CSO Master Plan

Part 3A – CSO Master Plan Summary

Revision 03

August, 2019

City of Winnipeg

CSO Master Plan

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Jacobs Engineering Group Inc.

1301 Kenaston Blvd
Winnipeg, MB,
R3P 2P2
Canada

www.jacobs.com

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2	08/09/2019	Final Draft Submission	SG	MF	JB / DJT
3	08/16/2019	Final Submission For CSO Master Plan	MF	SG	JB / DJT

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Acronyms and Abbreviations

AACE	American Association of Cost Engineers
BFR	basement flooding relief
CEC	Clean Environment Commission
City	City of Winnipeg
CS	combined sewer
CSO	Combined Sewer Overflow
DEP	district engineering plan
DWF	dry weather flow
EA	Environment Act Licence
GFC	gravity flow control
GI	green infrastructure
LDS	land drainage sewer
MSD	Manitoba Sustainable Development
NEWPCC	North End Sewage Treatment Plant
No.	Number
NPV	Net Present Value
O&M	operations and maintenance
RTC	real time control
SEWPCC	South End Sewage Treatment Plant
SRS	storm relief sewer
STP	sewage treatment plant
WEWPCC	West End Sewage Treatment Plant
WSTP	Winnipeg Sewage Treatment Program
WWF	wet weather flow
WWS	wastewater sewer

1. Introduction

1.1 Background

Development of the Combined Sewer Overflow (CSO) Master Plan has been structured in a three-phased approach. Development of potential plans for each of the five alternative control limits, were included in the first phase and was followed by a detailed evaluation in the second phase. The findings from the first two phases were documented in the CSO Master Plan Preliminary Proposal and submitted to Manitoba Sustainable Development (MSD) by the submission deadline of December 31, 2015. MSD then approved the Preliminary Proposal recommendation and provided notification to proceed with the with the development of the CSO Master Plan on November 24, 2017.

1.2 Purpose

The purpose of this document is to provide a summary of the proposed CSO Master Plan and highlight the technical approach used in its development. This includes the identification of CSO control projects proposed for each sewer district, the budget estimate cost summary and program implementation schedule.

The CSO Master Plan was developed by evaluating a series of control option solutions for each district, followed by evaluation of implementation scenarios using the selected control options. Only the final selection of control options and implementation scenarios are included in Part 3A of this report.

Each section included in this Part 3A report is described as follows:

- **Regulatory Background:** Provides background on the CSO Master Plan performance target selection and identifies applicable regulatory requirements.
- **Project Development:** Identifies the projects selected as part of the CSO Master Plan and provides details on the approach to project selection.
- **Program Development:** Describes the CSO Master Plan implementation and provides details on the approach to the program selection.
- **CSO Master Plan Details:** Describes the projects, costs and performance of the CSO Master Plan.
- **CSO Master Plan Monitoring and Reporting:** Describes current and future monitoring and reporting requirements.
- **Master Plan Update:** Describes how updates may apply to the CSO Master Plan and details the requirements of the 2030 CSO Master Plan update.

1.3 Supplemental Documentation

This summary report is supported by both the Part 3B – District Engineering Plans (DEPs) and Part 3C – Standard Details that all form part of Phase 3 of the CSO Master Plan. Part 3B of the CSO Master Plan includes all 43 of the combined sewer DEPs, which provide background on the specific sewer district, the control options recommended in the district, and the performance costs of these recommended control options. Part 3C describes the control option technologies selected as representative for use in development of the CSO Master Plan.

All Part 3 documents are identified as “living documents”, allowing for new information and modifications to be made as new information is received or CSO Master Plan projects are completed. Additionally, the Part 2 – Technical Report is referenced throughout this report and should be reviewed when additional detail on the overall program or individual projects is needed.

1.3.1 Part 2 – Technical Report

The Part 2 – Technical Report provides the background for the development of the CSO Master Plan. It includes details on the licensing process, technical development of the control options and the basis for the program. The Part 2 report provides a technical overview of the entire program / project and should be reviewed if more detail on items discussed in this report is needed.

1.3.2 Part 3B – District Engineering Plans

The Province of Manitoba's *Environment Act Licence No. 3042* (EA No. 3042) (Manitoba Conservation and Water Stewardship, 2013) requires the development of detailed engineering plans as part of the CSO Master Plan submission. Clause 11 includes this requirement as follows:

> *The Licencee shall, on or before December 31, 2017, file a final Master Plan, including the detailed engineering plans, proposed monitoring plan, and implementation schedule for the approved design identified in the preliminary plan above. The Master Plan is to be filed for approval by the Director. The Licencee shall implement the plan by December 31, 2030, unless otherwise approved by the Director.*

Although identified as "detailed" plans, the proposed control option solutions within each sewer district engineering plan (DEP) have been developed to a conceptual level of detail. This is considered suitable for the level of study completed during a master planning project of this nature. This approach was confirmed with MSD at the June 15, 2018 Regulatory Working Committee meeting.

The DEPs identify and describe the proposed projects for each district that will achieve the 85 percent CSO capture in a representative year target, but do not identify their order of implementation. The sequence of project implementation may be reordered at any time to accommodate potential changes to the CSO Master Plan in future conditions.

All 43 combined sewer districts have a DEP and these are included as Appendix A of Part 3B. Each DEP is laid out in the same manner and contains similar information relevant to the specific sewer district.

General information including a description of the existing sewer systems and a summary of current planning and investment work can be found in each DEP. The remainder of the DEP contains the CSO Master Plan information with a summary of the proposed projects and a description on how they have been applied conceptually. The performance of these solutions, using the 2019 updated hydraulic model simulated under the 1992 representative year conditions is included for each district. The capital costs for the recommended solutions and how they may have changed in comparison to the capital cost projections in the Preliminary Proposal is also included. The impacts resulting from a potential migration from 85 percent capture to the future performance target is commented on in the DEPs. This includes prioritization of districts where there may be potential "sunken" costs on solutions to address the 85 percent capture target, only to not be required to meet the future performance target. Finally, the DEPs include potential risks and opportunities for the solutions recommended for the district present in the future.

1.3.3 Part 3C – Standard Details

Part 3C is a supporting document to both the Part 3A – Master Plan Summary report and Part 3B – District Engineering Plans that all form part of Phase 3 of the Master Plan.

It provides background information on the CSO technologies recommended through the CSO Master Plan, including detailed descriptions of conceptual solutions, design rationale and considerations, and other rationale for their selection (such as operations and maintenance [O&M] considerations). Where appropriate, industry products with a history of use in these types of applications for each CSO technology are highlighted to demonstrate what type of products may be selected for this work. It includes

further details for sewer separation, latent storage, in-line storage, screening, gravity flow control and off-line storage tank and off-line storage tunnel solutions.

2. Regulatory Requirements

The CSO Master Plan provides a roadmap for program implementation in conformance with the regulatory requirements. Therefore, it must adhere to a specific set of conditions as stipulated by EA No. 3042 and confirmed during the Preliminary Proposal development and review phase. EA No. 3042, with additional clarifications, is the basis for the CSO Master Plan. A summary of the relevant regulatory requirements is included here for reference. Further details and background on these regulatory requirements are described in detail in Section 2.2 and Section 2.7 of the Part 2 – Technical Report. Specific clarifications of the regulatory requirements were also developed by engaging with MSD. The results from these regulatory clarifications are included in Appendix B of the Part 2 - Technical Report.

The CSO Master Plan has been developed on a percent capture basis with a performance target of 85 percent capture. This is noted as Control Option No. 1 – 85 Percent Capture in a Representative Year as approved by MSD.

The control limit will be monitored on the basis of percent capture for the representative year. The representative year is 1992 based on a detailed review of the historical data. The 1992 rainfall trends are used to assess the performance of the system within the developed InfoWorks hydraulic model of the Winnipeg sewer system. The normal summer water level (NSWL) for the City of Winnipeg is used in this hydraulic model as a conservative alternative to the 1992 river levels. The output from this InfoWorks hydraulic model has then been assessed to calculate the percent capture of the overall system and determine the level of compliance. The 85 Percent Capture in a Representative Year control limit will be achieved upon completion of all the proposed projects based on this modeling work completed.

Table 2-1 lists the Preliminary Proposal (2013) and CSO Master Plan (2019) baseline and future performance for CSO volume, with the complete implementation program based on achieving 85 percent capture under the 1992 representative year.

Table 2-1. Percent Capture Calculation Summary

Condition	Total CSO Volume (m^3)	Total Dry Weather Flow Volume (m^3)	Total Wet Weather Flow Volume Captured (m^3)	Target Reduction in CSO Volume (m^3)	Percent Capture [a] (%)
PP Baseline (2013) CSO	5,260,000	7,749,000	7,317,000	-	74
CSO PP 85 Percent Capture in the 1992 Representative Year	2,980,000	7,749,000	9,593,000	2,300,000	85
MP Baseline (2019) CSO	5,170,000	7,749,000	6,660,000	-	74
CSO MP 85 Percent Capture in the 1992 Representative Year	2,900,000	7,749,000	8,8920,000	2,270,000	85

[a] Percent Capture = $\frac{(\text{Total Dry Weather Flow Volume} + \text{Total Wet Weather Flow Volume Captured})}{(\text{Total CSO Volume} + \text{Total Dry Weather Flow Volume} + \text{Total Wet Weather Flow Volume Captured})}$

Therefore, the total targeted CSO reduction for Control Option No. 1 is 2,270,000 m^3 and is used for performance tracking over the course of the program. Ultimately the CSO reduction target with the updated CSO Master Plan (2019) model is only a minor difference, as a result of model updates. Rounding the updated figure results in the same 2,300,000 m^3 reported during the Preliminary Proposal. This same 2,300,000 m^3 was therefore selected and referenced throughout this document as the target reduction in overflow volume to reach the 85 percent capture target in the latest hydraulic model.

Additional licence requirement dictated by MSD in EA No. 3042 include:

- no DWF overflows in the combined sewer system (Clause 7),
- no increase in CSOs as a result in-fill development (Clause 8),
- public notification of CSOs (Clause 10),
- incorporation of green infrastructure within the CSO Master Plan solutions where possible (Clause 11),
- reduction of floatable materials entering the river stream (Clause 12), and
- regulatory progress reporting (Clause 13).

The CSO Master Plan has been developed to incorporate each of these elements. Each requirement is discussed in detail in Section 2.2.6 of the Part 2 – Technical Report.

2.1 Migration to Future Control Targets

The Preliminary Proposal approval letter from MSD dated Nov 24, 2017, includes the condition that Control Option No. 1: 85 Percent Capture In A Representative Year be implemented in such a way that Control Option No. 2: No More Than Four Overflows In A Representative Year may eventually be phased in.

MSD and the City held multiple meetings during the development of the CSO Master Plan to discuss this migration requirement. An alternative approach has been presented to MSD, of migrating to Control Option No. 2 based on an equivalent percent volume capture target. This has been presented in order to main volume percent capture as the performance metric. This would avoid throw-away costs by allowing for contiguous projects and maintaining a percent volume capture evaluation framework.

MSD confirmed during the Regulatory Working Committee meeting of November 26, 2018 that the bacteriological water quality improvement identified for Control Option No. 2 is required to be met regardless of how the program is initiated, and ultimately any alternative approach would need to demonstrate equivalent or better bacteriological water quality improvement for approval. The agreed resolution was to work towards implementing Control Option No. 1 and at the same time further evaluate the water quality implications of maintaining a percent capture program. The results of the further evaluation will be part of the required 2030 Master Plan update submission.

3. Project Development

As described in Section 3.5 of Part 2 – Technical Report, the project selection completed for the Preliminary Proposal forms the basis for this phase of the evaluation. The control options were reevaluated through additional modelling refinements based on information gathered during the Phase 3 development.

Project development within each sewer district was carried out in two steps. Step One: Initial Control Option Selection was completed to identify committed projects, optimization of the use of existing infrastructure and addition of end-of-pipe screening at primary outfalls. Step Two: Control Option Refinements included a series of analyses to develop a system wide set of control options that could achieve the performance target. Refinements were made as part of Step Two where cost benefits were identified or where the conceptual practicality of the control option was not justifiable. A summary of the resulting projects selected as part of Step One and Step Two are detailed below. Specific details of the processes used part of Step One and Step Two can be found in Section 3.5 of the Part 2 – Technical Report.

3.1 Step One: Initial Control Option Selection

The first step of project development included the selection and evaluation of previously committed projects, followed by in-line and latent storage, off-line screening and gravity flow control (GFC) evaluations on a district-by-district basis. The applicability of a control option within a sewer district was evaluated based on a number of criteria including compatibility with existing sewer infrastructure, proximity to the primary CS outfall/interceptor sewers, and estimated hydraulic performance. The initial solution configurations were implemented within the InfoWorks model based on system hydraulics and then locations were verified with GIS in terms of constructability and feasibility.

These assessments led to the initial control option recommendations in each district listed in Table 3.1.

Table 3.1. Step One: Initial Control Option Selection Process – Recommended Projects

District	Complete Separation	Partial Separation	Latent Storage (River Control)	In-Line Storage Via Control Gate	Floatables Management Via Screens	Gravity Flow Control
Woodhaven				Yes	Yes	
Strathmillan				Yes	Yes	
Moorgate				Yes	Yes	
Douglas Park [a]	Yes					
Ferry Road [a]	Yes					
Tuxedo				Yes	Yes	
Doncaster				Yes	Yes	
Parkside [a]	Yes					
Riverbend [a]	Yes					
Tylehurst	Yes					
Clifton			Yes	Yes	Yes	
Ash		Yes	Yes	Yes	Yes	
Aubrey			Yes	Yes	Yes	
Cornish			Yes	Yes	Yes	
Colony			Yes	Yes	Yes	Yes
River					Yes	
Assiniboine			Yes		Yes	Yes
Cockburn [a]		Yes		Yes	Yes	
Baltimore			Yes	Yes	Yes	
Metcalfe				Yes	Yes	
Mager				Yes	Yes	
Jessie [a]		Yes		Yes		
Marion			Yes	Yes		
Despins				Yes		
Dumoulin				Yes	Yes	
La Verendrye				Yes	Yes	
Bannatyne			Yes		Yes	Yes
Alexander					Yes	Yes
Mission [a]	Yes					
Roland			Yes	Yes	Yes	
Syndicate				Yes	Yes	
Selkirk			Yes	Yes	Yes	Yes
Hart				Yes	Yes	
St John's				Yes	Yes	Yes
Polson				Yes		Yes
Munroe				Yes	Yes	Yes
Jefferson [a]		Yes		Yes	Yes	Yes
Linden				Yes	Yes	
Newton				Yes	Yes	Yes
Armstrong [a]	Yes					
Hawthorne				Yes	Yes	

[a] denotes a Committed Project to the CSO and BFR program

3.2 Step Two: Control Option Refinement Process

Refinements were completed for initial control option selection to respond to operational challenges and to achieve the 85 percent capture target. This included:

- a review and further evaluation of sewer districts with screening operational challenges,
- incorporation of additional complete or partial sewer separation where cost-effective,
- the addition of flap gate control and/or CS-SRS interconnection adjustments to accommodate additional latent storage,
- incorporation of additional off-line storage where required to provide volume capture remaining required to meet Control Option No. 1,
- These refinements resulted in the final control option selections for each district shown in Table 3.2. These control option selections form the projects recommended in this CSO Master Plan submission. Further details of each of these refinements included in Step Two of the project development process are defined in Section 3.5.4 of the Part 2 – Technical Report.

Table 3.2. Step Two: Control Option Refinements Process – Selected Projects

District	Complete Separation - District Specific Evaluation	Complete Separation – System-Wide Evaluation	Partial Separation	Latent Storage (River Control)	Latent Storage (Flap Gate Control Upgrades)	Latent Storage (Interconnection Upgrades)	In-Line Storage Via Control Gate	In-Line Storage Via Existing Weir	Floatables Management Via Screens	Alternative Floatables Management	Off-Line Storage Tanks	Off-line Tunnel Storage	Gravity Flow Control
Woodhaven [b]							Yes		Yes				
Strathmillan [b]							Yes		Yes				
Moorgate							Yes		Yes				
Douglas Park [a]	Yes												
Ferry Road [a]	Yes												
Tuxedo		Yes											
Doncaster		Yes											
Parkside [a]	Yes												
Riverbend [a]	Yes												
Tylehurst	Yes												
Clifton				Yes	Yes		Yes		Yes				
Ash			Yes	Yes	Yes		Yes		Yes				
Aubrey				Yes		Yes	Yes		Yes				
Cornish [b]				Yes			Yes		Yes				
Colony				Yes			Yes		Yes				Yes
River								Yes	Yes				
Assiniboine				Yes				Yes	Yes				Yes
Cockburn [a]			Yes				Yes		Yes				
Baltimore				Yes			Yes		Yes				
Metcalfe		Yes											
Mager							Yes		Yes				
Jessie			Yes					Yes		Yes			
Marion				Yes				Yes		Yes			
Despins		Yes											
Dumoulin							Yes		Yes				
La Verendrye		Yes										Yes	
Bannatyne				Yes				Yes	Yes				Yes
Alexander								Yes	Yes				Yes
Mission [a]	Yes												
Roland				Yes			Yes		Yes				
Syndicate							Yes		Yes				
Selkirk				Yes			Yes		Yes				Yes
Hart							Yes		Yes				
St John's				Yes			Yes		Yes				Yes
Polson								Yes		Yes			Yes
Munroe							Yes		Yes				Yes
Jefferson [a]			Yes				Yes		Yes				Yes
Linden		Yes											
Newton							Yes		Yes				Yes
Armstrong [a]	Yes												
Hawthorne							Yes		Yes				

[a] denotes a Committed Project to the CSO and BFR program

[b] In-Line Storage Control Gate recommended for this district primarily to provide hydraulic head for screen operation. This solution does not provide sufficient additional volume capture to be cost-effective based on performance alone. Should screens no longer be required for this district, In-Line Storage Control Gate recommendation should be reassessed.

3.3 Capital Cost Summary

A conceptual level Class 5 estimate was developed for the CSO Master Plan. A Class 5 estimate is defined by the *American Association of Cost Engineers International, (AACE) Cost Estimate Classification System - As Applied In Engineering, Procurement, and Construction for the Process Industries* (AACE, 1997) as having a project definition of zero to two percent to be used in a conceptual study with an expected range of accuracy from -50 percent to +100 percent .

The total capital cost to implement the CSO Master Plan including the 10 percent Green Infrastructure (GI) allowance is estimated as $1,150,400,000 in 2019 dollars. Applying the maximum +100 percent of the Class 5 estimating range, the total capital cost for budgeting purposes is estimated to be $2,300,800,000. The capital cost summary is shown in Table 3.3.

Table 3.3. CSO Master Plan Capital Cost Estimate (2019-dollars)

Item	2019 Capital Cost Estimate
Class 5 Estimated Capital Costs	$1,045,800,000
Green Infrastructure Allowance	$104,600,000
Subtotal – Capital Cost Estimate	**$1,150,400,000**
Class 5 Estimate Range of Accuracy: -50% to +100%	$575,200,000 to +$2,300,800,000
Total Capital Cost for Budgeting Purposes	**$2,300,800,000**

A capital cost for each of the proposed control options was developed and totaled to form a cost for the proposed work within each sewer district. The district capital costs were then totaled to calculate the total estimated capital costs of the CSO Master Plan. A 53 percent markup was then applied to these estimated construction costs to arrive at the Class 5 Estimated Capital Costs included in Table 3.3 above. A green infrastructure allowance of 10 percent of these costs was then added to result in the Subtotal – Capital Cost Estimates amount. Finally the maximum of the estimate accuracy range of +100 percent was applied to the capital cost sub-total to produce the capital cost total to be used by the City of Winnipeg for budgeting proposes.

This markup of 53 percent applied to the estimated construction costs included the following components:

- Engineering – 13 percent
- Project Design Contingencies – 30 percent
- Program Management – 2 percent
- Manitoba Retail Sales Tax – 8 percent (reduced to 7 percent in 2019, but not applied)

Exclusions specific to the capital cost values provided in Table 3.3 included the following:

- Finance and Administration – 3.25 percent
- Federal Goods and Services Tax (GST) –not included because of the municipal exemptions applicable to the work associated with the CSO Master Plan. Normally 5 percent for all private goods and services.
- Land Acquisition Costs (as applicable) – site specific based on the final locations selected for construction of the measures recommended in the CSO Master Plan and was therefore not included in the capital cost estimates.

Operations and maintenance (O&M) costs are identified separately from the capital costs and for the purposes of comparing solutions in the DEPs were considered over a 35 year lifecycle. Lifecycle costing allowed for comparative evaluations to be completed as control options in specific districts were refined. Additionally, this method aligns with the City's current business case evaluation process and will allow the long term O&M costs of the solutions recommended to be referenced for development of the future business cases for each project.

The CSO Master Plan estimates are focused on future budgeting, and do not report the following project costs which are attributable to the total cost of the program:

- Program Support Services:
  - Field services by internal resources, consulting services, and contracts for carrying out or supporting the engineering evaluations, pilot testing, and RTC works in support of program management have not been included in the capital costs for the CSO Master Plan.
  - These support services costs will be refined and better understood during the CSO Master Plan implementation phase.
- Combined Sewer Overflow and Basement Flooding Relief Program Committed Projects:
  - Projects as part of the CSO and BFR program which are underway at the time of writing were considered in the cost estimation. Anything completed prior to the completion of this report was not included in the estimate.
  - The value of these works either already constructed or currently underway as part of the CSO and BFR program is approximately $540,000,000.
- Sewage Treatment Plant Upgrades:
  - Combined sewage captured under the CSO program to achieve 85 percent capture (2 percent increased volume) will be routed to sewage treatment plants for wet weather flow (WWF) treatment.
  - WWF treatment upgrades are underway at the South End Sewage Treatment Plant (SEWPCC) and will be funded as part of the Winnipeg Sewage Treatment Program budget.
  - The future North End Sewage Treatment Plant (NEWPCC) project is to include an independent treatment facility for WWF, which will be used by the CSO program. The costs associated with these upgrades have been budgeted in the NEWPCC upgrade project estimates.
  - The capital and operating costs of all WWF treatment is included the STP upgrade budgets and has not been included in the CSO program capital cost estimates.

4. Program Development

Program development refers to the process of arranging the proposed projects as identified in Section 3 into a sequential plan that best meets the program criteria and constraints. Multiple program scenarios based on the anticipated level of funding from each level of government were evaluated in terms of overall program cost and timeline. Three funding scenarios were considered in the program development process. The assumptions used to develop the program and the comparative evaluation of the scenarios is described in Section 4 of the Part 2 – Technical Report. This section provides a summary of each of the three scenarios evaluated.

4.1 Funding Scenarios

Three funding scenarios were identified to align with the 2003 Clean Environment Commission (CEC) hearings recommendation for government cost sharing for upgrading the sewer collection and treatment systems. The program scenarios used in the program development are described as follows:

- **Scenario 1 – Shared Tri-Level Funding:** Tri-level funding agreement between the Government of Canada, Manitoba Government and the City of Winnipeg. The City has an expectation that the program will be equally funded through a cost-sharing arrangement with the provincial and federal governments, at one-third equal funding contributions from each level of government. This scenario places a cap of $30 million per year on funding from each of the three levels of government ($90 million per year maximum), with the program completion date being extended as necessary to complete the program.
- **Scenario 2 – Shared Bi-level Funding:** Bi-level funding agreement between the City of Winnipeg and either the Manitoba Government or the Government of Canada. As a compromise to three-way sharing, the second scenario assumes that one of two senior levels of government will not participate in the funding arrangement. This has the effect of maintaining the same $30 million per year level of funding per year from two of the three levels of government ($60 million per year maximum) and extending the program until its completion.
- **Scenario 3 –City-only Funding:** This scenario assumes the two senior levels of government will not participate in shared funding, with the program being fully funded by the City at a cap of $30 million per year. The schedule would be extended as necessary at the fixed rate of funding to complete the program.

4.2 Program Evaluation Summary

The three scenarios identified in Section 4.1 were compared to evaluate the overall timeline and total capital expenditure. A program work book was created for each funding scenario using the same implementation strategy with the only difference being the annual funding. A high level comparison of the funding scenarios expenditures and timeline is included in this section. More details on the evaluation of the scenarios are included in Section 4.4 of the Part 2 – Technical Report. The breakdown of the annual costs based on the project sequencing, resulting in the total expenditures and timeline shown below can be found in Appendix D and Appendix E of the Part 2 – Technical Report.

The implementation scenarios evaluated as part of the workbook include four main parts; the project details, O&M cost summary, capital cost summary, and a budget schedule. A comparison of the total capital expenditure and implementation timelines for each of the three scenarios is shown in Table 4-1.

Table 4-1. Program Scenario Implementation Comparison

Program Scenario	Description	Funding by	Annual Budget	Total Capital Expenditure	Timeline
Scenario 1	3 Levels of Funding 3 x $30 Million	Tri-level: Government of Canada, Manitoba Government and the City of Winnipeg	$90 Million	$3,667,000,000	27 years (2047)
Scenario 2	2 Levels of Funding 2 x $30 Million	Bi-Level: City of Winnipeg and either the Manitoba Government or the Government of Canada	$60 Million	$4,482,000,000	39 years (2059)
Scenario 3	City Only $30 Million	One Level: City of Winnipeg Only	$30 Million	$8,659,000,000	75 years (2095)

The results of the evaluations show that a shared, tri-level funding arrangement where all three levels of government contribute results in the shortest timeline and lowest capital expenditure. Under this scenario each level of government would contribute $30 Million per year for a total annual contribution of $90 Million per year. This is in line with the CEC recommendation for shared funding and has a completion date that is the closest to the 2045 date identified by MSD. Scenario 1 forms the basis of the recommended CSO Master Plan and is described in further detail in Section 5 of Part 3A.

5. CSO Master Plan Summary

The CSO Master Plan consists of a number of control option solutions that, when combined, will function to meet the Control Option No. 1: 85 Percent Capture In A Representative Year performance target. It predominately includes a combination of sewer separation, in-line storage, floatables management, latent storage, and gravity flow control throughout the CS districts to meet the target. This section summarizes the projects, performance and implementation schedule for the CSO Master Plan. It is intended to be a conceptual road map that will continue to evolve and be updated as the implementation of the program progresses.

5.1 Project Summary

The CSO Master Plan is developed from a detailed analysis of all CS districts to determine a suitable combination of proposed control option solutions that will meet the 85 percent capture in a representative year performance target. The details of the project selection are included in Section 3. The summary list of district-specific projects that are proposed as part of the CSO Master Plan is provided in Table 5-1. A more detailed breakdown of the components of the projects selected for each district can be found in Table 3.1 and Table 3.2.

Table 5-1. Control Option Selection for the CSO Master Plan

District	Latent Storage	In-line Storage	Screening	Gravity Flow Control	Off-line Storage	Complete District Sewer Separation	Partial District Sewer Separation
Woodhaven [a]		Yes	Yes				
Strathmillan [a]		Yes	Yes				
Moorgate		Yes	Yes				
Douglas Park						Yes	
Ferry Road						Yes	
Tuxedo						Yes	
Doncaster						Yes	
Parkside						Yes	
Riverbend						Yes	
Tylehurst						Yes	
Clifton	Yes	Yes	Yes				
Ash	Yes	Yes	Yes				Yes
Aubrey	Yes	Yes	Yes				
Cornish [a]	Yes	Yes	Yes				
Colony	Yes	Yes	Yes	Yes			
River			Yes				
Assiniboine	Yes		Yes	Yes			
Cockburn		Yes	Yes				Yes

Table 5-1. Control Option Selection for the CSO Master Plan

District	Latent Storage	In-line Storage	Screening	Gravity Flow Control	Off-line Storage	Complete District Sewer Separation	Partial District Sewer Separation
Baltimore	Yes	Yes	Yes				
Metcalfe						Yes	
Mager		Yes	Yes				
Jessie							Yes
Marion	Yes						
Despins						Yes	
Dumoulin		Yes	Yes				
La Verendrye					Yes	Yes	
Bannatyne			Yes	Yes			
Alexander			Yes	Yes			
Mission						Yes	
Roland	Yes	Yes	Yes				
Syndicate		Yes	Yes				
Selkirk	Yes	Yes	Yes	Yes			
Hart		Yes	Yes				
St John's	Yes	Yes	Yes	Yes			
Polson				Yes			
Munroe		Yes	Yes	Yes			
Jefferson E		Yes	Yes	Yes			Yes
Jefferson W							
Linden						Yes	
Newton		Yes	Yes	Yes			
Armstrong						Yes	
Hawthorne		Yes	Yes				

[a] In-Line Storage Control Gate recommended for this district primarily to provide hydraulic head for screen operation. This solution does not provide sufficient additional volume capture to be cost-effective based on performance alone. Should screens no longer be required for this district, In-Line Storage Control Gate recommendation should be reassessed.

Figure 5-1 provides an overview map of the location of the proposed control options in each district.

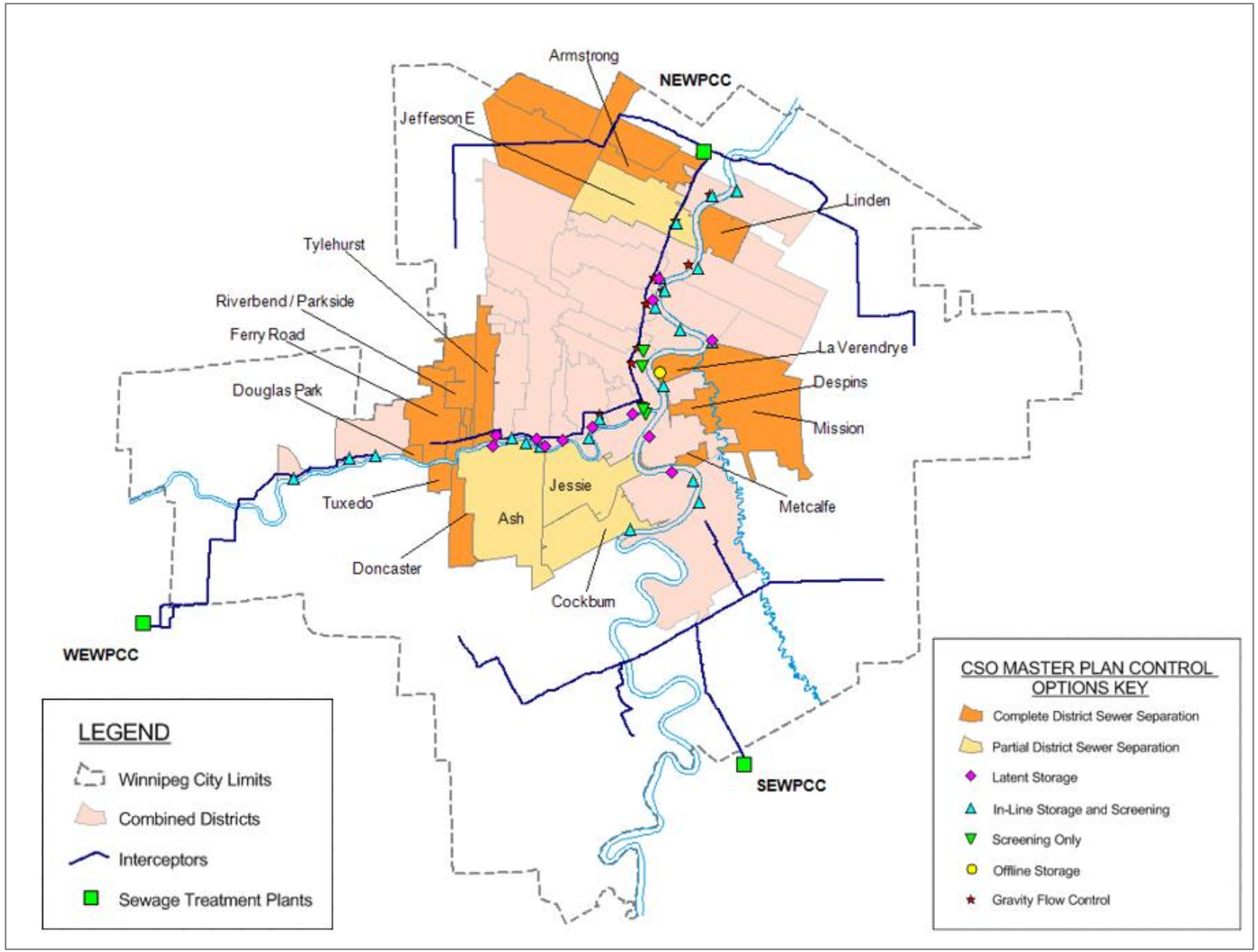

Figure 5-1. CSO Master Plan Project Overview Map

5.1.1 Project Costs

The costs were developed on a district basis and are summarized in terms of capital and O&M costs in Table 5-2.

Table 5-2. Sewer District Capital Cost Summary

District	Capital Cost (2019 Dollars)	2019 Total Operations and Maintenance Cost (Over 35-year period)	Total Lifecycle Cost
Woodhaven	$4,430,000	$2,070,000	$6,500,000
Strathmillan	$5,040,000	$2,050,000	$7,090,000
Moorgate	$5,540,000	$2,240,000	$7,780,000
Douglas Park	$0	$0	$0
Ferry Road	$142,300,000	$1,820,000	$144,120,000
Tuxedo	$9,670,000	$120,000	$9,790,000
Doncaster	$54,880,000	$700,000	$55,580,000
Parkside	$0	$0	$0
Riverbend	$84,250,000	$1,080,000	$85,330,000
Tylehurst	$95,340,000	$1,220,000	$96,560,000
Clifton	$11,320,000	$5,170,000	$16,490,000
Ash	$45,850,000	$5,650,000	$51,500,000
Aubrey	$12,620,000	$6,380,000	$19,000,000
Cornish	$7,930,000	$3,980,000	$11,910,000
Colony	$9,650,000	$4,940,000	$14,590,000
River	$3,250,000	$1,050,000	$4,300,000
Assiniboine	$7,470,000	$3,390,000	$10,860,000
Cockburn	$67,300,000	$2,570,000	$69,870,000
Baltimore	$7,360,000	$3,530,000	$10,890,000
Metcalfe	$19,170,000	$390,000	$19,560,000
Mager	$4,730,000	$1,670,000	$6,400,000
Jessie	$31,280,000	$1,420,000	$32,700,000
Marion	$5,390,000	$2,870,000	$8,260,000
Despins	$43,980,000	$560,000	$44,540,000
Dumoulin	$4,590,000	$2,040,000	$6,630,000
La Verendrye	$3,450,000	$260,000	$3,710,000
Bannatyne	$5,790,000	$2,000,000	$7,790,000
Alexander	$4,360,000	$1,530,000	$5,890,000
Mission	$143,350,000	$1,830,000	$145,180,000
Roland	$8,050,000	$3,620,000	$11,670,000

Table 5-2. Sewer District Capital Cost Summary

District	Capital Cost (2019 Dollars)	2019 Total Operations and Maintenance Cost (Over 35-year period)	Total Lifecycle Cost
Syndicate	$4,650,000	$2,240,000	$6,890,000
Selkirk	$9,460,000	$4,740,000	$14,200,000
Hart	$5,810,000	$2,380,000	$8,190,000
St John's	$11,310,000	$5,070,000	$16,380,000
Polson	$4,210,000	$1,760,000	$5,970,000
Munroe	$8,020,000	$3,260,000	$11,280,000
Munroe Annex	$15,000	$0	$0
Jefferson W	$0	$0	$0
Jefferson E	$168,090,000	$4,680,000	$172,770,000
Linden	$11,990,000	$150,000	$12,140,000
Newton	$6,240,000	$2,490,000	$8,730,000
Armstrong	$67,190,000	$1,340,000	$68,530,000
Hawthorne	$5,100,000	$2,220,000	$7,320,000
TOTAL	**$1,150,425,000**	**$96,480,000**	**$1,246,890,000**

The control option costs per district are identified in Figure 5-2. This provides perspective on the type of work and relative cost within each sewer district. Note that where *Additional* is noted in the figure, it corresponds with assorted pipe work relocation, such as removal and replacement of the existing off-take structure, construction of additional CS-SRS interconnections, or other miscellaneous construction work.

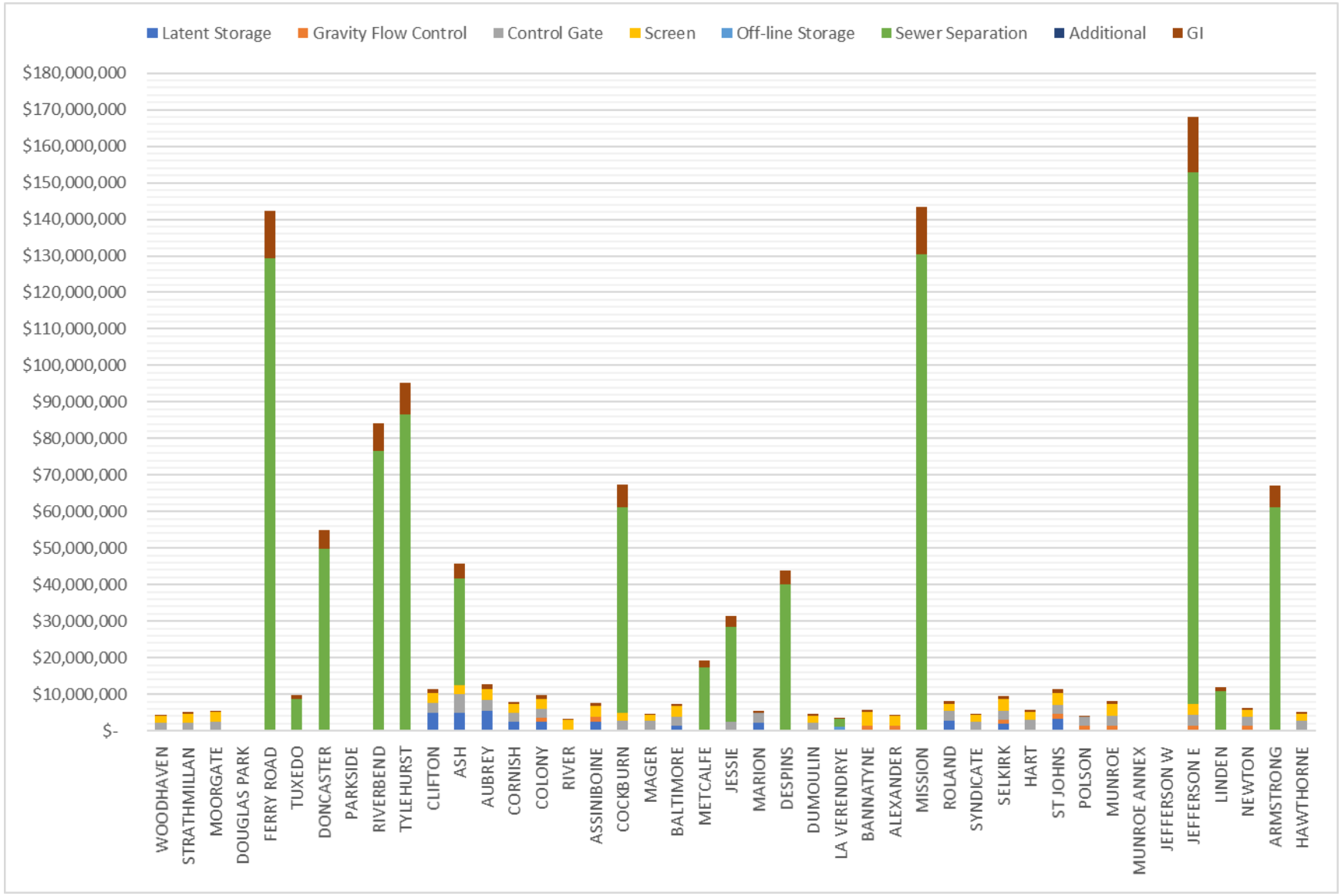

Figure 5-2. Sewer District Cost Summary

The costs associated with each type of control option are listed in Table 5-3. This illustrates the number of projects recommended related to each type of control option and the total cost impact of each control option technology. Sewer separation represents a significant portion of the planned work. Where *Additional* is noted in the table, it corresponds with assorted pipe work relocation, such as removal and replacement of the existing off-take structure, construction of additional CS-SRS interconnections, or other miscellaneous construction work.

Table 5-3. Control Option Cost Summary for the CSO Master Plan

Control Option	Master Plan 2019 Dollars	
	Number of Districts	Total Costs
Latent Storage	13	$29,300,000
Flap Gate Control	2	$4,800,000
Gravity Flow Control	10	$12,900,000
Control Gate	24	$64,200,000
Screen	25	$63,500,000
Off-line Storage Tank	0	N/A
Off-line Storage Tunnel	0	N/A
Sewer Separation	15	$869,900,000
Additional	3	$1,300,000
SUBTOTAL	**41**	**$1,045,800,000**
Green Infrastructure	41	$ 104,600,000
SUBTOTAL		**$1,150,400,000**

5.1.2 Performance

The purpose of the CSO Master Plan program is to capture 85 percent of the CSO that occur in the 1992 representative year. As described in Section 2 of Part 3A, this will be achieved when the reduction of the CSO volume reaches 2,300,000 m^3 as modelled against the 1992 representative year. The CSO volumes under the 1992 representative year conditions under each district are shown below in Table 5-4.

Each of the components in Table 5-4 are explained as follows:

- **2018 Baseline CSO Volume:** This represents the total overflow volume from each specific district, based on the updated 2018 hydraulic model utilized during the CSO Master Plan development.
- **Completed CSO Master Plan CSO Volume:** This represented the modelled overflow volume remaining in each specific district, after the control options recommended in each DEP have been implemented.
- **Reduction in CSO Volume:** This represents the reduction in CSO volume as a result of the control options recommended in each district, in comparison to 2018 Baseline CSO Volume.
- **Reduction In CSO Volume (%):** This shows the same CSO volume reduction as a result of the controls recommended in each district, as a percentage of the 2018 Baseline CSO Volume.

Table 5-4. Sewer District CSO Reduction

District	2018 Baseline CSO Volume (m^3)	Completed CSO Master Plan CSO Volume (m^3)	Reduction in CSO Volume (m^3)	Reduction in CSO Volume (%)
Woodhaven	12,120	11,900	220	0.0%
Strathmillan	39,684	18,936	20,748	0.8%
Moorgate	64,937	57,419	7,518	0.3%
Douglas Park	739	0	739	0.0%
Ferry Road	136,599	0	136,599	5.0%
Tuxedo	13,843	0	13,843	0.5%
Doncaster	30,644	0	30,644	1.1%
Parkside	2,979	0	2,979	0.1%
Riverbend	87,057	0	87,057	3.2%
Tylehurst	206,812	0	206,812	7.5%
Clifton	114,875	88,392	26,483	1.0%
Ash	341,484	258,264	83,220	3.0%
Aubrey	141,643	81,709	59,934	2.2%
Cornish [a]	64,659	63,724	935	0.0%
Colony	163,833	108,985	54,848	2.0%
River [a]	15,904	15,904	0	0.0%
Assiniboine	13,005	11,549	1,457	0.1%
Cockburn	188,459	6,183	182,276	6.6%
Baltimore	72,575	66,599	5,976	0.2%
Metcalfe	12,191	0	12,191	0.4%
Mager	21,912	1,056	20,856	0.8%
Jessie	187,594	164,392	23,202	0.8%
Marion	51,773	37,548	14,225	0.5%
Despins	43,955	0	43,955	1.6%
Dumoulin	49,524	42,539	6,985	0.3%
La Verendrye	13,191	0	13,191	0.5%
Bannatyne	148,170	115,571	32,598	1.2%
Alexander	26,851	26,142	708	0.0%
Mission	12,809	0	12,809	0.5%
Roland	299,396	181,108	118,287	4.3%
Syndicate	57,357	51,571	5,786	0.2%
Selkirk	172,507	150,161	22,346	0.8%
Hart	202,745	165,575	37,171	1.3%

Table 5-4. Sewer District CSO Reduction

District	2018 Baseline CSO Volume (m^3)	Completed CSO Master Plan CSO Volume (m^3)	Reduction in CSO Volume (m^3)	Reduction in CSO Volume (%)
St John's [a]	149,432	125,828	23,604	0.9%
Polson [a]	455,282	455,282	0	0.0%
Munroe	432,465	370,430	62,035	2.2%
Jefferson	287,466	47,252	240,215	8.7%
Linden	14,033	0	14,033	0.5%
Newton	8,614	2,994	5,620	0.2%
Armstrong	749,622	0	749,622	27.2%
Hawthorne	33,245	30,493	2,753	0.1%
TOTAL	**5,141,983** [b]	**2,757,506** [b]	**2,384,477** [b]	**100.0%**

[a] Influence from neighboring districts resulted in performance values in error for this district. Individual district model performance values utilized for evaluation purposes.

[b] Values provided are approximations using a combination of system-wide and individual district hydraulic model results. These values will differ from the results in Table 5-5.

The performance results from Table 5-4 have been developed using the sewer system hydraulic model results and indicates both complex district interactions and instabilities within some districts performance, as noted in the footnotes below. The City is committed to reducing the CSO volumes within the CS sewerage districts and will not allow negative impacts to be developed, where control option solutions transfer CSO volume to another district. Refer to the individual DEPs in Part 3B of the CSO Master Plan for further assessment of the control option proposals and commentary on model instability issues where they have been found to occur.

Overall the performance for CSO capture on a system wide basis can be summarized as illustrated in Table 5-5. Table 5-5 includes a comparison of the performance results to the performance modelled as part of the Preliminary Proposal development.

Each of the model conditions in Table 5-5 are explained as follows:

- **2013 PP Baseline:** This represents the model conditions for the 2013 Baseline hydraulic model used during the Preliminary Proposal, showing how the sewer system functions currently.
- **PP 85 Percent Capture in the 1992 Representative Year:** This represents the model conditions of the same 2013 Baseline model used during the Preliminary Proposal, showing the performance after each of the control options recommended in the Preliminary Proposal are implemented.
- **2018 MP Baseline:** This represents the model conditions for the updated 2018 Baseline hydraulic model used during the CSO Master Plan development, showing how the sewer system functions currently.
- **MP 85 Percent Capture in the 1992 Representative Year:** This represents the model conditions of the same 2018 Baseline model used during the CSO Master Plan, showing the performance after each of the control options recommended in the CSO Master Plan are implemented.

Table 5-5. System Wide CSO Reduction

Condition	Total CSO Volume (m^3)	Total Dry Weather Flow Volume (m^3)	Total Wet Weather Flow Volume Captured (m^3)	Target Reduction in CSO Volume (m^3)	Percent Capture [a] (%)
2013 PP Baseline	5,260,000	7,749,000	7,317,000	-	74%
PP 85 Percent Capture in the 1992 Representative Year	2,980,000	7,749,000	9,593,000	2,300,000	85%
2018 MP Baseline	5,170,000	7,749,000	6,660,000	-	74%
MP 85 Percent Capture in the 1992 Representative Year	2,900,000	7,749,000	8,920,000	2,270,000	85%

[a] Percent Capture = (DWF + Captured WWF) / (Overflow + DWF + Captured WWF)

5.2 Program Summary

The CSO Master Plan was developed into a program that fits into the selected funding Scenario 1. The estimated capital cost breakdown for the CSO Master Plan is illustrated in Figure 5-3. This is the base capital cost utilized for the program development. As described in Section 3.3, the upper limit of the estimated range, $2,300,800,000 has been used for the budget analysis and in developing the implementation schedule.

For the CSO Master Plan, it is assumed the program will be equally funded through a cost-sharing arrangement with the provincial and federal governments, at a one-third share each. This scenario places a limit of $30 million per year on funding from each of the three levels of government ($90 million per year total), with the program completion date being extended as necessary to complete the program.

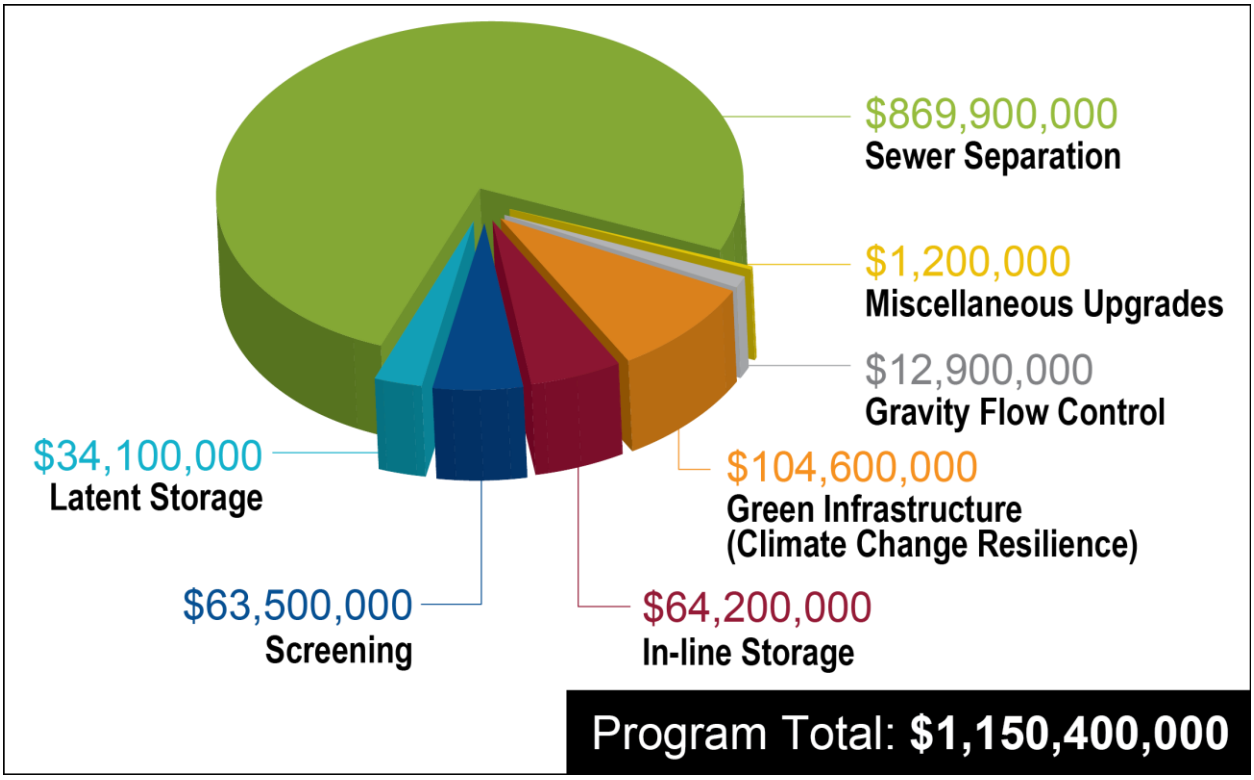

Figure 5-3: CSO Master Plan Capital Cost Summary (2019 Dollars)

The proposed projects are compiled based on the implementation strategy to form the project work schedule. Cost inflation and discounting is applied based on when a project begins. An overview of the CSO Master Plan implementation program showing when work is proposed for each CS district is shown in Figure 5-4.

District	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Alexander																													
Armstrong																													
Ash																													
Assiniboine																													
Aubrey																													
Bannatyne																													
Clifton																													
Colony																													
Cornish																													
Despins																													
Doncaster																													
Douglas Park																													
Dumoulin																													
Ferry Road																													
Hart																													
Hawthorne																													
Jefferson																													
Jessie																													
La Verendrye																													
Linden																													
Marion																													
Mission																													
Munroe																													
Newton																													
Parkside																													
Polson																													
River																													
Riverbend																													
Roland																													
Selkirk																													
St John's																													
Syndicate																													
Tuxedo																													
Tylehurst																													
Baltimore																													
Cockburn																													
Mager																													
Metcalfe																													
Moorgate																													
Strathmillan																													
Woodhaven																													
Number of Districts CSO Mitigation Work Underway	2	2	2	2	4	4	5	4	5	6	4	4	3	2	2	2	3	3	5	5	5	4	4	8	13	13	13	12	5
		Work Recommended As Part of CSO Master Plan Anticipated To Be Underway In This District												Work Complete As Part of CSO Master Plan Anticipated to be Completed In This District															

Figure 5-4. CSO Master Plan Sewer District Based Implementation Schedule

The rate of reduction in CSOs is directly impacted to the implementation period for the CSO Master Plan and the reductions can be shown as the projects are completed. Timing of the cumulative reduction in the annual CSO volume, based on the project sequencing and CSO program under Scenario 1 is shown in Figure 5-5. This shows that the 85 percent capture target would be met in the year 2047.

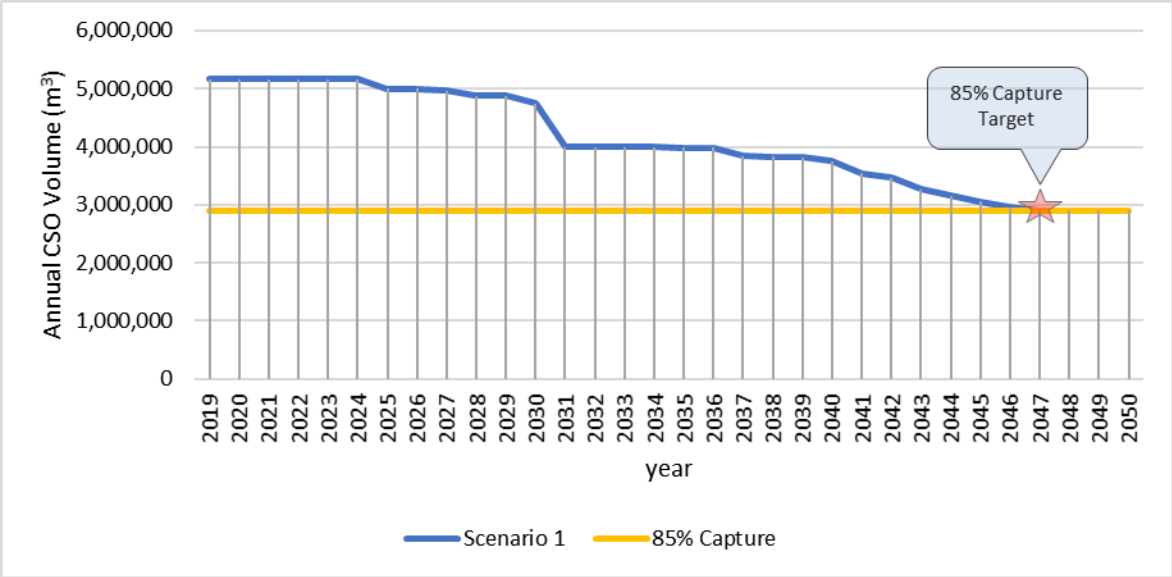

Figure 5-5. CSO Master Plan Predicted Annual CSO Volume Reductions

5.2.1 Capital Budgets

The CSO Master Plan program is based on equally shared costs by the three levels of government for a total of $90 million per year in 2019 dollars. This means that the annual budget of $90 million per year is expected to rise in line with inflation, and the associated funding provided by the three levels of government to rise with inflation as well. The programming goal was to develop relatively uniform annual budgets in 2019-dollars after accounting for the initial funding gap for the startup period.

The annual budgets based on the CSO Master Plan recommended project sequencing, in 2019 dollar terms are shown in Figure 5-6.

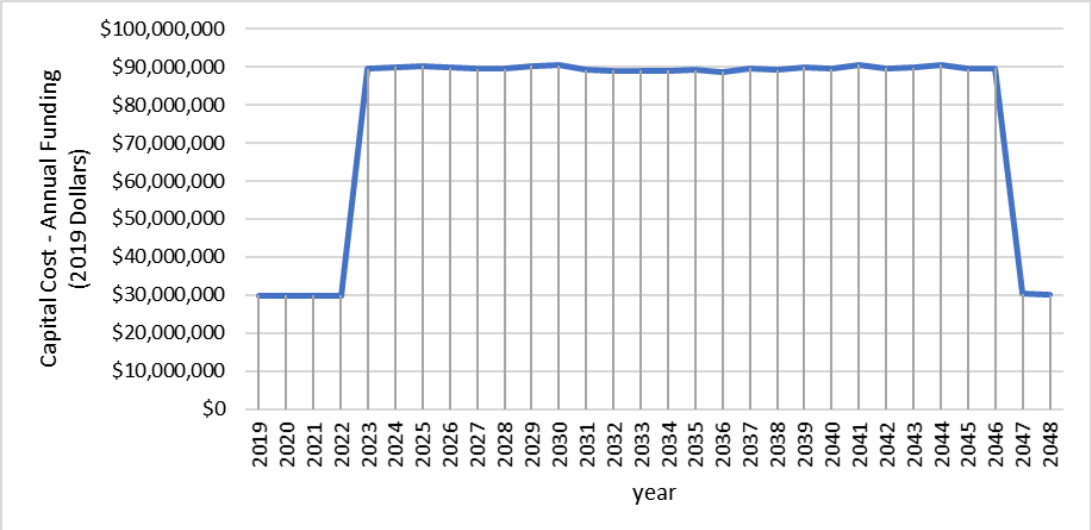

Figure 5-6. CSO Master Plan Annual Capital Budget (2019-dollars)

Figure 5-6 shows that the shared annual budget varies slightly from year to year which is a result of discrete project costs that cannot readily be smoothed out to accommodate uniform budgeting. The overall budget however is approximately $90 million per year in 2019 dollar terms. The accumulated implementation costs do not exceed the accumulated budget.

The shared annual capital budget values inflated at 3 percent per year are shown in Figure 5-7 for comparison. The inflated values show the increase to the annual budget over the implementation time period. The shared annual capital budget in the second last year of the Master Plan implementation period under Scenario 1 is approximately $199 million dollars.

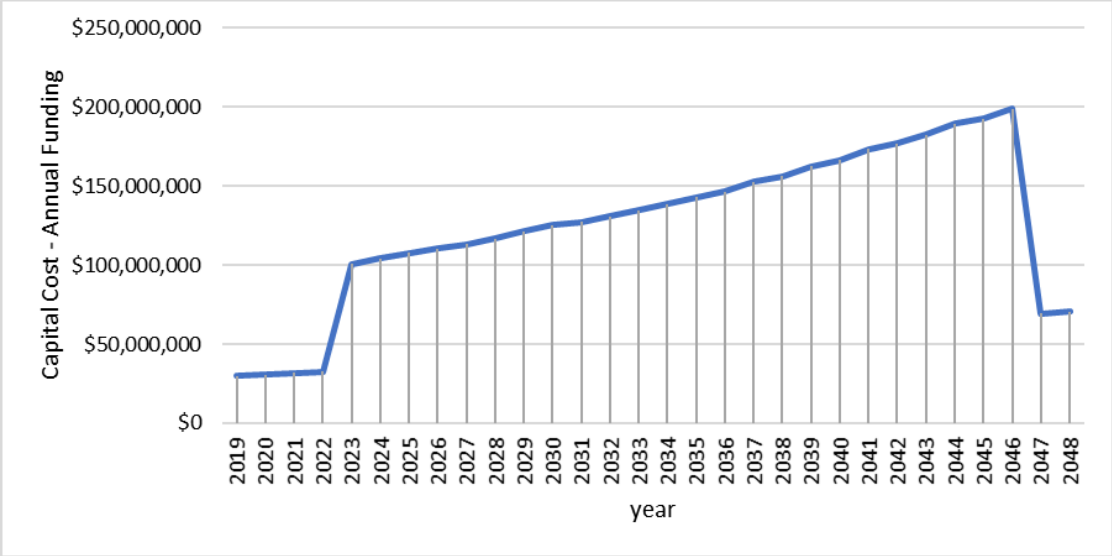

Figure 5-7. CSO Master Plan Capital Budget Inflated at 3 Percent Annually

The CSO Master Plan shared annual budget in 2019-dollar values is next plotted on a cumulative basis as shown in Figure 5-8. The projects are sequenced by year in the budget schedule, per the project sequence determined during the program development, and they show the budget value for the year of construction. Based on an escalation of 3 percent per year, the total for the future budget amounts would be $3,667,000,000 in 2047 dollars.

- The NPV of this cumulative total budgeted amount for the CSO Master Plan is $1,534,000,000 based on a 6 percent discount rate.

Expenditures that are scheduled later in the program or use longer implementation periods would reduce the NPV. shows that the implementation of the CSO Master Plan can be completed within 25 years with a starting year 1 annual budget of approximately $91 million.

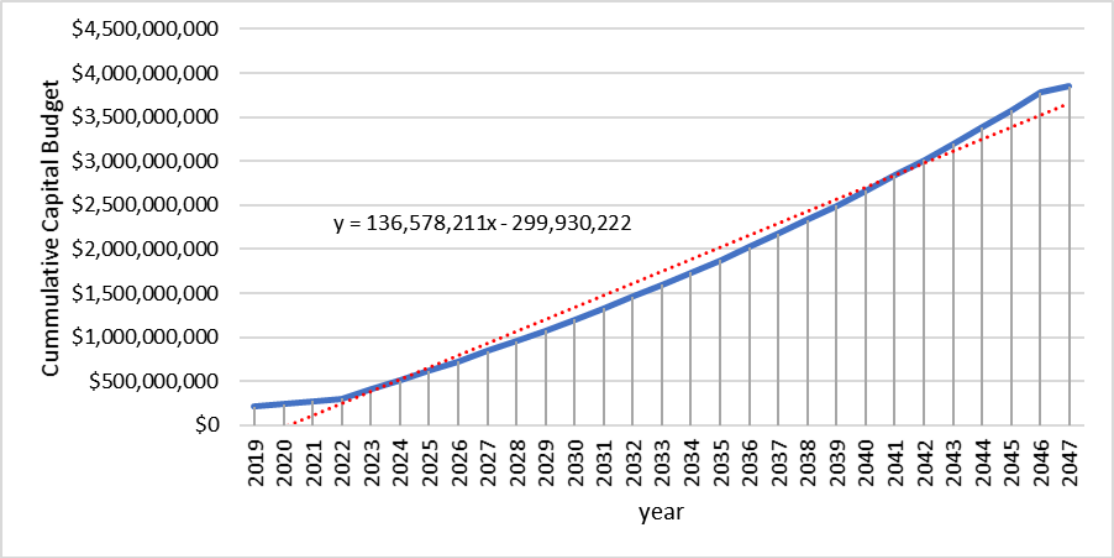

Figure 5-8. CSO Master Plan Cumulative Capital Budget with 3 Percent Inflation

The annual costs under the assumption of three-way capital cost sharing between the three levels of government will be within the $30,000,000 affordability limit identified by the City of Winnipeg. This affordability limit, and in turn cost sharing amounts with the three levels of government is assumed to increase due to inflation as part of these capital budget estimates with a year 25 inflated annual budget of approximately $199 million. There is a significant risk that this type of increase in the annual budget may not be sustainable.

5.2.2 Operations and Maintenance Budget

The additional operations and maintenance (O&M) budgeted costs associated with the projects recommended in the CSO Master Plan are considered separate from the capital cost budget. There is no target O&M budget value comparable to the capital budget, as operation and maintenance costs are a function of the control technologies selected and the timing of their implementation. The annual additional O&M budget variations in 2019 dollar terms, based on the project sequencing for Scenario 1, are shown in Figure 5-9. Upon completion of the program, the annual O&M costs in 2019 dollars terms will result in $4,490,000 additional annual O&M costs by the year 2048 in which all projects are complete.

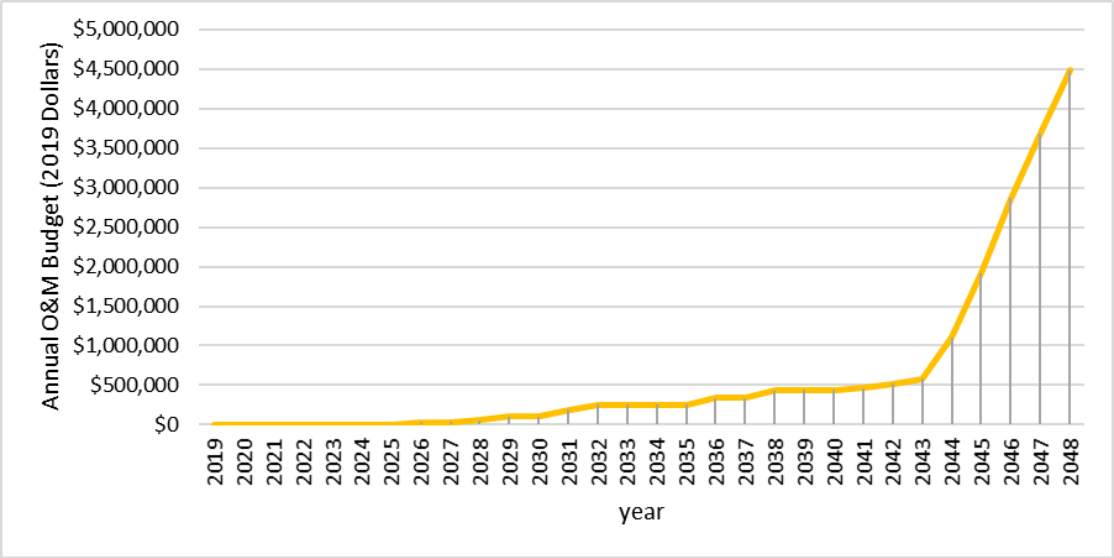

Figure 5-9. CSO Master Plan Additional Annual O&M Budget (2019-dollars)

The CSO Master Plan cumulative O&M costs under Scenario 1 are shown in Figure 5-10. Projects with higher O&M requirements have been scheduled to take place later in the program which is reflected in the figure. The steep rise in the operating budget results from the cumulative effect of having to operate and maintain the several new infrastructure components recommended in the CSO Master Plan.

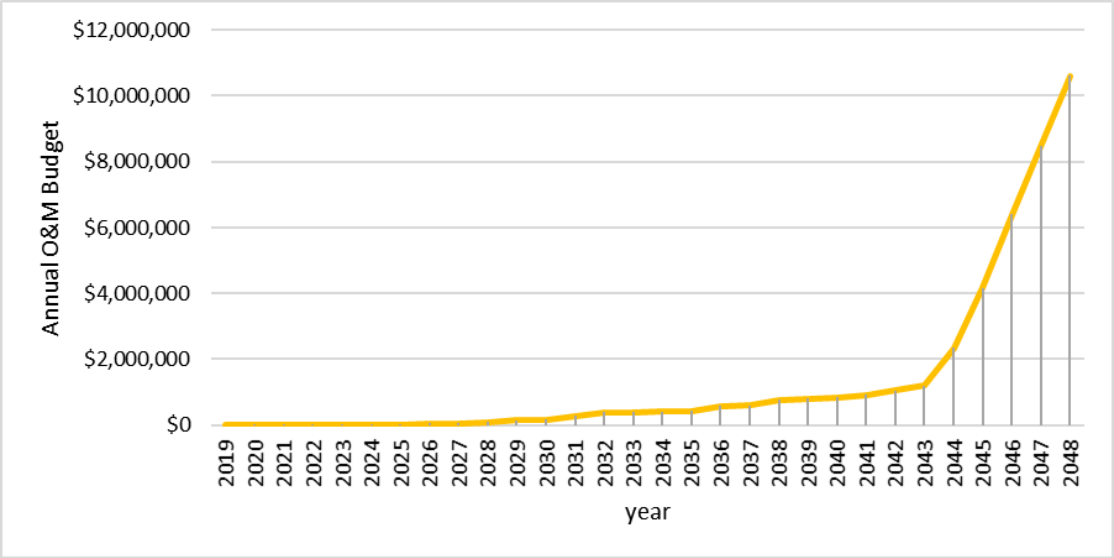

Figure 5-10. CSO Master Plan Additional O&M Budget Inflated at 3 Percent Annually

The estimated O&M costs shown in Figure 5-10 have been inflated to the year of expenditure at 3 percent annual inflation, the same as shown for the capital budgets. The inflated additional annual cost of O&M as a result of the works recommended in the CSO Master Plan, at the end of the implementation period in 2047, is estimated to be approximately $10,580,000 per year in 2048 dollars.

5.3 Monitoring and Reporting

Progress reporting for implementation of Control Option No. 1 - 85 Percent Capture in a Representative Year will be based on project completion performance modelled over time in comparison to that projected in the CSO Master Plan. Annual reporting will update on construction progress and the work plan for the subsequent year. Annual progress reporting is a requirement of EA No. 3042 Clause 13 and is stated as follows:

> *"The Licencee shall, upon approval of the Master Plan submitted pursuant to Clause 11 of this Licence, implement the plan such that progress towards meeting the required level of treatment is demonstrated annually by submission of an annual report, due March 31 of each year for the preceding calendar year. Annual submissions shall include the progress made on the plan pursuant to Clause 11 including monitoring results and the work plan for the subsequent calendar year."*

The reporting approach is dictated by selection of the percent capture performance metric. Each project of the CSO Master Plan will contribute to the percent capture improvements, and progress can only be tracked by the progress on their implementation.

The use of percent capture with the 1992 representative year means that compliance must be measured in terms of performance of the projects recommended in the hydraulic model of the sewer system, with the 1992 representative year conditions applied. The representative year will act as a benchmark where all current and future benefits will be measured against, and will not be reproducible in the natural environment. Although the representative year cannot be applied in the field; post construction monitoring will be used to verify the performance of the control options. This will include continued CSO monitoring and flow monitoring within each district where solutions have been implemented.

Real events can be measured and related to the representative year but must be used with caution because of the natural variation with these types of events. Any result or series of results that appears to over or under-perform relative to the representative year results is no guarantee that a trend is occurring and could easily change under future conditions.

Other performance metrics (including the actual volume of CSO, number of overflows, and water quality measurements) may be of interest during the reporting process but are not to be used for compliance tracking.

5.3.1 Current CSO Reporting

The City currently completes a quarterly and annual CSO reporting program to track variations and trends in system performance in terms of number and volume of CSO events throughout the year.

This reporting is based on actual rainfall and sewer system level field measurements via permanent instrumentation. Outfall monitoring instrumentation in combination with the city-wide sewer hydraulic model results are validated against each other to determine the volume and frequency of CSOs. These reports are submitted to MSD to comply with the EA No. 3042. The City also maintains reporting to MSD upon the occurrence of unique or significant events to comply with the EA Licence No. 3042. A unique or significant event is defined by the occurrence of a 10-year rainfall event within the limits of the City of Winnipeg.

5.3.2 CSO Master Plan Implementation Reporting

The City will continue with the current annual reporting process and will initiate the implementation progress reporting upon CSO Master Plan approval. The implementation reporting will include progress made on the plan, which will include the results of the updated hydraulic model to evaluate percent capture performance in comparison to the 1992 representative year. A summary of planned and completed projects and updates to a benefits register will also be included with these annual updates.

5.4 Dewatering and Treatment

The future CSO storage control solutions, lift stations, interceptor system, and STPs must function as an integrated system. Discharges from CSO storage facilities and lift stations must not overload the interceptors, and the interceptors must not overload the STPs; otherwise, CSOs will simply be relocated. The planning and management of these components is carried out through the dewatering strategy.

The approach requires that dewatering rates be developed for each combined sewer district, and that they operate within the interceptor and STP constraints. The strategy must also accommodate future growth for the separated sewer districts within the STP service area.

The CSO program will change the method and means of flow collection, and in turn overall volume of combined sewage captured in the CS system. An additional 2,300,000 m^3 of CSO will be diverted from the river to achieve 85 percent capture in the representative year. This includes 30,000 m^3, 230,000 m^3, and 2,010,000 m^3 additional volume capture for WEWPCC, SEWPCC and NEWPCC Service Areas respectively. This will encompass both an increase in captured combined sewage that is conveyed to treatment and the elimination of flow entirely entering the system because of selected district sewer separation. The reduction of flow from sewer separation benefits the whole system by increasing available capacity. The additional captured combined sewage will be gradually released to the interceptors and treatment systems to ensure these critical sewer system components are not overwhelmed. This additional level of control will require upgrading the existing system to optimize the flows, which ultimately forms the dewatering strategy.

The dewatering strategy was established for the NEWPCC as part of the Preliminary Proposal, as the NEWPCC services the majority of the combined sewage from the City. This approach has been applied to the smaller SEWPCC and West End Sewage Treatment Plant (WEWPCC) systems as well during the CSO Master Plan, to develop the dewatering strategy for the entire combined sewage sewer system. Further details on the Dewatering Strategy Approach can be found in Section 3.2 of the Part 2 – Technical Report.

5.4.1 Dewatering Upgrades

Dewatering rates were initially determined for each district based on the control options selected for the district and the requirement for a maximum dewatering time of 24 hours following the end of an overflow event. The analysis found that the capacity of all existing pumping stations will be sufficient to meet this 24 hour dewatering requirement. Even though there will be a larger volume pumped for each event, the maximum rate of pumping will be the same as currently exists, with the pumps being required to run for longer durations at the existing constant rate.

Several sewer districts do not have pumping stations and instead drain by gravity to the interceptor system. For these situations, gravity flow controllers are proposed to monitor and control the gravity discharge rate to the interceptor system. The analysis also indicated that these gravity discharge districts meet the dewatering capacity requirements. The existing offtake pipes within these gravity discharge districts are sufficiently sized currently to accommodate the 24 hour dewatering requirement.

The dewatering strategy implemented in the future assumes that a control system will be used to adjust pumping rates for each district to optimize the available conveyance and treatment capacity. This will require that monitoring and pumping rate controls be installed for each location. Pumping rates will range from diurnal dry weather low flows to the peak dewatering rates.

The dewatering strategy provides the opportunity to implement the RTC program opportunity in the future. This would be particularly effective for dealing with spatially distributed rainfalls, where districts receiving higher rainfall could dewater faster than those with low or no rainfall.

5.4.2 Wet Weather Flow Treatment Upgrades

The CSO program will have an impact on the three STPs through potential WWF increases that result from a change in the percent capture and dewatering strategy. The total WWF capture increase required to meeting the Control Option No. 1 target is equivalent to an increase of 33.9 percent in WWF collection. A 15.7 percent increase in total flow collection from the system is noted, considering DWF in the collection system.

For the NEWPCC, which has the largest potential for an increase in flows due to its large collection area, only a 2 percent increase in total flows is noted for the full representative year period. This equates to a 41.9 percent increase in wet weather collection and a 32.6 percent increase in total flow collection assessed during WWF events.

The CSO Master Plan maintains the assumption that the NEWPCC will be upgraded in the future to handle a 705 ML/d WWF treatment rate, and upgrading will be implemented and funded through the concurrent Winnipeg Sewage Treatment Program (WSTP).

The SEWPCC and WEWPCC serve relatively smaller CS areas than the NEWPCC, and there is no additional WWF treatment capacity required to meet the CSO Master Plan Dewatering Strategy.

5.5 City Investments Towards CSO Mitigation To Date

The CSO Master Plan project was initiated in 2013 and since that time the City has invested over $90 million in infrastructure and system upgrades with another $140 million committed for investment. The following list includes the type and value of investment implemented since the EA No. 3042 was issued in 2013.

- CSO Master Plan study and development - $5.4 million
- Interceptor Monitoring - $1.0 million
- District Flow Monitoring - $2.5 million
- Sewer Instrumentation - $0.5 million
- InfoWorks ICMLive - $0.4 million
- Sewer Relief Work - $74.0 million
    - Cockburn / Calrossie / Jessie - $53.0 million LDS separation
    - Ferry Road / Riverbend / Parkside / Douglas Park - $13.0 million LDS separation including the elimination of one CSO outfall in Douglas Park
    - Jefferson - $8.0 million LDS separation
- Latent Storage Dewatering Stations - $5.0 million
    - Bannatyne – McDermot SRS - $2.5 million
    - River – Fort Rouge SRS - $2.5 million
- Sewer Cleaning (outside of annual program)
    - Mission - $0.9 million
- Green Infrastructure
    - Bannatyne – North East Exchange Sustainable Drainage System - $0.5 million

Additional work has been completed outside of the CS area that also benefits the long term goals of the CSO Master Plan. This work has included:

- Upgrading the Northeast Interceptor river crossing to include a redundant crossing
- Installation of a relief sewer in the separate sewer districts surrounding the Transcona neighborhood

- Elimination of 20 cross connections between the WWS and LDS systems

5.6 Opportunities

A number of opportunities to improve the percent capture during the program were identified during the development of the CSO Master Plan. The main areas where additional gains in CSO reduction could be made are discussed in this section. Further background on each of these program opportunities can be found in the Part 2 – Technical Report.

5.6.1 Floatables Management

The CSO Master Plan includes end of pipe screening to the primary CS outfall in each combined sewer district, where it was determined to be hydraulically feasible and where complete sewer separation of the district was not recommended. In each applicable case, the primary outfall has an off-line screen installed that would capture floatables from the first flush of an overflow.

An alternative floatable management approach, focused on creating a floatables source control program and using public education to reduce floatables initially entering the sewer system has been developed by the City. This alternative approach may provide an opportunity to replace the need for end of pipe screens. The City will complete pilot studies of this alternative approach specifically in those districts where the installation of screens was determined to not be hydraulically feasible, with the goal to demonstrate and evaluate the potential of this alternative approach to replace the requirement for screening. The alternative approach to floatable management is described in more detail in Section 5.2.3 of the Part 2 - Technical Report.

5.6.2 Green Infrastructure and Climate Change Resiliency

EA No. 3042 includes a requirement to use green technology in the design and operation of all new and upgraded infrastructure. Similarly, the United States Environmental Protection Agency (US EPA) also recognizes the connection between Green Infrastructure (GI) and climate change with a publication *Green Infrastructure and Climate Change Collaborating to Improve Community Resiliency* (US EPA, 2016). This document provides a summary of a number of case studies held across the US to discuss climate change and GI.

GI technology applied as part of the CSO Master Plan has the potential to offset the impacts of climate change and reduce requirements for grey infrastructure. GI will also help in achieving the City's objectives for flood management and basement flooding. GI acts as additional storage volume for rain events and prevents runoff from entering the collection system and contributing to CSOs. This additional storage reduces the volume transferred to the STPs; reducing the sewage conveyance and treatment capacity impacts.

For the CSO Master Plan, GI has been included as a necessary component of all proposed projects. The scope of application for the various types of GI however will need be confirmed in the early stages of implementation. This will be completed through additional investigations that will determine the suitability of GI in Winnipeg, pilot green technologies, and monitor performance. The CSO Master Plan capital cost estimates have included a 10 percent allowance to allocate towards GI pilot testing, and future implementation work. Further detail on GI is included in Section 5.2.1 of the Part 2 - Technical Report.

5.6.3 Real Time Control

RTC is not required under EA No. 3042 but is recognized by the City as an opportunity to improve the operation of the system and further reduce CSO volumes. Due to Winnipeg's flat topography and large-diameter pipe network, the case for implementing an RTC program opportunity is strong. The CS area in the City represents approximately 32 percent of the sewer network. Rainfall events are not uniform across the entire area, which creates the opportunity to actively manage CS flow to temporarily delay flow to the interceptors. This would allow the interceptor to accommodate the additional flows from areas experiencing the rainfall event. RTC is generally based upon instruments placed throughout the sewer

network and computer models to predict flow based on real time rainfall data and treatment flows at the STPs. An automated logic based component is then provided, where actuators open and close various valves and gates throughout the CS network based on levels and instrument readings in other areas. This allows the system to automatically restrict or accommodate flow from specific combined sewer districts based on the spatial variation of the rainfall event.

The CSO Master Plan includes recommendations for gravity flow controller installation for combined sewer districts with gravity flow to the interceptor, and installation of flow monitors and pumping controls on all lift stations. These measures specifically accommodate future RTC measures.

The primary program opportunity provided by RTC is from expanding to a global system so that the City of Winnipeg can respond to spatially distributed rainfalls and, potentially, to rainfall prediction. RTC is described in more detail in Section 5.2.2 of the Part 2 - Technical Report.

6. CSO Master Plan Implementation

The CSO Master Plan will be continually updated as the program is underway. This includes the requirement for a formal update to the plan in 2030. This Part 3 component of the overall CSO Master Plan is a living document and will be updated for each change in strategy and completed project. Each component of Part 3, including the individual DEPs, will be updated on a regular basis. This section describes the limitations, initial implementation steps and major changes that are planned or have occurred.

6.1 Design Limitations of Proposed Projects

The CSO Master Plan and the DEPs have been developed to a conceptual level of detail. The individual project selections and designs are based on the hydraulic model evaluations and high level assessments of constructability. It is expected that the proposed projects identified will change and adapt as further information is collected during the program implementation and individual project design studies. This process is illustrated in Figure 6-1.

Figure 6-1: Key Design Stages in Life of a CSO Project

The City plans to complete a number of additional evaluations based on the details presented in the DEPs to form the basis of further design and construction within each of the sewer districts. Each of the proposed projects will undergo a preliminary and detailed design stage to confirm their constructability. A potential approach to the design process would be for a collection of neighboring sewer districts to be further refined as a package during the preliminary design phase. Additional detail would be collected and evaluated to fully understand the existing sewer system and confirm selection of the optimal CSO control technology. This would be followed by detailed design where the parameters of the control technology would be finalized for construction.

Once constructed, each control option will be monitored to determine the level of performance achieved. This information will be input into the hydraulic model and applied as part of future design. System monitoring and operation and maintenance will continue for the life of the infrastructure.

6.2 Primary Implementation Tasks

There will be several responsibilities and areas of support required to implement the recommendations included in this CSO Master Plan. A list of the program management responsibilities is provided to support these future activities, with many of these tasks being dependent on future decisions as follows:

- **Administration:** The CSO program will require a high level of administration for budgeting, accounting, and reporting of routine activities.
- **Engineering Investigations:** The CSO Master Plan assumes that review, and acceptance of technologies will be completed within the implementation phase prior to some projects commencing. This includes review of control gates, flap gate control, screens and a floatables management approach, RTCs, and GI. Each of these will be evaluated within the program and may lead to pilot testing or demonstration projects.
- **Land Use Planning:** A continual process will be required to identify and account for changes to service areas, technologies, standards, and expectations, and to prepare for project implementation. Land acquisition and preliminary studies may need to take place several years before actual construction can begin.

- **Coordination:** The CSO program will impact and be impacted by other programs and services. By integration of the CSO and BFR program, the parameters for project prioritization and selection are affected. Additionally, large scale developments can impact option selection and implementation scheduling. Coordination must occur with the STPs and their upgrades . Construction projects, such as sewer construction work required as part of sewer separation, must routinely be coordinated with street works and traffic movement.
- **Project Delivery:** Alternative methods of project delivery need to be considered, as well as how studies are carried out and by whom. Conceptual designs and preliminary engineering are usually required before detailed design and tendering can commence.
- **Risk Management:** As with any large program, there are multiple risks and opportunities to be considered and dealt with. These will require management of risk responses and contingency budgets.
- **Regulatory Liaison:** The City has responsibility for reporting and responding to the Province on all matters related to the EA No. 3042. One of the major tasks will be to comply with the request for a CSO Licence update for migration to Control Option No. 2 by April 30, 2030.
- **Public Communication:** The projects associated with the CSO Master Plan recommendations will have a public engagement program focused on providing information and education as the works occur. It will be important to provide public notifications for construction works affecting the public.
- **Master Plan Maintenance:** The Master Plan is intended to be a living document. The information will be updated as the projects are completed and as new developments or redevelopments within the districts occur. Reprioritization of the projects may result from updates involving factors beyond the collections or treatment system. This is further detailed in Section 6.3 below.
- **Master Plan Update:** A formal update of the CSO Master Plan is required under EA No. 3042 by April 30, 2030. See Section 6.4 for further details of this update process.

A number of additional tasks and studies will be required prior to and during the CSO Master Plan implementation. These tasks are summarized as follows:

- **Real Time Control**: Collection system operation can be improved with the addition of RTC to the system. An evaluation of the best approach to RTC and how to integrate with the CSO Master Plan will be required.
- **Green Infrastructure**: The City intends to catalogue its existing GI asset inventory and evaluate the suitability of the types of GI for use in this climate.
- **Asset Surveys:** The City will continue to review and update the existing asset database. This includes weir heights, pipe connections, and pump arrangements.
- **Sewer Hydraulic Model Maintenance:** The InfoWorks hydraulic model of the entire City of Winnipeg sewer system will continue to be updated based on new asset information and implemented projects. Focused updates will occur to the districts anticipated to have the CSO Master Plan recommended solutions implemented in the immediate future.
- **Flow Monitoring:** The City will continue with its existing flow monitoring program. Data will be used to update the hydraulic model and to improve the understanding of the system. Flow monitoring will also be completed in districts in which the control options recommended have been implemented, to verify performance.
- **Asset Rehabilitation and Renewal:** Sewer cleaning and investigation will continue as part of the annual program. Gate chamber and lift station upgrades will also be continued.

6.3 CSO Master Plan Updates During Implementation

The CSO Master Plan is intended to be a "living" document to allow for changes over time. During implementation, the CSO Master Plan will be updated to reflect any changes made as a result of additional studies and analysis. Areas of the plan that are likely to have changes include the following:

- **Proposed Control Options:** Preliminary design is expected to include flow monitoring, hydraulic model refinement and calibration, and updated solutions. Detailed design will include the project design details required to tender and construct the work. Both phases of work must be completed prior to the implementation of any project.
- **Project Refinement and Innovation:** The proposed control options may change based on the results of pilot studies and from lessons learned with new technologies. New technologies are likely to be developed over the course of the program and should be reviewed for suitability.
- **Development:** The City is constantly changing and redevelopment within the combined sewer area will continue. This will include development and changes that were not known at the time of this study. Redevelopment will have to consider the impact to the sewer system and contribution to CSOs as part of the City's existing policy.
- **Reprioritization:** This plan has scheduled the implementation of projects based on work that is currently committed occurring first. The remaining projects are sequenced based on the level of additional CSO volume capture provided. There is potential for new information to reshape the direction of the plan, which will impact the project prioritization. The City of Winnipeg is actively working on a prioritization model that will evaluate the project sequences on a multitude of factors and will allow deviations to the project sequences as new information becomes available.

The CSO Master Plan will evolve throughout its implementation based the above points and numerous other external influences. The plan will be reassessed on a regular basis to maintain a high cost benefit ratio while achieving the CSO reduction target.

6.4 CSO Master Plan Update For Migration To Future Control Targets

The November 24, 2017 letter provided the Director's approval for the Preliminary Proposal recommendations, with the condition that "*Control Option No. 1 be implemented in such a way so that Control Option No. 2 may be eventually phase in.*" The letter required the submission of a CSO Master Plan for Control Option No. 1 - 85 Percent Capture In A Representative Year by August 31, 2019, and an update for Control Option No. 2 - Four Overflows In A Representative Year by April 30, 2030.

It is understood that the intent of the migration is to improve the performance of the combined sewer system in the City in terms of water quality. The change in the performance metric utilized for each control target creates additional risk. Specific impacts associated with upgrading to Control Option No. 2, and moving from a percentage capture to a number of overflows performance metric, are as follows:

- **Control Option No. 1 – 85 Percent Capture in a Representative Year:** This system-wide performance measure aligns with the City's current plans to continue with sewer separation in CS districts. It also accommodates selection of the most cost-effective project in other districts. The plan proposes that every one of the 41 districts will have at least some level of CSO control, but it will result in a wide range of performance. If it were most cost effective to have all CSO control within only a portion of the districts, this would be allowed with the percent capture performance measure.
- **Control Option No. 2 – Four Overflows in a Representative Year:** This option requires a maximum of four overflows in the representative year for each district. Projects completed to achieve the Control Option No. 1 performance may have to be further upgraded to meet the increased performance target. Projects in districts that are shown to have a low cost benefit may have to be completed.

To reduce the risk to the program, the City will maintain a percent capture approach on the basis that the Preliminary Proposal results show that Control Option No. 2 is approximately 98 percent capture. The

estimated improvement in reduction of nutrient discharges between the two control options is marginal. The results however cannot confirm equivalent improvement in the number of days bacteria levels would exceed 200 MPN/100 ml. Water quality assessments for 98 percent capture must ultimately be completed to the same level of detail as Control Option No. 2. The assessment must demonstrate the equivalent percent capture target will result in an equivalent or better water quality conditions than Control Option No. 2. The City intends to carry out these evaluations as part of the 2030 Master Plan Update.

The City will continue implementation of the previously committed projects, which do not compromise the City's plan to meet future targets.

6.5 CSO Master Plan Update Process Summary

The steps planned for completing the Master Plan update prior to April 30, 2030 are listed as follows:

1) Submit the CSO Master Plan by August 31, 2019, in accordance with EA No. 3042 with the performance target based on Control Option No. 1 – 85 Percent Capture in a Representative Year.
2) Continue with the sewer separation projects identified in the CSO Master Plan through the initial period of implementation.
3) Complete the water quality performance evaluations and pilot studies to determine the percent capture required to meet the water quality performance identified for Control Option No. 2 in the Preliminary Proposal.
4) Collaborate with MSD regarding any changes necessary to the CSO Master Plan or EA No. 3042 in order to meet the required performance target.
5) Submit the updated CSO Master Plan before April 30, 2030, in accordance with EA No. 3042. The update will incorporate any agreed changes required to achieve Control Option No. 2 water quality performance equivalence.
6) Continued implementation of the updated CSO Master Plan following acceptance by MSD.

The update will also report on the results of the program since the submission of the CSO Master Plan in 2019. This aspect of the CSO Master Plan Update is expected to include the following:

- Update on results to date: volume of CSO, number of events, money invested.
- Discussion on path forward to meet the Control Option No. 2 water quality target.
- Conceptual cost estimate to move an increased capture rate beyond 85 percent.
- New timeline and implementation schedule for the migration to Control Option 2.
- Climate Change impacts assessed since 2019 CSO Master Plan submission.
- Update on pilot studies, alternative floatables management, RTC and GI program opportunities.

7. References

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