Dillon Consulting

City of Windsor

West Windsor Flood Risk Study

Climate Change Risk Assessment

January 2023 – 21-2409

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City of Windsor
Engineering Department
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Engineer II

West Windsor Flood Risk Study

We are pleased to present this complete final report for the West Windsor Flood Risk Study for your review and comment.

Sincerely,

DILLON CONSULTING LIMITED

Nick Emery, P.Eng.
Project Manager, Associate

NE:tfn

Our file: 21-2409

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Acronyms and Abbreviations

AR4 – Fourth Assessment Report Released by IPCC

AR5 – Fifth Assessment Report Released by IPCC

C-Clap – Clausius-Clapeyron Temperature Scaling Method

CCRA – Climate Change Risk Assessment

CGVD – Canadian Geodetic Vertical Datum

CMIP5 – Coupled Model Intercomparison Project 5

CSO – Combined Sewer Overflow

DMAF – Disaster Mitigation and Adaptation Funding

EA – Environmental Assessment

ECCC – Environment and Climate Change Canada

ETR – Essex Terminal Railway

EVA – Extreme Value Analysis

GCM – Global Climate Model

GEV – Generalized Extreme Value Analysis

GHG – Greenhouse Gas

HGL – Hydraulic Grade Line

HIRA – County of Essex Hazard Identification and Risk Assessment

IPCC – Intergovernmental Panel on Climate Change

IGLD'85 – International Great Lakes Datum 1985

I&I – Inflow and Infiltration

LOS – Level of Service

LRWRP – Lou Romano Water Reclamation Plant

MEA – Municipal Engineers Association

MH – Maintenance Hole

NOAA – National Oceanic and Atmospheric Administration

PIC – Public Information Centre

PIEVC – Public Infrastructure Engineering Vulnerability Committee

ROW – Right-of-Way

RTB – Retention Treatment Basin

SCFPMP – City of Windsor Sewer and Coastal Flood Protection Master Plan

TBL – Triple Bottom Line Analysis

WPA – Windsor Port Authority

Executive Summary

The Detroit River has undergone a period of high water levels in recent years, peaking in May 2020. The West Windsor area experienced localized flooding at a number of shoreline properties and municipal roadways in proximity to the riverfront. In addition, the elevated river levels during this time caused a substantial increase of flow to enter the Lou Romano Water Reclamation Plant.

The West Windsor Flood Risk Study and Climate Change Risk Assessment (the Study) was developed in accordance with recommendations of the City of Windsor Sewer and Coastal Flood Protection Master Plan (Windsor SCFPMP) (Dillon and Aquafor Beech, 2020) which recognized the West Windsor shoreline as being vulnerable to high river levels. Due to the noted increased vulnerability within the area, the Windsor SCFPMP recommended the completion of an additional Flood Risk Assessment for the West Windsor Area.

The primary goals of the Study were to:

1. Using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol, evaluate the vulnerability of assets within the study area related to coastal flooding and inflow and infiltration into the municipal sewer system caused by extreme Detroit River levels;
2. Identify problem areas based on the evaluation of assets; and
3. Present conceptual design solutions and recommendations to mitigate these flood risks.

The Study was completed in accordance with the PIEVC protocol. This protocol is a step-by-step methodology of risk assessment with further optional engineering analysis for evaluating the impacts of a changing climate on existing infrastructure.

As part of the Study, four main types of flooding were identified to be linked to high Detroit River levels in the West Windsor area:

1. **Direct Coastal Flooding** – Potential to affect shoreline properties that are lower than the 1:100 year Detroit River water level.

2. **Inflows to the Wastewater System** – Coastal water due to high Detroit River levels have the potential to flow directly into the combined sewer system through Combined Sewer Overflows and catchbasins that are lower than the 1:100 year Detroit River water level.

3. **Basement Flooding** – Coastal waters during high Detroit River levels are not a direct cause of basement flooding, but can increase the extent and severity of basement flooding by reducing the available capacity in the sewer network during storm events.

4. **Local Surface Flooding** – Surface flooding during large storm events has the potential to be further exacerbated due to limited available capacity in the local storm and combined drainage systems during periods of high Detroit River levels.

The PIEVC protocol was used to develop flood risk scores for each asset affected by the evaluated climate change scenarios. Each risk score was the product of the probability of flooding occurring at each asset and the severity of the consequences of flooding on that asset. The consequences ranged from a minor temporary nuisance, to the need for repairs, or complete loss of the asset. The overall resulting risk scores were used to identify assets requiring enhancements for a more robust flood protection solution. Feedback from City Administration and stakeholders were collected through a workshop on May 19, 2022 to guide the development of proposed solutions.

The Study also identified target levels of service for the proposed solutions, which included:

- Reducing dry weather flow volumes entering the LRWRP under high river levels to similar magnitudes as low river levels;
- Eliminating surface ponding within the right-of-ways (ROWs) for all storm events up to and including the 1:5 year under all Detroit River Level conditions;
- Limiting the maximum ponding depths within the ROWs to 0.30 m during the 1:100 year storm event year under all Detroit River water level conditions;
- Reduce Hydraulic Grade Lines (HGL)s in the sanitary/combined systems to 1.8 m below the existing ground elevation for all design events up to and including the 1:100 year storm event under all Detroit River water level conditions; and

- Recommending a minimum target design elevation of 176.4 m for all proposed solutions intended to limit the direct encroachment of river water into inland areas.

Each solution was developed to mitigate the impact of high Detroit River water levels on the study area and to meet the targeted level of service where feasible. A summary of the proposed solutions developed as part of the Study include:

- Recommendations for individual site improvements on shoreline properties to limit coastal flooding;
- Improvements to the following ROWs to limit coastal flooding:
  - Mill Street west of Russell Street;
  - Prospect Avenue; and
  - Sandwich Street from McKee Road to Ojibway Parkway.
- Recommendations for the proposed McKee Park improvements to limit coastal flooding;
- Recommendations for an adaptive response strategy to manage coastal flooding on Russell Street near Chappell Avenue;
- Installation of rain catchers at low lying sanitary sewer maintenance holes;
- Installation of backflow preventers at combined sewer overflows (CSOs) to reduce the risk of river water entering the wastewater system;
- Recommendations for individual site improvements to mitigate the impacts of local flooding; and
- Improvements to the drainage systems on the following ROWs to limit local flooding:
  - Morton Avenue;
  - Russell Street;
  - Ojibway Parkway; and
  - Sprucewood Avenue and Maplewood Drive.

Additionally, the following projects previously identified within the study area will also mitigate the potential impacts of high river levels:

- LRWRP retention treatment basin (RTB);
- Prince Road Trunk Storm Sewer Outfall and Pump Station;
- Detroit Street Trunk Outfall;
- Combined sewer separation program; and
- Private property basement flood protection measures.

1.0 Introduction

Peak water levels in the Detroit River have risen significantly in recent years, peaking during May 2020. These high water levels have had significant impacts on the City of Windsor (City)'s coastal areas and municipal storm, sanitary and combined sewer infrastructure.

Notably, high river levels in recent years have increased the volume of Inflow and Infiltration (I&I) into the existing municipal sewer system through connections to the Detroit River during dry weather periods. This increased I&I has ultimately affected operations at the Lou Romano Water Reclamation Plant (LRWRP) as well as other critical pieces of infrastructure across the City of Windsor (the City). The latest I&I monitoring of the LRWRP identified an approximately 50 percent increase of inflow volume in 2019 compared to 2014. This surge in treatment volume resulted in an approximately 30 percent increase in greenhouse gas (GHG) emissions over the City's 2014 baseline GHG inventory.

Beyond the increase in I&I to the treatment plant, high river levels have ultimately reduced the capacity of the City's drainage system. Extreme water levels within the Detroit River have the potential to exacerbate the risk of flooding caused by heavy rainfall events, similar to the basement and surface flooding experienced during the severe storm events that occurred in 2016 and 2017.

The overall purpose of this study is to develop a flood risk profile for the West Windsor area under extreme Detroit River water levels and to identify recommended flood protection solutions. A climate risk assessment was prepared using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol to evaluate the impacts of extreme weather and climate change on coastal flooding in the West Windsor study area. Solutions are targeted at reducing coastal flooding, and I&I into the municipal infrastructure system due to extreme Detroit River water levels.

1.1 Project Scope and Objectives

Extreme Detroit River water levels present a flood risk to the West Windsor area. Under changing climate conditions, there is a risk that the frequency of extreme river levels may increase. Furthermore, extreme river levels combined with other extreme weather events may exacerbate known flood risks.

The goals of the West Windsor Flood Risk Assessment are to:

1. Using the PIEVC Protocol, evaluate the vulnerability of assets within the study area related to coastal flooding and I&I into the municipal sewer system caused by extreme Detroit River levels;
2. Identify problem areas based on the evaluation of assets; and
3. Present recommendations to mitigate these flood risks.

Implementation of flood protection solutions developed through this study are expected to improve the performance of the existing municipal infrastructure and operations at the LRWRP during high Detroit River water levels. The recommended improvements from this study will ultimately result in more sustainable municipal infrastructure and will reduce the risk of both surface and basement flooding, including reducing the impacts of high river levels on the treatment plant. The project objectives are itemized as follows:

- Reduce the susceptibility of West Windsor to coastal flooding;
- Reduce the impact of increased I&I into the municipal system from high Detroit River water levels;
- Improve the performance of the existing infrastructure during high water levels and reduce peak flows at the Lou Romano WRP;
- Provide more sustainable municipal infrastructure; and,
- Reduce the risk of surface and basement flooding.

1.2 PIEVC Approach and Process

The Study was completed in accordance with the PIEVC protocol. The Protocol is a step-by-step methodology of risk assessment and optional engineering analysis for evaluating the impact of a changing climate on infrastructure. The PIEVC protocol is one of several ISO 31000 compliant climate change risk assessment (CCRA) frameworks meeting Infrastructure Canada’s Climate Lens requirements. The protocol, currently managed by the Climate Risk Institute and the Institute for Catastrophic Loss and Reduction, was developed between 2005 and 2012 by Engineers Canada in partnership with Natural

Resources Canada. The Protocol is a structured, rigorous quantitative process to assess the risks and vulnerabilities of infrastructure or infrastructure systems to current and future extreme weather events and climatic changes.

The PIEVC Protocol is comprised of a five step process. Within each step of the process, recommended tasks are designed to allow the Protocol users to adequately prepare for and manage the project, and to produce reliable outputs.

1.2.1 Step 1 – Project Definition

This stage of the process requires an assessment and finalization of project parameters. This includes preparation for the project, including identification of infrastructure for assessment (existing or new) and determination of assessment scope, including budget, timeline, and participants. Additional project definition includes:

- **Define structural and non-structural infrastructure components;**
- **Define climate parameters of interest/concern;**
- **Define future climate period(s) of interest;**
- **Define geographic location and boundaries;**
- **Develop risk levels and scoring (e.g., five or seven point scale); and**
- **Identify high, medium and low risk scores.**

1.2.2 Step 2 – Data Gathering and Sufficiency

Once the project scope and boundaries were defined, the project team worked with infrastructure owners and operators to secure documentation, drawings, maintenance schedules, jurisdictional constraints, codes and standards, etc.

In this Step, climate parameters were defined and climate thresholds were identified, in relation to infrastructure/component damage or failure. For each climate parameter, the threshold at which infrastructure performance is affected was identified based on design guidelines, operating and maintenance procedures, standards and professional judgement. Both historical climate data and future climate projections were evaluated to identify the probability that each threshold may be exceeded within the study time horizon. Consultation with key stakeholders (e.g., operators and managers) was an important part of this stage of the process.

Before entering Step 3, a data gap analysis was completed to verify that there were sufficient data to move forward with the risk assessment.

1.2.3 Step 3 – Risk Assessment

The risk assessment Step includes the quantitative analysis of risk, using the following two term equation:

Risk = Probability (P) x Severity (S)

An assessment of interactions among defined assets/components and climate hazards was addressed first. This was completed by conducting a yes/no analysis to identify whether each climate parameter was likely to affect the asset.

Next, the Probability scores for exceedance of climate thresholds were developed for both current and future climate conditions. Then, Severity scores were developed for each asset/climate interaction. Risk assessment workshops were completed with asset owners and operators to gather feedback on the Severity scoring values.

Risk scores were calculated for all climate/component interactions and documented in risk matrices. Matrices were developed for both current climate conditions and the future climate conditions. Of greatest concern are increases in risk scores from current to future climate conditions, especially where the risk level is shifted into the high category. High risk interactions require earlier and possibly immediate adaptation action.

1.2.4 Step 4 – Engineering Analysis

This is an optional Step within the PIEVC protocol. The need to complete this step is determined from the risk assessment results. Typically, the Engineering Analysis is completed only for assets that are characterized with high risk. However, assets with interactions characterized by very low likelihood but very high consequence, or vice versa (also called “special cases”) may also be evaluated in this Step. Other assets characterized by very high risk, or that are critical components to infrastructure functionality, may be evaluated in this Step as well. The analysis involves quantifying the quantifying both the magnitude of each climate parameter and the capacity of each asset to accommodate it. Vulnerabilities are identified where infrastructure has insufficient capacity to withstand the anticipated loads from the evaluated climate parameters. Infrastructure is resilient when it has sufficient capacity to withstand increasing loads caused by climate change.

1.2.5 Step 5 – Conclusions and Recommendations

This Step includes the development of adaptation measures or solutions, designed to address medium and high risks, and some of the “special cases”. These can include structural modifications, design requirements (e.g., loading factor changes), policy and procedure recommendations, and nature-based solutions.

1.2.6 PIEVC Outputs

PIEVC outputs include a list of assets/asset components and their associated risk profiles, showing how risk changes over time, and which assets are at greatest risk now and into the future. Prioritization of action typically follows the risk assessment: medium and high risk assets and components should be addressed sooner than low risk components. Additionally, timelines for adaptation action can be derived from risk profile results – assets for which risk increases slowly over the timeframe(s) in scope may be able to be addressed later in the future; whereas for assets at risk now and with increasing risk in the future, adaptation action should be taken in the more immediate future.

Adaptation solutions, as developed in Step 5 of the PIEVC Protocol, are designed to support risk mitigation. Implementation of these measures, in the timeframes recommended, should work to reduce risk scores – aiming to reduce the consequence of impact, and improving the time it takes to bounce back from a climate hazard event.

1.3 Assumptions and Limitations

A risk assessment provides a snapshot in time of the overall system vulnerability and resiliency. This is based on the information available to the study team as of May 2022, including reports, modelling results, mapping, discussions with staff, professional experience of team members and workshop participant comments. The risks scores calculated in this assessment are based solely on the current state and capacity of assets (i.e., not taking into account future replacements, modifications, or degradation).

This report was prepared by Dillon Consulting Limited (Dillon) for the sole benefit of the City for the purposes outlined in our approved scope of work. The material in this report reflects Dillon's best judgment in light of the information available at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

2.0 Project Definition (PIEVC Step 1)

The first step of the PIEVC protocol is the development of the project definition, which outlines the scope of the climate change vulnerability assessment. Step 1 includes the following components:

- Identify the existing infrastructure to be evaluated for climate change vulnerability;
- Identify the climate parameters that will be considered in the evaluation;
- Identify the time horizon for projecting future climate trends and evaluating the infrastructure;
- Describe the study area geography; and,
- Identify jurisdictions, laws, regulations, guidelines and administrative processes that are applicable to the infrastructure included in the assessment.

Each of these components is discussed in further detail in the following sections and the completed PIEVC Worksheet Step 1 is presented in **Appendix A**.

2.1 Infrastructure Included in Assessment

An infrastructure asset list was developed based on available City of Windsor GIS information, mapping, and input from City and stakeholder staff to document the assets within West Windsor to be evaluated through the PIEVC assessment. The infrastructure included in the West Windsor Flood Risk Study includes infrastructure at risk of experiencing impacts from riverine and pluvial flooding, including storm, sanitary, combined sewers, the LRWRP (not including internal plant operations), and key adjacent city and third party assets (schools, parks, arterial roads, etc.).

The PIEVC Protocol is scalable and can be applied to different levels and scales of infrastructure assessment. Considering the purpose of the study, the significant geographic coverage, and the depth and breadth of analysis required for each infrastructure asset included, this study identified infrastructure classes (e.g., combined water and storm water assets), and specified infrastructure assets (e.g., combined sewers) for inclusion.

The following infrastructure classes were included in this study:

- **Storm, Sanitary and Combined conveyance assets;**
- **End-of-pipe wastewater systems assets;**
- **End-of-pipe stormwater systems assets;**
- **Shoreline stormwater and flood protection infrastructure;**
- **Transportation assets;**
- **Institutional buildings;**
- **Park assets;**
- **Energy and communications infrastructure;**
- **Residential buildings;**
- **Commercial buildings; and**
- **Industrial assets.**

2.2 Climate Parameters

Climate parameters are defined by climate trends and weather events that are considered through the PIEVC assessment to assess infrastructure vulnerability. For the West Windsor Flood Risk Study, both the direct effects of high Detroit River levels and the combined effects of high river levels with severe rainfall events were identified as the main concerns. Additional climate parameters were also considered, including extreme winds, ice storms, and freeze/thaw cycles. A comprehensive list of the climate parameters considered in the West Windsor Flood Risk study is provided in the PIEVC Worksheet presented in **Appendix A**.

2.3 Time Horizon

The Study time horizons for the West Windsor Flood Risk Assessment are based on:

- Expected service life of infrastructure and components;
- Consideration of climate “normals” – a meteorological record of 30 years; and
- Uncertainty of future climate change projections.

For this Study, 30-year time frames were selected to balance the considerations between expected service life of individual components, the standard averaging period for climate data, and future climate uncertainty. Climate hazard projections for 2050 and 2080 were then developed for the West Windsor Flood Risk Study. As part of this initial assessment, the following process was used:

- Climate hazard probabilities based on average climate conditions for baseline normals period (1981-2010, the official and most recent available); and
- Climate change projections compiled for the time period of 2041 to 2070 (i.e. 2050), and 2071 to 2100 (i.e., 2080).

The climate change projections were developed using the full Coupled Model Intercomparison Project 5 (CMIP5) ensemble of 37 Global Climate Models (GCM) released by the Intergovernmental Panel on Climate Change (IPCC) (2013).

2.4 Study Area Geography

The Study Area for the flood risk profile is generally bounded by the Detroit River to the west, Huron Church Road and Ambassador Bridge to the north, the Essex Terminal Railway and College Street to the east, and the Town of LaSalle municipal boundary to the south.

The LRWRP is located within the Study Area, but its service area extends beyond the Study Area limits and includes a portion of the Town of LaSalle. The service area within the City includes approximately 420 km of sanitary sewers, 46 km of storm sewers and 184 km of combined sewers. Within the service area, there are approximately 25 storm gravity outlets with connections to the Detroit River and 28 CSOs with either connections to the respective storm system or direct outfalls to the Detroit River. The sanitary and combined sewer systems include ten pumping stations. A map of the Study Area is shown in **Figure 1**.

As shown on **Figure 2,** the Study Area was divided into three zones based on the predominant land uses, average elevation, and local sewer servicing, as follows:

- **Zone 1** is the northeast portion of the Study Area and includes Sandwich Street West and the inland neighborhoods to the east. The ground elevations within this zone are typically 4 m or more above the Detroit River shoreline. The land use within this zone is primarily a mix of residential and industrial. Approximately 46% of the total area is residential, 32% is industrial and the remaining balance is institutional and commercial. The wastewater servicing for most of this area is primarily provided by combined sewers, though sewer separation has been completed in some areas south of Brock Street. The LRWRP is located within this zone along Ojibway Parkway.

- **Zone 2** includes the shoreline properties located along the Detroit River, west of Russell Street and north of Broadway Street. The land-use in this zone is primarily industrial. The Riverside Drive interceptor trunk sewer generally follows the Russell Street right-of-way (ROW) and conveys wastewater from central Windsor to the LRWRP. The average ground elevations in Zone 2 are significantly lower than Zone 1, with portions of the shoreline properties lower than the current conditions 1:100 year Detroit River water level.
- **Zone 3** includes the southern portion of the Study Area. Most of the properties in this zone are industrial with wastewater servicing provided by a separated sanitary sewer system that drains to the LRWRP. A sanitary forcemain on Ojibay Parkway conveys wastewater from the Town of LaSalle to the LRWRP. Stormwater servicing for most of this area is provided by roadside ditches. Stormwater runoff from this area is shown to drain both directly to the Detroit River and to Turkey Creek. Similar to Zone 2, the average ground elevations in Zone 3 are typically lower than Zone 1, with portions of the shoreline properties lower than the current conditions 1:100 year Detroit River water level.

The Study Area topography generally slopes from east to west, towards the Detroit River, and from north to south. The highest ground elevations are approximately 185 m and are located near the northeast portion of the study area. The lowest ground elevations are less than 176 m and are located along the Detroit River shoreline.

Based on the information presented on the Soil Map of Essex County, the soils within West Windsor are predominately Burford Loam, with patches of Berrein Sand and Granby Sand.

2.5 Jurisdictional Considerations

In accordance with the PIEVC process, the various laws, regulations, guidelines and administrative processes that apply to the infrastructure within the West Windsor study area have been documented in the PIEVC Worksheet presented in **Appendix A**.

3.0 Data Gathering and Sufficiency (PIEVC Step 2)

This step involves information gathering and data set development. For Step 2, the following tasks were completed:

- Development of asset listings based on potentially affected infrastructure previously scoped and identified in Step 1. A site visit and interviews with key City staff were completed to support the development of the overall asset list;
- Development of climate hazard listings, including 1:100 year flood levels for current and future timeframes, as well as extreme rainfall events that have resulted in urban flooding impacts; and
- Evaluation of the existing infrastructure performance under the identified climate hazards.

Corresponding PIEVC Step 2 Worksheet is presented in **Appendix A**

3.1 Background Documents

The following background reports and studies relevant to the Study Area were reviewed by the Project Team as part of this study:

- Windsor Port Authority Climate Change Risk Assessment (Dillon, 2021);
- Windsor Sewer and Coastal Flood Protection Master Plan (Dillon, 2020);
- ERCA Floodplain Prioritization Study Report (Dillon, 2022);
- City of Windsor Official Plan, Municipal Cultural Master Plan (2010);
- Prince Road Sewer Study (Stantec, 2001);
- Windsor Riverfront West CSO Control “Schedule C” Class EA (Stantec, 2019);
- Functional Design Report - Sanitary Sewerage and Stormwater Drainage - Malden/Prairie Grass (Dillon, 1993);
- Ojibway Sanitary Sewer Infrastructure Rehabilitation Needs Study (La Fontaine, 1992);
- ERCA Shoreline Management Plan (N.K. Becker, 1986);
- Ontario Ministry of Natural Resources Great Lake Systems and Water Related Hazards and Other Extreme Lake Levels (1989);
- Windsor Archeological Master Plan (CRM Group, 2005);

- Proposed Sewer and Sanitary Sewer Prince Road (Golder, 1986);
- Prince Road Trunk Storm Sewer Study (James F. MacLaren, 1978a); and,
- Interim Report on Investigations of the Ojibway Sanitary Sewerage Area (James F. MacLaren, 1978b).

3.2 Climate Analysis Methodology

The risk assessment necessitates the analysis of both historical and future climate information. Historical climate information serves two key purposes:

1. Provides a baseline for historical operating conditions for the assets under study; and,
2. Provides a reference point to establish necessary context for climate change projections (i.e., how far will changes in climate deviate from current conditions?).

From a climate change perspective, a historical background investigation is critical to providing a point of reference for climate change information. Historical and recent climate conditions can indicate the type of operating environment which has already interacted with the assets under this study. Based on previous experience, climate projections can provide little value unless the projected changes are provided within the context of these current operating conditions.

3.2.1 Historical Data

The majority of historical climate baseline information used in this project was derived from climate observations at climate stations available representing climate near the assets being evaluated. A meteorological record of 30 years (1981 to 2010), a so-called "climate normals" period, was used for historical baseline data calculations. Historical climate data was obtained from Environment and Climate Change Canada using the Windsor International Airport location. Additionally, river level data was obtained from the US Army Corps of Engineers for the Fort Wayne station.

3.2.2 Climate Change Projections

Having established a historical baseline, the analysis then required guidance to assess potential changes in key hazards and climate parameters under a changing climate. The methodology employed here uses the “Delta” or *change factor* method to both downscale GCM projections to the local scale needed for decision making, and to account for climate model biases. This method assumes that future changes to the climate of the study location will mainly be driven by changes to the climate at coarse scales and that relationships between variables at the local scale are assumed to remain relatively constant in the future period. Most studies indicate that credible climate change projections at the local to regional scale are highly contingent upon GCMs being able to faithfully represent the large-scale processes and relevant features of the climate system (IPCC, 2013).

This method of model bias correction and downscaling is able to make use of many models – called a “multi-model” ensemble – with the reliability of the outputs being much improved over the use of any single, higher resolution model. The selection of a single model or a small subset of climate models has the potential to lead to costly maladaptive decisions, particularly since the use of ensembles helps to moderate the effects of differing assumptions inherent in each model.

Employing this method, this study used an ensemble of all Fifth Assessment Report (AR5) global climate models initially released by the Intergovernmental Panel on Climate Change (IPCC) in 2013, with outputs for the climate parameters of interest and representative of the Windsor region. First, average climate conditions were obtained for the baseline normals period (1981-2010, the official and most recent available), and then the average change in climate conditions for the future periods (i.e., 2050s and 2080s) were obtained from the multi-model ensemble. The *change* from baseline to future produced by the model ensemble was then added to the actual historical station observations. This method avoids any inherent model biases by only considering the change – or “delta” – of the projections and adding this to the analyses of the historically observed climate.

From an ensemble of 37 GCMs, the grid point value corresponding to the City location was selected. Grid point size differs between models but is approximately 150 km x 150 km when all models are re-gridded to a common scale prior to averaging. The use of an ensemble of models is approved by the IPCC (2013). In effect, this method applies a climate change factor to a baseline high resolution observation (i.e., station corresponding to the Windsor study area) to estimate future climate conditions.

3.2.3 Climate Projections for Complex Hazards

Complex hazards, meaning those that are characterized being highly localized (with respect to model grid scales described above), short duration, extremes, and/or combined or concurrent (synergistic) events, require specialized studies and are not directly available as raw outputs from GCMs. In these cases, future climate conditions for the Windsor area were derived from specialised studies available in the peer-reviewed published literature (e.g., Cheng et al., 2012, 2014 for high winds and ice storms; Diffenbaugh et al. 2013 for changes in severe thunderstorm activity). Where projection guidance was not available in any form, professional judgement was applied based on an integration and assessment of all available guidance (e.g., trends in parameters contributing to a given hazard) and the climate expertise of the Dillon team.

In particular, a comprehensive review of all climate change and Great Lakes level studies undertaken by Canada or the United States since 2011 was used to assess and update the future lake level projections provided for the earlier Riverside East and Windsor Port Authority PIEVC risk assessments. Several new water level studies were reviewed that included either more recent climate change models, a greater number of climate change models, added regional scale climate modelling results, more GHG emission assumptions and/or improved lake dynamics modelling.

3.3 Detroit River Water Levels

A hydrologic analysis was completed to estimate the 1:100 year Detroit River flood level for the West Windsor study area. The 1:100 year flood level is the sum of the mean river level and storm surge with a combined probability of a 1:100 year return period (i.e., on average, has a 1 percent probability of occurring in any given year or on average once in 100 years). A detailed description of the hydrologic analysis is provided in the Climate Data and Analysis Summary presented in **Appendix D**.

Provided below is a brief description of the methodology and results of the hydrologic analysis.

3.3.1 Previous Studies

The Great Lakes System Flood Levels and Water Related Hazards report (OMNR, 1989) provides estimates of the 1:100 year flood level at several locations along the Detroit

River. The West Windsor study area is shown to fall within river reach DR-3 of the OMNR report which has a reported 1:100 year flood level of 176.0 m (IGLD'85).

The International Great Lakes Datum 1985 (IGLD'85) is often used with respect to water levels and bathymetry, and Geodetic Datum (CGVD) is often used with respect to topographic survey and LiDAR data. It is important to recognize that there is a slight difference between IGLD'85 and Geodetic at the project location. At Tecumseh, the closest site where this datum discrepancy is defined, IGLD'85 is 0.01 m lower than Geodetic. Survey data can therefore be adjusted using the equation below:

$$IGLD'85 - CGVD = 0.01\ m$$

The MNR study states that no climate change considerations were included in the estimate of these 1:100 year flood levels.

3.3.2 Historical Water Level Data

The National Oceanic and Atmospheric Administration (NOAA) Detroit River Gauge at Fort Wayne (Station # 9044036) is located on the opposite bank the river from the West Windsor study area. As shown on **Figure 3**, the gauge is located in the United States, approximately 600 m from the West Windsor shoreline. Hourly water level measurements were available for this gauge for the historical period from 1970 to 2021. The data from this gauge was determined to be the most accurate available information at this time for extreme water level analysis due to the fact that:

- The gauge is located close to the study area, and consequently the measured water levels should be representative of the river conditions in West Windsor;
- The available period of record spans approximately 50 years, which should provide sufficient data to accurately estimate the 1:100 year water level; and,
- The data set is reasonably complete with few gaps.

The long-term average of the recorded water level measurements is 174.94 m, IGLD'85. The maximum measured water level was 175.87 m, recorded in July of 2019. A probability of exceedance curve developed based on the historical data suggests that the recorded water level exceeds 175.6 m just under 1% of the period of record, and 175.7 m approximately 0.1 % of the time.

3.3.3 Extreme Value Analysis

An extreme value analysis (EVA) was completed on the Fort Wayne gauge data to identify peak water levels for the Study Area. The EVA defines the cumulative probability distribution using several statistical distributions. The results of the EVA can be used to define extreme values for a variety of defined return periods.

To reduce the dataset, the maximum monthly water levels were used as the inputs for the EVA. The cumulative probability distribution was estimated using four statistical distributions:

- General Pareto Distribution;
- Generalized Extreme Value Analysis (GEV);
- Weibull; and
- Log-Normal.

As summarized in the following table, each distribution shows a strong correlation (r-squared value) with the peak gauge data. However, the Weibull and GEV distributions are shown to have the best fit with the lower frequency (higher return period) events.

Table 1: Summary of Extreme Value Analysis Fort Wayne (Station #9044036)

Return Period	Water Level (m, IGLD'85)			
	General Pareto Distribution	Generalized Extreme Value	Weibull	Log-Normal
1	175.76	175.62	175.63	175.63
2	175.79	175.66	175.67	175.67
5	175.83	175.76	175.79	175.79
10	175.85	175.81	175.86	175.88
20	175.86	175.86	175.93	175.95
25	175.86	175.87	175.95	175.97
50	175.86	175.90	176.01	176.04
100	175.87	175.93	176.07	176.11
r^2 value	**0.991**	**0.999**	**0.998**	**0.997**

3.3.4 Existing Condition 1:100 Year Detroit River Water Level

As part of this analysis, the EVA results were compared with peak values from the 1989 MNR study. The GEV distribution was identified to have a better fit with the peak data, and the Weibull distribution being shown to be more consistent with the previous study by MNR. Both distributions are shown to have a close correlation with the monthly maximum.

Although the MNR study does not mention which cumulative probability distribution was used to estimate the peak water levels, the Weibull distribution was likely used since it was a commonly used probability distribution at the time of the study publication. Based on this assumption and the findings noted above, the EVA results using the Weibull distribution for the West Windsor Flood Risk Study was selected as the preferred.

Based on the historical data, the Detroit River 1:100 year water level was estimated to be 176.1 m, IGLD'85 for the purposes of this study.

3.3.5 Climate Change 1:100 Year Detroit River Water Level

A review of five recently published studies that predict the effects of climate change on the Great Lakes was completed to assess how peak water levels on the Detroit River may change in the future. Each study used a different analysis methodology with varying conclusions. The review results identified four common trends:

1. All of the reviewed studies acknowledged that the interactions of the factors that influence the Great Lakes water levels are very complex;
2. All of the studies recognized that there is uncertainty associated with predicting future lake levels and that these uncertainties increase the further along you predict into the future;
3. Rapid changes due to low lake levels to high lake levels and vice versa can be anticipated; and
4. All of the studies predicted an inverse correlation between global future greenhouse gas emissions and lake levels. Increasing GHG emissions are shown to be linked to lower future Great Lakes water levels.

Each of the reviewed Great Lakes studies relied on the results of different climate models and considered different scenarios to predict future lake levels. As a result, each study provided a range of future water level predictions based on different assumptions. Most of the climate models generally predict that lake levels will likely decrease in the future.

However, for the West Windsor Flood Risk Study a conservative estimate of the future flood elevations is required to address the considerable uncertainty associated with these predictions, and develop a design elevation for proposed flood protection solutions. Based on the reviewed climate change studies, the highest reasonable predicted increase in peak water levels is shown to be approximately 20 cm.

Adding this increase to the existing condition water level calculated from the extreme value analysis results in a future condition 1:100 year Detroit River water level of 176.3 m IGLD’85 for the purposes of this study.

3.4 Climate Parameters/Hazards

The climate hazards considered in the PIEVC assessment are described in the following sections.

3.4.1 Precipitation/Drainage/Flooding Events

These types of events are climate hazards capable of causing primary or direct impacts to critical infrastructure. These factors include high water levels (river), multi-day rainfall events, and combination probability events (high water level and rainfall events).

3.4.1.1 High Water Levels

The extreme river levels used in the risk assessment and the methodologies used to develop them are documented in Section 3.3 of this report.

3.4.1.2 Rainfall Events

Two rainfall events were considered as part of this Study; Major (1:100 year storm, 82 mm) and Minor (1:5 year storm, 50 mm) events. These events were used to model and evaluate the performance of the infrastructure systems.

Climate change projections indicate that both events show significant increases in likelihood under climate warming. In particular, the 82 mm event, currently considered the Major or 1:100 year storm, is projected by mid-century to increase in frequency by over 3 times, reducing it to an approximate 1:30 year return period. The 82 mm storm is also expected to increase in frequency towards the end of the century, roughly equivalent to a
1:15 year return period by the 2080s. These rainfall projections were based on the Clausius-Clapeyron (C-Clap) temperature scaling method (Ball et al., 2016), as described in the Climate Data and Analysis Summary presented in **Appendix D**.

3.4.1.3 Combined Probability Events

The combined events considered for this study include simultaneous occurrence of high water levels and rainfall events. The variety of climate and hydrological/hydraulic processes operating at different time scales and influencing lake levels suggest that it is not reasonable to determine whether patterns influencing heavy precipitation events are linked to other conditions that influenced high to extreme lake levels. It is also uncertain how these relationships would change when considering climate change.

For the purposes of this Study, a local analysis was undertaken to determine whether there is any relationship between extreme precipitation events and extremes of water levels and the impact on flooding. The extreme precipitation events were compared against water level observations at two locations: St. Clair Shores and Fort Wayne.

Based on the statistical analyses conducted for rainfall and extreme lake level events, it was concluded that combined event probabilities can be treated as statistically independent events. Since extreme rainfall and high Detroit river levels can be treated as statistically independent, their individual likelihoods are simply *multiplied* to arrive at an overall likelihood of simultaneous occurrence for both events.

3.4.2 Secondary and Long-Term Impacts

Additional hazards and secondary climatic events were investigated for their potential to cause long-term (gradual) damage to drainage and shoreline protection infrastructure or exacerbate impacts to drainage and sanitary systems (e.g., through reduced or blocked surface transportation access, loss of power to treatment plants and pumps, etc.).

3.4.2.1 Shoreline Erosion

As part of the background investigation, no historical database of shoreline erosion for the Detroit River was found. The respective impacts and rate of change therefore could not be statistically evaluated. However, through City staff interviews, stakeholder consultation as well as the County of Essex Hazard Identification and Risk Assessment (HIRA) (County of Essex, 2019) indicated significant concerns regarding shoreline erosion. This was therefore included as a key hazard consideration within the findings of the flood assessment.

3.4.2.2 Weathering

Many municipalities and other infrastructure and asset owners across Canada have suggested that weather related deterioration of assets may have accelerated in recent years. The assignment of cause in these cases is difficult given other potential contributing factors (e.g., under-investment in long-term asset maintenance), but these observations do highlight the importance of slow, creeping processes on the degradation of critical assets.

The impact of freeze-thaw cycles relating to the weathering of critical assets were evaluated based on laboratory tests of reinforced concrete samples. These tests indicate that visible damage can begin after approximately 30 cycles (Sun et al. 1999; Ruedrich et al,2011).

In summary, when considering both factors, while the total number of freeze-thaw cycles decreases, this decrease is not substantial, and weathering from this process is expected to continue through the rest of the century.

3.4.2.3 Ice Storms

At this time, there is no existing national database for ice storm events for Canada. As part of this Study, research was completed to identify historical events through literature review and media searches (Klaassen et al., 2003; Mclachlan and Smith, 1976). A statistical analysis was then calculated based on these events and compared for consistency against ice accretion design data in infrastructure standards (i.e., CSA 2010). A downscaled climate projection of ice storm activity from the literature (Cheng et al. 2011) was then applied to future time periods. As part of this analysis, two thresholds were used; 15 mm for when power outages tend to occur due to tree contacts from large branches, and 25 mm, which is the minimum design threshold for overhead systems.

Cheng et al. (2011) produced downscaled projections based on weather patterns obtained for major historical ice storm events, which suggested a slight increase in event frequency under warming climate conditions. A more recent study by Jeong et al. (2019) is consistent with Cheng et al.'s (2011) earlier findings, indicating an increase in 50-year return period ice loads for a global average warming of 3°C or less. However, results from Jeong et al. (2019) were not presented in a format allowing derivation of the numerical event frequency values and changes. These findings are also in general agreement with earlier research from Klaassen et al. (2003). The earlier study noted that higher ice accretion values had occurred in recent decades for ice storm events occurring immediately south of Canada-U.S. border in the states of Michigan and New York. The same storm events tended to generate lower ice accretion values or heavy snowfall in adjacent areas of Ontario and Quebec. The study proposed that a poleward shift in storm tracks has the potential to increase significant ice storm events in adjacent portions of southern Canada. However, it is noted that these changes in event frequencies result in little future change for ice impacts compared to the baseline. For example, the approximately 10 % projected increase in event frequency for 25 mm ice storms still results in a low overall event frequency, increasing from 8 % per year to 9 % per year annual probability.

3.4.2.4 High Winds – Severe Thunderstorms, Tornadoes

The consideration of high winds as part of this study used two different thresholds for the analysis; Gusts in excess of 120 km/hr (year round, localized severe thunderstorm driven winds, and tornadoes of EF2 and higher intensity.

Wind Gusts - All Event Types

A threshold of 120 km/h was used to help identify potentially high impact wind cases that may result in significant secondary impacts to critical services such as electrical power and surface transportation. A statistical analysis was completed based on data directly from wind observations at Windsor Airport and cross-referenced with the Detroit Wayne County Airport data.

At this time, wind gusts are not directly available as outputs from a global or regional climate models. Guidance from specialized downscaling studies available within the literature Cheng et al. (2012) and Cheng et al. (2014) conducted a number of statistical downscaling climate projection studies using approaches similar to the work referenced earlier for ice storm events. Their findings indicate potential increases in the number of days with wind gusts exceeding damaging thresholds. Recent research using a smaller set of regional climate models by Jeong and Sushama (2019) also support the potential for increases in wind gust frequency and more year-to-year variability in extreme wind gusts by the end of the century.

Tornado and other Localized Severe Thunderstorm Winds

Severe thunderstorm winds were evaluated using a review of Environment and Climate Change Canada (ECCC) storm spotter damage reports (Chadwick, 2005), media searches and case study review of high impact historical events. The frequency of occurrence, specifically how often severe thunderstorm wind damage is reported, but not detected at Windsor Airport, was used to estimate the true prevalence and frequency of these events.

Tornado frequency was evaluated using the National Tornado Database (Cheng et al. 2013) and counting all tornadoes above the defined thresholds that occurred anywhere within the City of Windsor. Most large tornadoes affecting Windsor have crossed the Detroit River (in one case twice), when entering/exiting the City, and so the total frequency is representative of events which could impact shoreline assets and properties directly.

Due to the extremely complex nature of tornadoes and other severe thunderstorm related hazards, understanding the effects of climate change on their behaviour has shown to be challenging. Unlike other hazards, tornadoes are the result of a combination and balance of a set of meteorological conditions, which at least partly explains their rarity compared to other atmospheric hazards. Only recently have detailed studies of climate change effects on severe thunderstorm activity been able to provide some indication of the potential impacts of climate change on tornado hazards over the North American continent.

Recent studies of historical tornado activity trends in the United States indicate no discernable changes in total frequency of tornadoes over recent decades, but a decreasing trend in the total number of days experiencing tornadic activity (Brooks et al., 2014). However, several climate change projection studies using both previous IPCC Fourth Assessment Report (AR4) and AR5 era global climate models (Trapp et al. 2007; Diffenbaugh et al. 2013) indicate the potential for significant increases in the number of days with favourable conditions for severe thunderstorm outbreaks (including tornadoes). This suggests that the frequency of these events may increase in some regions.

More recent research on trends in tornado activity in the United States. (Strader et al., 2017; Gensini & Brooks, 2018) indicate both historically recent and future projected shifts in conditions conducive to tornado occurrence, which are of potential relevance to the City of Windsor and surrounding areas. Gensini and Brooks (2018) also report an observed increase in days with potential for significant (i.e., EF2 or stronger) tornado development in northeastern North America over the past approximately 40 years.

3.5 Existing Drainage Infrastructure Assessment Summary

A hydrologic/hydraulic assessment was completed to evaluate the performance of the existing drainage infrastructure. The assessment process is detailed in **Appendix E** and a brief summary is provided below.

The hydrologic/hydraulic model completed as part of the Windsor SCFPMP was used as to develop baseline conditions for the current analysis. The modelling analysis was completed using the Infoworks-ICM modelling package, distributed by Innovyze. While the Windsor SCFPMP Infoworks model takes into consideration high water levels as a downstream boundary condition for the sewer system and at CSO outfalls, it does not simulate overland flooding along the shoreline due to high water levels. The model is not set-up to simulate the effects of dynamic wave action in addition to fixed high Detroit River water levels.

For the purposes of this study, the existing conditions calibrated Windsor SCFPMP hydrologic/hydraulic model was used to complete the analysis. The model represents the City infrastructure condition as of 2020, and City administration confirmed that there have been no subsequent changes to the infrastructure in the Study Area. Boundary conditions, in the form of fixed water levels at sewer outfall locations in the Detroit River, were updated for the current analysis, as summarized below:

- 1:100 year return period – 176.10 m; and
- 1:100 year return period (considering impacts of climate change) – 176.30 m.

To remain consistent with the original modelling approach used for the SCFPMP, the original design storm events from the SCFPMP were used for the analysis within this Study. The objective of the modelling analysis was to evaluate flood risk during a number of joint probability events. These scenarios evaluated the estimated flood risk and respective impact on municipal infrastructure that could occur under a simultaneous high water level and synthetic design rainfall event on the watershed.

Under the existing conditions analysis, the following modelling scenarios were evaluated:

- 1:100 year return period water levels in Detroit River occurring concurrently with:
  - 1:5 year return period design storm event; and
  - 1:100 year return period design storm event.
- Low water levels in Detroit River occurring concurrently with:
  - 1:5 year return period design storm event; and
  - 1:100 year return period design storm event.

The design storm events for this analysis used 4-hour synthetic rainfall events with 10-minute time intensity intervals using the Chicago distribution.

3.5.1 Evaluation Criteria

For the current analysis, the Level of Service (LOS) criteria developed through the Windsor SCFPMP were used to evaluate the performance of the existing drainage infrastructure. The flood risk due to each joint probability event was analysed using the HGL elevations in the sewer systems, and surface flooding due to sewer surcharging. Sewers are typically considered to be surcharged when the HGL elevation is above the obvert of the sewer pipes.

The SCFPMP recommends that the HGL in sanitary and combined sewers to remain 1.8 m below the existing ground elevation. This 1.8 m was originally assumed to be the approximately basement floor depth from ground. HGLs in the sanitary and combined sewer systems above this elevation are shown to represent an estimated high risk of basement flooding due to sewer surcharging. The Windsor SCFPMP recommends surface flooding depth on roadways during a 1:100 year rainfall event are not to exceed 0.30 m.

Additionally, the SCFPMP recommends surface flooding depths on major roadways (arterial and collector streets) during a climate change rainfall event to not exceed 0.30 m. Although this criterion has not been adopted regionally in the Windsor/Essex Region Stormwater Management Standards Manual (December, 2018) or within the City of Windsor Development Manual, it has been used for the current climate change analysis for joint probability simulations when considering 1:100 year return period water levels within the Detroit River. This includes a sensitivity assessment to identify roadway flooding when considering climate change impacts.

3.5.2 Existing Condition Modelling Results

Two modelling scenarios representing two joint probability event scenarios were simulated using the 1:100 year return period water levels in the Detroit River as downstream boundary conditions. Results from these simulations are represented in **Figure 4** and **Figure 5**.

Most combined sewers in Zone 1 are observed to be surcharged during the 1:5 year return period rainfall event simulation. Storm sewers conveying stormwater runoff to gravity outfalls are surcharged due to high water levels in the River backing up through the sewers. The Riverside Drive interceptor sewer, shown on **Figure 1**, conveying sewage from central Windsor to the LRWRP is also surcharged during the 1:5 year simulation. The sanitary sewer system servicing industrial development in Zone 3 is also surcharged, and HGL elevations in the system are estimated to be above the assumed basement floor elevation. No significant surface flooding is observed along municipal ROWs during the 1:5 year rainfall event simulation.

The outlet sewer from the LRWRP is surcharged during these simulations due to high water levels in the Detroit River, potentially affecting operations at the LRWRP.

During the 1:100 year rainfall event simulation, a larger number of combined sewer maintenance holes (MHs) in Zone 1 show an estimated higher risk of basement flooding, with HGLs above the assumed basement floor elevation. In addition, a number of sanitary and storm MHs in areas that are serviced by separated sewers are also estimated in the model to have high HGLs throughout the system. Estimated surface flooding along municipal roadways with depths great than 0.30 m are observed along both Russell Street and Sandwich Street.

3.5.3 Climate Change Drainage Infrastructure Assessment

As part of the climate change analysis, the following modelling scenarios were evaluated:

- 1:100 year return period climate change water levels in Detroit River occurring concurrently with:
  - Existing 1:5 year return period design storm event; and,
  - Existing 1:100 year return period design storm event.

The results from each joint probability event, with consideration of higher water levels in the Detroit River due to impacts of climate change, show estimated higher HGLs in the sewer systems. This is due to a higher tailwater effect caused by the higher water levels within the Detroit River. Results for these simulations are represented in **Figure 6** and **Figure 7**.

Correspondingly, the surface flooding extents along municipal ROWs representing flooding with depths estimated to be greater than 0.30 m are higher during the joint probability event using 1:100 year rainfall event.

3.6 Flood Mechanisms

The following information was used to identify locations of estimated flood occurrence during the simulated events and potentially why flooding occurs within the study area:

- Topographic mapping to identify areas below the Detroit River 1:100 year water level;
- Computer aided modelling (Infoworks ICM) to assess the City's sewer and drainage networks; and
- Anecdotal observations of previous flooding from City operations staff and stakeholders.

Four main types of flooding were identified to be linked to high Detroit River levels for the West Windsor area based on investigation of the above noted items:

1. **Direct Coastal Flooding** – Potential to affect shoreline properties that are lower than the anticipated peak Detroit River levels.

2. **Inflows to the Wastewater System** – Coastal water due to high Detroit River levels have the potential to flow directly into the combined system through CSOs and catchbasins that are lower than the anticipated peak Detroit River levels.
3. **Basement Flooding** – Coastal waters during periods of high Detroit River levels are not a direct cause of basement flooding, but can increase the extent and severity of basement flooding by reducing the available capacity in the sewer network during storm events.
4. **Local Surface Flooding** –Surface flooding during large storm events has the potential to be further exacerbated due to limited available capacity in the local drainage systems during high Detroit River levels.

3.6.1 Coastal Flooding

Coastal flooding is shown to affect lands that are currently lower than the 1:100 year Detroit River level. These are properties located near the shoreline that are directly flooded when the river levels are high. A topographic analysis was completed to identify the areas lower than the target river levels as shown on **Figures 8, 8a, 8b, 8c** and **8d**.

A summary of affected assets in the study area is presented in the following table.

Table 2: Infrastructure Affected by Coastal Flooding

Asset Class	Description
Parks	McKee Park
	Black Oak Heritage Park
Roads	Mill Street
	Russell Street
	Prospect Avenue
	Sandwich Street
	Morton Avenue
Shoreline Properties	HMCS Hunter
	WPA Lands
	Shoreline Industrial Properties

3.6.2 Inflows to the Wastewater System

During periods of high water levels in the Detroit River, water from the coastline has the potential to enter into the sanitary and combined sewer system at a number of CSO locations. A review of each location and respective spill elevation in the West and Central

Windsor region showed that most CSO spill elevations are lower than the historical 1:100 year return period water level in the Detroit River. These findings suggest that the infrastructure would be at risk of taking in water during periods of high water level in the Detroit River. The additional volume entering the sanitary/combined system during rainfall events ultimately sends additional flow to the LRWRP for treatment. During heavy rainfall events, flow to the treatment plant is high due to Rainfall Derived I&I entering the combined/sanitary system. The additional volume entering through backflow at CSO locations further exacerbates the problem, resulting in surcharging at the treatment plant. This causes sanitary and combined sewers to back up and increases the likelihood of basement flooding due to sanitary/combined sewer surcharging within the LRWRP service area. The impact at the LRWRP can also have the potential to cause excessive surface flooding in areas serviced by combined sewers.

3.6.3 Basement Flooding

Basement flooding occurs during wet weather events when the water level in the municipal sanitary or combined sewer is higher than the elevation of the basement. Runoff enters the wastewater system both through direct connections and through sources of I&I such as pipe joints and MH lids.

These inflows have the potential to overwhelm the wastewater system and cause backups through existing building floor drains and into the structure. The likelihood of basement flooding is therefore increased by extreme river levels due to a portion of the capacity of the wastewater system being used up by river water.

3.6.4 Local Surface Flooding

Local surface flooding occurs during storm events when the local drainage system surcharges due to insufficient capacity to convey incoming flows. Surcharging of the conveyance system results in peak water level rising above the maximum design level in the drainage system. Within a storm sewer, this is when water levels within MHs exceed ground level elevations. For a ditch system, this is when the water level rises above the top of bank. High river levels can exacerbate the local flooding condition by reducing the available capacity of the local storm drainage system.

The results of the West Windsor flood assessment suggest that the following locations are prone to local flooding which is likely to be exacerbated by high Detroit River levels:

- **Morton Avenue** – Existing roadside ditch inverts are estimated to be lower than the Detroit River 1:100 year climate change water level. High tailwater elevations have the potential to contribute to localized flooding during severe storm events.
- **Sprucewood Avenue and Maplewood Drive** – Similar to Morton Avenue, the roadside ditch inverts on Sprucewood Avenue are estimated to be lower than the Detroit River 1:100 year water level. The ditches within this drainage system are considered a designated municipal drain and a recent drainage report (Meritech, 2021) suggests that their capacity is very limited.
- **Ojibway Parkway** – Anecdotal observations from Dillon project team members suggests that prolonged surface ponding occurs on Ojibway Parkway during moderate storm events.
- **Sandwich Street near McKee Creek** – The available topographic information suggests that the Sandwich Street profile near McKee Creek Drain is relatively low. Drainage Reports reviewed for the McKee Drain suggests that the existing drain capacity downstream of Sandwich Street is limited due to undersized structures, sediment accumulation, and vegetation growth.
- **Russell Street** – Existing roadside ditch inverts are estimated to be lower than the Detroit River 1:100 year water level. Based on information provided by project stakeholders, portions of the roadside ditches north of Chippewa Street frequently contain standing water.

4.0 Risk Assessment (PIEVC Step 3)

The purpose of the risk assessment is to identify conditions where the risks posed by high Detroit River water levels result in adverse effects on assets within the study area that may require flood protection solutions.

The probability of each climate occurring within the project 30-year time horizons was estimated and assigned a corresponding probability score. Severity scores were then developed for each asset category to quantify the anticipated consequences of flooding. Risk scores were calculated for each asset/hazard interaction by multiplying the probability and severity scores. A risk assessment workshop was completed with key City staff and stakeholders to gather feedback and revisions on the preliminary probability, severity, and risk scoring. Assets with high calculated risk scores were then identified for further assessment in Step 4.

The supporting PIEVC worksheets are presented in **Appendix A** and a summary of the risk assessment process is provided in the following sections.

4.1 Probability Rating Scale

As part of the climate change scenarios for the Study, climate hazards of concern were developed by the PIEVC team and validated and revised through City staff interviews, historical event research, and stakeholder workshop discussions. The climate hazards included in the study are presented in the following table. The table also includes annual frequency of the event, and a 30-year probability score based on a 7 point scale. Annual frequencies and scores are presented for the current timeframe, and two future timeframes (2050s and 2080s).

Table 3: Climate Hazard Probability Scores

Hazard	Threshold		Current		2050s		2080s	
			Estimated 30-Year Probability (%)	Score	Estimated 30-Year Probability (%)	Score	Estimated 30-Year Probability (%)	Score
Extreme Rainfall	1:5 Year Storm		> 99	7	> 99	7	100	7
	1:100 Year Storm		20	4	> 60	6	> 85	7
Extreme River Levels	Current HWL		25	4	30	5	> 30	5
	Projected CC HWL		20	4	25	4	25	4
Combination Events	Current HWL + 1:100 Year Storm		7	2	12	2	26	4
	Current HWL + 1:5 Year Storm		26	4	30	4	> 30	5
	Projected CC HWL + 1:100 Year Storm		5	2	16	4	23	4
	Projected CC HWL + 1:5 Year Storm		26	4	26	4	30	4
	HWL + Wave Action (freeboard)		> 95	7	N/A	7	N/A	7
Secondary Impact Events	Major Ice Storm		25	4	30	4	25	4
	Extreme Wind Event		80	6	85	7	85	7
	Tornado - (E)F2+		5	2	7	2	9	2
	Freeze/ Thaw	Total Cycles	100	7	100	7	100	7
		30 Cycle Increments	> 99	7	> 99	7	> 99	7

As part of this assessment, several hazards were removed from consideration after extensive stakeholder engagement and historical events research. These included:

- Extreme air temperature (hot and cold);
- Heavy snowfall events and seasonal snow accumulation; and
- Rainfall plus hail combination events.

Other hazards removed from this assessment included shoreline erosion, river ice and ice jam flood events, as they were not able to be statistically analyzed for frequency of occurrence due to lack of reliable data.

4.2 Severity Rating Scale

To characterize the severity of climate change impacts, the PIEVC Protocol makes use of a standardized impact scoring scale ranging from 0 to 7. As part of this study, the criteria for assigning each severity rating was developed for each type of asset.

4.2.1 Storm Drainage Infrastructure

The criteria used to evaluate the severity of flood impacts on storm drainage infrastructure is summarized in the following table.

Table 4: Storm Drainage Infrastructure Severity Ratings

Severity Rating	Original PIEVC Severity Descriptors	Evaluation Criteria
0	Negligible; Not applicable	No Impacts
1	Very Low; Some measurable change	Regular use, peak flow < 50% capacity
2	Low; Slight loss of serviceability	Regular use, peak flow > 50% capacity
3	Moderate loss of serviceability	Peak flow approaching capacity limit (≥ 80%)
4	Major loss of serviceability; Some loss of capacity	Several segments approaching capacity limit, one or two nodes fully surcharged (but surface ponding < 0.3 m above ground surface)
5	Loss of capacity; Some loss of function	Multiple conveyance segments fully surcharged, maximum ponding depth < 0.3 m above ground surface
6	Major; Loss of function	Trunk storm sewers fully surcharged, one or more nodes 0.3 m to 0.5 m above ground surface
7	Extreme; Loss of Asset	Multiple trunk lines fully surcharged, ponding at one or more nodes > 0.5 m above ground surface

4.2.2 Lou Romano Treatment and Wastewater Drainage Infrastructure

The criteria used to evaluate the severity of flood impacts on wastewater infrastructure is summarized in the following table.

Table 5: Wastewater Infrastructure Severity Ratings

Severity Rating	Original PIEVC Severity Descriptors	Evaluation Criteria
0	Negligible; Not applicable	No Impacts
1	Very Low; Some measurable change	Peak flow/wastewater volume greater than dry weather flow
2	Low; Slight loss of serviceability	Peak flow/wastewater greater than average annual maximum
3	Moderate loss of serviceability	Multiple maintenance access covers and drains partially blocked
4	Major loss of serviceability; Some loss of capacity	Multiple maintenance access covers and drains fully blocked
5	Loss of capacity; Some loss of function	Flow at treatment plant approaching max capacity; Some pump stations no longer functioning, may require significant repair
6	Major; Loss of function	Treatment Plant Shut-Off – sewer back-up 10s of properties; Individual pump stations damaged, needing replacement
7	Extreme; Loss of Asset	Treatment Plant Shut-Off – sewer back-up 100s properties; Most pump stations destroyed or offline - sewer back-up 100s properties

4.2.3 Shoreline Infrastructure

The criteria used to evaluate the severity of flood impacts on shoreline infrastructure is summarized in the following table.

Table 6: Shoreline Infrastructure Severity Ratings

Severity Rating	Original PIEVC Severity Descriptors	Evaluation Criteria
0	Negligible; Not applicable	No Impacts
1	Very Low; Some measurable change	Regular seasonal erosion/wear-and-tear on shoreline (soft soils)
2	Low; Slight loss of serviceability	Excessive seasonal erosion, resulting in more mass loss than usual
3	Moderate loss of serviceability	Excessive seasonal erosion, resulting in need for greater than normal maintenance
4	Major loss of serviceability; Some loss of capacity	Water level begins to overtop unprotected shoreline
5	Loss of capacity; Some loss of function	Water level beings to overtop protected shoreline; Erosion of unprotected shoreline will require repairs (i.e., soil replacement)
6	Major; Loss of function	Shoreline protection damaged with some assets requiring significant repairs; levees or other riverine flood protection begin to be overtopped
7	Extreme; Loss of Asset	Shoreline protection destroyed with assets requiring replacement; levees or other riverine flood protection are overtopped resulting in standing water > 0.5 m deep in formerly protected areas

4.2.4 Surface Transportation Routes

The criteria used to evaluate the severity of flood impacts on roadways and railways is summarized in the following table.

Table 7: Surface Transportation Route Severity Ratings

Severity Rating	Original PIEVC Severity Descriptors	Evaluation Criteria
0	Negligible; Not applicable	No Impacts
1	Very Low; Some measurable change	Regular rainfall events
2	Low; Slight loss of serviceability	Sufficient rainfall for ground saturation
3	Moderate loss of serviceability	Surface flow transports leaf litter, branches, etc. from properties, partially blocking drainage
4	Major loss of serviceability; Some loss of capacity	Temporary ponding in low lying areas (e.g., immediately surrounding drains), maximum depth < 0.1 m
5	Loss of capacity; Some loss of function	Standing water < 0.3 m (for 1:100 year storm) or HGL > 0.3 m BGS (1:5 year storm)
6	Major; Loss of function	Standing water 0.3 to 0.5 m above ground surface (1:100 year storm) - passenger/commercial vehicles may be stranded; any partial erosion of roadbeds, embankments, water crossing footings/foundations; *Any* ponding/standing water from 1:5 year storm
7	Extreme; Loss of Asset	> 0.5 m AGL depth - vehicles may become buoyant; Any washouts due to any failure (e.g., culvert failures, road bed erosion, slope failure, etc.) resulting in loss of one or more lanes of traffic

4.3 Risk Assessment Workshops

An initial internal risk assessment workshop was conducted with the project engineering team leads from the City and Dillon to identify relevant climate-asset interactions (the so-called “Yes/No” analysis) and to estimate preliminary numerical risk score values. The results of this internal risk assessment were presented during a facilitated half-day workshop with key City staff and stakeholders, at which the consulting team refined scoring based on feedback and requested revisions. As per the PIEVC Protocol, future risk scores were calculated based on current consequence/severity scores, and projected future climate hazard probabilities. The risk assessment workshop information is documented in **Appendix B**.

4.4 Risk Scoring

The range of potential risk scores based on the product of the probability and severity ratings is summarized in the following table. The risk scores were ranked as shown to identify assets that require a response to address the corresponding climate hazard.

Table 8: Risk Scores

Severity Rating	Probability Rating							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6	7
2	0	2	4	6	8	10	12	14
3	0	3	6	9	12	15	18	21
4	0	4	8	12	16	20	24	28
5	0	5	10	15	20	25	30	35
6	0	6	12	18	24	30	36	42
7	0	7	14	21	28	35	42	49

Low Risk – No further action
Special Case – Operation, planning and/or management response
Medium Risk – Requires monitoring, possible engineering analysis
High Risk – Response required

4.5 Risk Assessment Results

A summary of the risk assessment results for each Zone in the Study Area is provided in the following sections.

4.5.1 Zone 1

The Zone 1 infrastructure components with high calculated risk scores associated with the evaluated climate hazards is summarized in the following table.

Table 9: Zone 1 Risk Assessment Summary

Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
LRWRP	Extreme River Levels, Combination Events, Extreme Rainfall	Inflows to the Wastewater System, Basement Flooding	49	49	49
Sandwich Street at McKee Creek Drain	Extreme Rainfall, Combination Events	Local Surface Flooding	35	36	42
ETR Rail at Sandwich Street	Extreme Rainfall, Combination Events	Local Surface Flooding	35	36	49
Felix Avenue – Combined Sewer	Extreme Rainfall	Basement Flooding	35	36	42
Mill Street – Combined Sewer	Extreme Rainfall	Local Surface Flooding, Basement Flooding	24	36	42
Riverside Drive – Combined Sewer	Extreme Rainfall	Local Surface Flooding, Basement Flooding	21	30	35
Sandwich Street - Combined Sewer	Extreme Rainfall	Local Surface Flooding, Basement Flooding	42	42	42
Canada South Science City	Extreme Rainfall	Basement Flooding	35	36	42
West Windsor Mosque	Extreme Rainfall	Basement Flooding	42	42	42
Islamic Academy/St Vincent de Paul Society/Sandwich Teen Action Group	Extreme Rainfall	Basement Flooding	42	42	42
Commercial and Residential Areas Serviced by Combined Sewers	Extreme Rainfall	Local Surface Flooding, Basement Flooding	42	42	49
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre	Extreme Rainfall	Local Surface Flooding	49	49	49

Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
General Brock Public School	Extreme Rainfall	Basement Flooding	35	35	35
Sandwich First Baptist Church	Extreme Rainfall	Basement Flooding	21	30	35

With the exception of the LRWRP and the Sandwich Street ROW at McKee Creek Drain, the risk scores at assets located in Zone 1 are not influenced by extreme Detroit River levels. This result is expected since the ground elevations in most of Zone 1 are significantly higher than the extreme river levels. Basement flooding and local surface flooding caused by extreme rainfall events are the prominent potential impacts within most of Zone 1. The risk assessment scores at many of these assets suggest increasing potential risk of impacts due to climate change in the future.

High risks of impacts at the LRWRP are caused by extreme river levels, extreme rainfall events, and combination events. Additional wastewater flows to the LRWRP caused by these climate hazards could exceed the plant capacity, resulting in upstream basement flooding.

The high risk on Sandwich Street and the Essex Terminal Rail (ETR) rail line at McKee Creek Drain is due to the relatively low ground elevations at this location and the limited capacity of the existing local storm drainage system.

4.5.2 Zone 2

The Zone 2 infrastructure components with high calculated risk scores associated with the evaluated climate hazards is summarized in the following table.

Table 10: Zone 2 Risk Assessment Summary

Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
Prospect Avenue	Extreme River Levels, Extreme Rainfall, Combination Events	Coastal Flooding, Local Surface Flooding	35	36	42
Windsor Salt (Prospect Avenue)	Extreme Rainfall, Combination Events	Local Flooding	42	42	49
Russell Street	Extreme Rainfall	Local Surface Flooding	24	36	42
Mill Street – West of Russell Street	Extreme River Levels, Combination Events	Coastal Flooding	35	42	42
McKee Road - Pumping Station	Extreme River Levels, Extreme Rainfall	Local Surface Flooding	35	42	42
McKee Creek Drain	Extreme River Levels, Extreme Rainfall	Coastal Flooding, Local Surface Flooding	35	42	42
Brighton Beach Generation Station	Extreme Rainfall	Local Surface Flooding	49	49	49
Keith Transmission Station - Hydro One	Extreme Rainfall	Local Surface Flooding	21	30	42
Chateau Park LTC	Extreme Rainfall	Basement Flooding	35	35	35
Great Lakes Institute for Environmental Studies	Extreme Rainfall	Basement Flooding	35	35	35
McKee Park	Extreme River Levels	Coastal Flooding	35	35	35
ETR Rail at Russell Street	Extreme River Levels, Extreme Rainfall, Combination Events	Coastal Flooding, Local Surface Flooding	35	36	49
Windsor Biosolids Processing Plant	Extreme Rainfall, Combination Events	Local Surface Flooding	35	42	42
Brock Street - Outfall	Erosion	Erosion	28	28	35
HMCS Hunter	Extreme River Levels	Coastal Flooding	35	35	42

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Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
CSOs	Extreme River Levels, Combination Events	Inflows to the Wastewater System, Basement Flooding	35	35	35
Residential Areas Serviced by Combined Sewers	Extreme Rainfall	Local Surface Flooding, Basement Flooding	49	49	49
Commercial Areas Serviced by Combined Sewers	Extreme Rainfall	Local Surface Flooding	42	42	49

Infrastructure assets located in Zone 2 with high calculated risk scores include ROWs and shoreline properties. Since the ground elevations in Zone 2 are generally low relative to the Detroit River, assets in this zone are prone to extreme river levels.

The Brock Street storm sewer outfall consists of twin concrete box pipes located in a drainage easement west of Russell Street. Both the Windsor Port Authority (WPA) and City administration noted concerns with the condition of the outfall. Erosion of the ground surface above the pipes suggests that deterioration of the pipe barrels has occurred. Climate change impacts are likely to exacerbate the existing deterioration.

4.5.3 Zone 3

The Zone 3 infrastructure components with high calculated risk scores associated with the evaluated climate hazards is summarized in the following table.

Table 11: Zone 3 Risk Assessment Summary

Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
Ojibway Parkway	Extreme Rainfall, Combination Events	Local Surface Flooding	35	42	49
Windsor Salt Mine – Morton Avenue	Extreme River Levels, Extreme Rainfall, Combination Events	Local Surface Flooding	49	49	49
Detroit-Windsor Truck Ferry	Extreme Rainfall, Combination Events	Local Surface Flooding	42	42	49
Sprucewood Avenue	Extreme Rainfall, Combination Events	Local Surface Flooding	42	42	49
Black Oak Heritage Park	Extreme Rainfall, Combination Events	Local Surface Flooding	35	35	35
Railway Tracks – Ojibway Parkway	Extreme Rainfall, Combination Events	Local Surface Flooding	35	42	49

Stormwater servicing in Zone 3 is generally provided by roadside ditches that discharge to the Detroit River. The infrastructure assets in Zone 3 with high calculated risk scores may be prone to local surface flooding caused by the limited available capacity of the roadside ditches, which could be exacerbated by extreme river levels.

4.5.4 General Study Area

The following table summarizes infrastructure components dispersed throughout the Study Area with high calculated risk scores associated with the evaluated climate hazards.

Table 12: Study Area-Wide Risk Assessment Summary

Infrastructure Component	Climate Hazard	Potential Impact	Risk Score		
			Current	2050s	2080s
Overhead Electrical Distribution Equipment	Extreme Wind Events	Loss of Electrical Power	30	35	35
Pad-Mounted Electrical Distribution Equipment	Extreme Rainfall	Loss of Electrical Power, Electrical Safety	28	42	49
Communications Equipment	Extreme Wind Events	Disruption of Monitoring Equipment	30	35	35

5.0 Engineering Assessment (PIEVC Step 4)

Based on the findings of the PIEVC risk assessment and joint probability modelling scenarios, the project team identified flood protection measure objectives and the study target levels of service of future flood protection measures. These were then used to develop flood mitigation solutions for assets identified as being highly vulnerable to the evaluated climate hazards.

5.1 Flood Protection Measure Objectives

The following objectives were developed for the proposed West Windsor flood protection solutions:

- Reduce susceptibility of coastal flooding within the study area;
- Reduce impact of increased I&I into the municipal system from high Detroit River water levels;
- Improve the performance of the existing infrastructure during high water levels and reduce peak flows at the LRWRP;
- Provide more sustainable municipal infrastructure; and
- Reduce risk of surface and basement flooding.

5.2 Target Level of Service

The target the LOS criteria is based on recommendations from the Windsor SCFPMP (Dillon and Aquifor Beech, 2020). The following is a summary of the target LOS criteria for the study area:

- Reduce dry weather flow volumes entering the LRWRP under high river levels to similar magnitudes as during low river levels;
- Eliminate surface ponding within the ROW for all storm events up to and including the 1:5 year storm event under all Detroit River Level conditions;
- Allow no more than 0.30 m in maximum surface ponding depths within the ROW during 1:100 year storm event year under all Detroit River water level conditions; and

- Reduce HGLs in the sanitary/combined systems to 1.8 m below the existing ground elevation for all design events up to and including the 1:100 year storm event under all Detroit River Level conditions.

In addition to the SCFPMP criteria summarized above, a design elevation to mitigate the risk of flooding caused by Detroit River extreme water levels was developed. As described in Section 3.3, an extensive literature analysis was conducted for extreme high water levels, including considerations for climate change. Although there have been a number of projections made in previously completed studies, most include a high degree of uncertainty. Given that these future high water level projections are considered to be highly uncertain, it is recommended for this study that high river level resilience actions address the current 100-year historical high water level of 176.1 m plus 0.3 m of freeboard that includes include margins for climate change, rather than to select a highly uncertain climate change water level. The resulting target design elevation for solutions to mitigate the risk of coastal flooding is therefore 176.4 m.

5.3 Solutions Identification and Development

Based on the information presented in Steps 1 through 3 of the PIEVC procedure, the study developed a number of solutions to mitigate the impacts of high river levels on the Study area and critical assets to attempt to meet the targeted level of service criteria. Feedback from City Administration and stakeholders was gathered through a workshop on May 19, 2022, which was used to guide the development of the proposed solutions. The workshop presentation is provided in **Appendix B**.

5.3.1 Coastal Flooding

The following solutions were developed to address direct flooding impacts caused by extreme Detroit River levels.

5.3.1.1 Shoreline Properties

The need for a continuous landform barrier similar to the solutions proposed in the East Riverside Flood Risk Assessment (Landmark, 2019) and SCFPMP (Dillon and Aquafor Beech, 2020) to protect shoreline properties in West Windsor from high river levels was evaluated. The results suggest that this is not a viable solution for the West Windsor area for the following reasons:

- The vast majority of the shoreline properties in West Windsor are industrial lands that require direct access to the Detroit River shoreline for their operations;
- Most of the shoreline properties are privately owned, making access for construction and future maintenance of any proposed flood protection works problematic; and,
- The shoreline flooding limits in West Windsor does not significantly encroach inland beyond the shoreline properties. Consequently, only the shoreline properties themselves would benefit from any proposed flood protection measures.

Coastal flooding on privately owned shoreline properties is best to be mitigated by individual site solutions implemented by the individual property owners. Private site coastal flooding solutions include:

1. Temporary measures implemented during periods of high river levels such as sandbag barriers or temporary changes to site operations such as relocating affected activities to locations outside of the flooded areas; and,
2. Permanent measures such as site grading improvements to raise critical portions of the site above the Detroit River high water level, or constructing permanent flood protection barriers such as berms.

The minimum recommended design elevation for individual site solutions to mitigate coastal flooding on the shoreline properties is 176.4 m.

5.3.1.2 Mill Street

The western portion of Mill Street adjacent to HMCS Ojibway is lower than the existing 1:100 year water level of 176.1 m and has the potential to experience prolonged surface ponding during periods of extreme river levels. The existing road profile is recommended to be raised to provide safe access the HMCS Ojibway site. The available topographic information suggests that raising the Mill Street profile to the minimum recommended design flood protection elevation of 176.4 m likely isn't feasible due to adjacent site grading constraints. Instead, the Mill Street road profile should be raised to a minimum design elevation of 176.1 m, as shown on **Figure 9**.

The proposed grading design should be coordinated with any proposed flood protection measures on the HMCS Ojibway site. Additionally, the proposed road profile should be design to direct overland flows from the right-of-way away from the HMCS Ojibway site entrance. The existing Mill Street storm sewer outfall should also be inspected to assess its condition and capacity.

5.3.1.3 Russell Street at Chappell Avenue

The southern portion of Russell Street near Chappell Avenue is lower than the existing 1:100 year water level of 176.1 m and may experience prolonged surface ponding greater than 0.30 m deep during periods of extreme high water elevations. The ETR spur line located near the Russell Street/Chappell Avenue intersection limits the possibility of raising the existing Russell Street profile to the minimum recommended design elevation of 176.4 m to prevent local roadway ponding. For this area, an adaptive solution is recommended, as shown on **Figure 10**.

During periods of extreme river levels, it is recommended that the City assess mitigation measures during this time, including consideration to temporarily close the southern portion of Russell Street, using appropriate road closure signage. Traffic diversion during these closures would be required, including acceptable diversion of trucking routes. The consideration for road closure would still allow local traffic to access 3795 Russell Street via the existing secondary driveway entrance from Chappell Street. The maximum ponding depths at the existing 3800 Russell Street site entrance are anticipated to be less than 0.3 m, and consequently should not prevent site access.

Flooding encroachment onto the adjacent private properties from the Russell Street ROW can be mitigated through site improvements implemented by individual property owners. Typically, this involves modifying the site grading to direct water away from homes and businesses and reduce maximum ponding depths. Any modifications to site grading will need to be reviewed and accepted by the City of Windsor.

5.3.1.4 Prospect Avenue

To provide a flooding solution to protect Prospect Avenue during extreme Detroit River levels, the existing roadside ditches and drains are recommended to be improved and a permanent pump station constructed at the storm sewer outlet to the Detroit River. As part of these improvements, the roadside ditch on the north side of Prospect Avenue will need to be extended, while culverts will need to be installed at driveway and road crossings along the west end of Prospect Avenue to outlet to the Detroit River via the proposed pump station outlet, as shown on **Figure 11**.

The proposed Prospect Avenue stormwater pump station will provide for a hydraulic disconnection from the drainage system to the Detroit River during periods of high river levels. Grading along Prospect Avenue is to be designed to maintain the overland flow route from Sandwich Street to the Detroit River at a minimum longitudinal slope of approximately 0.3%.

The proposed Prospect Avenue improvements and outlet works are expected to be coordinated with the proposed LRWRP Retention Treatment Basin project. Opportunities to use the future RTB outlet to convey discharges from the proposed stormwater pump station to the Detroit River should be evaluated.

5.3.1.5 Sandwich Street Drainage Improvements

The currently ongoing Gordie Howe International Bridge construction includes improvements along Sandwich Street from Ojibway Parkway to McKee Street. The proposed improvements include providing an urban cross section complete with curb and gutter and a proposed storm sewer, as shown on **Figure 12**. The proposed storm sewer is shown to discharge into the existing roadside ditch located on the south side of Prospect Avenue, which conveys stormwater westward to the Detroit River. The proposed storm sewer design is being completed by others and has not been evaluated through this project.

The proposed Prospect Avenue stormwater pump station will provide for a hydraulic disconnection from the drainage system to the Detroit River during periods of high river levels. The drainage design for the proposed Sandwich Street Improvements should be coordinated with the proposed Prospect Avenue improvements.

5.3.1.6 McKee Park Improvements

The City is planning proposed improvements at McKee Park that include replacing the existing riverside boardwalk, asphalt trails, a gazebo, lighting, and benches. The study team met with City Staff to review flood protection solutions for McKee Park.

Providing a flood protection barrier or grading the site to the minimum recommended protection elevation of 176.4 m to raise McKee Park above extreme Detroit River levels is not feasible at this time due to grading constraints. Installing a protection barrier would block surface runoff during rainfall events from travelling to the Detroit River and cause interference with the existing boat ramp. In lieu of this solution, an adaptive strategy is recommended:

- Construct all proposed pathways and surface works to a minimum design elevation of 176.1 m (1:100 year historical Detroit River water level);
- Flood proof all electrical systems to a minimum elevation of 176.4 m; and
- It is recommended that the City of Windsor develop a response plan for the park during high river level conditions to protect public safety.

5.3.2 Inflows to Wastewater System

Solutions to reduce inflows to the wastewater system include both source control measures and previously planned capital projects. Examples of source control measures include rain catchers at sanitary sewer MH lids and backflow prevention measures at CSOs.

Recommendations developed from previously completed studies for the area and future capital improvement projects identify additional solutions already proposed to reduce inflows into the wastewater system. This includes the proposed LRWRP RTB, Prince Road Trunk Storm Sewer Outfall, and a number of streets for combined sewer separation.

5.3.2.1 Rain Catchers

The installation of rain catchers within existing sanitary sewer MHs has been identified as an immediate improvement that will provide benefit for the sanitary system through a reduction of rainfall derived and coastal water inflow from entering the sanitary MHs.

Rain catchers are seals placed between the MH frame and cover to reduce surface water flows from entering the sanitary system.

To assist the City in developing a feasible plan for installing these units, an assessment was completed to identify locations where the potential for inflow is highest and where MH sealing should be prioritized. The MHs to be prioritized in the study area were selected where rim elevations are below the 1:100 year historical Detroit River water level of 176.1 m and the future climate change water level of 176.3 m. **Table 7** below summarizes the MHs in the study area to be prioritized for the installation of rain catchers, and their locations are shown on **Figure 13**.

Table 13: Rain Catcher Locations

MH ID	Rim Elevation (m)	Street Name/Location
Manholes below 1:100 Year HWL of 176.10 m		
5S607	175.54	Ojibway Parkway at Prospect Avenue
5S609	175.98	Ojibway Parkway at Prospect Avenue
5S721	176.01	Russell Street
5S724	176.01	ETR Railway
5S935	175.53	Below Ambassador Bridge
Manholes below Climate Change Event HWL of 176.30 m		
5S722	176.12	Russell Street
5S723	176.21	ETR Railway
5S987	176.21	North Prospect Avenue

The MH elevations within this table are taken from City Lidar elevation surface data that is assigned to each location within the City InfoWorks ICM model. A Field investigation and/or topographic survey of each location is recommended to confirm final elevations.

5.3.2.2 Combined Sewer Outlet Protection

As part of protecting combined sewer outlets from high Detroit River levels, two possible solutions were evaluated to reduce water from entering the wastewater system during periods of extreme river levels. This included:

- Backflow preventers such as flap gates or inline check valves to prevent reverse flows from the river through the CSOs; and
- Raising the existing internal structure CSO weir elevations to the estimated Detroit River 1:100 year future climate change water level of 176.30 m.

Backflow preventers are devices that allow water to flow in only one direction. The devices are to be oriented to prevent Detroit River water from entering the combined storm sewer during high lake levels, while allowing overflows to enter the Detroit River during periods of severe rainfall, thereby protecting upstream homes and businesses from basement flooding.

Under extreme rainfall events and high Detroit River levels, backflow preventers require additional upstream head to open and release overflows to the Detroit River, resulting in slightly higher upstream water levels within the combined and sanitary system. This prevention measure has the potential for higher risks of basement and surface flooding during times when the backflow device is fully closed. A hydraulic analysis was completed to evaluate the impacts of backflow preventers on the wastewater system performance. To complete this task, the City SCFPMP Baseline Infoworks model was modified as follows:

- Boundary conditions were set at both the historical and climate change 1:100 year return period Detroit River water levels; and
- Backflow prevention devices were modelled in each noted CSO with spill elevations lower than 176.3 m using default head loss coefficients[1].

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[1] Flow characteristics at flap gates modelled in Infoworks are calculated using the following equation:

$Q = (1/C_d) A_m V_m$

Where

A_m – average cross sectional area (m^2)

V_m – average velocity (m/s)

C_d – discharge coefficient

Q – discharge (m^3)

The modified Infoworks model was used to simulate the following storm scenarios and the Detroit River 1:100 year future climate change water level of 176.30 m under the river levels stated above:

- 1:5 year return period rainfall event; and
- 1:100 year return period rainfall event.

The modelling results identify that the calculated peak HGLs during the 1:5 year rainfall event are slightly higher in isolated areas of the service area when compared to the scenario without backflow prevention devices installed at CSO locations. The calculated peak HGLs during the 1:100 year rainfall event are generally lower across the service area when compared to a similar scenario without backflow prevention devices installed at CSO locations.

Instead of backflow prevention devices, an alternative is to raise the CSO overflow weirs to the Detroit River 1:100 year future climate change water level of 176.3 m. Raising the weirs will reduce the volume of untreated wastewater being diverted into the Detroit River during high flow events and will decrease the volume of river water entering the LRWRP during high water levels. This solution was considered as part of the Windsor SCFPMP which concluded that while there is a meaningful increase in HGL upstream of each weir, this increase only propagates slightly upstream of each structure. Any increases in HGL during periods of low Detroit River water levels is expected as the HGL in the system would need to increase to the new weir elevation before a spill occurs.

Both options are shown to decrease the risk of backflow from the Detroit River entering the combined and sanitary system. However, backflow prevention devices offer the following advantages:

- They are less likely than weirs to raise the upstream HGLs during wet weather events when the Detroit River water levels are low; and
- They will reduce the possibility of inflow from the river if the Detroit River water levels rise above the estimated 1:100 year climate change elevation.

The default discharge coefficient of 1.0 corresponds to a steel check valve.

Based on the modelling analysis completed and discussed through this section, a combination of flap gates and check valves are recommended as backflow prevention devices. **Flap gates** are proposed at all CSOs requiring backflow prevention where it is feasible to install the backflow prevention device at the open downstream outlet to the Detroit River and the pipe diameter is greater than or equal to 1800 mm. **Inline check valves** are proposed at all CSOs requiring backflow prevention where the pipe diameter is less than 1800 mm. All inline check valves must be installed in the existing combined sewer upstream of the Detroit River and in close proximity to a maintenance hole. If there are no nearby MHs, a new structure will be required. The proposed backflow preventer locations are documented in **Appendix G** and their locations are shown on **Figure 14**.

5.3.2.3 Lou Romano Retention Treatment Basin

In 2019, the City of Windsor completed an environmental assessment for a proposed retention treatment basin (RTB) at the LRWRP (Stantec, 2019). The RTB will provide primary treatment of wastewater during wet weather events when the flows to the plant are greater than the plant capacity. Wet weather flows include both wastewater from residential properties and businesses, as well as storm runoff that enters the sewer network either intentionally through combined systems or unintentionally through inflow and infiltration sources. Additionally, the RTB will provide primary treatment of wastewater during emergencies, such as a catastrophic failure at the plant. The proposed RTB location is shown on **Figure 15**.

As part of the recent City award of the Disaster Mitigation and Adaptation Funding (DMAF) for the RTB, detailed design for the project is expected to begin in 2023, with construction estimated to begin in 2026/2027.

In addition to the RTB, conveyance from the CSO chambers on Hill Avenue, Detroit Street and Bridge Avenue will be improved during wet weather flow events. A proposed CSO collection sewer extension will convey these additional flows to the proposed RTB.

5.3.2.4 Prince Road Trunk Storm Sewer Outfall and Pump Station

The City of Windsor SCFPMP completed in 2020 (Dillon and Aquafor Beech) identified the need to separate all combined sewers with separate storm and sanitary systems.

One of the projects recommended to support this goal is the construction of a new stormwater pumping station and outfall from the Prince Road trunk storm sewer to the Detroit River. This new outfall will provide a stormwater outlet to direct stormwater that would otherwise go to the LRWRP to the Detroit River.

The City of Windsor completed an Environmental Assessment to establish the location of the proposed outfall works (Stantec, 2022). The proposed location of the outfall and pump station is detailed in **Figure 16.**

Construction of the proposed outfall and pumping station will allow disconnection of the existing Russell Street catchbasins located south of Hill Avenue from the combined sewer system.

5.3.2.5 Detroit Street Trunk Outfall

Similar to the proposed Prince Road Trunk Storm Sewer Outfall, the SCFPMP recommended construction of a new trunk storm sewer and outfall from Detroit Street in the northern portion of the West Windsor study area. This new outfall will provide a stormwater outlet to allow upstream combined sewer separation to proceed, and direct stormwater that would otherwise go to the LRWRP to the Detroit River. The proposed outfall location is shown on **Figure 17**.

Several challenges are anticipated with the proposed outfall construction. The existing storm sewer easement from Detroit Street to the Detroit River is located on industrial land currently used for stockpiling aggregates. The proposed outfall is expected to be designed to bear the anticipated loading of the stockpiled material and equipment. Construction activities will also need to be coordinated to reduce risk of impacts to the ongoing site operations.

5.3.2.6 Combined Sewer Separation

Currently, stormwater runoff enters the LRWRP through the upstream combined sewer system. Separating the stormwater flows from the combined sewers in the Study area is a collection system improvement that will reduce flows to the LRWRP. This recommended improvement involves installing a separate storm sewer conveyance system to take all stormwater runoff flows from the study area directly to the Detroit River without entering the LRWRP. The combined sewer locations within the Study Area are shown on **Figure 18**.

The City of Windsor has a number of ongoing projects to eliminate stormwater flows into its combined sewer system. However, given the many kilometers of existing combined sewers, it is expected to take many years for a full separation of the Study area.

5.3.3 Basement Flooding

Each of the solutions for reducing inflows the wastewater system is expected to help reduce basement flooding. However, these programs will take time to implement. Property owners are expected to have a role to play in protecting their residences and businesses from basement flooding. These solutions can be implemented readily and provide immediate protection to individual properties while programs to improve the municipal drainage systems are implemented. Examples of private property improvements that can provide basement flood mitigation are shown on **Figure 19** and include:

- Disconnecting downspouts from foundation drains and directing them instead to the ground surface;
- Disconnecting foundation drains from the private drain connection and directing them instead to a sump pump;
- Installing a backflow preventer to prevent wastewater backups into the residence; and
- Providing separate private drain connections, one for sanitary flows and one for storm flows, in areas serviced by separate storm and sanitary systems.

The City of Windsor currently has two programs to help homeowners protect their homes from basement flooding.

1. The Downspout Disconnection Program provides free assistance to help property owners safely redirect the flows from their eaves troughs to the ground surface; and
2. The Basement Flood Protection Subsidy Program provides homeowners with up to $2,800 per property towards the costs of installing eligible flood protection measures such as backflow preventers, new sump pump installations, and foundation drain disconnections.

The City of Windsor provides information on these programs on City's official website. Additional education and outreach is recommended to increase participation in these programs for properties located within the Study area. Potential outreach measures could include program information provided with existing communications to property owners such as property tax bills.

5.3.4 Local Surface Flooding

Local surface flooding is generally the result of limited available drainage capacity and is further exacerbated during periods of high Detroit River water levels.

5.3.4.1 Right-of-Ways

As part of this study, local improvements are recommended in the following ROWs to manage local surface flooding:

- Morton Avenue;
- Russell Street;
- Ojibway Parkway; and
- Sprucewood Avenue and Maplewood Drive.

The currently known inverts of the Morton Avenue ditches are shown to be lower than the Detroit River 1:100 year climate change water level of 176.30 m, and consequently the ditch capacity may be reduced under periods of extreme river levels. A detailed assessment of ditch capacities is recommended to verify whether ditch improvements are required. The location of the proposed Morton Avenue improvements is shown on **Figure 20**.

The majority of Russell Street is currently serviced by roadside ditches and frequent surface ponding has been observed, based on anecdotal information provided by stakeholders. The available topographic information suggests that portions of the roadside ditches have invert elevations lower than the Detroit River 1:100 year climate change water level of 176.30 m. Since Russell Street provides access to industrial properties, there is concern that heavy truck traffic on the saturated road structure will lead to pavement deterioration. Furthermore, a significant portion of Russell Street drains via an outlet that is not located with a municipal drainage easement. Future maintenance of this outlet could be problematic. It is recommended that drainage improvements along the portion of Russell Street shown on **Figure 21** should be completed to:

- Reduce the frequency and severity of local ponding;
- Establish outlets to the Detroit River located in drainage easements or on municipally owned lands; and
- Provide an outlet to the southern portion of Russell Street via the proposed Prince Street storm sewer outlet.

Surface ponding frequently occurs along Ojibway Parkway during heavy rainfall events. Roadside ditch maintenance is recommended to improve the drainage system capacity as shown on **Figure 22**. The roadway is recommended to be monitored to evaluate whether additional drainage improvements are required. The available topographic information suggests that the Ojibway Parkway roadside ditches invert elevations are higher than the Detroit River 1:100 year climate change water level of 176.30 m.

Based on the information presented in a recent drainage report (Meritech, 2021), the Sprucewood Avenue and Maplewood Drive roadside ditches currently do not prove sufficient capacity to convey the peak flow from a 1:2 year design rainfall event. Furthermore, the available topographic information suggests that portions of the roadside ditches have invert elevations lower than the Detroit River 1:100 year climate change water level of 176.30 m, as shown on **Figure 23**. These roads provide access to industrial properties and the Detroit-Windsor Truck Ferry. Drainage improvements are required to reduce the possibility of local flooding in these ROWs. Any drainage improvements will need to be completed in accordance with the provisions of the *Drainage Act*.

5.3.4.2 McKee Creek Municipal Drain

As part of this study, drainage improvements are recommended to the McKee Creek Municipal Drain to reduce the possibility of local surface flooding caused by limited drain capacity and high river levels. A previously completed engineer's report evaluated the existing drain condition and recommended improvements on behalf of the City of Windsor. The proposed improvements to the McKee Creek Drain are presented in the Drainage Report for the McKee Drain (Landmark, 2022) are shown on **Figure 24** and include the following measures within the Study area:

- Clearing and grubbing the drain from the west side of Sandwich Street to the Detroit River;
- Removing accumulated sediment and reprofiling the drain from Sandwich Street to the Detroit River; and
- Replacing the existing ETR bridge located approximately 260 m downstream from Sandwich Street.

These proposed improvements are expected to reduce the possibility of local flooding within the McKee Creek Municipal Drain drainage area by increasing the drain capacity. The increased capacity will improve the drain performance during periods of high river levels.

5.3.4.3 Site Improvements

Local flooding along private properties can be mitigated through site improvements implemented by individual property owners. Typically this involves modifying the site grading to direct water away from homes and businesses, and reduce maximum ponding depths. Any modifications to site grading will need to be reviewed and accepted by the City of Windsor.

5.4 Public Consultation

A virtual Public Information Centre (PIC) for the West Windsor Flood Risk Study was posted to the project page on the City of Windsor website on October 6, 2022. The PIC was presented as a pre-recorded slideshow that described the West Windsor study area, the project scope and purpose, the flood risk study methodology, the effects of the flooding and flood mitigation solutions. The PIC slides and corresponding script are presented in **Appendix F**.

5.4.1 PIC Announcement

Advertising for the PIC was completed through social media postings and by email circulated to stakeholders. A copy of the stakeholder contact list and the corresponding email is presented in **Appendix F**.

5.4.2 PIC Feedback

PIC attendees were given the opportunity to provide feedback to the project team through an online survey or via email. The online survey questions and a summary of the collected feedback and corresponding responses is presented in **Appendix F**.

A total of six respondents completed the online survey and three comments were provided. None of the comments provided through the online survey were relevant to the West Windsor Flood Risk Study nor did any of the survey respondents provide their contact information.

5.5 Cost Estimates

In order to assist the City with projection planning and implementation of the proposed works, estimated construction costs have been developed. All costs are based on a conceptual design and general extents of the proposed improvements and do not represent pre-design costs. The capital construction costs for the various recommended solutions are based on 2022 construction prices.

During further design of any solutions, updates to the cost estimates should be completed to more accurately estimate overall costs for the proposed improvements. This section includes a summary of the costing assumptions and methodology as well as the high-level costs related to the proposed solutions.

5.5.1 Costing Assumptions and Methodology

The cost assumptions for all recommended improvements include, but are not limited to, the following:

- Construction cost estimates, including labour, are based on 2022 unit prices and the accuracy of each estimate is +/- 30 % and dependent on the timing of implementation;
- Future engineering costs calculated as 20 % of capital construction costs;
- Due to material supply issues, global increase in fuel costs and local market fluctuations a Contingency cost of 30 % has been applied to all construction costs; and
- Costs exclude any further studies required for each recommended solution, including municipal drainage assessments.

Land acquisition costs required to construct any recommended solutions on private property are not included in the cost estimates. Land acquisition requirements and the associated costs shall be confirmed during detailed design.

5.5.2 Unit Prices

Approximate unit prices were developed based on 2022 average construction costs for similar projects. The unit prices were utilized to determine the total construction costs for the recommended solutions within the Study Area. To simplify the costs for the proposed works, majority of the unit prices were developed on a per metre basis, with a few others developed on a per item basis.

5.5.3 Implementation Variances

Due to the scale of the proposed works and the implementation schedule, actual construction costs may vary significantly depending on the year of implementation and market conditions. Priority projects recommended for implementation in the near future will have a higher degree of cost accuracy than works to be completed many years in the future.

5.5.4 Operation and Maintenance Costs

The costs to operate and maintain the various infrastructure improvements that have been recommended were not included in the cost estimate. Due to the implementation time horizon, operation and maintenance costs could vary significantly. The City will need to include the recommended solution to its operations and maintenance programs once they are constructed. As the improvements are constructed, the City should have a better idea of what the costs are to maintain the infrastructure.

On-going monitoring and maintenance will need to take place to ensure that the infrastructure is not altered in any way that could make the system vulnerable to failure. The costs for maintenance may vary significantly from year to year, so it is important to be conservative when estimating the City's operation maintenance costs.

5.5.5 Cost Estimate Summary

The following table summarizes the total cost for each solution based on the estimated construction cost, engineering cost, and contingency cost as detailed above.

Table 14: Cost Estimate Summary

Solution	Solution Cost	Additional Costs
Install Backflow Prevention at CSOs along Detroit River	$2.7 M	Functional Design, Property Acquisition if Required
LRWRP RTB[1]	$75 M	Property Acquisition if Required
Combined Sewer Separation[2]	$747 M	Property Acquisition if Required
Prince Road Trunk Storm Sewer Outfall and Pumping Station[3]	$8.3 M	Property Acquisition if Required
Detroit Street Trunk Storm Sewer and Outfall[2]	$3.3 M	Property Acquisition if Required
Sandwich Street Drainage Improvements	$1.8 M	Property Acquisition if Required
McKee Creek Drain Maintenance from Detroit River to Sandwich Street[4]	$0.2 M	Monitoring of Drain Performance
McKee Creek Drain ETR Culvert Replacement[4]	$0.4 M	Monitoring of Drain Performance
Prospect Avenue Drainage Improvements	$2.7 M	Property Acquisition if Required
Mill Street Improvements	$0.3 M	
Maplewood Drive and Sprucewood Avenue Drainage Maintenance	$1.6 M	Monitoring of Drain Performance
Ojibway Parkway Roadside Ditch Maintenance – Broadway Avenue to Morton Drive	$1.7 M	Monitoring of Ditch Performance
Ojibway Parkway Drainage Improvements – Broadway Avenue to Morton Drive	$3.8 M	Functional Design, Property Acquisition if Required
Install Rain Catchers at Low Lying Sanitary Manholes	$0.1 M	
Russell Street Local Drainage Improvements	$2.4 M	Functional Design, Property Acquisition if Required
Morton Avenue Roadside Ditch Maintenance	$0.8 M	Monitoring of Ditch Performance
TOTAL	**$852.1 M**	

Notes:

1. Based on costs presented in the corresponding Environmental Assessment (Stantec, 2019).
2. Based on costs presented in the SCFPMP (Dillon and Aquifor Beech, 2020).
3. Based on costs presented in the corresponding Environmental Assessment (Stantec, 2022).
4. Based on costs presented in the Drainage Report (Landmark, 2022).

Further supporting documentation for the cost estimates is presented in **Appendix H**.

5.6 Triple Bottom Line Assessment

Upon completion of the PIEVC process to identify the medium and high climate and infrastructure risks, the next step is to develop an adaptation evaluation to allow the City to focus on solutions that provide the greatest risk reduction and increases current and future resilience.

Although unusual, the most comprehensive PIEVC Protocol assessments include an additional Triple Bottom Line (TBL) analysis on the various proposed adaptation options. The TBL analysis considers the economic efficacy and the social and environmental benefits and costs of the different alternative adaptation options for the community. The PIEVC TBL is not intended as a substitute or an addition to the risk assessment process, but to ensure that the adaptation recommendations consider their economic, social and environmental implications under current and future climates. The end result should be balanced recommendations that optimize the City's investments without compromising the core purpose of the asset and system. The multi-factored TBL analyses also should incorporate consultation with an appropriate range of stakeholders.

Table 15 depicts a set of economic, social and environmental TBL criteria. The TBL criteria, indicators and scores borrow heavily from and are consistent with the City of Windsor's Sewer and Coastal Flood Protection Master Plan completed in late 2020. These TBL criteria are applied across sub-drainage areas and proposed solutions. While the proposed solutions mainly refer to City actions, they do require a partnership between private property owners and the City since private property improvements are needed to reduce flood risk and to mitigate impacts to the municipal system.

Table 15: Scoring of Adaptation Options using TBL Criteria and Indicators

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments
			0	5	10	
ECONOMIC						
Cost effectiveness	Projects with lower capital costs impacts taxpayers the least and will require less budget allocation.	2	Cost > $4M	Cost Between $1-4M	Cost/< $1M or Private Property Costs.	Based on 2022 Estimated Project Construction Costs and does not factor inflation.
Asset Risk Rating	Higher priority if asset condition indicates need for refurbishment or replacement.	1	<10% rated as poor condition, acceptable condition or new infrastructure.	10-30% Rated as poor condition	>30% Rated as poor condition	Condition ratings were obtained via the City's Information System as of 2017.
Synergistic implementation, timing with other projects or opportunities (*e.g., Gordie Howe Bridge, Sandwich Street reconstruction, Great Lakes WQA)*	Higher priority and advantages for earlier action if synergistic opportunities support co-funding or achieve similar goals (*e.g., Intl Bridge; GLWQA)*	2	Likely no synergies or opportunities for overlapping funding or receiving support from other projects	Potential for synergies with one other project or potential funding opportunity	Potential for synergy with MORE than one other project or funding is available.	Survey of potential opportunities for synergistic projects.
If solution fails or is not implemented, high replacement costs or extreme challenges if catastrophic failure occurs (e.g., high costs to replace, time without services)	Higher priority for action if high costs or long disruptions could be incurred from catastrophic failure of critical asset (*e.g., Lou Romano WWTP, pumping stations)*	1	Low Reduction	Median Reduction	High Reduction	If solutions are not implemented what is the extent of property damage or failure of 3rd party assets during high river level events.
Ease, cost and complexity of measure's ongoing operations and maintenance.	Higher acceptance for action if ongoing O&M efforts are relatively lower.	2	Poor acceptance of measure, unknown technology and significant number of labour hours for maintenance and operation.	Some training needed. Mid-level number of labour hours for maintenance and operation.	Known technology and minimal labour hours are acceptable.	
Level of Basement Flooding	Higher priority and need for action in areas with greatest basement flooding risks and for solutions that mitigate basement flood risk.	2	Lowest amount of basement flooding risk mitigation by the solution.	Not Used	Highest amount of basement flooding risk mitigation by the solution.	Solutions that will reduce extraneous flows entering the system or will reduce sanitary sewer system hydraulic gradeline levels.
Level of Extent of Surface and Coastal Flooding	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Lowest amount of flooding risk mitigated by the solution.	Not Used	Highest amount of flooding risk mitigated by the solution.	Total Area of 1:100 year flood risk being removed.

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments
			0	5	10	
Access Risk - Level of Risk to Roadways or Railway Crossing	Higher priority and need for action if surface flooding along major arterial roadways impacts for emergency access and continue critical transportation connections.	2	Solution mitigates flooding along Collector roadways.	Solution mitigates flooding along Arterial Roadways	Solution mitigates flooding along Arterial roadways and Railway Corridors – Including critical connections (hospital routes, border access).	Road classifications from the City's Data System (2021).
Public Confidence and City Reputation	Higher priority and need for action if greater population density in area (reflecting potentially displeased citizens)	1	Low Density of homes/businesses within area impacted by potential service disruptions.	Mid Level Density of homes/businesses within area impacted by potential service disruptions.	High Density of homes/businesses within area impacted by potential service disruptions.	High Density = Residential/Urban Areas Mid Level Density = Commercial Developments, Industrial Sites Low Level Density = Vacant and Industrial Sites.
Level of Disruption to Archaeological and Cultural Heritage Resources	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Significant impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.	Not Used	Minimal impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.	Any excavation works along the waterfront areas (high archaeological risks) or construction impacts to private property areas that may contain built heritage features and/or cultural landscapes such as parks, naturalized areas.
ENVIRONMENTAL						
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.	Not Used	Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	**Reduces** amount of contaminants from reaching Detroit River or sensitive habitat.	**Prevents** or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminant risk associated with sewage backup from combined sewer on surface.
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g., increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g., additional electricity, additional LRWRP treatment, etc.)

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments
			0	5	10	
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g., shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g., sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at least one of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves two or more of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.

Weighting: Weighting applied to the Score, where 1 indicates that the calculated score is used and 2 indicates a doubling (weighted as a 2).

Assumptions:

(1) Costs effectiveness considers the capital construction costs to implement the recommended solutions within each respective drainage area.

(2) Costs exclude source control, private property measures and/or operation and maintenance costs.

(3) Conditions rating are based on available information provided by the City of Windsor.

Where possible, it will be important to identify opportunities for synergies or overlap with other ongoing projects in the West Windsor region. This includes opportunities for funding or flood risk reduction actions supported through other projects (e.g., Gordie Howe International Bridge stormwater management, LRWRP RTB, road reconstruction projects).

Other projects and funding sources may provide similar opportunities for coordination of timing or implementation of adaptation solutions to reduce the PIEVC identified higher risk assets and regions. In other cases, the Great Lakes Water Quality Agreement may be able to support some work to reduce local and Detroit River contamination risks and habitat creation or protection.

Prior to completing this evaluation and project comparison, there were a number of solutions that were excluded:

- Projects that involve additional monitoring, engineering study or implementation of small-scale works that can more easily be accommodated within the City's operational budget and will depend on climate trends and/or other flood protection initiatives; and
- Improvements to private property areas have been excluded as these improvements must be initiated and maintained by the individual property owners.

Table 16 and **Table 17** summarize those projects.

Table 16: Projects Requiring Monitoring and Operation

Project
Recalibrate Sanitary Service Area Model
Monitoring River Levels
Black Oak Heritage Park - Develop an Emergency Response Plan for Park When Flooded

Table 17: Projects Requiring Private Property Improvements

Project
Russell Street - Private Site Improvements (entrance grading)
Private Solutions to Prevent Surface Flooding from High Water Levels
Private Solutions to Prevent Surface Flooding from Local Flooding
Windsor Biosolids Plant - Site Drainage and Grading Improvements

The detailed TBL assessment is included in **Appendix H**. Based on the total score for each solution, an optional adaptation project list (**Table 18**) has been developed. This list applies priorities to solutions based on the assessment, high, medium and low which shall be used as a reference to assist with the planning and implementation of projects. These results are supplementary to the PIEVC assessment and should be used in tandem to schedule necessary capital projects.

Table 18: Adaptation Options

Solution	Score
High Priority	
Prince Road Trunk Storm Sewer Outfall and Pump Station	140
Install Rain Catchers	140
Install Backflow Prevention at CSOs along Detroit River	135
LRWRP RTB	130
Combined Sewer Separation	120
McKee Creek Drain Maintenance from Detroit River to Sandwich Street	120
Prospect Avenue Drainage Improvements	120
Ojibway Parkway Drainage Improvements	120
Medium Priority	
Install Basement Flood Protection Measures	110
Sandwich Street Drainage Improvements	110
Mill Street Drainage Improvements	110
McKee Park Improvements	110
Detroit Street Trunk Storm Sewer and Outfall	100
Russell Street Local Drainage Improvements	100
Ojibway Parkway - Roadside Ditch Maintenance	90
Low Priority	
McKee Creek Drain Improvements	85
Brock Street - Inspect Shoreline/Outfall Condition and Local Repair Plan	85
Maplewood Drive and Sprucewood Avenue Drainage Maintenance	80
Morton Avenue Drainage Improvements	80
Maplewood Drive Sanitary Pump Station Monitoring	40

6.0 Recommendations and Conclusions (PIEVC Step 5)

The following sections summarize the next steps and recommendations to reduce climate change vulnerability in the Study Area.

6.1 Class EA Implications

A high-level screening was completed to identify future Class Environmental Assessment (EA) implications based on the recommended flood mitigation measures. Anticipated Class EA Schedules were selected based on Municipal Engineers Association (MEA) guidance. A brief summary is provided in the following table.

Table 18: Class EA Requirements

Project	Anticipated EA Schedule	Notes
Prospect Avenue Improvements	A	Assumes that no land acquisition is required and that the outlet works will be coordinated with the LRWRP RTB design.
Ojibway Parkway Roadside Ditch Maintenance – Broadway Avenue to Morton Drive	A	Surface drainage services existing municipal road.
McKee Creek Drain Improvements (Clearing and Grubbing)	N/A	Works regulated under the *Drainage Act* are exempt under the *Ontario EA Act.*
Install Rain Catchers	A	Modification to an existing sewage collection system.
Detroit Street Trunk Outfall	B	Based on MEA guidance, this could be interpreted as a Schedule A project, since the existing outfall is located in an existing road allowance and utility corridor. However, given the likely technical challenges and potential impacts of the proposed works, a Schedule B undertaking is recommended, consistent with the SCFPMP recommendations.
Install Backflow Prevention at CSOs along Detroit River	A	Modification to an existing sewage collection system. Assumes that no land acquisition is required.
Morton Avenue Drainage Improvements	A	Surface drainage services existing municipal road.
Russell Street Drainage Improvements	B	Additional property will likely be required for improvements to the drainage system.
Sprucewood Avenue and Maplewood Drive Drainage Improvements	N/A	Works regulated under the *Drainage Act* are exempt under the *Ontario EA Act.*
Mill Street	A	Reconstructed for the same use, capacity, and at the same location.
McKee Creek Drain Improvements (ETR Culvert Replacement)	N/A	Works regulated under the *Drainage Act* are exempt under the *Ontario EA Act.*
Combined sewer separation	A+	Establish a sewage collection system to an existing sewage outlet. Assumes that no land acquisition is required.

6.2 Implementation Plan

An implementation plan was developed based on the results of the TBL and the anticipated timelines of previously identified projects. A summary of the recommended implementation plan for the proposed solutions is provided in the following table.

Table 19: Solution Implementation Summary

Timing	Project	Notes
Short Term	Lou Romano Retention Treatment Basin	EA has been completed. Design to begin in 2023.
	Prospect Avenue Improvements	Outlet for proposed Prospect Avenue pump station and drainage improvements recommended to be coordinated with the Lou Romano Retention Treatment Basin outlet design.
	Sandwich Street Improvements	Drainage strategy recommended to be coordinated with the Lou Romano Retention Treatment Basin and Prospect Avenue Improvements.
	Prince Road Trunk Storm Sewer Outfall	EA completed in 2022.
	Ojibway Parkway Roadside Ditch Maintenance	Complete ditch maintenance and monitor drainage system performance.
	McKee Park Improvements	Incorporate flood mitigation measures into proposed park improvement design.
	McKee Creek Drain Improvements	Clear and grub drain from Sandwich Street to Detroit River.
	Install Rain Catchers	Field verify MH lid elevations. Include in current implementation plan under East Windsor MH seals installation.
Medium Term	Detroit Street Trunk Outfall	EA will be required. Completion of the outfall works will permit separation of the upstream combined sewer system.
	Combined Sewer Outlet Protection	Install backflow prevention measures concurrent with other sewer rehabilitation projects.
	Morton Avenue Drainage Improvements	Complete drainage assessment to evaluate need for additional improvements.
	Russell Street Drainage Improvements	Develop drainage strategy for proposed improvements.
	Sprucewood Avenue and Maplewood Drive Drainage Improvements	Develop drainage strategy for proposed improvements.
	Mill Street	Raise profile of west limit of Mill Street.
Long Term	Combined Sewer Separation	To be completed concurrent with other servicing and transportation projects.
	McKee Creek Drain Improvements	Replace ETR bridge. To be completed in accordance with the *Drainage Act.*

6.3 Recommendations

The following comments and recommendations were developed based on the results of the PIEVC assessment:

- Design of the LRWRP RTB should be coordinated with the proposed Sandwich Street and Prospect Avenue improvements. Opportunities to coordinate the proposed RTB outlet and the proposed Prospect Avenue pumping station outlet designs should be evaluated;
- A functional drainage analysis for the Prospect Avenue improvements should be completed to identify the proposed pumping station capacity and design requirements;
- The feasibility of completing a soft separation of the combined sewer on Russell Street south of Hill Avenue in conjunction with the construction of the proposed Prince Road pump station and outfall should be considered;
- A monitoring plan to evaluate the performance of the roadside ditches on Ojibway Parkway, Morton Avenue, Sprucewood Avenue, and Maplewood Drive should be developed;
- A functional drainage analysis of the Russell Street Drainage system should be completed to identify specific system improvements;
- Permanent physical flood protection measures implemented on shoreline properties will require ERCA approval through a permit in accordance with Section 28 of the Conservation Authorities Act;
- The existing Brock Street storm sewer outfall should be inspected to document its condition and capacity;
- A traffic study should be completed to identify alternate truck route if temporary closure of Russell Street at Chappell Avenue is required during periods of extreme river levels; and
- Prepare an emergency response plan for Black Oak Heritage Park and McKee Park to manage these facilities during periods of extreme river levels.

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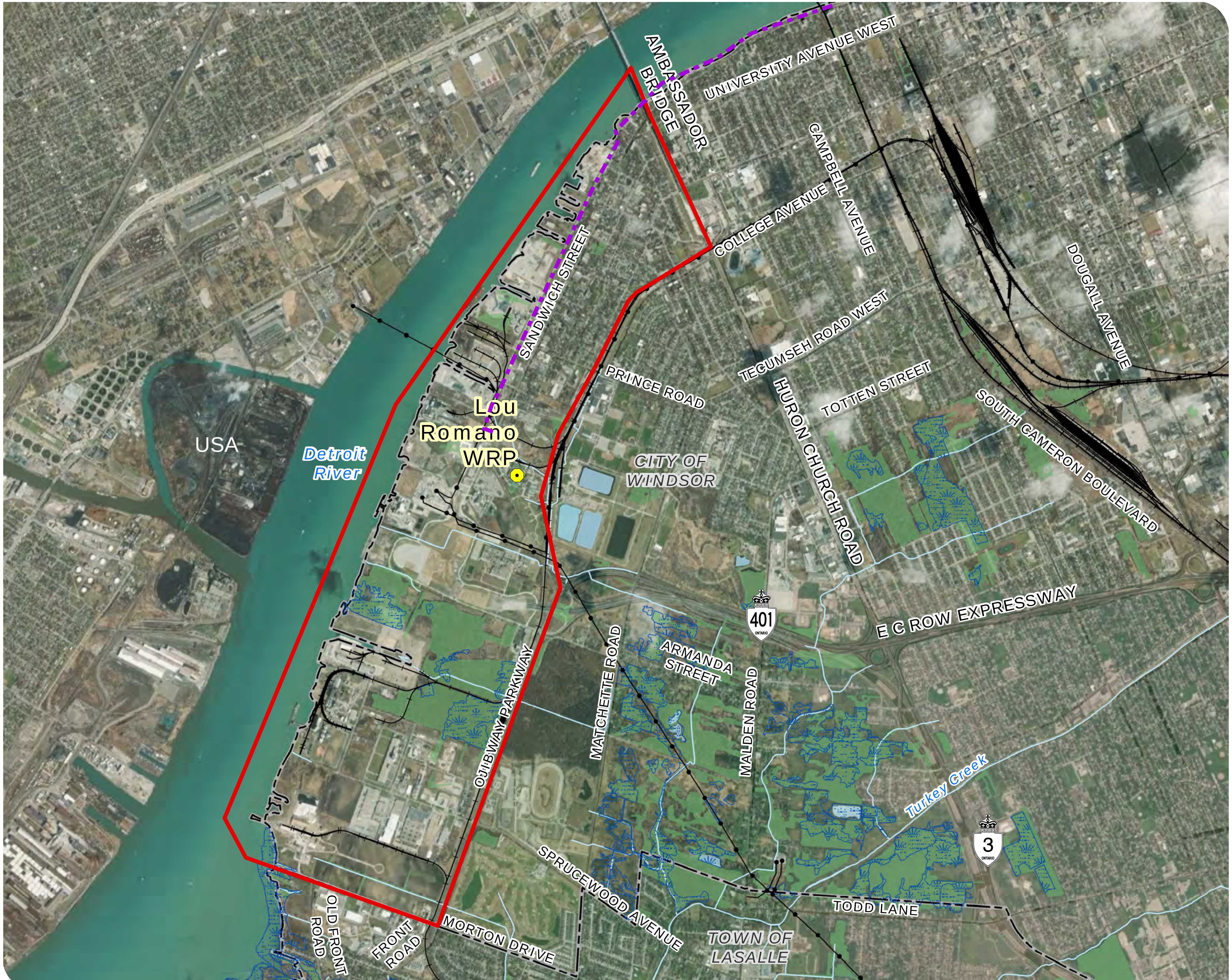
Figures

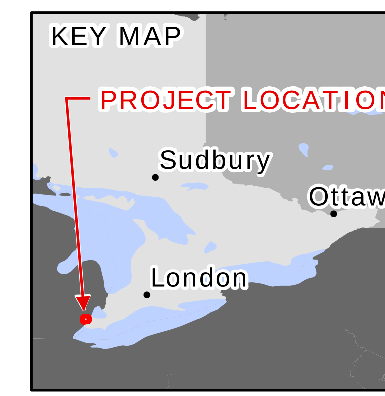
WEST WINDSOR FLOOD RISK STUDY

STUDY AREA
FIGURE 1



- Study Area
- Lou Romano WRP
- Railway
- Utility Line
- Watercourse
- Municipal Boundary
- Provincially Significant Wetland
- Water Body
- Wooded Area
- Riverside Drive Interceptor Sewer

KEY MAP



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MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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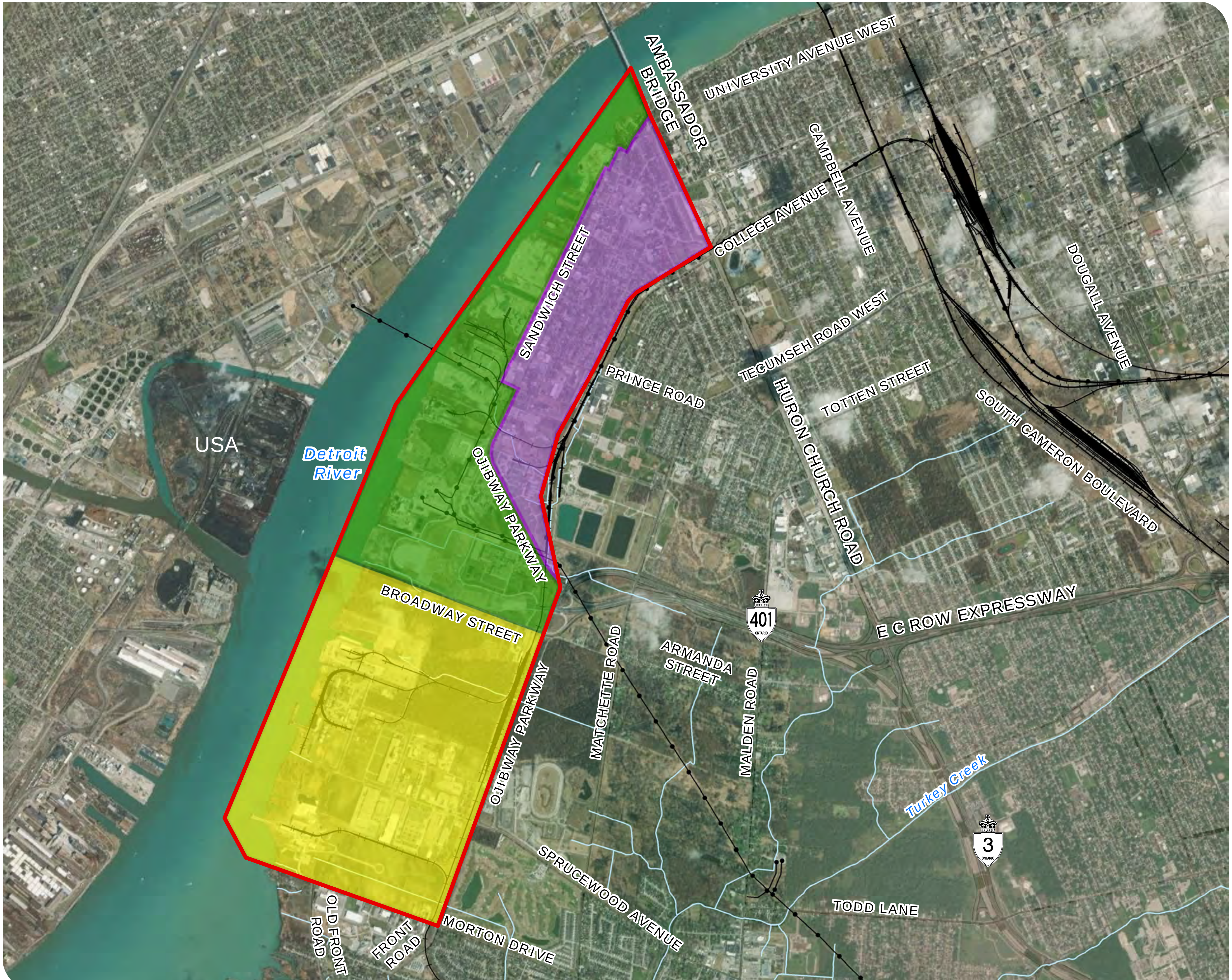

WEST WINDSOR
FLOOD RISK STUDY

STUDY AREA ZONES
FIGURE 2

Study Area

Zone (Land Area)

Zone 1 (205 ha)

Zone 2 (252 ha)

Zone 3 (385 ha)

Railway

Utility Line

Watercourse

SCALE 1:30,000

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N E S W

MAP DRAWING INFORMATION:
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MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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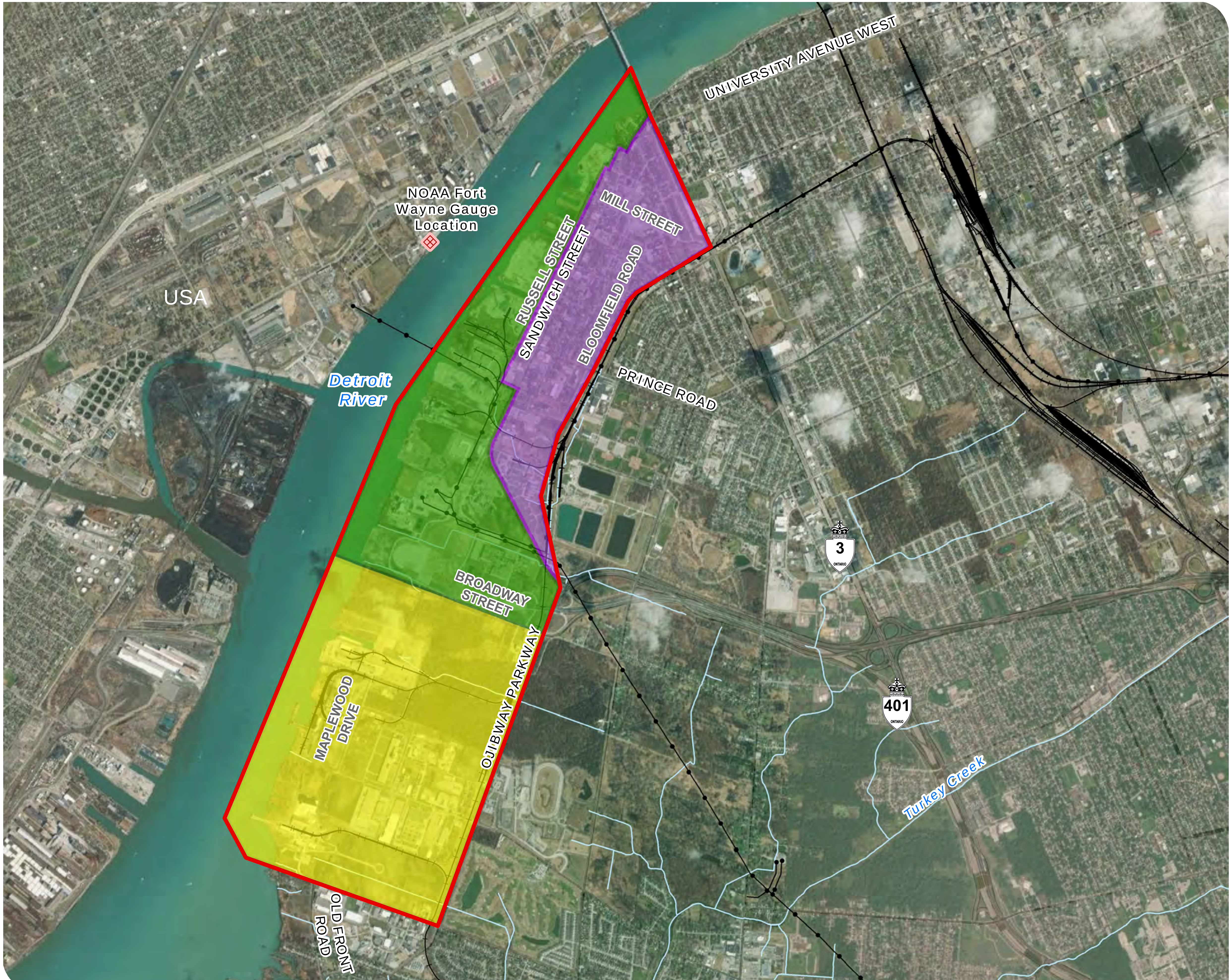

WEST WINDSOR

FLOOD RISK STUDY

NOAA FORT WAYNE GAUGE LOCATION

FIGURE 3

- NOAA Fort Wayne Gauge Location
- Study Area
- Zone 1
- Zone 2
- Zone 3
- Railway
- Utility Line
- Watercourse

SCALE 1:30,000

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N W E S

MAP DRAWING INFORMATION:
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PROJECT: 21-2409
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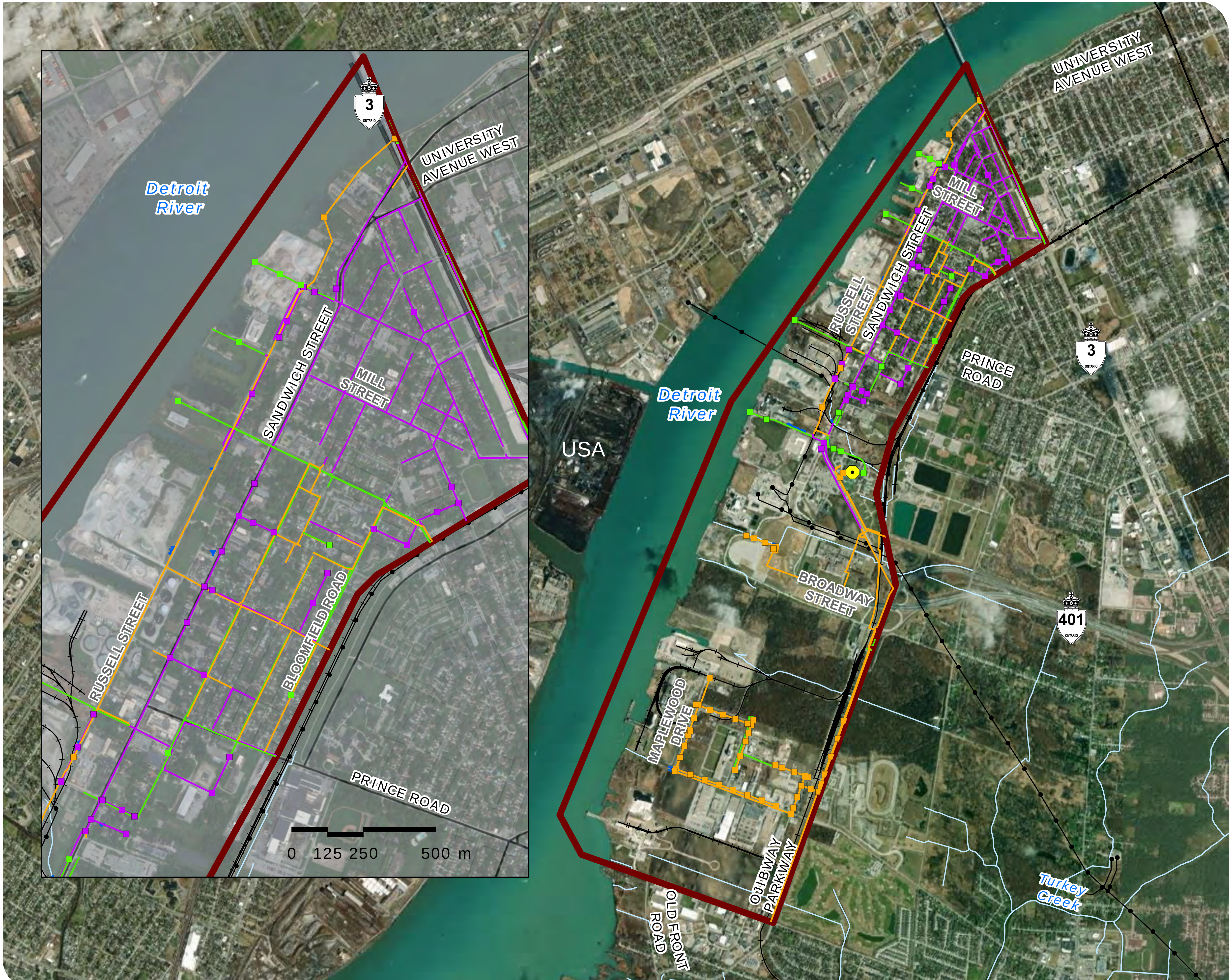
DATE: 2022-12-23



WEST WINDSOR

FLOOD RISK STUDY

EXISTING SYSTEM PERFORMANCE
(1:5 YEAR STORM AND 1:100 YEAR DETROIT RIVER WATER LEVEL)
FIGURE 4

- Combined Manhole
- Sanitary Manhole
- Storm Manhole
- Combined - Surcharged
- Sanitary - Surcharged
- Storm - Surcharged
- Surface Ponding >0.3m
- Study Area
- Lou Romano WRP
- Railway
- Utility Line
- Watercourse

SCALE 1:30,000

0 400 800 1,600 m

N E S W

MAP DRAWING INFORMATION:
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PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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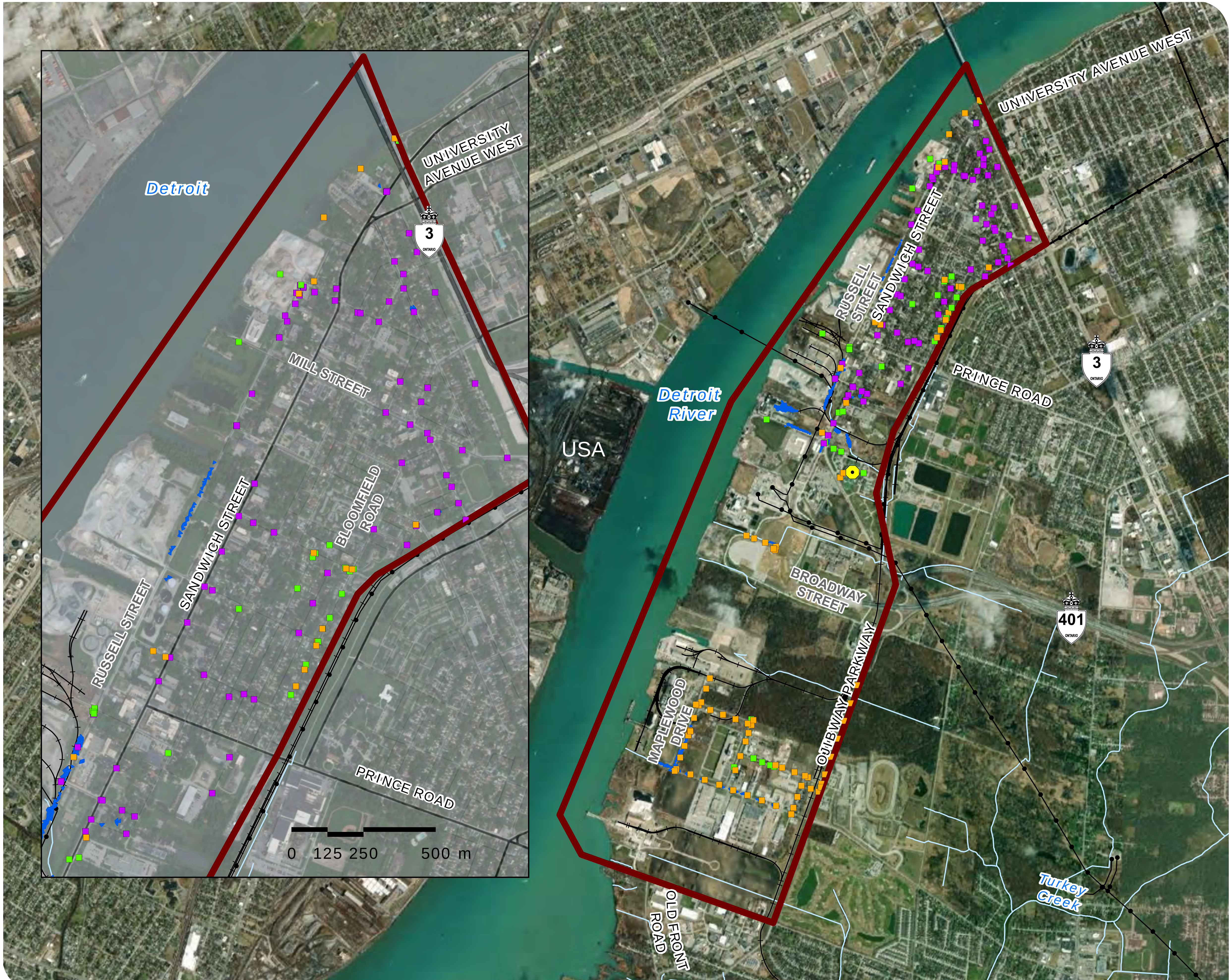

WEST WINDSOR

FLOOD RISK STUDY

EXISTING SYSTEM PERFORMANCE
(1:100 YEAR STORM AND 1:100 YEAR DETROIT RIVER WATER LEVEL)
FIGURE 5

- Combined Manhole
- Sanitary Manhole
- Storm Manhole
- Surface Ponding >0.3m
- Study Area
- Lou Romano WRP
- Railway
- Utility Line
- Watercourse

SCALE 1:30,000

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MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF, National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS)

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MAP CHECKED BY: NE
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PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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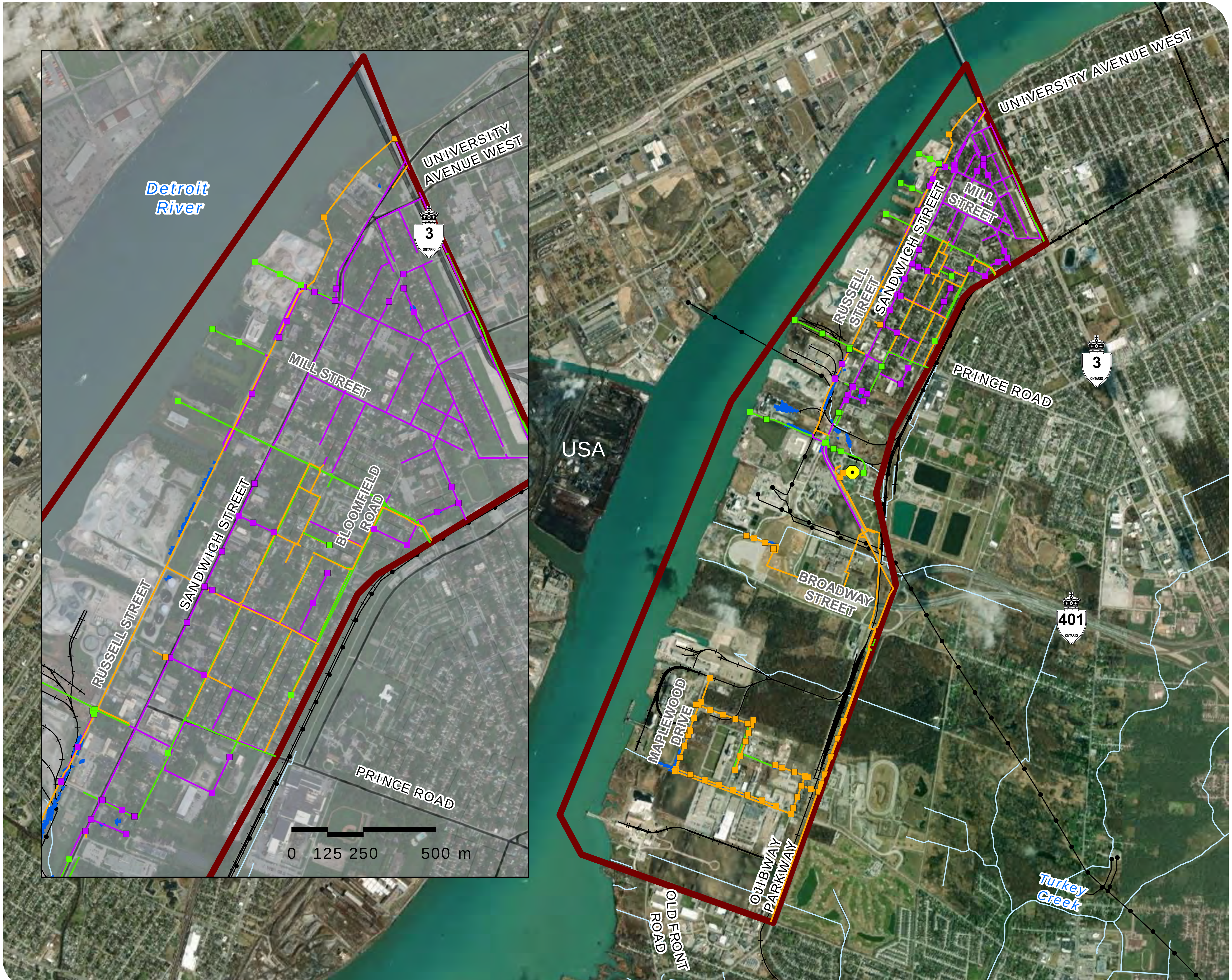

WEST WINDSOR

FLOOD RISK STUDY

EXISTING SYSTEM PERFORMANCE
(1:5 YEAR STORM AND 1:100 YEAR CLIMATE CHANGE DETROIT RIVER WATER LEVEL)

FIGURE 6

- Combined Manhole
- Sanitary Manhole
- Storm Manhole
- Combined - Surcharged
- Sanitary - Surcharged
- Storm - Surcharged
- Surface Ponding >0.3m
- Study Area
- Lou Romano WRP
- Railway
- Utility Line
- Watercourse

SCALE 1:30,000

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N E S W

MAP DRAWING INFORMATION:
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MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

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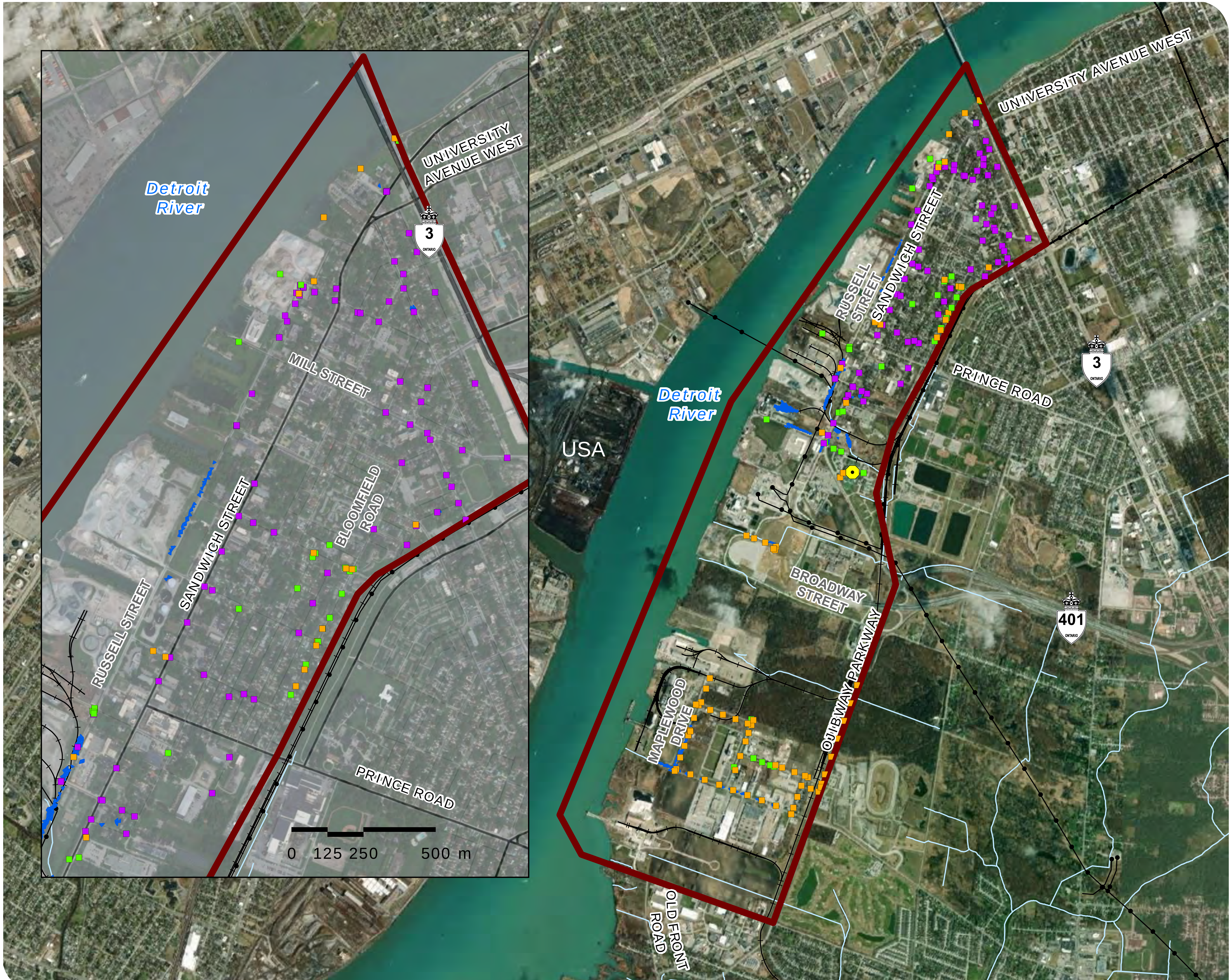

WEST WINDSOR

FLOOD RISK STUDY

EXISTING SYSTEM PERFORMANCE
(1:100 YEAR STORM AND 1:100 YEAR CLIMATE CHANGE DETROIT RIVER WATER LEVEL)

FIGURE 7

- Combined Manhole
- Sanitary Manhole
- Storm Manhole
- Surface Ponding >0.3m
- Study Area
- Lou Romano WRP
- Railway
- Utility Line
- Watercourse

SCALE 1:30,000

0 400 800 1,600 m

N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF, National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS)

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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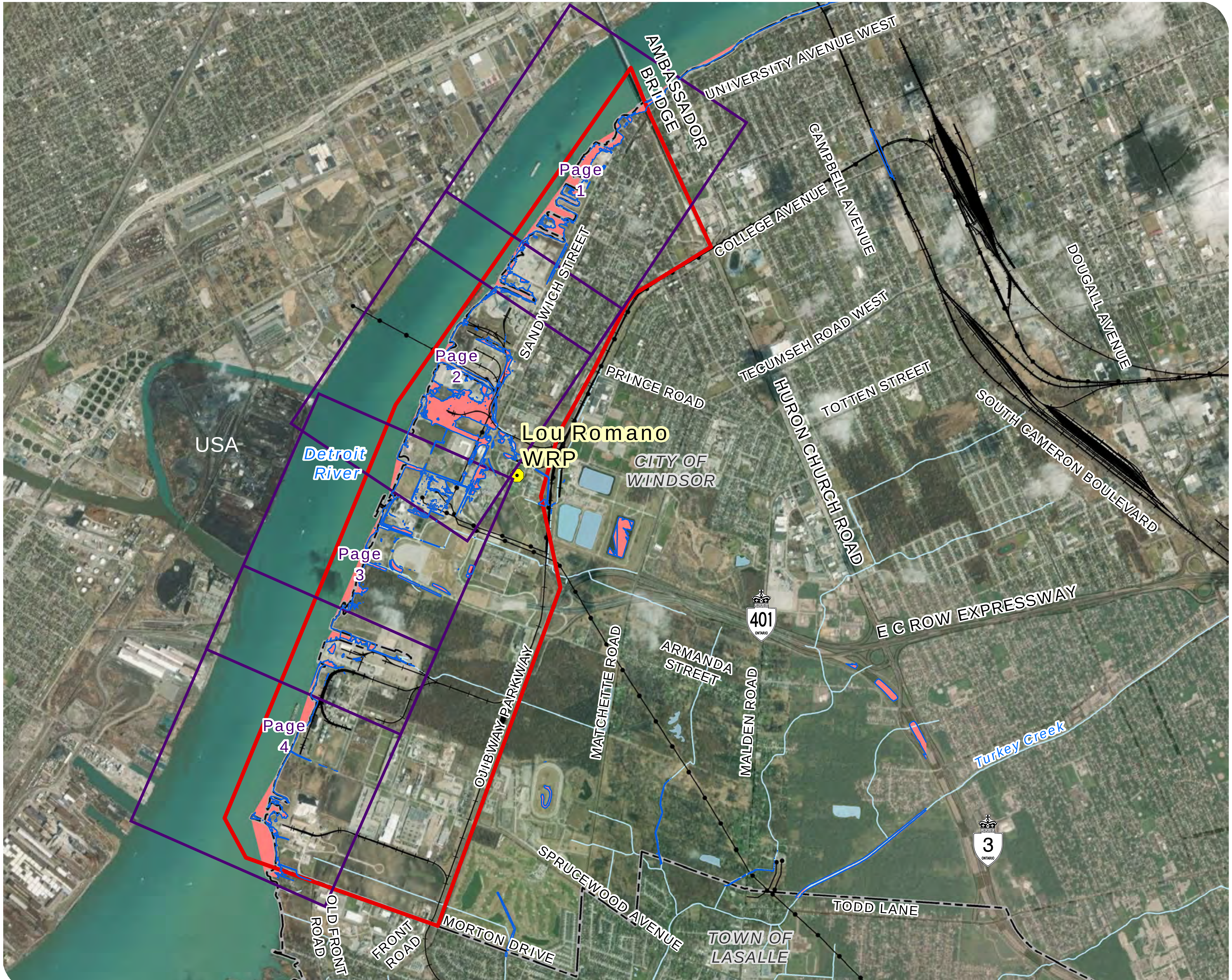

WEST WINDSOR

FLOOD RISK STUDY

COASTAL FLOODING LOCATIONS - KEY PLAN

FIGURE 8

- Study Area
- Page Extent
- Lou Romano WRP
- 100-year Climate Change Water Level (176.3 m)
- Railway
- Utility Line
- Watercourse
- Municipal Boundary
- Water Body
- Areas Below 176.3m

SCALE 1:30,000

0 400 800 1,600 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

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PROJECT: 21-2409
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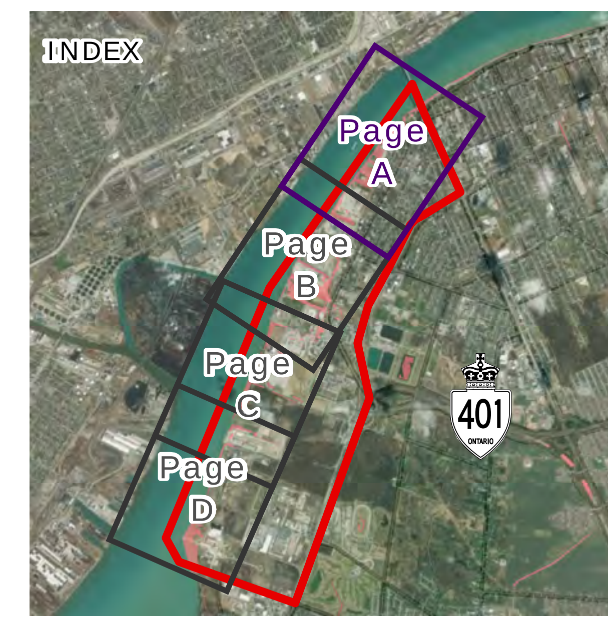
FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_F8_WaterLevel_100yr.mxd

WEST WINDSOR
FLOOD RISK STUDY

COASTAL FLOODING LOCATIONS
FIGURE 8-A

- Study Area
- 100-year Climate Change Water Level (176.3 m)
- Railway
- Areas Below 176.3m



SCALE 1:7,000

0 95 190 380 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_F8ad_WaterLevel_100yrDDP.mxd

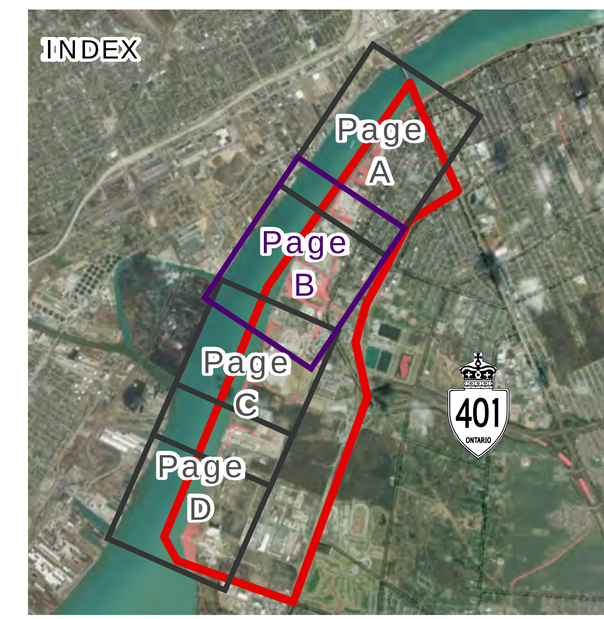
WEST WINDSOR

FLOOD RISK STUDY

COASTAL FLOODING LOCATIONS

FIGURE 8-B

- Study Area
- Lou Romano WRP
- 100-year Climate Change Water Level (176.3 m)
- Railway
- Water Body
- Watercourse
- Areas Below 176.3m



SCALE 1:7,000

0 95 190 380 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

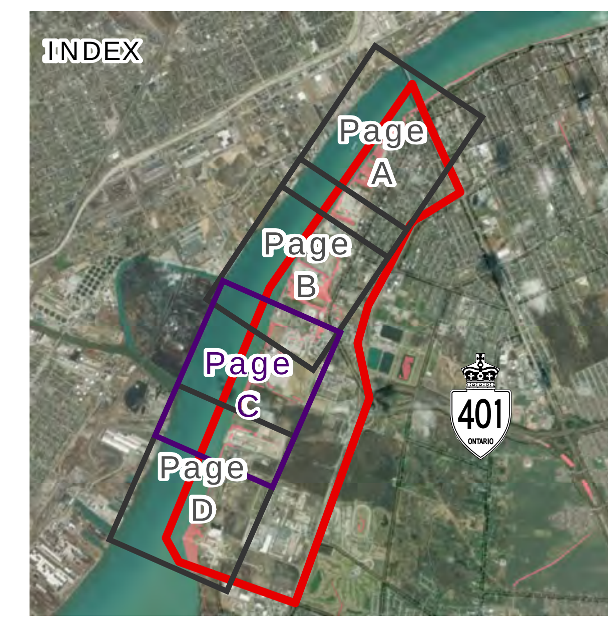
PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_F8ad_WaterLevel_100yrDDP.mxd

WEST WINDSOR
FLOOD RISK STUDY

COASTAL FLOODING LOCATIONS
FIGURE 8-C

- Study Area
- Lou Romano WRP
- 100-year Climate Change Water Level (176.3 m)
- Railway
- Watercourse
- Areas Below 176.3m



SCALE 1:7,000

0 95 190 380 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_F8ad_WaterLevel_100yrDDP.mxd

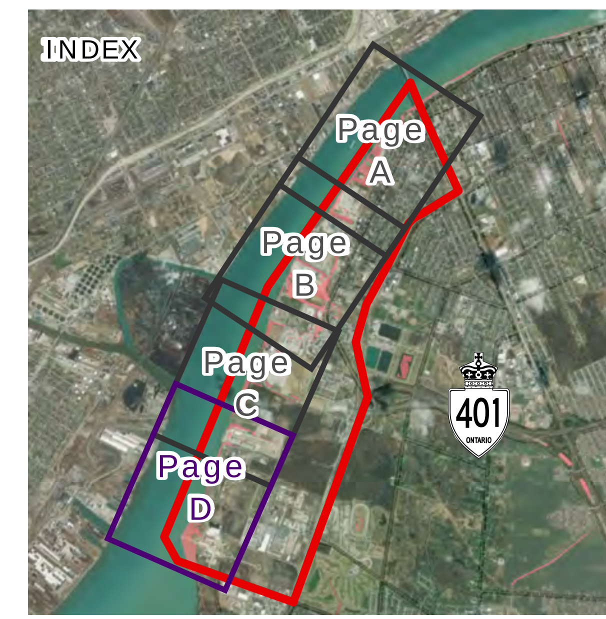
WEST WINDSOR

FLOOD RISK STUDY

COASTAL FLOODING LOCATIONS

FIGURE 8-D

- Study Area
- 100-year Climate Change Water Level (176.3 m)
- Railway
- Watercourse
- Areas Below 176.3m



SCALE 1:7,000

0 95 190 380 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: LMM
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MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
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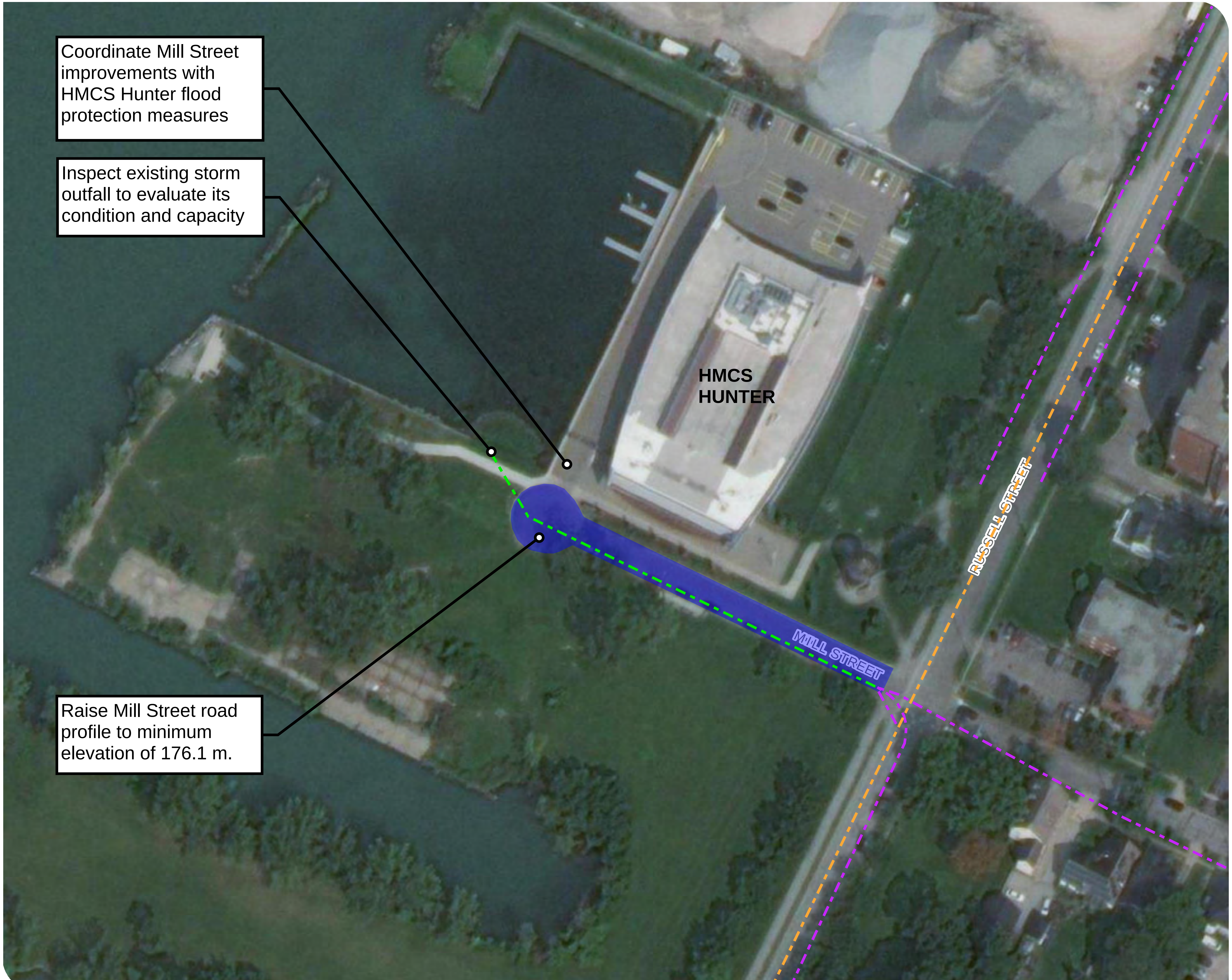

WEST WINDSOR

FLOOD RISK STUDY

MILL STREET COASTAL FLOOD MITIGATION

FIGURE 9

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Approximate Limits of Proposed Road Improvements

SCALE 1:1,000

0 12.5 25 50 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
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MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409

STATUS: FINAL

DATE: 2022-12-23

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WEST WINDSOR

FLOOD RISK STUDY

RUSSELL STREET AT CHAPPELL AVENUE COASTAL FLOOD MITIGATION

FIGURE 10

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Approximate Limits of Potential Coastal Flooding in ROW (176.3 m)

SCALE 1:2,000

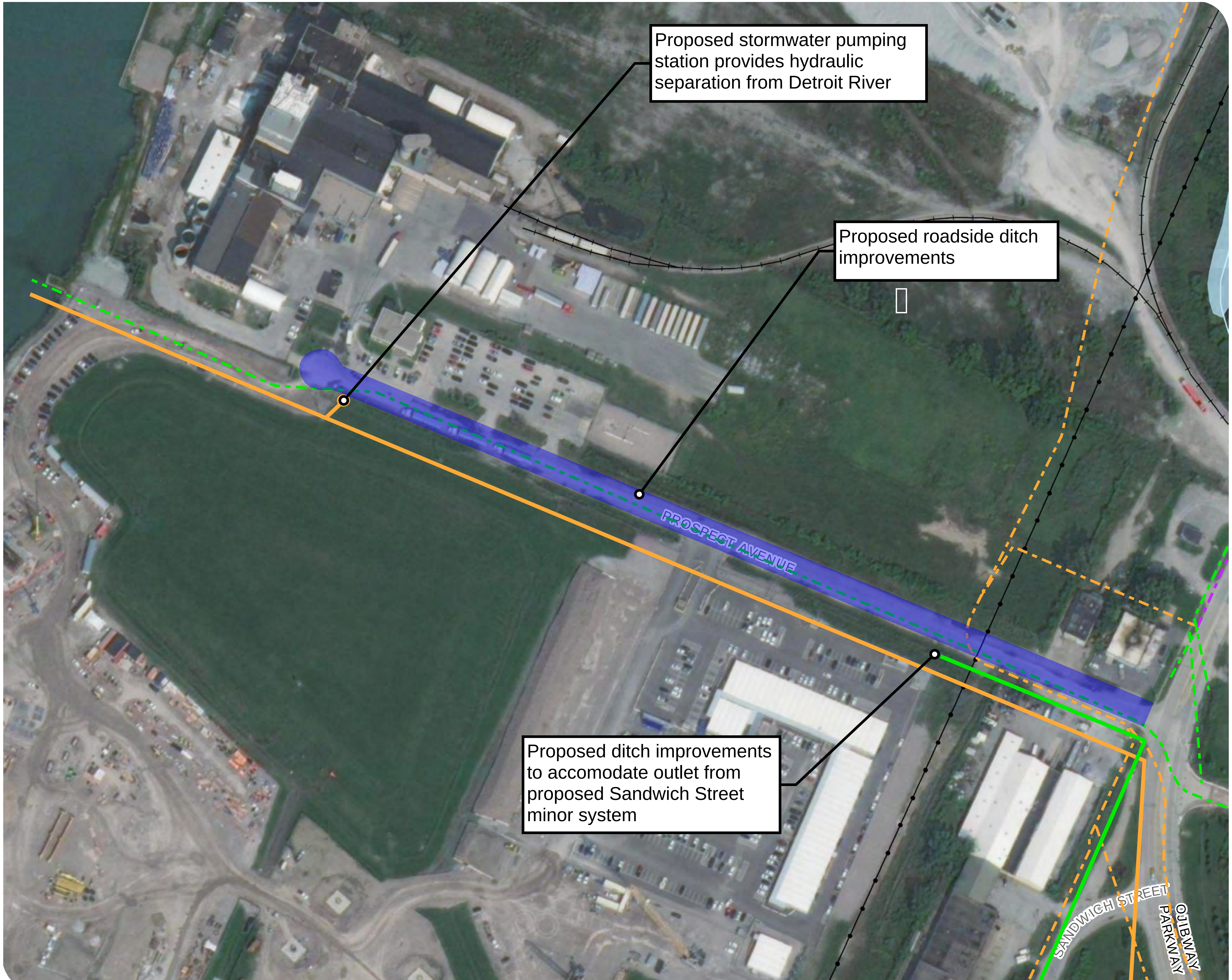
0 25 50 100 m

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23



WEST WINDSOR
FLOOD RISK STUDY

PROSPECT AVENUE COASTAL FLOOD MITIGATION

FIGURE 11

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Proposed LRWRP RTB Outlet
- Approximate Limits of Proposed Drainage Improvements
- Proposed Sandwich Street Storm Sewer

SCALE 1:2,000

0 25 50 100 m

N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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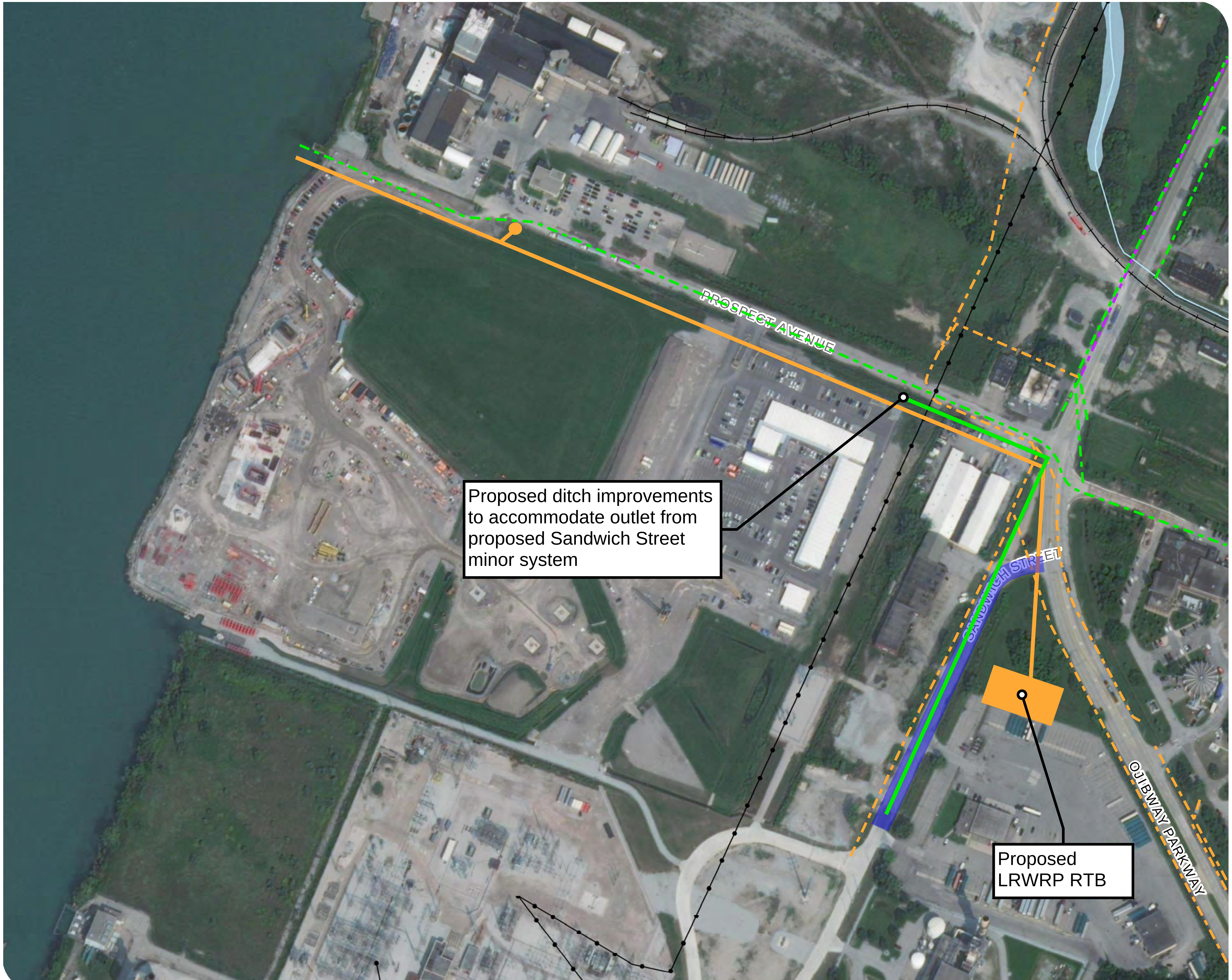

WEST WINDSOR

FLOOD RISK STUDY

SANDWICH STREET COASTAL FLOOD MITIGATION

FIGURE 12

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Proposed LRWRP RTB Outlet
- Approximate Limits of Proposed Drainage Improvements
- Proposed Sandwich Street Storm Sewer

SCALE 1:3,000

0 40 80 160 m

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409

STATUS: FINAL

DATE: 2022-12-23

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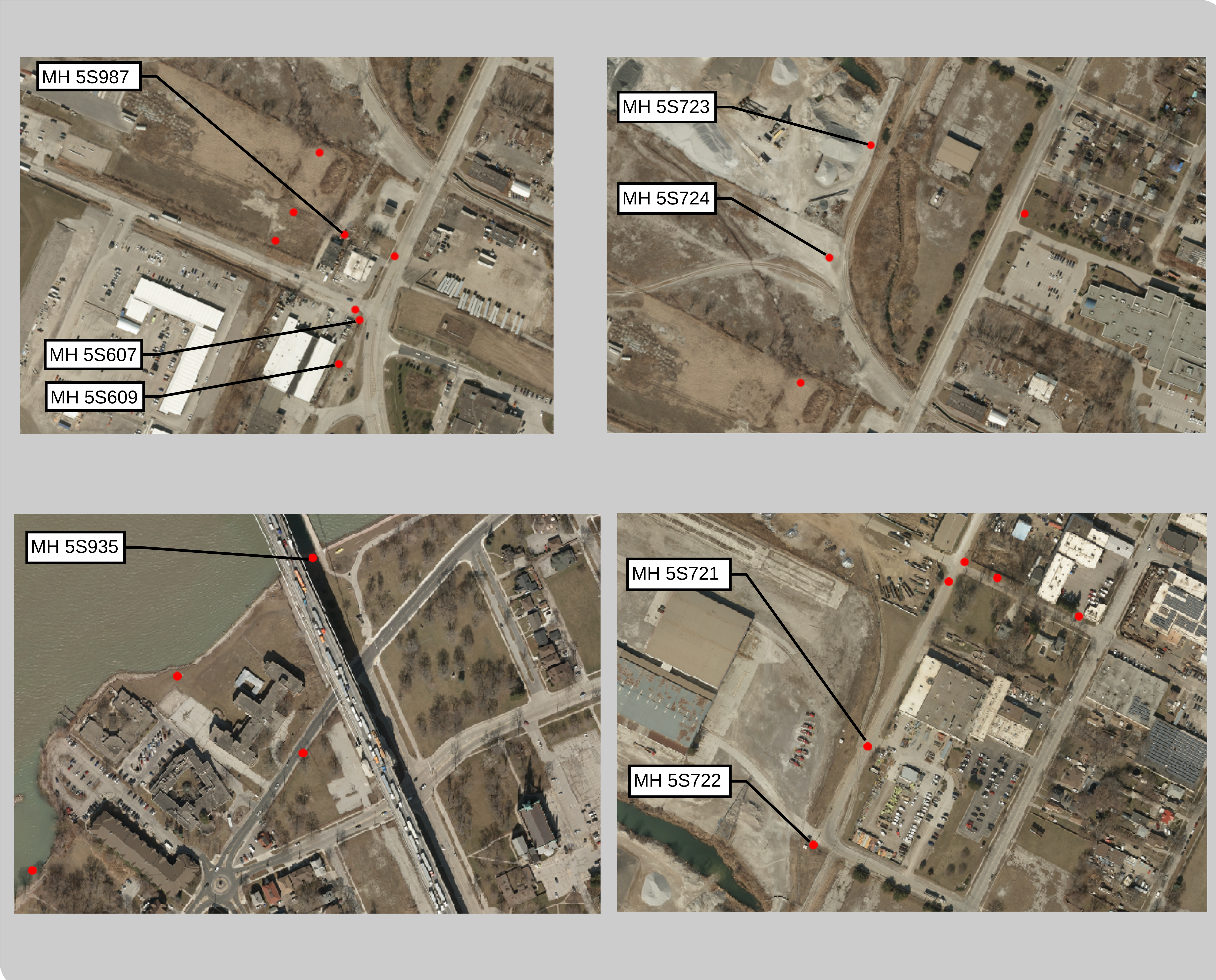

WEST WINDSOR

FLOOD RISK STUDY

PROPOSED RAIN CATCHER LOCATIONS
FIGURE 13

● Existing Sanitary Sewer Maintenance Hole

N
W E
S

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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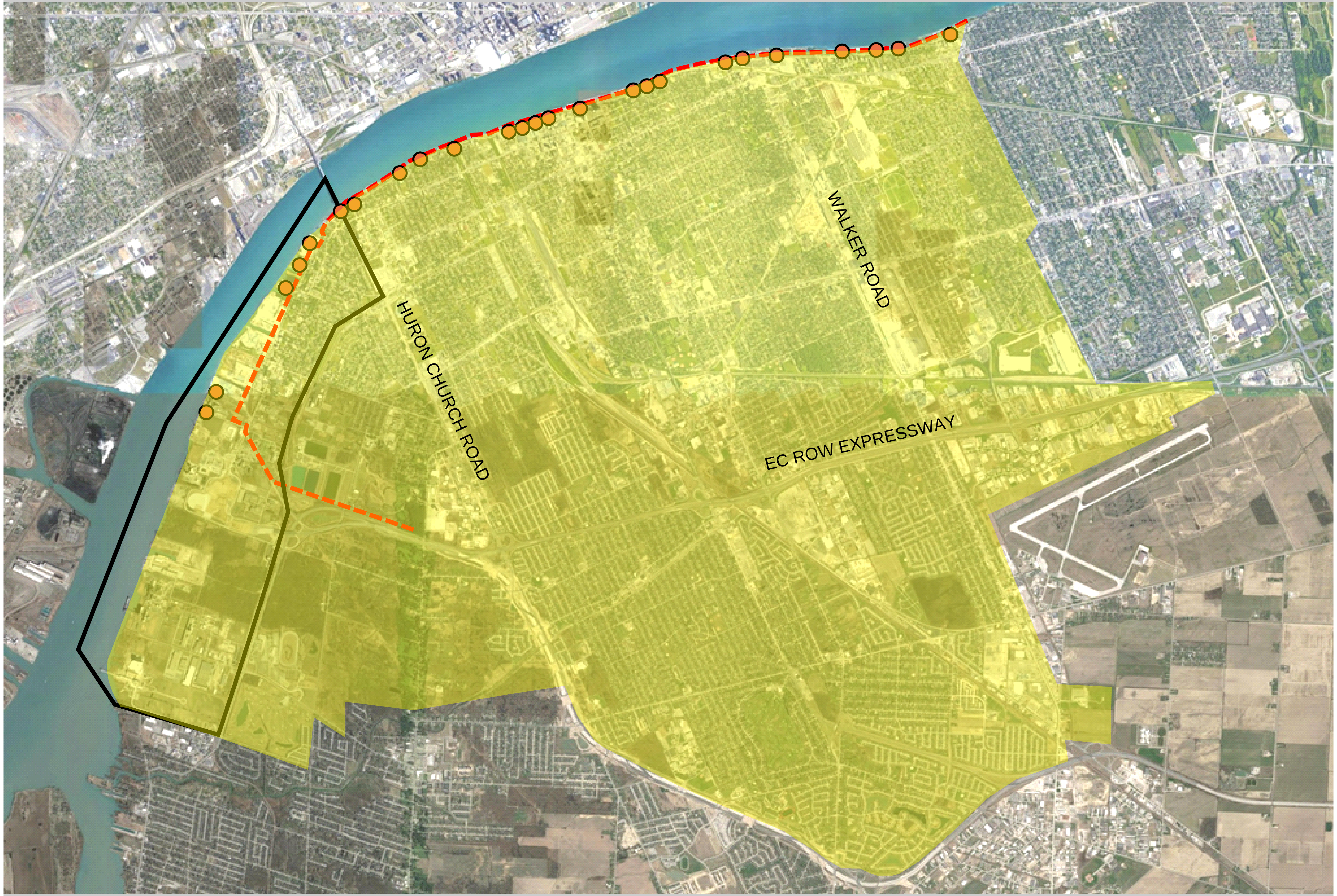
WEST WINDSOR

FLOOD RISK STUDY

COMBINED SEWER OUTLET PROTECTION
FIGURE 14



- LRWRP Service Area
- CSO Location
- Trunk Sanitary Sewer
- Study Area Boundary

N
W E
S

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
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WEST WINDSOR FLOOD RISK STUDY

LOU ROMANO RETENTION TREATMENT BASIN

FIGURE 15

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Proposed LRWRP RTB Outlet

SCALE 1:4,000

0 55 110 220 m

N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
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WEST WINDSOR
FLOOD RISK STUDY

PRINCE ROAD TRUNK STORM SEWER OUTLET AND PUMP STATION
FIGURE 16

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Proposed Storm Sewer

SCALE 1:2,000
0 25 50 100 m
N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

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PROJECT: 21-2409
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WEST WINDSOR
FLOOD RISK STUDY

DETROIT STREET TRUNK OUTFALL

FIGURE 17

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Proposed Storm Sewer

SCALE 1:2,000

0 25 50 100 m

N S E W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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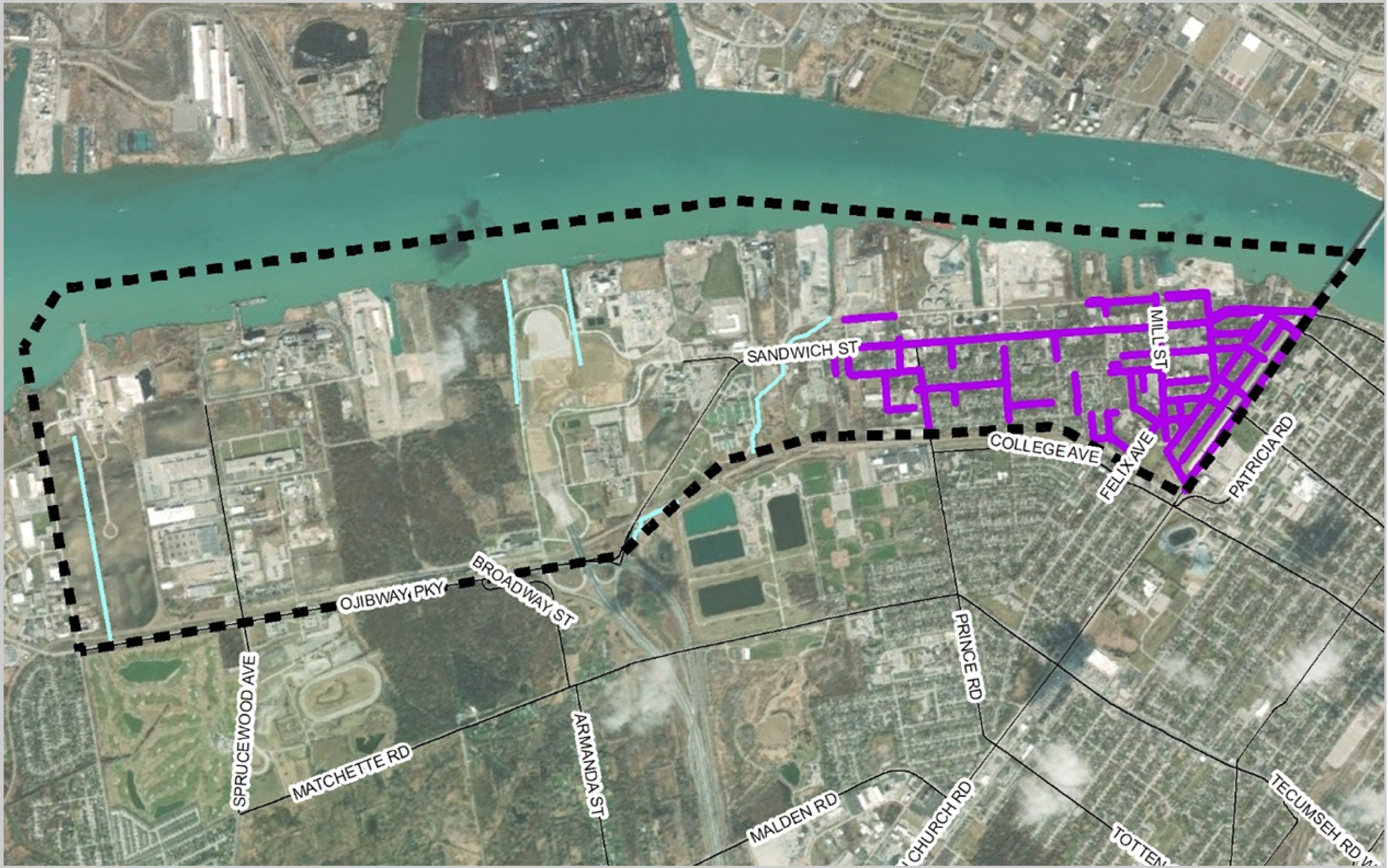


WEST WINDSOR

FLOOD RISK STUDY

EXISTING COMBINED SEWER LOCATIONS
FIGURE 18

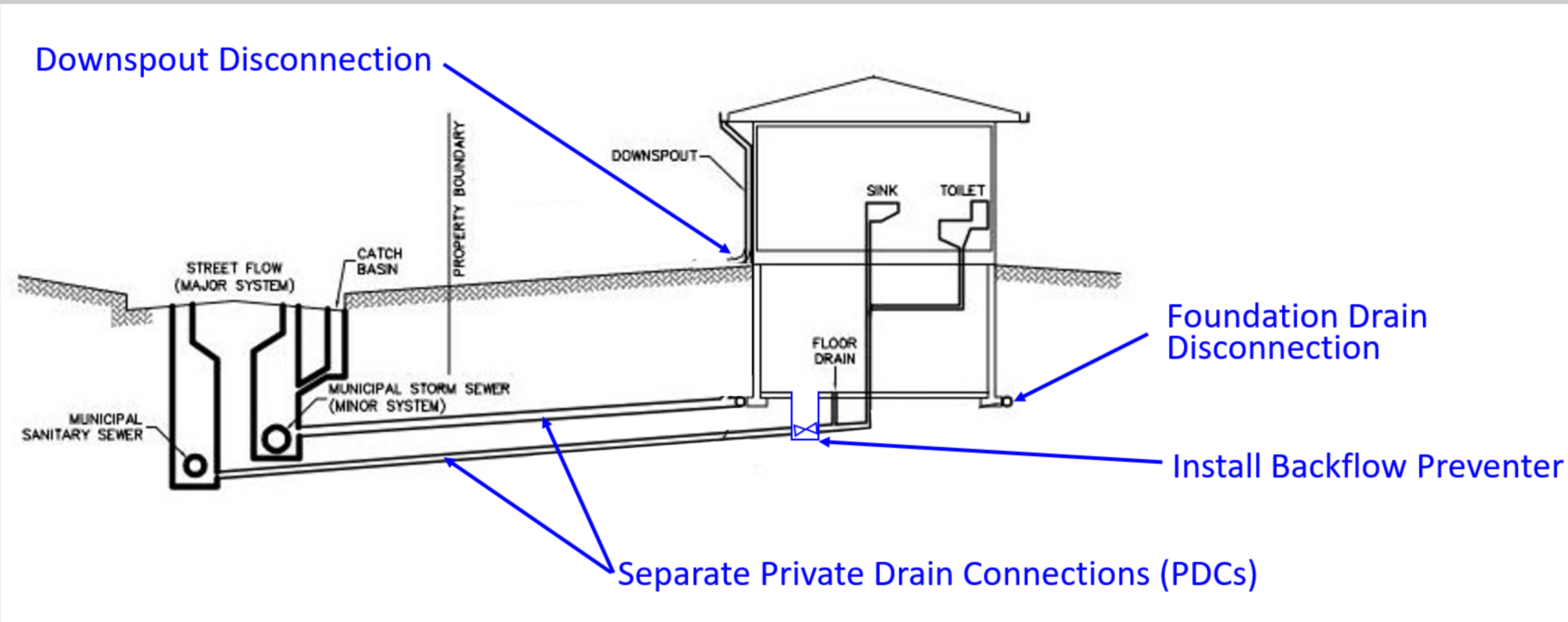
Existing Combined Sewer

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

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_00_AerialTemplate.mxd



WEST WINDSOR

FLOOD RISK STUDY

BASEMENT FLOOD
MITIGATION MEASURES
FIGURE 19

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

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_00_AerialTemplate.mxd

WEST WINDSOR
FLOOD RISK STUDY

MORTON AVENUE LOCAL DRAINAGE IMPROVEMENTS
FIGURE 20

- Existing Sanitary Sewer
- Railway
- Watercourse
- Provincially Significant Wetland
- Approximate Limits of Proposed Drainage Improvements

SCALE 1:4,000
0 55 110 220 m
N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

FILE LOCATION: K:\2021\212409 - West Windsor Flood Risk\Product\Client\FloodRiskStudy\212409_00_AerialTemplate.mxd

WEST WINDSOR
FLOOD RISK STUDY

RUSSELL STREET DRAINAGE IMPROVEMENTS
FIGURE 21

Approximate Limits of Proposed Drainage Improvements

N
W E
S

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

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
DATE: 2022-12-23

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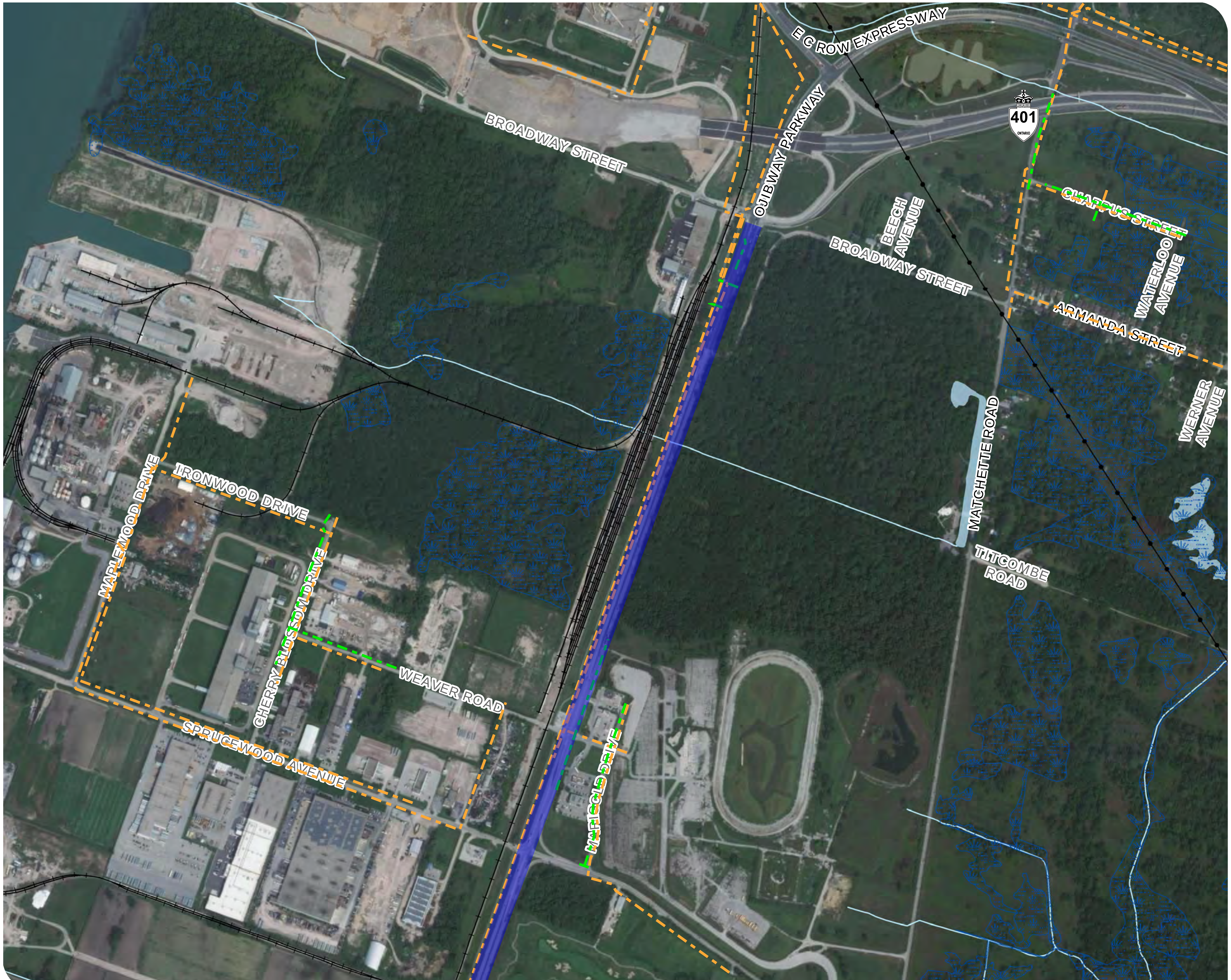

WEST WINDSOR
FLOOD RISK STUDY

OJIBWAY PARKWAY LOCAL DRAINAGE IMPROVEMENTS
FIGURE 22

- Existing Sanitary Sewer
- Existing Storm Sewer
- Railway
- Utility Line
- Watercourse
- Provincially Significant Wetland
- Approximate Limits of Proposed Drainage Improvements

SCALE 1:9,000
0 120 240 480 m
N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

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WEST WINDSOR
FLOOD RISK STUDY

SPRUCEWOOD AVENUE AND MAPLEWOOD AVENUE LOCAL
FIGURE 23

- Existing Sanitary Sewer
- Existing Storm Sewer
- Railway
- Watercourse
- Provinically Significant Wetland
- Approximate Limits of Proposed Drainage Improvements

SCALE 1:4,000

0 55 110 220 m

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

DILLON CONSULTING

PROJECT: 21-2409
STATUS: FINAL
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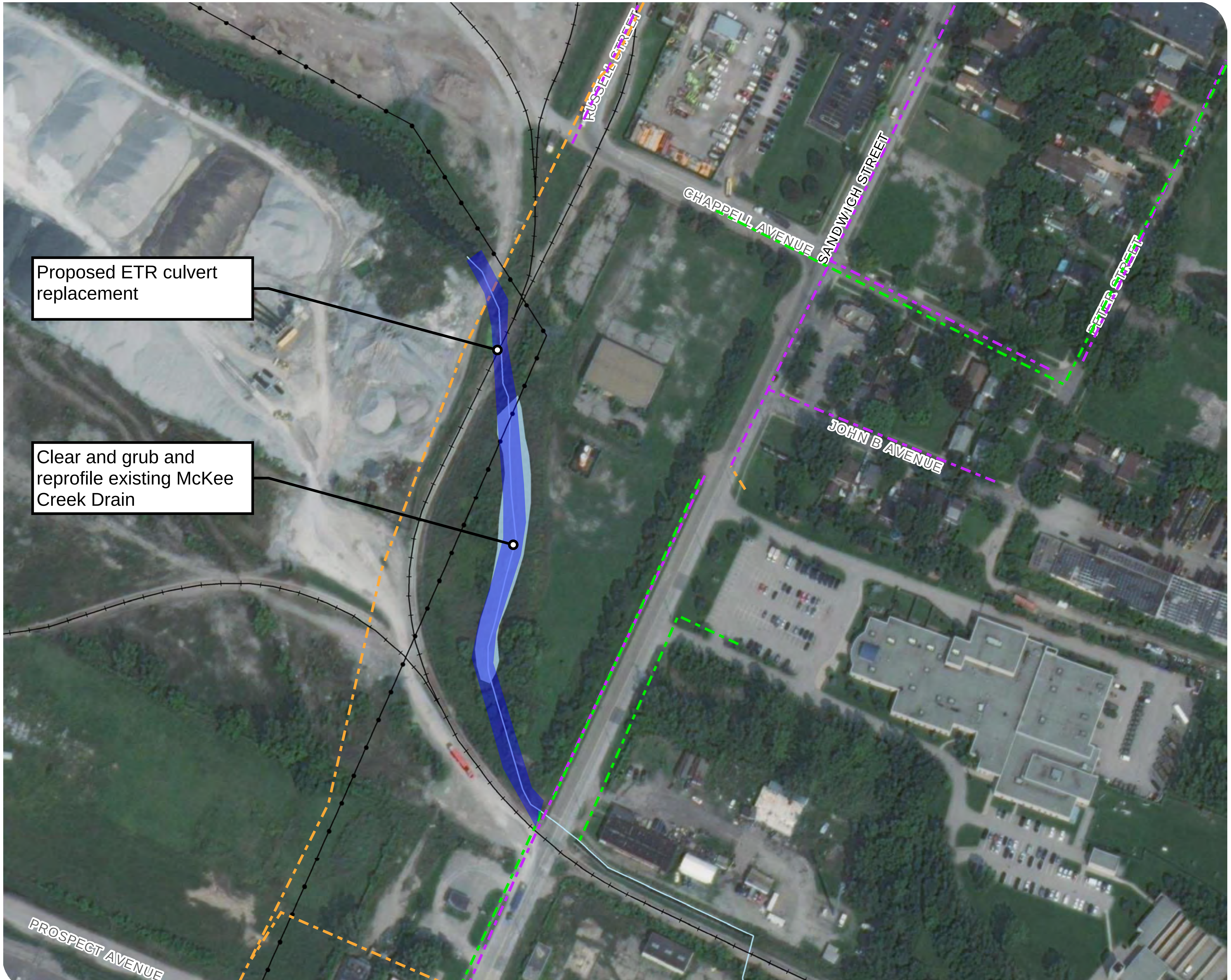

WEST WINDSOR
FLOOD RISK STUDY

MCKEE CREEK DRAIN IMPROVEMENTS

FIGURE 24

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Sewer
- Railway
- Utility Line
- Watercourse
- Approximate Limits of Proposed Drainage Improvements

SCALE 1:2,000

0 25 50 100 m

N E S W

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI Imagery BaseMap

MAP CREATED BY: LMM
MAP CHECKED BY: NE
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

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Appendix A

PIEVC Protocol Worksheets

Appendix A – PIEVC Protocol Worksheets

1. Worksheet Step 1 – Project Definition
2. Worksheet Step 2 – Data Gathering and Sufficiency
3. Worksheet Step 3 – Risk Assessment
4. Worksheet Step 4 – Engineering Analysis
5. Worksheet Step 5 – Recommendations and Conclusions

PIEVC Engineering Protocol

For

Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate

Worksheet Step 1

Project Definition

Revision 1.1

Effective March 30, 2020, the PIEVC Program is operated jointly by the Institute for

Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

For further information about this ***Engineering Protocol*** or the ***PIEVC Program*** please contact ICLR.

Dan Sandink, ICLR

210-20 Richmond St. E.
Toronto, Ontario, Canada
M5C 2R9

dsandink@iclr.org

(416) 364-8677 Ext. 3212

Instructions

This worksheet is designed to allow practitioners to document that they have actively considered and evaluated each step of the Protocol. The worksheet also provides a document were practitioner considerations regarding each task of the Protocol are recorded.

Complete Every Field

To ensure complete coverage of the Protocol steps, when completed, the practitioner should have entered a response in every field of this worksheet.

Document Tasks That Do Not Apply

Where a particular task is not relevant to the current assessment:

- Enter **N/A** in the relevant field of this worksheet and
- Provide rational for the decision in the comments field of the task.

Document Tasks That Are Omitted

Where a practitioner has chosen to omit a particular step of the Protocol:

- Enter **OMITTED** in the relevant field; and
- Provide rational for the decision in the comments field of the task.

Protocol for Changing Climate Infrastructure Vulnerability Assessment

Practitioners are strongly cautioned to avoid the following common pitfalls in executing a vulnerability assessment based on the Protocol.

i. ***Skipping Protocol tasks***.

Although it is acceptable to select to not execute a particular task, the practitioner should nonetheless evaluate the question posed by that task and document the basis for the decision.

ii. Using previous case study reports as a template for the analysis.

Although previous studies provide an excellent reference, the application of the Protocol is highly specific to infrastructure. Applying previous case studies as a template can often lead the practitioner to miss key factors that contribute to the overall risk profile of the infrastructure.

iii. Using the worksheets without reference to the Protocol.

Although the worksheets parallel the Protocol, they do not provide supplementary context that may be necessary to correctly address the specified Protocol task.

1 Step 1 – Project Definition

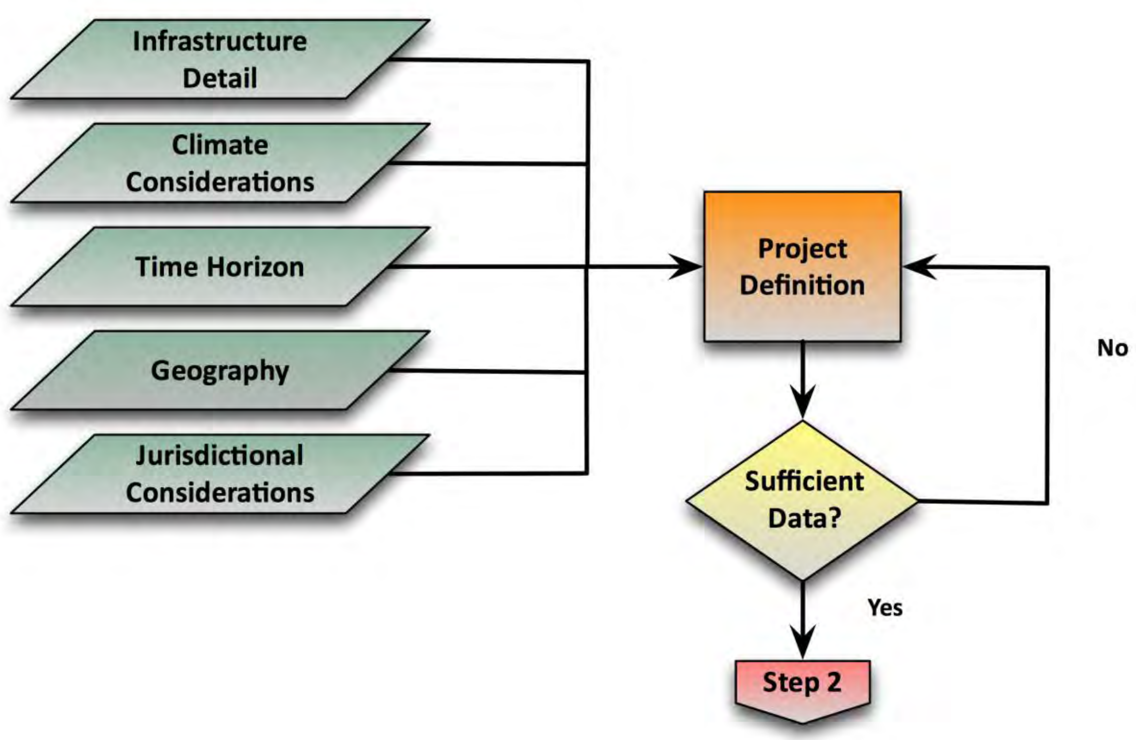
In this step the practitioner will define the global project parameters and boundary conditions for the engineering vulnerability assessment. This step will define:

- Which infrastructure is being assessed;
- Its location;
- Climatic, geographic considerations; and
- Uses of the infrastructure.

This is the first step of narrowing the focus to allow efficient data acquisition and vulnerability assessment.

The process flowchart for Step 1 of the Protocol is presented in **Figure 1**.

Figure 1: Step 1 – Project Definition Process Flowchart



1.1 Prepare Step 1 Worksheet

	Enter ***Yes*** or ***No***	
a. Use this ***Worksheet***; or	Yes	
b. Prepare practitioner specific documentation. i. Practitioner specific documentation ***MUST*** detail each task outlined in this step of the Protocol.		
Comments and Observations Additional documentation also provided in the main Assessment Report, including Triple Bottom Line solutions costing and benefits.		

1.2 Identify the Infrastructure

a. Choose the infrastructure to be evaluated for changing climate vulnerability.	Storm water infrastructure (pump stations), sewage infrastructure (sewers, catch basins, and backflow preventers), drainage infrastructure, storage infrastructure, sanitary and combined sewer infrastructure, storm sewer infrastructure. Public and private Infrastructure
b. Provide a general description of the infrastructure.	Basic and physical systems and services that are needed in order for the waste and storm water and for transportations systems to function properly
c. Reference additional background and detailed information sources.	Asset listing excel and master plan reports, as references in the main Assessment Report and in subsequent worksheets.
Comments and Observations More detailed infrastructure systems details found in worksheets and main report.	

1.3 *Identify Climate Parameters*

a. State the climate parameters that will be considered in the evaluation.

Add rows as necessary.

i. Based on professional judgement, identify which climate trends and weather events may contribute to infrastructure vulnerability.
• Extreme rainfall – extreme 4 hour rainfall at 5 and 100 year return periods
• Extreme wind gusts
• Heavy snowfall accumulations, snowmelt + rainfall events
• Tornado frequencies
• Regionally extreme ice storms
• Weathering via freeze-thaw processes – annual, frequencies above threshold numbers
• Extreme High Water Level (100 year climate change potential HWL)
• Weathering: Freeze Thaw Cycles annually; frequency of at least 30 freeze-thaw cycles
• Extreme heat events, if relevant to assets
ii. Based on professional judgement, identify which climatic trends and/or weather events may *combine* to create infrastructure vulnerability.
• Current High Water Level + wave action (freeboard)
• Combination events: Current High water levels (100 year HWL) + minor event rainfalls (5 year return period)
• Combination events: Current High water levels (100 year HWL) + major event rainfalls (100 year return period)
• Combination events: Extreme High water levels (100 year climate change potential HWL) + major event rainfalls (100 year return period)
• Combination events: Extreme High water levels (100 year climate change potential HWL) + minor event rainfalls (5 year return period)
• Combination events: Extreme High water levels (100 year climate change potential HWL) + major event rainfalls (100 year return period)

1.4 *Identify the Time Horizon*

a. Define the period over which the infrastructure must operate and for	Baseline or Current, 2050s and 2080s

which climate trends will be projected for the engineering vulnerability assessment.	
<u>Comments and Observations</u> N/A	

1.5 *Identify the Geography*

Add rows as necessary.

a. Summarize site-specific, local, and/or geographical features relevant to the evaluation.
• Located on the south bank of Detroit River
• The topography of this area is mostly flat without significant change in slopes. The area lies within Little River, Turkey Creek and Detroit River watersheds
• The majority of Windsor consists of clay soils, which have low infiltration rates
• Within the city, the two major wastewater treatment plants are: (1) Lou Romano Water Reclamation Plant (LRWRP) and (2) Little River Pollution Control Plant (LRPCP)
• The main receiving water courses that influence flood relief solutions include: Detroit River, Little River, Grand Marais Drain, Lennon Drain and Cahill Drain
• The West Windsor study area is divided into three specific zones that account for similarities in climate, hydrology, land use and river influences : (1) Zone 1 “inland” residential, institutional and industrial; (2) Zone 2 shoreline industrial; and (3) Zone 3 industrial and parkland
b. Provide references.
• Appendix D - Technical Volume 1: Sewer Model Development & Existing Conditions, Sewer and Coastal Flood Protection Master Plan Report
• Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Soil distribution
Comments and Observations

1.6 *Identify Jurisdictional Considerations*

Add rows as necessary.

a. List the jurisdictions, laws, regulations, guidelines and administrative processes that are applicable to the infrastructure. • **1995 National Marine Policy -** laid out a detailed framework for Canada’s marine transportation system.
• **1998 Canada Marine Act** (S.C. 1998, c. 10) – created 17 ports, designated others a public ports, gave Minister of Transport certain authorities
• **Section 10 of the Rivers and Harbours Act of 1899** (33 U.S.C. 403) - U.S.

federal jurisdiction applies to projects affecting federal navigation works
• **Section 404 of the Clean Water Act** (33 U.S.C. 1344) **-** U.S. federal jurisdiction applies to projects affecting federal navigation works
• **Natural Resources Environmental Protection Act -** This statute is divided into numerous parts, which address many of the different and complex components of resource management and environmental protection
• **Section 33 Fisheries Act (**R.S.C., 1985, c. F-14) **-** Projects affecting levels and flows in Canadian waters come under federal aegis through federal responsibilities for fisheries
• **Navigable Waters Protection Act** (R.S.C., 1985, c. N-22) **-** Projects affecting levels and flows in Canadian waters come under federal aegis through federal responsibilities for fisheries
• **Canadian Environmental Assessment Act of 1995** (S.C. 2012, c. 19, s. 52)
• **Public Lands Act (R.S.O. 1990, c. P.43) -** Provincial control is exercised through the Ontario Ministry of Natural Resources and its Public Lands Act and Lakes and Rivers Improvement Act
• **Rivers Improvement Act** (R.S.O. 1990, c. L.3) **-** Provincial control is exercised through the Ontario Ministry of Natural Resources and its Public Lands Act and Lakes and Rivers Improvement Act
• **Emergency Management and Civil Protection Act** (R.S.O. 1990, c. E.9) – enables emergency response plans
• **Conservation Authorities Act (**R.S.O. 1990, c. C.27) **-** Control has also been delegated to the local level through the Conservation Authorities Act
• **By-Law No. 1** Harbour Fees and Cargo Rates - effective May 1, 2019 - a By-Law fixing the fees to be paid to enter or use the Port of Windsor
• **By-Law No. 2** Wharfage Rates - effective May 1, 2019 - a By-Law fixing the fees to be paid in respect of Wharfage
• **Boundary Waters Treaty of 1909**
• **Canada Coast Guard and WPA Memorandum of Understanding**
• **St. Clair and Detroit River Navigation Safety Regulations (SOR/84-335)**
• **Port Authorities Operations Regulations (SOR/2000-55)**
• **Port Authorities Management Regulations (SOR/99-101)**
• **Marine Transportation Security Regulations (SOR/2004-144)**
• **Port of Windsor Practices and Procedures**
• **Federation of Canadian Municipalities (FCM)**
• **Canadian Society of Civil Engineers (CSCE),**
• **Canadian Public Works Association (CPWA)**
• **Canadian Construction Association (CCA)**
b. Provide references.
• City of Windsor – Corporate Asset Management Plan, July 16, 2019

• *See main report for various climate study references*
<u>Comments and Observations</u>

1.7 Site Visit

a. Conduct a site visit.
<u>If Site Visit Not Conducted – Explain Why and Provide Supporting Information</u> COVID-19 restrictions limited site visits for much of the study period. Several of the team members are located in Windsor and provided needed site and regional information. As well, many of the assets and sites were investigated when various Dillon team members developed a 2020 City of Windsor Sewer and Coastal Flood Master Plan Report. The Dillon Project Manager also undertook a personal site visit.
b. Based on information gathered to date, conduct interviews with facility owners and operating personnel in order to field-test and validate initial project definition findings.
<u>Notes and Observations from Interviews</u> Several online interviews were arranged, including discussions with: City Parks; Wastewater operators including manager; ENWIN Utilities Ltd who manage the electricity distribution system and Water Utilities Commission services for the City of Windsor; Windsor Port Authority; other City of Windsor employees (see next paragraph). Note: Several workshops and many discussions were undertaken with stakeholders to discuss approach, preliminary findings, interim and final results and solution options. Stakeholders in discussions included City of Windsor staff (≥ 10 members) as well as police, Conservation Authority, Windsor Port Authority, County of Essex, etc.
c. Examine infrastructure and local geographical features as they may apply to the vulnerability assessment.
See an attached list of critical assets approved by City of Windsor for risk assessment.
<u>Notes and Observations from Infrastructure Examination</u>
i. Note key observations and areas for follow-up in subsequent assessment steps.

Key Observations
• Threshold criteria established based on interview results, forensic investigation of past high impact events, hydraulic and hydrological modelling results (calibrated as best possible for events and against elevations and locations) and approved by City . • See attached Tailored Thresholds Severity Scale and see Main Report for summaries of key observations and subsequent forensic investigations of events.
Additional Comments and Observations N/A

1.8 *Assess Data Sufficiency*

Review the data set developed in **Sections 1.1 through 1.7**.

Add rows as necessary.

a. Where assumptions are proposed for the assessment, identify these as such and provide a rationale for their use.	
Assumption	**Rationale**
Nil	N/A
Very few assumptions were required for this assessment since the assets and their conditions were relatively well known in developing the 2020 Sewer Master Plan. The climate data was available from the Windsor International airport with climatologically representative measurements and since calibrated hydrology and hydraulic modelling was available for integration with the climate analyses. Climate change projections were based on peer-reviewed literature and studies and, as needed, from ensemble climate change projections based on the IPCC AR5 models.	

b. Document where there is insufficient information currently available to proceed with an element of the assessment.

See section (a) above. This study was a comprehensive PIEVC assessments that included significant and comprehensive hydrology and hydraulic modelling support, previous asset condition information and was complemented with a full costing and evaluation of risk reduction solutions, benefits and environmental impacts via a Triple Bottom Line assessment.

Insufficient Information	i. Where there is insufficient information currently available, identify a process to develop or infill that data.	ii. Where data cannot be developed, identify the data gap as a finding in Step 5 of the Protocol – Recommendations.
Projections for future lake levels were conflicting. A recent flooding risk assessment of assets just north of this study area indicated that the lake level results from a 2011 study used in that risk assessment required review and updating, particularly in light of the extreme low and high levels of the past decade.	Projections of Great Lake and connecting river levels are exceedingly complex and conflicting. A comprehensive literature review of all Great Lake level studies was undertaken to update the earlier PIEVC assessment for nearby region. Additional study results were added to the earlier 2011 lake level projections under future climate conditions.	The earlier suggested lake level increases based on a previous PIEVC study (i.e. based on a 2011 study) were modified to indicate that future lake levels could not be projected with confidence, that the previous projected lake levels likely were high compared to more recent studies and climate change projections and that lake levels were likely to remain highly variable.
Further information is needed on river ice conditions, impacts of ice jams on river water levels (relatively short-lived) and on shoreline erosion risk locations.	Databases would need to be developed on historical river ice conditions and erosion impacts for the shorelines of interest. Relatively to other risks, this would require significant efforts.	See main report and PIEVC sheet #2.

Date:	November 15, 2022
Prepared by:	Simon Eng and Heather Auld

PIEVC Engineering Protocol

For

Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate

Worksheet Step 2

Data Gathering and Sufficiency

Revision 1.1

Effective March 30, 2020, the PIEVC Program is operated jointly by the Institute for

Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

For further information about this ***Engineering Protocol*** or the ***PIEVC Program*** please contact ICLR.

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Instructions

This worksheet is designed to allow practitioners to document that they have actively considered and evaluated each step of the Protocol. The worksheet also provides a document were practitioner considerations regarding each task of the Protocol are recorded.

Complete Every Field

To ensure complete coverage of the Protocol steps, when completed, the practitioner should have entered a response in every field of this worksheet.

Document Tasks That Do Not Apply

Where a particular task is not relevant to the current assessment:

- Enter **N/A** in the relevant field of this worksheet and
- Provide rational for the decision in the comments field of the task.

Document Tasks That Are Omitted

Where a practitioner has chosen to omit a particular step of the Protocol:

- Enter **OMITTED** in the relevant field; and
- Provide rational for the decision in the comments field of the task.

Protocol for Changing Climate Infrastructure Vulnerability Assessment

Practitioners are strongly cautioned to avoid the following common pitfalls in executing a vulnerability assessment based on the Protocol.

i. ***Skipping Protocol tasks***.

Although it is acceptable to select to not execute a particular task, the practitioner should nonetheless evaluate the question posed by that task and document the basis for the decision.

ii. Using previous case study reports as a template for the analysis.

Although previous studies provide an excellent reference, the application of the Protocol is highly specific to infrastructure. Applying previous case studies as a template can often lead the practitioner to miss key factors that contribute to the overall risk profile of the infrastructure.

iii. Using the worksheets without reference to the Protocol.

Although the worksheets parallel the Protocol, they do not provide supplementary context that may be necessary to correctly address the specified Protocol task.

2 Step 2 – Data Gathering and Sufficiency

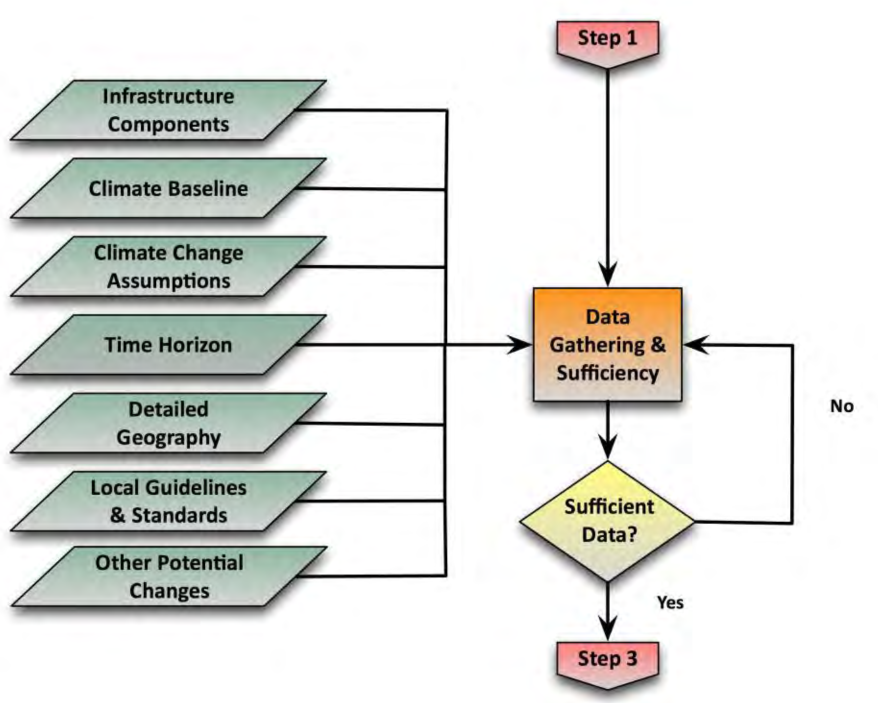
In this step the practitioner will provide further definition regarding the infrastructure and the particular climate trends that are being considered in the evaluation. The practitioner will undertake a data acquisition exercise and identify where, in their professional judgment, the data is insufficient. Data insufficiency may arise from:

- Poor quality;
- High levels of uncertainty; or
- Lack of data altogether.

This step further focuses the evaluation and starts to establish activities to infill poor quality or missing data.

The process flowchart for Step 2 of the Protocol is presented in **Figure 2**.

Figure 2: Step 2 – Data Gathering and Sufficiency Process Flowchart



2.1 Prepare Step 2 Worksheet

	Enter ***Yes*** or ***No***	
a. Use this ***Worksheet***; or	Yes	
b. Prepare practitioner specific documentation. i. Practitioner specific documentation ***MUST*** detail each task outlined in this step of the Protocol.		
Comments and Observations Tasks also outlined in the main Assessment Report.		

2.2 State Infrastructure Components

Add rows as necessary.

a. List the major components of the infrastructure that are influenced by climate. i. Only select those infrastructure components that, in the practitioner's professional judgment, are relevant to this assessment. ii. Where available, review operations incident reports, daily logs and reports to assist in the identification of infrastructure components with a history that could result in vulnerability and are relevant to this process. iii. Interview infrastructure owner's operators and maintenance staff to identify historical events that may not be documented or retrievable from databases and evaluate if these events are relevant to this assessment.
• Lou Romano Water Reclamation Plant (and storage)
• Stormwater Infrastructure including catchment basins
• Sewage Infrastructure; Combined sewers; Combined sewer outfalls; Pumping stations
• Drainage Infrastructure (channel drainage, monitoring systems)
• Gordie Howe Bridge (under final construction) and its approaches, drainage,etc; Ambassador Bridge entrances and ramps
• Public Infrastructure (road surfaces, culverts)
• Other Public/Private infrastructure (rail lines, electrical distribution systems, drinking water systems, Port, Biosolids Processing Plant, etc)

• Parklands and boat launches; Black Oat Heritage Park; Port; Playgrounds; Walking trails, etc
• Private Infrastructure (buildings, facilities, etc)
• Windsor salt Mine, facilities, buildings, etc
• Rail tracks and lands
• Detroit-Windsor Truck Ferry facilties
• Other critical Third party Assets – electrical transmission and distribution stations
• Residental areas serviced by combined sewers
• Detroit River and its water levels (+ ice cover + shoreline erosion)
b. Provide references.
See attached listing of assets and climate thresholds used for these assets. Worksheets #3 and #4 also include a detailed listing of all assets that were included in the PIEVC assessment.
Comments and Observations N/A

2.3 *State the Time Horizon for the Assessment*

a. State the period over which the infrastructure must operate. *Windsor Asset Management Plan, 2018*	1. Roads and Alleys: 25-45 years 2. Structures: 100 years 3. Wastewater: 24-75 years 4. Stormwater: 75-100 years 5. Riverfront Parks Shore wall: 50-75 years 6. Trails: 20 years, a few trails with 30-50 years
b. State the design life of the infrastructure components. *City of Windsor Asset Management Plan, 2018 and City of Windsor Sewer and Coastal Flooding Master Plan Report, 2020*	1. Temporary structures: 10 years. 2. Replaceable structural parts: 10 to 25 years.

	3. Agricultural and similar buildings: 15 to 30 years. 4. Building structures and other common structures: 50 years. 5. Monumental building structures, bridges and other civil engineering structures: 100 years. 6. Storm Sewer: 1:2 year to 1:5 year Rainfall Event
c. Document the maintenance and/refurbishment schedule for the infrastructure as it may apply to the useful service life of the infrastructure. *City of Windsor Asset Management Plan, 2018 – Sections 3, 5 and Appendix G*	1. Road segment inspection schedule: once a year to a minimum of once in 7 year 2. Structures (i.e. bridges and culverts (over a 3m span)) are inspected every two years in accordance with the Ontario Structure Inspection Manual (OSIM) 3. Storm and Sanitary Sewer Network: The zoom camera sewer inspection project will be formulated for a 5-year city-wide cycle program to cover 90% of the entire network. Buried or not found manholes will be inspected on a 2-year basis as they are located 4. Projected maintenance schedule for Lou Romano Water Reclamation Plant,

	Little River Plant and 45 Pump Stations is 20 years 5. Roads that are in fair condition need rehabilitation within 5 to 10 years of becoming deficient 6. Roads that are in good condition need rehabilitation within 6 to 10 years of becoming deficient
d. State the useful service life remaining in the infrastructure components.	Variable. Some assets are well beyond their serviceable lifespans, others within 5 years of remaining service life while other assets have recently been replaced or will be constructed in the near future.
Comments and Observations References and sources include: Client interviews and workshops; Various sections and appendices of the 2018 City of Windsor Asset Management Plan; 2020 City of Windsor Sewer and Coastal Flooding Master Plan Report. All assets for consideration in the assessment were approved by the City of Windsor and collaborating agencies.	

2.4 *State the Geography*

Add rows as necessary.

a. List the major features of the local geography that may influence the microclimate of the infrastructure or impose peripheral risk. i. Specifically identify hills, valleys, river systems, lakes, ocean frontage that may moderate the climate parameters considered in the evaluation. ii. Only select those geographical features that, in the practitioner's professional judgment, are relevant to this assessment.

• Site area is located on the south bank shoreline of the Detroit River
• The topography of this area is mostly flat without significant change in slopes, although the general slope of the land surface is towards the Detroit River
• The soil type within the study area mainly consists of native silty clay, often overlain with thin and discontinuous sand and gravel deposits closer to the Detroit River. Industrial land use areas, especially near the Detroit River, include landfills, salt mine waste, quarries, aggregate excavations and sewage lagoons. Soils along the bank of the Detroit River are considered to be relatively well drained with higher infiltration rates. Further inland, soils are relatively poorly drained with lower infiltration rates. Some shoreline areas are subject to soil erosion, particularly during high water levels.
b. Provide references.
• Geotechnical Review of Selected Sites for the City of Windsor Sewer and Coastal Flooding Master Plan Report, 2020
• Appendix D - Technical Volume 1: Sewer Model Development & Existing Conditions, Sewer and Coastal Flood Protection Master Plan Report
• Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Soil distribution
• Flood Risk study memo
Comments and Observations N/A

2.5 *State Specific Jurisdictional Considerations*

a. As applicable, itemize:		b. Provide references.
▪ Jurisdictions that have direct control/influence on the infrastructure;	1. 1995 National Marine Policy 2. Section 404 of the Clean Water Act (33 U.S.C. 1344) 3. Section 10 of the Rivers and Harbours Act of 1899 (33 U.S.C. 403)	Publicly available
▪ Sections of laws and bylaws that are relevant to the infrastructure;	1. By-Law No. 1 Harbour Fees and Cargo Rates - effective May 1, 2019 - a By-Law fixing the fees to be paid to enter or use the Port of Windsor 2. By-Law No. 2 Wharf age	Publicly available

	Rates - effective May 1, 2019 - a By-Law fixing the fees to be paid in respect of Wharf age	
▪ Sections of regulations that are relevant to the infrastructure;	Natural Resources Environmental Protection Act: - This statute is divided into numerous parts, which address many of the different and complex components of resource management and environmental protection	Publicly available
▪ Standards that are relevant to the design, operation and maintenance of the infrastructure;	1. City of Windsor Standard Specifications for Sewers (January, 1999) 2. City of Windsor Standard Specifications for Maintenance Holes and Catch basins (March 2018) 3. City of Windsor Standard Specifications for Sewer Pipeline and Culvert Rehabilitation by Cured-in-Place Pipe (May, 2017) 4. City of Windsor Standard Specifications for Culverts, Headwalls and Roadside Drainage (May, 2017) 5. City of Windsor Standard Specifications for Cleaning of Gravity Sewers, Manholes and Catch basins (January, 2015) 6. City of Windsor Standard Specifications for Bridges 7. Highway Drainage Design Standards, Ontario Ministry of Transportation 8. Ministry of the Environment Design guidelines for Sewage Works	Standard Specifications, City of Windsor (https://www.citywindsor.ca/business/buildersanddevelopers/Pages/Standard-Specifications.aspx)
▪ Guidelines that are relevant to the design, operation and maintenance of the infrastructure; and	1. Windsor/Essex Region Stormwater Standard Manual: Provides guidelines regarding detailed design of storm sewer infrastructure 2. City of Windsor Development	City of Windsor Website: https://www.citywindsor.ca/business/buildersanddevelopers/Pages/Municipal

	Manual 3. Street Lighting Design and Installation Guidelines, City of Windsor 4. MECP (May 2020) LID stormwater management guidance manual	-Infrastructure-Requirements.aspx
▪ Infrastructure owner/operator administrative processes and policies as they apply to the infrastructure.	City of Windsor Standard Specifications for Replacement of Private Drain Connections (May, 2017)	Also see City of Windsor Sewer and Coastal Flooding Master Plan Report
Comments and Observations N/A		

2.6 *State Other Potential Changes that May Affect the Infrastructure*

a. Identify and document other factors that can affect the design, operation, and maintenance of the infrastructure:	
i. Document changes in use pattern that increase/decrease the capacity of the infrastructure.	• City's population is expected to grow over the next 25 years - up to 35% population growth projected overall, but not all areas will be equally impacted. The assets and services for the increased population need to become climate resilient. (Ontario Ministry of Finance, 2021) • City's capital plan includes improved traffic flow; reduced basement flooding; repairs to various bridges and sidewalks; expanded park facilities and trails; upgraded building facilities. • The construction of the Gordie Howe International Bridge under Windsor-Detroit Bridge Authority provides some benefits to the City via traffic redirection, regional drainage upgrades and improvements and plans to upgrade and slightly raise Sandwich Street. • Other in progress changes include construction or upgrades to the Lou Romano RTP, McKee Park and the Prince Road Outlet as potential solutions to existing flooding issues.
ii. Document operation and maintenance practices that increase/decrease the capacity or useful life of the infrastructure.	Roads and Sidewalks: • **Alley Maintenance:** Paved alleys are maintained on an as-needed basis, Gravel alleys are re-graded twice per year • **Bridge Maintenance:** The City of Windsor maintains 84 bridges and 216 municipal culverts Repairs include parapet walls, bearing plates, deck rehabilitation, foundation repairs, bridge washing, and total reconstruction • **Public Fence Repair:** The Operations Department repairs damaged public

	fences in right-of-ways, such as walkways and along railways. The Parks Department repairs fences within the City's parks. • **Road Maintenance**: Includes pothole repair, road rehabilitation, repairing and replacing curb and gutter. Shoulder grading is carried out twice per year on all rural cross section roads
iii. Document changes in management policy that affect the load pattern on the infrastructure.	• Community Energy Plan (CEP) by the City of Windsor: Identifies ways to improve energy efficiency, improve energy security, and reduce greenhouse gas emissions while contributing to the overall quality of life of the Windsor • Climate Resilient Home: The City of Windsor has retrofitted a City-owned home built in the City's core in the 1920s with the goal of reducing the risk of basement flooding • Sewer Master Plan: The Sewer Master Plan will take a system-wide approach to identify specific improvement projects that can be undertaken by the City to improve sewer efficiency and reduce the risk of flooding caused by wet weather • Corporate Climate Action Plan (CCAP) • Climate Change Adaptation Plan
iv. Document changes in laws, regulations and standards that affect the load pattern on the infrastructure.	Changes in Ontario Building Code and relevant standards from their historical load requirements were considered as needed.
Comments and Observations N/A References: City of Windsor web site • City of Windsor web site https://www.citywindsor.ca/residents/building-Windsors-Future/Pages/Capital-Plan.aspx • City of Windsor Asset Management Plan, • https://www.citywindsor.ca/residents/environment/climate-change-adaptation/climate-	

resilient-home/Pages/default.aspx

2.7 *Identify Relevant Climate Parameters*

Add rows as necessary.

a. List the relevant climate parameters associated with the design, development, and management of the infrastructure. i. Use the ***Climate Parameter List*** provided in **Appendix A** as a guideline. ii. Additional guidance can be found in: ▪ The ***PIEVC Data Integrity and Availability Review*** and/or ▪ ***Environment Canada's National Climate Data Archive*** (http://climate.weatheroffice.ec.gc.ca/Welcome_e.html).	b. State the climate information source(s). Sources may include, but are not limited to: ▪ National Building Code of Canada Appendix Tables ▪ Intensity Duration Frequency (IDF) curves, ▪ Flood plain mapping, ▪ Heat units, ▪ Water elevation ▪ Etc.
Extreme Rainfall	City of Windsor guidance and recommendations; Forensic analysis of past events; Interviews, Analysis of Windsor and Detroit Airport rainfall data; Review of published and climatologically representative studies on historical rainfall events; Newspaper reports, etc; Detailed hydrology and hydraulics modelling for Detroit River and sewer systems. See Assessment Report for more details.
Great Lakes and Detroit River Water Levels	Analysis of historical water level records and

and associated Flooding; Extreme River Levels	return periods associated with past events; IJC, NOAA and MNRF (Ontario) evidence and studies on lake levels; Peer reviewed literature on past and future lake and river flooding frequencies; Detailed hydrology and hydraulics modelling. Includes preliminary review of river/lake ice and ice jam contributions to water levels (less significant than persistent high levels). Literature review of climate change projected lake levels, watersheds and hydraulics/routing modelling studies to update earlier lake level information. Hydraulic and hydrological analysis of extreme low water levels combined with extreme rainfalls.
Snow accumulation/Melt	Analyses of Windsor and Detroit airport historical records together with forensic evidence; Newspaper reports; Professional expertise on rainfall, water level, snowpack and snowfall events
Tornado frequencies	ECCC and UWO updated tornado database events; Newspaper reports; Professional expertise on severe convective storm and tornado events
Heat Events	Analysis of Windsor Airport data; Professional expertise to identify critical heat thresholds
Major Ice Storm	Analysis of past ice storm events; Professional expertise and interpretation of major ice storm events and associated modelling results (i.e. for overhead system designs, etc); Review of several (scarce) ice storm events, newspaper reports, etc.
Extreme Wind	Analysis of historical wind data from Windsor and Detroit Airports (as relevant, mainly captures synoptic scale events); Building Code design limits and updates; Newspaper damage reports, interviews; Professional expertise in extreme wind events and impacts on infrastructure.
Freeze/ thaw	Analysis of Windsor Airport freeze-thaw

	frequencies; Studies on critical thresholds for freeze-thaw weathering impacts on concrete and other materials; Professional expertise
Combined Events (HWL+Rainfall)	Detailed hydrology and hydraulics modelling combined with analysis of IJC river level data and rainfall data, published studies, newspaper reports
Climate Change Projections	Analysis of an ensemble of IPCC AR5 climate change projections using the Dillon climate analytical system, peer-reviewed studies and lake level modelling and projections (e.g. McGill group, NOAA), ECCC climate change guidance documentation, discussions with U.S. Great Lakes Integrated Science and Assessments (GLISA) unit, Great Lakes Environmental Research Laboratory (GLERL) studies, etc.
Comments and Observations Data on river ice, ice jams and on shoreline erosion susceptible not available for further analysis.	

2.8 *Identify Infrastructure Threshold Values*

Add rows as necessary.

a. For each climate parameter selected, identify a threshold value above which, or below which, the infrastructure performance will be affected.

   i. Threshold values may be based on:

   - Codes;
   - Standards;
   - Engineering Guidelines;
   - Operating or Maintenance Procedures;
   - Professional Judgement; and/or
   - Other, as appropriate.

   ii. As appropriate, a number of different thresholds may be identified for a specific climate parameter based on varying degrees of infrastructure response arising from parameter values changing over a broader range.

   - In such cases, each parameter-threshold pair would be treated as a separate event within the context of the assessment.

Threshold Value	b. Clearly document the source of the threshold value.	c. Provide justification for the threshold value selected.
Extreme Rainfall: • "Major" 100-yr Storm - 82 mm in 4 hrs, peak rate of 145 mm/h • "Minor" 5-year Storm - 50 mm in 4 hrs, peak rate 29.5 mm/hr	Discussions with City, interviews, design criteria, forensic analysis of past events	See attached document "West Windsor flood PIEVC Assessment Tailored Severity Scale" for summary of tailored thresholds identified to be critical for various stakeholders, impacts, city services in the
Rapid Snowmelt of snowpack: Snow water equivalent - 85mm	Threshold based on 2014 record breaking snowpack (also 133 year Detroit record broken); Flooding impacts noted for study region; Past	Forensic analysis of past snowmelt flooding events (greatest snowpack); Results compared using snowpack data and impacts for Detroit;

	emergency evacuations of facilities due to snowmelt flooding	Events where rivers and ditches reached flood crest stage by late winter. Later stage stakeholder consultations eventually identified this parameter as having lesser importance for flooding (e.g. also dependent on rates of late winter warming).
Snow Accumulations: Accumulation 250cm	See above snowpack threshold for snow water equivalent amounts. Record-breaking 2013-14 Windsor Airport snowfall accumulations >250cm - agrees with snowpack data from Detroit. Note that the 2013-14 winter broke the previous record for 2004-05 accumulations of 226cm (previous record).	High transportation impacts; drainage assets buried; Many of the rivers and ditches reached flood crest stage from water, snow or ice; Local flooding; Building snow overloading risks regionally. Later stage stakeholder consultations eventually identified this parameter as having lesser importance for flooding (e.g. also dependent on rate of late winter warming).
Major Ice Storm: >28mm accretion	Design ice loading criteria for critical overhead systems (electrical, communications); Peer-reviewed studies and professional expertise of severe ice storms and ice loading.	Internal Ontario ice storm database to 2005; Peer-reviewed studies on severe ice storm events and risks. Ice storms with more than 25 mm of freezing rain are typically associated with significant damage to trees, telecom and overhead infrastructure, and correspond with design thresholds for failure of overhead electrical systems.
Extreme Wind: >120km/hr	Analysis of Windsor Airport wind gust records; Building Code design criteria identified 120 km/hr as a damage	Widespread power outages, potential structural damages (beyond building cladding); Professional expertise on

	threshold See main report.	design wind pressures/speeds with potential for structural damages
Tornado: (E)F2+	ECCC and UWO tornado database	Reasonable design considerations for critical assets; Professional expertise on design basis tornadic events and impact thresholds
Weathering or Freeze/Thaw cycling	Analysis of Windsor Airport data Annual frequencies and number of 30-cycle plus years	Freeze-thaw cycle impacts are based on laboratory tests of reinforced concrete samples, which indicated that visible damage can begin after approximately 30 freeze-thaw cycles annually. In both scenarios (total cycles and 30-cycle increments), although the future total number of freeze-thaw cycles decreases, this decrease is not substantial but is likely to remain of concern during the mid-winter months.
Coastal Erosion Processes City staff interviews, stakeholder consultation as well as the County of Essex Hazard Identification and Risk Assessment (HIRA; County of Essex, 2019) all indicated significant concerns regarding shoreline erosion, and it was therefore included initially as a hazard for consideration	No historical database could be identified that captured shoreline erosion risks along the Detroit River. As a result, the relative impacts, risks and rate of change could not be statistically evaluated	Not evaluated due to lack of data
High River Levels (HWL): • Current 100 year return period HWL = 175.9 m from 2020	Detroit River IJC water level records for representative gauge site; Extreme value analyses including extreme high levels from 2020;	Significant coastal/river flooding impacts resulted from record high levels in 2020. Note that record low levels were recorded in the

• "Likely" (potentially extreme) climate change HWL = 176.1 m	Comparison to analyses by OMNRF for extreme high water levels during the 1980s and comparison to historical data	period leading up to 2013.
Combination Events: Detroit R High Water Levels + Storm Rainfall	**See next section 2.9**	
<u>Comments and Observations</u> N/A		

2.9 *Identify Potential Cumulative or Synergistic Effects*

Add rows as necessary.

a. Review the selected climate parameters and threshold values and evaluate the potential cumulative impact of combining or sequencing weather events and/or climate trends to assess the possibility of these combined events yielding a higher impact compound event. b. Include relevant cumulative or synergistic events on the list of climate parameters carried forward for risk assessment. i. The practitioner must exercise professional judgment in establishing conceivable combined or synergistic events to avoid assessing multiple, improbable, combinations.		
Cumulative and/or Synergistic Event	**Threshold Value**	**Justification**
Combination Events: Detroit R High Water Levels + Storm Rainfall	See different thresholds below	

Current 100 yr HWL + Major rainstorm (100-year return period, 4 hour)	Hydrology and hydraulic modelling of the representative portion of Detroit River; Detailed elevation data; Calibration against past flooding events	Historical/current worst case high water levels with extreme rain storm (also needed to assess performance of river risk reduction options under a major extreme rainstorm and for TBL evaluations of solutions)
Current 100 yr HWL + Minor rainstorm (5-year return period, 4 hour)	Hydrology and hydraulic modelling of representative portion of Detroit River; Detailed elevation data; Calibration against past flooding events	Historical/current worst case high water levels with minor rain storm (also needed to assess river flood risk reduction options under moderate rainstorms for TBL evaluations of solutions)
Potential Extreme Climate Change HWL + Major rain storm (100 year RP, 4-hour)	Hydrology and hydraulic modelling of representative portion of Detroit River under best estimate of future climate change high water levels together with a major extreme rainstorm; detailed elevation data	Future climate change worst case increased high water levels combined with major extreme rain storm (needed to assess river flood risk reduction options for land drainage under extreme rainstorms). See main report discussions on probabilities of lowering extreme high lake levels under climate change with high GHG emissions.
Potential Extreme Climate Change HWL + Minor rain storm (5 year RP, 4-hour)	Hydrology and hydraulic modelling of representative portion of Detroit River under best estimate of future climate change high water levels together with a minor rainstorm; detailed elevation data	Future climate change worst case high water levels combined with minor rain storm (needed to assess river flood risk reduction options for land drainage under minor rainstorms). See main report discussions on probabilities of lowering extreme high lake levels under climate change with high GHG emissions.
Current 100-year return period HWL + wave action (freeboard)	Hydrology and hydraulic modelling of representative portion of Detroit River + “safety factor” allowance for	Essex County HIRA + historical forensic events for extreme flooding conditions. Note that climate change

	freeboard (wave action)	projections of future river levels are conflicting, with more estimates for decreasing levels after 2050s than increases. Climate variability from extreme high to extreme low levels will remain a concern.
Rainfall + hail and wind for debris	Not evaluated in risk assessment – other hazards pose much greater risks	Considered for debris blocking stormwater drainage. Considered as having a minor impact relative to other flooding risks

Comments and Observations

- Initial investigation undertaken of impacts of ice jam and breakup events on extreme winter flooding risks, but would need a database of ice jam and breakup events to investigate further and quantify.
- Shoreline erosion impacts also of concern, but no databases are known that can capture shoreline erosion risks along the Detroit River. As a result, the relative impacts and rate of change could not be statistically evaluated

2.10 State Climate Baseline

Add rows as necessary.

a. List historical extreme weather events:

   i. Identify the frequency of the events
   ii. Identify the duration of the events
   iii. Identify the date(s) of the events
   iv. Identify the magnitude/intensity of the events

b. If data is not available:

   i. Based on professional judgement, infill missing data using reasonable assumptions
   ii. Provide written justification/substantiation for the assumptions.

c. List the values that are chosen.

d. Provide references.

Historic Extreme Weather Event	Value	Reference
See West Windsor Flood PIEVC Assessment Study Tailored Severity Scale (attached)	Various	
EXAMPLE EVENTS – Many other events collected		
Significant surface and basement Flooding: September 28, 2016	100 mm of rainfall over 24 hours on the east side of the city	Appendix D - Technical Volume 1: Sewer Model Development & Existing Conditions, Sewer and Coastal Flood Protection Master Plan Report
Significant surface and basement Flooding: June 4,5,6, 2010	90 mm of rain fell in Windsor between 11:00 pm June 5th and 3:00 am June 6th	Appendix D - Technical Volume 1: Sewer Model Development & Existing Conditions, Sewer and Coastal Flood Protection Master Plan Report
Significant surface and basement Flooding: August 28/29, 2017	A maximum measured rainfall amount of 212 mm was logged southwest of Huron Estates PS and 189 mm at the Howard Grade Separation PS.	Appendix D - Technical Volume 1: Sewer Model Development & Existing Conditions, Sewer and Coastal Flood Protection Master Plan Report
February 12, 2019	Morning, mainly impacts to commute (vehicles, pedestrians); However, localized power outages in City, including scattered outages in S Windsor, and ~1,000 customers out in Riverside and Pillet areas lasting a few hours (as of 3 PM same day); imagery suggests total accumulations ~10-15 mm	Windsor Star - February 13, 2019

Date unknown, occurred in 1999 or 2000	Ice storm generated widespread Power outages, requiring door-to- door well checks of local residents.	P. Berry, pers. comm.
March 1-7, 1976	"Main brunt of the freezing rain came on the 2nd and 3rd with isolated thunderstorms giving 20–40 mm of freezing rain from Windsor to just west of Hamilton. Power outages in some localities lasted as long as eight days." Mclaughlan and Smith indicate up to 10 or more locally	Klaassen et al. (2003); Mclachlan and Smith (1976)
February 24, 2016 and March 3, 2015: Events with several hours of freezing rain reported in media and in airport weather records, but no direct impacts could be confirmed		Windsor Star; ECCC Online Climate Data for Windsor Airport
Record-breaking snowfall accumulations winter 2013-14; Previous record at 225.5 cm from 2004-05	249cm from Nov, 2013 to April 2014; Previous record 2004-05 at 225.5 cm for Windsor Airport (record dates from 1940)	Windsor CTV News: https://windsor.ctvnews.ca/it-s-official-windsor-has-broken-its-all-time-snowfall-record-1.1725689 https://www.csmonitor.com/USA/Latest-News-Wires/2014/0415/Detroit-snow-breaks-records-topples-power-lines-creates-flooding-risk
Extreme Snowstorm: Feb. 1, 2015	More than 40 centimeters of snow	CBC News, January 1, 2020
Flooding from 50mm rainfall plus snowmelt, 2017-18	50mm rainfall on snowmelt	Windsor CTV news https://windsor.ctvnews.ca/flooding-remains-a-possibility-for-windsor-essex-and-chatham-kent-1.3813067
Tornado: June 6, 2010	A series of tornadoes tracked through Essex County	CBC News, January 1, 2020
Comments and Observations		

N/A

3 State the Changing Climate Assumptions

Add rows as necessary.

a. Assess the relevancy and applicability of observed global, regional or site-specific changing climate trends with respect to the infrastructure. i. Document how these trends influence the infrastructure.	
Trend	**Influence**
Increased precipitation: • Average (mean) annual precipitation increased across Canada from 1948 to 2012. Due to insufficient data coverage nationally, national precipitation trend analyses of precipitation cannot be updated after 2012. • For the Windsor area, total precipitation trends from 1981-2019 indicate small increases over the period (~60mm), although the totals are highly variable from year-to-year. The greatest increases were observed for the autumn period. Similar trends have been noted for the Detroit area. Nonetheless, intense, localized storms have been observed outside of the Windsor Airport and within the City, resulting in widespread flooding. The most significant short duration rainfall trend increases are noted for 24 hour rainfall durations.	Increased total annual precipitation over time has the potential to increase lake and river levels, also depending strongly on winter ice cover and summer temperature influences on Great Lakes multi-year balances between precipitation, runoff and evaporation. It is the small differences between incoming precipitation and runoff and outgoing evaporation processes that pose many uncertainties and challenges for projections of future lake levels. Extreme rainfall (or snowmelt with rainfall) events can locally or regionally overwhelm stormwater and combined sewer systems, even when river water levels are not impacting the systems. Time for drainage increases while pumping systems may not be effective locally when lake/river water levels are high.
High and Low Great Lakes and Connecting Rivers Water Levels • Water levels on the Great Lakes and Detroit River typically fluctuate on multi-	High water levels result in coastal flooding, severe coastline erosion, damages or an inability to use coastal and port assets, damages to coastal road and walk ways,

decadal time scales, but recent fluctuations between lows and highs have been more rapid and extreme. Record low levels on the Detroit River from 1999-2013 and rose to record highs in the 2019-20 period. Levels have slowly declined since 2020. • The more recent record low levels resulted largely from warming air and water temperatures, reduced winter ice cover and increased lake evaporation over an extended season. The rapid recovery from record low levels began from winter 2013-14 after a particularly cold polar vortex winter, heavier ice cover and less lake evaporation that was followed by heavier precipitation seasons and some notable extreme precipitation events.	ineffective pumping, inundation of storm and waste water sewers and a potentially overwhelmed wastewater treatment plant. Some of these assets may require significant repairs or rebuilding. Note that the County of Essex was under flood watch or warning status for 182 days in 2019. As noted in the main PIEVC report, future lake levels will depend on future GHG levels, with the possibility that lake levels might be even higher than recent records if GHG emissions are reduced and climate warming is restricted. Gradually lowering lake levels appear more probable under the more realistic high GHG assumptions after mid-century. Based on the results from five studies after 2011, an additional 20 cm of lake level rise by mid-century would likely represent an almost worst case, and would be more likely for lower global GHG emissions scenarios.
Increased annual temperature: • The average (mean) annual temperature in *Canada* increased by 1.7 °C from 1948 to 2016, about double the global rate. • Mean annual temperatures in the *Windsor Airport* area have increased steadily over the period 1981-2019. • The number of hot days with temperatures above 31°C are also increasing as the warm season gradually lengthens. The number of these hot days is expected to roughly double (from 5 to 10 days/year) by the 2050s under high GHG emission scenarios.	Warmer summer and winter temperatures result in greater evaporative loss from the Great Lakes and connecting river systems surface and from the land basin areas. Warmer lake and river temperatures have the potential to support growth of algae locally, depending on wind and flow rates. The warm convective rainfall season is expected to lengthen with warming. Since warmer air has the potential to "hold" more moisture for precipitation, it is expected that convective or thunderstorm type rainfall events could persist into a later autumn or develop earlier in the spring season. Note that Windsor currently records more thunder and lightning storms than any other city in Canada, reflecting the region's relatively longer and more active convective precipitation season.
River Ice Cover • Highly variable. Warming or shorter	Decreasing ice cover can shoreline areas more exposed to storm action and more prone

winter cold seasons potentially will reduce the amount of ice cover on the Great Lakes and connecting rivers.	to erosion and winter flooding. Decreasing ice cover is also associated with increased evaporation from the Great Lakes.
Changes in Snow: • Ironically, while the number of days with snow on the ground has gradually decreased across much of southern Canada, the seasonal snowfall amounts and extreme snowfall amounts can follow different trends. • Snowfall accumulations have broken long-term records twice in the period 2004-2014. Potential exists for lake effect snowfall events in the presence of cold Polar Vortex weather systems when the Great Lakes are relatively warm and ice-free in early winter.	Changes in patterns of seasonal snow accumulation in Canada pose a risks for infrastructure and its operations and maintenance. For example, increased winter snow or lake effect snow events during a shorter snow accumulation period can increase the potential of roof collapse. Rapid warming and significant mid to late winter rainfall events plus snowmelt can fill drainage channels, block stormwater catch basins, flood streets, etc.
Weathering/ Freeze-Thaw Cycling • The number of freeze-thaw cycles are expected to gradually decrease as winter and the shoulder seasons warm. The frequency could actually increase during the mid-winter months, indicating that winter weathering may shift seasonally and could increase in mid-winter.	In both scenarios (total cycles and 30-cycle increments), the future total number of freeze-thaw cycles decrease, although this decrease is not substantial and is likely to remain of concern during the mid-winter months. Winter weathering processes impact the durability, lifespan and maintenance requirements for concrete and masonry based assets. Weathering processes also impact shoreline erosion processes, especially under conditions of reduced ice cover.
Shoreline Erosion • Decreasing lake and river ice cover trends and extreme high water levels will increase shoreline erosion risks, which are already of significant concern.	City staff interviews, stakeholder consultation as well as the County of Essex Hazard Identification and Risk Assessment (HIRA; County of Essex, 2019) all indicated significant concerns regarding shoreline erosion, and it was therefore included as a key hazard consideration for the flood risk assessment. Unfortunately, no databases or collected data is available to assess the shoreline erosion risks along the Detroit River and their trends.
Comments and Observations	

See notes on shoreline erosion and river ice cover influences on water levels. Further discussion in the main PIEVC report.

b. Where appropriate, identify incremental changes to the **Climate Baseline** conditions based on the trends identified in (a) above.

Incremental Change	**Influence**

Comments and Observations
N/A. Covered in the above discussion in section (a)

c. Where appropriate, identify incremental changes to the **Climate Baseline** conditions based on sensitivity analysis.
   i. Increase or decrease Climate Baseline conditions by percentages selected based on the practitioner's professional judgement.
   ii. Provide written justification/substantiation for the assumptions and incremental values used in the sensitivity analysis.

Incremental Change	**Justification**

Comments and Observations
N/A. Thresholds were confirmed via processes discussed earlier.

d. Where appropriate, use surrogate information from other geographic areas to respond to identified data gaps and uncertainties.

i. Document the source of the infill data.
ii. Provide written justification/substantiation for using the infill data.

Incremental Change	**Justification**
N/A.	Local to regional climate information and localized hydrologic and hydraulic modelling were used in the assessment.

Comments and Observations

N/A. Not required except for some consultation with NOAA and Detroit studies.

e. Where appropriate, arbitrarily define changing climate assumptions or predictions.

i. Provide written justification/substantiation for using the assumptions.

Incremental Change	**Justification**
Climate trends analyses, published studies and ensemble climate change projections were incorporated throughout the study.	Assumptions were few (except for future levels of GHG emissions). All risk assessments were based on expert climatological analyses, peer reviewed studies and approaches, hydrological and hydraulic modelling, forensic analyses, etc.

Comments and Observations
N/A

f. Where appropriate, employ regional climate change models to project changing climate effects in the region of the infrastructure.

ii. Review the basis and basic assumptions of the model(s).
iii. Provide written justification/substantiation for using the model in the evaluation.

Incremental Change	Justification
Temperatures and Precipitation: Temperatures and seasonal precipitation trends indicate ongoing increases. The greatest changes are expected for high temperature extremes and short and longer duration precipitation extremes. Many future extremes for precipitation types, winds, etc are difficult or impossible to infer from models alone and detailed peer reviewed studies and extensive professional climate experience and expertise were needed to assess trends into the future. Changes in high extremes will impact all of the assets considered.	Interviews, historical codes and standards, discussions with stakeholders and forensic analysis of past climate impacted events and risks were all used to confirm the importance of future trends leading to increased climate risks. The study team included climatologists and climate change experts with collective experience spanning many decades.
Extreme Climate Variables and River Water Levels: Any climate change driven increases in extreme coastal lake/river and precipitation processes will increase flooding and risks for the wastewater and stormwater assets. Other increases in extremes e.g. severe ice storms, extreme winds, tornadoes, etc will have secondary impacts that include structural damages, prolonged loss of power, electrical hazards, emergency responses and were assessed as secondary impacts.	High extremes will impact all assets and flooding processes. Low water levels were also considered in this study. The study team members have years to multiple decades of recognized climate and climate change expertise. The climatologists were able to undertake extreme and forensic analysis of events and to interpret the published literature.
Changes in Climate Models: Climate change models change over time too. Temperature and Precipitation changes were projected using an ensemble of climate	The latest IPCC climate change models and projections from the 2021 release were compared to the sets of climate change models still widely in use (i.e. 2013 released

change projections from both the IPCC AR5 models (2013) and AR6 models (2021) assuming conservative or limited future reductions in GHG emissions i.e. AR5 models using RCP8.5 emissions and AR6 models using SSP370 (SSP3) emissions. The differences in future trends of temperature and precipitation averages (Normals) was minimal for these GHG assumptions.	AR5 models). It was important to ensure that the results and guidance from this PIEVC assessment could be used to guide infrastructure investments well into the future and that the results could be more readily updated into the future.
Extreme River Water Levels: Extremes in lake levels and their variability strongly influence river/lake coastal flooding as well as basement and land flooding risks. The efficacy of the wastewater, stormwater and combined sewer systems are sensitive to river level influences for many sections of the study area. Record breaking low and high water levels have been experienced in the past decade and it is critical that their changes be considered for the future.	This study included a comprehensive review and assessment of all Great Lakes level projections under climate change for updates, improvements and changes since 2011, when Great Lakes process and routing models were revised for improved land runoff evaporation. The previous Windsor coastal flooding study was based on a 2011 study of Great Lakes levels that incorporated a limited number of older driving climate change models. These results were updated using Great Lakes level studies released since 2011 that incorporated a greater number of more recent driving climate change models as well as improved processes influencing on Great Lakes water levels.
Downscaling for Climate Change Projections – Other Approaches: Downscaling approaches for climate change projections – use of dynamic or regional climate models or statistical downscaling. Most climate change models do not handle trends in localized extremes well (ie perform "better" for average trends) and alternate but scientifically recognized approaches were used.	A mixture of downscaling approaches were included in the study. The statistical delta approach was used where direct downscaling from ensembles of climate change models were needed. The peer reviewed climate change projection studies incorporated into the PIEVC assessment used a mix of dynamic (regional models) and statistical downscaling approaches.
Comments and Observations N/A	

3.2 *Establish Changing climate Probability Scores*

a. From **Figure 3**, choose Method A or Method B to define probability scores. i. Record in project documentation the Method that was used. ii. Use the same method for all probabilities used in the evaluation.	**Method** **Enter Either A or B** Quantitative Method B Scores based on changes in Likelihood
b. Choose the changing climate probability scoring approach. Either: i. Assign scores for the probability of climate parameters changing over the time horizon of the assessment such that the infrastructure threshold is triggered. ▪ If this approach is selected, go to **Task 2.12.c**	**Method** **Enter Either Yes or No** **Yes** (absolute risk)
OR: i. Assign scores for the probability of climate parameters triggering infrastructure thresholds in the baseline climate and assign scores for the probability that climate parameters will trigger the infrastructure thresholds in the future climate. Changing climate impacts are assessed from the difference between the two scores. ▪ If this approach is selected, go to **Task 2.12.d**	**Method** **Enter Either Yes or No** No

c. Scoring Changing climate Probability

Add rows as necessary.

		Will the Interaction Change Over Time Horizon of Assessment?	More-Same-Less?	Projected Change in Magnitude?	Projected Change in Frequency	Robustness of Forecast?	Professional Judgment	Probability Score
		Y/N	+ 0 -	H M L	H M L	H M L	Comments	0-7
		☟	☟	☟	☟	☟	P = ƒ (A,B,C,D, & E)	
Climate Parameter	**Infrastructure Indicator**	A	B	C	D	E	☞	**P**

ALTERNATIVELY

d. Scoring Probability for Both Baseline and Future Climates

For the Baseline Climate

Add rows as necessary.

		Thresholds Triggered?	Magnitude of Event	Frequency of Event	Robustness of Forecast	Professional Judgment	Probability Score
		Y N	H M L	H M L	H M L	Comments	0-7
		☟	☟	☟	☟	P =ʄ (A,B,C,D, & E)	
Climate Parameter	Infrastructure Indicator	B	C	D	E	☞	P

For the Future Climate

Add rows as necessary.

		Thresholds Triggered?	Magnitude of Event	Frequency of Event	Robustness of Forecast	Professional Judgment	Probability Score
		Y N	H M L	H M L	H M L	Comments	0-7
		☟	☟	☟	☟	P = ƒ (A,B,C,D, & E)	
Climate Parameter	Infrastructure Indicator	B	C	D	E	☞	P

e. As appropriate, the practitioner may select an alternative probability scoring methodology.

   i. If the practitioner selects an alternative scoring methodology they are directed to substantiate and document this choice in the project report.
   ii. Whatever method is used, it must be used consistently throughout the probability scoring process.

Methodology	Substantiation

Figure 3: Probability Score Definitions

The practitioner is directed to express a professional opinion regarding the probability that a climate event that triggers an infrastructure threshold will occur. This should not be confused with the consequences of that climate event. The practitioner is asked to score the probability of the event in this step and assess the severity and/or consequences in the next step of the protocol.

Score	Probability	
	Method A	Method B
0	Negligible Not Applicable	< 0.1 % < 1 in 1,000
1	Highly Unlikely Improbable	1 % 1 in 100
2	Remotely Possible	5 % 1 in 20
3	Possible Occasional	10 % 1 in 10
4	Somewhat Likely Normal	20 % 1 in 5
5	Likely Frequent	40 % 1 in 2.5
6	Probable Very Frequent	70 % 1 in 1.4
7	Highly Probable Approaching Certainty	> 99 % > 1 in 1.01

3.3 *Assess Data Sufficiency*

Review the data set developed in **Sections 2.1 through 2.12**.

a. For data selected for the evaluation, assess and comment on:

▪ Data gaps;	Windsor International Airport represented the main climate station used for relevant climate variables, with comparison to results from the Detroit Airport. IJC lake and connecting river measurements were analyzed for lake/river level studies and return period estimates. Hydrological and hydraulic modelling was calibrated against flow, forensic evidence and guidance from Conservation Authority and City staff. In many cases where information was not available, published climate studies were incorporated into the assessment.
▪ Data quality;	The quality of the Airport climate data was reasonably complete and records were long while the hydraulic and hydrology (H&H) modelling was comprehensive. Efforts were made to ensure that the H&H modelling reflected observed conditions. Published studies used had undergone peer review processes.
▪ Data accuracy;	See above comment.
▪ The applicability of trends;	Considered and incorporated. See previous section 3(f). All climate team members have significant experience and recognized expertise in climate extremes analyses, climate change projections, marine and lake levels, forensic analysis and in undertaking PIEVC assessments and can interpret and develop climate trends and projection information.
▪ Reliability of selected climate model(s);	Best climate change projection and downscaling practices were incorporated, considering the uncertainties of the climate and climate change information and the

	sensitivities of the assets to climate/weather.
▪ Reliability of changing climate assumptions or scenarios; and	The latest climate change model outputs (IPCC AR6, 2021) were compared to the still more widely used IPCC AR5, 2013 released models and changes in the means/averages were limited. All studies used ensembles of climate change models and/or applied peer reviewed studies. Significant stakeholder consultations were undertaken in spite of COVID-19 challenges at the time.
▪ Other factors.	N/A
Comments and Observations N/A	

b. Clarify and summarize the priority of the documentation referenced in the evaluation. i. Present these in a tabulated prioritized form	
Document	**Priority**
Comments and Observations	

c. Document where there is insufficient information currently available to proceed with a particular portion of the assessment.		
Insufficient Information	i. Where there is insufficient information currently available, identify a process to develop or infill that data.	ii. Where data cannot be developed, identify the data gap as a finding in Step 5 of the Protocol – Recommendations.
Lake and river ice	Additional ice cover information	It is likely that the influence will

influences on water levels	and documentation of events would be needed.	be less or of considerably shorter duration than the longer duration trends during fluctuating lake levels. An updated risk assessment in future would benefit from updated and improved lake level models that integrate the new IPCC AR6 climate change models and update relevant lake level processes.
Shoreline Erosion Risks	A database of shoreline erosion events needs to be collected (locally variable) for further analysis	Initial attempts to develop an Detroit River erosion event database would be helpful for the City. The database should also include Lake St Clair events.

Date:	November 17, 2022
Prepared by:	Simon Eng and Heather Auld (UWO and Dillon Consultants)

Climate change risk assessment of the City of Windsor's West Windsor public, private and institutional assets and third party risks, focussing on flooding risks

This PIEVC risk assessment is divided into 4 parts. Parts 1, 2 and 3 reference Zones 1, 2 and 3 respectively, and refer to assets with medium to high climate change risks. These higher risks were identified via City of Windsor guidance, interviews, forensic analysis of past impacts, other reports and informed by modelling of the City's sewer, surface and river level flows. Part 4 refers to system-wide risks and third party services.

Highlighted Infrastructure components indicate Medium to High site risks

Current Conditions

			1 Extreme Rainfall					2 Extreme Rainfall					3 Extreme River Levels					4 Extreme River Levels					5 Combination Events					6 Combination Events				
	Infrastructure Class	Infrastructure Components	"Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)				Model storms 4-hour Chicago distribution based on peak rainfall rate	"Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)				Model storms 4-hour Chicago distribution based on peak rainfall rate	"Likely" high CC HWL - 176.1 m				Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	Current HWL - 175.9 m				Current 100 year level for Detroit River in region; 100 year level in 2020	Current 100 yr HWL + extreme rainfall (100 year storm)				Combined probability event modeling results: HWL + extreme 4-hour rainfall event	Current 100 yr HWL + Moderate Rainfall (5-year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check
			Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
	Part 1																															
	Zone 1 - E of Russel S																															
	Combined Sewers	**Felix Avenue - Combined sewer**		4	6	24	Max risk 35= Combined prob event; fails 5 year design storm criteria		7	5	35			4	7	28			4	5	20			2	7	14			4	7	28	
		Mill St - combined sewer		4	6	24	Max 24= 100 yr rain		7	3	21			4	5	20			4	6	24			2	6	12			4	6	24	
		Riverside Dr - combined sewer		4	5	20	Max 21=100 year rain		7	3	21			4	4	16			4	4	16			2	6	12			4	4	16	
2		Interceptor Maintenance Holes (MH)		4	5	20			7	3	21			4	7	28			4	7	28			2	7	14			4	7	28	
3	Wastewater System Assets	Sanitary Sewers		4	5	20			7	4	28			4	7	28			4	7	28			2	7	14			4	7	28	
4		Maintenance Covers		4	2	8			7	2	14			4	7	28			4	7	28			2	7	14			4	7	28	
5		Pump Stations		4	5	20			7	4	28			4	7	28			4	7	28			2	7	14			4	7	28	
		Lou Romano Water Reclamation Plant (LRWRP): *Inflow from Western Trunk line specifically* (<<100 year water levels for impacts)		4	6	24	Max 49 = <<100 yr HWL; comb events with high river		7	4	28			4	6	24			4	5	20			2	7	14			4	7	28	
		Lou Romano Water Reclamation Plant (LRWRP)		4	7	28	Max 49 risk w<<100 yr HWL; Blockage main outfall, backflow into plant for treatment river water; loss capacity		7	5	35			4	7	28			4	7	28			2	7	14			4	7	28	
7	Stormwater System Assets	Open drainage channels		4	4	16			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		Russell Street - open channel drainage		4	6	24	Max 24=xtrm rain		7	2	14			4	3	12			4	2	8			2	6	12			4	3	12	
8		Storm Sewers		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
9		Outfalls		4	4	16			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
#		Maintenance holes		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
#		Catch Basins		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
#		Drains		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
#		Culverts		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
14	Transportation	**Major Roadway - Felix Avenue (due combined sewer)**		4	6	24	Fails 5 yr; 35=Max due xtrm rain; combination events		7	5	35			4	7	28			4	6	24			2	7	14			4	7	28	
#		Major Roadway - Huron Church Road		4	4	16			7	2	14			4	4	16			4	N/A				2	5	10			4	2	8	
16		**Major Roadway - Mill Street (due combined sewer)**		4	6	24	Max 24=due 100yr rain		7	2	14			4	4	16			4	4	16			2	6	12			4	3	12	
#		Major Roadway - Ojibway Parkway		4	4	16			7	2	14			4	3	12			4	3	12			2	4	8			4	2	8	
#		Major Roadway - Prince Road		4	4	16			7	2	14			4	3	12			4	3	12			2	4	8			4	2	8	
19		**Major Roadway - Riverside Drive (due combined sewer)**		4	5	20	Max 21= 100yr rain, LOS requirements		7	3	21			4	4	16			4	4	16			2	5	10			4	4	16	
20		**Major Roadway - Sandwich Street**		4	6	24	Max 35=100 yr rain; combination, high HGL, mdt ponding		7	4	28			4	5	20			4	4	16			2	7	14			4	5	20	
#		Major Roadway - University Avenue		4	4	16			7	3	21			4	4	16			4	4	16			2	5	10			4	4	16	
#		Major Roadway - Wyandotte Street W		4	4	16			7	3	21			4	4	16			4	4	16			2	5	10			4	4	16	
23		**Ambassador Bridge/Canadian Border Services: Entrance/onramp**		4	6	24	Max 35= 100 yr rain; combination		7	4	28	35=Master due xtrm rain; combination (??)		4	4	16			4	4	16			2	7	14			4	6	24	
24		**Rail Tracks**		4	3	12	Max 35=combination events		7	2	14			4	6	24			4	5	20			2	7	14			4	6	24	
#	Institutional Buildings	St Michael's Adult Secondary School		4	3	12			7	2	14			4	5	20			4	5	20			2	6	12			4	5	20	
#		Duff - Baby House (museum)		4	3	12			7	2				4	5	20			4	5	20			2	5	10			4	5	20	
27		**Canada South Science City - Tourist Attraction**		4	6	24	Max 35=due 100yr & 5yr rain; high HGL		7	5	35			4	5	20			4	4	16			2	7	14			4	6	24	
28		**West Windsor Musallah - Mosque**		4	7	28	Max 42= 100 yr or 5yr rain & combination; High HGL		7	6	42			4	5	20			4	4	16			2	7	14			4	6	24	
29		Windsor Essex Community Health - Community Centre		4	3	12			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16	
30		**Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre**		4	7	28	Max 49=100 yr or 5yr rain & combination; sig bsmt flood - emerg response critical		7	7	49			4	6	24			4	6	24			2	7	14			4	7	28	
#		Mackenzie Hall Cultural Centre		4	3	12			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16	
#		St John's Anglican Church - historic site		4	3	12			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16	
33		**Islamic Academy Windsor**		4	6	24	Max 42= 5 & 100yr & combination		7	6	42			4	5	20			4	4	16			2	7	14			4	6	24	
34		**Society of St Vincent de Paul**		4	6	24	Max 42= 5 & 100yr & combination		7	6	42			4	5	20			4	4	16			2	7	14			4	6	24	
35		**General Brock Public School**		4	5	20	Max 35=5 & 100yr & combination		7	5	35			4	5	20			4	4	16			2	6	12			4	5	20	
36		**Sandwich Teen Action Group**		4	6	24	Max 42=5 & 100yr & combination		7	6	42			4	5	20			4	4	16			2	7	14			4	6	24	
37		**Sandwich First Baptist Church**		4	5	20	Max 21= due 100yr rain		7	3	21			4	2	8			4	2	8			2	5	10			4	3	12	
	Park Assets	Paterson Park		4	4	16			7	2	14			4	3	12			4	3	12			2	5	10			4	2	8	
		Bradley Park		4	4	16			7	2	14			4	2	8			4	2	8			2	2	4			4	2	8	
		Mackenzie Hall Park		4	4	16			7	2	14			4	2	8			4	2	8			2	2	4			4	2	8	
41	Energy and Communications Infrastructure	Overhead electrical distribution		4	3	12	Max 30= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;		7	2	14			4	2	8			4	1	4			2	3	6			4	2	8	
42		Sub-grade vaults and/or transformers		4	7	28	Max 28= due 100yr rain & HWL blo gnd; wind, ice abv gnd		7	2	14			4	5	20			4	2	8			2	7	14			4	6	24	
43		Telecommunication		4	4	16	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;		7	2	14			4	3	12			4	2	8			2	4	8			4	3	12	
	Other Residential Buildings	**See Part 4**																														
	Other Commercial Buildings	**See Part 4**																														
	Industrial Assets	*Sterling Fuels - Office and tank farm E of Russel St*		4	4	16			7	2	14			4	4	16			4	3	12			2	5	10			4	4	16	
		Other Industrial Buildings - **See Part 4**																														
	Part 2																															
	Zone 2 - W of Russel St., N of Broadway St., W to shoreline																															
	Wastewater System Assets	**Ojibway Parkway - Combined Sewer**		4	5	20	21=100 yr rainfall; sig HGLs		7	3	21			4	3	12			4	2	8			2	7	14			4	3	12	
		Riverside Dr - Combined Sewer		4	5	20	21=100 yr rainfall; sig HGLs		7	3	21			4	3	12			4	2	8			2	7	14			4	3	12	
		Sandwich Street - Combined Sewer		4	6	24	42=5 yr & 100 yr rainfall; mdt sfc flooding (0.5-1m)		7	6	42			4	4	16			4	3	12			2	7	14			4	6	24	
		Interceptor Maintenance Holes (MH)		4	5	20			7	3	21			4	7	28			4	7	28			2	7	14			4	7	28	
		Sanitary Sewers - See Part 4		4	5	20			7	4	28			4	7	28			4	7	28			2	7	14			4	7	28	
		Maintenance Covers		4	2	8			7	2	14			4	7	28			4	7	28			2	7	14			4	7	28	
		Pump Stations		4	5	20			7	4	28			4	7	28			4	7	28			2	7	14			4	7	28	
		Prospect Ave Pump Station (temporary) - power + outfall Ave		4	6	24	35=Most high water levels (<< 100 year event)		7	3	21			4	7	28			4	5	20			2	7	14			4	6	24	
		Pump Station - McKee Road		4	7	28	35=<100 yr HWL; extreme rain; backflow during HWL. Street flooding		7	3	21			4	7	28			4	6	24			2	7	14			4	6	24	
	Stormwater System Assets	Open drainage channels		4	4	16			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		Storm Sewers		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		Brock Street Outfall		4	5	20	28=significant shoreline erosion		7	2	14			4	6	24			4	5	20			2	7	14			4	6	24	
		Maintenance holes		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		Catch Basins		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		McKee Creek catch basin		4	7	28	35 = <100 yr HWL & extreme rain; submerged HWK & surcharged extreme rain		7	3	21			4	7	28			4	6	24			2	7	14			4	5	20	
		Drains		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
		Culverts		4	5	20			7	2	14			4	7	28			4	7	28			2	6	12			4	7	28	
	Shoreline Stormwater/ Flood Protection Infrastructure	**Outfall for Lou Romano Water Reclamation Plant (LRWRP)**		4	7	28	Max 49 risk w<<100 yr HWL; Blockage main outfall, backflow into plant for treatment river water		7	5	35			4	7	28			4	7	28			2	7	14			4	7	28	
		Mill St - Outfall, CS & catchment basin		4	6	24	35=<100 year HWL, combined river level or wave/freeboard		7	3	21			4	7	28			4	6	24			2	6	12			4	6	24	
	Transportation	**Major Roadway - Ojibway Parkway**		4	6	24	35=100 year rain, outfall higher than ditch, floods right over		7	5	35			4	5	20			5	5	25			2	7	14			4	5	20	
		Road & Open Ditch - Prospect Ave		4	6	24	35=100 year rain possibly lower, outfall higher than ditch, floods right over		7	5	35			4	5	20			4	5	20			2	7	14			4	5	20	
		Major Roadway - Riverside Drive		4	5	20			7	2	14			4	3	12			4	2	8			2	7	14			4	3	12	
		Major Roadway - Sandwich Street		4	6	24			7	6	42			4	4	16			4	3	12			2	7	14			4	6	24	
		Ambassador Bridge/Huron-Church catch basin, outfall, weir		4	7	28	35=extreme rain with <<100 yr HWL; 100 yr rain; 5 yr rain		7	5	35			4	6	24			4	6	24			2	7	14			4	6	24	
		Prospect Ave - Road and open drainage		4	6	24	36=100 year rain possibly lower, outfall higher than ditch, floods right over		7	5	35			4	5	20			4	5	20			2	7	14			4	5	20	
		ETR Rail and Gore Creek		4	6	24	35=extreme rain and HWL; Gore Ck flooding across Sandwich St, ETR rail and siding		7	3	21			4	6	24			4	5	20			2	6	12			4	5	20	
		ETR Rail and McKee Creek		4	6	24	35=extreme rain and HWL; Road flooding, flagged by City		7	3	21			4	6	24			4	5	20			2	6	12			4	5	20	
		Rail Tracks		4	3	12	Max 35=combination events		7	2	14			4	6	24			4	5	20			2	7	14			4	6	24	
		St Michael's Adult Secondary School		4	3	12			7	2	14			4	5	20			4	5	20			2	6	12			4	5	20	
		Duff - Baby House (museum)		4	3	12			7	2	14			4	5	20			4	5	20			2	5	10			4	5	20	
		Canada South Science City - Tourist Attraction		4	6	24	Max 35=due 100yr & 5yr rain; high HGL		7	5	35			4	5	20			4	4	16			2	7	14			4	6	24	
		West Windsor Musallah - Mosque		4	7	28	Max 42= 100 yr or 5yr rain & combination; High HGL		7	6	42			4	5	20			4	4	16			2	7	14			4	6	24	

			7 Combination Events					8 Combination Events					9 Combination Events					10 Secondary Impact Events					11 Secondary Impact Events					12 Secondary Impact Events					13 Secondary Impact Events					14 Secondary Impact Events				
	Infrastructure Class	Infrastructure Components	Climate Chg HWL + extreme rainfall (100 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	Climate Chg HWL + moderate rainfall (5 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	HWL + wave action (freeboard)				Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	Major ice storm - 28mm or more				Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2	Extreme Wind Event - 120 km/h				debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	Tornado - (E)F2+				debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	Weathering (freeze thaw) - Concrete and masonry impacts - total cycles					Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments				
			Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
	Part 1																																									
	Zone 1 - E of Russel S																																									
	Combined Sewers	**Felix Avenue - Combined sewer**		4	7	28			4	7	28			7	4	28			4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
		Mill St - combined sewer		4	6	24			4	6	24			7	4	28			4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
		Riverside Dr - combined sewer		4	5	20			4	4	16			7	4	28			4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
2		Interceptor Maintenance Holes (MH)		4	7	28			4	7	28			7	N/A				4	3	12			6	3	18			2	5	10			7	1	7			7	1	7	
3	Wastewater System Assets	Sanitary Sewers		4	7	28			4	7	28			7	N/A				4	3	12			6	3	18			2	4	8			7	1	7			7	1	7	
4		Maintenance Covers		4	7	28			4	7	28			7	N/A				4	4	16			6	2	12			2	5	10			7	3	21			7	3	21	
5		Pump Stations		4	7	28			4	7	28			7	N/A				4	4	16			6	4	24			2	5	10			7	1	7			7	1	7	
		Lou Romano Water Reclamation Plant (LRWRP): *Inflow from Western Trunk line specifically* (<<100 year water levels for impacts)		4	7	28			4	7	28			7	7	49			4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
		Lou Romano Water Reclamation Plant (LRWRP)		4	7	28			4	7	28			7	7	49			4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
7	Stormwater System Assets	Open drainage channels		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	3	21			7	3	21	
		Russell Street - open channel drainage		4	6	24			4	3	12			7	3	21			4	2	8			6	2	12			2	5	10			7	2	14			7	2	14	
8		Storm Sewers		4	7	28			4	7	28			7	N/A				4	2	8			6	3	18			2	5	10			7	2	14			7	2	14	
9		Outfalls		4	7	28			4	7	28			7	N/A				4	2	8			6	2	12			2	3	6			7	2	14			7	2	14	
#		Maintenance holes		4	7	28			4	7	28			7	N/A				4	4	16			6	3	18			2	6	12			7	2	14			7	2	14	
#		Catch Basins		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
#		Drains		4	7	28			4	7	28			7	N/A				4	4	16			6	4	24			2	5	10			7	2	14			7	2	14	
#		Culverts		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	6	12			7	3	21			7	3	21	
14	Transportation	**Major Roadway - Felix Avenue (due combined sewer)**		4	7	28			4	7	28			7	N/A				4	3	12			6	3	18			2	6	12			7	3	21			7	3	21	
#		Major Roadway - Huron Church Road		4	5	20			4	4	16			7	N/A				4	2	8			6	2	12			2	6	12			7	3	21			7	3	21	
16		**Major Roadway - Mill Street (due combined sewer)**		4	6	24			4	4	16			7	N/A				4	2	8			6	2	12			2	6	12			7	3	21			7	3	21	
#		Major Roadway - Ojibway Parkway		4	3	12			4	3	12			7	N/A				4	3	12			6	3	18			2	7	14			7	3	21			7	3	21	
#		Major Roadway - Prince Road		4	5	20			4	4	16			7	N/A				4	2	8			6	2	12			2	6	12			7	3	21			7	3	21	
19		**Major Roadway - Riverside Drive (due combined sewer)**		4	5	20			4	4	16			7	3	21			4	3	12			6	3	18			2	7	14			7	3	21			7	3	21	
20		**Major Roadway - Sandwich Street**		4	7	28			4	6	24			7	5	35			4	3	12			6	4	24			2	7	14			7	3	21			7	3	21	
#		Major Roadway - University Avenue		4	5	20			4	4	16			7	N/A				4	3	12			6	3	18			2	7	14			7	3	21			7	3	21	
#		Major Roadway - Wyandotte Street W		4	5	20			4	4	16			7	N/A				4	3	12			6	3	18			2	7	14			7	3	21			7	3	21	
23		**Ambassador Bridge/Canadian Border Services: Entrance/onramp**		4	7	28			4	5	20			7	5	35			4	5	20			6	5	30			2	7	14			7	3	21			7	3	21	
24		**Rail Tracks**		4	7	28			4	6	24			7	5	35			4	3	12			6	3	18			2	3	6			7	2	14			7	2	14	
#	Institutional Buildings	St Michael's Adult Secondary School		4	6	24			4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
#		Duff - Baby House (museum)		4	5	20			4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
27		**Canada South Science City - Tourist Attraction**		4	7	28			4	7	28			7	5	35			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
28		**West Windsor Musallah - Mosque**		4	7	28			4	7	28			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
29		Windsor Essex Community Health - Community Centre		4	4	16			4	4	16			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
30		**Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre**		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
#		Mackenzie Hall Cultural Centre		4	4	16			4	4	16			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
#		St John's Anglican Church - historic site		4	4	16			4	4	16			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
33		**Islamic Academy Windsor**		4	7	28			4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
34		**Society of St Vincent de Paul**		4	7	28			4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
35		**General Brock Public School**		4	7	28			4	5	20			7	4	28			4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
36		**Sandwich Teen Action Group**		4	7	28			4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
37		**Sandwich First Baptist Church**		4	5	20			4	3	12			7	3	21			4	3	12			6	3	18			2	7	14			7	2	14			7	2	14	
	Park Assets	Paterson Park		4	5	20			4	2	8			7	3	21			4	3	12			6	4	24			2	6	12			7	2	14			7	2	14	
		Bradley Park		4	2	8			4	2	8			7	1	7			4	3	12			6	4	24			2	6	12			7	2	14			7	2	14	
		Mackenzie Hall Park		4	2	8			4	2	8			7	1	7			4	3	12			6	4	24			2	6	12			7	2	14			7	2	14	
41	Energy and Communications Infrastructure	Overhead electrical distribution		4	2	8			4	2	8			7	1	7			4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
42		Sub-grade vaults and/or transformers		4	7	28			4	3	12			7	4	28			4	5	20			6	4	24			2	5	10			7	2	14			7	2	14	
43		Telecommunication		4	4	16			4	2	8			7	2	14			4	4	16			6	5	30			2	7	14			7	2	14			7	2	14	
	Other Residential Buildings	**See Part 4**																																								
	Other Commercial Buildings	**See Part 4**																																								
	Industrial Assets	*Sterling Fuels - Office and tank farm E of Russel St*		4	6	24			4	5	20			7	3	21			4	5	20			6	4	24			2	7	14			7	2	14			7	2	14	
		Other Industrial Buildings - **See Part 4**																																								
	Part 2																																									
	Zone 2 - W of Russel St., N of Broadway St., W to shoreline																																									
	Wastewater System Assets	**Ojibway Parkway - Combined Sewer**		4	5	20			4	3	12			7	2	14			4	2	8			6	2	12			2	6	12			7	2	14			7	2	14	
		Riverside Dr - Combined Sewer		4	5	20			4	3	12			7	2	14			4	2	8			6	2	12			2	6	12			7	2	14			7	2	14	
		Sandwich Street - Combined Sewer		4	7	28			4	6	24			7	2	14			4	3	12	debris generation		3	4	12	debris generation; tree uprooting		2	5	10			7	2	14			7	2	14	
		Interceptor Maintenance Holes (MH)		4	7	28			4	7	28			7	N/A				4	3	12			6	3	18			2	5	10			7	1	7			7	1	7	
		Sanitary Sewers - See Part 4		4	7	28			4	7	28			7	N/A				4	3	12			6	3	18			2	4	8			7	1	7			7	1	7	
		Maintenance Covers		4	7	28			4	7	28			7	N/A				4	4	16			6	2	12			2	5	10			7	3	21			7	3	21	
		Pump Stations		4	7	28			4	7	28			7	N/A				4	5	20	power outages		6	5	30	power outages, debris		2	5	10			7	1	7			7	1	7	
		Prospect Ave Pump Station (temporary) - power + outfall Ave		4	7	28			4	7	28			7	5	35			4	5	20	power outage		6	5	30	power outage, debris		2	6	12			7	2	14			7	2	14	
		Pump Station - McKee Road		4	7	28			4	7	28			7	5	35			4	5	20	power outage		6	5	30			2	6	12			7	2	14			7	2	14	
	Stormwater System Assets	Open drainage channels		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	3	21			7	3	21	
		Storm Sewers		4	7	28			4	7	28			7	N/A				4	2	8			6	3	18			2	5	10			7	2	14			7	2	14	
		Brock Street Outfall		4	7	28			4	6	24			7	4	28			4	2	8			6	2	12			2	6	12			7	3	21			7	3	21	
		Maintenance holes		4	7	28			4	7	28			7	N/A				4	4	16			6	3	18			2	6	12			7	2	14			7	2	14	
		Catch Basins		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
		McKee Creek catch basin		4	7	28			4	6	24			7	5	35			4	2	8			6	2	12			2	6	12			7	2	14			7	2	14	
		Drains		4	7	28			4	7	28			7	N/A				4	4	16			6	4	24			2	5	10			7	2	14			7	2	14	
		Culverts		4	7	28			4	7	28			7	N/A				4	5	20			6	5	30			2	6	12			7	3	21			7	3	21	
	Shoreline Stormwater/ Flood Protection Infrastructure	**Outfall for Lou Romano Water Reclamation Plant (LRWRP)**		4	7	28			4	7	28			7	7	49			4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
		Mill St - Outfall, CS & catchment basin		4	7	28			4	7	28			7	5	35			4	3	12			6	3	18			2	6	12			7	2	14			7	2	14	
	Transportation	**Major Roadway - Ojibway Parkway**		4	7	28			4	5	20			7	4	28			4	4	16			6	3	18			2	6	12			7	2	14			7	2	14	
		Road & Open Ditch - Prospect Ave		4	7	28			4	5	20			7	4	28			4	4	16			6	3	18			2	6	12			7	2	14			7	2	14	
		Major Roadway - Riverside Drive		4	5	20			4	3	12			7	2	14			4	2	8			6	2	12			2	6	12			7	2	14			7	2	14	
		Major Roadway - Sandwich Street		4	7	28			4	6	24			7	2	14			4	3	12	debris generation		6	4	24	debris generation; tree uprooting		2	5	10			7	2	14			7	2	14	
		Ambassador Bridge/Huron-Church catch basin, outfall, weir		4	6	24			4	6	24			7	5	35			4	3	12			6	3	18			2	6	12			7	3	21			7	3	21	
		Prospect Ave - Road and open drainage		4	7	28			4	5	20			7	4	28			4	4	16			6	3	18			2	6	12			7	2	14			7	2	14	
		ETR Rail and Gore Creek		4	7	28			4	6	24			7	5	35			4	2	8			6	3	18			2	6	12			7	3	21			7	3	21	
		ETR Rail and McKee Creek		4	7	28			4	6	24			7	5	35			4	2	8			6	3	18			2	6	12			7	3	21			7	3	21	
		Rail Tracks		4	7	28			4	6	24			7	5	35			4	3	12			6	3	18			2	3	6			7	2	14			7	2	14	
		St Michael's Adult Secondary School		4	6	24			4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
		Duff - Baby House (museum)		4	5	20			4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
		Canada South Science City - Tourist Attraction		4	7	28			4	7	28			7	5	35			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
		West Windsor Musallah - Mosque		4	7	28			4	7	28			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	

Infrastructure Class	Infrastructure Components	1 Extreme Rainfall: "Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)			Model storms 4-hour Chicago distribution based on peak rainfall rate	2 Extreme Rainfall: "Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)			Model storms 4-hour Chicago distribution based on peak rainfall rate	3 Extreme River Levels: "Likely" high CC HWL - 176.1 m			Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	4 Extreme River Levels: Current HWL - 175.9 m			Current 100 year level for Detroit River in region; 100 year level in 2020	5 Combination Events: Current 100 yr HWL + extreme rainfall (100 year storm)			Combined probability event modeling results: HWL + extreme 4-hour rainfall event	6 Combination Events: Current 100 yr HWL + Moderate Rainfall (5-year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	7 Combination Events: Climate Chg HWL + extreme rainfall (100 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check
Institutional Buildings	Windsor Essex Community Health - Community Centre	4	3	12		7	2	14		4	4	16		4	4	16		2	4	8		4	4	16		4	4	16	
	Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre	4	7	28	Max **49**=100 yr or 5yr rain & combination; sig bsmt flood - emerg response critical	7	7	**49**		4	6	24		4	6	24		2	7	14		4	7	28		4	7	28	
	Mackenzie Hall Cultural Centre	4	3	12		7	2	14		4	4	16		4	4	16		2	4	8		4	4	16		4	4	16	
	St John's Anglican Church - historic site	4	3	12		7	2	14		4	4	16		4	4	16		2	4	8		4	4	16		4	4	16	
	Islamic Academy Windsor	4	6	24	Max 42= 5 & 100yr & combination	7	6	**42**		4	5	20		4	4	16		2	7	14		4	6	24		4	7	28	
	Society of St Vincent de Paul	4	6	24	Max 42= 5 & 100yr & combination	7	6	**42**		4	5	20		4	4	16		2	7	14		4	6	24		4	7	28	
	General Brock Public School	4	5	20	Max 35=5 & 100yr & combination	7	5	**35**		4	5	20		4	4	16		2	6	12		4	5	20		4	7	28	
	Sandwich Teen Action Group	4	6	24	Max 42=5 & 100yr & combination	7	6	**42**		4	5	20		4	4	16		2	7	14		4	6	24		4	7	28	
	Sandwich First Baptist Church	4	5	**20**	Max 30= due 100yr rain	7	3	21		4	2	8		4	2	8		2	5	10		4	3	12		4	5	20	
	Chateau Park LTC Centre	4	6	24	35=100 year rain; wind, waves	7	3	21		4	5	20		4	5	20		2	6	12		4	5	20		4	6	24	
	Great Lakes Institute for Environmental Studies (U of Windsor)	4	6	24	35=100 year rain; High HGL?; basement flooding'	7	3	21		4	5	20		4	5	20		2	6	12		4	5	20		4	6	24	
	HMCS Hunter Navy Facility	4	3	12	35=<100 year HWL;erosion; WPA shoreline property, high occup building	7	2	14		4	7	28		4	6	24		2	6	12		4	6	24		4	7	28	
Park Assets	**McKee Park - Sandwich and Chewett Streets**	4	3	12	35= < 100 year HWL; shoreline flooding	7	2	14		4	5	20		4	5	20		2	5	10		4	5	20		4	5	20	
	Brock Park	4	4	16		7	2	14		4	4	16		4	3	12		2	4	8		4	4	16		4	5	20	
	Mill Park	4	4	16		7	2	14		4	2	8		4	2	8		2	2	4		4	2	8		4	2	8	
	Queen's Park	4	4	16		7	2	14		4	2	8		4	2	8		2	2	4		4	2	8		4	2	8	
	Chateau Park - Ambassador Bridge area	4	3	12	35=<100 year HWL; retaining wall submerged	7	1	7		4	6	24		4	5	20		2	5	10		4	5	20		4	6	24	
Energy and Communications Infrastructure	**JC Keith Transformer Station**	4	5	20	21=flooding w high HGLs; critical 3rd party infrastructure, further study	7	3	**21**		4	4	16		4	3	12		2	6	12		4	4	16		4	5	20	
	Overhead electrical distribution	4	3	12	Max 30= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;	7	2	14		4	2	8		4	1	4		2	3	6		4	2	8		4	2	8	
	Sub-grade vaults	4	7	**28**	Max 28= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		4	2	8		2	7	14		4	6	24		4	7	**28**	
	Sub-grade transformers	4	4	16	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		4	2	8		2	4	8		4	3	12		4	4	16	
	Atura Power Brighton Beach Gen Station	4	7	28	49=Combined events, 100 year rain, 5 year rain; subgrade flooding due HGL, flooding to 0.3m	7	3	21		4	7	28		4	7	28		2	7	14		4	7	28		4	7	28	
	Telecommunication	4	4	16	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		4	2	8		2	4	8		4	3	12		4	4	16	
Residential Buildings	Buildings - **See Part 4**																												
Commercial Buildings	Buildings - **See Part 4**																												
Industrial Assets	Transpo/Trucking/Logistics - Van De Hogan Group (VG; trucking); Cole-Carriers Inc.; Stantec Trailers	4	3	12		7	1	7		4	3	12		4	2	8		2	4	8		4	2	8		4	4	16	
	Windsor Biosolids Processing Plant	4	7	28	35=combined prob event, extremes rainfall; flooding >1m	7	3	21		4	5	20		4	4	16		2	7	14		4	4	16		4	7	28	
	Windsor Salt	4	7	28	42=Master; erosion 100 year rain; combined prob	7	3	21		4	5	20		4	5	20		2	7	14		4	6	24		4	7	28	
	Newmak Windsor Aluminum Plant	4	4	16		7	2	14		4	2	8		4	2	8		2	4	8		4	2	8		4	4	16	
Part 3																													
Zone 3 - W of Ojibway Pkwy., N of Morten Dr. to Broadway St.																													
Wastewater and Stormwater System Assets	**Sprucewood Ave - Combined Sewer**	4	7	28	42=Combined event; 100 year and 5 year rain; ~1m flooding all rain events; Sig HGL/surcharge	7	6	**42**		4	5	20		4	4	16		2	7	14		4	6	24		4	7	28	
	Sprucewood Ave - Open ditches	4	6	24	42 = Extreme 5 & 100 year rain; workshop participants indicated	7	6	**42**		4	4	16		4	3	12		2	7	14		4	6	24		4	7	28	
	Maintenance Covers	4	2	8		7	2	14		4	7	28		4	7	28		2	7	14		4	7	28		4	7	28	
	Pump Stations	4	5	20		7	4	28		4	7	28		4	7	28		2	7	14		4	7	28		4	7	28	
	Open drainage channels	4	4	16		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Storm Sewers	4	5	20		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Outfalls - Location Specific	4	4	16		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Maintenance holes	4	5	20		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Catch Basins	4	5	20		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Drains	4	5	20		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
	Culverts	4	5	20		7	2	14		4	7	28		4	7	28		2	6	12		4	7	28		4	7	28	
Shoreline Stormwater/ Flood Protection Infrastructure	**CSOs**	4	5	20		7	4	28		4	6	24		7	5	35		2	7	14		4	5	20		4	7	28	
Transportation	**Major Roadway - Ojibway Parkway**	4	7	28	35=Combined prob events;100 year rain, 5 year rain; LOS for 63% road	7	5	**35**		4	2	8		4	2	8		2	7	14		4	6	24		4	7	28	
	Major Roadway - Sprucewood Avenue	4	7	28	42=100 year & 5 year rain; adjacent to wetland; modelling	7	6	**42**		4	2	8		4	2	8		2	7	14		4	6	24		4	7	28	
	Detroit-Windsor Truck Ferry	4	7	28	42=100 year rain, 5 year rain, Combined prob event; 0.75-1m surface flooding, trade importance	7	6	**42**		4	3	12		4	2	8		2	7	14		4	6	24		4	7	28	
	Rail Tracks	4	7	28	35=100 year & 5 year rain;Combined events; mdt surface flooding for 100 year rain	7	5	**35**		4	2	8		4	2	8		2	6	12		4	5	20		4	6	24	
Park Assets	**Black Oak Heritage Park**	4	5	20	30=100 year rain & combined; Extreme wind, ice storm; sfc flooding >0.3m w 100 year rain	7	3	21		4	2	8		4	2	8		2	6	12		4	3	12		4	6	24	
Energy and Communications Infrastructure	**Overhead electrical distribution**	4	3	12	Max 30= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;	7	2	14		4	2	8		4	1	4		2	3	6		4	2	8		4	2	8	
	Sub-grade vaults	4	7	**28**	Max 28= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		4	2	8		2	7	14		4	6	24		4	7	**28**	
	Sub-grade transformers	4	4	16	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		4	2	8		2	4	8		4	3	12		4	4	16	
	Telecommunication	4	4	16	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		4	2	8		2	4	8		4	3	12		4	4	16	
Industrial Assets	**Shoreline Properties - Mortrem Ltd; ADM Windsor;**	4	5	20		7	3	21		4	3	12		4	2	8		2	6	12		4	4	16		4	6	24	
	Windsor Salt Mine - ditch entrance	4	7	28	49=HWL <100 yr; Combined prob; 100 year rain; 5 year rain	7	5	35		4	6	24		4	6	24		2	7	14		4	7	28		4	7	28	
	Windsor Salt Mine	4	7	28	49 = 5 & 100 year extreme rain; Combined probabilities; surface flooding 0.75->1m; extreme HGLs	7	5	35		4	6	24		4	6	24		2	7	14		4	6	24		4	7	28	
	Shoreline Protection - retaining walls, rip-rap	4	3	12		7	1	7		4	5	20		4	4	16		2	5	10		4	4	16		4	6	24	
Part 4																													
System-Wide Risks for Similar Assets and Critical Third Party Services - Generic																													
System-Wide (assuming nearly worst case)	*Zone 1* Residential Areas serviced by combined sewers	4	6	24	Max 42=Combined prob; 5 & 100 year rain generally	7	6	**42**		4	4	16		4	4	16		2	7	14		4	6	24		4	7	28	
	Zone 1 Commercial Areas serviced by combined sewers	4	7	28	Max 42=Combined prob; 5 & 100 year rain generally; Likely basement flooding; Surface flooding extreme rain	7	6	**42**		4	4	16		4	4	16		2	7	14		4	6	24		4	7	28	
	Zone 1 Industrial Buildings serviced by combined sewers	4	6	24	Max 42=100 & 5 year rain; Mainly surface & basement flooding	7	6	**42**		4	4	16		4	3	12		2	7	14		4	6	24		4	7	28	
	Zone 2 Combined Sewer Outfalls	4	5	20	Max 35=Combined prob events & high river levels above 174.6m; blocked outfalls and back feeding into combined system; Lost sewer capacity for extreme rain	7	3	21		4	7	28		4	6	24		2	7	14		4	6	24		4	7	28	
	Zone 2 Residential Areas serviced by combined sewers	4	7	28	Max 49 = Heavy rainfalls; Surface flooding >1m; Potential basement flooding	7	7	**49**		4	4	16		4	3	12		2	7	14		4	4	16		4	7	28	
	Zone 2 Commercial Areas serviced by combined sewers	4	7	28	Max 42 = Heavy rainfall; Surface flooding >1m	7	6	**42**		4	2	8		4	2	8		2	7	14		4	6	24		4	7	28	
	Loss of Electrical power delivery - Pumps	4	4	16	30 =Any events damaging power delivery; Any assets below-grade (water intrusion); Power assets in Zone 2 flagged for further study	7	2	**14**		4	2	8		4	2	8		2	5	10		4	3	12		4	6	24	
	Loss of Comumunications - equipment monitoring	4	4	16	Max 30=Events giving damage to telephone lines; Below grade assets	7	3	21		4	2	8		4	2	8		2	5	10		4	3	12		4	6	24	
	Surface drainage and surface transportation (emergemcy response)	4	5	20	Max 30 = any wind >102 kph gusts or other damaging event affecting emergency response; Debris generation	7	3	21		4	2	8		4	2	8		2	5	10		4	3	12		4	5	20	
	Pad mounted electrical	4	7	**28**	Max 28= 100 year rainfall event; Extremely sensitive to surface flooding < 1m or more in depth; potential public safety risk	7	1	7		4	1	4		4	1	4		2	7	14		4	2	8		4	7	28	

Infrastructure Class	Infrastructure Components	8 Combination Events: Climate Chg HWL + moderate rainfall (5 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	9 Combination Events: HWL + wave action (freeboard)			Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	10 Secondary Impact Events: Major ice storm - 28mm or more			Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2	11 Secondary Impact Events: Extreme Wind Event - 120 km/h			debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	12 Secondary Impact Events: Tornado - (E)F2+			debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	13 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - total cycles				14 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments			
Institutional Buildings	Windsor Essex Community Health - Community Centre	4	4	16		7	N/A			4	5	20		6	5	30		2	7	14		7	2	14		7	2	14	
	Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre	4	7	28		7	N/A			4	5	20		6	5	30		2	7	14		7	2	14		7	2	14	
	Mackenzie Hall Cultural Centre	4	4	16		7	N/A			4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	St John's Anglican Church - historic site	4	4	16		7	N/A			4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	Islamic Academy Windsor	4	6	24		7	4	28		4	3	12		6	4	24		2	7	14		7	2	14		7	2	14	
	Society of St Vincent de Paul	4	6	24		7	4	28		4	3	12		6	4	24		2	7	14		7	2	14		7	2	14	
	General Brock Public School	4	5	20		7	4	28		4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	Sandwich Teen Action Group	4	6	24		7	4	28		4	3	12		6	4	24		2	7	14		7	2	14		7	2	14	
	Sandwich First Baptist Church	4	3	12		7	3	21		4	3	12		6	3	18		2	7	14		7	2	14		7	2	14	
	Chateau Park LTC Centre	4	5	20		7	5	**35**		4	5	20		6	5	30		2	7	14		7	3	21		7	3	21	
	Great Lakes Institute for Environmental Studies (U of Windsor)	4	5	20		7	5	**35**		4	5	20		6	5	30		2	7	14		7	2	14		7	2	14	
	HMCS Hunter Navy Facility	4	7	28		7	5	**35**		4	3	12		6	5	30		2	7	14		7	3	21		7	3	21	
Park Assets	**McKee Park - Sandwich and Chewett Streets**	4	5	20		7	5	**35**		4	2	8		6	2	12		2	7	14		7	3	21		7	3	21	
	Brock Park	4	5	20		7	4	28		4	2	8		6	3	18		2	6	12		7	3	21		7	3	21	
	Mill Park	4	2	8		7	2	14		4	2	8		6	4	24		2	6	12		7	2	14		7	2	14	
	Queen's Park	4	2	8		7	2	14		4	2	8		6	4	24		2	6	12		7	2	14		7	2	14	
	Chateau Park - Ambassador Bridge area	4	6	24		7	5	**35**		4	2	8		6	2	12		2	5	10		7	3	21		7	3	21	
Energy and Communications Infrastructure	**JC Keith Transformer Station**	4	4	16		7	3	21		4	5	20		6	3	18		2	6	12		7	2	14		7	2	14	
	Overhead electrical distribution	4	2	8		7	1	7		4	5	20		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	4	3	12		7	4	28		4	5	20		6	4	24		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	4	2	8		7	2	14		4	4	16		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Atura Power Brighton Beach Gen Station	4	7	28		7	7	**49**		4	4	16		6	4	24		2	6	12		7	2	14		7	2	14	
	Telecommunication	4	2	8		7	2	14		4	4	16		6	5	**30**		2	7	14		7	2	14		7	2	14	
Residential Buildings	Buildings - **See Part 4**																												
Commercial Buildings	Buildings - **See Part 4**																												
Industrial Assets	Transpo/Trucking/Logistics - Van De Hogan Group (VG; trucking); Cole-Carriers Inc.; Stantec Trailers	4	2	8		7	1	7		4	4	16		6	4	24		2	6	2		7	1	7		7	1	7	
	Windsor Biosolids Processing Plant	4	5	20		7	5	**35**		4	3	12		6	3	18		2	7	14		7	2	14		7	2	14	
	Windsor Salt	4	5	20		7	6	**42**	High water action, erosion	4	3	12		6	4	24		2	7	14		7	2	14		7	2	14	
	Newmak Windsor Aluminum Plant	4	2	8		7	2	14		4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
Part 3																													
Zone 3 - W of Ojibway Pkwy., N of Morten Dr. to Broadway St.																													
Wastewater and Stormwater System Assets	**Sprucewood Ave - Combined Sewer**	4	6	24		7	5	35		4	5	20	power and pumping needed	6	5	30	power	2	6	12		7	2	14		7	2	14	
	Sprucewood Ave - Open ditches	4	6	24		7	4	28		4	3	12		6	3	18		2	6	12		7	3	21		7	3	21	
	Maintenance Covers	4	7	28		7	N/A			4	4	16		6	2	12		2	5	10		7	3	21		7	3	21	
	Pump Stations	4	7	28		7	N/A			4	5	20	power outages	6	5	30	power outages, debris	2	5	10		7	1	7		7	1	7	
	Open drainage channels	4	7	28		7	N/A			4	5	20		6	5	30		2	7	14		7	3	21		7	3	21	
	Storm Sewers	4	7	28		7	N/A			4	2	8		6	3	18		2	5	10		7	2	14		7	2	14	
	Outfalls - Location Specific	4	7	28		7	N/A			4	2	8		6	2	12		2	3	6		7	2	14		7	2	14	
	Maintenance holes	4	7	28		7	N/A			4	4	16		6	3	18		2	6	12		7	2	14		7	2	14	
	Catch Basins	4	7	28		7	N/A			4	5	20		6	5	30		2	7	14		7	2	14		7	2	14	
	Drains	4	7	28		7	N/A			4	4	16		6	4	24		2	5	10		7	2	14		7	2	14	
	Culverts	4	7	28		7	N/A			4	5	20		6	5	30		2	6	12		7	3	21		7	3	21	
Shoreline Stormwater/ Flood Protection Infrastructure	**CSOs**	4	6	24		7	N/A		Location specific	4	4	16		6	4	24		2	5	10		7	3	21		7	3	21	
Transportation	**Major Roadway - Ojibway Parkway**	4	7	28		7	5	35		4	4	16		6	4	24		2	6	12		7	2	14		7	3	21	
	Major Roadway - Sprucewood Avenue	4	6	24		7	2	14		4	4	16		6	3	18		2	6	12		7	2	14		7	2	14	
	Detroit-Windsor Truck Ferry	4	5	20		7	5	35		4	5	20		6	5	30		2	6	12		7	2	14		7	2	14	
	Rail Tracks	4	5	20		7	2	14		4	4	16		6	3	18		2	6	12		7	2	14		7	2	14	
Park Assets	**Black Oak Heritage Park**	4	4	16		7	3	21		4	5	20		6	5	**30**		2	6	12		7	2	14		7	2	14	
Energy and Communications Infrastructure	**Overhead electrical distribution**	4	2	8		7	1	7		4	5	20		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	4	3	12		7	4	28		4	5	20		6	4	24		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	4	2	8		7	2	14		4	4	16		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Telecommunication	4	2	8		7	2	14		4	4	16		6	5	**30**		2	7	14		7	2	14		7	2	14	
Industrial Assets	**Shoreline Properties - Mortrem Ltd; ADM Windsor;**	4	5	20		7	4	28		4	4	16		6	4	24		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine - ditch entrance	4	7	28		7	7	**49**		4	2	8		6	2	12		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine	4	7	28		7	7	**49**		4	2	8		6	4	24		2	6	12		7	3	21		7	3	21	
	Shoreline Protection - retaining walls, rip-rap	4	5	20		7	4	28		4	2	8		6	3	18		2	5	10		7	3	21		7	3	21	
Part 4																													
System-Wide Risks for Similar Assets and Critical Third Party Services - Generic																													
System-Wide (assuming nearly worst case)	*Zone 1* Residential Areas serviced by combined sewers	4	6	24		7	4	28		4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	Zone 1 Commercial Areas serviced by combined sewers	4	6	24		7	4	28		4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	Zone 1 Industrial Buildings serviced by combined sewers	4	6	24		7	4	28		4	4	16		6	4	24		2	7	14		7	2	14		7	2	14	
	Zone 2 Combined Sewer Outfalls	4	6	24		7	5	**35**		4	2	8		6	3	18		2	5	10		7	3	21		7	3	21	
	Zone 2 Residential Areas serviced by combined sewers	4	7	28		7	3	21		4	5	20		6	5	30		2	6	12		7	2	14		7	2	14	
	Zone 2 Commercial Areas serviced by combined sewers	4	6	24		7	3	21		4	2	8		6	3	18		2	6	12		7	2	14		7	2	14	
	Loss of Electrical power delivery - Pumps	4	3	12		7	3	21		4	6	24		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Loss of Comumunications - equipment monitoring	4	3	12		7	3	21		4	5	20		6	5	**30**		2	7	14		7	2	14		7	2	14	
	Surface drainage and surface transportation (emergemcy response)	4	3	12		7	3	21		4	6	24		6	5	**30**		2	7	14		7	1	7		7	1	7	
	Pad mounted electrical	4	2	8		7	2	14		4	4	16		**6**	2	12		2	7	14		7	2	14		7	2	14	

Climate change risk assessment of the City of Windsor's West Windsor public, private and institutional assets and third party risks, focussing on flooding risks

This PIEVC risk assessment is divided into 4 parts. Parts 1, 2 and 3 reference Zones 1, 2 and 3 respectively, and refer to assets with medium to high climate change risks. These higher risks were identified via City of Windsor guidance, interviews, forensic analysis of past impacts, other reports and informed by modelling of the City's sewer, surface and river level flows. Part 4 refers to system-wide risks and third party services.

Highlighted Infrastructure components indicate Medium to High site risks

Future Condition - 2050

	Infrastructure Class	Infrastructure Components	1 Extreme Rainfall: "Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)				Models storms 4-hour Chicago distribution based on peak rainfall rate	2 Extreme Rainfall: "Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)				Models storms 4-hour Chicago distribution based on peak rainfall rate	3 Extreme River Levels: "Likely" CC HWL - 176.1 m				Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	4 Extreme River Levels: Current HWL - 175.9 m				Current 100 year level for Detroit River	5 Combination Events: Current 100 yr HWL + extreme rainfall (100 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	6 Combination Events: Current 100 yr HWL + Moderate Rainfall (5-year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	7 Combination Events: Climate Chg HWL + extreme rainfall (100 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check
			Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
	Part 1																																						
	Zone 1 - E of Russel St																																						
	Wastewater System Assets	**Felix Avenue - Combined sewer**		6	6	**36**	Max risk 36= Combined prob event; fails 5 year design storm criteria		7	5	35			4	7	28			4	5	20			2	7	14			4	7	28			4	7	28	
		Mill St - combined sewer		6	6	**36**	Max 36 = risk w 100 yr rain		7	3	21			4	5	20			4	6	24			2	6	12			4	6	24			4	6	24	
		Riverside Dr - combined sewer		6	5	**30**	Max 36 = risk w 100 yr rain		7	3	21			4	4	16			4	4	16			2	6	12			4	4	16			4	5	20	
2		Interceptor Maintenance Holes (MH)		6	5	30	Location specific		7	3	21	Location specific		4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites
3		Sanitary Sewers		6	5	30	Location specific		7	4	28	Location specific		4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites
4		Maintenance Covers		6	2	12	Location specific		7	2	14	Location specific		4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites
5		Pump Stations		6	5	30	Location specific		7	4	28	Location specific		4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites
		Lou Romano Water Reclamation Plant (LRWRP): ***Inflow from Western Trunk line specifically*** **(<<100 year water levels for impacts)**		6	6	36	Max 49 = <<100 yr HWL; comb events with high river		7	4	28			4	6	24			5	5	25			2	7	14			4	7	28			4	7	28	
6		**Lou Romano Water Reclamation Plant (LRWRP)**		6	7	42	Max 49 risk w<<100 yr HWL; Blockage main outfall, backflow into plant for treatment river water; loss capacity		7	4	28			4	7	28			5	7	35			2	7	14			4	5	20			4	7	28	
7	Stormwater System Assets	Open drainage channels		6	4	24	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
		Russel Street - open channel drainage		6	6	**36**	36=Master @24 due xtrm rain		7	2	14			4	3	12	worst case-see specific sites		5	2	10	worst case-see specific sites		2	6	12	worst case- specific sites		4	3	12	worst case- specific sites		4	6	24	
8		Storm Sewers		6	5	30	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
9		Outfalls		6	4	24	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	2	10	worst case-see specific sites		2	6	12	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
#		Maintenance holes		6	5	30	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
#		Catch Basins		6	5	30	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
#		Drains		6	5	30	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
#		Culverts		6	5	30	Location specific		7	2	14			4	7	28	worst case-see specific sites		5	7	35	worst case-see specific sites		2	7	14	worst case- specific sites		4	7	28	worst case- specific sites		4	6	24	
14	Transportation	**Major Roadway - Felix Avenue**		6	6	**36**	Fails 5 yr; **36**=Master due xtrm rain: combination events		7	5	35			4	7	28			5	6	30			2	7	14			4	6	24			4	7	28	
#		Major Roadway - Huron Church Road		6	4	24			7	2	14			4	4	16			5	N/A				2	5	10			4	3	12			4	5	20	
#		**Major Roadway - Mill Street**		6	6	36	Excessive HGL		7	2	14			4	4	16			5	4	20			2	7	14			4	3	12			4	6	24	
#		Major Roadway - Ojibway Parkway		6	4	24			7	2	14			4	3	12			5	3	15			2	4	8			4	3	12			4	4	16	
#		Major Roadway - Prince Road		6	4	24			7	2	14			4	4	16			5	3	15			2	5	10			4	3	12			4	5	20	
#		**Major Roadway - Riverside Drive**		6	5	30	Excessive HGL		7	3	21			4	4	16			5	4	20			2	5	10			4	4	16			4	5	20	
20		**Major Roadway - Sandwich Street**		6	6	**36**	Max 36=100 yr rain; combination, high HGL, mdt ponding		7	4	28			4	5	20			5	4	20			2	7	14			4	5	20			4	7	28	
#		Major Roadway - University Avenue		6	4	24			7	2	14			4	4	16			5	4	20			2	5	10			4	4	16			4	5	20	
#		Major Roadway - Wyandotte Street W		6	4	24			7	2	14			4	4	16			5	4	20			2	5	10			4	4	16			4	5	20	
23		**Ambassador Bridge/Canadian Border Services**		6	6	**36**	Max 36= 100 yr rain; combination		7	4	28			4	4	16			5	4	20			2	7	14			4	6	24			4	7	28	
#		**Rail Tracks**		6	3	18	Max 42= combination events		7	2	14			4	6	24			5	5	25			2	7	14			4	6	24			4	7	28	
#	Institutional Buildings	St Michael's Adult Secondary School		6	3	18			7	2				4	5	20			5	5	25			2	6	12			4	5	20			4	6	24	
#		Duff - Baby House (museum)		6	3	18			7	2				4	5	20			5	5	25			2	5	10			4	5	20			4	5	20	
27		**Canada South Science City - Tourist Attraction**		6	6	**36**	Max 36=r due 100yr & 5yr rain		7	5	35			4	6	24			5	5	25			2	7	14			4	6	24			4	7	28	
28		**West Windsor Musallah - Mosque**		6	7	**42**	Max 42=r due 100 yr or 5 yr rain & combination: High HGL		7	6	**42**			4	5	20			5	4	20			2	7	14			4	6	24			4	7	28	
29		Windsor Essex Community Health - Community Centre		6	3	18			7	2				4	4	16			5	4	20			2	4	8			4	4	16			4	4	16	
30		**Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre**		6	7	**42**	Max **49**= due 100 yr or 5yr rain & combination; sig bsmt flood - emerg response critical		7	7	**49**			4	6	24			5	6	30			2	7	14			4	7	28			4	7	28	
#		Mackenzie Hall Cultural Centre		6	3	18			7	2				4	4	16			5	4	20			2	4	8			4	4	16			4	4	16	
#		St John's Anglican Church - historic site		6	3	18			7	2				4	4	16			5	4	20			2	4	8			4	4	16			4	4	16	
33		**Islamic Academy Windsor**		6	6	36	Max 42= due 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			2	7	14			4	6	24			4	7	28	
34		**Society of St Vincent de Paul**		6	6	36	Max 42= 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			2	7	14			4	6	24			4	7	28	
35		**General Brock Public School**		6	5	30	Max 35= 5 & 100yr & combination		7	5	**35**			4	5	20			5	4	20			2	6	12			4	5	20			4	7	28	
36		**Sandwich Teen Action Group**		6	6	36	Max 42=due 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			2	7	14			4	6	24			4	7	28	
#		**Sandwich First Baptist Church**		6	5	**30**	Max 30=due 100yr rain		7	3	21			4	2	8			5	2	10			2	5	10			4	3	12			4	5	20	
	Park Assets	Paterson Park		6	4	24			7	2	14			4	3	12			5	3	15			2	5	10			4	2	8			4	5	20	
		Bradley Park		6	4	24			7	2	14			4	2	8			5	2	10			2	2	4			4	2	8			4	2	8	
		Mackenzie Hall Park		6	4	24			7	2	14			4	2	8			5	2	10			2	2	4			4	2	8			4	2	8	
41	Energy and Communications Infrastructure	**Overhead electrical distribution**		6	3	18	Max 35= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;		7	2	14			4	2	8			5	1	5			2	3	6			4	2	8			4	2	8	
42		**Sub-grade vaults and/or transformers**		6	7	**42**	Max 42= due 100yr rain & HWL blo gnd; wind, ice abv gnd		7	2	14			4	5	20			5	2	10			2	7	14			4	6	24			4	7	28	
43		**Telecommunication**		6	4	24	Max 35=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;		7	2	14			4	3	12			5	2	10			2	4	8			4	3	12			4	4	16	
	Residential	**See Part 4**		6					7					4					5										4					4			
	Commercial Buildings	**See Part 4**		6					7					4					5										4					4			
	Industrial Assets	Sterling Fuels - Office and tank farm E of Russel St		6	4	24			7	2	14			4	4	16			5	3	15			2	5	10			4	4	16			4	6	24	
		Other Industrial Buildings - **See Part 4**																																			
	Part 2																																						
	Zone 2 - W of Russel St., N of Broadway St., W to shoreline																																						
	Wastewater System Assets	**Ojibway Parkway - Combined Sewer**		6	5	**30**	21=100 yr rainfall; sig HGLs		7	3	21			4	3	12			5	2	10			2	7	14			4	3	12			4	5	**20**	
		Riverside Dr - Combined Sewer		6	5	**30**	21=100 yr rainfall; sig HGLs		7	2	14			4	3	12			5	2	10			2	7	14			4	3	12			4	5	**20**	
		Sandwich Street - Combined Sewer		6	6	36	42=5 yr & 100 yr rainfall; mdt sfc flooding (0.5-1m)		7	6	**42**			4	4	16			5	3	15			2	7	14			4	6	24			4	7	28	
		Maintenance Covers		6	2	12			7	2	14			4	7	28			5	7	35	Location specific		2	7	14			4	7	28			4	7	28	
		Interceptor Maintenance Holes (MH)		6	5	30			7	3	21			4	7	28			5	7	35			2	7	14			4	7	28			4	7	28	
		Pump Stations		6	5	30			7	4	28			4	7	28			5	7	35	Location specific		2	7	14			4	7	28			4	7	28	
		Pump Station - Prospect Ave		6	6	**36**	36=Most high water levels (<< 100 year event), power from street light		7	2	14			4	7	28			5	6	30	35=Most high water levels (<< 100 year event), power from street light		2	7	14			4	6	24			4	7	28	
		Pump Station - McKee Road		6	6	36	42=<100 yr HWL; extreme rain; backflow during HWL. Street flooding		7	3	21			4	7	28			5	6	30			2	7	14			4	6	24			4	7	28	
	Stormwater System Assets	Open drainage channels		6	4	24			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
		Storm Sewers		6	5	30			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
		Brock Street Outfall		6	5	**30**	30=significant shoreline erosion		7	2	14			4	6	24			5	5	25			2	7	14			4	6	24			4	7	28	
		Maintenance holes		6	5	30			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
		Catch Basins		6	5	30			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
		McKee Creek catch basin		6	7	**42**	42 = <100 yr HWL & extreme rain; submerged HWK & surcharged extreme rain		7	3	21			4	7	28			5	6	30			2	7	14			4	5	20			4	7	28	
		Drains		6	5	30			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
		Culverts		6	5	30			7	2	14			4	7	28			5	7	35			2	6	12			4	7	28			4	7	28	
	Shoreline Stormwater/ Flood Protection Infrastructure	**Outfall for Lou Romano Water Reclamation Plant (LRWRP)**		6	6	36	42=<100 year HWL, combined river level+wave/freeboard		7	3	21			4	7	28			5	6	30			2	6	12			4	6	24			4	7	28	
		Mill St - Outfall, CS & catchment basin		6	6	**36**	36=<100 year HWL, combined river level or wave/freeboard		7	3	21			4	7	28			5	6	30			2	6	12			4	6	24			4	7	28	
	Transportation	**Major Roadway - Ojibway Parkway**		6	6	**36**	36=100 year rain, outfall higher than ditch, floods right over		7	5	35			4	5	20			5	5	25			2	7	14			4	5	20			4	7	28	
		Road & Open Ditch - Prospect Ave		6	6	**36**	36=100 year rain possibly lower, outfall higher than ditch, floods right over		7	5	35			4	5	20			5	5	25			2	7	14			4	5	20			4	7	28	
		Major Roadway - Riverside Drive		6	5	**30**			7	2	14			4	3	12			5	2	10			2	7	14			4	3	12			4	5	20	
		Major Roadway - Sandwich Street		6	6	36			7	6	**42**			4	4	16			5	3	15			2	7	14			4	6	24			4	7	28	
		Ambassador Bridge/Huron-Church catch basin, outfall, weir		6	7	**42**	42=extreme rain with <<100 yr HWL; 100 yr rain; 5 yr rain		7	5	35			4	6	24			5	6	30			2	7	14			4	6	24			4	6	24	
		ETR Rail and Gore Creek		6	6	**36**	36=extreme rain and HWL; Gore Ck flooding across Sandwich St, ETR rail and siding		7	3	21			4	6	24			5	5	25			2	7	14			4	5	20			4	7	28	
		ETR Rail and McKee Creek		6	6	**36**	36=extreme rain and HWL; Road flooding, flagged by City		7	3	21			4	6	24			5	5	25			2	6	12			4	5	20			4	7	28	
		Rail Tracks		6	3	18	Max 35=combination events		7	2	14			4	6	24			5	5	25			2	7	14			4	6	24			4	7	28	
	Institutional Buildings	St Michael's Adult Secondary School		6	3	18			7	2	14			4	5	20			4	5	20			2	6	12			4	5	20			4	6	24	
		Duff - Baby House (museum)		6	3	18			7	2	14			4	5	20			4	5	20			2	5	10			4	5	20			4	5	20	
		Canada South Science City - Tourist Attraction		6	6	36	Max 35=due 100yr & 5yr rain; high HGL		7	5	**35**			4	5	20			4	4	16			2	7	14			4	6	24			4	7	28	
		West Windsor Musallah - Mosque		6	7	42	Max 42= 100 yr or 5yr rain & combination: High HGL		7	6	**42**			4	5	20			4	4	16			2	7	14			4	6	24			4	7	28	
		Windsor Essex Community Health - Community Centre		6	3	18			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16			4	4	16	
		Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		6	7	42	Max **49**=100 yr or 5yr rain & combination; sig bsmt flood - emerg response critical		7	7	**49**			4	6	24			4	6	24			2	7	14			4	7	28			4	7	28	
		Mackenzie Hall Cultural Centre		6	3	18			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16			4	4	16	
		St John's Anglican Church - historic site		6	3	18			7	2	14			4	4	16			4	4	16			2	4	8			4	4	16			4	4	16	
		Islamic Academy Windsor		6	6	36	Max 42= 5 & 100yr & combination		7	6	**42**			4	5	20			4	4	16			2	7	14			4	6	24			4	7	28	
		Society of St Vincent de Paul		6	6	36	Max 42= 5 & 100yr & combination		7	6	**42**			4	5	20			4	4	16			2	7	14			4	6	24			4	7	28	
		General Brock Public School		6	5	30	Max 35=5 & 100yr & combination		7	5	**35**			4	5	20			4	4	16			2	6	12			4	5	20			4	7	28	
		Sandwich Teen Action Group		6	6	36	Max 42=5 & 100yr & combination		7	6	**42**			4	5	20			4	4	16			2	7	14			4	6	24			4	7	28	
		Sandwich First Baptist Church		6	5	**30**	Max 30= due 100yr rain		7	3	21			4	2	8			4	2	8			2	5	10			4	3	12			4	5	20	
		Chateau Park LTC Centre		6	5	30	35=100 year rain; wind damages, waves		7	3	21			4	5	20			5	5	25			2	6	12			4	5	20			4	5	20	

Infrastructure Components	8 Combination Events: Climate Chg HWL + moderate rainfall (5 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	9 Combination Events: HWL + wave action (freeboard)				Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	10 Secondary Impact Events: Major ice storm - 28mm or more				Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2	11 Secondary Impact Events: Extreme Wind Event - 120 km/h				debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	12 Secondary Impact Events: Tornado - (E)F2+				debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	13 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - total cycles					14 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments				
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
Part 1 – Zone 1 - E of Russel St																																			
Felix Avenue - Combined sewer		4	7	28			7	4				4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
Mill St - combined sewer		4	6	28			7	4	28			4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
Riverside Dr - combined sewer		4	4	16			7	4	28			4	3	12			6	3	18			2	5	10			7	3	21			7	3	21	
Interceptor Maintenance Holes (MH)		4	7	28	worst case- specific sites		7	N/A				4	3	12			7	3	21			2	5	10			7	1	7			7	1	7	
Sanitary Sewers		4	7	28	worst case- specific sites		7	N/A				4	3	12			7	3	21			2	4	8			7	1	7			7	1	7	
Maintenance Covers		4	7	28	worst case- specific sites		7	N/A				4	4	16			7	2	14			2	5	10			7	3	21			7	3	21	
Pump Stations		4	7	28	worst case- specific sites		7	N/A				4	4	16			7	4	28			2	5	10			7	1	7			7	1	7	
Lou Romano Water Reclamation Plant (LRWRP): Inflow from Western Trunk line specifically (<<100 year water levels for impacts)		4	7	28			7	7	**49**			4	4	16			4	4	16			2	7	14			7	2	14			7	2	14	
Lou Romano Water Reclamation Plant (LRWRP)		4	7	28			7	7	**49**			4	4	16			7	4	28			2	7	14			7	2	14			7	2	14	
Open drainage channels		4	7	28	worst case- specific sites		7	N/A				4	5	20			7	5	35			2	7	14			7	2	14			7	2	14	
Russel Street - open channel drainage		4	3	12			7	3	21			4	3	12			7	3	21			2	5	10			7	2	14			7	2	14	
Storm Sewers		4	7	28	worst case- specific sites		7	N/A				4	3	12			7	3	21			2	5	10			7	2	14			7	2	14	
Outfalls		4	7	28	worst case- specific sites		7	N/A				4	3	12			7	3	21			2	5	10			7	2	14			7	2	14	
Maintenance holes		4	7	28	worst case- specific sites		7	N/A				4	4	16			7	3	21			2	6	12			7	2	14			7	2	14	
Catch Basins		4	7	28			7	N/A				4	5	20			7	5	35			2	7	14			7	2	14			7	2	14	
Drains		4	7	28			7	N/A				4	4	16			7	4	28			2	5	10			7	2	14			7	2	14	
Culverts		4	7	28			7	N/A				4	5	20			7	5	35			2	6	12			7	3	21			7	3	21	
Major Roadway - Felix Avenue		4	7	28			7	5	35			4	3	12			7	3	21			2	6	12			7	3	21			7	3	21	
Major Roadway - Huron Church Road		4	4	16			7	N/A				4	2	8			7	2	14			2	6	12			7	3	21			7	3	21	
Major Roadway - Mill Street		4	4	16			7	5	35			4	2	8			7	2	14			2	6	12			7	3	21			7	3	21	
Major Roadway - Ojibway Parkway		4	3	12			7	3	21			4	3	12			7	3	21			2	7	14			7	3	21			7	3	21	
Major Roadway - Prince Road		4	4	16			7	3	21			4	2	8			7	2	14			2	6	12			7	3	21			7	3	21	
Major Roadway - Riverside Drive		4	4	16			7	5	35			4	3	12			7	3	21			2	7	14			7	3	21			7	3	21	
Major Roadway - Sandwich Street		4	6	24			7	4	28			4	5	20			7	5	35			2	7	14			7	3	21			7	3	21	
Major Roadway - University Avenue		4	4	16			7	N/A				4	3	12			7	3	21			2	7	14			7	3	21			7	3	21	
Major Roadway - Wyandotte Street W		4	4	16			7	N/A				4	3	12			7	3	21			2	7	14			7	3	21			7	3	21	
Ambassador Bridge/Canadian Border Services		4	5	20			7	5	35			4	2	8			7	2	14			2	2	4			7	3	21			7	3	21	
Rail Tracks		4	6	24			7	6	**42**			4	3	12			7	3	21			2	3	6			7	2	14			7	2	14	
St Michael's Adult Secondary School		4	5	20			7	N/A				4	4	16			7	4	28			2	7	14			7	2	14			7	2	14	
Duff - Baby House (museum)		4	5	20			7	N/A				4	4	16			7	4	28			2	7	14			7	2	14			7	2	14	
Canada South Science City - Tourist Attraction		4	7	28			7	5	35			4	3	12			7	4	28			2	7	14			7	2	14			7	2	14	
West Windsor Musallah - Mosque		4	7	28			7	4	28			4	3	12			7	4	28			2	7	14			7	2	14			7	2	14	
Windsor Essex Community Health - Community Centre		4	4	16			7	N/A				4	5	20			7	5	35			2	7	14			7	2	14			7	2	14	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		4	7	28			7	N/A				4	5	20			7	5	35			2	7	14			7	2	14			7	2	14	
Mackenzie Hall Cultural Centre		4	4	16			7	N/A				4	4	16			7	4	28			2	7	14			7	2	14			7	2	14	
St John's Anglican Church - historic site		4	4	16			7	N/A				4	4	16			7	4	28			2	7	14			7	2	14			7	2		
Islamic Academy Windsor		4	6	24			7	4	28			4	3	12			7	4	28			2	7	14			7	2	14			7	2	14	
Society of St Vincent de Paul		4	6	24			7	4	28			4	3	12			7	4	28			2	7	14			7	2	14			7	2	14	
General Brock Public School		4	5	20			7	4	28			4	4	16			7	4	28			2	7	14			7	2	14			7	2	14	
Sandwich Teen Action Group		4	6	24			7	4	28			4	3	12			7	4	28			2	7	14			7	2	14			7	2	14	
Sandwich First Baptist Church		4	3	12			7	3	21			4	3	12			7	3	21			2	7	14			7	2	14			7	2	14	
Paterson Park		4	2	8			7	3	21			4	3	12			7	4	28			2	6	12			7	2	14			7	2	14	
Bradley Park		4	2	8			7	1	7			4	3	12			7	4	28			2	6	12			7	2	14			7	2	14	
Mackenzie Hall Park		4	2	8			7	1	7			4	3	12			7	4	28			2	6	12			7	2	14			7	2	14	
Overhead electrical distribution		4	2	8			7	1	7			4	5	20			7	5	**35**			2	7	14			7	2	14			7	2	14	
Sub-grade vaults and/or transformers		4	3	12			7	4	28			4	5	20			7	4	28			2	5	10			7	2	14			7	2	14	
Telecommunication		4	2	8			7	2	14			4	5	20			7	5	**35**			2	7	14			7	2	14			7	2	14	
See Part 4 (Residential)			N/A				7					4	4	16			7	4	28			2	6	12											
See Part 4 (Commercial Buildings)			N/A				7					4					7	4	28			2	6	12											
Sterling Fuels - Office and tank farm E of Russel St		4	5	20			7	3	21			4	5	20			7	4	28			2	7	14			7	2	14			7	2	14	
Other Industrial Buildings - **See Part 4**																																			
Part 2 – Zone 2 - W of Russel St., N of Broadway St., W to shoreline																																			
Ojibway Parkway - Combined Sewer		4	3	12			7	2	14			4	2	8			7	2	14			2	6	12			7	2	14			7	2	14	
Riverside Dr - Combined Sewer		4	3	12			7	2	14			4	2	8			7	2	14			2	6	12			7	2	14			7	2	14	
Sandwich Street - Combined Sewer		4	6	24			7	2	14			4	3	12	debris generation		7	4	28	debris generation; tree uprooting		2	5	10			7	2	14			7	2	14	
Maintenance Covers		4	7	28			7	N/A		Location specific		4	4	16			7	2	14			2	5	10			7	3	21			7	3	21	
Interceptor Maintenance Holes (MH)		4	7	28			7	N/A				4	3	12			7	3	21			2	5	10			7	1	7			7	1	7	
Pump Stations		4	7	28			7	N/A		Location specific		4	4	16			7	4	28			2	5	10			7	1	7			7	1	7	
Pump Station - Prospect Ave		4	7	28			7	6	**42**			4	5	20			7	5	**35**	S=4 or 5? 35=Most high water levels (<< 100 year event), power from street		2	7	14			7	2	14			7	2	14	
Pump Station - McKee Road		4	7	28			7	6	**42**			4	5	20	power		7	5	35	power		2	7	14			7	2	14			7	2	14	
Open drainage channels		4	7	28			7	N/A		Location specific		4	5	20			7	5	35			2	7	14			7	3	21			7	3	21	
Storm Sewers		4	7	28			7	N/A		Location specific		4	2	8			7	3	21			2	5	10			7	2	14			7	2	14	
Brock Street Outfall		4	6	24			7	4	28			4	2	8			7	2	14			2	6	12			7	3	21			7	3	21	
Maintenance holes		4	7	28			7	N/A				4	4	16			7	3	21			2	6	12			7	2	14			7	2	14	
Catch Basins		4	7	28			7	N/A				4	5	20			7	5	35			2	7	14			7	2	14			7	2	14	
McKee Creek catch basin		4	6	24			7	5	**35**			4	2	8			7	2	14			2	6	12			7	2	14			7	2	14	
Drains		4	7	28			7	N/A				4	4	16			7	4	28			2	5	10			7	2	14			7	2	14	
Culverts		4	7	28			7	N/A				4	5	20			7	5	35			2	6	12			7	3	21			7	3	21	
Outfall for Lou Romano Water Reclamation Plant (LRWRP)		4	7	28			7	5	35			4	3	12			7	3	21			2	6	12			7	2	14			7	2	14	
Mill St - Outfall, CS & catchment basin		4	7	28			7	5	35			4	3	12			7	3	21			2	6	12			7	2	14			7	2	14	
Major Roadway - Ojibway Parkway		4	5	20			7	4	28			4	4	16			7	3	21			2	6	12			7	2	14			7	2	14	
Road & Open Ditch - Prospect Ave		4	5	20			7	4	28			4	4	16			7	3	21			2	6	12			7	2	14			7	2	14	
Major Roadway - Riverside Drive		4	3	12			7	2	14			4	2	8			7	2	14			2	6	12			7	2	14			7	2	14	
Major Roadway - Sandwich Street		4	6	24			7	2	14			4	3	12	debris generation		7	4	28	debris generation; tree uprooting		2	5	10			7	2	14			7	2	14	
Ambassador Bridge/Huron-Church catch basin, outfall, weir		4	6	24			7	5	**35**			4	3	12			7	3	21			2	6	12			7	3	21			7	3	21	
ETR Rail and Gore Creek		4	6	24			7	5	35			4	2	8			7	3	21			2	6	12			7	3	21			7	3	21	
ETR Rail and McKee Creek		4	6	24			7	5	35			4	2	8			7	3	21			2	6	12			7	3	21			7	3	21	
Rail Tracks		4	6	24			7	5	**35**			4	3	12			6	3	18			2	3	6			7	2	14			7	2	14	
St Michael's Adult Secondary School		4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
Duff - Baby House (museum)		4	5	20			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
Canada South Science City - Tourist Attraction		4	7	28			7	5	**35**			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
West Windsor Musallah - Mosque		4	7	28			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
Windsor Essex Community Health - Community Centre		4	4	16			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		4	7	28			7	N/A				4	5	20			6	5	30			2	7	14			7	2	14			7	2	14	
Mackenzie Hall Cultural Centre		4	4	16			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
St John's Anglican Church - historic site		4	4	16			7	N/A				4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
Islamic Academy Windsor		4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
Society of St Vincent de Paul		4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
General Brock Public School		4	5	20			7	4	28			4	4	16			6	4	24			2	7	14			7	2	14			7	2	14	
Sandwich Teen Action Group		4	6	24			7	4	28			4	3	12			6	4	24			2	7	14			7	2	14			7	2	14	
Sandwich First Baptist Church		4	3	12			7	3	21			4	3	12			6	3	18			2	7	14			7	2	14			7	2	14	
Chateau Park LTC Centre		4	5	20			7	5	**35**			4	5	20			7	5	35			2	7	14			7	3	21			7	3	21

Infrastructure Class	Infrastructure Components	1 Extreme Rainfall: "Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)			Models storms 4-hour Chicago distribution based on peak rainfall rate	2 Extreme Rainfall: "Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)			Models storms 4-hour Chicago distribution based on peak rainfall rate	3 Extreme River Levels: "Likely" CC HWL - 176.1 m			Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	4 Extreme River Levels: Current HWL - 175.9 m			Current 100 year level for Detroit River	5 Combination Events: Current 100 yr HWL + extreme rainfall (100 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	6 Combination Events: Current 100 yr HWL + Moderate Rainfall (5-year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	7 Combination Events: Climate Chg HWL + extreme rainfall (100 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	8 Combination Events: Climate Chg HWL + moderate rainfall (5 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	9 Combination Events: HWL + wave action (freeboard)			Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	10 Secondary Impact Events: Major ice storm - 28mm or more			Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2	11 Secondary Impact Events: Extreme Wind Event - 120 km/h			debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	12 Secondary Impact Events: Tornado - (E)F2+			debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	13 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - total cycles				14 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments			
	Great Lakes Institute for Environmental Studies (U of Windsor)	6	5	30	35=100 year rain; basement flooding	7	3	21		4	5	20		5	5	25		2	6	12		4	3	12		4	6	24		4	3	12		7	5	**35**		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	HMCS Hunter Navy Facility	6	4	24		7	2	14		4	5	20		5	5	25		2	6	12		4	5	20		4	6	24		4	5	20		7	5	**35**		4	5	20		7	4	28		2	7	14		7	3	21		7	3	21	
Park Assets	McKee Park - Sandwich and Chewett Streets	6	3	18	35= < 100 year HWL; shoreline flooding	7	2	14		4	5	20		5	5	25		2	5	10		4	5	20		4	5	20		4	5	20		7	5	**35**		4	2	8		7	2	14		2	7	14		7	3	21		7	3	21	
	Brock Park	6	4	24		7	2	14		4	4	16		5	3	15		2	4	8		4	4	16		4	5	20		4	5	20		7	4	28		4	2	8		7	3	21		2	6	12		7	3	21		7	3	21	
	Mill Park	6	4	24		7	2	14		4	2	8		5	2	10		2	2	4		4	2	8		4	2	8		4	2	8		7	2	14		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Queen's Park	6	4	24		7	2	14		4	2	8		5	2	10		2	2	4		4	2	8		4	2	8		4	2	8		7	2	14		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Chateau Park - Ambassador Bridge area	6	4	24	35=<100 year HWL; retaining wall submerged	7	1	7		4	6	24		5	5	25		2	5	10		4	5	20		4	6	24		4	6	24		7	5	**35**		4	2	8		7	2	14		2	5	10		7	3	21		7	3	21	
Energy and Communications Infrastructure	JC Keith Transformer Station	6	5	**30**	30=flooding w high HGLs; critical 3rd party infrastructure, further study	7	3	21		4	4	16		5	3	15		2	6	12		4	4	16		4	5	20		4	4	16		7	3	21		4	5	20		7	3	21		2	6	12		7	2	14		7	2	14	
	Overhead electrical distribution	6	3	18	Max 35= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;	7	2	14		4	2	8		5	1	5		2	3	6		4	2	8		4	2	8		4	2	8		7	1	7		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	6	7	**42**	Max 42= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		5	2	10		2	7	14		4	6	24		4	7	28		4	3	12		7	4	28		4	5	20		7	4	28		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	6	4	24	Max 35=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		2	4	8		4	3	12		4	4	16		4	2	8		7	2	14		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Atura Power Brighton Beach Gen Station	6	7	42	49=Combined events, 100 year rain, 5 year rain; subgrade flooding due HGL, flooding to 0.3m	7	3	21		4	7	28		5	7	35		2	7	14		4	7	28		4	7	28		4	7	28		7	7	**49**		4	6	24		7	5	35		2	6	12		7	2	14		7	2	14	
	Telecommunication	6	4	24	Max 35=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		2	4	8		4	3	12		4	4	16		4	2	8		7	2	14		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
Residential	Buildings - See Part 4																																																									
Commercial Buildings	Buildings - See Part 4																																																								
Industrial Assets	Transpo/Trucking/Logistics - Van De Hogan Group (VG; trucking); Cole-Carriers Inc.; Stantec Trailers	6	3	18		7	1	7		4	3	12		4	2	8		2	4	8		4	2	8		4	4	16		4	2	8		7	1	7		4	4	16		7	4	28		2	6	2		7	1	7		7	1	7	
	Windsor Biosolids Processing Plant	6	7	**42**	42=combined prob event, extremes rainfall; flooding >1m	7	3	21		4	5	20		5	4	20		2	7	14		4	4	16		4	7	28		4	5	20		7	5	35		4	3	12		7	3	21		2	7	14		7	2	14		7	2	14	
	Windsor Salt - end of Prospect Ave	6	7	**42**	42=Master; erosion 100 year rain; combined prob	7	3	21		4	5	20		5	5	25		2	7	14		4	6	24		4	7	28		4	5	20		7	6	**42**		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	Newmak Windsor Aluminum Plant	6	4	24		7	2	14		4	2	8		5	2	10		2	4	8		4	2	8		4	4	16		4	2	8		7	2	14		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	

Part 3

Zone 3 - W of Ojibway Pkwy., N of Morten Dr. to Broadway St.

Infrastructure Class	Infrastructure Components	1 P	1 S	1 R	1	2 P	2 S	2 R	2	3 P	3 S	3 R	3	4 P	4 S	4 R	4	5 P	5 S	5 R	5	6 P	6 S	6 R	6	7 P	7 S	7 R	7	8 P	8 S	8 R	8	9 P	9 S	9 R	9	10 P	10 S	10 R	10	11 P	11 S	11 R	11	12 P	12 S	12 R	12	13 P	13 S	13 R	13	14 P	14 S	14 R	14
Wastewater and Stormwater System Assets	Sanitary Sewers																																																								
	Sprucewood Ave - Combined Sewer	6	7	**42**	42=Combined event; 100 year and 5 year rain; ~1m flooding all rain events; Sig HGL/surcharge	7	6	**42**		4	5	20		5	4	20		2	7	14		4	6	24		4	7	28		4	6	24		7	5	35		4	3	12		7	3	21		2	6	12		7	2	14		7	2	14	
	Sprucewood Ave - Open ditches	7	6	**42**	42 = Extreme 5 & 100 year rain; workshop participants indicated problem area	7	6	**42**		4	4	16		5	3	15		4	7	28		5	6	30		4	7	28		4	6	24		7	4	28		4	3	12		7	3	21		2	6	12		7	3	21		7	3	21	
	Maintenance Covers	6	2	12		7	2	14		4	7	28		5	7	35		2	7	14		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	4	16		7	2	14		2	5	10		7	3	21		7	3	21	
	Pump Stations	6	5	30		7	4	28		4	7	28		5	7	35		2	7	14		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	5	20	power outages	7	5	35	power outages, debris	2	5	10		7	1	7		7	1	7	
	Open drainage channels	6	4	24		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	7	14		7	3	21		7	3	21	
	Storm Sewers	6	5	30		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	2	8		7	3	21		2	5	10		7	2	14		7	2	14	
	Outfalls	6	4	24		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	2	8		7	2	14		2	3	6		7	2	14		7	2	14	
	Maintenance holes	6	5	30		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
	Catch Basins	6	5	30		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	7	14		7	2	14		7	2	14	
	Drains	6	5	30		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	4	16		7	4	28		2	5	10		7	2	14		7	2	14	
	Culverts	6	5	30		7	2	14		4	7	28		5	7	35		2	6	12		4	7	28		4	7	28		4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	6	12		7	3	21		7	3	21	
Shoreline Stormwater/ Flood Protection Infrastructure	CSOs	6	5	30		7	4	28		4	6	24		5	5	25		2	7	14		4	5	20		4	7	28		4	6	24		7	N/A		Location specific	4	4	16		7	4	28		2	5	10		7	3	21		7	3	21	
Transportation	Major Roadway - Ojibway Parkway	6	7	**42**	42=Combined prob events;100 year rain, 5 year rain; LOS for 63% road	7	5	35		4	2	8		5	2	10		2	7	14		4	6	24		4	7	28		4	7	28		7	5	35		4	4	16		7	4	28		2	6	12		7	2	14		7	3	21	
	Major Roadway - Sprucewood Avenue	6	7	**42**	42=100 year & 5 year rain; adjacent to wetland; modelling	7	6	**42**		4	2	8		5	2	10		2	7	14		4	6	24		4	7	28		4	6	24		7	2	14		4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
	Detroit-Windsor Truck Ferry	6	7	**42**	42=100 year rain, 5 year rain, Combined prob event; 0.75-1m surface flooding, trade importance	7	6	**42**		4	3	12		5	2	10		2	7	14		4	6	24		4	7	28		4	6	24		7	5	35		4	5	20		7	5	35		2	6	12		7	2	14		7	2	14	
	Rail Tracks	6	7	**42**	42=100 year & 5 year rain;Combined events; mdt surface flooding for 100 year rain	7	5	35		4	2	8		5	2	10		2	6	12		4	5	20		4	6	24		4	5	20		7	2	14		4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
Park Assets	Black Oak Heritage Park	6	5	30	35=100 year rain & combined; Extreme wind, ice storm; sfc flooding >0.3m w 100 year rain	7	3	21		4	2	8		5	2	10		2	6	12		4	3	12		4	7	28		4	4	16		7	3	21		4	5	20		7	5	**35**		2	5	10		7	2	14		7	2	14	
Energy and Communications Infrastructure	Overhead electrical distribution	6	3	18	Max 30= sensitive to wind, ice abv gnd; Also 100yr rain & HWL below ground;	7	2	14		4	2	8		5	1	5		2	3	6		4	2	8		4	2	8		4	2	8		7	1	7		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	6	7	**42**	Max 28= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		5	2	10		2	7	14		4	6	24		4	7	**28**		4	3	12		7	4	28		4	5	20		7	4	28		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	6	4	24	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		2	4	8		4	3	12		4	4	16		4	2	8		7	2	14		4	4	16		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Telecommunication	6	4	24	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		2	4	8		4	3	12		4	4	16		4	2	8		7	2	14		4	4	16		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Shoreline Properties - Mortrem Ltd; ADM Windsor;	6	5	30		7	3	21		4	3	12		5	2	10		2	6	12		4	4	16		4	6	24		4	5	20		7	4	28		4	4	16		7	4	28		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine - ditch entrance	6	7	42	49=HWL <100 yr; Combined prob; 100 year rain; 5 year rain	7	5	35		4	6	24		5	6	30		2	7	14		4	7	28		4	7	28		4	7	28		7	7	**49**		4	2	8		7	2	14		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine	6	7	42	49 = 5 & 100 year extreme rain; Combined probabilities; surface flooding 0.75->1m; extreme HGLs	7	5	35		4	6	24		5	6	30		2	7	14		4	6	24		4	7	28		4	7	28		7	7	**49**		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Shoreline Protection - retaining walls, rip-rap	6	3	18		7	1	7		4	5	20		5	4	20		2	5	10		4	4	16		4	6	24		4	5	20		7	4	28		4	2	8		7	3	21		2	5	10		7	3	21		7	3	21	

Part 4

System-Wide Risks and Critical Third Party Services

Infrastructure Class	Infrastructure Components	1 P	1 S	1 R	1	2 P	2 S	2 R	2	3 P	3 S	3 R	3	4 P	4 S	4 R	4	5 P	5 S	5 R	5	6 P	6 S	6 R	6	7 P	7 S	7 R	7	8 P	8 S	8 R	8	9 P	9 S	9 R	9	10 P	10 S	10 R	10	11 P	11 S	11 R	11	12 P	12 S	12 R	12	13 P	13 S	13 R	13	14 P	14 S	14 R	14
System-Wide Assets	*Zone 1* Residential Areas serviced by combined sewers	6	6	36	42=Combined prob; 5 & 100 year rain; Likely basement flooding; Surface flooding extreme rain	7	6	**42**		4	4	16		5	4	20		2	7	14		4	6	24		4	7	28		4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 1 Commercial Areas serviced by combined sewers	6	7	**42**	42=Combined prob; 5 & 100 year rain generally; Likely basement flooding; Surface flooding extreme rain	7	6	**42**		4	4	16		5	4	20		2	7	14		4	6	24		4	7	28		4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 1 Industrial Buildings serviced by combined sewers	6	6	36	42=100 & 5 year rain; Mainly surface & basement flooding	7	6	**42**		4	4	16		5	3	15		2	7	14		4	6	24		4	7	28		4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 2 Combined Sewer Outfalls	6	5	30	[illegible]=Combined prob events & high river levels above 174.6m; blocked outfalls and back feeding into combined system; Lost sewer capacity for extreme rain	7	3	21		4	7	28		5	6	30		2	7	14		4	6	24		4	7	28		4	6	24		7	5	**35**		4	2	8		7	3	21		2	5	10		7	3	21		7	3	21	
	Zone 2 Residential Areas serviced by combined sewers	6	7	**42**	49 = Heavy rainfalls; Surface flooding >1m; Potential basement flooding	7	7	**49**		4	4	16		5	3	15		2	7	14		4	4	16		4	7	28		4	7	28		7	3	21		4	5	20		7	5	35		2	6	12		7	2	14		7	2	14	
	Zone 2 Commercial Areas serviced by combined sewers	6	7	**42**	42 = Heavy rainfall; Surface flooding >1m	7	6	**42**		4	2	8		5	2	10		2	7	14		4	6	24		4	7	28		4	6	24		7	3	21		4	2	8		7	3	21		2	6	12		7	2	14		7	2	14	
	Loss of Electrical power delivery - Pumps	6	4	24	30 =Any events damaging power delivery; Any assets below-grade (water intrusion); Power assets in Zone 2 flagged for further study	7	2	14		4	2	8		5	2	10		2	5	10		4	3	12		4	6	24		4	3	12		7	3	21		4	6	24		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Loss of Comumunications - equipment monitoring	6	4	24	35=Events giving damage to telephone lines; Below grade assets	7	3	21		4	2	8		5	2	10		2	5	10		4	3	12		4	6	24		4	3	12		7	3	21		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Surface drainage and surface transportation (emergecny response)	6	5	30	Max 35 = any wind >102 kph gusts or other damaging event affecting emergency response; Debris generation	7	3	21		4	2	8		5	2	10		2	5	10		4	3	12		4	5	20		4	3	12		7	3	21		4	6	24		7	5	**35**		2	7	14		7	1	7		7	1	7	
	Pad mounted electrical	6	7	**42**	42= 100 year rainfall event; Extremely sensitive to surface flooding < 1m or more in depth; potential public safety risk	7	1	7		4	1	4		5	1	5		2	7	14		4	2	8		4	7	28		4	2	8		7	2	14		4	4	16		7	2	14		2	7	14		7	2	14		7	2	14	

Climate change risk assessment of the City of Windsor's West Windsor public, private and institutional assets and third party risks, focussing on flooding risks

This PIEVC risk assessment is divided into 4 parts. Parts 1, 2 and 3 reference Zones 1, 2 and 3 respectively, and refer to assets with medium to high climate change risks. These higher risks were identified via City of Windsor guidance, interviews, forensic analysis of past impacts, other reports and informed by modelling of the City's sewer, surface and river level flows. Part 4 refers to system-wide risks and third party services.

Highlighted Infrastructure components indicate Medium to High site risks

Future Condition - 2080

	Infrastructure Class	Infrastructure Components	1 Extreme Rainfall: "Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)				Models storms 4-hour Chicago distribution based on peak rainfall rate	2 Extreme Rainfall: "Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)				Models storms 4-hour Chicago distribution based on peak rainfall rate	3 Extreme River Levels: "Likely" CC HWL - 176.1 m				Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	4 Extreme River Levels: Current HWL - 175.9 m				Current 100 year level for Detroit River	5 Combination Events: Current 100 yr HWL + extreme rainfall (100 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check
			Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
	Part 1																										
	Zone 1 - E of Russel St., N of Ojibway Pkwy to Huron Church Rd.																										
	Wastewater System Assets	**Felix Avenue - Combined sewer**		7	6	**42**	Max risk 42= Combined prob event; fails 5 year design storm criteria		7	5	35			4	7	28			5	5	25			4	7	28	
	Wastewater System Assets	**Mill St - combined sewer**		7	6	**42**	**42**=Excess HGL-abv sfc for 100yr rain ..Inconsistent? Combine with Trans or separate?		7	3	21			4	5	20			5	6	30			2	6	12	
	Wastewater System Assets	**Riverside Dr - combined sewer**		7	5	**35**	35=Master @100 yr rain... Same w trans?		7	3	21			4	4	16			4	4	16			2	6	12	
2	Wastewater System Assets	Interceptor Maintenance Holes (MH)		7	5	**35**	See Part 4		7	3	21			4	7	28			5	7	35			4	7	28	
3	Wastewater System Assets	Sanitary Sewers		7	5	**35**	See Part 5		7	4	28			4	7	28			5	7	35			4	7	28	
4	Wastewater System Assets	Maintenance Covers		7	2	14	See Part 6		7	2	14			4	7	28			5	7	35			4	7	28	
5	Wastewater System Assets	Pump Stations		7	5	35	See Part 7		7	4	28			4	7	28			5	7	35			4	7	28	
	Wastewater System Assets	**Lou Romano Water Reclamation Plant (LRWRP):** ***Inflow from Western Trunk line specifically*** **(for much less than 100 year year river level)**		7	6	42	Max 49 risk = <<100 yr HWL; comb extreme river and rainfall events; Excess inflow throttle or close gates; potential basement flooding		7	4	28			4	6	24			5	5	25			4	7	28	
6	Wastewater System Assets	**Lou Romano Water Reclamation Plant (LRWRP) - Note for much less than 100 year river levels**		7	6	42	Max 49 risk w<<100 yr HWL; Blockage main outfall, backflow into plant for treatment river water; loss capacity		7	4	28			4	6	24			5	5	25			4	7	28	
7	Stormwater System Assets	Open drainage channels		7	4	28			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
	Stormwater System Assets	**Russel Street - open channel drainage**		7	6	**42**	Max 42=extrm rain; ditches completely fill		7	2	14			4	3	12	worst case- specific sites		5	2	10	worst case- specific sites		4	6	24	worst case- specific sites
8	Stormwater System Assets	Storm Sewers		7	5	35			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
9	Stormwater System Assets	Outfalls		7	4	28			7	2	14			4	7	28	worst case- specific sites		5		0	worst case- specific sites		4	6	24	worst case- specific sites
#	Stormwater System Assets	Maintenance holes		7	5	35			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
#	Stormwater System Assets	Catch Basins		7	5	35			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
#	Stormwater System Assets	Drains		7	5	35			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
#	Stormwater System Assets	Culverts		7	5	35			7	2	14			4	7	28	worst case- specific sites		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites
#	Transportation	**Major Roadway - Felix Avenue**		7	6	**42**	Excessive HGL		7	5	35			4	7	28			5	6	30			4	7	28	
#	Transportation	Major Roadway - Huron Church Road		7	4	28			7	2	14			4	4	16			5	N/A				4	5	20	
#	Transportation	**Major Roadway - Mill Street**		7	6	**42**	Excessive HGL		7	2	14			4	4	16			5	4	20			4	7	28	
#	Transportation	Major Roadway - Ojibway Parkway		7	4	28			7	2	14			4	3	12			5	3	15			4	4	16	
#	Transportation	Major Roadway - Prince Road		7	4	28			7	2	14			4	4	16			5	3	15			4	5	20	
#	Transportation	**Major Roadway - Riverside Drive**		7	5	**35**	Excessive HGL		7	3	21			4	4	16			5	4	20			4	5	20	
20	Transportation	**Major Roadway - Sandwich Street**		7	6	**42**	Max 42=combined & 100 yr Xtrm rain		7	4	28			4	5	20			5	4	20			4	7	28	
#	Transportation	Major Roadway - University Avenue		7	4	28			7	2	14			4	4	16			5	4	20			4	5	20	
#	Transportation	Major Roadway - Wyandotte Street W		7	4	28			7	2	14			4	4	16			5	4	20			4	5	20	
23	Transportation	**Ambassador Bridge/Canadian Border Services**		7	6	**42**	Max 42=100 yr rain; combination		7	4	28			4	4	16			5	4	20			4	7	28	
#	Transportation	**Rail Tracks**		7	3	21	Max 49=combination events		7	2	14			4	6	24			5	5	25			4	7	28	
#	Institutional Buildings	St Michael's Adult Secondary School		7	3	21			7	2	14			4	5	20			5	5	25			4	6	24	
#	Institutional Buildings	Duff - Baby House (museum)		7	3	21			7	2	14			4	5	20			5	5	25			4	5	20	
27	Institutional Buildings	**Canada South Science City - Tourist Attraction**		7	6	**42**	Max 42 = xtrm rain and 5 yr. Combined.		7	5	35			4	6	24			5	5	25			4	7	28	
28	Institutional Buildings	**West Windsor Musallah - Mosque**		7	7	**49**	Max **49**= due 100 yr or 5yr rain & combination; High HGL		7	6	**42**			4	5	20			5	4	20			4	7	28	
29	Institutional Buildings	Windsor Essex Community Health - Community Centre		7	3	21			7	2	14			4	4	16			5	4	20			4	4	16	
30	Institutional Buildings	**Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre**		7	7	**49**	Max **49**= due 100 yr or 5yr rain & combination; emerg response critical		7	7	**49**			4	6	24			5	6	30			4	7	28	
#	Institutional Buildings	Mackenzie Hall Cultural Centre		7	3	21			7	2	14			4	4	16			5	4	20			4	4	16	
#	Institutional Buildings	St John's Anglican Church - historic site		7	3	21			7	2	14			4	4	16			5	4	20			4	4	16	
33	Institutional Buildings	**Islamic Academy Windsor**		7	6	**42**	Max 42= due 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			4	7	28	
34	Institutional Buildings	**Society of St Vincent de Paul**		7	6	**42**	Max 42= due 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			4	7	28	
35	Institutional Buildings	**General Brock Public School**		7	5	**35**	Max 35= due 5 & 100yr & combination		7	5	**35**			4	5	20			5	4	20			4	6	24	
36	Institutional Buildings	**Sandwich Teen Action Group**		7	6	**42**	Max 42=r due 5 & 100yr & combination		7	6	**42**			4	5	20			5	4	20			4	7	28	
#	Institutional Buildings	**Sandwich First Baptist Church**		7	5	**35**	Max 35=due 100yr rain		7	3	**21**			4	N/A				5	N/A				4	5	20	
	Institutional Buildings	**Great Lakes Institute for Environmental Studies (U of Windsor)**		7	5	**35**	35=100 year rain; basement flooding		7	3	21			4	5	20			5	5	25			4	6	24	
	Institutional Buildings	HMCS Hunter Navy Facility		7	4	28			7	2	14			4	5	20			5	5	25			4	6	24	
	Park Assets	Paterson Park		7	4	28			7	2	14			4	3	12			5	3	15			4	5	20	
	Park Assets	Bradley Park		7	4	28			7	2	14			4	2	8			5	2	10			4	2	8	
	Park Assets	Mackenzie Hall Park		7	4	28			7	2	14			4	2	8			5	2	10			4	2	8	
41	Energy and Communications Infrastructure	**Overhead electrical distribution**		7	3	21	Max 35= sensitive to wind, ice abv gnd; Also 100yr rain & HWL blo gnd;		7	2	14			4	2	8			5	1	5			4	3	12	
42	Energy and Communications Infrastructure	**Sub-grade vaults and/or transformers**		7	7	**49**	Max 49= due 100yr rain & HWL blo gnd; wind, ice abv gnd		7	2	14			4	5	20			5	2	10			4	7	28	
43	Energy and Communications Infrastructure	**Telecommunication**		7	4	28	Max 35=due wind, ice abv gnd; Also 100yr rain & HWL below gnd;		7	2	14			4	3	12			5	2	10			4	4	16	
		See Part 4																						4	7	28	
	Commercial Buildings	**See Part 4**																						4	N/A		
	Industrial Assets	Sterling Fuels - Office and tank farm E of Russel St		7	4	28			7	2	14			4	4	16			5	3	15			4	5	20	
	Industrial Assets	Other Industrial Buildings - **See Part 4**																									
	Part 2																										
	Zone 2 - W of Russel St., N of Broadway St., W to shoreline																										
		Ojibway Parkway - Combined Sewer		7	5	**35**	35=Master for 100 yr rain		7	3	21			4	3	12			5	2	10			4	5	20	
		Riverside Dr - Combined Sewer		7	5	**35**	35=Master for 100 yr rain		7	2	14			4	3	12			5	2	10			4	5	20	
		Sandwich Street - Combined Sewer		7	6	**42**	42=5 yr & 100 yr rainfall; mdt sfc flooding		7	6	**42**			4	4	16			5	3	15			4	6	24	
		Interceptor Maintenance Holes (MH)		7	5	35			7	3	21			4	7	28			5	7	35			4	7	28	
		Sanitary Sewers		7	5	35			7	4	28			4	7	28			5	7	35	Location specific		4	7	28	
		Maintenance Covers		7	2	14			7	2	14			4	7	28			5	7	35	Location specific		4	7	28	
		Pump Stations		7	5	35			7	4	28			4	7	28			5	7	35	Location specific		4	7	28	
		Pump station - Prospect Ave		7	6	**42**	42=Most high water levels (<< 100 year event), power from street light, outfall higher than ditch		7	2	14			4	7	28			5	6	30			4	7	28	
		Pump Station - McKee Road		7	6	**42**	42=<100 yr HWL; extreme rain; backflow during HWL. Street flooding		7	3	21			4	7	28			5	6	30			4	7	28	
	Stormwater System Assets	Open drainage channels		7	4	28			7	2	14			4	7	28			5	7	35			4	6	24	
	Stormwater System Assets	Storm Sewers		7	5	35			7	2	14			4	7	28			5	7	35			4	6	24	
	Stormwater System Assets	**Brock Street Outfall**		7	5	**35**	35_=significant shoreline erosion		7	2	14			4	6	24			5	5	25			4	7	28	
	Stormwater System Assets	Maintenance holes		7	5	35			7	2	14			4	7	28			5	7	35			4	6	24	
	Stormwater System Assets	Catch Basins		7	5	35			7	2	14			4	7	28			5	7	35			4	6	24	
	Stormwater System Assets	McKee Creek catch basin		7	7	**49**	42 = <100 yr HWL & extreme rain; submerged HWK & surcharged extreme rain		7	3	21			4	7	28			5	6	30			4	7	28	
	Stormwater System Assets	Drains		7	5	35			7	2	14			4	7	28			5	7	35			4	6	24	
	Stormwater System Assets	Culverts		7	5	35			7	2	14			4	7	28			5	7	35			4	6	24	
		Outfall for Lou Romano Water Reclamation Plant (LRWRP)		7	6	**42**	42=<100 year HWL, combined river level+wave/freeboard		7	3	21			4	7	28			5	6	30			4	6	24	
		Mill St - Outfall, CS & catchment basin		7	6	**42**	42=<100 year HWL, combined river level or wave/freeboard		7	3	21			4	7	28			5	6	30			4	6	24	
	Transportation	**Major Roadway - Ojibway Parkway**		7	6	**42**	42=100 year rain, outfall higher than ditch, floods right over		7	5	35			4	5	20			5	5	25			4	7	28	
	Transportation	**Road & Open Ditch - Prospect Ave**		7	6	**42**	42=100 year rain, outfall higher than ditch, floods right over		7	5	35			4	5	20			5	5	25			4	7	28	
	Transportation	Major Roadway - Riverside Drive		7	5	**35**			7	2	14			4	3	12			5	2	10			4	7	28	
	Transportation	Major Roadway - Sandwich Street		7	6	**42**			7	6	**42**			4	4	16			5	3	15			4	7	28	
	Transportation	**Ambassador Bridge/Huron-Church catch basin, outfall, weir**		7	7	**49**	42=extreme rain with <<100 yr HWL; 100 yr rain; 5 yr rain		7	5	35			4	6	24			5	6	30			4	6	24	
	Transportation	**ETR rail and Gore Creek**		7	6	**42**	42 =extreme rain and HWL; Gore Ck flooding across Sandwich St, ETR rail and siding		7	3	21			4	6	24			5	5	25			4	6	24	
	Transportation	**ETR rail and McKee Creek**		7	6	**42**	49=extreme rain and HWL; Road flooding, flagged by City		7	3	21			4	6	24			5	5	25			4	6	24	
	Transportation	**Rail Tracks**		7	3	21	Max 35=combination events		7	2	14			4	6	24			5	5	25			4	7	28	
	Institutional Buildings	St Michael's Adult Secondary School		7	3	21			7	2	14			4	5	20			5	5	25			4	6	24	
	Institutional Buildings	Duff - Baby House (museum)		7	3	21			7	2	14			4	5	20			5	5	25			4	5	20	
	Institutional Buildings	**Canada South Science City - Tourist Attraction**		7	6	42	Max 35=due 100yr & 5yr rain; high HGL		7	5	**35**			4	5	20			5	4	20			4	7	28	
	Institutional Buildings	**West Windsor Musallah - Mosque**		7	7	49	Max 42= 100 yr or 5yr rain & combination; High HGL		7	6	**42**			4	5	20			5	4	20			4	7	28	
	Institutional Buildings	Windsor Essex Community Health - Community Centre		7	3	21			7	2	14			4	4	16			5	4	20			4	4	16	
	Institutional Buildings	**Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre**		7	7	49	Max **49**=100 yr or 5yr rain & combination; sig bsmt flood -		7	7	**49**			4	6	24			5	6	30			4	7	28	

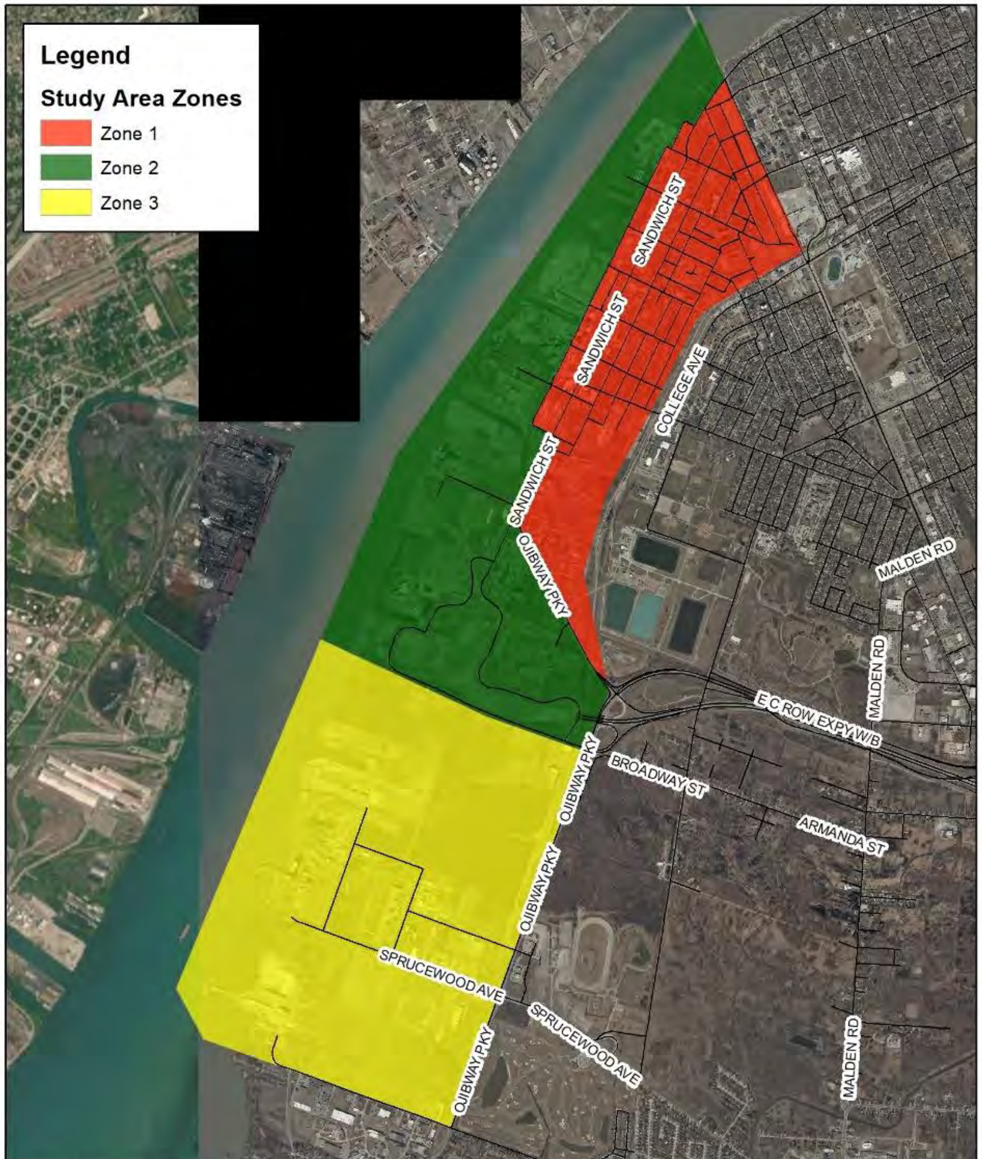
Infrastructure Components	6 Combination Events: Current 100 yr HWL + Moderate Rainfall (5-year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	7 Combination Events: Climate Chg HWL + extreme rainfall (100 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	8 Combination Events: Climate Chg HWL + moderate rainfall (5 year storm)				Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	9 Combination Events: HWL + wave action (freeboard)				Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	10 Secondary Impact Events: Major ice storm - 28mm or more				Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
Part 1 - Zone 1																									
Felix Avenue - Combined sewer		5	7	35			4	7	28			4	7	28			7	4	28			4	3	12	
Mill St - combined sewer		5	6	30			4	6	24			4	6	24			7	4	28			4	3	12	
Riverside Dr - combined sewer		5	4	20			4	5	20			4	4	16			7	4	28			4	3	12	
Interceptor Maintenance Holes (MH)		5	7	35			4	7	28			4	7	28			7	N/A				4	3	12	
Sanitary Sewers		5	7	35			4	7	28			4	7	28			7	N/A				4	3		
Maintenance Covers		5	7	35			4	7	28			4	7	28			7	N/A				4	4	16	
Pump Stations		5	7	35			4	7	28			4	7	28			7	N/A				4	4	16	
Lou Romano Water Reclamation Plant (LRWRP): Inflow from Western Trunk line specifically (for much less than 100 year year river level)		5	7	35			4	7	28			4	7	28			7	7	**49**			4	4	16	
Lou Romano Water Reclamation Plant (LRWRP) - Note for much less than 100 year river levels		5	7	35			4	7	28			4	7	28			7	7	**49**			4	4	16	
Open drainage channels		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	5	20	
Russel Street - open channel drainage		5	3	15	worst case- specific sites		4	6	24	worst case- specific sites		4	3	12	worst case- specific sites		7	3	21			4	2	8	
Storm Sewers		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	2	8	
Outfalls		5	7	35	worst case- specific sites		4	6	24	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	2	8	
Maintenance holes		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	4	16	
Catch Basins		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	5	20	
Drains		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	4	16	
Culverts		5	7	35	worst case- specific sites		4	7	28	worst case- specific sites		4	7	28	worst case- specific sites		7	N/A				4	5	20	
Major Roadway - Felix Avenue		5	6	30			4	7	28			4	7	28			7	5	35			4	3	12	
Major Roadway - Huron Church Road		5	3	15			4	5	20			4	4	16			7	N/A				4	2	8	
Major Roadway - Mill Street		5	3	15			4	6	24			4	4	16			7	5	35			4	2	8	
Major Roadway - Ojibway Parkway		5	3	15			4	4	16			4	3	12			7	3	21			4	3	12	
Major Roadway - Prince Road		5	3	15			4	5	20			4	4	16			7	3	21			4	2	8	
Major Roadway - Riverside Drive		5	4	20			4	5	20			4	4	16			7	5	35			4	3	12	
Major Roadway - Sandwich Street		5	5	25			4	7	28			4	6	24			7	4	28			4	3	12	
Major Roadway - University Avenue		5	4	20			4	5	20			4	4	16			7	N/A				4	3	12	
Major Roadway - Wyandotte Street W		5	4	20			4	5	20			4	4	16			7	N/A				4	3	12	
Ambassador Bridge/Canadian Border Services		5	6	30			4	7	28			4	5	20			7	5	35			4	5	20	
Rail Tracks		5	6	30			4	7	28			4	6	24			7	7	**49**			4	3	12	
St Michael's Adult Secondary School		5	5	25			4	6	24			4	6	24			7	N/A				4	4	16	
Duff - Baby House (museum)		5	5	25			4	5	20			4	5	20			7	N/A				4	4	16	
Canada South Science City - Tourist Attraction		5	6	30			4	7	28	severity = 6 vs 5 for xtrm rain alone		4	7	28			7	5	35			4	3	12	
West Windsor Musallah - Mosque		5	6	30			4	7	28			4	7	28			7	4	28			4	3	12	
Windsor Essex Community Health - Community Centre		5	4	20			4	4	16			4	4	16			7	N/A				4	5	20	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		5	7	35			4	7	28			4	7	28			7	N/A				4	5	20	
Mackenzie Hall Cultural Centre		5	4	20			4	4	16			4	4	16			7	N/A				4	4	16	
St John's Anglican Church - historic site		5	4	20			4	4	16			4	4	16			7	N/A				4	4	16	
Islamic Academy Windsor		5	6	30			4	7	28			4	7	28			7	4	28			4	3	12	
Society of St Vincent de Paul		5	6	30			4	7	28			4	7	28			7	4	28			4	3	12	
General Brock Public School		5	5	25			4	6	24			4	7	28			7	4	28			4	4	16	
Sandwich Teen Action Group		5	6	30			4	7	28			4	7	28			7	4	28			4	3	12	
Sandwich First Baptist Church		5	5	25			4	5	20			4	5				7	3	21			4	3	12	
Great Lakes Institute for Environmental Studies (U of Windsor)		5	3	15			4	6	24			4	3	12			7	5	**35**			4	3	12	
HMCS Hunter Navy Facility		5	5	25			4	6	24			4	5	20			7	5	**35**			4	5	20	
Paterson Park		5	2	10			4	5	20			4	2	8			7	3	21			4	3	12	
Bradley Park		5	2	10			4	2	8			4	2	8			7	1	7			4	3	12	
Mackenzie Hall Park		5	2	10			4	2	8			4	2	8			7	1	7			4	3	12	
Overhead electrical distribution		5	2	10			4	2	8			4	2	8			7	1	7			4	5	20	
Sub-grade vaults and/or transformers		5	6	30			4	7	28			4	3	12			7	4	28			4	5	20	
Telecommunication		5	3	15			4	4	16			4	2	8			7	2	14			4	5	20	
See Part 4		5	6	30			4	7	28			4	6	24											
Commercial Buildings - See Part 4			N/A				4	N/A					N/A												
Sterling Fuels - Office and tank farm E of Russel St		5	4	20			4	6	24			4	5	20			7	3	21			4	5	20	
Other Industrial Buildings - See Part 4																									
Part 2 - Zone 2																									
Ojibway Parkway - Combined Sewer		5	3	15			4	5	20			4	3	12			7	1	7			4	2	8	
Riverside Dr - Combined Sewer		5	3	15			4	5	20			4	3	12			7	1	7			4	2	8	
Sandwich Street - Combined Sewer		5	6	30			4	7	28			4	6	24			7	2	14			4	3	12	
Interceptor Maintenance Holes (MH)		5	7	35			4	7	28			4	7	28			7	N/A				4	3	12	
Sanitary Sewers		5	7	35			4	7	28			4	7	28			7	N/A		Location specific		4	3	12	
Maintenance Covers		5	7	35			4	7	28			4	7	28			7	N/A		Location specific		4	4	16	
Pump Stations		5	7	35			4	7	28			4	7	28			7	N/A		Location specific		4	4	16	
Pump station - Prospect Ave		5	7	35			4	7	28			4	7	28			7	5	35			4	5	20	
Pump Station - McKee Road		5	6	30			4	7	28			4	7	28			7	5	35			4	5	20	
Open drainage channels		5	7	35			4	7	28			4	7	28			7	N/A		Location specific		4	5	20	
Storm Sewers		5	7	35			4	7	28			4	7	28			7	N/A		Location specific		4	2	8	
Brock Street Outfall		5	6	30			4	7	28			4	6	24			7	4	28			4	2	8	
Maintenance holes		5	7	35			4	7	28			4	7	28			7	N/A				4	4	16	
Catch Basins		5	7	35			4	7	28			4	7	28			7	N/A				4	5	20	
McKee Creek catch basin		5	5	25			4	7	28			4	6	24			7	5	**35**			4	2	8	
Drains		5	7	35			4	7	28			4	**7**	28			7	**N/A**				4	**4**	16	
Culverts		5	7	35			4	7	28			4	7	28			7	N/A				4	5	20	
Outfall for Lou Romano Water Reclamation Plant (LRWRP)		5	6	30			4	7	28			4	7	28			7	5	35			4	3	12	
Mill St - Outfall, CS & catchment basin		5	6	30			4	7	28			4	7	28			7	6	**42**			4	3	12	
Major Roadway - Ojibway Parkway		5	5	25			4	7	28			4	5	20			7	4	28			4	4	16	
Road & Open Ditch - Prospect Ave		5	5	25			4	7	28			4	5	20			7	4	28			4	4	16	
Major Roadway - Riverside Drive		5	3	15			4	5	**20**			4	3	12			7	2	14			4	2	8	
Major Roadway - Sandwich Street		5	6	30			4	7	28			4	6	24			7	2	14			4	3	12	debris generation
Ambassador Bridge/Huron-Church catch basin, outfall, weir		5	6	30			4	7	28			4	6	24			7	6	**42**			4	4	16	
ETR rail and Gore Creek		5	5	25			4	7	28			4	6	24			7	6	**42**			4	3	12	
ETR rail and McKee Creek		5	5	25			4	7	28			4	6	24			7	5	35			4	2	8	
Rail Tracks		5	6	30			4	7	28			4	6	24			7	5	**35**			4	3	12	
St Michael's Adult Secondary School		5	5	25			4	6	24			4	5	20			7	N/A				4	4	16	
Duff - Baby House (museum)		5	5	25			4	5	20			4	5	20			7	N/A				4	4	16	
Canada South Science City - Tourist Attraction		5	6	30			4	7	28			4	7	28			7	5	**35**			4	3	12	
West Windsor Musallah - Mosque		5	6	30			4	7	28			4	7	28			7	4	28			4	3	12	
Windsor Essex Community Health - Community Centre		5	4	20			4	4	16			4	4	16			7	N/A				4	5	20	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		5	7	35			4	7	28			4	7	28			7	N/A				4	5	20	

Infrastructure Components	11 Secondary Impact Events: Extreme Wind Event - 120 km/h				debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	12 Secondary Impact Events: Tornado - (E)F2+				debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	13 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - total cycles					14 Secondary Impact Events: Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments				
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
Part 1 - Zone 1																				
Felix Avenue - Combined sewer		7	3	21			2	5	10			7	3	21			7	3	21	
Mill St - combined sewer		7	3	21			2	5	10			7	3	21			7	3	21	
Riverside Dr - combined sewer		7	3	21			2	5	10			7	3	21			7	3	21	
Interceptor Maintenance Holes (MH)		7	3	21			2	5	10			7	1	7			7	1	7	
Sanitary Sewers		7	3	21			2	4	8			7	1	7			7	1	7	
Maintenance Covers		7	2	14			2	5	10			7	3	21			7	3	21	
Pump Stations		7	4	28			2	5	10			7	1	7			7	1	7	
Lou Romano Water Reclamation Plant (LRWRP): Inflow from Western Trunk line specifically (for much less than 100 year year river level)		7	4	28			2	7	14			7	2	14			7	2	14	
Lou Romano Water Reclamation Plant (LRWRP) - Note for much less than 100 year river levels		7	4	28			2	7	14			7	2	14			7	2	14	
Open drainage channels		7	5	35			2	7	14			7	2	14			7	2	14	
Russel Street - open channel drainage		7	3	21			2	5	10			7	2	14			7	2	14	
Storm Sewers		7	3	21			2	5	10			7	2	14			7	2	14	
Outfalls		7	3	21			2	5	10			7	2	14			7	2	14	
Maintenance holes		7	4	28			2	6	12			7	2	14			7	2	14	
Catch Basins		7	5	35			2	7	14			7	2	14			7	2	14	
Drains		7	4	28			2	5	10			7	2	14			7	2	14	
Culverts		7	5	35			2	6	12			7	3	21			7	3	21	
Major Roadway - Felix Avenue		7	3	21			2	6	12			7	2	14			7	2	14	
Major Roadway - Huron Church Road		7	2	14			2	6	12			7	2	14			7	2	14	
Major Roadway - Mill Street		7	2	14			2	6	12			7	2	14			7	2	14	
Major Roadway - Ojibway Parkway		7	3	21			2	7	14			7	2	14			7	2	14	
Major Roadway - Prince Road		7	2	14			2	6	12			7	2	14			7	2	14	
Major Roadway - Riverside Drive		7	3	21			2	7	14			7	2	14			7	2	14	
Major Roadway - Sandwich Street		7	4	28			2	7	14			7	2	14			7	2	14	
Major Roadway - University Avenue		7	3	21			2	7	14			7					7			
Major Roadway - Wyandotte Street W		7	3	21			2	7	14			7					7			
Ambassador Bridge/Canadian Border Services		7	5	35			2	7	14			7	2	14			7	2	14	
Rail Tracks		7	3	21			2	3	6			7	2	14			7	2	14	
St Michael's Adult Secondary School		7	4	28			2	7	14			7	2	14			7	2	14	
Duff - Baby House (museum)		7	4	28			2	7	14			7	2	14			7	2	14	
Canada South Science City - Tourist Attraction		7	4	28			2	7	14			7	2	14			7	2	14	
West Windsor Musallah - Mosque		7	4	28			2	7	14			7	2	14			7	2	14	
Windsor Essex Community Health - Community Centre		7	5	35			2	7	14			7	2	14			7	2	14	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		7	5	35			2	7	14			7	2	14			7	2	14	
Mackenzie Hall Cultural Centre		7	4	28			2	7	14			7	2	14			7	2	14	
St John's Anglican Church - historic site		7	4	28			2	7	14			7	2	14			7	2	14	
Islamic Academy Windsor		7	4	28			2	7	14			7	2	14			7	2	14	
Society of St Vincent de Paul		7	4	28			2	7	14			7	2	14			7	2	14	
General Brock Public School		7	4	28			2	7	14			7	2	14			7	2	14	
Sandwich Teen Action Group		7	4	28			2	7	14			7	2	14			7	2	14	
Sandwich First Baptist Church		7	3	21			2	7	14			7	2	14			7	2	14	
Great Lakes Institute for Environmental Studies (U of Windsor)		7	4	28			2	7	14			7	2	14			7	2	14	
HMCS Hunter Navy Facility		7	4	28			2	7	14			7	3	21			7	3	21	
Paterson Park		7	4	28			2	6	12			7	2	14			7	2	14	
Bradley Park		7	4	28			2	6	12			7	2	14			7	2	14	
Mackenzie Hall Park		7	4	28			2	6	12			7	2	14			7	2	14	
Overhead electrical distribution		7	5	**35**			2	7	14			7	2	14			7	2	14	
Sub-grade vaults and/or transformers		7	4	28			2	5	10			7	2	14			7	2	14	
Telecommunication		7	5	**35**			2	7	14			7	2	14			7	2	14	
See Part 4																				
Commercial Buildings - See Part 4		7	4	28			2	6	12											
Sterling Fuels - Office and tank farm E of Russel St		7	4	28			2	7	14			7	2	14			7	2	14	
Other Industrial Buildings - See Part 4																				
Part 2 - Zone 2																				
Ojibway Parkway - Combined Sewer		7	2	14			2	6	12			7	2	14			7	2	14	
Riverside Dr - Combined Sewer		7	2	14			2	6	12			7	2	14			7	2	14	
Sandwich Street - Combined Sewer		7	4	28			2	5	10			7	2	14			7	2	14	
Interceptor Maintenance Holes (MH)		7	3	21			2	5	10			7	1	7			7	1	7	
Sanitary Sewers		7	3	21			2	4	8			7	1	7			7	1	7	
Maintenance Covers		7	2	14			2	5	10			7	3	21			7	3	21	
Pump Stations		7	4	28			2	5	10			7	1	7			7	1	7	
Pump station - Prospect Ave		7	5	35			2	7	14			7	2	14			7	2	14	
Pump Station - McKee Road		7	5	35			2	7	14			7	2	14			7	2	14	
Open drainage channels		7	5	35			2	7	14			7	3	21			7	3	21	
Storm Sewers		7	3	21			2	7	14			7	2	14			7	2	14	
Brock Street Outfall		7	2	14			2	6	12			7	3	21			7	3	21	
Maintenance holes		7	3	21			2	6	12			7	2	14			7	2	14	
Catch Basins		7	5	35			2	7	14			7	2	14			7	2	14	
McKee Creek catch basin		7	2	14			2	6	12			7	2	14			7	2	14	
Drains		7	4	28			2	5	10			**7**	2	14			**7**	2	14	
Culverts		7	5	35			2	6	12			7	3	21			7	3	21	
Outfall for Lou Romano Water Reclamation Plant (LRWRP)		7	3	21			2	6	12			7	2	14			7	2	14	
Mill St - Outfall, CS & catchment basin		7	3	21			2	6	12			7	2	14			7	2	14	
Major Roadway - Ojibway Parkway		7	3	21			2	6	12			7	2	14			7	2	14	
Road & Open Ditch - Prospect Ave		7	3	21			2	6	12			7	2	14			7	2	14	
Major Roadway - Riverside Drive		7	2	14			2	6	12			7	2	14			7	2	14	
Major Roadway - Sandwich Street		7	4	28	debris generation; tree uprooting		2	5	10			7	2	14			7	2	14	
Ambassador Bridge/Huron-Church catch basin, outfall, weir		7	3	21			2	6	12			7	2	14			7	2	14	
ETR rail and Gore Creek		7	3	21			2	6	12			7	2	14			7	2	14	
ETR rail and McKee Creek		7	3	21			2	6	12			7	3	21			7	3	21	
Rail Tracks		7	3	21			2	3	6			7	2	14			7	2	14	
St Michael's Adult Secondary School		7	4	28			2	7	14			7	2	14			7	2	14	
Duff - Baby House (museum)		7	4	28			2	7	14			7	2	14			7	2	14	
Canada South Science City - Tourist Attraction		7	4	28			2	7	14			7	2	14			7	2	14	
West Windsor Musallah - Mosque		7	4	28			2	7	14			7	2	14			7	2	14	
Windsor Essex Community Health - Community Centre		7	5	35			2	7	14			7	2	14			7	2	14	
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre		7	5	35			2	7	14			7	2	14			7	2	14	

		1 Extreme Rainfall				2 Extreme Rainfall				3 Extreme River Levels				4 Extreme River Levels				5 Combination Events				6 Combination Events				7 Combination Events			
Infrastructure Class	Infrastructure Components	"Major" 100-yr Storm - 82mm in 4 hours (Peak rate of 145 mm/h)			Models storms 4-hour Chicago distribution based on peak rainfall rate	"Minor" 5-year Storm - 50mm in 4 hours (peak rate of 29.5 mm/hr)			Models storms 4-hour Chicago distribution based on peak rainfall rate	"Likely" CC HWL - 176.1 m			Adjusted HWL for our study - Based on HA's lit review and extensive group discussion	Current HWL - 175.9 m			Current 100 year level for Detroit River	Current 100 yr HWL + extreme rainfall (100 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	Current 100 yr HWL + Moderate Rainfall (5-year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	Climate Chg HWL + extreme rainfall (100 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check
	Mackenzie Hall Cultural Centre	7	3	21		7	2	14		4	4	16		5	4	20		4	4	16		5	4	20		4	4	16	
	St John's Anglican Church - historic site	7	3	21		7	2	14		4	4	16		5	4	20		4	4	16		5	4	20		4	4	16	
	Islamic Academy Windsor	7	6	**42**	Max 42= 5 & 100yr & combination	7	6	**42**		4	5	20		5	4	20		4	7	28		5	6	30		4	7	28	
	Society of St Vincent de Paul	7	6	**42**	Max 42= 5 & 100yr & combination	7	6	**42**		4	5	20		5	4	20		4	7	28		5	6	30		4	7	28	
	General Brock Public School	7	5	**35**	Max 35=5 & 100yr & combination	7	5	**35**		4	5	20		5	4	20		4	6	24		5	5	25		4	7	28	
	Sandwich Teen Action Group	7	6	**42**	Max 42=5 & 100yr & combination	7	6	**42**		4	5	20		5	4	20		4	7	28		5	6	30		4	7	28	
	Sandwich First Baptist Church	7	5	**35**	Max 30= due 100yr rain	7	3	21		4	2	8		5	2	10		4	5	20		5	3	15		4	5	20	
	Chateau Park LTC Centre	7	5	**35**	35=100 year rain; wind, waves	7	3	21		4	5	20		5	5	25		4	6	24		5	5	25		4	5	20	
	Great Lakes Institute for Environmental Studies (U of Windsor)	7	5	**35**	35=100 year rain; basement flooding; wind, waves	7	3	21		4	5	20		5	5	25		4	6	24		5	3	15		4	6	24	
	HMCS Hunter Navy Facility	7	4	28	42=<100 year HWL;erosion; WPA shoreline property, high occup building	7	2	14		4	7	28		5	6	30		4	6	24		5	6	30		4	7	28	
Park Assets	**McKee Park - Sandwich and Chewett Streets**	7	3	21	35= < 100 year HWL; shoreline flooding	7	2	14		4	5	20		5	5	25		4	5	20		5	5	25		4	5	20	
	Brock Park	7	4	28		7	2	14		4	4	16		5	3	15		4	4	16		5	4	20		4	5	20	
	Mill Park	7	4	28		7	2	14		4	2	8		5	2	10		4	2	8		5	2	10		4	2	8	
	Queen's Park	7	4	28		7	2	14		4	2	8		5	2	10		4	2	8		5	2	10		4	2	8	
	Chateau Park - Ambassador Bridge area	7	3	21	35=<100 year HWL; retaining wall submerged	7	1	7		4	6	24		5	5	25		4	5	20		5	5	25		4	6	24	
Energy and Communications Infrastructure	**JC Keith Transformer Station**	7	5	**35**	35=flooding w high HGLs; critical 3rd party infrastructure, further study	7	3	21		4	4	16		5	3	15		4	6	24		5	4	20		4	5	20	
	Overhead electrical distribution	7	3	21	Max 35= sensitive to wind, ice abv gnd; Also 100yr rain & HWL	7	2	14		4	2	8		5	1	5		4	3	12		5	2	10		4	2	8	
	Sub-grade vaults	7	7	**49**	Max 42= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		5	2	10		4	7	28		5	6	30		4	7	28	
	Sub-grade transformers	7	4	28	Max 35=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		4	4	16		5	3	15		4	4	16	
	Telecommunication	7	4	28	Max 35=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		4	4	16		5	3	15		4	4	16	
	Atura Power Brighton Beach Gen Station	7	7	**49**	49=Combined events, 100 year rain, 5 year rain; subgrade flooding due HGL, flooding to 0.3m	7	3	21		4	7	28		5	7	35		4	7	28		5	7	35		4	7	28	
Residenial Buildings	**Buildings - See Part 4**																												
Commercial Buildings	**Building - See Part 4**																												
Industrial Assets	Transpo/Trucking/Logistics - Van De Hogan Group (VG; trucking); Cole-Carriers Inc.; Stantec Trailers	7	3	21		7	1	7		4	3	12		5	2	10		4	4	16		5	2	10		4	4	16	
	Windsor Biosolids Processing Plant	7	7	**49**	42=combined prob event, extremes rainfall; flooding >1m	7	3	21		4	5	20		5	4	20		4	7	28		5	4	20		4	7	28	
	Windsor Salt - end of Prospect Ave	7	7	**49**	49=Master; erosion 100 year rain; combined prob	7	3	21		4	5	20		5	5	25		4	7	28		5	6	30		4	7	28	
	Newmak Windsor Aluminum Plant	7	4	28		7	2	14		4	2	8		5	2	10		4	4	16		5	2	10		4	4	16	
Part 3																													
Zone 3 - W of Ojibway Pkwy., N of Morten Dr. to Broadway St.																													
	Sprucewood Ave - Combined Sewer	7	7	**49**	49=Combined event; 100 year and 5 year rain; ~1m flooding all rain events; Sig HGL/surcharge	7	6	42		4	5	20		5	4	20		4	7	28		5	6	30		4	7	28	
	Sprucewood Ave - Open ditches	7	7	**49**	49 = Extreme 5 & 100 year rain; workshop participants indicated problem area	7	6	42		4	4	16		5	3	15		4	7	28		5	6	30		4	7	28	
	Maintenance Covers	7	2	14		7	2	14		4	7	28		5	7	35		4	7	28		5	7	35		4	7	28	
	Pump Stations	7	5	35		7	4	28		4	7	28		5	7	35		4	7	28		5	7	35		4	7	28	
	Open drainage channels	7	4	28		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Storm Sewers	7	5	35		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Outfalls	7	4	28		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Maintenance holes	7	5	35		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Catch Basins	7	5	35		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Drains	7	5	35		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
	Culverts	7	5	35		7	2	14		4	7	28		5	7	35		4	6	24		5	7	35		4	7	28	
Shoreline Stormwater/ Flood Protection Infrastructure	**CSOs**	7	5	35		7	4	28		4	6	24		5	5	25		4	7	28		5	5	25		4	7	28	
Transportation	**Major Roadway - Ojibway Parkway**	7	7	49	49=Combined prob events;100 year rain, 5 year rain; LOS for 63% road	7	5	35		4	2	8		5	2	10		4	4	16		5	2	10		4	4	16	
	Major Roadway - Sprucewood Avenue - open ditches	7	7	**49**	49=100 year & 5 year rain; adjacent to wetland; modelling	7	6	42		4	2	8		5	2	10		4	7	28		5	6	30		4	7	28	
	Detroit-Windsor Truck Ferry	7	7	**49**	49=100 year rain, 5 year rain, Combined prob event; 0.75-1m surface flooding, trade importance	7	6	42		4	3	12		5	2	10		4	7	28		5	6	30		4	7	28	
	Rail Tracks	7	7	**49**	49=100 year & 5 year rain;Combined events; mdt surface flooding for 100 year rain	7	5	35		4	2	8		5	2	10		4	6	24		5	5	25		4	6	24	
Park Assets	**Black Oak Heritage Park**	7	5	**35**	35=100 year rain & combined; Extreme wind, ice storm; sfc flooding >0.3m w 100 year rain	7	3	21		4	2	8		5	2	10		4	6	24		5	3	15		4	7	28	
Energy and Communications Infrastructure	**Overhead electrical distribution**	7	3	21	Max 30= sensitive to wind, ice abv gnd; Also 100yr rain & HWL below ground;	7	2	14		4	2	8		5	1	5		4	3	12		5	2	10		4	2	8	
	Sub-grade vaults	7	7	**49**	Max 28= due 100yr rain & HWL blo gnd; wind, ice abv gnd	7	2	14		4	5	20		5	2	10		4	7	28		5	6	30		4	7	**28**	
	Sub-grade transformers	7	4	28	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		4	4	16		5	3	15		4	4	16	
	Telecommunication	7	4	28	Max 30=due wind, ice abv gnd; Alao 100yr rain & HWL below gnd;	7	2	14		4	3	12		5	2	10		4	4	16		5	3	15		4	4	16	
Industrial Assets	**Shoreline Properties - Mortrem Ltd; ADM Windsor;**	7	5	35		7	3	21		4	3	12		5	2	10		4	6	24		5	4	20		4	6	24	
	Windsor Salt Mine - ditch entrance	7	7	**49**	49=HWL <100 yr; Combined prob; 100 year rain; 5 year rain	7	5	35		4	6	24		5	6	30		4	7	28		5	7	35		4	7	28	
	Windsor Salt Mine	6	7	42	49 = 5 & 100 year extreme rain; Combined probabilities; surface flooding 0.75->1m; extreme HGLs	7	5	35		4	6	24		5	6	30		2	7	14		4	6	24		4	7	28	
	Shoreline Protection - retaining walls, rip-rap	7	3	21		7	1	7		4	5	20		5	4	20		4	5	20		5	4	20		4	6	24	
Part 4																													
System-Wide Risks and Critical Third Party Services																													
System-Wide Assets	*Zone 1* Residential Areas serviced by combined sewers	7	7	**49**	42=Master for combined prob; 5 & 100 year rain (??)	7	6	**42**		4	5	20		5	4	20		4	7	28		5	6	30		4	7	28	
	Zone 1 Commercial Areas serviced by combined sewers	7	7	**49**	42=Combined prob; 5 & 100 year rain generally; Likely basement flooding; Surface flooding extreme rain	7	6	**42**		4	4	16		5	4	20		4	7	28		5	6	30		4	7	28	
	Zone 1 Industrial Buildings serviced by combined sewers	7	6	**42**	42=100 & 5 year rain; Mainly surface & basement flooding	7	6	**42**		4	4	16		5	3	15		4	7	28		5	6	30		4	7	28	
	Zone 2 Combined Sewer Outfalls	7	5	**35**	high river levels above 174.6m; blocked outfalls and back feeding into combined system; Lost sewer capacity for extreme rain	7	3	21		4	7	28		5	6	30		4	7	28		5	6	30		4	7	28	
	Zone 2 Residential Areas serviced by combined sewers	7	7	**49**	49 = Heavy rainfalls; Surface flooding >1m; Potential basement flooding	7	7	**49**		4	4	16		5	3	15		4	7	28		5	4	20		4	7	28	
	Zone 2 Commercial Areas serviced by combined sewers	7	7	**49**	49 = Heavy rainfall; Surface flooding >1m	7	6	**42**		4	2	8		5	2	10		4	7	28		5	6	30		4	7	28	
	Loss of Electrical Power Delivery - Pumps	7	4	28	delivery; Any assets below-grade (water intrusion); Power assets in Zone 2 flagged for further study	7	2	14		4	2	8		5	2	10		4	5	20		5	3	15		4	6	24	
	Loss of Comumunications - equipment monitoring	7	4	28	35=Events giving damage to telephone lines; Below grade assets; Loss of pump monitoring	7	3	21		4	2	8		5	2	10		4	5	20		5	3	15		4	6	24	
	Surface drainage and surface transportation (emergency response)	7	5	35	Max 35 = any wind >102 kph gusts or other damaging event affecting emergency response; Debris generation	7	3	21		4	2	8		5	2	10		4	5	20		5	3	15		4	5	20	
	Pad mounted electrical	7	7	**49**	49= 100 year rainfall event; Extremely sensitive to surface flooding < 1m or more in depth; potential public safety risk	7	1	7		4	1	4		5	1	5		4	7	28		5	2	10		4	7	28	

		8 Combination Events				9 Combination Events				10 Secondary Impact Events				11 Secondary Impact Events				12 Secondary Impact Events				13 Secondary Impact Events				14 Secondary Impact Events			
Infrastructure Class	Infrastructure Components	Climate Chg HWL + moderate rainfall (5 year storm)			Combined probability event modeling results. Currently based on stat independent mult. - Need stat dependence check	HWL + wave action (freeboard)			Case Studies (from HIRA): November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019	Major ice storm - 28mm or more			Multi-day loss of power - CSA Overhead Design 100 year event - between reliability 1 and 2	Extreme Wind Event - 120 km/h			debris generation, loss of site access, damage to above-ground infrastructure (plant, pump houses)	Tornado - (E)F2+			debris generation, loss of site access, severe damage to above-ground infrastructure (plant, pump houses)	Weathering (freeze thaw) - Concrete and masonry impacts - total cycles				Weathering (freeze thaw) - Concrete and masonry impacts - 30-cycle increments			
	Mackenzie Hall Cultural Centre	4	4	16		7	N/A			4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	St John's Anglican Church - historic site	4	4	16		7	N/A			4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Islamic Academy Windsor	4	6	24		7	4	28		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	Society of St Vincent de Paul	4	6	24		7	4	28		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	General Brock Public School	4	5	20		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Sandwich Teen Action Group	4	6	24		7	4	28		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	Sandwich First Baptist Church	4	3	12		7	3	21		4	3	12		7	3	21		2	7	14		7	2	14		7	2	14	
	Chateau Park LTC Centre	4	5	20		7	3	21		4	5	20		7	5	**35**		2	7	14		7	3	21		7	3	21	
	Great Lakes Institute for Environmental Studies (U of Windsor)	4	3	12		7	5	**35**		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	HMCS Hunter Navy Facility	4	7	28		7	5	**35**		4	3	12		7	5	**35**		2	7	14		7	3	21		7	3	21	
Park Assets	**McKee Park - Sandwich and Chewett Streets**	4	5	20		7	5	**35**		4	2	8		7	2	14		2	7	14		7	3	21		7	3	21	
	Brock Park	4	5	20		7	4	28		4	2	8		7	3	21		2	6	12		7	3	21		7	3	21	
	Mill Park	4	2	8		7	2	14		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Queen's Park	4	2	8		7	2	14		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Chateau Park - Ambassador Bridge area	4	6	24		7	5	**35**		4	2	8		7	2	14		2	5	10		7	3	21		7	3	21	
Energy and Communications Infrastructure	**JC Keith Transformer Station**	4	4	16		7	3	21		4	5	20		7	3	21		2	6	12		7	2	14		7	2	14	
	Overhead electrical distribution	4	2	8		7	1	7		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	4	3	12		7	4	28		4	5	20		7	4	28		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	4	2	8		7	2	14		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Telecommunication	4	2	8		7	2	14		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Atura Power Brighton Beach Gen Station	4	7	28		7	7	**49**		4	6	24		7	5	35		2	6	12		7	2	14		7	2	14	
Residenial Buildings	**Buildings - See Part 4**																												
Commercial Buildings	**Building - See Part 4**																												
Industrial Assets	Transpo/Trucking/Logistics - Van De Hogan Group (VG; trucking); Cole-Carriers Inc.; Stantec Trailers	4	2	8		7	1	7		4	4	16		7	4	28		2	6	12		7	1	7		7	1	7	
	Windsor Biosolids Processing Plant	4	5	20		7	5	35		4	3	12		7	3	21		2	7	14		7	2	14		7	2	14	
	Windsor Salt - end of Prospect Ave	4	5	20		7	6	42		4	3	12		7	4	28		2	7	14		7	2	14		7	2	14	
	Newmak Windsor Aluminum Plant	4	2	8		7	2	14		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
Part 3																													
Zone 3 - W of Ojibway Pkwy., N of Morten Dr. to Broadway St.																													
	Sprucewood Ave - Combined Sewer	4	6	24		7	5	35		4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
	Sprucewood Ave - Open ditches	4	6	24		7	4	28		4	3	12		7	3	21		2	6	12		7	3	21		7	3	21	
	Maintenance Covers	4	7	28		7	N/A		Location specific	4	4	16		7	2	14		2	5	10		7	3	21		7	3	21	
	Pump Stations	4	7	28		7	N/A		Location specific	4	5	20	power outages	7	5	35	power outages, debris	2	5	10		7	1	7		7	1	7	
	Open drainage channels	4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	7	14		7	3	21		7	3	21	
	Storm Sewers	4	7	28		7	N/A		Location specific	4	2	8		7	3	21		2	5	10		7	2	14		7	2	14	
	Outfalls	4	7	28		7	N/A		Location specific	4	2	8		7	2	14		2	3	6		7	2	14		7	2	14	
	Maintenance holes	4	7	28		7	N/A		Location specific	4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
	Catch Basins	4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	7	14		7	2	14		7	2	14	
	Drains	4	7	28		7	N/A		Location specific	4	4	16		7	4	28		2	5	10		7	2	14		7	2	14	
	Culverts	4	7	28		7	N/A		Location specific	4	5	20		7	5	35		2	6	12		7	3	21		7	3	21	
Shoreline Stormwater/ Flood Protection Infrastructure	**CSOs**	4	6	24		7	N/A		Location specific	4	4	16		7	4	28		2	5	10		7	3	21		7	3	21	
Transportation	**Major Roadway - Ojibway Parkway**	4	2	8		7	2	14		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Major Roadway - Sprucewood Avenue - open ditches	4	6	24		7	2	14		4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
	Detroit-Windsor Truck Ferry	4	6	24		7	5	35		4	5	20		7	5	35		2	6	12		7	2	14		7	2	14	
	Rail Tracks	4	5	20		7	2	14		4	4	16		7	3	21		2	6	12		7	2	14		7	2	14	
Park Assets	**Black Oak Heritage Park**	4	4	16		7	3	21		4	4	16		7	5	**35**		2	5	10		7	2	14		7	2	14	
Energy and Communications Infrastructure	**Overhead electrical distribution**	4	2	8		7	1	7		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Sub-grade vaults	4	3	12		7	4	28		4	5	20		7	4	28		2	5	10		7	2	14		7	2	14	
	Sub-grade transformers	4	2	8		7	2	14		4	4	16		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Telecommunication	4	2	8		7	2	14		4	4	16		7	5	**35**		2	7	14		7	2	14		7	2	14	
Industrial Assets	**Shoreline Properties - Mortrem Ltd; ADM Windsor;**	4	5	20		7	4	28		4	4	16		7	4	28		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine - ditch entrance	4	7	28		7	7	**49**		4	2	8		7	2	14		2	6	12		7	2	14		7	2	14	
	Windsor Salt Mine	4	7	28		7	7	**49**		4	2	8		7	4	28		2	6	12		7	2	14		7	2	14	
	Shoreline Protection - retaining walls, rip-rap	4	5	20		7	4	28		4	2	8		7	3	21		2	5	10		7	3	21		7	3	21	
Part 4																													
System-Wide Risks and Critical Third Party Services																													
System-Wide Assets	*Zone 1* Residential Areas serviced by combined sewers	4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 1 Commercial Areas serviced by combined sewers	4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 1 Industrial Buildings serviced by combined sewers	4	6	24		7	4	28		4	4	16		7	4	28		2	7	14		7	2	14		7	2	14	
	Zone 2 Combined Sewer Outfalls	4	6	24		7	5	**35**		4	2	8		7	3	21		2	5	10		7	3	21		7	3	21	
	Zone 2 Residential Areas serviced by combined sewers	4	7	28		7	3	21		4	5	20		7	5	35		2	6	12		7	2	14		7	2	14	
	Zone 2 Commercial Areas serviced by combined sewers	4	6	24		7	3	21		4	2	8		7	3	21		2	6	12		7	2	14		7	2	14	
	Loss of Electrical Power Delivery - Pumps	4	3	12		7	3	21		4	6	24		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Loss of Comumunications - equipment monitoring	4	3	12		7	3	21		4	5	20		7	5	**35**		2	7	14		7	2	14		7	2	14	
	Surface drainage and surface transportation (emergency response)	4	3	12		7	3	21		4	6	24		7	5	**35**		2	7	14		7	1	7		7	1	7	
	Pad mounted electrical	4	2	8		7	2	14		4	4	16		7	2	14		2	7	14		7	2	14		7	2	14	

Zones 1, 2 and 3 for the West Windsor Study Region



Name	Area	Residential		Industrial		Commercial		Institutional		Green District		Other	
	(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Zone 1	158	73	46%	51	32%	7	4%	13	8%	2	1%	12	8%
Zone 2	249	5	2%	234	94%	4	2%	1	0%	2	1%	4	1%
Zone 3	397	-	0%	302	76%	-	0%	-	0%	93	23%	3	1%

ZONE 1: Priority Assets at Risk and Proposed Short-Term and Long-Term Solutions.

Climate risks are identified as due to surface flooding, high Detroit River Levels, basement flooding (combined sewers) and/or erosion.

Short-term solutions (to 5 years) and longer-term solutions are proposed for each high risk issue linked to flooding.

ZONE 2: Priority Assets at Risk and Proposed Short-Term and Long-Term Solutions.

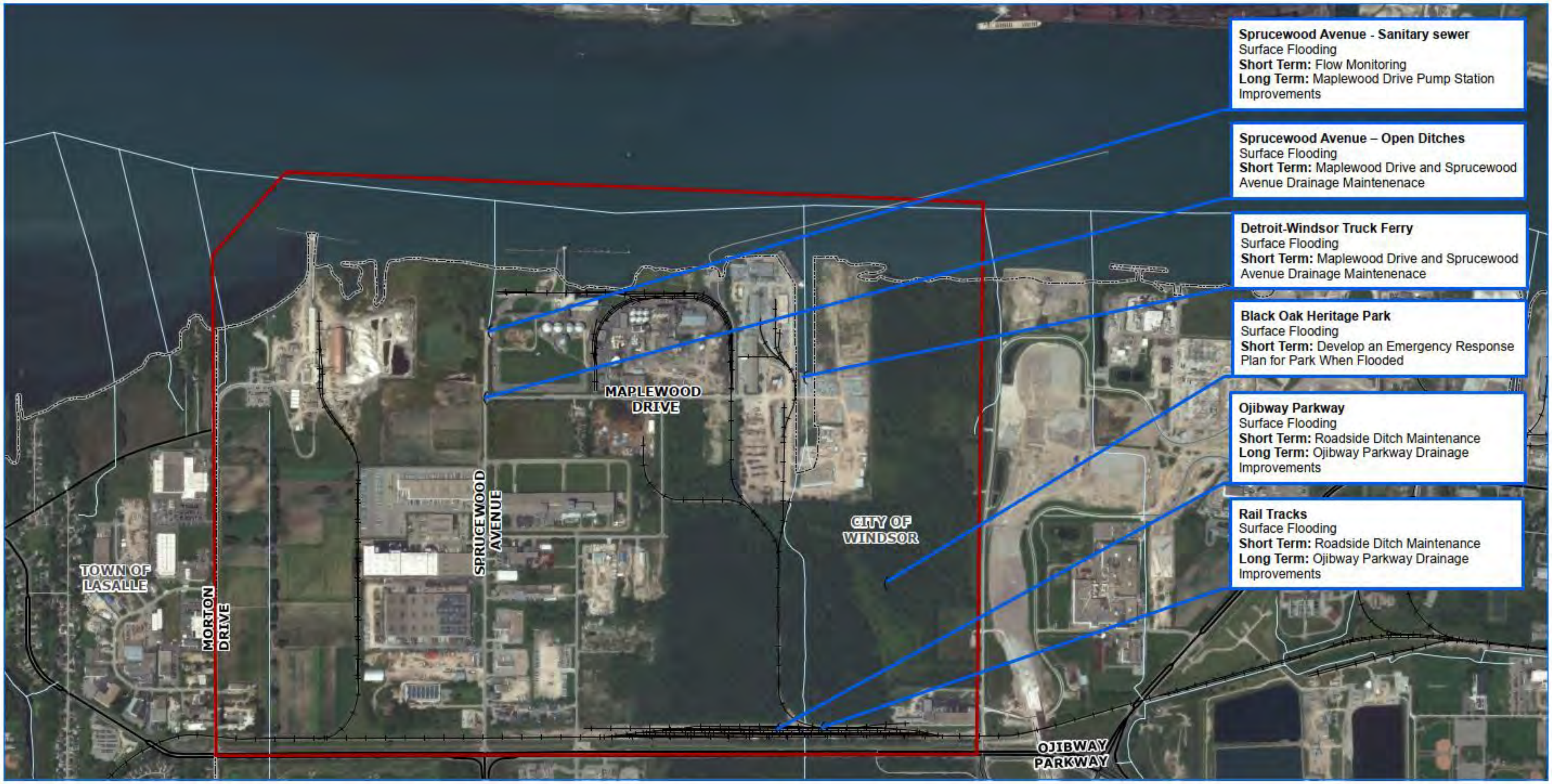
Climate risks are identified as due to surface flooding, high Detroit River Levels, basement flooding (combined sewers) and/or erosion.

Short-term solutions (to 5 years) and longer-term solutions are proposed for each high risk issue linked to flooding.

ZONE 3: Priority Assets at Risk and Proposed Short-Term and Long-Term Solutions.

Climate risks are identified as due to surface flooding, high Detroit River Levels, basement flooding (combined sewers) and/or erosion.

Short-term solutions (to 5 years) and longer-term solutions are proposed for each high risk issue linked to flooding.



<u>West Windsor Study Area</u>:
Summary of Medium and High Risks for Sites and Infrastructure Components

Risk Level (and corresponding scores)	
Low (<21)	
Medium (21-30)	(yellow)
High (31-42)	(red)
Extremely High or Potentially Life Threatening (>42)	(dark red)

Infrastructure Component	Climate Hazard	Potential Impact	Current	2050s	2080s
Zone 1					
Lou Romano Water Reclamation Plant – Inflow from Western Trunk line specifically	Combined probability events << 100 year river level	*Excess inflow results in need to throttle gates; complete closure of gates rapidly results in extensive 3rd party (res./commercial) basement flooding (Ed Valdez); main sources of excessive flow, with LaSalle and Riverside considered 2nd and 3rd (Phong Nguy, City of Windsor); "our issue is... Western Trunk" (Roberta Harrison, City of Windsor)*	**49**	**49**	**49**
Lou Romano Water Reclamation Plant	High River Levels - << 100 year river level	*Blockage of main outfall, backflow into plant (incl. fish) resulting in treatment of river water; loss of outflow capacity for high flow events*	**49**	**49**	**49**
Russell Street - open channel drainage	Extreme rainfall	*Ditches filled completely during heavy rainfall*	24	**36**	**42**
Sandwich Street	Combined probability event; Extreme rainfall- “100 year” storm	*high HGL, moderate (0.3-0.5 m) surface ponding*	**35**	**36**	**42**
Ambassador Bridge - Entrance/onramp	Combined probability event; Extreme rainfall- “100 year” storm	*surface flooding and excess HGL - note this is just outside of Zone 1 but is included due to criticality of asset*	**35**	**36**	**42**
Felix Ave. - combined sewer	Combined probability event	*Excessive HGL - fails 5-year design storm criteria*	**35**	**36**	**42**

Mills St. – Combined sewer	Extreme Rainfall – "100 year" event	*Excessive HGLs (above surface for 100 year event), failure of LOS requirements*	**24**	**36**	**42**
Riverside Dr. – Combined sewer	Extreme Rainfall – "100 year" event	*Excessive HGLs (above surface for 100 year event), failure of LOS requirements*	**21**	**30**	**35**
Canada South Science City	Extreme Rainfall – "100 year" and "5 year" events	*potential basement flooding (High HGL)*	**35**	**36**	**42**
West Windsor Mosque	Combined probability event; Extreme Rainfall "100 year" event; Heavy rainfall "5 year" event	*potential basement flooding (High HGL)*	**42**	**42**	**49**
Islamic Academy/St Vincent de Paul Society/Sandwich Teen Action Group	Combined probability event; Extreme Rainfall "100 year" event; Heavy rainfall "5 year" event	*All 3 adjacent buildings - potential basement flooding (High HGL)*	**42**	**42**	**42**
Major F.A. Tilston, VC, Armoury and Windsor Police Training Centre	Extreme Rainfall – "100 year" event; Heavy rainfall "5 year" event	*Significant potential for basement flooding (high HGLs), moderate surface flooding 0.5-1.0 meter; Flooding slightly less severe but facility considered critical to emergency response.*	**49**	**49**	**49**
General Brock Public School	Extreme Rainfall – "100 year" event; Heavy rainfall "5 year" event	*Potential basement flooding (High HGL)*	**35**	**35**	**35**
Sandwich First Baptist Church	Extreme Rainfall – "100 year" event;	*Potential basement flooding (High HGL)*	**21**	**30**	**35**
Rail Tracks	Combined probability event	*Excess inflow results in need to throttle gates; complete closure of gates rapidly results in extensive 3rd party (res./commercial) basement flooding; main sources of excessive flow*	**35**	**42**	**49**
Zone 2					
Prospect Ave. - Pump station (incl. power connections) and outfall	High river levels - <<100 year HWL	*Blockage of outfall preventing drainage; outfall is higher than ditch, replaced diesel pump to low voltage feed from street light (Phong Nguy, City of Windsor)*	**35**	**36**	**42**

Prospect Ave. - Road and open drainage	Extreme rainfall - "100 year" storm, poss. lower	*Road and ditch flooding; outfall is higher than ditch (Phong Nguy, City of Windsor); Prospect "floods right over" (Ed Valdez, City of Windsor)*	**35**	**36**	**42**
Windsor Salt (end of Prospect Ave.)	Erosion; Extreme rainfall "100 Year" event; Combined probability event	*Modeling indicates dangerous ponding (>1 m) with 100 year and combined prob events; also potential for slump events resulting in salt entering Detroit River (one event 1954)*	**42**	**42**	**49**
Ojibway Parkway – Combined sewer	Extreme rainfall - "100 year" storm	*Significant HGLs*	**21**	**30**	**35**
Riverside Drive- Combined sewer	Extreme rainfall - "100 year" storm	*Significant HGLs*	**21**	**30**	**35**
Sandwich Street - Combined sewer	Extreme rainfall - "100 year" storm; Heavy rainfall "5 year" event	*Moderate surface flooding (0.5 to 1.0 meter) and significant HGLs*	**42**	**42**	**42**
Mill St. - Outfall and catchment basin	High river levels - < 100 year HWL; combined river level and freeboard/wave action	*blockage of outfall from high river levels preventing drainage, secondary street flooding*	**35**	**36**	**42**
Huron-Church (Ambassador Bridge) - catch basin, outfall and overflow weir wall	High river levels - <100 year HWL; extreme rainfall "100 year" event; Heavy rainfall "5 Year" event	*submersion during high river levels with 2nd ary road flooding and road base erosion; some sfc flooding reported with heavy rainfall; weir wall either has or is planned to increase in height (Roberta Harrison, City of Windsor); report to council with details is available (Karina Richters, Sustainability and CC, City of Windsor)*	**35**	**42**	**49**
McKee Rd. - Pumping station	High river levels - <100 year HWL; extreme rainfall	*Backflow during high water levels, also street flooding/surface ponding*	**35**	**42**	**42**
McKee Creek - catch basin	High river levels - <100 year HWL, extreme rainfall	*Submerged at < 100 year high water level; surcharged during extreme rainfall events*	**35**	**42**	**42**
Brighton Beach Generation Station	Combined probability events; Extreme rainfall "100 Year" event; Heavy rainfall "5-year" event	*Potential for sub-grade infrastructure flooding (extreme HGL), also minor to moderate (up to 0.3 m) flooding*	**49**	**49**	**49**
Keith Transmission Station - Hydro One	Potential sub-grade flooding (high	*Critical 3rd Party infrastructure - significant amt of sub-grade*	**21**	**30**	**42**

	HGLs, adjacent significant ponding)	*infrastructure, surface flooding adjacent properties – **Recommend further study***			
Chateau Park LTC	Extreme rainfall "100 year" event	*High HGLs - potential basement flooding*	**35**	**35**	**35**
Great Lakes Institute for Environmental Studies	Extreme rainfall "100 year" event	*High HGLs - potential basement flooding*	**35**	**35**	**35**
Chateau Park (Ambassador Bridge area)	<100 year HWL	*Retaining wall submerged*	**35**	**35**	**35**
McKee Park - Sandwich and Chewett Streets	<100 year HWL	*Shoreline flooding resulting in erosion damage and boat launch closure*	**35**	**35**	**35**
Gore Creek and ETR Rail	surface flooding - extreme rainfall and high water levels	*"Gore Creek flooding across Sandwich Street, ETR rail line and siding resulting in traffic diversion and rail line closure" Peter Barry, WPA*	**35**	**36**	**42**
McKee Creek and ETR Rail	surface flooding - extreme rainfall and high water levels	*Road flooding, already flagged by city (Roberta Harrison, City of Windsor; Peter Barry, WPA)*	**35**	**36**	**49**
Windsor Biosolids Processing Plant	combined probability event, extreme rainfall	*Significant surface flooding (> 1 m) form model, reports of surface flooding during real events (Ed Valdez)*	**35**	**42**	**49**
Brock Street - Outfall	**Erosion**	*"Brock Street outfall, significant shoreline erosion, infrastructure in decaying condition. In early planning stages of restoration and renaturalization of land within 5 years - PB Port Authority"; No significant impacts (as at lower elevation ones) but "should be looked at (Roberta Harrison)*	**28**	**30**	**35**
Goose Bay Park - Riverside Drive	High river levels - <100 year HWL	*Boat ramp and walking path underwater for several months*	**35**	**35**	**42**
HMCS Hunter	High river levels - <100 year HWL; **Erosion**	*High occupancy building (3rd Party) - Impacts to shoreline, WPA shoreline property*	**35**	**35**	**42**
Zone 3					
Ojibway Parkway	Combined probability events; Extreme rainfall "100 year" event;	*Extremely high HGLs for all rainfall events, failure of LOS requirements for 63% of road*	**35**	**42**	**49**

	Heavy rainfall "5-Year" event				
Windsor Salt Mine - Ditch entrance	High river levels - < 100 year HWL; Combined probability events; Extreme rainfall "100 year" event; Heavy rainfall "5-Year" event	*Loss of drainage capacity*	**49**	**49**	**49**
Windsor Salt Mine	Extreme rainfall "100 year" event; Heavy rainfall "5-Year" event Combined probability events;	*Moderate to significant surface flooding (~0.75 to >1 m); extreme HGLs*	**49**	**49**	**49**
Detroit-Windsor Truck Ferry	Extreme rainfall "100 year" event; Heavy rainfall "5-Year" event Combined probability event	*Moderate to significant surface flooding (~0.75 to 1 m); extreme HGLs; international trade importance, high impact when affected (as with Ambassador Bridge)*	**42**	**42**	**49**
Sprucewood Ave. - Combined sewer	Combined probability event; Extreme rainfall "100 year" event; Heavy rainfall "5-Year" event	*Moderate to significant surface flooding (~1 m) for all rainfall events; Significant HGL/surcharge during combined probability event*	**42**	**42**	**49**
Sprucewood Ave. – open ditches	Extreme rainfall "100 year" event; Heavy rainfall "5-Year" event	*Workshop attendees indicated problem area, adjacent to wetland, coincides with modeling data for avenue*	**42**	**42**	**49**
Black Oak Heritage Park	Extreme rainfall "100 year" event; Combined probability events w/ 100-year rainfall	*Surface flooding >0.3 meters for 100 year rainfall event*	**30**	**35**	**35**
Rail Tracks	Extreme rainfall "100 Year" Event; Heavy Rainfall "5 Year" event; Combined probability events	*High HGLs, moderate surface flooding for 100 year event*	**35**	**42**	**49**

General/System-Wide Risks and Critical 3rd Party Services					
Infrastructure Component	**Climate Hazard**	**Potential Impact**	**Current**	**2050s**	**2080s**
Loss of electrical power delivery - pumps	Any events resulting in damage to electrical power delivery (e.g., wind storms); Any below-grade assets sensitive to water intrusion	*Loss of power to critical pumps can result in rapid increase in sewer back-up risk.* *Keith TS, Altura Power Station, Gordi Howe Bridge sub-grade vault all potentially sensitive to flooding.* ***Flagged for further study.***	**30**	**35**	**35**
Loss of communications – equipment monitoring	Any events resulting in damage to telephone lines (e.g., wind storms); Any below-grade assets sensitive to water intrusion	*Disruption of monitoring to pumps and other equipment. Will be converted to internet-based monitoring. When monitoring disrupted, requires deployment of staff to equipment site.*	**30**	**35**	**35**
Surface drainage and surface transportation	Any wind (i.e., 120 km/hr gusts; tornado) or other damaging event (e.g., ice storm, heavy snowfall) to adjacent trees, foliage and industrial site storage yards	*Downing of trees and utility poles during wind events can block surface access routes to infrastructure, affecting emergency event response and access to equipment and assets.* *Debris generation during high winds can result in blockage of surface drainage, including open channels, culverts and catch basins.*	**30**	**35**	**35**
Zone 1 – Residential Areas serviced by combined sewers	Combined probability event; "100 year" event; Heavy rainfall "5 year" event	*Basement flooding risk - high HGL; Surface flooding from extreme rainfall*	**42**	**42**	**49**
Zone 1 - Commercial Areas - Combined sewer	Combined probability event; "100 year" event; Heavy rainfall "5 year" event	*Likely basement flooding (high HGL); Surface flooding from extreme rainfall*	**42**	**42**	**49**
Zone 1 – Industrial Buildings - Combined sewer	"100 year" event; Heavy rainfall "5 year" event	*Surface flooding from extreme rainfall*	**42**	**42**	**42**
Zone 2 – Combined Sewer Outfalls	Combined probability events; High river levels	*Lake levels above 174.6 m will result in blocked outfalls and back feeding of Detroit River water into combined*	**35**	**35**	**35+**

		system; Also significant reduction in combined sewer capacity during extreme rainfall events			
Zone 2 - Residential Areas - Combined sewer	Heavy rainfall	*Significant surface flooding (> 1 m); Potential basement flooding extreme HLGs (i.e., above surface)*	**49**	**49**	**49**
Zone 2 - Commercial Areas - Combined sewer	Heavy rainfall	*Significant surface flooding (> 1 m)*	**42**	**42**	**49**
Pad-mounted Electrical distribution equipment	Extreme rainfall "100 year" event; Combined probability event	*Extremely sensitive to surface flooding < 1.0 m in depth, can result in electrification of flood waters posing fatal hazard to public;* ***Flagged for further study***	**28**	**42**	**49**

PIEVC Engineering Protocol

For

Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate

Worksheet Step 4

Engineering Analysis

Revision 1.1

Effective March 30, 2020, the PIEVC Program is operated jointly by the Institute for Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

For further information about this ***Engineering Protocol*** or the ***PIEVC Program*** please contact ICLR.

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Instructions

This worksheet is designed to allow practitioners to document that they have actively considered and evaluated each step of the Protocol. The worksheet also provides a document were practitioner considerations regarding each task of the Protocol are recorded.

Complete Every Field

To ensure complete coverage of the Protocol steps, when completed, the practitioner should have entered a response in every field of this worksheet.

Document Tasks That Do Not Apply

Where a particular task is not relevant to the current assessment:

- Enter **N/A** in the relevant field of this worksheet and
- Provide rational for the decision in the comments field of the task.

Document Tasks That Are Omitted

Where a practitioner has chosen to omit a particular step of the Protocol:

- Enter **OMITTED** in the relevant field; and
- Provide rational for the decision in the comments field of the task.

Companion Excel Workbook Supports This Step of the Protocol

Practitioners may use the accompanying ***Excel Worksheet 4*** to formally document the results of their analysis.

Protocol for Changing Climate Infrastructure Vulnerability Assessment

Practitioners are strongly cautioned to avoid the following common pitfalls in executing a vulnerability assessment based on the Protocol.

i. ***Skipping Protocol tasks***.

   Although it is acceptable to select to not execute a particular task, the practitioner should nonetheless evaluate the question posed by that task and document the basis for the decision.

ii. ***Using previous case study reports as a template for the analysis.***

   Although previous studies provide an excellent reference, the application of the Protocol is highly specific to infrastructure. Applying previous case studies as a template can often lead the practitioner to miss key factors that contribute to the overall risk profile of the infrastructure.

iii. ***Using the worksheets without reference to the Protocol.***

   Although the worksheets parallel the Protocol, they do not provide supplementary context that may be necessary to correctly address the specified Protocol task.

4 Step 4 – Engineering Analysis

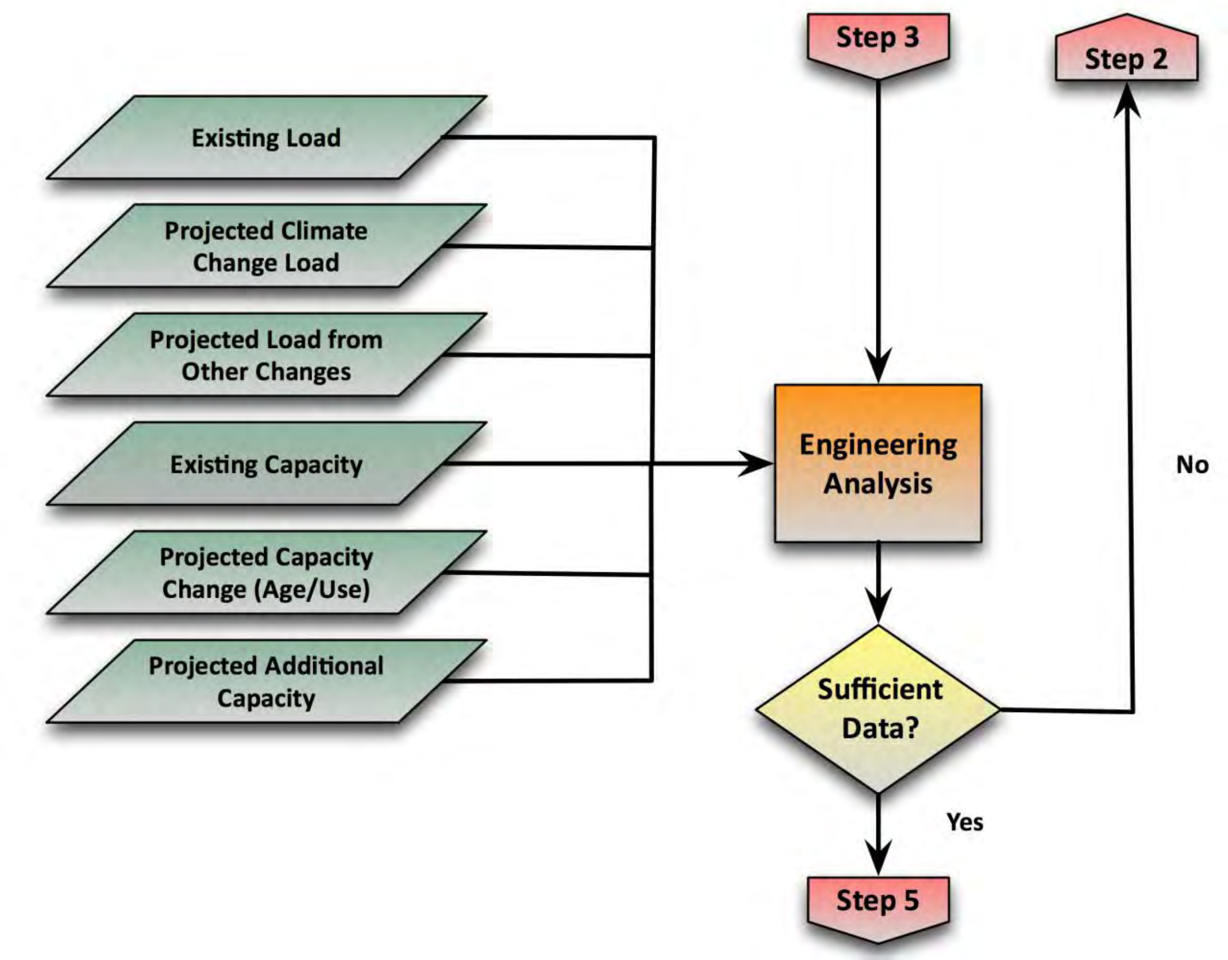
In this step the practitioner will assess the impact of projected changing climate loads placed on the infrastructure and its capacity. Vulnerability exists when infrastructure has insufficient capacity to withstand the projected or anticipated loads that may be placed on it. Resiliency exists when the infrastructure has sufficient capacity to withstand increasing loads resulting from changing climate.

Engineering Analysis requires the assessment of the various factors that affect load and capacity of the infrastructure. Based on this assessment, indicators or factors are determined in order to relatively rank the potential vulnerability of the infrastructure components to various climate effects.

Much of the data required for Engineering Analysis may not exist or may be very difficult to acquire. Engineering Analysis requires the application of multi-disciplinary professional judgement. Thus, even though numerical analysis is applied, the practitioner is cautioned to avoid the perception that the analysis is definitively quantitative or based on measured parameters. The results of the analysis yield a set of parameters that can be ranked relative to each other, based on the professional judgement of the practitioner. This can be used to rank the relative vulnerability or resiliency of the infrastructure.

The process flowchart for Step 4 of the Protocol is presented in **Figure 7**.

Figure 7: Step 4– Engineering Analysis Process Flowchart



4.1 *Prepare Step 4 Worksheet*

	Enter ***Yes*** or ***No***	
a. Use this ***Worksheet***; or		No
b. Prepare practitioner specific documentation. i. Practitioner specific documentation ***MUST*** detail each task outlined in this step of the Protocol.		No

Comments and Observations
A detailed asset and engineering risk assessment was completed for this study, including a relatively comprehensive Triple Bottom Line (TBL) assessment of costs of potential solutions and the relative impacts reduced by the proposed solutions including their social and environmental implications. Potential opportunities for synergistic benefits with other ongoing projects also were explored briefly and scored in the TBL.

In the following steps, the Practitioner may either record results in Excel Worksheet 4 or in their own working papers. In any event, the information stipulated by this Protocol should be duly recorded.

4.2 *Calculate the Existing Load (L_E)*

Calculate the existing load on the infrastructure components that the practitioner selected for Engineering Analysis.

	Check Complete
a. Determine the existing load on the infrastructure based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or	

▪ Assumptions based on professional judgement. *The aim of Step 4 was to develop a flood risk profile for the three Zones of the West Windsor area and to identify short-term (within 5 years) and longer-term recommended flood protection solutions. Detailed H&H modelling results were calibrated to identify the potential benefits or reduced flooding risks for each of the proposed solutions.*	
b. Substantiate the rationale for the methodology used. The proposed solutions build on the detailed PIEVC risk assessment Step 3 and earlier studies for flooding risks within the City of Windsor. These past studies spanning the past decade indicate the highest risk areas and their resilience options and have been considered in detail by the City. For example, while the 2020 City of Windsor Sewer and Coastal Flood Master Plan Report (prepared by Dillon) generally highlighted solutions and costs/benefits for priority flooding regions across the City, this study examined these risks and options in greater granularity and with detailed extreme weather and climate analyses for the West Windsor region, including shorelines along the Detroit River.	
Comments and Observations N/A	

4.3 *Calculate Changing Climate Load (L_C)*

Calculate the projected changing climate load placed on the infrastructure components that the practitioner selected for engineering analysis.

	Check Complete
a. Determine the projected Changing Climate load on the infrastructure based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or ▪ Assumptions based on professional judgement.	

b. Substantiate the rationale for the methodology used. As described in PIEVC worksheet #2, a combination of sources were used to project future loads for the system. To project future climatic loads, outputs from an ensemble of all IPCC AR5 models were downscaled to the regional scale using Delta methods where appropriate, while peer-reviewed climate change studies based on different climate change models were used for other variables (e.g. Detroit River water levels, ice and wind storm extremes). Extreme rainfall variables were projected using the Clausius-Clapeyron and climate change modelling approaches, as outlined in the 2019 updated CSA PLUS 4013 Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners. Population densities and projections are incorporated into the H&H modelling. Detailed climate analyses was used to “drive” the hydraulic and surface flow or hydrology (H&H) modelling of the City of Windsor’s sanitary, storm and combined sewer system and its overland drainage and storage network. The modelling has been calibrated against recent extreme storm rainfall events as detected by a network of 14 City-maintained rain gauges and recent high water levels (2019), as well as basement and flooding incident reports. The modelling includes details of the sewer system including interceptor maintenance holes, overflow sewers, overland stormwater conveyance and storage systems and incorporates land uses and topographical LiDAR information. The modelling has been designed to highlight the sewer system nodes that don’t meet LOS criteria as well as surface flooding depths and surface flooding extents (i.e. % of area > 0). Other climate hazard load thresholds were identified from applicable codes and standards, design criteria, LOS statements and forensic analyses of past failures. The Tailored Severity Scale associated with with PIEVC worksheet #2 provides the background and limits on the various load thresholds.	
Comments and Observations N/A	

4.4 Calculate Other Change Loads (L_O)

Calculate the projected Other Change load placed on the infrastructure components that the practitioner selected for engineering analysis.

	Check Complete
a. Determine the other projected loads on the infrastructure based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or ▪ Assumptions based on professional judgement.	
b. Substantiate the rationale for the methodology used. See Section 4.3 (above)	
Comments and Observations N/A	

4.5 Calculate Total Load (L_T)

	Check Complete
Calculate the total projected load on the infrastructure components that the practitioner selected for engineering analysis, using the equation: $\mathbf{L_T = L_E + L_C + L_O}$ Where: L_T = Total projected load on the infrastructure L_E = Existing load on the infrastructure L_C = Projected load on the infrastructure resulting from changing climate L_O = Projected load on the infrastructure resulting from other changes	

See earlier section 4.3 (above). Loads are provided for current conditions and projected for the 2050s and 2080s using RCP8.5 or high greenhouse gas emission assumptions.	
Comments and Observations N/A	

4.6 *Calculate the Existing Capacity (C_E)*

Calculate the existing capacity of the infrastructure components that the practitioner selected for engineering analysis.

	Check Complete
a. Determine the existing capacity of the infrastructure based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or ▪ Assumptions based on professional judgement.	
b. Substantiate the rationale for the methodology used. Detailed calibrated overland flow and sewer system modelling were used to evaluate capacities for different locations and assets. The calibration of the modelling was based on past extreme events where extreme rainfall and high river levels brought more water to the City sewers, overland conveyance and storage systems, roadways and open drains than there was capacity to manage. Overall, many of the West Windsor assets and locations are sensitive to small future increases in rainfall events and high water levels.	
Comments and Observations N/A	

4.7 Calculate the Projected Change in Existing Capacity ($C_{\Delta E}$)

Calculate the projected change (loss) in capacity arising from aging and normal wear and tear of the infrastructure components that the practitioner selected for engineering analysis.

	Check Complete
a. Determine the projected change, if any, to the capacity of the infrastructure over the time horizon of the evaluation; based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or ▪ Assumptions based on professional judgement.	
b. Substantiate the rationale for the methodology used. Various assets are beyond their expected service lifespans and are planned for replacement in the near future or are in the process of being replaced or upgraded. Many of these near-term changes have not been incorporated into the modelling, meaning that the overall system should have greater resilience when completed than indicated in this study i.e. results should reflect worst case risks. For example, drainage improvements from the construction of the Gordie Howe International Bridge and related upgrading of Sandwich Street may add improved resilience for a portion of Zones 1 and 2. Any improvements to separate combined sewer systems or add storage retention capacity for the Lou Romano RTB will increase capacity and resilience beyond the snapshot provided in this study.	
Comments and Observations N/A	

4.8 Calculate Additional Capacity (C_A)

Calculate other projected additional capacity of the infrastructure components that the practitioner selected for engineering analysis.

	Check Complete
a. Determine the projected additional capacity of the infrastructure over the time horizon of the evaluation; based on: ▪ Definitions; ▪ Direct measurements; ▪ Engineering calculations; or ▪ Assumptions based on professional judgement.	
b. Substantiate the rationale for the methodology used. As discussed in earlier sections, the capacity and resilience added to vulnerable assets as a result of the proposed short-term and longer-term solutions were evaluated using the H&H modelling results and other considerations. The increased future loading to the sewer and drainage systems under climate change was incorporated directly into the modelling results and evaluated through systems engineering considerations.	
Comments and Observations N/A	

4.9 Calculate the Projected Total Capacity (C_T)

	Check Complete
Calculate projected total capacity of the infrastructure components that the practitioner selected for engineering analysis, using the equation: $\mathbf{C_T = C_E - C_{\Delta E} + C_A}$ Where: C_T = Total projected capacity of the infrastructure C_E = Existing capacity of the infrastructure $C_{\Delta E}$ = Projected change in capacity of the infrastructure resulting from	

aging and normal wear and tear C_A = Projected additional capacity of the infrastructure	
Completed, as discussed in the main report and in the Triple Bottom Line assessments for each resilience measure (by specific asset and location). Modelling of the sewer and overland flow and storage systems reflected the variable and potentially exceeded capacities for different assets under critical climate hazards, whether extreme rainfall, extreme high water levels or their various combination events.	
Comments and Observations N/A	

4.10 *Calculate Vulnerability Ratio*

	Check Complete
Evaluate the vulnerability of the infrastructure components that the practitioner selected for engineering analysis, using the ratio: $V_R = \frac{L_T}{C_T}$ Where: V_R = Vulnerability Ratio L_T = Projected total load on the infrastructure C_T = Projected total capacity of the infrastructure	

When $V_R > 1$, the infrastructure component is vulnerable **When $V_R < 1$, the infrastructure component has adaptive capacity** Completed, as discussed in the main report and in the Triple Bottom Line assessments for each resilience measure by asset and location.	
Comments and Observations N/A	

4.11 Calculate Capacity Deficit

	Check Complete
Where vulnerability has been identified for the infrastructure components that the practitioner selected for engineering analysis, calculate the projected capacity deficit using the following equation: $\mathbf{C_D = L_T - C_T}$ $\mathbf{= L_T - (C_E + C_{\Delta E} + C_A)}$ Where: C_D = Projected capacity deficit of the infrastructure component L_T = Projected total load on the infrastructure component C_E = Existing capacity of the infrastructure component $C_{\Delta E}$ = Projected change in capacity of the infrastructure component resulting from aging and normal wear and tear C_A = Projected additional capacity of the infrastructure component	
Comments and Observations	

Handled for capacity through calibrated system H&H modelling. Note that many parts of the West Windsor sewer and drainage system have minimal capacity for increased rainfall and high water level events.	

4.12 *Assess Data Sufficiency*

Add rows as necessary.

a. Document where there is insufficient information currently available to proceed with an element of the assessment.		
Insufficient Information	i. Where there is insufficient information currently available, identify a process to develop or infill that data.	ii. Where data cannot be developed, identify the data gap as a finding in Step 5 of the Protocol – Recommendations.
Reasonably complete datasets, with relatively good quality modelling calibrated against recent high impact extreme events	It would be advantageous to include 2020 record high Detroit River was levels in the H&H model, although the high impact extreme water levels of 2019 were included in the calibration and modelling of system performance.	Not needed at this point, but for consideration in a future update of the modelling.

4.13 *Evaluate Need for Additional Work*

Add rows as necessary.

a. Identify matters that require additional study or evaluation outside of the current vulnerability assessment. These would normally include: i. Interactions requiring additional data that cannot be acquired within the schedule of the current risk assessment. ii. Evaluating climatic events that specifically contribute to heightened infrastructure risk where the practitioner and/or infrastructure owner determine that a better understanding of the factors that contribute to the event can help resolve identified risks. iii. Areas where identified patterns of risk could be resolved through the development or amendment of codes, standards, guidelines, procedures, etc. iv. Other issues deemed appropriate by the practitioner.
A long-standing need is for improved modelling of Great Lakes water levels under climate change conditions. In particular, improvements to the modelling of Great Lakes runoff and land evaporation processes since 2011 have changed the consensus on future water level projections from decreasing levels to highly variable levels in future, with levels dependent on GHG emission assumptions. Further improvements will be added in the near future with the latest climate change models e.g. IPCC AR6 climate change models released in 2021 and with higher resolution and improved 3-dimensional Great Lakes hydrodynamic (atmosphere-lake-land) models. Since Great Lakes levels respond to small differences in hydrodynamic processes i.e. temperature and precipitation, there is potential for the water level projections used in this study to differ with the next generation of water level projections. Higher water levels that exceed the 2020 extremes would be problematic for many assets in this West Windsor region. This study added a climate change “buffer” or safety margin to the 2020 extreme high water levels.
Ice cover conditions on the Great Lakes are dependent on air and water temperatures and wind conditions and have a significant influence on evaporation rates. Ice cover conditions can also impact flows and water levels when ice jam conditions occur, but the influence is short-lived compared to multi-year fluctuating river and lake levels.
The H&H modelling used for this study could improve with additional calibration and better capture of the details of the sewer and overland flow systems.
All of the above improvements require significant efforts by others but can be expected to evolve slowly.
Comments and Observations

N/A

	Check Complete
b. Document the additional work identified above as recommendations in Step 5. Included.	
Comments and Observations N/A	

4.14 Identify Conclusions and Recommendations

	Check Complete
a. Where the practitioner deems that they have sufficient, reliable, data to draw conclusions and make recommendations, proceed to Step 5. • See the Mapped Medium and High Risks and the Summary of Medium and High Risks documents from PIEVC worksheet#3 indicating the at-risk assets, their locations and proposed short-term and long-term solutions. • See the main report for a more complete discussion of risks and recommended solutions as well as the Triple Bottom Line discussion on the costing-benefits-environmental considerations of the proposed solutions	
Comments and Observations N/A	

Date:	November 28, 2022
Prepared by:	Heather Auld & Simon Eng Dillon Consulting Limited

PIEVC Engineering Protocol

For

Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate

Worksheet Step 5

Recommendations and Conclusions

Revision 1.1

For further information about this ***Engineering Protocol*** or the ***National Engineering Vulnerability Assessment*** **Project** please contact Engineers Canada.

David Lapp, P.Eng.
Practice Lead, Engineering and Public Policy
Engineers Canada

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Ottawa, Ontario, K1P 6L5   Canada

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Protocol for Changing Climate Infrastructure Vulnerability Assessment

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i. ***Skipping Protocol tasks***.

Although it is acceptable to select to not execute a particular task, the practitioner should nonetheless evaluate the question posed by that task and document the basis for the decision.

ii. Using previous case study reports as a template for the analysis.

Although previous studies provide an excellent reference, the application of the Protocol is highly specific to infrastructure. Applying previous case studies as a template can often lead the practitioner to miss key factors that contribute to the overall risk profile of the infrastructure.

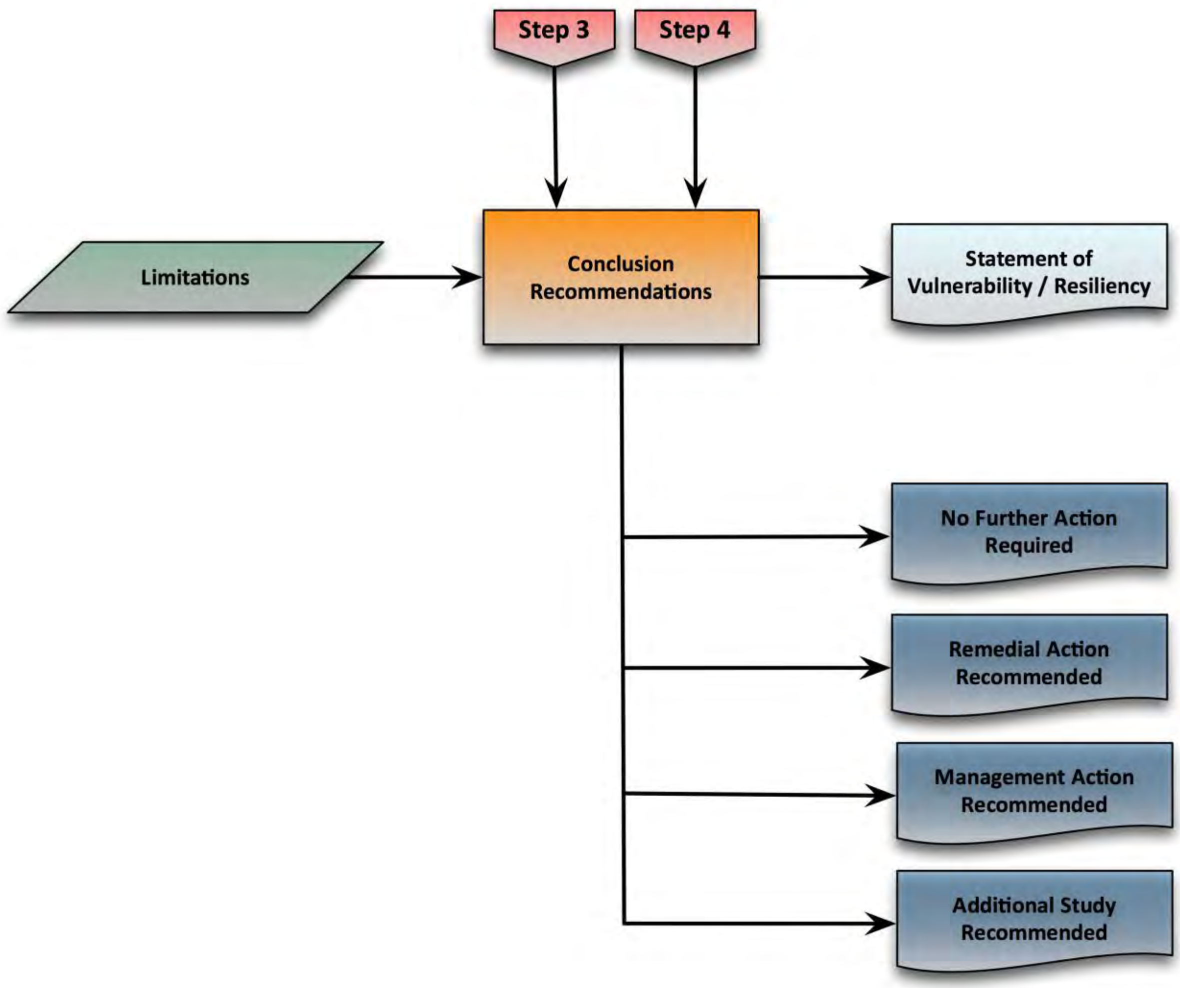
iii. Using the worksheets without reference to the Protocol.

Although the worksheets parallel the Protocol, they do not provide supplementary context that may be necessary to correctly address the specified Protocol task.

5 Step 5 – Recommendations and Conclusions

The process flowchart for Step 5 of the Protocol is presented in **Figure 8**.

Figure 8: Step 5 – Recommendations Process Flowchart



5.1 *Prepare Step 5 Worksheet*

	Enter ***Yes*** or ***No***	
a. Use this ***Worksheet***; or	Yes	
b. Prepare practitioner specific documentation. i. Practitioner specific documentation ***MUST*** detail each task outlined in this step of the Protocol.		No
Documentation on Tasks is also provided in the main report and its Appendices.		
Comments and Observations N/A		

5.2 *Declare Assumptions Regarding Available Information, Data Sources, Uncertainties and Relevant Limitations*

Add rows as necessary.

a. Comment on the limitations of the vulnerability assessment. These include limitations associated with: i. Major assumptions. ii. Available infrastructure information and sources. iii. Available changing climate information and sources. iv. Available other change information and sources. v. The use of generic or specific examples to represent populations. vi. Uncertainty and related concepts. vii. Other relevant limitations, if they exist.
Data coverage and modelling: Overall, rainfall and river water level coverage for the assessment was relatively good (compared to many other PIEVC studies) and the detailed modelling of the flooding and infrastructure system risks was extremely helpful in assessing the impacts of climate events and the costs and benefits (TBL) of different resilience

solutions.
Great Lakes Water Levels: A risk assessment provides a snapshot in time of the overall system vulnerability and resiliency. It is based on the information available to the team at the time of the assessment, including future projections of Great Lakes water levels. Many sewer and drainage assets in West Windsor were found to be highly sensitive to high lake levels (and some to low lake levels). However, the studies and projections of future extreme high and low water levels on the Great Lakes and their connecting rivers (Detroit River) remain uncertain under a changing climate. As noted in PIEVC worksheet #4, the earlier "consensus" on projections of lake levels had indicated lowering lake levels but these projections changed after 2011 due to improved hydrodynamic-climate processes in the Great Lakes flow models. The results after 2011 all indicated greater uncertainty in water levels, with potential for either increasing or decreasing near extreme levels. These future lake levels were found to be highly sensitive to the different climate change projections and especially to future global GHG emission trends. Fluctuations in multi-year water levels have been record-breaking over the past decade, with record breaking low levels observed in 2013 transitioning to record breaking high levels in 2020. While multi-year water levels have fluctuated since they were first recorded in 1860, the variability over the past decade has been unprecedented historically and continuing high variability is expected into the future. Multi-year high or low Great Lakes water levels can be very difficult to predict in the near term and even more difficult to project under climate change influences due to their strong dependence on relatively small differences in climate, hydrological and hydraulic processes. These small differences include the net flow of water in and out of the lake system driven by incoming precipitation over the lakes and runoff from the surrounding watersheds, outgoing evaporation from the lakes as a result of warmer air and lake waters and reduced ice cover as well as smaller influences from net flows and diversions between the lakes and consumptive removals. It is not surprising that future water levels will depend on small differences between the projections of rate of temperature warming and rates of precipitation increase, which is turn will depend on future rates of increases in global greenhouse gas emissions. With the release of the latest generation of climate change models (IPCC AR6), improvements to climate change downscaling approaches for the Great Lakes region, as well as improvements to the modelling of Great Lakes hydrodynamic-climate processes, it is likely that upcoming lake level projections will differ from those used in this study. The efforts to generate new lake level projections is highly complex and requires contributions from many Canadian and U.S. centres of expertise.
Climate Change Projection Uncertainties: The future climate change hazards were derived from several sources, with each source sometimes using different climate change projection methods and often, different driving climate change models and uncertainties. For example,

some of the study's projected climate variables were derived from an ensemble of the 2013 released IPCC AR5 climate models, which were compared to the 2021 released AR6 climate models whenever possible. For some extreme climate variables that were based on peer-reviewed studies, the results will be based on the earlier 2007 released AR4 generation of climate change models. Generally, the uncertainties in the climate change projections were due to: 1. Natural climate variability (i.e., the natural fluctuations of the current and future climate); 2. Climate Model and Downscaling uncertainty (i.e., different parameterizations and sensitivities in models; different spatial and temporal resolutions); and, 3. Future greenhouse-gas (GHG) emissions (i.e., accumulated GHG emissions globally and the uncertainty on the magnitude of future GHG forcing and its impact on climate). Uncertainties (1) and (2) were addressed through the use of multi-model ensembles or climate models from various global climate modelling centres. Uncertainty (3) was addressed through use of a "conservative" or high future emissions GHG scenario driving greater or faster changes in climate (i.e., RCP8.5).
Modelling of river water level and overland flow and storage processes: As discussed in worksheet #4, the H&H modelling would improve with additional calibration with capture of the 2020 extreme high water levels and extreme rainfall events after 2017 and better depiction of the details of the sewer and overland flow systems. However, these improvements require significant efforts and investments and may not be immediately justified given other uncertainties. Nonetheless, improvements can be expected to evolve slowly over time.
<u>Comments and Observations</u> N/A

5.3 *State Conclusions*

Add rows as necessary.

a. Present specific conclusions arising from Steps 1 through 4. i. Report on infrastructure components that have been assessed to be vulnerable. ii. Summarize infrastructure components that have been assessed to have adaptive capacity.

***Medium to High Risk Infrastructure Components*:** Many West Windsor infrastructure components were found to be at medium to high risk from climate events currently and/or into the future. Note that Zone 1 or "inland" represents infrastructure in residential, institutional and industrial areas; Zone 2 represents a shoreline industrial area; while Zone 3 represents an industrial and parkland area. Flooding from either extreme rainfalls or high water levels or their combinations represent the primary hazards resulting in medium to high risk vulnerabilities. Of the medium to high risks noted currently or into the future, the assessment identified at least 15 City infrastructure vulnerabilities in Zone 1, while some 22 vulnerabilities were noted in Zone 2 and 8 vulnerabilities in Zone 3. Some 10 medium to high risks were assessed for third party infrastructure types. The Summary of Medium and High Risks provided with PIEVC worksheet #3 summarizes the vulnerable infrastructure components and their associated hazards for Zones 1, 2 and 3 in the West Windsor study region. The Summary indicates the main climate hazards contributing to the risks, comments on the potential impacts and highlights the resulting risk scores for the current, 2050s and 2080s periods. Similarly, the Mapped Medium and High Risks provided with PIEVC worksheet#3 highlights the main vulnerabilities by mapped locations and infrastructure system components and indicates the primary hazards contributing to the vulnerabilities with their recommended short-term (within 5 years) and long-term resilience solutions.
Comments and Observations See the main project report for further description of potentially vulnerable infrastructure-climate interactions which were scored as medium or high (i.e., overall risk scores of 36-49).

5.4 *State Recommendations*

Add rows as necessary.

a. Present specific recommendations arising from Steps 1 through 4. As appropriate, classify recommendations into the following categories:

i. Remedial engineering actions;
ii. Monitoring activities; or
iii. Management actions.

Recommended Short and Longer-term Resilience Solutions for Flooding: Generally, the recommended short and longer-term flooding resilience solutions can be summarized as:

- *Reduction of excess flows to Lou Romano Reclamation Plant including:*
  - Backflow prevention at CSOs
    - i. Weirs to reduce river water inflows during high water levels
    - ii. Flapgates to reduce inflows
  - Lou Romano Retention Treatment Basin (RTB)
  - Combined Sewer Separation

(Note: The Lou Romano Water Reclamation Plant services a larger total area of the City of Windsor with generally older sewers. The City recently has completed construction of the RTB, which will provide capacity to retain a significant amount of the combined sewer overflows from the sewer systems. Priority sections of the City currently are under mandatory downspout disconnection requirements, which will increase capacity in the sewer system.)

- *Reduction of Potential Surface Flooding through:*
  - Raising Ground Elevations (Grading Improvements)
  - Dewatering Pumping
  - Conveyance Improvements. For example, through upgrades to:
    - Prince Road Trunk Storm Sewer Outfall and Pumping Station
    - Detroit Street Trunk Storm Sewer and Outfall
    - Combined Sewer Separation
    - Roadside Drainage Improvements

- *Reduction of Basement Flooding through:*
  - Basement Flood Protection Measures
    - Backflow Prevention
    - Downspout Disconnection
  - Combined Sewer Separation
    - PDC Separation
    - Foundation Drain Disconnection

• *Shoreline Erosion Protection and Response through:*
    • Monitoring and Local Repair Plans
    • Improved understanding and mapping of high risk erosion locations

Monitoring Activities • Monitoring of high impact shoreline erosion localities to evaluation of causes of higher risks and potential longer term solutions • Monitoring of river ice conditions, including ice jams, for impacts on short duration higher (or lower) river levels and on shoreline erosion rates • Monitoring of Detroit River levels and any changes to their variability (i.e. rates of fluctuation from high to low levels for needed response times and options) • Monitoring and awareness of the most recent Great Lakes and climate change water level projection studies and their implications for updates to the flood resilience actions • Maintain and/or increase ongoing site rainfall monitoring by the City • Ongoing monitoring of medium risk climate-infrastructure interactions to detect trends towards higher impacts and risks • Monitor effectiveness of resilience actions through tracking and documentation on measures implemented and note over time whether these measures have proven effective in reducing or responding to identified risks
Resilience and Management Activities • Ongoing implementation of the City of Windsor Sewer Master Plan for the medium to high vulnerability West Windsor infrastructure components • Further assessment of the costs, benefits, implementation challenges and maintenance requirements and costing for the solutions at each vulnerability and location (e.g. different backflow prevention options) • Ongoing implementation of basement flood protection measures through City's downspout disconnect requirements and incentives • Ongoing implementation of combined sewer separation measures - as existing and any new funding opportunities allow • Ongoing localized grading improvements in areas most vulnerable to flooding • Priority area installation and use of weirs and flap gates to reduce river water inflows for periods of high river water levels (and their low water level implications) • Installation of rain catchers within existing maintenance holes (MHs) to reduce stormwater inflow to the sanitary MHs during a storm event. An assessment was completed to determine where the potential for inflow was highest and where MH

sealing should be prioritized
- Investigate the contributions and opportunities from additional resilience actions by third parties to the overall West Windsor region flood risk sensitivities e.g. Gordie Howe Bridge drainage improvements, rebuilding of Sandwich Street, etc
- Actively monitor severe weather watches and warnings for significant rainfall and/or rain plus snowmelt events (levels of monitoring will be dependent on sensitivities to critical return period rainfall events)
- Actively monitor Canada-U.S. seasonal predictions of lake and river high water level conditions for needed shorter-term resilience responses, which could include overland flow reduction measures among others
- Monitor and consider revisions to the long-term Resilience Plans should new future projections of Great Lakes and Detroit River water levels indicate further increases

Comments and Observations

Note that remedial engineering actions are already planned under the Sewer Master Plan (plus potential for third parties resilience actions). See the main report for further details.

b. Report on data gaps and availability; requiring additional work or studies.

See earlier Section 5.2 and main report. Note that data coverage and modelling guidance was good relative to many PIEVC assessments.
It is expected that work to increase resilience to the West Windsor drainage and sewer challenges by the City will likely continue for the highest priority risks and as infrastructure is replaced.

Comments and Observations

N/A

c. Identify matters that require further action.

Along with the implementation of the short-term and long-term resilience measures, it is important for locations and assets with vulnerabilities to high river and lake water levels to monitor the coordinated Canada and U.S. measurements and seasonal predictions (*not* projections) of potential high water levels on the Detroit River system to support very short-term or emergency responses.

While predictions of seasonal lake and Detroit River water levels are difficult, efforts to *project*

future water levels long into the future under different GHG assumptions is multiple times more challenging while being subject to high uncertainties. New and improved climate change models with more realistic assumptions on future global GHG emissions, as well as improvements to linked 3-dimensional Great Lakes hydrodynamic and climate models could change the projections of future levels significantly. As a result, it is important that changes to studies and modelling of Great Lakes water levels under climate change be monitored carefully since it is likely that the understanding and projections of future lake levels may change from the summary provided in this assessment. Funding for the various flooding resilience measures and any enforcement actions will continue to be challenging, but progress is ongoing and steady. As well, some of the third party impacts such as those impacting electricity generation and distribution infrastructure will have implications for the region and for other components of this PIEVC assessment. Other changes to drainage and sewer systems from ongoing third party projects, such as completion of the Gordie Howe International Bridge, will also have implications for West Windsor infrastructure components. Due to the multiple interactions of the climate and lake/river hazards i.e. the cascading nature of the hazards and risks, it also is important that the hydraulic and hydrological modelling and studies of the drainage and sewer system be continuously improved. The updating of the systems modelling also needs to account for the potential benefits of the added resilience responses.
<u>Comments and Observations</u> N/A

5.5 *Prepare Statement of Vulnerability / Resiliency*

	Check Complete
a. Based on the limitations, conclusions and recommendations outlined above, prepare a Statement of Vulnerability / Resiliency.	
<u>Comments and Observations</u> Due to the generally low lying terrain within the City of Windsor, its proximity to the Great Lakes and connecting rivers and location in one of Canada's	✓

southernmost climate/weather zones, it is not surprising that the West Windsor area is prone to various types of climate hazards and flooding risks. Windsor's relatively higher exposure to flooding hazards of all types results in overland drainage and sewer capacity challenges in many localities. Overall, the West Windsor PIEVC assessment identified many medium to high climate change risks, mainly from high lake/river levels and from extreme rainfall events. For some of the highest risk sewer and drainage systems, even a 5 year return level rainfall event was noted to produce notable impacts. But, for infrastructure components near the shorelines of the Detroit River, it is the combinations of high lake/river levels combined with a heavy rainfall event that pose significant challenges and will require significant resilience actions.	

	Identify Vulnerability or Resiliency **Mark Yes or No**
b. For infrastructure that is deemed to be generally resilient the statement should include: i. A declaration that the infrastructure is generally resilient. ii. A declaration of the global limitations of the assessment. iii. A declaration of the time horizon of the assessment. iv. A declaration of climate trends or interactions that may contribute to the vulnerability of the infrastructure.	Yes
c. For infrastructure that is deemed to be generally vulnerable the statement should include: i. A declaration that the infrastructure is generally vulnerable. ii. A declaration of the global limitations of the assessment.	Yes

iii. A declaration of the time horizon of the assessment. iv. A declaration of climate trends or interactions that significantly contribute to the vulnerability of the infrastructure	
Many infrastructure components of the West Windsor region are moderately to highly vulnerable to the current and future climate, as discussed in earlier section.	
Comments and Observations N/A	

	Check Complete
d. The practitioner may use a format of their own choosing to prepare the Statement but, as a minimum, it must: i. Make a declaration regarding the degree of vulnerability or resiliency of the infrastructure. ii. Make a declaration of the global limitations of the assessment. iii. Make a declaration of the time horizon of the assessment. iv. Make a declaration of climate trends or interactions that contribute, or may contribute, to the vulnerability of the infrastructure.	✓
Comments and Observations See earlier sections (especially 5.5a) and main report.	

Date:	December 1, 2022
Prepared by:	Simon Eng and Heather Auld Dillon Consulting Ltd

Appendix B

Risk Assessment Workshop

Appendix B – Risk Assessment Workshops

1. Internal Workshop, October 20, 2021
2. Internal Workshop, October 26, 2021
3. External PIEVC Assessment Workshop, January 7, 2022
4. Review of Solutions and Initial Recommendations, May 19, 2022

West Windsor Flood/PIEVC Assessment

Internal Workshop
October 20, 2021

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Agenda

1. Intro/Agenda
    1. Review of Climate Hazards List
2. Interactions Matrix – Y/N Analysis

    10:30 AM – 10 min Break

3. Impact Severity Ranking Discussion
    1. Review of Methodology/Ranking Method
    2. Review of Preliminary Ratings
4. Preliminary Design Solutions Discussion

Hazards List

Hazard/Element	Threshold	Comments
Extreme rainfall	82 mm in 4 hrs, peak rate of 145 mm/hr	"Basic" model storm, 15 min intervals
	114 mm in 4 hrs, peak rate 203 mm/hr	"Climate Change Enhanced" model storm
	3rd extreme rainfall event?	Recent historical basement flooding events
Riverine and Creek Flooding	Multi-day rainfall	Case study - **June 2017**
	Ice jam events	No historical database of events, flagged for further study
Snow	Rapid snowmelt - **SWE value**	Frozen ground, ice and snow blocked drainage, snowmelt
	Snow accumulations - 250 cm	**Winter 2013-2014 case study** - mobility impacts, drainage
Extreme River Levels	Extreme HWL - 176.3 m	Combined probability event modeling
	"Likely" HWL - 176.1 m	Combined probability event modeling
	All time low water level	
Combination Events	HWL + extreme rainfall	Combined probability event modeling
	Rainfall + hail and wind	Debris blockage of drainage infrastructure
	HWL + wave action (freeboard)	*Case Studies (from HIRA):* November 13-15, 1972, March 31 & April 6, 1985, April 4, 1987, June 2015, Spring 2019
Secondary Impact Events	Major ice storm	*Multi-day loss of power*
	Extreme wind event - 120 km/h	debris generation, loss of site access, damage to above-ground
	Tornado - (E)F2+	debris generation, loss of site access, severe damage to above-
	Extreme Temperatures - heat and cold	Brownouts due to excessive loading - ***poss. not needed if sufficient power back-up***
	Shoreline and creek erosion	Impacts to CSOs, any other adjacent infrastructure
	River ice	Shoreline erosion and infrastructure impacts potential
	Weathering (freeze thaw)	Concrete and masonry impacts

Executing in Pieces – PIEVC Worksheet 3

Infrastructure Components	Infrastructure Response Considerations									
	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Environmental Effects
	Mark Relevant Responses with ✓									
Component 1										
Component 2										
Component 3										
Etc.										

Infrastructure Components	Climate Parameter 1					Climate Parameter 2				
	Enter Infrastructure Threshold Value Here				Enter rationale for Infrastructure Threshold here. Identify reference to code or standard if relevant.	Enter Infrastructure Threshold Value Here				Enter rationale for Infrastructure Threshold here. Identify reference to code or standard if relevant.
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severity Score
Component 1										
Component 2										
Component 3										
Etc.										

Infrastructure Components	Climate Parameter 3					Etc.				
	Enter Infrastructure Threshold Value Here				Enter rationale for Infrastructure Threshold here. Identify reference to code or standard if relevant.	Enter Infrastructure Threshold Value Here				Enter rationale for Infrastructure Thresh here. Identify referenc code or standard i relevant.
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Rationale For Severi Score
Component 1										
Component 2										
Component 3										
Etc.										

Severity Rating Process

1) Rating impact severity of given hazard, at a given intensity/threshold, for *existing* assets.

2) When considering if impacts are important (Y/N Analysis) how to rate impacts:

i) Does the interaction contribute to the risk being assessed (i.e., city drainage and flood protection infrastructure and results of failure/underperformance)?

ii) Does the interaction result in impacts to response measures/actions?

Severity Scale	Method D	Method E
0	No effect	Negligible; Not applicable
1	Measurable	Very Low; Some measurable change
2	Minor	Low; Slight loss of serviceability
3	Moderate	Moderate loss of serviceability
4	Major	Major loss of serviceability; Some loss of capacity
5	Serious	Loss of capacity; Some loss of function
6	Hazardous	Major; Loss of function
7	Catastrophic	Extreme; Loss of Asset

Yes/No Analysis

- See Excel Spreadsheet – Will be executed in table "sections"

			Extreme rainfall			Riverine and Creek Flooding		
Asset Class	Infrastructure Class	Component	82 mm in 4 hrs, peak rate of 145 mm/h	114 mm in 4 hrs, peak rate 203 mm/hr	*3rd extreme rainfall event?*	Multi-day rainfall	Ice jam events	Rapid snowmelt - **SWE value**
Main Project Assets	Combined Waste and Storm Water	Combined Sewers - Low Elevation	✓	✓	✓	✓		✓
		Combined Sewers - High Elevation	✓	✓	✓	✓	?	✓
		Interceptor Maintenance Holes (MH)	✓	✓	✓	✓	?	✓
	Wastewater System Assets - Higher Elevation	Sanitary Sewers	?	?	?	✓		✓
		Storm Drains	✓	✓	✓			✓
		Pump Stations	?	?	?	✓		✓
		Lou Romano Water Reclamation Plant (LRWRP)	?	?	?	✓	?	✓
	Wastewater System Assets - Lower Elevation	Sanitary Sewers	?	?	?	✓		✓
		Storm Drains	✓	✓	✓			✓
		Pump Stations	?	?	?	✓		✓
		Lou Romano Water Reclamation Plant (LRWRP)	?	?	?	✓	?	✓
	Stormwater System Assets - Higher Elevation	Open drainage channels	✓	✓	✓	✓		✓
		Storm Sewers	✓	✓	✓	✓		✓
		Maintenance holes	✓	✓	✓	?		✓
		Culverts	✓	✓	✓	✓		✓
	Stormwater System Assets - Lower Elevation	Open drainage channels	✓	✓	✓	✓		✓
		Storm Sewers	✓	✓	✓	✓	?	✓
		Maintenance holes	✓	✓	✓	?		✓

Severity Ranking

Severity Scale	Method E
0	Negligible; Not applicable
1	Very Low; Some measurable change
2	Low; Slight loss of serviceability
3	Moderate loss of serviceability
4	Major loss of serviceability; Some loss of capacity
5	Loss of capacity; Some loss of function
6	Major; Loss of function
7	Extreme; Loss of Asset

Design Solutions Development

- Immediately obvious responses based on modeling?
- Potential responses that require additional analysis/data/information to define?
- Potential responses which require additional feedback from the client to determine if appropriate?

Comments:

- ...

Thanks for Your Time and Attention!

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416-356-8447

West Windsor Flood/PIEVC Assessment

Second Internal Workshop
October 26, 2021

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Agenda

1. Intro/Agenda – *2:00 PM Start*
2. Impact Severity Ranking Discussion
   1. Intro to methodology
   2. Completion of "?"s for Y/N Analysis

      3:00 PM – 5 min Break
   3. Review of flagged impact ratings
3. Next Steps Discussion – *3:50 PM to End*
   1. External Workshop Timing
   2. Key Staff Interviews and Site Visits

Severity Rating Process

1) Rating impact severity of given hazard, at a given intensity/threshold, for *existing* assets.

2) When considering if impacts are important (Y/N Analysis) how to rate impacts:

   i) Does the interaction contribute to the risk being assessed (i.e., city drainage and flood protection infrastructure and results of failure/underperformance)?

   ii) Does the interaction result in impacts to response measures/actions?

Instructions: Please have *Slide 4* open on your desktop for rating exercise.

- Completing Y/N + Rating Simultaneously – Start w/ Question Marks (H33)
- Review of flagged (yellow highlights) severity ratings

Severity Ranking

Severity Scale	Method E
0	Negligible; Not applicable
1	Very Low; Some measurable change
2	Low; Slight loss of serviceability
3	Moderate loss of serviceability
4	Major loss of serviceability; Some loss of capacity
5	Loss of capacity; Some loss of function
6	Major; Loss of function
7	Extreme; Loss of Asset

Next Steps - Discussion

- Timing of External Workshop
- Additional Refinement Tasks:
  - Key Staff Interviews
  - Site Visits – Targeted Locations?

Thanks for Your Time and Attention!

SEng@Dillon.ca
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West Windsor Flood Assessment Study

External PIEVC Assessment Workshop

January 7, 2022

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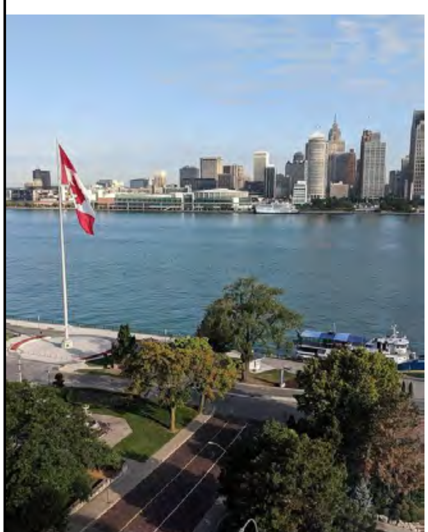
Welcome and Introductions



- Welcome – Project Managers for City of Windsor, Dillon Consulting Limited
- Attendee List Review – Name and Position

- Purpose of Today's Workshop
  - *Validation* of methods and assumptions
  - Modified workshop format from "standard" PIEVC
  - Opportunities for further feedback: site visits, bilateral meetings

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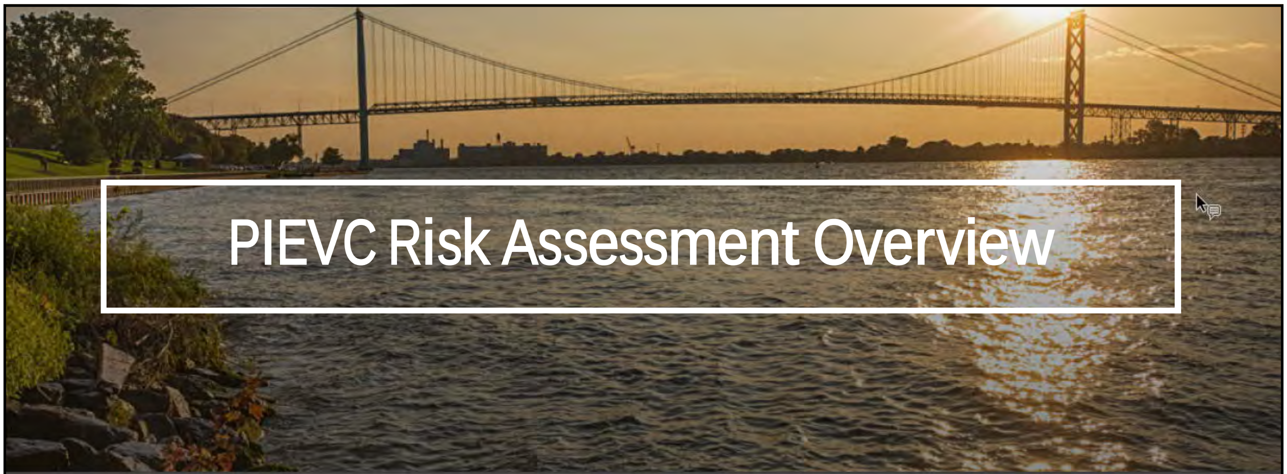

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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Overall Project Goals and Intended Outputs

Project Goals: Develop a flood risk profile for the West Windsor area and identify alternative and recommended flood protection solutions.

Flood protection solutions will:

- Reduce susceptibility of coastal flooding within the study area, reduce impact of increased inflow and infiltration (I&I) into the municipal system from high Detroit River water levels;
- Improve the performance of the existing infrastructure during high water levels and reduce peak flows at the Lou Romano WRP;
- Provide more sustainable municipal infrastructure; and,
- Reduce risk of surface and basement flooding.

Next Steps following risk assessment:

- Alternate solutions development
- Public consultation

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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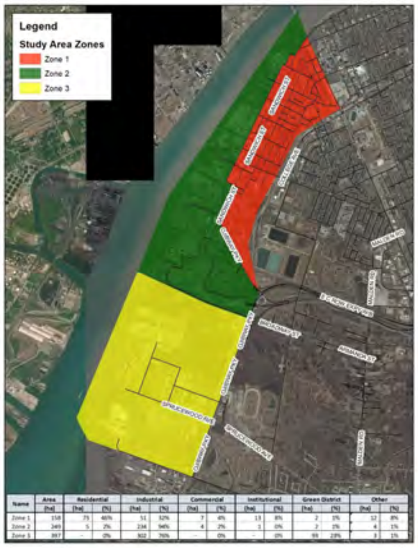
Scope and Boundaries



- Boundaries: Ojibway Pky and College St.; LaSalle border; Huron-Church/Ambassador Bridge
  - Zone 1 “inland” residential, institutional and industrial;
  - Zone 2 shoreline industrial; and
  - Zone 3 industrial and parkland.
- Assets: Drainage, sanitary, combined sewers, including Lou Romano* plant, and key adjacent city and 3rd party assets (schools, parks, arterial roads, etc.)
- Impacts: drainage/sanitary system overloading and failures, immediate effects on surrounding critical assets, 3rd party assets critical to operations of drainage/sanitary

* Note: *Internal treatment plant operations not in scope*

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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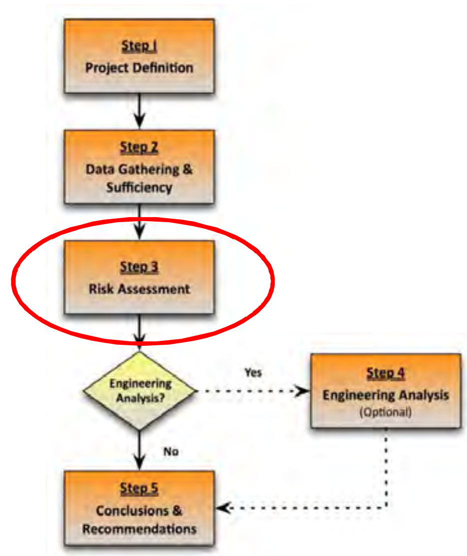
Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol & Outputs

PIEVC Protocol

- Based on standard risk assessment methodology
- 5-steps
  - #4 usually omitted
- Although presented as linear, generally *iterative* in practice
- Effectiveness relies on tailoring and expertise of practitioners

Outputs

- *Prioritized list* of risks



West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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PIEVC Protocol and Outputs – Triple Bottom Line Module

- PIEVC (Step 5) usually ends with “technical” response considerations *only*
- *“Triple Bottom Line” Multi-Factor Analysis* considers weighting based on economic, social and environmental considerations
  - Includes “do nothing” as an option

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

PIEVC Step 3 - The Risk Equation

At its essence, risk is the product of two components:

$$R = P \times S$$

Severity of resulting impact on your asset

Climate hazard occurrence data

Where those components are:
P= Probability – how *likely* is this to occur; and,
S= Severity of the consequence of an event, *should it occur*.

Additional Notes:
- “Exposure” taken into account in “P” where needed
- “Severity” rating needs to be tailored to a given system

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

Actions Linked to Risk Level

Severity \ Probability	0	1	2	3	4	5	6	7
7	0	7	14	21	28	35	42	49
6	0	6	12	18	24	30	36	42
5	0	5	10	15	20	25	30	35
4	0	4	8	12	16	20	24	28
3	0	3	6	9	12	15	18	21
2	0	2	4	6	8	10	12	14
1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0

Legend: Special Case | Low Risk | Medium Risk | High Risk

- *High Risk* = unacceptable, immediate response
- *Medium Risk* = requires monitoring, possible engineering analysis needed
- *Low Risk* = acceptable risk
- *Special Case* = operational, planning and/or management response

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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Frequently Asked Questions

- "If we have drainage modeling (depth and hydraulic gradient) information, why use categorical scales for risk ranking?"
  - Severity ratings provide tailored context – e.g., what do these depths *mean* in terms of impacts?
  - Need to define *when* response is needed.
- "How can you rate probability without detailed statistical information?"
  - Climate data is not available for every important hazard
  - Key hazards subject to significant uncertainty
    - Great Lakes/Detroit River Levels
    - Likelihood of joint probability scenarios

  …*professional judgement* based on all available guidance information ("ingredient" parameters, scientific literature)

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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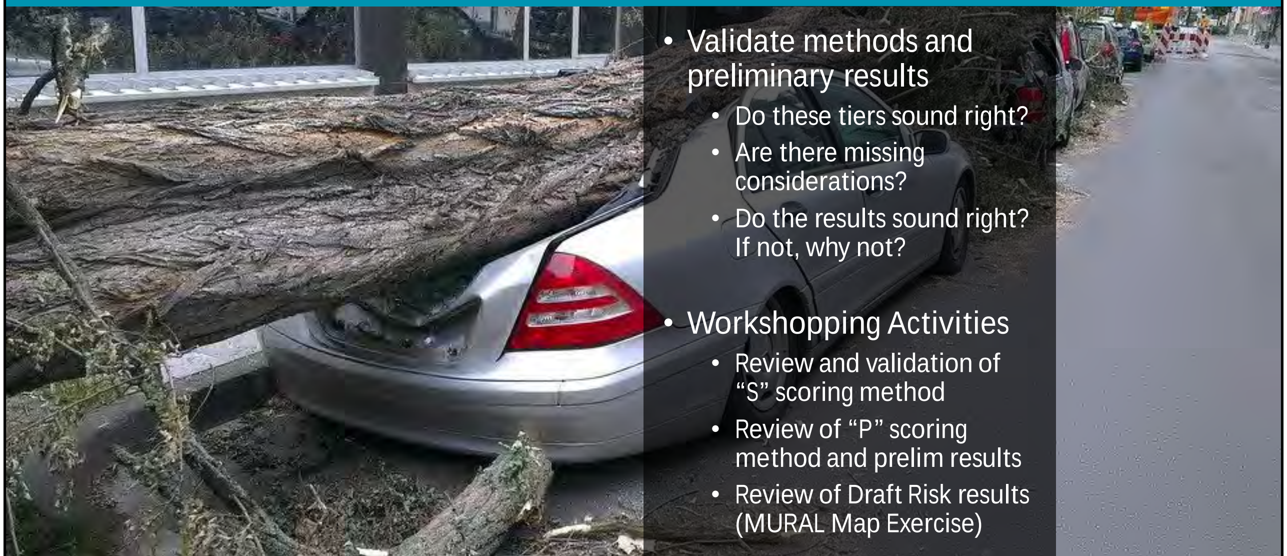
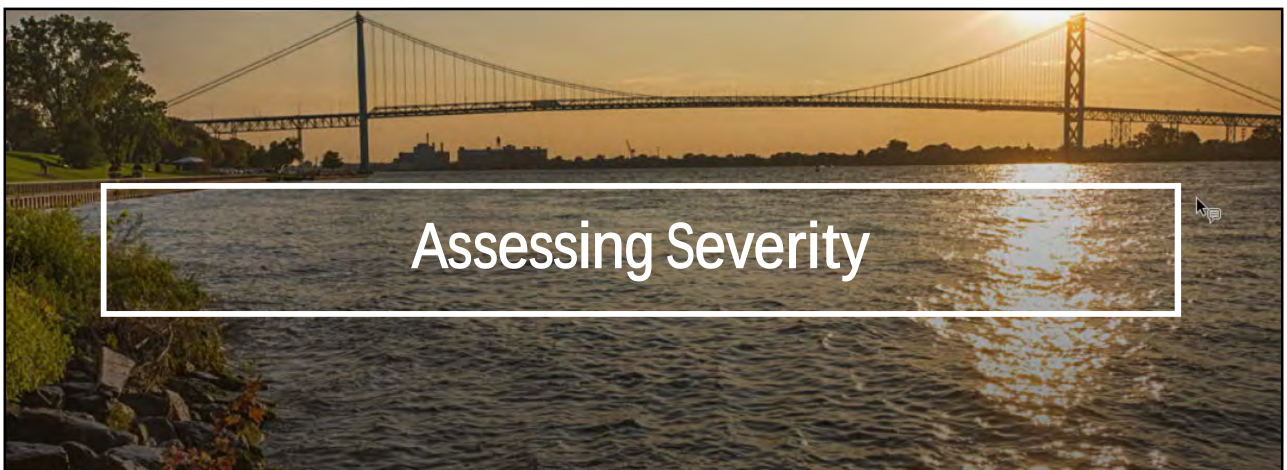
Workshop – Requested Inputs



- Validate methods and preliminary results
  - Do these tiers sound right?
  - Are there missing considerations?
  - Do the results sound right? If not, why not?
- Workshopping Activities
  - Review and validation of "S" scoring method
  - Review of "P" scoring method and prelim results
  - Review of Draft Risk results (MURAL Map Exercise)

West Windsor Flood Risk Assessment PIEVC - January 7, 2022



Assessing Severity

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

Simplified Severity Rating Scale – Quantitative Ratings – Exercise 1

Question – Do these reflect how you would rank impacts based on hazard posed by these values?

- Based on literature regarding impacts from varying flood depths
- Differentiates between serviceability requirements for 5- vs 100-year storms

Severity	PIEVC Definition	Surface Flooding and Hydraulic Grade Line Thresholds
1	Very Low; Some measurable change	Sufficient rainfall for ground saturation
2	Low; Slight loss of serviceability	Sufficient surface flow transporting leaf litter, etc., partial drainage block
3	Moderate loss of serviceability	Temporary ponding in low lying areas (e.g., immediately surrounding drains) < 0.1 m
4	Major loss of serviceability; Some loss of capacity	Standing water < 0.3 m (for 100 yr storm) *or* HGL < 0.3 m BGS (5 yr storm)
5	Loss of capacity; Some loss of function	Standing water 0.3 to 0.5 m AGL (100 yr storm) - vehicles may be stranded; partial erosion of roadbeds, embankments; *Any* ponding/standing water from 5 year storm
6	Major; Loss of function	> 0.5 m AGL depth - vehicles may become buoyant; Any washouts resulting in loss of 1 or more lanes of traffic
7	Extreme; Loss of Asset	≥ 1.0 m AGL depth OR depth X velocity ≥ 0.4 m^2/s; Total loss of multiple transportation corridors

Simplified Severity Rating Scale – Qualitative Ratings – Plant and Shoreline – Exercise 1 Continued

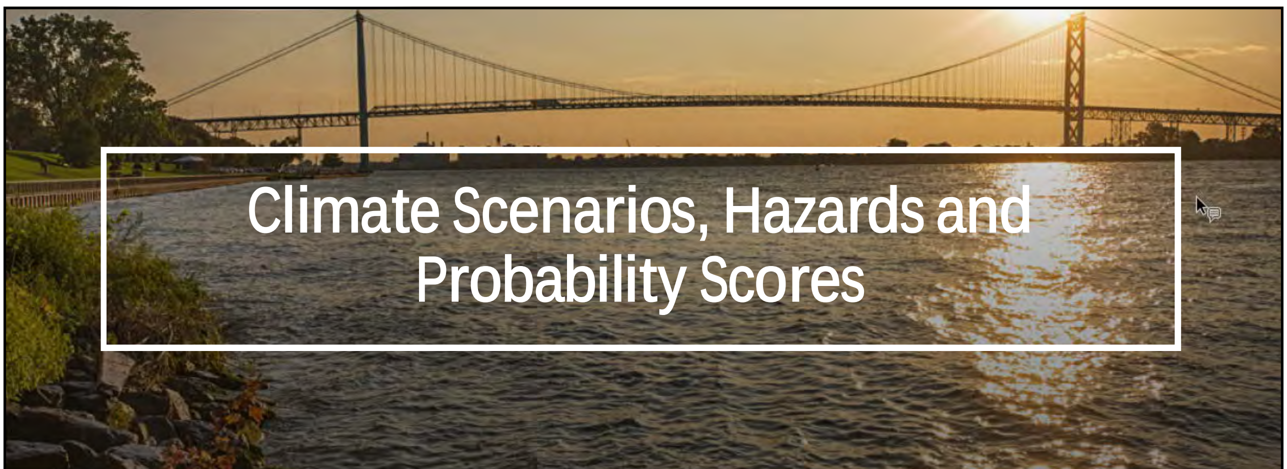
Question – Do these reflect how you would rank impacts based on hazard posed by these impacts?

Severity	PIEVC Definition	Treatment Plant	Shoreline Infrastructure
1	Very Low; Some measurable change	Flow/water volume greater than average annual maximum	Excessive seasonal erosion, noticeable mass loss
2	Low; Slight loss of serviceability	Maint. access covers and drains partially blocked	Excessive seasonal erosion, greater than normal maintenance
3	Moderate loss of serviceability	Maint. access covers and drains fully blocked	Spray begins to overtop unprotected shoreline
4	Major loss of serviceability; Some loss of capacity	Flow at plant approaching max capacity; Some pump stations no longer functioning, may require repair	Spray begins to overtop protected shoreline; Erosion of unprotected shoreline requires repairs
5	Loss of capacity; Some loss of function	Treatment Plant Shut-Off - sewer back-up 10s of properties	Shoreline protection dmg requiring significant repairs; levees or other riverine flood protection overtopped by wave action
6	Major; Loss of function	Treatment Plant Shut-Off - sewer back-up 100s properties	Shoreline protection destroyed; levees or other riverine flood protection overtopped, standing water 0.5 to 1.0 m
7	Extreme; Loss of Asset	Treatment Plant Shut-Off - sewer back-up 1000s properties; Destruction and/or removal of water control infrastructure	Flooding event results in destruction and/or removal of flood control infrastructure; movement/destruction of vehicles, structures and people (> 1.0 m AGL water levels)

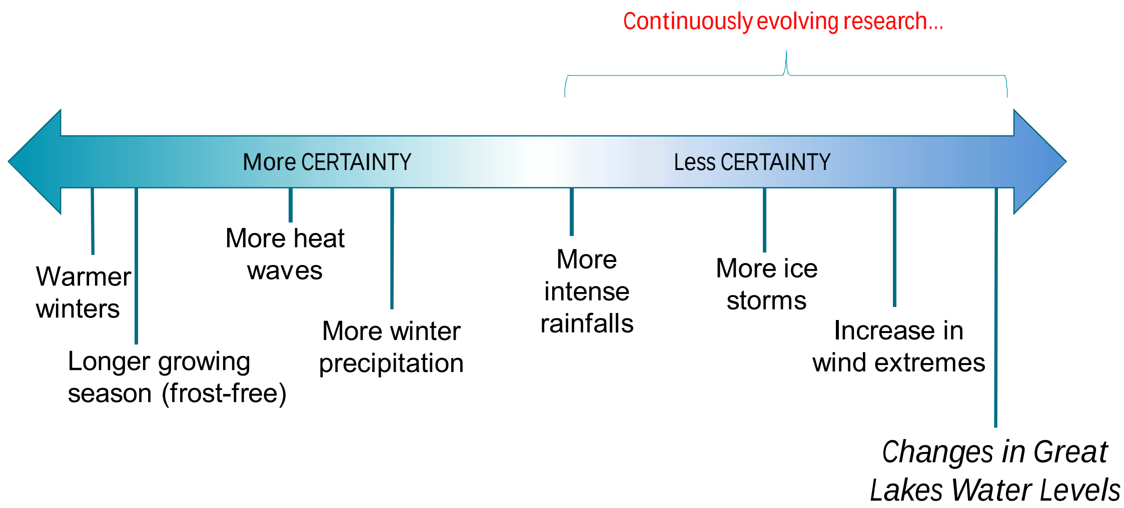
Simplified Severity Rating Scale – 3rd Party Private Assets – Exercise 1 Continued

Question – Do these reflect how you would rank impacts based on hazard posed by these impacts?

Severity	PIEVC Definition	3rd Party Private
1	Very Low; Some measurable change	Sufficient rainfall for ground saturation
2	Low; Slight loss of serviceability	Sufficient surface flow transporting leaf litter, branches, etc. from properties, partially blocking drainage
3	Moderate loss of serviceability	Debris generation (e.g., siding, roof gravel) may result in blockage of surface drainage
4	Major loss of serviceability; Some loss of capacity	Ground water levels approach basement level but still > 1.8 m HGL, sump pumps activated; Isolated cases of water damage may occur due to failure of sump pumps, other protective systems
5	Loss of capacity; Some loss of function	Any basement flooding, water level < 1.8 m HGL; Minor to moderate industrial containment breach non-hazardous materials
6	Major; Loss of function	Basement flooding, HGL < 1.3; Surface flooding 0.5 m to 1.0 m AGL; Industrial hazardous materials containment breach into water bodies
7	Extreme; Loss of Asset	Basement flooding, HGL above sfc; Surface flooding > 1.0 m AGL; Major industrial containment spill of hazardous materials onto adjacent private and public properties



Not All Climate Hazards are the Same…



Climate Change within PIEVC Assessment Context

"P" Defined by *climate parameter*:

$$R = P \times S$$

Held constant (S)

"Detects" or "sees" climate change (P)

Climate *parameter* needed

- Statistical information used in risk assessment
- i.e., element, value and duration

e.g., heavy rainfall? 25 mm in 1 hour, 15 mm in 15 min?

- "P" based on likelihood over *30-year time period*

Climate Parameters Review – Exercise 2

Precipitation/Drainage/Flooding Events

- Combined probability event modeling
  - Design rainfall events: 5-year and 100-year 4-hour "Chicago" storm
  - Detroit River Levels – Current 100 year, "Future" 100 year and extreme low
  - High-water-level + freeboard
- Multi-day rainfall (June 2010 case)
- Snow accumulations/melt (2014 case)

Secondary and Long-Term Impacts

- Major ice storm - 28 mm or more
- Extreme wind event – gusts ≥120 km/h
- Tornado - (E)F2+
- Rainfall + hail and wind
- Shoreline and creek erosion
- Weathering (freeze thaw)
- River ice

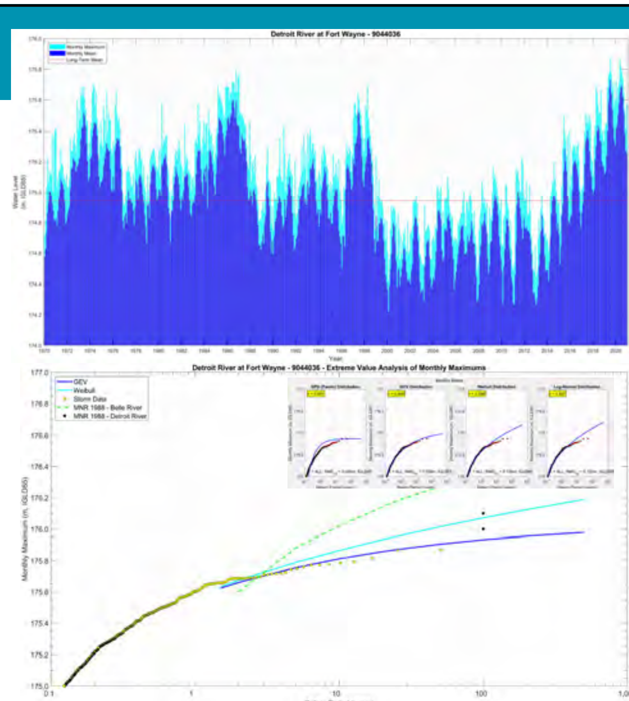
Discussion Questions

- Include extreme temperatures?
  - electrical power delivery impacts
- Others event types not covered here?

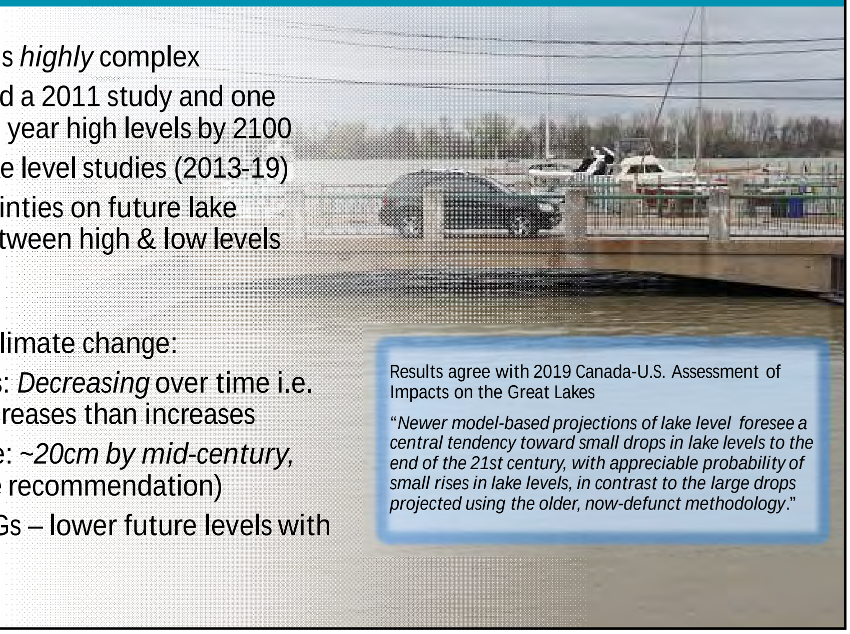
Detroit River Level - Historical Analysis

- Located Near Project Site
- Hourly Data – 1970 – Present
- Peaks: Max = 175.9, Min = 173.8

- Extreme Value Analysis (EVA)
  - Storm Listing - Monthly Maxima
  - Weibull EVA - Good Match with Low Frequency (High Return Periods)
- 100-Year Weibull Prediction Has Best Agreement with 100-Year (MNR 1989, DR2 and DR3)
  - Weibull most Likely Distribution used in MNR 1989



Great Lake Levels and Climate Change



- Great Lakes water level system is *highly* complex
- Earlier Windsor study referenced a 2011 study and one model projection of +30cm in 100 year high levels by 2100
- Added 5 climate change and lake level studies (2013-19)
- All studies project huge uncertainties on future lake levels; Expect *rapid* transitions between high & low levels

Projections of lake levels under climate change:

- Median of all model projections: *Decreasing* over time i.e. more climate models indicate decreases than increases
- 75th percentile highest increase: *~20cm by mid-century,* kept similar to 2100 (conservative recommendation)
- But, projections depend on GHGs – lower future levels with higher GHG emissions

Results agree with 2019 Canada-U.S. Assessment of Impacts on the Great Lakes

"*Newer model-based projections of lake level foresee a central tendency toward small drops in lake levels to the end of the 21st century, with appreciable probability of small rises in lake levels, in contrast to the large drops projected using the older, now-defunct methodology*."

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

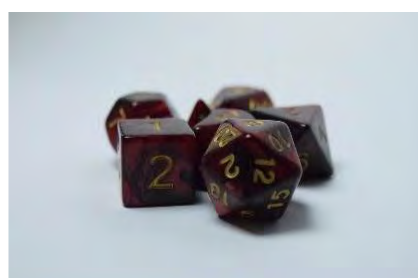
Climate Analytics – Methods and Key Findings - Joint Probability Events

"It is difficult to determine the joint probability of both extreme rainfall and high lake levels (i.e. it is unknown what the probability of occurrence would be for both a 100-year storm event and concurrent 100-year lake level)."

- Windsor/Essex SWM Standards Manual

...we're gonna try anyway.

- P_1 x P_2 ...*only* if statistically independent.
- Determining "P" value challenging
  - Currently using stat independent assumption
  - Statistical dependence investigation ongoing



West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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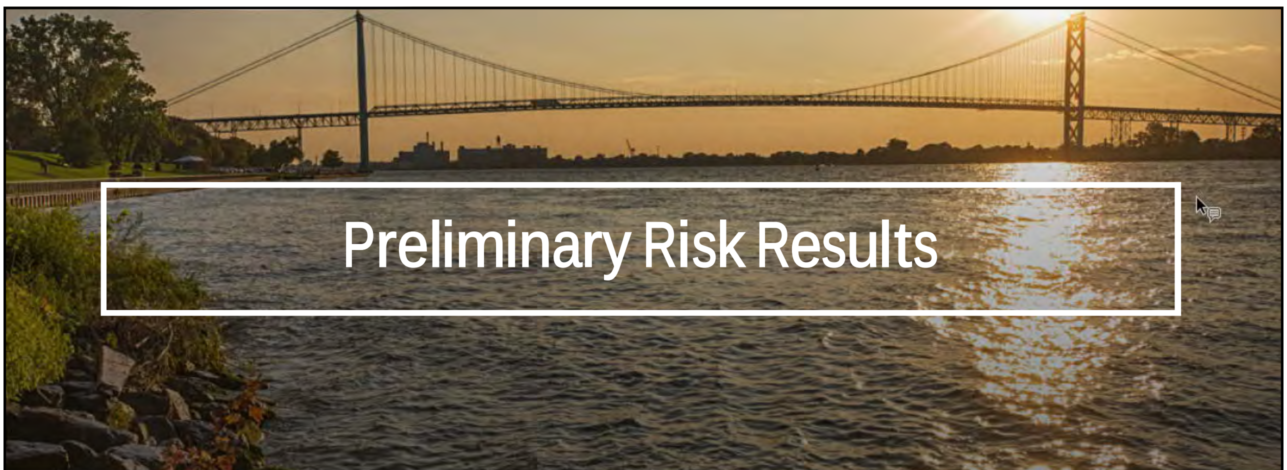
Climate Analytical Results & Discussion

Findings

- Detroit River Levels
  - Review of additional literature (research is ongoing) suggests slightly lower future peak river levels
- Event Probability Changes
  - Extreme rainfall very sensitive to warming, main driver of future changes in risk
  - Current 100-year rainfall reduced to 33-year by 2050s, 15-year by 2080s
    - Consistent with other studies and agreement among methods (e.g., climate analogues)
      - Equivalent to ~40% climate change safety factor currently in use
  - No significant changes in other parameters, including cool season/winter hazards

Discussion Questions

- Are there important events that are not covered in this list of hazards?



Interactive Review of Risk Results – Exercise 3

- Group will be redirected to the MURAL virtual whiteboard
  - Annotated map of the study area with highest risks indicated
  - 5-minutes allotted to allow attendees to get familiar with the tool
    - If more than one user present at computer, elect data input person
  - 20-minutes allotted for review and information input
  - 15-minutes for discussion of results and input

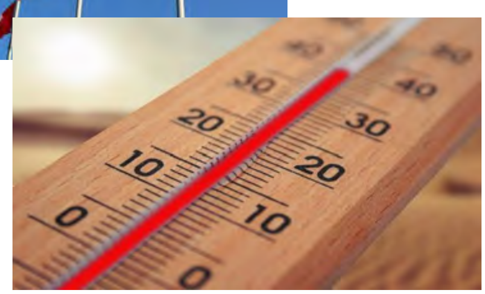
- A link to the workspace can be found here: https://app.mural.co/t/dillonconsulting7627/m/dillonconsulting7627/1640109666555/dde48c0c2fd41376e10cdaed9b179bb4027b5354?sender=u0b47aeec169a0431b8606900

Next Steps

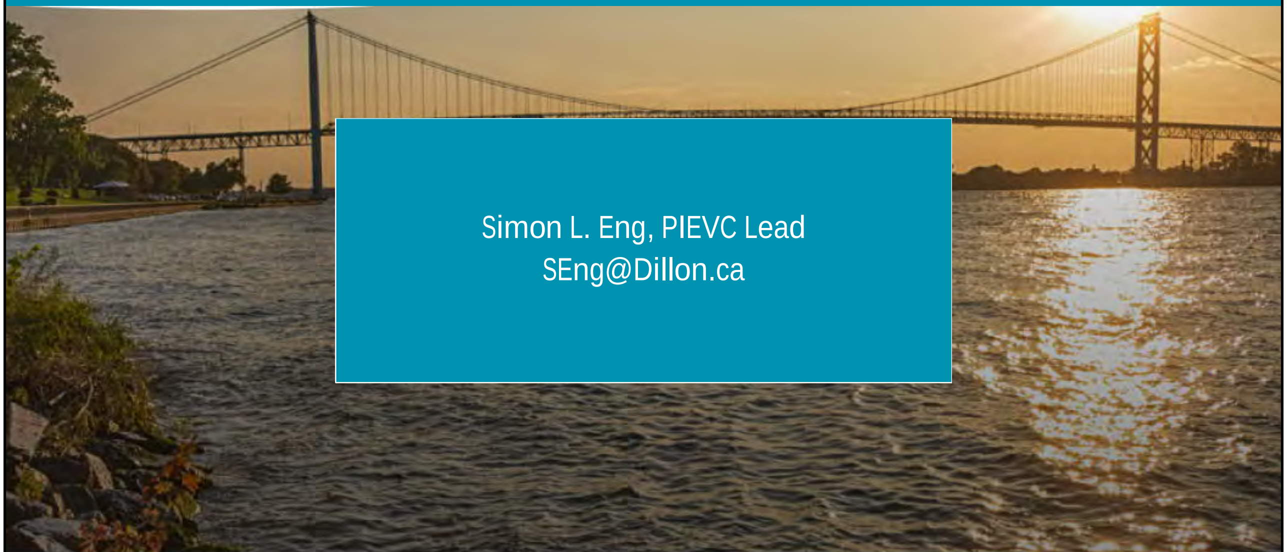
Solutions Development

- Development of list of solutions for problem areas
  - Triple-Bottom-Line (TBL) Module
  - Stakeholder Consultation Meeting to review proposed solutions and TBL outcomes
  - External Public Consultation Meeting to review refined list of proposed solutions

Final Project Reporting



Final Discussion/Questions



Simon L. Eng, PIEVC Lead
SEng@Dillon.ca

West Windsor Flood Risk Assessment PIEVC - January 7, 2022

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West Windsor Flood Assessment Study

Review of Solutions and Initial Recommendations

May 19, 2022

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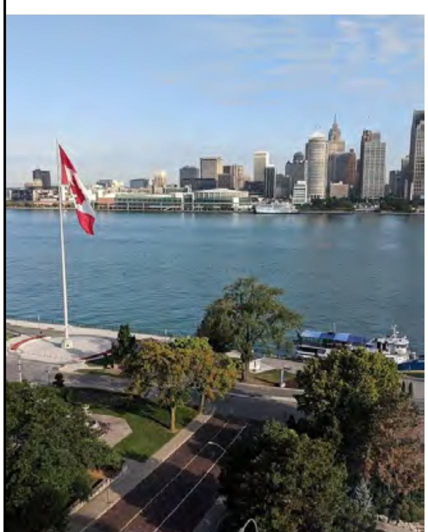
Welcome and Introductions



- Welcome – Project Managers for City of Windsor, Dillon Consulting Limited
- Purpose of Today's Workshop
  - Review results of PIEVC STEP 3
  - Review solutions and initial recommendations
  - Opportunities for further feedback

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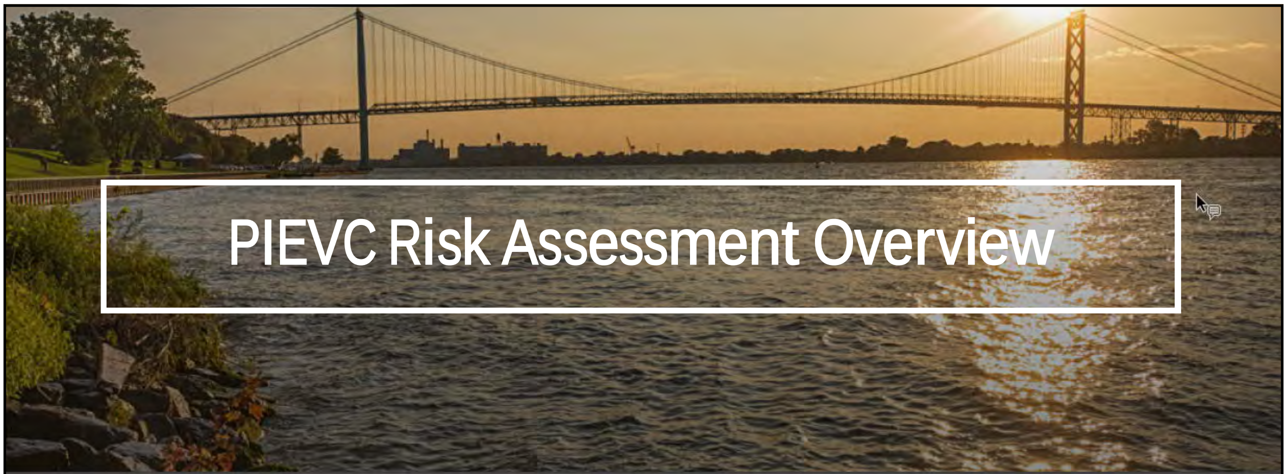


PIEVC Risk Assessment Overview

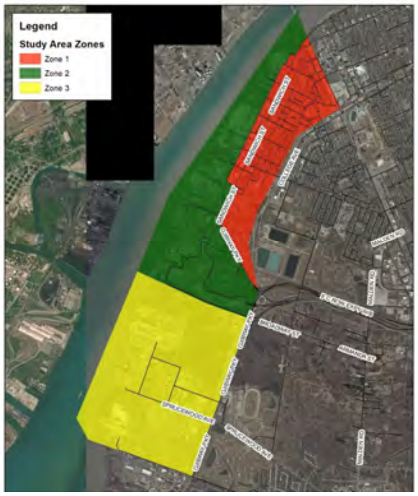
Overall Project Goals and Intended Outputs

Project Goals: Develop a flood risk profile for the West Windsor area and identify recommended flood protection solutions.

Flood protection solutions have been developed to:
- Reduce susceptibility of coastal flooding within the study area, reduce impact of increased inflow and infiltration (I&I) into the municipal system from high Detroit River water levels;
- Improve the performance of the existing infrastructure during high water levels and reduce peak flows at the Lou Romano WRP;
- Provide more sustainable municipal infrastructure; and,
- Reduce risk of surface and basement flooding.

Next Steps following solution finalization:
- Public consultation; and
- Final reporting.

Project Area



Boundaries: Ojibway Pky and College St.; LaSalle border; Huron-Church/Ambassador Bridge

- Zone 1 “inland” residential, institutional and industrial;
- Zone 2 shoreline industrial; and
- Zone 3 industrial and parkland.

Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol & Outputs

PIEVC Protocol

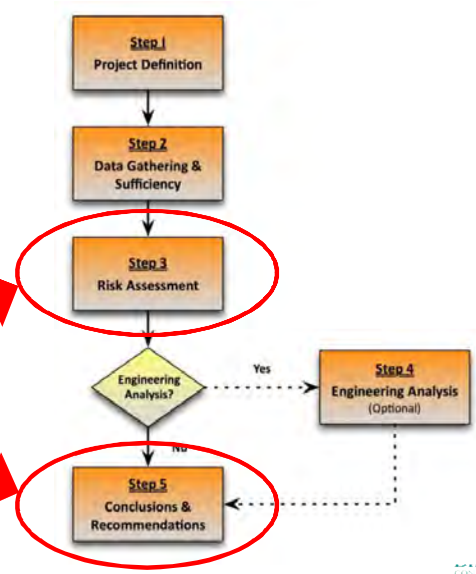
- Based on standard risk assessment methodology

Outputs

- *Prioritized list* of risks

January Workshop

Where we are now



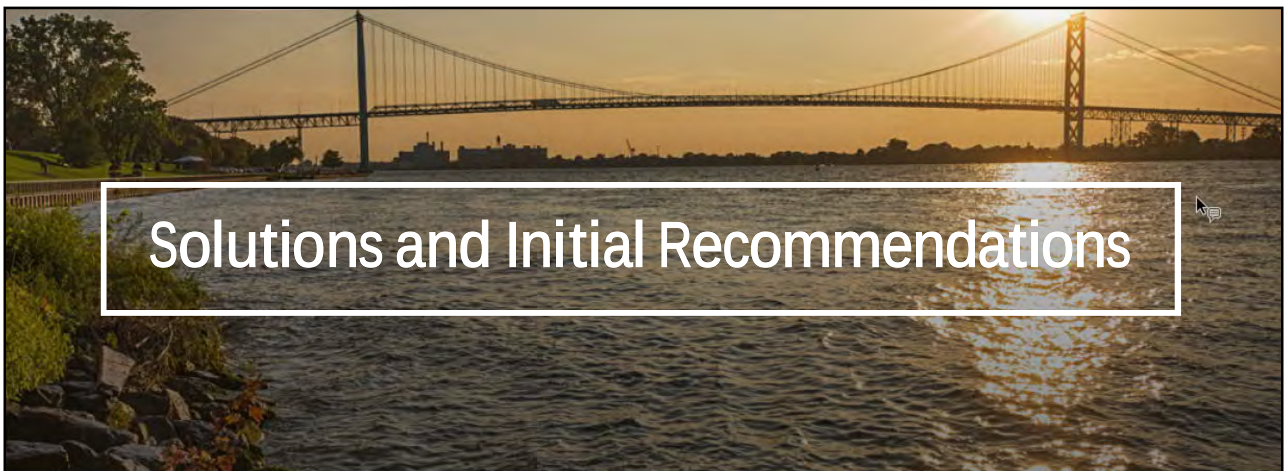
West Windsor Flood Study PIEVC Overview

1. Identified Assets: Drainage, sanitary, combined sewers, including Lou Romano* plant, and key adjacent city and 3rd party assets (schools, parks, arterial roads, etc.)
2. Assessed Impacts due to Climate Change Events: Drainage/sanitary system overloading and failures, immediate effects on surrounding critical assets, 3rd party assets critical to operations of drainage/sanitary system
3. Developed Risk Scores:

Risk = Probability x Severity

4. Identified Solutions: Recommendations to address risks at assets with the highest scores

* Note: *Internal treatment plant operations not in scope*



General Solutions

Excess Flows to Lou Romano Water Reclamation Plant

- Backflow Prevention at CSOs
  - Weirs
  - Flapgates
- Lou Romano RTB
- Combined Sewer Separation

Surface Flooding

- Raise Ground Elevations (Grading Improvements)
- Dewatering Pumping
- Conveyance Improvements
  - Prince Road Trunk Storm Sewer Outfall and Pumping Station
  - Detroit Street Trunk Storm Sewer and Outfall
  - Combined Sewer Separation
  - Roadside Drainage Improvements

General Solutions - Continued

Basement Flooding

- Basement Flood Protection Measures
  - Backflow Prevention
  - Downspout Disconnection
- Combined Sewer Separation
  - PDC Separation
  - Foundation Drain Disconnection

Shoreline Erosion

- Monitoring and Local Repair Plans

Zone 1

Zone Characterization

- Inland, mainly residential, institutional and commercial
- Includes Lou Romano Water Reclamation Plant
- Ground elevations mostly higher than Detroit River HWL

Flood Hazard Characterization

- Basement Flooding – surcharging of combined systems
- High Flows to Lou Romano – high river levels, wet weather I/I
- Surface Flooding
  - High Detroit River levels – Russell Street, Sandwich Street
  - Severe rainfall – localized, combined sewer surcharging

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Zone 1

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Zone 2

Zone Characterization

- Detroit River shoreline, mainly industrial
- Includes WPA lands, WDBA lands, Brighton Beach Generation Station, Keith Transmission Station
- Ground elevations close to Detroit River HWL

Flood Hazard Characterization

- Surface Flooding
  - High Detroit River levels – Prospect Avenue, Sandwich Street, McKee Park
  - Severe rainfall – localized, conveyance system surcharging
- Shoreline Erosion Concerns

Zone 2

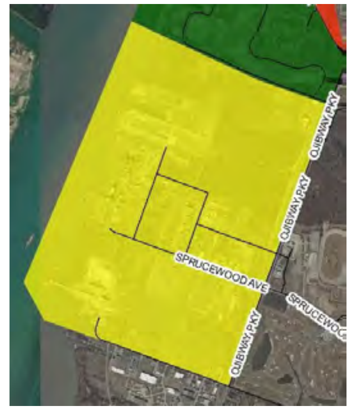
Zone 3

Zone Characterization

- Detroit River shoreline, mainly industrial
- Includes Black Oak Heritage Park, Truck Ferry
- Ground elevations generally 1-2 m above Detroit River HWL

Flood Hazard Characterization

- Surface Flooding
  - Roadside Drainage Capacity – Ojibway Parkway, Sprucewood Avenue
  - Sanitary Surcharging – localized, severe rainfall



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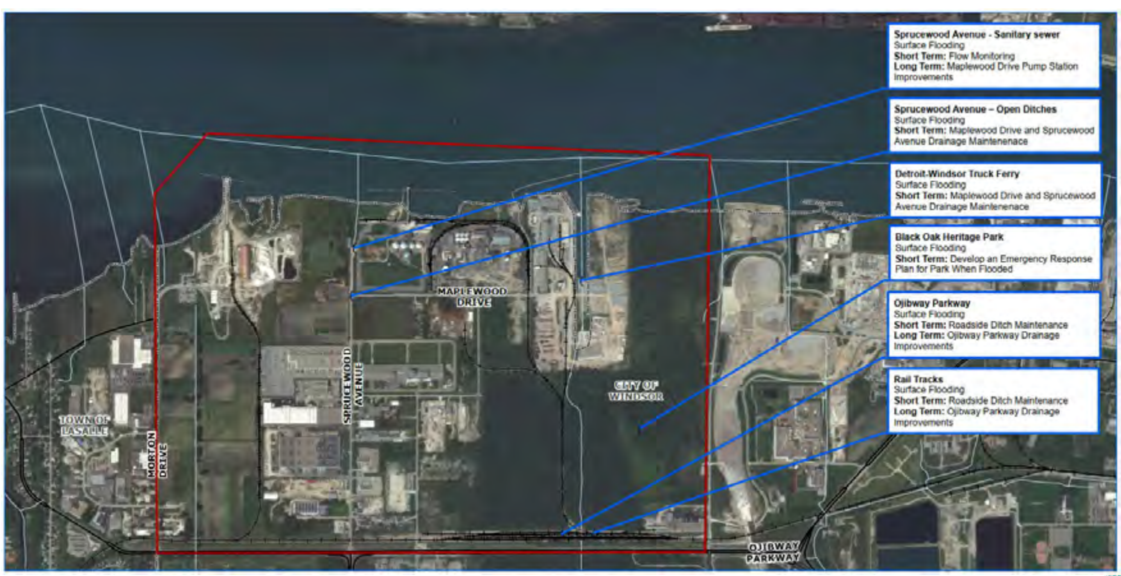
Zone 3



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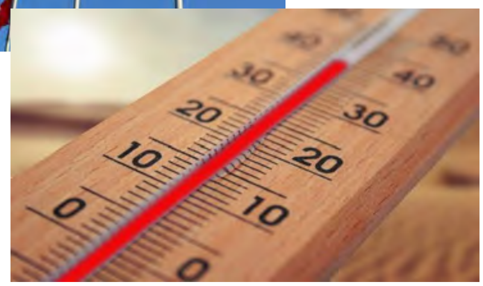
Next Steps

- Refine Proposed Solutions
  - Triple-Bottom-Line (TBL) Module
- External Public Consultation Meeting to review refined list of proposed solutions
- Final Project Reporting



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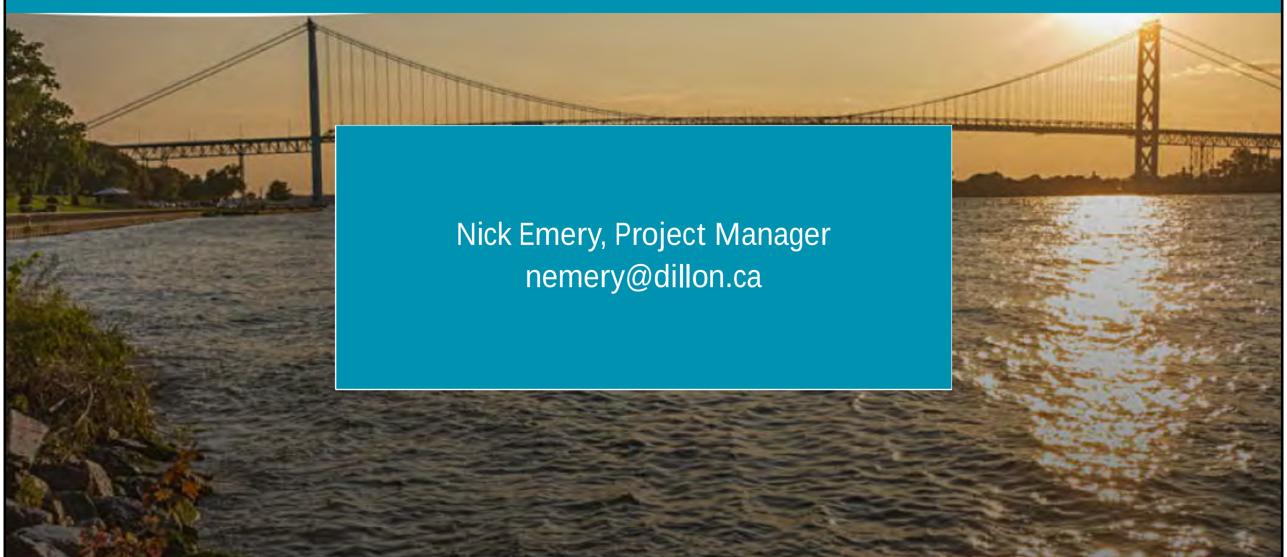
Final Discussion/Questions



Nick Emery, Project Manager
nemery@dillon.ca

DILLON CONSULTING

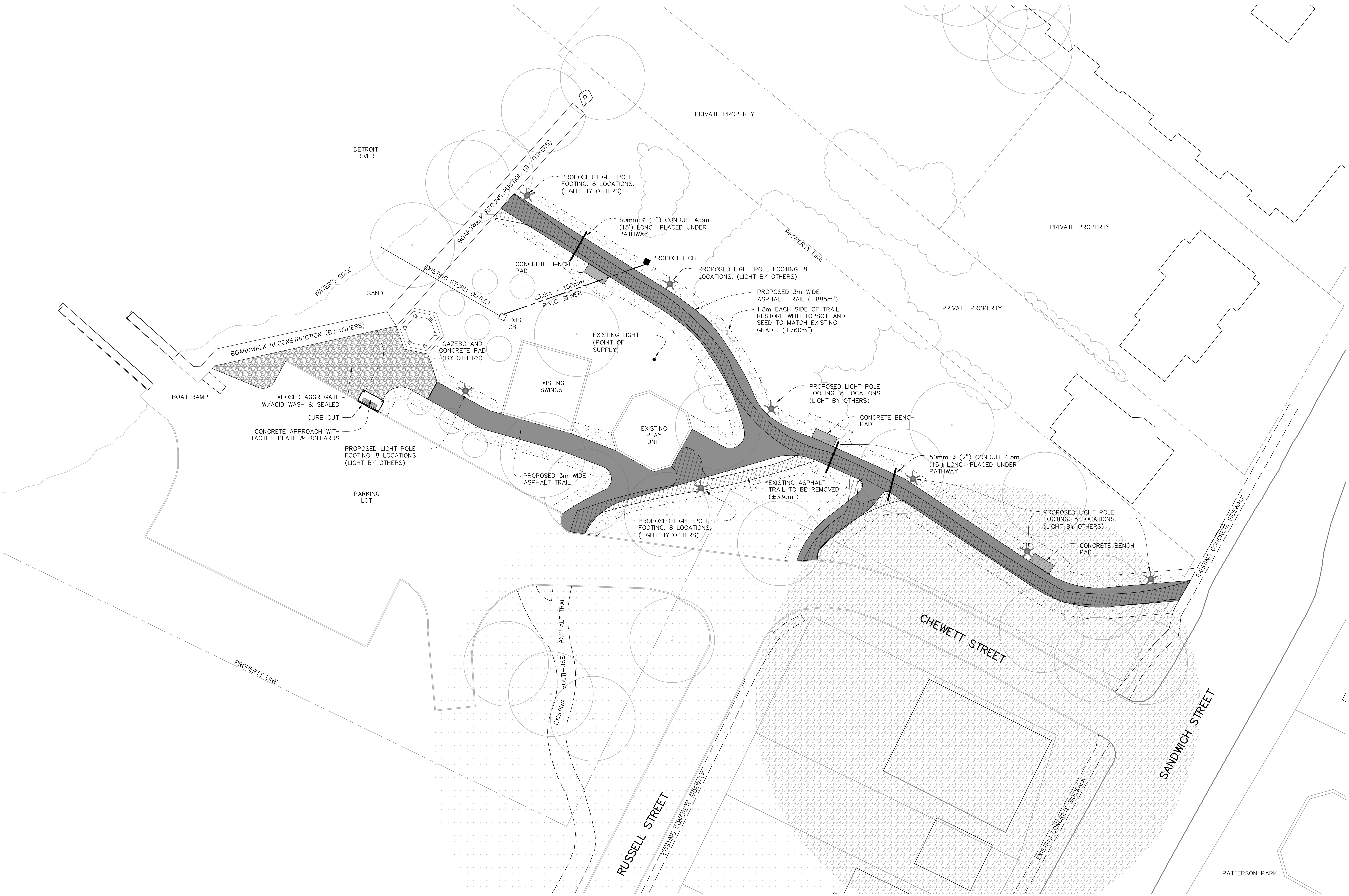
Appendix C

Background Information

Appendix C – Background Information

1. McKee Park Improvements Site Plan, March 2022

5. Sandwich Street ETR Crossing Pavement Rehabilitation and Culvert Extension, Proposed Pavement Upgrades, February 2022



GENERAL NOTES:

1. CONTRACTOR TO CALL FOR LOCATES PRIOR TO COMMENCEMENT OF ANY WORK ON SITE. CONTRACTOR TO DETERMINE AND VERIFY THE LOCATION AND EXISTENCE OF ALL UNDERGROUND UTILITIES PRIOR TO COMMENCING CONSTRUCTION. ADVISE THE PROJECT MANAGER FOR ANY CONFLICT BETWEEN EXISTING UTILITIES AND NEW WORK.
2. THE LOCATION OF UTILITIES IF INDICATED ON THE DRAWING IS NOT CERTIFIED TO BE ACCURATE. THE ONUS LIES ON THE CONTRACTOR AFTER ACCEPTANCE OF ANY CONTRACT AWARD TO OBTAIN AT THEIR OWN EXPENSE THE EXACT LOCATION OF EACH UTILITY. NO EXTRAS TO THE CONTRACT OR CLAIM FOR COMPENSATION WILL BE ALLOWED IF IT SHOULD BE DISCOVERED THAT ANY UTILITY IS ACTUALLY LOCATED IN THE SITE, LINE OR GRADE THAT IS IN VARIANCE WITH THE SITE, LINE OR GRADE SHOWN ON THIS DRAWING.
3. CONTRACTOR TO INFORM CITY PROJECT MANAGER OF COMMENCEMENT OF WORK DATE OF WORK START UP TIME PRIOR TO ANY ONSITE OPERATIONS TAKING PLACE. THE CITY WILL MEET CONTRACTOR ON SITE TO REVIEW ALL WORK PRIOR TO COMMENCEMENT. A MINIMUM OF 48HOURS NOTICE SHALL BE GIVEN TO THE CITY PRIOR TO STARTING WORK.
4. THE CONTRACTOR TO VERIFY THE GRADES OF ALL PROPOSED INVERTS, CATCH BASINS AND MANHOLE TOP ELEVATIONS AND ADJUST TO SUITE EXISTING GRADES. ALL DRAINAGE INSTALLED AS A RESULT OF THIS WORK SHALL HAVE POSITIVE DRAINAGE TO EXISTING CATCH BASINS AND OR MANHOLES. CONTRACTOR TO VERIFY DEPTHS AND GRADES IN THE FIELD WITH CITY PROJECT MANAGER. CONTRACTOR TO OBTAIN ALL PERMITS REQUIRED FOR ANY DRAINAGE WORK IF NECESSARY.
5. REPAIR ANY DAMAGE DONE AS A RESULT OF CONSTRUCTION. VERIFY THAT ALL EXISTING SITE CONDITIONS ARE AS SHOWN ON THE PLANS. THE CONTRACTOR IS RESPONSIBLE TO THE CITY FOR ANY DAMAGE DONE TO A UTILITY THROUGH ANY ACT OF NEGLECT BY THE CONTRACTOR OR ANYONE ACTING UNDER THE AUTHORITY OF THE CONTRACTOR.
6. ALL WORK TO BE PERFORMED IN COMPLIANCE WITH THE HEALTH AND SAFETY ACT LATEST REVISIONS AS WELL AS THE CITY OF WINDSOR HEALTH AND SAFETY REGULATIONS
7. RESTORATION OF ANY AREAS DISTURBED AS A RESULT OF CONSTRUCTION WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO RESTORE TO EXISTING CONDITIONS OR BETTER INCLUDING DAMAGED ASPHALT, CONCRETE, CURBS OR ANY OTHER SITE FEATURE DAMAGED AS A RESULT OF CONTRACTOR OPERATIONS. GRADING WILL BE RESTORED AS ROUGH FINISHED GRADE AND THE CITY WILL PERFORM ALL FINISHED SITE GRADING AFTER WORK HAS BEEN COMPLETED. ROUGH GRADING INCLUDES ELIMINATING ANY TRIP HAZARDS UNEVEN AREAS TO ALLOW FOR POSITIVE DRAINAGE.
8. ANY GRADES AND DIMENSIONS ARE PROVIDED FOR CONVENIENCE TO BIDDER AND ARE THE RESPONSIBILITY OF THE CONTRACTOR TO PROVIDE OR VERIFY WITH THE CITY PROJECT MANAGER.
9. CONTRACTOR TO PROVIDE SITE LAYOUT SERVICES BY CERTIFIED SURVEYOR TO CONFORM WITH DRAWINGS AND CAD FILES PROVIDED BY THE CITY. LAYOUT, GRADES AND DEPTHS MUST BE CONFIRMED BY CITY PROJECT MANAGER PRIOR TO FINALIZING PATHWAY LAYOUT, DEPTHS OF STONE, AND FINISHED GRADES OF CATCH BASINS, ASPHALT, CONCRETE, SITE FEATURES, AND GENERAL SITE GRADING.

EXISTING TREE PROTECTION

1. THE FOLLOWING NOTES WILL PERTAIN TO ANY AND ALL EXISTING TREES ON THE SITE LOCATED WITHIN THE CONSTRUCTION AREA OR ADJACENT TO ANY CONSTRUCTION OPERATIONS AS A RESULT OF WORK BEING PERFORMED.
2. PRIOR TO ANY DEMOLITION OR CONSTRUCTION, PROTECT ALL TREES TO REMAIN AS DIRECTED BY THE PROJECT MANAGER OR BY ERECTING SNOW FENCE BEYOND THE DRIP LINE OR AS CLOSE AS POSSIBLE TO THE DRIP LINE TO THE SATISFACTION OF THE PROJECT MANAGER. DO NOT STORE OR STOCKPILE ANY BUILDING MATERIALS OR EQUIPMENT INSIDE THE DRIP LINE OF EXISTING TREES.
3. IF RE-GRADING IS REQUIRED BETWEEN THE DRIP LINE OF AN EXISTING TREE, DO NOT REMOVE OR ADD MORE THAN 100mm (4") OF SOIL. IF THE SITUATION REQUIRES A CHANGE IN GRADE OF MORE THAN100mm (4") NOTIFY THE CITY PROJECT MANAGER FOR FURTHER INSTRUCTION.
4. ANY TREES DAMAGED AS A RESULT OF CONSTRUCTION BEYOND REPAIR MUST BE REPLACED TO THE SATISFACTION OF THE CITY OF WINDSOR WITH NEW TREE CALIPER NO LESS THAN 150mm. THE CONTRACTOR TO NOTIFY THE CITY PROJECT MANAGER AS SOON AS ANY DAMAGE HAS OCCURRED TO ANY EXISTING TREE.

Date	Issued for
03/2022	TENDER

Revisions

THE CITY OF WINDSOR ONTARIO, CANADA

City of Windsor
Parks and Recreation
2450 McDougall St. Windsor Ontario N8X 3N6 253 – 2300

Project: McKEE PARK IMPROVEMENTS ASPHALT TRAIL REDEVELOPMENT

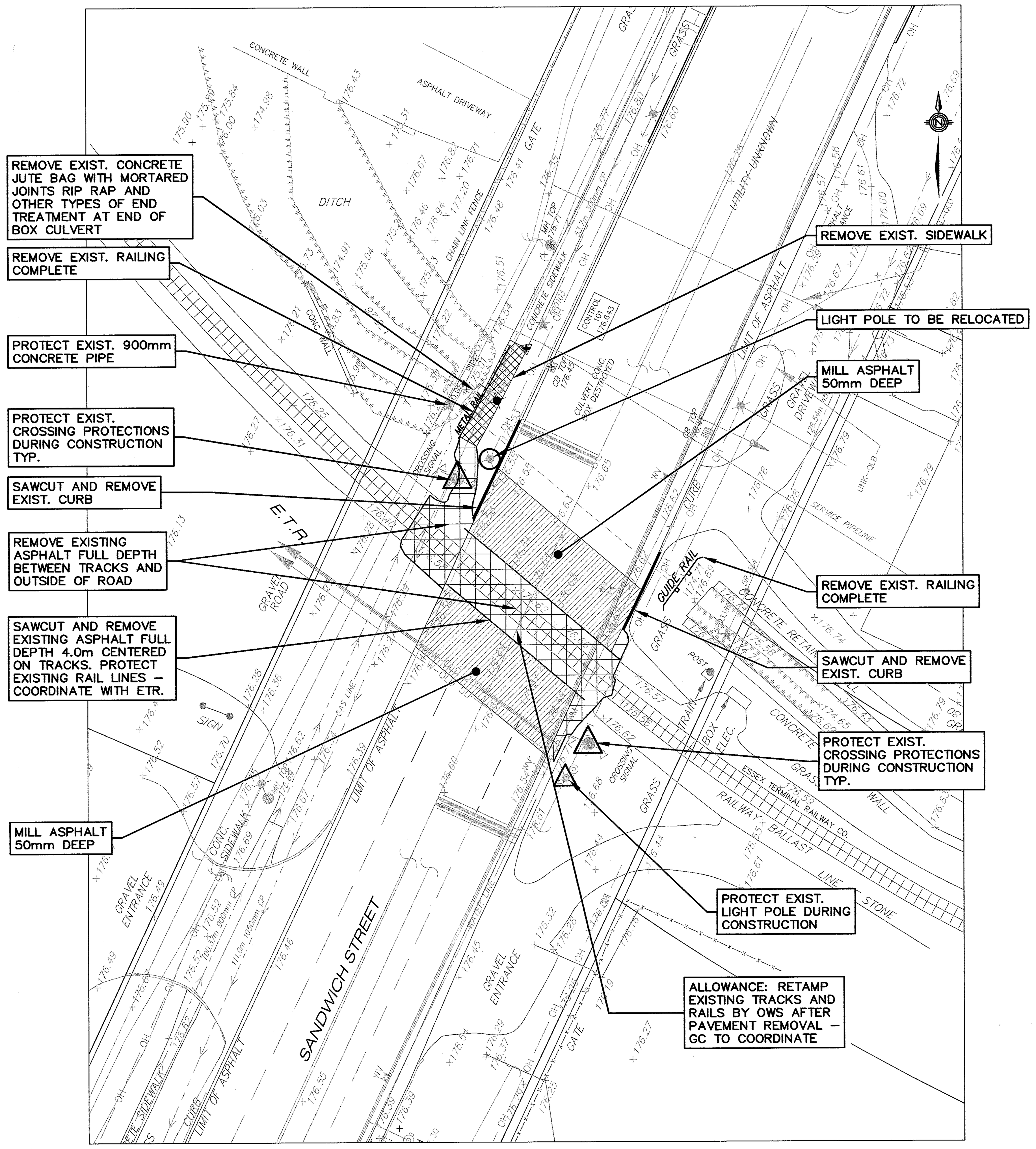
Sheet Title: SITE PLAN

Date	MARCH 2022	Approved
Design	D. A.	Tender No.
Drawn	S. H.	Project No.

Scale: 1 : 250

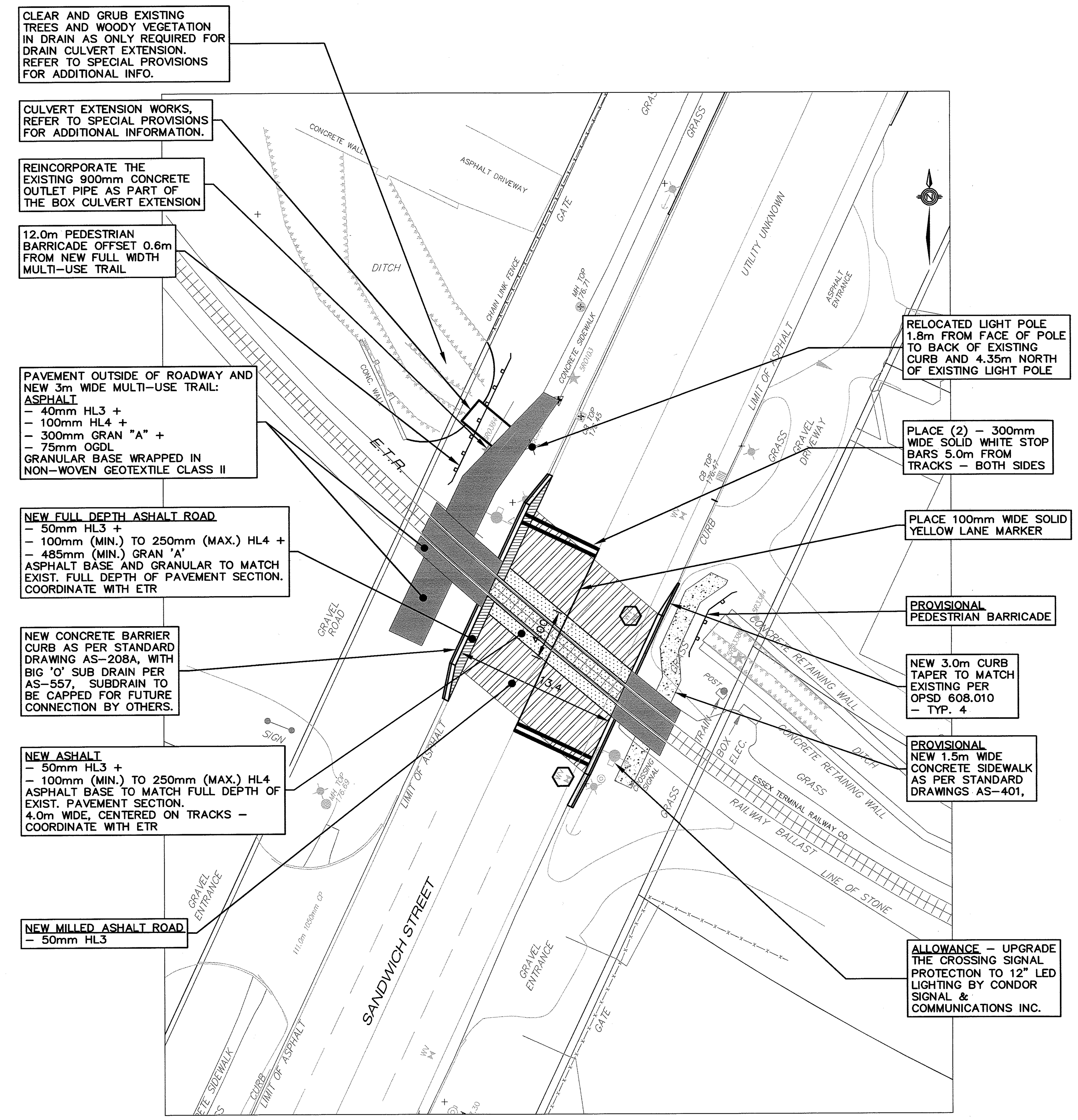
North

Sheet No. 1 of 2



EXISTING CONDITIONS & REMOVALS

SCALE 1:250



PROPOSED NEW CONSTRUCTION

SCALE 1:250

NOTES

1. PROVIDE SILT FENCE FOR SEDIMENT AND EROSION CONTROL ALONG EXISTING ROADSIDE DITCHES AND MUNICIPAL DRAIN DURING CONSTRUCTION. CONTRACTOR TO MONITOR DAILY.
2. CONTRACTOR SHALL PROTECT EXISTING CATCH BASINS AND PIPE END SECTIONS FROM SEDIMENT WITH FILTER CLOTH OR OTHER APPROVED METHOD. ALL SUMP TO BE KEPT CLEAN DURING CONSTRUCTION.
3. NO WORKS TO BE UNDERTAKEN WITHIN THE MUNICIPAL DRAIN UNLESS OTHERWISE SHOWN ON THE CONTRACT DOCUMENTS OR AS PER PRIOR APPROVAL BY OWNER.
4. ALL DISTURBED AREAS SHALL BE FINE GRADED WITH TOPSOIL, HYDRO SEED AND EROSION CONTROL BLANKETS
5. ALL DIMENSIONS SHOWN ON PLANS ARE MINIMUM REQUIREMENTS FOR TENDER.
6. REFER TO ALL CONTRACT DOCUMENTS FOR ADDITIONAL INFORMATION.
7. CONTRACTOR TO COORDINATE ALL WORKS WITH ETR WHEN WORKING WITHIN 4.6m OF THE RAIL LINES. REFER TO ALLOWANCE – ESSEX TERMINAL RAILWAY FLAGMEN FOR ALL WORK WITHIN THE ETR RIGHT OF WAY
8. CONTRACTOR TO COORDINATE UPGRADES TO CROSSING PROTECTION "BY OTHERS" DURING CONSTRUCTION.
9. CONTRACTOR TO CONFIRM LAYOUTS WITH THE CITY BEFORE NEW WORKS COMMENCE.

PAVING NOTES:

- CONTRACTOR TO REMOVE EXISTING CATCHBASIN/ LIGHTING POLE AND REMOVE OR ABANDON EXISTING CB LEAD
- CONTRACTOR TO PROTECT/ADJUST EXISTING APPURTENANCE DURING CONSTRUCTION
- CONTRACTOR TO PROTECT/SUPPORT EXISTING HYDRO/LIGHT/BELL FACILITIES DURING CONSTRUCTION
- EXISTING ETR CROSSING PROTECTION
- REMOVE EXISTING CURB AND GUTTER
- REMOVE EXISTING ASPHALT (FULL DEPTH)
- REMOVE EXISTING CONCRETE SIDEWALK
- MILL 50mm OF EXISTING ASPHALT
- NEW ASPHALT AND MULTI USE TRAIL (40mm HL3 SURFACE, 60mm HL4 BASE, 300mm GRANULAR "A")
- NEW ASPHALT (50mm HL3 SURFACE, 100mm MIN. HL4 BASE)
- NEW FULL DEPTH ASPHALT ROAD (50mm HL3 SURFACE, 100mm MIN. HL4 BASE + 485mm MIN. GRAN "A")
- NEW 50mm HL3 SURFACE COURSE ASPHALT FOR COLD MILLING
- NEW CONCRETE SIDEWALK (AS-401) (LIMITS TO BE APPROVED BY THE CITY ENGINEER) **(PROVISIONAL)**

LEGEND

DESCRIPTION	EXISTING	PROPOSED
UNDERGROUND BELL	BELL	
UNDERGROUND HYDRO	HYD	
UNDERGROUND TRAFFIC	T	
STORM SEWER		
SANITARY SEWER		
DUAL SEWER		
WATERMAIN	WM	
GASMAIN	G	
SEWER MANHOLE	SMH	
WATER VALVE	WV	
FIRE HYDRANT	FH	
GAS VALVE	GV	
LIGHT STANDARD	LS	
TRAFFIC LIGHT	TL	
HYDRO POLE	H	
BELL POLE	B	
ROAD SIGN	S	
CATCH BASIN	CB	
SURVEY BAR		

ATTENTION:

CONTRACTOR IS RESPONSIBLE FOR THE EXACT LOCATION AND PROTECTION OF EXISTING UTILITIES DURING CONSTRUCTION.

No.	REVISIONS	DATE	INIT.

ISSUED FOR PREQUALIFICATON/ TENDER DATE : FEBRUARY 4, 2022

ISSUED FOR CONSTRUCTION DATE :

AS CONSTRUCTED DATE :

SCALES

10m 5 0 10 20 30 40m

HORIZONTAL 1 : 500

LICENSED PROFESSIONAL ENGINEER J.R. DATTILO 100009085 PROVINCE OF ONTARIO

DATE DRAWN: JAN. 2021

DRAWN BY: J. MUEGGE/D. BAUGHAN

CHECKED: P. UBENE

DESIGN: J. DATTILO

CHECKED: C. MIDDAUGH

CHRIS NEPSZY, P.Eng.
COMMISSIONER OF INFRASTRUCTURE SERVICES

THE CORPORATION OF THE CITY OF WINDSOR
ENGINEERING DEPARTMENT

SANDWICH STREET ETR CROSSING
PAVEMENT REHABILITATION AND CULVERT EXTENSION

SANDWICH STREET AT ETR

PROPOSED PAVEMENT UPGRADES

EXISTING CONDITIONS AND REMOVALS AND PROPOSED NEW CONSTRUCTION

PREQUALIFICATION/ TENDER No. 16–22

ACCOUNT No. 7141048

DRAWING No. P–2009

SHEET 1 OF 6

Appendix D

Climate Data and Analysis Summary

To: Project File

From: Heather Auld

Date: February 16, 2022

Subject: West Windsor Flood Risk Assessment
Climate Data and Analysis Summary

Our File: 21-2409

Purpose and Scope

This report serves as a technical summary for climate data, information and analyses executed within the context of the Public Infrastructure and Engineering Vulnerability Committee (PIEVC) Protocol risk assessment. It provides detailed technical information on the data sources, analytical methods, analytical results and final application and contextualization of those results within the context of the PIEVC assessment.

Climate Analytical Methodology – Historical Data and Future Projections

The risk assessment necessitates the analysis of both historical and future climate information. Historical climate information serves two key purposes:

1. It provides a baseline for historical operating conditions for the assets under study; and,
2. It provides a reference point to establish necessary context for climate change projections; i.e., how far will changes in climate deviate from current conditions?

A historical background is critical to providing a point of reference for climate change information, since it can indicate the type of operating environment which has already interacted with the assets under study. Climate projections are of little value unless the projected changes are provided within the context of these current conditions.

Historical Data

The majority of the historical climate baseline information used in this project was derived from climate observations from the most representative climate stations available near the assets being evaluated. A meteorological record of 30 years (1981 to 2010), a so-called "climate normals" period, was used for historical baseline data calculations. Historical climate data were obtained from the Environment and Climate Change Canada (ECCC) Windsor International Airport station. Additionally, Detroit River level data were obtained from the US Army Corps of Engineers for the Fort Wayne stream gauge station.

Climate Change Projections

Having established a historical baseline, the analysis then required guidance to assess potential changes in key hazards and climate parameters under a changing climate. The methodology employed here uses the "Delta" or *change factor* method to both downscale Global Climate Model (GCM) projections to the local scale needed for decision making, and to account for climate model biases. This method assumes that future changes to the West Windsor study area climate will be directly correlated to changes to the regional climate and that relationships between variables at the local scale are assumed to remain relatively constant in the future period. Not surprising, most studies indicate that credible climate change projections at the local to regional scale are highly contingent upon GCMs being able to faithfully represent the large-scale processes and relevant features of the climate system (IPCC 2013).

This method of model bias correction and downscaling is able to make use of many models – called a "multi-model" ensemble – with the reliability of the outputs being much improved over the use of any single, higher resolution model. The selection of a single model or a small subset of climate models could lead to costly maladaptive decisions, particularly since the use of ensembles helps to moderate the effects of differing assumptions inherent in each model.

This study used an ensemble of all AR5 global climate models initially released by the Intergovernmental Panel on Climate Change (IPCC) in 2013, with outputs for the climate parameters of interest and representative of the Windsor region. Dillon first obtained the average climate conditions for the baseline normals period (1981-2010, the official and most recent available), and then projected the average change in climate conditions for the future periods (i.e., 2050s and 2080s) from the multi-model ensemble. The *change* from baseline to future produced by the model ensemble was then added to the actual historical station observations. This method avoids any inherent model biases by only considering the change – or “delta” – of the projections and adding this to the analyses of the historically observed climate.

From an ensemble of 37 GCMs, the grid point value corresponding to the Windsor location was selected. Grid point size differs between models, but is approximately 150 km x 150 km when all models are re-gridded to a common scale prior to averaging. The use of an ensemble of models is approved by the Intergovernmental Panel on Climate Change (IPCC, 2013). In effect, this method applies a climate change factor to a baseline high resolution observation (i.e. station corresponding to the Windsor study area) to estimate future climate conditions.

Climate Projections for Complex Hazards

Complex hazards, meaning those that are characterized as being highly localised (with respect to model grid scales described above), short duration, extremes, and/or combined or concurrent (synergistic) events, require specialized studies and are not directly available as raw outputs from GCMs. In these cases, future climate conditions for the Windsor area were either derived from specialised studies available in the peer-reviewed published literature (e.g. Cheng et al., 2012, 2014 for high winds and ice storms; Diffenbaugh et al. 2013 for changes in severe thunderstorm activity).

Where projection guidance was not available in any form, professional judgement was applied based on an integration and assessment of all available guidance (e.g., trends in parameters contributing to a given hazard) and the climate expertise of the Dillon team.

In particular, a comprehensive review of all climate change and Great Lakes level studies undertaken by Canada or the United States since 2011 was used to assess and update the future lake level projections developed for the earlier Riverside East and Windsor Port Authority PIEVC risk assessments. Several new water level studies were reviewed that included more recent climate change models, a greater number of climate change models, added regional scale climate modelling results, more GHG emission assumptions and improved lake dynamics modelling.

Selection of Representative Concentration Pathways (RCPs)

In the currently valid IPCC AR5 assessment, greenhouse gas emission assumptions or representative concentration pathways, or simply “RCPs”, were developed to describe alternate possible future climates based on the amounts of greenhouse-gas (GHG) emissions that may be emitted and accumulated long into the future. RCPs refer to a consistent set of internationally agreed upon assumptions on GHG emissions activities that are used by climate modellers to explore plausible future emission scenarios and their implications for the globe's climate responses.

The future pathways for GHG emissions are largely unknown, but historically the trends in emissions have been most closely following the RCP8.5 or *high* emission trajectory (**Figure 1**). This trajectory represents an additional 8.5 W/m^2 of energy to the atmosphere by the year 2100 and approximates a mostly "business as usual" carbon emissions situation. In the absence of any truly enforceable global GHG reduction program, this would seem to be the most likely (and extreme) path. This RCP 8.5 emission pathway is also useful as a risk averse lens to climate change assessments, since it represents the "worst case" emissions path which can be used to avoid under-adaptation.

A second often considered pathway is RCP4.5, which represents notable reduction in GHG emission undertaken globally through multiple means (e.g., reduction of the use of coal, increased reliance on renewables). Contrasting the two scenarios, projections using RCP8.5 generate a global average temperature increase of between 4 and 6 °C degrees by the year 2100, whereas the RCP4.5 scenario projects an increase of 2 to 3 °C by the end of the century (Peters et al. 2012).

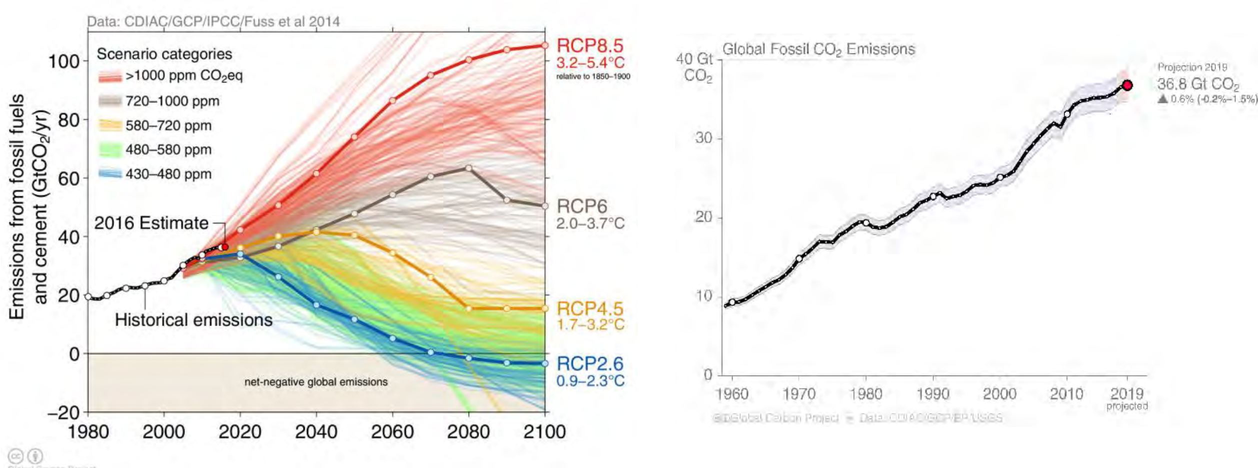


Figure 1 - RCPs and associated emissions compared to historical values. Left figure (a) shows GHG emissions up to 2016, right figure (b) shows carbon emissions up to 2019.[1]

[1] The IPCC 6th Assessment Report (AR6) will feature a change from RCPs to so-called "Shared Socioeconomic Pathways," or SSPs, and therefore graphics comparing recent historical GHG emissions to RCPs are not available.

For this study, RCP8.5 was used as the basis for future projections and the risk assessment calculations. Climate change projections were compiled for the time period 2041 - 2070 (i.e., the 2050s), and 2071 - 2100 (i.e., 2080s) using the full Coupled Model Intercomparison Project 5 (CMIP5) ensemble of 37 Global Climate Models (GCM) associated with the IPCC 5th global assessment released in 2013. As noted above, the emission scenario RCP8.5 is used for its consistency with "business as usual" conditions resulting from continued global growth in GHG emissions. In many cases, the RCP8.5 emission assumption represents a global temperature increase likely to exacerbate the intensity and frequency of extreme climatic and weather events (Climate Nexus, 2021). The emission scenario of RCP8.5 was selected as a conservative, risk averse assumption for most extreme climate variables to best inform the vulnerability assessment and its risk management planning.

Global GHG emissions continue to grow. Selecting a less conservative RCP would assume global GHG reductions that have yet to occur, possibly underestimating impacts. Selecting an RCP that aligns with recent and current global GHG emissions trends is preferable for applications intended to inform risk management planning.

Threshold Selection and Probability Scoring

As statistical information for both historical and projected hazard event frequencies was available for most of the climate parameters identified in the study, the more quantitative PIEVC Protocol Method B was used to develop the probability scores for each parameter. Where such statistical information is available, the probabilities for each climate parameter are converted from numerical probabilities into PIEVC score categories. The PIEVC Protocol makes use of standardized climate probability scores ranging from 0 to 7, employed in parallel with the 0 to 7 impact scoring scale used for severity assessment, as summarized in Table 1. A score of 0 refers to a climate event that likely will not occur, while a score of 7 refers to an event that is "highly probable" to occur over the service life of the structure (i.e., a probability approaching 100%). However, because the original scale only provides individual values for each category, ranges (far-right column) were derived to better define each probability score value.

Table 1 – General Climate Parameter Probability Scoring

Probability Scale	PIEVC Value (%)	Range (%)
0	<0.1%	<0.1%
1	1%	0.1 to 2.5 %
2	5%	2.5 to 12.5 %
3	10%	12.5% to 15%
4	20%	15% to 30%
5	40%	30% to 55%
6	70%	55% to 85%
7	99%	85% to 100%

Furthermore, probabilities calculated for this study are based on the probability of event occurrence within a 30-year period (i.e., an event with a 1% annual probability of occurrence has an approximate probability of 26% within any given 30-year time period). This 30-year time frame was used as a compromise between expected service life of individual components, and is also the standard averaging period for climate data (i.e., the "climate normals" described above).

Climate Parameter Threshold Selection

Climate parameters used in the risk assessment are based on asset-relevant "thresholds". These thresholds are defined by the intensity and duration of key hazards directly relevant to the design capacity and/or risk characteristics relevant to assets under assessment. In this case, heavy and extreme rainfall values and Detroit River levels were defined based on the drainage model values used to assess the performance of the infrastructure. These specifically included the 4-Hour 5-Year and 100-Year return period design storms using a Chicago synthetic rainfall distribution, as well as the 100-Year and "Climate Change" high river levels.

Secondary impact events, those which may occur in tandem with or in rapid succession with extreme rainfall events, were defined based on thresholds relevant to critical *adjacent* and interconnected infrastructure (i.e., surface transportation, electrical power and communications). These events were included in the analysis to determine if they could result in significant, additional exacerbation of impacts on the drainage and sanitary systems (e.g., what are the impacts of power loss on pumping stations and treatment plant operations).

Key Climate Hazards – Historical and Future Conditions

Table 2 below provides a summary of the statistical information and PIEVC probability scores assigned to each climate parameter for which statistical information was available. The annual frequency, 30-year probability and associated PIEVC 0-7 probability score are provided for each of the three time horizons (i.e., current, 2050s and 2080s).

Additional climate parameters and related were initially included in the analysis, namely extreme air temperatures, heavy snowfall events and seasonal snow accumulations, as well as combined rainfall and hail events. Staff interviews, historical events research and stakeholder workshop discussions subsequently indicated that these event types were not important to the overall impacts to the drainage and sanitary systems, and as such were removed from the analysis. Finally, some important hazards (i.e., shoreline erosion, river ice, and ice jam floods events) are included in the risk assessment and discussions, but reliable data were not available for statistical analysis.

Detailed discussion of each climate parameter is provided in the following sections.

Table 2 – Climate Parameter Thresholds and Probabilities

Hazard/ Element	Threshold	Annual Frequency	30-Year Probability and Score		Annual Frequency	30-Year Probability and Score		Annual Frequency	30-Year Probability and Score	
		Current			2050s			2080s		
Extreme rainfall	"Major" 100-yr Storm - 82 mm in 4 hrs, peak rate of 145 mm/h	0.0068966	~20%	4	0.03125	>60%	6	0.0666667	>85%	7
	"Minor" 5-year Storm - 50 mm in 4 hrs, peak rate 29.5 mm/hr	0.1724138	>99%	7	0.3703704	>99%	7	0.5263158	100%	7
Extreme River Levels	"Likely" CC HWL - 176.1 m	0.0066667	~20%	4	0.01	~25%	4	0.01	~25%	4
	Current HWL - 175.9 m	0.01	~25%	4	0.012	30%	5	>0.012	> 30%	5
Combination Events	Current 100 yr HWL + extreme rainfall (100 year storm)	N/A	7%	2	N/A	12%	2	N/A	26%	4
	Current 100 yr HWL + Moderate Rainfall (5-year storm)	N/A	26%	4	N/A	30%	4	N/A	> 30%	5
	Climate Chg HWL + extreme rainfall (100 year storm)	N/A	5%	2	N/A	16%	4	N/A	23%	4
	Climate Chg HWL + moderate rainfall (5 year storm)	N/A	26%	4	N/A	26%	4	N/A	30%	4
	HWL + wave action (freeboard)	0.1	>95%	7	**N/A - Steady or increasing**	N/A	7	**N/A - Steady or increasing**	N/A	7
Secondary Impact Events	Major ice storm - 28 mm or more	0.01	*~25%*	*4*	0.0108	~30%	4	0.01004	~25%	4
	Extreme wind event - 120 km/h	0.05	~80%	6	0.062	85%	7	0.063	85%	7
	Tornado - (E)F2+	0.002	~5%	2	0.0025	~7%	2	0.003	9%	2
	Weathering (freeze thaw)	14.1	100%	7	10.5	100%	7	7.8	100%	7
		0.47	>99%	7	0.35	>99%	7	0.26	>99%	7

Detroit River Water Levels

Although Great Lakes water levels have fluctuated considerably over the past century, the fluctuations from the extreme low to extreme high levels from 2011 to 2021 have been among the most extreme seen in the observations. Levels typically fluctuate on multi-decadal time scales, but the recent fluctuations have been more rapid, dropping to record lows on the Great Lakes from 1999 to 2013 and then rising to record highs, particularly for the 2019 to 2021 period.

Water levels on the Great Lakes are determined by the net flow of water in and out of the lake system. The processes that drive the changes in water levels and their connecting channels are complex and vary over time periods from seasons to years to multi-decades. In general, the annual fluctuations in water levels can be attributed to the seasons, the longer-term or multi-year fluctuations can be attributed to climate and the short-term fluctuations in levels can be associated with weather.

The annual and climate fluctuations result from three main factors:

1. Changes in rainfall and snowfall over the lakes,
2. Evaporation from the lakes, and
3. Inflow or runoff from tributaries and rivers that enters each lake from the surrounding land and any diversions or management changes, as shown in **Figure 2**.

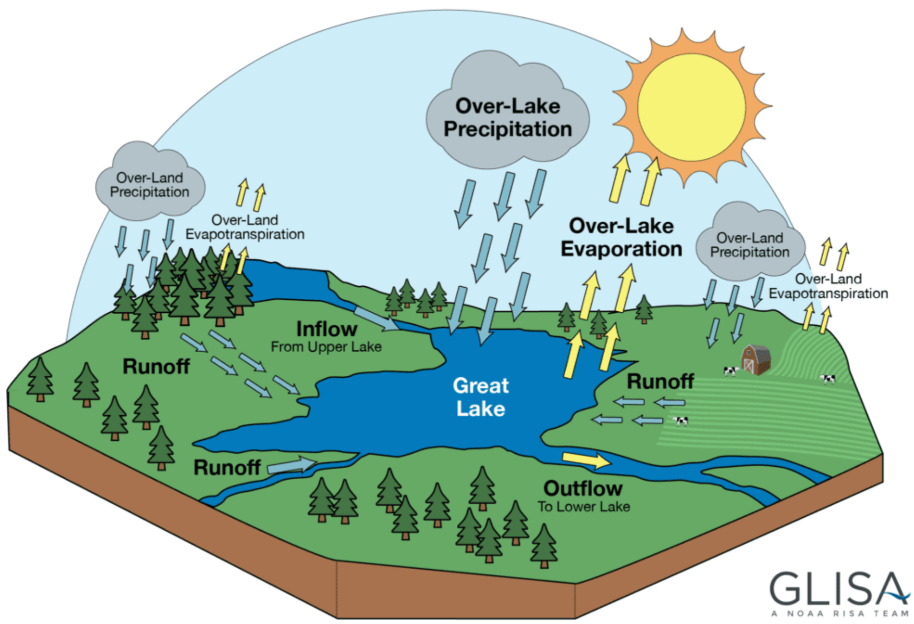


Figure 2 Climate, hydrologic and hydraulic processes affecting Great Lakes water levels. From GLISA (Great Lakes Integrated Sciences and Assessments, NOAA). Accessed from: https://glisa.umich.edu/sustained-assessment/lake-levels/

Seasonally, water levels rise through the spring and summer with snowmelt and spring rainfall, peak around July, then decline through the fall and winter, with a low point around February. The winter ice cover timing and ice amount have a significant influence in controlling evaporation and shoreline erosion and on spring water levels. This seasonal rise and fall varies from approximately 40 to 60 cm on average. Water levels also can fluctuate on very short-term scales along the shorelines during wind-driven, localized weather events, e.g. the southern shoreline of Lake St Clair.

Historical Data and Extreme Value Analysis

A statistical analysis was completed to calculate the Detroit River 100-year water level based on historical water level measurements.

Vertical Datum

The International Great Lakes Datum 1985 (IGLD'85) is often used with respect to water levels and bathymetry, and the Canadian Geodetic Datum (CGVD) is often used with respect to topographic survey and LiDAR data. It is important to recognize that there is a slight difference between IGLD’85 and CGVD at the project location. At Tecumseh, the closest site where this datum difference is defined, IGLD’85 is 0.01 m lower than Geodetic. Any survey data can therefore be adjusted using the equation below:

IGLD’85 – CGVD = 0.01 m

Observational Data

Hourly water level measurements were obtained from the National Oceanic and Atmospheric Administration (NOAA, 2006) for the Fort Wayne Gauge on the Detroit River (Station # 9044036). The period of record of the measurements used for this analysis is from 1970 to August 2021.

A time series of the water level measurements is provided in **Figure 3** and a probability of exceedance curve of the measurement data is provided in **Figure 4.** The long-term average of the recorded water level measurements is 174.94 m, IGLD’85. The maximum measured water level was 175.87, recorded in July of 2019. The probability of exceedance curve shows that the recorded water exceeds 175.6 m just under 1% of the period of record, and 175.7 m approximately 0.1 % of the time.

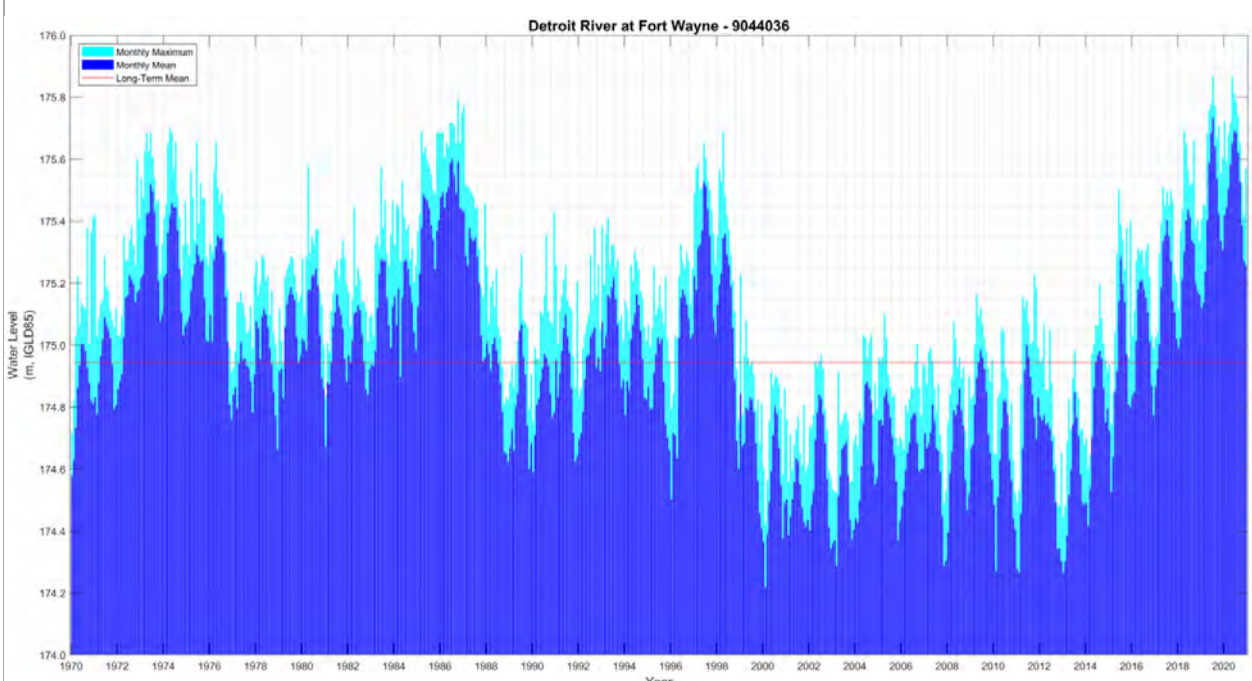


Figure 3 – Water Level Measurements at Fort Wayne (NOAA Gauge 9044036)

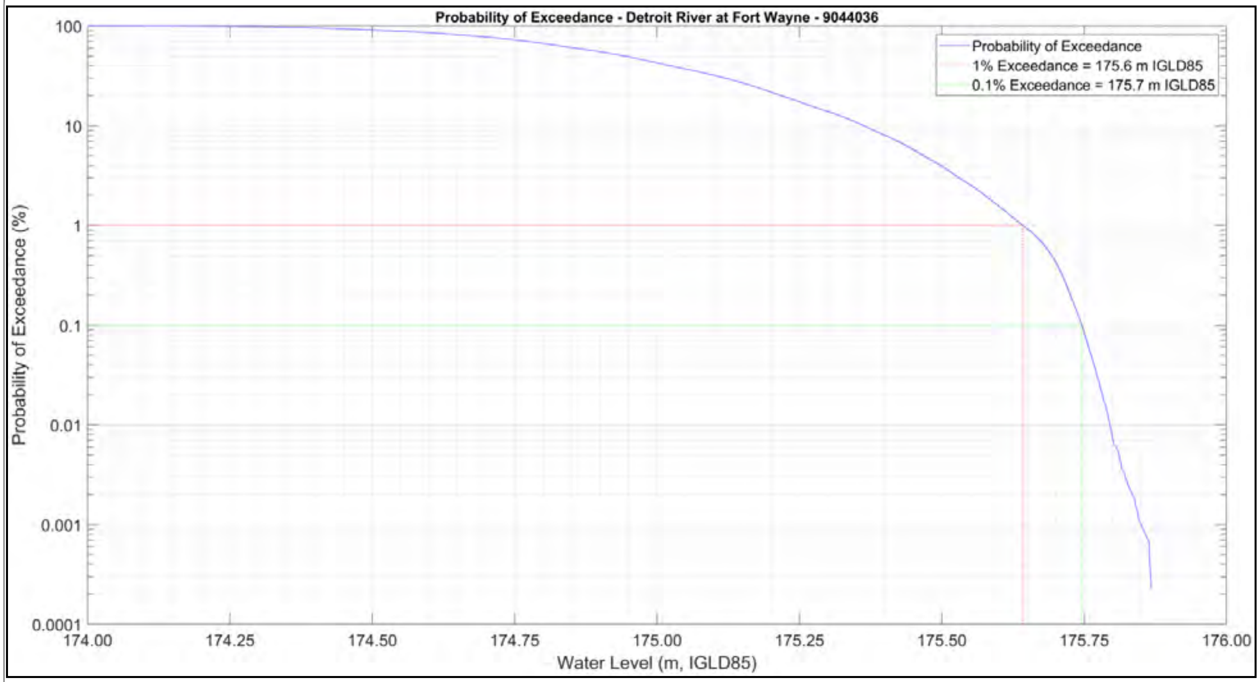


Figure 4 – Probability of Exceedance on Water Level Measurements (NOAA Gauge 9044036, Fort Wayne)

Extreme Value Analysis

An extreme value analysis (EVA) was completed on the gauge data to identify peak water level data for the study area. The EVA defines the cumulative probability distribution using several statistical distributions. In other words, the results of the EVA can be used to define extreme values for a variety of defined return periods.

In order to reduce the dataset, the maximum monthly water levels were used as the inputs for the EVA. The cumulative probability distribution was estimated using four statistical distributions (General Pareto Distribution, Generalized Extreme Value Analysis, Weibull, and Log-Normal) are summarized in **Table 3** and plotted on **Figure 5.** The actual peak values are plotted as points, and the fits are plotted as lines. Each distribution shows a strong correlation (r-squared value) with the peak gauge data; however, the Weibull and GEV distributions appear to have the best fit with the lower frequency (higher return period) events.

Table 3 - Summary of Extreme Value Analysis of Fort Wayne Gauge Data

Return Period (years)	Water Level (m, IGLD'85)			
	General Pareto Distribution	Generalized Extreme Value	Weibull	Log-Normal
1	175.76	175.62	175.63	175.63
2	175.79	175.66	175.67	175.67
5	175.83	175.76	175.79	175.79
10	175.85	175.81	175.86	175.88
20	175.86	175.86	175.93	175.95
25	175.86	175.87	175.95	175.97
50	175.86	175.90	176.01	176.04
100	175.87	175.93	176.07	176.11

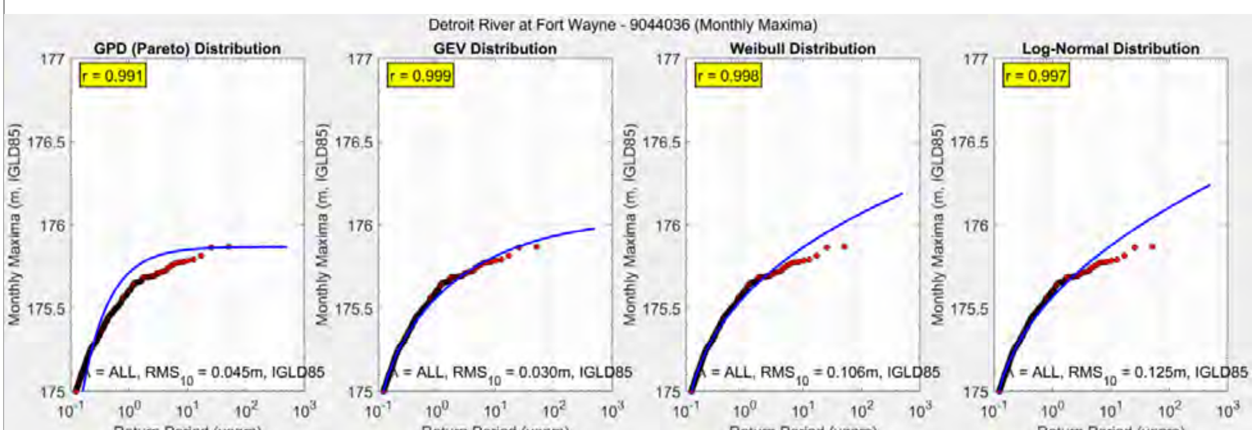


Figure 5 – Extreme Value Analysis Results for Various Statistical Distributions

Previous Studies

The 100-year flood level is the sum of the mean lake level and storm surge with a combined probability of a 100-year return period (i.e., on average, has a 1 percent probability of occurring in any given year or on average once in 100 years). The Great Lakes System Flood Levels and Water Related Hazards report (MNR 1989) provides estimates of the 100-year flood level for several locations on the Detroit River. The study area falls between two of these locations; DR2 and DR3. The 100-year flood level for DR2 is 176.1 m, IGLD'85. The 100-year flood level for DR3 is 176.0 m, IGLD'85. The MNR study specifically mentions that there are no climate change considerations included in the estimate of the 100-year flood levels.

Summary of EVA of Historical River Levels

A comparison of the EVA and the peak values from the 1989 MNR study are provided in **Figure 6**. The GEV distribution has a better fit with the peak data, and the Weibull distribution has better agreement with the previous study by MNR. Both distributions are well correlated with the monthly maxima.

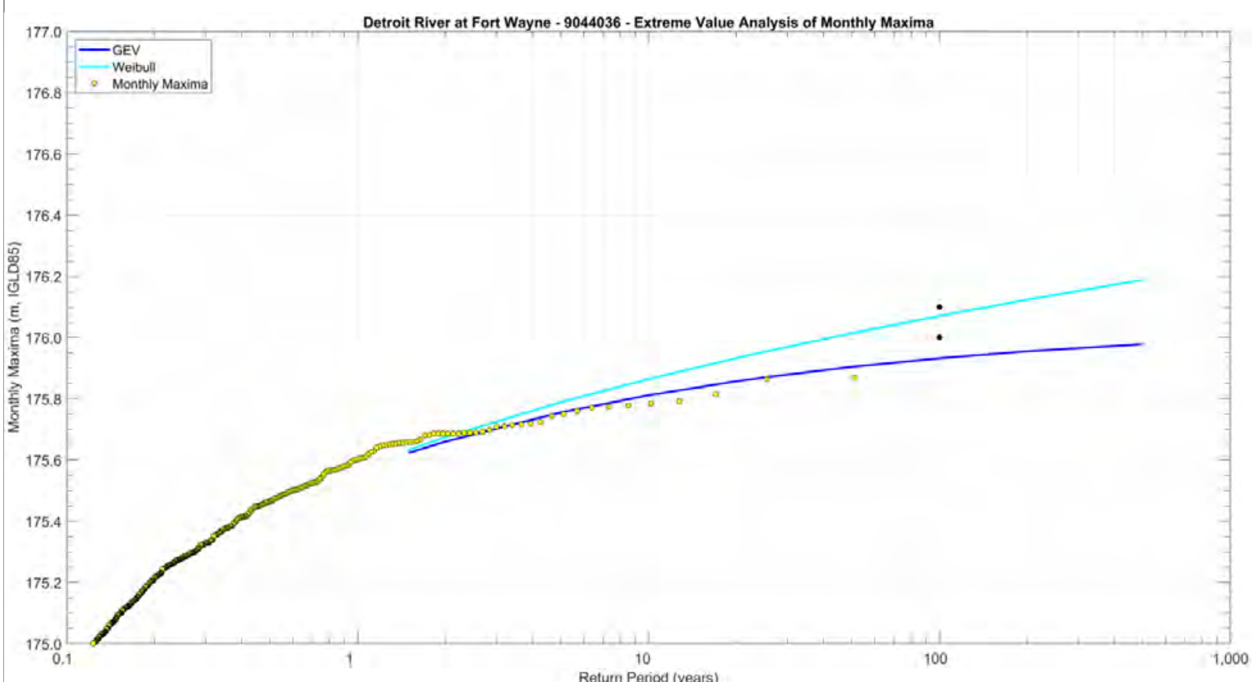


Figure 6 –Extreme Value Analysis Comparison with MNR 1989

Although the MNR study does not mention which cumulative probability distribution was used to estimate the peak water levels, it is likely that the Weibull distribution was used. As such, the EVA estimates using the Weibull distribution should be used for the coastal flooding study.

Consequently, the 100-year Detroit River water level for the West Windsor area is 176.1 m, IGLD'85.

Prediction and Projection of Near and Long-term Water Levels

Multi-year periods of high or low Great Lakes water levels can be very difficult to predict in the near term and even more difficult to project for longer periods into the future due to the strong dependence on small relative differences between the climate, hydrological and hydraulic processes. For example, the low water levels shown in **Figure 7** covering the period from the late 1990s to around 2013 resulted largely from warming air temperatures with surface water temperatures on Lakes Michigan-Huron and the other lakes rising by roughly 2 degrees C. This resulted in evaporation rates that were nearly 30% above annual average levels and reduced the ice cover that further extended the evaporation seasons. As a result, many Great Lakes water levels dropped to their lowest levels ever recorded. The strong El Niño event in 1997 may also have played a role in the lower levels during the period and reduced precipitation. Impacts from these low water levels included reduced shipping and cargo tonnage, increased shipping costs, challenges in using docks and piers, a need to extend the reach of water intake pipes, increased algal growth and impacts on shoreline ecosystems. Climate change and warming temperatures are likely to bring repeated low water levels and disruptions in future decades.

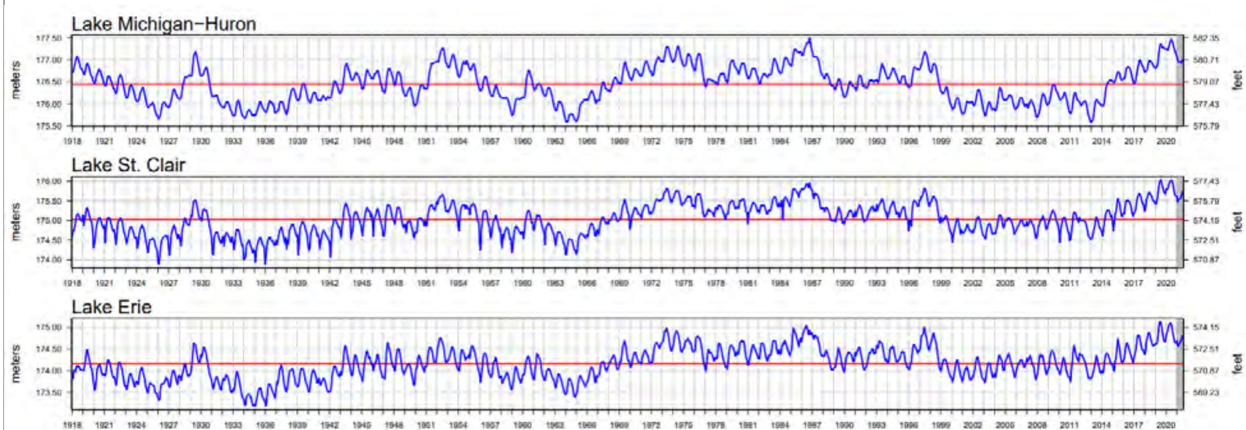


Figure 7 – Great Lakes Monthly Average Water Levels

Recovery from these record low water levels began in 2013 with a particularly cold polar vortex winter of 2013-14 that brought heavier ice cover and less lake evaporation. This change was accompanied by several increased precipitation seasons, particularly for winter and spring (e.g., 2017, 2019), and some notable extreme precipitation events. For example, high water levels in spring 2019 were accompanied by a heavy snow winter, early snowmelt and a wet spring. In the near future, periods of increased precipitation along with the occasional cold polar vortex winters could drive water levels to at least the highs seen in recent years. Impacts from the high water levels have included extreme shoreline flooding, property inundation, contamination of the Detroit River waters from land inundation, severe coastal erosion, surcharged sewer systems, unusable docks, beaches and parks, flooded roads and buildings, shipping challenges in clearing bridges and overhead cables, and health impacts from mold, sewer surcharging, fast river currents, contamination of wells, etc.

To put the impacts of the different lake level processes into perspective, the typical annual and seasonal variability of the Great Lakes is approximately 40 to 60 cm, while the longer term climate fluctuations due to persistent low and high water levels accounts for approximately 60 to 90 cm of variation. Fluctuations from decisions on water diversions and regulation of the lakes accounts for only 5 to 10 cm. Glacial isostatic adjustment or GIA, which refers to the ongoing movement of the earth's crust as it rebounds following the retreat of the glaciers at the end of the last ice age, has a very small impact but is effectively tilting the basin southward over time. The result is a very slow tendency for lowering of water levels in the upper Great Lakes and very slow rising levels more predominant for the lower lakes.

The combined Lakes Michigan and Huron fluctuate the most of the Great Lakes over the longer climate period and impact Windsor's water levels both along Lake St Clair shoreline and along the Detroit River. Water levels on Lake Erie, downstream of Windsor, generally experience similar fluctuations to those of Lake Michigan-Huron and Lake St Clair but typically with a smaller amplitude. The net result is that there sometimes can be a backwater influence on the slope of the connecting Detroit River. More often than not, these large fluctuations and their extremes have been associated with the fluctuating climate.

Projections of Future Great Lakes Water Levels and their Extremes

Historical trends and future climate change projections indicate increasing precipitation, warming air and water temperatures, potential for recurring periods of high evaporation, and the occasional polar vortex winter. In future, this combination of both gradual climate trends and extreme climate events is expected to force more rapid transitions between the extreme high and low water levels in the Great Lakes.

While the changing climate is turning up the dials on the factors that both increase and decrease water levels, the projections on potential water levels remain highly uncertain. Prior to about 2011, most climate change and lake level modelling studies pointed to lowering lake levels as the new “Normal” for the future. These earlier projections assumed that atmospheric temperatures could be used as a proxy when modelling lake and runoff evaporation rates. Lofgren et al (2011) introduced energy budget-based methods for estimating land and runoff based evaporation and evapotranspiration instead of the more common use of air temperatures as a proxy. The land evapotranspiration, which is part of the calculation of runoff, was depicted as being extremely sensitive to climate warming, likely resulting in overestimated reductions in runoff and overestimated lake level declines (Hayhoe et al., 2010, Lofgren et al., 2011, Lofgren and Rouhana, 2016).

The first study to indicate the potential for both lake level rises and declines this century was undertaken by Lofgren et al (2011) and was based on improved methods to estimate runoff evaporation and evapotranspiration. The new methods were driven by two older or third generation climate change models. Today, the most recent set of climate change models are known as the sixth generation climate models from the 6th Intergovernmental Climate Change Panel Assessment Report 6 (IPCC AR6). The outputs from this Lofgren et al (2011) climate study were used for the 2019 East Windsor study (Landmark/RWDI, 2019), as presented in Table 4, and for the Windsor Port Climate Change Risk Assessment.

Table 4 – 1:100 year Instantaneous Water Levels, Lake St Clair in Windsor, historical data (Instantaneous) and future climate projections (monthly). *From Landmark/RWDI, 2019 with future projections of levels based on Lofgren et al. 2019*.

Station and Dataset	1:100 Year Instantaneous Water Level (m, IGLD)
Historical Data	
Windmill Point, 6 Minute	176.1
Windmill Point, Hourly	176.4
Windmill Point, Monthly	176.5
St Clair Shores, 6 Minute	176.3
St Clair Shores, Hourly	176.4
St Clair Shores, Monthly	176.5
Belle River, Daily	176.4
Tecumseh, Daily	176.5
Future Climate Projections	
Lake St Clair, Monthly, CGCM3, AE	176.8
Lake St Clair, Monthly, CGCM3, Delta	176.0
Lake St Clair, Monthly, GFDL, AE	175.6
Lake St Clair, Monthly, GFDL, Delta	175.4

A total of four future results were derived from use of two climate models with different greenhouse gas emission assumptions (high A1, moderate A1B) and two different runoff models. Of the four results, three indicated decreases in future extreme high lake levels ranging from 50-110 cm, while one result indicated increases of 30 cm in average lake levels (based on the Canadian climate change model and one runoff model). These future differences in average lake levels to the end of the century were used to adjust the historical 100-year return period high water level estimate for the mid and end century.

Based on the highest result, a recommended 30 cm increase to the historical 100-year high water level was provided for the East Riverside flood assessment. The Landmark/RWDI study interpolated instantaneous water levels of 176.6 m and 176.8 m for 2030 and 2050, respectively for southern Lake St Clair.

Updated Climate Change and Lake Level Projections

While the Lofgren et al. (2011) study initiated a “revolution” in Great Lakes water level projections for the future, several other studies followed that further improved runoff estimates while also incorporating a greater number of newer, improved and higher resolution climate change models. Overall, more of these more recent climate change studies projected a central tendency towards small drops in lake levels by the end of the 21st century, with some probability of small rises in lake levels (e.g., MacKay and Seglenieks, 2012; Notaro et al., 2015; Lofgren et al., 2016).

Lofgren and Rouhana (2016) updated the original Lofgren et al. (2011) study for the Great Lakes using eight sets of the newer fifth generation climate change models (IPCC AR5 climate models) and three different greenhouse gas emission scenarios, while also considering future time periods representing the 2050s and 2100s. These combinations resulted in 32 climate model projections over two future time periods. The updated study also improved land evapotranspiration and river and tributary runoff processes. For mid-century, the median of these 32 climate model projections indicated decreasing lake levels, with fewer climate change model combinations showing increases than decreases, as shown in Figure 8.

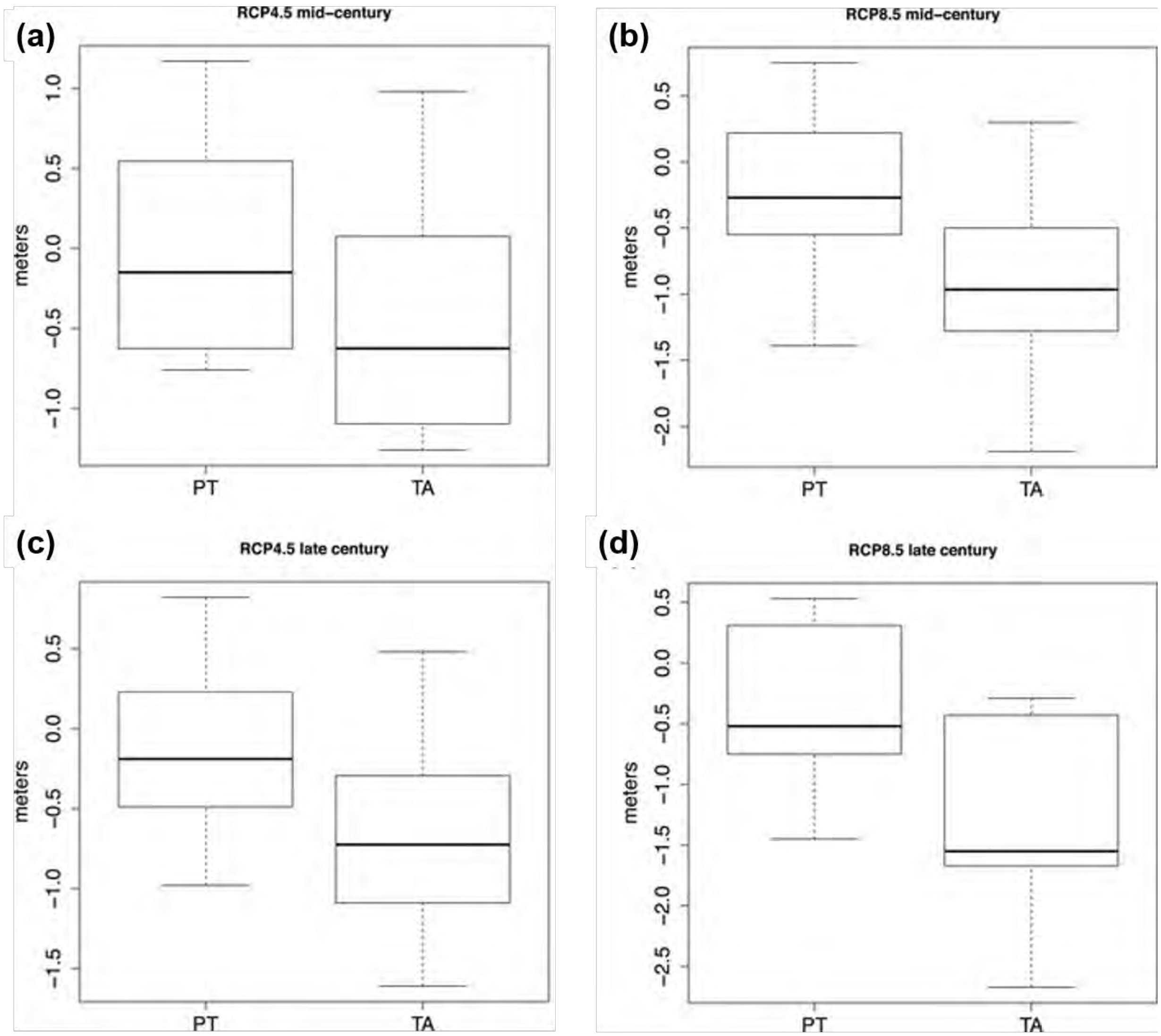


Figure 8 – Lake Michigan–Huron future water levels using two runoff estimation methods, namely the TA or temperature adjusted method with greater evapotranspiration, and the Priestly-Taylor or PT energy adjusted methods for subsets of the Global Climate Model projections. Note that the scale can differ significantly among the panels. (a) Mid-twenty-first century for low global GHG emissions, RCP 4.5, (b) Mid-twenty-first century for high or almost "business as usual" global GHG emissions, RCP 8.5, (c) Late twenty-first century for lower GHG emissions, RCP 4.5, (d) Late twenty-first century for high GHG emissions, RCP 8.5. The box plots indicate the 25th to 75th percentile of the different climate model results, while the bottom and top horizontal lines represent the extreme (outlier) low and high results. The Priestly-Taylor or PT runoff method is considered to be more realistic than the TA method. *From: Journal of Hydrometeorology 17, 8;* 10.1175/JHM-D-15-0220.1

Note that Figure 8 depicts future conditions for the combined Lakes Michigan-Huron rather than water levels for Lake St Clair. As noted earlier, the combined Lake Michigan and Huron experience the highest fluctuations of the Great Lakes, although variability for Lake St Clair is similar. The use of the Lakes Michigan and Huron water levels probably adds conservatism to the results. Note as well that two different runoff methods are shown in Figure 8, with the Priestly-Taylor (PT) evapotranspiration and runoff method considered to more closely represent reality for the Great Lakes (Lofgren and Rouhana, 2016).

Given the uncertainties, an approach with added safety margins for the mid-century period would consider the 75th percentile high of all the projections rather than the median. By mid-century, the largest increases in lake levels are projected for significantly reduced global GHG emissions or RCP4.5 assumptions, although higher global GHG assumptions are more likely for this mid-century period. The combination of the 75th percentile high water level projection risks, the more realistic PT runoff model, and a more realistic RCP8.5 high GHG assumptions, indicates a potential for roughly a 20 cm increase in future high water levels. This set of assumptions *represents an almost "**worst case**" projection of mid- century lake level rises,* keeping in mind that more of the future projections call for declining levels. The late-century results indicate potential for a similar high lake level, although an even greater majority of the projections indicate decreases in water levels.

Given that these future lake level projections are highly uncertain, it is recommended that high lake level resilience actions address the current 100-year historical high water level risks plus any needed freeboards that could include margins for climate change. Depending on the guidance from a Triple Bottom Line analysis and the timing required to fund, design and implement resilience options, there may be advantages for some risks in awaiting outputs from improved lake level studies based on the newly released 6th generation climate change models. Given that the water level projections are highly dependent on the quality of the climate models, any new projections of water levels could be driven by better climate models and better runoff formulations. The new set of 6th generation climate models is currently being released by the IPCC, although it will take some time before the models can be screened for their ability to better depict Great Lakes dynamics and combined to drive the various Great Lakes water level models. The new climate models include better climate physics (e.g., improved treatment of climate and weather systems, clouds, biogeochemical cycles, permafrost, wetlands, aerosols), higher spatial resolutions, increased GHG emissions scenarios that are more realistic and policy relevant, better carbon cycling, a greater number of contributing climate modelling groups, etc.

Additional Climate Change and Water Level Studies and their Caveats

The conclusions from the updated Lofgren and Rouhana (2016) are supported by other lake level studies. For example, a study by Notaro et al. (2015) evaluated all available 5th generation climate change models including fine resolution climate models for their ability to capture the locations and dynamics of the Great Lakes climate and lake levels. Only two sets of climate change models – one set from France and another from Japan - were able to meet the rigorous screening requirements set by the U.S. NOAA/GLERL group undertaking the study. Although both sets of models were rigorous in depicting current Great Lake dynamics, their future climate projections and lake levels differed greatly. One set of models indicated a tendency towards increasing lake levels, depending on GHG emission assumptions, while the other set indicated significant decreases in levels. The differences between the models in their projections of future rates of warming versus rates of precipitation increases were critical in determining future trends.

Overall, climate models with higher GHG assumptions and greater rates of warming tend to project lower water levels. This was seen in the Lofgren and Rouhana (2016) results and in the various other studies. Climate models with relatively higher rates of temperature increases tend to project lower water levels, while models with greater rates of precipitation increases and relatively modest warming tend to project the highest water levels. The greatest risks for higher lake levels are associated with climate models showing a slower rate of warming, such as might result under reduced GHG emissions or climate models with relatively lower sensitivities to GHG emissions, and with significantly greater precipitation increases. All climate models indicate warming in future but significant differences are noted seasonally in their future precipitation projections.

Table 5 summarizes the results from a number of water level studies that have been released since the Lofgren et al (2011) study. These later studies are driven by either 3rd or 5th generation global climate models released by the IPCC, which can add to challenges of comparing results. The studies represent a range of climate model resolutions from less than 25 km to roughly 200 km, depending on whether downscaling or regional climate models were added. More study results indicated future decreases in water levels and the potential for smaller increases. All of the studies highlighted the huge uncertainties in the future lake level projections. Most of the studies in **Table 5** incorporated the higher GHG emission assumptions, either RCP8.5 or A2, while some also included lower GHG assumptions such as RCP4.5 that can only be reached through aggressive global GHG reduction actions.

Table 5 - Great Lakes Water Level or Net Basin Supply and Climate Change Studies from 2011

Climate and Lake Level Studies	Climate Models used	Great Lakes	Resolution	Projection Period, *(GHGs)*	Study Outcomes
Landmark/RWDI 2019 study using Lofgren et al (2011)	2@ IPCC 3rd generation climate models – CGCM3 and GFDL2.0 plus two runoff models (4 results)	All except Lake Ontario	~200 km	2081-2100 *(high A2 & mod A1B)*	Lake St Clair by end century: (3 results) dropping by 50-1100 cm and (1 result) rising by 30cm
Lofgren and Rouhana (2016)	8@ IPCC 5th generation climate models with 3 sets of GHG assumptions 32 model combinations divided over mid to late century periods	All	Estimated 60-200 km	2056-2075 and 2081-2100 *(RCP4.5 & RCP8.5)*	Median: Decreases under high GHG assumptions (RCP8.5); more decreases Lake Michigan-Huron (25-75%tiles): 2060s: -50cm to +20cm 2090s: -75 to +30cm
Mackay and Segenicks (2013)	1@ 3rd generation GCM; Canadian Regional Climate Model (RCM)	Lake Erie	~22.5 km	2021-2050 *(high A2)*	Lake Erie ~6 cm lower
Notaro et al (2015)	32@ IPCC 5th generation climate models. Screened to 2 models based on ability to depict Great Lakes locations and dynamics. Both downscaled using 25Km regional climate model.	All	~ 25 km	2050s and 2080s *(RCP8.5)*	Contrasting climate projections. By late century, one by -30cm, other by +42 cm. Depends on climate model projections, relative rate of temperature and precipitation changes, GHG assumptions
Music et al (2015)	3@ 3rd generation RCMs	Mich-Huron	45-50 km	2041-70 *(high A2)*	Lakes Michigan-Huron NBS: ~1% increase
Mailhot et al (2019)	5@ 5th generation RCMs with 2 GHG assumptions (total of 28 simulations covering 2 time periods) Analysis of extremes and variability	All Great Lakes; Basin NBS each	15-30 km	2041-2070 and 2071-2100 *(RCP4.5 & RCP8.5)*	Average NBS: 2 to 9% increase in NBS (not lake levels) Extreme highs: NBS increases of 1-9% Extreme lows: NBS decreases of 18-29%

Notes:

RCM: Regional scale climate model that is driven by a larger scale model or global climate model (GCM)

GHG: Greenhouse gas assumptions; 5th generation models, assume low = RCP4.5, high = RCP8.5; 3rd generation models, assume high = A2

2050s: Usually period from 2041-2070; 2080s: Usually period from 2071-2100
NBS: Net Basin Supply (differences between inflow and outflow) is the primary driver of lake level changes

All of the climate models indicate future increases in both temperature and precipitation across the Great Lakes Basin, with warming temperatures contributing to declining levels while increasing precipitation contributed to rising levels. It is not surprising that the future projections of water levels can be highly uncertain and variable since different climate models indicate different rates of future warming and precipitation increases. Adding to the uncertainty, many of the climate change models used to drive the lake level processes either don't represent the Great Lakes or place them in the wrong locations, miss or configure the lakes incorrectly while also poorly depicting the lake-land-atmosphere dynamics.

Summary of the Lake Level Projections

Historical records of lake levels over several decades show that trends are small but the variability in lake levels is high (Wuebbles, 2019). Under a changing climate, it is likely that lake water levels will continue to fluctuate and that the time span for their variability between highs and lows may become shorter. The model-based projections of lake levels completed since 2011 indicate central tendencies towards smaller drops in lake levels to the end of the 21st century, with an appreciable probability of small rises in lake levels, in contrast to the large drops that were projected using the older and, now-defunct runoff methods (Wuebbles et al, 2019).

Overall, lowering lake level projections appear more probable under the more realistic higher emissions greenhouse gas assumptions, while projected increases are more probable in the near term and if global GHG emissions are significantly reduced (i.e., the climate is expected to respond more strongly to global GHG emissions after mid-century). Regardless of the studies referenced, it is recommended that any projected lake level recommendations be based on work from 2011 and preferably, using a greater number of recent climate change models with better depictions of Great Lakes and climate dynamics. The latest 6th generation climate models may be able to better depict the Great Lakes and their climate and hydrology-hydraulics dynamics for many of the reasons discussed earlier.

This report's documentation of studies (Table 5) and recommendations for future lake levels include a number of conservative (safety margin) assumptions. These include the recommended use of the 75th percentile highest climate change projection rather than the median or average lake level change and the use of Lake Michigan-Huron lake level changes, which can be similar or higher than those of Lake St Clair.

It is plausible that recent extreme high water levels could be reached again in the near decades or exceeded, although more of the existing lake level models and studies indicate that overall levels may decrease during this century. As a result, an additional 20 cm of water level rise is recommended for the study's coastal areas, with these high water levels more likely until mid-century. Increasingly, researchers are concluding that the rapid transitions between extreme high and low water levels in the Great Lakes may represent the "new normal" (Gronwald and Hood, 2019).

Extreme Rainfall – Historical Investigation

The trends and impacts of extreme precipitation were based on the long-term record of precipitation from Windsor Airport. The trend in mean annual precipitation at Windsor Airport has been trending upwards over the most recent 80 year period, increasing from near 800 mm/year in the 1940s to 1000 mm/year more recently, as shown in Figure 9.

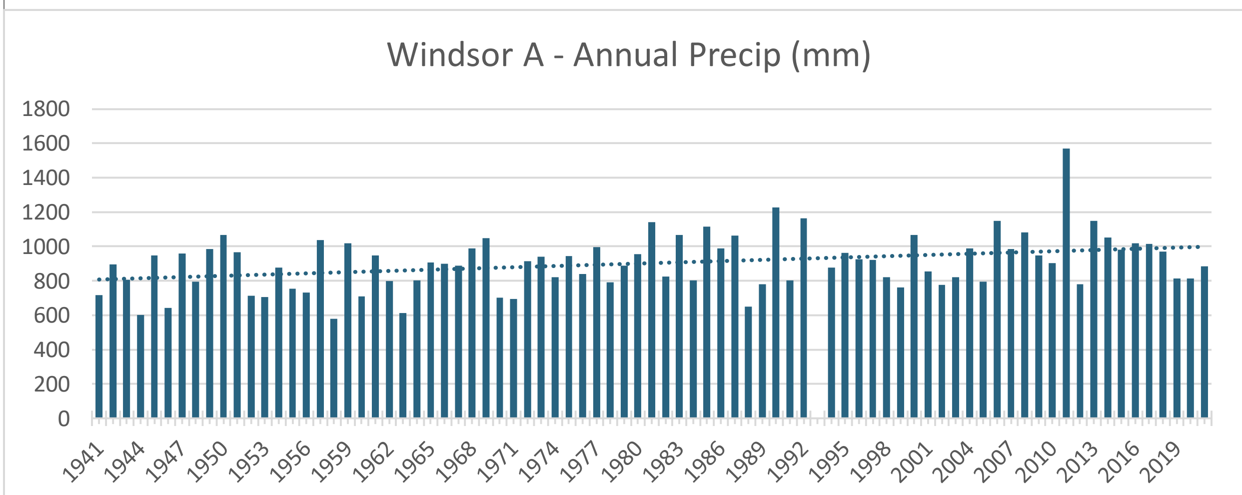


Figure 9 – Trends in Windsor Airport's annual total precipitation since 1941

The vertical bars indicate the annual precipitation totals while the dotted line represents a linear trend-line based on the data.

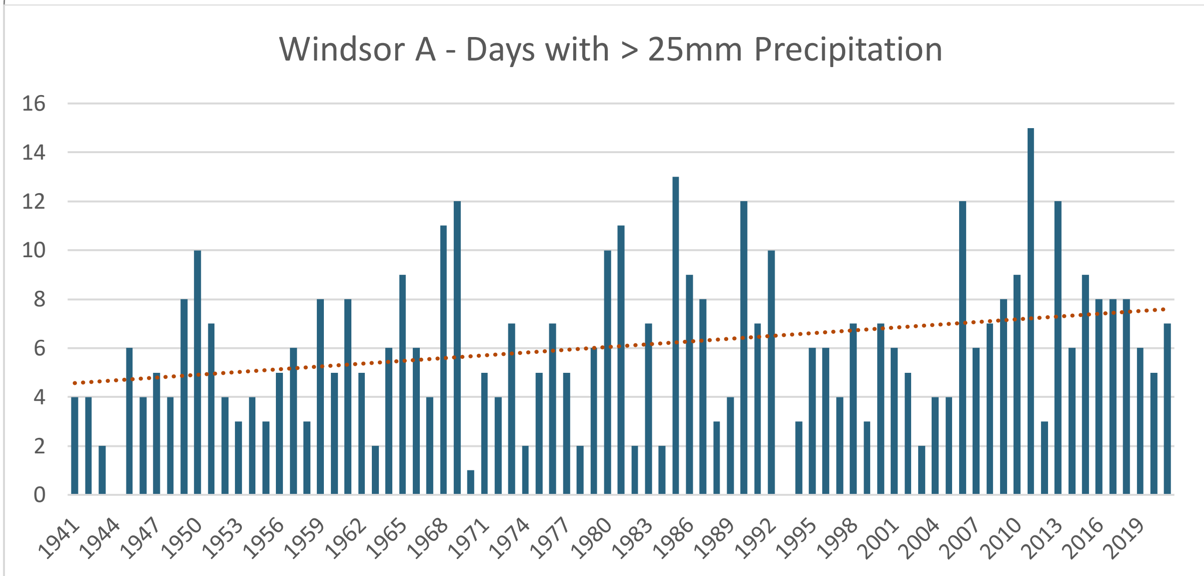
An investigation was undertaken to assess whether extreme daily precipitation events might be contributing more over time to this increasing annual precipitation total. Two thresholds were considered:

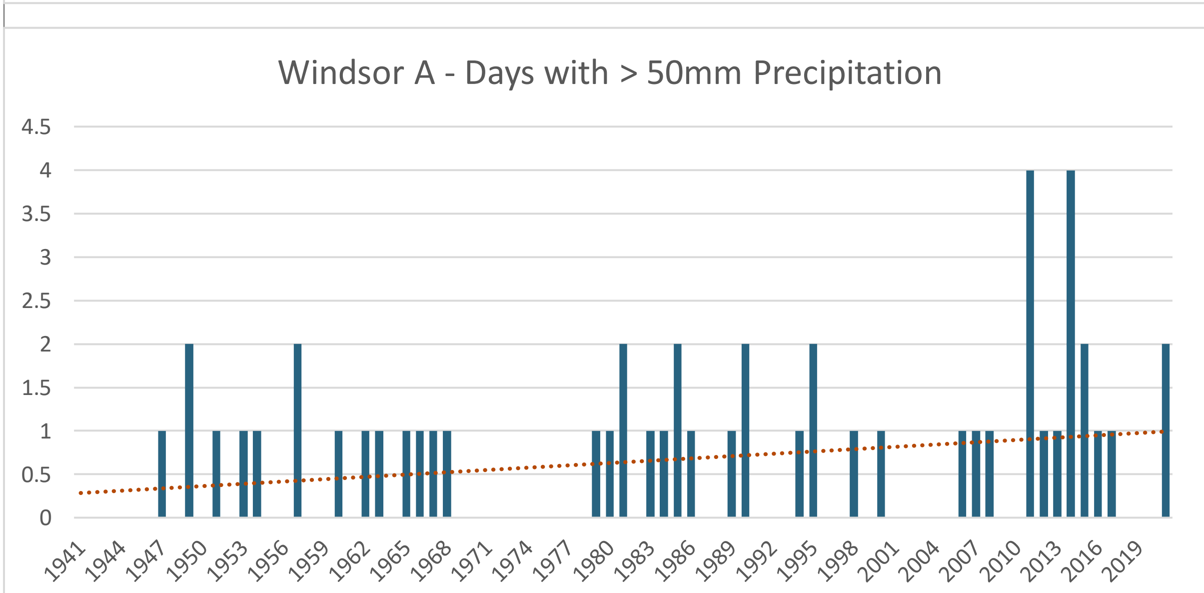
1. The days where greater than 25mm of precipitation occurred; and
2. The days where greater than 50mm of precipitation occurred.

Summing the annual precipitation totals attributed to just these heavier precipitation days, it was possible to determine the contribution of these extreme daily amounts to the annual total precipitation using the following relationship:

(SUM of >XX days precipitation / SUM of ALL precipitation) x 100 = Percent contribution of heavier events

The historical occurrence of days with greater than 25 mm of precipitation (solid and liquid) has increased since 1941 from on average about 5 days to 8 days per year. The number of days per year with greater than 50 mm per day has also increased from 0.2 days/year (or once every 5 years), to 1 day per year on average. **Figures 10a** and **10b** highlight these trends in heavier precipitation events.





Figures 10a (top) and 10b (bottom) depict the frequency of days per year with: (10a) 25 mm or more and (10b) 50 mm or more of precipitation. The upward trend is particularly notable for days per year with 25 mm or more of precipitation.

There were many more daily events with 25 mm or more of precipitation than for the more extreme daily threshold of 50mm or more over the period. The percent contribution of these heavier precipitation days to the annual precipitation totals also show increasing trends over the period. As shown in Figure 11, the contribution of the greater than 25mm/day events has increased from about 20% on average in the 1940s to about 27% in recent years (so, on average contributing from one-fifth to now over one-quarter of the annual precipitation total). Most recently, the year 2021 stands out where 37% of the annual precipitation total was contributed by the sum of daily events measuring at least 25 mm of precipitation.

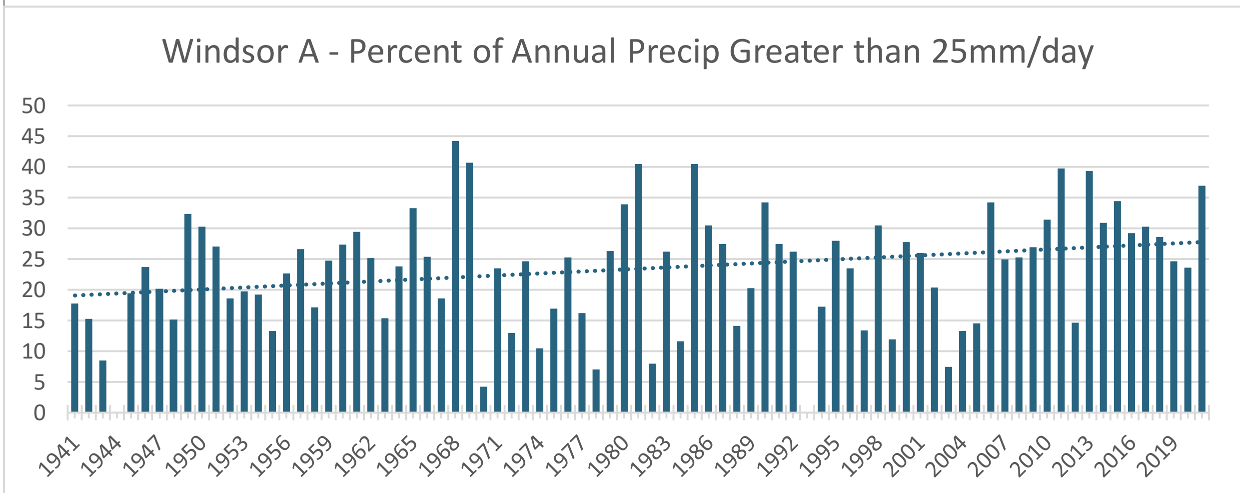


Figure 11 – Annual Contribution of Precipitation Events Greater than 25 mm

Considering the higher threshold of days with greater than 50 mm of precipitation, an increasing trend is also noted in their contributions to the annual total since 1941. These heavy precipitation events are far fewer in number and contribute much less to the annual precipitation total, increasing from nearly 2% to a more recent 6% of the annual precipitation amount. The two highest contribution years occurred relatively recently in 2014 (24% of the annual total contributed by days with at least 50 mm) and in 2021 (16% contribution). The year 2014 was particularly notable, with May 27 measuring a 58.2 mm rainfall, June 18 with 56.4 mm, August 11 with 73.6 mm, and September 10 noted a 64.8 mm event.

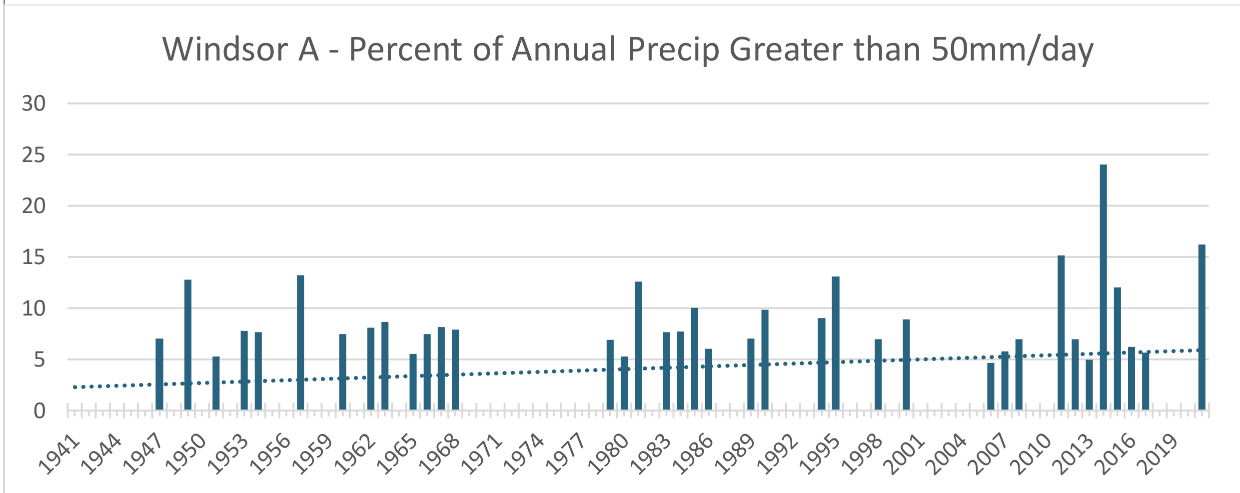


Figure 12 – Annual Contribution of Precipitation Events Greater than 50 mm

A 2014 study on "Extreme Storms in Michigan" (Saunders et al, 2014) found that extreme 50 mm (2 inch) rain storms had more than doubled over the period from 1964 to 2013 for southern Michigan. This study used different analysis approaches that incorporated all long-term rainfall measurements. Since precipitation and particularly, extreme heavy precipitation amounts, can vary greatly over very short distances and result in a principal climate station missing significant events, it can be challenging to capture trends and potential risks using a single station unless it has a very long and consistent data record or unless continuous precipitation records in space and time are used. The Windsor Airport's climate record is considered to be relatively long.

Extreme Precipitation Projections

Two design rainfall events (5-year and 100-year 4-hour storms, corresponding to 50 mm and 82 mm, respectively) were used to model and evaluate the performance of the West Windsor infrastructure system. However, the PIEVC assessment process also requires that potential future changes in the likelihood of these events be assessed to evaluate whether any important changes in future risks may occur.

Projections indicated that both events showed significant increases in likelihood under climate warming. In particular, the 82 mm event, currently considered the "100-year" storm, was projected by mid-century to increase in frequency by over *3 times*, reducing to ~30-year return period. This event likelihood was projected to increase further by late-century, roughly equivalent to a *15-year return period* by the 2080s.

These rainfall projections were based on the Clausius-Clapeyron (C-Clap) temperature scaling method (Ball et al., 2016), which is a theoretical relationship between air temperature and the amount of water the air could potentially hold and release. While there is an expanding body of research on the development of future climate change driven extreme intensity-duration-frequency (IDF) rainfall design values derived from downscaled climate models, many of these approaches are still experimental and there is a lack of consensus on the most appropriate ones to use (Coulibaly et al., 2016; CSA, 2019). However, when climate change “adjustment factors” or augmentation factors for the future climate are needed, climate research increasingly supports some defensible and simple future climate approaches for extremes. These approaches are founded on the C-Clap relation.

The method is explained in detail in the CSA PLUS 4013 IDF Guide (CSA, 2019), but can be simply described as the use of projected changes in air temperature as the basis for scaling changes in precipitation intensity (i.e., extreme rainfall for multi-year to multi-decadal return period events). For every degree increase in air temperature, the C-Clap relation indicates that the atmosphere can carry approximately 7% more moisture. Observational regional studies (Panthou et al., 2014) as well as state-of-science fine-scale climate change modelling studies indicate that this is a good approximation for observed changes in rainfall intensity, depending on air temperature. Because the assessment required a measure of the change in event *probabilities* under warming conditions – as opposed to a change in *intensity* for the same event frequency – an additional step was needed to interpolate the new event frequency. A key caveat is that this method assumes the same statistical distribution for the future as assumed within the historical rainfall data, an assumption that does not take into account potential changes in the variability of the extreme rainfall intensities.

Correlation Investigation - Extreme Precipitation and Extreme Great Lakes Water Levels

Great Lakes Basin wet and dry periods are influenced by storm tracks, which can often be linked to global-scale processes such as El Niño or Atlantic Multi-decadal Oscillation, while cold air outbreaks that influence ice cover and evaporation rates can often be related to the Arctic Oscillation and other shifts in the polar jet stream. In spite of these persistent storm track influences, the interactions of these global patterns with lake levels are complex and unclear. The variety of climate and hydrological/hydraulic processes operating at different time scales and influencing Great Lake levels suggest that it is difficult and maybe impossible to determine whether patterns influencing heavy precipitation events can be linked to other conditions that influenced high to extreme lake levels. It is also uncertain how these relationships will change with climate change.

For completeness, a local study was undertaken to determine whether any relationship existed between such extreme precipitation events and extremes of water levels and flood contributions. The extreme precipitation events were compared against water level observations at two locations: St. Clair Shores and Ft. Wayne. Level data was obtained from the US Army Corps of Engineers website:

https://tidesandcurrents.noaa.gov/waterlevels.html?id=9034052&units=metric&bdate=20210101&edate=20211231&timezone=LST&datum=IGLD&interval=d&action=

An initial review of total annual precipitation and mean annual water levels at the St. Clair Shores and stations revealed no correlation at the coarse scale. A more refined daily precipitation comparison was undertaken for the last year of full data in 2021 to daily total precipitation for events equal to or above 10 mm and daily average water levels. As shown in **Figures 13** and **14**, the results indicate that there is very little daily correlation between the amount of daily precipitation received at Windsor Airport above 10mm and the daily average water levels at both of these stations as shown below since lake levels reflect a complex and long set of interactions influenced by many climate, hydrologic and hydraulic processes rather than sudden extreme daily events.

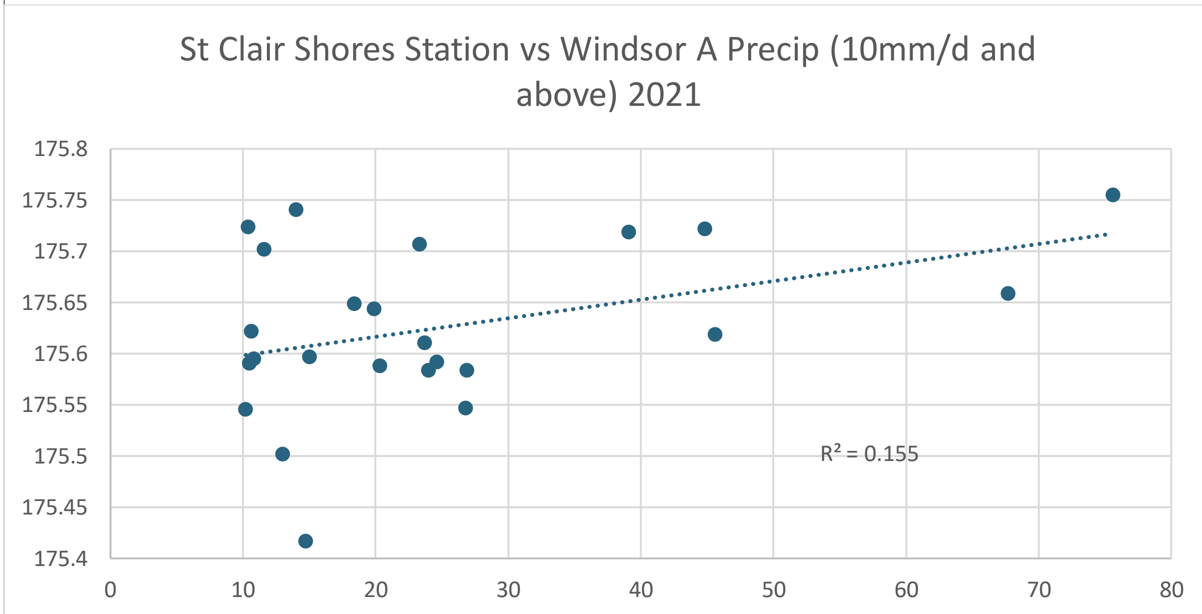


Figure 13 – Comparison of Precipitation and Water Level at St. Clair Shores

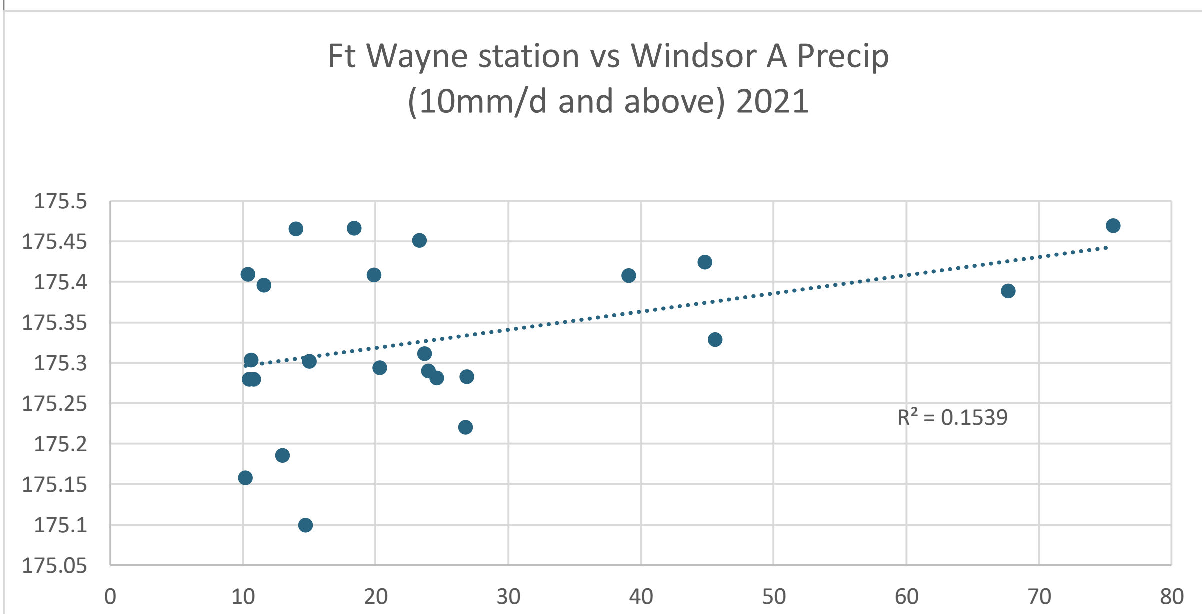


Figure 14 – Comparison of Precipitation and Water Level at Fort Wayne

Based on this correlation analysis, it was determined that the combined event probabilities for design rainfall and extreme lake levels (i.e., those used to evaluate drainage system performance using the drainage model) can defensibly be treated as statistically independent events. Since extreme rainfall and high Detroit river levels can be treated as statistically independent, their individual likelihoods are simply *multiplied* to arrive at an overall likelihood of simultaneous occurrence for both events.

Secondary and Long-Term Impact Events

Additional hazards were investigated for the potential to generate either long-term (gradual) damage and impacts to drainage and shoreline protection infrastructure and/or secondary climatic events that can result in exacerbating impacts to drainage and sanitary systems (e.g., through reduced or blocked surface transportation access, loss of power to treatment plants and pumps, etc.).

Shoreline Erosion

No historical database of shoreline erosion for the Detroit River was identified, and so impacts and rate of change could not be statistically evaluated. However, City staff interviews, stakeholder consultation as well as the County of Essex Hazard Identification and Risk Assessment (HIRA; County of Essex, 2019) all indicated significant concerns regarding shoreline erosion, and it was therefore included as a key hazard consideration within the findings of the flood assessment.

Weathering

Many municipalities and other infrastructure and asset owners across Canada have suggested that weathering related deterioration of assets may have accelerated in recent years. Assignment of cause in these cases is difficult given other potential contributing factors (e.g., under-investment in long-term asset maintenance) but these observations do highlight the importance of slow, creeping processes on degradation of important assets.

The freeze-thaw cycles used here are based on laboratory tests of reinforced concrete samples, indicating that visible damage can begin after approximately 30 cycles (Sun et al. 1999; Ruedrich et al, 2011). While the total number of freeze-thaw cycles is anticipated to decrease over the project time horizon, this decrease is not substantial, and weathering from this process is expected to continue through the rest of the century.

Ice storms

Because there exists no national database of ice storm events for Canada, the research here required the identification of historical events through literature review and media searches (Klaassen et al., 2003; Mclachlan and Smith, 1976). Statistics were then calculated based on this table and compared for consistency against ice accretion design data in infrastructure standards (i.e., CSA 2010). Finally, downscaled climate projections of ice storm activity from the literature (Cheng et al. 2011) were then applied to future time periods. Two thresholds were used, 15 mm for when power outages tend to occur due to tree contacts from large branches, and 25 mm, which is the minimum design threshold for overhead systems.

Cheng et al. (2011) produced downscaled projections based on weather patterns obtained for major historical ice storm events, suggesting a slight increase in event frequency under warming climate conditions. A more recent study by Jeong et al. (2019) is consistent with Cheng et al.'s (2011) earlier findings, indicating an increase in 50-year return period ice loads for a global average warming of 3°C or less. However, results from Jeong et al. (2019) were not presented in a format allowing derivation of the numerical event frequency values and changes. These findings are also in general agreement with earlier research from Klaassen et al. (2003). The earlier study noted that higher ice accretion values had occurred in recent decades for ice storm events occurring immediately south of the Canada-U.S. border in the states of Michigan and New York. The same storm events tended to generate lower ice accretion values or heavy snowfall in adjacent areas of Ontario and Quebec. The study proposed that a poleward shift in storm tracks could result in a potential increase in more significant ice storm events in adjacent portions of southern Canada. However, we note these changes in event frequencies result in little future change for ice impacts compared to the baseline. For example, the approximate 10% projected increase in event frequency for 25 mm ice storms still results in a low overall event frequency, increasing from 8% per year to 9% per year annual probability.

High winds – Severe Thunderstorms, Tornadoes

The consideration of high winds used two different thresholds. Gusts in excess of 120 km/hr (year round) were analysed, as were localised severe thunderstorm driven winds, and tornadoes of EF2 and higher intensity.

Gusts from All Event Types

A threshold of 120 km/h was used to help identify potentially high impact wind cases that may result in significant secondary impacts to critical services such as electrical power and surface transportation. Statistics were calculated directly from wind observations at Windsor Airport and checked against Detroit Wayne County Airport.

Wind gusts are not directly available as outputs from global or regional climate models. We therefore needed to again employ guidance from specialized downscaling studies available within the literature. Cheng et al. (2012) and Cheng et al. (2014) conducted statistical downscaling climate projections studies using approaches similar to the work referenced earlier on ice storm events. Their findings indicate potential increases in the number of days with wind gusts exceeding damaging thresholds. More recent research using a small set of regional climate models by Jeong and Sushama (2019) also supports the potential for increases in wind gust frequency and more year-to-year variability in extreme wind gusts, particularly for scenarios under the RCP8.5 emissions pathway by the end of the century. The indicated 24% increase in daily wind gust frequency is taken directly from Cheng et al. (2014) projected changes in wind gust frequency for the study region.

Tornado and other Localized Severe Thunderstorm Winds

Severe thunderstorm winds were evaluated using a review of ECCC storm spotter damage reports (Chadwick, 2005), media searches and case study reviews of high impact historical events. The frequency of their occurrence, specifically how often severe thunderstorm wind damage is reported but not detected at Windsor Airport, was then used to estimate the true prevalence and frequency of these events.

Tornado frequency was evaluated using the National Tornado Database (Cheng et al. 2013) and counting all tornadoes above the defined thresholds which occurred anywhere within the City of Windsor. Most large tornadoes affecting Windsor have crossed the Detroit River (in one case twice), when entering/exiting the City, and so the total frequency is representative of events which could impact shoreline assets and properties directly.

Due to the extremely complex nature of tornadoes and other severe thunderstorm related hazards, understanding the effects of climate change on their behaviour has been challenging. Unlike other hazards, tornadoes are the result of a combination and balance of a set of meteorological conditions, which at least partly explains their rarity compared to other atmospheric hazards. Only relatively recently have detailed studies of climate change effects on severe thunderstorm activity been able to provide some indication of the potential impacts of climate change on tornado hazards over the North American continent.

Recent studies of historical tornado activity trends in the United States indicate no discernable changes in total frequency of tornadoes over recent decades, but a decreasing trend in the total number of days experiencing tornadic activity (Brooks et al., 2014). However, several climate change projection studies using both previous AR4 and AR5 era global climate models (Trapp et al. 2007; Diffenbaugh et al. 2013) indicates the potential for significant increases in the number of days with favourable conditions for severe thunderstorm outbreaks (including tornadoes), suggesting that the frequency of these events may increase in some regions. More recent research on trends in tornado activity in the United State (Strader et al., 2017; Gensini & Brooks, 2018) also indicate both historically recent and future projected shifts in conditions conducive to tornado occurrence, which are of potential relevance to the City of Windsor and surrounding areas. Gensini and Brooks (2018) also report an observed increase in days with potential for significant (i.e., EF2 or stronger) tornado development in northeastern North America over the past approximately 40 years.

Conclusions

Having completed the climate data analysis and scoring, key findings are the following:

- Analyses of both historical and projected Great Lakes levels resulted in updated 100-Year and projected “Climate Change” Detroit River levels.
- Extreme value analysis indicated no significant changes in estimated 100-year return period events, even when including the most recent years of high water levels.
- Review of updated climate projection literature suggests a lower future potential Great Lakes basin elevation than was indicated in previous studies.
- The greatest changes in risk across time are associated with changes in extreme rainfall frequency, with significant increases in the likelihood what are currently considered the 5-year and 100-year 4-hour storms, increasing future scores for both combined event modeling cases (i.e., rainfall and high river levels) as well as “rainfall only” hazard events.

- Several important parameters, particularly shoreline erosion and river ice related hazards, were flagged for the need for increased quantitative monitoring. These hazards were considered important but no quantitate monitoring database is currently available to assess the frequency, severity, etc., of these events.

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Appendix E

Hydraulic Assessment

Memo

To: Project File

From: Aakash Bagchi, P.Eng., Aryn Cain, EIT

Date: December 2, 2022

Subject: West Windsor Flood Risk Study
Existing Condition Model Review and Flood Risk Assessment

Our File: 21-2409

Dillon Consulting (Dillon) was retained by the City of Windsor (City) to complete a flood risk study to identify and quantify flood risk for West Windsor. The study area is generally bounded by the Detroit River to the North and West, Huron Church Road and the Essex Terminal Railway to the East and the municipal boundary with the Town of LaSalle to the South. The West Windsor region has been impacted by record high water levels in the Detroit River in the recent past. High water levels have resulted in surface flooding, backing up of gravity storm sewer outlets in to the Detroit River, and have affected operations at the Lou Romano Water Reclamation Plant (LRWRP). The LRWRP, located within the study area, is a critical piece of municipal infrastructure that services the central and southern parts of the City of Windsor.

This memo summarises the hydrologic/hydraulic modelling analysis undertaken to identify infrastructure at risk due to joint probability events, which include high water levels in the Detroit River occurring concurrently with rainfall events.

1 West Windsor Study Area

Figure 1 shows the extents of the West Windsor study area and lists major land uses. The study area was divided into three zones based on the dominant land uses, topography, and type of sewer infrastructure:

Zone 1 – includes the developments along Sandwich Street West, also known as Sandwich Towne. The land use within this zone is primarily a mix of residential and industrial land uses. Residential forms approximately 46% of the total area while industrial comprises of 32% of the total area. This zone also has some institutional and commercial land use. This area is serviced primarily by a combined sewer system. Sewer separation has been achieved in some areas south of Brock St.

Zone 2 – includes areas along the Detroit River, west of Russell St. The land use in this zone is primarily industrial. The Riverside Drive interceptor trunk sewer lies in this zone, along Russell Street. It conveys sewage during dry weather conditions to the LRWRP from the combined sewers in the central Windsor area. The LRWRP is located along Ojibway Parkway in this zone.

Zone 3 – forms the southern portion of the study area. Industrial land use forms a majority of area within this zone. Green spaces form the next major land use in this zone. Industrial developments along Sprucewood Avene are serviced by a sanitary sewer system that drains to the LRWRP. Stormwater runoff from this area drains to the Detroit River through a local storm sewer system and the Sprucewood Avenue Drain.

Figure 2 shows the existing topography within the study area. The areas along the banks of the Detroit River are generally at a lower elevation than inland areas. The general slope of the ground surface is towards the Detroit River.

The soil types within the study area include Burford Loam, Berrein Sand and Granby Sand. The soil type along the bank of Detroit River is primarily Burford Loam, which is considered to be a well drained soil with high infiltration rates. Soil types in areas further inland are Berrein Sand and Granby Sand. These soils are poorly drained and have lower infiltration rates.

2 Background Investigation

2.1 Review of Background Reports and Studies

Background reports and studies relevant to the study area were reviewed by the Project Team. The following reports and data were reviewed as part of this study:

- Prince Road Sewer Study (Stantec, 2001)
- Functional Design Report - Sanitary Sewerage and Stormwater Drainage - Malden/Prairie Grass (Dillon, 1993)
- Ojibway Sanitary Sewer Infrastructure Rehabilitation Needs Study (La Fontaine, 1992)
- Proposed Sewer and Sanitary Sewer Prince Road (Golder, 1986)
- Prince Road Trunk Storm Sewer Study (MacLAREN, 1978)
- Interim Report on Investigations of the Ojibway Sanitary Sewerage Area (MacLAREN, 1978)

2.2 Review of City of Windsor Sewer and Coastal Flood Protection Master Plan

The City recently completed the Sewer and Coastal Flood Protection Master Plan (SCFPMP) (Dillon, 2020). The SCFPMP identified problem areas, which are at risk of flooding due to sewer surcharging and coastal flooding under different return period rainfall events. Impacts of coastal flooding were analysed for the East Windsor Area. The SCFPMP also recommended short and long term solutions to mitigate the risk of residential basement flooding, surface flooding and coastal flooding (East Windsor area).

The following solutions were recommended for the West Windsor study area through the Windsor SCFPMP:

- 2700 mm diameter storm sewer outlet from the Prince Road sewer, at Chappell Avenue, to McKee Creek, along with a dewatering pump of 0.085 m^3/s capacity;
- Separation of combined sewer systems; and
- Improvements to the Detroit Street storm sewer system including a 1200 mm diameter storm sewer and an improved outlet to the Detroit River.

3 Hydrologic/Hydraulic Assessment

The hydrologic/hydraulic model completed as part of the Windsor SCFPMP was used to evaluate the performance of the existing drainage infrastructure in West Windsor. The modelling analysis was completed using the Infoworks-ICM modelling package, distributed by Innovyze. Infoworks-ICM is a modelling software for stormwater, wastewater, and watershed systems.

The hydraulic model used for the Windsor SCFPMP included all major storm, sanitary and combined sewers in the City of Windsor. The model was calibrated using observed sewer flow data. Details about the model setup and calibration are provided in the Windsor SCFPMP Report (Dillon, 2020). The model also includes a 2D mesh that represents the existing ground surface. Flooding in the 2D mesh represents surface flooding due to sewer surcharging or limited sewer inlet capacity.

While the model simulates high water levels as downstream boundary conditions to the sewer system, it does not simulate overland flooding along the shore due to high water levels. As such, the model is not setup to simulate effects of wave action in addition to high Detroit River water levels.

The existing conditions calibrated Windsor SCFPMP hydrologic/hydraulic model was used to complete this analysis. Boundary conditions, in the form of fixed water levels at sewer outfall locations in the Detroit River, were updated for the current analysis, as summarised below.

3.1 Detroit River Water Levels and Model Boundary Condition

Dillon undertook an analysis of historic water levels in the Detroit River to determine the 1:100 year return period water levels in the Detroit River near the study area. Details about this analysis are provided in **Climate Data and Analysis Summary**. The 1:100 year return period water level of 176.1 m in the Detroit River was used as the downstream boundary condition for the existing conditions analysis.

In addition to an analysis of historic water levels, Dillon completed an analysis of the impacts of climate change on water levels in the Detroit River, and recommended a Climate Change water level of 176.3 m. Details about this analysis are provided in the **Climate Data and Analysis Summary**. This water level was used as the boundary condition to estimate flood risk for the future climate change scenarios.

In addition to analysing impacts on the study area due to high water levels, an additional low water level scenario was evaluated to estimate flood risk due to rainfall events. This modelling scenario evaluated the flood risk when high water levels in the Detroit River would not be a causing a tailwater condition on underground sewer systems. For this analysis, the Average Annual Minimum Monthly Mean water level in the Detroit River near the study area was used.

The following water levels were used as boundary conditions for the hydraulic modelling analysis:

- 1:100 year return period – 176.10 m
- 1:100 year return period (considering impacts of climate change) – 176.30 m
- Low water level – 174.22 m

3.2 Modeling Approach

The calibrated Infoworks-ICM model set up for the Windsor SCFPMP was used for the hydrologic/hydraulic assessment. Updates were made to the boundary conditions applied to sewer outfalls along the Detroit River to reflect recommendations from the water level analysis completed as part of this study.

To remain consistent with the modelling approach used for the SCFPMP, design storm events used for the SCFPMP were used for the current modelling analysis. The objective of the modelling analysis was to evaluate flood risk during a number of joint probability events. These scenarios evaluated flood risk occurring due to high water levels in the Detroit River and concurrent rainfall on the watershed.

Results from the model simulations were analysed to estimate flood risk for the West Windsor study area, in general, and specific public and private infrastructure within the study area.

3.3 Design Scenarios

For the current analysis, the following modelling scenarios were evaluated:

- 1:100 year return period water levels in Detroit River concurrent with:
    - 1:5 year return period design storm event; and
    - 1:100 year return period design storm event.
- 1:100 year return period climate change water levels in Detroit River concurrent with:
    - 1:5 year return period design storm event; and
    - 1:100 year return period design storm event.
- Low water levels in Detroit River concurrent with:
    - 1:5 year return period design storm event; and
    - 1:100 year return period design storm event.

The design storm events used for this analysis were 4-hour rainfall events with 10-min time intensity intervals, using the Chicago distribution.

3.4 Evaluation Criteria

For the current analysis, the Level of Service (LOS) criteria developed through the SCFPMP were used. The flood risk due to joint probability events were analysed using the Hydraulic Grade Line (HGL) elevations in the sewer systems, and reported surface flooding due to sewer surcharging. Sewers are typically considered to be surcharged when the HGL elevation is above the obvert of the sewer pipes.

The SCFPMP recommends HGL in sanitary and combined sewers to remain 1.8 m below the existing ground elevation. 1.8 m is the assumed basement floor depth from ground. HGLs in sanitary and combined sewer system above this elevation represent a high risk of basement flooding due to sewer surcharging. The SCFPMP recommends surface flooding depth on roadways during a 1:100 year rainfall event to not exceed 0.30 m.

Additionally, the SCFPMP recommends surface flooding depths on major roadways (arterial and collector streets) during a climate change rainfall event to not exceed 0.30 m. This criteria was adapted for the current analysis to identify roadway flooding during joint probability simulations with a 1:100 year return period water level in Detroit River with consideration to climate change impacts.

4 Modeling Results

4.1 1:100 Year Return Period Water Levels (Historic)

Two modelling scenarios representing two joint probability events were simulated using the 1:100 year return period water levels in the Detroit River as downstream boundary conditions. Results from these simulations are represented in **Figures 3** and **4**.

The model results suggest that most combined sewers in Zone 1 are surcharged during the 1:5 year return period rainfall event simulation. Storm sewers conveying stormwater runoff to gravity outfalls are surcharged due to high water levels in the River backing up through the sewers. The Riverside Drive Interceptor sewer conveying sewage from central Windsor to the LRWRP is also surcharged during the 1:5 year simulation. The sanitary sewer system servicing industrial development in Zone 3 is also surcharged, and HGL elevations in the system are above the assumed basement floor elevation. No significant surface flooding is observed along municipal right-of-ways (ROWs) during the 1:5 year rainfall event simulation.

The outlet sewer from the LRWRP is surcharged during these simulations due to high water levels in the Detroit River, potentially affecting operations at the plant.

During the 1:100 year rainfall event simulation, a larger number of combined sewer MHs in Zone 1 report a higher risk of basement flooding, with HGLs above the assumed basement floor elevation. In addition, a number of sanitary and storm MHs in areas that are serviced by separated sewers report high HGLs. Surface flooding of depths greater than 0.30 m is observed along Russell Street and Sandwich Street.

4.2 1:100 Year Return Period Water Levels (Climate Change)

Results from joint probability events considering higher water levels in the Detroit River due to impacts of climate change show higher HGLs in the sewer systems, due to a higher tailwater effect caused by higher water levels. Results for these simulations are represented in **Figures 5** and **6**.

Correspondingly, the surface flooding extents along municipal ROWs representing flooding with depths greater than 0.30 m are higher during the joint probability event using 1:100 year rainfall event.

5 Identification of Flood Risk Areas

Figures 7 represents land parcels that are at risk of flooding due to either sewer surcharging or surface flooding, while **Figure 8** represents critical infrastructure at risk of flooding during the joint probability event simulation with 1:100 year return period water levels in the Detroit River and 1:100 year rainfall event.

Similarly, **Figures 9** and **10** represent land parcels and critical infrastructure at risk of flooding during joint probability simulation with 1:100 year return period water levels considering effects of climate change, concurrent with a 1:100 year rainfall event.

To identify land parcels at risk of flooding, proximity to MHs reporting high HGLs and surface flooding locations was investigated.

A number of residential land parcels in Zone 1 were identified to be under risk of basement flooding due to sewer surcharging. A number of land parcels with industrial land uses were identified in Zone 2. It must be noted here that these parcels are at risk of flooding from high River water levels since they are located along the River bank.

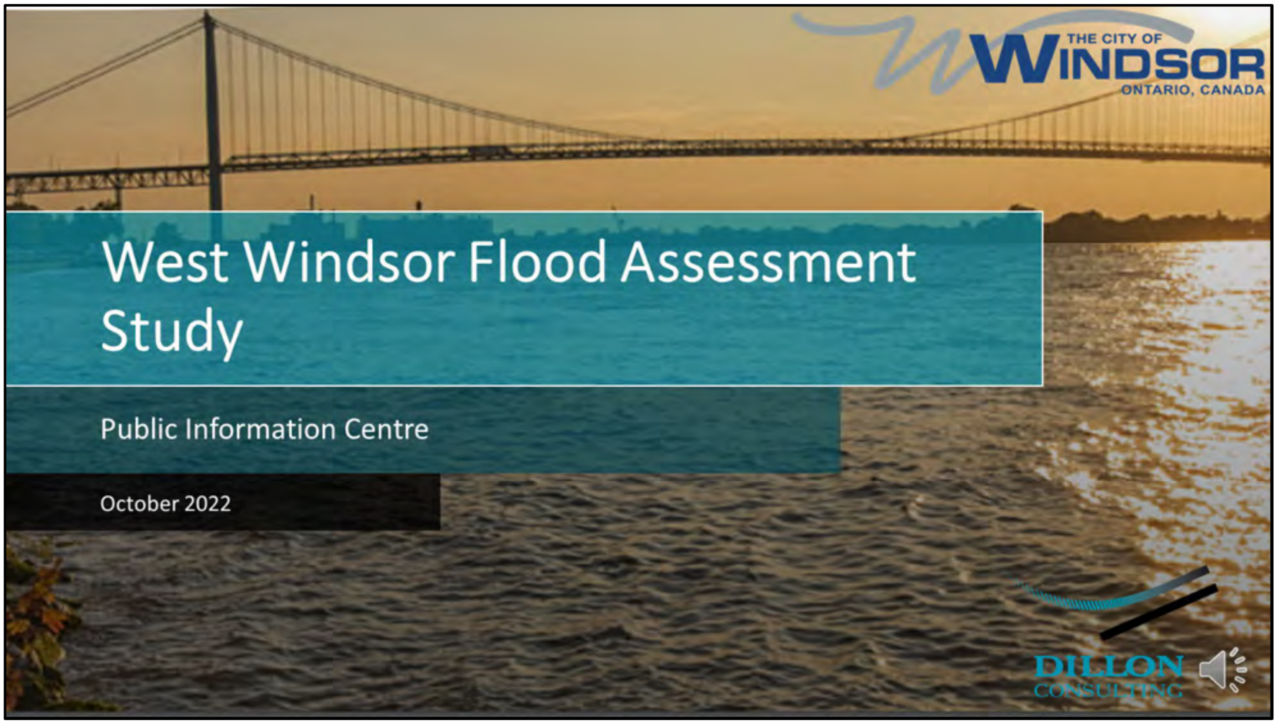
A number of land parcels identified as critical infrastructure are also at risk of flooding. These include schools/childcare centres, nursing homes, armoury and the LRWRP.

Appendix F

Public Information Centre

Appendix F – Public Information Centre

1. Presentation Slideshow
2. Stakeholder Contact List
3. Public Information Centre Stakeholder Email
4. Public Consultation Record



Hello! And thank you for joining the Virtual Public Information Centre for the West Windsor Flood Assessment Study. My name is Nick Emery and I am the project manager with Dillon Consulting Limited. Dillon was retained by the City of Windsor, Ontario to complete this project.

Study Area

Study Area Boundaries:
- Ojibway Parkway and College Street;
- LaSalle border;
- Detroit River; and
- Huron-Church Road/Ambassador Bridge.

I'd like to begin by outlining the portion of the City of Windsor that we studied for this project. Our study area is generally bounded by Ojibway Parkway, the Essex Terminal Railway and College Street to the east, the Town of LaSalle municipal boundary to the south, the Detroit River to the west, and Huron Church Road and the Ambassador Bridge to the north. From here forward we will refer to this area as West Windsor.

Project Background

- Recent record of high Detroit River water levels caused:
  - Increased flows to the Lou Romano Water Reclamation Plant; and
  - Local flooding (basements, properties, roads)
- Sewer and Coastal Flood Protection Master Plan
  - Identified need for West Windsor Flood Risk Assessment

I'd now like to provide a little bit of background information to explain why this project was undertaken.

Water levels on the Detroit River vary from year to year. However, in recent years, river levels were especially high, peaking in May 2020.

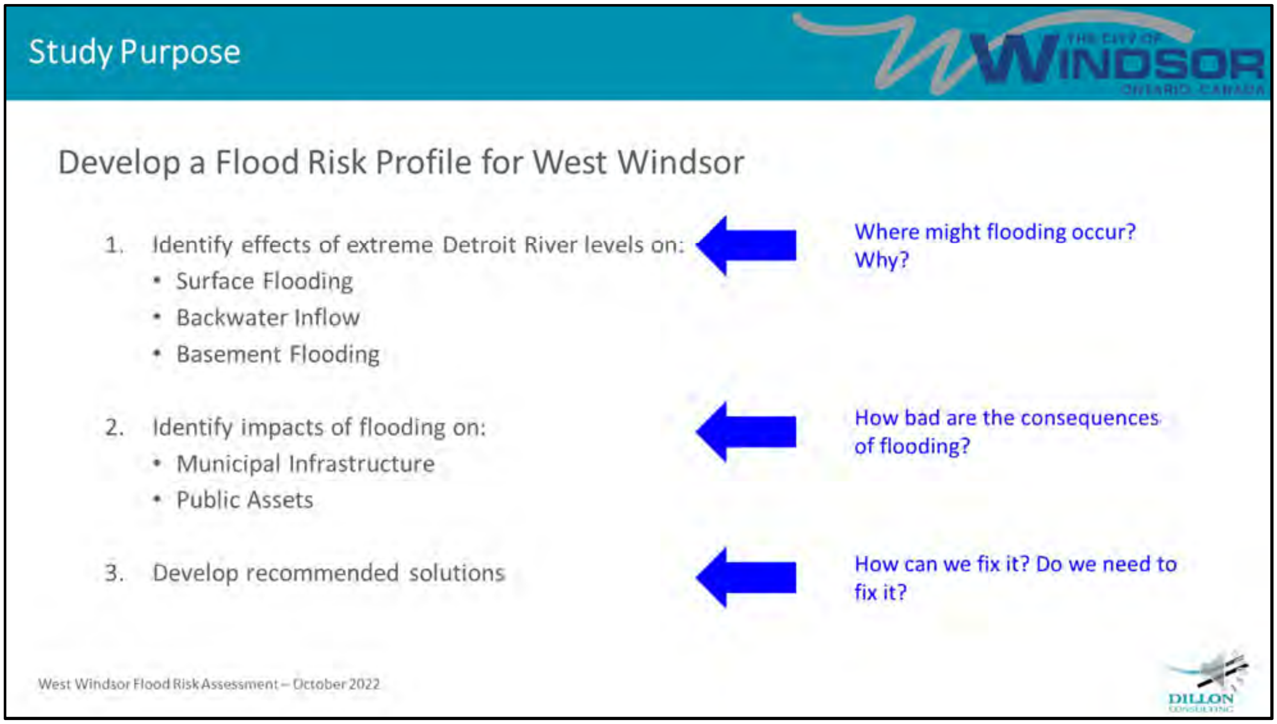
As some of you listening to this presentation may remember, these increased water levels caused several impacts across the City of Windsor. Some of the most visible impacts were at marinas, boat launches, and shoreline parks.

Similarly, in West Windsor, these high river levels caused local flooding along shoreline properties and municipal roadways near the riverfront. This also exacerbated the risk of basement flooding further inland within the West Windsor area.

Another, less visible, effect was that the high river levels increased the sewer flows sent to the Lou Romano Water Reclamation Plant. This plant is responsible for treating wastewater from most of the City of Windsor. These additional flows resulted in higher operating costs and reduced capacity to accommodate peak flows.

While these recent high river levels were occurring, the City of Windsor was in the process of completing its city-wide “Sewer and Coastal Flood Protection Master Plan” which recognized the shoreline within West Windsor as being vulnerable to high river levels. Due to this increased vulnerability, the Masterplan recommended the completion of an additional Flood Risk Assessment for the West Windsor Area.

The City of Windsor secured funding for this project from the Government of Canada through the National Disaster Mitigation Program. This program was established to reduce the impacts of natural disasters, including flooding, on Canadians.



The purpose of this project is to develop a flood risk profile for the West Windsor area.

There are 3 main objectives that this study will accomplish.

The first is to identify the impacts of extreme Detroit River levels on the West Windsor Area. Particularly focusing on how the increased levels impact:
Surface flooding on properties and streets;
Inflow to the local sewer system; and
Local basement flooding.

The questions we are trying to answer with this first objective are:

Where in West Windsor do high river levels cause flooding or other impacts? and
Why does it happen at these locations?

The next objective is to identify the effects of high river levels in West Windsor on municipal infrastructure and public assets

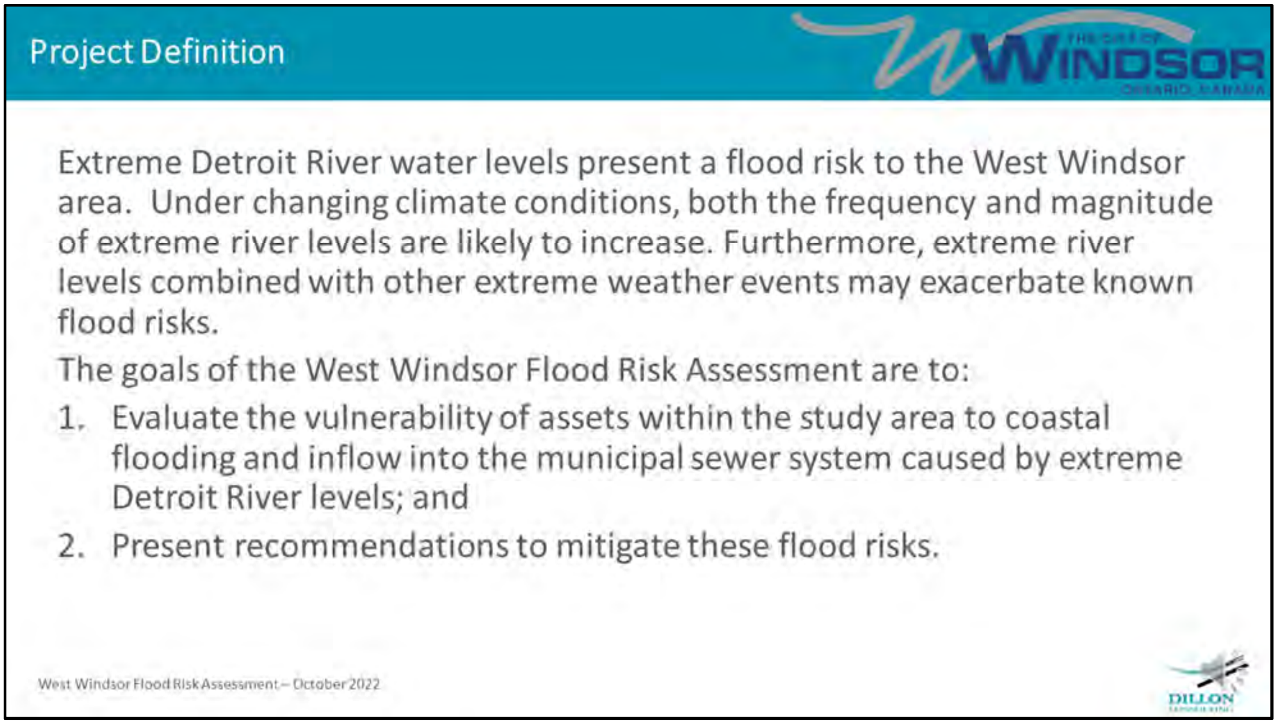
For instance if a road is flooded, how much of a hazard does that present?

Is it still passable to traffic?
Does it prevent access to properties and public facilities? OR
Is it so severe that it prevents emergency vehicles from responding?

To put it another way, what are the consequences of flooding in West Windsor? By understanding these consequences, we can prioritize where we need to develop solutions.

Which brings me to our final objective, which is to identify and evaluate possible solutions to address the impacts of high river levels.

How do we fix the problem? Are the consequences severe enough that we need to develop a solution

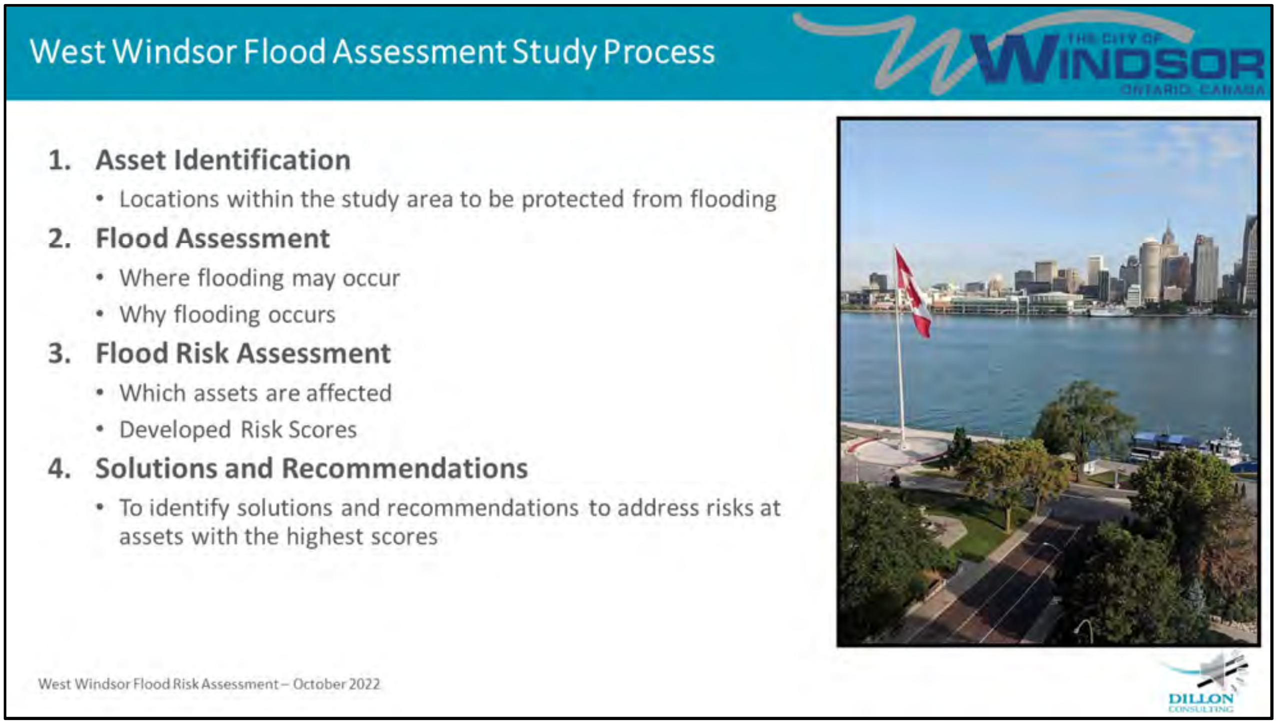


Based on the background information and the objectives that we've just outlined, this project definition was developed to help guide the completion of the West Windsor Flood Risk Assessment:

Extreme Detroit River water levels present a flood risk to the West Windsor area. Under changing climate conditions, both the frequency and magnitude of extreme river levels are likely to increase. Furthermore, extreme river levels combined with other extreme weather events may exacerbate known flood risks.

The goals of the West Windsor Flood Risk Assessment are to:

1. Evaluate the vulnerability of assets within the study area to coastal flooding and inflow into the municipal sewer system caused by extreme Detroit River levels; and
2. Present recommendations to mitigate these flood risks.



Equipped with that project definition to guide us, the project team then set out to complete the West Windsor Flood Assessment using the following process:

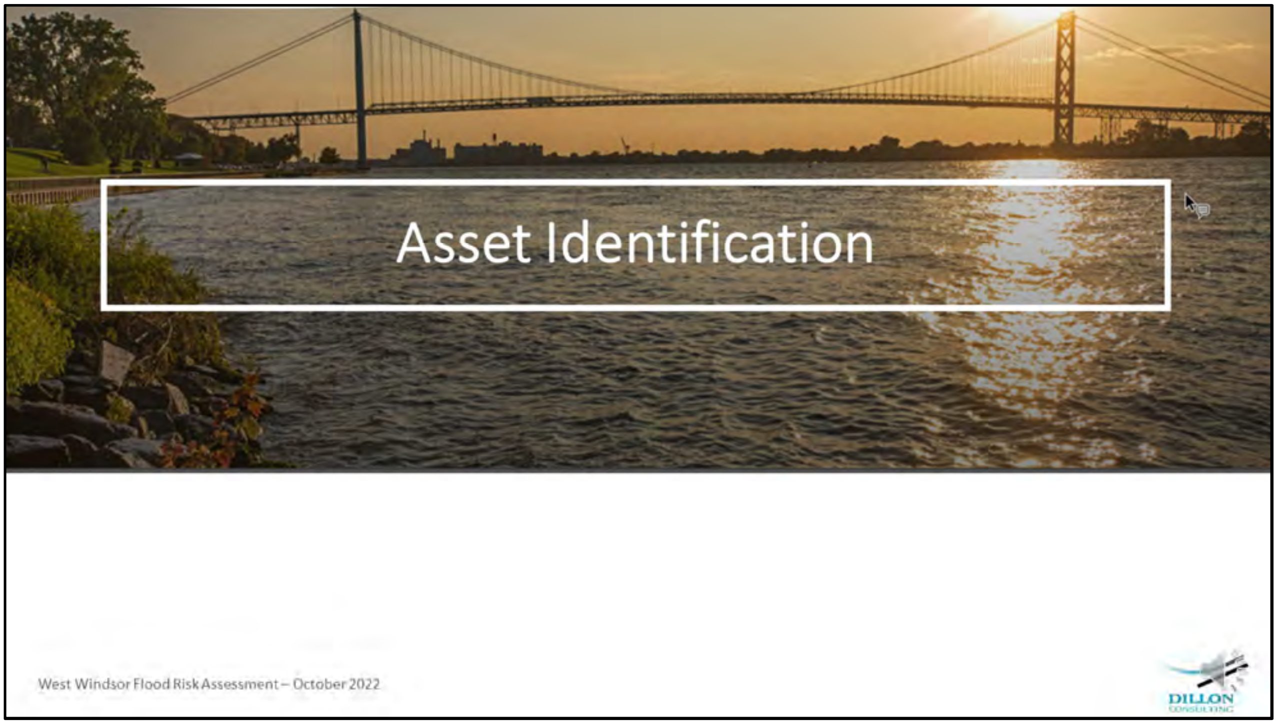
Our first step was to identify the critical assets within West Windsor that need to be protected from flooding.

Next, we completed a flood assessment to identify flooding locations and to examine the role that high river levels have in contributing to this flooding.

Then, we completed a flood risk assessment using the PIEVC protocol to identify which assets in West Windsor are susceptible to flooding under high river levels, and to develop risk scores for each of the affected assets

Finally, guided by the risk scoring in the previous step, we developed solutions and recommendations to address flooding at assets where unacceptable impacts are likely to occur.

I’ll be explaining each of these steps in further detail as we work through the rest of this presentation.



Our first step was to understand the types and locations of assets within the West Windsor area that need to be protected during periods when the Detroit River water levels are extremely high

Asset Identification

- Municipal Infrastructure
  - Lou Romano Water Reclamation Plant
  - Sanitary Sewers

West Windsor Flood Risk Assessment – October 2022

The first category of assets that we identified was municipal infrastructure.

This includes the Lou Romano Water Reclamation Plant, which treats wastewater from the City of Windsor to that it can be safely released to the Detroit River; and
The upstream sanitary sewers that convey wastewater to the Lou Romano Plant. When I talk about sanitary sewers, these are the pipes that take the wastewater away from your home whenever you take a shower, run your tap, or flush your toilet.

Asset Identification

- Municipal Infrastructure
  - Lou Romano Water Reclamation Plant
  - Sanitary Sewers
  - Storm Sewers

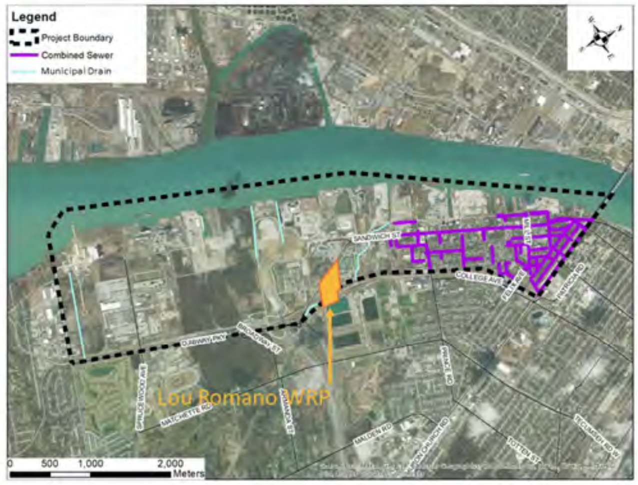
West Windsor Flood Risk Assessment – October 2022

The next municipal infrastructure items are storm sewers. These pipes collect surface runoff from rain storms and snowmelt and convey that water to either an open channel, a roadside ditch, or directly to the Detroit River.

Asset Identification

THE CITY OF WINDSOR ONTARIO, CANADA

- Municipal Infrastructure
  - Lou Romano Water Reclamation Plant
  - Sanitary Sewers
  - Storm Sewers
  - Combined Sewers
  - Roadways



West Windsor Flood Risk Assessment – October 2022

DILLON CONSULTING

A combined sewer system services much of the residential area within West Windsor. These are typically older systems that collect both sanitary and storm flows and convey them to the Lou Romano Water Reclamation Plant. These systems also have overflows that spill directly into the Detroit River during severe storm events. We call these CSOs, which stands for combined sewer overflows. I'll be talking about these in further detail later on in this presentation.

The final pieces of municipal infrastructure that we considered are the public roadways within West Windsor.

Asset Identification

- Municipal Infrastructure
  - Lou Romano Water Reclamation Plant
  - Sanitary Sewers
  - Storm Sewers
  - Combined Sewers
  - Roadways
- Parks

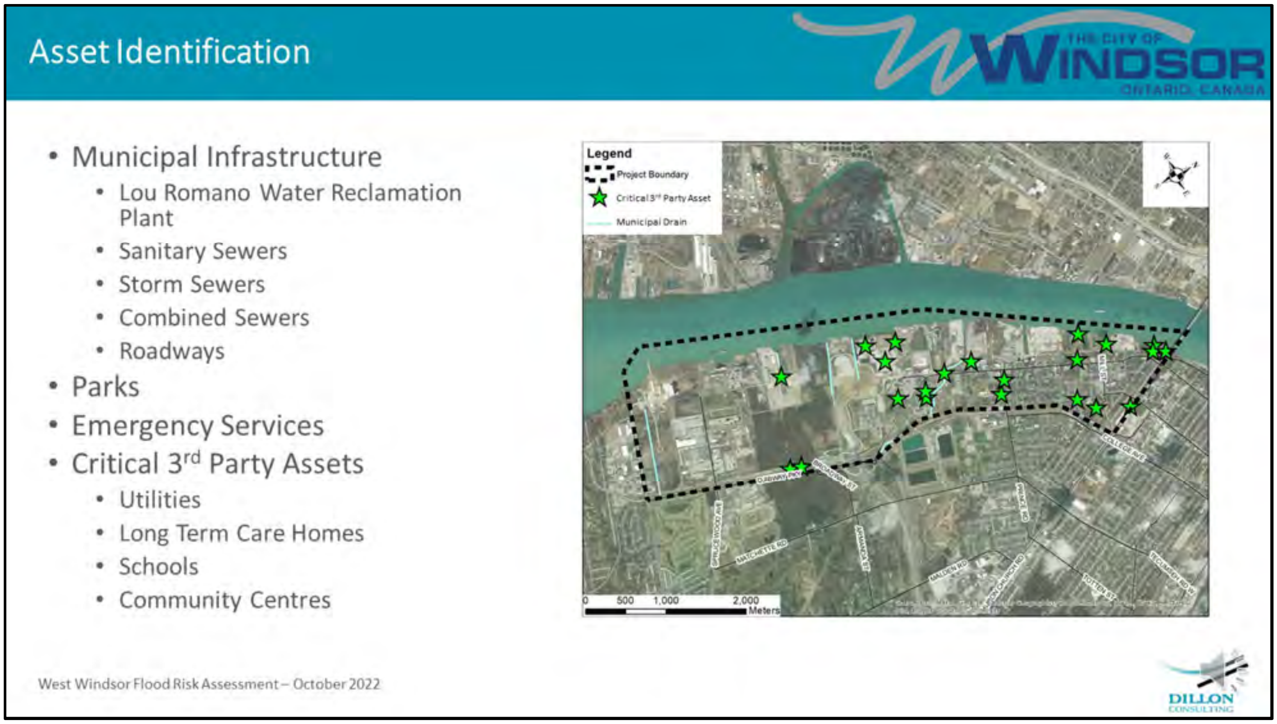
West Windsor Flood Risk Assessment – October 2022

The next assets we identified are municipal parks and green spaces, including McKee Park, Mill Park, Brock Park, and Black Oak Heritage Park.

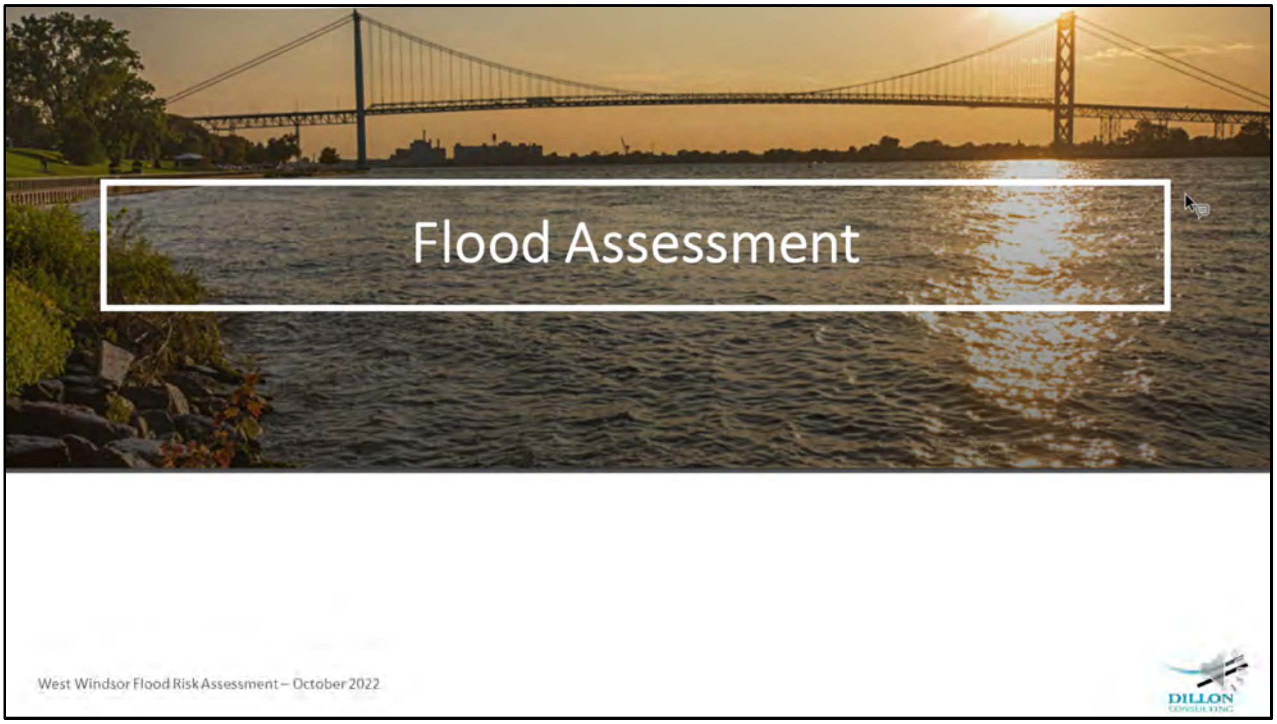
Asset Identification

- Municipal Infrastructure
  - Lou Romano Water Reclamation Plant
  - Sanitary Sewers
  - Storm Sewers
  - Combined Sewers
  - Roadways
- Parks
- Emergency Services

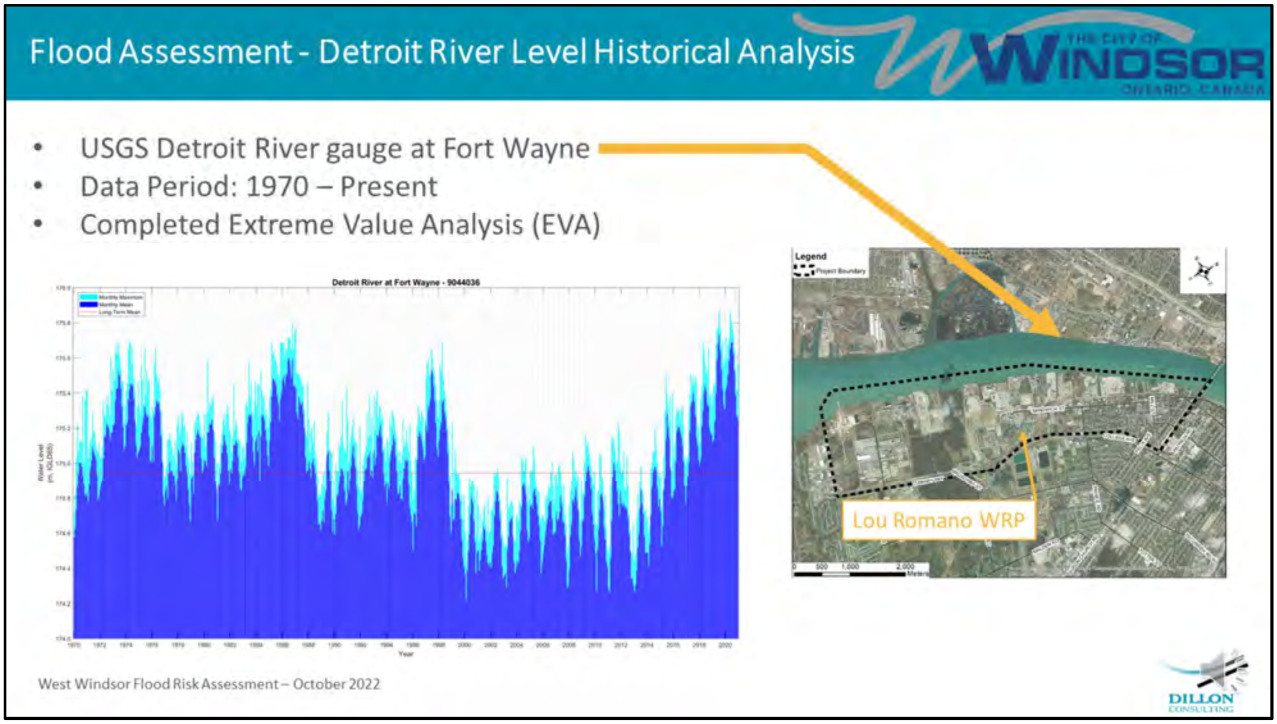
We also identified emergency services which include both health care facilities and police stations. Fire stations were also included in our search, but there aren't any located within our study area



Lastly, we identified all the Critical third Party Assets which include utilities, long term care homes, schools and community centers.
So the list that you see on this slide summarizes all of the assets that we investigated in this study



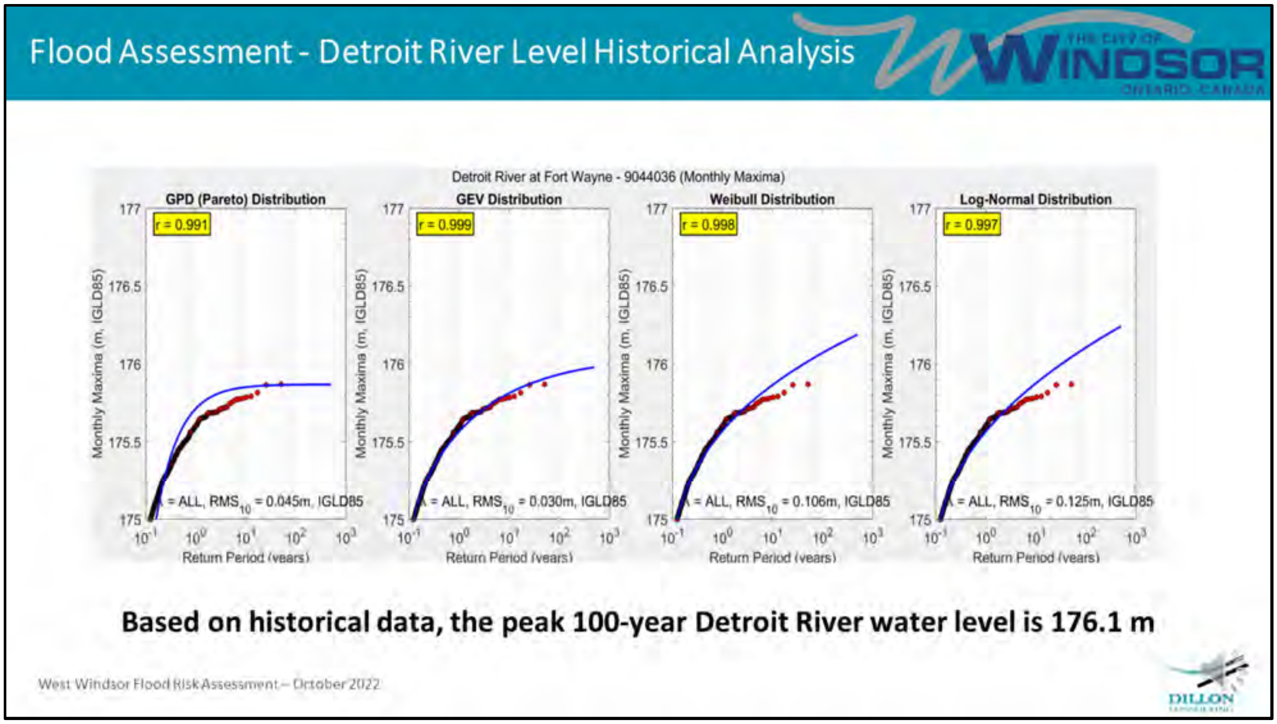
Our next step was to complete the flood risk assessment to identify locations where extreme Detroit River levels are likely to contribute to flooding and to understand why that flooding occurs.



We all understand that water levels on the Detroit River fluctuate, so there must be a range of water levels that we can reasonably expect to see. But What does it mean when we talk about extreme water levels? For the purposes of this study we're interested in the 100-year water level. This is the maximum water level that we can anticipate during a 100-year time period. We can also think of this as the maximum water level that has a 1% chance of occurring in any given year.

So, what is that water level for the West Windsor study area?

Fortunately, we had access to some really great historical data to help us answer that question. Just across the river from West Windsor, there's a United States Geological Service stream gauge which records the Detroit River level every hour – the graph on this shows those recorded water levels. We gathered the over 50 years of available data and used it to complete an extreme value analysis.



The historical data were plotted and compared with standard probability distributions to identify a curve that best fits the measured peak water levels. The curve with the best fit was then used to estimate the Detroit River 100-year water level.

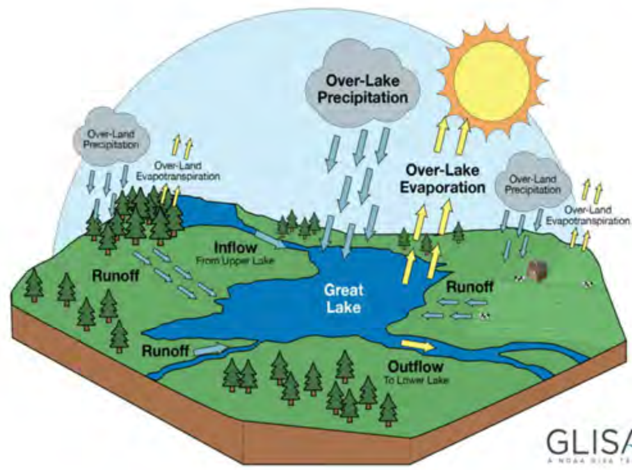
Based on our extreme value analysis results, a 1:100-year water level of 176.1 m was calculated for the West Windsor Area.

We need to keep in mind that this value is based on historical data. We also need to know if future climate change is likely to affect this number.

Flood Assessment - Detroit River Level Climate Change

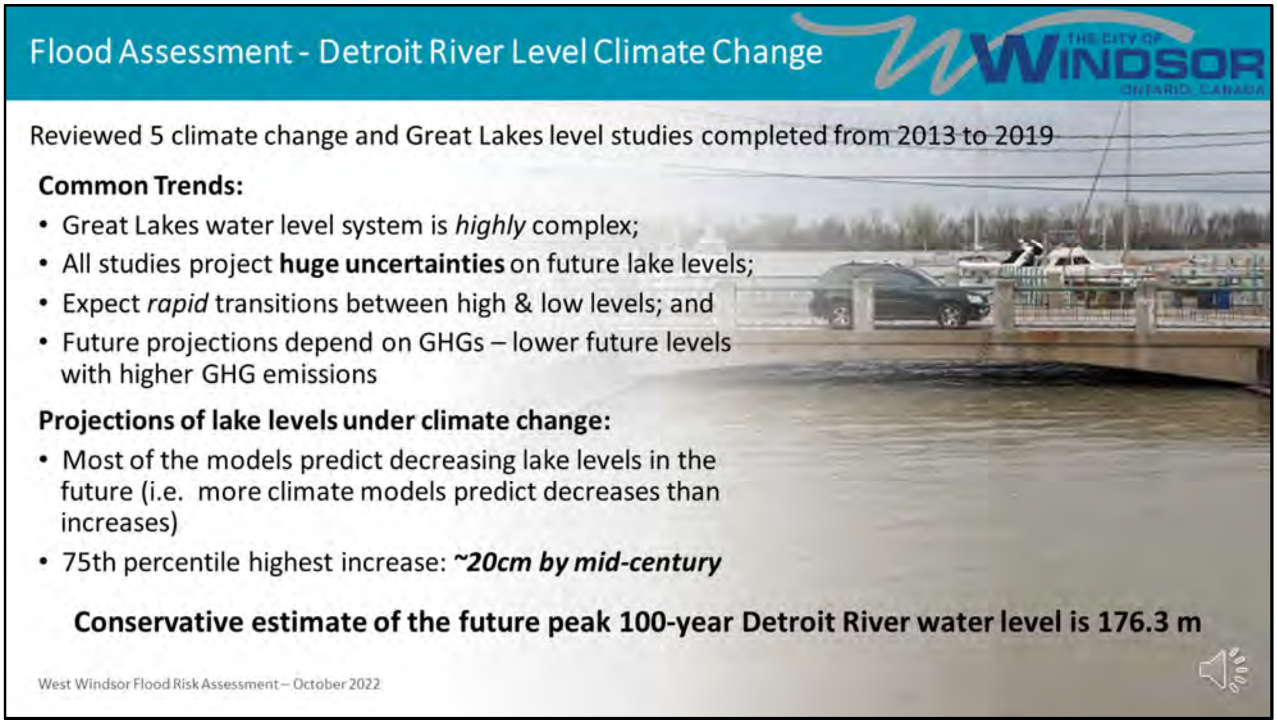
Changes in water levels within the Great Lakes system are primarily caused by the following factors:

- Changes in precipitation
- Changes in evaporation from the lakes
- Changes in the inflow and outflow from the systems



As you know, the Detroit River is part of the Great Lakes system, connecting Lake St. Clair to Lake Erie. Each of the Great Lakes' water levels fluctuates annually due to three main factors:

1. changes in rainfall and snowfall over the lakes,
2. changes in evaporation from the lakes, and
3. changes in the flows from tributaries and rivers that enter the Great Lakes from the surrounding lands and any diversions or management changes



To answer the question of how peak water levels on the Detroit River may change in the future, we completed a review of 5 recently published studies that predict the effects of climate change on the Great Lakes.

Now, as you may guess, five different studies with five different analysis methodologies are going to draw five different sets of conclusions. However, based on our review we identified 4 common trends:

All of the studies that we reviewed acknowledge that the interactions of the factors that influence the Great Lakes water levels are very complex;

All of the studies recognize that there is uncertainty associated with predicting future lake levels and, just like our local weather forecasts, these uncertainties increase the further into the future we're trying to predict;

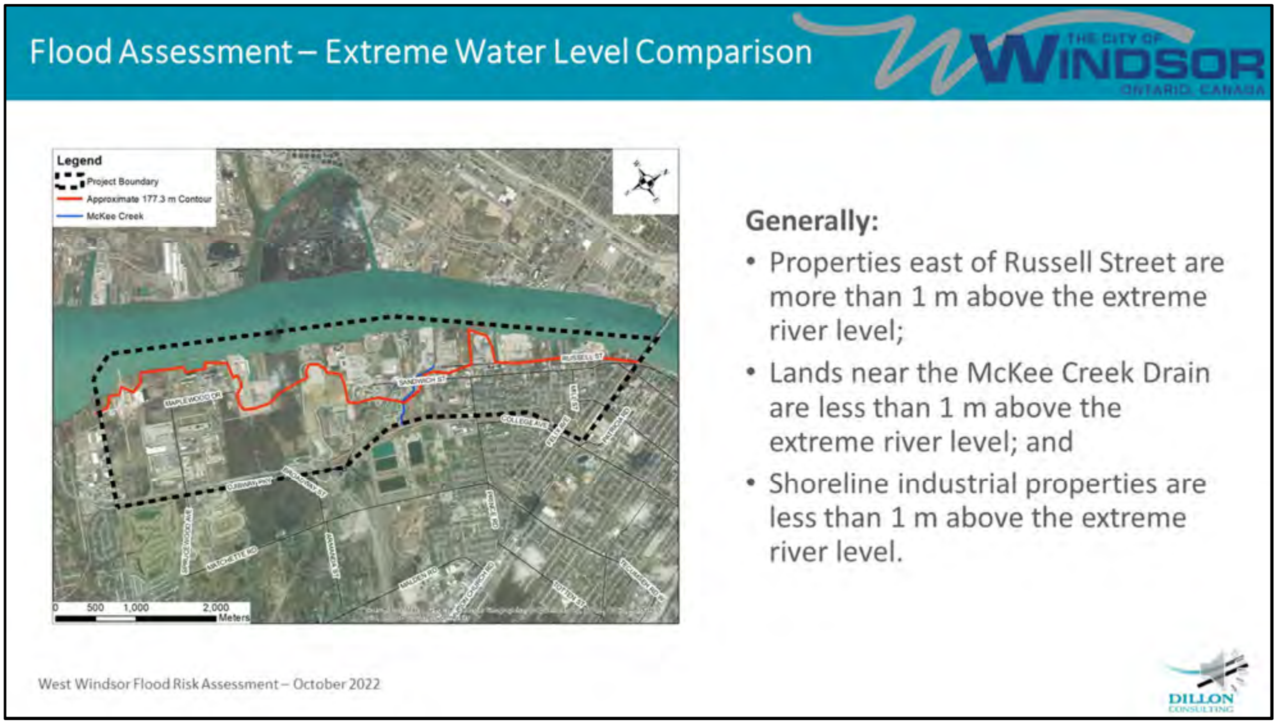
More definitively, we can expect quicker changes from low lake levels to high lake levels and vice versa;

And finally, all of the studies predict an inverse correlation between future greenhouse gas emissions and lake levels. Increasing GHG emissions are linked to lower future lake levels.

Each of the Great Lakes studies that we reviewed relied on the results of different climate models and considered different scenarios to predict future lake levels. As a result, each study provides a range of future water level predictions based on different assumptions. In general, most of the climate models predict that lake levels will likely decrease in the future.

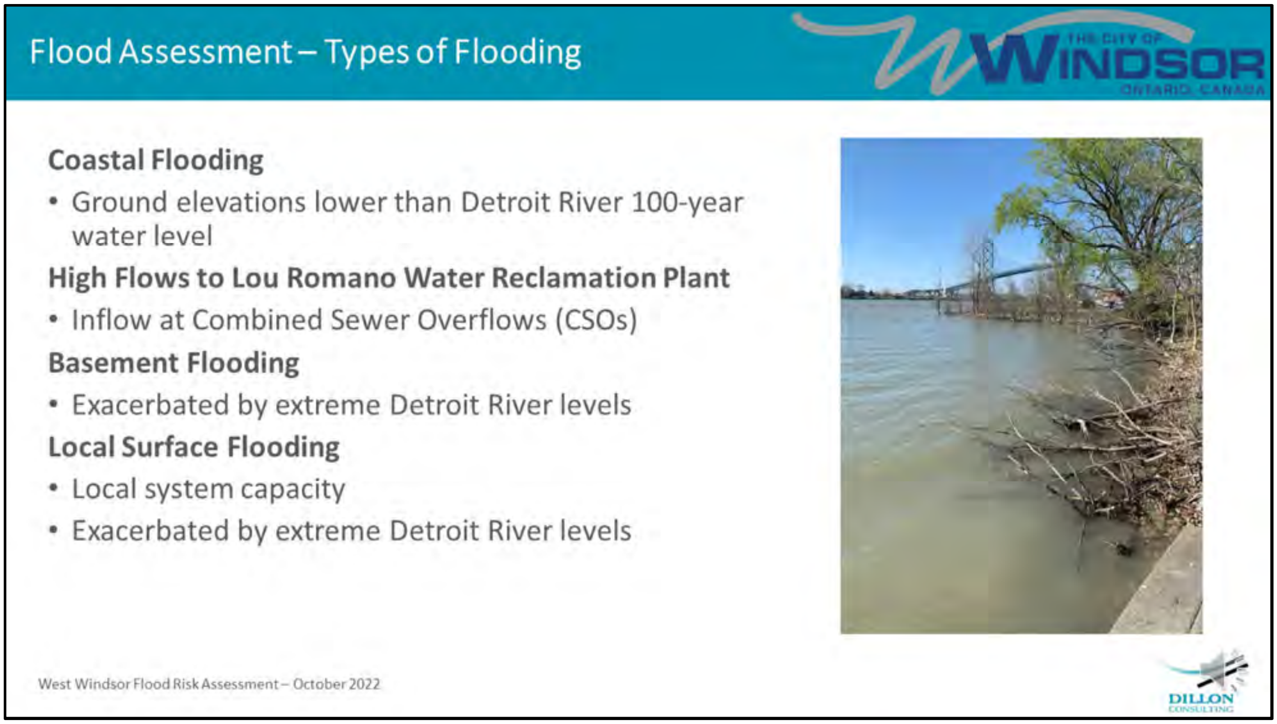
However, we wanted to look at the worst case scenario because first of all, we know that there's considerable uncertainty associated with these predictions and secondly, because we wanted to have a conservative high water level to use to predict future flooding and develop flood protection solutions. Based on the climate change studies that we reviewed, the highest predicted increase in peak water levels is about 20 cm.

Adding this increase to the water level calculated from our extreme value analysis gives us a future condition 100-year Detroit River water level of 176.3 m. Again, this is a conservative estimate of the peak water level that we can expect, considering climate change impacts.



So, now that we've defined our extreme Detroit River level, how does it compare in relation to the West Windsor area? To get a sense of this, we've show the 177.3 m contour as the red line on this slide. This contour is 1 m higher than our 100-year water level to help highlight the portions of West Windsor that may be affected by high river levels either by direct surface flooding or by backups of the local storm drainage system.

From this slide, we can draw three significant conclusions:
Overall the majority of residential properties in West Windsor, which are located east of Russell Street are more than 1 m above the extreme river level;
Lands located near the McKee Creek Drain are generally less than 1 m above the extreme water level; and
Many shoreline industrial properties are less than 1 m above the extreme river level.



The next step in the project was to identify where and why flooding caused by high river levels could occur in West Windsor. We used a few different methods to examine this including:

- A topographic mapping assessment to identify areas below the Detroit River 100-year water level;
- Computer modelling of the City's sewer and drainage networks; and
- Gathered observations of previous flooding from City operations staff and stakeholders.

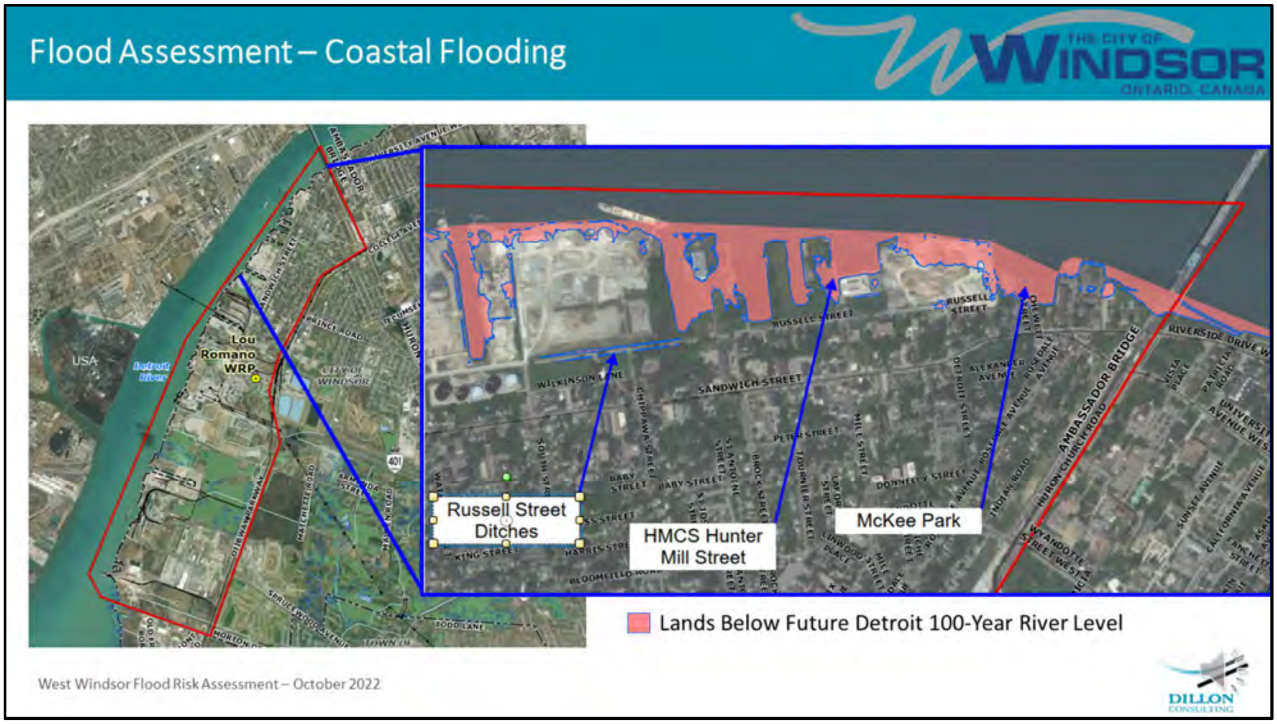
From this, we identified 4 main types of flooding in West Windsor linked to high Detroit River levels:

1. The first is coastal flooding which affects lands that are lower than the 1:100 year Detroit River Level. What we're talking about here is shoreline properties that are directly flooded when the river levels are high.
2. The next impact that we identified is increased flows to the Lou Romano Water Reclamation Plant caused by river water flowing directly into the combined system through Combined Sewer Overflows (CSOs) that are lower than the 100-year Detroit River level. During the recent period of high river levels, the plant saw a substantial increase in flows because river water was making its way into the City of Windsor's sewer network and getting mixed with wastewater.
3. Basement flooding is also a concern under high river level conditions. Now, basement

flooding usually occurs due to severe storm events. While high river levels don't directly cause basement flooding in West Windsor, they can increase the extent and severity of basement flooding by reducing the available capacity in the sewer network during storm events.

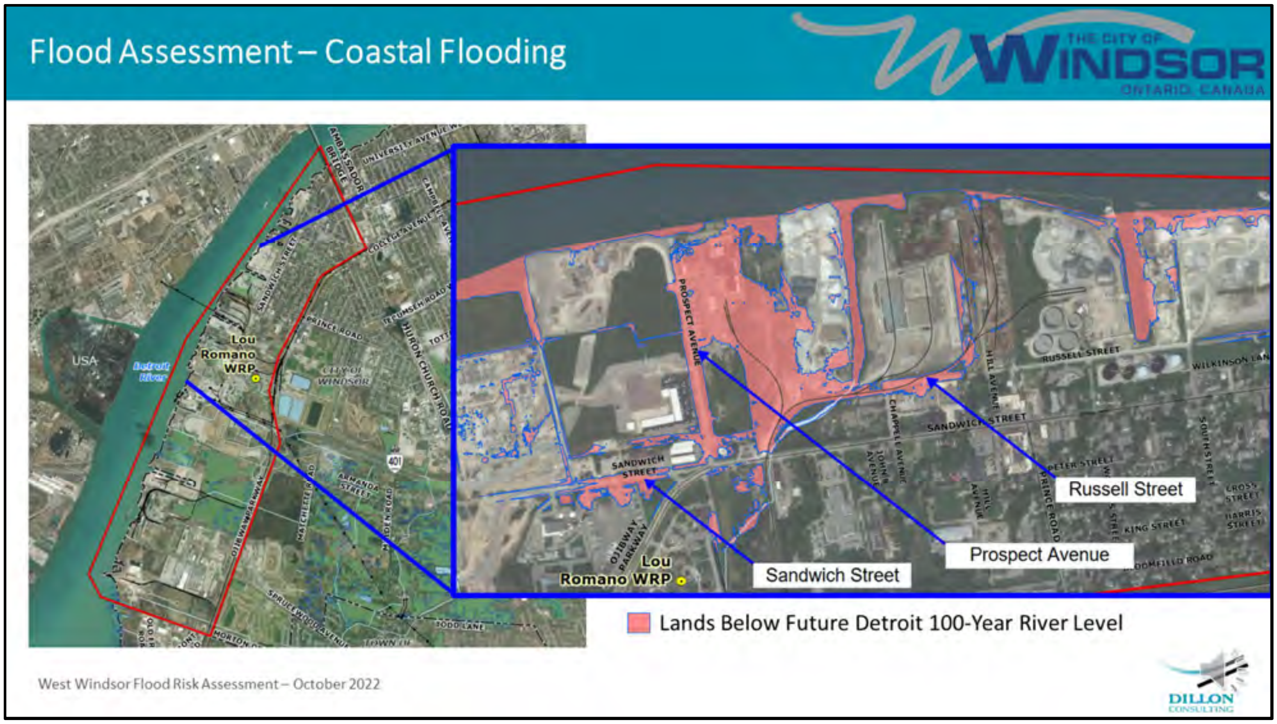
4. The final type of flooding that we identified in West Windsor is local surface flooding. This is inland flooding caused by storm events due to limited available capacity in the local storm drainage systems. Similar to basement flooding, this isn't caused directly by high river levels, but they can exacerbate it by reducing the available capacity in the storm drainage system.

Over the next few slides, we're going to take a look at where each of these types of flooding occurs in West Windsor.



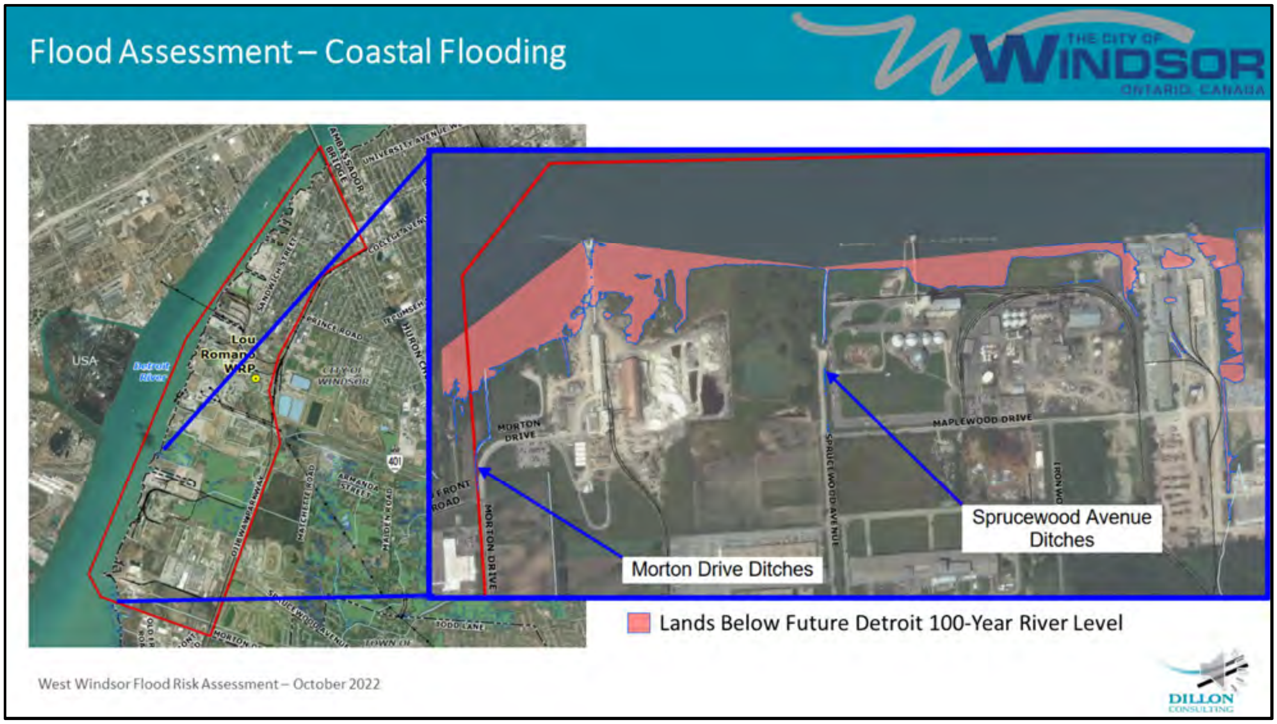
First off is coastal flooding. These are the areas shown in pink on the inset, where the ground elevation is lower than the 100 year Detroit river level.

Working our way along the shoreline from north to south, the assets that are directly affected by coastal flooding include:
McKee Park, which is important because the City of Windsor is in the process of planning park improvements;
The westernmost portion of Mill Street and HMCS Hunter; and
Portions of the Russell Street ditches.

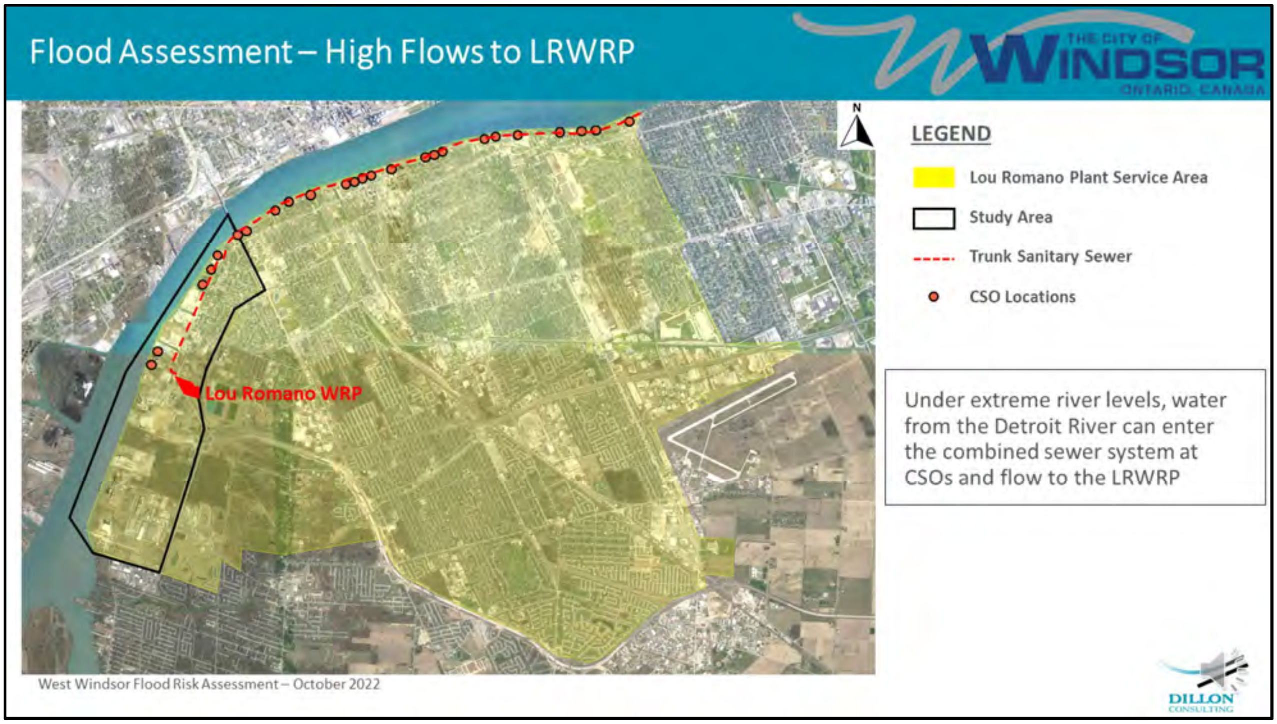


Further south, portions of Russell Street, Prospect Avenue, and Sandwich Street are all lower than the Detroit River 100-year water level. This is a problem because roadway flooding creates a hazard to traffic, it may limit access to properties, and prolonged flooding can damage the road structure. It's also important to note that the roadway flooding that we're talking about here can persist for weeks of months, depending on river levels. Creating a potentially long-term hazard.

Another asset that's expected to experience coastal flooding under high river level conditions is Black Oak Heritage Park. The available topography suggests that shoreline flooding will occur and may encroach inland.



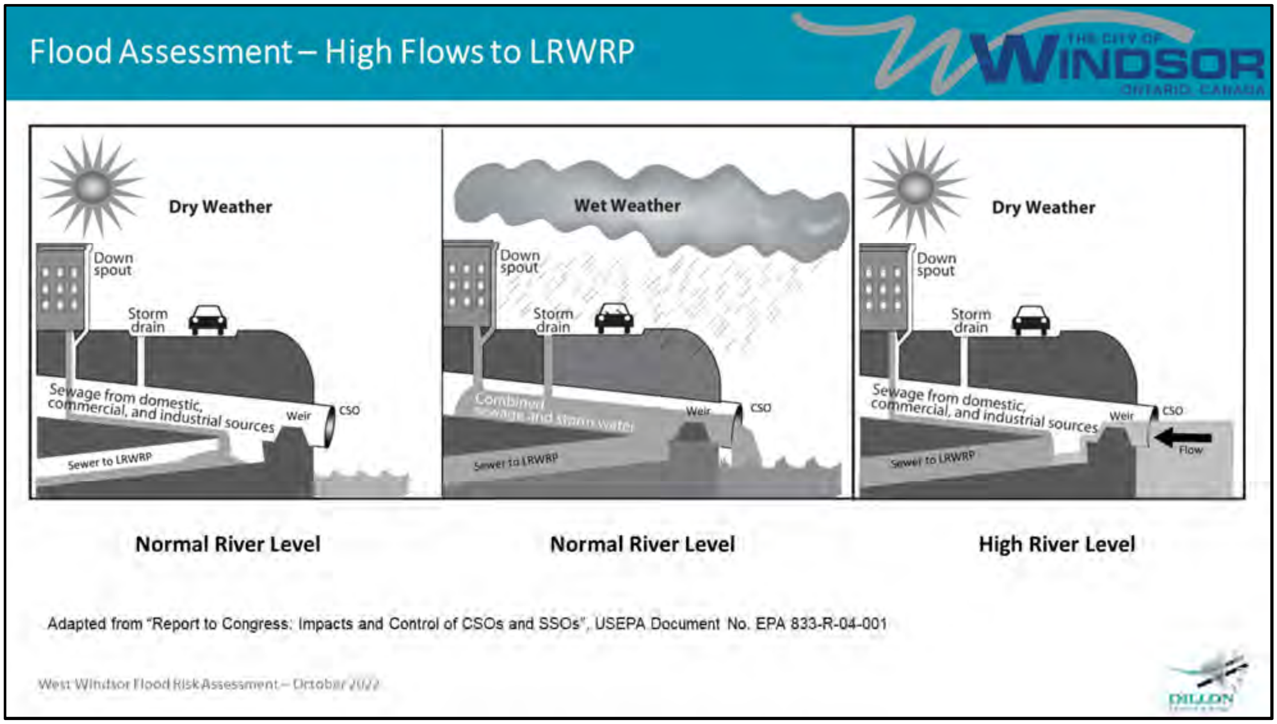
Lastly, the bottoms of the Morton Drive and Sprucewood Avenue roadside ditches are lower than the Detroit River 100-year water levels. We can expect this to reduce the available capacity of the drainage system during severe storm events.



The next impact of high river levels that we'll go over is their effect on the flows entering the Lou Romano Water Reclamation Plant. The area shown in yellow on this slide is the Lou Romano plant's service area. Wastewater from all of the homes and businesses in this area is collected by sanitary and combined sewers and sent to the treatment plant through a huge trunk sanitary sewer located parallel to the Detroit River shoreline. This trunk sewer is shown as the red dashed line on this slide.

However, when the Detroit River water levels are high, river water can enter the trunk sanitary sewer at each of the combined sewer overflows. And as you can see, there are quite a number of CSOs located both within and upstream of our study area that contribute to this problem.

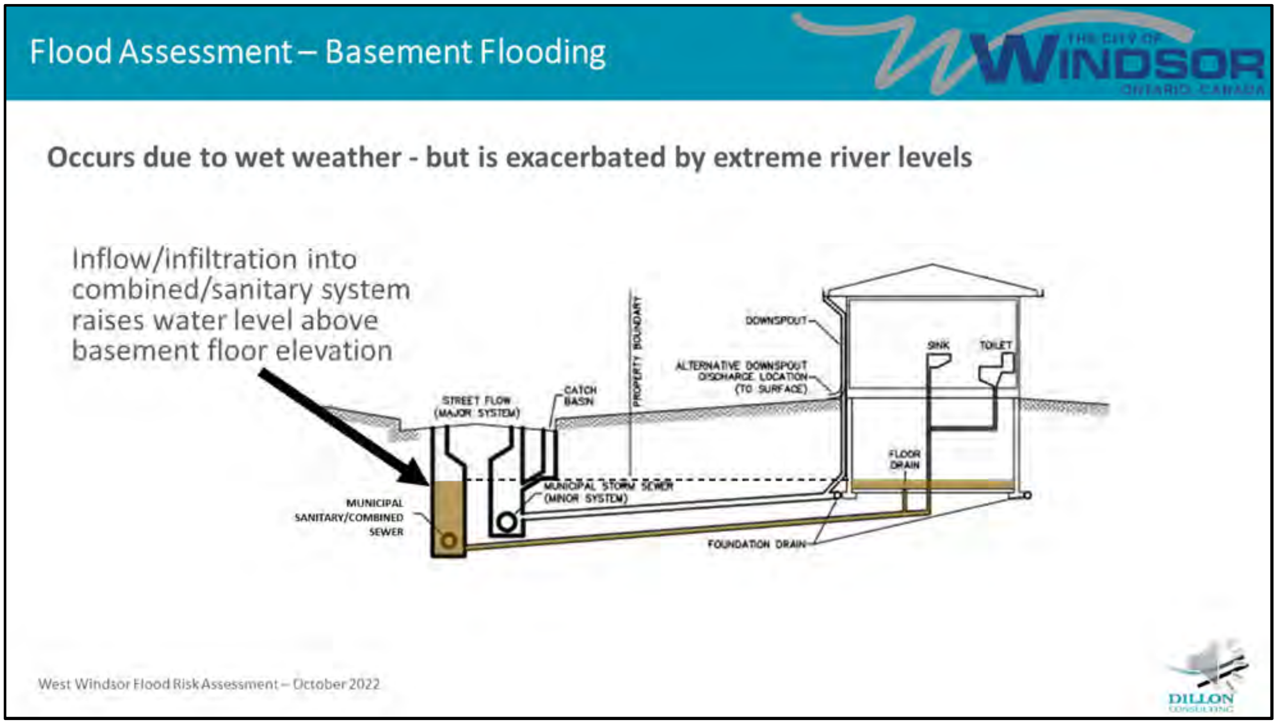
Our next slide illustrates how CSOs allow river water to enter the City of Windsor sewer system in a bit more detail.



The graphic on the left shows how CSOs operate during dry weather conditions under normal river levels. Wastewater from our upstream homes and businesses is all collected by sanitary and combined sewer systems and sent to the Lou Romano plant to be treated before flowing into the Detroit River.

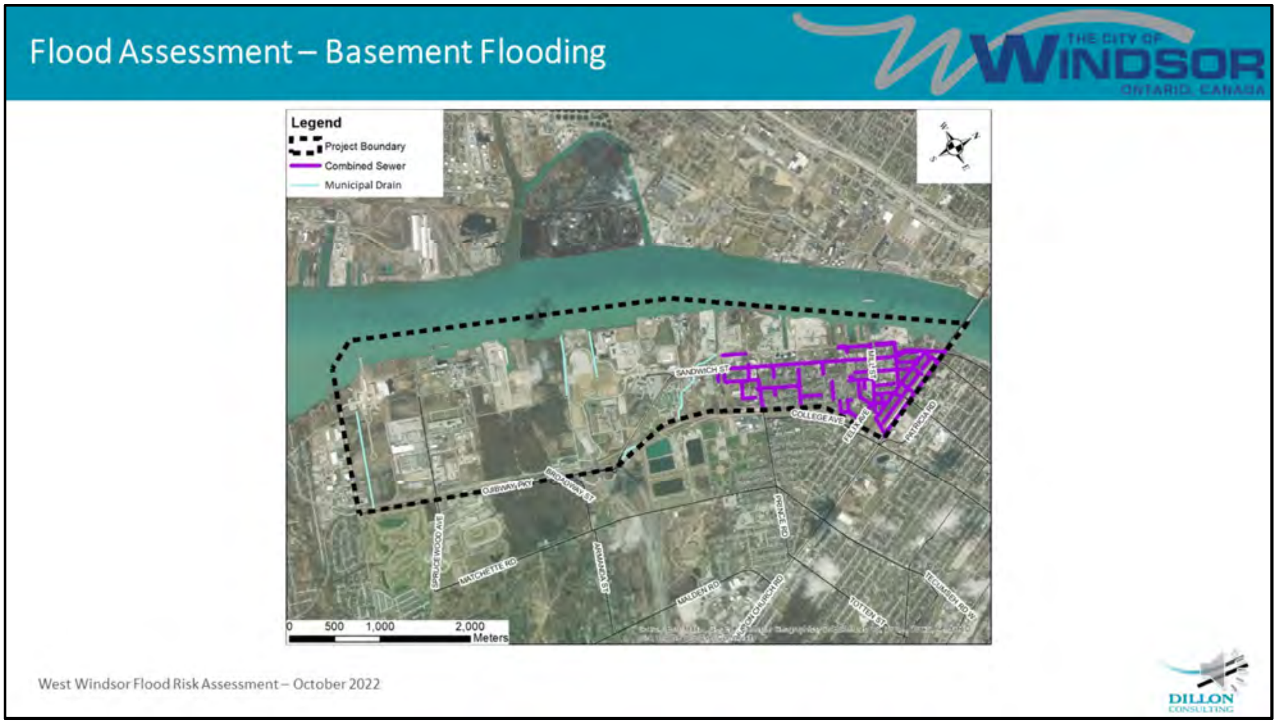
The middle graphic shows how CSOs operate during severe storm events under normal river level conditions. During these severe storms, a portion of the wastewater flows directly to the Detroit River through the CSOs. The reason why this is allowed to happen is to reduce the possibility of basement flooding and to reduce the risk of overwhelming the treatment plant. This only happens during severe storms and the City of Windsor is actively working to reduce the number of overflow occurrences through a number of ongoing projects.

These first two graphics show how CSOs operate under normal river level conditions. The graphic on the right shows us what happens when the Detroit River water levels rise above the CSOs. As you can see in this case, river water is now entering the sewer system and being sent to the Lou Romano plant for treatment.

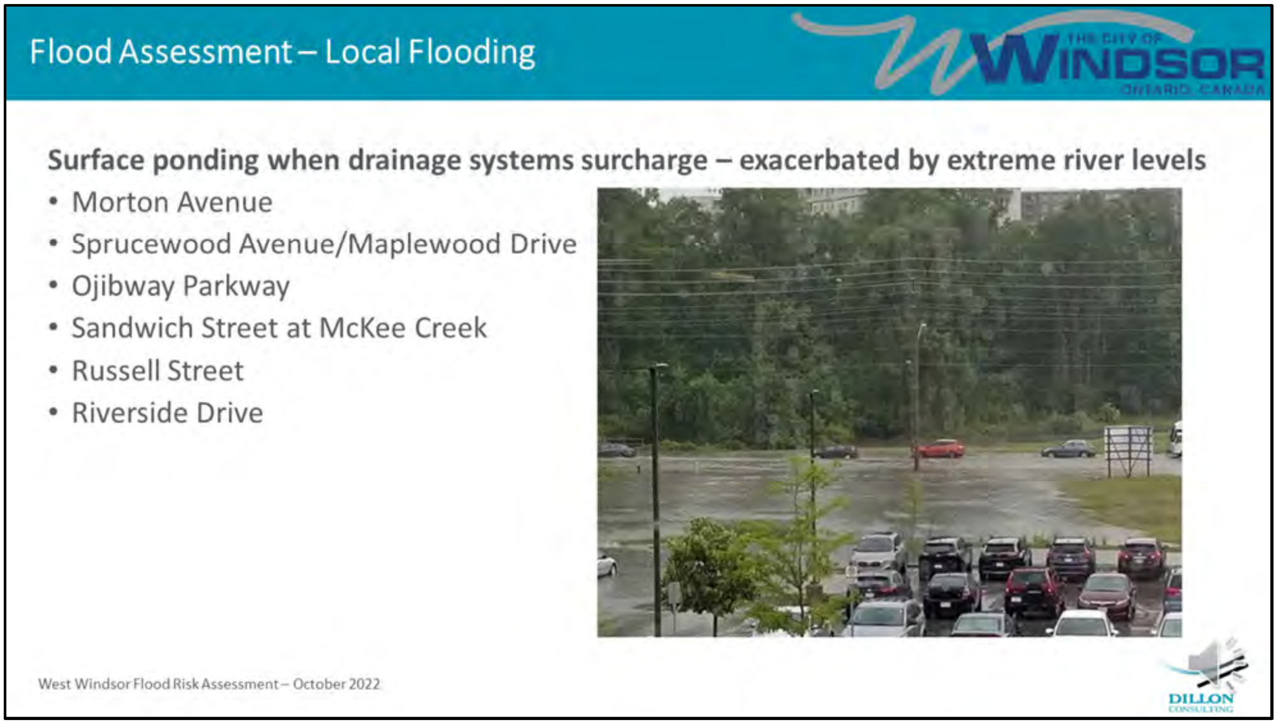


Basement flooding occurs during wet weather when the water level in the municipal sanitary or combined sewer is higher than the elevation of the basement. When we talk about wet weather, we typically mean rain storms or sudden snowmelt events. When these happen, runoff enters the wastewater system both through direct connections and through inflow and infiltration pathways such as pipe joints and maintenance hole lids.

These inflows flood the wastewater system and can back up through the floor drain and into the home. The risk of basement flooding is increased by extreme river levels because as we showed on the last slide, a portion of the capacity of the wastewater system is being used up by river water.



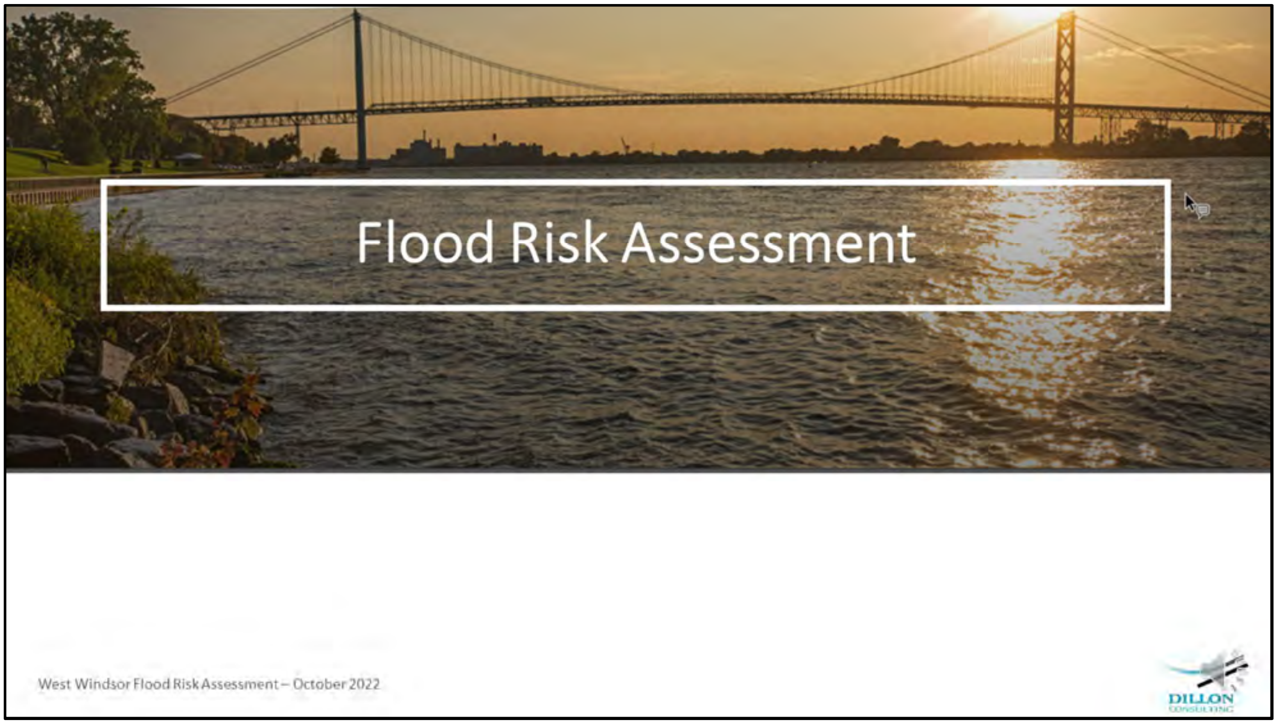
The portions of West Windsor that may be most at risk of basement flooding are the areas serviced by combined sewers, shown in purple on this slide.



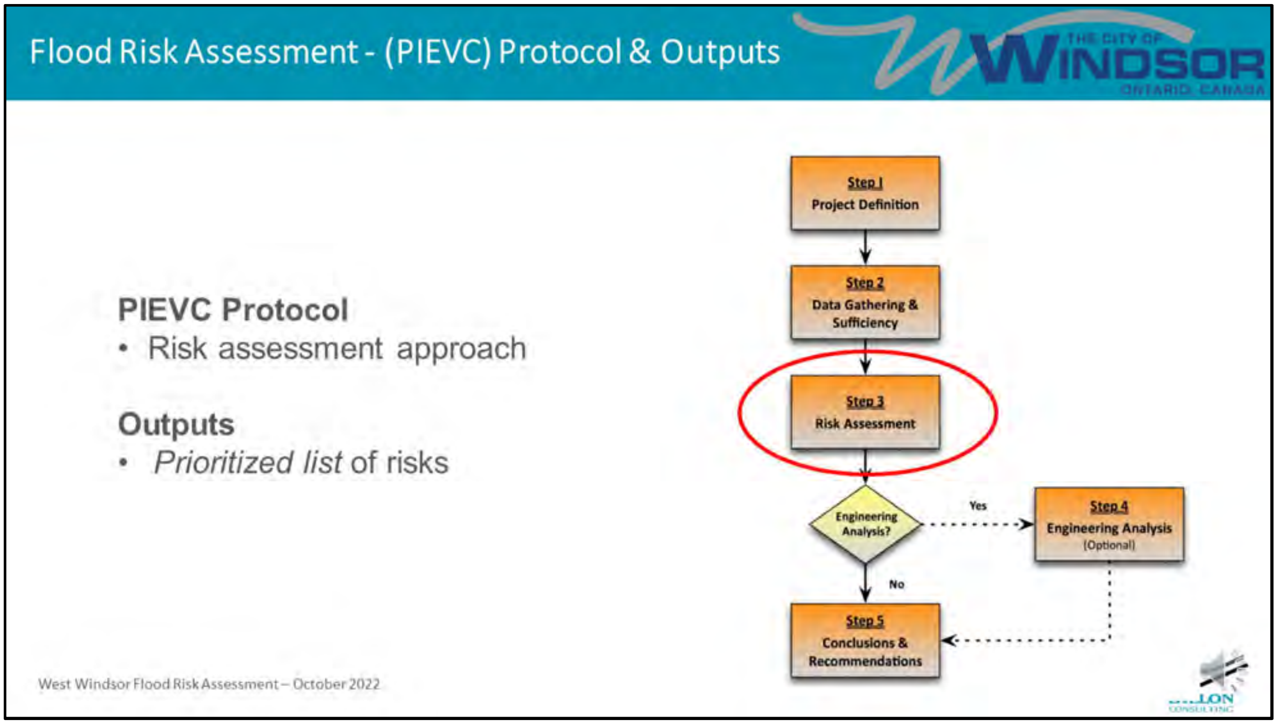
Local surface flooding occurs during storms when the local drainage system surcharges because it simply isn't big enough to handle the incoming flows. When we use the word surcharge in these cases, what we mean is the peak water level rises above the maximum design level in the drainage system. For a storm sewer, this is when maintenance holes begin to flood, and for a ditch system, this is when the water level rises above the top of bank. High river levels can exacerbate these local flooding conditions by reducing the available capacity of the local storm drainage system.

Based on our flood assessment of the West Windsor area, Morton Avenue, Sprucewood Avenue, Maple Wood Drive, Ojibway Parkway, Sandwich Street near McKee Creek, Russell Street and Riverside Drive may all experience surface ponding during wet weather events.

Now that we've talked about the impacts of high river levels in West Windsor and where they happen, in the next section of the presentation we'll talk about the severity of those impacts.



The Flood Risk Assessment was completed to develop flood risk scores for each asset affected by high Detroit River levels.



To accomplish this, the study team used the PIEVC protocol. PIEVC stands for Public Infrastructure Engineering Vulnerability Committee and the protocol was developed by Engineers Canada in partnership with Natural Resources Canada. PIEVC is a structured, rigorous quantitative process to assess the risks and vulnerabilities of infrastructure to current and future extreme weather events and climatic changes.

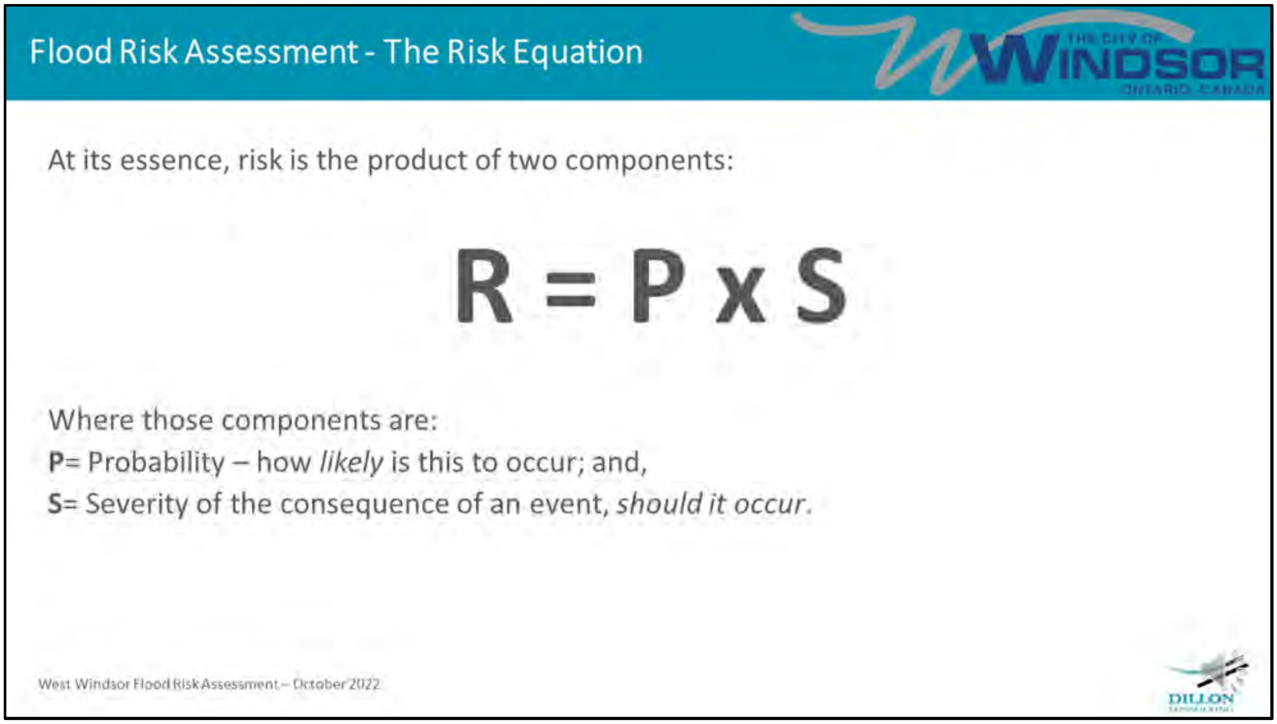
The PIEVC protocol follows the framework shown by the flow chart on this slide:

1. First a project definition is developed which requires an assessment and finalization of project parameters including the identification of infrastructure for assessment, and determination of assessment scope. We touched on these points earlier in this presentation.
2. Data is gathered which includes working with stakeholders to identify all assets that should be considered, defining climate parameters and thresholds for both existing and future conditions, and identifying where flooding occurs and the main drivers causing flooding. We discussed these items in the flood assessment portion of this presentation.
3. In Step 3, a risk assessment is completed determine what assets are impacted by flooding and assigning a risk score to each asset. We'll be talking about this over the next two slides.
4. Following the risk assessment, an engineering analysis was completed to develop and

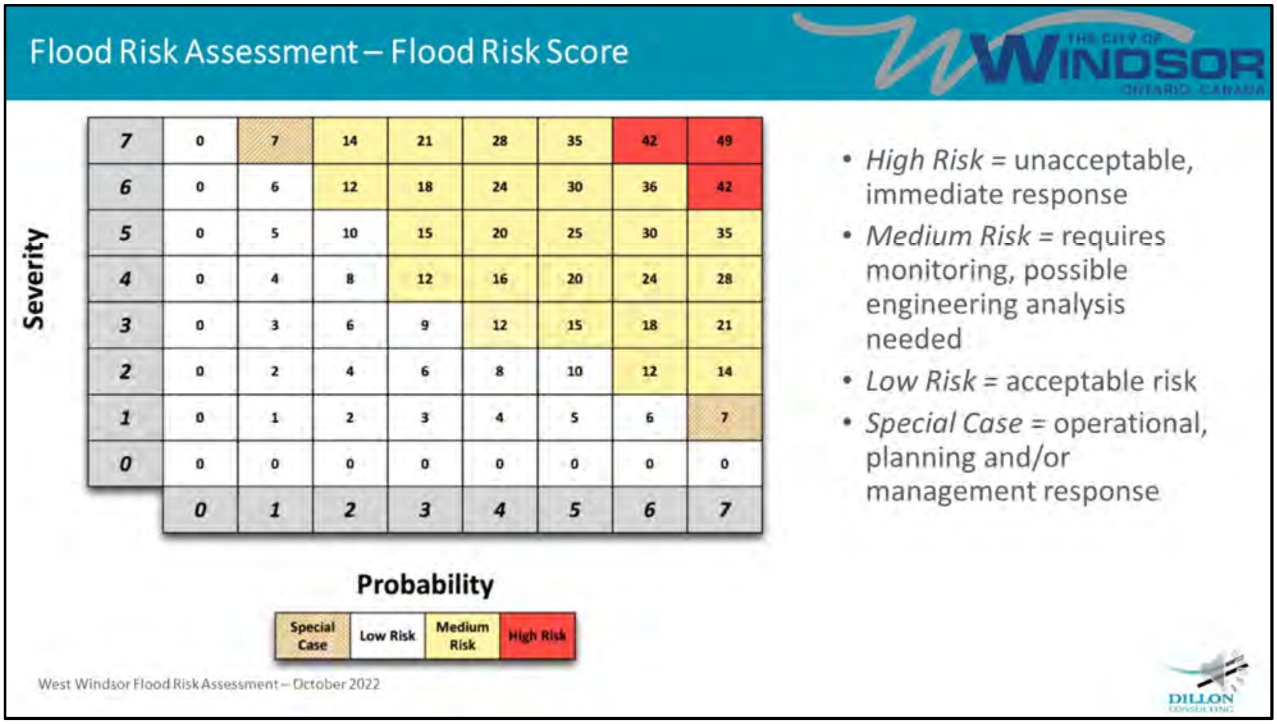
evaluate solutions. We’ll be talking about these a little bit later in this presentation.

5. And finally, Conclusions and Recommendations are developed.

Our next two slides will be focusing on Step 3.



Using the PIEVC protocol, we calculated a risk score for every asset that we identified in the West Windsor area. As this equation shows, the risk score is the product of two components. The first is the probability of flooding occurring at the asset. The second is the severity of the consequences of flooding on that asset. Those consequences may range from a minor temporary nuisance, to the need for repairs, or - most extreme – the complete loss of the asset.



Severity \ Probability	0	1	2	3	4	5	6	7
7	0	7	14	21	28	35	42	49
6	0	6	12	18	24	30	36	42
5	0	5	10	15	20	25	30	35
4	0	4	8	12	16	20	24	28
3	0	3	6	9	12	15	18	21
2	0	2	4	6	8	10	12	14
1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0

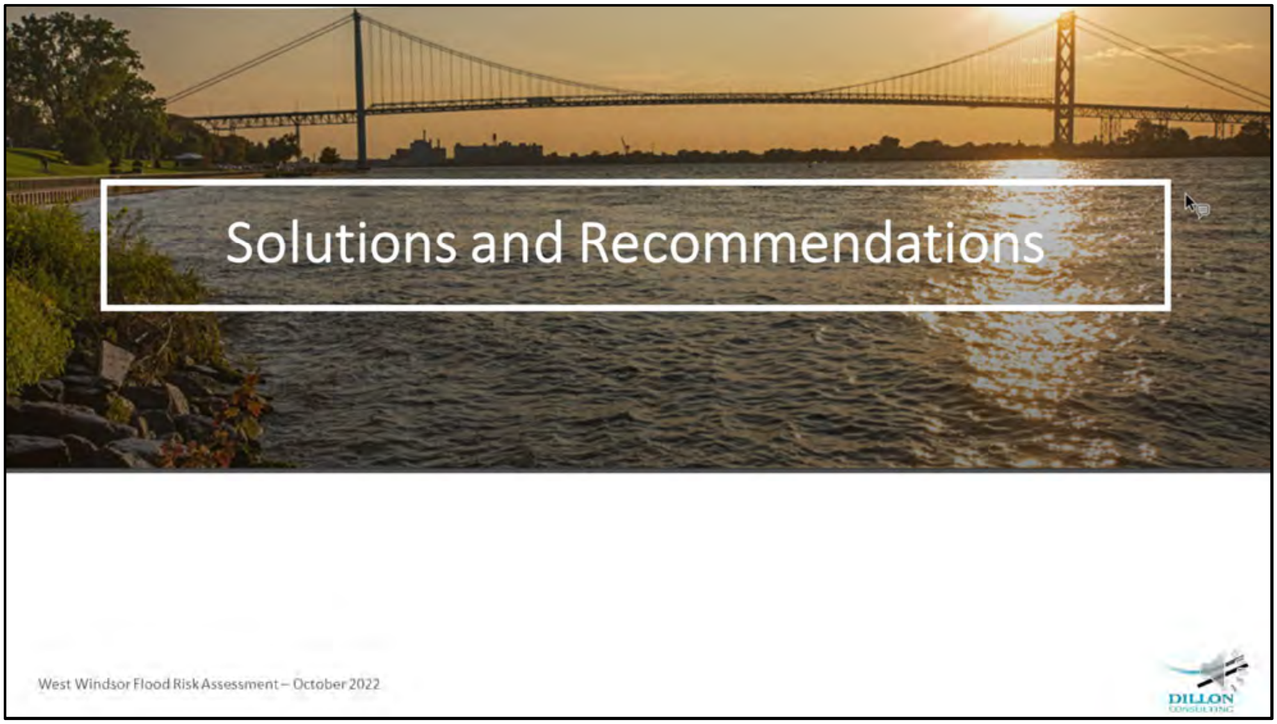
The range of resulting flood risk scores is summarized in the following table. Each asset was assigned a level of risk based on its flood risk score.

High risk scores were assigned where the consequences of flooding on an asset are unacceptable and a mitigation solution is required.

Medium Risk scores require monitoring and possible solutions.

Low Risks are acceptable.

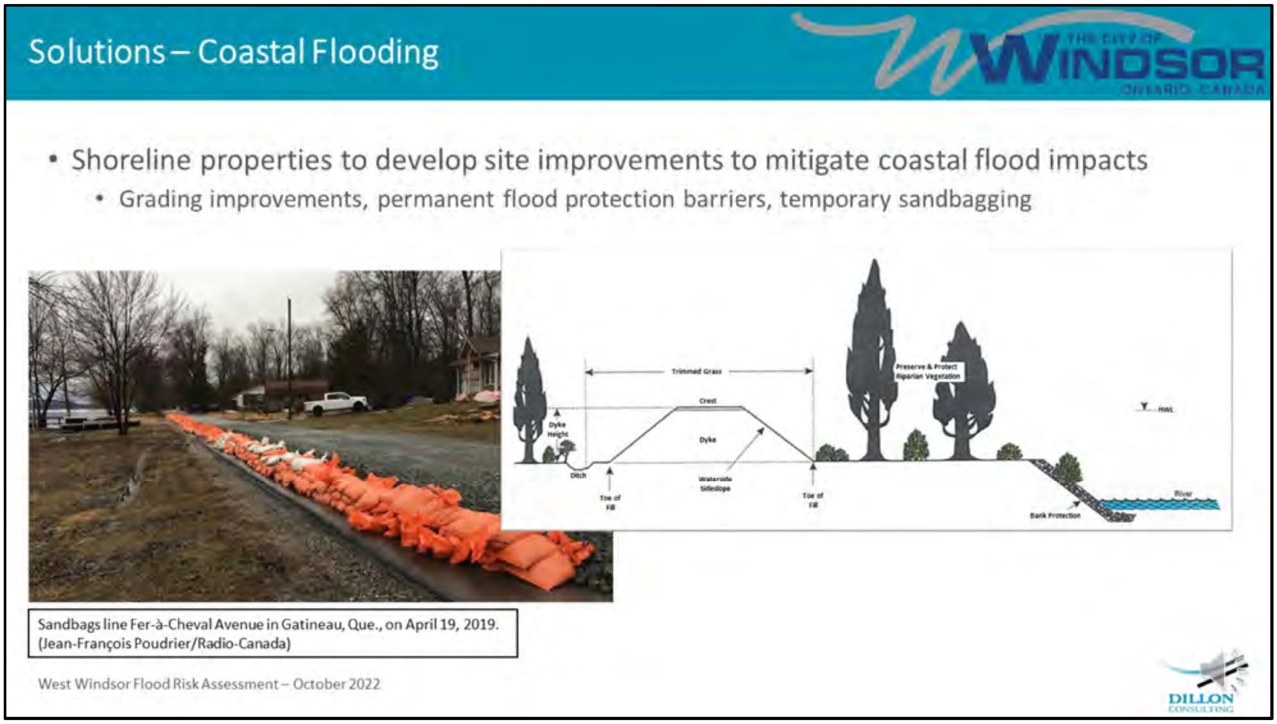
Lastly, special cases were identified where operational changes, planning considerations, or management response are required.



So, to recap what we've discussed so far:

- We've characterized the impacts of extreme river levels on West Windsor;
- We've identified which assets in West Windsor will likely be affected; and
- We've assessed the risk to each asset to help us identify where we need to develop responses.

We're now going to go over the solutions and recommendations that have been prepared to address each type of flooding that we identified earlier in the presentation.

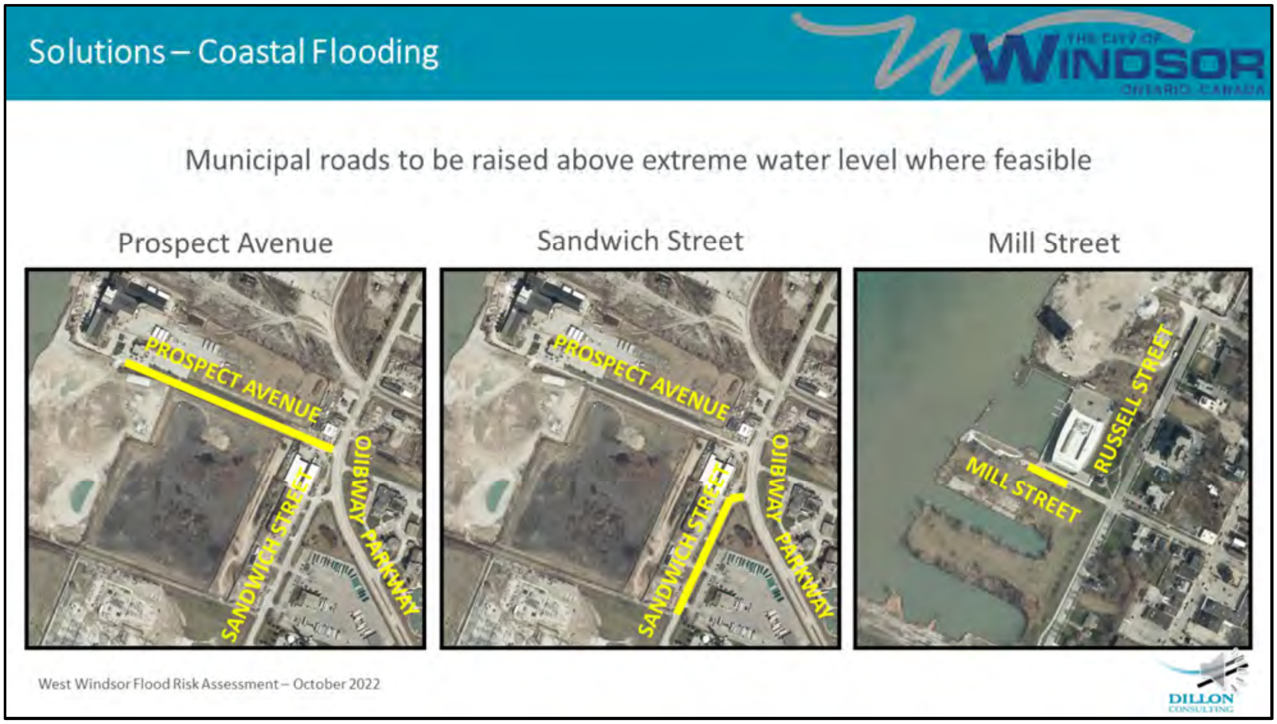


We'll begin by talking about solutions to address coastal flooding.

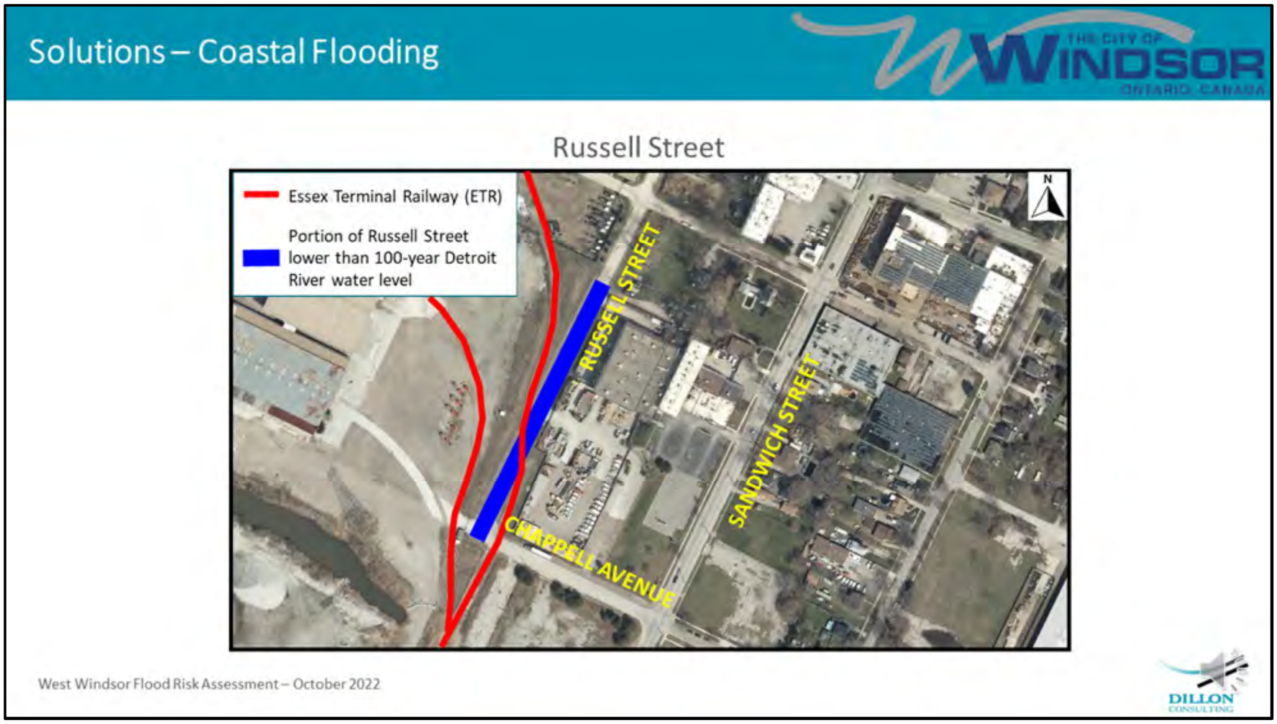
You'll remember that this is flooding of low lying shoreline properties caused directly by extreme river levels. Since these are mostly privately owned industrial lands, and since coastal flooding generally doesn't encroach inland beyond these properties, we recommend that these properties implement their own site improvements to protect themselves from coastal flooding. This will give individual shoreline property owners the flexibility to select measures that meet the specific needs of their operations.

Site owners can consider both temporary and permanent coastal flood protection measures during periods of extreme water levels.

- Temporary measures could include sandbag barriers or moving site operations to locations outside of the flooded areas;
- While permanent measures may include site grading improvements to raise critical portions of the site above the high water level, or constructing permanent flood protection barriers such as berms.



The other assets affected by coastal flooding are municipal roads. Portions of Prospect Avenue, Sandwich Street, and Mill Street are lower than the 100-year Detroit river water level. Where feasible, the profiles of Prospect Avenue, the portion of Sandwich Street immediately south of Ojibway Parkway, and the west limit of Mill Street will be raised to mitigate flooding during periods of high river levels.

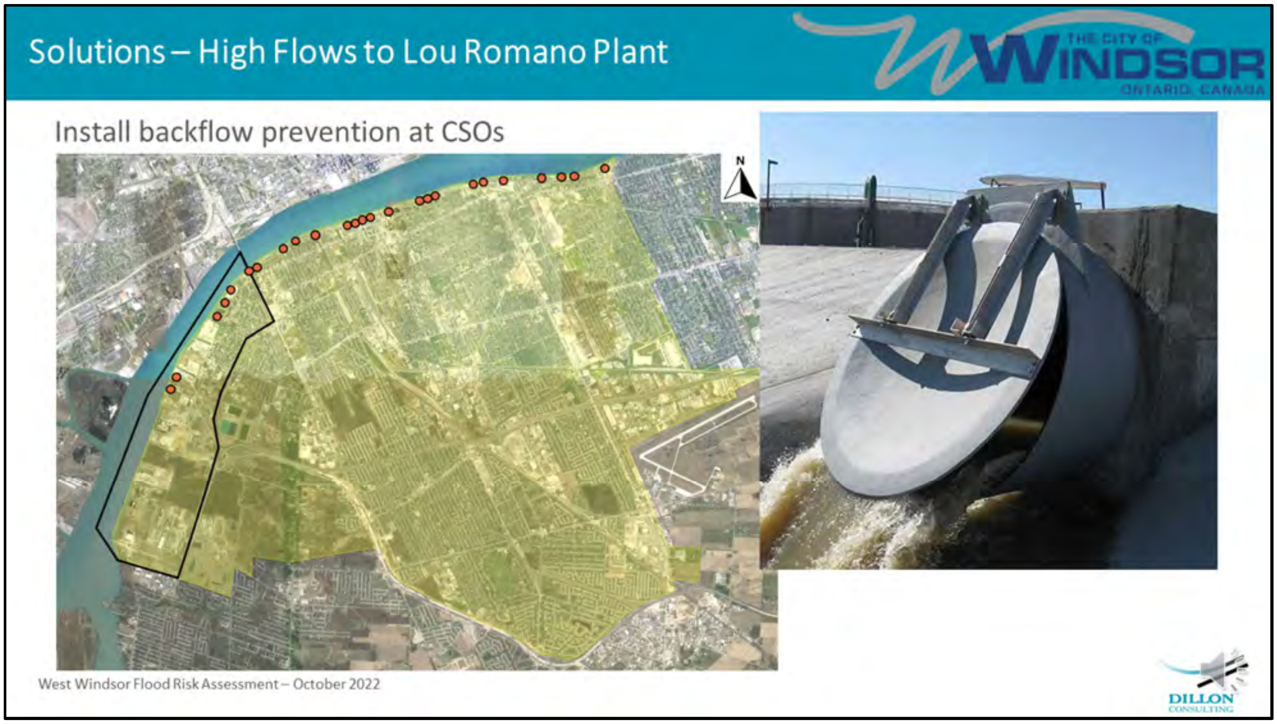


The southernmost portion of Russell Street near its intersection with Chappell Street is also lower than the Detroit River 100-year water level. However, in this case, simply raising the Chappell Street road profile isn't feasible because the Essex Terminal Railroad crosses the right-of-way at two locations. Any changes to the road profile would also require changes to the railway line and would have significant impacts on neighboring properties.

In this case, an adaptive solution is proposed. This portion of Russell Street serves to provide local property access and is not an arterial road. If this area becomes flooded, there are alternate routes for through traffic. Furthermore, the estimated flood depths are not sufficient to prevent traffic access to the fronting properties.

For this area, a flood response plan should be developed to:

- Warn of the flood hazard;
- Block through traffic; and
- Confirm that property access is maintained.



Our next set of solutions addresses the additional flows to the Lou Romano Water Reclamation Plant.

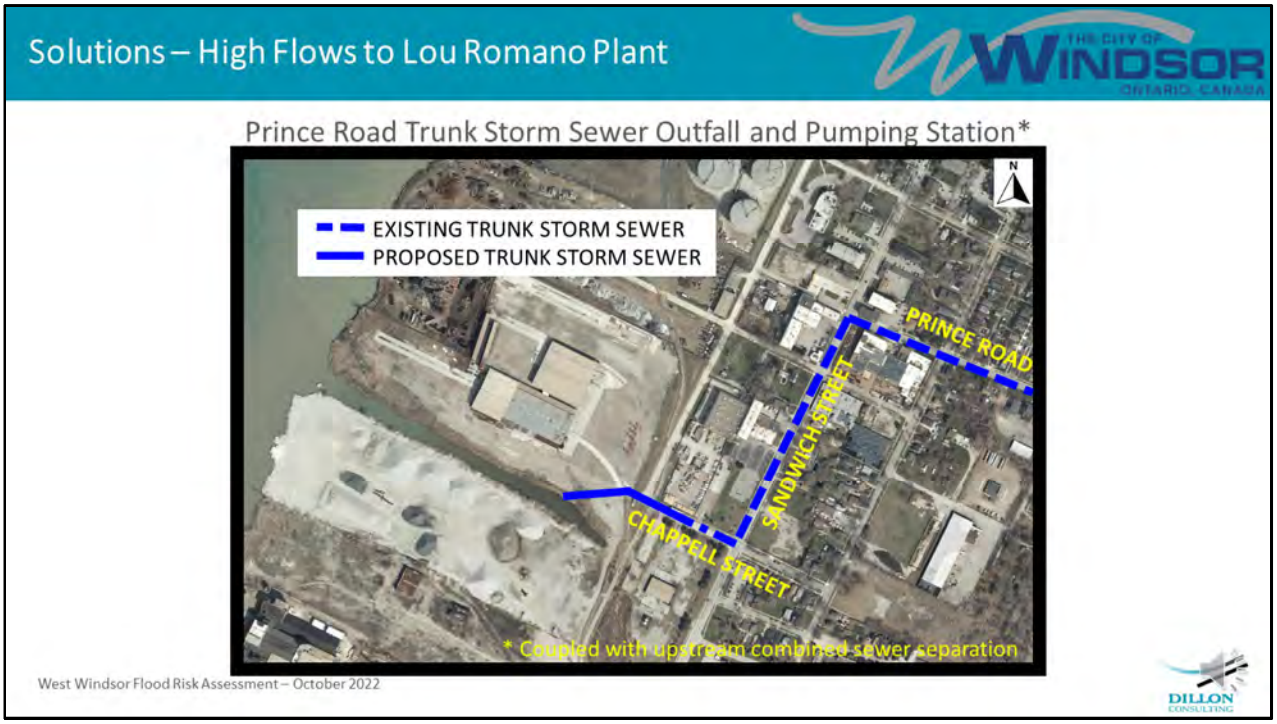
The first component of the recommended solution is to install backflow prevention at all CSOs that are below the projected Detroit River 100-year water level. This includes the CSOs located in the West Windsor area, as well as those located upstream.

Backflow preventers are devices that allow water to flow in only one direction – examples include flap gates such as the one shown in the image on the righthand side of this slide, check valves, and weirs. Whatever devices are chosen, they will be oriented to prevent Detroit River water from entering the combined storm sewer, while allowing overflows to enter the Detroit River during periods of severe rainfall, thereby protecting upstream homes and businesses from basement flooding.

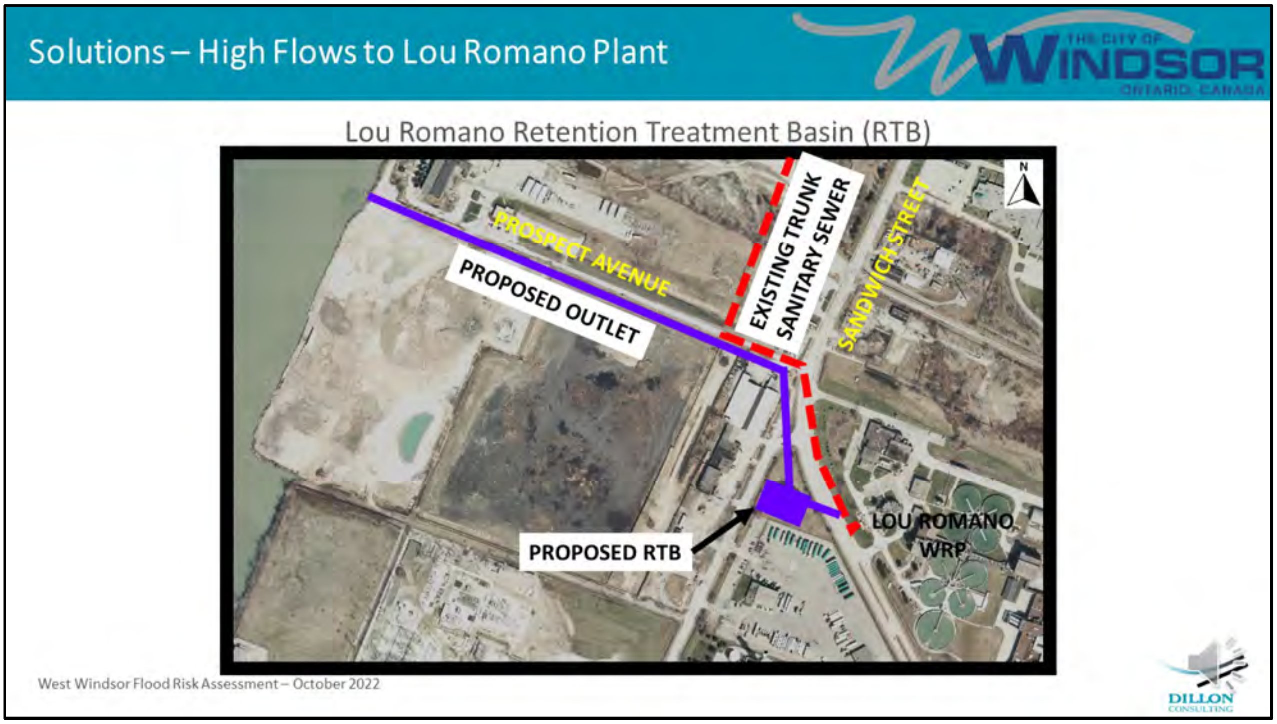
Backflow preventers can be implemented in the near term but there are other solutions located in the West Windsor area that have been recommended through previous studies that will also help to reduce the flows to the Lou Romano plant. I'll be covering those in the next four slides.

The City of Windsor Sewer and Coastal Flood Protection Master Plan completed in 2020 identified the need to separate the combined sewers, which means replacing the existing combined sewers with separate storm and sanitary systems.

One of the projects recommended in the Master Plan to support this goal is the construction of a new trunk storm sewer and outfall from Detroit Street in the northern portion of the West Windsor study area. This new outfall will provide a stormwater outlet to allow upstream combined sewer separation to proceed, and direct stormwater that would otherwise go to the Lou Romano plant to the Detroit River.

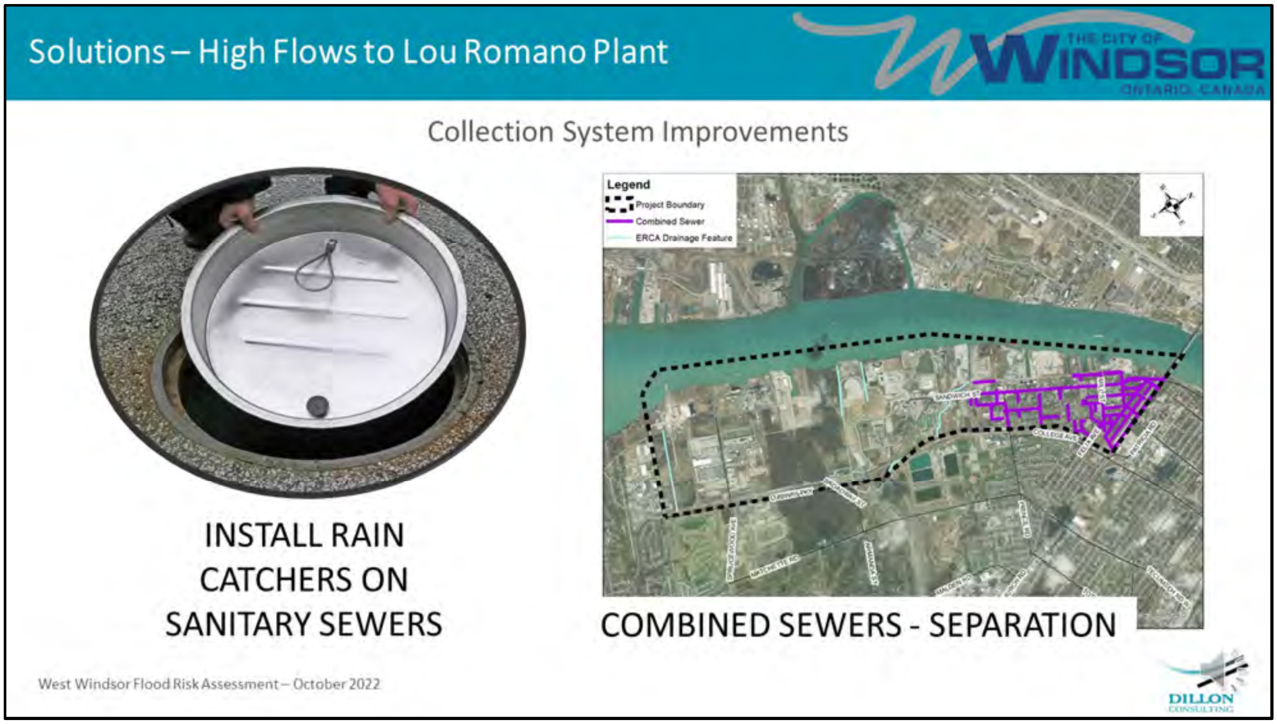


Another proposed storm sewer outfall recommended through the Sewer and Coastal Flood Protection Master Plan is the Prince Road Trunk Storm Sewer Outfall and Pumping Station. Similar to the proposed Detroit Street Outfall, the project will direct stormwater away from the flows entering the Lou Romano plant. The City of Windsor is in the process of completing an Environmental Assessment to establish the location of the proposed outfall works. That process is expected to be completed in 2022.



In 2019, the City of Windsor completed an environmental assessment for a proposed retention treatment basin, or RTB, at the Lou Romano Treatment Plant. The RTB will provide primary treatment of wastewater during wet weather events when the flows to the plant are greater than the plant capacity. Wet weather flows include both wastewater from our homes and businesses, and storm runoff that enters the sewer network either intentionally through combined systems or unintentionally through inflow and infiltration sources. Additionally, the RTB will provide primary treatment of wastewater in an emergency situation, such as a catastrophic failure at the plant.

Construction for the Lou Romano RTB is expected to begin in 2023.

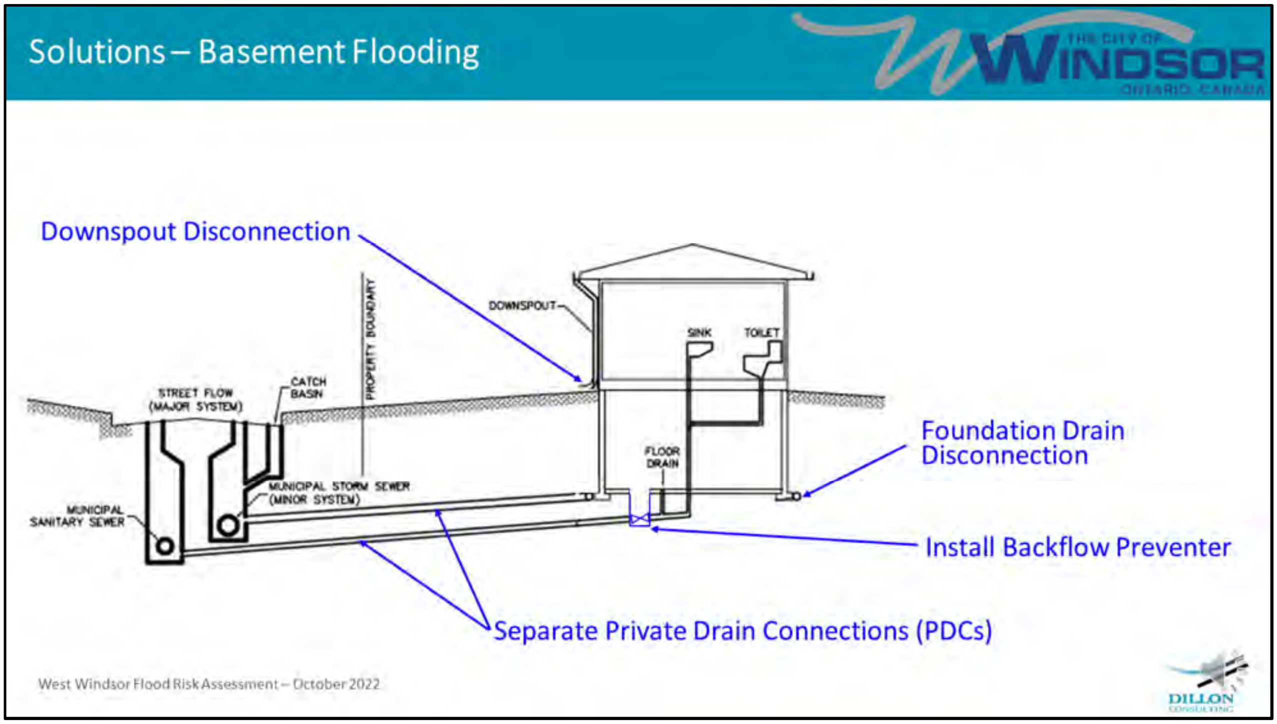


The final solutions to reduce wet weather flows to the Lou Romano treatment plant involve improvements to the upstream wastewater collection system.

During wet weather events, rainwater can enter the sanitary sewer through pick holes and ill-fitting maintenance hole covers. Flow through a pick hole alone can be on the order of 3 L/s. While this may not sound like much, when you consider the hundreds of sanitary maintenance holes in West Windsor, it adds up to a significant volume during a single storm event.

Rain catchers, which are essentially removable pans that fit directly beneath the maintenance hole lid are recommended at all locations where surface ponding is expected to occur. These are an easily implemented way of reducing flows to the Lou Romano plant.

The other collection system improvement that will reduce flows to the Lou Romano plant is combined sewer separation. The City of Windsor has a number of ongoing projects to eliminate stormwater flows to its combined sewers. However, given the many kilometers of existing combined sewers it will take many years to separate all of these systems.



Each of the solutions that we've discussed so far that reduce the flows entering the sanitary and combined sewer systems will also help to reduce basement flooding. However, these programs will take time to implement.

Homeowners also have a role to play in protecting their residences from basement flooding. These solutions can be implemented readily and provide immediate protection to individual properties while programs to improve the municipal drainage systems are implemented. Examples of home improvements that can provide flood mitigation include:

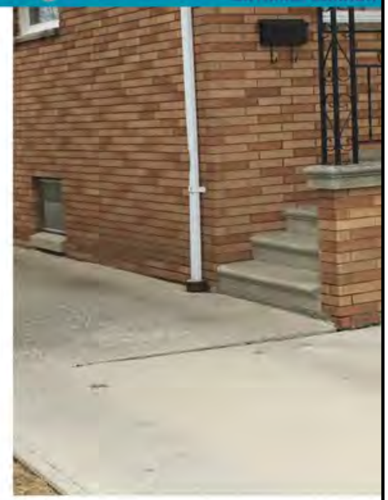
- Disconnecting downspouts from foundation drains and directing them instead to the ground surface;
- Disconnecting foundation drains from the private drain connection and directing them instead to a sump pump;
- Installing a backflow preventer to prevent wastewater backups into the come; and
- Providing separate private drain connections, one for sanitary flows and one for storm flows.

Solutions – Basement Flooding

City of Windsor Downspout Disconnection Program

- No cost to property owner
- Windsor residents can call 311 or 519-255-2489

https://www.citywindsor.ca/residents/maintenanceandfieldservices/sewers-/pages/downspout-disconnection.aspx



City of Windsor Basement Flood Protection Subsidy Program

- Eligible items:
  - Install backwater valve
  - Install sump pump (not replacement sump pump)
  - Disconnect foundation drains
- Maximum of $2,800 per property

https://www.citywindsor.ca/residents/maintenanceandfieldservices/Sewers-/Documents/2020-BFPSP-Information%20Package.pdf

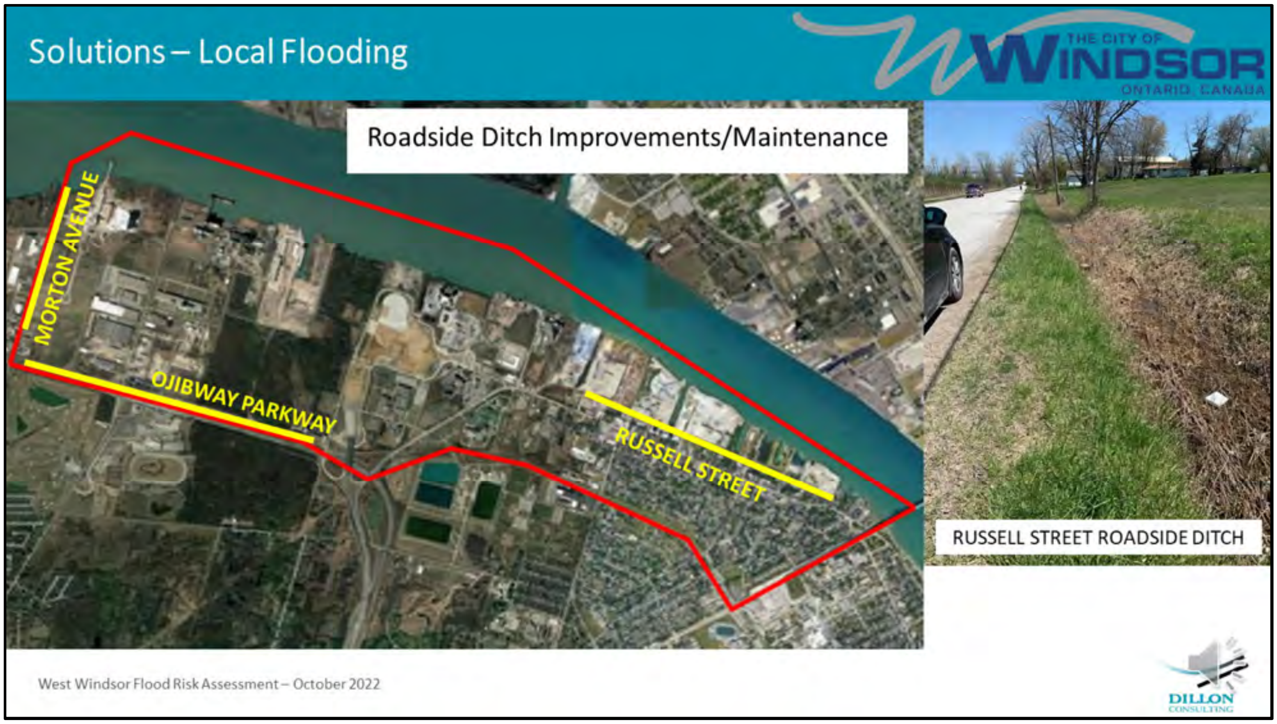
West Windsor Flood Risk Assessment – October 2022

The City of Windsor currently has two programs to help homeowners protect their homes from basement flooding.

The Downspout Disconnection Program provides free assistance to help property owners safely redirect the flows from their eaves troughs to the ground surface.

The Basement Flood Protection Subsidy Program provides homeowners with up to $2,800 per property towards the costs of installing eligible flood protection measures such as backflow preventers, new sump pump installations, and foundation drain disconnections.

More information on both of these programs can be found on the City of Windsor at the links provided here, or by telephoning the City of Windsor.

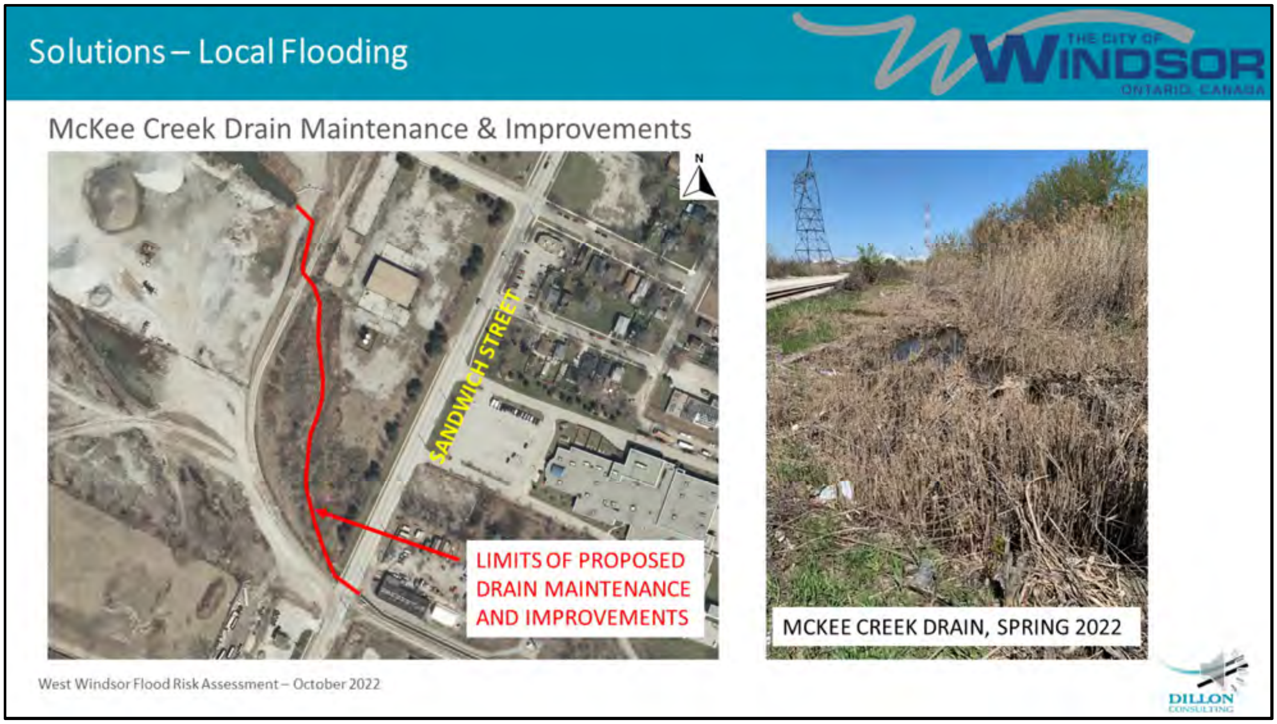


To address local flooding, improvements and maintenance to roadside ditches are recommended on:

- Morton Avenue;
- Ojibway Parkway; and
- Russell Street.

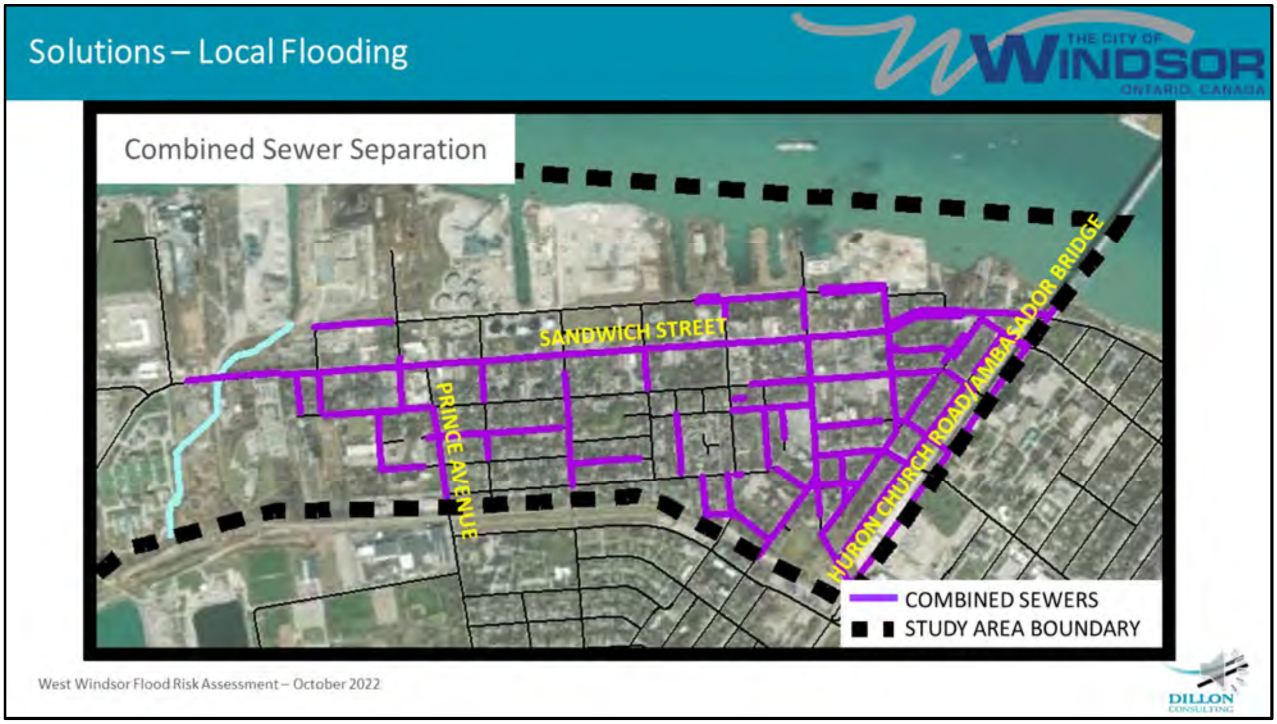
This work will likely involve vegetation removal, minor regrading, and could also include ditch widening at some locations.

Similar improvements are recommended to the roadside ditches on Maplewood Drive and Sprucewood Avenue. Since there is some information to suggest that these ditches may be part of a municipal drain system, any improvements or maintenance will need to be completed in accordance with the Drainage Act.



Another area where this a significant risk of local flooding is McKee Creek, which is a municipal drain. Similar to the recommendations for the roadside ditches that we discussed on the previous slide, the proposed solution for McKee Creek is to perform drain maintenance and assess the need for drain improvements.

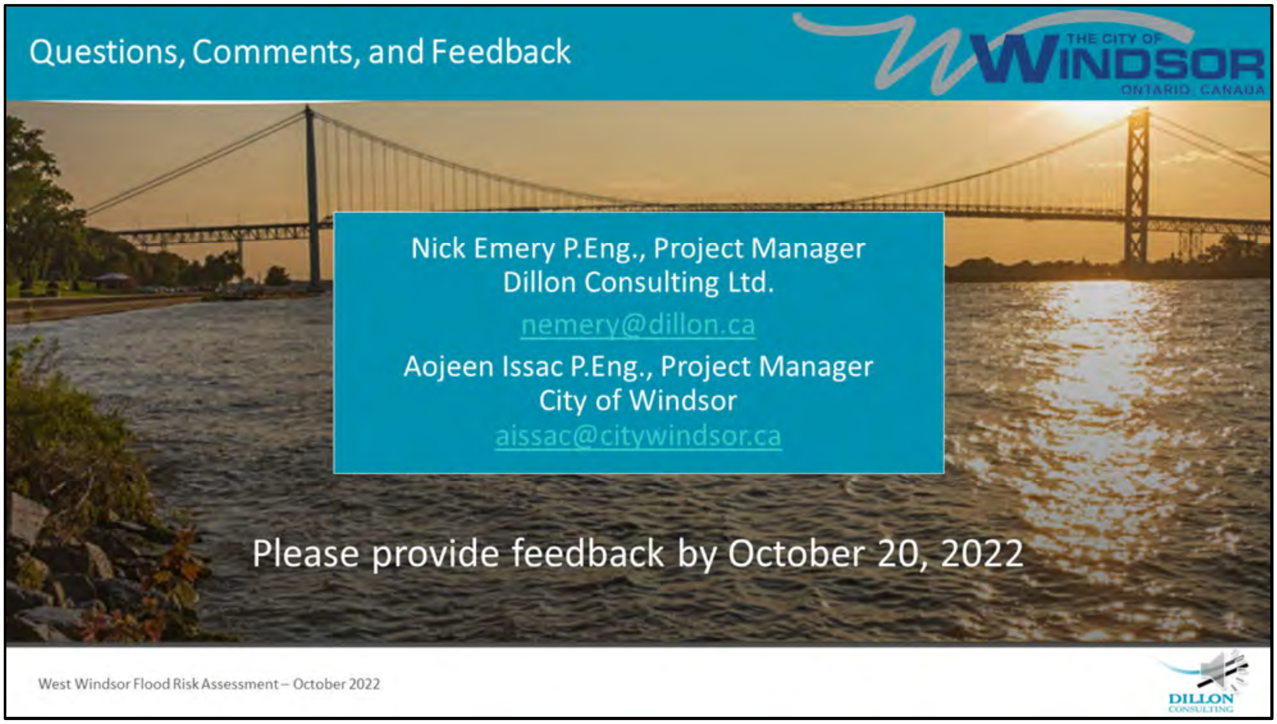
Since McKee Creek is a municipal drain, all of these works will need to be completed in accordance with the Drainage Act. Drain maintenance is recommended in the short term to improve the existing drain capacity. This includes removing vegetation and accumulated sediment from the channel. Over the long term, the need for drain improvements should be assessed. Drain improvements may include widening the channel and replacing existing culvert crossings.



As we've already mentioned, combined sewer separation has a significant role to play to address flooding in West Windsor. By providing storm sewers in areas currently serviced by combined systems, the depth and frequency of roadway ponding during severe storm events will be reduced.

I'd just like to remind you that this is a long-term solution that will take time to implement in West Windsor.

The final solution to address local flooding is private site improvements. These are measures that property owners can implement to reduce the risk of surface flooding. Typically this involves modifying the site grading to direct water away from homes and businesses and reduce maximum ponding depths.



This brings us to the end of our virtual Public Information Centre for the West Windsor Flood Assessment Study. The next step in the project is for the study team to prepare its final report to document the study findings and recommendations. If you have any questions, comments, or feedback on the information provided in this presentation or the project in general, please feel free to contact the project managers at the email addresses shown on this slide. Thank you very much for taking the time to listen to this presentation.

West Windsor Flood Risk Study - Stakeholder List

Date Added	Organization	Title	First Name2	Last Name	Email 1	Phone Number	Address 1	City	Provinc	Postal Code
Mayor, Council, and Municipal Staff - Windsor										
08/05/2021	City of Windsor	Mayor	Drew	Dilkens	mayorsoffice@citywindsor.ca	519-255-7796	350 City Hall Square West	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Ward 1 Councillor	Fred	Francis	ffrancis@citywindsor.ca	519-250-4607	350 City Hall Square West, Suite 220	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Ward 2 Councillor	Fabio	Costante	fcostante@citywindsor.ca	519-252-1005	350 City Hall Square West, Suite 220	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Senior Economic Development Officer	Milan	Vujanovic	mvujanovic@citywindsor.ca	519-255-6100 x6608	350 City Hall Square West	Windsor	ON	N9A 6S1
09/20/2021	City of Windsor	Commissioner of Infrastructure Services	Chris	Nepszy	cnepszy@citywindsor.ca	(519) 255-6247x6356 / mobile: (519) 791-5564	1266 McDougall Ave	Windsor	ON	N8X 3M7
08/05/2021	City of Windsor	Senior Manager, Infrastructure & Transportation	France	Isabelle-Tunks	ftunks@citywindsor.ca	519-255-6100 ext 6402	350 City Hall Square West, Room 302	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Manager, Design and Development	Fahd	Mikhael	fmikhael@citywindsor.ca		350 City Hall Square West	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Deputy City Solicitor	Wira	Vendrasco	wvendrasco@citywindsor.ca		350 City Hall Square West	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Manager, Real Estate Services	Frank	Scarfone	fscarfone@citywindsor.ca		350 City Hall Square West	Windsor	ON	N9A 6S1
08/05/2021	City of Windsor	Supervisor, Environmental Sustainabilty and Climate C	Karina	Richters	krichters@citywindsor.ca		350 City Hall Square West	Windsor	ON	N9A 6S1
09/20/2021	City of Windsor	Manager of Parks Development	Wadah	Al-Yassiri	walyassiri@citywindsor.ca	519-253-2300 ext 2740	2450 McDougall Street	Windsor	ON	N8X 3N6
08/05/2021	City of Windsor	Manager of Contracts, Field Services & Maintenance	Phong	Nguy	pnguy@citywindsor.ca	519-255-6560 ext 4253	1266 McDougall Avenue	Windsor	ON	N8X 3M7
08/05/2021	City of Windsor		Stephen	Habrun	shabrun@citywindsor.ca	519-944-4111	3700 North Service Road East	Windsor	ON	N8W 5X2
08/05/2021	City of Windsor	City Planner/Executive Director	Thom	Hunt	thunt@citywindsor.ca	519-255-6543	350 City Hall Square West	Windsor	ON	N9A 6S1
09/20/2021	City of Windsor	Engineer II	Aojeen	Issac	alssac@citywindsor.ca	519-255-6257 ext 6368	351 City Hall Square West	Windsor	ON	N9A 6S2
05/10/2022	City of Windsor	Manager of Process Engineering & Maintenance	Ed	Valdez	evaldez@citywindsor.ca	(519) 253-7111 ext. 3366	4155 Ojibway Parkway	Windsor	ON	N9C 4A5
05/10/2022	City of Windsor	Plant Manager	Kevin	Cabana	kcabana@citywindsor.ca	(519) 253-7111 ext. 3383	4156 Ojibway Parkway	Windsor	ON	N9C 4A6
05/10/2022	City of Windsor	Maintenance Coordinator	Roberta	Harrison	roharrison@citywindsor.ca					
05/10/2022	City of Windsor	Manager Parks Development	Wadah	Al-Yassiri	walyassiri@citywindsor.ca	(519) 255-6100 ext. 6494	350 City Hall Square West	Windsor	ON	N9A 6S1
06/10/2022	City of Windsor	Engineer II	Ian	Wilson	IWilson@citywindsor.ca					
06/10/2022	City of Windsor	Water & Wastewater Engineer	Ryan	Langlois	RLanglois@citywindsor.ca					
06/10/2022	City of Windsor	Manager, Development	Stacey	McGuire	smcguire@citywindsor.ca					
09/20/2021	City of Windsor	Senior Manager of Pollution Control	Jake	Renaud	jrenaud@citywindsor.ca	519-253-7111 ext 3229	4155 Ojibway Parkway	Windsor	ON	N9C 4A4
Municipal Staff - Town of Tecumseh										
06/10/2022	Town of Tecumseh	Deputy Clerk & Manager Legislative Services	Jennifer	Alexander	jalexander@tecumseh.ca	519-735-2184 ext 139	917 Lesperance Road	Tecumseh	ON	N8N 1W9
08/05/2021	Town of Tecumseh	Drainage Superintendent/ Engineering Technologist	Sam	Paglia	spaglia@tecumseh.ca	519-735-2184 ext 105	917 Lesperance Road	Tecumseh	ON	N8N 1W9
08/05/2021	Town of Tecumseh	Director Planning & Building Services	Brian	Hillman	bhillman@tecumseh.ca	519-735-2184 ext 131	917 Lesperance Road	Tecumseh	ON	N8N 1W9
08/05/2021	Town of Tecumseh	Manager Engineering	John	Henderson	jhenderson@tecumseh.ca	519-735-2184 ext 166	917 Lesperance Road	Tecumseh	ON	N8N 1W9
	Town of Tecumseh	Director Public Works & Environmental Services	Phil	Bartnik	pbartnik@tecumseh.ca	519-735-2184 ext 148	917 Lesperance Road	Tecumseh	ON	N8N 1W9
Municipal Staff - Town of LaSalle										
09/20/2021	Town of LaSalle	Director of Council Services/Clerk	Jennifer	Astrologo		519-969-7770 ext 1223	5950 Malden Road	LaSalle	ON	N9H 1S4
08/05/2021	Town of LaSalle	Manager of Engineering	Jonathan	Osborne	josborne@lasalle.ca	519-969-7770 ext 1255	5950 Malden Road	LaSalle	ON	N9H 1S4
08/05/2021	Town of LaSalle	Director of Public Works	Peter	Marra	pmarra@lasalle.ca	519-969-7770 ext 1475	5950 Malden Road	LaSalle	ON	N9H 1S4
08/05/2021	Town of LaSalle	Chief Administrative Officer	Joe	Milicia		519-969-7770 ext 1224	5950 Malden Road	LaSalle	ON	N9H 1S4
Provincial Agencies										
08/05/2021	Indigineous Relations and Reconciliation	(Acting) Manager, Ministry Partnerships Unit	Rachel	Manson-Smith	MAA.EA.Review@ontario.ca	416-325-7032	160 Bloor Street East, 9th Floor	Toronto	ON	M7A 2E6
08/05/2021	Ministry of the Environment, Conservation and Parks	Supervisor	Crystal	Lafrance	crystal.lafrance@ontario.ca	226-919-7304	733 Exeter Rd	London	ON	N6E 1L3
08/05/2021	Ministry of Natural Resources and Forestry	District Planner	Karina	Cerniavskaia	MNRF.Ayl.Planners@ontario.ca	519-773-4757	615 John Street	Aylmer	ON	N5H 2S8
Federal Agencies										
08/05/2021	Nav Canada	No Contact - Send to General Email			service@navcanada.ca	1-613-563-5588	77 Metcalfe Street	Ottawa	ON	K1P 5L6
08/05/2021	CP Rail	Manager	Jennifer	Benedict	Jennifer_Benedict@cpr.ca	905-803-5989	1290 Central Parkway West	Mississauga	ON	L5C 4R3
08/05/2021	CN Rail	Senior Manager	Stefan	Linder	stefan.linder@cn.ca	905-669-3133	1 Administration Rd	Concord	ON	L4K 1B9
08/05/2021	CN Rail	Manager	Michael	Vallins	michael.vallins@cn.ca	905-669-3264	1 Administration Rd	Concord	ON	L4K 1B9
06/10/2022	CN Rail				ER-Public-Works@cn.ca					
Community Organizations										
08/05/2021	Windsor Essex Community Housing Corporation	No Contact - Send to General Email			info@wechc.com	519-254-1681	P.O. Box 1330	Windsor	ON	N9A 6R3
Emergency Service Providers										
08/05/2021	Central Ambulance Communications Centre		Robin	Souchuk	robin.souchuk@ontario.ca	519-256-2373	4510 Rhodes Drive, Suite 320	Windsor	ON	N8W 5K5
08/05/2021	City of Windsor	Director of Planning and Physical Resources	Barry	Horrobin	bhorrobin@police.windsor.on.ca	519-255-6700 ext 4471	150 Goyeau Street	Windsor	ON	N9A 6J5
08/05/2021	Ontario Provincial Police					519 723-2491	1219 Hicks Rd., P.O. Box 910	Essex	ON	N8M 2Y2
08/05/2021	City of Windsor	Fire Chief	Stephen	Laforet	slaforet@citywindsor.ca	519-253-3016 ext 253	815 Goyeau Street	Windsor	ON	N9A 1H7
08/05/2021	Essex-Windsor EMS		Bruce	Krauter	bkrauter@countyofessex.on.ca	519-776-6441 ext 2654	360 Fairview Avenue West, Suite 115	Essex	ON	N8M 1Y6
08/05/2021	Town of LaSalle	Fire Chief	Dave	Sutton	dsutton@lasalle.ca	519-966-0744	1900 Normandy Street	LaSalle	ON	N9H 1P8
08/05/2021	Town of Tecumseh	Director Fire Services & Fire Chief	Doug	Pitre	dpitre@tecumseh.ca	519-979-4041 ext 210	985 Lesperance Rd.	Tecumseh	ON	N8N 1W9
Environmental Organizations										
08/05/2021	Essex Region Conservation Authority (ERCA)	Director, Watershed Management Services	James	Bryant	JBryant@erca.org	519-776-5209 ext 246	360 Fairview Avenue West, Suite 311	Essex	ON	N8M 1Y6
08/05/2021	Essex Region Conservation Authority (ERCA)	Water Resources Engineer	Tian	Martin	tmartin@erca.org	519-776-5209 ext 304	360 Fairview Avenue West, Suite 311	Essex	ON	N8M 1Y6
08/05/2021	Essex Region Conservation Authority (ERCA)	Planning Department			planning@erca.org	519-776-5209	360 Fairview Avenue West, Suite 311	Essex	ON	N8M 1Y6
09/29/2022	Essex Region Conservation Authority (ERCA)	Watershed Engineer	Lina	Florian	lflorian@erca.org	519-776-5209 ext 314	361 Fairview Avenue West, Suite 311	Essex	ON	N8M 1Y7
08/05/2021	Great Lakes Institute for Environmental Research	Director	Trevor	Pitcher	glierdir@uwindsor.ca	1-519-253-3000 ext 2710	2601 Union Street	Windsor	ON	N9B 3P4
08/05/2021	Windsor Essex County Environment Committee	Environment and Sustainability Coordinator	Averil	Parent	aparent@citywindsor.ca	519-253-7111	Council Services Department 350 City Hall	Windsor	ON	N9A 6S1
08/05/2021	Detroit River Canadian Cleanup	RAP Coordinator	Claire	Sanders	sanders@detroitriver.ca	519-776-5209 ext 356	311-360 Fairview Ave West	Essex	ON	N8M 1Y6
08/05/2021	International Joint Commission	Director	Trish	Morris	morrisp@windsor.ijc.org	519-257-6715	100 Ouellette Ave., 8th Floor	Windsor	ON	N9A 6T3

West Windsor Flood Risk Study - Stakeholder List

Indigenous Communities and Organizations										
08/05/2021	Can-Am Indian Friendship Centre	No Contact - Send to General Email			admin@caifc.ca	519-253-3243	2929 Howard Ave	Windsor	ON	N8X 4W4
03-10-2022	Chippewas of the Thames First Nation	Chief	Jacqueline	French	jfrench@cottfn.com	519-289-5555	320 Chippewa Road R.R. #1	Muncey	ON	N0L 1Y0
08/05/2021	Chippewas of the Thames First Nation	Consultation Coordinator	Fallon	Burch	consultation@cottfn.com	519-264-0776	320 Chippewa Road R.R. #1	Muncey	ON	N0L 1Y0
03-10-2022	Chippewas of Kettle & Stony Point First Nation	Chief	Jason	Henry	KPAssistant@kettlepoint.org Jason.Henry@kettlepoint.org	519-786-2125	6247 Indian Lane	Lambton Shores	ON	N0N 1J1
08/05/2021	Chippewas of Kettle & Stony Point First Nation	Consultation Coordinator	Valerie	George	fdesk@kettlepoint.org	519-786-2125	6247 Indian Lane	Lambton Shores	ON	N0N 1J1
03-10-2022	Aamjiwnaang First Nation	Chief	Christopher	Plain	chief.plain@aamjiwnaang.ca	519-336-8410	978 Tashmoo Avenue	Sarnia	ON	N7T 7H5
05-10-2022	Aamjiwnaang First Nation	Environmental Coordinator	Cathleen	O'Brien	cobrien@aamjiwnaang.ca	519-336-8410 Ext. 245	978 Tashmoo Avenue	Sarnia	ON	N7T 7H5
03-10-2022	Bkejwanong Territory (Walpole Island First Nation)	Chief	Charles	Sampson	Charles.sampson@wifn.org	519-627-1481	117 Tahgahoning Rd.	Walpole Island	ON	N8A 4K9
03-10-2022	Caldwell First Nation	Chief	Mary	Duckworth	ChiefMaryDuckworth@caldwellfirstnation.ca	519-358-6922	14 Orange Street	Leamington	ON	N8H 1P5
03-10-2022	Caldwell First Nation	Consultation Coordinator	Michelle	McCormack	ecc@caldwellfirstnation.ca	519-322-1766	14 Orange Street	Leamington	ON	N8H 1P5
03-10-2022	Caldwell First Nation	Consultation Coordinator	Zack	Hamm	ecc2@caldwellfirstnation.ca	519-322-1766	14 Orange Street	Leamington	ON	N8H 1P5
03-10-2022	Oneida Nation of the Thames	Chief	J. Todd	Cornelius	todd.cornelius@oneida.on.ca	519-318-4605	2210 Elm Avenue	Southwold	ON	N0L 2G0
03-10-2022	Metis Nation of Ontario	Manager, Lands, Resources and Consultations			consultations@metisnation.org	416-977-9881	75 Sherbourne Street	Toronto	ON	M5A 2P9
03-10-2022	Metis Nation of Ontario	Director of Lands, Resources and Consultations	Lina	Norheim	LindaN@metisnation.org	(416) 433-1315				
03-10-2022	Union of Ontario Indians	Grand Council Chief	Reg	Niganobe	info@anishinabek.ca	705-497-9135	1 Migizii Miikan, P.O Box 711	North Bay	ON	P1B 8J8
03-10-2022	Chiefs of Ontario	Director of Environment	Kathleen	Padulo	Kathleen.Padulo@coo.org	416-597-1266	468 Queen St. E, Suite 400	Toronto	ON	M5A 1T7
03-10-2022	Chiefs of Ontario	Ontario Regional Chief	Glen	Hare	ORCEA@coo.org	416-597-1266	468 Queen St. E, Suite 400	Toronto	ON	M5A 1T7
03-10-2022	Southern First Nations Secretariat	Executive Director	Jennifer	Whiteye	jenwhiteye@sfns.on.ca	519-692-5868 ext. 242	22361 Austin Line	Bothwell	ON	N0P 1C0
03-10-2022	Windsor Essex Kent Metis Council	Communications Officer	Kayla	Martin	communications@sfns.on.ca		22361 Austin Line	Bothwell	ON	N0P 1C0
08/05/2021	Windsor Essex Kent Metis Council	Executive Assistant	Lori	Fisher	exec.assistant@sfns.on.ca	519-974-0860	145-600 Tecumseh Road East	Windsor	ON	N8X 4X9
08/05/2021	Windsor Essex Kent Metis Council	President	Sharlene	Lance	windsoressexmetiscouncil@outlook.com	519-974-0860	145-600 Tecumseh Road East	Windsor	ON	N8X 4X9
Utility Providers										
08/05/2021	Bell Canada	Access Network Coordinator	Dave	Cowing	david.cowing@bell.ca	519-973-6702	1149 Goyeau Street, Floor 1	Windsor	ON	N9A 1H9
08/05/2021	Bell Canada	Implementation Specialist	Clifford	Trepanier	clifford.trepanier@bell.ca	519-973-6761	1149 Goyeau Street, Floor 1	Windsor	ON	N9A 1H9
08/05/2021	Cogeco Cable Solutions	Planning Leadhand - West Region	Bill	Sorrell	bill.sorrell@cogeco.com	519-972-4013	2525 Dougall Ave.	Windsor	ON	N8X 5A7
08/05/2021	MNSI	Network Planner	Dave	Hartleib	hartleib@mnsi.net	519-985-8435	3363 Tecumseh Road East	Windsor	ON	N8W 1H4
08/05/2021	Enbridge		Mary Jane	Patrick	ontugllandsinq@enbridge.com	519-436-4600	50 Keil Drive North	Chatham	ON	N7M 5M1
08/05/2021	Enbridge	Construction Project Manager	Will	Ceccacci	wceccacci@enbridge.com	519-251-6810	3840 Rhodes Drive	Windsor	ON	N9A 6N7
08/05/2021	Ontario Power Generation Inc.	Director of Environmental Services	Susan	Rapin	susan.rapin@opg.com	416-592-6399	700 University Avenue	Toronto	ON	M5G 1X6
08/05/2021	ENWIN Utilities Ltd.	Director, Water Engineering	Norbert	Poggio	npoggio@enwin.com	519-251-7300	787 Ouellette Avenue, P.O. Box 1625, Station A	Windsor	ON	N9A 5T7
08/05/2021	Enwin Utilities Ltd.	Director, Hydro Engineering	Marvio	Vinhaes	mvinhaes@enwin.com	519-251-7300	787 Ouellette Avenue, P.O. Box 1625, Station A	Windsor	ON	N9A 5T7
Stakeholders										
03-10-2022	Windsor Essex Catholic District School Board (477 Detroit Street)	Manager of Construction & Engineering	Greg	Koppeser	greg_koppeser@wecdsb.on.ca	519 253 2481 Ext. 1211	1325 California Avenue	Windsor	ON	N9B 3L5
03-10-2022	University of Windsor	President	Dr. Rob	Gordon	Robert.Gordon@uwindsor.ca	(519) 253-3000 Ext: 2000	Room 126 Assumption Hall 400 Huron Church Rd	Windsor	ON	N9C 2J9
03-10-2022	Essex Terminal Railway Co.	Superintendent	Ivan	Pratt	ipratt@etr.ca	519 973-8222 EXT. 227	1601 Lincoln Road	Windsor	ON	N8Y 2J3
05-10-2022	Windsor Port Authority	Harbour Master	Peter	Berry	pberry@portwindsor.com		3190 Sandwich Street	Windsor	ON	N9C 1A6
06-10-2022	Windsor Port Authority	President & CEO	Steve	Salmons	ssalmons@portwindsor.com		3190 Sandwich Street	Windsor	ON	N9C 1A6
03-10-2022	Hand In Hand Support (3020 Sandwich St, Windsor, ON)	No Contact - Send to General Email			Info@handinhand-support.org	519-419-5500	3020 Sandwich Street	Windsor	ON	N9C 1A3
03-10-2022	Coco Group General Email				info@cocogroup.com					
03-10-2022	Coco Paving Inc. (on 3800 Russel Street)	Director, Land Development & Government Relations	Anthony	Rossi	ARossi@cocogroup.com		949 Wilson Avenue	Toronto	ON	M3K 1G2
03-10-2022	Coco Group - Coco Homes Office	After Sales Contact	Rebecca	Danial	labouzeeni@cocogroup.co	519-948-7133	RR 2 6725 South Service Road E	Windsor	ON	N8N 2M1
03-10-2022	Green Infrastructure Partners		David	Colle	dcolle@gipi.com	(519) 256-8633	4016 Sandwich Street	Windsor	ON	N9C 1C4
	Green Infrastructure Partners	Windsor Aggregate Dock Manager	Ernie	Scerbo	escerbo@gipi.com					
03-10-2022	K S Windsor Salt Ltd. (Ojibway Mine)	General Manager -Ojibway Mine	Pierre	Girard	pgirard@windsorsalt.com	(519) 972-2209	200 Morton Drive	Windsor	ON	N9C 3W9
03-10-2022	Nemak of Canada Corporation	No Contact - Send to General Email			contact@nemak.com	519-251-4400	4600 GN Booth Drive	Windsor	ON	N9C 4G8
03-10-2022	Transport Canada	No Contact - Send to General Email			questions@tc.gc.ca		4900 Yonge Street	Toronto	ON	M2N 6A6
03-10-2022	Ontario Power Generation (on 40 Broadway Street)	Director of Environmental Services	Susan	Rapin	susan.rapin@opg.com	416-592-6399	700 University Avenue HLC D16 1	Toronto	ON	M5G 1X6
05-10-2022	Southwestern Sales Corporation Limited (on 210 Detroit Street)	No Contact - Send to General Email			info@southwesternsales.ca	(519) 254-1811	210 Detroit Street	Windsor	ON	N9C 2P1
03-10-2022	Canadian Transit Company	No Contact - Send to General Email			commandcenter@ambassadorbridge.com	519-977-0700	PO Box 869	Warren	MI	48090
03-10-2022	K Scrap Resources Ltd.	General Manager	Tom	Meloche	admin@kscrap.com	519.254.5188 ext 204	110 Hill Avenue	Windsor	ON	N9C 3B8
03-10-2022	Hydro One Networks Inc. (on 20 Broadway Street)	Regulatory Affairs General Email Address			Regulatory@HydroOne.com	416-345-5000	483 Bay St. (South Tower), 8th Floor Reception	Toronto	ON	M5G 2P5
03-10-2022	ADM Agri-Industries Ltd.	Plant Manager	Trevor	Durrant	trevor.durrant@ADM.com	(519) 972-8100	5550 Maplewood Drive	Windsor	ON	N9C 0B9
05-10-2022	Greater Essex County District School Board	Coordinator of Engineering	Guiliana	Hinchliffe	giuliana.hinchliffe@publicboard.ca		451 Park St W	Windsor	ON	N9A 6K1

DILLON CONSULTING

Emery, Nick <nemery@dillon.ca>

West Windsor Flood Assessment Study - Notice of Virtual Public Information Centre

1 message

Emery, Nick <nemery@dillon.ca> Thu, Oct 6, 2022 at 10:59 AM

Good morning,

On behalf of the West Windsor Flood Assessment Study project team, we invite you to review the public information centre material available at the project page on the CIty of Windsor website here: https://www.citywindsor.ca/residents/Construction/Environmental-Assessments-Master-Plans/Pages/West-Windsor-Flood-Assessment-Study.aspx

Additional information is provided in the attached project notice.

Have a great day!

DILLON CONSULTING

CANADA BEST MANAGED COMPANIES
Platinum member

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Associate
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nemery@dillon.ca
www.dillon.ca

NOTICE OF VIRTUAL PUBLIC INFORMATION CENTRE.pdf
560K

West Windsor Flood Risk Study - Public Consultation Record

Source	Contact	Date	Comment Summary	Addressed in Report Section
Chippewas of the Thames First Nation	Fallon Burch	November 4, 2022	After reviewing the West Windsor Flood Assessment Study, we have identified no concerns with your project or the information that you have presented to us at this time. We ask that if there are any changes to your project that are of a substantive nature that you keep us informed. If there is an Archaeology Assessment conducted, we require notification and the opportunity to actively participate by sending First Nation Field Liaisons on behalf of this First Nation.	
Windsor Port Authority	Peter Berry	October 18, 2022	Supports raising Mill Street and notes concerns with condition of existing outlet. Notes concerns with raised road profile causing flow into HMCS Hunter driveway.	
Windsor Port Authority	Peter Berry	October 18, 2022	Concerns regarding proposed Detroit Street trunk sewer onstructability, including weight of aggregate stockpiles and potential construction impacts on site operations.	
Windsor Port Authority	Peter Berry	October 18, 2022	Concerns with existing drainage on Russell Street and effects on port operations.	
Resident	Carl Maiolani	October 25, 2022	A quick question re high river levels and the connection between same and green-house gas levels… as shown in the video.. "lower future levels with higher GHG emissions".. please elaborate on the relationship between these two things..	
Survey	Anonymous	-	6 surveys completed.	
City of Windsor	Ryan Langlois	October 19, 2022	How does the level of 176.3 m (conservative estimate of future peak 100 year) relate to other studies completed upstream (ex. Landmark/RWDI Study) for East Riverside? Is the increase from the previous 100yr level to the new predicted in that area of Windsor similar to the increase identified through this study?	
City of Windsor	Ryan Langlois	October 19, 2022	Can you confirm if the shoreline property improvements proposed (ex. Grading improvements, permanent flood protection barriers and temporary sandbagging) will be the responsibility of the owner, or will the City be taking on this task? As a land owner, why should I have to pay the full cost for a solution which also protects others?	
City of Windsor	Ryan Langlois	October 19, 2022	"Municipal Roads to be raised above extreme water levels where feasible" If the roadways are raised up, does that mean that my adjacent property will now be lower. Under a current condition, the lakewater would be getting into the municipal storm sewer system and away from my home, or stored along the roadways. Will this solution make flooding worse on my property?	

West Windsor Flood Risk Study - Public Consultation Record

Source	Contact	Date	Comment Summary	Addressed in Report Section
City of Windsor	Ryan Langlois	October 19, 2022	Wouldn't a more logical and feasible solution to have a barrier landform along the coastline to stop water from getting onto the roadway in the first place, or is there a gravity outlet sewer connected to the river which propagates water inland? In this case, would a backflow preventer solve this problem instead of raising the roadways?	
City of Windsor	Ryan Langlois	October 19, 2022	Will ERCA approve a solution to raise the roadways above the 100 year Detroit Level Water Level?	
City of Windsor	Ryan Langlois	October 19, 2022	What is the ponding depth along these roadways? Greater than 0.30 m?	
City of Windsor	Ryan Langlois	October 19, 2022	So through the installation of backflow preventers at CSO outfalls, during high water levels, CSO's will be unable to function as designed and during larger storm events, the area will now be susceptible to basement flooding due to combined sewer surcharging?	
City of Windsor	Ryan Langlois	October 19, 2022	I was under the assumption that the MECP were no longer supporting RTB's. Are there any other solutions proposed in the instance where this solution is not approved by the ministry?	
City of Windsor	Ryan Langlois	October 19, 2022	AIM development property is in the process of an expansion with additional hard surface. As part of this work, a council report went out (Item No. 8.1, Council report 136/2021 – October 4, 2021) and it was identified that the drain is currently servicing at below a 2 year level of service, but the improvements would not increase the level of service to the 1:2 year (typical municipal drainage standard). A relocation of the culvert crossing Maplewood Avenue within the Sprucewood drain is also proposed. This Municipal Drainage Report should take into consideration any improvements necessary to reduce local flooding (does it require just drain cleaning, or a full enhancement to a typical level of service?).	

Source	Contact	Date	Comment Summary	Addressed in Report Section
Hydro One	Secondary Land Use Asset Optimization Strategy & Integrated Planning Hydro One Networks Inc.	October 31, 2022	At this time we do not have sufficient information to comment on the potential resulting impacts that your project may have on our infrastructure. As such, we must stay informed as more information becomes available so that we can advise if any of the alternative solutions present actual conflicts with our assets, and if so; what resulting measures and costs could be incurred by the proponent. Note that this response does not constitute approval for your plans and is being sent to you as a courtesy to inform you that we must continue to be consulted on your project.	

Appendix G

Backflow Preventers

WEST WINDSOR FLOOD PROTECTION STUDY
CSO BACKFLOW PREVENTION DEVICES

Backflow Preventer #	Street Name	U/S Structure ID	D/S Structure ID	D/S Invert Elevation (m)	Sewer Size (m)	Sewer Type	Existing Weir Protection Installed? (Yes/No)	Existing Weir Spillover Elevation (m)	Backflow Preventer Required (Yes/No)	Proposed Backflow Prevention Device	Construction Location	Maintenance Access	Proposed Maintenance Structure Required? (Yes/No)
1	Brock Street	5RJ3652	5RO964	170.000	1.975	Circular	Yes	175.963	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
2	Brock Street	5RJ3652	5RO964	170.000	1.975	Circular	Yes	175.963	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
3	Mill Street	5C481	5R87	174.277	0.675	Circular	Yes	175.971	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
4	Prospect Avenue	5R991	5RO958	171.298	2.125	Circular	No	-	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
5	Hill Ave	5R104	5RO465	173.000	1.350	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
6	Detroit Street	5R3084	5RO955	172.640	0.900	Circular	Yes	175.196	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
7	Huron Church Road	5RJ1006	5RO962	170.500	2.725	Circular	Yes	174.600	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
8	Patricia Road	5R706	5RO704	175.521	1.050	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
9	Askin Avenue	5C249	5R951	175.006	1.800	Circular	Yes	176.566	No	-	-	-	-
10	Bridge Avenue	5CPS10000	5RO960	174.040	1.500	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	Yes
11	Curry Avenue	5R993	5RO959	175.137	0.600	Circular	Yes	175.936	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
12	Elm Avenue	4C948	4RO907	174.000	1.200	Circular	Yes	174.850	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
13	Crawford Avenue	4R3350	4RO908	175.000	0.600	Circular	Yes	176.471	No	-	-	-	-

14	Bruce Avenue	4R35	4RO1	174.000	0.700	Circular	Yes	175.810	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
15	Church Street	4R277	4RO901	174.000	0.750	Circular	Yes	178.930	No	-	-	-	-
16	Church Street	4RJ3313	4RO469	171.789	2.725	Circular	No	-	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
17	Church Street	4RJ914	4RO443	172.500	1.200	Circular	Yes	175.044	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
18	Ferry Street	4R38	4RO900	173.000	1.375	Circular	Yes	176.211	No	-	-	-	-
19	Oullette Avenue	4R3008	4RO903	173.000	1.825	Circular	Yes	175.730	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	No
20	Goyeau Street	4RJ916	4RO455	173.250	1.450	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
21	McDougall Street	4R3235	4RO906	174.085	1.200	Circular	Yes	176.080	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
22	McDougall Street	4RJ3133	4RO3052	170.574	2.100	Circular	No	-	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
23	Glengarry Avenue	3RJ3410	3RO3411	171.000	2.250	Circular	Yes	176.800	No	-	-	-	-
24	Marantette Ave	3R18	3RO703	174.255	1.050	Circular	Yes	176.095	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
25	Parent Ave	3C3413	3RO704	174.769	1.500	Circular	Yes	175.280	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	Yes
26	Langlois Avenue	3RJ903	3RO702	171.765	1.825	Circular	Yes	175.682	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
27	Lincoln Road	2RJ3107	2RO910	171.000	3.350	Circular	Yes	176.539	No	-	-	-	-
28	Chilver Road	2R555	2RO914	175.000	1.050	Circular	Yes	177.000	No	-	-	-	-
29	Chilver Road	2R555	2RO913	175.000	1.200	Circular	Yes	176.268	No	-	-	-	-

30	Argyle Road	2R379	2RO916	173.500	1.500	Circular	Yes	175.140	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
31	Walker Road	2R3313	2RO915	173.500	0.650	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
32	Albert Road	1RJ136	1RO136	173.448	1.650	Circular	Yes	175.914	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
33	Belleview Avenue	1RJ937	1RO137	174.637	1.050	Circular	Yes	178.904	No	-	-	-	-
34	Strabane Avenue	1R375	1RO134	174.015	1.200	Circular	Yes	174.960	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
35	George Avenue	1R1450	1RO1	173.000	2.125	Circular	No	-	Yes	Mueller HydroGate - Model 50C Round Opening	Flap gate installed at opening of downstream end of outlet	Assuming there is no access to the outlet opening, an access chamber will need to be installed upstream of the CSO Outlet	Yes
36	Rossini Boulevard	1RJ930	1RO199	173.000	1.200	Circular	Yes	175.288	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No
37	Riverside Drive East	1R330	1RO330	175.000	0.600	Circular	No	-	Yes	WaPro WaStop - Inline Check Valve	Inline check valve inserted directly into sewer at downstream end of existing MH	Dewatering of the downstream sewer is required prior to installation of the backflow prevention device	No

City of Windsor

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1: 2,500

127.0 0 63.50 127.0 Meters

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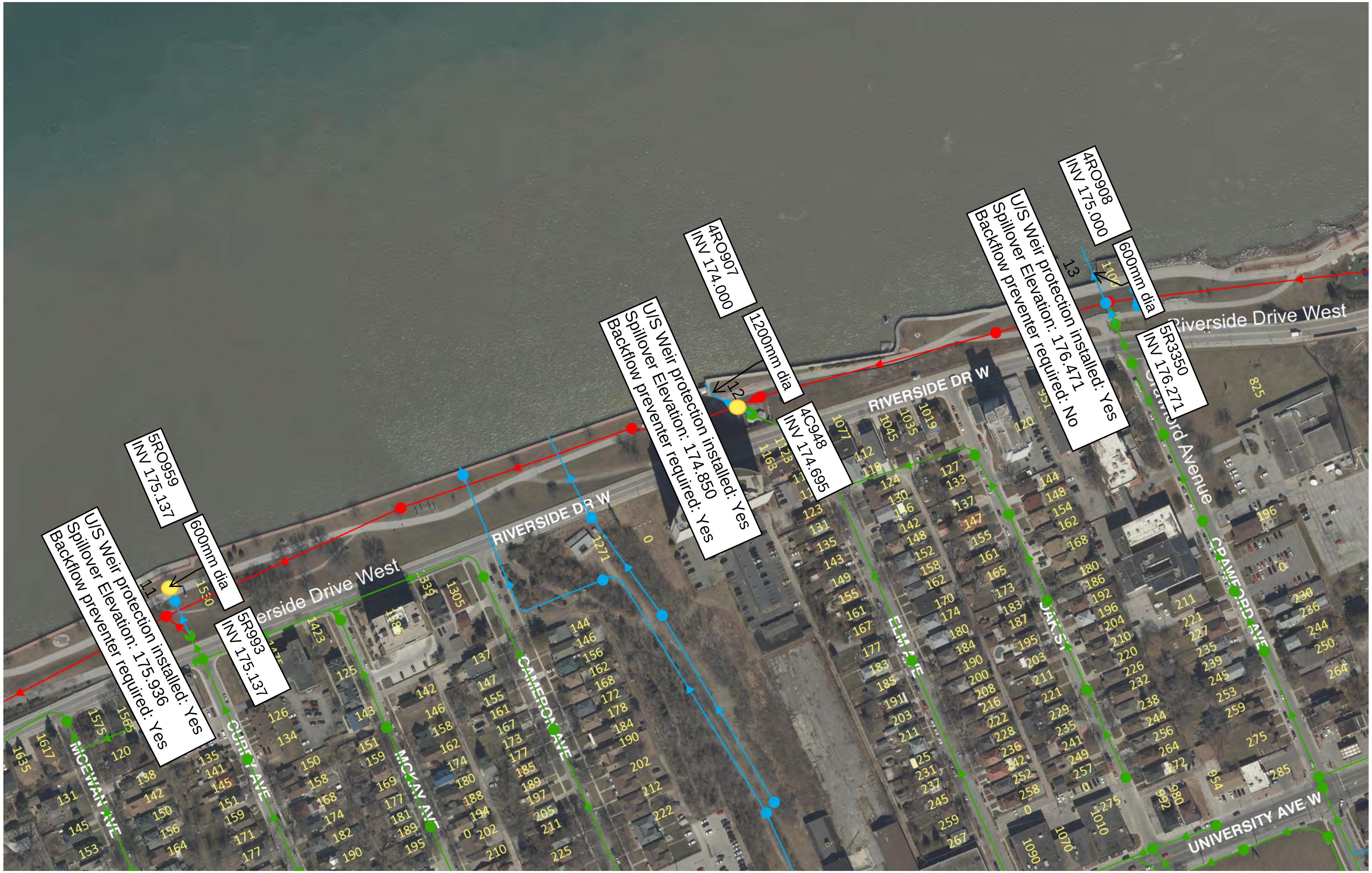

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Appendix H

Cost Estimate and TBL Assessment Matrix

West Windsor Flood Protection Study
Appendix H - Table H.1 Solution Summary and Budgetary Cost Estimates

Date 2022-11-22

No.	Solution	Local/ Regional	Applicable Zones	Description	Construction Cost	Engineering Cost (20%)	Contingency Cost (30%)	Total Solution Cost
1	Install Backflow Prevention at CSOs along Detroit River	Local	1&2	See West Windsor Flood Protection Study - CSO Backflow Prevention Devices in Appendix G of the West Windsor Flood Risk Study Report for proposed locations, sizes, and additional details.	$ 1,795,000	$ 359,000	$ 538,500	$ 2,692,500
2	Lou Romano RTB	Regional	1	Solution detailed in the Sewer and Coastal Flood Protection Master Plan for additional details on the proposed retention treatment basin (RTB) at Lou Romano Water Reclamation Plant and Windsor Riverfront West CSO Control "Schedule C" Class EA Environmental Study Report. A portion of this project will be funded through the Federal Goverment via the DMAF funding.	$ 50,000,000	$ 10,000,000	$ 15,000,000	$ 75,000,000
3	Combined Sewer Separation	Regional	1&2	Long term solution to separate all combined sewers in the West Windsor Flood Study area into separate saniitary sewage and storm water systems.	$ 497,776,000	$ 99,555,200	$ 149,332,800	$ 746,664,000
4	Install Basement Flood Protection Measures	Regional	1&2	Solution to provide flood relief to private residences that are at risk for basement flooding in the study area. All homes that are older than 1980 would be subject to these improvements. Solutions include installation of backflow preventors, sump pump, power backup, foundation drain disconnection, lot grading etc.	Cost per home. $25,000.	-	-	-
5	Prince Road Trunk Storm Sewer Outfall and Pump Station	Local	1&2	Solution detailed in the Sewer and Coastal Flood Protection Master Plan for additional details on the proposed outfall and pump station see Prince Road Storm Sewer Outlet - Envrionmental Study Report Schedule C Municipal Class EA.	$ 5,510,000	$ 1,102,000	$ 1,653,000	$ 8,265,000
6	Detroit Street Trunk Storm Sewer and Outfall	Local	1&2	See the Sewer and Coastal Flood Protection Master Plan for additional details on the proposed Detroit Street trunk storm sewer and outfall improvements.	$ 2,162,400	$ 432,480	$ 648,720	$ 3,243,600
7	Russell Street - Private Site Improvements	Local	1	Seed West Windsor Flood Risk Study Report for further details	$ 127,000	$ 25,400	$ 38,100	$ 190,500
8	Sandwich Street Drainage Improvements	Local	1	Sandwich Street improvements between Ojibway Parkway and McKee Road.	$ 1,200,000	$ 240,000	$ 360,000	$ 1,800,000

West Windsor Flood Protection Study
Appendix H - Table H.1 Solution Summary and Budgetary Cost Estimates

Date 2022-11-22

No.	Solution	Local/ Regional	Applicable Zones	Description	Construction Cost	Engineering Cost (20%)	Contingency Cost (30%)	Total Solution Cost
9	Private Solutions to Prevent Surface Flooding from High Water Levels	Local	2	Solutions from the Sewer and Coastal Flood Protection Master Plan - private property.	N/A	N/A	N/A	N/A
10	Private Flood Protection Solutions	Local	2	Solutions from the Sewer and Coastal Flood Protection Master Plan - private property.	N/A	N/A	N/A	N/A
11	Windsor Biosolids Plant - Site Drainage and Grading Improvements	Local	2	Solutions from the Sewer and Coastal Flood Protection Master Plan - private property.	N/A	N/A	N/A	N/A
12	Recalibrate Sanitary Service Area	Local	2	Updating the City of Windsor Master Plan modelling to recalibrate sanitary service areas based on current conditions.	-	$ 100,000	-	$ 100,000
13	McKee Creek Drain Maintenance from Detroit River to Sandwich Street	Local	2	Maintain the McKee Creek Drain from the Detroit River to Sandwich Street. Including: cleaning and grubbing and cleanout. See Landmark Drainage Report (Feb. 2022)	$ 119,000	$ 23,800	$ 35,700	$ 178,500
14	McKee Creek Drain Improvements	Local	2	Replace existing ETR Crossing. See Landmark Drainage Report (Feb. 2022)	$ 224,000	$ 44,800	$ 67,200	$ 336,000
15	Monitoring River Levels	Local	2	Ongoing observation of water levels within the Great Lakes system to ensure that the recommended infrastructure and protection measures are implemented in advance of rising levels and climate change impacts. This may involve updated future climate/river level assessments in the future.	N/A	N/A	N/A	N/A
16	Dewatering Pump Station	Local	2	City of Windsor to monitor and maintain the pump station after maintenance period is complete. This is currently being monitored and maintained by the Windsor Detroit Bridge Authority.	N/A	N/A	N/A	N/A
17	Prospect Avenue Improvements	Local	2	See Figure 3 - Grade Protection Plan - Prospect Avenue in the ***Figures*** section of the West Windsor Flood Risk Study Report along with ***Section 6.2.2*** of the West Windsor Flood Risk Study Report for additional details.	$ 1,800,000	$ 360,000	$ 540,000	$ 2,700,000

West Windsor Flood Protection Study
Appendix H - Table H.1 Solution Summary and Budgetary Cost Estimates

Date 2022-11-22

No.	Solution	Local/ Regional	Applicable Zones	Description	Construction Cost	Engineering Cost (20%)	Contingency Cost (30%)	Total Solution Cost
18	Brock St - Inspect Shoreline and Outfall Condition and Develop Local Repair Plan	Local	2	Provide inspection of the shoreline and outfall condidtions for Brock Street, assess conditions and prepare a report.	-	-	-	$ 40,000
19	Reprofile Mill Street	Local	2	Existing Mill Street road grades to be raised to a minimum grade of 176.10 to protect against costal flooding.	$ 200,000	$ 40,000	$ 60,000	$ 300,000
20	Private Flood Protection and Erosion Solutions	Local	2	Solutions from the Sewer and Coastal Flood Protection Master Plan - private property.				
21	McKee Park Improvements	Local	2	See Figure 5 - Grade Protection Plan - McKee Park in the ***Figures*** section of the West Windsor Flood Risk Study Report along with ***Section 6.2.2*** of the West Windsor Flood Risk Study Report for additional details.	$ 440,000	$ 88,000	$ 132,000	$ 660,000
22	Maplewood Drive Pump Station Improvements	Local	3	Improve the condition and capacity of the Maplewood Drive Pump Station including a proposed 1 CMS pump to handle additional flows from rising water levels	$ 200,000	$ 40,000	$ 60,000	$ 300,000
23	Maplewood Drive and Sprucewood Avenue Drainage Maintenenace	Local	3	Maintain the Maplewood Drive and Sprucewood Avenue drainage including: clearing and grubbing, excavation and disposal of material off site	$ 1,040,400	$ 208,080	$ 312,120	$ 1,560,600
24	Black Oak Heritage Park - Develop an Emergency Response Plan for Park When Flooded	Local	3	Solutions from the Sewer and Coastal Flood Protection Master Plan - private property.	N/A	N/A	N/A	N/A
25	Ojibway Parkway - Roadside Ditch Maintenance	Local	3	Maintain the Ojibway Parkway roadside ditch including: cleaning, flushing, repairs, and intermittent inspection	$ 1,125,000	$ 225,000	$ 337,500	$ 1,687,500
26	Ojibway Parkway Drainage Improvements	Local	3	Improve the condition and capacity of the Ojibway Parkway drainage including roadside ditches, underground storm system, and outlet capacity	$ 2,500,000	$ 500,000	$ 750,000	$ 3,750,000

Date 2022-11-22

No.	Solution	Local/ Regional	Applicable Zones	Description	Construction Cost	Engineering Cost (20%)	Contingency Cost (30%)	Total Solution Cost
27	Install Rain Catchers	Regional	1 & 2	Install rain catchers at sanitary MHs located in low lying areas	$ 70,000	N/A	$ 21,000	$ 91,000
28	Russell Street Local Drainage Improvements	Local	2	Improve the condition and capacity of the Russell Street drainage including roadside ditches and outlet capacity	$ 1,560,000	$ 312,000	$ 468,000	$ 2,340,000
29	Morton Avenue Roadside Ditch Improvements	Local	3	Improve and maintain the condition and capacity of the Morton Avenue roadside ditches including: excavation, cleaning, widening, and intermittent inspection and maintenance	$ 531,000	$ 106,200	$ 159,300	$ 796,500

West Windsor Flood Protection Study -
Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	1	2	3	4	5	6	8	15	16	18
			0	5	10		Install Backflow Prevention at CSOs along Detroit River	Lou Romano RTB	Combined Sewer Separation	Install Basement Flood Protection Measures	Prince Road Trunk Storm Sewer Outfall and Pump Station	Detroit Street Trunk Storm Sewer and Outfall	Sandwich Street Drainage Improvements	McKee Creek Drain Maintenance from Detroit River to Sandwich Street	McKee Creek Drain Improvements	Prospect Outlet Dewatering Pump Station
ECONOMIC																
Cost effectiveness	Projects with lower capital costs impacts taxpayers the least and will require less budget allocation.	2	Cost > $4M	Cost Between $1-4M	Cost/< $1M or Private Property Costs.	Based on 2022 Estimated Project Construction Costs and does not factor inflation.	Assume all completed as on comprehensive project.	Cost > $4M	Several kilometers of combined sewer including restoration will have significant costs.	Assume City will contribute to residential property protection costs via subsidy program.	Cost Between $1-4M	Cost Between $1-4M	Cost/< $1M	Cost/< $1M or Private Property Costs.	Cost Between $1-4M	Cost Between $1-4M
						Score	10	0	0	10	10	10	20	20	10	10
Asset Risk Rating	Higher priority if asset condition indicates need for refurbishment or replacement.	1	<10% rated as poor condition, acceptable condition or new infrastructure.	10-30% Rated as poor condition	>30% Rated as poor condition	Condition ratings were obtained via the City's Information System as of 2017.	Various conditions however most are older structures.	New Infrastructure.	Various conditions however most are older structures.	New Infrastructure.	New Infrastructure.	Sewer in acceptable condition. Constructed in 2001.	Drainage swales and road should be maintained.	Drainage swales and road should be maintained.	Drainage swales and road should be maintained.	New Infrastructure.
						Score	10	0	10	0	0	0	10	10	10	0
Synergistic implementation, timing with other projects or opportunities *e.g. Gordie Howe Bridge, Sandwich St reconstruction, Great Lakes WQA*	Higher priority and advantages for earlier action if synergistic opportunities support co-funding or achieve similar goals *e.g. Intl Bridge; GLWQA*	2	Likely no synergies or opportunities for overlapping funding or receiving support from other projects	Potential for synergies with one other project or potential funding opportunity	Potential for synergy with MORE than one other project or funding is available.	Survey of potential opportunities for synergistic projects.	Works to be done independent from other projects.	Received DMAF contribution from federal government.	Opportunity to separate sewer during road reconstruction projects.	Works to be done independent from other projects.	Opportunity to complete this work in conjunction with the McKee Creek Improvements (Solution 15).	Works to be done independent from other projects.	Works to be done independent from other projects.	Opportunity to complete this work in conjunction with the Prince Road Trunk Storm Sewer Outfall and Pump Station (Solution 5).	Works to be done independent from other projects.	Opportunity to complete this work in conjunction with the Prospect Road Reprofiling.
						Score	0	20	10	0	10	0	0	20	0	10
If solution fails or is not implemented, high replacement costs or extreme challenges if catastrophic failure occurs (e.g. high costs to replace, time without services)	Higher priority for action if high costs or long disruptions could be incurred from catastrophic failure of critical asset *e.g. Lou Romano WWTP, pumping stations*	1	Low Reduction	Median Reduction	High Reduction	If solutions are not implemented what is the extent of property damage or failure of 3rd party assets during high river level events.	Median Reduction	High Reduction	Low Reduction	Low Reduction	High Reduction	Low Reduction	Low Reduction	Low Reduction	Median Reduction	Median Reduction
						Score	5	10	0	0	10	0	0	0	5	5
Ease, cost and complexity of measure's ongoing operations and maintenance.	Higher acceptance for action if ongoing O&M efforts are relatively lower.	2	Poor acceptance of measure, unknown technology and significant number of manhours for maintenance and operation.	Some training needed. Mid-level number of manhours for maintenance and operation.	Known technology and minimal labour hours are acceptable.		O&M shall be completed per the City's typical sewer system practices.	Complex and increased O&M for an additional pump station and large scale storage unit.	Significant length of sewer to be added to City Asset.	No ongoing O&M needs.	Increased O&M for an additional pump station.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	Increased O&M for an additional pump station.
						Score	20	0	0	20	0	20	20	20	20	0
						Total Score (Economic)	45	30	20	30	30	30	50	70	45	25

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Table H-2 - Triple Bottom Line Criteria, Evaluation ar

		19	20	21	23	24	25	27	28	29	30	31
TBL Ranking Criteria	Methodology and Indicator	Reprofile Prospect Avenue	Brock St - Inspect Shoreline and Outfall Condition and Develop Local Repair Plan	Reprofile Mill Street	McKee Park Improvements to be constructed above Detroit River high water level	Maplewood Drive Sanitary Pump Station Improvements	Maplewood Drive and Sprucewood Avenue Drainage Maintenance	Ojibway Parkway - Roadside Ditch Maintenance	Ojibway Parkway Drainage Improvements	Install Rain Catchers	Russell Street Local Drainage Improvements	Morton Ave. Drainage Improvements
ECONOMIC												
Cost effectiveness	Projects with lower capital costs impacts taxpayers the least and will require less budget allocation.	Cost Between $1-4M	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.	Cost > $4M	Cost > $4M	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.	Cost/< $1M or Private Property Costs.
		10	20	20	20	20	0	0	20	20	20	20
Asset Risk Rating	Higher priority if asset condition indicates need for refurbishment or replacement.	Drainage swales and road in poor condition.	Infrastructure in poor condition.	Road and drainage acceptable condition.	Park facilities acceptable condition.	New Infrastructure.	Drainage swales and road should be maintained.	Drainage swales and road should be maintained.	Drainage swales and road should be maintained.	New Infrastructure.	Drainage swales and road should be maintained.	Drainage swales and road should be maintained.
		10	10	0	0	0	10	10	10	0	10	10
Synergistic implementation, timing with other projects or opportunities *e.g. Gordie Howe Bridge, Sandwich St reconstruction, Great Lakes WQA*	Higher priority and advantages for earlier action if synergistic opportunities support co-funding or achieve similar goals *e.g. Intl Bridge; GLWQA*	Opportunity to complete this work in conjunction with the new RTB's outlet to the Detroit River.	Works to be done independent from other projects.	Works to be done independent from other projects.	Funding opportunities available in conjunction with the Gordie Howe Bridge.	Works to be done independent from other projects.	Works to be done independent from other projects.	Works to be done independent from other projects.	Works to be done independent from other projects.	Works to be done independent from other projects.	Works to be done independent from other projects.	Works to be done independent from other projects.
		20	0	0	20	0	0	0	0	0	0	0
If solution fails or is not implemented, high replacement costs or extreme challenges if catastrophic failure occurs (e.g. high costs to replace, time without services)	Higher priority for action if high costs or long disruptions could be incurred from catastrophic failure of critical asset *e.g. Lou Romano WWTP, pumping stations*	High Reduction	Median Reduction	High Reduction	Low Reduction	Low Reduction	Low Reduction	Low Reduction	Low Reduction	Low Reduction	Low Reduction	Low Reduction
		10	5	10	0	0	0	0	0	0	0	0
Ease, cost and complexity of measure's ongoing operations and maintenance.	Higher acceptance for action if ongoing O&M efforts are relatively lower.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	Increased O&M for an additional pump station.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.	O&M shall be completed per the City's typical sewer system practices.
		20	20	20	20	0	20	20	20	20	20	20
		70	55	50	60	20	30	30	50	40	50	50

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	1	2	3	4	5	6	8
			0	5	10		Install Backflow Prevention at CSOs along Detroit River	Lou Romano RTB	Combined Sewer Separation	Install Basement Flood Protection Measures	Prince Road Trunk Storm Sewer Outfall and Pump Station	Detroit Street Trunk Storm Sewer and Outfall	Sandwich Street Drainage Improvements
SOCIAL													
Level of Basement Flooding	Higher priority and need for action in areas with greatest basement flooding risks and for solutions that mitigate basement flood risk.	2	Lowest amount of basement flooding risk mitigation by the solution.		Highest amount of basement flooding risk mitigation by the solution.	Solutions that will reduce extraneous flows entering the system or will reduce sanitary sewer system hydraulic gradeline levels.	Reduces backflow of river water into the sanitary system.	Reduces risk of backup of wastewater within the sanitary system.	Reduces inflow of rainwater into the into the sanitary system.	Direct protection of individual basement flood risk is most effective.	Supports combined sewer separation which reduces basement flood risk.	Marginal impact to basement flood risk.	Solution will not directly reduce basement flood risk.
						Score	20	20	20	20	10	0	0
Level of Extent of Surface and Coastal Flooding	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Lowest amount of flooding risk mitigated by the solution.		Highest amount of flooding risk mitigated by the solution.	Total Area of 1:100 year flood risk being removed.	Median level of surface flood risk reduction.	Low level of surface flood risk reduction.	Low level of surface flood risk reduction.	Low level of surface flood risk reduction.	High level of surface flood risk reduction.	Mid level improvement for surface and coastal flood risk reduction. Up	High level of surface flood risk reduction.
						Score	10	0	0	0	20	10	20
Access Risk - Level of Risk to Roadways or Railway Crossing	Higher priority and need for action if surface flooding along major arterial roadways impacts for emergency access and continue critical transportation connections.	2	Solution mitigates flooding along Collector roadways.	Solution mitigates flooding along Arterial Roadways - do NOT provide critical connections.	Solution mitigates flooding along Arterial roadways and Railway Corridors – DO provide critical connections (hospital routes, border access).	Road classifications from the City's Data System (2021).	No impact to surface flooding.	No impact to surface flooding.	Reduction of surface flooding throughout study area.	No impact to surface flooding.	Direct benefit on Prince Road which provide access to Hôtel-Dieu Grace Healthcare.	Collector Roadways.	Collector Roadway.
						Score	0	0	0	0	20	0	0
Public Confidence & City Reputation	Higher priority and need for action if greater population density in area (reflecting potentially displeased citizens)	1	Low Density of homes/businesses within area impacted by potential service disruptions.	Mid Level Density of homes/businesses within area impacted by potential service disruptions.	High Density of homes/businesses within area impacted by potential service disruptions.	High Density = Residential/Urban Areas Mid Level Density = Commercial Developments, Industrial Sites Low Level Density = Vacant and Industrial Sites	High Density	Regional Solution impacts all development areas.	Regional Solution Benefital all development areas.	High Density	High Density	High Density	Low Density
						Score	10	10	10	10	10	10	0
Level of Disruption to Archaeological and Cultural Heritage Resources	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Significant impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.		Minimal impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.	Any excavation works along the waterfront areas (high archaeological risks) or construction impacts to private property areas that may contain built heritage features and/or cultural landscapes such as parks, naturalized areas.	Mid Level impact. May require some excavation to construct CSO Chambers.	Mid Level impact. May require some excavation to construct RTB chamber and sanitary trunk sewers.	Significant level of distruption throughout the study area to separate combined sewer.	Minimal Impact, Assume areas are already disturbed.	High level of impact due to location of works.	High level of impact due to location of works.	Minimal Impact, Assume areas are already disturbed.
						Score	10	10	0	20	0	0	20
						Total Score (Social)	50	40	30	50	60	20	40

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Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	15	16	18	19	20	21	23
			0	5	10		McKee Creek Drain Maintenance from Detroit River to Sandwich Street	McKee Creek Drain Improvements	Prospect Outlet Dewatering Pump Station	Reprofile Prospect Avenue	Brock St - Inspect Shoreline and Outfall Condition and Develop Local Repair Plan	Reprofile Mill Street	McKee Park Improvements to be constructed above Detroit River high water level
SOCIAL													
Level of Basement Flooding	Higher priority and need for action in areas with greatest basement flooding risks and for solutions that mitigate basement flood risk.	2	Lowest amount of basement flooding risk mitigation by the solution.		Highest amount of basement flooding risk mitigation by the solution.	Solutions that will reduce extraneous flows entering the system or will reduce sanitary sewer system hydraulic gradeline levels.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.
						Score	0	0	0	0	0	0	0
Level of Extent of Surface and Coastal Flooding	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Lowest amount of flooding risk mitigated by the solution.		Highest amount of flooding risk mitigated by the solution.	Total Area of 1:100 year flood risk being removed.	Median level of surface flood risk reduction.	High level of surface flood risk reduction.	High level of surface flood risk reduction.	High level of surface flood risk reduction.	Median level of surface flood risk reduction.	High level of surface flood risk reduction.	Median level of surface flood risk reduction.
						Score	10	20	20	20	10	20	10
Access Risk - Level of Risk to Roadways or Railway Crossing	Higher priority and need for action if surface flooding along major arterial roadways impacts for emergency access and continue critical transportation connections.	2	Solution mitigates flooding along Collector roadways.	Solution mitigates flooding along Arterial Roadways - do NOT provide critical connections.	Solution mitigates flooding along Arterial roadways and Railway Corridors – DO provide critical connections (hospital routes, border access).	Road classifications from the City's Data System (2021).	Proximity to Essex Terminal Railway (ETR)	Proximity to Essex Terminal Railway (ETR)	Collector Road however no other egress/ingress.	Collector Road however no other egress/ingress.	Collector Road	Arterial Roadway	Collector Road
						Score	20	20	20	20	0	10	0
Public Confidence & City Reputation	Higher priority and need for action if greater population density in area (reflecting potentially displeased citizens)	1	Low Density of homes/businesses within area impacted by potential service disruptions.	Mid Level Density of homes/businesses within area impacted by potential service disruptions.	High Density of homes/businesses within area impacted by potential service disruptions.	High Density = Residential/Urban Areas Mid Level Density = Commercial Developments, Industrial Sites Low Level Density = Vacant and Industrial Sites	Low Density	Low Density	Low Density	Low Density	High Density	High Density	High Density
						Score	0	0	0	0	10	10	10
Level of Disruption to Archaeological and Cultural Heritage Resources	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Significant impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.		Minimal impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.	Any excavation works along the waterfront areas (high archaeological risks) or construction impacts to private property areas that may contain built heritage features and/or cultural landscapes such as parks, naturalized areas.	High level of impact due to location of works along River waterline.	High level of impact due to location of works along River waterline.	Mid Level impact. Excavation for pump station required.	Mid Level impact. Regarding of existing roadway.	High level of impact due to location of works along River waterline.	Mid Level impact. Regarding of existing roadway.	High level of impact due to location of works along River waterline.
						Score	0	0	10	10	0	10	0
						Total Score (Social)	30	40	50	50	20	50	20

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TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	24	25	27	28	29	30	31
			0	5	10		Maplewood Drive Sanitary Pump Station Improvements	Maplewood Drive and Sprucewood Avenue Drainage Maintenance	Ojibway Parkway - Roadside Ditch Maintenance	Ojibway Parkway Drainage Improvements	Install Rain Catchers	Russell Street Local Drainage Improvements	Morton Ave. Drainage Improvements
SOCIAL													
Level of Basement Flooding	Higher priority and need for action in areas with greatest basement flooding risks and for solutions that mitigate basement flood risk.	2	Lowest amount of basement flooding risk mitigation by the solution.		Highest amount of basement flooding risk mitigation by the solution.	Solutions that will reduce extraneous flows entering the system or will reduce sanitary sewer system hydraulic gradeline levels.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.	Reduces quantity of stormwater entering the sanitary sewer system.	Solution will not directly reduce basement flood risk.	Solution will not directly reduce basement flood risk.
						Score	0	0	0	0	10	0	0
Level of Extent of Surface and Coastal Flooding	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Lowest amount of flooding risk mitigated by the solution.		Highest amount of flooding risk mitigated by the solution.	Total Area of 1:100 year flood risk being removed.	High level of surface flood risk reduction.	High level of surface flood risk reduction.	Median level of surface flood risk reduction.	High level of surface flood risk reduction.	Low level of surface flood risk reduction.	High level of surface flood risk reduction.	Median level of surface flood risk reduction.
						Score	20	20	10	20	10	20	10
Access Risk - Level of Risk to Roadways or Railway Crossing	Higher priority and need for action if surface flooding along major arterial roadways impacts for emergency access and continue critical transportation connections.	2	Solution mitigates flooding along Collector roadways.	Solution mitigates flooding along Arterial Roadways - do NOT provide critical connections.	Solution mitigates flooding along Arterial roadways and Railway Corridors – DO provide critical connections (hospital routes, border access).	Road classifications from the City's Data System (2021).	Collector Road	Collector Road	Arterial Roadway (Emergency Route)	Arterial Roadway (Emergency Route)	No road surface impact.	Collector Road	Collector Road
						Score	0	0	20	20	0	0	0
Public Confidence & City Reputation	Higher priority and need for action if greater population density in area (reflecting potentially displeased citizens)	1	Low Density of homes/businesses within area impacted by potential service disruptions.	Mid Level Density of homes/businesses within area impacted by potential service disruptions.	High Density of homes/businesses within area impacted by potential service disruptions.	High Density = Residential/Urban Areas Mid Level Density = Commercial Developments, Industrial Sites Low Level Density = Vacant and Industrial Sites	Low Density	Low Density	Low Density	Low Density	Retrofit of manholes is proposed within high density areas.	Low Density	Low Density
						Score	0	0	0	0	10	0	0
Level of Disruption to Archaeological and Cultural Heritage Resources	Higher priority and need for action in areas with greatest flooding risks associated with high water levels and for solutions that mitigate surface flood risk.	2	Significant impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.		Minimal impact to Archaeological and Cultural Heritage Resources due to construction excavations and new infrastructure.	Any excavation works along the waterfront areas (high archaeological risks) or construction impacts to private property areas that may contain built heritage features and/or cultural landscapes such as parks, naturalized areas.	High level of impact due to location of works along River waterline.	Low level of impact.	Low level of impact.	Low level of impact.	Low level of impact.	Low level of impact.	Mid Level impact. Regarding of existing roadway.
						Score	0	20	20	20	20	20	10
						Total Score (Social)	20	40	50	60	50	40	20

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Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	1	2	3
			0	5	10		Install Backflow Prevention at CSOs along Detroit River	Lou Romano RTB	Combined Sewer Separation
ENVIRONMENTAL									
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Minimal reduction in number of CSO events.	Will measurably reduce the frequency of CSOs.	Removing stormwater from wastewater system will reduce the number of CSO events.
						Score	0	20	20
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Reduces number of combined/sanitary sewer system back up events.	Reduces number of combined/sanitary sewer system back up events.	Reduces number of combined/sanitary sewer system back up events.
						Score	20	20	20
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	New/bigger pump station will have higher electrical needs.	No electricity required for long term solution implementation.
						Score	10	0	10
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at least one of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves two or more of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Reduces basement flood risk including health risks associated with sewage backup.	Reduces basement flood risk including health risks associated with sewage backup.	Reduces basement flood risk including health risks associated with sewage backup.
						Score	10	20	20
						Total Score (Environmental)	40	60	70

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TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	4	5	6	8
			0	5	10		Install Basement Flood Protection Measures	Prince Road Trunk Storm Sewer Outfall and Pump Station	Detroit Street Trunk Storm Sewer and Outfall	Sandwich Street Drainage Improvements
ENVIRONMENTAL										
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Does not reduce risk of CSOs.	Improving stormwater drainage will reduce CSO frequency.	Does not significantly reduce risk of CSOs.	Improving stormwater drainage will reduce CSO frequency.
						Score	0	10	0	10
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Does not reduce number of combined/sanitary sewer system back up events.	Reduces number of combined/sanitary sewer system back up events.	Reduces number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.
						Score	0	20	20	0
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	New/bigger pump station will have higher electrical needs.	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.
						Score	10	0	10	10
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at least one of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves two or more of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Reduces basement flood risk including health risks associated with sewage backup.	Reduces basement flood risk including health risks associated with sewage backup.	Reduces basement flood risk including health risks associated with sewage backup.	Minimal health or well being benefits.
						Score	20	20	20	0
						Total Score (Environmental)	30	50	50	20

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Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	15	16	18	19
			0	5	10		McKee Creek Drain Maintenance from Detroit River to Sandwich Street	McKee Creek Drain Improvements	Prospect Outlet Dewatering Pump Station	Reprofile Prospect Avenue
ENVIRONMENTAL										
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Improving stormwater drainage will reduce CSO frequency.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.
						Score	10	0	0	0
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.
						Score	0	0	0	0
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	New/bigger pump station will have higher electrical needs.	New/bigger pump station will have higher electrical needs.	
						Score	10		0	
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at <u>least one of</u>: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves <u>two or more</u> of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Minimal health or well being benefits.	Minimal health or well being benefits.	Minimal health or well being benefits.	Minimal health or well being benefits.
						Score	0	0	0	0
						Total Score (Environmental)	20	0	0	0

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TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	20	21	23	24
			0	5	10		Brock St - Inspect Shoreline and Outfall Condition and Develop Local Repair Plan	Reprofile Mill Street	McKee Park Improvements to be constructed above Detroit River high water level	Maplewood Drive Sanitary Pump Station Improvements
ENVIRONMENTAL										
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.
						Score	0	0	0	0
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.
						Score	0	0	0	0
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.	New/bigger pump station will have higher electrical needs.
						Score	10	10	10	0
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at <u>least one of</u>: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves <u>two or more</u> of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Minimal health or well being benefits.	Minimal health or well being benefits.	Benefit related to the maintenance of public park access.	Minimal health or well being benefits.
						Score	0	0	20	0
						Total Score (Environmental)	10	10	30	0

West Windsor Flood Protection Study -
Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	25	27	28	29
			0	5	10		Maplewood Drive and Sprucewood Avenue Drainage Maintenance	Ojibway Parkway - Roadside Ditch Maintenance	Ojibway Parkway Drainage Improvements	Install Rain Catchers
ENVIRONMENTAL										
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.	Reducing stormwater entering the wastewater system have some benefit.
						Score	0	0	0	20
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.	Reduce number of combined/sanitary sewer system back up events.
						Score	0	0	0	20
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.
						Score	10	10	10	10
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at least one of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves two or more of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Minimal health or well being benefits.	Minimal health or well being benefits.	Minimal health or well being benefits.	Minimal health or well being benefits.
						Score	0	0	0	0
						Total Score (Environmental)	10	10	10	50

West Windsor Flood Protection Study -
Table H-2 - Triple Bottom Line Criteria, Evaluation and Scoring

TBL Ranking Criteria	Methodology and Indicator	Weighting	Comparison Score: 0/5/10			Source of Comparison Data and Comments	30	31
			0	5	10		Russell Street Local Drainage Improvements	Morton Ave. Drainage Improvements
ENVIRONMENTAL								
CSO overflows	Higher priority and need for action if solution reduces CSO overflow risks.	2	Lowest reduction of CSO Frequency.		Highest reduction of CSO Frequency.	High reduction of CSO events may be attributed to solutions that reduce stormwater inflow or reduces the HGL in the into the sanitary system.	Does not reduce risk of CSOs.	Does not reduce risk of CSOs.
						Score	0	0
Risk of contaminants reaching Detroit River or other sensitive habitat.	Higher priority and support for action if solution reduces land contamination risks for sensitive habitat and the Great Lakes Area of Concern	2	Does NOT notably reduce contaminant risks.	Reduces amount of contaminants from reaching Detroit River or sensitive habitat.	Prevents or contains land contaminants from reaching Detroit River or sensitive habitat.	Contaminate risk associated with sewage backup from combined sewer on surface.	Does not reduce number of combined/sanitary sewer system back up events.	Does not reduce number of combined/sanitary sewer system back up events.
						Score	0	0
Reduces GHG and/or air quality emissions.	Higher priority and support for action if solution offers emission or GHG reductions (e.g. reduces loads on LRWRP, reduced electricity for pumping)	2	May add to GHG emissions (e.g. increased electricity, fossil fuel needs).		Potential for emission reductions.	Qualitative evaluation (e.g. additional electricity, additional LRWRP treatment, etc.)	No electricity required for long term solution implementation.	No electricity required for long term solution implementation.
						Score	10	10
Human Health and/or Well-Being	Higher priority and support for action if the public can be warned and can take action to reduce their health and safety risks, encourage inclusion and well-being (e.g. shading, parks, recreation).	2	Does not increase public response times to reduce of health and safety risks (e.g. sewer backup, escape from heavy flooding hazards). Does not improve well-being or human health.	Improves at least one of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Improves two or more of: Increases public response times to reduce health and safety risks; Improves well-being or human health.	Human health is associated with reduction in basement flood risk or reduction of surface flooding. Well being is associated odour nuisance, aesthetics, beneficial uses, well-being and associated human health.	Minimal health or well being benefits.	Minimal health or well being benefits.
						Score	0	0
						Total Score (Environmental)	10	10

Appendix H

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