



## **CSO Master Plan**

### **Part 3C - Standard Details**

Revision 02

July 18, 2019

City of Winnipeg



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# Contents

<b>Acronyms and Abbreviations .....</b>	<b>v</b>
<b>1. Introduction .....</b>	<b>1-1</b>
1.1 Purpose .....	1-1
1.2 Approach to Product Selection .....	1-1
1.3 Organization of this Report .....	1-1
<b>2. Sewer Separation .....</b>	<b>2-1</b>
2.1 Facilities and Equipment .....	2-1
2.2 Product Selection .....	2-1
2.3 Alternative Products .....	2-1
2.4 Design Considerations .....	2-2
2.5 Climate Change .....	2-3
2.6 Typical Drawings .....	2-3
2.7 Operations and Maintenance .....	2-3
<b>3. Latent Storage .....</b>	<b>3-1</b>
3.1 Facilities and Equipment .....	3-1
3.2 Product Selection .....	3-2
3.2.1 Flap Gate (with control) .....	3-2
3.3 Alternative Products .....	3-2
3.4 Design Considerations .....	3-2
3.4.1 Gate Design .....	3-3
3.4.2 Lift Station Design .....	3-3
3.5 Typical Drawings .....	3-5
3.6 Operations and Maintenance .....	3-5
<b>4. In-Line Storage .....</b>	<b>4-1</b>
4.1 Facilities and Equipment .....	4-1
4.2 Product Selection .....	4-1
4.3 Alternative Products .....	4-2
4.3.1 Downward Opening Weir Gate, Manufactured by Instream .....	4-2
4.4 Design Considerations .....	4-2
4.5 Typical Drawings .....	4-2
4.6 Operations and Maintenance .....	4-3
<b>5. Screening .....</b>	<b>5-1</b>
5.1 Facilities and Equipment .....	5-1
5.2 Product Selection .....	5-1
5.2.1 Static Screens .....	5-1
5.2.2 Non-mechanical Self-cleaning Screens .....	5-1
5.2.3 Mechanically Cleaned Screens .....	5-1
5.2.4 Representative Product .....	5-2
5.2.5 Screenings Removal .....	5-3
5.3 Alternative Products .....	5-3
5.3.1 Hydro-Static Screen .....	5-3
5.3.2 Hydro-Jet Screen .....	5-4
5.4 Design Considerations .....	5-5
5.4.1 Screen .....	5-6
5.4.2 Control Weir / Gate .....	5-7

5.4.3	Lift Station .....	5-7
5.5	Typical Drawings .....	5-7
5.6	Operations and Maintenance .....	5-7
<b>6.</b>	<b>Gravity Flow Control .....</b>	<b>6-1</b>
6.1	Facilities and Equipment .....	6-1
6.2	Product Selection .....	6-1
6.3	Alternative Products .....	6-2
6.3.1	Vortex Style Flow Control Valve .....	6-2
6.4	Design Considerations .....	6-2
6.5	Typical Drawings .....	6-3
6.6	Operations and Maintenance .....	6-4
<b>7.</b>	<b>Off-Line Storage .....</b>	<b>7-1</b>
7.1	Tank Storage .....	7-1
7.1.1	Facilities and Equipment .....	7-1
7.1.2	Product Selection .....	7-1
7.1.3	Alternative Products .....	7-2
7.1.4	Design Considerations .....	7-2
7.1.5	Typical Drawings .....	7-3
7.1.6	Operations and Maintenance .....	7-3
7.2	Tunnel Storage .....	7-4
7.2.1	Facilities and Equipment .....	7-4
7.2.2	Design Considerations .....	7-6
7.2.3	Operations and Maintenance .....	7-7

**Appendixes**

A	Example Screen Sizing Calculation
B	Figures
B-1	SRS Chamber with Flap Gate and Off-Take
B-2	Off-Line Deep Storage Tank, 1 of 2
B-3	Off-Line Deep Storage Tank, 2 of 2
B-4	Off-Line Near Surface Storage Tank, 1 of 2
B-5	Off-Line Near Surface Storage Tank, 2 of 2
B-6	In-Line Gate Chamber with Side Addition of Screening Chamber
C	Design Table for Latent Storage Option

**Tables**

Table 2-1.	Types of Sewer Separation .....	2-1
Table 3-1.	Typical Operational Problems with Gates .....	3-6
Table 4-1.	Typical Operational Problems with Weirs .....	4-4
Table 5-1.	Typical Operational Problems with Screens .....	5-8
Table 6-1.	Indicative Sizing of Flow Monitoring and Regulating HYDROVEX <i>FluidMIDu</i> .....	6-3
Table 6-2.	Typical Operational Problems with Flow Monitoring and Regulating Stations .....	6-5

**Figures**

Figure 2-1.	Partial Separation Schematic .....	2-2
Figure 3-1.	Latent Storage Schematic .....	3-1
Figure 3-2.	Example ACU-GATE Installation .....	3-2
Figure 4-1.	Examples of TRU-BEND Installations .....	4-1
Figure 4-2.	Example of Instream's Downward Opening Gate Installation .....	4-2
Figure 5-1.	Examples of ACU-SCREEN Installations .....	5-3
Figure 5-2.	Example Installation of a Hydro-Static Screen .....	5-4

Figure 5-3. Example Installation of Hydro-Jet Screen ..... 5-5

Figure 6-1. Example of HYDROVEX® *FluidMIDu* Installation ..... 6-1

Figure 6-2. Typical Flow Monitoring and Regulating Station ..... 6-2

Figure 6-3. Typical Flow Monitoring and Regulating Station Chamber ..... 6-4

Figure 7-1. StormTrap Detention Tank ..... 7-2

Figure 7-2. Two TBMs Currently Being Used in the Thames Tideway Project in London, UK ..... 7-5

Figure 7-3. A TBM Beginning Boring Operation in London for the Thames Tideway Project ..... 7-5

Figure 7-4. West Side CSO Tunnel Under Construction in Portland, Oregon ..... 7-6

## Acronyms and Abbreviations

CS	combined sewer
CSO	combined sewer overflow
GI	Green Infrastructure
Inv	Invert
LDS	land drainage sewer
NWL	Normal Water Level
NSWL	Normal Summer Water Level
O&M	operations and maintenance
RTC	Real Time Control
SCADA	supervisory control and data acquisition
SRS	storm relief sewer
TBM	tunnel boring machine
WWF	wet weather flow
WWS	wastewater sewer

# 1. Introduction

## 1.1 Purpose

This document forms part of Phase 3 of the combined sewer overflow (CSO) Master Plan, to provide background information on CSO technologies including detailed descriptions of conceptual solutions, design rationale and considerations, and other rationale for their selection (such as operations and maintenance [O&M]) and, where appropriate, industry products with a history of use in these types of applications.

This 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.

## 1.2 Approach to Product Selection

The approach to selecting products has given preference to ‘tried and true’ products. These are products that:

- Operators would be familiar with.
- Can be sourced readily from local suppliers.
- Have been used before in CSO control applications across North America.

Any specific manufacturer or product selection in this report is for reference use and example only. It is neither intended as an endorsement of the product specified, nor is it an exclusion of other manufacturers or suppliers. When applicable, other viable alternatives have also been documented for future consideration.

Design considerations presented in this report are conceptual and general in nature and should be revisited on a project-by-project basis during the preliminary and detailed design stages.

## 1.3 Organization of this Report

The six methods of CSO control and reduction considered in this report have been grouped in individual sections as follows:

- Section 2 Sewer Separation
- Section 3 Latent Storage
- Section 4 In-Line Storage
- Section 5 Screening
- Section 6 Gravity Flow Control
- Section 7 Off-Line Storage (i.e. Tank Storage and Tunnel Storage)

In each section listed above, there is a description of the CSO control option and a discussion of design and O&M considerations. Representative products and drawings describing typical details have also been included, where appropriate.

Appendix A is a Screen Sizing Calculation, which steps through the logic for mechanical screen sizing and gives an indicative size for the screen and screening chamber.

Appendix B presents the large format figures referenced in the report.

Appendix C presents a design table for the Latent Storage Option.

## 2. Sewer Separation

A short description of sewer separation is included here to facilitate discussion of design and O&M considerations. For a more detailed description of this solution, see Part 2, Section 3.3.1. For information on the City's approach to sewer separation to date, see Part 2, Section 2.4.

### 2.1 Facilities and Equipment

There are several types of separation that can be referred to when discussing sewer separation. Table 2-1 summarizes the typical types of sewer separation methodologies available.

**Table 2-1. Types of Sewer Separation**

Type of Separation	Features
Complete Separation	All wet weather flow is collected and conveyed by a LDS system. All wastewater flows are collected and conveyed by a WWS system.  All road drainage is collected within the CS district by reconnecting all catch basins to the LDS system. Private foundation drains, sump pumps, and roof drain connections from older properties may remain connected to the CS system that is being used as part of the WWS system. A WWF response is likely to remain in this type of WWS system.
Partial Separation "Separation Ready"	Separation of selected regions within a sewer district is carried out to achieve a desired level of basement flooding protection or CSO relief. The entire CS district is not separated. Small separate areas within the district may be referred to as Separation Ready: typically, where the area can be connected to an existing LDS.
LDS Separation	A new LDS system is constructed and catch basins in the CS district are reconnected to the new LDS system. The existing CS system is then converted to a WWS system unless significant impermeable area (>4% of total area) is still connected from properties.
WWS Separation	A new wastewater system is installed to collect domestic sewage. The existing CS system is then converted to a LDS system.

Notes:

CS = combined sewer  
LDS = land drainage sewer  
WWF = wet weather flow  
WWS = wastewater sewer

In a separate system, storm water is conveyed via the LDS system to a LDS outfall for discharge directly into the receiving water. This removal of storm water from the CS flow reduces the flow entering the CS system and reduces the amount of CSO occurring during WWF events. Figure 2-1 is a schematic representation of partial separation where a new LDS system is constructed, in which catch basins in the CS district are reconnected to the new LDS system and discharge directly to the receiving water.

### 2.2 Product Selection

There are no preferred products noted for sewer separation, as sewer infrastructure is generic and supplied by a wide range of suppliers.

### 2.3 Alternative Products

As discussed in Section 2.2, no alternative products are here listed, as there are many suppliers that stock the generic components of sewer infrastructure.



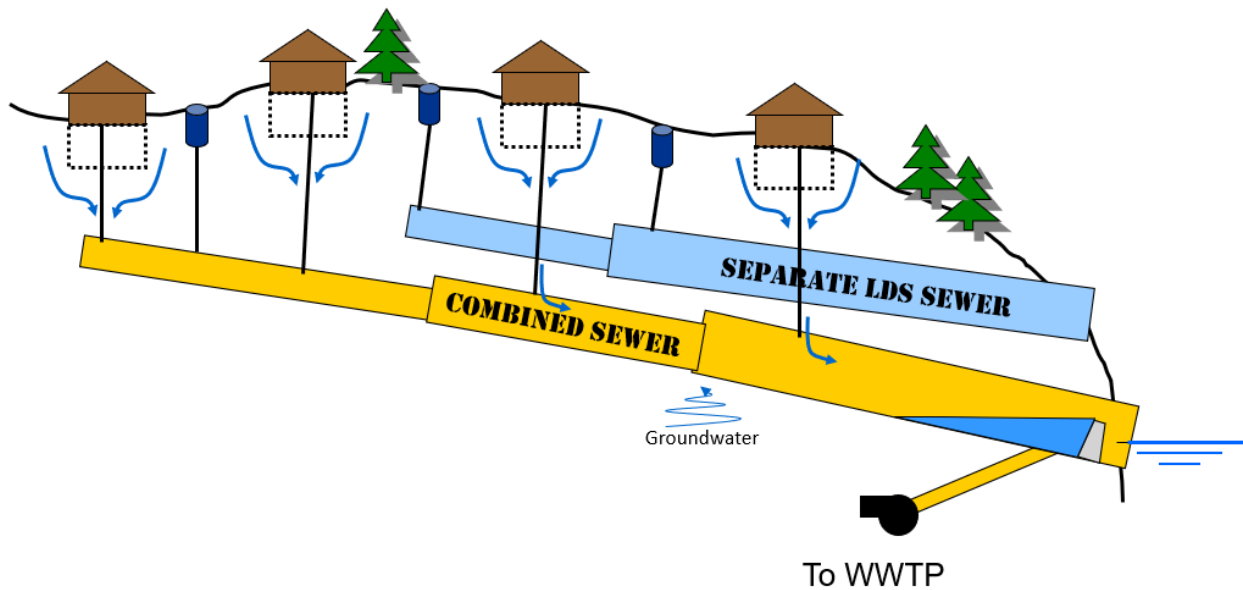


Figure 2-1. Partial Separation Schematic

## 2.4 Design Considerations

Sewer flow has been modelled assuming the 1992 representative year of rainfall with the Normal Summer Water Level (NSWL) assumed. For more information on flow and drainage modelling assumptions see Part 2, Section 3.5 of the Master Plan.

Sewer alignment considerations include:

- existing underground infrastructure;
- required cover for frost protection; and
- the level of the receiving waterbody.

Design considerations include:

- The City's Standard Construction Specifications, CW 2130 – Gravity sewers.
- Pipe sizing with Winnipeg's flat topography, river levels, clay soils, buildability, considering:
  - Minimum slopes
  - Minimum pipe cover
  - Pipe diameter and pipe type (i.e. Manning's value)
  - Minimum flushing/scouring velocities
  - Maximum allowable velocity
- Design events:
  - 1 in 5 year McLaren for CS and LDS
  - 1 in 10 year McLaren for WWS
  - Need for multi duration events (e.g. 30, 60, 120, 300, 600 and 1440 minutes)
- Other pipe sizing issues:
  - Lack of detailed GIS information
  - Permeable and impermeable areas within catchment area
  - Ten percent silt assumption
  - Consideration of adjacent water course(s)
- Manholes:
  - At every change of direction
  - At every change in slope
  - Maximum 185 metre spacing

- At upper end of sewer run for maintenance purposes

A initial high-level assessment is completed to size the sewer. An area takeoff is required, and assumptions are made of the area that is going to be serviced by the new sewer. The rational method or other comparable method is then used to generate the estimated runoff flow based on the design event. A baseflow allowance is then calculated and added to this number using parameters such as per capita sewage flow rates, business, industrial, commercial and institutional flows. Flow rates should also consider land use zoning densities for future infill and densification areas.

These flows are calculated at different sections of the catchment area and then used to size the sewer through look-up tables or other such methods. Using the hydraulic model, boundary conditions (e.g. river level, ground level, alignment, roughness, silt, etc.) can be added and any changes made are documented with justification.

Changes that occur during either preliminary or detailed design (e.g. new asset, geotechnical, flow survey information) can be tracked, their impact assessed and made transparent to the City.

Post monitoring can validate performance and any significant differences can be used to update the process in the future.

## **2.5 Climate Change**

Precipitation is expected to change over time because of the effects of greenhouse gases on the environment. Therefore, climate change could potentially have a worsening effect on the CSO program because of greater rates and volumes of runoff that must be managed by the CSO controls.

Long term precipitation records were reviewed to identify any climate change trends that may already be in progress. The rainfall categories used for the representative assessment are useful for this evaluation, since the assessment compares not only the total annual and event rainfalls, but the number of rainfalls of varying sizes. The review of long-term trends indicated the following:

- There was no increasing trend observed for annual rainfall accumulations.
- There was no increasing trend observed for any of the larger amounts of rainfall.
- The 0 to 5 mm amounts of rainfall showed an increased number in recent years, but this will not be significant in terms of the CSO program because the CSO control system will capture these smaller events.

However, there is a high degree of uncertainty in the long-term trends. As such, the CSO Master Plan includes a provision for a response to climate change through the use of Green Infrastructure (GI), rather than more complex and costly changes to the planned grey infrastructure. A 10 percent funding allowance is included in the budget for GI, which is over and above the Preliminary Proposal estimate.

Furthermore, the CSO Master Plan prioritizes sewer separation work upfront; this makes the system more resilient to climate change, as runoff will primarily be directed to LDSs.

## **2.6 Typical Drawings**

The City's Standard Construction Specification, CW 2130 – Gravity sewers City has standard drawings showing generic gravity main components, accessible at <https://www.winnipeg.ca/matmgt/spec/>.

## **2.7 Operations and Maintenance**

Maintenance schedules already in place for the existing CS can be duplicated for the newly installed LDS. The additional cost in O&M is a function of the increased number and length of sewers. This is discussed in Part 2 and budgeted at \$4 per metre of sewer per year.

Physical inspections are performed to accomplish the following:

- Identify defects in the system that can contribute to or cause backups and overflows.
- Identify chronic problem areas, so maintenance can be planned and scheduled.
- Identify defects that, if not fixed, will result in a future failure.
- Determine the system needs for long-term replacement and rehabilitation.
- Develop a baseline for future comparison to determine rates of deterioration.

The City has construction work specifications for the commissioning and inspection of gravity mains using video surveillance equipment (CW 2145 – Sewer and Manhole Inspection) and for the cleaning of gravity mains using high pressure hoses and vacuum units (CW 2140 – Sewer and Manhole Cleaning).

### 3. Latent Storage

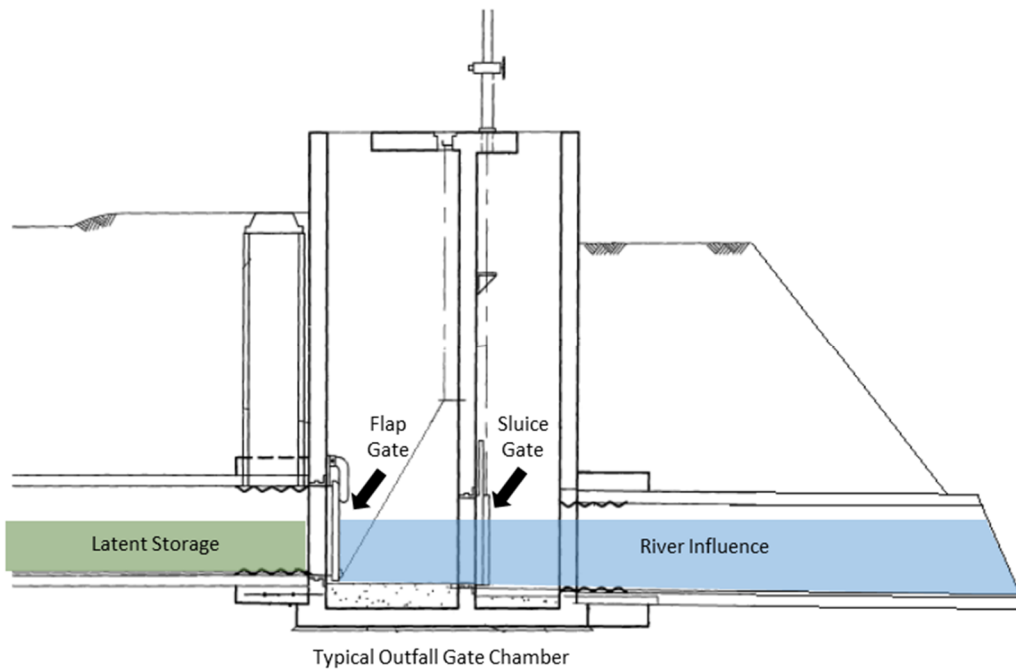
A short introductory description of latent storage is included here to facilitate discussion of design and O&M considerations. For a more detailed description of this option see Part 2, Section 3.3.2.

#### 3.1 Facilities and Equipment

Latent storage refers to an available volume of storage in the storm relief sewer (SRS) system below the river level, which cannot dewater by gravity because of backpressure from the river on the flap gate, as shown on Figure 3-1. The available latent storage volume is based on the NSWL at the outfall and extends upstream through the SRS system.

A small SRS volume may not provide enough benefit to install a dewatering system. Flap gate control is a means to increase SRS available storage. The locking mechanism allows the level within the system to surpass the river level without opening the flap gate, thereby allowing for a higher volume of capture as compared to no flap gate control.

An off-line lift station located at the discharge end of the SRS empties the latent storage, readying the system for the next wet weather event. New level sensors, pump, and chamber are required near SRS outfalls suitable for latent storage. A force main from the new lift station connecting to the CS is also required. Where flap gate control is needed to increase SRS storage, a new latched flap gate and gate chamber are needed. Real time control (RTC) can be used to enhance this option and its operation in conjunction with other control options across districts. See Part 2, Section 7.3 for more information.



**Figure 3-1. Latent Storage Schematic**

### 3.2 Product Selection

#### 3.2.1 Flap Gate (with control)

Where flap gate control is required, the ACU-GATE manufactured by Grande Water Management has been selected as the representative product for the CSO Master Plan. These gates have been used extensively in CSO projects in the past and have a proven track record.

The ACU-GATE is a latched gate, where the latching mechanism is hydraulically operated. Figure 3-2 shows an example installation.



**Figure 3-2. Example ACU-GATE Installation**  
*(Picture credit: courtesy of Grande, priv comm 9/11/2018)*

Other features include the following:

- An entirely stainless steel construction, with gate latches protected from debris by the gate frame, thereby requiring little maintenance.
- A system of hydraulically operated latches, which rotate upwards when opening, so that additional clearance below the gate is not required.
- A design that is easy to retrofit into existing installations, with float or pneumatic operation available.

### 3.3 Alternative Products

Where flap gate control is required, an alternative arrangement would be to retrofit a winch and gear system that would secure the flap gate closed and would be set to fail open.

### 3.4 Design Considerations

Figure B-1 in Appendix B depicts the general arrangement of a sluice gate constructed 'in-line' with the CS. It includes a flap gate, the sluice gate with operator in its own structure and an off-take line to a sewage lift station. The lift station will provide a method of emptying the latent storage, readying the system for the next wet weather event. Critical design parameters for the gate chambers and lift station are below.

### 3.4.1 Gate Design

Design parameters and calculations for the latent storage option are set out in a table in Appendix C. These include:

- Storm Relief Sewer Dimensions
  - Horizontal inside and outside dimensions of the sewer main (d1 and d2);
  - Vertical inside and outside dimensions of the sewer main, if not a round pipe (v1 and v2);
  - Maximum SRS storage required;
  - Invert elevation at diversion weir (Inv); and,
  - River normal summer elevation (NWL).
- Gate Chamber Design Information
  - Chamber height;
  - Chamber length;
  - Chamber width; and,
  - Elevation and size of off-take to pump station.

### 3.4.2 Lift Station Design

Because lift stations are expensive facilities to operate and maintain, in the conceptual design stage a cost benefit analysis should be undertaken. There are a variety of different issues to consider during the cost benefit analysis, and the subsequent conceptual and detailed design, including:

- contributing per capita rates with respect to flow;
- critical infrastructure such as hospitals and schools serviced by the lift station (e.g. use of in-situ standby power versus maintenance crews hauling in a portable standby power unit);
- minimum pass forward flows;
- impact on downstream CSO service areas and trunk lines;
- minimum storage volume where the lift station is more cost effective than constructing storage;
- pump start stop settings and how they interact with either the gate or weir controls;
- integration with RTC; and,
- merits of a prefabricated lift station versus one constructed in place.

A minimum of two pumps is required for each pumping station, although three is preferred. These pumps should be identical and interchangeable. If two pumps are used, each unit should be capable of pumping at the peak design capacity flow rate for the station under service conditions. If three pumps are used, the two smallest pumps operating in parallel should be capable of pumping at the design capacity flow.

Another important consideration is redundancy in the power supply. Each lift station must continue operation when its primary power source is not available. The source of temporary power could be a natural gas, propane or diesel powered generator set, or a hook-up point that a mobile generator source can be brought in by field crews. The latter is less desirable, as emergency storage must be provided to allow time for a field crews to mobilize and hook up the temporary external power source.

The feasibility of a gravity overflow in the event of the failure of all lift station pumps should be evaluated and emergency storage provided if gravity discharge is not available. Emergency storage should be sized on peak flows and the response time for emergency crews to bring in a back-up power generator and pumps. Sizing should be on a case-by-case basis, and a cost benefit analysis undertaken to

determine the appropriate sizing based on criticality of the lift station, the presence of back-up power and the response time of field crews.

The feasibility of installing an oversize pipe upstream of the lift station to store excess flow if the lift station pumps fail is also to be evaluated. The pipe is to be sized as indicated above.

Alarms must be relayed back via a phone line or cellular service to the operations centre responsible for sending a crew to investigate the reason for the alarm.

Pump start and stop level configurations should not exceed six starts per hour for dry well pumps and 12 starts per hour for wet well or submersible pumps. Normal lift station operation of pump starts and stops subject the force mains to cyclic pressure loading, which may reduce the allowable maximum pressure or the pipe life, or both, particularly for flexible pipe materials such as PVC. Existing and future forcemains should be checked to verify that cyclic loading does not introduce design limitations for the selected pipe. Maximum pump discharge pressures should also be checked to confirm they are suitable for existing forcemains.

Velocities need to be kept within a maximum range to avoid excessive head loss and vibration problems from turbulence in fittings and valves. Conversely, minimum velocities in the wet well will cause sediment to deposit in the base of the wet well, reducing storage capacity and increasing pump starts. Increasing pump starts increases wear and tear on the pumps and lowers the pumps' efficiency. Reducing the number of starts could cause the sewage to become septic, so a balance is required. Whether the lift station has a dry or wet well will also affect the frequency of the pump starts. The wet well will allow more starts than the dry well because of the cooler pump motors. Lift station wet well capacity should be maintained by regular inspection and proactive maintenance to remove silt. Wet wells should be designed so dead spots are not created in the sump where the silt can settle out.

Other design considerations include:

- Solids handling capacity of the pumps and their ability to handle floatables such as natural debris, grease and scum, plastics and paper products.
- Hydraulic considerations such as suction levels and total system head (i.e. pump basics).
- Pump efficiency and energy efficiency requirements.
- Valves, piping and fittings.
- Interior linings for corrosion resistance.
- Design of any concrete structures should be in accordance with the City's Construction Work Specification CW 2160 – Concrete underground structures and works, which gives guidance on the preferred process for concrete formwork.
- Access for maintenance personnel and confined space entry. Physical access can be provided using manhole covers and ladders. However, the infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified. This may be as simple as equipping crews with sewer inspection cameras mounted on poles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.
- Access for replacement of pumps and controls.
- Vehicle access and parking for maintenance vehicles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.
- Odour control.

### 3.5 Typical Drawings

Figure B-1 in Appendix B presents the general configuration, plan and section drawings for a SRS chamber with flap gate, sluice gate, and off-take.

### 3.6 Operations and Maintenance

General O&M should include regular inspection of facilities. O&M manuals are available from suppliers, but details such as frequency of inspection and maintenance activities should be flexible and tailored to each district, as debris will differ from catchment to catchment area. If required, high pressure hoses can be used to dislodge stringy materials or other debris interfering with the proper working of the either the flap gate or sluice gate. The ACU-GATE representative product includes a flushing mechanism that will be used to flush debris settled downstream of the gate and near the gate frame.

Initial operation should include inspection of gate chambers and lift stations following every WWF event to develop an understanding for the type of debris and amount of sedimentation encountered during each high flow event. Access to the gate control chamber and the lift station will be required for inspection and cleaning. As such, secure access manhole covers and ladders will be provided for these chambers. However, the infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified. This may be as simple as equipping crews with sewer inspection cameras mounted on poles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.

The maintenance schedule for flap gate controls should be broken down as follows: after a WWF event, weekly operations, and monthly operations.

After a WWF event, the following should be completed:

- The gate, upstream and downstream piping, and diversion pipe to lift station should be inspected and cleaned if necessary to confirm that no build-up of sediment, debris, grease, or malodorous materials has occurred.
- The gate control mechanism (disc or flap, seating face, guides and hinges, operating stem, latches, and motorized and manual operators) should be inspected. Obstructions in the seating surfaces and paths of gate travel should be removed.
- All moving parts should be lubricated and adjusted as recommended by the manufacturer.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections are similar to weekly inspections plus the following: if the flap gate is hydraulically controlled, the hydraulic system should be cycled and checked for proper operation, and the system should be checked for hydraulic leaks. The function of gate position indicators should also be checked and adjusted if necessary. The working condition of back-up power should be checked, if so equipped.

Lift stations should be visited daily, or at least every other day with remote monitoring, to verify that the system is functioning properly. Any alarms recognized by the telemetry or supervisory control and data acquisition (SCADA) system should be responded to and addressed during these daily visits. Regular maintenance intervals should be broken down as follows: after a WWF event, weekly, monthly, and every six months.

After a WWF event, the following should be completed:

- Visually inspect pumps, piping, and fittings and clean if necessary.
- Remove any trash, debris, or malodorous materials from the sump and screen (if so equipped).
- Record run-time hours for each pump.
- Run pumps using manual control to verify proper operation. Leave pumps in automatic mode.



Weekly inspections are similar to a WWF event, plus the following:

- Confirm working condition of back-up power, if so equipped.
- Confirm that check valves are seating properly and are not plugged with debris.
- Check pump seal failure lights (if so equipped).
- Confirm that ventilation system is operating properly.
- Test all control panel operations and lights.
- Inspect the station for vandalism or damage, and clean station grounds.

Monthly inspections usually add the following tasks:

- Clean floats and level controller, if needed.
- Blow out lines on bubbler system, if so equipped.
- Visually inspect wet well for grease build-up, and clean if needed.
- Wash wet well down, if needed.
- Confirm operation of any gate or plug valves.
- Confirm operation of flushing valve, if so equipped.
- Confirm proper cycling of lead-lag pumps.
- Test alarm system.

The inspections every six months should also include the following:

- Remove grit and grease from wet well (usually by vacuum truck).
- Operate automatic transfer switch and back-up power under load (if so equipped) by manually tripping line power.

Annual calibration services include the following:

- Confirm accuracy of flow meter (if so equipped) by performing a draw-down test.
- Assess operating set points (on / off) for pumps and adjust as necessary to improve system performance.

Each gate should be taken out of service for maintenance on a routine basis. Units should be cleaned, and the components checked for such potential issues as leakage when closed, corrosion, removal of obstructions, flushing of closure areas, and adjustment or repacking of seals if so equipped. If not used frequently, gate controls should be cycled at least once every six months.

Common problems that arise in flap or sluice gates are summarized in Table 3-1.

**Table 3-1. Typical Operational Problems with Gates**

Operational Problem	Cause	Solution
Seat leakage	Gate not seating properly	Check for obstruction between gate and seat or obstruction in path of travel. Check for bent operating mechanism and functioning of hydraulic system (if so equipped).
Gate difficult to operate	Operating mechanism not lubricated often enough	Lubricate. Check function of hydraulic system (if so equipped).
Jammed mechanism	Obstruction Moment / torque setting for mechanism set too low.	Remove obstruction. Consult manufacturer for setting adjustment.
Gate will not operate	Broken mechanism Defective controls	Inspect mechanism and repair. Check control circuits and hydraulic system (if so equipped), and repair or replace.

## 4. In-Line Storage

A short description of in-line storage is included here to facilitate discussion of design and O&M considerations. For a more detailed description of this option see Part 2, Section 3.3.3.

### 4.1 Facilities and Equipment

In-line control gates allow for the effective use of the excess upstream storage capacity, reducing the frequency and severity of CSOs without reducing the level of basement flood protection. The main objective for in-line storage is to temporarily contain a volume of CSO in the system until sufficient capacity exists in the interceptor system to convey flows to a wastewater treatment plant.

The infrastructure required for the option include a new in-line gate and chamber, which will also include housing for the mechanism that lifts and lowers the in-line gate. Level sensors and RTC can be used to enhance this option and its operation in conjunction with other control options across other districts. See Part 2, Section 7.3 for more information.

### 4.2 Product Selection

The TRU-BEND weir, manufactured by Grande Water Management, has been selected as the representative product for the CSO Master Plan. These overflow gates have been used extensively in in-line storage projects in the past and have a proven track record. Recent installations have been completed in New York City, NY; Ottawa, ON, Quebec City, QC and Columbus, OH to name a few. Figure 4-1 shows example installations of this product.

Features of the TRU-BEND weir include the following:

- A non-powered self-adjusting counterweight allows just enough water to overflow, while maintaining the desired constant upstream water level. Once a predetermined inflow is exceeded, the gate fully opens.
- The weir has all stainless steel construction, for easy operation and low maintenance.



**Figure 4-1. Examples of TRU-BEND Installations**

(Picture credit: <http://grandeinc.com/product/overflow-control/tru-bend/>)

**4.3 Alternative Products**

The product listed below has been selected as an alternative, as it has a negligible weir sill that can be installed almost flush with the pipe floor.

**4.3.1 Downward Opening Weir Gate, Manufactured by Instream**

Figure 4-2 shows an example installation of the Instream Water Control Projects Ltd. downward opening weir gate. This type of gate is similar to the example given previously, but rather than being controlled by a counterweight, the Instream downward opening gate is lowered or raised by a winched cable system, with cables connected to the far edges of the gates. The gate has specially designed side rub plates that keep the cables outside the flow, preventing debris from getting hung up on them, ensuring a smooth uninterrupted flow channel.

Instream’s downward opening weir gate can also open flat with minimal flow restrictions, so that the capacity of the conveyance system is maintained during high flows. Controls can be programmed so a loss of power or system error code will cause the gate to open, eliminating the added risk of flow restriction and basement flooding. Several of these gates have been used in the City of Lethbridge, Alberta’s wastewater treatment plant to control upstream water levels in various treatment basins. They are available in 304, 316 and 316L stainless steel for corrosive environments.



**Figure 4-2. Example of Instream’s Downward Opening Gate Installation**  
*(Picture credit: Instream Water Control Projects Ltd.)*

**4.4 Design Considerations**

An in-line gate chamber may be stand-alone or combined with a screening chamber. The design of an in-line gate chamber as a proposed solution for the CSO Master Plan has been conservatively designed to include a side overflow weir (for screening). As such, the design for the in-line gate chamber is combined with the design for the overflow screening. See Section 5.4 for the combined design considerations of in-line gate chambers and off-line screening chambers. In addition, designers need to verify that screens are not drowned out by high tailwater levels, as this undermines their self-cleaning system.

**4.5 Typical Drawings**

Figure B-6 in Appendix B shows the general layout for in-line gate chambers and screening chambers.

## 4.6 Operations and Maintenance

Initial operation should include inspection of weir stations following every WWF event to develop an understanding for the type of debris and amount of sedimentation encountered during each high flow event. The maintenance schedule for control gates (weirs) should be broken down as follows: after a WWF event, weekly, and monthly.

After a WWF event, operation should include the following:

- The weir and upstream and downstream piping should be inspected and cleaned if necessary to confirm that there is no build-up of sediment, debris, grease, or malodorous materials.
- Document any movement of the overflow detection device and reset if necessary. It is recommended that the City install overflow detection devices to identify CSOs that may have occurred between inspections. These devices usually consist of a small wooden block positioned on the weir and tethered to the chamber wall. Movement of the device is indicative of an overflow.
- Document any instances of backflow from the river; the water level should be below the crest of the weir, so that it prevents river water from entering the sewer.
- Inspect the weir control mechanism for proper operation (weir plates, counter weight, guides and hinges, latches, and motorized and manual operators).
- All moving parts should be lubricated and adjusted as recommended by the manufacturer.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections are similar to weekly inspections plus the following:

- If the weir is hydraulically controlled, the hydraulic system should be cycled and checked for proper operation, and the system should be checked for hydraulic leaks.
- If the weir is controlled by a winch and cable system, the system should be cycled and checked for proper operation and the cables should be checked for any debris and cleaned if necessary.
- The function of any weir position indicators should also be checked and adjusted if necessary. The working condition of back-up power should be checked, if so equipped.
- Weir controls should be checked for fail-safe open operation.

Each weir should be taken out of service for maintenance on a routine basis. Units should be cleaned, and the components checked for such potential issues as leakage around seals when closed, corrosion, removal of obstructions, and flushing of closure areas. If not used frequently, weir controls should be cycled at least once every six months.

General O&M should also include regular inspection of facilities. O&M manuals are available from suppliers, but details such as frequency of inspection and maintenance activities should be flexible and tailored to each district. If required, high pressure hoses can be used to dislodge stringy materials or other debris interfering with the proper working of the weir.

Access to the weir chamber will be required for inspection and cleaning. This is addressed in Section 5.4.

Common problems that arise in weirs are summarized in Table 4-1.

**Table 4-1. Typical Operational Problems with Weirs**

Operational Problem	Cause	Solution
Weir leakage	Weir not seating properly	Check for obstruction between weir and seat or obstruction in path of travel. Check for bent operating mechanism and functioning of hydraulic system (if so equipped). Check for misaligned or missing counterweight.
Weir difficult to operate	Operating mechanism not lubricated often enough	Lubricate.
Jammed mechanism	Obstruction Weir and counterweight not balanced	Remove obstruction. Consult manufacturer for setting adjustment.
Weir will not operate	Broken mechanism Defective controls	Inspect mechanism and repair. Check control circuits and hydraulic system (if so equipped), and repair or replace.

## 5. Screening

### 5.1 Facilities and Equipment

Screening operation typically requires the installation of an in-line control gate to generate sufficient hydraulic head differential for screening operation to function. The control gate would capture all sewage, including floatables, up to the design capacity, and screening would only take place beyond that point. Excess flow beyond the design capacity is diverted through a side-diversion weir to the screening chamber. The screening chamber returns screened material back to the interceptor downstream of the control gate for final routing to the sewage treatment plant.

Screening operations require hydraulic head, which varies by district location. In cases of minimal hydraulic grade, screenings will be pumped back to the interceptor sewer.

The screening operation takes place to a predetermined rate, after which the control gate would open restoring the full system hydraulic capacity to avoid impacting the level of basement flooding protection.

A powered kiosk for electronic components of the mechanical screens is required. The kiosk houses an interface display, the screen system Central Processing Unit, and other controls for screen operation. If in-line storage is required, the screening system can be incorporated into the in-line gate RTC, such that screening is automatically initiated once a water level threshold is reached or can be manually or remotely engaged. As such, RTC with a SCADA system or incorporated level sensors is also required.

### 5.2 Product Selection

There are number of screen systems that can be used to control CSO floatables. An overview of the more common options is provided in the following subsections.

#### 5.2.1 Static Screens

Static screens have no moving parts or electrical requirements. Static screens are comprised of a bar rack or perforated mesh that may be mounted vertically in the wastewater flow or horizontally above it. Static screens may be designed with self-cleaning features that direct collected material out of the wastewater flow, but they require manual cleaning after each event. Because static screens are susceptible to blinding, they are typically used for locations with fewer CSOs or for those with smaller peak flow rates in the order of 100 L/s or less.

#### 5.2.2 Non-mechanical Self-cleaning Screens

Self-cleaning screens are like static screens, in that there are no moving parts or electrical requirements. Self-cleaning screens comprise a bar rack or perforated mesh that is mounted horizontally above the wastewater flow. During a WWF event, levels in the screening chamber rise, and the combined sewage flows over a weir onto and then through the screens, such that screenings are captured on top of the screen. A siphon is included, which is used to induce a "scouring backwash" that lifts debris from the mesh and flushes it down the screenings return channel. Self-cleaning screens are less susceptible to blinding than static screens, but they require greater head differential and a larger construction footprint to house the siphons and screening return channels. Self-cleaning screens are typically used for CSOs with peak flow rates in the order of 200 L/s or less.

#### 5.2.3 Mechanically Cleaned Screens

Mechanically cleaned screens are stationary fine screens that are cleaned with a brush driven by a motor or hydraulic pack. They are arranged in either a horizontal or vertical position to the CSO flow. The screen consists of modules of horizontal or vertical fixed bar racks and cleaning assemblies mounted along a weir wall. Each module is made of stainless steel bars with pre-determined spacing or a stainless

steel perforated mesh. Spacing or mesh size typically ranges from 4 to 6 mm, with 4 mm being most commonly used for CSO floatables control when flows are directed to receiving waters.

During a CSO event, the water level rises, and the comb or brush begins its raking operation based on a signal from a level sensor. In the horizontal configuration, the flow is upward through the bars / mesh to the receiving body of water, while the solids and floatables are brushed to the edges of the screen and into storage areas reserved for screened material. When the water level drops below the weir, the sensor signals the rake assembly to stop, and screened material is discharged to the dry weather sewer. Though the screens are brushed during operation, they require periodic cleaning with a high-pressure hose by the facility operators to dislodge accumulated stringy materials.

#### 5.2.4 Representative Product

The ACU-SCREEN mechanical screen, manufactured by Grande Water Management, has been selected as the representative product for the CSO Master Plan. These screens have been used extensively in CSO screening projects in the past and have a proven track record. Figure 5-1 shows example installations of this product.

The ACU-SCREEN design is based on a special stainless steel screening surface, with slotted screen openings of 5 mm by 25 mm and a total free area of 50 percent, achieving a high degree of solids retention while minimizing the head loss. Other features include the following:

- Stainless steel 316 construction.
- Self-adjusting brush which provides automatic cleaning of the screening surface in both directions.
- A cleaning system that may be driven by a water wheel (requiring no external energy) or by an electrohydraulic drive, depending on site constraints.
- A slotted screening surface which retains solids greater than 5 mm.
- A design that verifies that moving parts are never submerged.
- A modular screen design that allows for installation over virtually any overflow weir type and size.
- An assembly that is easy to retrofit into existing structures.
- An assembly that may be installed in the vertical or diagonal position, when the preferred horizontal arrangement is not possible due to site constraints.



**Figure 5-1. Examples of ACU-SCREEN Installations**

(Picture credit <http://grandeinc.com/product/overflow-screening/acu-screen/>)

### 5.2.5 Screenings Removal

Screened material is pushed and retained in storage areas adjacent to the mechanical screen. Where there is available head and space, screenings can be returned to the main interceptor under gravity after the overflow event. Where there are space or head constraints, a pumping system is required to remove screenings and return them to the main interceptor for final routing to the sewage treatment plant. There are several suppliers in the market that can provide entire lift station packages with the wet well or provide the pumping, piping, and operational components independently of a wet well.

## 5.3 Alternative Products

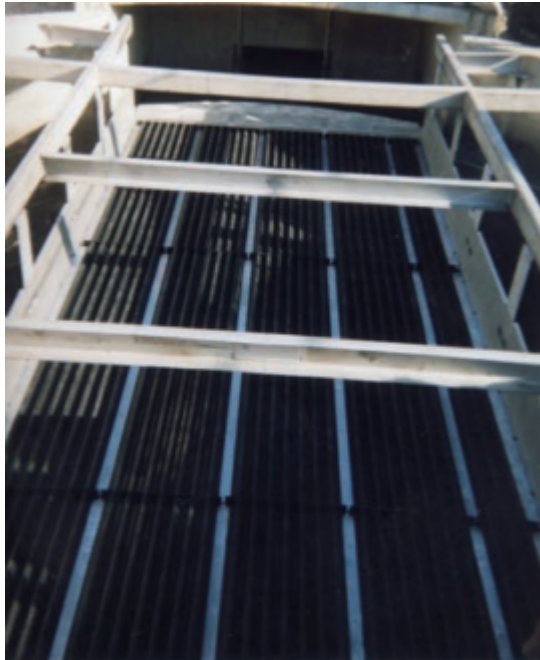
Products listed in the following subsections have been selected as alternative products, as they do not have electrical or moving mechanical components, which is advantageous from a maintenance and occupational health and safety perspective.

### 5.3.1 Hydro-Static Screen

This static screen is manufactured by Hydro International. It features no moving parts, is self-activating, and has flow-modifying baffles incorporated into the design that provide partial self-cleaning. Material greater than 4 mm or 6 mm is retained by coated screen panels that resist grease build-up. Figure 5-2 shows an example installation of this product.



Hydro-Static screens will be appropriate for sites that have smaller peak flows and less frequent spills, as these screens need to be manually cleaned after each overflow event.



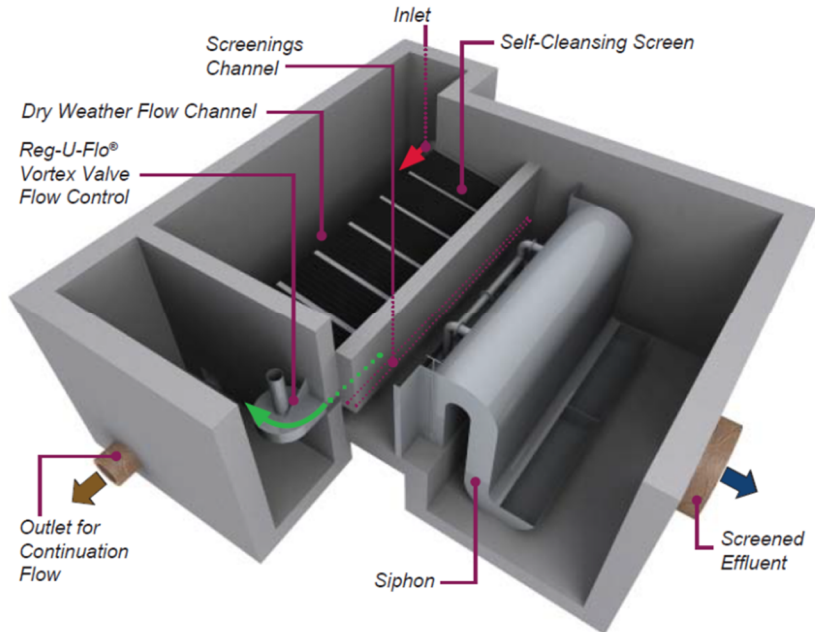
**Figure 5-2. Example Installation of a Hydro-Static Screen**

*(Picture credit: <https://www.hydro-int.com/sites/default/files/hydro-static-screen-brochure-en-gb.pdf>)*

### **5.3.2 Hydro-Jet Screen**

This self-cleaning screen is manufactured by Hydro International. Hydro-Jet screens also feature no moving parts. They are self-activating and self-cleaning, removing material greater than 4 mm in two directions. Compared to the Hydro-Static screen, Hydro-Jet screens require minimal maintenance but do have a larger construction footprint and require greater head loss. Figure 5-3 shows an example installation of this product.

Hydro-Jet screens will be appropriate for sites where a larger construction footprint could be accommodated and where there is greater differential head loss available for screening.



**Figure 5-3. Example Installation of Hydro-Jet Screen**  
(Picture credit: Hydro International UK Ltd.)

## 5.4 Design Considerations

Figure B-6 in Appendix B depicts the screening chamber as a side addition to the control gate chamber, and includes a side overflow weir, screens, and a discharge channel. Where there is sufficient hydraulic grade, screenings will be returned to the interceptor sewer by gravity. In cases of minimal hydraulic grade, screenings will be pumped back to the interceptor sewer and flow to the wastewater treatment plant.

A cost benefit analysis should be undertaken. There are a variety of issues to consider during the cost benefit analysis, and the subsequent conceptual and detailed design including:

- Ability to retrofit an existing chamber versus construction of a new chamber.
- Ability to construct a new chamber 'off-line' to reduce flow interruption.
- Peak flow to be captured by screen.
- Level of screen blinding assumed.
- Risk of basement flooding should screen be 100 percent blinded.
- Fail safe mechanisms.
- Access for maintenance personnel and confined space entry. Secure access manhole covers and ladders must be provided for these chambers. However, the infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified. This may be as simple as equipping crews with sewer inspection cameras mounted on poles.
- Access for replacement of control weir / gate and screen.
- Screen cleaning mechanism.
- Odour control.

- Design of any concrete structures should be in accordance with the City's Construction Work Specification CW 2160 – Concrete underground structures and works, which gives guidance on the preferred process for concrete formwork.
- Vehicle access and parking for maintenance vehicles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.
- Is a new outfall required?
- Power requirements and redundancy.

Design parameters and calculations for sizing of the screen are set out in a table in Appendix A. These include:

- Storm Relief Sewer Dimensions
  - Horizontal inside and outside dimensions of the sewer main (d1 and d2);
  - Vertical inside and outside dimensions of the sewer main, if not a round pipe (v1 and v2);
  - Invert elevation at diversion weir (Inv); and,
  - River normal summer elevation (NWL).
- Gate Chamber Design Information
  - Chamber height (GH);
  - Chamber width (GW) [usually default to d1];
  - Control gate top elevation (GTE) [usually Inv + GH];
  - Side weir crest elevation (SWCE) [usually Inv + (GH x 0.50)]; and,
  - Side weir length (SWL).
- Screen Chamber Design information
  - Peak Screen Rate [input parameter in cu.m. per second]; and
  - Screen Chamber Maximum Head (Head) [function of screen selection].

An example screen sizing calculation is included in Appendix A.

#### **5.4.1 Screen**

Screen sizing will be determined by the peak discharge over the weir and available head for each outfall, per Table A-1 of Appendix A. The maximum head available for screening is the side overflow weir crest elevation minus the NWL in the receiving river. A 100 mm vertical allowance for end of screens discharge to river level is assumed. Figure B-6 in Appendix B shows the general arrangement of the screening chamber. Head losses labelled in this drawing are the design parameters set out in Table A-2 of Appendix A.

An example screen sizing calculation is included in Appendix A.

Design of screens should be such that the velocity through the screen will be sufficient for matter to attach itself to the screen without producing excessive loss of head or complete clogging of the bars or mesh. At the same time, velocities in the upstream piping network should be sufficient to avoid deposition of solids.

Screen piping and channels should be designed for approach velocities between 0.6 and 1.0 m/s. If velocities drop below 0.6 m/s, grit and screenings might accumulate upstream of the screen. Accumulated debris might lead to functional problems once a WWF event flushes that debris to the screens within a short time period. If velocities are higher than 1.0 m/s, debris might bypass the screen and end up downstream.

### 5.4.2 Control Weir / Gate

Design considerations for the control weir are outlined in Section 4.4 and for gate design are outlined in Section 3.4.1.

### 5.4.3 Lift Station

In cases of minimal hydraulic grade, screenings may need to be pumped back to the interceptor sewer. This will be done via a sewage lift station constructed adjacent to the screening chamber. As a minimum, a duplex pump-style lift station with one pump meeting 100 percent of design flow is recommended. Design considerations for the lift station are outlined in Section 3.4.2.

## 5.5 Typical Drawings

Figure B-6 in Appendix B shows the general layout for in-line gate chambers and screening chambers.

## 5.6 Operations and Maintenance

Initial operation should include the inspection of screens following every WWF event to develop an understanding for the type of floatables and amount of sedimentation encountered during each high flow event. The maintenance schedule for screening facilities should be broken down as follows: after a WWF event, weekly, monthly, and every six months.

After a WWF event, operation should include the following:

- Remove remaining screenings to avoid odour and vermin nuisance. Screenings removed should be disposed of as soon as possible, and the storage area should be regularly washed and cleaned.

Manually cleaned screens require little or no equipment maintenance and provide a good alternative for smaller flows with few floatables. However, manually cleaned screens require frequent raking to prevent clogging. Cleaning frequency primarily depends upon the amount and composition of floatables in the wastewater flow. Static screens may be designed with self-cleaning features that direct collected material into the wastewater flow to be treated. After a spill event, screens should be relatively clear of debris; if excessive debris is observed, an upstream surcharge condition likely occurred.

Mechanically cleaned screens usually require less labour for operation than do manually cleaned screens, because screenings are raked or brushed with a mechanical device rather than by operations personnel. However, they still require periodic cleaning with a high-pressure hose to dislodge accumulated stringy material, and the brush or rake teeth on mechanically cleaned screens must be routinely inspected because of their susceptibility to breakage and bending.

- The upstream and downstream piping and the overflow weir should be inspected and cleaned if necessary to confirm that no build-up of sediment or malodorous materials has occurred. It should be noted that screening areas are one area where odours are difficult to avoid.
- The screen raking mechanism (raking chain, sprockets, teeth, brushes, and other moving parts) should be inspected after every WWF event to prevent fouling due to grease, grit, stringy material and rags. All moving parts should be lubricated and adjusted as recommended by the manufacturer.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections usually add the following task:

- Confirm operation of screen raking mechanism.

Every six months, screens should be taken out of service and the following completed:

- Obstructions should be removed.

- Units should be cleaned.
- Components should be checked for such potential conditions as corrosion, frayed cables, worn chains, teeth or brush replacement, and straightening of bent bars or mesh.

O&M manuals are available from suppliers, but details such as frequency of inspection and maintenance activities should be flexible and tailored to each district.

Access to chambers is required for inspection and cleaning of screens. This is addressed in Section 6.4.

Operators should maintain records of the quantities of screenings observed. They should also note any problems with screening equipment or problems associated with particularly heavy screenings loads. The occurrence of unusual or excessive quantities of screenings should prompt investigation of potential sources both to alleviate the problem at the screening works and to avoid potential problems in the upstream sewer network.

The floatables component of the **2002 CSO Management Study**<sup>1</sup> documented the results of a pilot screening study, which captured floatables in booms installed at outfalls in four districts in Winnipeg. A wide variation in floatable types and weights between the study catchments was found. In general, the debris primarily consisted of the following (in order from high to low loading rates): natural debris, grease and scum, plastics, paper products, and hygienic products.

Common problems that arise in the screening facilities are summarized in Table 5-1.

**Table 5-1. Typical Operational Problems with Screens**

Operational Problem	Cause	Solution
Odours or vermin	Improper or prolonged storage of screenings Screenings are not being returned to the trunk sewer	Provide proper storage and increase removal and disposal. Confirm that return pipe to trunk sewer is not plugged.
Excessive clogging	Unusual amount of debris in wastewater flow Velocity through screen too low Screen not cleaned often enough	Identify source of debris and implement corrective measures. Increase screen opening size. Increase frequency of screen cleaning.
Excessive grit accumulation	Low velocities in piping network	Remove irregularities in floor, weir, or channel. Flush screening chamber regularly.
Jammed raking or brush mechanism	Obstruction Moment setting for mechanism set too low	Remove obstruction. Consult manufacturer for setting adjustment.
Rake or brush will not operate	Broken mechanism Defective controls	Inspect mechanism and repair. Check control circuits, repair or replace.

<sup>1</sup> 'Combined Sewer Overflow Management Study' by Wardrop Engineering Inc., TetreES Consultants Inc., CH2M HILL Canada, and EMA Services Inc., prepared for the City of Winnipeg, Water and Waste Department

## 6. Gravity Flow Control

A short description of gravity flow control is included here to facilitate discussion of design and O&M considerations. For a more detailed description of this option see Part 2, Section 3.3.5. Orifice control was considered during the modeling exercise but is not the preferred option. Static optimization such as the raising of weirs or pipe reductions, was outside the scope of this exercise but should be evaluated during preliminary design.

### 6.1 Facilities and Equipment

Districts that discharge to the main interceptor via gravity have no mechanism to modulate flow. These districts would require installation of a flow meter and flow regulating system to allow for integrated system control. This would enable optimal and equitable discharge to the main interceptor across all districts and will give the system the ability to react to local storms, giving one district greater share of the main interceptor capacity when required.

Individual components for this option are shown on Figure 6-2 including a flow meter, flow modulator and other required instrumentation. An aboveground kiosk, housing a control panel and interface, is also required. RTC can be used to enhance this option and its operation in conjunction with other control options across districts. See Part 2, Section 7.3 for more information.

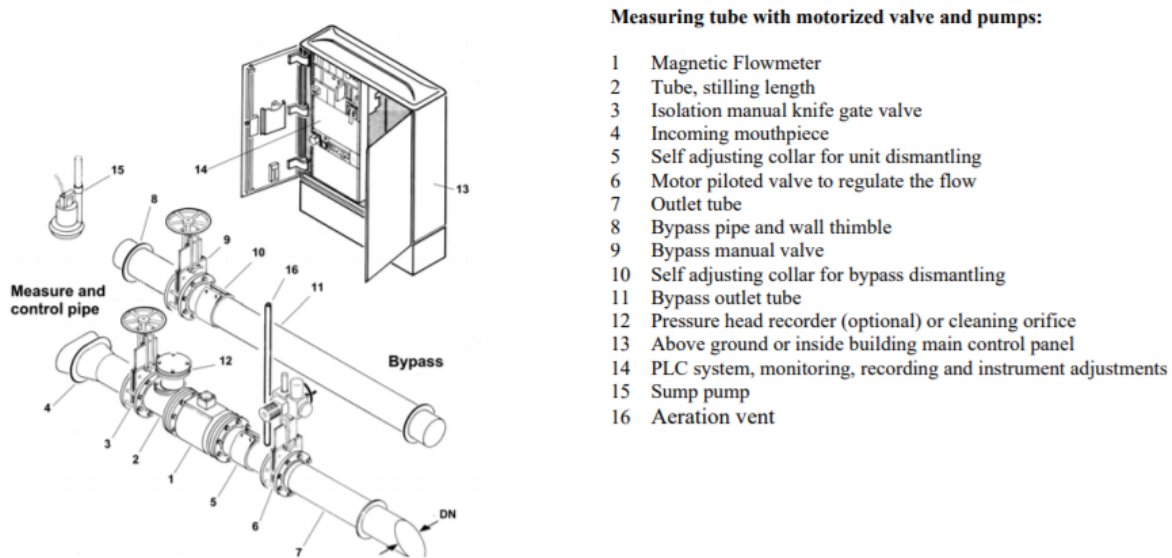
### 6.2 Product Selection

The HYDROVEX *FluidMIDu*, manufactured by Veolia Water Technologies, has been selected as the representative product for gravity flow control for the CSO Master Plan. This product has been used extensively in CSO management projects in the past and has a proven track record. Figure 6-1 shows an example installation of this product. Figure 6-2 is a labelled schematic of the components in a typical flow monitoring and regulating station.



Figure 6-1. Example of HYDROVEX® *FluidMIDu* Installation

(Picture credit courtesy of Veolia, priv comm 9/11/18)



Measuring tube with motorized valve and pumps:

- 1 Magnetic Flowmeter
- 2 Tube, stilling length
- 3 Isolation manual knife gate valve
- 4 Incoming mouthpiece
- 5 Self adjusting collar for unit dismantling
- 6 Motor piloted valve to regulate the flow
- 7 Outlet tube
- 8 Bypass pipe and wall thimble
- 9 Bypass manual valve
- 10 Self adjusting collar for bypass dismantling
- 11 Bypass outlet tube
- 12 Pressure head recorder (optional) or cleaning orifice
- 13 Above ground or inside building main control panel
- 14 PLC system, monitoring, recording and instrument adjustments
- 15 Sump pump
- 16 Aeration vent

Figure 6-2. Typical Flow Monitoring and Regulating Station

(Picture credit Veolia Water Technologies)

### 6.3 Alternative Products

#### 6.3.1 Vortex Style Flow Control Valve

A vortex-style flow control valve regulates flow by hydraulic effect. It controls the rate of discharge by creating an air-filled vortex in the valve outlet. These valves rely on upstream hydraulic head, and the flow rate can be customized for a wide range of applications. During low flows, these valves operate like an oversized orifice. During high flows, the valves create a vortex that limits the flow rate.

The advantages of vortex-style flow control valves are their stainless steel construction, which resists corrosion; their ability to maintain constant flow rate without operator intervention; their design, which reduces clogging and maintenance; and a bypass, which allows access for cleaning.

A vortex-style flow control valve could be combined with a RTC-operated gate valve to control flow rate from a catchment area to either 'On with a set flow rate' or to 'Off'. The disadvantage of this type of valve is that, once installed, the flow rate is not adjustable: it only provides one set flow rate restriction. This limitation needs to be considered in design if this type of control valve is to be installed, so that the threshold for throttled flow is correctly set.

### 6.4 Design Considerations

Consideration of available upstream storage is necessary when deciding if gravity flow control is applicable. If there is little to no upstream storage, there would be little to no benefit controlling flows. One practical application of this approach could be to only install gravity flow control in locations where there are more than two hours of dry weather flow storage upstream.

A cost benefit analysis should be undertaken. There are a variety of issues to consider during the cost benefit analysis, and the subsequent conceptual and detailed design, including:

- Ability to retrofit an existing chamber versus construction of a new station.
- Ability to construct a new station 'off-line' to reduce flow interruptions.

- Minimum and maximum flow rates to be controlled.
- Hydraulic head available.
- Fail safe mechanism should flow control valve fail closed (i.e. bypass line).
- Materials of construction for valves, piping and fittings, including linings and coatings for corrosion protection.
- Physical location of station with respect to adjacent utilities and surface structures.
- Design of any concrete structures should be in accordance with the City's Construction Work Specification CW 2160 – Concrete underground structures and works, which gives guidance on the preferred process for concrete formwork.
- Access for maintenance personnel and confined space entry. The infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified . This may be as simple as equipping crews with sewer inspection cameras mounted on poles.
- Access for replacement of flow meter and control valve.
- Vehicle access and parking for maintenance vehicles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.
- Power requirements and redundancy.

Sizing of the HYDROVEX *FluidMIDu* is dependent on the minimum and maximum flow range required. Table 6-1 shows indicative ranges achievable for various nominal diameters

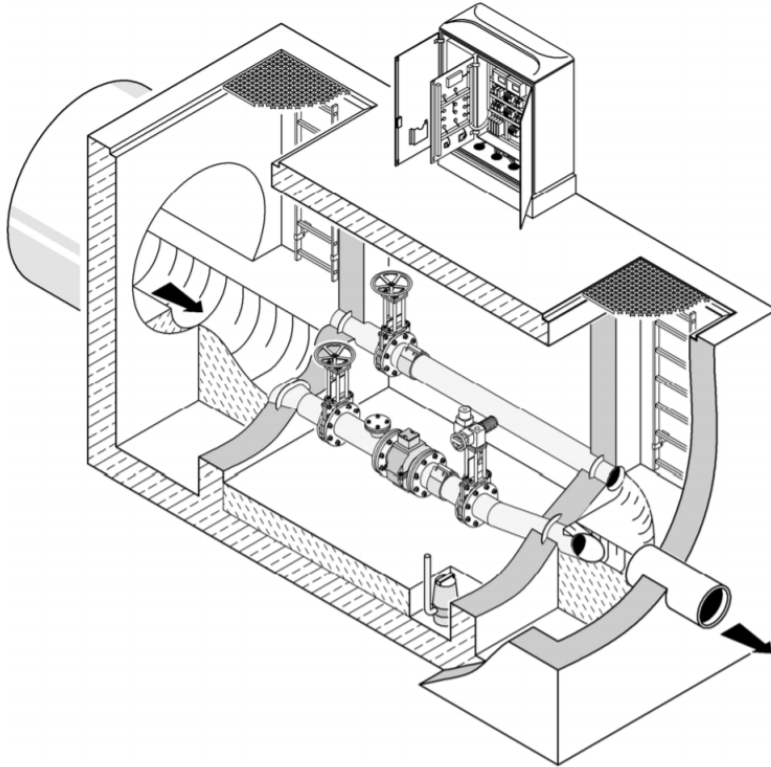
**Table 6-1. Indicative Sizing of Flow Monitoring and Regulating HYDROVEX *FluidMIDu***

Nominal Diameter (Nominal Pipe Size)	Q minimum (L/s)	Q maximum (L/s)
200 mm	10	66
250 mm	17	115
300 mm	28	182
350 mm	43	267
400 mm	61	373
500 mm	109	652
600 mm	176	1,029

## 6.5 Typical Drawings

Figure 6-3 provides an isometric drawing of a typical flow monitoring and regulating installation.





**Figure 6-3. Typical Flow Monitoring and Regulating Station Chamber**  
*(Picture credit Veolia Water Technologies)*

## 6.6 Operations and Maintenance

O&M manuals are available from suppliers, but details such as frequency of inspection and maintenance activities should be flexible and tailored to each district, as debris will differ from catchment to catchment area. If required, high pressure hoses can be used to dislodge stringy materials or other debris interfering with the proper working of the flow monitoring and regulating station.

Initial operation should include inspection of the flow control chamber and the piping and controls contained within it following every WWF event to develop an understanding for the type of debris and amount of sedimentation encountered during each high flow event. Access to the flow control chamber will be required for inspection and cleaning. As such, secure access manhole covers and ladders will be provided for these chambers.

The maintenance schedule for gravity flow controls should be broken down as follows: after a WWF event, weekly, and monthly operations.

After a WWF event, the following should be completed:

- The flow meter, flow control valve, piping and fittings should be inspected and cleaned if necessary to confirm that there is no build-up of sediment, grease, or malodorous materials.
- Moving parts should be lubricated and adjusted as recommended by the manufacturer.
- The bypass line should be checked for blockages, sediment, and grease.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections are similar to weekly inspections, plus the sump pump should be checked (if so equipped) to confirm that it functions and keeps the chamber dry.

Each station should be taken out of service for maintenance on a routine basis. Stations should be cleaned, and the components checked for potential issues such as corrosion, removal of obstructions, and flushing of piping. If not used frequently, both the valve operator and sump pump should be cycled at least once every six months.

Common problems that arise in flow monitoring and regulating stations are summarized in Table 6-2.

**Table 6-2. Typical Operational Problems with Flow Monitoring and Regulating Stations**

Operational Problem	Cause	Solution
Seat leakage	Flow control valve (usually a knife gate) not seating properly	Check for obstruction between gate and seat. Check for bent operating mechanism.
Valve difficult to operate	Operating mechanism not lubricated often enough	Lubricate.
Jammed mechanism	Obstruction Moment / torque setting for operator set too low	Remove obstruction. Consult manufacturer for setting adjustment.
Valve not operating	Broken mechanism Defective controls	Inspect mechanism and repair. Check control circuits, and repair or replace.
Excessive grit or clogging of piping	Unusual amount of debris in wastewater flow Velocity through piping too low	Identify source of debris and implement corrective measures. Flush piping regularly. Increase slope on piping.
Improper flow measurement	Magnetic flow meter not measuring properly. Mouthpiece on entrance piping missing or damaged.	Clean flow meter electrodes of grease and grit. Consult manufacturer for calibration. Repair or replace mouthpiece.

## 7. Off-Line Storage

A CSO volume can be stored off-line in either near surface or deeper underground facilities during the peak of a WWF event. Tanks, shafts, or pipes are all types of potential underground storage. Once flow subsides and sufficient capacity is available in the interceptor to convey flows to the wastewater treatment plant, the facilities are then drained into the CS.

Two types of off-line storage are presented below, tank storage and tunnel storage.

### 7.1 Tank Storage

#### 7.1.1 Facilities and Equipment

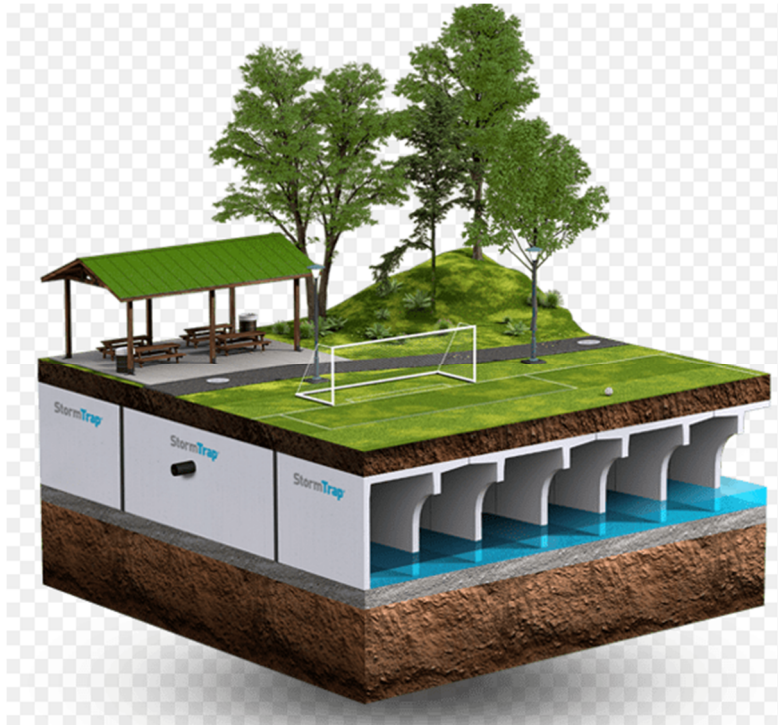
The infrastructure required for this option includes concrete or high density polyethylene storage tanks, shafts, or pipes; lift stations to either fill the storage tank and or dewater it depending on the elevation differences between the storage tank and sewer infrastructure; and level sensors, which will also allow for future RTC. Gravity flow control and odour control may also be required.

Figure B-2 in Appendix B shows a schematic representation where a high water level side weir is constructed in the main trunk, which allows overflow into an off-line deep tank via gravity. After the WWF event, the tank is drained by pumping the stored CSO volume back to the main interceptor and on to further treatment (Figure B-3 in Appendix B).

Figure B-4 in Appendix B shows a schematic representation of near surface storage. During the peak of the WWF event, flow will spill from the main trunk through a high level side weir to a pump well chamber, where it is lifted to storage at a higher elevation. After the event, dewatering can occur via gravity or by a second dewatering pump (Figure B-5 in Appendix B).

#### 7.1.2 Product Selection

Most underground CSO storage tanks are constructed from either precast or cast-in-place concrete. StormTrap by LaFarge (Figure 7-1) is a precast concrete tank system. Although traditionally used for storm water detention, StormTraps has also been used in CSO projects.



**Figure 7-1. StormTrap Detention Tank**  
*(Picture credit: LaFarge)*

**7.1.3 Alternative Products**

Alternative products would include cast-in-place reinforced concrete tanks, deep storage shafts and pipe storage.

**7.1.4 Design Considerations**

Off-line CSO storage can be either gravity fed or pumped to storage. In gravity fed storage the volume is pumped back to the sewer after the storm event. In pumped storage the volume is pumped from the sewer main to storage then released back to the sewer after the storm event at a controlled flow rate.

A cost benefit analysis should be undertaken. There are a variety of issues to consider during the cost benefit analysis, and the subsequent conceptual and detailed design, including:

- Deep storage versus near surface storage. Deep storage tanks, shafts, or pipes are costly to construct and maintain, posing a greater health and safety risk than near surface storage. In built-up urban areas, deep storage can be easier to locate away from existing underground services.
- Forcemain length and return connection length back into the interceptor. Storage tanks, shafts, or pipes should be located reasonably close to the interceptor network.
- Location of storage facility with respect to adjacent utilities and surface structures.
- Pumps and gravity flow controllers should be sized to dewater tanks within 24 hours of the WWF event.
- Design of any concrete structures should be in accordance with the City's Construction Work Specification CW 2160 – Concrete underground structures and works, which gives guidance on the preferred process for concrete formwork.

- Off-line storage tank floors should be designed with adequate slope to promote self-cleaning and adequate flushing velocities, which help to reduce the maintenance burden. Consideration should be made to installing flushing pipes along the ceiling of any storage facility to facilitate cleaning.
- Consideration should be made for mixing storage contents to help reduce accumulated solids.
- Large storage facilities should be divided into multiple compartments that can be filled sequentially to enhance flexibility and reduce clean-up time after a small wet weather event.
- Access for maintenance personnel and confined space entry. Physical access can be provided using manhole covers and ladders. However, the infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified. This may be as simple as equipping crews with sewer inspection cameras mounted on poles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.
- Vehicle access and parking for maintenance vehicles. Off-line storage systems require regular pumping and servicing. Secure service accesses must be provided into each compartment, tank, or storage pipe; and pumping access ports should be brought to or above the ground surface for emergency pumping access.
- Large off-line storage facilities should have multiple pumping ports and service accesses. All covers should be leak-proof to prevent both infiltration and exfiltration. The area around these access points should be graded, so that any spillage can be washed back into the tank.
- Power requirements and redundancy.
- Odour control.

### **7.1.5 Typical Drawings**

Figures B-2 and B-3 in Appendix B are schematic representations of an off-line deep storage tank.

Figures B-4 and B-5 in Appendix B are schematic representations of an off-line near surface storage tank.

### **7.1.6 Operations and Maintenance**

Operators should maintain records of the quantities of sludge, grit, and floatables found in any off-line storage system. They should also note any problems associated with particularly heavy rainfall events.

The maintenance schedule for off-line storage facilities should be broken down as follows: after a WWF event, weekly, monthly, and every six months.

After a WWF event, operation should include the following:

- Inspect the storage facility for significant quantities of sludge, grit, or floatables remaining in the bottom of the tank or stuck to the level controls.
- Both the tank and pumping station should be inspected and cleaned if necessary to confirm that no build-up of sediment or malodorous materials has occurred. It should be noted that holding tanks are one of the areas where odours are difficult to avoid.
- All rotating or moving parts in the pumping station should be lubricated as recommended by the manufacturer. Confirm that the float controls are operational.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections usually add the following tasks:

- Clean floats and level controller, if needed.
- Blow out lines on bubbler system, if so equipped.

- Visually inspect storage tank for grease build-up, and clean if needed.

Every six months, storage tanks should be taken out of service and the following completed:

- Inspect components for corrosion.
- Flush tanks.

O&M requirements for storage tank pumping systems are similar to lift stations. These requirements are outlined in Section 3.6.

## 7.2 Tunnel Storage

### 7.2.1 Facilities and Equipment

Tunnel storage is a variant of off-line storage, where large tunnels or pipes are used for storage instead of tanks. Unlike storage tanks, which relieve the system at a specific location, storage tunnels have multiple connections to the sewer system at strategic locations for relief at the broader system level. Tunnels have several advantages, including the following:

- Storage tunnels can convey as well as capture CSO volumes, acting as secondary interceptor sewers crossing catchment areas to utilize excess capacity in adjacent areas or transport wastewater to the treatment facility.
- Tunnels are cost competitive with storage tanks and are easier to locate in CS areas.
- Construction techniques make it possible to design tunnels at nearly any depth and alignment, allowing the tunnel to be filled from CS by gravity drainage rather than high-rate pumping.

Tunnel storage usually involves large diameter and deep pipes, often located alongside rivers to intercept the CSO volume that would otherwise be discharged to the receiving waters. Due to the difficult alluvial ground conditions, large pipe diameters, and built-up urban settings, tunnel storage is often constructed using tunnel boring machines (TBMs). TBMs are used in these situations, as they limit the disturbance to the surrounding ground, excavating at the face of the machine while concurrently building the tunnel wall around it. The CSO Master Plan considered construction of tunnels ranging up to 5,000 mm in diameter and located throughout the CS area.

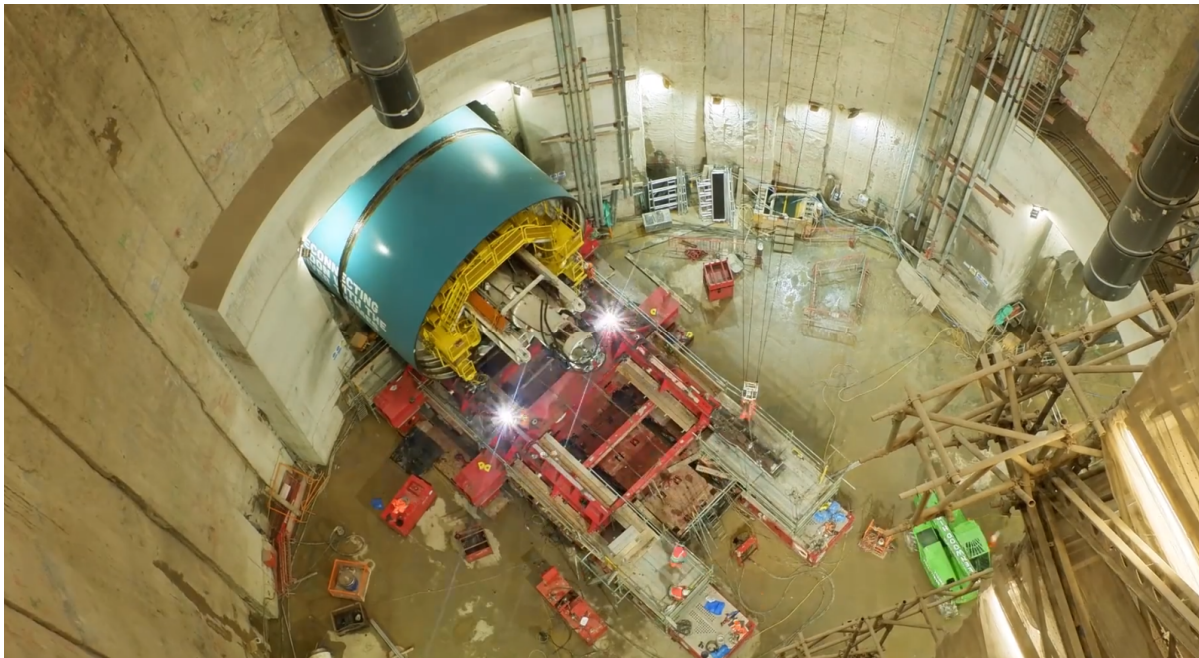
An example of a TBM is shown on Figure 7-2. Figure 7-3 shows a TBM just starting operation, after it has been lowered into a deep shaft to begin tunneling underground toward the terminal shaft.

Tunnel storage projects often include RTC components to control both the flow into storage and the dewatering process after the WWF event. Given that tunnel storage is often at depth, tunnel dewatering usually involves pumps, which also require RTC and an integrated network of level sensors and flow meters.

One of the biggest examples of a storage and transport tunnel being constructed at the time of writing is the Thames Tideway project. To be completed by 2023, the Tideway tunnel will be 25 km long, up to 7 m in diameter, and up to 66 m deep. The tunnel intercepts 34 CSO outfalls, and it will capture, store, and convey over 39 million cubic metres of untreated raw sewage that would otherwise discharge to the Thames River in the heart of London. The captured CSO volume will be conveyed to a wastewater treatment plant, which is to be upgraded and sized for the new tunnel sewer.



**Figure 7-2. Two TBMs Currently Being Used in the Thames Tideway Project in London, UK**  
 (Picture credit: <https://www.tideway.london/the-tunnel/the-engineering/>)



**Figure 7-3. A TBM Beginning Boring Operation in London for the Thames Tideway Project**  
 (Picture credit: <https://www.tideway.london/the-tunnel/the-engineering/>)

Other recent and North American examples of storage and transport tunnels are the W12 tunnel in Edmonton, Alberta; the West Side CSO Tunnel in Portland, Oregon; and the Deep Tunnel in Chicago, Illinois.

- The Edmonton W12 tunnel is a 2.5 m diameter, 1.2 km long tunnel that conveys combined sewage flows under the North Saskatchewan River to the Gold Bar Wastewater Treatment Plant during WWF events and times of high flow.
- The West Side CSO Tunnel in Portland is 4.3 m in diameter and 5.6 km long and connects to dozens of smaller sewer overflow interceptors along the western side of the Willamette River, conveying

combined sewage flows to the Swan Island Pump Station. Figure 7-4 shows the inside of a completed section of the tunnel during the construction phase and prior to commissioning.



**Figure 7-4. West Side CSO Tunnel Under Construction in Portland, Oregon**  
*(Picture credit: [https://en.wikipedia.org/wiki/West\\_Side\\_CSO\\_Tunnel](https://en.wikipedia.org/wiki/West_Side_CSO_Tunnel))*

While tunnels are a viable option for CSO control, they require a major investment and have inherent construction risks, such as variations in geology and hydrogeology and the contractor’s interpretation of these conditions.

The cost of tunnel storage was found to be comparable with off-line tank storage during the cost comparison updates. As such, each district was assessed for both tunnel storage and off-line storage during development of the Phase 2, 85 percent capture option.

**7.2.2 Design Considerations**

Tunnels are typically constructed using precast concrete, segmental lined panels. Tunnel lining design is a specialized discipline that not only looks at strength, but also at variable loadings such as ground movement and the lining’s interaction and flexural behavior, joint reaction, and seismic stability. Panels need to be coated to prevent corrosion from sulphide generation, sewage, and groundwater infiltration. Technologies should also be evaluated to prevent hydrogen sulphide gas collection in the headspace and drop shafts and the resulting odour releases.

Considerations for design of CSO tunnel storage are tunnel dimensions and alignment. The CSO volume to be stored and the location of the wastewater treatment plant are parameters that will dictate the diameter and length of the tunnel. The alignment and depth of the tunnel will be influenced by the location of the CSO outfalls or interceptor mains to be relieved, and other existing underground infrastructure.



Tunnel depth can be significant if the tunnel is to cross under a river, as was the case with the W12 siphon.

For tunnel storage, the requirement for a 4-lane road to allow construction and contractor activities is necessary to provide adequate traffic movement and minimize disruptions, as shaft chamber dimensions could be potentially restrictive for a local road location. This issue led to the proposed offline tunnel locations as defined in Part 3B of the CSO Master Plan.

### 7.2.3 Operations and Maintenance

Secure service access must be provided into the tunnel storage pipe at regular intervals. Large off-line storage facilities should have multiple service accesses. All covers should be leak-proof to prevent both infiltration and exfiltration. The area around these access points should be graded, so that any spillage can be washed back into the tank.

Physical access can be provided using manhole covers and ladders. However, the infrastructure should be designed to permit as much inspection from the surface as possible, so that entry into the structures is not required unless correctable problems are identified. This may be as simple as equipping crews with sewer inspection cameras mounted on poles. If possible, entry into structures should be located outside of roadways to avoid the need for traffic control measures.

Generally, tunnel storage is self-flushing with the next storm event. Regardless, operators should maintain records of the quantities of sludge, grit, and floatables found in the tunnels. They should also note any problems associated with particularly heavy rainfall events.

The maintenance schedule for tunnel storage facilities should be broken down as follows: after a WWF event, weekly, monthly, and every six months.

After a WWF event, operation should include the following:

- Inspect for significant quantities of sludge, grit, or floatables remaining in the bottom of the tunnel.
- The tunnel, diversion structure, and RTC chambers should be inspected and cleaned if necessary to confirm that no build-up of sediment or malodorous materials has occurred.
- If equipped with a pumping station, all rotating or moving parts should be lubricated as recommended by the manufacturer. Confirm that the float controls are operational and not covered with grease or sludge.

Weekly inspections are similar to a WWF event, if no such event has occurred in the past week.

Monthly inspections usually add the following tasks:

- Visually inspect the storage tunnel for grease build-up, and clean if needed.

Every six months, storage tanks should be taken out of service and the following completed:

- Inspect components for corrosion.
- Flush tanks and clean them of debris.

O&M requirements for pumping systems are similar to lift stations. These requirements are outlined in Section 3.6.

# APPENDIX A

## EXAMPLE SCREEN SIZING CALCULATION



## Design Tables

**Table A-1. Design Table for In-line Gate and Screening Option**

Description		Calculations	Notes
<b>Station information</b>			
Trunk Horizontal ID	d1		To Be Entered During Preliminary Design Typical for egg-shape $d1 < v1$
Trunk Horizontal OD	d2		To Be Entered During Preliminary Design
Trunk Vertical ID	v1		To Be Entered During Preliminary Design
Trunk Vertical OD	v2		To Be Entered During Preliminary Design
Invert Elevation at Diversion Weir	Inv		To Be Entered During Preliminary Design
River Normal Summer Elevation	NWL		To Be Entered During Preliminary Design
<b>Gate Chamber Design Information</b>			
Control Gate Height	GH		To Be Entered During Preliminary Design
Control Gate Width	GW		Default to d1
Control Gate Top Elevation	GTE		Invert + gate height
Side Weir Crest Elevation	SWCE		Default Invert + (GH x 0.50)
Side Weir Length	SWL		Default 50 percent of pipe width
<b>Screen Chamber Design Information</b>			
Peak Screen Rate			To Be Entered During Preliminary Design
Screen Chamber Maximum Head	Head		To Be Entered During Preliminary Design
Screen Channel Head Loss	hl_SC	0.100 m	Default value
Outfall Head Loss	hl_Out	0.100 m	Default value
Maximum Screen Loss	hl_max		Maximum head available minus hl_SC minus hl_Out
<b>Mechanical Screen Design</b>			
Design Screen Flow			Normally designed for peak
Design Screen Head Loss			Must not exceed maximum
Number of Rows			Maximum of 2
Screen Width	SW		Either 0.800 or 1.600 m
Design Screen Length			Based on manufacturer's information, selected from Table A-2
Screen Length	SL		Calculated
Screening Area			Normally designed for peak
<b>Screen Chamber Design Information</b>			
Screen Chamber Width	SCW		SW + default 0.500 m
Screen Chamber Length	SCL		SL + SWL + default 1.000 m
<b>Gate Chamber Dimensions</b>			

**Table A-1. Design Table for In-line Gate and Screening Option**

Description		Calculations	Notes
Gate Chamber Length	GCL		GH + default 4.500 m
Gate Chamber Width			d2 + default 1.000 m
Counter Weight Chamber	GCW		Manufacturer's recommendations

**Table A-2. Screen Sizing Table, based on ACU-SCREEN**  
*(Assuming 2 rows of 0.8 m wide linear screen and horizontal screens)*

Linear Screen Length (m) for Peak flow (m <sup>3</sup> /s) and Head (m)					
Flow (m <sup>3</sup> /s)	Head (m)				
	0.1	0.2	0.3	0.4	0.5
0.2	2.67	1.04	0.65	0.47	0.37
0.4	5.33	2.09	1.30	0.94	0.74
0.6	8.00	3.13	1.95	1.41	1.11
0.8	10.67	4.17	2.59	1.88	1.48
1.0	13.33	5.22	3.24	2.35	1.85
1.2	16.00	6.26	3.89	2.82	2.22
1.4	18.67	7.30	4.54	3.29	2.58
1.6	21.33	8.35	5.19	3.76	2.95
1.8	24.00	9.39	5.84	4.24	3.32
2.0	26.67	10.43	6.49	4.71	3.69
2.2	29.33	11.48	7.13	5.18	4.06
2.4	32.00	12.52	7.78	5.65	4.43
2.8	37.33	14.61	9.08	6.59	5.17
3.0	40.00	15.65	9.73	7.06	5.54
3.2	42.66	16.70	10.38	7.53	5.91
3.4	45.33	17.74	11.03	8.00	6.28
3.6	48.00	18.78	11.68	8.47	6.65
3.8	50.66	19.83	12.32	8.94	7.02
4.0	53.33	20.87	12.97	9.41	7.38


## Example Screen Sizing Calculation

Design Parameters – Cockburn:

- $Q_{\text{peak}} = 0.520 \text{ m}^3/\text{second}$
- $H_{\text{max}} = 0.650 \text{ m}$
- Inside Pipe Dimensions = 2.700 m wide x 2.075 m high
- Outside Pipe Dimensions = 3.000 m wide x 2.375 m high (assumed 0.15 m wall thickness)
- Invert Elevation = 223.070 m
- Normal Summer River Level = 223.750 m
- Control Gate Height = 1.35 m

Use Tables A-1 and A-2 and the following figures to calculate screening chamber size.

Yellow highlights are input data. 

Blue highlights are calculated. 

### Example Screen Sizing Calculation

Description		Calculations	Notes
<b>Station Information</b>			
Trunk Horizontal ID	d1	2.700 m	Typical for egg-shaped, $d1 < v1$
Trunk Horizontal OD	d2	3.000 m	
Trunk Vertical ID	v1	2.075 m	
Trunk Vertical OD	v2	2.375 m	
Invert Elevation at Diversion Weir	Inv	223.070 m	
River Normal Summer Elevation	NWL	223.750 m	
<b>Gate Chamber Design Information</b>			
Control Gate Height	GH	1.350 m	
Control Gate Width	GW	2.700 m	Default to d1
Control Gate Top Elevation	GTE	$223.070 + 1.350 = 224.420 \text{ m}$	Invert + gate height
Side Weir Crest Elevation	SWCE	$223.070 + (1.350 \times 0.50) = 223.745 \text{ m}$	Default Invert + (GH x 0.50)
Side Weir Length	SWL	$2.700 / 2 = 1.350 \text{ m}$	Default 50 percent of pipe width
<b>Screen Chamber Design Information</b>			
Peak Screen Rate		0.520 m <sup>3</sup> /second	
Screen Chamber Maximum Head	Head	0.650 m	
Screen Channel Head Loss	hl_SC	0.100 m	Default value
Outfall Head Loss	hl_Out	0.100 m	Default value
Maximum Screen Loss	hl_max	$0.650 - 0.100 - 0.100 = 0.450 \text{ m}$	Maximum head available minus hl_SC minus hl_Out

**Example Screen Sizing Calculation**

Description		Calculations	Notes
<b>Mechanical Screen Design</b>			
Design Screen Flow		0.520 m <sup>3</sup> /second	Normally designed for peak
Design Screen Head Loss		0.200 m	Must not exceed maximum
Number of Rows		2	Maximum of 2
Screen Width	SW	1.600 m	Either 0.800 or 1.600 m
Design Screen Length		3.13 m	Based on manufacturer's information – <b>From Table 4</b>
Screen Length	SL	3.500 m	
Screening Area		1.600 m x 3.500 m = 5.600 m <sup>2</sup>	Based on horizontal screens
<b>Screen Chamber Design Information</b>			
Screen Chamber Width	SCW	1.600 + 0.500 = 2.100 m	SW + default 0.500 m
Screen Chamber Length	SCL	3.500 m + 1.350 m + 1.000 m = 5.850 m	SL + SWL + default 1.000 m
<b>Gate Chamber Dimensions</b>			
Gate Chamber Length	GCL	1.350 - 4.500 = 5.350 m	GH + default 4.500 m
Gate Chamber Width	GCW	3.000 + 1.000 = 4.000 m	d2 + default 1.000 m
Counter Weight Chamber		Not applicable in this example	Manufacturer's recommendation

**Example Screen Sizing Table, based on ACU-SCREEN**

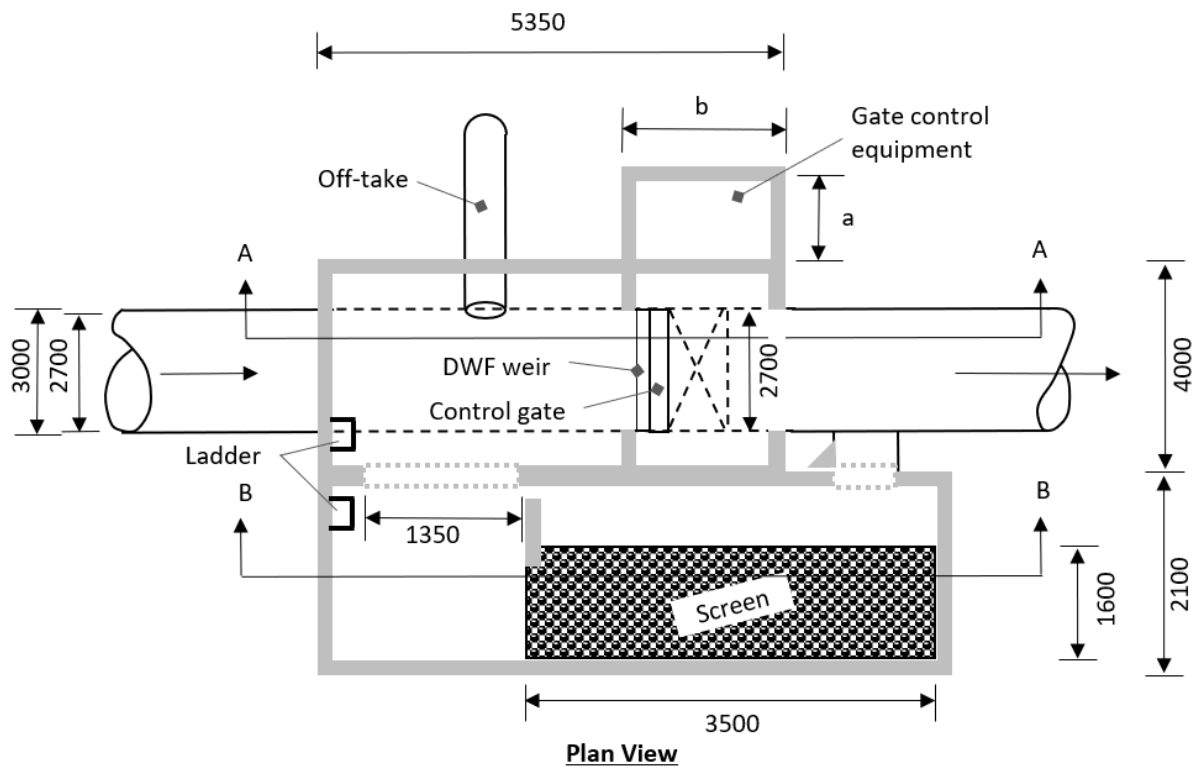
(Assuming 2 rows of 0.8 m wide linear screen and horizontal screens)

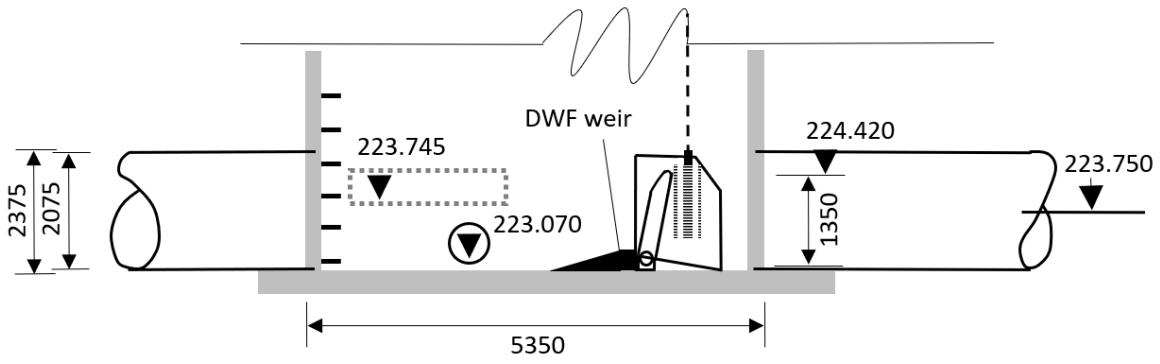
Linear Screen Length (m) for Peak flow (m <sup>3</sup> /s) and Head (m)					
Flow (m <sup>3</sup> /s)	Head (m)				
	0.1	0.2	0.3	0.4	0.5
0.2	2.67	1.04	0.65	0.47	0.37
0.4	5.33	2.09	1.30	0.94	0.74
0.6	8.00	3.13	1.95	1.41	1.11
0.8	10.67	4.17	2.59	1.88	1.48
1.0	13.33	5.22	3.24	2.35	1.85
1.2	16.00	6.26	3.89	2.82	2.22
1.4	18.67	7.30	4.54	3.29	2.58
1.6	21.33	8.35	5.19	3.76	2.95
1.8	24.00	9.39	5.84	4.24	3.32
2.0	26.67	10.43	6.49	4.71	3.69
2.2	29.33	11.48	7.13	5.18	4.06
2.4	32.00	12.52	7.78	5.65	4.43

**Example Screen Sizing Table, based on ACU-SCREEN**

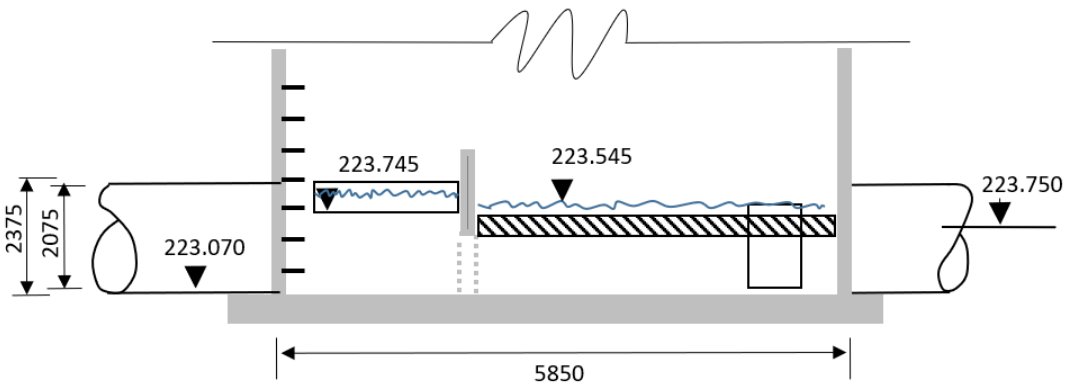
(Assuming 2 rows of 0.8 m wide linear screen and horizontal screens)

Linear Screen Length (m) for Peak flow (m <sup>3</sup> /s) and Head (m)					
Flow (m <sup>3</sup> /s)	Head (m)				
	0.1	0.2	0.3	0.4	0.5
2.8	37.33	14.61	9.08	6.59	5.17
3.0	40.00	15.65	9.73	7.06	5.54
3.2	42.66	16.70	10.38	7.53	5.91
3.4	45.33	17.74	11.03	8.00	6.28
3.6	48.00	18.78	11.68	8.47	6.65
3.8	50.66	19.83	12.32	8.94	7.02
4.0	53.33	20.87	12.97	9.41	7.38





**Section A - A**

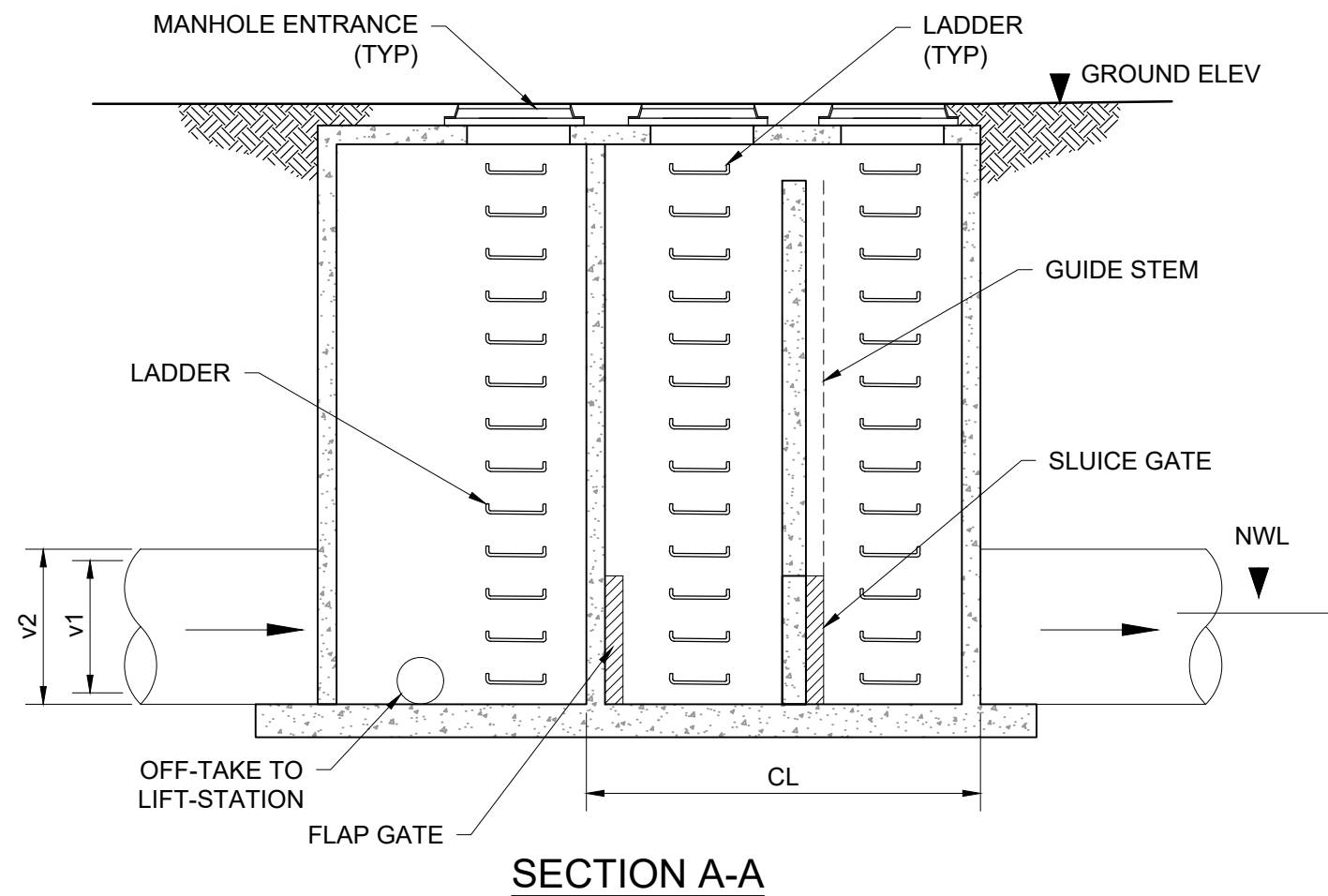
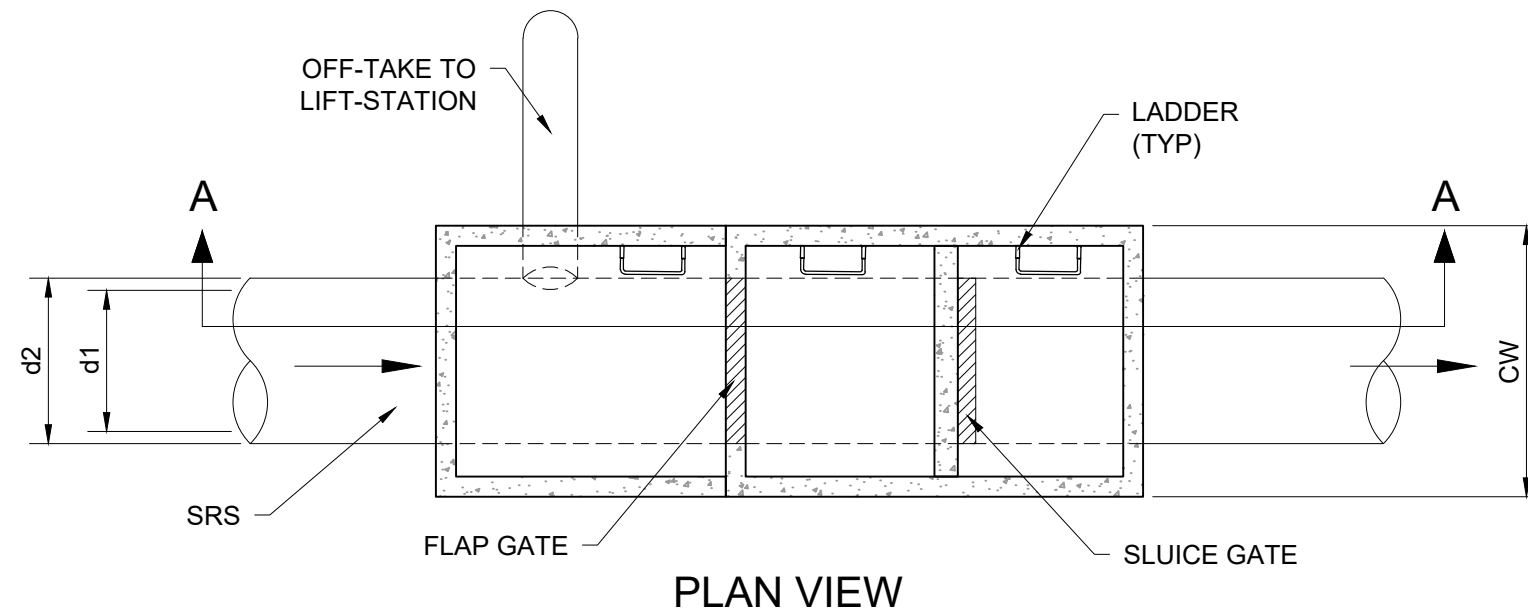


**Section B - B**

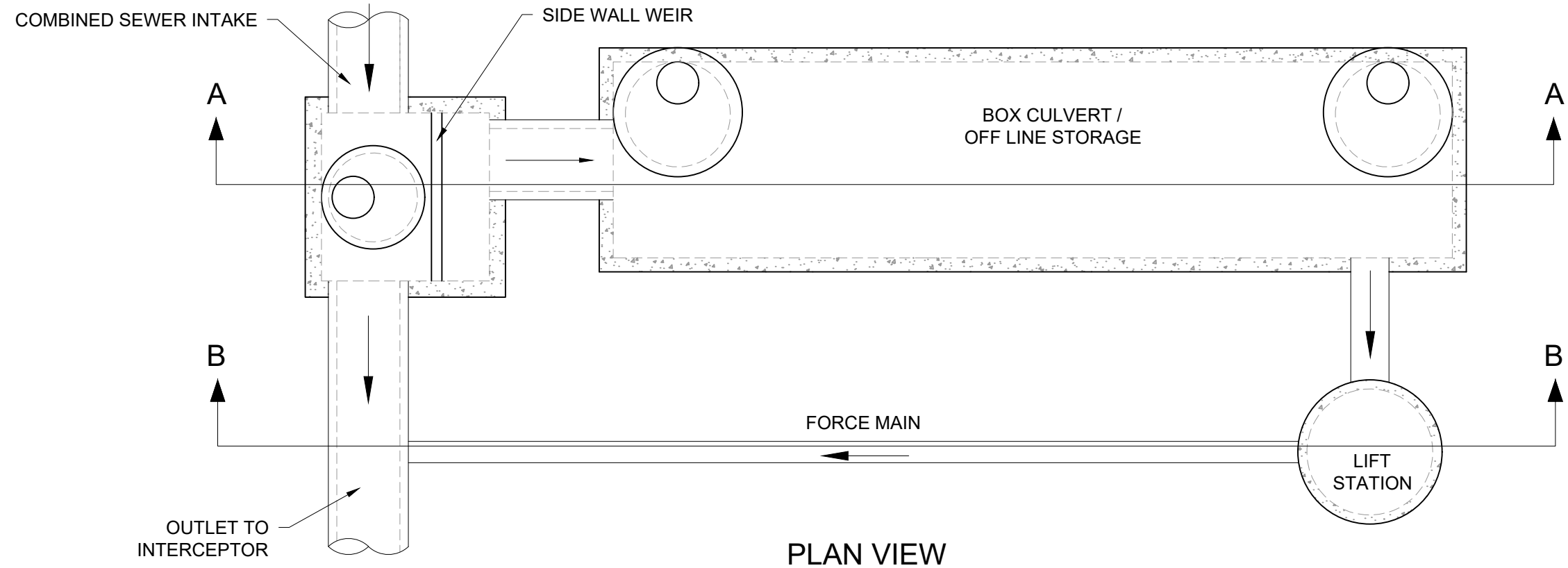


# APPENDIX B FIGURES

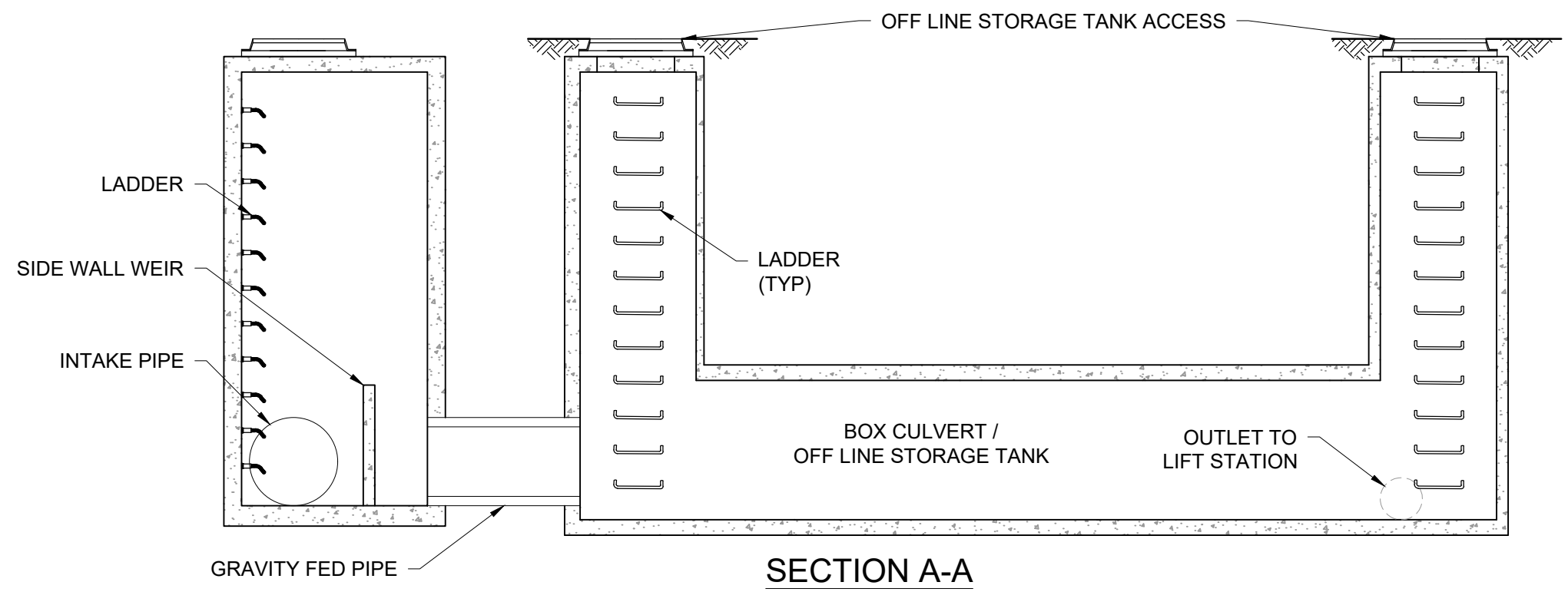




CITY OF WINNIPEG  
 CSO MASTER PLAN  
 FIGURE B-1 : SRS CHAMBER WITH FLAP  
 GATE AND OFF-TAKE



PLAN VIEW

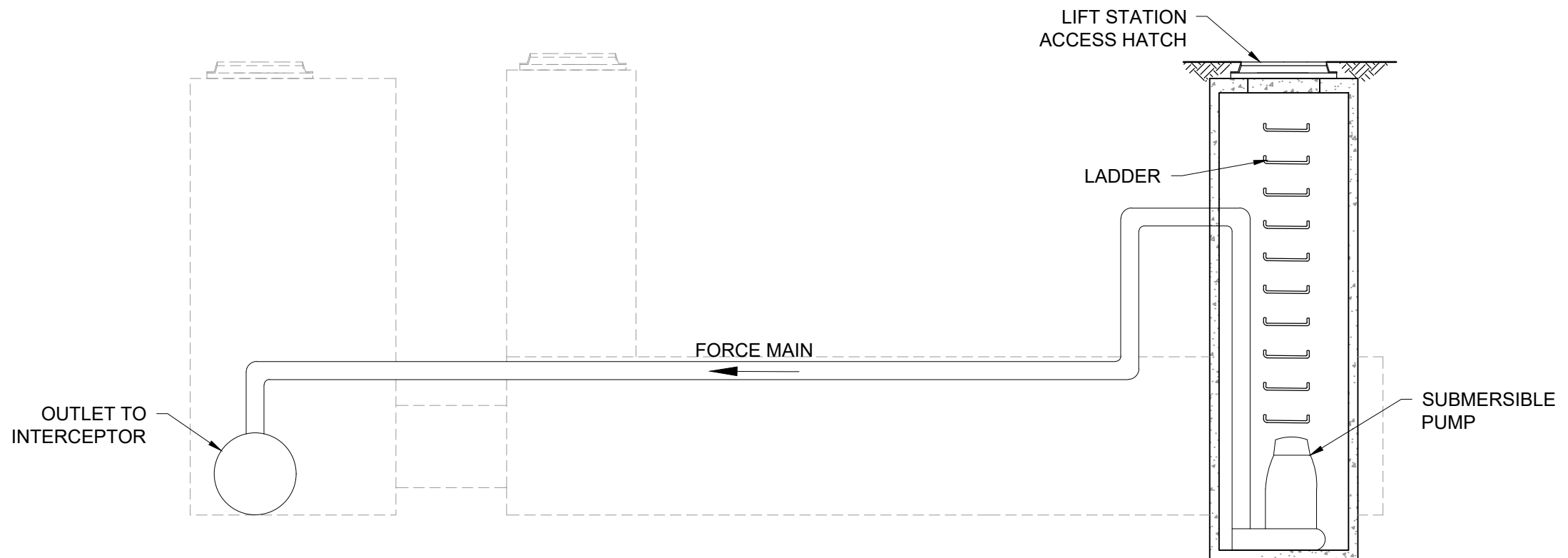


SECTION A-A

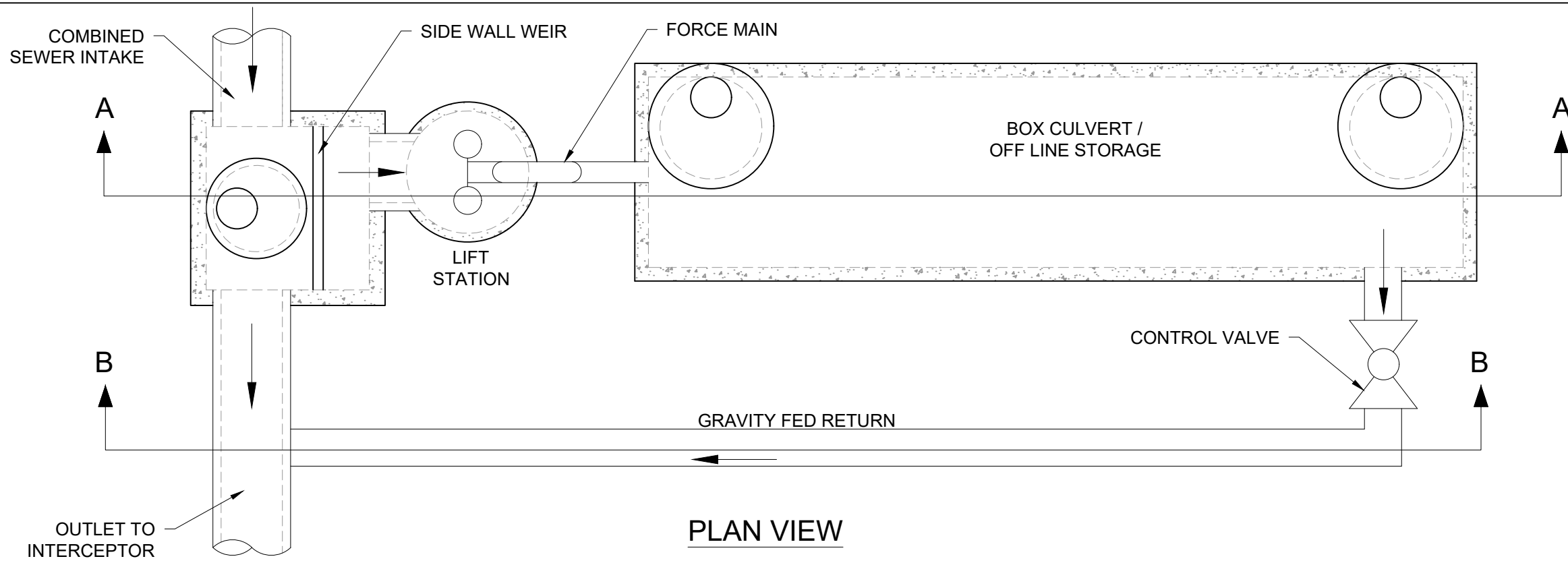


CITY OF WINNIPEG  
CSO MASTER PLAN

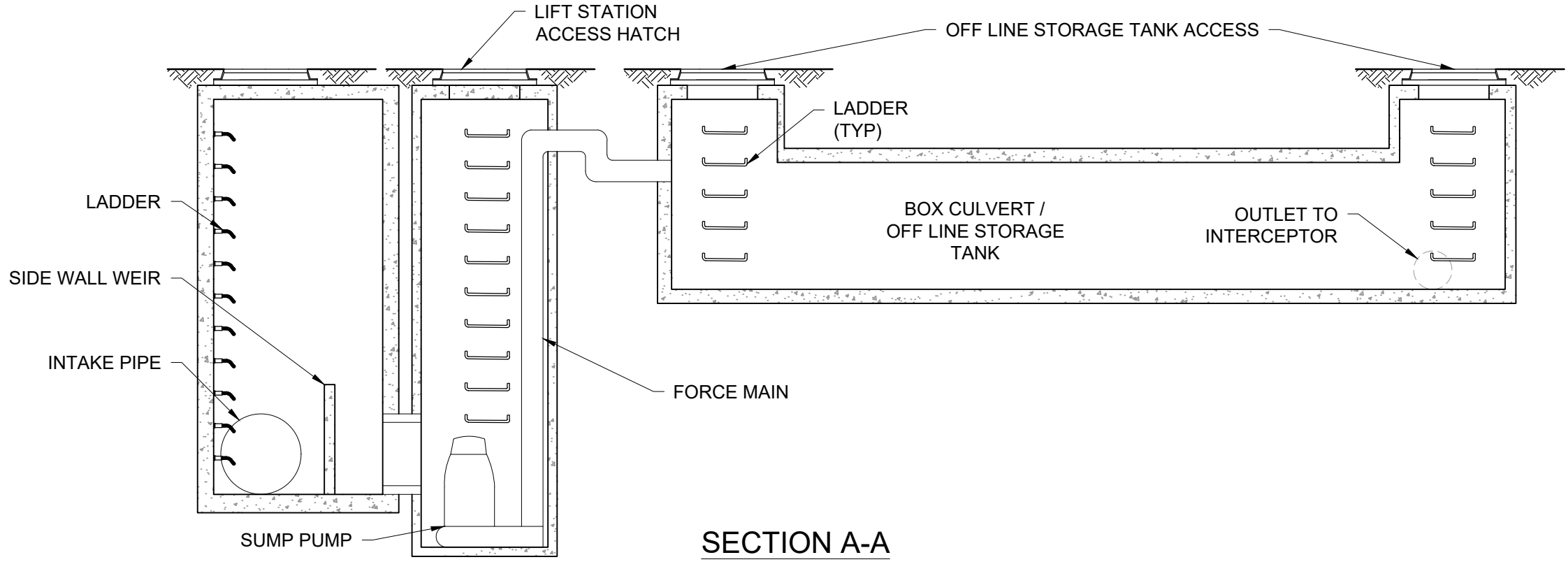
FIGURE B-2 : OFFLINE DEEP STORAGE TANK



SECTION B-B



PLAN VIEW

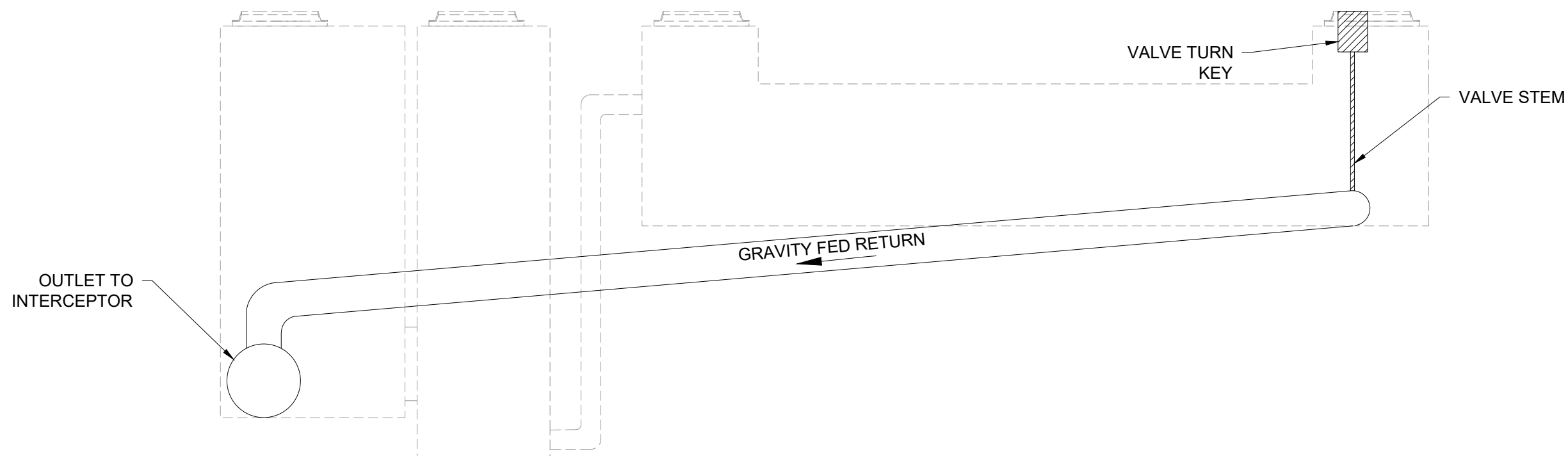


SECTION A-A



CITY OF WINNIPEG  
CSO MASTER PLAN

FIGURE B-4 : OFFLINE NEAR SURFACE STORAGE TANK

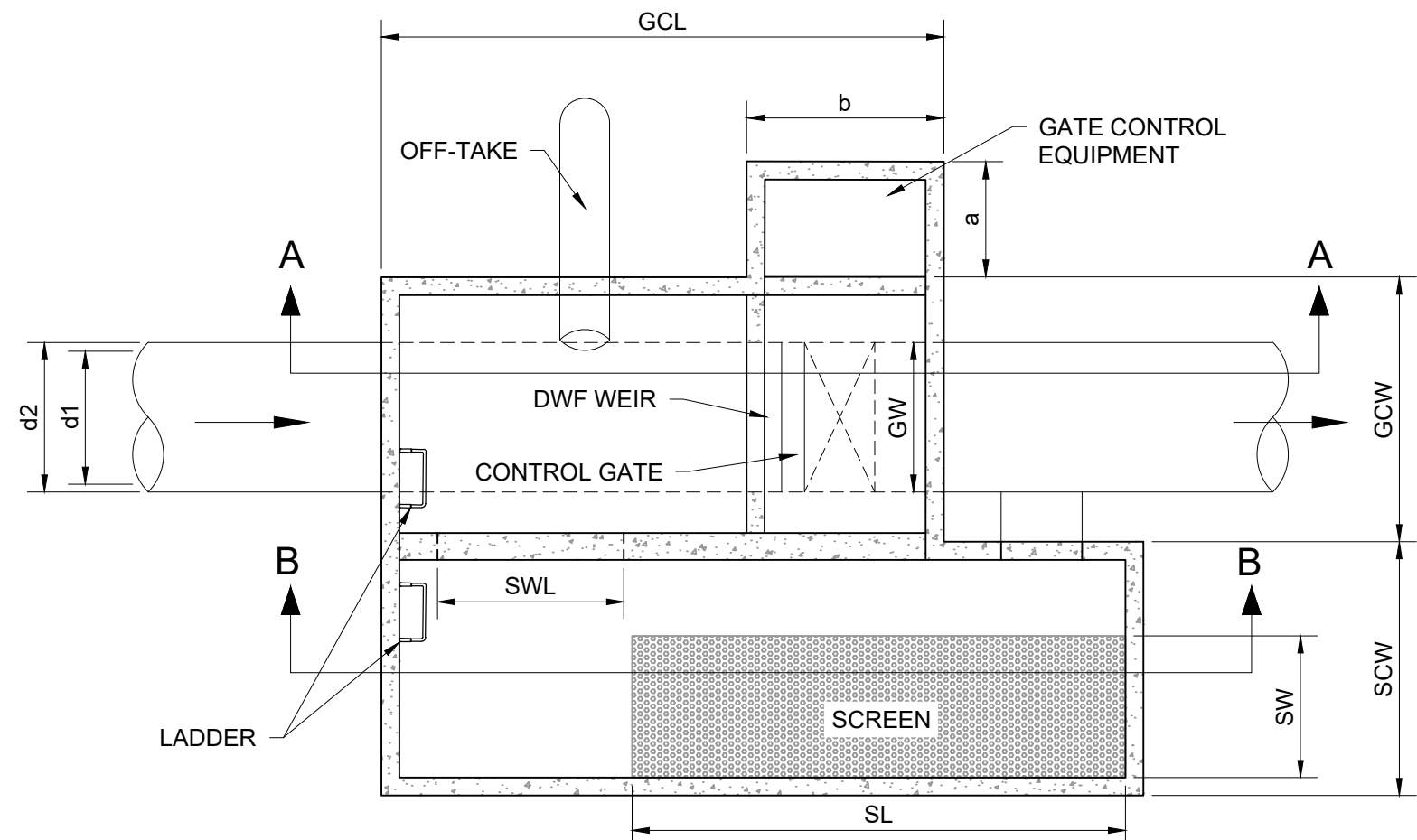


SECTION B-B

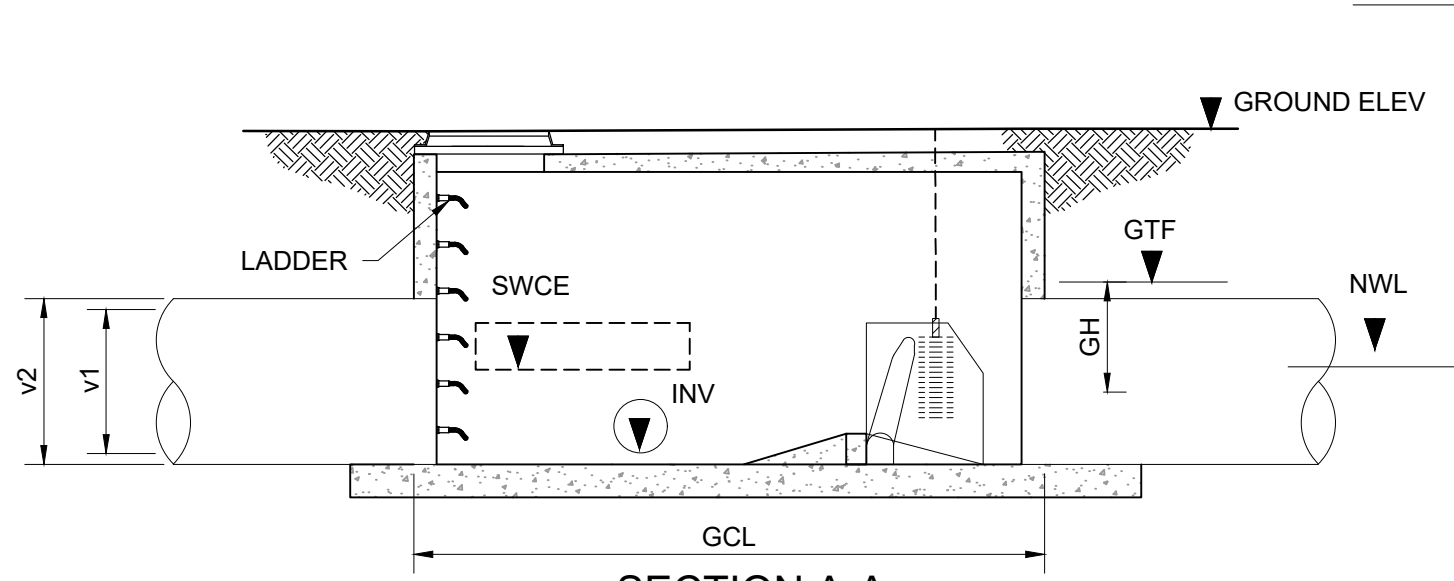


CITY OF WINNIPEG  
CSO MASTER PLAN

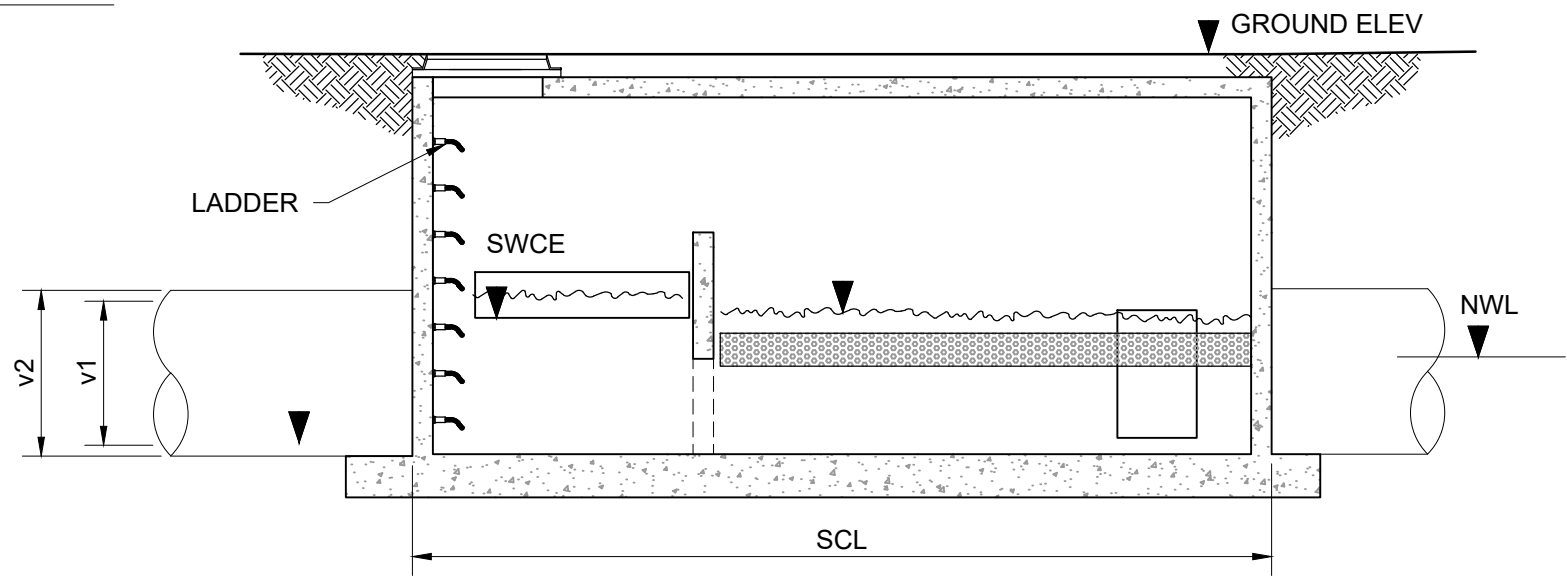
FIGURE B-5 : OFFLINE NEAR SURFACE STORAGE TANK  
2 of 2



PLAN VIEW



SECTION A-A



SECTION B-B



CITY OF WINNIPEG  
CSO MASTER PLAN

FIGURE B-6 : IN LINE GATE CHAMBER WITH  
SIDE ADDITION OF SCREENING CHAMBER

APPENDIX C  
DESIGN TABLE FOR LATENT  
STORAGE OPTION





## Design Table for Latent Storage Option

Table C-1. Design Table for Latent Storage Option

Description		Calculations	Notes
<b>SRS Dimensions</b>			
SRS Horizontal ID	d1		To Be Entered During Preliminary Design
SRS Horizontal OD	d2		To Be Entered During Preliminary Design
SRS Vertical ID	v1		To Be Entered During Preliminary Design
SRS Vertical OD	v2		To Be Entered During Preliminary Design
SRS Maximum Storage			To Be Entered During Preliminary Design
Invert Elevation at Diversion Weir	Inv		To Be Entered During Preliminary Design
River Normal Summer Elevation	NWL		To Be Entered During Preliminary Design
<b>Gate Chamber Design Information</b>			
Chamber Height			To Be Entered During Preliminary Design
Chamber Length			To Be Entered During Preliminary Design
Chamber Width			To Be Entered During Preliminary Design
Off-Take to Pump Well ID			To Be Entered During Preliminary Design
<b>Gate Design Information</b>			
Flap Gate Height			ACU-GATE available in 2 sizes: 41 cm high by 51 cm wide 41 cm high by 508 cm wide
Flap Gate Width			Calculated, usually matching chamber width.
Sluice Gate Height			Calculated
Sluice Gate Width			Calculated
<b>Pump Design Information</b>			
Dewatering Rate			From storm water modelling
Wet Well Depth			To Be Entered During Preliminary Design
ON Level			Calculated, based upon sump capacity and dimensions
OFF Level			Calculated, based upon sump capacity and dimensions
No. Pumps			Minimum design capacity with one pump out of service
<b>Force Main Design Information</b>			
Force Main ID			To Be Entered During Preliminary Design
Force Main Length			To Be Entered During Preliminary Design

Notes:

ID = inside diameter

Inv = Invert

NWL = Normal Water Level

OD = outside diameter