SEWPCC Upgrading/Expansion
Conceptual Design Report

SECTION 3 - Design Flows and Interceptor Capacity

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3.0 Design Flows and Interceptor Capacity

3.1 INTRODUCTION

The purpose of this section is to confirm the design maximum Wet Weather Flow (WWF) to the SEWPCC. Finalizing the magnitude of the WWF is required in order to proceed with the sizing of new pumps, the determination of total and firm pumping capacity requirements, stand-by power requirements, by-pass channels, the proposed outfall twinning and other items in the plant required to convey the WWF.

This section will:

- Review the Preliminary Design Report (PDR) WWF conclusions as they compare to the Phase 1 South End Water Pollution Control Centre (SEWPCC) Service Boundary Inflow and Infiltration (I/I) and Cross-Connection Study (Wardrop, 2007) draft conclusions and recommendations.
- Summarize the findings of a more detailed examination of the St. Mary's Interceptor capacity using the hydraulic modeling software InfoWorks by Wallingford software. The implications of the proposed "Waverley West" Interceptor to the SEWPCC collection system will also be described.
- Describe a preliminary strategy for Basement Flood Relief of the SEWPCC Catchment area.

3.2 SOUTH END I / I STUDY PHASE 1 OVERVIEW

In January 2007 a draft copy of the Phase 1 SEWPCC Service Boundary Inflow/Infiltration and Cross-Connection Study (Wardrop, 2007) was delivered to the City. The study stated that the maximum I / I generation rate averaged over the entire SEWPCC service area was about 0.55 l/s/ha on March 31 2006. The next largest overall rate was only 0.33 l/s/ha. The study stated that "based on the 2006 data, the overall SEWPCC service area would not appear to have a significant I / I problem". The study also stated that "from past experience it is known that this not the case, the SEWPCC has a great problem with I / I." The low I / I generation rates experienced in 2006 could result from the fact that 2006 was one of the driest years in regards to lack of rainfall in recent memory.

Since 2006 was a very dry year and not representative of the precipitation that occurs during a normal year, the study has recommended that the operation of the Phase 1 primary and secondary monitoring networks continue into 2007. The reason for the extension is to obtain more typical data, so greater insight into the SEWPCC service area I /I conditions can be obtained. 2007 was a much wetter year, and while further data was collected, to date further analysis has not been completed.

An InfoWorks® hydraulic model of the SEWPCC was developed as part of the Phase 1 Study. The I / I model was calibrated using flow values obtained during 2006. The I / I calibration was based on the dry conditions of 2006, which had low soil saturation for all events. The cross connections between the waste water sewer and the land drainage sewer had not yet been identified and thus are not included in the model.

The Phase 1 Report is still a draft document. The results are also inconclusive as they relate to establishing a maximum hour and maximum day 2031 design flow to the plant.

Therefore, since the Phase 1 Study results were inconclusive due to a dry 2006 monitoring season, the preliminary results from the 2031 design flows developed in the SEWPCC Upgrade / Expansion PDR will be used as the design flows for the plant expansion.

3.3 YEAR 2031 - DESIGN WET WEATHER FLOWS

As stated in Section 3.2, the 2031 design flows developed for the SEWPCC Upgrade / Expansion PDR will be used as the design flows for the plant expansion.

Assumptions used in the PDR to develop the 5 year Design WWF included:

- The WWF was distributed equally across the existing area regardless of the type of land use.
- The average population density throughout the South End area of 27.5 people per hectare was used to allocate these flows to each of the sewer districts, both for existing and future developed areas.
- The areas developed from 2005 to 2031 are assumed to have I/I equal to 25% of the current estimated I/I to account for new areas having tighter systems and enforcement of sump pump and lot-grading bylaws.
- The hourly and daily flow records for the past five years were analyzed to determine a peaking factor to estimate hourly flow based on the daily maximum flow. On average, the wet-weather hourly peaking factor was 1.6 times the maximum flow each year. Therefore, the estimate of the maximum hourly event is determined by multiplying the maximum day event times 1.6.

Based on the above assumptions the flows established for the 2031 Design Period are a summer maximum day flow of 300 ML/d and a summer maximum hour flow of 480 ML/d.

3.4 ANALYSIS OF INTERCEPTOR CAPACITY

3.4.1 Revisions to the InfoWorks® Model

As stated in Section 3.2, a calibrated model of the SEWPCC interceptor collection system was developed as part of the Phase 1 SEWPCC Service Boundary Inflow/Infiltration and Cross-Connection Study (Wardrop, 2007). This model was calibrated using flow monitoring data gathered during 2006.

The 2031 design flows established in the SEWPCC Upgrade / Expansion PDR were input into the InfoWorks model. This was achieved by inputting the new and existing area WWF rates developed in the PDR into the Infoworks model. The WWF rates were inputted in the model as a steady-state flow.

The InfoWorks® model was set up to convey all flows through the SEWPCC plant without restrictions. Therefore, pumping was not a limiting factor in the model. To accurately model the collection system in 2031, the proposed Waverley West Interceptor was included in the model.

The catchment area for the Waverley West Interceptor includes all existing sewer districts south of Bison Drive and the University of Manitoba lands. This includes the sewer districts of Kilkenny, Area 14, Grandmont and St. Norbert. All remaining sewer districts in the SEWPCC Catchment Area are part of the St. Mary's Interceptor's catchment area.

Figure 3.1 shows a schematic of the existing SEWPCC interceptor system including the future Waverley West Interceptor.

To model the effects of future elimination of Wet Weather Overflows (WWO) in the system, all overflows were removed from the InfoWorks Model (i.e. D'Arcy, St. Mary's, Kilkenny, Windsor Park, Mager, U of M, Willow and Crane).

The reasoning for considering this condition is the trend by regulators across North America to implement strategies designed to reduce, eliminate or control these overflows. At some time in the future, it is possible that Manitoba Conservation will either move to reduce or eliminate WWO from the South End wastewater collection system.

Modeling the elimination of the St. Mary's Overflow will also show the effects on the collection system during high river levels when the St. Mary's overflow becomes non-operational. Therefore, to model the future elimination of WWO in the system, the InfoWorks® model is setup so that all flows generated in the SEWPCC Catchment area will be conveyed to the plant.

The calibrated InfoWorks® model will be used to model different flow scenarios and to confirm the capacity of the St. Mary's Interceptor, which was documented in Section 9 – St. Mary's

Overflow / Interceptor System of the PDR. These results were estimated using a steady-state un-calibrated Excel spreadsheet model.

The four scenarios which were modeled using InfoWorks® for this section are:

1. System response to a 2031 Maximum Day Design Flow of 300 ML/d.
2. System response to a 2031 Maximum Hour Design Flow of 480 ML/d.
3. Determination of the Maximum Capacity of the St. Mary's Interceptor.
4. System response to a Max Hour Flow with Standby Pumping of 300 ML/d.

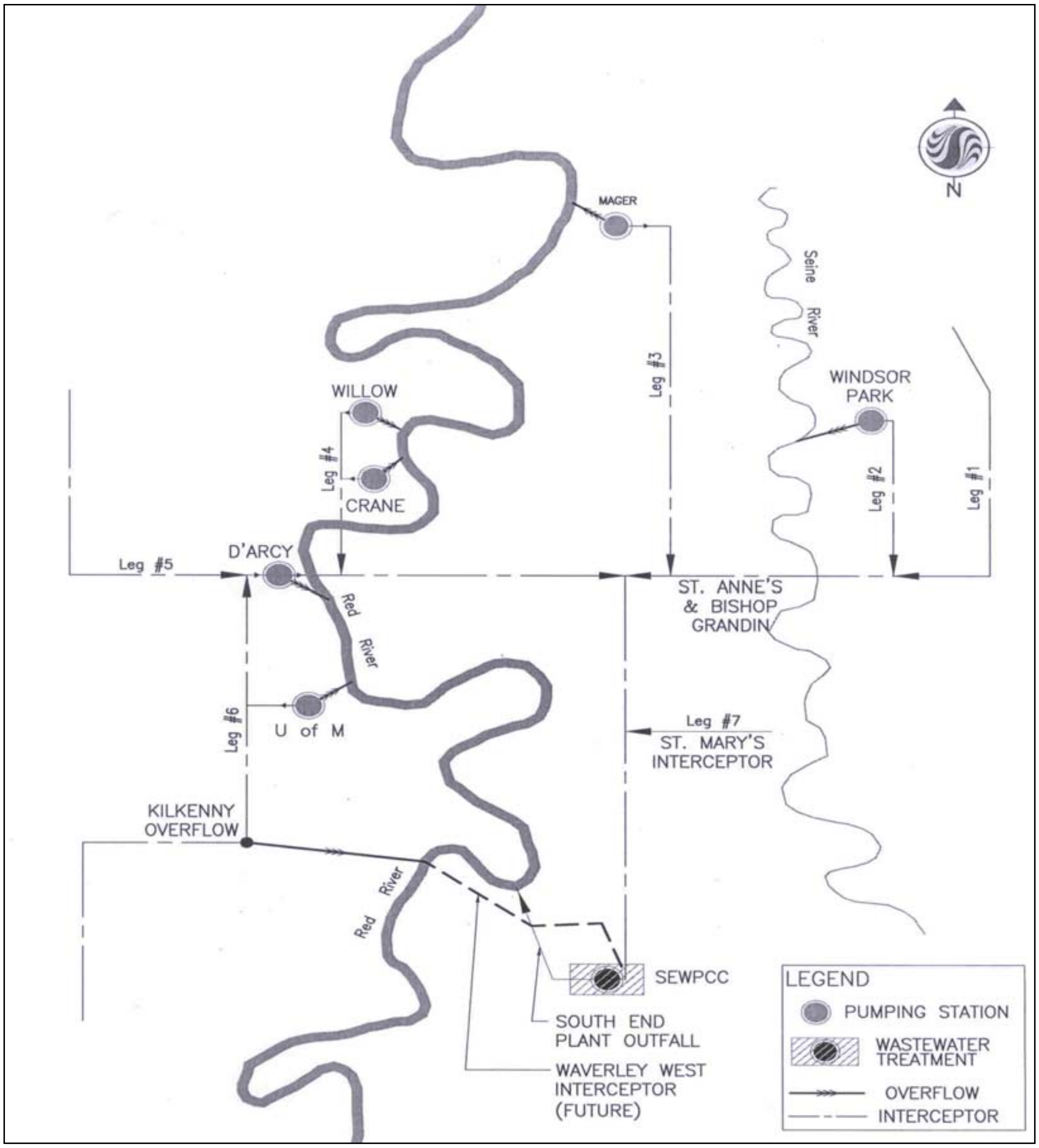

Figure 3.1: Schematic showing the SEWPCC Collection Systems

3.4.2 Scenario 1 - 2031 Maximum Day Flow of 300 ML/d

This scenario demonstrates the effects on the system when the 2031 maximum day design flow of 300 ML/d was input into the InfoWorks® Model. The model was run and the results showing the hydraulic profile for the St. Mary's Interceptor and the Waverley West Interceptor are shown in Figure 3.2. Basements levels were assumed to be 2.5 meters (8 ft) below ground level. The model demonstrates that the design maximum day flow of 300 ML/d is easily conveyed to the plant with only minor surcharging along the pipe. For this scenario the flow distribution between the two interceptors was 280 ML/d through the St. Mary's Interceptor and 20 ML/d through the proposed Waverley West Interceptor.

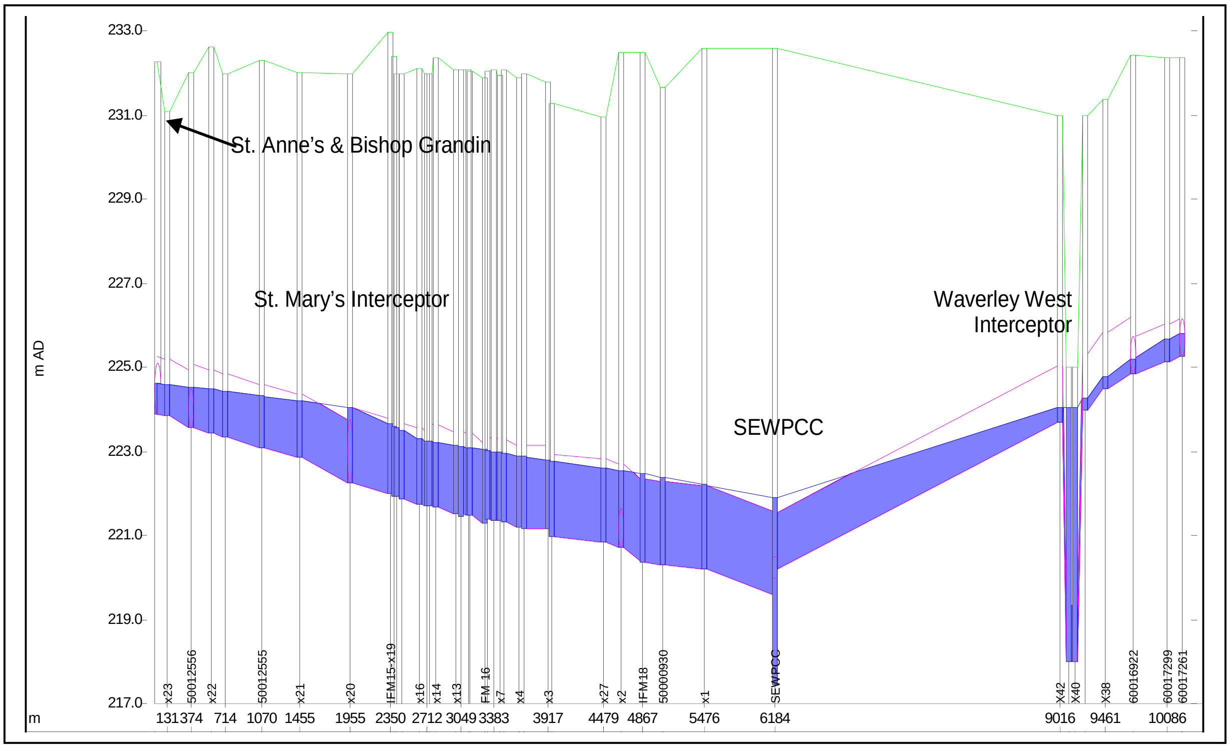

Figure 3.2: Hydraulic Profile for a Flow of 300 ML/d

3.4.3 Scenario 2 - 2031 Maximum Hour Flow of 480 ML/D

This scenario demonstrates the effects on the system when the 2031 maximum hour design flow of 480 ML/d was input into the InfoWorks® Model. The model was run and the results showing the hydraulic profile for the St. Mary's Interceptor and the Waverley West Interceptor are shown in Figure 3.3. Basements levels were assumed to be 2.5 meters (8 ft) below ground level. The model demonstrates that the design maximum hour flow of 480 ML/d is conveyed to the plant with surcharging occurring along the length of the St. Mary's Interceptor. The highest point of the surcharging for this scenario occurs at the location of St. Anne's Road and Bishop Grandin Boulevard where the Hydraulic Grade Line (HGL) is still approximately 4.0 m below the ground level. This HGL is 1.5 m below the assumed basement elevation of 2.5 m. For this scenario the flow distribution was 363 ML/d through the St. Mary's Interceptor and the proposed Waverley West Interceptor conveying 117 ML/d.

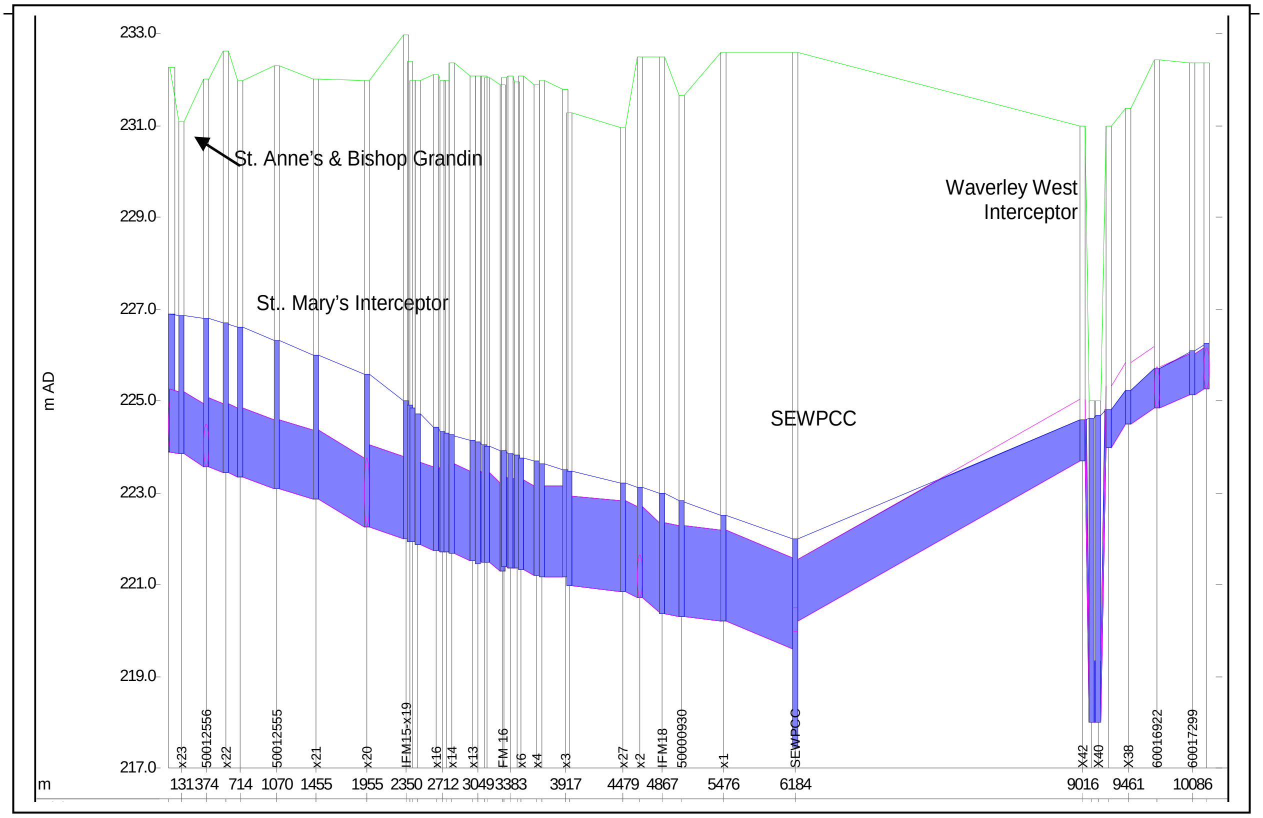

Figure 3.3: Hydraulic Profile for a Peak Hour Flow of 480 ML/d

3.4.4 Scenario 3 - 2031 Maximum Flow through the St. Mary's Interceptor

This scenario was run to determine the maximum flow that could be conveyed through the St. Mary's Interceptor. The limiting factor that determines the maximum amount of flow that can be conveyed through the pipe is the elevation of the HGL, which cannot exceed 2.5 m below ground level at any point along the interceptor in order to protect against basement flooding.

The model was run with a series of progressively larger flows until modeling results demonstrated a HGL that was 2.5 m below ground level at some point within the collection system.

Figure 4.4 demonstrates that a flow of 430 ML/d produces a HGL of 2.5 meters below ground level at the St. Anne's Road and Bishop Grandin Boulevard location. Therefore, this scenario demonstrates the maximum flow that can be conveyed through the St. Mary's Interceptor is 430 ML/d.

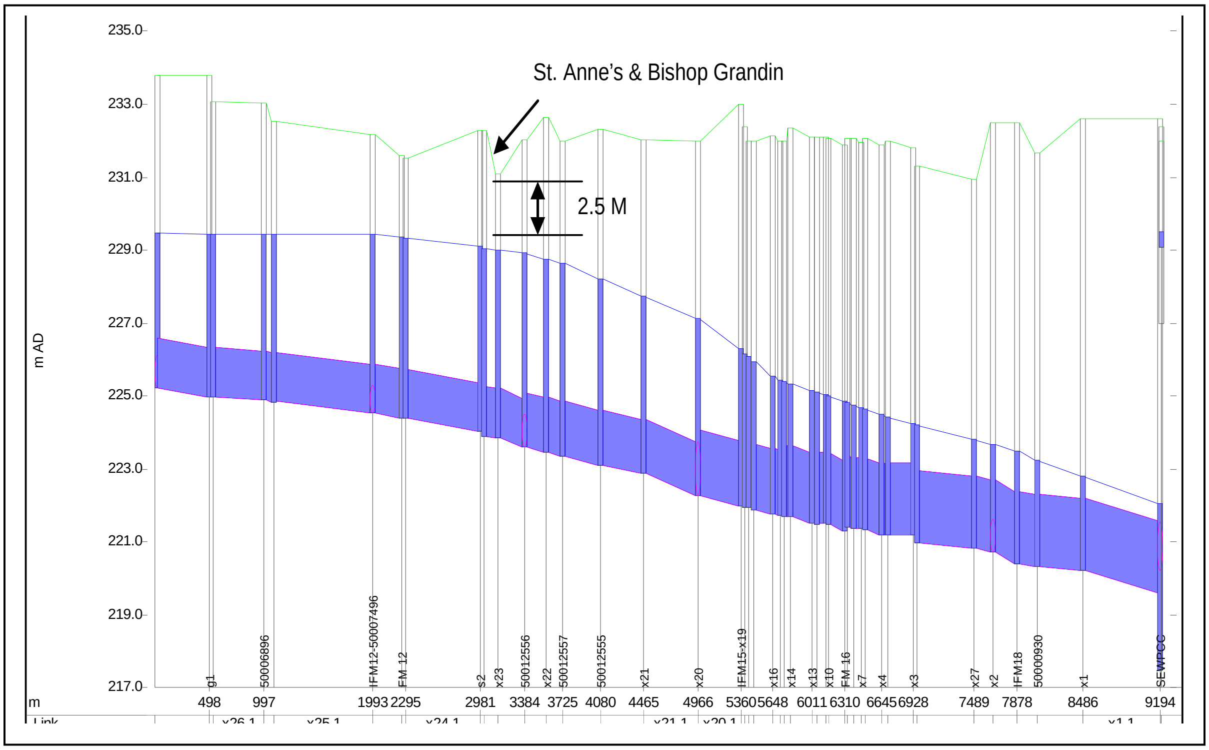

Figure 3.4: Hydraulic Profile for a Flow of 430 ML/d being conveyed through the St. Mary's Interceptor

3.4.5 Scenario 4 - 2031 Maximum Hour Flow of 480 MLD with 300 MLD Pumping at the Plant and Shedding at D'Arcy

The PDR indicates a Total Pumping Capacity of 415 ML/d and a Firm Pumping Capacity of 300 ML/d. This scenario was run to determine the effect on the system if during a maximum hour event of 480 ML/d one of the large pumps was inoperable resulting in only 300 ML/d of available pumping. In this scenario, it was assumed the option of shedding flow at D'Arcy would be implemented. This would simulate a situation where standby pumping at the SEWPCC was only available for the firm pumping capacity of 300 ML/d and the Red River was at a stage that made the St. Mary's interceptor overflow non-operational. This scenario would be considered a "worst case" in regards to events happening that would create the greatest flood risk to basements in the catchment area.

The model was run with the above described conditions. As the HGL is approximately 1.5 m below the ground level, it can been seen in Figure 3.5 that this scenario produces basement flooding in the area around St. Anne's Road and Bishop Grandin Boulevard.

During this scenario approximately 292 ML/d is flowing through the St. Mary's Interceptor with 180 ML/d being discharged at D'Arcy and 8 ML/d flowing through the Waverley West Interceptor.

It can be seen in this scenario that less flow is going through the Waverley West Interceptor than what occurred in Scenario 2. Flow results from the model showed the flows on the west side of the river following the path of less resistance, which was toward the D'Arcy overflow instead of flowing to the plant via the Waverley West Interceptor, which is severely surcharged due to the decreased pumping capacity at the plant. This occurred because the model still had the two interceptor catchment areas connected via a highpoint manhole.

The advantage or disadvantage of leaving the two catchment areas connected will require further examination in the future as part of the design of the Waverley West Interceptor.

It also should be noted that this scenario assumes that the system does not have any cross connections to the Land Drainage System that would result in some reduction in the flow to the plant. At this point the effect of these cross connections cannot be quantified.

This scenario also highlights the problem of basement flooding caused by high extraneous inflows into the system. Any removal in the future of extraneous inflows will provide multiple benefits such as decreased flows to the plant, the freeing up of capacity in the collection systems and reducing the probability of basement flooding during extreme rainfall events.

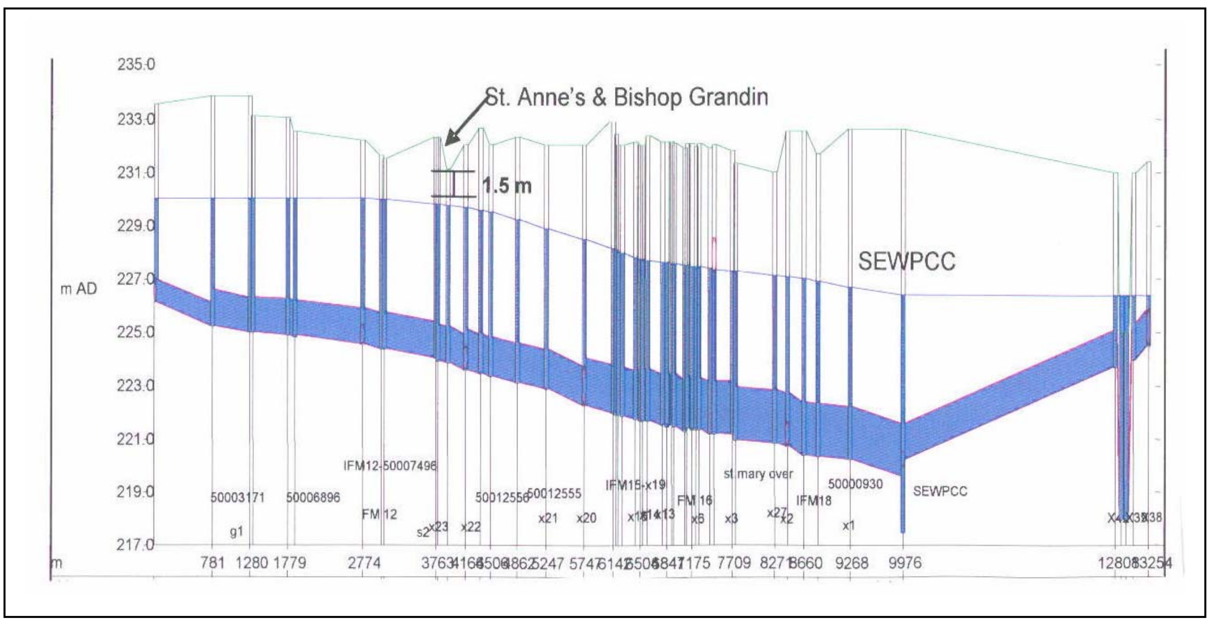

Figure 3.5: Hydraulic Profile for a Flow of 480 ML/d with Firm Pumping (300 ML/d) and shedding at D'Arcy

3.5 SEWPCC RAW SEWAGE PUMPING

3.5.1 Total / Firm Pumping Capacity

The current City standards for designing the capacity of a pumping station is 3 times Dry Weather Flow (DWF) for a separated system and 2.75 times DWF for a combined system. The City confirmed that combined system pumping stations in the future will be designed for 4 to 5 times DWF.

The proposed SEWPCC firm pumping capacity presented in the PDR is 300 ML/d and the total pumping capacity is proposed to be 415 ML/d. Based on the 2031 DWF of 68.4 ML/d, the firm pumping capacity at the Plant would be 4.4 times the DWF and the total pumping capacity would be 6.06 times the DWF.

A firm pumping capacity of 300 ML/d is within the design objectives of 4 to 5 times DWF. With the ability to shed flows in excess of 300 ML/d at D'Arcy and at the St. Mary's overflow (during normal river levels) the City will have exercised reasonable care in protecting against basement flooding within the SEWPCC service area. Therefore, it is recommended that the City design the SEWPCC raw sewage pumping capacity with 300 ML/d firm pumping capacity and 415 total pumping capacity.

3.5.2 Standby Power Requirements

During a major rainfall event it is possible that the SEWPCC may experience a power failure, necessitating the use of standby power to operate the pumps in order to handle the incoming WWF.

The current City policy for the design of separated and combined sewer pumping stations is to provide standby power for the total pumping capacity of the station, which are typically two pumps.

In the case of the SEWPCC it is proposed to provide standby power for the Firm Pumping Capacity of 300 ML/d.

3.6 SEWPCC COLLECTION SYSTEM FLOW MONITORING

The operation of the SEWPCC and the south end collection system should be considered as an Integrated System. If any future system operation includes the decision to shed flow at D'Arcy (and/or other locations) to prevent basement flooding, water level or flow information at strategic locations throughout the South End Collection System will be required.

By installing additional flow monitoring equipment within the collection system and connecting it to a ‘live” model of the collection / treatment system, the integrated sewer system could be actively managed to maximize the capture of sewer flow and minimize the risk of basement flooding.

The SEWPCC would be a logical location where system management decisions could be made and actions taken. However, currently the SEWPCC is unmanned after normal work hours. If the current operating procedures continue at the SEWPCC, the after hour responsibilities could be transferred to the McPhillips Pumping Station, which has personnel on duty 24 hours a day.

It is recommended that the City investigate the operation of the SEWPCC and South End Collection System as an integrated system. Furthermore, it is recommended that the City install permanent flow monitoring equipment in strategic locations within the system to feed “live” information to a future “live” model at the SEWPCC.

3.7 BASEMENT FLOOD RELIEF STRATEGY FOR SEWPCC CATCHMENT AREA

Scenario 4 presented in Section 3.4.5 demonstrated that if a high flow event such as a maximum hour flow of 480 ML/d were to occur when only a standby pumping capacity of 300 ML/d is available, there would bring be a high risk of basement flooding within the SEWPCC catchment area.

The following are measures that the City could implement to decrease the risk of basement flooding within the SEWPCC catchment area.

- During normal operations the expanded plant will be able to handle flows up to 415 ML/d, which is the recommended total pumping capacity. If there was a power failure at the plant only the firm pumping capacity of 300 ML/d would be available via the standby power generation.
- WWF greater than 415 ML/d (or 300 ML/d during a power outage) would be required to be shed to the Red River without treatment. Manitoba Conservation has recently provided a clarification to Clause 28 of the SEWPCC license. The clarification states that flows greater than 300 ML/d will not require any treatment prior to discharging to the river. Therefore, this activity would be within the intent of the license.
- During normal river levels the St. Mary’s overflow could be used to shed any additional flow over 300 ML/d. However, during high river levels the St. Mary’s overflow becomes non-operational. At this point it is recommended that flows coming from the west side of the river via the D’Arcy pump station be shed directly to the Red River. On the east side of the river both the Mager and the Windsor Park pumping stations could also shed flow directly to the Red or Seine Rivers. This would further reduce the flow directed to the plant.

- As stated earlier in Section 3.7, this type of basement flood relief strategy would require some intelligence of the system performance (i.e. flows and levels). This “real time” information could be communicated to the SEWPCC, (or the McPhillips Pumping Station after normal operating hours), where decisions regarding the appropriate action to protect basements from flooding could be performed.

3.8 CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Key Findings

The key findings that have been discussed in this section are:

- The Phase 1 SEWPCC Service Boundary Inflow/Infiltration and Cross-Connection Study (Wardrop, 2007) is still in draft form. The results are inconclusive as they relate to establishing a maximum hour and maximum day 2031 design flow to the plant.

- Due to the inconclusive results found in the Phase 1 Study the 2031 design flows developed in the SEWPCC Upgrade / Expansion PDR will be used as the design flows for the plant expansion. These flows are a summer maximum day flow of 300 ML/d and a summer maximum hour flow of 480 ML/d.

- With the addition of the Waverley West Interceptor, the collection system has the capacity to convey the Year 2031 Maximum Hour Design Flow of 480 ML/d to the plant without any basement flooding provided the upstream restrictions, such as undersized pumping stations are upgraded.

- The calibrated InfoWorks model developed as part of the Phase 1 South End Pollution Control Centre (SEWPCC) Service Boundary Inflow/Infiltration and Cross-Connection Study (Wardrop, 2007) shows that the maximum capacity of the St. Mary’s Interceptor is 430 ML/d. This number is consistent with the results presented in Section 4 of the SEWPCC Upgrade / Expansion PDR.

- There is a need in the future to reduce the amount of extraneous inflow that enters the system. Any extraneous flow removed from the system in the future will result in the reduction of flow to the SEWPCC, free up additional capacity in the existing SEWPCC collection system and provide additional basement flood protection during extreme rainfall events.

- Based on the clarification of Clause 28 of the SEWPCC license, Manitoba Conservation requires only the treatment of 300 ML/d of flow. Therefore, a firm pumping capacity of 300 ML/d complete with standby power and a total pumping capacity of 415 ML/d is recommended for the SEWPCC expansion.

- A future basement flood relief strategy could include the use of total pumping capacity at the SEWPCC to convey WWF of up 415 ML/d. If there is a power failure at the SEWPCC a firm pumping capacity of 300 ML/d would be available via the standby power generation. Any flows above the pumping capacity of the plant would be required to be shed at D'Arcy, the St. Mary's overflow (if the river level is low enough) or the Mager and Windsor Park Pumping Stations. This type of basement flood strategy could include the use of "real time" flow monitoring in the system. Details of this strategy will require more analysis by the City in the future.