Combined Sewer Overflow Management Study

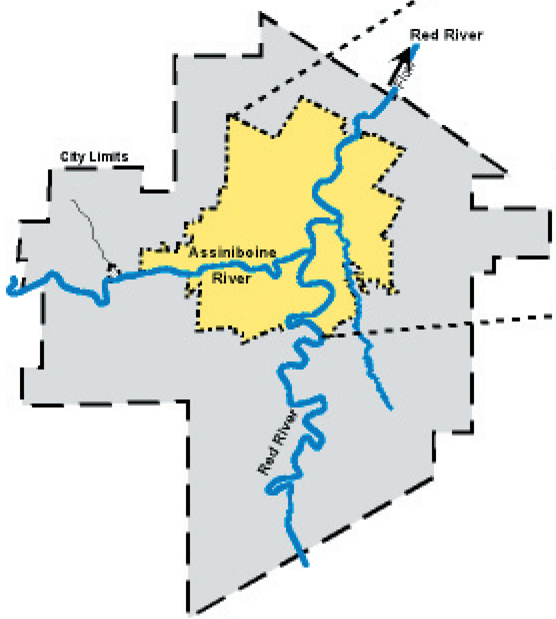
Executive Summary: Combined Sewer Overflow Management Study

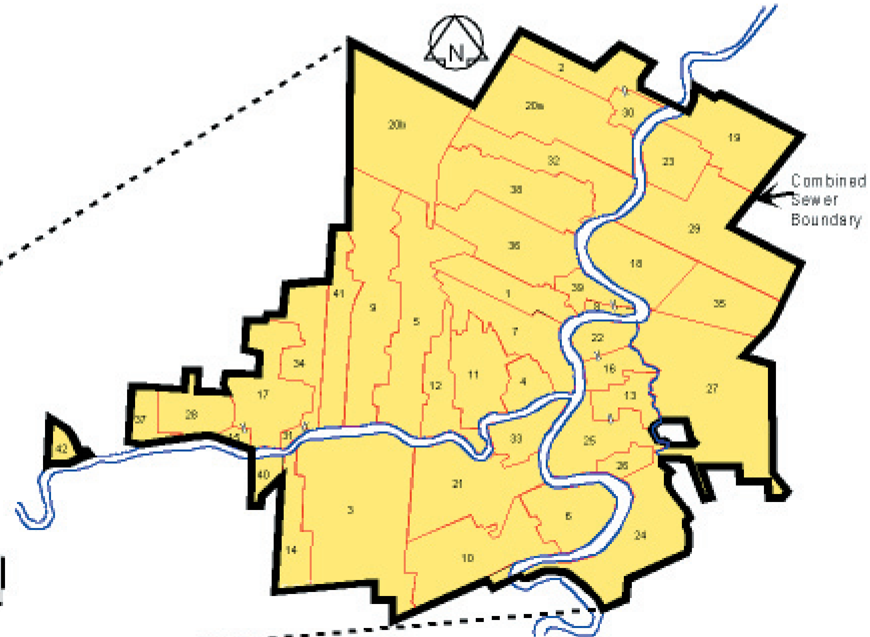
Report to:

Winnipeg

Embrace the spirit

Water and Waste Department





WARDROP Engineering Inc. and **TetrES CONSULTANTS INC.**

In Association With:

CH2M Hill Canada and **EMA Services Inc.**

Table of Contents

Introduction....................................4

Clean Environment Commission
Hearings—4
Objectives of CSO Study—4

Background....................................5

History of Combined Sewers—5
Combined Sewer Overflows—5

Performance Measures..........................7

Public Consultation...............................8

Current Conditions................................9

Potential Illustrative Program...............11

Optimize Existing Infrastructure—12
New Initiatives—14
Monitoring/Reporting—16
Cost and Timing of the Illustrative Program—16
Going Forward—16

Introduction

Clean Environment Commission Hearings

This Combined Sewer Overflow (CSO) Management Study involved several years of study activity. It represents the culmination of the City of Winnipeg Water and Waste Department's investigation of its combined sewer system in terms of the effects of combined sewer overflows on river water quality and related river issues. Such an investigation had long been planned by the City of Winnipeg and was precipitated by the Clean Environment Commission (CEC) recommendation that site-specific studies be undertaken to determine water-quality impacts of CSOs and to formulate remedial measures for potential CSO control. The City is required to provide a report to the CEC for their consideration in making recommendations to the Minister of Conservation on appropriate action.

The CEC hearings were held in 1991 and early 1992. The subsequent CEC report identified the types of beneficial uses, such as recreation, to be protected during dry weather flow (DWF). With respect to CSOs, the CEC concluded that there was insufficient site-specific information to advocate a requirement that CSOs be regulated and, accordingly, recommended that studies be undertaken to determine water-quality impacts, to formulate potential remedial measures for CSO control, and to enable a review of wet weather river quality objectives.

This very important planning study will help to define the next generation of water pollution control in the City. The study will contribute to the development of significant long-term environmental policies in relation to the Red and Assiniboine Rivers and could result in a substantive long-term commitment of financial resources.

Objectives of CSO Study

The objectives of the CSO Management Study were to:

- develop an understanding of the effects of CSOs on river quality and river use;
- develop comparative cost and benefit information for practicable CSO control alternatives;
- provide relevant information to enable informed value-judgements by policymakers and the public; and finally
- to assist in defining a cost-effective, prioritized implementation plan for remedial work.

The study plan will be used by the City, after consultation with the public and regulatory agencies, as the basis for the development of an approved plan.

Background

History of Combined Sewers

Combined sewers were built in Winnipeg between 1880 and 1960 (Figure 1).

They originally served an area of about 10,500 ha (35% of the currently developed area). Through selective separation in conjunction with the Basement Flood Relief Program, the combined sewer area has been reduced to a current 8,700 ha.

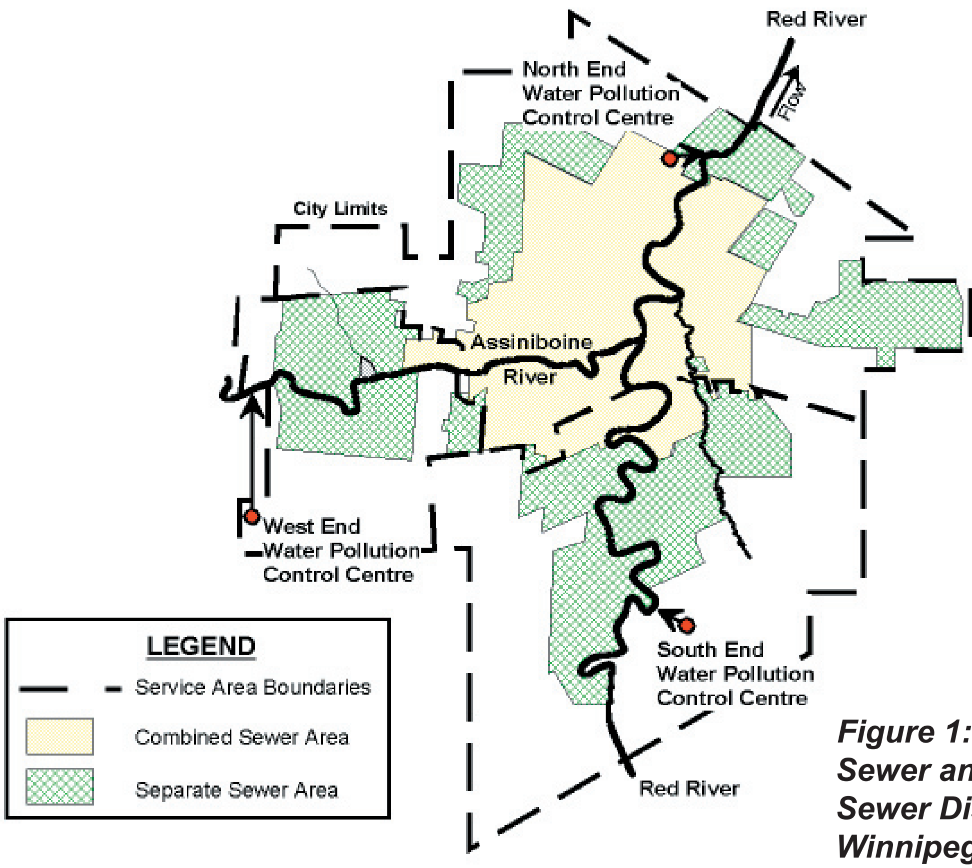


Figure 1: Combined Sewer and Separated Sewer Districts in Winnipeg

Combined Sewer Overflows

There are 43 combined sewer districts in the City with a total of 72 combined sewer outfalls to the rivers, including storm relief pipes. These sewers carry wastewater only, during dry weather, and stormwater plus wastewater during rainstorms. The sewers overflow to the rivers during all but the smallest rainstorms.

The long-term record shows that CSOs occur, on average about 18 times per year, during the open-water recreation season. During these overflows the sewers discharge a mixture of wastewater and drainage of approximately 4 million m^3 of combined sewage into the rivers. This represents about 60% of the runoff from the combined sewer districts. The remainder is conveyed to the treatment plants through the City's interceptor sewer system. Almost all of the CS districts are connected to the North End Water Pollution Control Centre (NEWPCC) via the Main Interceptor. These overflows include about 1% of the total annual volume of wastewater generated by the City.

The diversion arrangement for CSOs is illustrated in Figure 2. All dry weather flows are diverted to the Interceptor sewers for treatment at the 3 WPCCs.

Background

Combined Sewer Overflows..

During rainfall, most of the combined wet weather/wastewater flow is discharged to the rivers.

The combined sewage discharges contribute oxygen-demanding organic material, suspended solids, bacteria and floatables to the rivers, as well as other constituents associated with urban runoff. Water quality modelling and river quality monitoring have shown that the CSOs slightly depress the DO levels in the rivers, but not to the point where the level falls below that required to sustain healthy aquatic life. The rivers already carry large volumes of suspended soils, which gives them their characteristic murky brown appearance: typical of prairie rivers. This particular characteristic already limits water contact activities such as swimming. Accordingly, sediments are not considered an important issue for the CSO study.

The main issues related to CSOs, from a river-quality perspective (and also as indicated by the CEC), are the levels of bacteria (as indicated by fecal coliform concentrations), and floatables attributable to sewage, whose source is CSOs. In addition to these impacts, the CSO discharges are offensive in that, during periods of overflow, dilute raw sewage is discharged into the rivers.

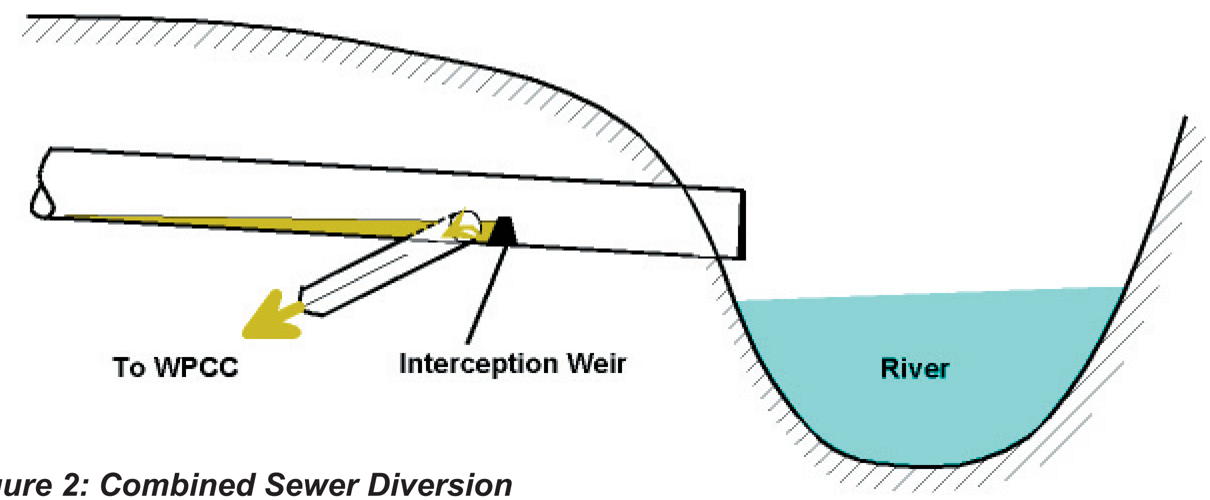


Figure 2: Combined Sewer Diversion

Performance Measures

A key product of the CSO Management strategy for the City of Winnipeg is the establishment of a cost-effective prioritized implementation plan(s) for remedial work, based on an assessment of cost and benefits of practicable alternatives. The following goals provide a context for this objective:

- provide protection for beneficial uses of the rivers;
- respond to the reasonable expectations of the public and stakeholders;
- recognize the provincial surface water quality objectives for the Red and Assiniboine Rivers;
- consider the prevailing environmental practices and policies in terms of CSO control in Canada and the U.S.A.; and
- ensure that any recommended remedial work implemented will not increase risk of basement flooding.

The different CSO control plans considered covered a broad range of performance characteristics, as illustrated in Figure 3.

The range of control options considered began with an assessment of the existing baseline situation and then progressively included various levels of incremental control, such as optimizing the use of the existing infrastructure, adding storage, through to complete separation of the existing combined sewer system.

A number of sources were explored in terms of evolving CSO control guidance or policy. These included the then draft CSO Control Policy developed by the Environmental Protection Agency (EPA) of the USA, other Canadian provincial policies, and the Association of Metropolitan Sewerage Agencies .

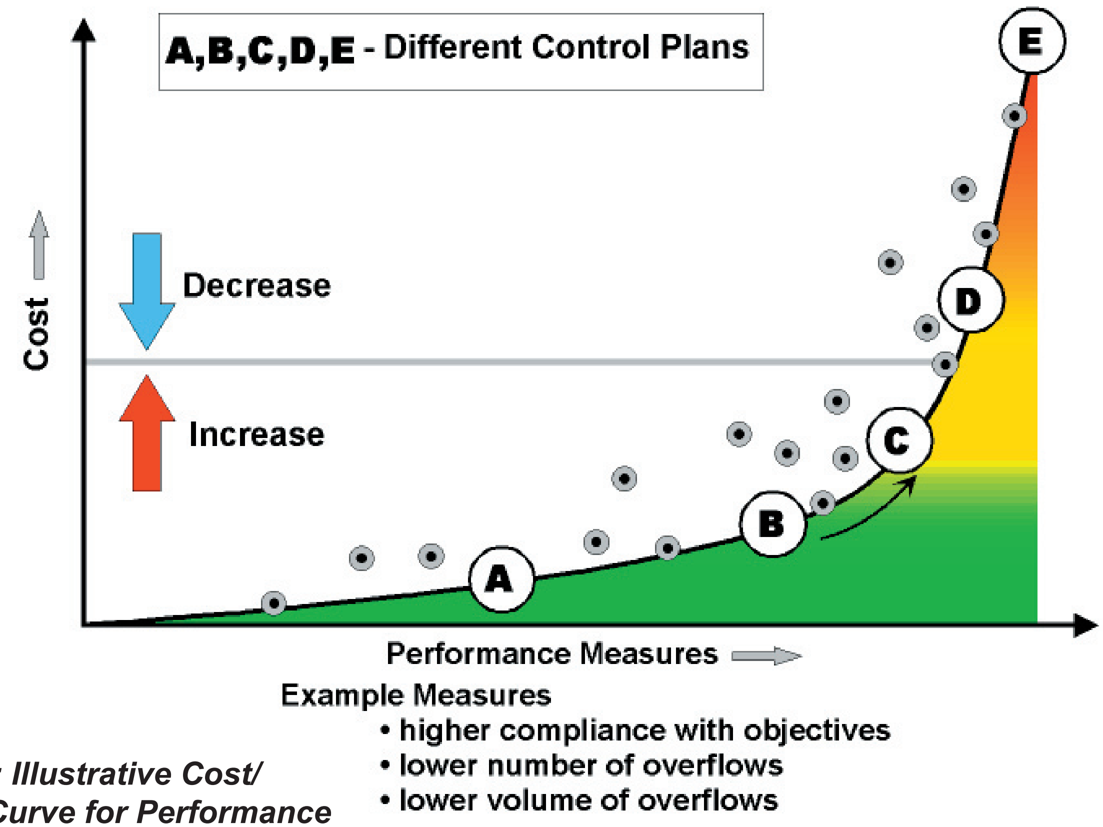


Figure 3: Illustrative Cost/ Benefit Curve for Performance Measures

Public Consultation

The Environmental Protection Agency (EPA) of the USA has been a leader in developing CSO policy and many agencies have patterned their policies using the EPA approach as a guideline. The EPA advocates that a long-term CSO control program be developed to meet certain control "benchmarks", and sufficient to meet the state water quality standards.

Candidate CSO control plans for the Winnipeg situation were identified for a range of performance measures including U.S. EPA benchmarks of 4 CSOs per year or 85% volumetric control, along with zero overflows and compliance with Manitoba Surface Water Quality Objectives. The results of this analysis were used to develop "trade-off" curves, as illustrated in Figure 3 to assist in the evaluation of potential control strategies.

Public participation in the CSO Management Study is warranted from the standpoint of City policy, as well as through the direction of the CEC. The public involvement program, as executed, was intended to accomplish the following:

- develop public awareness of how CSOs occur and their impact on river water quality;
- enable the public to have a better understanding of the CSO control planning process;
- help determine and define the public's judgements on issues and priorities;
- create understanding among the stakeholders of the trade-offs involved in CSO control options; and
- demonstrate to Manitoba Conservation that the City has made reasonable efforts to inform the various publics and to obtain meaningful feedback from these publics.

As part of the public consultation program an external Advisory Committee was formed in the fall of 1994. The Committee's responsibilities included providing advice (from an external perspective) to the CSO Study Team as the study progressed, and reporting to the CEC upon completion of the study. Its members were selected to represent a cross-section of major stakeholders from whom the City would receive ongoing feedback. The Committee met periodically throughout the study.

Current Conditions

The performance of the existing system was evaluated by simulation of the representative year (1992) and the long-term actual record of rainfall for Winnipeg. The long-term record shows that CSOs occur about 18 times per year on average, during the May 1 – Sept. 30 period. Figure 4 presents the frequency of overflows in various City districts.

On a city-wide basis, compliance with the provincial fecal coliform objectives of 200 fc/100 mL is about 65%, on average. With WPCC effluent disinfection in place, compliance would be achieved about 95% of the time, on a city-wide basis.

Notwithstanding the above general compliance, immediately following a significant rainfall, and depending on the amount of the rainfall, fecal coliform concentrations can rise several orders of magnitude as illustrated on Figure 5. This situation occurs primarily as a direct result of CSO discharges which would be unaffected by WPCC effluent disinfection. These high coliform incidents (spikes) can last from hours to several days before the levels return to normal dry weather concentrations as the organisms die off in the river.

Illness Risk Perspective

Fecal coliforms are an indicator organism used to indicate fecal contamination and therefore the possible presence of pathogens which could result in Gastrointestinal Illnesses (GI).

Using the estimations of fecal coliform densities and river use (i.e., numbers of people swimming, waterskiing, etc.), an estimate of the incidence of GI can be developed using epidemiological (dose-response ["D-R"]) equations. These models allow the estimation of risk rates for contracting GI from primary recreation in the Red River. They are not able to estimate skin, ear, or respiratory infections from such use.

The D-R models and the associated estimated disease caseload indicate that there is no reason to expect that a

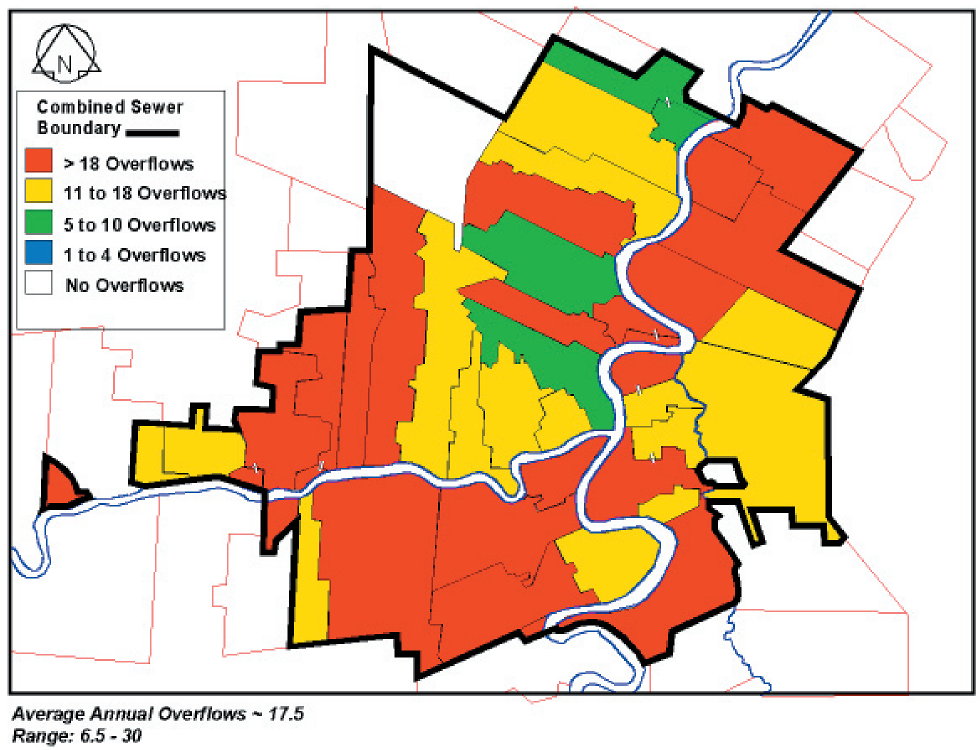


Figure 4: Existing Conditions - Long-Term Performance

Current Conditions..

significant disease caseload exists from recreation in the Red River.

Aside from avoided disease, there are other community health considerations which could be factors in determining CSO control policy. These were explored in the risk assessment, as summarized below.

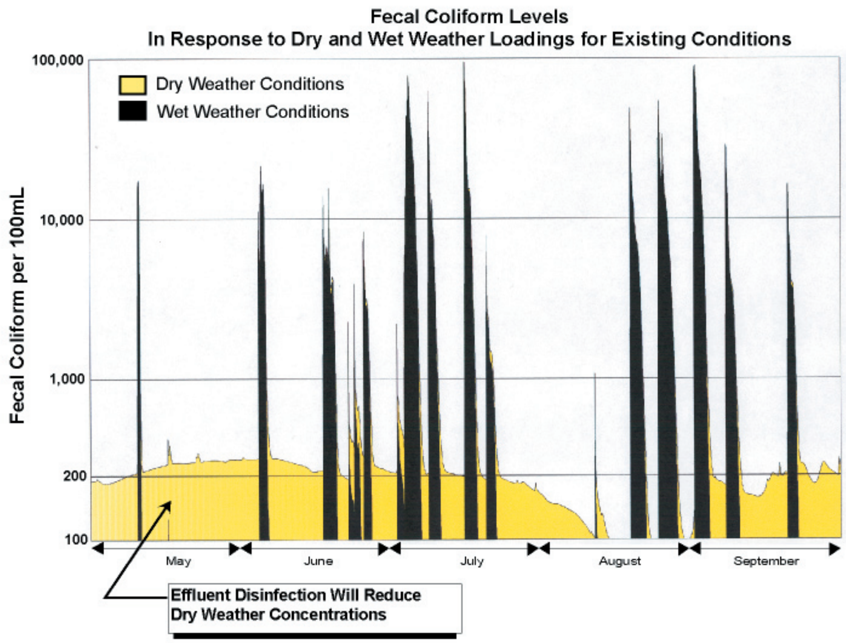


Figure 5: Predicted Benefit of Effluent Disinfection at Redwood Bridge

The Red River has naturally high levels of turbidity, strong currents, relatively steep muddy banks and concealed objects. Accordingly, the use of the Red River for primary recreation, such as swimming or waterskiing, has attendant risks due to these characteristics of the water.

Safety Considerations in Use of Rivers

Manitoba Conservation does not recommend swimming in the rivers when turbidity levels exceed 50 NTU. The rationale is based on the need for clarity for situations where swimmers are in distress. The actual turbidity levels in the Red River frequently exceed this level and indicate that the river, in its natural state, is not very suitable for primary recreation. The elimination of CSOs would not change the clarity of the rivers for swimming.

Increased Use of Rivers

If additional control of CSOs resulted in the increased use of the Red River for primary recreation, a small increase in disease caseload could result; along with more accidents and incidents of personal injury. On the other hand, this increase could result in improved public perception and community pride in the rivers.

An illness risk assessment report was prepared for the CSO study. It concluded that:

"CSO control will be costly and the benefits are subjective. There are many reasons to consider CSO control, including improving compliance with environmental guidelines, improvements in aesthetic and/or microbiological water quality, improving public perception and pride in the local rivers. The weight of the evidence and analysis indicates CSO control should not be considered a significant public health issue in the conventional context of avoiding disease. The extent of CSO control that is appropriate and acceptable to the community is fundamentally a public policy and a regulatory compliance issue."

Potential Illustrative Program

The attributes of the range of potential plans, in terms of costs, control performance, and other evaluation criteria, were analyzed during the course of the Study. The analysis confirmed that the **degree of CSO control is primarily a public and environmental policy issue**. In terms of the benefits of CSO control, the following considerations apply:

- •improved CSO control will result in a modest improvement in compliance with MSWQO fecal coliform numerical limits;

- •CSOs are not a major public health issue in the conventional sense of avoiding disease;

- •improved CSO control could contribute to the general "wellness" of the community primarily through an improved perception of river quality; and

- •floatables control could help to improve river aesthetics at points of particular interest, if considered necessary.

In proposing a CSO control plan, the analysis has also shown that:

- •compliance with dry-weather objectives during wet-weather is not practicable, even with complete CSO control, and therefore some CSOs may have to be accepted;

- •CSO control is very costly;

- •dealing with wet weather discharges is a difficult policy issue for the City and for Manitoba Conservation; and

- •the current trend is for cities to implement site-specific long-term CSO control programs to reduce the number and volume of CSOs.

With this perspective, this section will present a illustrative CSO control program for consideration by the various parties involved in defining public policy.

A large number of control plans were analyzed in order to determine cost versus performance (mainly number of overflows/season). The results for the most cost-effective options are illustrated on Figure 6.

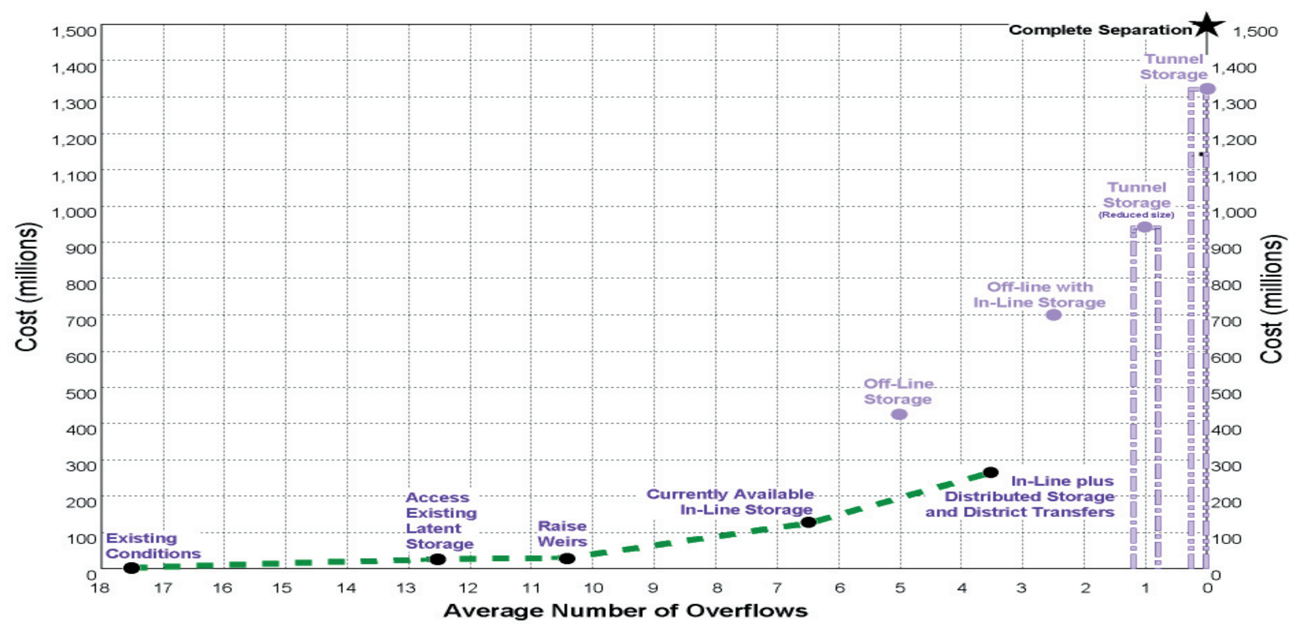


Figure 6: Proposed Illustrative CSO Control Plan

Potential Illustrative Program..

In reviewing potential CSO control plans, the analysis indicates that the modest identifiable improvements realized from reaching a target of one to zero overflows do not appear to justify the additional expenditure, i.e., an increment in the range of $600 to $1,200 M, when compared to plans that could control overflows to about 4 per recreation season (RS). Indeed, separation of the combined sewers would be less effective in terms of compliance with Manitoba's objectives for fecal coliform, than a control plan based on 4 overflows per RS.

Accordingly, 4 overflows per RS were selected as a target for the illustrative program.

The potential, illustrative, long-term CSO control plan comprises in-line/off-line storage plus inter-district transfers of flows.

The proposed control plan is described below in the context of (1) optimizing existing infrastructure; and (2) new initiatives. The plan is projected to be a progressive, staged program.

Optimize Existing Infrastructure

The single most cost-effective means of reducing the volumes of combined sewage being discharged into the river is to develop the available latent in-line storage as illustrated in Figure 7. In the case of many relief pipes, the pipe is partially submerged and is filled with combined sewage, during most rainfalls, which is currently not pumped back to the interceptor. In the control program, the captured combined sewage would be pumped back to the interceptor, after the rainfalls, for treatment at the WPCC.

At the same time, the combined sewer interception weirs would be raised (to about a nominal 40% of the sewer height), thus increasing capture of the combined sewage.

In addition to the above activities, the current interception rate, which is nominally based on 2.75x Dry Weather Flow (DWF), would be modified so as to be proportional to the run-off from each district. This change would optimize the proportion of wastewater diverted to treatment (i.e., from the river) in wet weather. This would require modifying the pumping rates, where intercepted flows are pumped, and providing flow control devices on the 10 districts which currently discharge by gravity to the interceptor.

The results of implementing the above three options, in terms of reducing the number of overflows, is illustrated on Figure 8 (compare to Figure 4). The average overflows/RS reduces from about 18 to about 11.

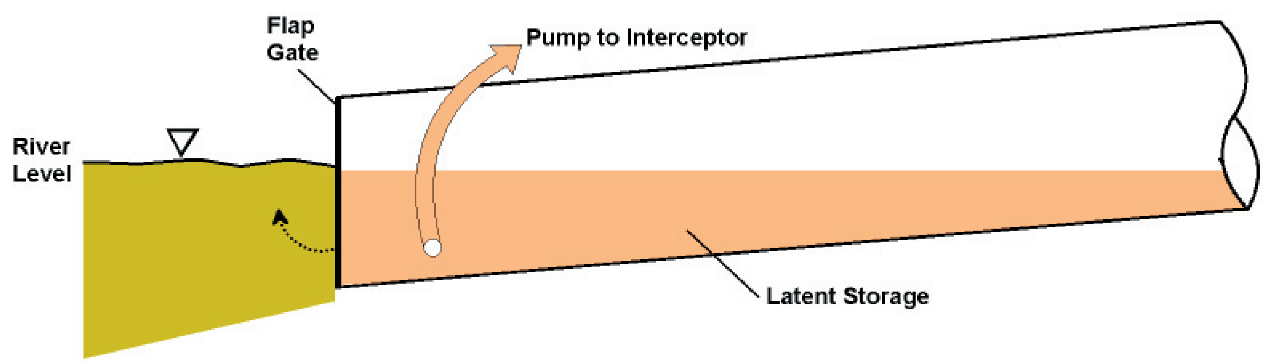


Figure 7: Available latent storage in existing infrastructure

Potential Illustrative Program..

Optimize Existing Infrastructure..

The CSO control program would be integrated, from the outset, with the ongoing Basement Flood Relief (BFR) program and the Sewer Rehabilitation Program (SRP). The City's combined sewer systems were installed prior to the 1960s.

In the 1970s, the City initiated a program of Basement Flood Relief which, in many cases, resulted in large relief sewers which reduced the frequency of basement flooding. By temporarily storing wastewater in these relief sewers, and in the original combined sewers, the resultant "in-line storage" would reduce the frequency of overflows.

The City plans to invest $110M in some 13 districts to alleviate basement flooding. During the course of the development of a BFR program for any CS district the possibility of reducing CSOs by oversizing relief sewers or through partial separation of the districts would be investigated. The cost of such enhancements would be weighed against the cost of off-line storage. Where the economics indicate, the CSO program would cover the cost of the oversizing.

In the case of the SRP, the City plans to invest about $150M city-wide. It may prove possible to oversize significant lengths of trunk sewer and thereby enhance CSO control. The cost of such oversizing would be covered by the CSO control program when the benefit was economically justified (as noted above).

The effect of this integration, of additional in-line storage or reduced CSOs result, will be to shorten the time taken to reach the program target (4 overflows/RS) and would reduce the cost.

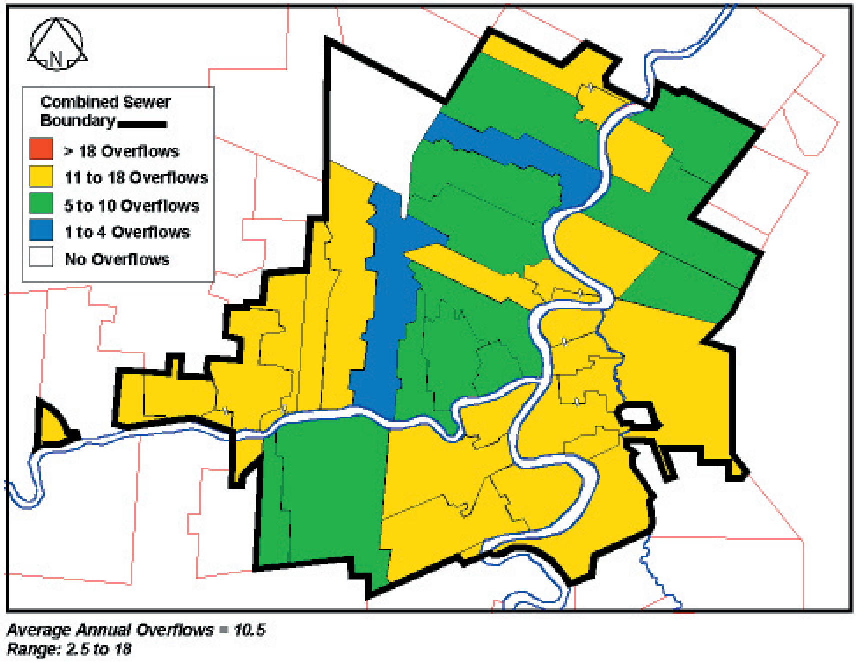


Figure 8: Modified Interception Rate; Latent Storage and Raised Weirs

Potential Illustrative Program..

New Initiatives

In-line storage is the next most cost-effective option. In-line storage would be realized by installing an inflatable dam (Figure 9) in the CS trunks and relief pipes. The system would be designed so as to be fail-safe with regard to basement flood relief in the combined sewer districts. Implementation of the potential in-line storage would reduce the cost of CSO control by about $200 million, compared to constructing equivalent new storage.

The inflatable dam has been demonstrated to be effective and reliable in similar applications in North American cities (viz. Cleveland and Detroit). It has not, however, been used in the City of Winnipeg. Accordingly, the short term program would include the design, construction and monitoring of a demonstration/pilot project.

The demonstration program would be designed to evaluate:

- the potential for odour generation of stored wastewater;
- the potential for sediment build-up in the sewers;
- the flushing of sediment during larger storms;
- the impact of flushed sediments on river quality;
- the need for and means of cleaning sediments after an event.

and to develop confidence in its operation.

Once a pilot program has proven the viability of in-line storage in Winnipeg, the program would proceed with the implementation of this technology.

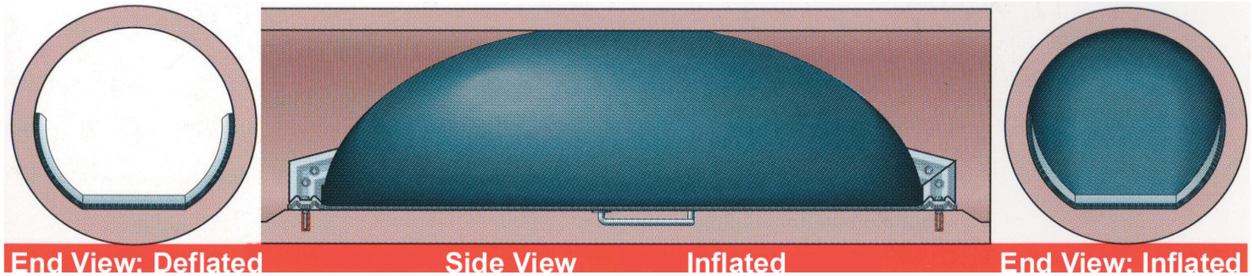


Figure 9: Inflatable Dam

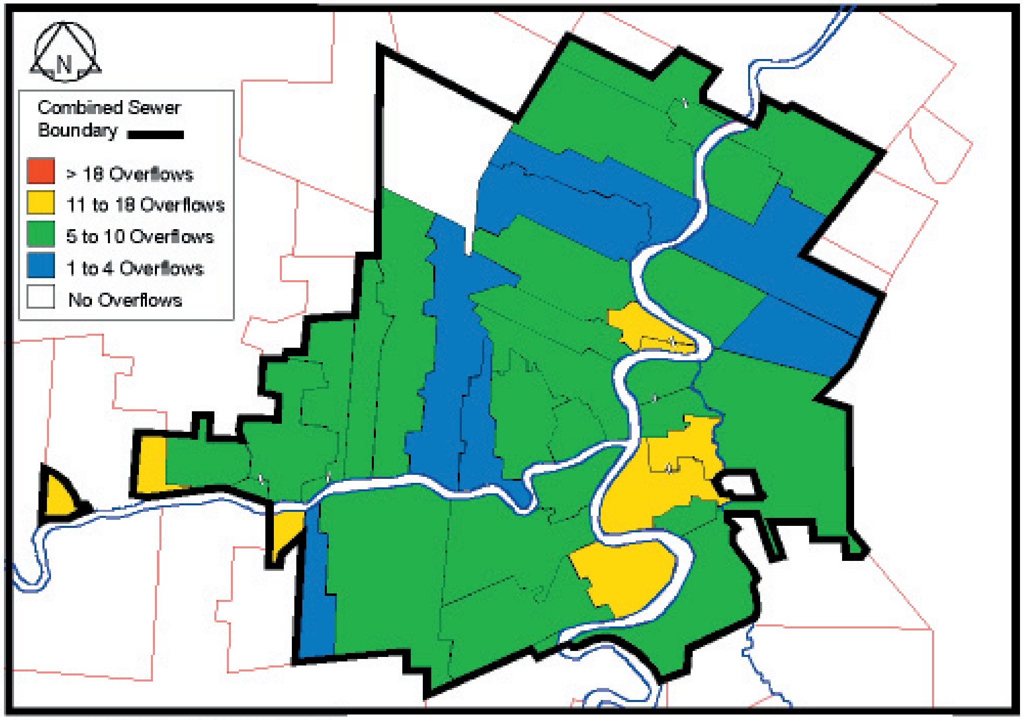
Potential Illustrative Program..

New Initiatives..

The results of the in-line storage program, once implemented, are illustrated on Figure 10. As noted, the average annual number of overflows would reduce from 18 for the existing condition (Figure 4) to 7 with in-line storage. The range of overflows in the districts would be from 2 to 17 per year.

If further improvement is needed (beyond in-line storage) the next most cost-effective means would be the construction of off-line storage, either in the form of near-surface tanks or local tunnels.

During wet weather events, all combined sewage (CS) would be pumped to the off-line storage until it is full. The CS would be stored until capacity is available in the Interceptors to convey it to the WPCC.



Average Annual Overflows = 7
Range: 2 to 17

Figure 10: Long-term Modified Interception Rate and In-line Storage

Initiation of the new initiatives could have an impact on the NEWPCC. Most of the combined sewers are tributary to the NEWPCC collection system. The extended periods of time over which peak wet weather flows will be conveyed to the NEWPCC (for dewatering of stored combined sewage after the rainfall) may necessitate modification of the plant. It is recommended that pilot tests be run, once some of the CSO control systems are in place, to determine the extent and nature of the changes required in the plant. It is projected that this could involve an investment of some $17 million (2001 $) 20 to 30 years in the future.

Potential Illustrative Program..

Monitoring/Reporting

It is recommended that the City undertake a monitoring/reporting program throughout the duration of the implementation of the CSO control program. The aim would be three-fold:

•to determine changes in the magnitude, frequency and duration of CSOs during implementation of the program;

•to determine the quality of sewage stored in-line and off-line and the overall success of capturing CS for temporary storage during wet weather; and

•the changing water quality in the rivers.

This monitoring program should include provision for a Supervisory Control and Data Acquisition (SCADA) system.

A periodic reporting (say, every 5 to 10 years) of the overall CSO control program, costs, improvements in CSO control and compliance with objectives would be done for review by the City, Manitoba Conservation and the public to assess the direction and scope of ongoing control programs. The program could be terminated when it is deemed that the additional benefits are not commensurate with the costs.

Cost and Timing of the Illustrative Program

An illustrative implementation program for the preferred option was developed on the basis of allocating of $4.5 million (2001 $) per year for investment in CSO control. Over a 60-year period, this represents an expenditure of about $270 million.

The operating revenue of the sewer utility includes an allowance of $7 million/year for an “Environmental Projects Reserve” (EPR). The implementation of Illustrative Program (@ $4.5M/yr) could fit into the current program so long as there are no exceptional demands on the EPR and the EPR is adjusted for inflation.

Figure 11 illustrates the manner in which a projected target of 4 overflows per RS could be reached via an illustrative program financed on the basis of $4.5 million per year (current $). Any change in the annual amount would have a direct effect on the schedule and implementation of the program.

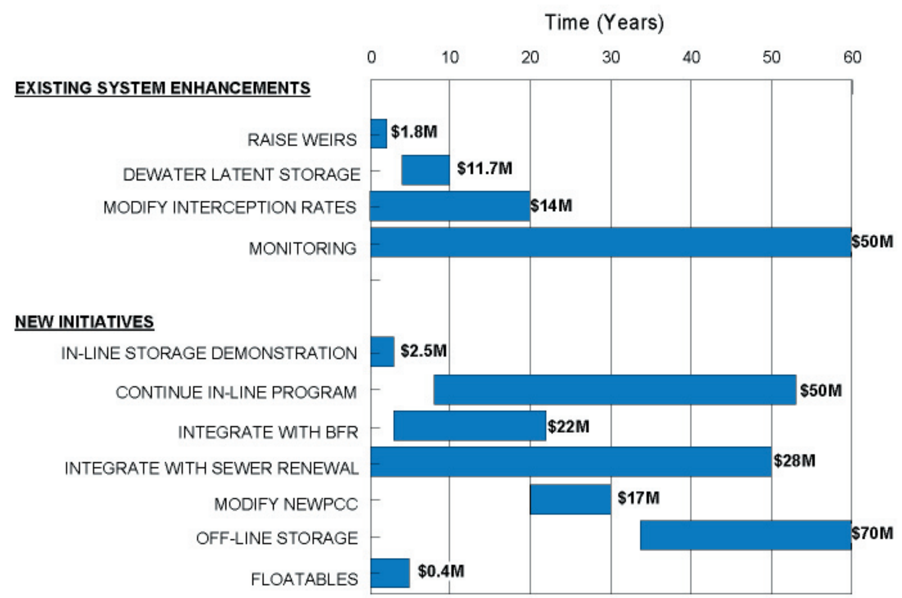


Figure 11: Illustrative Costs

Going Forward

The potential CSO Control Program will be reviewed by the City of Winnipeg and subsequently taken through the provincial regulatory process. The public will be provided opportunity to participate during this review process and also through Clean Environment Commission public hearings.