the Engineered Soil Mix. The filtered runoff can either be designed to enhance groundwater infiltration or can be collected in an underdrain and discharged per local storm water management requirements.

DRAFT

Key elements:

- Storm water management design intended to replicate a site's pre-developed natural hydrologic processes through runoff storage and filtration.
- Flexible in size and configuration; can be used for a wide variety of applications. Can be used for Water Quality Volume (WQv) requirements for most local ordinances.
- Water Quality and Quantity volume that drains down in no more than 72 hours.
- Engineered Soil Mix that provides storm water treatment through filtration while enhancing plant growth.
- Native and/or ornamental vegetation that provide evapotranspiration of storm water, pollutant filtration, and an aesthetically designed landscape area.
- Flood control bypass system for runoff in excess of designed filtration capacity.
- Maintenance of Engineered Soil Mix and vegetation is required.

Highlights:

- Contributes to enhanced air quality, water quality and can assist in directly reducing urban heat island impacts.
- Can improve property value through attractive landscaping.

Effectiveness

- Structural storm water management practices such as bioretention can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Bioretention systems tend to behave similarly to swales; their pollutant removal rates are relatively high.

SEATTLE STREET EDGE ALTERNATIVES (SEA)

Table 4.5.1: Biorention Potential Application and Storm Water Regulation

Potential applications		Storm water regulations		
			Infiltration	No Infiltration
Residential Subdivision:	Yes	Water Quality Benefit	Yes	Yes
Commercial:	Yes	Water Quantity Benefit	Yes	Yes
Ultra Urban:	Yes	Volume Reduction	Yes	Yes
Industrial:	Yes	Attenuation Benefit	Yes	Yes
Retrofit:	Yes	Level of Benefit dependent on design criteria		
Highway Road:	Yes			

PRE-TREATMENT IN INDIANAPOLIS CULTURAL TRAIL BIORETENTION (ALABAMA STREET)

Acceptable forms of pre-treatment

- Energy dissipation to prevent erosion and scour of BMP.
- Pretreatment pollutant removal areas for concentrated collection of trash, debris, sediment, and other suspended and dissolved pollutants.

DRAFT

Bioretention in the Urban Landscape

Bioretention systems are shallow, vegetated depressions used to promote absorption and infiltration of storm water runoff. This management practice is very effective at removing pollutants and reducing runoff volume. Storm water flows into the bioretention area, ponds on the surface, infiltrates into the soil bed, and is used by plants and trees in the system.

OVERFLOW PIPE

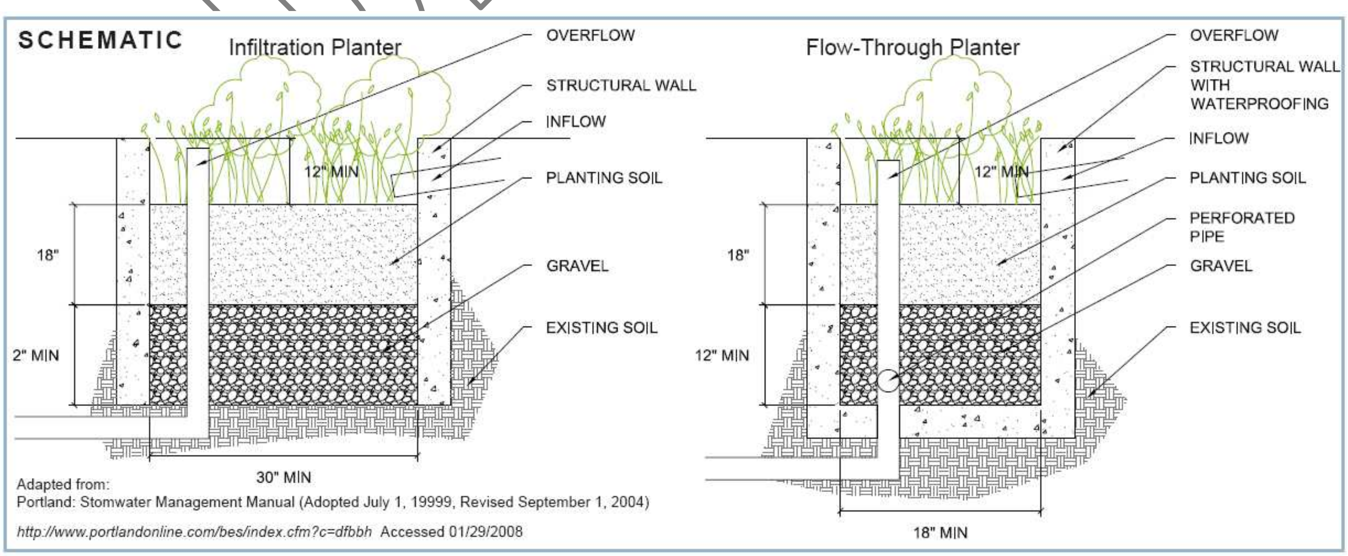
Bioretention areas are suitable for many types and sizes of development, including single-family residential, high-density commercial, and ultra urban re-development projects. Bioretention areas are generally relatively small landscaped areas that can be integrated throughout a site to manage all or part of the site's storm water runoff. Flexible and easy to incorporate in landscaped areas, bioretention facilities are ideal for placement in roadway median strips and parking lot islands. They can also provide water quality treatment from pervious areas, such as golf courses, filter strips and other large lawn areas.

In highly urbanized watersheds, bioretention is often one of the few retrofit options that can be cost effectively employed by modifying existing landscaped areas, converting islands or under-used parking areas, or integrating into the resurfacing of a parking lot. Applications of bioretention systems in urban environments include planter boxes, residential, commercial and/or industrial on site landscaping, parking lots, and roadways, which can capture both site and roof runoff. The applications of bioretention systems are not limited to this list; however, examples for each of these alternatives are provided below.

DRAFT

Planter Boxes

A flow-through the planter box is designed with an impervious bottom or is placed on an impervious surface. Pollutant reduction is achieved as the water filters through the soil. Flow control is obtained by storing the water in a reservoir above the soil and detaining it as it flows through the soil. This planter can be used adjacent to a building if the box is properly lined.



Residential On-lot

Landscaped garden areas (rain gardens) can be designed with bioretention systems to create decorative features, habitat, and storm water treatment at a residential site. The design can be as simple as incorporating a planting bed into the lowest point on a site. It is recommended that downspouts be directed into these systems after appropriate pre-treatment.

BIORETENTION INTEGRATED INTO URBAN LANDSCAPE (ALABAMA STREET, INDIANAPOLIS)

Tree Wells

Bioretention principles can be incorporated into a tree well design to create mini- treatment areas throughout a site. Care should be taken to ensure that the Engineered Soil Mix, in-situ soils and ponding area depth is appropriate to the tree size and species.

ALTERNATIVE "STREAM BED" URBAN BIORETENTION

Parking Lots

Parking lots are an ideal location for bioretention systems. Bioretention can be incorporated as an island, median, or along the perimeter of the parking area. Bioretention areas can enhance the aesthetics of a parking lot while managing storm water from the site. Bioretention is an excellent discharge location for parking lot pervious pavement sub-drain seep or direct discharges. Whether by curb cuts, sheet flow or sub-drains, runoff flowing into bioretention must not result in erosive velocities.

DRAFT

Roads and Highways

Linear bioretention basins can be constructed alongside roads or highways, in roadway medians, or in bump-outs that double as traffic calming devices. The system will manage runoff from the street and help to control automotive pollutants. The systems can also help to control roadway flooding.

Commercial/Industrial/Institutional

At commercial, industrial, and institutional sites, areas for storm water management and green space are often limited. At these sites, bioretention systems serve the multiple purposes of storm water management and landscaping. Bioretention areas can be used to manage runoff from impervious site areas such as parking lots, sidewalks, and rooftops.

NATIVE/ORNAMENTAL MIX PARKING ISLAND LANDSCAPING

Typical Components of a Bioretention System

Bioretention systems can be designed to infiltrate all or some of the flow that they treat. The primary components of a bioretention system are:

- Pretreatment
- Flow entrance/inlet
- Surface storage (ponding area)
- Organic layer or mulch
- Engineered Planting Soil Mix filter media
- Vegetation (Native and Ornamental plantings)
- Sand bed or stone filter and underdrain, if required
- Stone storage for additional storage, if needed
- Positive overflow

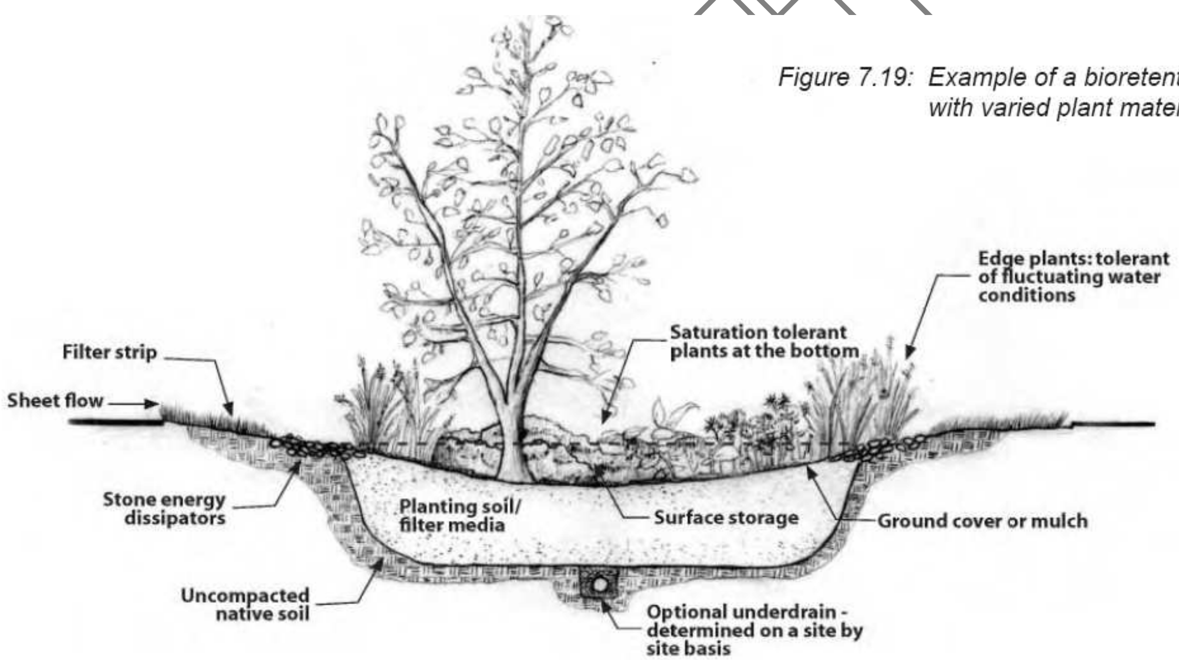


Figure 7.19: Example of a bioretention system with varied plant materials

Pretreatment

Pretreatment is required for all bioretention systems in order to protect the soil-plant system that provides treatment. Pretreatment protects and prolongs the life of the system by reducing sediment and other pollutant loads.

Flow Entrance / Inlet

It is recommended that runoff is conveyed to bioretention areas via sheet flow over a vegetated or gravel filter level spreader strip. This is not always possible due to site constraints or space limitations. On sites where curb removal is not an option or where flow is concentrated by the time it reaches the bioretention area, energy dissipation and equal flow distribution is required. Roof leaders that flow into bioretention areas also require flow energy dissipaters and equal distribution to prevent erosion in the bed.

CURB CUT INLET – INDIANAPOLIS CULTURAL TRAIL BIORETENTION (ALABAMA STREET)

Surface Storage (Ponding Area)

Surface storage provides temporary storage of storm water runoff before infiltration, filtration, evaporation, and uptake (evapotranspiration) can occur within the bioretention system. Ponding time provides water quality benefits by allowing larger debris and sediment to settle out of the water. Ponding design depths are directly related to the Engineered Soil Mix design criteria and are generally limited to a range of 6-inches to 18-inces in order to reduce hydraulic loading of underlying soils, minimize facility drainage time, and prevent standing water.

Engineered Planting Soil Mix and Filter Media

The Engineered Soil Mix provides a medium suitable for plant growth. This designed media acts as a physical filter between the surface storage and the native soil or sub-drainage system. It provides additional storage and a place for biological and chemical pollutant treatment before the water infiltrates into the native soil or sub-drainage system. Storage area is a function of both soil depth and bioretention surface area.

Native and Ornamental Vegetation

The plant material in a bioretention system provides a physical barrier for pollutant filtration and energy dissipation; removes nutrients and storm water pollutants through vegetative uptake; removes water through evapotranspiration; and, creates pathways for infiltration through root development and plant growth. A varied plant community is recommended to avoid susceptibility to insect and disease infestation and to ensure viability. A mixture of groundcover, grasses, shrubs, and trees is recommended to create a microclimate that can improve urban stresses as well as discourage weed growth and reduce maintenance.(Refer to Chapter 5: Storm Water Landscape Guidance) Do not use invasive species as listed by local, state and federal; agencies.

Organic layer or mulch

The organic layer or mulch provides a medium for biological growth, decomposition of organic material, adsorption, and binding of heavy metals. The mulch layer can also serve as a sponge that absorbs water during storms and retains water for plant growth during dry periods. It is recommended that shredded hardwood mulch be utilized to minimize washout from storm water flows.

DRAFT

Stone bed or filter and Underdrain (if necessary)

An underdrain is generally a perforated pipe or protected bed of gravel that collects water at the bottom of the system and conveys it to the system outlet. Underdrains eliminate most infiltration because they provide a preferential pathway for flow. A large diameter rock or gravel filter should surround the underdrain to facilitate flow to the underdrain. The underdrain stone bed should be surrounded by a non-woven, geotextile filter fabric to prevent clogging.

INSTALLATION OF BIORETENTION UNDERDRAIN

Stone Storage (if necessary)

A stone storage layer can be included to provide higher void space storage if needed in addition to the surface and soil storage.

Positive Overflows

A positive overflow must be provided at the maximum ponding depth. When runoff exceeds system storage capacity, the excess flow leaves the system through the positive overflow. If additional storm water controls are required on the site, the overflow can connect to a system that will provide further quantity control. If no additional storm water controls are required, the overflow can be connected to storm sewer or receiving water in compliance with local storm water management requirements.

DRAFT

Design Considerations

Design of bioretention systems is somewhat flexible. The area, depth, and shape of the system can be varied to accommodate site conditions and constraints. The following design procedures are general guidelines that designers can follow.

- Determine the Water Quality and Quantity requirements on the site. See City of Fort Wayne's Development Standards/Criteria Manual.
- Investigate the feasibility of infiltration in the area proposed for bioretention. If infiltration is not feasible, consider an underdrained bioretention system or an alternate location for the bioretention area. If infiltration is feasible, determine the saturated vertical infiltration rate.

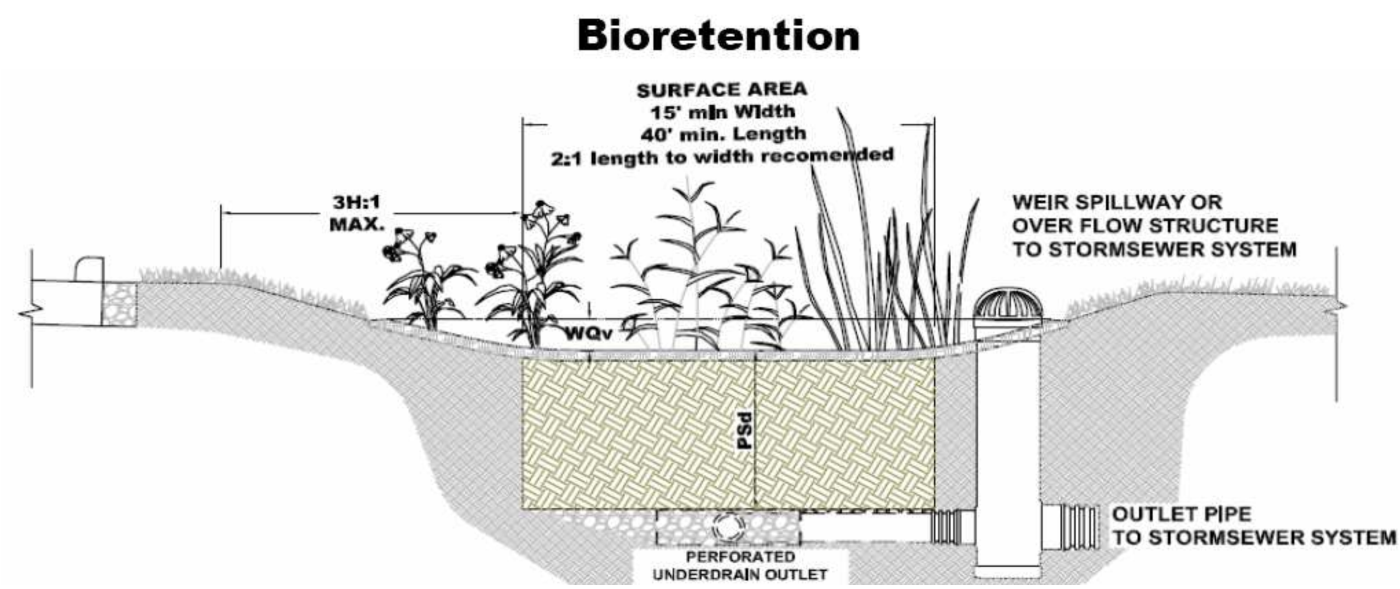
Table 4.5.2: Suggested Starting Design Values for Areas and Depths

Area (surface area and infiltration area)	Largest feasible on site (*sized for expected runoff volume)
Typical Ponding Depth	6-18 inches
Soil Depth	2-4 feet

*Note pond depth may not exceed 3 feet

DRAFT

- Estimate the total storage volume and adjust area and/or depths as needed to provide required storage.
- Estimate how long the surface ponding and soil storage will take to drain based on the infiltration area and the saturated vertical infiltration rate of the native soil. The maximum drain down time for the surface storage volume is 72 hours. If storage does not drain in the time allowed, adjust surface depth, soil depth, and/or surface area. Adjust the design until the volume, drainage time, and site constraints are met.
- Underdrain if necessary.



- Choose plants, trees, and either mulch or seeding appropriate to the site.

Materials

Planting Soil

Refer to Chapter 5: Storm Water Landscape Guidance.

Mulch

Organic mulch shall be aged, double-shredded hardwood bark mulch or composted leaf mulch.

Plants

It is critical that plant materials are appropriate for soil, hydrologic, light, and other site conditions. Select bioretention plants that will survive within the selected zone of ponding, drain down time, sunlight, salt tolerance, and other site specific conditions. Refer to Chapter 5: Storm Water Landscape guidance for plant selection. Although plants will be subject to ponding, they may also be subject to lack of water (drought) especially in areas that get a lot of sunlight or are in otherwise highly impervious areas.

Construction Guidelines and Considerations

- Areas for bioretention shall be clearly marked before any site work begins to avoid soil disturbance and compaction during construction.
- Provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed bioretention location. Proposed bioretention areas may only be used as sediment traps during construction if at least two feet of soil are removed and replaced.
- Complete site elevation grading and stabilize the soil disturbed within the limits of disturbance. Do not finalize bioretention excavation and construction until the drainage area is fully stabilized.
- Excavate bioretention area to proposed invert depth and manually scarify the existing soil surfaces. Do not compact in-situ soils. Heavy equipment shall not be used within the bioretention basin. All equipment shall be kept out of the excavated area to the maximum extent possible.
- If using an underdrain and/or a gravel storage bed, place filter fabric or gravel filter, then place the rock, and set the underdrain according to the plans.
- Backfill the excavated area as soon as the subgrade preparation is complete to avoid accumulation of debris. Place bioretention soil in 12-18 inch lifts without compaction. Overfilling will be necessary to account for settlement. Presoak soil at least one day prior to final grading and landscaping to allow for settlement.
- After allowing soil to settle, complete final grading within 2 inches of the proposed design elevations, leaving space for top dressing of mulch or mulch/compost blend.
- Seed and plant vegetation as indicated on the plans and specifications.
- Place mulch and hand grade to final elevations.
- Water vegetation regularly during first year to ensure successful establishment.

Maintenance Guidelines

Properly designed and installed bioretention systems require little maintenance. Bioretention requires landscaping maintenance to ensure that the area is functioning properly. Bioretention areas initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor, who may already be hired at the site. Landscaping maintenance requirements can be less resource intensive than with

DRAFT

traditional landscaping practices such as elevated landscaped islands in parking areas. During periods of extended drought, bioretention systems may require watering as needed.

Curb Inlet, Pre-treatment and Raised Outlet for Indianapolis Cultural Trail Bioretention (Alabama Street)

DRAFT

Table 4.5.3: Bioinfiltration/Bioretention Maintenance Guidelines

	Activity	Schedule
	• Water vegetation at the end of each day for two weeks after planting is completed. • Water vegetation regularly to ensure successful establishment.	First year after installation or as needed during drought conditions
	• Remulch void areas. • Treat diseased trees and shrubs. • Keep overflow free and clear of leaves.	As needed
	• Inspect soil and repair eroded areas. • Remove litter and debris. • Clear leaves and debris from overflow.	Monthly
	• Inspect trees and shrubs to evaluate health, replace if necessary. • Inspect underdrain cleanout. • Verify drained out time of system.	Twice Per Year
	• Add additional mulch. • Inspect for sediment buildup, erosion, vegetative conditions, etc.	Annually
	• Maintain records of all inspections and maintenance activity.	Ongoing

Note: Design of bioretention systems are not limited to the examples shown within this text. Successful storm water management plans will combine appropriate materials and designs specific to each site.

4.5.1 Bioretention Designer/Reviewer Checklist

Item	Yes	No	N/A	Notes
Appropriate areas of the site evaluated?				
Infiltration rates measured?				
Were the bioretention design guidelines followed?				
Soil permeability acceptable?				
If not, appropriate underdrain provided?				
Natural, uncompacted soils?				
Level infiltration area (bed bottom)?				
Excavation in bioretention areas minimized?				
Hotspots/pretreatment considered?				
Ponding depth limited to 18 inches?				
Drawdown time less than 72 hours?				
Positive overflow from system?				
Erosion and Sedimentation control?				
Feasible construction process and sequence?				
Entering flow velocities non-erosive or erosion control devices?				
Acceptable planting soil specified?				
Appropriate native plants selected?				
Maintenance accounted for and plan provided?				
Review of treatment volume?				
Review of calculations?				

DRAFT

Green Infrastructure Checklist

Bioretention/Rain Gardens:

Site requirements for use:

- High water table depth to top of subgrade must be 4’ or greater. (This is to prevent high water table from reducing infiltration effectiveness.)
- If buildings adjacent to rain garden have basements make sure that the rain garden is a minimum of 10’ from the building/basement. Also, depending on soil type, a waterproof membrane may be needed on the side adjacent to the building. This should be evaluated on a case by case basis.
- If adjacent buildings don’t have basements, the rain garden should be located a minimum of 5’ from the building.
- Note any buildings offsite near the proposed rain garden & verify city complaints/maintenance records regarding sewer backups, basement flooding, etc. for the area. If a high water table exists, extensive use of infiltration methods where none previously existed could aggravate an existing problem, especially if there are basements.

Design Considerations:

- Slope of rain garden bottom can be flat to allow uniform infiltration over the entire bottom area.
- Use of an underdrain is required for areas with Hydrologic Group C & D soils. Underdrain should have positive outlet to open area, level spreader or inlet structure.
- Use of amended soils to be evaluated on a case by case basis as needed for achieving desired infiltration rate. Depth of amended soil shall be determined by type of vegetation used. 18” for plants/shrubs, deeper section when trees are used.

Construction Considerations:

- Erosion control is a must - any sediment laden water shall not be allowed to flow into the rain garden. Use of a sediment forebay/basin during construction is recommended for easier removal of sediment.
- Roof leaders and other impervious areas draining to the newly constructed rain garden should be adequately protected so as to prevent erosion. Operations & Maintenance manual shall provide for an item to monitor erosion and replace mulch/gravel as needed. Once plants are established this should not be an issue.

DRAFT

4.5.2. Bioretention Maintenance Inspection Checklist

Bioretention (Rain Garden) O & M Manual

BMP Narrative:

Rain Gardens shall be in accordance with the following inspection and maintenance criteria:

Inspection:
Inspection of the rain garden is required after each major rain (more than 1" of rainfall) or at least 4 times per year during the growing season (March - November).
During inspection the following should be noted on the inspection form attached:

- Presence of any trash, debris and soil accumulation
  - Note that Rain Garden #1 is designed to have 6" of depth available for storage prior to overflow into the outlet structure. Ensure that the 6" depth is maintained as shown on the plans.
- Presence of weeds
- Depth of mulch material present
- Condition of plants (note any plants that appear to be dead or dying)
- Condition of rain garden overflow structure. (Most rain gardens do not have overflow structures, however, they are used in this project to ensure storm water has a viable outlet.)
- Visible indication of rain garden clogging or overtopping.

Maintenance:
Maintenance of the rain garden is required when inspection reveals the following are present:

- Trash, debris and soil accumulation
  - Remove all trash and debris and dispose in accordance with city regulations
  - Remove soil accumulation and use on-site in other areas or dispose in accordance with city regulations.
  - Ensure depth of rain garden is maintained to the design depth shown on the plans.
- Weeds
  - Remove weeds regularly during the establishment period (the first couple of years). Hand weed to ensure that the soil in the rain garden does not get compacted and to minimize disturbance to plants and mulch.
  - Remove invasive weeds (Canada Thistle, Garlic Mustard and any tree seedlings) immediately to discourage their establishment.
  - Weed after watering or after a rain event for minimal disturbance and ease of removal.
- Mulch depth less than 3 inches
  - Maintain a mulch depth of 3 to 4 inches. Use hardwood mulch material. Mulch should be reapplied annually to maintain desired depth.

DRAFT

- Water needed (Plants appear to be dead or dying)
    - Watering is required to maintain plants during the establishment period to ensure healthy growth. Once established, plants should only require water during drought conditions.
- Overflow structure in need of cleaning (ex: grate covered with grass/leaves)
    - Keep inlet grate clear of obstructions to maintain storm outlet.
    - If damage to the inlet structure exists, repair immediately in accordance with the City of Fort Wayne Drainage Standards.
- Indication that rain garden has insufficient capacity (debris on pavement surrounding the rain garden, etc.). Rain garden maximum ponding time is 48 hours. If evidence that rain garden does not drain down within the required 48 hour period, soil maintenance will be required to restore the soil porosity to the required level to obtain the drain down time.
- The amended soils must be sandy loam, loamy sand or loam mixture with clay content rating from 10 to 25 percent. The soil must have an infiltration rate of **at least 0.8 inches per hour** and a pH between 5.5 and 6.5. In addition, the planting soil should have a 1.5 to 3 percent organic content and a maximum 500-ppm concentration of soluble salts. The mulch layer must consist of 3-4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips.

DRAFT

Inspector:
Date:
Time:
Weather: Rainfall over previous 2-3 days?
Rain Garden Location: Rain Garden 1 (At entrance from Fletcher Avenue)

Mark items in the table below using the following key:

- **X** Needs immediate attention
- – Not Applicable
- ✓ Okay
- **?** Clarification Required

Rain Garden Components:

Items Inspected	Checked		Maintenance Needed		Inspection Frequency
DEBRIS CLEANOUT	Y	N	Y	N	**M**
1. Rain gardens and contributing areas clean of debris.					
2. No dumping of yard wastes into rain garden.					
3. Litter (trash, debris, etc.) have been removed.					
VEGETATION					**M**
4. No evidence of erosion.					
5. Is plant composition still according to approved plans.					
6. No placement of inappropriate plants.					
DEWATERING AND SEDIMENTATION					
7. Rain garden dewaters between storms.					
8. No evidence of standing water.					
9. No evidence of surface clogging.					
10. Sediments should not be greater than 20% of swale design depth.					
OUTLETS/OVERFLOW SPILLWAY					**A, AMS**
11. Good condition, no need for repair.					
12. No evidence of erosion.					
13. No evidence of any blockages.					
INTEGRITY OF BIOFILTER					**A**
14. Rain garden has not been blocked or filled inappropriately.					
15. Mulch layer is still in place (depth of at least 3").					
16. Noxious plants or weeds removed.					

Inspection Frequency Key **A= Annual, M= Monthly, AMS= After Major Storm**

DRAFT

COMMENTS:

OVERALL CONDITION OF FACILITY:

In accordance with approved design plans? Y / N In accordance with As Built plans? Y / N
Dimension on as built:
Field Verified Dimension:
Maintenance required as detailed above? Y / N Compliance with other consent conditions? Y / N

Comments: ____
____
____

Dates by which maintenance must be completed: _______ / __ / ___

Dates by which outstanding information as per consent conditions is required by: : _________ / __ / ____

Inspector’s signature: ____

Consent Holder/Engineer/Agent’s signature: ____

Consent Holder/Engineer/Agent’s name printed: _______________________________________
______

DRAFT