Final Infiltration and Inflow Report

Village of Merrickville-Wolford
Merrickville, Ontario

Prepared for

MERRICKVILLE-WOLFORD
Jewel of the Rideau

The Village of Merrickville-Wolford
Project File No. 19-5031D

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1 Executive Summary

The Village of Merrickville wastewater treatment plant has an 800 m^3/day annual daily average rated capacity. The average influent flow to the plant over 2014 - 2018 is 619 m3/day, though high sanitary flows in the spring melts, particularly in 2017 when the plant experienced a peak flow of 3058 m3/day, have initiated a review of the system capacity. The May 15, 2018 MOE Plant Inspection Report # 1-I96OE highlighted this issue and the Municipality engaged Jp2g to perform this Infiltration and Inflow (I&I) Study as part of their on-going effort to reduce extraneous flows. This study will follow the procedures outlined in the Federation of Canadian Municipalities Best Practice Guideline “Infiltration/Inflow Control/Reduction For Wastewater Collection Systems”.

Catchment areas are defined by the areas draining to the St. Lawrence Street main, to the Church Street main and to the header on Main Street collecting all flows to the pump station.

The findings are summarized below:

Catchment Area	Ground Water Infiltration (GWI)		Rainfall Derived Infiltration and Inflow (RDII)				
	(m3/day)	(L/s/ha)	(m3/day)	(L/Ha.day)	(L/d/km.cm)	(L/week/ km.cm)	(L/s/Ha)
Main Street	135	0.14	389	35355	10557	4235	0.41
Church Street	1	0.00	17	1001	431	6283	0.01
St. Lawrence Street	44	0.02	458	19087	8607	7697	0.22
Total	180	0.04	864	16615	6670	7334	0.19
Guideline Limit		0.12		11,200 to 12000	3000 to 5000	1400	0.28
		(Ontario Ministry of the Environment)		(Greater Vancouver Regional District Liquid Waste Management Plan, Ministere de L’Environment du Quebec)	(Ministere de L’Environment du Quebec)	(Ontario Ministry of the Environment)	(City of Ottawa Design Value)

Table 1 – Summary of Findings

All catchment areas are above the 1400 L/cm.km per peak week noted by the MOE Sewer System Design Guidelines as the threshold above which it is economical to pursue rehabilitation. Main Street and St Lawrence Street are both above the 12,000 L/Ha/day limit recommended by the Quebec Ministry of the Environment. Church Street is within acceptable levels per hectare and per pipe length-diameter.

A review of the flow profiles of each catchment area reveals that Church Street flows remain relatively stable even during rainfall events. St. Lawrence Street flows peak during a rainfall event, which likely indicate direct storm water inflow to the sanitary sewer in that catchment area. This is possibly due to direct roof drain connections to sanitary, sump pump connections to sanitary, unsealed sanitary manhole covers, or a combination thereof.

St Lawrence Street is the largest area and its flows follow the plant flow profile closely, whereas Church Street remains relatively flat even during rainfall events. Both Main Street and St Lawrence Street exceed guidelines for acceptable infiltration and inflow amounts per hectare and per km.cm of pipe. The peaks in flow on St. Lawrence Street and the steadily above-average flows on Main Street are the major contributing areas to the overall excessive I&I. Based on the analysis of flow data, the St. Lawrence Street catchment is most impacted by direct inflow and the Main Street catchment is most impacted by groundwater infiltration and these areas should be given a high priority for corrective action.

A calibration exercise in 2020/2021 resulted in an upwards adjustment to the Main Street flows, underlining the importance of further investigation along Main Street.

Recommended actions are as follows:

1. CCTV Inspection and Grouting Program in Main Street and St. Lawrence Street Catchment Areas - Work completed in 2019, recommend implementing long term program.
2. Manhole Inspection and Sealing Program to reduce infiltration and inflow
3. Inspection and Disconnection from Sanitary System of Dwelling Roof Leader and Sump Connections
4. Public Awareness Campaign to gain public support to disconnect roof leaders and sump connections
5. Stormwater System Assessment to confirm capacity for alternative outlets for inflow.
6. Study of WWTP Process Components To Identify Capacity Restrictions

2 Background

2.1 Context and Scope

The Village of Merrickville owns a communal wastewater collection and treatment system. The system consists of 5.95 km of gravity pipeline (ranging from 200mm to 300mm in diameter), one (1) pumping station with associated forcemain and a 800 m^3/day annual daily average rated capacity sequencing batch reactor with Integrated Surge Anoxic Mixing waste water treatment plant. The maximum hydraulic capacity of the plant is 3,800 m^3/day, though practical experience reported from the plant operators indicates difficulties in maintaining required effluent criteria at flows above the average daily rated capacity. The plant was constructed in 2010 and has been operational since that time. Within the Village there are approximately 385 municipal sewer connections to the sanitary sewer network and 29 equivalent lots approved to be connected in the future, servicing approximately 797 residents.

The average influent flow to the plant over 2017 - 2021 is 611 m3/day, though high sanitary flows in the spring melts, particularly in 2017 when the plant experienced a peak flow of 3058 m3/day, have initiated a review of the system capacity. The May 15, 2018 MOE Plant Inspection Report # 1-I96OE highlighted this issue and recommended "that the Municipality of Merrickville-Wolford review and update any/all of it's current Water and Sewer use by-laws to provide an enforceable prohibition of un-authorized connections to its sewage collection system." This action will assist with the reduction of long-term inflow due to illegal stormwater connections to the sanitary collection system. The Village has also initiated a sanitary sewer grouting program with the aim to reduce direct infiltration into the sanitary sewer system. 2019 sewer grouting along Brock Street was completed.

In addition to the above actions, the Municipality has engaged Jp2g to perform this Infiltration and Inflow (I&I) Study. This study will follow the procedures outlined in the Federation of Canadian Municipalities Best Practice Guideline "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems". This procedure establishes flows in various catchment areas using flow monitors. The results of the individual wet weather and dry weather flow analysis in each catchment area will aid in quantifying and isolating infiltration and inflow and will provide supporting information for CCTV inspection, infrastructure repair prioritization, inspection of sump pump and roof drain connections to the system, and installation of stormwater collection infrastructure.

2.2 Methodology

The following is the outline of the strategy recommended by the Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems".

Stage 1: Knowledge of the Sewer System

1.1 Review system information and compile into a Sewer Map which includes details of the system infrastructure including street names, flood plains, pump stations and treatment plants, piping layouts, sizing and slopes, etc.

1.2 Interview staff and prepare a Field Information and Observation Map which overlays notes on the system performance onto the Sewer Map and includes maintenance and operations data of infiltration observations in manholes and pipes, potential inflow sources, presence of sediments in manholes, traces of surcharge in manholes, high level of water during wet weather, emergency pumping sites, abnormal dry weather flows, location of overflow and basement flooding events, manholes in low lying areas, and CCTV inspection results.

1.3 Determine sub-basins using the above information. Each sub-basin should be less than 500 hectares and complete with a permanent structure for flow monitoring (pumping station treatment plant, flow meter, etc).

Stage 2: Monitoring Flows

Flows are recorded at manholes receiving from each sub-basin area, main pump stations and treatment plants. Flow monitoring is performed with continuous flow monitors and data loggers through wet and dry seasons (April to August, for example) to determine the parameters that allow for the calculation of infiltration (the lowest of the recorded dry weather flow), and calculation of inflow (total flow during rainfall event excluding dry weather flow).

2.1 Determine Dry Weather and Wet Weather Flow by performing continuous flow monitoring in each sub-basin area during wet weather and dry weather periods.

2.2 Determine Emergency/Bypass Flow. If overflows occur during rainfall events the flows must be monitored and included in the wet weather flow calculation.
2.3 Gather Rainfall and Plant Flows for the period of dry and wet weather flow to confirm dry and wet weather periods. Treatment and pump station flow data will be used to confirm total flows of all sub-basin areas.
2.4 Evaluate sub-basin infiltration and inflow to narrow the scope of further investigation to the areas that have excessive infiltration and inflow to find exact points of infiltration and inflow.
2.5 Determine the methods to be used for further investigation such as smoke testing, dye testing, building plumbing inspection, manhole inspection, flow isolation, TV inspection, lateral testing.

Stage 3: Sewer Assessment and Analysis
3.1 Perform testing/investigation and determine points of infiltration/inflow.
3.2 Perform a structural assessment of the sewer system where points of infiltration and inflow have been discovered to determine the degree of remediation required.
3.3 Perform a hydraulic assessment of the sewer system to determine if sections of the system are not performing as expected and if increases in drainage capacity are required.
3.4 Prepare a report that compiles all flow test results, investigation results, analysis, recommendations for remediation options, and costs for recommended options

Stage 4: System Remediation Plan Development
4.1 Establish priorities in remediation work based on the cost of the required work, the improvement in performance of the work, social implications, plant performance and operation and maintenance costs.
4.2 Prepare design and construction drawings of remediation work.

Stage 5: System Remediation Plan Implementation
5.1 Perform construction of remediation work
5.2 Perform flow monitoring to ensure the predicted improvements in flow reduction have been achieved.
5.3 Update sewer maps and records based on the remediation work.

The following progress descriptions indicate the level of completion of each stage of the study to date:

Stage 1 - Knowledge of the Sewer System - was performed in 2019, by gathering existing drawing information and subdividing the sewer system into catchment areas that would lend themselves to flow measurement.

Stage 2 – Monitoring Flows – was performed in 2019 and formed the basis of the draft report submission. Subsequent flow testing was performed through 2020 to compare the flow monitor data with the flows recorded by the plant influent flow monitor. This served as a calibration for the flow monitor data and an adjustment to the preliminary flow information was made for this report submission.

Stage 3 – Sewer Assessment and Analysis – was performed in 2020 and 2021. This stage involved a visual inspection of manhole structures to find possible infiltration points. CCTV footage was provided by OCWA from their ongoing camera inspection of the sewers. This footage was reviewed for possible infiltration points. This updated report is the final component of Stage 3 of the Infiltration and Inflow work.

Stage 4 -5 are dependent on the findings under Stages 1-3.

2.3 Definitions

Infiltration: water entering a sewer system, including building sewers, from the ground through such means as defective pipes, pipe joints, connections or manhole walls.

Inflow: water discharged to a sanitary sewer system, including service connections, from sources such as roof leaders, cellar, yard or area drains, foundation drains, drainage from springs and swampy areas, manhole covers, interconnections from storm sewers, combined sewers and catch basins, storm waters, surface runoff, street wash waters or drainage.

Base Sanitary Flow: The wastewater flow generated from building domestic and process systems only.

L/d/ km.cm: A characterization of the amount of pipe in a catchment area equal to the total length of pipe segments multiplied by the diameter of those segments. This value is intended to reflect not just the length of pipe but the size of the pipe, as a larger surface area of pipe and a larger number of joints with larger perimeters would provide more opportunity for infiltration to occur.

2.4 References

- Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems".
- U.S. EPA Sewer System Infrastructure Analysis and Rehabilitation
- Ministry of the Environment Sanitary Sewer System Programme 1-0019-66 Drawing
- Ministry of the Environment Design Guidelines for Sewer Works, 2008
- MOE Plant Inspection Report # 1-I96OE
- Jp2g Letter January 20, 2020: MOE Procedure D-5-1 "Calculating and Reporting Uncommitted Reserve Capacity at Sewage and Water Treatment Plants."
- Jp2g Letter January 20, 2020: Merrickville STP capacity Review

3 Investigation Results

3.1 Stage 1 - Knowledge of the Sewer System

Review of the existing sewer system drawings shows that the sewer along Main Street is a main header which collects flows from the Church Street and St. Lawrence Street main sewers and then terminates at the sewage lift station to be lifted to the sewage treatment plant. Catchment areas are determined by areas draining to St. Lawrence Street, to Church Street and to Main Street and are shown in the figure below.

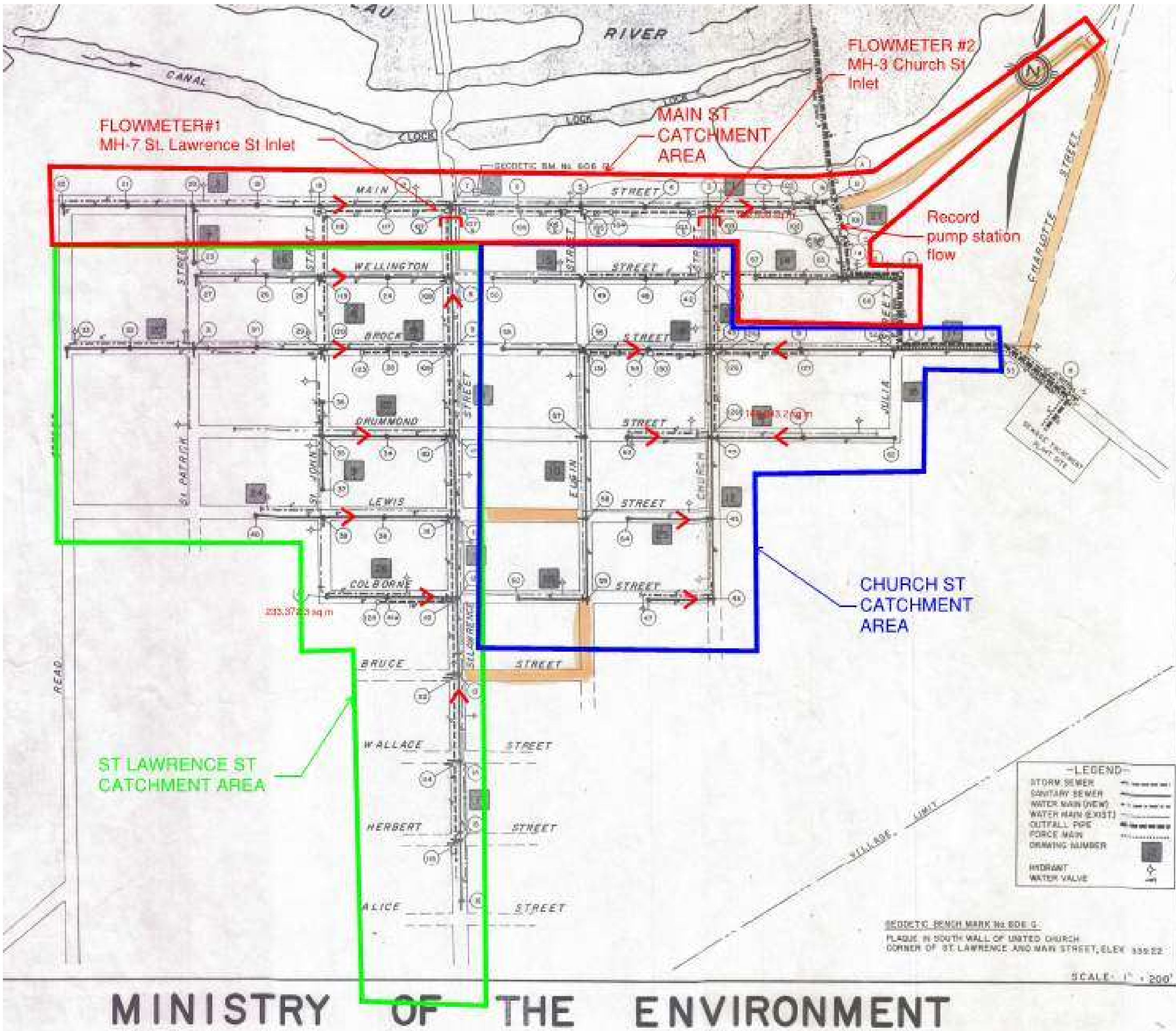

Figure 1: Catchment Areas

In this study catchment areas are defined in terms of area, the amount of pipe within each catchment, and the number of sanitary connections in each catchment. This will help align with the various benchmarking parameters available. The details of each catchment area are as follows:

	Area (Ha)	Pipe (km.cm)	Connections
Main St	11	36.84	84
Church St	17	39.47	137
St. Lawrence St	24	53.22	153
Total	52	129.53	374

Table 2 – Catchment Area Details

3.2 Stage 2 - Monitoring Flows

3.2.1 Initial Flow Monitoring

Flow monitors were installed in two locations on Main Street in March of 2019. One flow monitor was installed at manhole 7 where the collected outlet from St. Lawrence street connects to Main Street. A second monitor was installed in manhole 3 where the collected flow from Church Street connects to Main St. Flows for Main Street were calculated by subtracting the St. Lawrence and Church Street flows from the daily influent flow recorded at the treatment plant.

The flow monitors used for this study were Greyline AVFM ultrasonic area-velocity type flow meters simultaneously measuring depth of flow in the pipe and flow velocity. Sensors were secured inside the pipe discharging into the respective manhole with a metal retaining band that ensured the sensor was level. Battery-powered data recording boxes were secured to the manhole ladder rungs at the top of the manhole for easy data retrieval throughout the flow monitoring period. Monitors were installed by Ontario Clean Water Agency employees under the supervision of Jp2g Consultants Inc. staff. Data was collected starting March 17th, 2020, with measurements taken at 2 minute intervals.

Several days of flow information were lost due to sensors being covered by a buildup of sanitary wipes covering the sensors. On those occasions it was also impossible to derive flow data for Main Street, which is calculated as the remainder of total flow at the plant less the flow of the other catchment areas. Compounding this, the only numbers that were recorded by the sensors for long time periods were large pulses of water that temporarily uncovered the sensors for less than two minutes. The small number of data points at such a high flow created a false average daily flow value higher than even the plant total flow. Therefore, average flow values were manually interpolated for the time periods that the sensors were covered.

Rainfall data was gathered from the Environment Canada website. The closest weather station with complete daily rainfall data is the Ottawa International Airport, approximately 50km away.

3.2.2 Flow Monitor Calibration Exercise

The flow monitoring procedure performed in 2019 depended on subtracting flow monitor data from the plant influent flow meter data and relied on results from different types of equipment. A calibration exercise was performed in 2020/2021 to directly compare the flow monitor measurements to the plant influent flow meter. To do this, the Church Street flow monitor was relocated to the manhole directly in front of the pump station feeding the sanitary plant. The flow data gathered from the relocated flow monitor showed that the flow monitors were reporting flows approximately 25% higher than the plant influent flow meter. The flow monitors measure water depth and velocity and the flow is calculated by translating the water depth to an area and multiplying by the velocity. It is typical that build up on the inside of the pipe and the thickness of the metal band for the flow sensor effectively reduce the inside diameter of the pipe which means the actual area of water is smaller and therefore the actual flow is smaller.

The flow data gathered in 2019 was adjusted to decrease the flow monitor values by 25%. The effect of this was to increase the calculated flow for Main Street which is the difference between the plant flow meter and the two flow monitors. The collected flow information for the plant and for each catchment area is provided in the figure below.

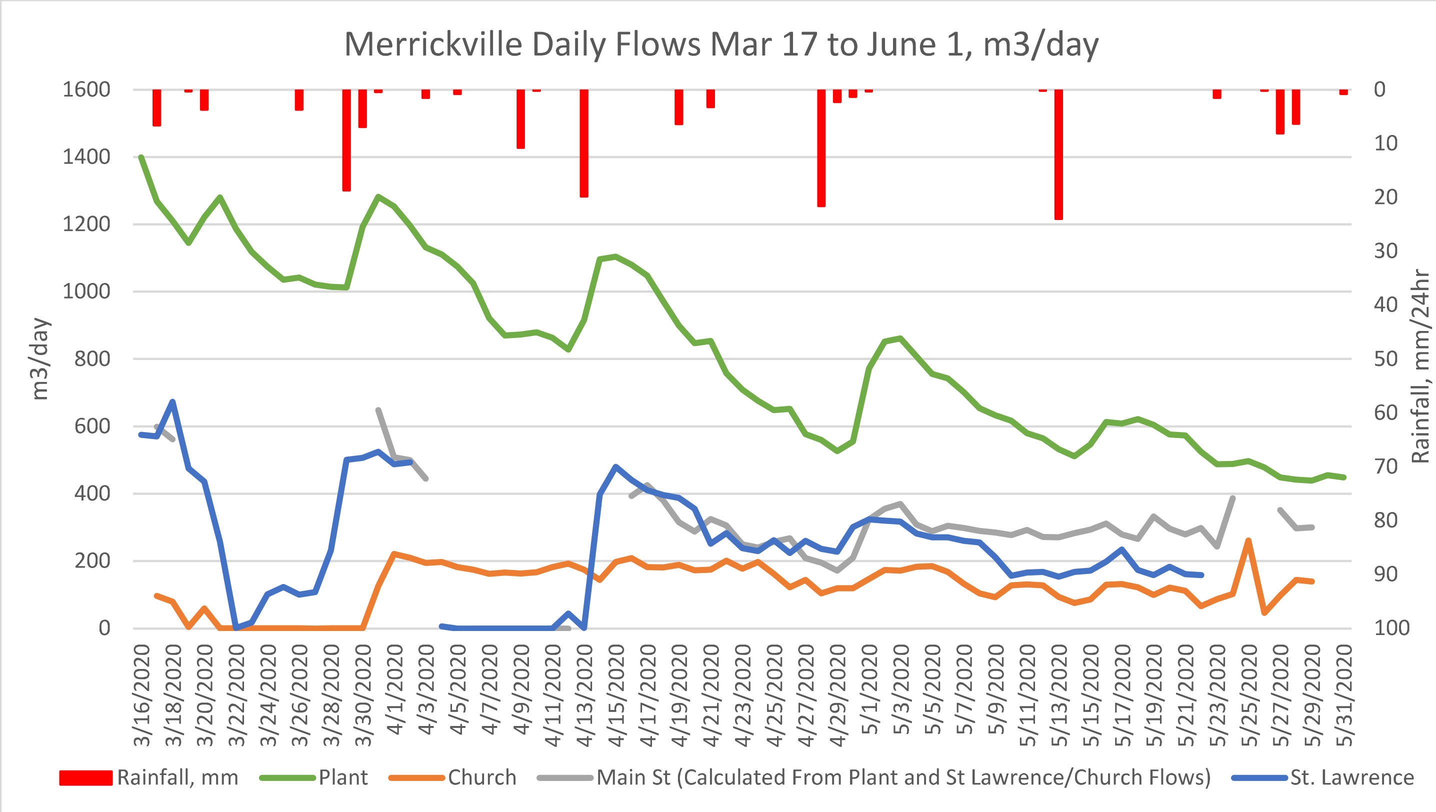

Figure 2: Merrickville Flows March 17th to June 1st, 2020

3.3 Stage 3 – Sewer System Investigation

3.3.1 Manhole Investigation

Two site surveys were conducted to review the structural integrity of manholes throughout the system. During the surveys the manholes were reviewed for general structural integrity and for typical points of infiltration as illustrated in Figure 3.

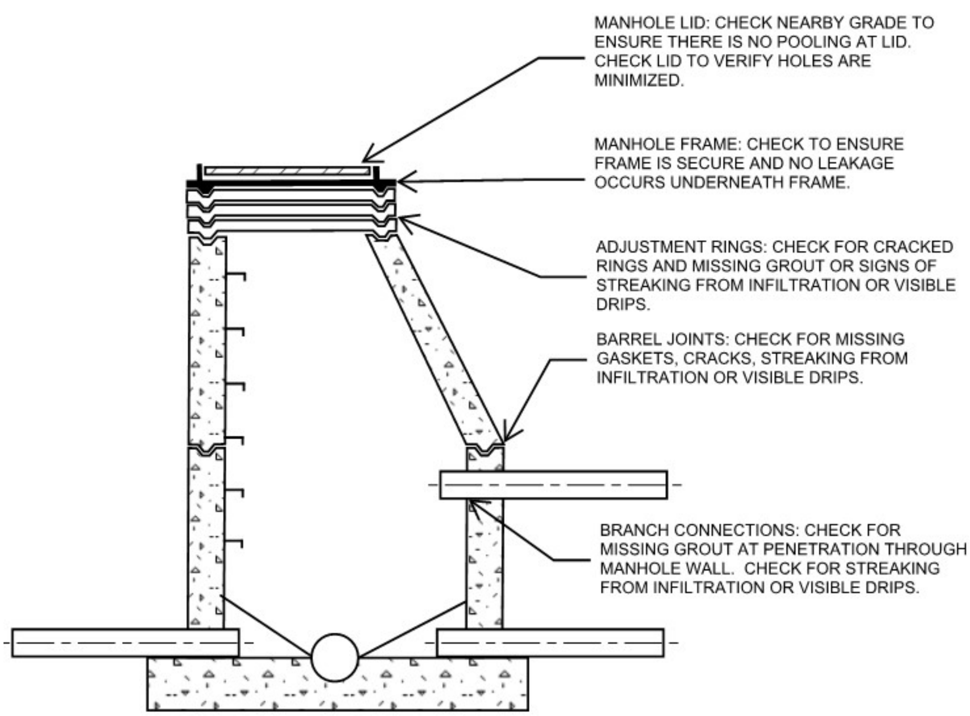

Figure 3: Manhole Structure Potential Inflow Points

The first review of manhole structures was performed on June 5, 2020. Manholes along Main Street and two blocks south along St. Lawrence and Church Street, as shown in the figure below, were reviewed. No major concerns were noted in the manholes with very few cracks being noted, little evidence of streaking from water infiltration, and no major issues with manhole covers or frames. Detailed results of the review can be found in Appendix A.

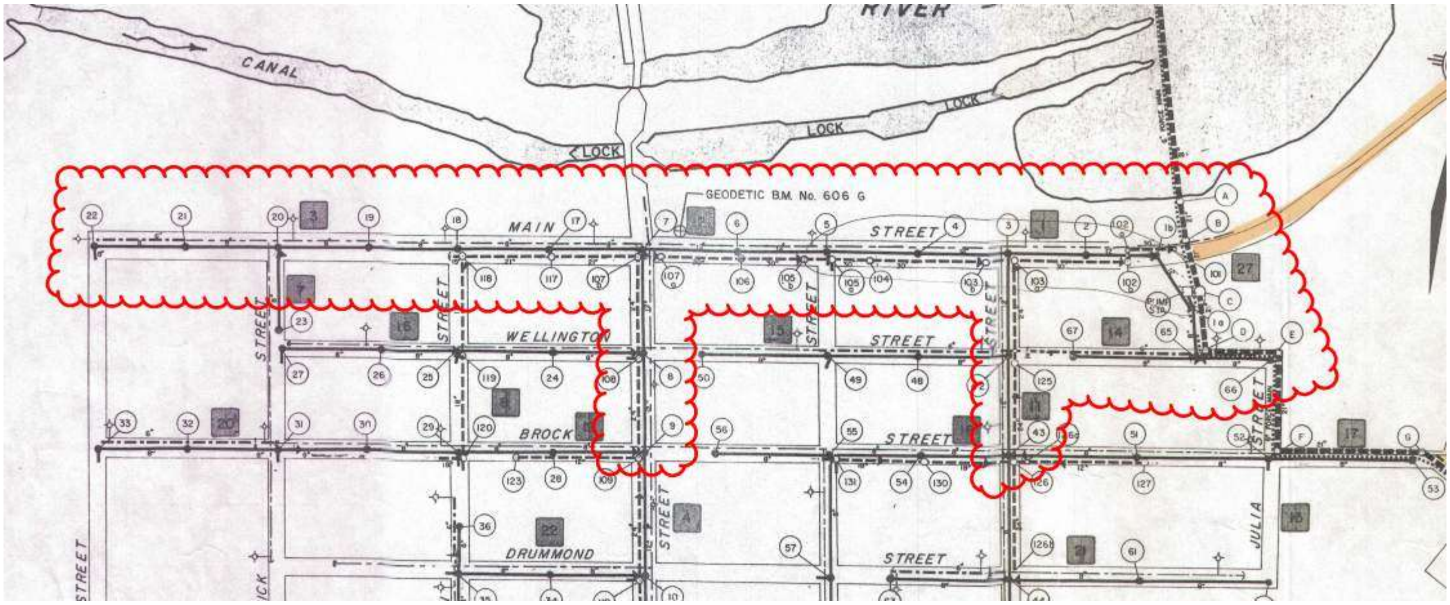

Figure 4: Manhole Structure Review Area June 2020

A second review of manholes was performed on March 26th, 2021. The review was conducted during a large rain event that would help trace inflow to the manholes. Manholes were opened along the full length of Main Street, up St. Lawrence Street from Main Street as far as Bruce Street, up Church Street as far as Lewis Street, and along Wellington Street West and Brock Street West. This afforded a qualitative snapshot of the relative flows throughout the system. It was found that apparent flows tapered off very quickly when proceeding south from Main Street along St. Lawrence and Church Street. During the rain event the flows at streets further south than Brock Street were very small, indicating that the south portions of the St. Lawrence and Church catchment areas are well sealed.

In general the manholes were in good condition and very little inflow was observed through the structures. Some minor issues were recorded as follows:

Water into manhole covers set below grade: SAMH-10, SAMH-31, SAMH-30, SAMH-22.
Water through cracked risers inside manhole: SAMH-30, SAMH-24, SAMH-03.
Water through gap in seam between cone and bottom section of manhole: SAMH-46 (Church St, next to a creek).
Water through loose frame: SAMH-13, SAMH-28.
Water through leaky service connection to barrel of manhole: SAMH-33 (service from 354 Read), SAMH-06.

3.3.2 CCTV Investigation by OCWA

OCWA has been performing CCTV reviews of the sanitary system independently of this study. Detailed results of the CCTV investigation are available in the report 98486SA1 compiled by Clean Water Works and released on January 4, 2021. The report noted structural defects in segments of piping throughout the village, including Main St, St. Lawrence, Bruce Street, Church Street, St. John Street, and Lewis Street. The map of the CCTV scope is provided below for reference.

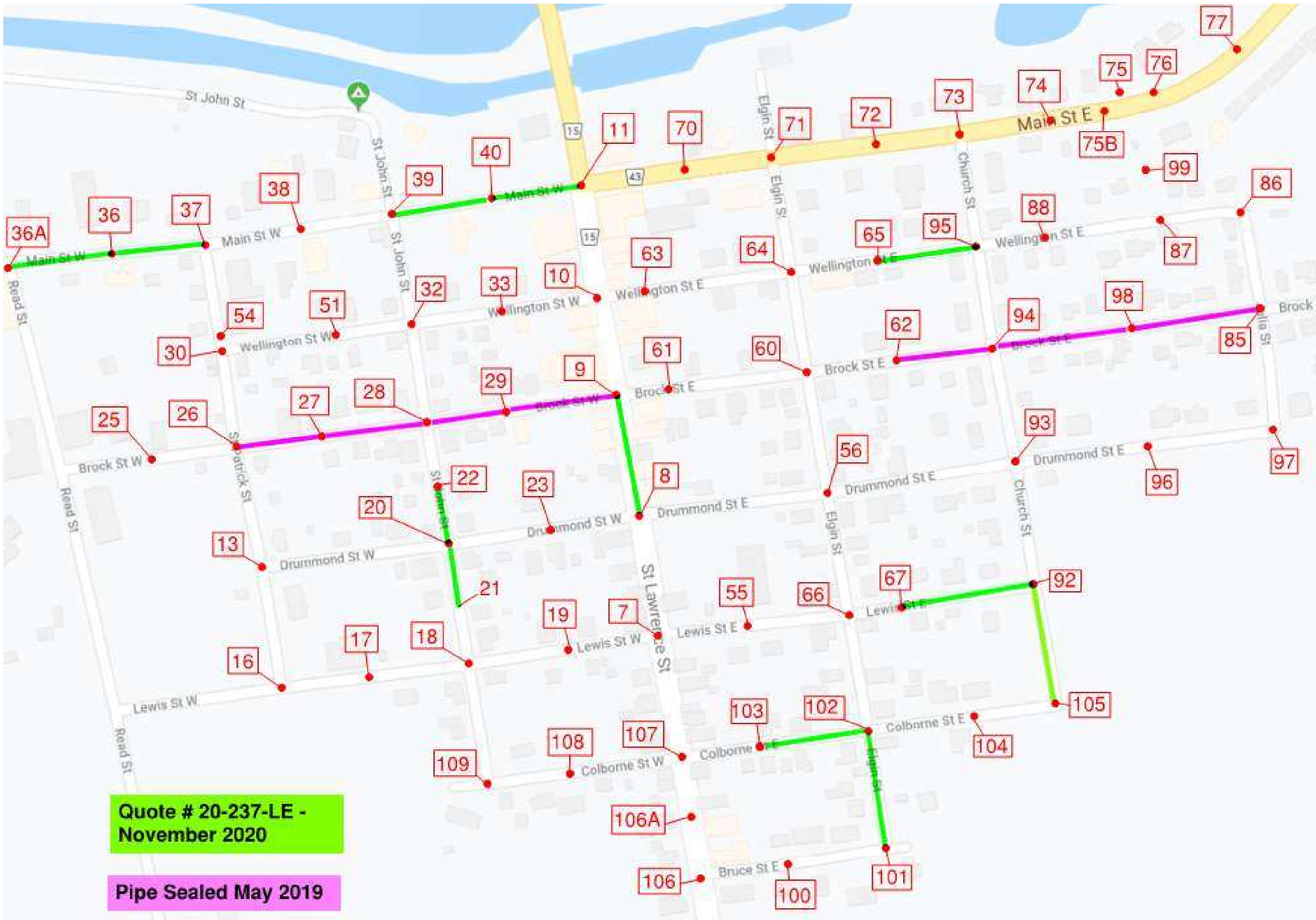

Figure 5: CCTV Report Scope of Work Map

It is useful to view the CCTV results and recommendations in conjunction with the flow monitor results. The flow monitoring has provided the understanding that the system flows are very high on Main Street and at the north end of St. Lawrence Street and the north end of Church Street, therefore any structural defects noted in the CCTV report in those areas should be prioritized for repair, whereas structural defects noted in the south half of the village would not be expected to provide a large benefit to the system if repaired.

The CCTV report identified a significant source of inflow as follows: the branch connection between MH038 and MH039 on Main Street, very close to St. John Street, labeled “EXTREME INFLOW” and “INFLOW @ 54.5 S/C IS #205 MAIN ST W” . Refer to Figure 6, from the CCTV report.

This connection was repaired in March 2021.

Figure 6: CCTV Report Extreme Inflow Noted at Main St and St. John

3.3.3 Ongoing Monitoring of Plant Flows, 2020, 2021, 2022

Plant flows have been tracked and compared year-to-year along with rainfall information gathered from Environment Canada for Drummond Centre (30km away) and Kemptville (20 km away). In this time frame the peak flows in spring have consistently risen to approximately 1700m3/day. Overall system flows in this time frame have been lower than the 5-year average. This is possibly due to lower amounts of precipitation, ongoing grouting work reducing infiltration and inflow, or a combination of both. There have been no incidences of plant effluent exceeding parameters due to high flows.

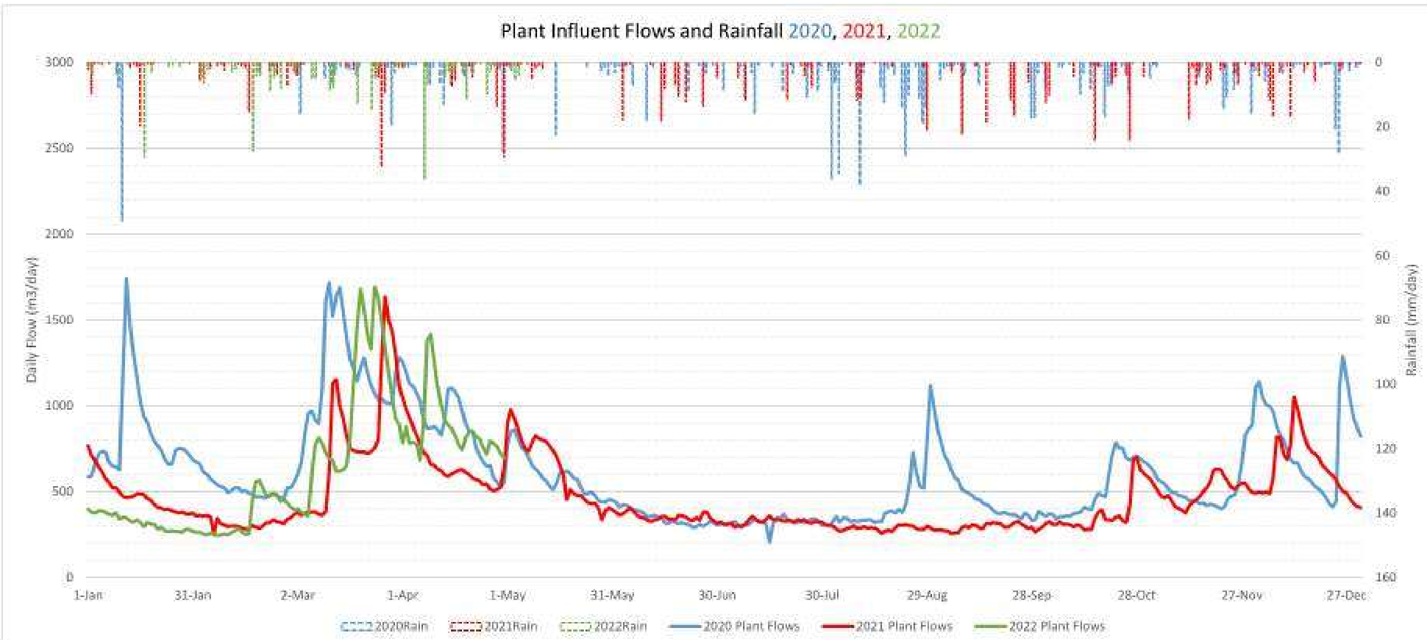

Figure 7: Plant Influent Flows and Rainfall, 2020, 2021, 2022

4 Analysis

4.1 Infiltration and Inflow Analysis Procedure

Infiltration and inflow amounts are determined in accordance with the following procedure from the Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems" and the U.S. EPA Sewer System Infrastructure Analysis and Rehabilitation:

- Plot wastewater flow rate as a function of time
- Establish the estimated wastewater production rate based on water supply records and draw the line on the plot for this flow (waste water production rate is normally comparable to potable water production).
- Draw a line through the lower limit of the recorded flows. The distance between this line and the wastewater production rate provides an estimate of the infiltration.
- The area left above the infiltration line is an estimate of the inflow.

4.2 Benchmarking Data of Acceptable Infiltration and Inflow Amounts

Many benchmarking values are available for infiltration and inflow; some related to the overall area of a catchment, or the size and length of pipe in a catchment, or the number of buildings serviced in a catchment (connections).

The following values are benchmarking figures from various sources

Infiltration And Inflow Limit Benchmarking		
Parameter Value	**Source**	**Notes**
11 200 l/ha/d as a result of a storm with less than a five year return period (infiltration + inflow design allowance)	Greater Vancouver Regional District, Liquid Waste Management Plan, February 2001	Table 3-1: Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems".
12 000 l/ha/d or 3,000 l/cm/km/d (average infiltration in existing systems)	Ministere de l'Environment du Quebec, Directive 004, 1989	Table 3-1: Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems".
5000 l/cm/km/day or 150 l/m/d (further investigations were required when infiltration exceeds one or both parameters)	Ministere de l'Environnement du Quebec, Guide technique sur la realisation des etudes preliminaires, October 1988	Table 3-1: Federation of Canadian Municipalities' 2003 Best Practice Guide: "Infiltration/Inflow Control/Reduction For Wastewater Collection Systems".
1400 L/km.m (average flow in a peak week)	MOE Sewer System Design Guidelines, 2008	This is noted as the level below which it is not "economical for rehabilitation".
Dry weather I/I: 0.05 L/s/ha Wet Weather I/I: 0.28 L/s	City of Ottawa Design Guidelines - Sewer Technical Bulletin ISTB-2018-01	Allowances for new sewer system design

Table 3 – Benchmarking Infiltration and Inflow Limits

4.3 Dry Weather Analysis

The objective of the dry weather flow analysis is to determine the infiltration rate and the base sanitary flow rate. The lower limit of waste water flow during dry weather periods is a combination of the base sanitary flow from domestic and process uses and the groundwater infiltration. The base sanitary flow of the whole system is determined from the water plant records. The portion of this base sanitary flow used in each catchment area is estimated to be proportionate to the number of sanitary system connections in each catchment area. These base sanitary flows are subtracted from the minimum flows in each catchment area to define the groundwater infiltration rate in each area.

Throughout June the average recorded waste water flow was 347m3/day and represents the dry weather minimum flow for the system. The lowest-recorded flow during the study period was 487m3/day and occurred on May 23rd, 2020 and is used to establish the proportionate dry weather flows for each catchment area. The minimum water supply is estimated to be 300 L/cap/day x 797 people = 239 m3/day. The Federation of Canadian Municipalities Best Practice Guide states that "In general, around 70 percent of the water consumed is returned to the wastewater system in summer. This figure increases to about 90 percent in the winter months." The base sanitary flow is then estimated to be 239 m3/day x 0.7 = 167 m3/day and is apportioned to each catchment area by the relative number of connections.

When the base sanitary flow is subtracted from the average dry weather flow for each catchment area, the result is the estimated amount of groundwater infiltration and is presented in the table below.

Catchment Area	Avg. Dry Weather Flows	Base Sanitary Flow	Groundwater Infiltration (GWI)	
	(m3/day)	(m3/day)	(m3/day)	(L/s/ha)
Main Street	172	38	135	0.14
Church Street	62	61	1	0.00
St. Lawrence Street	113	68	44	0.02
Total	347	167	180	0.04
MOE Guideline	N/A			0.12
City of Ottawa Design				0.05

Table 4 Summary Table for Dry Weather Analysis

This analysis has shown that the Main Street catchment has the highest unit rate of infiltration and is above the MOE Guideline limits during dry weather conditions and it is above the target design value for City of Ottawa sewer systems.

Excess Ground Water Infiltration originates from causes such as poorly grouted sanitary main connections, underground structure cracking, deteriorating or displaced pipe joints, root intrusion, hydrogen sulfide corrosion, pipe defects and cracking from loading, sump pump connections in low lying areas, drainage tile in low lying areas, etc. Infiltration generally increases over time, as the condition of the sanitary sewer network deteriorates.

Monitoring results indicate that GWI flows are likely highest during the spring melt period. During the peak melting time, it is difficult to separate ground water infiltration from inflow sources. Outside of the spring period, there are clear GWI differences between the catchment areas. These could be due to the material, age and condition of the various sanitary mains, together with subsurface soil conditions. The cost effectiveness of rehabilitating this pipe for the purpose of obtaining GWI improvements should be carefully considered in conjunction with other options to reduce extraneous flows.

Since the Main Street catchment area has the highest unit groundwater infiltration rates it is recommended that sewer grouting based on review of CCTV inspections focus on the Main Street catchment in order to address repairs and/or localized relining.

4.4 Wet Weather Analysis

The objective of the wet weather analysis is to characterize the wet weather flows and determine to what extent Rainfall Derived Infiltration and Inflow (RDII) may be occurring in each catchment area. The Rainfall Derived Infiltration and Inflow is defined as the water inflow to the sewer system over and above the constant minimum base sanitary flows and groundwater infiltration. It is determined by measuring the highest system flow during a rain event and then subtracting the baseline sanitary flow and groundwater infiltration.

Short term spikes in raw sewage flow rates due to a rainfall event are normally due to rainwater leader connections, manhole cover leakage, combined sewer sections and sump pump connections. Since the sudden peak in flow rate can cause operational issues in the sewage treatment plant, a program of replacing manhole covers with sealed covers (particularly in locations where manholes covers are prone to flooding) and disconnecting rain water leaders, sump pumps, etc. where they are discovered as part of other projects is recommended.

Peak wet weather flow was measured on March 18th, 2020 with the total flow of 1211 m3/day. St. Lawrence Street catchment was measured at 561m3/day, Church Street at 79m3/day and Main Street was calculated at 571m3/day. The flow measured at the St. Lawrence Street catchment was approximately 50% of the total system flow, which is proportionate to the relative area of the catchment. Main Street experienced wet weather flows above the expected amount given its relative area.

The rainfall-derived inflows for each catchment area are summarized below:

Catchment	Base Sanitary Flow	GWI	Wet Weather Flow		Rainfall Derived Infiltration and Inflow (RDII)				
	(m3/day)	(m3/day)	(m3/day) (1)	(m3/week average) (2)	(m3/day)	(L/Ha.day)	(L/d/km.cm)	(L/week/ km.cm)	(L/s/ha)
Main St	38	135	561	156	389	35355	10557	4235	0.41
Church St	61	1	79	248	17	1001	431	6283	0.01
St. Lawrence St	68	44	571	410	458	19087	8607	7697	0.22
Total	167	180	1211	950	864	16615	6670	7334	0.19
Guideline Limit						11,200 to 12000	3000 to 5000	1400	0.28
Notes:									

1) Peak wet weather flow measured on March 18th, 2020 – higher RDII was encountered at the plant earlier in March and in April, before measured data was gathered for catchment areas, so these wet weather flows do not represent the worst case for the system.
2) Average peak flow week of April 14-21st used. Previous weeks with higher flows have incomplete data

Table 5 – Summary Table for Wet Weather Analysis

The St. Lawrence and Main Street catchment areas received the highest rainfall-derived flows and exhibited large peaks coinciding with the largest increases in flows at the plant. It is recommended that flow reduction efforts focus on these catchment areas.

The most important recommendation within the municipal right of way is to identify and confirm if there are any stormwater catchbasins directly connected to the sanitary sewer main. The stormwater catchbasins would collect significant amounts of rainwater and a direct connection to the sanitary main could account for a significant portion of the excess inflows that are observed. This information could be obtained through interviews with system operators and/or through dye testing. Once these direct connection locations are known, recommendations for correcting the issue can be developed.

It would also be cost effective to identify and seal existing manholes that are allowing storm water to flow into sanitary sewers. Disconnecting sump pumps and roof drains from the sanitary sewer system will need to be done in conjunction with the confirmation of stormwater outlet availability and/or development and implementation of an improved storm water management system. The improved storm water management infrastructure would provide an outlet for the diverted storm water coming from sump pumps, roof drains and other storm drains.

4.5 Summary of Infiltration and Inflow Analysis

All catchment areas are above the 1400 L/cm.km per peak week noted by the MOE Sewer System Design Guidelines as the threshold above which it is economical to pursue rehabilitation. Main Street and St Lawrence Street are both above the 12,000 l/Ha/day limit recommended by the Quebec Ministry of the Environment. Church Street is within acceptable levels per hectare and per pipe length-diameter.

A review of the flow profiles of each catchment area reveals that Church Street flows remain relatively stable even during rainfall events. St. Lawrence Street flows peak during a rainfall event, which could indicate a direct storm system connection to the sanitary sewer in that catchment area.

St Lawrence Street is the largest area and its flows follow the plant flow profile closely, whereas Church Street remains relatively flat even during rainfall events. Both Main Street and St Lawrence Street exceed guidelines for acceptable infiltration and inflow amounts per hectare and per km.cm of pipe. The peaks in flow on St. Lawrence Street and the steadily above-average flows on Main Street are the major contributing areas to the overall excessive I&I. Based on the analysis of flow data, the St. Lawrence Street catchment and the Main Street catchment should be given a high priority for corrective action.

5 Recommendations

On the basis of our I & I Study, the following recommendations are provided to address infiltration and inflow over the long term:

1. <u>CCTV Inspection and Pipe Grouting Program</u>

CCTV inspection has been performed by OCWA and Clean Water Works and has formed the basis of the grouting work which has been completed in 2019 and 2020 (map shown below). Operators have reported noticeable flow reductions from the work that has been performed so far. It is recommended that this process of CCTV review and pipe grouting be instituted as a permanent program performed annually to completely review the entire system and also monitor for new breakages that may appear as the system ages. We also recommend focusing the next stage of camera review on Main Street East between St. Lawrence Street and Charlotte Street where the system flows are the highest and the ground water is presumed to be highest. This section of the system is the most challenging to review as the piping is nearly completely full so temporary bypass pumping would be required to draw down the water to allow camera inspection, which is best performed at night when system flows are lowest. A budgetary figure from CWW for this work is $36,000 - $50,000. A detailed breakdown of this work is provided in Appendix B

Grouting has been performed at cracks identified by CCTV review in the areas shown on the map below.

Figure 8: Scope of Sewer Repair Work 2018 - 2020

2. Manhole Inspection and Sealing Program

As a result of the manhole investigation a few minor repair items are listed below to help reduce infiltration and inflow:

Provide gasketed manhole covers with closed pickholes for covers set below grade: SAMH-10, SAMH-31, SAMH-30, SAMH-22.
Provide grouting of cracked risers inside manhole: SAMH-30, SAMH-24, SAMH-03.
Repair joint between cone and bottom section of manhole: SAMH-46 (Church St, next to a creek).
Repair loose frame: SAMH-13, SAMH-28.
Seal around service connection to barrel of manhole: SAMH-33 (service from 354 Read), SAMH-06.

Manholes should be reviewed on an ongoing basis to identify new cracks that may appear in the structures.

3. Inspection of Dwelling Roof Leader and Sump Connections

The municipality should consider enforcing the proposed sewer use bylaw and undertake property-by-property or structure-by-structure visual inspections from the municipal right of way to determine if roof leaders and sump outlets are discharging onto the surface. Notices could be sent to owners where there is evidence of roof leaders heading into the ground and not discharging onto ground surface. Follow-up visits by the Chief Building Official with the owner would confirm the removal of any direct connections.

The priority areas for these inspections are along Main Street and the portion of St. Lawrence Street between Main Street and Charlotte Street as the system flows are highest in these areas and groundwater levels are presumed to be highest in these areas. A map of the proposed investigations is provided below.

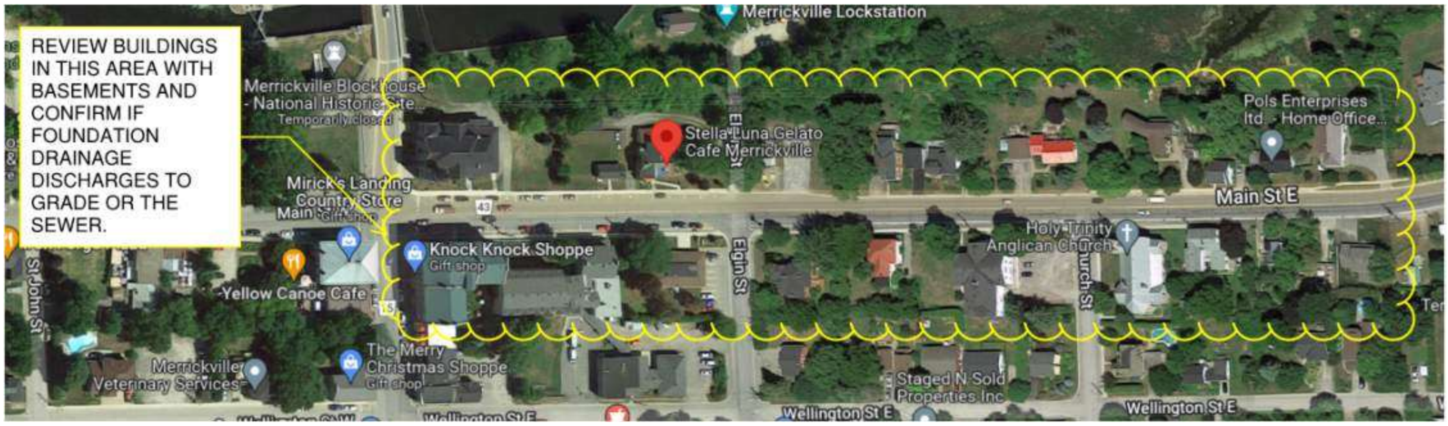

Figure 9: Scope of Proposed St. John / Main Street Investigations

4. Public Awareness Campaign

The municipality has initiated a public awareness campaign with the goal of encouraging ratepayers to reduce and/or eliminate illegal stormwater connections to the sanitary system. This has been achieved with "Disconnect & Protect" flyers included with water bills that explain the municipal sanitary and storm infrastructure and the importance of avoiding storm connections to the sanitary. Additional public education would continue to inform residents of the negative impacts of sump pump, foundation drain, and downspout connections. The public are being made aware that direct connections from sump pumps and roof leaders to the sanitary system consume valuable treatment capacity and contribute to hydraulic stress of the WTTP. Some homeowners may be unaware that direct connections are problematic. While the long term effectiveness of this measure may be uncertain, the municipality will continue to educate residents to aid in mitigating hydraulic stress and prolong the operational life of the current WWTP.

Direct storm connections to a sanitary outlet from private property are not permitted under the Ontario Building Code. The municipality may authorize inspections of sanitary connections and order disconnections, if required. The challenge with disconnections is that the owner may comply at the time of inspection, but over time the direct connections may be re-established by the current or future homeowner.

Sump pump discharge to sanitary sewer is often the result of not having reasonable alternatives such as ditches, storm sewers etc. Remedies for private property infiltration sources that focus on the identification and removal of direct connections are likely to be unsuccessful in the long run unless redirection of these connections onto landscaped surfaces allows the water to reach storm sewers in the municipal right of way as opposed to the sanitary network. Such redirection would decrease peak flows significantly, buffering the impacts of rainfall events and would direct rainfall into the stormwater system. The effectiveness would strongly depend on local grade conditions. Therefore, development and implementation of a stormwater management program to divert stormwater and sump pump discharges from the sanitary sewage collection system is recommended, providing home owners with alternative disposal locations thereby reducing incentive to connect sump pumps to sanitary sewers.

5. Stormwater System Assessment

The disconnection of possible sump pumps and roof drains from the sanitary sewer system and redirection to the storm water system will result in increased demand on the storm system. A review of the storm system capacity should be undertaken to confirm the available capacity where those new loads occur.

6. Study of WWTP Process Components To Identify Capacity Restrictions

OCWA reports that the effluent criteria for total suspended solids are exceeded when the wastewater treatment plant experiences flows that are above the average daily flow rating for the plant yet are still well below the peak flow rating of the plant. A high-level desktop review performed by Jp2g in 2020 confirmed the sizing of the plant components per design criteria of the MOE Design Guidelines for Sewage Works. A more in-depth study could be performed to determine the exact upper limit of flow from the plant and identify any opportunities for improvement in the process. The NRC has published a Wastewater Treatment Plant Optimization Best Practice Guide which recommends procedures such as hydraulic modelling, tracer dye testing to verify mixing performance in tanks, clarifier state point analysis, calibration of instrumentation, and establishing a yearly monitoring program to verify performance improvements.

Hydraulic modelling is performed using computational fluid dynamics software and has the advantage of being able to run multiple scenarios with individual parameters such as temperature and solids loading varied individually to isolate their impact on the process. Stress testing is a real-life exercise performed by directing multiple train flows to a single train to temporarily increase flow, or is performed during an actual wet season peak flow period and has the advantage of being an ideal performance test of the system. During stress testing multiple grab samples of influent and effluent BOD, TSS and sludge consistency and depth are taken at approximately twenty-minute intervals. A plan needs to be in place for capturing or recirculating flows if effluent parameters are exceeded.

An in-depth study would use hydraulic modelling and stress testing combined with real-time data gathering to determine the following at high flows and a variety of temperatures, influent BOD and TSS:

- Confirm if solids settling is affected by high levels of fats, oils, greases that cause the sludge blanket and floc to float
- Investigate denitrification occurring in anoxic conditions to see if nitrogen bubbles are causing sludge to float
- Confirm that mixing of coagulants is complete and there are no solids bypassing coagulant and then floating
- Confirm mixing within the tanks and identify short-circuits, dead zones or thermal currents.
- Confirm solids settleability
- Confirm influent diffusers slow flow enough not to impact sludge blanket when the high flows cause surges from the anoxic chamber into the SBR tanks during the settle and decant phases.

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