Green City, Clean Waters

Green Infrastructure Maintenance Manual Development Process Plan

Consent Order & Agreement

Deliverable II

City of Philadelphia Combined Sewer Overflow Long Term Control Plan Update

Submitted to

The Commonwealth of Pennsylvania

Department of Environmental Protection

By The Philadelphia Water Department

June 1, 2012

1.0 Introduction

The Water Department is committed to ensuring that Stormwater Management Practices (SMPs) and their associated Greened Acres continue to operate as designed for the duration of the program plus 20 years as prescribed in the Consent Order and Agreement (COA), signed on June 1, 2011. The Water Department's Maintenance program seeks to:

- ensure sufficient maintenance of Green Stormwater Infrastructure (GSI) to keep assets performing as designed,
- develop and standardize long-term, cost effective maintenance protocols,
- assess existing organizational capacity of the Water Department and partnering organizations for supporting maintenance, and
- provide feedback to improve future designs to the GSI design group based on maintenance, inspection and monitoring experiences.

The purpose of this Maintenance Manual Development Process Plan is to outline the process to create the first edition of a GSI Maintenance Manual over the coming two years. The Water Department understands that maintenance responsibilities may be undertaken or assigned to other entities, therefore, the Green Infrastructure Maintenance Manual will be designed to be used by a broader audience.

The Water Department is evaluating and documenting maintenance protocols to prepare for development of the Green Stormwater Infrastructure Maintenance Manual, due on June 1, 2014. It will take a number of years of performing maintenance tasks, including a number of seasons and environmental conditions, to establish reliable and effective standard operating procedures.

The COA describes the Green Infrastructure Maintenance Manual requirements as follows:

> *"The Manual will address the operation and maintenance of the full range of types of green stormwater infrastructure projects that have been, and that are proposed to be, implemented by the City as part of the CSO Program. The Manual will be designed to be used by City agencies and anyone else who has responsibility for performing maintenance of green stormwater infrastructure. The Deliverable required by the Consent Order and Agreement should be considered the "first edition" of the Manual, since it is expected that the Manual will need to be updated periodically as the technology of green stormwater infrastructure advances, and as experience is gained with practices. The first edition of the Manual should propose a schedule for the planned preparation of a second edition."*

2.0 Evaluation of Current Maintenance Practices

Routine maintenance of GSI is needed to maximize its full range of benefits. Water Department staff perform maintenance on subsurface components and manage a contract for maintenance of surface level features including landscaping and other general maintenance needs at GSI sites. This current maintenance process will continue over the coming years to inform the Water Department of effective maintenance protocols, standard procedures, costs, and recommended design enhancements, to assist in the development the Green Infrastructure Maintenance Manual, and to support the overall program needs.

CURRENT MAINTENANCE PRACTICES

The current maintenance program focuses on data collection at GSI sites to assess the performance of various SMP designs and to develop and refine maintenance tasks. Routine inspections and maintenance activities are conducted to evaluate and document the condition of site features, identify maintenance needs, and report on site issues in need of further attention. Major goals of the current maintenance program include:

- Maintenance of GSI sites to ensure continuous performance
- Identification of effective and sustainable SMP types
- Development of interim protocols based on current maintenance activities
- Documentation of time, effort and materials
- Feedback and recommendations to enhance design performance and ease of maintenance
- Evaluation of public acceptance, aesthetics and stewardship

A list of SMP types for which standardized maintenance processes are being developed is shown in Table 2.1. The current program involves activity and materials tracking to facilitate development of these maintenance protocols and specifications that will be refined and used as the basis for the Green Infrastructure Maintenance Manual and the full-scale GSI Maintenance Program.

Table 2.1: SMPs for which Standardized Maintenance Processes are being developed

SMP Type	Definition/Purpose
Stormwater Tree Trench	A stormwater tree trench is a system of trees connected by a subsurface infiltration / storage trench. It is designed to infiltrate and/or detain and release stormwater runoff where necessary.
Rain Garden	A rain garden is a vegetated area designed to infiltrate and/or detain and release stormwater runoff where necessary. Rain gardens are also commonly referred to as bio-infiltration basins and bio-retention basins. They are typically integrated into landscape features (*e.g.* median strips) and are non-mowed areas.
Stormwater Planter	A stormwater planter is a structure filled with soil media and planted with vegetation or trees. It is designed to infiltrate and/or detain and release stormwater runoff where necessary. Planters can be designed below street grade or above grade and often contain curb edging as the structure surrounding the planter.
Stormwater Bumpout	A stormwater bumpout is a vegetated curb extension that intercepts street and sidewalk flow along the curb-line. It is designed to infiltrate and/or detain and release stormwater runoff where necessary.
Infiltration/Storage Trench	An infiltration/storage trench is a subsurface structure designed to infiltrate and/or detain and release stormwater runoff where necessary.
Pervious Paving	Pervious paving is a hard permeable surface commonly composed of concrete, asphalt or pavers. It is designed to infiltrate and/or detain and release stormwater runoff where necessary.
Stormwater Wetland	A stormwater wetland is a vegetated basin designed principally for pollutant removal. It typically holds runoff for periods longer than 72 hours. Wetlands can also detain and release stormwater runoff.
Cistern/Rain Barrel	A cistern/rain barrel is a tank or storage receptacle that captures and stores runoff for up to 72 hours and can thereby reduce runoff volume. The stored water may be used to serve a variety of non-potable water needs (*e.g.*, irrigation).
Green Roof	A green roof is a vegetated surface installed over a roof surface. Green roofs are effective in reducing the volume and rates of stormwater runoff.
Swale	A swale is a channel designed to convey stormwater. It can be designed to attenuate and/or infiltrate runoff where feasible.
Stormwater Basin	A stormwater basin is a basin or depression that is vegetated with mowed grass. It is designed to infiltrate and/or detain and release stormwater runoff where necessary.
Disconnection (impervious to pervious)	Disconnection is when runoff from an impervious area is directed to available adjacent pervious area.
Stormwater Tree	A stormwater tree is a tree that has stormwater runoff directed to its pit. It is designed to infiltrate and/or detain and release stormwater runoff where necessary.
Non-Credit Tree	A non-credit tree is a tree planted in a pervious area.

Surface Level Maintenance

The Water Department's current maintenance contract includes routine maintenance of and reporting on more than twenty green stormwater infrastructure projects located throughout the City of Philadelphia. Maintenance activities are dependent on a variety of factors, including

location, age of infrastructure and SMP type. Broadly, the following actions are performed during routine maintenance:

- Removal of trash from site,
- Removal of accumulated sediment, organic material (e.g., leaf litter),
- Control of invasive and non-target vegetative species,
- Control of target vegetation by pruning, mulching and reseeding,
- Structural repairs, erosion control, and other corrective needs, and
- Addressing issues resulting from urban stresses.

Information gathered from maintenance activities will help to develop appropriate task and event frequencies, which will streamline inspection and maintenance as the program expands. Development of interim maintenance procedures is underway to support the frequency and type of maintenance activities that occur at GSI sites. An interim protocol for invasive vegetation assessment is attached as Appendix I. In addition, an example of routine maintenance tasks for field crews are provided in Appendix II and a template for data collection provided as Appendix III.

Subsurface (Underground) Maintenance

Water Department staff is responsible for inspecting and maintaining subsurface green infrastructure components. The subsurface maintenance process includes the inspection and cleaning of inlets, distribution and underdrain pipes, and additional maintenance needs as identified. Due to the complex nature of subsurface maintenance tasks, the Water Department is assessing existing equipment capabilities and evaluating future potential equipment needs to support streamlining the maintenance process. To successfully accomplish these tasks, the Water Department utilizes the following procedures:

- use of Closed Circuit Television (CCTV) equipment to inspect and record pre and post maintenance conditions to evaluate the volume and consistency of debris accumulations,
- use of a vactor and combo truck equipment to flush distribution and underdrain pipes and clean inlets, and
- use of manual labor to facilitate maintenance on non-standard inlet design features.

The Water Department has standard maintenance procedures for traditional stormwater infrastructure, including city inlets and sewers. These procedures will be reviewed for applicability to GSI projects in developing the Green Infrastructure Maintenance Manual. A summary version of the Water Department's Sewer Cleaning Manual is provided in Appendix IV. As the maintenance of GSI continues, acquisition of new equipment could enhance subsurface maintenance and help to refine the frequency and effectiveness of maintenance. To support and track field data, an interim form, found in Appendix V, has been established to gather and organize critical information for the Water Department staff. As more GSI sites are maintained, standard operating procedures will evolve.

SCHEDULING AND COORDINATION

Due to the weather-dependent nature of green infrastructure maintenance and the constant exposure of SMPs to urban stressors, flexible logistical support will be critical to the program. Logistical aspects of the maintenance program involve scheduling, coordination between involved parties, and procurement of equipment, materials, and permits. Program coordination ensures that crews are properly informed and equipped to address routine maintenance needs before arriving at a site. Examples include:

- coordinating with and engaging other responsible parties,
- designating, mobilizing, and ensuring the availability of appropriate crews for specific maintenance tasks, and
- grouping maintenance of sites to maximize efficiency.

3.0 Development of Protocols, Checklists, and Schedules

The Water Department will continue to build upon current tasks that support the development of the Green Infrastructure Maintenance Manual. Data collected through on-going maintenance activities will be evaluated to update procedures and protocols. The Water Department will seek to standardize routine subsurface maintenance and inspections in addition to the development of surface and vegetated maintenance and inspection protocols, procedures, and field documentation.

MAINTENANCE MANAGEMENT SYSTEMS

Information collected from GSI site activities includes data related to personnel, material and equipment requirements, cost, frequencies, performance, site issues, and required knowledge, skills, and training to perform necessary tasks. A Cityworks work order management system to track various maintenance functions will be linked to the City's GIS network. The Water Department will continue to update and improve the GIS network to support the tracking of GSI assets in addition to providing critical information for resources like the Pennsylvania One call System to prevent damage of underground infrastructure and promote effective communication. The Cityworks work order management system provides tools to track and manage maintenance of the Water Department's assets such as fire hydrants, inlets, water mains, sewers and GSI. The goal of including GSI maintenance in this system is to provide the capability to schedule and track processes and needs of GSI as they become better defined. The Water Department envisions linking Cityworks with the Green City, Clean Waters program tracking systems to enable a cohesive and comprehensive maintenance program. The intent is to maximize efficiency to track data for program needs, regulatory compliance, and feedback mechanisms, in addition to triggering the required and immediate maintenance needs.

At present a database is used to record landscaping schedules, data and programmatic information. The Water Department will continue to coordinate internally and with other City agencies and partners so that notifications and activities are forwarded to the appropriate parties to ensure that inspection, monitoring and maintenance processes are initiated and tracked.

FORTHCOMING MAINTENANCE CONTRACTS

In the spring of 2012, the Water Department released a Request for Proposals (RFP) to support the GSI Maintenance Program. Many of the components in the previous contract were replicated, including vegetative maintenance, monitoring, and inspection requirements of GSI located throughout the City. In addition to these tasks, the new RFP also includes the following responsibilities:

- support for Water Department crews to conduct routine inspections and maintenance of subsurface components,

- utilization of suitable equipment and personnel for inspection and maintenance tasks, and
- aid in the development and documentation of specification and standard procedures, based on lessons learned and maintenance activities.

In conjunction with the items listed above, efforts will focus on understanding maintenance needs with respect to personnel, equipment, frequency of labor, health and longevity of vegetative features, and integrity of subsurface components.

PROTOCOL DEVELOPMENT

An important component of the GSI Maintenance Manual is the development of standard operating procedures and protocols for GSI maintenance that will form the basis for the full scale GSI Maintenance Program. Protocols will:

- standardize inspection and maintenance procedures for each SMP type,
- establish safety procedures,
- provide guidance for handling issues such as site access, regulatory approvals and notifications,
- establish minimum training, skill, equipment and materials requirements,
- establish administrative, data management and reporting procedures for the program, and
- obtain and manage maintenance feedback from the public, partner organizations and City agencies.

General SMP Protocols

The Water Department will seek to identify common maintenance elements among SMP types to support the Green Infrastructure Maintenance Manual development. Through this process, detailed site specific management could be enhanced to include general SMP protocols. Maintenance Protocols will be developed for individual tasks (e.g., pruning, seeding, weeding, etc.), to provide a list of required materials and equipment and outline the execution process for individual tasks.

Site Specific Management Plans

Development of the Green Infrastructure Maintenance Manual may support the creation of more detailed site specific plans to prescribe specific maintenance regimes for particular sites based on SMP types present and other characteristics influencing maintenance.

Service Level Goals

The SMP maintenance protocols will be used to set service level goals. Service level goals are an established target amount of similar maintenance tasks, visits or actions which can be used as a benchmark to provide feedback on the maintenance program's progress and success. The data collection and tracking tasks built into current maintenance activities for both GSI and traditional Water Department infrastructure will facilitate measurement of maintenance

activities against these prescribed targets. This information will also facilitate feedback on site specific SMPs to enhance design.

4.0 National Inventory of Maintenance Practices and Procedures

The Water Department compiled a nationwide review of green stormwater infrastructure maintenance programs and manuals. A total of 152 stormwater maintenance manuals were evaluated from a mix of cities, states, and government agencies. Research consisted of a nation-wide query of current green stormwater programs and their respective guidelines, manuals, checklists, or other practices associated with green stormwater infrastructure maintenance activities. The result is a compilation of relevant data to support the development of PWD's Green City, Clean Waters maintenance program, which is found in Appendix VI. The information includes:

- Maintenance frequency
- Inspection requirements
- Maintenance activities and field practices
- Reporting of maintenance and inspections
- Design issues

The results are organized by SMP and the SMP's associated maintenance activities, issues or concerns. The compilation of SMP maintenance activities will be used in the development of the GSI Maintenance Manual and will be updated as the Water Department gathers additional information on maintenance practices and procedures from other entities around the country.

Additionally, several green infrastructure maintenance manuals were reviewed for relevant manual content and organization that can potentially be used as a reference in the development of the Green Infrastructure Maintenance Manual. The review of these manuals resulted in a list of those having the most relevant detail, information, and applicability to Philadelphia's GSI program; Table 4.1 summarizes these manuals' table of contents.

Table 4.1 Relevant Table of Contents from National Inventory of Maintenance Manual Research.

Portland, Oregon (2008)	Minnesota (2010)	North Carolina (2010)	Eugene, Oregon (2008)
City of Portland Stormwater Management Manual	**University of Minnesota**	**North Carolina Department of Transportation**	**City of Eugene Stormwater Management Manual**
Chapter 3: Operations and Maintenance	**Stormwater Treatment: Assessment and Maintenance**	**Stormwater Control Inspection and Maintenance Manual**	**Chapter 3: Operation and Maintenance**
1 – Applicability of O&M Requirements **2 – O&M Requirements** 2.1 – Simplified approach for private facilities 2.2 – Presumptive and performance approach for private facilities 2.3 – Presumptive and performance approach for public facilities 2.3.1 – Warranty period responsibilities and inspections for public facilities **3 – O&M Submittal Guide** 3.1 – O&M specifications for simplified approach 3.2 – O&M plan for presumptive and performance approaches 3.2.1 – Facility maintenance guidelines 3.2.2 – Sample O&M plan for presumptive and performance approach **4 – O&M Enforcement** **5 – O&M Revisions**	**1 – Introduction** **2 – Stormwater treatment processes** **3 – Developing an assessment program** 3.1 – Level 1: Visual inspection 3.2 – Level 2: Capacity testing 3.3 – Level 3: Synthetic runoff testing 3.4 – Level 4: Monitoring 3.5 – Recommendations for assessment 3.6 – Maintenance 3.7 – Water budget measurement 3.8 – Sampling methods 3.9 – Analysis of water and soils 3.10 – Data analysis **4 – Filtration practices** 4.1 – Visual inspection 4.2 – Capacity testing 4.3 – Synthetic runoff testing 4.4 – Monitoring 4.5 – Maintenance 4.6 – Recommendations **5 – Infiltration Practices** *Same subsections as Section 4* **6 – Sedimentation Practices** *Same subsections as Section 4* **7 – Biologically enhanced practices** *Same subsections as Section 4* **8 – Case studies** **Appendices** Automatic sampling suspended solids Assessing thermal impacts Particle size distribution	**1 – Introduction** **2 – Inspection** 2.1 – Inspections 2.2 – Frequency of inspection 2.3 – Site visit preparation 2.4 – Safety considerations 2.5 – Reporting and record keeping **3 – Maintenance** 3.1 – Maintenance of stormwater controls 3.2 – Routine maintenance 3.3 – Emergency Maintenance **4 – Reporting and Record Keeping** 4.1 – Reporting overview 4.2 – Inspection documentation 4.3 – Level of service ratings 4.4 – Reporting special circumstances 4.5 – Stormwater control management system **Remaining Chapters – O&M of individual BMPs** **Appendix A – Inspection checklists**	**1 – Introduction O&M** **2 – O&M application submittals** 2.1 – Privately maintained facilities 2.2 – City-maintained facilities **3 – O&M plan enforcement** 3.1 – Form O&M 3.2 – Example of Form O&M 3.3 – Example of O&M agreement 3.4 – Inspection log sample 3.5 – Facility-specific O&M plans

5.0 Maintenance Contract Management

The Water Department's current maintenance contract includes the routine maintenance and status reporting of GSI projects. The growth of the program from pilot scale to citywide implementation necessitates clear processes and procedures for contract management. This contract will assist the Water Department in the development of the Green Infrastructure Maintenance Manual through tracking of maintenance tasks and procedures by GSI type. This section describes the procedures and processes to be enhanced into standard protocols for the management of contracts.

To better facilitate contract management processes, the Water Department is developing a series of internal contract management protocols. These will include:

- Protocols for the Contract Management Process, including descriptions of roles and responsibilities, definitions, and reference to the contract related procedures,
- Descriptions of contract types,
- Overview of how contracts are monitored including assignment of both project and contract managers and tracking of:
    - contract terms,
    - funding,
    - expenditures to date,
    - earned value.
- Invoicing and details about contractor submission process and requirements, compliance with Office of Economic Opportunity (OEO) policies and reporting requirements, and general overview of the review of invoices by various parties including project management staff, contract management staff, and Water Department Administration and Finance, and
- Contractor Performance Evaluations and how that information is translated to future amendment of contracts and selection of contractors for future new contracts.

The Water Department seeks to document and monitor work conducted by contractors and by Water Department staff to eliminate duplicative tasks so that effort, costs, and resources are efficiently utilized.

6.0 Evaluation of Program Improvement and Enhancement

The Water Department has identified a number of approaches and methods to increase efficiency and effectiveness of the maintenance program. Programmatic improvements are generated and evaluated through observation and documentation of current tasks, site needs, and stakeholder feedback. Areas where the potential for improvement were identified include:

- identifying opportunities for targeted outreach and education that would benefit long-term performance/sustainability;
- developing strategies for optimizing crew scheduling, deployment, and routing;
- developing strategies for improving the efficiency of data collection and reporting;
- refining designs to better incorporate maintenance needs; and
- identifying the appropriate personnel for staffing GSI maintenance crews

Examples of approaches that the Water Department may investigate to maximize maintenance efforts are described below.

COMMUNITY ENGAGEMENT

The City of Philadelphia has an active community of individuals, partners, and community groups interested in sustainability and green infrastructure. The Water Department will explore and evaluate the options for potential collaboration efforts and educational opportunities within the community. Among other tools, the Water Department plans to investigate the following:

- Assessing potential civic based involvement to support volunteer maintenance actions
- Developing a guide of recommended maintenance activities
- Expanding or adapting existing programs to include GSI maintenance

Community acceptance and adoption of projects may enhance the health, success and appearance both during the construction of GSI and over the lifetime of the infrastructure. Additionally, the Water Department is in the process of piloting a public Ambassador/Adoption program in which community members volunteer to be trained by Water Department staff to support public outreach events, community input on GSI projects, and site level maintenance activities. The Water Department also is developing an adoption handbook to help guide volunteer recommended activities (e.g., litter removal, watering, etc.). Pilot initiatives will be evaluated for potential benefits to aid the Water Department in better understanding on-the-ground capacity to support SMP maintenance.

TARGETED COLLABORATION

Within the City of Philadelphia, there are many unique commercial corridors where needs often are addressed via establishment of Special Service District (SSD) or Business Improvement

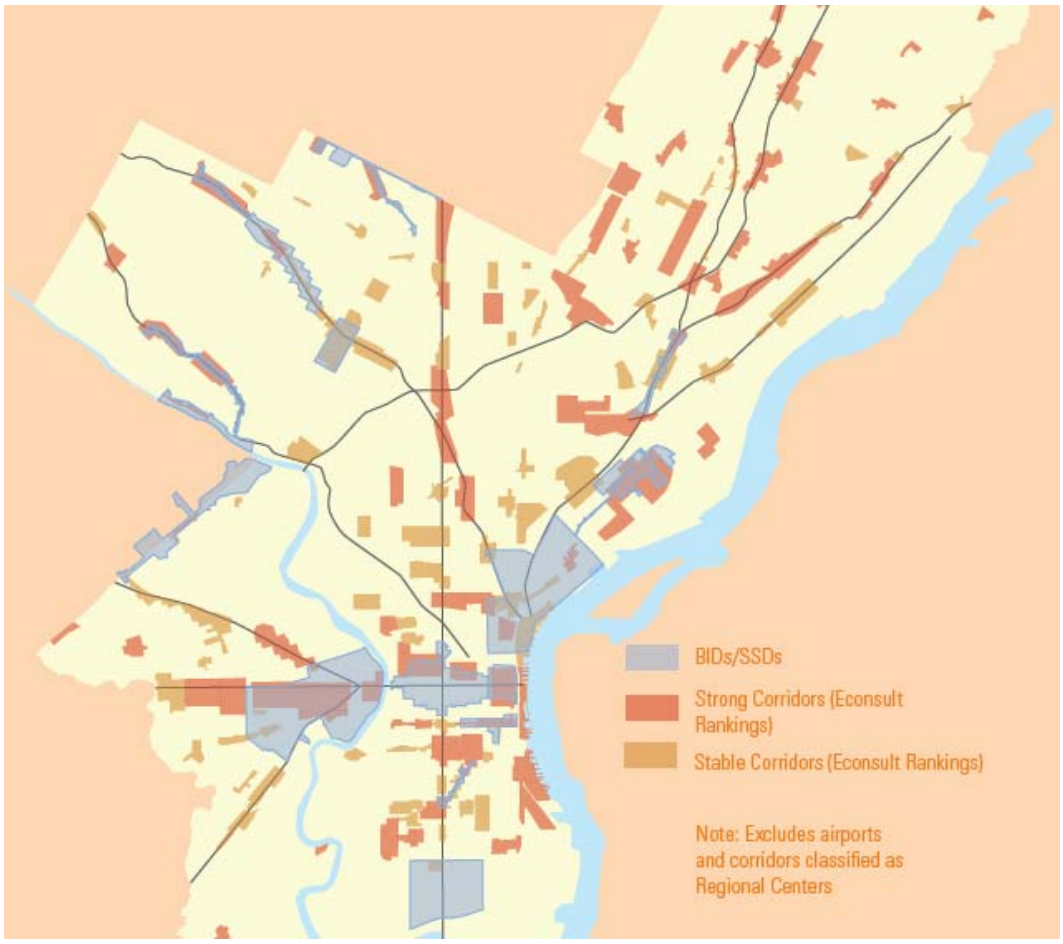
District (BID). As legal entities under Pennsylvania State Law, these districts have the ability to obtain operating funds through an additional fee paid by commercial property owners located within the defined district boundaries. With these funds, the improvement districts initiate programs to clean and beautify, provide security, and otherwise promote economic development.

The Water Department is exploring opportunities to partner with SSDs/BIDs for GSI maintenance. To explore the potential for collaboration, the Water Department is:

- identifying the SSDs/BIDs located within the combined sewer system,
- conducting research on the types of services provided by SSDs/BIDs to find out how many perform regular maintenance activities, and
- coordinating with the Philadelphia Commerce Department to determine capabilities of SSD/BID maintenance programs to carry out GSI maintenance.

SSDs and BIDs currently exist in a diverse mix of residential neighborhoods and commercial corridors. Figure 6.1, outlines the areas which existing SSDs and BIDs are located, as well as existing strong commercial corridors that have the potential to form new districts.

Figure 6.1 Services provided by existing districts in Philadelphia (Source: Philadelphia 2035 Comprehensive Plan)



TRAINING AND EDUCATION

The goal of the Maintenance Manual is to provide descriptions, protocols, recommended scheduling and frequency for maintenance activities that will serve a number of users. Staff, contractor and partner training are essential for a consistent, cohesive and successful program. To ensure that the desired benefits of GSI are achieved, it is necessary that all those involved in maintenance and inspection-related activities have a consistent level of technical expertise and professionalism. Training programs will be evaluated and incorporated.

Stormwater infrastructure maintenance training programs exist at both the state and local levels nationwide. The most notable examples are the certification programs offered by university extensions programs like those through North Carolina State and the University of Minnesota. Counties, cities, and municipalities can require or recommend that their maintenance staff or contractors obtain these certifications. Training sessions are often multi-day workshops explaining applicable stormwater regulations, the importance of maintenance, and the different types of tasks required for a variety of stormwater practices. The Water Department will evaluate opportunities to enhance the program with these types of additional resources.

7.0 Green Stormwater Infrastructure Operations & Maintenance Program Budget Development

Operations and maintenance (O&M) program planning-level costs for green stormwater infrastructure were developed for the Combined Sewer Overflow Long Term Control Plan Update (LTCPU), and included in the Alternatives Costing Tool (ACT). These planning costs are the basis for the initial green stormwater infrastructure O&M budget, and will be refined with additional knowledge of O&M labor and material costs through contract management and internal tracking.

The O&M costs derived for the LTCPU were summarized in five categories: porous pavement, subsurface infiltration, green roofs, bioretention, and street trees. For each of these, O&M costs were broken down into required operations and maintenance activities as described in the Philadelphia Stormwater Management Guidance Manual. Operations and maintenance activities, length, and frequency were also estimated. The O&M costs included locally based labor, materials and equipment costs. Further detail about the planning level estimates for GSI operations and maintenance costs are summarized in LTCPU Supplemental Documentation Volume 3.

The 25 year schedule for implementation of the program that was developed for the COA with the Pennsylvania Department of Environmental Protection assumed the cost of operations and maintenance to be 1.5-2% of each year's capital expenditure for implementing GSI. Total program maintenance cost will vary depending on a variety of factors, including: actual GSI implementation schedule, selected GSI management practices (porous pavement, subsurface infiltration, bioretention, street trees, etc.), and GSI practice drainage area and volume. The current estimate of total O&M cost for the GSI program is 15-20% of total program cost.

Appendix I

Invasive Species Protocol Example

I. CATEGORY: Vegetation

a. ITEM: Invasive Species

i. DESCRIPTION

1. Inspect green monitored areas for invasive species, to include, stream restoration sites, infiltration basins, constructed wetlands, bio retention basins, swales, and tree planters for the following invasive species(but not limited to)
    a. Multi flora rose
    b. Norway maple
    c. Japanese honeysuckle
    d. Knotweed
    e. Barberry
    f. Stilt Grass
    g. Oriental Bittersweet
    h. Burning Bush
    i. Japanese Privet
2. Observe and identify invasive species
3. Explain factors contributing to invasive species establishment

ii. FREQUENCY

1. May/June

iii. EQUIPMENT REQUIRED

1. Tablet PC w/ on-board digital camera and base mapping
2. Back up paper copies of site plans and monitoring sheets
3. Back up camera

iv. PERMITS/APPROVALS REQUIRED

1. None

v. NOTIFICATIONS REQUIRED

1. Notify Project Owner, Property Owner, and Database Manager shall be provided via email at least two (2) working days prior to conducting work

vi. TRAINING REQUIRED

1. Inspection to be conducted by individual with specialized training in plant identification and invasive species management

vii. ACCESS REQUIREMENTS

1. General: none
2. Site specific:

viii. FOLLOW-ON ACTIONS

1. REPORTING
    a. Map location, species type, and frequency of invasive species in ArcPad
    b. Obtain photo-documentation of problem where necessary
    c. Detail corrective action to be taken on site
    d. Provide recommendations concerning additional corrective-action
2. CORRECTIVE ACTION
    a. Minor Invasive species removal
        i. Description
            1. Remove small patches of invasive species in planting areas.
            2. Dig out small areas of invasive species, including root mass (being careful not to damage native species root system.)
            3. Cut off stem/trunk of invasive species and treat with appropriate herbicide
            4. Replant area
            5. Cover bare soil with mulch/leaf matter
        ii. Applicability
            1. The corrective action is applicable where invasive species are small areas and can impact larger areas.
            2. If corrective action can be preformed with the skills available at time of inspection, then perform work.
            3. If corrective action can not be preformed with the skills available at time of inspection, then identify items for follow up action.
                a. Describe item and required action in detail, and provide photographs
                b. If corrective action **cannot** be performed with the tools and skills available at the time of inspection, **and** the condition constitutes an immediate risk to public health or safety, then stabilize the condition with tools and skills available, or;
                c. If corrective action **cannot** be performed with the tools and skills available at the time of inspection,

and the condition constitutes an immediate risk to public health or safety, **and** the condition cannot be stabilized with tools and skills available, isolate the area with cones, caution tape, warning signs, etc. as appropriate

4. If unsure whether corrective action can be completed at the time of the inspection, then contact designated Project Manager or her/his designee for guidance

iii. Authorization
   1. XXX

iv. Equipment and Materials
   1. Shovel
   2. Hand saw
   3. Pruners
   4. herbicide and applicator
   5. tarp

v. Specialized Training
   1. All work shall be preformed by a trained properly supervised personal in accordance with US forest service guidelines for controlling invasive species
   2. All herbicides to be applied by a PA licensed applicator.

vi. Safety Issues
   1. Herbicides to be applied in accordance with label, MSDS sheets, and P.E.P equipment

vii. Notifications
   1. Notification to the PWD Project Manager, Property Owner, and Database Manager shall be provided at least two (2) days prior to conducting this work.
   2. Check hypersensitivity list when applying pesticide. Notify anyone on the list at least 12 hrs in advance, but not more than 72 hrs prior to application

viii. Access
1. XXX

ix. Timing Restrictions
1. Work should be performed before invasive species sets seed.

b. Major Invasive species removal

i. Description
1. Mow large invasive species areas with a forestry mower, brush hog, or flail mower
2. Basal bark treatment on large trees
3. Herbicide applications on stumps shrubs and perennial plant material that have been cut.
a. Herbicide application to cut plant material should be done immediately after being cut

ii. Applicability
1. Invasive species removal of larger areas of high impact will require approval/adjustments by PWD and may change the original landscaping plan prior to execution.
2. Replacement of native species will be necessary to fill the voids of the invasive species once the invasive species have been removed

iii. Authorization:
1. Notification to the Project Manager, Property Owner, and Database Manager shall be provided at least two (2) days prior to conducting this work

iv. Equipment and Materials
    1. Equipment, materials, and herbicide will vary depending on the size and type of invasive species present.

v. Specialized training
    1. All work shall be preformed by a trained properly supervised personal in accordance with US forest service guidelines for controlling invasive species
    2. All herbicides to be applied by a pa licensed applicator.

vi. Safety Issues
    1. Herbicides to be applied in accordance with label, MSDS sheets, and P.E.P equipment.
    2. Herbicide application should be precautions to ensure public health

vii. Notifications
    1. Notification to the Project Manager, Property Owner, and Database Manager shall be provided at least two (2) days prior to conducting this work

viii. Access
    1. Sensitive environmental areas (e.g., wetlands, steep slopes, etc.) should use the appropriate herbicide for the area

ix. Timing restrictions
    1. Work should be performed during actively growing season or before leaf drop

x. Follow-on effort
    1. Treated areas where invasive species are removed should be carefully monitored for re-growth and re-sprouting

Appendix II

Routine Maintenance Tasks Template

Philadelphia Water Department
Office of Watersheds
Green Infrastructure Maintenance and Monitoring Program
Stormwater Management Practice (SMP) Routine Maintenance Tasks
Draft Rain Garden [Page 1 of 2]

Maintenance Tier 1 - Safety and Core Function Routine Tasks

Task	Schedule	Special Considerations
Record Keeping:		
Document of all materials removed and added to the site	During each event	
Document time each crew member spent on each maintenance task	During each event	
Document and photograph any potential hazards to public safety or welfare	As needed	Immediately contact PWD if hazards are identified
Document and photograph any unusual observations in SMP function	As needed	
Document and photograph any sinkholes	As needed	
Document and photograph any standing water or evidence of standing water in atypical places	As needed	
Document and photograph erosion and/or scour	As needed	
Document and photograph any damaged structural features	As needed	
Document and photograph any dead, severely stressed, or severely damaged trees and vegetation	As needed	
Structural Maintenance:		
Remove trash, sediment, and organic debris from all surface stormwater conveyance features (including inlet and control structure grates)	Every other month	Remove trash, sediment, and organic debris up to four (4) feet upstream of all stormwater inflow locations
Clear debris from low flow orifices	Every other month	
Perform minor repairs to structural features (e.g., resetting stones, fine grading, etc..)	As needed	
Remove trash and organic debris from basin areas*	As needed	*When materials pose a clogging risk to stormwater conveyance structures. Retain all organic debris on site that does not inhibit stormwater conveyance.
Remove thick sediment accumulation from basin areas that appear to be impacting plant growth	As needed	Typically when sediment depth exceeds one (1) inch
Repair damaged no-mow edge by replacing rope, stakes, and signs as necessary	As needed	
Replace mulch, when applicable	Annually, March	Use mulch type specified in site-specific plan
Stabilize eroded, scoured, or undermined features by filling, inter-seeding, installation of erosion mat and seeding, or transplanting	As needed	Contact PWD for preferred stabilization methods for specific sites
Flush underdrain / cleanout structures	Annually	
Vacuum truck cleaning of all inlets and stormwater control structures	Annually	Do not allow sediment and debris to accumulate above lowest pipe invert

Philadelphia Water Department
Office of Watersheds
Green Infrastructure Maintenance and Monitoring Program
Stormwater Management Practice (SMP) Routine Maintenance Tasks
Draft Rain Garden [Page 2 of 2]

Maintenance Tier 1 - Safety and Core Function Routine Tasks (Continued)

Task	Schedule	Special Considerations
Vegetation Maintenance:		
Prune trees and shrubs to maintain public safety and plant condition	As needed	Avoid pruning more than 30% of a tree or shrub in one year
Hand pull aggressive non-target species and remove from site	Monthly to bimonthly*	*Depending on species and season. Species may include: morning glory; hops; porcelainberry; lesser celandine; smartweed; other non-targets as defined in site-specific plan
Treat thistle-spray with glyphosate herbicide	Biweekly to monthly for 2 - 4 applications in spring*	*Follow with 2 applications in fall if new growth observed
Treat Japanese knotweed-string trim or lop canes to ~4 in. and spray with glyphosate herbicide	One treatment in early summer and one in fall	A precision sprayer with concentrated herbicide is recommended
Cut non-target grasses seed heads and remove from site	As needed	Foxtail; Others as defined in site-specific plan
Cut deep rooted weeds at base to provide a competitive advantage for target species while retaining ground cover	As needed	
Cut back grasses to approximately six (6) inches	Annually*	*March or November as defined on site-specific plan
Reseed/interseed bare soil to maintain ground cover	As needed in spring or fall	
Mulch planted areas as per direction from PWD	Annually	
Treat diseased target species	As needed or annually*	*As defined in site-specific plan
Replace dead or diseased target species	As needed	
Install and fill tree gators during extended periods of drought	As needed or weekly*	*Frequency dictated by species and weather
Water target species (shrub and herbaceous) during extended periods of drought	As needed or weekly*	*Frequency dictated by species and weather

Maintenance Tier 2 - Aesthetic Routine Tasks

Task	Schedule	Special Considerations
Record Keeping:		
Document and photograph any unusual observations in SMP aesthetics	As needed	
Document and photograph any graffiti or other vandalism	As needed	
Structural Maintenance:		
Remove of all trash, sediment, and organic debris from basin areas	Monthly	Maintain trash-free appearance
Replenish and redistribute mulch to maintain aesthetic	As needed	
Remove/clean graffiti and vandalism	As needed	May require specialized cleaning materials/paint remover and training in use and disposal
Supplement, repair or replace degraded edges to aesthetic standard	As needed	
Vegetation Maintenance:		
Prune trees and shrubs to maintain aesthetic (plant form, shape, and habit)	March	Avoid pruning more than 30% of a tree or shrub in one year
Water weekly if no soaking rain	June to August	
Weed basin areas to maintain aesthetic standard	Every other week or monthly*	*Depending on season and aesthetic style as defined in site-specific plan. Informal SMPs require less frequent weeding than formal SMPs.
Replace target species in poor condition	As needed	
Vegetate bare soil with plugs or mature plants to maintain ground cover and aesthetic	As needed in spring or fall	

Appendix III

Maintenance Data Sheet Template

MAINTENANCE REPORT

[INSERT SITE IDENTIFICATION NUMBER AND NAME]

[INSERT SITE IDENTIFICATION NUMBER AND NAME]

I. MAINTENANCE VISIT

Maintenance Date	[INSERT DATE]
Maintenance Start Time	[INSERT START TIME]
Maintenance End Time	[INSERT END TIME]
Precipitation Depth Since Last Maintenance (inches)	[INSERT INCHES OF RAIN]
Crew Name	[INSERT CONTRACT COMPANY NAME]

II. SUMMARY TABLE OF MAINTENANCE AND LABOR

Task	**Labor Effort by Classification (Hr.)**				
	Project Manager	**Landscape fore-person**	**Landscape laborer**	**Mason**	**Total**
[INSERT ROUTINE MAINTENANCE TASK 1]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]
Subtotal Routine Maintenance	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**
[INSERT SPECIAL MAINTENANCE TASK 1]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]	[INSERT HOURS]
Subtotal Special Maintenance	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**
Total	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**	**[INSERT HOURS]**

III. SUMMARY TABLE OF MATERIALS USED AND/OR REMOVED

Task	**Material**	**Quantity**	**Units**
[INSERT ROUTINE MAINTENANCE TASK 1]	[INSERT MATERIAL]	[INSERT QUANITITY]	[INSERT UNIT]
[INSERT SPECIAL MAINTENANCE TASK 1]	[INSERT MATERIAL]	[INSERT QUANITITY]	[INSERT UNIT]

IV. NOTABLE MAINTENANCE OBSERVATIONS, SPECIAL MAINTENANCE DESCRIPTIONS, AND COMMUNITY COMMENTS

Notable Maintenance Observations and Special Maintenance Descriptions
• [INSERT NOTABLE OBSERVATION INCLUDING ISSUES WITH SMP FEATURES] • [INSERT DESCRIPTION OF SPECIAL OR UNEXPECTED MAINTENANCE]
Community Comments
• [INSERT ANY COMMENTS MADE BY COMMUNITY MEMBERS]

V. PHOTODOCUMENTATION

[INSERT PHOTOS OF NOTABLE OBSERVATIONS AND SPECIAL MAINTENANCE WITH CAPTIONS]

Appendix IV

Philadelphia Water Department Sewer Assessment Program Cleaning Training Manual

Philadelphia Water Department
Sewer Assessment Program
Cleaning Training Manual

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Appendix V

Philadelphia Water Department Collector System Support Engineering Field Sheet

The ARAMARK Tower
1101 Market Street
Philadelphia, Pennsylvania 19107-2994

Howard Neukrug
Commissioner

Collector System Support Engineering Field Sheet

CSS Engineer _____ Date_____

Location _____ Pictures Taken (circle): Yes No

Weather Condition (Circle):

Showers Snow Windy Thunderstorms Fog Cold Sunny/Hot

Project Description_____

Work# _____ Sheet# _____

Work Component Numbers

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

Water Access: Yes No

If yes describe location:_____

If used, describe use:_____

Project Description (circle) Green Inlets Dist. Pipe U.D. Pipe

Local Environmental Conditions:

_____

_____

_____

_____

Crew-Equipment Info

A. On-Site Equipment _____ Crew Number _____

B. On-Site Equipment _____ Crew Number _____

C. On-Site Equipment _____ Crew Number _____

D. On-Site Equipment _____ Crew Number _____

Component _____

Crew-Equipment	Initial Set-up Time	Active Work Time	Close out Time
A _____	_____ to _____	_____ to _____	_____ to _____
B _____	_____ to _____	_____ to _____	_____ to _____
C _____	_____ to _____	_____ to _____	_____ to _____
D _____	_____ to _____	_____ to _____	_____ to _____

Defects and Difficulties
A _____
B _____
C _____
D _____

Component _____

Crew-Equipment	Initial Set-up Time	Active Work Time	Close out Time
A _____	_____ to _____	_____ to _____	_____ to _____
B _____	_____ to _____	_____ to _____	_____ to _____
C _____	_____ to _____	_____ to _____	_____ to _____
D _____	_____ to _____	_____ to _____	_____ to _____

Defects and Difficulties
A _____
B _____
C _____
D _____

General Notes and Observations

Appendix VI

Inventory of Maintenance Practices and Procedures by GSI Practice

Appendix X: National Inventory of Maintenance Practices and Procedures by GSI Practice

Contents

Bioretention/Bioinfiltration

SMP Description

Bioretention Basin: Also known as bioinfiltration basin or rain garden, a bioretention basin is an excavated depression landscaped with native vegetation that filters, treats, and infiltrates stormwater runoff. Where infiltration is not feasible, underdrain pipe networks slowly release the filtered runoff.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to bio-infiltration/bio-retention maintenance from various stormwater maintenance manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Remove woody vegetation within 15 ft of the toe embankment or 25 ft from the principal spillway or growing on other structural features. ▪ Inspect for erosion, cracking, embankment subsidence, burrowing animals, and sediment and clogging in the emergency spillway, drain, and forebay. ▪ If erosion channels are evident, they can be stabilized with additional growth medium that is similar to the original. Use small stones to stabilize the erosion along the drainage paths.	▪ If sediment build-up is preventing flow through the wetland, remove gravel and sediment from cells. Replace with clean gravel and replant vegetation. ▪ Remove sediment from main cells of pond once the original volume has been significantly reduced every 5-10 years. ▪ Remove sediment from forebay every 5-6 years or when 50% full ▪ Repair/replace structural elements as necessary. ▪ Remove larger burrowing animals as necessary. ▪ Replace pea gravel diaphragm when needed. ▪ Do not stockpile snow in rain garden and do not place grass clippings/landscape waste in rain garden in order to prevent clogging of soil mix, which would limit infiltration capacity. ▪ Replace soil onceevery 20 years or as needed. ▪ Fertilize once initially. ▪ The basin floor should be covered with a 3”-4” layer of mulch.
Monthly	▪ Ensure that inlets and outlets are free from debris and not clogged. ▪ Monthly-Quarterly or after a major storm (>1”) inspect low flow orifices and other pipes for clogging ▪ Inspect plants to make sure they are free of pests and diseases.	▪ Mow rain garden if needed, making sure to collect and dispose of all grass clippings.
Quarterly		▪ Clean and remove debris from inlet/outlet structures. ▪ Repair/replace vegetation as necessary to maintain full cover.

Semi-Annually	▪ The rain garden system should drain within 48 hours of a storm event. Core aeration can be used to refresh infiltration capacity.	▪ Mow, remove debris, remove undercut, eroded, and back soil area. ▪ Remove sediments if they are within 18" of an outlet opening. ▪ In spring and fall seasons, add 1" of mulch to rain garden. ▪ Prune rain garden. ▪ Re-seed if necessary.
Annually	▪ Check for sediment build-up in general bed. ▪ Ensure that 50% of plants survive each year ▪ Inspect daylight pipes and overflow pipes to make sure they aren't clogged. ▪ Inspect pH of infiltration/planting soils in the rain garden soils. If pH is below 5.2, limestone should be applied. If the pH is above 7.0-8.0, then iron sulfate plus sulfur can be added to reduce the pH.	
Upon Failure	▪ Ponded water should infiltrate into the filter media within 48-72 hours of a storm event; prolonged ponding indicates that the filter media or underdrain system requires maintenance.	

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Rain Gardens:
  - Detritus may need to be removed approximately twice a year. Perennial plantings may be cut down at the end of the growing season.
  - Within the first year, 10% of plants may die. Survival rates increase with time.
- Fertilize grass only lightly. Excessive fertilizer is a pollutant.

References

ID	Location	Title	Year
CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacramento and South Placer Regions	2007
CA-SA-3	Sacramento, CA	Caltrans Stormwater Quality Handbook	2003
EPA-5	EPA	Stormwater Best Management Practice Design Guide Vol. 2 – Vegetative Bio-Filters	2004
GA-2	Georgia	Stormwater Wetlands: Georgia Stormwater Management Manual Vol. 2	2001

GA-5	Georgia	Bio-Retention Areas: Georgia Stormwater Management Manual Vol. 2	2001
GA-11	Georgia	Submerged Gravel Wetlands: Georgia Stormwater Management Manual Vol. 2	2001
GA-GC-1	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
I-AUS-1	New South Wales, Australia	App. D – Stormwater Maintenance Plan	2007
IA-3	Iowa	Bioretention Systems – Iowa Stormwater Management Manual	2009
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Chp. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MA-2	Massachusetts	Massachusetts Statewide Stormwater Management Training Seminar Series	
MD-CE-1	Centreville, MD	Environmental Site design Manual	2007
ME-6	Maine	Underdrained Bio-retention Cell: Maine Stormwater Best Management Practices Manual	2005
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
MN-MI-1	Minneapolis, MN	Stormwater Best Management Practice Operation and Maintenance Bioretention/Rain Garden	2005
NC-1	North Carolina	Backyard Rain Gardens – North Carolina Cooperative Extension	
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
NC-RA-1	Raleigh, NC	Stormwater Management Design Manual	2002
NY-2	New York	New York State DOT – Region 8 – Stormwater Facilities Operation and Maintenance Manual	2003
SC-BC-1	Beaufort County, SC	Manual for Stormwater Best Management Practices	2010
TN-CH-1	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Constructed Wetlands	ChattanoogaTN_ConstructedWetlands.pdf	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
Pond Facilities	GwinnettCountyGA_PondFacilities.pdf	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
Bioretention Area	KingsportTN_BioretentionAreas.pdf	Kingsport, TN	Stormwater Management Manual	
Submerged Gravel Wetland	KingsportTN_SubmergedGravelWetland.pdf	Kingsport, TN	Stormwater Management Manual	
Stormwater Wetland	KingsportTN_SWWetland.pdf	Kingsport, TN	Stormwater Management Manual	
Rain Garden	LibertyvilleIL_RainGarden.pdf	Libertyville, IL	Maintenance Plan Stormwater Management System	2004

Bioretention	MI_Bioretention.pdf	Michigan	Low Impact Development Manual for Michigan – App. F	
Rain Garden	MinneapolisMN_RainGarden.pdf	Minneapolis, MN	Stormwater Best Management Practice Operation and Maintenance Plan Bioretention/Rain Garden	2005
Bioretention Facilities	MN_BioretentionFacilities.pdf	Minnesota	Stormwater Maintenance Best Management Practice Resource Guide	2009
Stormwater Wetland	NC_SWWetland.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Bioretention Filter	NY_BioretentionFilter.pdf	New York	New York State Management Design Manual – App. G	2003
Stormwater Pond/Wetland	NY_SWPond&Wetland.pdf	New York	New York State Management Design Manual – App. G	2003
Treatment Wetland	PierceCountyWA_TreatmentWetland.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Wetponds	PierceCountyWA_Wetponds.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Infiltration/Filtration/ Bioretention	PulaskiCountyAR_InfiltrationFiltrationBioretention.pdf	Pulaski County, AR	Stormwater Management and Drainage Manual	2010
Stormwater Pond and Wetland	PulaskiCountyAR_SWPond&Wetland.pdf	Pulaski County, AR	Stormwater Management and Drainage Manual	2010
Bioretention	VA_Bioretention.pdf	Virginia	Virginia Stormwater Management Handbook – Chp. 9	2009
Constructed Wetlands	VA_ConstructedWetlands.pdf	Virginia	Virginia Stormwater Management Handbook – Chp. 9	2009

Green Roofs

SMP Description

Green Roof: A vegetated surface installed over an existing roof surface. Vegetated roofs are effective in reducing the volume and velocity of stormwater runoff. A typical green roof consists of a waterproofing and root barrier layer, insulation, drainage and filter layer, growth media, and plants. Green Roofs can either be installed as a fixed structure or as a series of removable modules.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements and field practices related to green roof maintenance compiled from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Inspect for ponding, dead or stressed vegetation, tall or sun scorched grass, weeds, and mechanical equipment for leaks and spills.	▪ Weeding should be manual with no pesticides or herbicides used. ▪ Irrigation can be accomplished through hand watering or automatic sprinkler system if necessary during the establishment period. ▪ Drain inlet pipe should be cleared when clogged with soil substrate, vegetation, debris or other materials. ▪ Plant material should be maintained to provide 90% plant cover. ▪ Mulch, water, and cover with plants as needed. ▪ Prune tall, dry grasses and remove clippings. ▪ Remove any woody substances that may become established on the roof.
Quarterly	▪ Growing medium inspection for evidence of erosion from wind or water.	▪ During first year, basic weeding, fertilizing and in-fill planting may be required. ▪ If erosion channels are evident, they can be stabilized with additional growth medium similar to the original material.
Semi-Annually	▪ Qualified staff should thoroughly inspect the roof twice/year in the spring and fall. ▪ Look for problems such as split seams, separated layers, failed flashings, clogged drains, surface punctures. ▪ Inspection should include an examination of the building interior areas directly below the roof. ▪ Pay particular attention to rooftop equipment and other roof penetrations, such as skylights, exhaust fans, air handlers, and vent stacks. Grease from exhaust fans, oil leaking	▪ Debris and sediment removal, if necessary. ▪ Weed. ▪ Repair any leaks or structural deficiencies.

Frequency	Inspection Requirements	Field Practice
	from HVAC units, and air pollutants can damage roof materials.	
Annually	▪ Inspect drain inlet pipe and contaminant system.	▪ If fertilizer is necessary, only apply once/year and only use fertilizers containing nitrogen, phosphorous, potassium, and micronutrients to support the living plants.

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Unhealthy plants have been seen to have been caused by: over-watering, lack of watering, over-fertilization, HVAC condensate, air vent damage, and people.
- For a green roof, weeds are considered as plants that can penetrate the membrane, dry out and cause a fire hazard, and are an invasive species.
- Manual or mechanical removal is suggested for weeding. Trimming and edging are usually not necessary.
- Leaks are rare, but if they occur they are usually around membrane penetrations such as vents. Contact the manufacturer for repair or replacement parts.

References

ID	Location	Title	Year
CT-MA-1	Manchester, CT	From Grey to Green – Sustainable Practices for Redeveloping A Vacant Shopping Center	2010
EPA-3	EPA	Operation and Maintenance of Green Infrastructure	
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
MA-1	Massachusetts	Vol. 2 Chp. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MA-2	Massachusetts	Massachusetts Statewide Stormwater Management Training Seminar Series	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
OR-PO-1	Portland, OR	Stormwater Management Manual – Chp. 3	
OR-PO-11	Portland, OR	Cost Benefit Evaluation of Ecoroofs	2008
PA-2	Pennsylvania	The Pennsylvania Green Building Operation & Maintenance Manual	
TN-NA-1	Nashville, TN	Green Infrastructure Using Low Impact Development	2009

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Green Roof	IndianapolisIN_Green_Roofs.pdf	Indianapolis, IN	Stormwater Design and Specification Manual	
Vegetated Roofs	VA_VegetatedRoofs.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Pervious Pavement

SMP Description

Porous Asphalt: Porous asphalt pavement consists of a modified open-graded friction courseasphalt pavement with sufficient interconnected voids to make it highly permeable to water.

Pervious Concrete: Pervious concrete consists of specially formulated mixtures of Portland cement, uniform, open-graded coarse aggregate, and water. Pervious concrete has enough void space to allow rapid percolation of liquids through the pavement.

Grid/Lattice Systems: A pavement surface composed structural units with void areas that are filled with pervious materials such as sand or grass turf. Porous pavers are installed over a gravel base course that provides storage as runoff infiltrates through the porous paver system into underlying permeable soils.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements and field practices related to pervious pavement maintenance compiled from various stormwater manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Ensure contributing area is clear of debris and stabilized.	▪ Surface sedimentation of reinforced turf shall be removed by a vacuum sweeper and not be power-washed into the bed. ▪ Maintain planted areas adjacent to pavement. ▪ Immediately clean any soil deposited on pavement. ▪ Do not allow construction staging, soil/mulch storage, etc. on unprotected pavement surface. ▪ Snow plowing is fine but should be done carefully (set blade slightly higher than usual). Snow plow piles should not be left on the side of the pavement to melt as clogging of pores can develop more quickly. ▪ Salt application is acceptable, although more environmentally benign deicers are preferable. Road salt application can be reduced up to 75%. ▪ May need occasional refilling of crushed rock or gravel. ▪ Remove trash and debris. ▪ Repair eroded areas and address the cause. ▪ For interlocking pavers: periodically add joint material to replace material that has been moved/worn by traffic or weather. ▪ Mow upland and adjacent areas, and seed bare areas.

		▪ Prevent large root systems from damaging subsurface structural components.
Monthly	▪ Ensure the pavement is free of sediment and make sure that the system dewaters between storms.	
Quarterly	▪ Water depth in the well shall be measured at 0-, 24-, and 48- hour intervals after a storm to determine the clearance rate.	▪ Vacuum Sweep or power wash ▪ Facility managers are generally advised to power wash and then vacuum.
Semi-Annually	▪ Inspect overflow outlet for clogging.	▪ Clean inlets draining to the subsurface bed. ▪ Remove noxious weeds and unwanted vegetation.
Annually	▪ Inspect for surface deterioration or spalling. ▪ After a major storm monitor percolation rate of parking lot system.	
Upon Failure	▪ N/A	▪ Total rehabilitation including top and base course as needed. ▪ Spot clogging can be handled by drilling ¼" – ½" holes through the pavement every few feet. ▪ Repair potholes and cracks using conventional asphalt patching mixes as long as the cumulative area does not exceed 10% of the parking lot area. ▪ Damaged areas less than 50 square ft can be patched with porous or standard asphalt.

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Sand or ash shall never be applied to porous pavement.
- DO NOT use surfactants
- Do not use sand during the winter months
- Surface should never be seal-coated.
- Restrict dirt-prone activities such as driving over parking lot with muddy tires, accessing the fields via the parking lot, or stockpiling soil directly on pavement in order to prevent clogging of pavement. The surface should be kept clean from debris such as leaves. No materials storage. No parking of heavy equipment or vehicles for extended periods of time.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacrament and South Placer Regions	2007
CA-SF-1	San Francisco, CA	San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook – 1st Edition	2009
CA-SF-2	San Francisco, CA	San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm	2010
CA-VE-1	Ventura, CA	Pavement Maintenance Plan	
CO-DC-1	Douglas County, CO	Standard Operating Procedures for Extended Detention Basin	2006
CT-MA-1	Manchester, CT	From Grey to Green – Sustainable Practices for Redeveloping A Vacant Shopping Center	2010
EPA-1	EPA	Green Parking Lot Resource Guide	2008
EPA-2	EPA	Green Streets Managing Wet Weather with Green Infrastructure Municipal Handbook	2008
EPA-3	EPA	Operation and Maintenance of Green Infrastructure	
GA-7	Georgia	Porous Concrete – Georgia Stormwater Management Manual Vol. 2	2001
GA-12	Georgia	Modular Porous Paver System – Georgia Stormwater Management Manual Vol. 2	2001
GA-GC-1	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
ID-1	Idaho	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	2005
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
IL-LI-1	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
NY-1	New York	New York State Stormwater Management Design Manual – Chp. 5	
OR-PO-1	Portland, OR	Stormwater Management Manual – Operation and Maintenance – Chp. 3	
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UCD-1	UC Davis	Green Streets – An Innovative Design Approach for Northern California	2009
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000
WA-SE-1	Seattle, WA	Traffic Control Plan – Construction and Maintenance – Chp. 5	
WA-SE-3	Seattle, WA	High Point Community – Natural Drainage and Landscape Maintenance Guidelines for Right-of-way and Open Space	2010

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Modular Porous Pavement Systems	KingsportTN_ModularPorousPaverSystems.pdf	Kingsport, TN	Stormwater Management Manual	
Porous Pavement	KingsportTN_PorousPavement.pdf	Kingsport, TN	Stormwater Management Manual	
Porous Parking Lot	LibertyvilleIL_PorousParkingLot.pdf	Libertyville, IL	Maintenance Plan Stormwater Management Systems	2004
Pervious Pavement	PierceCountyWA_PerviousPavement.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Permeable Pavement	VA_PermeablePavement.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Subsurface Infiltration/Detention

SMP Description

Subsurface Infiltration/Detention Basin: An underground structure designed to manage stormwater runoff by infiltration or detention and slow-release. Stormwater is typically conveyed via underground pipes to the basin which consists of a perforated pipe network and gravel storage bed.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to subsurface infiltration/detention maintenance compiled from various stormwater manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Inspect to see if anyinletsare blocked or damaged. ▪ Inspect for any voids or openings allowing soil or ground water to enter the facility. ▪ Look to see if any part of the tank/pipe is bent more than 10% out of shape. If so replace or fix it. ▪ Inspect outflow location to make sure a tail-water condition is not impeding discharge from the device. If this is the case, the tail-water level must be lowered.	▪ Control erosion, stabilize banks, remove excessive debris, and clean and repair inlet/outlet pipes. ▪ Prevent large root systems from damaging subsurface structural components. ▪ Tilling of subgrade soil below reservoir may be necessary prior to backfill. ▪ Remove sediment when it accumulates to 10% of the depth of a rectangular vault or 1/10 the diameter of a round tank or vault. ▪ Repair all cracks greater than ¼".
Monthly		▪ Measure the water depth in the observation well at 24- and 48- hour intervals after a storm. Calculate clearance rates. ▪ Ensure the contributing drainage area, facility, and inlets are clear of debris. Ensure that the contributing area is stabilized. Remove sediment and oil/grease from pre-treatment devices, as well as overflow structures.
Quarterly	▪ Ground water should be analyzed for indicator parameters such as pH, specific conductance, dissolved oxygen, and chloride. Zinc has been found as a stable heavy metal and should also be measured.	▪ Floating debris should be removed.
Semi-Annually	▪ Inspect pre-treatment devices and diversion structures for sediment buildup and structural damage.	▪ Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging.
Annually	▪ Infiltration facilitiesand surrounding areas should be inspected for pollutants	▪ Remove any trash, debris, and sediment that accumulated in tank/vault.

Frequency	Inspection Requirements	Field Practices
	such as leaks from dumpsters, minor spills, and oil dumping.	
Upon Failure	▪ N/A	▪ If the subsurface infiltration basin doesn't dissipate stormwater, it should be replaced or repaired. It is possible to restore some infiltration capacity by water-jetting clogged openings

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Safety: Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.
- Removed sediment must be disposed in the garbage as solid waste. Water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according the manufacturer's instructions.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
GA-1	Georgia	Detention Structural Stormwater Controls – Georgia Stormwater Management Manual	
GA-14	Georgia	Underground Detention – Georgia Stormwater Management Manual Vol. 2	2001
GA-GC-1	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
IA-1	Iowa	Infiltration Trenches – Iowa Stormwater Management Manual	2009
IA-2	Iowa	Infiltration Basins – Iowa Stormwater Management Manual	2009
ID-1	Idaho	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	2005
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Chp. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
ME-4	Maine	Infiltration Best Management Practices	2005
MI-1	Michigan	Low Impact Development for Michigan – App. F	

ID	Location	Title	Year
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
NC-GR-1	Greensboro, NC	Stormwater Management Manual	2009
NY-2	New York	New York State DOT – Region 8 – Stormwater Facilities Operation and Maintenance Manual	2003
OR-PO-1	Portland, OR	Stormwater Management Manual – Operation and Maintenance – Ch. 3	
SC-BC-1	Beaufort County, SC	Manual for Stormwater Best Management Practices	2010
TN-CH-1	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
U-UMN-3	University of MN	Maintenance for Infiltration Practices	
U-UMN-4	University of MN	Maintenance for Sedimentation Practices	
WA-BG-1	Battle Ground, WA	Stormwater Facility Maintenance Manual	2009
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Infiltration Trench	AR_InfiltrationTrench.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Tanks/Vaults	AR_TanksVaults.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Infiltration Trench	KingsportTN_InfiltrationTrench.pdf	Kingsport, TN	Stormwater Management Manual	
Underground Detention	MN_UndergroundDetention.pdf	Minnesota	Stormwater Maintenance Best Management Practice Research Guide	2009
Underground Treatment Devices	MN_UndergroundTreatmentDevices.pdf	Minnesota	Stormwater Maintenance Best Management Practice Research Guide	2009
Drywell	PierceCountyWA_Drywell.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Infiltration Facilities	PierceCountyWA_InfiltrationFacilities.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Infiltration Trench	PierceCountyWA_InfiltrationTrench.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Inlet/Outlet Pipe	PierceCountyWA_InletOuletPipe.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Tanks/Vaults	PierceCountyWA_TanksVaults.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Wet Vault	PierceCountyWA_WetVault.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Closed Detention Systems.	TumwaterWA_ClosedDetentionSystems.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Wet Vaults	TumwaterWA_WetVaults.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002

Surface Infiltration/Detention/Retention

SMP Description

Dry Extended Detention Basin: A large excavated depression that provides temporary storage of runoff and functions hydraulically to attenuate stormwater runoff peaks. The basin can be designed with extended flow paths with native vegetation to maximize water quality benefits.

Wet Pond/Retention Basin: A wet pond is a stormwater basin that includes a permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff storage.

Infiltration Basin: A shallow impoundment that stores and infiltrates runoff over a level, uncompacted area with relatively permeable soils.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to surface infiltration/detention maintenance compiled from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Note any standing water or evidence of extended ponding not intended in the design or function of the system. ▪ Check and record drawdown time during and after major storm events to document infiltration rates. ▪ Inspect for algae growth. Treat with EPA approved chemicals. ▪ Check for signs of unhealthy or overpopulation of fish and plants. ▪ Note signs of pollution, such as oil sheens, discolored water or unpleasant odors. ▪ Inspect inlet/outlet after any storm greater than 0.5" for clogging and remove debris.	▪ Sediment removal in the forebay shall occur when 50% of the total forebay capacity has been lost. ▪ The sediment chamber outlet devices shall be cleaned and/or repaired when drawdown times within the chamber exceed 36 hrs. ▪ Open channel sediment buildup within the bottom of the channel or filter strip shall be removed when 25% of the original Water Quality Volume (WQV) has been exceeded. ▪ Side slopes should be maintained as needed to promote dense vegetative cover with extensive root growth that enhances infiltration through the slope surface, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth. ▪ Repair undercut or eroded areas. ▪ Mow side slopes if necessary. ▪ Manage pesticides and nutrients. ▪ Inlets and outlets should be regularly cleared to prevent obstructions and reduced efficiency of the system. ▪ All mechanical equipment, such as gates, valves, locks, or other components, must be kept in working order in case of emergency. ▪ In wet pond systems, eliminate regular mowing of the shoreline edge to a minimum

Frequency	Inspection Requirements	Field Practice
		of 5-10 ft and allow vegetation to grow to 24”-30”. Reduced mowing will promote deeper root growth and soil stability at the pond edge. The vegetation will filter runoff from surrounding areas reducing nutrients and other pollutants in the pond. The vegetation will also deter use of the facility by unwanted Canada geese through the physical and visual barrier. ▪ Remove sediment from wet pond every 5-10 years. ▪ Remove sediment from dry pond every 2-10 years. ▪ Replace splash blocks or inlet gravel/rock. ▪ Fill, lightly compact, and install plant vegetation to disperse flow. ▪ Rake, till, or amend to restore infiltration rate. ▪ Stabilize 3:1 slopes/banks with plants. ▪ Remove sediment when it accumulates to 2” or if the facility does not drain between storms or meet 90% of design capabilities. If the facility has a sediment trap, clean out facility when ½ ft accumulates. ▪ Trees should not be allowed to grow on emergency overflows and berms that are over 4 ft high. Trees can block flows and roots can lead to berm failure. Remove woody vegetation within 15ft of the toe of the embankment, or 25ft of the principal spillway. ▪ Use jet-vac to remove debris if needed. ▪ The vegetative cover should be maintained at 85%. ▪ The underdrain system should be flushed and its components replaced/repaired as necessary. A high-pressure hose can be used to flush out underdrain systems by spraying water into cleanouts. ▪ Remove poisonous, nuisance vegetation, and noxious weeds.
Monthly		▪ Mowing should be done when needed ▪ Meadow Management: Reduce mowing frequency of the basin bottom and embankments to a single monthly mowing at a height of 6”-8” during the months of May-Sept. ▪ Clean out inlet and outlet pipes.
Quarterly	▪ Inspect and clean pre-treatment devices.	
Semi-	▪ Note erosion of pond banks or bottom.	▪ Cut back grass and prune overgrowth.

Frequency	Inspection Requirements	Field Practice
Annually	▪ Inspect inlets, outlets, side slopes, and other features for damage, significant erosion, graffiti, or vandalism, etc. ▪ Inspect for sediment accumulation in the inlet pipes.	▪ Average plant heights are greater than 12". Cut or remove vegetation and clippings once during the wet and dry season. ▪ Remove trash and debris. ▪ Manually remove weeds. ▪ Clean out sediment that might be restricting water flow ▪ If stone around the outlet pipe has accumulated sediment, vegetation, and/or debris to an extent that water is not flowing through the stone and out of the pond as originally designed, then the stone should be replaced with clean 3" diameter stone choked with a clean 6A stone.
Annually	▪ Inspect for damage to the embankment. Monitor for sediment accumulation in the facility and forebay. ▪ Examine to ensure that inlet/outlet devices are free of debris and operational. ▪ Inspect burrows, holes, or mounds annually and after vegetation trimming. Where burrows cause seepage, erosion, and leakage, backfill firmly. ▪ Inspect riprap at the inlet pipes. ▪ The extended dry detention basin shall be evaluated every 2 years to assess the need for a major cleanout. ▪ Inspect check dams.	▪ Annual mowing of the pond buffer is only required along maintenance right-of-way and the embankment. The remaining buffer can be managed as a meadow. Mow preferably after August. ▪ Seed or sod to restore dead or damaged ground cover. ▪ Irrigate as needed and mulch banks annually. Do not apply fertilizers, herbicides, or pesticides. ▪ Every 5-7 years remove sediment from the forebay or when it has accumulated to 5". ▪ Dredging should be considered every 10 years to assure that the pond can retain water and filter out pollutants. ▪ Removal of the top foot or so of soil is generally necessary every 5-10 years. If only dense clay remains after soil removal, it may be necessary to replace the removed sediments with clean topsoil, which should be seeded. Soil should be removed during drier summer periods to allow time for the grass to become re-established in the bottom of the basin. ▪ Maintain grass on check dam to prevent erosion and correct erosion problems before they become serious. ▪ Clean catch basins when they become 1/3 full to maintain sediment trapping capacity. Remove debris and litter as well. ▪ Basins should be re-mulched every 2-3 years.
Upon Failure	▪ A thorough inspection of the observation points should be made if there is a decrease in retention basin capacity. Inspection points can include monitoring ports built into the base of the facility and water table depth	▪ If after 2 applications (2 seasons) of reseeding/revegetating growth is still unsuccessful, consider installation of an erosion blanket or equivalent protection over eroding areas. No erosion blanket should be installed in the basin invert.

Frequency	Inspection Requirements	Field Practice
	monitoring wells. Water levels in these inspection points can provide information about the performance of the facility. ▪ Infiltration basins should drain completely during dry periods; standing water in the basin may indicate the need for maintenance.	▪ Identify and remove pollutant sources to the facility. ▪ If the facility is overflowing for storms it was designed to infiltrate, it needs to be repaired. This requires removing accumulated sediment and cleaning or rebuilding the system so that it works according to design. ▪ If liner has more than 3 holes with ¼" diameter in it, replace the liner.

Issues/Concerns

- Common plant diseases:
  - Dark gray to tan sunken spots on leaves: May be caused by anthracnose.
    - Avoid overhead watering.
    - Add mulch to root zone.
    - Increase air circulation around plant.
    - Remove and destroy infected portions of plant.
  - Blackened portions of plant: May be caused by fire-blight.
    - Remove and destroy infected portions of plant, pruning 6" minimum from diseased area.
  - Dull, yellow leaves, sparse, wilting, whitish fungal tissue below on roots below soil line: May be caused by oak root fungus.
    - Remove tree and all roots larger than ½" in diameter.
  - White to gray circular patches, poor growth and fruiting: May be caused by powdery mildew.
    - Spray infected areas with water early in the day to wash spores from plants.
    - Spray with IPM-approved natural treatment, such as Neem oil, vegetable oil or a 10:1 mix of water and milk.
  - Wilting, leaves with poor color and premature drop: May be caused by root rots or water molds:
    - Check irrigation to eliminate over-watering.
    - Check for and remedy poor drainage.
  - Yellow to purple-brown bumps on leaf underside or yellow spots: May be caused by rust.
    - Remove infected leaves.
    - Remove fallen leaves or branches.
    - Increase air circulation around plants.
  - Coniferous trees, particularly cedar and cypress species, exhibiting yellowing, wilting, or browning through all or most of crown: May be caused by Phytophthora spp., a fungus which attacks the roots.
    - Consult immediately with a certified arborist.
    - Test root material and/or adjacent soil for presence of the fungus.
    - If disease is strongly suspected or confirmed, remove tree and surrounding soil from site.
    - Use extreme care not to spread or track any soil or plant material from site of diseased tree to other areas of site.

    - Clean and disinfect any equipment used to remove, handle, or transport any diseased plant material or soil.
- Infiltration Basins:
    - Sediment should be removed only when the surface is dry and "mud-cracked."
    - Light equipment must be used in order to avoid compacting soils. After removal of sediment, the infiltration area should be deep tilled to restore infiltration rates.
- How to prevent algae blooms:
    - Soil test – Have your soil tested to find out which nutrients it may be lacking.
    - Mow high – Avoid mowing directly to the edge of lakes and streams. Grass clippings can get into the water and add excess nutrients as they breakdown. Having turf grass directly at the edge of a pond also can exacerbate erosion problems.
    - Use low or no phosphorous fertilizers
    - Fertilize after and not before a rain event or irrigation – Never fertilize when heavy rain is predicted. Rain can wash the fertilizer into the pond and promote algae growth.
    - Remove dead vegetation – These materials release excess nutrients as they decompose and will lead to more algae growth.
    - Use pond water, which can be rich in nutrients, to water your lawn.
- Mosquito control:
    - Prevent debris and soil from washing into the pond to create mosquito breeding habitat.
    - Use bacterial larvicides available from home improvement stores in pre-treatment devices.
    - Stock fish to eat mosquito larvae. Sunfish and mosquito fish are best.
    - Install aerator (foundation) to reduce stagnation and decrease mosquito population.
    - Install bat houses or purple martin houses to encourage these insect-eating animals.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-SA-1	Sacramento, CA	Stormwater Quality Manual for the Sacramento and South Placer Regions	2007
CA-SA-3	Sacramento, CA	Caltrans Stormwater Quality Handbook	2003
CO-DC-1	Douglas County, CO	Standard Operating Procedures for Extended Detention Basin	2006
GA-1	Georgia	Detention Structural Stormwater Controls – Georgia Stormwater Management Manual	
GA-4	Georgia	Stormwater Ponds – Georgia Stormwater Management Manual Vol. 2	2001
GA-6	Georgia	Dry Detention/Dry ED Basins – Georgia Stormwater Management Manual Vol. 2	2001
GA-13	Georgia	Multi-purpose Detention Areas – Georgia Stormwater Management Manual Vol. 2	2001
GA-GC-1	Gwinnett County, GA	Stormwater Facilities Installation Standards and Specifications	2006
IA-2	Iowa	Infiltration Basins – Iowa Stormwater Management Manual	2009
ID-1	Idaho	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	2005
ID-2	Idaho	Erosion and Sediment Control Best Management Practice Manual	2011
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011

IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
LA-BR-1	Baton Rouge, LA	Stormwater Best Management Practice for East Baton Rouge Parish – Master Development Program	
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-3	Maryland	Maryland Stormwater Design Manual	2000
ME-1	Maine	Peak Flow Control/Detention Basins – Maine Stormwater Best Management Practices Manual	2005
ME-2	Maine	Wet Ponds – Maine Stormwater Best Management Practices Manual	2005
MI-1	Michigan	Low Impact Development Manual for Michigan – App. F	
MI-4	Michigan	Catch Basins	1992
MI-5	Michigan	Infiltration Basins	1992
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
NC-GR-1	Greensboro, NC	Stormwater Management Manual	2009
NC-RA-1	Raleigh, NC	Stormwater Management Design Manual	2002
NJ-2	New Jersey	New Jersey Stormwater Best Management Practice Manual – Standard for Extended Detention Basins	2004
NJ-3	New Jersey	Stormwater Management Basins and Their Maintenance	
NV-1	Nevada	Stormwater Quality Manuals	2006
NY-2	New York	New York State DOT – Region 8 – Stormwater Facilities Operation and Maintenance Manual	2003
OR-PO-1	Portland, OR	Stormwater Management Manual – Operation and Maintenance – Ch. 3	
SC-BC-1	Beaufort County, SC	Manual for Stormwater Best Management Practices	2010
SC-GC-1	Greenville County, SC	Stormwater Pond Management and Maintenance	
TN-CH-1	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-4	University of MN	Maintenance for Sedimentation Practices	
WA-BG-1	Battle Ground, WA	Stormwater Facility Maintenance Manual	2009
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000
WA-FE-1	Ferndale, WA	Stormwater Pond Maintenance	
WA-SE-3	Seattle, WA	High Point Community – Natural Drainage and Landscape Maintenance Guidelines for Right-of-way and Open Space	2010

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Catch Basin	AR_CatchBasin.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Ponds	AR_Ponds.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Dry Detention Pond	ChattanoogaTN_DryDetentionPond.pdf	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
Infiltration	ChattanoogaTN_Infiltration	Chattanooga, TN	Maintenance of Detention Devices –	2003

Basin	Basin.pdf		Stormwater Best Management Practices Manual	
Wet Detention Basin	ChattanoogaTN_WetDetentionBasin.pdf	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
Conventional Dry Detention Basin	KingsportTN_ConventionalDryDetentionBasin.pdf	Kingsport, TN	Stormwater Management Manual	
Dry Extended Detention Basin	KingsportTN_DryExtendedDetentionBasin.pdf	Kingsport, TN	Stormwater Management Manual	
Stormwater Basin	KingsportTN_StormwaterBasin.pdf	Kingsport, TN	Stormwater Management Manual	
Detention	MI_Detention.pdf	Michigan	Low Impact Development Manual for Michigan – App. F	
Detention Pond	MI_DetentionPondChecklist.pdf	Michigan	Maintaining Your Detention Pond – A Guidebook for Private Owners in Southeast Michigan	
Infiltration	MI_Infiltration.pdf	Michigan	Low Impact Development Manual for Michigan – App. F	
Infiltration	MN_Infiltration.pdf	Minnesota	Stormwater Maintenance Best Management Practice Report	2009
Stormwater Ponds	MN_StormwaterPonds.pdf	Minnesota	Stormwater Maintenance Best Management Practice Report	2009
Dry Detention Basin	NC_DryDetentionBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Bioretention Basin	NC_BioretentionBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Filtration Basin	NC_FiltrationBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Hazardous Spill Basin	NC_HazardousSpillBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Infiltration Basin	NC_InfiltrationBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Wet Detention Basin	NC_WetDetentionBasin.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Infiltration Practices	NY_InfiltrationPractices.pdf	New York	New York State Stormwater Management Design Manual – App. G	2003
Catch Basin	PierceCountyWA_CatchBasin.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Detention Pond	PierceCountyWA_DetentionPond.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Infiltration Retention Pond	PierceCountyWA_InfiltrationRetentionPond.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Storm Filter	PierceCountyWA_Stormfilter.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Catch Basin Insert	TumwaterWA_CatchBasinInsert.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002

Catch Basins and Inlets	TumwaterWA_CatchBasins &Inlets.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Ponds	TumwaterWA_Ponds.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Extended Detention Ponds	VA_ExtendedDetentionPonds.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Infiltration Practices	VA_InfiltrationPractices.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Wet Ponds	VA_WetPonds.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Constructed Wetlands

SMP Description

Constructed Wetland: A wetland is a shallow marsh system planted with emergent vegetation that is designed to treat stormwater runoff. They function hydraulically to mitigate peak rates and reduce runoff volume while providing aesthetic and wildlife benefits. Constructed wetlands use a relatively large amount of space and require an adequate source of sustained inflow or baseflow to maintain a permanent water surface.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to constructed wetland maintenance from various stormwater maintenance manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Ensure that at least 50% of shallow marsh area is covered by wetland vegetation. ▪ Remove woody vegetation within 15 ft of the toe embankment or 25 ft from the principal spillway or growing on other structural features. ▪ Inspect for erosion, cracking, embankment subsidence, burrowing animals, sediment and clogging in the emergency spillway, drain and forebay. ▪ If erosion channels are evident, they can be stabilized with additional growth medium that is similar to the original. Use small stones to stabilize the erosion along the drainage paths.	▪ If sediment build-up is preventing flow through the wetland, remove gravel and sediment from cells. Replace with clean gravel and replant vegetation. ▪ Remove sediment from main cells of pond once the original volume has been significantly reduced every 5-10 years. ▪ Remove sediment from forebay every 5-6 years or when 50% full; from wetland if 25% of capacity is lost or long flow path of water is hindered. ▪ Repair/replace structural elements as necessary. ▪ Remove larger burrowing animals as necessary. ▪ Replace mulch over the entire area every 2-3 years. ▪ Replace pea gravel diaphragm when needed. ▪ Replace soil once/every 20 years or as needed.
Monthly	▪ Ensure that inlets and outlets are free from debris and not clogged. ▪ Monthly-Quarterly or after a major storm (>1”) inspect low flow orifices and other pipes for clogging; check the permanent pool or dry pond area for floating debris, undesirable vegetation; investigate the shoreline for erosion; monitor wetland plant composition and health. ▪ Inspect plants to make sure they are free of pests and diseases.	

Frequency	Inspection Requirements	Field Practices
Quarterly	▪ Inspect wetland for abnormal algae growth and address as needed.	▪ Clean and remove debris from inlet/outlet structures. ▪ Repair/replace vegetation as necessary to maintain full cover.
Semi-Annually	▪ Monitor wetland plant composition and health; Identify invasive plants.	▪ Mow, remove debris, remove undercut, eroded, and back soil area. ▪ Harvest wetland plants; replant vegetation; repair broken mechanical components (if needed). ▪ Remove sediments if they are within 18" of an outlet opening. ▪ Re-seed if necessary.
Annually	▪ Check for sediment build-up in general bed. ▪ Ensure that 50% of plants survive each year; check for invasive wetland plants. ▪ Inspect wetland in early spring. ▪ Inspect daylight pipes and overflow pipes to make sure they aren't clogged.	▪ Stock with mosquito fish for mosquito control. ▪ Mow side slopes, embankments, emergency spillways, and access road at least annually, preferably after August. ▪ Harvest wetland plants that have been "choked out" by sediment build-up. ▪ Burn vegetation or clip standing dead vegetation stalks in order to maintain weed free vegetation. Stems and seed heads can be left for winter interest, wildlife cover, and bird food. If burning isn't possible, dead plant material should be trimmed when new growth is 4"-6" tall.
Upon Failure	▪ Ponded water should infiltrate into the filter media within 48-72 hours of a storm event; prolonged ponding indicates that the filter media or underdrain system requires maintenance.	▪ Sparse vegetation or clumps of cattail do not properly treat stormwater. Try to find the cause of the problem and fix it to ensure dense vegetation. Cut back excessive cattail shoots. ▪ Large cattail colonies should be removed with a backhoe. Chemical application may be used for small or new cattail growth.

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Wetland water level should remain near the drawdown device, except under drought conditions.
- If a constructed wetland is not retaining pollutants at expected levels, the following steps should be taken:
    - Check to make sure that the desired levels of pollutant capture are realistic. For example, if the sediment size distribution contains an uncharacteristically large fraction of fines, the hydraulic retention time may not be adequate to achieve the desired retention rate. If retention of the desired pollutant is not realistic, consider implementing another SW treatment practice to achieve desired results. Or, if the

pollutant is primarily in dissolved form and the vegetation in the wetland is known not to uptake the pollutant at significant levels, it is unrealistic to expect significant levels of retention.

- Perform a sediment capacity test to determine the remaining sediment storage capacity of the wetland. If the storage capacity is exhausted or nearly exhausted, the retained sediment should be removed.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacramento and South Placer Regions	2007
CA-SA-3	Sacramento, CA	Caltrans Stormwater Quality Handbook	2003
EPA-5	EPA	Stormwater Best Management Practice Design Guide Vol. 2 – Vegetative Bio-Filters	2004
GA-2	Georgia	Stormwater Wetlands: Georgia Stormwater Management Manual Vol. 2	2001
GA-5	Georgia	Bio-Retention Areas: Georgia Stormwater Management Manual Vol. 2	2001
GA-11	Georgia	Submerged Gravel Wetlands: Georgia Stormwater Management Manual Vol. 2	2001
GA-GC-1	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
I-AUS-1	New South Wales, Australia	App. D – Stormwater Maintenance Plan	2007
IA-3	Iowa	Bioretention Systems – Iowa Stormwater Management Manual	2009
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MA-2	Massachusetts	Massachusetts Statewide Stormwater Management Training Seminar Series	
MD-CE-1	Centreville, MD	Environmental Site design Manual	2007
ME-6	Maine	Underdrained Bio-retention Cell: Maine Stormwater Best Management Practices Manual	2005
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
MN-MI-1	Minneapolis, MN	Stormwater Best Management Practice Operation and Maintenance Bioretention/Rain Garden	2005
NC-1	North Carolina	Backyard Rain Gardens – North Carolina Cooperative Extension	
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
NC-RA-1	Raleigh, NC	Stormwater Management Design Manual	2002
NY-2	New York	New York State DOT – Region 8 – Stormwater Facilities Operation and Maintenance Manual	2003
SC-BC-1	Beaufort County, SC	Manual for Stormwater Best Management Practices	2010
TN-CH-1	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Constructed Wetlands	ChattanoogaTN_ConstructedWetlands.pdf	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
Pond Facilities	GwinnettCountyGA_PondFacilities.pdf	Gwinnett County, GA	Stormwater Systems and Facilities Installation Standards and Specifications	2006
Bioretention Area	KingsportTN_BioretentionAreas.pdf	Kingsport, TN	Stormwater Management Manual	
Submerged Gravel Wetland	KingsportTN_SubmergedGravelWetland.pdf	Kingsport, TN	Stormwater Management Manual	
Stormwater Wetland	KingsportTN_SWWetland.pdf	Kingsport, TN	Stormwater Management Manual	
Rain Garden	LibertyvilleIL_RainGarden.pdf	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
Bioretention	MI_Bioretention.pdf	Michigan	Low Impact Development Manual for Michigan – App. F	
Rain Garden	MinneapolisMN_RainGarden.pdf	Minneapolis, MN	Stormwater Best Management Practice Operation and Maintenance Plan Bioretention/Rain Garden	2005
Bioretention Facilities	MN_BioretentionFacilities.pdf	Minnesota	Stormwater Maintenance Best Management Practice Resource Guide	2009
Stormwater Wetland	NC_SWWetland.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Bioretention Filter	NY_BioretentionFilter.pdf	New York	New York State Management Design Manual – App. G	2003
Stormwater Pond/Wetland	NY_SWPond&Wetland.pdf	New York	New York State Management Design Manual – App. G	2003
Treatment Wetland	PierceCountyWA_TreatmentWetland.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Wetponds	PierceCountyWA_Wetponds.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Infiltration/Filtration/ Bioretention	PulaskiCountyAR_InfiltrationFiltrationBioretention.pdf	Pulaski County, AR	Stormwater Management and Drainage Manual	2010
Stormwater Pond and Wetland	PulaskiCountyAR_SWPond&Wetland.pdf	Pulaski County, AR	Stormwater Management and Drainage Manual	2010
Bioretention	VA_Bioretention.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Constructed Wetlands	VA_ConstructedWetlands.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Roof Leaders – Rain Barrel/Cistern

SMP Description

Rain Barrel/Cistern: A rain barrel is a storage device that captures and stores runoff from roof leaders and is effective in reducing runoff volume from small storms. Stored water may be discharged to a pervious area, or treated and distributed to serve a variety of on-site water needs (i.e. irrigation).

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of rain barrels from various stormwater manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Inspect the cistern periodically to ensure debris doesn't clog the system. ▪ Check for leaks at connection points. ▪ Inspect roof catchments to ensure that minimal amounts of particulate matter or other contaminants are entering the gutter and downspout. ▪ Inspect diverts, cleanout plugs, screens, covers, and overflow pipes and repair or replace as needed.	▪ Repair/seal cracks. Replace when repair is insufficient. ▪ Rain barrel must be sealed during warm months and drained before winter.
Monthly		▪ For maximum benefits, empty the barrel between rain events in the wet season.
Quarterly	▪ Inspect rooftop detention for clogging after every storm greater than 1".	
Annually	▪ Inspect storage area to ensure that encroachments or renovations do not reduce available storage.	▪ Clean the cistern/rain barrel interior with a brush and vinegar or other non-toxic cleaner that will not degrade water quality or harm the cistern. The washout cleaning can be disposed of onsite to vegetated areas if disinfecting agents are adequately diluted so they don't harm plants.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-LA-1	Los Angeles, CA	Green Streets and Alleys Design Guidelines Standards – 1st Edition	2009

CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacramento and South Place Regions	2007
CA-SF-2	San Francisco, CA	San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm	2010
CA-VE-2	Ventura, CA	Green Streets Matrix – Dept. of Public Works	2008
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
IL-LI-1	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
IN-ID-1	Indianapolis, IN	4.1 Green Roofs	
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
NC-1	North Carolina	Backyard Rain Gardens – North Carolina Cooperative Extension	
NY-1	New York	New York Stormwater Management Design Manual – Ch. 5	
OR-PO-1	Portland, OR	Stormwater Management Manual – Operation and Maintenance – Ch. 3	
TN-NA-1	Nashville, TN	Green Infrastructure Design Using Low Impact Development	2009
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Cistern	PierceCountyWA_Cistern.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Drywells, French Drains, or Downspouts	TumwaterWA_DrywellsFrenchDrainsDownspouts.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Rain Tanks and Cistern	VA_Cistern.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Rooftop Disconnection	VA_RooftopDisconnection.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Roof Leaders – Stormwater Planter

SMP Description

Stormwater Planter: A structure filled with planting media and planted with herbaceous vegetation. Planters are designed to detain, treat, and infiltrate or release runoff from rooftops.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of stormwater planters from various stormwater manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Check for leaks at connection points. ▪ Inspect roof catchments to ensure that minimal amounts of particulate matter or other contaminants are entering the gutter and downspout. ▪ Inspect diverts, cleanout plugs, screens, covers, and overflow pipes and repair or replace as needed.	▪ Repair/seal cracks. Replace when repair is insufficient. ▪ Irrigate as needed. ▪ Manually remove weeds. ▪ Screen all vents to prevent mosquito breeding.
Monthly	▪ N/A	
Quarterly	▪ Inspect inlets or outlets, cracked drain pipes, dead or strained vegetation, tall or overgrown plants, weeds, erosion, and ponding. ▪ Inspect rooftop detention for clogging after every storm greater than 1”.	▪ Periodically remove debris and sediment from planter. ▪ Repair/replace vegetation as necessary to maintain full cover.
Annually	▪ Inspect storage area to ensure that encroachments or renovations do not reduce available storage.	
Upon Failure	▪ During times of extended drought, look for physical features of stress.	▪ Rake, till, or amend to restore infiltration rate.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-LA-1	Los Angeles, CA	Green Streets and Alleys Design Guidelines Standards – 1st Edition	2009
CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacramento and South Place Regions	2007
CA-SF-2	San Francisco, CA	San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm	2010

CA-VE-2	Ventura, CA	Green Streets Matrix – Dept. of Public Works	2008
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
IL-LI-1	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
IN-ID-1	Indianapolis, IN	4.1 Green Roofs	
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
NC-1	North Carolina	Backyard Rain Gardens – North Carolina Cooperative Extension	
NY-1	New York	New York Stormwater Management Design Manual – Ch. 5	
OR-PO-1	Portland, OR	Stormwater Management Manual – Operation and Maintenance – Ch. 3	
TN-NA-1	Nashville, TN	Green Infrastructure Design Using Low Impact Development	2009
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Cistern	PierceCountyWA_Cistern.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Drywells, French Drains, or Downspouts	TumwaterWA_DrywellsFrenchDrainsDownspouts.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Rain Tanks and Cistern	VA_Cistern.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Rooftop Disconnection	VA_RooftopDisconnection.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Filter Strips

SMP Description

Filter Strip: A densely vegetated strip of land that treats sheet flow stormwater from adjacent pervious and impervious areas. They function by slowing runoff, trapping sediment and pollutants, and in some cases infiltrating a portion of the runoff.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of filter strips from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Inspect vegetation on slopes for erosion and formation of rills or gullies, correct as needed. ▪ Inspect for pools of standing water or litter ▪ Inspect for concentrated flows, sediment accumulation, adequacy of grass coverage in grassy filter strip, and erosion in contributing drainage area.	▪ Remove accumulated sediment ▪ Harvesting and pruning of excessive growth will need to be done occasionally. Weeding to control unwanted or invasive plants may also be necessary ▪ Mow and trim vegetation to ensure safety and aesthetics or to suppress weeds and invasive vegetation; dispose of cuttings in a local composting facility ▪ Plant alternative grass species in the event of unsuccessful establishment. ▪ Re-seed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming. ▪ Water during dry periods, fertilize, and apply pesticide only when absolutely necessary. ▪ Filter strips need grass to be cut no less than 4". Greater than 5" is preferred. Maximum of 8". ▪ Fertilize and lime as needed to maintain dense vegetation. ▪ Manually remove weeds. ▪ If ruts develop, fill them with coarse soil, level the surface, and re-seed.
Monthly	▪ N/A	▪ Maintain vegetation monthly during first year to enhance appearance and prevent erosion/clogging of bio-swale soil mix.
Quarterly	▪ Inspect all vegetated strip components expected to receive and/or trap debris and sediment for clogging and excessive debris and sediment accumulation.	▪ Remove sediment during dry periods.
Semi-Annually	▪ Vegetated areas should be inspected for erosion, scour, and unwanted growth. This should be removed with minimum disruption to the planting	▪ If mowing is desired, only hand-held string trimmers or push-mowers are allowed on the filter (no tractor) and the grass bed should be mowed to a height no less than

Frequency	Inspection Requirements	Field Practice
	soil bed and remaining vegetation. ▪ Inspect grass filter strip for erosion or gullying. ▪ Inspect trees, shrubs, and vegetation to evaluate their health.	6". ▪ Remove sediment and correct grading and flow channels during dry periods. ▪ Meadow buffers may be mowed no more than twice per year.
Annually	▪ Inspections should be conducted and when possible coordinated to correspond with a significant storm (2"-3" of rainfall). ▪ Inspect pH of soil in planting area. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0-8.0, then iron sulfate plus sulfur can be added to reduce pH.	▪ Sediment and plant debris should be removed from the pretreatment structure at least annually. ▪ Correct any erosion problems and damage to vegetation. ▪ After the first year, only spot clipping (or spot chemical treatment) should be done, rather than clipping or otherwise treating the entire strip. If noxious weeds develop, clip in the spring to prevent weed seeds from dispersing. ▪ Mow grassy filter strips at least once per year. Vegetated filter strips should not be mowed in order to allow for natural succession.
Upon Failure	▪ N/A	▪ N/A

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-1	California	Stormwater Quality Handbooks	2003
CA-LA-1	Los Angeles, CA	Green Streets and Green Alleys Design Guidelines Standards – 1st Editions	2009
CA-SF-2	San Francisco, CA	San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm	2010
CA-VE-2	Ventura, CA	Green Streets Matrix – Dept. of Public Works	2008
CT-1	Connecticut	Connecticut Guidelines for Soil Erosion and Sediment Control	2002
EPA-5	EPA	Stormwater Best Management Practices Design Guide Vol. 2 – Vegetative Bio-Filters	2004
GA-8	Georgia	Enhanced Swales – Georgia Stormwater Management Manual Vol. 2	2001
GA-9	Georgia	Filter Strip – Georgia Stormwater Management Manual Vol. 2	2001
GA-10	Georgia	Grass Channel – Georgia Stormwater Management Manual Vol. 2	2001
ID-1	Idaho	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	2005
ID-2	Idaho	Erosion and Sediment Control Best Management Practices Manual	2011
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
IL-LI-1	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
IN-ID-2	Indianapolis, IN	4.4 Stormwater Green Infrastructure Guidance – Filter Strips	2008
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007

ID	Location	Title	Year
ME-3	Maine	Vegetated Buffers – Maine Stormwater Best Management Practices Manual	2005
ME-9	Maine	Vegetated Swales – Maine Stormwater Best Management Practices Manual	2005
MI-1	Michigan	Low Impact Development Manual for Michigan – App. F	
MI-3	Michigan	Buffer/Filter Strips	1997
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual – North Carolina DOT	2010
NC-GR-1	Greensboro, NC	Stormwater Management Manual	2009
NC-RA-1	Raleigh, NC	Stormwater Management design Manual	2002
NV-1	Nevada	Stormwater Quality Manuals – Nevada DOT	2006
NY-1	New York	New York State Stormwater Management Design Manual – Ch. 5	
OR-PO-1	Portland, OR	Stormwater Management Manual – O&M – Ch. 3	
PA-3	Pennsylvania	Best Management Practices #: Vegetated Swale	
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	
VA-FA-1	Fairfax, VA	Stormwater Pond and Wetlands Maintenance Guidebook	2004
WA-1	Washington	Vegetated Stormwater Facility Maintenance	2000
WA-BG-1	Battle Ground, WA	Stormwater Facility Maintenance Manual	2009
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000
WA-SE-3	Seattle, WA	High Point Community – Natural Drainage and Landscape Maintenance Guidelines for Right-of-way and Open Space	2010

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Bio-filtration Swale	AR_BiofiltrationSwales.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Dispersion Trenches	AR_DispersionTrenches.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Enhanced Swales	KingsportTN_EnhancedSwales.pdf	Kingsport, TN	Stormwater Management Manual	
Filter Strip	KingsportTN_FilterStrip.pdf	Kingsport, TN	Stormwater Management Manual	
Grass Channel	KingsportTN_GrassChannel.pdf	Kingsport, TN	Stormwater Management Manual	
Bioswale/Bioretention	LibertyvilleIL_BioswaleBioretention.pdf	Libertyville, IL	Stormwater Management System Maintenance Plan	2004
Vegetated Swale	MartinezCA_VegetatedSwale.pdf	Martinez, CA	Stormwater Control Operation and Maintenance Plan	
Bioswale Filter Strip	MI_BioswaleFilterStrip.pdf	Michigan	Low Impact Development for Michigan – App. F	
Level Spreader	NC_LevelSpreader.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Swale	NC_Swale.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Open Channel	NY_OpenChannel.pdf	New York	New York State Stormwater Management Design Manual – App. G	2003
Bio-infiltration	PierceCountyWA_Bioinfiltrati	Pierce County,	Stormwater Maintenance Manual	

Swale	onSwaels.pdf	WA		
Field Inlet	PierceCountyWA_FieldInlet.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Filter Strip	PierceCountyWA_FilterStrip.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Wet Bio-infiltration Swale	PierceCountyWA_WetBioinfiltrationSwales.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Grass Swale	PierceCountyWA_GrassSwale.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Open Channel	PierceCountyWA_OpenChannel.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Conveyance Pipes, Ditches, and Swales	TumwaterWA_ConveyancePipesDitchesSwales.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Storm Filter	TumwaterWA_StormFilter.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Dry Swale	VA_DrySwales.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Filtering Practices	VA_FilteringPractices.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Filter Strips	VA_FilterStrips.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Grass Channels	VA_GrassChannels.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Wet Swales	VA_WetSwales.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Filters

SMP Description

Filter: A structure or excavated area containing a layer of sand, compost, organic material, peat, or other filter media. They reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Filtered stormwater may be infiltrated or released to a sewer or receiving water.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of filters from various stormwater manuals.

Frequency	Inspection Requirements	Field Practices
As Needed	▪ Inspect for clogged inlets or outlets, weeds, large shrubs and trees, ponding, gullies, erosion, and cracked drain pipes, liners, walls, or traps. ▪ Inspect for proper dewatering. Filter should be dewatered 48 hours after a storm event. ▪ A record should be kept of the dewatering time. ▪ Inspect for rillying and gullying of embankments or sedimentation forebay.	▪ Remove sediment and debris from silt traps, trench drains, inlets, and pipes to maintain at least 50% conveyance capacity at all times. ▪ Repair/seal cracks. Replace when repair is insufficient. ▪ Manually remove weeds. ▪ Prevent large root systems from damaging subsurface structural components. ▪ Do not apply herbicides or pesticides. ▪ Rake and remove layer of oil and sediment and restore infiltration rate. ▪ Restore outfalls or splash blocks where necessary. ▪ Fill, lightly compact, and install flow spreader/plant vegetation to disperse flow. ▪ Replace sand layer in filtration basin when filtration capacity is diminished. ▪ Clean drains; jet-vac if needed. ▪ Remove sediment when buildup exceeds 3”. Sediment can be removed by hand using a shovel or rake or from larger areas by excavation. ▪ Watering may be necessary to establish plant growth during the first few months. Remove debris and weeds as needed.
Monthly	▪ Check the contributing drainage area, facility, inlets and outlets for debris; Check to ensure that the filter surface is not clogging.	▪ Mow and stabilize (prevent erosion, vegetate denuded areas) the area draining to the filter. Collect and remove grass clippings. ▪ Remove trash and debris.
Quarterly	▪ N/A	▪ If filter is vegetated with grass, mow to a maximum height of 12”.
Semi-Annually	▪ Inspect drains for evidence of deterioration or scour.	▪ Repair or replace any damaged parts ▪ Stabilize eroded areas.
Annually	▪ Check to see that the filter bed is clean of sediment and the sediment chamber is not more than 50% full or 6”, whichever is less, of sediment.	▪ Repair leaks from the sedimentation chamber or deterioration of structural components. ▪ Remove the top few inches of sand and cultivation of the surface when filter bed is clogged. ▪ Clean-out accumulated sediment from filter bed

Frequency	Inspection Requirements	Field Practices
	▪ Inspect grates, inlets, outlets, and overflow spillway to ensure good condition and no evidence of erosion. ▪ Check to see if stormwater flow is bypassing the facility. ▪ Ensure that no noticeable odors are detected outside the facility.	chamber when it exceeds 1". Sediment should be removed from the sedimentation chamber when 6" have accumulated at the bottom. ▪ Replenish mulch layer to its original depth every 2 years. The removed mulch layer shall be properly disposed of or roto-tilled into the surface. Ensure that mulch does not contain seeds of plants considered invasive.
Upon Failure	▪ If at any time, it is determined that filtration rates are too large or the total suspended solids retention rate is too low, it is likely that there is a shortage circuit in the filter media. One should perform a visual inspection of the filer media to ensure no holes, ruts, or other openings in the media that would allow runoff to pass without being sufficiently filtered. Or one can perform a capacity test to determine filtration rates at various locations. ▪ Outflow rate should be checked if necessary.	▪ Snake and flush underdrain system to remove any blockages, if water is not draining within 48 hours after a storm event.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-SA-1	Sacramento, CA	Stormwater Quality Design Manual for the Sacramento and South Placer Regions	2007
CO-DC-3	Douglas County, CO	Standard Operation Procedure for Sand Filter Basin	2006
I-AUS-1	New South Wales, Australia	App. D – Stormwater Maintenance Plan	2007
ME-5	Maine	Grasses Underdrain Soil Filter – Maine Stormwater Best Management Practices Manual	2005
ME-7	Maine	StormTreat Filter – Maine Stormwater Best Management Practices Manual	2005
OR-PO-1	Portland, OR	Stormwater Management Manual – Ch. 3	
TN-CH-1	Chattanooga, TN	Maintenance of Detention Devices – Stormwater Best Management Practices Manual	2003
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-2	University of MN	Maintenance for Filtration Practices	

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Bio-Filters	ChattanoogaTN_Biofilters.pdf	Chattanooga, TN	Maintenance of Detention Devices	2003
Surface Sand Filter	KingsportTN_SurfaceSandFilter.pdf	Kingsport, TN	Stormwater Management Manual	
Sand and Organic Filter	NY_Sand&OrganicFilter.pdf	New York	New York State Stormwater Management Design Manual – App. G	2003
Sand Filter Above Ground	PierceCountyWA_SandFilterAbove.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Sand Filter Below Ground	PierceCountyWA_SandFilterBelow.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Sand Filters	TumwaterWA_SandFilters.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002

Swales

SMP Description

Swale: An open channel vegetated with a combination of grasses and other herbaceous plants, shrubs, and trees. A swale reduces peak flow at the discharge point by increasing travel time and friction along the flow path. Dense vegetation provides some infiltration and water quality treatment.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of swales from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Inspect vegetation on side slopes for erosion and formation of rills or gullies, correct as needed. ▪ Inspect for pools of standing water or litter and inlets/outlets for signs of clogging. ▪ Inspect for concentrated flows, sediment accumulation, adequacy of grass coverage in grassy filter strip, and erosion in contributing drainage area. ▪ Swales should be carefully monitored so they do not contribute sediment to receiving waters. ▪ Inspect for dense clumps of cattail which do not allow water to pass and remove if necessary. Can be removed by cutting/pulling the shoots below water level or other means. ▪ Inspect for swale issues due to flooding. ▪ Inspect channel linings periodically and repair as needed.	▪ Remove sediment from pretreatment when depth exceeds ½ design depth; clean/repair when drawdown exceeds 36 hrs. ▪ Harvesting and pruning of excessive growth will need to be done occasionally. Weeding to control unwanted or invasive plants may also be necessary. ▪ Mow and trim vegetation to ensure safety, aesthetics, proper swale operation, or to suppress weeds and invasive vegetation; dispose of cuttings in a local composting facility; mow only when swale is dry to avoid rutting. ▪ Plant alternative grass species in the event of unsuccessful establishment. ▪ Re-seed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming. ▪ Rototill and replant swale if draw down time is more than 48 hours. ▪ Water during dry periods, fertilize, and apply pesticide only when absolutely necessary. ▪ Fertilize and lime as needed to maintain dense vegetation. ▪ Use a rake/shovel to remove any sediment accumulated by hand in the bottom of the channel when depth reaches 2”. ▪ Repair rills in channel bottom with compacted topsoil, anchored with mesh or filter fabric, seed, and mulch. ▪ Manually remove weeds. ▪ Replace mulch when needed. ▪ Percolation test once every 3 years; completely replace soil once every 20 years. ▪ Remove sediment when it reaches 50% of checkdam height. ▪ Remove sediment from swale once it has accumulated to 10% of the original design volume.

Frequency	Inspection Requirements	Field Practice
		▪ If ruts develop, fill them with coarse soil, level the surface, and re-seed. ▪ Vegetation should only be removed when it reduces free movement of water throughout the ditch.
Monthly	▪ N/A	▪ Maintain vegetation monthly during first year to enhance appearance and prevent erosion/clogging of bio-swale soil mix.
Quarterly	▪ Inspect all vegetated strip components expected to receive and/or trap debris and sediment for clogging and excessive debris and sediment accumulation. ▪ Inspect storm overflow inlets to make sure they aren't clogged.	▪ Remove sediment during dry periods. ▪ Minimum of 4 grass cuttings/year.
Semi-Annually	▪ The soil filter should be inspected after every major storm in the 1st year and then every 6 months to ensure that it is draining within 48 hours following a 1" storm or greater. ▪ Vegetated areas should be inspected for erosion, scour and unwanted growth. This should be removed with minimum disruption to the planting soil bed and remaining vegetation. ▪ Inspect all level spreading devices for trapped sediment and flow spreading abilities. ▪ Inspect trees, shrubs, and vegetation to evaluate their health.	▪ If mowing is desired, only hand-held string trimmers or push-mowers are allowed on the filter (no tractor) and the grass bed should be mowed to a height no less than 6". ▪ Remove sediment and correct grading and flow channels during dry periods. ▪ Refresh infiltration capacity of bioswale if monitoring reveals reduced infiltration capacity. Core aeration can be used.
Annually	▪ Inspections should be conducted and when possible coordinated to correspond with a significant storm (2"-3" of rainfall). ▪ Inspect pH of soil in planting area. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0-8.0, then iron sulfate plus sulfur can be added to reduce pH.	▪ Sediment and plant debris should be removed from the pretreatment structure at least annually. ▪ Correct any erosion problems and damage to vegetation. ▪ Every 3 years replace mulch within entire bioswale. ▪ After the first year, only spot clipping (or spot chemical treatment) should be done, rather than clipping or otherwise treating the entire strip. If noxious weeds develop, clip in the spring to prevent weed seeds from dispersing. ▪ De-thatch swale bottom and remove thatching. Disc or aerate swale bottom. ▪ Every 5 years: scrap swale bottom, and remove sediment to restore original cross-section and infiltration rate. Seed or sod to restore ground cover.
Upon Failure	▪ N/A	▪ N/A

Issues/Concerns

The following issues were described in various manuals or documents and assembled here for the benefit of inventorying specific concerns with maintaining these types of SMPs:

- Grass should not be trimmed extremely short, as this will reduce the filtering effect of the swale. The cut vegetation should be removed to prevent the decaying organic litter from adding pollutants to the discharge from the swale. The mowed height of the grass should be 2"-4" taller than the maximum flow depth of the design water quality storm. A minimum mow height of 6" is generally recommended.
- Drainage Swales:
    - Excessive and Repeated Erosion:
        - When working in swales, protect from compaction by placing 2-4 foot long by 6"-8" wide boards for walking and standing on in swales, to distribute weight.
        - Install cobbles at top of erosion channel. Cobble area should be 3 times the width of the erosion channel and at least 12" minimum length.
    - Repeated Sediment Buildup:
        - Identify upstream source and install cobbles at the source.
    - Excessive Vegetation:
        - Determine that pruning or other routine maintenance is not adequate or feasible to maintain proper plant density and aesthetics in an efficient manner.
        - Determine if planting type should be replaced to avoid ongoing maintenance issues.
            - An aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow.
        - Look for areas that were planted too densely.
            - A moderate grower planted too densely should be thinned by transplanting some individuals to make space for future growth while allowing for adequate flow-through.
- A good time to clean is during the growing season, when it's easiest to reestablish vegetation. (Generally April – June, and Sept. – Oct.)
- Avoid using water to clean up work sites. Sweep or vacuum dust and debris from the repair job. Do not wash materials into storm sewers.
- Do not stockpile snow in bioswale. Do not place grass clippings/landscape waste within bioswale in order to prevent clogging of bioswale soil mix, which would limit infiltration capacity.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
CA-1	California	Stormwater Quality Handbooks	2003

ID	Location	Title	Year
CA-LA-1	Los Angeles, CA	Green Streets and Green Alleys Design Guidelines Standards – 1st Editions	2009
CA-SF-2	San Francisco, CA	San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm	2010
CA-VE-2	Ventura, CA	Green Streets Matrix – Dept. of Public Works	2008
CT-1	Connecticut	Connecticut Guidelines for Soil Erosion and Sediment Control	2002
EPA-5	EPA	Stormwater Best Management Practices Design Guide Vol. 2 – Vegetative Bio-Filters	2004
GA-8	Georgia	Enhanced Swales – Georgia Stormwater Management Manual Vol. 2	2001
GA-9	Georgia	Filter Strip – Georgia Stormwater Management Manual Vol. 2	2001
GA-10	Georgia	Grass Channel – Georgia Stormwater Management Manual Vol. 2	2001
ID-1	Idaho	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	2005
ID-2	Idaho	Erosion and Sediment Control Best Management Practices Manual	2011
IL-CH-3	Chicago, IL	Stormwater Management Ordinance Manual	2011
IL-CH-4	Chicago, IL	A Guide to Stormwater Best Management Practices	2003
IL-LI-1	Libertyville, IL	Maintenance Plan Stormwater Management System	2004
IN-ID-2	Indianapolis, IN	4.4 Stormwater Green Infrastructure Guidance – Filter Strips	2008
KA-KC-1	Kansas City, KA	Manual of Best Management Practices for Stormwater Quality	2008
MA-1	Massachusetts	Vol. 2 Ch. 2 – Structural Best Management Practice Specifications for the Massachusetts Stormwater Handbook	
MD-CE-1	Centreville, MD	Environmental Site Design Manual	2007
ME-3	Maine	Vegetated Buffers – Maine Stormwater Best Management Practices Manual	2005
ME-9	Maine	Vegetated Swales – Maine Stormwater Best Management Practices Manual	2005
MI-1	Michigan	Low Impact Development Manual for Michigan – App. F	
MI-3	Michigan	Buffer/Filter Strips	1997
MN-2	Minnesota	Housekeeping Best Management Practice Maintenance	1999
NC-2	North Carolina	Stormwater Control Inspection and Maintenance Manual – North Carolina DOT	2010
NC-GR-1	Greensboro, NC	Stormwater Management Manual	2009
NC-RA-1	Raleigh, NC	Stormwater Management design Manual	2002
NV-1	Nevada	Stormwater Quality Manuals – Nevada DOT	2006
NY-1	New York	New York State Stormwater Management Design Manual – Ch. 5	
OR-PO-1	Portland, OR	Stormwater Management Manual – O&M – Ch. 3	
PA-3	Pennsylvania	Best Management Practices #: Vegetated Swale	
TN-KI-1	Kingsport, TN	Stormwater Management Manual	
U-UMN-5	University of MN	Maintenance for Biologically Enhanced Practices	
VA-FA-1	Fairfax, VA	Stormwater Pond and Wetlands Maintenance Guidebook	2004
WA-1	Washington	Vegetated Stormwater Facility Maintenance	2000
WA-BG-1	Battle Ground, WA	Stormwater Facility Maintenance Manual	2009
WA-CC-1	Clark County, WA	Stormwater Facility Maintenance Manual	2000
WA-SE-3	Seattle, WA	High Point Community – Natural Drainage and Landscape Maintenance Guidelines for Right-of-way and Open Space	2010

The following maintenance and inspection checklists were found during this research process. They list exactly what to look for during inspection, how to solve a problem, if any, and at what time to perform all these tasks.

SMP	PDF Name	Location	Title of Source	Year
Bio-filtration Swale	AR_BiofiltrationSwales.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	
Dispersion Trenches	AR_DispersionTrenches.pdf	Arkansas	Generic Stormwater Maintenance Manual – App. 8B	

Enhanced Swales	KingsportTN_EnhancedSwales.pdf	Kingsport, TN	Stormwater Management Manual	
Filter Strip	KingsportTN_FilterStrip.pdf	Kingsport, TN	Stormwater Management Manual	
Grass Channel	KingsportTN_GrassChannel.pdf	Kingsport, TN	Stormwater Management Manual	
Bioswale/Bioretention	LibertyvilleIL_BioswaleBioretention.pdf	Libertyville, IL	Stormwater Management System Maintenance Plan	2004
Vegetated Swale	MartinezCA_VegetatedSwale.pdf	Martinez, CA	Stormwater Control Operation and Maintenance Plan	
Bioswale Filter Strip	MI_BioswaleFilterStrip.pdf	Michigan	Low Impact Development for Michigan – App. F	
Level Spreader	NC_LevelSpreader.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Swale	NC_Swale.pdf	North Carolina	Stormwater Control Inspection and Maintenance Manual	2010
Open Channel	NY_OpenChannel.pdf	New York	New York State Stormwater Management Design Manual – App. G	2003
Bio-infiltration Swale	PierceCountyWA_BioinfiltrationSwaels.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Field Inlet	PierceCountyWA_FieldInlet.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Filter Strip	PierceCountyWA_FilterStrip.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Wet Bio-infiltration Swale	PierceCountyWA_WetBioinfiltrationSwales.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Grass Swale	PierceCountyWA_GrassSwale.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Open Channel	PierceCountyWA_OpenChannel.pdf	Pierce County, WA	Stormwater Maintenance Manual	
Conveyance Pipes, Ditches, and Swales	TumwaterWA_ConveyancePipesDitchesSwales.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Storm Filter	TumwaterWA_StormFilter.pdf	Tumwater, WA	Stormwater Facility Maintenance Guide	2002
Dry Swale	VA_DrySwales.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Filtering Practices	VA_FilteringPractices.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Filter Strips	VA_FilterStrips.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Grass Channels	VA_GrassChannels.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009
Wet Swales	VA_WetSwales.pdf	Virginia	Virginia Stormwater Management Handbook – Ch. 9	2009

Planters

SMP Description

Stormwater Planter: A stormwater planter is a specialized planter installed in the sidewalk area that is designed to manage street and sidewalk runoff. The planter is lined with a permeable fabric, filled with gravel or stone, and topped off with soil, plants, and sometimes trees. The top of the soil in the planter is lower in elevation than the sidewalk, allowing for runoff to flow into the planter through an inlet at street level.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of stormwater planters from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Ensure that structural components such as inlets and outlets/overflows freely convey stormwater ▪ Inspect for clogged inlets or outlets ▪ Check for structural damage such as cracking or loose concrete ▪ During the establishment period (18-24 months), irrigate regularly to ensure proper plant growth ▪ Check that overflow pipes are clear of debris ▪ Check for dead, strained, or diseased vegetation ▪ Inspect for weeds and invasive plant species ▪ Inspect for bad odors ▪ Inspect for spills of polluting substances such as oil, fuel, etc.	▪ Manually remove sediment, debris, trash, and organic material ▪ Repair or seal cracks. Replace when repair is insufficient ▪ Remove weeds and invasive plants ▪ Replace dead plants ▪ Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged ▪ Fallen leaves from deciduous plant foliage shall be raked and removed ▪ Releases of pollutants shall be corrected as soon as identified ▪ Remove dead and rotting organic material
Monthly	▪	▪ Clear sediment and debris from splash blocks or inlet rock
Quarterly	▪ Inspect for the occurrence of gullies, erosion, and ponding	▪ Remove sediment, debris, trash, and organic material ▪ Fill, lightly compact, and plant vegetation to disperse flow ▪ Stabilize soils with native plantings ▪ Rake, till, or amend soils to restore infiltration rate
Semi-Annually	▪ Inspect for the presence of borrowing animals and mosquitos. ▪ Inspect for overgrown vegetation that limits access or interferes with planter operation. Overgrown vegetation can also limit site lines of drivers and pedestrians	▪ Replant exposed soil and replace dead plants ▪ Remove sediment and plant debris ▪ Take measures to remove pests such as rodents and insects ▪ Prune or remove excess vegetation
Annually	▪ Monitor infiltration and flow-	▪ Make any structural repairs to inlets, outlets,

Frequency	Inspection Requirements	Field Practice
	through rates. Planter shall infiltrate within 48 hours	overflow pipes, or splash blocks ▪ Improve filter medium as needed ▪ Replace mulch annually
Upon Failure	▪ All facilities should drain within 48 hours. If ponding water remains in the facility for longer periods of time it could indicate failure.	▪

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
OR-PO-1	Portland, OR	Stormwater Management Manual – O&M – Ch. 3	2008
	Eugene, OR	Stormwater Management Manual Chapter 3.0 Operations & Maintenance	2008

Street Trees and Stormwater Tree Pits

SMP Description

Street Tree:A curbside tree planted in the public right-of-way. Street trees can manage a small volume of stormwater by interception and evapotranspiration.

Stormwater Tree Pit: A small bioretention or bioinfiltration facility that consists of a street tree in an engineered soil media, a curb cut inlet, and an underground infiltration structure or underdrain system. These facilities receive runoff from roads, sidewalks, or parking lots and manage the stormwater via infiltration or flow through slow release, uptake by roots, and evapotranspiration.

Maintenance Activities

The following table provides an overview of the frequency, inspection requirements, and field practices related to maintenance of stormwater planters from various stormwater manuals.

Frequency	Inspection Requirements	Field Practice
As Needed	▪ Inspect curb and inlet for clogging due to sediment, trash, debris, and organic material ▪ Look through tree grate cover to see if the ponding area is filled with sediment, leaves, or trash ▪ Check for structural damage ▪ Check that the overflow pipe is clear of debris ▪ Check for erosion or scour. Repair and provide energy dissipation if necessary	▪ Young trees may need staking for support until they are mature ▪ Water the tree weekly for the first two years of the tree's life. After the tree is established, watering is only required during periods of extreme drought. ▪ Remove trash, debris, sediment, and organic material to prevent clogging of inlets and soil media ▪ Clean out inlet/outlet pipes as needed to maintain flow ▪ Fill any holes in the filter media.
Monthly	▪ Check the health of the plant ▪ Check that hazardous materials such as fuel, paint, oil, etc. are not polluting the stormwater and soil.	▪ Watering may be required during dry periods, especially during plant establishment ▪ If pollution is present, fix immediately upon discovery
Quarterly	▪ Check stakes and ties and replace or repair if necessary ▪ Check for damage requiring repair such as cracking, loose concrete, or similar ▪ Check for clogging or blockage of inlets and overflow pipes ▪ Assess plants for disease, pest infection, stunted growth, or invasive plants. Treat or replace if necessary ▪ Inspect to identify the presence of rapidly spreading weeds.	▪ Remove trash, debris, sediment, and organic material to prevent clogging of inlets and soil media ▪ Remove weeds by hand, removing tree grate if necessary ▪ Do not use herbicides or pesticides as these will pollute stormwater
Semi-Annually	▪ Check that the tree is not blocking pedestrian or vehicle lines of sight ▪ Test that the overflow pipe is not blocked by filling with water and	▪ If necessary, prune as advised by an arborist to reestablish blocked lines of site ▪ If the water in the overflow pipe does not drain, clean the pipe with a hose or manually

Frequency	Inspection Requirements	Field Practice
	checking that the water drains away ▪ Check for unpleasant odors coming from the pit	▪ Remove dead and rotting organic material
Annually	▪ Check that the inlet, curb, and pit are structurally sound by looking for cracks and damage ▪ Check for damage of plant covers/tree grates and repair if possible ▪ Check that the level of soil and mulch is set below the curb inlet ▪ Ensure that the soil mix surface does not have a layer of fine sediment that prevents draining ▪ Check that water is not still ponding 24 hours after rain ▪ Test infiltration by filling with water and monitoring over 24 hours ▪ Check that soil is not compacted, is free draining, and the pit is not over or underfilled	▪ Replace mulch annually ▪ Remove and rework top layer of soil if necessary ▪ If compacted, remove the top layer of soil and scarify the ponding area to reestablish infiltration
Upon Failure	▪	▪ If the tree pit is still not draining after attempting to reestablish infiltration, the pit may need plants and mulch removed and plant soil and underdrain system replaced.

References

The following documents were used to compile data for this report and also include relevant inspection reports/checklists.

ID	Location	Title	Year
	Boston, MA	Charles River Water Authority: Stormwater, Trees, and the Urban Environment	2009
	Auckland, NZ	Tree Pits Operation and Maintenance	
	Monash University, Australia	Raingardens and Bioretention Tree Pits Maintenance Plan	2008