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Project #: 60645745 (505)
From: Mike Gaudreau, P. Eng.

Memorandum

Subject: **High Risk River – Phase 3 – West Perimeter Force Main - Hydraulics Analysis**

1. Introduction

The hydraulic analysis of the West Perimeter Force Main (WPFM) and West Perimeter Pump Station (WPPS) was undertaken to assess the required operational procedures to accommodate the proposed inspection of the WPFM crossing of the Assiniboine River.

The WPPS is located approximately 90 m west of the Perimeter Highway and 150 m north of the Assiniboine River and discharges into the WPFM. The WPFM is comprised of approximately 3 km of 400 mm force main, where the approximately 165 m crossing of the Assiniboine River consists of steel pipe and the remaining force main is DR 25 PVC. The WPFM discharges into a 600 mm gravity sewer approximately 750 m north of Wilkes Avenue, where the gravity sewer ultimately discharges into the Perimeter Road Pump Station.

The WPPS and WPFM services a waste water collection system comprising of approximately 80 ha of residential and commercial area north of the Assiniboine River and west of the Perimeter Highway. The catchment area and system configuration are provided in Figure 1.

As part of the *High Risk River Crossings - Phase Three*, the 400 mm steel force main crossing of the Assiniboine River will be inspected. The inspection of the 400 mm steel force main will require modifications of the pipeline to accommodate the internal Remote Field Technology (RFT) as outlined in the *Inspection Program Technical Memorandum*.

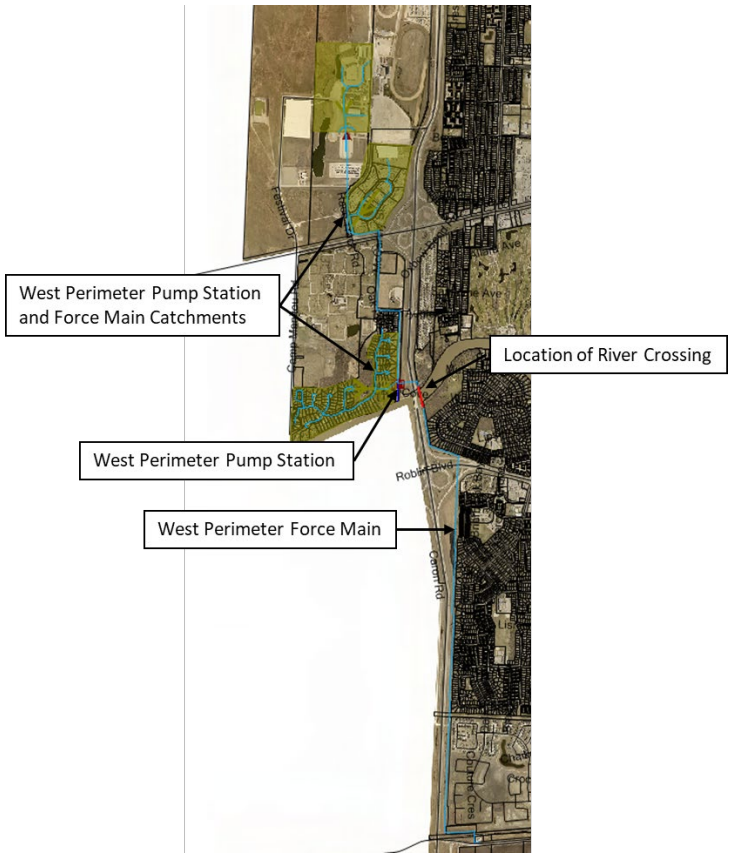

Figure 1 – West Perimeter Pump Station and Force Main

In order to complete the RFT inspection of the steel force main, the approximate 165 m crossing of the Assiniboine River will need to be bypassed such that normal dry weather flow (DWF) can be maintained throughout the course of the inspection. Consequently, AECOM reviewed the available shut-down window for installation of a flow bypass and have developed a flow bypass plan to maintain operation of the WPPS during the inspection period, where:

- Under DWF periods, there appears to be an approximate six (6) hour window from 12 a.m. to 6 a.m. where the WPPS can be shutdown to accommodate the installation of the bypass system.
- The proposed flow bypass would consist of the following:
    - A submersible pump capable of delivering approximately 15-20 l/s inserted into the WPPS wet well.
    - The submersible pump will discharge into an a suitably sized bypass pipe based on exact pump selection, estimated at approximately 150 mm.
    - The bypass piping would be routed out of the access hatch exterior the building, and routed along Oxbow Bend Road beneath the Perimeter Highway Bridge, placed on the sidewalk on the east side of the bridge, and extended to the discharge location.
    - The exact discharge location will be confirmed during detailed design, but is anticipated to be located between the Robar coupling connecting the steel and PVC (Station 37+85 in Figure 2) and the Air Release Chamber (Station 34+80) located approximately 300 m south of the coupling location.

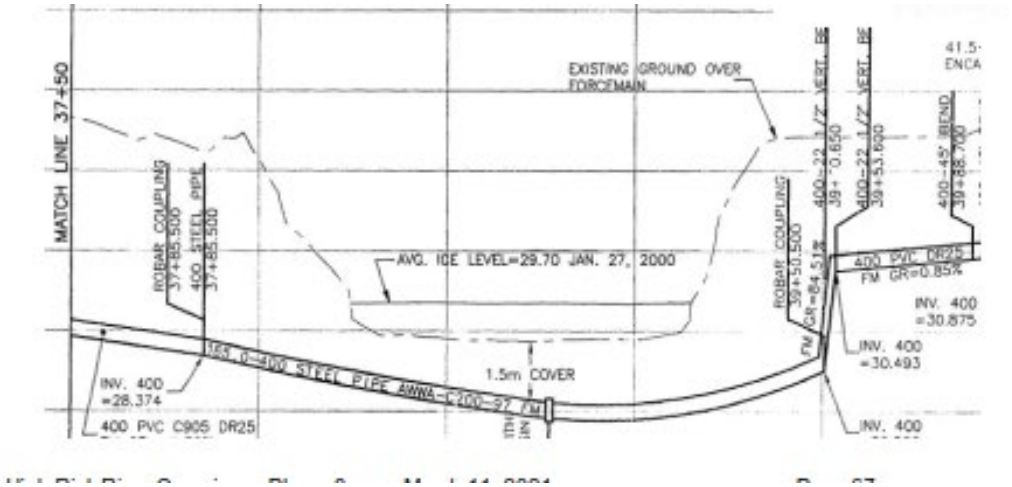

Figure 2 – West Perimeter Force Main Crossing of the Assiniboine River

The City's SCADA data was used to assess typical dry weather flows and diurnal variation during the anticipated fall inspection period. The City's InfoWorks ICM hydraulic model was used to confirm the operational plan to accommodate the inspection, where the *Current Network 2019* was utilized for the assessment.

2. Inspection Plan

The inspection of the 400 mm WPFM will require the shutdown of the WPPS to allow for the installation of the flow bypass system such that DWF can be accommodated.

A review of the City's SCADA data at the WPPS was completed to determine the average DWF expected during the fall inspection program. The City's hydraulic model was then used to confirm the allowable shutdown period.

The low basement elevation is estimated at approximately 231.51 m using the City's LiDAR data, which is consistent with the lowest waste water rim elevation (Asset ID: S-MH70023104) in the West Perimeter Sewer District from the City's GIS, corresponding to an approximate basement elevation of 231.71 m (234.11 m rim elevation). As the overflow piping elevation in the WPPS is approximately 230.6 m, it is recommended that levels are maintained below this elevation, providing approximately 0.9 m of free board to the low basement.

The general procedure relating to the installation of the flow bypass system is as follows:

1. Installation of the bypass piping from the WPPS to the discharge location.
    a. Location to be confirmed during detailed design between the Robar coupling and the southern Air Release Chamber.
2. Excavation of the force main.
3. Installation of a tap on the force main for controlled draining of the force main.
4. Closure of the sluice gate in the WPPS.
    a. Operability should be confirmed prior to closure in the event a controlled spill is required.
5. Shutdown of WPPS.
    a. Monitor levels in the inlet chamber adjacent to the wet well such that they do not exceed the 230.6 m invert of the 600 mm overflow pipe.
    b. Should levels be nearing the invert, the Contractor shall have stand-by hydro-vac trucks to keep up with unexpected flows.
6. Closure of the valve at the pump out manhole at station 28+79.5 to limit volume of sewage required to drain.
7. Drain the sewage in the force main and pump out to hydro-vac trucks.
8. Installation of a valve and ninety degree bend for the bypass piping tie-in on the WPFM.
9. Insert the submersible pump into the wet well, close the drain tap, open the valve at pump out manhole (Station 28+79.5) and begin pumping.
10. Undertake the inspection program.
    a. Further detail relating to the inspection program of the WPFM is provided in the *Inspection Program Technical Memorandum*.
11. Upon completion:
    a. Remove the submersible pumps from the wet well.
    b. Close the valve at 28+79.5 and the newly installed valve.
    c. Remove the ninety degree bend and re-connect the river crossing to the newly installed valve.
    d. Open new valve and valve at 28+79.5.
    e. Restart normal operation of the WPPS.

A test should be completed in advance of the proposed shutdown to confirm the available shut-down window in the WPPS.

3. Hydraulic Modelling

Using the City's InfoWorks ICM hydraulic model network *Current Network 2019*, and the SCADA data collected at the WPPS during September 2019 and 2020, AECOM undertook the following:

1. Identified a shutdown period available for installation of the flow bypass system.
2. Developed a bypass system to accommodate normal DWFs expected.

3.1 Dry Weather Flow Review

AECOM reviewed the City's SCADA information for both pump operation and flows through the WPPS during September 2019 and September 2020 to determine anticipated DWF patterns for the WPFM inspection program.

As shown in Figure 3 and Figure 4, the anticipated average DWF is approximately 2 to 2.5 l/s, where the peak DWF can range between 3 to 6 l/s depending on the year. It is anticipated that due to COVID pandemic the DWFs were somewhat moderated during the September 2020 period due to limited commercial use in the catchment area. Additionally, there appear to be some moderate events that increased the response through the WPPS and, therefore, the shutdown should be planned for a period of DWF.

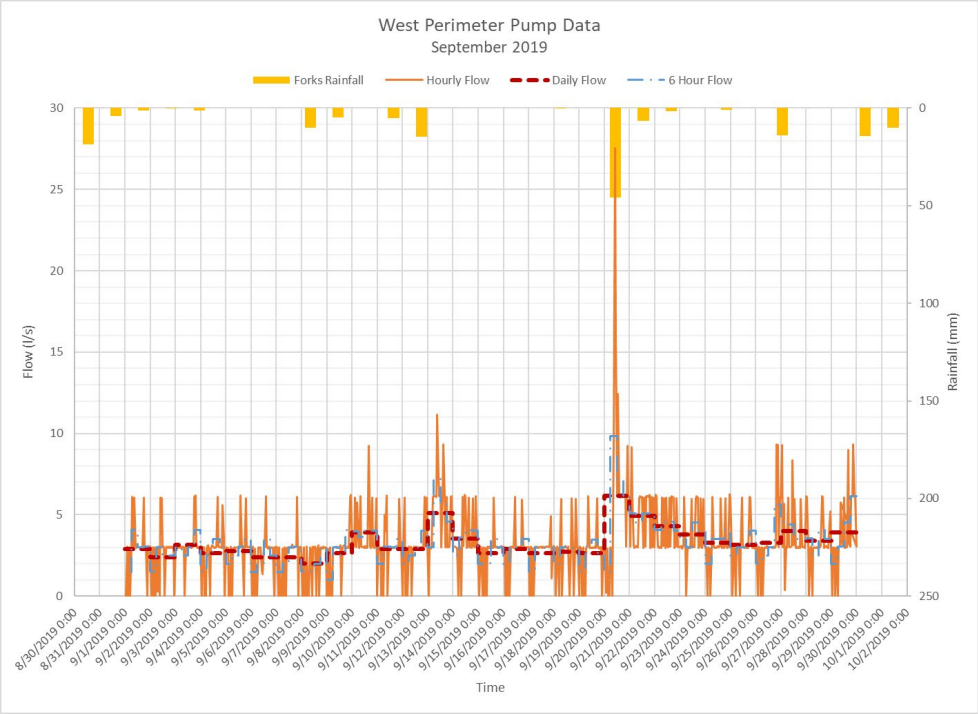

Figure 3 - September 2019 West Perimeter Flow Data

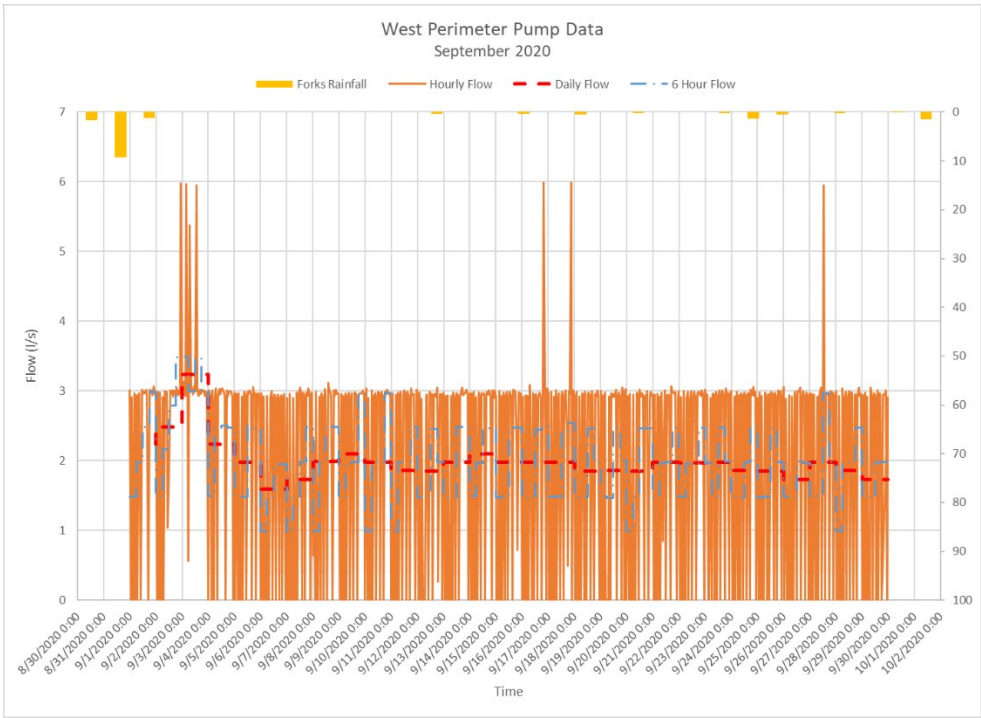

Figure 4 - September 2020 West Perimeter Flow Data

Using the City of Winnipeg's design parameters for waste water flow, the approximately 80 ha of development, assumed as residential for the purposes of our review, we have determined a design average DWF of approximately 8.4 l/s. As design values within the City have been observed to be approximately 2-3 times larger than measured values, the design DWF estimated appears to be consistent with the measured 2 l/s to 2.5 l/s DWF at the WPPS. As such, the SCADA flow data is deemed acceptable for the development of the flow bypass system to accommodate the WPFM inspection program.

As it is expected that the installation of the flow bypass system would be completed during a nighttime shutdown, a review of the typical overnight low was also completed. As shown in Figure 3 and Figure 4, the average flow over the 12 a.m. to 6 a.m. period ranges between 1-2 l/s.

To assess the available shutdown window, the InfoWorks ICM hydraulic model was used, where the diurnal pattern at the WPPS is shown in Figure 5. As the low flow period in the InfoWorks ICM model is approximately 4 l/s beginning around 1 a.m. and ending around 5 a.m., the hydraulic model was deemed conservative in nature when compared to the measured SCADA data and, therefore, was used to assess the shutdown window.

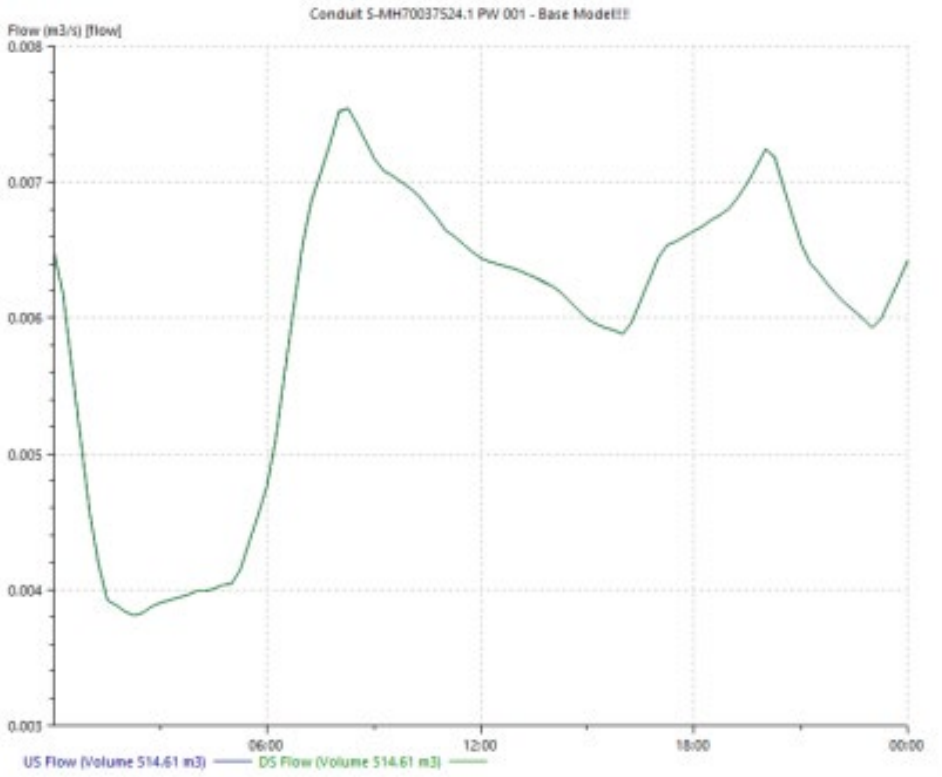

Figure 5 - InfoWorks ICM Diurnal Pattern at the West Perimeter Pump Station

3.2 Review of Available Shutdown Window

The City's ICM InfoWorks and SCADA data at the WPPS were reviewed to assess the available shutdown during the nighttime low DWFs, anticipated between 12 a.m. and 6 a.m.

3.2.1 Model Configuration

The City-wide hydraulic model was trimmed to only include the WPPS catchment, inclusive of the WPFM and downstream gravity sewer to the Perimeter Road Pump Station as shown in Figure 1. For the purpose of our review, the Perimeter Road Pump Station was assumed as a free outfall, as the downstream boundary impacts on the WPPS are anticipated to be negligible during periods of DWF.

The hydraulic model was also updated to include the pump curves, which were provided by the City. It is of note that the expected and measured capacity of the pumps is approximately 227 l/s, which is substantially higher than the inflows to the WPPS during periods of dry weather. The pumps were assigned real time control (RTC) parameters such that they are shut off at 12 a.m. and restarted at 6 a.m.

The model was also updated to include the approximately 15 m^2 wet well area in the station, where the pump on and pump off levels of 229.5 m and 228.5 m, respectively, were included in accordance with the record drawings (corresponding to an approximate 15 m^3 active storage volume in the wet well)

The overflow piping from the WPPS was also removed to replicate the closed sluice gate within the station, which is recommended to be closed during the operation to limit the risk of an inadvertent sanitary sewer overflow.

3.2.2 Modelling Results

The model was run to assess a shutdown window between 12 a.m. and 6 a.m. for the installation of the flow bypass system.

As shown in Figure 6, it appears that at approximately 5:30 a.m. the levels in the wet well exceed the 230.6 m critical level (as discussed in Section 2). Levels reached approximately 230.66 m after the 6 hour window, which still remains well below the low basement elevation of 231.5 m. Given that the InfoWorks ICM model nighttime low flow value (approx. 4 l/s) is approximately twice the value of the anticipated night-time low diurnal patterns as measured in the SCADA data(up to 2 l/s), a 6 hour window should be achievable for the work.

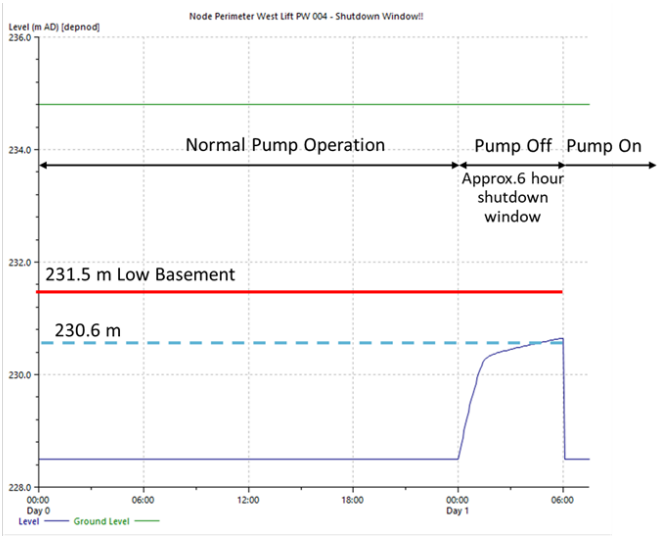

Figure 6 - WPPS Shutdown Window

Furthermore, as shown in Figure 7, the hydraulic model suggests there is approximately 100 m^3 of available storage between 228.5 m and 230.6 m, which consists of approximately 30 m^3 of wet well storage (updated from record drawings) and approximately 70 m^3 of pipe storage. As such, assuming a 2 l/s nighttime low flow as measured in the SCADA data, there would be approximately 14 hours of storage at that inflow rate. Consequently, it is anticipated that a 6 hour shutdown window between 12 a.m. and 6 a.m. will be available for the installation of the flow bypass system.

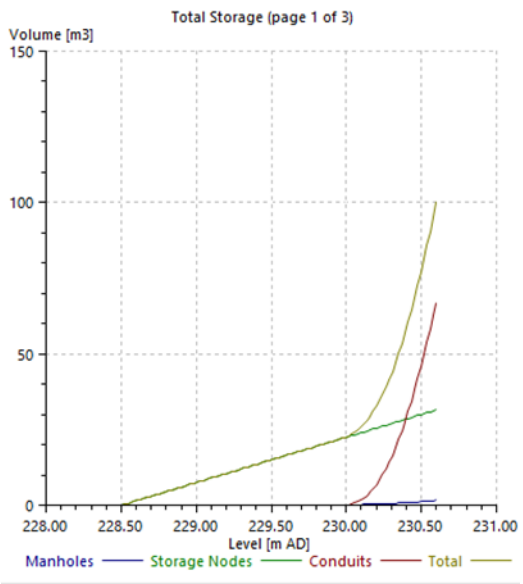

Figure 7 – Available storage in WPPS Catchment

3.3 Flow Bypass Plan

AECOM reviewed the normal operation of the WPPS under DWF conditions to develop a flow bypass plan that could be implemented to accommodate the inspection of the WPFM crossing of the Assiniboine River.

The following two operations were reviewed:

1. Connect a temporary discharge line immediately downstream of the pumps within the WPPS and run the line at grade to the discharge location.
2. Insert a submersible pump in the wet well, and run a discharge hose, designed to work with the pump hydraulics (i.e. pump curve), to the discharge location.

Our review indicates that while it may be possible to connect a discharge line to the existing pumps at the WWPS, the size and length of the discharge line required to maintain the pump operation within the allowable range would be cost prohibitive as an option.

However, as the WPPS pumps are known to be oversized for the existing DWF condition , implementing a small pump in the range of 15-20 l/s with a smaller discharge hose would be more practical, while still providing some level of extra capacity for smaller wet weather events.

For either option, the discharge piping will be routed out of the station, then along Oxbow Bend Road beneath the Perimeter Highway Bridge, placed on the sidewalk on the east side of the bridge, and extended to the discharge location. The discharge location, as previously discussed, will be confirmed during detailed design. A general plan of the discharge piping is provided in Figure 8.

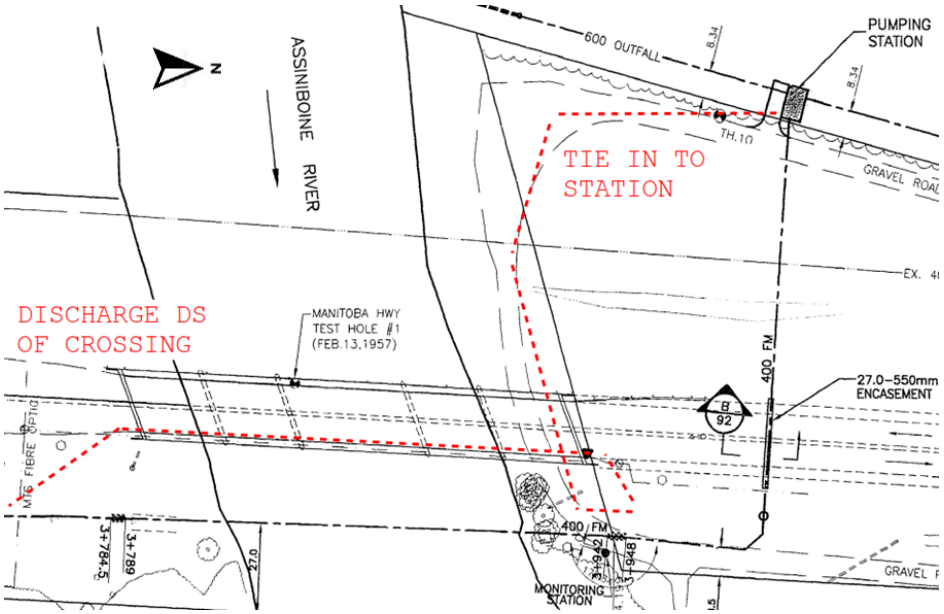

Figure 8 - Bypass Plan

3.3.1 Option 1 – Direct Connection to the WPPS Pump Discharge

The first option would consist of connecting the discharge piping directly to the discharge side of the pumps, where a single pump could be isolated, and the ninety degree bend could be removed and a tee installed (Figure 9). The tee would then allow for both pumps to allow to operate under normally, and essentially could be done while maintaining system operation.

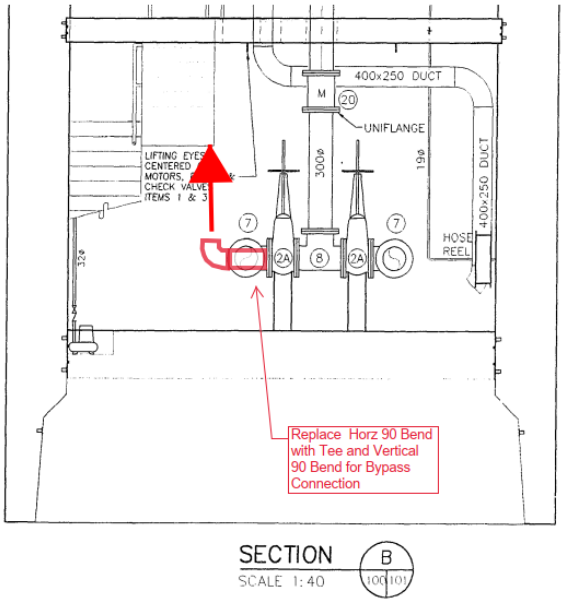

Figure 9 - WPPS Pump Bypass

In order to utilize the existing pumps in the WPPS, a minimum 300 mm diameter pipeline ranging from 350 m to 750 m in length (depending on the discharge location) would be required to maintain the pump operation within the allowable operating range. As shown in Figure 10, the minimum operating discharge is approximately 162 l/s, where for both discharge locations the pump would still operate within the allowable range, and at a reduced capacity from normal between 170 l/s to 190 l/s. As normal DWF ranges up to 6 l/s during peak condition, the reduction in pump capacity is not a concern for normal flow conditions.

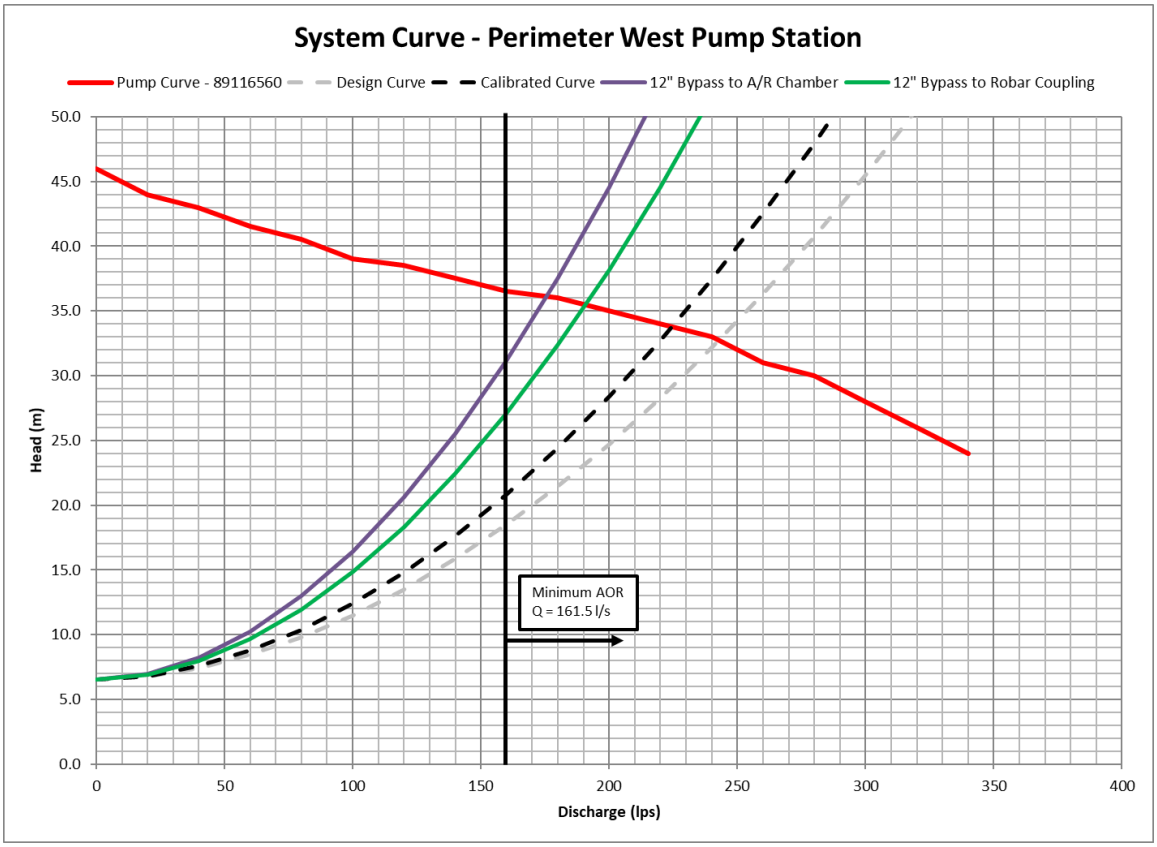

Figure 10 - WPPS Pump System Curve

The minimum 300 mm pipeline diameter required for the pump operation to remain within the allowable operating range is, however, likely to be extremely cost prohibitive, and it is unlikely that this will be the preferred option by the Contractor to undertake the work.

3.3.2 Option 2 – Insertion of a Submersible Pump in WPPS Wet Well

The second option would consist of dropping a submersible pump into the wet well, and connecting a hose from the pump to the discharge location as discussed previously.

Our review of the responses in September 2019 and 2020 suggest that smaller wet weather induced events could range up to 10 l/s for smaller rainfall events. As such, provision of submersible pumps that can accommodate some level of wet weather flow was deemed prudent for the inspection, where we suggest that the Contractor provide a pump capable of providing between 15 l/s to 20 l/s in discharge. For the purpose of our review, we selected a Bibeau Flygt Pump available from Canada Dewatering, where using a 150 mm (6”) hose would allow for operation in the design 15 to 20 l/s range as shown in Figure 11.

Consequently, the installation of a submersible pump in the wet well, and the associated bypass piping can be practically achieved such that the existing level of service in the WPPS catchment is maintained under DWF conditions.

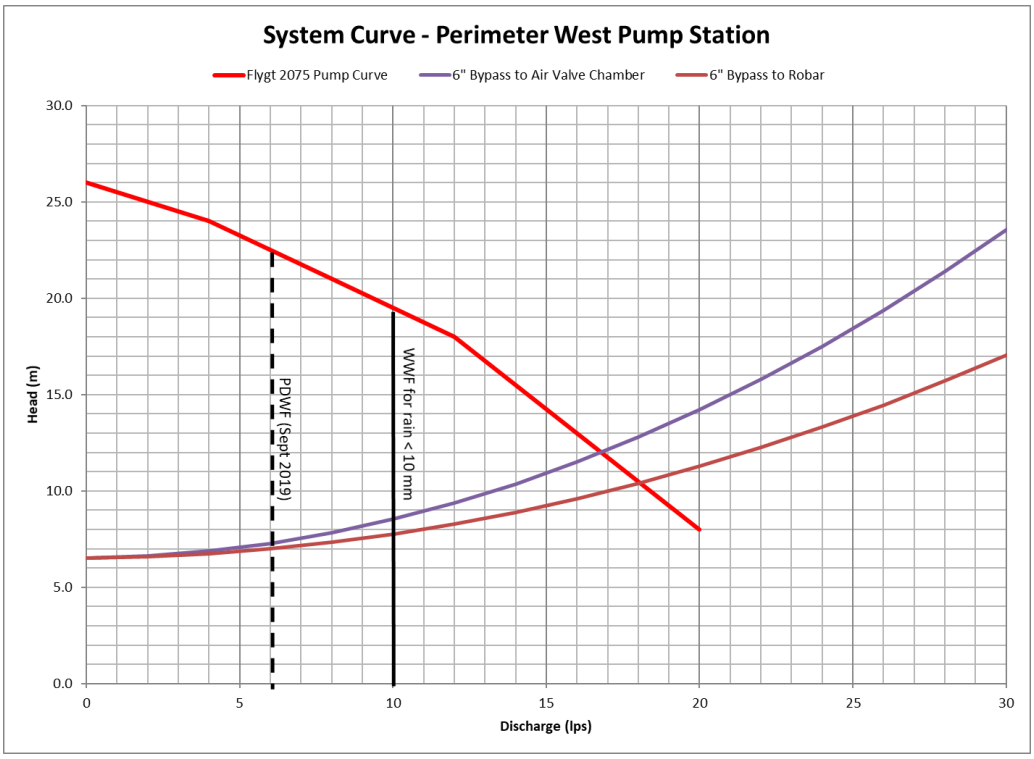

Figure 11 - WPPS Submersible Pump Discharge Curve

4. Conclusions

Based on our hydraulic review of the City's SCADA and the City's InfoWorks ICM hydraulic model, there is approximately a 6 hour lift station shutdown window between 12 a.m. and 6 a.m. during periods of DWF where a flow bypass system will be installed. It is anticipated that the majority of the flow bypass system will be installed prior to the shutdown, and the work during the shutdown period will consist of the following (depending on either the installation or removal of the system):

- Close the valve at pump out pit at 28+79.5.
- Drain the sewage in the force main to hydro-vac trucks via a previously installed tap.
- Installation of a valve and installation (or removal) of ninety degree bend for bypass piping tie-in on WPFM.
- Insert (or removal) submersible pump into the wet well, close tap, open valve at 28+79.5 and begin pumping.

The anticipated flow bypass system will consist of a submersible pump inserted in the wet well, with a capacity between 15 and 20 l/s to accommodate smaller wet weather flow events during the inspection period. The bypass piping will be sized to fit the selected pump hydraulics (e.g. pump curve), and will be routed along Oxbow Bend Road, then up and along the sidewalk on the Perimeter Highway Bridge and discharge at a location between the Robar coupling just south of the Assiniboine River and the Air Release Chamber another approximately 300 m south.

5. Recommendations

The recommended operational procedures to accommodate the inspection of the 400 mm steel WPFM crossing of the Assiniboine River are outlined in Table 1.

Table 1 - Inspection Operational Procedures

Task	Location	Time/Notes
1. Installation of flow bypass piping	From the West Perimeter Pump Station, along Oxbow Road and east sidewalk on the Perimeter Highway Bridge to the selected discharge location	Any time before shutdown of the West Perimeter Pump Station Piping to be connected to submersible pump and ready for use
2. Excavation to the tie-in location, and installation of the tap for draining of the force main	Between the Robar Coupling (Station 37+85)) and the Air Release Chamber (Station 34+80)	Any time before shutdown of the West Perimeter Pump Station
3. Closure of the sluice gate on the 600 mm overflow pipe from the West Perimeter Pump Station to the Assiniboine River	West Perimeter Pump Station	Shortly before shutdown of the West Perimeter Pump Station
4. Drawdown levels in the West Perimeter Wet Well to 228.5 m, and shutdown the pumps and close vales at pump out manhole	West Perimeter Pump Station Valve at pump out manhole (Station 28+79.5)	Commence work at approximately 12 a.m. Valve to be closed before opening tap for draining Monitor levels in the wet well such that they do not exceed the critical elevation of 223.6 m for entire period pumps are offline Provide hydro vac trucks in the event of excess inflows
5. Drain and pump the force main into hydro vac trucks	Discharge location	Allow for approximately 1 hour to drain the existing line Close tap once drained
6. Cut into the existing pipe, install valve and connect discharge piping, start pumping with submersible	Discharge location West Perimeter Pump Station	Open valve at Station 28+79.5 once line is filled, use air release valve to release any air build up Continue monitoring levels, if levels exceed normal 229.5 m, provide hydro vac truck to maintain levels below 230.6 m Open sluice gate in West Perimeter Pump Station to protect against basement flooding in the event of unforeseen wet weather event
7. Complete inspection of 400 mm West Perimeter Force Main crossing of the Assiniboine River	West Perimeter Force Main crossing at the Assiniboine River	Any time after bypass flow system has been implemented and confirmed to be operable
8. Prepare for reconnection of the force main	Discharge location	Any time before shutdown of flow bypass system

Task	Location	Time/Notes
9. Closure of the sluice gate on the 600 mm overflow pipe from the West Perimeter Pump Station to the Assiniboine River	West Perimeter Pump Station	Any time before shutdown of the flow bypass system
10. Drawdown levels in the West Perimeter Wet Well to 228.5 m, and shutdown/remove the flow bypass pumps and close vales at pump out manhole	West Perimeter Pump Station Valve at pump out manhole (Station 28+79.5)	Commence work at approximately 12 a.m. Valve to be closed before opening tap for draining Monitor levels in the wet well such that they do not exceed the critical elevation of 223.6 m for entire period pumps are offline Provide hydro vac trucks in the event of excess inflows
11. Remove the bypass piping fitting and reconnect the existing pipe, open newly installed valve and re-start pumping at the WPPS	Discharge location West Perimeter Pump Station	Open valve at Station 28+79.5 once line is filled, use air release valve to release any air build up Open the newly installed valve Open sluice gate in West Perimeter Pump Station to protect against basement flooding in the event of unforeseen wet weather event

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