

18.7 OPERATION & MAINTENANCE GUIDANCE

Maintenance is a critical aspect of a properly functioning BMP. Pursuant to the Wastewater/Stormwater Discharge Regulations, sites with BMPs are required to enter into long-term Operations & Maintenance (O&M) agreements with MSD regarding the inspection and maintenance requirements for the BMPs. Annual reports are required for all BMPs. These records must be made available to MSD or Louisville Metro government upon request.

18.7.1 Overview of Maintenance Procedures

Routine inspections will help to maintain function of the BMP systems and prevent problems from arising. As most BMP systems are largely affected by the seasonal changes and storms, inspections should typically be conducted at the beginning of each season as well as after large rain events.

In general, the inspection and maintenance of BMP systems includes:

- Removal of sediment buildup
- Removal of debris from any inflow and outflow points
- Local erosion prevention and sediment control
- Routine inspection of the structural integrity of the BMP to ensure function
- Replacement of filter media (if needed)

In general vegetation maintenance includes:

- Irrigation and weeding during the first few months of planting to ensure species establishment
- Maintenance of the health and abundance of native species and plantings
- Annual trimming or pruning to prevent woody species growth
- Removal of any invasive species

This section provides detailed O&M procedures for each BMP.

18.7.2 Bioretention (Rain Garden, Bioswale, Tree Box or Planter Box)

Maintenance should be periodically conducted to ensure that the bioretention area is functioning properly. Initially (for the first year), the plantings will require more intensive maintenance to ensure proper species establishment and function. This initial maintenance of the system will primarily consist of:

- Monthly inspections of the soil
- Removal of accumulated debris or sediment buildup
- Erosion repair
- Watering during periods with no rain
- Replacement of dead or diseased vegetation
- Weeding of non-native invasive species.

Vegetation should be cut back and removed from the garden during the winter months when plants are dormant. Mulch should be added every 1-2 years; 2-3 inches of shredded hardwood mulch is preferred. Care should be given when mulching not to allow mulch to pile up on the stems of plants (woody or herbaceous).

After major rain events, it is important to inspect bioretention cell and make sure drainage paths are clear and any pooling water dissipates within 36 hours; note that water may pool for longer times during the winter and early spring.

If the bioretention BMP is not functioning properly, repairs to the under-drain as well as inflow and outflow structures may be needed.

By their design, bioretention cells are not in danger of becoming a breeding ground for mosquitoes. It takes 24 to 36 hours for a mosquito egg to hatch, after which it takes 10 to 14 days for the mosquito to complete its larval development to become an adult. By having a properly functioning and draining bioretention cell, the chances of providing mosquito habitat are virtually eliminated. If the bioretention cell holds enough water for mosquitoes to successfully breed, there is a problem with the soil, underdrain or outflow structure that should be addressed.

Table 18.16 Bioretention (Rain Garden, Bioswale, Tree Box or Planter Box) Maintenance Schedule	
Schedule	Activity
As needed	<ul style="list-style-type: none"> • Water as recommended by the nursery during establishment and then as needed during dry conditions
At least 3 times per year	<ul style="list-style-type: none"> • Prune and control weeds • Remove and replace dead or damaged vegetation • Mow perimeter areas as needed
Semi-annually in spring and fall	<ul style="list-style-type: none"> • Remove sediment, trash and debris from inlets/forebays • Inspect inflow points for clogging and remove any sediment • Inspect for erosion, rills or gullies and repair • Herbaceous trees and shrubs should be inspected to evaluate their health and remove any dead or severely diseased vegetation • Remove fallen, clipped or trimmed plant material from rain garden to prevent clogging and replace dead plants • Develop/adjust vegetation maintenance plan for trimming and dividing perennials (if applicable) to prevent overcrowding and stress and to achieve desired aesthetic qualities; remove any non-native, invasive species • Inspect vegetation for health and signs of stress; if vegetation begin showing signs of stress, including drought, flooding, disease, nutrient deficiency, insect attack or improper mowing, treat the problem or replace the plants • Observe infiltration rates after rain events; bioretention BMPs should drain within 36 hours of a storm event • A mulching depth of about 2-3 inches should be inspected and obtained, and additional mulch should be added if necessary • Evaluate areas containing low flow stone or gravel; replace if necessary
Upon failure	<ul style="list-style-type: none"> • Replace/repair inlets, outlets, scour protection or other structures as needed • Replace vegetation as needed to align with original planting plan • If the rain garden is not meeting desired infiltration rates or over time soil has compacted, check soil infiltration rates by performing a percolation test • Re-aerate or replace soil and mulch layers as needed to achieve infiltration rate of 0.5 inches per hour • When removing soil for replacement, take to landfill or soil recycling center

18.7.3 Constructed Wetland

Constructed wetlands should be visited every quarter and following major rain events during the first year after construction. Inspections should evaluate:

- The success of the native plantings
- Establishment of invasive non-native plants
- Inlet/outlet conditions
- Sediment/debris accumulation

Repairs, replacements, and maintenance should be conducted as problems arise to maintain the functionality of the wetland. Maintenance will consist of:

- Repairs to the structural integrity of the outlet and containment edges
- Erosion and burrow repair
- Monitoring and removal of debris and sediment buildup with special care not to impact water storage capacity
- Invasive non-native species control
- Replacement of native plant material as needed to a minimum coverage of 50% of the wetland

Visits to the site can be reduced to 2 times per year in the second and third years after establishment.

A high level of qualitative monitoring should occur during the first three years after the wetland is installed to insure proper function and establishment of the constructed wetland. Monitoring should focus on successful establishment of native wetland plants, water storage capacity, and pollutant removal. Visual observations of the wetland can be recorded to determine how frequently sediment/debris should be removed. Over time, large wetlands that are heavily loaded will require more frequent monitoring than smaller less loaded wetlands.

Visual observations should be recorded for the establishment and density of native wetland vegetation and the presence of non-native and invasive species. Changes of concern include an increase in the numbers of aggressive non-native species, a decrease in the density of the vegetative cover to less than 50% of the wetland, and signs of disease. An invasive species management plan may need to be implemented if invasive species are present within the constructed wetland.

If near a populated area, monitor the wetland regularly for mosquito populations and develop and implement a control plan as needed.

Table 18.17 Constructed Wetland Maintenance Schedule	
Schedule	Activity
Quarterly during the first growing season	<ul style="list-style-type: none"> • Remove and replace dead, severely diseased vegetation, or damaged plants • Remove or control weeds and invasive species • Monitor wetland after major storm events to ensure structures are functioning properly and inspect for erosion
Semi-annually in spring and fall	<ul style="list-style-type: none"> • Inspect inflow points for clogging • Inspect for erosion, rills or gullies along the embankments and repair • Remove fallen, clipped, or trimmed plant material from wetland to prevent outlet clogging • Harvesting of seasonally dead plant material in the fall may be needed if high nutrient level treatment is desired • Inspect vegetation for health and signs of stress; if plants begin showing signs of stress, including drought, flooding, disease, nutrient deficiency, insect attack or improper mowing, treat the problem or replace the plants • Observe water levels to confirm that they are as designed • Mow maintenance access areas around wetland • Maintain signs in “no mow” areas
Annually or as needed	<ul style="list-style-type: none"> • Remove sediment, trash and debris from inlets/forebays when one-quarter of the forebay volume has been lost
5 plus years or upon failure	<ul style="list-style-type: none"> • Monitor sediment accumulation and remove when one-quarter of the constructed wetland’s design volume has been lost • Dredge sediment to meet original design volume and replace vegetation as needed to align with original planting plan

18.7.4 Green Wet Basin

A wet basin should be inspected semi-annually in the Spring and Fall as well as after major rain events. The basin should be maintained for structural stability and proper inflow and outflow discharge. Accumulated sediment and debris should be removed from the basin as well as the inflow area to prevent future clogging during rain events. Overall health and abundance of the native vegetation should be maintained, replacing dead or diseased plants as necessary. In addition, seasonal or yearly management should be conducted to remove or control invasive non-native vegetation from the site as well as to remove woody vegetation from all embankment areas.

Inspection of the buffer zone, downstream of the outflow point, should be conducted regularly to make sure that the wet basin is functioning properly and the outflow is not negatively impacting downstream habitats. This includes inspection for any erosion along the embankment of the basin.

Table 18.18 Green Wet Basin Maintenance Schedule

Schedule	Activity
Monthly during the first growing season	<ul style="list-style-type: none"> Remove and replace dead or damaged plants Remove or control weeds and invasive species Inspect and repair erosion Water as needed to keep plants alive
Semi-annually in Spring and Fall	<ul style="list-style-type: none"> Inspect inflow/outflow points for clogging Remove any trash and debris Inspect for erosion, rills or gullies along the embankments and repair Vegetation should be inspected to evaluate their health and remove any dead or severely diseased vegetation Remove fallen, clipped or trimmed plant material from basin to prevent outlet clogging If plants begin showing signs of stress, including drought, flooding, disease, nutrient deficiency, insect attack or improper mowing, treat the problem or replace the plants Inspect for plant root damage due to piping and mammal burrows; remove/repair when discovered Mow maintenance access areas around green wet basins; do not mow buffer area around basin Clean pond and forebay of debris and trash
Annually	<ul style="list-style-type: none"> Remove sediment from inlets/forebays when one-quarter of the forebay volume has been lost
5 plus years or upon failure	<ul style="list-style-type: none"> Monitor sediment accumulation and remove when one-quarter of the green wet basin's design volume has been lost Dredge sediment to meet original design volume and replace vegetation as needed to align with original planting plan

18.7.5 Green Dry Basin

The seasonal maintenance of a dry basin consists primarily of the inspection of the inlet and outlet pipes for structural integrity; the clearing of sediment and debris from the inlet and outlet pipes as well as the basin; and the removal of debris from upstream areas to prevent it from washing into the basin. It is important to note that improperly maintained basins can reduce the storage volume of the pond as well as create breeding areas for mosquitoes.

Native vegetation should be maintained seasonally and after major rain events. Maintenance consists of replacement of dead or diseased plants, replanting of eroded areas, and invasive species control. The basin should also be trimmed annually to prevent the growth of woody species.

Table 18.19 Green Dry Basin Maintenance Schedule

Schedule	Activity
Monthly during the first growing season	<ul style="list-style-type: none"> Remove and replace dead or damaged plants Remove or control weeds and invasive species Inspect for erosion Water as needed to keep plants alive
Semi-annually in spring and fall	<ul style="list-style-type: none"> Inspect inflow/outflow points for clogging Remove any trash and debris from forebay Inspect for erosion, rills or gullies along the embankments and repair Vegetation should be inspected to evaluate their health and remove any dead or severely diseased vegetation Remove fallen, clipped or trimmed plant material from basin to prevent outlet clogging If plants begin showing signs of stress, including drought, flooding, disease, nutrient deficiency, insect attack or improper mowing, treat the problem or replace the plants Inspect for plant root damage due to piping and mammal burrows; remove/repair when discovered Mow maintenance access areas around green dry basins Green dry basins should drain within 36 hours of a storm event Clean pond of debris and trash Remove any sediment accumulation
Annually	<ul style="list-style-type: none"> Remove sediment from inlets/forebays when one-quarter of the forebay volume has been lost
5 plus years or upon failure	<ul style="list-style-type: none"> Monitor sediment accumulation and remove when one-quarter of the green dry basin's design volume has been lost Remove sediment to meet original design volume and replace vegetation as needed to align with original planting plan

18.7.6 Green Roof

Green roofs will require irrigation or natural precipitation at least once a week until the plants have fully established. Once the plants have matured, extensive green roofs no longer need to be irrigated except in cases of extreme drought. The roof will require regular weeding during the establishment phase and only seasonal weeding thereafter. Vegetation should be monitored seasonally to maintain overall health and plants should be replaced or resown as needed. Plants should be fertilized annually or as recommended by the source nursery.

The increased weight and the addition of more intensive plantings tend to increase the maintenance requirements of those green roofs. The same overall maintenance noted for an intensive green roof should be followed, but on a more frequent basis. Plantings will need additional care and maintenance due the increased soil depth and the likelihood of additional invasive exotic plants becoming established.

The severe consequences of drainage backups, root punctures, and leaks in the waterproofing membrane system make seasonal inspections crucial. Drainage routes should be kept clear so that

leakage is avoided and plants are not susceptible to increased moisture in the soil. Debris and dead vegetation should be removed along with any woody vegetation. See minimum maintenance schedule in Table 18.17 below.

Table 18.20 Green Roof Maintenance Schedule (Extensive and Intensive Green Roofs)	
Schedule	Activity
As needed	<ul style="list-style-type: none"> Water as recommended by the nursery during establishment and then as needed during dry conditions
Minimum 3 times during growing season	<ul style="list-style-type: none"> Remove sediment, trash, weeds and debris Implement landscaping maintenance plan for trimming to achieve desired aesthetic qualities Mulch as needed Inspect landscaping for health and signs of stress If vegetation begins showing signs of stress, including drought, flooding, disease, nutrient deficiency or insect attack, treat the problem or replace the vegetation Inspect underneath roof system Drainage routes should be kept clear so that leakage is avoided and plants are not susceptible to increased moisture in the soil Observe infiltration rates after rain events; green roof should drain within 24 hours of a storm event
Upon failure	<ul style="list-style-type: none"> Replace green roof system

18.7.7 Permeable Pavement

Permeable pavers, require that the surface be kept clean of organic materials and debris through periodic vacuuming and low-pressure washing. Cleaning should be conducted seasonally with certain sites requiring additional maintenance due to the local conditions, and the frequency of storm events. Such cleaning will help to maintain the pavement's flow capacity and restore permeability. Areas should be routinely inspected for settling and loss of water flow through the system and maintenance should be conducted as problems arise. Regular maintenance should help prevent these issues.

For permeable pavers, after cleaning additional aggregate fill may need to be added and the pavers should be inspected for damages and repaired as needed. Research has shown that the use of a street sweeper or air jet to maintain pavers is relatively ineffective, that a vacuum/water jet combination attachment is most effective for surface maintenance, and that the rate of surface clogging can be slowed by adding a chip stone to the gaps between blocks.

Table 18.21 Permeable Pavement Maintenance Schedule

Schedule	Activity
At least once per year	<ul style="list-style-type: none"> • Vacuum/water jet combination attachment • Replace aggregate between pavers as necessary (if applicable)
Monthly during the growing season	<ul style="list-style-type: none"> • Inspect the pavement for trash, debris and dirt • Keep weeds and grass out of the paved area (unless concrete grid pavers are being used) • Mow/trim adjacent vegetation and remove clippings and other debris from the area using a leaf blower • Visually inspect the pavement after large storms to ensure the overflow drainage system is working After cleaning, additional aggregate fill may need to be added and the pavers should be inspected for damage and repaired as needed
Semi-annually in spring and fall or as needed	<ul style="list-style-type: none"> • Sweep or vacuum the pavement with a street sweeper or street vacuum • If the pavement are installed in an area that is subject to higher than normal amounts of sediment (i.e. an area with large trucks traveling on it daily) it may need to be cleaned more often • Replace any joint material that may have eroded • Observe the system during a rain event • Areas should be routinely inspected for settling and loss of water flow through the system
As needed in winter	<ul style="list-style-type: none"> • Organic deicers may be used to melt ice and snow • Snow plows may be used when necessary under the following conditions: <ul style="list-style-type: none"> ○ The edges of the plow are beveled ○ The blade of the snow plow is raised 1 to 2 inches ○ The snow plow is equipped with snow shoes which allow the blade to glide across uneven surfaces
Upon failure	<ul style="list-style-type: none"> • When the base layer becomes clogged, remove pavers or pavement and replace/repair base layer to achieve design infiltration volume/rate. Note: Chip stone aggregate may be used between paver joints to prevent complete failure

18.7.8 Tree Boxes

Tree boxes should be kept free of debris and trash, and periodic cleaning should be conducted to clear the inflow and outflow mechanisms. The vegetation in the boxes will require more intensive maintenance over the first several months after installation, but this demand will decrease as the plants become established. Boxes should be kept free of invasive species and the overall health of the plants should be maintained. The soil and mulch in the boxes should be tested periodically to avoid the build-up of pollutants that may harm the vegetation. Any mulch used should be replaced biannually.

Tree boxes require regular irrigation during dry periods. If an under-drain system is used, maintenance of inflow and outflow structures will require periodic inspection and removal of sediment and debris, if necessary. In addition to general maintenance procedures, the tree/shrub should be trimmed or pruned according to an established maintenance plan.

18.22 Tree Box Maintenance Schedule	
Schedule	Activity
As needed	<ul style="list-style-type: none"> Water as recommended by the nursery during establishment and then as needed during dry conditions
Semi-annually in spring and fall	<ul style="list-style-type: none"> Remove sediment, trash, weeds and debris Implement vegetation maintenance plan for trimming to achieve desired aesthetic qualities Inspect vegetation for health and signs of stress If tree/shrub begins showing signs of stress, including drought, flooding, disease, nutrient deficiency or insect attack, treat the problem or replace the vegetation Observe infiltration rates after rain events. The tree box should drain within 24 hours of a storm event Replace mulching as needed, maintain at least 2-3 inches of mulch
10-25 years	<ul style="list-style-type: none"> Remove tree/shrub and replace with smaller specimen

18.7.9 Vegetated Buffer

Initially, vegetated buffers should be inspected after major rain events to ensure proper draining. The vegetated buffer should maintain desired slope, length and width. Bare spots or eroded areas should be repaired to ensure they are functioning according to design specifications. Vegetation should only be mowed according to maintenance plans and “No Mow” areas should be clearly defined. Inspections should consist of replacement and care of plant materials and irrigation during dry periods. Accumulated sediment or other trash and debris should be removed and the buffer should be checked for erosion.

Table 18.23 Vegetated Buffer Maintenance Schedule	
Schedule	Activity
As needed	<ul style="list-style-type: none"> • Water as recommended by the nursery during establishment and then as needed during dry conditions • Trim vegetation in accordance with nursery recommendations
Semi-annually in spring and fall during first year and annually thereafter	<ul style="list-style-type: none"> • Inspect grading of vegetated buffer to ensure sheet flow across the entire buffer length and width • Inspect vegetation for health and signs of stress; if tree/shrub/grass begins showing signs of stress, including drought, flooding, disease, nutrient deficiency or insect attack, treat the problem or replace the vegetation • Inspect buffer for erosion and bare spots and repair
Following significant rain events (>10 yrs)	<ul style="list-style-type: none"> • Inspect and repair eroded or damaged areas to maintain sheet flow to and across the vegetated buffer

18.7.10 Catch Basin Inserts

Catch basin inserts will require very frequent sediment removal as their volume is very limited in comparison to the volume of the catch basin sump. It is necessary to routinely remove sediment, trash and debris and to replace the inserts if they are damaged. Inspections of catch basin inserts should be scheduled, at a minimum, prior to the first seasonal rains as well as during and after each major rain event.

The site should also be checked for excessive erosion or sediment flow upstream of the catch basin. It may also be necessary to periodically check the catch basin to ensure stormwater is flowing through the filter system. In addition to general maintenance procedures, the catch basin inserts should be replaced annually.

Table 18.24 Catch Basin Inserts Maintenance Schedule	
Schedule	Activity
Preventative measures	Inflow should flow through the filter system
Regularly and after Major Storm Events	Inspect catch basin inserts for clogging and remove sediment, trash or debris
Semi-annually in spring and fall	Visit site to ensure there is not excessive erosion or sediment flow upstream of the catch basin insert
As Needed	Replace catch basin inserts

18.7.11 Proprietary Water Quality Units

Proprietary water quality units should be inspected seasonally and after major rain events or per manufacturer’s recommendations to ensure proper function. Manufacturer’s guidelines should be followed and an individual maintenance plan should be developed for all systems based on routine inspections. In general, maintenance will include pumping and pressure washing the unit and cleaning blockage or sediment buildup with use of vacuum trucks or boom trucks. Drainage areas should be regularly maintained to prevent the flow of trash, sediment and debris into the system. Note that the system may need additional cleaning in the event that a spill of a foreign substance enters the unit.

Inspections should be conducted after the first rain event and also after major storms. Repairs to inlets, outlets, control valves or other structures should be performed periodically. Safety and maintenance practices for confined spaces should be followed when appropriate.

Table 18.25 Proprietary Water Quality Units Maintenance Schedule	
Schedule	Activity
As needed	<ul style="list-style-type: none"> • Inspect drainage areas to proprietary WQUs for trash, erosion and debris • Perform cleanout if hazardous or foreign substances are spilled in the drainage areas • Repair inlets, outlets, control valves or other structural features as needed • Inspect system after major rain events to ensure it is draining properly
Quarterly	<ul style="list-style-type: none"> • Inspect system for blockage or sediment buildup and perform cleanout if necessary • Follow manufacturer’s guidelines and develop/adjust maintenance plan for the system
Annually	<ul style="list-style-type: none"> • Perform cleanout of the system with vacuum or boom trucks • Clean any sediment or oil chambers • Inspect inlets, outlets and other structural features; repair as needed

18.7.12 Infiltration Trench or Basin (Open and Underground Storage)

Infiltration trenches and basins (Open or Underground Storage) will require maintenance inspections at least annually but more frequent inspections are recommended. It is necessary to check the observation well for clogging annually or as-needed basis (if applicable). All pretreatment systems and other structures connected to the infiltration BMP should be routinely checked for clogging. If the aggregate layer becomes clogged with sediment and debris, it may be necessary to remove the layer and replace it with new aggregate. It may also be necessary to check the observation well after major rain events to ensure the trench is draining properly. The top of the trench and all pretreatment devices should be cleared of leaves and other debris routinely. It is necessary to mow the area around the pretreatment devices, as well as the perimeter of the trench to clear access for maintenance. If the entire system appears to be clogged with sediment and is no longer functioning properly, this may trigger the removal of the sediment accumulation and replacement aggregate.

Table 18.26 Infiltration Trench Maintenance Schedule (Open and Underground Storage)

Open Storage	
Schedule	Activity
2-3 times per year as needed	<ul style="list-style-type: none"> • Monitor the drain observation well after large rain events and check for any ponding water • Mow or trim the perimeter of the practice and any pretreatment devices; grass clippings should be removed to prevent clogging • Check observation well for clogging
Semi-annually	<ul style="list-style-type: none"> • Check pretreatment systems and other structures for clogging; remove sediment and debris as necessary • Inspect the top layer of the trench for ponding water, leaves, grass clippings or other debris • Inspect any piping or other structural devices for damage and replace as necessary
Upon failure	<ul style="list-style-type: none"> • If the entire system becomes clogged, remove and install clean, double washed trench aggregate • It may also be necessary to replace piping, filter fabric, etc.
Underground Storage	
As needed	<ul style="list-style-type: none"> • Inspect drainage areas to BMP for trash, erosion and debris • Perform cleanout if hazardous or foreign substances are spilled in the drainage areas • Repair inlets, outlets, control valves or other structural features as needed • Inspect system after major rain events to ensure it is draining properly
Quarterly	<ul style="list-style-type: none"> • Inspect system for blockage or sediment buildup and perform cleanout if necessary
Annually or as needed	<ul style="list-style-type: none"> • Perform cleanout of the system with vacuum or boom trucks • Clean pretreatment device • Clean any trapped or sump manhole structures connected to system (if applicable) • Inspect inlets, outlets and other structural features; repair as needed
Upon failure	<ul style="list-style-type: none"> • When the base layer becomes clogged and no longer infiltrates at the design rate/volume, the subsurface will need to be removed and replace to achieve the design infiltration rate/volume <p>Note: Pretreatment is required for the system to prevent complete failure</p>