Township of Madawaska Valley
Road Flooding Risk

Final

November 27, 2025

Agile
INFRASTRUCTURE

Table of Contents

1 Introduction

1.1 Project Overview

Agile Infrastructure Limited was retained by the Canadian Urban Institute (CUI) to provide expertise to the Township of Madawaska Valley following a catastrophic rain event in 2024 that caused significant damage to various road segments across the community.

The project focuses on understanding road flooding risks throughout the road network by evaluating the road cross-culverts and ditches that combine to perform road drainage functions and offering mitigation options to improve the network's resiliency to climate events.

Key objectives include:

- Understanding flooding risks for all roads in the Township using historic and forecasted climate data, topographic data, and drainage system (culverts and ditches) information.
- Providing analysis results and recommendations that the Township can use to enhance resilience against future significant precipitation and runoff events, and the potential effects of climate change.

1.2 Project Outcomes

The outcomes of the analysis support the Township in both the short and long term:

1. In the short term, there are recommendations for isolated ditch or culvert improvements to improve the road resilience.
2. In the medium to long term, staff can confirm the required culvert diameter for any replacements that are occurring as part of a road reconstruction project in the 2026 (and beyond) capital plan.

2 Data Sources

The following data sources were used in the analysis:

Publicly Available:

- Medium resolution digital elevation data for Canada
- Ontario roads layers
- National Hydraulic Network for stream layers
- HYDAT hydraulic data
- IDF data for the Combermere, ON climate station (STN_ID 4252), elevation ~286 m (ID 6101820)

Township data:

- Culverts inventory

3 Field Data Collection

The project included an effort to collect additional field data. The locations visited were prioritized based on estimated flow runoff rates and at locations with recent flooding issues. The project team visited approximately 50 culverts and collected the following information:

- Pictures
- Culvert dimensions (diameter and invert elevations)
- Road width
- Road freeboard (i.e. vertical distance from culvert obvert to road surface)
- Upstream and downstream water conditions
- Culvert material
- Culvert physical condition (based on visual observation)

4 Review of 2024 Event

4.1 Event Overview

On August 18, 2024, the Township of Madawaska Valley experienced severe flooding and road damage due to heavy rainfall from the remnants of Tropical Cyclone Debby. The area, already saturated from prior storms, received unprecedented precipitation, with 51.5 mm falling between noon and 2 pm, after previously receiving 41.3 mm on August 17. This isolated event caused rapid erosion, washouts, and infrastructure collapse across multiple roadways (refer to Figure 1 for a map of these locations):

- At 1 pm, the Township received reports of flooding on Lower Craigmont Road near Combermere. At 1:30 pm, staff observed water 150 mm to 200 mm deep flowing down the adjacent hillside, overwhelming culverts and ditches
- By 2:45 pm, a resident reported a washout on Perrier Road. Township staff arrived to at 2:53 to observe that half of the roadway had completely washed out and collapsed
- At 3:22 pm, Township staff were contacted by Renfrew County staff who indicated two County roads in the Township (Rockingham Road and Dafoe Rao) were also washed out.
- At 3:34, Township staff observed 200 mm of water flowing over Old Barry's Bay Road.
- At 4:08 pm, staff received a call that Stanley Olsheski Road was washed out entirely.

Total impacted roads requiring rehabilitation activities included 631 m of Stanley Olsheski Road, 203 m of Lower Craigmont Road, and 196 m of Perrier Road.

Repairs began immediately and persisted through the week. On Perrier Road, the damage required external contractor supports, with a request for quotation issued Friday, August 23 and the contractor beginning work on September 6. The Township filed a funding request through the Ontario Municipal

Disaster Recovery Assistance Program for $195,821.49, which was the total cost paid to all contracts for repairs.

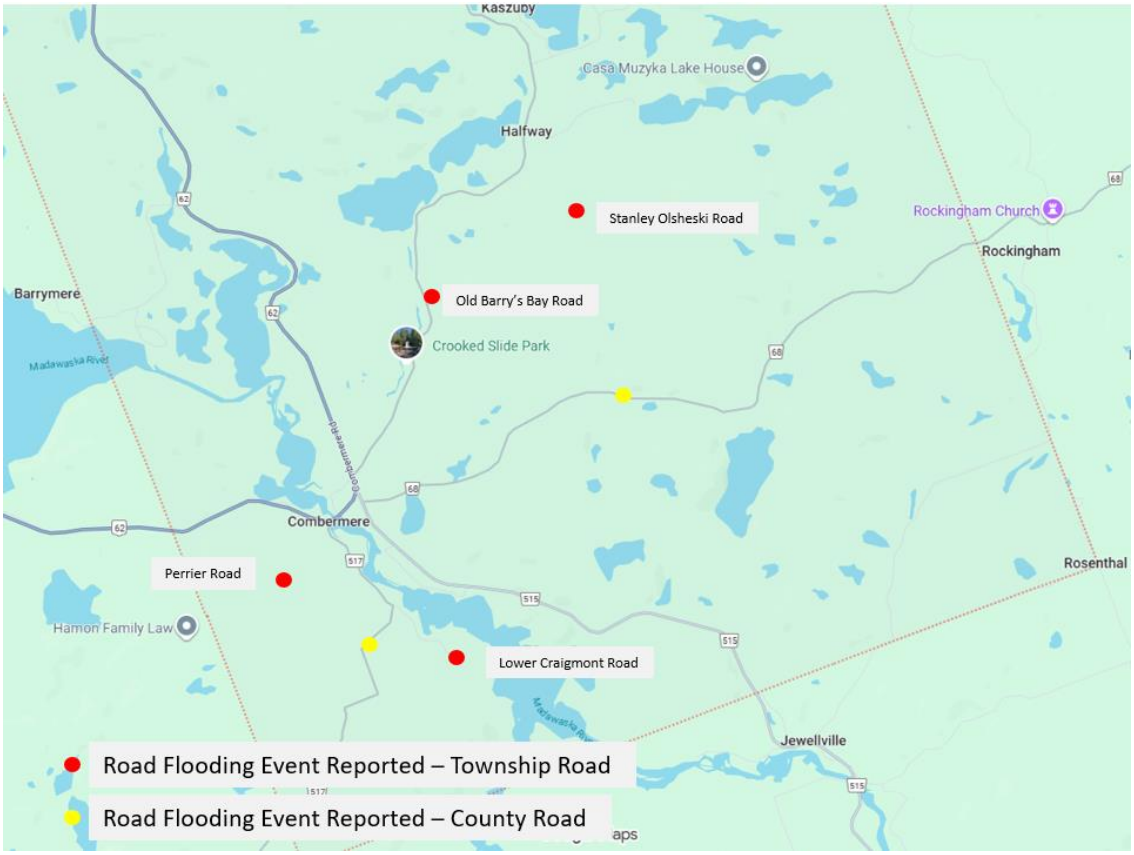


Figure 1 – Locations of Road Flooding on August 18, 2024

4.2 Return Period Analysis

The rainfall estimates provided in Section 4.2 can be used to establish the return period of the event by reviewing the IDF information for the Combermere location[1]. The information is presented below.

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.9	12.2	13.8	17.0	20.9	25.7	35.8	44.2	54.4
5-yr	13.2	16.2	18.3	22.6	27.8	34.2	47.7	58.7	72.4
10-yr	15.3	18.8	21.3	26.2	32.3	39.8	55.4	68.2	84.1
25-yr	17.9	22.1	25.0	30.8	37.9	46.7	65.0	80.1	98.6
50-yr	19.9	24.6	27.7	34.2	42.1	51.9	72.2	88.9	109.6
100-yr	21.9	27.0	30.5	37.6	46.3	57.0	79.4	97.8	120.5

[1] https://idfcurves.mto.gov.on.ca/results_out.shtml?coords=45.365534,-77.615677

The return period analysis is as follows:

- 41.3 mm in 24 hours on August 17, 2024 is equal to just under the 2-year return period event (which is 54.4 mm in 24 hours in the table above).
- 51.5 mm in 2 hours on August 18, 2024 is approximately equal to the 50-year return period event (which is 51.9 mm in 2 hours in the table above).

5 Road Flooding Analysis

5.1 Vulnerable Areas

Over the course of the project, through both discussions with Township staff and the field visits, there were seven vulnerable areas identified. Four of the locations were identified during the August 18, 2024 event as described in Section 5.1. Three additional areas were identified during the field visit. The locations are as follows

1. Stanley Olsheski Road
2. Perrier Road
3. Lower Craigmont Road
4. Old Barry's Bay Road
5. Martin Siding Road
6. Peplinski Road
7. Wilno Road North

Appendix A provides the following for each area:

- Location with Google Map link
- Description of Program
- Solutions
- Picture Map showing the general area
- Pictures of each area to showcase the problem

The overall recommendations for 4 of these areas are related to improving ditch resilience to high water velocities during heavy flow events through improved armouring. This involves constructing the ditch with larger riprap rock that resist washout. The recommendations for these areas also include installing check dams, which work to slow down water velocities and reduce sediment transport.

5.2 Individual Culvert Needs

During the field investigation, there were needs identified at eight individual culverts:

- 6 culverts that had structurally failed.
- 1 culvert that required upstream brushing to clean the inlet.
- 1 location where there was no culvert observed, but there was clearly a natural creek that regularly washes over the road (and therefore a culvert should be installed).

Appendix B provides the following for each culvert:

- Map Link
- Comment
- Pictures

5.3 Culvert Hydraulic Analysis

To support future culvert sizing decisions, the project also reviewed the hydraulic capacity of the Township's culverts. This section describes this process.

5.3.1 Culvert Inventory

The Township has an inventory with 632 cross culverts. The following points summarize the completeness of the inventory:

- All 632 culverts have an x/y coordinate, meaning they can be plotted on a map.
- 453 of the culverts had no other information other than their physical location.
- 179 of the culverts had diameter, length, and a condition rating from 2010.
    - 3 culverts have a diameter of 250 mm
    - 50 culverts had a diameter of 300 mm
    - 77 culverts have a diameter of >300 mm and < 600 mm
    - 26 culverts have a diameter of > 600 mm and < 900 mm
    - 23 culverts have a diameter of > 900 mm

For the purposes of this report, a minimum culvert diameter of 300 mm has been assumed for any culvert with missing size information, as it is assumed that these culverts were not originally prioritized for data collection in 2010 due to their small size. Township staff will continue to collect information for these culverts in the future, and the analysis will be updated to reflect the actual size information.

5.3.2 Culvert Design Standards

The following points summarize the culvert flow design standards from the Ontario Ministry of Transportation Highway Draining Design Standards (MTO; 2008):

- Culverts on Local Roads with a span less than 6.0 m should convey the 10-year flows (Standard WC-1).
- 400 mm minimum culvert diameter for local roads and private entrances (Standard WC-8).

The Standard only applies to roads under the jurisdiction of the MTO. The Township's roads have lower volumes, as such it may be appropriate to lower the design flow and the minimum culvert diameter.

The hydraulic analysis section has been completed for a range of flow events, from 2-year to 100-year. This provides the Township with perspective when deciding on the culvert diameter for any replacement activities completed moving forward.

5.3.3 Hydraulic Analysis Approach

The following points describes the culvert hydraulic performance analysis methodology:

1. **Calculation of Runoff Flow Rates**: The first step was to forecast flow rates reaching every culvert. The included the application of baseline and forecasted Intensity-Duration-Frequency (IDF) data from idfcurves.mto.gov.on.ca against a topographic analysis to establish catchment areas for each culvert. Flow rates were calculated for the 2-, 10-, 25-, 50-, and 100-year return periods for 5 scenarios:
    - Historic baseline
    - Representative Concentration Pathway (RCP) of 4.5 W/m^2 for +30-year horizon
    - RCP of 4.5 W/m^2 for +50-year horizon
    - RCP of 8.5 W/m^2 for +30-year horizon
    - RCP of 8.5 W/m^2 for +50-year horizon

    The example Figure 2 graph is available for each culvert.
2. **Identify Probable Missing Culvert**: The analysis determined 201 locations where there is a probable chance that a culvert does exist but is not contained in the Township's inventory. This is because the topographic analysis shows a clear catchment resulting in reasonable flows at this location, where it intercepts a roadway, but no culvert is in the vicinity. These locations will be investigated by the Township in a priority manner to determine if a culvert exists, and if so, to collect the information in the inventory.
3. **Culvert Capacity Analysis**: 179 culverts had sufficient information to enable a reasonable capacity calculation. For the remaining 453 culverts, a capacity equal to a 300 mm diameter was assumed because it is likely that these are culverts that support water draining across a road and are not in a defined stream pathway. The capacity is then compared against the flow forecasts to determine what return period event can be conveyed through the culvert before surcharging and potential road over-topping occurs.

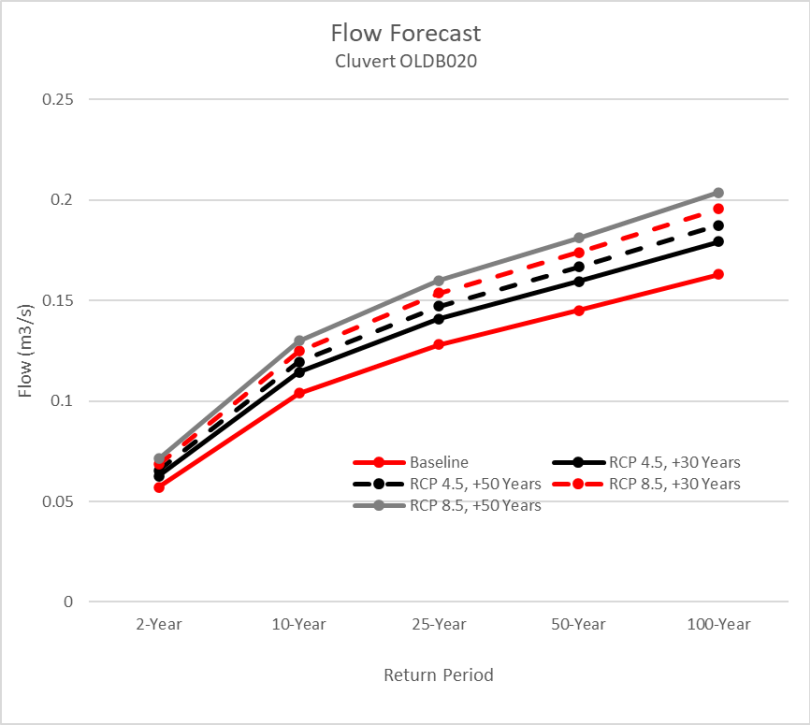


Figure 2 – Typical Culvert Flow Forecast

4. **Culvert Hydraulic Performance Category**: A Hydraulic Performance Category was assigned to each culvert and related road segment based on the combined hydrologic and hydraulic analyses. The following performance categories were assigned to each culvert based on the analysis:

    - **Good Performance** means the culvert has ample capacity to convey the worst-case (i.e. flows based on the RCP 8.5, +50 Year scenario) 10-year flow estimate (i.e. the ideal design standard) and is in acceptable physical condition. These culvert sizes are appropriate.
    - **Fair Performance** means the culvert has approximately the same capacity as the worst-case 10-year flow estimate and is in acceptable physical condition. If possible, these culverts should be made larger if feasible when they are replaced.
    - **Poor Performance** means the culvert is too small to convey the worst-case 10-year flow estimate and is in acceptable physical condition. These culverts should be made larger when they are replaced.
    - **Failed** means the culvert has failed from an engineering perspective, meaning the culvert has partially collapsed or the invert of the culvert is partially rusted through (reducing its structural integrity).

5.3.4 Culvert Hydraulic Performance Results

The results are delivered in web-browser ready maps and graphs. The results include:

1. A culvert capacity versus flow graph:
    - Culvert Capacity (vertical axis) and Culvert Flow (horizontal axis) are plotted against each other.
    - The diagonal line is when 'Flow'=Capacity:
        - Culverts below the line are too small (red).
        - Culverts above the line have sufficient size (green)
        - Culverts near the line are close, but not below, the threshold capacity (yellow).
    - The graphs are available for all of the return period events, with and without climate change.

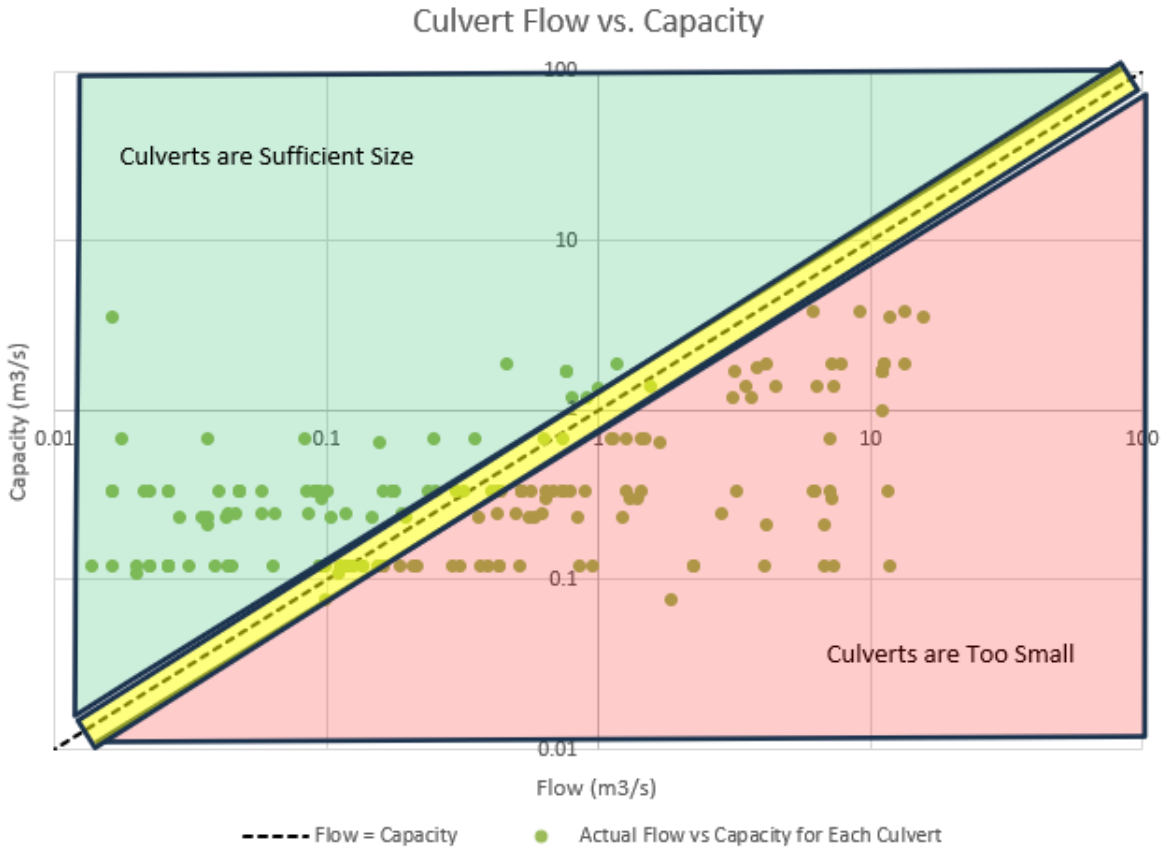


Figure 3 – Capacity vs Flow for 179 Culverts with Capacity Information, 2-year Event

2. An interactive map:
    - This is intended to help the Township quickly understand if a culvert should be bigger in the immediate repair process to fix a washed-out road section.
    - The map shows all culverts, categorized as follows:
        - The 179 culverts with sufficient data to determine capacity are coloured based on their hydraulic performance (red = too small, yellow = borderline, green = sufficient size). Township staff can click on each of these culverts to see catchment area and flow runoff estimates, which then supports real-time decisions to decide what size of culvert to install if there has been a failure.
        - The remaining culverts are identified as hollow black circles. The Township can use this to prioritize additional culvert data collection. These culverts are shown as 'No Data' even though their size has been assumed, rather than indicating their capacity performance based on the analysis. This ensures that staff understand that the culvert is missing data and that the diameter should be measured and the analysis updated before making decisions about the size of a culvert to install in a particular location.

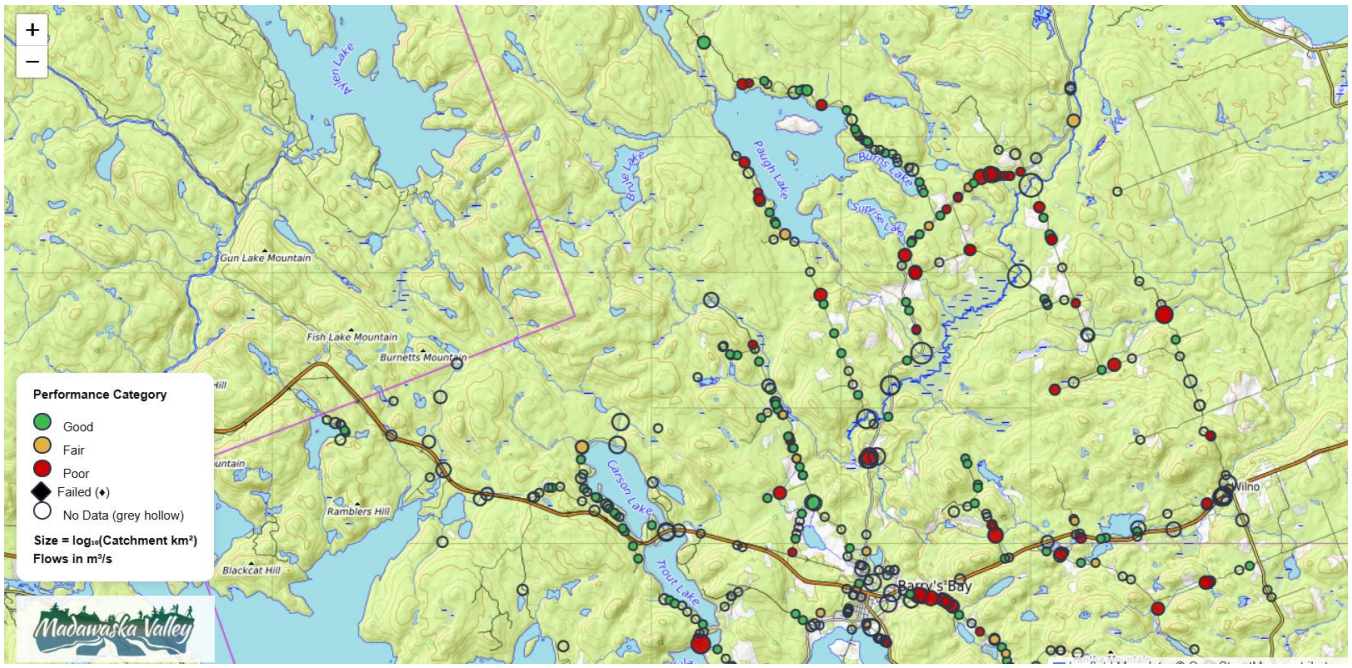


Figure 5 – Map Showing Culvert Hydraulic Performance Category for Several Culverts

6 Recommendations

The following recommendations are proposed to enhance the resiliency of the road network to flooding events:

1. **Improvements to Vulnerable Area**
    - The project identified 7 specific areas where ditch upgrades along road segments will increase resilience to road washouts. Four of these areas were identified during the August 18, 2024, flooding event, and three additional areas were noted during the July 2025 field visit.

      Areas impacted on August 18, 2024:

        1. Stanley Olsheski Road - Make the north ditch larger and appropriately armoured with check dams.
        2. Perrier Road - To prevent the diversion, the south ditch needs to be blocked to force water to go through the culvert. The south ditch also requires additional armouring with check dams. The culverts should be installed to direct the north ditch flows into the woods.
        3. Lower Craigmont Road – No improvement works recommended.
        4. Old Barrys Bay Road – Install larger culverts at two locations.

      Additional vulnerable areas identified during the field visit:

        5. Martin Siding Road - Install a longer and larger culvert, a wider road platform with proper slope.
        6. Peplinski Road - Make the south ditch larger and better armoured with check dams.
        7. Wilno Road North – Make the west ditch larger and better armoured with check dams.
    - The Township should make improvements to these areas as the budget and schedule permit.
2. **Improvements to Individual Culverts**
    - The project identified 8 culverts where isolated work is recommended.
    - The Township should complete the work as the budget and schedule permit.

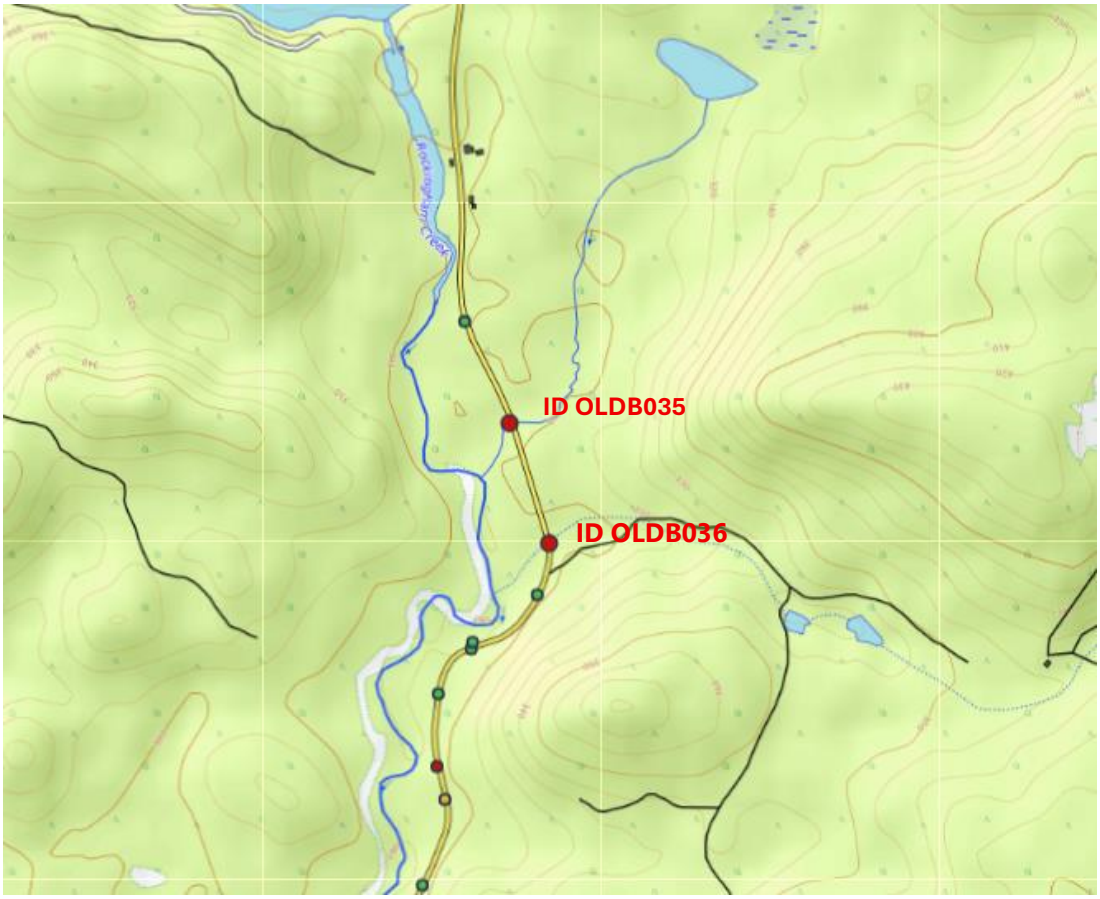
3. **Incorporate Changes to 2026 and Beyond Capital Program**
    - The Township completes a major road reconstruction project every few years. As part of these projects, the culverts on the road segments are often replaced due to their age and condition.
    - The Township should review the hydraulic performance of the culverts that are being replaced and install a larger culvert if necessary.
4. **Opportunistic Culvert Upsizing**
    - It is not financially feasible for the Township to replace all of the undersized culverts.
    - When a road over-topping event occurs, the Township should review the hydraulic performance results of the nearby culverts. If there is already work required to reinstate the road, the Township should consider the opportunity to increase the culvert size or add a twin culvert.
5. **Additional Field Assessments**
    - The Township should continue to collect pictures and dimensions for culverts without this information. This will improve future updates to the culvert analysis.
6. **General Recommendations**
    - The following are common problems and solutions to improve the resiliency of the road network to flooding events:
        1. Steep roads lead to high water velocities.
            - A steep channel design standard with large rip rap and check dams should be applied to these areas if there is sufficient distance between the road property line and the road platform.
        2. Beaver blockages on smaller culverts.
            - Beavers tend to build dams to stop water from flowing in smaller culverts.
            - The Township should try to upsize culverts to a minimum of 1.2 m diameter in beaver-prone areas.
            - The Township should also purchase better beaver management equipment and perform regular debris removal.
        3. Culverts that are smaller than the natural river channel.
            - Even if the location is not prone to over-topping, having the culvert smaller than the natural river channel leads to debris accumulations on the upstream end.
            - Installing culverts that are at least as wide as the natural stream channel will result in improved performance.

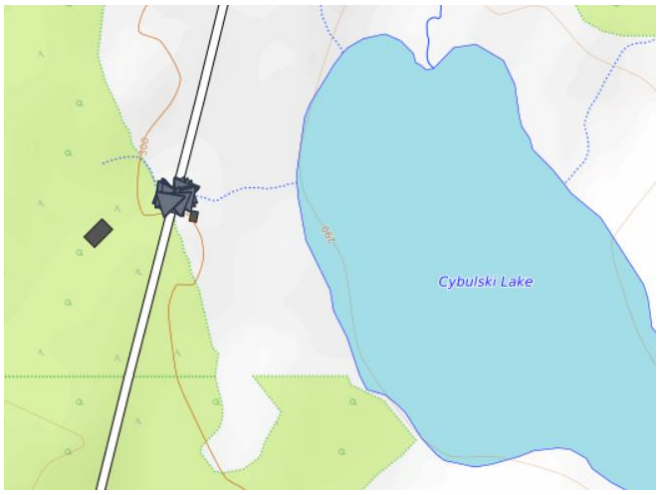
Appendix A – Analysis of Vulnerable Areas

Location 1	Stanley Olsheski Road https://maps.app.goo.gl/j8JkRLJFHCBbn8wy9
Description of Problem	The steep slope of the surrounding lands causes high water runoff velocity. The ditch has insufficient armouring to prevent scour issues, resulting in sediment moving.
Solutions	Make the east ditch larger and appropriately armoured with check dams.
Map	
Pictures	   

Location 2	Perrier Road https://maps.app.goo.gl/ve5VxWxF44vrRyvR8
Description of Problem	Surcharging of the culvert causes road overtopping. The water bypasses the culvert (diverts down the ditch). The road crown elevation is not high enough to retain water within the culvert.
Solutions	To prevent diversion, the south ditch needs to be blocked to force water to flow through the culvert. The south ditch also required additional armouring with check dams. The culverts should be installed to direct the north ditch flows into the woods.
Map	
Pictures	 

Location 3	Lower Craigmont Road https://maps.app.goo.gl/KEYBkG5nNYpfsEDS8
Description of Problem	• The steep hill to the south and west of Lower Craigmont Road results in high water velocities during heavy precipitation events.
Solutions	• Although there are debris and sediment flow concerns, the road did survive the 50-year flooding event. There is nothing that could be practically done by the Township to improve road resiliency.
Map	

Location 4:	Old Barrys Bay Road https://maps.app.goo.gl/DN4FzWrqUwdBb9gv8
Description of Problem	• Culverts ID OLDB035 and OLDB036 were calculated to have insufficient capacity. • This likely contributed to the road overtopping, but as noted in the report, there was no damage to this section.
Solutions	• The Township should install larger culverts at locations OLDB035 and OLDB036
Map	

Location 5:	Martin Siding Road https://maps.app.goo.gl/QziT18eb3LUtbguT9
Description of Problem	The culvert is not long enough and is too small. The roadside slope is too steep, resulting in instable shoulder and sediment washout during overtopping events.
Solutions	Install a longer and larger culvert, along with a wider road platform with a proper slope.
Photo Map	
Pictures	   

Location 6:	Peplinski Road https://maps.app.goo.gl/fpwuLVXuygxsFWY78
Description of Problem	The south ditch has naturally soft soils, which are not armoured enough.
Solutions	Larger and better armoured south ditch with check dams.
Photo Map	
Pictures	 

Location 7:	Wilno Road North https://maps.app.goo.gl/rzaej6sBfgBT4qKj6
Description of Problem	West ditch is insufficient.
Solutions	Larger and better armoured west ditch with check dams.
Photo Map	
Pictures	  

Appendix B – Individual Culvert Needs

Location 1	
Asset ID	**POTCREEK156**
Location	https://maps.app.goo.gl/epvxaTcJwZTFyvp89
Comment	The culvert has failed.
Picture **SQEX4646**	

Location 2	
Asset ID	**WIL3090**
Location	https://maps.app.goo.gl/tuhd6AS4HnUQc7kF6
Comment	The culvert has failed.
Picture **MSKE2667**	

Location 3	
Asset ID	**POTCREEK197**
Location	https://maps.app.goo.gl/JgGhudCnbw5WSafW7
Comment	The culvert has failed.
Picture **YEPH1410**	

Location 4	
Asset ID	**POTCREEK099**
Location	https://maps.app.goo.gl/Sbj9jB1Pr4QdKQxR9
Comment	The culvert has failed.
Picture LJEE6986	

Location 5	
Asset ID	**POTCREEK157**
Location	https://maps.app.goo.gl/HXBMjVDYWfbkQ7hc6
Comment	Clearing and grubbing are required upstream of the culvert.
Picture FOAW1894	

Location 6	
Asset ID	**OHI08**
Location	https://maps.app.goo.gl/pR1tjhUz6GTjGSvDA
Comment	The culvert has failed
Picture	

Location 7	
Asset ID	**OHI06**
Location	https://maps.app.goo.gl/RfsZssY94VUKybwi6
Comment	The culvert has failed.
Picture NPRJ1145	

Location 8	
Asset ID	**POTCREEK060**
Location	https://maps.app.goo.gl/V8dSBB5obsaBjqE16
Comment	Needs a new culvert. There is currently no culvert, but a natural creek is washing over the road.
Picture FMNR3635