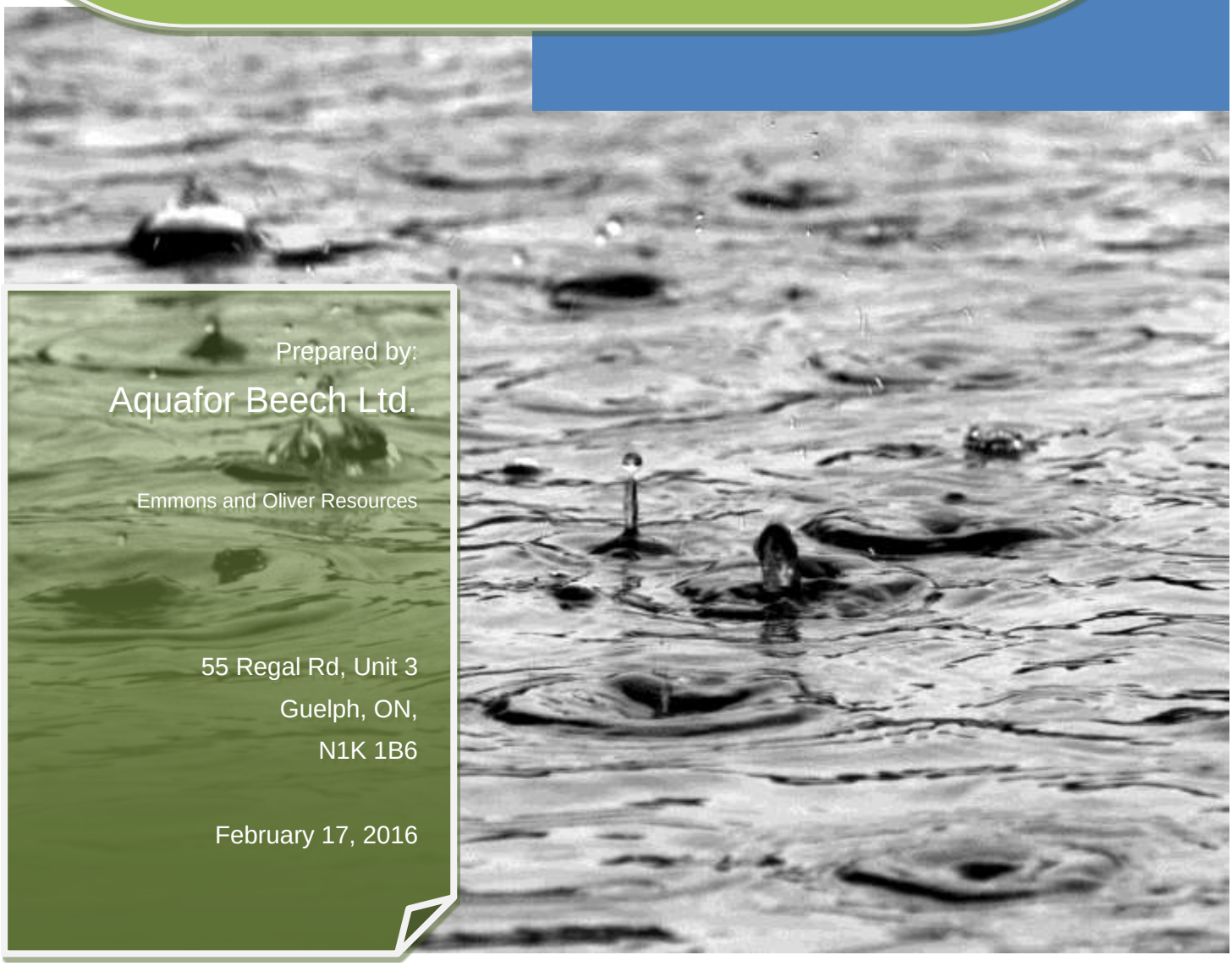
Prepared for:

Ministry of the Environment & Climate Change

Jurisdictional Scan of Canadian, US and International Stormwater Management Volume Control Criteria

Draft Final Report



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1 INTRODUCTION

This Jurisdictional Scan has been undertaken to inform the development of the Ministry of the Environment & Climate Change (MOECC) Low Impact Development Stormwater Management Guidance Manual.

The jurisdiction scan is intended to be a broad overview of key Canadian, US, and International jurisdiction who have established stormwater control criteria as part of national, state, regional criteria or municipal standards. All levels of government and oversight have been included to acknowledge that stormwater management criteria or guidelines can originate from:

a) Centralized regional, provincial/ state or national agencies. Referred to as a "top-down" process whereby local communities are the recipient of policies from higher authorities.

b) Municipal level government who as pioneers develop their own guidance and management or design criteria, going beyond centralized regional, provincial or national agencies. Some examples include, but are not limited:
    - Portland, Oregon;
    - Seattle, Washington;
    - Chicago, Illinois;
    - City of Toronto;
    - City of Edmonton
    - City of Halifax.

While available information relating to stormwater control criteria has been collected and summarized within the following document (including **Appendix A)** special emphasis was placed on jurisdictions which have:

- Implemented 'volume control' targets;
- Have regulations, guidelines and or criteria relating to the implementation of Low Impact Development (LID) and/or
- Are recognized leaders in stormwater management and LID.

These jurisdictions represent potential examples which may inform the Runoff Volume Targets Report as well as the overall development of the MOECC Low Impact Development Stormwater Management Guidance Manual development.

Canadian, American, and International jurisdictions reviewed as part this report includes:

- **Canada:**
    - Province of British Columbia
        - Coquitlam, B.C.
        - Chilliwack, B.C.
    - Edmonton, Alberta
    - Halifax, Nova Scotia
    - Toronto and Region Conservation Authority (TRCA) Watershed, Ontario
    - Credit Valley Conservation (CVC) Authority Watershed, Ontario

- City of Toronto, Ontario
- Lake Simcoe Region Conservation Authority (LSRCA) Watershed
- Province of Quebec

- **United States:**
  - State of Alaska
  - State of Connecticut
  - State of Delaware
  - District of Columbia, Washington, D.C.
  - Chicago, Illinois
  - State of Indiana
  - State of Iowa
  - State of Maine
  - State of Maryland
  - State of Massachusetts
  - State of Michigan
  - Minneapolis, Minnesota
  - State of Minnesota
  - State of Montana
  - State of New Jersey
  - State of New Hampshire
  - State of New York
  - State of North Dakota
  - State of Ohio
  - Portland, Oregon
  - Philadelphia, Pennsylvania
  - State of Pennsylvania
  - State of Rhode Island
  - Burlington, Vermont
  - State of Virginia
  - State of Georgia

- **European/ International:**
  - Singapore
  - European Union
  - England
  - Australia
    - Upper Parramatta River, New South Wales, Australia
  - New Zealand
    - National Standards
    - Christchurch
    - Auckland
  - Netherlands-Bloemendaal
  - France
    - Paris and Yerre Catchment

1.1 Purpose

The purpose of this report is to identify and recommend the five (5) most appropriate jurisdictions to be studied in detail and form the basis for the development of the Volume Targets for Ontario Report.

This jurisdictional scan is the first component in the development of the subsequent Volume Targets for Ontario Report.

1.2 Report Process

The following report has been completed using a two (2) phased approach.

Phase 1 included the completion of a Broad Jurisdictional Scan whereby Canadian, US, and International jurisdictions with existing stormwater criteria were identified. This knowledge gathering exercise was undertaken with the goal of identifying jurisdictions with existing LID or stormwater management (SWM) volume control targets and criteria implemented as part of national, state, regional criteria or municipal standards. A 'short-list' of jurisdictions is the subject of the more detailed review in Phase 2.

Phase 2 included the completion of a detailed Jurisdictional review based on the `short-list` of jurisdictions developed as part of Phase 1. The detailed review includes, where relevant, summaries of:

- Background information;
- Policy frameworks;
- Stormwater management criteria and targets;
- Best Management Practices (BMP) performance;
- Winter Stormwater Management Approaches (four-season approaches to stormwater management); and
- Key definitions.

Additionally, summaries of complimentary or supporting programs, legislative, and initiatives are also included in the section below and in **Appendix A** in order to better understand the implementation mechanisms and as a means to provide a view of 'what is possible'. This additional information includes but is not limited to:

- Redevelopment Standards;
- Offset and Mitigation Programs;
- Off-site option; and
- Credit programs.

1.3 Report Structure

This report contains five (5) sections relating to the following:

- **Section 1** - Introduces the document and outlines the report purpose, process and structure.

- **Section 2** –provides an overview of the various types of stormwater criteria and provides a summary of potential benefits and efficiencies.

- **Section 3** – Details Phase 1 of the report process, specifically the completion of a Broad Jurisdictional Scan of ten (10) Canadian jurisdictions, twenty-six (26) America

jurisdictions, and fourteen (14) international jurisdictions and the creation of a jurisdictional 'short-list' carried forward to Phase 2.

- **Section 4 –** Details Phase 2 of the report process, specifically the completion of a Detailed Review of the 'short-listed' jurisdictions carried forward from Phase 1.

- **Section 5 –** Lists the five (5) recommend jurisdictions to be studied in detail and form the basis for the development of the Volume Targets for Ontario Report.

2 OVERVIEW OF TYPES OF STORMWATER CRITERIA

For the purpose of this report, **Criteria** has been defined per (Sage et. al., 2015) as consisting of numerical targets or management principles given to practitioners for stormwater control, which may not systematically be regulatory and can be found as prescriptions or recommendations. Management criteria may hence either result from State/ Provincial rules and guidelines or local codes or ordinance/ by-laws set by counties or municipalities.

Through-out this report the following terminology has been used where possible. Where not defined, the original definitions per the respective source have been used.

2.1 Volume Retention/ Reduction Criteria

Also referred to as:

- "permanent interception"
- "zero discharge" and/or
- "infiltration target"

The captured volume is ultimately infiltrated, evapotranspired or re-used. The specified volume will not later be discharged to sewer networks or surface waters and does not therefore become runoff. Rationale for the development of the criteria varies between jurisdictions, and can include but is not limited to:

- Believed to have less variable pollution control over Volume Capture and Treatment criteria, as pollutant loads are reduced through infiltration and evapotranspiration and additional water quality benefits result from treatment processes of filtration, adsorption and sedimentation;
- Urban flood prevention. Advocated for by sewer network operators (i.e. Paris – zero discharge requirements);
- Maintenance of pre-development groundwater recharge or hydrologic cycle preservation through infiltration;
- Preservation of groundwater quantity and levels;
- Water Quality and quantity control (i.e. Oregon, New-York State and Province of British Columbia & Chilliwack); and
- Pollution reduction (i.e. Portland).

In many cases, infiltration as a stand-alone criterion or within the Volume Retention/ Reduction Criteria can refer to either:

- Temporary storage in the upper soil layers prior to evapotranspiration; or
- Water that percolates down to local aquifers.

As such according to Sage et. al. (2015), "volume reduction" and or "permanent interception" criteria terminology may be preferred over 'infiltration' since massive infiltration may not always be desired in highly pervious soils which are vulnerable to groundwater contamination. In addition, infiltration within low permeability soils may result in efficacy being significantly diminished.

2.2 Volume Capture and Treatment Criteria

Also referred to as `*treatment and release*` these criteria directly aim at reducing surface water impairment through detention and treatment of a given volume, often referred to as a "water quality volume". Volume is typically captured, treated and released. Applies primarily to water

quality objectives and is often assumed to enable capture and treatment of 80% to >90% of the annual runoff volume and is typically expressed as rainfall depth (mm or inches), either associated with a design storm (for which runoff shall be treated), or simply representing a storage volume. Noted discrepancies between the definitions/ terminology of the volume capture and treatment criteria within various jurisdictions include:

- Jurisdictions may require or simply prefer, but not specify, treatment approaches which include infiltration, filtration, evapotranspiration settling, absorption and reuse;
- Specification that the water quality volume be “managed” and or “treated” on-site without clear direction as to approved practices or methods;
- Several jurisdictions explicitly require a fraction of the overall water quality volume be infiltrated, harvested or evapotranspired.

2.3 Flow Rate Limitation Criteria

Peak-flow control is perhaps the most common approach to conventional stormwater management, and generally aims at preventing urban floods or combined sewer overflows during infrequent storms. In Europe and North America, allowable flow-rates are usually justified by (1) drainage network capacity, (2) preservation of downstream “pre-development runoff rate” or (3) maintenance of peak-flow rates in the receiving stream below pre-construction levels to prevent flood and stream channel erosion (Sage et. al., 2015).

2.4 Volume Detention

Volume detention is runoff captured and stored within a facility and released at a reduced rate over a prolonged period of time. Detention can be a component of both Capture and Treatment criteria as well as Flow Rate Limitation criteria.

2.5 Load Reduction Criteria

Are numerical targets related to minimum pollutant load reductions, instead of hydrologic criteria such as those listed in **Section 2.1** to **Section 2.4.** This approach implicitly supposes that annual load reductions for key contaminants (i.e. in Australia - TSS, nitrogen and phosphorous) or surrogate contaminants ensure the removal of all contaminants of concern. For non-point source contaminants, this approach would typically require some form of Volume Retention/ Reduction. In this manner, for example, the current Enhanced (Level 1) MOECC Water quality control requirement of 80% long-term TSS removal, would become a requirement for an 80% reduction of annual TSS load, which would require some form of Volume Retention/ Reduction.

2.6 Criteria Summary, Benefits and Efficacy

Table 2.1 below summarizes the various stormwater criteria discussed above and highlights the relative benefits and efficacy in regards to common stormwater design and environmental protection objectives.

Table 2.1 – Stormwater Criteria, Benefits and Efficacy

Criteria Type	Benefits/ Efficacy								
	Peak Flow Reduction	Runoff Volume Reduction	Water Quality (Load reduction)	Water Balance	Erosion Control	Flood Control	Thermal Impact Mitigation	Preservation of Aquatic Habitat & Species	Preservation of Terrestrial Habitat & Species
Volume Retention/ Reduction									
Volume Capture and Treatment									
Flow Rate Limitations									
Volume Detention									
Load Reduction Criteria									
Relative Effectivness									
Low Low to Moderate Moderate Moderate to High High									

3 BROAD JURISDICTIONAL REVIEW

The following section describes the results of the broad jurisdictional review, completed as a first Phase in the competition of this Jurisdictional Scan Report.

This first phase was completed in order identify Canadian, US, and International jurisdictions with existing stormwater criteria. This knowledge gathering exercise was undertaken with the goal of identifying jurisdictions with existing LID or stormwater management (SWM) control criteria or targets implemented as part of national, state, regional criteria or municipal standards.

Upon completion of the broad jurisdictional review, a 'short-list' of jurisdictions has been selected and carried forward to Phase 2 where a more detailed review will be completed. The subsequent detailed review is included as **Section 4.0**.

3.1 Objective of the Broad Jurisdictional Review

The objectives of the broad jurisdictional review is first and foremost to identify Canadian, American and International jurisdictions which currently have stormwater criteria and or targets in place and to note where relevant those that have developed and implemented volume control criteria as detailed in **Section 2.0.**

Secondary objectives included providing an overarching perspective in regards to:

- State of the practice within each jurisdiction
- Type of stormwater criteria and targets specified
- Type of volume control criteria and targets specified
- Approaches for implementing the criteria and achieving the targets
- Identifying jurisdictions who are leaders in stormwater management and LID
- Understand the current climate conditions within the jurisdictions (with special focus on cold climates).

Upon completion of the Broad Jurisdictional Scan, a 'shot-list' of jurisdictions has been selected to be carried forward to a more detailed review. The selection of the jurisdictional 'short-list' is detailed in **Section 3.3.**

3.2 Jurisdictions Included

As part of the broad jurisdictional review completed in Phase 1 of this report, fifty (50) jurisdictions were reviewed. They include ten (10) Canadian jurisdictions, twenty-six (26) America jurisdictions, and fourteen (14) international jurisdictions were reviewed. Jurisdictions include are listed below:

- **Canada:**
    - Province of British Columbia
        - Coquitlam, B.C.
        - Chilliwack, B.C.
    - Edmonton, Alberta
    - Halifax, Nova Scotia
    - Toronto and Region Conservation Authority (TRCA) Watershed, Ontario
    - Credit Valley Conservation (CVC) Authority Watershed, Ontario
    - City of Toronto, Ontario

- Lake Simcoe Region Conservation Authority (LSRCA) Watershed
- Province of Quebec

- **United States:**
  - State of Alaska
  - State of Connecticut
  - State of Delaware
  - District of Columbia, Washington, D.C.
  - Chicago, Illinois
  - State of Indiana
  - State of Iowa
  - State of Maine
  - State of Maryland
  - State of Massachusetts
  - State of Michigan
  - Minneapolis, Minnesota
  - State of Minnesota
  - State of Montana
  - State of New Jersey
  - State of New Hampshire
  - State of New York
  - State of North Dakota
  - State of Ohio
  - Portland, Oregon
  - Philadelphia, Pennsylvania
  - State of Pennsylvania
  - State of Rhode Island
  - Burlington, Vermont
  - State of Virginia
  - State of Georgia

- **European/ International:**
  - Singapore
  - European Union
  - England
  - Australia
    - Upper Parramatta River, New South Wales, Australia
  - New Zealand
    - National Standards
    - Christchurch
    - Auckland
  - Netherlands-Bloemendaal
  - France
    - Paris and Yerre Catchment.

The following tables summarize Canadian Jurisdictions (**Table 3.0**), American Jurisdictions **(Table 3.1)** and International Jurisdictions **(Table 3.2).** Where relevant, each table summarizes the following information:

- If the respective jurisdiction current has volume control targets;
- Method by which the control target is achieved;
- Volume control criteria type and the method for achieving the volume control;
- Mean annual rainfall depth for each location and division between rainfall and snowfall where relevant (as available);
- Additional information relating to volume control targets or criteria, other stormwater criteria specified by the individual jurisdiction (for information purposes only) and identification if Low Impact Development (LID) techniques are recommended, required or supported with the jurisdiction.

Figure 3.0 illustrates Canadian jurisdictions and their respective volume control targets, while American jurisdictions and their respective volume control targets are illustrated as **Figure 3.1.**

Additional information can be found in **Appendix A.**

Table 3.0 – Summary of Canadian Jurisdictions: Stormwater Control Targets and Criteria

Location	Volume Target	Volume Control Criteria & Method for Achieving Control	Mean Annual Rainfall (mm)	Notes
Prov. of British Columbia	90% of mean annual rainfall volume	**Volume Retention –** Infiltration & ET or **Volume Detention**	2,000 mm (250 to 3,000 mm)	Runoff Volume – 90% of mean annual rainfall volume Runoff Rate – Natural Mean Annual Flow[1] (MAF) occur no more than once per year.
Coquitlam, B.C.	6 month 24 hour storm	**Volume Detention (**Structural Facility)	1,500 mm	Maintain runoff volumes to pre-development levels
Chilliwack, B.C	First 30 mm	**Volume Retention** - Infiltration, ET & reuse	1,650 mm	Runoff Volume = 50% Mean Annual Rainfall (MAR of 63 mm, 24 hr) - corresponds to what some jurisdictions describe as the '6-month storm
	Next 30 mm	**Volume Detention**		Runoff Rate – Natural Mean Annual Flow (MAF) occur no more than once per year, on average.
Edmonton, AB	26 mm – Detention 12 mm – Infiltration BMP	**Volume Detention** **Volume Capture and Treatment**	475 mm 365 mm rainfall 110 mm snow	Capture and treat the first flush, determined to be the depth of the 90th percentile storm, which is 26 mm. The runoff from a 12 mm storm is considered appropriate for infiltration BMPs.

[1] Mean annual flow is the average flow for the individual year or multi-year period of interest. When working with hydrologic data it is customary to view the data by water years (October-September) rather than by calendar years (January-December).

Location	Volume Target	Volume Control Criteria & Method for Achieving Control	Mean Annual Rainfall (mm)	Notes
Halifax, NS	25 mm	**Volume Detention**	1,450 mm	Detain and release. Must treat 25 mm of a 6 hr storm (24-48 hr drawdown).
Toronto Region Conservation Authority (TRCA)	5 mm – Erosion	**Volume Retention** - Infiltration, ET & reuse	890 mm	Erosion – Detain 5 mm on site or detain 25 mm-48 hr for SWM ponds Flooding - Pre to Post control Water quality – 80% TSS Water Balance –Specific water balance required for SGRA, EGRA, and HGRA. Best efforts for LGRA. Includes the use of LIDs
Credit Valley Conservation (CVC)	5 mm – Erosion Min. 3 mm– Water Balance	**Volume Retention –** Infiltration & ET (3-5 mm); **Volume Capture and Treatment; &** **Volume Detention**	890 mm	Erosion – Detain 5 mm on site or detain 25 mm-48 hr for SWM ponds Flooding - Pre to Post control Water quality – 80% TSS Water Balance – recharge min 3 mm. Specific water balance required for SGRA, EGRA, HGRA & MGRA Includes the use of LIDs for water quality and thermal protection
City of Toronto	5 mm - Erosion	**Volume Retention** - Infiltration, ET & reuse	890 mm	Retain 5 mm on-site for Water Balance. Promotes use of LIDs

Location	Volume Target	Volume Control Criteria & Method for Achieving Control	Mean Annual Rainfall (mm)	Notes
Lake Simcoe Region Conservation Authority (LSRCA)	90th percentile storm thresholds of 25 mm (1 in)	**Volume Retention –** Infiltration & ET; **Volume Capture and Treatment; &** **Volume Detention**	890 mm	New non-linear & redevelopment – retain the first 25 mm from impervious surfaces Linear Development, greater of: • The first 12.5 mm of runoff from new a fully reconstructed • The first 25 mm of runoff from the net increase in impervious area Flexible (restricted sites): 1. Min 12.5 mm & 75% annual TP load reduction 2. Maximum extent practical of vol. reduction & 60 annual TP load reduction 3. Off-site treatment Requires the use of LIDs
Province of Quebec	25 mm	25 mm design basis.	1100 mm	Rainfall analysis completed for Montreal and Quebec City. Recommended for all of Quebec to design LID systems based on a storm event corresponding to 90% of rainfall with value of **25 mm of rain**

Insert Figure 3.1

Table 3.1– Summary of American Jurisdictions: Stormwater Control Targets and Criteria

Location	Volume Target	Volume Control Criteria & Method for Achieving Control	Mean Annual Rainfall (mm)	Notes
State of Alaska	13 mm (0.52 in)	**Volume Retention**	2,310 mm 410 mm rainfall 1,900 mm snow	Retain runoff from first 0.52 inches of rainfall from a 24 hr event preceded by 48 hours of no measureable precipitation. Achieve 80% TSS reduction. Retain from 24 hour event preceded by 48 hours of no precipitation
State of Connecticut	25 mm (1 in)	**Volume Capture and Treatment**	1,250 mm	Peak flow control & Runoff volume reduction Wet ponds designed with adequate storage volume to capture and retain the RCV or infiltration practices can be used to satisfy the runoff capture volume criterion.
State of Delaware	69 mm (2.7 in) 1-year 24 hr storm	**Volume Retention**	1,1150 mm 190 – 500 mm snowfall	Mimic predevelopment rates, volumes, and flow durations. Aims to achieve 0% effective imperviousness to the maximum extent practicable (MEP).
District of Columbia, Washington DC	30 mm (1.2 in)	**Volume Retention**	980 mm	Unified Sizing Criteria - New Developments

	20 mm (0.8 in)	**Volume Retention**		Unified Sizing Criteria - Re-development
Location	**Volume Target**	**Volume Control Criteria & Method for Achieving Control**	**Mean Annual Rainfall (mm)**	**Notes**
Chicago, Illinois	13 mm (0.5 in)	**Volume Retention**	990 mm	Minimize stormwater runoff to the MEP
	5-100-Yr	**Volume Detention**		Minimize stormwater runoff to the MEP
State of Indiana	25 mm (1 in)	**Volume Capture and Treatment**	1,000 mm	Performance-Based Design: Treat WQ Volume for 80% TSS reduction, and remove floatables
State of Iowa	32 mm (1.25 in)	**Volume Capture and Treatment**	1,000 mm	Detention (1 yr 24 hr storm), and Reduce TSS loadings by 80%
State of Maine	25 mm (1 in) * TIMP and 10 mm (0.4 in) * Pervious Area)	**Volume Capture and Treatment**	1,200 mm	Detention and Volume control (based on location), and Phosphorus standards if draining to a lake Infiltration not required
State of Maryland	25 mm	**Volume Retention**	1,100 mm	Unified Sizing Criteria - Eastern Maryland

	(1 in)			
	23 mm (0.9 in)	**Volume Retention**		Unified Sizing Criteria - Western Maryland
Location	**Volume Target**	**Volume Control Criteria & Method for Achieving Control**	**Mean Annual Rainfall (mm)**	**Notes**
State of Massachusetts	13 mm (0.5 in) 25 mm (1 in) in critical areas	**Volume Retention-** Infiltrate to Predevelopment discharge	1,275 mm	Peak flow control & Runoff volume reduction, Treat WQ volume for 80% TSS reduction - Only required for wetland areas
State of Michigan	25 mm	**Volume Capture and Treatment**	815 mm (120 mm snow)	One inch of runoff generated from the entire project site. Uses the 90th percentile storm.
Minneapolis, MN	28 mm (1.1 in)	**Volume Retention**	780 mm	Post retained to pre-development levels. New, nonlinear developments and redevelopments
	Less than 160 L/s (5.66 cfs)	**Volume Detention**		Post retained to pre-development levels. All remaining runoff may leave the facility with a maximum outflow rate of 5.66 cfs
State of Minnesota	28 mm (1.1 in)	**Volume Retention** - Infiltration, ET & reuse	800 mm	Minimal Impact Design Standards (MIDS) - Post retained to pre-development levels Also, designs must meet water quality

				removal standards for Total P and TSS via infiltration. When new impervious area is proposed
Location	**Volume Target**	**Volume Control Criteria & Method for Achieving Control**	**Mean Annual Rainfall (mm)**	**Notes**
State of Montana	13 mm (0.5 in)	**Volume Retention** - Infiltration, ET & reuse	450 mm	Detain 2 year storm, Treat the 24-hour storm preceded by 48 hours of no measurable precipitation.
State of New Jersey	32 mm (1.25in) in two hours	**Volume Retention** - Infiltration	1,150 mm	Maintain pre-construction runoff volume for two-year storm. 80% TSS load reduction.
State of New Hampshire	25 mm (1 in)	**Volume Retention** - Infiltration, ET & reuse	1,200 mm	Infiltrate, etc. first 1 inch from a 24 hour storm preceded by 48 hours of no measurable precipitation.
State of New York	23 mm (0.8 in) to 34 mm (1.2 in)	**Volume Retention**	1,200 mm	Maintain pre-development infiltration, runoff, and volume. Achieve 80% TSS reduction and 40% Phosphorus reduction.
State of North Dakota	13 mm (0.5 in)	**Volume Capture and Treatment**	500 mm	
State of Ohio	21 mm (0.75 in)	**Volume Capture**	1,000 mm	Detain water quality volume for 24-48

		and Treatment		hours to minimize stream bed erosion. Achieve 80% TSS reduction and floatable debris.
Location	**Volume Target**	**Volume Control Criteria & Method for Achieving Control**	**Mean Annual Rainfall (mm)**	**Notes**
Portland, OR	24 mm (0.83 in)	**Volume Retention** - Infiltration & Volume Detention	1,100 mm	Capture and treat 80% of the average annual runoff. Must detain over 24 hours with a volume of basin/volume of runoff ratio of 2 to be in compliance
Philadelphia, PA	42 mm (1.5 in)	**Volume Retention**	1,050 mm	Maintain pre-development runoff volumes.
State of Pennsylvania	13 mm (0.5 in)	**Volume Retention** - Infiltrate	1,075 mm	Maintain pre-development runoff volumes. All developments, at least the first 0.5 inches of runoff must be infiltrated.
State of Rhode Island	30 mm (1.2 in)	**Volume Capture and Treatment**	1,275 mm	Retain entire post-development water quality storm event. Volume requirement may be waived or reduced by applying disconnection-based LID practices
Burlington, Vermont	0.9 ” 90th percentile storm	**Volume Detention**	935 mm	Unified Sizing Criteria

Seattle, WA	6 month 24 hour storm or - 91st percentile 24 hr runoff volume	**Volume Retention** - Infiltrate, disperse, and retain to MEP	958 mm	Continuous simulation model. Must use continuous simulation to design facility to infiltrate 91% of total annual runoff volume
Location	**Volume Target**	**Volume Control Criteria & Method for Achieving Control**	**Mean Annual Rainfall (mm)**	**Notes**
State of Virginia	25 mm (1 in) – New Developments	**Volume Retention**	1,100 mm	First 25 mm of rainfall must be 100% managed with no discharge to surface waters, except when the project is eligible for a reduction based on the type of development. New Developments - Keep and manage runoff from 24-hour storm preceded by 48 hours of no rain.
	5 mm (0.2 in) to 19 mm (0.75 in) – Re-developments	**Volume Retention**		
State of Georgia	31 mm	**Volume Capture and Treatment** - from the 85th percentile storm. Infiltration not recommended due to high occurrence of clay soils.	1100 mm	Storage volume equates to corresponding runoff depth. Use Unified Sizing Criteria

Insert Figure 3.2

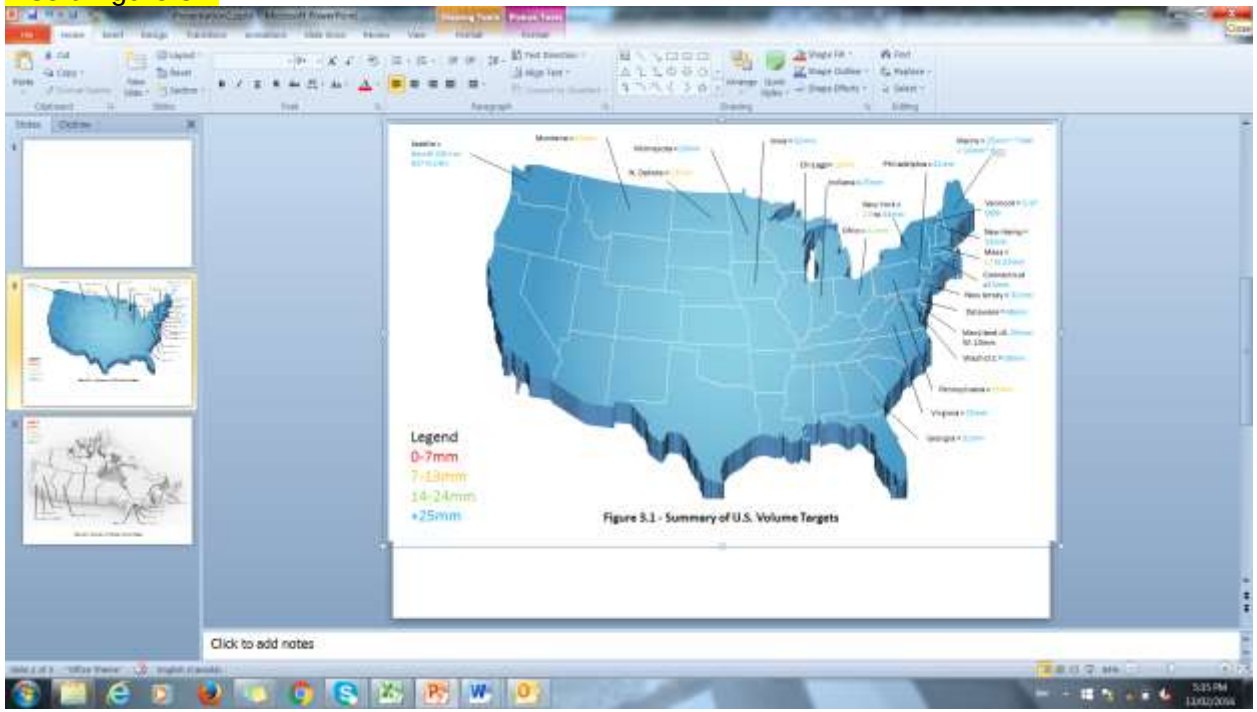


Table 3.2 – Summary of International Jurisdictions: Stormwater Control Targets and Criteria

Location	Volume Target	Volume Control Criteria & Method for Achieving Control	Mean Annual Rainfall (mm)	Notes
England	5-10 mm	**Volume Retention Volume Detention Infiltration**	900 mm	Recommendations only. Infiltration of at least 5 mm, preferably 10 mm
Australia	Assigned at the local level	**Volume Retention** - Infiltration, ET & reuse		
New Zealand-national	15-43 mm	**Volume Capture and Treatment**	600-1600 mm	Storage volume or design storm approach
New Zealand-Auckland	25 mm	**Sedimentation, adsorption, filtration**	1100 mm	Storage volume or design storm approach
New-Zealand-Christchurch	25 mm	**Volume Capture and Treatment**	600 mm	Storage volume equates to corresponding runoff depth
Netherlands-Bloemendaal and AA and Maas	2-9 mm	**Volume Retention Infiltration**	760 mm	Storage volume expressed as runoff depth
France-Paris and Yerre Catchment	Zero Discharge or 4-16 mm,	**Infiltration & Zero Discharge**	860 mm	Daily volume reduction capacity

3.3 Selection of the Jurisdictional 'Short-list'

The selection of the jurisdictional 'short-list' has been based on the following rationale:

- The jurisdiction represents emerging or next generation SWM targets, criteria and approaches;
- The jurisdiction includes volume based SWM criteria and/or targets;
- The jurisdictional volume based SWM criteria and/or targets are within the top two (2) depth ranges of 14-24 mm and >25 mm respectively (see **Figure 3.1** and **Figure 3.2**) as compared to the broader jurisdictions reviewed (i.e. the target is considered 'aggressive');
- The jurisdiction discharges to the Great Lakes (i.e. is a Great Lake State);
- The jurisdiction has comprehensive regulatory requirements and supporting programs and or incentives;
- The jurisdiction includes individual approaches for new development, redevelopment and linear development (roads and transportation networks);
- The jurisdiction provides flexible criteria, targets and or treatment options for sites with technical restrictions;
- The jurisdictional criteria is founded upon the principles of the Unified Sizing Criteria;
- The jurisdiction supports LID techniques and approaches
- The jurisdiction is a cold climate and or criteria has been developed with consideration for cold climates;
- The jurisdictional criteria includes additional consideration for performance targets, beyond volume control including but not limited to:
    - Preserving natural vegetation cover, natural features (e.g. wetlands);
    - Limiting impervious areas;
    - Preserving natural infiltration;
    - Preserving or restoring natural ET capacity through conservation and landscaping; and
    - Re-using rainwater.
- The jurisdiction is acknowledged as a leader in stormwater management and LID
- The current jurisdictional regulatory framework represents an evolution from early approaches based on an adaptive management approach and has a proven track-record.

Jurisdictions which satisfy a minimum of nine (9) of the thirteen (13) rationale listed above were carried forward to the detailed review in **Section 4.0**. **Table 3.3** and **Table 3.4** below summarize the results of the selection process for the Canadian Jurisdictions and US jurisdictions respectively. Jurisdictions which are highlighted within **Table 3.3** and **Table 3.4** have been carried forward to the detailed review.

International jurisdictions have been carried forward to the detailed review without an intermediate assessment due to the relatively few jurisdictions where information was readily available without extensive translation requirements which are beyond the scope of this project. Stormwater criteria for Singapore was also reviewed but has not been included in the sub sequent sections due to Singapore's primary focus on flood control as a result of the seasonal monsoons. This particular climatic condition was not considered relevant to this study.

Table 3.3 – Canadian Jurisdictional Short List Selection Summary

Jurisdiction	Emerging/ Next Generation SWM Targets	Volume Criteria and/or Targets	Comp. Regulatory Req. & Supporting Programs	Volume Target within Upper Two Range Categories	Discharges to the Great Lakes	Approaches for New Dev., Re-Dev & Linear Dev.	Flexible Criteria	Utilizes the Unified Sizing Criteria	Supports LID	Cold Climate SWM	Considers Performance beyond Volume	Leader in SWM & LID	Proven Track Record	Totals
Prov. of B.C,	●	●	●	●				●	●	●	●	●	●	**10**
Coquitlam, B.C.		●		●				●	●	●	●	●	●	**8**
Chilliwack, B.C	●	●		●				●	●	●	●	●	●	**9***
Edmonton, AB		●	●	●			●	●	●	●	●		●	**9**
Halifax, NS	●	●	●	●						●†	●			**6†**
TRCA		●	●		●				●	●	●	●	●	8
CVC		●	●		●				●	●	●	●	●	8
City of Toronto		●			●				●	●				4
LSRCA	●	●	●	●		●	●	●	●	●	●	●		**11**
Prov. of Quebec	●	●	●	●				●	●	●	●		●	**9**

† Note: Although Halifax did not achieve the minimum nine (9) of the thirteen (13) rationale as listed previously, it is recommended to be carried forward to detail review for its unique consideration of winter design requirements, specifically the use of 25 mm winter rain event to generate the peak flow water quality criterion.
* The City of Chilliwack is carried forward and shall be reviewed together with the Province of British Columbia, as the City of Chilliwack Policy and Design Criteria Manual for Surface Water Management (May 2002) was developed as a case study application of Stormwater Planning: A Guidebook for British Columbia. See Sections 4.2.1.4

Table 3.4 – U.S. Jurisdictional Short List Selection Summary

Jurisdiction	Emerging/ Next Generation SWM Targets	Volume Criteria and/or Targets	Comp. Regulatory Req. & Supporting Programs	Volume Target within Upper Two Range Categories	Discharges to the Great Lakes	Approaches for New Dev., Re-Dev & Linear Dev.	Flexible Criteria	Utilizes the Unified Sizing Criteria	Supports LID	Cold Climate SWM	Considers Performance beyond Volume	Leader in SWM & LID	Proven Track Record	Totals
State of Alaska		●								●	●			3
State of Connecticut				●				●	●	●				4
State of Delaware	●	●		●			●		●	●				6
District of Columbia	●	●	●	●		●		●	●	●		●	●	**10**
Chicago, Illinois	●	●	●		●	●	●	●	●	●		●	●	**11**
State of Indiana		●		●				●	●					5
State of Iowa		●		●					●	●				4
State of Maine	●	●		●			●	●	●	●				7
State of Maryland	●	●	●	●		●		●	●	●	●	●	●	**11**
St. of Massachusetts	●	●		●			●		●	●	●			7
State of Michigan	●	●		●	●	●		●	●	●	●			**9**
Minneapolis, MN	●	●		●	●		●	●	●	●	●	●		**11**
State of Minnesota	●	●	●	●	●	●	●	●	●	●	●	●	●	**13**
State of Montana	●	●		●					●	●				5
State of New Jersey	●	●							●	●				4
St. of New Hampshire	●	●		●				●	●	●			●	7
State of New York	●	●	●	●	●			●	●	●		●	●	**10**
State of North Dakota		●							●	●				3
State of Ohio		●		●	●				●	●				5
Portland, OR	●	●	●	●		●	●	●	●		●	●	●	**11**
Philadelphia, PA	●	●	●	●		●	●	●	●	●	●	●	●	**12**
St. of Pennsylvania	●	●			●		●		●	●				6
State of Rhode Island		●		●			●		●	●				5
Burlington, Vermont		●		●				●	●	●				5
Seattle, WA	●	●	●	●		●	●	●	●	●	●	●	●	**12**
State of Virginia	●	●		●		●	●		●	●		●	●	**9**
State of Georgia		●		●			●	●	●					5

4 DETAILED JURISDICTIONAL REVIEW

The following section comprises Phase 2 of the report and provides a detailed summary of each of the twenty-four (24) jurisdictions carried forward from Phase 1. The jurisdictions have been categorized as follows:

1. Great Lake States
    a. The State of Minnesota
    b. Chicago, Illinois
    c. The State of Michigan
    d. The State of New York

2. Broader Canadian Jurisdictions
    a. The Province of British Columbia & the City of Chilliwack
    b. The Lake Simcoe Region Conservation Authority Watershed (LSRCA)
    c. Halifax, Nova Scotia
    d. Edmonton, Alberta
    e. Province of Quebec

3. Broader USA
    a. State of Maryland
    b. District of Columbia (Washington, D.C).
    c. Philadelphia, Pennsylvania
    d. State of Virginia
    e. Portland, Oregon
    f. Seattle, Washington

4. International Jurisdictions
    a. European Union
    b. England
    c. Australia
        i. Upper Parramatta River, New South Wales, Australia
    d. New Zealand
        i. National Standards,
        ii. Christchurch
        iii. Auckland
    e. Netherlands-Bloemendaal
    f. France
        i. Paris and Yerre Catchment

The following subsections review examples of stormwater management policies and related guidance material. Description of the general approach, volume targets and criteria of each of the above jurisdictions is detailed in the subsequent sections. Additional information can be found in **Appendix A.**

In general, the recommended jurisdictions have been included because they are recognized leaders in stormwater management and LID with emerging (next generation) volume control criteria that is considered to be ‘aggressive’ in that is it within the top two (2) ranges, 14-24 mm and >25 mm) respectively as compared to the broader jurisdictions reviewed. In addition, the

following jurisdictions may also have varying approaches to new development, re-development and linear development, have flexible criteria, support LID, are in a cold climates or include cold climate considerations in design and implementation, and have complimentary programs.

4.1 Great Lake States

The Great Lakes region of North America is a bi-national Canadian-American region that includes portions of the eight (8) U.S. states including Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin as well as the Canadian province of Ontario.

The following section describes the jurisdictions carried forward from Phase 1, which are within the Great Lakes region and therefore discharge to the one or multiple Great Lakes. They include:

- The State of Minnesota
- Chicago, Illinois
- The State of Michigan
- The State of New York

Source: http://www.great-lakes.net/lakes/

4.1.1 State of Minnesota

Minnesota is the 12th largest state by area and 21st most populous state of the U.S. It borders Wisconsin to the east, North Dakota and South Dakota to the west, Iowa to the south, and Manitoba and Ontario to the north.

Source: Ezilon.com Regional Maps, 2009

Minnesota is known as the land of 10,000 lakes, many of which have and are struggling with eutrophication from non-point source pollution, specifically as a result of increase phosphorous released.

The north-east portion of Minnesota drains to Lake Superior.

4.1.1.1 State Policy

Minnesota is a National Pollutant Discharge Elimination System (NPDES) delegated state. Its Stormwater Regulatory Program has been developed based on the NPDES stormwater program to address polluted stormwater runoff

across the state. It is administered by the Minnesota Pollution Control Agency (MPCA) with oversight from the EPA. Minnesota's stormwater runoff is regulated via the State Disposal System (SDS) by two types of NPDES/SDS permits: general permits and individual permits.

The SDS is generally a permit type issued by the state of Minnesota for non-surface water discharging or land application facilities. It regulates the construction and operation of wastewater disposal systems, including land treatment systems. Conversely, NPDES permits regulate wastewater discharges to lakes, streams, wetlands, and other surface waters. The combined NPDES/SDS permit establishes specific limits and requirements to protect surface and ground water quality. Although Minnesota's Stormwater Program is regulatory, Minnesota's Stormwater Manual is voluntary and provides guidance and technical support for the NPDES/SDS permits.

Minnesota's NPDES/SDS permits are categorized into 4 types:

1. General Stormwater Permit for Construction,
2. General Stormwater Permit for Industrial,
3. General Stormwater Permit for Municipal Separate Storm Sewer Systems, and a
4. NPDES/SDS Individual Stormwater Permit.

With a NPDES/SDS General Stormwater Permit for Construction, permittees are required to comply with post-construction standards for new development or redevelopment.

4.1.1.2 Background

Stormwater management has evolved substantially during the past 20 years in Minnesota. Historically, the goal was to move water off the landscape quickly and reduce flooding concerns. Many policymakers and stormwater experts are now focusing on keeping the raindrop where it falls by mimicking natural hydrology in order to minimize the amount of pollution reaching lakes, rivers and streams, and to recharge ground waters. In response to this need, and advanced by a diverse group of partners, the Minnesota Legislature directed state agencies to "develop performance standards, design standards or other tools to enable and promote the implementation of low impact development and other stormwater management techniques." [i]

The Minimal Impact Design Standards (MIDS) scheme was developed in response to this direction. It is based on Low Impact Development (LID)—an approach to storm water management that mimics a site's natural hydrology as the landscape is developed. Using the Low Impact Development approach, storm water is managed on-site and the rate and volume of storm water reaching receiving waters is unchanged from predevelopment levels. The calculation of predevelopment hydrology is based on native soil and vegetation existing before the land is disturbed. MIDS is also designed to be flexible, in recognition that no two sites or projects are exactly similar.

In October 2009, the Minnesota Pollution Control Agency (MPCA) initiated the process that created MIDS by collecting input from developers, municipal planners, public works departments, and decision makers. MPCA hoped to identify and prioritize the most important structural and non-structural best management practices necessary for effective stormwater management. In January 2010, the MIDS workgroup was formed under the auspices of the Minnesota Stormwater Steering Committee. Members of the workgroup provided guidance and recommendations to the MPCA on the MIDs project. In April 2011, MIDS work group members agreed on a performance goal for new development. In June, 2013, the MIDS work group members agreed on a performance goal for redevelopment and linear development projects

(i.e. road construction). The MIDS standards and the Minnesota Stormwater Manual were finalized and published in 2013.

MIDS represents the next generation of stormwater management, and contains four main elements that address current challenges:

1. A higher clean water performance goal for new development and redevelopment that provides enhanced protection for Minnesota's water resources.
2. New modeling methods and credit calculations that standardize the use of a range of "innovative" structural and non-structural stormwater techniques.
3. A credits system that allow for increased flexibility and a streamlined approach to regulatory programs for developers and communities.
4. A Community Assistance Package (CAP) that provides model ordinances and tools to help integrate LID principles, including the MIDS performance goals and MIDS calculator, into existing ordinances or establish new stormwater ordinances.

4.1.1.3 Stormwater Targets

The stakeholder input, working group discussions, and expert recommendations resulted in several innovative and strict Performance Goals. These three elements are further parsed into specific performance goals.

1. New, nonlinear developments that create more than one acre of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on-site for 1.1 inches (28 mm) of runoff from impervious surfaces statewide.

2. Nonlinear redevelopment projects on sites without restrictions, that create one or more acres of new and/or fully reconstructed impervious surfaces shall capture and retain on-site 1.1 inches (28 mm) of runoff from the new and/or fully reconstructed impervious surfaces.

3. Linear projects on sites without restrictions that create one acre or more of new and/or fully reconstructed impervious surfaces, shall capture and retain the larger of either:
    1. 0.55 inches (14 mm) of runoff from the new and fully reconstructed impervious surfaces; or
    2. 1.1 inches (28 mm) of runoff from the net increase in impervious area. Mill and overlay and other resurfacing activities in linear projects are not considered fully reconstructed.

The MIDS approach further requires that all projects must first attempt to meet the volume reduction Performance Goal on site. However, if an applicant is unable to achieve the full Performance Goal due to site restrictions as attested by the local authority and documented by the applicant, the development project must follow one of three (3) Flexible Treatment Options.

1. Flexible Treatment Option 1: Applicant attempts to comply with the following conditions:
    i. Achieve at least 0.55 inch (14 mm) volume reduction goal, and
    ii. Remove 75 percent of the annual total phosphorus load, and

iii. Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site

2. Flexible Treatment Option 2: Applicant attempts to comply with the following conditions:
    i. Achieve volume reduction to the maximum extent practicable (as determined by the Local Authority), and
    ii. Remove 60 percent of the annual total phosphorus load, and
    iii. Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site.

3. Flexible Treatment Option 3: Off-site mitigation (including banking or cash or treatment on another project, as determined by the local authority) equivalent to the volume reduction performance goal can be used in areas selected in the following order of preference:
    i. Locations that yield benefits to the same receiving water that receives runoff from the original construction activity.
    ii. Locations within the same Department of Natural Resources (DNR) catchment area as the original construction activity.
    iii. Locations in the next adjacent DNR catchment area up-stream.
    iv. Locations anywhere within the local authority's jurisdiction.

These performance goals are based on a report conducted by Barr Engineering Company in 2011.[ii] This report used long-term, continuous simulation, XP-SWMM models, for three regions of Minnesota (Twin Cities Metropolitan area, Southeast, and North-Central). The models used between twenty-six and thirty-five years of measured precipitation data with a time increment of 15 minutes. Precipitation in the form of rain and snow on frozen and unfrozen ground conditions was also used to determine the effectiveness of common volume control performance goals on annual runoff.[iii] Performance goals were assessed based on estimated total phosphorus (TP) and total suspended solids (TSS) removal efficiency on an average annual basis.

Three (3) options were considered:

(1) The volume of 1 inch (25 mm) from impervious surfaces which is equivalent to current permit requirements;

(2) The 95th percentile rainfall event, which at the time was being considered by the U.S. Environmental Protection Agency (EPA) as a national standard;

(3) The 1 year, 24-hour storm event, and the 2-year, 24-hour storm event.

After considerable discussion, the workgroup chose a modified version of the second choice: the 90th percentile rainfall event (1.1 inches) as preferred option.

MIDS is especially effective in Minnesota because it is typically implemented by several overlapping authorities, including watershed districts, water management organizations, counties, and municipalities. At the watershed level, watershed districts (WD) and water management organizations (WMO) have some of the powers of a municipality, for instance the power to levy taxes to fund planning, implementation, and enforcement. WDs and WMOs also

conduct long-term watershed planning, in-depth study of watershed conditions, and monitoring & evaluation of programs and projects, all of which are crucial to the success of the MIDS regulatory scheme. As of August 2015, a significant number of Watershed Districts, Water Management Organizations, Lake Improvement Districts, Soil and Conservation Districts, and municipalities are actively preparing to adopt MIDS standards.[iv] The Minnesota Department of Natural Resources, a state-level agency, incorporated the MIDS performance goals into its Stormwater and Shoreline Best Management Practices for Public Water Accesses.

In May of 2014, the Minnesota Pollution Control Agency (MPCA), in a letter to Communities Interested in Adopting MIDS, approved the use of MIDS to help communities meet a number of goals. Specifically, MIDS can be used to improve water quality; meet the permit conditions for post-construction stormwater management for new development and redevelopment as required by the general permit for small Municipal Separate Storm Sewer Systems (MS4); meet anti-degradation requirements; meet future volume control and pollutant reduction requirements; and achieve waste load reductions as specified in a Total Maximum Daily Load (TMDL). The MIDS Calculator will also help communities quantify load reductions for funding applications.

4.1.1.4 BMP Performance

A performance goal specifies what level of stormwater treatment must be achieved. The MIDS performance goals were developed to satisfy the legislation by determining how much precipitation must be retained on a particular site.

Performance goals were assessed based on estimated total phosphorus (TP) and total suspended solids (TSS) removal efficiency on an average annual basis. The portion of average annual runoff volume captured onsite varies depending on the performance goal and resulting BMP volume. While strongly correlated with the amount of runoff captured and infiltrated, the overall pollutant removal efficiency is also dependent on other factors such as the varying concentration of pollutants in runoff (such as the “first flush effect”) and pollutant removal that occurs through sedimentation or other mechanisms. Six of the Twin Cities region development scenarios were modeled using P8 modeling software to evaluate the overall average annual phosphorus and total suspended solids removal efficiencies expected from the four performance goals (Barr Engineering Co., 2010). Those four performance goals included retainage of a runoff volume:

- Equal to 1.0 inches times the proposed impervious surfaces;
- Equivalent to the post-runoff volume on site for the 95th percentile storm, which is approximately 1.4 inches in the Minneapolis-St. Paul metro area;
- Necessary to match the native runoff volume to the 1-year 24-hour design storm (e.g., not allow an increase in the runoff volume from the 1-year 24-hour design storm); and
- Necessary to match the native runoff volume to the 2-year 24-hour design storm (e.g., not allow an increase in the runoff volume from the 2-year 24-hour design storm).

The following conclusions are based on the XP-SWMM and P8 modeling results:

- Rate and volume control Best Management Practices (BMPs) are needed to mimic native hydrology from developed conditions.
- Developed sites without volume control BMPs produce approximately two to four times the average annual runoff volume of native conditions.
- All of the volume control performance goals evaluated do well at matching native conditions on an average annual basis.

- Volume control BMPs controlled the 1-year, 24-hour peak rates to flows less than or equal to native conditions for most scenarios evaluated.
- Volume control performance goals result in significant pollutant loading reduction from developed sites.
- All volume control performance goals evaluated have similar removal efficiencies for TP and TSS.
- The BMP size required to match native runoff volumes on an average annual basis varied with soil type, impervious percentage, and region of the state.

The Work Group discussed the modeling results and considered the level of simplicity, incentive to reduce impervious surfaces, and accounting for different regions of the state for each modeling approach. After a vote, the Work Group selected an approach that would retain a runoff volume equal to an amount times the proposed impervious surfaces. The Work Group decided that one value would be best rather than varying the value by soil type, impervious surface percentage, and location within the state. They selected 1.1 inches as the statewide average.

In April 2011, the MIDS Work Group members agreed on the performance goal for new development:

For new, nonlinear developments that create more than one acre of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site for 1.1 inches of runoff from impervious surfaces statewide

4.1.1.5 Comparison of Current Water Budget Standards and Current Practices

The MOECC's current approach in the 2003 SWMPD is based on the water balance method developed by Thornthwaite and Mather in 1957. The method requires monthly or daily precipitation, monthly or daily temperature, latitude of the site, vegetation type, soil type, and a series of tables. The Thornthwaite and Mather method includes multiple assumptions, including mature vegetation and does not account for seasonal variations in evapotranspiration.

In simple terms, a water budget is a method for accounting for water inputs, outputs and changes in storage within a particular area. The inputs into the area (precipitation) must be equal to the outputs (evaporation, transpiration, infiltration, and runoff) and any changes in storage within that area. Figure 4.1, below, illustrates these components. Water that remains after the natural output processes (evaporation, transpiration, and infiltration) generally becomes either surface run-off or subsurface interflow. In Ontario, there are six (6) steps to develop a water budget:

(1) Determine study objectives, area boundaries and temporal scales;

(2) Acquire complete data from reliable sources;

(3) Develop initial conceptual model of inputs and outputs in the study area;

(4) Conduct numeric modeling;

(5) Establish quantitative targets for water quality and quantity, and biological and habitat requirements;

(6) Collect information to fill gaps and refine water budget.

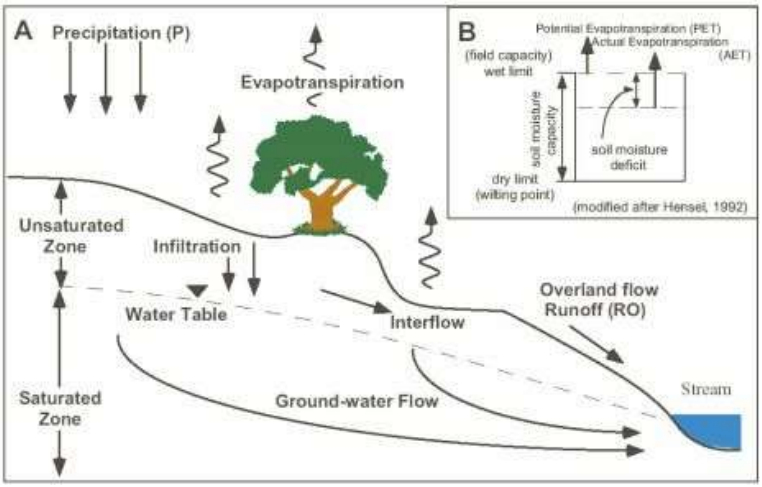


Figure 4.1: Water budget components (source: Gerber and Howard, 1997)

MIDS and the other stormwater management systems described below generally rely on statistical thresholds established through observation of local rainfall trends. Many other jurisdictions use the 90th percentile rainfall event as volume reduction performance target. The 90th percentile rainfall event represents a precipitation amount which 90 percent of all rainfall events for the period analyzed does not exceed. In more technical terms, the 90th percentile rainfall event is defined as the measured precipitation depth accumulated over a 24-hour day for the period analyzed that ranks as the 90th percentile rainfall depth based on the range of all daily event occurrences during this period. In general, at least a 20- 30 year period of rainfall record is recommended for such an analysis. Small rainfall events that are 0.1 of an inch or less are excluded from the percentile analysis because this rainfall generally does not result in any measureable runoff due to absorption, interception and evaporation by permeable, impermeable and vegetated surfaces.

Adopting the 90th percentile (or larger storm) and a detailed explanation of how to apply it to a development project would improve the functionality and value of future provincial guidance. Further, MIDS, and other approaches do not involve complicated, often inaccurate or unverifiable assumptions in calculating volumes. MIDS enriches the modeling and stormwater volume calculation process by using refined data sources (20 to 30 years of precipitation data at 15 minute intervals), and focusing only on observed rainfall events. Finally, multiple expert comparisons of water budget systems and MIDS, including LSCRA's review of MIDS, demonstrate that MIDS more effectively reduces stormwater volumes.

4.1.1.6 Process to Address Specific Water Quality Impairments

Section 303(d) of the Clean Water Act requires various governing bodies, including states, territories, and authorized tribes, to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by those same governmental entities with technology-based controls alone. The law requires that these jurisdictions establish priority rankings for waters on the lists. Priority rankings take into account the pollution severity and designated uses of water from that particular waterbody. Once these waters are identified and ranked, states must develop Total Maximum Daily Loads (TMDLs) for each, at the level necessary to achieve the State water quality standards applicable to that body of water. In Canada, watershed managers call TMDLs "Assimilative Capacity Studies."

In the U.S., a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. The elements of a TMDL are described in Section 303(d) of the CWA, in regulations,[v] and also in U.S. Environmental Protection Agency guidance[vi] (U.S. EPA, 1991). A TMDL is defined as "the sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL must also include seasonal variations and a margin of safety to address uncertainty in the analysis. In addition, states must develop water quality management plans to be used to directly implement the plan elements, including TMDLs.

Often times a general standard like the MIDS thresholds do not go far enough to reduce volume and pollutant loading and a more specific standard must be adopted to improve receiving waters. Total Maximum Daily Loads require extensive technical expertise and experience in characterizing watersheds, and watershed modeling that results in detailed and implementable plans. It requires comprehensive planning that incorporates all of the EPA's Nine Elements for Watershed Plans. Plans to reduce stormwater runoff that integrate data and experience from numerous modeling efforts, watershed studies, and management plans are especially crucial to addressing waters with quality impairments. Finally, close collaboration between local, state, regional, and federal agencies and organizations is necessary to identify causes and sources of impairments, establish stormwater quantity and quality plans and verify that impairments are addressed in the TMDL study.

The MIDS approach has served as a template for the current LSRCA stormwater management guidelines discussed in more detail **Section 4.2.2.**

4.1.1.7 Winter Stormwater Management

Special management of cold weather runoff is usually required because of the extended storage of precipitation and pollutants in catchment snowpack, the processes occurring in snowpack, and the changes in the catchment surface and transport network by snow and ice. The discharges that come from urban meltwater may cause physical, chemical, biological and combined effects in receiving waters and thereby limit their quality, ecosystems and beneficial uses.

For many years the old adage "one size fits all" was tried for the management of all runoff management. Once the effects of this approach were scrutinized, however, it became apparent that applying traditional rainfall runoff BMPs was not working for meltwater in spite of their success with rainfall. The problem is usually not the large volume resulting from a significant event, although serious flooding certainly can occur. Rather, it is that the BMPs are prevented from working as intended because of ice, cold water, highly concentrated pollution and lack of biological activity. Complications encountered in cold climates simply work against many of the commonly used warm weather BMPs, reinforcing the need for the development or adaptation (e.g. revised criteria and specifications) of existing treatment practices to better address melt runoff. Additionally, the usually poorer performance exhibited during cold weather is generally not considered when management approaches are designed because of the perceived uselessness in trying to overcome the challenges to managing runoff in cold climates. The problems cannot be entirely negated, but any improvement in the quantity and quality of runoff will be a step forward.

Typical results of the conditions listed above include flow by-passing and flooding, lack of reaeration in the water column, pond stratification, decreased settling and biological uptake,

flushing of previously settled material, and reduced infiltration capacity. The Minnesota Stormwater Manual lists five steps for winter stormwater management:

Step 1 - Pollution Prevention

Pollution prevention is always the best way to manage the quality of runoff from urban and rural surfaces.

Step 2 - Infiltration

The highly soluble and perhaps toxic “first flush” should be infiltrated to the extent possible provided the source area is not concentrated in chloride (Cl) or other toxic pollutants. This can be done on-site in areas with a high degree of pervious surfaces, or perhaps routed to an area where short-term detention and infiltration can occur. For source areas high in Cl and soluble toxics or near drinking water sources, infiltration should be avoided in favor of storage and slow release once sufficient flow occurs in the receiving water to dilute the effects. Note also that snow deposits should not be located directly over a designed infiltration facility because of the possibility of clogging from debris in the snow.

Step 3 - Meltwater Storage

Excess flow that cannot be infiltrated because of preventive (frozen) or pollution conditions should be collected in a meltwater storage area with excess capacity to hold it for the later influx of water volume and particulates. These particulates can adsorb soluble particles and settle, thus removing a portion of the more toxic soluble load.

Step 4 - Filtration

When fine- and medium-grained solids begin to move, settling BMPs can be incorporated starting with local application, and moving to regional storage as the need dictates. Some adaptations will be needed to incorporate storage around ice layers that might be present.

Step 5 - Housekeeping

Much of the remaining solids are too heavy to be moved by melt so they remain near the roadside, in gutters, or in the location they were dumped as part of a snow pile, available for wash-off when spring rains come. After the snowpack has totally melted and before the first rainfall (if possible) preventive measures such as street and parking lot sweeping should be pursued. Note that Step 5 could occur after Step 1 for those communities or commercial/industrial facilities that practice cleaning activities during the winter.

The sequence above is an optimal approach and ideal conditions seldom occur.

4.1.2 Chicago, Illinois

4.1.2.1 Background

Chicago is the 3rd most populous city in the United States, with over 2.7 million residents. Drainage from Chicago is discharged primarily to Lake Michigan.

The City of Chicago (City) is committed to protecting, conserving and managing their water wisely. The City has developed "Chicago's Water Agenda 2003" (Water Agenda) to encapsulate its goals for water management in the City and to outline its strategies for accomplishing these goals.

The Water Agenda details many steps that the City has taken to address stormwater management issues.

First, it has begun promoting green building design and best management practices (BMPs). By encouraging applicants to obtain Leadership in Energy and Environmental Design (LEED) certification and incorporate BMPs into design plans, the City hopes to reduce impacts from stormwater runoff.

Second, the City has taken steps to prevent polluted stormwater from roadways from discharging directly into Lake Michigan and the Chicago and Calumet Rivers. The reconstruction of Wacker Drive was designed to divert first-flush stormwater from the roadway to sewage treatment facilities.

Third, the City has also developed a sewer inlet control system called the "Rainblocker Program" to reduce combined sewer overflows and reduce basement flooding. Wherever appropriate, residents are asked to disconnect their downspouts from the sewer system and allow the downspouts to drain instead onto permeable surfaces such as lawns. The City is also working to comply with National Pollutant Discharge Elimination System (NPDES) Phase II requirements. Primarily, the City has focused on stormwater control areas, such as areas relying on separate storm sewers and riparian areas that allow stormwater to flow directly into water bodies.

Within the context of this broader push for improved stormwater management, the City recently passed its "Chicago Stormwater Management Ordinance" (Ordinance). The Ordinance applies to certain types of new developments and redevelopment and requires specific practices to ensure that stormwater is responsibly managed in accordance with the goals of the Water Agenda. The purpose of this "Stormwater Manual" (Manual) is to help applicants understand and comply with the Ordinance.

4.1.2.2 Stormwater Targets

The 2014 City of Chicago Stormwater Management Ordinance includes the following requirements related to volume control:

Stormwater drainage systems shall reduce the volume of runoff from a Regulated Development by one of the following measures:

1. Capture 0.5 inches of runoff from all impervious surfaces in accordance with volume control BMPs

2. For Developments that do not directly discharge to Waters or to a municipal separate storm sewer system, achieve a 15% reduction in impervious surfaces from existing conditions

The above shows that the volume target is not based on a storm event, but rather on a volume that is 0.5 inches deep, covering all impervious surfaces.

4.1.2.3 BMP Performance Standards

All proposed BMPs are subject to rate control or volume control design requirements that are based on tested performance standards. These performance standards are designated based on the receiving water (sewer or water body), as well as the type of proposed activity based on the amount of proposed impervious area, amount of land disturbed, and type of construction.

4.1.2.4 Winter Stormwater Management

Limited guidance or direction in regards to winter stormwater management is provided. The following exceptions are noted:

- Rain barrels must be drained before winter to prevent any damage from freezing and thawing.
- It is also recommended to not spread sand over permeable pavers during winter months to prevent clogging the void spaces.
- In regards to green roofs, the growing medium in an extensive green roof should be a lightweight mineral material with a minimum of organic material and should stand up to freeze/thaw cycles.

4.1.2.5 BMP Performance

According to the Chicago Stormwater Maintenance Ordinance, each BMP requires ongoing maintenance, which includes a BMP performance spreadsheet to regularly monitor the BMP performance.

4.1.3 State of Michigan

4.1.3.1 Background

The State of Michigan is the 10th most populous state and has the 11th most extensive total area. The state is bordered by three (3) of the Great Lakes: Lake Michigan, Lake Huron and Lake Erie.

Michigan's National Pollutant Discharge Elimination System (NPDES) Permit Application for Discharge of Storm Water to Surface Waters from a Municipal Separate Storm Sewer System (MS4) requires the applicant to provide a description of the Best Management Practices (BMP) that will be implemented for each minimum control measure and the applicable water quality requirements. These BMPs build the applicant's Storm Water Management Program (SWMP). The applicant must submit a complete application containing a SWMP to be approved as part of issuance of an individual permit. The applicant may choose the BMPs to meet the application requirements and develop an approvable SWMP. The Post-Construction Storm Water Runoff Program is one of the minimum control measures. Post-construction regulations are discussed

in the 2014 Post-Construction Stormwater Runoff Controls Program by the Michigan Department of Environmental Quality.

4.1.3.2 Stormwater Targets

The treatment volumes specified are based on capturing and treating the volume of storm water that is the first to runoff in a storm and expected to contain the majority of pollutants. This volume of runoff is often referred to as the "first flush." Sizing the BMPs to meet the stormwater requirements ensures acceptable storm water treatment that minimizes water quality impacts.

A permit applicant may choose one or both of the following minimum treatment volume standards specified in the Application:

1) One inch (25 mm) of runoff generated from the entire project site (see below Calculate One Inch of Runoff from the Entire Project Site).

2) The calculated site runoff for the entire project site from the 90 percent annual non-exceedance storm for the region or locality according to one of the following (see below Calculate Runoff Generated by 90 Percent Annual Non-Exceedance Storm):

- The statewide analysis by region for the 90 Percent Annual Non-Exceedance Storms summarized in a memorandum dated March 24, 2006, and available on the Internet at http://www.michigan.gov/documents/deq/lwm-hsu-nps-ninety-percent_198401_7.pdf.
- The analysis of at least ten years of local published rain gauge data following the method in the memo "90 Percent Annual Non-Exceedance Storms" cited above.

Calculate One Inch of Runoff from the Entire Project Site

This is the simplest and most conservative approach. Research has shown that nearly all the pollutants washed off in the "first flush" of runoff from impervious surfaces are contained in the first inch of runoff. To calculate, determine the area of land contributing storm runoff (A) in square feet and multiply by 1/12 feet;

$A\ ft^2 \times 1/12\ ft$ = Minimum Treatment Volume in cubic feet

Calculate Runoff Generated By 90 Percent Annual Non-exceedance Storm

This method is a more rigorous analysis of the runoff generated from different land types for the entire project site for 90 percent of all the storms that generate runoff. It is a more accurate representation of the runoff from the project site and usually results in a smaller treatment volume than using one inch of runoff from the entire project site.

The 90 percent storms for ten regions of the state (from the memo mentioned above) are shown in tabular format. They range in rainfall from 0.77 inch to 1.0 inch. An acceptable substitute for the statewide regional analysis would be an analysis of a minimum of ten years of local published rain gauge data (using the method in the memo mentioned above).

4.1.3.3 Winter Stormwater Management

There is no mention of winter stormwater management in the 2014 Post-Construction Stormwater Runoff Controls Program by the Michigan Department of Environmental Quality.

4.1.3.4 BMP Performance

The water quality treatment and channel protection performance standards are listed in the 2014 Post-Construction Stormwater Runoff Controls Program by the Michigan Department of Environmental Quality. These standards focus on maintaining or restoring stable hydrology. When developing a post-construction program for redevelopment, the permit applicant may want to consider potential physical constraints that may limit the ability to fully meet the post-construction requirements at the project site. Redevelopment can reduce regional land consumption and minimize new land disturbance; however, redevelopment may also present site-specific challenges such as land use that is not conducive to the capture and use of storm water, limited space available, or contaminated soils. When these physical constraints limit the feasibility of maintaining or restoring hydrology the application includes an option for establishing a program to move off site for these types of redevelopment projects.

A permittee is in compliance if the minimum treatment volume from a project site is treated by properly designed BMPs that achieve either 80 percent removal of TSS, or discharge 80 mg/l or less of TSS according to accepted literature. It is also important to note that new development will often meet the water quality treatment performance standard if the volume control specified in the channel protection requirement of this permit is achieved. Compliance with the water quality treatment performance standard may be shown through calculation or through direct measurement. Calculations or measurements must show reductions to the calculated TSS concentration in uncontrolled runoff using the data provided here or another acceptable literature source.

4.1.4 New York State

4.1.4.1 Background

New York State is the 4th most populous with an estimated 19.8 million residents and 7th most densely populated state. Portions of the state discharge to Lake Ontario and Lake Erie, as well as numerous interior lakes and the Atlantic Ocean.

The first stormwater guidelines were published in the 2010 New York State Stormwater Design Manual. These were then superseded by the current 2015 New York State Stormwater Design Manual.

Pursuant to Section 402 of the Clean Water Act (“CWA”), operators of small municipal separate storm sewer systems (“small MS4s”), located in urbanized areas and those additionally designated by New York State are unlawful unless they are authorized by a National Pollutant Discharge Elimination System (“NPDES”) permit or by a state permit program. New York State Pollutant Discharge Elimination System (“SPDES”) is an NPDES-approved program with permits issued in accordance with the Environmental Conservation Law (“ECL”).

Only those small MS4 operators who develop and implement a stormwater management program (SWMP) and obtain permit coverage in accordance with Part II of this SPDES general permit are authorized to discharge stormwater from their small MS4 under this SPDES general permit.

A covered entity authorized under GP-0-10-002 as of the effective date of GP-0-15-003, shall be permitted to discharge in accordance with the renewed permit, GP-0-15-003, upon the submission of their Annual Report, unless otherwise notified by the Department.

Covered entities must develop (for newly authorized MS4s) implement, and enforce a SWMP designed to reduce the discharge of pollutants from small MS4s to the maximum extent practicable in order to protect water quality and to satisfy the appropriate water quality requirements of the ECL and the CWA. The objective of the permit is for MS4s to assure achievement of the applicable water quality standards. Covered entities under permit GP-0-10-002 must have prepared a SWMP plan documenting modifications to their SWMP. The SWMP and SWMP plan may be created by an individual covered entity, by a shared effort through a group or coalition of individual covered entities, or by a third party entity.

4.1.4.2 Stormwater Targets

The 2010 New York State Stormwater Management Design Manual (NYSSMDM) uses the Unified Sizing Criteria for sizing green infrastructure. The Water Quality Volume (denoted as the WQv) is designed to improve water quality sizing to capture and treat 90% of the average annual stormwater runoff volume. The WQv is directly related to the amount of impervious cover created at a site. Contour lines of the 90% rainfall event are presented below. These contours represent a design rainfall depth ranging between 0.8 and 1.2 inches.

4.1.4.3 Winter Stormwater Management

Cold climate regions of New York State may present special design considerations. Each section in Chapter 6 of the NYSSMD includes a summary of possible design modifications that address the primary concerns associated with the use of each BMP in cold climates. In addition, Appendix I of the NYSSMD provides some sizing examples that incorporate cold climate design.

4.1.4.4 BMP Performance

Chapter 6 of the NYSSMD outlines performance criteria for five groups of structural stormwater management practices (SMPs) to meet water quality treatment goals. These include ponds, wetlands, infiltration practices, filtering systems and open channels. Each set of BMP performance criteria, in turn, is based on six (6) performance goals:

1. Feasibility - Identify site considerations that may restrict the use of a practice.

2. Conveyance - Convey runoff to the practice in a manner that is safe, minimizes erosion and disruption to natural channels, and promotes filtering and infiltration.

3. Pre-treatment - Trap coarse elements before they enter the facility, thus reducing the maintenance burden and ensuring a long-lived practice.

4. Treatment Geometry - Provide water quality treatment, through design elements that provide the maximum pollutant removal as water flows through the practice.

5. Environmental/Landscaping - Reduce secondary environmental impacts of facilities through features that minimize disturbance of natural stream systems and comply with environmental regulations. Provide landscaping that enhances the pollutant removal and aesthetic value of the practice.

6. Maintenance - Maintain the long-term performance of the practice through regular maintenance activities, and through design elements that ease the maintenance burden.

4.1.4.5 Key definitions

The following key definitions are noted within the New York State Stormwater Design Manual.

BIORETENTION - A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff by collecting it in shallow depressions, before filtering through a fabricated planting soil media.

DETENTION - The temporary storage of storm runoff in a SMP with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

DISTURBED AREA - An area in which the natural vegetative soil cover has been removed or altered and, therefore, is susceptible to erosion.

EXTENDED DETENTION (ED) - A stormwater design feature that provides for the gradual release of a volume of water over a 12 to 48 hour interval in order to increase settling of urban pollutants and protect downstream channels from frequent storm events.

FILTER MEDIA - The sand, soil, or other organic material in a filtration device used to provide a permeable surface for pollutant and sediment removal.

GREEN INFRASTRUCTURE – In the context of stormwater management, the term green infrastructure includes a wide array of practices at multiple scales to manage and treat stormwater, maintain and restore natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of stormwater, and establishment of natural vegetative features. On a regional scale, green infrastructure is the preservation and restoration of natural landscape features, such as forests, floodplains and wetlands, coupled with policies such as infill and redevelopment that reduce overall imperviousness in a watershed or ecoregion. On the local scale green infrastructure consists of site- and neighborhood-specific practices and runoff reduction techniques. Such practices essentially result in runoff reduction and or establishment of habitat areas with significant utilization of soils, vegetation, and engineered media rather than traditional hardscape collection, conveyance and storage structures. Some examples include green roofs, trees and tree boxes, pervious pavement, rain gardens, vegetated swales, planters, reforestation, and protection and enhancement of riparian buffers and floodplains.

INFILTRATION RATE (Fc) - The rate at which stormwater percolates into the subsoil measured in inches per hour.

NATURAL AREAS - This is undisturbed land or previously disturbed land that has been restored and that retains pre-development hydrologic and water quality characteristics.

NEW DEVELOPMENT – Any construction or disturbance of a parcel of land that is currently undisturbed or unaltered by human activities and in a natural state.

PERFORMANCE CRITERIA: The Design criteria that results in the performance required by the Design Manual (80 % TSS and 40% Phosphorus removal); defined by two parts; Design Guidelines and Required Elements.

PRETREATMENT - Techniques employed in stormwater SMPs to provide storage or filtering to help trap coarse materials before they enter the system.

REDEVELOPMENT - Reconstruction or modification to any existing, previously developed land such as residential, commercial, industrial, institutional or road/highway, which involves soil disturbance. Redevelopment is distinguished from development or new development in that new development refers to construction on land where there had not been previous construction. Redevelopment specifically applies to constructed areas with impervious surface.

RETENTION - The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

TOTAL IMPERVIOUS AREA - This is the total area within a watershed of all materials or structures on or above the ground surface that prevents water from infiltrating into the underlying soils. Impervious surfaces include, without limitation: paved parking lots, sidewalks, rooftops, patios, and paved, gravel and compacted dirt surfaced roads. Gravel parking lots and/or compacted urban soils are often not included in total impervious area but may have hydrologic characteristics that closely resemble paved areas.

ULTIMATE CONDITION - Full watershed build-out based on existing zoning.

WATER QUALITY VOLUME (WQV) - The storage needed to capture and treat 90% of the average annual stormwater runoff volume.

4.2 Broader Canadian Jurisdictions

4.2.1 Province of British Columbia

The following section describes the stormwater management policies and related guidance material within the Province of British Columbia. For clarity and continuity, the City of Chilliwack has been included in subsequent sections. **Sections 4.2.1.1** to **Section 4.2.1.3** describe the overarching Provincial policies and guidance, while Sections 4.2.1.4 describe the City of Chilliwack.

4.2.1.1 Background

British Columbia (B.C.) is the western most province in Canada and is a component of the Pacific Northwest. B.C. is home to the Cities of Victoria and Vancouver, the 15th largest and 3rd largest metropolitan regions in Canada respectively. B.C. drains to many interior lakes and rivers as well as the Pacific Ocean.

Prior to 2002, site design practices were not clearly laid out in stormwater policy objectives. The British Columbia (B.C.) Stormwater Planning Guidebook pioneered the use of "adaptive management" in stormwater management. The goal of Adaptive Management is to learn from experience and constantly improve land development and rainwater management practices over time. Implicit in an adaptive management approach is recognition of the need to both accept and manage risk if the state-of-the-practice is to be advanced.

In British Columbia, the term Integrated Stormwater Management Plan (ISMP) has gained widespread acceptance by local governments and the environmental agencies to describe a comprehensive approach to stormwater planning. The purpose of an ISMP is to provide a clear picture of how to be proactive in applying land use planning tools to protect property and aquatic habitat, while at the same time accommodating land development and population growth. The Guidebook also introduced the concept of Performance Targets to facilitate implementation of the Integrated Strategy for managing the complete rainfall spectrum. The Stormwater Guidebook established the framework for making integrated and adaptive management of stormwater and land development a reality.

The Guidebook is structured to meet the needs of different audiences: from senior managers and elected officials, to professional planning and engineering staff, to land developers and property owners. To provide for this range of audiences, the Guidebook is organized in three (3) parts.

1. Part A - identifies problems associated with traditional stormwater management and provides the rationale for a change from traditional to integrated stormwater management. Some guiding principles of integrated stormwater management are introduced.

2. Part B - outlines the scope and policy framework for integrated stormwater management, and presents a cost-effective methodology for developing stormwater solutions.

3. Part C - describes a process that will lead to better stormwater management solutions. The role and design of action plans are introduced to bring a clear focus to what needs to be done, with what priority, by whom, with related budgets. Part C also provides

guidance for organizing an administrative system and financing strategy for stormwater management.

4.2.1.2 Stormwater Targets

Performance targets are the foundation for implementing common sense solutions that eliminate the source of stormwater related problems. Further, performance targets provide a starting point to guide the actions of local government in the right direction. Runoff volume-based performance targets are not only quantifiable, but also synthesizes complex information into a single number that is simple to understand and achieve, yet is comprehensive in scope.

The B.C. Stormwater Design Guidebook recommends 90% of *rainfall volume* as the target best able to achieve the biophysical target conditions for the watershed.

Rationale - When the impervious area of watersheds with traditional ditch and pipe systems reaches the 10% threshold, about 10% of the total rainfall volume becomes runoff that enters receiving waters; this runoff volume is the root cause of aquatic habitat degradation. Note that there is virtually no surface runoff from the naturally vegetated portion of a watershed, but nearly all rain that falls on directly connected impervious surfaces becomes runoff. An appropriate performance target for managing runoff volume is to limit total runoff volume to 10% (or less) of total rainfall volume. This means that 90% of rainfall volume must be returned to natural hydrologic pathways, through infiltration, evapotranspiration or re-use on the development site. Managing 90% of the rainfall volume throughout a watershed should achieve the biophysical target condition for the watershed. Managing 90% of rainfall volume therefore becomes the volume-based performance target.

In the same vein, the *runoff rate target* should be set to ensure that streamflow rates that correspond to the natural Mean Annual Flood (MAF) occur once per year, on average.

Rationale - MAF is defined as the channel-forming event; as the MAF increases with development, stream channels erode to expand their cross-section, thereby degrading aquatic habitat. To achieve this target, stormwater systems should be designed to limit the frequency that the natural MAF is exceeded.

Finally, the Guidebook also recommends additional science-based indicators as performance targets, including:

- Maintain stream base flow at a minimum of 10% of the Mean Annual Discharge.
- Maintain natural total suspended solids (TSS) loading rates.
- Maintain key indicators of aquatic ecosystem health (e.g. maintain Benthic Index of Biological Integrity (B-IBI) score above 30).
- Preserve a 30-metre wide intact riparian corridor along all streamside areas.
- Retain 65% forest cover across the watershed

To achieve runoff volume and rate targets, development sites and their stormwater systems must be designed to replicate the functions of a naturally vegetated watershed. This requires stormwater source control strategies that capture rainfall at the source and return it to natural hydrologic pathways (i.e. infiltration and evapotranspiration) or re-use it at the source. Source control solutions effective at maintaining or restoring natural runoff volume and rates, include:

- Preserving natural vegetation cover, natural stormwater management features (e.g. wetlands), and limiting the extent of impervious areas through low impact development practices;
- Preserving or restoring natural infiltration capacity by infiltrating runoff from impervious surfaces and applying absorbent landscaping;
- Preserving or restoring natural evapotranspiration capacity to the extent possible through conservation, landscaping and the application of green roofs; and
- Re-using rainwater for irrigation and for indoor uses

In addition to the runoff volume and rate targets, Integrated Stormwater Management Plans (ISMPs) should address stream health. Stream health can be addressed by many of the same strategies applied to achieve performance targets.

Both the runoff volume target and runoff rate targets are derived from a thorough understanding of the rainfall spectrum. A key parameter for describing the rainfall spectrum is the Mean Annual Rainfall (MAR): the rainfall event that occurs once per year, on average. To simplify performance targets, the Guidebook organized rainfall volumes into three Tiers:

1. Tier A Events: small rainfall events less than half of the Mean Annual Rainfall (MAR).

2. Tier B Events: large events greater than half the size of the MAR, but smaller than the MAR.

3. Tier C Events: extreme rainfall events greater than the MAR.

Location	Tier A Events (less than 50% of MAR)	Tier B Events (between 50% of MAR and MAR)	Tier C Events (greater than MAR)
Vancouver (North Shore)	< 40 mm	40 to 80 mm	> 80 mm
Chilliwack	< 30 mm	30 to 60 mm	> 60 mm
Nanaimo	< 20 mm	20 to 40 mm	> 40 mm
Kelowna	< 10 mm	10 to 20 mm	> 20 mm

Roughly *90% of all rainfall events are Tier A events*; about 10% of rainfall events are in Tier B, and Tier C events may or may not occur in a given year.

Each tier corresponds to a component of the ISMP. Rainfall capture (source control) is designed to manage smaller Tier A rainfall events. On-lot and on-street BMPs, such as rain gardens and infiltration pits, keep rain on site. Runoff control (detention) is able to manage large Tier B rainfall events. BMPS deployed for these events address runoff rate targets by delaying overflow runoff, thereby eliminating spikes in stormwater runoff. Typical BMPs include ponds and other detention storage. Flood risk management (contain and convey) reduces the threats to public safety and damage to property from extreme Tier C events. These practices reduce flooding by providing sufficient hydraulic capacity to contain and convey runoff from large

storms. The Guidebook provides a very useful example to explain how the integrated stormwater planning process moves from defining the rainfall spectrum to setting performance targets for each tier of rainfall events to establishing design criteria for specific practices.

4.2.1.3 BMP Performance

Chapter 7 of the Guidebook describes site design strategies for achieving performance targets. The chapter focuses on Low Impact Development, and source control practices. Information on how to communicate performance targets and related design guidelines to developers so that they can be applied at the site level is also included. For each practice, the Guidebook provides a variety of information such as pictures, technical drawings, performance analyses, and cost estimations. Chapter 8 discusses, and provides examples for how to apply the performance targets at the watershed scale.

Part C of the Guidebook is titled "Moving from Planning to Action." It provides information on how local governments can develop and implement an integrated stormwater management plan. The process is simplified to seven steps ranging from gaining initial political support, to refining the ISMP through adaptive management. Part C finishes with brief sections about funding planning activities and building consensus.

4.2.1.4 Chilliwack, B.C

The City of Chilliwack Policy and Design Criteria Manual for Surface Water Management (May 2002) was developed as a case study application of Stormwater Planning: A Guidebook for British Columbia, a collaborative effort of an inter-governmental partnership that was initiated by local government. Through interaction with the Chilliwack community during its development, the Manual has also provided a feedback loop for the Guidebook process.

At the Watershed and Neighbourhood Scales the manual provides the City with a comprehensive framework that will guide the development and implementation of individual Integrated Master Drainage Plans over a multi-year period. At the Subdivision Scale the manual provides land developers with direction in undertaking the stormwater component of sustainable urban design.

Manual Purpose

The City of Chilliwack's Policy and Design Criteria Manual for Surface Water Management serves two purposes:

- Provide a comprehensive framework that will guide the development of individual Master Drainage Plans over a multi-year period
- Provide land developers with specific direction in undertaking the stormwater component of sustainable urban design.

In order to accomplish this, the Manual:

- Defines a drainage planning philosophy
- Formulates a set of supporting policy statements
- Establishes design criteria to achieve the policies

Stormwater Criteria

At its core, the manual aims to manage the *Complete Spectrum of Rainfall Events*. The City's approach to stormwater management is evolving, from a reactive approach that only dealt with

the consequences of extreme events, to one that is proactive in managing all 170 rainfall events that occur in a year. The objective is to control runoff volume so that watersheds behave as though they have less than 10% impervious area. The manual states – that "reducing runoff volume at the source – where the rain falls - is the key to protecting property, habitat and water quality". The City of Chilliwack is addressing the root cause of drainage related problems – "that is, land development alters the Natural Water Balance." Thus, Chilliwack's approach to stormwater management is evolving from a reactive approach that only 'deals with the consequences' of land use change, often at great public expense to a proactive approach that also 'eliminates the root cause of problems' by reducing the volume and rate of runoff at the source.

Chilliwack's stormwater management approach is to manage the complete spectrum of rainfall events, from the very small to the extreme. The operative words offered within the Manual are retain, detain, and convey:

- **Retain** - The small rainfall events, which account for the bulk of the total rainfall volume, are to be captured and infiltrated (or reused) at the source. The Rainfall Capture (retention) performance target is to Capture the first 30 mm of rainfall per day and restore it to natural hydrologic pathways by promoting infiltration, evapo-transpiration or rainwater reuse.

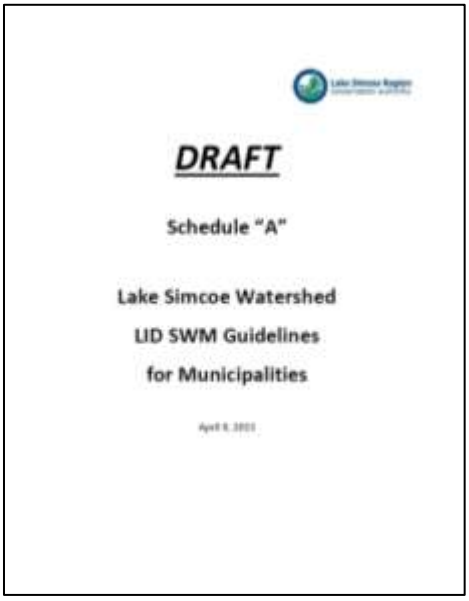
- **Detain** - The intermediate events are to be detained and released to watercourses or drainage systems at a controlled rate. The Runoff Control (detention) performance target is to Detain the next 30 mm of rainfall per day and release to drainage system or watercourses at natural interflow rate.

- **Convey** – The extreme events are to be safely conveyed to downstream watercourses without causing damage to property. The conveyance (Flood Risk Management) performance target is to ensure that the stormwater plan can safely convey storms greater than 60 mm (up to a 100-year rainfall).

4.2.2 Lake Simcoe Region Conservation Authority Watershed

4.2.2.1 Background

In April of 2015, the Lake Simcoe Region Conservation Authority (LSRCA) released the Draft Lake Simcoe Watershed LID SWM Guidelines for Municipalities. The MIDS approach (See **Section 4.1.1**) served as a template for the current LSRCA stormwater management guidelines and as such has been included in order to describe the current LSRCA approach in relation to the MIDS approach.


DRAFT

Schedule "A"

Lake Simcoe Watershed
LID SWM Guidelines
for Municipalities

The Draft LSRCA LID SWM Guidelines were developed in response to the Lake Simcoe Protection Plan. The plan is based on the Lake Simcoe Protection Act (2008) which intends to restore and protect the ecological health of the watershed. The act allows policies in relation to research and monitoring of activities that impact ecological health within the watershed. These policies include the following which are relevant to the impact of development on stormwater and measures to address stormwater management issues within the watershed.

4.2.2.2 Stormwater Targets

Similar to the MIDS approach, the Draft LSRCA LID SWM Guidelines include provisions and targets for:

- New Development
- Redevelopment
- Linear Development
- Flexible Treatment Options for Sites with Restrictions

The specifics of each are detailed below.

New Development

For new, nonlinear developments that create more than 0.5 hectares of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site from runoff of the first 25 mm of rainfall from all impervious surfaces on the site.

Redevelopment

Nonlinear redevelopment projects on sites without restrictions that create 0.5 or more hectares of new and/or fully reconstructed impervious surfaces shall capture and retain on site the first 25 mm of runoff from the new and/or fully reconstructed impervious surfaces.

Linear Development

a) Linear projects on sites without restrictions that create 0.5 or greater hectares of new and/or fully reconstructed impervious surfaces, shall capture and retain the larger of the following:

I. The first 12.5 mm of runoff from the new and fully reconstructed impervious surfaces on the site
II. The first 25 mm of runoff from the net increase in impervious area on the site

b) Mill and overlay and other resurfacing activities are not considered fully reconstructed.

4.2.2.3 Flexible Treatment Options for Sites with Restrictions

Proponent shall fully attempt to comply with the appropriate performance goals described above. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site such as:

i. Karst geology,
ii. Shallow bedrock,
iii. High groundwater,
iv. Hotspots or contaminated soils,
v. Areas with high salt concentrations,
vi. Significant Groundwater Recharge Area and Wellhead Protection Areas or Intake Protection Zones or within 200 feet of drinking water well,
vii. Zoning, setbacks or other land use requirements,
viii. Excessive cost, and
ix. Poor soils (infiltration rates that are too low or too high, problematic urban soils, such as soils that are highly compacted or altered)

The proponent shall document the flexible treatment options sequence starting with Alternative #1 in a hierarchical approach ending with Alternative #3.

Alternative #1: Proponent attempts to comply with the following conditions:

I. Achieve at least 12.5 mm volume reduction from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site.
II. Remove 75% of the annual Total Phosphorus (TP) load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site.
III. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site.

Alternative #2: Proponent attempts to comply with the following conditions:

I. Achieve volume reduction to the maximum extent practicable.
II. Remove 60% of the annual TP load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site.
III. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site.

Alternative #3: Off-site Treatment.

Mitigation equivalent to the performance of 25 mm of volume reduction for new development or redevelopment as described above in this section can be performed off-site to protect the

receiving water body. Off-site treatment shall be achieved in areas selected in the following order of preference:

I. Locations within the same LSRCA catchment area as the original construction activity.
II. Locations within the next adjacent catchment area upstream.
III. Locations that yield benefits to the same receiving water that receives runoff from the original construction activity.
IV. Locations anywhere within the Lake Simcoe Watershed within the municipal boundary jurisdiction.

4.2.3 Halifax. Nova Scotia

4.2.3.1 Background

Halifax is the capital city of Nova Scotia, and is home to some 415,000 residents. Runoff from Halifax is discharged to the Bedford Basin and ultimately the Atlantic Ocean.

The Constitution Act, 1867, which allocates powers to the federal and provincial levels of government, has resulted in shared jurisdiction between Canada and the provinces over water, environmental protection and public health. However, the federal government has focused primarily on its constitutional responsibility for fisheries and navigation, and for waters that lie on or across international borders, while the provinces have assumed the primary responsibility for water management and drinking water safety. There is currently no federal legislation relating directly to stormwater.

The Navigable Waters Protection Act and the Fisheries Act are federal legislation related to infrastructure works where there is some potential for navigation or fisheries habitat impacts. The Navigable Waters Protection Act involves limiting actions that affect the ability to navigate a watercourse. Many of the watercourses within Halifax Regional Municipality (HRM) could be considered navigable, but navigability is typically determined on a project basis. The Fisheries Act provides protection of fish and the natural environment systems that support fish. A municipal government could be charged under the Fisheries Act if it was found that stormwater-related discharges were deleterious to fish.

The Constitution Act grants the provincial government jurisdiction over property and civil rights, and consequently over water and watercourses. Therefore the provinces have the most direct authority over environmental matters (with the exception of the Fisheries Act). The primary legislation enacted by the provincial government for the protection of the environment is the Environment Act. The Environment Act authorizes the Nova Scotia Environment and Labour (NSEL) to:

- Ensure the health and integrity of aquatic ecosystems, protect the habitat for animals and plants, and provide for continued recreational benefits;
- Designate protected water areas to protect water supply sources;
- Approve, restrict or prohibit the alteration of watercourses;
- Make regulations respecting the uses of specified watercourses and the works which may be permitted in or around watercourses;
- Administer an environmental assessment process, applicable to both public and private projects.

The Environment Act restricts HRM from discharging contaminants into the environment by requiring approvals for designated activities. The design, construction, operations and maintenance of stormwater collection, pumping, storage and treatment systems are regulated through the Approvals required under the Environment Act.

Construction of stormwater management facilities, as designated in the Environment Act under the Activities Designation Regulations, requires approvals from NSEL under the Storm Drainage Works Approval Policy. This includes the construction, operation or reclamation of a storm drainage works including:

- Storm collection systems and pumping stations;
- Retention or storage facilities;
- Treatment facilities;
- Outfalls

The Storm Drainage Works Approval Policy contains detailed requirements for the approval application. An approval is only granted if a number of criteria are met by the proposed facility, such as:

1. The owner ensures that the facility will be installed, used and operated to achieve compliance with the approval;
2. The proposed works are acceptable to NSEL;

The owner must also undertake all necessary investigations to ensure that the facility would not:

- Create public safety hazards;
- Impair fish passage;
- Destroy aquatic habitat; or
- Degrade the water quality.

The authority of HRM for stormwater management is delegated from the Province under the Municipal Government Act (MGA). The MGA enables HRM to make by-laws for municipal purposes, and provides for authority to enforce those by-laws and charge offenders. The MGA further enables the Municipality with the primary responsibility for planning within its jurisdiction, through the use of municipal planning strategies and land use by-laws, consistent with interests and regulations of the Province. A municipal planning strategy may include land use planning restrictions to provide for stormwater management (e.g., by controlling development in flooding zones, in environmentally sensitive areas, on steep slopes, in wetlands, etc.). Where a municipal planning strategy so provides, a land use by-law may also prescribe methods for controlling erosion and sedimentation during the construction of a development. HRM may also prescribe a subdivision by-law. Within the subdivision by-law the Municipality may provide minimum requirements for stormwater management. They may also require that the infrastructure be installed as part of the subdivision. The MGA further enables the Municipality to collect fees for stormwater management.

The existing HRM by-laws and policies with respect to stormwater management are for the most part those of the four former Municipalities. The two main exceptions include the Municipal Services Systems (MSS) which detail the design requirements for stormwater infrastructure and the Wastewater Discharge By-law that regulates the quality of single point source discharges into HRM sewers. The MSS specifies general guidelines for stormwater and erosion and sediment control, but the long-term quality of stormwater is not specified. The Wastewater

Discharge Bylaw does specify quality limits, but there is no direction for how to achieve the limits.

4.2.3.2 Stormwater Targets

The water quality volume criteria for sizing BMPs for the HRM area was determined from an analytical model. Long-term local rainfall data was analyzed to determine storage requirements for different impervious conditions and TSS removal efficiencies. The total storage volume in a wet pond or in a constructed wetland consisting of a permanent pool and an extended detention should generally be equivalent to the runoff volume generated by 90% of the long-term rainfall events observed in HRM.

The peak flow water quality criterion is based on a statistical analysis of local precipitation data. It is recommended that a 25 mm winter rain event or annual flow (whichever is greater) should be used to estimate the peak flow generated by the proposed land use. This storm should be based on a 6 hour Chicago distribution event and should be routed through a storage facility assuming a gradual release rate with a drawdown time of 24-48 hours. For sensitive streams, the longer drawdown time should be used. The required storage is then compared to the extended quality control storage, and the greater of the two is used for design.

For BMPs other than wet pond/wetland, the analysis of downstream channel conditions should determine the need for flow control or erosion protection requirements based on velocities and erosive forces generated by a 25 mm winter rain.

The water quality criterion for sizing stormwater management facilities has two components:

1. For sizing storage facilities a volume criterion; and
2. For flow-through BMPs a peak flow criterion is recommended.

4.2.3.3 Winter Stormwater Management

In the selection of design criteria, one major factor that should be incorporated in the selection of design rainfall events for the HRM area is the winter rainfall, or snowmelt and rain combination, which could produce unique runoff conditions. The design criteria are based off of a 25 mm winter rain event to estimate peak runoff flow rates. Also, design criteria include incorporating winter precipitation and ice/snowmelt rates where the time of concentration is calculated to be greater than six hours.

In regards to BMPs, it is noted that porous pavements are “very rare” in Canada due to the severe winter conditions, the difficulty of rehabilitating clogged porous pavements, lack of experience in construction and operation, the highly skilled labour requirement, and the possibility of groundwater contamination.

4.2.3.4 BMP Performance

The Halifax Regional Municipality Stormwater Management Guidelines (HRMSMG) recommends that in controlling the pollutant efficiency of a BMP, Total Suspended Solids (TSS) should be adopted as a primary indicator. The goal of the operation and maintenance program is to ensure within an economic framework, an acceptable standard of stormwater management and BMP facilities in terms of structural and public safety, aesthetic effectiveness, and convenience. The main objectives are:

- To protect and prolong the useful life of facilities;

- To identify, repair and rehabilitate structures; and
- To provide a sound basis for a management system for the planning and funding of the operation, maintenance and rehabilitation of facilities.

All three aspects of a stormwater management facility: Design, construction, and long-term maintenance are equally important to insure a long useful life and high performance.

4.2.4 Edmonton, Alberta

4.2.4.1 Background

Edmonton is the capital city of Alberta and the province's 2nd largest city and Canada's 5th largest municipality. Edmonton is the northernmost North American city with a metropolitan population over one million. Stormwater drainage from the City of Edmonton is discharge to the North Saskatchewan River.

The latest LID guidelines are found in the November 2011 Low Impact Development Best Management Practices Design Guide. This document was drafted in June 2011 by AMEC Earth & Environmental with assistance from Armin A. Preiksaitis & Associates Ltd. and Progressive Engineering Ltd. The Drainage Planning section of the City's Drainage Services Branch made further revisions to the draft Design Guide. The Design Guide development fully incorporated stakeholder inputs from advocacy and technical roundtable sessions.

4.2.4.2 Stormwater Targets

According to the 2011 Low Impact Development Best Management Practices Design Guide, LIDs deals with smaller and more frequent rainfall events. These events are usually less than 2 year return period but generate most of the annual runoff from an urban watershed. Small rainfall events tend to dominate hydrologic design of systems aimed at improving water quality.

The water quality capture volume represented by rainfall depth provides a practical means for establishing an appropriate hydrologic design basis for LID systems. Analysis of the long-term rainfall record provides guidance on selecting an appropriate water quality capture volume. For the Edmonton region, most rainfall events are less than about 26 mm in depth and have durations of 5 hours or less. For LID hydrological design purpose, the water quality capture volume of 26 mm (per day) should be used to meet the first flush capture requirement. This provides a familiar design event size and distribution that is consistent with existing drainage design standards. (1:2 year event).

This value of 26 mm was determined by analyzing a summary of runoff volumes generated by rainfall events of various recurrence intervals, based on 585 precipitation events at the Edmonton City Centre Airport Gauge. From this data, it was determined that LID systems that were designed to capture 26 mm of rainfall would capture 90% of the total rainfall depth.

Stormwater runoff from new developments and lands being re-developed will receive an acceptable level of treatment prior to discharge to the stormwater drainage system or the receiving watercourse.

It is considered that storing the volume of runoff from a 25 mm storm over the contributing area is appropriate for Alberta for stormwater quality control using detention devices such as dry ponds, wet ponds, and constructed wetlands. A detention time of 24 hours should also be used

for detention facilities. The runoff from a 12 mm storm over the contributing area is considered appropriate for infiltration BMPs.

4.2.4.3 Winter Stormwater Management

Limited guidance or direction in regards to winter stormwater management is provided. The following exceptions are noted:

- All city operated snow storage sites require permanent facilities for on-site treatment to control settleable and floatable materials prior to discharging stormwater into the drainage system or receiving watercourses. Rationale: Melt from snow storage sites contains significant amounts of constituents such as settleable and floatable solids, chlorides from road salt, petroleum products, and heavy metals. On-site Best Practical Technology for treatment of snow melt targets settleable and floatable materials and will remove only a small portion of the petroleum and heavy metal constituents. The City of Edmonton is responsible for the release of constituents when melt water from the site is not treated.
- If improving water quality is a major goal, then subsurface water flow through wet stormwater basins during the winter may be worth incorporating into the design specifications. A configuration that is deep and permits water flow during low winter temperatures may be appropriate.

4.2.4.4 BMP Performance

The following details key elements of BMP performance requirements, including but not limited to:

- Stormwater discharged from newly developed residential lands and lands being redeveloped shall:
    - Comply with the Sewer Use Bylaw
    - Comply with the relevant City-approved Best Management Practice (BMP) codes of practice
    - Meet Alberta Environments policy of 85% removal (by mass) of suspended solids ≥ 75 µm particle size.
- Base flow, and limited wet weather flow of stormwater, from the four major storm outfalls in Edmonton's existing stormwater system to receive treatment that will provide a 50% reduction in mass loading in the treated flow.
- Manage the risk of spills and illegal discharges.
- Examine water quality parameters related to emerging environmental and public health issues.
- Support stakeholder initiatives for the improvement of stormwater quality.
- Harmonize federal and provincial regulatory expectations.

Measures of performance include conforming to the BMP checklist for site installations in the design phase and adherence to BMP codes of practice for operations.

Furthermore, the developer is required to monitor stormwater quality. If required by the City effluent from the permanent pool shall be sampled and tested for the following parameters: TSS, TP, NH3, BOD and fecal coliforms each year during the maintenance period and the data provided to the City. The developer must also monitor wetland and upland vegetation and take any corrective action required during the maintenance period. At the end of the maintenance period, before the issuance of the Final Acceptance Certificate (F.A.C), the developer is required to ensure that at least 75% of the grass cover and 30% of the non-grass emergent vegetation around the wetland's edge has established given normal seasonal conditions. A vegetation survey by a qualified professional shall be submitted to the City.

4.2.4.5 Key Definitions

BEST MANAGEMENT PRACTICE – An activity, procedure, device or method for removing, reducing, retarding, or preventing stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters.

INFILTRATION – The slow passage of a liquid through a filtering medium; "the percolation of rainwater through the soil".

WETLANDS – Lands that are seasonally or permanently covered by shallow water as well as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

4.2.5 Province of Quebec

4.2.5.1 Background

The Quebec Stormwater Guide was written taking into account the documents already produced by various Quebec departments and attempting not to duplicate information that may already be available elsewhere. The Guide is linked to the Directive 004, which regulates more generally design sewage systems in Quebec. Both are complementary in many aspects but the Stormwater Guide gives descriptions and analysis principles for stormwater management that are much more detailed the Directive 004.

Another concept that encompasses the stormwater management principle is watershed management, which has grown significantly in recent years in Quebec following the implementation of the Water Policy in 2002. Several documents were produced to support efforts to prepare wide management plans and some watershed matters discussed in this Guide will obviously fit into the broader vision that underlies watershed management.

In general the Quebec Stormwater Guide is written as a highly technical resource manual, complete with hydrology, hydraulics, geomorphology, erosion and water quality control guidance. The guide heavily cites the MOE, 2003 Manual, Claytor et Schueler, 1996 and other primary stormwater documents,

4.2.5.2 Stormwater Targets

For the region of Montreal, 90% of rainfall events have a rainfall of less than 22 mm (26 mm in the case of Quebec City) and 80% of rainfall quantity is less than 14 mm (17 mm in the case of Quebec City). That means in order to address 22 mm of rain, the Montreal area would treat 90%

averaged over the territory. The average length of rain events obtained with this approach, however, are on the order of 6 hours. Considering that these analyses have not been made for all other stations in Quebec, it is recommended that all of Quebec design LID systems based on a storm event corresponding to 90% of rainfall with value of 25 mm.

4.2.5.3 BMP Performance Standards

BMPs are organized into charts and ranked based on their expected water quality and quantity reduction/treatment performance. Designers may choose the best-suited BMP based in the list. Removal rates are included for LID controls for phosphorous (min, max and median values), nitrates, TKN, Cooper Zinc, Lead and Bacteria. Anticipated LID volume reductions are also included

4.2.5.4 Winter Stormwater Management

Section 11.2.4 of the guide, addresses cold climate adaptations, which include increased storage volumes due to the effect of ice and snow, how to size and locate the inlet and exit structures to avoid clogging or damage due to ice and the advice not to perform complete draining of ponds in early spring to avoid the release of high rates of chlorides and other contaminants. Winter conditions and their effects on stormwater systems are also detailed, specifically cold temperatures, frozen soils, growing season and snow fall.

The guide also notes the importance of selecting BMPs that are designed to survive freezing or saturated soil conditions during the winter and spring. BMPs with filters and/or bioretention are exposed to similar issues. In the winter there is an increased risk of clogging due to sand spreading activities or de-icing salt. There is also an increased potential contamination of the groundwater with chlorides associated with the salting. To prevent this contamination, bypasses for BMPs can be activated several weeks before the spring when the snow melts. In areas with curbs and gutters, the street system should be cleaned before bypasses are disabled.

4.3 Broader US Jurisdictions

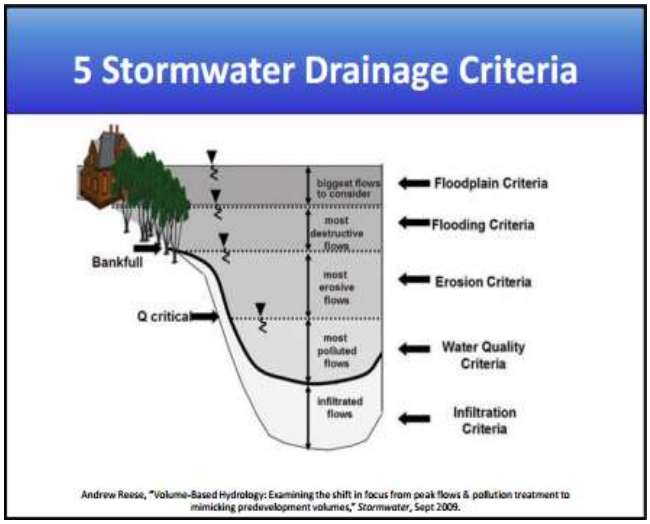
4.3.1 State of Maryland

Maryland State Stormwater Management Program was developed to control stormwater runoff from development to Chesapeake Bay. In accordance to the program, the Maryland Stormwater Design Manual Volumes I & II provide guidance to permittees working on new development and redevelopment projects in the state. It also offers a unique approach to stormwater management by using a Unified Stormwater Sizing Criteria Model that has been emulated in states like Minnesota and Washington, D.C.

4.3.1.1 Stormwater Targets

For new development, permittees must implement the Environmental Site Design (ESD) practices defined in the Stormwater Design Manual to manage 1 inch (25 mm) of stormwater runoff volume in the Maryland Eastern Rainfall Zone and 0.9 inch (23 mm) in the Western Rainfall Zone.

In regards to the channel protection requirement, an ESD must be implemented to the Maximum Extent Possible (MEP) to mimic predevelopment conditions when subject to a 1-year, 24-hour design rain event. This means that ESD practices must provide retention storage sufficient to reduce the runoff depth of the proposed development to that of woods in good condition. Any volume remaining after the implementation of ESD to the MEP can be managed using practices such as detention ponds, filtration, or other treatment structures as defined in the Manual.



Source: WPO 2014

Maryland's Unified Stormwater Sizing Criteria Model is divided into five volume increments:

1. Recharge/Infiltration Volume (Infiltration Criteria) is the groundwater recharge volume and is a fraction of the water quality volume based on the pre-developed hydrologic soil group. Therefore, ESD must be implemented to manage both groundwater recharge and water quality volumes.
2. Water Quality Volume (Water Quality Criteria) includes a minimum 40% reduction in phosphorus and 80% reduction in TSS. Assumed to be met if on-site volume control requirements are met.
3. Channel Protection Storage Volume (Erosion Criteria) requires the site to mimic the predevelopment conditions when subject to a 1-year, 24-hour design rain event.
4. Overbank Flood Protection Volume (Flooding Criteria) is an optional criterion applied at the discretion of the appropriate plan review/approval authority to control the developed condition peak rate of discharge from the 10-year 24-hour design storm event to the pre-development rate.
5. Extreme Flood Volume (Floodplain Criteria)

Volume increments from 1 to 5 ranges from 1 being small storm events to 5 being very large storm events.

4.3.1.2 Redevelopment Standards

For redevelopment projects, any activity that disturbs 5,000 square feet (465 m^2) or more where existing land use is commercial, industrial, institutional, or multifamily residential and where it exceeds 40% of impervious areas must achieve one of the following:

- Reduce existing impervious area by at least 50%;
- Implement ESD to the MEP to provide water quality treatment to 1 inch or 0.9 inch for at least 50% of the existing impervious area; or
- Use a combination of the first or second options for at least 50% of the existing impervious area

4.3.1.3 Offset and Mitigation Programs

Maryland Department of the Environment (MDE) has developed a Phase I Point Source Nutrient Trading Policy for point source discharges. Draft Phase II A and Phase II B Guidelines that govern the generation and purchase of Agricultural Nonpoint Nutrient Credits have been developed. No program exists for urban nonpoint nutrient trading or offset and/or in-lieu fee program.

4.3.2 District of Columbia (Washington, D.C.)

Arguably the most comprehensive approach to stormwater management in the Chesapeake Bay watershed is the District of Columbia's (D.C.) Department of the Environment (DDOE) new stormwater rules. The "2013 Rule on Stormwater Management and Soil Erosion and Sediment Control"[vii] rule was published in July 2013.[viii] More information on the other Chesapeake Bay states is available through each state's relevant regulatory agency,[ix] through other online resources.[x] A brief comparison of these states is contained in the tables in Appendix A.

4.3.2.1 Background

District of Columbia's Stormwater Program is much like Minnesota and West Virginia's stormwater programs except it includes a 'one-of-a-kind' credit trading program. The Stormwater Division of the District Department of the Environment (DDOE) oversees the Stormwater Program in conjunction to its sister agencies: the Stormwater Advisory Panel and the Technical Working Group.

4.3.2.2 Stormwater Targets

D.C.'s new framework includes stormwater retention performance standards designed to considerably reduce stormwater runoff's harmful impacts to the Anacostia and Potomac Rivers, Rock Creek, and their tributaries.

Stormwater retention performance standards in the District of Columbia are based on the 90th percentile rainfall event, and the "unified sizing approach" advocated by stormwater expert Tom Schueler. The goal of the unified framework is to develop a consistent approach for sizing stormwater practices that can perform efficiently and effectively, be administered simply, promote better site design, and be flexible in responding to special needs. A unified framework

for sizing stormwater practices provides greater consistency and integration among the many city, county, watershed organization, regional and statewide stormwater requirements and ordinances adopted over the years. It also establishes a common framework to address all stormwater problems caused by development sites over the entire spectrum of rainfall events. Simply stated, the unified sizing approach seeks to manage the range and frequency of rainfall events that are anticipated at development sites, by setting the control threshold at the 90th percentile. The unified approach proposes to standardize the basic approach to stormwater design for regular waters of the state, while also defining certain site conditions or development scenarios where individual stormwater sizing criteria may be relaxed or waived. The unified framework also clearly indicates when sizing criteria need to be enhanced to provide a higher degree of water resource protection for special or sensitive waters.[xi]

Permittees of the MS4 permits are subject to new development and redevelopment standards. For new development, any development that affects 5,000 square feet of land or greater, except in Public Right of Way (PROW)[xii] areas are subject to the specific stormwater requirements.

- First, the first 1.2 inches (30 mm) of rainfall from a 24-hour rainfall event with a 72-hour dry period must be retained on-site or through a combination of on-site and off-site retention methods.
- Second, a peak discharge rate for a 2-year frequency 24-hour storm to pre-development conditions must be maintained; and a peak discharge rate for a 15-year frequency, 24-hour storm to must be maintained to predevelopment conditions.
- Lastly, appropriate BMPs must be selected and implemented to achieve the retention standard. If PROW areas are affected by new development, stormwater retention must be achieved to its Maximum Extent Practicable[xiii].

For redevelopment, any improvement activity where the cost of the project is less than or equal to 50% of its previous development cost and exceeds a land disturbance of 5,000 square feet (465 m^2) must retain the first 0.8 inch (20 mm) of rainfall on-site through a combination of on-site and off-site retention methods. Any land disturbance within the PROW areas must achieve stormwater retention from PROW's Maximum Extent Practicable (MEP) standards.

Runoff reduction practices are triggered by two different categories of projects:

1. Major land-disturbing activity: Sites that disturb 5,000 square feet (465 m^2) or more of land[xiv] will be required to retain the first 1.2 inches of rainfall, either on-site or through both on-site and off-site retention.

2. Major substantial improvement projects: Renovations of existing structures that have a 5,000 ft^2 (465 m^2) footprint and project costs that exceed 50% of the pre-project value of the structure, must retain the first 0.8 (20 mm) inches of rainfall on-site, or through a combination of on-site and off-site retention.

4.3.2.3 Off-Site Options

Development projects can use "over control"[2] to retain more than 1.2 inches (30 mm) of stormwater volume in one area and less in another. Projects can thus achieve on-site retention with a "Shared BMP" that is off-site. Projects are also allowed to use off-site mechanisms if a

[2] "Over control" is a method of balancing the amount of water retained in multiple areas.

minimum of 50% retention has been met on-site. If it is under the 50% minimum, then it must demonstrate that on-site retention is inconceivable or environmentally harmful.

There are two off-site options:

1. Pay an In-Lieu Fee (ILF) to DDOE. The ILF is set at $3.50 per gallon of retention per year, but will be adjusted over time for inflation and other cost changes.

2. Purchase a privately tradable Stormwater Retention Credit (SRC). One SRC is equal to one gallon of retention for one year.

If a site (1) increases the size of a special flood hazard area, or (2) does not discharge to the sewer system *and* has a post-development peak discharge rate for a 100-year-frequency storm event that will cause flooding to a building, the project is mandated to meet the "extreme flood requirements." The intent of this criteria is to prevent flood damage from large storm events, while also maintaining the boundaries of the 100-year floodplain. The extreme flood requirements entail a downstream analysis that describes drainage areas, outfalls, channel profiles and detailed hydrologic and hydraulic calculations to determine the extent of water elevations.

The performance standards described above will be phased-in during a number of transition periods. In official statements the DDOE recognized that the new requirements are essential to the restoration of the District's waterbodies, and in the absence of such requirements, full use of District waterbodies is unlikely to be restored to residents, visitors, and businesses. On the other hand, requiring regulated projects to immediately meet new requirements may impose significant costs and time delays on these projects. The rule thus creates several transition periods, depending on the type and extent of land disturbance. The rule is fully effective, for every development as of July 14, 2015. The Final Rule's provisions related to SRC trading and to erosion and sediment control take effect upon final publication in the DC Register.

4.3.2.4 Stormwater BMPs

Thirteen "groups" of stormwater best management practices (BMPs) are recommended by the District's new rules. These groups include green roofs, rainwater harvesting, impervious surface disconnection, permeable pavement systems, bioretention, filtering systems, infiltration, open channel systems, ponds, wetlands, storage practices, proprietary practices, and tree planting and preservation. Each group of BMPs includes at least two, and up to several unique practices considered acceptable forms of treatment, and/or retention. The Stormwater Management Guidebook has several chapters concerning BMPs, and includes a chapter on standard design guidance applicable to every BMP, chapters on each BMP group, and guidance for effective selection and location of stormwater BMPs.

4.3.2.5 Stormwater Retention Credit Trading Program

The Stormwater Retention Credit trading program is the first of its kind in the United States. It has the potential to increase the new standards' benefit to District waterbodies while reducing the cost of compliance and providing other sustainability benefits. These credits are intended to be not only a stormwater best practice, but also a financial incentive and business opportunity for voluntary installation of stormwater retrofits to can be sold to other development sites in order to meet retention requirements. To be eligible, the retention capacity in a BMP is certified by the DDOE to do the following:

- Achieve retention volume in excess of regulatory requirements, but less than the SRC ceiling;
- Be designed and installed in accordance with a DDOE-approved Stormwater Management Plan (SWMP) and the Stormwater Management Guidebook;
- Pass a post-construction inspection and ongoing maintenance inspections; and
- Provide a maintenance contract or maintenance agreement(s) for ongoing maintenance.

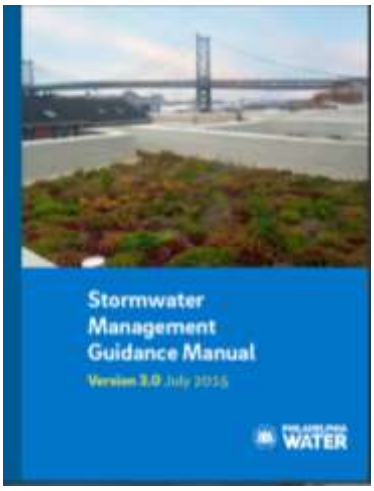
To be eligible for SRCs, unregulated projects or voluntary stormwater retrofits[xv] must achieve retention volumes in excess of predevelopment retention, but less than the SRC maximum. Development projects can generate SRCs on-site, or on another site owned by the same developer. One SRC is equal to one gallon of retention for one year. An SRC has a lifespan of one-year, and starts when it is used to satisfy an Off-Site Retention Volume. Unused SRCs can be banked for future use without expiring, or can be traded. Finally, an SRC can be voluntarily retired without being used. Retention capacity installed before the new stormwater rules were established may be eligible for SRCs under certain circumstances, but only after applying for certification.

All projects subject to the new stormwater rules must submit a Stormwater Management Plan (SWMP). A SWMP contains supporting computations, drawings, and sufficient information to evaluate the environmental characteristics of the affected areas, the potential impacts of the proposed development on water resources, the effectiveness and acceptability of BMPs and land covers for managing stormwater runoff, and maintenance and construction schedules. If the applicant proposes to use off-site retention, the SWMP must indicate the number of gallons the applicant is required to retain off-site. Upon receiving an application, DDOE will determine if the application is complete and acceptable for review, accept it for review with conditions, or reject the application. Regardless of its decision, the DDOE must communicate the reasons for that decision. Applications that are denied may be re-submitted. The SWMP should include, at minimum:

- A detailed site plan;
- Stormwater retention volume computations;
- Pre- and post-development hydrologic computations;
- Hydraulic computations;
- Schedules and reports detailing inspections before, during, and after construction, and long-term preventative maintenance; and
- A duly executed and recorded declaration of covenants that binds current and future owners of the land served by the BMP and SWMP.

4.3.3 Philadelphia, PA

4.3.3.1 Background



Philadelphia began following updated stormwater regulations July 1, 2015 in order to meet the requirements of the Clean Water ACT. More than two years in the making, the regulations are meant to ensure new developments contribute to Philadelphia's Green City, Clean Waters plan.

New developments are now required to handle more water, slow stormwater more effectively, and improve pollutant reduction. These changes will help minimize local flooding, encourage the use of green infrastructure, and improve the health of local waterways.

As part of the updated Stormwater Regulations, the Water Quality requirement has changed to achieve compliance with State and Federal requirements within both separate and combined sewersheds. These changes allow development sites to manage more stormwater runoff, reduce the rate at which the runoff reaches PWD's wastewater treatment plants, and remove pollutants from the dirtiest runoff.

Pennsylvania Stormwater Management Program was developed based on the federal NPDES program. Post-construction standards are based on Phase I and Phase II of the NPDES permit program. At the Federal legislative level, regulations are subject to the Clean Water Act, Section 402, 1972, last amended 1987, and 40 CFR Part 122, 1987. At the State legislative level, regulations are per Pennsylvania Stormwater Management Act, 1978 (The Comprehensive Stormwater Management Policy, 2002). The administrative authority is the Pennsylvania Department of Environmental Protection (The Bureau of Point and Non-Point Source Management (BPNPSM)), and The Bureau of Waterways Engineering and Wetlands.

A summary of the past stormwater regulations and current SWM regulations are summarize in **Table 4.3** below.

Table 4.3 – Comparisons of Past and Current SWM Regulations

Item	Before July 2015	After July 2015
Water Quality Release Volume	1.0 inch (25 mm)	1.5 inch (38 mm)
Water Quality Release Rate	0.24 cfs/acre of DCIA	0.05 cfs/acre of DCIA
Water Quality Treatment: Separate Sewer and Direct Discharge	100% Volume-Reducing	100% Pollutant-Reducing*
Water Quality Treatment: Combined Sewer	20% Volume-Reducing	100% Pollutant-Reducing*

*acceptable non-infiltrating pollutant-reducing practices – Bioretention, Porous Pavement, Green Roofs, Cisterns, Blue Roofs. Ponds & Wet Basins, Vegetated Media filters, Media filters, Roof Runoff Isolation (not for Separate Sewers)

According to Philadelphia Water Department (PWD), it also has improved the process for submitting and reviewing stormwater plans and has enhanced access to its Stormwater Regulations Guidance Manual. The guide is searchable, and the website includes other tools to help site developers comply with the new stormwater regulations.

4.3.3.2 Stormwater Targets

Stormwater treatment standards in Philadelphia are based on maintaining pre-development runoff volumes. The City of Philadelphia recently released new stormwater management criteria where the target design depth for the water quality volume was increased from 1 inch (25 mm) to 1.5 inches (38 mm). The goal is to permanently remove at least the first 1.5 inches (38 mm) of runoff from new impervious surfaces by means of infiltration, retention, water reuse, among other methods. If infiltration is feasible on the project site, the Water Quality requirement must be met by infiltrating 100% of the water quality volume through stormwater management practices.

4.3.3.3 Key Definitions

IMPERVIOUS SURFACE: Any building, pavement, or other material that impedes the natural infiltration of surface water into the soil.

INFILTRATION: The process by which water enters the soil from the ground surface and can be measured as a rate.

NEW DEVELOPMENT: Development project on an unimproved tract of land where structures or impervious surfaces were removed before January 1, 1970.

PREDEVELOPMENT CONDITION: For New Development and Redevelopment, the dominant land use for the previous ten years preceding the planned project.

REDEVELOPMENT: Development on an improved tract of land that includes, but is not limited to, the demolition or removal of existing structures or impervious surfaces and replacement with new impervious surfaces. This includes replacement of impervious surfaces that have been removed on or after January 1, 1970.

STORAGE VOLUME: The volume of stormwater runoff that can be held within the above-ground surface area and the pore spaces of any subsurface media or structure of a stormwater management practice.

STORMWATER PRETREATMENT: Techniques employed to remove pollutants before they enter the SMP, including, but not limited to, the techniques listed as pre-treatment in this Manual.

4.3.3.4 Supporting Initiatives

Another key part of Green City, Clean Waters is encouraging green infrastructure retrofits on private property. In early June, PWD released the Stormwater Retrofit Guidance Manual for its non-residential customers. These customers can benefit most from using green infrastructure because they are billed based on the amount of impermeable surface on their properties. The guide includes information on credits and incentives offered through PWD's Green Acres Retrofit Program and Stormwater Management Incentives Program as well as instructions for selecting green infrastructure according to property and maintenance requirements. In addition,

the City also offers a Green Roof Tax Credit, a Basement Protection Program, and Free Assistance Program for Green Retrofits.

An additional component to the guidance manual is Credits Explorer, a new mobile application that allows users to virtually add green infrastructure to non-residential properties and determine potential savings. The stormwater regulations also include guidance for Low Impact Development (LID) design. These regulations are based on a design approach that aims to maintain pre-development runoff volumes.

The City of Philadelphia has also established a Stormwater Utility for residential and non-residential customers.

4.3.4 State of Virginia

4.3.4.1 Background

The first addition of the Virginia Stormwater Management Handbook came out in 1999. The latest Handbook is dated 2013.

4.3.4.2 Stormwater Targets

The specified design storms shall be defined as either a 24-hour storm using the rainfall distribution recommended by the U.S. Soil Conservation Service when using U.S. Soil Conservation Service methods or as the storm of critical duration that produces the greatest required storage volume at the site when using a design method such as the Modified Rational Method.

The Virginia Stormwater Management Regulations require that the first flush of runoff be captured and "treated" to remove pollutants. The first flush, or water quality volume (WQV) is generally defined as the first ½" to 1" (determined by the desired pollutant removal efficiency) of runoff from impervious surfaces. For example, using a depth of 0.5" obtains a target phosphorus removal efficiency of 50%, while a depth of 1" obtains a removal efficiency of 65%.

4.3.4.3 Winter Stormwater Management

Limited information is included within the manual in regards to winter stormwater management considerations or guidance, with the exception of planting recommendations, specifically, that plants that are not winter-hardy should be avoided for use in stormwater management practices.

4.3.4.4 BMP Performance

For land development, the calculated post-development nonpoint source pollutant runoff load shall be compared to the calculated pre-development load based upon the average land cover condition or the existing site condition. A BMP shall be located, designed, and maintained to achieve the target pollutant removal efficiencies to effectively reduce the pollutant load to the required level based upon the following four applicable land development situations for which the performance criteria apply:

1) Situation 1 consists of land development where the existing percent impervious cover is less than or equal to the average land cover condition and the proposed improvements will create a total percent impervious cover which is less than the average land cover condition.

Requirement: No reduction in the after development pollutant discharge is required.

2) Situation 2 consists of land development where the existing percent impervious cover is less than or equal to the average land cover condition and the proposed improvements will create a total percent impervious cover which is greater than the average land cover condition.

   Requirement: The pollutant discharge after development shall not exceed the existing pollutant discharge based on the average land cover condition.

3) Situation 3 consists of land development where the existing percent impervious cover is greater than the average land cover condition.

   Requirement: The pollutant discharge after development shall not exceed (i) the pollutant discharge based on existing conditions less 10% or (ii) the pollutant discharge based on the average land cover condition, whichever is greater.

4) Situation 4 consists of land development where the existing percent impervious cover is served by an existing stormwater management BMP that addresses water quality.

   Requirement: The pollutant discharge after development shall not exceed the existing pollutant discharge based on the existing percent impervious cover while served by the existing BMP. The existing BMP shall be shown to have been designed and constructed in accordance with proper design standards and specifications, and to be in proper functioning condition.

4.3.4.5 Key definitions

“BEST MANAGEMENT PRACTICE (BMP)" means a structural or non-structural practice which is designed to minimize the impacts of development on surface and groundwater systems.

“BIORETENTION BASIN” means a water quality BMP engineered to filter the water quality volume through an engineered planting bed, consisting of a vegetated surface layer (vegetation, mulch, and ground cover), planting soil, and sand bed, and into the in-situ material.

“BIORETENTION FILTER” means a bioretention basin with the addition of a sand filter collector pipe system beneath the planting bed.

"CONSTRUCTED WETLANDS" means areas intentionally designed and created to emulate the water quality improvement function of wetlands for the primary purpose of removing pollutants from stormwater.

“GRASSED SWALE” means an earthen conveyance system which is broad and shallow with erosion resistant grasses and check dams, engineered to remove pollutants from stormwater runoff by filtration through grass and infiltration into the soil.

"INFILTRATION FACILITY" means a stormwater management facility which temporarily impounds runoff and discharges it via infiltration through the surrounding soil. While an infiltration facility may also be equipped with an outlet structure to discharge impounded runoff, such discharge is normally reserved for overflow and other emergency conditions. Since an infiltration facility impounds runoff only temporarily, it is normally dry during non-rainfall periods.

Infiltration basin, infiltration trench, infiltration dry well, and porous pavement shall be considered infiltration facilities.

"POST-DEVELOPMENT" refers to conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land.

"PRE-DEVELOPMENT" refers to the conditions that exist at the time that plans for the land development of a tract of land are approved by the plan approval authority. Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing conditions at the time prior to the first item being approved or permitted shall establish predevelopment conditions.

“SAND FILTER” means a contained bed of sand which acts to filter the first flush of runoff. The runoff is then collected beneath the sand bed and conveyed to an adequate discharge point or infiltrated into the in-situ soils.

"STORMWATER DETENTION BASIN" OR "DETENTION BASIN" means a stormwater management facility which temporarily impounds runoff and discharges it through a hydraulic outlet structure to a downstream conveyance system. While a certain amount of outflow may also occur via infiltration through the surrounding soil, such amounts are negligible when compared to the outlet structure discharge rates and are, therefore, not considered in the facility's design. Since a detention facility impounds runoff only temporarily, it is normally dry during non-rainfall periods.

"STORMWATER EXTENDED DETENTION BASIN" OR “EXTENDED DETENTION BASIN” means a stormwater management facility which temporarily impounds runoff and discharges it through a hydraulic outlet structure over a specified period of time to a downstream conveyance system for the purpose of water quality enhancement or stream channel erosion control. While a certain amount of outflow may also occur via infiltration through the surrounding soil, such amounts are negligible when compared to the outlet structure discharge rates and, therefore, are not considered in the facility's design. Since an extended detention basin impounds runoff only temporarily, it is normally dry during non-rainfall periods.

“STORMWATER EXTENDED DETENTION BASIN-ENHANCED” OR “EXTENDED DETENTION BASIN-ENHANCED” means an extended detention basin modified to increase pollutant removal by providing a shallow marsh in the lower stage of the basin.

"STORMWATER MANAGEMENT FACILITY" means a device that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release or the velocity of flow.

"STORMWATER RETENTION BASIN" OR "RETENTION BASIN" means a stormwater management facility which includes a permanent impoundment, or normal pool of water, for the purpose of enhancing water quality and, therefore, is normally wet, even during non-rainfall periods. Storm runoff inflows are may be temporarily stored above this permanent impoundment for the purpose of reducing flooding, or stream channel erosion.

“STORMWATER RETENTION BASIN I” OR “RETENTION BASIN I” means a retention basin with the volume of the permanent pool equal to three times the water quality volume.

“STORMWATER RETENTION BASIN II” OR “RETENTION BASIN II” means a retention basin with the volume of the permanent pool equal to four times the water quality volume.

“STORMWATER RETENTION BASIN III” OR “RETENTION BASIN III” means a retention basin with the volume of the permanent pool equal to four times the water quality volume with the addition of an aquatic bench.

“VEGETATED FILTER STRIP” means a densely vegetated section of land engineered to accept runoff as overland sheet flow from upstream development. It shall adopt any natural vegetated form, from grassy meadow to small forest. The vegetative cover facilitates pollutant removal through filtration, sediment deposition, infiltration and absorption, and is dedicated for that purpose.

"WATER QUALITY VOLUME" means the volume equal to the first 1/2 inch of runoff multiplied by the impervious surface of the land development project.

4.3.5 Seattle, Washington

4.3.5.1 Background

The NPDES program is a key element of the Federal Clean Water Act[1] aimed at controlling and reducing waterborne pollutants discharged from point sources such as wastewater and stormwater. The Washington State Department of Ecology (Ecology) has jurisdiction for implementing the federal NPDES program in the State of Washington. In implementing this program, Ecology issues NPDES permits to cover individual facilities or groups of multiple entities with common activities under a general NPDES permit. These permits must meet federal minimum requirements. For regulated municipal stormwater discharges, the NPDES program requires permits for large, medium and small MS4s as defined in federal regulations. The Phase I regulations of the MS4 program went into effect in 1990 and apply to MS4s in municipalities with populations of more than 100,000 (medium and large MS4s).

The first Phase I MS4 permit was issued by Ecology in July 1995 to the cities of Seattle and Tacoma and counties of Clark, King, Pierce and Snohomish. The MS4s owned or operated by the Washington State Department of Transportation (WSDOT) located in these cities and counties were also regulated under the 1995 permits. To meet the requirements of the 1995 Permit, the City prepared and managed stormwater under a SWMP that was approved by Ecology in 1997. The City provided updates on stormwater management activities to Ecology in annual reports that were submitted from 1996 to 2005. The new format for SWMPs and Annual Reports pursuant to the 2007 and 2013 Permits replaces the City’s 1997 SWMP.

On January 17, 2007, Ecology re-issued the Phase I MS4 permit. The Permit became effective on February 16, 2007, was modified on June 17, 2009 and September 1, 2010 and bore an expiration date of February 15, 2012. (The Phase II MS4 permit was issued concurrently and applied to approximately 90 small cities and counties in Western Washington and approximately 30 cities and counties in Eastern Washington).

On August 1, 2012, Ecology re-issued, with limited changes, the Phase I MS4 permit, effective September 1, 2012, and having an expiration date of July 31, 2013 (Ecology, 2012a). Ecology also reissued the updated 2013-2018 Phase I MS4 permit on August 1, 2012, to become effective on August 1, 2013 (Ecology 2012b). The 2013 permit was appealed to the Washington State Pollution Control Hearing Board (PCHB). Appeal hearings were held in October 2013, and the Findings of Fact, Conclusions of Law, and Order were issued on March 21, 2014. The Pollution Control Hearing Board’s ruling on vesting was appealed to the courts. Ecology

modified the Phase I and Phase II permits effective January 16, 2015 in response to the PCHB rulings.

4.3.5.2 Stormwater Targets

Target Runoff Volume

Stormwater treatment facilities are designed based on the stormwater runoff volume from the contributing area or a peak flow rate. According to the Seattle Stormwater Municipal Code 22.805.090.B.1, water quality treatment facilities must be designed to treat the daily runoff volume at or below which 91 percent of the total runoff volume for the simulation period occurs, as determined using an approved continuous model. This volume is calculated as follows:

1. Rank the daily runoff volumes from highest to lowest
2. Sum all the daily volumes and multiply by 0.09
3. Sequentially sum daily runoff volumes, starting with the highest value, until the total equals 9 percent of the total runoff volume as calculated in Step 2. The last daily value added to the sum is defined as the water quality design volume.

Target Runoff Flow Rate

Different design flow rates have been established depending on whether the proposed treatment facility will be located upstream or downstream of a detention facility.

Facilities Located Upstream of Detention Facilities or when Detention Facilities are not required: The design flow rate is the flow rate at or below which 91 percent of the total runoff volume for the simulation period is treated, as determined using an approved continuous runoff model.

Facilities Located Downstream of Detention Facilities: The design flow rate is the release rate from the detention facility that has a 50 percent annual probability of occurring in any given year (2-year recurrence interval), as determined using an approved continuous runoff model. Treatment facilities that are located downstream of detention facilities shall only be designed as on-line facilities. High flow bypasses are not permitted.

Treatment facilities located upstream of a detention system can be designed as online or offline facilities.

- On-line facilities: Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met.

- Offline facilities: For treatment facilities not preceded by an equalization or storage basin, flows exceeding the water quality design flow rate may be bypassed around the treatment facility. However, during bypass events, the facility shall continue to receive and treat the water quality design flow rate. Only the higher incremental portions of flow rates are bypassed around a treatment facility.

- Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the total runoff volume predicted by an approved continuous runoff model is treated.

Infiltration Facilities Providing Water Quality Treatment: Infiltration facilities designed for water quality treatment must infiltrate 91 percent of the total runoff volume as determined using an

approved continuous runoff model. The procedure is the same as for designing infiltration for flow control (see Chapter 4, Section 4.5), except that the target is to infiltrate 91 percent of the total runoff volume. In addition, to prevent the onset of anaerobic conditions, an infiltration facility designed for water quality treatment must be designed to drain the water quality design treatment volume (the 91st percentile, 24-hour volume) within 48 hours. This can be calculated by using a horizontal projection of the infiltration basin mid-depth dimensions and the estimated long-term infiltration rate.

4.3.5.3 Winter Stormwater Management

Winter in the Seattle area is designated as the "wet" season. Therefore, stormwater management practices that are not designated as wetlands are recommended to be designed to allow a drying time where soils can dry out. If a stormwater management practice is expected to receive continuous flows or long periods of saturation, the stormwater management practice should be designed with the proper plants that can withstand the expected amount of standing water and saturated soil.

4.3.5.4 BMP Performance

The Seattle Municipal Code sets key minimum requirements for stormwater (BMP) practices to maintain an expected level of performance. They are as follows:

Performance standards for flow control:

- Flow Control Minimum Requirement #1 (FC#1) – Implement Green Stormwater Infrastructure. Install and maintain green stormwater infrastructure to the maximum extent feasible. Green stormwater infrastructure BMPs are detailed in Section 4.4.

- Flow Control Minimum Requirement #2 (FC#2) – Wetland Protection. Protect the functions and values of the wetland.

- Flow Control Minimum Requirement #3 (FC#3) – Pre-developed Forest. Match the post-development discharge flow rates and durations to a predeveloped forest condition for the range of predeveloped discharge rates from 50 percent 2-year recurrence interval flow up to the 50-year recurrence interval flow.

- Flow Control Minimum Requirement #4 (FC#4) – Pre-developed Pasture. Match the post-development discharge flow rates and durations to a pre-developed pasture condition for the range of predeveloped discharge rates from 50 percent of 2-year recurrence interval flow up to the 2-year recurrence interval flow.

- Flow Control Minimum Requirement #5 (FC#5) – Peak Flow Control. The post-development 25-year recurrence interval flow shall not exceed 0.4 cubic feet per second per acre; and the 2-year recurrence interval flows shall not exceed 0.15 cubic feet per second per acre. When triggered, flow control facilities must be installed to manage flows from the impervious surfaces and converted pervious surfaces on the site being developed. Post development discharge determination must include flows from dewatering activities. When offsite flows cannot feasibly bypass proposed flow control facilities, the flow control facilities shall be sized for the combined total of onsite and offsite flows with the allowable discharge rates determined by the onsite runoff

calculations (see Section 4.2.4). All projects shall use green stormwater infrastructure to the maximum extent feasible to meet the minimum requirements.

SPECIAL NOTES:

If a project requires FC#5 and either FC#3 or FC#4, the facility shall be sized to the largest applicable size (i.e., to meet the more stringent of the requirements).

Stormwater flow control and treatment facilities are not required if the site produces no stormwater runoff discharge as determined by a licensed civil engineer using an approved continuous runoff model.

Performance standards for volume control:

The performance standards applicable to the key Minimum Requirements for Treatment are summarized below. The applicability of each minimum requirement depends upon the project type, size, and receiving water as summarized in Section 2.5.3.

- Treatment Minimum Requirement #1 (WQ#1) – Basic Treatment. Install and maintain a basic water quality treatment facility. The requirements for determining the applicable water quality treatment volume and/or rate are presented in Section 2.4.7, with additional modeling requirements and guidance presented in Chapter 6. If the requirement for basic treatment applies to a project, all other treatment minimum requirements (WQ#2, WQ#3 and WQ#4) must be evaluated to determine if they are applicable.

- Treatment Minimum Requirement #2 (WQ#2) – Oil Control. Install and maintain an oil control treatment facility for high-use sites.

- Treatment Minimum Requirement #3 (WQ#3) – Phosphorus Treatment. Install and maintain a phosphorus treatment facility for projects discharging into nutrient-critical receiving waters.

- Treatment Minimum Requirement #4 (WQ#4) – Enhanced Treatment. Install and maintain an enhanced treatment facility. When triggered, water quality treatment facilities must be installed to treat flows from the pollution generating pervious and impervious surfaces on the site being developed. When stormwater flows from other areas, including non-pollution generating surfaces (e.g., roofs), dewatering activities, and offsite areas cannot be separated or bypassed, treatment BMPs shall be designed for the entire area draining to the treatment facility. All projects shall use green stormwater infrastructure the maximum extent feasible to meet the minimum requirements.

  SPECIAL NOTES:

  Stormwater flow control and treatment facilities are not required if the site produces no stormwater runoff discharge as determined by a licensed civil engineer using an approved continuous runoff model.

4.3.5.5 Key Definitions

BEST MANAGEMENT PRACTICE: A schedule of activities, prohibitions of practices, operational and maintenance procedures, structural facilities, or managerial practice or device that, when used singly or in combination, prevents, reduces, or treats contamination of drainage

water, prevents or reduces soil erosion, or prevents or reduces other adverse effects of drainage water on receiving waters.

DETENTION: Temporary storage of drainage water for the purpose of controlling the drainage discharge rate.

DEVELOPMENT: Land disturbing activity or the addition or replacement of impervious surface.

DRAINAGE BASIN: The tributary area or subunit of a watershed through which drainage water is collected, regulated, transported, and discharged to receiving waters.

GREEN STORMWATER INFRASTRUCTURE: A drainage control facility that uses infiltration, evapotranspiration, or stormwater reuse. Examples of green stormwater infrastructure include permeable pavement, bioretention facilities, and green roofs.

IMPERVIOUS SURFACE: Any surface exposed to rainwater from which most water runs off. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, formal planters, parking lots or storage areas, concrete or asphalt paving, permeable paving, gravel surfaces subjected to vehicular traffic, compact gravel, packed earthen materials, and oiled macadam or other surfaces which similarly impede the natural infiltration of stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of stormwater modeling.

INFILTRATION: The downward movement of water from the surface to the subsoil.

INFILTRATION FACILITY: A drainage control facility that temporarily stores, and then percolates drainage water into the underlying soil.

LAND DISTURBING ACTIVITY: Any activity that results in a movement of earth, or a change in the existing soil cover, both vegetative and non-vegetative, or the existing topography. Land disturbing activities include, but are not limited to, clearing, grading, filling, excavation, or addition of new or the replacement of impervious surface. Compaction, excluding hot asphalt mix, which is associated with stabilization of structures and road construction, shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land disturbing activities.

PRE-DEVELOPED CONDITION: The vegetation and soil conditions that are used to determine the allowable post-development discharge peak flow rates and flow durations, such as pasture or forest.

4.3.6 Portland, Oregon

4.3.6.1 Background

The Portland Stormwater Management Manual (SWMM) was initially adopted in 1999, revised in 2004, and was most recently revised in 2008 and 2014. For the 2014 revision, the overall structure of the SWMM remains the same. The SWMM was edited and reorganized to clarify the requirements, eliminate duplication, and improve the overall presentation of the information.

Before the adoption of the September 2004 Stormwater Management Manual revision, Portland relied on a single treatment storm methodology, using a storm of 0.83 inches over 24 hours

(NRCS Type 1A rainfall distribution). Used since 1994, the original intent of this design storm was to: 1) treat the "first-flush" or first 0.5 inches of runoff from all storm events and 2) pass 100% to 95% of all storm events through the treatment facility. There did not seem to be a direct environmental or economic justification for choosing 95% of storm events at the time. The justification was mainly social/political in that it sounded like a reasonable standard.

The City of Eugene uses a treatment goal of 80% of the average annual runoff, and the justification seems to be both social/political and economic, as an attempt was made to choose a treatment intensity at the "knee" of an intensity versus percentage of annual runoff volume treated curve. The Washington State Department of Ecology (and thus many other jurisdictions in Washington) uses 91%, and claims that an economic analysis was performed to justify the goal.

Rather than stating a treatment volume goal without a link to environmental or economic considerations, Portland has chosen to consider economic factors to provide the most "bang for the buck". From a social/political and environmental perspective it is also desirable to set a minimum value to this goal. A continuous simulation analysis has been performed on multiple years of rainfall data to determine the percentage of average annual rainfall that should be treated to maximize treatment efficiency. This analysis indicates a knee in the curve somewhere between 80 and 85 percent of the average annual volume. It may not be desirable to set the treatment goal directly at the economically optimal point, as stormwater treatment facilities do not always operate at their optimal design flow rates. Filters blind over time, or swales accumulate sediments that decrease the effective treatment flow rate through them. A margin of safety should be incorporated into the treatment volume goal. For these reasons, the City of Portland has chosen to set its treatment volume goal at 90% of the average annual rainfall volume.

4.3.6.2 Stormwater Targets

In Portland, flow rate-based pollution reduction facilities are designed to treat runoff generated by a rainfall intensity of 0.19 inches per hour (depending on time of concentration). The rainfall intensities must be used in the Rational Method (Q=C×I×A) equation to calculate pollution reduction runoff rates for rate-based pollution reduction facilities.

Facilities sized by routing a hydrograph through the facility (rate-based facilities with a storage volume component) may use a continuous simulation program (with a minimum of 20 years of Portland rainfall data) or a single-storm hydrograph-based analysis method, such as the Santa Barbara Urban Hydrograph (with 0.83 inches of rainfall over 24 hours and NRCS Type 1A rainfall distribution), to demonstrate treatment of 90 percent of the average annual runoff volume.

Volume-based facilities are designed to treat runoff generated by 0.83 inches of rainfall over 24 hours (with NRCS Type 1A rainfall distribution) with a volume of basin/volume of runoff ratio of 2 and will treat roughly 90 percent of the average annual runoff.

The City of Portland has the following citywide pollution reduction requirements for all projects that develop or redevelop over 500 square feet of impervious area and all existing development that proposes to create new offsite stormwater discharges:

- Seventy percent (70%) removal of total suspended solids (TSS) is required from 90 percent of the average annual runoff. (See Appendix E for more detailed information about the formulation of Portland's pollution reduction standards.)

- In watersheds that have established total maximum daily loads (TMDLs) or that are on DEQ's 303(d) list of impaired waters (Exhibit 1-5), stormwater management facilities must be capable of reducing the pollutant(s) of concern, as approved by BES.

4.3.6.3 Winter Stormwater Management

There is no mention of winter stormwater management, except for ongoing maintenance and inspections of post-construction stormwater management practices.

4.3.6.4 BMP Performance

The Performance Approach is a design method that is based on the design of stormwater management facilities meeting or exceeding the pollution reduction requirements listed among the stormwater targets. It is available for projects with unique circumstances that require analysis that goes beyond the capabilities or specifications of the Simplified and Presumptive approaches. It may be used to address a range of circumstances, including but not limited to:

- Size a performance-based facility (wetlands, ponds, grassy swales, etc.)
- Propose an alternate design methodology or facility specification
- Address unique site conditions
- Apply a new or emerging design technology, such as manufactured stormwater treatment technologies not approved for general use in the City of Portland

The Performance Approach requires the assistance of a licensed engineer or qualified professional. Detailed engineering calculations must be provided as evidence of the proposed design's performance with respect to the Portland stormwater requirements. Permeable pavement, grass swales must be designed according to the Performance Approach, to ensure proper design and performance.

Furthermore, The City will accept a design proposed for pollution reduction requirements if the applicant demonstrates the following:

- Facilities will perform at the required efficiency: 70 percent total suspended solids (TSS) removal from 90 percent of the average annual runoff and is capable of reducing Total Maximum Daily Load (TMDL) pollutants of concern (if applicable). Documented performance is required and must include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.

4.3.6.5 Key Definitions

BEST MANAGEMENT PRACTICES (BMPS): Operational, maintenance and other practices that prevent or reduce environmental, health or safety impacts. BMPs include structural controls, modification of facility processes, and operating and housekeeping pollution control practices.

DETENTION FACILITY: A facility designed to receive and hold stormwater and release it at a slower rate, usually over a number of hours. The facility may provide minimal or no volume reduction.

DETENTION TANK, VAULT, and OR OVERSIZED PIPE: A structural subsurface facility used to provide flow control for a particular drainage basin.

DRYWELL: A subsurface structure (e.g. cylinder or vault) with perforated sides and/or bottom, used to infiltrate stormwater into the ground. A drywell is a UIC by DEQ definition.

INFILTRATION: The percolation of water into the ground. Infiltration is often expressed as a rate (inches per hour), which is determined through an infiltration test.

PARTIAL INFILTRATION: When the total infiltration design storm (or another specified design storm as required) is unable to be completely percolated into the ground.

PERVIOUS PAVEMENT (AKA POROUS PAVEMENT OR PERMEABLE PAVEMENT): Alternative pavement systems that allow water to percolate into subsurface drainage systems or the ground. Examples include permeable pavers, pervious asphalt, and pervious concrete systems.

PLANTER: A structural facility filled with topsoil and gravel and planted with vegetation. The stormwater planter receives runoff from impervious surfaces, which is filtered and retained for a period of time. Planters may be further classified by their ability to infiltrate. An infiltration planter has an open bottom, allowing water to infiltrate into the ground. A flow-through planter has an overflow that must be directed to an acceptable discharge point. Flow-through planters may have an impervious or sealed bottom, either through a waterproof liner or a poured concrete base. Site conditions will determine appropriate facility selection.

RAINWATER HARVESTING: The collection and use of rainwater or stormwater runoff for water use purposes such as irrigation and toilet flushing. A facility that harvests rainwater is considered a stormwater facility only if the facility has water quality or flow control benefit, as determined by BES.

REDEVELOPMENT: Any development that requires demolition or complete removal of existing structures or impervious surfaces at a site and replacement with new impervious surfaces. Maintenance activities such as top-layer grinding, repaving (where all pavement is not removed), and reroofing are not considered to be redevelopment. Interior remodeling projects and tenant improvements are also not considered to be redevelopment. Utility trenches in streets is not considered to be redevelopment unless more than 50 percent of the street width is removed and repaved.

RESERVOIR: The temporarily stored volume of runoff prior to overflow. For vegetated surface facilities it is defined as the volume between the top of the growing medium, the design water surface elevation (overflow elevation), and the edges of the facility (whether sloped or vertical). In a sedimentation chamber, it is defined as the volume of runoff stored prior to discharge to the receiving system.

RETENTION FACILITY: A facility designed to receive and hold stormwater runoff so that some volume of stormwater that enters the facility is not released offsite. Retention facilities permanently retain a portion of the water onsite, where it infiltrates, evaporates, or is absorbed by surrounding vegetation.

SAND FILTER: A structural pollution reduction or flow control facility using a layer of sand and optional vegetation to manage stormwater runoff.

SOAKAGE TRENCH: A subsurface infiltration stormwater management facility that includes a perforated pipe laid in drain rock. A soakage trench is a UIC by DEQ definition.

STORMWATER FACILITY LANDSCAPING (LANDSCAPING): The vegetation (plantings), topsoil, rocks, and other surface elements associated with stormwater management facility design.

STORMWATER MANAGEMENT: Techniques used to reduce pollutants from, detain, retain, or provide a discharge point for stormwater runoff that best preserves or mimics the natural hydrologic cycle. Stormwater management reduces combined sewer overflows and basement sewer backups, and helps meet the capacity of existing infrastructure.

STORMWATER MANAGEMENT FACILITY: A facility or other technique used to reduce the volume, flow rate or pollutant content of stormwater runoff. Stormwater facilities may reuse, collect, convey, detain, retain, or provide a discharge point for stormwater runoff.

SURFACE INFILTRATION FACILITY: A vegetated facility designed to receive and infiltrate stormwater runoff at the ground surface to meet stormwater infiltration/discharge requirements.

TOTAL SUSPENDED SOLIDS (TSS): Total suspended matter that either floats on the surface or is suspended in water or wastewater and that is removable by laboratory filtering in accordance with 40 CFR Table B.

VEGETATED FILTER: A gently sloping, densely vegetated area used to filter, slow, and infiltrate sheet flow stormwater.

VEGETATED INFILTRATION BASIN (RAIN GARDEN): A vegetated facility that temporarily holds and infiltrates stormwater into the ground.

VEGETATED SWALE (BIOSWALE): A long, narrow, vegetated channel used to collect, convey and reduce pollutants from stormwater runoff. Check dams are used to slow runoff, settle sediment, and improve infiltration and pollution reduction.

WET POND: A vegetated basin with a permanent pool of water, used to provide pollution reduction for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out and extended wet detention ponds have additional storage capacity for flow control.

WETLAND: An area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas, except those constructed as pollution reduction or flow control facilities.

4.4 International Jurisdictions

4.4.1 European Union

4.4.1.1 Background and Context

The following section was taken from the published paper: Delivering more effective stormwater management in the UK and Europe – lessons from the Clean Water Act in America

Europe is required to implement the “good status” requirements of the Water Framework Directive (WFD) by 2015 (Commission of the European Communities, 2000). This provides the European Community (EC) framework for the protection of waters. The aim is to promote the sustainable use of water, while progressively reducing or eliminating pollutants for the long-term protection and enhancement of the aquatic environment. A new proposal for a Directive on the Assessment and Management of Floods (Floods Directive) (Commission of the EC, 2006) sets out to reduce and manage flood risk. The Floods Directive and measures taken to implement it are to be closely linked to the implementation of the WFD. The EC proposes to fully align the organisational and institutional aspects and timing between the Directives, based on river basin districts defined in the WFD.

Particular challenges for stormwater management are two WFD ‘daughter’ Directives in preparation. One concerns groundwater and the definition of good chemical quality, and the other, the way in which the most polluting substances are handled, the ‘priority substances’ (PS) and the ‘priority hazardous substances’ (PHS); some of which, such as nickel, are ubiquitous in stormwater. Notwithstanding the daughter Directives, stormwater sewers and drains are known to convey significant pollutants and need to be better controlled under the WFD; albeit such pollution being better managed at source than in drains.

The WFD is an opportunity to ensure a consistent and integrated approach to the way in which we currently manage water within defined river basin districts. The establishment of the European 'priority list' of substances posing a threat to or via the aquatic environment is significant. There are currently 33 priority substances on this priority list (Official Journal of the EC, 2001; Commission of the EC, 2006a). Estimates of the costs of compliance for the UK suggest some €9 Billion would be needed to deal with these substances for the discharges from point sources alone. Even with this level of investment, only some 70% of the PHS would actually be removed (Ross et al, 2004). However, the 33 so far identified could be added to significantly in the future and this may add additional treatment and financial burdens and possibly require the development and installation of new technologies. Inevitably the Directive will mean that some stormwater and other discharges to water bodies will be required to cease or at the least have substantial treatment systems installed.

The precise standards to be attained to comply with the WFD are being set within and by each member state. Ecosystems do not recognise state boundaries and hence there has to be harmonisation especially across shared borders. Even in the UK the approach to the implementation and adoption of proposals is likely to vary for each constituent country, depending on present and proposed legislation and on policy differences. It will also depend on the need for Ireland and the UK, as separate Member States, to harmonise standards, where appropriate, within shared River Basin Districts (UKTAG, 2006).

Currently the place of stormwater (and water) within formal planning processes in many EU countries is not considered to be very important. In view of the future uncertainties from climate

change and impacts from current legislation (WFD in particular), the place of stormwater management will need to take a more central role in all aspects of urban planning. In addition, regulatory systems will need to become more flexible and adaptable to new knowledge.

4.4.2 England

4.4.2.1 Background

Definition of a "water quality volume" is probably the most common approach for pollution control. This criterion is widely adopted in Northern America (US and Canada), but also in England. Contrary to peak-flow control strategies, such a criterion directly aims at reducing surface water impairment through detention and treatment of a given volume. Although water quality volume definition may vary from a country to another, it generally encompasses the following objectives (as summarized in British guidelines); "Capture and treat the runoff from frequent small events and a proportion of the initial runoff from larger and rarer events". This criterion is often supposed to enable capture and treatment of 80 to 90% of annual runoff volumes and is usually expressed as a rainfall depth, either associated with a design storm (for which runoff shall be treated), or simply representing a storage volume (corresponding runoff depth is then computed from rational or "curve number" methods). Few details are however given about the rationale underlying the determination of the amount of water to be captured and volume targets value may thus differ significantly from a community to another.

4.4.2.2 Stormwater Targets

There are no strict stormwater targets in England, but rather, recommendations for improving stormwater quality. The recommended water quality treatment options are as follows:

1. Treatment of stormwater using Infiltration (Interception storage). Good site design does not allow runoff from impermeable surfaces to pass to the river for the range of smaller, polluting events (**at least 5 mm, preferably 10 mm**). This is likely to be through the use of infiltration techniques that treat smaller events via filtration through the soil and discharge them to groundwater. Rainwater harvesting can also be used.

2. Treatment of stormwater using filtration Improvements to stormwater quality can be achieved by filtering the runoff (particularly for small, frequent events) using a variety of filtration media e.g. sands (e.g. sand filters), gravels (e.g. permeable pavements, filter trenches), soils (e.g. bioretention), grasses and other surface vegetation (e.g. swales, detention basins) or aquatic vegetation (e.g. wetlands). The travel time or flow velocity through the system is specified to maximize treatment benefits.

3. Treatment of stormwater using detention storing runoff volumes within basins, using outflow controls, contributes primarily to meeting hydraulic criteria, but such systems also allow sedimentation to take place which contributes to water quality improvement.

4. Treatment of stormwater using permanent pond volumes ponds can provide significant water quality improvements by capturing small events which allow the settling out of fine silts and promote plant and microbial activity to encourage adsorption and biodegradation of contaminants and nutrient removal. The permanent pond volume is

effectively the volume of water that remains in ponds during the dry weather periods between rainfall events. It is often known as the Water Quality Treatment Volume (or Vt) and should be sized to accommodate at least 10 mm of runoff from the impermeable surfaces, although this can be reduced where upstream treatment components are part of the Sustainable Drainage Systems (SuDS) management train (synonymous with Low Impact Development Principles).

4.4.2.3 BMP Performance Standards

The water quality treatment volume may be managed within a single SuDS technique or within a series of techniques, forming part of the treatment train. Each technique has a different removal efficiency for each pollutant of concern. However, for most sites, general water quality improvement is required across the suite of urban pollutants. Where there are particular pollutants of concern, the selected techniques must be appropriate for their management to acceptable levels. Hydraulic criteria will require peak flow and volume control for a range of return periods (or probabilities). Flow rates are likely to be a function of the extent of structural hydraulic control at the system outfall, together with the size of attenuation storage provided in the system design. Significant volume control will be possible only through the use of infiltration systems, although extended detention (e.g. in basins, or beneath pavements) can promote significant losses through evaporation. Some systems are not appropriate for managing extreme flood events, e.g. filtration systems will be designed for maximum flow rates and high through-flows may damage their operational performance. In such cases, high flows should be diverted upstream of the SuDS technique. A summary has been reproduced in the Table below.

SuDS group	Technique	Water quality treatment potential					Hydraulic control			
		Total suspended solids removal	Heavy metals removal	Nutrient (phosphorous, nitrogen) removal	Bacteria removal (*)	Capacity to treat fine suspended sediments and dissolved pollutants	Runoff volume reduction	Suitability for flow rate control (probability)		
								0.5 (1/2 yr)	0.1 – 0.3 (10/30 yr)	0.01 (100 yr)
Retention	Retention pond	H	M	M	M	H	L	H	H	H
	Subsurface storage	L	L	L	L	L	L	H	H	H
Wetland	Shallow wetland	H	M	H	M	H	L	H	M	L
	Extended detention wetland	H	M	H	M	H	L	H	M	L
	Pond/wetland	H	M	H	M	H	L	H	M	L
	Pocket wetland	H	M	H	M	H	L	H	M	L
	Submerged gravel wetland	H	M	H	M	H	L	H	M	L

	Wetland channel	H	M	H	M	H	L	H	M	L
Infiltration	Infiltration trench	H	H	H	M	H	H	H	H	L
	Infiltration basin	H	H	H	M	H	H	H	H	H
	Soakaway	H	H	H	M	H	H	H	H	L
Filtration	Surface sand filter	H	H	H	M	H	L	H	M	L
	Sub-surface sand filter	H	H	H	M	H	L	H	M	L
	Perimeter sand filter	H	H	H	M	H	L	H	M	L
	Bioretention/filter strips	H	H	H	M	H	L	H	M	L
	Filter trench	H	H	H	M	H	L	H	H	L
Detention	Detention basin	M	M	L	L	L	L	H	H	H
Open channels	Conveyance swale	H	M	M	M	H	M	H	H	H
	Enhanced dry swale	H	H	H	M	H	M	H	H	H
	Enhanced wet swale	H	H	M	H	H	L	H	H	H
Source control	Green roof	n/a	n/a	n/a	n/a	H	H	H	H	L
	Rain water harvesting	M	L	L	L	n/a	M	M	H	L
	Permeable pavement	H	H	H	H	H	H	H	H	L

* limited data available

n/a = non applicable M = medium potential

H = high potential L = low potential

4.4.2.1 Key Definitions

ATTENUATION STORAGE - Volume used to store runoff during extreme rainfall events. Comes into use once the inflow is greater than the controlled outflow.

BALANCING POND - A pond designed to attenuate flows by storing runoff during the storm and releasing it at a controlled rate during and after the storm. The pond always contains water.

BASIN - A ground depression acting as a flow control or water treatment structure that is normally dry and has a proper outfall, but is designed to detain stormwater temporarily.

BIORETENTION AREA - A depressed landscaping area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal.

DETENTION BASIN - A vegetated depression that is normally dry except following storm events. Constructed to store water temporarily to attenuate flows. May allow infiltration of water to the ground.

DETENTION POND/TANK - A pond or tank that has a lower outflow than inflow. Often used to prevent flooding.

EXTENDED DETENTION - A detention basin where the runoff is stored beyond the time basin for attenuation. This provides extra time for natural processes to remove some of the pollutants in the water.

FILTER DRAIN - A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage.

FILTER STRIP - A vegetated area of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.

FILTRATION - The act of removing sediment or other particles from a fluid by passing it through a filter.

GREEN ROOF - A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater, and promotes evapotranspiration. Sometimes referred to as an alternative roof.

INFILTRATION BASIN - A dry basin designed to promote infiltration of surface water to the ground.

INFILTRATION DEVICE - A device specifically designed to aid infiltration of surface water into the ground.

INFILTRATION TRENCH - A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.

PERMEABLE PAVEMENT - A permeable surface that is paved and drains through voids between solid parts of the pavement.

PERMEABLE SURFACE - A surface that is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration of water to the sub-base through the pattern of voids, for example concrete block paving.

POND - Permanently wet depression designed to retain stormwater above the permanent pool and permit settlement of suspended solids and biological removal of pollutants.

POROUS ASPHALT - An asphalt material used to make pavement layers pervious, with open voids to allow water to pass through (previously known as pervious macadam).

POROUS PAVING - A permeable surface that drains through voids that are integral to the pavement.

RAINWATER BUTT - Small scale garden water storage device which collects rainwater from the roof via the drainpipe.

RAINWATER HARVESTING - A system that collects rainwater from where it falls rather than or rainwater allowing it to drain away. It includes water that is collected use system within the boundaries of a property, from roofs and surrounding surfaces.

RETENTION POND - A pond where runoff is detained for a sufficient time to allow settlement and biological treatment of some pollutants.

SOAKAWAY - A sub-surface structure into which surface water is conveyed, designed to promote infiltration.

SuDS - Sustainable drainage systems: an approach to surface water management that combines a sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.

SWALE - A shallow vegetated channel designed to conduct and retain water, but may also permit infiltration. The vegetation filters particulate matter.

WATER QUALITY VOLUME - The proportion of total runoff from impermeable areas that is treatment volume captured and treated to remove pollutants.

WETLAND - Flooded area in which the water is shallow enough to enable the growth of bottom-rooted plants.

4.4.3 Australia

4.4.3.1 *Background*

Australians live in the driest inhabited continent. Managing scarce water resources requires a complete water cycle approach to protecting the country's unique ecosystems.

The variability of rainfall and runoff is more extreme than other parts of the world. Australians have made a large investment in stored water capacity to supply rural and urban users in this climate. While stormwater runoff from the cities is about equal to the amount of drinking quality water that is supplied at considerable cost each year, little stormwater is captured, with most adding to the pollution of waterways.

Urban stormwater is defined as runoff from urban areas, including the major flows during and following rain, as well as dry-weather flows. Many factors influence the amount of stormwater and the contaminants that are transported by it, including:

- Duration and intensity of rainfall.
- Proportion of impervious surfaces.
- Shape of the land.
- Land use.
- Design and management of stormwater systems.

In addition to washing contaminants from the atmosphere, rainfall in the form of stormwater runoff flushes material accumulated on surfaces including litter, dust and soil, fertilisers and other nutrients, chemicals and pesticides, micro-organisms, metals, oils and grease into waterways.

Overall, about 12% of Australia's rainfall finds its way into surface streams. By contrast, in highly urbanised zones up to 90% of the rainfall may flow into the stormwater system. These flows are complemented by dry weather drainage, flows from garden watering, wash downs and illegal discharges. In some systems wet weather overflows from sewerage systems create significant health and environmental impacts on our waterways.

In the past, the prime objective of urban stormwater management has been flood mitigation. In Australia, local councils can be held liable for flood damage caused by stormwater.

Traditionally in Australia, stormwater has been transported separately from the sewerage system. Unlike sewage, stormwater has received little, if any, treatment. The aim has been to

channel the stormwater as rapidly and invisibly as possible from within our urban areas to the nearest waterway, usually on the coast.

The necessity to deal with both the quantity and quality of runoff is now recognised in Australia. The 'hard' engineering strategy for the management of stormwater is being modified by an increase in the application of Water Sensitive Urban Design (WSUD). This strategy focuses on the sources of runoff and pollution and the tools to contain and reuse the water within urban housing, commercial and industrial areas.

Today Australians have the tools to focus on Ecological Sustainable Development (ESD) in stormwater management. Stormwater can be treated as a resource that can bring environmental, economic and social benefits to our urban areas. Rather than going to waste and causing pollution, through capture, treatment and reuse, stormwater can become a major alternative to damming more rivers to ensure water supply.

4.4.3.2 Stormwater Targets

Stormwater targets are assigned at the local level. With water being a national priority, the Council of Australian Governments representing the Commonwealth, State, Territory and Local Government in Australia at the highest level, has adopted a National Water Quality Management Strategy (NWQMS). This Strategy includes a major focus on water quality linked to Ecological Sustainable Development, that is: "To achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development'. To achieve this objective, a three-tiered approach to water quality management - national, state, and local - is focused on regional catchments. In practice, each sphere of government uses its own water quality planning, environmental policy and regulatory tools to address the challenge.

The optimum solution for managing an increased volume of runoff is to encourage infiltration, storage and reuse. A goal for new development is to ensure that the post-development peak discharge rate, volume, timing and pollutant load does not exceed pre-development levels.

4.4.3.3 BMP Performance

Best management practices (BMPs) are not 100 percent effective in removing stormwater pollutants. For this reason, government agencies in each region have set performance standards that are based on risk analysis and feasibility of implementation. Some of the performance standards are based on achieving water quality targets in regional waterways.

4.4.3.4 Key Definitions

BEST MANAGEMENT PRACTICE (BMP) - Structural measures used to store or treat urban stormwater runoff to reduce flooding, remove pollution or to provide other amenities.

DETENTION (DRY) BASINS - A basin designed to temporarily detain, storm or flood waters, to attenuate peak flows downstream to acceptable levels.

INFILTRATION PIT, TRENCH, BASIN - A stone filled pit, trench or detention basin designed to enhance runoff infiltration into the subsoil and groundwater zones.

ON-SITE STORMWATER DETENTION (OSD) - A requirement for developers of land to compensate for increased runoff due to increases in imperviousness on blocks.

PERMEABLE (POROUS) PAVEMENT - Pavements comprising materials which facilitate infiltration of rainwater and transfer to the underlying sub-soil.

POLLUTION CONTROL PONDS - A shallow pool of water, characterised by areas of emergent aquatic plants and open water, designed to intercept event discharges and enable adsorption and sedimentation of pollutants, and to support a diverse range of micro-organisms and plants associated with the breakdown of organic material and uptake of nutrients. The detention of event flows and settling of suspended particles and associated pollutants is a key component of pond pollutant interception processes.

RAINWATER TANKS - Tanks used to collect and store rainfall from household roofs for beneficial use.

RECYCLED WATER - Treated stormwater, greywater or black water

SWALES - A grassed open channel, designed to intercept and convey surface runoff to a drainage network inlet, promote infiltration, promote interception of particulate material by the vegetation, and to provide a landscape element.

WETLANDS (ARTIFICIAL) - A shallow pool of water, characterised by extensive areas of emergent aquatic plants, designed to support a diverse range of micro-organisms and plants associated with the breakdown of organic material and uptake of nutrients. Wetlands may be designed as permanent wet basins (perennial), or alternating between dry and wet basins (ephemeral), or combining these two systems (extended detention).

4.4.3.5 Upper Parramatta River, New South Wales, Australia

The Upper Parramatta River catchment is located in several western suburbs of the Sydney Metropolitan Area. It consists of four councils: Baulkham Hills, Blacktown, Holroyd, and Parramatta. These four local governments collaborated with the Upper Parramatta River Trust to develop the On-Site Stormwater Detention Handbook.[xvi] The on-site detention (OSD) policy aims to ensure that subsequent developments will not increase flooding or stormwater flows at any downstream locations, in all flood events up to and including 100 year average recurrence interval (ARI) events. The policy also aims to reduce post-development peak discharge rates throughout the catchment in the 1.5-yr ARI event to as close to natural levels as practical and to encourage the integration of other water quality measures. Finally, the policy encourages integration of OSD systems in site plans in the early stages of design, promotes sustainable water management planning, and ensures OSD systems are properly constructed and maintained.

The OSD policy applies to a wide range of development and redevelopment projects, whether located on “flood liable” or “flood-free sites.” For instance, the following types of projects must comply with the policy: subdivisions; commercial, industrial, and special use developments and buildings; roads, car parks, paths, and other sealed (paved) areas; public buildings; and several others. The policy also lists several project types that are not required to comply with the OSD requirements. Generally, OSD facilities must be applied to the entire development site. However, exceptions exist for additions to already developed property, subdivision of existing residential property (i.e. lot splits), portion of lots that are not developed, among others. Several control and operating standards are mandated for specific aspects of the OSD system. Unique

to the OSD policy, developers are required to install small signs on or near the OSD facility in order to alert future owners of the existence and maintenance obligations of the facility.

The on-site detention policy has a three-step approval process which strongly encourages consideration of OSD as early in the design process as possible. First, applicants must submit a Development Application. The main element of this application is a Stormwater Concept Plan (SCP). The SCP ensures that OSD and drainage requirements are considered. Further, an SCP identifies any drainage constraints and demonstrates that the OSD system can be integrated into the site's proposed layout, and will effectively manage stormwater runoff. At a minimum, the SCP must include estimates of runoff volume and OSD capacity; a description of the relationship between OSD and any Water Sensitive Urban Design (WSUD) proposals for the site, estimates of maximum flow rates and flowpaths, and a detailed site plan.

Second, applicants must submit for approval detailed design plans. This section of the handbook is meticulous. In summary, applicants must submit calculations for each storage, OSD facility design plans and construction drawings, maintenance schedules and allocation of maintenance obligations. The final stage of the approval process involves ensuring the system was constructed properly and will be protected and maintained for the foreseeable future. The constructed system should conform exactly to the approved design plans submitted in the second step. Applicants must submit work-as-executed drawings, certificates of hydraulic compliance, and any legal instruments created to protect the OSD system.

4.4.4 New Zealand – National and Christchurch

4.4.4.1 Background

In 2001, many respondents made unprompted suggestions that a guideline was needed for better stormwater management throughout New Zealand, while more than two-thirds of respondents agreed with the proposition that a New Zealand guideline on comprehensive stormwater management was necessary. Plans were laid for New Zealand Water Environment Research Foundation (NZWERF) to carry out the project in 2003, funding was sought from a range of organisations during the year, and work on the project began in January 2004. Through the Minister for the Environment's Sustainable Management Fund and the other funding contributors listed earlier, NZWERF has produced the current guideline to meet the needs – and concerns – identified in that 2001 survey.

The current guideline is part of a stormwater management resources programme being carried out by NZWERF. The programme is made up of two components, the other one being the Stormwater directory of New Zealand. The Stormwater directory of New Zealand comprises an internet based, searchable database of stormwater information resources, such as guidelines and design manuals. Resources are listed in four main categories;

1. Regulations and legislation,
2. Catchment analysis,
3. Stormwater design and construction and
4. Asset management.

A stormwater links page includes an education and research links section and an online form for adding and updating resources. The Stormwater Directory of New Zealand is available here: www.stormwaterdirectory.org.nz.

4.4.4.2 Stormwater Targets

The national stormwater targets are based on either Auckland Regional Council (ARC) approach or the Christchurch City Council (CCC) approach.

The Auckland approach is as follows: The water quality design storm for the ARC method has been developed from detailed analysis of long term rainfall records at one rain gauge, which yielded a water quality design storm depth of 25 mm, equivalent to one third of the 2 year average recurrence interval (ARI) daily rainfall at this location. The ARC method provides for the water quality design storm to be calculated for any location in the region by dividing the 2 year ARI daily rainfall at that location by a factor of 3. For the Auckland region the water quality design storm depths are:

- Range over the Auckland region: from 16.7 mm to 43.3 mm
- Most of the urbanised area: 26.7 mm

4.4.4.3 Christchurch approach

The Christchurch approach is as follows:

Environment Canterbury consent CR C000315 (granted to the Christchurch City Council for green fields development in the Upper Heathcote / Wigram area) requires capture and treatment of the first 12.5 mm of all rainfall events prior to discharge to ground. This first flush interception will achieve treatment of 58% of the Christchurch average annual rainfall depth falling on the recipient catchment.

A suggested requirement within Environment Canterbury's Draft Canterbury Natural Resources Regional Plan (2002) is for first flush to be considered as the first 15 mm of all rainfall events followed by 72 hours detention prior to discharge to surface water. Christchurch City Council recommends as best practice the capture of runoff from the first 25 mm of storm rainfall depth, but not less than 15 mm. average detention time prior to discharge to surface waters should be at least 24 hours. To be effective in treating dissolved pollutants, detention time in wetlands and wet ponds should be longer.

The CCC (2003) method uses average effective impervious area percentages based on land use zonings to calculate first flush volumes. The CCC (2003) first flush method is limited to the design of ponds and wetlands.

4.4.4.4 BMP Performance Standards

BMP performance standards are regulated through the design of the BMP. The design regulations were put in place in order to achieve a desired performance standard for each LID feature that follows these design regulations.

4.4.4.5 Key Definitions

DETENTION OF STORMWATER - Temporarily detaining runoff on a site before discharging it to reticulated or natural system (refer also 'retention')

LOW IMPACT DESIGN - Design approach for site development that protects and incorporates natural site features into erosion and sediment control and stormwater management plans

RETENTION - A system that temporarily retains runoff and then disposes of it on site by infiltration

WATER SENSITIVE URBAN DESIGN - Low impact development as defined above, with an added emphasis on sustainable vegetation practices and low-level of water usage

4.4.5 New Zealand – Auckland

4.4.5.1 Background

The Resource Management Act (RMA) sets up the statutory framework requiring stormwater discharge permits. Activities which do not meet the permitted activity criteria of the Transitional Regional Plan and the proposed Regional Plan: Air, Land, and Water (ALW) require resource consents.

Permitted activities allow the discharge of water to any land or water body from any development which has an impermeable surface area of less than 1000 square metres.

When considering a resource consent application, the ARC must have regard to the policy set down in the Regional Plan: Air, Land, and Water and the Auckland Regional Policy Statement. The ALW Plan requires the “best practicable option” (BPO) to be implemented with respect to minimising the effects of stormwater discharges. The BPO will vary depending upon the discharge quality, site conditions, and opportunities for mitigation, the downstream receiving environment values and technical and financial constraints.

To protect the human and ecological values attributed to receiving waters and to guide the selection of the BPO, the ARC uses three categories of stormwater management objectives which are set out in the proposed Regional Plan. These are:

- water quantity objectives,
- water quality objectives and
- aquatic resource protection objectives.

4.4.5.2 Stormwater Targets

An analysis of rainfall from the rain gauge at the Botanic Gardens at Manurewa arrived at a rainfall depth of 25 mm for the Stormwater Quality Design Storm (Sd). In order to make allowance for the differences in location, the rainfall depth corresponding to the site location is obtained from Figures in the TP-10 manual, the 2 Year average recurrence interval (ARI) Daily Rainfall Depth.

Sd = (2 year 24-hour rainfall depth at site) /3

This rainfall depth is to be applied on a 24-hour event. The Stormwater Quality Design Storm, Sd, is the rainfall depth chosen from hydrological analysis of a rain gauge located in the Auckland Region that enables 80% of the runoff volume of all storms to be captured and treated.

4.4.5.3 BMP Performance Standards

When using the treatment design guidelines discussed in the previous sections, it is expected that a detention basin would see a 75% removal of total suspended solids on a long term average basis.

For water quantity, the primary water quantity objective of treatment devices is to match the pre-development and post-development peak flow rates for the 50%, 10%, and 1% Annual Exceedance Probability (AEP) rainfall events. Where significant aquatic resources are identified in a freshwater receiving environment, additional water quantity requirements may be required.

For water quality, the primary water quality objective of the treatment devices in this manual is to remove 75% of total suspended sediment on a long term average basis. Removal of sediment will remove many of the contaminants of concern, including; particulate trace metals, particulate nutrients, oil and grease on sediments and bacteria on sediments.

4.4.6 Netherlands-Bloemendaal, AA and Maas

4.4.6.1 Background

The vision of rainwater policy is based on the policy Regenwater and the national water plan. It contains five central pillars for rainwater policy:

1. Source Control; preventing contamination of rainwater;
2. Rainwater beneficial reuse fit into the space as an added value for experience / greening
3. Rainwater retention / infiltration;
4. Separate disposal of waste water;
5. Comprehensive assessment at the local level.

4.4.6.2 Stormwater Targets

For stormwater quantity design, there are two options for the storage of different types of stormwater systems the values as listed below:

- Wastewater System (Joint) will not connect. Design targets are 9 mm (minimum), 15 mm (preferred)
- Rainwater System. Design targets are between 2 and 4 mm

4.4.7 France-Paris and Yerre Catchment

4.4.7.1 Background

In France, infiltration or “zero discharge” (total infiltration) regulations adopted by some sewer networks operators are essentially intended to prevent floods and CSO, although national and regional agencies’ guidance documents indicate that infiltration should generally be preferred for on-site pollution control.

In 2009, the Water Agency Seine Normandie (AESN) entrusted the design office Urban component (hydrology and landscape) and LEESU (laboratory water environment and urban systems research) to conduct a study on stormwater good management tools in urban areas. This was based on the observation that some devices, however widely criticized for more than ten years, continued to be used for any newly created parking. The study aimed to identify the

logic leading to these choices and the state of knowledge on contamination of runoff. It allowed for the development of the French Stormwater Guidance Document for better control of pollution. This document takes into account recent developments and regulatory environment on the one hand, and scientific and technical knowledge on the other, particularly with regard to hazardous substances.

With this document, the Water Agency Seine Normandie makes available a methodological urban development framework and information from studies and recent research to help meet the objectives of the SDAGE.

4.4.7.2 Stormwater Targets

In France, the only discharge criteria given to developers by local communities and treatment devices are usually only required for highly polluted urban areas (e.g. car-parks or fuel transfer stations). In France, sewer systems operators rarely give developers specific criteria to prevent pollutants from entering drainage systems because they probably remain more receptive to quantity control issues like urban flooding, rather than surface water pollution even if they are liable for environmental damage. More generally, the lack of institutional capacity and technical expertise are significant impediment to the adoption of innovative approaches at the local scale. One could therefore argue that these local criteria may sometimes be erroneously perceived as suitable for pollution control by practitioners, by requiring the use of stormwater BMP.

To control the flow of pollutant requires control of both the water quality and quantity to fully reduce pollutant levels. At equal concentrations, the amount of contaminants released into the environment receiving water during a rainfall event is directly proportional to the runoff volume.

To limit the impact of discharges urban wet weather on shallow water environments, it is thus reducing the volume of runoff directed to the sanitary network that is needed. Management techniques upstream stormwater, slowing the water transfer on the watershed and promoting longer contact water with permeable surfaces tend to reduce the volumes of runoff. Therefore, France recommends a target treatment design with:

1. Zero Discharge, or
2. 4-16 mm, depending on the rainfall at the project site.

This has been quantified by A. Bressy in 2010 for several small Watersheds combining various alternative management techniques. At the annual level, 40 to 50% of the volume runoff was highlighted on the "alternative" sites, in comparison with a classic design with sanitary sewerage network. This reduction in volume is accompanied by a reduction of 20% to 80% the pollutant mass released at the outlet, primarily related to loss of volume.

5 RECOMMENDED JURISDICTIONS - BASIS FOR THE VOLUME TARGETS FOR ONTARIO REPORT.

From the two (2) phase approach completed as part of this study, the following five (5) jurisdictions have been recommended to be studied in detail and form the basis for the development of the Volume Targets for Ontario Report. In several cases multiple jurisdictions have been proposed due to their inherent similarities or connections between jurisdictions and the development of the relevant stormwater criteria. The five (5) recommended jurisdictions include:

1. Province of British Columbia and the City of Chilliwack
2. State of Minnesota & the Lake Simcoe Region Conservation Authority
3. Great Lake States: New York State & the State of Michigan
4. District of Columbia, Washington, D.C.
5. New Zealand – National & Christchurch

The five jurisdictions have been primarily selected due to the following rationale:

1. **Province of British Columbia and the City of Chilliwack** - are two (2) examples of Canadian jurisdictions that are proven leaders in stormwater management and Low Impact Development. The volume targets within these jurisdictions are within the top depth range of >25 mm and include both Volume Retention and Detention Criteria. In addition, the City of Chilliwack Policy and Design Criteria Manual for Surface Water Management (May 2002) was developed as a case study application of Stormwater Planning: A Guidebook for British Columbia, a collaborative effort of an inter-governmental partnership that was initiated by local government. This is a unique opportunity to study a "top-down" process whereby local communities are the recipient of policies from higher authorities and how this Provincial direction is applied and implemented.

2. **State of Minnesota & the Lake Simcoe Region Conservation Authority** – are examples of a proven US leader in stormwater management and a Canadian jurisdiction who have adopted the US approach. The volume targets within these jurisdictions are within the top two (2) depth ranges of 14-24 mm and >25 mm respectively and include Volume Retention Criteria. In addition, these jurisdictions provide specific criteria for new development, redevelopment and linear development, utilize the Unified Sizing Criteria and provides flexible criteria, targets and or treatment options for sites with technical restrictions. Finally both jurisdictions are cold climate regions, have nutrient load reduction goals as primary drivers and Minnesota provides some insight into potential cold climate considerations and is a Great Lake State.

3. **Great Lake State: New York State and the State of Michigan** – both jurisdictions are great lake states, which employ Volume Retention and Volume Capture and Release Criteria. New York is also a known leader in LID implementation, with multiple complimentary programs and initiatives which have applied the stated criteria. The volume targets within these jurisdictions are within the top depth range of >25 mm. New York specifically includes additional consideration for performance

targets, beyond volume control to include broader environmental goals and objectives.

4. **District of Columbia, Washington, D.C.** – is arguably the most comprehensive approach to stormwater management in the Chesapeake Bay watershed which includes the use of aggressive Volume Retention Criteria (20-30 mm) and includes specific criteria to new development, redevelopment and linear development. Washington D.C. also has a comprehensive regulatory requirements and supporting programs and or incentives which includes a 'one-of-a-kind' credit trading program and off-site control options.

5. **New Zealand – National & Christchurch –** are examples of international jurisdictions who are leaders in LID or Water Sensitive Urban Design (WSUD) that have existing Volume Capture and Treatment criteria within the top depth range of >25 mm. While not cold climate, these two jurisdictions provide a unique approach to the determination of the water quality design storm which may present a counter-point or at least a point of comparison to the North American approaches (i.e. the Unified Sizing Criteria).

Per the terms of reference, written approval from the MOECC confirming the selection of the five (5) recommended jurisdictions is required prior to begin the development of the Volume Targets for Ontario Report.

APPENDIX A – SOURCE INFORMATION & WEB-LINKS

Canadian Jurisdictions

Province of British Columbia

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Stormwater Planning" A Guidebook for British Columbia (2002) – Part B The purpose of this Guidebook is to provide a framework for effective stormwater management that is usable in all areas of the province. The Guidebook presents a methodology for moving from planning to action that focuses the limited financial and staff resources of governments, non-government organizations and the development community on implementing early action where it is most needed. The Local Government Act - has vested the responsibility for drainage with municipalities. With the statutory authority for drainage, local governments can be held liable for downstream impacts that result from changes to upstream drainage patterns – both volume and rate. The Act also enables local governments to be proactive in implementing stormwater management solutions that are more comprehensive than past practice. Liquid Waste Management Plans (LWMPs) - a stormwater component is a requirement for approved LWMPs. Guidelines for developing a LWMP were first published in 1992. LWMPs are created by local governments under a public process in co-operation with the Province. Official Community Plan (OCP) – where an OCP is in place, the local government planning statement (bylaw) will form the basis for a LWMP. The purposes of a LWMP are to minimize the adverse environmental impact of the OCP and ensure that development is consistent with Provincial objectives.	Runoff Volume – 90% of mean annual rainfall volume Rationale - When the impervious area of watersheds with traditional ditch and pipe systems reaches the 10% threshold, about 10% of the total rainfall volume becomes runoff that enters receiving waters; this runoff volume is the root cause of aquatic habitat degradation. Note that there is virtually no surface runoff from the naturally vegetated portion of a watershed, but nearly all rain that falls on directly connected impervious surfaces becomes runoff. An appropriate performance target for managing runoff volume is to limit total runoff volume to 10% (or less) of total rainfall volume. This means that 90% of rainfall volume must be returned to natural hydrologic pathways, through infiltration, evapotranspiration or re-use on the development site. Managing 90% of the rainfall volume throughout a watershed should achieve the biophysical target condition for the watershed. Managing 90% of rainfall volume therefore becomes the volume-based performance target. Runoff Rate – Natural Mean Annual Flo (MAF) occur no more than once per year, on average. Rationale - MAF is defined as the channel-forming event; as the MAF increases with development, stream channels erode to expand their cross-section, thereby degrading aquatic habitat. To achieve this target, stormwater systems should be designed to limit the frequency that the natural MAF is exceeded.	Unknown

Chilliwack, BC

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Policy and Design Criteria Manual for Surface Water Management in the City of Chilliwack (May 2002) **http://www.chilliwack.ca/main/attachments/Files/658/Surface_Water_Management.pdf** The City of Chilliwack's Policy and Design Criteria Manual for Surface Water Management serves two purposes: • provide a comprehensive framework that will guide the development of individual Master Drainage Plans over a multi-year period • Provide land developers with specific direction in undertaking the stormwater component of sustainable urban design. In order to accomplish this, the Manual: • Defines a drainage planning philosophy • Formulates a set of supporting policy statements • Establishes design criteria to achieve the policies The Manual was undertaken as a case study application of Stormwater Planning: A Guidebook for British Columbia, a collaborative effort of the Federal and Provincial governments that was funded under the Georgia Basin Ecosystem Initiative. The Manual content has been, and continues to be, tested and refined on the basis of Chilliwack-specific case study applications.	All new development projects in the City of Chilliwack must incorporate stormwater management systems that meet the following Performance Targets: • Rainfall Capture (retention) - Capture the first 30 mm of rainfall per day and restore it to natural hydrologic pathways by promoting infiltration, evapotranspiration or rainwater reuse. • Runoff Control (detention) -Detain the next 30 mm of rainfall per day and release to drainage system or watercourses at natural interflow rate. • Flood Risk Management (conveyance) - Ensure that the stormwater plan can safely convey storms greater than 60 mm (up to a 100-year rainfall).	Unknown

Coquitlam, BC

	Control Criteria	Incentives, Utilities, and Water Reuse
Peak Flow and Runoff Volume Control Peak flow and runoff volume control for both major and minor storms will be required to protect downstream properties, infrastructure, natural streams and other resources. In general, stormwater management measures shall include both flood prevention and erosion control measures for natural watercourses for both large, infrequent storms and smaller, more frequent storms. Stormwater management measures suitable for flood protection and erosion control are described in Section C of this Manual. Controls to prevent erosive flows in watercourses shall recognize both peak flow rates and the duration of peak flows. The objective is to limit both the magnitude and the duration of post-development peak flows to that of the pre-development peak flows as far as possible. In the absence of specific requirements or other measures developed in the Watershed Studies and/or agreements with other jurisdictions approved by Council, the following criteria shall be used to limit flows in natural watercourses except for discharge directly to the Fraser River, the Coquitlam River, the Pitt River and DeBoville Slough: • Limit the post-development peak rate of runoff from the development site from the two-year design storm to 50 percent of the pre-development peak runoff flow from the two-year design storm. Water Quality Control A water quality control plan may be required as part of the Stormwater Management Plan at the discretion of the City where there are reasonable grounds to anticipate discharge of prohibited materials to the drainage system as defined in City bylaws. Bio-retention or dry swale with under-drain systems or equivalent shall be provided to treat the runoff from all uncovered paved parking areas capable of containing ten or more vehicles. Parking areas surfaced with (porous) concrete grid or modular pavers shall be exempt from providing bio-retention or dry swale systems. Water Quality Design Volume Where structural facilities for contaminant removal are required and single event runoff models are used, facilities shall be designed to treat the runoff volume resulting from the 24-hour storm with a six-month return frequency, unless specified otherwise in a Watershed Study. The six-month, 24-hour storm can be estimated as 70 percent of the two-year, 24 hour storm. Where continuous runoff modelling is used, contaminant removal facilities shall be designed to treat 90 percent of the runoff volume in an average year. Coquitlam Stormwater Management Policy and Design Manual www.coquitlam.ca	Must treat the 6 month 24 hour storm event. This is equivalent to 70% of the 2 year 24 hour storm	

Calgary, Alberta

	Control Criteria	
Stormwater Source Control Practices Handbook, City of Calgary (2007) **https://www.calgary.ca/UEP/Water/Documents/Water-Documents/Stormwater%20Source%20Control%20Practices%20Handbook%20-%20November%202007.pdf?noredirect=1**	N/A – primarily design guidance	N/A

Edmonton, Alberta

Regulations/Policy	Control Criteria	
City of Edmonton Low Impact Best Management Practices Design Guide (2011, V1.0): **http://www.edmonton.ca/city_government/documents/LIDGuide.pdf** Local rain gauge data was collected from 585 observed precipitation events at the City of Edmonton Centre Airport Gauge in order to characterize rainfall within the Edmonton Area. It was noted that 73% of the total rainfall depth was generated by events smaller than the 2-year rainfall event. Therefore, is was concluded that in order to achieve a capture of 90% of the total rainfall depth for water quality treatment, that LID systems be designed to capture 26 mm of rainfall. LID-BMP designs may require additional input on approvals from City Departments outside of the Infrastructure Services Department. The level of involvement from other departments will depend on the City's plans for an appropriate approval process for LID-BMP implementation. Implementation plans and any related approval requirements specific to LID-BMP were not in place at the time of this publication (November 2011).	The water quality capture volume represented by rainfall depth provides a practical means for establishing an appropriate hydrologic design basis for LID systems. Analysis of the long-term rainfall record provides guidance on selecting an appropriate water quality capture volume. For the Edmonton region, most rainfall events are less than about 26 mm in depth and have durations of 5 hours or less.	

Lake Simcoe Region Conservation Authority (LSRCA) Watershed

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Conservation Authorities Act - mandates CAs to prevent, eliminate, or reduce the risk to life and property from flooding and erosion, and to encourage the protection and regeneration of natural systems. Through study, management, and enforcement, Ontario's CAs work with municipal, provincial, and private sector partners to maintain the safety, quality, and sustainability of the water resources within our communities. CAs also have Memoranda of Understanding (MOUs) with their partner municipalities to ensure that the tenets of the Provincial Policy Statement (PPS) are upheld, and that no adverse effects to significant natural features result from development applications approved through the Planning Act. Lake Simcoe Protection Plan (LSPP) The Lake Simcoe Protection Plan applies to the Lake Simcoe watershed. The plan is based on the Lake Simcoe Protection Act (2008) which intends to restore and protect the ecological health of the watershed. The act allows policies in relation to research and monitoring of activities that impact ecological health within the watershed. These policies include the following which are relevant to the impact of development on stormwater and measures to address stormwater management issues within the watershed.	New Development - For new, nonlinear developments that create more than 0.5 hectares of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site from runoff of the first 25 mm of rainfall from all impervious surfaces on the site. Redevelopment - For new, nonlinear developments that create more than 0.5 hectares of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site from runoff of the first 25 mm of rainfall from all impervious surfaces on the site. a) Linear projects on sites without restrictions that create 0.5 or greater hectares of new and/or fully reconstructed impervious surfaces, shall capture and retain the larger of the following: I. The first 12.5 mm of runoff from the new and fully reconstructed impervious surfaces on the site II. The first 25 mm of runoff from the net increase in impervious area on the site b) Mill and overlay and other resurfacing activities are not considered fully reconstructed. Flexible Treatment Options for Sites with Restrictions – Proponent shall fully attempt to comply with the appropriate performance goals described above. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site such as: i. Karst geology, ii. Shallow bedrock, iii. High groundwater, iv. Hotspots or contaminated soils, v. Areas with high salt concentrations, vi. Significant Groundwater Recharge Area and Wellhead Protection Areas or Intake Protection Zones or within 200 feet of drinking water well, vii. Zoning, setbacks or other land use requirements, viii. Excessive cost, and ix. Poor soils (infiltration rates that are too low or too high, problematic urban soils, such as soils that are highly compacted or altered) The proponent shall document the flexible treatment options sequence starting with Alternative #1 in a hierarchical approach ending with Alternative #3. Alternative #1: Proponent attempts to comply with the following conditions: IV. Achieve at least 12.5 mm volume reduction from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site. V. Remove 75% of the annual Total Phosphorus (TP) load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site. VI. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site. Alternative #2: Proponent attempts to comply with the following conditions: IV. Achieve volume reduction to the maximum extent practicable. V. Remove 60% of the annual TP load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site. VI. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site. Alternative #3: Off-site Treatment. Mitigation equivalent to the performance of 25 mm of volume reduction for new development or redevelopment as described above in this section can be performed off-site to protect the receiving water body. Off-site treatment shall be achieved in areas selected in the following order of preference: V. Locations within the same LSRCA catchment area as the original construction activity. VI. Locations within the next adjacent catchment area upstream. VII. Locations that yield benefits to the same receiving water that receives runoff from the original construction activity. VIII. Locations anywhere within the Lake Simcoe Watershed within the municipal boundary jurisdiction.	Unknown

Credit Valley Conservation (CVC) Authority Watershed, Ontario

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Conservation Authorities Act - mandates CAs to prevent, eliminate, or reduce the risk to life and property from flooding and erosion, and to encourage the protection and regeneration of natural systems. Through study, management, and enforcement, Ontario's CAs work with municipal, provincial, and private sector partners to maintain the safety, quality, and sustainability of the water resources within our communities. CAs also have Memoranda of Understanding (MOUs) with their partner municipalities to ensure that the tenets of the Provincial Policy Statement (PPS) are upheld, and that no adverse effects to significant natural features result from development applications approved through the Planning Act. Credit Valley Conservation, Stormwater Management Criteria (August 2012) http://www.creditvalleyca.ca/wp-content/uploads/2014/09/cvc-swm-criteria-appendices-Aug12-D-july14.pdf This document provides guidance in the planning and design of stormwater management infrastructure for developers, consultants, municipalities, and landowners, and outlines the processes and infrastructure needed to address flooding, water quality, erosion, water balance, and natural heritage. Throughout CVC‟s jurisdiction.	Flooding – Post to Pre control of peak flows to the appropriate Watershed Flood Control Criteria (Watershed specific) i.e. for Cooksville Creek watershed, all new, redeveloped, and intensified land developments are required to control post-developed storm runoff rates from all storm events up to the 100 year design storm to the 2-year pre-development condition. Erosion - At a minimum detain 5 mm on site where conditions do not warrant the detailed analyses. If a site drains to a sensitive creek, or a sub watershed study or EIR is required, then the proponent must complete a geomorphologic assessment study to determine the site appropriate erosion threshold. For sites with SWM ponds, 25 mm-48hr detention may also be required, depending on the results of the erosion assessment. Water Quality – Enhanced Level of Protection (80% TSS removal) as per the latest MOE SWMPD Manual is required. Where applicable, water quality controls should be further informed by goals and objectives arising out of applicable sub watershed studies and source water protection plans. To minimize thermal impacts, preventative measures (i.e. LID practices) and mitigation measures should be applied. Water Balance –For Significant, Ecologically Significant, High and Medium Volume Groundwater Recharge Areas (SGRA, EGRA, HGRA and MGRA), site specific water balance analyses and maintenance of recharge are required. For Low Volume Groundwater Recharge Areas (LGRA), provided the site does not impact a sensitive ecological feature, or require a sub watershed study, or EIR, the proponent has the option to provide a minimum post development recharge of the first 3 mm for any precipitation event; or complete a site specific water balance to identify pre-development groundwater recharge rates to be maintained post-development. For natural features (woodlands, wetlands, watercourses) maintain hydrologic regimes and hydro periods to avoid adverse effects on the features	N/A

Toronto and Region Conservation Authority (TRCA) Watershed, Ontario

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Conservation Authorities Act - mandates CAs to prevent, eliminate, or reduce the risk to life and property from flooding and erosion, and to encourage the protection and regeneration of natural systems. Through study, management, and enforcement, Ontario's CAs work with municipal, provincial, and private sector partners to maintain the safety, quality, and sustainability of the water resources within our communities. CAs also have Memoranda of Understanding (MOUs) with their partner municipalities to ensure that the tenets of the Provincial Policy Statement (PPS) are upheld, and that no adverse effects to significant natural features result from development applications approved through the Planning Act. Toronto and Region Conservation Authority , Stormwater Management Criteria (August 2012, V 1.0) **http://sustainabletechnologies.ca/wp/wp-content/uploads/2013/01/SWM-Criteria-2012.pdf** The Stormwater Management Criteria document has been prepared to supplement the Planning and Development Procedural Manual (PDP Manual, 2007) with more detailed direction regarding the Stormwater Management (SWM) component of development approvals. The purpose of this document is to consolidate and build upon current design guidelines and requirements relating to SWM from watershed plans and hydrology studies, and provide additional and specific detail for those areas within TRCA's jurisdiction.	The criteria described in this document may be augmented or in some cases superseded by legislative requirements or unique situations Stormwater Quantity - Control Peak Flows to the appropriate Watershed Flood Control Criteria. Unit Flow Rates for predevelopment conditions are provided in Appendix format. Erosion - At a minimum retain 5 mm on site where conditions do not warrant the detailed analyses. If a site drains to a sensitive creek, or a sub watershed study or MESP is required, then the proponent must complete a geomorphologic assessment study to determine the site appropriate erosion threshold provided in Appendix format. For sites with SWM ponds, 25 mm-48 hr detention may also be required, depending on the results of the erosion assessment Stormwater Quality - Enhanced Level of Protection (80% TSS removal) as per the latest MOE SWMPD Manual is required. Where applicable, mitigate potential thermal and bacteriological impacts. Water Balance – For Significant, Ecologically Significant, and High Volume Groundwater Recharge Areas (SGRA, EGRA and HGRA), site specific water balance analyses and maintenance of recharge are required. For Low Volume Groundwater Recharge Areas (LGRA), site specific water balance analyses are typically not required, and best efforts to maintain recharge are expected. For natural features (woodlands, wetlands, watercourses) maintain hydrologic regimes and hydro periods.	N/A

City of Toronto, Ontario

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Toronto City Council adopted the Wet Weather Flow Master Plan (WWFMP) and a 25-Year Implementation Plan in 2003. The goal of the WWFMP is to reduce and ultimately eliminate the adverse impacts of wet weather flow, which is runoff generated when it rains or snows, to protect our environment improve the ecosystem health of the watersheds. The Plan was developed with the recognition that wet weather flow will be managed on a watershed basis accompanied by a hierarchy of solutions starting with "at source", followed by "conveyance," and concluding with "end-of-pipe." Source controls - Source control measures are the first step in the hierarchical approach to managing wet weather flows by dealing with stormwater on site where it falls. These measures are carried out through programs such as: • Mandatory Downspout Disconnection Program: This program reduces basement flooding, decreases lake and river pollution, and captures water from disconnected downspouts and then reuses it for watering gardens and grass. • Green Roof Incentive Pilot Program: The overall goal of this program is to encourage green roof construction in the City. In addition, the program will benefit stormwater management by the reduction in stormwater flows. • Rainwater Harvesting Demonstration Project: Rainwater harvesting not only manages the path taken by storm runoff to the lake but also diverts it to on-site non-potable uses such as irrigation and toilet flushing, thereby reducing potable water use, saving energy, operating costs and meeting WWFMP goals. Demo project will be taking place at the Automotive Building at Exhibition Place. • Tree Planting: Planting trees can have multiple benefits in urban areas, including reducing the volume of stormwater runoff. While planting trees can help capture an initial portion of stormwater runoff, it can also increase evapotranspiration (water expelled to the atmosphere) and infiltration. Beach water quality improvements - **Toronto's beaches are some of our greatest treasures. But a few times during the summer, stormwater pollution can take away the pleasure we get from swimming in them during those hot, humid days. That's why we have to capture the stormwater before it enters the beach and treat it. And we plan to do this with end-of-pipe solutions such as tanks, tunnels and a flow balancing system. Sounds like a book title…but it's actually an effective way to improve beach water quality. Here's how:** • Tanks and tunnels capture and hold combined sewer overflows and stormwaters which then are treated before returning to the lake. • The captured flow in tunnels and tanks use ultraviolet lights to kill bacteria in the water before releasing it slowly back into the lake. • Flow balancing captures stormwater runoff and filtrates treat it through the use of ponds and wetlands. One example of a flow balancing system is Dunker's Flow at the Scarborough Bluffs. Using tanks and tunnels for storing sewer discharge for subsequent treatment is an effective concept that we're already using in this city. In fact, our eastern beaches have tanks and our western beaches have a storage tunnel but more is needed to protect the environment. Areas scheduled for work in the early stage of the plan include the Eastern Beaches and the Etobicoke, Toronto (Ellis Ave.) and Scarborough waterfronts. City of Toronto Wet Weather Flow Management Guidelines (2006) -In September 2003, Toronto City Council adopted a Wet Weather Flow Management Policy, which provides direction on how to manage wet weather flow on a watershed basis. Since that time, all new developments in the City have had to comply with the policy. It was determined that a set of Wet Weather Flow Management Guidelines would be developed as a companion document to: 1) Guide the design and implementation of stormwater management measures at source necessary to achieve the long-term goal and objectives of the Wet Weather Flow Management Plan; 2) Harmonize stormwater management policies and practices of former municipalities; and 3) Provide guidance on stormwater management practices and approval requirements to City staff, development industry and property-owners Source: City of Toronto Wet Weather Flow Management Policy (2003 - WWFMP 25-Year Plan: http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=d4e249983587f310VgnVCM10000071d60f89RCRD&vgnextchannel=972bab501d8ce310VgnVCM10000071d60f89RCRD http://www1.toronto.ca/city_of_toronto/toronto_water/files/pdf/wwfm_guidelines_2006-11.pdf	Water Balance – a) Retain stormwater on-site, to the extent practicable, to achieve the same level of annual volume of overland runoff allowable b) If the allowable annual runoff volume from the development site under post-development conditions is less than the pre-development conditions, then the more stringent runoff volume requirement becomes the governing target for the development site. The maximum allowable annual runoff volume from any development site is 50% of the total average annual rainfall depth. c) In most cases, the minimum on-site runoff retention requires the proponent to retain all runoff from a small design rainfall event - typically 5 mm (In Toronto, storms with 24-hour volumes of 5 mm or less contribute about 50% of the total average annual rainfall volume) through infiltration, evapotranspiration and rainwater reuse.	Water Reuse: Rainwater Harvesting Demonstration Project: Rainwater harvesting not only manages the path taken by storm runoff to the lake but also diverts it to on-site non-potable uses such as irrigation and toilet flushing, thereby reducing potable water use, saving energy, operating costs and meeting WWFMP goals. Demo project will be taking place at the Automotive Building at Exhibition Place.

Halifax, Nova Scotia

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Stormwater Inflow Reduction (SIR) Program: to assist customers in identifying measures that can be taken on their properties. The goals of the SIR Program are to: 1. Raise awareness to reduce overflows and protect the health of HRM residents and our environment. 2. Inspect private properties (indoor and outdoor) for potential sources of Stormwater Inflow. (Inspection is mandatory and the first inspection is free) 3. Require customers to disconnect sources of Stormwater Inflow. **http://www.halifax.ca/hrwc/wastewaterinfiltration-inflow.php** Wet Weather Management Program: currently running 3 pilot projects to validate what Rainfall Derived I&I (RDII) reduction can be accomplished via various reduction strategies. **http://www.halifax.ca/hrwc/documents/2015_16HWBusPlan_FINAL_DigitalCopy.pdf** see page 54 - 62 Sewer Charge By-Law: **http://www.halifax.ca/legislation/bylaws/hrm/documents/By-LawS-100.pdf** Wastewater Discharge By-Law**:** **http://www.halifax.ca/legislation/bylaws/hrm/documents/By-LawW-101.pdf** Halifax Water Rules and Regulations: **http://www.halifax.ca/hrwc/wastewaterinfiltration-inflow.php#StormwaterInflow** Integrated Resource Plan (IRP): defines water resource needs for the next thirty years (2013 - 2043). The IRP responds to the combined requirements of regional growth, present and expected regulatory compliance and asset renewal. **http://halifax.ca/hrwc/IntegratedResourcePlan_2013.php** Stormwater Guidelines, 2006**:** **http://www.halifax.ca/energy-environment/environment/documents/HRMStormwaterManagementGuidelines2006.pdf** Halifax Regional Water Commission Act: **http://www.halifax.ca/hrwc/documents/HRWCAct2012.pdf** Halifax Regional Municipality Charter: **http://nslegislature.ca/legc/bills/60th_2nd/3rd_read/b179.htm**	Water Quantity Control Generally, the criteria are to control post-development peak flows for the 2, 5, 25, 50 and 100–year storms, 24-hour duration, to pre-development levels. Water Quality Volume The water quality volume criteria for sizing BMPs for the HRM area was determined from an analytical model as described in Appendix F. Long-term local rainfall data was analyzed to determine storage requirements for different impervious conditions and TSS removal efficiencies. The total storage volume in a wet pond or in a constructed wetland consisting of a permanent pool and an extended detention should generally be equivalent to the runoff volume generated by 90% of the long-term rainfall events observed in HRM. It is recommended that a 25 mm winter rain event should be used to estimate the peak flow generated by the proposed land use. Design Criteria for Erosion Control The preferred approach for addressing erosion concerns is at the watershed/sub watershed planning level. During watershed/ sub watershed planning, pre and post-development exceedance erosive index values are computed for a watercourse to determine the need for and the magnitude of erosion control measures. To select the erosion criterion when no such information is available, it is recommended to undertake an analysis of downstream channel conditions to assess the potential effects of post-development flows, water levels, and velocities on erosion. Such an analysis of erosion potential should extend downstream to a point where the runoff from the upstream drainage area controlled by the pond represents only 10% of the total drainage area. In the absence of information on downstream channel conditions, a 25 mm winter storm is	Incentives: **-N/A** Utilities: Fee Structure: On July 11, 2013, the Nova Scotia Utility and Review Board (NSUARB) approved rates for water, wastewater and stormwater services effective July 1, 2013, and April 1, 2014. The approved rate structure also separated the stormwater charge from the combined wastewater/stormwater charge to provide a more equitable user pay system. For the Site Generated Flow component of the stormwater fee, residential properties (up to three units) are charged based on an impervious area of 224.5 square metres, which is the average for all residential properties within the Stormwater Service Boundary. For this customer group, effective July 1, 2013, the annual stormwater charge is $29.86/year (or $7.47/quarter). Effective April 1, 2014, the annual stormwater charge is $33.39/year (or $8.35/quarter). Multi-residential, industrial, commercial and institutional properties are charged based on the impervious area specific to each individual property. The rate effective July 1, 2013 is $0.133/square metre. The rate effective April 1, 2014 is $0.1490/square metre. As directed through the March 2014 HRM Regional Council motion, the HRM Right of Way portion of the stormwater charge of $39 will be billed through the Halifax Water billing process as an additional line item commencing in January 2015. The HRM Right of Way stormwater charge will apply to any properties receiving the Halifax Water Site Generated Flow stormwater charge. Stormwater Service is funded 100% by two charges – the Site Generated Flow Charge, and the HRM Right Of Way Charge. There are two primary cost drivers for the stormwater services Halifax Water provides, and two distinct benefits received by customers: • Site Generated Flow Charge – is based on the stormwater that flows from each private property into the Halifax Water stormwater system. This charge is calculated based on the stormwater rate times the impervious area on the property. For all Residential properties a standard flat rate has been used. • HRM Right of Way (ROW) Charge – is based on stormwater that flows from the public (HRM) street right of way into Halifax Water's stormwater system. Roads/streets are impervious areas that create stormwater runoff into Halifax Water's stormwater drainage system. The stormwater charge for roads/streets (impervious area) within the municipality is billed to HRM, as directed by the NSUARB, because HRM owns the municipal roads and streets. **http://www.halifax.ca/hrwc/residential-stormwater-billing.php** Water, Wastewater/Stormwater Rates & Fees: Halifax Water is regulated by the Nova Scotia Utility and Review Board (NSUARB). The following amended water, wastewater, and stormwater rates have been approved by the NSUARB and will apply on water consumed on and after April 1, 2014. **http://www.halifax.ca/hrwc/RatesAndFees.php**

recommended for the erosion control design event. This storm should be based on a 6 hour Chicago distribution event and should be routed through a storage facility assuming a gradual release rate with a drawdown time of 24-48 hours. For sensitive streams, the longer drawdown time should be used. The required storage is then compared to the extended quality control storage, and the greater of the two is used for design.

For BMPs other than wet pond/wetland, the analysis of downstream channel conditions should determine the need for flow control or erosion protection requirements based on velocities and
erosive forces generated by a 25 mm winter rain.

Regional Development Charge: **http://www.halifax.ca/hrwc/documents/HWfinalNOCROP.pdf**

SCHEDULE OF RATES, RULES & REGULATIONS FOR WATER, WASTEWATER, AND STORMWATER SERVICES, July, 2013**:**
http://www.halifax.ca/hrwc/_assets/documents/HRWCRegsRDCSWConsolidated.pdf

SCHEDULE OF Water & Wastewater Services RATES AND CHARGES FOR AEROTECH/AIRPORTSYSTEM, Effective 2014**:**
http://www.halifax.ca/hrwc/_assets/documents/AerotechRegsRDC-PDFversiontoaddtowebsite-August272014.pdf

Framework for Area Rates – Stormwater Right-of-Way Costs: In the 2013 Rate Hearing Decision, the NSUARB directed that the portion of stormwater costs related to the street right of way should be billed to HRM. In March 2014 HRM Regional Council passed a motion to request that Halifax Water collect the Right of Way portion of the stormwater charge for HRM through the Halifax Water billing process. The motion established a Stormwater Right of Way Charge of $39 to be levied commencing in 2014/15 against any properties receiving the Halifax Water stormwater charge. Beginning in January 2015, all properties receiving the Halifax Water stormwater charge will be billed for the HRM Right of Way stormwater charge retroactive to April 1, 2014.
http://www.halifax.ca/council/agendasc/documents/140114ca1122.PDF

WATER, WASTEWATER AND STORMWATER COST-OF-SERVICE RATE DESIGN MANUAL, 2012**:**
http://www.halifax.ca/hrwc/documents/FinalCOSManualOctober312012.pdf

Quebec

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Quebec Stormwater Guide was written taking into account the documents already produced by various Quebec departments and attempting not to duplicate information that may already be available elsewhere. The document that is most directly influenced This Guide is linked to the Directive 004, which regulates more generally design sewage systems in Quebec. Both are complementary in many aspects but note the Guide gives course descriptions and principles analysis for stormwater management that are much more detailed the Directive 004. Generally, the use of the principles and elements will be preferred Analysis presented in the Guide if a point is addressed in both documents. Another concept that encompasses the management principle Stormwater is the watershed management, which has grown significantly in recent years in Quebec Following the implementation of the National Policy Water in 2002. Several documents were produced to support efforts to prepare wide management plans and some watershed matters discussed in this Guide will obviously fit into the broader vision that underlies this watershed management. http://www.mddelcc.gouv.qc.ca/eau/pluviales/guide-gestion-eaux-pluviales.pdf	For the region of Montreal, 90% of rainfall events have a rainfall of less than 22 mm (26 mm in the case of Quebec) and 80% of rainfall quantity is less than 14 mm (17 mm in the case of Quebec). That means in order to address 22 mm rain, the Montreal area would treat 90% averaged over the territory. The average length of rain obtained with this approach, however, are of the order of 6 hours. Considering that these analyses have not been made to all other stations in Quebec, it is recommended for all of Quebec to design LID systems based on a storm event corresponding to 90% of rainfall with value of 25 mm of rain.	

US Jurisdictions

City of Portland, Oregon

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Clean Water Act of 1972 (amended in 1987) prohibits the discharge of pollutants into waters of the United States unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. The permit requirements, published in 1990, require large (Phase I) cities such as Portland to obtain an NPDES permit for their municipal separate storm sewer system (MS4) discharges. Compliance with the NPDES MS4 permit requires cities to establish a comprehensive stormwater management program, including establishing controls on post-development stormwater runoff and source controls for industrial facilities that contribute substantial pollutant loading to the MS4 system. In addition, the federal Safe Drinking Water Act (SDWA) of 1974 provides a comprehensive framework to ensure the quality and safety of drinking water supplies. Within the state of Oregon, the Department of Environmental Quality (DEQ) regulates stormwater discharges to underground injection control (UIC) systems under the SDWA. UICs are used to infiltrate stormwater runoff from both public and private properties. Innovative Wet Weather Program: The program consists of numerous individual projects and activities at locations throughout the City of Portland. The goal is to reduce the peak volume of stormwater entering the combined system and manage stormwater to reduce pollutant concentrations. Funding for projects is in whole or in part by EPA grants. Proposed projects are in five main categories: •Water quality-friendly streets and parking lots •Downspout disconnections •Eco-roofs •Monitoring and feasibility studies •Educational Efforts **http://www.portlandoregon.gov/bes/article/62175** Stormwater Management Plan -January, 2011: The plan identifies Best Management Practices (BMP's) to be implemented to meet the requirements of Portland's Municipal Stormwater Permit. **http://www.portlandoregon.gov/bes/article/126117** Stormwater Management Plan - Public Involvement: Outreach and education of the public promotes environmental stewardship, pollution prevention, and sustainable stormwater management. The following Strategies have been implemented (see pages 13- 18 of the Stormwater Management Plan): Community Stewardship Grants Program: in place since 1995, provides up to $10,000 per project to citizens and organizations to encourage watershed protection. Projects must be within the City of Portland, promote citizen	The thresholds for proposals that are subject to the requirements are as follows: • Properties that propose new offsite discharges or new connections to the public system are required to comply with stormwater requirements for the impervious area draining to the discharge point. • Projects that develop or redevelop over 500 square feet of impervious surface are required to comply with stormwater requirements for the impervious area at the site. Flow Volume - Based Facilities Volume-based pollution reduction facilities included in this manual (wet ponds and extended wet detention ponds) must use the predetermined volume of 0.83 inches over 24 hours with a volume of basin/volume of runoff ratio of 2 to be in compliance. Through a continuous simulation model using Portland rainfall data, BES has determined that this volume provides adequate detention time to treat 90 percent of the average annual runoff volume. Infiltration and Discharge If surface infiltration facilities such as swales, planters, or basins are proposed to meet infiltration requirements, the sizing methodology must rely on retaining the 10-year storm through a facility that can be calculated using SBUH, NRCS TR-55, HEC-1, or SWMM. The Rational Method must be used to design the infiltration flow rate for public infiltration sumps. Detention 1. Discharge to any other overland storm drainage system, including streams, drainage ways, and ditches, or to any storm pipe system that eventually discharges to an overland drainage system. • Use onsite retention (flow volume control) facilities and infiltrate onsite to	Incentives: Clean River Rewards: User fee discounts of as much as 100% of the monthly stormwater management charge for private on-site facilities that manage stormwater runoff, and 100% of the monthly on-site stormwater management charge for Drainage District residents and businesses. At the end of April 2014, a total of 35,813 utility ratepayers with active accounts have registered for stormwater discounts: 34,480 single family residential ratepayers (accounting for a total of 76,511,888 square feet of impervious area managed for stormwater) and 1,333 multifamily, commercial, and industrial ratepayers (accounting for a total of 69,393,012 square feet of impervious area managed for stormwater). **http://www.portlandoregon.gov/bes/article/390568** - Summary of the program **http://www.portlandoregon.gov/bes/article/402804** - Detailed program document Green Streets Policy: The goal is to promote and incorporate the use of green street facilities in public and private development. Key Program Elements: Infrastructure Projects in the Right of Way will incorporate green street facilities into all City of Portland funded development, redevelopment or enhancement projects as required by the City's Stormwater Management Manual. If a green street facility is not incorporated into the Infrastructure Project, or only partial management is achieved, then an off-site project or off site management fee will be required. ECO Roof Floor Area Ratio Bonus Option: The amount of FAR bonus allowed to a developer depends on the percentage of eco roof coverage in relation to the building footprint. 10% – 30% coverage earns 1 square foot of additional floor area per square foot of eco roof 30% - 60% coverage earns 2 square feet of additional floor area per square foot of eco roof 60% or greater earns 3 square feet of additional floor area per square foot of eco roof. **http://www.portlandoregon.gov/bes/article/474490** Treebate Program: Treebate is an incentive to plant yard trees at Portland residences. Homeowners can receive a credit to water/sewer utility bill for half the purchase price per tree up to $15 (small), $25 (medium) or $50 (large) depending on mature tree size and stormwater management potential. **http://www.portlandoregon.gov/bes/article/314187?#eligible** Downspout Disconnection: In targeted neighborhoods, the City pays homeowners $53 for each downspout they disconnect themselves, or will do the work for free. **http://www.portlandoregon.gov/bes/article/127466** Utility Fee Structure: Portland finances stormwater management services by collecting public utility fees on developed property, and system development charges (SDCs) on new development. **http://www.portlandoregon.gov/bes/article/402775** 1. Residential Users a. Single Family and Duplexes

involvement in watershed stewardship, and benefit the public. From 1995 through June 2011, the program allocated over $948,000 to 198 projects.

Clean Rivers Education Programs: free water quality classroom and field science education programs for grades K through 12 within the City of Portland. The Goal is to provide outreach to approximately 15,500 K-12students annually'

Regional Coalition for Clean Rivers and Streams: a group of agencies and municipalities in the Portland/Vancouver metro area dedicated to educating the public about the impacts of stormwater runoff. The coalition develops an annual region wide public awareness campaign that can reach more than 1.4 million people living in the four-county area.

Watershed Education and Stewardship: The watershed-based approach stresses comprehensive, multi-objective watershed management through inter-jurisdictional coordination within each watershed. Each program includes public education and stewardship

Publication & Signage: Examples include water bill inserts, plant posters with stormwater pollution prevention messages, eco roof question and answer fact sheets, landscape swale posters, a "Stormwater Cycling" brochure and map for a self-guided tour of demonstration projects, erosion control information for street tree plantings, and educational materials for community meetings and events.

Stormwater Management Facilities – Operation & Maintenance Guide for Private Property Owners: Property owners are legally responsible for inspecting and maintaining the stormwater management facilities on their sites. Required maintenance is outlined in the operations and maintenance (O&M) plan for the facility. This handbook supplements the O&M Plan.
http://www.portlandoregon.gov/bes/article/54730

Ordinance to establish rates for stormwater management services, Sept, 2012**:**
http://www.portlandoregon.gov/bes/article/413237

Portland Stormwater Management Manual, January 2014: This document outlines stormwater management requirements and the related regulations and policies. **http://www.portlandoregon.gov/bes/article/474043**

Stormwater Management Program for the period 2011-2016: This document outlines the goals and mandates of the program.
http://www.portlandoregon.gov/bes/article/126117

the maximum extent feasible.
- Limit post-development peak runoff rates as follows:
  - 2-year post-development peak rate to one-half of the 2-year predevelopment peak rate
  - 5-year post to 5-year pre
  - 10-year post to 10-year pre
  - 25-year post to 25-year pre

2. Discharge to a combined sewer
- Use onsite retention (flow and volume control) facilities and infiltrate onsite to the maximum extent feasible.
  - Limit 25-year post-development peak runoff rate to 10-year predevelopment peak rate

3. Base requirement for all other discharge points.
- Use onsite retention (flow volume control) facilities and infiltrate onsite to the maximum extent feasible
  - Maintain peak flow rates at their predevelopment levels for the 2-, 5-, and 10-year, 24-hour runoff events.

Off-site charge $16.17 per user account per month; On-site charge $8.71 per user account per month
b. 3-Plex and 4-Plex Residences
Off-site charge $6.74 per dwelling unit per month; On-site charge $3.63 per dwelling unit per month
c. Developments of 5 or More Units
Off-site charge $6.74 per 1,000 square feet of impervious area per month; On-site charge $3.63 per 1,000 square feet of impervious area per month

2. Non-Residential Users
Off-site charge $7.13 per 1,000 square feet of impervious area per month
On-site charge $3.84 per 1,000 square feet of impervious area per month

System Development Charges - Stormwater Management System**:**
http://www.portlandoregon.gov/bes/article/402777
a. Single Family or Duplex Residence - $824.00 per parcel
b. 3-Plex Residential Development - $953.00 per parcel
c. 4-Plex Residential Development - $1,307.00 per parcel
d. All Other Developments
i. Impervious Area Component - $169.00 per 1000 square feet of impervious area
ii. Frontage Component - $5.50 per linear foot of frontage
iii. Trip Generation Component - $2.91 per daily vehicle trip

Sewer & Drainage Rates and Charges, Fiscal 2014 -2015**:**
http://www.portlandoregon.gov/bes/article/402789

% For Green Program: The City of Portland requires all public and private development projects to manage stormwater on-site to the extent possible. Some right-of-way projects do not trigger application of this requirement. A percentage of the budget of these projects goes to the % for Green Program to help fund green infrastructure projects throughout the city. Two funding sources are combined to fund % for Green projects:
• City right-of-way projects not required to meet the Stormwater Management Manual (SWMM) requirements
• Off-site management fees collected when a private development cannot meet the SWMM requirements due to site conditions
Funds may not be used on a project to meet SWMM requirements, but may be used for projects that go above & beyond the requirements.
http://www.portlandoregon.gov/bes/article/465399
Any City of Portland funded development, redevelopment or enhancement project, that does not trigger the Stormwater Manual but requires a street opening permit or occurs in the right of way, shall pay into a "% for Green" Street fund. The amount shall be 1% of the construction costs for the project.

Green Streets Policy:**http://www.portlandoregon.gov/shared/cfm/image.cfm?id=154231**
Green Streets Resolution: **http://www.portlandoregon.gov/shared/cfm/image.cfm?id=154232**

Seattle, Washington

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The United States Environmental Protection Agency (EPA) develops the stormwater regulations, in accordance with the Clean Water Act (CWA). The Washington State Department of Ecology (Ecology) develops stormwater regulations in Washington State, in accordance with Chapter 90.48 of the Revised Code of Washington, Water Pollution Control. Residential Rain Wise Program: Provides technical support, education/outreach to assist homeowners, landscapers and property managers in understanding low impact development techniques such as site design, pervious paving, vegetation retention, sustainable landscape practices, and other natural drainage solutions. **http://www.seattle.gov/util/groups/public/@spu/@drainsew/documents/webcontent/01_025302.pdf** Green Stormwater Infrastructure Program Background: In July 2013, City Council unanimously passed Resolution 31549: •Green Stormwater Infrastructure (GSI) should be relied upon to manage stormwater wherever possible •Target to manage 700 MG annually with GSI by 2025 •City Departments shall collaborate with Office of Sustainability & Environment (OSE) to produce Implementation Strategy for meeting new target Executive Order: 2013-01 Citywide Green Stormwater Infrastructure Goal & Implementation Strategy: An Executive Order directing City departments to coordinate to develop an implementation strategy for managing 700 million gallons of stormwater annually with green stormwater infrastructure approaches by 2025. To be considered Green Stormwater Infrastructure, it must provide a function in addition to stormwater management such as water reuse, providing greenspace and/or habitat in the City. **http://clerk.seattle.gov/~scripts/nph-brs.exe?s1=green+stormwater+infrastructure&s3=&s2=&s4=&Sect4=AND&l=20&Sect2=THESON&Sect3=PLURON&Sect5=CFCF1&Sect6=HITOFF&d=CFCF&p=1&u=%2F~public%2Fcfcf1.htm&r=1&f=G** Seattle Stormwater Code Ordinance: http://clerk.ci.seattle.wa.us/~scripts/nph-brs.exe?s1=&s3=&s4=123105&s2=&s5=&Sect4=AND&l=20&Sect2=THESON&Sect3=PLURON&Sect5=CBORY&Sect6=HITOFF&d=ORDF&p=1&u=%2F~public%2Fcbor1.htm&r=1&f=G Seattle Stormwater Code: **http://www.seattle.gov/dpd/codesrules/codes/stormwater/default.htm and,** **https://www.municode.com/library/wa/seattle/codes/municipal_code?searchRequest={%22searchText%22:%22SMC%2023.66%22,%22pageNu**	Projects with more than 750 square feet of land disturbing activity require a Construction Stormwater Control and Soil Amendment Standard Plan. All Single-family residential projects and all other projects with 7,000 square feet or more of land disturbing activity or 2,000 square feet or more of new plus replaced impervious surface must implement green stormwater infrastructure to infiltrate, disperse, and retain drainage water onsite to the maximum extent feasible without causing flooding, landslide, or erosion impacts. Most new construction projects and larger additions or alterations also require a Drainage Control Plan for Small Projects and the Green Stormwater Requirement Calculator. For example, you would need these documents if your project adds or replaces hard surface that covers 1,500 square feet for single-family residential projects or 2,000 square feet for other types of projects. If you are building a "small project" (less than 5,000 sf of new plus replaced hard surface) in one of these areas, you must infiltrate all of your stormwater into the ground. Sizing is based on a table with pre-determined basin depths, that are sized to minimize the 25-year peak flow target to no more than 0.0001 cfs. Stormwater treatment facilities shall be designed based on the stormwater runoff volume from the contributing area or a peak flow rate as follows: a. The daily runoff volume at or below which 91 percent of the total runoff volume for the simulation period occurs, as determined using an approved continuous model. It is calculated as follows: 1) Rank the daily runoff volumes from highest to lowest. 2) Sum all the daily volumes and multiply by 0.09. 3) Sequentially sum daily runoff volumes, starting with the highest value, until the total equals 9 percent of the total runoff volume. The last daily value	Incentives: Low Impact Rates: Discounts of 20 to 41 percent are applied to the rate for undeveloped natural areas of 0.5 acres or greater containing sufficient amounts qualifying "highly infiltrative" surface (i.e. forested areas, unmanaged grasslands, etc.). Certain athletic facilities with engineered designs that mimic the stormwater retention benefits of these large natural areas are also eligible for low impact rates. **http://www.seattle.gov/util/MyServices/Rates/DrainageRates/RateSchedule/index.htm** Stormwater Facility Credit Program: program offers credits of up to 50 percent for privately-owned systems that slow down stormwater flow and/or provide water quality treatment for run-off from impervious areas, thus lessening the impact to the City's stormwater system, creeks, lakes or Puget Sound. Stormwater systems are structures such as vaults, rain gardens, permeable pavements and filtration systems. **http://www.seattle.gov/util/groups/public/@spu/@ssw/documents/webcontent/spu01_006501.pdf** Rain Wise Rebate Program: provides rebates to private landowners (at their request and if eligible) for the installation of rain gardens and cisterns to reduce stormwater runoff from their private properties. In target areas, qualifying properties may be eligible to receive a rebate of up to $3.50 for each square foot of runoff controlled using a rain garden and/or cistern, both forms of green infrastructure. **http://www.seattle.gov/util/groups/public/@spu/@usm/documents/webcontent/02_008093.pdf** The King County 2012 Surface Water Management Rate Study: assesses changes to program requirements and funding availability under the County's surface water management fee. In particular, the study focuses on revising the existing rate adjustment ("discount") program for non-residential parcels. The intent is to offer direct incentives to landowners to encourage them to better control stormwater runoff and improve water quality on private property. **http://www.kingcounty.gov/environment/wlr/surface-water-mgt-fee/2012-rate-study.aspx** Utilities: Drainage Fees: Seattle charges a drainage fee on all properties in the City, with the exception of certain exempt properties. Drainage fees do not appear on utility bills. Seattle uses King County as its billing agent for the drainage fee. The drainage fee is shown on King County property tax statements as Surface Water Management (SWM) or Drainage. The method for calculating the drainage fee depends on the size and type of property owned. Single family and duplex properties smaller than 10,000 square feet are assigned to drainage rate categories based on the size of the parcel. All properties in a given rate category pay the same flat rate. This rate is also equal to the total bill, or charge. For example, parcels between 3,000 and 4,999 square feet will be subject to an annual drainage charge of $234.87 in 2014 while parcels between 5,000 and 6,999 square feet will all be subject to an annual drainage charge of $318.92 in the same year

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Requirements for Green Stormwater Infrastructure to the Maximum Extent Feasible for Single-Family Residential and Parcel Based Projects**:**
http://www.seattle.gov/dpd/codes/dr/DR2012-15.pdf

Requirements for Green Stormwater Infrastructure to the Maximum Extent Feasible for Roadway, Trail, and Sidewalk Projects:
http://www.seattle.gov/dpd/codes/dr/DR2012-16.pdf

The Right-of-Way Improvement Manual: Chapter 6.4, provides information on rules specific to the use of GSI Facilities within the Right-of-way (ROW).
http://www.seattle.gov/transportation/rowmanual/manual/6_4.asp

Stormwater Code & Rules Update: Seattle is in the process of revising their Stormwater Code regulations to be equivalent to Ecology's 2012 Stormwater Manual.
http://www.seattle.gov/dpd/codesrules/changestocode/stormwatercode/whatwhy/default.htm

Seattle Stormwater Management Program, 2014:
http://www.seattle.gov/util/cs/groups/public/@spu/@drainsew/documents/webcontent/1_037857.pdf

Surface Water Management, Title 9, King County: (updated May, 2014)
http://www.kingcounty.gov/council/legislation/kc_code/12_Title_9.aspx

OTHER:
City of Seattle - Stormwater Low Impact Development Practices: A 10 page paper that examines Seattle's success with GSI.
http://www.seattle.gov/util/groups/public/@spu/@usm/documents/webcontent/spu02_020004.pdf

added to the sum is defined as the water quality design volume.

b. Different design flow rates are required depending on whether a treatment facility will be located upstream or downstream of a detention facility:
   1) For facilities located upstream of detention or when detention is not required, the design flow rate is the flow rate at or below which 91 percent of the total runoff volume for the simulation period is treated, as determined using an approved continuous runoff model.
   2) For facilities located downstream of detention, the design flow rate is the release rate from the detention facility that has a 50 percent annual probability of occurring in any given year (2-year recurrence interval), as determined using an approved continuous runoff model.
c. Infiltration facilities designed for water quality treatment must infiltrate 91 percent of the total runoff volume as determined using an approved continuous runoff model. To prevent the onset of anaerobic conditions, an infiltration facility designed for water quality treatment purposes must be designed to drain the water quality design treatment volume (the 91st percentile, 24-hour volume) within 48 hours.

All other properties, including single family/duplex properties 10,000 square feet and larger, are assigned to rate categories based on how much impervious surface is contained on the parcel. Each rate category is assigned a rate which is multiplied by the parcel area (in 1,000s of square feet) to calculate the total charge, or bill.

Low Impact Rates: apply to large residential and commercial parcels with significant amounts of highly pervious surface, such as forested land, unmanaged vegetated areas such as pasturelands and meadows and athletic fields designed with specific drainage characteristics. This highly pervious surface must cover a continuous area of at least one-half an acre, although this coverage may span more than one parcel. Low impact rates are available for the Undeveloped (0-15 percent impervious), Light (16-35 percent impervious) and Medium (36-65 percent impervious) rate categories.
http://www.seattle.gov/util/MyServices/Rates/DrainageRates/UnderstandingYourBillFAQ/index.htm

Drainage Rate Schedule 2014 & 2015:
http://www.seattle.gov/util/MyServices/Rates/DrainageRates/RateSchedule/index.htm

Exemptions: The following properties, or qualifying portions of properties, are exempt from payment of drainage charges:
submerged land, houseboats, piers, City streets, State of Washington highways, and other streets that provide drainage services in the same manner as City streets, islands that contain highly infiltrative pervious surface and less than ten percent impervious surface area, riparian corridors that contain highly infiltrative pervious surface and meet certain qualification criteria and wetlands that meet certain qualification criteria (effective January 1, 2014). Adjustments to drainage fees are available for low income, elderly or handicapped people that meet qualifications.

District of Columbia, Washington, D.C.

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The U.S. Constitution grants Congress "exclusive jurisdiction" over the District of Columbia as it is considered a federal district, and not a state. On December 24, 1973, Congress enacted the District of Columbia Home Rule Act, providing for an elected mayor and the 13-member Council of the District of Columbia. The Council has the ability to pass local laws and ordinances. However, pursuant to the Home Rule Act all legislation passed by the D.C. government, including the city's local budget, remains subject to the approval of Congress. The official listing of District of Columbia laws is called the DC Code. Washington, D.C., had an estimated population of 658,893 in 2014, the 23rd-most populous city in the United States. Commuters from the surrounding Maryland and Virginia suburbs raise the city's population to more than one million during the workweek. The Washington metropolitan area, of which the District is a part, has a population of 5.8 million, the seventh-largest metropolitan statistical area in the country. NPDES Permit: **http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/DCMS4permit2011.pdf** 2013 Rule on Stormwater Management and Soil Erosion and Sediment Control: **http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/2013%20SW%20Rule.pdf** 2013 Stormwater Management Rule and Guidebook**:** **http://ddoe.dc.gov/node/610572**	Permittees of the MS4 permits are subject to new development and redevelopment standards. For new development, any development that affects less than 5,000 square feet of land, except in Public Right of Way (PROW) areas are subject to the specific stormwater requirements. First, the first 1.2 inches of rainfall from a 24-hour rainfall event with a 72-hour dry period must be retained on-site or through a combination of on-site and off-site retention methods. Second, a peak discharge rate for a 2-year frequency 24-hour storm to pre-development conditions must be maintained; and a peak discharge rate for a 15-year frequency, 24-hour storm to must be maintained to predevelopment conditions. Lastly, appropriate BMPs must be selected and implemented to achieve the retention standard. If PROW areas are affected by new development, stormwater retention must be achieved to its Maximum Extent Practicable. For redevelopment, any improvement activity where the cost of the project is less than or equal to 50% of its previous development cost and exceeds a land disturbance of 5,000 square feet must retain the first 0.8 inch of rainfall on-site through a combination of on-site and off-site retention methods. Any land disturbance within the PROW areas must achieve stormwater retention from PROW's Maximum Extent Practicable (MEP) standards. Development projects can use "over control" to retain more than 1.2 inches of stormwater volume in one area and less in another. Projects can thus achieve on-site retention with a	Incentives: Stormwater Fee Discount Program, 2013: The RiverSmart Rewards program provides District property owners and tenants who install systems that retain stormwater runoff, with discounts of up to 55% on its stormwater fee. Customers who are awarded RiverSmart Rewards will automatically be enrolled in the Clean Rivers Impervious Area Charge (IAC) Incentive Program, which offers a discount of up to 4% on the IAC. **http://ddoe.dc.gov/release/district-establishes-new-stormwater-fee-discount-program** RiverSmart Homes Program: Targets single family homes. Offers incentives to District of Columbia homeowners interested in reducing stormwater pollution from their properties. Homeowners receive up to $1,200 to adopt one or more of the following landscape enhancements: Shade tree planting, rain barrels, rain gardens, pervious pavers, bay scaping. **http://ddoe.dc.gov/service/riversmart-homes-overview** **and** **http://ddoe.dc.gov/service/riversmart-rebates** RiverSmart Communities Program: Targets larger Properties (i.e. apartments, condominiums and businesses). There are two options available to participate in the Communities Program: Option 1: Rebate (open city-wide): offers rebates of up to 60% of the project cost of specific LID practices to multi-family residences such as condominiums, co-ops, apartments, small locally-owned businesses and houses of worship. This program is open city-wide. Option 2: Design/Build (restricted to priority watersheds). Properties in designated high-priority watersheds will be considered for fully funded design/build LID projects. **http://ddoe.dc.gov/service/riversmart-communities** RiverSmart Rewards: property owners can earn a discount of up to 55% off the Stormwater Fee when they reduce stormwater runoff by installing green infrastructure (GI) such as green roofs, bioretention, permeable pavement, and rainwater harvesting systems. DC Water also offers a similar incentive program for its customers to earn a discount of up to 4% off the Clean Rivers Impervious Area Charge (IAC). Using one application, District residents, businesses, and property owners can apply for discounts through RiverSmart Rewards and the Clean Rivers IAC Incentive Program. Discounts are based on the stormwater retention volume achieved and are posted to DC Water bills. **http://ddoe.dc.gov/riversmartrewards** RiverSmart Roof Tops Rebate: The 2014-2015 green roof rebate program will provide base funding of $10 per square foot, and up to $15 per square foot in targeted subwatersheds. There is no cap on the size of projects eligible for the rebate. Properties of all sizes including residential, commercial and institutional are encouraged to apply. For buildings with a footprint of 2,500 square feet or less, funds are available to defray the cost of a structural assessment. Additional funding may be available for features that further advance environmental goals. **http://ddoe.dc.gov/greenroofs** RiverSmart Schools Program: In addition to installing new schoolyard greenspace, the RiverSmart Schools program provides teachers with the training they need to use their conservation site with confidence to teach lessons based on the DCPS Standards. The gardens serve as a permanent outdoor learning tool that can enhance many areas of study. This year, funding is available for five schools with a minimum of $3,500 and up to $70,000 in gardening and classroom resources, plus additional technical assistance and in-kind support. **http://ddoe.dc.gov/page/riversmart-schools-application** Stormwater Retention Credits (SRC): Major development projects undergoing permitting in the District must now meet river-protecting stormwater retention standards and can use SRCs to meet a portion of their requirement. The SRC trading program, established on July 19, 2013, is the first of its kind in the nation. Property owners generate SRCs by installing green infrastructure that captures and retains stormwater runoff. DDOE certifies SRCs for eligible best management practices and land cover changes. Owners can sell SRCs in an open market to buyers who can use them to meet regulatory requirements for retaining stormwater. The SRC program embraces two key ideas: 1) Allowing regulated projects to achieve a portion of their obligation off-site; and 2) Establishing a private market that pays dividends to property owners for retrofits and

Stormwater Management Laws and Regulations: A comprehensive listing and associated links for all regulations pertaining to stormwater management.
http://dcregs.dc.gov/Gateway/ChapterHome.aspx?ChapterNumber=21-5

2013 Stormwater Management Rule and Guidebook:
http://ddoe.dc.gov/swregs

Stormwater Database: the purpose is to enhance transparency and effectiveness of the stormwater plan review process for regulated and voluntary projects. The new database will also streamline participation in the Stormwater Retention Credit and RiverSmart Rewards programs, which incentivize installation of runoff-reducing Green Infrastructure.
http://ddoe.dc.gov/node/951112

Sustainable DC Omnibus Amendment Act of 2014: The components of this legislation address the challenges as prioritized in the Sustainable DC Plan including: growing jobs and the economy, improving health and wellness, ensuring equity and diversity, and protecting the District's climate and the environment.
http://www.georgetownclimate.org/resources/sustainable-dc-omnibus-amendment-act-of-2014-washington-dc
and,
http://www.sustainabledc.org/in-dc/legislation/

"Shared BMP" that is off-site. Projects are also allowed to use off-site mechanisms if a minimum of 50% retention has been met on-site. If it is under the 50% minimum, then it must demonstrate that on-site retention is inconceivable or environmentally harmful.

There are two off-site options: 1) Payment-in-lieu or 2) Stormwater Retention Credits (SRCs). The in-lieu fee (ILF) is $3.50/gallon/year and must be made payable to the DDOE. The Stormwater Retention Credit Trading Program was designed for properties with eligible retention practices, meaning that they must meet the development standards, e.g. land disturbing activity of 5,000 square feet, and be approved. Eligible SRC owners must apply for certification, use, transfer, and retirement of SRCs. Off-site volume reduction targets are obligated to be met on a yearly basis using a combination of ILFs or SRCs and targets be reduced in the future by increasing on-site retention. The SRC program aims to achieve reduction in stormwater volume runoff using a watershed-based approach.

improves benefits for District waterbodies in the process.
http://ddoe.dc.gov/service/leading-example

Article - Green Infrastructure Incentives in the Nation's Capital: The article explains the District of Columbia's Stormwater Retention Credit Trading Program. It is reprinted from the September 2013 issue of BioCycle, with permission.
http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Trading%20Retention%20Credits%20Green%20Infrastructure%20Incentives%20in%20the%20Nation%E2%80%99s%20Capital.pdf

Article - Making stormwater retrofits pay: Creating a market for stormwater retrofits to harness self-interest, leverage river protections, and promote sustainable development in the District of Columbia
http://www.wef.org/publications/page_wet.aspx?id=8589935179&page=feature

Stormwater Retention Credit Trading and In-Lieu Fee Analyses: provide compliance options for sites that face retention requirements. The first spreadsheet explains DDOE's calculation of the in-lieu fee and contains estimates of SRC demand and supply, price to recover the costs for installing projects to generate SRCs, and financial returns from participating in the SRC and stormwater fee discount programs. The other spreadsheet contains a calculator that estimates the financial return from installing a green infrastructure practice to participate in DDOE programs.
http://ddoe.dc.gov/service/stormwater-retention-credit-trading-and-lieu-fee-analyses

Stormwater Credit Exchange Program: The Stormwater Credit Exchange (SCE) is a clearinghouse service that allows participants who reduce their "stormwater runoff footprint," the total stormwater runoff from a property during a storm event, to market those credits. Participants who do not reduce their footprint can make offers to purchase offset credits via the SCE. Requirements and associated Fees are listed:
http://www.cfece.org/scehome.htm

DDOE has established a public SRC Registry where sellers list their SRCs for sale, including an initial listing price. SRC buyers and sellers negotiate a final purchase price independent of DDOE.
http://ddoe.dc.gov/node/822802

Grants for LID Rebates & Environmental Education: program of incentivizing low impact development (LID) implementation on private property in the District and to assist DDOE in providing a meaningful watershed education experiences for every student enrolled in District public schools. The total amount available for this initiative is approximately $1,310,000.00.
http://ddoe.dc.gov/release/grants-lid-rebates-environmental-education

Rain Barrel and Cistern Rebate: Homeowners can purchase and install up to two rain barrels or cisterns and receive $50 to $500 back by submitting an application, receipt, and pictures of the installed barrel. The rebate amount is dependent on volume: $1 per gallon stored.
http://ddoe.dc.gov/service/riversmart-rebates

Tree Rebate: provides rebates to individuals who purchase and plant a tree on private property, residential or commercial. There is no maximum number of rebates per property. 40 species noted for their large canopy and environmental benefits qualify for rebates up to $100 per tree. Small and medium canopy trees are eligible for rebates up to $50 per tree, as long as the tree reaches 15' tall and wide at maturity.
http://caseytrees.org/programs/planting/rebate/

Rain Garden, Pervious Paver, and Impervious Surface Removal Rebate: The rebate is based on how many square feet of impervious area is treated with rain garden or pervious pavers/impervious surface removal. The rebate will reimburse homeowners $1.25 per impervious square foot treated. The minimum square footage that must be treated is 400 square feet (a $500 rebate). The maximum rebate is $1,000 or treating 800 square feet or more of impervious surface.

http://ddoe.dc.gov/service/riversmart-rebates

The Clean Marinas Program: is a partnership among the District Department of the Environment/Watershed Protection Division, the National Park Service/National Capital Region (NPS), and marinas in the District. It is a voluntary program through which marina operations become more environmentally responsible and marina managers educate the boating public on environmentally responsible boating practices.
http://ddoe.dc.gov/service/reduce-stormwater-runoff

Green Jobs Grant: Stormwater Retention Best Management Practice Maintenance Training Course: Funds are available for non-profit organizations or educational institutions to develop a training course for District residents to learn the specific skills required for maintenance of stormwater retention Best Management Practices (BMPs). The amount available for the project in this RFA is approximately $150,000.
http://ddoe.dc.gov/node/831062

Grants for Demonstration of Innovative Green Practices (a 2013 initiative): on-going program of incentivizing Low Impact Development (LID) Green Infrastructure (GI) implementation District on properties and to participate, in whole or in part, in demonstrations of innovative LID-GI practices on private and public spaces. The amount available for the projects in this RFA is approximately $2,110,000.
http://ddoe.dc.gov/node/468782

Utilities:
Fee Structure: There are two utility charges that apply: The Impervious Surface Area Charge (IAC) and the Stormwater Fee. Both fees relate to improving the District's water quality. However, the Stormwater Fee and the DC Impervious Surface Area Water Charge address separate pollution control requirements.

IAC Charge: DC Water implemented the IAC charge in 2009 to recover the cost of the $2.6 billion federally mandated Combined Sewer Overflow Long Term Control Plan to control overflow into the waterways. This includes building large metro sized tunnels to store overflow until it can be treated at the wastewater treatment plant. The charge is based on a property's contribution of rainwater to the District's sewer system. Because charges are based on the amount of impervious area on a property, owners of large office buildings, shopping centers and parking lots will be charged more than owners of modest residential dwellings. All residential and non-residential customers are billed for CRIAC. The FY 2015 monthly charge is $16.75 per equivalent residential unit (ERU).

Residential: Includes condominium or apartment units where each unit is served by a separate line and is individually metered; multi-family structures of less than 4 units where all are served by a single service line that is master metered; and single family dwellings. There is a six tiered rate for residential customers. The tiers were developed in order to bill residential customers more equitably, based on the size of their properties.

Non- Residential: The fee is based on the total amount of impervious service area at a property. The total amount of impervious area is converted to ERU's and reduced to the nearest 100 sq feet.

http://www.aoba-metro.org/uploads/docs/2012/FINAL%20912012%20%20UTILITY%20COMMITTEEE%20UPDATED%20UNDERSTANDING%20DC%20WATER%20BILL%20Presentation-1.pdf and,
http://www.dcwater.com/customercare/iab.cfm

Stormwater Fee: The federal government requires that the District controls pollution from stormwater runoff. The stormwater fee provides a dedicated funding source to pay for these pollution control efforts. This fee helps to pay for green roofs, rain gardens, tree planting, street sweeping, and other activities that help keep waterways clean. Effective May 1, 2009, the stormwater fee collected from each District of Columbia retail water and sewer customer shall be based upon the Equivalent Residential Unit (ERU). An ERU is defined as 1,000 square feet of impervious area of real property. Each ERU is charged $2.67 per month. A program to assist Low income residents with water bills is under development.

The Department of the Environment (DDOE) manages the fee program.
http://www.dcregs.dc.gov/Gateway/RuleHome.aspx?RuleID=474056

Residential: A residential customer means a single-family dwelling used for domestic purposes, a condominium or apartment unit where each unit is served by a separate service line and is individually metered and the unit is used for domestic purposes, or a multifamily structure of less than four apartment units where all the units are served by a single service line that is master metered. Residential customers shall be assessed ERUs for the square feet of impervious surface on the property, as follows:

(a) 0.6 ERUs for 100 to 600 square feet of impervious surface;
(b) 1.0 ERU for 700 to 2,000 square feet of impervious surface;
(c) 2.4 ERUs for 2,100 to 3,000 square feet of impervious surface;
(d) 3.8 ERUs for 3,100 to 7,000 square feet of impervious surface;
(e) 8.6 ERUs for 7,100 to 11,000 square feet of impervious surface; and
(f) 13.5 ERUs for 11,100 square feet or more of impervious surface.

Non-Residential: All non-residential customers shall be assessed ERU(s) based upon the total amount of impervious area on each lot. This total amount of impervious area shall be converted into ERU(s), reduced to the nearest 100 square feet. Non-residential customers shall include all customers not within the residential class.

Impervious-only properties: are properties that have not, prior to May 1, 2009, had metered water/sewer service and require the creation of new customer accounts for billing of stormwater fees. (I.e. parking lots). The DC Water and Sewer Authority, pursuant to the Water and Sewer Authority Establishment and Department of Public Works Reorganization Act of 1996, effective April 18, 1996 (D.C. Law 11-111, §§ 203(3), (11) and 216; D.C. Code §§ 34-2202.03(3), (11)), shall establish accounts for and bill these impervious-only properties for stormwater fees pursuant to its regulations in 21 DCMR Chapter 41
http://www.dcregs.dc.gov/Gateway/RuleHome.aspx?RuleID=474056

Summary of FY 2015 Applicable Rates: an overview of DC Water customer rates
http://www.dcwater.com/customercare/rates.cfm

Notice of Final Stormwater Fee Rulemaking:
http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Stormwater%20Fee%20Notice%20of%20Final%20Rulemaking.pdf

Stormwater Taxes/Fees in Washington Metropolitan Area: A summary of the various utility fee structures throughout the Greater Washington Metropolitan area
http://www.cfece.org/SCEInformation.htm

State of Minnesota

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Stormwater Program is a comprehensive state stormwater program based on the Federal NPDES program and administered by the MPCA with oversight by the USEPA. The program is based on federal Clean Water Act requirements for addressing polluted stormwater runoff. Stormwater disposal is regulated nationally through the National Pollutant Discharge Elimination System (NPDES) and Minnesota regulates the disposal of stormwater through the State Disposal System (SDS) MPCA issues combined NPDES/SDS permits. A 1987 amendment to the Federal Clean Water Act required implementation of a two-phase comprehensive national program to address stormwater runoff. Phase I regulated large construction sites, 11 categories of industrial facilities, and major metropolitan municipal separate storm sewer systems (MS4s), including Minneapolis and St. Paul. Phase II includes smaller construction sites, municipally owned or operated industrial activity, and many more municipalities. Stormwater permits require permittees to control polluted discharges. Regulated parties must develop stormwater pollution prevention plans (or stormwater pollution prevention programs, for Municipal Separate Storm Sewer Systems (MS4s)) to address their stormwater discharges. Each regulated party determines the appropriate best management practices (BMPs) to minimize pollution for their specific site. The three permit types - construction, industrial, and municipal - have distinct requirements and some regulated parties may require more than one permit. There are two types of NPDES/SDS permits: general permits and individual permits. If work meets the requirements of a specific general permit, an individual permit is not required. Currently the three categories for stormwater permitting are Municipal, Industrial and Construction. **http://stormwater.pca.state.mn.us/index.php/Regulatory_information** Stormwater Program for Municipal Separate Storm Sewer Systems: **http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/municipal-stormwater/municipal-separate-storm-sewer-systems-ms4.html** Industrial Stormwater Program**:** **http://www.pca.state.mn.us/index.php/water/water-types-and-**	1. New, nonlinear developments that create more than one acre of new impervious surface on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on-site for 1.1 inches (28 mm) of runoff from impervious surfaces statewide. 2. Nonlinear redevelopment projects on sites without restrictions, that create one or more acres of new and/or fully reconstructed impervious surfaces shall capture and retain on-site 1.1 inches (28 mm) of runoff from the new and/or fully reconstructed impervious surfaces. 3. Linear projects on sites without restrictions that create one acre or more of new and/or fully reconstructed impervious surfaces, shall capture and retain the larger of either: a. 0.55 inches (14 mm) of runoff from the new and fully reconstructed impervious surfaces; or b. 1.1 inches (28 mm) of runoff from the net increase in impervious area. Mill and overlay and other resurfacing activities in linear projects are not considered fully reconstructed. 4. The MIDS approach further requires that all projects must first attempt to meet the volume reduction Performance Goal on site. However, if an applicant is unable to achieve the full Performance Goal due to site restrictions as attested by the local authority and documented by the applicant, the development project must follow one of three Flexible Treatment Options. a. Flexible Treatment Option 1: Applicant attempts to comply with the following conditions: i. Achieve at least 0.55 (14 mm) inch volume reduction goal, and ii. Remove 75 percent of the annual total phosphorus load, and iii. Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site b. Flexible Treatment Option 2: Applicant attempts to comply with the following conditions: i. Achieve volume reduction to the maximum extent practicable (as determined by the Local	Incentives: The Stormwater Credit system: provides up to 50% credit (reduction) in your stormwater utility fee for management tools/practices that address stormwater quality, and 50% or 100% credit (reduction) in your stormwater utility fee for management tools/practices that address stormwater quantity. Maximum credits are cumulative and cannot exceed 100% credit. **http://www.ci.minneapolis.mn.us/publicworks/stormwater/fee/stormwater_fee_stormwater_mngmnt_feecredits** Stormwater Quality Credit Program: offers property owners a credit equivalent to fifty percent of the stormwater charges for the portion of their impervious area that drains to an approved stormwater quality management tool. Examples include, rain gardens, pervious pavers and green roofs. **http://www.ci.minneapolis.mn.us/www/groups/public/@publicworks/documents/webcontent/convert_276373.pdf** Stormwater Quantity Credit Program: only those properties that can demonstrate the capacity to handle a 10-year or 100-year rain event can receive a stormwater quantity credit. Property owners must have their applications certified by a state licensed engineer or landscape architect. Property owners can apply for either the "Standard Quantity Reduction Credit" or the "Additional Quantity Reduction Credit." **http://www.ci.minneapolis.mn.us/publicworks/stormwater/fee/stormwater_fee_stormwaterquantitycredits** Utility Fee Structure: The Stormwater Utility Fee was established in 2005. The stormwater utility fee is based on impervious area and is charged on a per unit basis. Each ESU (Equivalent Stormwater Unit) is 1,530 square feet of impervious area on a property. The impervious area was calculated based on the size of the property, as well as the current use. Single family properties are billed using one of the following rates: High 1.25 ESU $14.93 Medium 1.00 ESU $11.94 Low .75 ESU $8.96 Stormwater charges for all other properties will be based on the following calculation: (Gross Lot Size in sq.ft. X Runoff Coefficient)÷ 1,530 sq. ft.= # of ESU# of ESU X $11.94= Monthly Fee Additional details of the fee structure can be found here: **http://www.minneapolismn.gov/www/groups/public/@clerk/documents/webcontent/wcms1p-118065.pdf** Storm Water Fund 2014 Budget Financial Plan: The Storm Water Fund is comprised of

programs/stormwater/industrial-stormwater/index.html

Stormwater Program for Construction Activity:
http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/index.html

Minnesota Stormwater Manual - Cold Climate Impact On Runoff Management:
http://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management

Stormwater Management Ordinance:
http://www.pca.state.mn.us/index.php/view-document.html?gid=7427

Stormwater Management for Development and Re-development Ordinance: The ordinance establishes requirements for projects with land disturbing activities on sites greater than one (1) acre, including phased or connected actions, and for existing stormwater devices.
An option is reserved for only those sites that demonstrate that performance of on-site stormwater management is not feasible. With approval of the City Engineer, the Ordinance allows developers to contribute to the construction of a regional stormwater facility in lieu of on-site treatment/management.
http://www.ci.minneapolis.mn.us/publicworks/stormwater/dev/index.htm

Combined Sewer Overflow (CSO): The Combined Sewer Overflow project started in 2004. Working with property owners, this project aims to identify and disconnect roof drain overflow from the sanitary system (Flood Mitigation). This is an on-going program. For 2014, $700,000 has been allotted from the operating budget with additional funding available from the Capital programs.
http://www.ci.minneapolis.mn.us/www/groups/public/@finance/documents/webcontent/wcms1p-113436.pdf

CSO Program Outline and Ordinance:
http://www.ci.minneapolis.mn.us/publicworks/stormwater/cso/cso_rainleader-ordinance

CSO Disconnection Information for Commercial and Multi-Unit Residential Buildings:
http://www.ci.minneapolis.mn.us/publicworks/stormwater/cso/cso_commercial

Authority), and
   ii. Remove 60 percent of the annual total phosphorus load, and
   iii. Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site.

c. Flexible Treatment Option 3:
Off-site mitigation (including banking or cash or treatment on another project, as determined by the local authority) equivalent to the volume reduction performance goal can be used in areas selected in the following order of preference:
   i. Locations that yield benefits to the same receiving water that receives runoff from the original construction activity.
   ii. Locations within the same Department of Natural Resources (DNR) catchment area as the original construction activity.
   iii. Locations in the next adjacent DNR catchment area up-stream.
   iv. Locations anywhere within the local authority's jurisdiction.

the Storm Water Collection and Street Cleaning programs. The Fund accounts for street cleaning and the design, construction, and maintenance of the City's storm drain system. A portion of the Storm Water Fund is used for sanitary water interceptor and treatment services. The Fund also accounts for the Combined Sewer Overflow program. 2014 budget information:
http://www.ci.minneapolis.mn.us/www/groups/public/@finance/documents/webcontent/wcms1p-113436.pdf

Stormwater Fee Ordinance:
http://www.minneapolismn.gov/www/groups/public/@council/documents/webcontent/convert_263412.pdf

Water Reuse:
Water Resource Ordinances: Table B-2 on page 31 of the report contains a summary of Minneapolis ordinances that help protect water resources in the City. The table also references related ordinances and state laws.
http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_281304.pdf

Prohibited Discharge to Sanitary Sewer System Ordinance: Also known as the Rainleader Ordinance. In support of the CSO program, the purpose is to define regulations that will aid the City in limiting inflow of rainwater to the sanitary sewer system. It authorizes the City to:

- Perform inspections to identify sources of prohibited stormwater runoff discharge into the sanitary sewer system
- Require identified sources to be disconnected from the sanitary sewer system
- Issue Administrative Citations to continuing violators. The first Citation includes a fine of $750, the second Citation includes a fine of $1,500, the third and all subsequent Citations are $2,000.

http://www.ci.minneapolis.mn.us/publicworks/stormwater/cso/cso_rainleader-ordinance & http://www.ci.minneapolis.mn.us/www/groups/public/@publicworks/documents/webcontent/convert_281922.pdf

Permeable Pavement Zoning Code Amendment:
http://www.minneapolismn.gov/www/groups/public/@council/documents/webcontent/convert_275393.pdf

Vegetation Management Policy:
http://www.ci.minneapolis.mn.us/www/groups/public/@citycoordinator/documents/webcontent/wcms1p-132021.pdf

Local Surface Water Management Plan: The City of Minneapolis completed its LSWMP in October, 2006. The Metropolitan Area Surface Water Management Act was created by Minnesota legislature to protect surface water resources. It resulted in the creation of Watershed Management Organizations (WMO) that were given the role of managing individual water bodies in the Twin Cities area. There are four in Minneapolis, including:

- Bassett Creek Water Management Commission (BCWMC)
- Minnehaha Creek Watershed District (MCWD)
- Mississippi Watershed Management Organization (MWMO)
- Shingle Creek Watershed Management Commission (SCWMC)

Each municipality creates and implements its own local water management plan, consistent with those of the watershed management organizations within its boundaries.
http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_253419.pdf

City of Philadelphia, Pennsylvania

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Pennsylvania Stormwater Management Program was developed based on the federal NPDES program. Post-construction standards are based on Phase I and Phase II of the NPDES permit program. At the Federal legislative level, regulations are subject to the Clean Water Act, Section 402, 1972, last amended 1987, and 40 CFR Part 122, 1987. At the State legislative level, regulations are per Pennsylvania Stormwater Management Act, 1978 (The Comprehensive Stormwater Management Policy, 2002). The administrative authority is the Pennsylvania Department of Environmental Protection (The Bureau of Point and Non-Point Source Management (BPNPSM)), and The Bureau of Waterways Engineering and Wetlands Stormwater Management Guidance Manual: created to assist developers in meeting the requirements of the Philadelphia Stormwater Regulations. **http://www.pwdplanreview.org/StormwaterManual.aspx** Stormwater Regulation Ordinance: **http://www.phillyriverinfo.org/WICLibrary/StormwaterRegulations.pdf** Green Streets Design Manual: **http://www.phillywatersheds.org/what_were_doing/gsdm**	The State of Pennsylvania has adopted the following NPDES standard for new development or re-development: Any land disturbance is subject to: • Capture at least 2 inches of runoff from all impervious surfaces • The first inch of runoff from new impervious surfaces shall be removed from the runoff flow • The first 0.5" shall be removed using infiltration Note that these design standards are not regulatory by the state but may be regulatory via municipalities. City of Philadelphia SWM Regulations prior to July 2015 • Water Quality Release Volume - 1.0 inch (25 mm) • Water Quality Release Rate - 0.24 cfs/acre of DCIA • Water Quality Treatment: Separate Sewer and Direct Discharge - 100% Volume-Reducing • Water Quality Treatment: Combined Sewer - 100% Volume-Reducing SWM Regulations prior to After 2015 • Water Quality Release Volume - 1.5 inch (38 mm) • Water Quality Release Rate - 0.05 cfs/acre of DCIA • Water Quality Treatment: Separate Sewer and Direct Discharge - 100% Pollutant-Reducing* • Water Quality Treatment: Combined Sewer - 100% Pollutant-Reducing* * Acceptable non-infiltrating pollutant-reducing practices – Bioretention, Porous Pavement, Green Roofs, Cisterns, and Blue Roofs. Ponds & Wet Basins, Vegetated Media filters, Media filters, Roof Runoff Isolation (not for Separate Sewers)	Incentives: Stormwater Charge Senior Discount: A 25% Senior Citizen Discount Rate is available. As always, conditions apply…. **http://www.phila.gov/waterrev/billsPayments.html** Stormwater Credits Program: offers Non-residential and Condominium customers (with at least 500 square feet of gross area) the opportunity to reduce their total SWMS Charge. Three classes of credits are available and depending on the types of SMPs present on the property and whether the customer holds a valid industrial NPDES permit for the site, a parcel may be eligible for all three classes of credits: • Impervious Area Stormwater Credit (IA Credit) - (Tree canopy cover, Roof leader/downspout disconnections, Pavement disconnections, Green Roofs, Porous Pavement) • Gross Area Stormwater Credit (GA Credit) – Two options available: 1) Management of the First Inch of Runoff (Impervious Area Only) and 2) Credit Based on NRCS-CN (Open Space Only) • National Pollutant Discharge Elimination System Credit (NPDES Credit) for industrial stormwater discharge activities - customer must demonstrate that the parcel is subject to an active NPDES Permit for industrial stormwater discharge activities See page 16 of the document: **http://www.phila.gov/water/wu/Stormwater%20Resources/scaa_manual.pdf** Stormwater Management Incentives Program: offers non-residential property owners low-interest financing to stimulate investment in and utilization of stormwater best management practices which reduce a parcel's contribution of stormwater to the City's system. **https://business.phila.gov/Documents/SMIP_information.pdf and,** **http://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/SMIPFactSheet.pdf** Greened Acre Retrofit Program: provides stormwater grants to contractors, companies or project aggregators who can build large-scale stormwater retrofit projects across multiple properties. Additionally, upon completion of the project, participating property owners (or customers) will be eligible for credits against their stormwater charges. **http://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/GARPFactSheet.pdf and,** **http://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/GARPSeminar1.pdf** Green Roof Tax Credits: The credit is for 25% of the cost of installing the green roof, up to $100,000. **http://philadelphiaretail.com/pdf/GreenRoofTaxCredit.pdf** **http://www.phila.gov/Revenue/Tax%20Credits/taxcredit_greenroof_overview.pdf** Basement Protection Program: This Program provides eligible residents with free installation of backwater valves and modifications to downspouts that help prevent sewage back up in their basements. **http://www.phillywatersheds.org/watershed_issues/flooding/basement_backup_protection** **http://www.phillywatersheds.org/doc/BPP_Summary_Application_2.pdf** Green Roof Tax Ordinance: **http://www.phila.gov/Revenue/Tax%20Credits/taxcredit_greenroof_overview.pdf** Free Assistance Program: The Philadelphia Water Department provides free assistance through site inspections and design recommendations for green retrofits that allow customers to obtain stormwater credits. This program minimizes the up-front costs to customers for preliminary evaluation and concept design, including evaluation of available credits. Green Guide for Property Management: A guide to help commercial property owners reduce stormwater fees through innovative green projects on their properties. **http://www.phila.gov/water/wu/Stormwater%20Resources/PWD_GreenGuide.pdf**

Utility Fee Structure:
Residential Stormwater Charge: Residential customers pay a standard amount based on the average surface area of impervious cover on residential properties throughout the city. SWMS charge is NOT based on monthly water consumption. The SWMS Charge is based on two parameters: the average Gross Area square footage and the average Impervious Area square footage for all residential properties. The average Gross Area for a residential property is 2,110 square feet. The average Impervious Area for a residential property is 1,050 square feet. Based on this average Gross Area and Impervious Area values, a uniform monthly charge has been defined for all residential properties. All Residential Properties are charged a monthly SWMS charge and a monthly Billing and Collection charge. Effective July 14, 2014 - (SWMS) $11.80, Billing & Collection $1.69
http://www.phila.gov/water/wu/stormwater/Pages/ResidentialSWBilling.aspx
Non-Residential Stormwater Charge: the cost to manage stormwater is based on the specific square footage of impervious area covering the property and the total square footage of the property.
Effective July 1, 2014 the minimum monthly charges shall be as follows: SWMS $12.46 Billing & Collection $2.19
http://www.phila.gov/water/wu/Stormwater%20Resources/scaa_manual.pdf - page 34 of the document and,
http://www.phila.gov/water/wu/stormwater/Pages/NonResidentialStormwaterBilling.aspx
Stormwater Management Service Charges Transition: effective July 1, 2010, PWD is transitioning from an equivalent meter based SWMS Charge to a parcel area based SWMS Charge. See page 58 of the report:
http://www.phila.gov/water/PDF/PWDRegulationsRev02.07.14.pdf
SWMS Charge CAP: The objective of the SWMS Charge CAP is to enable stormwater customers to mitigate the annual fiscal year increase on their monthly SWMS Charge due to the transition from a meter based to a parcel area based charge. See page 13 of the document:
http://www.phila.gov/water/wu/Stormwater%20Resources/scaa_manual.pdf
Stormwater Billing Map Viewer: This web application lets users explore parcels on an interactive map, including high resolution ortho-photography, transparent overlays of impervious surfaces, and tools to make approximate measurements of length and area.
http://www.phila.gov/water/swmap/#eyIhZ3NNYXAiOsSAem9vbcSIMCwieMSIMjcwNTI2Ny4yOTA4ODE1xJF5xJQ1MzY2MS4wMDc4NjQxMn3EkW1lYXN1cmXEiMSAY29udHJvbEFjdGl2xL06bnVsbMS1ImxlZ2VuZMS%2BIkFlcmlhbDIwMTDEiGbFoHNlxJFwdl9kYXRhLTHEiMWDdWV9fQ%3D%3D

State of New York

	Control Criteria	Incentives, Utilities, and Water Reuse
New York State Stormwater Program was developed in alignment with the NPDES program. The New York State Stormwater Management Design Manual was developed as a guidance manual. NPDES permits for stormwater runoff are a key component of the manual; permits are regulatory. The New York State Department of Environmental Conservation (DEC) and the Lake George Park Commission have the administrative authority when it comes to the NPDES permits. For redevelopment, permittees must attempt to comply with the post-construction management requirements outlined in the manual.	New development projects that disturb greater than or equal to 1 acre of land, or less than or equal to 1 acre of land that is part of a larger common plan of development must achieve 100% of stormwater runoff volume reduction on-site by using retention or volume control measures with a 0.8 to 1.2 inch standard. Retention or volume control measures such as the infiltration, groundwater recharge, reuse and recycle, and evapotranspiration can be used to meet this standard. Concentrated runoff can be minimized using a treatment first approach before runoff reaches the collection system. This can be achieved through on-site green infrastructure techniques, standard stormwater management practices with runoff reduction capacity, and with good operation and maintenance.	

City of Chicago, Illinois

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
As part of the Mayor's Green Stormwater Infrastructure Strategy (which is one of the largest voluntary investments in this type of infrastructure by a US City) ¸the Department of Water Management (DWM) has worked with City agencies to identify opportunities to incorporate green infrastructure into existing and ongoing capital projects. For 2014, DWM has identified 39 such projects, which include four schoolyard projects, five complete streets projects and 30 traffic calming projects. In sum, these 39 projects will receive $6.1 million in funding from DWM and will leverage nearly $18 million in additional funding from Chicago Public Schools (CPS), the Chicago Department of Transportation (CDOT), the Metropolitan Water Reclamation District (MWRD) and other partners CDOT and DWM are also collaborating to include green infrastructure for approximately 30 traffic calming bumpouts at various locations throughout the City. DWM and CDOT will also incorporate green infrastructure into five complete streets projects this year, which will include infiltration planters, tree pits, permeable pavement and bioswale. The City has received two Shoreline Cities grants from the U.S. Environmental Protection Agency (EPA) totaling $1 million under the Great Lakes Restoration Initiative to support green infrastructure. The grants will be used for two projects: One to install green infrastructure along a 1-mile segment of a Chicago street (Leland Avenue on the City's north side) as part of a Neighborhood Greenway project. This work will include the installation of traffic-control measures that will incorporate green infrastructure like bioswales and infiltration planters. It is estimated that, once complete, this project will prevent approximately 868,000 gallons of untreated stormwater from entering the City's combined sewer system each year, helping to reduce the likelihood of combined sewer system overflows into Lake Michigan. Joint venture with Centre for Neighbourhood Technology (CNT) involving a pilot study in 2 Chicago communities. Testing a flood reduction/readiness program Wetrofit®, involving auditing of homes and businesses to identify opportunities for infiltrating water on-site and retrofitting for flood protection/mitigation. CNT primarily and energy retrofit focused org. but evolving a stormwater program for homes, businesses and communities. Stormwater program currently not well established and focused on Chicago pilots.	Volume-Based BMPs: Stormwater drainage systems shall reduce the volume of runoff from a Regulated Development by one of the following measures: (A) Capture one-half inch of runoff from all impervious surfaces in accordance with volume control BMPs; or (B) For Developments that do not directly discharge to Waters or to a municipal separate storm sewer system, achieve a fifteen-percent reduction in impervious surfaces from existing conditions Detention: Between the 5-year and 100-year storm event.	Incentives: Working with CPS and MWRD, DWM will provide funding to the Space to Grow program, an initiative by Openlands and Healthy Schools Campaign to convert public school asphalt schoolyards into green playgrounds. Donald Morrill Math & Science Elementary School, Virgil Grissom Elementary School, George Leland Elementary School and Theophilus Schmid Elementary School are currently in the design phase, with construction anticipated to begin this summer. These projects will contain several green infrastructure components, including rain gardens, bioswales and permeable pavement to help absorb rainfall. Water Reuse: The City encourages the capture of water for reuse in irrigation. Up to 10 percent of a detention facility may be set aside for capture and reuse of the water.

City of Burlington, Vermont

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Vermont Stormwater Program: **http://www.anr.state.vt.us/dec/waterq/stormwater/docs/sw_Stormwater_101.pdf** Vermont Watershed Management Division - Green Infrastructure New and Noteworthy: **http://www.vtwaterquality.org/stormwater/htm/sw_gi_newandnoteworthy.htm** Wastewater, Stormwater and Pollution Control Ordinance – Chapter 26 The Burlington City Council adopted a revised Chapter 26, December 15, 2008. The effective date is April 1, 2009. **http://www.codepublishing.com/vt/burlington/?Burlington26/Burlington26.html** Decision to pursue municipal delegation of wastewater permitting: Chapter 26 The wastewater sections of Chapter 26 will be revised to reflect the decision to pursue municipal delegation of wastewater permitting. Wastewater permits are presently administered by the state. Beginning July 1, 2007, every parcel of land came under the authority of the state's on-site wastewater & potable water supply system program. As a result, a state permit is needed for most repairs, upgrades, and new construction of on-site wastewater treatment and disposal facilities, and connections to municipal water distribution and wastewater collection systems. Delegation of the state's regulatory program means that the state would transfer administration of its wastewater systems permit program to the city if the city makes a request in writing and meets specific criteria. Currently the city participates in project review and the writing of letters of sufficient capacity or allocation for the water and wastewater systems. Assuming the additional responsibility of permit administration is feasible if incorporated into a package with the proposed stormwater program. It will capture	Note: Uses Unified Sizing Criteria Volume-based sizing: The following equation shall be used to determine the water quality storage volume (WQv) (in acre- feet of storage): WQv= (P) (Rv) (A)/12 where: WQv= water quality volume (in acre-feet) P = 90% Rainfall Event (0.9 inches across Vermont) Rv= volumetric runoff coefficient equal to: [0.05 + 0.009(I)], where I is a whole number percent impervious cover at the site (ex. 25, not .25) A = site area (in acres) Detention: Channel Protection (CPv) • Default Criterion: CPv= 12 hours extended detention of post-developed 1-year, 24-hour rainfall event in coldwater fish habitats (24 hr. detention in warmwater fish habitats). Overbank Flood (Qp10) • Control the post-developed peak discharge from the 10-year storm to 10-year pre-development rates. Extreme Storm (Qp100) • Control the peak discharge from the 100-year storm to 100-year pre-development rates.	Incentives: Stormwater Credit Manual: Fee credit program for directly assessed properties. The credit program is not yet available for those properties with a flat fee. Multiple credits can be given to eligible properties. The total credit given to any property shall not exceed 50% of the stormwater user fee for that property, and in no event shall a property pay a stormwater user fee less than the flat fee for a detached single family home. Water Quantity Reduction Credits: available to properties whose peak stormwater runoff rate is restricted and/or controlled through onsite structural control facilities such as detention and retention ponds or chambers. If a higher level of detention is provided than required by the Vermont Stormwater Manual, then additional credits may be granted. The credit will be granted for the portion of impervious area that drains to the BMP. The maximum water quantity credit is 50%. Approved water quantity reduction credits can be applied in addition to any other approved credits. Water Quality Treatment Credits: offered to properties that discharge a portion of the runoff to approved structural BMPs) which significantly reduce pollutants in stormwater runoff. The goal for water quality practices is for the removal of 80% total suspended solids (TSS) for 90% of all Vermont storms, estimated as a 0.9 inch/24 hour event. Approved water quality credits can be applied in addition to any other approved credits. The maximum water quality credit for a property is 25% reduction in stormwater user fees for BMPs with 80% TSS removal. Credit for BMPs with lower TSS removals shall be prorated using the following formula: % Credit = 0.31 x (Estimated % TSS Removal). The credit will be granted for the portion of impervious area that drains to the BMP. Non-Structural Practices: In some instances the ability to strictly meet the requirements may not be possible, feasible or desired in an urban landscape. As such, the City encourages the use of alternative management practices and technologies as a way to both satisfy the requirements of this Division, to give flexibility to design and to encourage Green Infrastructure (green), Best Management Practices (BMP), Low Impact Design (LID) or other innovative practices that satisfy the requirements. Such practices include but are not limited to, green roofs, alternative detention practices, water reuse, including stormwater use, infiltration practices, including pervious and porous pavements and pavers. Application of Non-Structural Practice Credits are identical to those offered under Water Quantity Credits and Water Quality Credits. MS4 Permitted Facilities: Eligible MS4 entities can receive a 10% reduction in the total stormwater fee assessed to their property. If the MS4 entity owns multiple properties located in Burlington and currently receives multiple water/sewer bills, the 10% credit will be applied to every property within the MS4 permit boundaries. The total credit given to any property shall not exceed 50% of the stormwater user fee for that property, and in no event shall a property pay a stormwater user fee less than the flat fee for a detached single family home. Water Education Credit: Approval of the credit application will result in a 10% credit to the assessed stormwater fee. **http://www.burlingtonvt.gov/sites/default/files/DPW/Stormwater/Stormwater%20Credit%20Manual.pdf** Stormwater Friendly Driveways: A stormwater friendly driveway can reduce the amount of coverage calculated for zoning permit purposes and may allow property owners to construct additional building space elsewhere on their lot. Currently "strip driveways" provide this benefit, but soon other stormwater drive types may provide up to 50% coverage credit if proposed amendments to zoning regulations are approved in early 2014. **http://www.burlingtonvt.gov/DPW/Stormwater-Friendly-Driveways** LET IT RAIN STORMWATER BEST MANAGEMENT PRACTICE GRANTS Private and public property owners are eligible for funds through this program. This includes all residents, non-profits, businesses, corporations, churches, private schools, homeowner associations, lake associations and municipal entities located within the Vermont portion of the Lake Champlain Basin.

permit fees presently going to the state and will provide one-stop-shopping for applicants. **http://www.burlingtonvt.gov/sites/default/files/DPW/Stormwater/Stormwater%20Taskforce%20Report.pdf** –page 2

How does Chapter 26 affect new development and redevelopment in the City?
Chapter 26 contains standards for construction site erosion control. The standards are basically split between large and small projects. Large projects include all "major impact," "subdivision," and "planned unit developments" as defined in the City's Comprehensive Development Ordinance. Small projects are all others with at least 400 square feet area of disturbed earth involved in the construction process.
Chapter 26 also contains standards for post-construction stormwater management plans. All projects that result in greater than or equal to ½ acre of clearing, grading, construction or land disturbance activity, and create greater than or equal to ½ acre of impervious surface are required to have a post-construction stormwater management plan.
Chapter 26 includes provision for City administration of wastewater permits upon delegation by the State of Vermont. Previously, all wastewater permits were issued by the State of Vermont DEC Wastewater Division. City administration of wastewater permits will allow one stop shopping for applicants upon implementation.
http://www.burlingtonvt.gov/sites/default/files/DPW/Stormwater/Stormwater%20FAQs.pdf

Burlington Comprehensive Development Ordinance:
http://www.burlingtonvt.gov/PZ/CDO

Backwater Valve Ordinance:
http://www.burlingtonvt.gov/assets/0/122/318/303/2180/8f0253c9-5b37-4627-b9e7-ee875e73d98e.pdf

Downspout Disconnection - up to $20
Rain Barrel - up to $25
Rain Garden - up to $250
Cistern - up to $500
Permeable Pavers - up to $1 per square foot
Other - dependent on practice
http://www.burlingtonvt.gov/DPW/Get-Involved

Adopt-a-Drain Program: encourages community awareness of stormwater management.
http://www.burlingtonvt.gov/DPW/ADOPT-A-DRAIN

Utilities:
Background: In 2008, as the result of increasing regulatory obligations and the City's desire for a more sustainable approach towards managing stormwater infrastructure and improving water quality outcomes in Burlington, the City Council established a dedicated Stormwater Program. In order to fund the operation of the program, a stormwater user fee structure and initial user fee rate were adopted by the City Council as part of the program creation and were phased in beginning in 2009. Because the stormwater fee is a user fee and not a tax, all properties regardless of ownership are required to pay for the services provided by the Burlington stormwater management system. This includes non-profit entities such as churches, schools and institutions, as well as properties owned by the City of Burlington, the State of Vermont, as well as the federal government. Only impervious surfaces within the public right-of-way (i.e. streets and sidewalks) are exempt.

Fee Structure:
The stormwater fee is based on impervious area and is charged on a per unit basis. Each ISU (Impervious surface unit) is 1,000 square feet of impervious area on a property. Single family, duplex, triplex homes, as well as seasonal and mobile homes pay a flat fee based on the average amount of impervious associated with these parcel types. Other types of properties (commercial parcels and vacant lots) are assessed a fee based on the amount of impervious surface on the parcel. Non-residential properties are eligible to apply for up to 50% credit on their stormwater bill if they can document that they have implemented stormwater management practices on their property.

Stormwater Rates (effective January 1, 2014)
Flat Fee Customers:
Single Family: $4.50/month (2.67 ISU's)
Duplex: $4.47/month (2.65 ISU's)
Triplex: $5.16/month (3.06 ISU's)

Directly Assessed Customers:
Properties other than single family, duplex and triplex: $1.687 x ISU/month (1 ISU = 1,000 sq.ft. impervious)

Note regarding fees: Fees from 2009 – 2013 remained constant. A 50% rate increase was approved for 2014 to address the following:
*Hire of an additional staff person to assist in infrastructure assessment, project review and Chapter 26 compliance
*Rehabilitation of existing infrastructure
* Need for matching funds for grants to further advance water quality improvements
*Additional increases in regulatory obligations (MS-4 permit obligations, Stormwater Impaired Watershed Restoration Plans)
*Comprehensive planning to identify stormwater retrofit opportunities
http://www.burlingtonvt.gov/DPW/Billing and
http://www.burlingtonvt.gov/Press/Mayor-Miro-Weinberger-Welcoming-Remarks-at-the-Vermont-Environmental-Consortium-3rd-Annual

State of Virginia

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
As a NPDES delegated state, West Virginia's Stormwater Program aligns with the NPDES program. The program offers four types of permits: Construction Stormwater General Permit, Multi-sector Stormwater General Permit, Municipal Separate Storm Sewer Systems, and Oil & Gas Construction Stormwater General Permit. The Stormwater Permit Team administers all stormwater related permits and conducts technical reviews of applications and stormwater pollution prevention plans. Like Minnesota's Stormwater Regulatory Program, West Virginia's program must implement BMPs that focus on the six Minimum Control Measures listed in Phase II of the NPDES Storm Water Program. West Virginia's Stormwater Manual emphasizes reduction of runoff volume and protection of water quality. However, the Manual is voluntary and used as a guidance tool for NPDES permittees.	West Virginia's post-construction standards for new development are based on its MS4 Stormwater General Permit. Permittees of an MS4 permit must retain one inch of rainfall on-site for a 24-hour storm following 48 hours of no rainfall to manage the impact of stormwater on surface waters. The first one inch must be 100% managed and cannot discharge the retained water to surface waters except when the permittee takes one of the following actions: • Treat the stormwater before releasing it to surface waters using the infiltration method • Develop and implement a payment-in-lieu program for on-site retention • Develop and implement an off-site mitigation program • Develop and obtain an approval of an alternative BMP for managing the first one inch of rainfall For redevelopment, runoff reduction practices apply when a construction activity alters less than 5000 square feet of land. It must reduce 0.2 inches of rainfall and be managed on-site. For brownfields, lands with high density (less than 7 units per acre), or lands with a vertical density (floor to area ratio) must reduce a minimum of 0.2 inches to a maximum of 0.75 inches on s-site. For redevelopment projects that cannot meet 100% of the on-site runoff reductions requirements, the permittee must prepare for off-site mitigation or opt for a payment-in-lieu program. In order to select the most effective BMP and evaluate its performance in managing the one inch of runoff volume, the permittee must determine the Target Treatment Volume (Tv). Tv equates to one inch of rainfall multiplied by the runoff coefficient of the site.	

State of Maryland

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
In order to meet the requirements of the federal Clean Water Act to restore water quality and protect public health, local implementation of stormwater utility fees is mandated by the Watershed Protection and Restoration Program (House Bill 987) passed in the 2012 session of the Maryland General Assembly. This law, sponsored by sixteen members of the House of Delegates, passed by the full Legislature and signed into law by the Governor last year, requires nine Counties and Baltimore City to establish local fee systems by July 1, 2013, to address water pollution that occurs when rainfall carries sediment, nutrients from fertilizers and pet wastes, and toxic chemicals from rooftops, roads, urban and suburban lawns and institutional grounds into local storm drains, streams, rivers and drinking water reservoirs of the State, and ultimately to the Chesapeake Bay. **http://www.mde.maryland.gov/programs/Marylander/Pages/StormwaterFAQ.aspx** Maryland's Stormwater Management Program**:** **http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/SedimentandStormwater/home/index.aspx**	Note: Uses Unified Stormwater Sizing For new development, permitteees must implement the Environmental Site Design (ESD) practices defined in the Stormwater Design Manual to manage 1 inch of stormwater runoff volume in the Maryland Eastern Rainfall Zone and 0.9 inch in the Western Rainfall Zone. An ESD must be implemented to the MEP to mimic predevelopment conditions when subject to a 1-year, 24-hour design rain event. This means that ESD practices must provide retention storage sufficient to reduce the runoff depth of the proposed development to that of woods in good condition. Any volume remaining after the implementation of ESD to the MEP can be managed using practices such as detention ponds, filtration, or other treatment structures as defined in the Manual. Maryland's Unified Stormwater Sizing Criteria Model is divided into five volume increments: 1. Recharge/Infiltration Volume = Infiltration Criteria - the groundwater recharge volume is a fraction of the water quality volume based on the pre-developed hydrologic soil group. Therefore, ESD must be implemented to manage both groundwater recharge and water quality volumes. 2. Water Quality Volume = Water Quality Criteria includes a minimum 40% reduction is phosphorus and 80% reduction in TSS. Assumed to be met if on-site volume control requirements are met. 3. Channel Protection Storage Volume = Erosion Criteria requires the site to mimic the predevelopment conditions when subject to a 1-year, 24-hour design rain event 4. Overbank Flood Protection Volume = Flooding Criteria is an optional criteria applied at the discretion of the appropriate plan review/approval authority to control the developed condition peak rate of discharge from the 10-year 24-hour design storm event to the pre-development rate. 5. Extreme Flood Volume = Floodplain Criteria Volume increments from 1 to 5 ranges from 1 being small storm events to 5 being very large storm events. For redevelopment projects, any activity that disturbs 5,000 square feet or more where existing land use is commercial, industrial, institutional, or multifamily residential and where it exceeds 40% of impervious areas must achieve one of the following: • Reduce existing impervious area by at least 50%; • Implement ESD to the MEP to provide water quality treatment to 1 inch or 0.9 inch for at least 50% of the existing impervious area; or • Use a combination of the first or second options for at least 50% of the existing impervious area	In order to meet the requirements of the federal Clean Water Act to restore water quality and protect public health, local implementation of stormwater utility fees is mandated by the Watershed Protection and Restoration Program (House Bill 987) passed in the 2012 session of the Maryland General Assembly. This law, sponsored by sixteen members of the House of Delegates, passed by the full Legislature and signed into law by the Governor last year, requires nine Counties and Baltimore City to establish local fee systems by July 1, 2013, to address water pollution that occurs when rainfall carries sediment, nutrients from fertilizers and pet wastes, and toxic chemicals from rooftops, roads, urban and suburban lawns and institutional grounds into local storm drains, streams, rivers and drinking water reservoirs of the State, and ultimately to the Chesapeake Bay. **http://www.mde.maryland.gov/programs/Marylander/Pages/StormwaterFAQ.aspx** Maryland's Stormwater Management Program**:** **http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/SedimentandStormwater/home/index.aspx**

Georgia

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
Georgia Stormwater Management Manual Vol. 2, 2001 This Manual has been developed to provide guidance on the latest and most relevant stormwater management strategies and practices for the state of Georgia. The Manual itself has no independent regulatory authority. The minimum requirements and technical guidance included in the Manual can only become required through: (1) Ordinances and rules established by local communities; and (2) Permits and other authorizations issued by local, state and federal agencies. Adoption of either the Georgia Stormwater Management Manual – Volume 2 or an equivalent stormwater design manual is required for all municipalities covered under the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit.	Uses Unified Sizing Criteria Treat the runoff from 85% of the storms that occur in an average year. For Georgia, this equates to providing water quality treatment for the runoff resulting from a rainfall depth of 1.2 inches. Reduce average annual post-development total suspended solids loadings by 80%.	Non-structural stormwater control practices are increasingly recognized as a critical feature in every site design. As such, a set of stormwater "credits" has been developed to provide developers and site designers an incentive to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. The credit system directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities. The basic premise of the credit system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the water quality treatment volume (WQv). If a developer incorporates one or more of the credited practices in the design of the site, the requirement for capture and treatment of the water quality volume will be reduced. The better site design practices that provide stormwater credits are listed in Table 1.4.4-1. Site specific conditions will determine the applicability of each credit. For example, stream buffer credits cannot be taken on upland sites that do not contain perennial or intermittent streams. It should be noted that better site design practices and techniques that reduce the overall impervious area on a site already implicitly reduce the total amount of stormwater runoff generated by a site (and thus reduce WQv) and are not further credited under this system. For each potential credit, there is a minimum set of criteria and requirements which identify the conditions or circumstances under which the credit may be applied. The intent of the suggested numeric conditions (e.g., flow length, contributing area, etc.) is to avoid situations that could lead to a credit being granted without the corresponding reduction in pollution attributable to an effective site design modification. Site designers are encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area). Due to local safety codes, soil conditions, and topography, some of these site design credits may be restricted. Designers are encouraged to consult with the appropriate approval authority to ensure if and when a credit is applicable and to determine restrictions on non-structural strategies.

France

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
In France, infiltration or "zero discharge" (total infiltration) regulations adopted by some sewer networks operators are essentially intended to prevent floods and CSO, although national and regional agencies' guidance documents indicate that infiltration should generally be preferred for on-site pollution control. In 2009, the Water Agency Seine Normandie (AESN) entrusted the design office Urban component (hydrology and landscape) and LEESU (laboratory water environment and urban systems research) conducting a study on stormwater good management tools in urban areas. She was based on the observation that some devices, however widely criticized for more than ten years, continued to be used for any newly created parking. The study aimed to identify best the logic leading to these choices and the state of knowledge on contamination of runoff. It allowed the development of the French Stormwater Guidance Document for better control of pollution from the outset runoff. This document takes into account recent developments and regulatory environment on the one hand, and scientific and technical knowledge on the other, particularly with regard to hazardous substances. With this document, the Water Agency Seine Normandie makes available actors of urban development a methodological framework and elements information from studies and recent research to help meet the objectives of the SDAGE.	To control the flow of pollutant requires control of both the water quality and quantity to fully reduce pollutant levels. At equal concentrations, the amount of contaminants released into the environment receiving water during a rainfall event is directly proportional to the runoff volume. To limit the impact of discharges urban wet weather on shallow water environments, it is thus reducing the volume of runoff directed to network sanitation and likely to produce emissions. Management techniques upstream storm water, slowing the water transfer on the watershed and promoting longer contact water with permeable surfaces tend to reduce the volumes of runoff. Therefore, France recommends a target treatment design with zero discharge, or 4-16 mm, depending on the rainfall at the project site	**None found**

New Zealand – National and Christchurch

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
In 2001, many respondents made unprompted suggestions that a guideline was needed for better stormwater management throughout New Zealand, while more than two-thirds of respondents agreed with the proposition that a New Zealand guideline on comprehensive stormwater management was necessary. Plans were laid for NZWERF to carry out the project in 2003, funding was sought from a range of organisations during the year, and work on the project began in January 2004. Through the Minister for the Environment's Sustainable Management Fund and the other funding contributors listed earlier, NZWERF has produced this guideline to meet the needs – and concerns – identified in that 2001 survey. This guideline is part of a stormwater management resources programme being carried out by New Zealand Water Environment Research Foundation (NZWERF). The programme is made up of two components, the other one being the Stormwater directory of New Zealand. The Stormwater directory of New Zealand comprises an internet based, searchable database of stormwater information resources, such as guidelines and design manuals. Resources are listed in four main categories; regulations and legislation, catchment analysis, stormwater design and construction and asset management. A stormwater links page includes an education and research links section and an online form for adding and updating resources. The *Stormwater Directory of New Zealand* is available here: www.stormwaterdirectory.org.nz.	The ARC approach is to capture 75% of total suspended sediment on a long term average basis. This is the water quality objective of ARC TP 10 and is also the treatment objective of a number of overseas agencies (Seyb, 2001, *A revised stormwater treatment design methodology for the new TP10*, 2nd South Pacific Stormwater Conference 2001). The water quality design storm for the ARC method has been developed from detailed analysis of long term rainfall records at one rain gauge, which yielded a water quality design storm depth of 25 mm, equivalent to one third of the 2 year ARI daily rainfall at this location. The ARC method provides for the water quality design storm to be calculated for any location in the region by dividing the 2 year ARI daily rainfall at that location by a factor of 3. For the Auckland region the water quality design storm depths are: • range over the Auckland region: from 16.7 mm to 43.3 mm • most of the urbanised area: 26.7 mm The ARC method provides for using the water quality design storm together with catchment physical characteristics to calculate a 'water quality volume' for the catchment area contributing to a device. This method is calculated in TP108 (Auckland Regional Council, 1999, *Guidelines for stormwater runoff modelling in the Auckland region*, ARC Technical Publication No. 108) using the US Soil Conservation Service rainfall-runoff model, based largely on its Technical Release No. 55 (SCS 1986). The model takes into account rainfall losses based on ground cover and soil type. It also allows calculation of peak flows taking into account rainfall temporal pattern. Peak flows associated with the water quality design storm can be calculated for use in design of devices such as swales. ARC TP10 then stipulates in its design methodology for different devices: • the proportion of the WQV to be captured for ponds, wetlands, filters, rain gardens • a nominated hydraulic retention time for the water quality flow rate for swales.	Incentives: None Utilities: None Reuse: Rain tanks may be used for water quality purposes.

New Zealand - Auckland

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The Resource Management Act (RMA) sets up the statutory framework requiring stormwater discharge permits and is shown in Figure 1-1. Stormwater Discharge Permits are issued under section 15 of the RMA which controls the discharge of "contaminants or water into water". Activities which do not meet the permitted activity criteria of the Transitional Regional Plan and the proposed Regional Plan: Air, Land, and Water (ALW) require resource consents. Permitted activities allow the discharge of water to any land or water body from any development which has an impermeable surface area of less than 1000 square metres. When considering a resource consent application, the ARC must have regard to the policy set down in the Regional Plan: Air, Land, and Water and the Auckland Regional Policy Statement. The ALW Plan requires the "best practicable option" (BPO) to be implemented with respect to minimising the effects of stormwater discharges. The BPO will vary depending upon the discharge quality, site conditions, opportunities for mitigation, the downstream receiving environment values and technical and financial constraints. The RMA defines BPO as: To protect the human and ecological values attributed to receiving waters and to guide the selection of the BPO, the ARC uses three categories of stormwater management objectives which are set out in the proposed Regional Plan. These are: ➢ water quantity objectives, ➢ water quality objectives and ➢ aquatic resource protection objectives. Water quantity objectives generally relate to the protection of public safety from the flooding and erosion effects of stormwater. Water quality objectives protect downstream receiving waters from the physical-chemical effects associated with the accumulation of stormwater contaminants. Where the discharge is to a watercourse with high ecological value, aquatic resource protection objectives such as hydrological erosion control requirements or additional water quality measures may also be required.	An analysis of rainfall from the rain gauge at the Botanic Gardens at Manurewa arrived at a rainfall depth of 25 mm for Sd. In order to make allowance for the differences in location, the rainfall depth corresponding to the site location is obtained from Figures in the TP-10 manual, the 2 Year ARI Daily Rainfall Depth. Sd = (2 year 24-hour rainfall depth at site) /3 This rainfall depth is to be applied on a 24-hour event. The Stormwater Quality Design Storm, Sd, is the rainfall depth chosen from hydrological analysis of a rain gauge located in the Auckland Region that enables 80% of the runoff volume of all storms to be captured and treated.	None found

England

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
In England, the Government issues advice as Planning Policy Statements (PPSs), which update the former Planning Policy Guidance notes (PPGs). Government policy on SuDS is clear in PPS25. The document discusses the impact of new development on flood risk and advises that the restriction and reduction of surface water runoff should be encouraged via the implementation of SuDS. It recognises that SuDS can also contribute to good design in improving the amenity and wildlife interest of a development as well as encouraging infiltration and groundwater recharge. Scottish Planning Policy (SPP) 7) sets out some of the issues relating to planning and flood management and calls for the consideration of SuDS for all new development. The Scottish Executive Planning Advice Notes (PAN) 61 and PAN 69 also provide specific guidance and recommendations. For Wales, a revised Technical Advice Note TAN 15 provides further advice on the use of SuDS where appropriate and in Northern Ireland PPS 15 suggests that SuDS may be a useful tool in managing flood risk. Consideration needs to be given to the legal aspects of installing SuDS as opposed to conventional drainage facilities. All drainage (including SuDS) must comply with all relevant UK statutes, and designs should adhere to relevant codes of practice and available flood control and pollution prevention legislation and guidance. CIRIA publication C625 (Shaffer *et al*, 2004), provides a comprehensive review of legislation and guidance. A summary of some of the main documents relevant to SuDS is provided here. Compliance with the relevant environmental legislation is a vital consideration for all drainage systems, including SuDS. The environmental regulator controls pollution of controlled waters through the issue of authorisations, permits or consents, and any discharge of pollutants must be authorised by them in advance. In Scotland, the Water Environment and Water Services (WEWS) (Scotland) Act 2003 gave SEPA powers to introduce regulatory controls over activities to protect and improve Scotland's water environment. These regulatory controls – the Water Environment (Controlled Activities) (Scotland) Regulations (CAR) 2005 – mean that it is an offence to discharge to any wetlands, surface water systems, and groundwater systems without a CAR authorisation (replacing the Control of Pollution Act 1974).	Good site design does not allow runoff from impermeable surfaces to pass to the river for the range of smaller, polluting events (at least 5 mm, preferably 10 mm). This is likely to be through the use of infiltration techniques that treat smaller events via filtration through the soil and discharge them to groundwater. Rainwater harvesting can also be used. Ponds can provide significant water quality improvements by capturing small events which allow the settling out of fine silts and promote plant and microbial activity to encourage adsorption and biodegradation of contaminants and nutrient removal. The permanent pond volume is effectively the volume of water that remains in ponds during the dry weather periods between rainfall events. It is often known as the Water Quality Treatment Volume (or Vt) and should be sized to accommodate at least 10 mm of runoff from the impermeable surfaces (see Section 4.5.6 for calculation details), although this can be reduced where upstream treatment components are part of the SuDS management train.	Incentives: none Utilities: none Reuse: The size of a storage tank to provide effective stormwater management as well as provision for reuse is dependent on the same factors, with additional storage provided based on the design storm to be served. An indicative volume for the stormwater component is 2 m^3 for a standard house. The effectiveness of the stormwater management will depend on all the factors above and can only be assessed using a time series approach. There is a need to provide an overflow to cater for excess inflows. In addition, a facility to flush out floating debris is useful.

Netherlands

Regulations/Policy	Control Criteria	Incentives, Utilities, and Water Reuse
The vision of rainwater policy is based on the policy regenwater1 and the national water plan. It contains for rainwater policy five central pillars: 1. Approach to the source; preventing contamination of rainwater; 2. Rainwater beneficial reuse fit into the space as an added value for experience / greening 3. Rainwater retention / infiltration and mountains (and then drain); 4. Rainwater separate disposal of waste water; 5. Comprehensive assessment at local level. The Municipal Water Act and the Water Task his land owner and municipality primary task managers to shape this policy. Executive (BWK) is a strong emphasis on working together in the field of stormwater. The new Water Act extends to the entire water field (Article 3.8). This licensing process between governments fades into the background and enforcement seen as a final safety net. Another organization of (waste) water will be shaped in the coming period. http://www.aaenmaas.nl/binaries/content/assets/am---website/over-aa-en-maas/beleid/hemelwater/beleidsnota-hemelwater.pdf	For stormwater quantity design, there are two options for the storage of different types of stormwater systems the values as listed below: • Wastewater System (Joint) will not connect. Design targets are 9 mm (minimum), 15 mm (preferred) • Rainwater System. Design targets are between 2 and 4 mm	None found

European/ International Jurisdictions

Although volume based stormwater management targets and criteria could not be identified for European and international jurisdictions, these jurisdictions complement the Canadian and U.S. examples by illustrating the range of stormwater management practices still in use. Stormwater management ranges from the very cutting edge of sustainable urban drainage to traditional on-site detention strategies. The following jurisdictions have been included for information only.

For example, sustainable urban drainage as applied in Malmö, Sweden demonstrates thoughtful and often beautiful integration of stormwater management practices in existing urban areas. It provides an example of what new regulation by the MOECC could create. Sustainable urban drainage could be used to inspire communities in Ontario to think critically about how to manage stormwater. Although some would argue stormwater management systems based entirely on detention strategies is inadequate, the MOECC may still learn valuable lessons from the Upper Parramatta example. For instance, the MOECC could require a plan similar to a Stormwater Concept Plan as the first step in any development application. This guarantees applicants systematically consider stormwater management. This could be improved by tailoring the submission requirements to reflect the values of Ontario's peoples, and to address the needs of particular water bodies, like Lake Ontario and Lake Simcoe.

City of Malmö, Sweden – Blue-Green Fingerprints

The concept of sustainable urban drainage was introduced in the city of Malmö in the late 1980s. Over the next two decades the new drainage concept gradually developed and was further refined. In a nutshell, Malmö attempted to transition from a traditional urban drainage system comprised almost entirely of buried pipes and stormwater ponds, to sustainable urban drainage in open systems and multi-functional eco-corridors. This transition applied both to the physical planning and to technical configurations.

The defining characteristic of sustainable urban drainage is the attempt to address the quantity and quality aspects of stormwater runoff together, while also addressing the various social aspects of urban drainage. Instead of thinking of stormwater as an unwanted result of development, it is considered a valuable resource created by the urban landscape. Sustainable urban drainage can enrich an urban community by adding values such as recreational value, aesthetic value, biological/zoological value, and ecological value. Planning sustainable urban drainage is thus a multi-disciplinary, long-term process.

In Malmö, stormwater management is handled by Malmö Water, a division of the publically controlled regional organization VA SYD. Sustainable drainage gained international notoriety, and local acceptance after the integrated park and drainage facility—Toftanas Wetland Park—was constructed. The concept gained support and was incrementally improved in the 1990s. At the end of the decade, the city began the process of drafting a stormwater policy that incorporated the sustainable drainage concept. The basic principles of the policy provided a foundation for general goals for the management of stormwater in Malmö:

- The natural water balance shall not be affected by urbanization;
- Pollutants shall, to the extent possible, not be permitted to enter urban runoff;
- The drainage system shall be designed to avoid overflow and downstream flooding;
- The drainage system shall be designed to remove at least part of the pollutants from the runoff before it reaches the receiving waters; and
- Stormwater should be considered a positive resource in the urban landscape.

The policy presumes extensive cooperation will occur between the City's technical departments and other stakeholders during the stormwater planning process. The sustainable drainage

policy was followed by more detailed stormwater directives in 2008. The directives were intended to serve as a continuously updated communication platform—a living document—for all actors involved in the planning and design of drainage facilities. The directives established unambiguous roles and responsibilities for every phase in planning, constructing, and maintaining stormwater and drainage facilities. The directives categorize stormwater types by the pollutant characteristics and treatment requirements. Similarly, receiving waters are categorized based on location and volume of flows.

The directives resulted in a number of innovative, effective, and conceptually fascinating stormwater management facilities. A few examples are drainage corridors that provide habitat for flora and fauna as well as pre-treatment and flow equalization; functional green roofs and constructed wetlands that provide not only retention value but also educational opportunities for school children; a “cube canal” with concrete features designed to slow water transport, provide space for aquatic vegetation to grow, and add recreational and aesthetic values to the mouth of a constructed wetland; and conveyance facilities integrated into public spaces as works of art.

On-Site Stormwater Management Guideline, New Zealand Water Environment Research Foundation (2004)

This guideline aims to provide design professionals with the information they need or appropriate sources to select and design appropriate on-site stormwater management devices for any given application in New Zealand. It overviews on-site stormwater management concepts in order to provide a sound basis for selecting and designing specific devices, based on a review of New Zealand and overseas precedents and use or adaptation of these to reflect New Zealand wide needs. The guideline recommends step-by-step design procedures for a range of commonly used devices where it was thought most useful to consolidate and clarify the Section 1: Background, scope and aims of this guideline design issues. Where this information is already well known and/or available elsewhere, such as for oil and water separators or proprietary devices, it refers to the relevant sources.

Regional variations in natural and institutional conditions mean that the individual designer needs to make an informed choice of device, based on the guidance given, in order to meet the needs of his or her general geographical area and the particular site. Wherever possible, the guideline spells out what background assumptions are known and not known about various devices and design methodologies in order to enable users to use different assumptions if desired. The guideline also provides a useful consolidated summary of information about on-site stormwater management in the New Zealand context, as well as highlighting areas where perhaps more work can usefully be done.

APPENDIX B – BAY STATES (US) STORMWATER PROGRESS SUMMARY

Figure 1: Key to Bay Stormwater Assessment	
	The tool is churning out BMPs for the Bay
	The tool is now in place
	The tool is on track to be used
	The tool needs significant improvement
	The tool either doesn't exist or work
	The tool does not apply in the state
Note: the color variations (lighter/darker) indicate uncertainty in tracking.	

Table 1: Bay States' Stormwater Status, Circa 2006							
CORE TOOL	DC	DE	MD	PA	NY	VA	WV
Local WIPs for Bay TMDL							
Large MS4 Permits							
Small MS4 Permits							
Regs for New Development							
Regs for Redevelopment							
Stormwater Manual							
Fertilizer P Ban							
Industrial Permits							
Construction Permits							
Permit Enforcement							
Local/ State Financing							

Table 2: Bay States' Stormwater Progress, Circa 2014							
CORE TOOL	DC	DE	MD	PA	NY	VA	WV
Local WIPs Bay TMDL							
Large MS4 Permits							
Small MS4 Permits							
Regs for New Development							
Regs for Redevelopment							
Stormwater Manual							
Fertilizer P Ban							
Industrial Permits							
Construction Permits							
Permit Enforcement							
Local/ State Financing							

Table 3: Forecasted Bay States' Stormwater Progress by 2017-2025							
CORE TOOL	DC	DE	MD	PA	NY	VA	WV
Local WIPs Bay TMDL							
Large MS4 Permits							
Small MS4 Permits							
Regs for New Development							
Regs for Redevelopment							
Stormwater Manual							
Fertilizer P Ban							
Industrial Permits							
Construction Permits							
Permit Enforcement							
Local/ State Financing							

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[i] Minn. Stat. § 115.03 subd. 5c (2009); this section states: "The agency [MPCA] shall develop performance standards, design standards, or other tools to enable and promote the implementation of low-impact development and other stormwater management techniques. For the purposes of this section, "low-impact development" means an approach to storm water management that mimic's a site's natural hydrology as the landscape is developed. Using low-impact development approach, storm water is managed on-site and the rate and volume of predevelopment stormwater reaching receiving waters is unchanged. The calculation of predevelopment hydrology is based on native soil and vegetation."

[ii] Barr Engineering, Assessment of MIDS Performance Goal Alternatives: Runoff Volumes, Runoff Rates, and Pollutant Removal Efficiencies, (June 30, 2011) *available at* **http://www.pca.state.mn.us/index.php/view-document.html?gid=15664**.

[iii] *Id*.

[iv] See "Minnesota Stormwater Manual - Communities that Adopted MIDS, at **http://stormwater.pca.state.mn.us/index.php/Community_Assistance_Package;** Since MIDS was released in 2013, four watershed districts, one water management organization, and two cities have adopted MIDS.

[v] 40 CFR 130.2 and 130.7 *available at* **http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol18/pdf/CFR-2002-title40-vol18-sec130-2.pdf**.

[vi] U.S. Environmental Protection Agency. 1991. Guidance for Water Quality-based Decisions: The TMDL Process. EPA 440/4-91-001. Office of Water, Washington, D.C. *available at* **http://water.epa.gov/scitech/datait/models/upload/1999_11_05_models_SASD0109.pdf**.

[vii] D.C. Mun. Regs. Tit. 21, § 500 *et seq. available at* **http://www.dcregs.dc.gov/Gateway/ChapterHome.aspx?ChapterNumber=21-5**.

[viii] Much of the description of the D.C. stormwater rule is adapted from various facts sheets available online, including D.C. Dept. of Energy & Envt., *Stormwater Rule Fact Sheet*, **http://sustainable.dc.gov/release/district-establishes-new-river-protecting-stormwater-management-standards**.

[ix] Delaware Dept. of Nat. Resources & Envt. Control – **Sediment and Stormwater Management program**; Maryland Dept. of the Envt. – **Stormwater Management Program**; New York Dept. of Envt. Conservation – **Stormwater Management Design Manual**; Pennsylvania Dept. of Envt. Protection - **Bureau of Point and Non-Point Source Management**; Virginia Dept. of Envt. Quality - **Stormwater Management and Nonpoint Source Pollution Control Programs**; West Virginia Dept. of Envt. Protection – **Stormwater Program**,; Federal facilities.

[x] See Chesapeake Stormwater Network: **http://chesapeakestormwater.net/**; The Chesapeake Bay Program: **http://www.chesapeakebay.net/**; Chesapeake Bay Founation: **http://www.cbf.org/**; are just a few that have collected and published information regarding stormwater management practices in the Bay watershed.

[xi] More information about unified sizing criteria can be found at **http://stormwater.pca.state.mn.us/index.php/Unified_sizing_criteria**.

[xii] According to DDOE (2014), "PROW is defined as the surface, the air space above the surface (including air space immediately adjacent to a private structure located on public space or in a PROW), and the area below the surface of any public street, bridge, tunnel, highway, railway track, lane, path, alley, sidewalk, or boulevard, where a property line is the line delineating the boundaries of public space and private property" (p. B-1)

[xiii] According to the DDOE (2014), "Maximum extent practicable, or "MEP," is the language of the Clean Water Act that sets the standards to evaluate efforts pursued to achieve pollution reduction to United States waterbodies. MEP

[xiv] This threshold (disturbance of 5,000 ft^2) has been a trigger for stormwater management BMPs since stormwater management regulations were first established in 1988.

[xv] These are projects that do not fall under the two categories that trigger mandatory compliance with the stormwater rules—projects that are not major land-disturbing activities, or major substantial improvement projects.

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