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Final Report
Study on Identification and Characteristics of Sewer Overflows in Newfoundland and Labrador

February 20, 2012

Prepared For: Water Resources Management Division – NL Department of Environment and Conservation

EXECUTIVE SUMMARY

Reliable data collection was dependent, to a large extent, on the field program which relied on surveys, questionnaires, field visits and interviews with key town staff and management. Some information gaps remain, but the data collection and organization efforts have resulted in a good understanding of the infrastructure and conditions that exist throughout the Province as it relates to sewer overflows and sewage treatment bypasses throughout Newfoundland and Labrador (NL).

On February 17, 2009, the *Canada-Wide Strategy for the Management of Municipal Wastewater Effluent* (MWWE strategy) was endorsed by the majority of Ministers that comprise the Canadian Council of Ministers of the Environment (CCME). While NL did not sign or endorse the MWWE strategy, the proposed *Wastewater Systems Effluent Regulations* (WSER) under the federal Fisheries Act are based on the MWWE strategy and will be applicable to NL when it officially becomes law. The MWWE strategy includes proposed national standards for CSOs and SSOs, as well as overflow objectives to protect the beneficial uses of the receiving environment.

The proposed WSER describes how the allowable timeframe for communities to achieve compliance with the proposed regulations is based on the allocation of points relating to its overflow risk characterization for combined sewers as set out in Schedule 4 of the regulations. However, most communities in NL have very little information regarding historical frequency and volume of CSO events, making accurate determinations of risk level (as per the WSER classifications) very difficult to generate.

Risk levels for each CSO outfall in NL were calculated based on the updated criteria/system of points as per Schedule 3, Subsection 24(2), Subsection 25(1) and 26(2) of the proposed WSER. These CSO point scores have been included as an additional field in the sewer overflow database and have been used (in conjunction with other information gathered and prepared by this study) to prioritize the implementation of CSO control measures across the Province. CSO risk assessment scores for communities in NL range from 35 to 80, with most outfalls having scores in the range of 40 to 60 with CSO frequency generally accounting for most of the total scores. The highest priority locations for remediation are the CSO outfalls in Port-aux-Basques, Gander and St. Lawrence.

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Data on actual measured sewage flow rates in dry and wet weather was generally not available from the communities, making it very difficult to accurately quantify the contribution to sewers from such secondary sources during dry and wet conditions, and provide an accurate estimate of the scale of deviation (increase) from average wastewater flows during wet weather conditions. As a result, the assessment of the conditions/causes of sewer overflows was necessarily more qualitative than quantitative.

There are a variety of available CSO and SSO control technologies including source control measures, sewer system controls, high rate treatment systems, floatables control measures, disinfection methods and odour control measures. Source controls used to manage wet weather flow through infiltration, evapotranspiration and rainwater harvesting are increasingly referred to as 'green infrastructure' and is an approach to WWF management that is cost-effective, sustainable and environmentally friendly. 'Green infrastructure' is gaining wider acceptance for CSO control.

The NL 'Guidelines for the Design, Construction and Operation of Water and Sewage Systems' (ENVC, 2005) provide detailed guidance on the design, construction, operation and maintenance of sanitary sewage collection (and treatment) systems, but additional guidance is required for remedial measures to reduce and/or eliminate discharges from existing CSOs and SSOs. Key elements missing from the current guidelines include the definition of objectives or targets for reducing the volume, frequency and/or mass of pollutants from existing CSO and SSO outfalls in the Province. Also, there is little or no information on the planning, design, operation and maintenance of strategies or technologies to control CSOs and SSOs. Other jurisdictions and organizations have developed detailed regulations, procedures and guidance documents for CSO and SSO control that can be readily applied to CSO/SSO control in NL.

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1.0 BACKGROUND & INTRODUCTION

1.1 Introduction

Combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and sewage treatment plant bypasses all pose a significant threat to human health and the environment in Newfoundland and Labrador (NL). The Department of Environment and Conservation (ENVC) in collaboration with other stakeholders has recognized this threat, and together with the Department of Municipal Affairs (DMA) issued a Request for Proposals (RFP) in May 2010 to undertake a comprehensive inventory and characterization of sewer overflows in NL.

Newfoundland and Labrador, like most coastal jurisdictions in Canada, can be described as having limited or no wastewater treatment infrastructure. On a national level, wastewater management is a shared jurisdiction and there have been different approaches and/or perspectives with respect to regulatory requirements and treatment. At least in part, the May 2010 RFP was issued in response to the 2009 Canadian Council of Ministers of the Environment (CCME) *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (MWWE Strategy) and the proposed *Wastewater System Effluent Regulations* (WSER) under Section 36(3) of the Fisheries Act.

In June, 2010, ENVC contracted Hatch Mott MacDonald (HMM) to complete an inventory and characterization of sewer overflows in Newfoundland and Labrador.

1.2 Study Objectives

The main objectives of the study include:

- Identification of location of CSOs and SSOs on public wastewater collection systems in NL;
- Identification of the location of wastewater treatment plant (WWTP) bypasses;
- Identification of the location of sewage lift stations associated with sewer overflows;
- Creation of a database of individual CSOs, SSOs, WWTP bypasses and sewage lift stations and associated characteristic information;
- Creation of a GIS layer of individual CSOs, SSOs, WWTP bypasses and sewage lift stations and associated characteristic information;
- Risk characterization of CSOs as per Schedule 4 of proposed *Wastewater System Effluent Regulations;*

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- Determination of the cause of overflows or reasons for bypassing at WWTPs; and,
- Review of the *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* for requirements relating to sewer overflows, WWTP bypasses and sewage lift stations and provision of recommendations for improved design, construction and operation.

1.3 Background Information

Combined Sewer Overflows (CSOs)

The first drainage systems were built to carry storm water runoff away from populated areas. Discharge of fecal matter and other wastes to these systems was forbidden well into the 19th century, and combined sewers were 'invented' when communities began to admit these wastes into the existing storm sewers. The next step in the evolution of combined sewer systems (CSS) was the construction of large interceptor sewers to collect and convey sanitary dry weather flow (DWF) from the CSS to wastewater treatment plants (WWTPs) that were being built to treat wastewater.

The decision to collect only DWF, along with a small portion of wet weather flow (WWF) was based on a combination of economics and the understanding of environmental factors at the time. Typically, CSS were designed to capture between 3 to 5 times DWF rates, and the prevailing belief was that CSOs were dilute enough to have minimal impact on the receiving waters. We know now that this is not the case, and that CSOs can significantly impact the environment.

CSOs contain untreated wastewater and storm water, and contribute microbial pathogens and other pollutants to surface waters. CSOs can cause or contribute to:

- water quality impairments;
- beach closures;
- contamination of drinking water supplies; and,
- Elevated pollutant concentrations in receiving waters, which may be sufficient to cause water quality standards violations, which may in turn prevent beneficial uses such as swimming, boating, and fishing.

Combined sewer systems were popular in the late 1800s and into the early 1900s when little or no wastewater treatment was required or provided, and populations were smaller. The construction of new combined sewers in Canada was prohibited by the mid 1970s, and currently no jurisdiction in

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Canada allows new combined sewers or combined sewer extensions to be built. However, many older municipalities in Canada are still at least partially serviced by combined sewer systems, including the following seven (7) communities in Newfoundland and Labrador:

- The City of St. John's (Eastern Region). St. John's has three (3) existing CSO outfalls, which discharge into St. John's Harbour. The City is in the process of implementing its Harbour Cleanup Program, which will provide control of these CSOs.
- The Town of Harbour Grace (Eastern Region) discharges into Conception Bay. Harbour Grace has one (1) existing CSO overflow, but of the 14 outfalls it is unknown how many are discharging combined sewage.
- The Town of St. Lawrence (Eastern Region). St. Lawrence has two (2) existing CSOs discharging to different outfalls, which both discharge into Great St. Lawrence Harbour.
- The Town of Springdale (Central Region). Springdale has one (1) existing CSO overflow which discharges into Indian Brook Arm.
- The Town of Gander (Central Region). Gander has four (4) existing CSOs, which all connect into one (1) sewer outfall which discharges to an unknown water body.
- The Town of Channel-Port aux Basques (Western Region). Channel Port aux Basques has one (1) existing CSO outfall which discharges into Rat Island Cove.
- The City of Corner Brook (Western Region). Corner Brook has two (2) existing CSO outfalls, which discharge into the Humber Arm along its southern shore.

Table 1-1 - Regional Distribution of CSOs

Region	Community	No. of CSOs
Eastern	St. John's	3
	Harbour Grace	1
	St. Lawrence	2
Central	Springdale	1
	Gander	4
Western	Channel-Port aux Basques	1
	Corner Brook	2
Labrador	None	N/A

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Sanitary Sewer Overflows (SSOs)

Eighty-three (83) communities in NL report having SSOs. There are eighteen (18) communities on the island, which HMM did not get information from.

Table 1-2 - Regional Distribution of SSOs

Region	Communities Completed	No. of SSOs
Eastern	Arnold's Cove	3
	Bay de Verde	1
	Bonavista	2
	Burin	6
	Carbonear	1
	Clarenville	4
	Conception Bay South	11
	Hant's Harbour	1
	Harbour Grace	1
	Heart's Content	3
	Heart's Delight-Islington	1
	Holyrood	4
	Lamaline	1
	Marystown	1
	New Perlican	1
	Old Perlican	5
	Petty Harbour-Maddox Cove	3
	Port Blandford	2
	Portugal Cove-St. Phillips	1
	Pouch Cove	1
	Red Harbour	2
	Spaniards Bay	3
	Torbay	2
	Trinity Bay North	5
	Upper Island Cove	1
	Victoria	1
	Subtotal:	67
Central	Campbellton	1
	Centerville-Wareham-Trinity	6

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Table 1.2 – Regional Distribution of SSOs Cont'd		
	Comfort Cove-Newstead	2
	Conne River	8
	Cottlesville	1
	Dover	3
	Embree	2
	Fogo	6
	Gambo	5
	Gander	3
	Glovertown	5
	Grand Falls-Windsor	2
	Greenspond	1
	Hare Bay	1
	Indian Bay	1
	Joe Batts Arm-Barr'd Island-Shoal Bay	1
	King's Point	2
	Leading Tickles	1
	Little Burnt Bay	2
	Lumsden	1
	Milltown-Head of Bay D'Espoir	1
	Musgrave Harbour	2
	New-Wes-Valley	1
	Norris Arm	3
	Peterview	1
	Pilley's Island	4
	Point Leamington	6
	Springdale	2
	St. Alban's	10
	Summerford	5
	Triton	3
	Twillingate	10
	Subtotal:	102
Western	Burnt Islands	1
	Channel-Port aux Basques	2
	Cow Head	3
	Englee	1
	Fleur de Lys	1

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Table 1.2 – Regional Distribution of SSOs Cont'd		
	Main Brook	1
	Meadows	1
	Ming's Bight	2
	Norris Point	6
	Pacquet	2
	Port au Choix	2
	Rocky Harbour	3
	Roddickton-Bide Arm	4
	St. Anthony	2
	St. George's	3
	St. Lunaire Griquet	1
	Steady Brook	4
	Trout River	4
	Woodstock	1
	Woody Point	3
	Subtotal:	47
Labrador	Mary's Harbour	5
	Rigolet	1
	Subtotal:	6
	GRAND TOTAL FOR NL:	222

The completion of the above tasks required the collection, review and organization of a significant amount of data and information pertaining to the Province's CSOs, SSOs, WWTP bypasses, and sewage lift stations associated with sewer overflows. The results are based on available data, findings of telephone interviews with, and questionnaires/surveys sent to municipal wastewater collection system staff in NL communities; and site visits to NL communities.

Sources of information utilized during the course of the study include, but are not limited to, the following:

- Canada Wide Strategy for the Management of Municipal Wastewater Effluent;
- Proposed Wastewater System Effluent Regulations;
- Guidelines for the Design Construction and Operation of Water and Sewage Systems;
- Newfoundland and Labrador Water Resources Web Portal;
- Water Resources Management Division web site;

- ENVC Outfall Database;
- ENVC Wastewater Treatment System Database;
- ENVC Community Water and Wastewater Design Spreadsheets;

Other sources of information that were useful during the study included:

- DMA Municipal Infrastructure Databases;
- Regional staff with ENVC;
- Regional staff with DMA;
- Management and operations personnel at the Municipal level;
- Other Consultants;
- Equipment Suppliers, i.e. ITT Flygt; and,
- AWWA, WEF, USEPA publications.

HMM compiled sewer overflow data and information available from different sources and developed a detailed plan for the collection of additional data identified in Annex A-D of the RFP.

1.4 Contents of Report

This Study Report is divided into the following key sections:

1) Background & Introduction;
2) Sewer Overflow Data Collection;
3) Sewer Overflow Data Organization;
4) Risk Characterization of CSOs;
5) Assessment of Conditions/Causes of Sewer Overflows;
6) Review of CSO Control Technologies & Approaches;
7) Review of Newfoundland and Labrador Design Guidelines; and
8) Conclusions and Recommendations.

2.0 SEWER OVERFLOW DATA COLLECTION

2.1 Review of Existing Information and Data

The first phase of the data collection process was to gather sewer overflow data and information from existing sources. ENVC furnished a number of report/studies that were reviewed in detail prior to commencing with the field data collection efforts throughout the province. The value of the information contained in these reports/studies was somewhat limited, and it was recognized that the field data collection process would be crucial to fill significant data gaps. The field program focused on the location, type and characteristics of sewer overflows.

2.2 Data Collection and Methodology

The initial step in the field data collection process was the distribution of a questionnaire to all Towns which own and operate wastewater collection systems. In getting the Towns to complete and return this questionnaire, it provided valuable information on how many locations that would need to be visited in each region. There were a number of towns in each region that did not respond despite our repeated attempts. Refer to Table 2.1 for a summary of non-respondent Towns.

The field program involved making arrangements to meet with a designated Town employee and visit the location of the overflows. Mapping was used in the field to help locate the outfall that was associated with each SSO/CSO. The mapping was later used in the office in conjunction with the Water Resources Map Viewer to determine the appropriate outfall ID for each lift station. Data collected included a geo-referenced location on the overflow, the overflow discharge point, as well as pictures of the receiving environment, the outlet of the overflow, and the lift station. The length of the overflow pipe was field measured where possible, but in some cases where the discharge point of the overflow was not known, the lift station was opened to determine the size/diameter of the overflow pipe.

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2.3 Summary of Data Collection Results

2.3.1 Eastern Region

Throughout the eastern region, HMM completed an analysis of twenty-seven (27) towns. Of the twenty-seven (27) towns, only St. John's, Harbour Grace and St. Lawrence had CSOs. Six (6) had a WWTP with bypass including Conception Bay South, Holyrood, Portugal Cove-St. Phillips, Whitbourne, Marystown and Victoria. Of all the Towns in the eastern region that responded to our surveys/questionnaires, five (5) had overflows that HMM was unable to visit or arrange a time to meet including Brigus, Southern Harbour, Wabana, Trepassey and Terrenceville.

2.3.2 Central Region

Throughout the central region, HMM completed an analysis of thirty-two (32) towns. Seven (7) had a WWTP with bypasses including Centerville-Wareham-Trinity, Conner River, Gambo, Gander, Grand Falls-Windsor, Lumsden and St. Albans. Gander and Springdale have CSOs. Of all the towns in the central region that responded to our surveys/questionnaires, there were six (6) which HMM was unable to visit or arrange a time to meet including Bishop Falls, Beachside, Little Bay, Little Bay Islands, Millertown and South Brook.

2.3.3 Western Region

In the western region, HMM completed an analysis of twenty-one (21) towns. Only Corner Brook and Channel Port aux Basques has CSOs. For the towns in the western region that responded to our surveys/questionnaires there were three (3) Towns that we were unable to visit or arrange a time to meet including Irishtown-Summerside, Ramea and Stephenville.

2.3.4 Labrador

The response to our questionnaire in the Labrador region has been poor. Database spreadsheets are completed for Mary's Harbour and Rigolet.

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Table 2-1 - Non-Respondent Towns

Region	Community
Eastern	0
Central	7
Western	1
Labrador	10

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3.0 SEWER OVERFLOW DATA ORGANIZATION

3.1 Data Organization Methodology

The database spreadsheets for the SSO/CSOs, WWTP by-passes and the SLSs were populated with information gathered in the field and then finished with some additional desk-top work back in the office. Most of the information was gathered during the field visit with the exception of some form of identification for each lift station and overflow. The system used for identifying the Lift Station SSO/CSO on the database spreadsheets and filenames for each photo is as follows:

- Sewage by-pass: LGP# - outfall# - SBP
- Lift Station: LGP# - outfall# - LS – number
- Overflow: LGP# - outfall# - SO – either S (Sanitary) or C (Combined) - number
- Photo: Community name – number– LS/SSO (whatever appropriate)-number

Lift stations and overflows are numbered sequentially starting from those nearest to the outfall and working back up the collection system. Each lift station associated with an overflow share the same lift station ID numbers and the same SSO/CSO ID numbers on the database sheets, so when the sheets are developed into a GIS database the two will be connected.

3.2 Updated Sewer Overflow Database

The database spreadsheets are provided in Appendix A.

3.2.1 Eastern Region

For the eastern region the feedback on the questionnaire was excellent. All the Towns in the eastern region responded to the questionnaire. Generally, the municipalities were very accommodating, with only a few exceptions.

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3.2.2 Central Region

In the central region, the feedback for the questionnaire was not quite as good. There were seven (7) Towns which did not respond, or HMM could not contact. HMM visited the Bishop Falls Town Hall on several occasions, but they were never available. Visits were also done in South Brook and Little Bay but the Town Hall had been closed at the time of visit, and HMM was unable to locate the sewer overflows.

3.2.3 Western Region

For the western region the feedback from the questionnaire was poor. HMM had to work the phones frequently to gather the information needed to determine which Towns had sewer overflows. After much persistence, there was one (1) Town which HMM could not contact. As for the site visits, in the western region HMM would only meet with a representative from the Town if the lift stations with overflows could not be found.

3.2.4 Labrador

For the Labrador region, the feedback from the questionnaire was poor, with HMM receiving responses from thirteen (14) Towns out of twenty-four (24). The database sheets for two (2) Towns (Rigolet and Mary's Harbour) was completed from information that HMM had on file. Based on the survey and anecdotal information from the regional office of DMA in Happy Valley-Goose Bay, indicating that there are nine (9) towns in the Labrador region which have sewer overflows.

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4.0 RISK CHARACTERIZATION OF COMBINED SEWER OVERFLOWS

4.1 Background and Methodology

CSOs and SSOs contain untreated wastewater and storm water, and contribute microbial pathogens and other pollutants to surface waters. CSOs and SSOs can cause or contribute to:

- water quality impairments;
- beach closures;
- contamination of drinking water supplies; and,
- elevated pollutant concentrations in receiving waters, which may be sufficient to cause water quality standards violations, which may in turn prevent beneficial uses such as swimming, boating, and fishing.

Average CSO and SSO bacteria concentrations may be several thousand times greater than WQS criteria, and receiving waters may lack sufficient dilution or assimilative capacity. Microbial pathogens and toxins can be present in CSOs and SSOs at levels that pose risks to human health. Human health impacts occur when people become ill due to contact with water or ingestion of water or shellfish that have become contaminated by CSOs and SSOs. Basement flooding within sanitary and combined sewer systems provides a direct pathway for human contact with untreated wastewater.

In the USA, 828 NPDES permits authorize discharges from over 9,300 CSO outfalls in 32 states, and the EPA estimates the CSO volume discharged annually in the USA is approx 850 billion gallons, or approx 3.4 billion m^3. The EPA estimates that between 23,000 and 75,000 SSO events occur per year in the USA, with a total annual volume of 3 to 10 billion gallons, or 12 to 40 million m^3. Recent CSO occurrence and volume estimates are unavailable for Canada or Newfoundland and Labrador, but annual CSO volumes are likely to be in the hundreds of millions of m^3 across Canada.

A key factor influencing CSO pollutant concentrations includes the relative amounts of domestic, commercial, and industrial wastewater and urban storm water present in the CSS during a specific wet weather event. Some other factors that contribute to variability of pollutant concentrations include the elapsed time since wet weather began (with higher pollutant concentrations expected in early stages of an event (often referred to as the ‘first flush’ effect); the time since the previous wet weather event (with higher concentrations expected after longer dry periods); and the intensity and duration of wet weather events. The first flush effect can occur when pollutants are washed from streets and parking lots combine with pollutants re-suspended from settled deposits within the CSS, and are typically observed during first 30-60 minutes of a CSO discharge.

The costs of controlling CSOs are very significant. The EPA estimated future capital needs for CSO control in the USA at $50.6 billion (2000 dollars), based on current LTCPs and CSO planning documents, and a model used to estimate missing costs. Similar estimates do not exist for Canada or Newfoundland and Labrador, but CSO control costs across Canada will certainly be in the billions, or possibly tens of billions of dollars.

Some specific impacts of CSOs are discussed further below:

Human Health

- CSOs and SSOs contain pathogens, including viruses, bacteria, worms and protozoa. Diseases resulting from enteric pathogens range from stomach flu and upper respiratory infections to potentially life-threatening illnesses such as cholera, dysentery, Hepatitis B, and cryptosporidiosis. Children, the elderly, and people with suppressed immune systems face added risk of contracting serious illnesses.
- Health related impacts can occur from swimming in open water, drinking from a contaminated water supply, eating contaminated fish or shellfish, or from exposure to sewage from basement flooding.

Recreation

- Contamination from CSOs and SSOs closes hundreds of beaches each year, often several times per year, and for extended periods of time.
- Contamination of fisheries by CSOs and SSOs reduces their productivity, negatively impacting sport fishing and the economic benefits it also provides.

Natural Resources

- CSOs and SSOs can contain high levels of floatables, pathogenic micro organisms, suspended solids, oxygen-demanding organic compounds, nutrients, oil and grease, toxic contaminants and other pollutants.

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- CSOs and SSOs contribute pathogens, nutrients and metals to rivers, streams and estuaries, causing hypoxia, harmful algal blooms, habitat degradation, floating debris, and impacts to threatened or endangered species.

Damage to Public and Private Property

- CSOs and SSOs can also cause private basement backups. In addition to the problem of human exposure to sewage, these spills can cause structural damage to building frames and foundations, and water damage to appliances typically located in the basement (e.g. furnaces, water heaters, washers, dryers and refrigerators). They can also damage floor and wall coverings and personal property. SSOs can frequently spill into homeowner's yards, damaging landscaping, driveways and outside possessions.
- Municipal property damage from major CSO or SSO events can be severe. Communities in North America pay billions per year to clean up and repair CSO/SSO damage to sewer infrastructure, roads and other transportation assets, parks and recreation areas, and municipal water supplies and treatment facilities.

Other Economic Impacts

- CSOs and SSOs can significantly impact shell fish beds and fisheries. The primary basis for harvest restriction is the concentration of bacteria typically found in sewage. Closures can have a devastating impact on local economies.
- Commercial and recreational fishing suffers when CSOs and SSOs impact fishing waters. Polluted water creates lowered fishery productivity, reduced volume and more costly harvests, and weakened consumer confidence. These impacts on the fishing industry also impact local economies in coastal regions. Each year, commercial fishing enterprises in North America spend millions on boats, motors, docking fees, fuel, etc. Industry cutbacks mean loss of income to local service providers in small fishing communities that have grown up around the fishing industry and have few other employment replacement options. They also lead to a reduction in the food supply, which leads to higher prices for consumers and more imports.
- Manufacturers need access to adequate wastewater collection and treatment facilities in order to sustain or increase production. In communities that are experiencing capacity problems

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and/or CSOs and SSOs, manufacturers may not be able to obtain increased sewage discharge limits needed to expand their operations, forcing them to relocate.

- Property with access to surface water is worth more to homeowners and businesses if the water is perceived to be of high quality, but neighbourhoods that experience chronic CSOs or SSOs or perceived impairments to water quality from them will drop in value.

Implications for Small Communities

- Many small communities have limited resources for public works projects and limited access to technical resources that are needed to completely eliminate CSOs and SSOs.

4.1.1 Risk Characterization Methodology

Sections 21(5), 22, 23(2) of the proposed Wastewater Systems Effluent Regulations (WSER) published in the Canada Gazette Part I (Vol. 144, No. 12 – March 20, 2010) describe how the allowable timeframe for communities to achieve compliance with the proposed regulations is based on the allocation of points relating to its overflow risk characterization for combined sewers as set out in Schedule 4 of this regulation. For each identified CSO outfall, we have evaluated the information collected and assigned the correct number of CSO points based on the classifications presented in Schedule 4 of the proposed WSER (some of which were modified during the course of this study as noted below). It must be noted however, that communities in NL have very little information regarding the historical frequency and volume of CSO events, making accurate determinations of risk level (as per WSER classifications) very difficult to generate.

Environmental risk management is a key element of the Canada-wide Strategy for the Management of Municipal Wastewater Effluent (MWWE). The environmental risk management framework set out in Technical Supplement 2 of the Strategy (and shown on Figure 4.1) provides a decision making process that is intended to manage municipal wastewater effluent to protect the environment and human health, while taking into account site-specific factors. The framework:

- Identifies a list of substances of national concern and develops achievable and desirable performance standards for them.

- Integrates the characteristics of the site specific receiving environment into the development of these standards.

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- Includes a risk-based decision-making process where performance standards can be adjusted depending on risk. The onus is on the discharger to demonstrate the absence of adverse effects.

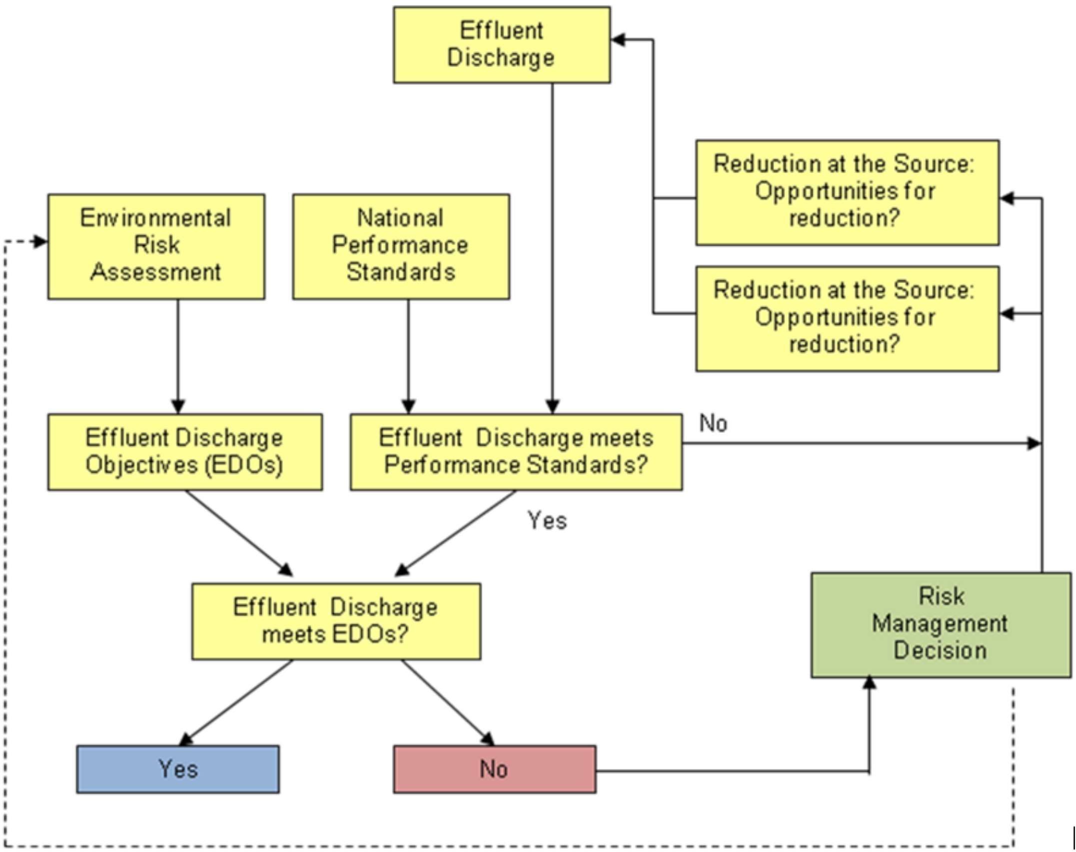

Figure 4-1 - Environmental Risk Management Framework (CCME, 2008)

The environmental risk management framework includes National Performance Standards (i.e., minimum discharge limits) for common substances. These Standards are applicable to all MWWE discharges in Canada and are achievable by commonly available technology. They are equivalent to what can be achieved with a minimum of conventional secondary treatment for five day carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS) and total residual chlorine (TRC).

Where CSOs occur, facilities must produce a long term CSO reduction plan and submit it to the regulatory authority. This plan may be combined with the action plan to achieve the National Performance Standards. Where multiple actions are required to meet the requirements of the Strategy, the action plan will address prioritization of all work to be completed. This may include work needed to meet Effluent Discharge Objectives (EDOs).

Section 5.7 of Technical Supplement 2 of the proposed WSER states that overflow events (CSOs and SSOs) must be recorded in order to assess the frequency and severity of overflows, and there should be no dry weather overflows (CCME, 2008). Overflows may be monitored for frequency of flow through simple mechanical measures that clearly indicate flow has occurred and that are reset quickly after a storm event. Where possible and feasible, the volume or duration of an overflow should be recorded or estimated using more sophisticated methods and equipment, starting with major CSOs or those causing the greatest concern. The data should be recorded, along with information on storm event and snowmelt event occurrence (dates) and severity (rainfall), in order to help design any required mitigation of CSOs. The USEPA publication entitled Combined Sewer Overflows Guidance for Monitoring and Modeling provides additional guidance on CSO monitoring (USEPA, 1999).

Section 6 of Technical Supplement 2 offers guidance on how to make environmental risk management decisions when MWWE discharges are not meeting EDOs. The risk management decision process described in the document is directed at the main effluent discharge (from WWTPs), but as discussed in Section 8 of the same document, the process can be adjusted for use with sewer overflows, as shown in Figure 4.2.

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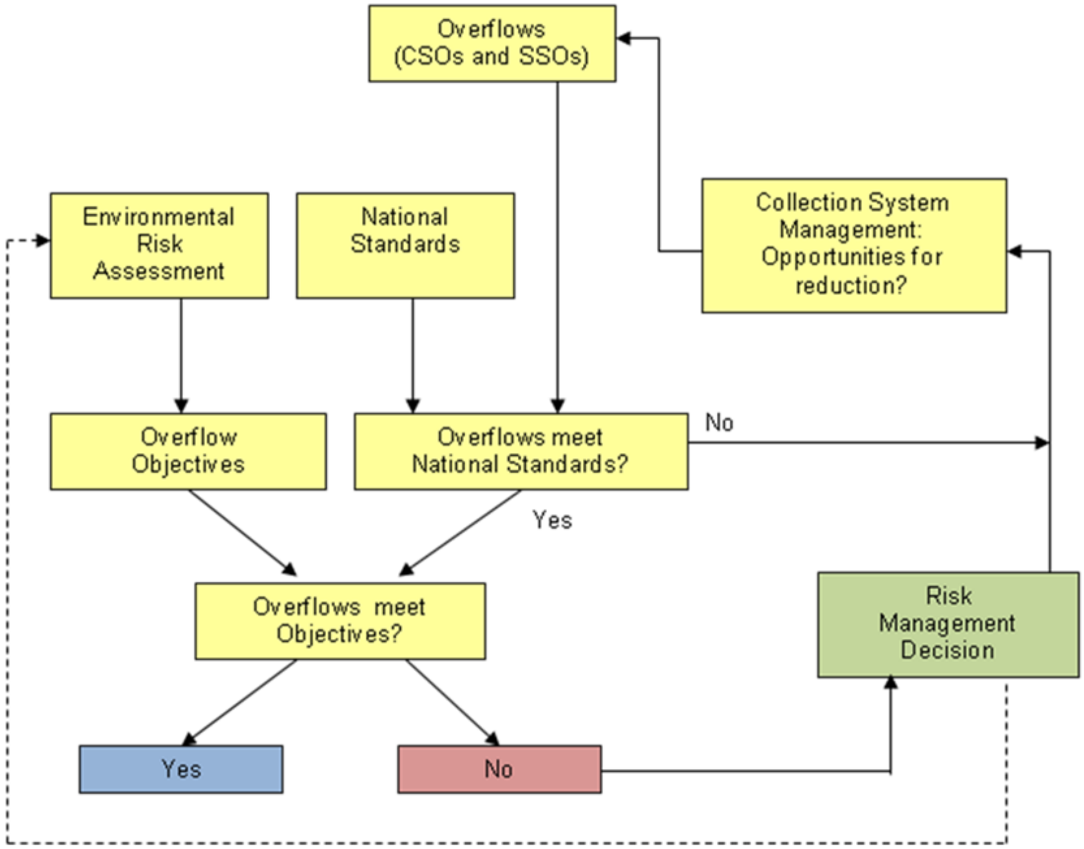
Figure 4-2 - Environmental Risk Management Framework for Overflows (CCME, 2008)



Under the Strategy, three National Overflow Standards are established for CSOs:

a. No increase allowed in CSO frequency due to development or redevelopment, unless it occurs as part of an approved CSO management plan.

b. No CSO discharge allowed during dry weather, except during spring thaw and emergencies.

c. Floatable materials will be removed, where feasible.

In addition to these standards, overflow objectives should be established to protect the beneficial uses of the receiving environment. For example, overflows should not occur upstream from designated areas such as fish spawning sites, beaches and drinking water intakes. Wastewater carrying industrial

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or hospital waste should not overflow either. Frequency, volume and/or treatment objectives should be set.

As discussed further in Section 7 of this report, some provinces have general overflow objectives. Ontario's Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems requires the capture and treatment of all dry weather flow plus 90% of volume resulting from wet weather flow above the dry weather flow, for a seven month period starting within 15 days of April 1. It also requires primary treatment of overflows, even for satellite wastewater facilities, which it defines as 30% removal of BOD and 50% removal of TSS. Ontario also has specific beach protection objectives, which include no violation of the body contact recreational water quality objective at swimming and bathing beaches and no more than two overflow events per season (June 1 to September 30). British Columbia's Municipal Sewage Regulation specifies that no CSO should occur during storm or snowmelt events with less than a five year return period, and also requires an average of 1% per year total volume reduction of CSOs with at least primary treatment of discharges. Quebec has site specific objectives, including no CSOs within 1 km of drinking water intakes or shellfish harvesting sites, no CSOs into, or immediately upstream, of fish spawning sites, and a maximum of one CSO per month in a continuous flow zone or one CSO per two months in an accumulation zone where human activities occur during periods when these events occur. These and other CSO control requirements and targets across North America, are discussed in further detail in Section 7 of this report.

Since facilities have no control over weather, frequency objectives may not be achieved every year. However, they should be achieved (on average) when comparing results obtained over a number of years. The MWWE Strategy recommends the following steps to control CSOs:

1. Record CSO events, at least on an occurrence basis;
2. Achieve the National Overflow Standards, as presented above;
3. Demonstrate at a facility level that everything that can be done with existing equipment is being done to limit CSO occurrences; and,
4. Develop a long term plan to reduce CSOs and capture substances, based on achieving jurisdictional overflow objectives.

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When overflow objectives are not achieved, wastewater facilities should consider several options in their long-term plans, including reducing overflows through sewer system separation and storage techniques, reducing substance release through treatment, and relocating outfalls (see Figure 4.3). Since the highest concentrations of substances in CSOs occur during what is called the "first flush" (the early part of a high rainfall event after a prolonged dry spell), it is particularly important to capture the early portions of CSOs.

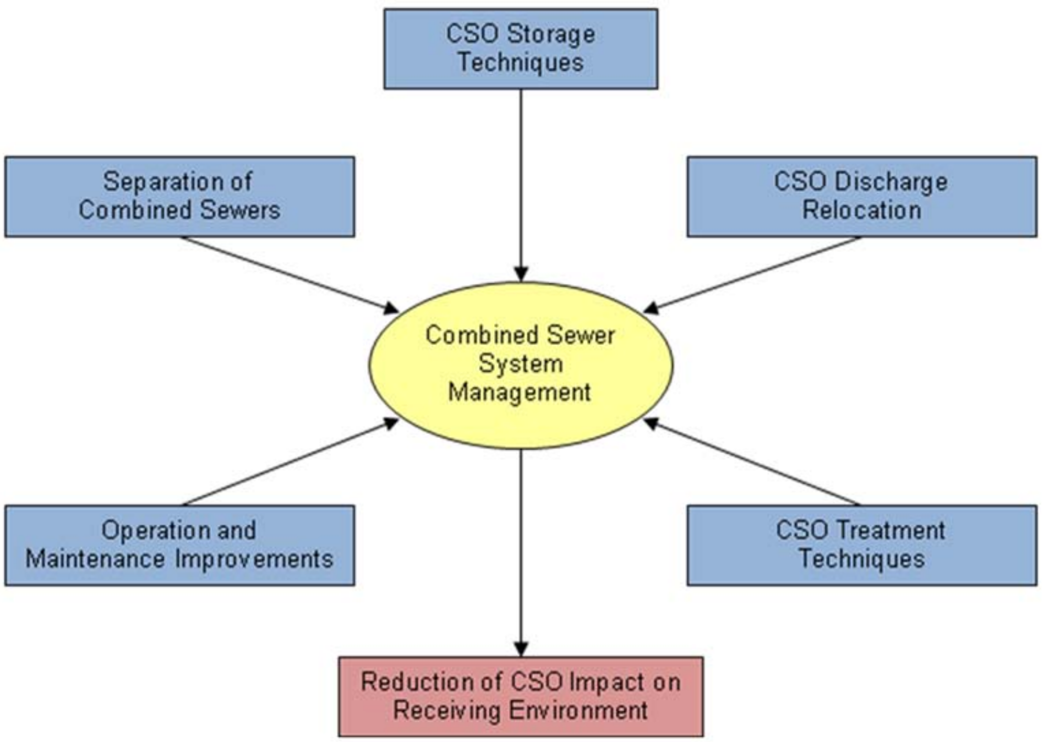

Figure 4-3 - Environmental Risk Management Framework for Overflows (CCME, 2008)

Combined sewers should have CSO discharge limits (in the form of frequency and/or volume limits), or treatment requirements, as close as possible to established overflow objectives. Ontario Procedure F-5- 5: Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems (MOE, 1997) and the Combined Sewer Overflow Treatment Technologies Manual (XCG, 2004) provide some guidance to help communities prepare long term CSO abatement plans. Long-term CSO control plans should establish priorities based on risk. The USEPA also provides a number of very useful guidance documents to help communities develop and implement their CSO control programs, which are discussed further in Section 7 of this report.

Facilities with CSO locations that have a risk level higher than the risk level of the main effluent may work on CSO reduction first, and therefore delay work on meeting the NPS. The objective is to reduce the risk levels associated with CSOs to at least as low as the risk level of the main effluent, before starting work on meeting the NPS, but the facility must still achieve the NPS within the 30 year timeline of the Strategy.

The approach consists of looking at every single CSO location and determining which ones have an unacceptable impact on the receiving environment and its uses. Those that accumulate more points than the main effluent (as defined in section 9.1 of Technical Supplement 2) are considered a higher risk and should be dealt with first. Points for CSO risk levels are allocated based on Table 4.1. If the risk associated with one or more CSO location is greater than that posed by the main effluent, an action plan is developed by the owner addressing how both the CSOs will be managed and how the NPS will be achieved within the 30 year timeline of the Strategy. The action plan is then submitted for approval. CSO units with treatment (solids removal or disinfection) should not be considered in this exercise.

4.2 Risk Characterization of Combined Sewer Overflows

Risk levels for each CSO outfall in NL were calculated based on the updated criteria / system of points presented in Table 4.1.

Key CSO information required to complete this exercise included the following:

- Ratio, during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER, of the "estimated average DWF that circulates in the combined sewer at the overflow point" to the "estimated average DWF that is deposited at the final discharge point", expressed as a percentage (e.g. < 10%, 10-25%, 25-50% or >50%).
- Number of deposits via the overflow point during the same 12 month period referred to above (e.g. <5, 5-15, 15-25 or >25 deposits)
- Proximity of location where effluent is deposited via each overflow point to environmentally sensitive areas (e.g. shellfish harvesting area within 500 m; endangered species or fish

spawning area within 500 m downstream; lake, reservoir marine estuary, or enclosed bay as defined in Section 1 of Schedule 2 of the proposed WSER).

These CSO point scores have been included as an additional field in the Sewer Overflow Database, and have been used (in conjunction with other information gathered and prepared by this study) to prioritize the implementation of CSO control measures across the Province.

Table 4-1 - System of Points for Calculation of Risk Level of Individual CSO Locations[1]

Item	Column 1 - Factors	Column 2 - Criteria	Column 3 - Points
1	The ratio – during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER – of the "estimated average dry weather flow that circulates in the combined sewer at the overflow point" to the "estimated average dry weather flow that is deposited at the final discharge point", expressed as a percentage.	≥ 50% ≥ 25% and < 50% ≥ 10% and < 25% < 10%	30 points 20 points 10 points 5 points
2	The number of deposits via the overflow point during the period of 12 consecutive months referred to in section 14(1) of the proposed WSER.	> 25 deposits > 15 deposits and ≤ 25 deposits > 5 deposits and ≤ 15 deposits 5 deposits or less	30 points 20 points 10 points 0 points
3	Water where effluent is deposited via each overflow point (the sum of points for all that apply).	shellfish harvesting area within 500 m of any point of entry where effluent is deposited in the water via the overflow point aquatic species that is a protected species frequents the area or is found, or fish spawning area is found, within 500 m of any point of entry where effluent is deposited in the water via the overflow point lake, natural wetland, reservoir, estuary, or enclosed bay as defined in Section 1 of Schedule 2 of the proposed WSER	20 points 10 points 10 points

1. As per Schedule 3, Subsection 24(2), subsection 25(1) and 26(2) of the proposed WSER (using revised definitions provided to HMM by ENVC).

Table 4.2 provides a summary of the results of our Preliminary CSO Risk Assessment for the remaining CSO outfalls in NL, based upon the criteria / system of points defined by the proposed WSER and presented in Table 4.1. Note that this is a preliminary assessment, based on the information we were able to collect from the municipalities responsible for the operation and maintenance of these CSO outfalls, and from our own site visits conducted in these communities. In a number of cases, some of the information required to complete the CSO risk assessment was

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unavailable and/or could not be determined from the information provided by the municipalities in response to our requests. In general, the municipalities did not have flow monitoring data to confirm the average DWF or number of deposits (CSOs) occurring at their existing CSO overflow points during a 12 period, so in some cases, the ratio of average DWF at the overflow points to the discharge points were estimated from provided design flows, and overflow frequencies were roughly estimated based upon typical annual storm event frequencies and typical CSO design capacities. For St. John's, where new CSO control measures have already been implemented at part of their Harbour Clean-up Program, average annual CSO frequency was estimated to be 7 deposits based on the design capacity of the new CSO control structures (hence with an associated category 2 risk score of 10 points). For the remaining CSOs in Harbour Grace, St. Lawrence, Springdale, Gander, Channel Port aux Basques and Corner Brook, average annual CSO frequency was estimated to be greater than 25/year, assuming there are typically at least this many rainfall events in an average year that are large enough to cause CSO events. This assumption is based on typical findings from other CSO communities in Canada and North America, from studies we have conducted, from literature reviews, and from various USEPA documents. Our methodology used for estimating the CSO risk levels presented in Table 4-2 is further explained in the Regional Database Spreadsheets included in Appendix A.

Accordingly, we recommend that the Province consider implementing a program to assist Communities to collect missing/better information on the performance of the CSO/SSO systems, to support efforts to improve accuracy of CSO Risk Assessment calculations required by CCME/WSER, and to improve confidence in development of future CSO/SSO Control Programs/Projects to meet CCME/WSER CSO/SSO control targets/objectives.

CSO Risk Assessment scores for the seven (7) NL communities with CSO outfalls range from 35 (for outfall in Harbour Grace) to 80 (for outfall in Channel-Port aux Basques), with most outfalls having scores of 40 to 60, and the scores for Item 2 (CSO frequency) generally accounting for most of the total scores. The CSO outfalls with the highest risk assessment scores are the outfalls with the highest priority for implementation of measures to reduce or eliminate CSOs. Based on the scores provided in Table 4-2, the highest priority locations for remediation are the CSO outfalls in Corner Brook, Channel-Port aux Basques, Gander and St. Lawrence.

Table 4-2 - Summary of Preliminary CSO Risk Assessment for CSO Outfalls in NL

CSO Outfall Location	CSO Risk Assessment Score (Points determined as per Table 4-1)			
	Item 1[1]	**Item 2[2]**	**Item 3[3]**	**Total**
EASTERN				
St. Johns				
4400-4-SO-C-1 – Prescott St	20	10	10	40
4400-5-SO-C-1 – Temperance St	20	10	10	40
4400-7-SO-C-1 – Pleasantville	20	10	10	40
Harbour Grace				
2125-10-SO-C-1 – Murray's Square	5	30	0	35
St. Lawrence				
4435-7-SO-C-1 – Director Dr	20	30	10	60
4435-8-SO-C-1	20	30	0	50
CENTRAL				
Springdale				
4910-4-SO-S-1 – Little Bay Rd	20	30	0	50
Gander				
1760-2-SO-C-3 – Cobham Rd	30	30	0	60
1760-2-SO-C-4 – Bennett Dr	30	30	0	60
1760-2-SO-C-5 – Towers Ave	30	30	0	60
1760-2-SO-C-7 – Carr Cr	30	30	0	60
WESTERN				
Channel-Port aux Basques				
1025-23-SO-C-1 – Rat Island Cove	30	30	20	80
Corner Brook				
1200-4-SO–C-1 – Lewin Pkwy & Main St	20	30	10	60
1200-5-SO-C-1 – Broadway & Caribou Rd	20	30	10	60

Notes:
1 The ratio – during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER – of the "estimated average dry weather flow that circulates in the combined sewer at the overflow point" to the " estimated average dry weather flow that is deposited at the final discharge point", expressed as a percentage.
2 The number of deposits via the overflow point during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER.
3 Sensitivity of the water where the effluent is deposited via each overflow point (the sum of all points for all that apply).

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5.0 ASSESSMENT OF SEWER OVERFLOWS

5.1 Background and Methodology

It is important to understand the cause/reasons for combined and sanitary sewer overflows and WWTP bypasses in order to develop/update CSO/SSO control regulations, policies and guidelines; to identify and develop measures to control or eliminate their occurrence; and to prioritize individual CSO/SSO control measures/projects for implementation across the Province.

Combined sewer systems (CSS) typically began as storm sewers designed to collect and convey stormwater runoff away from populated areas. Combined sewers were 'invented' when communities began to admit sewage into the existing storm sewers, and large interceptor sewers were constructed to collect and convey the sewage to wastewater treatment plants (WWTPs) being built to treat sewage. CSS were typically designed to capture and convey between 3 to 5 times average DWF rates (and sometimes more), and as such, the cause of the majority of CSOs (both frequency and volume) is generally the storm water runoff that is permitted to enter the sewer system by design. This is not to say that infiltration into a CSS through leaky pipes and manholes does not occur, just that the amount of infiltration is typically dominated by the storm water runoff entering the CSS. Removal of extraneous groundwater and rainfall dependent infiltration into a CSS can still help to reduce the impact of CSOs.

Sanitary sewer systems are designed to carry sanitary sewage only, without any purpose-built inputs of additional wet weather flow (WWF). In reality, sanitary sewer systems often (usually) contain aging and deteriorating infrastructure, including leaking pipes and manholes that permit increased rainfall dependent infiltration and inflow (RDII) into the system during wet weather, and may also contain equipment such as pumps and gates that can fail and cause infrequent overflows of untreated sewage from the system to local receiving waters.

Sanitary sewer overflows (SSOs) are often attributed to immediately traceable conditions such as pump failures or pipe breaks, but simply repairing a failed pump or ruptured pipe without understanding the underlying cause of its failure may not protect against future SSOs. The major causes leading to SSOs include age, lack of maintenance, poor operational procedures, and inadequate flow capacity. Many sewer system failures are attributable to natural aging processes, such as:

- Years of wear and tear on system equipment such as pumps, lift stations, check valves, gates and other moveable parts that can lead to mechanical or electrical failure;
- Freeze thaw cycles, groundwater flow, and subsurface conditions that can result in pipe movement, warping, brittleness, misalignment, and breakage; and
- Deterioration of pipes and joints.

Lack of maintenance exacerbates age-related deterioration. Systems that are not routinely cleaned and repaired experience more frequent clogged and collapsed sewers due to root growth and accumulation of debris, sediment, oil and grease. Similarly, the condition and function of mechanical equipment degrades much faster without regular maintenance. Regular sewer system inspection and cleaning can eliminate many of these problems and keep the system functioning smoothly.

Sewer system bottlenecks not only lead directly to SSOs, but they also exert hydraulic stress on other parts of the system, resulting in an expanding web of failures.

Operational procedures that lead to SSOs include mistakes, such as accidentally activating a pump without ensuring that all necessary check valves are in position, or disregarding available alarms/warning mechanisms.

Rapid development can also cause sewage flows to exceed current system capacity. Proactive solutions include imposing growth restrictions or building moratoriums until sewer capacity can be increased. But often, municipalities are uncertain of the actual design capacity of their sewer systems, or do not adequately consider it in their planning process. Capacity constrained areas may need additional miles of sewer pipe, bigger interceptors, more underground storage capacity (to attenuate peak flows), and/or additional treatment capacity (at central or satellite treatment facilities) to control their SSOs. Any of these causes, by themselves or in combination, can lead to SSOs.

In the case of NL, it is also important to distinguish between infrequent overflows from sanitary sewer systems that convey the majority of flows to a wastewater treatment plant, and sanitary sewer systems that have been purposefully designed to discharge sewage to receiving waters without treatment.

Accordingly, we have determined the common causes of sewer overflows and reasons for the occurrence of sewage bypassing at WWTPs across the Province. Typical causes of sewer overflows and WWTP bypasses include, but are not limited to:

- Connection of household roof leaders, basement sumps and weeping tiles to sanitary and combined sewers;
- Infiltration into leaky sanitary and combined sewers;
- Inflow into sanitary sewers (inflow to combined sewers is expected);
- Blockages in sanitary and combined sewers;
- Equipment failure (e.g. pumps in sewage list stations);
- Rainfall events; and
- Exceedence of design capacities of sewers, lift stations and WWTPs.

5.2 Assessment of Conditions/Causes of Sewer Overflows

Data on actual measured sewage flow rates in dry and wet weather was generally not available from the responding communities, making it very difficult to accurately quantify the contribution to sewers from such secondary sources during dry and wet conditions, and provide an accurate estimate of the scale of deviation (increase) from average wastewater flows during wet weather conditions, for each sewer overflow, so the assessment of the conditions/causes of sewer overflows provided below is necessarily more qualitative than quantitative.

5.2.1 Combined Sewer Overflows

As with all combined sewer systems, CSOs in NL occur when the capacity of the sewage interception system in place to convey sewage flows to the downstream WWTP for treatment is exceeded, and the frequency and volume of CSOs at each location depends upon the sewage interception capacity that was originally designed within each system. CSOs generally occur when flows in the sewer system exceed 3 to 5 times average DWF rates (but this varies from site), and typically this interception capacity is sufficient to capture most small and some medium sized storm events. Typically, average annual CSO frequencies range from 20-40/year (but again, this varies from site to site depending upon their individual designed sewage capture capacities).

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5.2.2 Sanitary Sewer Overflows

SSOs in NL are caused by a number of different and related reasons, which based on our investigations, include the following items:

- Insufficient hydraulic conveyance capacity (during larger storm events), both within the sanitary sewer system and at sewage pumping stations, which is often a result of excessive infiltration and inflow into the sanitary sewer system, which is often caused by the general deterioration of the condition of sewer infrastructure (sewer and manholes) and the connection of roof downspouts and/or foundation drains to the sanitary sewer system.
- Infrequent mechanical equipment failures, generally with sewage pumps, but also occasionally with standby power generation systems.
- Major power outages (which typically occur during wet weather when sewage flows are higher) impacting sewage pumping capability where no standby power exists.
- Sewer breaks causing sewage to leak into ground surrounding damaged pipes.
- Sewer blockages causing sewer and basement backups.
- Cross connections between storm and sanitary sewers.

5.2.3 Sewage Lift Station Bypasses

Sewage lift station bypasses occurring in NL are generally the result of excess wet weather flows within the contributing sanitary sewer system, which are typically caused by excessive infiltration and inflow within the contributing sewer system. Some bypasses are designed to occur (based on original design of facilities) to prevent capacity exceedences and flooding within the upstream and downstream sewer system. Un-designed and unexpected bypasses may also occur due to mechanical equipment failures within the station, generally with sewage pumps, but also occasionally with standby power generation systems (possibly even caused by running out of fuel for the generator).

5.2.4 WWTP Bypasses

WWTP bypasses (including full or partial plant process bypasses) occurring in NL are also generally the result of excess wet weather flows within the contributing sanitary sewer system exceeding the design capacity of the facility, which are typically caused by excessive infiltration and inflow within the contributing sewer system. Some bypasses are designed to occur (based on original design of facilities) to protect plant treatment processes (e.g washout of biological treatment). Un-designed and unexpected bypasses may also occur due to temporary mechanical equipment failures within specific treatment processes, including equipment which may be temporarily unavailable due to repairs, replacement or new construction projects.

5.3 Measured Flow Data

Table 5-1 includes actual measured flow data at ten (10) different sites throughout NL. Average flow, peak flow, and peaking factor data is provided along with the Municipality, measurement location, outfall ID number, date/period of monitoring, and supporting comments and/or references. Excluding the data recorded on September 21, 2010 during the Hurricane Igor event, peaking factors ranged from 2.63 in Victoria to 4.9 in St. Georges, while the average peaking factor is approximately 3.81.

Table 5-1: Measured Flow Data

Town	Description	Outfall	Date of Monitoring	Average Flow (L/s)	Minimum Flow (L/s)	Peak Flow (L/s)	Peaking Factor	Comments / References
St. George's		4380-1	Apr 29-Jun 17, 2010	4.5		29.1	4.9	
Gander	Magee WWTP	1760-1	Apr 30-Oct 4, 2010	24.7	-	765.3	31	Hurricane Igor- 100 yr flood
Gander	Beaverwood WWTP- 600mm into plant	1760-2	Apr 30-Oct 4, 2010	37.8	-	568.1	15	Hurricane Igor- 100 yr flood
Gander	Beaverwood WWTP- 200mm into plant	1760-2	Apr 30-Oct 4, 2010	2.9	-	82.7	28.5	Hurricane Igor- 100 yr flood
CBS and Paradise	Cronin's Head outfall	1145-2	Oct 14-Dec 18, 1998	88		337	3.8	Sewage Treatment Study - Towns of CBS and Paradise. Bae-Newplan. March 1999
CBS and Paradise	Topsoil Treatment Plant	1145-1	Oct 14-Dec 18, 1998	20		81	4.05	Sewage Treatment Study - Towns of CBS and Paradise. Bae-Newplan. March 1999
Brigus		615-1	Oct 17-Nov 17, 1990	5.53		24.3	3.73	Sewage Treatment Study - Town of Brigus. Harris & Associates Ltd. February 1994
Victoria	Sewage Lagoon	5225-1	Mar 8-Oct 8, 2002	52.6		140	2.63	Sewage Lagoon Upgrading Analysis of Aerated Lagoon System - Town of Victoria. Harris & Associates Ltd. October 2005.
Bishop Falls	See Comments	See Comments	Jan 24-Feb 21, 2000	37		123.7	3.34	Wastewater Treatment Study - Town of Bishop's Falls. Design Management Group Ltd. April 2000. (Study performed throughout all six outfalls.)
Wabush	Commercial Street WWTP	5249-1	Jan 21-Oct 29, 2006	22		28.9	1.3	Sewage Treatment Assessment - Town of Wabush. Kendall Engineering Ltd. January 2007.
Stephenville	West Street Manhole	4945-1	Sept 27-Oct 23, 2001	31.6		134	4.24	Sewage Treatment Study - Town of Stephenville. Bae-Newplan. October 2002

6.0 REVIEW OF CSO CONTROL TECHNOLOGIES & APPROACHES

Potential CSO control alternatives can generally be grouped into three main categories:

Source Controls

Source Controls are measures implemented upstream of the CSS, which decrease CSO pollution by reducing the amount (or rate) of runoff and/or pollutants entering the CSS. Some examples are listed in Table 6.1. Although these measures typically cannot provide the reductions required to meet desired CSO reduction targets on their own, combinations of source controls can yield noticeable CSO reductions and can reduce the overall costs of CSO control when considered as part of an overall implementation program. Source controls to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as 'Green Infrastructure'. Green Infrastructure approaches currently in use include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used almost anywhere where soil and vegetation can be worked into the urban or suburban landscape. Green Infrastructure is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets.

Sewer System Controls

Sewer System Controls are measures implemented within the CSS, which decrease CSO pollution by increasing the amount of combined sewage conveyed to the WWTP. Improved CSS maintenance, regulator adjustments, sewer separation, storage and real time control can all be highly effective in reducing CSO volumes. Some common sewer system control options are listed in Table 6-1.

CSO Treatment

CSOs can also be treated, either at a central WWTP or by satellite treatment facilities located at the CSO outfalls. The treatment processes of the WWTPs should first be optimized to minimize the pollutant loadings under wet weather conditions. This may lead to wet weather-specific operating conditions that may produce lower overall pollutant loadings. Options to be considered for WWTPs include expansion and/or upgrade of existing treatment processes, installation of new treatment technologies, and innovative approaches to the operation of existing or new treatment processes.

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Table 6-1 - Potential CSO Control Alternatives

SOURCE CONTROLS	Bioretention Areas Catch Basin Cleaning Green Roofs Infiltration and Inflow Control Low Impact Development Permeable Pavement Pesticide Reduction Public Education Rainwater Harvesting Roof Downspout Disconnection Sewer Use By-laws Street Sweeping Water Conservation
SEWER SYSTEM CONTROLS	Catch Basin Inlet Control Deep Tunnel Storage Dynamic Regulators Flow Balance Method Off-line Storage Real Time Control Regulator Adjustments Sewer Separation
CSO TREATMENT	Continuous Deflective Separation Coarse and Fine Screens Dissolved Air Floatation High Rate Filtration High Rate Physical Chemical Treatment Treatment Shafts Vortex Separators
FLOATABLES CONTROL	Catch Basin Modifications Containments Booms Netting Systems Screens and Trash Racks Underflow Baffles
DISINFECTION	Chlorine Chlorine Dioxide Electron Beam Irradiation Ozone Peracetic Acid UV Irradiation

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Satellite treatment facilities may be cost-effective where there are space limitations or limited capacity in the collection system to convey excess flows to the WWTP. Some of these technologies are only effective at removing certain types of pollutants (e.g. disinfection and screening), and technologies may need to be combined to ensure that specified CSO treatment requirements are met. Close attention needs to be paid to the effluent treatment requirement for satellite treatment facilities. For example, MOE Procedure F-5-5 requires a minimum level of primary treatment, and the discharge from these facilities must achieve an effluent concentration for Total Suspended Solids of not more than 90 mg/l, for at least 50 % of the period from April 1 to October 31.

Other treatment systems, providing partial treatment of CSOs (or SSOs) include Floatables Control and Disinfection, which are often used in combination in the USA to control CSOs.

The following provides a brief discussion of each of the technologies and approaches reviewed. The discussions below are grouped into the same categories presented above: Source Controls, Sewer System Controls and Treatment, including Floatables Control and Disinfection.

6.1 Source Controls

Bioretention Areas:

Bioretention is a stormwater infiltration practice that treats runoff from an impervious area by using soil and vegetation to remove contaminants through various physical, chemical and biological processes. This practice has the potential to provide a significant improvement in contaminant removal over other stormwater infiltration practices due to the added treatment benefits of microbial activity and plant uptake. By infiltrating and evapotranspiring runoff volumes, bioretention systems also help to reduce pollutant loads to watercourse and recharge groundwater. A variety of design variations of bioretention are possible. Most are designed as swales or islands, and are constructed adjacent to roads, parking lots or other paved areas. Runoff from these impervious surfaces are directed into the bioretention area, where it ponds and slowly infiltrates. Flows from large rainfall events bypass the bioretention areas and are conveyed directly to the sewer system.

Figure 6-1 - Bioretention Area (STEP, 2011)

Catch Basin Cleaning:

Catch basins are constructed with a sump located below the invert of the discharge pipe to retain sediment and debris that enters the catch basins. This removes sediment and debris that would otherwise be carried to local receiving waters or accumulate in the CSS causing blockages. Previous studies have estimated that catch basins can retain up to 57% of coarse solids and 17% of cBOD (USEPA, 1999).

Green Roofs:

Green roofs are lightweight, engineered, rooftops designed to promote the growth of vegetation while protecting the structural integrity of the roof. The technology addresses a wide array of environmental issues associated with urbanization. Environmental and human health benefits of green roofs include air purification, urban heat island amelioration, lower building energy costs, increased urban biodiversity, reduced stormwater runoff and improved stream water quality. The stormwater management benefit provided by green roofs lies in the ability of the roof media and plants to retain stormwater, increase evapotranspiration, and allow stormwater runoff to be released gradually back into the sewer system and ultimately the receiving waters at reduced peak flow rates. The plants and soil also capture pollutants deposited from the atmosphere and eliminate leaching of metals and other pollutants from conventional roof materials. Where roof downspouts are connected to combined or sanitary sewers, green roofs can help to reduce inflow into these sewer systems, which can reduce the frequency, volume and mass of pollutants discharged by sewage overflows.

Figure 6-2 - Green Roof (Chicago, Illinois)

Infiltration and Inflow (I/I) Control:

Inflow is stormwater that enters sanitary sewers from the surface. Sources of inflow include roof drains, leaky manhole covers and cross connections. Combined sewers are designed to accept most of this flow, just as separate storm sewers are, however, the disconnection of roof drains will reduce inflows to the CSS, and is discussed below as a separate alternative. Groundwater infiltration enters the CSS through leaky manholes and pipes and can contribute significant flow into the CSS during both dry and wet weather. Extraneous groundwater inflows during wet weather take up valuable capacity for incoming stormwater runoff and increase CSO volume and frequency. NL's sanitary sewer design standards generally allow 0.28 L/sec/ha of infiltration, but allow 0.4 L/s per manhole for manholes that are located in sags in the roadways. Flow monitoring and dye and smoke testing can be used to assist in identifying areas of high I/I and quantifying its magnitude, and sewer system modeling can be used to evaluate the impacts of potential solutions to reduce I/I. These areas can also be inspected by CCTV and/or zoom cameras to aid in the development of remediation plans. Some common methods to reduce groundwater infiltration include sewer lining, pressure grouting of sewers and manholes, and replacement of sewers and manholes.

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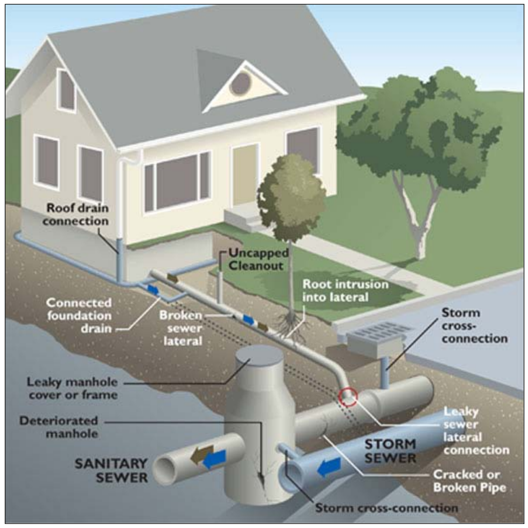
Figure 6-3 - Common Sources of Infiltration and Inflow



<u>Low Impact Development (LID):</u>

Low impact development (LID) is a term used to describe a land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID is similar to sustainable urban drainage systems (SUDS), a term used in the United Kingdom, or water sensitive urban design (WSUD), a term used in Australia. LID practices are selected for an individual site considering the site's land use, hydrology, soil type, and climate and rainfall patterns. Frequently used practices include: bioretention areas/cells, also known as rain gardens; cisterns and rain barrels; green roofs; pervious concrete, similar to permeable pavement; grasses swales, also know as bioswales; and commercially manufactured stormwater management devices that capture pollutants (e.g. media filters) and/or aid on-site infiltration. Some of these practices are discussed separately above and below (e.g. bioretention areas, green roofs, permeable pavement, rain barrels). Potential benefits of LID include: habitat protection; improved management of water quantity (e.g. reduced risk of flooding); reduction of impervious surfaces and runoff (peak flow rates and volumes); groundwater recharge through infiltration; water quality improvements; community value (i.e. increased aesthetics); and cost savings.

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Figure 6-4 - Low Impact Development (STEP, 2011)

Permeable Pavement:

Building parking lots, driveways and roads using permeable pavement helps to restore natural infiltration functions to the landscape and reduce impacts to watercourses by allowing rainwater to slowly infiltrate into the ground. Contaminants are removed from the stormwater as it infiltrates slowly through the gravel sub-base and into the native soil. A variety of different types of permeable pavements are available, and are typically categorized in one of three main types: 1) modular interlocking concrete block pavement; 2) porous asphalt or concrete; and 3) plastic grid systems. The main environmental benefits of permeable pavements include reduction of runoff, which reduce flood risk, stream erosion and damage to downstream infrastructure; removal of contaminants from infiltrated stormwater; and reduction in heat flux from the pavement surface to the atmosphere, which helps to mitigate against the urban heat island.

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Figure 6-5 - Permeable Pavement

Pesticide Reduction:

Pesticides, which include pesticides (bug killers), herbicides (weed killers) and fungicides (fungus killers), are washed into the CSS when it rains. Pesticides can be lethal to aquatic life. The cumulative effect of these pollutants from individual residential lawns, businesses and parks can be significant. However, to be successful and have a considerable impact, the reduction of pesticide use requires the support of the business community, general public and government.

Public Education:

One of the best allies in the control of source-based pollution is the public-at-large. Educating the public about the importance of reducing the frequency and impacts of CSOs through source-based controls has two benefits. The first is the environmental impact and the second is the raising of public awareness of the CSO problem. The environmental benefit may be relatively small; however gaining public support is crucial to securing funds for the construction and continued operation of future CSO control facilities. In addition, public education programs aimed at source control and pollution prevention can have a positive impact on CSO control efforts.

Rainwater Harvesting:

Rainwater harvesting refers to the practice of collecting rainwater from a roof or other surface and using it to augment freshwater supplies. Water collected is typically used as a non-potable source for uses such as toilet flushing, urinals and irrigation. If the water is treated, it can also be used as potable

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water for drinking, dishwashing or bathing. A rainwater harvesting system typically consists of gutters or conduits that convey rainfall from a catchment area - such as a roof or paved area - to a cistern for storage and later use. Water exceeding the cistern capacity can be diverted to a soak-away pit or vegetated area for groundwater recharge, or to municipal sewers.

Roof Downspout Disconnection/Rain Barrels:

Building rooftops provide large surface areas that are completely impermeable to rainfall. Eaves troughs and downspouts are designed to quickly collect runoff and channel it from the roof. Roof downspouts that are connected to sanitary and storm sewer laterals can contribute significant flow into the CSS during wet weather and this can increase CSO volume and frequency. The disconnection of downspouts from the sewer laterals and the discharge of the roof runoff directly to grassed areas (or into rain barrels for subsequent discharge to grassed areas), reduces the volume and rate of runoff entering the CSS, which can in turn reduce CSO volume and frequency. Discharging roof downspouts to pervious surfaces such as lawns provides an opportunity for the runoff to infiltrate into the ground. Capturing the runoff in a rain barrel has a dual purpose. The runoff is stored for future use in irrigating gardens and this reduces water consumption from the community water supply. This in turn reduces flows in the CSS, which can reduce CSOs. While these measures will typically not provide the required levels of CSO control on their own, they can provide significant reductions in CSO volume, which can either reduce the capacity of other required CSO control measures, or improve their performance.

Figure 6-6 - Roof Downspout Disconnection / Rain Barrels

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Sewer Use By-laws:

A sewer use by-law is a source-based control of contaminants in sanitary and storm sewage. The by-law forces stewardship onto users of the sewer system to be responsible for the quality of the effluent they discharge into the sewer system. Sewer use by-laws define acceptable levels of various parameters in sanitary and storm discharges including bacteria, nutrients, and heavy metals. By providing a maximum acceptable limit of these parameters in the sewer system, there is greater control over the level of treatment required from the wastewater treatment facility. In a CSS, it is imperative that these contaminant levels be reduced since CSOs may carry these pollutants to receiving waters without any treatment. Marbek (2009) prepared a Model Sewer Use Bylaw Guidance Document, as a general tool to be used by municipalities, utilities and other organizations providing wastewater services to communities in Canada, to assist in the implementation of source controls for contaminants discharged to community sewer systems. The document was developed as part of the CCME MWWE Strategy to harmonize the management approach for municipal wastewater in Canadian provinces and territories, and on federal and Aboriginal lands.

Stormwater Infiltration Pipes/Ditches:

Traditionally, stormwater has been captured and conveyed to receiving waters, or in CSS, to the WWTP. In recent years, there has been interest in groundwater recharge through stormwater infiltration. Examples include the use of perforated storm sewers and soak-away pits. These practices can reduce the volume of flow entering the CSS, and hence reduce CSO volume and frequency.

Figure 6-7 - Stormwater Infiltration Pipes / Ditches

Street Sweeping:

Street sweeping involves the use of specialized cleaning equipment to remove litter, loose gravel, soil, pet waste, vehicle debris and pollutants, de-icing chemicals and sand, and industrial debris from road surfaces, and is an integral part of a municipality's housekeeping efforts. Street sweeping equipment usually consists of a truck or truck-like vehicle equipped with multiple brushes, pick-up deflector, holding bin, water sprayer, vacuum nozzle and filter, or a combination of some or all of these features. Benefits include improved aesthetics and reduced sediment, nutrient and metals loadings carried into the CSS. When done regularly, street sweeping can remove 50-90% of street pollutants that can enter the CSS. The efficiency of the program is enhanced through proper maintenance of equipment, comprehensive training of staff and developing routes that optimize resources by addressing high loading areas with greater frequency.

Water Conservation:

Water conservation measures reduce water consumption and hence reduce the amount of sanitary sewage discharged into the CSS during dry and wet weather. This frees capacity within the CSS, which can in turn reduce CSO volume and frequency. Water conservation measures include the use of low-flow toilets, low-pressure faucets and showerheads. Universal water metering has also been shown to reduce water consumption and resulting sewage flows. Reduced water consumption also lowers overall costs for water and wastewater treatment.

6.2 Sewer System Controls

Catch Basin Inlet Control:

Flow restrictors are installed under the catch basin grate and consist of a steel plate with an orifice that controls the rate of flow entering the catch basin and CSS during periods of heavy runoff, freeing capacity with the CSS during wet weather. Excess runoff is stored safely on the roadway and slowly allowed into the CSS as runoff rates subside. The approach is not universally feasible - roads should provide adequate grade to create a safe overland flow route but be flat enough to provide the necessary storage.

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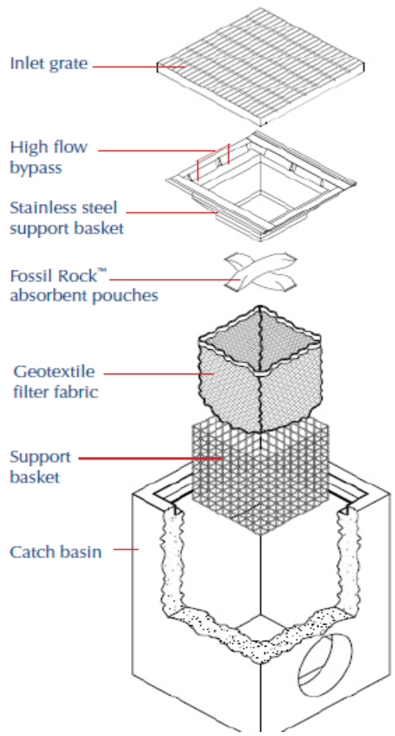
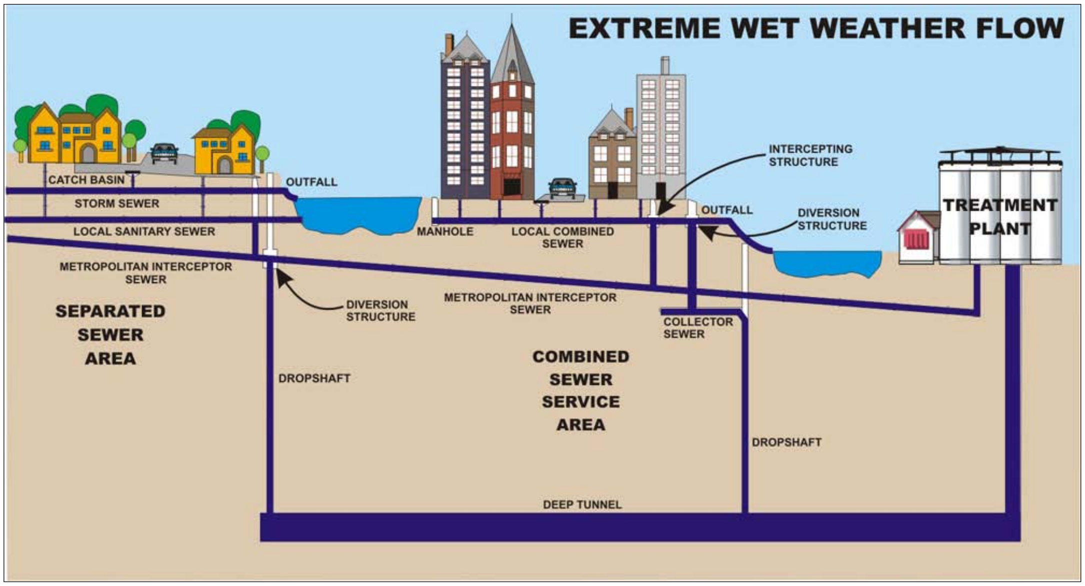
Figure 6-8 - Catch Basin Inlet Controls



Deep Tunnel Storage:

In areas where there is little or no available land for an off-line storage tank, municipalities have provided underground storage in large diameter tunnels. Traditionally, the CSO stored in these tunnels has been pumped back into the CSS and conveyed to a WWTP. Alternatively, the stored CSO can be decanted and the cleaner supernatant can be disinfected and discharged to local receiving waters. Settled solids are still returned to the WWTP. The City of Toronto has recently employed this approach for its Western Beaches CSO Tunnel. Construction costs for the tunnel were further reduced by providing much of the required storage within enlarged vertical tunnel access shafts. This allowed for a much smaller diameter conveyance tunnel, which significantly reduced tunnelling costs.

Figure 6-9 - Deep Tunnel Storage (Milwaukee Metropolitan Sewerage District)



Dynamic Flow Regulators:

Dynamic flow regulators can be installed within sanitary or combined sewer systems to maximize flow to the WWTP and/or create additional in-line storage within the sewer system. Dynamic flow regulators include motorized sluice gates and weirs, mechanical regulators and inflatable fabric dams. These regulators can be adjusted manually or remotely via telemetry and real time control to fill or draw-down in-system storage. Real time control systems can enhance/improve operations.

Flow Balance Method:

The Flow Balance Method (FBM) is a novel approach which employs a system of pontoons with heavy hanging curtains to create an artificial embayment to contain CSOs in the receiving water. The system was first demonstrated in Sweden. The design principle is based upon the stratification of two fluids with different specific gravities. The pontoons are configured to provide a number of cells in "series" or "plug flow". During a storm, CSOs are discharged into the embayment created by the pontoons and curtains and displace the fresh water previously contained in the first (upstream) cell. Once the first cell is full, the sewage enters the second cell, displacing the contents of that cell and so on until all cells are full. Only after the capacity of all of the cells is exceeded does the CSO discharge into the watercourse. When the storm subsides and there is again suitable capacity in the interceptor sewer, the contents of the cells are emptied in reverse order and pumped back into the

CSS or treated and released. As the stored CSO is pumped from each cell, the cells are replenished with fresh receiving water. FBM systems can achieve solids capture efficiencies of up to 70% and floatables capture efficiencies of up to 95%. The technology has been implemented in Scarborough, Ontario and Jamaica, New York, but is felt to have limited application for CSO outfalls in NF, because of the heavy ship traffic (in St. John's and Corner Brook) and potential for winter freeze-up of receiving waters.

Figure 6-10 - Dunkers Flow Balance Method (STEP, 2011)

Off-line Storage:

Off-line detention storage is a popular and effective means of reducing pollution from CSOs, which has been employed widely in North America and Europe. Underground storage tanks that are typically constructed of reinforced concrete capture CSOs prior to discharge to local receiving waters and store them during wet weather. During dry weather, the captured flows are pumped and/or drained back into the CSS and conveyed to the WWTP for treatment. Solids that remain in the tank after its liquid contents are drained and conveyed to the WWTP are washed from the floor of the tank and also conveyed to the WWTP for treatment.

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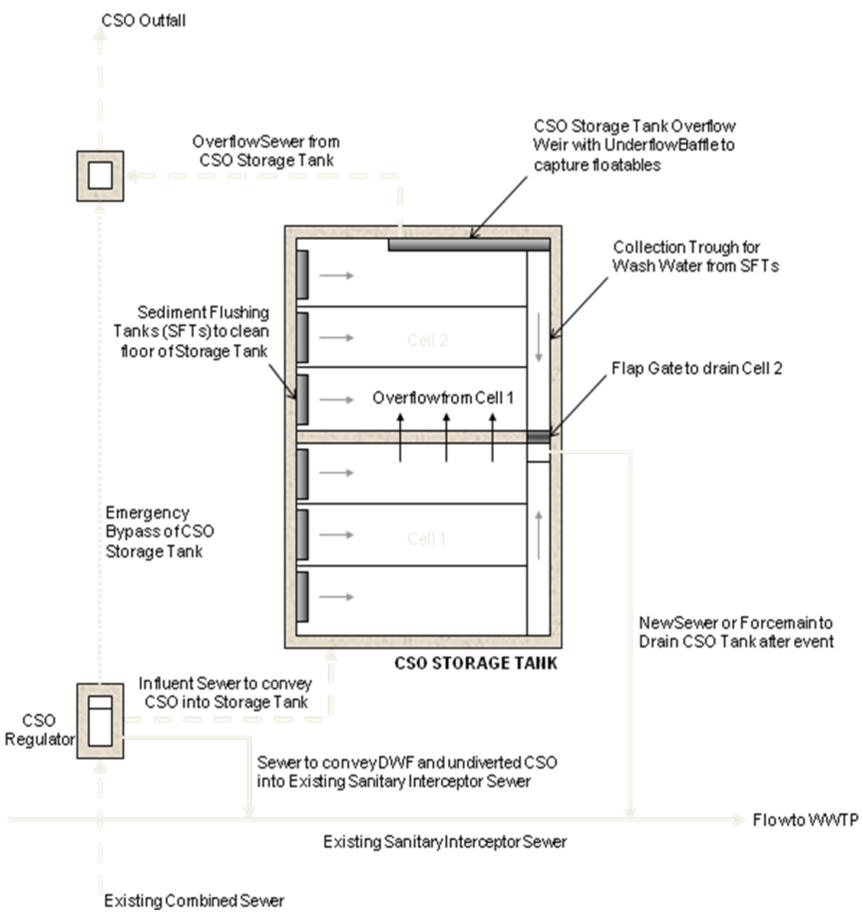
Figure 6-11 - Off-line CSO Storage Facility under Construction (Hamilton, Ontario)

Figure 6-12 - Typical Components of an Off-line CSO Storage Facility



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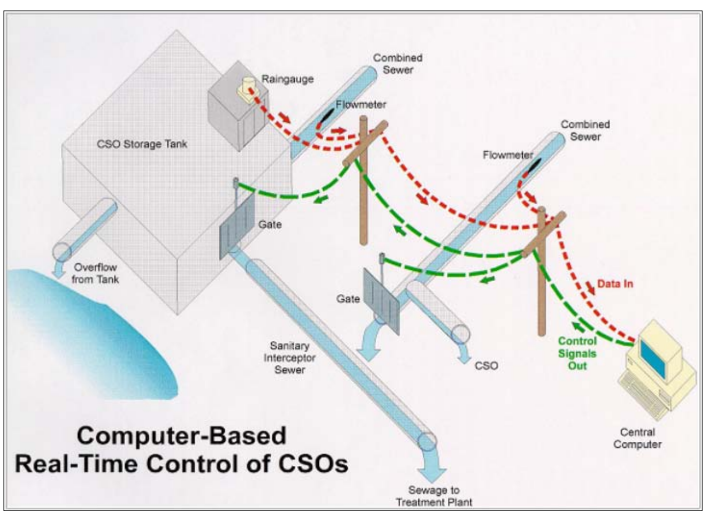
Real Time Control:

A Real Time Control (RTC) system continually adjusts the levels of existing regulator gates and storage facilities according to changing rainfall and flow conditions, in order to maximize the use of the storage capacity available (in-line and off-line) within the CSS and minimize overflow volumes during each storm event. Typically, a RTC system includes a network of rain gauges and flow sensors located throughout the CSS, which provides a continuous stream of real time measurements to a central control room and computer system. This information is displayed to the operators, and possibly used by the central computer to simulate the operation of the CSS and predict flow rates and depths at important points within the system. The objective is typically to minimize CSO frequency or volume at selected outfalls or for the system as a whole. From the information provided, the central computer determines which gates should be opened or closed, for how long, and when further adjustments might be necessary. The net result should be that as much flow is sent to the WWTP as it can treat, at all times. Practically speaking, this is not always fully attainable because the entire CSS may not be automatically controllable (remember the static regulators). Finally, the operator (in the case of supervisory control) or the central computer (in the case of automatic control) will determine the desired control setpoints for each individual CSO control gate and storage facility, and transmit the corresponding control signal to each device. Upon receipt of these signals, the devices will move to their new optimal positions. RTC systems can often create additional CSO storage within the existing CSS, at a fraction of the cost of creating new storage, and can, for this reason, be a very cost-effective CSO control technology.

Figure 6-13 - Real Time Control (RTC) of CSOs



Regulator Adjustments:

CSO regulators including static overflow weirs and dynamic controls gates within the CSS regulate the amount of flow that is conveyed to the WWTP during both dry and wet weather. The removal of CSO regulators or adjustments to increase the thresholds at which these regulators begin to divert CSOs to local receiving waters sends more flow to the WWTP and decreases the volume, and sometimes the frequency of CSOs. Where the removal or adjustment of regulators is possible, they must be carefully investigated to ensure that the increased flows sent to the WWTP do not cause downstream flooding, or are not simply diverted without treatment at some downstream location. Removal or adjustment may not be possible or effective at some CSO regulators for these reasons.

Sewer Separation:

Sewer separation is the practice of separating the combined, single pipe system into separate sewers that carry sanitary sewage and stormwater, and eliminating all connections (or overflows) between the two sewer systems. Stormwater that formerly entered the combined sewers is instead conveyed to a stormwater outfall where it is discharged directly into local receiving waters. Complete separation of the CSS also involves the separation of combined sewer laterals on private property and/or disconnection of all stormwater inputs, including roof downspouts, foundation drains and sump pumps. Depending upon grade restrictions, a newly separated sewer system may require a number of new satellite pumping stations. Done properly, the sewer separation will ultimately eliminate CSOs altogether and have a significant positive impact on the environment. Former CSO outfalls become separate storm sewer outfalls that should not contain any sanitary sewage. However, sewer separation greatly increases the volume of stormwater discharged to receiving waters, which if not also treated can significantly offset the pollutant loading reductions provided by separating the CSS. Many studies have found that stormwater runoff can be highly polluted. This is especially true of the runoff, which occurs at the beginning of a rainfall event, which washes off pollutants, which have accumulated on roads, roofs and other surfaces during dry weather. This is commonly referred to as the “first flush”. In a CSS, a significant portion of the stormwater (and an even greater proportion of the first flush) is captured and conveyed to the WWTP for treatment.

6.3 CSO Treatment

Continuous Deflective Separation:

Developed in Australia, Continuous Deflective Separation (CDS) is a liquid/solid separation method consisting of a stainless steel perforated and deformed separation plate placed in a hydraulically balanced separation chamber. CDS also provides screening for control of floatables. CDS has been applied successfully to treat stormwater, but the ability of the CDS technology to consistently treat CSOs to an effluent quality that meets or exceeds primary treatment equivalent (e.g. as required by Procedure F-5-5) has not yet been adequately demonstrated. Removal of cBOD and enhancement of Dissolved Oxygen (DO) levels vary widely, and ammonia removal is negligible. Disinfection of the treated CDS effluent will be required to remove bacteria. CDS can be implemented in either in-line or off-line configurations; and as satellite treatment facilities located at individual outfalls or centralized treatment facilities located at the receiving WWTP.

Figure 6-14 - In-line CDS® Unit Schematic (CDS Technologies)

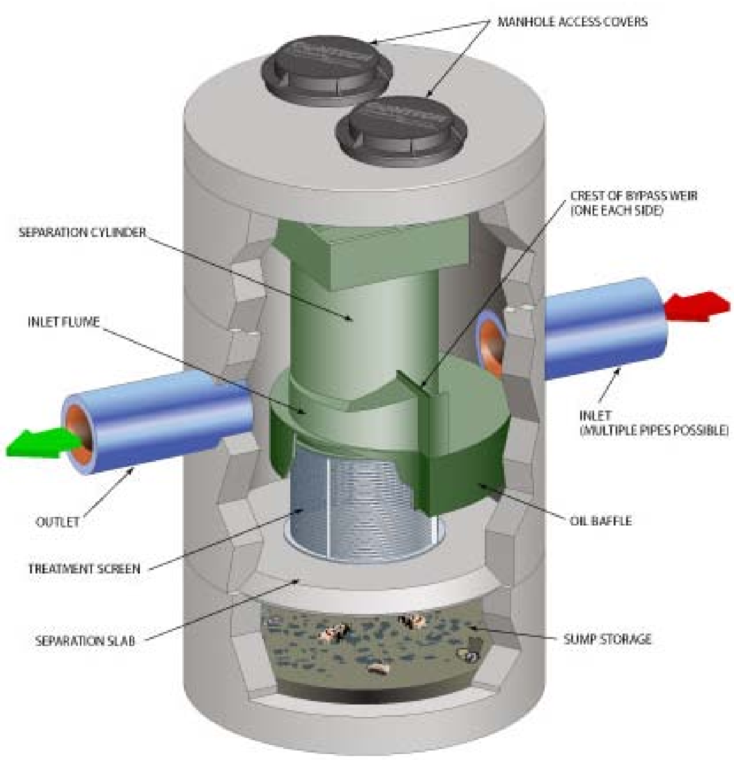


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Figure 6-15 - Off-line CDS® Unit Schematic (CDS Technologies)

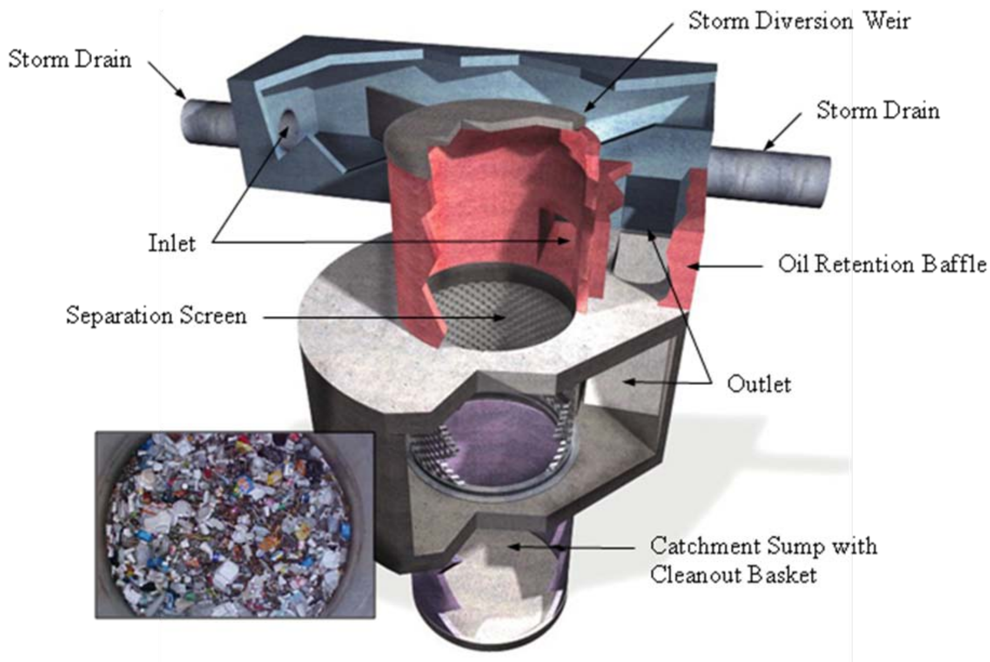

Figure 6-16 - Satellite CDS® Facility (XCG, 2004)

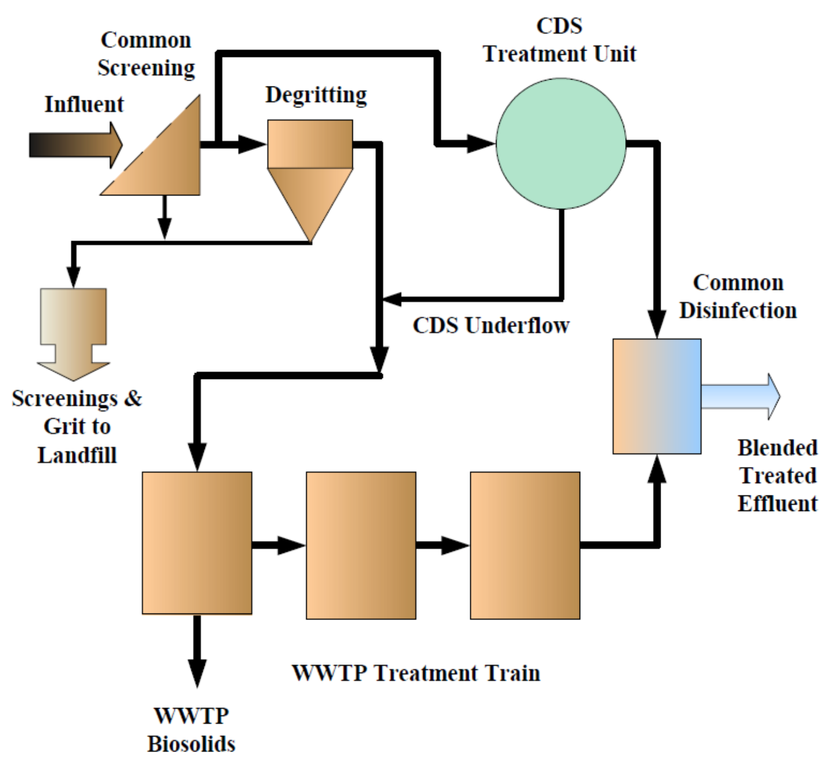

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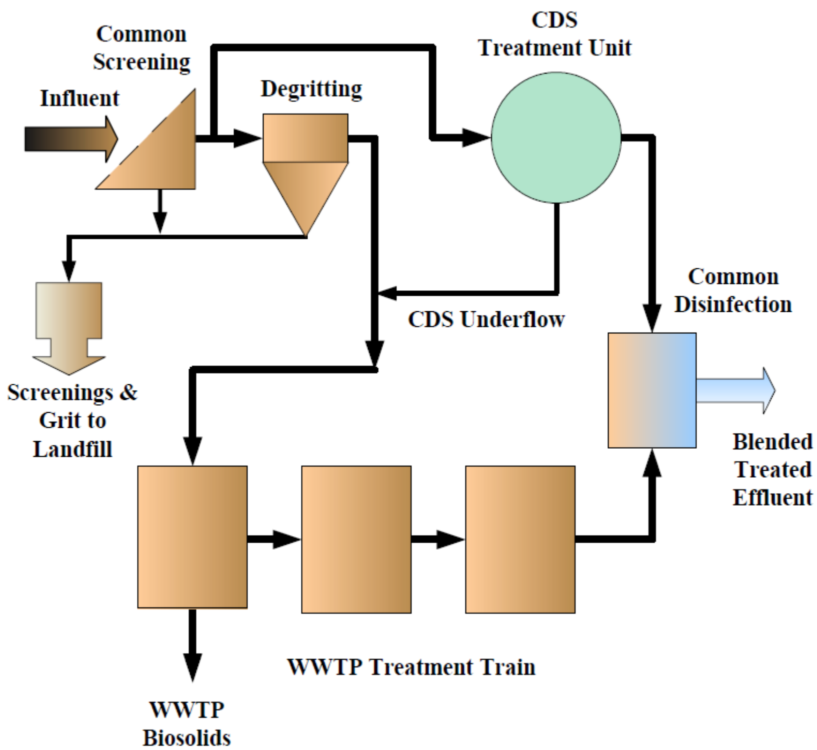
Figure 6-17 - Integrated CDS® Facility at Central WWTP (XCG, 2004)



<u>Coarse and Fine Screens:</u>

Coarse screens with wide parallel bar spacing are often placed in the flow of wastewater to remove large objects and floatable material. Three types of coarse screens are in use for removal of gross solids from CSO: trash racks, manually cleaned screens and automatically cleaned screens. Coarse screens are discussed further under Floatables Control. Fine screens typically follow coarse screens in the treatment train of CSO. Screening is a physical treatment where by its efficiency is dictated by the size of the openings in the screen, typically 0.2 to 12.7 mm. The use of both static and rotary screens has been applied to CSO. Coarse and fine screens can be implemented as satellite treatment facilities located at individual outfalls or centralized treatment facilities located at the receiving WWTP.

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Figure 6-18 - Romag™ Screen (XCG, 2004)

Figure 6-19 - Low Profile Overflow Screen (XCG, 2004)

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Figure 6-20 - Rotary Drum Sieve (XCG, 2004)

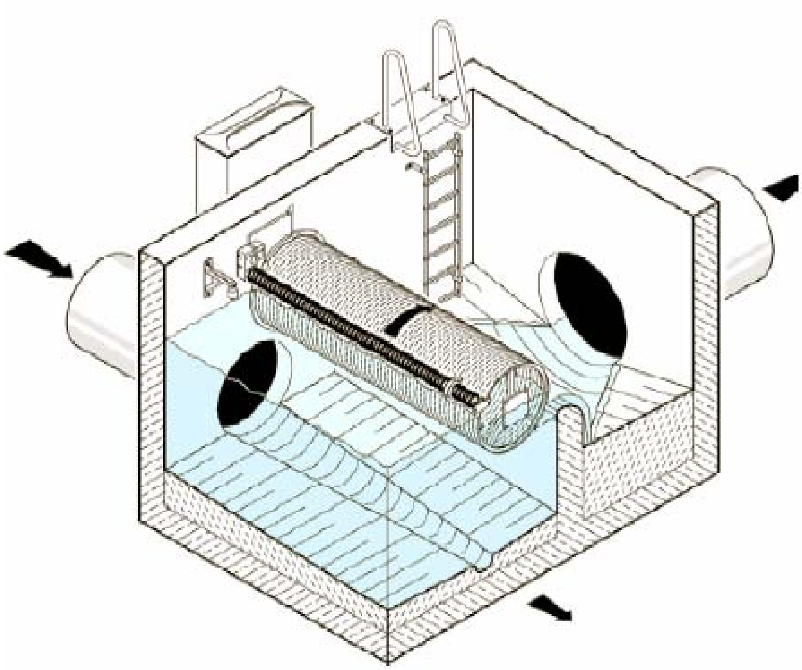

Figure 6-21 - Coarse Bar Screen

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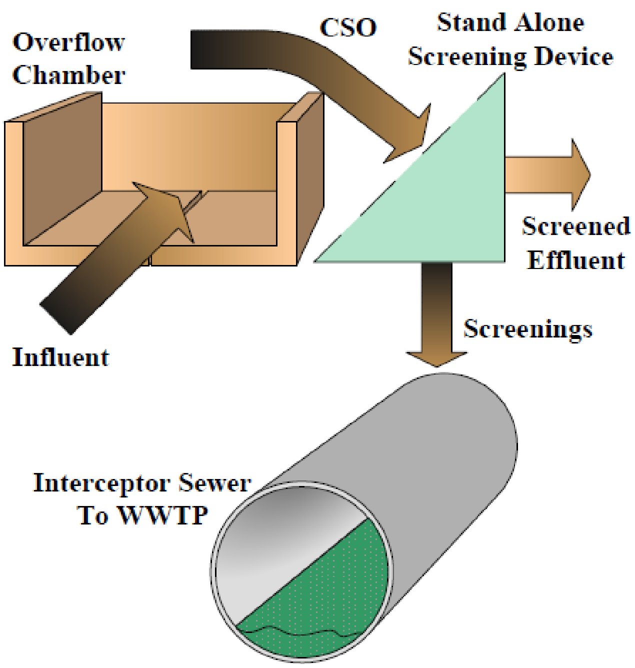
Figure 6-22 - Fine Bar Screen (Headworks/Mahr)

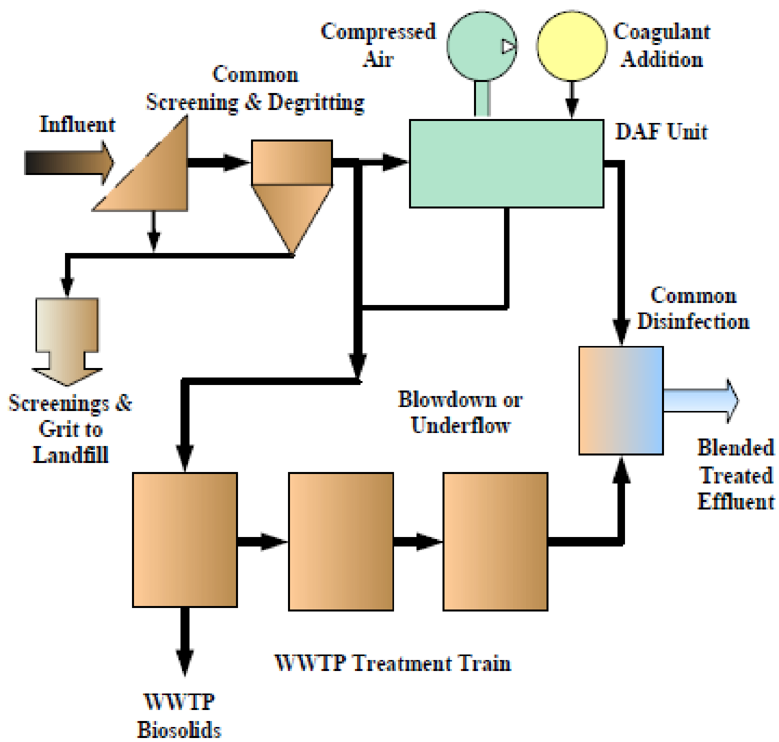
Figure 6-23 - Satellite Screen Application (XCG, 2004)



Dissolved Air Flotation:

Dissolved air flotation (DAF) is a unit process that separates solid matter from liquid. Dissolved air in solution is mixed with a polymer laden waste stream. The polymer coagulates the wastewater solids, and the solids attach to minute air bubbles and are floated to the surface of the tank and removed by skimmers. Clarified liquid (supernatant) is discharged over a weir at the back of the tank. DAF has proven to be effective in the treatment of CSO for removal of suspended solids, floatable, oil and grease. DAF requires both the addition of a chemical coagulant and compressed air requiring the storing and handling of chemicals and electricity to operate blowers. The heavy sludge produced by the process will also have to be handled. Experienced operator supervision is required to ensure the process is working effectively. These factors must be weighed against the removal efficiency of the process when considering its implementation. Disinfection of the treated DAF effluent will be required to remove bacteria.

Figure 6-24 - Integrated Dissolved Air Floatation at Central WWTP (XCG, 2004)



High Rate Filtration:

High rate filtration, using deep bed dual media, shallow bed sand, and compressed synthetic media filter, has been used to treat CSOs. The use of a dual-media filter of anthracite, coal and sand filter media can reduce TSS and cBOD at a high rate of flow. Pilot studies for CSO treatment have taken place in Cleveland, Ohio and Richmond, Virginia. TSS removal rates in Cleveland were 95% with polymer addition, and 50-80% without. The Schreiber Fuzzy Filter® employs compressed synthetic fibre spheres to achieve high TSS removals at very high hydraulic loadings (i.e. over 20 $L/m^2/s$). Influent enters the unit and travels through the filter media bed. The low density and high porosity of the media results in more solids being captured per volume of media, and because the filter media is compressible, the porosity of the filter bed can be altered (by a moveable plate above the media) to suit different influent characteristics. The process also represents a departure from conventional filtration, in that the influent is filtered through the media itself, and not through the pores created by the media, as in sand and anthracite filters. The filter media bed is cleaned by air scouring. During the wash cycle, the media bed is uncompressed and influent continues to enter the uncompressed filter (filtered water is not necessary for washing the media) while an external blower supplies air at the bottom of the chamber to agitate the media. The uncompressed media, which is retained between two perforated plates, is subjected to vigorous air scouring to free the captured solids. After the washing cycle, the media is returned to its compressed state, and filtration is resumed.

Figure 6-25 - Schreiber Fuzzy Filter® (Schreiber, 2011)

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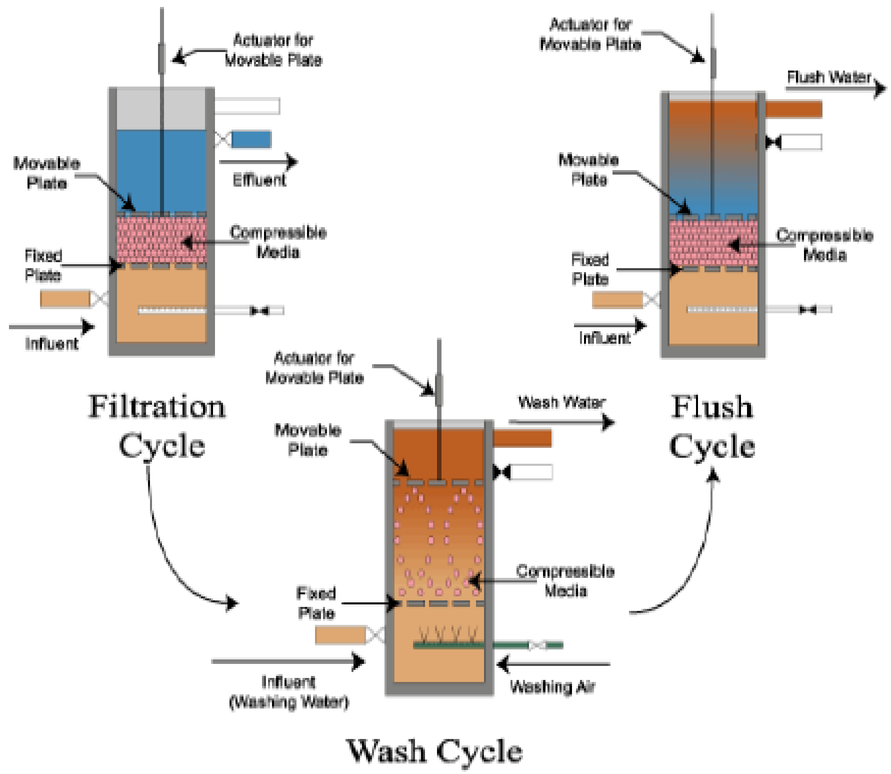
Figure 6-26 - Fuzzy Filter® Operation Cycle (Schreiber, 2011)



<u>High Rate Physical-Chemical Treatment:</u>

High rate physical-chemical treatment (HRPCT) technology was developed in Europe and has recently been introduced to North America. The USEPA's Environmental Technologies Verification Program prepared a generic protocol for testing of HRPCT to assist with validating the performance of the equipment currently available as well as technologies developed in the future. Ballasted flocculation is a high rate physical/chemical precipitation process that uses an iron or aluminum coagulant with polymer to remove suspended solids from the wastewater stream. It provides primary treatment utilizing less tankage and therefore less space. Conventional primary clarifiers have a loading of about 1 L/m^2/s, whereas ballasted flocculation typically has loading in the range of 37-42 L/m^2/s, reducing the required construction footprint by 25 to 50 times. There are currently two ballasted flocculation technologies readily available, the Actiflo process from US Filter, and the

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Densadeg 4D process from Infilco Degremont. Numerous pilot studies have been conducted utilizing the technology for removing suspended solids (SS) from CSO discharges. Both technologies have been effective in reducing SS, but the Actiflo process has demonstrated a considerably shorter start-up time, and has typically demonstrated better and more consistent pollutant removal efficiencies. Another effective high rate treatment option involves the addition of cationic polymer to the combined sewage in Retention-Treatment Basins (RTBs). Again, the addition of polymer in the RTBs greatly increases surface loading rates, and significantly reduces the required volume and footprint of the satellite treatment facility. Disinfection of the treated effluent will be required to remove bacteria. HRPCT can be implemented as satellite treatment facilities located at individual outfalls or centralized treatment facilities located at the receiving WWTP.

Figure 6-27 - Actiflo® Ballasted Flocculation Unit (Actiflo®)

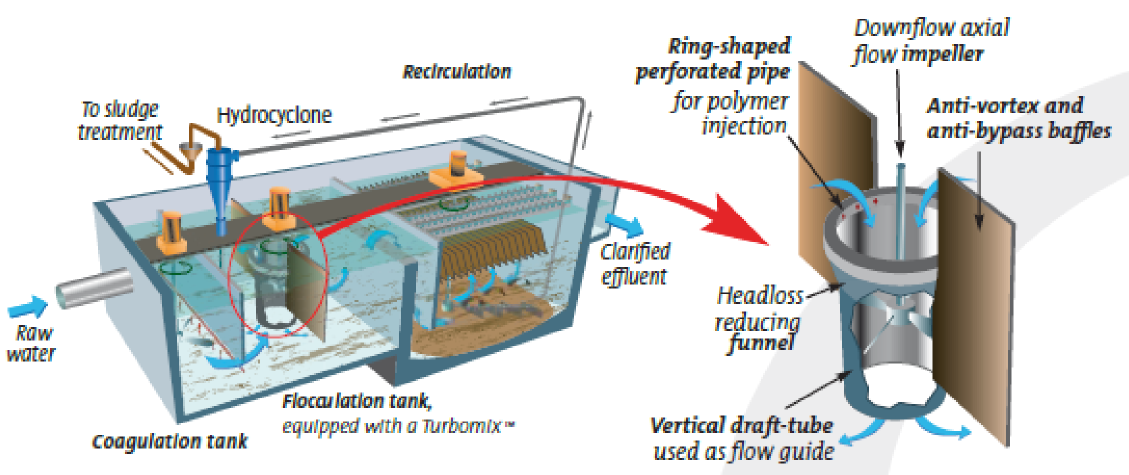

Figure 6-28 - Satellite Actiflo® Facility (XCG, 2004)

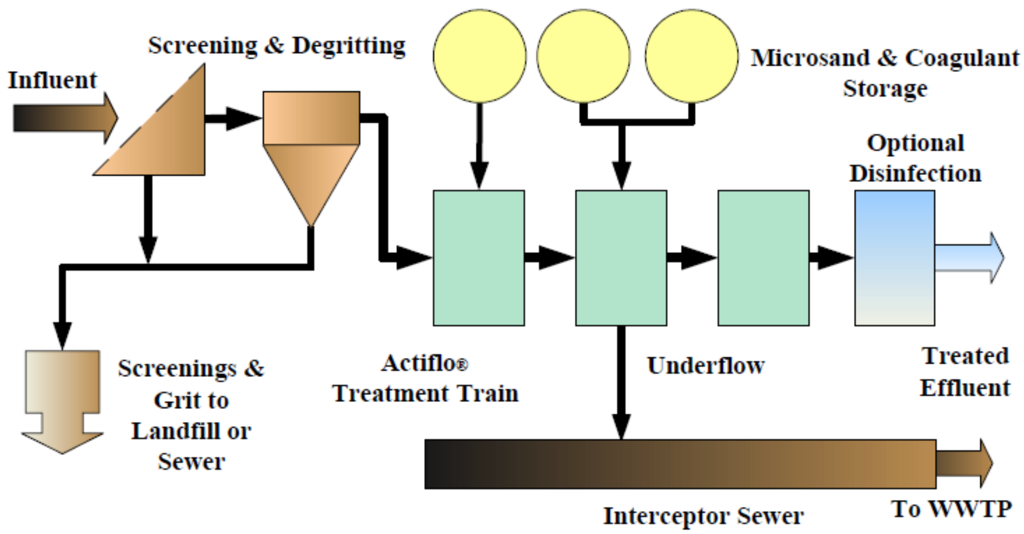

Figure 6-29 - Densadeg® Flow Schematic (Densadeg®)

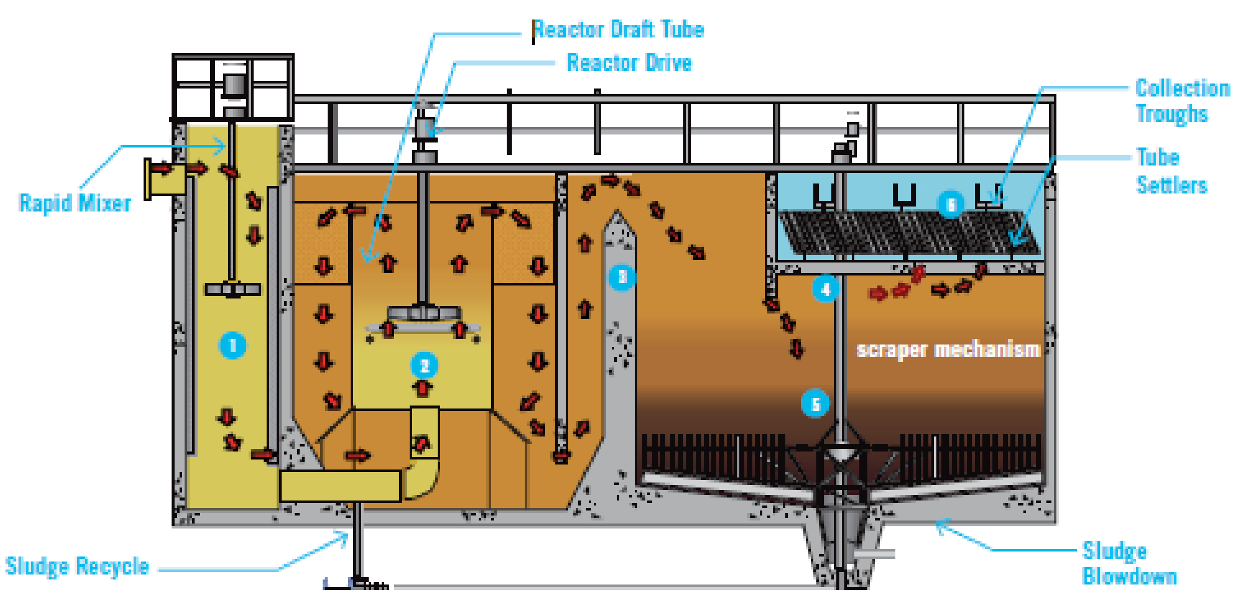

Figure 6-30 - Satellite Densadeg® Facility (XCG, 2004)

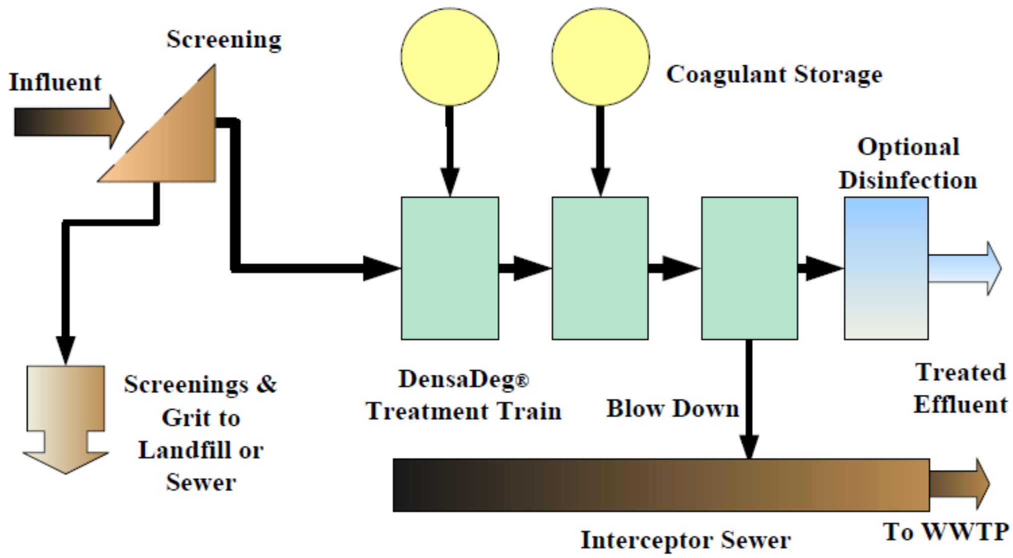

Figure 6-31 - Satellite Retention Treatment Basin (XCG, 2004)

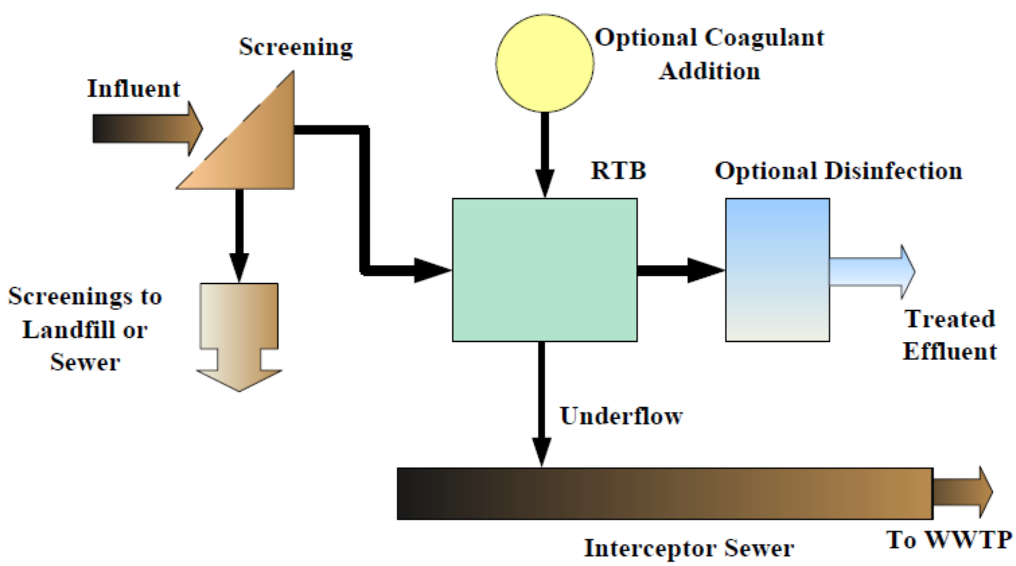

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Figure 6-32 - Integrated Retention Treatment Basin at Central WWTP (XCG, 2004)

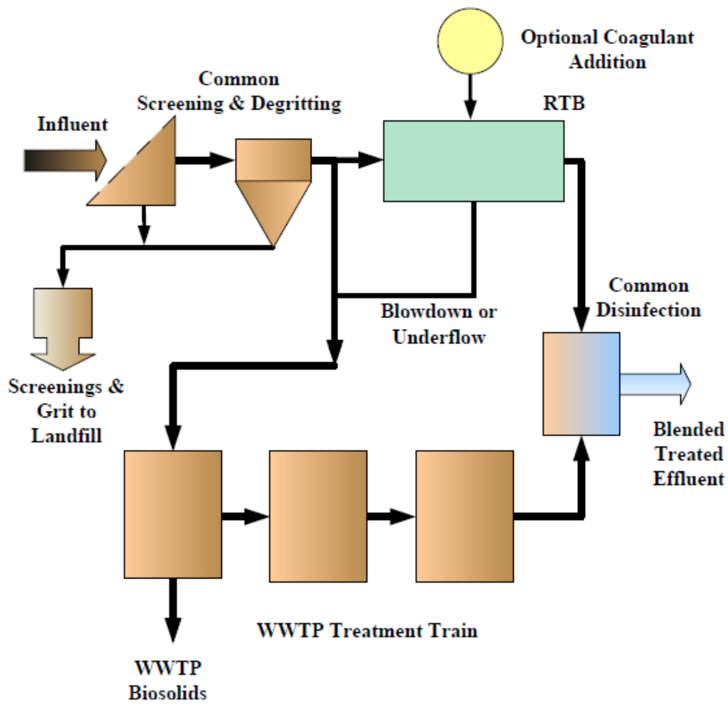
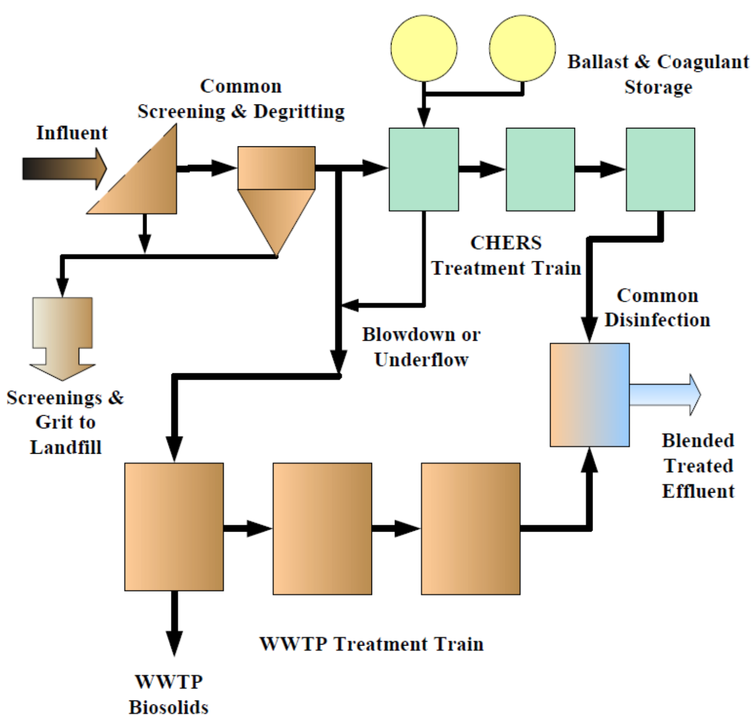


Figure 6-33 - Chemically Enhanced Primary Treatment at Central WWTP (XCG, 2004)



<u>Treatment Shafts:</u>

Treatment shafts are a relatively new concept, which provides multiple levels of CSO/SSO treatment within a single vertical shaft. In addition to the complete capture of overflows for the vast majority of events (depending upon selected design criteria) for subsequent conveyance and treatment at the receiving WWTP, the patented "Treatment Shaft Technology" also provides high-rate flow-through treatment of overflows beyond the shaft's storage capacity, including skimming, settling, screening and disinfection, all within a compact footprint that is typically only about 15% of surface storage facilities of the same volume. A key feature of the treatment shaft design is its low hydraulic headloss and upward velocity, which promotes settling of suspended organic and inorganic solids. Horizontal raked bar screens are used on the effluent side, and the horizontal configuration of the screens ensures that all flows, high or low, are screened with minimum velocities through the screens. During a treated overflow event, the screens are continually raked by a hydraulically driven system. All materials collected during operation automatically end up at the bottom of the shaft, where they are pumped back into the sewer system and conveyed to the receiving WWTP after the storm event (typically within 24 to 48 hours), without additional handling or use of trash containers. A flushing system consisting of water jets is employed to clean the bottom of the shaft in preparation for the next storm event. When disinfection of overflows is required, the treatment shafts can work with a variety of sewage disinfection methods (some of which are discussed below in Section 6.5).

Figure 6-34 - CSO Treatment Shaft (Applied Engineering Technologies)

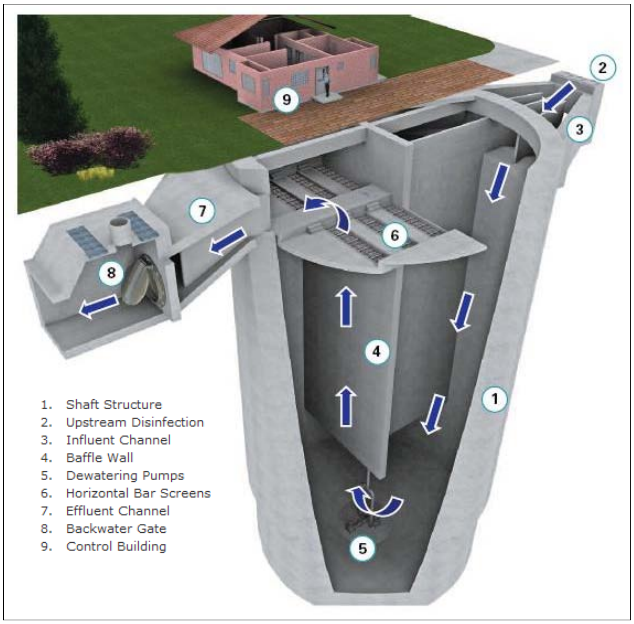


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Figure 6-35 - CSO Treatment Shaft under Construction (Dearborn, Michigan)

Vortex Separators:

Vortex Solids Separators (VSS) utilize cyclone action or centrifugal forces to separate solid material suspended in a fluid. VSS units operate passively, requiring no electricity and they have no moving parts. The unit operates using the head of the incoming wastewater, thus, a constant hydraulic head must be present. Wastewater enters the cone-like device tangentially, and heavy material migrates outward toward the walls where the velocity is slower and eventually slips down the wall to the base of the cone. Material is then collected and pumped back to the interceptor sewer for treatment at a WWTP. Clear liquid moves toward the center of the cone to an area of high velocity. From here it is discharged from the unit. Reported TSS removals range widely from 5% to 80%. Opinions on the ability of this technology to consistently treat CSOs to an effluent quality that meets the primary treatment equivalent (as specified by Procedure F-5-5) are mixed, and it is apparent that chemical addition will be required to meet these treatment objectives, and disinfection of the treated effluent will be required to remove bacteria. In order to determine the required dosages of chemicals and the expected performance of the treatment devices, it is necessary to collect accurate and reliable information on the quality and characteristics of the CSOs to be treated at any given site, and to conduct pilot testing of the devices.

Figure 6-36 - Storm King® Overflow with Swirl-Cleanse™ Screen (Hydro International)

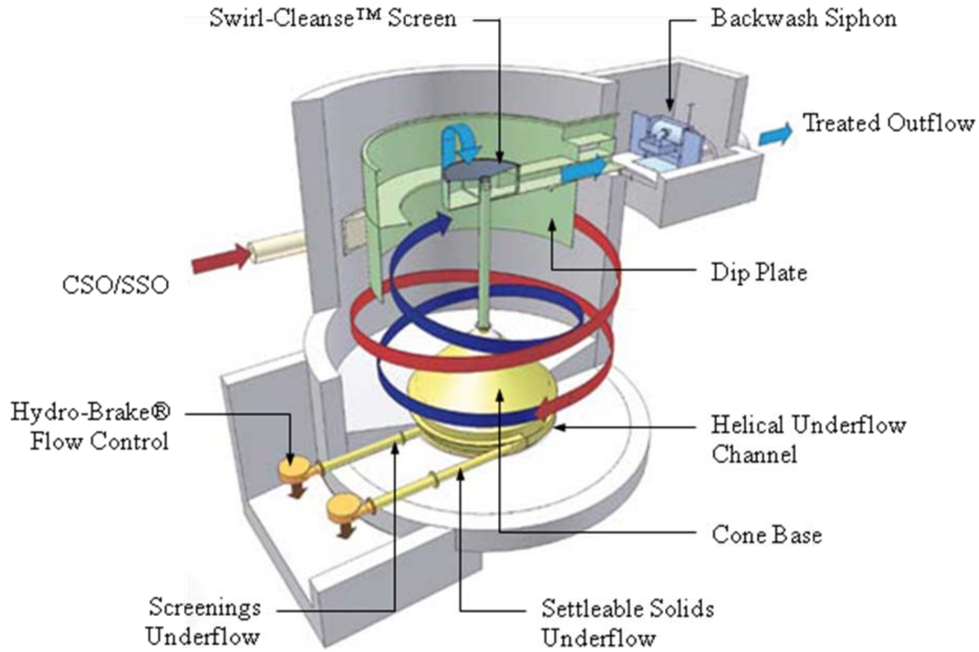

Figure 6-37 - Satellite Vortex Treatment Facility (XCG, 2004)

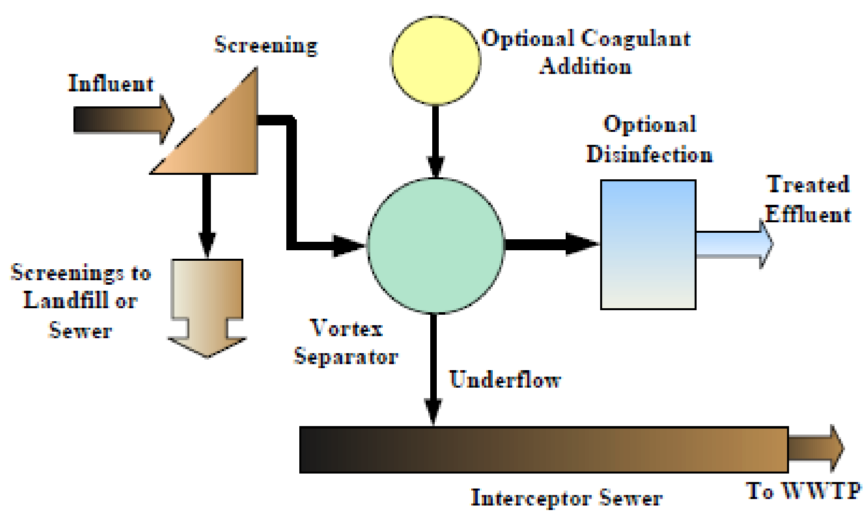

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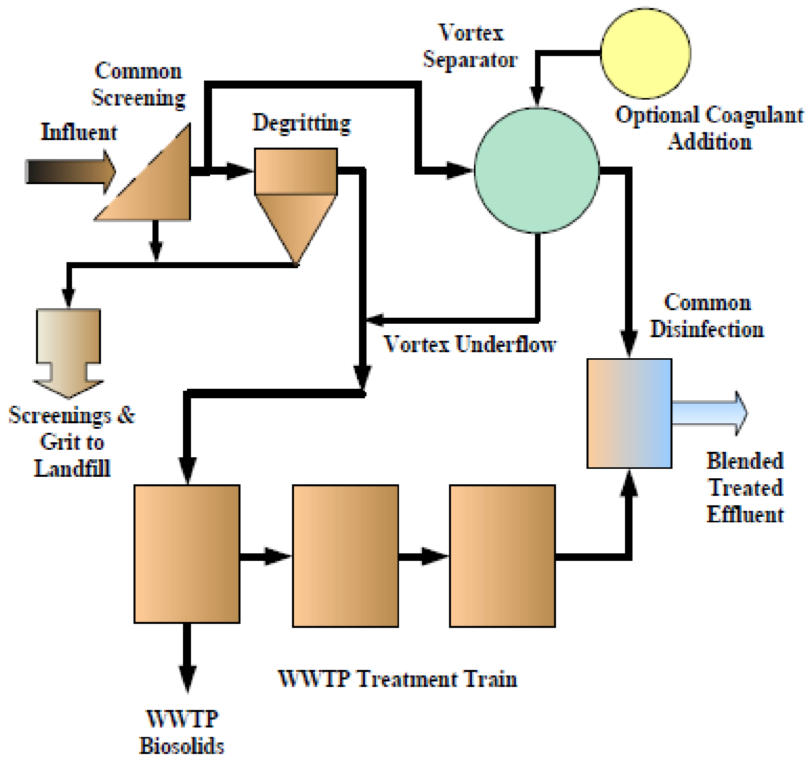
Figure 6-38 - Integrated Vortex Treatment Facility at Central WWTP (XCG, 2004)



6.4 Floatables Control

Most existing CSO control policies/guidelines (e.g. MOE Procedure F-5-5 and the USEPA CSO Control Policy) require the development and implementation of a program to control the discharge of coarse solids and floatable materials from the CSS. This may include measures to reduce or eliminate the entry of these materials into the CSS, to remove them from the CSS before discharge, or to remove them from the receiving water after discharge. Some commonly employed methods of controlling floatables from CSOs are discussed below:

<u>Catch Basin Modifications:</u>

Inlet grates can be installed above the catch basins to reduce the amount of street litter and debris that enters the catch basins, and trash buckets can be installed in the basin beneath to capture any materials, which pass through the grates. Other catch basin modifications include hoods, submerged outlets and vortex valves. Costs for catch basin modifications vary greatly depending upon the method employed.

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Figure 6-39 - Vortex Valve Flow Regulator

Containment Booms:

Booms are containment systems that employ fabricated floats and curtains to capture floating materials discharged by CSO outfalls. Captured materials are typically removed manually or by a vacuum truck following a CSO event. Containment booms are very expensive to purchase and maintain.

Figure 6-40 - Containment Boom

Netting Systems:

Two types of netting systems can be used to collect floatables from CSS. In-line netting systems are installed within the CSS to capture floatables at key points in the CSS. The flow in the CSS carries the floatables into the nets where they are captured. The nets are replaced following each storm event. Floating nets are installed in the receiving water to capture floatables discharged at the CSO outfall. The nets are single use, and are typically removed after a CSO event and taken to a disposal area. Netting systems are very expensive to purchase and maintain.

Figure 6-41 - In-line Netting System (Freshcreek®)

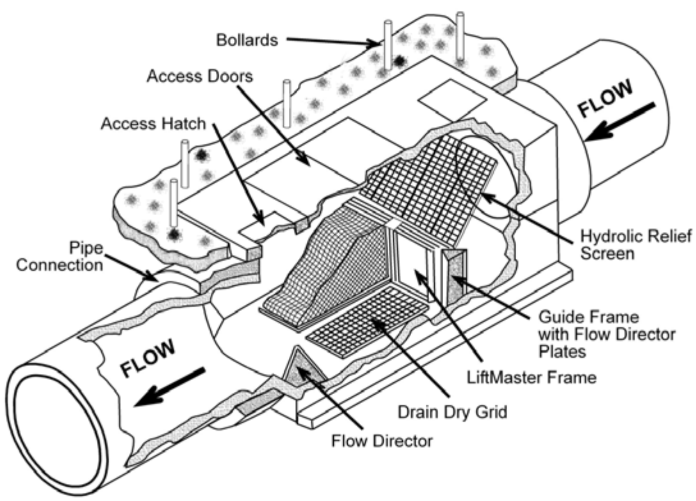
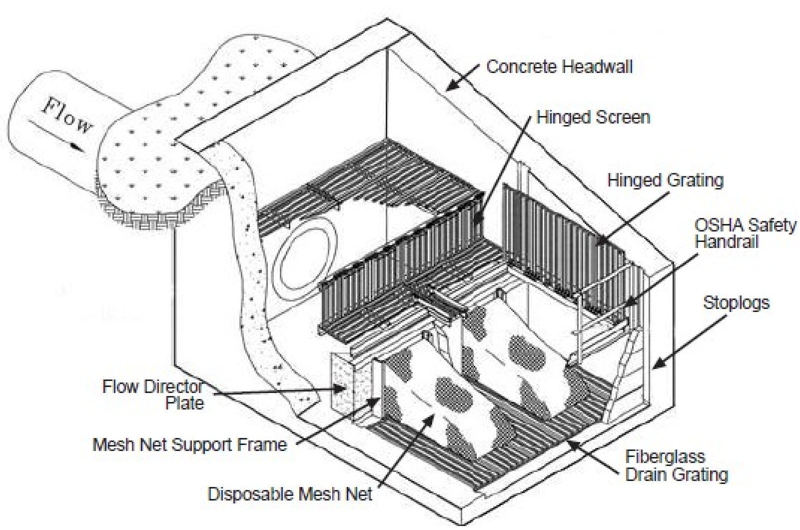


Figure 6-42 - End-of-Pipe Netting System (Freshcreek®)



Screens and Trash Racks:

Screens and trash racks consist of a series of vertical and horizontal bars or wires that trap floatables while allowing water to pass through the openings. Screens commonly employed for CSO floatables control include mechanically cleaned screens, static screens, traveling screens and rotating drum screens. Screens are typically classified by the size of floatable material they are designed to capture. Bar screens typically capture materials larger than 2.5 cm in diameter; coarse screens capture materials larger than 0.5 cm; and fine screens capture materials larger than 0.01 cm. The screens most commonly used for CSO floatables control are trash racks and coarse screens.

Figure 6-43 - Trash Racks

Underflow Baffles:

Underflow baffles can be located in regulator chambers and consist of a plate (steel or concrete) which drops down from the obvert of the sewer to a level just below the top of the overflow weir. Baffles can be constructed in new chambers or retrofitted into existing chambers. During an overflow event, CSO discharged over the weir first passes under the baffle. Floatables are retained behind the baffle until the water level subsides and they are subsequently conveyed to the WWTP by the sewage still flowing in the CSS. Underflow baffles are relatively inexpensive to install and require little maintenance.

Figure 6-44 - Underflow Baffle on CSO Tank Overflow (Hamilton, Ontario)

6.5 Disinfection

Disinfection is the process of reducing pathogens from wastewater effluent. CSOs require disinfection when the effluent affects swimming and other areas of public health concern. Chlorine, in its many forms, has historically been the conventional method of disinfecting wastewaters, including CSO. However, several alternative methods are available, including Ultra-Violet (UV) irradiation, ozonation, peracetic acid, electron beam irradiation and chlorine dioxide. Most of these disinfection technologies can be coupled with other CSO control technologies (e.g. screening, storage and high rate treatment) and can be implemented at satellite treatment facilities located at individual outfalls or centralized treatment facilities located at the receiving WWTP, although the need to deliver and store potentially dangerous chemicals at satellite locations is often impractical or undesirable from an operations and maintenance standpoint, and unacceptable to local residents.

<u>Chlorine:</u>

Chlorine is a very effective means of reducing pathogenic micro organisms when applied correctly. Like most disinfection methods, its effectiveness depends upon the concentration of suspended solid material as well as length of contact time and dosage. Chlorine is most effective when the suspended solids are low and the clusters of bacteria are small. Chlorination should be followed by dechlorination to minimize the potential adverse effects of chlorine residuals on public health and the aquatic environment.

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Figure 6-45 - Satellite RTB with Chlorination/Dechlorination Facility (XCG, 2004)

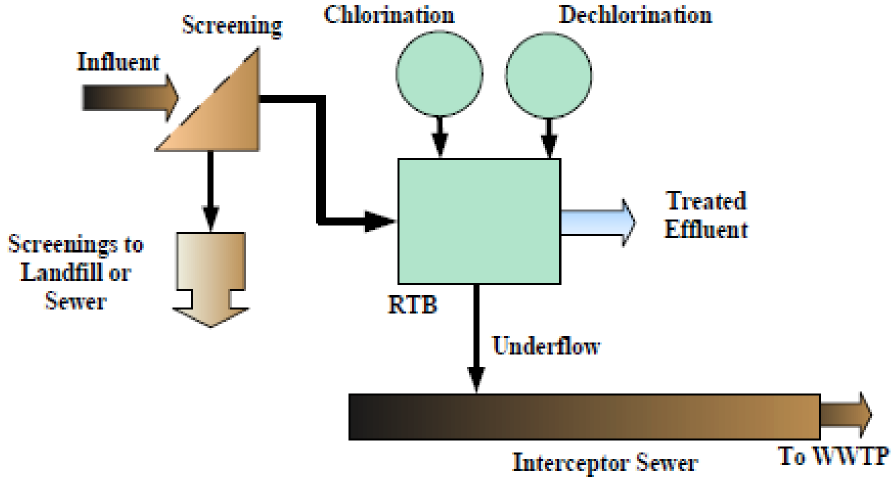
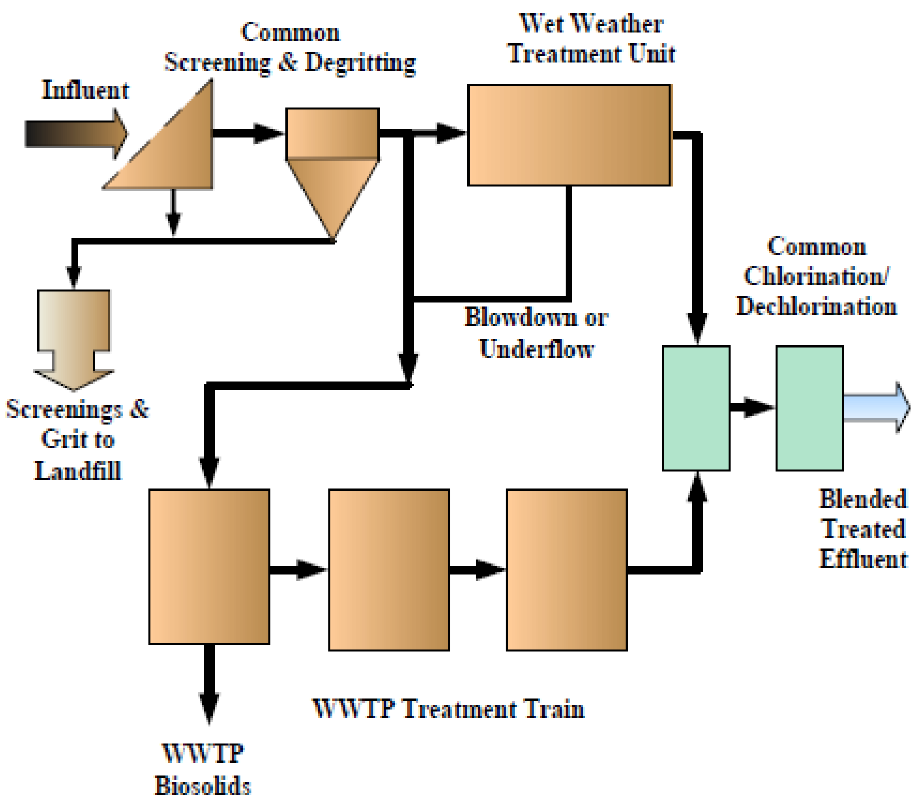


Figure 6-46 - Integrated Chlorination/Dechlorination at Central WWTP (XCG, 2004)



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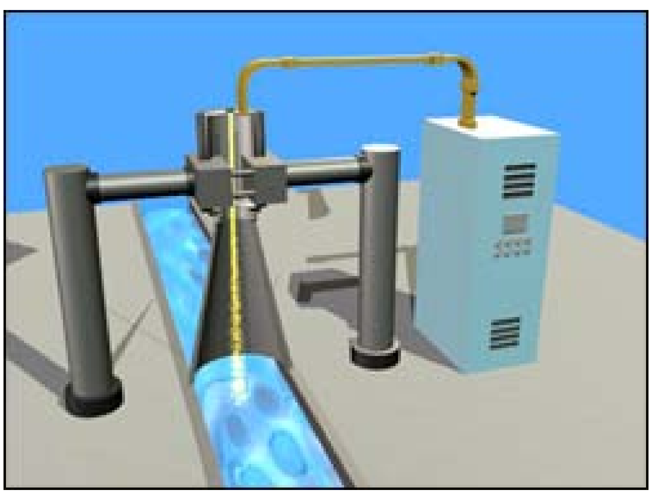
Chlorine Dioxide:

Chlorine Dioxide is economical to produce and hazardous to transport. Therefore, it is typically generated on-site by one of three generation methods: combining sodium chloride with either aqueous or gaseous chlorine; combining sodium chlorite with hydrochloric acid; or radiating sodium chlorite with UV irradiation. Chlorine dioxide is applied to the waste stream in a similar manner as chlorine. It is injected at a metered rate based upon flow, mixed and allowed to react in a contact chamber. Unlike conventional chlorine, chlorine dioxide does not generate toxic by-products such as THMs unless there is excess chlorine remaining from the formation of chlorine dioxide. Over-dosing is of concern as it can lead to the development of chlorite and chlorate.

Electron Beam Irradiation:

Electron Beam (or e-Beam) Irradiation is in the development stage as a wastewater disinfection technology. The e-Beam process uses a stream of high-energy electrons to break down the water molecules from a thin film of wastewater to form oxidizing agents. Developed as a means of disinfecting municipal biosolids and irradiating hazardous organic compounds, the USEPA is continuing to investigate its potential uses in the wastewater treatment field.

Figure 6-47 - Electron Beam Irradiation



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Ozone:

Ozone provides a more powerful means of disinfecting wastewater than chlorine, although its behaviour is similar. The half-life of ozone is 20 minutes, requiring that it be generated on site by passing either pure oxygen or air through an electric arc. The cost of purchasing oxygen or purifying atmospheric air for ozone generation must therefore be considered when evaluating ozonation as a disinfection alternative.

Figure 6-48 - Ozonation

Peracetic Acid:

Peracetic Acid (PAA) is emerging as a viable disinfection option for wastewater. PAA is a very strong oxidizer. In fact, it is so reactive that it must be mixed on site by combining glacial acetic acid, hydrogen peroxide and water. Sulfuric acid is added as a catalyst for the reaction and a stabilizer is also added to slow/control the biodegradation. Limited demonstrations have taken place utilizing PAA as a disinfectant for treatment plant effluent, although some preliminary results indicate that PAA is effective and does not produce any toxic by products.

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UV Irradiation:

UV irradiation has been gaining acceptance as a method of disinfecting wastewater effluent, including CSOs. Wastewater is passed through multiple banks of UV lights that alter the DNA of the bacteria, rendering them unable to replicate. UV does not require a long contact time, and does not create any disinfection by-products. However, in order to be effective, the effluent being treated with UV must be relatively clear, having a low suspended solids concentration.

Figure 6-49 - Ultraviolet (UV) Irradiation Unit

Figure 6-50 - Satellite CEPT with Ultraviolet (UV) Irradiation (XCG, 2004)

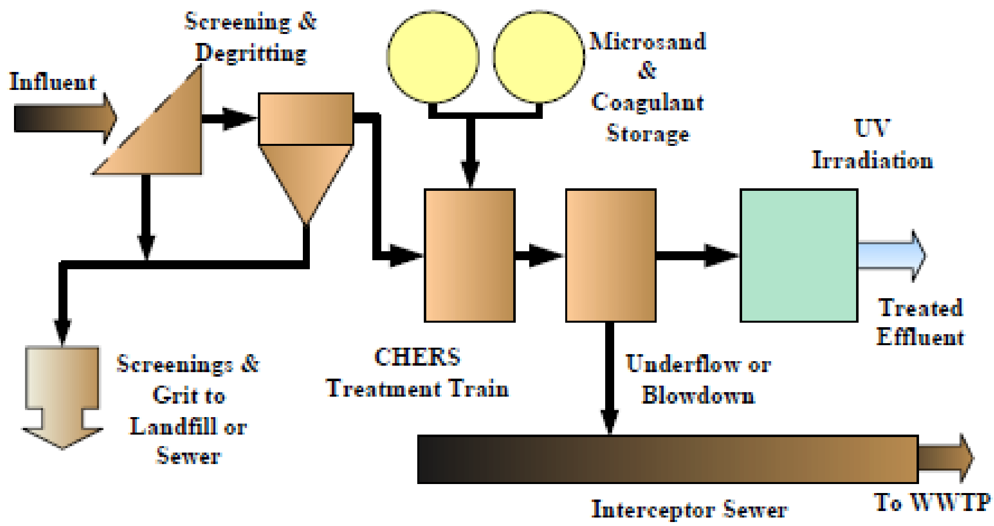
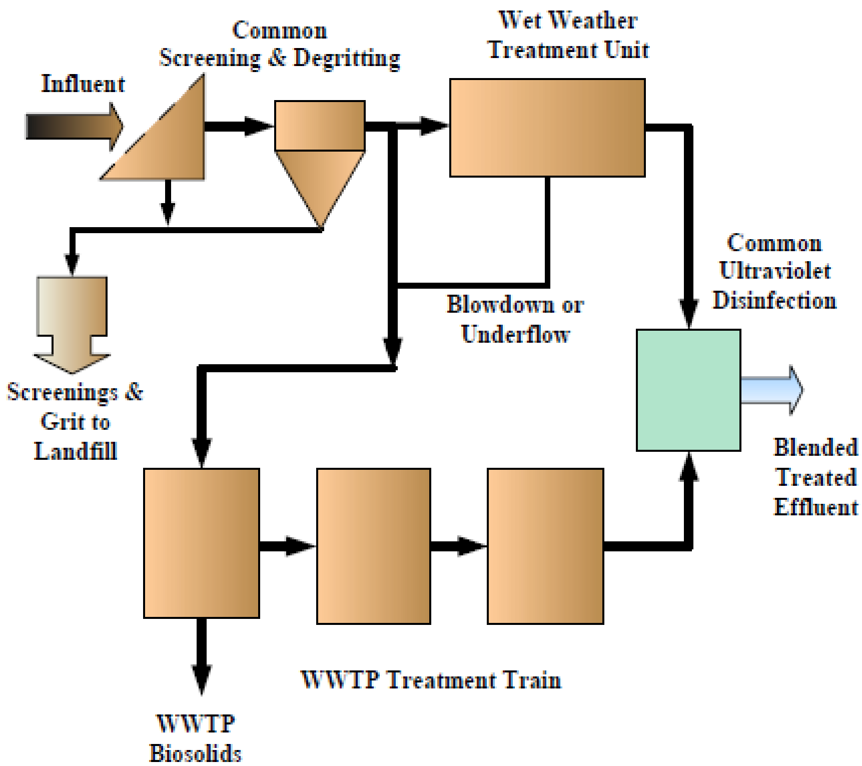


Figure 6-51 - Integrated Ultraviolet (UV) Irradiation at Central WWTP (XCG, 2004)



6.6 Odour Control

While not really a CSO control technology, the implementation of methods to control odours generated by the CSS or by existing or planned CSO control facilities should be given strong consideration.

Odours are generated by the biological activity in wastewater, which may be either aerobic or anaerobic. A by-product of bacteria feeding off organic material in the wastewater, the odours generated in an anaerobic environment are more offensive than those generated in a healthy aerobic environment. Thus, two approaches may be adopted to control odours: reduce the proliferation of odours or provide some type of treatment of the gases that cause the odours.

One of the conventional methods of curbing odour generation is to develop an environment that is not conducive to anaerobic bacterial activity by introducing a source of oxygen. This can be achieved through air entrainment by mixing of diffused air from a blower. Reducing turbulent wastewater flow

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by modifying piping (to eliminate free surface discharge at junctions or wet wells) can also control odour generation, as can minimizing stagnant retention time and wastewater temperature.

Hydrogen sulphide (H_2S) is a common source of odours from municipal wastewaters. A number of different methods are commonly practiced to reduce hydrogen sulphide gas in wastewater collection systems. Examples include shock dosing with NaOH to kill micro organisms; acid/iron addition to precipitate sulfide from wastewater; oxidation of sulfides with chlorine, hydrogen peroxide, potassium permanganate or oxygen; spraying of pipe crowns with magnesium hydroxide slurries; nitrate addition intended to promote biologic nitrate reduction over sulphate reduction; or combinations of these techniques.

Due to the acid/base chemistry of sulphide species, pH control of the wastewater is among the most effective methods to reduce the release of hydrogen sulphide gas from wastewater. Raising the pH of the wastewater will shift the sulphide species from H2S to HS-, which decreases the concentration of aqueous phase H2S that causes the odours. Bioaugmentation (i.e. the addition of chemicals to change the characteristics of wastewater) is a common method of controlling pH in municipal wastewater. For example, the addition of a relatively small volume of magnesium hydroxide can shift the pH of the wastewater by 1 or 2 points, and completely eliminate the release of hydrogen sulphide gas from the wastewater. The addition of magnesium hydroxide has other benefits within the sewer system, including reducing corrosion and reducing fats, oils and greases. It also benefits the treatment of municipal wastewater by improving settling characteristics; reducing consumption of other treatment chemicals; reducing energy consumption, reducing biosolids output, and increasing treatment capacity.

The second approach is to capture and treat the discharged offensive air. Masking agents have been used in an effort to cover up odours. Neutralizers adjust the pH in wastewater to reduce the generation of hydrogen sulfide gas. Air scrubber systems have been installed which precipitate out the offending compounds. Activated carbon filters have been used because of their ability to absorb hydrogen sulfide and organic material. In vapour-phase reactors, chemicals are combined with offensive gases to form less offensive compounds. Many objectionable sewage odours are airborne intermediates from the partial degradation of organic materials. Engineered biofilters employ natural materials such as wood chips or compost to complete this degradation, using the offensive organics as a food source for eliminating the odours. The by-products of this bio-oxidization process are

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primarily carbon dioxide and water vapour. Engineered biofilters are gaining popularity as a means of treating offensive odours at sewage lift stations and treatment plants.

Figure 6-52 - Typical Activated Carbon Scrubber

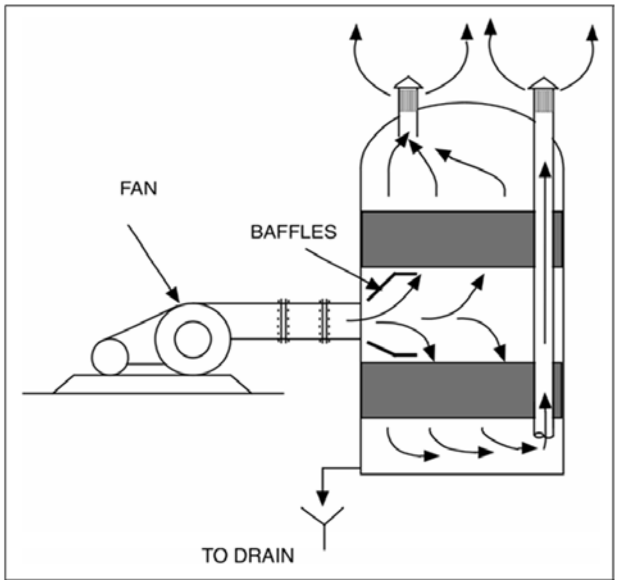

Figure 6-53 - Typical In-Ground Biofilter

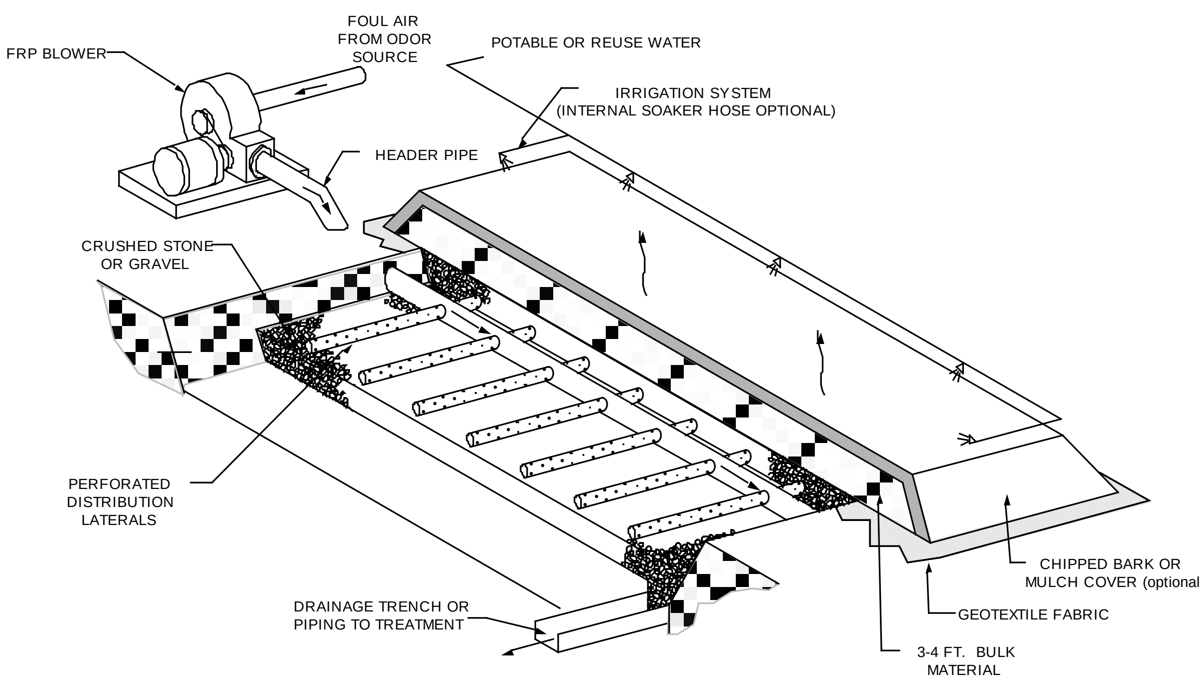

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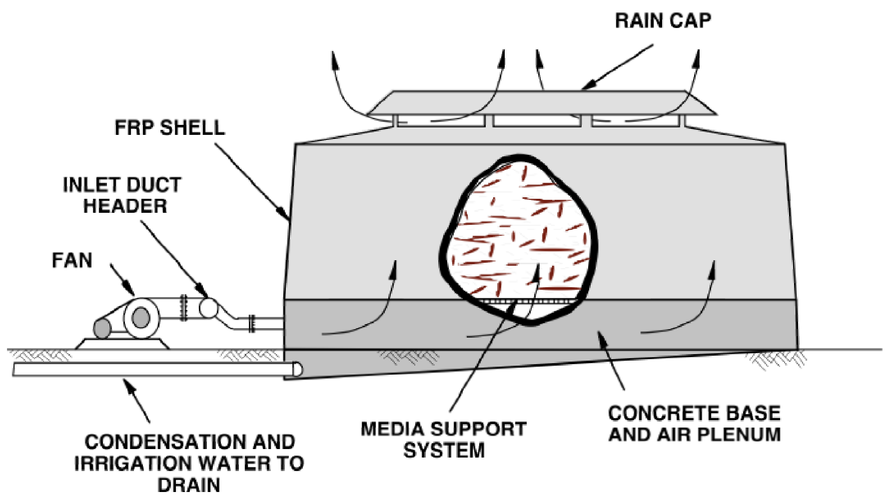
Figure 6-54 - Typical Packaged Biofilter



6.7 Discussion

<u>Source Controls</u>

Although source control measures typically cannot provide the level of CSO control required by most CSO control policies/guidelines on their own, combinations of source controls can yield noticeable CSO reductions, and can reduce the overall costs (or improve the overall performance level) of CSO control programs when considered as part of an overall implementation program. Measures such as water conservation, catch basin cleaning, street sweeping and litter control, pesticide reduction, household hazardous waste disposal programs and sewer use control programs should be considered as part of an overall CSO control implementation plan. Continued public education will also be required to obtain the maximum benefit from such programs. Source controls to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as 'Green Infrastructure'. Green Infrastructure approaches currently in use include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used almost anywhere where soil and vegetation can be worked into the urban or suburban landscape. Green Infrastructure is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets.

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Sewer System Controls

Sewer System Controls such as improved CSS maintenance and operation, CSO regulator adjustments, sewer separation, detention storage, and real time control can all be highly effective in reducing CSO volumes.

CSO storage is one of the best documented, and most effective means of achieving significant CSO volume and frequency reductions, but can be expensive. Sewer separation is typically a very costly and very disruptive approach to reducing CSOs, but done properly, it completely eliminates the potential for the discharge of sanitary sewage to local receiving waters. However, sewer separation greatly increases the volume of stormwater discharged to receiving waters, which if not also treated, can significantly offset or even exceed the pollutant loading reductions achieved by separating the CSS. CSO detention storage and sewer separation are the options that provide the greatest potential CSO reductions, and they can both be easily implemented to meet or exceed the CSO control levels required by most existing CSO control policies/guidelines.

CSO regulator adjustments, real time control, and to a lesser extent improved CSS maintenance, can also provide noticeable CSO reductions. Although these approaches typically cannot provide the level of CSO control required by most existing CSO control policies/guidelines on their own, they can reduce the overall costs (or improve the overall performance level) of CSO control programs when considered as part of an overall implementation program.

CSO Treatment

Satellite treatment facilities may be cost-effective where there are space limitations or limited capacity in the collection system to convey excess flows to the WWTP. Some of these technologies are only effective at removing certain types of pollutants (e.g. disinfection and screening), and technologies may need to be combined to ensure that CSO requirements are met. Close attention needs to be paid to the effluent treatment requirement for satellite treatment facilities. For example, MOE Procedure F-5-5 requires a minimum level of primary treatment, and the discharge from these facilities must achieve an effluent concentration for Total Suspended Solids of not more than 90 mg/l, for at least 50 % of the period from April 1 to October 31. Some satellite treatment technologies (e.g. continuous deflective separation and vortex separators) do not appear to be able to consistently meet these effluent treatment requirements for CSOs.

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High rate physical-chemical treatment (HRPCT) technologies have demonstrated the ability to consistently meet or exceed the effluent treatment requirements of Procedure F-5-5. The addition of chemicals to enhance settling greatly increases surface loading rates over that of conventional primary clarifiers, and significantly reduces the required volume and footprint of these treatment facilities. Ballasted flocculation is a high rate physical/chemical precipitation process that uses an iron or aluminum coagulant with polymer to remove suspended solids from the wastewater stream. There are currently two ballasted flocculation technologies readily available, the Actiflo process from US Filter, and the Densadeg 4D process from Infilco Degremont. Both technologies have been effective in reducing SS, but the Actiflo process has demonstrated a considerably shorter start-up time, and has typically demonstrated better and more consistent pollutant removal efficiencies. Another effective high rate treatment option involves the addition of cationic polymer to the combined sewage in Retention-Treatment Basins (RTBs).

Other treatment systems, providing partial treatment of CSOs (or SSOs) include Floatables Control and Disinfection, which are often used in combination in the USA to control CSOs, and are often used to augment other CSO control measures such as CSO storage tanks and tunnels.

6.8 Summary

Future CSO control programs across the province will likely comprise a multitude of different source control measures, sewer system controls, high rate treatment systems, floatables control measures, and disinfection methods, and will typically include a healthy mix of both green and grey infrastructure. This will vary from community to community, and can only be confirmed by detailed analysis, evaluation and planning, conducted as part of the development of a comprehensive Pollution Prevention and Control Plan (PPCP) or Long Term CSO Control Plan. Most of the afore-mentioned CSO control technologies and approaches can be successfully applied in NL, but there are some additional considerations, including the following comments and exceptions.

Source control measures or green infrastructure, are typically the most cost-effective and easily implemented approaches to CSO control, and are therefore typically the first component to consider in any CSO control program. Many of these measures involve collecting and discharging or storing/ponding rainwater on ground/roof surfaces or in shallow infiltration pits, so careful consideration should be given to the potential for freezing of discharged/stored rainwater and related safety issues, when designing and implementing measures such as roof leader disconnection, green

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roofs, rain gardens, pocket wetlands, shallow infiltration planters, permeable pavement, etc. This will be more of an issue in colder climates, so possibly a greater concern in some areas of Labrador. Regular programs to inspect and maintain existing combined and sanitary sewer systems, including repair and replacement when necessary, will reduce I/I, freeing capacity within the sewer systems and reducing the frequency and volume of sewage overflows, and should be part of any CSO or SSO control program.

Source control measures will typically not be sufficient on their own to achieve desired targets for CSO control, and CSO control programs will typically also need to include additional sewer system controls and/or CSO treatment systems to augment the benefits provided by source control.

Sewer system controls such as catch basin inlet control, flow regulator adjustments, sewer separation, and detention storage, can all be successfully implemented for CSO control in NL. As already noted above, the Dunkers flow balancing method is felt to have limited application for CSO outfalls in NL, because of the heavy ship traffic (in St. John's and Corner Brook) and potential for winter freeze-up of receiving waters. Catch basin inlet controls and flow regulator adjustments will typically be more cost-effective in reducing CSOs than sewer separation and detention storage, but may not be sufficient to meet desired CSO control targets on their own. Sewer separation can be quite expensive and disruptive in more urbanized areas (e.g. St. John's and Corner Brook), and is generally more cost-effective and easier to implement in areas immediately adjacent to receiving waters (where new storm sewers and outfalls are shorter. Detention storage is often used to reduce CSOs, but this approach requires a downstream WWTP to accept and treat the stored sewage following wet weather events. If no downstream WWTP exists, satellite treatment of CSOs at existing CSO outfalls may be more a more cost effective option for controlling CSOs. Where a community has multiple CSO outfalls to control, it may be more cost effective to provide a single, central CSO storage facility to control multiple outfalls, which would also require construction of a new interceptor sewer(s) to collect the excess overflows from the individual CSO outfalls and convey them to the central facility. Where the required storage volume to meet desired CSO control targets is relatively small, say just a few hundred m^3 (e.g. at smaller outfalls and/or smaller NL communities), the storage can be provided within oversized in-line sewer pipes instead of off-line, cast-in-place, reinforced concrete storage tanks, providing a more cost effective solution. Deep tunnel storage is typically implemented to control CSOs in much larger communities, and is not likely to be a cost effective option in NL.

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As already noted, satellite CSO treatment facilities may be cost-effective where there are space limitations or limited capacity in the collection system to convey excess flows to the WWTP, or where there is no existing downstream WWTP (as is the case in many NL communities). Some of these technologies are only effective at removing certain types of pollutants (e.g. disinfection and screening), and technologies may need to be combined to ensure that desired CSO targets are met. Some satellite treatment technologies (e.g. continuous deflective separation and vortex separators) do not appear to be able to consistently meet primary treatment requirements for CSOs, without the addition of chemicals to improve pollutant removal. High rate physical-chemical treatment (HRPCT) technologies have demonstrated the ability to consistently meet or exceed these requirements, and can be a very cost effective solution when implemented at the downstream WWTP. Ballasted flocculation and retention treatment basins (RTBs) are two high rate treatment technologies that have been successfully implemented to treat CSOs, but there are only a few current installations of these technologies in North America. CSO treatment shafts are an even more recent technology, which appears to have significant merit, but again have few current installations in North America.

Floatables control measures including catch basin modifications, containment booms, netting systems, screens and trash racks, and underflow baffles, can all be successfully implemented for CSO control in NL, but all will require regular maintenance programs to retrieve and dispose of the collected floatable debris. Careful consideration should be given to the potential for freezing when considering containment booms. Based upon our review, netting systems would appear to be a good general approach to floatables control in NL.

CSO disinfection technologies can be coupled with other CSO control technologies (e.g. screening, storage and high rate treatment) and can be implemented at satellite treatment facilities located at individual outfalls or centralized treatment facilities located at the receiving WWTP, although the disinfection of CSOs will be most cost effective when applied at a central facility such as a downstream WWTP.

All of these disinfection processes would require significant capital investment and would require either significant chemical use (e.g. chlorine, chlorine dioxide, ozone, peracetic acid) or significant electrical power (e.g. electron beam irradiation, ultra-violet irradiation) on an ongoing basis. The disinfection of CSO at individual outfalls would therefore add significant complexity and cost to the operation of the sewer system and would be cost prohibitive. It should also be noted that the need to

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deliver and store potentially dangerous chemicals at satellite locations is often impractical or undesirable from an operations and maintenance standpoint, and typically unacceptable to local residents. CSO chlorination would also require de-chlorination to ensure no chlorine residual remains to be discharged to the environment (due to toxicity of chlorine).

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7.0 REVIEW OF NEWFOUNDLAND & LABRADOR DESIGN GUIDELINES

The Province of Newfoundland and Labrador has its own *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems*, which include reference to sewer overflows, bypasses and lift stations. These Guidelines include significant details pertaining to the design of gravity sewers and forcemains, sewage pumping stations, and sewage treatment plants, but provide limited guidance pertaining to the design (and sizing) of CSO and SSO control measures. Section 5.1 – Regulations, of the Guidelines, reference the Province's *Environmental Control Water & Sewage Regulations, 2003*, but these regulations do not provide specific targets for CSO control measures.

This section of the report presents the results of a detailed review of the relevant sections of the Guidelines for the Design, Construction and Operation of Water and Sewerage Systems, and comparison of these guidelines with wastewater collection and treatment regulations, standards and guidelines from other jurisdictions across Canada and internationally.

7.1 Review of Existing Wastewater Design Guidelines

The Province of Newfoundland and Labrador has its own *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems*, which were updated by the Water Resources Management Division of the Department of Environment and Conservation in December 2005 (ENVC, 2005).

The document provides general guidance on good engineering practices for the design, construction, operation and maintenance aspects of water and sewerage systems. As part of the process to update the previous version of the document (dated April 1980), the authors referred to and reviewed the following documents:

- *Nova Scotia Department of Environment Standards and Guidelines Manual for the Collection, Treatment and Disposal of Sanitary Sewage.*
- *Alberta Environmental Protection Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems.*
- *Atlantic Canada Standards and Guidelines Manual for the Collection, Treatment and Disposal of Sanitary Sewage.*

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- *Great Lakes - Upper Mississippi River Board of State Public Health & Environmental Managers Recommended Standards for Water Works and Recommended Standards for Wastewater Facilities.*
- *Government of Newfoundland Labrador Municipal Water, Sewer and Road Specifications.*

The current document provides detailed guidance on the design, construction, and operation and maintenance of wastewater collection and treatment systems in general, including detailed design criteria for sanitary sewers and appurtenances, including the following topics:

- Different types of sewers (gravity, forcemains, vacuum and alternative systems)
- Hydraulic capacity of sewers
- Sewage flow estimates
- Extraneous inflow and infiltration
- Sewer size and grade
- Sewer location, depth and alignment
- Service connections, including manholes and sewer laterals
- Outfall sewers
- Sewer inspection and testing
- Sewage pumping stations
- Sewage flow equalization

While the document provides very detailed guidance on the design, construction, operation and maintenance of sanitary sewage collection (and treatment) systems, it does not provide a great deal of guidance on the reduction of CSOs. This is probably due, in part, to the fact that the construction of new combined sewer systems has not been permitted for several decades in Canada, but some guidance is still required for remedial measures to reduce and/or eliminate discharges from existing CSOs. The key elements missing from the current guidelines from the CSO standpoint, is the definition of objectives or targets for reducing the volume, frequency and/or mass of pollutants from

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existing CSO outfalls in the province, and information on the planning, design, operation and maintenance of state-of the-art methods, approaches and technologies for controlling CSOs (and SSOs). Other jurisdictions and organizations have developed detailed regulations and procedures and guidance documents for CSO (and SSO) control, and the following sections of the report discuss some of the targets and guidelines developed by others, which may be relevant to CSO/SSO control in Newfoundland and Labrador.

7.2 Review of Existing CSO/SSO Policies and Regulations

Our Team is familiar with the new CCME MWWE Strategy, and with CSO/SSO control regulations, policies, and guidelines developed and used elsewhere across Canada and internationally. Some examples reviewed in detail in this section of the report include:

1) *Canadian Council of Ministers of the Environment (CCME) Canada-wide Strategy for the Management of Municipal Wastewater Effluent (MWWE Strategy);*
2) *United States Environmental Protection Agency (USEPA) Combined Sewer Overflow Control Policy;*
3) *United States Environmental Protection Agency (USEPA) Capacity Management Operation and Maintenance (CMOM) Program;*
4) *Ontario Ministry of the Environment (MOE) Procedure F-5-5, for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems;*
5) *Ontario Ministry of Environment Procedure (MOE) F-5-1, for the Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works Discharging to Surface Waters; and,*
6) *Alberta Environment (AENV) Municipal Policies and Procedure Manual.*

Each of these CSO/SSO policies/procedures is discussed further below.

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7.2.1 USEPA Combined Sewer Overflow Control Policy

The United States Environmental Protection Agency (USEPA) final *CSO Control Policy* was issued in April 1994. The intent of the CSO Control Policy is to:

- Provide guidance to permittees with CSOs, *National Pollutant Discharge Elimination System (NPDES)* permitting and enforcement authorities and State water quality standards authorities;
- Ensure coordination among appropriate parties in planning, selecting, designing and implementing CSO management practices and controls of the CWA; and,
- Ensure public involvement during the decision making process.

The policy contains provisions for developing appropriate, site specific NPDES permit requirements for all combined sewer systems. The policy establishes objectives for CSO communities to:

1) Implement the Nine Minimum Controls (NMC) and submit documentation on NMC; and
2) Develop and implement a Long-Term Control Plan (LTCP).

The policy assigns primary responsibility for its implementation and enforcement to NPDES authorities and water quality standards authorities.

The policy requires the development and implementation of the following Nine Minimum Controls:

1) Proper operation and regular maintenance programs for the sewer system and CSO outfalls;
2) Maximum use of the collection system for storage;
3) Review and modification of pre-treatment requirements to ensure that CSO impacts are minimized;
4) Maximization of flow to the publicly owned treatment works (POTW) for treatment;
5) Elimination of CSOs during dry weather;
6) Control of solid and floatable materials in CSOs;
7) Pollution prevention programs for contaminants in CSOs;
8) Public notification of CSO occurrences and impacts; and
9) Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

Permittees are required to develop a LTCP for controlling CSOs, employing one of two approaches:

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A. Demonstration Approach – demonstrate that the plan is adequate to meet the water quality based requirements of the Clean Water Act (CWA),

or

B. Presumption Approach – implement a minimum level of treatment (e.g. primary clarification of at least 85% of the collected combined sewage flows) that is presumed to meet the water quality based requirements of the CWA, unless data indicate otherwise.

Under the Demonstration Approach, permittees are required to demonstrate each of the following:

i. The planned control program is adequate to meet Water Quality Standards (WQS) and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;
ii. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment. Where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation, or other means should be used to apportion pollutant loads;
iii. The planned control program will provide the maximum pollution reduction reasonably attainable; and,
iv. The planned control program is designated to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.

Under the Presumptive Approach, a program that meets any of the criteria listed below would be presumed to provide an adequate level of control to meet the water-quality based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas described above. These criteria are provided because data and modeling of wet weather flows often do not give a clear picture of the level of CSO controls necessary to protect WQS.

i. No more than an average of four overflow events allowed per year.

ii. The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis.

iii. The elimination or removal of no less than the mass of pollutants, identified as causing water quality impairment, for the volumes that would be eliminated or captured for treatment under paragraph ii above.

Regardless of the approach selected, the LTCP should contain the same following elements:

- Characterization, monitoring, and modeling of CSS;
- Public participation;
- Consideration of sensitive areas;
- Evaluation of alternatives;
- Consideration of cost/performance;
- Operational plan;
- Maximization of treatment at POTW/WWTP;
- Implementation schedule; and,
- Post-construction compliance monitoring program.

The USEPA provides a number of very useful guidance documents to help permittees/municipalities develop and implement their CSO control programs, including the following documents:

- Combined Sewer Overflows – Guidance for Long-Term Control Plan (EPA 832-B-95-002);
- Combined Sewer Overflows – Guidance for Nine Minimum Controls (EPA 832-B-95-003);
- Combined Sewer Overflows – Guidance for Screening and Ranking Combined Sewer Overflow System Discharges (EPA 832-B-95-004);
- Combined Sewer Overflows – Guidance for Monitoring and Modeling (EPA 832-B-95-005);
- Combined Sewer Overflows – Guidance for Financial Capability Assessment (EPA 832-B-95-006);
- Combined Sewer Overflows – Guidance for Funding Options (EPA 832-B-95-007);
- Combined Sewer Overflows – Guidance for Permit Writers (EPA 832-B-95-008); and,
- Combined Sewer Overflows – Questions and Answers on Water Quality Standards and the CSO Program (EPA 832-B-95-009).

A copy of the *USEPA CSO Control Policy* can be found on the USEPA CSO Control website at: http://www.epa.gov/npdes/pubs/owm0111.pdf

7.2.2 USEPA Green Infrastructure Initiative

Source controls used to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as 'Green Infrastructure'. Green infrastructure is an approach to WWF management that is cost-effective, sustainable and environmentally friendly, which is gaining wider acceptance for CSO control. Green infrastructure also provides a variety of other community benefits including economic savings, green jobs, neighbourhood enhancements and sustainable communities. The USEPA has recently issued a Memorandum on 'Protecting Water Quality with Green Infrastructure in EPA Water Permitting and Enforcement Programs' (USEPA, 2011), which strongly encourages and supports the use of green infrastructure approaches to manage wet weather flows, including stormwater runoff and CSOs.

7.2.3 USEPA Capacity, Management, Operation and Maintenance Program

Sanitary sewer systems are designed to remove wastewater from homes and other buildings and convey it to a wastewater treatment plant (WWTP). The collection system is a critical element in the successful performance of the wastewater treatment process. The USEPA estimates that collection systems in the U.S. have a total replacement value between $1 to $2 trillion. Under certain conditions, poorly designed, built, managed, operated, and/or maintained systems can pose risks to public health, the environment, or both. These risks arise from sanitary sewer overflows (SSOs) from the collection system or by compromised performance of the WWTP. Effective and continuous management, operation, and maintenance, as well as ensuring adequate capacity and rehabilitation when necessary, are critical to maintaining collection system capacity and performance while extending the life of the system.

Typical causes of SSOs include, but are not limited to the following:

- Blockages;
- Structural, mechanical, or electrical failures;
- Collapsed or broken sewer pipes;
- Insufficient conveyance capacity; and,

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- Vandalism.

Additionally, high levels of I/I during wet weather can cause SSOs. Many collection systems experience wet weather SSOs because levels of I/I may exceed levels originally expected; prevention of I/I has proven more difficult and costly than anticipated; or the capacity of the system has become inadequate due to an increase in service population without corresponding system upgrades (EPA 2004).

SSOs can cause or contribute to environmental and human health impacts (e.g., water quality standards violations, contamination of drinking water supplies, beach closures, etc.) which, in addition to flooded basements and overloaded wastewater treatment plants, are some symptoms of collection systems with inadequate capacity and improper management, operation, and maintenance. These problems create the need for both the owner or operator and the regulatory authority to conduct more thorough evaluations of sanitary sewer collection systems.

The *USEPA Capacity, Management, Maintenance and Operation (CMOM) Program* incorporates many of the standard operation and maintenance activities that are routinely implemented by the owner or operator with a new set of information management requirements in order to:

- Better manage, operate, and maintain collection systems;
- Investigate capacity constrained areas of the collection system;
- Proactively prevent SSOs; and,
- Respond to SSO events.

The CMOM approach helps the owner or operator provide a high level of service to customers and reduce regulatory non-compliance. CMOM can help utilities optimize use of human and material resources by shifting maintenance activities from “reactive” to “proactive”, often leading to savings through avoided costs due to overtime, reduced emergency construction costs, lower insurance premiums, changes in financial performance goals, and fewer lawsuits. CMOM programs can also help improve communication relations with the public, other municipal works and regional planning organizations, and regulators.

It is important to note that the collection system board members or equivalent entity should ensure that the CMOM program is established as a matter of policy. The program should not be micro-managed, but an understanding of the resources required of the operating staff to implement and maintain the program is necessary.

In CMOM planning, the owner or operator selects performance goal targets, and designs CMOM activities to meet the goals. The CMOM planning framework covers operation and maintenance (O&M) planning, capacity assessment and assurance, capital improvement planning, and financial management planning. Information collection and management practices are used to track how the elements of the CMOM program are meeting performance goals, and whether overall system efficiency is improving.

On an periodic basis, utility activities should be reviewed and adjusted to better meet the performance goals. Once the long-term goal of the CMOM program is established, interim goals may be set. For instance, an initial goal may be to develop a geographic information system (GIS) of the system. Once the GIS is complete, a new goal might be to use the GIS to track emergency calls and use the information to improve maintenance planning.

An important component of a successful CMOM program is periodically collecting information on current systems and activities to develop a "snapshot-in-time" analysis. From this analysis, the owner or operator evaluates its performance and plans its CMOM program activities.

Maintaining the value of the investment is also important. Collection systems represent major capital investments for communities and are one of the communities' major capital assets. Equipment and facilities will deteriorate through normal use and age. Maintaining value of the capital asset is a major goal of the CMOM program. The infrastructure is what produces sales and service. Proper reinvestment in capital facilities maintains the ability to provide service and generate sales at the least cost possible and helps ensure compliance with environmental requirements. As a capital asset, this will result in the need for ongoing investment in the collection system and treatment plant to ensure design capacity while maintaining existing facilities and equipment as well as extending the life of the system.

The performance of wastewater collection systems is directly linked to the effectiveness of its CMOM program. Performance characteristics of a system with an inadequate CMOM program include frequent blockages resulting in overflows and backups. Other major performance indicators include pump station reliability, equipment availability, and avoidance of catastrophic system failures such as a collapsed pipe.

A CMOM program is what an owner or operator should use to manage its assets; in this case, the collection system itself. The CMOM program consists of a set of best management practices that have been developed by the industry and are applied over the entire life cycle of the collection system and treatment plant. These practices include:

- Designing and constructing for O&M;
- Knowing what comprises the system (inventory and physical attributes);
- Knowing where the system is (maps and location);
- Knowing the condition of the system (assessment);
- Planning and scheduling work based on condition and performance;
- Repairing, replacing, and rehabilitating system components based on condition and performance;
- Managing timely, relevant information to establish and prioritize appropriate CMOM activities; and,
- Training of personnel.

The key elements of the CMOM program include:

- Collection System Management;
- Collection System Operation;
- Collection System Maintenance; and,
- Collection System Capacity Evaluation.

7.2.4 Canada-wide Strategy for the Management of Municipal Wastewater Effluent

The Canadian Council of Ministers of the Environment (CCME) has developed a *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (MWWE Strategy), which was endorsed by the majority of Ministers on February 17, 2009. This is a collective agreement reached by the 14 Ministers of the Environment to ensure that municipalities will have regulatory clarity in managing municipal wastewater effluent under a harmonized framework that is protective of human health and the environment. It should be noted however that the Province of Newfoundland and

Labrador (NL), along with Quebec and Nunavut, did not sign or endorse the MWWE Strategy and are not obligated to undertake any of the requirements in the Strategy. The proposed *Wastewater Systems Effluent Regulations* (WSER) is based on the MWWE Strategy and will be applicable to NL when it officially becomes law.

The MWWE Strategy requires that all facilities achieve minimum national performance standards and develop and manage site-specific effluent discharge objectives. It also outlines risk management activities to be implemented to reduce the risks associated with CSOs and SSOs.

The proposed national standards for CSOs are:

- No increase in CSO frequency due to development or redevelopment, unless it occurs as part of an approved CSO management plan;
- No CSO discharge during dry weather, except during spring thaw and emergencies; and,
- Removal of floatable materials where feasible.

The proposed national standards for SSOs are:

- SSO frequencies will not increases due to development or redevelopment; and
- SSOs will not occur during dry weather, except during spring thaw and emergencies.

In addition to theses standards, overflow objectives should be established to protect the beneficial uses of the receiving environment. For example, overflows should not occur upstream of designated areas such as fish spawning sites, shell fish harvesting areas, beaches, and drinking water intakes. CSOs (and SSOs) should also not include industrial or hospital waste. CSO frequency, volume and/or treatment objectives should be set. A number of provinces, including Ontario, Quebec, Alberta and British Columbia have general overflow objectives, and these are discussed further below.

Overall timelines for implementation of the MWWE Strategy include the following:

- Within three (3) years, all facilities will begin to monitor effluent quality, including monitoring of compliance with the National Performance Standards and with any Effluent Discharge Objectives;
- Within five (5) years, a mechanism will be developed under CCME for jurisdictions to monitor the receiving environment at a watershed level; and,

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- Within three (3) years, all owners of facilities will meet public reporting requirements as per the requirements established by the jurisdiction, which will be on at least an annual basis.

The federal government will develop a national database to house the regulatory reporting information.

Overall timelines for implementation of the MWWE Strategy include the following:

- Where CSS are present, the risks posed by CSOs will be assessed against the risks posed by the WWTP effluent;
- Effective immediately, jurisdictions will ensure that CSOs and SSOs will not increase in frequency due to development, unless it occurs as part of an approved long-term management plan;
- Within seven years, the National Standards for CSOs and SSOs must be met; and,
- Within seven years, long-term plans to reduce CSOs and capture substances will be in place and based upon achieving jurisdictional overflow objectives.

It is important to note that the MWWE Strategy does not set any specific objectives or targets with respect to the reduction of CSO volume, frequency or pollutant loads, so we must look elsewhere for this type of CSO control guidance, and some potential approaches used by other jurisdictions in Canada are discussed below.

7.2.5 Ontario Ministry of Environment Procedure F-5-5

The Ontario Ministry of the Environment (MOE) released CSO Control *Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems* in February 1997 (MOE, 1997). The goals of the procedure are to eliminate the occurrence of dry weather overflows, minimize the potential for impacts on human health and aquatic life resulting from CSOs, and achieve as a minimum, compliance with body contact recreational water quality objectives at beaches impacted by CSOs. The procedure requires municipalities with CSS to develop Pollution Prevention and Control Plans (PPCPs) that outline the nature, cause and extent of pollution problems, examine CSO control alternatives and propose remedial measures, and recommend an implementation program including costs and schedules.

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Procedure F-5-5 was modeled on the *USEPA CSO Control Policy*, and includes many similar requirements, including the requirement to develop a Pollution Prevention and Control Plan or PPCP (called a Long Term Control Plan or LTCP in the USA), and prepare the following minimum CSO Controls:

- Eliminate CSOs during dry weather periods except under emergency conditions;
- Establish and implement Pollution Prevention programs that focus on pollutant reduction activities at source;
- Establish and implement proper operation and regular inspection and maintenance programs for the combined sewer system to ensure continued proper system operation;
- Establish and implement a floatables control program to control coarse solids and floatable materials;
- Maximize the use of the collection system for the storage of wet weather flows which are conveyed to the Sewage (or Wastewater) Treatment Plant (WWTP) for treatment when capacity is available;
- Maximize the flow to the WWTP for the treatment of wet weather flows. Utilize secondary treatment capacity as much as possible for treating wet weather flows with the balance of flows being subject to primary treatment. Investigate measures to increase the wet weather hydraulic capacity at the WWTP; and,
- During a seven-month period commencing within 15 days of April 1, capture and treat for an average year all the dry weather flow plus 90% of the volume resulting from wet weather flow that is above the dry weather flow.

The 90% volumetric control criterion is applied to the flow collected by the combined sewer system immediately above each overflow location, unless it can be shown through modelling and on-going monitoring, that the criterion is being achieved on a system-wide basis. No increases in CSO volumes above existing levels at each outfall will be allowed except where the increase is due to the elimination of upstream CSO outfalls. During the remainder of the year, at least the same storage and treatment capacity should be maintained for treating wet weather flow (WWF).

CSO control measures that should be examined, include, but are not limited to the following:

- Source controls;

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- Inflow/infiltration reduction;
- Operation and maintenance improvements;
- Control structure improvements;
- Collection system improvements;
- Storage technologies;
- Treatment technologies; and,
- Sewer separation.

The treatment processes at WWTPs should be optimized to minimize pollutant loadings under WWF, and the PPCP should evaluate the operation of the WWTP under WWF in conjunction with MOE staff

During wet weather, the minimum level of treatment required for flows above the DWF from the CSS is primary treatment or equivalent, which is defined as 30% removal of BOD_5 and 50% removal of TSS. The baseline for the calculation of average pollutant removal is the influent passing the headworks of the WWTP under wet weather flow conditions.

Treatment of WWF from CSS may occur at the central WWTP or at other locations such as satellite treatment facilities. For satellite treatment facilities, the procedure also requires that the effluent concentration of TSS shall not exceed 90 mg/L for more than 50% of the time for an average year during the specified 7 month period defined above.

Effluent disinfection is required where the effluent affects swimming and bathing beaches and other areas where there are public health concerns. The interim effluent water quality criteria for disinfected combined sewage during wet weather is a monthly geometric mean not exceeding 100 E. coli per 100 ml. This criterion may be modified by the MOE on a case-by-case basis due to specific site conditions. Where chlorination is used, subsequent de-chlorination of effluents shall be used to minimize adverse impacts of chlorine residuals on public health and aquatic environment as deemed necessary.

Additional controls above the minimum CSO controls presented above are required for the protection of swimming and bathing beaches affected by CSOs, consisting of:

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- No violation of the body contact recreational water quality objective for E. coli of 100 E. coli per 100 ml, based on a geometric mean at swimming and bathing beaches as result of CSOs, for at least 95% of the four-month season (June 1 to September 30) for an average year; and,
- Limiting CSO frequency to not more than 2 per season (Jun 1 to Sep 30) for an average year, with the combined duration of CSOs at any single CSO location being less than 48 hours, and ensuring that the controlled combined sewage receives primary treatment plus disinfection, is deemed to satisfy the above requirement.

Monitoring of wastewater flows and CSOs should be undertaken at locations within the CSS for the purposes of assessing upgrading requirements and determining compliance with MOE requirements. The nature of the monitoring programs shall be specified in the PPCP or as determined by MOE Regional staff, and the responsibility for providing monitoring shall rest with the municipality or operating authority of the CSS.

From an implementation and enforcement standpoint, Procedure F-5-5 is used to:

- Review applications for approval to ensure that the proponent is in compliance with the Procedure prior to issuance of a Certificate of Approval;
- Assist MOE regional staff in setting minimum requirements in preparing Control Orders to bring systems into compliance with the Procedure; and,
- Assist MOE enforcement staff in evaluating a CSS operator's due diligence when investigating violations of the Environmental Protection Act and/or Ontario Water Resources Act.

The procedure recognizes the site-specific nature and impacts of CSOs, and there is flexibility for selecting controls for local situations. The procedure makes it possible to view CSO control, not just in isolation, but also in conjunction with the wet weather operation of WWTPs. This permits municipalities to consider their collection and treatment systems as a single entity, and opens up a number of other innovative approaches to operating these systems in the future.

The complete text of Procedure F-5-5 can be found on the MOE website at: http://www.ene.gov.on.ca

7.2.6 Ontario Ministry of Environment Procedure F-5-1

MOE Procedure F-5-1, for the Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works Discharging to Surface Waters (MOE, 1994), defines sewage treatment requirements, including sewage bypasses from nominally separate sewer systems and combined sewer systems.

Within nominally separate sewer systems, emergency bypasses are permitted only to provide protection from basement flooding, to prevent damage to equipment at treatment works or pumping facilities or to prevent treatment process wash-out, and measures shall be taken to reduce the frequency and volume of sewage bypasses to an acceptable minimum.

Where existing sewer systems are found to experience excessive infiltration and inflow (I/I) problems, which result in unacceptable frequencies or quantities of bypasses, staged programs should be developed to reduce I/I to the sewer systems.

Within combined sewer systems, it is realized that a certain degree of overflowing will occur for some period both during and shortly after severe storm events and spring melts, however, all municipalities serviced by combined sewerage should prepare a staged program leading towards the ultimate goal of total containment for treatment of all sewage flows, including the sewerage works required along with their anticipated timing of implementation.

Many communities are served by nominally separate sanitary and storm sewer systems (with separate sanitary and storm sewers), which experience significant extraneous I/I during wet weather, and act essentially as combined sewer systems during large storms. Often, a significant portion of the I/I in these systems comes from private side sources such as roof leaders, foundations drains and sump pumps connected to the sanitary sewers, and these systems can be more accurately defined as partially separate sewer systems.

Source control measures, including water conservation and I/I reduction can certainly contribute to reducing flows in these systems during wet weather and reducing the volume of sewer overflows, but often cannot provide the desired level of overflow control on their own, at least not within a reasonable period of time. More capital intensive measures, such as detention storage or high rate treatment, are typically required to achieve desired control targets (such as MOE Procedure F-5-5 or the USEPA CSO Control Policy) within a short period of time.

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In some communities in Ontario with partially separate sewer systems, we have recommended (and the MOE has accepted) a phased sewer overflow reduction program, comprising the following components:

1) In the short term, sewage equalization storage facilities, sized to capture 97-98% of the annual WWF volume entering the contributing sewer system (significantly exceeding the 90% WWF control target of MOE Procedure F-5-5); and

2) In the longer term, implementation of an I/I investigation and reduction program, to achieve the remaining 2-3% WWF control required to completely eliminate sewer overflows (the ultimate objective of MOE Procedure F-5-1).

Long-term I/I reduction efforts, including water conservation measures and sewer system rehabilitation, implemented as part of a staged I/I reduction program, will complement the more immediate benefits of the sewage equalization storage tank. The increased removal of I/I from the sanitary sewer system as specific measures are implemented, will reduce the frequency and volume of overflows from the sewage equalization storage tank, and will ultimately eliminate these overflows altogether, meeting the objective of MOE Procedure F-5-1.

The complete text of Procedure F-5-1 can be found on the MOE website at: http://www.ene.gov.on.ca

7.2.7 CSO Control in Alberta

Only one municipality in Alberta, the City of Edmonton, is serviced (in part) by a combined sewer system. Alberta Environment (AENV) regulates the construction and operation of municipal waterworks, wastewater and storm drainage systems, and the province's policy with respect to combined sewers is covered by Section 3 of its *Municipal Policies and Procedure Manual* dealing with Wastewater Bypasses and Spills (AENV, 2001). The CSO policy requires that:

1. No new combined sewer systems or additional combined sewer overflows will be allowed in Alberta. The AENV's policy is to encourage the development of a comprehensive, cost-effective control strategy that will result in minimizing the environmental impacts of the City of Edmonton's combined sewer system. This may include immediate separation on a limited and opportunistic basis. Separate storm and sanitary sewers are to be used for new systems. AENV policy is to encourage ultimate, i.e. 50 to 100 years, elimination of CSOs or measures

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that would result in an equivalent or better level of environmental protection than would be achieved by complete separation.

2. Existing combined systems should be separated where possible, as old sewers are replaced or upgraded. It is recognized that a program extending over decades may be required. Alternative mitigative measures (e.g. storage, satellite treatment, relief sewers, etc.) should be used to control CSO impacts to acceptable levels.

3. Existing combined systems will be allowed to continue on an interim basis provided a CSO control strategy is developed to determine what interim treatment or reduction of CSOs is desirable in the near term, i.e. 5 to 25 years. A long term, i.e. 25 to 50 years, CSO mitigation strategy must also be developed and include public consultation and receiving stream environmental assessments. As a minimum, the City should:

    - determine methods to eliminate any dry weather overflows and implement immediately;
    - characterize the CSO quantity and quality;
    - determine the areal extent and the storm conditions beyond which Alberta Ambient Surface Water Quality Guidelines cannot be met;
    - evaluate mitigation methods to achieve water quality objectives;
    - evaluate non-structural best management practices for CSOs and implement cost effective controls;
    - outline an implementation plan to cost effectively mitigate CSO impacts in the long term, i.e. 25 to 50 years; and
    - establish general timelines and schedules to achieve ultimate, i.e. 50 to 100 years, control objectives that either involve complete separation or have control measures that achieve an equivalent or better level of environmental protection than would be achieved through complete separation.

7.2.8 CSO Control in British Columbia

CSOs, SSOs and I/I in British Columbia are regulated under the province's Municipal Sewage Regulation, B.C. Reg 129/99, O.C. 507/99. The regulation defines a combined sewer system as ditches, drains, sewers, treatment facilities and disposal facilities that collect, transport, treat or dispose of a combination of municipal sewage and stormwater in a single system.

With respect to CSOs, Section 15 of the policy stipulates that:

(1) The discharger must ensure that no person allows a CSO to occur during storm or snowmelt events with less than a 5-year return period unless,

  (a) for municipal sewage collection systems for which the contributory population equivalent is equal to or greater than 10,000 persons, the person responsible for the municipal sewage collection system addresses as part of a liquid waste management plan existing CSOs including undertaking measures to eliminate overflows; or,

  (b) for municipal sewage collection systems for which the contributory population equivalent is less than 10,000 persons, the person responsible for the municipal sewage collection system addresses as part of a liquid waste management plan or conducts a study and develops and implements measures such that CSOs are eventually eliminated.

(2) Despite subcondition (1), the discharger must ensure that the person responsible for the municipal sewage collection system, on the request of a director and at least once in each 10 year period, prepares and maintains for inspection a record containing all the following information:

  (a) an estimate of the volume, frequency, and number of CSO occurrences for each overflow location;

  (b) based on the estimate in paragraph (a), an estimate of the total annual volume of all CSO occurrences which occur during storm or snowmelt events with less than a 5-year return period;

  (c) the steps that have been or will be taken to reduce volume, frequency and number of CSO occurrences;

  (d) a plan for the reduction in the volume estimated under paragraph (b) by an average 1.0% per year over a 10 calendar year period;

  (e) an assessment of the potential impact of the overflow occurrences on the receiving environment at each overflow location; and,

  (f) a record of each overflow occurrence which occurs during storm or snowmelt events with less than a 5 year return period.

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(3) The discharger may not employ storage or conveyance facilities to reduce the amount of sewer separation required, unless the facilities immediately reduce and ultimately prevent the occurrence of CSOs.

(4) If facilities are used under subcondition (3), and primary and secondary treatment are available, the discharger must:

(a) provide at least primary treatment for the flows greater than 2.0 times the ADWF;

(b) utilize the full secondary capacity of the treatment plant;

(c) combine the primary and secondary effluent prior to discharge;

(d) maintain a minimum receiving environment to discharge dilution ratio of 40:1; and,

(e) if disinfection is required, provide adequate excess disinfection capacity to ensure disinfection of the entire discharge flow.

With respect to SSOs, Section 16 of the policy specifies that:

(1) The discharger must ensure that no person allows a sanitary sewer overflow to occur during storm or snowmelt events with less than a 5-year return period, unless:

(a) for municipal sewage collection systems for which the contributory population equivalent is equal to or greater than 10,000 persons, the person responsible for the municipal sewage collection system addresses as part of a liquid waste management plan existing SSOs including undertaking measures to eliminate overflows; and,

(b) for municipal sewage collection systems for which the contributory population equivalent is less than 10,000 persons, the person responsible for the municipal sewage collection system develops a liquid waste management plan or conducts a study and develops and implements measures such that SSOs are eliminated.

(2) Despite subcondition (1), the discharger must ensure that the person responsible for the sewage collection system, on the request of a director and, at least once in each 10 year period, prepares and maintains for inspection a record containing all the following information:

(a) an estimate of the volume, frequency and number of SSO occurrences for each overflow location;

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(b) based on the estimate in paragraph (a), an estimate of the total annual volume of all SSO occurrences which occur during storm or snowmelt events with less than a 5 year return period;

(c) the steps that have been or will be taken to reduce volume, frequency and number of SSO occurrences;

(d) a plan for the reduction in the volume estimated under paragraph (b) by an average 10.0% per year over a 10 calendar year period;

(e) an assessment of the potential impact of the overflow occurrences on the receiving environment at each overflow location; and,

(f) a record of each overflow occurrence which occurs during storm or snowmelt events with less than a 5 year return period.

(3) The discharger may not employ storage or conveyance facilities to reduce the amount of I/I reduction required, unless the facilities immediately reduce and ultimately prevent the occurrence of SSOs.

(4) If facilities are used under subcondition (3) and primary and secondary treatment are available, the discharger must do all of the following:

(a) provide at least primary treatment for the flows greater than 2.0 times the ADWF;

(b) utilize the full secondary capacity of the treatment plant;

(c) combine the primary and secondary effluent prior to discharge;

(d) maintain a minimum receiving environment to discharge dilution ratio of 40:1; and,

(e) if disinfection is required, provide adequate excess disinfection capacity to ensure disinfection of the entire discharge flow.

With respect to Infiltration and Inflow (I/I), Section 17 of the policy specifies that:

(1) The discharger must ensure that no person allows I/I so that the maximum average daily flow exceeds 2.0 times ADWF to occur during storm or snowmelt events with less than a 5-year return period unless,

(a) if 2.0 times ADWF is exceeded at the treatment plant and for municipal sewage collection systems for which the contributory population to the treatment plant is equivalent to or exceeds 10,000 persons, the discharger addresses how I/I can be reduced as part of a liquid waste management plan; or,

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(b) if 2.0 times ADWF is exceeded at the treatment plant and for municipal sewage collection systems for which the contributory population equivalent to the treatment plant is less than 10,000 persons, the discharger either develops a liquid waste management plan or conducts a study and develops and implements measures that are developed in either the liquid waste management plan or the study such that I/I is reduced.

(2) Despite subcondition (1), if reductions below 2.0 times ADWF are not possible or cost effective based on a cost/benefit analysis, the discharger must:

(a) provide full secondary treatment for the entire flow at all times; or

(b) undertake all of the following:

(i) provide at least primary treatment for flows greater than 2.0 times the ADWF;

(ii) utilize the full secondary treatment capacity of the treatment facility;

(iii) combine the primary and secondary effluent prior to discharge;

(iv) maintain a minimum receiving environment to discharge dilution ratio of 40:1;

(v) if disinfection is required, provide adequate excess disinfection capacity to ensure disinfection of the entire discharge flow.

7.2.9 CSO Control in Manitoba

The Province of Manitoba does not have a formal CSO control policy, but the City of Winnipeg is busy implementing a significant program to reduce its remaining CSOs, with an estimated capital cost of $270 million, with the objective to achieve a city-wide CSO frequency of 4 events per summer recreation season (reduced from existing 18 events), to be completed within a 45-50 year timeframe.

7.2.10 CSO Control in Quebec

The Province of Quebec does not have a formal CSO control policy, but the *Quebec Water Policy*, released in 2002, highlighted issues regarding the need for integrated management of water resources with a view to sustainable development. One of the commitments of the policy requires the government to supplement clean-up efforts. With regards to untreated urban discharges, the Province of Quebec undertakes to:

- Urge and assist municipalities to reduce the frequency of CSOs by 20% by 2007. The government of Quebec attempts to achieve this goal by encouraging the installation of control

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infrastructure such as retention ponds, optimizing existing systems by utilizing the retention capacities of the sewer lines, and implementing more effective management systems.

- Eliminate by 2007 wastewater discharges during dry weather periods. Municipalities are to present action plans to meet this commitment, focusing specifically on eliminating illegal hook-ups and intersecting (sanitary and storm) sewer lines.

- Put into place a strategy governing urban discharges, such as overflows from combined and storm sewers, including plans generating long-term environmental targets for discharges, a mechanism for issuing renewable depollution attestations, and environmental guidelines for grant programs.

Technical Supplement 2 of the MWWE Strategy (2008) also notes that the Province of Quebec has since applied some site specific objectives pertaining to CSO control, including the following:

- Prohibiting CSOs within 1 km of drinking water intakes or shellfish harvesting areas;
- Prohibiting CSOs into or immediately upstream of fish spawning sites; and,
- Allowing a maximum of one (1) CSO per month in a continuous flow zone or one (1) CSO per two (2) months in an accumulation zone where human activities occur during periods where these activities occur.

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7.3 Summary of CSO Management Practices / Policies in Canada

Table 7.1 provides a summary of CSO Management Practices / Policies across Canada.

Table 7-1 - Summary of CSO Management Practices / Policies in Canada

Province	CSOs?	Performance Requirements
Alberta	Yes (Edmonton)	Minimize releases. Striving for 85% equivalent separation of combined sewers by 2012
British Columbia	Yes	No new construction or expansion of CSOs. Separation of sewers when feasible. Minimize frequency and volume of releases.
Manitoba	Yes	Separate sewers when feasible. Objective to reduce discharges to maximum of 4 per year.
New Brunswick	Yes	No new construction or expansion of CSOs. Approvals to operate specify that efforts be taken to reduce infiltration and ultimately separate sewers.
Newfoundland & Labrador	Yes	Same requirements apply as for MWWE, but not universally required/enforced.
Northwest Territories	No	
Nova Scotia	Yes	Discharges greater than 100 litres must be reported.
Nunavut	No	
Ontario	Yes	Requires development of Pollution Prevention and Control Plan including 7 minimum CSO controls, including maximization of CSS for storage/conveyance of flows to the WWTP during wet weather, and capture and treatment of at least 90% of WWF entering CSS on an average annual basis. Minimum level of CSO treatment required is primary (defined as 30% BOD and 50% TSS removal), and more stringent requirements for CSO outfalls discharging to bathing beaches.
Prince Edward Island	Yes	CSOs being eliminated over next four years.
Quebec	Yes	Remove floating debris. No dry weather discharge. Sometimes maximum discharge frequency is specified. No CSO discharge in fish spawning areas or within 1 km of drinking water intake or shellfish harvesting.
Saskatchewan	No	
Yukon	No	

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7.4 Existing Regulatory Framework in Newfoundland & Labrador

Unlike all other provinces in Canada, Newfoundland & Labrador maintain the authority to manage and control industrial, commercial and institutional sources of discharge to sewer systems, and do not delegate this authority to its municipalities.

Delegation of Authority to Municipalities

The province does not delegate industrial permitting for discharges to sewers to municipalities. All dischargers must conform to the provincial requirements described following, including industrial dischargers to municipal systems as well as municipalities for their wastewater effluent discharges.

Under the Municipalities Act, 1999 - water and sewage systems: 156. (1) A council may construct, own and operate b) a public sewage system for the collection and disposal of sewage within or, with the approval of the minister, outside of the municipality.

Product or Pre-disposal Controls

S. 40 of the Environmental Protection Act (EPA) prohibits the disposal of pesticides or containers for pesticides in a manner not approved; although disposal of pesticides to sewers is not specifically mentioned, it is prohibited under this section.

Influent (Source) Controls

Industrial dischargers to municipal sewers fall under the Environmental Control Water and Sewage (ECWS) Regulations of the Water Resources Act (WRA), which requires any person discharging sewage and other materials into a body of water, public sewer or sewer leading to a public sewer to comply with conditions for discharged materials. The control of industrial dischargers is intended to protect the municipal sewer system as well as environmental protection.

The quality of wastewater entering the sanitary sewer system must meet conditions outlined by the Province, specifically:

- Limits are placed on the concentrations of specific substances and substances with specific characteristics (e.g. flammable, cause obstructions, temperature, pH);
- Materials controlled include oil or by-products of oil, flammable, explosive, toxic, poisonous or corrosive liquids, solids or gases, fats, congealing materials and other substances. In

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addition, limits are specified for a list of substances and temperatures in excess of 65° Celsius are prohibited; pH less than 5.5 or greater than 9.0 is prohibited. Similarly, discharge of radioactive substances is controlled;

- Section 4 prohibits discharge of materials that would impede the flow of sewage or interfere with the public sewer works; and,
- The regulation must not be interpreted as permission to discharge a pollutant into a body of water.

Collection System Controls

Permits to Construct and Permits to Operate are issued under the WRA. Currently, 89% of communities in NL with wastewater collection (WWC) systems have Permits to Operate their WWC systems. CSOs are not prohibited under regulation, but the province encourages municipalities to separate sewers where possible.

Treatment Controls

Wastewater treatment facilities are permitted under the WRA. Facilities require permits to construct and these permits have a two year limit. A process has been established to issue operational permits to all facilities with specific monitoring, reporting and other operational and maintenance requirements.

Currently, 59% of communities with secondary wastewater treatment (WWT) systems have Permits to Operate. Primary treatment systems do not require a Permit to Operate for Wastewater Treatment.

Treatment objectives are to achieve 20 mg/L BOD, 30 mg/L suspended solids, and bacteriological limits (i.e. equivalent to secondary treatment). In permitting treatment facilities and other discharges, the province also takes into consideration fiscal constraints of communities and receiving water characteristics.

The WRA also makes provisions to require plans and specifications for the construction of sewage works or changes to existing sewage works, and the location of the discharge of the effluent, together with other information that the minister may require, in order to obtain a permit for the proposed works. The WRA provides the Lieutenant-Governor in Council power to make regulations (d) respecting sewage or other works for which a person is required to obtain a licence or permit under the Act.

Release

Release of industrial wastewater effluent is subject to permit under the EPA. Discharge points must be in the best dispersion areas, and avoid sensitive areas such as mud flats and tidal areas. CCME Guidelines are used as well as Environment Canada Environmental Quality Guidelines for shellfish.

There are no controls on releases to air for municipal wastewater effluents.

Sludge and biosolids are not land-applied in the province. Sludge stabilization plants are in place to accept sludge from haulers for the east and west portions of the island; stabilized waste is disposed of adjacent to the plant; there are plans to eventually use the biosolids for soil conditioning. Currently, central island sludges are deposited in a pre-excavated pit, covered with lime and re-buried.

Section 64 of the WRA notes that the Lieutenant-Governor in Council may make regulations prohibiting or restricting the discharge of stormwater, sewage and waste effluents into bodies of water.

Environment

In areas where receiving water sensitivity or resource conflicts are of concern, the level of treatment necessary to satisfy quality issues or no adverse effects would be requested in a receiving water assessment report. Guidance is provided related to receiving water study for sensitive areas and sewage quality.

The WRA states that the minister may control the use of wetlands, including the addition of wastewater or stormwater discharges to, or the physical, chemical or biological modification of wetlands where there may be an impact upon the hydrology of that wetland or its recreational, aesthetic or other natural functions and uses.

Monitoring and Reporting

With the plans for new permitting requirements, monitoring and reporting responsibilities will also be required of facility operators/ owners.

A Federal / Provincial agreement is in place for monitoring of inland waters for the province. Ambient Agreement water quality data is available on-line at the Canada Newfoundland/ Labrador Aqua Link (CANAL). The website provides dynamic access to station descriptions, data and metadata for over 100 shared water quality stations throughout Newfoundland and Labrador, and can be found at http://map.ns.ec.gc.ca/canal/root/main/

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The WRA states that the minister may require the person responsible for an undertaking to carry out and report on tests on water emitted from, surrounding or connected with that undertaking. The Environmental Control Water and Sewage Regulations, 2003 state that all analytical work in relation to effluent samples and receiving water samples is to be carried out using analytical procedures acceptable to the Assistant Deputy Minister of Environment.

Compliance and Promotion

It is a condition of every licence and permit issued under the Act that the holder allows inspectors to carry out inspections. Ministerial Orders can be issued to shut down, alter or add to sewage works in accordance with directions set out in the order. The provincial approach to compliance for municipal facilities is consultative, negotiated compliance over time.

Deposit out of Course of Normal Events

Any SSO will be subject to the requirements of the proposed WSER, and also fits the definition of a Deposit out of the Course of Normal Events (DONCE). Accordingly, communities experiencing an SSO will be required to notify the Newfoundland and Labrador Regional Office, Canadian Coast Guard Fisheries, Fisheries and Oceans Canada of any overflow.

7.5 Discussion

The CSO policies/guidelines discussed above specify some minimum CSO control measures to be implemented for controlling CSOs, and some provide specific volumetric CSO control and treatment targets to be met by the communities with CSS within their respective jurisdictions. Some common themes/targets of these existing CSO policies/guidelines include requirements to:

- Proper operation and regular maintenance programs for the sewer system and CSO outfalls;
- Maximize use of the collection system for storage;
- Review and modify pre-treatment requirements to ensure that CSO impacts are minimized;
- Maximize flow conveyed to the WWTP for treatment;
- Eliminate all CSOs during dry weather;
- Control solid and floatable materials in CSOs;
- Implement pollution prevention programs for contaminants in CSOs;
- Provide public notification of CSO occurrences and impacts; and

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- Provide field monitoring to effectively characterize CSO impacts and efficacy of implemented CSO controls.

Some jurisdictions have provided specific targets for CSO control, although these vary from one jurisdiction to another and even from one outfall to another, within the same jurisdiction. Some typical CSO targets include requirements to:

- Limit the frequency of remaining CSO events to a given target (typically to 1-4 per year);
- Reduce existing annual CSO volume to a given target (typically by 80-90% per year); and,
- Capture and treat a given proportion of existing annual WWF volume entering the CSS (typically by 85-90% per year) to a given treatment level (typically primary treatment).

More stringent requirements must often be met in circumstances where CSOs discharge to sensitive areas such as bathing beaches, shellfish harvesting areas, and drinking water intakes. This includes providing higher levels of treatment to remaining CSOs, which may include providing effluent disinfection or sometimes even secondary instead of primary treatment of remaining overflow volumes.

7.6 Cost Implications of CSO Control

The specific targets set for CSO control can significantly impact the cost of implementing a CSO control program. Tables 7-2 and 7-3 provide an example to illustrate the potential impact of some different CSO control targets on the required capacity and associated cost of implementing CSO control measures, in this case for CSO detention storage facilities determined (by continuous long-term modeling for an average year) to be needed to meet some different CSO control targets in a large (un-named) combined sewer system in Ontario (serving approximately 250,000 persons).

Table 7-2 - CSO Control Requirements - Estimated Volumes for CSO Storage Facilities

	Required Storage Volumes for Future Proposed CSO Control Facilities[1] (m^3)					
CSO Outfall/Storage Facility	1 CSO/yr[2]	2 CSO/yr	3 CSO/yr	4 CSO/yr	90% WWF[3]	85% WWF[4]
CSO #1 (stand-alone tank)	8,885	5,545	3,885	2,855	15,000	5,205
CSO #2 (stand-alone tank)	5,935	3,735	3,165	2,445	4,425	2,810
CSO #3 (stand-alone tank)	4,385	2,990	2,180	1,640	1,050	0
CSO #4 (stand-alone tank)	80,600	65,700	54,800	46,200	65,000	53,100
CSO #5 (stand-alone tank)	88,000	68,800	59,100	50,400	64,800	51,800
CSO #6 (stand-alone tank)	11,900	9,720	8,260	7,010	8,750	7,040
CSO #7						
CSO #8						
CSO #9						
CSO #10						
CSO #11						
CSO #12						
CSO #7-12 (lumped tunnel)	276,500	227,400	192,400	164,400	189,000	148,000
Total (12 CSO outfalls)	476,205	383,890	323,790	274,950	348,025	267,955

Notes:

[1] As estimated from long-term continuous modeling for 1970-99 using SWMM Runoff and Transport.

[2] Remaining CSO Frequency for the period from April 1 to October 31.

[3] Ontario MOE CSO Criteria, which requires 90% control of WWF above DWF for the period from Apr 1 to Oct 31.

[4] USEPA CSO Criteria, which requires 85% control of WWF above DWF, assumed here to also be for Apr 1 to Oct 31.

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Table 7-3 - CSO Control Requirements - Estimated Costs for CSO Storage Facilities

CSO Outfall	Estimated Capital Costs for Future Proposed CSO Control Facilities[1] ($1,000)					
	1 CSO/yr[2]	2 CSO/yr	3 CSO/yr	4 CSO/yr	90% WWF[3]	85% WWF[4]
CSO #1 (stand-alone tank)	$7,997	$4,991	$3,497	$2,570	$11,250	$4,685
CSO #2 (stand-alone tank)	$5,342	$3,362	$2,849	$2,201	$3,983	$2,529
CSO #3 (stand-alone tank)	$3,947	$2,691	$1,962	$1,640	$1,575	$0
CSO #4 (stand-alone tank)	$48,360	$39,420	$32,880	$27,720	$39,000	$31,860
CSO #5 (stand-alone tank)	$52,800	$41,280	$35,460	$30,240	$38,880	$31,080
CSO #6 (stand-alone tank)	$8,925	$8,748	$7,434	$6,309	$7,875	$6,336
CSO #7						
CSO #8						
CSO #9						
CSO #10						
CSO #11						
CSO #12						
CSO #7-12 (lumped tunnel)	$165,900	$136,440	$115,440	$98,640	$113,400	$88,800
Total (12 CSO outfalls)	$293,270	$236,931	$199,521	$169,319	$215,963	$165,290

Notes:

[1] Estimated costs (in $2003) for required volumes determined from long-term modeling for Apr 1 to Oct 31, 1970-99.

[2] Remaining CSO Frequency for the period from Apr 1 to Oct 31.

[3] Ontario MOE CSO Criteria, which requires 90% control of WWF above DWF for the period from Apr 1 to Oct 31.

[4] USEPA CSO Criteria, which requires 85% control of WWF above DWF, assumed here to also be for Apr 1 to Oct 31.

Table 7-3 compares the estimated costs required to provide enough CSO storage capacity to achieve the following alternative CSO control objectives:

- 90% control of WWF entering the contributing CSS, as required by Ontario MOE Procedure F-5-5;
- 85% control of WWF entering the contributing CSS, as required by the USEPA CSO control policy, and also targeted by the City of Edmonton, Alberta;
- Reduction of annual CSO frequency to 1 per year, as targeted by the City of Hamilton, Ontario for more sensitive receiving waters to achieve specific CSO pollutant loading targets set by the Hamilton Harbour Remedial Action Plan;

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- Reduction of annual CSO frequency to 4 per year, as required by the USEPA 'presumptive' CSO control policy, and also targeted by Province of Manitoba;
- Reduction of annual CSO frequency to 2 and 3 per year, in-between the 1 and 4 per year targets.

Some key findings/highlights from this analysis include the following:

- Overall (for all 12 CSO outfalls), approximately 30% more CSO storage volume (at approximately 31% more cost) is required to increase the average annual WWF control level from 85% (USEPA and Edmonton, Alberta target) to 90% (Ontario MOE target). The reason for the small difference in the volume and cost premiums here is that the unit costs for CSO storage facilities can vary depending upon the volume of the specific facilities to be constructed (with unit costs decreasing significantly for larger volume facilities);
- Overall (for all 12 CSO outfalls), approximately 18% more CSO storage volume and cost is required to reduce the frequency of CSOs from 4 per year (USEPA target) to 3 per year;
- Overall (for all 12 CSO outfalls), approximately 19% more CSO storage volume and cost is required to reduce the frequency of CSOs from 3 per year to 2 per year;
- Overall (for all 12 CSO outfalls), approximately 24% more CSO storage volume and cost is required to reduce the frequency of CSOs from 2 per year to 1 per year;
- Overall (for all 12 CSO outfalls), approximately 73% more CSO storage volume and cost is required to reduce the frequency of CSOs from 4 per year (USEPA target) to 1 per year; and,
- Overall (for all 12 CSO outfalls), comparing the average annual WWF control targets to the CSO frequency targets, the 90% WWF control level corresponds to approximately 2-3 CSOs per year, and the 85% WWF control target appears to correspond to more than 4 CSOs per year (probably around 5 CSOs per year). Based on our experience with a number of CSO storage facilities, these appear to be a reasonable 'rules of thumb', but this relationship can vary significantly from CSO outfall to outfall, based on the hydraulic characteristics of the individual CSS.

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The above analysis also shows that the cost of implementing CSO control increases significantly as the control target becomes more stringent. CSO control costs increase quite rapidly for frequency targets of less than 2 CSO per year (for April 1 to October 31).

It is important to note that these are average annual requirements, based on the average annual performance of the proposed CSO control measures for the period from April 1 to October 31 for an average year, which is defined by MOE Procedure F-5-5 (actually defined as a 7-month period beginning within 15 days of April 1). Procedure F-5-5 requires that CSO controls be demonstrated and designed to meet the 90% WWF control target during this period for an average year. Procedure F-5-5 specifies no CSO performance targets for the remainder of the year (i.e. say November 1 to March 31), but does require that any provided CSO control measures are operated and maintained to reduce CSOs during the entire year. Although not explained in Procedure F-5-5, we believe that the CSO performance monitoring requirements were restricted to the April to October period because accurate CSS modeling and design of CSO control measures to control overflow events during the remaining (winter) period is impractical given the difficultly in modeling snowmelt events. The USEPA CSO control policy does not make this distinction, but we believe it is an important distinction to make when considering new CSO control policies guidelines for NL.

The specific alternatives implemented to control CSOs can also have a significant impact on the costs to implement improved CSO control in NL. As noted above, the costs of CSO can be very high, and the specific objectives/targets defined by a new CSO control guideline procedure for the Province of NL will play a significant role in determining these future costs. While there are only a handful of remaining CSO outfalls in the Province (especially with the City of St. Johns already on the way to implementing new CSO controls as part of their Harbour Clean Up Program), total CSO control costs could still be in the tens or even hundreds of millions of dollars Province-wide.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and sewage treatment plant bypasses all pose a threat to human health and the environment in Newfoundland and Labrador (NL). The Department of Environment and Conservation (ENVC) in collaboration with other stakeholders has recognized this threat, and together with the Department of Municipal Affairs (DMA) issued a Request for Proposals (RFP) in May 2010 to undertake a comprehensive inventory and characterization of sewer overflows in NL.

Newfoundland and Labrador, like most coastal jurisdictions in Canada, can be described as having limited or no wastewater treatment infrastructure. On a national level, wastewater management is a shared jurisdiction and there have been different approaches and/or perspectives with respect to regulatory requirements and treatment. At least in part, the May 2010 RFP was issued in response to the 2009 Canadian Council of Ministers of the Environment (CCME) *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (MWWE Strategy) and the proposed *Wastewater System Effluent Regulations* (WSER) under Section 36(3) of the Fisheries Act.

In June, 2010, ENVC contracted Hatch Mott MacDonald (HMM) to complete an inventory and characterization of sewer overflows in Newfoundland and Labrador.

Sewer Overflow Data Collection, Organization and Findings

Reliable data collection depended, to a large extent, on the field data collection process. The report and studies provided by ENVC proved some value, but there were significant data gaps that could only be filled by means of direct surveys/questionnaires, field visits, and interviews with Town employees and/or management. Data collection efforts were largely successful in the Eastern, Central, and Western regions of the province, but data collection in Labrador was less successful, and a different approach may be required in the future to fully document CSO/SSO conditions in that region.

Data organization was a collaborative effort between HMM and ENVC and resulted in comprehensive Microsoft Excel Spreadsheets for SSOs, CSOs and WWTP by-passes. All sewer overflows were given a unique ID and identified as either a SSO or CSO. All SSOs were further

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distinguished as an overflow at a SLS, or at a sanitary sewer manhole. WWTP by-passes were also given a unique ID. The data organization provides a very good understanding of the infrastructure and conditions that currently exist throughout the province. The database sheets for each Town completed can be found in Appendix A.

CCME Canada-Wide Strategy for the Management of Municipal Wastewater Effluent

The Canadian Council of Ministers of the Environment (CCME) has developed a *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (MWWE Strategy), which was endorsed by the majority of Ministers on February 17, 2009. This is a collective agreement reached by the 14 Ministers of the Environment to ensure that municipalities will have regulatory clarity in managing municipal wastewater effluent under a harmonized framework that is protective of human health and the environment. It should be noted however that the Province of Newfoundland and Labrador (NL), along with Quebec and Nunavut, did not sign or endorse the MWWE Strategy and are not obligated to undertake any of the requirements in the Strategy. The proposed *Wastewater Systems Effluent Regulations* (WSER) is based on the MWWE Strategy and will be applicable to NL when it officially becomes law.

The MWWE Strategy requires that all facilities achieve minimum national performance standards and develop and manage site-specific effluent discharge objectives. It also outlines risk management activities to be implemented to reduce the risks associated with CSOs and SSOs.

The proposed national standards for CSOs are:

- No increase in CSO frequency due to development or redevelopment, unless it occurs as part of an approved CSO management plan;
- No CSO discharge during dry weather, except during spring thaw and emergencies; and,
- Removal of floatable materials where feasible.

The proposed national standards for SSOs are:

- SSO frequencies will not increases due to development or redevelopment; and
- SSOs will not occur during dry weather, except during spring thaw and emergencies.

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In addition to theses standards, overflow objectives should be established to protect the beneficial uses of the receiving environment. For example, overflows should not occur upstream of designated areas such as fish spawning sites, shell fish harvesting areas, beaches, and drinking water intakes. CSOs (and SSOs) should also not include industrial or hospital waste. CSO frequency, volume and/or treatment objectives should be set.

Overall timelines for implementation of the MWWE Strategy include the following:

- Within three (3) years, all facilities will begin to monitor effluent quality, including monitoring of compliance with the National Performance Standards and with any Effluent Discharge Objectives;
- Within five (5) years, a mechanism will be developed under CCME for jurisdictions to monitor the receiving environment at a watershed level; and,
- Within three (3) years, all owners of facilities will meet public reporting requirements as per the requirements established by the jurisdiction, which will be on at least an annual basis.

With respect to CSOs and SSO, overall timelines for implementation include the following:

- Where CSS are present, the risks posed by CSOs will be assessed against the risks posed by the WWTP effluent;
- Effective immediately, jurisdictions will ensure that CSOs and SSOs will not increase in frequency due to development, unless it occurs as part of an approved long-term management plan;
- Within seven (7) years, the National Standards for CSOs and SSOs must be met; and,
- Within seven (7) years, long-term plans to reduce CSOs and capture substances will be in place and based upon achieving jurisdictional overflow objectives.

It is important to note that the MWWE Strategy does not set any specific objectives or targets with respect to the reduction of CSO volume, frequency or pollutant loads, so we had to look elsewhere for this type of CSO control guidance, and some potential approaches used by other jurisdictions in Canada and elsewhere were reviewed in detail in Chapter 7 and discussed further below.

CSO Risk Characterization

The proposed WSER describes how the allowable timeframe for communities to achieve compliance with the proposed regulations is based on the allocation of points relating to its overflow risk characterization for combined sewers as set out in Schedule 4 of the regulation. For each identified CSO outfall, we have evaluated the information collected and assigned the correct number of CSO points based on the classifications presented in Schedule 4 of the proposed WSER (some of which were modified during the course of this study). It must be noted however, that communities in NL have very little information regarding the historical frequency and volume of CSO events, making accurate determinations of risk level (as per WSER classifications) very difficult to generate.

Where CSOs occur, facilities must produce a long term CSO reduction plan and submit it to the regulatory authority. This plan may be combined with the action plan to achieve the National Performance Standards. Where multiple actions are required to meet the requirements of the Strategy, the action plan will address prioritization of all work to be completed. This may include work needed to meet Effluent Discharge Objectives (EDOs).

Section 5.7 of Technical Supplement 2 of the proposed WSER states that overflow events (CSOs and SSOs) must be recorded in order to assess the frequency and severity of overflows, and there should be no dry weather overflows (CCME, 2008). Where possible and feasible, the volume or duration of an overflow should be recorded or estimated using more sophisticated methods and equipment, starting with major CSOs or those causing the greatest concern. The data should be recorded, along with information on storm event and snowmelt event occurrence (dates) and severity (rainfall), in order to help design any required mitigation of CSOs.

In addition to the standards, overflow objectives should be established to protect the beneficial uses of the receiving environment. For example, overflows should not occur upstream from designated areas such as fish spawning sites, beaches and drinking water intakes. Wastewater carrying industrial or hospital waste should not overflow either. Frequency, volume and/or treatment objectives should be set.

As discussed further in Section 7 of this report, some provinces have general overflow objectives. Ontario's Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems requires the capture and treatment of all dry weather flow plus 90% of volume resulting from wet weather flow above the dry weather flow, for a seven month period starting within 15 days of April 1. It also requires primary treatment of overflows, even for satellite wastewater facilities, which it defines as 30% removal of BOD and 50% removal of TSS. Ontario also has specific beach protection objectives, which include no violation of the body contact recreational water quality objective at swimming and bathing beaches and no more than two overflow events per season (June 1 to September 30). British Columbia's Municipal Sewage Regulation specifies that no CSO should occur during storm or snowmelt events with less than a five year return period, and also requires an average of 1% per year total volume reduction of CSOs with at least primary treatment of discharges. Quebec has site specific objectives, including no CSOs within 1 km of drinking water intakes or shellfish harvesting sites, no CSOs into, or immediately upstream, of fish spawning sites, and a maximum of one CSO per month in a continuous flow zone or one CSO per two months in an accumulation zone where human activities occur during periods when these events occur. These and other CSO control requirements and targets across North America, were discussed in some detail in Section 7 of this report.

Since facilities have no control over weather, frequency objectives may not be achieved every year. However, they should be achieved (on average) when comparing results obtained over a number of years. The MWWE Strategy recommends the following steps to control CSOs:

1. Record CSO events, at least on an occurrence basis;
2. Achieve the National Overflow Standards, as presented above;
3. Demonstrate at a facility level that everything that can be done with existing equipment is being done to limit CSO occurrences; and,
4. Develop a long term plan to reduce CSOs and capture substances, based on achieving jurisdictional overflow objectives.

Combined sewers should have CSO discharge limits (in the form of frequency and/or volume limits), or treatment requirements, as close as possible to established overflow objectives. Ontario Procedure F-5- 5: Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems (MOE, 1997) and the Combined Sewer Overflow Treatment Technologies Manual (XCG, 2004) provide some guidance to help communities prepare long term CSO abatement plans. Long-term CSO control plans should establish priorities based on risk. The USEPA also provides a number of very useful guidance documents to help communities develop and implement their CSO control programs, which were listed in Section 7 of this report.

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Facilities with CSO locations that have a risk level higher than the risk level of the main effluent may work on CSO reduction first, and therefore delay work on meeting the NPS. The objective is to reduce the risk levels associated with CSOs to at least as low as the risk level of the main effluent, before starting work on meeting the NPS, but the facility must still achieve the NPS within the 30 year timeline of the Strategy.

Table 8-1 - System of Points for Calculation of Risk Level of Individual CSO Locations[1]

Item	Column 1 - Factors	Column 2 - Criteria	Column 3 - Points
1	The ratio – during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER – of the "estimated average dry weather flow that circulates in the combined sewer at the overflow point" to the "estimated average dry weather flow that is deposited at the final discharge point", expressed as a percentage.	≥ 50% ≥ 25% and < 50% ≥ 10% and < 25% < 10%	30 points 20 points 10 points 5 points
2	The number of deposits via the overflow point during the period of 12 consecutive months referred to in section 14(1) of the proposed WSER.	> 25 deposits > 15 deposits and ≤ 25 deposits > 5 deposits and ≤ 15 deposits 5 deposits or less	30 points 20 points 10 points 0 points
3	Water where effluent is deposited via each overflow point (the sum of points for all that apply).	shellfish harvesting area within 500 m of any point of entry where effluent is deposited in the water via the overflow point aquatic species that is a protected species frequents the area or is found, or fish spawning area is found, within 500 m of any point of entry where effluent is deposited in the water via the overflow point lake, natural wetland, reservoir, estuary, or enclosed bay as defined in Section 1 of Schedule 2 of the proposed WSER	20 points 10 points 10 points

1. As per Schedule 3, Subsection 24(2), subsection 25(1) and 26(2) of the proposed WSER (using revised definitions provided to HMM by ENVC).

The approach consists of looking at every single CSO location and determining which ones have an unacceptable impact on the receiving environment and its uses. Those that accumulate more points

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than the main effluent (as defined in section 9.1 of Technical Supplement 2) are considered a higher risk and should be dealt with first. Points for CSO risk levels are allocated based on Table 8.1 (presented earlier as Table 4.1).

Risk Characterization of Combined Sewer Overflows in NL

Risk levels for each CSO outfall in NL were calculated based on the updated criteria / system of points presented in Table 8.1 (presented earlier as Table 4.1).

Key CSO information required to complete this exercise included the following:

- Ratio, during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER, of the "estimated average DWF that circulates in the combined sewer at the overflow point" to the "estimated average DWF that is deposited at the final discharge point", expressed as a percentage (e.g. < 10%, 10-25%, 25-50% or >50%).
- Number of deposits via the overflow point during the same 12 month period referred to above (e.g. <5, 5-15, 15-25 or >25 deposits)
- Proximity of location where effluent is deposited via each overflow point to environmentally sensitive areas (e.g. shellfish harvesting area within 500 m; endangered species or fish spawning area within 500 m downstream; lake, reservoir marine estuary, or enclosed bay as defined in Section 1 of Schedule 2 of the proposed WSER).

These CSO point scores have been included as an additional field in the Sewer Overflow Database, and have been used (in conjunction with other information gathered and prepared by this study) to prioritize the implementation of CSO control measures across the Province.

Table 8.2 (presented earlier as Table 4.2) provides a summary of the results of our Preliminary CSO Risk Assessment for the remaining CSO outfalls in NL, based upon the criteria / system of points defined by the proposed WSER and presented in Table 8.1. Note that this is a preliminary assessment, based on the information we were able to collect from the municipalities responsible for the operation and maintenance of these CSO outfalls, and from our own site visits conducted in these communities. In a number of cases, some of the information required to complete the CSO risk assessment was unavailable and/or could not be determined from the information provided by the municipalities in response to our requests. In general, the municipalities did not have flow monitoring data to confirm the average DWF or number of deposits (CSOs) occurring at their existing

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CSO overflow points during a 12 period, so in some cases, the ratio of average DWF at the overflow points to the discharge points were estimated from provided design flows, and overflow frequencies were roughly estimated based upon typical annual storm event frequencies and typical CSO design capacities. For St. John's, where new CSO control measures have already been implemented at part of their Harbour Clean-up Program, average annual CSO frequency was estimated to be 7 deposits based on the design capacity of the new CSO control structures (hence with an associated Category 2 risk score of 10 points). For the remaining CSOs in Harbour Grace, St. Lawrence, Springdale, Gander, Channel Port aux Basque and Corner Brook, average annual CSO frequency was estimated to be greater than 25/year, assuming there are typically at least this many rainfall events in an average year that are large enough to cause CSO events. This assumption is based on typical findings from other CSO communities in Canada and North America, from studies we have conducted, from literature reviews, and from various USEPA documents.

Accordingly, we recommend the following:

R1. The Province consider new program(s) to assist Communities in NL to collect missing/better information on the performance of the CSO/SSO systems, to support efforts to improve the accuracy of CSO Risk Assessment calculations required by the proposed WSER, and to improve the confidence in development of future CSO/SSO Control Programs/Projects to meet future CSO/SSO control targets/objectives.

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Table 8-2 - Summary of Preliminary CSO Risk Assessment for CSO Outfalls in NL

CSO Outfall Location	CSO Risk Assessment Score (Points determined as per Table 4-1)			
	Item 1[1]	Item 2[2]	Item 3[3]	Total
EASTERN				
St. Johns				
4400-4-SO-C-1 – Prescott St	20	10	10	40
4400-5-SO-C-1 – Temperance St	20	10	10	40
4400-7-SO-C-1 – Pleasantville	20	10	10	40
Harbour Grace				
2125-10-SO-C-1 – Murray's Square	5	30	0	35
St. Lawrence				
4435-7-SO-C-1 – Director Dr	20	30	10	60
4435-8-SO-C-1	20	30	0	50
CENTRAL				
Springdale				
4910-4-SO-S-1 – Little Bay Rd	20	30	0	50
Gander				
1760-2-SO-C-3 – Cobham Rd	30	30	0	60
1760-2-SO-C-4 – Bennett Dr	30	30	0	60
1760-2-SO-C-5 – Towers Ave	30	30	0	60
1760-2-SO-C-7 – Carr Cr	30	30	0	60
WESTERN				
Channel-Port aux Basques				
1025-23-SO-C-1 – Rat Island Cove	30	30	20	80
Corner Brook				
1200-4-SO–C-1 – Lewin Pkwy & Main St	20	30	10	60
1200-5-SO-C-1 – Broadway & Caribou Rd	20	30	10	60

Notes:
1 The ratio – during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER – of the "estimated average dry weather flow that circulates in the combined sewer at the overflow point" to the " estimated average dry weather flow that is deposited at the final discharge point", expressed as a percentage.
2 The number of deposits via the overflow point during the period of 12 consecutive months referred to in subsection 24(1) of the proposed WSER.
3 Sensitivity of the water where the effluent is deposited via each overflow point (the sum of all points for all that apply).

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CSO Risk Assessment scores for the seven (7) NL communities with remaining CSO outfalls range from 35 (for the outfall in Harbour Grace) to 80 (for the outfall in Channel-Port aux Basques), with most outfalls having scores of 40 to 60, and the scores for Item 2 (CSO frequency) generally accounting for most of the total scores. The CSO outfalls with the highest risk assessment scores are the outfalls with the highest priority for implementation of measures to reduce or eliminate CSOs. Based on the scores provided in Table 8-2, the highest priority locations for remediation are the CSO outfalls in Channel-Port aux Basques, Gander and St. Lawrence.

Accordingly, we recommend the following:

R2. The Province place priority for the development and implementation of CSO Control Measures on the CSO communities and outfalls with the highest risk levels, but that this determination be made only after the collection and analysis of actual CSO frequency and volume measurements over a period of at least one full year (or seven-month season) at each NL CSO outfall (as presented in R1 above), in order to more accurately estimate the CSO risk level and confirm the priority of the outfall for remediation.

Assessment of Conditions/Causes of Sewer Overflows

Chapter 5 provided an assessment of the conditions/causes of sewer overflows, based on our own knowledge of these problems, and our review of existing information from and site visits and discussions held with many communities in NL. It is important to understand the cause/reasons for combined and sanitary sewer overflows and WWTP bypasses in order to develop/update CSO/SSO control regulations, policies and guidelines; to identify and develop measures to control or eliminate their occurrence; and to prioritize individual CSO/SSO control measures/projects for implementation across the Province. In the case of NL, it is also important to distinguish between infrequent overflows from sanitary sewer systems that convey the majority of flows to a wastewater treatment plant, and sanitary sewer systems that have been purposefully designed to discharge sewage to receiving waters without treatment.

Typical causes of sewer overflows and WWTP bypasses include, but are not limited to:

- Connection of household roof leaders, basement sumps and weeping tiles to sanitary and combined sewers;
- Infiltration into leaky sanitary and combined sewers;

- Inflow into sanitary sewers (inflow to combined sewers is expected);
- Blockages in sanitary and combined sewers;
- Equipment failure (e.g. pumps in sewage list stations);
- Rainfall events; and
- Exceedence of design capacities of sewers, lift stations and WWTPs.

Data on actual measured sewage flow rates in dry and wet weather was generally not available from the responding communities, making it very difficult to accurately quantify the contribution to sewers from such secondary sources during dry and wet conditions, and provide an accurate estimate of the scale of deviation (increase) from average wastewater flows during wet weather conditions, for each sewer overflow, so our assessment of the conditions/causes of sewer overflows was necessarily more qualitative than quantitative.

As with all combined sewer systems, CSOs in NL occur when the capacity of the sewage interception system in place to convey sewage flows to the downstream WWTP for treatment is exceeded, and the frequency and volume of CSOs at each location depends upon the sewage interception capacity that was originally designed within each system. CSOs generally occur when flows in the sewer system exceed 3 to 5 times average DWF rates (but this varies from site), and typically this interception capacity is sufficient to capture most small and some medium sized storm events. Typically, average annual CSO frequencies range from 20-40/year (but again, this varies from site to site depending upon their individual designed sewage capture capacities).

SSOs occurring in NL are caused by a number of different and related reasons, which based on our investigations, include the following items:

- Insufficient hydraulic conveyance capacity (during larger storm events), both within the sanitary sewer system and at sewage pumping stations, which is often a result of excessive infiltration and inflow into the sanitary sewer system, which is often caused by the general deterioration of the condition of sewer infrastructure (sewer and manholes) and the connection of roof downspouts and/or foundation drains to the sanitary sewer system.
- Infrequent mechanical equipment failures, generally with sewage pumps, but also occasionally with standby power generation systems.

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- Mains power outages (which typically occur during wet weather when sewage flows are higher) impacting sewage pumping capability where no standby power exists, or possibly running out of fuel to drive generator and pumps during longer power outages.
- Sewer breaks causing sewage to leak into ground surrounding damaged pipes.
- Sewer blockages causing sewer and basement backups.
- Cross connections between storm and sanitary sewers.

Sewage lift station bypasses occurring in NL are generally the result of excess wet weather flows within the contributing sanitary sewer system, which are typically caused by excessive infiltration and inflow within the contributing sewer system. Some bypasses are designed to occur (based on original design of facilities) to prevent capacity exceedences and flooding within the upstream and downstream sewer system. Un-designed and unexpected bypasses may also occur due to mechanical equipment failures within the station, generally with sewage pumps, but also occasionally with standby power generation systems (possibly even caused by running out of fuel for the generator).

WWTP bypasses (including full or partial plant process bypasses) occurring in NL are also generally the result of excess wet weather flows within the contributing sanitary sewer system, exceeding the design capacity of the facility, which are typically caused by excessive infiltration and inflow within the contributing sewer system. Some bypasses are designed to occur (based on original design of facilities) to protect plant treatment processes (e.g washout of biological treatment). Un-designed and unexpected bypasses may also occur due to temporary mechanical equipment failures within specific treatment processes, including equipment which may be temporarily unavailable due to repairs, replacement or new construction projects.

Review of CSO Control Technologies and Approaches

Chapter 6 provided a detailed review of available CSO and SSO control technologies, including a multitude of different source control measures, sewer system controls, high rate treatment systems, floatables control measures, disinfection methods, and odour control measures. Source controls used to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as ‘Green Infrastructure’. Green infrastructure is an approach to WWF management that is cost-effective, sustainable and environmentally friendly, which is gaining wider acceptance for CSO control. Green infrastructure also provides a variety of other community benefits including economic savings, green jobs, neighbourhood enhancements and sustainable communities. The USEPA has recently issued a Memorandum on 'Protecting Water Quality with Green Infrastructure in EPA Water Permitting and Enforcement Programs' (USEPA, 2011), which strongly encourages and supports the use of green infrastructure approaches to manage wet weather flows, including stormwater runoff and CSOs. Typically, the best solutions involve a combination of green and grey infrastructure. We therefore recommend the following:

R3. The Province consider encouraging and/or providing additional support for 'Green Infrastructure' solutions for controlling CSOs (instead of or in conjunction with more traditional 'Grey Infrastructure' solutions).

Review of Newfoundland and Labrador Design Guidelines

The CCME MWWE Strategy provides municipalities with some regulatory clarity for managing municipal wastewater effluent under a harmonized framework that is protective of human health and the environment, and includes some general guidance with respect to CSO and SSO control, but it does not set any specific objectives or targets with respect to the reduction of CSO volume, frequency or pollutant loads.

Similarly, the Province of Newfoundland and Labrador's Guidelines for the Design, Construction and Operation of Water and Sewerage Systems (ENVC, 2005) provide very detailed guidance on the design, construction, operation and maintenance of sanitary sewage collection (and treatment) systems, but additional guidance is required for remedial measures to reduce and/or eliminate discharges from existing CSOs and SSOs. Key elements missing from the current guidelines include the definition of objectives or targets for reducing the volume, frequency and/or mass of pollutants from existing CSO and SSO outfalls in the province, and information on the planning, design, operation and maintenance of state-of the-art methods, approaches and technologies for controlling CSOs and SSOs. Accordingly, we recommend the following:

R4. The Province expand their existing Guidelines for the Design, Construction and Operation of Water and Sewerage Systems to include the planning, design, construction and operation of CSO/SSO control technologies and facilities, including specific targets for CSO/SSO control.

Chapter 7 presented the results of a detailed review of the relevant sections of the Guidelines for the Design, Construction and Operation of Water and Sewerage Systems, and comparison of these guidelines with wastewater collection and treatment regulations, standards and guidelines from other jurisdictions across Canada and internationally. Other jurisdictions and organizations have developed detailed regulations and procedures and guidance documents for CSO (and SSO) control, which have been reviewed in detail above, and some of these could be readily applied to CSO/SSO control in Newfoundland and Labrador. The most comprehensive the Canadian CSO regulations/procedures is MOE Procedure F-5-5, which was modeled closely on the US EPA CSO Control Policy, but as a procedure or guideline to be followed to reduce CSOs, not as a regulation including a formal permitting system.

Our preliminary recommendation, would be to adopt a CSO control guideline similar to MOE Procedure F-5-5 (or the presumptive approach from the US EPA CSO Control Policy), requiring completion of a CSO Pollution Prevention and Control Plan (or Long Term Control Plan as per US EPA Control Policy) and implementation of a suite of minimum CSO controls, including specific objectives or targets for the control of CSO volume, frequency and/or pollutant loads on an average annual basis. We would recommend maintenance of the 7-month period during the spring, summer and fall as the measure for compliance with the set objectives, as opposed to an entire year, because of the difficulty of accurately quantifying snowfall and snowmelt.

One drawback to the approach defined by MOE Procedure F-5-5, as we see it, is the requirement to capture 90% of the average annual WWF volume entering the CSS, or more specifically the requirement to demonstrate compliance with this requirement. This volume cannot be practically or accurately measured in the field, so it is generally estimated with the assistance of long-term hydrologic and hydraulic modeling of the CSS, which can be time consuming and costly. A simpler approach would be to select a suitable CSO frequency target of say 4 CSOs per year on an average annual basis (which could be made more stringent under specific environmental circumstances). This is similar to the presumptive approach available under the US EPA CSO Control Policy, and would be much simpler to monitor and demonstrate compliance. With respect to future CSO targets for NL, at this time, we recommend the following:

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R5. Implementation of a simple approach akin to the 'Presumptive Approach' of the USEPA CSO Control Policy, with a targeted Average Annual CSO Frequency of four (4) CSOs per year. The compliance monitoring period in each year should be limited to a seven-month period in the spring, summer and fall, but CSO control measures should be operated year-round to maintain the same level of CSO control throughout the entire year.

R6. Implementation of a program for controlling SSOs, employing some of the more cost-effective and more easily implemented components of the USEPA Capacity, Management, Operation and Maintenance (CMON) Program, including elimination of all dry weather SSOs in the short term, and elimination of wet weather SSOs in the longer term.

As noted above, the costs of CSO/SSO control can be very high, and the specific objectives/targets defined by a new CSO/SSO control guideline procedure for the Province of NL will play a significant role in determining these future costs. While there are only a handful of remaining CSO outfalls in the Province (especially with the City of St. Johns already on the way to implementing new CSO controls as part of their Harbour Clean Up Program), total CSO control costs could still be in the tens or even hundreds of millions of dollars, and SSO control costs will likely be in the hundreds of millions of dollars. Accordingly, we recommend the following:

R7. The Province consider a CSO/SSO Cost Sharing Program(s) with NL communities for funding the development and implementation of required CSO/SSO Control Programs/Projects, possibly in conjunction with the Federal Government.

R8. The Province consider implementation of a Financial Hardship Program similar to USEPA, to relax CSO/SSO control requirements or preferably extend the required timeframe for implementation (based on demonstrated financial hardship) timeframe, and/or provide additional funding to help financially distressed communities to implement CSO/SSO control programs.

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10.0 LIST OF ACRONYMS

ADWF	Average Dry Weather Flow
AENV	Alberta Environment
AWWA	American Water Works Association
BOD	Biochemical Oxygen Demand
BOD_5	5-day Biochemical Oxygen Demand
$cBOD_5$	5-day Carbonaceous Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CCTV	Closed Circuit Television
CDS	Continuous Deflective Separation
CMOM	Capacity, Management, Operation and Maintenance program (USEPA)
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act (Canada)
DAF	Dissolved Air Flotation
DMA	Department of Municipal Affairs (Newfoundland & Labrador)
DO	Dissolved Oxygen
DONCE	Disposal out of the Normal Course of Events
DWF	Dry Weather Flow
ECWS	Environmental Control Water and Sewage Regulations (Canada)
EDO	Effluent Discharge Objective
ENVC	Department of Environment and Conservation (Newfoundland & Labrador)
EPA	Environmental Protection Act (Canada)
FBM	Flow Balance Method
GIS	Geographic Information System
H_2S	Hydrogen Sulphide
HRPCT	High Rate Physical-Chemical Treatment
HRT	High Rate Treatment

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I/I	Infiltration and Inflow
LTCP	Long Term Control Plan
MOE	Ontario Ministry of the Environment
MWWE	Canada-wide Strategy for the Management of Municipal Wastewater Effluent
NaOH	Sodium Hydroxide
NL	Newfoundland and Labrador
NMC	Nine Minimum Controls
NPDES	National Pollutant Discharge Elimination System (USEPA)
NPS	National Performance Standards (CCME)
O&M	Operation and Maintenance
PAA	Peracetic Acid
POTW	Publicly Owned Treatment Works
PPCP	Pollution Prevention and Control Plan
RDII	Rainfall Derived Infiltration and Inflow
RTB	Retention Treatment Basin
RTC	Real Time Control
SLS	Sewage Lift Station
SPS	Sewage Pumping Station
SS	Suspended Solids
SSO	Sanitary Sewer Overflow
STEP	Sustainable Technology Evaluation Program
STP	Sewage Treatment Plant
THM	Trihalomethane
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
USA	United States of America
USEPA	United States Environmental Protection Agency
UV	Ultra-Violet

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VSS	Vortex Solids Separator
WEF	Water Environment Federation
WPCP	Water Pollution Control Plant
WQS	Water Quality Standards
WRA	Water Resources Act (Canada)
WRMD	Water Resources and Management Division (Newfoundland & Labrador)
WSER	Wastewater Systems Effluent Regulations (Canada)
WWF	Wet Weather Flow
WWTP	Wastewater Treatment Plant

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