Prepared for:

City of Markham

Engineering Department
101 Town Centre Blvd.
Markham, ON, L3R 9W3

Schedule B Municipal Class Environmental Assessment – Project File
Mount Joy Creek Flood Mitigation

Submitted by:

Aquafor Beech Limited

in association with

New Era Archaeology Inc.

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Contact:
Rob Amos, MASc, P. Eng
Aquafor Beech Limited
Amos.R@aquaforbeech.com
5405 Eglinton Ave W, Suite 106, Toronto, ON, M9C 5K6
T. 416.705.2367
Aquafor Beech Reference: 67657

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EXECUTIVE SUMMARY

Overview

The City of Markham (City) has commissioned Aquafor Beech Limited (Aquafor) to undertake a Municipal Class Environmental Assessment (MCEA) for the Mount Joy Creek corridor between Major Mackenzie Drive East and Bur Oak Avenue. This area is bordered between residential properties to the west and a Metrolinx Rail Corridor to the east, as is illustrated in **Figure 1** below.

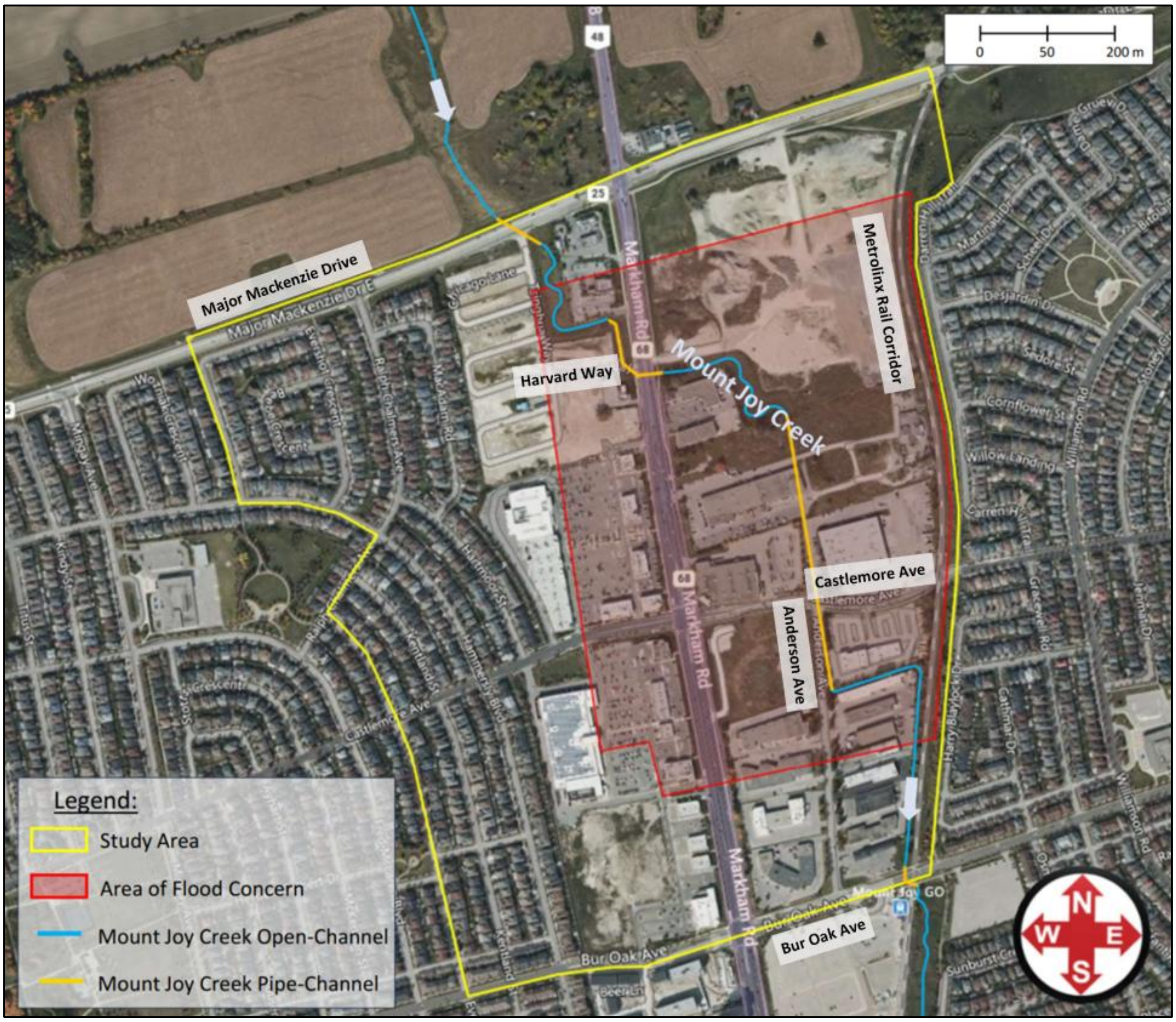

Figure 1: Study Area for the Municipal Class Environmental Assessment at Mount Joy Creek

Mount Joy Creek has undergone several modifications over the past decades. Within the study area, Mount Joy Creek is composed of a combination of piped and open channel segments. Culverts within the study area do not have sufficient capacity to convey peak flows. As a result, this has caused flooding at the inlets of the pipe and has led to localized floods within the study area.

Study Objective

The objective of the Municipal Class Environmental Assessment study is to propose flood mitigation alternatives that reduce frequent tableland flooding of the properties adjoining the creek corridor. This will also facilitate the future development ambition for the area defined in the recently completed Markham Road Mount Joy Secondary Plan, and other stakeholder initiates.

Development and Evaluation of Alternatives

Design alternatives for the watercourse were developed based on a series of existing conditions, inventories, and technical studies. These alternatives were evaluated based on a variety of criteria including social, economic, environmental, and technical considerations, to determine the preliminary preferred alternative. This evaluation process was further refined through First Nations engagement, public consultation and discussions with regulatory agencies. At this stage of the project, the preliminary preferred alternative has been presented to the public for feedback. The verbal feedback received from the presentation of the preliminary preferred alternative was used to reassess the design to move forward to the detailed design.

First Nations Consultation

The Ministry of Environment, Conservation and Parks (MECP) were contacted to determine First Nation communities that may be interested in the Class EA. Communities contacted include:

- Alderville First Nation
- Curve Lake First Nation
- Hiawatha First Nation
- Huron Wendat First Nation
- Kawartha Nishnawbe First Nation
- Mississaugas of Scugog Island First Nation
- Mississaugas of the Credit First Nation

A Notice of Commencement and draft Archaeological Assessment Report was shared with First Nations Communities. Additional Notices with updated documents were sent to First Nation Communities upon completion of the draft Project File. Of the seven (7) First Nation communities that were contacted, five (5) of them responded with interest to review project materials, with input incorporated into the file and commitments from the City for ongoing consultation through detailed design.

Public Consultation

Aquafor prepared project notices and was responsible for delivering all notices to the respective parties. To date three (3) notices regarding the project were sent to the City. These notifications include Notice of Commencement and two (2) notice of a Public Information Centre. The Notice of Commencement was sent to the City in January 2025 and is dated January 8th, 2025. A notice for the first Public Information Centre was sent to the City in April 2025 and occurred on May 5th, 2025. A notification of the second Public Information Centre was sent to the City in July 2025 and occurred on September 10th, 2025 and can be seen in **Appendix I**.

Conclusions and Recommendations

In summary, this report signifies the completion of the draft Mount Joy Creek Flood Mitigation Municipal Class Environmental Study and determined that the preliminary preferred alternative is to replace the existing culverts on site with larger ones. With the feedback acquired on the preferred alternative from City comments, public consultation and agency consultation, the next steps are to prepare a finalized preferred alternative to carry out into the detailed design phase. Prior to construction, all required regulatory approvals will be procured and targeted community notifications will be undertaken.

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1 INTRODUCTION

1.1 Study Overview

The study area for this Municipal Class Environmental Assessment (MCEA) encompasses a section of a residential area and industrial area located in the Mount Joy Creek (Exhibition Creek) corridor. The watercourse is located between Major Mackenzie Drive and Bur Oak Avenue for the Northern and Southern limits, and between Kentland Street and Metrolinx Railway corridor for the western and eastern limits. Within this area, Mount Joy Creek is an intermittent watercourse with a combination of piped and open channel segments causing reoccurring tableland flooding problems. **Figure 1-1** below provides a general overview of the study area extents.

Figure 1-1: Mount Joy Creek Flood Mitigation Study Area

1.2 Problem Definition

Flooding is prominent within the study area. As a part of past developments, Mount Joy Creek was buried with undersized pipes that led to a reduction in conveyance capacity of the watercourse. This in turn caused local tableland flooding at culvert inlets and the Toronto and Region Conservation Authority (TRCA) identified three (3) spill areas within the project area. Localized property damage and flooding risks will only intensify without properly addressing the under-capacity watercourse.

This assessment has been prepared on the assumption that all future private property grading will remain compliant with the approved design and will be constructed in accordance with the established grading intent. The analysis is limited by the information available at the time of review, including current topographic data, design drawings, and any third-party materials provided.

Based on the continued risked within the study area, it is clear a long-term solution is required to mitigate flooding risks from Major Mackenzie Drive to Bur Oak Avenue.

1.3 Study Objectives

The objective of the project is to propose flood mitigation alternatives that reduce frequent tableland flooding of the properties adjoining the creek corridor. This will also facilitate the future development ambition for the area defined in the recently completed Markham Road Mount Joy Secondary Plan.

1.4 Class Environmental Assessment Process

The Environmental Assessment Act was legislated by the Province of Ontario in 1975 to ensure that an Environmental Assessment (EA) is conducted prior to the onset of development and development-related (servicing) projects. The "environment" as defined by the EA Act is understood broadly to include the biophysical, socio-cultural, built and economic environments and the interrelationships between them. The EA Act applies primarily to public sector undertakings and extends to private sector projects where designated under the regulation. Depending on the individual project to be completed, there are different processes that municipalities must follow to meet Ontario's Environmental Assessment requirements.

The EA Act draws a distinction between "Individual" and "Class" environmental assessments. Individual EAs are prepared for large, complex projects in which significant environmental impacts are foreseeable. A "Terms of Reference" are devised which outline the EA process, and the final EA document is submitted to the Ministry of the Environment, Conservation and Parks (MECP) for approval. Alternatively, a Class EA is a streamlined approval process for a group of routine undertakings with predictable environmental impacts. Once a Class EA planning document is approved by the MECP, all projects of this type are pre-approved provided that they adhere to its design. In this fashion, the Class EA process expedites approval for smaller, recurring projects.

The MCEA, which is followed here, outlines how municipal infrastructure projects are planned in accordance with the EA Act. The MCEA is consistent with the EA Act's five (5) key principles for successful planning, which include:

- Consultation with affected parties early on and throughout the process, such that the planning process is a cooperative venture;
- Consideration of a reasonable range of alternatives, both the functionally different "alternatives to" and the "alternative methods" of implementing the solution;
- Identification and consideration of the effects of each alternative on all aspects of the environment;
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects; and,
- Provision of clear and complete documentation of the planning process followed, to allow "traceability" of decision-making with respect to the project.

As the project being undertaken is defined as a flood mitigation project, the Schedule B process as defined in the Municipal EA (2023) document, as amended in February 2024, is applicable.

A summary of the Class EA process and phases is provided below, with the accompanying flow chart (**Figure 1-2**) illustrating the process followed in the planning and design of projects covered by this Class Environmental Assessment:

Phase 1: Identify the problem or deficiency.

Phase 2: Identify alternative solutions to the problem by taking into consideration the existing environment, and establish the preferred solution taking into account public and agency review and input. At this point, determine the appropriate Schedule for the undertaking and document decisions in a Project File for Schedule B projects, or proceed through the following phases for Schedule C projects.

Phase 3: Examine alternative methods of implementing the preferred solution, based upon the existing environment, public and government agency input, anticipated environmental effects and methods of minimizing negative effects and maximizing positive effects.

Phase 4: Document, in an Environmental Study Report, a summary of the rationale and the planning, design, and consultation process of the project as established throughout the above phases, and make such documentation available for scrutiny by review agencies and the public.

Phase 5: Complete contract drawings and documents, and proceed to construction and operation; monitor construction for adherence to environmental provisions and commitments. Where special conditions dictate, also monitor the operation of the completed facilities. Public and agency consultation is also an important and necessary component of the five phases.

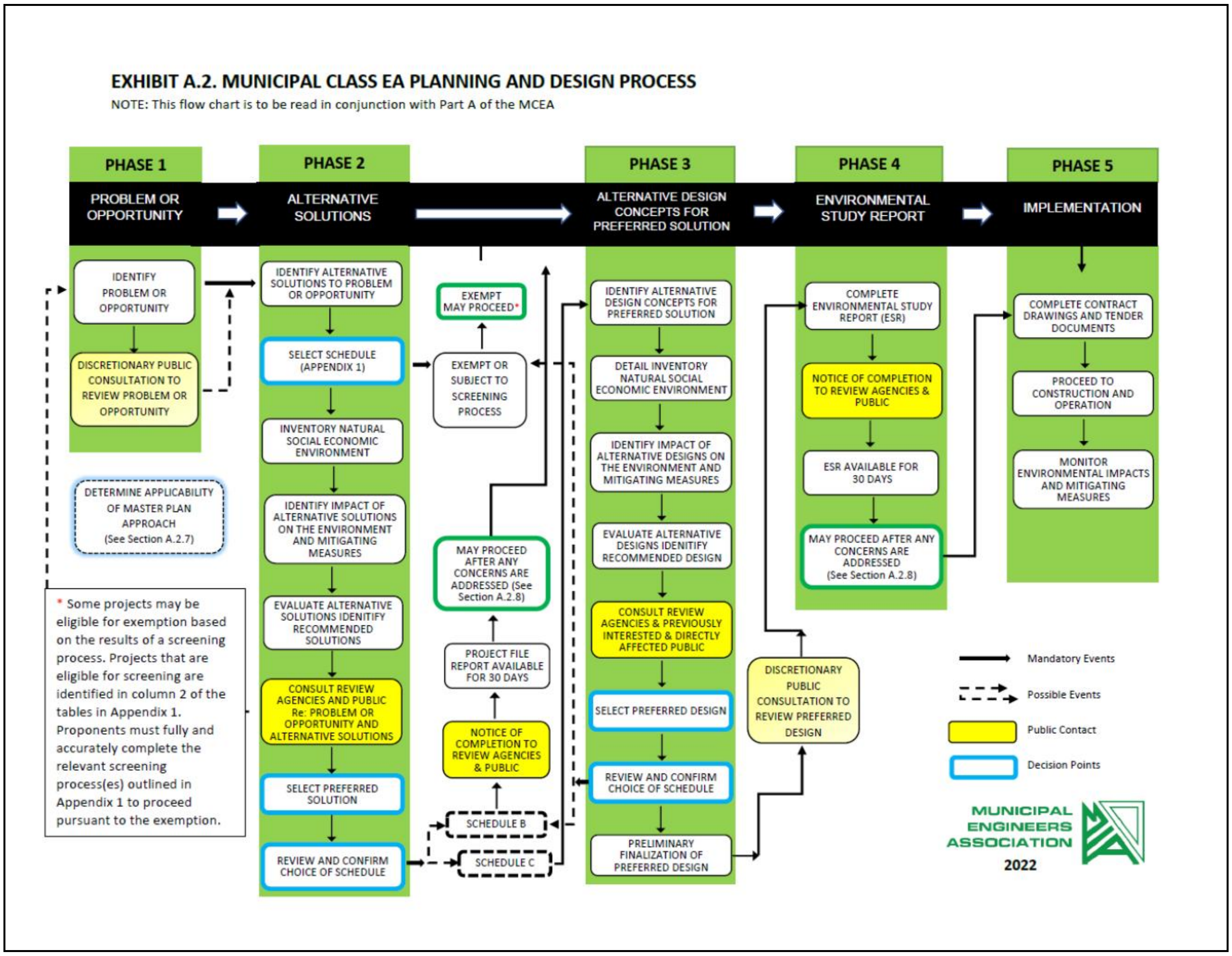


Figure 1-2: Municipal Class Environmental Assessment Planning and Design Process

The Municipal Engineers Association's Class EA document also classifies projects as Exempt, Eligible for Screening, Schedule B or Schedule C depending on their level of environmental impact and public concern.

- **Exempt** projects include specific municipal maintenance, operational activities, rehabilitation works, minor reconstruction or replacement of existing facilities, and new facilities that are limited in scale and have minimal adverse effects on the environment. These projects are exempt from the requirements of the *Environmental Assessment Act*.

- **Eligible for Screening to Exempt** projects may be eligible for exemption based on the results of a screening process. Proponents may choose to complete the applicable screening process to determine whether their project is eligible for exemption from the EA or proceed with the applicable Schedule B or Schedule C process.

- **Schedule 'B'** projects have the potential for some adverse environment effects. Projects generally include improvements and minor expansions to existing facilities.

These projects require completion of Phases 1 and 2 of the Class EA process, before proceeding to Phase 5 Implementation.

- **Schedule 'C'** projects have the potential for significant environmental effects. Projects generally include the construction of new facilities and major expansions to existing facilities. These projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 Implementation.

The Mount Joy Creek Flood Mitigation MCEA is classified as a Schedule B project and follows Phases 1 and 2 of the planning and design process with Phase 5 to follow at a subsequent stage.

1.5 Background Review

The following reports were reviewed and summarized to see if they contained information that would influence any of Aquafor's proposed designs. It should be noted that these reports have not yet been approved by the City of Markham and even though their contents are not finalized they still provide a general understanding on what is currently being proposed for Mount Joy Creek and its surrounding area.

1.5.1 *Markham Road-Mount Joy Secondary Plan Study Documents*

The Markham Road-Mount Joy Secondary Plan outlines a comprehensive framework for developing a healthy and complete community centred around the Major Transit Station Area (MTSA). This Secondary Plan required a comprehensive study to evaluate realignment options for Mount Joy Creek in consultation with TRCA, the City, and all relevant stakeholders. A key component of this plan addresses environmental sustainability, with specific focus on water resources and stormwater management (SWM) within the Mount Joy Creek subwatershed. For water resources a municipal servicing study was undertaken to evaluate infrastructure needs based on the project build-out of the Secondary Plan Area. The study recommended several water resource management strategies, including the realignment of Mount Joy Creek and daylighting a portion of the Creek that is currently buried. These proposed implementations aim to eliminate the existing tableland while restoring the natural habitat of the area. For stormwater management, SWM facilities will be designed to safeguard water quality, protect aquatic ecosystems, and regulate water quantity and erosion within this subwatershed. Additionally, where feasible Low Impact Development (LID) techniques will be integrated throughout the Secondary Plan Area in alignment with the City's LID Guidelines. These measures will help achieve water balance and support groundwater recharge functions.

1.5.2 *Counterpoint Engineering - Municipal Servicing Study*

The Municipal Servicing Report that was completed by Counterpoint Engineering in February 2024 reviewed and refined the previously completed reports and proposed works within the Markham Road and Mount Joy study area. The scope includes delineating pre-development and post-development drainage boundaries, analyzing hydrology and hydraulics, and ensuring compliance with TRCA requirements. The report also defines the study's SWM design criteria, recommendations for SWM control measures on-site, and identifies necessary upgrades to the existing storm infrastructure.

Implementation recommendations include the re-alignment of Mount Joy Creek north of the Olive Branch Community Centre to align with the recently modified section at 9999 Markham Road. This work is recommended to precede development of affected lands with TRCA approval and align with the updated MIKE 2D floodplain model. Other implementation recommendations suggested by this report include upgrading local storm sewers to eliminate surcharging, maintaining Pond 93 and Pond 11 as per the original design intent, and assessing the geotechnical stability during detailed design. The report lastly suggests that innovative SWM solutions and retrofit opportunities should be considered at the Block Level Detailed Design approval stage to enhance overall performance.

1.5.3 *Valdor Engineering Inc. – 1D/2D Flood Impact Analysis for Proposed Mixed-Use Development 9900 Markham Road*

The 1D/2D Flood Impact Analysis that was completed by Valdor Engineering Inc. in November 2023 assessed the hydraulic implications of the proposed residential/commercial development located at 9900 Markham Road. The analysis utilized the MIKE FLOOD modeling software, evaluated both the existing and proposed grading conditions to determine potential floodplain impacts within the study area that includes Exhibition Creek (Mount Joy Creek) and the adjacent portions of the Rouge River Watershed.

The study concluded that the preliminary grading plan prepared by SCS Consulting Group Limited (SCS Consulting) provided Regional level flood protection for the subject property and eliminates Regional flooding along Markham Road. Hydraulic comparisons between updated existing and proposed conditions showed that changes in the Water Surface Elevation (WSE) and flood depth have a difference generally less than 0.11 m and is considered minimal. It is also noted that flow velocities and depth x velocity differences are both considered to be negligible with differences approximately 0.10 m/s and 0.05 m^2/s. The report then states that the findings demonstrate that the proposed grading plan does not adversely affect floodplain dynamics and satisfies the requirements of the TRCA's Living City Policy 8.5.1.10 regarding floodplain spill areas.

Based on these results the Valdor Engineering report recommends that the development proceeds in accordance with the proposed grading plan prepared by SCS Consulting. It is also recommended that a minimum elevation of 212.17 m be maintained for the finished floor, building opening elevations for the proposed building north of Harvard Way, and the surface grading to the east, west, and north of this proposed building. The report concludes by stating that if these measures are followed it will ensure a freeboard of 0.30 m is maintained along most of the north property line.

1.5.4 *Masongsong Associated Engineering Limited - Anderson Avenue Extension Class EA*

An Environmental Study Report was completed by Masongsong Associates Engineering Limited (Masongsong) in May 2023 and evaluated the proposed extension of Anderson Avenue to Major Mackenzie Drive, as recommended by the 2014 Official Plan and Markham Transportation Planning Strategy. This Municipal Class Environmental Assessment (Class EA) was undertaken as a Schedule "C" study, that reaffirmed the need for the extension by assessing multiple alternatives. The identified preferred alternative was the road extension and the study then progressed to determine the preferred alignment of Anderson Avenue.

The study focuses on transportation and servicing compatibility within the Anderson Avenue corridor and addresses that the Markham Road – Mount Joy Secondary Plan mainly focuses on the larger area and entails a wider range of studies. The report also addresses the extension's most significant impact will be to the Krashnik property at 9821 Markham Road and the Islamic Centre at 1330 Castlemore Avenue. The report then mentioned that both property owners were to meet to review design options and discuss impacts to their properties.

The report then outlined that a Problem/Opportunity statement that was done to evaluate all potential alternatives which includes the option of no road extension and to assess whether the extension of Anderson Avenue is necessary to facilitate the planned development within the area and reduce traffic congestion along Markham Road.

Additionally, the Anderson Avenue Extension Class EA completed a high-level analysis on whether the Mount Joy Creek flow can be conveyed along the future Anderson Avenue alignment. In this analysis two (2) scenarios were considered. The first scenario recommended that Anderson Avenue trunk sewer can convey Mount Joy Creek. The second scenario, stated that if preferable, a culvert crossing can be installed under the Anderson Avenue and realign the Creek eastward toward the Railway Corridor.

1.5.5 *SCS Consulting Group Limited - Upper Markham Village Master Environmental Servicing Plan*

The February 2025 Upper Markham Village Master Environmental Servicing Plan is a draft report prepared by SCS Consulting Group Limited and was prepared in support of an Official Plan Amendment application to permit urban residential land uses to allow the development of a residential community on the Subject Lands. A portion of the subject lands described in this report represent the headwater drainage area of Mount Joy Creek.

The report's SWM plan mentions that the proposed SWM concept for the Subject Lands will include seven (7) end-of-pipe SWM Facilities and Low Impact Development (LID) measures utilizing Best Management Practices (BMPs). SWM Facility number 4, 6, and 7 are to each service portions of the Mount Joy Headwater Drainage Features (HDF) that will ultimately drain into Mount Joy Creek running at Major Mackenzie Drive East. The report also notes that the Mount Joy HDF are protected lands within the Greenbelt's boundary.

The Mount Joy Storm Drainage and Floodplain Assessment section of the report identifies that the TRCA's 2022 Regional Floodplain Map shows a Regional floodplain that covers the Mount Joy HDF all the way up to its upstream end and extends beyond the Greenbelt's border. The proposed conditions section of the report mentions that a majority of the drainage area is expected to be directed to two (2) of the SWM Facilities and almost all of the drainage to the feature would be eliminated with the exception of rear lot drainage. The proposed design also states that the post-development peak flow rates will be reduced to pre-development levels for the 2-year to 100-year and Regional storm events. As well, approximately 26 hectares (ha) of drainage from the Mount Joy subwatershed is to be diverted to the Little Rouge Creek watershed.

Other proposed works that could impact Aquafor's proposed design include a potential future sanitary sewer sub-trunk along Markham Road within vicinity of Mount Joy Creek and a Greenway Trail network proposed to connect the Mount Joy Greenway system with other surrounding Greenway trail systems in the City.

As noted above this report is a draft report and it is not currently endorsed by the TRCA. Additionally, it should be noted that the SWM strategy provided with this report is currently being discussed between the TRCA and SCS Consulting and has not been finalized.

1.5.6 _WSP Canada Inc. – Technical Memorandum_

The June 2025 MIKE Flood Modelled Flood Risk Issue on Adjacent Municipal Lands for Mount Joy Passing Track Project, prepared by WSP Canada Inc. (WSP) found, that there would be an overall negligible water surface level increase of less than 0.05 m for the WSP proposed conditions in comparison to the existing conditions for the Regional storm event. The memorandum does not discuss peak flow and water level impacts for non regulatory events. Though higher localized water surface levels increase ranging from 0.10 m to 0.45 m and mainly occurred within the proposed railway ditch beside the rail corridor and fence of Mount Joy Community Centre building.

The memorandum additionally noted that there would be negligible impacts on the City's lands as water levels would only rise in grassed areas. With most of the proposed Regional water depth being less than 0.30 m it would be categorized as "Low Risk – Vehicular and Pedestrian Access/Egress is Available". The memorandum also notes that under existing conditions spills would occur on Highway 48 near 9900 Markham Road and Bur Oak Avenue. WSP then recommended potential solutions to resolving these flooding issues may include installing storage pipes inside of the Right-of-Way, increasing the track subdrain and using it as additional conveyance capacity, upside the ditch outside of the Right-of-Way and developing an alert system that identifies high water surface levels.

1.5.7 _WSP Canada Inc. – Stormwater Management Final Report – IFT – Mount Joy passing Track_

The December 2024 Stormwater Management Final Report for the Mount Joy Passing Track prepared by WSP for Metrolinx determined the following. The WSP proposed design will include soak away pits that will provide both quantity and quality control for the study area. The hydraulic assessment determined that the existing rail culverts are still considered to be adequate to convey the proposed drainage conditions. This includes the Bur Oak triple box culvert still being able to convey the TRCA's updated Regional storm flow without overtopping onto the road. The report also states that the Regional storm water surface levels generally have a negligible increase by less than 0.05 m when comparing the WSP proposed conditions to the WSP revised existing conditions. Though it should be noted that there are higher localized increases ranging from 0.10 m to 0.45 m occurring between the rail corridor and fence of Mount Joy Community Centre building. Additionally the Regional storm flow velocity comparison between the WSP proposed conditions and the WSP revised existing conditions show that the flow velocity would be generally less than 0.05 m/s. Recommendations made by the report for future work include the following: A subdrain system to collect the track drainage under the passing track ballast, an oversized drainage swale with a controlled outlet to control proposed conditions peak flows to existing conditions target peak flows for the 2-year to 100-year storm events, and soak away pits that will provide 5 mm retention of runoff. These cumulative impacts in the watershed due to development have not been assessed and the subject development will increase flood levels downstream.

1.5.8 _Greck and Associates Limited – Proposed Enhanced Valley/Channel Design Brief for 9900 Markham Road and 9999 Markham Road_

The August and September 2015 Design Brief, prepared by Greck and Associates Limited (Greck and Associates) for CIM Global Development LP outlines plans for an enhanced valley/channel system. The designed corridor will feature a low-flow channel engineered to manage storm events ranging from the 2-year to the 100-year and Regional storm events. The implementation for this design is proposed at the headwaters of Mount Joy Creek, situated approximately 1.5 kilometres north of Major Mackenzie Drive East, and will ultimately discharge into the Mount Joy Creek Flood Mitigation Study Area. Beyond flood management, the redesigned valley/channel aims to restore a natural watercourse that closely resembles pre-existing conditions, increase the net ecological benefit, and enhance the aesthetics of the overall area. Hydrologic modeling indicated that there was a negligible increase in upstream flood elevations of approximately 0.01 metres when comparing the proposed to the existing conditions results. Though the report noted that this is mainly due to the undersized culvert beneath Markham Road (Hwy 48) near Harvard Way that is causing this insignificant increase.

1.5.9 _Masongsong Associates Engineering Limited – FSR and Floodplain Impact Study for 9781 Markham Road._

The July 2023 Functional Servicing Report (FSR) and the November 2023 Floodplain Impact Study by Masongsong Associates Engineering Limited determined the following:

The FSR indicated that the organization of 9781 Markham Road Limited Partnership is proposing the development of a high-rise residential building at 9781 Markham Road. The site will be fully serviced by existing municipal infrastructure, with no new installations required beyond standard connection points to the existing services located along Markham Road. Stormwater quantity control for the development will be managed through an underground storage tank, designed to attenuate post-development flows to pre-development levels. This approach ensures that downstream storm sewer capacity and flood levels will not be adversely affected.

The floodplain Impact Study confirms that the TRCA MIKE FLOOD model was updated to reflect the proposed grading plan and building envelope. Results from the revised model show that 9781 Markham Road is located outside the floodplain boundary. The development is not expected to significantly impact the surrounding floodplain, with only a minor increase in flood elevation ranging from 0.01 – 0.05 metres. Furthermore, the proposed road alignment lies outside the floodplain, and no adverse impacts are anticipated for the existing or adjacent buildings or structures.

2 EXISTING CONDITIONS

2.1 Study Area

Mount Joy Creek is a tributary of the Rouge River and an "Urban River Valley" in the Provincial Greenbelt Plan which conveys flows through Major Mackenzie Drive and Bur Oak Avenue. The watercourse flows from the northwest to southeast and is composed of open channels and piped segments. At the upstream extents of the study area, Mount Joy Creeks travels through the Major Mackenzie Drive culvert into an open channel. As the watercourse approaches Harvard Way, it enters a concrete box culvert and is piped underneath from Harvard Way to Markham Road. The area above this pipe section is underdeveloped. After Markham Road, the watercourse enters open channel conditions for approximately 300 metres before entering a piped section. The area above this piped section consist of both developed and undeveloped areas. The piped section ends at Anderson Avenue and the watercourse remains in open channel conditions until Bur Oak Avenue. Mount Joy Creek flows parallel to a rail corridor between Anderson Avenue to Bur Oak Avenue. The study area is further illustrated in **Figure 2-1**.

The natural state of Mount Joy Creek has been significantly affected throughout the past decades. Past developments have resulted in the watercourse being piped throughout the study area. There were records of unauthorized placement of fill material and Mount Joy Creek was realigned. A combination of piped segments, placement of fill materials, and channel realignment has limited the conveyance capacity of the watercourse and caused localized flooding. It must be noted that the City has worked to restore and enhance other segments of Mount Joy Creek.

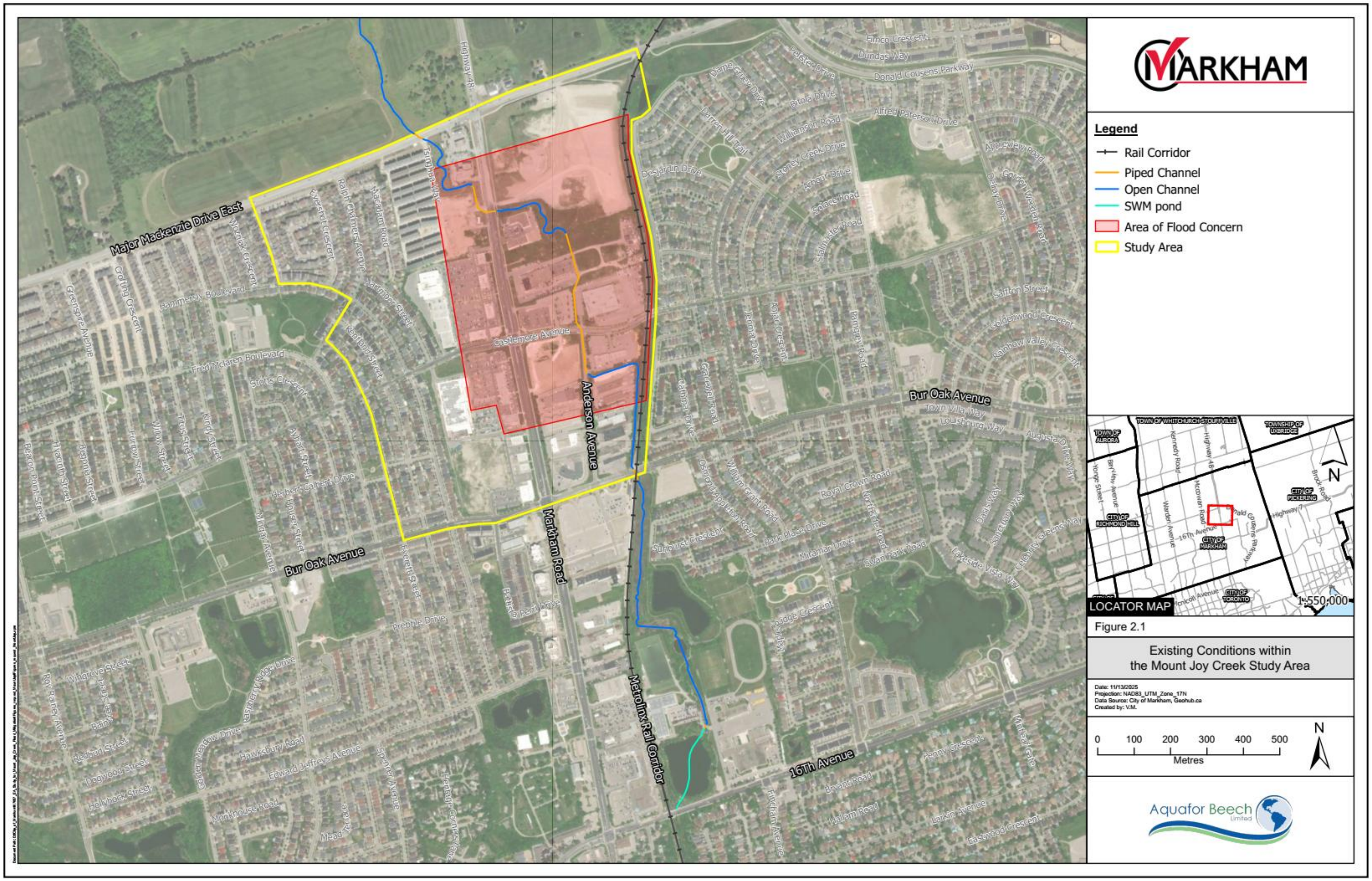


Figure 2-1: Existing Conditions within the Mount Joy Creek Study Area

2.2 Watercourse Structures

There are several structures that the watercourse travels through in the study area. The following subsections summarize the structures present within the study area.

2.2.1 *Structure #1 – Major Mackenzie Drive East*

Mount Joy Creek travels through Major Mackenzie Drive East using a culvert. This corrugated steel pipe (CSP) culvert is approximately 75 metres in length and has a diameter of 1500 mm. The culvert is projected at the upstream end and is connected to a concrete headwall at the downstream extents. Concrete wingwalls extend from the headwall at both a 0° and 90° angle. No inlet or outlet grates were seen on the culvert. There were no signs of erosion at the culvert although extensive vegetated growth may have obscured localized erosion. Photos of the structure are shown in **Figure 2-2** to **Figure 2-5**.

Figure 2-2: Major Mackenzie Drive East Upstream Culvert Face

Figure 2-3: Major Mackenzie Drive East Upstream Channel

Figure 2-4: Major Mackenzie Drive East Downstream Culvert Face

Figure 2-5: Major Mackenzie Drive East Downstream Channel

2.2.2 Structure #2 –Harvard Way and Markham Road

Mount Joy Creek enters a culvert upstream of Harvard Way, travels underneath Harvard Way and Markham Road, and enters open channel conditions downstream of Markham Road. This segment of the watercourse enters piped conditions for approximately 130 metres. The culvert inlet is a 1500 mm (height) x 3000 mm (span) box culvert with a concrete headwall and wingwall. In between Markham Road and Harvard Way, the culvert transitions from a 1500 mm x 3000 mm box culvert with three (3) 45° bends to two (2) circular culverts. The two (2) circular culverts are 1500 mm and 1050 mm in diameter. At the outlet, these circular culverts connect to a concrete headwall and wingwall. Both the culvert inlet and outlet have grates. There wasn’t any erosion present at the culvert inlet or outlet however, vegetated growth may have obstructed erosion. Select photos of the culvert are shown in **Figure 2-6** to **Figure 2-9**.

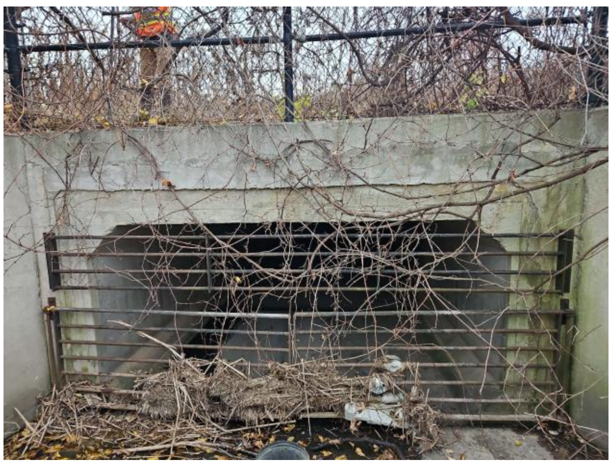


Figure 2-6: Harvard Way Upstream Culvert Face

Figure 2-7: Harvard Way Upstream Channel

Figure 2-8: Markham Road Downstream Culvert Face

Figure 2-9: Markham Road Downstream Channel

2.2.3 *Structure #3 – Near Anderson Avenue*

Mount Joy Creek enters a culvert upstream of Anderson Avenue, travels underneath Anderson Avenue and Castlemore Avenue, and enters open channel conditions downstream of Anderson Avenue. This segment of the watercourse enters piped conditions for approximately 320 metres. The culvert inlet is a twin 900 mm (height) x 1450 mm (span) CSP arch culvert with a concrete headwall. While underground, the culvert transitions from a twin arch culvert to a single 1100 mm (height) x 1700 mm concrete arch culvert. At the outlet, the culvert connects to a concrete apron. The concrete apron is also connected to an outfall and an energy dissipator device. An outlet grate is attached to the outlet of the culvert however; there isn't an inlet grate at the upstream face. There wasn't any channel erosion present at the culvert inlet or outlet however, vegetated growth may have obstructed erosion. There was some erosion behind the headwall at the culvert inlet and sections of the headwall have been disintegrate. Select photos of the culvert are shown in **Figure 2-10** to **Figure 2-13**.

Figure 2-10: Upstream Culvert Face (Near Anderson Avenue)

Figure 2-11: Upstream Channel (Near Anderson Avenue)

Figure 2-12: Downstream Culvert Face (Near Anderson Avenue)

Figure 2-13: Downstream Channel (Near Anderson Avenue)

2.2.4 *Structure #4 –Bur Oak Avenue*

Mount Joy Creek travels through Bur Oak Avenue and a railway using three (3) box culverts. These box culverts are approximately 55 metres in length and are concrete box culverts. The size of the box culvert at the inlet is 1200 mm (height) x 2400 mm (span) and connects to a concrete headwall. At the outlet, the size of each box culvert changes to 1500 mm (height) x 2450 mm (span), 1200 mm (height) x 1800 mm (span), and 1200 mm (height) x 2400 mm (span). No inlet or outlet grates were seen on the culvert. There were no signs of erosion at the culvert although extensive vegetated growth may have obscured localized erosion. Field staff noted that there was a significant bend on the inside of the culvert. Photos of the structure are shown in **Figure 2-14** to **Figure 2-17**.

Figure 2-14: Bur Oak Avenue Upstream Culvert Face

Figure 2-15: Bur Oak Avenue Upstream Channel

Figure 2-16: Bur Oak Avenue Downstream Culvert Face

Figure 2-17: Bur Oak Avenue Downstream Channel

Field investigations were carried out by Valdor in December 2022 to confirm culvert configurations, dimensions, and physical characteristics. The measured dimensions were compared with those provided in the approved TRCA model. Findings indicated that the pipe extensions installed to the east of the original 1500 mm and 1050 mm pipes are constructed of concrete rather than steel, as assumed in the TRCA model. Further details are provided in **Section 3.5.2**.

2.3 Utility Investigation

Aquafor undertook a utility investigation of the area. The utility investigation included a review of the City GIS utility database and a Subsurface Utility Engineering (SUE) Quality Level D investigation. The investigation included a detailed review of base mapping, past design drawings and a field survey of any visible utilities by Aquafor staff, to identify utilities within the study area. **Figure 2-18** illustrates the storm sewer, sanitary sewer and watermain locations within the project area as identified by the City GIS utility database.

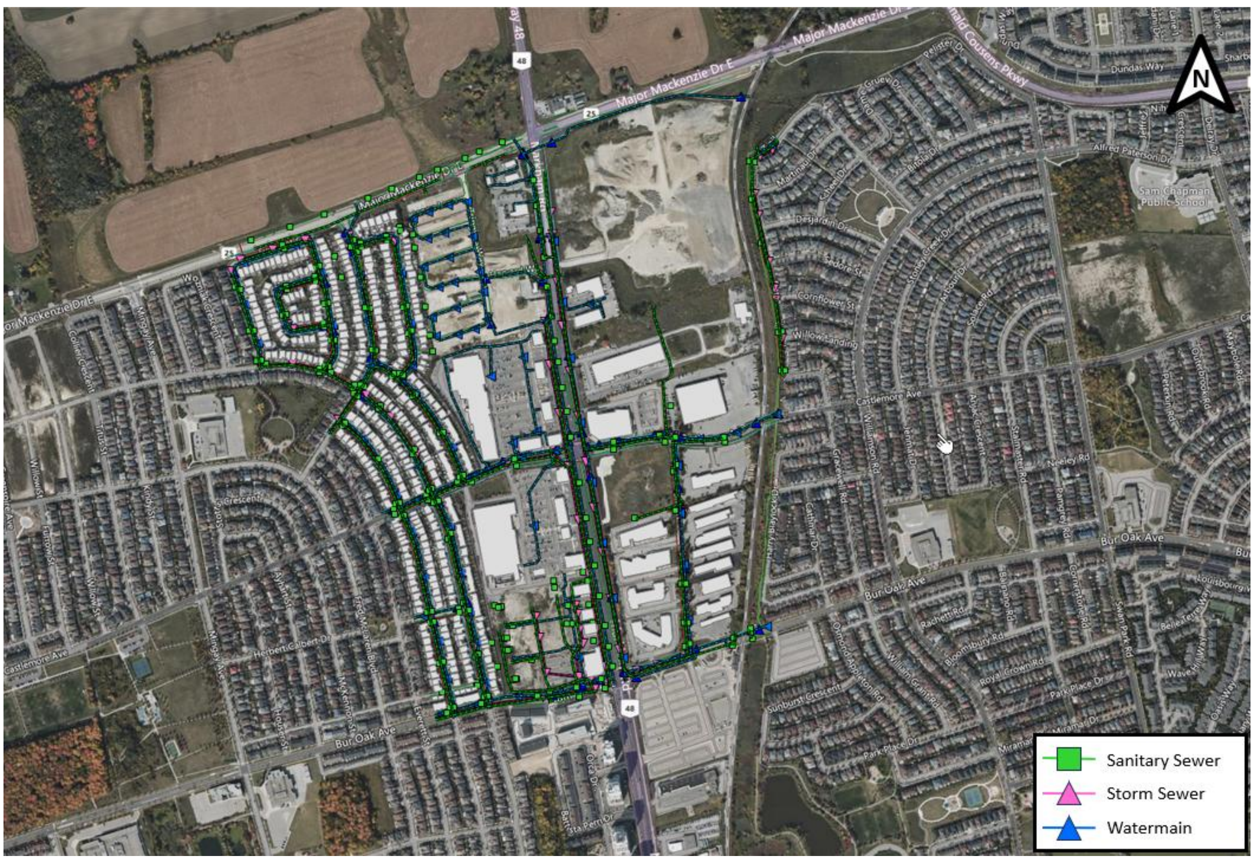


Figure 2-18: Storm, Sanitary and Watermain

An Ontario One Call ticket was filled out to identify any other existing utilities along the potential assess route and study area.

Figure 2-19 illustrates the location selected during the creation of the Ontario One Call ticket.

Ontario One Call notified G-Tel for Enbridge Gas Pre-Engineering Distribution, Rogers Communications - Design & Planning, York Region, Bell Canada – Planning, Alectra Utilities Planning. Information was received from Bell, Enbridge Gas, Roger, and York Region, please refer to **Appendix K**. Information provided indicates that the following items are located in the study area:

- Fibre Cables;
- Gas Lines;
- Bell Infrastructure;
- Existing Conduits;

A detailed utility investigation by both the design consultant and contractor will be required to confirm the presence of all utilities in the area.

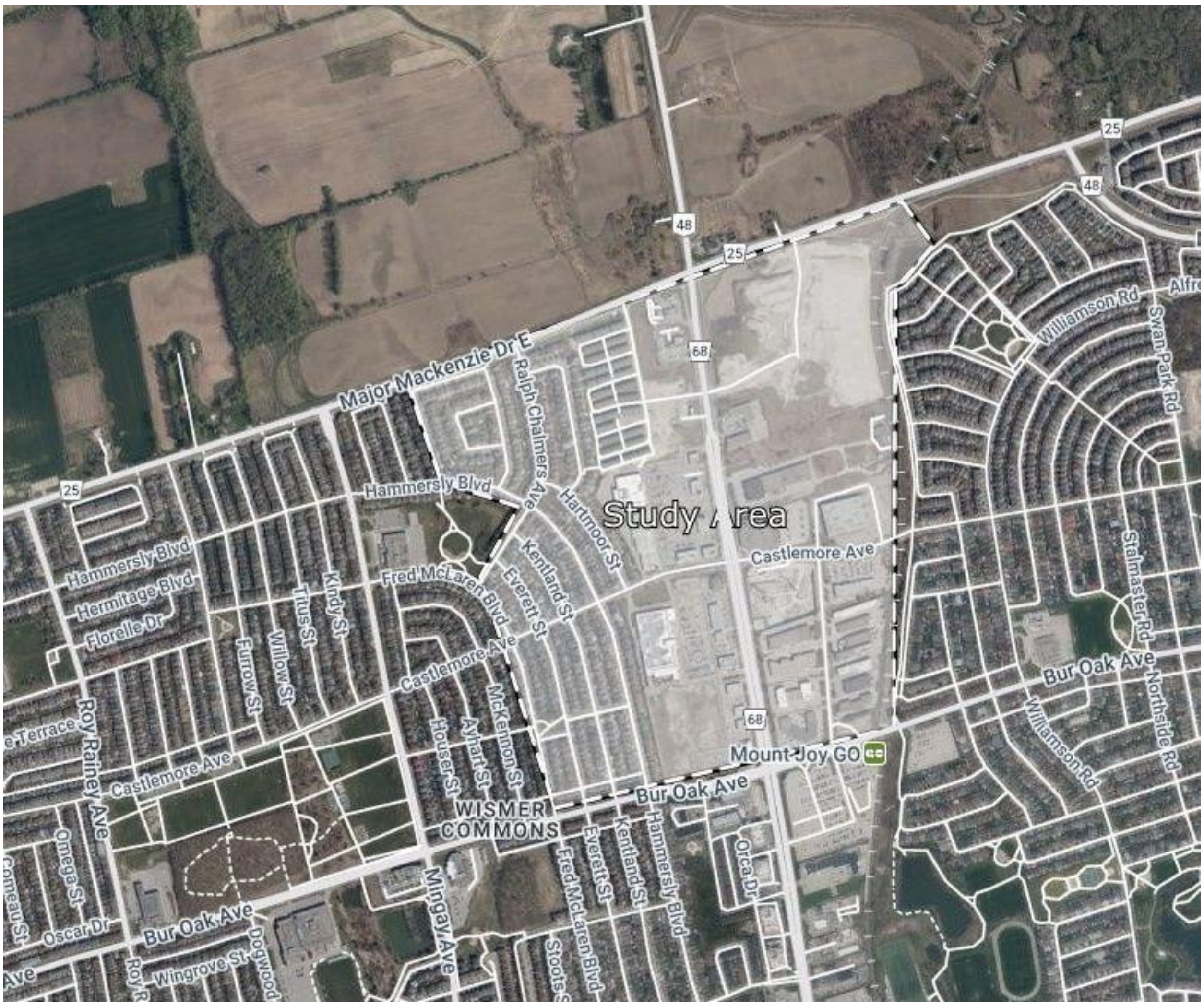


Figure 2-19: Extents of the Ontario One Call

Based on a detailed review of the utility background information as noted above, the existing storm network alignment crosses a number of utilities within the project area. **Table 2-1** below illustrates the roadway crossings; utilities present and key elevations at utility crossings.

Table 2-1: Utility Roadway Crossing Summary

Roadway	Roadway Centerline Average Elevation (m)	Multi-Use Pathway (MUP) Average Elevation (m)	Hydro	Gas Main Average Invert Elevation (m)	Watermain Average Invert Elev (m)	Sanitary Average Invert Elev (m)	Storm Sewer Average Elevation (m)	Existing Sewer Average Height (m)	Existing STM Sewer Average Cover (m)
Markham Road	211.41	211.33	OH	P	P x2	206.72	208.23	1.50	1.68
Private Driveway	209.28		OH	N/A	N/A	N/A	206.07	1.10	2.11
Castlemore Ave	209.00		UG	P	P	205.10	205.69	1.35	1.96
Anderson Ave	208.50		UG	P	P	204.68	205.06	1.10	2.34

<u>**Legend**</u>
P = Ultility present, elevation un-known
OH = Overhead
UG = Under ground

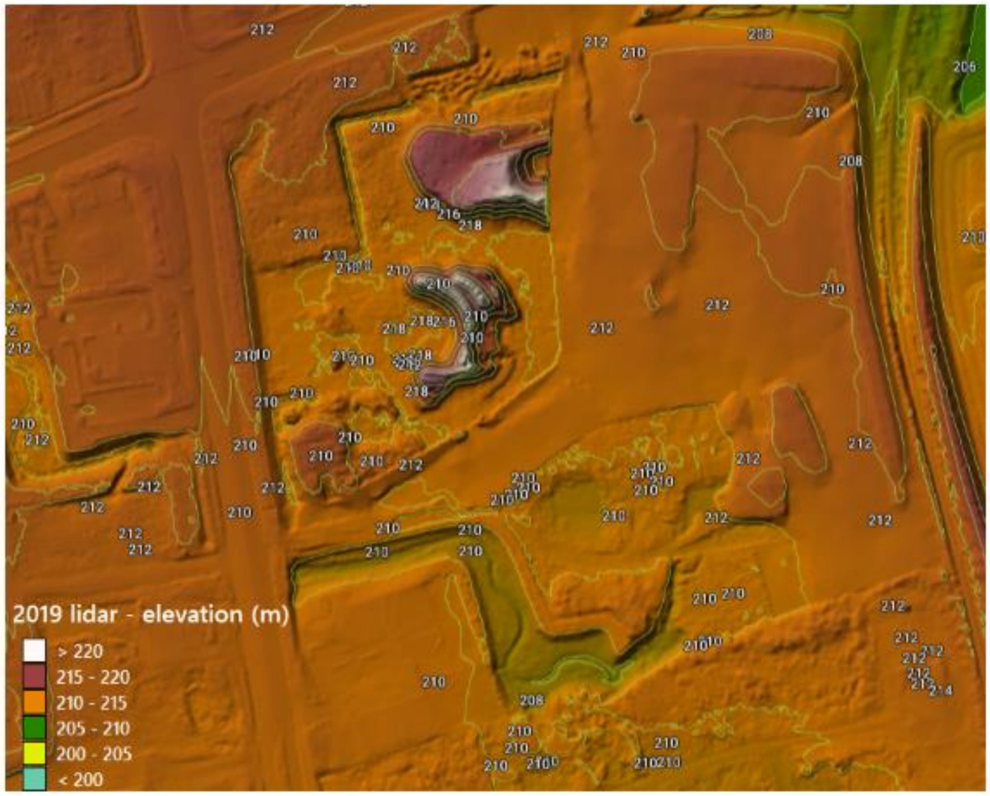
Aquafor recommends that a SUE Quality Level C investigation take place for the detailed design phase of this EA. Further commentary on utility impacts has been provided in **Section 4.0** of this report.

2.4 LiDAR 2019 vs LiDAR 2023

Aquafor did not use the 2023 LiDAR dataset for the MIKE+ mesh or cross-section updates because no additional background information was provided to clarify why several areas in the 2023 surface differed noticeably from the 2019 LiDAR. Based on our review, the 2019 LiDAR appeared to better represent existing ground conditions, as it incorporates spliced portions of earlier LiDAR datasets captured during leaf-off conditions and includes grading updates associated with two major developments, as follows:

- **the OnePiece Development at 9999 Markham Road:** additional grading information was obtained in the form of a ground survey dated November 10th, 2021. This information was used to supplement the 2015/2019 LIDAR by splicing it with the grading information. This ground survey indicated that a portion of the site (eastern half) was raised compared to the original 2019 LIDAR. This information is not reflected in the 2023 LiDAR, as shown in **Figure 2-20**.

LiDAR2019



LiDAR 2023

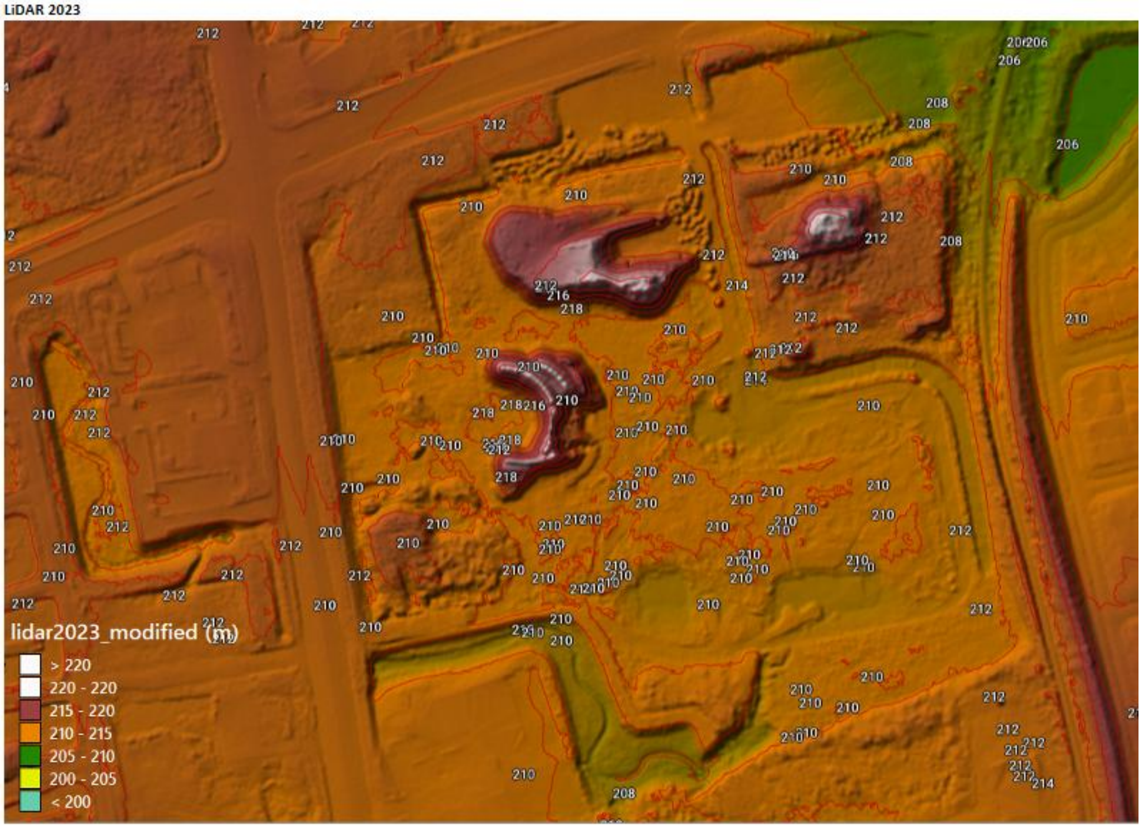
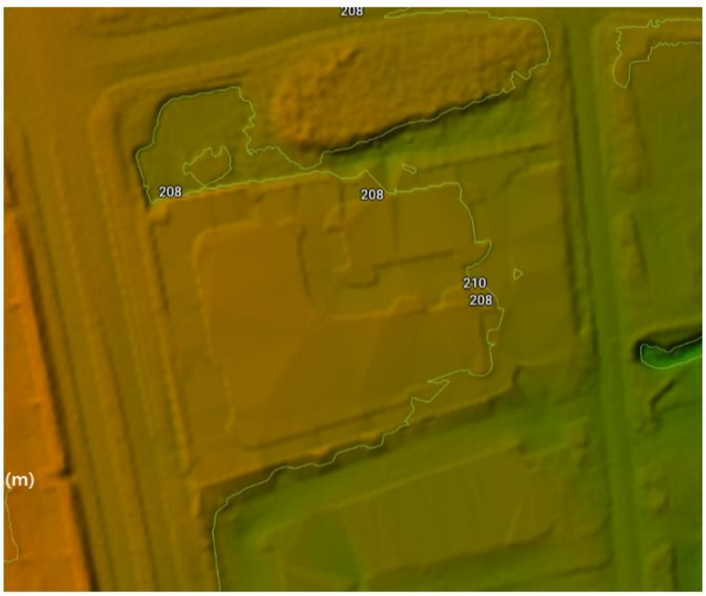


Figure 2-20: Comparison of LiDAR 2019 and LiDAR 2023 at 9999 Markham Road

- **Joy Station Condo by Liberty – 9781 Markham Road:** There is no direct impact to the creek, but the overland flow characteristic has been significantly altered by recent grading work. A grading plan dated February 2020 was spliced into the 2019 LIDAR to update this area. This information is not reflected in the 2023 LiDAR, as shown in **Figure 2-21**.
- **North of Mckenzie Road:** certain areas or creek corridors and areas north of Major Mackenzie used 2015 LIDAR, by splicing this information into the 2019 LIDAR as it captures the leaf-off conditions. This information is not reflected in the 2023 LiDAR, as shown in **Figure 2-22**.

LiDAR2019



LiDAR 2023

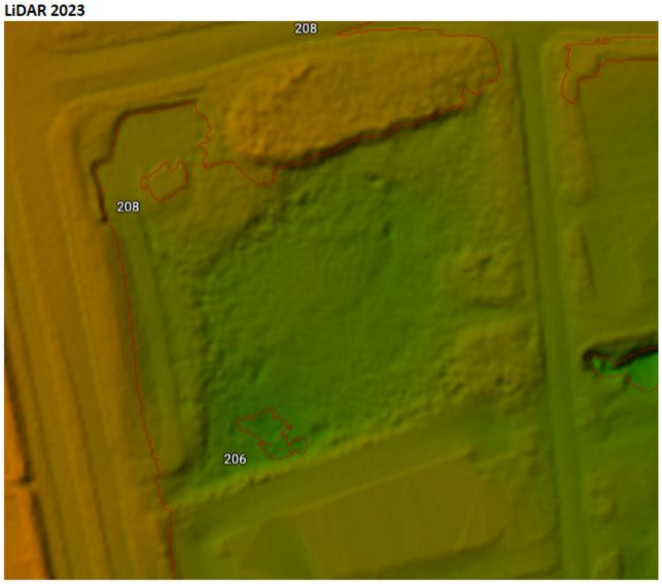
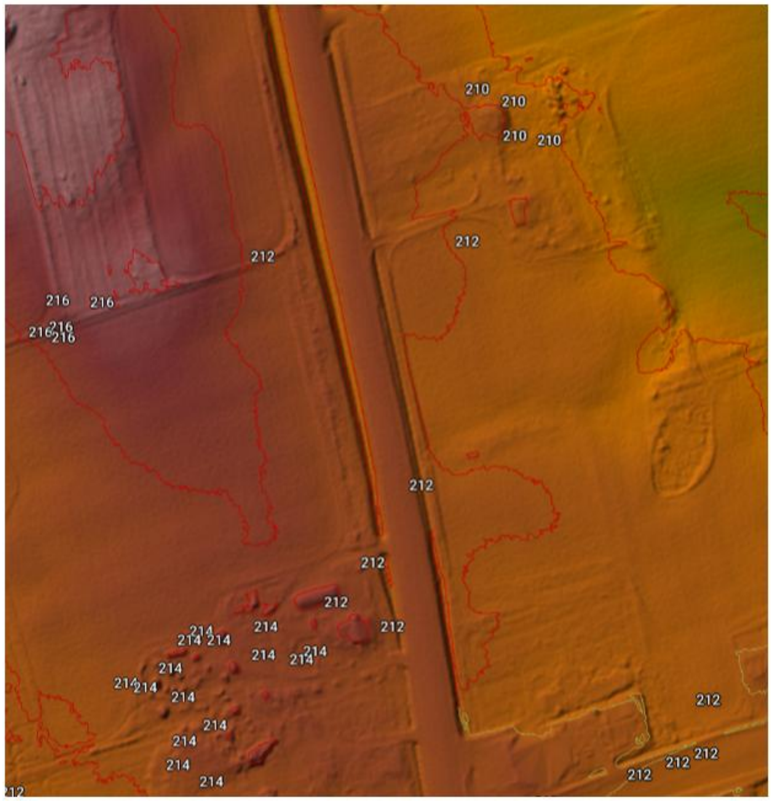


Figure 2-21: Comparison of LiDAR 2019 and LiDAR 2023 at 9781 Markham Road

LiDAR2019



LiDAR 2023

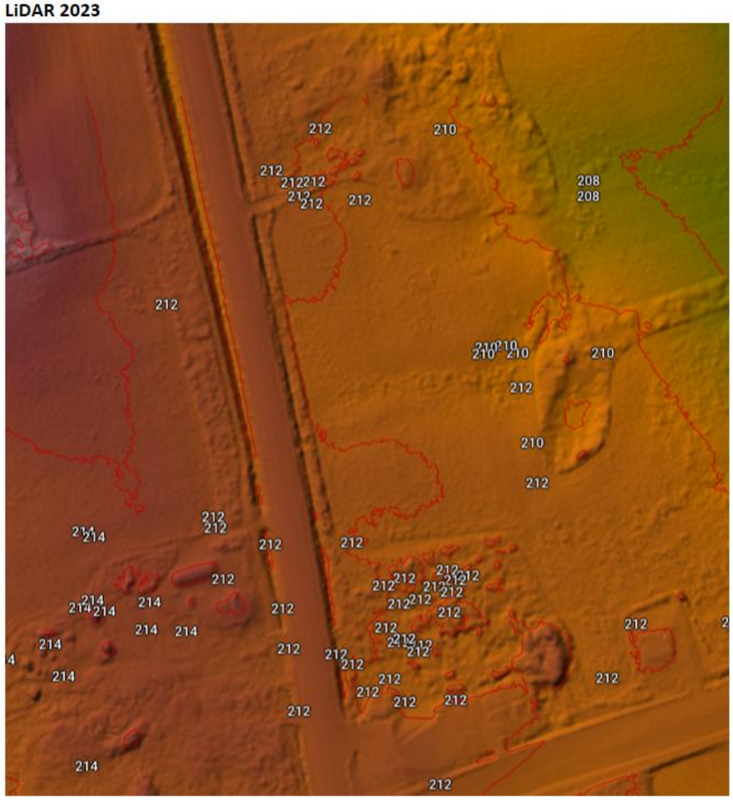


Figure 2-22: Comparison of LiDAR 2019 and LiDAR 2023 North of Mackenzie Road

3 TECHNICAL ASSESSMENTS

3.1 Fluvial Geomorphic Assessment

Fluvial geomorphology is the study of the processes associated with streams and rivers, including stream hydraulics and sediment movement. Variables that influence the morphology of a stream include discharge, velocity, sediment load and grainsize, channel slope, and the width and depth of the channel. A change in one of these variables will eventually alter another variable causing the channel to adjust. Land-use changes within a subwatershed can alter the amount of surface runoff and the amount of sediment reaching a stream. This can result in erosion and flooding problems, as well as poor aquatic habitat. Channel restoration works can mitigate the impacts of land-use change, through natural channel design or other river engineering approaches. A detailed fluvial geomorphic assessment of Mount Joy Creek through was conducted on January 10th, 2025 by Aquafor Beech Fluvial Geomorphic staff.

3.1.1 *Reach Delineation*

Geomorphic stream reaches are relatively uniform lengths of channel in terms of surface geology, hydrology, channel slope, boundary materials, and vegetation that control dominant geomorphic processes and sediment transport dynamics. In other words, the physical channel processes and resulting river morphology are relatively consistent over the length of the reach as compared to the differences between adjacent reaches. As such, the watercourse within the study area has been categorized into different reaches to better understand the factors taking place. As part of the assessment for Mount Joy Creek within the City of Markham, about one (1) kilometre of the exposed creek was walked to visually assess the channel and the surrounding area. The reach delineation was confirmed and refined in the field to fully account for geomorphically significant changes in channel conditions.

A synoptic level fluvial geomorphic field assessment was completed where existing conditions within Mount Joy Creek were noted, and erosion site identification and photographic inventory for watercourse reach conditions were collected. The study area is contained within the road crossings of Bur Oak Avenue to the south and Major Mackenzie Drive East to the north. The extents of the study area and assessed watercourse are shown in **Figure 3-1** where the delineated reaches are labelled downstream to upstream including Reach MJC-1, Reach MJC-2, Reach MJC-3, and Reach MJC-4. A reach delineation of Mount Joy Creek downstream of Bur Oak Avenue was not performed as it extends beyond the study area, extending approximately 570 m further south. The reach of Mount Joy Creek upstream of the study area, however, was delineated and assessed (MJC-4), and extends from Major Mackenzie Drive East approximately 135 m upstream to the farm crossing. This was undertaken to obtain further context, necessary to inform the creek conditions downstream within the study area.

Majority of the channel and channel corridor through the study area is infilled with the invasive vegetation species, known as Phragmites. Due to this, processes of aggradation are present throughout the study area. While inherent erosional and aggregational processes are expected in a natural watercourse; these can be exacerbated by urbanization within a catchment area through alteration of the watercourse and changes in the rainfall-runoff response due to decreased infiltration. The existing fluvial conditions for each reach have been summarized in the sections below, accompanied by representative photographs.

Figure 3-1: Delineated Reaches within the Mount Joy Creek Study Area

3.1.1.1 Downstream of Study Area – South of Bur Oak Avenue

Mount Joy Creek, downstream of the study area, bypasses underneath Bur Oak Avenue and is outlet through a triple box culvert into a 30- to 40-metre-wide corridor which trends north to south. The corridor is surrounded by the Mount Joy GO Station parking lot and rail line to the west and, some parking and primarily residential land use to the east. The conditions downstream of the road consist of poor channelization of the creek where Phragmites have established and occupied the entire width of the corridor. The creek through this corridor extends approximately 570 m through the Phragmites downstream to a Storm Water Management (SWM) facility, and although appears to be primarily single-threaded, likely transitions to multi-threaded throughout some parts of the corridor. **Figure 3-2** shows the un-channelized reach through the Phragmites infested channel corridor from the west side looking from the Mount Joy GO Station parking lot in January 2025. Similar conditions can be seen in April 2024 (**Figure 3-3**) where the extent of the Phragmites through the wide corridor can be seen on aerial imagery.

Figure 3-2: Looking east from Mount Joy GO Station at the un-channelized reach showing Phragmites infested channel corridor (January 2025)

Figure 3-3: Aerial view of Phragmites infilled channel corridor downstream of Bur Oak Avenue (Google Earth, April 2024)

3.1.1.2 Reach MJC-1 – Bur Oak Avenue to Anderson Avenue

Reach MJC-1 is approximately 420 metres in length and extends from the Bur Oak Avenue culvert (**Figure 3-4**) upstream to the Anderson Avenue culvert. The bank material predominantly consists of sandy loam with silt. The bed material consists of fine to medium sand with silt. The average bankfull width is 3.5 metres and the average bankfull depth ranges between 0.6 metres to 0.8 metres. The channel through this reach is surrounded by industrial land use on either side. In particular, the 290-metre-long segment which runs in the north-south direction is surrounded by industrial property parking lot to the west and Railway Corridor on the east. Similarly, the 130-metre-long segment of the reach which runs in the east-west direction is confined by industrial building to the south – being within less than 1 metre of the watercourse – and a steep valley wall supporting the parking lot and buildings to the north.

This reach of Mount Joy Creek has been historically straightened and consists of a very narrow riparian corridor. The reach is channelized with no floodplain and the channel exhibits shallow pool – riffle morphology. The extent of the Phragmites at the downstream extent is approximately 20 metres where the channel narrows to ~ 1.5 metres through the dense vegetation growth (**Figure 3-5**). The segment of the channel trending north-south is within 1 metre of the commercial property parking lot (**Figure 3-6**). A severe woody debris jam can be seen in **Figure 3-7** due to leaning and fallen trees within the segment of the channel trending east-west. Within this upstream section, the southern channel top of bank as seen in **Figure 3-8** is within 1 metre of the commercial building posing erosional risks. Weir structure is located downstream of the Anderson Avenue culvert to act at energy dissipation structures.

Figure 3-4: Upstream side of Bur Oak Ave culvert, facing west towards Carwash

Figure 3-5: Looking downstream at start of Phragmites lining the channel

Figure 3-6: Looking upstream at channel in close proximity to parking lot

Figure 3-7: Severe woody debris jam due to leaning and fallen trees

Figure 3-8: Looking upstream at channel south bank within 1 m of commercial buildings

Figure 3-9: Anderson Ave culvert at upstream extent of the reach

3.1.1.3 Reach MJC-2 – Confluence with Tributary at Twin Culvert to Markham Road Culvert

Reach MJC-2 extends from the confluence of the tributary with Mount Joy Creek and extends approximately 266 metres upstream to the Markham Road culvert. A twin culvert is located at the downstream extent of the reach and conveys flows underneath the commercial properties to the south, connecting with Reach MJC-1. The reach does not exhibit pool – riffle morphology. The bankfull width ranges from 4 – 8 metres and the bankfull depth ranges from 0.3 – 0.5 metres. The bank material consists of silty sandy loam and the bed material ranges from silt with fine sand and some clay. The channel has been lined with small cobbles at the downstream extent.

Although some channel morphology is visible including the channel banks and bed, the reach is infilled with Phragmites which start upstream at the Markham Road (**Figure 3-10**). The channel is unconfined where it borders commercial properties to the west and south, and the areas north and east of the reach are under construction. The exposed section of Mount Joy Creek channel can be seen in **Figure 3-11** where less Phragmites are present and channel banks and bed can be visible. The tributary of Mount Joy Creek joining from the west at the downstream extent of the reach can be seen in **Figure 3-12** which is approximately 1.5 metres in bankfull width and 0.8 metres in bankfull depth. At the same location, the twin CSP culvert with concrete headwall at the downstream extent of the reach can be seen in **Figure** 3-13**.** The deteriorated culvert has been undermined and outflanked due to the increased flow from the tributary. This is discussed in further detail in **Section 3.1.3.2**.

Figure 3-10: Looking upstream at the twin culvert with concrete headwall and the start of Phragmites within the reach

Figure 3-11: Looking upstream at the exposed section of Mount Joy Creek channel where less Phragmites are present

Figure 3-12: Looking upstream at the tributary of Mount Joy Creek joining from the west at the downstream extent of the reach

Figure 3-13: Deteriorated twin CSP culvert with concrete headwall at the downstream extent of the reach

3.1.1.4 Reach MJC-3 – Markham Road to Major Mackenzie Drive East

This reach spans from the Markham Road culvert extending approximately 225 metres upstream to Major Mackenzie Drive East culvert. The channel is characterized by shallow banks and lacks pool – riffle morphology. The reach is surrounded by residential land use to the west and commercial properties with impermeable asphalt parking lots to the east and south. The average bankfull width within the reach is approximately 6 metres and the average bankfull depth is 0.3 metres. The bed material ranges from silt to medium sand with dense vegetation consisting of mostly Phragmites and some Cattails throughout the channel bed. The bank material consists of silty sandy loam. This reach has low to moderate sinuosity with a sinuosity index of 1.54.

A CSP culvert with concrete headwall located at upstream extent of reach conveying flow under Major Mackenzie Road East can be seen in **Figure 3-14**. Sediment accumulation can be seen throughout the reach where Phragmites have infilled the channel (**Figure 3-15**). **Figure 3-16** shows the upstream view from the Markham Road culvert at slight channelization seen within the densely vegetated channel corridor infilled with Phragmites. The concrete box culvert located at the downstream extent of the reach at Markham Road can be seen in **Figure 3-17**.

The reach has been historically modified with an engineered planform, gradient, and sinuosity. The modification resulted in an increase in sinuosity, and a decrease in gradient which has likely led to frequent ponding of water throughout the channel corridor resulting in sediment accumulation. As such, active channel bed aggradation has been occurring through the reach leading to poor flow conveyance. Further geomorphic adjustment in the form of aggregational processes is occurring as a result of urban hydromodification in response to higher peak flows, greater runoff volumes, and more frequent flow events bringing in more sediment. As the channel is filled with dense vegetation consisting primarily of Phragmites and some Cattails, this has further led to sedimentation accumulation of the channel bed and floodplain, leading to poor flow conveyance and flooding.

Figure 3-14: CSP culvert with concrete headwall located at upstream extent of reach conveying flow under Major Mackenzie Road East

Figure 3-15: Sediment Accumulation throughout reach where channel is infilled with Phragmites and some Cattails

Figure 3-16: Looking upstream from Markham Road culvert at slight channelization through dense Phragmites

Figure 3-17: Concrete box culvert located at the downstream extent of the reach at Markham Road

3.1.1.5 Reach MJC-4 – Major Mackenzie Drive East to Farm Crossing

Reach MJC-4 extends upstream from Major Mackenzie Drive East CSP culvert approximately 145 metres to the farm crossing. The bank material consists of sandy loam and the bed material consists of fine to medium sand and sandy loam. The bankfull width ranges from 3 – 6 metres and the average bankfull depth is 0.5 metres. This reach lacks pool – riffle morphology and consists of low-lying areas where the watercourse transitions between channelized and un-channelized forms. Overall, the reach is characteristic of a poorly defined urban drainage ditch, with a heterogenous cross-sectional area along its length and intermittent access to the adjacent floodplain. Looking at the CSP culvert upstream of Major Mackenzie Drive East conveying flow from open agricultural land (**Figure 3-18**). The un-channelized portion of Reach MJC-4 within Mount Joy Creek can be seen in **Figure 3-19**. **Figure 3-20** shows the treeline and potentially channelized portion of the reach towards the east. The farm crossing located at the midpoint of the reach can be seen in **Figure 3-21**.

Figure 3-18: Looking at the CSP culvert upstream of Major Mackenzie Drive East conveying flow from open agricultural land

Figure 3-19: Looking upstream at Reach MJC-4 at the un-channelized portion of Mount Joy Creek

Figure 3-20: Looking east towards treeline and potentially channelized portion of the reach

Figure 3-21: Farm crossing located at the midpoint of the reach

3.1.2 *Geomorphic Stability Assessment*

The Rapid Geomorphic Assessment (RGA) tool was used during field walks to assess the fluvial conditions of the watercourses. The RGA protocol uses visual indicators to determine whether a given stream is stable, in transition, or in adjustment. Stability of the channel is determined by adjustments in slope; the bed elevation may be increasing due to sediment deposition (aggradation) or decreasing due to bed erosion (degradation). Consideration of increases in bank-to-bank width (widening) and indicators suggesting a change in the planform regime (planimetric form adjustment) are also part of the assessment. Based on the results of the RGAs, reaches were classified as "in regime", "in transition", or "in adjustment" depending on the stability index value as described in **Table 3-1**.

Table 3-1: Rapid Geomorphic Assessment Descriptions Based on Index Value

Stability Index Value	Stability Class	Description
0 - 0.20	In Regime	Channel morphology is within the expected range of variance for stable channels of similar type. Channels are in good condition with minor adjustments that do not impact the function of the watercourse.
0.25 – 0.40	In Transition	Channel morphology is within the expected range of variance but with evidence of stress. Significant channel adjustments have occurred and additional adjustment may occur.
0.40 – 1.0	In Adjustment	Metrics are outside of the expected range of variance for channels of similar type. Significant channel adjustments have occurred and are expected to continue.

RGA stability results are provided for three reaches described below are listed in **Table 3-2**, while the actual RGA evaluation sheets are contained in **Appendix A**.

Table 3-2: RGA Values for the Three Reaches of Mount Joy Creek within the Study Area

Reach	RGA Stability Index	RGA Stability	RGA Dominant Process	Number of Erosion Sites
MJC-1	0.49	In Adjustment	Widening	1
MJC-2	0.32	In Transition	Aggradation	1
MJC-3	0.28	In Transition	Aggradation	1
MJC-4	Not Applicable			

The RGA scores highlighted in **Table 3-2** reveal that reach MJC-1 is in adjustment and is dominated by widening processes. Reaches MJC-2 and MJC-3 are in transition and are dominated by the processes of aggradation within the channel. Although Reach MJC-3 is in the lower end of transition, additional adjustments may continue to occur. The processes taking place within the reaches are described below.

Reach MJC-1 has a stability index of 0.49 and although it is dominated by the process of widening, evidence of planimetric form adjustment can also be seen. Widening is the dominating process as evidence of exposed tree roots, fracture lines along top of bank, and basal scour is present through the extent of the reach. This reach is characterized by a steep valley wall on the north bank. Occurrence of large organic debris, exposed tree roots, and fallen or leaning trees causing a severe debris jam is present at portions of the reach evidencing the process of widening is taking place. The channel is also undergoing planform channel adjustment as evidence of formation of chutes and poorly formed or removed bars was observed.

Reach MJC-2, having a stability index of 0.32, is being influenced by the process of aggradation as evidence of siltation in the pools can be seen. Severe siltation of the channel bed is also prevalent and the channel is infilled with Phragmites.

Reach MJC-3 has a stability index of 0.28 and comprises a single thread channel which lacks pool – riffle channel morphology. The dominant process taking place within this reach is aggradation. The process of aggradation is evidenced from the severe siltation of the channel bed, where the channel is infilled with Phragmites and very little Cattails.

Reach MJC-4 was assessed and it was determined that the RGA tool is not applicable, as this reach is primarily un-channelized and consists of a wetland-like environment.

The RGA tool is also not applicable to the reach of Mount Joy Creek downstream of the study area – south of Bur Oak Avenue, as the channel corridor is consistent of a wetland environment and the corridor is entirely infilled with Phragmites.

None of the three reaches are in regime or "stable" but instead, are in transition or adjustment indicating geomorphic instability, likely due to the effects of urbanization leading to access sedimentation incoming from adjacent land use and 'snow salting' practices. This may be exasperated by the reduction in channel gradient leading to slow down of flow velocities within the creek. Urbanization and poor channel design has led to the reduction of infiltration throughout the study area which has caused considerable change to the hydraulic regime of Mount Joy Creek.

3.1.3 *Geomorphic Characterization of the Erosion Sites*

3.1.3.1 Erosion Site 1

Erosion Site 1 is located within Reach MJC-1 is located approximately 115 metres downstream of the Anderson Avenue culvert. It is characterized by a severe debris jam which consists of mature trees and woody vegetation (**Figure 3-22**) fallen into and on top of the channel. **Figure 3-23** shows the trees breaking from the top of slope and banks of the channel resulting in the debris jam. The creek at low flow, is not heavily impacted as the flow is able to be conveyed beneath the woody debris. During heavy flow and storm events, however, this could lead to severe backwatering of the channel resulting in flooding of the surrounding areas as it would obstruct flow within the channel. Here, the toe of the bank is within 1 – 2 metres of the building on the south bank and within ~ 4 metres of the parking lot on the north bank. Overtime, along with recurrent flooding, this could also lead to erosion of the toe of bank and slopes, leading to slope failure and putting adjacent parking lot, infrastructure, or building footings at risk.

Figure 3-22: Severe debris jam approx. 115 m downstream of Anderson Ave culvert

Figure 3-23: Debris jam resulting from broken and fallen trees located at top of slope and channel banks

3.1.3.2 Erosion Site 2

Erosion Site 2 is located at the downstream-most extent of Reach MJC-2 and is characterized by a deteriorated twin CSP culvert with concrete headwall (**Figure 3-24**). The site exhibits severely undermined and outflanked concrete headwall and CSP culvert where the exposed CSP and deteriorated concrete casing behind the headwall can be seen in **Figure 3-25**. The concrete headwall is at a risk of collapsing due to its outflanked and undermined base and sides. A tributary of Mount Joy Creek can be seen in **Figure 3-26** joining from the west at the confluence. It may be contributing significant flow to the system which is directed at the base of the culvert with no erosion protection in place, leading to the outflanking and undermining of twin culvert overtime. Along with the culvert, the banks of the tributary are also experiencing severe erosion with leaning and fallen trees seen within tributary channel. This is indicative of high flow velocities and shear within the tributary. In comparison, the flows within Mount Joy Creek may be lower as no active erosion is seen within the channel, which in fact is undergoing processes of severe aggradation. The conditions of Mount Joy Creek surrounded by a wooded riparian corridor upstream of the deteriorated culvert can be seen in **Figure 3-27** where approximately 30 metres of the 260-metre-long reach is exposed and not infilled by Phragmites.

Figure 3-24: Outflanked and undermined twin CSP culvert with Concrete Headwall at downstream end of Reach MJC-2

Figure 3-25: Exposed CSP and deteriorated concrete casing behind the headwall

Figure 3-26: Tributary of Mount Joy Creek from the west at downstream extent of reach; contributing significant flow directed at the culvert

Figure 3-27: Mount Joy Creek upstream of the deteriorated twin culvert surrounded by wooded riparian corridor

3.1.3.3 Erosion Site 3

Erosion Site 3 is located within Reach MJC-3 and is characterized by a buried and non-functional stormwater outfall with a concrete headwall and fence (**Figure 3-28**). The severe sediment accumulation within the channel (**Figure 3-29**) has led to the stormwater outfall to fill with sediment and the headwall to become partially buried. This outfall appears to be designed to convey runoff from the adjacent commercial properties to the east (**Figure 3-30**). As such, sediment accumulation within the outfall is likely resulting in the backwatering of the drainage system, and may be leading to the flooding observed within the area.

Figure 3-28: Looking directly at the buried stormwater outfall with concrete headwall and fence

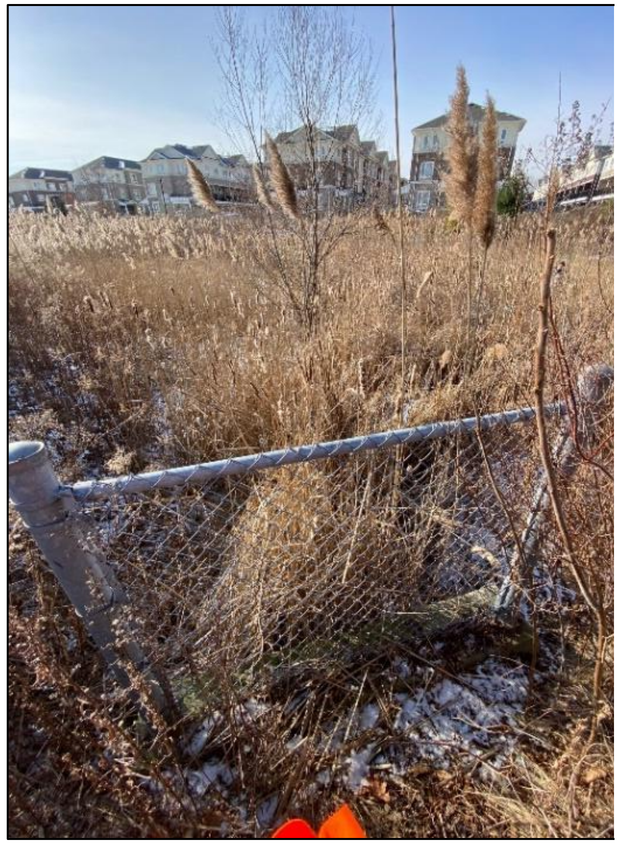


Figure 3-29: Looking downstream from the buried stormwater outfall at the aggraded and Phragmites infilled channel

Figure 3-30: Phragmites infilled channel adjacent to commercial properties and parking lot leading to increased drainage and run-off into the channel and the outfall

3.2 Natural Heritage

Natural heritage conditions in the study area were characterized using existing information to identify ecological features and functions that could be affected by the proposed works. Resources that were utilized for this process include:

- The 2023 Anderson Avenue Extension Class EA Environmental Study Report completed by Masongsong Associates Engineering Limited, which covered roughly the eastern half of the current study area (i.e., east of Markham Road) and included a Natural Environment Report (SLR, 2022) addressing a portion of that area;
- Rouge River Watershed Plan report completed by the Toronto and Region Conservation Authority (2007)
- The Ontario Natural Heritage Information Center (NHIC) online database and mapping of significant features, areas and species;
- Community science websites eBird and iNaturalist;
- The Ontario Breeding Bird Atlas (OBBA), Ontario Reptile and Amphibian Atlas (ORAA), and Ontario Butterfly Atlas (OBA);
- Fisheries and Oceans Canada online aquatic Species at Risk mapping;
- Aquatic Resource Areas mapping provided by the Ministry of Natural Resources and Forestry; and
- Current and historical aerial photos available via Google Earth.

3.2.1 *Terrestrial Ecosystems*

3.2.1.1 Vegetation Communities

The overall study area is highly developed with few remaining patches of natural or regenerating habitat that exhibit evidence of past disturbance or other anthropogenic influence. The 2022 Natural Environment Report by SLR noted that the eastern half of the study area included only cultural vegetation communities (Cultural Meadow – CUM; Cultural Thicket – CUT) and landscaped areas associated with anthropogenic features (e.g., houses, roads, parking lots).

West of Markham Road, air photo interpretation suggests similar conditions.

Figure 3-31: Cultural Thicket - Upstream of Anderson Drive

Figure 3-32: Cultural Thicket - Downstream of Harvard Way

Figure 3-33: Cultural Meadow - Downstream of Major MacKenzie Drive

3.2.1.2 Terrestrial Wildlife

SLR's 2022 Natural Environment Report included the results of breeding bird surveys completed in 2019, as follows:

Confirmed Breeding:
- Song Sparrow (Melospiza melodia)

Probably Breeding:
- Yellow Warbler (Setophaga petechia)
- Gray Catbird (Dumetella carolinensis)
- Red-winged Blackbird (Agelaius phoeniceus)
- Willow Flycatcher (Empidonax traillii)
- Warbling Vireo (Vireo gilvus)
- American Robin (Turdus migratorius)

Possible breeding:

- Common Grackle (Quiscalus quiscula)
- Brown-headed Cowbird (Molothrus ater)
- European Starling (Sturnus vulgaris)
- House Sparrow (Passer domesticus)

No evidence of breeding/incidental:

- Feral Pigeon (Columba livia)
- Ring-billed Gull (Larus delawarensis)
- Bank Swallow (Riparia riparia) – Threatened
- Barn Swallow (Hirundo rustica) – Special Concern
- Canada Goose (Branta canadensis)
- Eastern Phoebe (Sayornis phoebe)
- American Goldfinch (Spinus tristis)

Other wildlife noted incidentally by the 2022 SLR report include Racoon (Procyon lotor) and Spring Peepers (Pseudacris crucifer).

The iNaturalist community science website also contains some research-grade (i.e., confirmed ID via photo upload) records of wildlife for the study area, including the following species over and above those previously listed: Red-tailed Hawk (Buteo jamaicensis), Mourning Dove (Zenaida macroura), Eastern Cottontail (Sylvilagus floridanus), and Common Green Darner (Anax junius). The iNaturalist website also provides a confirmed record of nesting Barn Swallow on the building just northeast of the intersection of Markham Road and Major Mackenzie Drive ("Kim's Nature Garden Center", just outside the study area) which could account for the foraging Barn Swallow observations made by SLR in 2019. There were no birding "hotspots" in the study area per the eBird community science website and few individual birding checklists contributed for the area, the results of which generally align with the results of the bird surveys completed by SLR as listed above.

3.2.2 *Aquatic Ecosystems*

Aquatic ecology features within the study area were evaluated using available background sources through the Ministry of Natural Resources and Forestry, Fisheries and Oceans Canada as well as reports provided by the Toronto and Region Conservation Authority.

The study area encompasses Mount Joy Creek, a tributary to the Rouge River in the City of Markham, which flows south towards Lake Ontario. The headwaters of Mount Joy Creek are located approximately 1 km upstream of the study area, which features an open, straightened channel confined by agricultural land use. The confluence of Mount Joy Creek and the Rouge River is located south of Highway 7, and is approximately 5 km downstream of the study area. The only natural habitat conditions in Mount Joy are observed through the downstream half of the watercourse and well outside of the study area, with the Fish IBI rating measured as "poor" (Toronto and Region Conservation Authority, 2007).

Within the study area, large portions of the Creek have been historically buried and confined to pipes determined to have insufficient conveyance capacity. As a result, the systems conveyance capacity is restricted which causes local table land flooding in the area. Many storm outfalls flow directly into Mount Joy Creek, which may contribute high levels of contaminants and nutrients to the watercourse. This section of Mount Joy Creek has undergone various anthropogenic interventions through realignment and underground piping, resulting in a heavily altered and straightened channel. **Figure 3-34** outlines the existing conditions within Mount Joy Creek, highlighting the Greenbelt Boundary and the large portion of channelized watercourse.

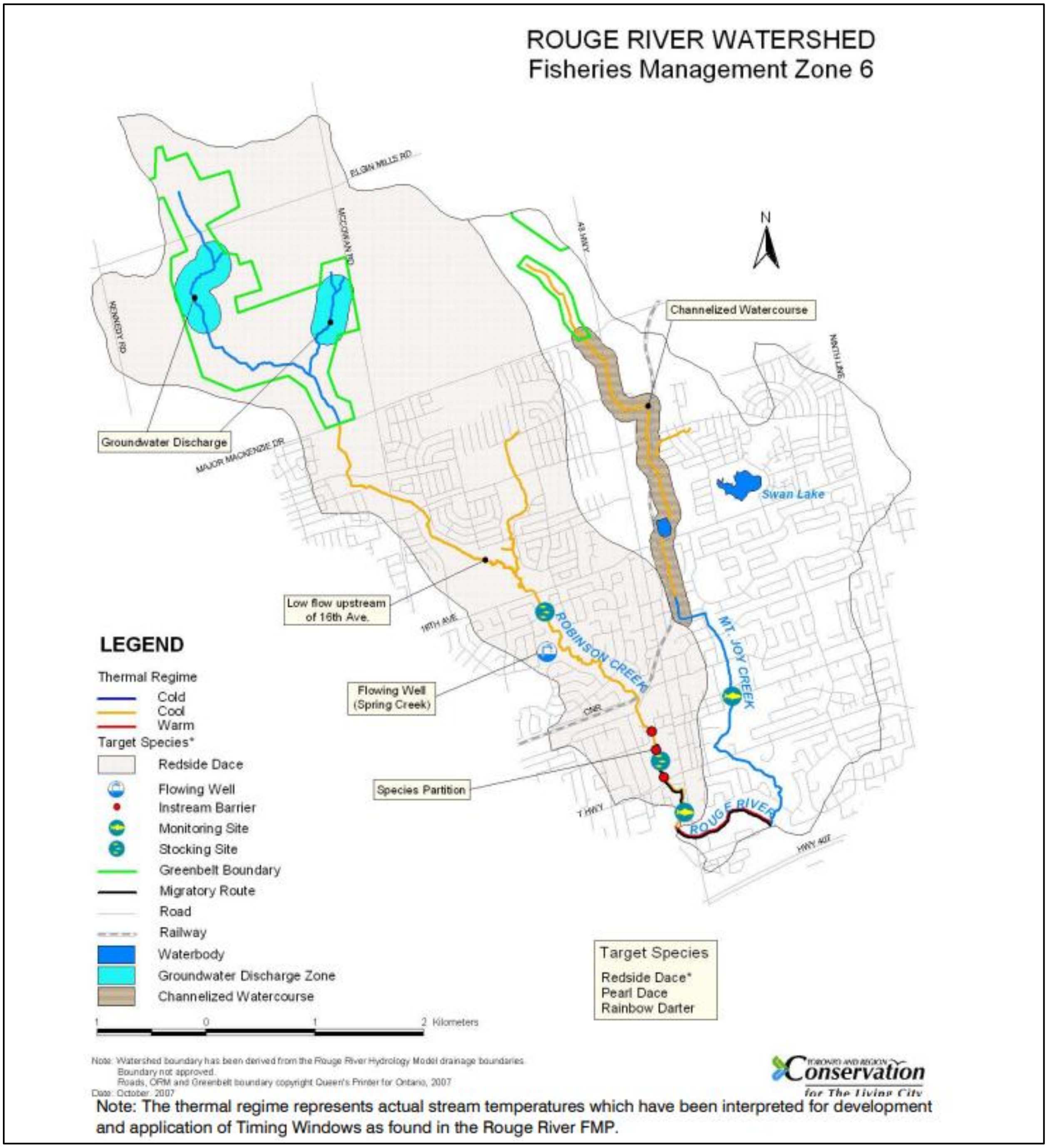


Figure 3-34: Existing Conditions in Mount Joy Creek (Toronto and Region Conservation Authority, 2007)Fish Community Assessment

As discussed above, the study area encompasses Mount Joy Creek which is located in Fish Management Zone 6 (**Figure 3-34**) within The Rouge River Watershed Plan. Target species in this management zone include, "Redside dace, Pearl dace and Rainbow darter". The thermal regime of the study area is classified as warmwater habitat due to water temperature monitoring through the Ministry of Natural Resources data (Ministry of Natural Resources and Forestry, 2019). This section of Mount Joy Creek is noted to have potential for coldwater habitat rehabilitation by the MNRF. A list of previously found species of fish anticipated to be found, as updated by the MNRF on September 30, 2019, made available through the Ministry of Natural Resources and Forestry Aquatic Resource Area (ARA) data (Ministry of Natural Resources and Forestry, 2019) is shown in **Table 3-3**.

Table 3-3: General Fish Community within the Study Area

Species		Characteristics			
Common Name	**Scientific Name**	**Tolerance**	**Thermal Regime**	**General Abundance**	**Spawning Months**
Bluegill	*Lepomis macrochirus*	Intermediate	Warmwater	Common	June – August
Brook stickleback	*Culaea inconstans*	Intermediate	Coolwater	Common	May – July
Brown bullhead	*Ameiurus nebulosus*	Intermediate	Warmwater	Common	May – June
Common carp	*Cyprinus carpio*	Tolerant	Warmwater	Common	May – August
Fathead minnow	*Pimephales promelas*	Tolerant	Warmwater	Common	May – August
Goldfish	*Carassius auratus*	Tolerant	Warmwater	Common	May – July
Largemouth bass	*Micropterus nigricans*	Tolerant	Warmwater	Common	May – June
Pumpkinseed	*Lepmois gibbosus*	Intermediate	Warmwater	Common	May – August
Redside dace	*Clinostomus elongatus*	Intolerant	Coolwater	Rare	May – June
Data retrieved from MNRF Aquatic Resource Line Data (Ministry of Natural Resources and Forestry, 2019) and Ontario Freshwater Fishes Life History Database (Eakins, 2024)					

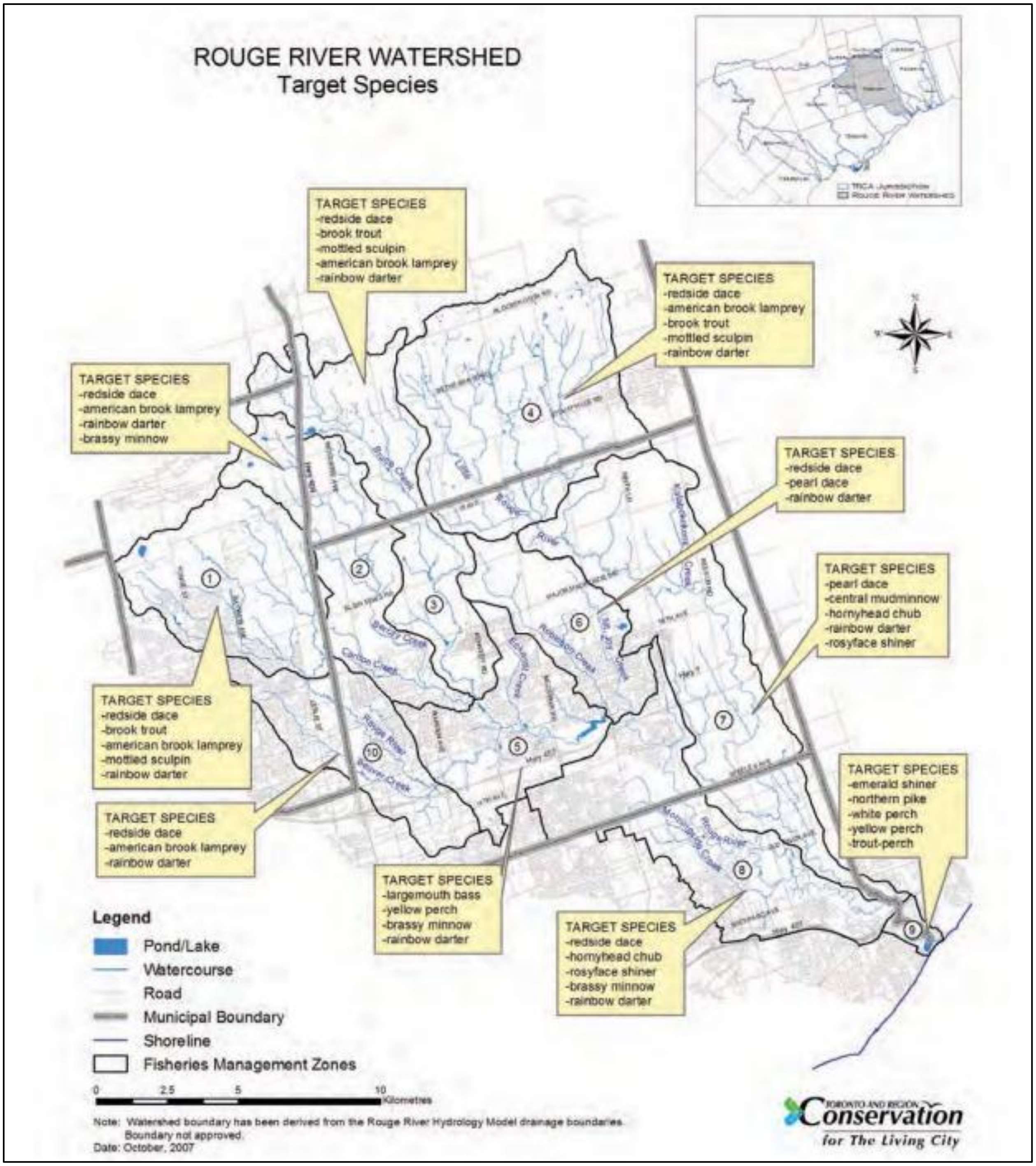


Figure 3-35: Rouge River Watershed Plan – Fisheries Management Zone mapping (Toronto and Region Conservation Authority, 2007)

As detailed above in **Table 3-3**, all species recorded in the study area, with the exception of Redside dace (Clinostomus elongatus), are common and intermediately tolerant to tolerant of disturbance. Notably, the fish community represents spring spawning and majorly warmwater species. Both Common carp (Cyprinus carpio) and Goldfish (Carassius auratus) represent non-native, invasive species within the study area, which are well-established within the region of Southern Ontario.

Table 3-3 suggests that Redside dace, a Provincially and Federally Endangered species under the Endangered Species Act (ESA) and Species at Risk Act (SARA), is found or could be found within the study area. However, federal records provided by Fisheries and Oceans Canada Species at Risk Mapping (Fisheries and Oceans Canada, 2023) indicates that no species at-risk are found (or potentially found) within the study area, including Redside Dace. Moreover, habitat noted at the study site through aerial imagery and background sources does not appear to support the requirements identified for Redside Dace, as the species are generally found in pools and slow-moving areas of small streams and headwaters with a gravel bottom and are generally found in areas with overhanging grasses and shrubs (Ministry of Natural Resources and Forestry, 2016).

3.2.3 *DFO Self Assessment*

The federal Fisheries Act requires that projects avoid causing the death of fish and the harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near waterbodies that support fish at any time during any given year or are connected to waterbodies that support fish at any time during any given year. As noted above, the study area(s) does contain fish at any time during any given year. Therefore, the Fisheries Act applies to works conducted in or near water at the site.

Upon completion of the detailed design for the channel works at the study site, the works should be cross-referenced with the DFO "Projects Near Water" online service to determine if a request for regulatory review under the federal Fisheries Act is required (Department of Fisheries and Oceans, 2019). Based on background information, the study area does contain fish at any time during any given year. It is therefore the opinion of Aquafor Beech Limited that a request for regulatory review by Fisheries and Oceans Canada will be required. It is recommended that the proponent exercise the Measures to protect fish and fish habitat listed by Fisheries and Oceans Canada to avoid contravention with the federal Fisheries Act and exercise due diligence by further mitigating accidental death of fish and the harmful alteration, disruption or destruction of fish habitat (Fisheries and Oceans Canada, 2023). It is further recommended that these mitigation measures be included in the detailed designs, with any and all applicable Codes of Practice (Fisheries and Oceans Canada, 2022) exercised where feasible.

3.2.4 *In-Water Timing Window*

As discussed above and as outlined in the federal Fisheries Act, the proponent is to exercise mitigation measures to avoid contravention with the Act and exercise due diligence by further mitigating accidental death of fish and the harmful alteration, disruption or destruction of fish habitat. With the proposed works being undertaken within and/or adjacent to Mount Joy Creek, construction should be undertaken such that the construction timing will be limited to outside of the critical life stages of the fish community listed above in **Table 3-3**. Therefore, the In-water Work Timing Window Guideline (Fisheries and Oceans Canada, 2013) outlines that based on the reproduction requirements of the fish community within the watercourse and study area, in-water works are to take place within the construction timing window of **July 15th** to **March 15th** of any given year (Ministry of Natural Resources and Forestry, 2016). These timing window guidelines are to be confirmed by the DFO during the Regulatory Review.

3.2.5 *Species at Risk Screening*

Table 3-4 provides a summary of the results of the Species at Risk (SAR) screening that was completed for the study area. Species lists as endangered (END) or threatened (THR) may have regulatory considerations should any impacts to habitat be proposed. Species listed as special concern (SC) do not have regulatory protection, but important habitat features or areas for those species may qualify as Significant Wildlife Habitat and have requirements under municipal policy.

Table 3-4: Species at Risk Screening Summary

Species Common Name	Status	Data Source	Discussion
Mammals			
Eastern Red Bat (*Lasiurus borealis*)	*not yet listed, but recommended to be designated END	General screening	Anticipated low habitat potential based on site condition and SLR's discussion of other bat species, but recommend to confirm via tree inventory/removals plan.
Eastern Small-footed Myotis (*Myotis leibii*)	END	General screening	Potential for habitat associated with rock/debris piles and similar features.
Hoary Bat (*Lasiurus cinereus*)	*not yet listed, but recommended to be designated END	General screening	Anticipated low habitat potential based on site condition and SLR's discussion of other bat species, but recommend to confirm via tree inventory/removals plan.
Little Brown Myotis (*Myotis lucifugus*)	END	SLR 2022	SLR report noted low habitat potential – only small diameter trees in study area. Recommend to confirm via tree inventory/removals plan.

Species Common Name	Status	Data Source	Discussion
Northern Myotis (*Myotis septentrionalis*)	END	SLR 2022	SLR report noted low habitat potential – only small diameter trees in study area. Recommend to confirm via tree inventory/removals plan.
Silver-haired Bat (*Lasionycteris noctivagans*)	*not yet listed, but recommended to be designated END	General screening	Anticipated low habitat potential based on site condition and SLR's discussion of other bat species, but recommend to confirm via tree inventory/removals plan.
Tri-colored Bat (*Perimyotis subflavus*)	END	SLR 2022	SLR report noted low habitat potential – only small diameter trees in study area. Recommend to confirm via tree inventory/removals plan.
Birds			
Bank Swallow (*Riparia riparia*)	THR	SLR 2022, OBBA	Foraging habitat only.
Barn Swallow (*Hirundo rustica*)	SC	SLR 2022, iNaturalist, OBBA	Foraging habitat only. Records of nesting on building to north of study area.
Bobolink (*Dolichonyx oryzivorus*)	THR	OBBA	Potential nesting habitat is absent – no large patches of open meadow, pasture, etc.
Eastern Meadowlark (*Sturnella magna*)	THR	NHIC	Potential nesting habitat is absent – no large patches of open meadow, pasture, etc.
Eastern Wood-pewee (*Contopus virens*)	SC	NHIC, OBBA	Potential habitat is absent – this species prefers mature woodlands.
Wood Thrush (*Hylocichla mustelina*)	SC	NHIC, OBBA	Potential habitat is absent – this species prefers mature woodlands.
Plants			
Butternut (*Juglans cinerea*)	END	NHIC, SLR 2022	No confirmed records/locations within study area but recommend to confirm via tree inventory/removals plan.
Reptiles			
Midland Painted Turtle	SC (federal only)	NHIC, ORAA	Potential for habitat in Mount Joy Creek; recommend mitigation and good practices for wildlife

Species Common Name	Status	Data Source	Discussion
(*Chrysemys picta marginata*)			protection be provided during construction.
Snapping Turtle (*Chelydra serpentina*)	SC	NHIC, SLR 2022, ORAA	Potential for habitat in Mount Joy Creek; recommend mitigation and good practices for wildlife protection be provided during construction.
Insects			
Monarch (*Danaus plexippus*)	SC	SLR 2022, OBA	Assume habitat potential in any area of unmown vegetation with wildflowers, particularly if Milkweed is present.
Nine-spotted Lady Beetle (*Coccinella novemnotata*)	END	SLR 2022	Not expected to be present – no records of this species in Ontario since mid-1990s, potentially extirpated.
Fish and Mussels			
Eastern Pondmussel (*Ligumia nasuta*)	SC	NHIC	Suitable habitat likely absent in study area – prefers lakes and slow-moving rivers. Study area is not in known range of remaining Ontario populations.
Redside Dace (*Clinostomus elongatus*)	END	NHIC	Suitable habitat not present in study area. DFO mapping does not indicate the presence of critical habitat or species presence.

3.3 Archaeological Assessment

New Era Archaeology completed a Stage 1 Archaeological Assessment of the study area. A Stage 1 Archaeological Assessment consists of a review of geographic land use, historical records and maps, and current aerial photography for the subject area and relevant surrounding area, a site visit to confirm the project area conditions (didn’t occur due to weather conditions), and contacting the Ministry of Citizenship and Multiculturalism (MCM) to find out whether or not there are any known archaeological sites on or near the subject area. The purpose of the assessment is to determine if the project site has areas of archaeological potential, if any past land within the project site has removed areas of potential, and to identify further archaeological assessment (e.g., Stages 2-4) as necessary. The final Stage 1 Archaeological Assessment report is provided in **Appendix B**. All archaeological assessment works were completed in conformity with the Ministry of Citizenship and Multiculturalism (MCM), formerly Ontario Ministry of Tourism and Culture (MTC), Standards and Guidelines for Consultant Archaeologists (MTC 2011) and the Ontario Heritage Act (RSO 1990a).

The area assessed for the Stage 1 Archaeological Assessment included Part of Lots 18-20, Concession 7 and the Road Allowance Between Lots 20 and 21, Concession 7 and Part of Lots 18-20, Concession 8 (Former Township of Markham, County of York), City of Markham, Regional Municipality of York. It was determined the project area has the potential for both Indigenous (pre-contact) and historic (post-contact) archaeological resources. Some archaeological potential has been removed from portions of the project area subject to modern development.

While some archaeological resources have been removed, the Stage 1 Archaeological Assessment recommended that a Stage 2 Archaeological Assessment by test pit survey is completed for the portions of the project area which retain archaeological potential (**Figure** 3-36 and **Figure 3-37**). Test pits should be conducted at a 5-metre interval. Additionally, the previously disturbed areas are to be documented during the Stage 2 Archaeological Assessment.

Should previously undocumented archaeological resources be discovered, they may be a new archaeological site and therefore subject to Section 48(1) of the Ontario Heritage Act. The proponent or person discovering the archaeological resources must cease alteration of the site immediately and engage a licensed consultant archaeologist to carry out an archaeological assessment, in compliance with Section 48(1) of the Ontario Heritage Act.

The Funeral, Burial, and Cremation Services Act, 2002, S.O. 2022, c.33 requires that any person discovering human remains must cease all activities immediately and notify the police or coroner. If the coroner does not suspect foul play in the disposition of the remains, in accordance with Ontario Regulation 30/11 the coroner shall notify the Registrar, Ontario Ministry of Public and Business Service Delivery and Procurement, which administers provisions of that Act related to burial sites. In situations where human remains are associated with archaeological resources, the MCM should also be notified (at archaeology@ontario.ca) to ensure that the archaeological site is not subject to unlicensed alterations which would be a contravention of the Ontario Heritage Act.

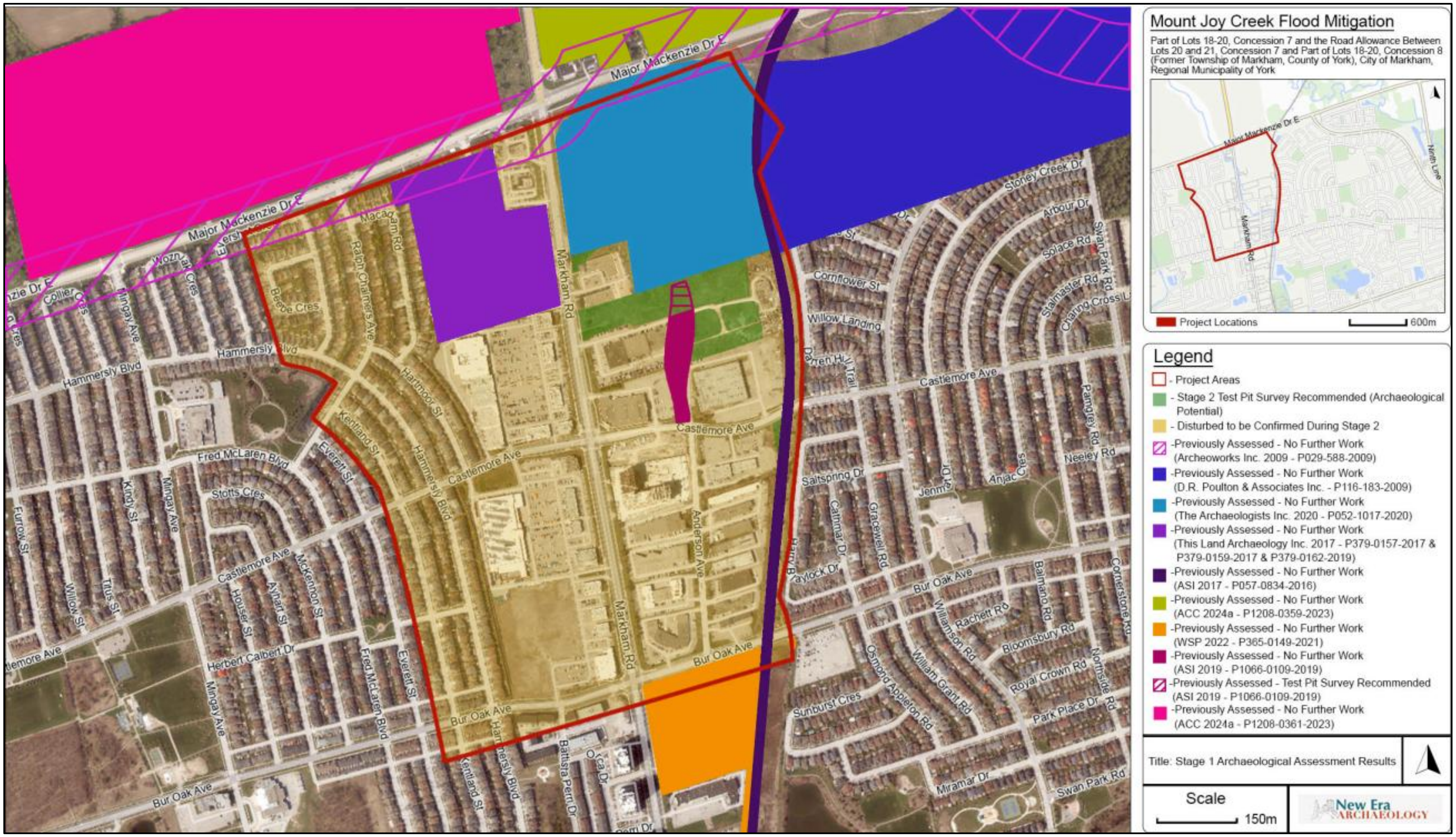


Figure 3-36: Stage 1 Archaeological Assessment Results and Recommendations (1/2)

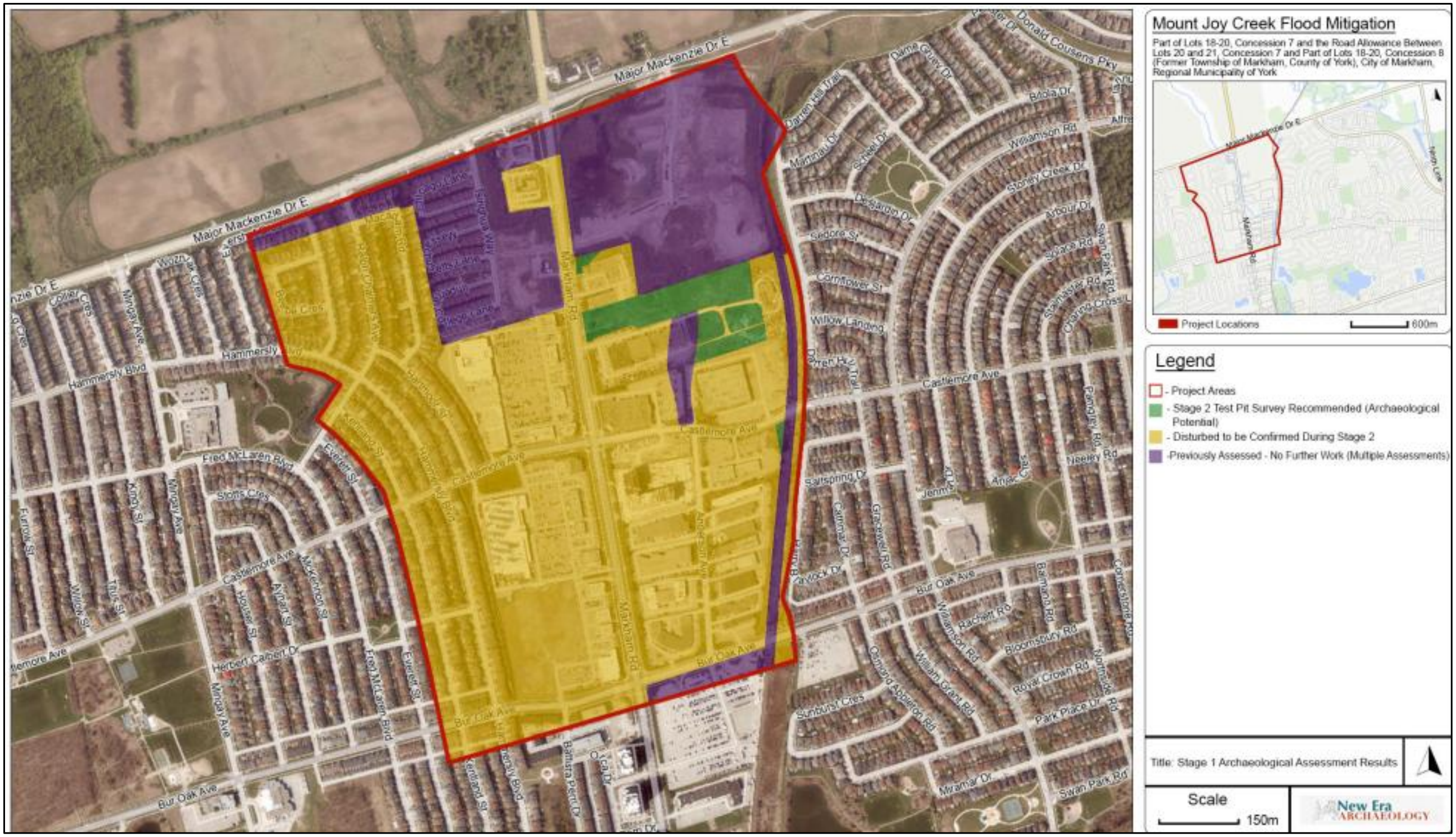


Figure 3-37: Stage 1 Archaeological Assessment Results and Recommendations (2/2)

3.4 Built Heritage Resources and Cultural Heritage Landscapes

The Municipal Heritage Register (the Register) is comprised of the heritage properties regulated by the City of Markham under the Ontario Heritage Act (OHA). Properties designated under the OHA are either individual properties (Part IV designation) or within a heritage conservation district (Part V designation).

New Era conducted a screening of the cultural heritage properties within the study area using the City's Heritage Property Search to support the environmental assessment being conducted. The study area was searched for any properties with parcels that exist within.

Aquafor's review of the City of Markham's Heritage Property Search, it was determined that one property currently exist within the study area as seen below in **Figure 3-38**. Photographs of the existing property are seen below in **Figure 3-39** and **Figure 3-40**.

Table 3-5 provides details regarding the properties within the study area, noting their designation status.

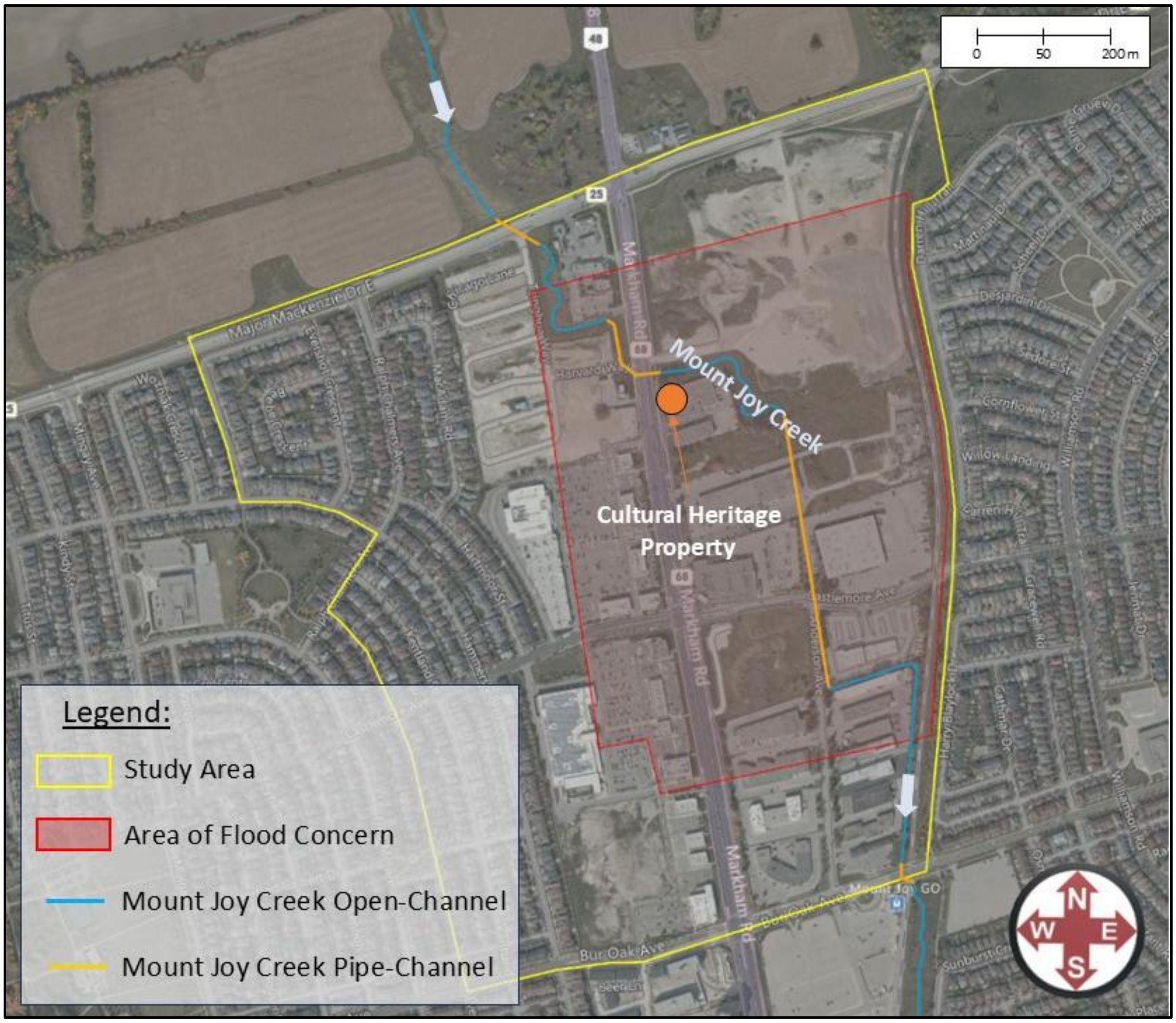


Figure 3-38: Cultural Heritage Properties Within Study Area

Figure 3-39: Contemporary Photograph of Cultural Heritage Property

Figure 3-40: Heritage Photograph of Cultural Heritage Property

Table 3-5: Cultural Heritage Site Information Within Study Area

Address	Property Legal Description	Historical Name	Ward	Heritage Conservation District
9899 Markham Rd	YORK REGION CONDO PLAN 1078 LEVEL 1 UNIT 18	The William Read House	4	N/A
Year Built	**Architectural Style**	**Heritage Status of Property**	**Designation Bylaw**	**Heritage Easement Agreement**
1840	Georgian Tradition	Part IV (Individual)	2023-12, 2002-168	Yes

3.5 Hydrologic and Hydraulic Modelling - Existing Conditions

3.5.1 *2022 TRCA MIKE Modelling*

The existing hydrologic and hydraulic conditions of Mount Joy Creek through the study area are defined and management by TRCA. At the onset of the study, TRCA provided a MIKE Flood 1D-2D coupled model with technical memo (2022) for Mount Joy Creek defining the existing conditions. The provided model includes the Regional Storm Event – Hurricane Hazel, with distinct flow nodes along the length of the corridor. A copy of the TRCA's memo is provided in **Appendix C** for reference.

The study area modelling is defined using the MIKE Flood interface that features the dynamic coupling of the MIKE HYDRO and MIKE 21 hydrodynamic modules. River reaches and all crossings were handled using the 1D MIKE HYDRO modelling routine, with overland surfaces being modelled using the 2D MIKE 21 modelling routine. MIKE Flood integrates these two models into a single dynamically coupled mode. The setup of the model is illustrated in the figure below. It should be noted that the figure referenced reflects the existing conditions cross-sections from TRCA model, and does not represent newly developed cross-sections by Aquafor. Consistent with this, for existing conditions updated model (explained in **Section 3.5.3**) and Alternatives models, Aquafor followed the same approach of not including cross sections in this transect since it has been modelled as a long pipe, cross sections are assigned where an open channel section is present.

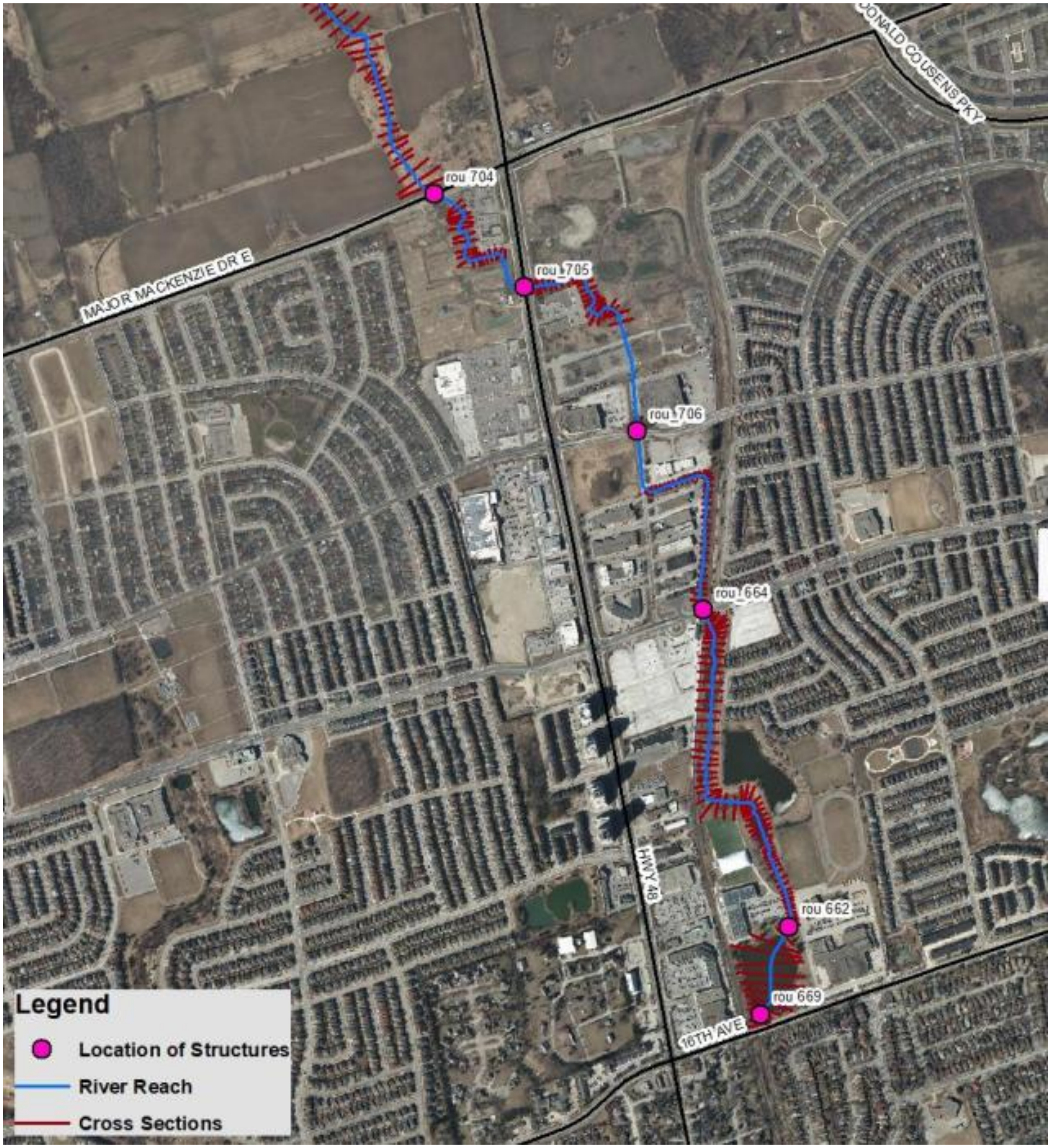


Figure 3-41: MIKE Flood Modelled Study Extents (TRCA, 2022).

The specific locations of flow nodes, which include flood flows ranging from the frequent 2-year return through the 100 year and Regional are illustrated on the adjacent figure, with the pertinent flows summarized in **Table 3-6** below.

Table 3-6: Flow Node Hydrology for the Mount Joy Flood Mitigation EA (Existing Conditions, 2022 TRCA Model).

Flows (m^3/s)	Source	J5670.032 (point source)	J4789.696 (point source)	J4309.178 (point source)	J4145.856 (point source)	J3661.799 (point source)	J253 (point source)
Applied in model at chainage		0	1260	2259	2730	2874	3443
2	(TRCA, 2022)	1	1.68	0	0	0.2	1.63
5	(TRCA, 2022)	1.5	2.43	0	0	0.68	2.24
10	(TRCA, 2022)	2	2.9	0	0	1.07	2.75
25	(TRCA, 2022)	2.7	3.51	0	0	1.43	3.25
50	(TRCA, 2022)	3.3	4.03	0	0	1.76	3.61
100	(TRCA, 2022)	3.9	5.05	0	0	2.16	4.04
Regional	(TRCA, 2022)	5.78	6.11	0	0	5.67	11.91

Figure 3-42: MIKE Flood Hydrologic Flow Nodes (TRCA, 2022).

The TRCA Memo identifies three spill locations between Castlemore Avenue to the south and Major Mackenzie Road to the north, using the 2D modelling platform to characterize the spill and flooding conditions. The spills and associated flood hazard are defined using flood risk categories based on risk, and adapted from the Technical Guide River and Stream Systems: Flooding Hazard Limit prepared by the Ontario Ministry of Natural Resources (2002). The categories are defined as follows:

Low Risk	Vehicular and Pedestrian Access/Egress is Available (depth <0.3m),
Moderate	Pedestrian Access/Egress ONLY Available (Product Depth & Velocity <0.37m2/s), Depth <0.8m and Velocity <1.7m/s,
High Risk	Depth &Velocity product > 0.37 m2/s **or** Depth >0.8m or Velocity >1.7m/s

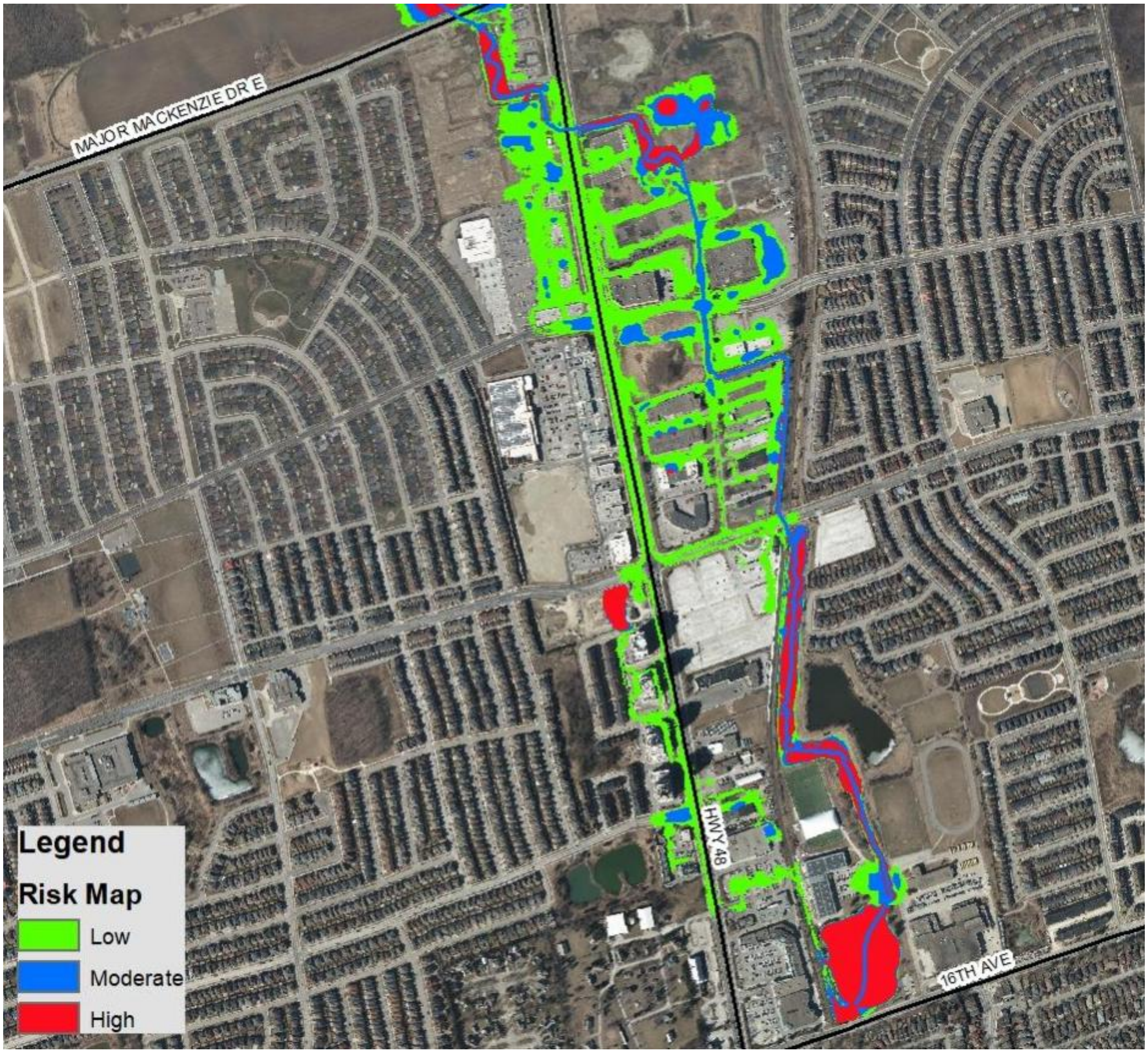


Figure 3-43: Existing Conditions Flood Hazard and Spill Areas (TRCA, 2022).

The above results currently define the existing flood hazard conditions and regulatory limits, which impact existing opportunities for safe use and development of adjacent private properties. The alternatives defined for flood hazard and risk improvement will look to mitigate these current conditions.

3.5.2 2023 Valdor Engineering Modelling

Valdor reported peak flows that were higher than those used in the TRCA model, and these values were carried forward into the updated MIKE Flood model. The peak flows applied to the revised existing conditions are summarized in **Table 3-7**, which also provides a comparison with the TRCA peak flows.

Table 3-7: Comparison of Regional peak flows from previous reports

Flows (m^3/s)	Source	J5670.032 (point source)	J4789.696 (point source)	J4309.178 (point source)	J4145.856 (point source)	J3661.799 (point source)	J253 (point source)
Node		0	1260	2259	2730	2874	3443
Regional	**(TRCA, 2022)**	5.78	6.11	0	0	5.67	11.91
Regional	**(Valdor, 2023)**	7.09	6.04	0	0	5.67	11.91

In addition, Valdor (2022) completed field investigations to verify the configuration, dimensions, and physical characteristics of the culvert system beneath Markham Road adjacent to their site at 9900 Markham Road. The investigation confirmed that the 1500 mm pipe is a corrugated steel pipe (CSP), while the 1050 mm pipe is a smooth steel pipe—differing from the TRCA's assumption that both were CSPs. It was also observed that the pipe extensions located east of the original 1500 mm and 1050 mm pipes (likely installed during Markham Road improvements) are constructed of concrete rather than steel.

To enable the coding of the complex culvert system consisting of multiple culverts in series and in parallel with varying dimensions and roughness values, the culvert system was modelled in MIKE FLOOD using the "Closed Section" approach. As the "closed section" approach does not account for entrance and exit losses, the Manning's n values were chosen to reflect all losses of the existing culvert system (i.e., entrance, exits, and bends), with a PCSWMM model support.

A comparison of the culvert configurations between the TRCA and Valdor is provided in **Table 3-8** for the Markham Road and Anderson Avenue culverts (comparison for other culverts, between existing and each alternative can be found on **Table 4-1** to **Table 4-6**). For reference, and a more detailed methodology for Valdor modelling, refer to **Appendix D**.

Table 3-8: Comparison of culverts configuration between TRCA 2022 and Valdor 2023 models

Culvert	Chainage		Manning		Bends	
	TRCA Modelling	Valdor Modelling	TRCA Modelling	Valdor Modelling	TRCA Modelling	Valdor Modelling
Markham Rd Culvert 1 (1500 mm dia)	1383-1500	1474-1500	0.024	0.034	3 bends (45°)	No bends/increased manning
Markham Rd Culvert 2 (1050 mm dia)	1383-1500	1474-1500	0.024	0.019	3 bends (45°)	No bends
Markham Rd Culvert 3 (3000 x1500 mm box)	Not modelled	1383-1474	Not modelled	0.019	Not modelled	3 bends (45°)
Anderson_Culvrou_706 (1100mm x 1700mm)	1780-2184.5	1780-2184.5	0.013	0.013	1 slight bend (45°)	1 slight bend (45°)

3.5.3 *2025-2026 Aquafor Modelling*

Aquafor agreed with TRCA and the City that a MIKE product is the appropriate modelling tool for evaluating alternative solutions, given the hydraulic complexity of the study area associated with the Mount Joy Creek spill zones. The original TRCA model (see **Section 3.5.1**), which was developed in MIKE FLOOD using dynamic coupling between the MIKE HYDRO River and MIKE 21 hydrodynamic modules, was converted to MIKE+. This conversion was necessary as the MIKE FLOOD, MIKE HYDRO River, and MIKE 11 were formally decommissioned as of the 2024 release, with their functionality fully replaced by MIKE+ (Group, 2025).

3.5.3.1 Model Conversion

Based on the commentary above, the first step in establishing the existing hydraulic modelling for the project is the conversion of the previous MIKE modelling to the new MIKE + platform. Accordingly, the following information has been provided to detail the steps completed to compile the new MIKE+ model for the Mount Joy EA project.

- Model check: Ensured that the original model (MIKE 11, MIKE HYDRO River, MIKE 21 and MIKE FLOOD) opened and run correctly in its native environment, using a previous Mike Flood 2021 version provided by DHI. This helped to identify any existing issues before importing.
- Created a New MIKE+ Project / Database: A SQLite, model type, and coordinate system was chosen based on TRCA previous setup
- Import: Predefined import tools for MIKE FLOOD were used as: "Import full MIKE FLOOD model setup", to set up all coupled components (culverts, weirs, etc)
- Review Import Logs and Warnings: Examined the warnings (especially in orange) for features that may not have transferred exactly or require special attention.
- Cross-Check and Validate the Imported Model: Compared the original model's elements (geometry, boundary conditions, couplings, flow paths, structures) to those in the MIKE+ project. Some structures and automatic coupling links were fixed

3.5.3.2 LiDAR

The 2D domain was based on the 2019 LiDAR dataset obtained from the original TRCA (2022) model. This dataset was produced by combining the 2015 and 2019 LiDAR surveys to ensure leaf-off coverage within the creek corridors and improve representation of overbank areas.

TRCA also provided a newer 2023 LiDAR dataset; however, it was not used for the model conversion. The 2023 data lacked sufficient detail regarding grading in recently developed areas, which were better captured in the 2019 LiDAR. In addition, no significant grading changes have occurred across most of the study area between 2019 and 2023, and therefore the 2019 dataset was considered the most reliable and consistent base for the modelling.

3.5.3.3 TRCA Peak flow values

The boundary conditions for the 1D riverine component of the MIKE+ model are consistent with the 2022 TRCA MIKE FLOOD setup. Total inflows were applied at the upstream end of Mount Joy Creek, with incremental flows introduced as point sources along the reach. Steady-state peak flows were ramped over a 1-hour period and then held constant for 15 hours, following the original TRCA modelling approach.

The downstream water level boundary condition was adopted from TRCA's 2018 Rouge River HEC-RAS model (TRCA, 2019), which includes Mount Joy Creek. **Figure 3-44** shows the locations of the peak flow nodes used as boundary conditions for the 2-year through 350-year design storms and the regional storm.

Alternatives 1 (Existing Conditions) to Alternative 7 were originally developed using the 2022 TRCA flow data. However, following comments from the City, it was recommended that all models to be updated to reflect the 2023 Valdor flow conditions, as presented in Table 3-7. Aquafor updated flows in this new EA revised submission for Existing Conditions model and Alternative 7 model.

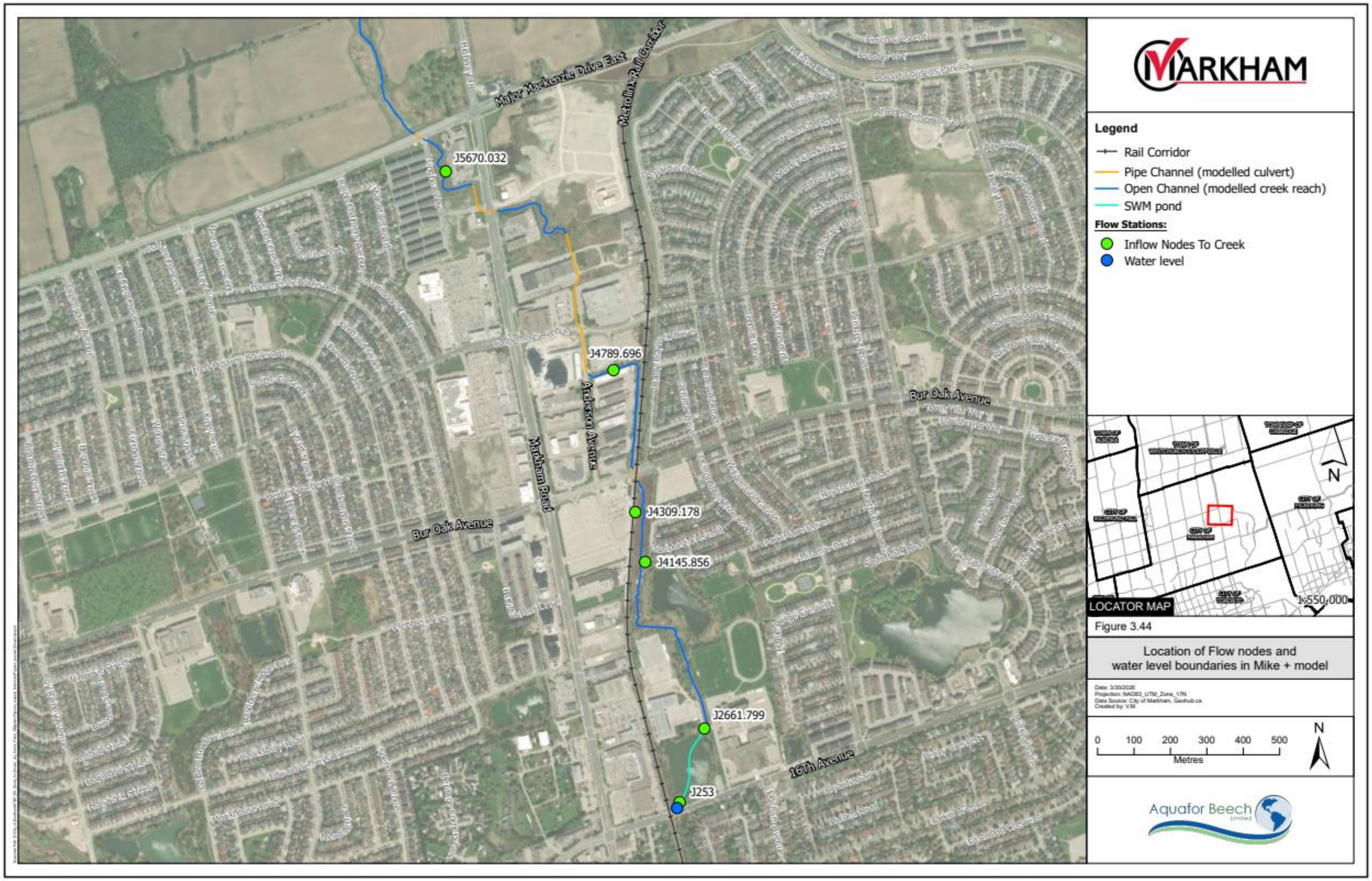


Figure 3-44: Boundary Conditions for Mike + Model

3.5.3.4 Culverts

The configuration of the existing culverts in the MIKE+ converted model follows the same locations and assumptions used in the 2022 TRCA model. Updates to the culvert system or a change from culvert structure to closed section approach provided in the Valdor model were not incorporated, as Aquafor did not receive the supporting background data or instructions directly from TRCA before Aquafor's model conversion, Hence, the TRCA model remains the only approved reference to date.

The following assumptions were applied in MIKE+ for the existing conditions:

Highway 48 (Markham Road) Crossing – South of Major Mackenzie

Existing Crossing Configuration (field)
- One 3.0 m × 1.5 m concrete box culvert (upstream)
- Two corrugated steel pipe (CSP) culverts with diameters 1.5 m and 1.05 m

Model Representation (downstream)
- For conservatism, the crossing was represented in the MIKE+ model as two circular CSP culverts (1.5 m and 1.05 m).

Bend Loss Assumptions
- Bend losses equivalent to three 45° bends for a box culvert were included.
- Bend loss coefficients applied: 0.025, 0.025, and 0.31.
- Total bend loss coefficient = 0.818, based on FEMA – Hydraulic Design of Highway Culverts (April 2012).

Reason for Conservative Representation
- The Highway 48 (Markham Road) crossing representation in MIKE+ is conservative as the upstream 3.0 m × 1.5 m box culvert was simplified as circular CSP culverts with additional bend losses. Circular pipes and added bend losses result in higher hydraulic losses and reduced conveyance compared to the actual box culvert geometry. This approach produces higher modelled upstream water levels, providing a conservative estimate of existing-condition hydraulic performance. If the system performs adequately under these assumptions, it is expected to perform adequately under real-world conditions.
- The TRCA existing model approach and the Highway 48 and Major Mackenzie 2D Modeling Report represent these features using the same dimensions and physical properties.

Manning's Roughness
- To simplify modelling of the 1500 mm and 1050 mm pipes, the highest roughness value within each pipe system was applied as a conservative assumption. Manning's n = 0.024.

Culvert Modelling Approach
- Given the complexity of the culvert system (multiple culverts in series and parallel with varying dimensions and roughness values), the culverts were modelled in MIKE+ using the culvert structure approach.
- This approach is consistent with the 2022 TRCA-approved model methodology.

Dimensions and Inverts

- Culvert dimensions and invert elevations were verified to match field survey data or Valdor model

Anderson Avenue Long Culvert

Existing Crossing Configuration (field)

- Upstream: two ellipse-shaped CSPs (1.5 m span × 0.95 m rise)
- Downstream: one ellipse-shaped concrete pipe (1.7 m span × 1.1 m rise)

Model Representation (Existing Conditions)

- For conservatism, this crossing was coded as a single 1.7 m × 1.1 m elliptical concrete pipe, including one bend loss (loss coefficient = 0.11) as per FEMA guidance.

Bend Loss Assumptions

- Bend losses equivalent to one 45° bends for a culvert were included.
- Total bend loss coefficient = 0.11 for long-radius bend, based on FEMA – Hydraulic Design of Highway Culverts (April 2012).

Reason for Conservative Representation

- As the actual crossing consists of two upstream elliptical CSP culverts that transition into a single downstream elliptical pipe was simplified as circular CSP culverts with additional bend losses. The culvert system includes multiple barrels with different shapes and transitions, which can introduce instability and unnecessary complexity in 1D hydraulic modelling. Representing the system as a single equivalent pipe: simplifies the model setup, reduces uncertainty associated with modelling short transition structures that do not significantly influence overall hydraulic control. Since the flow ultimately passes through a single downstream barrel, that barrel effectively controls the hydraulic capacity of the system. This approach ensures the model represents the controlling conveyance element of the crossing, which is the 1.7 x 1.1 culvert.
- The TRCA existing model approach and the Highway 48 and Major Mackenzie 2D Modeling Report represent these features using the same dimensions and physical properties.

Culvert Modelling Approach

- Given the complexity of the culvert system (multiple culverts in series and parallel with varying dimensions and roughness values), the culverts were modelled in MIKE+ using the culvert structure approach.
- This approach is consistent with the 2022 TRCA-approved model methodology.

Dimensions and Inverts

- Culvert dimensions and invert elevations were verified to match field survey data or Valdor model at the upstream and downstream face of the culvert

A summary of the existing culvert configurations is provided in **Table 3-9**.

Table 3-9: Existing Conditions – Culvert Configurations

Existing Conditions (Reality)						Existing Conditions (Modelled)																
Creek	ID	number of culverts	Width (m)	Height (m)	Diameter (m)	ID	Chainage	Type	Width (m)	Height (m)	Diameter (m)	ups inv (m)	down inv (m)	Length (m)	number of culverts	offset	section	manning	inflow	outflow	free	bends
Mount Joy	MajorMac_Culv rou_704	1			1.5	MajorMac_Culv rou_704	1103.05	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Circular			1.5	208.84	208.43	133.95	1	-0.6	Closed	0.024	0.5	1	1	0.818
Mount Joy	HWY48 Culv_2 rou_705	1			1.05	HWY48 Culv_2 rou_705	1487.13	Circular			1.05	208.84	208.43	133.95	1	0.4	Closed	0.024	0.5	1	1	0.818
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5																		
Mount Joy	Anderson_Culv 1 rou_706	2	1.47	0.91		Anderson_Culv rou_706	2046.23	Irregular				207.6	205.4	400.23	1	0	Closed	0.013	0.5	1	1	0.11
Mount Joy	Anderson_sewer rou_706	1			1.35																	
Mount Joy	Anderson_Culv 2 rou_706	1	1.7	1.1																		
Mount Joy	BurOak_Culv_1 rou_664	2	2.44	1.22		BurOak_Culv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Culv_2 rou_664	1	1.82	1.22		BurOak_Culv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriveWay_Culv rou 662	2	2.5	1.9	0	PrivateDriveWay_Culv rou 662	3456.63	Irregular				196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond _Culv rou_669	1			0.8	SWM Pond _Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

3.5.3.5 Existing conditions - 1D updates

No major modifications were required to the Existing Conditions model following the conversion. Inverts and geometry for each structure were confirmed with LiDAR 2023 and supplemented with topographic survey data where applicable

3.5.3.6 Existing conditions - 2D updates

The 1D river model consists of channel cross-sections that are linked to a 2D surface at the top of bank. The 2D component provides a detailed representation of spill locations along the watercourse and the associated overland flow paths throughout the study area. It captures bank geometry, overland conveyance, and physical obstructions.

Coupling links were not automatically generated during the import process, the 1D–2D links had to be manually added along the top-of-bank and at the 2D mesh boundaries. **Figure** 3-45 illustrates the MIKE + configuration, including the 1D cross-sections, culverts, weirs and coupling links.

Figure 3-45: Model Structures used in the Mike + model setup

3.5.4 *Hydrology & Existing Flooding Conditions / TRCA Spillways*

TRCA, Counterpoint, and Valdor Engineering completed a spill analysis of Mount Joy Creek while working on the Markham Road Mount Joy Secondary Plan. A 1-D hydraulic analysis was completed by Counterpoint and several spill points were identified. Following discussions between the City and TRCA, it was determined that both a 1-D and 2-D model be created to identify the spill areas. The 2-D model was created by TRCA and validated by Valdor Engineering. Three major spill areas were identified (**Figure 3-46**) and are summarized below.

- Spill #1 – Major Mackenzie Drive East
  - Mainly caused due to undersized culvert & low point on Major Mackenzie Drive East
- Spill #2 – West Side of Hwy 48 near 9900 Markham Rd
  - Mainly caused due to low point of a swale
- Spill #3 – Inlet of Buried Pipes on Anderson Ave
  - Mainly caused due to undersized buried long pipes

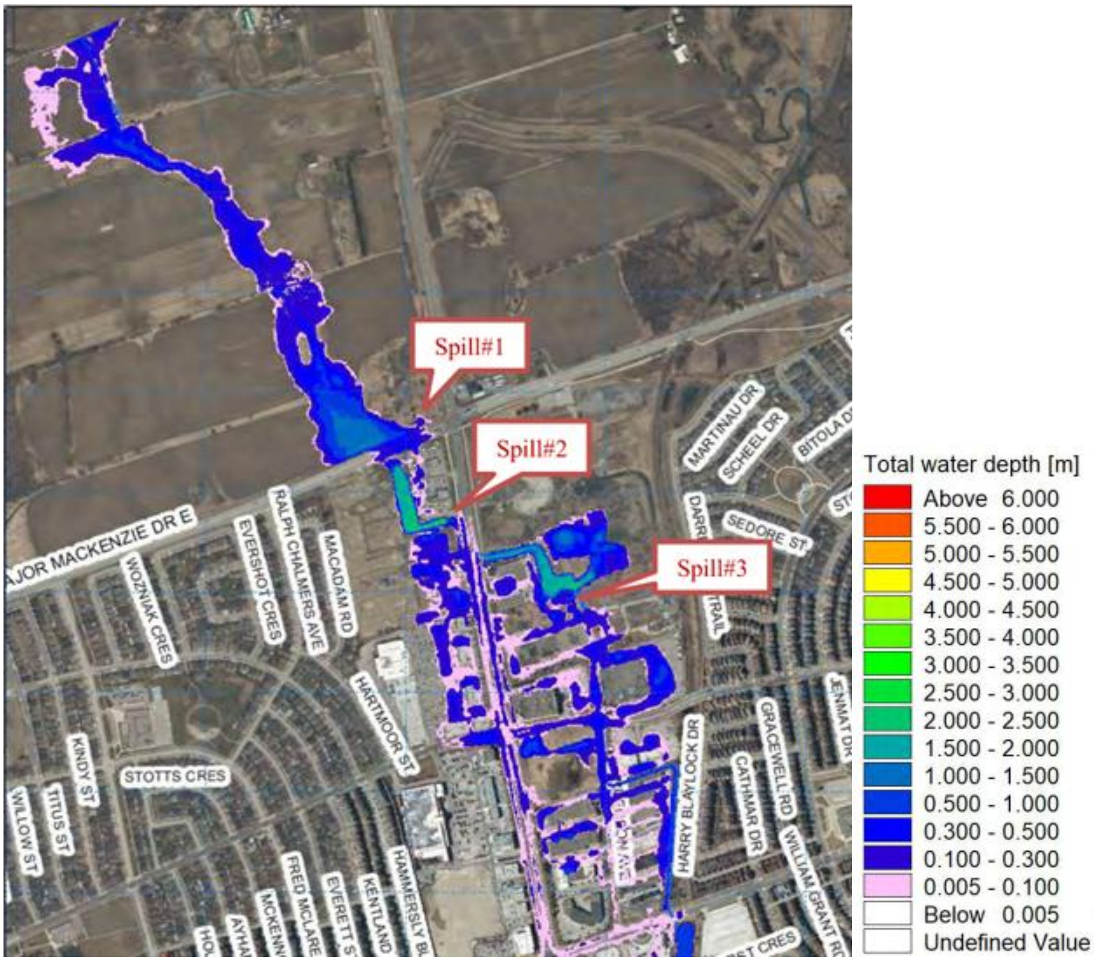


Figure 3-46: TRCA Spill Areas (Image from *Flood Impact Analysis for Proposed Mixed-Use Development, 9900 Markham Road*, Valor Engineering, 2023)

Similarly, Aquafor reviewed the TRCA model to update and confirm the existing conditions and to support the development of proposed alternatives for flood reduction. Culvert configurations and invert elevations, based on 2023 LiDAR data, were incorporated into the new MIKE+ converted model. LiDAR 2019 was used as the base terrain to build the 2D mesh instead of LiDAR 2023 because it more accurately represented current ground conditions and aligned better with the TRCA's previous cross-sections. Results show the same spill extensions than TRCA, as indicated in **Figure 3-47**.

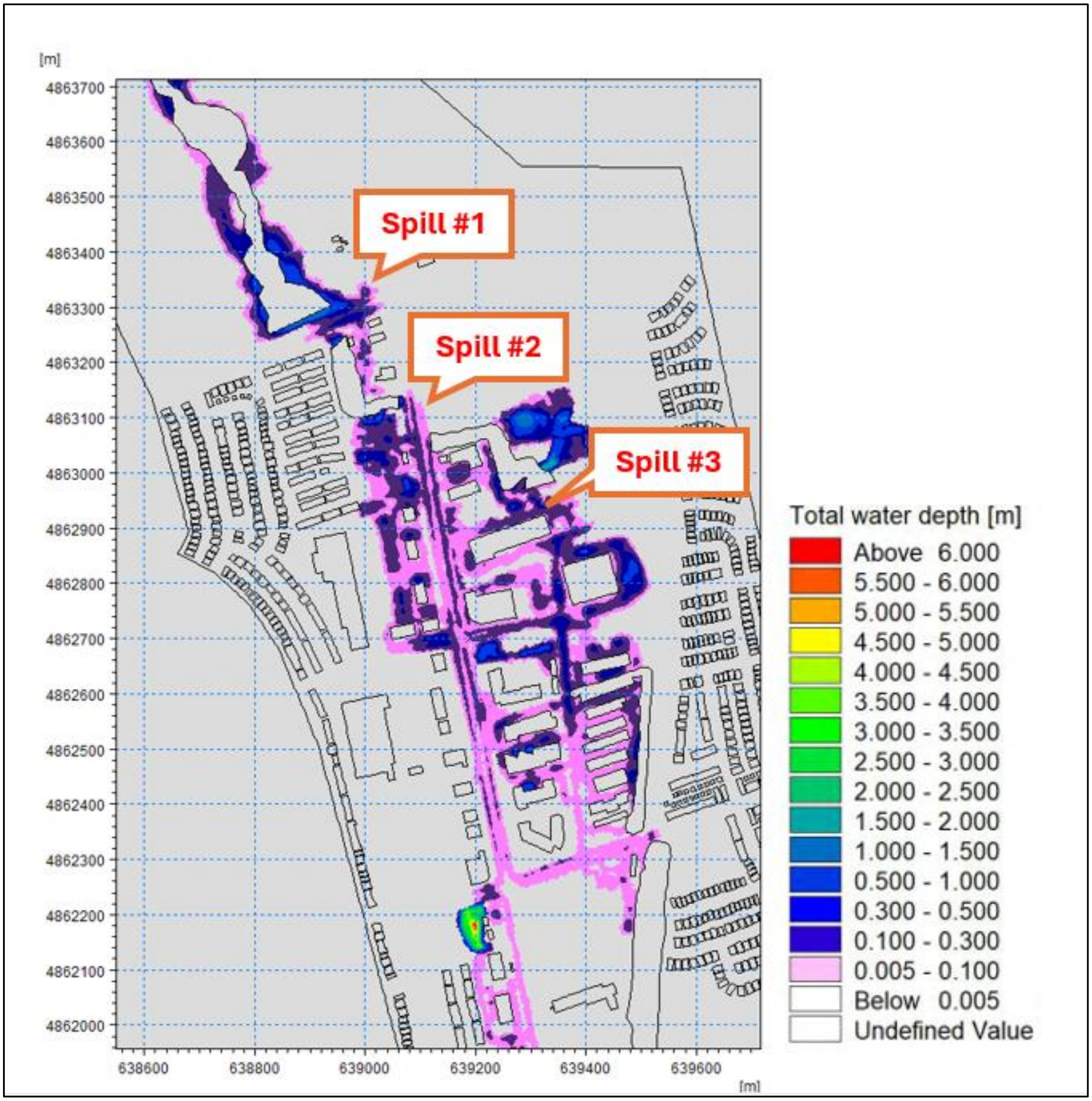


Figure 3-47: Aquafor Spill Areas (Image from Results files from Mike + Existing Conditions)

3.5.5 *Comparison of Engineering Modelling Results*

The results of the 1D/2D MIKE FLOOD Valdor hydraulic model indicate that the study property at 9900 Markham Road is subject to partial flooding under regional storm conditions, as shown in **Figure 3-48**. In comparison, the WSEL mapping from the current approved TRCA model (**Figure 3-49**) shows a larger flood extent in the vicinity of 9900 Markham Road.

Most changes in flood water surface elevations (WSEL) within the study area—and outside the proposed residential/commercial development grading limits—are relatively minor, generally represent a decrease of 0.12 to 0.36 m.

For reference, a comparison of the resulting WSELs from the MIKE+ converted model for the same area is provided in **Figure 3-50** and **Figure 3-51**. Comparison with Aquafor existing conditions model is provided in **Figure 3-50** and **Figure 3-51**.

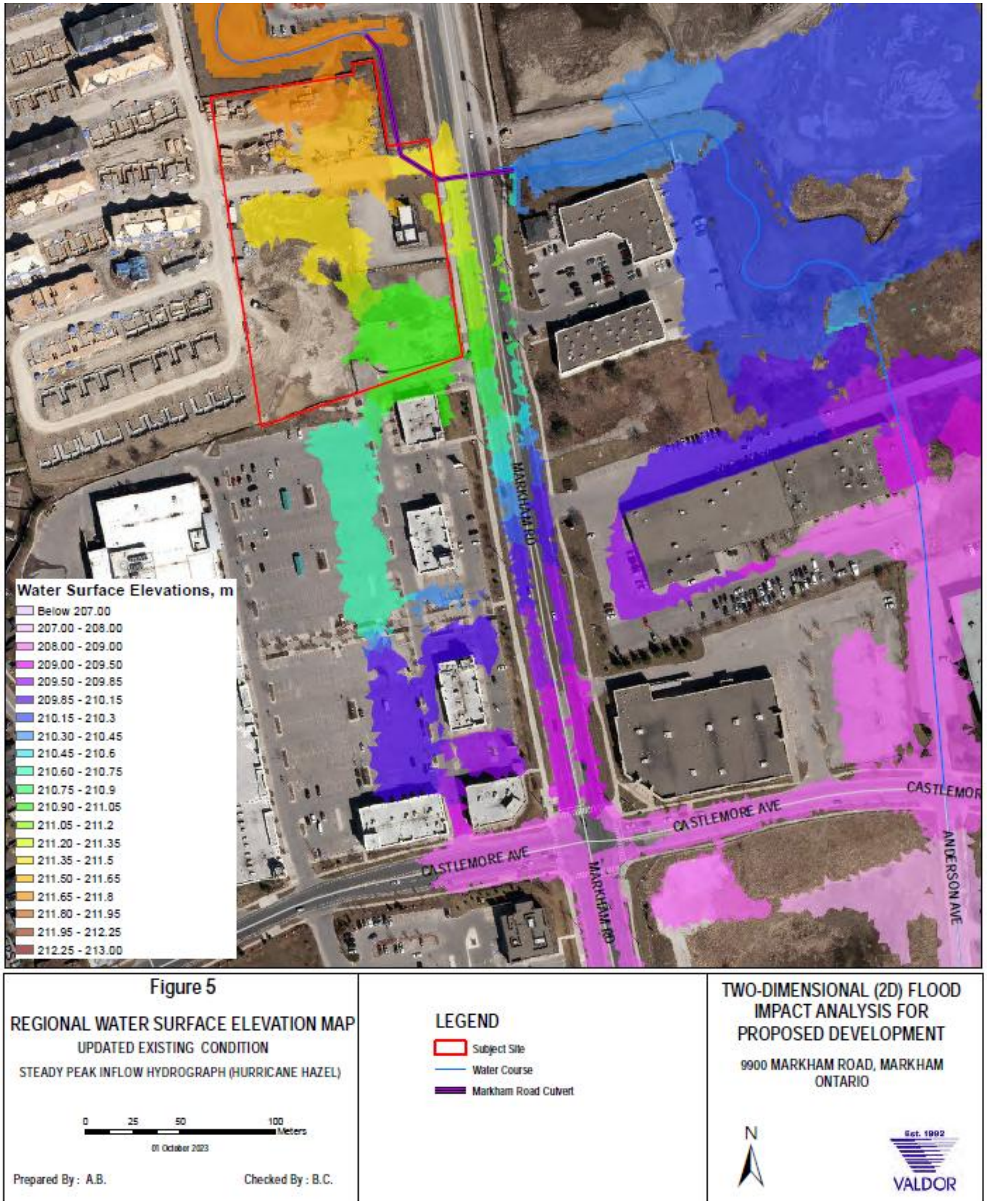


Figure 3-48: Valdor Modelling results for Regional Water Surface Elevation

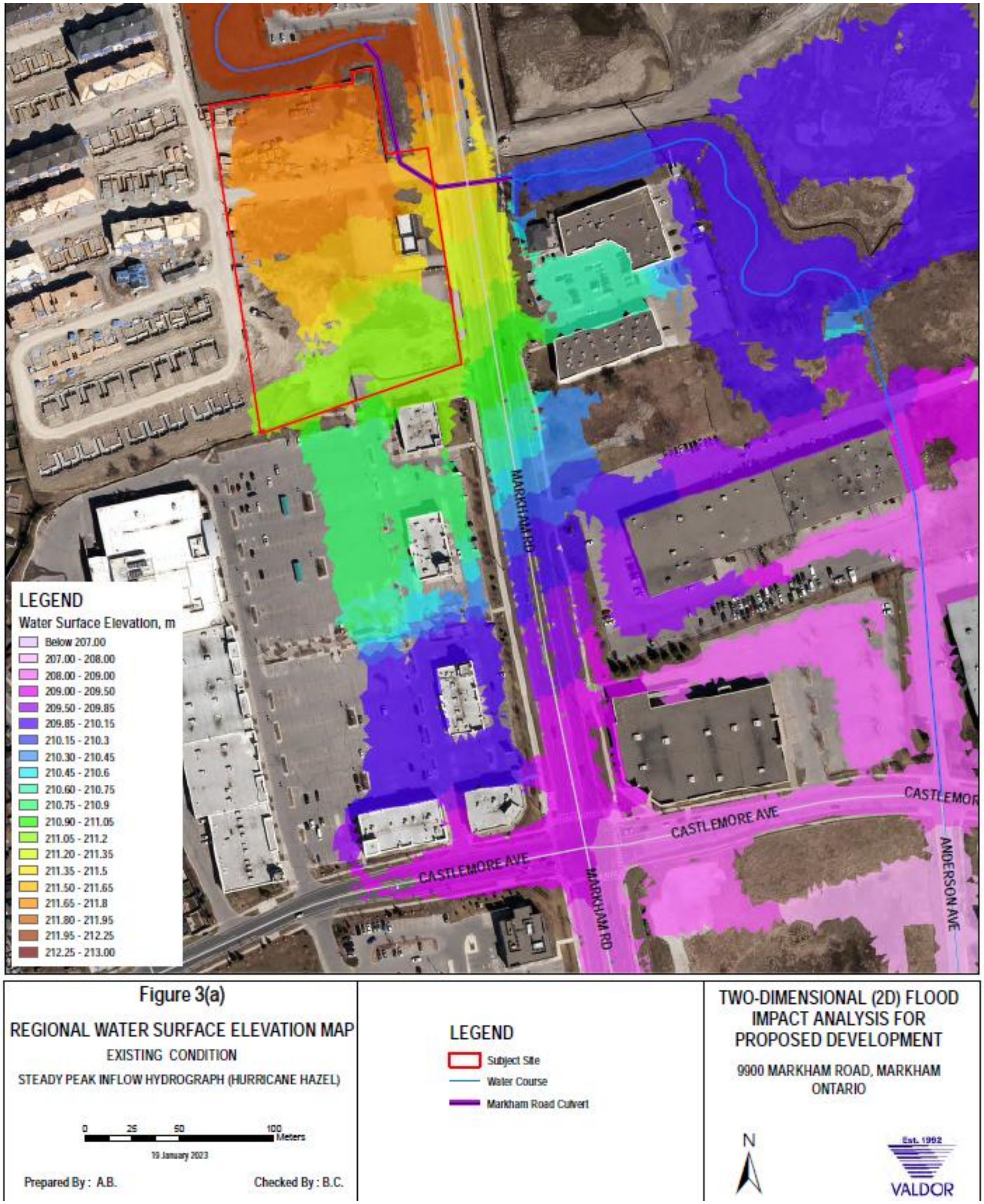


Figure 3-49: TRCA Modelling results for Regional Water Surface Elevation

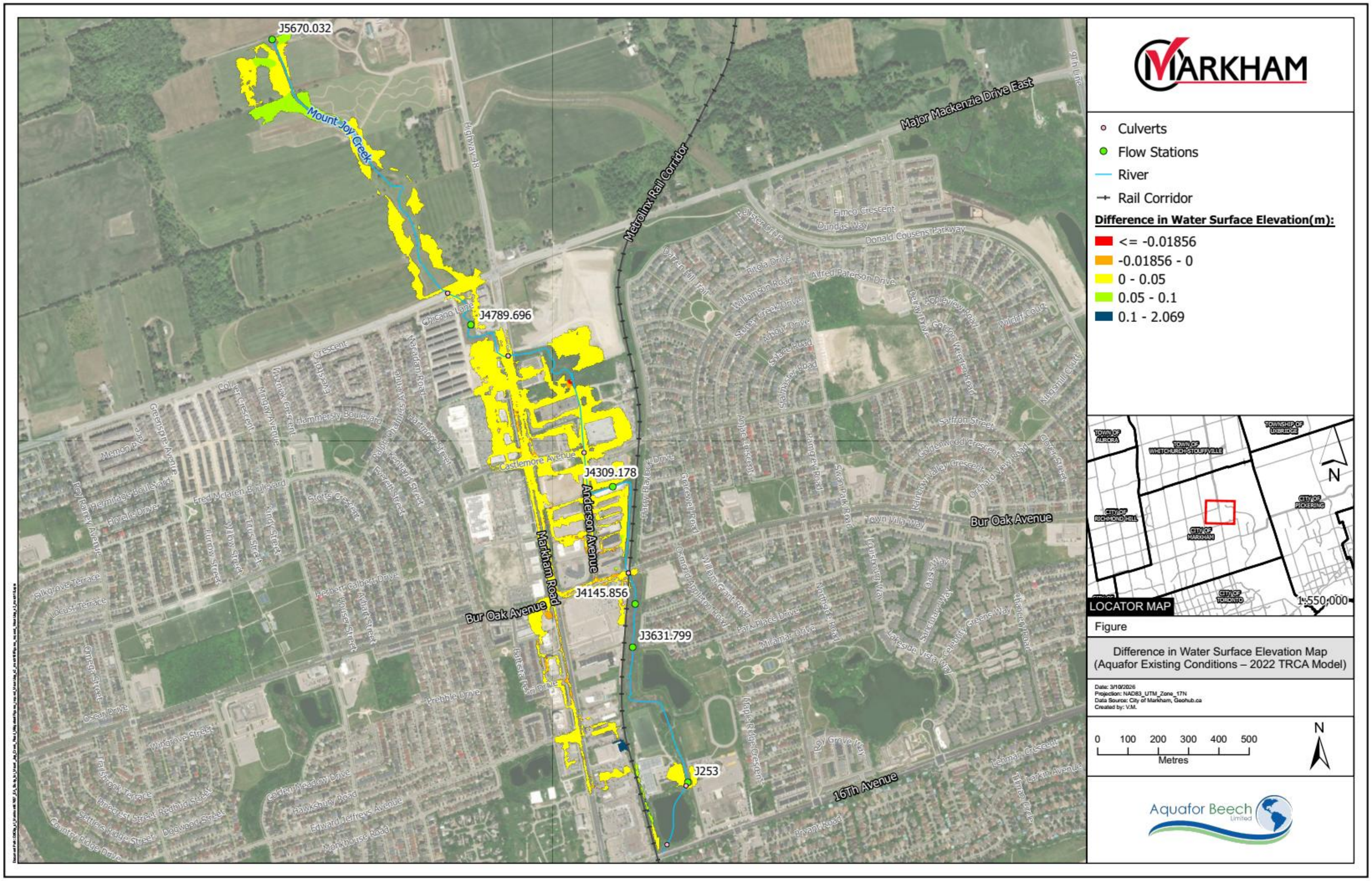


Figure 3-50: Difference for Regional Water Surface Elevation between 2026 Aquafor Model and 2022 TRCA Model

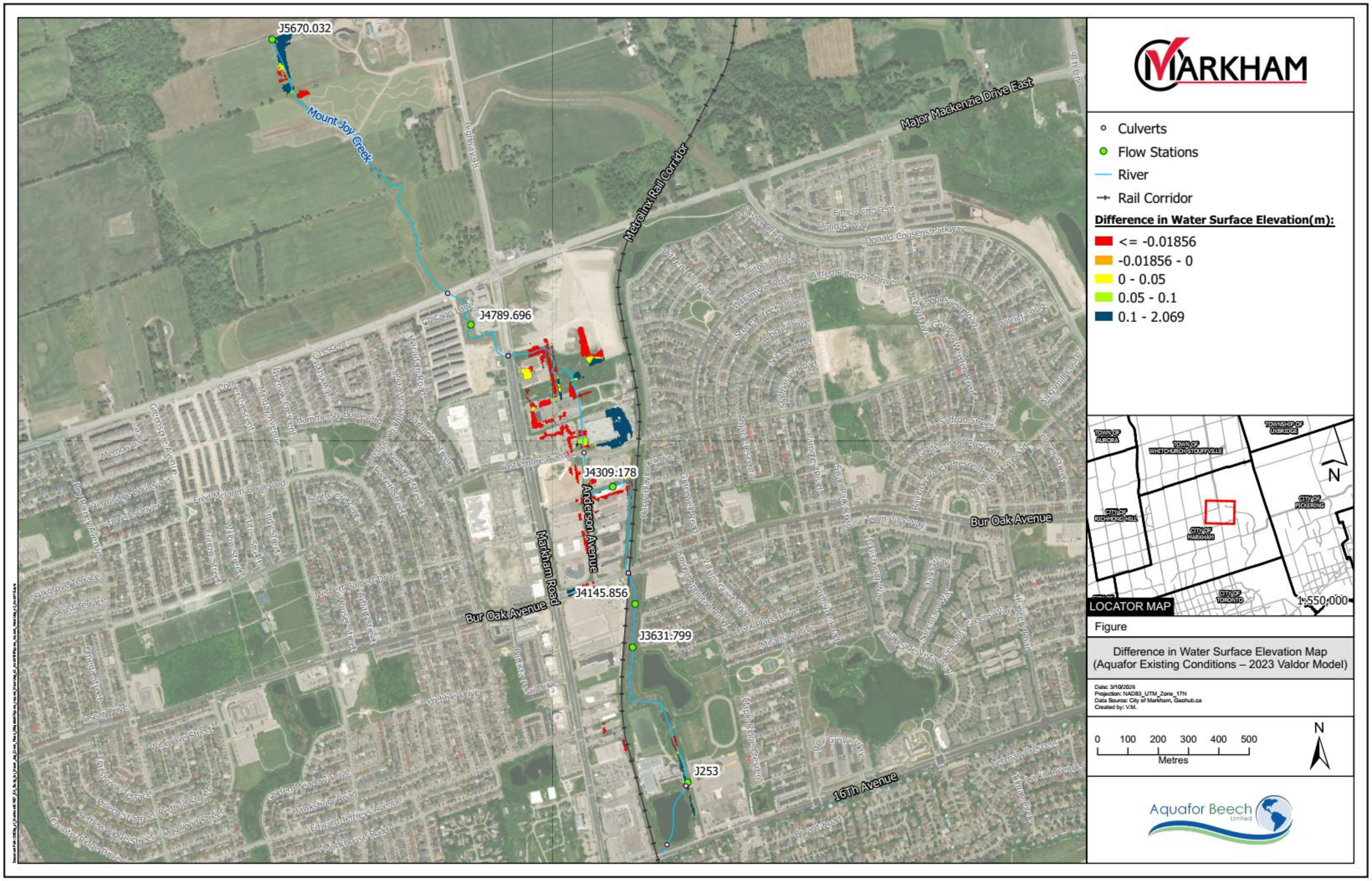


Figure 3-51: Difference for Regional Water Surface Elevation between 2026 Aquafor Model and 2023 TRCA Model

3.6 Geotechnical Assessment

A formal geotechnical investigation within the project area is outside the scope of this EA. However, site specific geotechnical investigations and soil testing will be required near culvert replacement locations to obtain an understanding of current soil conditions. results of these investigations may impact detailed design considerations.

4 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

4.1 Alternatives – 2025-2026 Aquafor Modelling

Aquafor used the MIKE+ converted model to evaluate six (6) proposed alternative solutions within the study area, which are described individually in **Section 4.2**. The existing MIKE model was modified to represent the specific conditions associated with each alternative solution under consideration.

4.1.1 *LiDAR*

The LiDAR information presented in **Section 3.5.3.2** has been used in the preparation and evaluation of conveyance alternatives within the project area. Manual 1D modelling adjustments have been made to replicate new open channel conditions, where applicable to alternatives re-directing flows away from the existing watercourse alignment.

4.1.2 *TRCA Peak flow values*

Peak flow values have been referenced from **Section 3.5.3.3** and further from the existing TRCA MIKE model.

4.1.3 *Alternatives - 1D updates*

Model updates included replacing river reaches, revising chainages for the main Mount Joy Creek, updating channel cross-sections, and adjusting 1D–2D coupling locations. Weir structures were added at new locations to represent overflow, and culverts were added, replaced, or removed conceptually depending on the alternative, to allow assessment of idealized conditions. Interpolated cross-sections downstream of Mount Joy Creek were recut from terrain in the floodplain and parts of the creek where a proposed open channel was suggested.

It should be noted that the channel manning's n for some of the revised cross-sections do not fully capture the proposed banks of the watercourse. Further revisions at the detailed design stage of the project are required to ensure that the proposed channel is represented with an accurate roughness value.

4.1.4 *Alternatives - 2D updates*

For certain alternatives, a new LiDAR surface and 2D mesh were generated to represent sections of the creek proposed as open channels. As a result of these changes, new 1D–2D coupling links were manually added in addition to the existing condition links to ensure proper flow connectivity along the modified channels.

A series of alternatives were developed to specifically address the observed concerns within the study area, using the information gathered from the technical assessments. A brief description of the alternatives are provided in the following subsections. A complete set of alternative drawings is provided in **Appendix E**. Alternatives 2-8 have been configured to explore drainage improvements in an upstream to downstream direction.

4.1.5 *Alternative 7 – 2026 updates*

- **Channel Geometry Adjustments**
    - Minor channel bed adjustments applied **upstream and downstream of the Anderson Avenue culvert**.
    - Channel bed lowered between approximately **stations 1682–2170** to achieve a realistic hydraulic profile. Adjustments made to reflect that **ground elevations near 9833 Markham Road appear lower than existing sewer inverts**.
- **Culvert Configuration**
    - Proposed **twin culverts sized at 2.4 m × 1.5 m** implemented for the Anderson Avenue crossing.
    - For modelling purposes, the **Anderson culvert system was simplified as a single continuous structure** to reduce uncertainty associated with short transition structures.
    - Inverts lowered to 207 upstream face, and 205.2 downstream face
- **Hydraulic Representation Updates**
    - **Traditional weir approach** applied for roadway overflow representation where applicable (Markham Road and Anderson Avenue). Bur Oak has the same explicit branch as initial model
    - **Explicit branch approach also tested** to verify differences; results showed no significant impact on conveyance.
- **Hydraulic Loss Adjustments**
    - Bend losses updated to represent **three 45° bends**, with an assumed **bend loss coefficient of approximately 0.7**, as indicated in the Minor Loss Coefficients for Storm Drain Modeling with SWMM (Frost, 2006)

4.2 Description of Alternatives

4.2.1 *Alternative 1: Do Nothing*

This alternative is required as part of the EA process; however, it would entail continued flooding within the spill areas, leading to economic damages and restrict future development at the study area.

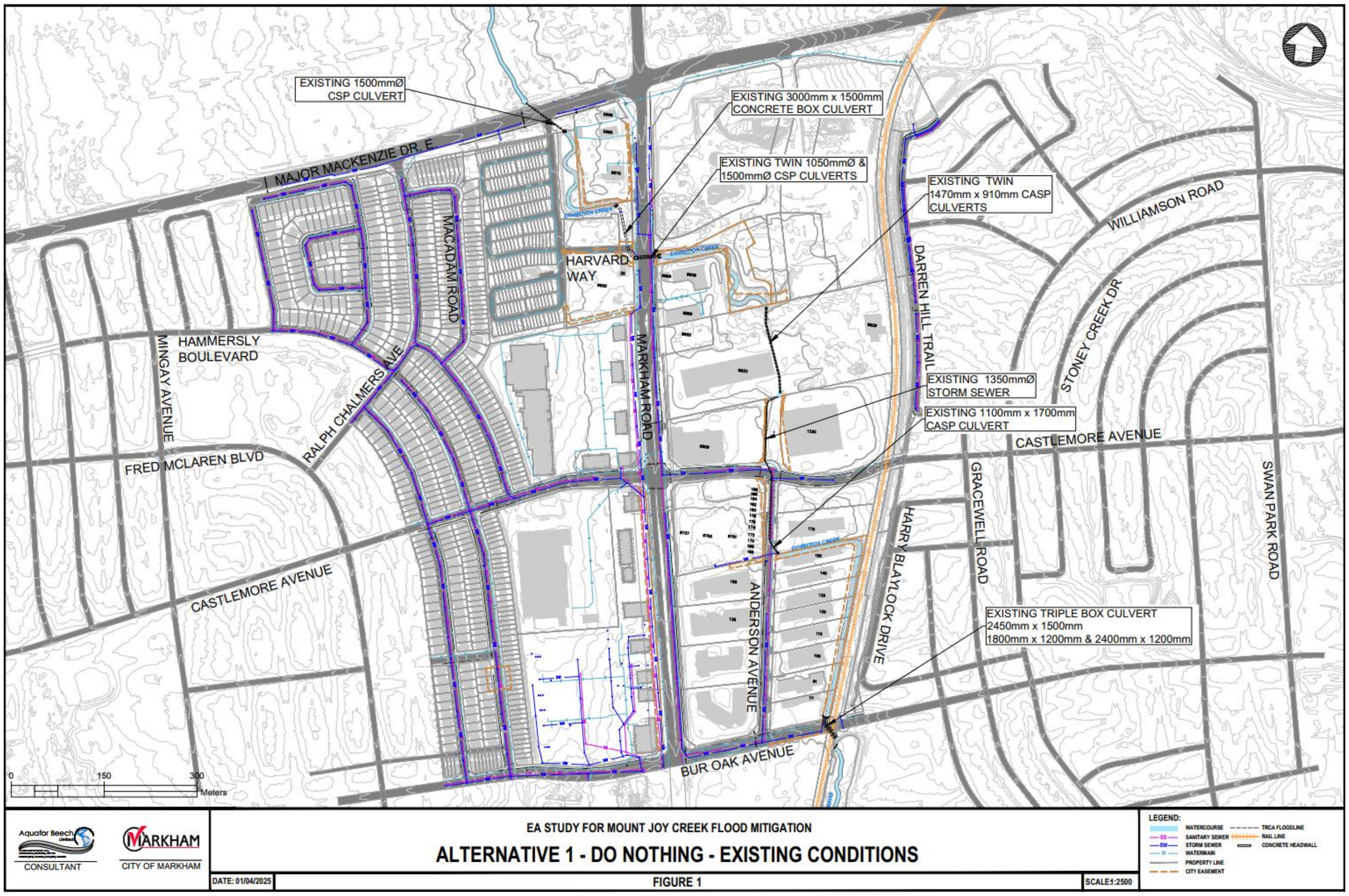


Figure 4-1: Alternative 1 – Do Nothing – Existing Conditions

4.2.2 _Alternative 2: Stormwater Reduction Pond_

This alternative would consist of a Stormwater Management (SWM) pond to be constructed immediately upstream of the study area. This will be positioned immediately north of Major Machenzie Drive East. The pond will be an offline SWM pond, run in parallel with Mount Joy Creek, and be placed east of the creek. This alternative requires no changes to be made to any of the stormwater infrastructure within the Study Area. This alternative aligns with the recommendations outlined in the 2025 Upper Markham Village draft Report prepared by SCS Consulting. This alternative also aligns with the recommendations with the 2021 FSR prepared by Masongsong Associates, which also suggested installing stormwater storage facility to reduce post-development flows to pre-development levels.

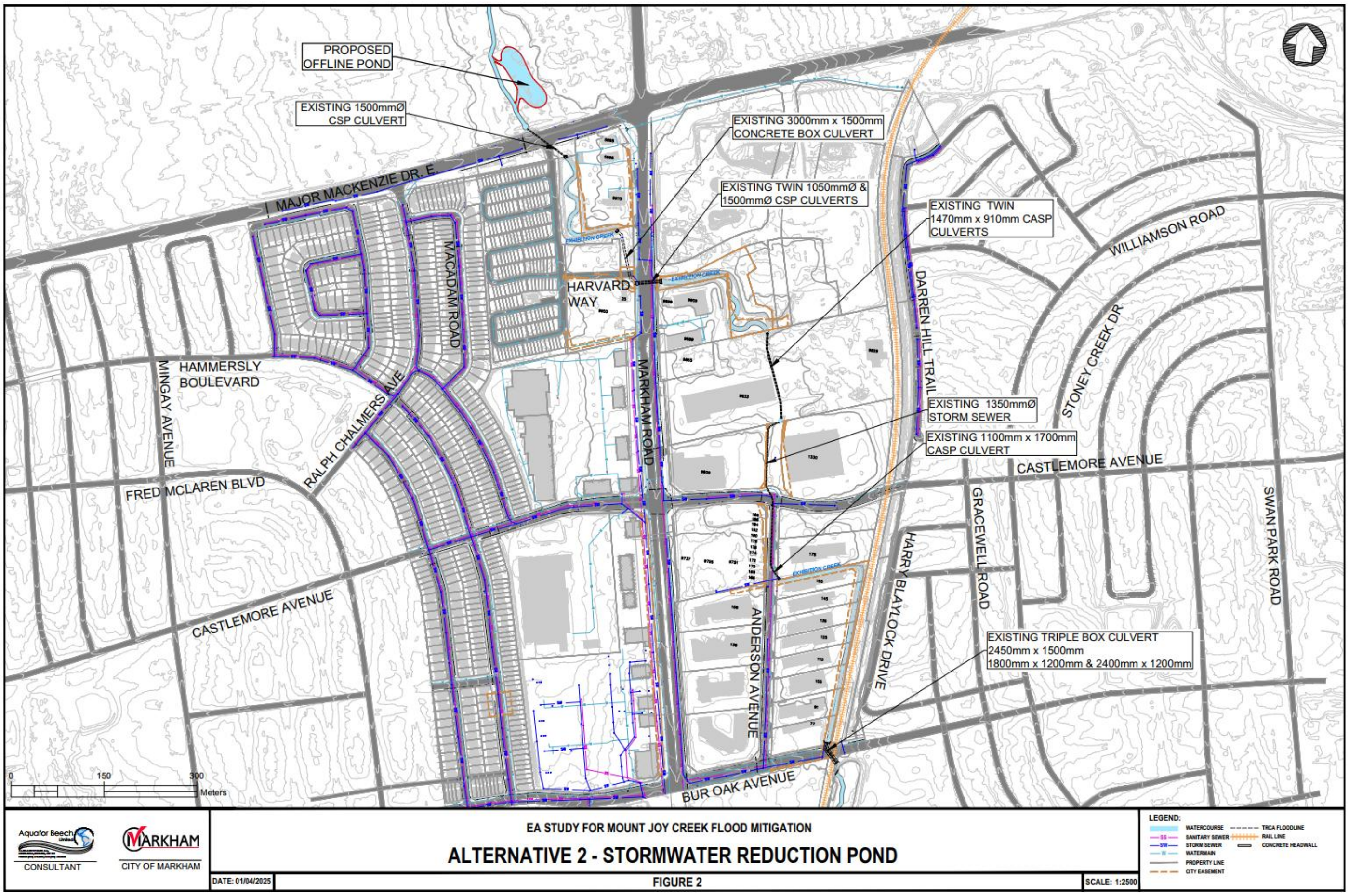


Figure 4-2: Alternative 2 – Stormwater Reduction Pond

4.2.3 *Alternative 3: Upstream Only Improvements*

This alternative would consist of removing the existing culverts located south of 9970 Markham Road extending to Mount Joy Creek north of 9899 Markham Road. The first half of the removed culverts will be replaced with a trapezoidal channel consisting of a 3.5 m bottom width and 2.5:1 side slopes, extending to the north side of Harvad Way. The second half of the removed culverts, twin 1050 mm diameter and 1500 mm diameter CSP culvert, will be replaced with a larger proposed 3000 mm x 1500 mm concrete box culvert. This alternative does not include modification to any of the stormwater infrastructure located in the downstream half of the study area. This alternative aligns with the recommendations outlined in the 2015 Greck and Associates Limited, which also proposed an open channel at the upstream ends of Mount Joy Creek.

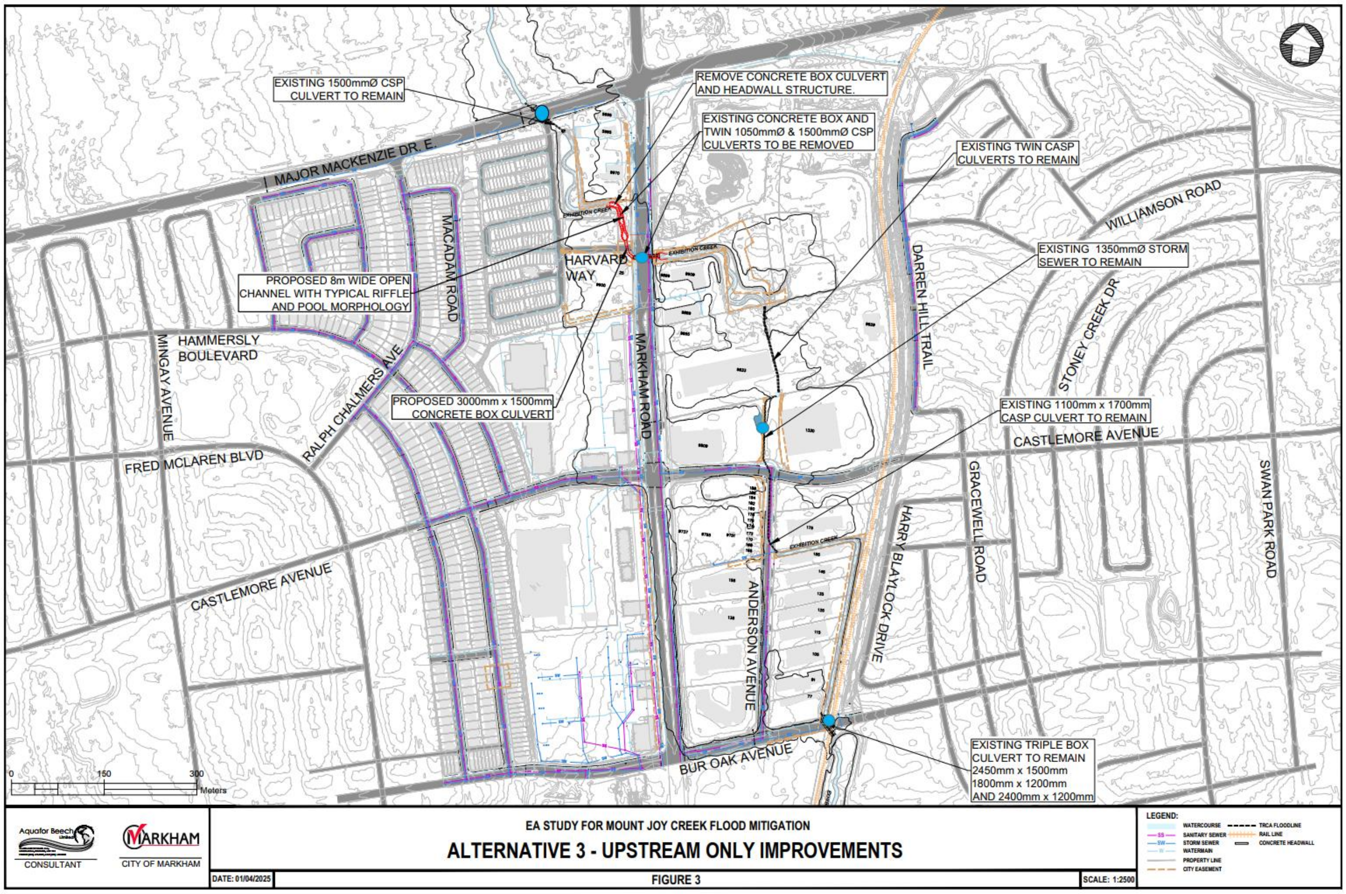


Figure 4-3: Alternative 3 – Upstream Only Improvements

Configuration of modelled culverts is show in the following **Table 4-1**:

Table 4-1: Updates for culvert configuration for Alternative 3

	Existing Conditions					Alternative 3 (modelled in November 2025; not updated in the 2026 model revision).																
Creek	ID	number of culverts	Width (m)	Height (m)	Diameter (m)	ID	Chainage	Type	Width (m)	Height (m)	Diameter (m)	ups inv (m)	down inv (m)	Length (m)	number of culverts	offset	section	manning	inflow	outflow	free	bends
Mount Joy	MajorMac_ Culv rou_704	1			1.5	MajorMac_ Culv rou_704	1103.05	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Rectangular	3	1.5		208.704	208.428	40	1	-0.5	Closed	0.013	0.5	1	1	current bend:0.818, but it will be updated to one 45 deg bend (0.70)
Mount Joy	HWY48 Culv_2 rou_705	1			1.05																	
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5																		
Mount Joy	Anderson_ Culv1 rou_706	2	1.47	0.91		Anderson_ Culv rou_706	2046.23	Irregular	1.7	1.1		207.6	205.4	400.23	1	0	Closed	0.013	0.5	1	1	current bend:0.11, but it will be updated to four 45 deg bend (2.8)
Mount Joy	Anderson_ sewer rou_706	1			1.35																	
Mount Joy	Anderson_ Culv2 rou_706	1	1.7	1.1																		
Mount Joy	BurOak_Cu lv_1 rou_664	2	2.44	1.22		BurOak_Cu lv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Cu lv_2 rou_664	1	1.82	1.22		BurOak_Cu lv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriv eWay_Culv rou 662	2	2.5	1.9	0	PrivateDriv eWay_Culv rou 662	3456.63	Irregular	2.5	1.9		196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond _Culv rou_669	1			0.8	SWM Pond _Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

4.2.4 *Alternative 4: Open Channel Realignment*

This alternative would consist of replacing culverts, abandoning or removing culvert, and realignment of the watercourse. Similar to Alternative 3, the culverts near Markham Road and Harvard Way will be replaced with an extended open channel and larger sized culvert. The existing 1350 mm diameter storm sewer located east of 9833 and 9809 Markham Road will be abandoned or removed. Flow from Mount Joy Creek would be redirected east towards Darren Hill Trail and then south at the rail corridor towards. The redirected watercourse will run parallel to the railway corridor and connect to the existing watercourse near Bur Oak Avenue. For this stretch, the watercourse with a trapezoidal channel consisting of a 3 m bottom width and 2.5:1 Side slopes. This alternative aligns with the recommendations outlined in the 2015 Greck and Associates Limited report, which also proposed an open channel at the upstream ends of Mount Joy Creek. Lastly, this alternative also aligns with the recommendations outlined in the 2024 Counterpoint Engineering Municipal Servicing Study, which suggested the re-alignment of Mount Joy Creek north of the Olive Branch Community Centre.

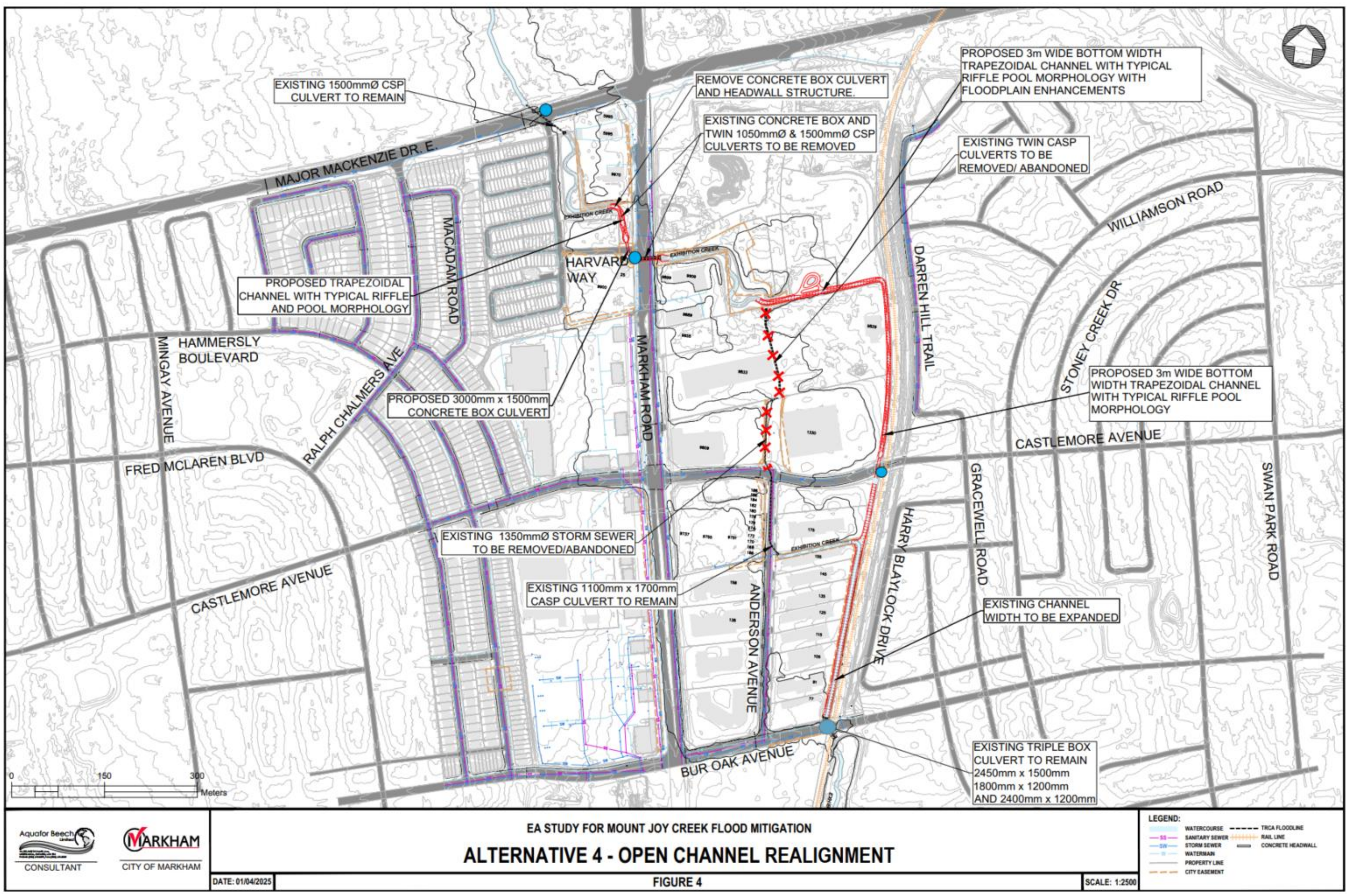


Figure 4-4: Alternative 4 – Open Channel Realignment

Configuration of modelled culverts is show in the following **Table 4-2**:

Table 4-2: Updates for culvert configuration for Alternative 4

	Existing Conditions					Alternative 4 (modelled in November 2025; not updated in the 2026 model revision).																
Creek	ID	number of culverts	Width (m)	Height (m)	Diameter (m)	ID	Chainage	Type	Width (m)	Height (m)	Diameter (m)	ups inv (m)	down inv (m)	Length (m)	number of culverts	offset	section	manning	inflow	outflow	free	bends
Mount Joy	MajorMac_ Culv rou_704	1			1.5	MajorMac_ Culv rou_704	1081.06	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Rectangular	3	1.5		208.704	208.428	will be updated to 40	1	-0.5	Closed	0.013	0.5	1	1	current bend:0.818, but it will be updated to one 45 deg bend (0.70)
Mount Joy	HWY48 Culv_2 rou_705	1			1.05																	
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5																		
Mount Joy	Anderson_ Culv1 rou_706	2	1.47	0.91		eliminated (conveyed to open channel)																
Mount Joy	Anderson_ sewer rou_706	1			1.35																	
Mount Joy	Anderson_ Culv2 rou_706	1	1.7	1.1																		
NA						RailwayNe w_Culv	2220	Rectangular	3	1.5	0	205.558	205.299	will be updated to 20	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Cu lv_1 rou_664	2	2.44	1.22		BurOak_Cu lv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Cu lv_2 rou_664	1	1.82	1.22		BurOak_Cu lv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriv eWay_Culv rou 662	2	2.5	1.9	0	PrivateDriv eWay_Culv rou 662	3456.63	Irregular	2.5	1.9		196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond _Culv rou_669	1			0.8	SWM Pond _Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

4.2.5 *Alternative 5: Culvert Expansion and Larger Culverts*

This alternative would consist of culvert replacement, culvert removal, and open channel conditions. At the upstream limits, the existing culverts near Markham Road and Harvard Way will be replaced with an extended open channel and larger 3000 mm x 1500 mm concrete box culvert. Moving downstream, the existing 1350 mm diameter storm sewer located east of 9833 and 9809 Markham Road and the existing 1100 mm x 1700 mm CASP culvert west of 175 Anderson Avenue will be removed. This segment and will be replaced with a 3000 mm x 1500 mm concrete box culvert. The concrete box culvert will extend to the existing Mount Joy Creek open channel just south of Castlemore Avenue. This alternative aligns with the recommendations outlined in the 2025 WSP Technical Memorandum, which also proposed to increase storage capacity for the stormwater infrastructure within the study area.

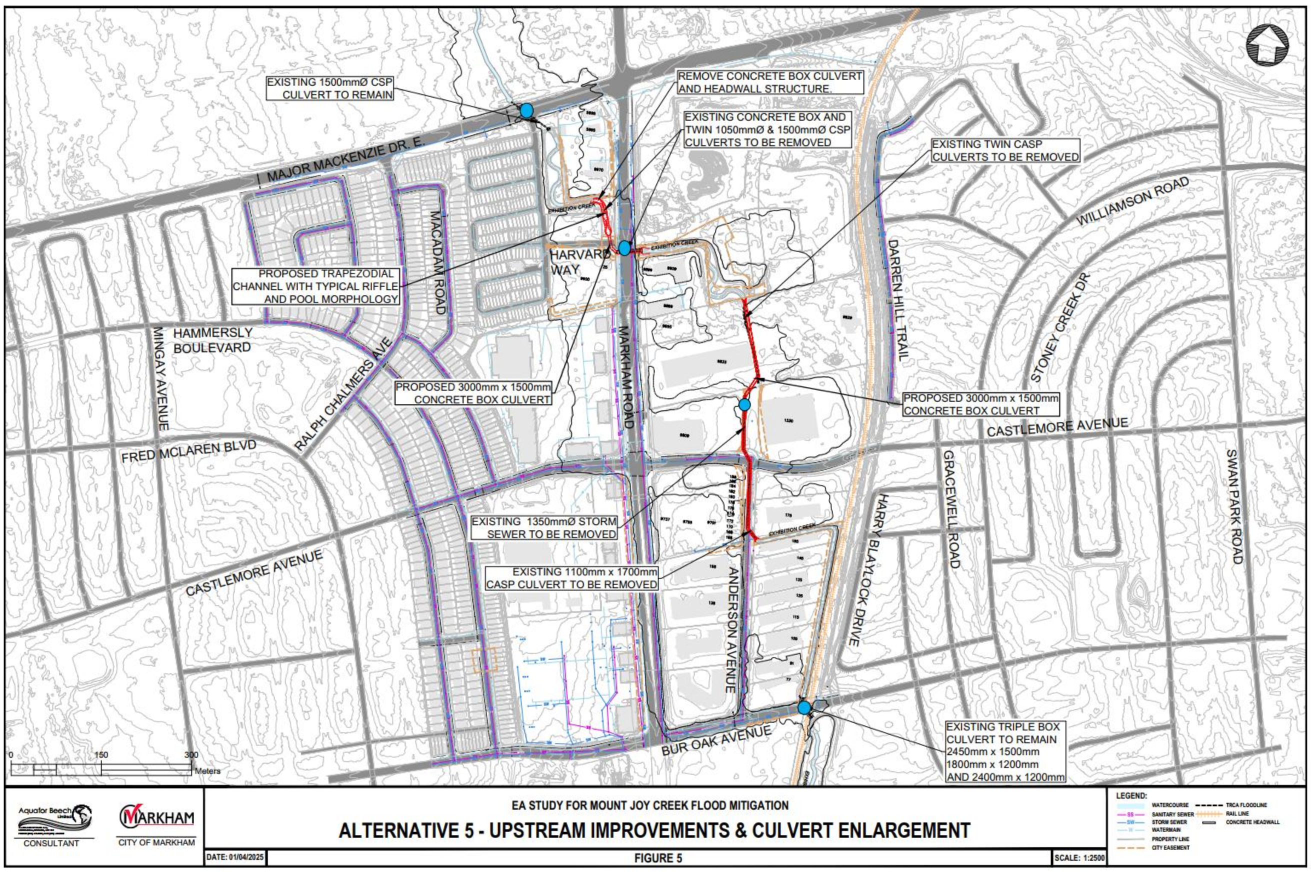


Figure 4-5: Alternative 5 – Upstream Improvements & Culvert Enlargement

Configuration of modelled culverts is show in the following **Table 4-3**:

Table 4-3: Updates for culvert configuration for Alternative 5

	Existing Conditions					Alternative 5 (modelled in November 2025; not updated in the 2026 model revision).																
Creek	ID	number of culverts	Width (m)	Height (m)	Diameter (m)	ID	Chainage	Type	Width (m)	Height (m)	Diameter (m)	ups inv (m)	down inv (m)	Length (m)	number of culverts	offset	section	manning	inflow	outflow	free	bends
Mount Joy	MajorMac_ Culv rou_704	1			1.5	MajorMac_ Culv rou_704	1103.05	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Rectangular	3	1.5		208.704	208.428	40	1	-0.5	Closed	0.013	0.5	1	1	current bend:0.818, but it will be updated to one 45 deg bend (0.70)
Mount Joy	HWY48 Culv_2 rou_705	1			1.05																	
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5																		
Mount Joy	Anderson_ Culv1 rou_706	2	1.47	0.91		Anderson_ Culv rou_706	2046.23	Rectangular	3	1.5		207.6	205.4	400.23	1	0	Closed	0.013	0.5	1	1	current bend:0.11, but it will be updated to four 45 deg bend (2.8)
Mount Joy	Anderson_ sewer rou_706	1			1.35																	
Mount Joy	Anderson_ Culv2 rou_706	1	1.7	1.1																		
Mount Joy	BurOak_Culv_1 rou_664	2	2.44	1.22		BurOak_Culv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Culv_2 rou_664	1	1.82	1.22		BurOak_Culv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriveWay_Culv rou 662	2	2.5	1.9	0	PrivateDriveWay_Culv rou 662	3456.63	Irregular	2.5	1.9		196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond _Culv rou_669	1			0.8	SWM Pond _Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

4.2.6 *Alternative 6: Upstream Improvements & Culvert Realignment*

Alternative 6 involves a combination of open channel extensions, increase the size of culvert, removal or abandonment of existing culverts, and channel realignment. The existing culverts near Markham Road and Harvard Way will be removed and a larger culvert will be used to convey flows under Markham Road. An existing 1350 mm diameter storm sewer located east of 9833 and 9809 Markham Road will be removed or abandoned. Flows from Mount Joy Creek will be redirected east towards Darren Hill Trail via a trapezoidal channel consisting of a 2.5 m bottom width and 2.5:1 Side slopes. At the rail corridor a proposed 3000 X 1500 mm concrete storm sewer will convey flows parallel to the rail corridor and outlet at the exiting Mount Joy Creek channel south of Castlemore Avenue. This alternative aligns with the recommendations outlined in the 2024 WSP Stormwater Management Final Report, which also proposed to increase the capacity for open channels (drainage swales) within the study area. This alternative also aligns with the recommendations outlined in the 2015 Greck and Associates Limited, which also proposed an open channel at the upstream ends of Mount Joy Creek.

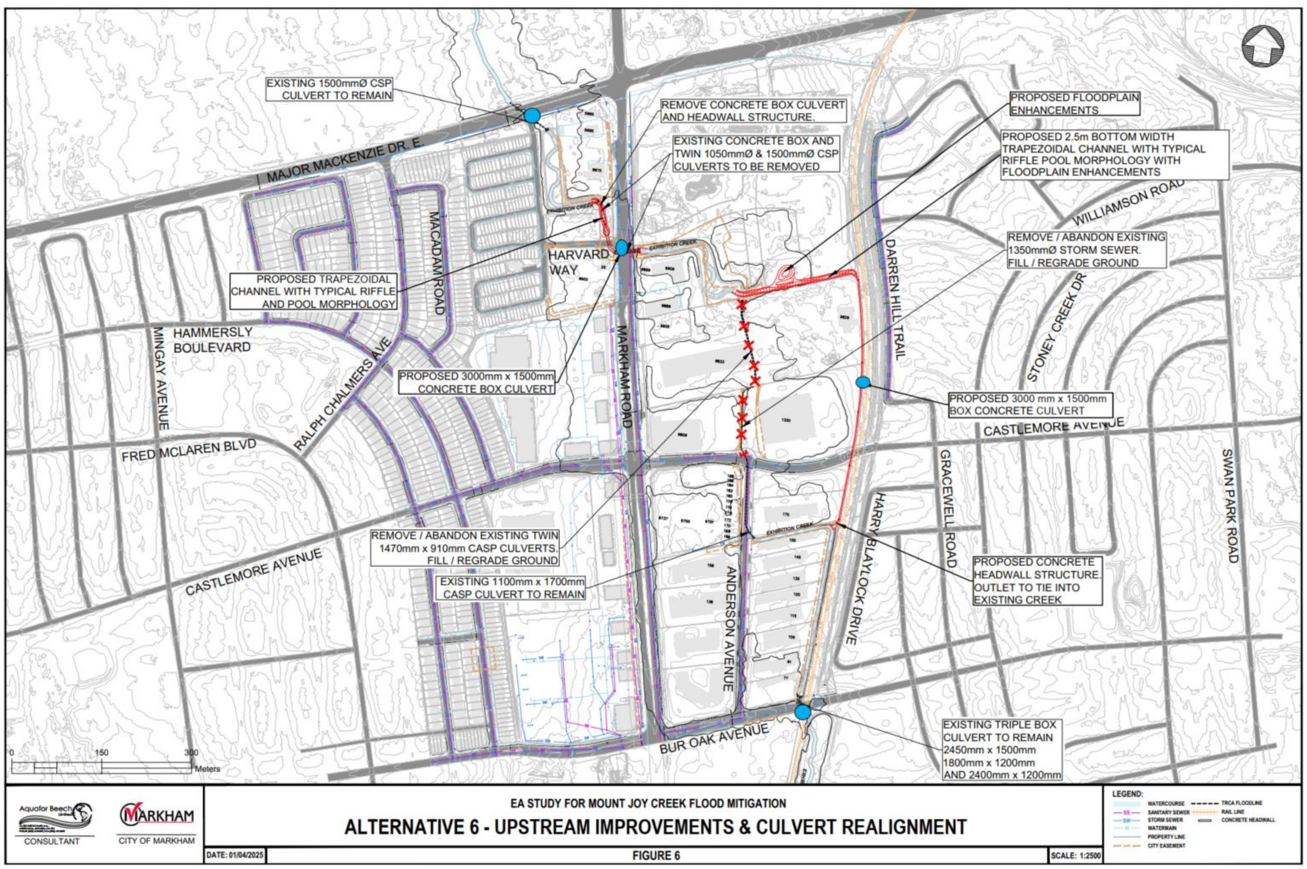


Figure 4-6: Alternative 6 – Upstream Improvements & Culvert Realignment

Configuration of modelled culverts is show in the following **Table 4-4**:

Table 4-4: Updates for culvert configuration for Alternative 6

	Existing Conditions					Alternative 6 (modelled in November 2025; not updated in the 2026 model revision).																
Creek	**ID**	**number of culverts**	**Width (m)**	**Height (m)**	**Diameter (m)**	**ID**	**Chainage**	**Type**	**Width (m)**	**Height (m)**	**Diameter (m)**	**ups inv (m)**	**down inv (m)**	**Length (m)**	**number of culverts**	**offset**	**section**	**manning**	**inflow**	**outflow**	**free**	**bends**
Mount Joy	MajorMac_Culv rou_704	1			1.5	MajorMac_Culv rou_704	1081.06	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Rectangular	3	1.5		208.704	208.428	will be updated to 40	1	-0.5	Closed	0.013	0.5	1	1	current bend:0.818, but it will be updated to one 45 deg bend (0.70)
Mount Joy	HWY48 Culv_2 rou_705	1			1.05																	
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5																		
Mount Joy	Anderson_Culv1 rou_706	2	1.47	0.91		eliminated (conveyed to open channel)																
Mount Joy	Anderson_sewer rou_706	1			1.35																	
Mount Joy	Anderson_Culv2 rou_706	1	1.7	1.1																		
NA						RailwayNew_Culv	2218	Rectangular	3	1.5	0	206.901	204.822	420	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Culv_1 rou_664	2	2.44	1.22		BurOak_Culv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Culv_2 rou_664	1	1.82	1.22		BurOak_Culv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriveWay_Culv rou 662	2	2.5	1.9	0	PrivateDriveWay_Culv rou 662	3456.63	Irregular	2.5	1.9		196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond_Culv rou_669	1			0.8	SWM Pond_Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

4.2.7 _Alternative 7: Culvert Enlargement_

This alternative would consist of replacing existing culverts with larger sized culverts. At the upstream limits, the eastern portion of the existing Markham Road crossing consisting of 1050 mm and 1500 mm diameter piped segment will be replaced with a 2-2400mm x 1500 mm concrete box culvert. Moving downstream, a 2-2400mm x 1500 mm concrete box culvert will be used to replace an existing 1350 mm diameter storm sewer (east of 9833 and 9809 Markham Road) and the existing 1100 mm x 1700 mm CASP culvert (west of 175 Anderson Avenue). This alternative aligns with the recommendations outlined in the 2025 WSP Technical Memorandum addressed to Metrolinx for the Mount Joy Passing Track Project, which also proposed to increase storage capacity for the stormwater infrastructure within the study area.

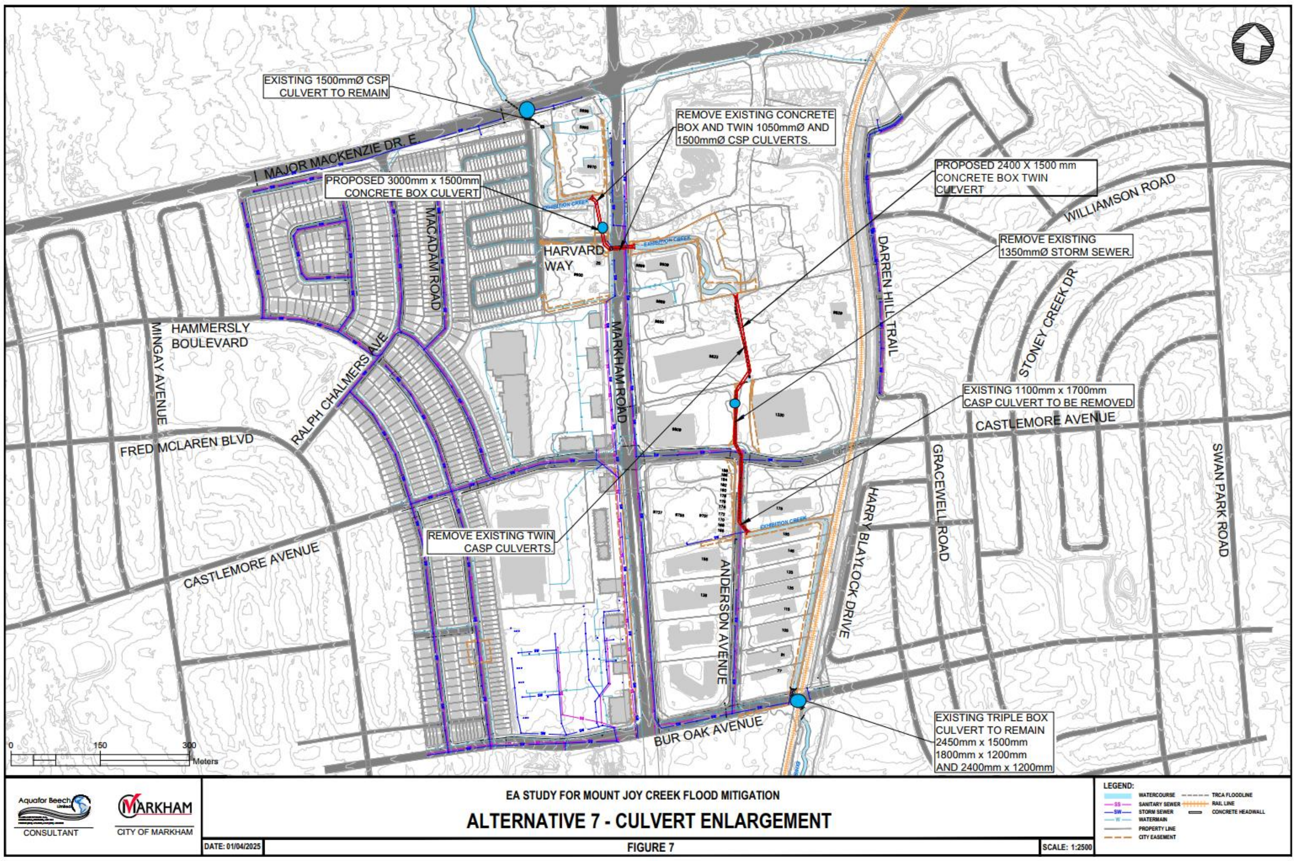


Figure 4-7: Alternative 7 – Culvert Enlargement

Configuration of modelled culverts is show in the following **Table 4-5**:

Table 4-5: Updates for culvert configuration for Alternative 7

	Existing Conditions					Alternative 7 (Modelled in 2026)																	
Creek	ID	number of culverts	Width (m)	Height (m)	Diameter (m)	ID	Chainage	Type	Width (m)	Height (m)	Diameter (m)	ups inv (m)	down inv (m)	Length (m)	number of culverts	offset	section	manning	inflow	outflow	free	bends
Mount Joy	MajorMac_Culv rou_704	1.0			1.5	MajorMac_Culv rou_704	1,103.1	Circular	-	-	1.5	210.6	209.9	74.8	1	-	Closed	0.024	0.9	1.0	1.0	0
Mount Joy	HWY48 Culv_1 rou_705	1.0			1.5	HWY48 Culv_1 rou_705	1,487.1	Rectangular	3.0	1.5		208.8	208.4	134.0	1	- 0.5	Closed	0.013	0.5	1.0	1.0	2.1
Mount Joy	HWY48 Culv_2 rou_705	1.0			1.1																	
Mount Joy	HWY48 Culv_3 rou_705	1.0	3.0	1.5																		
Mount Joy	Anders	2.0	1.5	0.9		Anderson_Culv rou_706	2,046.2	Rectangular	2.4	1.5		207.0	205.2	400.2	2	0.3	Closed	0.013	0.5	1.0	1.0	2.8
Mount Joy	Anderson_sewer rou_706	1.0			1.4																	
Mount Joy	Anderson_Culv	1.0	1.7	1.1																		
Mount Joy	BurOak_Culv_1 rou_664	2.0	2.4	1.2		BurOak_Culv_1 rou_664	2,621.4	Rectangular	2.4	1.2		202.2	201.6	52.7	2	-	Closed	0.013	0.5	1.0	1.0	0
Mount Joy	BurOak_Culv_2 rou_664	1.0	1.8	1.2		BurOak_Culv_2 rou_664	2,621.4	Rectangular	1.8	1.2		202.2	201.6	52.7	1	-	Closed	0.013	0.5	1.0	1.0	0
Mount Joy	Private DriveWay_Culv rou 662	2.0	2.5	1.9	-	PrivateDriveWay_Culv rou 662	3,456.6	Irregular	2.5	1.9		196.3	196.1	17.0	2	-	Closed	0.024	0.5	1.0	1.0	0
Mount Joy	SWM Pond _Culv rou_669	1.0			0.8	SWM Pond _Culv rou_669	3,666.7	Circular			0.8	195.1	195.0	22.9	1	-	Closed	0.013	0.5	1.0	1.0	0

4.2.8 *Alternative 8: Additional Parallel Culverts*

This alternative would consist of adding an additional concrete box culvert to run parallel to the existing culverts within the area. At the upstream limits, the piped segment near Markham Road and Harvard Way will be replaced with a larger 3000 mm x 1500 mm concrete box culvert.

Moving downstream, a second concrete box culvert will run parallel to the existing piped channel made up of a twin CASP culvert, a 1350 mm storm sewer, and a 1100 mm x 1700 mm CASP culvert. This alternative aligns with the recommendations outlined in the 2025 WSP Technical Memorandum addressed to Metrolinx for the Mount Joy Passing Track Project, which also proposed to increase storage capacity for the stormwater infrastructure within the study area.

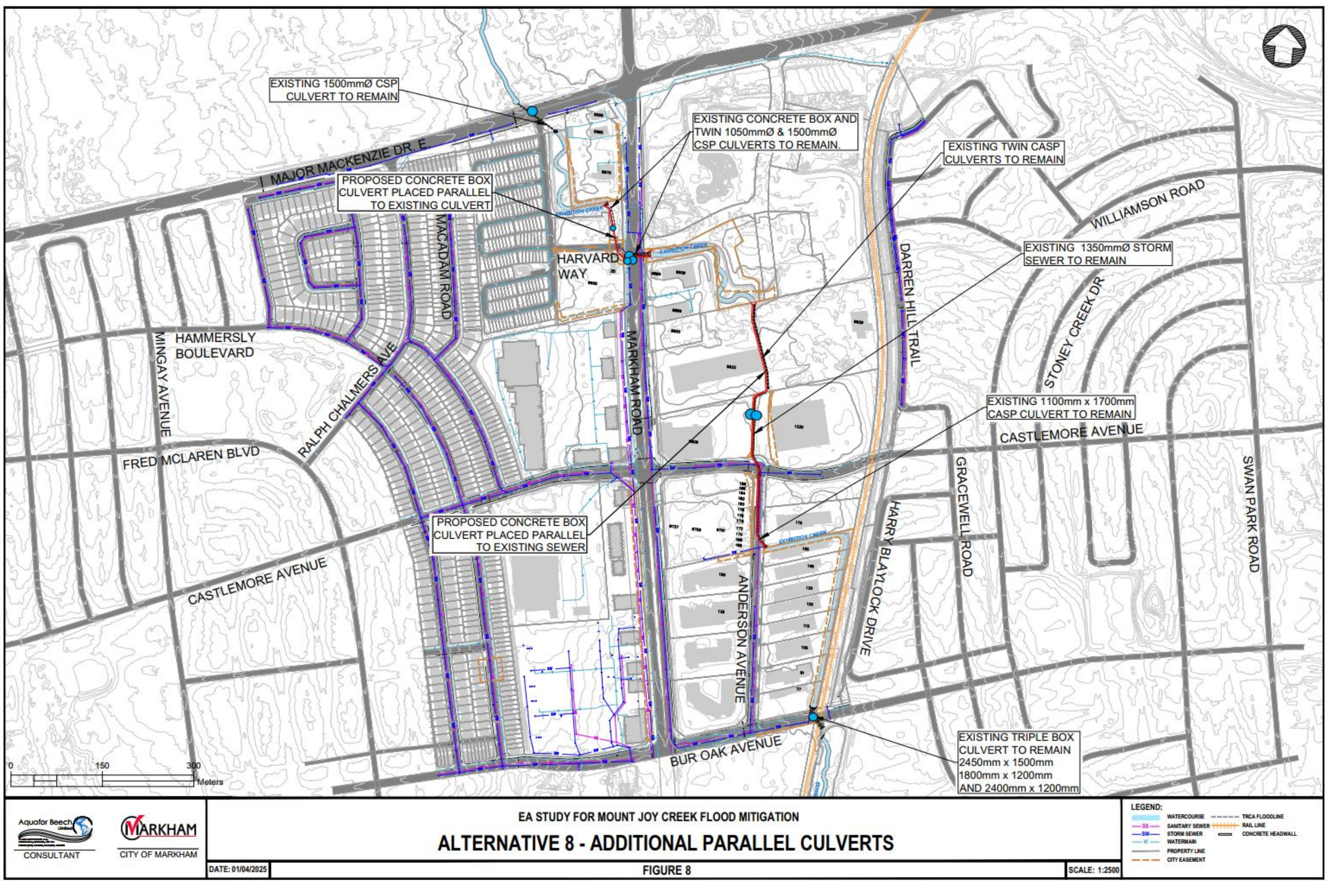


Figure 4-8: Alternative 8 – Additional Parallel Culverts

Configuration of modelled culverts is show in the following **Table 4-6**:

Table 4-6: Updates for culvert configuration for Alternative 8

	Existing Conditions					Alternative 8 (modelled in November 2025; not updated in the 2026 model revision).																
Creek	**ID**	**number of culverts**	**Width (m)**	**Height (m)**	**Diameter (m)**	**ID**	**Chainage**	**Type**	**Width (m)**	**Height (m)**	**Diameter (m)**	**ups inv (m)**	**down inv (m)**	**Length (m)**	**number of culverts**	**offset**	**section**	**manning**	**inflow**	**outflow**	**free**	**bends**
Mount Joy	MajorMac_Culv rou_704	1			1.5	MajorMac_Culv rou_704	1103.05	Circular			1.5	210.55	209.85	74.8	1	0	Closed	0.024	0.9	1	1	0
Mount Joy	HWY48 Culv_1 rou_705	1			1.5	HWY48 Culv_1 rou_705	1487.13	Circular			1.05	208.62	208.43	will be updated to 40	1	-0.5	Closed	0.024	0.5	1	1	0
Mount Joy	HWY48 Culv_2 rou_705	1			1.05	HWY48 Culv_2 rou_705	1487.13	Circular			1.5	208.62	208.43	will be updated to 40	1	0.4	Closed	0.024	0.5	1	1	0
Mount Joy	HWY48 Culv_3 rou_705	1	3	1.5		HWY48 Culv_3 rou_705	will be updated to 1420	Rectangular	3	1.5		208.84	208.62	will be updated to 93.5	1	-0.5	Closed	0.013	0	1	1	current bend:0.818, but it will be updated to three 45 deg bend (2.1)
						HWY48 Culv_4 rou_705	1487.13	Rectangular	3	1.5		208.84	208.43	133.95	1	-0.5	Closed	0.013	0	1	1	current bend:0.818, but it will be updated to three 45 deg bend (2.1)
Mount Joy	Anderson_Culv1 rou_706	2	1.47	0.91		Anderson_Culv1 rou_706	2046.23	Irregular	1.7	1.1		207.6	205.4	400.23	1	0	Closed	0.013	0.5	1	1	current bend:0.11, but it will be updated to four 45 deg bend (2.8)
Mount Joy	Anderson_sewer rou_706	1			1.35	Anderson_Culv2 rou_706	2046.23	Rectangular	3	1.5		207.6	205.4	400.23	1	0	Closed	0.013	0.5	1	1	current bend:0.11, but it will be updated to four 45 deg bend (2.8)
Mount Joy	Anderson_Culv2 rou_706	1	1.7	1.1																		
Mount Joy	BurOak_Culv_1 rou_664	2	2.44	1.22		BurOak_Culv_1 rou_664	2621.42	Rectangular	2.44	1.22		202.2	201.62	52.74	2	0	Closed	0.013	0.5	1	1	0
Mount Joy	BurOak_Culv_2 rou_664	1	1.82	1.22		BurOak_Culv_2 rou_664	2621.42	Rectangular	1.82	1.22		202.2	201.62	52.74	1	0	Closed	0.013	0.5	1	1	0
Mount Joy	PrivateDriveWay_Culv rou 662	2	2.5	1.9	0	PrivateDriveWay_Culv rou 662	3456.63	Irregular	2.5	1.9		196.26	196.13	17	2	0	Closed	0.024	0.5	1	1	0
Mount Joy	SWM Pond_Culv rou_669	1			0.8	SWM Pond_Culv rou_669	3666.67	Circular			0.8	195.1	195	22.9	1	0	Closed	0.013	0.5	1	1	0

4.3 Hydraulic Assessment of Alternatives

A hydraulic assessment was completed using the MIKE+ Water Modelling Software to determine which of the following alternatives would produce the greatest improvement to flood risks within the study area. Alternative 1 – Do Nothing was modelled to define existing conditions, and ensure consistency with the TRCA flood risk modelling presented in **Section 4.0**. Regional water surface elevations, depths, and flooding extents associated with each alternative are presented on the following figures with the exception of Alternative 2. It is important to note that in this revised second submission, Aquafor has reviewed the Existing Conditions model and the preferred Alternative 7 and updated the flows based on the 2023 Valdor flow data. The results for the remaining alternatives have not been modified at this time and remain unchanged until further notice. The Offline Pond Alternative was not progressed forward after it was determined in the preliminary phases of modeling that it would not be a feasible solution. **Figure 4-9** to **Figure 4-14**, and **Figure 4-16** show WSE results for not preferred alternatives 3, 4, 5, 6, and 8. Other comprehensive outputs from previous submissions are included within **Appendix F** for these alternatives. **Figure 4-14** and **Figure 4-15** show WSE and water depth for preferred alternative 7, for which updated model results have been provided in this second submission. For clarity **Table 4-7**, shows the Regional flow values from both sources, TRCA 2018 model and Valdor 2023 model.

Table 4-7: Regional Flow values comparison

		Flow entries in Mike +			Flow entries in Mike +				
Flows (m^3/s)	**Source**	**J5670.032 (point source)**	**J4789.696 (point source)**	**DS J4789.696 to Bur Oak** (accumulated)	**J4309.178 (point source)**	**J4145.856 (point source)**	**J3661.799 (point source)**	**J253 (point source)**	**Upstream 16th Avenue** (accumulated)
Node		0	1260	-	2259	2730	2874	3443	-
Regional	**(TRCA, 2022)**	5.78	6.11	11.89	0	0	5.67	11.91	29.47
Regional	**(Valdor, 2023)**	7.09	6.04	13.13	0	0	5.67	11.91	30.71

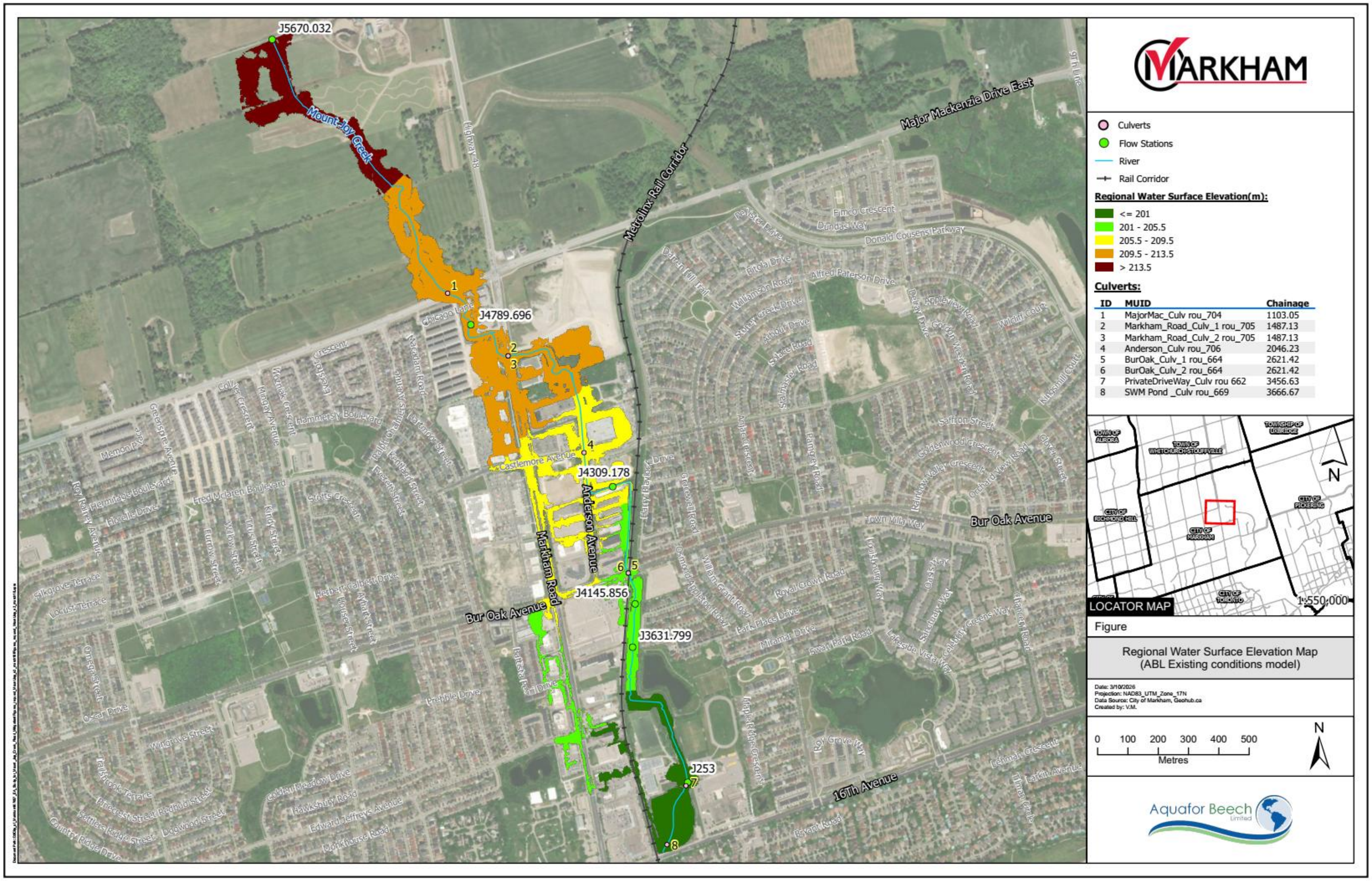


Figure 4-9: Alternative 1 – Do Nothing - Regional WSEL (m)

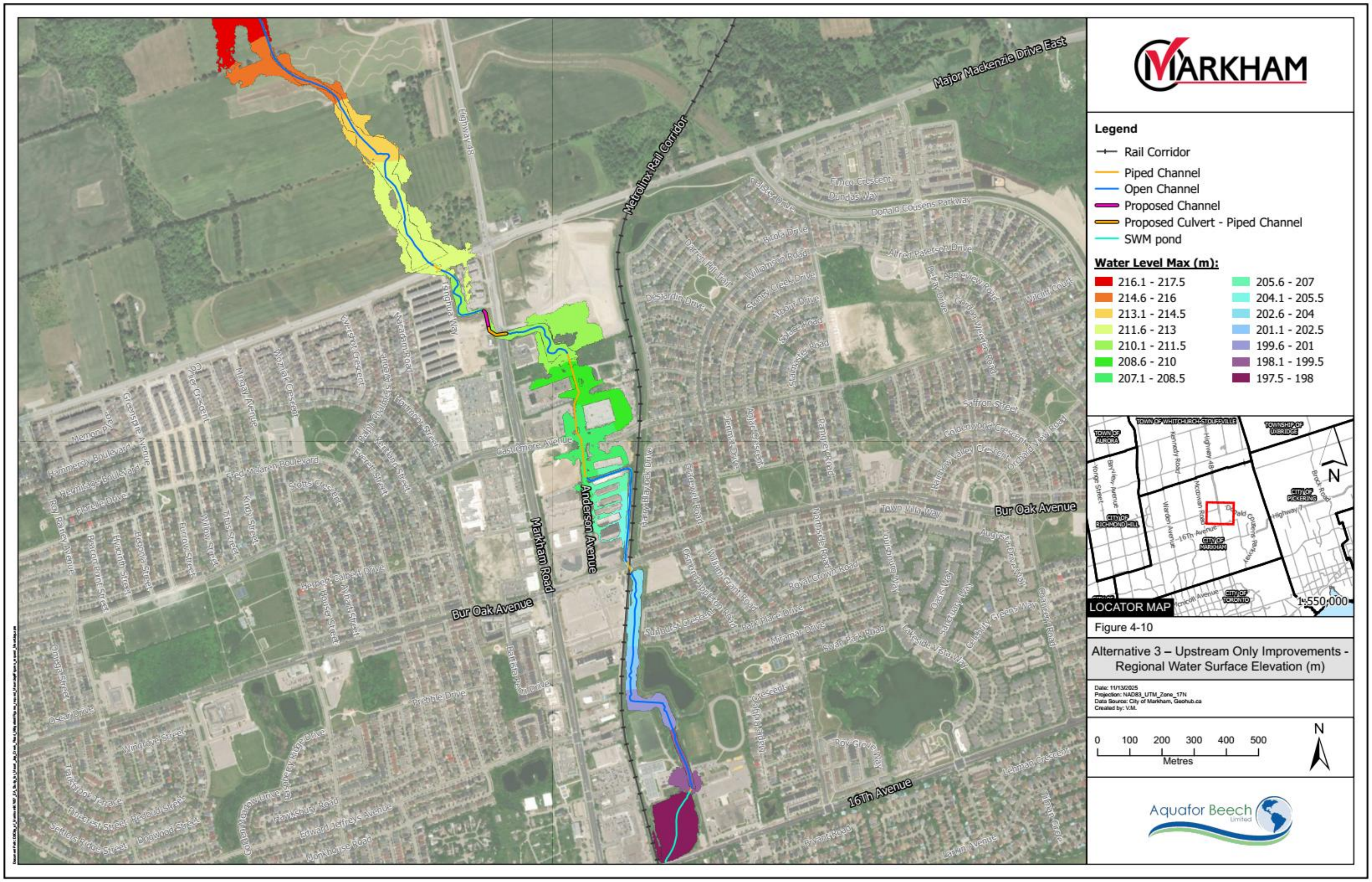


Figure 4-10: Alternative 3 - Upstream Only Improvements - Regional WSEL (m)

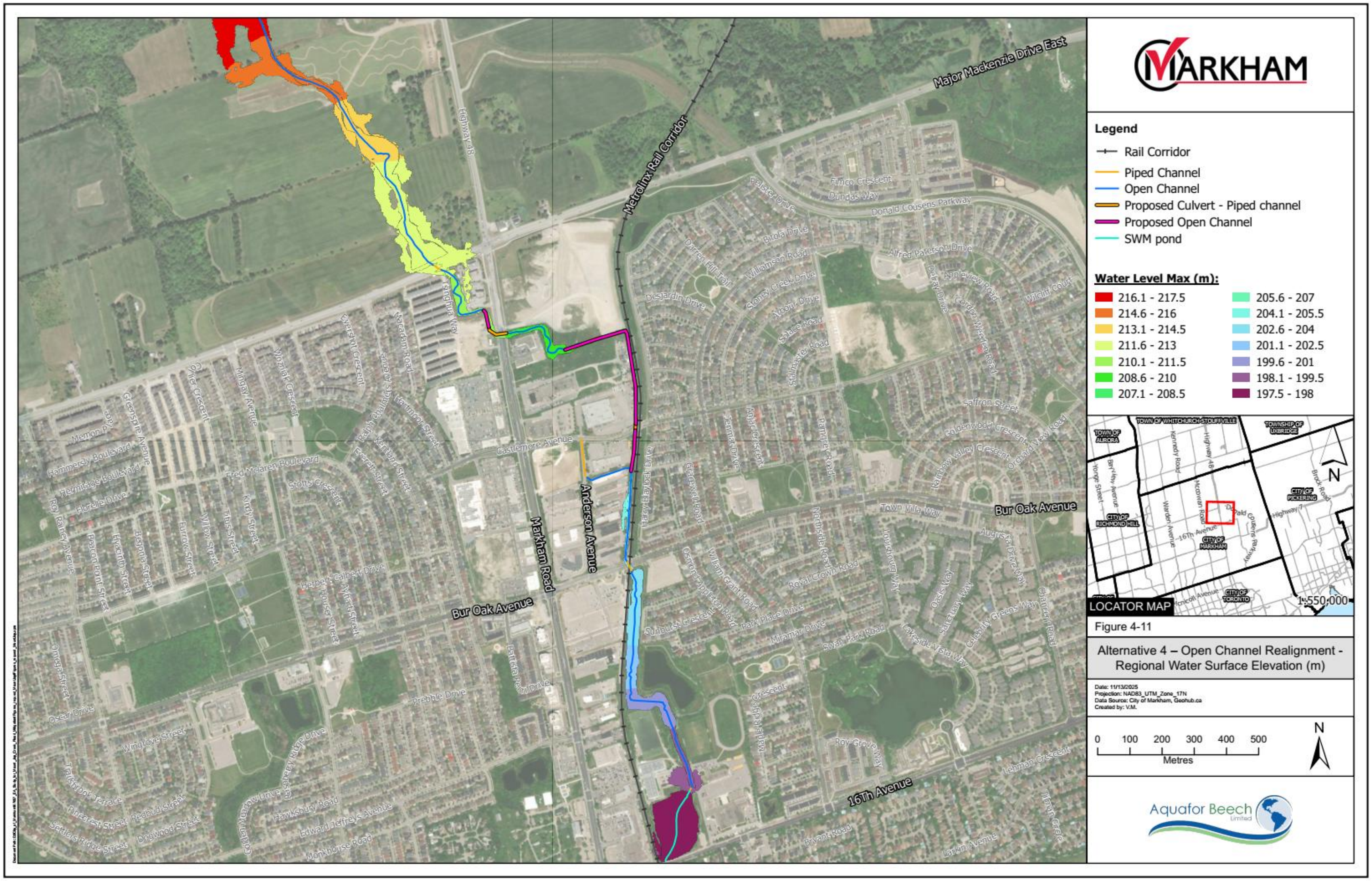


Figure 4-11: Alternative 4 - Open Channel Realignment - Regional WSEL (m)

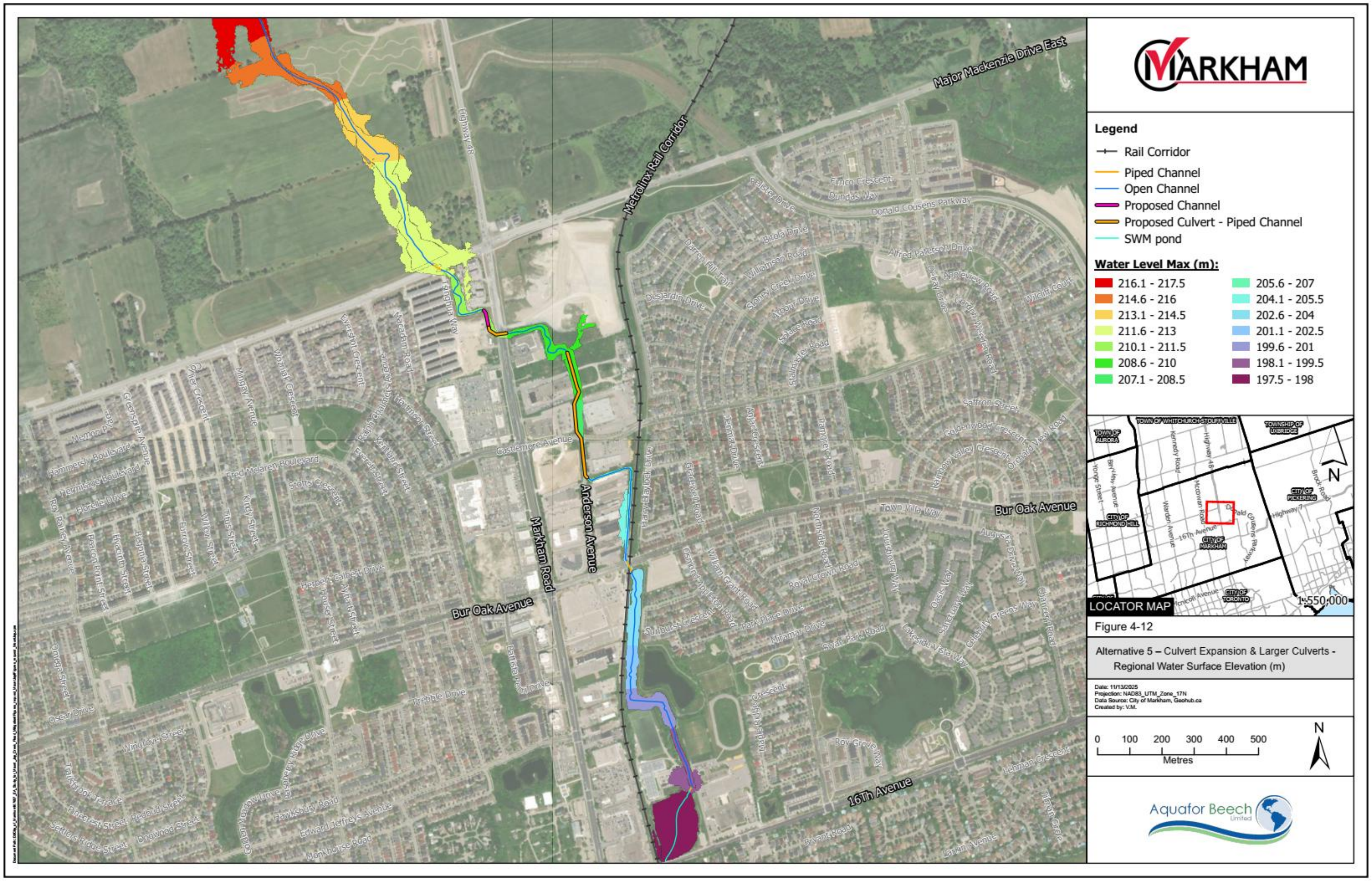


Figure 4-12: Alternative 5 - Open Channel Realignment - Regional WSEL (m)

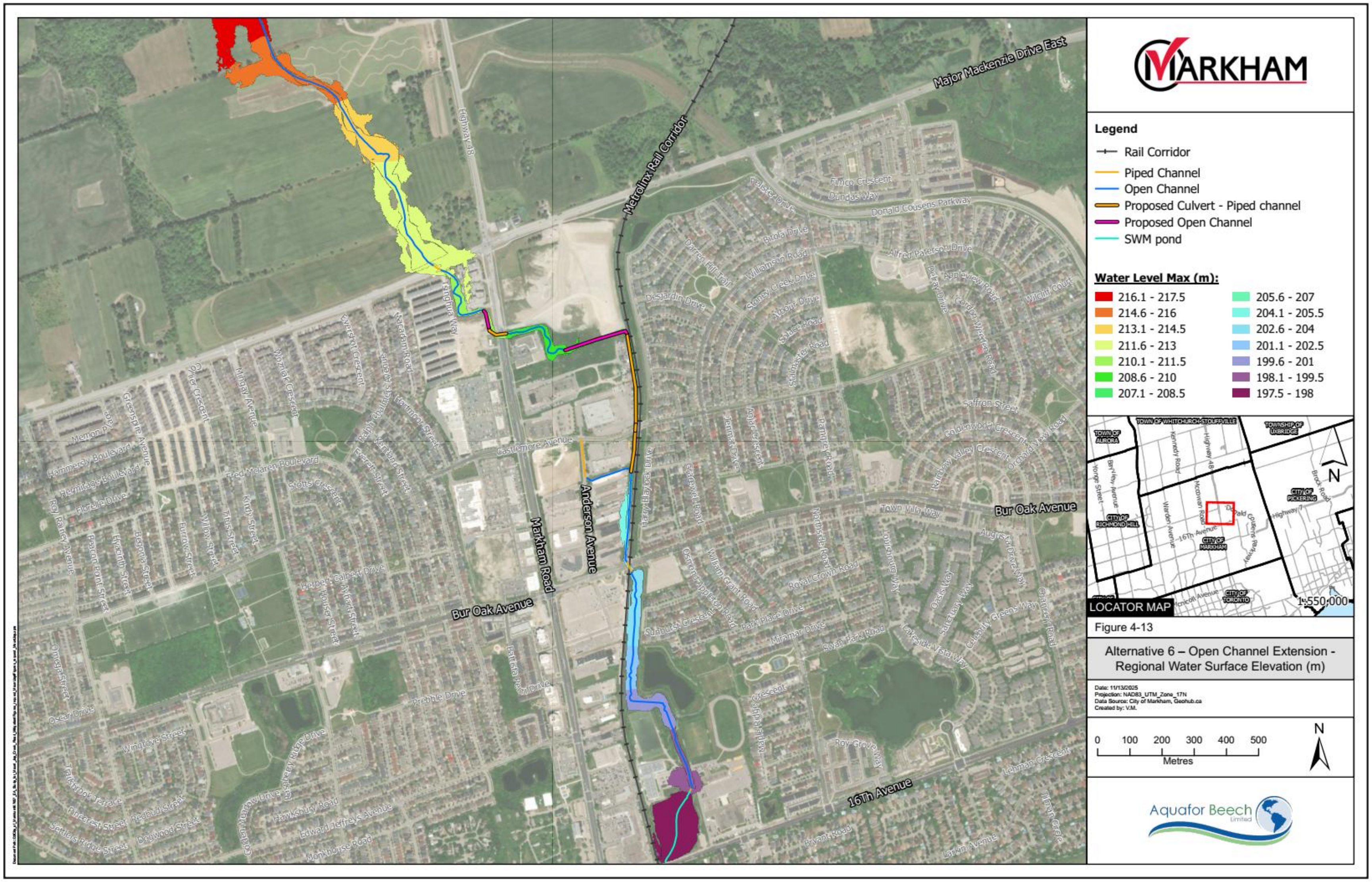


Figure 4-13: Alternative 6 - Open Channel Extension - Regional WSEL (m)

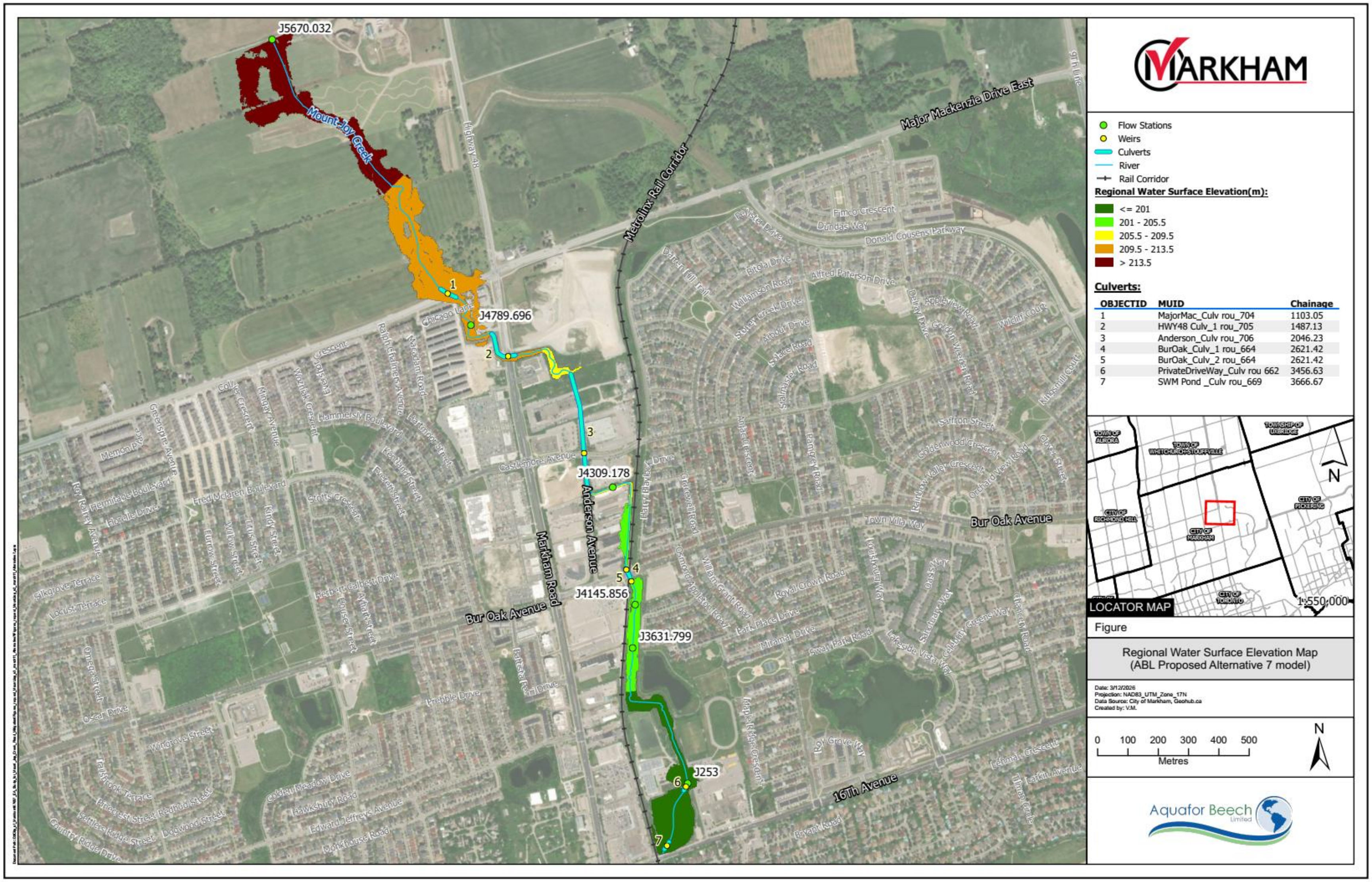


Figure 4-14: Alternative 7 Culvert Enlargement - Regional WSEL (m)

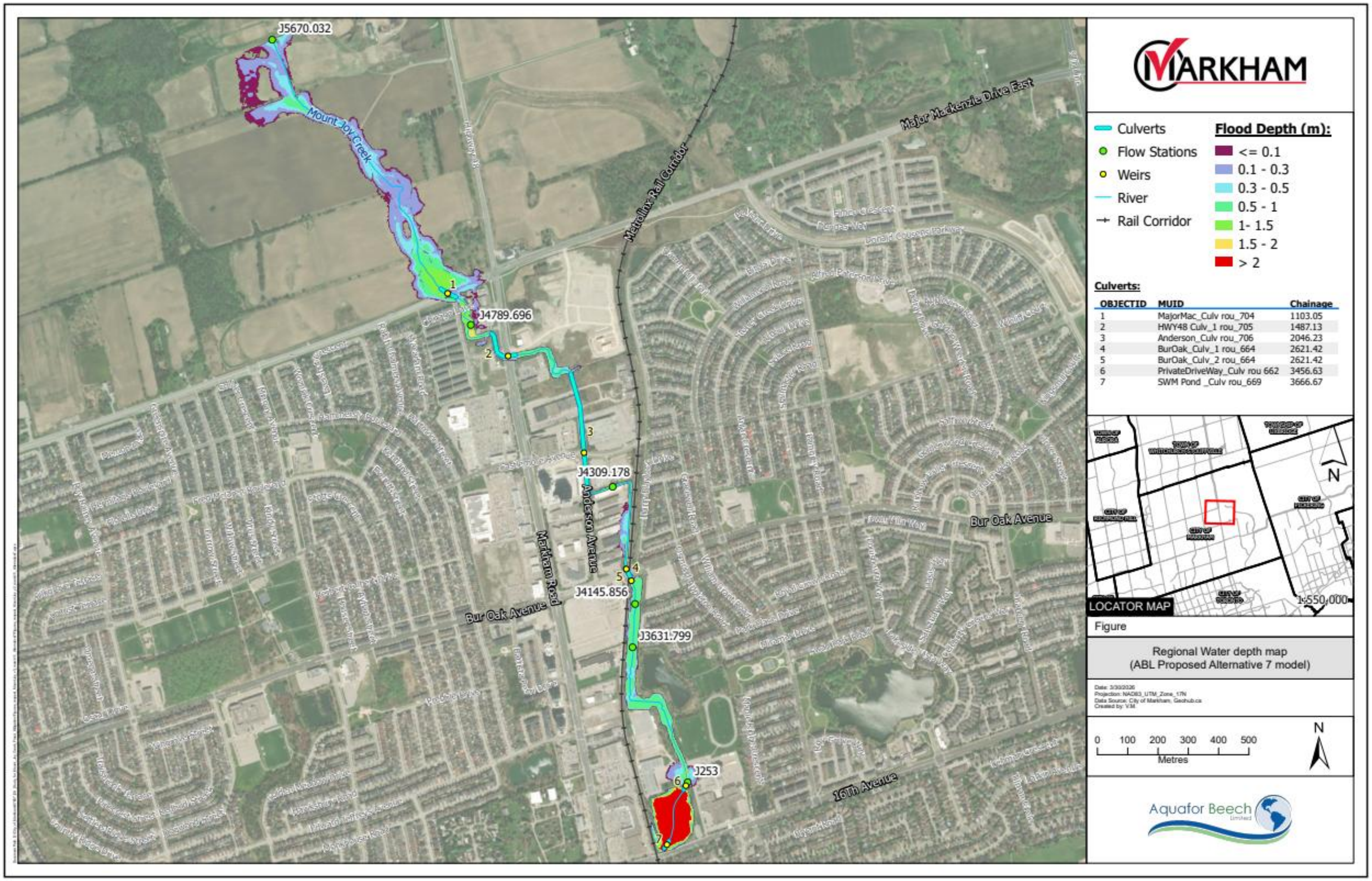


Figure 4-15: Alternative 7 Culvert Enlargement - Regional Water Depth (m)

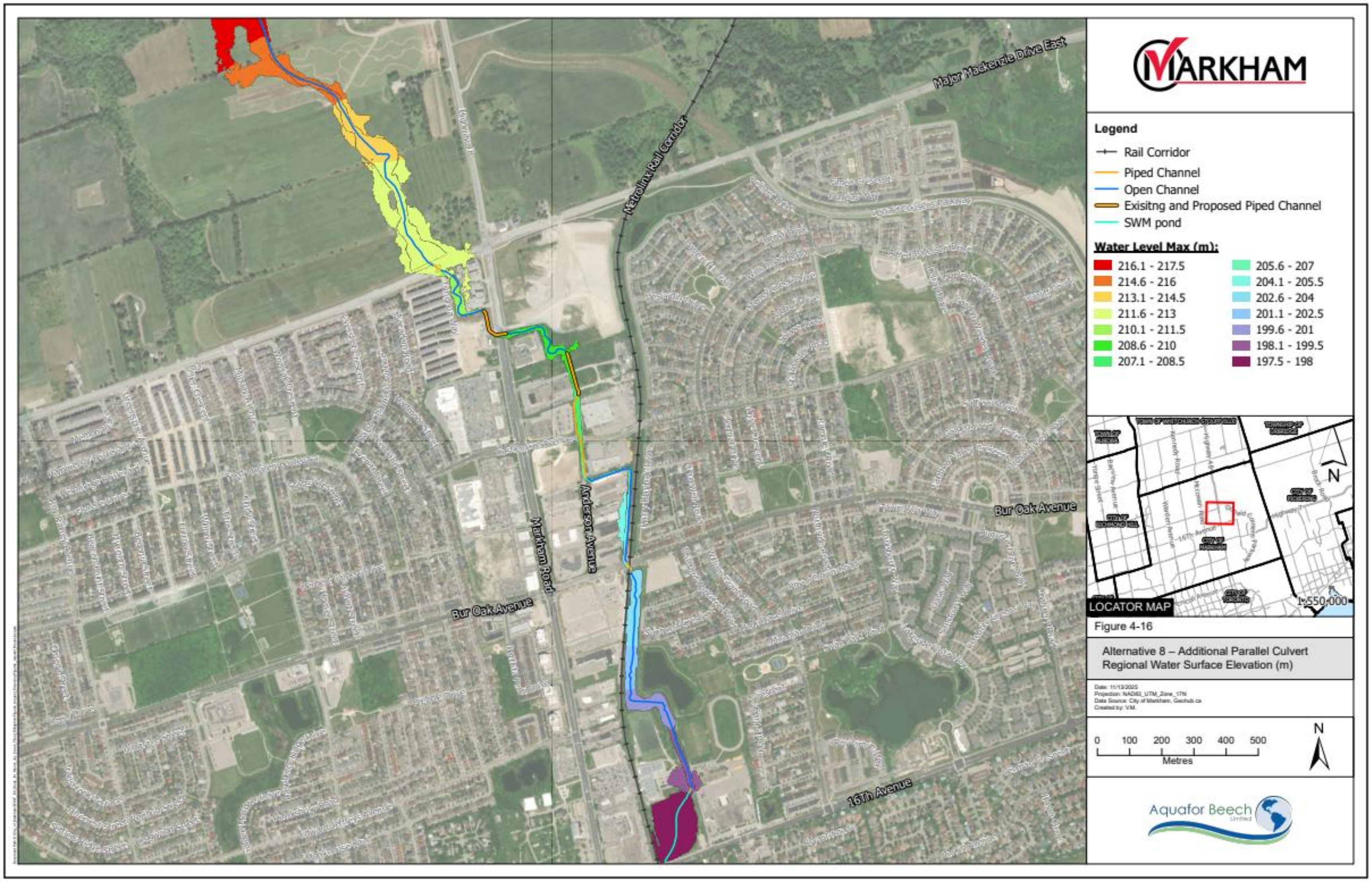


Figure 4-16: Alternative 8 – Additional Parallel Culverts - Regional WSEL (m)

A general review of Alternatives #4 to #8 indicates that all alternatives have the ability to convey Regional peak flows through the project area. We note however that Alternatives #5,#7 and #8 retain the location of the flood hazard in it's current location. Where as Alternatives #4 and #6 relocate the flood hazard to the east along the Metrolinx railway corridor. It should be noted when reviewing these results, that relocating the flood hazard does not mean that the flood hazard is mitigated from the study area.

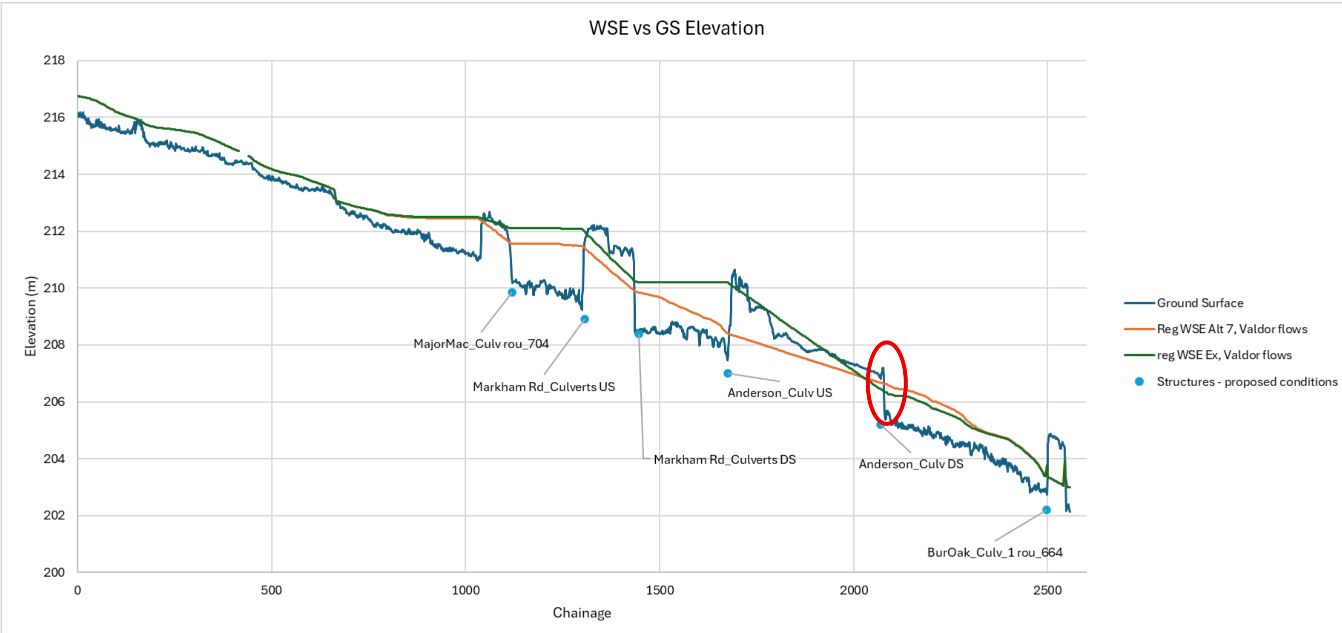


Figure 4-17: Regional Water Level Profiles for Existing and Proposed Alternatives through the Mount Joy Study Area

As shown in **Figure 4-17**, the longitudinal comparison of the 1D water surface elevation (WSE) profiles indicates that Alternative 7 generally maintains a similar hydraulic profile to the existing condition along most of the reach. However, improved conveyance is observed through the Markham Road channel section and the Anderson culvert under the proposed configuration. The updated channel geometry and culvert representation in Alternative 7 reduce localized hydraulic restrictions and allow flows to pass more efficiently through these crossings. As a result, water surface elevations downstream of these structures show a smoother transition and improved hydraulic performance while maintaining flow conveyance within the channel.

To obtain the WSE profile for Alternative 7, minor adjustments to the channel bed were applied upstream and downstream of the Anderson Avenue culvert faces (approximately between stations 1682 and 2170, as shown in **Figure 4-17**). These adjustments were required as it is considered that the ground surface around 9833 Markham Road is lower than the existing sewer inverts, which otherwise caused the modelled culvert to approach or intersect the roadway elevation.

There were some concerns regarding **Figure 4-14** and the appearance that the system may not convey the Regional flow. It should be noted that this figure displays the maximum water surface elevation (Max WSE) from both the 2D floodplain domain and the 1D hydraulic domain (channel and culvert system). As a result, the water levels shown within the culvert may visually resemble spilling. However, these values represent the hydraulic grade line within the culvert rather than overbank flooding. To avoid altering the model results, the channel was not cropped from the Max WSE figure. The figure below compares the WSE and ground elevations and demonstrates that the computed WSE remains below the ground surface and fully contained within the culvert barrel. This represents an improvement compared to the existing condition and confirms that the system conveys the Regional flow within the proposed infrastructure without overtopping. The reduction in WSE elevations also provides the opportunity for adjacent private properties to connect storm drainage systems directly to the revised infrastructure associated with Alternative 7. Localized grading improvements on private properties may be required to direct surface flows toward outlets located along the alignment of the preferred alternative.

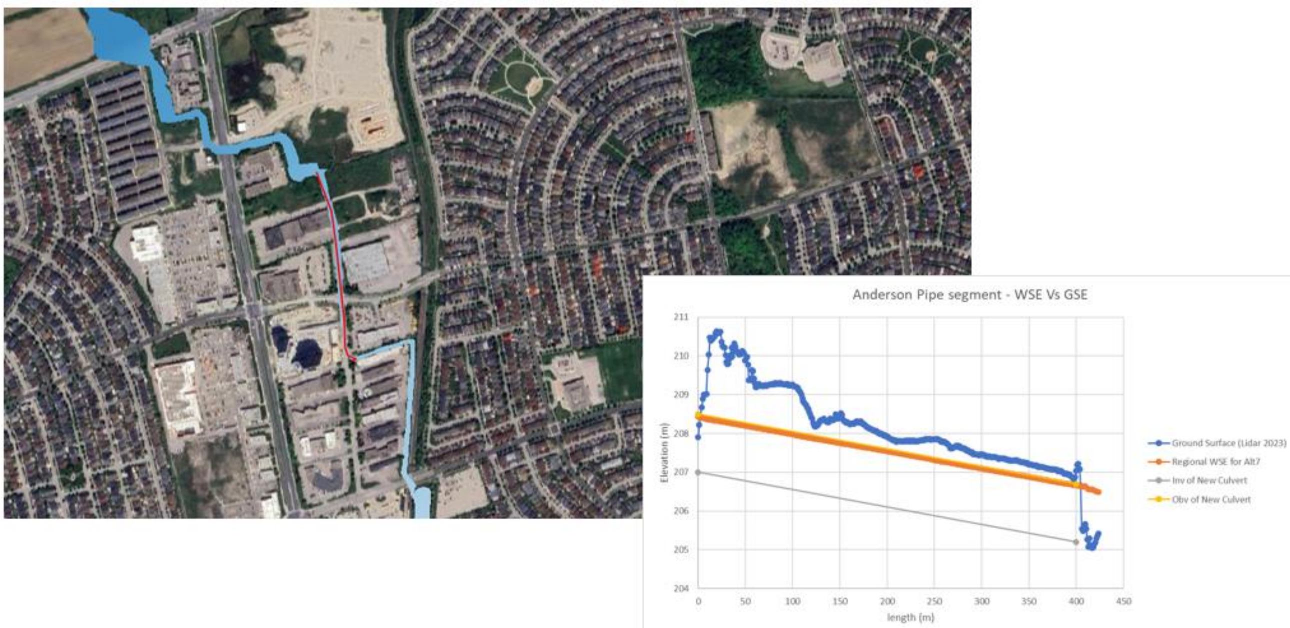


Figure 4-18: WSE vs GS comparison within Anderson culvert

4.4 Evaluation Criteria

As a part of the Municipal Class Environmental Assessment Process, each alternative must be evaluated based on a set of physical, natural, social, cultural, and economic environmental criteria, as well as technical and engineering considerations. These set of criteria were developed by Aquafor and reviewed by the City of Markham. The list of criteria and the associated description of the scoring rationale is presented in **Table 4-8** through **Table 4-11**.

Table 4-8: Alternative Evaluation Criteria – Physical / Natural Environment

Criteria	Description
Potential to Reduce Flooding Risks	Greater reduction of flooding risks to public and/or private lands for longer time scores higher
Potential to Improve Aquatic Habitat	Greater improvements to fish and aquatic habitat scores higher, including substrate, overhanging vegetation, turbidity, and passage/connectivity
Potential to Improve Terrestrial Habitat	Greater improvements to terrestrial habitat scores higher, including loss and replacement of vegetation and natural corridor connectivity
Potential to Reduce Erosion Risks	Greater reduction of erosion risks to public and/or private lands for longer time scores higher
Integration with Existing Environment and Infrastructure	Greater integration and compatibility with existing environment and infrastructure scores higher

Table 4-9: Alternative Evaluation Criteria – Social/Cultural Environment Criteria

Criteria	Description
Aesthetics / Recreation	Greater improvements to the aesthetics of the creek corridor and how the alternative impacts recreational use of the corridor score higher
Compatibility with Adjacent Land Use	Greater compatibility with the land use of adjacent properties scores higher
Community Disruption	Less disruption of the surrounding community and residents scores higher
Public Health and Safety	Greater protection of public health and safety for a longer time scores higher

Table 4-10: Alternative Evaluation Criteria – Economic Environment

Criteria	Description
Construction Costs	Lower construction cost relative to other alternatives scores higher
Operation and Maintenance Costs	Lower operations and maintenance costs relative to other alternatives scores higher
Life Cycle Costs	Lower life cycle costs relative to the other alternatives scores higher
Land Requirement Costs	Lower Land Requirement costs relative to other alternatives scores higher
Infrastructure Protection	Greater protection of existing infrastructure for a longer time scores higher

Table 4-11: Alternative Evaluation Criteria – Technical/ Engineering Considerations

Criteria	Description
Ease of Implementation	Greater ease of implementing scores higher
Agency Acceptance	Greater likelihood that TRCA will support the alternative scores higher
City Acceptance	Greater compliance with existing City plans, policies, and bylaw requirements scores higher
Technical Feasibility	Greater technical feasibility relative to other alternatives scores higher

A weighting factor was assigned to each category, which ensured that each category was valued appropriately, regardless of the number of sub-criteria presented within the larger category. The maximum points for each category are shown in **Table 4-12**.

Table 4-12: Criteria Weighting Factors

Category	Maximum Points for Category
Physical and Natural Environment Criteria	20
Social/Cultural Environment	16
Economic Environment	20
Technical/Engineering Considerations	16
TOTAL	**72**

For all the criteria, a score was applied ranging from 1 to 4 (**Table 4-13**), where:

- 1 = Least Favourable, negative impact
- 2 = Unfavourable, no impact
- 3 = Favourable, minor improvement
- 4 = Most Favourable, most improvement or most positive impact

Table 4-13: Ranking Scheme for Criteria Evaluation of Each Alternative

Ranking Scale					
No / Negative Impact	1	2	3	4	**Ideal / Most Positive Impact**

4.5 Evaluation of Alternatives

The Flood Mitigation alternatives were evaluated using this set of criteria. The evaluation matrix is provided in **Table 4-14** and **Table 4-15**.

Table 4-14: Evaluation Matrix for Flood Mitigation Alternatives

Evaluation Criteria	Alternative 1 - Do Nothing	Alternative 2 - Stormwater Reduction Pond	Alternative 3 - Upstream Only Improvements	Alternative 4 - Open Channel Realignment	Alternative 5 - Upstream Improvements & Culvert Enlargement	Alternative 6 - Upstream Improvements & Culvert Realignment	Alternative 7 - Culvert Enlargement	Alternative 8 - Additional Parallel Culverts
Physical/Natural Environment								
Potential to Reduce Flood Risks	◔ Negative impact to flood risk.	◔ Negative impact to flood risk.	◔ Negative impact to flood risk.	● Highest improvement to flood risk.	● Highest improvement to flood risk.	● Highest improvement to flood risk.	● Highest improvement to flood risk.	● Highest improvement to flood risk.
Potential to Improve Aquatic Habitat	◑ No effect to aquatic habitat.	● Greatest improvement to aquatic habitat.	◕ Positive impact to aquatic habitat.	◕ Positive impact to aquatic habitat.	◑ No effect to aquatic habitat.	◕ Positive impact to aquatic habitat.	◑ No effect to aquatic habitat.	◑ No effect to aquatic habitat.
Potential to Improve Terrestrial Habitat	◑ Some negative impacts to terrestrial habitat.	● Potential improvement to terrestrial habitat.	◕ No impact to terrestrial habitat.	● Potential improvement to terrestrial habitat.	◕ No impact to terrestrial habitat.	● Potential improvement to terrestrial habitat.	◕ No impact to terrestrial habitat.	◕ No impact to terrestrial habitat.
Potential to Reduce Erosion Risks	◔ Negative impact to erosion risk.	◑ No change to erosion risk.	◑ No change to erosion risk.	◕ Minor improvement to erosion risk.	◕ Minor improvement to erosion risk.	◕ Minor improvement to erosion risk.	● Highest improvement to erosion risk.	● Highest improvement to erosion risk.
Integration with the Existing Environment and Infrastructure	◑ Low Compatability with existing environment and infrastructure.	● Highest Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.	◕ High Compatability with existing environment and infrastructure.
Social/Cultural Environment								
Aesthetic/Recreation	◑ No aesthetic/ recreational benefit.	● Best improvement to aesthetic/ recreational benefit.	◕ Improvement to aesthetic/ recreational benefit.	● Best improvement to aesthetic/ recreational benefit.	◑ No aesthetic/ recreational benefit.	◕ Improvement to aesthetic/ recreational benefit.	◑ No aesthetic/ recreational benefit.	◑ No aesthetic/ recreational benefit.
Compatibility with Adjacent Land Use	● High compatibility with adjacent land use.	◕ Good compatibility with adjacent land use.	◑ Somewhat compatible with adjacent land use.	◑ Somewhat compatible with adjacent land use.	◕ Good compatibility with adjacent land use.	◑ Somewhat compatible with adjacent land use.	◕ Good compatibility with adjacent land use.	◕ Good compatibility with adjacent land use.
Community Disruption	● No community disruption.	◕ Minor community disruption.	◕ Minor community disruption.	◕ Minor community disruption.	◕ Minor community disruption.	◕ Minor community disruption.	◕ Minor community disruption.	◕ Minor community disruption.
Public Health and Safety	◔ Highest community disruption.	◑ Significant community disruption.	◑ Significant community disruption.	◕ Minor community disruption.	● No community disruption.	◕ Minor community disruption.	● No community disruption.	● No community disruption.
	○ Represents a low score for the alternative in the relevant criteria.			● Represents a high score for the alternative in the relevant criteria.				

Evaluation Criteria	Alternative 1 - Do Nothing		Alternative 2 - Stormwater Reduction Pond		Alternative 3 - Upstream Only Improvements		Alternative 4 - Open Channel Realignment		Alternative 5 - Upstream Improvements & Culvert Enlargement		Alternative 6 - Upstream Improvements & Culvert Realignment		Alternative 7 - Culvert Enlargement		Alternative 8 - Additional Parallel Culverts	
Economic Criteria																
Construction Costs	●	No cost.	◕	Lower cost.	◕	Lower cost.	◔	Greatest cost.	◑	High cost.	◑	High cost.	◑	High cost.	◑	High cost.
Operation & Maintenance Costs	◑	Major O&M cost.	◑	Major O&M cost.	◕	Minor O&M cost.	◑	Major O&M cost.	◕	Minor O&M cost.	◑	Major O&M cost.	◕	Minor O&M cost.	◕	Minor O&M cost.
Life Cycle Costs	◑	High cost.	◑	High cost.	◕	Lower cost.	◑	High cost.	◕	Lower cost.	◑	High cost.	◕	Lower cost.	◑	High cost.
Land Requirement Costs	●	No cost.	◕	Lower cost.	◕	Lower cost.	◔	Greatest cost.	◕	Lower cost.	◑	High cost.	◑	High cost.	◑	High cost.
Infrastructure Protection	◔	Lowest protection.	◔	Lowest protection.	◔	Lowest protection.	◕	High protection.	◑	Low protection.	◕	High protection.	●	Highest protection.	◕	High protection.
Technical/Engineering Considerations																
Ease of implementation	●	Least difficulty in implementing.	◕	Minor difficulty in implementing.	◕	Minor difficulty in implementing.	●	Least difficulty in implementing.	◕	Minor difficulty in implementing.	●	Least difficulty in implementing.	◕	Minor difficulty in implementing.	◕	Minor difficulty in implementing.
Agency Acceptance	◑	Acceptable.	◑	Acceptable.	◑	Acceptable.	◕	High agency acceptance.	◕	High agency acceptance.	◕	High agency acceptance.	◕	High agency acceptance.	◕	High agency acceptance.
City Acceptance	◔	Low acceptance of policy and by-law requirements.	◑	Achieves policy and by-law requirements.	◑	Achieves policy and by-law requirements.	◑	Achieves policy and by-law requirements.	◕	High level of acceptance of policy and by-law requirements.	◑	Achieves policy and by-law requirements.	●	Highest level of acceptance of policy and by-law requirements.	◕	High level of acceptance of policy and by-law requirements.
Technical Feasibility	◔	Least feasible.	◑	Somewhat feasible.	●	Highly feasible.	●	Highly feasible.	●	Highly feasible.	●	Highly feasible.	●	Highly feasible.	●	Highly feasible.
OVERALL RANKING																
	○	Represents a low score for the alternative in the relevant criteria.					●	Represents a high score for the alternative in the relevant criteria.								

Table 4-15: Evaluation Matrix – Raw Scoring

Evaluation Criteria	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5	Alt #6	Alt #7	Alt #8
Physical/Natural Environment (Max 20 points)								
Potential to Reduce Flood Risks	1	1	1	4	4	4	4	4
Potential to Improve Aquatic Habitat	2	4	3	3	2	3	2	2
Potential to Improve Terrestrial Habitat	2	4	3	4	3	4	3	3
Potential to Reduce Erosion Risks	1	2	2	3	3	3	4	4
Integration with the Existing Environment and Infrastructure	2	4	3	3	3	3	3	3
Social/Cultural Environment (Max 16 points)								
Aesthetic/Recreation	2	4	3	4	2	3	2	2
Compatibility with Adjacent Land Use	4	3	2	2	3	2	3	3
Community Disruption	4	3	3	3	3	3	3	3
Public Health and Safety	1	2	2	3	4	3	4	4
Economic Criteria (Max 20 points)								
Construction Costs	4	3	3	1	4	2	3	4
Operation & Maintenance Costs	2	2	3	2	3	2	3	3
Life Cycle Costs	2	2	3	2	3	2	3	1
Land Requirement Costs	4	3	3	2	3	2	3	3
Infrastructure Protection	1	1	1	3	2	3	4	2
Technical/Engineering Considerations (Max 16 points)								
Technical Feasibility	1	2	4	4	4	4	4	4
Agency Acceptance	2	2	2	3	3	3	3	3
Ease of implementation	4	3	3	3	4	3	4	4
City Acceptance	1	2	2	2	3	2	4	3
Total Score	**40**	**47**	**46**	**51**	**56**	**51**	**59**	**55**

4.6 Selection of the Preferred Alternatives

Table 4-14 and **Table 4-15** provide a graphical representation of the Evaluation Matrix completed for a total of eight (8) alternatives considered for the Mount Joy EA project. **Table 4-16** below provides the direct total scoring results of each alternative.

Table 4-16: Evaluation Matrix Total Scoring

Evaluation Criteria	Total Scoring Values for Each Alternative							
	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5	Alt #6	Alt #7	Alt #8
Physical/Natural Environment (Max 20 points)	8	15	12	17	15	17	16	16
Social/Cultural Environment (Max 16 points)	11	12	10	12	12	11	12	12
Economic Criteria (Max 20 points)	13	11	13	10	15	11	16	13
Technical/Engineering Considerations (Max 16 points)	8	9	11	12	14	12	15	14
Total Score	**40**	**47**	**46**	**51**	**56**	**51**	**59**	**55**

The completed Evaluation Matrix has identified Alternatives #1,#2 and #3 as being the lowest scoring alternatives. Accordingly, these alternatives will not be carried further for further consideration.

4.6.1 *Physical/Natural Environment Commentary*

Based on the evaluation matrix above, it should be noted that Alternatives #4 to #8 all provide similar total scoring results ranging from 51-59. This is largely attributed to the unique ability of these alternatives to convey Regional peak flows and their respective independent challenges and opportunities associated with each alternative. Alternatives #4 and #6 have a slight edge in the rankings in this category due to their higher positive impacts to both aquatic and terrestrial habitat.

4.6.2 *Social/Cultural Environment Commentary*

Subtle differences in the sub categories of the criteria also provide similar scoring results between Alternatives #4 to #8. We note that Alternatives #4,#5,#7 and #8 all produce a total category score of 12 despite the differences in the characteristics of the alternatives.

While higher scores of aesthetics are tied to Alternatives #4 and Alternative #6, lower scores are tied to these alternatives in the Public Health and Safety Category due to the open nature of the channels within the project area. Conversely, lower scores of aesthetics are tied to Alternatives #6 and Alternative #8, however, higher scores are tied to these alternatives in the Public Health and Safety Category to the nature of underground enclosed systems.

4.6.3 *Economic Criteria*

The economic ranking varies widely among the alternatives as the DNA of each alternative is distinctly different. Alternatives with open channels have higher Operational and Maintenance, Life Cycle and Land Requirement Costs. These types of alternatives are exposed to the elements and public and generally have lower infrastructure protection. We note that under existing conditions, sections of open channel are heavily clogged with dense vegetation (i.e. phragmites). The presence of phragmites' upstream, within and downstream of the project area reduces conveyance capacity of the drainage system and has been already observed to accumulate debris as identified via Erosion Site #1. Alternatives with open channels require larger land footprints and property acquisitions to construct the channel and will require higher costs to maintain in the future. Accordingly, Alternatives#4 and #6 have scored lower in this category in direct comparison to Alternatives #5,#7 and #8.

Conversely, enclosed systems typically have higher construction costs but lower Operational and Maintenance, Life Cycle and Land Requirement Costs. The increased scoring in this category is attributed with the enclosed nature of the system, therefore deterring the growth of dense vegetation and maintaining design conveyance through the project area. These types of alternatives are not exposed to the elements and public and generally have higher infrastructure protection. Alternative #8 has scored lower in this category as the existing Anderson Avenue storm sewer is to be maintained. The age of the existing Anderson Avenue storm sewer is not known; however, it is assumed that this section of CSP pipe at or nearing the end of it's service life, a replacement would be anticipated. Accordingly, Alternative #8 has scored lower than Alternatives #5 and Alternative #7.

Based on the above commentary, we note that Alternative #7 has scored higher than all other alternatives in this category.

4.6.4 *Technical/Engineering Considerations*

Based on the evaluation matrix Alternatives #4 to #8 all are technically feasible for the project area and accordingly, have been ranked as such. Based on public, City and Metrolinx feedback received throughout the duration of the project, preferred alternatives are alternatives that provide enclosed drainage corridors that do not re-direct the flood hazard closer to the Metrolinx railway corridor than existing conditions. Accordingly, these alternatives have been ranked higher in these categories.

4.6.5 *The Preferred Alternative*

Based on the evaluation matrix above, the highest scoring flood mitigation alternative was **Alternative 7 – Increased Culvert Size Replacement. Alternative 7 – Increased Culvert Size Replacement** had a score of **59** out of **72** (82%). This alternative is presented as the preferred alternative.

Figure 4-19 illustrates the proposed Regional Floodplain associated with Alternative #7.

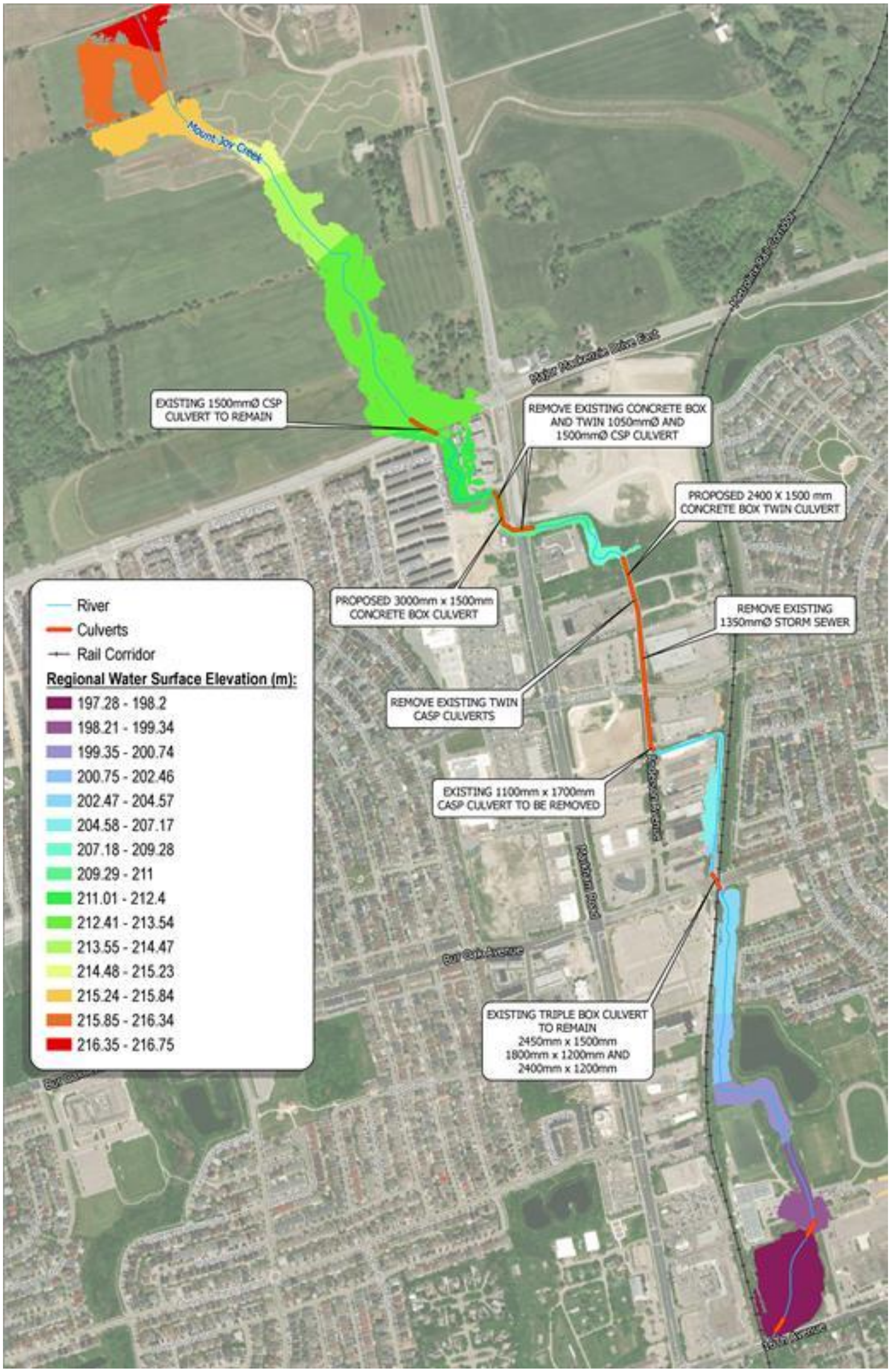


Figure 4-19: Annotated Hydraulic Modelling of Preferred Alternative 7

4.7 Description of the Preferred Alternative

The preferred alternative, Alternative 7 consists of replacing the existing culverts in the north half and south half of the study area with larger up-sized culverts. This alternative was found to have the highest score in comparison to the other alternatives for the following reasons.

Alternative 7 was able to address the key objective of the study which was to mitigate the flood concerns within the Mount Joy Creek study area. Additionally, the preferred alternative also demonstrated the highest improvement to flood risk among the other alternatives while also performing well in the other social, economic, and technical criteria groups. This alternative only involves replacing existing stormwater infrastructure in it’s current location without re-locating the flood hazard. There will be no new impacts or changes made to the surrounding community or natural environment when the construction phase is complete.

For the erosion sites identified in **Section 3.1.1**, the preferred alternative will address Erosion Site 2 and replace the deteriorated twin CSP culvert with concrete headwall. Aquafor recognizes that Erosion Site 2 is located with subdivision blocks that are subject to a restoration and compensation planting plan. The preferred alternative will ensure that the restoration efforts made to Erosion Site 2 will remains consistent with the previously approved requirements.

Erosion Site 1 is caused due to a debris jam located at the downstream limits of the Anderson Avenue culvert outlet. The section of channel between Anderson Avenue and Bur Oak Avenue, while has the capacity to convey Regional peak flows under existing conditions, is recommended to be cleaned out as a part of the preferred alternative. This section of channel is heavily clogged with vegetation and has not been maintained. A simple cleanout to restore the channel’s intended conveyance capacity will compliment the preferred alternative and reducing flood frequency.

Erosion Site 3 is caused due to sediment accumulation. This site cannot be addressed through any of the proposed alternatives and can only be mitigated through operation and maintenance activities.

With regards to erosion, it is recommended that all future storm sewer inlets and outlets be protected with an appropriate erosion method. Details surrounding future erosion protection may be accommodated at the detailed design stage.

The preferred alternative ranked very well in the economic and technical feasibility criteria in comparison to other flood mitigating criteria such as Alternatives 4 and Alternative 6. One key factor is that Alternative 7 avoided construction near the railway corridor. Based on Aquafor’s previous experience, any design that requires construction near a railway corridor can introduce significant challenges and costs. This can include the need for extensive coordination with external third parties, oversight from the railway company, and overall slower construction progress due to the strict safety protocols required near railway corridors.

Alternative 7 also performed slightly better in these criteria categories when compared to other alternatives that did not include work near the rail corridor (Alternative 5 & Alternative 8). Alternative 5 was less favourable due to the complexity and higher cost associated with converting a section of the watercourse from a culvert to an open channel. In the case of Alternative 8, it is acknowledged that installing a parallel culvert is typically more cost-effective than replacing an existing culvert. Though during the background review period of this project, it was found that the existing culvert is nearing the end of its service life and will require replacement in the near future. Undertaking two separate culvert installations would ultimately be more expensive than upsizing the current culvert. Lastly, it can be noted that the proposed twin 2400 mm x 1500 mm box culvert can be constructed under the future Anderson Avenue extension which can further reduce land requirements. Therefore, due to these reasons, Alternative 7 is considered to be the most feasible and cost-effective solution for addressing flood concerns within the Mount Joy Creek study area. The preferred alternative, Alternative 7: Culvert Enlargement has been updated to its 30% design phase and has the following Plan and Profile View Drawing seen in **Figure 4-20**. More details on the cross-sections referenced in this drawing can be seen in **Appendix L**.

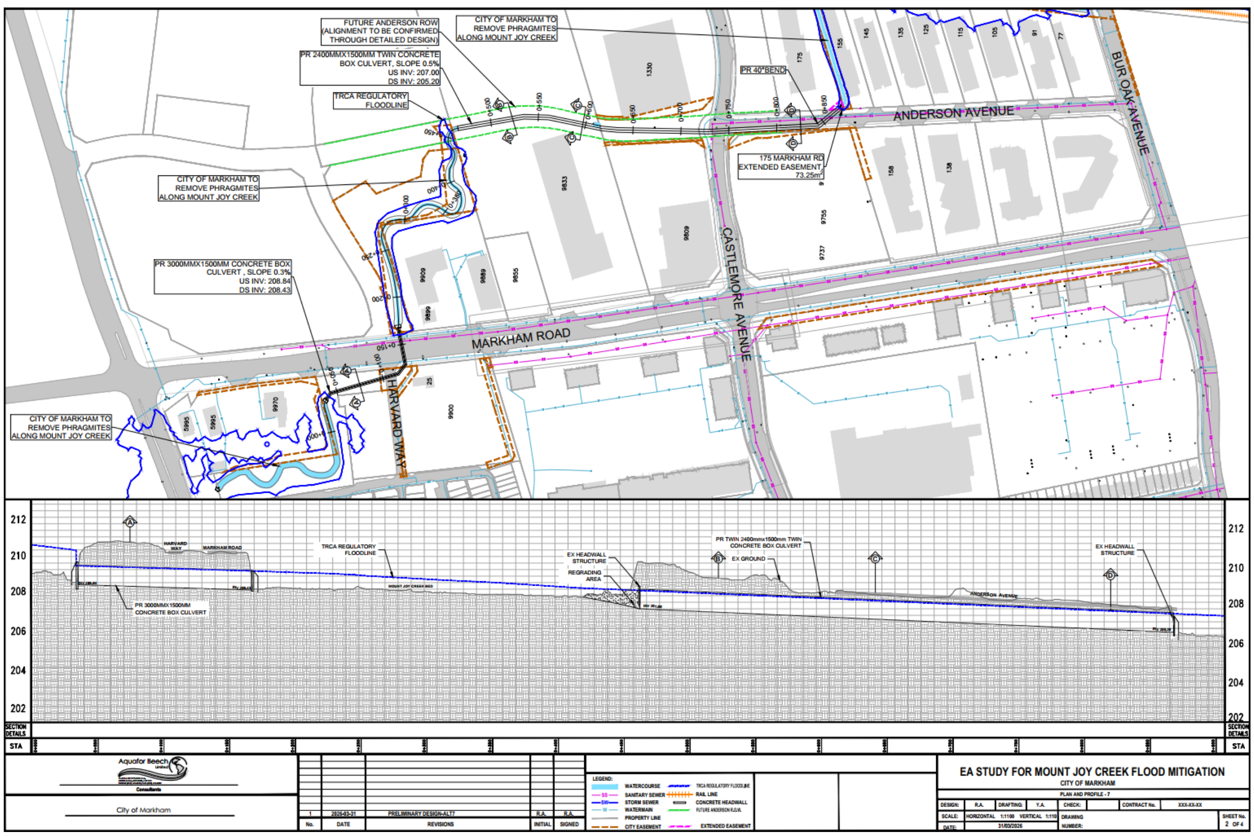


Figure 4-20: Preliminary Design Drawing for the Preferred Alternative

Aquafor, the City and the TRCA have met to discuss the preferred alternative on two (2) separate dates that include September 8th, 2025 and February 4th, 2026. During the February 4th, 2026 meeting it was noted that the TRCA can support the preferred alternative and its proposed recommendations for this EA so long as the results of this project file report demonstrate safe conveyance of the Regulatory and City Design storms.

4.8 Preferred Alternative – Constructability

The proposed culvert will cross beneath the Greenway Trail which is an existing multi-use path (MUP). During the detailed design phase, the project team will assess options for temporarily rerouting the path throughout the construction phase of this project. If a suitable detour cannot be found, the MUP will remain closed until construction activities are completed.

The following section of the report pertains to the constructability review of the alternative. Specifically, the preferred alternative has been broken down into five (5) sections and key aspects of the alternative including alignment and profile, Utility Conflicts and Property Acquisition have been detailed in **Table 4-17** below and a figure showing the location of each Section ID can be seen in **Figure 4-21**.

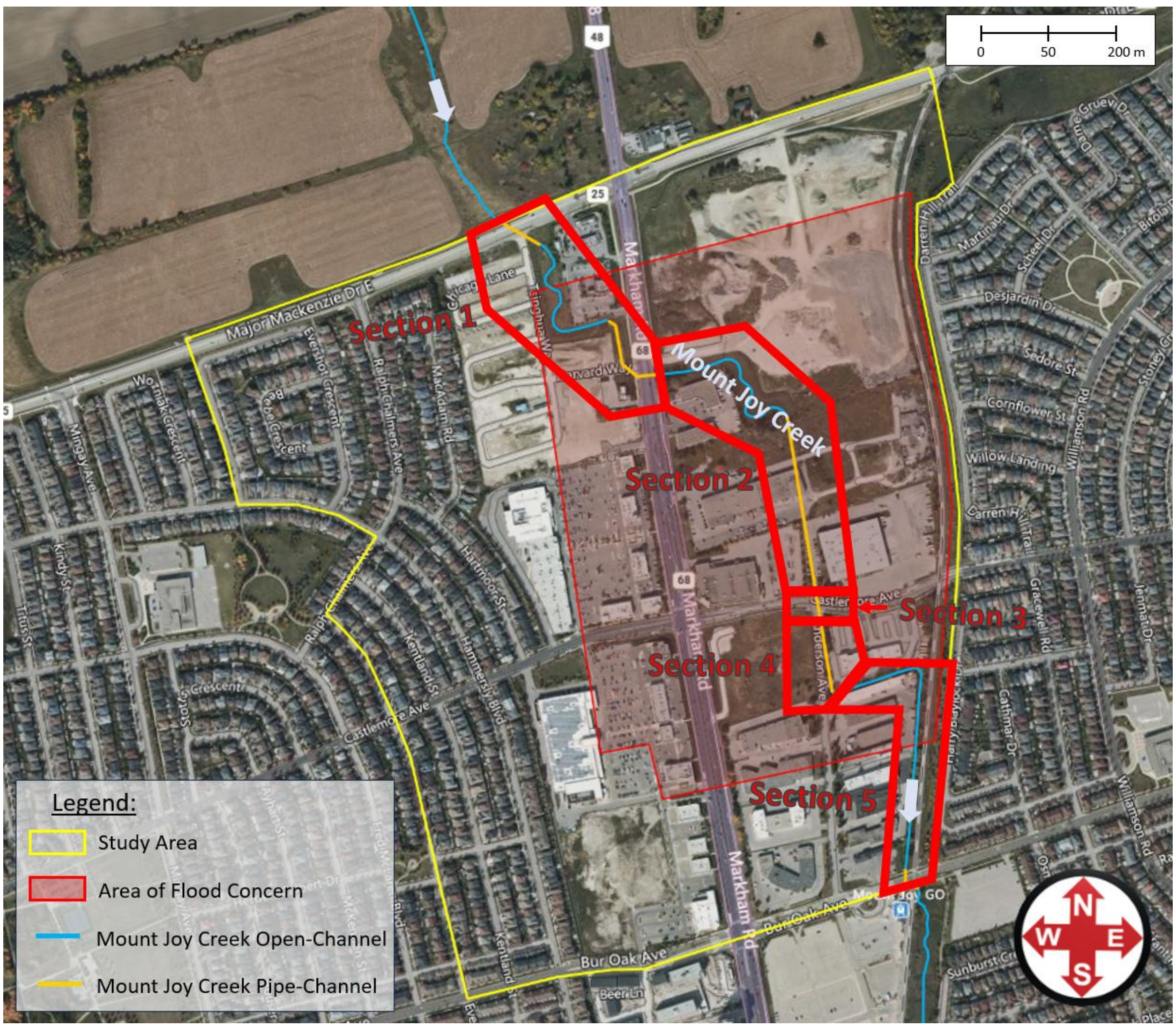


Figure 4-21: Study Area Section ID Locations

Table 4-17: Preferred Alternative Constructability

Section ID	Location	Alignment	Profile	Utility Conflicts	Property Acquisition
Section 1	Upstream of Markham Road and Within the Markham Road right-of-way	the intent of this section to replace the existing Markham Road culvert crossings with a consistent section of 3.0m span x 1.5m rise concrete box culvert. The upstream alignment of this section of box culvert has been intended to be centered within the existing culvert alignment but may be optimised during the detailed design stage	The existing profile is to be maintained to tie into both upstream and downstream sections of watercourse. Sufficient cover is anticipated beneath Markham Road.	Sanitary - the proposed alignment is anticipated to reside overtop of the existing sanitary sewer. Conflicts are not anticipated. Storm Sewer - local roadway storm sewer connections to be maintained. Watermain - existing watermain is present on both west and east of Markham Road. Elevations unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Gas - gas main is present. Elevations unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Hydro - overhead hydro is present. hydro pole is located approximately 5m south. Support may be required. MUP (Multi-Use Path) - MUP is anticipated to reside on top of proposed storm sewer. Section of MUP will be required for replacement of proposed STM.	Property acquisition is not anticipated for this section of Alternative 7.
Section 2	Upstream of Castlemore Avenue (future Anderson Ave Extension)	The intent of this section to replace the existing culvert with a consistent section of 2-2.4 m span x 1.5 m rise concrete box culverts. The alignment of this section of box culvert has been intended to be aligned with the Anderson Ave roadway extension. Alternatively, should the culvert replacement occur prior to the Anderson Ave roadway extension and as the existing culvert resides in close proximity to the back of the building at 9833 Markham Road, the existing culvert may be abandoned and the proposed culvert may be re-aligned to the east.	The existing profile is to be maintained to tie into the upstream watercourse and further to avoid utility conflicts at Castlemore Ave. Sufficient cover is present under existing conditions. Future roadway profiles are to be reviewed to ensure sufficient cover is provided for the Anderson Ave roadway extension.	Sanitary - existing sanitary sewer not present. Conflicts are not anticipated. Storm Sewer - local roadway storm sewer connections to be maintained. Watermain - existing watermain is not present. Conflicts are not anticipated. Gas - gas main is not present. Conflicts are not anticipated. Hydro - hydro is not present. Conflicts are not anticipated. MUP - MUP is not present. Conflicts are not anticipated.	The north limits of this section of existing storm sewer alignment traverses 9829 Markham Road in a north to south direction. A drainage easement may be required in advance of the Anderson Ave roadway extension to support the replacement of this section of storm sewer. The south limits of this section of existing storm sewer are located within a 2.4m wide drainage easement immediately west of the Islamic Centre of Markham at 1330 Castlemore Ave. This section of existing storm sewer also resides within a future road allowance for the Anderson Ave Roadway Extension. Accordingly, additional property requirements are anticipated at this location.

Section ID	Location	Alignment	Profile	Utility Conflicts	Property Acquisition
Section 3	Castlemore Avenue right of way	the intent of this section to replace the existing culvert with a consistent section of 2-2.4m span x 1.5m rise concrete box culverts. The alignment of this section of box culvert has been intended to be centered within the existing culvert alignment but may be optimised during the detailed design stage to align with the Anderson Ave roadway extension.	The existing profile is to be maintained to avoid utility conflicts at Castlemore Ave. Sufficient cover is present under existing conditions. Future roadway profiles are to be reviewed to ensure sufficient cover is provided for the Anderson Ave roadway extension.	Sanitary - the proposed alignment is anticipated to reside overtop of the existing sanitary sewer. SUE investigations are required to determine exact elevations of the sanitary sewer. Storm Sewer - local roadway storm sewer connections to be maintained. Watermain - existing watermain is present at the north limit of Castlemore Ave. Elevations are unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Gas - gas main is present. Elevations unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Hydro - location of hydro is unknown at this location. Further locates are required. MUP - MUP is not present. Conflicts are not anticipated.	Property acquisition is not anticipated for this section of Alternative 7.
Section 4	Anderson Ave (south of Castlemore Ave)	the intent of this section to replace the existing culvert with a consistent section of 2-2.4m span x 1.5m rise concrete box culvert. The alignment of this section of box culvert has been intended to be centered within the existing culvert alignment but may be optimised during the detailed design stage to align future Anderson Ave ROW typical roadway cross section	the existing profile is to be maintained to avoid utility conflicts within the Anderson Ave right of way and to tie into the existing watercourse downstream of Anderson Ave Sufficient cover is provided under proposed conditions.	Sanitary - sanitary main is located at the east limits of Anderson Ave. At the crossing, the proposed alignment is anticipated to reside overtop of the existing sanitary sewer. Conflicts are not anticipated. Storm Sewer - local roadway storm sewer connections to be maintained. Watermain - existing watermain is present at the north limit of Castlemore Ave. Elevations are unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Gas - gas main is present. Elevations unknown but assumed to reside below the existing storm sewer. Conflicts are not anticipated. Hydro - location of hydro is unknown at this location. Further locates are required. MUP - MUP is not present. Conflicts are not anticipated.	Property acquisition is not anticipated for this section of Alternative 7.
Section 5	Anderson Ave to Bur Oak Ave	this section of the watercourse has not been selected for conveyance improvements. However, we note that this section of watercourse contains dense vegetation including cat tails and phragmites. While direct conveyance improvements are not required, it is recommended for this section of watercourse to be cleaned out to return the existing conveyance characteristics.	the existing profile is to be maintained.	Private drain connections may be present and may require repair should the watercourse be cleaned out.	Drainage easements will be required to complete clean out.

4.9 Inspection and Maintenance Requirements of the Preferred Alternatives

While the preferred solution utilizes the same general type of stormwater infrastructure as the existing conditions, the replacement culvert is significantly larger in size. As a result, the operation and maintenance requirements will differ from those currently in place. The increased span and rise, may reduce the maintenance activities, as the larger culvert is less prone to blockages. Additionally, the larger culvert is expected to be walkable, allowing for visual inspection and manual debris removal, which could eliminate the need for specialized equipment such as CCTV. Inspection of a larger culvert of the proposed span are expected to include OSIM type inspections and confined space entry precautions. As a result, the proposed culvert costs are to be supposedly higher than routine CCTV inspections. Maintenance considerations should also include inspection and upkeep of culvert joints, which may be more accessible but require attention to ensure long-term structural integrity.

Additionally given that the proposed long trunk sewer will convey channel flow, there is a potential for debris accumulation, which may necessitate more frequent inspection and specialized maintenance.

4.10 Cost Estimate for the Preferred Alternative

As presented in **Table 4-18,** a preliminary cost estimate was prepared for the implementation of the preferred alternative, including both expected construction as well as engineering design costs. The cost estimate provided below includes a 30% contingency and is exclusive of HST. The provided estimates are based on 2025 costs. It is expected that the construction cost estimate will be further refined throughout the detailed design phase of this project. The preliminary cost estimates for all Alternatives can be found in **Appendix G**.

Table 4-18: Cost Estimate for the Preferred Alternative

Item	Description	Quantity	Unit	Unit Price	Price (Excl. HST)
SCHEDULE OF QUANTITIES					
EA Study for Mount Joy Creek Flood Mitigation - Alt #7 - Preliminary preferred					
City of Markham					
SECTION 1 - GENERAL					
Item	**Description**	**Quantity**	**Unit**	**Unit Price**	**Price (Excl. HST)**
1.1	Bonds and Insurance	1	L.S.	$ 240,000.00	$ 240,000.00
1.2	Traffic Control & Traffic Control Signage	1	L.S.	$ 150,000.00	$ 150,000.00
1.3	Utility, Service Locates and Construction Layout	1	L.S.	$ 50,000.00	$ 50,000.00
1.4	Mobilization, Demobilization, Access Route and Staging Area	1	L.S.	$ 1,400,000.00	$ 1,400,000.00
1.5	Tree Removals, Clearing, Grubbing and Compensation	1	L.S.	$ 52,000.00	$ 52,000.00
1.6	Stream Bypass, Dewatering and Flow Control	1	L.S.	$ 1,000,000.00	$ 1,000,000.00
1.7	Positive Dewatering	1	L.S.	$ 100,000.00	$ 100,000.00
1.8	Erosion & Sediment Control	1	L.S.	$ 100,000.00	$ 100,000.00
1.9	Obtain MNRF Fish Collection Permit and Fish Rescues	1	L.S.	$ 30,000.00	$ 30,000.00
1.10	Temporary Support and Protection of Utilities	1	L.S.	$ 250,000.00	$ 250,000.00
1.11	Off-Site Disposal of Excess Soil	1	L.S.	$ 145,000.00	$ 145,000.00
	Sub-total Tender Price Section 1				**$ 3,517,000.00**
SECTION 2 - CULVERT REPLACEMENT & ROAD RECONSTRUCTION					
Item	**Description**	**Quantity**	**Unit**	**Unit Price**	**Price (Excl. HST)**
2.1	Saw Cut, Excavate and Disposal of Materials for Culvert Replacement (Asphalt, Granular, Fill, Sidewalk, Curb and Gutter, Gabions, etc.)	1	L.S.	$ 1,500,000.00	$ 1,500,000.00
2.2	Supply and Installation of Culvert	556	m	$ 12,000.00	$ 6,672,000.00
2.3	Asphalt Restoration	97	m^2	$ 250.00	$ 24,243.38
2.4	Remove and Replace Maintenance Holes	3	ea.	$ 50,000.00	$ 150,000.00
2.5	Site Restoration Works (i.e., sodding, tree plantings, etc.)	1	L.S.	$ 350,000.00	$ 350,000.00
	Sub-total Tender Price Section 2				**$ 8,696,243.38**
SECTION 3 - ENGINEERING DESIGN					
Item	**Description**	**Quantity**	**Unit**	**Unit Price**	**Price (Excl. HST)**
3.1	Engineering Services and Design	1	L.S.	$ 1,600,000.00	$ 1,600,000.00
3.2	Construction Administration	1	L.S.	$ 4,300,000.00	$ 4,300,000.00
3.3	Construction Design Support During Implementation	1	L.S.	$ 480,000.00	$ 480,000.00
	Sub-total Tender Price Section 3				**$ 6,380,000.00**
SUMMARY					**Price (Excl. HST)**
SUB-TOTAL TENDER PRICE - SECTION 1 - General					$ 3,517,000.00
SUB-TOTAL TENDER PRICE - SECTION 2 - Culvert Replacement & Road Reconstruction					$ 8,696,243.38
SUB-TOTAL TENDER PRICE - SECTION 3 - Engineering Design					$ 6,380,000.00
SUB-TOTAL (Excluding Provisional Items)					**$ 18,593,243.38**
Contingency (30%)					$ 5,577,973.01
SUB-TOTAL TENDER PRICE (Excluding Provisional Items)					**$ 24,171,216.39**

5 PUBIC AND FIRST NATIONS CONSULTATION

5.1 First Nations Consultation

The Ministry of Environment, Conservation and Parks (MECP) were contacted to determine First Nation communities that can be interested in the Class EA. Communities contacted include:

- Alderville First Nation
- Curve Lake First Nation
- Hiawatha First Nation
- Huron Wendat First Nation
- Kawartha Nishnawbe First Nation
- Mississaugas of Scugog Island First Nation
- Mississaugas of the Credit First Nation

A Notice of Commencement was sent to First Nations Communities on January 8th, 2025. First Nation Communities requested information on any Stage 2 Archaeological Assessment and ecological investigations completed. The Notice of Commencement can be seen in **Appendix H** of this report.

On November 20th, 2025 a follow-up letter was sent to each First Nation. The letter provided an update on the project status, summarized the current progress of the Archaeological Assessment and outlined the work completed to date, and informed recipients that the EA Report will be published on the City's website. Of the seven (7) First Nation communities that were contacted, four (4) of them replied with interest to review project material. These communities included the Alderville First Nation, Kawartha Nishnawbe First Nation, the Mississaugas of Scugog Island, and the Mississaugas of the Credit First Nation. The remaining communities which include: Curve Lake First Nation, Hiawatha First Nation, and Huron Wendat First Nation were then sent second additional notices on March 3rd, 2026 both electronically by follow-up e-mail and physically via Canada Post. Of these three (3) First Nations communities, only Curve Lake First Nation responded with interest to review project material. With the submission of the second additional notice, now five (5) of seven (7) First Nations communities have responded with interest to review project material. Although Huron Wendat First Nation did not respond to either of the notice letters expressing interest to review project material, they did respond to the project's Notice of Commencement letter sent in January 2025. Their response communicated that the Huron Wendat community would be interested in participating in any archaeological assessment field work for this project. The project team will ensure that the Huron Wendat First Nation and the other First Nation communities will be informed of and invited to attend all future archaeological assessments within the Study Area.

Of the five (5) First Nations communities that reviewed the project material, Kawartha Nishnawbe First Nation and Alderville First Nation provided comments on the draft Stage 1 Archaeological Assessment. Aquafor provided all First Nation comments to New Era Technology who updated the report as per the comments. The final version of the Stage 1

Archaeological Assessment is included in **Appendix B** and is also summarized in **Section 3.3** of this report.

Personalized copies of all sent First Nation letters and responses are included in **Appendix H** and a summary of the current interest from First Nation Communities are included in **Table** 5-1.

Table 5-1: First Nation Community Interest

Summary of First Nation Responses			
First Nation Community	**Assessments of Interest**	**Consultation Fee**	**Current Status**
Alderville First Nation	Stage 1 Archaeological Assessment (AA) Stage 2-4 AA	$300 (Paid)	**March 30th, 2026 -** Aquafor received comments on Stage 1 AA **April 24th, 2026** - Aquafor sent updated Stage 1 AA to Alderville
Curve Lake First Nation	Stage 1 AA Other documents associated with Project	-	**March 13th, 2026** - Aquafor provided documents package. First Nation community in the process of review. Asked for input before March 30th, 2026
Hiawatha First Nation	No Response Received	-	-
Huron Wendat First Nation	Future Archaeological Assessment Field Work	-	**January 28th, 2025** - Responded to the Notice of Commencement, though has not responded to any correspondance since
Kawartha Nishnawbe First Nation	Stage 1 AA Stage 2 AA	$1,500 (Paid)	**February 15th, 2026** - Received comments on draft Stage 1 AA **March 12th, 2026** - Sent updated Stage 1 AA report to Kawartha Nishawbe
Mississaugas of the Credit First Nation	Wildlife Habitat Aquatic & Terrestrial Surveys Tree Assessment Stage 1 AA Heritage Assessments	1) $600 (Paid) 2) $225/hour a) $112.50 Invoice (Paid) b) $337.50 Invoice (Paid) c) $1,575.00 Invoice (Paid)	**June 19th, 2026** - Received comment from the MCFN's on the Project File **June 23rd, 2026** - Aquafor provided MCFN with a Response Letter addressing comments
Mississaugas of Scugog Island	Stage 1 AA Stage 2 AA	-	**March 4th, 2026** - Mississaugas of Scugog Island have no further comments at this time, the community looks forward to involvement in the Stage 2 AA

A communications log summarizing all emails received and sent to the seven (7) First Nations communities and all emails received and sent to the seven (7) First Nation communities are included in **Appendix H**.

5.2 Public Consultation

Project notification for public consultation was arranged by Aquafor. It has been assumed that the notifications were circulated to organizations and individuals on the City's stakeholder list. To date three (3) notices regarding the project were sent to the City. These notifications include Notice of Commencement and two (2) notices for the two (2) Public Information Centres (PICs). The Notice of Commencement was sent to the City in January 2025 and is dated January 8th, 2025. A notice for the first PIC was sent to the City in April and is dated for April 11th, 2025. A notification of the second PIC was sent to the City in July and is dated July 24th, 2025. All notifications were posted on the City's website prior to their scheduled dates. Additionally, the PIC information was shared on the City's website for the public to review and provide feedback. Aquafor also hand-delivered the notice to all residents, businesses, and other relevant stakeholders within the study area.

On Monday May 5th, 2025 the first Public Information Centre was held at the Markham Civic Centre. Members of the project team and the City of Markham were in attendance. Three (3) residents from the Greater Toronto Area attended and signed the sign-in form. An overview of the project was presented which included a summary of existing conditions and eight (8) alternatives that there being considered.

On Wednesday September 10th, 2025 the second Public Information Centre was held at the Markham Civic Centre. Members of the project team and the City of Markham were in attendance. Seven (7) residents from the Greater Toronto Area attended and signed the sign-in form. An overview of the project was presented which included a summary of existing conditions and the eight (8) alternatives that were considered. In addition, this PIC also presented the hydraulic modeling results of the alternatives along with the City and Aquafor's selection for the preferred design.

All Notices and feedback are included in the Public Consultation **Appendix I**, along with presentation materials for the Public Information Centres.

6 POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION

6.1 Surface and Groundwater

The entire study area is within the Toronto Source Protection Area. Information on this source protection area was found using the MECP Source Protection Information Atlas tool.

Source Protection details at the intersection of Markham Road and Major Mackenzie Drive East noted the following:

- Source Protection Area: **Toronto**
- Wellhead Protection Area: **No**
- Wellhead Protection Area (WHPA-E): **No**
- Issue Contributing Area: **No**
- Significant Groundwater Recharge Area: **No**
- Highly Vulnerable Aquifer: **Yes**; score is **6**
- Event Based Area: **No**
- Wellhead Protection Area Q1: **No**
- Wellhead Protection Area Q2: **No**
- Intake Protection Zone Q: **No**

Water Budget details at the intersection of Markham Road and Major Mackenzie Drive East noted the following:

- IPZ-Q Name: **N/A**
- WHPA-Q1 Name: **N/A**
- Significant Groundwater Recharge Area: **No**
- Wellhead Protection Area Q1: **No**
- Wellhead Protection Area Q2: **No**
- Intake Protection Zone Q: **No**

Water quality is not expected to be adversely impacted by any alternative discussed within this environmental assessment. As part of future detailed design and tender packages a detailed erosion and sediment control plan for the Contractor will be required which will protect surface water from sediment runoff during construction. No groundwater impacts are anticipated.

6.2 Air Quality, Dust and Noise

Limited local impacts to air quality from the proposed alternatives are expected only during construction activities. Construction impacts are short duration and low intensity, with minimal impact. Considering the lack of residential buildings at this specific stretch of Mount Joy Creek, there are no expected sensitive receptors within close proximity to the areas of impact. To be conservative, the use of non-chloride dust suppressants for the entrainment of fugitive dust particles is recommended during construction activities.

6.3 Tree Inventory and Protection Measures

Prior to construction a detailed tree inventory will be conducted and is discussed in greater detail in **Section 7.1.5** of this report. Though in summary, tree protection zones will be placed in accordance with the City's Tree Protection By-law and TRCA's guidelines where feasible. This includes the City's Tree Assessment and Protection Plan requirements as well as Tree Replacement / Compensation By-law. For trees that cannot be preserved due to the construction activities of this project, compensation measures will be implemented to offset the negative impacts of trees removal.

6.4 Contaminated Soils & Excess Materials Management

According to O. Reg. 406/19, consideration must be given to the management of excess construction soil, as well as identifying whether there is any risk of contaminants being in the soil existing in-situ. Review of aerial imagery available from the City of Markham shows that the area has commercial development on this stretch of the Mount Joy Creek. However, soil chemical analysis for any areas of excavation will be completed at both the detailed design and construction stages to characterize the soil quality prior to excavation and inform excess soil management as required.

6.5 Climate Change

There are two parts to assessing climate change as part of the environmental assessment process. First, consideration of the project's effect on climate change via emissions or other environmental impacts. Second, an assessment of the effects of climate change on the project over its lifespan and how those impacts may pose a risk to the environment. The following subsections describe these two climate change considerations.

6.5.1 *Project's Impact on Climate Change*

All alternatives in this environmental assessment will impact the environment in the form of construction emissions. Construction emissions are limited where possible with strategies such as cut/fill balances, which reduce the need for hauling material on and off site.

In the future development of the staging and access plans as part of the detailed design process, existing cleared areas will be utilized where feasible to limit the impacts of clearing vegetation in natural areas. This reduces emissions from clearing equipment, and provides positive benefit from the maintained vegetation's carbon capture and storage abilities. Furthermore, vegetation restoration plans will be completed for each project location. These plans ensure that any affected vegetation is properly replaced, ensuring biodiversity and promotion of a native ecosystem. Due to the nature of the alternatives, no emissions or associated monitoring programs are anticipated post construction.

6.5.2 *Impacts of Climate Change on the Project*

Climate change is expected to increase the intensity and frequency of extreme rainfall events. Particularly in urban areas, this has limited opportunities for infiltration and rainfall is instead directed through storm sewers to local waterways. This results in a rapid and unnatural increase in water levels, flows and hydraulic forces. The potential for more intense and frequent flood events presents risk to the durability and life expectancy of erosion control measures.

To ensure the stability and longevity of the proposed designs, all existing and proposed conditions will be hydraulically modelled during detailed design to quantify the forces endured under different storm events. Designs will be sized and otherwise adjusted to withstand these forces, or will be constructed in such a way that the expected movement of placed bank materials does not impact their effectiveness

7 DETAILED DESIGN RECOMMENDATIONS

7.1 Detailed Design and Investigations

Upon completion of the environmental assessment, the project will move forward into the detailed design component. The detailed design will include additional technical investigations and inventories, with the primary deliverable to be a design package used for construction. This package will be subject to regulatory review and permitting. A brief overview of the additional inventories and deliverables to be completed in support of the detailed design phase is summarized below.

For each project a detail design package will include the preparation of 60%, 90% and final design drawings for review by the City, TRCA and relevant stakeholders. Each detailed design package will include the following components:

- **General plan - Existing Conditions and Removals:** Outlines project extents, property ownership and proposed site removals;
- **General plan - Proposed Conditions:** Delineates the proposed restoration designs including the proposed length of rehabilitation works and any proposed erosion control structures;
- **Plan and profile drawings:** Defines alterations to the planimetric alignment and longitudinal profile of Mount Joy Creek;
- **Cross-Sections:** Outlines proposed changes to the cross-sectional configuration of Mount Joy Creek;
- **Site Access and Staging Plan:** Delineates the recommended site access, staging and stockpile areas;
- **Erosion and sediment control plan**: Defines ESC requirements as per the Erosion and Sediment Guidelines for Urban Construction, as well as applicable TRCA standards and guidelines. Should also include proposed flow management solutions to establish a dry working condition. Flow management solutions may include such measures as bypass pumping, implementation of a bypass flume or installation of longitudinal coffer dams;
- **Landscape restoration plans:** Includes tree removal, preservation and planting plans. The development of restoration plans should take into account impacts areas associated with different Ecological Land Classifications as well as the City's and TRCA guidelines and By-laws;
- **Construction details:** Outlines the construction requirements for key design components; and
- **Associated design brief:** Provides supplementary design information to support the permitting and construction process.

As part of the design process, additional inventories and plans will be required to further inform the design.

7.1.1 *Hydraulic Assessment*

A detailed hydraulic assessment of the proposed conditions for the preferred alternative will need to be undertaken to facilitate permitting with the TRCA. The results of the assessment will be included in the project design brief. Computation of peak velocities, shear stresses and stream powers for bank full and peak floods (i.e., 2–100-year events and Regional Storm) shall be included and incorporated into evaluation of the proposed remedial measures. The assessment will be used to confirm that no negative flooding or erosion impacts will result from the proposed works, a condition of TRCA permits, and to size any material for the rehabilitation works. Additionally, the proposed culvert/trunk sewer sizing is required to be reconfirmed through appropriate hydraulic assessment and modelling. To facilitate permitting, an existing and proposed conditions model will need to be prepared to allow for a comparison of the proposed designs impacts on water surface elevations as well as channel velocities, shear stresses and stream power values.

7.1.2 *Geotechnical Investigation*

A geotechnical investigation should be undertaken to determine the engineering properties of the existing soils within the project area, specifically in areas designated for culvert replacements and water course cleanouts. In this context, "watercourse cleanout" refers to the localized excavation and removal of accumulated sediment and dense vegetation within the channel. This activity is intended to restore the channel's hydraulic capacity and improve flow conveyance upstream / downstream of Anderson Avenue culvert.

Additionally, it is recommended that geotechnical investigations along the proposed alignment of the trunk sewer will be required. The details of the geotechnical investigation are to be determined by a qualified geotechnical engineer in consultation with the stream restoration consultant. These investigations will be summarized in a geotechnical study that will include all pertinent geotechnical recommendations and will be provided during the detailed design phase of the project.

Additionally, during the detailed design phase, a site grading strategy will be required. If this strategy results in proposed slopes or retaining structures adjacent to the culverts, these elements will need to be reviewed and approved by a qualified engineer.

Borehole logs containing appropriate and sufficient data should be prepared. Information from the boreholes is to be used for the assessments of slope stability, soil properties for channel and culvert design, soil contamination, and any other geotechnical recommendations for engineered structures. Furthermore, soil chemical testing should be undertaken to provide recommendations for the disposal of excess material offsite in accordance with O.Reg. 406/19.

7.1.3 _Erosion Hazard Assessment_

A detailed erosion hazard assessment will be completed as part of the subsequent detailed design process. Acknowledging that the proposed design is not intended to impact the erosion hazard limits within the study area, it will be ensured that the proposed design does not negatively impact the erosion hazard at any point within the study area as well as upstream and downstream of the study area. This includes the channel downstream of Castlemore Avenue.

7.1.4 _Future Culvert replacement_

The culvert and concrete headwall are anticipated to be municipal infrastructure owned and maintained by the City of Markham. Any rehabilitation or replacement works will require coordination with the City and confirmation of access and easement requirements prior to implementation, as per City By-law 2018-109 (Road Occupancy By-law).

7.1.5 _Tree Protection and Arborist Assessment_

Tree protection fences following the specifications in TRCA's guidelines should be erected along all construction access routes and work areas. If possible, it is also recommended that planting areas be fenced off for two (2) years to protect newly planted vegetation and to allow time for growth and to anchor soils. Some mature trees will need to be removed to accommodate construction. To compensate, native trees and shrubs that fit the existing vegetation communities will be included within the restoration plan of the detailed design drawings. TRCA's Guideline for Determining Ecosystem Compensation will be reviewed when developing the plan. To ensure that all these requirements are adhered to, it is recommended that an arborist be involved in the design process, and a standalone arborist report be prepared and submitted to the City of Markham and TRCA.

7.1.6 _Utilities Confirmation_

Further SUE investigations will be required to confirm the impact of each proposed alternative design on the utilities and underground services within the proposed restoration areas. The utilities may include, but are not limited to, electricity, natural gas, cable television, telephone, water, sanitary sewer, and storm sewer.

SUE investigations should be completed in sufficient detail to identify all above ground and buried infrastructure within each project site. Prior to the start of construction, utility protection measures will need to be confirmed with each corresponding utility authority.

7.1.7 *Archaeological Assessment*

A Stage 2 archaeological field assessment will be conducted within the proposed construction impact area in areas of archaeological potential as identified during the Stage 1 Archaeological Assessment. The potential for Stage 3 Archaeological Assessment based on Stage 2 results when available. Any additional portions of the construction impact area not covered by the Stage 1 report but deemed to have archaeological site potential based on visual inspection will also be subject to field survey.

7.1.8 *Fluvial Geomorphological Assessment*

While the preferred alternative maintains a similar alignment and profile to existing conditions, further fluvial geomorphological assessments are required to support the preferred alternative during the detailed design stage. To support the detailed design, a fluvial geomorphological report signed by a qualified professional to support the design of all proposed crossings and channel modifications (i.e., bank widths, low flow channel design, meander, riffle-pool design, bank/bed materials, etc.).

7.1.9 *General Mitigation Measures*

7.1.9.1 Erosion and Sediment Control

Erosion and sedimentation control techniques are necessary precautions to minimize sediment entry into surrounding creeks and/or storm sewer pipes. Installation of construction fencing and erosion & control silt fence are required well in advance of construction activities. Construction fencing and access routes shall be clearly delineated and appropriate setbacks maintained from private property for the duration of construction works. Sediment and erosion control measures should remain in place until vegetation has become established.

Sediment and erosion control measures should also act as wildlife exclusion fencing to prevent small mammals and herpetofauna from entering disturbance areas.

Public lands should be restored with woody vegetation as a part of bank stabilization efforts.

Potential sources for sedimentation related to construction activities include sediments disturbed and deposited by construction vehicles and blowing sand and dust. The following mitigating measures are proposed:

- Place sediment traps to receive storm runoff during construction;
- Provide tire washing facilities for construction vehicles that exit the site;
- Install silt fencing along the perimeters of the work sites where appropriate to prevent migration of sediment-laden storm runoff;
- Cover exposed excavated material to prevent erosion by rain and wind; and
- Water or other non chloride dust suppressants to be employed for the entrainment of fugitive dust particles is recommended during construction activities.

An erosion and sediment control plan will be prepared and the selection of appropriate measures will be addressed during the detailed design stage. The erosion and sediment controls indicated are the minimum that are required. It is necessary to ensure that all erosion and sediment control measures are functional prior to and throughout the duration of construction.

7.1.9.2 Fuel Spills

Fuel spills may occur during the onsite refueling of construction equipment, and may potentially contaminate surface and groundwater as well as soils. Recommended mitigation measures include the following:

- Refueling in designated areas outside of the NHS;
- Spill containment for on-site storage tanks; and
- Develop and Implement as needed a spill clean-up contingency plan.

7.1.9.3 Environment Disturbance

During the detailed design phase, every reasonable effort shall be undertaken to limit disturbance to the natural environment, including the following:

- Reduction of the disturbance limits and tree removals to only the strictly required areas;
- Strategical selection of access and staging/storage locations, using previously disturbed areas will low ecological value wherever possible.

7.1.10 Adherence to City and TRCA Guidelines

During the detailed design phase, adherence to City and TRCA's technical guidelines is required, including, but not limited to the following guidelines:

- City of Markham Stormwater Management Guidelines
- City of Markham Engineering Design Criteria
- City of Markham Health and Safety Policies
- TRCA's Standard Construction Notes
- TRCA's Guideline for Determining Ecosystem Compensation
- TRCA's Technical Guidelines for Flood Hazard Mapping
- TRCA's Crossing Guideline for Calley and Stream Corridors
- TRCA's Erosion and Sediment Control Guide for Urban Construction

7.1.11 Construction Services

All tender documentation will be completed applicable to the City or TRCA standards, with Special Provisions and Schedule of Quantities with refined engineering cost estimates provided. The package will include Project Descriptions, Special Provisions, Specifications, Form of Tender and a Schedule of Prices. The final detailed design drawings will be issued as a set of contract drawings with the completed tender package. The contract drawings will be stamped by a professional engineer, signed, and labeled "Issued for Tender" complete with all necessary material and performance specifications. The consulting engineer will typically assist the City during the tendering and procurement period as required, providing responses and clarification to bidders during the procurement process.

Inspection and administration services during construction under the guidance of a professional engineer (or geomorphologist) who has been integrated in the design and is well versed in similar construction projects is required. Tasks undertaken as part of the supervision role will include:

- Inspect all layout and construction work to ensure compliance with the contract specifications and drawings;
- Provide advice to the contractor regarding the interpretation of the contract drawings and specifications and the preparation of supplemental details, instruction and clarifications as required;
- Notify the contractor of any deficiencies in the construction of the work, instructing the contractor to take appropriate corrective measures, confirm and report results of the corrective measures during construction. The deficiency list will be maintained and coordination of rectification throughout the 2-year maintenance period;
- Review, monitor and ensure compliance with contractor environmental conditions (i.e., Erosion and Sediment Control Plan).
- Preparation and issuance of substantial Performance certificate and recommendations; and;
- Undertake a complete and thorough inspection of the contractor’s work and prepare a report which lists all outstanding deficiencies at the end of the warranty period and coordinate and ensure that contractor corrects all warranty deficiencies expeditiously and to the satisfaction of the City.

7.2 Monitoring Program

A 2-year annual monitoring plan is recommended following completion of construction, which will include Warranty Period engineering review, as well as assessment of the efficacy of restoration plantings. The program should include time for inspection of both the channel works and vegetation plantings by the project geomorphologist/engineer, as well as the project ecologist. Both the monitoring and warranty will be defined to suit the detailed design, and satisfy City, TRCA and other agency requirements.

7.3 As-Constructed Drawings and Analysis

This task will set baseline conditions following construction, which will enable future monitoring and comparative analysis. Specifically, an as-built survey of completed channel works (plan, profile, and cross sections) to verify implementation of design within reasonable tolerances should be undertaken. As-constructed drawings, together with a report summarizing pre- and post-construction conditions should be provided. The report should comment on significant deficiencies found with recommendations for correction or adaptive management as required.

8 CONCLUSION

In summary, a Municipal Class Environmental Assessment was conducted for the Mount Joy Creek between Major Mackenzie Drive and Bur Oak Avenue. The objective of the Municipal Class Environmental Assessment study was to develop and evaluate alternatives within the study area, to mitigate tableland flooding of the properties adjoining the creek corridor. Additionally, this will also facilitate the future development ambition for the area defined in the recently completed Markham Road Mount Joy Secondary Plan.

Alternatives for the watercourse were developed based on a series of existing conditions inventories and technical studies. These alternatives were evaluated based on a variety of criteria including social, economic, environmental, and technical considerations, to determine the preliminary preferred alternatives. This evaluation process was further refined during a meeting held by Aquafor with TRCA and the City on September 8th, 2025, to review the MIKE+ hydraulic modelling, discuss the results for each alternative, and obtain feedback on the preliminary preferred alternative.

The preliminary preferred alternative is Alternative 7: Culvert Enlargement. This alternative involves replacing the existing culverts with larger culverts. The piped watercourse near 9899 Markham Road will be replaced with a 3000 mm x 1500 mm concrete box culvert. At 9833 and 9809 Markham Road the piped section of the watercourse will be replaced with a twin 2400 mm x 1500 mm concrete box culvert.

As part of the environmental assessment process, the public, interested persons and agencies, and First Nations groups were consulted. Two (2) public information centres presented the project and alternatives assessed, and the preliminary preferred alternative to the public. All information and draft reports were shared with interested First Nations, and input was incorporated. Ongoing commitments for consultation have been provided for any Stage 2 Archaeological Assessment undertaken at detailed design.

9 SIGNATURES

This report was completed with input from the following consulting staff:

Robert Amos – Project Manager
Tim Koen – Water Resources Engineer
Karen Castro – Water Resources Analyst
Julie Michel – Water Resources Analyst
Michael Baldaro – Water Resources Engineer
Jedidah Gnanaraj – Water Resources Analyst
Terrance Singh – Water Resources Engineer
David Kynaston – Fluvial Geomorphologist
Tanisha Sharma – Fluvial Specialist
Julie Scott – Terrestrial Ecologist
Graham Eby – Aquatic Biologist
Eilish Neilly – Junior Aquatic Biologist
Palka Sharma – CAD Technician
Mitchell Tulloch– Topographic Surveyor
Owen Coyle – Topographic Surveyor
Sarah MacKinnon - Archaeologist

Should you have any questions please contact the undersigned at 416-705-2367.

Yours truly,

AQUAFOR BEECH LIMITED

Robert Amos, MASc., P.Eng
Aquafor Beech Limited

10 REFERENCES

City of Markham. (2024). OPA for the Markham Road Mount Joy Secondary Plan.

Counterpoint Engineering Inc. (2024). Municipal Servicing Report Mount Joy Secondary Plan.

Credit Valley Conservation. (2023). *Watershed Report Card .*

CVC, TRCA, City of Brampton, Region of Peel, Halton-North Peel Naturalists' Club and the South Peel Naturalists' Club. (2011). *Credit River Watershed and Region of Peel: Natural Areas Inventory - Volume 1.*

Department of Fisheries and Oceans. (2019, August 29). *Projects Near Water*. Retrieved from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

DHI Group. (2025). *DHI Support website*. Retrieved from https://support.dhigroup.com/knowledgebase/article/KA-01118/en-us

Eakins, R. J. (2023, 05 03). *Ontario Freshwater Fishes Life History Database*. Retrieved from Ontario Fishes: https://www.ontariofishes.ca/home.htm

Fisheries and Oceans Canada. (2013, December 27). *Ontario Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat*. Retrieved from Projects Near Water: https://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/on-eng.html

Fisheries and Oceans Canada. (2022, Novemeber 10). *Codes of Practice*. Retrieved from Government of Canada: https://www.dfo-mpo.gc.ca/pnw-ppe/practice-practique-eng.html

Fisheries and Oceans Canada. (2023, May 05). *Aquatic species at risk map*. Retrieved from https://www.dfo-mpo.gc.ca/species-especes/sara-lep/map-carte/index-eng.html

Fisheries and Oceans Canada. (2023). *Measures to protect fish and fish habitat.* Burlington, Ontario, Canada.

Frost, W.H. 2006. "Minor Loss Coefficients for Storm Drain Modeling with SWMM." Journal of Water Management Modeling R225-23. doi: 10.14796/JWMM.R225-23

Greck and Associates Limited. (2015). Proposed Enhanced Valley/Channel Design Brief for 9900 Markham Road

Greck and Associates Limited. (2015). Proposed Enhanced Valley/Channel Design Brief for 9999 Markham Road.

Masongsong Associates Engineering Limited. (2023). Floodplain Impact Study Proposed Site Plan Application 9781 Markham Road.

Masongsong Associates Engineering Limited. (2023). Functional Servicing and Stormwater Management Report.

Masongsong Associates Engineering Limited. (2023). Municipal Class Environmental Assessment Schedule 'C' Environmental Study Report Anderson Avenue Extension (From Castlemore Avenue to Street 'B').

Metrolinx and WSP. (2024). Stormwater Management Final Report - IFT Mount Joy Passing Track.

Ministry of Natural Resources. (2013, March 11). *In-water Work Timing Window Guidelines.* Retrieved from Government of Ontario: https://docs.ontario.ca/documents/2579/stdprod-109170.pdf

Ministry of Natural Resources. (2023, June 20). *Aquatic resource area line segment*. Retrieved from Government of Ontario: https://geohub.lio.gov.on.ca/datasets/lio::aquatic-resource-area-line-segment/about

MNRF and CVC. (2002). *A Cooperative Management Planning Initiative for the Credit River Fishery.*

SCS Consulting Group Limited. (2025). Upper Markham Village Master Environmental Servicing Plan.

Stanfield, L. (2017). *OSAP Version 10.*

Valdor Engineering Inc. (2023). 1D/2D Flood Impact Analysis for Proposed Mixed-Use Development 9900 Markham Road, City of Markham, Ontario

WSP Canada Inc. (2025). MIKE Flood Modelled Flood Risk Issue on Adjacent Municipal Lands for Mount Joy Passing Track Project Technical Memorandum.