



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

JUL 28 2011

MEMORANDUM

SUBJECT: Green Long Term Control Plan (LTCP) - EZ

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Water Permits Division

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Mark Pollins, Director  
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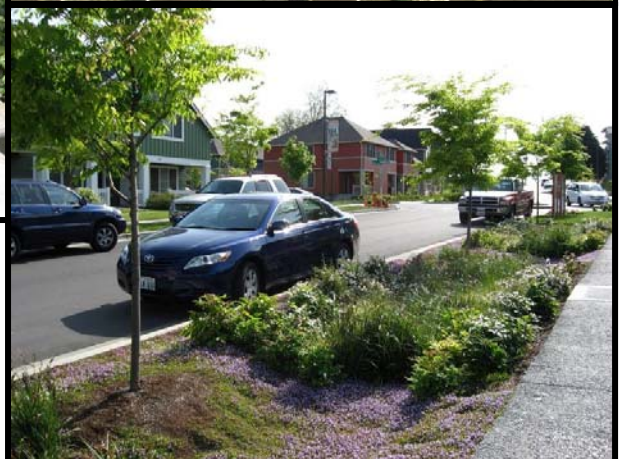
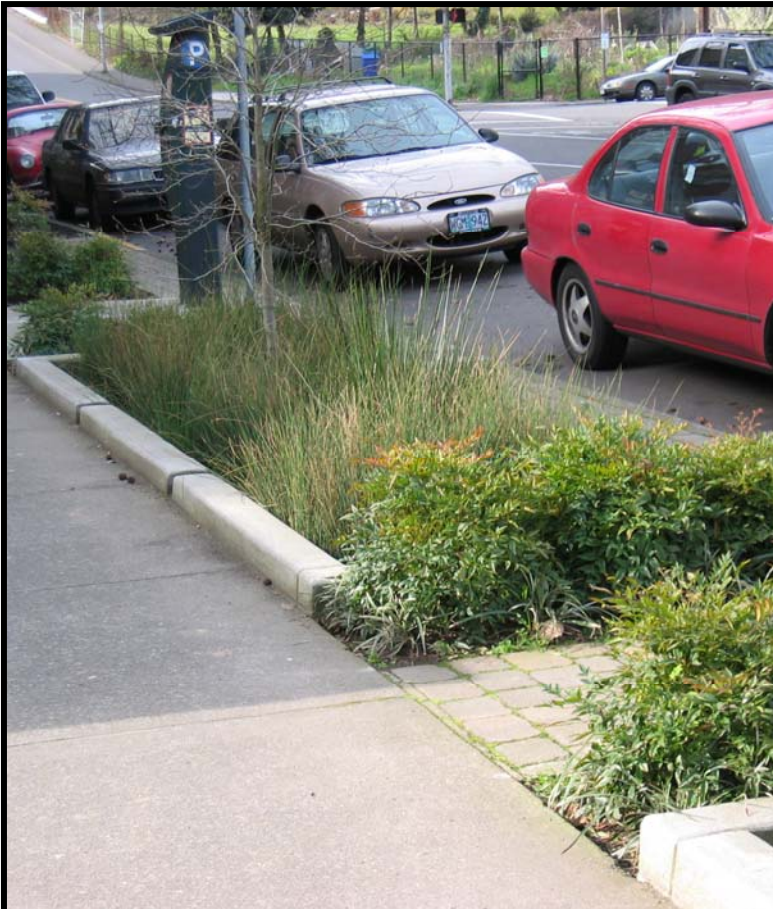
To: Stakeholders

We are pleased to announce that we have incorporated green infrastructure components into our existing LTCP-EZ template to help small combined sewer overflow (CSO) communities consider appropriate green practices as part of their long-term plans to control CSOs. This template, called the Green LTCP-EZ, incorporates green practices such as green roofs, vegetated swales, bioretention basins, pervious pavement, and rain barrels into the traditional LTCP. It can be found at [www.epa.gov/npdes](http://www.epa.gov/npdes). This effort has been completed as part of our green infrastructure strategy and is a key component of the recently released *Strategic Agenda to Protect Waters and Build More Livable Communities through Green Infrastructure*.

This template has been reviewed by our regional offices, states, and others. We have also pilot tested the template in two CSO communities. We encourage CSO communities who have not yet completed their long-term CSO control plans, or who are re-opening their long-term CSO control plans, to consider using this template to identify opportunities to utilize green infrastructure practices. Green infrastructure can be used to successfully reduce the volume of stormwater entering combined sewer systems, thereby reducing the frequency and volume of overflows. The new Green LTCP-EZ provides a tool for communities to estimate the performance and impacts of green infrastructure. In addition to the obvious public health benefits, green infrastructure can reduce hydrological impacts on streams, reduce pollutant discharges, reduce flooding, increase ground water recharge and baseflow, reduce energy consumption, improve air quality, reduce the urban heat island effect, enhance property values, save energy, and help make communities more livable.

We plan to revise this document periodically to incorporate new information as it becomes available and to reflect the experiences from communities who use the template and have suggestions for improving it. Please submit comments to Mohammed Billah at [billah.mohammed@epa.gov](mailto:billah.mohammed@epa.gov), (202)564-2228.

# **Green Long-Term Control Plan-EZ Template: A Planning Tool for Combined Sewer Overflow Control in Small Communities**





## **Disclaimer**

The U.S. Environmental Protection Agency (EPA) has designed Green LTCP-EZ Template as a tool to help small combined sewer overflow (CSO) communities develop their long-term CSO control plans under the 1994 CSO Control Policy. EPA is not mandating the use of Green LTCP-EZ or the use of the Presumption Approach under the 1994 CSO Control Policy. This document is not itself a regulation or legally enforceable, but rather provides a path towards compliance with requirements of the 1994 CSO Control Policy in accordance with section 402(q) of the Clean Water Act. Communities, small or otherwise, might find the tool useful and should consult with their permitting authorities to determine whether it is appropriate for them to use all or some portions of the Green LTCP-EZ Template.

## Contents

<b>Acronyms and Abbreviations .....</b>	<b>v</b>
<b>Background .....</b>	<b>1</b>
What is the Green LTCP-EZ Template and what is its purpose? .....	1
What is the relationship between the Green LTCP-EZ and the CSO Control Policy? .....	1
Who should use the Green LTCP-EZ Template? .....	2
What approach is used in the Green LTCP-EZ Template? .....	2
How is financial capability assessed? .....	4
Summary.....	4
<b>Rationale for Using Green Infrastructure for CSO Controls.....</b>	<b>5</b>
What is Green Infrastructure? .....	5
Why use Green Infrastructure to manage wet weather? .....	5
<b>Checklist of Materials Recommended for Completing Green LTCP-EZ.....</b>	<b>7</b>
<b>General Instructions: Green LTCP-EZ Template .....</b>	<b>11</b>
<b>Instructions: Form Green LTCP-EZ.....</b>	<b>13</b>
General Information .....	13
Nine Minimum Controls.....	13
Sensitive Areas .....	14
Water Quality Considerations .....	15
System Characterization.....	16
Public Participation .....	17
CSO Volume .....	19
Evaluation of CSO Controls .....	19
Financial Capability.....	19
Recommended CSO Control Plan.....	20
<b>Instructions: Schedule 4 – CSO Volume .....</b>	<b>22</b>
Introduction .....	22
Design Storm for Small Communities.....	22
The Rational Method.....	23
Calculation of CSO Volume .....	23
Summary.....	24
Sub-Sewershed Area.....	25
Runoff .....	25
Dry-Weather Flow within the CSS .....	26
Peak Wet-Weather Flow .....	26
Overflow .....	26
Diversion .....	27
Conveyance .....	27
Treatment.....	28
CSO Volume .....	29
<b>Instructions: Schedule 5A – CSO Runoff Control (Green Infrastructure Runoff Controls) .....</b>	<b>30</b>
Runoff Reduction via On-site Runoff Retention Standard or Goal .....	30
Runoff Reduction via Specific Green Infrastructure Practices.....	31
Recalculating CSO Volume .....	31
Impervious Area.....	32
Retention Standard or Goal .....	32
Runoff Reduction .....	32
Green Roofs.....	32
Bioretention .....	34
Vegetated Swales .....	35
Permeable Pavement .....	36

Rain Barrels and Cisterns .....	37
Cumulative Runoff Reduction Check .....	37
Runoff Recalculation .....	38
Peak Wet-Weather Flow .....	38
Revised Overflow .....	38
Revised Diversion .....	39
Revised Conveyance .....	39
Treatment .....	39
CSO Volume Recalculation .....	40
<b>Instructions: Schedule 5B – CSO Network and WWTP Control .....</b>	<b>41</b>
Conveyance and Treatment at the WWTP .....	41
Sewer Separation .....	41
Off-Line Storage .....	41
Cost of CSO Control .....	42
Summary .....	42
Conveyance and Treatment at the WWTP .....	43
Sewer Separation .....	43
Off-Line Storage .....	44
Summary of Controls and Costs .....	44
<b>Instructions: Schedule 6 – CSO Financial Capability .....</b>	<b>45</b>
Phase I Residential Indicator .....	46
Current Costs .....	46
Projected Costs (Current Dollars) .....	46
Cost Per Household .....	47
Median Household Income (MHI) .....	47
Residential Indicator .....	48
Phase II Permittee Financial Capability Indicators .....	48
Debt Indicators .....	49
Overall Net Debt .....	50
Socioeconomic Indicators .....	50
Unemployment Rate .....	51
Median Household Income .....	51
Financial Management Indicators .....	51
Property Tax and Collection Rate .....	52
Matrix Score: Analyzing Permittee Financial Capability Indicators .....	52
<b>References .....</b>	<b>55</b>
<b>Glossary of Terms .....</b>	<b>56</b>
<b>Appendix A. One-Hour, 3-Month Rainfall Intensities, Schedule 4 – CSO Volume .....</b>	<b>A-1</b>
<b>Appendix B. Hydraulic Calculations within Green LTCP-EZ, Schedule 4 – CSO Volume, and Schedules 5A and 5B – CSO Control .....</b>	<b>B-1</b>
<b>Appendix C. Cost Estimates for Green LTCP-EZ Template, Schedules 5A and 5B – CSO Control .....</b>	<b>C-1</b>
<b>Appendix D. Green Infrastructure Runoff Controls Fact Sheets and Additional Information for Schedule 5A – CSO Runoff Control .....</b>	<b>D-1</b>

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## Acronyms and Abbreviations

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AF	Annualization Factor
CFR	<i>Code of Federal Regulations</i>
CPH	Costs per Household
CPI	Consumer Price Index
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
DO	Dissolved Oxygen
DMR	Discharge Monitoring Report
DWF	Dry-Weather Flow
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
G.O.	General Obligation
I/I	Inflow/Infiltration
IR	Interest Rate
LTCP	Long-term Control Plan
MG	Million Gallons
MGD	Million Gallons per Day
MHI	Median Household Income
MPV	Market Property Value
NOAA	National Oceanic and Atmospheric Administration
NMC	Nine Minimum Controls
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
POTW	Publicly Owned Treatment Works
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
WQS	Water Quality Standards
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

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## Background

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### What is the Green LTCP-EZ Template and what is its purpose?

The Combined Sewer Overflow (CSO) Green Long-Term Control Plan (LTCP) Template for Small Communities (termed the *Green LTCP-EZ Template*) is a planning tool for small communities that are required to develop an LTCP to address CSOs. The Green LTCP-EZ Template provides a framework for organizing and completing an LTCP that builds on existing controls, including the use of both green and conventional gray infrastructures to assist in the elimination or control of CSOs in accordance with the federal Clean Water Act (CWA). Use of the Green LTCP-EZ Template and completion of the forms and schedules associated with the Green LTCP-EZ Template can help produce a Draft LTCP.

In May 2007, U.S. EPA developed a planning tool (LTCP-EZ) for small CSO communities to design long-term CSO control plans using the conventional gray CSO controls. The original LTCP-EZ Template is available at [www.epa.gov/npdes/cso](http://www.epa.gov/npdes/cso). The Green LTCP-EZ Template is an updated version of the original, in that it adds several "green" infrastructure practices such as green roofs, vegetated swales, bioretention basins, pervious pavements, rain barrels, in conjunction with conventional gray CSO control to develop a CSO long-term control plan. The Green LTCP-EZ can be used for communities who want to assess the potential for green infrastructure controls. For communities who do not wish to assess the potential for green infrastructure, the original LTCP-EZ Template can still be used.

Properly planned green practices naturally manages stormwater, improves water quality and control CSOs by keeping water out of the collection systems. The Green LTCP-EZ Template consists of FORM GREEN LTCP-EZ and related schedules and instructions. It provides a starting place and a framework for small communities to organize and analyze basic information that is central to effective CSO control planning. Specifically, FORM GREEN LTCP-EZ and Schedules 1 – NINE MINIMUM CONTROLS, 2 – MAP, and 3 – PUBLIC PARTICIPATION, allow organization of some of the basic information required to comply with the 1994 CSO Control Policy.<sup>1</sup> Schedule 4 – CSO VOLUME provides a process for assessing CSO control needs under the *presumption approach* of the CSO Control Policy. It allows the permittee or other user (the term *permittee* will be used throughout this document, but the term should be interpreted to include any users of the Green LTCP-EZ Template) to estimate a target volume of combined sewage that needs to be stored, treated, or eliminated. Schedules 5A and 5B– CSO RUNOFF, NETWORK AND WWTP CONTROLS enable the permittee to evaluate the ability of a number of widely used green infrastructure runoff controls and pipe network CSO controls to meet the reduction target. Finally, Schedule 6 – CSO FINANCIAL CAPABILITY provides a U.S. Environmental Protection Agency (EPA) financial capability analysis to determine the community's financial capabilities. Permittees are free to use FORM GREEN LTCP-EZ and as many schedules as needed to meet their local needs and requirements. FORM GREEN LTCP-EZ and its schedules are available in hard copy format or as computer-based spreadsheets.

This publication provides background information on the CSO Control Policy and explains the data and information requirements, technical assessments, and calculations that are addressed in the Green LTCP-EZ Template and are necessary for its application.

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### What is the relationship between the Green LTCP-EZ and the CSO Control Policy?

CWA section 402(q) and the CSO Control Policy (EPA 1994) require permittees with combined sewer systems (CSSs) that have CSOs to undertake a process to accurately characterize their sewer systems, demonstrate implementation of the nine minimum controls (NMCs), and develop an LTCP. EPA recognizes that resource constraints make it difficult for small communities to prepare a detailed LTCP. Section I.D of the CSO Control Policy states,

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<sup>1</sup> Combined Sewer Overflow (CSO) Control Policy, 59 Fed. Reg. 18688-18698 (April 19, 1994) (EPA 1994). Pursuant to section 402(q) of the Clean Water Act (CWA), permits, orders and decrees issued under the CWA for discharges from municipal combined storm and sanitary sewer systems "shall conform" to the CSO Control Policy.

The scope of the long-term CSO control plan, including the characterization, monitoring and modeling, and evaluation of alternatives portions of the Policy may be difficult for some small CSSs. At the discretion of the NPDES Authority, jurisdictions with populations under 75,000 may not need to complete all of the formal steps outlined in Section II.C. of this Policy, but should be required through their permits or other enforceable mechanisms to comply with the nine minimum control (II.B), public participation (II.C.2), and sensitive areas (II.C.3) portions of this Policy. In addition, the permittee may propose to implement any of the criteria contained in this Policy for evaluation of alternatives described in II.C.4. Following approval of the proposed plan, such jurisdictions should construct the control projects and propose a monitoring program sufficient to determine whether WQS are attained and designated use are protected.

EPA developed the Green LTCP-EZ Template, in part, because it recognizes that expectations for the scope of the LTCP for small communities might be different than for larger communities. However, the Green LTCP-EZ Template does not replace the statutory and regulatory requirements applicable to CSOs; those requirements continue to apply to the communities using this template. Nor does its use ensure that a community using the Green LTCP-EZ Template will necessarily be deemed to be in compliance with those requirements. EPA hopes, however, that use of the Green LTCP-EZ Template will facilitate compliance by small communities with those legal requirements and simplify the process of developing an LTCP.

**IMPORTANT NOTE:** Each permittee should discuss use of the Green LTCP-EZ Template and coordinate with the appropriate regulatory authority or with their permit writer and come to an agreement with the permitting authority on whether use of the Green LTCP-EZ Template or components thereof is acceptable for the community.

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### **Who should use the Green LTCP-EZ Template?**

The Green LTCP-EZ Template is designed as a planning tool for use by small communities that have not developed LTCPs and have limited resources to invest in CSO planning. It is intended to help small communities develop an LTCP that will build on NMC implementation and lead to additional elimination and reduction of CSOs where needed. CSO communities using the Green LTCP-EZ Template should recognize that this planning tool is for use in facility-level planning. Use of the Green LTCP-EZ Template should be based on a solid understanding of local conditions that cause CSOs. CSO communities should familiarize themselves with all the technical analyses required by the Green LTCP-EZ planning process. CSO communities should obtain the assistance of qualified technical professionals (e.g. engineers and hydraulic experts) to help complete analyses if they are unable to complete the Green LTCP-EZ Template on their own. More detailed design studies will be required for construction of new facilities.

Even though the Green LTCP-EZ Template is particularly well suited for small CSO communities that have relatively uncomplicated CSSs, it might be useful for large CSO communities with populations of greater than 75,000. Large CSO communities and small CSO communities that have many CSO outfalls and complex systems might need

to take a more sophisticated approach to LTCP development, and this should be evaluated by consultation with regulators as discussed above.

The Green LTCP-EZ Template is intended to provide a very simple assessment of CSO control needs. As such, it might reduce the effort and costs associated with CSO control development. However, because of its simple nature, the Green LTCP-EZ Template might not evaluate a full range of potential CSO control approaches. Permittees electing to follow the approach provided by the Green LTCP-EZ template remain subject to all requirements of the CWA and EPA's 1994 CSO Control Policy.

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### **What approach is used in the Green LTCP-EZ Template?**

Schedule 4 - CSO VOLUME and Schedules 5A and 5B – CSO CONTROL use the “presumption approach” described in the CSO Control Policy to quantify the volume of combined sewage that needs to



be stored, treated, or eliminated. The CSO Control Policy describes two alternative approaches available to communities to establish that their LTCPs are adequate to meet the water quality-based requirements of the CWA: the presumption approach and the demonstration approach (Policy Section II.C.4.a.) The presumption approach sets forth criteria that, when met, are presumed to provide an adequate level of control to meet the water quality-based requirements:

... would be presumed to provide an adequate level of control to meet water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable in light of data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas described above (in Section II.C.4.a). These criteria are provided because data and modeling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect WQS.

### ***Selected criterion under the presumption approach used in the Green LTCP-EZ Template***

Under the presumption approach set forth in the CSO Control Policy, a community may select from one of three sets of criteria that it must meet upon LTCP implementation (see CSO Control Policy Section II.C.4.a.i-iii). Calculations in some parts of the Green LTCP-EZ Template (specifically, Schedule 4) use the first criterion in section II.C.4.a.i., as follows:

No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified below.

The *minimum treatment specified* with respect to the criterion in Section II.C.4.a.i. of the CSO Control Policy is defined as follows:

- Primary clarification (Removal of floatable and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification);
- Solids and floatable disposal; and
- Disinfection of effluent, if necessary, to meet WQS, protect designated uses, and protect human health, including removal of harmful disinfection chemical residuals, where necessary.

This criterion is used because it allows quantification with simple procedures and a standardized format. It should be noted that a permittee could choose to use one of the other two criteria under the presumption approach, or the demonstration approach. Conversely, permittees may still use the other parts of the Green LTCP-EZ Template to help complete their LTCP even if they choose not to use Schedule 4 of the Green LTCP-EZ Template.

### ***Calculations within Schedule 4 - CSO VOLUME and Schedules 5A and 5B – CSO CONTROL***

EPA advises permittees to consider implementing a limited rainfall and flow monitoring program. Simple regression analyses (e.g., rainfall vs. flow response) can be used to refine the Green LTCP-EZ Template output and increase confidence in sizing the controls generated using the Green LTCP-EZ Template. For examples of this approach to rainfall response characterization, the permittee should refer to Combined Sewer Overflows Guidance for Monitoring

and Modeling (EPA 1999).

Schedules 4 and 5 use design storm conditions to assess the degree of CSO control required to meet the average of four overflow events per year criterion. Design storms are critical rainfall conditions that occur with a predictable frequency. They are used with simple calculations to quantify the volume of combined sewage to be stored, treated, or eliminated to meet the criterion of no more than four overflows per year, on average. The design storm is explained in further detail in the instructions for Schedule 4 – CSO VOLUME.

The Green LTCP-EZ Template also provides permittees with simple methods to assess the costs and effectiveness of a variety of CSO control alternatives in Schedules 5A and 5B – CSO CONTROL.

All CSO communities are obligated to meet the requirements of the CWA and the CSO Policy, but use of the presumption approach and the use of Schedules 4 and 5 is only one way to comply, and may not be appropriate for every community. Some states have specific requirements that are inconsistent with Schedules 4 and 5. Use of the Green LTCP-EZ Template does not preclude permitting authorities from requesting clarification or requiring additional information. Permittees should consult with the appropriate regulatory authority to determine whether or not the presumption approach and its interpretation under Schedules 4 and 5 are appropriate for their local circumstances.

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### **How is financial capability assessed?**

The CSO Financial Capability Assessment Approach outlined in EPA's Combined Sewer Overflows—Guidance for *Financial Capability Assessment and Schedule Development* (EPA 1997) is used to assess financial capability and is contained in Schedule 6 – CSO FINANCIAL CAPABILITY.

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### **Summary**

The Green LTCP-EZ Template is an optional CSO control planning tool to assist small communities in assembling and organizing the information required in an LTCP. FORM GREEN LTCP-EZ and Schedules 1 (Nine Minimum Controls), 2 (Map) and 3 (Public Participation) allow organization of some of the basic elements to comply with the CSO policy. Schedule 4 – CSO VOLUME allows the permittee to estimate a target volume of combined sewage that needs to be stored, treated, or eliminated. Schedules 5A and 5B – CSO CONTROL enable the permittee to evaluate the ability of a number of widely used green infrastructure runoff controls and pipe network CSO controls to meet the reduction target. Schedule 6 – CSO FINANCIAL CAPABILITY provides an EPA financial capability analysis to assess the CSO community's financial capabilities. FORM GREEN LTCP-EZ and its schedules are available in hard copy format or as computer-based spreadsheets.

The CSO Control Policy and all of EPA's CSO guidance documents can be found at the following link:[http://cfpub.epa.gov/npdes/home.cfm?program\\_id=5](http://cfpub.epa.gov/npdes/home.cfm?program_id=5).

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## **Rationale for Using Green Infrastructure for CSO Controls**

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### **What is Green Infrastructure?**

Green infrastructure is the interconnected network of open spaces and natural areas, such as greenways, wetlands, parks, forest preserves and native plant vegetation, that naturally manages stormwater, reduces flooding risk and improves water quality (Center for Neighborhood Technology.2008). Green infrastructure can cost less to install and maintain when compared to traditional forms of infrastructure. Green infrastructure projects also foster community cohesiveness by engaging all residents in the planning, planting and maintenance of the sites.

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### **Why use Green Infrastructure to manage wet weather?**

The main drivers for using green infrastructure is an approach to wet weather management is that it may be more cost-effective than conventional gray infrastructure, and provides sustainable, and environmentally friendly means of controlling wet weather discharges. Green Infrastructure management approaches and technologies infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore the approximate hydrology that existed before development.

At the largest scale, the preservation and restoration of natural landscape features (such as forests, floodplains and wetlands) are critical components of green stormwater infrastructure. By protecting these ecologically sensitive areas, communities can improve water quality while providing wildlife habitat and opportunities for outdoor recreation.

On a smaller scale, green infrastructure practices include rain gardens, porous pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting for non-potable uses such as toilet flushing and landscape irrigation, all of which help to manage stormwater runoff and improve water quality.

### **Why Use Green Infrastructure to Reduce CSO Events?**

The natural retention and infiltration capabilities of plants and soils used in green infrastructure practices limits the frequency of combined sewer overflow events by reducing runoff volumes and by reducing and delaying the effects of stormwater discharges on the CSS.

### **CSO Control Policy**

The CSO Control Policy contains four fundamental principles to ensure that CSO controls are cost-effective and meet environmental objectives:

- Providing clear levels of control that would be presumed to meet appropriate health and environmental objectives

- Providing sufficient flexibility to municipalities, especially financially disadvantaged communities, to consider the site-specific nature of CSOs and to determine the most cost-effective means of reducing pollutants and meeting CWA objectives and requirements
- Allowing a phased approach to implementation of CSO controls considering a community's financial capability
- Review and revision, as appropriate, of water quality standards and their implementation procedures when developing CSO control plans to reflect the site-specific wet weather impacts of CSOs

**Green infrastructure practices support implementation of the nine minimum controls and long term control plans by reducing runoff to**

- Maximize use of the collection system for storage
- Maximize flow to the POTW for treatment
- Minimizing and/or reducing the peaking factor
- Support pollution prevention
- Support proper operation and regular maintenance

Green infrastructure practices use vegetation and soils in urban and suburban areas to manage and treat precipitation naturally rather than collecting it in pipes. Thus, by preserving natural systems and using engineered systems such as green roofs, rain gardens, and vegetated swales, green infrastructure mimics natural functions. Green infrastructure also includes approaches that capture and re-use stormwater and provides the following benefits:

- Create peak and baseload capacity via conservation
- Effective for both new development and retrofit applications
- Adapt, (re)naturalize built landscape to absorb, treat and hold water
- Restore, recycle and extend natural and built regional infrastructure
- Performance can be measured and valued in volume left in natural drainage
- Drainage, flood control and pollution prevention moves upstream from treatment plant to distributed sites closer to water's origins
- Provides broad range of economic, social and ecological benefits (triple bottom line)
- Highly effective for stormwater runoff reduction and pollutant removal
- Saves money compared to conventional infrastructure
- Delivers multiple community benefits along with stormwater management

**Benefits of using Green Infrastructure**

- Cleaner water
- Stable hydrology/baseflow maintenance
- Reduced flooding
- Cleaner air
- Reduced urban temperatures
- Climate change mitigation and adaptation
- Jobs creation
- Water supply
- Energy savings
- Community benefits (recreation, public health, crime prevention)
- Cost savings
- Habitat protection

## Checklist of Materials Recommended for Completing Green LTCP-EZ

Note: This checklist is for use with the instructions beginning on page 13. The NPDES permit and information from various departments within the local utility or state and/or federal government will be essential sources of much of the information needed. These sources, relevant engineering studies and facility plans for the sewer system and WWTP and the web sites listed below will generally be the information sources necessary to complete the template.

Item and Line Number on Form	Most Likely Information Source	Actual Source Used/Comments
Community and system information ( <b>Form LTCP-EZ</b> , Lines 1 & 2)	Facility or system owner/operator	
CSS area ( <b>Form LTCP-EZ</b> , Line 3a)	NPDES permit, engineering studies or local utility/government	
Number of outfalls ( <b>Form LTCP-EZ</b> , Line 3b)	"	
WWTP capacity ( <b>Form LTCP-EZ</b> , Lines 4a & 4b) for both primary and secondary treatment units	"	
Average dry weather WWTP Flow ( <b>Form LTCP-EZ</b> , Line 4c)	"	
Nine Minimum Controls ( <b>Form LTCP-EZ</b> , Line 5)	"	
Sensitive Areas ( <b>Form LTCP-EZ</b> , Lines 6a - 6b) <i>Maps of impacted sensitive areas downstream of CSOs</i> <i>Water quality data from sensitive area locations</i>	Local FWS, NMFS, or State or Tribal Heritage Center	Threatened or Endangered Species or their habitat at: <a href="http://ecos.fws.gov/tess_public/StartTESS.do">http://ecos.fws.gov/tess_public/StartTESS.do</a> <a href="http://www.nmfs.noaa.gov/">http://www.nmfs.noaa.gov/</a>
Water Quality ( <b>Form LTCP-EZ</b> , Lines 6c - 6d; 7) <i>Pollutants of concern in CSO discharges</i> <i>Water quality standards in receiving water</i> <i>Impairments in receiving water(s)</i> <i>Determination of whether CSO discharges are contributing to impairment of receiving water</i>	NPDES authority or engineering studies	
System Characterization - general location map ( <b>Form LTCP-EZ</b> , Line 8)	Engineering studies or local utility/government	
CSO outfall number ( <b>Form LTCP-EZ</b> , Line 9a)	"	
Narrative description ( <b>Form LTCP-EZ</b> , Line 9b)	"	



Item and Line Number on Form	Most Likely Information Source	Actual Source Used/Comments
Latitude/longitude ( <b>Form LTCP-EZ</b> , Line 9c)	“	
Receiving water ( <b>Form LTCP-EZ</b> , Line 9d)	“	
Sub-sewershed area ( <b>Form LTCP-EZ</b> , Lines 10a)	“	This item is also used in Schedule 4 (CSO Volume)
Sub-sewershed principal land use ( <b>Form LTCP-EZ</b> , Lines 10b)	“	This item is also used in Schedule 4 (CSO Volume)
Type of CSO hydraulic control structure (e.g., weir or diversion) ( <b>Form LTCP-EZ</b> , Line 11a)	“	
CSO hydraulic control capacity ( <b>Form LTCP-EZ</b> , Line 11b)	“	This item is also used in Schedule 4 (CSO Volume) and Schedule 5A (CSO Runoff Control)
Name of downstream interceptor or pipe receiving diversion ( <b>Form LTCP-EZ</b> , Line 11c)	“	
Public Participation ( <b>Form LTCP-EZ</b> , Line 12)	Local utility/government	
Information on CSO controls planned for installation ( <b>Form LTCP-EZ</b> , Lines 16a - 16d) <ul style="list-style-type: none"> <li>- Number and type</li> <li>- Financing plan</li> <li>- Proposed installation schedule</li> </ul>	Engineering studies or local utility/government	
Unit costs of unit processes or CSO controls	”	
<b>Schedule 4 Information</b>		
<i>Sub-sewershed delineations for individual CSO outfalls</i>	“	
<i>Capacities of hydraulic control structures, interceptors, and wastewater treatment processes</i>	“	
<i>Peak rate of sewage from non-CSO areas (Schedule 4 - CSO Volume, Line 22)</i>	“	
<i>Peak rate of sewage from satellite communities (Schedule 4 - CSO Volume, Line 23)</i>	“	
<i>Number of households in service area</i>	“	
<i>Satellite areas (Schedule 4 - CSO Volume, Line 31)</i>	“	

Item and Line Number on Form	Most Likely Information Source	Actual Source Used/Comments
Information on how the CSS responds to rainfall <i>Modeling data</i> <i>Monitoring data</i> <i>Pump station records</i>	Engineering studies or local government	
Data required for <b>Schedule 5A – CSO Control, Green Infrastructure Runoff Controls</b> )		
Percent impervious area by sewershed	“	
Retention standard or goal	NPDES authority or local government	
Percent of area to be redeveloped over planning horizon	Local government; specific plan	
Quantity of green infrastructure to be implemented	“	
- Green roofs – number of installations and average area	“	
- Bioretention – number of installations and average area managed by an installation	“	
- Vegetated swales – acreage/area of installations and average area managed by an installation	“	
- Permeable pavement – area to be installed	“	
- Rain barrels/cisterns - number of installations and average volume of the barrel/cistern	“	
Local green infrastructure unit costs	“	
Percentage of installations that will be financed by the public	“	
Financial Capability Information (Data required for <b>Schedule 6 – CSO Capability</b> )		
Annual budgeted O&M expenses (excluding depreciation) of wastewater operations	Local utility/government	
Annual debt service on wastewater treatment debts	“	

Item and Line Number on Form	Most Likely Information Source	Actual Source Used/Comments
Projected annual O&M expenses for new wastewater projects	“	
Projected debt costs of new wastewater projects	“	
Median household income for the service area*	US Census Bureau and local utility/government	<a href="http://quickfacts.census.gov/qfd/index.html">http://quickfacts.census.gov/qfd/index.html</a> <a href="http://www.census.gov/">http://www.census.gov/</a>
National median household income	US Census Bureau	<a href="http://quickfacts.census.gov/qfd/states/00000.html">http://quickfacts.census.gov/qfd/states/00000.html</a>
Date of most recent general obligation (GO) bond, bond rating, indication of whether insurance was required on the bond, and name of credit agency	Local utility/government	
Direct net debt (GO bonds excluding double-barreled bonds - GO debt outstanding that is supported by the property in the permittee's service area)	“	
Debt of overlapping entities (proportionate share of multi-jurisdictional debt)	“	
Full market property value (MPV)	Local government	
Unemployment rate for permittee's service area	US Dept. of Labor Statistics and local utility/government	<a href="http://data.bls.gov/pdq/querytool.jsp?survey=la">http://data.bls.gov/pdq/querytool.jsp?survey=la</a>
Unemployment rate for permittee's county**	US Dept. of Labor Statistics	<a href="http://data.bls.gov/pdq/querytool.jsp?survey=la">http://data.bls.gov/pdq/querytool.jsp?survey=la</a>
Average national unemployment rate	“	<a href="http://www.bls.gov/">http://www.bls.gov/</a>
Property tax revenues	Local government	
Property taxes levied	“	
Property tax revenue collection rate	“	

\*To obtain median household income for the service area, from Census Bureau url, click on desired state and then select appropriate county. Note that approximations may be required to account for differences in county and service area boundaries.

\*\*To obtain county unemployment data from the url provided, select (1) state; (2) select area type of “counties or equivalent”; and (3) select the county or equivalent jurisdiction of interest. Data are provided for the past 10 years and include annual averages.

FWS = U.S. Fish and Wildlife Service; NMFS = NOAA National Marine Fisheries Service (NOAA = National Oceanic and Atmospheric Administration)

## General Instructions: Green LTCP-EZ Template

FORM GREEN LTCP-EZ encompasses all the information that most small CSO communities need to develop a draft LTCP. This includes characterizing the CSS, documenting NMC implementation, documenting public participation, identifying and prioritizing sensitive areas where present, and evaluating CSO control alternatives and financial capability.

The Green LTCP-EZ Template includes a form (Form Green LTCP-EZ) and schedules for organizing the following information:

- General information about the CSS, the wastewater treatment plant (WWTP) and the community served
- NMC implementation activities (Schedule 1 – NMC)
- Sensitive area considerations
- Water quality considerations
- System characterization, including a map of the CSS (Schedule 2 – MAP)
- Public participation activities (Schedule 3 – PUBLIC PARTICIPATION)
- CSO volume that needs to be controlled (Schedule 4 – CSO VOLUME)
- Evaluation of green infrastructure runoff controls (Schedule 5A – CSO RUNOFF CONTROL)
- Evaluation of pipe network CSO controls (Schedule 5B – CSO NETWORK and WWTP CONTROL)
- Financial capability analysis (Schedule 6 – CSO FINANCIAL CAPABILITY)
- Recommended CSO Control Plan, including financing plan and implementation schedule

Permittees intending to use the Green LTCP-EZ Template should assemble the following information:

- The NPDES permit.
- General information about the CSS and the WWTP including sub-sewershed delineations for individual CSO outfalls and the capacities of hydraulic control structures, interceptors, and wastewater treatment (WWT) processes.
- Relevant engineering studies and facility plans for the sewer system and WWTP if available.
- Maps for sewer system.
- General demographic information for the community.
- General financial information for the community.
- A summary of historical actions and current programs that represent implementation of the NMCs. The NMC are controls that can reduce CSOs and their effects on receiving waters, do not require significant engineering studies or major construction, and can be implemented in a relatively short period (e.g., less than approximately two years).
- Information on water quality conditions in local waterbodies that receive CSO discharges.

### **Using the Electronic Forms for the Green LTCP-EZ Template**

The electronic version of the Green LTCP-EZ Template forms have cells that link data in one worksheet to other worksheets. Therefore, it is important that you work on the worksheets in order and fill in all the pertinent information. If you are filling in the Green LTCP-EZ Template forms by hand, you will have to copy the information from one form into the other.

### **Guidance from EPA**

EPA has developed the *Combined Sewer Overflows Guidance for Long-Term Control Plan* (EPA 1995a) to help municipalities develop an LTCP that includes technology-based and water quality-based control measures that are technically feasible, financially capable, and consistent with the CSO Control Policy. The guidance is available at:

(<http://www.epa.gov/npdes/pubs/owm0272.pdf>)

Once complete, the Green LTCP-EZ Template (FORM GREEN LTCP-EZ with accompanying schedules) can serve as a draft LTCP for a small community. All the schedules provided in the Green LTCP-EZ Template might not be appropriate for every permittee. It might not be necessary to use all the schedules provided in this template to complete a draft LTCP. In addition, permittees can attach the relevant documentation to FORM GREEN LTCP-EZ in a format other than the schedules provided in the Green LTCP-EZ Template.



## Instructions: Form Green LTCP-EZ

### General Information

**Line 1 – Community Information.** Enter the community name, National Pollutant Discharge Elimination System (NPDES) permit number, owner/operator, facility name, mailing address, telephone number, fax number, email address, and the date.

**Line 2 – System Type.** Identify the type of system for which this LTCP is being developed:

- NPDES permit for a CSS with a WWTP or
- NPDES permit for a CSS without a WWTP

**Line 3a – CSS.** Enter the total area served by the CSS in acres.

**Line 3b –** Enter the number of permitted CSO outfalls.

**Line 4 – WWTP.** Enter the following information for WWTP capacity in million gallons per day (MGD).

- **Line 4a –** Primary treatment capacity in MGD.
- **Line 4b –** Secondary treatment capacity in MGD.
- **Line 4c –** Average dry-weather flow in MGD. Dry-weather flow is the base sanitary flow delivered to a CSS in periods without rainfall or snowmelt. It represents the sum of flows from homes, industry, commercial activities, and infiltration. Dry-weather flow is usually measured at the

WWTP and recorded on a Discharge Monitoring Report (DMR).

For the purposes of the calculation in the Green LTCP-EZ Template, base sanitary flow is assumed to be constant. There is no need to adjust entries for diurnal or seasonal variation.

### Nine Minimum Controls

The CSO Control Policy (Section II.B.) sets out NMCs that are technology-based controls that communities are expected to use to address CSO problems, without undertaking extensive engineering studies or significant construction costs, before long-term measures are taken. Permittees with CSSs experiencing CSOs should have implemented the NMCs with appropriate documentation by January 1, 1997. The NMCs are

- NMC 1. Proper operations and regular maintenance programs for the CSS and CSO outfalls.
- NMC 2. Maximum use of the CSS for storage.
- NMC 3. Review and modification of pretreatment requirements to ensure CSO effects are minimized.
- NMC 4. Maximizing flow to the publicly owned treatment works (POTW) for treatment.
- NMC 5. Prohibition of CSOs during dry weather.
- NMC 6. Control of solid and floatable materials in CSOs.
- NMC 7. Pollution prevention
- NMC 8. Public notification to ensure that the public receives adequate

notification of CSO occurrences and CSO impacts.

- NMC 9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

**Line 5 – NMC.** Permittees can attach previously submitted documentation on NMC implementation, or they can use Schedule 1 – NMC to document NMC activities. Please check the appropriate box on Line 5 to indicate how documentation of NMC implementation is provided.

If Schedule 1 – NMC is used, please document the activities taken to implement the NMC. Documentation should include information that demonstrates

- The alternatives considered for each minimum control
- The actions selected and the reasons for their selection
- The selected actions already implemented
- A schedule showing additional steps to be taken
- The effectiveness of the minimum controls in reducing/eliminating water quality impacts (in reducing the volume, frequency, and impact of CSOs)

If no activities have been undertaken for a particular NMC, leave the description blank. For examples of NMC activities and for further guidance on NMC documentation, see *Combined Sewer Overflows Guidance for Nine Minimum Controls* (EPA 1995b) for examples of NMC activities and for further

guidance on NMC documentation.

## Sensitive Areas

Permittees are expected to give the highest priority to controlling CSOs in sensitive areas (CSO Control Policy Section II.C.3). Permittees should identify all sensitive waterbodies and the CSO outfalls that discharge to them. Identifying sensitive areas can direct the selection of CSO control alternatives. In accordance with the CSO Control Policy, the LTCP should give the highest priority to the prohibition of new or significantly increased overflows (whether treated or untreated) to designated sensitive areas.

Sensitive areas, as identified in the CSO Control Policy, include the following:

- **Outstanding National Resource Waters.** These are waters that have been designated by some (but not all) states, “[w]here high quality waters constitute an outstanding National resource, such as waters of National Parks, State parks and wildlife refuges, and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected” (Title 40 of the *Code of Federal Regulations* [CFR] 122.12(a)(3)). Tier III Waters and Class A Waters are sometimes designated Outstanding National Resource Waters. State water quality standards authorities are the best source of information on the presence of identified Outstanding National Resource Waters.

- **National Marine Sanctuaries.** The National Oceanic and Atmospheric Administration (NOAA) is the trustee for the nation's system of marine protected areas, to conserve, protect, and enhance their biodiversity, ecological integrity and cultural legacy. Information on the location of National Marine Sanctuaries are at <http://sanctuaries.noaa.gov/>.
- **Waters with Threatened or Endangered Species and their Habitat.** Information on threatened and endangered species can be identified by contacting the Fish and Wildlife Service (FWS), NOAA Fisheries, or state or tribal heritage center or by checking resources such as the FWS Web site at <http://www.fws.gov/endangered/wildlife.html>. If species are listed in the area, contact the appropriate local agency to determine if the listed species could be affected or if any critical habitat areas have been designated in waterbodies that receive CSO discharges.
- **Waters with Primary Contact Recreation:** State water quality standards authorities are the best source of information on the location of waters designated for primary contact recreation.
- **Public Drinking Water Intakes or their Designated Protection Areas.** State water quality standards and water supply authorities are the best source of information on the location of public drinking water intakes or their designated protection areas. EPA's *Report to Congress—Impacts and*

*Control of CSOs and SSOs* identifies 59 CSO outfalls in seven states within one mile upstream of a drinking water intake (USEPA 2004).

- **Shellfish Beds.** Shellfish harvesting can be a designated use of a waterbody. State water quality standards authorities are a good source of information on the location of waterbodies that are protected for shellfish harvesting. In addition, the National Shellfish Register of Classified Estuarine Waters provides a detailed analysis of the shellfish growing areas in coastal waters of the United States. Information on the location of shellfish beds is at [http://gcmd.nasa.gov/records/GCMD\\_NOS00039.html](http://gcmd.nasa.gov/records/GCMD_NOS00039.html).

To determine if sensitive areas are present in the area of the CSO, contact the appropriate state and federal agencies. EPA recommends that the permittee attach to the Green LTCP-EZ Template forms all documentation of research regarding sensitive areas or contacts with agencies providing that information (including research on agency Web sites). In addition, EPA encourages the permittee to attach maps or other materials that provide backup information regarding the evaluation of sensitive areas.


**Line 6a** – Indicate if sensitive areas are present. Answer Yes or No. If sensitive areas are present, proceed to Line 6b and answer questions 6b, 6c, and 6d. Also provide an explanation of how the determination was made that sensitive areas are present. If sensitive areas are not present, proceed to Line 7. If

sensitive areas are not present, provide an explanation of how the determination was made.

**Line 6b** – Enter the type(s) of sensitive areas present (e.g., public beach, drinking water intake) for each CSO receiving water.

**Line 6c** – List the permitted CSO outfall(s) that could be affecting the sensitive areas. Add detail on impacts where available (e.g., CSO outfall is within a sensitive area, beach closures have occurred due to overflows.).

**Line 6d** – Are sensitive areas affected by CSO discharges? Answer Yes or No. If sensitive areas are present but not affected by CSO discharges, provide documentation on how the determination was made and proceed to Line 7.

 More detailed study might be necessary if sensitive areas are present *and* are affected by CSO discharges. Under such circumstances, use of the presumption approach in the Green LTCP-EZ Template might not be appropriate. The permittee should contact the permitting authority for further instructions on use of the Green LTCP-EZ Template and the presumption approach.

## Water Quality Considerations

The main impetus for implementing CSO controls is attainment of water quality standards, including designated uses. Permittees are expected to be knowledgeable about water quality conditions in local waterbodies that receive CSO discharges. At a minimum, permittees should check to see

if the local waterbodies have been assessed under the 305(b) program by the state water quality standards agency as being *good*, *threatened* or *impaired*.

Waters designated as impaired are included on a state's 303(d) list. A total maximum daily load (TMDL) is required for each pollutant causing impairment. EPA's *Report to Congress – Impacts and Control of CSOs and SSOs* (EPA 2004) identifies the three causes of reported 303(d) impairment most likely to be associated with CSOs:

- Pathogens
- Organic enrichment leading to low dissolved oxygen
- Sediment and siltation

Some states identify sources of impairment, and the activities or conditions that generate the pollutants causing impairment (e.g., WWTPs or agricultural runoff). CSOs are tracked as a source of impairment in some but not all CSO states.

If local waterbodies receiving CSO discharges are impaired, permittees should check with the permitting authority to determine whether the pollutants associated with CSOs are cited as a cause of impairment or if CSOs are listed as a source of impairment. In addition, permittees should check with the permitting authority to see if a TMDL study is scheduled for local waterbodies to determine the allocation of pollutant loads, including pollutant loads in CSO discharges.

The 305(b) water quality assessment information is at <http://www.epa.gov/waters/305b/index.html>. Note that not all


waters are assessed under state programs.

A national summary on the status of the TMDL program in each state is at <http://www.epa.gov/owow/tmdl/>. Note that not all waters are listed.

**Line 7a** – Indicate if local waterbodies are listed by the permitting authority as impaired. Answer Yes or No. If No, the permittee may continue to Line 8.

**Line 7b** – Indicate the causes or sources of impairment for each impaired waterbody.

**Line 7c** – Indicate if a TMDL has been scheduled to determine the allocation of pollutant loads. Answer Yes or No. If yes, provide the date.

 If the identified waterbodies have been assessed as threatened or impaired under the 305(b) program, and if CSOs are cited as a source of impairment or if the pollutants found in CSOs are listed as a cause of impairment, CSOs likely cause or contribute to a recognized water quality problem. Under such circumstances, permittees should check with the permitting authority to confirm that use of the Green LTCP-EZ Template or the presumption approach is appropriate.

If the waterbodies are not designated by the permitting authority as impaired or if the waterbody is impaired but the CSO discharges are not viewed as a cause of the impairment, the permittee may continue with the Green LTCP-EZ Template.

## System Characterization

CSO control planning involves considering the site-specific nature of CSOs. The amount of combined sewage flow that can be conveyed to the WWTP in a CSS depends on a combination of regulator capacity, interceptor capacity, pump station capacity, and WWTP capacity. The Green LTCP-EZ Template uses the term *CSO hydraulic control capacity* as a generic reference to these types of flow controls. In any system, one or more of the CSO hydraulic control capacities might be the limiting factor. If the community has not previously carried out an analysis of the peak capacity of each portion of its CSS, EPA strongly suggests that the determination of each CSO hydraulic control capacity be carried out by individual(s) experienced in such hydraulic analyses. EPA also cautions communities against evaluating CSO regulator capacity without considering interceptor capacity as well, because the nominal capacity of a given CSO regulator could exceed that of its receiving interceptor under the same peak wet-weather conditions.

To develop an adequate control plan, the permittee needs to have a thorough understanding of the following:

- The extent of the CSS and the number of CSO outfalls
- The interconnectivity of the system
- The response of the CSS to rainfall
- The water quality characteristics of the CSOs
- The water quality impacts that result from CSOs

Of those, the first three considerations are the most important for small communities. Communities using the Green LTCP-EZ Template are encouraged to obtain at least limited rainfall and system flow data to allow the runoff response calculated by the Green LTCP-EZ approach to be checked against actual system flow data.

Line 8 is used to indicate that a map has been attached to the Green LTCP-EZ Template. Lines 9-11 provide more specific information about the CSS. Information on Lines 9 through 11 is organized by CSO outfall and sub-sewershed.

### Line 8 – General Location.

Please check the box on Line 8 to indicate that Schedule 2 – MAP is attached to FORM GREEN LTCP-EZ. Schedule 2 – MAP should include a map or sketch of the CSS that shows the following:

- Boundaries of the CSS service area and, if different, total area served by the sewer system
- CSO outfall locations
- Boundaries of individual sub-sewersheds within the CSS that drain to a CSO outfall
- Location of major hydraulic control points such as CSO regulators (weirs, diversion structures, and such) and pump stations
- Location of major sewer interceptors (show as pathways to the WWTP)
- WWTP, if present
- Waterbodies

Delineation of the boundaries of the CSS and individual sub-sewersheds is very important.

Delineation is most often done by hand with sewer maps, street maps, contours, and the location of key hydraulic control points such as regulators and sewer interceptors. The measurement of CSS and sub-sewershed area is also very important. Area can be measured directly with geographic information systems (GIS), computer aided design systems, or it can be measured by hand by overlaying graph paper and counting squares of known dimension in the CSS or sub-sewershed boundary.

**Line 9 – CSO Information.** Use one column in Line 9 for each CSO outfall in the CSS (e.g., CSO A, CSO B). Space is provided for up to four CSO outfalls in FORM GREEN LTCP-EZ. Add additional columns if needed. See the example for Line 9.

- **Line 9a – Permitted CSO number.** Enter an identifying number for each CSO outfall.
- **Line 9b – Description of location.** Enter a narrative description of the location for each CSO outfall.
- **Line 9c – Latitude/Longitude.** Enter the latitude and longitude for each CSO outfall, where available.
- **Line 9d – Receiving water.** Enter the name of the receiving water for each CSO outfall.

**Line 10 – CSS Information.** Most (though not all) CSOs have a defined service area, and surface runoff in this area enters the CSS. For the purpose of the Green LTCP-EZ Template, *sub-sewershed area* is used to describe the defined

service area for each CSO in a CSS.

Use one column in Line 10 to describe the following information for each sub-sewershed area in the CSS. Space is provided for up to four sub-sewersheds. Add additional columns if needed. See the example for Line 10.

- **Line 10a – Sub-sewershed area.** Enter the area (in acres) for the contributing sub-sewershed. **Note 1:** the sum of sub-sewershed areas in CSS should be consistent with Line 3a. **Note 2:** this information is also used in Schedule 4 – CSO VOLUME.
- **Line 10b – Principal land use.** Enter the principal land use for the sub-sewershed (i.e., business - downtown, residential—single family) See Table 1 in Schedule 4- CSO VOLUME.

**Line 11 – CSO Hydraulic Control Capacity.** The amount of combined sewage that can be conveyed to the WWTP in a CSS depends on a combination of regulator, interceptor, pump

station, and WWTP capacity. The volume and rate of combined sewage that can be conveyed in a CSS depends on dry-weather flows and these capacities. In any system, one or more of the capacities could be the limiting factor.

The CSO hydraulic control capacity defines the amount of combined sewage that is diverted to the interceptor. Interceptors are large sewer pipes that convey dry-weather flow and a portion of the wet weather-generated combined sewage flow to WWTPs.

The CSO hydraulic control capacity of passive structures such as weirs and orifices can be calculated or estimated as long as drawings are available and the dimensions of the structures are known. The use of standard weir or orifice equations is recommended if they are appropriate for the structures that are present. As a general rule, the diversion rate is often three to five times greater than dry-weather flow. Permittees should consult a standard hydraulics handbook or a professional engineer

familiar with the design and operation of regulators if the CSO hydraulic control capacity is unknown and the permittee is unable to determine regulator capacity with the resources available.

Use one column in Line 11 to describe the following information for each CSO and sub-sewershed. See the example for Line 11.

- **Line 11a – Type of CSO hydraulic control.** Enter the type of hydraulic control used for this CSO, e.g., weir.
- **Line 11b – CSO hydraulic control capacity.** Enter the capacity in MGD of the CSO hydraulic control. **Note:** this information is also used in Schedule 4-CSO VOLUME and Schedule 5A-CSO RUNOFF CONTROL.
- **Line 11c – Name of interceptor or downstream pipe.** Enter the name of the interceptor that receives the diverted flow.

## Public Participation

The CSO Control Policy states, “in developing its long-term CSO control plan, the permittee will employ a public participation process that actively involves the affected public in the decision-making to select the long-term CSO controls” (II.C.2). Given the potential for significant expenditures of public funds for CSO control, public support is key to CSO program success.

### Example: Line 9 – CSO Information

a. Permitted CSO number	9a	001	002	003
b. Description of location	9b	Foot of King Street	Near Main Street	Near Water Street
c. Latitude/Longitude	9c	374637N 870653W	374634N 870632W	374634N 870633W
d. Receiving Water	9d	Green River	Green River	Green River

### Example: Line 10 – CSS Information

		CSO 001	CSO 002	CSO 003
a. Sub-sewershed area (acres)	10a	105	85	112
b. Principal land use	10b	Medium-Density Residential	High-Density Residential	Mixed Use



Public participation can be viewed as interaction between the permittee (the utility or municipality), the general public, and other stakeholders. Stakeholders include civic groups, environmental interests, and users of the receiving waters. The general public and stakeholders need to be informed about the existence of CSOs and the plan for CSO abatement and control. Informing the public about potential CSO control alternatives is one part of the public participation process.

Public meetings are typically used for describing and explaining alternatives. Technical solutions should be presented simply and concisely and understandable to diverse groups. The discussion should include background on the project, description of proposed facilities/projects, the level of control to be achieved, temporary and permanent impacts, potential mitigation measures, and cost and financial information. Presentations to the public should explain the benefits of CSO control. A key objective of the public education process is to build support for increases in user charges and taxes that might be required to finance CSO control projects.

The extent of the public participation program generally depends on the amount of resources available and the size of the CSO community. Public participation is typically accomplished through one or more activities, such as the following:

### Use of Schedules

The Green LTCP-EZ Template provides an organizational framework for collecting and presenting information and analysis that is essential for a draft LTCP. Once complete, FORM GREEN LTCP-EZ (with accompanying schedules) can serve as a draft LTCP for a small community under appropriate circumstances. Each of the following three sections on CSO Volume, Evaluation of CSO Controls, and CSO Financial Capability include schedules with calculation procedures that are potentially valuable for small communities. However, although the types of information used in, and generated by, such schedules is necessary for a draft LTCP, use of the schedules is optional. Permittees with extremely simple systems, permittees that have already completed an evaluation of CSO controls, and permittees that have previously conducted separate analyses could choose not to use the schedules. Under those circumstances, documentation of the evaluation of CSO control alternatives and selection of the recommended CSO Control Plan could be provided in another format.

#### *CSO Awareness:*

- Placing informational and warning signs at CSO outfalls
- Media advisories for CSO events

#### *Public Education:*

- Media coverage
- Newsletters/Information booklet
- Educational inserts to water and sewer bills
- Direct mailers
- CSO project Web sites

#### *Public Involvement:*

- Public meetings
- Funding task force
- Local river committee
- Community leader involvement
- General public telephone survey
- Focus groups

Successful public participation occurs when the discussion of CSO control has involved ratepayers and users of CSO-affected waterbodies.

For more information on public participation activities, see *Combined Sewer Overflows Guidance for Long-Term Control Plan* (EPA 1995a).

Examples of public participation can also be viewed at the following CSO project Web sites:

- City of Lansing, Michigan.  
([http://www.cityoflansingmi.com/pubserv/cso/the\\_cso\\_story.jsp](http://www.cityoflansingmi.com/pubserv/cso/the_cso_story.jsp))
- City of Manchester, New Hampshire.  
(<http://www.manchesternh.gov/Web/site/Departments/EnvironmentalProtection/tabid/254/Default.aspx>)
- City of St. Joseph, Missouri.  
([http://www.ci-st-joseph.mo.us/publicworks/wp\\_c\\_cso.cfm](http://www.ci-st-joseph.mo.us/publicworks/wp_c_cso.cfm))
- City of Wilmington, Delaware.  
([http://www.wilmingtoncso.com/CSO\\_home.htm](http://www.wilmingtoncso.com/CSO_home.htm))

**Line 12 – Public Participation.** Please check the box on Line 12 to indicate that Schedule 3 – PUBLIC PARTICIPATION is attached to FORM LTCP-EZ. Use Schedule 3 – PUBLIC PARTICIPATION to document

public participation activities undertaken (or planned) to involve the public and stakeholders in the decision process to evaluate and select CSO controls.

### CSO Volume

The Green LTCP-EZ Template applies the presumption approach described in the CSO Control Policy. The Green LTCP-EZ Template uses a design storm approach to identify the volume of combined sewage that needs to be stored, treated, or eliminated to reduce CSOs to no more than an average of four overflow events per year. In accordance with the presumption approach described in the CSO Control Policy, a program meeting that criterion is conditionally presumed to provide an adequate level of control to meet water quality-based requirements, provided that the permitting authority determines the presumption is reasonable, according to the data and analysis provided in the LTCP.

Use of other criteria under the presumption approach is valid but needs to be documented separately (not in Schedule 4 – CSO VOLUME).

**Line 13 – CSO Volume.** Check the appropriate box on Line 13 to indicate whether Schedule 4 – CSO VOLUME or separate

documentation is attached to FORM GREEN LTCP-EZ. Schedule 4 – CSO VOLUME is used to quantify the volume of combined sewage that needs to be stored, treated, or eliminated. This is called the *CSO volume* throughout the Green LTCP-EZ Template. Specific instructions for completion of Schedule 4 – CSO VOLUME are provided.

### Evaluation of CSO Controls

LTCPs should contain site-specific, cost-effective CSO controls. Small communities are expected to evaluate a simple mix of land management and pipe network controls to assess their ability to provide cost-effective CSO control. The Green LTCP-EZ Template considers the volume of combined sewage calculated in Schedule 4 – CSO VOLUME that needs to be stored, treated, or eliminated when evaluating alternatives for CSO controls.

Schedule 5 – CSO CONTROL has two parts that enable an evaluation of CSO control alternatives for the CSO volume calculated in Schedule 4 – CSO VOLUME. Schedule 5A evaluates the runoff reduction that could be achieved with certain green infrastructure runoff controls. Schedule 5B evaluates potential pipe network CSO controls. Specific instructions for completion of

both parts of Schedule 5 – CSO CONTROL are provided. Note that both parts of Schedule 5 – CSO CONTROL can be used iteratively to identify the most promising CSO control plan with respect to CSO volume reduction and cost.

### Line 14 – CSO Controls.

Check the appropriate box on Line 14 to indicate whether Schedules 5A and 5B – CSO CONTROL or separate documentation are attached to FORM GREEN LTCP-EZ.

### Financial Capability

The CSO Control Policy recognizes the need to address the relative importance of environmental and financial issues when developing an implementation schedule for CSO controls. The ability of small communities to fund CSO control influences the implementation schedule.

Schedule 6 – CSO FINANCIAL CAPABILITY provides an assessment of financial capability in a two-step process. Step One involves determination of a residential indicator to assess the ability of the resident and the community to finance CSO controls. Step Two involves determining a permittee's financial indicator to assess the financial capability of the permittee to fund and implement CSO controls. Information from both Step One and Step Two is used to determine financial capability.

### Line 15 – Financial Capability.

Permittees are encouraged to assess their financial capability to fund the LTCP. Check the box in Line 15 if Schedule 6 – CSO FINANCIAL CAPABILITY is attached to FORM GREEN LTCP-EZ and enter the

### Example: Line 11 – Pipe Capacity and Flow Information

		CSO 001	CSO 002	CSO 003
a. Type of CSO hydraulic control	11a	Weir	Weir	Pump station
b. CSO hydraulic control capacity (MGD)	11b	1.5	1.5	3.0
c. Name of interceptor or downstream pipe	11c	South Street Interceptor	South Street Interceptor	Central Force Main

appropriate financial capability burden in Line 15a. Otherwise, proceed to Line 16.

**Line 15a – Financial Capability Burden.** Enter the appropriate financial capability burden (low, medium, or high) from Schedule 6 – CSO FINANCIAL CAPABILITY.

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### Recommended CSO Control Plan

The Green LTCP-EZ Template guides permittees through a series of analyses and evaluations that form the basis of a draft LTCP for small communities. The recommended CSO controls need to be summarized so that the permitting authority and other interested parties can review them. Line 16 is used for this purpose.

**Line 16 – Recommended CSO Control Plan.** Documentation of the evaluation of CSO control alternatives is required (CSO Control Policy Section II.C.4.). Permittees that have used Schedules 5A or 5B - CSO CONTROL to select CSO controls should bring the information from Schedules 5A and/or 5B – CSO CONTROL forward to Line 16 in FORM GREEN LTCP-EZ. Permittees who have completed their own evaluation of CSO alternatives (that is, permittees that did not use Schedules 5A or 5B – CSO CONTROL) need to summarize the selected CSO control on Line 16 and attach the appropriate documentation.

**Line 16a –** Provide a summary of the CSO controls selected. This information can come from the controls selected on Schedules 5A or 5B – CSO CONTROL, or from other analyses. Section 3.3.5,

Identification of Control Alternatives, of EPA's *Combined Sewer Overflows Guidance for Long-Term Control Plan* document, lists the various source controls, collection system controls, and storage and treatment technologies that might be viable. This document also discusses preliminary sizing considerations, cost/performance considerations, preliminary siting issues, and preliminary operating strategies, all of which should be discussed on Line 16a of the Green LTCP-EZ Template.

**Line 16b –** Provide a summary of the cost of CSO controls selected. Project costs include capital, annual operation and maintenance (O&M), and life cycle costs. Capital costs should include construction costs, engineering costs for design and services during construction, legal and administrative costs, and typically a contingency. Annual O&M costs reflect the annual costs for labor, utilities, chemicals, spare parts, and other supplies required to operate and maintain the facilities proposed as part of the project. Life-cycle costs refer to the total capital and O&M costs projected to be incurred over the design life of the project.

At the facilities planning level, cost curves are usually acceptable for estimating capital and O&M costs. When used, cost curves should be indexed to account for inflation, using an index such as the *Engineering News-Record* Cost Correction Index.

**Line 16c –** Provide a description of how the CSO controls selected will be financed. Discuss self-financing

including fees, bonds, and grants.

Section 4.3, Financing Plan, of *Combined Sewer Overflows Guidance for Long-Term Control Plan* (EPA 1995a), states that the LTCP should identify a specific capital and annual cost funding approach. EPA's guidance on funding options presents a detailed description of financing options and their benefits and limitations, as well as case studies on different approaches municipalities took to fund CSO control projects. It also includes a summary of capital funding options, including bonds, loans, grants, and privatization, as well as annual funding options for O&M costs for CSO controls, annual loan payments, debt service on bonds, and reserves for future equipment replacement.

**Line 16d –** Describe the proposed implementation schedule for the CSO controls selected. The implementation schedule describes the planned timeline for accomplishing all the program activities and construction projects contained in the LTCP. Section 4.5.1.5 of *Combined Sewer Overflow Guidance for Permit Writers* (EPA 1995c) summarizes criteria that should be used in developing acceptable implementation schedules, including the following:

- Phased construction schedules should consider first eliminating CSOs to sensitive areas and use impairment.
- Phased schedules should also include an analysis of financial capability (see Schedule 6 – CSO FINANCIAL CAPABILITY).

- The permittee should evaluate financing options and data, including grant and loan availability, previous and current sewer user fees and rate structures, and other viable funding mechanisms and sources of funding.
- The schedule should include milestones for all major implementation activities, including environmental reviews, siting of facilities, site acquisition, and permitting.
- The implementation schedule is often negotiated with the permitting authority, and incorporating the information listed above in the schedule provides a good starting point for schedule negotiations.

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## Instructions: Schedule 4 – CSO Volume

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### Introduction

Understanding the response of the CSS to rainfall is critical for evaluating the magnitude of CSOs and control needs. Small CSO communities do not typically have the resources to conduct the detailed monitoring and modeling necessary to make this determination easily. Schedule 4 – CSO VOLUME of the Green LTCP-EZ Template provides a simple, conservative means for assessing CSO control needs. The technical approach contained in Schedule 4 – CSO VOLUME builds on the general information and CSS characteristics provided in FORM GREEN LTCP-EZ. It rests on a simple interpretation of the presumption approach described in the CSO Control Policy. Under the presumption approach, a CSO community controlling CSOs to no more than an average of four overflow events per year is presumed to have an adequate level of control to meet water quality standards.

The volume of combined sewage that needs to be treated, stored, or eliminated is calculated in Schedule 4 – CSO VOLUME. This is called the *CSO volume*. CSO volume is calculated with a *design storm*, application of the Rational Method (described below) to determine generated runoff, and use of an empirical equation to estimate excess combined sewage and conveyance within the CSS. Once construction of controls is completed, it is expected that compliance monitoring will be used to assess the ability of the controls to reduce CSO frequency to meet the average of four overflow events per year criterion.

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### Design Storm for Small Communities

Calculating the volume of runoff and combined sewage that occurs due to design storm conditions is the basis for determining what controls are needed to limit the occurrence of CSOs to an average of four overflow events per year. The Green LTCP-EZ Template uses two design storm values, each of which represents a rainfall intensity that, on average, occurs four times per year. These are

- The statistically derived one-hour, 3-month rainfall. This design storm represents a peak flow condition. It is reasonably intense, delivers a fairly large volume of rainfall across the CSS, and washes off the *first flush*. In addition, the one-hour, 3-month rainfall facilitates a simple runoff calculation in the Rational Method. The LTCP must provide control to eliminate the occurrence of CSOs for hourly rainfall up to this intensity.
- The statistically derived 24-hour, 3-month rainfall. This design storm complements the one-hour, 3-month rainfall in the Green LTCP-EZ Template. The longer 24-hour storm delivers a larger volume of rainfall with the same 3-month return interval. The LTCP must provide control to eliminate the occurrence of CSOs for rainfall up to this amount over a 24-hour period.

Using both of these design storms in conjunction with one another ensures that CSO control needs are quantified on the basis of both rainfall intensity and rainfall volume associated with the return frequency of four times per year.

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## The Rational Method

The Rational Method is a standard engineering calculation that is widely used to compute peak flows and runoff volume in small urban watersheds. The Rational Method with a design storm approach is used in the Green LTCP-EZ Template to quantify the amount of runoff volume (the CSO volume) that needs to be controlled for each CSO outfall and contributing sub-sewershed area. The Rational Method equation is given as follows:

$$Q = kCiA$$

where

- $Q$  = runoff (MGD)
- $k$  = conversion factor (acre-inches/hour to MGD)
- $C$  = runoff coefficient (based on land use)
- $i$  = rainfall intensity (in/hr)
- $A$  = sub-sewershed area (acres)

The Rational Method is applied twice in the Green LTCP-EZ Template: once to determine the peak runoff rate associated with the one-hour, 3-month rainfall, and once to determine the total volume of runoff associated with the 24-hour, 3-month rainfall. When applied properly, the Rational Method is inherently conservative.

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## Calculation of CSO Volume

CSO volume is calculated in sub-sewersheds at individual CSO hydraulic controls (i.e., weir, orifice) and at the WWTP. The procedures used to calculate CSO volume are documented in Appendix B. The following operations are central to the calculations:

- The average dry-weather flow rate of sanitary sewage is added to runoff to create a peak hourly flow rate and is used to calculate a total volume of flow over the 24-hour period.
- The ratio of the CSO hydraulic control capacity to the peak flow rate based on the one-hour, 3-month rainfall determines the fraction of overflow within sub-sewersheds. (Note: Identifying realistic hydraulic control capacities is an important part of the Green LTCP-EZ Template. Permittees might need to seek assistance from qualified professionals to successfully complete this part of the Template. In addition, it is important that interceptor capacity limitations be taken into account when identifying regulator capacities.)
- The overflow fraction is applied to the total volume of flow associated with the 24-hour, 3-month rainfall to quantify the volume of excess combined sewage at CSO hydraulic controls. This is the CSO volume at the CSO hydraulic control.
- Diversions to the WWTP at CSO hydraulic controls are governed by an empirical relationship based on the ratio of the CSO hydraulic control capacity to the peak flow rate and conveyance. The diversions to the WWTP at CSO hydraulic controls are a component of the peak sewage conveyed to the WWTP.
- The ratio of primary capacity to peak sewage conveyed to the WWTP determines the fraction of combined sewage untreated at the WWTP. This is the CSO volume at the WWTP.

The Schedule 4 – CSO VOLUME results identify the CSO volume, which is the volume of excess combined sewage that needs to be stored, treated, or eliminated to comply with the presumption approach. The results of the calculations, the excess CSO volumes, are linked to Schedules 5A and 5B – CSO CONTROL where green infrastructure or pipe network control alternatives are evaluated at the sub-sewershed level or at the WWTP.

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## **Summary**

The Green LTCP-EZ Template is designed to provide a very simple assessment of CSO control needs. Before entering data into the Green LTCP-EZ Template, permittees should collect good information on the characteristics of the CSS, including reliable information on CSO hydraulic control capacities.

Permitting authorities and permittees in cooperation with local authorities need to work closely or provide incentive for a maintenance agreement for green controls in the privately owned properties so that expected and designed results of green CSO controls can be achieved.

Additional detail and documentation on the approach used to identify overflow, diversion and WWTP overflow fractions are provided in Appendix B.



## Sub-Sewershed Area

This section characterizes the contributing area of each CSO sub-sewershed area, the predominant land use, and a runoff coefficient. These values are critical inputs to the runoff calculation developed in this schedule (the Rational Method). Schedule 4 – CSO VOLUME is set up to accommodate up to four sub-sewersheds. Additional columns can be added to the schedule as needed if there are more than four CSO sub-sewersheds. The number of sub-sewersheds evaluated on this schedule needs to correspond to the system characterization information included under Form GREEN LTCP-EZ and the map on Schedule 2 – MAP.

**Line 1 – Sub-sewershed area (acres).** Enter the area in acres for each sub-sewershed in the CSS (Line 10a on FORM GREEN LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically). Add additional columns if needed.

**Line 2 – Principal land use.** Enter the principal land use for each sub-sewershed area (Line 10b on FORM GREEN LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 3 – Sub-sewershed runoff coefficient.** Enter the runoff coefficient that is most appropriate for the sub-sewershed on Line 3. Runoff coefficients represent land use, soil type, design storm, and slope conditions. The range of runoff coefficients associated with different types of land use is presented in Table 1. Use the lower end of the range for flat

slopes or permeable, sandy soils. Use the higher end of the range for steep slopes or impermeable soils such as clay or firmly packed soils. The higher end of the range can also be used to add an additional factor of safety into the calculation.

The runoff coefficient selected should be representative of the entire sub-sewershed. Permittees should consider the distribution of land use in the sub-sewershed and develop a weighted runoff coefficient if necessary. For example, a sub-sewershed that is half residential single family ( $C = 0.40$ ) and half light industrial ( $C = 0.65$ ) would have a composite runoff coefficient of  $C = 0.525$   $[(0.40 + 0.65) / 2]$ .

At a minimum, the runoff coefficient should be equivalent to the percent imperviousness for the sub-sewershed as a decimal fraction. The percent imperviousness is the fraction of each sub-sewershed area that is covered by impervious surfaces (such as pavement, rooftops, and sidewalks) that is directly connected to the CSS

through catch basins, area drains or roof leaders.

## Runoff

### Line 4 Design storm rainfall.

The one-hour, 3-month rainfall intensity (inches per hour) is the design storm used in the Green LTCP-EZ Template to estimate peak runoff rate. The 24-hour, 3-month rainfall is used to estimate total volume of runoff generated over a 24-hour period.

Recommended one-hour, 3-month rainfall values by state and county are provided in Appendix A. These values are based on research and products provided by the Illinois State Water Survey and Midwest Climate Center (1992). Values for the midwestern states are very specific. Values for other states in the Northeast have been approximated on the basis of procedures developed by the Midwest Climate Center. A statistically derived multiplication factor of 2.1 is used to convert these one-hour, 3-month design rainfall conditions into the 24-hour, 3-month rainfall conditions.

**Table 1. Runoff coefficients for the rational formula**

Type of area (principal land use)	Runoff coefficient (C)
Business – downtown	0.70–0.95
Business – Neighborhood	0.50–0.70
Residential – Single family	0.30–0.50
Residential – Multi units, detached	0.40–0.75
Residential – Multi units, attached	0.60–0.75
Residential – Suburban	0.25–0.40
Residential – Apartments	0.50–0.70
Industrial – Light	0.50–0.80
Industrial – Heavy	0.60–0.90
Parks, cemeteries	0.10–0.25
Playgrounds	0.20–0.35
Railroad yard	0.20–0.35
Unimproved	0.10–0.30

Source: ASCE 2006

Site-specific rainfall values or other design storm intensities can be used to assess the response of the

CSS to rainfall. However, use of different rainfall periods could require a separate analysis outside of Schedule 4-CSO VOLUME.

Enter the one-hour design storm rainfall intensity in inches for each sub-sewershed on Line 4. (Note: this information is also used in Schedules 5A and 5B-CSO CONTROL).

**Line 5 – Calculated runoff rate.** Multiply Line 1 by Line 3 and then multiply this product by Line 4 for each sub-sewershed area and enter the result (acres-inches per hour) on Line 5.

**Line 6 – Peak runoff rate in MGD.** Multiply Line 5 by the conversion factor (k) of 0.6517 and enter the result for each sub-sewershed area on Line 6. This is the one-hour design storm runoff in MGD.

### Dry-Weather Flow within the CSS

**Line 7 – Dry-weather flow rate (MGD).** Enter the average dry-weather flow rate as a rate in MGD for each sub-sewershed on Line 7. If dry-weather flow is unknown on a sub-sewershed basis, develop an estimate supported by (1) direct measurement of dry-weather flow based on the average of a series of observations made at different times of the day; or (2) allocating the dry-weather flow reported on the DMR for the WWTP for the entire sewer service area. Using the allocation estimation approach should take into consideration characteristics of each sub-

sewershed that influence the rate of dry-weather flow including population, employment, and infiltration if known. The sum of dry-weather flow from the CSS plus the dry-weather flow from non-CSO areas and satellite communities, if present, should equal the dry-weather flow at the WWTP.

### Peak Wet-Weather Flow

**Line 8 – Peak flow rate (MGD).** The peak flow rate is the sum of the peak runoff rate and dry-weather flow in MGD. Add Lines 6 and 7 and enter the sum for each sub-sewershed area on Line 8.

### Overflow

**Line 9 – CSO hydraulic control capacity (MGD).** CSO hydraulic control capacity is the maximum flow that the sub-sewershed area sewer can deliver to the interceptor sewer. Enter the CSO hydraulic control capacity in MGD for each CSO sub-sewershed area on Line 9 (Line 11b on FORM GREEN LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 10 – Ratio of CSO hydraulic control capacity to peak flow rate.** Enter 1.0 on Line 10 if Line 9 is greater than Line 8. Otherwise, divide Line 9 by Line 8 and enter the quotient (result) on Line 10.

**Line 11 – Overflow fraction of combined sewage.** This is the overflow fraction of combined sewage within the sub-sewershed. It is based on the ratio of CSO hydraulic control capacity to peak flow rate. Take the square of (1 minus the value on Line 10) and enter it on Line 11. For example, if the ratio of

CSO hydraulic control capacity to peak flow rate on Line 10 is 0.15, the overflow fraction is  $(1 - 0.15)^2$ , or 0.7225.

### Line 12 – 24-hour rainfall.

Multiply Line 4 by 2.1 to obtain the 24-hour design rainfall and enter the product on Line 12.

### Line 13 – Volume of runoff (MG).

The volume of runoff for the 24-hour rainfall is obtained by multiplying Line 1 by Line 3 and Line 12 and converting to MG by applying the conversion factor 0.02715. Enter the product on Line 13.

### Line 14 – Volume of dry-weather flow (MG).

This is the total dry-weather flow in MG for the 24-hour design rainfall period. It is calculated by multiplying the dry-weather flow rate in MGD on line 7 by 24 hours. Enter this value on Line 14.

### Line 15 – Total volume of flow (MG).

This is the total volume of flow in MG within each sub-sewershed for the 24-hour design rainfall period. Add Lines 13 and 14 and enter the sum on Line 15.

### Line 16 – Volume of excess combined sewage at individual CSO hydraulic controls during 24-hour rainfall period.

This is also the CSO volume at the CSO hydraulic control and is the combined sewage that exceeds the diversion capacity determined by the CSO hydraulic control in each sub-sewershed. Multiply Line 11 by Line 15 and enter the product on Line 16.

## Diversion

**Line 17 – Diversion fraction of combined sewage.** This is the fraction of runoff within each subsewershed that is collected and diverted to the WWTP over the 24-hour design storm period. The diversion fraction is based on the ratio of CSO hydraulic control capacity to peak flow rate and conveyance. Determine the diversion fraction of combined sewage from Line 10 using Table 2, and enter on Line 17.

**Line 18 – Volume of runoff diverted to WWTP.** This is the volume of runoff within each sub-sewershed that is collected and diverted to the WWTP over the 24-hour design storm period. Multiply Line 13 by Line 17 and enter the product on Line 18.

**Line 19 – Total volume of combined sewage conveyed to WWTP during 24-hour rainfall period (MG).** Add Lines 14 and 18 and enter the sum on Line 19.

## Conveyance

**Line 20 – Peak rate of collected combined sewage diverted to the WWTP within sub-sewersheds.** Identify the smaller of Line 8 and Line 9 in each sub-sewershed and enter the peak rate in MGD on Line 20.

**Line 21 – Peak rate of combined sewage conveyed to WWTP (MGD).** This peak rate represents the sum of the peak rates of collected combined sewage diverted to the WWTP from individual sub-sewersheds in MGD. Add up sub-sewershed values on Line 20 and enter on Line 21.

**Table 2. Diversion Fraction of Combined Sewage from 24-Hour Storm**

Ratio of CSO hydraulic control capacity to peak flow rate	Diversion fraction
0.01 to 0.02	0.04
0.02 to 0.03	0.06
0.03 to 0.04	0.09
0.04 to 0.05	0.11
0.05 to 0.06	0.14
0.06 to 0.07	0.16
0.07 to 0.08	0.19
0.08 to 0.09	0.21
0.09 to 0.10	0.24
0.10 to 0.12	0.28
0.12 to 0.14	0.33
0.14 to 0.16	0.38
0.16 to 0.18	0.42
0.18 to 0.20	0.47
0.20 to 0.24	0.54
0.24 to 0.28	0.62
0.28 to 0.32	0.68
0.32 to 0.36	0.72
0.36 to 0.40	0.76
0.41 to 0.50	0.81
0.51 to 0.60	0.87
0.61 to 0.70	0.91
0.71 to 0.80	0.95
0.81 to 0.90	0.98
0.91 to 1.0	0.99

## Line 22 – Peak rate of sewage from non-CSO areas (MGD).

Non-CSO areas can be affected by wet weather conditions due to Inflow/Infiltration (I/I). The degree to which the peak rate of sewage in non-CSO areas is higher than the average dry-weather flow rate depends on site-specific conditions. Direct measurement of the peak rate of sewage during wet weather is the best approach for determining this rate. Estimation based on flow measured at the WWTP and local knowledge of

the distribution of flow in the service area provides another approach. Peaking factors can also be used to adjust the average dry-weather flow upward. Newer *tight* sewer systems might have peaking factors between 1.0 and 1.5. Older, leakier systems might have peaking factors between 1.5 and 3.0, or even higher. Enter on Line 22 the peak rate of sewage conveyed to the WWTP from non-CSO areas in the community (in MGD).

**Line 23 – Peak rate of sewage from satellite communities (MGD).**

Satellite communities can be affected by wet weather conditions due to I/I. The degree to which the peak rate of sewage in satellite communities is higher than the average dry-weather flow rate depends on site-specific conditions. Direct measurement of the peak rate of sewage during wet weather is the best approach for determining this rate. Estimation based on flow measured at the WWTP and local knowledge of the distribution of flow in the service area provides another approach. Peaking factors can also be used to adjust the average dry-weather flow upward. Newer tight sewer systems might have peaking factors between 1.0 and 1.5. Older, leakier systems might have peaking factors between 1.5 and 3.0, or even higher. The maximum rate of flow from capacity agreements can also be used and might be more appropriate than measurements or estimates. Enter on Line 23 the peak rate of sewage conveyed to the WWTP from satellite communities (in MGD).

**Line 24 – Peak rate of sewage conveyed to the WWTP (MGD).**

This is the peak rate of sewage flow in MGD received at the WWTP from the CSS and adjacent non-CSO areas in the community and satellite communities. Add Lines 21, 22 and 23 and enter the sum on Line 24.

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**Treatment**

**Line 25 – Primary treatment capacity (MGD).**

Enter the primary treatment capacity in MGD on Line 25 (Line 4a on FORM GREEN LTCP-EZ. If you are using the electronic version

of the form, this value will have been filled in automatically).

Using primary treatment capacity for CSO control is a viable option where approval of the regulatory agency has been obtained. The CSO Control Policy indicates that combined sewer flows remaining after implementing the NMCs and within the criteria under the presumption approach at a minimum should receive the following:

- Primary clarification (removal of floatables and settleable solids can be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification)
- Solids and floatables disposal
- Disinfection of effluent, if necessary, to meet WQS, protect designated uses and protect human health, including removal of harmful disinfection residuals, where necessary

The *Combined Sewer Overflows Guidance for Long-Term Control Plan* document, Section 3.3.3.5, Maximum Utilization of POTW Capacity and CSO-Related Bypass (EPA 1995a), addresses the specific case where existing primary treatment capacity exceeds secondary treatment capacity. For such cases, the CSO Control Policy states that at the request of the municipality, EPA may allow an NPDES permit “to approve a CSO-related bypass of the secondary treatment portion of the POTW treatment plant for CSOs in certain identified circumstances” (II.C.7). Under that provision, flows to the POTW within the capacity of primary treatment

facilities but in excess of the capacity of secondary treatment facilities may be diverted around the secondary facilities provided that “all wet weather flows passing the headworks of the POTW treatment plant will receive at least primary clarification and solids and floatables removal and disposal, and disinfection, where necessary, and any other treatment that can be reasonably provided” (II.C.7). In addition, the CSO-related bypass should not cause exceedance of water quality standards.

**Line 26 – Ratio of primary treatment capacity to peak rate of sewage conveyed to WWTP.** Enter 1.0 on Line 26 if Line 25 is greater than Line 24. Otherwise, divide Line 25 by Line 24 and enter the quotient (result) on Line 26.

**Line 27 – Fraction of combined sewage untreated at WWTP.** This is the fraction of sewage delivered to the WWTP during the 24-hour rainfall period that does not receive primary treatment. It is based on the ratio of primary treatment capacity to peak rate of sewage conveyed to the WWTP. Take the square of (1 minus the value on Line 26) and enter it on Line 27. For example, if the ratio of primary treatment capacity to peak rate of sewage conveyed to the WWTP on Line 26 is 0.80, the overflow fraction is  $(1 - 0.80)^2$ , or 0.04.

**Line 28 – Sum of combined sewage conveyed to WWTP during 24-hour rainfall period (MG).** Add up the sub-sewershed values in MG on Line 19 and enter the sum on Line 28.

**Line 29 – Dry-weather flow from the non-CSO area (MGD).** Enter the dry-weather flow rate from the non-CSO area in MGD on Line 29. If dry-weather flow for the non-CSO area is unknown, develop an estimate supported by (1) direct measurement of dry-weather flow based on the average of a series of observations made at different times of the day; or (2) allocating the dry-weather flow reported on the DMR for the WWTP for the entire sewer service area.

**Line 30- Volume of sewage from non-CSO areas during 24-hour rainfall period (MG).** The volume of sewage from non-CSO areas during the 24-hour rainfall period is likely to be higher than the average dry-weather flow rate (Line 29) because of I/I but less than the peak rate of sewage (Line 22). Typical daily wet-weather volumes should be used if measurements are available. Alternatively, an estimate based on the peak rate of sewage (Line 22) and the dry-weather flow rate (Line 29) can be used. Under that approach, it is assumed that flow to the WWTP from the non-CSO area over the course of the 24-hour rainfall period has a triangular shape. The volume is calculated by adding one-half the difference between Line 22 and 29 and adding the value to the dry-weather flow rate. Subtract Line 29 from Line 22, divide by 2, add the remainder to Line 29, and enter this value as a volume in MG on Line 30.

**Line 31 – Dry-weather flow from the satellite communities (MGD).** Enter the dry-weather flow rate from the satellite communities in MGD on Line 29. If dry-weather flow for the satellite communities is unknown, develop an estimate supported by (1) direct measurement of dry-weather flow based on the average of a series of observations made at different times of the day; or (2) allocating the dry-weather flow reported on the DMR for the WWTP for the entire sewer service area.

**Line 32- Volume of sewage from satellite communities during 24-hour rainfall period (MG).** The volume of sewage from satellite communities during the 24-hour rainfall period is likely to be higher than the average dry-weather flow rate (Line 31) because of I/I, but less than the peak rate of sewage (Line 23). Typical daily wet-weather volumes should be used if measurements are available. Alternatively, an estimate based on the peak rate of sewage (Line 23) and the dry-weather flow rate (Line 31) can be used. Under that approach, it is assumed that flow to the WWTP from the satellite communities over the course of the 24-hour rainfall period has a triangular shape. The volume is calculated by adding one-half the difference between Line 23 and 31 and adding the value to the dry-weather flow rate. Subtract Line 31 from Line 23, divide by 2, add the remainder to Line 31, and enter this value as a volume in MG on Line 32.

**Line 33 – Total volume of sewage during 24-hour rainfall event (MG).** Add Lines 28, 30 and 32 and enter the volume in MG on Line 33.

**Line 34 – Volume of combined sewage untreated at WWTP (MG).** This is also the CSO volume at the WWTP. Enter 0.0 on Line 34 if Line 25 is greater than Line 24. Otherwise, multiply Line 31 by Line 27 and enter the volume in MG on Line 34.

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### CSO Volume

The CSO volume that needs to be stored, treated or eliminated is calculated in SCHEDULE 4-CSO Volume. The CSO volumes are identified within individual sub-sewersheds at CSO hydraulic controls and at the WWTP.

**Line 35 – Volume of combined sewage overflows at CSO outfalls (MG).** This represents the volume of excess combined sewage in MG that is discharged at CSO outfalls. Sum all sub-sewershed volumes in MG on Line 16 and enter the value on Line 35.

**Line 36 – Volume of combined sewage overflow at WWTP (MG).** This represents the volume of excess combined sewage in MG that is collected and conveyed to the WWTP that does not receive at least primary treatment. Enter the value on Line 34 on Line 36.

## Instructions: Schedule 5A – CSO Runoff Control (Green Infrastructure Runoff Controls)

The calculation in Schedule 4 – CSO VOLUME quantifies the volume of combined sewage generated by a storm that occurs no more than four times per year (once every 3 months). That is the volume of combined sewage that needs to be stored, treated, or eliminated under the presumption approach so that there is no more than an average of four overflow events per year. The calculation leads the permittee to identify the rate and volume of combined sewage conveyed to the WWTP. It also identifies the rate and volume of combined sewage at sub-sewershed outfalls governed by CSO hydraulic controls. The permittee is expected to develop a simple LTCP based on CSS characterization, the hydraulic response of the CSS to precipitation established in Schedule 4 – CSO VOLUME, information presented on CSO controls, and an understanding of local conditions and circumstances. Schedules 5A and 5B – CSO CONTROL provide a simple approach to organize and evaluate control needs, performance, and costs. Small communities can use this schedule iteratively to identify the mix of CSO controls needed.

The calculations in Schedule 5A – CSO RUNOFF CONTROL quantify the volume of stormwater that can be eliminated before collection by using *green infrastructure* techniques. Green infrastructure practices are those that use or mimic natural processes to infiltrate, evapotranspire (i.e., return water to the atmosphere either through evaporation or through uptake by plants), or store (e.g., through rain barrels and cisterns) stormwater or runoff on or near the site where it is generated. Such practices reduce stormwater runoff, which in turn minimizes the frequency, duration and volume of CSOs. This schedule is intended to (1) help the permittee quantify the stormwater runoff reduction that could be achieved through green infrastructure practices, given a set runoff retention standard or goal, and (2) help the permittee evaluate the feasibility of the runoff retention standard or goal by estimating the number of green infrastructure runoff controls that would be required to meet the runoff retention standard or goal.

### Runoff Reduction via On-site Runoff Retention Standard or Goal

To determine how much runoff reduction a permittee can expect from incorporating green infrastructure practices, Schedule 5A uses a runoff retention standard or goal that can be associated with managed, directly connected impervious areas (see the definition to the right). Many municipalities are beginning to mandate on-site runoff retention standards (e.g., retain first one-inch of rainfall) for all new development or redevelopment that exceeds a certain size. If a specific codified runoff retention standard does not exist, the permittee could use a runoff retention goal that the permittee will enforce or otherwise encourage landowners to meet. Assuming that this runoff retention standard or goal is met within a planning horizon, the following formula can be used to calculate the runoff reduction volume achieved through implementation:

$$V = kAPR_v$$

where

$V$  = runoff reduction volume (gallons or million gallons [MG])

$k$  = unit conversion factor

$A$  = area of directly connected impervious surface managed (acres)

$P$  = depth of retention standard or goal (inches)

$R_v$  = volumetric runoff coefficient (default is 0.95)

#### Definition of directly connected impervious areas

Directly connected impervious areas are those impervious areas that are connected hydraulically to the combined sewer conveyance system without first flowing over a pervious area. For example, a street with a curb and gutter, where runoff flows into a catch basin and subsequently into the combined sewer system, is considered a directly connected impervious area. A rooftop that drains directly to this same street would also be considered directly connected. An example of a non-directly connected impervious area would be a parking lot where runoff flows through a grassy pervious area, and most of the water infiltrates into the ground. Schedule 5A considers only the management of directly connected impervious areas, because those are the impervious areas that are the most significant contributors of runoff to the combined sewer system.

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## Runoff Reduction via Specific Green Infrastructure Practices

To aid in planning, Schedule 5A also provides for the estimation of the number of green infrastructure practices that could be used to meet the runoff reduction standard or goal (note that the schedule estimates the number of practices that will be required to achieve the goal/standard, but it does not assess the capacity of the landscape to accommodate those practices). This part of the schedule serves as a quality control measure to assess the feasibility of the runoff retention standard or goal. While the true evaluation of volumetric reductions achieved by using different green infrastructure practices will be highly dependent on local conditions and sizing and design considerations, Green LTCP-EZ uses a simplified approach that includes using practice specific volumetric reduction rates to provide an estimate of the volumetric reductions that can be achieved through implementation of green practices. Before making a final selection on the approach to control overflows, the permittee needs to ensure that the green infrastructure practices are suitable for the landscapes. The volume of runoff reduction achieved for each practice category will be calculated using a variation of the following equation:

$$V = kAP_{24}RR$$

where

$V$  = runoff reduction volume (gallons or million gallons [MG])

$k$  = unit conversion factor

$A$  = area of impervious surface managed (acres)

$P_{24}$  = depth of 24-hour design storm rainfall (inches) (from Schedule 4)

$RR$  = average volumetric reduction rates (per practice)

Five general green infrastructure runoff controls are considered in this schedule. They are as follows:

- Green Roofs
- Bioretention
- Vegetated Swales
- Permeable Pavement
- Rain Barrels and Cisterns

Use of more than one green infrastructure practice type is common. The calculations in Schedule 5A can be used iteratively to identify the most appropriate mix of green infrastructure practices with respect to CSO reduction and cost. CSO communities are welcome to consider using other green infrastructure runoff controls outside the controls described above to reduce runoff. Appropriate analyses of other controls and their associated runoff reduction should be attached and submitted along with the other Green LTCP-EZ schedules and forms that the permittee has used to develop the LTCP.

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## Recalculating CSO Volume

Schedule 5A also includes a recalculation of the CSO volume determined in Schedule 4. The green infrastructure practices are runoff-reduction techniques that affect the peak flow rate and runoff volume from each sewershed, which in turn affects the overflow fraction, the diversion fraction, and the ultimate CSO volume requiring controls. Therefore, it is necessary to recalculate the peak flow rate and determine a new CSO volume for evaluation with Schedule 5B. The recalculation of the CSO volume in Schedule 5A follows the same procedure outlined in Schedule 4.

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## Impervious Area

This section is used to quantify the area of directly connected impervious surface (such as pavement, rooftops, and sidewalks) within each sub-sewershed that contributes runoff to the CSS. The directly connected impervious area can be measured directly using GIS data or aerial photos. If the data are not readily available, the percentage of directly connected impervious surface in a subsewershed can be estimated on the basis of the principal land uses previously identified for each sub-sewershed in Schedule 4.

**Line 1 – Sub-sewershed area (acres).** Enter the sub-sewershed area for each sub-sewershed on Line 1 (Line 10a on Form GREEN LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically.)

**Line 2 – Fraction of directly connected impervious area within sub-sewershed.** Enter the fraction of directly connected impervious area within each sub-sewershed on Line 2.

**Line 3 – Directly connected impervious area (acres) within sub-sewershed.** Multiply the sub-sewershed area on Line 1 by the fraction of directly connected impervious area within the sub-sewershed on Line 2 and enter the product on line 3.

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## Retention Standard or Goal

Many municipalities are beginning to mandate or encourage on-site runoff retention standards or goals (e.g., retain first one-inch of

rainfall) for development or redevelopment that exceeds a certain size. In many cases, green infrastructure practices or controls are directed to be the first management options considered. In this section, the permittee needs to supply the runoff retention standard or goal, as well as an estimate of the percentage of area in the sub-sewershed that will be redeveloped within the planning horizon.

### Line 4 – Fraction of sub-sewershed to be redeveloped over planning horizon.

Estimate the fraction of the sub-sewershed that is expected to be redeveloped over a planning horizon. This estimate should be based on municipal planning exercises or other long-range forecasts. For purposes of this calculation, the planning horizon should not exceed 25 years. If no redevelopment forecasts are available, the permittee can use a default redevelopment fraction of 0.30 (30 percent) over a 25-year planning period. Note that this calculation should consider only redevelopment. New development on previously undeveloped or *greenfield* areas should not be included in the fraction.

**Line 5 – Directly connected impervious area (acres) managed.** Multiply the directly connected impervious area (acres) within the sub-sewershed on Line 3 by the fraction of sub-sewershed to be redeveloped over the planning horizon on Line 4 and enter the product on line 5.

**Line 6 – Depth of rainfall retention standard or goal (inches).** Enter a depth that represents the quantity of precipitation that is expected or required to be retained

(i.e., infiltrated, stored, or evapotranspired) on-site with green infrastructure runoff controls. This depth cannot be greater than the 24-hour, 3-month rainfall previously calculated. Typical retention standards will likely be between 0.5 and 1.5 inches.

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## Runoff Reduction

The impervious area calculation and the retention standard or goal are used together to determine the associated runoff reduction.

### Line 7 – Runoff retained from managed directly connected impervious area (acre-in).

Multiply the directly connected impervious area (acres) managed on Line 5 by the depth of retention standard (inches) on Line 6. Multiply this product by 0.95, which is the runoff coefficient for impervious surfaces.

**Line 8 – Runoff reduction volume (MG).** To convert acre-inches to million gallons (MG), multiply the retained runoff from managed impervious area on Line 7 by 0.02715.

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## Green Roofs

Green roofs (also known as vegetated roofs, eco-roofs, or living roofs) are rooftop stormwater management practices that typically consist of drought-resistant vegetation, a soil or growing medium, a drainage layer, and a waterproof membrane. Green roofs have been shown to retain a portion of incident rainfall within the growing medium. The amount of rainfall stored in a green roof depends on a number of site specific factors, including the roof slope and the type and depth of the growing medium.



Local zoning and building codes should be consulted for any guidance on green roof specifications.

**Line 9 – 24-hour rainfall (inches)** Enter the 24-hour rainfall (inches) on Line 9 (Line 12 on Schedule 4: CSOVOL. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 10 – Number of existing buildings with green roofs expected to be installed.**

Enter the number of *existing* directly connected buildings on which green roofs are expected to be installed over the previously established planning horizon.

**Line 11 – Average roof area (sq ft) of buildings with green roofs expected to be installed.** The roof area of buildings can vary significantly. Residential roofs tend to be smaller than commercial and industrial rooftops. Urban residential rooftops are often smaller than suburban residential rooftops. An actual estimate of rooftop sizes can sometimes be estimated from GIS or from aerial photos. Note that some rooftops, like those with steep slopes, might not be as amenable to green roof installation. In addition, the permittee might also wish to consider that green roofs are often not installed over the entire building roof area. Rooftop space can also be required for HVAC equipment, access structures, or patios, causing such areas to be unavailable for green roof applications. Given all those considerations, enter a value that is characteristic of the

potential green roof area of buildings in the sub-sewershed(s).

**Line 12 – Average green roof runoff reduction rate.** The runoff reduction potential of a green roof depends on a number of site-specific factors, including the roof slope and the type and depth of the growing medium. On the basis of a qualitative understanding of the types of green roofs to be installed in the sub-sewershed, select a runoff reduction rate

with green roofs expected to be installed (Line 10) by the average roof area of buildings with green roofs expected to be installed (Line 11) by the average green roof reduction rate (Line 12). Multiply this product by 0.5922 (this factor includes the unit conversion to gallons, as well as the impervious area runoff coefficient of 0.95).

**Line 14 – Green roof runoff reduction volume (MG).** Divide the runoff to the CSS eliminated

**Table 3. Average green infrastructure practice runoff reduction rate**

Practice	Average runoff reduction rate	General guidance on selection of runoff reduction rate	
		When to select low-end values	When to select high-end values
Green Roofs	0.45–0.60	Sloped roofs predominate	Flat roofs predominate
Bioretention Facilities	0.40–0.80	Poorly draining soils predominate Typical design uses underdrains	Well draining soils predominate Typical design does not use underdrains
Vegetated Swales	0.40–0.60	Poorly draining soils predominate	Well draining soils predominate
Permeable Pavement	0.45–0.75	Poorly draining soils predominate Typical design uses underdrains	Well draining soils predominate Typical design does not use underdrains
Rain Barrels and Cisterns	0.10*–0.40	Residential rain barrels (50–150 gal) predominate	Larger capacity rain tanks and cisterns (1,000 - 10,000 gal) predominate

Sources: \*MWCOC 2001; all others Schueler 2008

from Table 3 and enter it on Line 12. The permittee can use a runoff reduction rate that is higher than those listed in Table 3 only if it is appropriately documented.

**Line 13 – Runoff to CSS eliminated due to green roof installation.** Multiply the 24-hour rainfall (Line 9) by the number of existing buildings

because of green roof installation (Line 13) by 1,000,000 to convert from gallons to MG.

**Line 15 – Unit cost per square foot for green roof installation.** Unit costs for green roof installations can vary significantly. Enter a cost that reflects local conditions.

**Line 16 – Fraction of publicly owned or subsidized buildings with green roofs.**

Determine the number of publicly owned buildings that will be retrofitted with a green roof and add to it any privately owned buildings for which green roofs are expected to be partially or wholly subsidized with public funds. For private installations, count only the portion of the total green roof installation cost that is publicly funded (i.e., if a public subsidy pays for 10 percent of a typical installation, count only 10 percent of that installation). The permittee might also need to consider the incentive cost to install green roof in the public property and any related cost for future maintenance.

**Line 17 – Estimated public cost of cumulative green roof installation.** Some of the costs of green roofs will be borne by private entities and will not be borne by the permittee. To determine the cost to the permittee, multiply the number of existing buildings with green roofs expected to be installed (Line 10) by the average roof area (sq ft) of buildings with green roofs expected to be installed (Line 11) by unit cost per square foot for green roof installation (Line 15) by fraction of publicly owned or subsidized buildings with green roofs (Line 16).

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**Bioretention**

Bioretention facilities (or rain gardens) typically consist of engineered, shallow, vegetated depressions that are used to manage stormwater runoff from impervious surfaces including rooftops, streetscapes, and parking lots. Bioretention facilities provide stormwater quantity control through runoff

capture, infiltration, and evapotranspiration.

Bioretention designs can vary significantly by size, depth, engineered soil characteristics, plant selection, and the presence and location of any subsurface drainage structures. Performance is highly site dependent and is affected by design parameters and local conditions, including topography and the infiltration capacity of surrounding soils. Local zoning and building codes should be consulted for any guidance on bioretention facility specifications.

**Line 18 – Number of bioretention facilities being installed.** Enter number of bioretention retrofits expected to be installed over the previously established planning horizon to manage runoff from *existing* directly connected impervious areas.

**Line 19 – Average directly connected impervious area (sq ft) being managed by each bioretention facility.** The size and design of bioretention facilities can vary significantly, thus influencing the size of the drainage area managed. Most bioretention facilities are sized and designed according to the available space and the drainage area to be managed. Depending on the characteristics of the drainage area, the bioretention facility footprint is typically 5 to 15 percent of the contributing impervious area being managed. In general, a bioretention facility drainage area should not exceed 3 to 5 acres. Given all those considerations, enter a value that is characteristic of each bioretention facility impervious

drainage area in the sub-sewershed(s).

**Line 20 – Average bioretention runoff reduction rate.** The runoff reduction potential of a bioretention facility depends on a number of site-specific factors, including the topography and infiltration capacity of local soils. On the basis of a general understanding of the local conditions in the sub-sewershed, select a runoff reduction rate from Table 3 and enter it on Line 20. The permittee can use a runoff-reduction rate that is higher than those listed in Table 3 only if it is appropriately documented.

**Line 21 – Runoff to CSS eliminated due to bioretention facility installation.** Multiply 24-hour rainfall (inches) (Line 9) by number of bioretention facilities expected to be installed (Line 18) by average directly connected impervious area (sq ft) being managed by each bioretention facility (Line 19) by average bioretention runoff reduction rate (Line 20). Multiply that product by 0.5922 (that factor includes the unit conversion to gallons as well as the impervious area runoff coefficient of 0.95).

**Line 22 – Bioretention runoff reduction volume (MG).** Divide runoff to CSS eliminated because of bioretention facility installation (Line 21) by 1,000,000 to convert from gallons to MG.

**Line 23 – Unit cost per square foot for bioretention installation.** Unit costs for bioretention facility installations can vary significantly. Enter a cost that reflects local conditions or use the default value of \$7 per square foot.

**Line 24 – Fraction of publicly owned or subsidized bioretention facilities being installed.** Determine the number of publicly owned bioretention facilities expected to be installed and add to it any privately owned bioretention facilities that are expected to be partially or wholly subsidized with public funds. For private installations, count only the portion of the total bioretention facility installation cost that is publicly funded (i.e., if a public subsidy pays for 10 percent of a typical installation, count only 10 percent of that installation). The permittee might also need to consider the incentive cost for bioretention facility in the public property and any related cost for future maintenance.

**Line 25 – Estimated public cost of cumulative bioretention installation.** Some of the costs of bioretention will be borne by private citizens or corporations and will not be borne by the permittee. To determine the cost to the permittee, multiply number of bioretention facilities expected to be installed (Line 18) by average directly connected impervious area (sq ft) being managed by each bioretention facility (Line 19) by unit cost per square foot for bioretention installation (Line 23) by fraction of publicly owned or subsidized bioretention facilities being installed (Line 24). Divide that product by 10 to account for the relationship between the impervious drainage area size and the bioretention facility size.

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## Vegetated Swales

Vegetated swales (or bioswales) are shallow, open channels with vegetation covering the side slopes and channel bottom.

They are primarily designed to collect and convey runoff to downstream discharge locations as alternatives to curbs, gutters, and stormwater pipes. They can be used to manage stormwater runoff from any number of impervious surfaces, including rooftops, streetscapes, and parking lots. While their primary function is conveyance and water quality management, they can actually provide significant water quantity management as well via infiltration and evapotranspiration.

Vegetated swales are linear features that can typically manage runoff from larger areas than can bioretention facilities (although the quantity management effectiveness will likely not be as high). As with bioretention facilities, vegetated swale designs can vary significantly by size, depth, engineered soil characteristics, and plant selection. Performance is highly site dependent and is affected by design parameters, as well as by local conditions, including topography and the infiltration capacity of surrounding soils. Local zoning and building codes should be consulted for any guidance on vegetated swale specifications.

**Line 26 – Cumulative directly connected impervious area (sq ft) expected to be managed by vegetated swales.** Most vegetated swales are sized and designed according to the available space and the type and configuration of the contributing drainage area to be managed. In general, a vegetated swale drainage area should not exceed 10 acres. Following an evaluation of the potential for vegetated swale installation, enter the *existing* cumulative directly connected

impervious area within the sub-sewershed(s) that is expected to be managed by vegetated swales over the planning horizon.

**Line 27 – Cumulative footprint area (sq ft) of vegetated swales.** Depending on the characteristics of the drainage area, the vegetated swale footprint is typically 3 to 5 percent of the contributing impervious area being managed. Given that, enter the cumulative footprint of vegetated swales that are expected to be installed over the planning horizon to manage the drainage area provided on Line 26.

**Line 28 – Average vegetated swale runoff reduction rate.** The runoff reduction potential of a vegetated swale depends on a number of site-specific factors, including the slope and infiltration capacity of local soils. On the basis of a general understanding of those local conditions in the sub-sewershed, select a runoff reduction rate from Table 3 and enter it on Line 28. The permittee can use a runoff reduction rate that is higher than those listed in Table 3 only if it is appropriately documented.

**Line 29 – Runoff to CSS expected to be eliminated due to vegetated swale installation.** Multiply 24-hour rainfall (inches) (Line 9) by cumulative directly connected impervious area (sq ft) being managed by vegetated swales (Line 26) by the average vegetated swale runoff reduction rate (Line 28). Multiply that product by 0.5922 (this factor includes the unit conversion to gallons as well as the impervious area runoff coefficient of 0.95).

**Line 30– Vegetated swale runoff reduction volume (MG).**

Divide runoff to CSS eliminated because of vegetated swale installation (Line 29) by 1,000,000 to convert from gallons to MG.

**Line 31– Unit cost per square foot for vegetated swale installation.** Unit costs for vegetated swale installations can vary significantly. Enter a cost that reflects local conditions or use the default value of \$15 per square foot.

**Line 32– Fraction of publicly owned or subsidized vegetated swales being installed.** Determine the fraction of vegetated swales expected to be installed that are to be publicly owned or partially or wholly subsidized with public funds. For private installations, count only the portion of the total vegetated swale installation cost that is publicly funded (i.e., if a public subsidy pays for 10 percent of a typical installation, count only 10 percent of that installation). The permittee might also need to consider the incentive cost for vegetated swales in the public property and any related cost for future maintenance.

**Line 33– Estimated public cost of cumulative vegetative swale installation.** Some of the costs of vegetated swales will be borne by private entities and will not be borne by the permittee. To determine the cost to the permittee, multiply cumulative footprint area (sq ft) of vegetated swales (Line 27) by unit cost per square foot for vegetated swale installation (Line 31) by fraction of publicly owned or subsidized vegetated swales expected to be installed (Line 32).

## Permeable Pavement

Permeable pavement (also referred to as pervious or porous pavement) can be used in lieu of traditional impervious pavements in applications that do not receive excessive vehicular loads (including parking lots, sidewalks, playgrounds, parking lanes, driveways, and such). Permeable pavement includes a range of materials that allow the water to move through the paving material, including permeable asphalt, permeable concrete, paving stones, interlocking pavers, and reinforced turf, among others.

Permeable pavement provides stormwater quantity control through runoff capture and infiltration. Designs can vary by paving material, depth of sub-base materials, and the presence and location of any subsurface drainage structures. Performance is highly site dependent and is affected primarily by the infiltration capacity of surrounding soils. Local zoning and building codes should be consulted for any guidance on permeable pavement specifications.

**Line 34 – Cumulative area (sq ft) of directly connected pavement expected to be replaced with permeable pavement.** Most permeable pavement retrofit applications are installed as complete or partial replacements of existing impervious pavement. Permeable pavement applications typically are not designed to accept runoff from other vegetated or non-impervious areas. Enter the *existing* cumulative directly connected impervious pavement within the sub-sewershed(s) that is expected to be replaced with

permeable pavement over the planning horizon.

**Line 35 – Average permeable pavement runoff reduction rate.** The runoff reduction potential of permeable pavement depends on a number of site specific factors, including the topography and infiltration capacity of local soils. On the basis of a general understanding of those local conditions in the sub-sewershed, select a runoff reduction rate from Table 3 and enter it on Line 35. The permittee can use a runoff reduction rate that is higher than those listed in Table 3 only if it is appropriately documented.

**Line 36 – Runoff to CSS expected to be eliminated due to permeable pavement installation.** Multiply the 24-hour rainfall (inches) (Line 9) by the cumulative area (sq ft) of directly connected pavement replaced with permeable pavement (Line 34) by the average permeable pavement runoff reduction rate (Line 35). Multiply that product by 0.5922 (this factor includes the unit conversion to gallons as well as the impervious area runoff coefficient of 0.95).

**Line 37– Permeable pavement runoff reduction volume (MG).** Divide the runoff to CSS eliminated due to permeable pavement installation (Line 36) by 1,000,000 to convert from gallons to MG.

**Line 38– Unit cost per square foot for permeable pavement installation.** Unit costs for permeable pavement installations can vary significantly. Enter a cost that reflects local conditions or use the default value of \$7 per square foot.

**Line 39– Fraction of publicly owned or subsidized permeable pavement installations.** Determine the fraction of permeable pavement applications being installed that are to be publicly owned or partially or wholly subsidized with public funds. For private installations, count only the portion of the total permeable pavement installation cost that is publicly funded (i.e., if a public subsidy pays for 10 percent of a typical installation, count only 10 percent of that installation)

**Line 40– Estimated public cost of cumulative permeable pavement installation.** Some of the costs of permeable pavement will be borne by private entities and will not be borne by the permittee. To determine the cost to the permittee, multiply the cumulative area (sq ft) of traditional pavement expected to be replaced with permeable pavement (Line 34) by the unit cost per square foot for permeable pavement installation (Line 38) by the fraction of publicly owned or subsidized permeable pavement installations (Line 39).

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### Rain Barrels and Cisterns

Rain barrels and cisterns are storage devices that can be used to manage rooftop runoff from residential, commercial and industrial buildings. Both rain barrels and cisterns typically include connection to a rooftop downspout, an overflow pipe, and a drainage spigot at or near the bottom. Rain barrels are more likely to be used in residential settings, because they are typically smaller (50–150 gallons). Cisterns are generally larger (typically between 1,500 and 10,000 gallons) and can be placed

above ground or underground. With either device, stored water can be used for irrigation or other non-potable uses. Local zoning and building codes should be consulted for any guidance on rain barrels or cistern specifications.

**Line 41 – Number of buildings with rain barrels/cisterns expected to be installed.** Enter the number of *existing* directly connected buildings where rain barrels or cisterns are expected to be installed over the previously established planning horizon.

**Line 42 – Average volume (gallons) of the rain barrels/cisterns.** Enter the average volume in gallons of the rain barrels and cisterns that will be installed.

**Line 43 – Average rain barrel/cistern runoff reduction rate.** The runoff reduction potential of a rain barrel or cistern depends on the capacity and how often it is emptied. Select a runoff reduction rate from Table 3 and enter it on Line 43. The permittee can use a runoff reduction rate that is higher than those listed in Table 3 only if it is appropriately documented.

**Line 44 – Runoff to CSS eliminated due to rain barrel/cistern installation.** Multiply number of buildings with rain barrels and cisterns expected to be installed (Line 41) by the average volume (gallons) of the rain barrels and cisterns (Line 42) by the average rain barrel and cistern runoff reduction rate (Line 43).

**Line 45– Rain barrel/cistern runoff reduction volume (MG).** Divide runoff to CSS eliminated because of rain barrel/cistern

installation (Line 44) by 1,000,000 to convert from gallons to MG.

**Line 46– Unit cost per rain barrel/cistern capacity (gallons).** Unit costs for rain barrels and cisterns vary by size and type. Enter a cost per gallon that reflects local conditions or use the default value of \$1.25 per gallon.

**Line 47– Fraction of publicly owned or subsidized rain barrels/cisterns.** Determine the fraction of rain barrels and cisterns being installed that are to be publicly owned or partially or wholly subsidized with public funds. For private installations, count only the portion of the rain barrel or cistern cost that is publicly funded (i.e., if a public subsidy pays for 10 percent of a typical installation, count only 10 percent of that installation)

**Line 48– Estimated public cost of cumulative rain barrel/cistern installations.** Some of the costs of rain barrels/cisterns will be borne by private entities and will not be borne by the permittee. To determine the cost to the permittee, multiply number of rain barrels/cisterns expected to be installed (Line 41) by the average volume of each rain barrel and cistern (Line 42) by the unit cost per rain barrel/cistern (Line 46) by the fraction of publicly owned or subsidized rain barrel/cistern installations (Line 47).

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### Cumulative Runoff Reduction Check

This section provides a check to ensure that the number and combination of green infrastructure practices selected above meet the retention standard or goal set on Line 6.

**Line 49 – Runoff reduction volume (MG) derived from retention standard.** Enter from Line 8.

**Line 50– Runoff reduction volume (MG) derived from sum of individual practices.** Add Lines 14, 22, 30, 37, and 45.

**Line 51 – Planning Check.** This calculation is meant to serve as a check for the permittee to show how realistic it will be to achieve the runoff retention standard or goal using green infrastructure.

Divide runoff reduction volume (MG) derived from sum of individual practices (Line 50) by runoff reduction volume (MG) derived from retention standard (Line 49). If this value is greater than or equal to 1.00 and less than 1.05, the number and combination of selected green infrastructure practices are sufficient to meet the runoff retention standard or goal.

If this value is less than 1.00, either the runoff retention standard or goal is set too high or the number and combination of selected green infrastructure practices is too low. If the value is greater than 1.05, either the runoff retention standard is set too low or the number and combination of selected green infrastructure practices is too high. Adjust the values associated with the runoff retention standard or goal or the green infrastructure practices until the value falls into the acceptable range if this is possible.

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### Runoff Recalculation

Because the green infrastructure practices evaluated in the previous

sections of this schedule reduce runoff before it gets to the collection system, the volume of runoff calculated in Schedule 4-CSO VOLUME will need to be recalculated.

**Line 52 – Original volume of runoff (MG).** Enter the original volume of runoff calculated in Schedule 4-CSO VOLUME for each sub-sewershed in the CSS (Line 13 on Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 53 – Runoff reduction volume (MG).** Enter the runoff reduction volume in MG calculated using the retention standard or goal for each sub-sewershed (Line 8). If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 54 – Revised volume of runoff (MG).** Subtract the runoff reduction volume (MG) on Line 53 from the original volume of runoff (MG) on Line 52 to obtain the revised runoff volume.

**Line 55 – Runoff reduction factor.** Divide the revised runoff volume on Line 54 by the original runoff volume on Line 52 to obtain the runoff reduction factor.

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### Peak Wet-Weather Flow

The relationship between the original runoff volume and the revised runoff volume (the runoff reduction factor) is used to modify the peak wet-weather flow rates that influence the overflow fraction and diversion fraction that was calculated in Schedule 4-CSO VOLUME.

**Line 56 – Original peak runoff rate (MGD).** Enter the original

peak runoff rate (MGD) calculated in Schedule 4-CSO VOLUME for each sub-sewershed in the CSS (Line 6 on Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 57 – Revised peak runoff rate (MGD).** Multiply the original peak runoff rate (MGD) on Line 56 by the runoff reduction factor on Line 55 to obtain a revised peak runoff rate for each sub-sewershed.

**Line 58 – Dry-weather flow rate (MGD).** Enter the dry-weather flow rate (MGD) from Schedule 4-CSO VOLUME for each sub-sewershed in the CSS (Line 7 on Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 59 – Revised peak flow rate (MGD).** The peak flow rate is the sum of the peak runoff rate and dry-weather flow in MGD. Add Lines 57 and 58 and enter the sum for each sub-sewershed area on Line 59.

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### Revised Overflow

**Line 60 – CSO hydraulic control capacity (MGD).** Enter the CSO hydraulic control capacity in MGD for each CSO sub-sewershed area on Line 60 (Line 11b on FORM LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 61 – Revised ratio of CSO hydraulic control capacity to peak flow rate.** Enter 1.0 on Line 61 if Line 60 is greater than Line 59. Otherwise, divide Line 60 by Line 59 and

enter the quotient (result) on Line 61.

**Line 62 – Revised overflow fraction of combined sewage.** This is a recalculation of the overflow fraction of combined sewage within the sub-sewershed. It is based on the ratio of CSO hydraulic control capacity to peak flow rate. Take the square of (1 minus the value on Line 61) and enter it on Line 62. For example, if the ratio of CSO hydraulic control capacity to peak flow rate on Line 10 is 0.15, the overflow fraction is  $(1 - 0.15)^2$ , or 0.7225.

**Line 63 – Volume of dry-weather flow (MG).** This is the total dry-weather flow in MG for the 24-hour design rainfall period. It was previously calculated in Schedule 4-CSO VOLUME (Line 14 on Schedule 4-CSO VOLUME. If you are using the electronic version of this form, this value will have been filled in automatically).

**Line 64 – Revised total volume of flow (MG).** This is the total volume of flow in MG within each sub-sewershed for the 24-hour design rainfall period. Add Lines 54 and 63 and enter the sum on Line 64.

**Line 65 – Revised volume of excess combined sewage at individual CSO hydraulic controls during 24-hour rainfall period.** This is the recalculated CSO volume at the CSO hydraulic control and is the combined sewage that exceeds the diversion capacity determined by the CSO hydraulic control in each sub-sewershed. Multiply Line 62 by Line 64 and enter the product on Line 65.

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## Revised Diversion

**Line 66 – Diversion fraction of combined sewage.** This is the fraction of runoff within each sub-sewershed that is collected and diverted to the WWTP over the 24-hour design storm period. The diversion fraction is based on the ratio of CSO hydraulic control capacity to peak flow rate and conveyance. It was previously calculated in Schedule 4-CSO VOLUME. Determine the diversion fraction of combined sewage again using the revised value on Line 61 along with Table 2, and enter it on Line 66.

**Line 67 – Revised volume of runoff diverted to WWTP.** This is the recalculated volume of runoff within each sub-sewershed that is collected and diverted to the WWTP over the 24-hour design storm period. Multiply Line 54 by Line 66 and enter the product on Line 67.

**Line 68 – Revised total volume of combined sewage conveyed to WWTP during 24-hour rainfall period (MG).** Add Lines 63 and 67 and enter the sum on Line 68.

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## Revised Conveyance

**Line 69 – Revised peak rate of collected combined sewage diverted to the WWTP within sub-sewersheds.** Identify the smaller of Line 59 and Line 60 within each sub-sewershed and enter the peak rate in MGD on Line 69.

**Line 70 – Revised peak rate of combined sewage conveyed to WWTP (MGD).** This peak rate represents the sum of the peak rates of collected combined sewage diverted to the WWTP from individual sub-

sewersheds in MGD. Add up sub-sewershed values on Line 69 and enter the sum on Line 70.

**Line 71 – Peak rate of sewage from non-CSO areas (MGD).** Enter the peak rate of sewage conveyed to the WWTP from non-CSO areas in the community in MGD on Line 71. (Line 22 on Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 72 – Peak rate of sewage from satellite communities (MGD).** Enter the peak rate of sewage conveyed to the WWTP from satellite communities in MGD on Line 72. (Line 23 on Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 73 – Revised peak rate of sewage conveyed to the WWTP (MGD).** This is the recalculated peak rate of sewage flow in MGD received at the WWTP from the CSS and adjacent non-CSO areas in the community and satellite communities. Add Lines 70, 71 and 72 and enter the sum on Line 73.

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## Treatment

**Line 74 – Primary treatment capacity (MGD).** Enter the primary treatment capacity in MGD on Line 74 (Line 4a on FORM LTCP-EZ. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 75 – Revised ratio of primary treatment capacity to peak rate of sewage conveyed to WWTP.** Enter 1.0 on Line 75

if Line 74 is greater than Line 73. Otherwise, divide Line 74 by Line 73 and enter the quotient (result) on Line 75.

**Line 76 – Revised fraction of combined sewage untreated at WWTP.** This is the fraction of sewage delivered to the WWTP during the 24-hour rainfall period that does not received primary treatment. It is based on the ratio of primary treatment capacity to peak rate of sewage conveyed to the WWTP. It was previously calculated in Schedule 4-CSO VOLUME. Recalculate it by taking the square of (1 minus the value on Line 75) and enter it on Line 76. For example, if the ratio of primary treatment capacity to peak rate of sewage conveyed to the WWTP on Line 26 is 0.80, the overflow fraction is  $(1 - 0.80)^2$ , or 0.04.

**Line 77 – Revised sum of combined sewage conveyed to WWTP during 24-hour rainfall period (MG).** Add up the sub-sewershed values in MG on Line 68 and enter the sum on Line 77.

**Line 78 – Volume of sewage from non-CSO areas during 24-hour rainfall period (MG).** The volume of sewage from non-CSO areas during the 24-hour rainfall period was previously calculated in Schedule 4-CSO VOLUME. Enter Line 30 from Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically.

**Line 79 – Volume of sewage from satellite communities during 24-hour rainfall period (MG).** The volume of sewage from satellite communities during the 24-hour rainfall period was previously calculated

in Schedule 4-CSO VOLUME. Enter Line 32 from Schedule 4-CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically.

**Line 80 – Revised total volume of sewage during 24-hour rainfall event (MG).** Add Lines 77, 78, and 79 and enter the volume in MG on Line 80.

**Line 81 – Revised volume of combined sewage untreated at WWTP (MG).** This is the recalculated CSO volume at the WWTP. If Line 74 is greater than Line 73, enter 0.0 on Line 81. Otherwise, multiply Line 80 by Line 76 and enter the volume in MG on Line 81.

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### CSO Volume Recalculation

The revised CSO volume that needs to be stored, treated or eliminated is recalculated. Those CSO volumes are identified within individual sub-sewersheds at CSO hydraulic controls, and at the WWTP.

**Line 82 – Revised volume of combined sewage overflows at CSO outfalls (MG).** This represents the volume of excess combined sewage in MG that is discharged at CSO outfalls. Sum all sub-sewershed volumes in MG on Line 65 and enter the value on Line 82

**Line 83 – Revised volume of combined sewage overflow at WWTP (MG).** This represents the volume of excess combined sewage in MG that is collected and conveyed to the WWTP that does not receive at least primary treatment. Enter the value from Line 81 on Line 83.



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## **Instructions: Schedule 5B – CSO Network and WWTP Control (Network and WWTP Controls)**

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Schedule 5A focused on controls that reduce runoff before entering the collection system. Schedule 5B focuses on CSO controls within the collection system.

Three general methods for pipe network CSO control are considered in this schedule. They are as follows:

- Conveyance and treatment at the WWTP
- Sewer separation
- Off-line storage

Permittees should evaluate these controls in the order presented. Using more than one CSO control in an LTCP is common. Using other controls not described herein is valid but would have to be documented separately in a similar effort to what is presented in this schedule.

Both Schedule 5A and 5B – CSO CONTROL should be used iteratively to identify the most appropriate mix of CSO controls with respect to CSO reduction and cost. For Schedule 5B-CSO NETWORK AND WWTP CONTROL, the volumes of combined sewage at CSO outfalls and at the WWTP that need to be controlled (Lines 82 and 83 on Schedule 5A – CSO RUNOFF CONTROL) serve as the reduction targets for this schedule.

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### **Conveyance and Treatment at the WWTP**

Maximizing treatment at the existing WWTP is emphasized in the CSO Control Policy, and it is an important feature of many LTCPs. In some CSO communities, combined sewage conveyed to the WWTP exceeds the primary capacity of the WWTP. The presence of this condition is assessed in Schedule 4 – CSO VOLUME, and the use of additional storage or treatment capacity at the WWTP is included in this schedule. The schedule is not set up to evaluate the opposite situation, where the WWTP has excess primary treatment capacity. Permittees with that situation could make use of available primary treatment capacity at the WWTP by adjusting CSO hydraulic controls, increasing interceptor conveyance capacity, or increasing pumping capacity. This analysis must be documented separately and attached to this schedule.

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### **Sewer Separation**

Sewer separation is the practice of replacing the single pipe system of a CSS with separate pipes for sanitary and stormwater flows. Sewer separation is highly effective and widely used. However, it can be expensive relative to other CSO controls. While sewer separation can be implemented on a broad basis across an entire CSS, it is most often implemented in selective portions of the CSS where localized circumstances make it less disruptive and more economical. Note that while sewer separation can help to mitigate CSO issues, it can increase the burden on the storm sewer system.

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### **Off-Line Storage**

*Off-line storage* is a phrase used to describe facilities that store combined sewage in added tanks, basins, tunnels or other structures. During dry weather, wastewater is passed around, not through, off-line storage facilities. During wet weather, combined sewage flows are diverted from the CSS to the off-line facility by gravity drainage or with pumps. The stored combined sewage is temporarily detained in the storage facility and returned to the CSS once conveyance and treatment capacity become available.

Off-line storage facilities can be expensive relative to other CSO controls. Near-surface storage facilities probably have the most utility in small communities because space could be more readily available than in large cities. Design, construction and O&M costs are less with near-surface storage than with deep underground tanks and tunnels.

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### **Cost of CSO Control**

Generalized cost information for CSO controls is provided. Background information or the derivation of this cost information is in Appendix C. Permittees should realize that CSO control costs are highly variable and dependent on site-specific conditions. Using actual or local cost data is always preferable where it is available. Permittees should verify the appropriateness of default cost values where they are used. Permittees should also note that cost estimates are for the construction of facilities. Additional operational costs and treatment costs are not expressly included in cost estimates for controls where primary capacity is added or where combined sewage is temporarily stored on-site at the WWTP or off-line and released for treatment following the rainfall event.

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### **Summary**

More information is at EPA's CSO control technology description at [http://www.epa.gov/npdes/pubs/csossoRTC2004\\_AppendixL.pdf](http://www.epa.gov/npdes/pubs/csossoRTC2004_AppendixL.pdf).

## Conveyance and Treatment at the WWTP

This section of Schedule 5 – CSO CONTROL considers conveyance and treatment of combined sewage at the WWTP. Additional treatment or storage can be added at the WWTP if the volume of combined flow to the WWTP exceeds primary capacity. Conversely, excess primary capacity at the WWTP provides an opportunity to maximize flow of combined sewage to the WWTP for treatment.

If you are not evaluating control alternatives at the WWTP, skip to Line 10.

**Line 1 – Peak rate of sewage conveyed to WWTP (MGD).** Enter the peak rate of sewage conveyed to the WWTP in MGD on Line 1 (If Schedule 5A-CSO RUNOFF CONTROL has been completed, use Line 73 on Schedule 5A-CSO RUNOFF CONTROL. Otherwise use Line 24 on Schedule 4 – CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 2 – Primary treatment capacity (MGD).** Enter the primary treatment capacity in MGD on Line 2 (Line 25 of Schedule 4 – CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 3 – Difference between primary treatment capacity and peak rate of sewage conveyed to WWTP (MGD).** Enter the combined sewage untreated at the WWTP in MGD (Line 32 on Schedule 4 – CSO VOLUME. If you are using the

electronic version of the form, this value will have been filled in automatically).

Untreated combined sewage at the WWTP can be controlled by adding additional treatment capacity (Line 4) or by adding storage (Line 7) to allow collected combined sewage to be retained temporarily until treatment capacity becomes available following the rainfall event. Permittees can estimate costs for both options and determine which is most appropriate for their facility.

**Note:** If Line 2 is greater than Line 1, the difference represents primary treatment capacity that could be available for treatment of combined sewage. Maximizing flow to the WWTP should be pursued under such circumstances. This could be done iteratively in Schedule 4 – CSO VOLUME by adjusting hydraulic control capacities or assessed in worksheets to supplement the Green LTCP-EZ Template.

**Line 4 – Additional primary treatment capacity required (MGD).** Additional primary treatment capacity can be added to the system to treat the combined flows that reach the WWTP during wet weather. Line 3 represents the minimal additional primary treatment capacity that will be required to treat the flows. Permittees can either enter the value from Line 3 on Line 4 or enter a larger number if they want to increase primary treatment capacity even further.

**Line 5 – Unit cost of primary treatment per MGD.** The unit cost of primary treatment varies greatly. Enter a cost that reflects local site-specific conditions, or

use the default value of \$2,000,000 per MGD.

**Line 6 – Estimated cost of new primary treatment capacity at WWTP.** Multiply the unit cost on Line 5 by the additional capacity required on Line 4.

**Line 7 – Volume of storage required at WWTP (MG).** The volume of storage required is determined by converting the flow rate in MGD on Line 3 to a volume in MG by multiplying Line 3 by 24 hours. Enter this value on Line 7.

**Line 8 – Unit cost of additional storage at WWTP.** The unit cost of storage varies greatly. Enter a cost that reflects local site-specific conditions, or use the default value of \$1,000,000 per MG.

**Line 9 – Estimated cost for storage at WWTP.** Multiply the additional storage volume required on Line 7 by the unit cost on Line 8.

## Sewer Separation

Sewer separation is the practice of separating the single pipe system of a CSS into separate pipe systems for sanitary and stormwater flows. Sewer separation is widely used as a CSO control. It is often applied opportunistically in small subareas to minimize disruption. Some small communities also invest in sewer separation on a system-wide basis.

**Line 10 – 24-hour design rainfall (inches).** Enter the 24-hour design rainfall in inches on Line 10 (Line 12 on Schedule 4 – CSO VOLUME. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 11 – Sub-sewershed area to be separated (acres).** Enter the area to be separated in each sub-sewershed.

**Line 12 – Runoff coefficient of area to be separated.** Enter the runoff coefficient entered on Line 3 on Schedule 4 – CSO VOLUME.

**Line 13 – Runoff to CSS eliminated due to sewer separation (Gal.).** Multiply Lines 10, 11, and 12. Multiply the product by 27,156 to convert to gallons.

**Line 14 – Volume reduction (MG).** Enter the volume reduction achieved through sewer separation. Divide Line 13 by one million.

**Line 15 – Unit cost of sewer separation per acre.** The unit cost of sewer separation is highly variable. Estimates range from less than \$10,000 to more than \$200,000 per acre. Enter a cost that reflects local site-specific conditions.

**Line 16 – Estimated cost of sewer separation.** Multiply the number of acres to be separated on Line 11 by the unit cost on Line 15 and enter on Line 16.

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### Off-Line Storage

The use of storage facilities to store and attenuate peak combined sewage flows is widely used as a CSO control. *Off-line storage* is the term used to describe facilities that store excess combined sewage in tanks, basins, tunnels, or other structures adjacent to the CSS.

**Line 17 – Volume reduction to be achieved with storage (MG).** Enter the proposed volume of storage in each sub-

sewershed. This can be established as the revised volume of excess combined sewage at individual CSO hydraulic controls (Line 65 on Schedule 5A – CSO VOLUME) minus reductions achieved through sewer separation.

**Line 18 – Unit cost per MG of storage.** The unit cost of off-line storage is highly variable and ranges from less than \$100,000 per MG to several million dollars per MG. Enter a cost that reflects local site-specific conditions.

**Line 19 – Estimated cost of storage.** Multiply Line 17 by Line 18.

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### Summary of Controls and Costs

The final CSO control alternatives selected on this schedule (and on supporting analysis if used) represent the CSO controls proposed for the draft LTCP. The level of CSO control proposed must be consistent with the CSO volumes determined to require control on Line 23 and 24 of Schedule 4 – CSO VOLUME.

Complete the following summary of recommended CSO controls and costs below and on FORM GREEN LTCP-EZ.

**Line 20 – Volume reduction from CSO controls in sub-sewersheds (MG).** Add Lines 14 and 17.

**Line 21– Cost of CSO controls in sub-sewersheds.** Add Lines 16 and 19.

**Line 22 – Total volume reduction in sub-sewersheds (MG).** Add up volumes across Line 20.

**Line 23 – Total cost of CSO controls in sub-sewersheds.** Add up costs across Line 21.

**Line 24 – Total cost of additional treatment or storage at WWTP.** Add costs on Line 6 and Line 9. If no additional control is planned at the WWTP, enter 0.0.

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## Instructions: Schedule 6 – CSO Financial Capability

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The CSO Control Policy recognizes the need to address the relative importance of environmental and financial issues when negotiating an implementation schedule for CSO controls. The ability of small communities to afford CSO control influences control priorities and the implementation schedule. Schedule 6 – CSO FINANCIAL CAPABILITY uses EPA’s financial capability analysis approach to develop a financial capability indicator for the community. The financial capability indicator *is not* to be interpreted as an indicator of whether communities can afford CSO controls; rather, the financial capability analysis is used as part of the planning process to determine the potential burden on the community for implementing the controls over a specific schedule. Thus, one of the primary uses of the financial capability analysis is in the negotiation of the CSO control implementation schedule. The financial capability analysis standardizes the determination of financial burden by using standard *big-picture* measures of a community’s financial capability (e.g., property tax rates, median household incomes, bond ratings). Once the overall financial capability is determined for a community, it can be used in discussions with regulators to determine a realistic schedule for implementing CSO controls that takes into account the financial burden to the community in implementing those controls.

This schedule presents a two-phase approach to assessing a permittee’s financial capability. The first phase identifies the combined effects of wastewater and CSO control costs on individual households. The second phase examines the debt, socioeconomic, and financial conditions of a permittee. The results of the two-phase analysis are combined in a Financial Capability Matrix.

Phase I determines a Residential Indicator. This indicator is the permittee’s average costs per household (CPH) for WWT and CSO controls as a percentage of the local median household income (MHI). It reflects the residential share of current and planned WWT and CSO control needs to meet the requirements of the CWA. A value for this indicator characterizes whether costs will impose a *low*, *mid-range*, or *high* financial effect on residential users.

Phase II develops the permittee’s Financial Capability Indicators. Six indicators are used to evaluate the debt, socioeconomic and financial conditions that affect a permittee’s financial capability to implement the CSO controls. The indicators serve as the basis for a second phase analysis that characterizes the permittee’s financial capability as *weak*, *mid-range*, or *strong*. Schedule 6 – CSO FINANCIAL CAPABILITY is based on *Combined Sewer Overflows—Guidance for Financial Capability Assessment and Schedule Development* (EPA 1997).

## Phase I Residential Indicator

In Phase I of the analysis of the permittee's financial capability, a Residential Indicator is calculated. The Residential Indicator measures the financial effect of the current and proposed WWT and CSO controls on residential users. Developing this indicator starts with determining the current and proposed WWT and CSO control costs per household (CPH). Next, the service area's CPH estimate and the median household income (MHI) are used to calculate the Residential Indicator. Finally, the Residential Indicator is compared to financial impact ranges to determine whether CSO controls will produce a possible *high*, *mid-range*, or *low* financial impact on the permittee's residential users.

The first step in developing the CPH is to determine the permittee's total WWT and CSO costs by summing the current costs for existing WWT operations and the projected costs for any proposed WWT and CSO controls. The next step is to calculate the residential share of the total WWT and CSO costs. The final step is to calculate the CPH by dividing the residential share of total WWT and CSO costs by the number of households in the permittee's total wastewater service area.

The permittee's latest financial reports should be used to develop the current WWT operations costs. To comply with accounting requirements, most permittees develop a combined statement of revenues, expenses, and changes in fund balance. Such

reports should be available directly from the accounting or financial departments in the permittee's community, or, in some states, from central records kept by the state auditor or other state offices (many states conduct audits and generate financial reports, i.e., balance sheet, statement of revenues, expenses, changes in fund balances, and statement of cash flows, for each permittee). Projected costs and the number of households in the wastewater service area should be available through planning documents.

The U.S. Census Bureau Web site (<http://factfinder.census.gov/home/saff/main.html?lang=en>) has data that can be used to estimate the number of households in a specific service area. The Consumer Price Index rate (CPI) is used in several calculations. The value used should be the average rate for the previous 5 years. The CPI is available through the Bureau of Labor Statistics (BLS) Web site at <http://www.bls.gov/cpi/>.

The first step in developing the Residential Indicator is to determine the CPH of total WWT and CSO costs. To do this, permittees must first calculate current WWT and CSO costs, and then projected costs of future WWT and CSO treatment. These steps are completed in Lines 1–17 below.

### Current Costs

Current WWT costs are defined as current annual wastewater O&M expenses (excluding depreciation) plus current annual debt service (principal and interest). That is a fair representation of cash expenses for current WWT operations (expenses for funded

depreciation, capital replacement funds, or other types of capital reserve funds are not included in current WWT costs because they represent a type of savings account rather than an actual O&M expense).

### Line 1 – Annual operations and maintenance expenses (excluding depreciation).

Enter the annual O&M costs including all significant cost categories, such as labor, chemicals, utilities, administration, and equipment replacement. Do not include depreciation.

**Line 2 – Annual debt service (principal and interest).** Enter the annual debt service paid on WWT debts.

**Line 3 – Current costs.** Add together the annual O&M expenses from Line 1 and the annual debt service from Line 2 and enter the sum on Line 3.

### Projected Costs (Current Dollars)

Estimates of projected costs are made for proposed WWT projects and for CSO controls. Any concerns about including specific proposed WWT projects or CSO controls in the projected costs, or the length of the planning period, should be discussed with the appropriate NPDES permitting and enforcement authorities. Such costs should include projected O&M expenses plus projected debt service costs for any proposed WWT and CSO controls. The residential or household costs (Lines 12–17) exclude the portion of expenses attributable to commercial, governmental, and industrial wastewater discharges. The costs are adjusted to current dollars (i.e., deflated).

**Line 4 – Projected annual operations and maintenance expenses (excluding depreciation).** Enter the projected annual WWT and costs for new CSO-related facilities.

**Line 5 – Present value adjustment factor.** The present value adjustment factor can be calculated using the formula presented below. The formula converts projected costs to current dollars using the average annual national CPI inflation rate (available from the BLS Web site at <http://www.bls.gov/cpi/>) for the past 5 years. The CPI is used as a simple and reliable method of indexing projected WWT costs and household income. For example, if the most recent 5-year average CPI is 4 percent, and the projected annual O&M and debt service costs will begin in 2 years, calculate the adjustment factor as follows:

$$\text{Adjustment Factor} = \frac{1}{(1 + \text{CPI})^{\text{years}}} = \frac{1}{(1 + .04)^2} = .925$$

**Line 6 – Present value of projected costs.** Multiply the projected annual O&M expenses on Line 4 by the present value adjustment factor on Line 5 and enter the result on Line 6.

**Line 7 – Projected costs.** Enter the projected debt costs for the proposed WWT projects and CSO controls on Line 7.

**Line 8 – Annualization factor.** Enter an annualization factor (AF) that reflects the local borrowing interest rate (IR) and

borrowing term of the permittee. Calculate the factor using the following formula:

$$AF = \frac{IR}{(1 + IR)^{\text{years}} - 1} + IR$$

**Line 9 – Projected annual debt service (principal and interest).** Multiply the projected debt cost on Line 7 by the annualization factor on Line 8, and enter the result on Line 9.

**Line 10 – Projected costs.** Add the present value of projected costs on Line 6 to the projected annual debt service on Line 9, and enter the result on Line 10.

**Line 11 – Total current and projected WWT and CSO costs.** Add the current costs on Line 3 to the projected costs on Line 10. Enter the result on Line 11.

### Cost Per Household

**Line 12 – Residential WWT flow (MGD).** Enter the portion of wastewater flow (including I/I) in MGD attributable to residential users.

- **Line 13 – Total WWT flow (MGD).** Enter the total wastewater flow at the WWTP in MGD.

**Line 14 – Fraction of total WWT flow attributable to residential users.** Divide the residential flow on Line 12 by the total flow on Line 13 and enter the result on Line 14. The result should be between 0 and 1.

**Line 15 – Residential share of total WWT and CSO costs.** Multiply the total current and projected WWT and CSO costs on Line 11 by the fraction of total WWT flow attributable to

residential users on Line 14, and enter the result on Line 15.

**Line 16 – Number of households in service area.** Enter the number of households associated with the residential flow.

**Line 17 – Cost per household (CPH).** Calculate the CPH by dividing the residential share of total WWT and CSO costs on Line 15 by the number of households in the service area on Line 16. Enter the result on Line 17.

### Median Household Income (MHI)

The second step in developing the Residential Indicator is to determine the adjusted MHI for the permittee's entire wastewater service area.

MHI is available for most communities from the latest census. In the few cases where a local jurisdiction's MHI is not available, the surrounding county's MHI might be sufficient. Each state has a state data center that serves as a local source of census data for public use.

**Line 18 – Census Year MHI.** Enter the MHI value from the most recent census year for the service area. The Census Bureau's designated MHI areas generally encompass most permittees' service areas. If the permittee's service area includes more than one jurisdiction, a weighted MHI for the entire service area could be needed. Additional instructions on developing a weighted MHI is in EPA's previously referenced *Combined Sewer Overflows—Guidance for Financial Capability Assessment and Schedule Development*.

**Line 19 - MHI adjustment factor.** The MHI adjustment factor converts the MHI from the latest census year to current dollars on the basis of the CPI inflation rate from the latest census year to the present. The MHI adjustment factor can be taken from Table CAF-3 (from EPA 1997) or calculated using the formula below:

$$\text{MHI Adjustment Factor} = (1 + \text{CPI})^{\text{Current Year} - \text{Census Year}}$$

For example, if a permittee's MHI was taken for the 1990 census year, the average annual CPI since 1990 was 4 percent and the current year is 1992, the adjustment factor would be 1.0816:

$$\text{MHI Adjustment Factor} = (1 + .04)^{1992-1990} = 1.0816$$

**Line 20 - Adjusted MHI.** Multiply the Census Year MHI in Line 18 by the MHI adjustment factor in Line 19, and enter the result in Line 20.

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### Residential Indicator

**Line 21 – Annual WWT and CSO control CPH as a percent of adjusted MHI.** Divide the CPH on Line 17 by the adjusted MHI in Line 20, and then multiply by 100. Enter the result on Line 21.

**Line 22 – Residential Indicator.** Enter the appropriate Financial Impact according to the value of CPH as percent MHI in Line 21. The appropriate Financial Impacts are defined below:

CPH as % of MHI	Financial Impact
< 1	Low
1 to 2	Mid-Range
> 2	High

### Analyzing the Residential Indicator

The Residential Indicator is used to help permittees, EPA, and state NPDES authorities to negotiate a reasonable and workable long-term CSO and WWT control schedules.

The Residential Indicator is used with the financial impact ranges that reflect EPA's previous experience with water pollution control programs. When the Residential Indicator is less than 1, between 1 and 2, and greater than 2, the financial impact on residential users to implement the CSO and WWT controls will be characterized as *low*, *mid-range*, and *high*, respectively. Unless there are significant weaknesses in a permittee's financial and socioeconomic conditions, second phase reviews for permittees that have a low residential indicator score (CPH as percent of MHI less than 1) are unlikely to result in longer implementation schedules.

In situations where a permittee believes that there are unique circumstances that affect the conclusion of the first phase, the permittee can submit documentation of its unique financial conditions to the appropriate state NPDES and EPA authorities for consideration.

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### Phase II Permittee Financial Capability Indicators

In Phase II of the analysis of the permittee's financial capability, selected indicators are assessed to evaluate the financial capability of the permittee. Such indicators examine the permittee's debt burden, socioeconomic

conditions, and financial operations. The second-phase review examines three general categories of financial capability indicators for the permittee.

- **Debt Indicators** – Assess current debt burden of the permittee or the communities in the permittee's service area and their ability to issue additional debt to finance the WWT and CSO control costs. The indicators selected for this purpose are as follows:

- Bond Ratings (General Obligation or Revenue Bond Fund or both)
- Overall Net Debt as a Percent of Full Market Property Value

- **Socioeconomic Indicators** – Assess the general economic well-being of residential users in the permittee's service area. The indicators selected for this purpose are as follows:

- Unemployment Rate
- MHI

- **Financial Management Indicators** – Evaluate the permittee's overall ability to manage financial operations. The indicators selected for this purpose are as follows:

- Property Tax Revenue Collection Rate
- Property Tax Revenues as a Percent of Full Market Property Value

Even though the financial capability analysis reflects current conditions, pending changes in the service area should be considered when developing the second phase indicators. For example, if the current unemployment rate is high, but there is a new industry opening that will stimulate



economic growth, the unemployment indicators for the service area would need to be modified to reflect the projected impact of the new plant. The permittee should submit documentation of such conditions to the appropriate EPA and state NPDES authorities for consideration. When the permittee is a sanitary district, sewer authority or similar entity, the second phase indicators related to property values and tax revenues might not be applicable. In such circumstances, the permittee can simply use the remaining indicators or submit other related documentation that will help assess its financial capability to implement the CSO controls.

### Debt Indicators

The debt indicators described below are used to assess the current debt burden conditions and the ability to issue new debt. Such indicators are the bond rating and overall net debt as a percent of full market property value (MPV). When those indicators are not available for the permittee, other financial data that illustrates debt burden and debt issuing capacity can be used to assess the permittee's financial capability in this area.

#### Bond Rating

Recent bond ratings summarize a bond rating agency's assessment of a permittee's or community's credit capacity. General obligation (G.O.) bonds are bonds issued by a local government and repaid with taxes (usually property taxes). They are the primary long-term debt funding mechanism in use by local governments. G.O. bond ratings reflect financial and

socioeconomic conditions experienced by the community as a whole.

*Revenue bond* ratings, in comparison, reflect the financial conditions and management capability of the wastewater utility. They are repaid with revenues generated from user fees. Revenue bonds are sometimes referred to as water or sewer bonds. In some cases, the bonds might have been issued by the state on behalf of local communities.

Bond ratings normally incorporate an analysis of many financial capability indicators. Such analyses evaluate the long-term trends and current conditions for the indicators. The ultimate bond ratings reflect a general assessment of the current financial conditions. However, if security enhancements such as bond insurance have been used for a revenue bond issue, the bond rating might be higher than justified by the local conditions.

Many small and medium-sized communities and permittees have not used debt financing for projects and, as a result, have no bond rating. The absence of bond rating does not indicate strong or weak financial health. When a bond rating is not available, this indicator can be excluded from the financial analysis.

Municipal bond reports from rating agencies (e.g., Moody's Bond Record, Standard & Poor's Corporation) provide recent ratings.

**Line 23a – Date of most recent general obligation bond.** Enter the date of issuance for the permittee's most recent G.O. bond.

**Line 23b – Rating agency.** Enter the name of the rating agency for the most recent G.O. bond.

**Line 23c – Rating.** Enter the rating provided by the rating agency for the most recent G.O. bond.

**Line 24a – Date of most recent revenue (water or sewer) bond.** Enter the date of issuance for the permittee's most recent revenue obligation bond.

**Line 24b – Rating agency.** Enter the name of the rating agency for the most recent revenue bond.

**Line 24c – Bond insurance.** Indicate whether bond insurance was required.

**Line 24d – Rating.** Enter the rating provided by the rating agency for the most recent revenue bond.

**Line 25 – Bond rating.** For the more recent of the bonds entered in Lines 23 and 24, enter a bond rating benchmark according to the schedule below:

If the rating agency is Moody's Investor Services, enter *Strong* for a rating of AAA, AA, or A; *Mid-Range* for a rating of Baa; and *Weak* otherwise.

If the rating agency is Standard & Poor's, enter *Strong* for a rating of AAA, AA, or A; *Mid-Range* for a rating of BBB; and *Weak* otherwise.

**Note:** this information is also used in Line 48a of Schedule 6–  
FINANCIAL CAPABILITY

## Overall Net Debt

Overall net debt is debt repaid by property taxes in the permittee's service area. It excludes debt that is repaid by special user fees (e.g., revenue debt). This indicator provides a measure of the debt burden on residents in the permittee's service area, and it assesses the ability of local governmental jurisdictions to issue additional debt. Net debt includes the debt issued directly by the local jurisdiction and debt of overlapping entities such as school districts. This indicator compares the level of debt owed by the service area population with the full market value of real property used to support that debt, and it serves as a measure of financial wealth in the permittee's service area.

**Line 26 – Direct net debt (G.O. bonds excluding double-barreled bonds).** Enter the amount of G.O. debt outstanding that is supported by the property in the permittee's service area. G.O. bonds are secured by the full faith and credit of the community and are payable from general tax revenues. This debt amount excludes G.O. bonds that are payable from some dedicated user fees or specific revenue source other than the general tax revenues. These G.O. bonds are called *double-barreled bonds*.

Debt information is available from the financial statements of each community. In most cases, the most recent financial statements are on file with the state (e.g., state auditor's office). Overlapping debt might be provided in a community's financial statements. The property assessment data should be readily available

through the community or the state's assessor office. The boundary of most permittees' service areas generally conforms to one or more community boundaries. Therefore, prorating community data to reflect specific service area boundaries is not normally necessary for evaluating the general financial capability of the permittee.

**Line 27 – Debt of overlapping entities (proportionate share of multijurisdictional debt).** Calculate the permittee's service area's share of any debt from overlapping entities using the process described. For each overlapping entity, do the following:

1. Identify the total amount of tax-supported outstanding debt for each overlapping entity in Column A and enter it in Column B. Money in a sinking fund is not included in the outstanding debt because it represents periodic deposits into an account to ensure the availability of sufficient monies to make timely debt service payments.
2. Identify the percentage of each overlapping entity's outstanding debt charged to persons or property in the permittee's service area and enter it in Column C. The percentage is based on the estimated full market value of real property of the respective jurisdictions.
3. Multiply the total outstanding debt of each overlapping entity by the percentage identified for the permittee's service area (Column B x C).
4. Add the figures and enter them in Column D to arrive at the total overlapping debt for the permittee's service area.

## Line 28 – Overall net debt.

Add the direct net debt on Line 26 to the overlapping entities debt on Line 27.

## Line 29 – Full market property value (MPV).

The MPV reflects the full market value of property in the permittee's service area. It is possible that the tax assessed property value will not reflect the full market value. This occurs when the tax assessment ratio is less than one. In such cases, the full MPV is computed by dividing the total tax assessment value by the assessment ratio (the assessment ratio represents the percentage of the full market value that is taxed at the established tax rate). For example, if the assessed value is \$1,000,000 and the assessment ratio is 50 percent, the full market value of real property is  $\$1,000,000 / 0.50 = \$2,000,000$ .

**Line 30 – Overall net debt as a percent of full market value of property.** Divide Line 28 by Line 29, then multiply by 100, and enter the value on Line 30.

## Line 31 – Net debt benchmark.

If the value in Line 30 is greater than 5, enter *Weak*. If the value is less than 2, enter *Strong*. Otherwise, enter *Mid-Range*. **Note:** this information is also used in Line 48b of Schedule 6– FINANCIAL CAPABILITY

## Socioeconomic Indicators

The socioeconomic indicators are used to assess the general economic well-being of residential users in the permittee's service area. The indicators used to assess economic conditions are unemployment rate and MHI. When the permittee has

additional socioeconomic data, it might want to submit the data to the appropriate EPA and state NPDES authorities to facilitate a better understanding of the permittee's unique economic conditions. Several examples of this type of socioeconomic data would be poverty rate, population growth, and employment projections.

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### Unemployment Rate

The unemployment rate is defined as the percent of a permittee's service area residents on the unemployment rolls. The BLS maintains current unemployment rate figures for municipalities and counties with more than 25,000 people. National and state unemployment data are also available for comparison purposes.

**Line 32 – Unemployment rate for permittee service area.** Enter the unemployment rate for the permittee's service area. Be sure to use the correct value to represent the percentage. The spreadsheet interprets the number entered as that percent, so the permittee would enter 6 for 6 percent, and so on. If doing the calculations by hand, use 0.06 for 6 percent. Please indicate the source in the line below the question.

**Line 33 – Unemployment rate for permittee's county.** Enter the unemployment rate for the permittee's county. Be sure to use the correct value to represent the percentage. The spreadsheet interprets the number entered as that percent, so the permittee would enter 6 for 6 percent, and so on. If doing the calculations by hand, use 0.06 for 6 percent. This will be used only when the

unemployment rate for a permittee's service area is not available. Indicate the source in the line below the question.

**Line 34 – Average national unemployment rate.** Enter the current average national unemployment rate. Be sure to use the correct value to represent the percentage. The spreadsheet interprets the number entered as that percent, so the permittee would enter 6 for 6 percent, and so on. If doing the calculations by hand, use 0.06 for 6 percent. Indicate the source of this number on the line below the question.

**Line 35 – Unemployment Rate Benchmark.** If the local unemployment rate is 1 percent or more below the national average, enter *Strong*. If the local rate is 1 percent or more above the national average, enter *Weak*. Otherwise, enter *Mid-Range*.

For example, if the national average unemployment rate is 6 percent and the unemployment rate for the permittee service area is 7 percent, the unemployment rate benchmark would be *weak*. If the unemployment rate for the permittee service area is 5 percent, the unemployment rate benchmark would be *strong*.

**Note:** This information is also used in Line 48c of Schedule 6–FINANCIAL CAPABILITY.

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### Median Household Income

MHI is defined as the median amount of total income dollars received per household during a calendar year in an area. It serves as an overall indicator of community earning capacity.

**Line 36 – Median household income - permittee.** Copy the value already entered in Line 20.

**Line 37 – Census Year national MHI.** Enter the most recent census value for National MHI. The national average MHI in 2004 was \$44,389 (Author year)([http://www.census.gov/Press-Release/www/releases/archives/income\\_wealth/005647.html](http://www.census.gov/Press-Release/www/releases/archives/income_wealth/005647.html)).

**Line 38 – MHI adjustment factor.** Copy the value from Line 19.

**Line 39 - Adjusted MHI.** Multiply the national MHI from Line 37 by the MHI adjustment factor in Line 38.

**Line 40 – MHI Benchmark.** If the permittee MHI in Line 36 is less than 75 percent of the adjusted national MHI in Line 39, enter *Weak*. If the permittee MHI is more than 125 percent of the adjusted national MHI, enter *Strong*; otherwise, enter *Mid-Range*. **Note:** this information is also used in Line 48d of Schedule 6–AFFORDABILITY.

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### Financial Management Indicators

The financial management indicators used to evaluate a permittee's financial management ability is property tax revenue as a percent of full MPV and property tax revenue collection rate.

#### Property Tax Revenues as a Percent of Full MPV

This indicator can be referred to as the *property tax burden* because it indicates the funding capacity available to support debt on the basis of the community's wealth. It also

reflects the effectiveness of management in providing community services.

The property assessment data should be readily available through the community or the state's assessor office (see instructions for Line 29). Property tax revenues are available in communities' annual financial statements. Occasionally, the assessment and tax revenue data of communities partially serviced by the permittee may need to be prorated to provide a clearer picture of the permittee's property tax burden.

**Line 41 – Full market value of real property.** Copy the value from Line 29.

**Line 42 – Property tax revenues.** Enter the most recent year's property tax revenue. General fund revenues are primarily property tax receipts.

**Line 43 – Property tax revenues as a percent of full MPV.** Divide Line 42 by Line 41, then multiply by 100, and enter the result on Line 43.

**Line 44 – Property Tax Benchmark.** If the value in Line 43 is above 4 percent, enter *Weak*. If the value is below 2 percent, enter *Strong*. Otherwise, enter *Mid-Range*. **Note:** this information is also used in Line 48e of Schedule 6–FINANCIAL CAPABILITY .

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### Property Tax and Collection Rate

The property tax revenue collection rate is an indicator of the efficiency of the tax collection system and the ability of the community to support the tax levels.

Property taxes levied can be computed by multiplying the assessed value of real property by the property tax rate, both of which are available from a community's financial statements or the state assessor's office. Property tax revenues are available in communities' annual financial statements. Occasionally, the assessment and tax revenue data of communities partially serviced by the permittee might have to be prorated to provide a clearer picture of the permittee's property tax revenue collection rate.

**Line 45 – Property taxes levied.** Enter on Line 45 the property taxes levied.

**Line 46 – Property tax revenue collection rate.** Divide Line 42 by Line 45, and then multiply by 100 to present the collection rate as a percentage. Enter the value on Line 46.

**Line 47 – Collection Rate Benchmark.** If the value in Line 46 is below 94, enter *Weak*. If the value is above 98, enter *Strong*. Otherwise, enter *Mid-Range*. **Note:** this information is also used in Line 48f of Schedule 6–AFFORDABILITY.

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### Matrix Score: Analyzing Permittee Financial Capability Indicators

This section describes how the indicators in the second phase can be used to generate an overall picture of a permittee's financial capability. The indicators are compared to national benchmarks to form an overall assessment of the permittee's financial capability and its effect on implementation schedules in the LTCP or on long-term plans for WWT.

In situations where a permittee has unique circumstances that could affect financial capability, the permittee can submit documentation of the unique financial conditions to the appropriate EPA and state NPDES authorities for consideration. The purpose of additional information is to clarify unique circumstances that are not adequately represented by the overall scores of the selected indicators. An example of a unique financial situation might be where a state or community imposes restrictions on the property taxes that are used to fund sewer service.

**Line 48 – Scoring of Financial Capability Benchmarks.** For each benchmark completed in this form, enter the benchmark and the corresponding score (*Weak* = 1, *Mid-Range* = 2, *Strong* = 3), then sum the scores and enter the value on Line 48g. Each line is described below.

**Line 48a – Bond Rating.** Enter the bond rating on Line 48a (Line 25 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48b – Net Debt.** Enter the net debt on Line 48b (Line 31 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48c – Unemployment Rate.** Enter the unemployment rate on Line 48c (Line 35 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48d – Median Household Income.** Enter the MHI on Line 48d (Line 40 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48e – Property Tax.** Enter the property tax on Line 48e (Line 44 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48f – Collection Rate.** Enter the collection rate on Line 48f (Line 47 on Schedule 6 – FINANCIAL CAPABILITY. If you are using the electronic version of the form, this value will have been filled in automatically).

**Line 48g – Sum.** Enter the total by adding 48a through 48f together.

**Line 49 – Permittee indicators score.** Divide the result in Line 48g by the number of benchmarks completed to determine the average financial capability score.

**Line 50 – Permittee Financial Capability Indicators**

**Descriptor.** If the value in Line 49 is less than 1.5, enter *Weak*. If the value is greater than 2.5, enter *Strong*. Otherwise, enter *Mid-Range*.

**Line 51 – Permittee Residential Indicator**

**Benchmark.** Copy from Line 22.

**Line 52 – Financial Capability.** Using Table CAF-4, cross-index the Financial Capability benchmark result in Line 50 with the Residential Indicator benchmark result in Line 51 to determine overall financial capability.

**Table CAF-4. Financial capability**

Permittee capability (socioeconomic, debt, and financial indicators)	Residential(CPH as %MHI)		
	Low	Mid-Range	High
Weak	Medium Burden	High Burden	High Burden
Mid-Range	Low Burden	Medium Burden	High Burden
Strong	Low Burden	Low Burden	Medium Burden



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## References

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## Glossary of Terms

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This glossary includes a collection of the terms used in this manual and an explanation of each term. To the extent that definitions and explanations provided in this glossary differ from those in EPA regulations or other official documents, they are intended to help you understand material in this manual only and have no legal effect.

**Bioretention Facility** – Bioretention facilities, or rain gardens, are landscaping features that are designed to capture and treat local stormwater runoff. The typical components of a bioretention facility include vegetation, a mulch-layer, and engineered soil, all of which lie in a depression such that it can capture local stormwater runoff.

**Cause of Impairment** – Where possible, states, tribes, and other jurisdictions identify the pollutants or stressors causing water quality impairment. Such causes of impairment keep waters from meeting the state-adopted water quality standards to protect designated uses. Causes of impairment include chemical contaminants (such as PCBs, metals, and oxygen-depleting substances), physical conditions (such as elevated temperature, excessive siltation, or alterations of habitat), and biological contaminants (such as bacteria and noxious aquatic weeds).

**Class A Waters** – A Use Classification that some states use in their water quality standards to designate high-quality waters.

**Combined Sewer Overflow (CSO)** – A discharge of untreated wastewater from a combined sewer system at a point before the headworks of a publicly owned treatment works plant.

**Combined Sewer System (CSS)** – A combined sewer system (CSS) is a wastewater collection system owned by a State or municipality (as defined by section 502 (4) of the Clean Water Act) which conveys sanitary wastewaters (domestic, commercial and industrial wastewaters) and storm water through a single-pipe system to a Publicly Owned Treatment Works (POTW) Treatment Plant (as defined in 40 CFR 403.3(p)).

**Combined Sewage** – Wastewater and storm water carried in the same pipe by design.

**Consumer Price Index (CPI)** – A statistical time-series measure of a weighted average of prices of a specified set of goods and services purchased by consumers.

**CSO Control Policy** – EPA published the CSO Control Policy on April 19, 1994 (59 *Federal Register* 18688). The policy includes provisions for developing appropriate, site-specific National Pollutant Discharge Elimination System permit requirements for combined sewer systems that overflow as a result of wet-weather events.

**Dissolved Oxygen (DO)** – The oxygen freely available in water, which is vital for sustaining fish and other aquatic life as well as for preventing odors. DO levels are considered one of the most important indicators of a waterbody's ability to support desirable aquatic life. Secondary treatment and advanced waste treatment are generally designed to ensure adequate DO in the water that receives WWTP effluent.

**Dry-Weather Flow Conditions** – Hydraulic flow conditions in the combined sewer system resulting from one or more of the following: flows of domestic sewage; groundwater infiltration; and commercial and industrial wastewaters.

**Dry-Weather CSO** – An unauthorized discharge from a combined sewer system that occurs during dry-weather conditions.



**First Flush** – The occurrence of higher concentrations of pollutants in stormwater or combined sewer overflow discharges at the beginning of a storm.

**Floatables and Trash** – Visible buoyant or semi-buoyant solids including organic matter, personal hygiene items, plastics, styrofoam, paper, rubber, glass and wood.

**Green Infrastructure** – stormwater management techniques that use or mimic natural processes to infiltrate, evapotranspire, or store stormwater or runoff on or near the site where it is generated.

**Green Roofs** – Vegetated roofing systems that can be installed or retrofitted on commercial, industrial, and residential buildings of all sizes. They typically consist of a waterproofing layer, a drainage layer, a root barrier, a water retention layer, and a growth medium layer. Green roofs help manage stormwater by providing detention storage of incident rainfall and facilitating evapotranspiration of the detained water.

**Headworks of a Wastewater Treatment Plant** – The initial structures, devices, and processes receiving flows from the sewer system at a wastewater treatment plant, including screening, pumping, measuring, and grit-removal facilities.

**Hyetograph** – A graphical representation of the distribution of rainfall over time.

**Imperviousness** – The fraction (%) of a sub-sewershed that is covered by non-infiltrating surfaces such as concrete, asphalt, and buildings.

**Infiltration** – Stormwater and groundwater that enter a sewer system through such means as defective pipes, pipe joints, connections, or manholes. (Infiltration does not include inflow.)

**Infiltration/Inflow (I/I)** – The total quantity of water from both infiltration and inflow.

**Inflow** – Water, other than wastewater, that enters a sewer system from sources such as roof leaders, cellar drains, yard drains, area drains, foundation drains, drains from springs and swampy areas, manhole covers, cross connections between storm drains and sanitary sewers, catch basins, cooling towers, stormwater, surface runoff, street wash waters, or other drainage. (Inflow does not include infiltration).

**Interceptor Sewers** – A sewer without building sewer connections that is used to collect and carry flows from main and trunk sewers to a central point for treatment and discharge.

**Long-Term Control Plan (LTCP)** – A water quality-based combined sewer overflow control plan that is ultimately intended to result in compliance with the Clean Water Act. As described in the 1994 CSO Control Policy, LTCPs should consider the site-specific nature of combined sewer overflows and evaluate the cost effectiveness of a range of controls.

**Median Household Income (MHI)** –The median amount of total income dollars received per household during a calendar year in a geographical area.

**Million Gallons per Day (MGD)** – A rate of flow commonly used for wastewater discharges. One MGD is equivalent to a flow rate of 1.547 cubic feet per second over a 24-hour period.

**National Pollutant Discharge Elimination System (NPDES)** – The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 318, 402 and 405 of the Clean Water Act.

**Nine Minimum Controls (NMC)** – The minimum technology-based combined sewer overflow controls designed to address combined sewer overflow problems without extensive engineering studies or significant construction costs before implementing long-term control measures. Municipalities were

expected to implement the NMC and submit appropriate documentation to NPDES permitting authorities no later than January 1, 1997.

**Permeable Pavement** – An alternative to conventional asphalt and concrete surfaces used mostly in non-street construction such as parking lots, sidewalks, and alleyways. Permeable pavement uses various types of materials, including permeable asphalt and concrete, and permeable or grass pavers. Permeable pavement helps manage stormwater by providing retention storage of surface runoff and allowing infiltration into underlying soil.

**Permittee** – An entity that holds a National Pollutant Discharge Elimination System permit. In the case of Green LTCP-EZ, the term should be interpreted to include any users of the Green LTCP-EZ Template.

**Permitting Authority** – The agency (EPA or the state or Indian tribe) that administers the National Pollutant Discharge Elimination System permit program.

**Primary Treatment** – The first steps in wastewater treatment in which screens and sedimentation tanks are used to remove most materials that float or will settle. Clean Water Act section 301(h), which addresses waivers from secondary treatment for discharges into marine waters, defines primary or equivalent treatment as that adequate to remove 30 percent of biochemical oxygen demand and 30 percent of suspended solids.

**Publicly Owned Treatment Works (POTW)** – As defined by section 212 of the Clean Water Act, a POTW is a treatment works that is owned by a state or municipality. This definition includes any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, and other conveyances only if they convey wastewater to a POTW plant.

**Rational Method** – A simple approach for estimating peak discharges for small drainage areas in which no significant flood storage occurs.

**Regulator** – A device in combined sewer systems for diverting wet-weather flows that exceed downstream capacity in the sewer system to a combined sewer overflow outfall.

**Runoff** – The flow of water from rain, snowmelt, or other sources over the land

**Sanitary Sewer System (SSS)** – A municipal wastewater collection system that conveys domestic, commercial, and industrial wastewater and limited amounts of infiltrated groundwater and stormwater to a POTW. Areas served by SSSs often have a municipal separate storm sewer system to collect and convey runoff from rainfall and snowmelt.

**Satellite Sewer Systems** – Combined or sanitary sewer systems that convey flow to a publicly owned treatment works owned and operated by a separate entity.

**Secondary Treatment** – Technology-based requirements for direct discharging municipal sewage treatment facilities. 40 CFR 133.102 defines secondary treatment as 30-day averages of 30 milligrams per liter (mg/L) BOD<sub>5</sub> and 30 mg/L suspended solids, along with maintenance of pH within 6.0 to 9.0 (except as provided for special considerations and treatment equivalent to secondary treatment).

**Sensitive Area** – An area of environmental significance or sensitivity that could be adversely affected by combined sewer overflow discharges. Sensitive areas include Outstanding National Resource Waters, National Marine Sanctuaries, water with threatened or endangered species, waters with primary contact recreation, public drinking water intakes, shellfish beds, and other areas identified by the permittee or National Pollutant Discharge Elimination System permitting authority, in coordination with the appropriate state or federal agencies.

**Sewer Separation** – The process of separating a combined sewer system into sanitary and separate storm sewer systems. It is accomplished by constructing a new pipe system (either sanitary or separate storm) and diverting the appropriate types of flows (sanitary or storm) into the new sewers while allowing the existing sewers to carry only the other type of flow (storm or sanitary).

**Source of Impairment** – Where possible, states, tribes, and other jurisdictions identify from where pollutants or stressors (causes of impairment) are coming. Such sources of impairment are the activities, facilities, or conditions that generate the pollutants that keep waters from meeting the state-adopted criteria to protect designated uses. Sources of impairment include, for example, municipal sewage treatment plants, factories, storm sewers, combined sewer overflows, modification of hydrology, agricultural runoff, and runoff from city streets.

**Sub-Sewershed Area** – An area within a combined sewer system that drains to one combined sewer overflow outfall.

**Tier III Waters** – Federal guidance establishes three levels or tiers of nondegradation, which is the model states are to use when adopting nondegradation provisions. Tier III provides the highest level of protection from pollution to waters specifically identified as very high quality, important recreational resources, ecologically sensitive, or unique.

**Total Suspended Solids (TSS)** – A measure of the filterable solids present in a sample of water or wastewater (as determined by the method specified in 40 CFR Part 136).

**Vegetated Swales** (sometimes called grassed swales) – Open-channels designed specifically to treat and attenuate stormwater runoff. Unlike traditional drainage ditches, the vegetation in a vegetated swale slows runoff to allow sedimentation and infiltration into the underlying soils.

**Wastewater Treatment Plant (WWTP)** – A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

**Water Quality Standards** – Standards established by regulatory agencies that consist of the beneficial use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that waterbody, and an antidegradation statement.

**Wet-Weather Event** – A discharge from a combined sewer system that occurs in direct response to rainfall or snowmelt.

**Wet-Weather Flow** – Dry-weather flow combined with stormwater introduced into a combined sewer system.

**Wet-Weather Flow Conditions** – Hydraulic flow conditions within the combined sewer system resulting from a wet-weather event.

# Appendix A. One-Hour, 3-Month Rainfall Intensities, Schedule 4 – CSO Volume

State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
CT	Fairfield	0.87	IL	Johnson	0.90	IL	Will	0.76	IN	Miami	0.71
CT	Hartford	0.87	IL	Kane	0.76	IL	Williamson	0.90	IN	Monroe	0.81
CT	Litchfield	0.87	IL	Kankakee	0.76	IL	Winnebago	0.78	IN	Montgomery	0.79
CT	Middlesex	0.87	IL	Kendall	0.76	IL	Woodford	0.76	IN	Morgan	0.74
CT	New Haven	0.87	IL	Knox	0.84	IN	Adams	0.65	IN	Newton	0.73
CT	New London	0.87	IL	La Salle	0.76	IN	Allen	0.65	IN	Noble	0.65
CT	Tolland	0.87	IL	Lake	0.76	IN	Bartholomew	0.74	IN	Ohio	0.74
CT	Windham	0.87	IL	Lawrence	0.79	IN	Benton	0.73	IN	Orange	0.81
DE	Kent	0.87	IL	Lee	0.78	IN	Blackford	0.69	IN	Owen	0.79
DE	New Castle	0.87	IL	Livingston	0.74	IN	Boone	0.74	IN	Parke	0.79
DE	Sussex	0.87	IL	Logan	0.76	IN	Brown	0.81	IN	Perry	0.81
DC	DC	0.87	IL	Macon	0.76	IN	Carroll	0.74	IN	Pike	0.83
IL	Adams	0.84	IL	Macoupin	0.79	IN	Cass	0.71	IN	Porter	0.73
IL	Alexander	0.90	IL	Madison	0.81	IN	Clark	0.74	IN	Posey	0.83
IL	Bond	0.81	IL	Marion	0.79	IN	Clay	0.79	IN	Pulaski	0.73
IL	Boone	0.78	IL	Marshall	0.76	IN	Clinton	0.74	IN	Putnam	0.79
IL	Brown	0.76	IL	Mason	0.76	IN	Crawford	0.81	IN	Randolph	0.69
IL	Bureau	0.78	IL	Massac	0.90	IN	Daviess	0.83	IN	Ripley	0.74
IL	Calhoun	0.79	IL	McDonough	0.84	IN	Dearborn	0.74	IN	Rush	0.74
IL	Carroll	0.78	IL	McHenry	0.76	IN	Decatur	0.74	IN	Scott	0.74
IL	Cass	0.79	IL	McLean	0.76	IN	DeKalb	0.65	IN	Shelby	0.74
IL	Champaign	0.74	IL	Menard	0.79	IN	Delaware	0.69	IN	Spencer	0.83
IL	Christian	0.79	IL	Mercer	0.78	IN	Dubois	0.83	IN	St. Joseph	0.71
IL	Clark	0.77	IL	Monroe	0.81	IN	Elkhart	0.71	IN	Starke	0.73
IL	Clay	0.79	IL	Montgomery	0.79	IN	Fayette	0.69	IN	Steuben	0.65
IL	Clinton	0.81	IL	Morgan	0.79	IN	Floyd	0.81	IN	Sullivan	0.83
IL	Coles	0.77	IL	Moultrie	0.77	IN	Fountain	0.79	IN	Switzerland	0.74
IL	Cook	0.76	IL	Ogle	0.78	IN	Franklin	0.74	IN	Tiptecanoe	0.79
IL	Crawford	0.77	IL	Peoria	0.76	IN	Fulton	0.71	IN	Tipton	0.74
IL	Cumberland	0.77	IL	Perry	0.81	IN	Gibson	0.83	IN	Union	0.69
IL	De Witt	0.76	IL	Piatt	0.76	IN	Grant	0.74	IN	Vanderburgh	0.83
IL	DeKalb	0.76	IL	Pike	0.79	IN	Greene	0.83	IN	Vermillion	0.79
IL	Douglas	0.77	IL	Pope	0.90	IN	Hamilton	0.74	IN	Vigo	0.79
IL	DuPage	0.76	IL	Pulaski	0.90	IN	Hancock	0.74	IN	Wabash	0.71
IL	Edgar	0.77	IL	Putnam	0.78	IN	Harrison	0.81	IN	Warren	0.79
IL	Edwards	0.79	IL	Randolph	0.81	IN	Hendricks	0.74	IN	Warrick	0.83
IL	Effingham	0.77	IL	Richland	0.79	IN	Henry	0.69	IN	Washington	0.81
IL	Fayette	0.77	IL	Rock Island	0.78	IN	Howard	0.74	IN	Wayne	0.69
IL	Ford	0.74	IL	Saline	0.90	IN	Huntington	0.65	IN	Wells	0.65
IL	Franklin	0.79	IL	Sangamon	0.79	IN	Jackson	0.81	IN	White	0.73
IL	Fulton	0.76	IL	Schuyler	0.76	IN	Jasper	0.73	IN	Whitley	0.65
IL	Gallatin	0.90	IL	Scott	0.79	IN	Jay	0.69	IA	Adair	0.83
IL	Greene	0.79	IL	Shelby	0.77	IN	Jefferson	0.74	IA	Adams	0.83
IL	Grundy	0.76	IL	St. Clair	0.81	IN	Jennings	0.74	IA	Allamakee	0.70
IL	Hamilton	0.79	IL	Stark	0.76	IN	Johnson	0.74	IA	Appanoose	0.75
IL	Hancock	0.84	IL	Stephenson	0.78	IN	Knox	0.83	IA	Audubon	0.75
IL	Hardin	0.90	IL	Tazewell	0.76	IN	Kosciusko	0.71	IA	Benton	0.72
IL	Henderson	0.84	IL	Union	0.90	IN	Lagrange	0.65	IA	Black Hawk	0.70
IL	Henry	0.78	IL	Vermilion	0.74	IN	Lake	0.73	IA	Boone	0.72
IL	Iroquois	0.74	IL	Wabash	0.79	IN	LaPorte	0.73	IA	Bremer	0.70
IL	Jackson	0.90	IL	Warren	0.84	IN	Lawrence	0.81	IA	Buchanan	0.70
IL	Jasper	0.77	IL	Washington	0.81	IN	Madison	0.74	IA	Buena Vista	0.67
IL	Jefferson	0.79	IL	Wayne	0.79	IN	Marion	0.74	IA	Butler	0.71
IL	Jersey	0.79	IL	White	0.79	IN	Marshall	0.71	IA	Calhoun	0.75
IL	Jo Daviess	0.78	IL	Whiteside	0.78	IN	Martin	0.83	IA	Carroll	0.75

State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
IA	Cass	0.83	IA	Muscatine	0.72	KY	Clinton	0.88	KY	Meade	0.88
IA	Cedar	0.72	IA	O'Brien	0.67	KY	Crittenden	0.93	KY	Menifee	0.80
IA	Cerro Gordo	0.71	IA	Osceola	0.67	KY	Cumberland	0.88	KY	Mercer	0.77
IA	Cherokee	0.67	IA	Page	0.83	KY	Daviess	0.93	KY	Metcalf	0.88
IA	Chickasaw	0.70	IA	Palo Alto	0.67	KY	Edmonson	0.88	KY	Monroe	0.88
IA	Clarke	0.75	IA	Plymouth	0.67	KY	Elliott	0.80	KY	Montgomery	0.77
IA	Clay	0.67	IA	Pocahontas	0.67	KY	Estill	0.80	KY	Morgan	0.80
IA	Clayton	0.70	IA	Polk	0.72	KY	Fayette	0.77	KY	Muhlenberg	0.93
IA	Clinton	0.72	IA	Pottawattamie	0.83	KY	Fleming	0.77	KY	Nelson	0.88
IA	Crawford	0.75	IA	Poweshiek	0.72	KY	Floyd	0.80	KY	Nicholas	0.77
IA	Dallas	0.72	IA	Ringgold	0.75	KY	Franklin	0.77	KY	Ohio	0.93
IA	Davis	0.75	IA	Sac	0.75	KY	Fulton	0.93	KY	Oldham	0.77
IA	Decatur	0.75	IA	Scott	0.72	KY	Gallatin	0.77	KY	Owen	0.77
IA	Delaware	0.70	IA	Shelby	0.75	KY	Garrard	0.77	KY	Owsley	0.80
IA	Des Moines	0.75	IA	Sioux	0.67	KY	Grant	0.77	KY	Pendleton	0.77
IA	Dickinson	0.67	IA	Story	0.72	KY	Graves	0.93	KY	Perry	0.80
IA	Dubuque	0.70	IA	Tama	0.72	KY	Grayson	0.88	KY	Pike	0.80
IA	Emmet	0.67	IA	Taylor	0.83	KY	Green	0.88	KY	Powell	0.80
IA	Fayette	0.70	IA	Union	0.75	KY	Greenup	0.80	KY	Pulaski	0.80
IA	Floyd	0.71	IA	Van Buren	0.75	KY	Hancock	0.93	KY	Robertson	0.77
IA	Franklin	0.71	IA	Wapello	0.75	KY	Hardin	0.88	KY	Rockcastle	0.80
IA	Fremont	0.83	IA	Warren	0.75	KY	Harlan	0.80	KY	Rowan	0.80
IA	Greene	0.75	IA	Washington	0.75	KY	Harrison	0.77	KY	Russell	0.88
IA	Grundy	0.72	IA	Wayne	0.75	KY	Hart	0.88	KY	Scott	0.77
IA	Guthrie	0.75	IA	Webster	0.72	KY	Henderson	0.93	KY	Shelby	0.77
IA	Hamilton	0.72	IA	Winnebago	0.71	KY	Henry	0.77	KY	Simpson	0.93
IA	Hancock	0.71	IA	Winneshiek	0.70	KY	Hickman	0.93	KY	Spencer	0.77
IA	Hardin	0.72	IA	Woodbury	0.75	KY	Hopkins	0.93	KY	Taylor	0.88
IA	Harrison	0.75	IA	Worth	0.71	KY	Jackson	0.80	KY	Todd	0.93
IA	Henry	0.75	IA	Wright	0.71	KY	Jefferson	0.88	KY	Trigg	0.93
IA	Howard	0.70	KY	Adair	0.88	KY	Jessamine	0.77	KY	Trimble	0.77
IA	Humboldt	0.71	KY	Allen	0.88	KY	Johnson	0.80	KY	Union	0.93
IA	Ida	0.75	KY	Anderson	0.77	KY	Kenton	0.77	KY	Warren	0.88
IA	Iowa	0.72	KY	Ballard	0.93	KY	Knott	0.80	KY	Washington	0.77
IA	Jackson	0.72	KY	Barren	0.88	KY	Knox	0.80	KY	Wayne	0.80
IA	Jasper	0.72	KY	Bath	0.77	KY	Larue	0.88	KY	Webster	0.93
IA	Jefferson	0.75	KY	Bell	0.80	KY	Laurel	0.80	KY	Whitley	0.80
IA	Johnson	0.72	KY	Boone	0.77	KY	Lawrence	0.80	KY	Wolfe	0.80
IA	Jones	0.72	KY	Bourbon	0.77	KY	Lee	0.80	KY	Woodford	0.77
IA	Keokuk	0.75	KY	Boyd	0.80	KY	Leslie	0.80	ME	Androscoggin	0.75
IA	Kossuth	0.71	KY	Boyle	0.77	KY	Letcher	0.80	ME	Aroostook	0.62
IA	Lee	0.75	KY	Bracken	0.77	KY	Lewis	0.80	ME	Cumberland	0.75
IA	Linn	0.72	KY	Breathitt	0.80	KY	Lincoln	0.77	ME	Franklin	0.75
IA	Louisa	0.75	KY	Breckinridge	0.88	KY	Livingston	0.93	ME	Hancock	0.75
IA	Lucas	0.75	KY	Bullitt	0.88	KY	Logan	0.93	ME	Kennebec	0.75
IA	Lyon	0.67	KY	Butler	0.88	KY	Lyon	0.93	ME	Knox	0.75
IA	Madison	0.75	KY	Calloway	0.93	KY	Madison	0.77	ME	Lincoln	0.75
IA	Mahaska	0.75	KY	Campbell	0.77	KY	Magoffin	0.80	ME	Oxford	0.87
IA	Marion	0.75	KY	Carlisle	0.93	KY	Marion	0.88	ME	Penobscot	0.75
IA	Marshall	0.72	KY	Carroll	0.77	KY	Marshall	0.93	ME	Piscataquis	0.75
IA	Mills	0.83	KY	Carter	0.80	KY	Martin	0.80	ME	Sagadahoc	0.75
IA	Mitchell	0.71	KY	Casey	0.88	KY	Mason	0.77	ME	Somerset	0.75
IA	Monona	0.75	KY	Christian	0.93	KY	McCracken	0.93	ME	Waldo	0.75
IA	Monroe	0.75	KY	Clark	0.77	KY	McCreary	0.80	ME	Washington	0.75
IA	Montgomery	0.83	KY	Clay	0.80	KY	McLean	0.93	ME	York	0.75

State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
MD	Allegany	0.75	MI	Clare	0.56	MI	Saginaw	0.52	MO	Howard	0.76
MD	Anne Arundel	0.87	MI	Clinton	0.61	MI	Sanilac	0.52	MO	Howell	0.84
MD	Baltimore	0.87	MI	Crawford	0.51	MI	Schoolcraft	0.50	MO	Iron	0.84
MD	Baltimore City	0.87	MI	Delta	0.50	MI	Shiawassee	0.61	MO	Jackson	0.76
MD	Calvert	0.87	MI	Dickinson	0.59	MI	St. Clair	0.56	MO	Jasper	0.90
MD	Caroline	0.87	MI	Eaton	0.61	MI	St. Joseph	0.61	MO	Jefferson	0.84
MD	Carroll	0.87	MI	Emmet	0.49	MI	Tuscola	0.52	MO	Johnson	0.84
MD	Cecil	0.87	MI	Genesee	0.56	MI	Van Buren	0.59	MO	Knox	0.75
MD	Charles	0.87	MI	Gladwin	0.56	MI	Washtenaw	0.56	MO	Laclede	0.90
MD	Dorchester	0.87	MI	Gogebic	0.59	MI	Wayne	0.56	MO	Lafayette	0.76
MD	Frederick	0.87	MI	Grand Traverse	0.49	MI	Wexford	0.49	MO	Lawrence	0.90
MD	Garrett	0.75	MI	Gratiot	0.56	MO	Adair	0.75	MO	Lewis	0.75
MD	Harford	0.87	MI	Hillsdale	0.61	MO	Andrew	0.76	MO	Lincoln	0.75
MD	Howard	0.87	MI	Houghton	0.59	MO	Atchison	0.76	MO	Linn	0.76
MD	Kent	0.87	MI	Huron	0.52	MO	Audrain	0.75	MO	Livingston	0.76
MD	Montgomery	0.87	MI	Ingham	0.61	MO	Barry	0.90	MO	Macon	0.75
MD	Prince George's	0.87	MI	Ionia	0.61	MO	Barton	0.90	MO	Madison	0.84
MD	Queen Anne's	0.87	MI	Iosco	0.51	MO	Bates	0.84	MO	Maries	0.84
MD	Somerset	1.00	MI	Iron	0.59	MO	Benton	0.84	MO	Marion	0.75
MD	St. Mary's	0.87	MI	Isabella	0.56	MO	Bollinger	0.84	MO	McDonald	0.90
MD	Talbot	0.87	MI	Jackson	0.61	MO	Boone	0.75	MO	Mercer	0.76
MD	Washington	0.75	MI	Kalamazoo	0.59	MO	Buchanan	0.76	MO	Miller	0.84
MD	Wicomico	0.87	MI	Kalkaska	0.49	MO	Butler	0.84	MO	Mississippi	0.90
MD	Worcester	1.00	MI	Kent	0.59	MO	Caldwell	0.76	MO	Moniteau	0.84
MA	Barnstable	0.87	MI	Keweenaw	0.59	MO	Callaway	0.75	MO	Monroe	0.75
MA	Berkshire	0.75	MI	Lake	0.53	MO	Camden	0.84	MO	Montgomery	0.75
MA	Bristol	0.87	MI	Lapeer	0.56	MO	Cape Girardeau	0.84	MO	Morgan	0.84
MA	Dukes	0.87	MI	Leelanau	0.49	MO	Carroll	0.76	MO	New Madrid	0.90
MA	Essex	0.87	MI	Lenawee	0.56	MO	Carter	0.84	MO	Newton	0.90
MA	Franklin	0.75	MI	Livingston	0.56	MO	Cass	0.84	MO	Nodaway	0.76
MA	Hampden	0.87	MI	Luce	0.50	MO	Cedar	0.84	MO	Oregon	0.84
MA	Hampshire	0.75	MI	Mackinac	0.50	MO	Chariton	0.76	MO	Osage	0.75
MA	Middlesex	0.87	MI	Macomb	0.56	MO	Christian	0.90	MO	Ozark	0.90
MA	Nantucket	0.87	MI	Manistee	0.49	MO	Clark	0.75	MO	Pemiscot	0.90
MA	Norfolk	0.87	MI	Marquette	0.59	MO	Clay	0.76	MO	Perry	0.84
MA	Plymouth	0.87	MI	Mason	0.53	MO	Clinton	0.76	MO	Pettis	0.84
MA	Suffolk	0.87	MI	Mecosta	0.56	MO	Cole	0.84	MO	Phelps	0.84
MA	Worcester	0.87	MI	Menominee	0.59	MO	Cooper	0.84	MO	Pike	0.75
MI	Alcona	0.51	MI	Midland	0.56	MO	Crawford	0.84	MO	Platte	0.76
MI	Alger	0.50	MI	Missaukee	0.49	MO	Dade	0.90	MO	Polk	0.90
MI	Allegan	0.59	MI	Monroe	0.56	MO	Dallas	0.90	MO	Pulaski	0.84
MI	Alpena	0.51	MI	Montcalm	0.56	MO	Daviess	0.76	MO	Putnam	0.76
MI	Antrim	0.49	MI	Montmorency	0.51	MO	DeKalb	0.76	MO	Ralls	0.75
MI	Arenac	0.52	MI	Muskegon	0.53	MO	Dent	0.84	MO	Randolph	0.75
MI	Baraga	0.59	MI	Newaygo	0.53	MO	Douglas	0.90	MO	Ray	0.76
MI	Barry	0.61	MI	Oakland	0.56	MO	Dunklin	0.90	MO	Reynolds	0.84
MI	Bay	0.52	MI	Oceana	0.53	MO	Franklin	0.75	MO	Ripley	0.84
MI	Benzie	0.49	MI	Ogemaw	0.51	MO	Gasconade	0.75	MO	Saline	0.76
MI	Berrien	0.59	MI	Ontonagon	0.59	MO	Gentry	0.76	MO	Schuyler	0.75
MI	Branch	0.61	MI	Osceola	0.56	MO	Greene	0.90	MO	Scotland	0.75
MI	Calhoun	0.61	MI	Oscoda	0.51	MO	Grundy	0.76	MO	Scott	0.90
MI	Cass	0.59	MI	Otsego	0.51	MO	Harrison	0.76	MO	Shannon	0.84
MI	Charlevoix	0.49	MI	Ottawa	0.59	MO	Henry	0.84	MO	Shelby	0.75
MI	Cheboygan	0.51	MI	Presque Isle	0.51	MO	Hickory	0.84	MO	St. Charles	0.75
MI	Chippewa	0.50	MI	Roscommon	0.51	MO	Holt	0.76	MO	St. Clair	0.84

State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
MO	St. Francois	0.84	NY	Chenango	0.75	OH	Allen	0.61	OH	Montgomery	0.70
MO	St. Louis	0.75	NY	Clinton	0.62	OH	Ashland	0.63	OH	Morgan	0.61
MO	St. Louis City	0.75	NY	Columbia	0.75	OH	Ashtabula	0.61	OH	Morrow	0.65
MO	Ste. Genevieve	0.84	NY	Cortland	0.75	OH	Athens	0.61	OH	Muskingum	0.61
MO	Stoddard	0.90	NY	Delaware	0.75	OH	Auglaize	0.65	OH	Noble	0.61
MO	Stone	0.90	NY	Dutchess	1.00	OH	Belmont	0.61	OH	Ottawa	0.60
MO	Sullivan	0.76	NY	Erie	0.62	OH	Brown	0.70	OH	Paulding	0.61
MO	Taney	0.90	NY	Essex	0.62	OH	Butler	0.70	OH	Perry	0.61
MO	Texas	0.84	NY	Franklin	0.62	OH	Carroll	0.61	OH	Pickaway	0.65
MO	Vernon	0.84	NY	Fulton	0.75	OH	Champaign	0.65	OH	Pike	0.69
MO	Warren	0.75	NY	Genesee	0.62	OH	Clark	0.65	OH	Portage	0.61
MO	Washington	0.84	NY	Greene	0.87	OH	Clermont	0.70	OH	Preble	0.70
MO	Wayne	0.84	NY	Hamilton	0.62	OH	Clinton	0.70	OH	Putnam	0.61
MO	Webster	0.90	NY	Herkimer	0.62	OH	Columbiana	0.61	OH	Richland	0.63
MO	Worth	0.76	NY	Jefferson	0.62	OH	Coshocton	0.63	OH	Ross	0.69
MO	Wright	0.90	NY	Kings	0.87	OH	Crawford	0.60	OH	Sandusky	0.60
NH	Belknap	0.75	NY	Lewis	0.62	OH	Cuyahoga	0.61	OH	Scioto	0.69
NH	Carroll	0.87	NY	Livingston	0.62	OH	Darke	0.65	OH	Seneca	0.60
NH	Cheshire	0.75	NY	Madison	0.75	OH	Defiance	0.61	OH	Shelby	0.65
NH	Coos	0.87	NY	Monroe	0.62	OH	Delaware	0.65	OH	Stark	0.61
NH	Grafton	0.75	NY	Montgomery	0.75	OH	Erie	0.60	OH	Summit	0.61
NH	Hillsborough	0.75	NY	Nassau	0.87	OH	Fairfield	0.65	OH	Trumbull	0.61
NH	Merrimack	0.75	NY	New York	0.87	OH	Fayette	0.65	OH	Tuscarawas	0.61
NH	Rockingham	0.75	NY	Niagara	0.62	OH	Franklin	0.65	OH	Union	0.65
NH	Strafford	0.75	NY	Oneida	0.75	OH	Fulton	0.61	OH	Van Wert	0.61
NH	Sullivan	0.75	NY	Onondaga	0.75	OH	Gallia	0.69	OH	Vinton	0.61
NJ	Atlantic	0.87	NY	Ontario	0.62	OH	Geauga	0.61	OH	Warren	0.70
NJ	Bergen	0.87	NY	Orange	0.87	OH	Greene	0.70	OH	Washington	0.61
NJ	Burlington	0.87	NY	Orleans	0.62	OH	Guernsey	0.61	OH	Wayne	0.63
NJ	Camden	0.87	NY	Oswego	0.62	OH	Hamilton	0.70	OH	Williams	0.61
NJ	Cape May	0.87	NY	Otsego	0.75	OH	Hancock	0.61	OH	Wood	0.61
NJ	Cumberland	0.87	NY	Putnam	0.87	OH	Hardin	0.65	OH	Wyandot	0.60
NJ	Essex	0.87	NY	Queens	0.87	OH	Harrison	0.61	PA	Adams	0.75
NJ	Gloucester	0.87	NY	Rensselaer	0.75	OH	Henry	0.61	PA	Allegheny	0.75
NJ	Hudson	0.87	NY	Richmond	0.87	OH	Highland	0.70	PA	Armstrong	0.75
NJ	Hunterdon	0.87	NY	Rockland	0.87	OH	Hocking	0.61	PA	Beaver	0.75
NJ	Mercer	0.87	NY	Saratoga	0.75	OH	Holmes	0.63	PA	Bedford	0.75
NJ	Middlesex	0.87	NY	Schenectady	0.75	OH	Huron	0.60	PA	Berks	0.87
NJ	Monmouth	0.87	NY	Schoharie	0.75	OH	Jackson	0.69	PA	Blair	0.75
NJ	Morris	0.87	NY	Schuyler	0.75	OH	Jefferson	0.61	PA	Bradford	0.75
NJ	Ocean	0.87	NY	Seneca	0.75	OH	Knox	0.63	PA	Bucks	0.87
NJ	Passaic	0.87	NY	St. Lawrence	0.62	OH	Lake	0.61	PA	Butler	0.75
NJ	Salem	0.87	NY	Steuben	0.75	OH	Lawrence	0.69	PA	Cambria	0.75
NJ	Somerset	0.87	NY	Suffolk	0.87	OH	Licking	0.65	PA	Cameron	0.75
NJ	Sussex	0.87	NY	Sullivan	0.87	OH	Logan	0.65	PA	Carbon	0.75
NJ	Union	0.87	NY	Tioga	0.75	OH	Lorain	0.60	PA	Centre	0.75
NJ	Warren	0.87	NY	Tompkins	0.75	OH	Lucas	0.61	PA	Chester	0.87
NY	Albany	0.75	NY	Ulster	1.00	OH	Madison	0.65	PA	Clarion	0.75
NY	Allegany	0.75	NY	Warren	0.62	OH	Mahoning	0.61	PA	Clearfield	0.75
NY	Bronx	0.87	NY	Washington	0.75	OH	Marion	0.65	PA	Clinton	0.75
NY	Broome	0.75	NY	Wayne	0.62	OH	Medina	0.61	PA	Columbia	0.75
NY	Cattaraugus	0.75	NY	Westchester	0.87	OH	Meigs	0.69	PA	Crawford	0.62
NY	Cayuga	0.75	NY	Wyoming	0.62	OH	Mercer	0.65	PA	Cumberland	0.75
NY	Chautauqua	0.62	NY	Yates	0.75	OH	Miami	0.65	PA	Dauphin	0.75
NY	Chemung	0.75	OH	Adams	0.69	OH	Monroe	0.61	PA	Delaware	0.87



State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
PA	Elk	0.75	VT	Grand Isle	0.62	VA	Hanover	0.87	VA	Suffolk	1.00
PA	Erie	0.62	VT	Lamoille	0.62	VA	Henrico	0.87	VA	Surry	1.00
PA	Fayette	0.75	VT	Orange	0.62	VA	Henry	1.00	VA	Sussex	1.00
PA	Forest	0.75	VT	Orleans	0.62	VA	Highland	0.75	VA	Tazewell	0.75
PA	Franklin	0.75	VT	Rutland	0.75	VA	Hopewell	0.87	VA	Virginia Beach	1.00
PA	Fulton	0.75	VT	Washington	0.62	VA	Isle of Wight	1.00	VA	Warren	1.00
PA	Greene	0.75	VT	Windham	0.75	VA	James City	1.00	VA	Washington	0.75
PA	Huntingdon	0.75	VT	Windsor	0.75	VA	King and Queen	0.87	VA	Westmoreland	0.87
PA	Indiana	0.75	VA	Accomack	1.00	VA	King George	0.87	VA	Williamsburg	1.00
PA	Jefferson	0.75	VA	Albemarle	1.00	VA	King William	0.87	VA	Wise	0.75
PA	Juniata	0.75	VA	Alexandria	0.87	VA	Lancaster	0.87	VA	Wythe	0.75
PA	Lackawanna	0.75	VA	Alleghany	0.75	VA	Lee	0.75	VA	York	1.00
PA	Lancaster	0.87	VA	Amelia	0.87	VA	Loudoun	0.87	WV	Barbour	0.75
PA	Lawrence	0.62	VA	Amherst	1.00	VA	Louisa	0.87	WV	Berkeley	0.75
PA	Lebanon	0.75	VA	Appomattox	1.00	VA	Lunenburg	0.87	WV	Boone	0.75
PA	Lehigh	0.87	VA	Augusta	1.00	VA	Lynchburg	1.00	WV	Braxton	0.75
PA	Luzerne	0.75	VA	Bath	0.75	VA	Madison	1.00	WV	Brooke	0.75
PA	Lycoming	0.75	VA	Bedford	1.00	VA	Manassas	0.87	WV	Cabell	0.75
PA	McKean	0.75	VA	Bland	0.75	VA	Manassas Park	0.87	WV	Calhoun	0.75
PA	Mercer	0.62	VA	Botetourt	1.00	VA	Mathews	1.00	WV	Clay	0.75
PA	Mifflin	0.75	VA	Brunswick	0.87	VA	Mecklenburg	0.87	WV	Doddridge	0.75
PA	Monroe	0.75	VA	Buchanan	0.75	VA	Middlesex	0.87	WV	Fayette	0.75
PA	Montgomery	0.87	VA	Buckingham	1.00	VA	Montgomery	0.87	WV	Gilmer	0.75
PA	Montour	0.75	VA	Campbell	1.00	VA	Nelson	1.00	WV	Grant	0.75
PA	Northampton	0.87	VA	Caroline	0.87	VA	New Kent	0.87	WV	Greenbrier	0.75
PA	Northumberland	0.75	VA	Carroll	0.87	VA	Newport News	1.00	WV	Hampshire	0.75
PA	Perry	0.75	VA	Charles City	0.87	VA	Norfolk	1.00	WV	Hancock	0.75
PA	Philadelphia	0.87	VA	Charlotte	0.87	VA	Northampton	1.00	WV	Hardy	0.75
PA	Pike	0.75	VA	Chesapeake	1.00	VA	Northumberland	0.87	WV	Harrison	0.75
PA	Potter	0.75	VA	Chesterfield	0.87	VA	Nottoway	0.87	WV	Jackson	0.75
PA	Schuylkill	0.75	VA	Clarke	0.87	VA	Orange	1.00	WV	Jefferson	0.87
PA	Snyder	0.75	VA	Colonial Heights	0.87	VA	Page	1.00	WV	Kanawha	0.75
PA	Somerset	0.75	VA	Craig	0.75	VA	Patrick	1.00	WV	Lewis	0.75
PA	Sullivan	0.75	VA	Culpeper	1.00	VA	Petersburg	0.87	WV	Lincoln	0.75
PA	Susquehanna	0.75	VA	Cumberland	0.87	VA	Pittsylvania	0.87	WV	Logan	0.75
PA	Tioga	0.75	VA	Dickenson	0.75	VA	Poquoson	1.00	WV	Marion	0.75
PA	Union	0.75	VA	Dinwiddie	0.87	VA	Portsmouth	1.00	WV	Marshall	0.75
PA	Venango	0.75	VA	Essex	0.87	VA	Powhatan	0.87	WV	Mason	0.75
PA	Warren	0.75	VA	Fairfax	0.87	VA	Prince Edward	0.87	WV	McDowell	0.75
PA	Washington	0.75	VA	Fairfax City	0.87	VA	Prince George	0.87	WV	Mercer	0.75
PA	Wayne	0.75	VA	Falls Church	0.87	VA	Prince William	0.87	WV	Mineral	0.75
PA	Westmoreland	0.75	VA	Fauquier	1.00	VA	Pulaski	0.75	WV	Mingo	0.75
PA	Wyoming	0.75	VA	Floyd	0.87	VA	Rappahannock	1.00	WV	Monongalia	0.75
PA	York	0.87	VA	Fluvanna	1.00	VA	Richmond	0.87	WV	Monroe	0.75
RI	Bristol	0.87	VA	Franklin	1.00	VA	Richmond City	0.87	WV	Morgan	0.75
RI	Kent	0.87	VA	Frederick	0.75	VA	Roanoke	1.00	WV	Nicholas	0.75
RI	Newport	0.87	VA	Fredericksburg	0.87	VA	Rockbridge	1.00	WV	Ohio	0.75
RI	Providence	0.87	VA	Giles	0.75	VA	Rockingham	1.00	WV	Pendleton	0.75
RI	Washington	0.87	VA	Gloucester	1.00	VA	Russell	0.75	WV	Pleasants	0.75
VT	Addison	0.62	VA	Goochland	0.87	VA	Scott	0.75	WV	Pocahontas	0.75
VT	Bennington	0.75	VA	Grayson	0.75	VA	Shenandoah	0.87	WV	Preston	0.75
VT	Caledonia	0.62	VA	Greene	1.00	VA	Smyth	0.75	WV	Putnam	0.75
VT	Chittenden	0.62	VA	Greensville	1.00	VA	Southampton	1.00	WV	Raleigh	0.75
VT	Essex	0.62	VA	Halifax	0.87	VA	Spotsylvania	0.87	WV	Randolph	0.75
VT	Franklin	0.62	VA	Hampton	1.00	VA	Stafford	0.87	WV	Ritchie	0.75

State	County	1hr-3mo (in.)	State	County	1hr-3mo (in.)
WV	Roane	0.75	WI	Oneida	0.67
WV	Summers	0.75	WI	Outagamie	0.59
WV	Taylor	0.75	WI	Ozaukee	0.65
WV	Tucker	0.75	WI	Pepin	0.67
WV	Tyler	0.75	WI	Pierce	0.67
WV	Upshur	0.75	WI	Polk	0.67
WV	Wayne	0.75	WI	Portage	0.65
WV	Webster	0.75	WI	Price	0.67
WV	Wetzel	0.75	WI	Racine	0.65
WV	Wirt	0.75	WI	Richland	0.68
WV	Wood	0.75	WI	Rock	0.68
WV	Wyoming	0.75	WI	Rusk	0.67
WI	Adams	0.65	WI	Sauk	0.68
WI	Ashland	0.67	WI	Sawyer	0.67
WI	Barron	0.67	WI	Shawano	0.57
WI	Bayfield	0.67	WI	Sheboygan	0.59
WI	Brown	0.59	WI	St. Croix	0.67
WI	Buffalo	0.67	WI	Taylor	0.67
WI	Burnett	0.67	WI	Trempealeau	0.67
WI	Calumet	0.59	WI	Vernon	0.68
WI	Chippewa	0.67	WI	Vilas	0.67
WI	Clark	0.67	WI	Walworth	0.65
WI	Columbia	0.68	WI	Washburn	0.67
WI	Crawford	0.68	WI	Washington	0.65
WI	Dane	0.68	WI	Waukesha	0.65
WI	Dodge	0.68	WI	Waupaca	0.65
WI	Door	0.59	WI	Waushara	0.65
WI	Douglas	0.67	WI	Winnebago	0.59
WI	Dunn	0.67	WI	Wood	0.65
WI	Eau Claire	0.67			
WI	Florence	0.57			
WI	Fond Du Lac	0.59			
WI	Forest	0.57			
WI	Grant	0.68			
WI	Green	0.68			
WI	Green Lake	0.65			
WI	Iowa	0.68			
WI	Iron	0.67			
WI	Jackson	0.67			
WI	Jefferson	0.68			
WI	Juneau	0.65			
WI	Kenosha	0.65			
WI	Kewaunee	0.59			
WI	La Crosse	0.67			
WI	Lafayette	0.68			
WI	Langlade	0.57			
WI	Lincoln	0.67			
WI	Manitowoc	0.59			
WI	Marathon	0.67			
WI	Marinette	0.57			
WI	Marquette	0.65			
WI	Menominee	0.57			
WI	Milwaukee	0.65			
WI	Monroe	0.67			
WI	Oconto	0.57			

Appendix B. Hydraulic Calculations within Green LTCP-EZ, Schedule 4 –  
CSO Volume, and Schedules 5A and 5B – CSO Control

## Introduction

It is necessary to make several important estimates within Schedule 4-CSO Volume (and again in Schedule 5A-CSO RUNOFF CONTROL). These estimates are for quantification of the amount of combined sewage that overflows the amount of combined sewage that is diverted to an interceptor and transported to the WWTP and, in some instances, the amount of combined sewage that goes untreated at the WWTP. Continuous simulation hydrology and hydraulic models like the storm water management model (SWMM) are often applied for these purposes. However, in the spirit of keeping Green LTCP-EZ easy, simple relationships and equations were used instead of detailed models. This appendix describes the method used to make these estimations in the Green LTCP-EZ Template.

## Overflow Fraction of Combined Sewage

The fraction of runoff volume that overflows at the CSO hydraulic control at the lower end of a sub-sewershed is dependent on peak flow rate within the sub-sewershed (runoff plus dry-weather flow) and the hydraulic control capacity. The peak runoff rate ( $Q_p$ ) for the one-hour, 3-month rainfall is calculated with the rational method. Similarly, the total volume of runoff ( $V_t$ ) for the 24-hour, 3-month rainfall is also calculated with the rational method. The peak runoff rate is compared with the capacity of the hydraulic control to determine whether or not an overflow occurs. The volume of overflow ( $V_o$ ) depends on the shape of the runoff hydrograph through the 24-hour rainfall period.

Dimensional reasoning suggests that the ratio of overflow volume to total runoff volume is a function of the ratio of hydraulic control capacity to the peak runoff rate. It can be shown that, for a triangular hydrograph, the following relationship holds:

$$\frac{V_o}{V_t} = \left(1 - \frac{Q_r}{Q_p}\right)^2 \quad (1)$$

where  $V_o$  = volume of overflow (MG);  
 $V_t$  = total volume of runoff (MG);  
 $Q_r$  = hydraulic control or pump station capacity (MGD); and  
 $Q_p$  = peak runoff rate (MGD).

The overflow fraction of combined sewage in Schedule 4-CSO Volume is defined as the ratio of overflow volume to total volume, and is calculated as follows:

$$f_o = \left(1 - \frac{Q_r}{Q_p}\right)^2 \quad (2)$$

where  $f_o$  = overflow fraction of combined sewage [-].

The actual overflow volume is then computed as follows:

$$V_o = f_o \times V_t \quad (3)$$

The situation from which Equation 1 was derived is depicted in Figure B-1. Empirical studies show that actual runoff hydrographs are likely to be shaped more *concave up* relative to the triangular assumption, so that the fraction of overflow volume would be less than that predicted with Equation 1. To test this, the

RUNOFF block within the SWMM Model was used to generate runoff hydrographs from design storms of various lengths and for a variety of catchment characteristics. A series of fractional overflow volumes were then computed from the resulting hydrographs by varying the hydraulic control flow rate, and the fractional volumes were compared with Equation 1. Three sets of catchments (designated as set A, set B, and set C) were used. These catchments represent a wide range of CSO sub-sewershed conditions and are representative of the conditions that would typically be found in a CSO community. Set A consisted of 161 catchments with areas ranging from 2.7 to 174 acres, and ground slopes ranging from 0.0002 to 0.0173. Set B consisted of 161 catchments with areas ranging from 0.3 to 37 acres, and ground slopes ranging from 0.0024 to 0.129. Set C consisted of 101 catchments with areas ranging from 16 to 4630 acres, and ground slopes ranging from 0.004 to 0.100. The results are depicted in Figure B-2, which shows that the observed ratios of overflow volume (represented by the individual points) are below the predicted ratios of overflow volume for all regulator flow/peak flow ratios (represented by the solid line). This suggests that using Equation 1 will provide conservative estimates of the volume of overflow at a CSO hydraulic control.

Note that the model results from this test are dependent on the assumed shape of the design storm hyetograph. This test and the SWMM Model application were based on the third quartile distribution of heavy rainfall at a point, taken from Table 10 of *Rainfall Frequency Atlas of the Midwest* (Huff and Angel 1992<sup>2</sup>). Use of rainfall at a point was considered appropriate for the relatively small sewersheds of Green LTCP-EZ permittees (less than 1,000 acres). The third quartile distribution is specified for storms of 12 to 24 hours.

### ***Diversion Fraction of Combined Sewage***

It is intuitive that the volume of runoff diverted to the interceptor and the WWTP is the difference between the total volume of runoff and the volume that overflows. However, if the estimate of overflow volume is conservatively high (using Equation 1), calculating diversion by subtraction (that is,  $1 - \text{Equation 1}$ ) will tend to underestimate the volume diverted. An alternate approach called the Hyetograph Approach was developed to determine a better and more conservative estimate of the fraction of runoff diverted to the interceptor and the WWTP. The Hyetograph Approach is also based on the ratio of hydraulic control capacity to peak runoff rate. It is recognized that a small degree of *double counting* occurs when the two approaches are used together. That is, the total estimated overflow plus the total estimated conveyance slightly exceeds the total runoff plus dry weather sanitary flow. This is acceptable, however, in that it provides a conservative estimate for both quantities, rather than forcing one quantity to be conservative at the expense of the other.

The Hyetograph Approach assumes that the runoff hydrograph has the same shape as the rainfall hyetograph, and that the total volume diverted is simply the sum of the volumes less than  $Q_r$  added up over the course of the storm. This concept is graphically depicted in Figure B-3, and it was tested with a simple spreadsheet model. The hyetograph is again the third quartile distribution of heavy rainfall at a point. Fractional volumes were quantified with a simple spreadsheet model for a range of  $Q_r/Q_p$  ratios, and those results are shown in Figure B-4 as the Hyetograph Approach. Rather than developing a regression equation from the results, a lookup table was compiled for inclusion in the Green LTCP-EZ form and reproduced here as Table B-1. For comparison, Figure B-4 also shows the diverted fraction of runoff that would be calculated on the basis of  $1 - \text{Equation 1}$ .

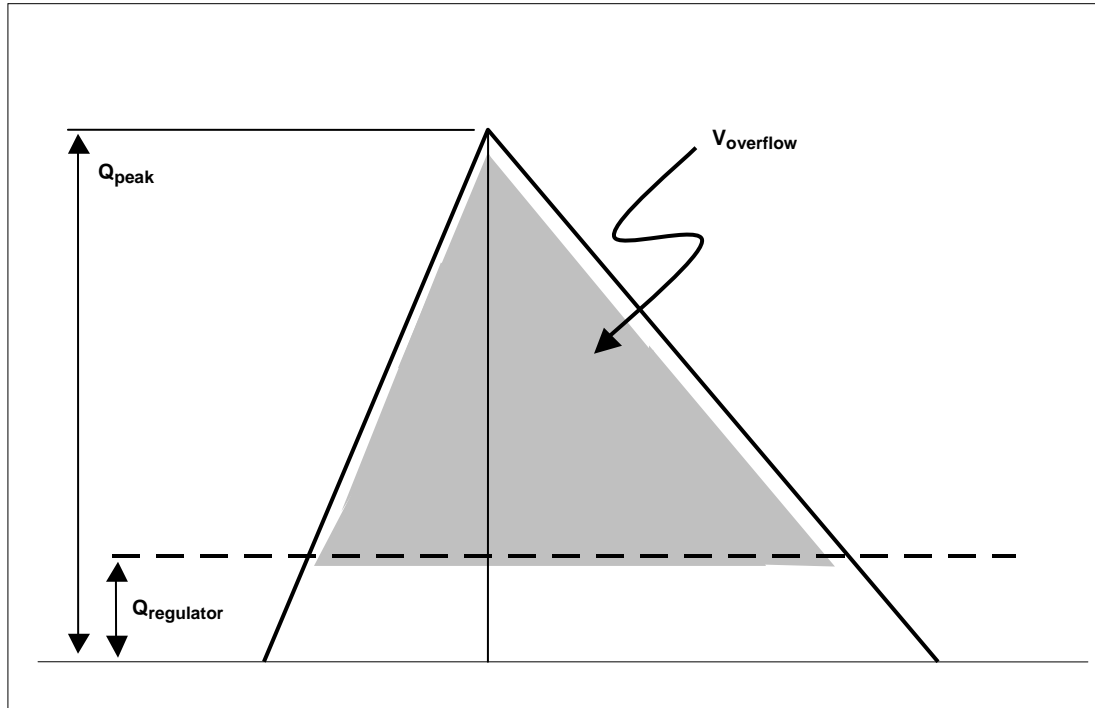
### ***Fraction of Combined Sewage Untreated at WWTP***

Similar to what occurs at a CSO hydraulic control, the fraction of combined sewage that overflows at the WWTP is dependent on the peak rate of sewage delivered to the WWTP and the primary treatment

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<sup>2</sup> Table 10 in *Rainfall Frequency Atlas of the Midwest* provides “the median distribution of heavy storm rainfall at a point.” Huff, Floyd A. and James R. Angel. *Rainfall Frequency Atlas of the Midwest*. Illinois State Water Survey, Champaign, Bulletin 71, 1992, pgs 20-21. (<http://www.isws.illinois.edu/pubdoc/B/ISWSB-71.pdf>, Date accessed October 22, 2009.)

capacity at the WWTP. The estimate of combined sewage that overflows or is untreated at the WWTP ( $V_o$ ) is also based on Equation 1 but with  $V_t$  equal to the total volume of sewage conveyed to the WWTP during the 24-hour rainfall event,  $Q_r$  equal to primary treatment capacity at the WWTP, and  $Q_p$  equal to the peak rate of sewage delivered to the WWTP. Use of Equation 1 for this estimation is also thought to be conservative in that it might slightly overestimate rather than underestimate the volume of combined sewage untreated at the WWTP.



**Figure B-1. Conceptual diagram of triangular runoff hydrograph**

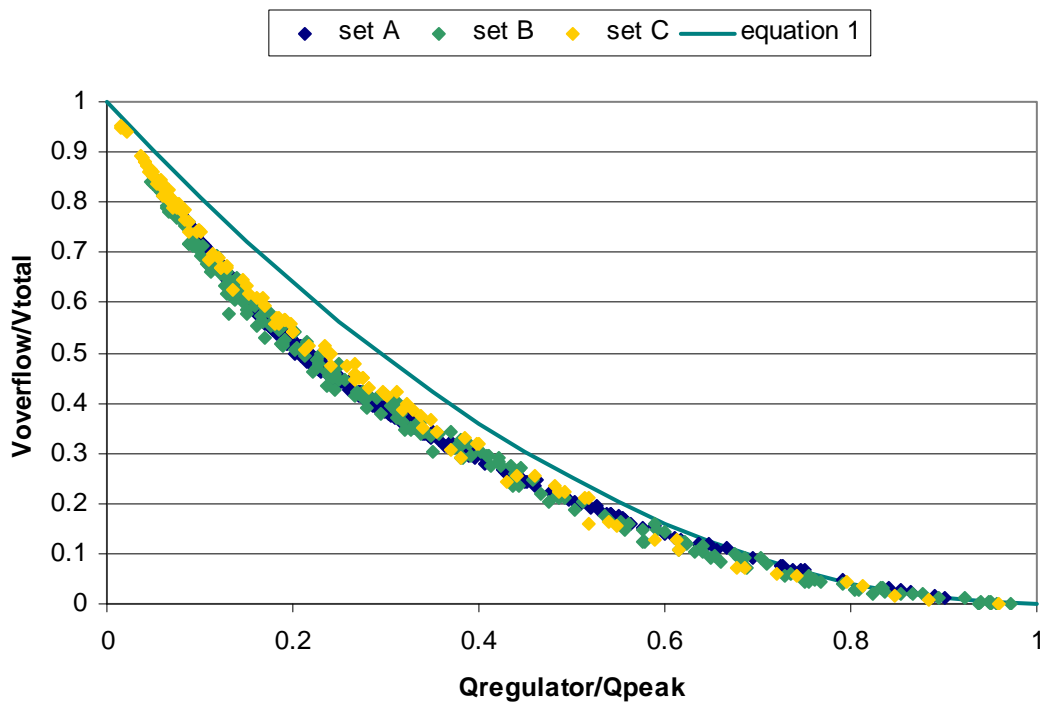


Figure B-2. Comparison of SWMM simulated overflow volumes with Equation 1.

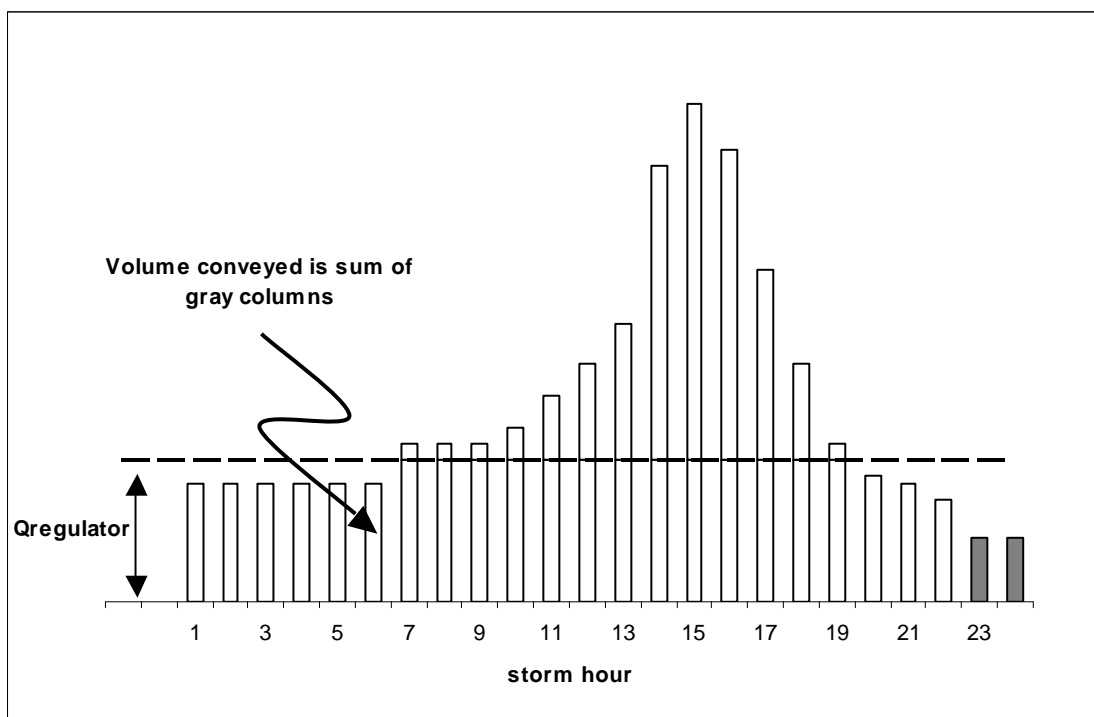


Figure B-3. Conceptual diagram of calculation of fraction diverted

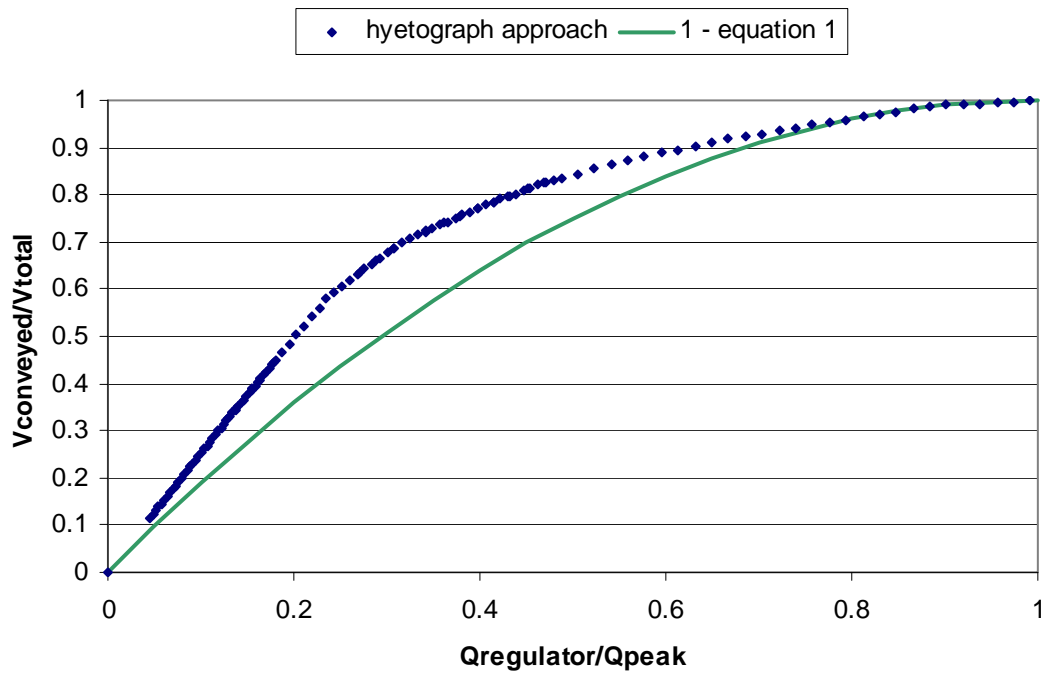


Figure B-4. Comparison of fraction conveyed by Hyetograph Approach versus Equation 1



**Table B-1. Fraction of total flow diverted to WWTP from 24-hour rainfall**

<b>Ratio of hydraulic control capacity to peak flow rate</b>	<b>Diversion fraction</b>
0.01 to 0.02	0.04
0.02 to 0.03	0.06
0.03 to 0.04	0.09
0.04 to 0.05	0.11
0.05 to 0.06	0.14
0.06 to 0.07	0.16
0.07 to 0.08	0.19
0.08 to 0.09	0.21
0.09 to 0.10	0.24
0.10 to 0.12	0.28
0.12 to 0.14	0.33
0.14 to 0.16	0.38
0.16 to 0.18	0.42
0.18 to 0.20	0.47
0.20 to 0.24	0.54
0.24 to 0.28	0.62
0.28 to 0.32	0.68
0.32 to 0.36	0.72
0.36 to 0.40	0.76
0.41 to 0.50	0.81
0.51 to 0.60	0.87
0.61 to 0.70	0.91
0.71 to 0.80	0.95
0.81 to 0.90	0.98
0.91 to 1.00	0.99

Appendix C. Cost Estimates for Green LTCP-EZ Template, Schedules 5A  
and 5B – CSO Control

This Appendix summarizes some of the cost estimate figures used in the Green LTCP-EZ Template Schedules 5A and 5B – CSO CONTROLS. Cost information is relative and depends on the location and market. Localized and/or site-specific costs should be used when they are available, because local values will give the most reliable results. Permittees should verify the actual cost for a better understanding of the effective cost analysis. However, EPA recognizes that local data will not always be available and has provided the information below, which is based on national data. Descriptions of how the cost estimates were derived are provided below.

### ***SCHEDULE 5A – CSO RUNOFF CONTROLS (Green Infrastructure Runoff Controls)***

#### ***Line 15 – Unit cost per square foot for green roof installation.***

The default value of \$20 per square foot was chosen as a median value from the published values below:

- Low Impact Development Center - \$15 to \$20/sq ft  
[http://www.lid-stormwater.net/greenroofs\\_cost.htm](http://www.lid-stormwater.net/greenroofs_cost.htm)
- Green Roofs for Healthy Cities - \$5 to \$20/sq ft  
<http://www.greenroofs.org/index.php>
- City of Portland, Bureau of Environmental Services, 2008 Cost Benefit Evaluation of Ecoroofs - \$15.750/sq ft
- Wetland Studies and Solutions, Inc. - \$31.80/sq ft  
[http://www.wetlandstudies.com/portals/4/docUpload/WSSI\\_LID\\_2007.pdf](http://www.wetlandstudies.com/portals/4/docUpload/WSSI_LID_2007.pdf)

#### ***Line 23 – Unit cost per square foot for bioretention installation.***

The default value of \$7 per square foot was chosen as a median value from the published values below:

- North Carolina State - \$2.32 to \$4.65/sq ft
- Brown and Schueler, 1997 -  $C = 7.3V^{0.99}$  with V in ft<sup>3</sup>
- The Economics of Stormwater BMPs in the Mid-Atlantic Region: Final Report.
- Center for Neighborhood Technology - \$7/sq ft  
<http://www.cnt.org/natural-resources/demonstration-projects/st-margaret-mary-church-case-study>
- Bannerman and Considine, 2003 - \$11/sq ft

#### ***Line 31– Unit cost per square foot for vegetated swale installation.***

The default value of \$15 per square foot was chosen as a median value from the published values below:

- City of Portland, Bureau of Environmental Services - \$5.50/sq ft
- Willamette Watershed Program - Task Memorandum 4.1 August 2005
- Water Environment Research Federation - \$15.00/sq ft
- Low Impact Development Best Management Practices Whole Life Cost Model 2007
- Center for Neighborhood Technology - \$24.00/sq ft  
<http://www.cnt.org/natural-resources/demonstration-projects/olgh-case-study>

#### ***Line 38– Unit cost per square foot for permeable pavement installation.***

The default value of \$7 per square foot was chosen as a median value from the published values below:

- Low Impact Development Center - \$5.50/sq ft  
[http://www.lowimpactdevelopment.org/lid%20articles/bigbox\\_final\\_doc.pdf](http://www.lowimpactdevelopment.org/lid%20articles/bigbox_final_doc.pdf)

- City of Portland, Bureau of Environmental Services - \$6.34/sq ft
- Willamette Watershed Program - Task Memorandum 4.1 August 2005
- Wetland Studies and Solutions, Inc. - \$7.10/sq ft  
[http://www.wetlandstudies.com/portals/4/docUpload/WSSI\\_LID\\_2007.pdf](http://www.wetlandstudies.com/portals/4/docUpload/WSSI_LID_2007.pdf)
- PlaNYC 2030 Sustainable Stormwater Management Plan - \$8.13/sq ft  
<http://www.nyc.gov/html/planyc2030/html/stormwater/stormwater.shtml>
- North Carolina Green Building Technology Database - \$11.60  
<http://www.ncgreenbuilding.org>

**Line 46– Unit cost per rain barrel/cistern capacity (gallons).**

The default value of \$1.25 per gallon was chosen as a median value from the published values below:

- Metropolitan Water Reclamation District of Greater Chicago – \$0.72/gal  
<http://www.mwrd.org/irj/portal/anonymous/rainbarrel>
- Water Environment Research Federation - \$1.45/gal
- Low Impact Development Best Management Practices Whole Life Cost Model 2007

**SCHEDULE 5B – CSO NETWORK and WWTP CONTROLS (Green Infrastructure Controls Network and WWTP Controls)**

**Line 5 –Unit cost of primary treatment per MGD**

EPA's document *Cost of Urban Storm Water Control* (EPA 600/R-02/021), January 2002, uses the following equation to estimate construction costs for off-line storage areas:

$$C = 2980 V^{0.62}$$

where

C = construction cost (\$ millions), in 1999 dollars

V = volume of storage system, in MG

The document indicates that this calculation is valid where 0.15 MG < volume < 30 MG

In addition to this equation, one cost value was collected from the literature. This cost is summarized below:

- Chamber Creek WWTP \$433,500/MG for primary treatment.  
<http://www.co.pierce.wa.us/xml/services/home/environ/planning/Appendix%20I.pdf>

**Line 21 – Unit cost for separation per acre**

Costs/acre of sewer separated:

- Seaford, Delaware: \$1,750
  - Skokie/Wilmette, Illinois: \$31,397
  - St. Paul, Minnesota: \$17,730
  - Portland, Oregon: \$19,000
  - Providence, Rhode Island: \$81,000
- These costs came from EPA's *Report to Congress: Impacts and Control of CSOs and SSOs*, August 2004 (EPA 833-R-04-001).

- Nashville Phase I – \$37,910 (\$6,634,372 for 175 acres)  
[http://www.atlantaga.gov/client\\_resources/mayorsoffice/special%20reports-archive/csositev.pdf](http://www.atlantaga.gov/client_resources/mayorsoffice/special%20reports-archive/csositev.pdf)
- Nashville Phase II – \$23,909 (\$12,552,277 for 525 acres)  
[http://www.atlantaga.gov/client\\_resources/mayorsoffice/special%20reports-archive/csositev.pdf](http://www.atlantaga.gov/client_resources/mayorsoffice/special%20reports-archive/csositev.pdf)
- Boston – ranged from \$60,000/acre for partially separated residential neighborhoods to \$190,000/acre for completely combined downtown. <http://books.nap.edu/books/0309048265/html/357.html>
- Atlanta - \$41,000/acre.  
[http://www.atlantaga.gov/client\\_resources/mayorsoffice/special%20reports-archive/csp.pdf](http://www.atlantaga.gov/client_resources/mayorsoffice/special%20reports-archive/csp.pdf)
- DCWASA - \$360,000/acre.  
<http://www.dcwasa.com/news/publications/Ops%20Minutes%20July%202004.pdf>

**Summary:** Sewer separation costs an average of approximately \$40,000/acre. This cost can be higher if the area to be separated is in a congested downtown.

Sewer separation costs per linear foot of sewer separated:

- Harbor Brook and Clinton sewer separation projects, Syracuse, New York, 2000. Cost was \$2,311,126 for 3812 feet of separated pipe, or \$606/ft. <http://www.lake.onondaga.ny.us/olpdf/ol303ad.pdf>
- Rouge River project - \$175-\$220/ft (CSO and SSO)
- Portsmouth, New Hampshire - ~\$500/ft (personal communication with Peter Rice, Portsmouth).

### ***Line 24 Unit cost per MG of storage***

EPA's document *Cost of Urban Storm Water Control* (EPA 600/R-02/021), January, 2002, uses the following equation to estimate construction costs for off-line storage areas:

$$C = 4.546 V^{0.826}$$

where

C = construction cost (\$ millions), in 1999 dollars

V = volume of storage system, in MG

The document indicates that this calculation is valid where 0.15 MG < volume < 30 MG.

In addition to this equation, a number of cost values were collected from the literature. These are summarized below:

- EPA's Report to Congress: Impacts and Control of CSOs and SSOs, August 2004 (EPA 833-R-04-001). Costs per MG of near surface storage ranged from < \$0.10 to \$4.61/gallon, with an average of \$1.75 gallon.
- EPA Combined Sewer Overflow Technology Fact Sheet: Retention Basins (EPA 832-F-99-032). Costs range from \$0.32 to \$0.98/gallon.
- Decatur McKinley - \$1.09/gallon.  
[http://www.nap.edu/catalog.php?record\\_id=2049#description](http://www.nap.edu/catalog.php?record_id=2049#description), pages 362-363.
- Decatur 7<sup>th</sup> Ward – \$0.76/gallon.  
[http://www.nap.edu/catalog.php?record\\_id=2049#description](http://www.nap.edu/catalog.php?record_id=2049#description), pages 362-363.

- Rouge River – range from \$2.86 to \$8.53/gallon of storage for aboveground facilities. The average was \$5.18/gallon.  
<http://www.rougeriver.com/cso/overview.html>
- San Francisco - \$2.35/gallon.  
<http://www.swrcb.ca.gov/rwqcb2/Agenda/07-16-03/07-16-03-fsheetattachments.doc>

**Summary:** On average, near surface storage costs \$2.00 per gallon of storage.

## Appendix D. Green Infrastructure Runoff Controls Fact Sheets and Additional Information for Schedule 5A – CSO Runoff Control

This Appendix presents fact sheets on the 6 green infrastructure technologies utilized by the Green LTCP-EZ (plus a fact sheet on the runoff reduction benefits available from tree planting). These fact sheets are intended to summarize some of the references and resources available to help users better understand the design, performance and implementation issues associated with green infrastructure. These resources are not a substitute for local design standards or guidance when available. The cost information provided in the fact sheets is relative and depends on the location and market. Permittees should verify the actual costs of these practices for their communities to provide for a more effective cost analysis.

The 6 green infrastructure technologies are:

- Green Roofs
- Rain Gardens
- Vegetated Swales
- Permeable Pavement
- Rain Barrels & Cisterns
- Constructed Wetlands

### **Overview and General Information References**

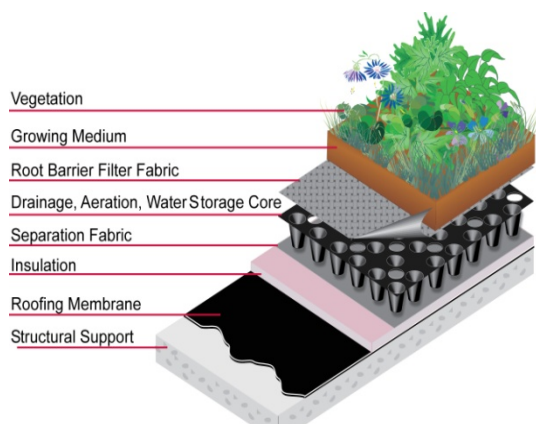
- *EPA Office of Wastewater Management (OWM), Managing Wet Weather with Green Infrastructure* Web site ([http://cfpub.epa.gov/npdes/home.cfm?program\\_id=298](http://cfpub.epa.gov/npdes/home.cfm?program_id=298)) – Contains information on EPA policies, case studies, technical information, and funding sources.
- *Center for Neighborhood Technology, Green Values Stormwater Toolbox* (<http://greenvalues.cnt.org/>) – Contains overview technical information and two green infrastructure stormwater calculators that can be used to estimate costs and benefits of various green infrastructure applications.
- *Center for Watershed Protection, Stormwater Manager's Resource Center* (<http://www.stormwatercenter.net/>) – Contains overview technical information, fact sheets, and design guidelines and manuals.
- *International Stormwater BMP Database* (<http://www.bmpdatabase.org/>) – Database of hundreds of BMPs performance studies (including many green infrastructure studies).
- *Water Environment Research Foundation (WERF), Livable Communities* Web site (<http://www.werf.org/livablecommunities/>) – Contains communication and implementation tools and resources and in-depth case studies.
- *Low Impact Development Center, LID Urban Design Tools* Web site, (<http://www.lid-stormwater.net/>) – Contains design tools, design examples, and in-depth case studies.

## Green Roofs

A green roof is a roof that is partially or completely covered with a layer of vegetation and growth medium over a waterproofing membrane. The depth of the planting medium, amount of maintenance and planted material varies depending on the design plan. Extensive green roofs have a thin soil layer and are lighter, less expensive and require less maintenance. Intensive green roofs are characterized by a deeper soil layer, are heavier, and have higher capital costs. Intensive green roofs may support an increased diversity of plants but also have a higher maintenance requirement.<sup>1</sup>

### Construction

Green roofs may be installed on a large or small scale either as a retrofit, or as part of new construction.<sup>2</sup> Prior to installation, roof structures must be capable of supporting the weight of an intensive or extensive green roof system. Once it is verified that the weight load can be accommodated, construction may begin. Most green roofs installed in North America consist of four distinct layers: an impermeable roof cover or roofing membrane, a lightweight drainage layer consisting of porous media capable of water storage, a geosynthetic layer to prevent fine soil media from clogging porous media soil or other lightweight planting or growth medium, and adapted vegetation.<sup>3,4</sup>



AMERGREEN prefabricated drain illustration published with permission from American Wick Drain Corporation.

### Benefits

The primary benefits of green roofs include retention of rainfall, reduction in stormwater quantity, and overall improvement of water quality.<sup>5</sup> Associated benefits may include enhanced stormwater management, reduced building energy demand associated with insulation of the green roof, reduced urban heat islands, improved air quality, reduced pollutant loads, and improved structural durability and roof longevity.<sup>6,7</sup> Moreover, green roofs may provide enhanced amenity value and habitat in urban areas.<sup>8</sup> For best stormwater management results, green roofs should be used in conjunction with other practices such as bio-infiltration and rain-gardens, where possible.

### Limitations

The greatest limitation to the installation and use of green roofs is cost relative to standard roofing practices. Estimates indicate that a new green roof may cost approximately \$15.52 per square foot and a retrofit may cost as much as \$25.87 per square foot (values inflated to January 2010 dollars).<sup>9</sup> Costs for a green roof are greater than conventional roofs which have construction costs of approximately \$10 per square foot.<sup>10</sup> For a 40,000 square foot roof, the increased cost associated for green roof installation ranges from \$220,800 to \$634,800 for a new and retrofitted roof, respectively. Despite lasting two to three times longer than a conventional roof,<sup>11</sup> having decreased replacement costs, and paying for itself within a 20 year roof life<sup>12</sup> many property owners remain hesitant to contribute the upfront costs necessary to install a green roof. However, A recent survey of 300 Brooklyn property owners found that approximately 77 percent of respondents would be willing to install a green roof on their property if cost neutral to a conventional roof.<sup>13</sup>



## Climate Considerations

Green roofs are appropriate for use in warm and cold climates given that the proper vegetation is installed. For example, research at the University of Toronto offers data suggesting that “winter green roofs,” composed of evergreens, juniper shrubs, and thicker soil base, provide heat loss and environmental benefits associated with standard green roofs.<sup>14</sup>

## CSO Impact

Stormwater retention by green roofs can vary seasonally and by media. During the summer months, a study determined nearly 95 percent of the precipitation was retained. During winter, retention was smaller



The Calhoun School, New York, NY. Courtesy of James D'Addio.

(<20 percent) and not significant. Seasonally adjusted, retention was approximately 50 percent of total precipitation during the study period.<sup>15</sup> Depending on media depth, annual runoff volume reductions can range from 40 percent (for 2 inch media)<sup>16</sup> to in excess of 50 percent for 3 inch media.<sup>17</sup>

A recent report published for New York City suggests that for every \$1,000 invested in new green roof construction, retrofits, and incentivized green roofs, will result in up to 810 gallons, 865 gallons, and 12,000 gallons of annual stormwater reductions, respectively.<sup>18</sup>

Computer modeling for the District of Columbia estimates that installing 20 million square feet of green roofs, 20 percent of the roof area for all city buildings over 10,000 square feet, over the next 20 years will result in citywide reduction in runoff of 1 percent and CSO discharges of 15 percent.<sup>19</sup> These modeling results suggest that green roofs are anticipated to retain and store 430 million gallons of rainwater annually.<sup>20</sup>

## Maintenance

Maintenance largely depends on the type of green roof system installed and the type of vegetation planted. Green roof maintenance may include watering, fertilizing and weeding and is typically greatest in the first two years as plants become established. Roof drains should be cleared when soil substrate, vegetation or debris clog the drain inlet. Basic maintenance for extensive vegetated covers typically requires about 3 man-hours per 1,000 square feet, annually.<sup>21</sup> Maintenance requirements in intensive systems are generally more costly and continuous, compared to extensive systems. The use of native vegetation is recommended to reduce plant maintenance in both extensive and intensive systems. Green roofs should be inspected frequently for leaks and other functional or structural concerns.<sup>22</sup>

## Costs

Green roofs cost from \$15.52 to \$25.87 per square foot to install (January 2010 dollars).<sup>23</sup> Roof retrofits and intensive roofs with soil deeper than 6 inches will be more expensive.<sup>24</sup> Operating and maintenance costs (January 2010 dollars) are estimated to be approximately \$1.74 per square foot per year.<sup>25</sup> Although green roof installation costs may be high, relative to other low-impact development BMPs, substantial cost savings may be observed in relation to decreased cooling and heating demand, avoided stormwater facility costs, increased roof longevity; and thus decreased life cycle costs.<sup>26</sup>

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- <sup>1</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.
  - <sup>2</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.
  - <sup>3</sup> Pennsylvania Association of Conservation Districts (PACD). (1998). *Pennsylvania Handbook of Best Management Practices for Developing Areas*. Harrisburg, PA. As cited in USEPA. (2009). *Green Roofs for Stormwater Runoff Control*. 81 pp. Available at: <<http://www.epa.gov/nrmrl/pubs/600r09026/600r09026.pdf>>.
  - <sup>4</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.
  - <sup>5</sup> Pennsylvania Association of Conservation Districts (PACD). (1998). *Pennsylvania Handbook of Best Management Practices for Developing Areas*. Harrisburg, PA. As cited in USEPA. (2009). *Green Roofs for Stormwater Runoff Control*. 81 pp. Available at: <<http://www.epa.gov/nrmrl/pubs/600r09026/600r09026.pdf>>.
  - <sup>6</sup> City of Portland Environmental Services. (2008). *Cost Benefit Evaluation of Ecoroofs*. 42 pp. Available at: <<http://www.portlandonline.com/BES/index.cfm?a=261053&c=50818>>.
  - <sup>7</sup> Velazquez, L. S. 2005. *Greenroofs.com*. Available at: <<http://www.greenroofs.com>>.
  - <sup>8</sup> Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <<http://www.nrdc.org/water/pollution/rooftops/contents.asp>>.
  - <sup>9</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.
  - <sup>10</sup> City of Portland Environmental Services. (2008). *Cost Benefit Evaluation of Ecoroofs*. 42 pp. Available at: <<http://www.portlandonline.com/BES/index.cfm?a=261053&c=50818>>.
  - <sup>11</sup> Penn State Green Roof Research. *About Green Roof Research*, Available at: <<http://hortweb.cas.psu.edu/research/greenroofcenter/history.html>>.
  - <sup>12</sup> Ballensky, D. (2006). *Built up roofs are expected to last 20 years. Roofing Life-Cycle Costs Emerge, Buildings*. Available at: <<http://www.buildings.com/ArticleDetails/tabid/3321/ArticleID/3187/Default.aspx>>.
  - <sup>13</sup> Montalto, F.A., Culligan, P.J., Behr, C.T., (2007). *Results of a property owner survey of acceptance of urban low impact development*. In: Montalto, F.A., Culligan, P.J. (Eds.), *Innovative Approaches to the Management of Urban Soil and Water*. ASCE Geotechnical Practice Publication, in preparation.
  - <sup>14</sup> University Of Toronto. (2005). *Green Roofs In Winter: Hot Design For A Cold Climate*. *Science Daily*. Available at: <<http://www.sciencedaily.com/releases/2005/11/051126141309.htm>> .
  - <sup>15</sup> USEPA. (2009). *Green Roofs for Stormwater Runoff Control*. 81 pp. Available at: <<http://www.epa.gov/nrmrl/pubs/600r09026/600r09026.pdf>>.
  - <sup>16</sup> Scholz-Barth, K. (2001). *Green roofs: Stormwater management from the top down*. *Environmental Design and Construction*. January/February. As cited in USEPA. (2009). *Green Roofs for Stormwater Runoff Control*. 81 pp. Available at: <<http://www.epa.gov/nrmrl/pubs/600r09026/600r09026.pdf>>.
  - <sup>17</sup> Miller, C. (1998). *Vegetated Roof Covers: A new method for controlling runoff in urbanized areas*. Proceedings: Pennsylvania Stormwater Management Symposium. Villanova University. Villanova, PA. As cited in USEPA. (2009). *Green Roofs for Stormwater Runoff Control*. 81 pp. Available at: <<http://www.epa.gov/nrmrl/pubs/600r09026/600r09026.pdf>>.
  - <sup>18</sup> Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: <<http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>>.
  - <sup>19</sup> Barbara Deutsch, et al. (2005). *Re-Greening Washington, DC: A Green Roof Vision Based On Storm Water and Air Quality Benefits*, Casey Tree Endowment Fund and LimnoTech, Inc., as cited in Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <<http://www.nrdc.org/water/pollution/rooftops/contents.asp>>.
  - <sup>20</sup> Barbara Deutsch, et al. (2005). *Re-Greening Washington, DC: A Green Roof Vision Based On Storm Water and Air Quality Benefits*, Casey Tree Endowment Fund and LimnoTech, Inc., as cited in Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <<http://www.nrdc.org/water/pollution/rooftops/contents.asp>>.
  - <sup>21</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <<http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>>.
  - <sup>22</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.
  - <sup>23</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

- <sup>24</sup> Peck, S. and M. Kuhn. *Design Guidelines for Green Roofs*. As cited in Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>.
- <sup>25</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>26</sup> City of Portland Environmental Services. (2008). *Cost Benefit Evaluation of Ecoroofs*. 42 pp. Available at: <http://www.portlandonline.com/BES/index.cfm?a=261053&c=50818>.

#### **Additional Resources for Green Roofs:**

- *Green Roofs for Healthy Cities, Green Roofs Tree of Knowledge* Web site (<http://greenroofs.org/grtok/>)  
Contains searchable database on green roofs research (including design and costs/benefits) and policy.
- *Green Roofs for Healthy Cities, Green Save Calculator* (<http://www.greenroofs.org/index.php/greensavecalc>)  
Allows user to compare cost of green roofs with conventional roofing systems.
- *North Carolina State University, Green Roof Research* Web site, (<http://www.bae.ncsu.edu/greenroofs/>)  
Contains background information and current performance research on green roofs.
- *Penn State, Center for Green Roof Research* Web site, (<http://horticulture.psu.edu/cms/greenroofcenter/>)  
Contains current performance research data related to green roofs.
- *Virginia Department of Conservation and Recreation, Stormwater Design Specifications* (<http://www.chesapeakestormwater.net/storage/first-draft-baywide-design-specifications/BAYWIDE%20No%205%20GREEN%20ROOF%20DESIGN%20SPECIFICATION.pdf>).  
Contains design specifications for green roofs.

## Rain Gardens

Rain gardens are man-made landscaped depressions designed to collect and store small volumes of stormwater runoff.<sup>1</sup> Rain gardens provide natural infiltration, directing stormwater to recharge groundwater rather than into storm drains.<sup>2</sup>

### Construction

Rain gardens, commonly used in residential settings,<sup>3</sup> are designed as passive filter systems, with or without an underdrain. Rain gardens typically require an area of 100 to 300 square feet, where water can collect and infiltrate.<sup>4</sup> Typical design generally includes an optional pretreatment, flow entrance, ponding area, a gravel drainage layer used for dispersed infiltration, organic or mulch layer, planting soil and filter media, plant material, sand bed and/or gravel base.<sup>5,6</sup> Stormwater directed into the rain garden temporarily ponds in the system and seeps into the soils over a period of one to two days. The ideal soil composition for infiltration typically contains 50 to 60 percent sand, 20 to 30 percent compost, and 20 to 30 percent topsoil.<sup>7</sup> Areas in which soils are not permeable enough to allow water to infiltrate and drain should be amended, to be closer to the ideal composition, prior to rain garden construction.



Rain Garden located at the Berkeley County Judicial Complex in Martinsburg, West Virginia. 29 April, 2008. Photo Courtesy of: Sherry Wilkins, WVDE.

### Benefits

Rain gardens provide many benefits; the most notable include pollutant treatment, groundwater recharge augmentation, addition of micro-scale habitat, aesthetic improvement, and transpiration via the planted vegetation.<sup>8</sup>

### Limitations

Rain gardens are fully functional in most settings. The most notable limitations to rain gardens are design limitations. For example, rain gardens require relatively flat slopes, augmentation based on soil type may be necessary to provide appropriate infiltration, and rain gardens cannot be used to treat large drainage areas including parking lots or roadway runoff.<sup>9</sup>

### Climate Considerations

Rain gardens are appropriate for almost every climate in the United States.<sup>10</sup> However, since rain gardens rely on a successful plant community to stabilize the ponding area, promote infiltration, and uptake pollutants, plant species must be selected that are adaptable to the given climate.<sup>11</sup> For best results, native plant species are suggested for planting.

### CSO Impact

Several studies have demonstrated that the installation of rain gardens can reduce CSO volume. One residential area model simulation suggested a 36 percent reduction in combined sewer overflow volume during major storm events, assuming 100 percent implementation of the rain gardens' design plan.<sup>12</sup> A hydraulic modeling study for the Norwood Park sewershed, a neighborhood outside of Chicago, Illinois,

determined that three-inch and six-inch-deep rain gardens installed at each home could reduce total runoff volume by approximately 4 percent and 7 percent, respectively, for the same six-month or one-year storm events.<sup>13</sup>

### Maintenance

Properly designed and installed rain gardens require regular maintenance. Rain gardens require living plants; thus pruning and weeding may be required, particularly during vegetation establishment. Mulch should be reapplied as needed when erosion is evident or once every 2 to 3 years. Rain gardens should be inspected at least two times per year for sediment buildup, detritus, erosion, etc. Trees and shrubs should be inspected twice per year to evaluate health.<sup>14</sup> During periods of extended drought, rain gardens may require watering.



Trent Street Rain Gardens, Victoria, BC, Canada. Courtesy of Murdoch de Greeff Inc.

### Costs

Construction costs associated with rain gardens vary depending on installation costs, size, and native plants selected. A recent study generalized the inflated cost for bioretention construction as follows:<sup>15</sup>

Construction, design and permitting cost =  $7.30 (\text{Volume of water treated by the facility, ft}^3)^{0.99}$

For self-installed rain gardens, costs inflated to January 2010 dollars generally range between \$3.88 and \$6.47 per square foot. Costs associated with hiring a landscaping company to install a residential rain garden can be in excess of \$15 per square foot (January 2010 dollars).<sup>16,17</sup> Operating and maintenance costs are estimated at 5.0 to 10.9 percent of the construction costs, annually. Based on a construction cost of approximately \$15, annual operation and maintenance costs (January 2010 dollars) are estimated to be approximately \$1.69/per square feet of drainage.<sup>18</sup>

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<sup>1</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>2</sup> Clean Water Campaign. *Rain Gardens for Home Landscapes*. 2 pp. Available at: <[http://www.epa.gov/owow/keep/NPS/toolbox/other/cwc\\_raingardenbrochure.pdf](http://www.epa.gov/owow/keep/NPS/toolbox/other/cwc_raingardenbrochure.pdf)>.

<sup>3</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>4</sup> Wisconsin Department of Natural Resources. (2003). *Rain Gardens: A how-to manual for homeowners*. 32 pp. Available at: <<http://dnr.wi.gov/org/water/wm/dsfm/shore/documents/rqmanual.pdf>>.

<sup>5</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <<http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>>.

<sup>6</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>7</sup> Clean Water Campaign. *Rain Gardens for Home Landscapes*. 2 pp. Available at: <[http://www.epa.gov/owow/keep/NPS/toolbox/other/cwc\\_raingardenbrochure.pdf](http://www.epa.gov/owow/keep/NPS/toolbox/other/cwc_raingardenbrochure.pdf)>.

<sup>8</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>9</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Bioretention (Rain Gardens)*. Available at: <[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=7](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=7)>.



- <sup>10</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Bioretention (Rain Gardens)*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=72&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72&minmeasure=5).
- <sup>11</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>12</sup> The Civic Federation. (2007). *Managing Urban Stormwater with Green Infrastructure: Case Studies of Five U.S. Local Governments*. Prepared for The Center for Neighborhood Technology. 56 pp. Available at: [http://www.cnt.org/repository/GreenInfrastructureReportCivicFederation\\_percent2010-07.pdf](http://www.cnt.org/repository/GreenInfrastructureReportCivicFederation_percent2010-07.pdf).
- <sup>13</sup> Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <http://www.nrdc.org/water/pollution/rooftops/contents.asp>.
- <sup>14</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>15</sup> Brown, W., and T. Schueler. (1997). *The Economics of Stormwater BMPs in the Mid-Atlantic Region*. Prepared for Chesapeake Research Consortium. Edgewater, MD. Center for Watershed Protection. Ellicott City, MD. As cited in USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Bioretention (Rain Gardens)*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=72&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72&minmeasure=5).
- <sup>16</sup> The Groundwater Foundation. *Rain Gardens 101*. Available at <http://www.groundwater.org/ta/raingardens.html>.
- <sup>17</sup> Wisconsin Department of Natural Resources. (2003). *Rain Gardens: A how-to manual for homeowners*. Available at: <http://dnr.wi.gov/org/water/wm/dsfm/shore/documents/rqmanual.pdf>.
- <sup>18</sup> Weiss, P.T., J. S. Gulliver and A. J. Erickson, (2005). *The Cost and Effectiveness of Stormwater Management Practices*. Prepared for Minnesota Department of Transportation. Report 2005-23. Available at: <http://www.lrrb.org/pdf/200523.pdf>.

#### Additional Resources on Rain Gardens and Bioretention:

- *Los Angeles County BMP Design Criteria* ([http://www.ci.chula-vista.ca.us/City\\_Services/Development\\_Services/Engineering/PDF%20Files/StormWaterManual/B-1.pdf](http://www.ci.chula-vista.ca.us/City_Services/Development_Services/Engineering/PDF%20Files/StormWaterManual/B-1.pdf)) – Contains design protocols and considerations for bioretention applications
- *University of Wisconsin – Madison, Civil & Environmental Engineering Department, RECARGA* (<http://dnr.wi.gov/runoff/stormwater/technote.htm>) – Bioretention sizing tool
- *North Carolina State University, Bioretention Web site*, (<http://www.bae.ncsu.edu/topic/bioretention/>) – Contains background information and current performance research on bioretention applications
- *Prince George's County, Maryland Bioretention Design Specifications and Criteria*, (<http://www.princegeorgescountymd.gov/der/bioretention.asp>) – Contains siting and design criteria for bioretention facilities
- *Virginia Department of Conservation and Recreation, Stormwater Design Specifications* (<http://www.chesapeakestormwater.net/storage/first-draft-baywide-design-specifications/BAYWIDE%20No%209%20BIORETENTION%20DESIGN%20SPECIFICATION.pdf>) – Contains design specifications for bioretention facilities

## Vegetated Swales

Vegetated swales, including the design variations of grassed channels, dry swales, wet swales, biofilters, and bioswales, are turf-lined open drainage channels designed to slow runoff, promote the infiltration of stormwater into the soil media, and reduce pollutant loads in the process of conveying runoff.<sup>1</sup>

### Construction

Swales are constructed as broad, shallow, trapezoidal or parabolic, channels and are often heavily vegetated with close growing, water-resistant, high pollutant removal plants.<sup>2</sup> Longitudinal slopes should be as low as possible, and never more than 4 percent. A small forebay should be used at the front of the swale to trap incoming sediments.<sup>3</sup> Vegetation is typically underlain by at least 24 inches of permeable soil and/or sand<sup>4</sup> to provide significant volume reduction and reduce the stormwater conveyance rate.<sup>5</sup> The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour and contain a high level of organic material to enhance pollutant removal. Swales should be designed to treat runoff from small drainage areas (less than 5 acres), so that the volume of flow does not overwhelm the filtering abilities of the BMP.<sup>6</sup>

### Benefits

Swales slow runoff velocity, filter out stormwater pollutants, reduce runoff temperatures, and under certain conditions, infiltrate runoff into the ground as groundwater.<sup>7</sup> Since swales may discretely blend in with existing landscape features, they can also provide an aesthetic enhancement, particularly if native vegetation is utilized.

### Limitations

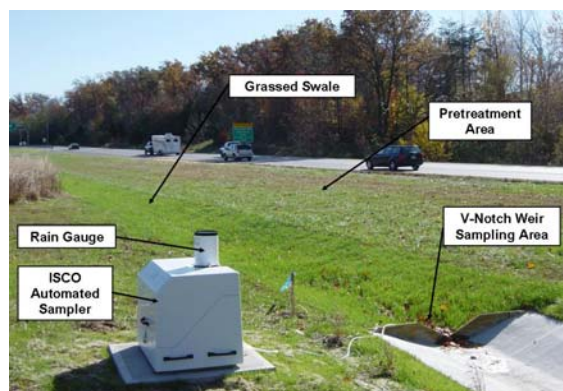
A major concern when designing swales is ensuring that excessive stormwater flows, slope, and other factors do not combine to produce erosive flows that may exceed the capacity of the swale. See above for construction specifications to ensure the most effective use of swales. Swales generally cannot treat drainage acres over 5 acres.<sup>8</sup>

### Climate Considerations

Swales can be applied in most regions of the United States. In arid and semi-arid climates, however, the value of installing and maintaining swales should be weighed against the needed to irrigate them.<sup>9</sup> If swales are to be implemented in arid or semi-arid climates, swales should be designed with drought-tolerant vegetation, such as buffalo grass.

### CSO Impact

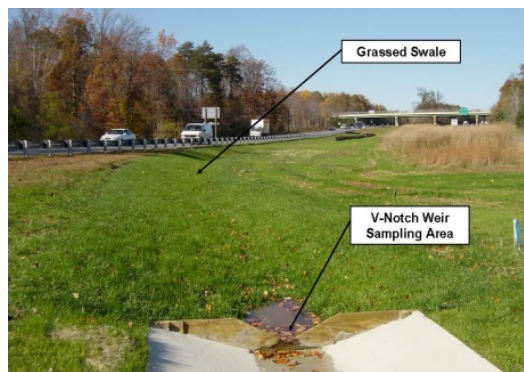
A study of a recent stormwater management project using bioswales in Portland, OR, estimated that implantation removed 1 million gallons of stormwater annually from the combined sewer system.<sup>10</sup> Reduction in stormwater flow to the combined sewer system may ultimately decrease the occurrence and severity of CSOs in the surrounding sewershed.



Grass Swale constructed in median on MD route 32 near Savage, MD. Courtesy of: James Stagge & Allen P. Davis, University of Maryland.

## Maintenance

Compared to other stormwater management measures, the required upkeep of vegetated swales is relatively low. Maintenance strategies focus on sustaining the hydraulic and pollutant removal efficiency of the channel, as well as maintaining a dense vegetative cover. The following maintenance activities are suggested annually, and within 48 hours after every major storm event: inspect and correct erosional problems, damage to vegetation, and sediment and debris accumulation; inspect vegetation on side slope for erosion and formation of gullies; inspect for pools of standing water; mow and trim vegetation to ensure safety, aesthetics and proper operation; inspect for litter and remove litter as appropriate; inspect for uniformity in cross-section and longitudinal slope; inspect inlet and outlet for signs of blockage, correct as needed.<sup>11</sup> Swales should be irrigated if implemented in arid or semi-arid climates.<sup>12</sup>



Grass Swale constructed in median on MD route 32 near Savage, MD. Courtesy of: James Stagge & Allen P. Davis, University of Maryland.

## Costs

The cost of installing and maintaining swales varies widely with design, local labor and material rates, real estate value, and contingencies. In general, swales are considered a relatively low cost control measure<sup>13</sup> at an implementation cost of approximately \$7.66 per square foot of swale (January 2010 dollars).<sup>14</sup> Annual operation and maintenance costs range from 5 to 7 percent of construction costs, or \$0.54 per square foot based on a construction cost of \$7.66 per square foot.<sup>15</sup>

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- <sup>1</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).
- <sup>2</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>3</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).
- <sup>4</sup> Tredyffrin Township, Chester County Pennsylvania Department of Public Works. *Vegetated Swale*. 9 pp. Available at: [http://www.tredyffrin.org/pdf/publicworks/CH2\\_percent20-percent20BMP2\\_percent20Vegetated\\_percent20Swale.pdf](http://www.tredyffrin.org/pdf/publicworks/CH2_percent20-percent20BMP2_percent20Vegetated_percent20Swale.pdf).
- <sup>5</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>6</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).
- <sup>7</sup> Charles River Watershed Association. (2008). *Low Impact Best Management Practice (BMP) Information Sheet: Vegetated Swale*. 2pp. Available at: [http://www.crrwa.org/projects/bmpfactsheets/crrwa\\_vegetated\\_swale.pdf](http://www.crrwa.org/projects/bmpfactsheets/crrwa_vegetated_swale.pdf).
- <sup>8</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).



- <sup>9</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).
- <sup>10</sup> Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <http://www.nrdc.org/water/pollution/rooftops/contents.asp>.
- <sup>11</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>12</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Grassed Swales*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=75&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75&minmeasure=5).
- <sup>13</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>14</sup> Stormwater Manager's Resource Center. *Stormwater management Fact Sheet: Grass Channel*. Available at: [http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6\\_Stormwater\\_Practices/Open%20Channel%20Practice/Grassed%20Channel.htm](http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Open%20Channel%20Practice/Grassed%20Channel.htm).
- <sup>15</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.

#### **Additional Information on Vegetated Swales:**

- *Los Angeles County BMP Design Criteria* ([http://www.ci.chula-vista.ca.us/City\\_Services/Development\\_Services/Engineering/PDF%20Files/StormWaterManual/B-13.pdf](http://www.ci.chula-vista.ca.us/City_Services/Development_Services/Engineering/PDF%20Files/StormWaterManual/B-13.pdf)) – Contains design protocols and considerations for vegetated swales
- *Virginia Department of Conservation and Recreation, Stormwater Design Specifications* (<http://www.chesapeakestormwater.net/storage/first-draft-baywide-design-specifications/BAYWIDE%20No%203%20GRASS%20CHANNEL%20SPECIFICATION.pdf>) – Contains design specifications for grass channels
- *University of Florida, Field Guide to Low Impact Development* ([http://buildgreen.ufl.edu/Fact\\_sheet\\_Bioswales\\_Vegetated\\_Swales.pdf](http://buildgreen.ufl.edu/Fact_sheet_Bioswales_Vegetated_Swales.pdf)) – Contains overview and design considerations for vegetated channels
- *Indianapolis SustainIndy, Swale Fact Sheet* (<http://www.sustainindy.org/assets/uploads/4.7%20Swales.pdf>) – Contains example of municipal design considerations for vegetated channels

## Porous Pavement and Permeable Pavers

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Permeable pavement is a class of paving materials that allow for the movement of water in and around the paving material. Permeable pavement is designed to infiltrate stormwater runoff through the surface and has two basic design variations: porous pavement and permeable pavers.<sup>1</sup>

### Construction

Porous pavement, similar in look to conventionally paved surfaces, is constructed from a permeable surface, generally concrete or asphalt, and has three main design components: surface, storage, and overflow.<sup>2</sup> Porous pavement is underlain by a choke course, open-graded base reservoir, open-graded subbase reservoir, optional underdrain, optional geotextile liner, and subgrade. An underdrain provides



Porous pavement close-up, Aurora, CO. Courtesy of: *The Colorado Association of Stormwater and Floodplain Managers (CASFM)*.

peak flow control so that water levels do not rise to the pavement level during large storm events.<sup>3</sup> A geotextile layer may be used to separate the subbase from the subgrade and prevent the migration of soils into the aggregate subbase or base.<sup>4</sup> As stormwater drains through the surface, it is temporarily held in the voids of the paving medium, and then slowly drains into the underlying, uncompacted soil.<sup>5</sup>

Permeable pavers, including reinforced turf, interlocking concrete modules, and brick pavers, do not require the same level of design intensity when compared to porous pavement. Permeable pavers are generally not as extensive in depth, and generally have no underground

stone reservoir.<sup>6</sup> However, these systems may provide some level of infiltration through the permeable surface to the ground and may be an important source of erosion control.

### Benefits

Porous pavement can dramatically reduce the rate and volume of runoff by providing temporary stormwater storage, can recharge the groundwater, promote infiltration, and improve water quality. Porous pavement has gained acceptance as a construction material for low traffic roads, parking lots, sidewalks, among others.<sup>7</sup> Permeable pavers are gaining acceptance for use in single-family residential driveways, sidewalks, plazas, and courtyard areas.<sup>8</sup> Permeable pavers may also provide aesthetic improvements in addition to the aforementioned stormwater management benefits.

### Limitations

The most significant limitation to use of porous pavement is the higher costs associated with installation as well as operation and maintenance cost<sup>9</sup>, relative to standard paving practices. A recent survey of 300 Brooklyn property owners found that approximately 79 percent of respondents would be willing to install porous pavement if cost neutral to other “gray” practices.<sup>10</sup> However, without subsidies, porous pavement in many areas may still be more expensive than traditional asphalt.<sup>11</sup> Additional limitations may be site specific including unsuitable grade and subsoils, and/or high flow volume sites which may be unsuitable for implementation of this BMP.

## Climate Considerations

Freeze-thaw cycles tend to not adversely affect porous pavement or permeable pavers because water drains through the surface and into the subsurface bed. In northern climates, porous pavement has less of a tendency to form black ice, require less plowing, and develops fewer cracks than conventional asphalt.<sup>12</sup> Some regional limitations associated with porous pavement including subsurface soil types, depths, and underlying soil permeability should be examined prior to implementation.<sup>13</sup>

## CSO Impact

USEPA research recognizes porous pavement as a cost-effective approach to reducing CSOs and improving urban water quality.<sup>14</sup> In a set of experiments in Athens, Georgia, a porous parking lot built over low permeability, clay-rich soils was found to produce 93 percent less runoff than a standard asphalt lot, as measured during nine different storms each totaling between 0.3 and 1.85 cm of rainfall.<sup>15</sup> Modeling data suggests maximum implementation of porous pavement alone may generate CSO reductions of approximately 11 percent.<sup>16</sup>



Permeable Pavers at the transit center parking lot in Mound, Minnesota. Courtesy of: Julie Westerlund, MN DNR.

## Maintenance

Porous pavement requires extensive maintenance compared with other practices, given the potential for clogging of the porous surface. To ensure the proper function of porous pavement the following activities should be completed on a monthly cycle: ensure that the paving area is clean of debris; ensure that the paving dewaterers between storms; ensure that the area is clean of sediment. The surface should be inspected annually for signs of deterioration. The surface should be vacuum swept as needed to keep it free of sediment.<sup>17</sup> Similar maintenance activities should be considered for permeable pavers. Properly installed and maintained porous pavement has a significant lifespan, in excess of 20 years.<sup>18</sup>

## Costs

Porous pavement is significantly more expensive than traditional asphalt. Porous pavement can range from \$3.93 to \$5.90 per square foot (January 2010 dollars), depending on the design.<sup>19</sup> In comparison to conventional pavement, porous pavement can cost \$45,000 to \$100,000 more per impervious acre treated.<sup>20</sup> Annual operation and maintenance costs are roughly 4 percent of capital costs, or approximately \$2.63 per square foot (January 2010 dollars).<sup>21</sup>

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<sup>1</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>2</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>3</sup> USEPA. (2009). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Porous Asphalt Pavement*. Available at: <[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=135&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=135&minmeasure=5)>.

<sup>4</sup> USEPA. (2009). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Porous Asphalt Pavement*. Available at: <[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=135&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=135&minmeasure=5)>.

- <sup>5</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>6</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>7</sup> Ferguson, B.K.. (2005). *Porous Pavements*. Taylor & Francis, Boca Raton, FL, 577 pp. As cited in Montalto, F., Behr, C., Alfredo, K., Wolf, M., Arye, M., and Walsh, M. (2007). *Rapid assessment of the cost-effectiveness of low impact development for CSO control*. *Landscape and Urban Planning*. 82:117-131.
- <sup>8</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>9</sup> The Center for Neighborhood Technology, prepared by The Civic Federation. (2007). *Managing Urban Stormwater with Green Infrastructure: Case Studies of Five U.S. Local Governments*. 56 pp. Available at: <http://www.cnt.org/repository/GreenInfrastructureReportCivicFederation%2010-07.pdf>.
- <sup>10</sup> Montalto, F., Behr, C., Alfredo, K., Wolf, M., Arye, M., and Walsh, M. (2007). *Rapid assessment of the cost-effectiveness of low impact development for CSO control*. *Landscape and Urban Planning*. 82:117-131.
- <sup>11</sup> The Civic Federation. (2007). *Managing Urban Stormwater with Green Infrastructure: Case Studies of Five U.S. Local Governments*. Prepared for The Center for Neighborhood Technology. 56 pp. Available at: <http://www.cnt.org/repository/GreenInfrastructureReportCivicFederation percent2010-07.pdf>.
- <sup>12</sup> USEPA. (2009). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Porous Asphalt Pavement*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menueofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=135&minmeasure=5](http://cfpub.epa.gov/npdes/stormwater/menueofbmps/index.cfm?action=factsheet_results&view=specific&bmp=135&minmeasure=5).
- <sup>13</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>14</sup> Field, R., Masters, H., Singer, M. (1982). *Status of porous pavement research*. *Water Research*. 16: 849–858.
- <sup>15</sup> Dreelin, E.A., Fowler, L., Carroll, C.R. (2006). *A Test of Porous Pavement Effectiveness on Clay Soils During Natural Storm Events*. *Water Research*. 40: 799–805.
- <sup>16</sup> Montalto, F., Behr, C., Alfredo, K., Wolf, M., Arye, M., and Walsh, M. (2007). *Rapid assessment of the cost-effectiveness of low impact development for CSO control*. *Landscape and Urban Planning*. 82:117-131.
- <sup>17</sup> Watershed Management Institute (WMI). (1997). *Operation, Maintenance, and Management of Stormwater Management Systems*. Prepared for US EPA Office of Water. Washington, DC.
- <sup>18</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>.
- <sup>19</sup> The Stormwater Manager's Resource Center. *Stormwater Management Fact Sheet Porous Pavement*. Available at: [http://www.stormwatercenter.net/Assorted percent20Fact percent20Sheets/Tool6\\_Stormwater\\_Practices/Infiltration percent20Practice/Porous percent20Pavement.htm](http://www.stormwatercenter.net/Assorted percent20Fact percent20Sheets/Tool6_Stormwater_Practices/Infiltration percent20Practice/Porous percent20Pavement.htm)
- <sup>20</sup> The Stormwater Manager's Resource Center. *Stormwater Management Fact Sheet Porous Pavement*. Available at: [http://www.stormwatercenter.net/Assorted percent20Fact percent20Sheets/Tool6\\_Stormwater\\_Practices/Infiltration percent20Practice/Porous percent20Pavement.htm](http://www.stormwatercenter.net/Assorted percent20Fact percent20Sheets/Tool6_Stormwater_Practices/Infiltration percent20Practice/Porous percent20Pavement.htm)
- <sup>21</sup> California Stormwater Quality Association. (2003). *California Stormwater BMP Handbook: New Development and Redevelopment: Pervious Pavement*. 10 pp. Available at: <http://www.cabmphandbooks.com/Documents/Development/SD-20.pdf>

#### **Additional resources on Porous Pavement and Permeable Pavers:**

- *Los Angeles County BMP Design Criteria* ([http://www.ci.chula-vista.ca.us/City\\_Services/Development\\_Services/Engineering/PDF%20Files/StormWaterManual/B-10.pdf](http://www.ci.chula-vista.ca.us/City_Services/Development_Services/Engineering/PDF%20Files/StormWaterManual/B-10.pdf)) – Contains design protocols and considerations for permeable pavement applications
- *University of New Hampshire Stormwater Center, Design Specifications for Porous Asphalt Pavement and Infiltration Beds* ([http://www.unh.edu/erg/cstev/pubs\\_specs\\_info/unhsc\\_pa\\_spec\\_posted\\_06\\_09.pdf](http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_spec_posted_06_09.pdf)) – Contains design specifications for permeable asphalt applications
- *North Carolina State University, Permeable Pavement Research Web site*, (<http://www.bae.ncsu.edu/info/permeable-pavement/>) – Contains background information and current performance research on permeable pavement applications

- *Virginia Department of Conservation and Recreation, Stormwater Design Specifications*  
(<http://www.chesapeakestormwater.net/storage/first-draft-baywide-design-specifications/BAYWIDE%20No%207%20PERMEABLE%20PAVERS.pdf>) – Contains design specifications for permeable pavers

## Rain Barrels and Cisterns

Rain barrels and cisterns are on-site rainwater collection systems, designed to collect roof stormwater runoff.<sup>1</sup>

### Construction

Rain barrels are generally above ground residential systems while cisterns are for commercial and/or industrial sites. Rain barrels can be created from any water-retaining material from an on-site or pre-manufactured source.<sup>2</sup> Rain barrels often hold between 55 to 250 gallons with 55 to 75 gallon barrels being the most commonly used sizes.<sup>3</sup>

Cisterns are large, underground or surface containers. Cisterns are generally constructed from fiberglass, steel, concrete, plastic, or brick. A typical cistern holds tens of thousands of gallons.<sup>4</sup>

The basic components of a rain barrel or cistern include a connection to the gutter downspout, watertight storage container, secure cover, debris/mosquito screen, coarse inlet filter with clean-out valve, overflow pipe, manhole or access hatch, drain for cleaning, hose connection for water reuse, and extraction system (tap or pump).<sup>5</sup> Additional features may include a water level indicator, sediment trap, or connector pipe to an additional tank for extra storage volume.<sup>6</sup>



Typical 55-gallon rain barrel. Photo courtesy of Lexington-Fayette Urban County Government (KY)

### Benefits

Benefits from rain barrels include applications from water re-use and reductions in stormwater volume. Captured water from rain barrels and cisterns may be re-used for irrigation, landscaping, sidewalk cleaning, industrial use, firefighting, or, in more elaborate systems, connected to the buildings cooling towers or plumbing for use in toilets.<sup>7</sup> Benefits related to reductions in stormwater volume include reductions in transportation of pollutants, especially heavy metals, associated with atmospheric deposition on rooftops into receiving waters and reduced water consumption for nonpotable uses.<sup>8</sup>

### Limitations

The biggest limitation to the installation and use of rain barrels and cisterns is the need for active management/maintenance and initial capital cost.<sup>9</sup> Generally, the ease and efficiency of municipal water supply systems and the low cost of potable water discourage people from implementing on-site rainwater collection and reuse systems. Improper or infrequent use of the collection system by the property owner, such as neglecting to empty the rain barrel between storm events, may result in unintended discharges.<sup>10</sup>

### Climate Considerations

Climate is an important consideration for rain barrel and cistern use as the system should be designed to account for freezing potential. Rain barrels and cisterns placed on the ground require extra insulation on the exposed surfaces which may include lining the intake pipe with heat tape and closing the overflow valve. Water levels must be lowered at the beginning of winter to prevent possible winter ice damage and provide the needed storage for capturing rooftop runoff from snow melt. The year round use of rain barrels in cold climates is not recommended since bursting may occur due to ice formation and freezing

temperatures.<sup>11</sup> It is recommended that disconnection occur from the roof gutters during winter months. During the time in which the rain barrel or cistern is disconnected downspout piping must be reconnected and directed to a grassy area away from the structure to prevent winter snowmelt from damaging building foundations.

### CSO Impact

Rain barrels and the associated stormwater captured can significantly reduce stormwater runoff into sewers. The City of Milwaukee found that attaching rain barrels to 40,000 houses could decrease runoff by 273 million gallons per year and decrease water treatment plant operation costs during light rainfall.<sup>12</sup>

### Maintenance

Rain barrel maintenance is not complicated when compared to other green practices. The following components should be inspected at least twice a year and repaired or replaced as needed: roof catchment, gutters, downspout, entrance at rain barrel, runoff /overflow pipe, and spigot.<sup>13</sup> On a monthly cycle the rain barrel should be emptied to allow for more rooftop runoff and decrease the likelihood of algal growth. Once a year the rain barrel should be tipped over and rinsed out with a hose. Leaks in rain barrels can be repaired with aquarium caulk, or a clear sealant available at most hardware stores.<sup>14</sup> Maintenance of cisterns is similar to rain barrels, although on a much larger scale.<sup>15</sup> The tank of a cistern should be cleaned out about once a year if debris is present. Screens should be cleared as necessary and compacted sediment cleaned out semi-annually.<sup>16</sup>

### Costs

Fifty-five-gallon rain barrels typically cost \$50 to \$100 for prefabricated units, or \$30 for do-it-yourself kits<sup>17</sup> (January 2010 dollars). Costs for large cistern systems are dependent on many site-specific factors, such as whether excavation is required for underground units. The following table shows cistern tank costs depending on the tank material and capacity. This table does not take into account the installation of the tank, site preparation, and other site-specific factors.

Cistern tank cost by type (\$/gallon, installation not included)*			
Fiberglass	Steel	Plastic	Concrete
10,000 gal and up \$1.34	500-15,000 gal \$2.54	50-1,500 gal \$1.45	2,000 gal and up \$1.68

Source: WERF BMP and LID Whole Life Cost Model, Version 2.0. As cited in Guidance for Federal Land Management in the Chesapeake Bay Watershed, 2010. \*Prices inflated from reported 2009 dollars to January 2010 dollars.

The operation and maintenance cost burden for rain barrels and cisterns is low.<sup>18</sup> Excluding the periodic operational activity of emptying the rain barrel, the annual maintenance associated with disconnecting and cleaning the barrel would only take about one hour. Based on annual operation and maintenance costs associated with fiberglass cisterns being approximately 3 percent of construction costs, a 10,000 gallon cistern would cost about \$400 per year to maintain.

<sup>1</sup>Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at:

< <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>>.

<sup>2</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.



- <sup>3</sup> USEPA. (2010). *Guidance for Federal Land Management in the Chesapeake Bay Watershed*. 848 pp. Available at: [http://www.epa.gov/owow\\_keep/NPS/chesbay502/](http://www.epa.gov/owow_keep/NPS/chesbay502/).
- <sup>4</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>5</sup> Water Use and Conservation Bureau, New Mexico Office of the State Engineer. *A Waterwise Guide to Rainwater Harvesting*. <http://www.ose.state.nm.us/water-info/conservation/rainwater-harvesting.pdf>. As cited in Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>.
- <sup>6</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>7</sup> Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>.
- <sup>8</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>9</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>10</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <http://www.dec.ny.gov/chemical/29072.html>.
- <sup>11</sup> Metropolitan Council, (2001). *Minnesota Urban Small Sites Best Management Practices (BMP) Manual*. Prepared for Metropolitan Council. 14 pp. Available at: [http://www.metrocouncil.org/environment/watershed/BMP/CH3\\_STInfilOnLot.pdf](http://www.metrocouncil.org/environment/watershed/BMP/CH3_STInfilOnLot.pdf).
- <sup>12</sup> Karen Sands and T. Chapman, Milwaukee Metropolitan Sewerage District, Milwaukee, Wisconsin. (2003). *Rain Barrels – Truth or Consequences*, presented at USEPA National Conference on Urban Stormwater: Enhancing Programs at the Local Level. p. 390-395. Available at: <http://www.epa.gov/owow/nps/natlstormwater03/fullreport.pdf>. As cited in Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>.
- <sup>13</sup> Urban Design Tools: Low Impact Development. *Rain Barrels and Cisterns*. Available at: [http://www.lid-stormwater.net/raincist\\_maintain.htm](http://www.lid-stormwater.net/raincist_maintain.htm).
- <sup>14</sup> Austin Water Utility Conservation Program. (2008). *Rainbarrel Maintenance 101*. Available at: [http://www.enewsbuilder.net/watercon/e\\_article001088596.cfm?x=bcDOLs9.b2PRJJ7I](http://www.enewsbuilder.net/watercon/e_article001088596.cfm?x=bcDOLs9.b2PRJJ7I).
- <sup>15</sup> University of Florida, Program for Resource efficient Communities. (2008). *Florida Field Guide to Low Impact Development: Cisterns/Rain Barrels*. Available at: [http://buildgreen.ufl.edu/Fact\\_percent20sheet\\_Cisterns\\_Rain\\_Barrels.pdf](http://buildgreen.ufl.edu/Fact_percent20sheet_Cisterns_Rain_Barrels.pdf).
- <sup>16</sup> Fairfax County Government. *Cistern Maintenance*. Available at: [http://www.resolve.org/fairfaxcountystormwater/homeowners/cistern\\_maintenance.pdf](http://www.resolve.org/fairfaxcountystormwater/homeowners/cistern_maintenance.pdf).
- <sup>17</sup> USEPA. (2010). *Guidance for Federal Land Management in the Chesapeake Bay Watershed*. 848 pp. Available at: [http://www.epa.gov/owow\\_keep/NPS/chesbay502/](http://www.epa.gov/owow_keep/NPS/chesbay502/).
- <sup>18</sup> University of Florida, Program for Resource efficient Communities. (2008). *Florida Field Guide to Low Impact Development: Cisterns/Rain Barrels*. Available at: [http://buildgreen.ufl.edu/Fact\\_percent20sheet\\_Cisterns\\_Rain\\_Barrels.pdf](http://buildgreen.ufl.edu/Fact_percent20sheet_Cisterns_Rain_Barrels.pdf).

#### Additional Resources for Rain Barrels and Cisterns:

- North Carolina State University, Rainwater Harvesting Web site, (<http://www.bae.ncsu.edu/topic/waterharvesting/>) – Contains background information and current performance research on rainwater harvesting techniques
- Virginia Department of Conservation and Recreation, Stormwater Design Specifications (<http://www.chesapeakestormwater.net/storage/first-draft-baywide-design-specifications/BAYWIDE%20No%206%20RAIN%20TANKS%20AND%20CISTERNs.pdf>) – Contains design specifications for rainwater harvesting
- Infrastructure Guidance: Cisterns and Rain Barrels ([http://www.sustainindy.org/assets/uploads/4\\_03\\_CisternsandRainBarrels.pdf](http://www.sustainindy.org/assets/uploads/4_03_CisternsandRainBarrels.pdf)) – Contains overview and design considerations for vegetated channels



## Constructed Wetlands

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Constructed wetlands (CWs) are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial population to treat a variety of wastewaters. Constructed wetlands are designed to mimic natural processes and serve as an alternative stormwater treatment process. Examples of constructed wetlands include shallow wetlands, extended detention wetlands, pond/wetland, and pocket wetland.<sup>1</sup> CWs may be classified according to the life form of the dominating vegetation into systems with free-floating, rooted emergent and submerged macrophytes. Further division could be made according to the wetland hydrology (free water surface and subsurface systems); subsurface flow CWs could be classified according to the flow direction (horizontal and vertical flow)<sup>2</sup>.

### Construction

Constructed wetlands consist of a basin that contains water, a substrate, and, most commonly, vascular plants.<sup>3</sup> Substrates used to construct wetlands may include soil, sand, gravel, rock, and organic materials such as compost.<sup>4</sup> Constructed wetlands may be used in conjunction with other BMP components such as a sediment forebay, buffer strip, micropool, berms, and bottom drain pipe.<sup>5,6</sup>



Constructed Wetland Designed by F.X. Browne, Inc.

### Benefits

Constructed wetlands have considerable ecologic and aesthetic benefits. Under the appropriate conditions wetlands can provide water quality improvement, flood storage, cycling of nutrients and other materials, reduction in pollutant loads, habitat for fish and wildlife, and passive recreation, such as bird watching and photography.<sup>7</sup>

### Limitations

Constructed wetlands require a relatively large amount of space and an adequate source of inflow to maintain a permanent water surface. Therefore constructed wetlands may have limited applicability in urbanized, or ultra urbanized areas where the required amount of space is unavailable.<sup>8,9</sup> Further, constructed wetlands may be unsuitable in arid and semi-arid climates where it may be difficult to maintain a permanent pool<sup>10</sup> necessary for normal operation of the system.

### Climate Considerations

Constructed wetlands, if planted properly, are designed to tolerate most local conditions. However, constructed wetlands require a minimum amount of water, and while they can tolerate temporary droughts, they cannot withstand complete dryness. Freezing of constructed wetland systems is generally not problematic in temperate regions since microbial activity usually generates enough heat to keep the subsurface layers from freezing.<sup>11</sup>



Courtesy of: Aleksandra Drizo, PhD; Associate Research Professor;  
University of Vermont.

### CSO Impact

A study examining the efficacy of constructed wetlands in pesticide removal from tailwaters in the Central Valley, CA, found that constructed wetlands reduced the flow volume by 68 to 87 percent, through percolation and evapotranspiration in addition to providing pollutant removal.<sup>12</sup> Reductions in flow volume to the treatment plants may ultimately decrease the intensity and frequency of CSOs.

### Maintenance

Constructed wetlands require maintenance, particularly during the first two years after construction. During the first growing season,

vegetation should be inspected every two to three weeks. During the first two years, constructed wetlands should be inspected at least four times a year and after major storms (greater than two inches in 24 hours). Sediment should be removed every three to seven years before sediment occupies 50 percent of the forebay. Over the life span constructed wetlands should be inspected semiannually and after major storms as well as after rapid ice breakup. Undesirable species should be removed and desirable replacements planted if necessary. Once established, properly designed and installed constructed wetlands should require little maintenance.<sup>13</sup>

### Costs

The construction costs of constructed wetlands can vary greatly depending on the configuration, location, and site-specific conditions. Typical construction costs (January 2010 dollars) range from \$0.89 to \$1.86 per cubic foot of water stored in the facility.<sup>14</sup> Costs are generally most dependent on the amount of earthwork and the planting. Annual operation and maintenance costs have been reported to be approximately 2 percent to 5 percent of the capital costs, or approximately \$0.09 per cubic foot of storage provided.<sup>15</sup>

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<sup>1</sup>New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>2</sup>Vymazal, J. (2010). *Review: Constructed Wetlands for Wastewater Treatment*. *Water* 2010, 2(3), 530-549. Available at: <<http://www.mdpi.com/2073-4441/2/3/530/pdf>>.

<sup>3</sup>USEPA. (1995). *Handbook of Constructed Wetlands: General Considerations: Volume 1*. 53 pp. Available at: <<http://www.epa.gov/owow/wetlands/pdf/hand.pdf>>.

<sup>4</sup>USEPA. (1995). *Handbook of Constructed Wetlands: General Considerations: Volume 1*. 53 pp. Available at: <<http://www.epa.gov/owow/wetlands/pdf/hand.pdf>>.

<sup>5</sup>Clermont County, Ohio. *Stormwater Wetland*. 4 pp. Available at: <<http://www.clermontstorm.net/wetland.pdf>>.

<sup>6</sup>Metropolitan Council. (Minneapolis-Saint Paul, MN). *Constructed Wetlands Stormwater Wetlands*. 15 pp. Available at: <[http://www.metrocouncil.org/environment/Water/BMP/CH3\\_STConstWLSwWetland.pdf](http://www.metrocouncil.org/environment/Water/BMP/CH3_STConstWLSwWetland.pdf)>.

<sup>7</sup>USEPA. (1995). *Handbook of Constructed Wetlands: General Considerations: Volume 1*. 53 pp. Available at: <<http://www.epa.gov/owow/wetlands/pdf/hand.pdf>>.

<sup>8</sup>Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at: <<http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>>.

<sup>8</sup>USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Stormwater Wetland*. Available at: <[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=74](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=74)>.

- <sup>10</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Stormwater Wetland*. Available at:  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=74](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=74)>.
- <sup>11</sup> USEPA. (1995). *Handbook of Constructed Wetlands: General Considerations: Volume 1*. 53 pp. Available at:  
<<http://www.epa.gov/owow/wetlands/pdf/hand.pdf>>.
- <sup>12</sup> Budd, R, O'Geen, A., Goh, K.S, Bondarenko, S. and Gan, J. (2009). *Efficacy of Constructed Wetlands in Pesticide Removal from Tailwaters in the Central Valley, California*. Available at:  
<<http://pubs.acs.org/doi/abs/10.1021/es802958q>>.
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<<http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>>.
- <sup>13</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Stormwater Wetland*. Available at:  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=74](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=74)>.
- <sup>15</sup> Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. (2006). *Pennsylvania Stormwater Best Management Practices Manual*. 685 pp. Available at:  
<<http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305>>.

## Tree Planting

Tree planting refers to the activity of planting trees either in concentrated groupings or, more likely the case in urbanized settings, in “tree boxes.” Tree planting is suited for all areas including landscaped areas, sidewalk cut-outs, parking lots, parks, shopping centers or other open or urbanized spaces.<sup>1</sup> The purpose of tree planting is to reduce stormwater runoff, increase nutrient uptake, and, where used in riparian zones, to provide bank stabilization.<sup>2</sup>

### Construction

Tree planting occurs by converting open or paved areas into planted areas. For planting in open spaces allow for appropriate planting depth according to tree species and size. In urbanized areas with impervious surfaces, impervious surfaces must be removed prior to tree planting, and installation generally includes the use of a “tree box” to protect the tree roots from heavy traffic. The tree box generally includes a 4-foot by 6-foot precast concrete frame fully capable of supporting traffic loading which surrounds the base of the tree.<sup>3</sup> After tree planting, stormwater may infiltrate naturally into the surrounding soils and groundwater through physical, chemical, and biological processes.<sup>4</sup>



Street trees with porous pavement, Pier A Park, Hoboken, New Jersey. Courtesy of: *Bruce K. Ferguson*.

### Benefits

Planting new trees can reduce stormwater runoff, promote evapotranspiration, increase nutrient uptake, provide shading and thermal reductions, encourage wildlife habitat, improve aesthetics in neighborhoods and parks,<sup>5</sup> and contribute to the process of air purification and oxygen regeneration.<sup>6</sup> For example, one report in New York City estimates that by adding 300,000 street trees to the 500,000 existing street trees, over 60 tons of air pollution can be removed each year.<sup>7</sup> The report also states estimates the addition of every 100,000 trees could decrease the city temperature by 1.4 degrees and decrease ozone annually by 12,000 pounds.<sup>8</sup>

### Limitations

Limitations to an effective tree planting program include the costs associated with buying, planting, and maintaining the planted area.<sup>9</sup> Further, unpredictable weather events with high winds, such as hurricanes, other large storms or droughts, and ice damage/scour may significantly damage newly planted areas.<sup>10</sup>

### Climate Considerations

Tree planting can be implemented in all climates, although local site characteristics must be considered when selecting tree species to be planted.<sup>11</sup> Depending on climate, tree species planted, and annual rainfall, watering may be necessary for trees to survive the growing season. For example, each street tree planted in New York City is estimated to require 20 gallons of water per day during the growing season to survive.<sup>12</sup>



## CSO Impact

Communities with higher percentages of tree cover have been found to have lower stormwater volumes and treatment costs.<sup>13</sup> Reductions in the amount of treated stormwater can translate into reductions in the volume and frequency of CSOs. Researchers at the University of California at Davis have estimated that for every 1,000 deciduous trees in California's Central Valley, stormwater runoff is annually reduced

nearly 1 million gallons.<sup>14</sup> Another study suggests that trees with mature canopies can absorb the first half-inch of rainfall.<sup>15</sup>



Charlotte, NC. Courtesy of: USDA Forest Service, PSW, Center for Urban Forest Research.

## Maintenance

Planted trees require minimal maintenance other beyond routine pruning, weeding, disease or insect damage inspection, and watering if applicable. During the first three years, mulching, watering and protection of young trees may be necessary. Tree should be inspected every three months and within one week of ice storms and high wind until trees have reached maturity.<sup>16</sup>

## Construction Costs

Tree planting costs can vary greatly. Tree planting costs include the cost of site preparation, seedlings or seed, cost of planting, and weed control for three to five years after planting. Low planting costs may be associated with community action programs that solicit volunteers to plant low priced saplings. Higher costs may be associated with professional landscape businesses.<sup>17</sup> Operation and maintenance costs are minimal given the anticipated maintenance activities stated above.

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<sup>1</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>2</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>3</sup> Water world. (2008). *Tree Filter Systems for Effective Urban Stormwater Management*. Available at: <[http://www.waterworld.com/index/display/article-display/articles/urban-water-management/volume-4/issue-4/features/tree-filter-systems-for-effective-urban-stormwater-management\\_.html](http://www.waterworld.com/index/display/article-display/articles/urban-water-management/volume-4/issue-4/features/tree-filter-systems-for-effective-urban-stormwater-management_.html)>

<sup>4</sup> Water world. (2008). *Tree Filter Systems for Effective Urban Stormwater Management*. Available at: <[http://www.waterworld.com/index/display/article-display/articles/urban-water-management/volume-4/issue-4/features/tree-filter-systems-for-effective-urban-stormwater-management\\_.html](http://www.waterworld.com/index/display/article-display/articles/urban-water-management/volume-4/issue-4/features/tree-filter-systems-for-effective-urban-stormwater-management_.html)>

<sup>5</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>6</sup> New York State Department of Environmental Conservation. (2010). *New York State Stormwater Management Design Manual*. 642 pp. Available at: <<http://www.dec.ny.gov/chemical/29072.html>>.

<sup>7</sup> Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: < <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>>.

<sup>8</sup> Plumb, M. (2008). *Sustainable Raindrops: Cleaning New York Harbor by Greening the Urban Landscape*. 40 pp. Available at: < <http://www.riverkeeper.org/wp-content/uploads/2009/06/Sustainable-Raindrops-Report-1-8-08.pdf>>.

- <sup>9</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Reforestation Programs*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=18](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=18)
- <sup>10</sup> USEPA. (2006). *National Pollutant Discharge Elimination System (NPDES) Menu of BMPs: Reforestation Programs*. Available at: [http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet\\_results&view=specific&bmp=18](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=18)
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- <sup>12</sup> New York City Department of Parks and Recreation, Caring for Street Trees and Greenstreets. Available at: [http://www.nycgovparks.org/sub\\_your\\_park/trees\\_greenstreets/tree\\_care\\_tips/water.html](http://www.nycgovparks.org/sub_your_park/trees_greenstreets/tree_care_tips/water.html).
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- <sup>14</sup> Rocky Mountain Institute. (2005). *Green Development Services: Village Homes— Davis, California*, <http://www.rmi.org/sitepages/pid209.php> As cited in Kloss, C and Calarusse, C. (2006). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Prepared for the Natural Resources Defense Council. 56 pp. Available at: <http://www.nrdc.org/water/pollution/rooftops/contents.asp>.
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