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TOWN OF TECUMSEH

Sanitary Model Recalibration and Basement Flood Risk Mitigation Study

January 2024 – 19-9298

Executive Summary

The Town of Tecumseh has experienced a number of intense rainfall events with prevalent surface and basement flooding throughout the Town over the past many years. Two major rain events occurred in 2016 and 2017 which resulted in 1,300 residents in the Town reporting basement flooding throughout the Town. As a result, Town Administration recommended eighteen (18) actions that would mitigate the risk of both surface stormwater and basement flooding within the Town of Tecumseh which was adopted by Council in 2018. As part of this multi faceted action plan, the Town initiated the completion of this sanitary sewer system assessment to continue to investigate sources of inflow and infiltration into the system and refine system improvement recommendations.

This sanitary sewer system assessment included the following tasks:

- Recalibrate the Town's existing sanitary sewer model based on monitored sewer data collected in 2019 and 2020, including conversion from XPSWMM to InfoWorks-ICM;
- Determine if the recently completed (2016-2018) sewer system repairs have shown benefit to the system;
- Understand the system's Rainfall Derived Infiltration and Inflow (RDII) response to various storm events;
- Determine which areas are vulnerable to basement flooding within the study area;
- Recommend a level of service for sanitary sewer design for existing and proposed development areas;
- Assess the benefit of private property improvements (elimination of cross connections by disconnecting foundation drains from the sanitary system);
- Recommend infrastructure improvements to reduce basement flood risk and redistribute sewage flow to optimize the sewer system outlet capacity; and
- Determine the cost of the proposed infrastructure and highlight implementation considerations.

This study area is comprised of the north settlement area of the Town, generally bounded by Lake St. Clair to the north, the City of Windsor limit to the west, the Town of Lakeshore limit to the east and Country Road 42 to the south. The Town's existing XPSWMM sanitary sewer model was converted to InfoWorks-ICM Drainage Design Software format and updated to reflect the Town's current conditions and calibrated to better represent current conditions and storm response. The model was calibrated based on in-situ monitoring of the sewer system completed in 2019 and 2020. The model is used to estimate both dry weather and wet weather flow based on in-sewer measurements of water levels (hydraulic grade line (HGL)) and correlating that data to measured rainfall volumes. The model can be used to simulate the sewer system's response to RDII during various rain events.

Between 2016 and 2018, the Town completed improvements to the Town's sanitary sewer system including installation of Rain Catchers in sanitary manholes and sanitary sewer and private drain connection repairs and sewer relining. Two sample areas where improvements were completed during this time period were used to measure the relative benefit of these RDII reduction measures. Comparing the system's RDII response from the system in 2011 (previously calibrated model results) with the newly updated model showed a reduction in the "slow response", infiltration component of RDII. This analysis also showed a larger percentage reduction of RDII during smaller rain events as compared to larger rain events. To continue to reduce RDII and mitigate basement flooding, it is recommended that these repair measures be continued as part of the regular maintenance of the existing system.

Using the developed model, vulnerable areas, where the HGL of the system is above average basement depths, were determined under both 1:5 year, 24 hour and 1:25 year, 4 hour rain events. Many of these areas were like those previously identified in previous system analyses including the Sanitary Sewage Collection System Improvements, Class Environmental Assessment (2013) (SS EA).

- Tecumseh Town (TE) Area
  - TE-1: Areas along Green Valley Drive, serviced by the Green Valley Drive trunk sanitary sewer; and
  - TE-2: Area to the west of Manning Road, north of CR22, along Lemire and Lanoue Streets.
- St. Clair Beach (SB) Area
  - SB-1: Areas along Brighton Road, serviced by the Brighton Road sanitary sewer;
  - SB-2: Areas south of Tecumseh Road, along Dresden Place and Dorset Park, serviced by the Arlington Boulevard sanitary sewer;
  - SB-3: Areas east of Arlington Boulevard and south of Riverside Drive, forming the Kensington Dish area; and
  - SB-4: Areas along Riverside Drive, west of Arlington Boulevard.
- Tecumseh Hamlet (TH) Area
  - TH-1: Areas along Charlene Lane, west of Lesperance Road; and
  - TH-2: Areas along Corbi Lane and Shawnee Street, draining to the Gouin Street sanitary sewer.

To mitigate flooding within the areas the following sanitary system improvements were explored:

- Reducing the volume of rainwater entering the system by disconnecting residential foundation drain connections within the system; and
- Providing in-line storage within the sewer system to reduce sewer surcharge (lower the HGL elevation).

Historically (pre-1980), residential foundation drains were permitted to be connected to available sanitary sewers. This practice is no longer permitted as these connections are a significant source of inflow into the sanitary system. It is encouraged that foundation drains be disconnected from the sanitary sewer and that sump pumps be installed with drainage redirected to discharge outside of homes or to the storm sewers. The reduced volume of inflow, from areas where these types of connections are expected, was estimated and the benefit of foundation drain disconnection was evaluated. It was determined that implementing foundation drain disconnections would have measurable reduction to the sewer HGL in areas where there is a higher percentage of homes with connected foundation drains. Ultimate redirection of rainwater from the sanitary system would reduce the volume of wastewater requiring treatment through the Little River Pollution Control Plant (LRPCP).

Where foundation drain disconnections alone cannot meet the basement flood risk reduction levels implementation of in-line storage was proposed where existing sanitary sewers are upsized to reduce surcharge of the sanitary sewer.

The system was evaluated based on various return periods (1:5, 1:25, 1:50 and 1:100), levels of FDD and inline storage improvements. Based on this evaluation, it is recommended that, although reducing RDII would be beneficial, the added cost and challenges associated with implementation would be greater and therefore the Town should initially rely on the use of in-line storage to provide basement flood risk reduction more immediately. FDD is the most sustainable solution which will have long term benefits of the system to reduce RDII, gain sewer capacity for infill development and reduce the volume wastewater requiring treatment. The recommended solution is based on reducing the sewer HGL below basement depths for a 1:25 year storm event. This translates to the reconstruction of 4490 m of sewer, with 3740 m and 750 m of sewer improvements in Tecumseh North and Tecumseh South, respectively (Scenario T3B and TH3B). Implementing mandatory foundation drain disconnection and promoting residents to implement private property protection measures including utilizing the Town's subsidy program should still be pursued to strive for sustainable long-term operation of the system. Table I summarizes the inline storage sewer improvements recommended in the Town.

Table I: Project Recommendations

Project Title	Project Description
Cedarwood PS Drainage Area	
Green Valley Drive/ Street Thomas Street/ Dillon Drive (Tecumseh Road E to Little River Boulevard.)	Replace 926 m of 450 mm dia. sewer with 900 mm dia. sanitary sewer. Replace 484 m of 450 mm dia. sewer with 1050 mm dia. sanitary sewer. Construct a 400m, 900 mm dia. parallel sewer between Little River Boulevard and Street Thomas Street.
Lemire Street and Lanoue Street	Replace 466 m of 300 mm dia. sewer with 1200 mm dia. sanitary sewer on Lemire Street. Replace 120 m of 250 mm dia. sewer with 1050 mm dia. sanitary sewer on Lanoue Street.
Riverside Drive	Replace 603 m of 400 mm dia. sewer with 2200 mm dia. sanitary sewer on Riverside Drive between Pentilly Road and West of Kensington Boulevard.

Project Title	Project Description
Arlington Boulevard	Replace 374 m of 300 mm dia. sewer with 1800 mm dia. sanitary sewer on Arlington Boulevard between Tecumseh Road E and St. Gregory's Road.
Edgewater Boulevard	Replace 360 m of 300 mm dia. sewer with 525 mm dia. sanitary sewer on Edgewater Boulevard between Riverside Drive and Hayes Avenue
CR22 Drainage Area	
Charlene Lane	Replace 180 m of 250 sewer with 600 mm dia. sanitary sewer on Charlene Lane between Roxanne Drive to Lesperance Road.
Lesperance Road/Gouin Street	Replace 115 m of 375 mm dia. sewer with 750 mm dia. sanitary sewer on Gouin Street, Lesperance Road, easterly to the boundary of the Manning Road Secondary Plan Area. Replace 210 m of 600 mm dia. sewer with 1050 mm dia. sanitary sewer on Lesperance Road.
Intersection Road	Replace 145 m of 300 mm dia. sewer with 600 mm dia. sanitary sewers on Intersection Road between Lesperance Road and St. Anne Street.
Lesperance Road (Charlene to Intersection Road)	Replace 74 m of 300 mm dia. sewer with 600 mm dia. sanitary sewer on Lesperance Road, between Charlene Lane and Intersection Road)
Gouin Street (Mayrand Crescent to Shawnee Road)	Replace 100 m of 250 mm dia. sewer with 450 mm dia. sanitary sewer on Gouin Street.

In addition to the above, in new development areas, sewers constructed shall be designed to meet the established level of service of 1:25 year HGL below average basement flood depths and it shall be demonstrated that new sewage flows will not have adverse impacts to the existing system.

The total cost to implement the basement flood mitigation strategy is estimated to be $34.48 Million for the Cedarwood PS drainage area and $3.13 Million for the CR22 drainage area, totalling $37.61 Million. Projects costs include road restoration costs, allowances for infrastructure relocations, engineering and construction costs.

In addition to the infrastructure improvements, it is recommended that the Town continue to implement programs, policies and improvements to continuously reduce RDII, reduce basement flooding risk, and maintain and operate the wastewater system.

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Sanitary System Recommendations

- Sewer Monitoring
  - Continually monitor the sanitary system and update the Townwide Sanitary Sewer Model based on changes to the Town's sanitary system. The Town shall continue using in sewer monitoring equipment and consider included additional monitors in problem areas identified in this report. Model updates will rely heavily on the accuracy and quantity of sewer operational data.
  - Frequency of sewer model calibration should be completed every 10 years, however, should sewer conditions that impact basement flood risk change, more frequent model calibration may be warranted. Examples of such factors are: more sever climate conditions, higher Lake St. Clair average daily levels, or significant sewer system improvements.
  - Monitoring can be used to determine new sources of Inflow and Infiltration (I&I) that may occur over time as the sewer system ages or illegal connections occur.
  - Regularly confirm sewer available sewer capacity and monitor the implementation of infill or additional residential units (ARUs).
- Monitoring Infill Development
  - As infill development proceeds, monitoring system capacity is imperative to adequately implement capacity improvements.
  - Use the master sanitary sewer model to confirm sanitary sewer capacity for new and infill development.
- Continue Basement Flood Protection Subsidies
  - Subsidies should reflect market costs to complete basement flood risk improvements.
  - Consideration for FDD program to cover implementation sewage ejector pumps, roof downspout disconnection, etc.
  - Implement policies to facilitate the mandatory installation of sewage ejector pumps for all new development.
- Private Property I&I Reduction
  - Sewer investigation of problem areas identified (such as the Lanoue/Lemire area) should be completed to determine sources of I&I, such as illegal connections or sewer deficiencies.
  - Implement by-Laws to investigate private properties using dye testing, sewer video, smoke testing and visual inspections.
- Sanitary System I&I Reduction
  - Continue the annual I&I reduction program.

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1.0 Introduction

1.1 Objective

The objective of this analysis is to provide recommendations to mitigate basement flood risk within the mainly urbanized residential areas of the Town of Tecumseh northern settlement area. This includes the assessment of sanitary sewer capacity, sanitary pump stations, and outlets to the City of Windsor sanitary system.

This sanitary sewer and basement flood risk analysis will:

- Provide an overview of updates that have been made to the Town's sanitary sewer model including conversion of the Town's sanitary sewers model from XPSWMM to InfoWorks-ICM;
- Determine if recent Rainfall Derived Inflow and Infiltration (RDII) reduction improvements have improved the level of service of the existing sanitary sewers;
- Identify areas vulnerable to basement flooding due to sanitary sewer surcharging based on the established level of service;
- Identify and evaluate term solutions to reduce the risks and impacts of this flooding; and
- Recommend an implementation strategy to mitigate basement flooding risks within the Town including high level cost estimates.

1.2 Study Area

As shown in Figure 1.1, the Study Area is approximately 16.7 km^2 in size, forming the urbanized portion of the Town of Tecumseh that is located in the north portion of the Town of Tecumseh. This area is bordered by Lake St. Clair to the north, Pike Creek and the Town of Lakeshore to the east, CR42 to the south and the City of Windsor to the west. The majority of the area is developed with a mixture of residential, institutional, commercial, and industrial land uses.

The study area is serviced by a separated sanitary sewer system that conveys domestic sewage via local service connections from residential, commercial, industrial, institutional and other land uses to the Little River Pollution Control Plant (LRPCP) in the City of Windsor, where it is treated and discharged to the Little River Drain and ultimately to the Detroit River. There is over 117 km of sanitary sewers modelled for this project which consisted of sewers ranging in diameters from 150 mm through 2250 mm.

Within this study area there are two (2) major sanitary outlets, where the Town's sanitary system discharges into the downstream City of Windsor sanitary sewer system:

- Cedarwood Pump Station (PS) at Gauthier Drive and Cedarwood Drive; and
- A 1200 mm dia. gravity sewer outlet at the intersection of Country Road 22 and Banwell Road.

This sanitary analysis focuses on existing developed areas and also includes provisions for future development areas within these sanitary sewer drainage areas. Further detail on developable areas are included below in Section 7.2. Considerations to increase outlet conveyance at these two outflow points were not considered as a potential action to reduce basement flooding as these flows are governed by an existing servicing agreement between the Town and the City of Windsor.

1.3 Background

Historically, the Town of Tecumseh has experienced significant rainfall events with prevalent surface and basement flooding throughout the Town. Over the last 13 years, a number of significant rainfall events have occurred in June 2010, September 2011, November 2011, July 2013, September 2016, August 2017, August 2020, and July 2021. Each event resulted in basement flooding within the Town which impacted a number of residents over the entire northern Town area.

In 2011, to respond to the basement flooding impacts from the 2010 and the two 2011 rain events, the Town initiated the completion of the Sanitary Sewage Collection System Improvements, Class Environmental Assessment (2013) (SS EA). An assessment of the Town's sanitary system, with a focus on basement flooding, was completed through the development and analysis of a XPWMM sanitary sewer model. This report summarized an evaluation of basement flooding and potential sources RDII. The report recommended improvements to reduce extraneous flows from the sanitary sewers including sealing manhole covers, disconnecting roof rainwater downspouts and correcting improper plumbing connections. Infrastructure improvements were also recommended to allow the sanitary system to better manage stormwater inflow during major rain events by providing temporary in-line pipe storage and improving conveyance of the Lakewood Pump Station (Lakewood PS). To date, the Town has implemented many of these measures and improvements which are summarized in the Rainfall Event of September 29, 2016 Council Report No. 40/16.

Subsequently, a major rain event occurred on September 29, 2016 and August 28, 2017 resulted in 1,300 residents in the Town reporting basement flooding. As a result, the Town recommended Eighteen (18) actions that would mitigate the risk of flooding within the Town of Tecumseh. These actions are included in the Flood Mitigation Strategy report, PWES-2018-17 dated June 26, 2018. Seven (7) of the Future System Actions where directly pertaining to improvements to the wastewater system and private property plumbing systems to reduce basement flood risk (Actions 10 to 17). This study contributes to the Town's continued effort to address flood risk and assists with the completion of the following Actions.

Action 11 lists the number of improvements that were identified in the SS EA (2013). Improvements listed under this item have been refined and integrated into the greater town-wide model based on more recent updates listed in this report.

Action 12 of this plan noted that the Town would continue to investigate the wastewater system and determine what improvements could be implemented in the system to manage RDII within the sanitary conveyance system. Summary of those investigations and subsequent improvements are summarized herein and are reflected in the solutions recommended.

A list of previously completed studies and other reference materials is listed in Section 3.4.

1.4 Data Collection

For the purpose of this study, sanitary flow data was sourced from the sanitary metering stations located downstream of the Cedarwood PS and along the CR 22 trunk outlet sewer. This data was provided in the form of peak flows in liters per second (l/s) at hourly time-intervals for the entire year from 2013 through to 2018. The data provided had gaps spanning from a few days to up to 60 days in some cases. A combination of the data from these two metering stations provided an idea of the sanitary flows from the entire study area.

In addition to the hourly sanitary flow data from the metering stations, data from sanitary flow monitors was sourced from flow monitors maintained by the Town within sanitary Maintenance Holes (MH). Since the flow monitors at all MH locations were not maintained for the entire time period under consideration (2013-2018), sewersheds were chosen for analysis based the availability of data. The following section of this document will discuss the method chosen to select sewersheds for analysis. Some of this data was sourced from the flow monitoring completed as part of Dillon's previous calibration exercise completed on the Town's XPSWMM model for the sanitary sewer network. This data provided peak flows in liters per second (l/s) at time-intervals ranging from 5 to 15 minutes.

Data regarding precipitation was sourced from rain-gauges maintained by the Town over this time period. Storm events were identified from the rainfall data. Similar storm events occurring in each of the years under consideration were chosen to compare the quantity of the RDII component in the sanitary flows. During periods when precipitation data from the rain-gauges maintained by the Town were not available, precipitation data from the AES climate station located at Windsor Airport was used to supplement the data. This was done mostly to identify dry days when there was no rainfall, to calculate Dry-Weather Flows (DWF) in the sanitary sewers.

The Town provided information about location and number of sanitary sewers lined, sanitary MHs sealed and sanitary service laterals repaired. The information provided was digitized in the form of GIS shapefiles for analysis and future representation.

Appendix A provides a summary of the data available for this study.

2.0 RDII System Improvements 2013-2018

Since the completion of the 2013 study, the Town of Tecumseh completed improvements to the sanitary sewer system to reduce the volume of RDII within the Town's system. One objective of this background data investigation study is to quantify the RDII entering the system and to understand the benefit of improvements completed from 2013 to 2018 has had on the sanitary sewer flow volumes and peak flow rates. To complete this preliminary analysis the original XPSWMM model was used in lieu of the updated Infoworks Model that included data collected after 2018.

Improvements undertaken between 2013 and 2018 included installation of Rain Catchers in sanitary manholes and sanitary sewer and private drain connection repairs and relining. The Town provided information about location and number of sanitary sewers lined, sanitary MHs sealed and sanitary service laterals repaired. The improvements were then digitized in the form of GIS shapefiles for analysis and future representation.

Historic flow monitor data at various locations in the Town's sanitary infrastructure was collected, along with available precipitation data from rain-gauges maintained by the Town. The Town provided information about locations of sanitary sewer improvements completed in the recent past Historic flow data was analyzed to evaluate changes in dry weather flow, including domestic flow and Dry Weather Inflow and Infiltration (DWII), and RDII.

Figures 2.1 and 2.2 represent the study area and locations of repairs and rehabilitation measures completed by the Town on sanitary infrastructure. Table 2.1 below provides a summary of improvements that were completed for the two main sanitary sewersheds within the Town, Tecumseh (TE464), drainage area serviced by the Green Valley Trunk Sewer, and St. Clair Beach (SB115), representing the drainage area upstream of the Riverside Drive Trunk sewer, east of the Beach Grove Golf Course.

2.1 Methods of RDII Analysis

Analysis of available data was completed using two methods.

- Method 1: Using flow monitoring data from flow-monitors installed in sanitary MHs; and
- Method 2: Using flow data from the sanitary metering stations maintained by the Town at outflow points into City of Windsor's sanitary sewer system.

This analysis allowed investigation of sanitary flows for the larger study area. Each analysis method is described in detail in Sections 2.1.1 and 2.1.2.

2.1.1 Method 1: Maintenance Hole (MH) Flow Data Comparison

2.1.1.1 Sewershed and Storm Event Selection

Two sewersheds upstream of the flow-monitoring locations were identified for analysis. These sewersheds had continuous data for 2011 and years 2016-2018 available. For each monitoring station, the sanitary flows from the year 2011 were used to set a baseline as most of the RDII reduction measures were completed after this year. To compare the effects of sanitary infrastructure improvements on sanitary flows, sanitary flow data from the years 2016 to 2018 were compared.

The selected sewersheds are referred to by the location of the flow-monitors, SB115 and TE464. Table 2.1 provides information about these sewersheds.

Table 2.1: Characteristics of Sewersheds Selected for Analysis

Sewershed ID	SB115	TE464
Area (ha)	56.1	96.0
Approximate Population	905	2385
Sanitary Improvements completed		
- Sanitary Sewer Mainline Repairs	15	8
- Sanitary Maintenance Hole Sealing	7	6
- Sanitary Sewer Lateral Repairs	0	4
Approximate percentage of residential properties fronting sanitary sewers installed pre-1985	82.2%	17.8%
Zoning Classification		
- Commercial	3.2%	21.5%
- Industrial	-	15.6%
- Institutional	2.1%	0.2%
- Recreational/Parkland	2.7%	4.1%
- Residential	91.9%	58.6%

The sewershed upstream of SB115 are smaller compared to TE464. The land-use is pre-dominantly residential, with a majority of homes fronting sanitary sewers which were installed before the year 1985. With most of the sanitary sewers in this sewershed being installed more than 30 years ago, it is reflected in the amount of sewer repairs completed by the Town. A larger number of sanitary sewers were repaired and MHs sealed when compared to TE464. It should be noted that for this purpose of this preliminary analysis 1985 was used as the benchmark year when residential home construction practices changed and foundation connection drain connections to the sewer system stopped. Subsequently, later in this study, the benchmark year of 1980 was used as this is when the Town's building codes were updated to prohibit the connection of foundation drains to the sanitary sewer.

The sewershed upstream of TE464 has a larger percentage of the total area formed by commercial and industrial land-uses. The residential land-use percentage is less as a result, but still forming a majority of the total area. It is also observed that most of the sanitary sewers are newer compared to SB115. This is reflected in the lower number of sewers and MHs repaired by the Town.

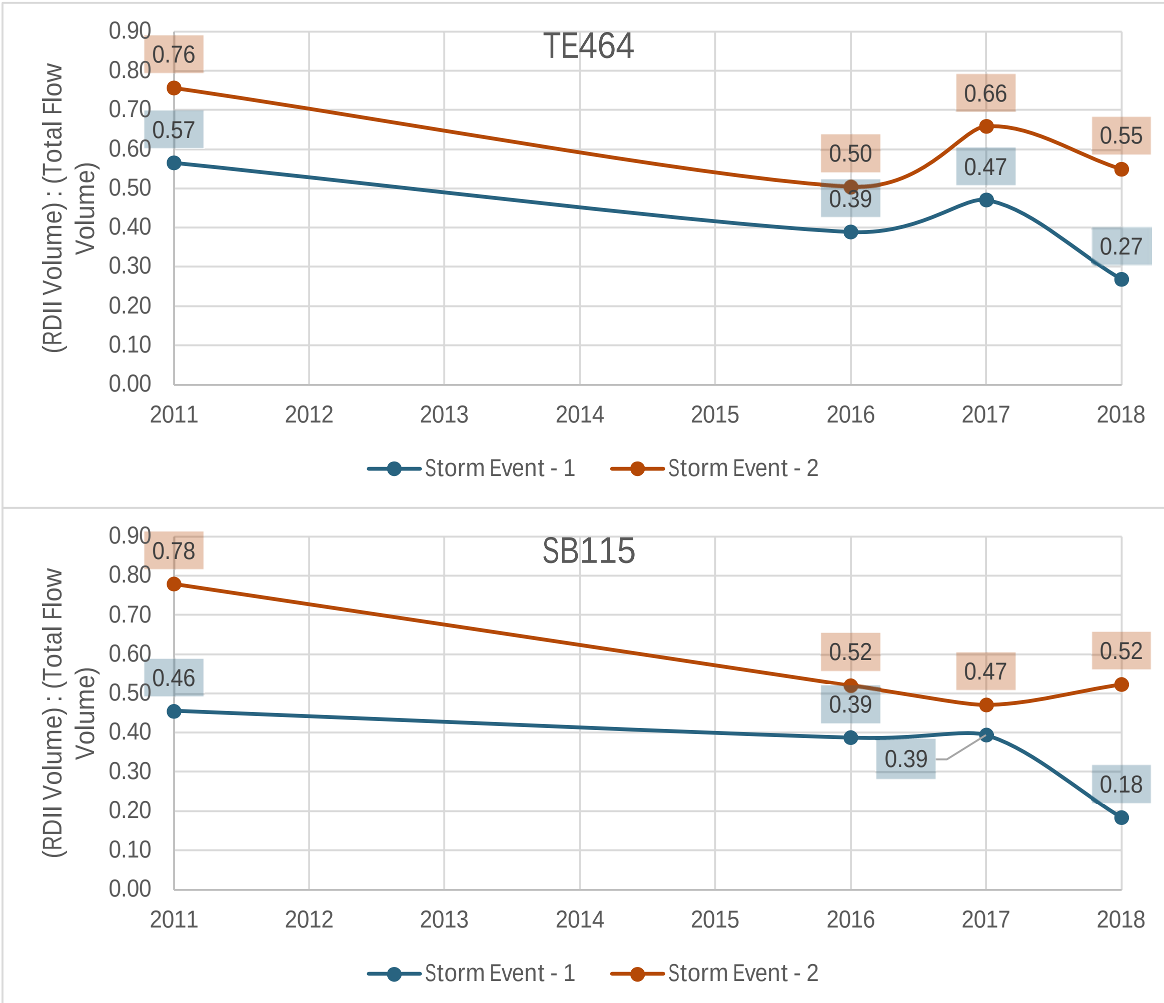
Observed Rain Events Selected for RDII Analysis

Several rain events that impacted the Town were selected for observation and categorized based on total rainfall depth. These categories were: Storm Event ID 1 (storms with total rainfall of approximately 30 mm) and Storm Event ID 2 (storms with total rainfall of approximately 50 mm). Storm Event ID 1 rainfall characteristics are similar to a 1:2 year storm return period, and Storm Event ID 2 is a marginally more intense event and is approaching the characteristics of a 1:5 year storm return period.

2.1.1.2 Analysis Results

Graph 2.1 below represents the ratio of RDII volume to the total flow volume during and after rain events. While it is difficult to discern a clear trend from this analysis, it shows that the volume of RDII has seen a decrease in years 2016 to 2018, when compared to 2011. Data tables used to plot the graphs are provided in Appendix A.

The graph lines shown in Graph 2.1 for Storm Events ID 1 and ID 2 are generally parallel to each other, demonstrating a resultant higher RDII volume for larger rain events. This trend shows a divergence in Storm Event 1 in 2018 for the SB115 sewershed. This can be attributed to spatial variation in the rainfall. Summer rainfall events in this region, such as the ones being analysed here, are typically localised over certain areas and do not occur uniformly across the sewershed. The August 2018 rain event evidently was concentrated on the western part of the Town and generally missed the sewershed of SB115.



Graph 2.1: Ratio of RDII Volume to Total Volume for TE464 (TOP) and SB115 (BOTTOM)

Graph 2.2 below represents the peak flows during and after rain events.

Peak flow reduction is higher for smaller storm events (Storm Event ID 1) as compared to larger events (Storm Event ID 2).

Graph 2.2: Peak Flows During and After Rain Events FOR TE464 (TOP) AND SB115 (BOTTOM)

The peak flow changes observed are summarized in Table 2.2:

Table 2.2: 2013-2018 Sewer System Improvements - Observed RDII Reduction

Sewershed ID	Storm Event ID 1	Storm Event ID 2
SB115	13% - 24% reduction	12% - 20% reduction
TE464	21% - 58% reduction	6% - 28% reduction

2.1.2 Method 2: Outlet Flow Data Comparison

The drainage areas of the Cedarwood PS and the outflow point along CR22, when combined, comprise the entire study area.

2.1.2.1 Sewershed Selection

Table 2.3 provides the characteristics for each of these service areas.

Table 2.3: Characteristics of Service Areas*

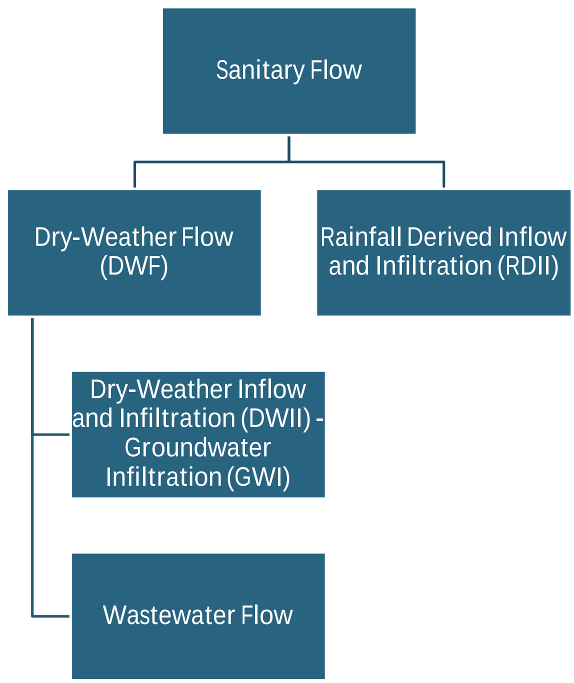
Service Area	Cedarwood PS	CR22 Outflow Point
Area (ha)	928.1	380.4
Population	15,682	4,421
Completed Sanitary Improvements		
- Sanitary Sewer Mainline Repairs	128	27
- Sanitary Maintenance Hole Sealing	64	23
- Sanitary Sewer Lateral Repairs	35	22
Percentage of residential properties fronting sanitary sewers installed pre-1985	62.8%	45.9%
Zoning Classification		
- Commercial	8.4%	11.9%
- Industrial	3.5%	4.9%
- Institutional	5.1%	3.1%
- Recreational/Parkland	13.4%	3.0%
- Residential	69.4%	66.2%
- Agricultural	0.2%	11.0%

Parameters above represent the land data used at the time of the analysis since were updated refined within this study.

The service area of the Cedarwood PS is larger compared to the drainage area of the CR22 outflow point. While most of the service area of the Cedarwood PS is developed, with only 0.2% of the total area zoned as agricultural. A larger part of the CR22 drainage area is zoned agricultural. The proportion of residential zoned areas are similar for both the service areas. But the northern areas of the Town have a larger proportion of the residential properties fronting sewers constructed before 1985. Majority of the sanitary infrastructure improvements completed by the Town are concentrated in the northern part of the Town, which forms the service area of the Cedarwood PS.

2.1.2.2 Sanitary Flow Components

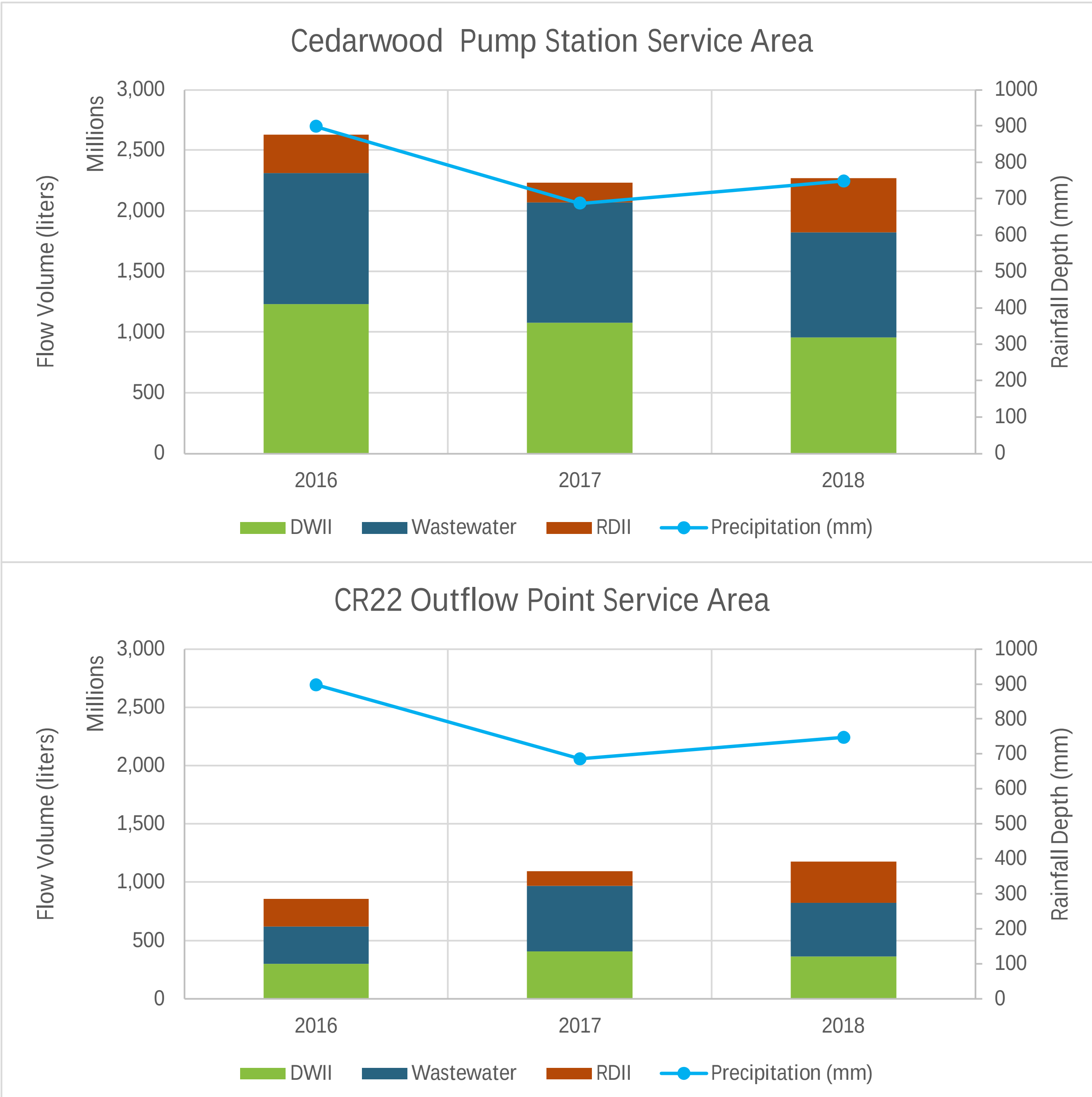
For this part of the analysis, the focus was to separate the total flow volumes into the different components of total sanitary flows. The components are illustrated in Graph 2.3.



Graph 2.3: Components of Sanitary Flow

To separate the different components of sanitary flow, Dry Weather Flow (DWF) volumes were subtracted from the total sanitary flow. The resulting components are DWF and RDII. The DWF component was further separated into Dry Weather Inflow and Infiltration (DWII) and Wastewater Flow. This was completed by analyzing the diurnal flow patterns during a typical dry day. It was found that the lowest flows occurred between the hours of 5:00-6:00 am. It was assumed that 90% of the total flow volumes during these hours were considered to be the base-flow or DWII. The difference of the total DWF and the DWII was assumed to be the wastewater flow in the sanitary sewers and comprised of sewage discharge from residential and other land uses.

Graph 2.4 illustrates the different components of sanitary flow for the service areas of the Cedarwood PS and the outflow point along CR22.



Graph 2.4: Sanitary Flow Components - Cedarwood PS Service Area (Top) and CR22 Outflow Point Service Area (Bottom)

The graphs above show the flow volumes for years 2016 to 2018 only, although the data available was for all years (2013 to 2018). Due to gaps in data in the years preceding 2016, an accurate estimate for total flows for comparison was not feasible. Data tables used to plot the graphs are provided in Appendix A.

2.1.2.3 Analysis Results - DWII Volumes

For the service area of the Cedarwood PS forming the northern part of the Study Area, the RDII volumes for years 2016 to 2018 are proportional to the total rainfall volumes for the respective years. However, the DWII volumes show a decreasing trend over this three-year period.

The wastewater flow volumes, when divided by the population of the service areas, provide values ranging from 150 litres per capita per day (lpcd) to 190 lpcd. These values, although lower than the average per capita wastewater flow rates of 229 lpcd (CH2M Hill, 2005) for the Town of Tecumseh, are within the range of 135 lpcd to 275 lpcd from previous studies commissioned by the Town (CH2M Hill, 2005). It should be noted that for larger service areas like the ones being analysed, the amount of DWII during low flow periods is a lower percentage than the standard 90% assumed for the analysis. One possible reason for this divergence could be due to discharge from industrial operations which traditionally do not follow the diurnal flow patterns observed in residential areas.

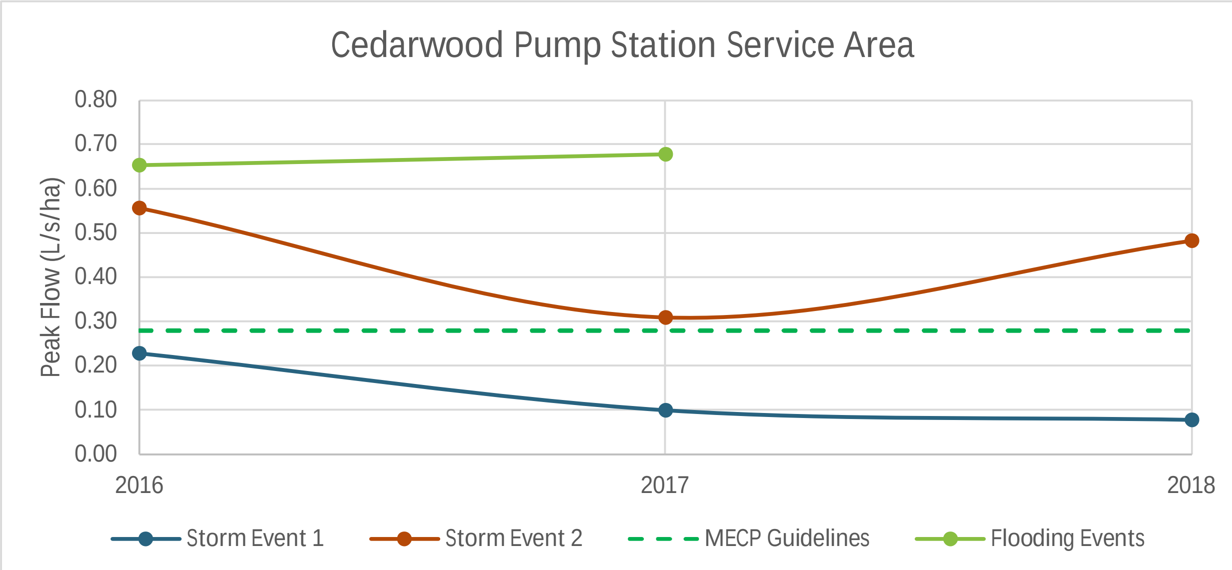
2.1.2.4 Analysis of Flow Data – Peak Flow Analysis

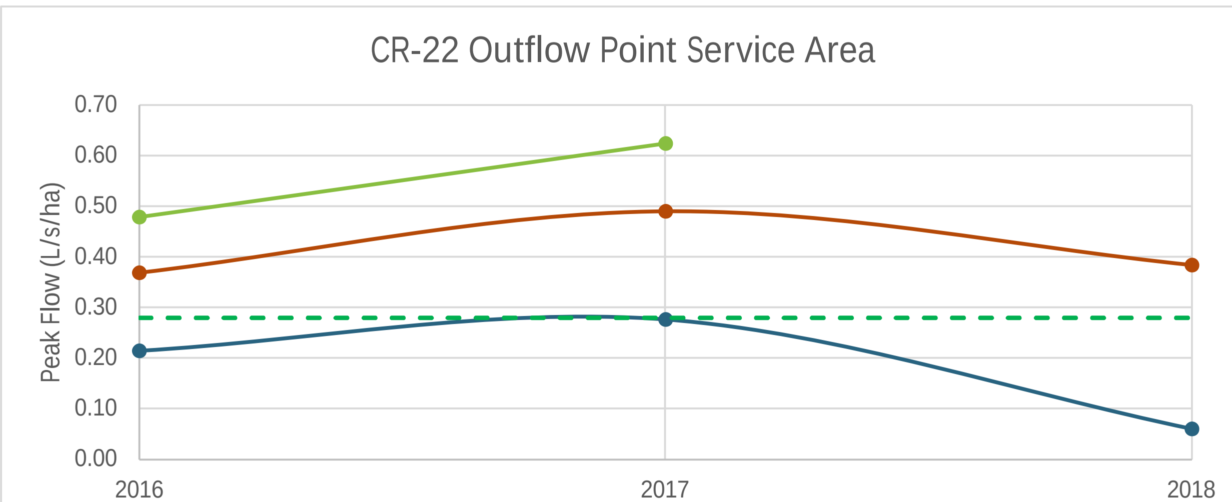
To compare the peak flows during wet-weather events to the RDII standards in the Sewer Design Guidelines (MECP, 1985), an analysis of the peak flows during selected storm events was completed. It is noted that the allowable extraneous flow listed in the MECP guidelines are meant to represent maximum Groundwater Infiltration (GWI) allowances closer to the end of the sewer's lifecycle, where infiltration is more likely due to deterioration of the sewers including cracks or other damage.

Graph 2.5 compares peak RDII flows to the MECP guidelines for extraneous flow. MECP guidelines published in 1985 specify an allowable range of extraneous flow, between 0.10 and 0.28 litres per second per hectare (L/s/ha).

It is observed that the peak RDII flows during the Storm Event-1 (<30 mm depth) are generally within the MECP guidelines, but for the larger Storm Event-2, the peak RDII flows are much larger than the MECP Guideline maximum of 0.28 L/s/ha.

During the flooding events of September 2016 and August 2017, the peak RDII ranged from 0.50 L/s/ha to 0.70 L/s/ha.





Graph 2.5: Peak RDII for Selected Storm Events for Cedarwood PS Service Area (Top) and CR-22 **Outflow Point Service Area (Bottom)**

2.2 Conclusions from Background Data Analysis

2.2.1 Method 1: Analysis of Flow Data in Selected Sewersheds

A reduction in RDII within the system is observed when comparing the RDII in 2011 versus the system conditions during the 2016-2018. This confirms that improvements to sanitary infrastructure completed by the Town in the years preceding 2016 have provided benefit. Rehabilitation of sewer infrastructure results in a reduction in the slow response, infiltration component of RDII. This analysis shows a larger percentage reduction of RDII during smaller rain events as compared to larger rain events.

Further reduction in faster response inflow sources into the sanitary sewers will have a greater impact in reducing RDII volumes in the sanitary sewers. Traditionally, inflow from foundation drains connected to the sanitary sewer system have been classified as 'slow' response. However, more recent studies have revealed that the time required for surface water to percolate into the backfill material around homes, into foundation drains and eventually into sanitary sewers is less than 10 minutes (City of Toronto, 2017) and therefore this study considers this a fast response inflow source.

The analysis shows that there has been a reduction in RDII due to rehabilitation of sanitary infrastructure completed by the Town, but further reduction in RDII is required to meet acceptable standards, especially through private property measures. Refer to Section 8.0 for private property measures that should be implemented to further reduce RDII.

2.2.2 Method 2: Analysis of Flow Data for Entire Study Area

A comparison of flow volumes for the years 2016, 2017 and 2018 shows a steady reduction in the DWII component of the sanitary flow over three years for the Cedarwood PS service area. The RDII volumes are proportional to the amount of rainfall measured at Town's rain-gauges for the respective year.

Analysis of the peak flows during and just after a rain event show that the peak RDII flows are much higher than the MECP guidelines for larger rain events. High peak flows observed during and after a rain event usually are evidence of inflow sources into the sanitary sewers. These can be either connected roof downspouts, catchbasins, foundation drains (homes pre-1985), or rear-yard drains connected to sanitary sewers or inflow through MH Covers.

It is worth noting that at the metering station located downstream of the Cedarwood PS, there is an approximately 25% reduction in the average peak flows measured before and after May-June 2016. Flows measured after this period show a reduction in the average flows, which is attributed to calibration of the metering station in that period. Analysis of data from this metering station was completed using flow data for years 2016, 2017 and 2018. Thus, a majority of the data used for analysis was after the said calibration process and no adjustments were made to the raw flow data.

No clear conclusion can be drawn from the available flow data for the outflow point along CR22, improvements. It should be noted that the CR22 Drainage area will be undergoing upgrades including replacement of sanitary sewers along CR42 and introduction of the West Hamlet Trunk sanitary sewer. Upon completion of these improvements, more detailed monitoring and investigation shall be completed to reduce RDII into the system. Efforts should focus on reducing foundation drain connections as noted in in Section 7.2.3 of this report.

3.0 Data Collection

For a reasonable representation of the flow characteristics of the Town's sanitary sewer system, both precipitation (rainfall) and flow monitoring data are required. This data is used to characterize and understand dry-weather (no rainfall) and wet-weather (rainfall) sewer flows. During dry-weather periods, the sanitary sewers convey only sewage from households, commercial, institutional and industrial land (wastewater flows) uses plus non-rainfall derived groundwater infiltration (baseflow).

Sanitary sewers are designed primarily to convey sewage plus a nominal allowance for infiltration based on total service area. Design infiltration allowance reflect an estimated infiltration that could result from groundwater infiltration for sewer pipes closer to the end of their lifespan. Based on previous studies, and confirmed through a review of the recent flow monitoring data, a response to wet-weather rain events was observed in all sanitary flow monitoring gauges with noticeable increases in flow.

The key data sources used for this project are identified below:

- The Town of Tecumseh has an on-going program with a network of rain gauges that record precipitation patterns within the municipal limits. The rain data from this network formed the primary source of precipitation data for the study;
- In 2019-20, 10 months of temporary sewer flow monitor data was collected at locations throughout the Town, focused on understanding sanitary sewer wet-weather response; and
- Starting in 2020, the Town collected sanitary sewer flow monitoring data at 4 additional locations throughout the Municipality. These monitors collected data from service areas which were identified as, either having a significant wet-weather response in the previous flow-monitoring exercise, or were focus of a detailed investigation of sewage flows from the new development.

Additional details about each of the above are identified in the subsequent sections.

3.1 Precipitation Data

The Town of Tecumseh maintains an active network of rain gauges that collect continuous records of rainfall rates and volumes. The precipitation data collected by these gauges was accessed through an online portal. Precipitation data was collected at the following locations:

- Tecumseh Town Hall located at the intersection of Lesperance Road and McNorton Street;
- St. Alphonse Avenue Sanitary PS located at the intersection of Country Road 42 (CR42); and
- Brighton Road Storm PS located at the intersection of Brighton Road and Tecumseh Road.

A map of all rain gauges used in the study is presented in Figure 3.1.

A list of the notable wet-weather events observed during the monitoring period are summarized in the Appendix A. It includes rainfall total volumes and peak intensities at each of the rain gauge locations which were used in the study. Rainfall events chosen for the study were selected based on the total volume of precipitation, peak intensity and the duration of the event. A comparison of the selected rain events to the IDF curves for the Windsor Airport climate station data for the following return periods: 1:2 year, 1:5 year, 1:10 year, 1:25 year, 1:50 year and 1:100 year, has also been included in Appendix A.

3.2 Sanitary Sewer Flow Data

AMG Environmental Inc. (AMG) was retained by Dillon to undertake this flow monitoring exercise, completed between April 2019 and July 2020.

A summary of maintenance hole (MH) locations in the Town's sanitary system, where sanitary sewer flow data was collected, with the respective flow monitoring periods highlighted, is provided in Table 3.1.

Table 3.1: Sewer Flow Monitoring Schedule

		Year																							
		2019												2020											
Area	Sanitary Flow Monitoring Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St. Clair Beach	SB007																								
	SB030																								
	SB060																								
	SB115																								
	SB339																								
	SB342																								
Tecumseh Town	TE464																								
	TE124																								
	TE011																								
	TE274																								
	TE148																								
	TE678																								
	TE714																								
Tecumseh Hamlet	TH078																								
	TH113																								
	TH010																								
	TH023																								

Legend

(grey)	2019 flow monitoring exercise
(green)	2020 flow monitoring exercise for new development areas within the Town
(orange)	2020 flow monitoring exercise for areas of interest based on previous flow monitoring and proposed infrastructure improvement projects

3.2.1 2019 Data Collection

Figure 3.1 represents the locations where flow monitoring (FM) was undertaken and the upstream drainage areas of each of these FM locations. FM locations were decided based on the following factors:

- Flow monitoring locations used during previous sanitary sewer studies completed by the Town;
- Areas identified as potential problem areas in previous sanitary system studies completed by the Town. These areas were suspected to have higher rates of RDII into the sanitary system, and were recommended to be investigated further;
- Older development areas of the Town, where foundation drains are suspected to be connected to the sanitary sewer system, causing a higher RDII rate during WWF events;

- Areas along Riverside Drive, in the northern part of the Town, which are generally lower than southern parts of the Town; and
- Major trunk sanitary sewers within the Town were selected for flow-monitoring.

In addition to the sewer flow monitoring conducted at various points in the Town's wastewater conveyance system, flow data collected through the metering stations downstream of Cedarwood PS and the gravity outfall along CR22 was provided for this analysis. This data was provided by the Town in April 2019, which included flow data from the year 2013 to 2019.

3.2.2 2020 Data Collection

Based on sewer flow data observed in the 2019 flow monitoring period, additional areas of interest were identified based on:

- "Focus Areas" identified as problem areas based on higher rates of RDII during events observed during the monitoring period in 2019, and subsequent calibration of the hydraulic model;
- Newer developments in the Town, to estimate the amount of RDII from new developments; and
- Areas where municipal infrastructure upgrades are proposed as part of planned roadway reconstruction projects.

3.2.2.1 2020 Flow Monitoring Exercise Areas

St. Alphonse PS Drainage Area CR42

Findings from the 2019 monitoring program resulted in hydraulic grade line (HGL) elevations that did not reflect the Town's observations in this area. To better represent this drainage area, two FMs were installed in the sanitary sewers along CR42 to observe flows during dry-weather and wet-weather events.

Monitoring was completed in 2020. Subsequently, the design and reconstruction of CR42 (CR42) from west of the 11th Concession (County Road 43) to east of Manning Road (County Road 19) located within the Town of Tecumseh, was undertaken by the County of Essex. This project is underway and the underground sewer works were completed in Summer 2023. To accommodate the road reconstruction, a large storm trunk sewer is required along CR42. Due to the depth and size of this sewer, in addition to the existing sanitary sewer on CR42, a parallel trunk sanitary sewer was constructed to provide private drain connections. Sizing and recommendations pertaining to those improvements are discussed more in Appendix B.

In addition to flow monitoring, a visual sensor was installed in MH TH010 and MH TH023 to provide a verification of high depths reported by the depth sensors installed as part of regular flow-monitoring equipment. The visual sensor was essentially a camera that provided images of inside the MH structure where flow-monitors were installed. A staff gauge was installed in the camera's field of vision with markings showing the depth from the invert of the lowest sewer connecting to the MH. The camera was programmed to take pictures at hourly intervals under free-flow conditions in the sewer. The pictures were taken every 15 minutes once the downstream sewer was surcharged, i.e. the level of sewage in the MH was higher than the obvert of the sewer leaving the MH structure.

Little River Boulevard Trunk Sewer

Flow-monitoring along the Little River Boulevard (LR) trunk sanitary sewer was extended into 2020. To analyse the risk of basement flooding in the drainage areas upstream of the LR trunk sewer, an accurate estimate of the HGLs in the trunk sewer was essential. A high HGL in the LR trunk sewer causes a tailwater condition within branch sewers draining into the LR trunk sewer, resulting a higher risk of basement flooding in upstream residential developments. Visual Sensors were also installed as part of the 2020 flow-monitoring period.

Lanoue/Lemire Drainage Area (TE678)

The drainage area upstream of TE678 was observed to have significantly high rates of RDII when compared to RDII rates in other parts of the Town. As such, flow-monitoring in this area was extended into 2020 to obtain additional data to investigate the causes of the high RDII rates. Visual Sensors were also installed in this MH as part of the 2020 flow-monitoring period.

New developments within the Town (SB339 & SB342; TE714)

Flow monitoring was completed in 2020 to estimate the RDII from newer developments within the Town. Two recent developments within the study area were chosen for monitoring of RDII flows. The data from these monitors were deemed inconclusive. While data at the Lakewood Park development in the SB area was influenced by high flows in the Hayes Avenue sanitary trunk sewer located downstream, the observed flows at the Carmelita development reported minimal extraneous flow. More information about this analysis is included in the MRSPA Functional Sanitary Service Modelling Technical Report (July 2023) prepared as part of the MRSPA Functional Service Report (July 2023).

3.3 GIS Data

Geodetic data was received from the Town regarding the following information:

- Parcel fabric for the Town, with population for each residential property parcel (sourced from MPAC 2019 data);
- Parcel fabric for the Town, with year of construction for buildings within each property parcel;
- Address points information for homes that reported basement flooding during the September 2016 and August 2017 rain events;
- Address points information for homes that have completed a voluntary foundation drain disconnection under the Town’s ongoing program;
- Polygon layer identifying the building footprint areas; and
- Zoning layer identifying land-use zones within the Town.

3.4 Background Document Review

The following documents were reviewed as part of this study:

- Hamlet Area Sanitary Sewer Update Report (Dillon, 1998);
- Sanitary Sewer Overflow Prevention Study for the City of Ann Arbor (CDM, 2001) [Ann Arbor 2001 study];
- Town of Tecumseh Inflow and Infiltration Control Study (CH2MHill, 2005);
- AZAR – Banwell Road Subdivision - Wastewater Servicing Capacity (KMK, 2007);
- Town of Tecumseh Water and Wastewater Master Plan Update, Class EA Report, AECOM (July 2008);
- Town of Tecumseh Sanitary Sewer Assessment Report (Dillon, 2010);
- Tecumseh Hamlet Sanitary Sewer Flow Monitoring and Modeling Updates-Summary of Work Completed (AECOM, 2010);
- Tecumseh Hamlet Sanitary Sewer Modelling Updates (AECOM, 2011);
- Tecumseh and St. Clair Beach Sanitary Sewer Modeling Updates (Dillon, 2012);
- Sanitary Sewage Collection System Improvements Class Environmental Assessment, Dillon (April 2013);
- Proposed Azar 11th Concession Development, South of CR42 – Sanitary System Capacity Review (Dillon, 2014);
- City of Ann Arbour, Sanitary Sewer Wet Weather Evaluation Project, OHM Engineering Advisors. (September 11, 2014);
- Water and Wastewater Master Plan Update (2019, CIMA) [WWMP 2018];
- Design Guidelines for Sewage Works, MECP Manual;
- Windsor-Essex Region Stormwater Management Standards Manual, Essex Region Conservation Authority (2019);
- CSA W204:19 - Flood Resilient Design of New Residential Communities (2019);
- Town of Tecumseh, Storm Drainage Master Plan, Dillon Consulting Limited (June 2019);
- Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction, Norton Engineering Report (November 2019);
- City of Windsor Sewer and Coastal Flood Protection Master Plan Report (November 2020);
- Town of Tecumseh Official Plan (Town of Tecumseh, 2021);
- County Road 42 Sanitary Sewer Improvement Assessment, (Jan 2021); and
- Manning Road Secondary Plan Area (MRSPA) Sanitary Servicing Modelling Technical Report (July 2023).

4.0 Hydrologic and Hydraulic Modelling

4.1 Modelling Platform

InfoWorks-ICM 11.0 was used to simulate existing and future flow conditions in the sanitary sewer infrastructure in the Town. The InfoWorks-ICM sewer existing conditions model includes approximately 1,465 sanitary sewer sections and 1,435 sanitary sewer MH. The study area is delineated into approximately 1195 subcatchments. Sanitary pumping stations within the study area were also incorporated into the model based on information provided by the Town and Ontario Clean Water Agency (OCWA).

Infoworks-ICM is a more robust hydrologic-hydraulic modelling platform than programs that use the EPA-SWMM engine, like XPSWMM. In addition, it allows a more granular and physical representation of RDII into sanitary sewers through the use of parameters like contributing area and the ability to define multiple surfaces within the same subcatchment. While EPA-SWMM based programs are useful and have been effectively used in smaller neighbourhood-scale modelling studies, Infoworks-ICM is more efficient in the use of available computing resources when simulating municipality-level models.

The current study and improvements recommended herein have been evaluated using the recently calibrated Infoworks-ICM hydrologic-hydraulic model, using a physical-based modelling approach. The Infoworks-ICM model is a better representation of the sanitary sewer flow conditions in the Town's sanitary system compared to the XPSWMM model used previously. Infoworks-ICM is a more robust modelling platform, and the physical based modelling approach is a better representation of RDII in sanitary sewers than the previously used RTK method. In addition, it allows accurate evaluation of reduction in sanitary flows due to source-control measures like foundation drain disconnection (FDD).

4.2 Network Development

Proper network development of the model was critical so that each sewer system element was representative of the current physical collection system.

To develop the model, the sewer network from the XPSWMM model calibrated and analysed in 2013 was exported to Infoworks-ICM. To confirm the accuracy of the data once imported, extensive quality checks were completed, and data gaps were filled in through review of as-built information and field drawings and use of best professional judgement to develop an accurate model.

Updated LiDAR provided by the Town in 2017 was used to develop a bare earth digital elevation model (DEM). This data was imported into InfoWorks-ICM as a ground model. All MH cover elevations were updated using the DEM. Any missing ground elevations were updated using the inference tool in

InfoWorks-ICM and invert elevations corrected using as-built information sourced from the Town's online geodetic database.

Further details about the sanitary network development has been discussed in the sanitary assessment memo provided as Appendix B.

4.3 Sanitary Pump Stations (PS)

4.3.1 Cedarwood PS

The pumping capacity of the Cedarwood PS in the Infoworks-ICM model reflects the capacity and configuration of the in-situ pumps in the PS. The modelling strategy is based on discussions the Town Staff and pump stage-discharge curves sourced from the pump supplier - Spans. There are 3 installed pumps with a total discharge capacity of 934 L/s. Monitoring information from the pump station was used to verify the calibration of the sewer model by comparing the shape of the outflow hydrograph and drawdown times.

During major storm events, the City of Windsor's wastewater conveyance system downstream of the Cedarwood PS is surcharged and HGLs in the sewer system are expected to be higher than the elevation of the PS outlet sewer. Due to the installed flap gate, the high HGLs in the City system are not expected to back-up into the Town's sanitary sewer system. It is expected that there would be periods of time where the total discharge from the PS would be lower than the Town's peak allowable discharge into the City of Windsor, as per their existing wastewater servicing agreement. This conclusion has been recently determined, through this analysis and the findings of the City of Windsor's Sewer and Coastal Flood Protection Master Plan (2020).

4.3.2 Other Sanitary PS (St. Alphonse PS, Sylvestre PS and Lakewood PS)

Other sanitary PS within the study area were largely kept unchanged from the previously completed XPSWMM model, with the exception of the Lakewood PS which was reconstructed in 2016 at a new location at the western boundary of Lakewood Park at Little River Boulevard.

This PS was updated in the model based on the as-built drawings and design documents provided by the Town.

4.4 Catchment Areas

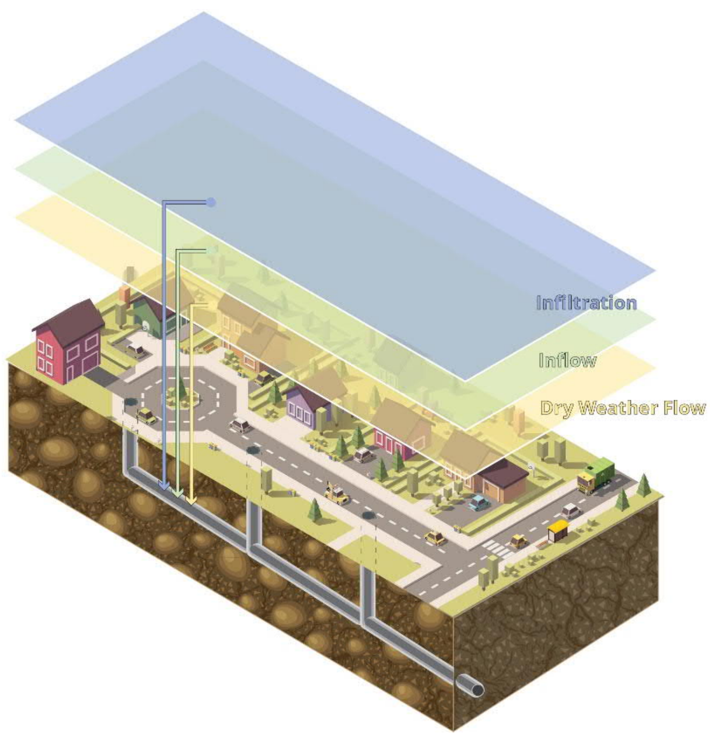
Due to the difference in the modelling approaches between the Infoworks-ICM and XPSWMM models, subcatchment areas needed to be delineated. Subcatchments are used to simulate RDII flow into the sanitary system instead of the RTK hydrograph method used in the previous modelling study. Subcatchment delineation in the model was completed on a MH to MH basis. Newly delineated subcatchments were based on the sewer segment, closest land parcel and were assigned to the upstream node of the closest sewer segment.

Three types of sub-catchments were setup in the Infoworks model.

1. Dry Weather Flow (DWF) represents wastewater from residential and industrial, commercial, and institutional (ICI) areas plus baseflow (i.e., groundwater infiltration or GWI) draining directly to corresponding sewer. This subcatchment area ID was given the suffix “DWF” in most cases.

2. Quick Response (Inflow) represents the area from surfaces that provide an immediate type flow to draining to the sanitary sewer. The flow from these types of subcatchments usually peaks during the precipitation event with flow ending relatively shortly after the rainfall stops. The surfaces represented by this subcatchment include direct sources, connected roofs, improper surface drainage, cross-connections with storm sewers and foundation drains. This subcatchment area ID was given the suffix “Inflow”; and

3. Slow Response (Infiltration) represents a delayed type hydrograph with a peak flow rate and an extended duration of flow, lasting well beyond the peak rainfall intensity and the end of the precipitation event, respectively. The slow response represents inflow sources such as foundation drains, ground water infiltration, and leaks in maintenance holes, service connections and sewer pipes. This subcatchment area ID was given the suffix “Infil”.



Schematic 4.1: RDII Subcatchment Representation in the Model

Foundation drains connected to the sanitary sewer system exhibit both inflow and infiltration type hydrologic responses and consequently were modelled with a combination of both types of subcatchments.

4.5 Level of Service

4.5.1 Existing Sanitary System Design Level of Service

Currently, the design criteria for new sanitary sewers in the Town of Tecumseh are as per the WWMP 2019. Table 4.1 summarizes the existing design criteria.

Table 4.1: Existing Design Criteria for New Sanitary Sewers in the Town

Dry Weather Flow	
Residential sewage flow	300 L/cap/day
Peaking Factor	Harmon formula
Wet Weather Flow	
Infiltration	16,415 L/ha/day
Sewer sizes, Slope and Velocity Parameters	MECP Sewer Design Guidelines 2008

Previous modelling studies of the sanitary system completed by the Town of Tecumseh have used the 1:5 year, 24 hour design storm event as the level of service to assess sanitary system capacity during wet-weather events and design solutions to reduce risk of residential basement flooding.

The SS EA (2013) used a 1:5 year level of service to identify basement flood risk areas and to size municipal infrastructure to provide inline storage and conveyance improvement to lower the sanitary system HGLs. This level of service identified a large portion of area within St. Clair Beach as well as areas serviced by the Green Valley Boulevard Sanitary Trunk Sewer. To mitigate basement flooding this study recommended the following:

- Increased capacity of the Lakewood Sanitary pump station, including relocation of the pump station to the western limit of Lakewood Park and construction of a large trunk in-line storage sewer between Hayes Avenue and the Manning Road outlet; and
- Implementation of a larger trunk sanitary sewer on Riverside Drive between Pentilly Road and Kensington Boulevard.

4.5.2 Level of Service – other Provincial Municipalities

Municipalities in the region who have established a level of service for sanitary sewer design are listed below in Table 4.2 with the design criteria selected by them.

Table 4.2: Established Level of Service in Various Municipalities in Ontario

Municipality	Maximum HGL	Return Period / Design Storm
Toronto	1.8 m below Ground Elevation for May 12, 2000 event	May 12, 2000 storm event (Return Period - 1:25 to 1:50 year; duration - 24 hours; Peak Intensity - [5 min] 160 mm/hr)
Kingston	Wet weather flow: HGL < 0.3 m above pipe obvert and; HGL > 2 m below finished ground	Up to and including the 1:100 year event
Hamilton	Dry Weather Flow - Sewer Sizes up to 450 mm dia.: 75% of full design capacity Sewer sizes 525 mm dia. Or greater: 60% of full design capacity	
Windsor	HGL > 1.8 m below finished ground	Up to and including the 1:100 year event
Amherstburg	Minimum – HGL > 1.8 m below finished ground Acceptable - HGL > 2.8 m below finished ground	Up to and including the 1:25 year event

4.5.3 Establishing a Level of Service

There is limited guidance available in terms of design criteria or regulation manuals regarding design of sanitary sewer systems to a certain level of service. Existing provincial guidelines recommend a maximum allowable infiltration rate into sanitary sewers, irrespective of whether it is dry or wet-weather infiltration. The design storm event this peak allowable infiltration is to be restricted to is left to the discretion of the governing municipality.

The Town of Tecumseh is in a unique position in this aspect since the Town does not treat its own sewage and sewage discharges first through the City of Windsor's existing sanitary sewers system. The Town has been allocated specific treatment capacities to the wastewater treatment plants and capacity in the sewage conveyance infrastructure in the City of Windsor. As such, it is difficult to quantify in monetary terms the benefits of reducing RDII and cost of treatment of this additional flow as the Town is required to pay a both volumetric rate and a fixed service rate. It is expected however that there would be savings associated with the reduction of WWF entering the City of Windsor municipal infrastructure. Also, the Town has a limited number of outlets to the City of Windsor's system and is constrained by the capacity of that system and cannot increase outlet capacity as it will pose negative impacts to the City's conveyance system.

The CSA W204:19 document (Flood resilient design of new residential communities) recommends a peak allowable I&I flow rate of 0.30 L/s/ha for the design event. And up to 0.50 L/s/ha for extreme events like the 1:100 year return period event.

For the current study, the capacity of the existing sanitary system was assessed using both the 1:5 year, 24 hour and the 1:25 year, 4 hour design storm events. Problem areas, which are at a higher risk of basement flooding due to sanitary surcharging, were assessed for these storm events. Areas in the Town where peak HGLs in the sanitary sewers are less than 1.5 m from the existing ground (or sanitary MH rim) elevation, were considered to be at a risk of basement flooding due to sanitary sewer surcharging. HGL depth of 1.5 m was considered to be the average depth of basements in the Town. This is consistent with previous sanitary sewer modelling studies completed by the Town.

Future development areas within the Town are expected to restrict RDII peak flow and volumes to the maximum allowable rates during the 1:5 year, 24 hour storm event. At the same time, new municipal sanitary infrastructure is proposed to be designed to a 1:25 year, 4 hour design storm event. Sanitary sewers within the Town will be designed so that peak HGLs will be below assumed basement floor elevations (1.5 m) during the 1:25 year, 4 hour design storm event.

Using more intense storm events were considered as a basis for the level of service. Both the 1:50 year and 1:100 year return periods were analyzed using this model since the major events that occurred in 2016 and 2017 are more similar to 1:100 in terms of volume and intensity and also resulted in widespread basement flooding. Under these events, most of the Town system is observed to have HGLs less than 1.5 m below grade. The corresponding improvements or system modifications would be significant. In addition to high capital costs, the level of improvements would be widespread and present a number of construction and maintenance constraints. From a construction perspective, the size of the sanitary infrastructure often would require full reconstruction of the municipal right of way and there is often limited vertical variation in grades to accommodate larger infrastructure. From a maintenance perspective, larger systems require increased maintenance to cleanse the system to avoid settlement of materials in the system and odour.

5.0 Model Calibration

The original Town sanitary sewer model was developed on the basis of three sanitary drainage areas; the Tecumseh Hamlet (TH) area located south of CR22, Tecumseh Town (TE) area located north of CR22 and west of Manning Road, and St. Clair Beach (SB) area located east of Manning Road.

The Tecumseh Town and St. Clair Beach areas were updated and calibrated by Dillon following a storm event on June 5-6, 2010, that resulted in widespread basement flooding. A hydrologic model (XPSWMM) was developed and calibrated in 2011 to simulate Rainfall Derived Inflow and Infiltration (RDII) for Wet Weather Flow (WWF) in the sanitary sewer system. The model was calibrated by using three parameters for RDII estimate as follows:

- R: the fraction of rainfall volume that enters the sewer system;
- T: the time from the onset of rainfall to the peak of the hydrograph; and
- K: the ratio of time to recession to the time to peak.

In 2019, Dillon began converting the original sanitary system model from XPSWMM to Infoworks ICM to better represent the sources of RDII throughout the system and re-calibrate both the Dry Weather Flow (DWF) and Wet Weather Flow (WWF) components based on 2019 flow monitoring data. This model update took sewer RDII mitigate improvements completed by the Town since the original 2011 study into consideration. Improvements included sewer lining, manhole repair and private drain connection repairs throughout the Town. The process of calibrating the model for WWFs is currently in its final stages based on measured flows from a total of 12 flow monitoring stations (six in Tecumseh Town, four in St. Clair Beach and two in the Tecumseh Hamlet area).

The Infoworks ICM model for the Town's sanitary system uses detailed physical parameters (i.e. percentage of drainage area, surface roughness, flow length, etc.) to determine the volume and timing of RDII entering the sanitary sewer system. Each component of sanitary flow is represented in different ways in the Infoworks ICM model.

5.1 Dry Weather Flow Calibration

The dry-weather diurnal wastewater component consists of domestic sewage and groundwater infiltration that would occur under dry conditions.

Groundwater infiltration (i.e. base flow) is represented using a constant inflow through each sanitary sewer conduit in the model and varies between different catchment areas depending on the DWF observed at each flow monitoring location. It is represented by 90% of the lowest observed daily flow.
Domestic wastewater flow is represented with populations sourced from MPAC information provided by the Town in April 2019, within each represented catchment area. Catchment areas upstream of each flow

monitor location were assigned daily per capita flow rates and diurnal flow pattern based on observed flow during dry weather periods.

Calibration for DWF was achieved by updating the per capita flow rates for each flow monitor catchment area.

Comparison graphs which compare observed and predicted dry-weather flow patterns for each of the flow-monitoring locations are provided in Appendix C.

5.2 Wet Weather Flow Calibration

During rainfall events, separated sanitary sewers convey both a dry-weather diurnal wastewater component and RDII.

To develop a representation of RDII, two major sources were accounted for in the model, as follows:

- Direct Inflow – modelled using subcatchments connected directly to the sanitary sewer.
    - Inflow - Subcatchments – These model elements were included to represent stormwater flows through direct connections including roof rainwater downspouts, basement foundation drains, surface drains (window wells, catch basins, broken cleanout caps, etc.) and improper plumbing connections. The model development procedure for these components are summarized as follows:
        - To model these more instantaneous and higher peak flow response, subcatchment parameters similar to wet-weather subcatchments were used.
        - Prior to calibration, the initial model parameters for these subcatchments were set to the roofed area of residential structures within these areas.
- Infiltration – modelled using subcatchments connected directly to the sanitary sewer.
    - Infiltration - Subcatchments – These model elements where included to represent a relatively delayed, longer duration flow pattern. Sources of rain-derived infiltration include groundwater that enters the sanitary sewage system through cracks or leaks in sewer pipes including public and private infrastructure and flow from foundation drains. Cracks or leaks may be caused by age-related infrastructure deterioration, loose joints, improper installation, damage, and root penetration.

The calibration procedure for the inflow and infiltration subcatchments was achieved by mainly adjusting the following parameters:

- Dimension – This parameter has a significant impact on the peak flows and the hydrograph shape. A higher value of dimension results in flows entering the sanitary conveyance system faster. As such, the dimension values were higher in the inflow subcatchments and lower in the infiltration subcatchments;

- Runoff Surface Area – This parameter represented the fraction of the total subcatchment area contributing flows to the sanitary system during a wet-weather event. Adjusting this parameter affected the volume and peak flow response of the subcatchments;
- Initial Abstraction – A higher initial abstraction was applied to infiltration subcatchments, as compared to inflow subcatchments, to account for soil holding capacity absorbing the first part of a rain event, before infiltration contributes to the sanitary sewer; and
- Roughness – This parameter accounts for surface roughness of the subcatchment area. Adjustments to this parameter had a small impact on the hydrograph shape. It was used to make finer adjustments to the calibration.

The calibration process was first completed using the gauges with the largest service area, the sub-service areas within the larger areas were then calibrated.

It is important to note here that at the onset of this study, through discussions with Town personnel, it was confirmed that a vast majority of sanitary MHs within the study area have been installed with sanitary rain-catchers. As such, the direct inflow of surface runoff into the sanitary system occurring through pick holes in sanitary MH lids was not considered a significant component of the wet-weather flow in sanitary sewers. This component of wet-weather inflow into sanitary sewers was disregarded for this study.

5.2.1 Calibration Criteria

The predicted flows in the Infoworks-ICM model were adjusted to match the observed flows for the selected rain events using the parameters listed above. The following hydrograph parameters were targeted during the calibration process. The percentage values represent closeness of the observed and predicted values.

- Peak Flows: -15% to +20%
- Volume: -15% to +15%
- Peak Depth: -20% to +20%
- Hydrograph Shape: Close match

5.2.2 Observed Rainfall Events used for Wet-Weather Calibration

Several storms were observed during the monitoring period. Of these, four were selected for calibration based on the total rainfall volumes and peak rainfall intensities.

Table 5.1 shows the selected storms along with their depth, duration, and intensities. Table 5.1 also mentions the comparable return period event that the observed rain event corresponds to. Refer to Appendix A for a list of all the rain events that occurred during the monitoring period, with their total rainfall volumes and peak intensities. The Windsor IDF information sourced from Environment Canada's Windsor-A gauge was used for this comparison. Intensities from Windsor-IDF are also included for reference in Appendix A.

Rain events from different times of the year and different prevailing soil moisture conditions were chosen to calibrate the hydraulic model.

Table 5.1: Observed Rainfall Event Summary

Storm ID	Rain Gauge	Total Rainfall Depth (mm)	Storm Duration (hr)	Average Intensity Over Total Duration (mm/hr)	Return Period
R_01 (April 30, 2019)	St. Alphonse	*	6.0	*	*
	Town Hall	51.1	6.6	7.8	< 5 year
	Brighton	46.7	6.6	7.1	< 5 year
R_10 (January 10-12, 2020)	St. Alphonse	52.8	46.5	1.1	< 2 year
	Town Hall	60.2	47.5	1.3	< 5 year
	Brighton	51.6	48.3	1.1	< 2 year
R_03 (June 26-27, 2020)	St. Alphonse	33.0	5.5	6.0	< 2 year
	Town Hall	40.6	5.3	7.7	2 year
	Brighton	41.1	4.9	8.4	2 year
R_04 (July 19, 2020)	St. Alphonse	33.5	1.3	26.8	< 5 year
	Town Hall	44.7	2.3	19.9	< 10 year
	Brighton	42.2	1.3	33.7	< 10 year

* No data was available for this storm event at this rain gauge.

The first rain event used during calibration was R_01_2019 which took place overnight from April 30, 2019 to May 1, 2019. The peak intensities of this storm resulted in a less than 1:2 year return period, however the 6 hour peak intensity is comparable to a 1:5 year storm. This storm was chosen to calibrate the model to saturated ground conditions. The soil in this region is typically saturated from spring melt at this time of the year. Any rainfall during this time results in rainwater entering the sanitary system relatively quickly since the infiltration capacity of the soil is very limited due to saturated conditions. A hydraulic model calibrated to a rain event during this time will generally provide conservative estimates of RDII entering the sewer system.

The second rain event, R_10_2020 took place over the weekend of January 10-12, 2020 and was the longest storm in terms of duration. This rain event had the greatest total rainfall depth among the storms chosen for calibration and the lowest average intensity with a return period of less than 1:5 years. This rain event was chosen for calibration since it was the largest rain event observed during the 2019 data collection period.

The third rain event, R_03_2020, took place on June 26, 2020. The peak intensities indicate a 1:2 year return period. The final rain event used for calibration was R_04_2020 which took place on July 19, 2020. This event had the shortest duration and highest average intensity. The peak intensities of this storm indicate are just less than a typical 1:10 year return period. These rain events were chosen to calibrate the model to summer conditions, when the soil is typically dry.

5.2.3 Wet-Weather Flow Calibration Results

The results of the wet-weather calibration process for the selected rain events are provided in Table E-1, 2 and 3. Comparison graphs representing a comparison of observed and model predicted flows, volumes and depths at flow monitoring locations are provided in Appendix C.

The results of calibration show a good match between observed and predicted flows, volumes and depths across the different storm events considered for calibration. A close match to the shape of hydrograph between observed and predicted is observed in almost all cases. Generally, the predicted flows, depths and volumes are lower than the observed for the spring rain event, under saturated soil conditions. While the predicted values are higher than observed for the summer rain event, under dry soil conditions. As such, the hydraulic model is expected to provide a reasonable estimate of basement flooding due to sanitary sewer surcharging.

The observed depths are higher than the predicted for the R_01_2019 rain event, especially in the St. Clair Beach area, while peak flows and volumes are a much closer match to observed values. A number of external factors could have been causing this, for example, high water levels in the Lake St. Clair causing high groundwater levels in this region, or local blockages in the sewer system causing sewers to back up during this rain event.

Refinements to the model calibration parameters was made in 2020 for the CR42 area. More details about this has been provided in the Appendix B.

6.0 Existing Conditions Analysis and Problem Area Definition

6.1 RDII Analysis using Observed Sewer Flow Data

An analysis of the RDII flow observed within the sanitary system at each monitoring location was undertaken to identify areas consistently reporting comparably higher rates of RDII. For this analysis, the observed DWF volume for the same period was subtracted from the total observed flow volume. The volume of flow for a 24 hour period from the beginning of the storm event was compared. The DWF flow volumes were calculated for dry days (no rainfall in the preceding 24 hours) for the same month that the storm event occurred. The RDII rate in L/ha/day was calculated for a uniform comparison across drainage areas. Table 6.1 shows the results available for each of storm event selected for calibration. For rainfall depths and peak intensities for the storm events used for this analysis, refer to Appendix A.

Table 6.1: RDII Rate Comparison by Monitor Location

Flow Monitor Location	Rain Event ID				
	R_01_2019	R_06_2019	R_10_2019	R_04_2020	R_06_2020
	RDII Rate (L/ha/day)				
SB007	44,450	5,847	54,698	-	-
SB030	69,632	10,726	77,823	-	-
SB060	65,981	6,315	56,593	-	-
SB115	33,947	3,742	42,083	-	-
TE464	50,139	9,706	93,135	-	-
TE124	52,235	2,803	24,628	-	-
TE011	45,888	6,834	47,535	17,531	39,891
TE274	54,708	-	79,306	-	-
TE148	32,749	4,278	34,905	-	-
TE678	114,565	23,212	211,943	30,475	71,025
TH078	34,936	4,388	50,156	-	-
TH113	55,479	4,567	-	-	-
TH010	-	-	-	902	-
TH023	-	-	-	13,092	-

As observed in the Table 6.1 above, the RDII rate during all the rain events are generally higher than the infiltration allowance for new development identified in the WWMP of 16,415 L/ha/day. The RDII rates are also generally higher than the infiltration allowances mentioned in the WWMP for existing developed areas in St Clair Beach (33,000 L/ha/day), Tecumseh Town (34,000 L/ha/day) and Tecumseh Hamlet (29,000 L/ha/day) areas.

Rain events in late winter and early spring (R_01_2019 and R_10_2019), during times of high antecedent moisture conditions and saturated soil conditions, result in higher RDII rates compared to rain events in summer when soils are less saturated. The flow values for R_06_2019 report comparatively lower RDII rates than other rain events since it was a relatively smaller event in terms of total volume and it was preceded by a dry period in late summer.

The original monitoring period for this study was established as April 2019 to January 2020, however to better refine findings of this study and to further investigate areas of concern, additional monitoring was completed in critical areas. The following can be inferred from analysing data collected during the additional monitoring that was completed in 2020 (additional monitoring period Jan 2020 to Jun 2020) to refine the sanitary system analysis:

- TE678 drainage area in the Tecumseh Town (TE) area reports consistently high rates of RDII compared to other drainage areas within the study area. This area was constructed after 1980 and therefore it is expected that foundation drains are not the sole contributor to the high RDII in this area and that a larger sewer interconnection may be present. Other possible contributors include broken cleanouts, cross-connections, or holes in the sanitary lines under homes (deficiencies introduced during foundation construction).
- The observed RDII rates in the TH010 drainage area, part of the St. Alphonse PS drainage area located west of St. Alphonse Avenue along CR42, are considerably lower compared to other drainage areas within the study area. Sanitary flows from this area were monitored in 2020 to inform the design of the sanitary sewer system along CR42 as part of the proposed reconstruction of CR42 being undertaken by the County of Essex.

6.2 Modelling Results Analysis

Figures 6.1 and 6.2 identify the basement flooding risk under existing conditions within the Tecumseh Town, St. Clair Beach and Tecumseh Hamlet areas, respectively, for the 1:5 year, 24 hour design storm event. Figures 6.3 and 6.4 identify the basement flooding risk under existing conditions within the Tecumseh Town, St. Clair Beach and Tecumseh Hamlet areas, respectively, for the 1:25 year, 4 hour design storm event. The calibrated existing conditions Infoworks-ICM model was used for this simulation.

The metric for basement flooding risk is based on the depth of the sewer's HGL as it relates to typical basement floor depths. It is assumed that average basement depths are 1.5 m (5 ft) below the existing ground. A summary of the basement flooding risk for the three main Town areas is provided in Table 6.2. The percentages represent the number of model nodes where the estimated HGL is less than 1.50 m below the ground surface divided by the total number of nodes in the service area.

Table 6.2: Existing Conditions – Percent of Nodes above Basement Floor Elevation

	Return Period	1:5 Year	1:25 Year
Percentage of Sanitary MH nodes with peak HGLs above basement floor elevation	Study Area (TE, SB and TH)	27.7%	42.2%
	Tecumseh Town (TE)	15.0%	18.9%
	St. Clair Beach (SB)	60.4%	88.4%
	Tecumseh Hamlet (TH)	26.5%	48.1%

The following parameters were used to define areas with a higher risk of basement flooding due to sanitary sewer surcharging and where solutions were recommended to reduce the risk of basement flooding:

- Review of the density of nodes within a given sewershed where the sanitary sewer HGLs are above basement flooding depths, based on calibrated model simulation results;
- Older development areas, developed prior to 1980, were expected to have their foundation drains connected to the sanitary sewer system, which in turn would result in higher RDII in these areas;
- Areas where DWF (dry weather baseflow) is high typically also corresponds to areas with high RDII;
- Basement flooding reported by homes during major rain events. A large number of homes reporting basement flooding during a rainfall event within a given area was considered evidence of high RDII in the area; and
- Planned future development in the Town, including Secondary Plan Areas, Community Improvement Plans, and known infill developments.

The following areas were identified as areas where higher risk of basement flooding is observed:

- Tecumseh Town (TE) Area
    - TE-1: Areas along Green Valley Drive, serviced by the Green Valley Drive trunk sanitary sewer; and
    - TE-2: Area to the west of Manning Road, north of CR22, along Lemire and Lanoue Streets.
- St. Clair Beach (SB) Area
    - SB-1: Areas along Brighton Road, serviced by the Brighton Road sanitary sewer;
    - SB-2: Areas south of Tecumseh Road (Dresdan Place and Dorset Park areas), serviced by the Arlington Boulevard sanitary sewer;
    - SB-3: Areas east of Arlington Boulevard and south of Riverside Drive, forming the Kensington Dish area; and
    - SB-4: Areas along Riverside Drive, west of Arlington Boulevard.
- Tecumseh Hamlet (TH) Area
    - TH-1: Areas along Charlene Lane, west of Lesperance Road; and

- o TH-2: Areas along Corbi Lane and Shawnee Street, draining to the Gouin Street sanitary sewer.

6.2.1 2013 SS EA vs 2020 Model Calibration – Findings Comparison

The high risk areas listed above are similar to those identified in the previous Sanitary Sewage Collection System Improvements Class Environmental Assessment (SS EA) completed by Dillon in 2013, especially in the TE and SB areas. The TE-1 and TE-2 areas were identified as potentially having high rates of RDII and higher risk of basement flooding. TE-1 is directly impacted by TE-2, which is just upstream of it. It was recommended in 2013 that these areas be investigated in future studies. Flow monitoring was undertaken for these areas as part of this study to further investigate. And it was found that there were comparatively higher rates of RDII reported from these areas, resulting in a higher risk of basement flooding during wet-weather events.

The SS EA 2013 recommended the following improvements within the SB Drainage area:

- Improved Lakewood Pump Station Capacity (15% Increased Capacity);
- Lakewood Park Trunk Sanitary Sewer (400 m, 2250 mm dia. sewer); and
- Riverside Drive, between Pentilly Road and Kensington Boulevard. (400 m, 1500 mm dia. sewer).

The Lakewood Pump Station Improvements and 2250 mm dia. Lakewood Park trunk sanitary sewer were installed in 2014.

The 2020 existing conditions model used for this analysis incorporated these improvements to sanitary infrastructure as an existing condition. These improvements provide relief to the areas along the Hayes Avenue trunk sanitary sewer, and reduce risk of basement flooding. Areas SB-1, SB-2 and SB-3 are located further upstream of the Lakewood Park improvements and were identified as problems areas in the SS EA 2013 study. This study recommends that the Riverside Drive improvements identified in 2013 continue to be planned due to limited capacity of the existing sanitary sewer system in these areas, and a large number of homes' foundation drains being potentially connected to the sanitary sewer system.

In contrast with the 2013 sanitary sewer analysis, the 2020 model results show a higher risk of basement flooding in the areas along Riverside Drive, west of Arlington Boulevard Comparing system and environmental conditions, the 2019 flow monitoring was conducted during record high water levels were recorded in Lake St. Clair. The higher water levels in Lake St. Clair is expected to result in high groundwater levels and saturated soil in areas along the shoreline, resulting in higher infiltration through any deficiencies in the sanitary sewer infrastructure. The higher RDII values observed are part of the calibration parameters used as a basis for the development of future condition recommendations.

The SS EA 2013 also noted that Dillon Drive/Green Valley area as an area that would require additional basement flood risk reduction measures which is consistent with the findings of this study and the corresponding solutions developed.

7.0 Future Conditions Analysis and Implementation

The objective of this analysis was to recommend solutions for the sanitary system to reduce risk of basement flooding in the problem areas identified in the existing conditions analysis. All known future development areas within the study area were incorporated in the future conditions modelling scenarios based on estimated population growth values and future land use designations.

Multiple design solutions were evaluated in the various modelling scenarios, which included a combination of improvements to municipal sanitary infrastructure as well as private-side improvements consisting of foundation drain disconnection in older areas (areas built prior to 1980). In addition to the above, the design solutions were evaluated under two levels of service, the 1:5 year, 24 hour design storm event and the 1:25 year, 4 hour design storm event.

The objective of each solution was to reduce the HGLs within the sanitary sewers system to elevations lower than assumed basement floor levels, as much as practically possible.

7.1 Ultimate Conditions – Model Development

For simulating RDII from proposed development within the study area, the 2018 WWMP Update recommends an infiltration allowance of 16,415 L/ha/day for new development. The *CSA W204:19 - Flood Resilient Design of New Residential Communities* document recommends a peak flow of 0.30 L/ha/s for new development for the design level of service. The 1:5 year, 24 hour design storm event, using Chicago distribution, was used as the design storm event for this purpose. For design scenarios, where sanitary infrastructure solutions were evaluated for the 1:25 year, 4 hour design storm event, the proposed development subcatchment RDII parameters were kept unchanged. This results in RDII during these scenarios (1:25 year, 4 hour event scenarios) being higher than the allowable rates of 16,415 L/ha/day and 0.30 L/ha/s. This approach was used to add resiliency to the Town's sanitary sewer system. This approach held the Town's sanitary infrastructure to a higher level of service while individual properties were not restricted to a lower allowable infiltration rate. It should be noted that these infiltration allowances were applied to existing developed areas to represent current RDII values.

For all future conditions scenarios evaluated, the sluice gate along the Lesperance Road sanitary trunk sewer at the CR22 is assumed to be completely closed and therefore 100% of flows from the Tecumseh Hamlet are routed to the CR22 relief sanitary sewer. Design alternatives, which determine the benefit of allowing a portion of flow to be routed north through this sluice gate, were evaluated as part of the sanitary assessment for the Manning Road Secondary Plan (MRSPA) development (MRSPA Functional Sanitary Service Modelling Technical Report (July 2023)). The recommended interim alternative in this study proposed a small portion of flow through the sluice gate to flow north (approximately 50 L/s) into the Cedarwood Drainage area. This caused an increase in HGLs in the northern areas of the Town, specifically within the St. Clair Beach area as further described in the MRPSA Functional Servicing Design Report (July 2023). While this may be considered acceptable in a 1-2 year period, the long-term solution recommended as part of this study should be implemented prior to support development within the MRSPA area. The long-term solution requires the first phase of the West Hamlet Trunk sanitary sewer to be constructed to add capacity in the Tecumseh Hamlet sanitary sewer system. This project is currently in the detailed design stage. The first phase of construction in 2024 will include the West Hamlet trunk sewer from CR22 to Intersection Road and the Sanitary relief sewer on Intersection Road connecting the St. Anne Street and to the West Hamlet trunk. Long-term solutions have been analysed in this section, hence the sluice gate considered closed during all evaluated scenarios. Figure 7.1 illustrates the future alignment of the West Hamlet Trunk Sanitary Sewer.

Infrastructure solutions to reduce the risk for basement flooding were proposed as part of the SS EA (2013) modelling assessment completed by Dillon. As noted in Section 1.3, the Town has proceeded with the implementation of some of these solutions, including upgrading the Lakewood PS and adding a storage structure in Lakewood Park. This solution, and others recommended in the SS EA (2013) study, were effective in reducing the risk of basement flooding in upstream drainage areas, as noted in Section 6.2.

7.2 Ultimate Condition Build Out

The ultimate condition analysis assumes that all development and infill areas within the Town of Tecumseh have been fully built out including the construction of trunk sanitary infrastructure recommended to service these areas. Below provides a summary of each development area and how they were incorporated into the ultimate conditions model. Figure 7.2 shows the location of these proposed development areas.

Manning Road Secondary Plan Area (MRSPA)

The Manning Road Secondary Plan Area, approximately 100 ha in size, is the secondary plan area that is located within the Tecumseh Hamlet area, east of existing residential development, west of Manning Road, south of CR22 and north of the CPR Railway. Under ultimate conditions, it is assumed that this area is fully built out based on the assumptions and sanitary wastewater servicing criteria outlined in the MRSPA Functional Sanitary Service Modelling Technical Report (July 2023).

Tecumseh Hamlet Secondary Plan Area (THSPA)

The Tecumseh Hamlet Secondary Plan Area includes two main portions of currently vacant area with the Tecumseh Hamlet area including the currently zoned agricultural land, east of Banwell Road, west of the existing residential development centred along Lesperance Road. As recommended in the Water and Wastewater Master Plan Update (2018), this area will be primarily serviced via the proposed West Hamlet Trunk Sanitary sewer that will connect to the existing 1200 mm dia. sanitary trunk sewer along CR22. The total land use and ultimate population growth estimates are based on the draft Secondary Plan Area land use presented to the public as part of the Tecumseh Hamlet Secondary Plan Area Environmental Assessment Public Information Centre in April 2023. The Town has retained Dillon as part of a separate study to complete the functional design of the West Hamlet Trunk Sanitary Sewer. This study is currently underway and will utilize the findings of this study to confirm the servicing strategy.

St. Alphonse PS Drainage Area (CR42)

The County of Essex is undertaking the reconstruction of CR42, from west of the 11th Concession (County Road 43) to east of Manning Road (County Road 19), generally located within the Town of Tecumseh. To accommodate the road reconstruction, a large storm trunks sewer is required along CR42 and due to the depth and size of this sewer an additional parallel trunk sanitary sewer is proposed to provide an outlet for private drain connections. Based on the findings of this study and a more detailed assessment was completed for the St. Alphonse PS Drainage Area County Road 42 Sanitary Sewer Improvement Assessment Area, Appendix B (April 2021). The ultimate drainage area contributing to the CR42 sewer has been refined and includes future commercial buildout up to the Town's current settlement area boundary. Construction of the two parallel sanitary sewers along CR42 were constructed Summer 2023.

CR42 Area, West of 11th Concession Road (CR43 Extension)

There is portion of the Town lands, west of 11th Concession, south of CR42 that is not currently within the town's settlement area boundary. CR42 is expected to redevelopment and infill of these areas is anticipated and therefore incorporating capacity for sanitary sewer expansion here is necessary. This area is planned to be served in the future by a separate sanitary outlet that will connect to the West Hamlet Sanitary trunk sewer which will extend to the CR42 right of way. This area has been assumed to be fully developed as commercial land use and will outlet to this trunk sewer in the future. Timing of the West Hamlet Sanitary trunk extension will be driven by development demand and unknown at this time.

Tecumseh Road Community Improvement Area (CIP)

The Town of Tecumseh Council has adapted the Tecumseh Road Main Street Community Improvement Plan (CIP) which provides the framework for development along the Tecumseh Road corridor between the west City/Town limits, west of Southfield Drive to the Via Rail At-Grade Crossing, east of Bedell Street and along Lesperance Road between Arbour Street and McNorton Street. The CIP plan provides a framework for the revitalization of this main street area which is expected to yield population growth through development and infill. Estimated population and land use for this area is based on the CIP document adopted by Council (January 2016) and per the Tecumseh Road CIP Functional Servicing Report (Draft April 2020).

Maidstone Hamlet

A constant pumped flow of 169 L/s contributing to the proposed West Hamlet Sanitary Trunk sewer was assumed for the Maidstone Hamlet. The pump rate was taken from the WWMP 2018. This WWMP protects growth in this development area to occur by 2036. Implementation of the forcemain outlet from this development and outlet to the west Hamlet Trunk sewer will be depending on development demands for this area and actual build out timelines.

Infill and Redevelopment

The latest Official Plan of the Town of Tecumseh (2021) was used to estimate the projected population of the Maidstone Hamlet area for a 2045 planning horizon. The total pumped flow includes flows from the Maidstone Hamlet development and Highway Commercial development.

There are areas of the Town where intensification is more likely and is warranted based on the Town's Official Plan policies. Specifically, higher density is expected to be in demand along arterial road corridors within the Town. To account for this, the following infill estimates have been included in the ultimate condition sewer system solutions.

- Lesperance Road (Riverside Drive to County Road 22)
    - North of McNorton Street
        - Assume 20% redevelopment to medium density units (townhomes, duplexes, apartments less than 3 stories).
        - Averaged over the area, assume increased density of 50 units/ha, 2.3 people per unit.
        - This equates to a 3X increase in population for this area.
    - South of McNorton Street
        - Assume 50% redevelopment to high density units (apartments up to 6 stories).
        - Averaged over the area, assume increased density of 125 units/ha, 1.8 people per unit.
        - This equates to a 3X increase in population for this area.
- Manning Road (Tecumseh Road to Street Gregory Street)
    - Assume 30% redevelopment to high density units (townhomes, duplexes, apartments 3 storeys or less), for commercial properties fronting Manning Road.
    - Averaged over the area, assume increased density of 125 units/ha, 1.8 people per unit.
    - This equates to a 5X increase in population for this area.

Individual Developments

It should be noted that as individual land use site plan approvals applications are submitted to the Town that may result in a change in the flows into the Town's sanitary system, a proposed conditions analysis should be evaluated so that redevelopment does not result in negative impacts to the Town's upstream sanitary system. A number of areas where redevelopment or infill development was anticipated were included in the ultimate condition model based on input provided by the Town in 2021.

In addition to the new development areas, improvements to the sanitary sewer along Riverside Drive between Edgewater Boulevard. and Arlington Boulevard. have been incorporated into the model. The construction of this sewer is scheduled for 2024 as part of the Scully Storm Pump Station and Riverside Drive Reconstruction project. This sewer will reallocate a portion of the upstream portion of the Street Mark sanitary sewer drainage area to the Edgewater Boulevard sewer.

7.2.2 Additional Residential Units (ARUs)

In December 2022, the Ontario government introduced legislation to support the intensification of existing residential areas in response to Bill 23, More Homes Build Faster Act. This regulation stipulates that residential properties can be expanded to accommodate a second or third additional residential units within an existing lot.

Additional units and intensification of existing residential areas has the potential to increase the sewage and stormwater outflow to the existing system however this depends largely on the level of intensity that is expected to occur. At this time, it is difficult to estimate the number of additional units that may be introduced in the system as it will be largely based on individual property owner requests. It is recommended that the number of units introduced to the system be monitored and should there be high demand for ARUs, provisions for sewer capacity be re-evaluated and impacts should be determined.

7.2.3 Foundation Drain Disconnection (FDD) Assessment

According to a study completed by the City of Ann Arbor, MI, USA in 2014, Foundation Drain Disconnection (FDD) was the lowest cost solution to reduce residential basement flooding risk due to sanitary sewer surcharging. Upon analysing the sanitary flow components of RDII, a co-relation was identified between volume contributed by foundation drains and total RDII volume. Homes in Ann Arbor built prior to 1980 did not have sump-pumps installed which would drain foundations to the storm system and often foundations drains were found connected directly into the sanitary sewer system. Based on the results of the Ann Arbor study, FDD was evaluated as a potential solution to reduce risk of basement flooding concerns within the study area.

For homes built between 1940 and 1980, the volume from foundation drain flow was identified as 8.5 m^3 per 25 mm of rainfall per home. This value is taken from the Ann Arbor Study (2014) which indicated 300 ft^3 per inch of rainfall for each connected foundation drain.

Using data provided by the Town, all homes built before the year 1980 were identified. Figure 7.1 represents the older residential development areas in the study area. The subcatchments (SC) containing these homes were divided into four categories based on the percentage of total SC area occupied by older properties within the SC: 25%, 50%, 75%, or 100%. To simulate reduction in RDII due to FDD, the total RDII flow from these subcatchments were adjusted by reducing the contributing areas of these SCs by applying a relative RDII contribution factor.

Table 7.1 lists the number of subcatchments by area coverage and the associated factor applied to them in the Infoworks-ICM model.

Table 7.1: Subcatchments by Area Coverage and Respective Safety Factors

Percent of Homes Built Pre-1980	Number of Subcatchment Areas	Contributing Area Reduction Factor
100%	650	0.44
75%	443	0.58
50%	119	0.72
25%	146	0.86
TOTAL	1358	

Implementing foundation drain disconnection will have challenges due to factors including but not limited to property owner cooperation or physical constraints on the private property side. Even assuming the Town implements a mandatory disconnection program, to account for the challenges listed above, it is assumed that 80% of identified homes will participate in this type of program. This factor has also been accounted for when simulating the various scenarios listed below.

7.2.3.1 Targeted FDD

Based on discussions with the Town, and review of previous studies completed on the Town's sanitary system, areas were identified to implement a targeted FDD program. These areas, shown in Figures 7.7 and 7.13, generally are older residential developments. Previous studies completed on the Town's sanitary sewer system have identified these areas as problem areas based on an increased risk of basement flooding due to sanitary sewer surcharging. A targeted approach to FDD was taken since it is a more feasible measure to implement by the Town, as opposed to implementation of a study area-wide FDD program.

A number of scenarios evaluated for future conditions (Table 7.2) simulated lower RDII from these areas based on disconnection of foundation drains from the sanitary system.

7.3 Solutions to Mitigate Basement Flooding Risk

As identified in previous sections, multiple future development solutions were evaluated based on the type of improvements (private property foundation drain disconnection (FDD) versus municipal infrastructure improvements), levels of service and the level of proposed development within the study area. Table 7.2 shows a summary of each evaluated scenario. A summary of the basement flooding risk during proposed conditions (Scenarios T3 and T3B) for the three main Town areas is provided in Table 7.3. The percentages represent the number of model nodes where the estimated HGL is less than 1.50 m below the ground surface divided by the total number of nodes in the service area.

Table 7.2: Summary of Evaluated Scenarios

	No.	Scenario Name	Description of Scenario	Development Conditions
Tecumseh Town (TE) and St Clair Beach (SB)	T1	Existing Conditions	Existing system conditions based on observed sewer monitoring.	No New Development
	T2	Ultimate Conditions – No Sewer Improvements or FDD (Baseline) – 1:5 Yr Storm	System conditions during 1:5 year, 24 hour storm, under full development without implementing measures to mitigate basement flooding or RDII.	All ultimate condition scenarios assume full build out of the main TE and SB drainage areas. Refer to the Figure 7.2 attached, which shows potential development areas.
	T2B	Ultimate Conditions – No Sewer Improvements or FDD (Baseline) – 1:25 Yr Storm	System conditions during a 1:25 year, 4 hour storm, under full development without implementing measures to mitigate basement flooding or RDII.	
	T3	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:5 Yr Storm	To determine what infrastructure improvements would be required to meet the level of service without implementing any FDD reduction improvements.	
	T3B	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:25 Yr Storm	To determine what infrastructure improvements would be required to meet the level of service without implementing any FDD reduction improvements.	
	T4	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:5 Yr Storm	Determine benefit a Foundation Drain Disconnection Program on a regional area basis.	
	T4B	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:25 Yr Storm	Determine benefit implementing a Foundation Drain Disconnection Program on a regional area basis.	
	T5	Ultimate Conditions – Sewer Improvements and Area Wide FDD – 1:25 Yr Storm	Determine benefit implementing an area-wide Foundation Drain Disconnection Program.	
Tecumseh Hamlet (TH)	TH1	Existing Conditions	System conditions based on observed sewer monitoring.	Existing Development Conditions.
	TH2	Interim Conditions	Assumes construction of the north portion of the West Tecumseh Hamlet Trunk sewer and the Intersection	Full build out of the drainage areas including: - Manning Road SPA,

No.	Scenario Name	Description of Scenario	Development Conditions
		Road Relief Sewer to St. Anne Street. Assumes that that the Sluice Gate at CR22/Lesperance Road is closed.	- Tecumseh Hamlet SPA, portion north of CP Rail, - Build Out of CR42 Corridor, and - Build Out of the Sylvestre Pump Station Drainage Area
TH3	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) - 1:5 Yr Storm	Assumes that the following infrastructure is in place: - West Tecumseh Hamlet Trunk Sewer (CR22 to CR42) - Intersection Road Relief Sewer to St. Anne Street. - St. Alphonse and Shields Sanitary Sewers - SE Tecumseh Hamlet (south of CP Rail) Sanitary PS and Outlet to Lesperance Road. - Maidstone Hamlet Forcemain Assumes that the Sluice Gate at CR22/Lesperance Road is closed.	Full build out of the drainage areas including: - Manning Road SPA - Tecumseh Hamlet SPA, both the NE, NE and SE Areas - Build Out of CR42 Corridor - Build Out of the Sylvestre Pump Station Drainage Area - Flows from the Maidstone Hamlet and Highway Commercial Area: Flows and volume per the Town's WWMP 2018, and Official Plan 2021.
TH3B	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:25 Yr Storm		
TH4	Ultimate Conditions – Sewer Improvements and Targeted FDD - 1:5 Yr Storm		
TH4B	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:25 Yr Storm		
TH5	Ultimate Conditions – Sewer Improvements and Area Wide FDD		

7.4 Analysis of Results of Future Conditions Modelling Simulations

7.4.1 Cedarwood PS Service Area (TE and SB areas) Results

Figures 7.3 to 7.9 show the basement flooding risk within the Cedarwood PS drainage area for the future conditions scenarios identified in Table 7.2 above. Figures 7.3 to 7.9 also show locations of sewer improvements proposed as part of the future conditions modelling analysis and areas within the study area where targeted FDD was simulated. Table 7.4 shows the existing and proposed sanitary sewer sizes in areas where sanitary sewer improvements are proposed.

To meet the level of service identified for each scenario, infrastructure improvements are recommended which consist of replacing existing sanitary sewers with larger sewer in the same alignment. The extent and size of sewer improvements depends on the targeted level of service and the corresponding degree of benefit from the FDD RDII reduction component. The sewer improvements proposed along Green Valley Drive and Lemire Street are similar for both scenarios, with and without FDD. Since targeted FDD areas are only in the St. Clair Beach Area, no reduction in RDII is expected in the TE areas due to source-control of RDII.

Table 7.3 shows a summary of the proposed improvements evaluated in the TE and SB areas, under the scenarios listed above.

Table 7.3: Cedarwood PS Drainage Area – Summary of Improvements per Scenario

Scenario		Green Valley Drive (Tecumseh Road E to Little River Boulevard)		Lemire Street and Lanoue Street		Riverside Drive (Pentilly Road to W of Kensington Boulevard)	Arlington Boulevard (Tecumseh Road E to Street Gregory's Road)	Edgewater Boulevard (Riverside Drive to Hayes Avenue)
T3	Length (m)	650		129	160	392	374	
	Existing (mm)	450		200	250	400	300	
	Proposed (mm)	1200		600	750	1950	525	
T3B[1]	Length (m)	*400*	*926/484*	466	120	603	374	360
	Existing (mm)	*450*	*450*	300	250	400	300	300
	Proposed (mm)	*900*	*900/1050*	1200	1050	2200	1800	525
T4	Length (m)	650		129	160			
	Existing (mm)	450		200	250			
	Proposed (mm)	1200		600	750			
T4B	Length (m)	285	364	466	120	392		
	Existing (mm)	450	450	300	250	400		
	Proposed (mm)	1500	1800	1200	1050	1650		
T5	Length (m)	650		129	160			
	Existing (mm)	450		200	250			
	Proposed (mm)	900		600	750			

Note 1: Green Valley sizing under this scenario assumes infill of developments along Manning Road as noted in Section 7.2.

7.4.2 CR22 Outfall Service Area (TH area) Results

Infrastructure improvements in the Tecumseh Hamlet area were divided into two categories: fixed and variable. This distinction was made primarily to get an accurate comparative cost estimate for all scenarios evaluated. 'Fixed' improvements included the West Hamlet Sanitary Trunk Sewer, sanitary sewer improvements along CR42 and new sanitary sewer proposed to service the MRSPA area. Table 7.4 below summarises the 'variable' infrastructure improvements proposed for the Tecumseh Hamlet area under the various scenarios evaluated.

Minor improvements in the Intersection Road sanitary sewer are proposed in scenario TH3 to relieve the Charlene Lane area. The 'fixed' infrastructure improvements provide adequate conveyance capacity for remaining new development in the Hamlet area in this scenario.

Figures 7.10 to 7.15 show the basement flooding risk within the study area for the future conditions scenarios identified in Table 7.4. Figures 7.10 to 7.15 also show locations of sewer improvements proposed as part of the future conditions modelling analysis, and areas within the CR22 drainage area where targeted FDD was simulated.

Table 7.4 shows the existing and proposed sanitary sewer sizes in areas where sanitary sewer improvements are proposed. Scenarios without infrastructure improvements are excluded from Table 7.4.

Table 7.4: CR22 Gravity Outlet – Summary of Improvements per Scenario

Scenario		Charlene (Roxanne Dr. to Lesperance Rd.)	Lesperance Rd. (Charlene Lane to Intersection Rd.)	Intersection Rd. (Lesperance Rd. to St. Anne St.)	Lesperance Rd. (Gouin St. to Cavalry Ct.)	Gouin (Deslippe Dr. to Lesperance Rd.)	Gouin (Mayrand Ct. to Shawnee Rd.)
TH3	Length (m)	-	-	145	-	-	-
	Existing (mm)	-	-	300	-	-	-
	Proposed (mm)	-	-	600	-	-	-
TH3B	Length (m)	180	74	145	210	115	100
	Existing (mm)	250	300	300	600	375	250
	Proposed (mm)	600	600	600	1050	750	450
TH4B	Length (m)	180	74	145	210		100
	Existing (mm)	250	300	300	600		250
	Proposed (mm)	450	600	600	900		450

The sanitary sewer improvements recommended have been reviewed as it relates to potential conflicts with the existing storm drainage system, existing watermain and proposed storm sewers as outlined in the Town's Master Drainage Study. The following summarizes potential conflicts and design considerations as it relates to the infrastructure proposed under the preferred scenarios.

- To accommodate the proposed sanitary sewer improvements along Lemire Street and Lanoue Street, the existing watermain within the municipal right-of-way will require relocation. In addition, trunk storm sewer improvements along these streets have been identified in the Town's Master Drainage Study (June 2019) to mitigate surface flooding in the area. Allowances for watermain relocation have been included in the total improvements cost estimate for the corresponding sanitary sewer solutions in Section 7.6 below. Storm sewer improvements costs as included the TMDS (2019).
- Along St. Thomas Street and Green Valley Drive, the existing sanitary sewer system is shallow and flatter than typical design standards. Increasing the size of the sanitary system would introduce conflicts with the existing storm sewer and storm private drain connections. To mitigate conflicts, two parallel trunk sanitary sewers are proposed to mitigate vertical conflicts. At intersections where storm sewers cross the sanitary sewer to service side streets, the sanitary sewers will need to maintain the existing 450 mm dia. size to reduce conflict. Examples of areas where this is anticipated is at the Amberly Crescent and the Rideau Place intersections.

Implementing the infrastructure improvements listed above results in a reduction of the HGL to almost the entire respective drainage area. Table 7.5 below shows the proportional change in HGL that results from the implementation of the above solutions.

Table 7.5: Proposed Conditions (T3/3B and TH3/3B) - Percent of Nodes above Basement Floor Elevation

Return Period		1:5 Year (T3)		1:25 Year (T3B)	
		Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
Percentage of Sanitary MH nodes with peak HGLs above basement floor elevation	Study Area (TE, SB and TH)	27.7%	1%	42.2%	2%
	Tecumseh Town (TE)	15.0%	2%	18.9%	2%
	St. Clair Beach (SB)	60.4%	0%	88.4%	1%
	Tecumseh Hamlet (TH)	26.5%	1%	48.1%	3%

7.5 Estimated Capital Costs

The estimated capital construction costs for the various solution scenarios were developed based on the year 2023 construction prices. The costs were developed to provide a comparison of solutions as it relates to capital costs which would be incurred by the Town. Depending on the timing of implementation, costs could vary significantly. Cost estimates are represented in order of magnitude to implement proposed infrastructure, including allowances for costs related to road reconstruction and construction of watermains where relocations have been identified as necessary to maintain minimum separation allowances. During detailed design, detailed cost estimates should be completed to accurately estimate the construction costs for the proposed improvements.

A summary of the cost estimate assumptions is included below.

- Includes removal of existing sanitary sewers and manholes;
- Includes construction of new trunk sanitary sewers recommended through this study but exclude new trunk infrastructure identified in the WWMP(2019);
- Allowance for construction of new sanitary private drain connections (PDCs);
- Full width road reconstruction based on Town of Tecumseh Service Standard, which includes full road restoration, curbs, boulevard restoration, catch basins and line painting;
- Costs exclude utility relocations, new streetlights, traffic signals, pathways, landscape, and property acquisition; and
- Costs include a 30% Contingency and 15% Engineering allowance.

To estimate the cost to implement a foundation drain program, an allowance of $20,000 per home for the improvements and program administration has been allocated. For areas where FDD would be required to achieve the basement flood risk reduction objective, a mandatory program would need to be implemented so that the minimum 80% of homes (as noted in Section 7.2.2) uptake in this program would be achieved.

Tables 7.6 and 7.7 outline the total estimated for the improvements with Area-Wide FDD in both design storm scenarios. Area Wide FDD refers to implementation of a foundation drain disconnection program that would require all properties (properties older than 1980) with foundation drains connected to the sanitary system to be disconnected throughout the Town. Detailed estimates are included in Appendix D for reference.

Table7.6: Scenario Cost Comparison for TE and SB Areas

Scenario	Description	No. of FDD Homes	FDD Costs	Infrastructure Costs	Total Costs	Relative Cost Benefit (Cost/HGL Reduction)
T1	Existing Conditions	-	-	-	-	-
T2	Future Conditions (No Improvements)	-	-	-	-	-
T3	LOS 1:5 Year Storm No FDD	-	-	$16.8M	$16.8M	$57,000

Scenario	Description	No. of FDD Homes	FDD Costs	Infrastructure Costs	Total Costs	Relative Cost Benefit (Cost/HGL Reduction)
T3B	LOS 1:25 Year Storm No FDD	-	-	$34.5M	$34.5M	$83,000
T4	LOS 1:5 Year Storm Targeted FDD	968	$19.4M	$11.5M	$30.9M	$105,000
T4B	LOS 1:25 Year Storm Targeted FDD	968	$21.3M	$19.8M	$41.1M	$98,000
T5	LOS 1:5 Year Storm Area-Wide FDD	2478	$49.6M	$9.8M	$59.4M	$200,000

Table 7.7: Scenario Cost Comparison for TH Area

Scenario	Description	No. of FDD Homes	FDD Costs	Infrastructure Costs	Total Costs	Relative Cost Benefit (Cost/HGL Reduction)
TH1	Existing Conditions	-	-	-	-	-
TH2	Future Conditions (No Improvements)	-	-	-	-	-
TH3	LOS 1:5 Year Storm No FDD	-	-	$0.62M	$0.62M	$7,000
TH3B	LOS 1:25 Year Storm No FDD	-	-	$3.2M	$3.2M	$17,000
TH4	LOS 1:5 Year Storm Targeted FDD	240	$4.8M	-	$4.8M	$53,000
TH4B	LOS 1:25 Year Storm Targeted FDD	240	$4.8M	$3.1M	$7.9M	$41,000
TH5	LOS 1:5 Year Storm Area-Wide FDD	400	$8.0M	-	$8.0M	$88,000

Costs included above do not include construction of trunk sanitary sewer infrastructure such as the West Tecumseh Hamlet Trunk Sewer, required to facilitate proposed development, noted as 'fixed' infrastructure improvements is Section 7.4.1.

Based on the comparison of these costs, it is concluded that the implementation of FDD programs are costlier for both the Cedarwood and CR22 drainage areas. For instance, in the Cedarwood PS, to reduce basement flood risk to meet a level of service for a 1:25 year event, the cost to implement FDD in targeted areas (T4B) along with infrastructure is $34.5 million whereas the infrastructure only solution (T3B) a total cost of $41.4 million is estimated. In the CR22 drainage area, the cost to implement FDD in target areas is $7.9 million in comparison to the cost of $3.2 million to implement in line storage only option.

Costs listed above are capital project implementation costs and do not factor in cost savings associated with less effluent requiring treatment at the LRPCP. As discussed in Section 4.5.3, it is difficult to quantity the cost savings due to the current payment structure that exists. To provide some context on cost savings we can assume that at a minimum treatment cost of $36.29 /m^3.

Included in Tables 5.5 and 5.6 are the cost benefit values for each scenario, these values represent the project costs relative HGL improvement. To determine the cost benefit, the total project cost was divided by the total number of "red" nodes that were eliminated when compared to existing conditions (manholes where the HGL has been lowered to below basement floor depth by implementing the solution). This measures the relative cost to achieve the noted level of service. Both the 1:5 and 1:25 year scenarios show less relative cost for HGL improvements than those that include FDD.

7.6 Recommended Infrastructure Improvements

Based on the cost comparisons above, the solution scenarios preferred are T3B and TH3B for the Cedarwood PS and CR22 outfall service areas, respectively. Both solutions are also preferred in terms of impacts to private property owners and ease of implementation. Capital works projects within the Town's right-of-way can be implemented in a timelier fashion with each project benefiting a large number of residents and providing opportunity to upgrade aging municipal infrastructure. Foundation drain disconnection within private property will be more disruptive and ensuring quality and correct completion disconnect would be difficult.

The improvements proposed as part of the recommended future conditions scenario have been designed to a 1:25 year return period level of service. The improvements recommended are public-side improvements only which are anticipated to be easier to implement. They include upgrading municipal sanitary infrastructure to provide increased in-line storage during wet-weather events and thereby reduce the risk of basement flooding in the upstream sewershed.

In this instance all new infill development will need to confirm that proposed development and infrastructure will not pose additional risk to the existing system to this level of service for a 1:25 year storm.

7.7 Tecumseh Sanitary System Outlet Capacity

The Town of Tecumseh has an agreement with the City of Windsor through which it is allowed a peak discharge into the City sanitary sewer system at various points. There are two discharge locations within the study area:

- Cedarwood PS – A peak allowable discharge of 935 L/s is permitted at this location; and
- CR22 Gravity Outlet – A peak allowable discharge of 1308 L/s is permitted at this location (this includes flows from Maidstone and Oldcastle).

The peak flow into the City during the 1:25 year, 4 hour design storm event simulation on the preferred ultimate conditions (T3B/TH3B) model at the two locations are shown below:

- Cedarwood PS – 935 L/s
- CR22 Gravity Outlet – 942 L/s (this includes flows from Maidstone and excludes flows from Oldcastle)

The outflow at these locations were analysed during the preferred ultimate conditions model simulation (T3B/TH3B). Since the Cedarwood PS is a pumped outlet, the flow to the City system is restricted to the installed pump capacity under all storm event simulations evaluated in this study. Though there is a gravity overflow sewer parallel to the PS, the HGL in the sanitary sewers upstream do not reach the invert of the overflow sewer under the storm events evaluated.

The ultimate conditions model include all known planned development as mentioned in Table 7.2. In addition, a constant peak flow from the Maidstone Hamlet was included in the simulation (Section 7.2). The simulation results show that under the design level of service (1:25 year), the gravity outfall at CR22 is very close to its allowable discharge rate. Any planned development in addition to the ones considered in the ultimate conditions scenario will need to be evaluated so as not to exceed the flow allocation at the CR22 location.

7.8 Future Conditions Scenario - Enhanced Level of Service

Providing a higher, more enhanced level of service through municipal sanitary sewer infrastructure upgrades alone were considered not feasible due to a number of reasons. Providing larger sanitary sewers within the municipal right-of-way would give rise to conflicts with existing underground utilities and would be difficult to implement from a constructability standpoint. Additionally, the cost to benefit ratio for more extensive infrastructure upgrades are expected to be higher.

It is recommended that to achieve a higher level of service, beyond the 1:25 year event, a combination of private and public-side improvements would be the most cost-effective option. While public-side improvements will continue to provide relief and lower basement flooding risk, private-side improvements, like FDD, would control RDII at the source, resulting in a lower risk of basement flooding during wet-weather events more intense than a 1:25 year event. To assess this option for a higher level of service, an additional modelling scenario was run to simulate this condition. This scenario included all sanitary sewer upgrades recommended under Scenario T3B/TH3B, detailed above in Section 7.4. In addition, area wide FDD (with 80% uptake) was assumed for this simulation. Pumped outflow from the Cedarwood PS into the City of Windsor system downstream was assumed to occur at the maximum allowable release rates without any impact of high HGLs in the downstream system. The model scenario was simulated using the 1:100 year return period design storm event. Results from this analysis are presented in Figures 7.16 and 7.17. It must be noted here that the output flow from the Cedarwood PS is expected to be less than its full installed capacity during periods where high HGL conditions downstream are expected to cause a tailwater condition, acting against the PS.

As seen in Figure 7.16, a combination of sanitary infrastructure improvements (public-side) and FDD (private-side) results in lowering the risk of basement flooding during the 1:100 year event. The HGL in the sanitary sewer system remains below assumed basement floor levels in most areas of the Town during this simulation.

It is to be noted here that this solution can only be implemented over a longer term. The implementation would be expected to take over 10 years, as this will involve disconnecting individual foundation drains from a large number of homes within the study area. While the Town already has a voluntary FDD program that provides subsidies for homeowners to disconnect their foundation drains from the sanitary sewer system, a mandatory FDD program would accelerate the process to achieve the higher level of service and result in lowering damages due to basement flooding during wet-weather events, in large parts of the Town.

7.9 Municipal Class Environmental Assessment Requirements

Under the Municipal Class Environmental Assessment (MCEA) process (March 2023), projects are identified within different categories depending on their complexity and potential for effects on the surrounding environment. Projects shall be identified as Exempt, Schedule B or C, as defined by the MCEA's guidance documents.

Per the MCEA the project classification listed below apply to the recommended Wastewater Management projects.

<u>Wastewater Project</u>

Exempt Projects

> Item 4b) Establish, extend, or enlarge a sewage collection system and all necessary works to connect the system to an existing sewage or water source, provided all such facilities are in either an existing road allowance or an existing utility corridor, including the use of Trenchless Technology for water crossings.
>
> Increase pumping station capacity by adding or replacing equipment where new equipment is located within an existing building or structure and where the existing rated capacity is not exceeded.

Schedule B

> Item 4c) Establish, extend or enlarge a sewage collection system and all works necessary to connect the system to an existing sewage outlet or water source, where such facilities are not in an existing road allowance or an existing utility corridor.

Based on the scope of the sanitary sewer improvements, the project EA Schedule classification for all sewer projects are "Exempt" as all improvements include enlargement of sewage collection system and connecting to an existing sewage outlet. The proposed sanitary sewer improvements are proposed within municipal right-of-way (ROW) for all projects, however, in some instances, where the ROW width is limited or conflicts exist, relocation of watermain or other utilities may be required. Where utility relocation is required, the need to obtain easements or widen the municipal ROW shall be identified. The Town should assess the need to complete the necessary functional design, site assessments, public and agency consultation and impact assessments that are required for Schedule B projects. The following additional considerations should be reviewed as it relates to the Project EA Schedule classification.

- <u>Green Valley Drive (Tecumseh Rd E to Little River Boulevard) Improvements:</u> A portion of the proposed improvements (400 m) requires the implementation of two trunk sanitary sewers to mitigate conflicts and constraints related to private drain connections. To accommodate these sewers, relocation of local storm sewer and watermain infrastructure will be required. Easements will be required to accommodate relocations including relocation of underground telecommunications, power and gas. A cost allowance for infrastructure relocation has been included in the overall project cost.
- <u>Lemire Street and Lanoue Street Improvements:</u> To accommodate both sanitary sewer improvements and the storm sewer improvements identified in the Town's Drainage Master Plan, the existing watermain will need to be relocated.
- <u>Riverside Drive (Pentilly Road to West of Kensington Boulevard.):</u> These improvements were included in the Sanitary Sewage Collection System Improvements Class EA (2013) report which satisfied the Schedule C requirements for this project. This project is now considered a Schedule B project per the 2023 MCEA revisions. Modifications to this

solution identified through this study do not revise the purpose of the improvements or pose additional impacts, therefore an addendum to that EA is not required.

- Cedarwood Pump Station Improvements: Any future modifications to the Cedarwood Pump Station would be considered Exempt project as increase to the rated capacity of the pump station would not be increased. This assumes that all improvements would remain within the existing pump station site.

Other sanitary sewer system improvements discussed in this study have been identified through the Town's Water and Wastewater Master Plan (2018) and their associated EA Schedule is noted in that plan.

7.10 Additional Flood Mitigation Measures

In addition to improvements listed above, the Town is recommended to also proceed with the following measures to continue to reduce RDII and to promote private property protection measures:

- Prior to implementation improvements along the Lemire Street/Lanoue Street area (TE678), additional investigation should be completed to determine the source for high RDII rates in this relatively newly constructed area;
- Continue the improvements to sanitary infrastructure to address inflow and infiltration issues into sanitary sewers, including sanitary sewer flow monitoring in areas suspected to have high rates of RDII;
- Continue subsidizing lot level basement flood prevention measures, including municipal inspections and foundation drain disconnections. Basement flood protection measures such as backflow prevention and implementation of sump pump and associated backup power is encouraged;
- Consider the implementation of policies and public guidance on the use of sewage ejector pumps for all new development areas to provide individual lot level protection; and
- To reduce the potential for new development causing additional flood risk due to RDII, the Town consider the implementation of a post-construction monitoring program by which developers are required to demonstrate that new sanitary systems have no inflow and infiltration above the design standards both after sewer construction and after private drains are connected to the system. Holding securities during this monitoring timeframe is one type of mechanism the Town can use to achieve this objective.

8.0 Conclusions and Recommendations

The completed analysis of the Town's sanitary system includes an assessment of the system's capacity in response to increasing rainfall and changing climate trends, an update on the sewer model conversion from XPSWMM to InfoWorks-ICM, and a detailed examination of vulnerable areas in the Town subject to basement flooding. An investigation was completed on various storm events the Town has experienced over the past 11 years and short-term and long-term solutions to the Town's flooding problems resulting from sanitary surcharge were proposed.

Several scenarios were modeled with varying levels of service, infrastructure improvements, and foundation drain disconnection implementation. Upon consultation with the Town, scenario T3B and TH3B were selected as the final solutions to be implemented in the regions north and south of CR22, respectively. Both scenarios recommend a 1:25 year level service, various sewer improvements, and no FDD implementation. Improvements are proposed at the following locations as part of the recommended solution scenario:

Table 8.1: Recommended Sanitary Sewer Improvements

Project Title	Project Description	Total Estimated Project Costs
Cedarwood PS Drainage Area		
Green Valley Drive/ Street Thomas Street/ Dillon Drive (Tecumseh Road E to Little River Boulevard.)	Replace 926m of sewer with 900 mm dia. sanitary sewer. Replace 484m of sewer with 1050 mm dia. sanitary sewer. Construct a 400m, 900 mm dia. parallel sewer between Little River Boulevard. and Street Thomas Street	$ 20,391,250
Lemire Street and Lanoue Street	Replace 466m of sewer with 1200 mm dia. sanitary sewer on Lemire Street Replace 120m of sewer with 1050 mm dia. sanitary sewer on Lanoue Street	$5,541,000
Riverside Drive	Replace 603m of sewer with 2200 mm dia. sanitary sewer on Riverside Drive between Pentilly Road and West of Kensington Boulevard.	$5,720,000
Arlington Boulevard	Replace 374m of sewer with 1800 mm dia. sanitary sewer on Arlington Boulevard between Tecumseh Road E. and Street Gregory's Road	$1,543,000

Project Title	Project Description	Total Estimated Project Costs
Edgewater Boulevard	Replace 360m of sewer with 525 mm dia. sanitary sewer on Edgewater Boulevard between Riverside Drive and Hayes Avenue.	$1,287,000
CR22 Drainage Area		
Charlene Lane	Replace 180 m of 250 sewer with 600 mm dia. sanitary sewer on Charlene Lane between Roxanne Drive to Lesperance Road.	$644,000.00
Lesperance Road/Gouin Street	Replace 115 m of 375 mm dia. sewer with 750 mm dia. sanitary sewer on Gouin Street, Lesperance Road, easterly to the boundary of the Manning Road Secondary Plan Area. Replace 210 m of 600 mm dia. sewer with 1050 mm dia. sanitary sewer on Lesperance Road.	$422,000.00
Intersection Road	Replace 145 m of 300 mm dia. sewer with 600 mm dia. sanitary sewers on Intersection Road between Lesperance Road and St. Anne Street.	$612,000.00
Lesperance Road (Charlene to Intersection Road)	Replace 74 m of 300 mm dia. sewer with 600 mm dia. sanitary sewer on Lesperance Road, between Charlene Lane and Intersection Road)	$1,042,000.00
Gouin Street (Mayrand Crescent to Shawnee Road)	Replace 100 m of 250 mm dia. sewer with 450 mm dia. sanitary sewer on Gouin Street.	$414,000.00

The associated cost of implementing these solutions is as follows:

- $34.48 million for the Cedarwood PS Service Area (T3B)
- $3.13 million for the CR22 Gravity Outfall Service Area (TH3B)
- $37.61 million total for the entire study area

It is recommended that the Town implement infrastructure solutions listed in conjunction with continued monitoring and implementation of RDII reduction measures including encouraging residents to complete FDD through Town's Basement Flood Protection Subsidy program. As development occurs within the vacant areas of the Town, new infrastructure and private drain connections shall also to be built to mitigate RDII into the sanitary system.

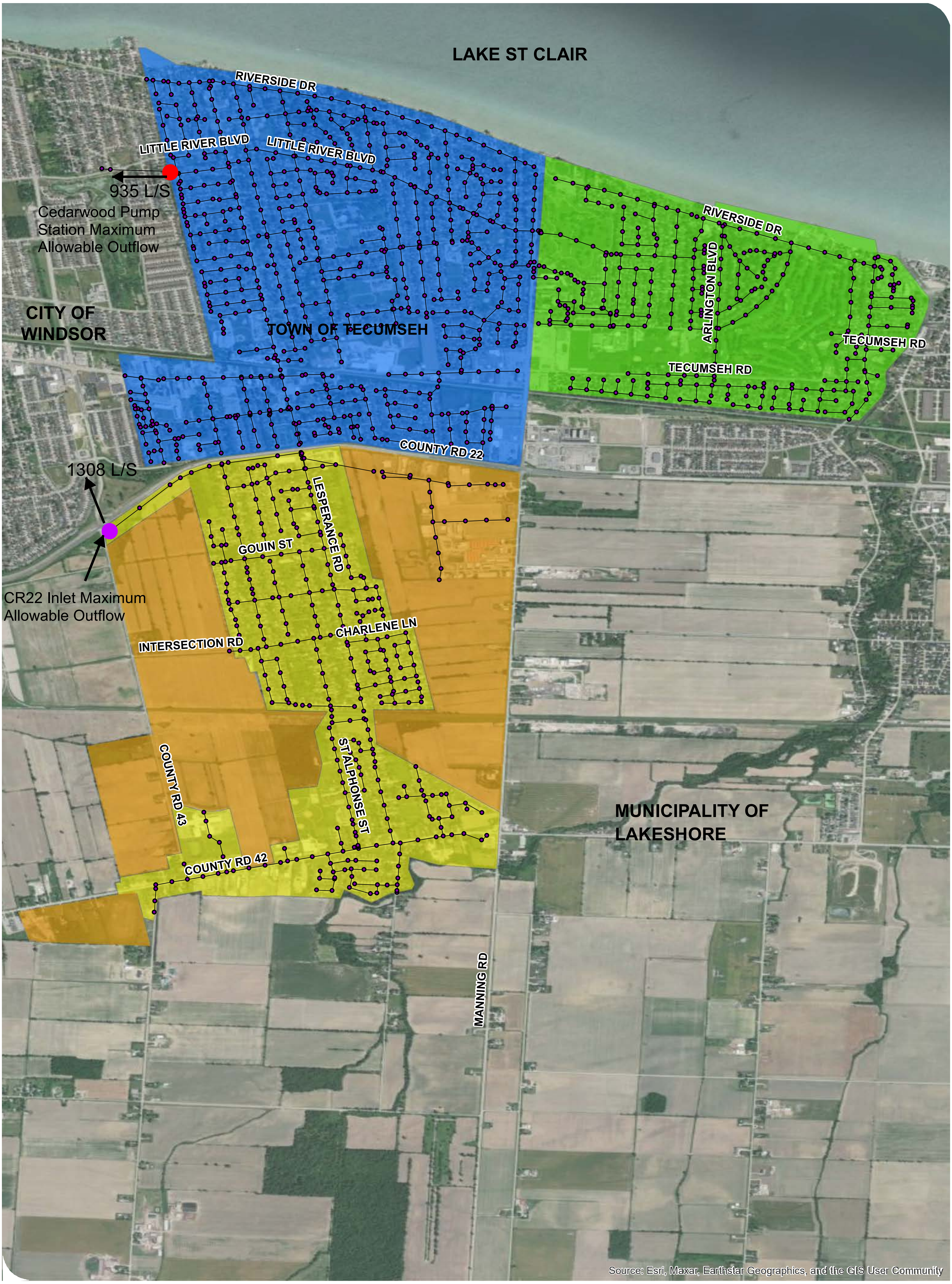
9.0 Closure

We hope that this report provides the Town guidance on mitigation of basement flood risk within the northern urban portions of the Town of Tecumseh. These recommendations shall become part of the Town's continued efforts to address flooding within the Town on an ongoing basis.

Regards,

Aakash Bagchi, P.Eng. Water Resource Engineer	Laura Herlehy, P.Eng. Project Engineer

Figures



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

STUDY AREA MAP

FIGURE 1.1

(blue)	TECUMSEH TOWN (TE) STUDY AREA	•	SANITARY MAINTENANCE HOLES
(green)	SAINT CLAIR BEACH (SB) STUDY AREA	——	SANITARY SEWERS
(yellow)	EXISTING TECUMSEH HAMLET (TH) STUDY AREA	(red dot)	CEDARWOOD PS OUTFLOW POINT
(orange)	PROPOSED DEVELOPMENT IN TECUMSEH HAMLET (TH) STUDY AREA	(purple dot)	CR22 OUTFLOW POINT

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

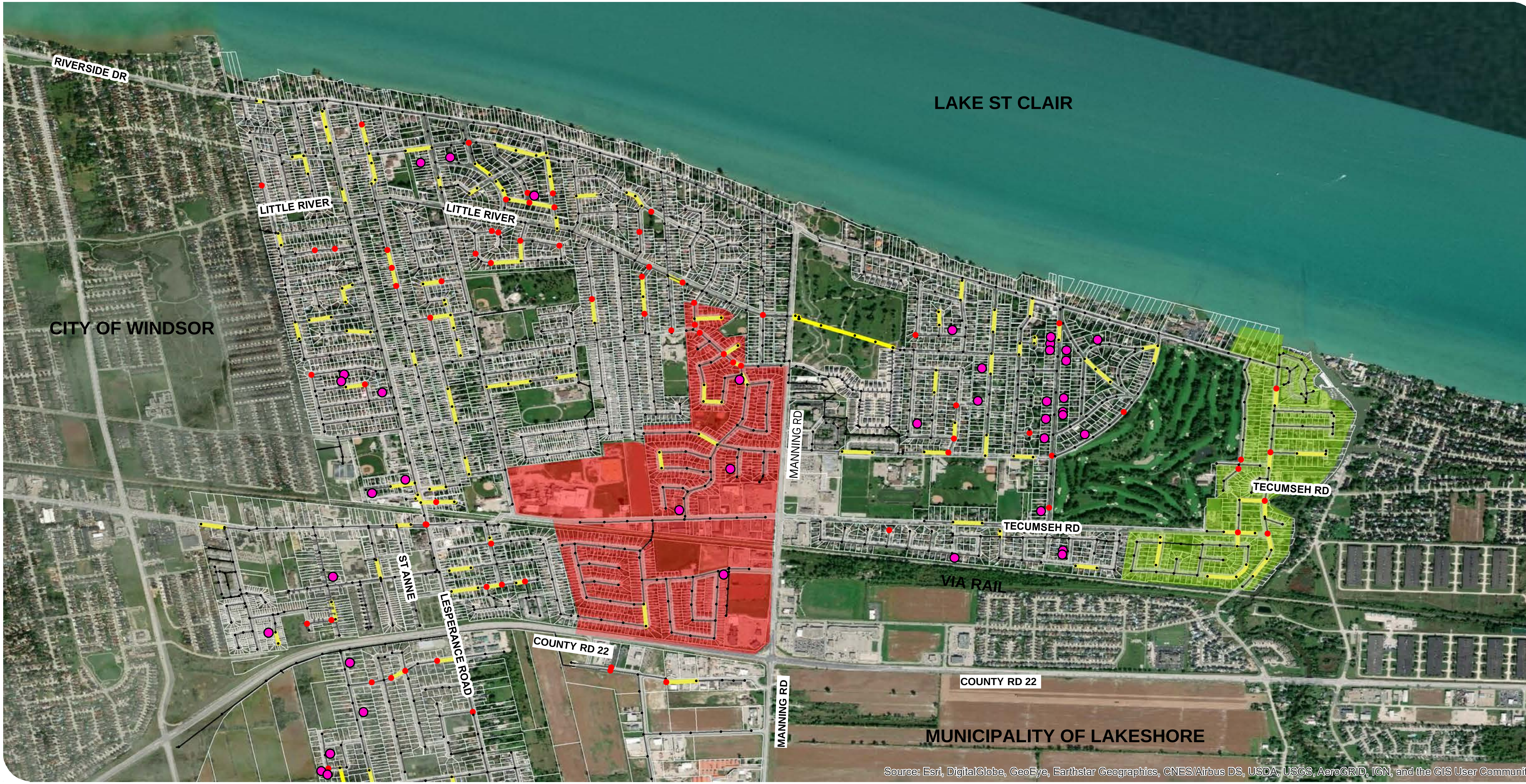
G:\CAD\GIS\Town of Tecumseh Sanitary Re-Calibration\GIS\

SCALE 1:28,000

0 0.25 0.5 1 km

N W E S

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

STUDY AREA MAP - SANITARY INFRASTRUCTURE REHABILITATION (C-G PS SERVICE AREA)

FIGURE 2.1

- REPAIRS TO SANITARY SEWER LATERALS
- SANITARY MH SEALED
- SANITARY MH
- SANITARY SEWER MAINS
- SANITARY SEWER MAINS REPAIRED
- SEWERSHED - SB115
- SEWERSHED - TE464

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY THE TOWN OF TECUMSEH

MAP CREATED BY: AB
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

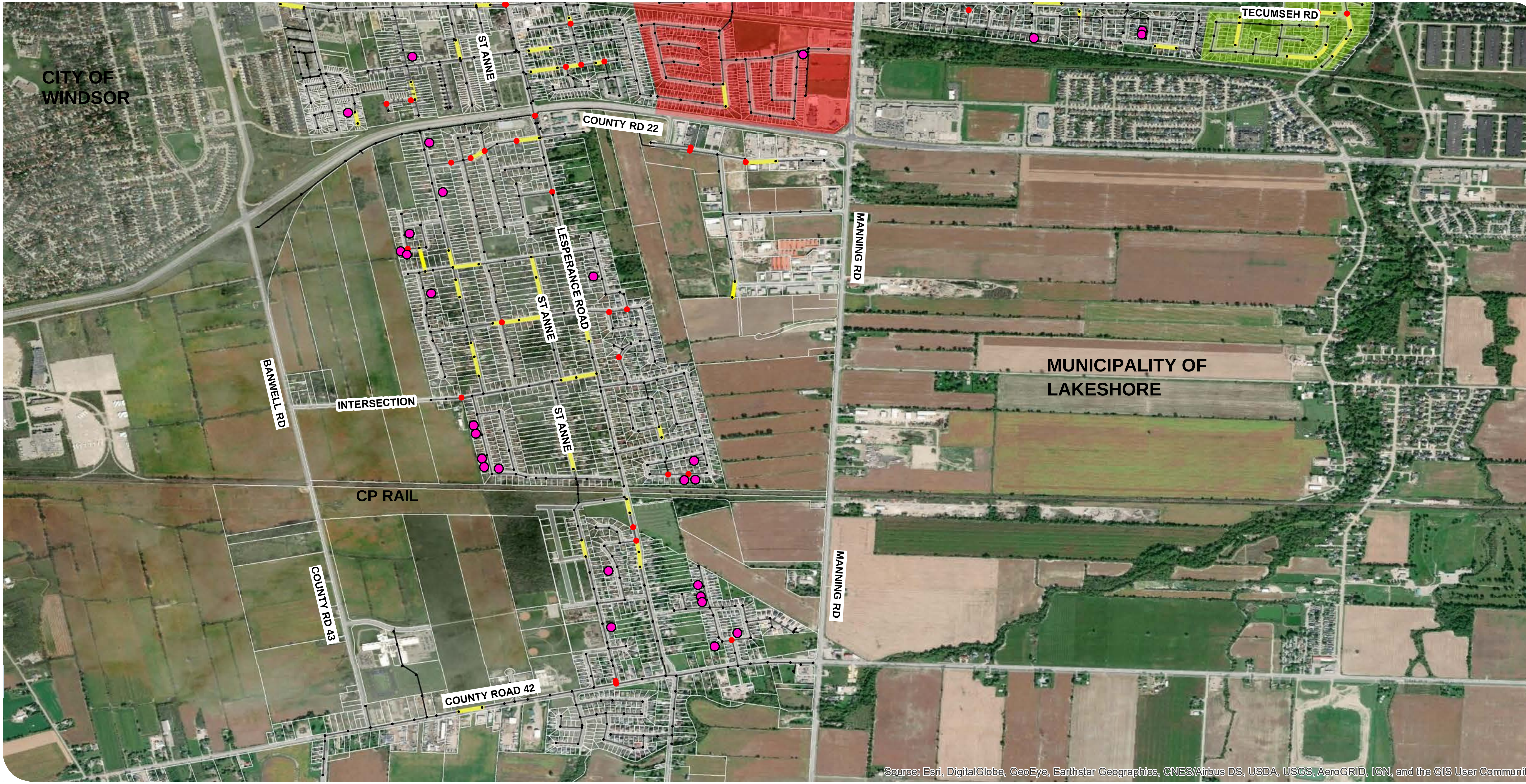
0 0.25 0.5 1 km

SCALE 1:20,000

N W E S

FILE LOCATION: \\DILLON.CA\DILLON_DFS\LONDON\LONDON CAD\GIS\ VISUAL COMMUNICATIONS DI\MXD TEMPLATES\ LIGHT BLUE - 11X17 LANDSCAPE - LEGEND BOTTOM.MXD

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

- REPAIRS TO SANITARY SEWER LATERALS
- SANITARY MH SEALED
- SANITARY MH
- SANITARY SEWER MAINS
- SANITARY SEWER MAINS REPAIRED

STUDY AREA MAP - SANITARY INFRASTRUCTURE REHABILITATION (CR-22 OUT-FLOW POINT SERVICE AREA)

FIGURE 2.2

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY THE TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY:AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

0 0.25 0.5 1 km

SCALE 1:20,000

N W E S

FILE LOCATION: \\DILLON.CA\DILLON_DFS\LONDON\LONDON CAD\GIS\VISUAL COMMUNICATIONS DI\MXD TEMPLATES\LIGHT BLUE - 11X17 LANDSCAPE - LEGEND BOTTOM.MXD

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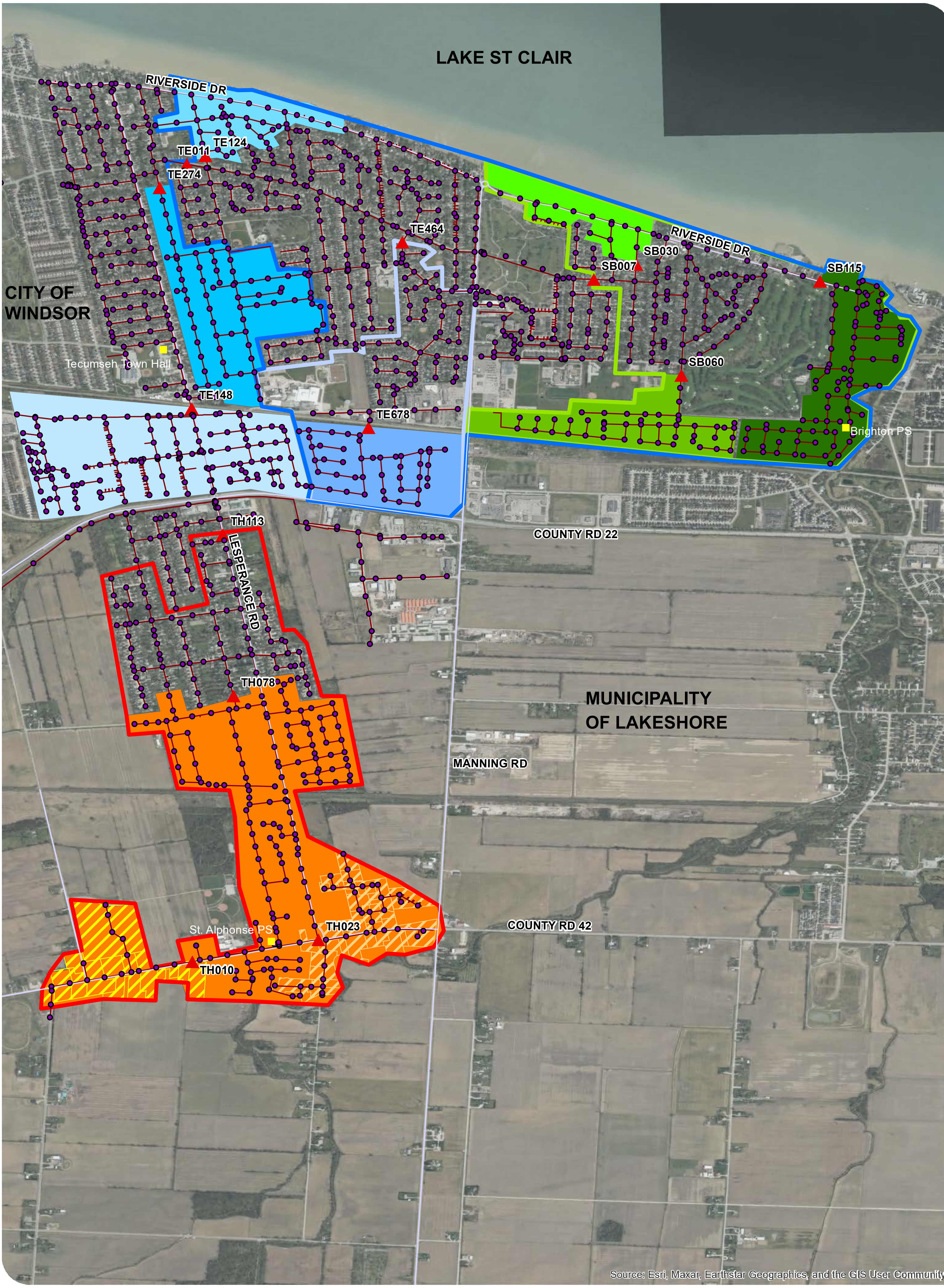

Drainage Areas of All Flow Monitors

TE011	TE148	SB115	TH010	Flow Monitor Location
SB007	TE124	SB030	TH023	Rain Gauge Location
TE464	TE274	SB060	Sanitary Sewers	
TH113	TE678	TH078	Sanitary Maintenance Holes	

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION

LOCATION OF SANITARY FLOW-MONITORS AND SEWERSHEDS

(AREA COVERED BY ALL EXISTING AND PROPOSED FLOW MONITORS)

FIGURE 3.1

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

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SCALE 1:25,000

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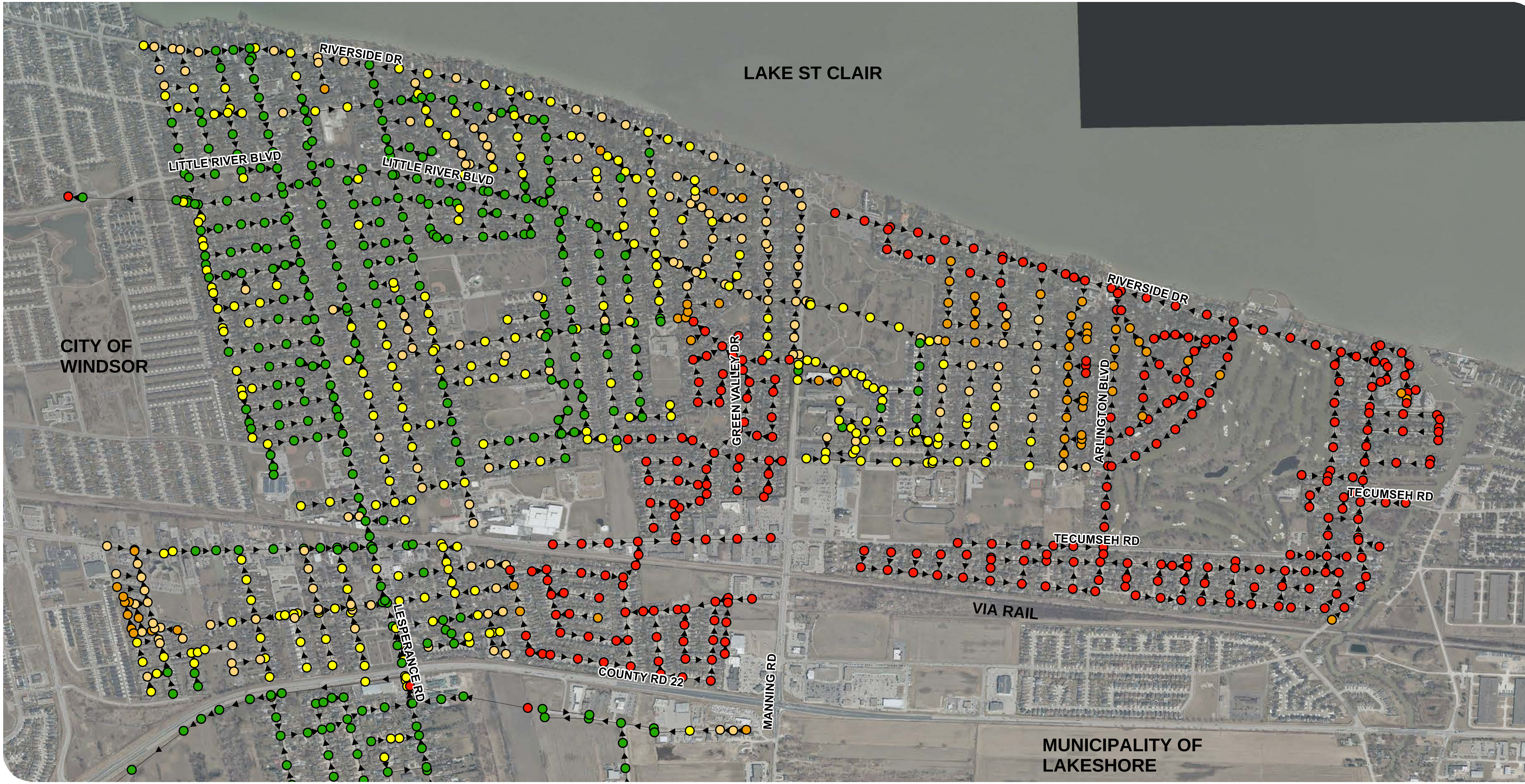
PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

RISK OF BASEMENT FLOODING TE AND SB AREAS

5 yr, 24 hr Design Storm Simulation (Existing Conditions)

FIGURE 6.1

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

FILE LOCATION: G:\CAD\GIS\19-9298 Town of Tecumseh Sanitary Re-Calibration\GIS\Final Figures

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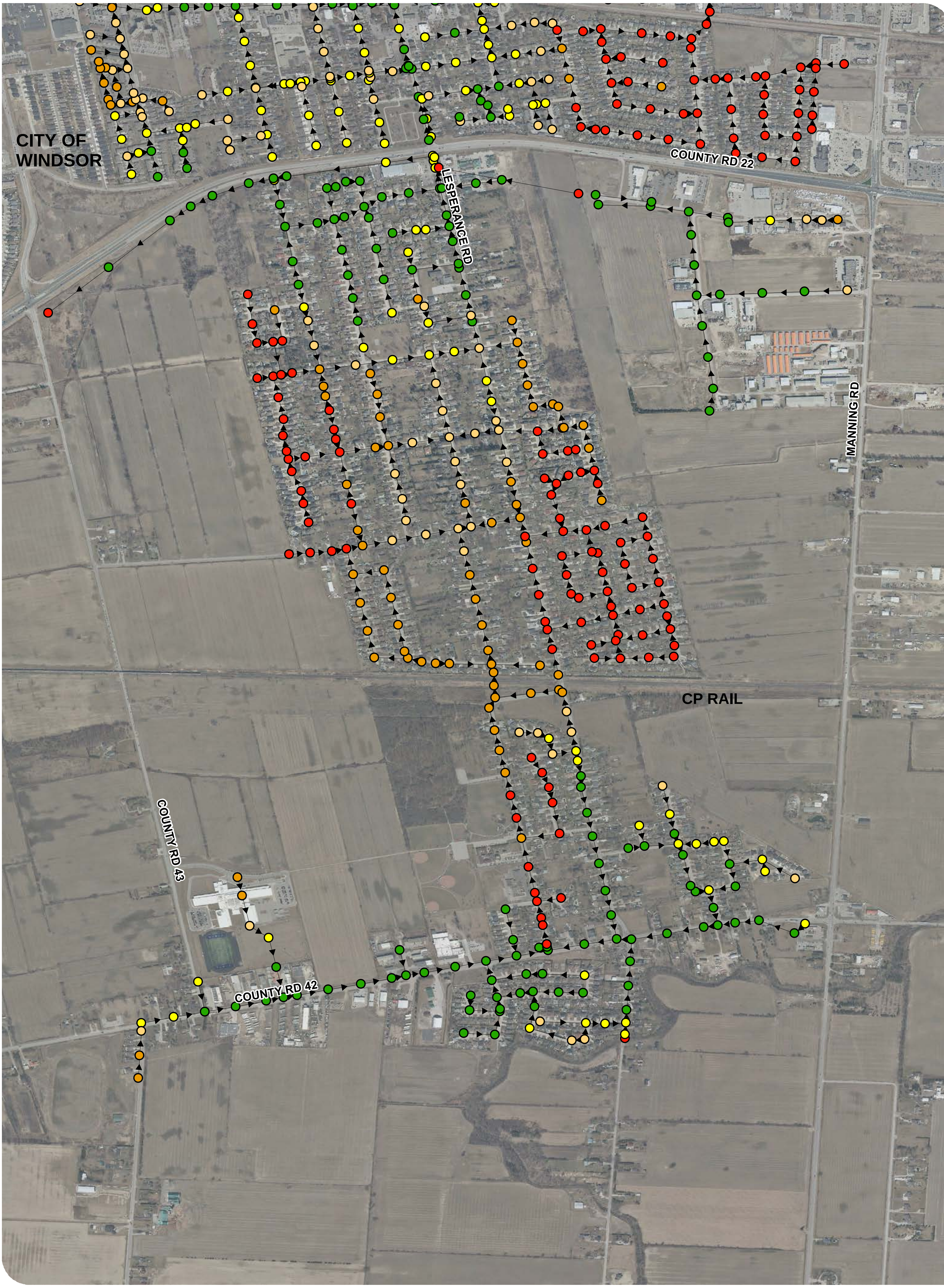

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

RISK OF BASEMENT FLOODING TH AREA

5 yr, 24 hr Design Storm Simulation (Existing Conditions)

FIGURE 6.2

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

DILLON CONSULTING

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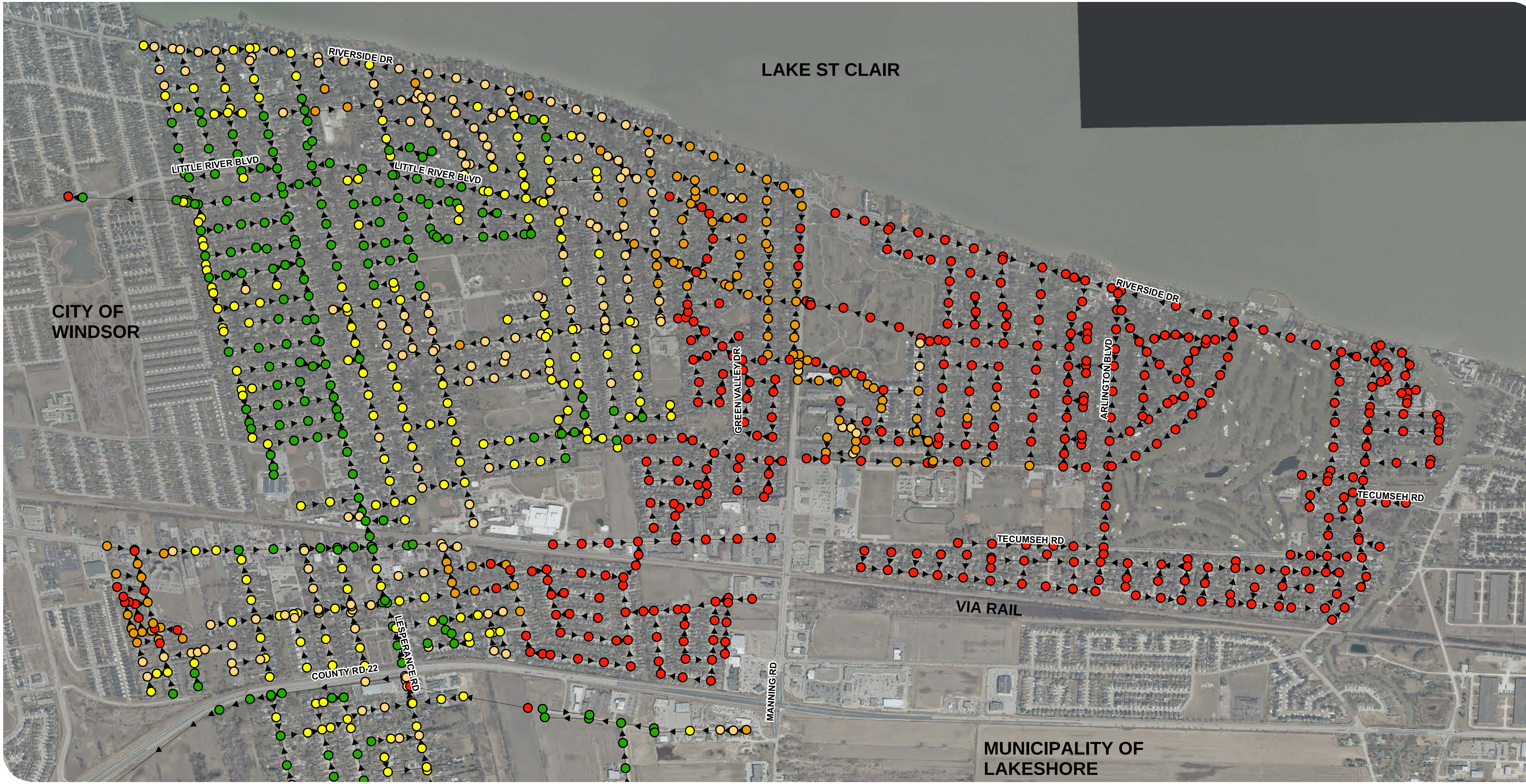
PROJECT: 19-9298 STATUS: FINAL DATE: 2021/06/24



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

RISK OF BASEMENT FLOODING
TE & SB AREAS

25 yr, 4 hr Design Storm Simulation (Existing Conditions)

FIGURE 6.3

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevation

- > 3 m (green)
- 2.5 - 3 m (yellow)
- 2.0 - 2.5 m (light orange)
- 1.5 - 2.0 m (orange)
- < 1.5 m (red)

Sanitary Conduits

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

N E S W

FILE LOCATION: \\DILLON.CA\

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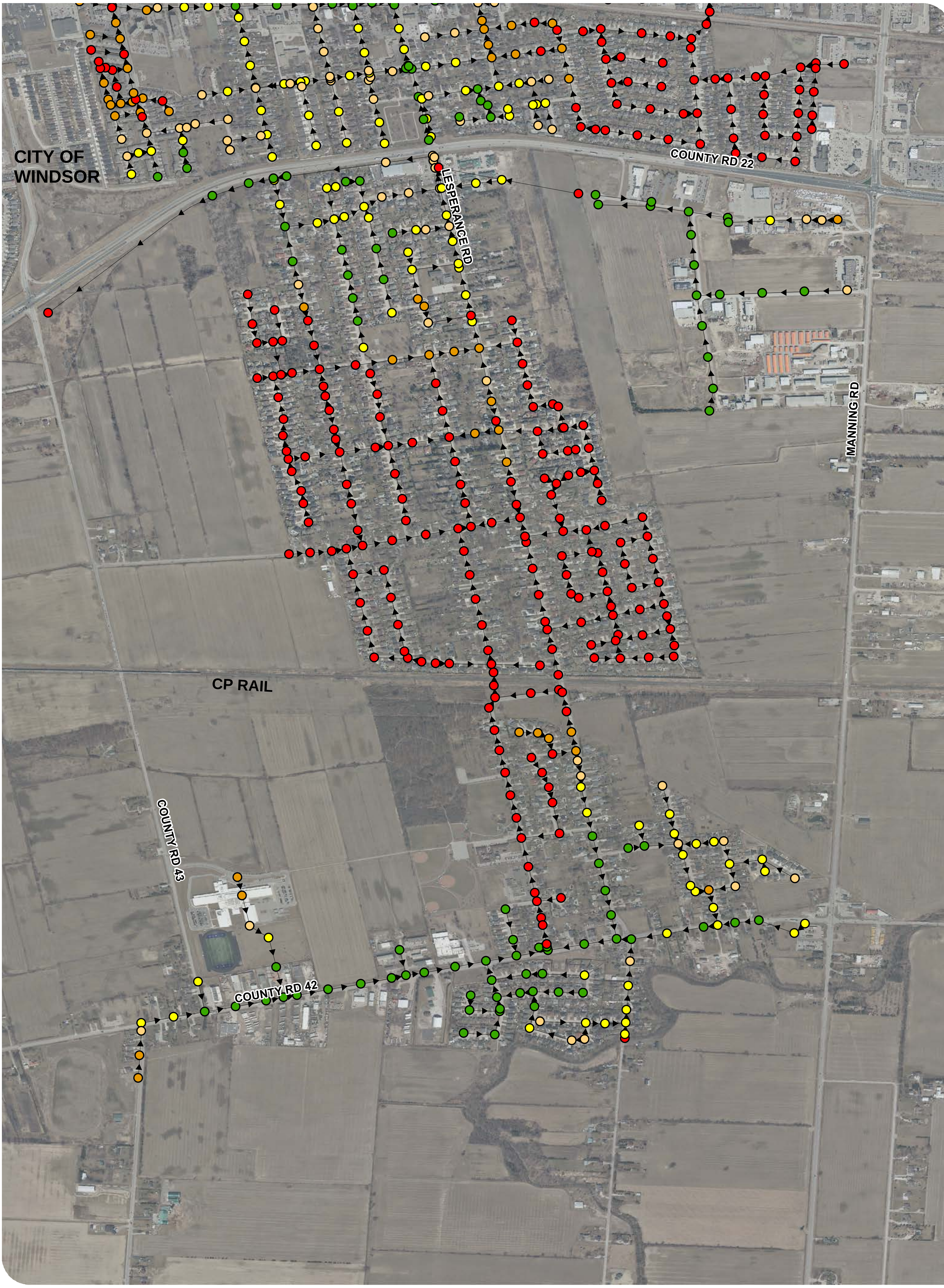

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

RISK OF BASEMENT FLOODING HAMLET AREA

25 yr, 4 hr Design Storm Simulation (Existing Conditions)

FIGURE 6.4

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m (green)
- 2.5 - 3 m (yellow)
- 2.0 - 2.5 m (light orange)
- 1.5 - 2.0 m (orange)
- < 1.5 m (red)

Sanitary Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

N W E S

DILLON CONSULTING

FILE LOCATION: \\DILLON.CA\

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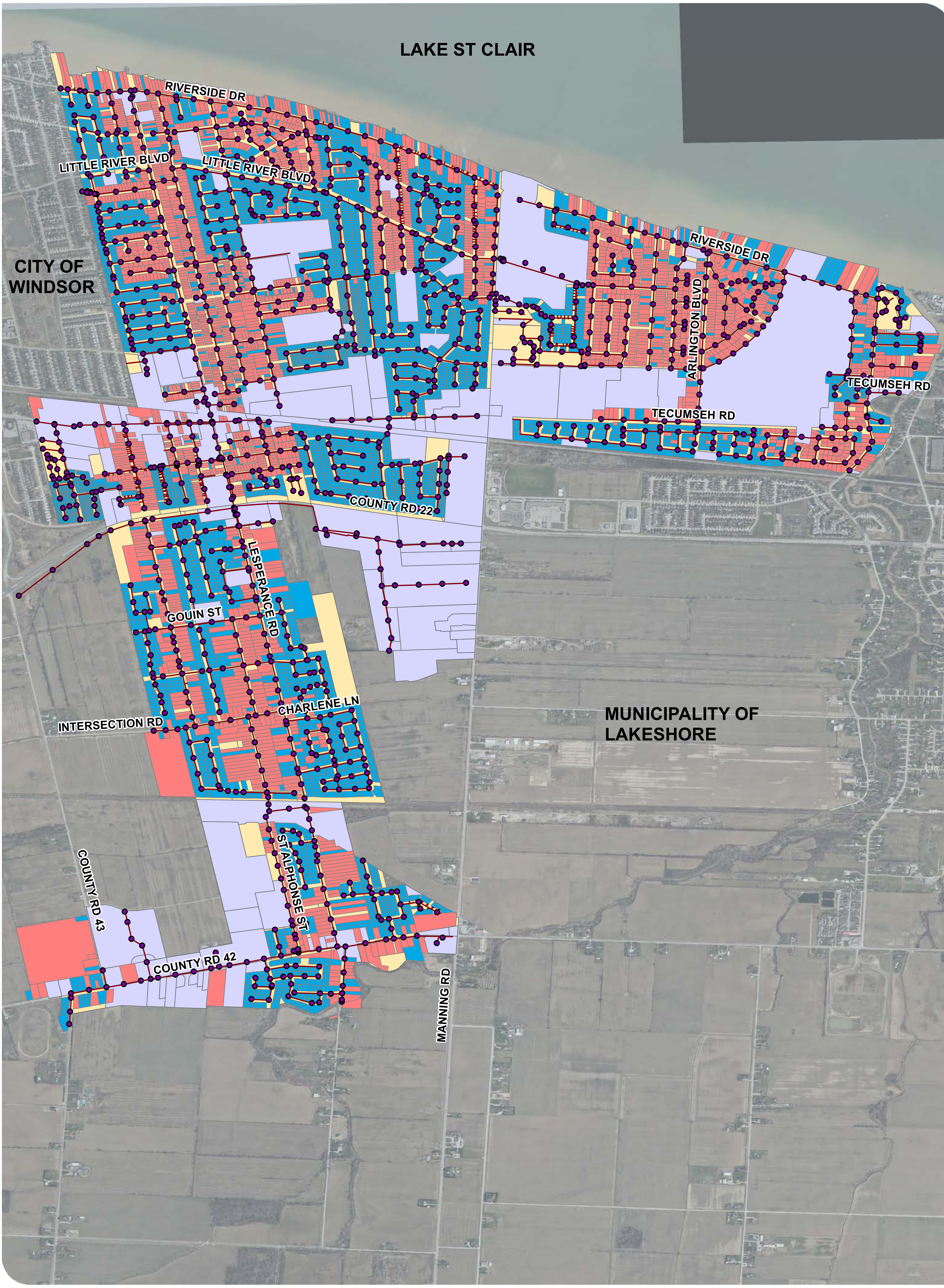

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

AGE OF HOMES

FIGURE 7.1

Non-Residential Land Uses	Sanitary Maintenance Holes
Residential property built during or before 1980	Sanitary Sewers
Residential property built after 1980	
Residential property build year unknown	

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

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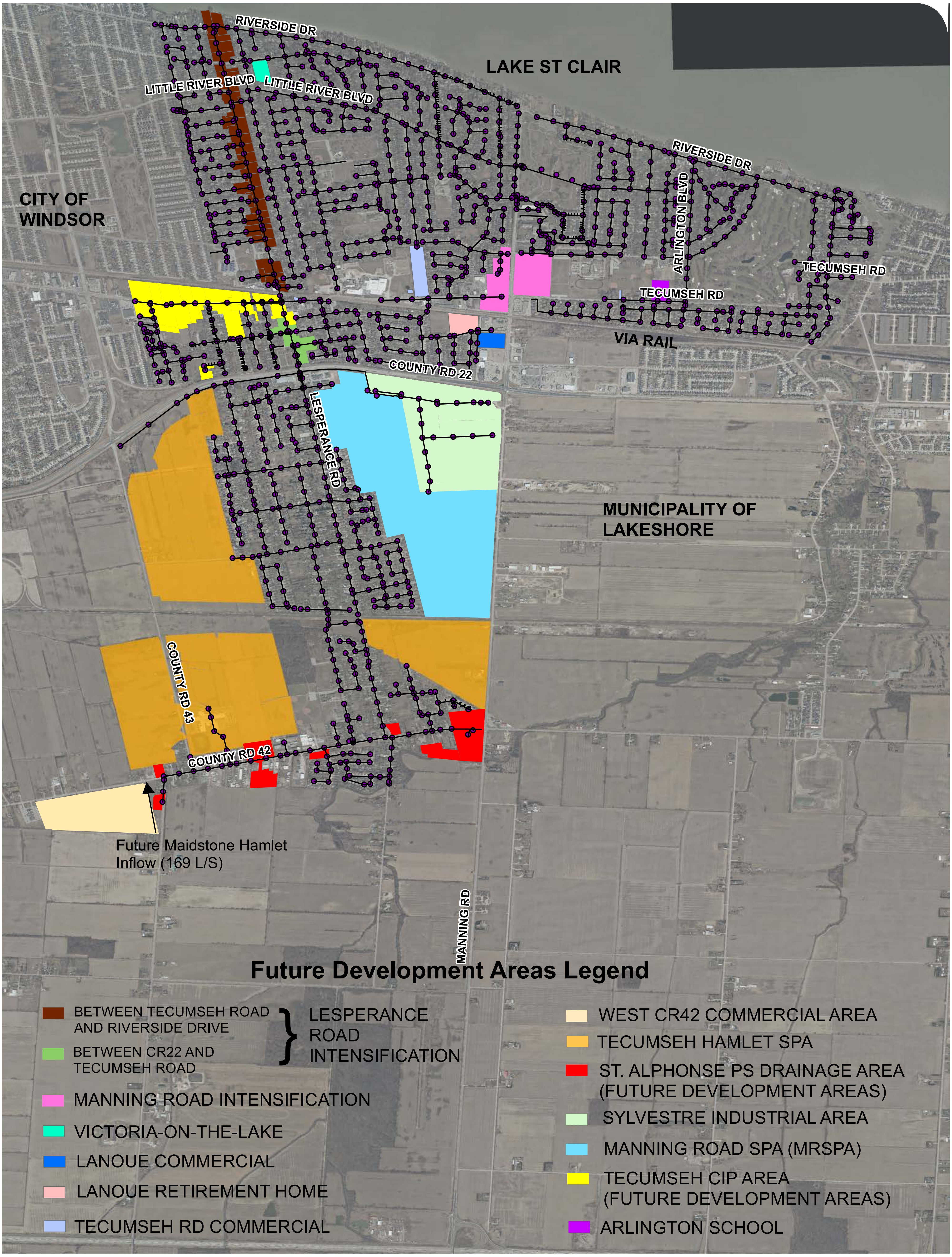
SCALE 1:25,000

0 0.25 0.5 1 km

N E S W

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

NEW DEVELOPMENT AREAS

FIGURE 7.2

● Sanitary Maintenance Holes

— Sanitary Sewers

DILLON CONSULTING

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MAP PROJECTION: NAD 1983 UTM Zone 17N

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SCALE 1:25,000

0 0.25 0.5 1 km

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T2: ULTIMATE CONDITIONS - NO SEWER IMPROVEMENTS OR FDD (BASELINE)

5 yr, 24 hr Design Storm Simulation

FIGURE 7.3

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

Problem Areas

DILLON CONSULTING

MAP DRAWING INFORMATION:
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MAP CREATED BY: AZS
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MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

N W E S

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PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T2: ULTIMATE CONDITIONS - NO SEWER IMPROVEMENTS OR FDD (BASELINE)

25 yr, 4 hr Design Storm Simulation

FIGURE 7.4

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

N W E S

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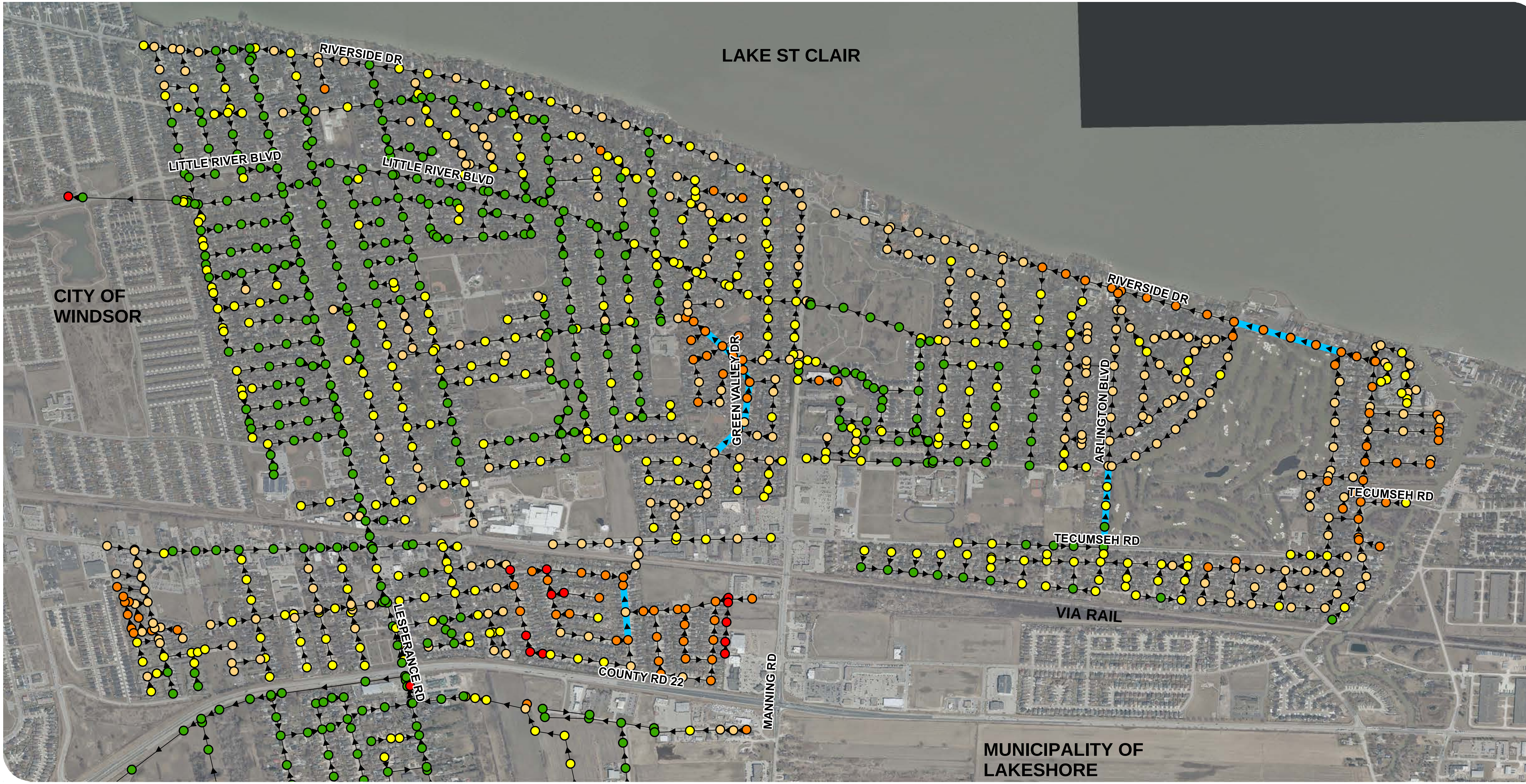


CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T3: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND NO FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.5

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

Sanitary Conduits With Proposed Improvements

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

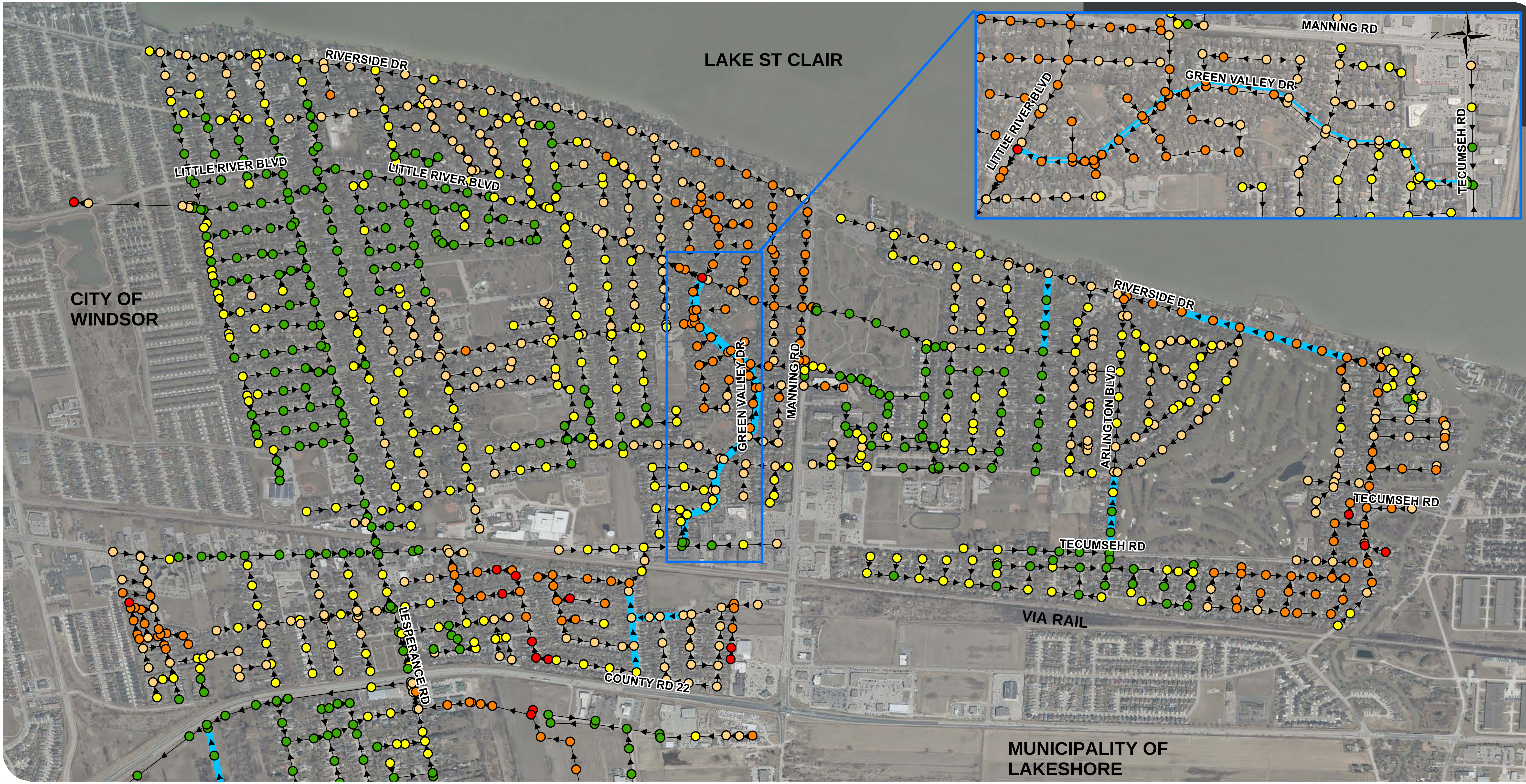
MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T3B: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND NO FDD

25 yr, 4 hr Design Storm Simulation

FIGURE 7.6

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

Sanitary Conduits With Proposed Improvements

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

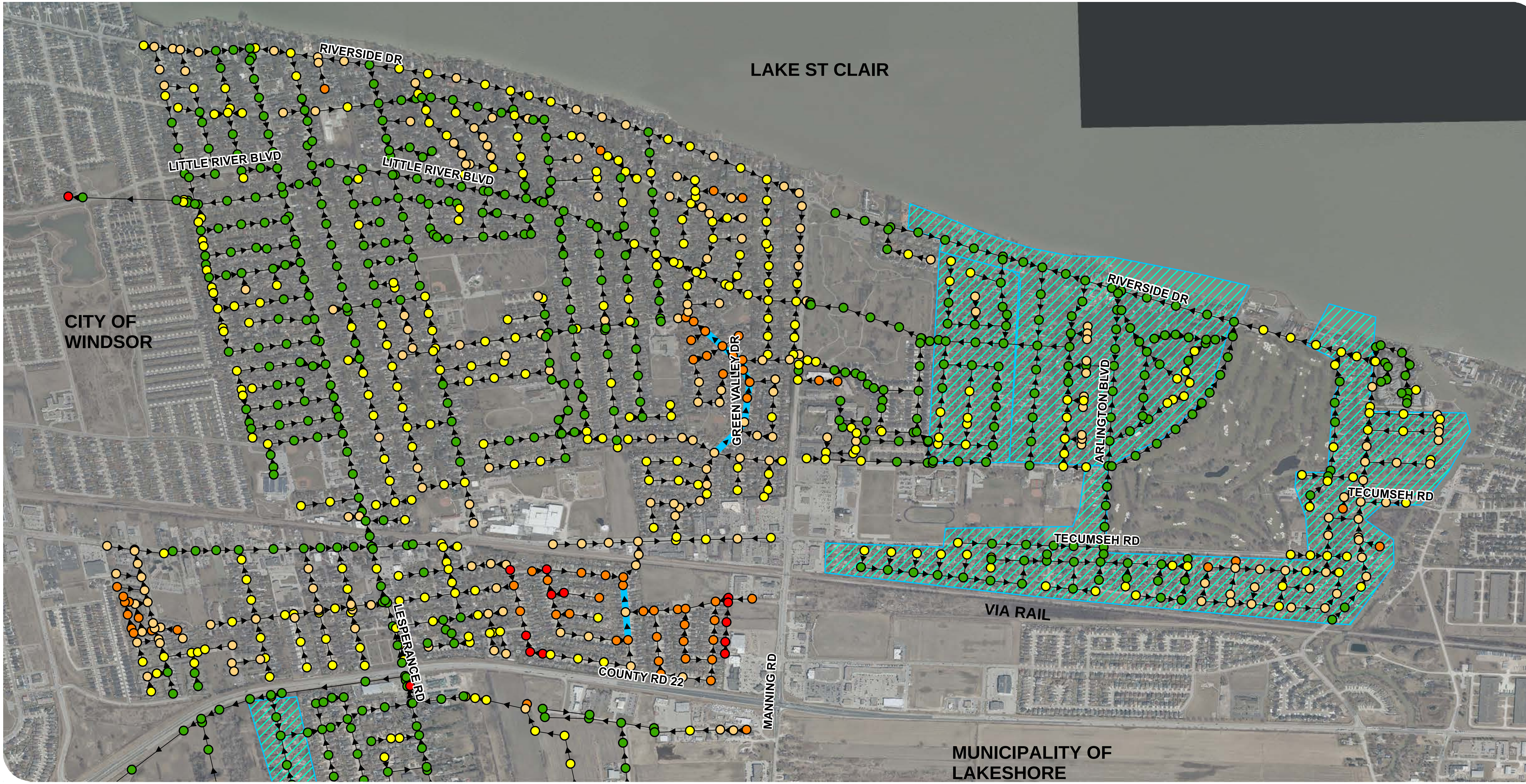
SCALE 1:17,000

0 0.5 1 2 km

N W E S

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T4: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND TARGETED FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.7

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

- Sanitary Conduits
- Sanitary Conduits With Proposed Improvements
- Targeted FDD Areas

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:17,000

0 0.5 1 2 km

N E S W

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T4B: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND TARGETED FDD

25 yr, 4 hr Design Storm Simulation

FIGURE 7.8

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Conduits

Sanitary Conduits With Proposed Improvements

Targeted FDD Areas

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

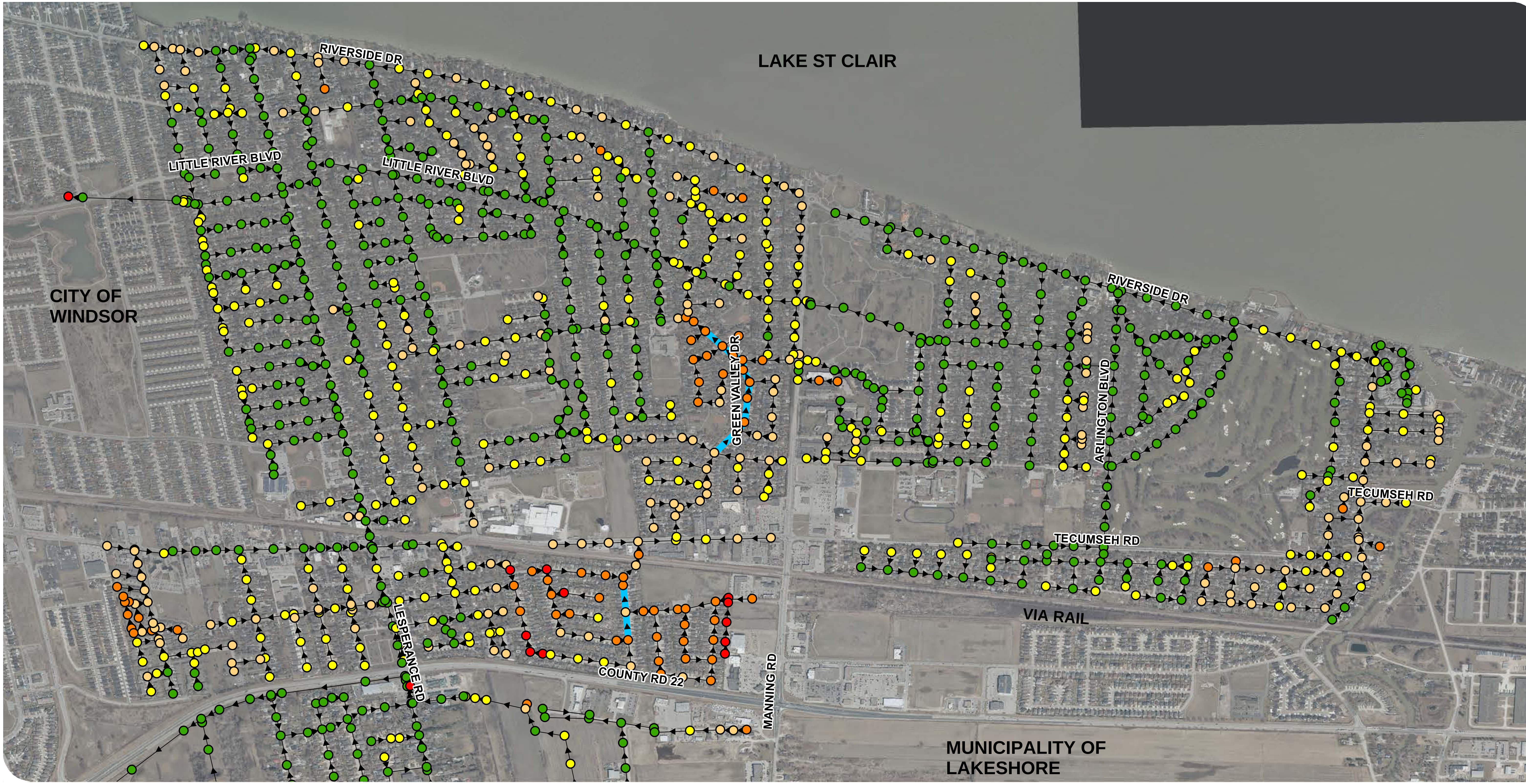
SCALE 1:17,000

0 0.5 1 2 km

N E S W

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

- Sanitary Conduits
- Sanitary Conduits With Proposed Improvements

Note: Area Wide FDD (RDII Reduction) Was Considered For All Homes Constructed Before 1980

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T5:ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND AREA WIDE FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.9

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

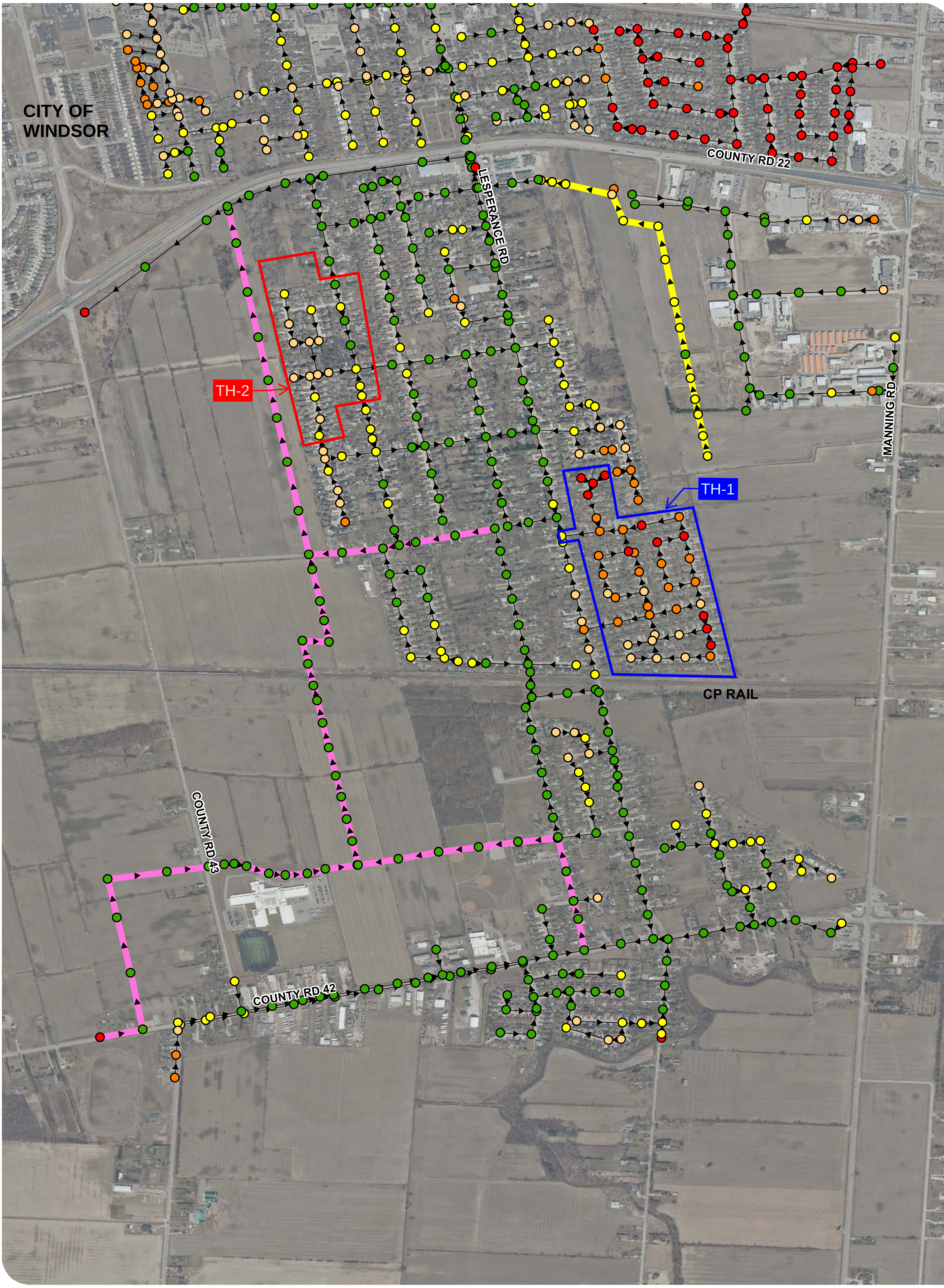
SCALE 1:17,000

0 0.5 1 2 km

N E S W

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH2: INTERIM CONDITIONS

5 yr, 24 hr Design Storm Simulation

FIGURE 7.10

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Sewers

Hamlet Trunk Sewers

MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

N W E S

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FILE LOCATION: \\DILLON.CA\

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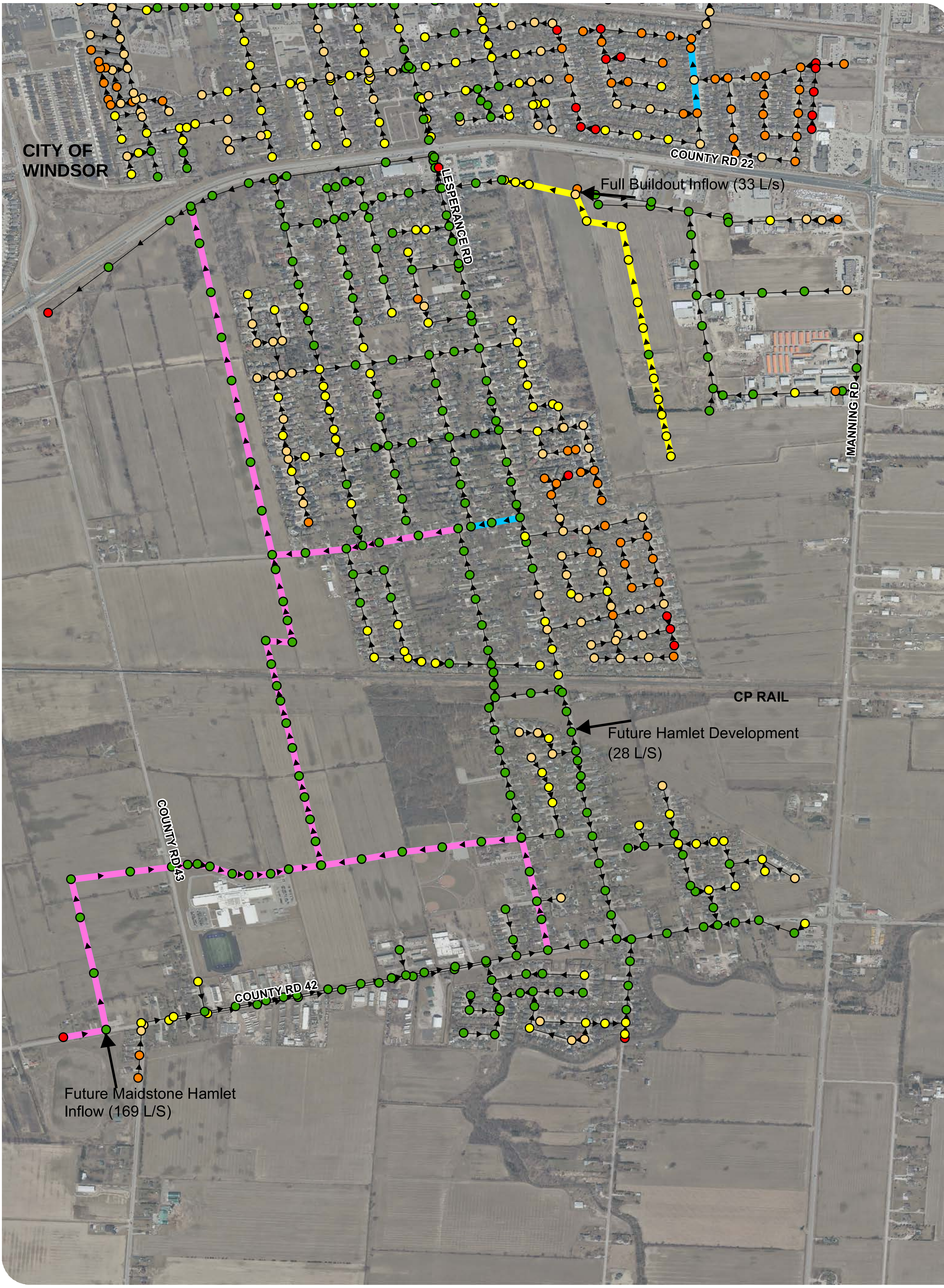

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH3: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND NO FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.11

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

- Sanitary Sewers
- Sanitary Conduits with Proposed Improvements
- Hamlet Trunk Sewers
- MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

DILLON CONSULTING

FILE LOCATION: \\DILLON.CA\

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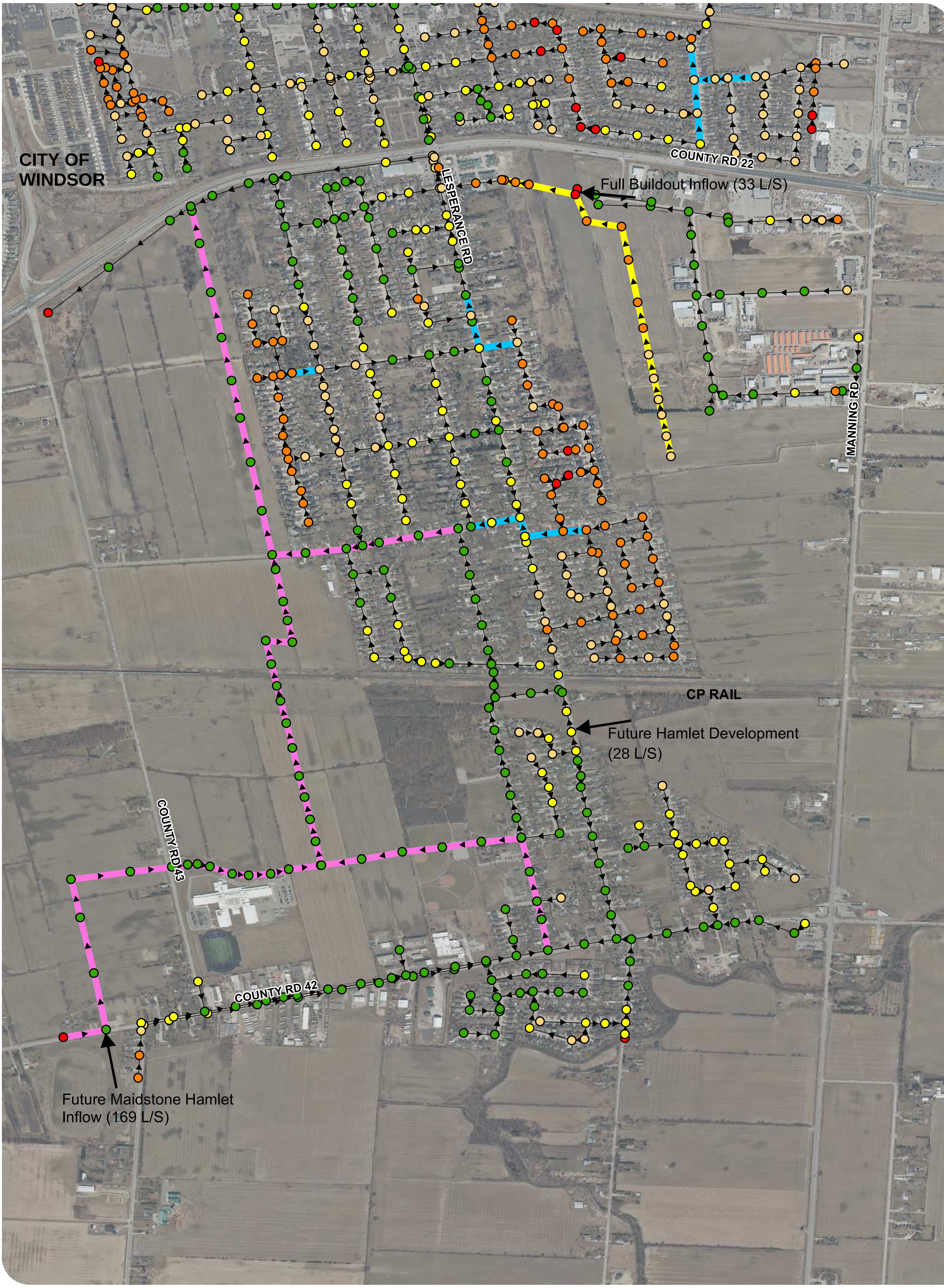

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH3B: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND NO FDD

25 yr, 4 hr Design Storm Simulation

FIGURE 7.12

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Sewers

Sanitary Conduits with Proposed Improvements

Hamlet Trunk Sewers

MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

N E S W

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FILE LOCATION: \\DILLON.CA\

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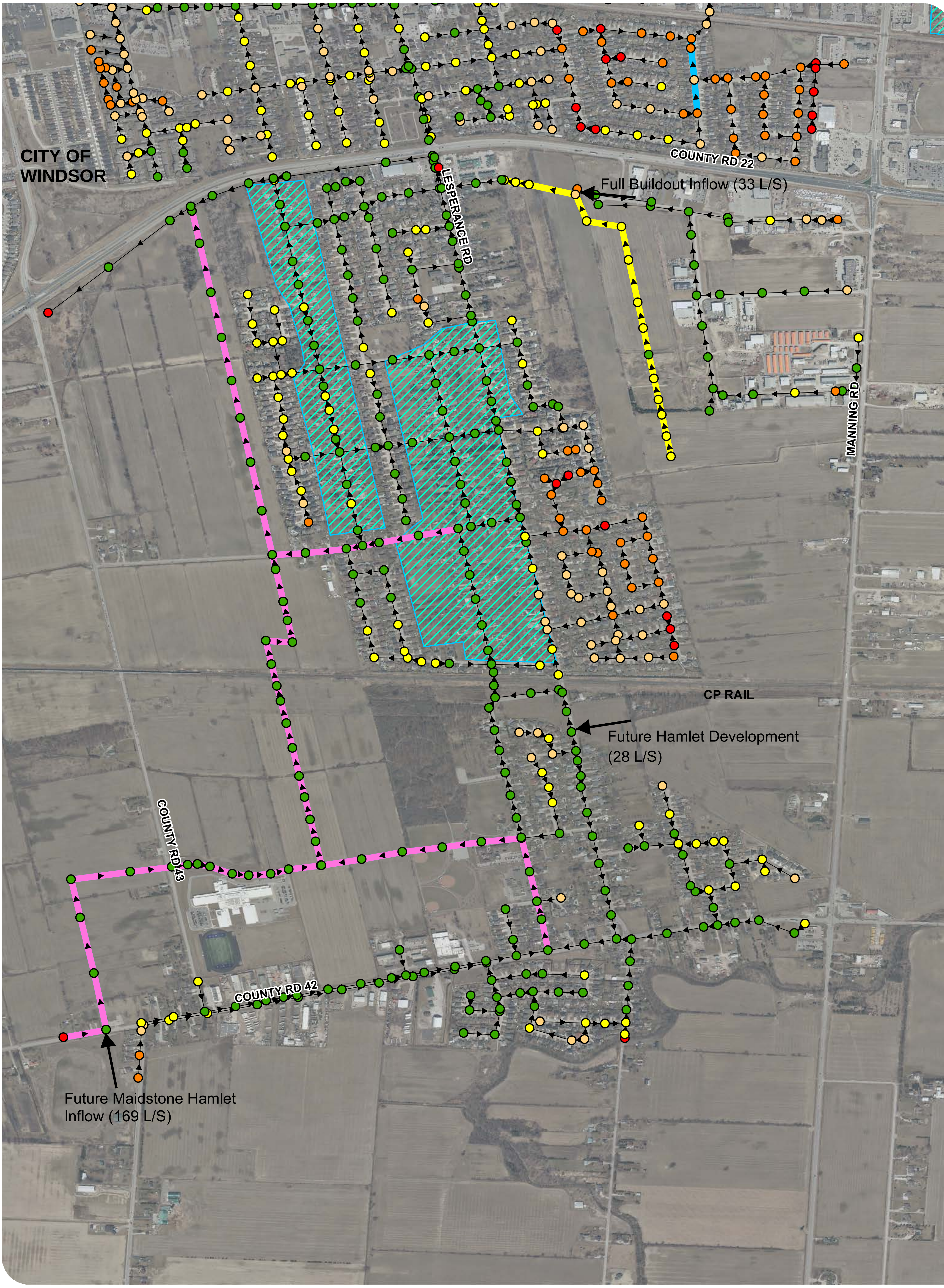

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH4: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND TARGETED FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.13

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

- Sanitary Sewers
- Targeted FDD Areas
- Sanitary Conduits with Proposed Improvements
- Hamlet Trunk Sewers
- MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

FILE LOCATION: \\DILLON.CA\

SCALE 1:14,000

0 0.5 1 km

N E S W

DILLON CONSULTING

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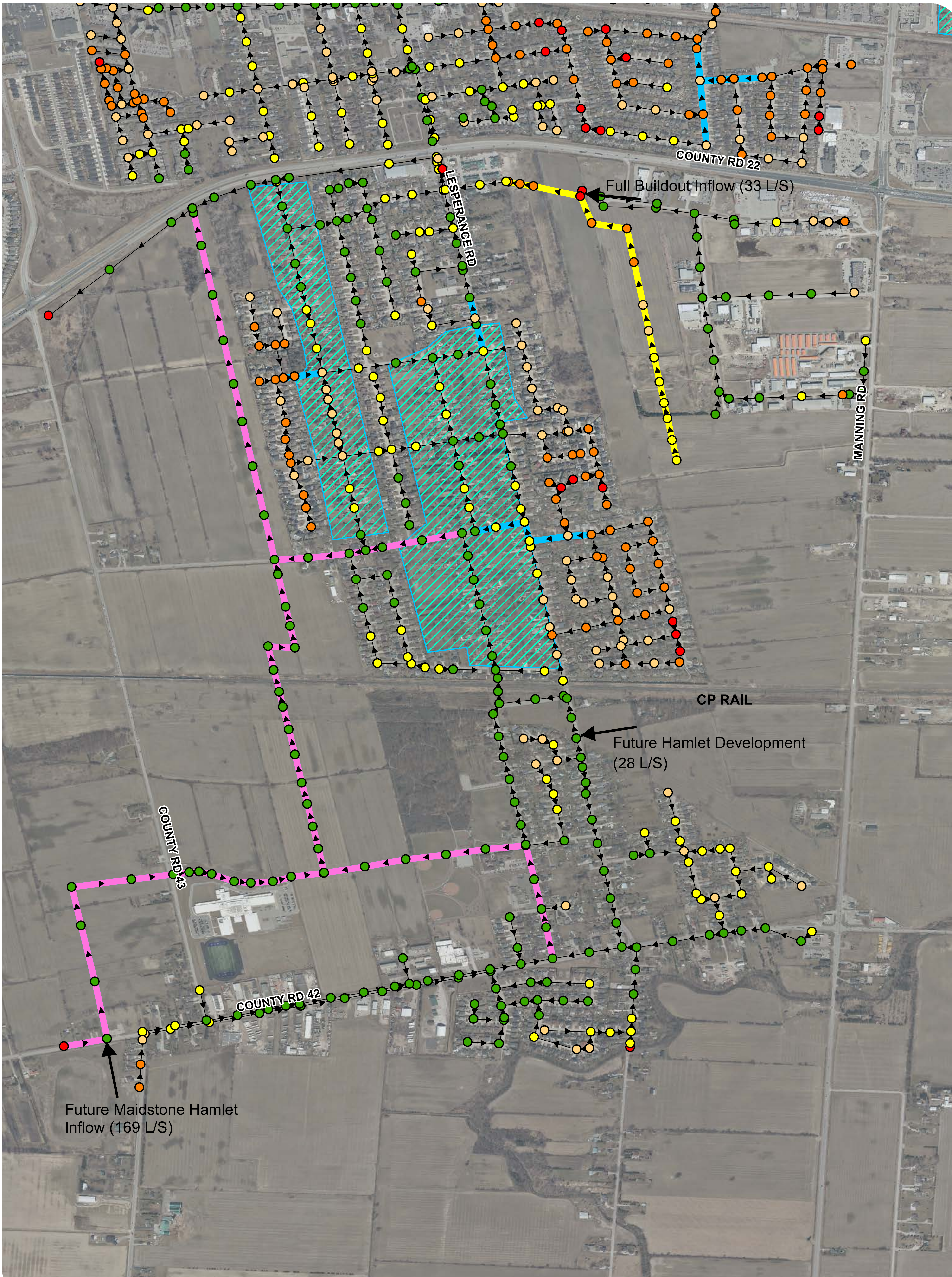

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH4B: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND TARGETED FDD

25 yr, 4 hr Design Storm Simulation

FIGURE 7.14

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

- Sanitary Sewers
- Targeted FDD Areas
- Sanitary Conduits with Proposed Improvements
- Hamlet Trunk Sewers
- MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
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MAP PROJECTION: NAD 1983 UTM Zone 17N

FILE LOCATION: \\DILLON.CA\

SCALE 1:14,000

0 0.5 1 km

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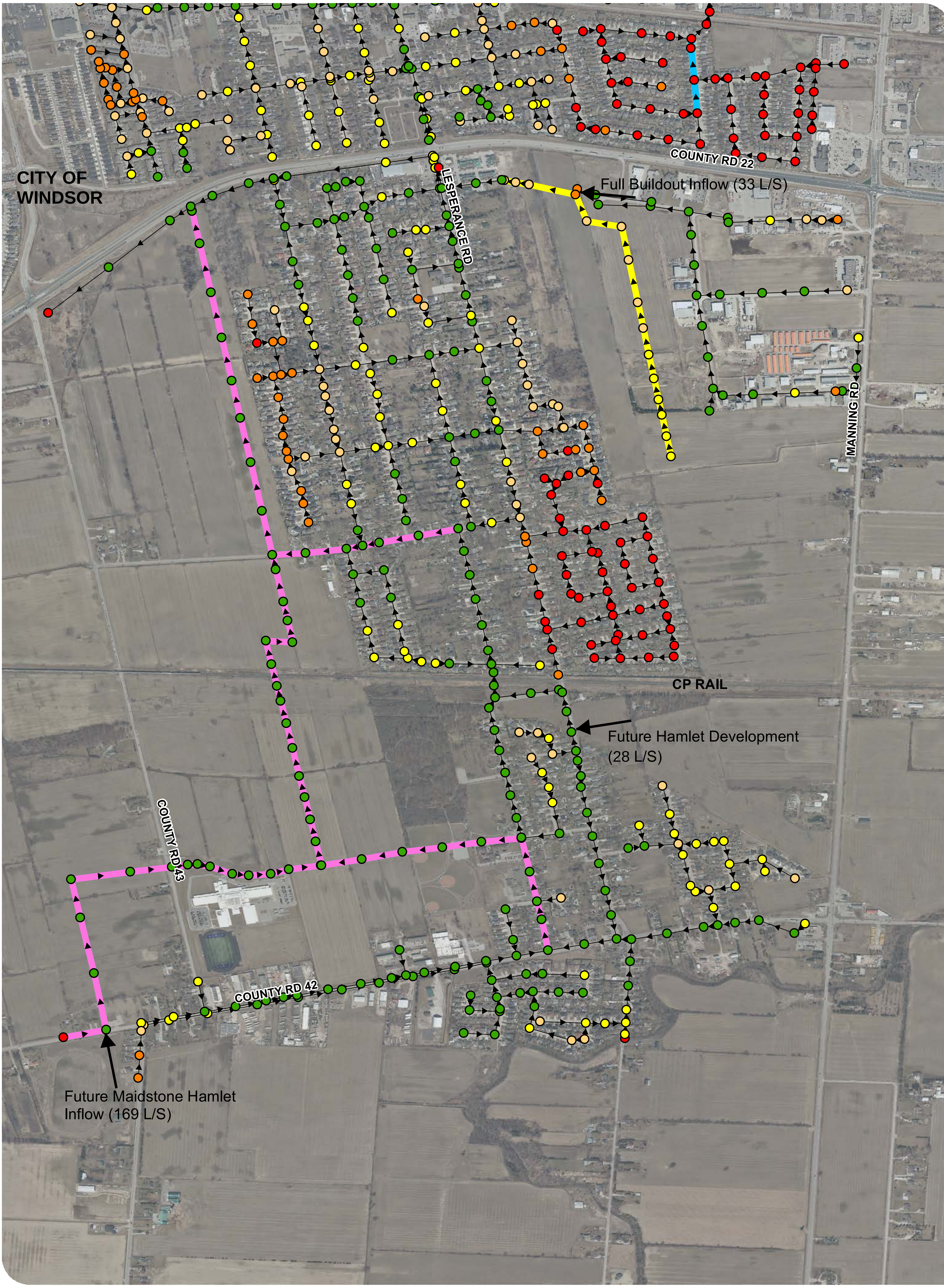

CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO TH5: ULTIMATE CONDITIONS - SEWER IMPROVEMENTS AND AREA WIDE FDD

5 yr, 24 hr Design Storm Simulation

FIGURE 7.15

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Sewers

Sanitary Conduits with Proposed Improvements

Hamlet Trunk Sewers

MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

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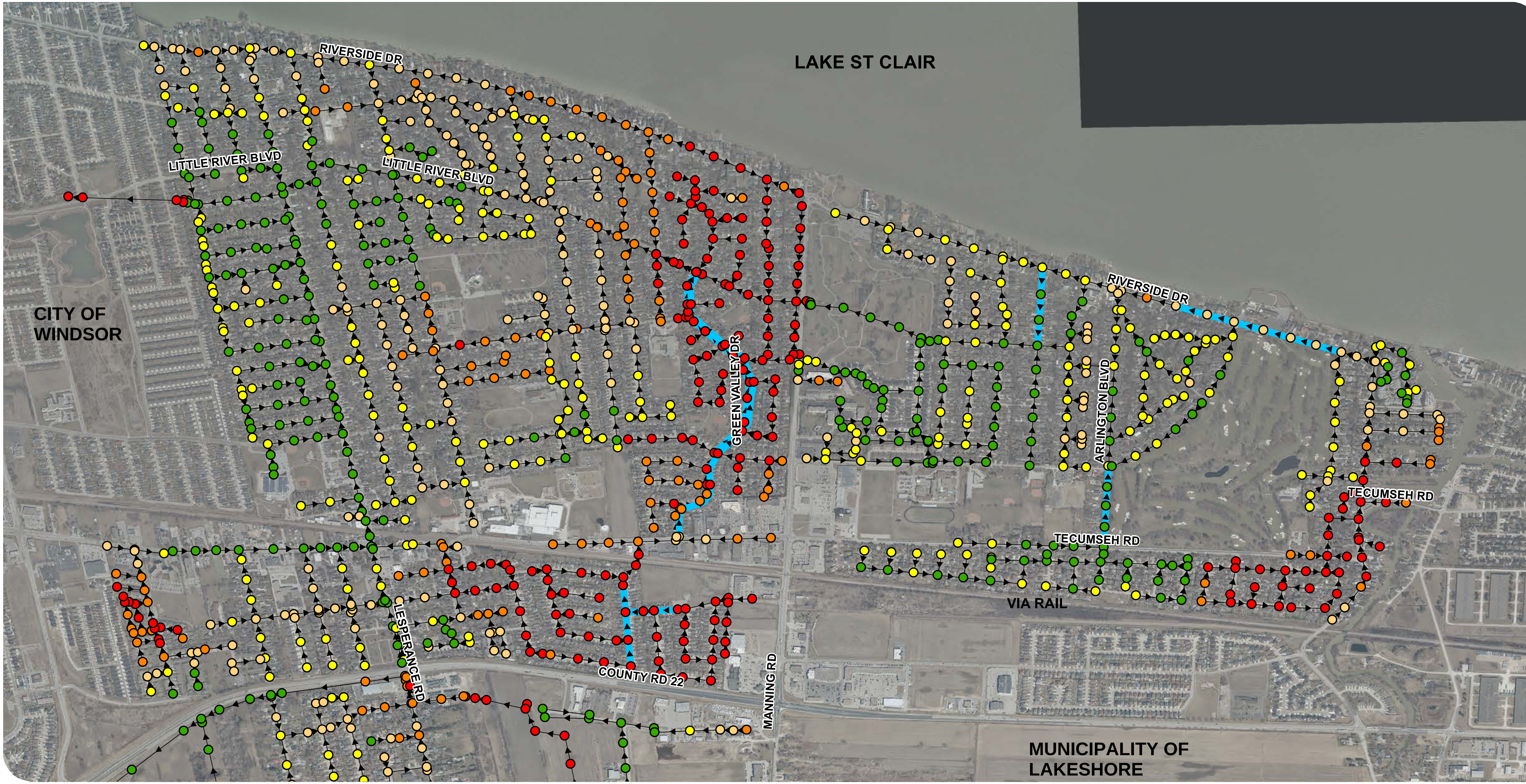


CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T3B + Area-wide FDD

100 yr, 4 hr Design Storm Simulation

FIGURE 7.16

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m
- Sanitary Conduits
- Sanitary Conduits With Proposed Improvements

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

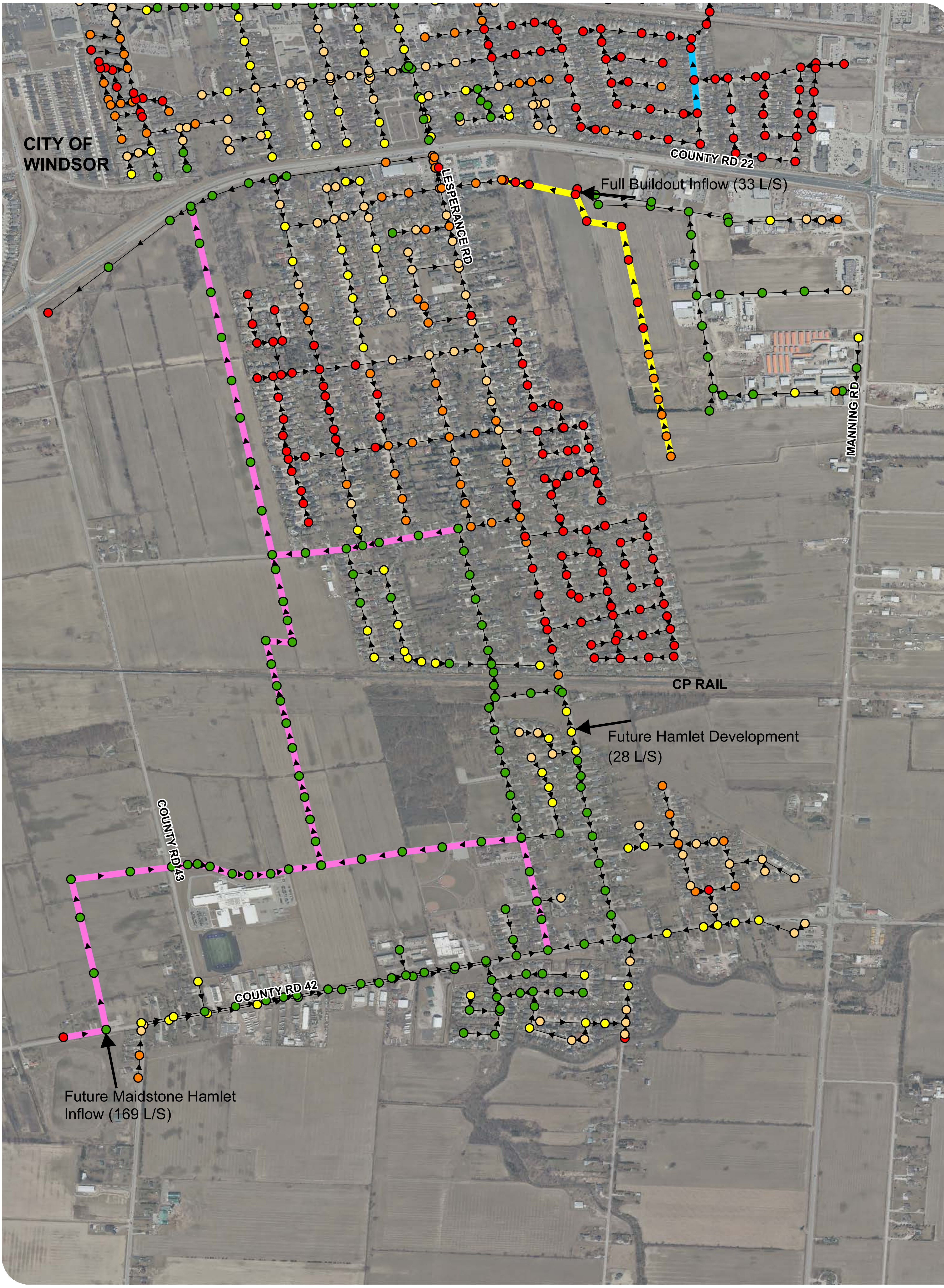
SCALE 1:17,000

0 0.5 1 2 km

N S E W

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10



CORPORATION OF THE TOWN OF TECUMSEH

SANITARY RE-CALIBRATION AND ANALYSIS

SCENARIO T3B + Area Wide FDD

100 yr, 4 hr Design Storm Simulation

FIGURE 7.17

Sanitary Sewer Maintenance Holes (Depth of Peak HGL below Existing Ground Elevations)

- > 3 m
- 2.5 - 3 m
- 2.0 - 2.5 m
- 1.5 - 2.0 m
- < 1.5 m

Sanitary Sewers

Sanitary Conduits with Proposed Improvements

Hamlet Trunk Sewers

MRSPA Sewers

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: SL
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

SCALE 1:14,000

0 0.5 1 km

DILLON CONSULTING

FILE LOCATION: \\DILLON.CA\

PROJECT: 19-9298 STATUS: FINAL DATE: 2024/01/10

Appendix A

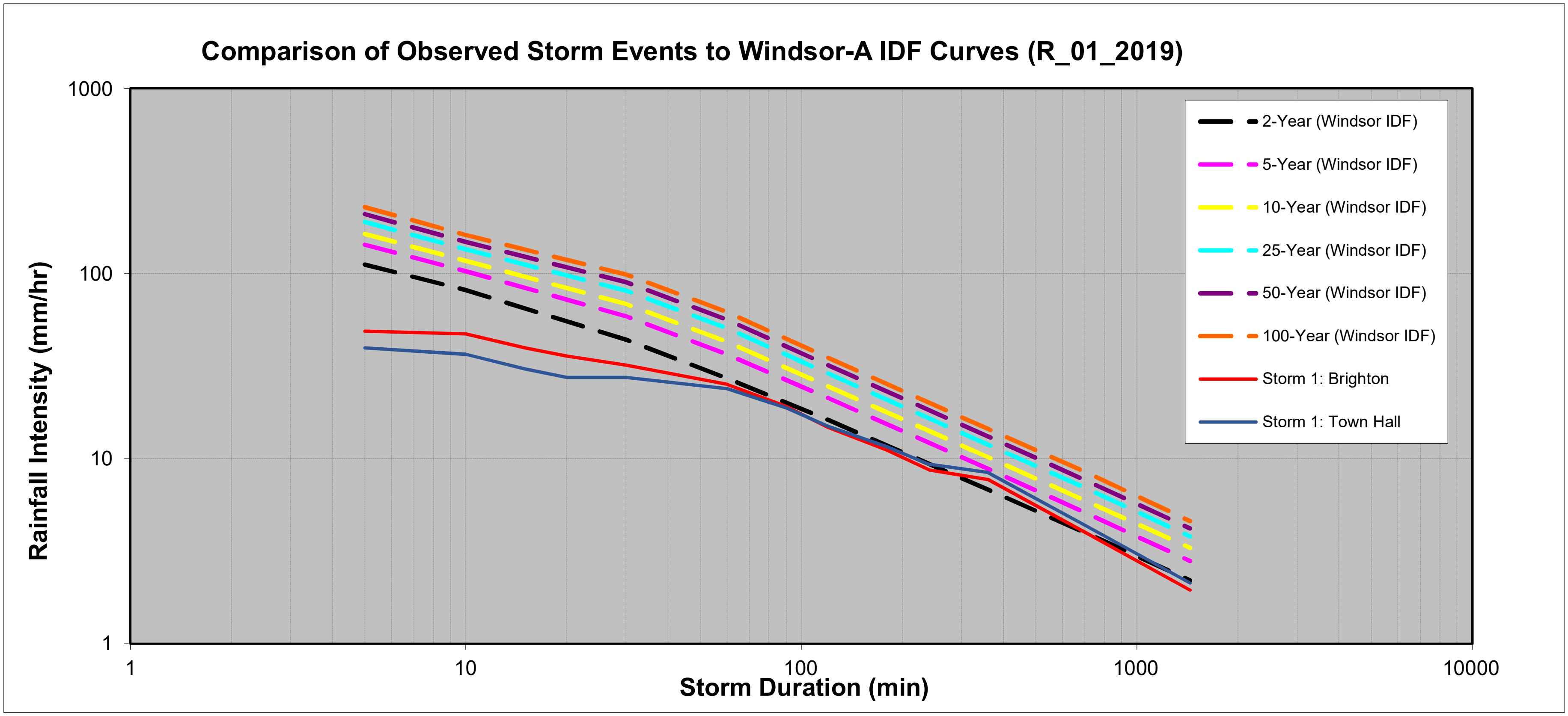
Rain Events and IDF Curves

Rainfall Data for Selected Storm Events (Total Rainfall Depth 10 mm or Greater)

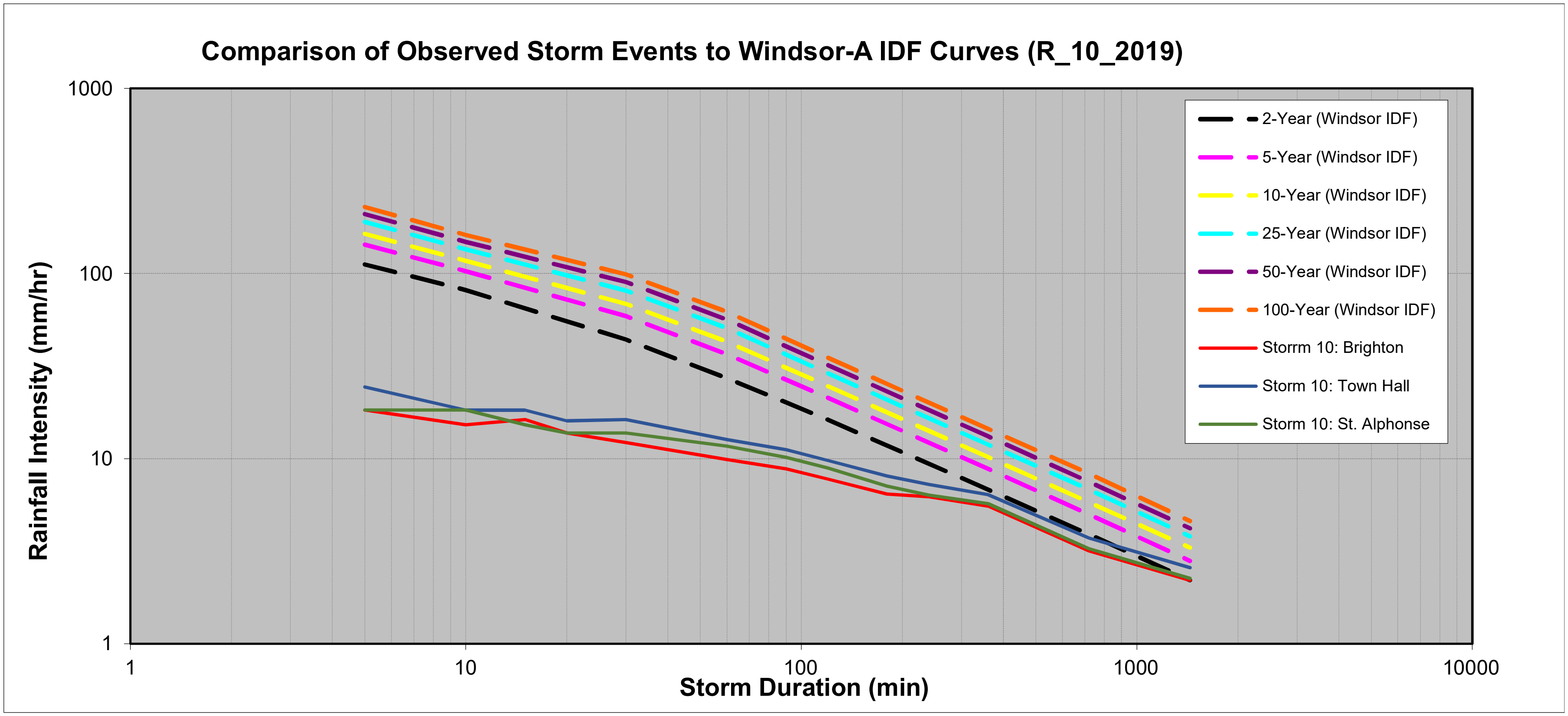
Brighton	Storm ID	Storm Start Time	Storm End Time	Total Rainfall Depth (mm)	Storm Duration (hr)	Average Intensity Over Total Duration (mm/hr)	Maximum Average Intensity (mm/hr)			Return Period
							10 min interval	30 min interval	60 min interval	
	R_01	Apr-30-2019 20:00	May-01-2019 6:00	46.7	6.6	7.1	47.2	32.0	25.1	< 5 year
	R_10	Jan-10-2020 0:00	Jan-12-2020 14:00	51.6	48.3	1.1	15.2	12.2	9.9	< 2 year
	R_03	Jun-26-2020 22:40	Jun-27-2020 3:40	41.1	4.9	8.4	51.8	30.5	24.4	2 year
	R_04	Jul-19-2020 12:30	Jul-19-2020 15:30	42.2	1.3	33.7	62.5	50.3	38.9	< 10 year

Town Hall	Storm ID	Storm Start Time	Storm End Time	Total Rainfall Depth (mm)	Storm Duration (hr)	Average Intensity Over Total Duration (mm/hr)	Maximum Average Intensity (mm/hr)			Return Period
							10 min interval	30 min interval	60 min interval	
	R_01	Apr-30-2019 20:00	May-01-2019 6:00	51.1	6.6	7.8	36.6	27.4	23.9	< 5 year
	R_10	Jan-10-2020 0:00	Jan-12-2020 14:00	60.2	47.5	1.3	18.3	16.3	12.7	< 5 year
	R_03	Jun-26-2020 22:40	Jun-27-2020 3:55	40.6	5.3	7.7	53.3	27.4	25.4	2 year
	R_04	Jul-19-2020 12:30	Jul-19-2020 15:30	44.7	2.3	19.9	85.3	54.9	40.4	< 10 year

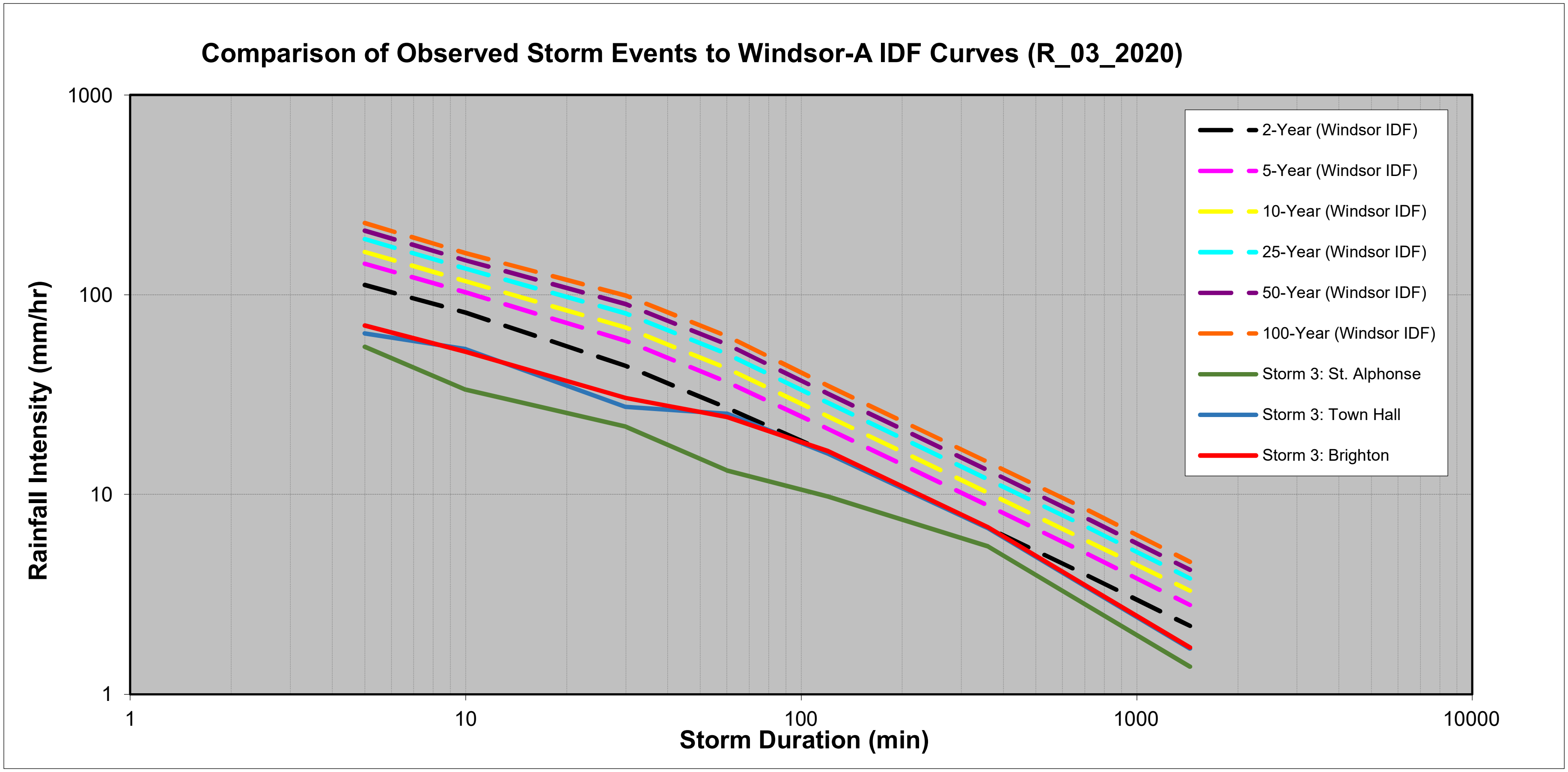
St. Alphonse	Storm ID	Storm Start Time	Storm End Time	Total Rainfall Depth (mm)	Storm Duration (hr)	Average Intensity Over Total Duration (mm/hr)	Maximum Average Intensity (mm/hr)			Return Period
							10 min interval	30 min interval	60 min interval	
	R_01	Apr-30-2019 20:00	May-01-2019 6:00							
	R_10	Jan-10-2020 0:00	Jan-12-2020 14:00	52.8	46.5	1.1	18.3	13.7	11.7	< 2 year
	R_03	Jun-26-2020 22:40	Jun-27-2020 4:30	33.0	5.5	6.0	33.5	21.8	13.2	< 2 year
	R_04	Jul-19-2020 12:30	Jul-19-2020 15:30	33.5	1.3	26.8	67.1	36.1	32.0	< 5 year



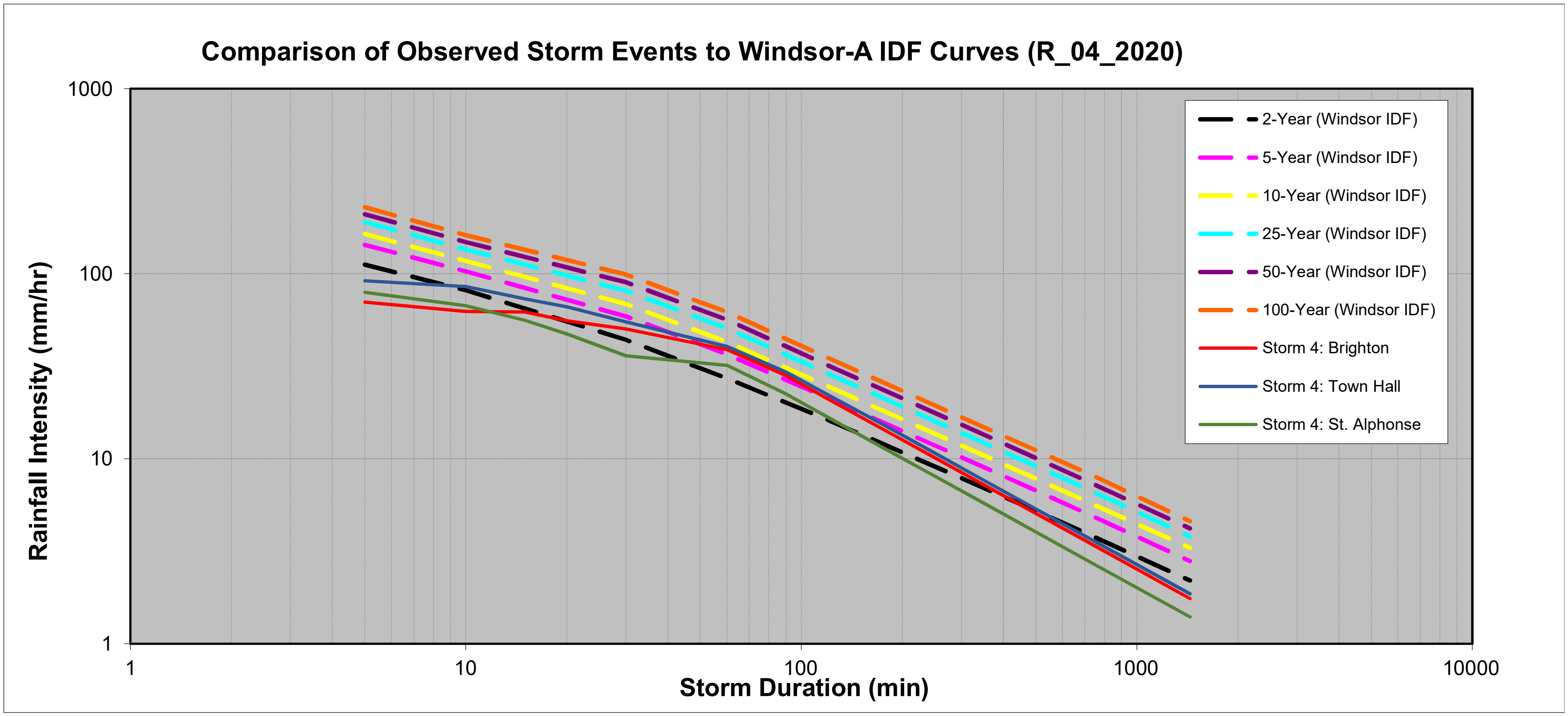
Comparison of Observed Storm Events to Windsor-A IDF Curves (R_01_2019)
Rainfall Intensity (mm/hr)
1000
100
10
1
1
10
100
1000
10000
Storm Duration (min)
2-Year (Windsor IDF)
5-Year (Windsor IDF)
10-Year (Windsor IDF)
25-Year (Windsor IDF)
50-Year (Windsor IDF)
100-Year (Windsor IDF)
Storm 1: Brighton
Storm 1: Town Hall



Comparison of Observed Storm Events to Windsor-A IDF Curves (R_10_2019)
Rainfall Intensity (mm/hr)
1000
100
10
1
1
10
100
1000
10000
Storm Duration (min)
2-Year (Windsor IDF)
5-Year (Windsor IDF)
10-Year (Windsor IDF)
25-Year (Windsor IDF)
50-Year (Windsor IDF)
100-Year (Windsor IDF)
Storrm 10: Brighton
Storm 10: Town Hall
Storm 10: St. Alphonse



Comparison of Observed Storm Events to Windsor-A IDF Curves (R_03_2020)
Rainfall Intensity (mm/hr)
1000
100
10
1
1
10
100
1000
10000
Storm Duration (min)
2-Year (Windsor IDF)
5-Year (Windsor IDF)
10-Year (Windsor IDF)
25-Year (Windsor IDF)
50-Year (Windsor IDF)
100-Year (Windsor IDF)
Storm 3: St. Alphonse
Storm 3: Town Hall
Storm 3: Brighton


Comparison of Observed Storm Events to Windsor-A IDF Curves (R_04_2020)
Rainfall Intensity (mm/hr)
1000
100
10
1
1
10
100
1000
10000
Storm Duration (min)
2-Year (Windsor IDF)
5-Year (Windsor IDF)
10-Year (Windsor IDF)
25-Year (Windsor IDF)
50-Year (Windsor IDF)
100-Year (Windsor IDF)
Storm 4: Brighton
Storm 4: Town Hall
Storm 4: St. Alphonse

Appendix B

CR42 Sanitary Sewer Analysis (April 2021)

TO:	Phil Bartnik, P.Eng, Director, Public Works & Environmental Services
CC:	John Henderson, P.Eng., Manager, Engineering Services Laura Herlehy, P.Eng.
FROM:	Chris Patten, P.Eng. Aakash Bagchi, P.Eng., M.Eng.
DATE:	January 6, 2021 (REVISION 1: April 21, 2021)
SUBJECT:	County Road 42 Sanitary Sewer Improvement Assessment
OUR FILE:	19-9298

The County of Essex (County) is undertaking the reconstruction of County Road 42 (CR42) from west of the 11th Concession (County Road 43) to east of Manning Road (County Road 19), generally located in the Town of Tecumseh (Town). As a result, the Town has requested Dillon Consulting Limited (Dillon) complete an assessment of the St. Alphonse Pump Station drainage area, to confirm the sanitary sewers along the CR42 corridor are sufficiently sized for current and future development conditions. This Pump Station (PS) is located at the northwest corner of the CR42/St. Alphonse intersection and has an approximate sanitary drainage area of 103 hectares.

In addition to this assessment, a new twin sanitary sewer on CR42 (parallel to the existing sanitary sewer) between Shiff Drive and 11th Concession has been incorporated into the ultimate conditions model. This twin sewer is required due to conflicts arising from a proposed large diameter storm sewer to be installed as part of the County of Essex's CR42/CR43 Road Reconstruction project. The proposed 250 mm diameter parallel sewer, south of the storm sewer, has been proposed by the County of Essex to provide sanitary sewer connections to the affected properties.

The purpose of this analysis is to determine if additional sanitary sewer system improvements are required to accommodate current and/or future development along CR42. Need for sanitary sewer improvements beyond those required to mitigate underground infrastructure conflicts will be identified. The improvements should be integrated into the CR42/CR43 Road reconstruction design to avoid the need to complete future sewer improvement within the newly constructed right-of-way.

Existing Conditions Analysis

Sanitary Sewer Model Background and Updated InfoWorks ICM Model

The original Town sanitary sewer model was developed as part of the Town of Tecumseh Inflow and Infiltration Control Study (CH2MHill, 2005), which identified three (3) main sanitary drainage areas within the Town; the Tecumseh Hamlet (TH) area located south of County Road 22, Tecumseh Town (TE) area located north of County Road 22 and west of Manning Road, and St. Clair Beach (SB) area located east of Manning Road.

The Tecumseh Town and St. Clair Beach areas were updated and calibrated by Dillon following a storm event on June 5-6, 2010 that resulted in widespread basement flooding. A hydrologic model (XPSWMM) was developed and calibrated in 2011 to simulate Rainfall Derived Inflow and Infiltration (RDII) for Wet

Weather Flow (WWF) in the sanitary sewer system. The model was calibrated by using three parameters for RDII estimate as follows:

- R: the fraction of rainfall volume that enters the sewer system;
- T: the time from the onset of rainfall to the peak of the hydrograph; and
- K: the ratio of time to recession to the time to peak.

In 2019, Dillon began converting the original sanitary system model from XPSWMM to Infoworks ICM to better represent the sources of RDII throughout the system and re-calibrate both the Dry Weather Flow (DWF) and Wet Weather Flow (WWF) components based on 2019 flow monitoring data. This model update took sewer RDII improvements completed by the Town since the original 2011 study into consideration. Improvements included sewer lining, manhole repair and private drain connection repairs throughout the Town. The process of calibrating the model for WWFs is currently in its final stages based on measured flows from a total of 12 flow monitoring stations (six in Tecumseh Town, four in St. Clair Beach and two in the Tecumseh Hamlet area).

The Infoworks ICM model for the Town's sanitary system uses detailed physical parameters (i.e. percentage of drainage area, surface roughness, flow length, etc.) to determine the anticipated volume and timing of RDII entering the sanitary sewer system. Each component of sanitary flow is represented in different ways in the Infoworks ICM model. This includes the following:

Dry Weather Flow (DWF) Components

- Groundwater infiltration (i.e. base flow) is represented using a constant inflow through each sanitary sewer conduit in the model and varies between different catchment areas depending on the DWF observed at each flow monitoring location;
- Domestic wastewater flow is represented with populations sourced from MPAC information provided by the Town in April 2019, within each represented catchment area. Catchment areas upstream of each flow monitor location were assigned daily per capita flow rates and a diurnal flow pattern (typical daily fluctuations) based on observed flow during dry weather periods; and
- DWF calibration was achieved by updating the per capita flow rates for each flow monitor catchment area.

Wet Weather Flow (WWF) Components

- Components are represented by two layers of catchment areas; direct inflow to represent fast-response RDII and infiltration to represent slow-response RDII; and
- Catchment parameters were adjusted to simulate the observed response, either fast or slow through the system based on the flow monitoring data collected. The volume of RDII in each component was simulated by assigning a percentage of the total catchment area as contributing runoff to the sanitary system.

The updated Town Sanitary System InfoWorks ICM model takes into consideration all identified improvements completed up to April 2019, through the Town's annual program to address extraneous flows in the sanitary sewer system. Since the flow data being used to calibrate the model is sourced from the flow monitoring completed during 2019, any reduction in extraneous flow due to the RDII reduction measures completed before April 2019 are automatically considered while calibrating the model to the observed flow data.

Calibration for St. Alphonse Pump Station Drainage Area

Initial calibration of the Infoworks-ICM model for the Tecumseh Hamlet area was completed using observed flow data from gauges located at TH078 (St. Anne Street, north of Intersection Road intersection) and TH113 (Lesperance Road, north of Lessard Street).

Additional flow monitoring along CR42 was completed (May 2020 to July 2020) in order to distinguish flows from the CR42 drainage area. The model was then calibrated using information from gauges located at TH010 (CR42, west of Odessa Drive intersection) and TH023 (CR42, west of Lesperance Road intersection). The sanitary drainage area upstream of TH010 includes mostly non-residential development from the section of CR42, west of St. Alphonse Avenue and the sanitary drainage area upstream of TH023 includes both residential and non-residential areas to the east of St. Alphonse Avenue. Further discussion on this calibration will be provided in the report for the Sanitary Re-calibration and Analysis Study (Dillon, Ongoing).

Existing Conditions for County Road 42

At present, a 200 mm to 250 mm diameter sanitary gravity sewer serves the area from 11th Concession to St. Alphonse Avenue (west to east) on CR42. Additionally, a 200 mm to 250 mm diameter sanitary sewer drains from Manning Road to St. Alphonse Avenue (east to west) on CR42. Both east and west sewers on CR42 drain to the St. Alphonse Pump Station (PS), located at the northwest corner of the CR42 and St. Alphonse Avenue intersection.

The St. Alphonse PS is a lift station that provides an outlet to the downstream Tecumseh Hamlet sanitary system. The flows into the downstream (St. Alphonse Ave.) sanitary sewer are restricted to the current capacity of the St. Alphonse PS. An emergency overflow sewer at the St. Alphonse PS location provides by-pass capacity at the PS in case of high HGLs upstream of the PS. In addition, there is a 200 mm dia. overflow outfall at the upstream end of the sanitary sewer (TH025), on 12th Concession Road. Under high HGL conditions in the sanitary sewers upstream of the St. Alphonse PS, sanitary sewage can overflow into Pike Creek. Based on as-built information, this overflow is equipped with a flap gate to mitigate stormwater flows within the Pike Creek from entering the Town’s sanitary sewer system.

Existing Conditions Analysis Results

Model simulation results indicate that the sanitary sewers along CR42 do not experience surcharging during DWF conditions. The maximum flow entering the St. Alphonse PS is 10.4 L/s during the DWF simulation, while the capacity of the PS is 67.2 L/s. The PS is functioning at 15.5% of its capacity during DWF conditions.

The existing conditions Infoworks ICM sanitary sewer model WWF simulation resulting from a 1:5 year, 24 hour design storm event are illustrated in Figure 1. The figure highlights the current development areas tributary to the CR42 sewer with each sanitary manhole node colour-coded to indicate the degree of surcharging in the existing sanitary sewer system, as described in the legend.

The existing and proposed conditions analysis discussed in this document have been evaluated using the 1:5 year, 24 hour design storm event to remain consistent with other similar types of analysis completed for the Town in the past. Currently, a 1:5 year, 24 hour level of service is used for sanitary sewer system design and analysis within the Town of Tecumseh. The 1:25 year, 4 hour design storm event simulation was used as a stress test, to test the resiliency of the system under more intense rain events.

For the purposes of this assessment, the Hydraulic Grade Line (HGL) elevation in the sanitary sewer system is used to indicate the estimated level of basement flood risk for the adjacent private property areas. Where HGL depths are above 1.5 m below existing ground, those areas are considered to be at risk of basement flooding during the specified wet weather storm event. Such nodes are highlighted red in Figure 1. The depth of 1.5 m below ground is used to generally represent average residential basement floor depths.

Nodes, where the HGL depths are between 1.5 m and 3.0 m below ground are highlighted yellow. The risk of basement flooding under the 1:5 year event, is lower at these locations. The nodes where the depth of maximum HGL is deeper than 3.0 m, are highlighted green in the Figure. This is to denote the lower risk of basement flooding in these areas. It should be noted that basement flood risk is being assessed as it relates to the Town's mainline sanitary sewer conditions only and does not reflect individual property conditions that may contribute to basement flooding risks, such as foundation cracks, sump pump malfunctions, foundation drain issues and lot grading.

As shown in Figure 1, under existing WWF conditions the sanitary sewer system along CR42 does not experience high water levels (surcharging above 1.5 m).

The HGL is consistently deeper than 1.5 m from the ground surface under design WWF conditions. The highest elevation (peak) HGL is 180.97 m at the upstream (western) end of CR42, approximately 2.7 m below the ground surface. The maximum HGL at the intersection of CR42 and St. Alphonse Avenue is 177.705 m, which is approximately 5.2 m below the ground surface. The existing HGLs in the CR42 sanitary sewers are represented in Table 1.

The overflow by-pass sewers at the St. Alphonse PS and at the Pike Creek overflow is not observed to be utilised during the existing conditions simulations. Also, the HGLs in the sanitary sewers upstream are not high enough to overflow into the emergency by-pass sewer.

Proposed Conditions Analysis

DWF Parameters

The future development areas total approximately 4.93 ha (as shown in Figure 1) along the CR42 corridor, per the Town of Tecumseh's 'Schedule A-1 Official Plan' which includes low density residential, general commercial and neighbourhood commercial development. To determine the estimate DWF from future development, the following criteria were used for population densities within the model:

- 2.8 persons/Residential lot (Town of Tecumseh standard density based on existing property boundaries, existing number of units, and as-built sanitary drainage area information);
- 93.3 persons/ha of floor area for Commercial/Industrial lands (Based on 2008 MECP Commercial sewage flows (Sec.5.5.2.2));
    - To get a realistic estimate of flows, 30% of the total lot area was assumed to be floor area; and
- 2,150 Tecumseh Vista School Population (as communicated by the Town).

The Town of Tecumseh, Water and Wastewater Master Plan Update (CIMA, 2019) (2019 WWMP) recommends a per capita flow rate of 300 L/capita/day for new development. This was used as the per capita flow for the future development areas.

WWF Parameters

The 2019 WWMP recommends an infiltration allowance of 16,415 L/ha/day for new development. The CSA W204:19 - Flood Resilient Design of New Residential Communities document recommends a peak flow of 0.30 L/ha/s for new development for the 1:5 year design storm event. The Town has chosen the 1:5 year, 24 hour design storm event, using Chicago distribution, as the level of service for design of sanitary conveyance infrastructure.

Updates to the sanitary sewer model, in Infoworks ICM, were made to reflect the increased flow generated from the planned development areas. A physical parameter-based approach was used in the Infoworks model to simulate RDII in the sanitary system. These parameters were calibrated to match the observed flows from the sanitary drainage areas as part of the model calibration process. For the current assessment, the parameters of subcatchments representing RDII during wet weather events were updated to reflect the increased development within the drainage area during proposed conditions.

The Town's sanitary sewer collection system experiences inflow and infiltration during wet weather conditions, which results in sewer surcharge. The addition of developable areas along CR42 will result in increased sewage generation and increased extraneous flows. In order to mitigate impacts of sewer surcharge under existing conditions and to accommodate future development, it is recommended that the Town implement infrastructure improvements by increasing the size of the proposed twin sanitary sewer along CR42 and the increasing the size of the sanitary sewer between TH013 and TH015. Two future development scenarios have been evaluated (discussed in the below sections) with varying degrees of improvements made to the sanitary system. The existing conditions scenario was modeled with the currently installed sanitary sewer infrastructure. The proposed conditions contain two development scenarios, interim and ultimate. All three WWF scenarios (existing/interim/ultimate) were simulated using a 1:5 year, 24 hour design storm.

Interim Conditions

Under Interim conditions, the St. Alphonse PS will remain in operation and planned development along CR42 (as shown in Figure 2) can proceed. As with the existing conditions, under interim conditions the St. Alphonse PS controls the outflow of this system. To mitigate the impacts of an increase in flow due to the planned new development(s), additional storage capacity within the sanitary sewer system is proposed.

These improvements include over-sizing sections of the proposed twin sanitary sewer from 250 mm dia. to 300 mm and 375 mm dia., and over-sizing the existing sewer from TH013 (Shiff Drive) to TH015 (St. Alphonse Avenue) from 250 mm dia. to 375 mm dia. Three 250 mm dia. interconnections between the existing sanitary sewer on CR42 and the proposed twin sewer are proposed, to permit sewage overflow from the existing sewer to the larger twin sanitary sewer during high HGL conditions. These interconnections are approximately equidistant from each other along the length of the twin sanitary sewer. The interconnecting sewers will be installed at higher elevations than the sanitary sewer mainline to avoid conflicts with the proposed storm sewers. All other existing sanitary sewers on CR42 will be maintained at their current sizes.

As noted above, the new parallel sanitary sewer, required to provide sanitary sewer connections to the properties located immediately south of CR42, due to conflicts arising from a proposed large diameter storm sewer. The extent or length of the proposed twin sanitary sewer is unchanged from the original design proposed by the County of Essex. The new over-sized parallel sanitary sewer will provide temporary surcharge storage of sanitary sewage to allow time for increase/stored flows to be pumped downstream by the St. Alphonse PS.

The interim condition analysis assumes the St. Alphonse Pump Station is still operational, at its current installed pump capacity.

Ultimate Conditions

Under Ultimate Conditions, the West Hamlet Trunk Sanitary Sewer, a 1200 mm diameter sanitary sewer from 11th Concession Rd to County Road 22 (CR22), is assumed to be fully built-out. This trunk sanitary sewer is proposed to drain future development areas in the western part of the Tecumseh Hamlet. The current drainage area of the St. Alphonse PS will form the upstream drainage area of this trunk sewer. Under ultimate conditions, the St. Alphonse PS is proposed to be decommissioned and the CR42 flows will gravity drain via a new 450 mm diameter trunk sewer on St Alphonse Avenue to the West Hamlet Trunk Sanitary Sewer. This 450 mm diameter sewer will flow north along St. Alphonse Avenue and west along Shields Avenue, before draining into the West Hamlet Trunk Sewer on Shields Avenue.

For the current CR42 analysis, for a conservative estimate of HGLs in the system, a fixed tailwater condition in the downstream end of the system was used. The tailwater elevation was assigned at the obvert of the 1200 mm diameter sewer on CR22 to account for flows from downstream developments in the City of Windsor.

Proposed Conditions Analysis Results

Dry-Weather Flows

Under interim conditions, the model identified a peak flow of 13.8 L/s in the sewer immediately upstream of the St. Alphonse PS, compared to a flow of 10.4 L/s in the same sewer during existing conditions. Under ultimate conditions, the model identified a flow of 13.5 L/s. A small reduction in flows is anticipated in the ultimate conditions simulation, due to attenuation happening upstream in the twin sewers along CR42.

Under interim conditions, approximately 22% of the capacity of the St. Alphonse PS is utilized during dry weather conditions, compared to 15.5% during existing conditions. Under Ultimate Conditions, the St.

Alphonse PS is proposed to be decommissioned and the sanitary sewers along St. Alphonse drain by gravity to the West Hamlet Trunk Sanitary sewer. The full flow capacity of the 450 mm diameter sanitary sewer along St. Alphonse Avenue is approximately 100 L/s. Under ultimate conditions, approximately 14% of the full flow capacity of the sewer is utilized.

Wet-Weather Flows

The Infoworks ICM model was utilized to assess the sanitary sewer system under WWF conditions to quantify the impact increasing sanitary flows from the planned developments along CR42 for the 1:5 year, 24 hour design storm event.

Interim Conditions

As represented in Table 1, infrastructure improvements along CR42 result in a reduction in sanitary sewer HGLs during interim conditions, in spite of increased dry and wet weather flow from planned development areas along CR42. Under this scenario, the risk of basement flooding is considered low.

Under interim conditions with the construction of additional sanitary sewers in the form of the twin sanitary sewer on CR42 proposed by the County of Essex and the upsizing proposed by the Town, no significant increase in the risk of basement flooding is expected. This provides opportunity for planned development along CR42 to proceed. New developments must not exceed minimum extraneous flow volume allowances, as recommended in the 2019 WWMP and peak flow allowances mentioned above. It is recommended that the Town require new developments to monitor and demonstrate that these allowances are not exceeded.

Figure 2 represents the risk of basement flooding in interim conditions during a WWF simulation.

Ultimate Conditions

Under Ultimate Conditions, HGLs are much lower when compared to the existing conditions at St. Alphonse Avenue (1.58 m reduction in HGL). In the western end of the CR42 sanitary sewer, a nominal reduction of up to 0.02 m is observed. A slight increase of up to approximately 0.01 m is observed in the eastern end of the sewer. Since the HGLs in this area are deep, this increase does not represent a significant increase in the risk of basement flooding in the area. The minimum depth of HGL below ground at this MH location (TH016) is 3.1 m. The HGLs and the difference compared to the existing conditions is represented in Table 1.

Figure 3 shows the relative depths of HGL at manholes in the study area. Compared to the HGL results shown in Figure 1, installing the proposed West Hamlet trunk sanitary sewer and connecting it to the St. Alphonse sanitary sewer, a general reduction of the HGLs and associated risk of basement flooding in the area is expected. These results assume that the HGL at the outlet of the West Hamlet trunk sewer at the intersection of Banwell Avenue and CR22 does not surcharge beyond the obvert of the pipe. This assumes that the downstream sanitary sewer, within the City of Windsor will not surcharge beyond the obvert of the outlet sewer. Also assumed is that new development within the Tecumseh Hamlet will meet maximum extraneous flow allowances noted above.

1:25 Year Simulation

The Interim and Ultimate condition scenarios were also simulated using the 1:25 Year, 4 Hour design storm event (Chicago distribution). This was considered a 'stress-test' of the sanitary infrastructure. To test the resilience of the infrastructure under more intense rain events than the 1:5 Year, 24 Hour event. The 1:25 year, 4 hour event was used since this design storm event is provided as a standard 1:25 year return period event in the Windsor-Essex Regional SWM guidelines published by Essex Region Conservation Authority (ERCA).

It was observed from the Interim conditions model results, that maximum HGLs in the sanitary sewer on CR42 are at a minimum depth of 2.0 m from the proposed ground elevations. While the minimum depth of HGL during the Ultimate conditions was observed to be 2.4 m.

While the HGLs during this simulation are higher than the 1:5 Year simulations which is expected for a larger design storm event, it is not expected to increase the risk of basement flooding as the depth of HGL below ground is generally lower than the assumed basement floor elevation of 1.5 m.

TABLE 1: COMPARISON OF HGLS IN SANITARY SEWERS ON CR42

Scenario	Return Period	Node (Town MH Number)	TH001	TH002	TH003	TH005	TH006	TH342	TH007	TH008	TH009	TH010	TH265	TH011	TH012	TH013	TH014	TH015 (at St. Alphonse Ave.)	TH024	TH023	TH022	TH021	TH020	TH281	TH019	TH018	TH017	TH016
		Existing Ground Elevation (m)	183.627	183.596	183.505	183.352	183.322	183.410	183.322	183.322	183.352	183.231	182.804	183.182	183.017	183.048	182.850	182.926	183.109	183.017	182.987	182.987	183.109	183.000	183.200	183.109	182.865	182.865
Baseline (DWF)	N/A	HGL (m)	180.940	180.574	180.152	179.891	179.636	179.514	179.405	179.147	178.897	178.527	178.43	178.367	178.102	177.863	177.577	176.493	176.999	177.262	177.374	178.357	178.657	178.718	178.892	179.091	179.518	179.884
		HGL Depth (m)	2.7	3.0	3.4	3.5	3.7	3.9	3.9	4.2	4.5	4.7	4.4	4.8	4.9	5.2	5.3	6.4	6.1	5.8	5.6	4.6	4.5	4.3	4.3	4.0	3.3	3.0
Baseline (WWF)	1:5 Year	HGL (m)	180.985	180.63	180.219	179.954	179.708	179.589	179.481	179.224	178.974	178.775	178.751	178.713	178.669	178.635	178.514	178.384	179.025	179.615	179.653	179.712	179.772	179.791	179.795	179.8	179.816	179.893
		HGL Depth (m)	2.6	3.0	3.3	3.4	3.6	3.8	3.8	4.1	4.4	4.5	4.1	4.5	4.3	4.4	4.3	4.5	4.1	3.4	3.3	3.3	3.3	3.2	3.4	3.3	3.0	3.0
		Proposed Ground Elevation (m)	183.396	183.400	183.273	182.831	183.138	183.030	183.173	183.160	183.067	182.973	182.989	182.809	182.747	182.804	182.827	182.936	182.972	182.695	182.854	182.532	182.591	182.722	182.540	182.416	182.426	183.030
Interim Conditions (DWF)	N/A	HGL (m)	180.925	180.559	180.138	179.878	179.622	179.506	179.397	179.139	178.889	178.52	178.42	178.359	178.094	177.85	177.566	176.723	177.006	177.269	177.38	178.363	178.663	178.727	178.899	179.099	179.527	179.892
		Difference from Existing (m)	-0.015	-0.015	-0.014	-0.013	-0.014	-0.008	-0.008	-0.008	-0.008	-0.007	-0.010	-0.008	-0.008	-0.013	-0.011	0.230	0.007	0.007	0.006	0.006	0.006	0.009	0.007	0.008	0.009	0.008

DILLON CONSULTING

Scenario	Return Period	Node (Town MH Number)	TH001	TH002	TH003	TH005	TH006	TH342	TH007	TH008	TH009	TH010	TH265	TH011	TH012	TH013	TH014	TH015 (at St. Alphonse Ave.)	TH024	TH023	TH022	TH021	TH020	TH281	TH019	TH018	TH017	TH016
		HGL Depth (m)	2.5	2.8	3.1	3.0	3.5	3.5	3.8	4.0	4.2	4.5	4.6	4.4	4.7	5.0	5.3	6.2	6.0	5.4	5.5	4.2	3.9	4.0	3.6	3.3	2.9	3.1
Interim Conditions (WWF)	1:5 Year	HGL (m)	180.963	180.61	180.205	179.949	179.695	179.575	179.468	179.212	178.962	178.602	178.533	178.44	178.322	178.304	178.291	178.278	178.956	179.574	179.617	179.683	179.751	179.772	179.778	179.785	179.811	179.902
		Difference from Existing (m)	-0.022	-0.020	-0.014	-0.005	-0.013	-0.014	-0.013	-0.012	-0.012	-0.173	-0.218	-0.273	-0.347	-0.331	-0.223	-0.106	-0.069	-0.041	-0.036	-0.029	-0.021	-0.019	-0.017	-0.015	-0.005	0.009
		HGL Depth (m)	2.4	2.8	3.1	2.9	3.4	3.5	3.7	3.9	4.1	4.4	4.5	4.4	4.4	4.5	4.5	4.7	4.0	3.1	3.2	2.8	2.8	3.0	2.8	2.6	2.6	3.1
Interim Conditions (WWF)	1:25 Year	HGL (m)	180.971	180.623	180.221	179.967	179.714	179.604	179.497	179.241	179.163	179.139	179.128	179.112	179.088	179.062	179.044	179.024	179.573	180.066	180.081	180.187	180.296	180.331	180.338	180.346	180.377	180.401
		HGL Depth (m)	2.4	2.8	3.1	2.9	3.4	3.4	3.7	3.9	3.9	3.8	3.9	3.7	3.7	3.7	3.8	3.9	3.4	2.6	2.8	2.3	2.3	2.4	2.2	2.1	2.0	2.6
Ultimate Conditions (DWF)	N/A	HGL (m)	180.925	180.559	180.139	179.881	179.625	179.48	179.372	179.114	178.866	178.496	178.39	178.337	178.073	177.843	177.56	176.481	177.007	177.27	177.382	178.363	178.663	178.728	178.9	179.1	179.527	179.892
		Difference from Existing (m)	-0.015	-0.015	-0.013	-0.010	-0.011	-0.034	-0.033	-0.033	-0.031	-0.031	-0.040	-0.030	-0.029	-0.020	-0.017	-0.012	0.008	0.008	0.008	0.006	0.006	0.010	0.008	0.009	0.009	0.008
		HGL Depth (m)	2.5	2.8	3.1	2.9	3.5	3.6	3.8	4.0	4.2	4.5	4.6	4.5	4.7	5.0	5.3	6.5	6.0	5.4	5.5	4.2	3.9	4.0	3.6	3.3	2.9	3.1

DILLON CONSULTING

Scenario	Return Period	Node (Town MH Number)	TH001	TH002	TH003	TH005	TH006	TH342	TH007	TH008	TH009	TH010	TH265	TH011	TH012	TH013	TH014	TH015 (at St. Alphonse Ave.)	TH024	TH023	TH022	TH021	TH020	TH281	TH019	TH018	TH017	TH016
Ultimate Conditions (WWF)	1:5 Year	HGL (m)	180.961	180.61	180.203	179.947	179.69	179.547	179.442	179.183	178.933	178.564	178.482	178.405	178.143	178.011	177.699	176.805	177.707	178.513	178.669	178.898	179.141	179.223	179.229	179.234	179.536	179.9
		Difference from Existing (m)	-0.024	-0.020	-0.016	-0.007	-0.018	-0.042	-0.039	-0.041	-0.041	-0.211	-0.269	-0.308	-0.526	-0.624	-0.815	-1.579	-1.318	-1.102	-0.984	-0.814	-0.631	-0.568	-0.566	-0.566	-0.280	0.007
		HGL Depth (m)	2.4	2.8	3.1	2.9	3.4	3.5	3.7	4.0	4.1	4.4	4.5	4.4	4.6	4.8	5.1	6.1	5.3	4.2	4.2	3.6	3.4	3.5	3.3	3.2	2.9	3.1
Ultimate Conditions (WWF)	1:25 Year	HGL (m)	180.97	180.622	180.219	179.964	179.707	179.565	179.46	179.202	178.952	178.585	178.511	178.425	178.175	178.082	177.784	177.565	178.394	179.135	179.29	179.513	179.741	179.815	179.823	179.83	179.853	179.903
		HGL Depth (m)	2.4	2.8	3.1	2.9	3.4	3.5	3.7	4.0	4.1	4.4	4.5	4.4	4.6	4.7	5.0	5.4	4.6	3.6	3.6	3.0	2.8	2.9	2.7	2.6	2.6	3.1

Legend (Basement Flooding Risk)	
0.5	- Ground Ele. - HGL (m) < 1.5 m
2.0	- 1.5 m < Ground Ele. - HGL (m) < 3.0 m
3.5	- Ground Ele. - HGL (m) > 3.0 m

Conclusions and Recommendations

The current analysis has been undertaken to assess the sanitary infrastructure required to enable planned development within the service area of the St. Alphonse PS. As part of the County of Essex's CR42/CR43 Road reconstruction project, the need to construct a new twin sanitary sewer, between Shiff Drive and 11th Concession was identified to avoid conflict with a proposed trunk storm sewer. The Town has expedited the sanitary sewer assessment of this drainage area to determine the need for additional infrastructure improvements under interim and ultimate conditions so these improvements can be integrated into the planned road reconstruction project.

The existing, interim and ultimate conditions analysis, and infrastructure recommendations provided above have been evaluated using the 1:5 year, 24 hour design storm event to remain consistent with other similar types of analysis completed for the Town in the past.

The existing conditions WWF simulation shows an acceptable level of surcharge where the HGL does not exceed 180.98 m. The risk of basement flooding is low as the maximum observed HGL is 2.6 m below the existing ground elevation.

The proposed twin sanitary sewer along CR42 was modelled from 11th Concession to Shiff Drive based on this assessment, the opportunity to utilize this new sanitary sewer to accommodate interim conditions was identified. By upsizing the sewer from a 250 mm diameter sewer (from the original design) to a 300-375 mm dia. sewer, desired minimum HGL depths could be attained as shown in Figure 2. Additionally, under interim conditions, the existing sanitary sewers from Shiff Drive to St. Alphonse Avenue were upsized to 375 mm diameter. Under ultimate conditions, the St. Alphonse PS is proposed to be decommissioned and a new trunk sanitary sewer is proposed to service future developments in the West Hamlet region.

Under interim and ultimate conditions DWF simulations, the sanitary infrastructure has adequate capacity to convey DWF generated from the planned development areas along CR42.

During WWF simulations, additional planned development along CR42 is not expected to significantly increase the risk of basement flooding in the area as the maximum observed HGL along CR42 is generally lower than the baseline condition.

Planned development along CR42 can therefore be permitted to proceed in the interim, before the West Hamlet Trunk Sanitary sewer is installed and the St. Alphonse PS is decommissioned. The extraneous flow from these developments is recommended to be monitored, to ensure it remains below the allowable RDII peak flows and volumes.

Under ultimate conditions, a reduction in the HGL is observed at most locations along CR42. Thus resulting in a net reduction in the risk of basement flooding in these areas. In the eastern leg (east of St. Alphonse Avenue) of the CR42 sanitary sewer, though a very minor increase in HGL is observed (0.01 m), it does not represent a significant increase in the risk of basement flooding. The minimum depth of HGL below ground is 2.4 m in this scenario.

The Interim and Ultimate condition scenarios were stress-tested using the 1:25 year design storm event. The peak HGLs are expected to be deeper than the assumed basement floor elevations during these simulations therefore basement flood risk is not expected to increase.

We trust that this evaluation provides the Town with the necessary information required to review the sanitary sewer improvements recommended to be included in the proposed CR42 road reconstruction project. Should you have any further questions, we would be pleased to discuss the results of our evaluation in further detail.

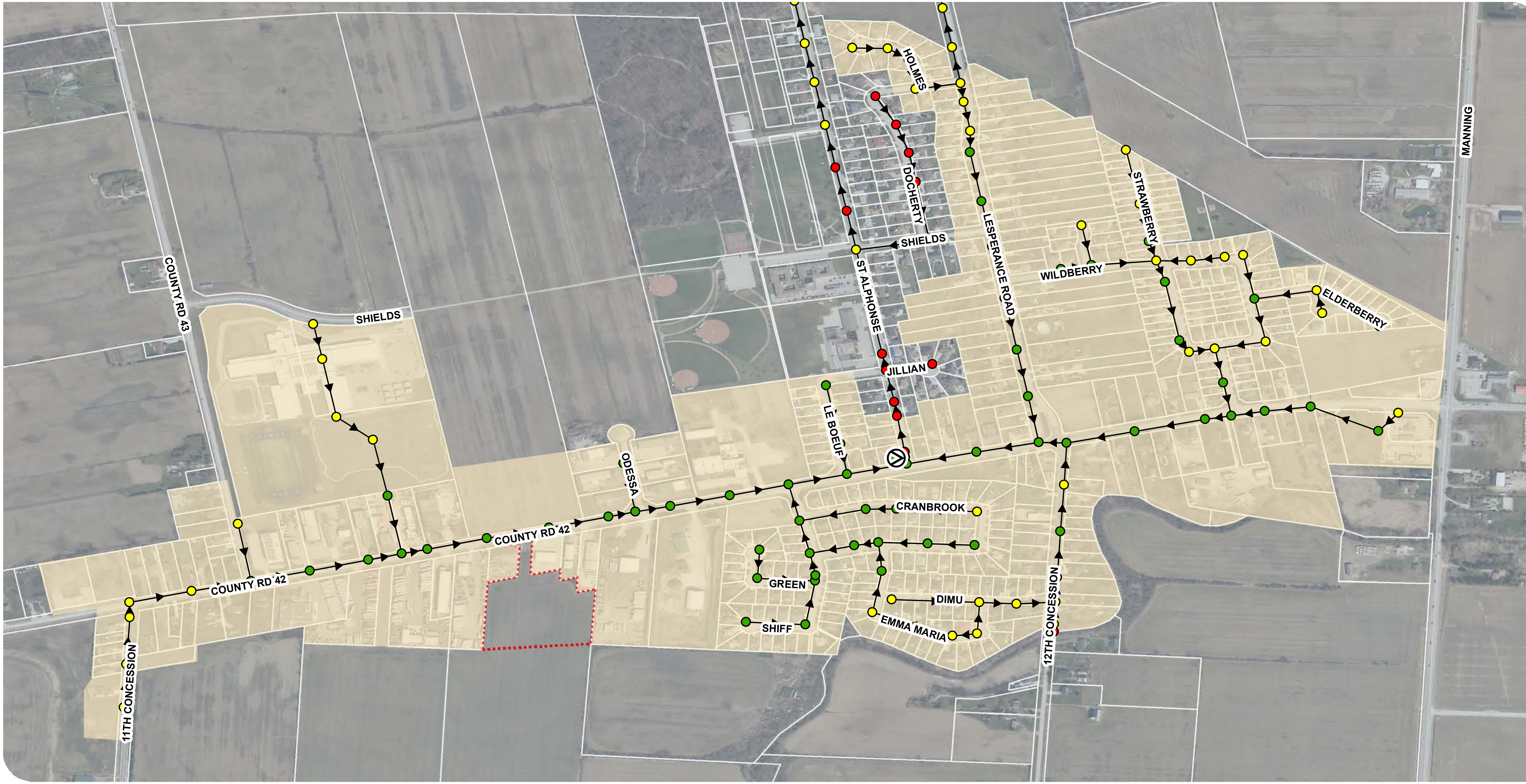
Yours sincerely,

DILLON CONSULTING LIMITED

Chris Patten, P.Eng.
Project Manager

Aakash Bagchi, P.Eng.
Water Resources Engineer

Figures



TOWN OF TECUMSEH

County Road 42 Sanitary Sewer Improvement Assessment

EXISTING CONDITIONS

FIGURE 1

Depth of Max HGL from Existing Ground

> 3 m	Sanitary Sewers	Temporarily Removed from Service Area by Agreement
1.5 - 3 m	St. Alphonse PS Drainage Area	St. Alphonse Pump Station
< 1.5 m	Town of Tecumseh Assessment Parcels	

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

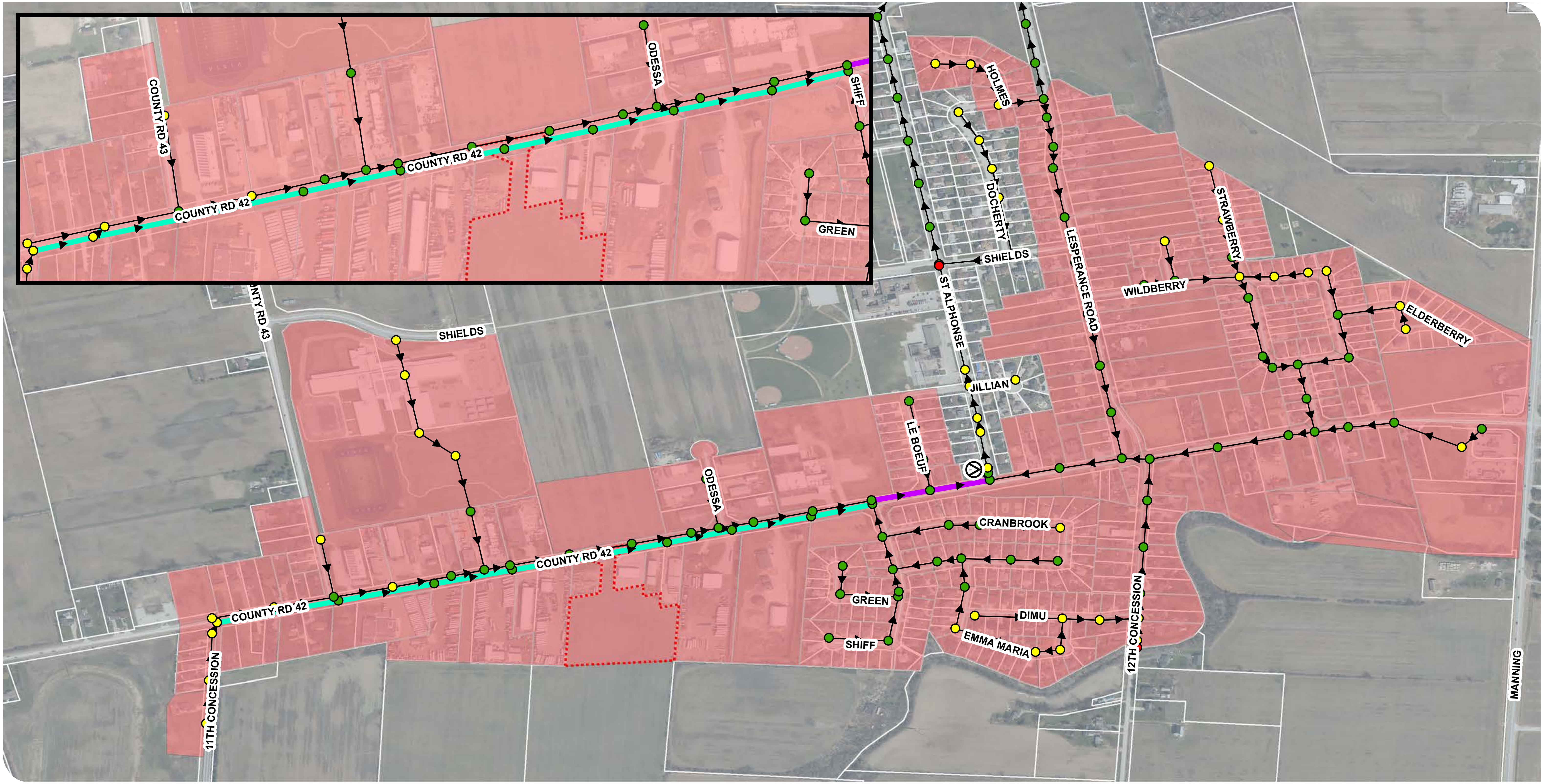
MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

0 0.125 0.25 km

SCALE 1:7,500

FILE LOCATION: \\dillon.ca\DILLON_DFS\Windsor\Windsor CAD\CAD\GIS\19-9298 Town of Tecumseh Sanitary Re-Calibration\GIS\CR42 analysis

PROJECT: 19-9298 STATUS: FINAL DATE: 15/Oct/2020



TOWN OF TECUMSEH

County Road 42 Sanitary Sewer Improvement Assessment

INTERIM CONDITIONS

FIGURE 2

Depth of Max HGL from Ground

- > 3 m
- 1.5 - 3 m
- < 1.5 m

- Sanitary Sewers
- Proposed Twin Sewer on CR42
- Proposed 375 mm dia. sewer
- Plannned Development Areas (Temporarily Removed from Service Area by Agreement)
- Town of Tecumseh Assessment Parcels
- Proposed St. Alphonse PS Drainage Area
- St. Alphonse Pump Station

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

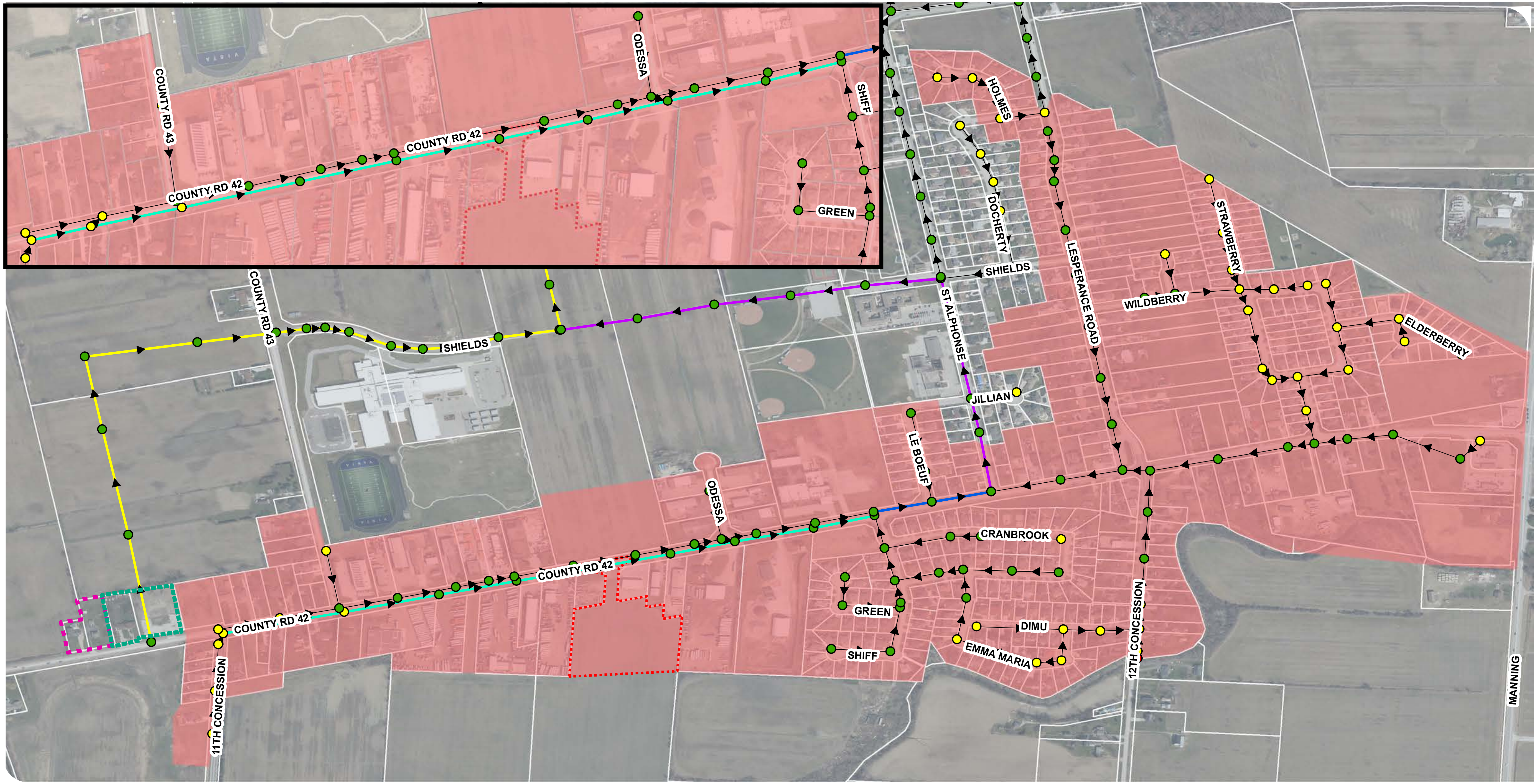
0 0.125 0.25 km

SCALE 1:7,500 (Inset 1:4,500)

N E S W

FILE LOCATION: FILE LOCATION: \\dillon.ca\DILLON_DFS\Windsor\Windsor CAD\CAD\GIS\19-9298 Town of Tecumseh Sanitary Re-Calibration\GIS\CR42 analysis

PROJECT: 19-9298 STATUS: FINAL DATE: 21/DEC/2020



TOWN OF TECUMSEH

County Road 42 Sanitary Sewer Improvement Assessment

ULTIMATE CONDITIONS

FIGURE 3

Depth of Max HGL from Existing Ground

- > 3 m
- 1.5 - 3 m
- < 1.5 m

- Sanitary Sewers
- Proposed Twin Sewer on CR42
- Proposed Shields Trunk
- Plannned Development Areas (Temporarily Removed from Service Area by Agreement)
- Town of Tecumseh Assessment Parcels
- County Road 42 Sanitary Sewer Drainage Area
- Proposed West Hamlet Trunk Sanitary Sewer
- Future ROW of CR-43/Banwell Road
- Included in West Hamlet Trunk Sanitary Sewer DA

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY TOWN OF TECUMSEH

MAP CREATED BY: AZS
MAP CHECKED BY: AB
MAP PROJECTION: NAD 1983 UTM Zone 17N

0 0.125 0.25 km

SCALE 1:7,500 (Inset 1:4,500)

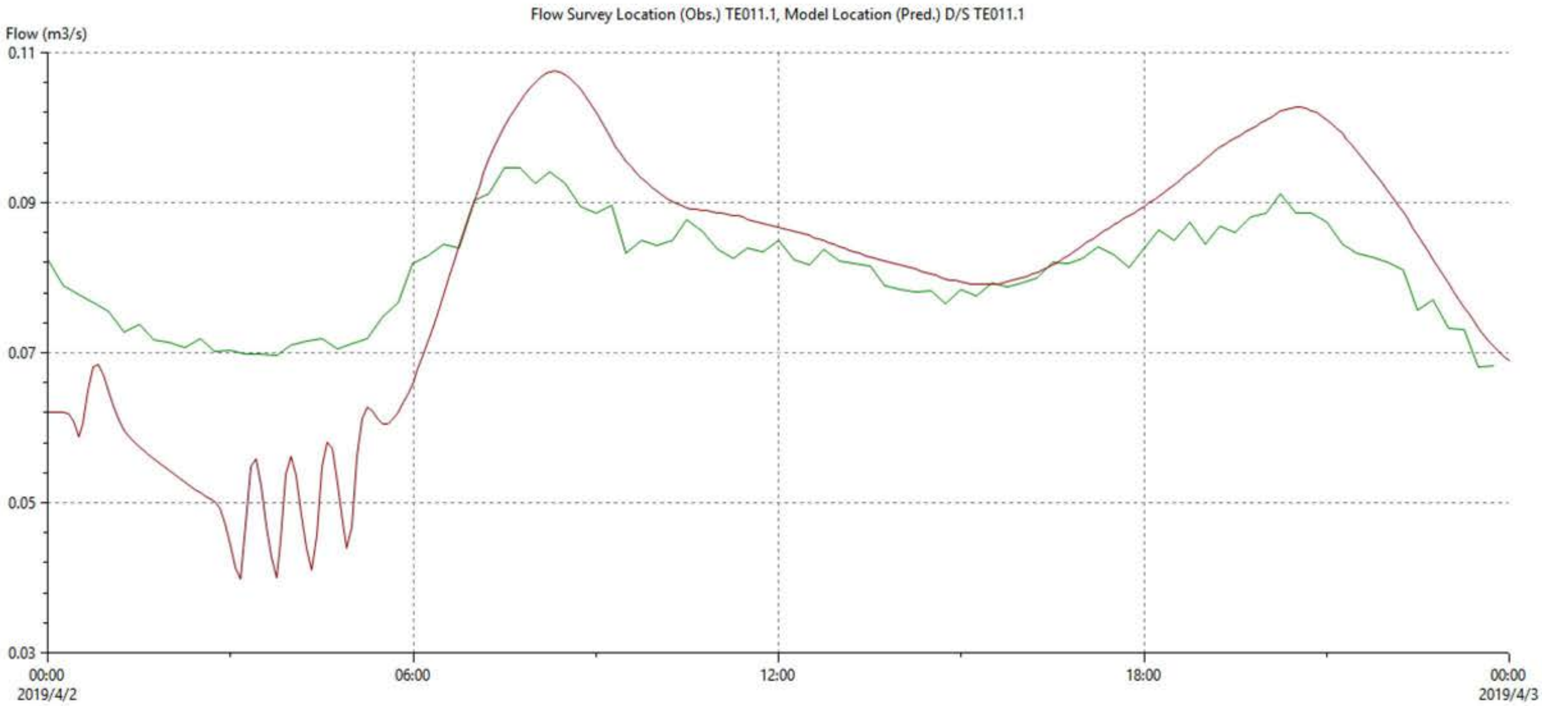
N W E S

FILE LOCATION: \\dillon.ca\DILLON_DFS\Windsor\Windsor CAD\CAD\GIS\19-9298 Town of Tecumseh Sanitary Re-Calibration\GIS\CR42 analysis

PROJECT: 19-9298 STATUS: FINAL DATE: 15/Oct/2020

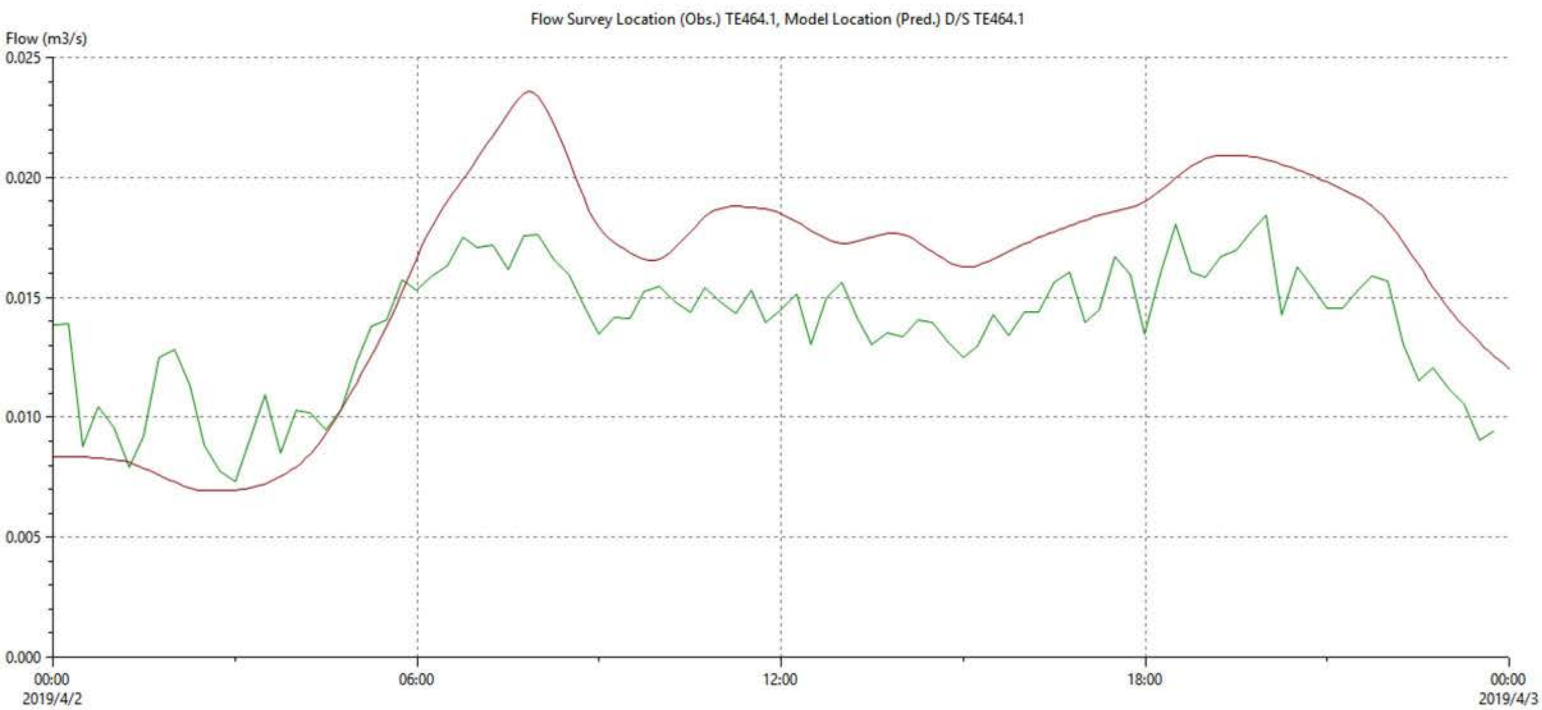
Appendix C

Comparison Graphs



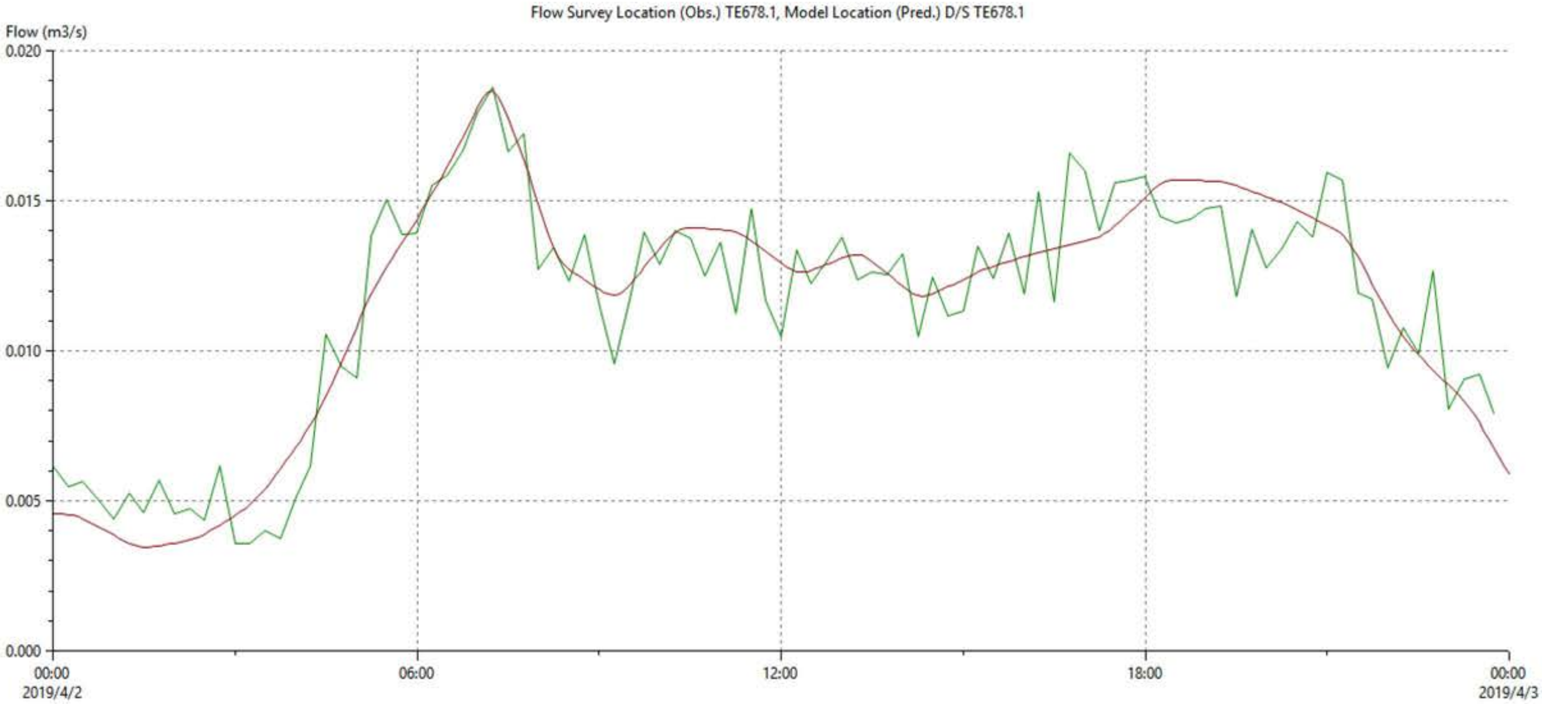
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.068	0.095	6924.425
April_DWF_1d_Run40>DWF	0.040	0.108	6962.457

TE011 (600 L/cap/day)



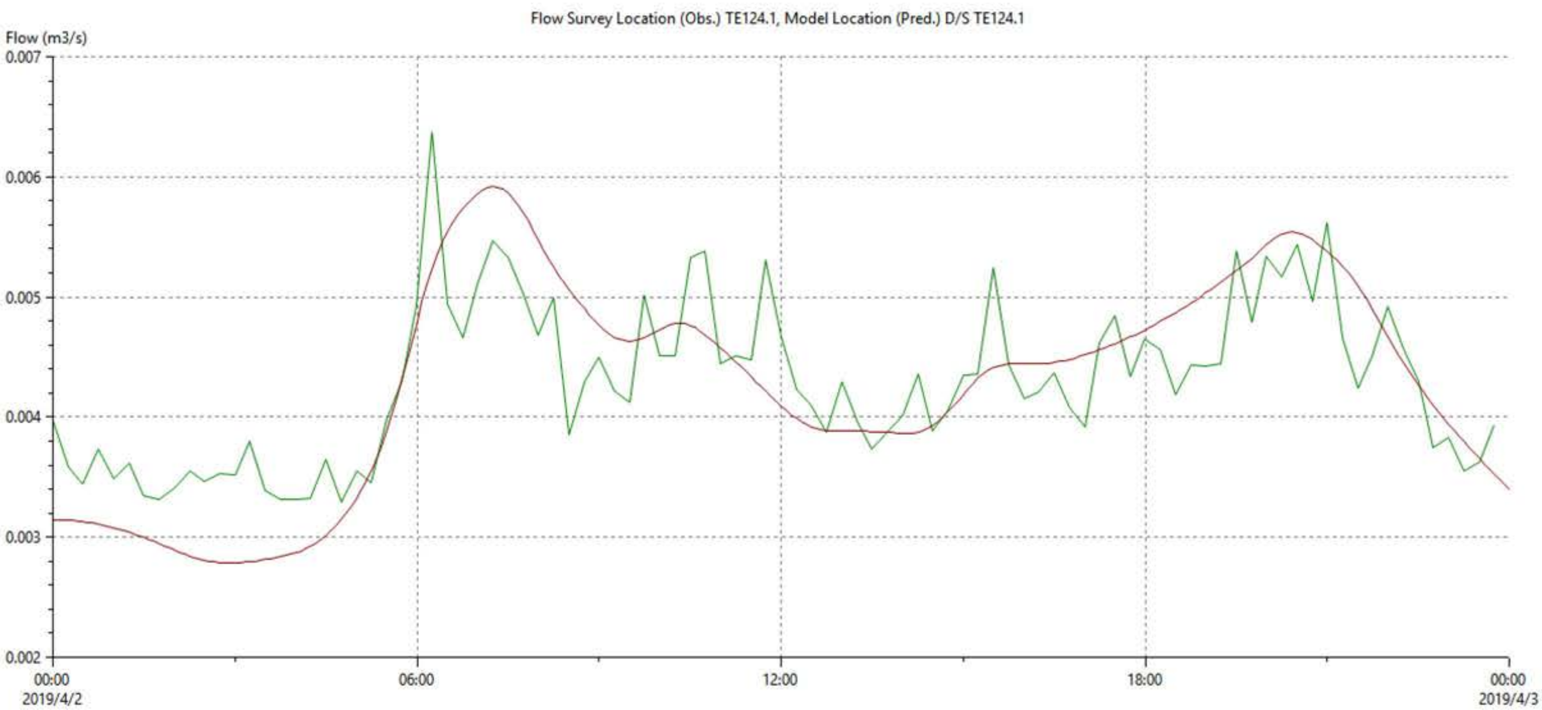
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.007	0.018	1180.508
April_DWF_1d_Run40>DWF	0.007	0.024	1383.850

TE464 (230 L/cap/day)



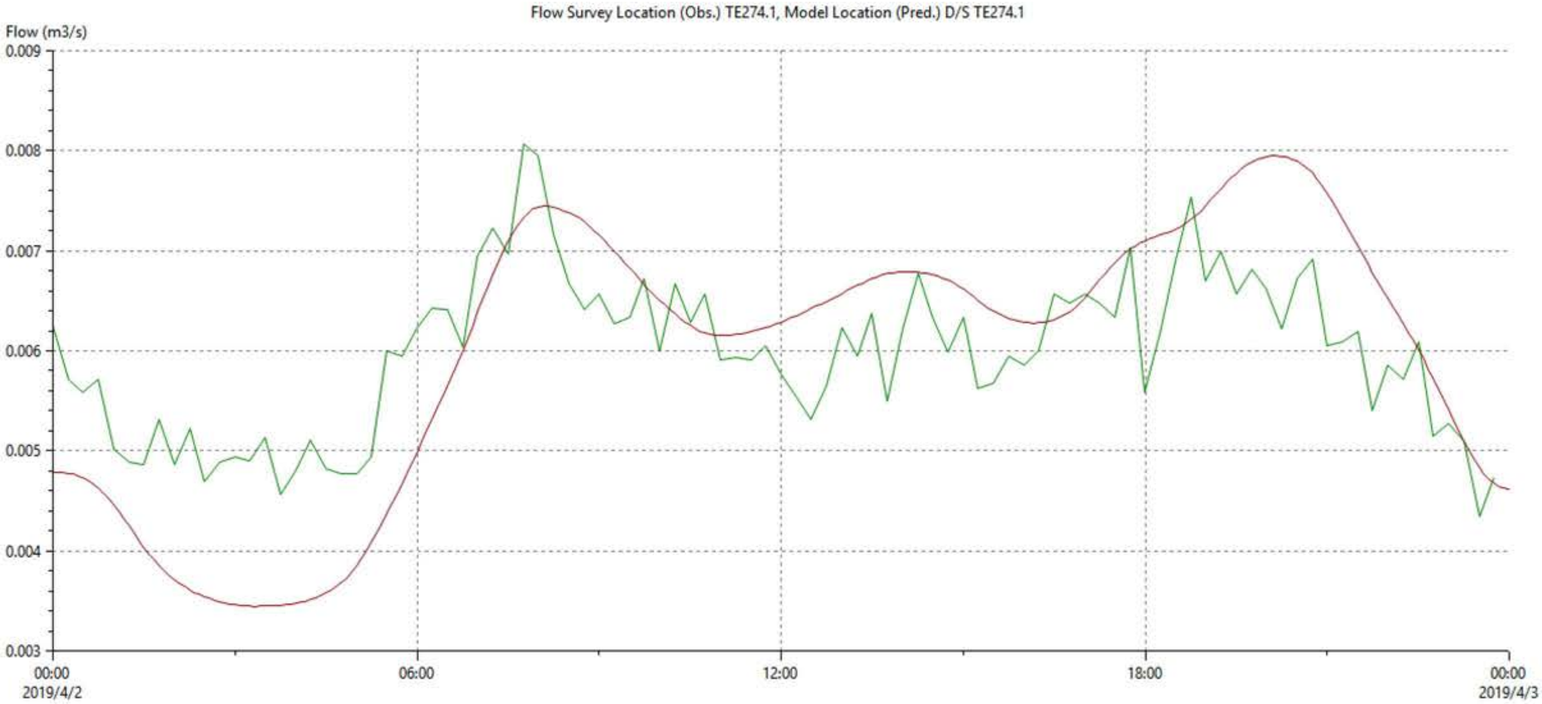
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.004	0.019	995.386
April_DWF_1d_Run40>DWF	0.003	0.019	1006.393

TE678 (980 L/cap/day)



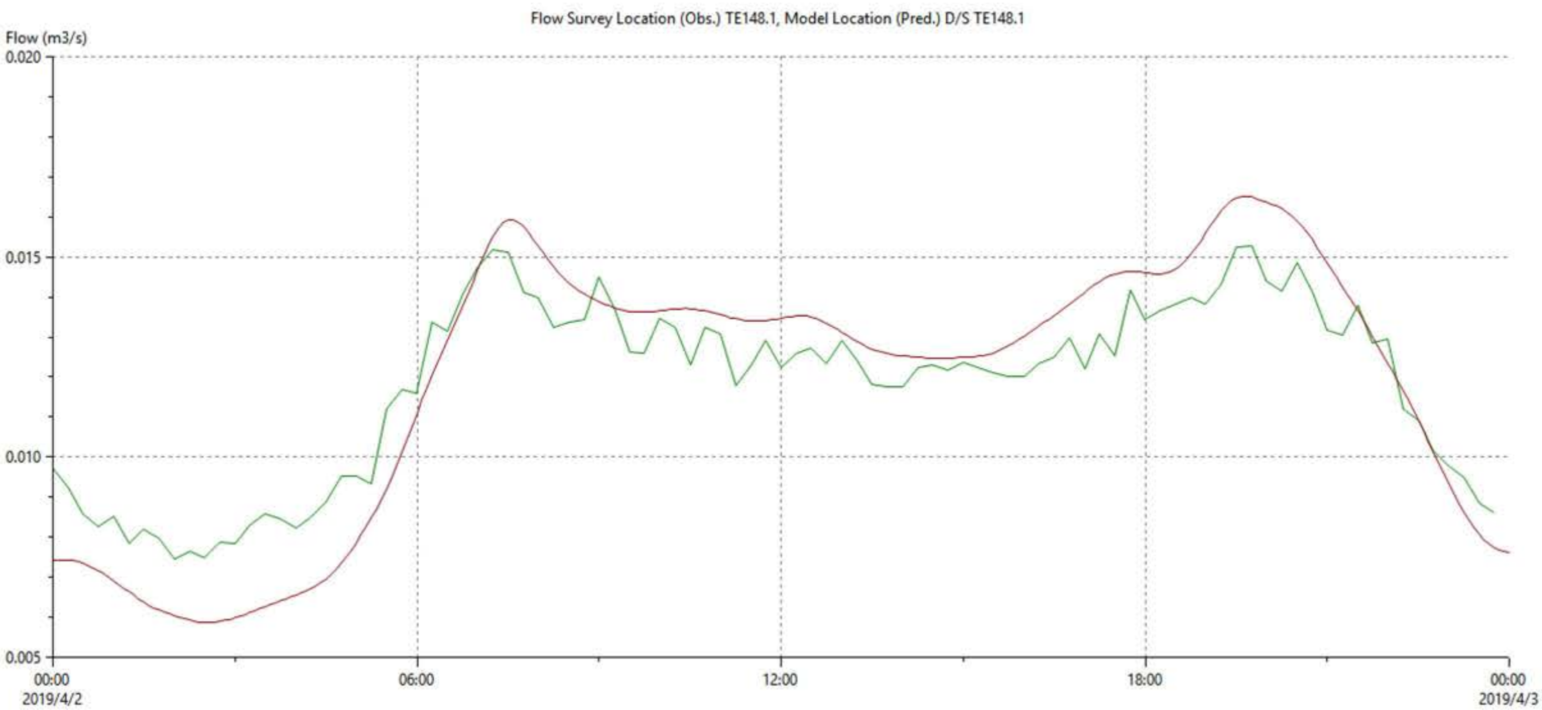
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.003	0.006	367.830
April_DWF_1d_Run40>DWF	0.003	0.006	369.662

TE124 (700 L/cap/day)



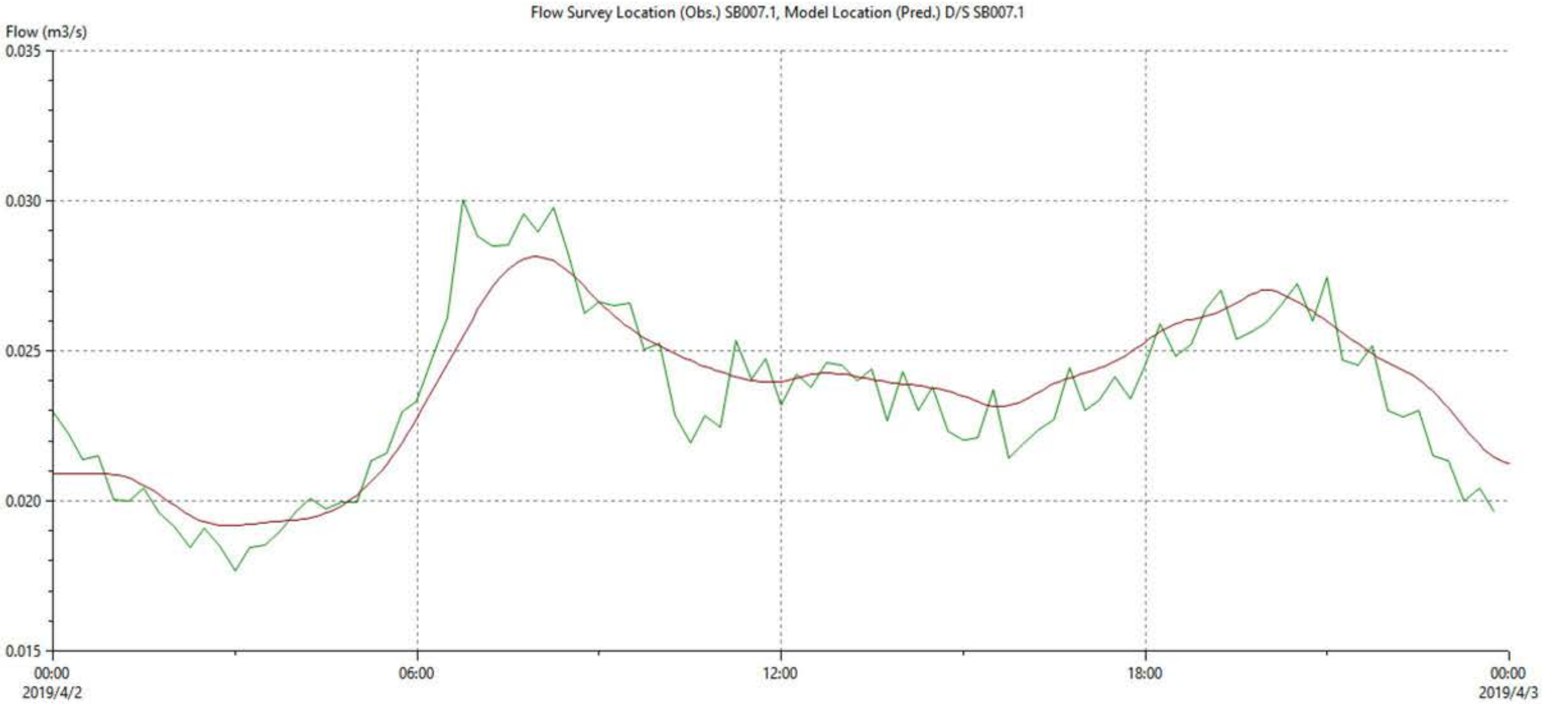
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.004	0.008	511.484
April_DWF_1d_Run40>DWF	0.003	0.008	516.250

TE274 (450 L/cap/day)



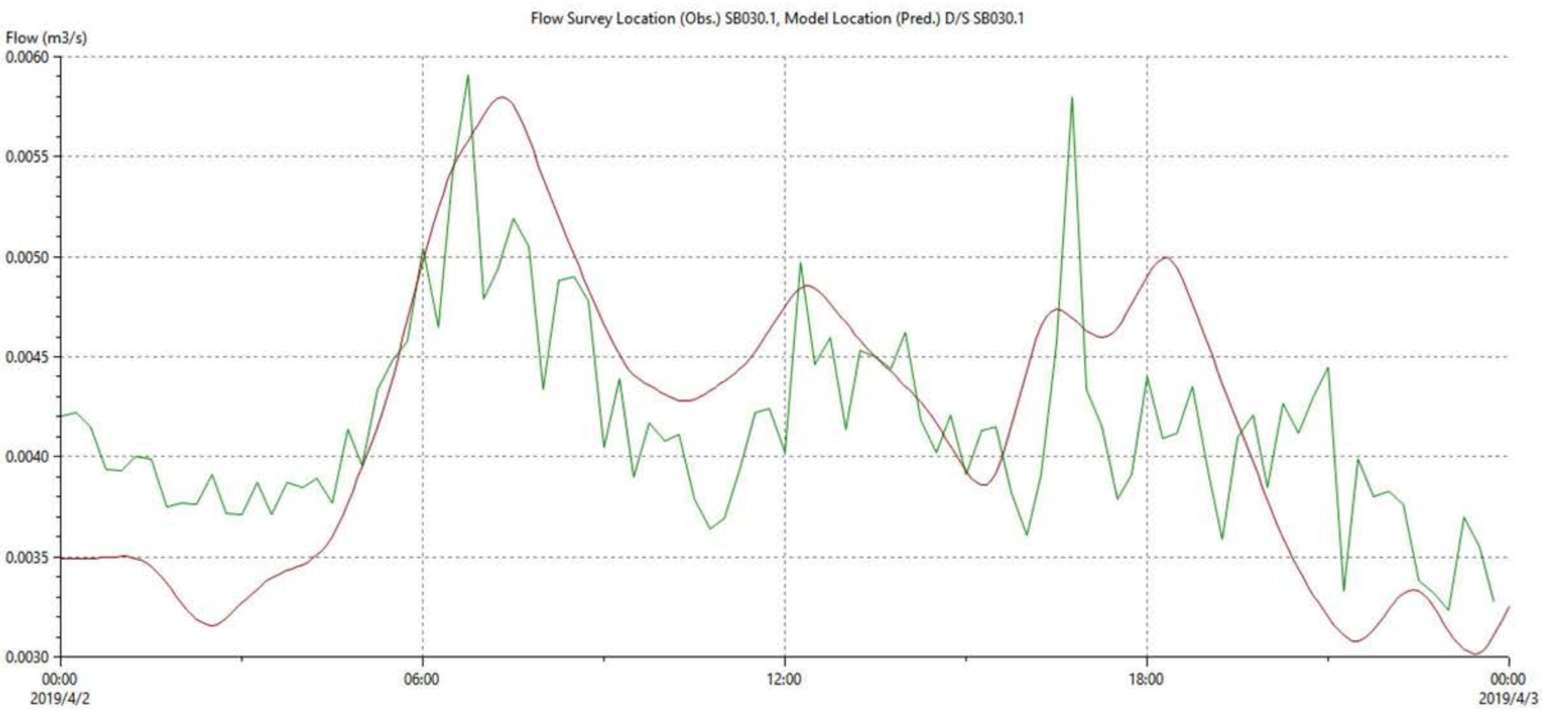
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.007	0.015	1012.370
April_DWF_1d_Run40>DWF	0.006	0.017	1026.107

TE148 (475 L/cap/day)



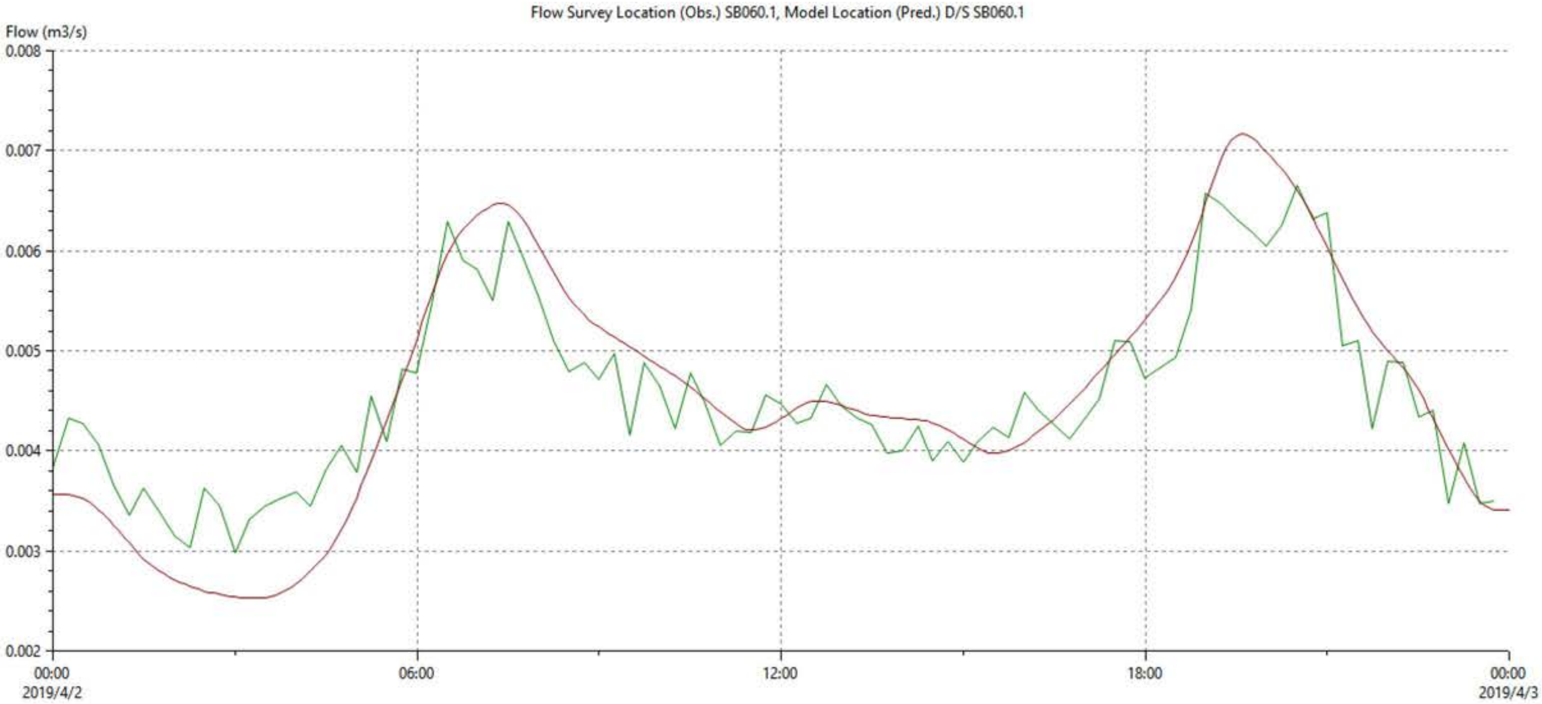
Observed / April_DWF_1d_Run40>DWF	Flow Min (m3/s)	Flow Max (m3/s)	Flow Volume (m3)
Observed	0.018	0.030	2008.697
April_DWF_1d_Run40>DWF	0.019	0.028	2049.601

SB007 (680 L/cap/day)



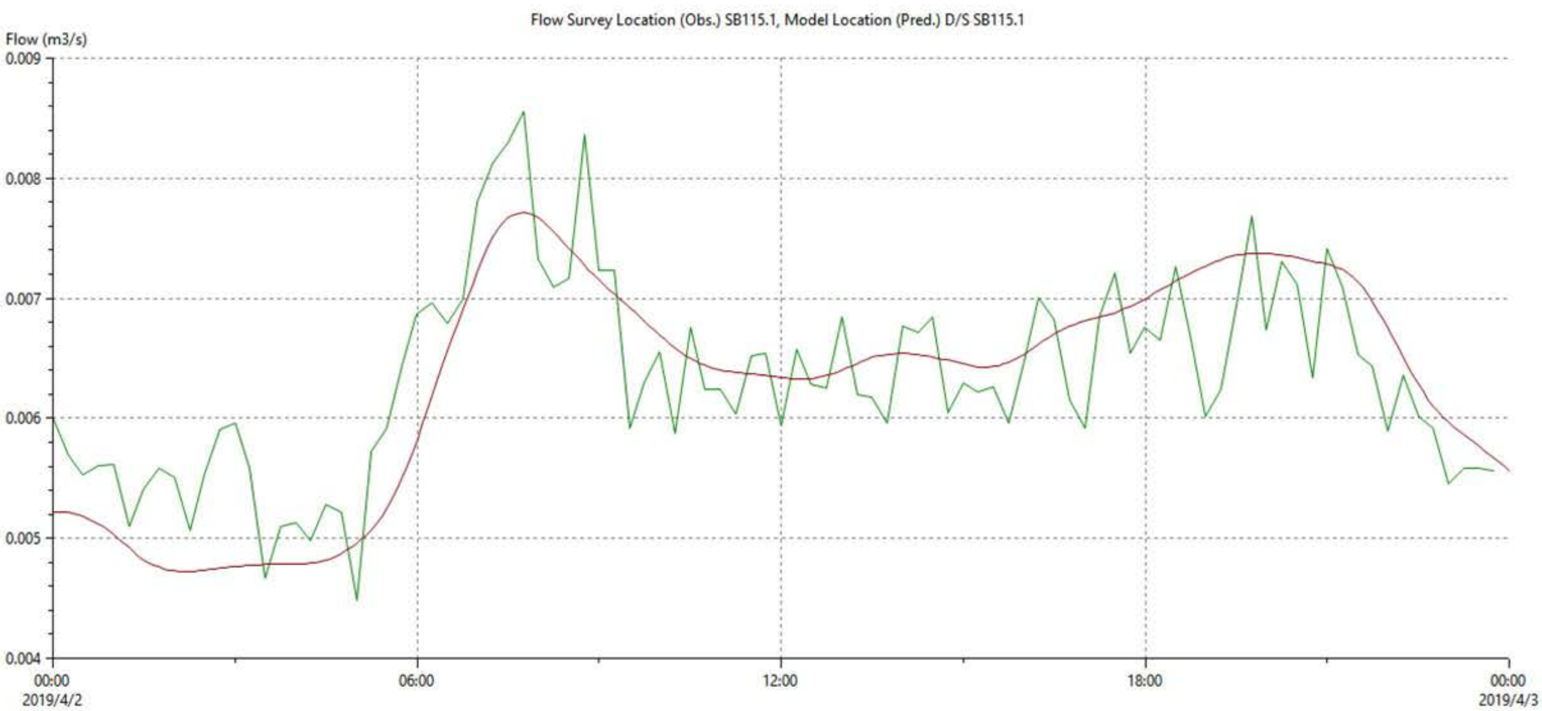
Observed / April_DWF_1d_Run40>DWF	Flow Min (m3/s)	Flow Max (m3/s)	Flow Volume (m3)
Observed	0.003	0.006	356.049
April_DWF_1d_Run40>DWF	0.003	0.006	359.218

SB030 (1220 L/cap/day)



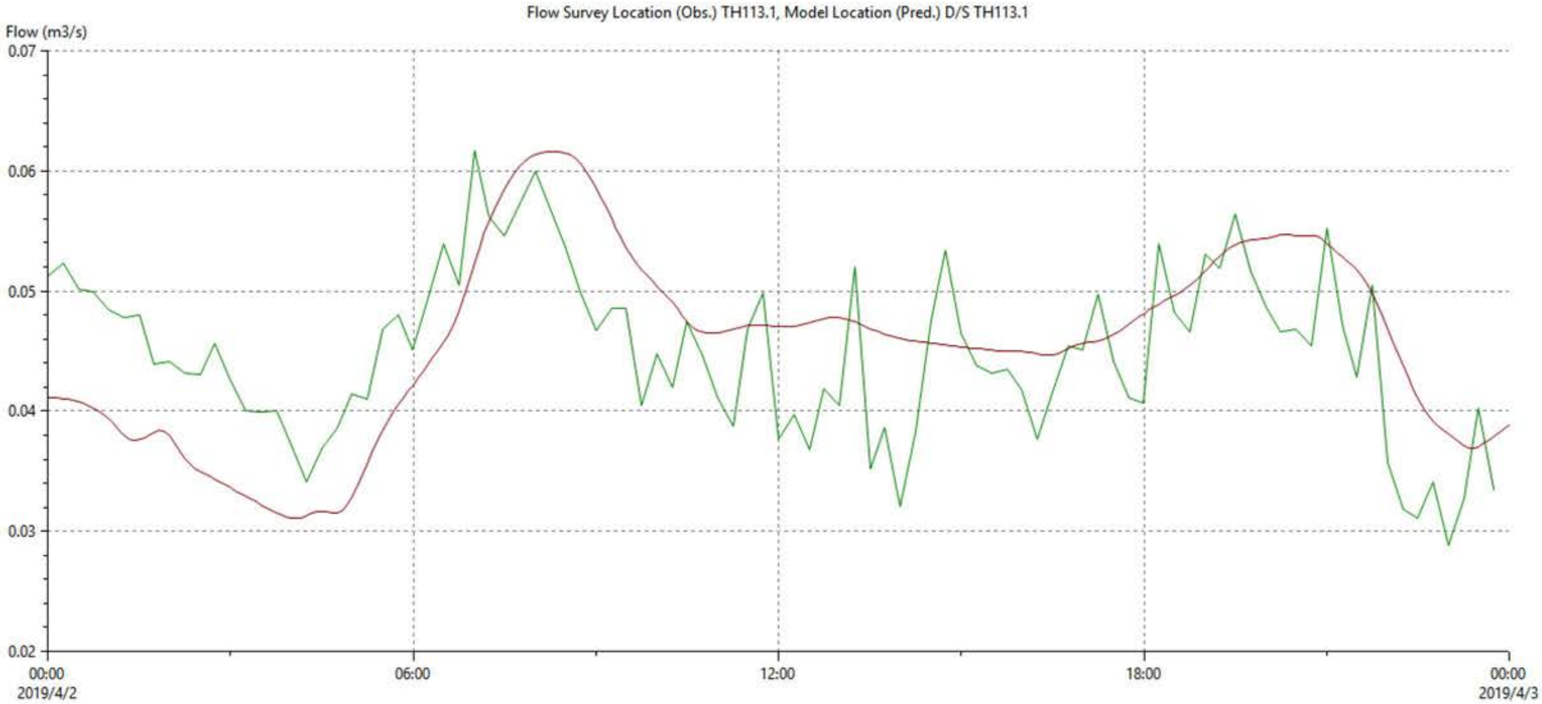
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.003	0.007	390.713
April_DWF_1d_Run40>DWF	0.003	0.007	396.280

SB060 (700 L/cap/day)



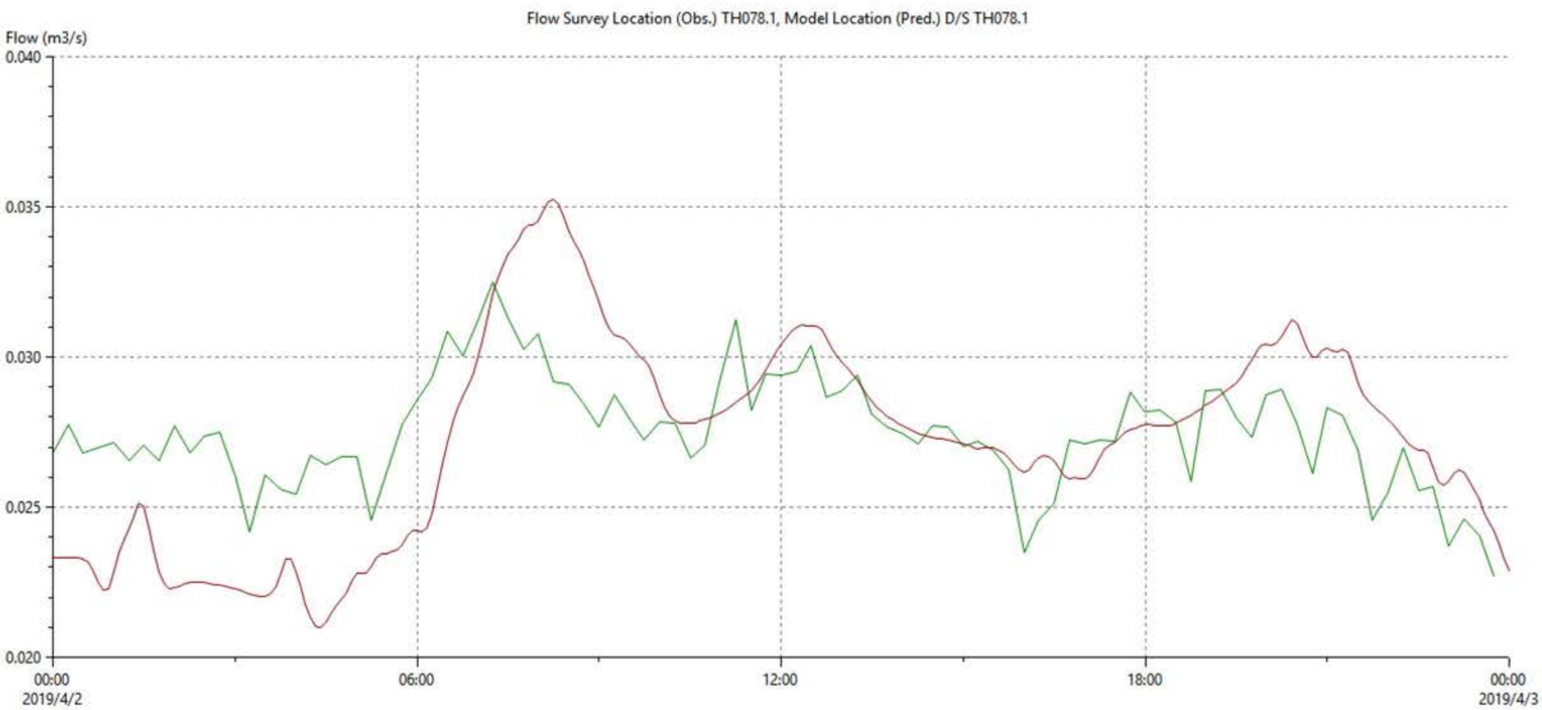
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.004	0.009	542.646
April_DWF_1d_Run40>DWF	0.005	0.008	545.060

SB115 (625 L/cap/day)



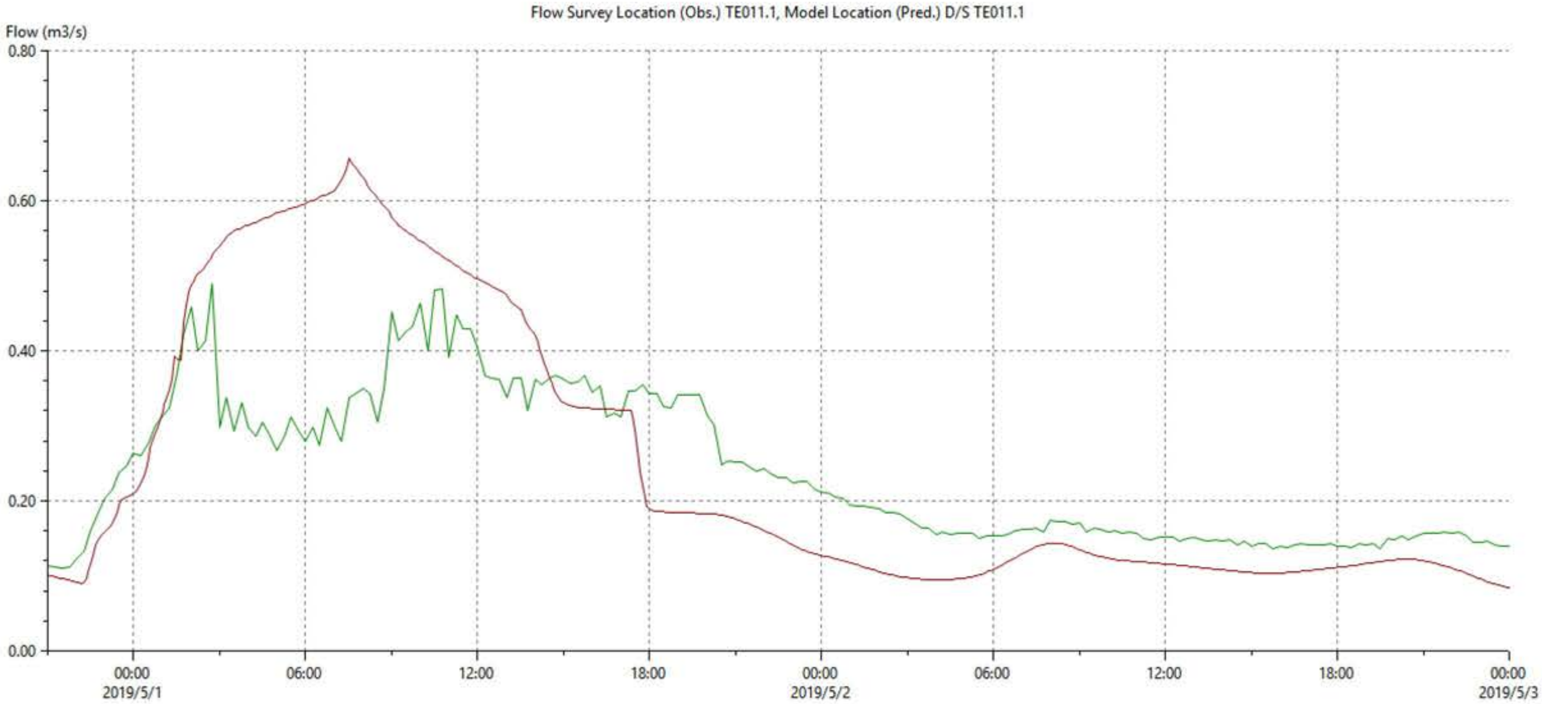
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.029	0.062	3845.529
April_DWF_1d_Run40>DWF	0.031	0.062	3942.113

TH113 (L/cap/day)



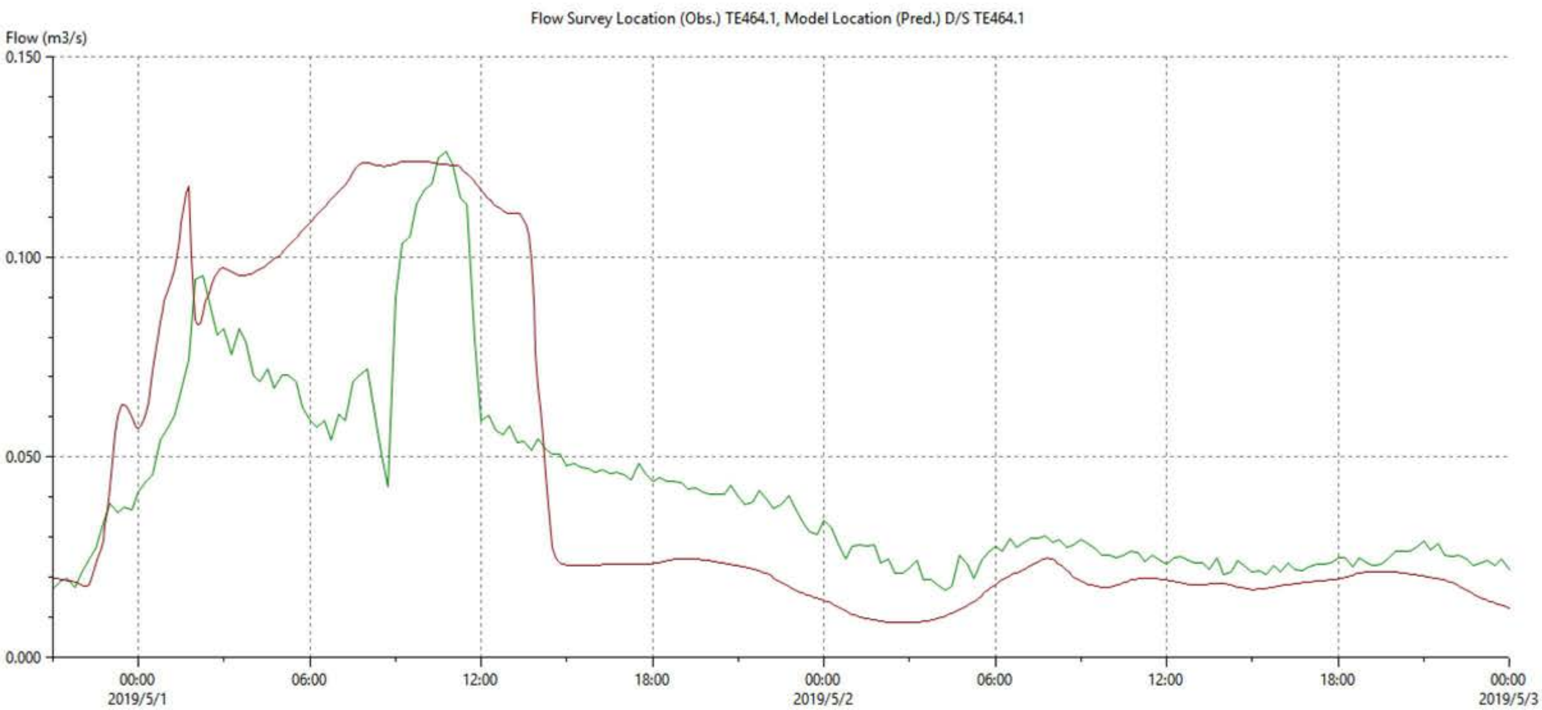
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.023	0.032	2353.369
April_DWF_1d_Run40>DWF	0.021	0.035	2353.673

TH078 (1200 L/cap/day)



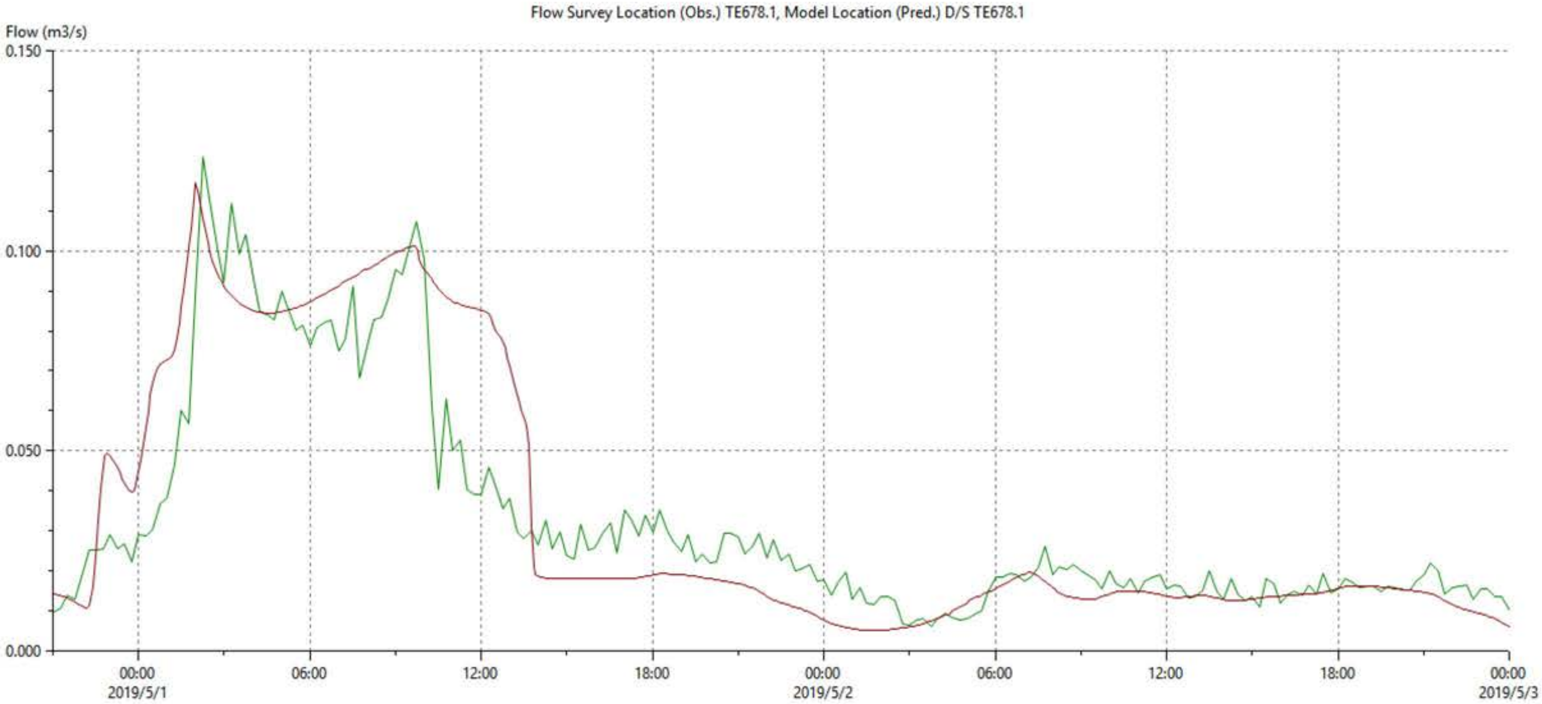
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.111	0.490	44214.102
WWF_R01_Run197>R_01_2019	0.085	0.656	45637.095

R_01_2019 TE011



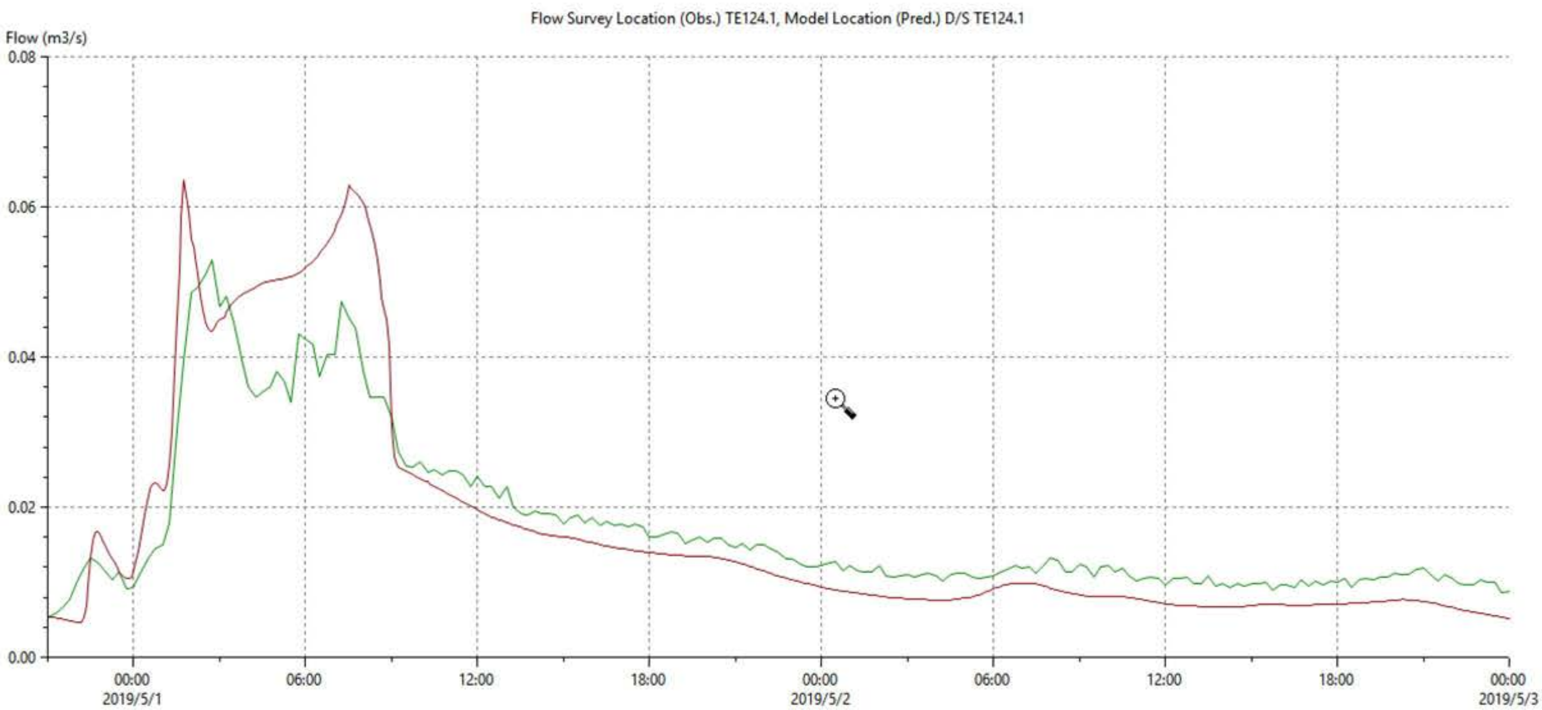
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.017	0.126	7750.903
WWF_R01_Run197>R_01_2019	0.009	0.124	8099.596

R_01_2019 TE464



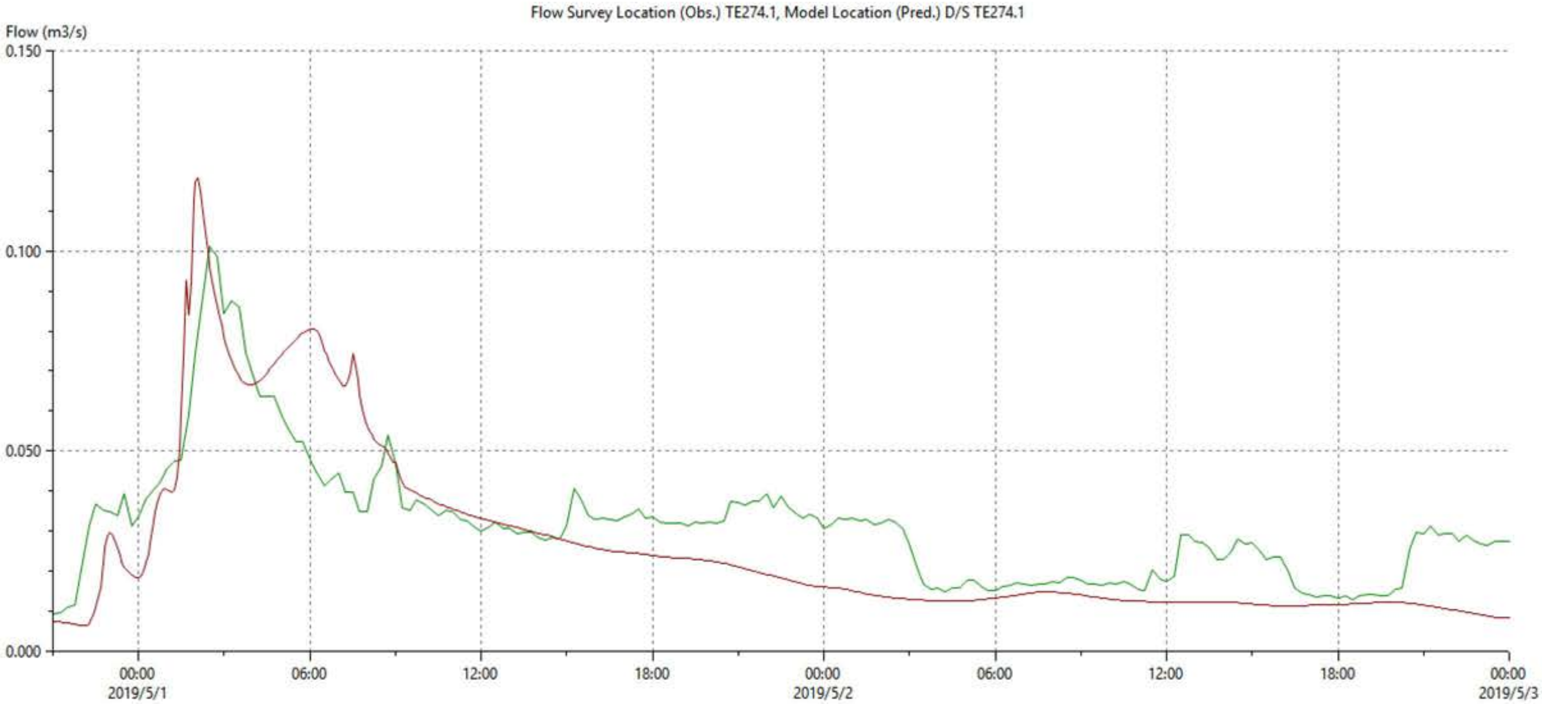
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.006	0.123	6057.203
WWF_R01_Run197>R_01_2019	0.005	0.117	6298.972

R_01_2019 TE678



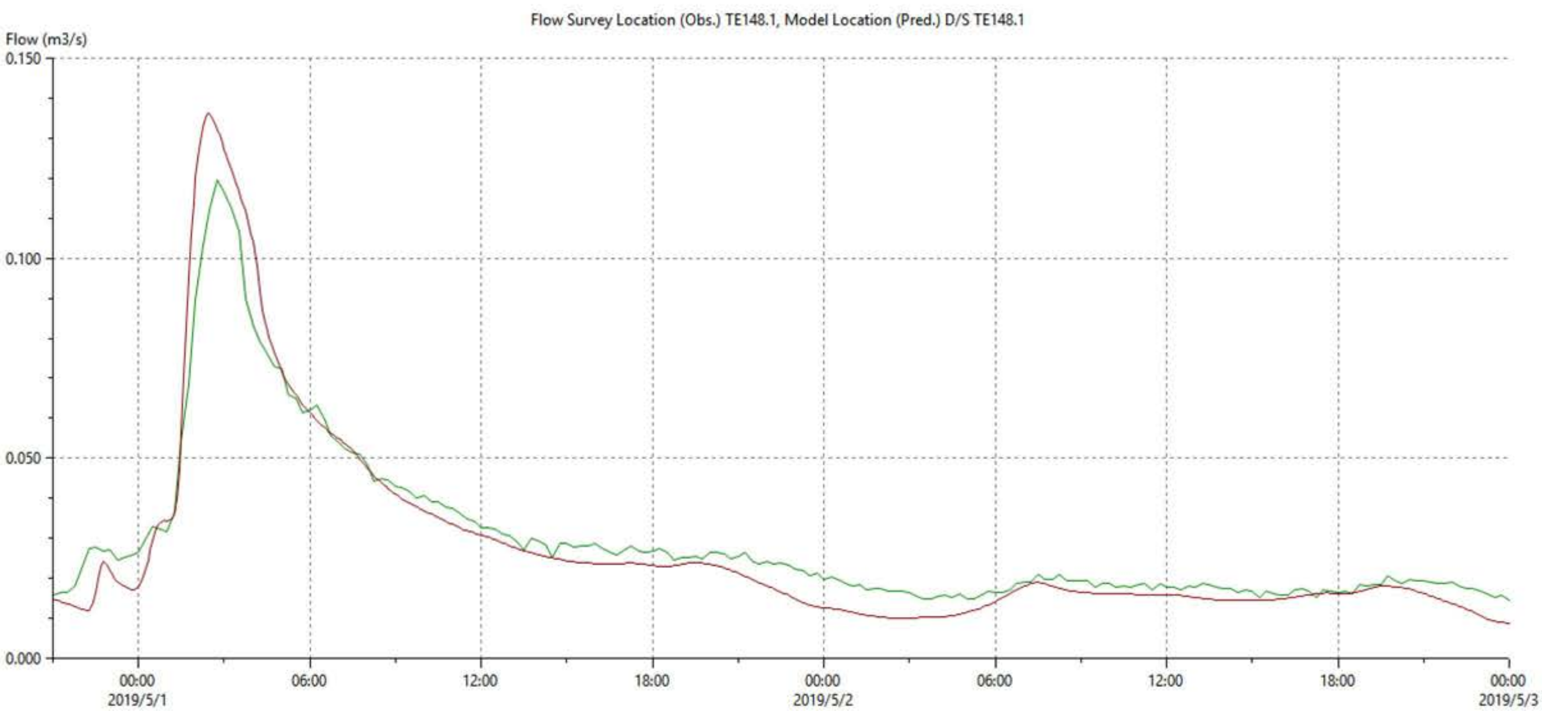
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.005	0.053	3228.750
WWF_R01_Run197>R_01_2019	0.005	0.064	3147.266

R_01_2019 TE124



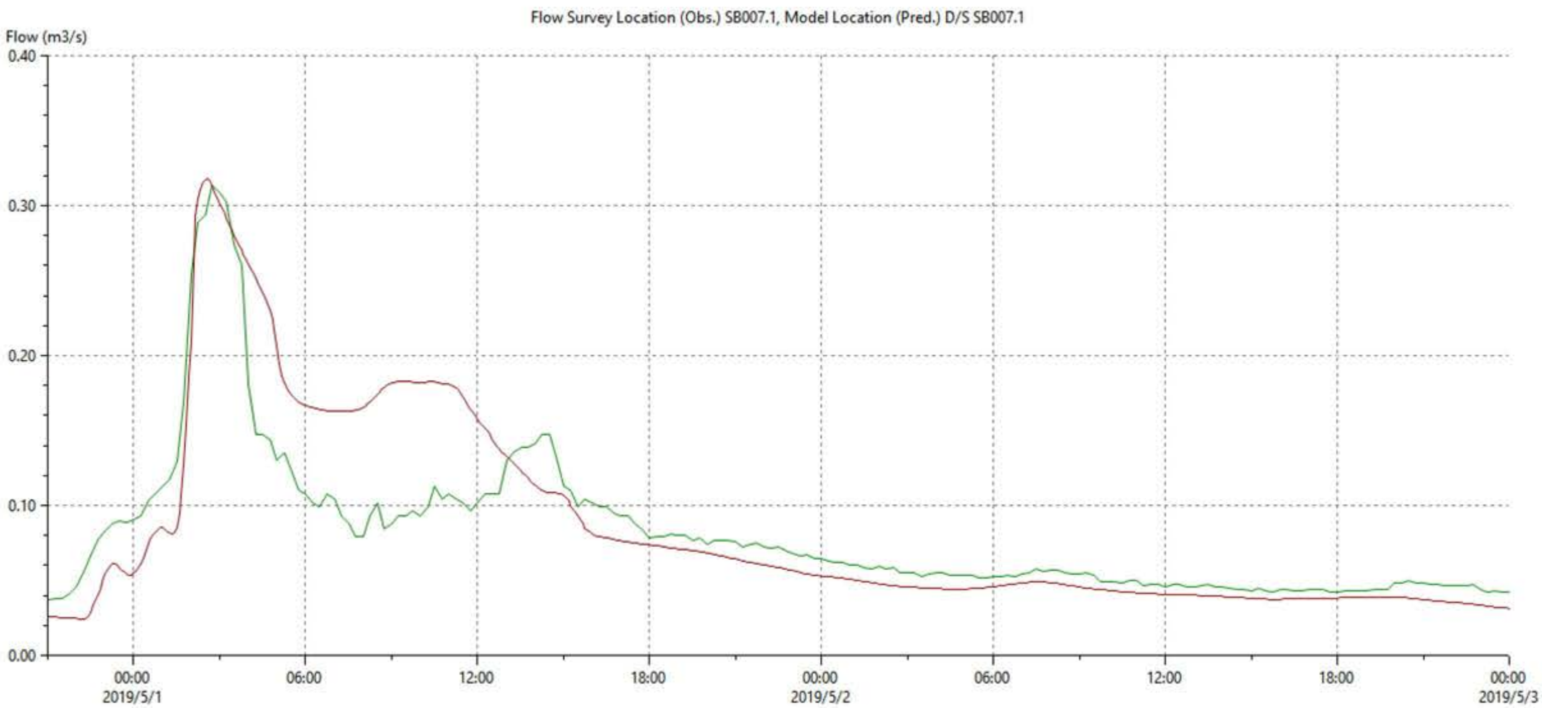
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.010	0.101	5809.932
WWF_R01_Run197>R_01_2019	0.006	0.118	4873.833

R_01_2019 TE274



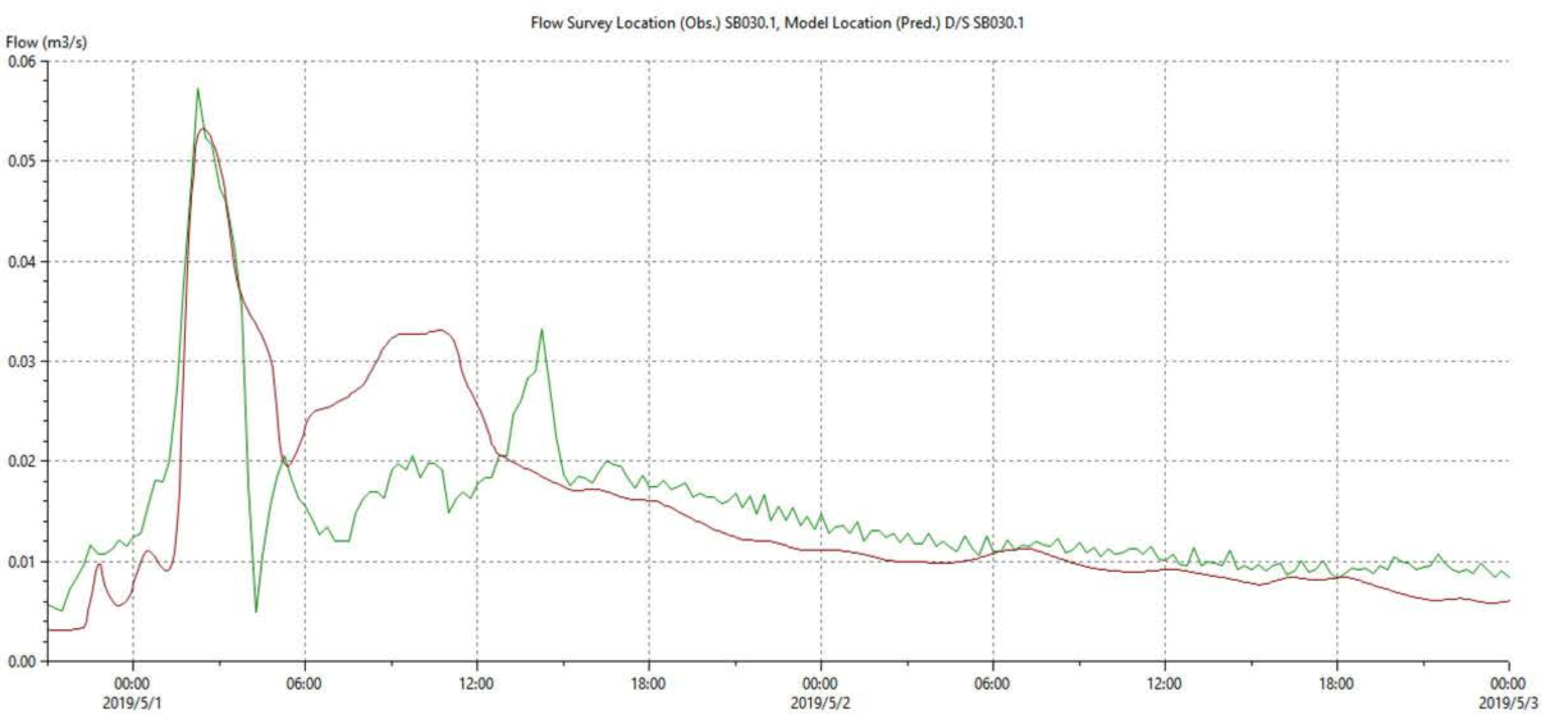
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.015	0.120	5476.311
WWF_R01_Run197>R_01_2019	0.009	0.136	5116.505

R_01_2019 TE148



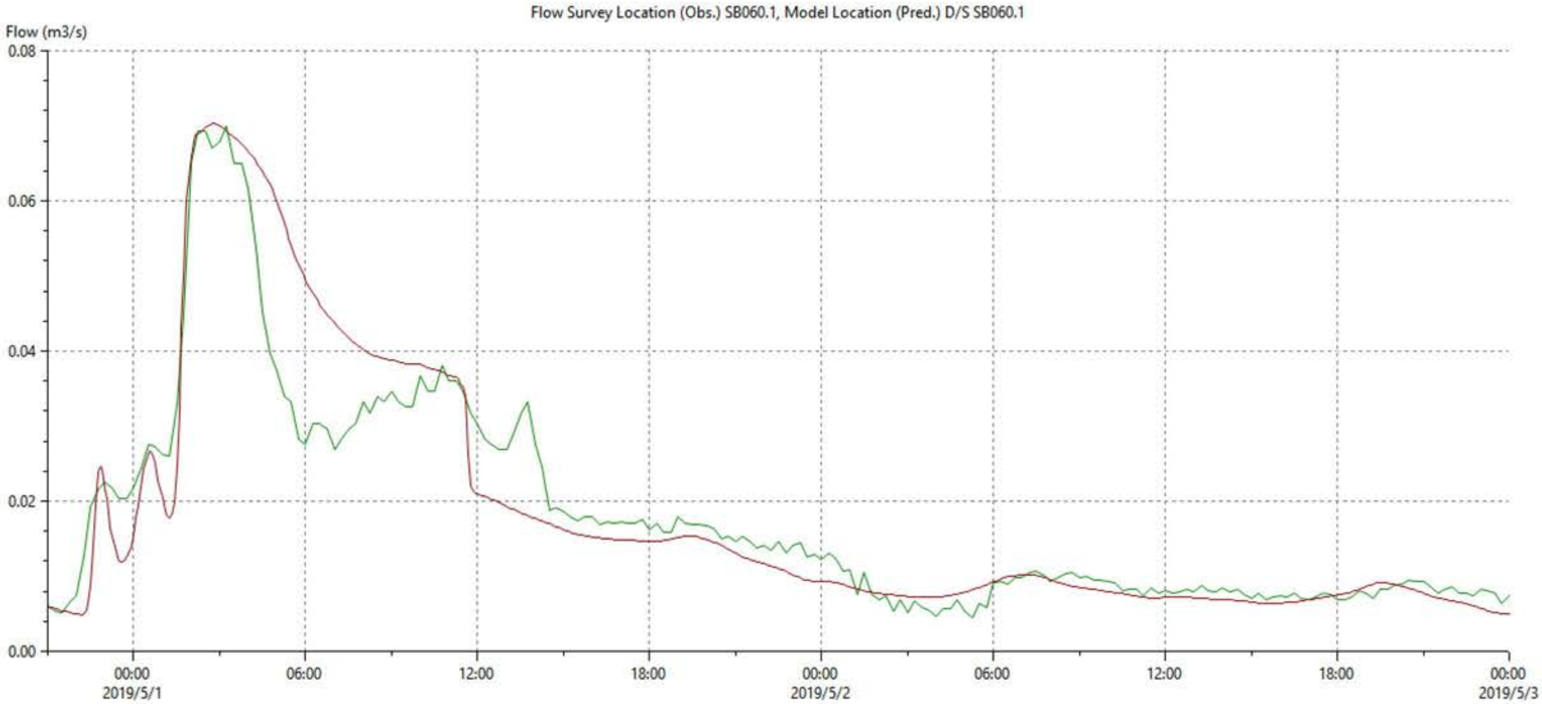
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.037	0.314	15035.760
WWF_R01_Run197>R_01_2019	0.024	0.318	15648.793

R_01_2019 SB007



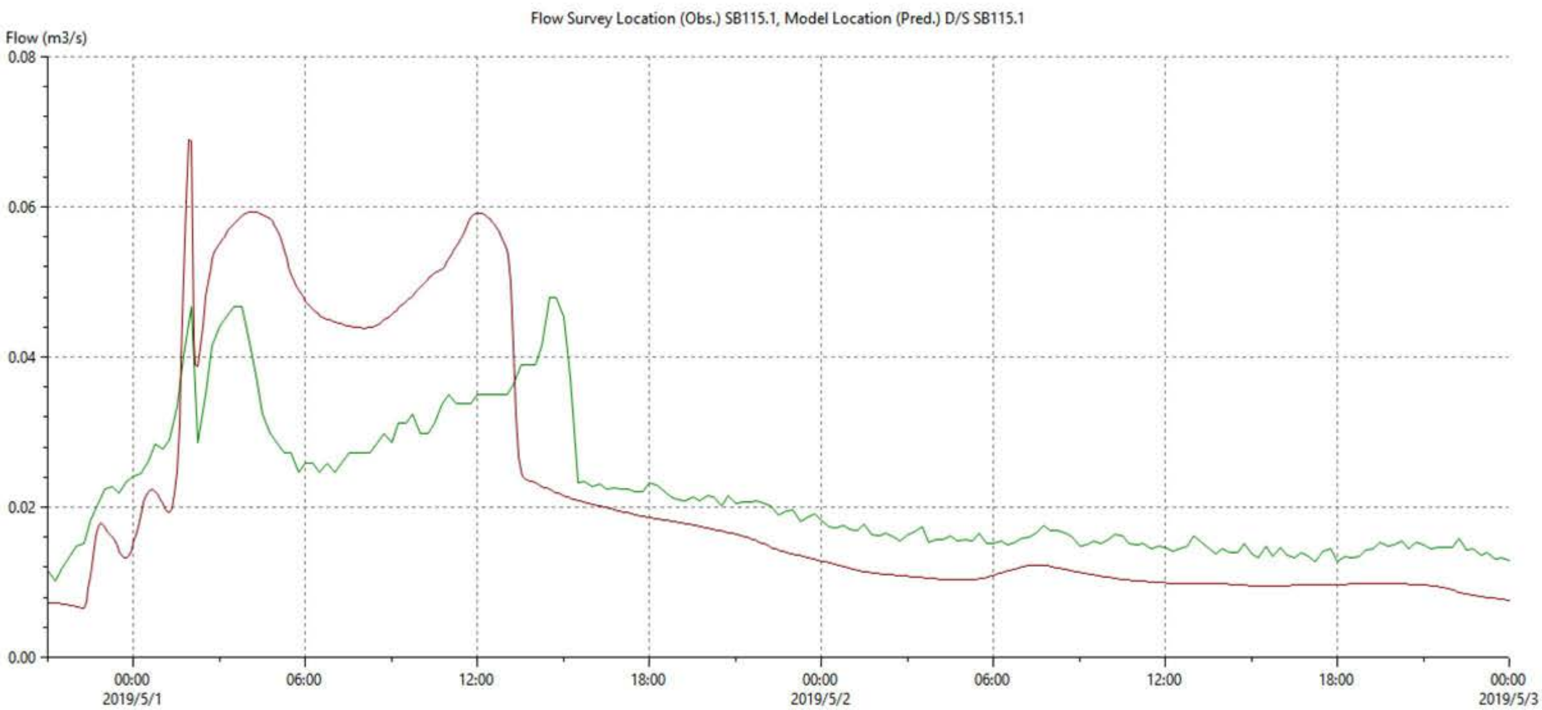
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.005	0.057	2777.724
WWF_R01_Run197>R_01_2019	0.003	0.053	2764.693

R_01_2019 SB030



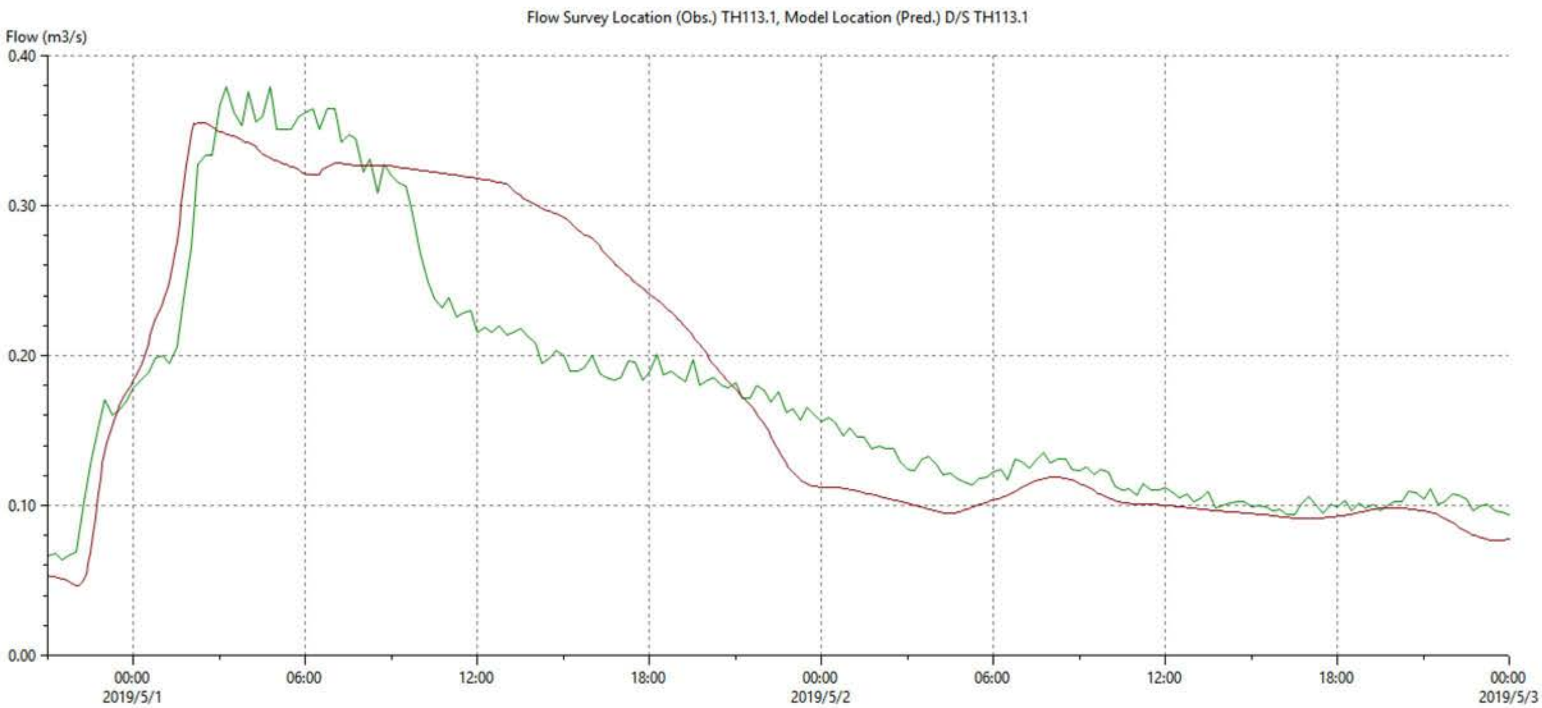
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.005	0.070	3361.860
WWF_R01_Run197>R_01_2019	0.005	0.070	3395.891

R_01_2019 SB060



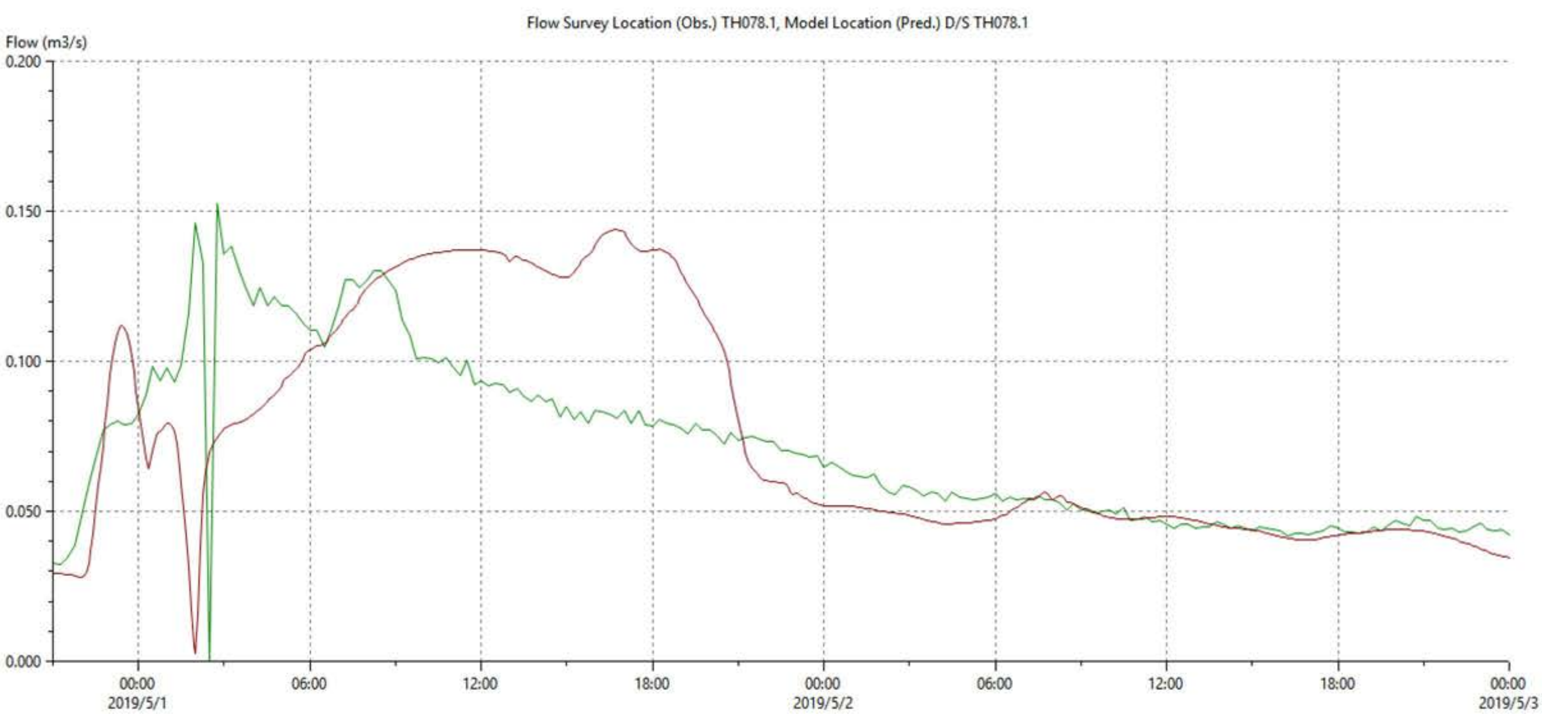
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.010	0.048	4012.718
WWF_R01_Run197>R_01_2019	0.007	0.069	3994.067

R_01_2019 SB115



	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.064	0.379	32396.854
WWF_R01_Run197>R_01_2019	0.047	0.356	33304.193

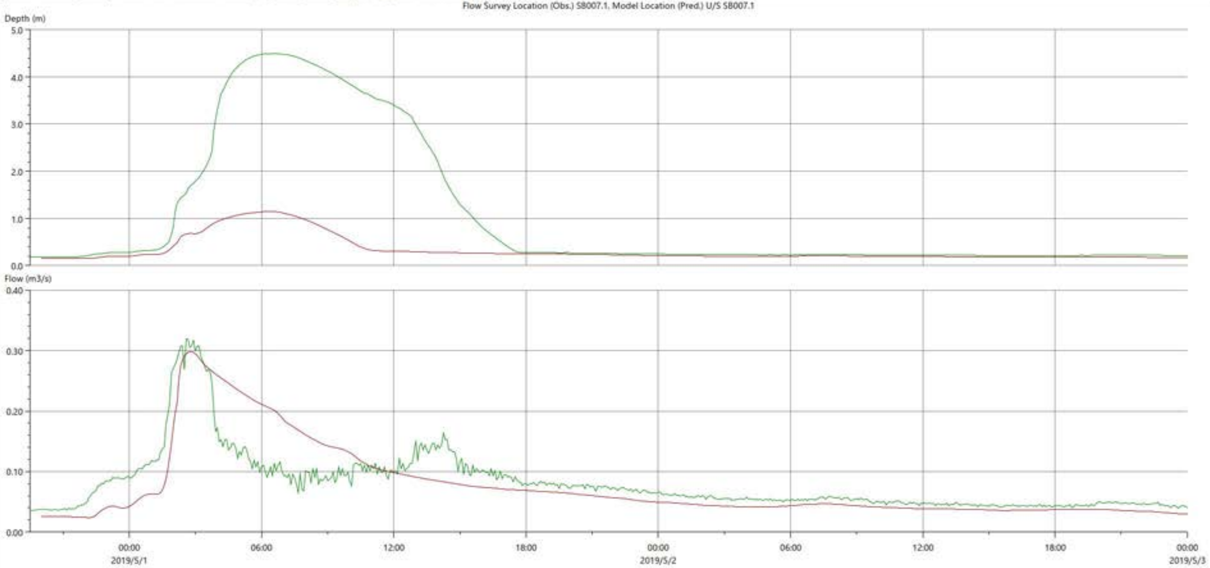
R_01_2019 TH113



	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.000	0.153	13218.471
WWF_R01_Run197>R_01_2019	0.002	0.144	13860.466

R_01_2019 TH078

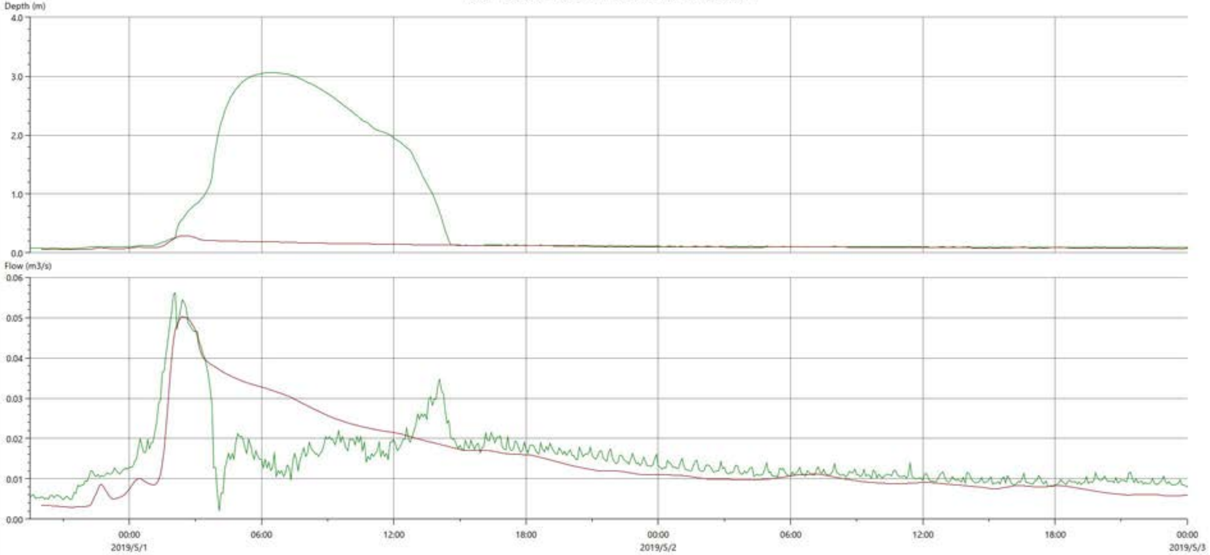
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 1 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.179	4.501	0.036	0.319	15240.550
..R01_Run202_FDV75_5May21>R_01_2019	0.151	1.149	0.024	0.298	14252.612

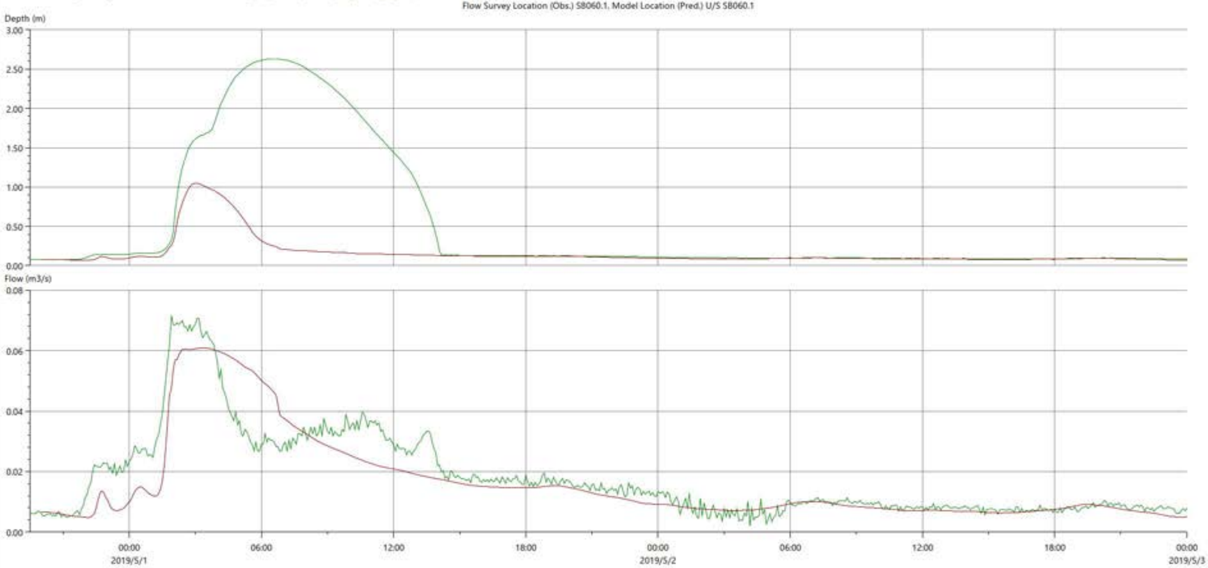
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)

Flow Survey Location (Obs.) S8030.1, Model Location (Pred.) U/S S8030.1



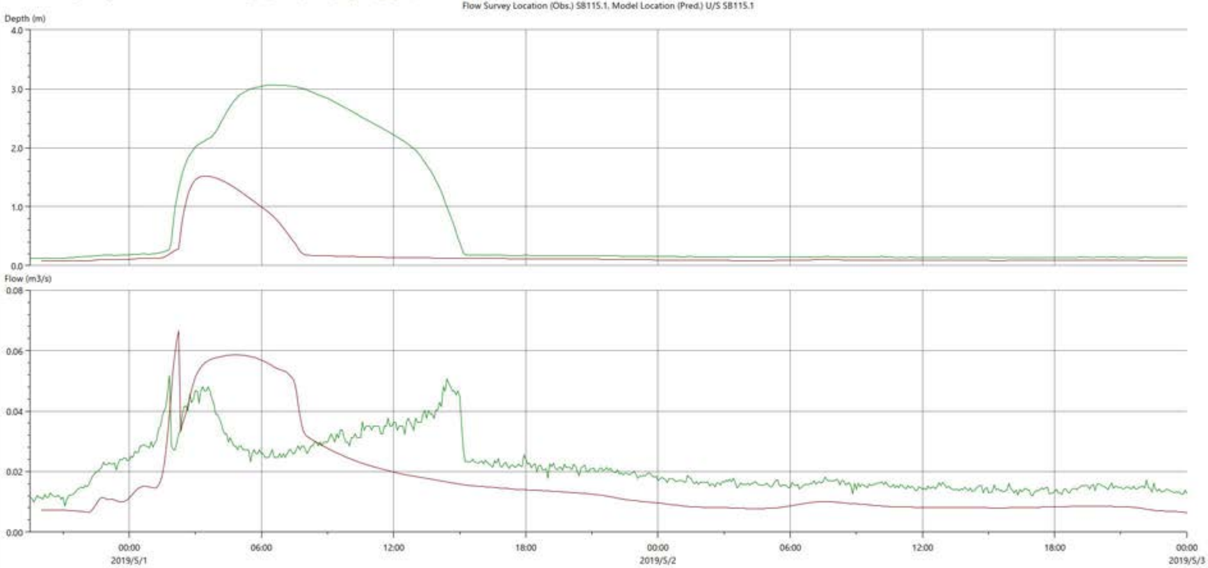
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.067	3.063	0.002	0.056	2803.379
..R01_Run202_FDV75_5May21>R_01_2019	0.057	0.292	0.003	0.050	2726.223

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 3 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.073	2.632	0.002	0.071	3391.918
..R01_Run202_FDV75_5May21>R_01_2019	0.069	1.048	0.005	0.061	3029.491

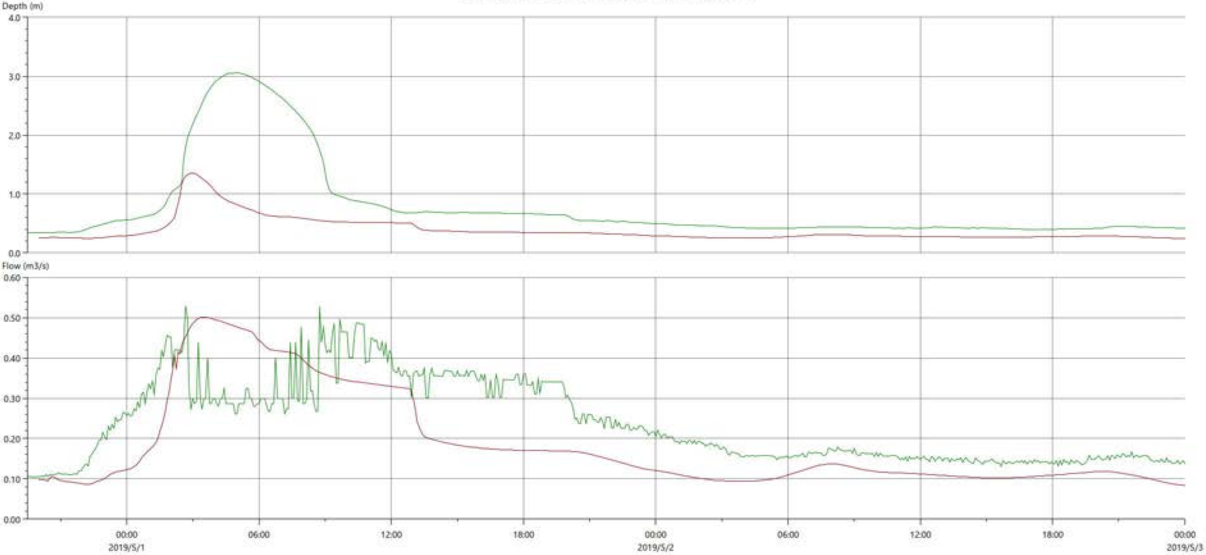
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.123	3.066	0.009	0.052	4079.990
..R01_Run202_FDV75_5May21>R_01_2019	0.081	1.519	0.006	0.067	3109.039

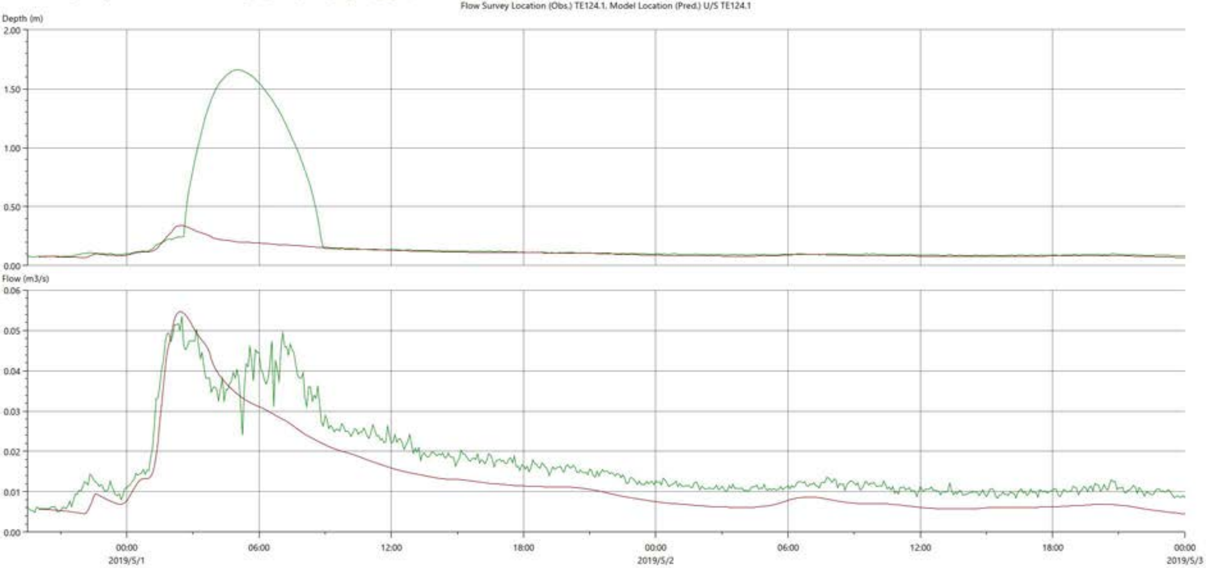
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 5 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)

Flow Survey Location (Obs.) TE011.1. Model Location (Pred.) U/S TE011.1



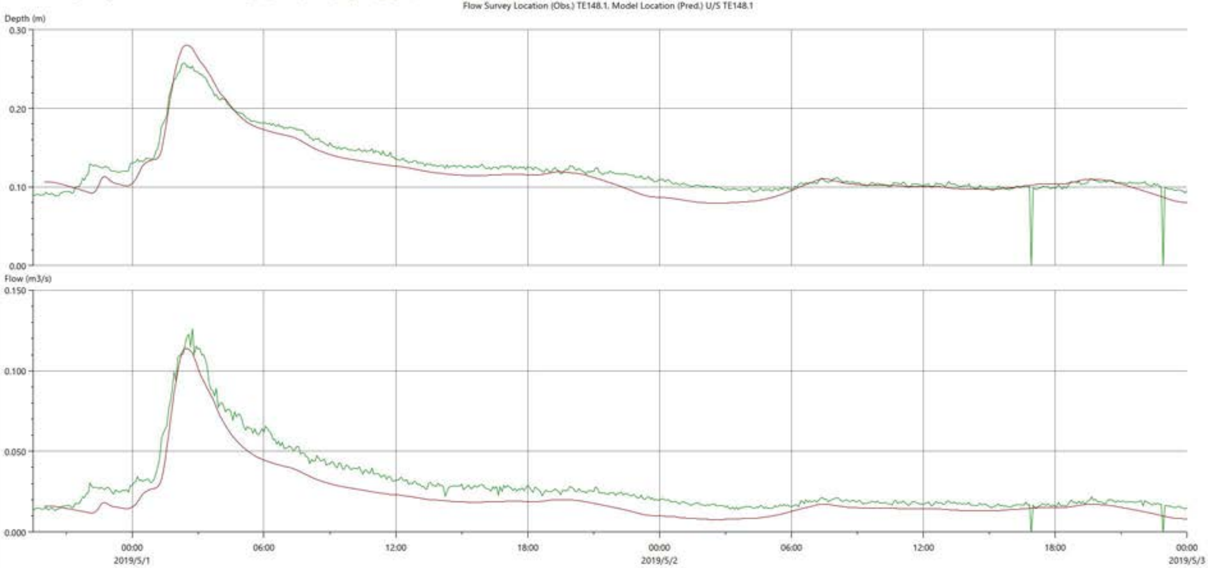
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.338	3.056	0.103	0.528	44808.826
..R01_Run202_FDV75_5May21>R_01_2019	0.244	1.357	0.084	0.501	34858.025

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 6 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



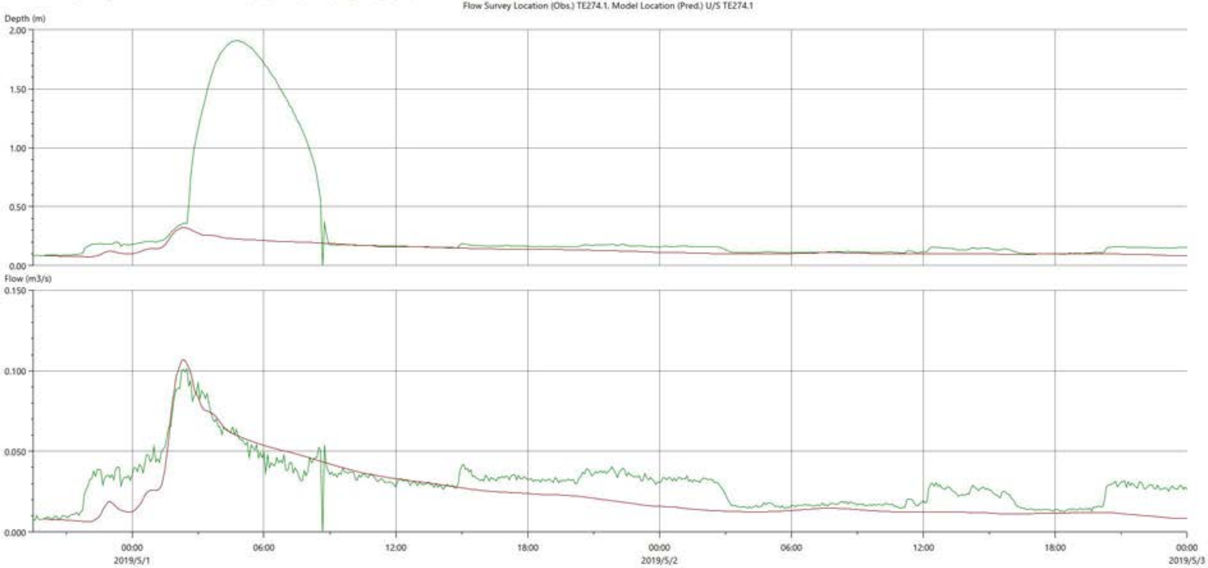
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.072	1.659	0.005	0.054	3256.234
..R01_Run202_FDV75_5May21>R_01_2019	0.069	0.340	0.005	0.055	2397.598

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.000	0.258	0.000	0.126	5545.354
...R01_Run202_FDV75_5May21>R_01_2019	0.079	0.281	0.008	0.114	4167.989

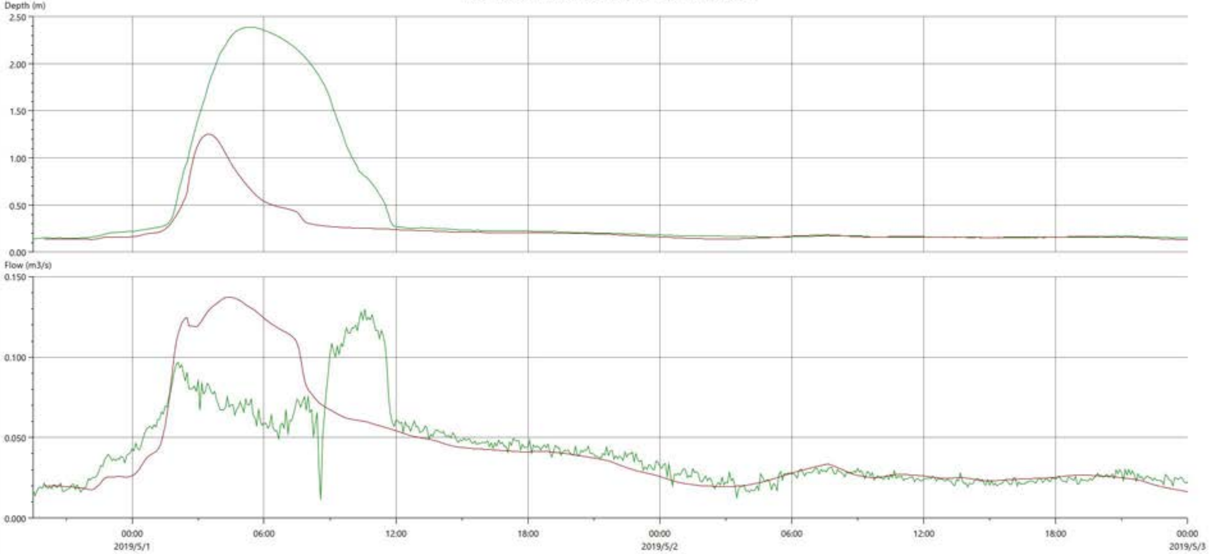
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.000	1.907	0.000	0.101	5842.363
..R01_Run202_FDV75_5May21>R_01_2019	0.074	0.322	0.006	0.107	4481.190

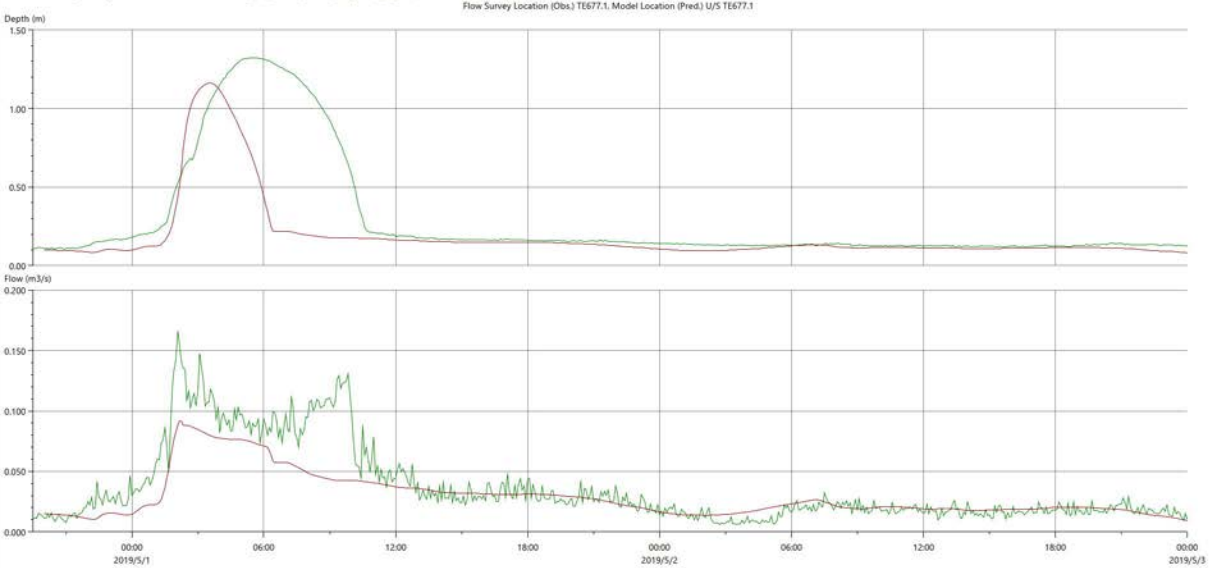
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 9 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)

Flow Survey Location (Obs.) TE464.1. Model Location (Pred.) U/S TE464.1



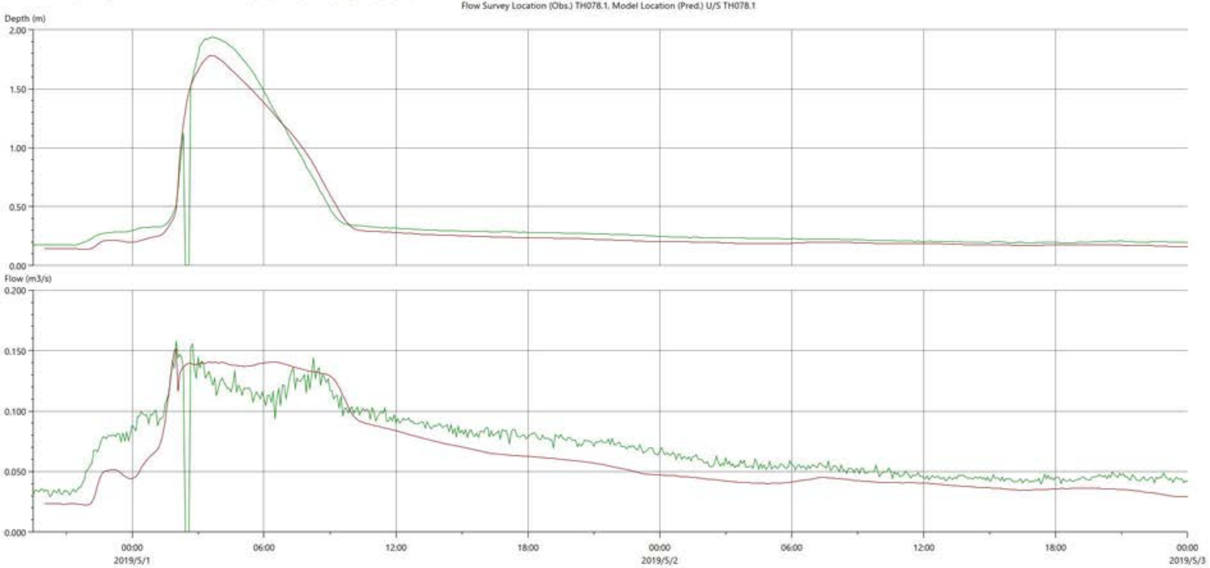
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.142	2.388	0.011	0.130	7846.480
..R01_Run202_FDV75_5May21>R_01_2019	0.131	1.253	0.016	0.137	8102.629

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



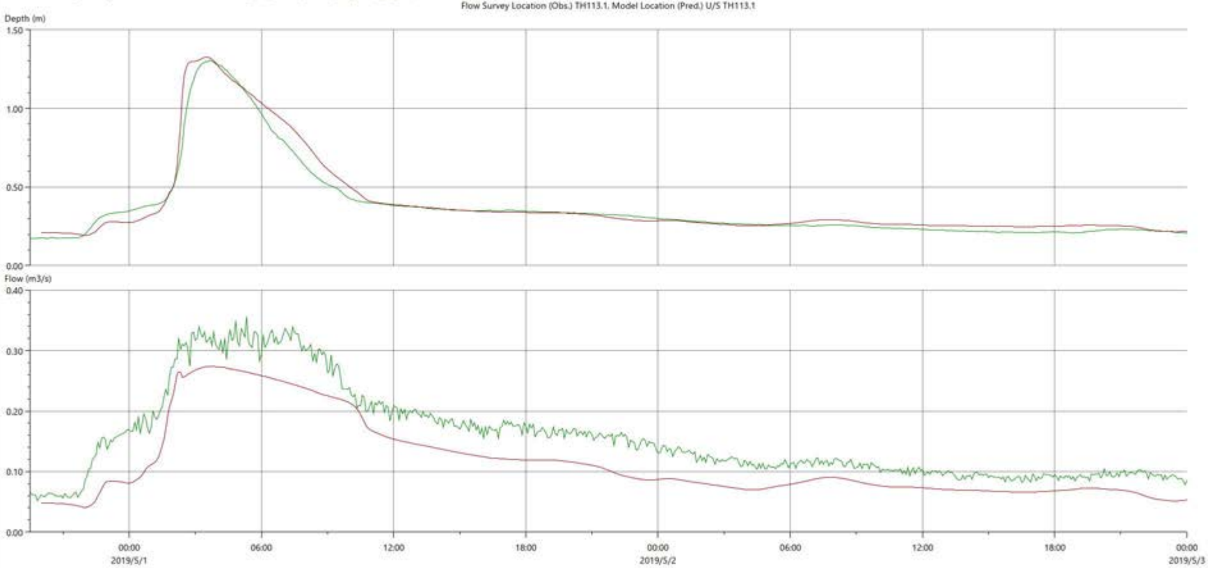
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.105	1.325	0.006	0.166	6862.282
...R01_Run202_FDV75_5May21>R_01_2019	0.080	1.162	0.009	0.092	5451.141

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.000	1.939	0.000	0.158	13399.834
..R01_Run202_FDV75_5May21>R_01_2019	0.139	1.779	0.022	0.152	11661.355

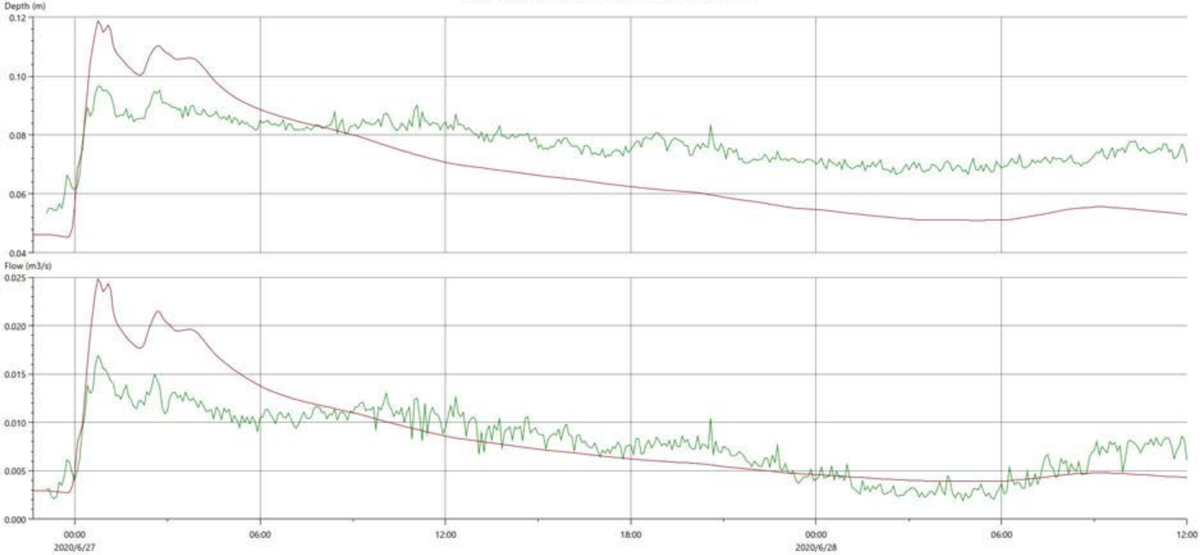
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:11:33 AM) Page 12 of 12
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-01 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R01_Run202_FDV75_5May21>R_01_2019 (2021-05-04 10:52:19 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.173	1.305	0.052	0.356	29710.773
..R01_Run202_FDV75_5May21>R_01_2019	0.192	1.327	0.041	0.274	21712.469

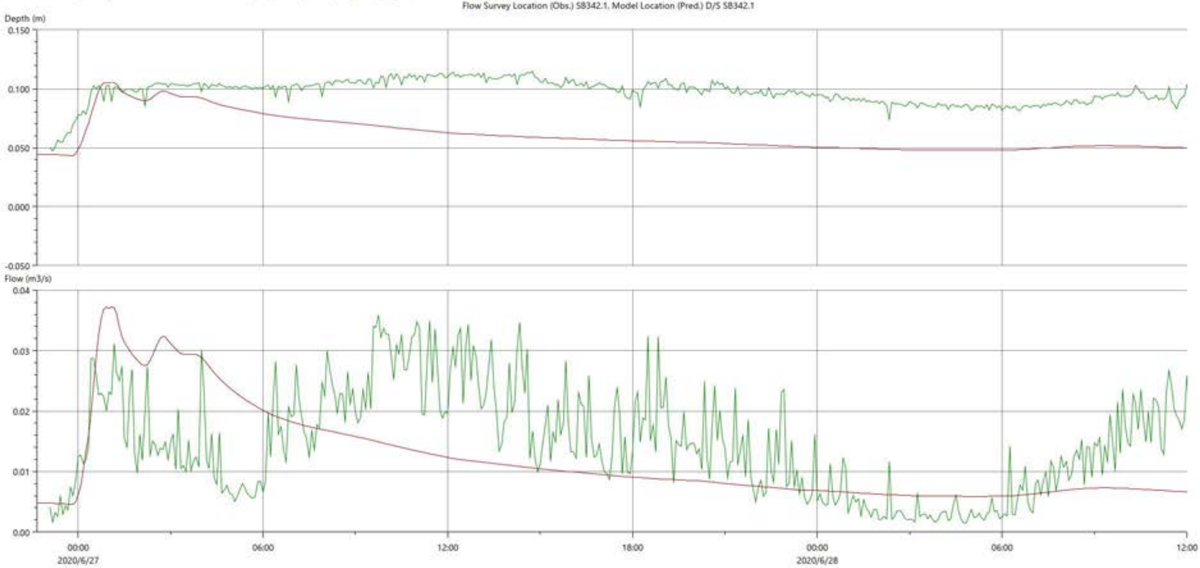
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:27:25 AM) Page 1 of 7
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

Flow Survey Location (Obs.) SB339.1, Model Location (Pred.) D/S SB339.1



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.053	0.097	0.002	0.017	1042.083
...R03_Run202_FDV75_5May21>R_03_2020	0.045	0.119	0.003	0.025	1103.610

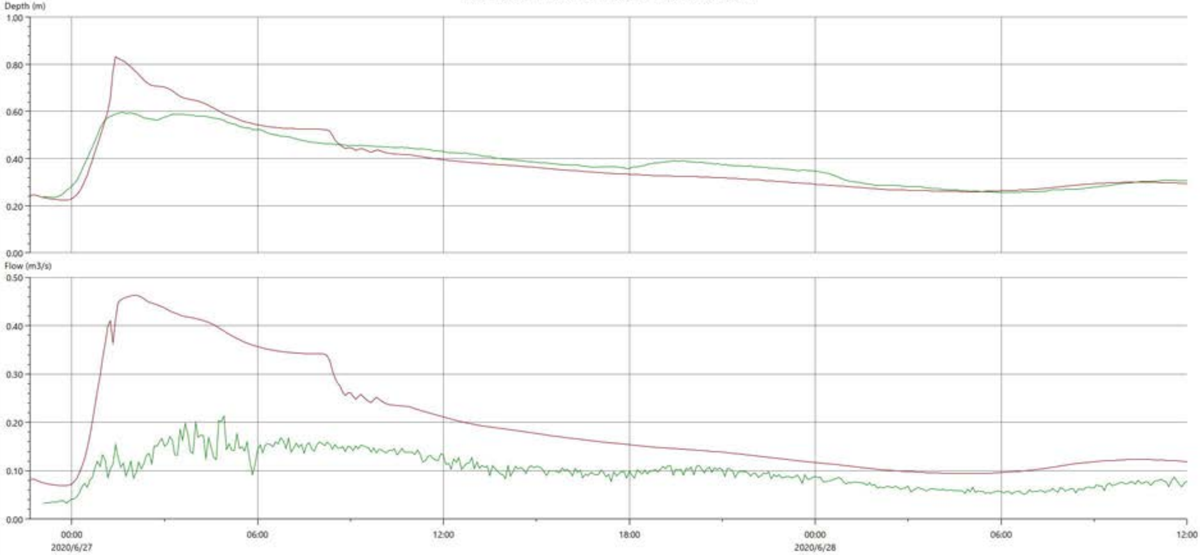
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.047	0.115	0.002	0.036	1949.761
...R03_Run202_FDV75_5May21>R_03_2020	0.043	0.105	0.005	0.037	1633.839

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:27:25 AM) Page 3 of 7
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

Flow Survey Location (Obs.) TE011.1, Model Location (Pred.) D/S TE011.1



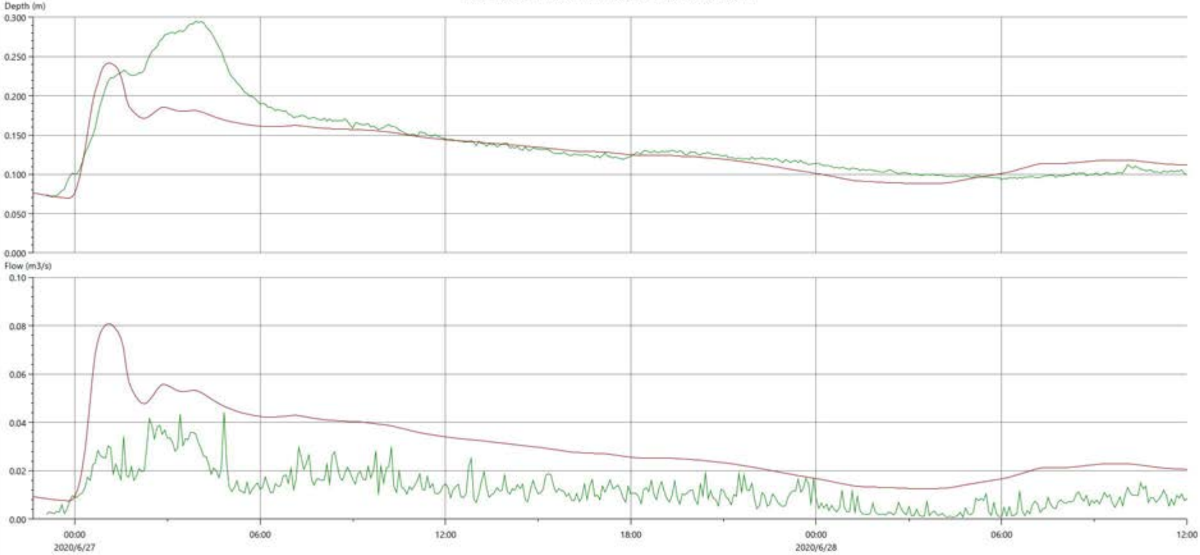
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.235	0.596	0.032	0.213	13222.680
...R03_Run202_FDV75_5May21>R_03_2020	0.224	0.833	0.069	0.463	25972.434

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:27:25 AM) Page 4 of 7

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)

Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

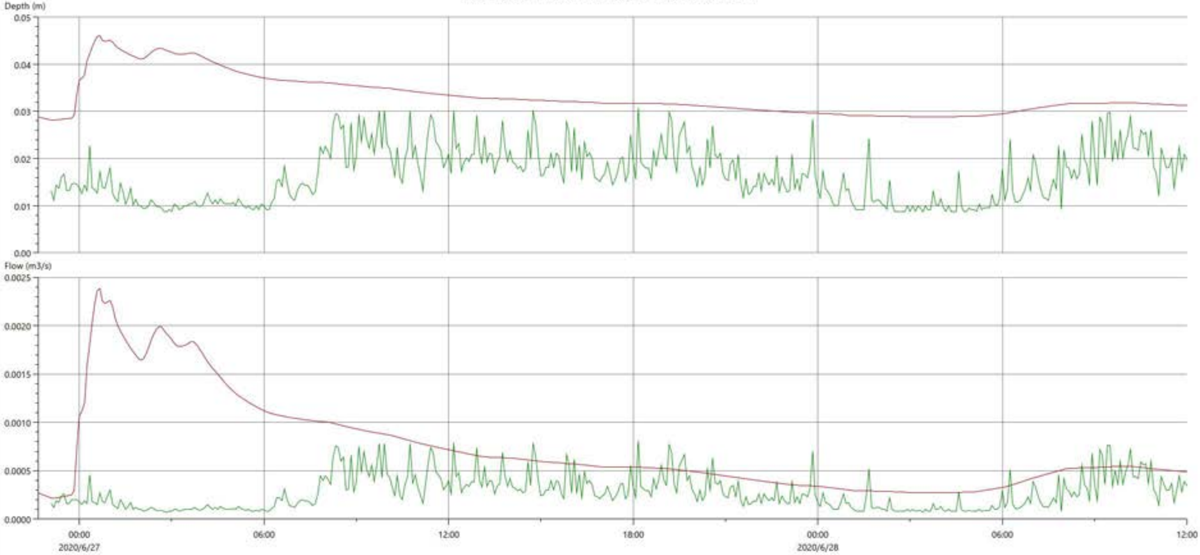
Flow Survey Location (Obs.) TE677.1, Model Location (Pred.) D/S TE677.1



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.071	0.295	0.001	0.044	1624.692
...R03_Run202_FDV75_5May21>R_03_2020	0.070	0.241	0.008	0.081	3915.162

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

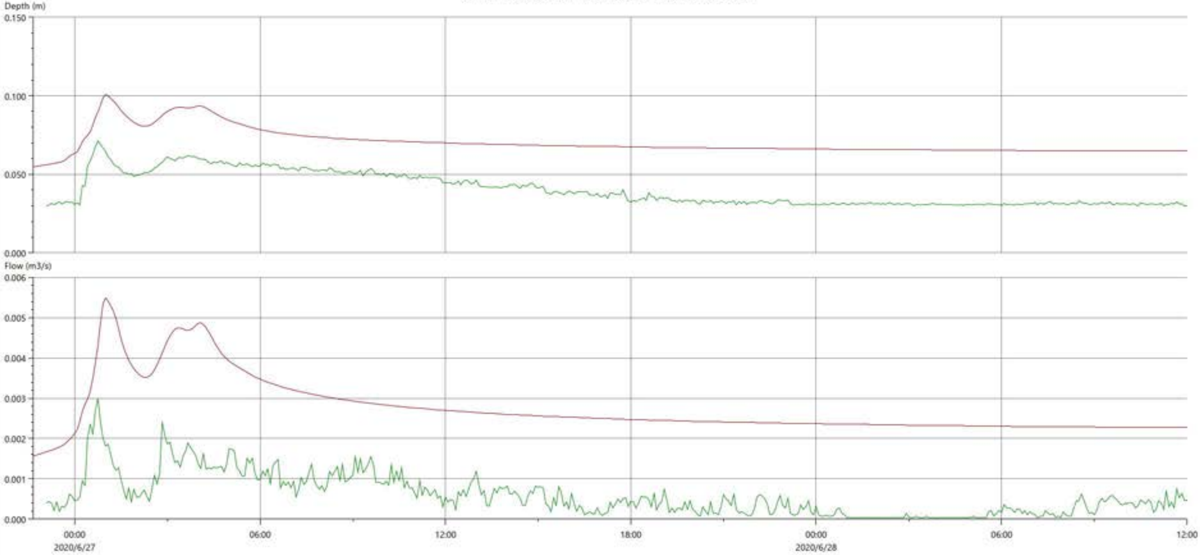
Flow Survey Location (Obs.) TE714.1, Model Location (Pred.) D/S TE714.1



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.009	0.031	0.000	0.001	36.602
...R03_Run202_FDV75_5May21>R_03_2020	0.028	0.046	0.000	0.002	97.610

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

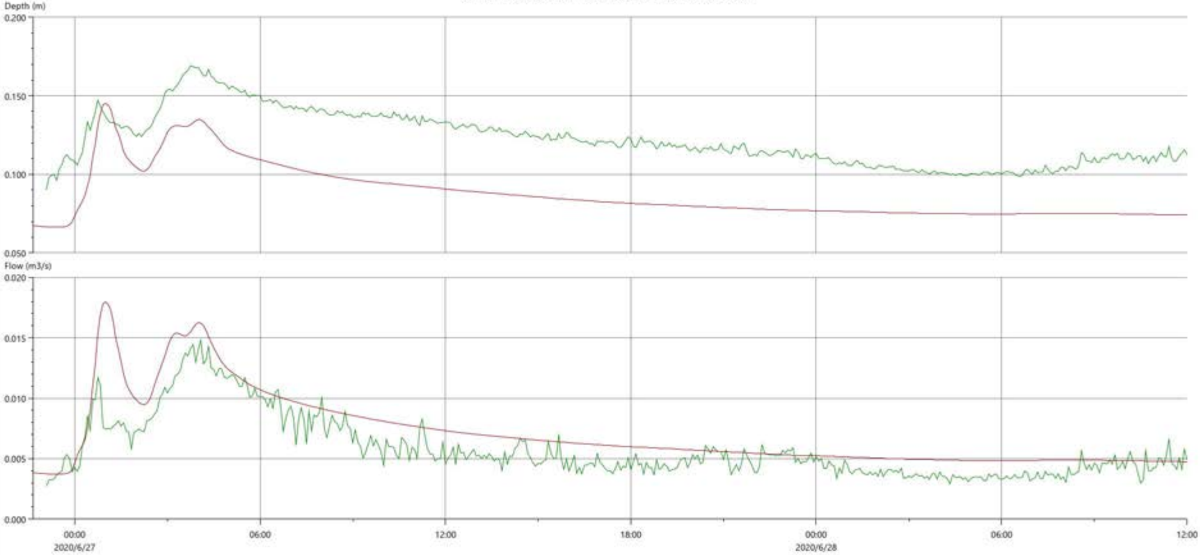
Flow Survey Location (Obs.) TH010.1, Model Location (Pred.) D/S TH010.1



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.030	0.071	0.000	0.003	76.973
...R03_Run202_FDV75_5May21>R_03_2020	0.055	0.101	0.002	0.005	369.012

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_03_2020 (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R03_Run202_FDV75_5May21>R_03_2020 (2021-05-04 10:56:10 AM)

Flow Survey Location (Obs.) TH023.1. Model Location (Pred.) D/S TH023.1

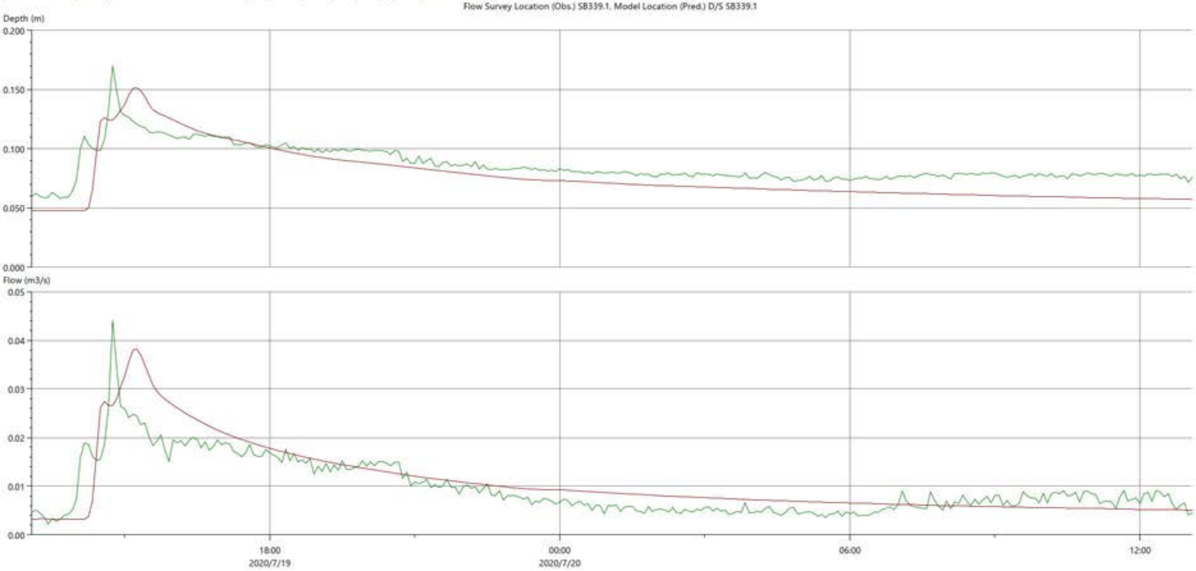


	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.090	0.169	0.003	0.015	770.528
...R03_Run202_FDV75_5May21>R_03_2020	0.066	0.145	0.004	0.018	955.004

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:31:26 AM) Page 1 of 7

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)

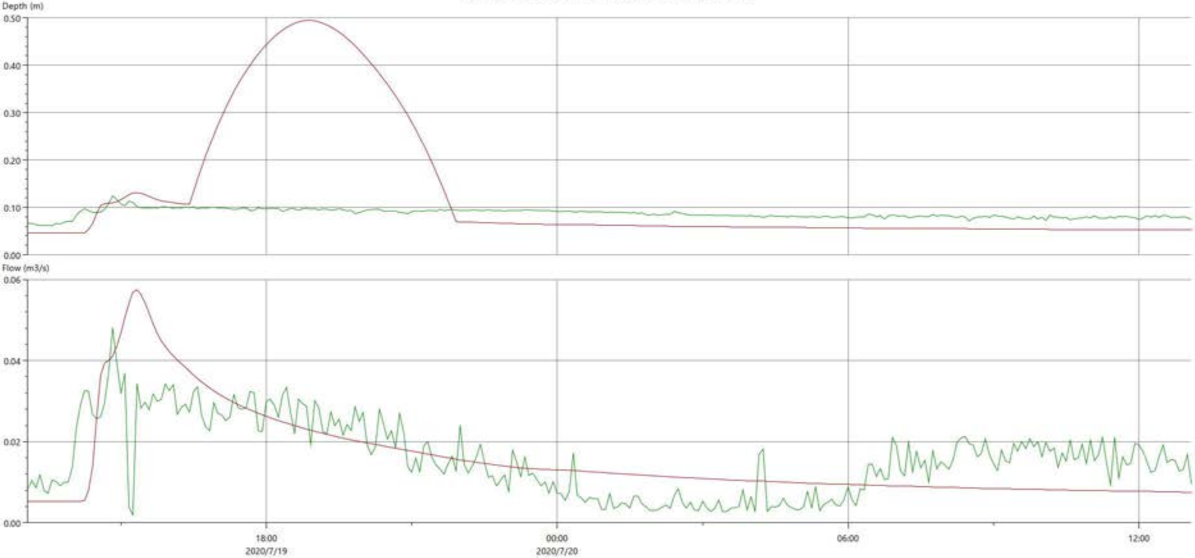
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)



		Depth		Flow		
		Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed		0.058	0.170	0.002	0.044	833.775
...R04_Run202_FDV75_5May21>R_04_2020		0.048	0.151	0.003	0.038	929.219

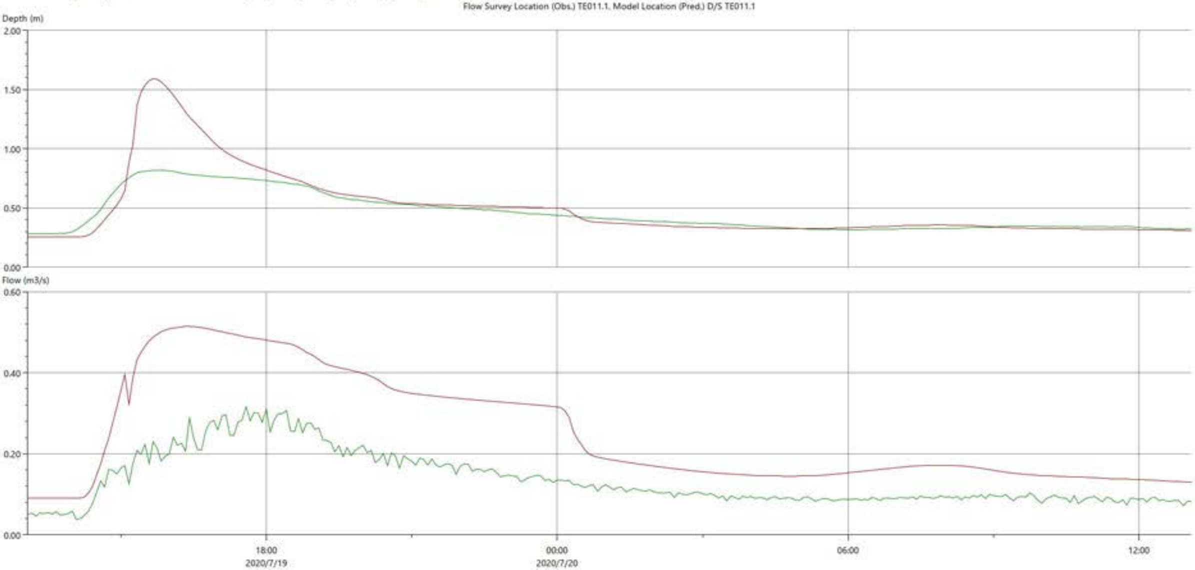
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)

Flow Survey Location (Obs.) SB342.1, Model Location (Pred.) D/S SB342.1



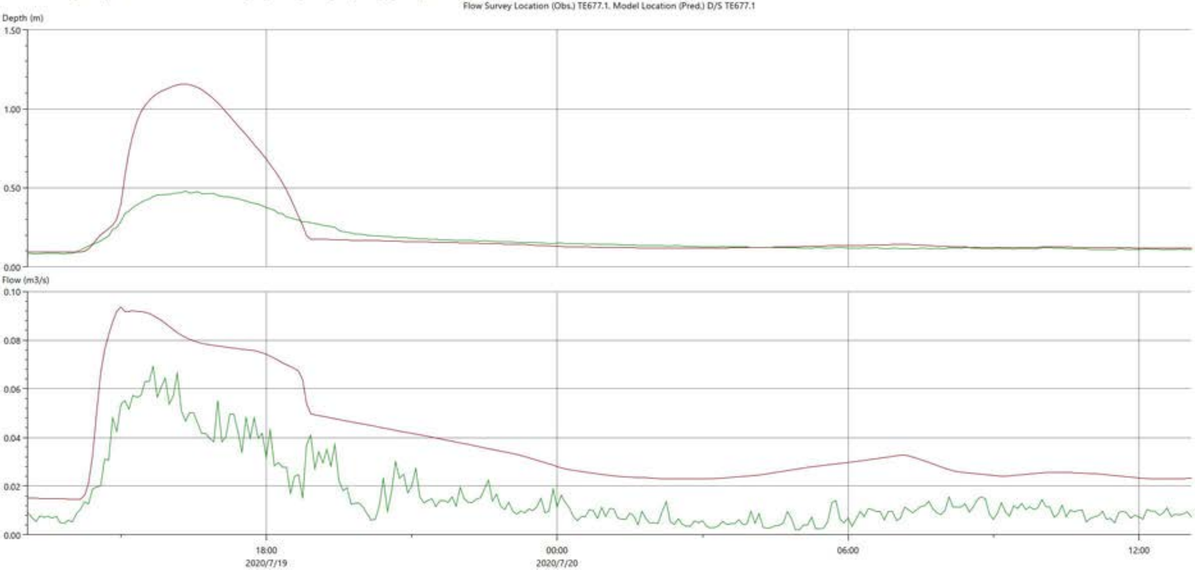
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.061	0.124	0.002	0.048	1369.098
...R04_Run202_FDV75_5May21>R_04_2020	0.046	0.495	0.005	0.057	1365.868

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)



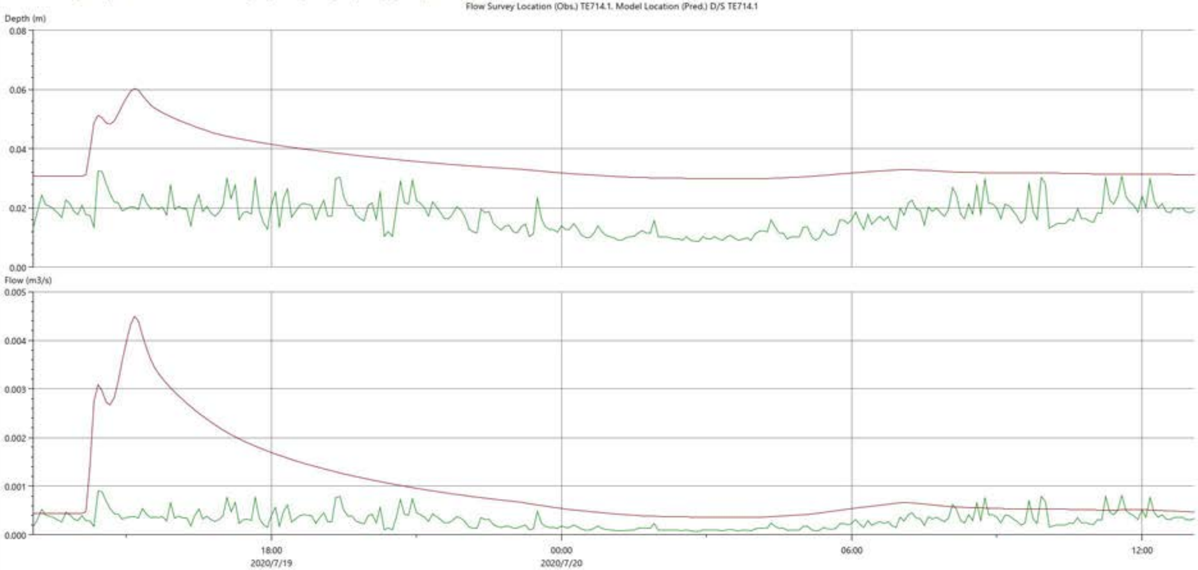
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.282	0.817	0.038	0.316	11755.148
...R04_Run202_FDV75_5May21>R_04_2020	0.256	1.591	0.090	0.515	21758.314

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:31:26 AM) Page 4 of 7
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)



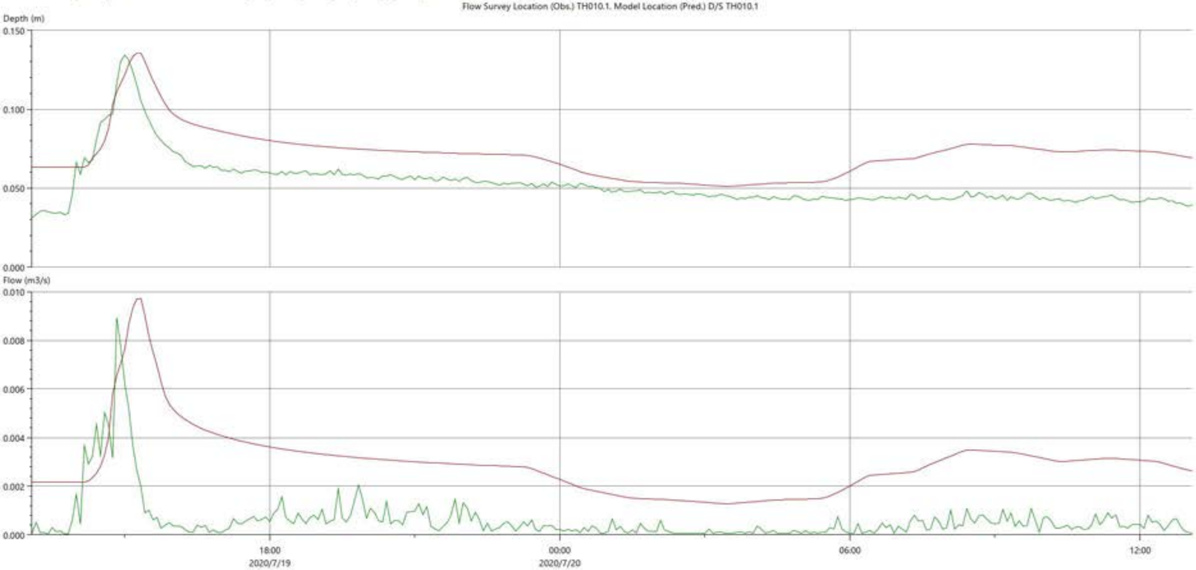
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.082	0.480	0.002	0.069	1425.860
...R04_Run202_FDV75_5May21>R_04_2020	0.095	1.155	0.015	0.094	3281.759

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:31:26 AM) Page 5 of 7
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.009	0.032	0.000	0.001	25.537
...R04_Run202_FDV75_5May21>R_04_2020	0.030	0.060	0.000	0.004	83.824

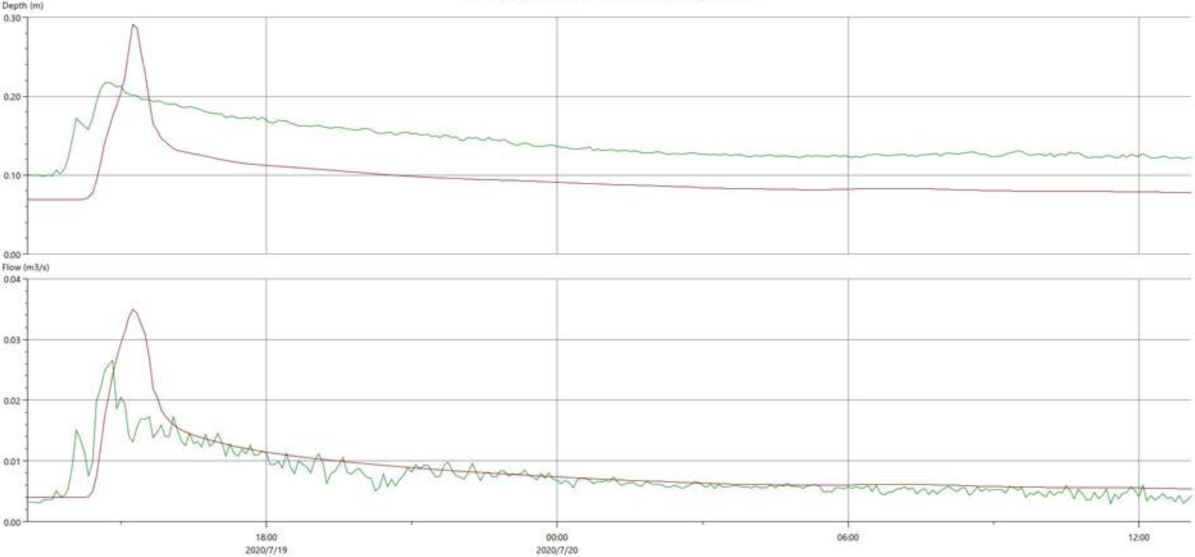
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.031	0.134	0.000	0.009	55.037
...R04_Run202_FDV75_5May21>R_04_2020	0.051	0.136	0.001	0.010	253.787

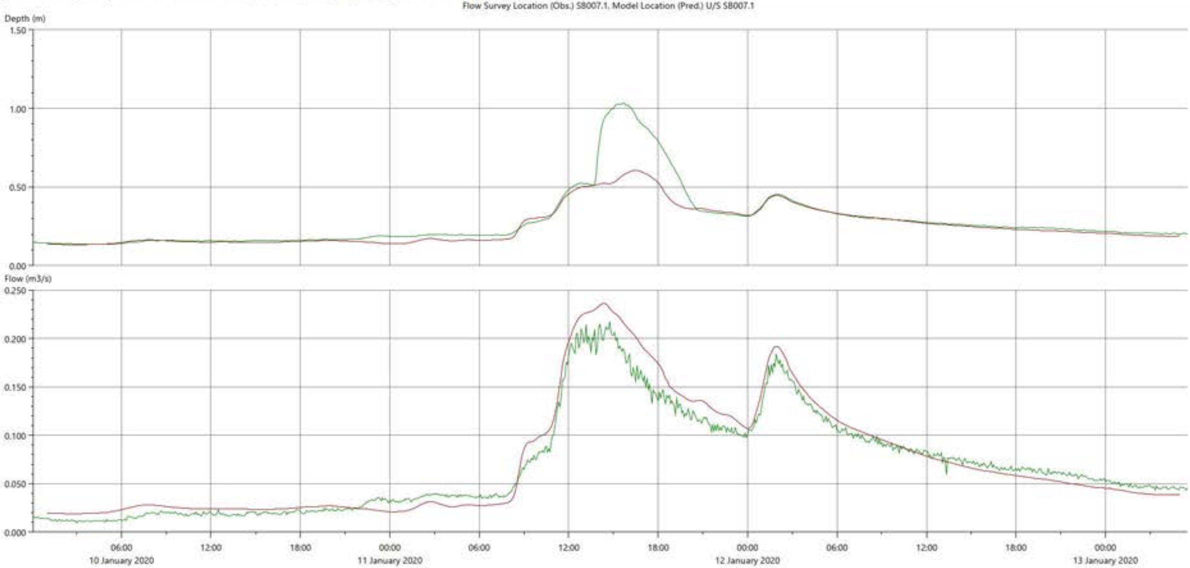
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:31:26 AM) Page 7 of 7
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R_04_2020! (2020-05-26 11:24:56 AM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R04_Run202_FDV75_5May21>R_04_2020 (2021-05-04 10:58:48 AM)

Flow Survey Location (Obs.) TH023.1. Model Location (Pred.) D/S TH023.1



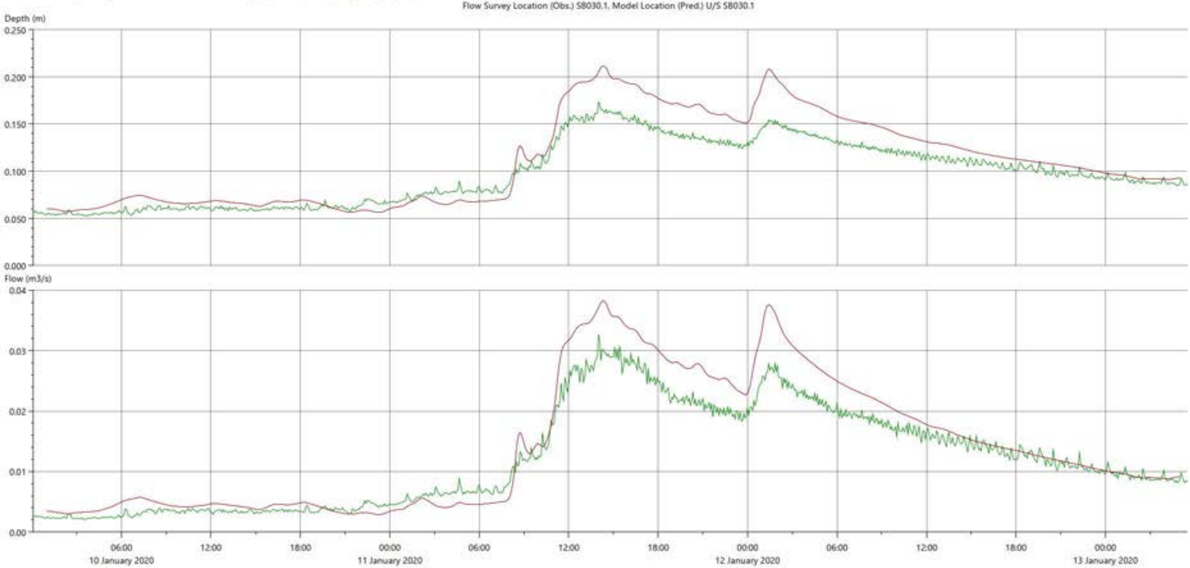
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.099	0.217	0.003	0.027	656.311
...R04_Run202_FDV75_5May21>R_04_2020	0.069	0.291	0.004	0.035	734.521

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 1 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.136	1.034	0.009	0.218	19222.334
..R10_Run202_FDV75_5May21>R_10_2020	0.135	0.607	0.019	0.236	20266.720

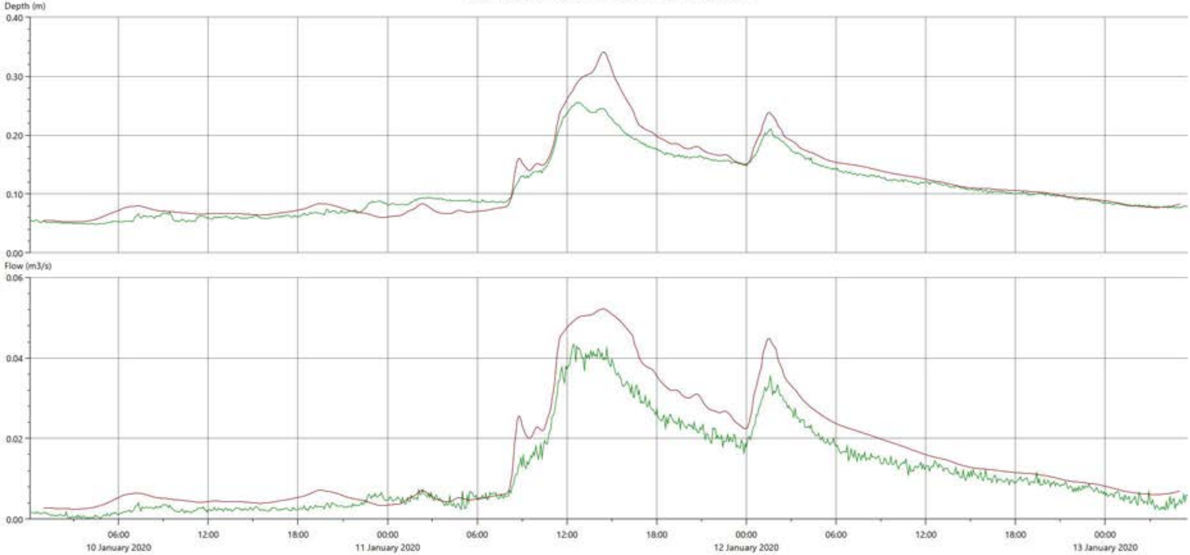
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.052	0.174	0.002	0.033	3369.732
..R10_Run202_FDV75_5May21>R_10_2020	0.056	0.212	0.003	0.038	3891.965

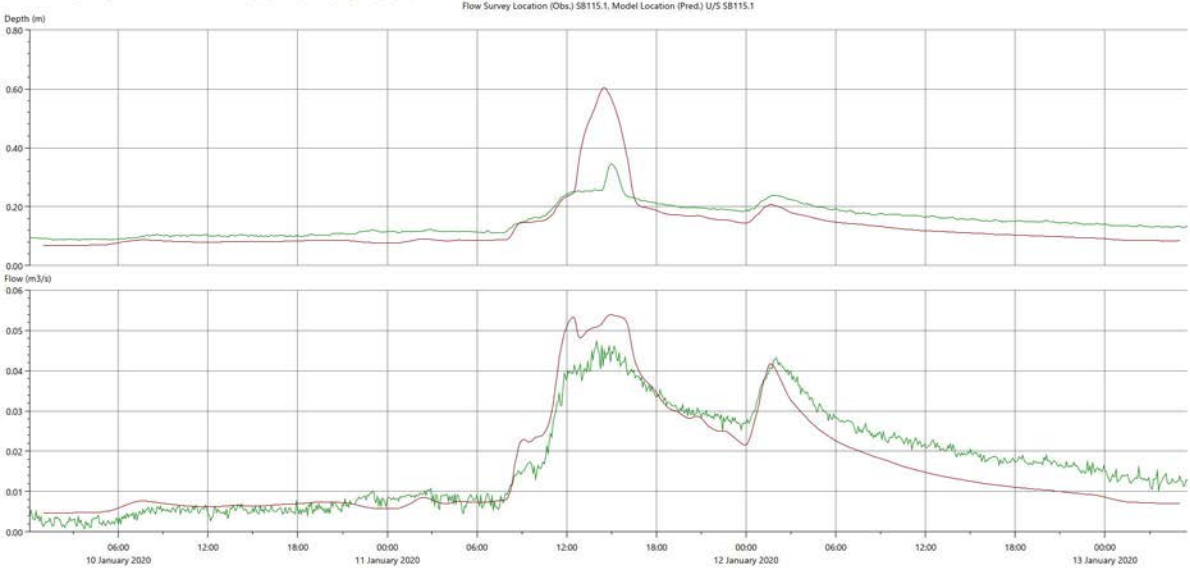
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 3 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)

Flow Survey Location (Obs.) S8060.1, Model Location (Pred.) U/S S8060.1



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.048	0.256	0.000	0.043	3255.975
...R10_Run202_FDV75_5May21>R_10_2020	0.052	0.341	0.002	0.052	4286.104

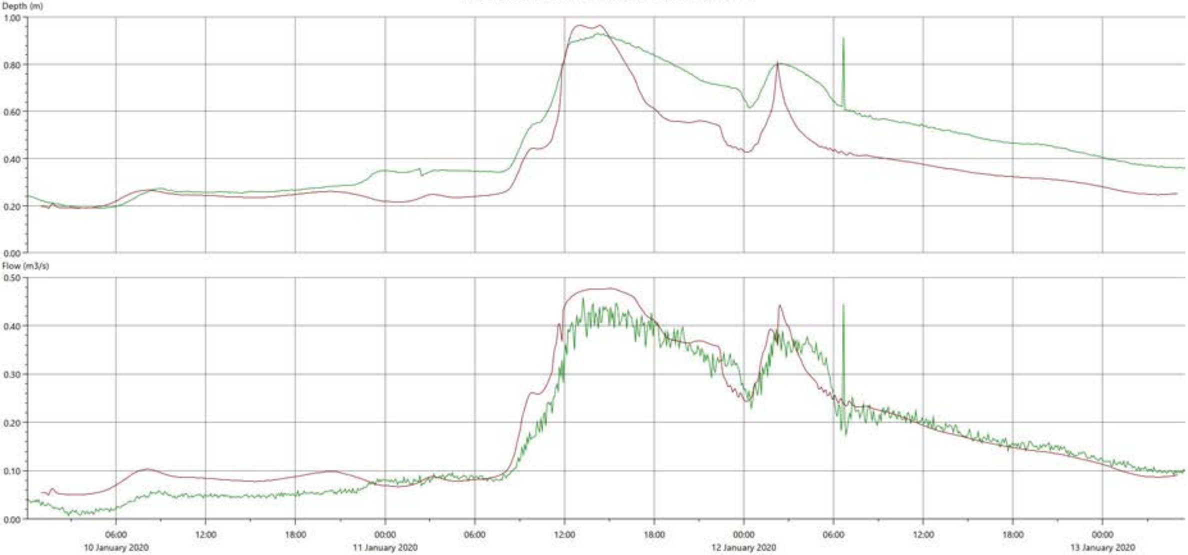
Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 4 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.086	0.346	0.001	0.047	4779.154
..R10_Run202_FDV75_5May21>R_10_2020	0.069	0.604	0.005	0.054	4418.150

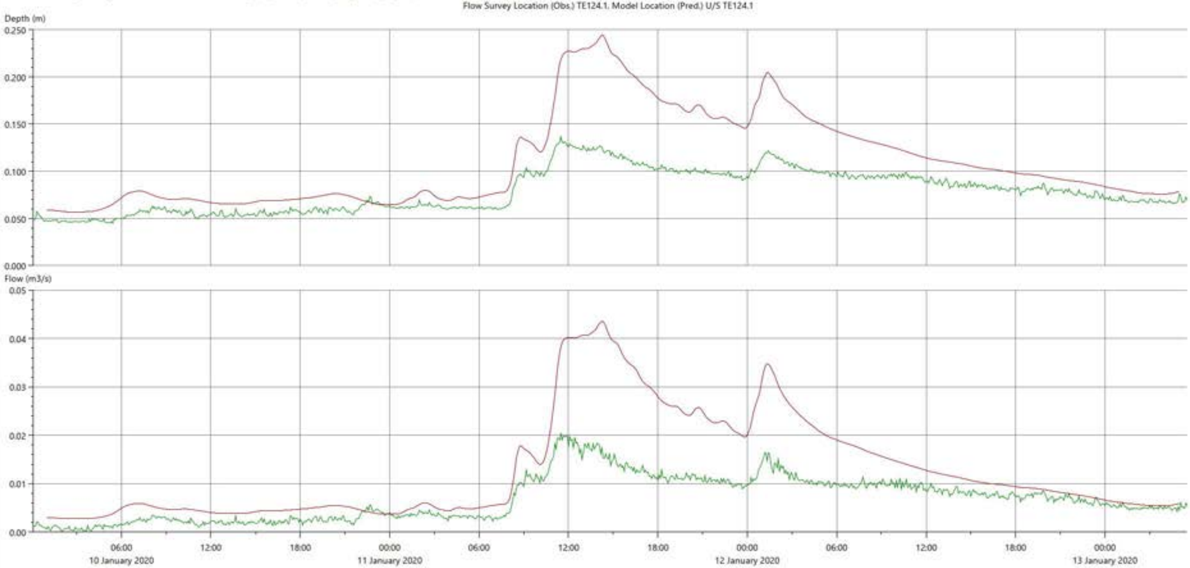
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)

Flow Survey Location (Obs.) TE011.1, Model Location (Pred.) U/S TE011.1



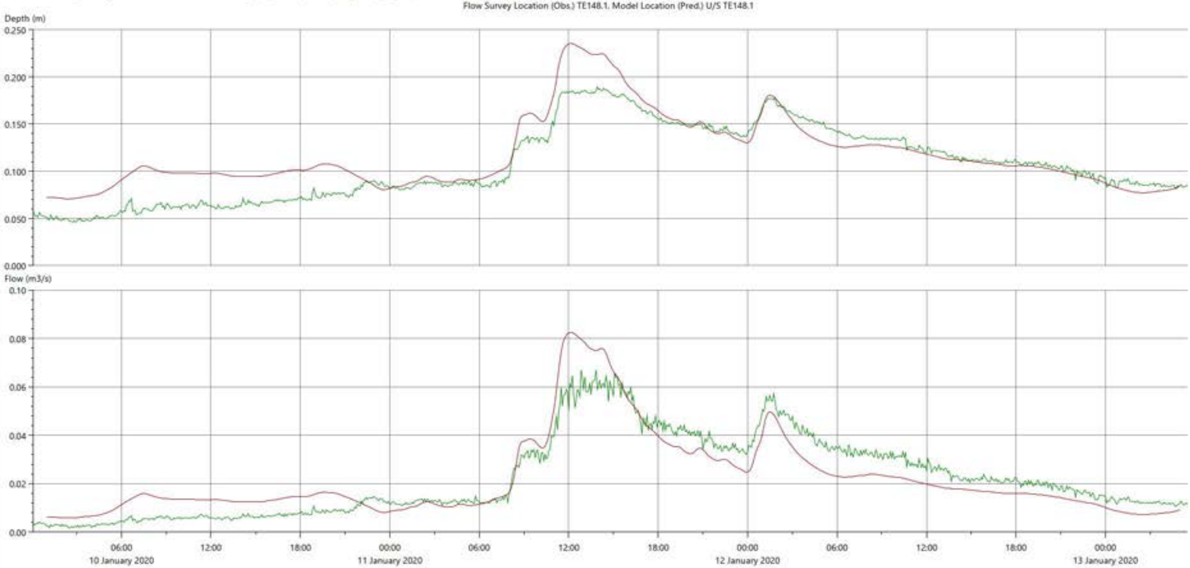
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.188	0.932	0.006	0.458	45890.529
...R10_Run202_FDV75_5May21>R_10_2020	0.189	0.966	0.050	0.477	49914.824

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 6 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



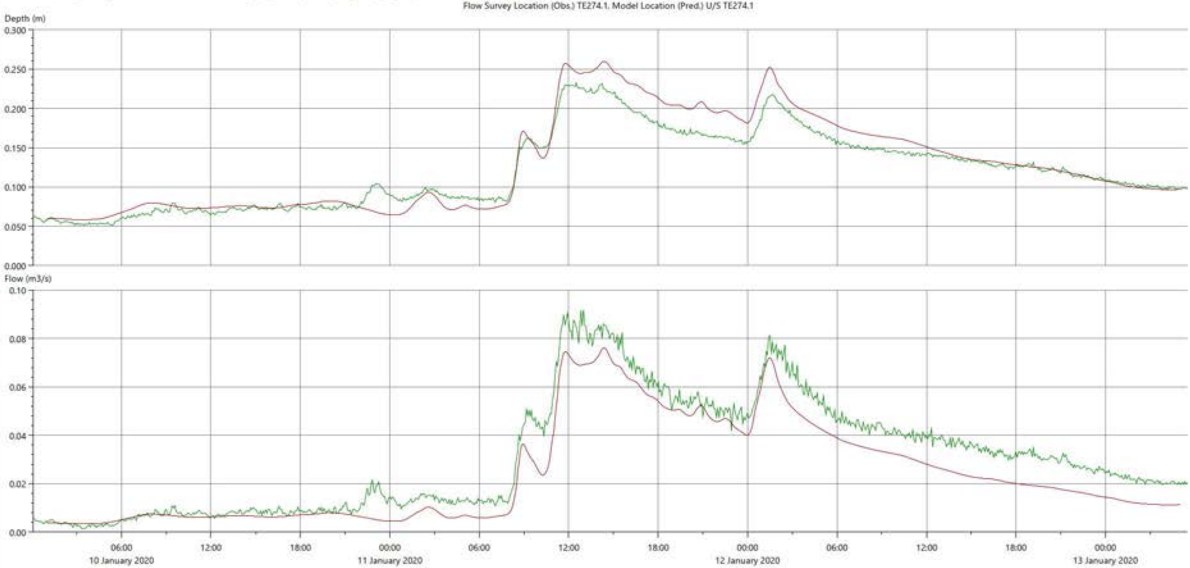
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.045	0.137	0.000	0.020	1905.441
...R10_Run202_FDV75_5May21>R_10_2020	0.057	0.244	0.003	0.044	3526.549

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



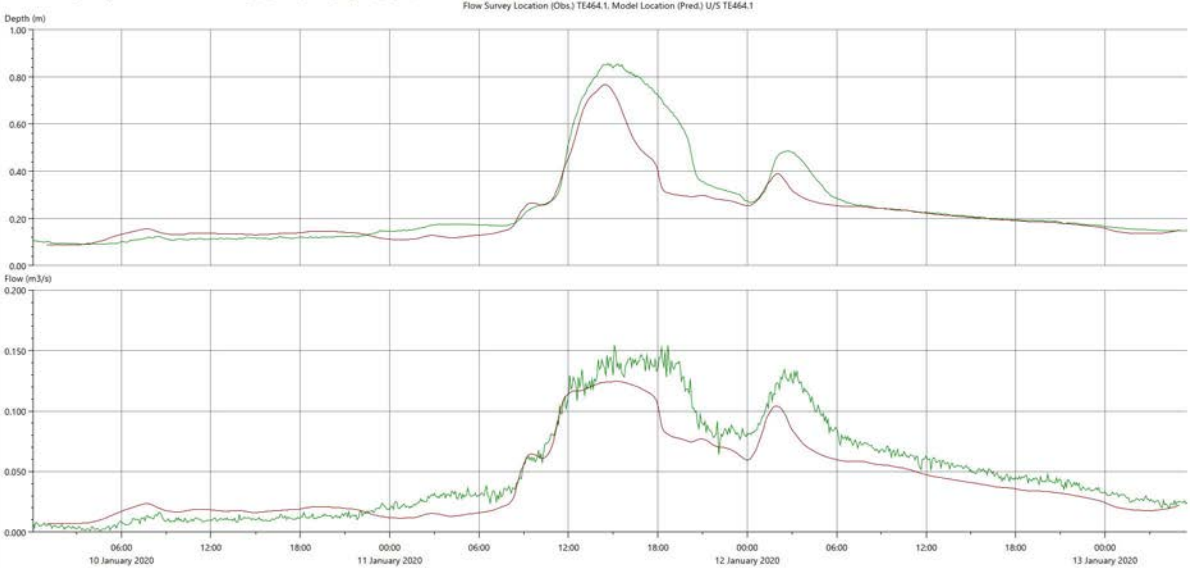
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.046	0.189	0.002	0.067	6216.400
..R10_Run202_FDV75_5May21>R_10_2020	0.071	0.235	0.006	0.083	6071.808

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



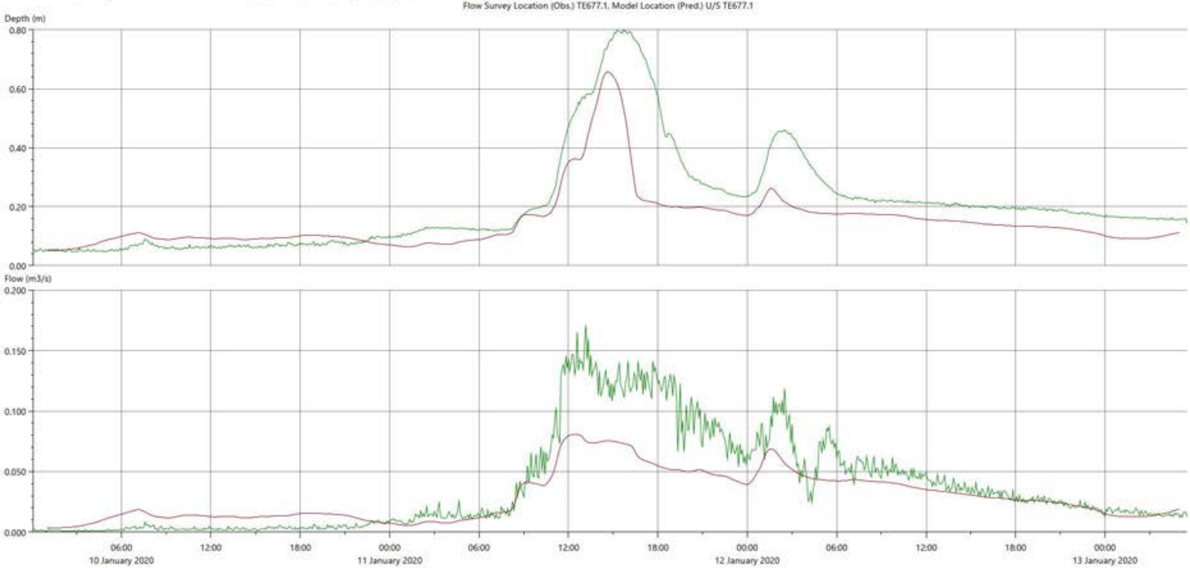
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.051	0.233	0.001	0.092	8606.239
..R10_Run202_FDV75_5May21>R_10_2020	0.058	0.260	0.003	0.076	6619.342

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 9 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



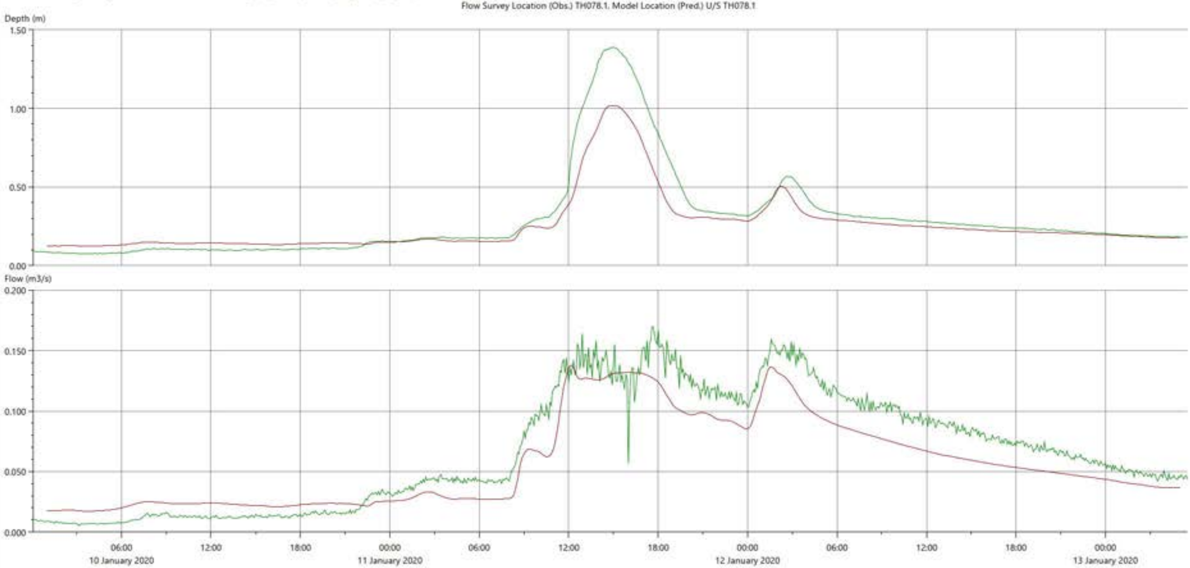
	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.090	0.857	0.001	0.154	14082.537
..R10_Run202_FDV75_5May21>R_10_2020	0.088	0.767	0.007	0.125	11699.151

Observed / Predicted Report Produced by 32AZS (2021-05-04 11:20:36 AM) Page 10 of 11
Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.046	0.799	0.000	0.171	10582.416
...R10_Run202_FDV75_5May21>R_10_2020	0.051	0.657	0.003	0.081	7881.816

Flow survey: >Tecumseh_Sanitary>Observed Flow Data>Depth-Flow-Velocity_R-10 (2020-03-06 12:00:26 PM)
Sim: >Tecumseh_Sanitary>RUNS>WWF Calibration>WWF_R10_Run202_FDV75_5May21>R_10_2020 (2021-05-04 10:53:44 AM)



	Depth		Flow		
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)
Observed	0.075	1.389	0.005	0.170	18652.882
..R10_Run202_FDV75_5May21>R_10_2020	0.124	1.018	0.017	0.138	15642.908

Appendix D

Solution Scenario Cost Summaries

DILLON CONSULTING

Table D.1 Solution Scenario Cost Summary - Cedarwood Drainage Area
Sanitary Model Recalibration and Basement Flood Mitigation Study
Town of Tecumseh

September 29, 2023

No.	Scenario	Description	Recommended Infrastructure	Recommended Sewer Size	Recommended Sewer Length	Road Reconstruction Costs *	Sewer Construction Costs*	Total Construction Costs *	Total Scenario Infrastructure Costs *	Recommended Number of Homes in FDD Program	Estimated FDD Program Costs	Total Scenario Costs	Watermain Improvements	Miscellaneous*	Total Infrastructure + Watermain Imrpovement Costs
T1	Existing Conditions	System conditions based on observed sewer monitoring.	N/A	-	-	-	-	-	-	-	-	-			
T2	Ultimate Conditions – No Sewer Improvements or RDII Reduction (Baseline)	Under a 1:5, 24 hour storm, level of service under full development without implementing measures to mitigate basement flooding or RDII.	N/A	-	-	-	-	-	-	-	-	-			
T3	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:5 Yr Storm	Infrastructure improvements required without implementing any RDII reduction improvements.	Riverside	1950	392	$ 1,125,000	$ 2,590,000	$ 3,715,000	$ 10,430,000	-	-	$ 10,430,000	-	-	$ 16,753,750
			Arlington	525	374	$ 1,075,000	$ 469,000	$ 1,544,000					-	-	
			St. Thomas/Green Valley	1200	650	$ 1,867,000	$ 2,036,000	$ 3,903,000					-	$ 4,878,750	
			Lemire	750	160	$ 460,000	$ 264,000	$ 724,000					$ 800,000	-	
			Lanoue	600	129	$ 371,000	$ 173,000	$ 544,000					$ 645,000	-	
T3B	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:25 Yr Storm	Infrastructure improvements required without implementing any RDII reduction improvements.	Riverside	2200	603	$ 1,732,000	$ 3,988,000	$ 5,720,000	$ 19,181,000	-	-	$ 19,181,000	-	-	$ 34,482,250
			Arlington	1800	374	$ 1,074,000	$ 469,000	$ 1,543,000					-	-	
			St. Thomas/Green Valley	900 (East)	926	$ 2,659,000	$ 1,934,000	$ 4,593,000					$ 4,630,000	$ 5,741,250	
				1050 (East)	484	$ 1,390,000	$ 1,306,000	$ 2,696,000						-	
				900 (West)	400	See above.	$ 731,000	$ 731,000					$ 2,000,000	-	
			Lemire*	1200	466	$ 1,338,000	$ 767,000	$ 2,105,000					$ 2,330,000	-	
			Lanoue	1050	120	$ 345,000	$ 161,000	$ 506,000					$ 600,000	-	
			Edgewater	525	360	$ 835,000	$ 452,000	$ 1,287,000					-	-	
T4	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:5 Yr Storm	Implementing a Foundation Drain Disconnection Program on a regional area basis.	Riverside	-	-	-	-	-	$ 5,171,000	967.2	$ 19,344,000	$ 24,515,000	-	-	$ 30,838,750
			Arlington	-	-	-	-	-					-	-	
			St. Thomas/Green Valley	1200	650	$ 1,867,000	$ 2,036,000	$ 3,903,000					-	$ 4,878,750	
			Lemire*	750	160	$ 460,000	$ 264,000	$ 724,000					$ 800,000	-	
			Lanoue	600	129	$ 371,000	$ 173,000	$ 544,000					$ 645,000	-	
T4B	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:25 Yr Storm	Infrastructure solutions required to meet a 1:25 year level of service.	Riverside	1650	392	$ 1,125,000	$ 2,051,000	$ 3,176,000	$ 11,804,000	967.2	$ 19,344,000	$ 31,148,000	-	-	$ 40,599,250
			Arlington	-	-	-	-	-					-	-	
			St. Thomas/Green Valley	1500	285	$ 819,000	$ 1,389,000	$ 2,208,000					-	$ 2,760,000	
				1800	364	$ 1,045,000	$ 1,964,000	$ 3,009,000					-	$ 3,761,250	
			Lemire*	1200	466	$ 1,338,000	$ 1,415,000	$ 2,753,000					$ 2,330,000	-	
			Lanoue	1050	120	$ 345,000	$ 313,000	$ 658,000					$ 600,000	-	
T5	Ultimate Conditions – Sewer Improvements and Area Wide FDD	Implementing a Foundation Drain Disconnection Program.	Green Valley	900	650	$ 1,867,000	$ 1,295,000	$ 3,162,000	$ 4,430,000	2477.6	$ 49,552,000	$ 53,982,000	-	$ 3,952,500	$ 59,379,500
			Lemire	750	160	$ 460,000	$ 264,000	$ 724,000					$ 800,000	-	
			Lanoue	600	129	$ 371,000	$ 173,000	$ 544,000					$ 645,000	-	

*Construction costs include 30% Construction Contingency and 15% Engineering.
** Sanitary Sewer Improvenents coinside with storm sewer improvement recommended in the Town of Tecumseh Master Drainage Plan
Construction costs are based on 2021 Construction prices.

Table D.2 Solution Scenario Cost Summary - CR22 Drainage Area
Sanitary Model Recalibration and Basement Flood Mitigation Study
Town of Tecumseh

September 29, 2023

No.	Scenario	Description	Recommended Infrastructure	Recommended Sewer Size	Recommended Sewer Length	Road Reconstruction Costs *	Sewer Construction Costs*	Total Construction Costs *	Total Infrastructure Costs *	Recommended Number of Homes in FDD Program	Estimated FDD Program Costs	Total Scenario Costs
TH1	Existing Conditions	System conditions based on observed sewer monitoring.	N/A	-	-	-	-	-	-	-	-	-
TH2	Interim Conditions	Assume construction of the north portion of the West Tecumseh Hamlet Trunk sewer and the Intersection Rd. Relief Sewer to St. Anne. Assumes that that the Sluice Gate at CR22/Lesperance is closed	N/A	-	-	-	-	-	-	-	-	-
TH3	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:5 Yr Storm	Improvements would be required without implementing any RDII reduction improvements.	Intersection	600	145	$ 417,000.00	$ 195,000.00	$ 612,000.00	$ 612,000.00	-	-	$ 612,000.00
TH3B	Ultimate Conditions – Sewer Improvements and No FDD (RDII Reduction) – 1:25 Yr Storm	Improvements required without implementing any RDII reduction improvements.	Charlene	600	180	$ 418,000.00	$ 226,000.00	$ 644,000.00	$ 3,134,000.00	-	-	$ 3,134,000.00
			Intersection	600	145	$ 417,000.00	$ 195,000.00	$ 612,000.00				
			Gouin	450	100	$ 288,000.00	$ 126,000.00	$ 414,000.00				
			Lesperance (N of Gouin)	750	112	$ 322,000.00	$ 100,000.00	$ 422,000.00				
			Lesperance (N of Charlene)	1050	210	$ 603,000.00	$ 439,000.00	$ 1,042,000.00				
TH4	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:5 Yr Storm	Implementing a Foundation Drain Disconnection Program on a regional area basis.	N/A	-	-	-	-	-	-	240	$ 4,800,000.00	$ 4,800,000.00
TH5	Ultimate Conditions – Sewer Improvements and Targeted FDD – 1:25 Yr Storm	Infrastructure solutions designed to meet a 1:25 year level of service.	Charlene	450	180	$ 418,000.00	$ 226,000.00	$ 644,000.00	$ 3,074,000.00	240	$ 4,800,000.00	$ 7,874,000.00
			Intersection	600	145	$ 417,000.00	$ 195,000.00	$ 612,000.00				
			Gouin	450	112	$ 322,000.00	$ 141,000.00	$ 463,000.00				
			Lesperance (N of Gouin)	600	74	$ 213,000.00	$ 100,000.00	$ 313,000.00				
			Lesperance (N of Charlene)	900	210	$ 603,000.00	$ 439,000.00	$ 1,042,000.00				
TH6	Ultimate Conditions – Area Wide FDD	Implementing a Foundation Drain Disconnection Program.	N/A	-	-	-	-	-	-	400	$ 8,000,000.00	$ 8,000,000.00
TH7	Ultimate Conditions – Targeted FDD	Implementing a Foundation Drain Disconnection Program.	N/A	-	-	-	-	-	-	240	$ 4,800,000.00	$ 4,800,000.00

*Construction costs include 30% Construction Contingency and 15% Engineering.
** Sanitary Sewer Improvements coincide with storm sewer improvements recommended in the Town of Tecumseh Master Drainage Plan (2019).
Construction costs are based on 2023 Construction prices.