LAKESHORE TRANSPORTATION STUDIES - LAKESHORE BUS RAPID TRANSIT (BRT) STUDY FLUVIAL GEOMORPHOLOGY ASSESSMENT REPORT

MISSISSAUGA, ONTARIO

Prepared for:
HDR CORPORATION

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DISCLAIMER

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1 INTRODUCTION

Matrix Solutions Inc. was retained by HDR to complete a fluvial geomorphic assessment of watercourse crossings as part of the Lakeshore Transportation Studies. The studies include three (3) infrastructure projects in the Lakeview, Port Credit, and Clarkson communities that build from the 2019 Lakeshore Connecting Communities Transportation Master Plan. These studies include the Lakeshore Bus Rapid Transit (BRT) Study, Lakeshore Complete Street Study, and the New Credit River Active Transportation Bridge Study.

The following report focuses on the fluvial geomorphic assessment of watercourse crossings associated within the Lakeshore BRT study area, with the remaining two studies to be discussed in separate reports.

As part of the Lakeshore Transportation Studies, the City of Mississauga is developing the preliminary design and completing the Transit Project Assessment Process (TPAP) for the Lakeshore BRT project. A TPAP is an expedited Environmental Assessment (EA) process in which the environmental effects of the project are analyzed. The Lakeshore BRT is planned to extend for two kilometres along Lakeshore Road from the Etobicoke Creek to East Avenue.

1.1 Scope

The geomorphic assessment included the following tasks:

- Background review
- Field reconnaissance, rapid geomorphic assessment, and pebble count at significant watercourses
- Erosion hazard delineation
- Geomorphic impacts and mitigation strategies for the preliminary design of the preferred solution

This fluvial geomorphology assessment report summarizes the findings and recommendations of the geomorphic assessment for watercourse crossings within the Lakeshore BRT study area (the study area). Watercourse crossings identified in the Transportation Master Plan (HDR 2019) in the study area include Etobicoke Creek, Applewood Creek and Serson Creek. Etobicoke Creek is under the jurisdiction of the Toronto and Region Conservation Authority (TRCA) and Applewood and Serson Creek are under the jurisdiction of the Credit Valley Conservation Authority (CVC).

2 STUDY AREA

2.1 Physiography and Surficial Geology

The surficial geology of the southern Ontario region is shaped by a legacy of bedrock erosion and sediment deposition following continental glaciations over geological timescales, and post-glacial incision by fluvial processes over the last 10,000 years. The resulting stream and river drainage networks-including their sediments and slope profiles-are conditioned by this glacial and post-glacial history. The physiography and surficial geology of the Lakeshore Transportation Studies study area is presented in Figure 1. Local topography, valleylands, watercourses, and crossing locations within the study area are presented in Figure 2.

2.1.1 Lakeshore Transportation Studies Area

Along the Lake Ontario shoreline, the study area of the Lakeshore Transportation Studies is located within the Iroquois Plain physiographic region (Figure 1), which is a region that was submerged by Glacial Lake Iroquois following the Wisconsinan ice age roughly 11,000 years ago (Chapman and Putnam 1984). As a result, the surficial geology is dominated by sand and gravel lake deposits and localized silt, clay, and till deposits blanketing the scoured bedrock surface. The underlying bedrock of the study area is primarily shale and limestone of the Georgian Bay Formation. This consists of interbedded grey-green to dark grey shale and fossiliferous calcareous siltstone to limestone (Armstrong and Dodge 2007). This shale is exposed in areas along the riverbed of Etobicoke Creek.

North of the Glacial Lake Iroquois Shoreline are more extensive glacial till and fine grained glacial lacustrine deposits that cover the gradually varying topography of the south slope physiographic region, ultimately trending upwards in elevation to the Oak Ridges Moraine (north) and Niagara Escarpment (west) that are the topographic highs in the region.

2.1.2 Lakeshore Bus Rapid Transit Study Area

The study area is situated within the bevelled till plains (Chapman and Putnam 1984) and crosses the lower reaches of Etobicoke Creek, Applewood Creek and Serson Creek. Etobicoke Creek drains a watershed of 211 km^2 from the south slope of the Oak Ridges Moraine, down the south slope and over the Lake Iroquois Plain, to empty into to Lake Ontario (TRCA 2021). The Etobicoke Creek watershed is one of the most urbanized catchments in the Toronto area (TRCA 2021).

The focused study area of this report includes Etobicoke Creek near its estuary at Lake Ontario. The surficial geology at this watercourse is characterized by recent river deposits of silt, sand, and gravel alluvium (Figure 1), with bedrock exposures as it is situated within well-defined valley corridor (Figure 2). The surficial geology of the Applewood Creek corridor is similar, and both valley landforms are more prominent upstream with the Lake Iroquois Plain and become less-well defined approaching the Lake Ontario shoreline. The study area also includes a lower reach of Serson Creek with a much smaller drainage area and a less-well defined valley landform and flows through a glaciolacustrine deposits of sand and clay (Figure 2).

However, the lower reaches of these watercourses have been significantly modified and infilled as described further in the historical assessment (Section 2.3). In this context, the natural fluvial process of flooding and erosion have been modified within the valleylands or floodplains, and thus the geomorphic erosion hazard (Section 4) is in some reaches highly managed and constrained by bank protection, recent channel stabilization works, existing transportation crossings and other urban land uses within former floodplains.

2.2 Background Review

Recent studies pertaining to watercourses and crossing structures within the study area were reviewed. These included the Lakeshore Transportation Master Plan (HDR 2019), the Lake Ontario Integrated Shoreline Strategy (LOISS; Aquafor Beech 2011), and design drawings and reports related to works near the Applewood Creek and Serson Creek Lakeshore Road crossings.

2.2.1 General Study Area Background Review

2.2.1.1 Lake Ontario Integrated Shoreline Strategy Background Review and Data Gap Analysis, Appendix B Fluvial Geomorphology Final Report (Aquafor Beech 2011).

The LOISS study included a 2011 rapid geomorphic assessment of Applewood Creek and Serson Creek near Lakeshore Road. Results of the 2011 assessment are presented in Table A. Applewood Creek was identified as backwatered within 150 m upstream from the lake. A barrier bar was observed at the confluence of Applewood Creek with Lake Ontario, which was described as controlling flow and water levels in the lowest reach of the watercourse.

TABLE A Lake Ontario Integrated Shoreline Strategy (2011) Geomorphic Assessment Results

Parameter	Applewood Reach 3	Applewood Reach 4	Serson Reach 2	Serson Reach 3
Location in relation to Lakeshore Road	Downstream	Upstream	Downstream	Upstream
Bankfull width (m)	6 m	3.3 m	4 m	1.75 m
Bankfull depth (m)	1.2 m	0.4 m	0.6 m	0.6 m
Average Valley Width (m)	20 m	10 m	30 m	40 m
Rapid Geomorphic Assessment Stability Index	0.48	0.11	0.46	0.35
Rapid Stream Assessment Technique Score	17	23	12	10
Dominant Process	Degradation	Aggradation	Planform Adjustment	Planform Adjustment

2.2.1.2 Lakeshore Road Transportation Master Plan (TMP) and Implementation Strategy DRAFT Final Report (HDR 2019)

The Lakeshore TMP provides information about existing watercourse crossing structures in the study area, and structural modifications required. The Applewood Creek and Serson Creek structures were recommended to be retained and widened. The Etobicoke Creek structure was recommended to be widened, however altering the Etobicoke Creek structure was not proposed as part of the current study.

2.2.2 Etobicoke Creek Background Review

2.2.2.1 50 Years Later… Hurricane Hazel's Legacy at the Mouth of Etobicoke Creek (Guy 2005)

This article outlines historical changes in management of Etobicoke Creek and settlement patterns near Lake Ontario. An overlay of the creek planform in the 1920s (Figure A) indicates that the creek formerly split into two channels between Lakeshore Road and the current shoreline. The mouth of the river flowed west behind a sand bar (or barrier beach) called Etobicoke Flats. In the early part of the century the sand bar was populated, but in the 1950s Hurricane Hazel destroyed many houses both on the sand bar and on the floodplain upstream. The destructed caused by Hazel provided the impetus to change land use practices in the floodplain, resulting in bylaws preventing building within floodplains, and redesignating the area around Etobicoke Creek as parkland. Marie Curtis Park was established in 1959.

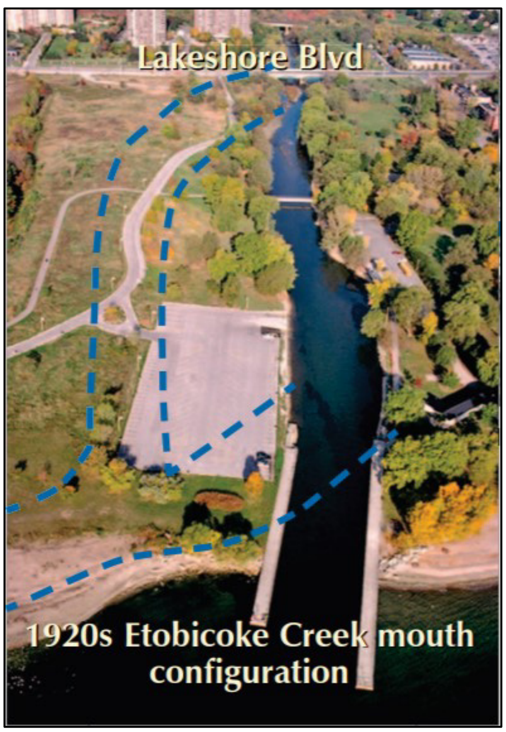


FIGURE A Etobicoke Creek planform, 1920s. Source: TRCA 2005

2.2.2.2 Etobicoke and Mimico Creeks Watersheds Technical Update Report (TRCA 2010)

This report analyzed and interpreted compiled earlier fluvial geomorphic data for Etobicoke Creek. Etobicoke Creek watershed can be considered an altered watercourse due to changes in land use and hydrology. Within the City of Toronto, Etobicoke Creek meanders through a bedrock valley. Bedrock controlled sites in the lower portion of the watershed tended to be wide and shallow.

The study area includes part of reach E1, which extends from Lake Ontario to north of Lakeshore Road. Reach E1 had a low gradient of 0.21% and was categorized as moderately sensitive to erosion. Bedrock sites that were monitored in the Lower Etobicoke Creek in the 2000s showed a trend toward erosion, typical of sediment-starved bedrock systems. Migration rates assessed in this and adjacent reaches were negligible between 1954 and 1999, and 0.21 m/year between 2006-2007.

2.2.3 Applewood Creek Background Review

2.2.3.1 Class Environmental Assessment Culvert and Creek Improvements on Lakeshore Road East over Applewood Creek (AECOM 2015)

The Class EA study laid the foundation for the Applewood Creek culvert replacement and channel restoration completed in 2018. The preferred alternative for Applewood Creek was to increase the culvert size to pass the Revised Regulatory flow, lower the culvert below an existing sanitary sewer and alter the channel bed profile upstream of Lakeshore Road East, as well as channel widening and terracing upstream and downstream of the new culvert, erosion control measures and site restoration. The earlier culvert was a 3.05 m by 1.25 m concrete box structure that included a 2 m drop to accommodate the sanitary sewer.

2.2.3.2 Replacement of the Lakeshore Road East Culvert Over Applewood Creek Including Creek Improvements - As-built Drawings (AECOM 2018)

The Applewood Creek culvert at Lakeshore Road was replaced with a new crossing structure in 2018. The as-built drawings include the new culvert and adjacent channel works. The new culvert is a two-cell open foot structure with spans of 6.1 m (east cell) and 7.58 m (west cell). The culvert was replaced at a lower elevation than the previous structure as recommended in the 2015 EA. Within the new structure the invert of the east cell is lower than the invert of the west cell. Upstream of the culvert, a retaining wall was constructed along the west slope, and the channel was re-constructed into a riffle pool system with an average reach slope of 2.46% for approximately 60 m upstream. Downstream, a 39 m length of channel was reconstructed which included a 21 m long outlet pool followed by an 18 m long riffle-pool-riffle sequence that tied into the downstream creek. Excerpted Applewood Creek Restoration drawings are included in Appendix A1.

2.2.4 Serson Creek Background Review

2.2.4.1 Serson Creek Geomorphic Assessment and Rehabilitation Design, Lakeview Village, City of Mississauga (Beacon Environmental 2020)

The proposed Lakeview Village redevelopment proposes to realign and rehabilitate the Serson Creek corridor south of Lakeshore Road East. A fluvial geomorphic study of Serson Creek was completed from Lakeshore Road and Lake Ontario to inform the design of rehabilitation works associated with the proposed Lakeview Village redevelopment. A meander belt width of 23 m was determined for the reach downstream of Lakeshore Road (R3). Reach R3 was described as partially confined on the right bank, and a long-term stable top of slope was assessed on that side by DS Consults Ltd. Rapid Geomorphic Assessment (RGA) results indicated that Reach S3 was "in adjustment," with a score of 0.41, with widening as the dominant process.

The proposed corridor will involve daylighting the piped portion of Serson Creek and realigning the existing channel up to Lakeshore Road. The proposed channel (as per drawings appended to the Serson Creek Design Brief (Beacon Environmental 2020) of Serson Creek angles southeast from the existing Lakeshore Road culvert outlet. Appendix A2 present the ultimate floodplain mapping and the future corridor of Serson Creek south of Lakeshore Road.

2.2.4.2 Jim Tovey Lakeview Conservation Area, Transforming Our Waterfront (CVC n.d.)

A new conservation area is under construction along the shore of Lake Ontario just east of the G.E. Booth Wastewater Treatment Plant (WWTP). The lands will be constructed lakeward of the WWTP using clean fill generated by regional infrastructure works. The 26-ha conservation area will include new meadow, forest, cobble beach, wetland, and estuary habitat. Serson Creek and Applewood Creek will be extended through the conservation area and will flow through wetlands near the new shoreline. The new channel will be constructed based on natural channel design. Constructed began in 2016 and the park is expected to open to the public between 2024-2026.

2.3 Historic Photograph Assessment

Further confirming the history summarized in the previous sections, aerial photographs from 1960 and 1978 were acquired from the National Air Photo Library and geo rectified for use in the historic channel and erosion hazard risk assessment. Publicly available satellite imagery from 2020 was also reviewed. Historic photographs and recent satellite imagery are included in Appendix B. An overlay of historic channel traces from each photograph year are presented on Figure 3.

Historic aerial photographs from 1947 and 1950 were also reviewed on the City of Toronto Archives publicly available website (City of Toronto 2021).

2.3.1 Overview

By the earliest available historic photograph date (1947) many of the main roadways within the study area had been established, including Lakeshore Road and at the railway north of Lakeshore Road. Much of the natural vegetation within the study area had been removed by 1947, and land use included urban development and agriculture.

2.3.2 Etobicoke Creek

In 1947, Etobicoke Creek outlet to Lake Ontario behind the large barrier beach that extended to the mouth of Applewood Creek. From the lake to Lakeshore Road, a side channel was present west of the main channel, extending from the lakeshore to approximately 150 m south of Lakeshore Road. This does not appear to connect to the main watercourse at its upstream extent. Housing had been constructed on the eastern floodplain and on the floodplain between these main and side channel. By 1950, the barrier bar had been cut through to allow Etobicoke Creek to flow directly into Lake Ontario.

By 1960, after Hurricane Hazel, all housing on the floodplains and barrier bar had been removed, and the side channel of Etobicoke Creek and the area behind the barrier bar had been infilled. Since that time, the bank linework has largely remained unchanged from upstream of Lakeshore Road to the lake. At the Lakeshore Road bridge, a vegetated mid-channel bar developed between 1960 and 1978. From 1978 to 2020 the bar expanded both upstream and downstream of the bridge and connected to the west creek bank.

2.3.3 Applewood Creek

In 1947, a large barrier beach over 400 m long was present along the lakeshore that extended from Applewood Creek to Etobicoke Creek. The barrier beach had been populated with cottages as discussed by TRCA (Guy 2005) in Section 2.2.2.1. By 1960, the barrier beach was no longer present. At Lakeshore Road, Applewood Creek had a tightly meandering planform within 50 m upstream and 150 m downstream of the crossing in 1960, with maximum lateral meander width of approximately 15 m. By 1978, this meandering area downstream of Lakeshore Road had been straightened. By 2020, the culvert and channel works discussed in Section 2.2.3.2 had been constructed. The channel had also been extended as the Lake Ontario shoreline had been built out lakeward in the area that will become Jim Tovey Conservation Area. The creek appears to be wider (possibly backwatered) within 250 m of the shoreline. The current channel has a straight planform in the reach downstream of Lakeshore Road, which becomes meandering further downstream through the forest adjacent to the WWTP.

2.3.4 Serson Creek

By 1960, Serson Creek had been straightened through the study area to Lake Ontario. The outlet of Serson Creek to the lake was located approximately 250 m west of the mouth of Applewood Creek. The creek approached the Lakeshore Road crossing at a perpendicular angle and turned east downstream of the crossing. By 1978, the creek had been realigned to flow straight instead of turning toward the east at the outlet of the Lakeshore Road crossing. This appears to have been completed to accommodate construction of a large building and parking lot immediately east of the creek. By 1978, the lower reach of Serson Creek had also been piped, with high flows diverted into a ditch running through the Region of Peel's G.E. Booth Wastewater Treatment Facility (WWTF) property. By 2020 the channel had become slightly sinuous upstream of Lakeshore Road. Downstream, a narrow riparian forest had grown along the creek, and parts of the planform are obscured by trees. The outlet of the ditch to the lake was extended due to lakeward expansion of the WWTP.

3 EXISTING GEOMORPHIC CONDITIONS

3.1 Drainage Area and Hydrological Flows

Watercourse drainage areas at Lakeshore Road crossings were obtained using the Ontario Flow Assessment Tool (MNRF 2021). The drainage areas for Etobicoke Creek, Applewood Creek and Serson Creek are 211.5 km^2, 5.7 km^2 and 1.6 km^2, respectively.

HEC-RAS models of Applewood and Serson Creek were provided by the CVC. A HEC-RAS model of Etobicoke Creek was provided by TRCA. Existing peak flow rates in the vicinity of Lakeshore Road were summarized from these models in Table B.

TABLE B Existing Peak Flow Rates

Watercourse	2-year (m^3/s)	5-year (m^3/s)	10-year (m^3/s)	25-year (m^3/s)	50-year (m^3/s)	100-year (m^3/s)	350-year (m^3/s)	Regional (m^3/s)
Etobicoke Creek	130.50	173.28	210.96	262.16	301.55	344.69	570.61	895.64
Applewood Creek	13.40	20.90	28.70	35.80	43.10	51.30	Not available	53.40
Serson Creek	4.90	8.20	11.80	14.30	16.70	19.20	Not available	19.10

Sources:
HEC-RAS models: Serson Creek (CVC 2019c), Applewood Creek (CVC 2019d), and Etobicoke Creek (TRCA 2015b)

3.1.1 Hydraulic Floodline Modelling

Regulatory floodline mapping for Etobicoke Creek dated April 24, 2015, was provided by the TRCA (Appendix C). The mapping indicates that the regulatory floodplain extends further to the east than to the west in the vicinity of Lakeshore Road. In this area, the width of the regulatory floodplain is estimated to be approximately 240 to 280 m. The Lakeshore Road and train bridge crossings appear to act as a local pinch point on the regulatory floodline. Upstream of the train bridge the valley is distinct and contains the regulatory floodline.

CVC provided regulatory floodline mapping for Applewood and Serson Creek. The Regulatory floodline is contained within a 12 to 25 m wide corridor in the reach upstream of Lakeshore Road, and within a 12 m wide corridor for approximately 35 m downstream of Lakeshore Road. Further downstream, the channel is less constrained and the width between floodlines is over 40 m. At Serson Creek, the Regulatory floodplain is approximately 30 m wide immediately upstream of Lakeshore Road, narrows to 10 m wide immediately downstream of the crossing and widens to an estimated 25 m further downstream.

Future conditions floodline mapping and hydraulic modelling information that reflect the proposed works will be reviewed in Section 5.1.2 when this information becomes available.

3.2 Reach Delineation

Reaches were delineated based on differences in channel planform, valley form, riparian vegetation, and lake backwatering. Reach breaks were generally set at Lakeshore Road due to differences in land use.

Where applicable, reach breaks delineated as part of the LOISS (Aquafor Beech 2011) were confirmed and re-used as part of the current study. For the purposes of this study reach names consisting of the first two letters of the creek name and a number, starting with 1 at the downstream-most reach walked, and increasing upstream (e.g., Applewood Creek downstream of Lakeshore Road = AP1). Road crossings often serve as reach breaks due to impacts from the crossing structure or changes in land use on either side of the road that impact channel morphology. At Applewood Creek, the upstream reach break was defined by the limits of recent channel works. At Etobicoke Creek, a reach break was delineated based on a change in Lake Ontario backwatering effects. Reach breaks are presented in Figure 3. Reach names and equivalent LOISS reach names are presented in Table C.

TABLE C Reach names

Watercourse	Location in relation to Lakeshore Road	Reach Name	LOISS Reach Name	Notes
Etobicoke Creek	Near lake (backwatered)	ET1	NA	Outside LOISS
	Upstream and downstream	ET2	NA	Outside LOISS
Applewood Creek	Downstream	AP1	Applewood R3	
	Upstream	AP2	Applewood R4	AP2 cover the lower portion of LOISS R4
Serson Creek	Downstream	SE1	Serson R2	
	Upstream	SE2	Serson R3	

3.3 Geomorphic Field Assessment

Matrix completed a geomorphic field assessment on July 31, 2021. The purpose of the geomorphic assessment is to characterize channel form and processes and identify any erosion hazards within the study area.

3.3.1 Rapid Geomorphic Assessment and Rapid Stream Assessments

Matrix assessed geomorphic conditions using the RGA technique and Rapid Stream Assessment Technique (RSAT). Results of the RGA and RSAT are presented in Tables D and E. Reach descriptions are summarized in Table F.

The RGA is used to evaluate dominant geomorphic processes. Field observations are evaluated using an indexed rating for channel sensitivity based on aggradation, degradation, channel widening, and lateral adjustment. The combined indices are used to provide an indication of current channel stability, with designations of 'in regime,' 'stressed/transitional,' or 'in adjustment.' The RGA is applied on a per reach basis (i.e., a defined length of channel with relatively uniform characteristics).

The RSAT (Galli 1996) uses a broad, qualitative approach to assess overall health and function of a reach from a more biological and water quality perspective. The indicators assessed in the RSAT technique are scored on a scale of 1 to 10 (with 10 being the better score), and cumulative scores produce an overall indication of stream health (<20 Low, 20 to 35 Moderate, >35 High). This approach is useful for assessing geomorphic conditions because in general the physical and biological features of a healthy stream also indicate geomorphic function.

TABLE D Summary of Rapid Geomorphic Assessment Scores

Reach	Factor Value				Stability Index	Condition	Dominant Process
	Aggradation	Degradation	Widening	Planimetric Adjustment			
ET1	Not Applicable (backwatered)						
ET2	0.43	0.33	0.25	0.00	0.25	Transitional	Aggradation
AP1	0.50	0.75	1.00	0.14	0.60	In Adjustment	Widening
AP2	Not Applicable (too recently constructed)						
SE1	0.29	0.20	0.50	0.43	0.32	Transitional	Widening
SE2	0.25	0.29	0.56	0.29	0.35	Transitional	Widening

TABLE E Summary of Rapid Stream Assessment Results

Reach	Factor Value						Overall Score	Condition
	Channel Stability	Scour/ Deposition	Instream Habitat	Water Quality	Riparian Condition	Biological Indicators		
Maximum Score	11	8	8	8	7	8	50	
ET1	Not Applicable (backwatered)							
ET2	6	5	5	5	3	6	30	Moderate
AP1	4	3	4	4	4	2	21	Moderate
AP2	10	6	4	4	3	3	30	Moderate
SE1	2	3	2	3	3	2	15	Low
SE2	4	5	3	3	3	2	20	Moderate

TABLE F Reach Descriptions

Reach	Average Bankfull Width (m)	Reach Description
ET1	30 m	The reach is backwatered by the lake and the dominant process is deposition. Creek bed was obscured. Banks are protected with sheet piling near the river's mouth, with riprap and armour stone up to the pedestrian bridge and are natural upstream. Natural banks were approximately 1.5 m high with minor erosion and exposed roots. The floodplain is park land with scattered trees. A parking lot and boat launch are present on the west bank near the shore. Site photos: Appendix D, Photos 10-12.
ET2	30 m	Reach has riffle-pool morphology. A large, vegetated bar has developed near the Lakeshore Road bridge. The thalweg passes through east bridge cell, with secondary flow through west. Areas of shale exposure were also observed. Riffles are composed of platey cobble and gravel. A pebble count indicated that the median grain size is very coarse gravel (D_{50} = 5.7 cm). The D_{10} was 0.6 cm, and the D_{90} was 17.6 cm. Shale exposures common on creek bed. Substrate within ET2 pools was also coarse with evidence of bed scour. Bank height varies from 1.2 to 4.5 m. Banks partially protected with block stone, gabion basket through reach. Water depth was 0.45 to 0.65 m. Nearby land use includes parks and private lands. Site photos: Appendix D, Photos 1-9.
AP1	5.1 m	Downstream of the Lakeshore right-of-way, the channel has been straightened, banks are not armoured, bank slumps are frequent, and connection to the floodplain is poor. At the culvert outlet, deposition has occurred within a constructed outlet pool (measured length approximately 18 m). Downstream of pool a constructed cobble riffle low-flow channel extends for approximately 20 m. Two-cell culvert with limited opening heights, soffit elevation 0.35 m lower in east cell than west cell at outlet. Site photos: Appendix D, Photos 18-22.
AP2	6.5 m	Steep constructed riffle-pool system consisting of a series of armour stone grade control steps, boulder riffles and stone-lined pools. The banks were steep, hardened and lacked overhanging vegetation. Wetted width ranged between 4 and 5 m. Site photos: Appendix D, Photos 13-17.
SE1	3.4 m	Straight, entrenched channel with low gradient and vertical banks. Bank height varies between 0.75 to 2.0 m, right bank partially confined. Run-pool morphology. Pools had a water depth of 0.5 with run depths of 0.15 m. Bank erosion is extensive through reach. Channel hardening consists of cobble lining near Lakeshore Road. Substrate includes silt, sand, and gravel. Site photos: Appendix D, Photos 28-36.
SE2	3.5 m	Straightened channel with low gradient, moderate entrenchment, and vertical bank angles. Bank heights ranged between 1.0 to 1.5 m. Substrate within the riffles was platey gravel and cobbles. Exposed tree roots common. Exposed clay till observed on lower banks. Lined with a narrow riparian strip in lower reach. In upper portion of reach, lawns lie near the left bank with dense grass along the right bank. Site photos: Appendix D, Photos 23-27.

3.3.2 Stream Crossing Assessments

The stream crossing assessment collects data specific to the channel and crossing structure within the vicinity of the road crossing. Information recorded includes crossing type, material, shape, dimensions, structural condition, as well as an assessment of potential issues relating to the channel near the crossing (e.g., bank erosion, bed scour, debris trapping, and fish passage). Table G summarizes the existing Lakeshore Road watercourse crossings.

TABLE G Crossing Assessment Results

Structure				Local Bankfull Dimensions		Channel Width : Opening Width	Gradient	Flow Restriction	Appendix D Photos
Crossing	Type	Opening Width (m)	Skew Angle (degrees)	Width (m)	Depth (m)				
Applewood Creek	Two-span concrete	13.5 (6.0 m & 7.5 m)	7°	6.0 to 6.5	0.5 to 0.8	Opening Wider than Channel	Low	Constructed cobble riffle acting as grade control downstream of outlet pool	17 to 18
Etobicoke Creek	Two-span bridge	42.6 (21.3 m × 2)	12°	31	1.2 to 1.4	Opening Wider than Channel	Moderate to Low	West bridge span partially blocked by vegetated island / bar	4 to 9
Serson Creek	Single-span concrete	10 m	<5°	3 to 3.5	0.3 to 0.4	Opening Wider than Channel	Low	Constructed cobble riffle acting as grade control downstream of outlet pool	25 to 29

Note: Skew angles measured between alignment of the crossing structures and Lakeshore Road centreline. The skew angle is 0° where the crossing structuring is perpendicular to the Lakeshore Road centreline.

4 EROSION HAZARD ASSESSMENT

4.1 Methodology

Watercourses within the study area have undergone extensive historic modification. The lower reaches of Applewood Creek and Serson Creek have been historically straightened and reach AP2 has been recently regraded and protected against erosion. Etobicoke Creek has undergone historic alteration, floodplain infilling and extensive bank protection. Additionally, Etobicoke Creek is less subject to lateral migration due to bedrock-controlled boundary conditions near Lakeshore Road (reach ET2) and backwatering by Lake Ontario downstream of Lakeshore Road (reach ET1).

Erosion hazard limits were therefore assessed using multiple lines of evidence, including historic observations, empirical meander belt relations, OMNR (MNR 2002) toe erosion allowances and multiples of channel bankfull width. Estimates of the toe erosion allowance were considered in the absence of measurable 100-year erosion limits. The recommended erosion hazard widths included estimates of the existing urban corridor and the unmanaged natural corridor. The existing urban corridor is based on three times the bankfull channel width plus two times the toe erosion allowance, with an added 20% factor of safety (10% per corridor side).

4.2 Results

Results of the erosion hazard assessment are presented in Table H.

TABLE H Recommended Erosion Hazard Widths at Watercourse Crossings

Crossing	Valley Considerations and Historic Observations	Empirical (Theoretical) Meander Belt Width(1) (m)	MNR (2002) Toe Erosion Allowance (m)	Three times Bankfull Width (m)	Existing Crossing Span (m)	Recommended Erosion Hazard Width (m)	
						Existing Urban Corridor	Unmanaged Natural Corridor
Etobicoke Creek	Limited change since mid-1900s floodplain modifications; Floodplain width 240 to 280 m	200 to 300	8 to **15**	3 × 31 **= 93**	21.3 × 2 **= 42.6**	**148**	250
Applewood Creek	Confined US of Lakeshore Rd; Maximum lateral meander belt widths (1960-1978): 15 to 20 m	50 to 80	5 to **8**	3 × 6.5 **= 19.5**	6.0 + 7.5 **= 11.5**	**43**	70
Serson Creek	West bank confined DS Lakeshore Road modification predates earliest available photograph	20 to 40	**5** to 8	3 × 3.3 **= 10**	10 × 1 **= 10**	**24**	30

[1]Sources: Dunne and Leopold (1978) (=120$Aw^{0.43}$), Collinson (1977) (=65.6$D_{max}^{1.57}$), PARISH (2004) (=8.32*ln(Aw*9806*Qbf*S)-14.83), Williams (1986) (=4.3$W^{1.12}$, =18$Ac^{0.65}$, =148$D^{1.52}$), Ward et al. (2002) (=6$W^{1.12}$). Where: Aw = drainage area, D = bankfull depth, W = bankfull width, Qbf = bankfull or 2-year discharge rate, S = slope.

At Etobicoke Creek, theoretical meander belt widths ranged from 200 to 300 m. The valley is distinct upstream of the study area and relatively well-defined in reaches ET2 and ET1, and the floodplains within ET1 and ET2 have been historically modified. The floodplain width in 1947 was estimated to be 300 m wide downstream of Lakeshore Road including the side channel. Currently the regulatory flood width is estimated to be approximately 240 to 280 m wide in ET1 and in ET2 near Lakeshore Road. The estimated width for the erosion hazard limit of the existing urban corridor is 148 m based on three times the bankfull width plus a toe erosion allowance of 15 m applied to both sides (MNR 2002), plus a 20% factor of safety. A theoretical unmanaged natural corridor width was estimated to be 250 m. It is noted that the erosion corridor width encompasses possible lateral migration tendencies, but also historic side channels and frequently inundated areas such as wetlands that may have been historically associated with the estuary.

At Applewood Creek, theoretical meander belt widths ranged from 50 to 80 m. Historic lateral meander widths were up to 15 to 20 m in historic air photos near Lakeshore Road. Based on observed bank materials in AP1, a toe erosion allowance of 5-8 m was considered appropriate (MNR 2002). The estimated width for the erosion hazard limit of the existing urban corridor is 43 m based on three times the bankfull width plus a toe erosion allowance of 8 m applied to both sides, plus a 20% factor of safety. A theoretical unmanaged natural corridor width was estimated to be 70 m. The estimated erosion hazard limit does not include stable slope allowances for reach AP2, which would also need to be assessed where the creek is locally confined, but it is noted that the creek grade and planform in AP2 are controlled by channel armouring including stable riffle features.

At Serson Creek, theoretical meander belt widths ranged from 20 to 40 m. As the watercourse is small (3.0 to 3.5 m wide), three times bankfull width was also considered as line of evidence for the potential erosion hazard. Three times the average bankfull width is 10 m. The estimated width for the erosion hazard limit of the existing urban corridor is 24 m based on three times the bankfull width plus a toe erosion allowance of 5 m applied to both sides, plus a 20% factor of safety. A theoretical unmanaged natural corridor width was estimated to be 30 m for reaches SE1 and SE2. This does not include a stable slope allowance along the west bank of reach SE1, which would also need to be assessed where the creek is locally confined.

4.3 Scour Hazards

The CVC (2019a) *Fluvial Geomorphic Guidelines: Factsheet VI: Scour Analysis* provides guidelines for scour assessment studies. CVC defines scour assessment as the technical and professional evaluation of the long-term risks due to potential vertical erosion and/or degradation of stream and river channels. A variety of rational and empirical methods are available to quantify the potential scour of a watercourse in anticipation of new infrastructure and hazard delineation. CVC (2019a) aims to guide such evaluations.

Following the completion of the Lakeshore Transportation Studies EA, the following additional assessment is recommended based on CVC guidelines:

- Scour assessment to identify the scour hazard limit at each watercourse crossing for which alterations to the crossing structure or watercourse are proposed. For the BRT study, this would include the proposed culvert extensions at Applewood and Serson creeks.
- Where engineering to the 100-year scour hazard limit is not practical or feasible with respect to impacting adjacent land uses and/or habitats, hazard mitigation and management plans will be required to the satisfaction of CVC and other stakeholders.

It is recommended that this assessment be completed by a qualified engineer and/or geoscientist at detailed design.

5 CROSSING RECOMMENDATIONS

5.1 Principles of Crossing Design and Crossing Design Guidance

Fluvial geomorphic recommendations regarding the proposed roadway improvements and crossing structure alterations have been developed based on the results of the desktop assessment, field investigation results, and geomorphic analysis to provide a geomorphic review of the preliminary design. A review of the proposed crossing extensions, skew, and adjacent works is provided to address risks associated with erosion hazards surrounding the channels. The fluvial geomorphic review involved the evaluation of the following criteria:

- **Valley Setting:** watercourses with wide, flat floodplains and low valley setting tend to migrate laterally across the floodplain over time. Watercourses within the study area are unconfined, except for Applewood Creek upstream of Lakeshore Road, which is confined, and the west bank of Serson Creek downstream of Lakeshore Road. All reaches have modified floodplains and show minimal evidence of lateral migration.
- **Channel size:** the potential for lateral channel movement and erosion for the watercourses within the study area generally increases with channel size up to and excluding estuary reaches, where stream power is lost. At Lakeshore Road, Etobicoke is a significant watercourse (bankfull width of 31 m), Applewood Creek is a moderate-sized channel (bankfull width of ~6.5 m) and Serson Creek is a small channel (bankfull width of <4 m).
- **RGA:** the RGA score provides a measure of the channel stability. Reaches near the crossings were Transitional or In Adjustment and are in the process of widening.
- **Erosion Hazard Limit:** the erosion hazard is assessed based on a number of conceptual and technical approaches depending on the watercourse context (e.g., natural, rural, urban) and available information (e.g., historic, topographic), including:

- **Meander belt width (MBW):** the MBW represents a conservative approach for crossing span recommends and considers the long-term migratory tendencies of the watercourse. Where it is not possible for the crossing to accommodate the MBW, alternative criteria are evaluated.

- **Meander geometry**: crossings are typically evaluated in terms of their relationship to the meander amplitude to ensure that channel processes and functions can be maintained within the crossing. Historic meander amplitudes could be measured at Applewood Creek.

- **100-year migration rate:** migration rates are typically estimated using historical aerial photography. Due to historical channel straightening, 100-year migration rates could not be estimated. Estimates of the toe erosion allowance can be considered in the absence of measurable 100-year erosion limits (MNR 2002).

Where a new crossing is proposed, a collective evaluation of all these factors is used to direct the development of new structural design parameters (span, length, and skew) that are appropriate from a fluvial geomorphic perspective. This process is also informed by local conservation authority guidelines. The CVC's *Fluvial Geomorphic Guidelines* (CVC 2015) states that a well-designed crossing:

- spans the stream and banks
- does not change water velocity
- has natural substrate
- creates no noticeable change in river form
- preferably structures include bridges, open bottom arches, or culverts that span and are embedded in the streambed

The CVC's *Technical Guidelines for Watercourse Crossings* (CVC 2019b) provides the following additional geomorphic guidance under Section 6: Design Principles:

- *The crossing design should respect the fluvial geomorphic process in the watercourse in order to minimize the negative impacts on the aquatic and terrestrial environment.*

- *The span of crossings should be selected based on detailed fluvial geomorphic analyses. Abutments, piers and other bridge components should be located outside of the 100-year local erosion hazard. Determination of the local erosion hazard is separate from the procedure of determining meander belt and scour potential at a specific site. The 100-year local erosion hazard will determine the extent at which the crossing infrastructure should be placed in order to avoid future channel realignment or unnecessary hardening of the channel or banks.*

- *Generally, a geomorphic study is required to determine the crossing opening. However, for the watercourses that are less than 4 m wide, the crossing opening of three times the bankfull channel can be adopted without undertaking a geomorphic study.*

- *Where the existing bridge abutments interfere with the erosion hazard, a fluvial geomorphic assessment must be completed in order to identify if the abutment needs removal or relocation.*

- *It is recognized that larger crossings may require piers in the watercourse. This must be specified early in the process. In some cases, as early as during the environmental assessment.*

- *For new crossings, the footing depths are based on the scour depth (see Section 6.3.1) as identified by a fluvial geomorphologist. Provide the method used, results of the analyses and the input parameters used to determine the type and depth of footings.*

- *The replacement or new construction of a crossing must be an open footing culvert or bridge, unless there is a compelling reason why a closed bottom culvert would provide greater social, economic and environmental benefits.*

TRCA also provides guidance for crossing design. The TRCA's *Crossing Guideline for Valley Stream Corridors* (TRCA 2015a) states that:

> *Crossings should be located away from geomorphically active and unstable areas and be designed to span the zone of potential future channel migration, as defined by the meander belt or 100-year erosion limit, to reduce risks from channel migration over time. However, it is recognized in some instances this may not be practical, particularly for modifications to existing crossings or for new crossings of small, stable watercourses.*

5.1.1 Erosion Risk Assessment Framework for Existing Crossings

To assess the erosion risk of existing crossings, a risk-based assessment method was applied using the following categories:

- **No Risk** - Spans the natural corridor MBW

- **Low Risk** - Spans the urban corridor erosion hazard limit

- **Moderate Risk** - Spans three times the bankfull width

- **High Risk** - Spans the bankfull channel width or less

Results of the erosion risk assessment are included in Section 5.2.

5.1.2 Geomorphic Impact Assessment of Proposed Hydraulic Conditions

Future conditions floodline mapping and hydraulic modelling information that reflect the proposed works will be reviewed when this information becomes available.

5.2 Geomorphic Impact Assessment of the Preliminary Design

As part of planned improvements to the Lakeshore BRT system, Lakeshore Road is proposed to be widened to the south. To accommodate this work, the existing Applewood Creek culvert is proposed to be extended to the south, and the Serson Creek culvert is proposed to be replaced and lengthened primarily to the south. No alterations are proposed to the Etobicoke Creek bridge.

Matrix reviewed the following design materials provided by HDR:

- Draft Roll Plan, Lakeshore Road (Part A) Transportation Study, East Ave W. to Etobicoke Creek, STA. 9+710 TO STA. 12+200. Date: April 2023.
- General Arrangement, Serson Creek Culvert. Lakeshore Road (Part A) Transportation Study, East Ave W. to Etobicoke Creek. Date: April 2022.
- AutoCAD file of the Draft Roll Plan and General Arrangement

An annotated map of the proposed works is presented on Figure 4.

5.2.1.1 Etobicoke Creek

Currently, the existing bridge at this location consists of a two-span 42.6 m wide bridge (opening width of each span = 21.3 m). Reach ET2 has a straight planform with an average bankfull channel width of 31 m. The main flow path passes through the east span of the Lakeshore Bridge, near the pedestrian walkway. Concentrated flows approaching and through the east span appear to have locally increased velocities and caused local bed scour near the east abutment. A large, vegetated bar extends upstream and downstream of the bridge from the bridge pier through the west cell. A smaller split flow channel has developed around the island through the west bridge cell. There are no meanders near the bridge.

The combined bridge spans are wider than average bankfull channel width, but do not span three times the bankfull channel width (93 m), the existing urban corridor of 148 m or the unmanaged natural corridor width of 250 m. The pier and bridge configuration appear to be locally impacting channel processes by altering nearby depositional patterns which narrow the active channel at the bridge and encourage bed scour through the east span, as the hardened east bank cannot adjust to accommodate the deposition on the west bank. Based on the risk methodology outlined above, the existing crossing is considered to have a high erosion risk. However, due to the nearby effects of lake backwatering, the erosion-resistance of the bedrock channel and the erosion protection measures already in place, the effective erosion risk at the bridge is considered **moderate**. Monitoring is recommended to ensure the bed scour in the east span does not impact the stability of the pedestrian crossing.

No alterations are proposed to the existing Etobicoke Creek bridge. However, a path is proposed on the south side of Lakeshore Road on the western floodplain. The grading limits should be confirmed to ensure there will be minimal encroachment by the road embankment into the floodplain.

5.2.1.2 Applewood Creek

The existing Applewood Creek culvert at Lakeshore Road (13.5 m total span) is wider than the bankfull channel width (6.0 to 6.5 m) but is less than three times bankfull width (6.5 × 3 = 19.5), the existing urban corridor width of 43 m, and the unmanaged natural corridor width of 70 m. As such the existing crossing is considered to have a high erosion risk based on the methodology outlined above. It is noted however that the reconstruction of Applewood Creek into a rocky riffle-pool system upstream of the crossing, and the constructed outlet pool and cobble riffles downstream of the crossing provide grade control and erosion protection. As such, the effective erosion risk at the crossing is considered **moderate**, and erosion mitigation works are recommended as part of the Lakeshore Road widening and culvert extensions.

Based on comments received January 31, 2022, CVC recommends that natural channel works extend upstream of the proposed culvert to remove excess rock and enhance aquatic habitat and fish passage, subject to engineering constraints. The feasibility, type, and extent of these works will be determined at detailed design. Should such works go forward, they may extend outside the future road right-of-way, which would require consideration of land acquisition or easement requirements at detailed design.

Downstream of Lakeshore Road, the proposed 12.5 m culvert extension will intercept the existing outlet pool which extends from the current culvert outlet for approximately 18 m (based on site assessment). To provide space for flow dissipation, it is recommended that the outlet pool be reconstructed downstream of the culvert extension. This will require grading of the channel banks and local tree removal. The approximately 18 m long cobble-lined channel which backwaters and provides grade control to the outlet pool should also be replicated to maintain existing channel processes through the culvert and upstream.

Tie-in recommendations are depicted schematically on Figure 4. The specific channel restoration lengths and areas recommended above are to be confirmed at the detailed design stage.

5.2.1.3 Serson Creek

The existing Serson Creek culvert at Lakeshore Road (10 m total span) is larger than the bankfull channel width (average 3.3 m) and is approximately equivalent to three times the average bankfull width (3.3 m × 3 = 10 m), but does not span the existing urban corridor of 24 m or the unmanaged natural corridor width of 30 m. The existing crossing has a **moderate** erosion risk. This risk appears to have been partially mitigated by the constructed outlet pool and cobble riffle downstream of the existing crossing. The existing culvert is 27.4 m long. Downstream of the outlet, the creek is slightly skewed to the east in relation to the culvert alignment.

The proposed Serson Creek culvert will be a single-span open foot structure with an opening span of 11 m and a length of 47 m. The proposed structure span will be 1 m wider than the existing span, and the structure will be 22.6 m longer than existing. The proposed culvert will extend 1.0 m upstream from the existing culvert inlet and 21.6 m downstream of the existing outlet, as measured along the centreline of the proposed culvert. The proposed Serson Creek culvert (11 m span) is larger than the bankfull channel width (average 3.3 m) and is approximately equivalent to three times the average bankfull width (3.3 m × 3 = 10 m), but does not span the existing urban corridor of 24 m or the unmanaged natural corridor width of 30 m. The proposed crossing will have a **moderate** erosion risk. Although under both existing and proposed scenarios the culverts have moderate erosion risk, under proposed conditions the risk of erosion may be slightly lower compared to existing conditions due to the increase in the culvert span which would reduce water velocities under higher return period flows. However, erosion mitigation due to the increase in span may be offset by the proposed increase in structure length. Review of detailed hydraulic modeling should be completed at detailed design to compare existing and proposed flow conditions, and to inform design of erosion mitigation works. Erosion mitigation works are recommended to protect the creek at the culvert tie-ins.

The proposed culvert will be skewed by approximately 6.3° compared to the existing culvert alignment; the proposed culvert outlet will shift to the east. The proposed outlet will tie into the existing channel planform downstream. The proposed culvert at the inlet will be slightly skewed to the angle of the channel centreline upstream; however, this will not impact the channel directly and can be accommodated with minor tie-in (see also comment from CVC regarding suggested extension of natural channel works upstream).

The proposed culvert replacement will extend beyond the existing outlet pool (approximately 10 m long) and the downstream cobble-lined channel (approximately 15 m long). To provide space for flow dissipation, it is recommended that the outlet pool be reconstructed downstream of the culvert replacement. This will require grading of the channel banks and local tree removal, and confirmation of grading limits along the west bank which requires a stable slope setback. The cobble-lined channel, which backwaters and provides grade control to the outlet pool, should also be replicated to maintain existing channel processes through the culvert and upstream. Tie-in recommendations are depicted schematically on Figure 4. The specific channel restoration lengths and areas recommended above are to be confirmed at the detailed design stage. At detailed design it should be confirmed if the tie-in works must extend beyond the future road right-of-way.

Based on comments received January 31, 2022, CVC recommends that natural channel works extend upstream of the proposed culvert to enhance aquatic habitat and fish passage. The feasibility, type, and extent of these works will be determined at detailed design. Should such works go forward, they may extend outside the future road right-of-way which would require consideration of land acquisition or easement requirements at detailed design.

Any channel tie in works should be co-ordinated with the Lakeview Village development to ensure they are tied into the Lakeview Village proposed channel improvements.

5.2.2 Recommendations for Detailed Design

To mitigate potential impacts of the proposed works, the following considerations should be made at detailed design:

- ensure hydraulic conveyance is met under all flood conditions for proposed culvert works, and confirm any geomorphic impacts of the proposed conditions hydraulics when detailed modelling information is available
- confirm that the Applewood Creek culvert extension will be open foot (the Serson Creek culvert GA indicates that the Serson Culvert replacement will be open foot) and identify the scour hazard limit through completion of a scour assessment to determine appropriate culvert footing depths for both the Applewood Creek culvert extension and Serson Creek replacement. If the scour hazard limit does not match the existing/proposed culvert footing depths, the proposed footing design will require additional approval from CVC with respect to scour hazard mitigation
- confirm the skew and final extent of the proposed Applewood culvert extension and Serson Creek culvert replacement, and associated structures such as wingwalls and stormwater outfalls
- complete the design of the low-flow channel and substrate gradations within the Serson Creek and Applewood Creek culvert crossings to enhance channel stability and fish passage
- confirm the extent and type of channel tie-in works at Applewood Creek and Serson Creek through a detailed geomorphic assessment and detailed channel design
    - confirm the engineering and geomorphic feasibility of extending channel works upstream of the Applewood Creek culvert to remove existing stone to enhance aquatic habitat and improve fish passage
- following confirmation of the channel tie-in works, confirm the disturbance limits of construction at Serson and Applewood Creeks and land acquisition or easement requirements, if any, at Applewood Creek
- proposed culvert works may, where feasible, incorporate ecological requirements (i.e., wildlife passage)
- coordinate Serson Creek tie-in works with the Lakeview Village proposed channel improvements

5.3 Conclusion

This fluvial geomorphology assessment report summarizes the findings and recommendations of the geomorphic assessment of Applewood Creek, Etobicoke Creek and Serson Creek within the BRT study area. The geomorphic assessment includes a background review and historical assessment, field reconnaissance, erosion hazard assessment, and provided geomorphic review of the preliminary design and recommendations for detailed design.

The desktop assessment indicated that watercourses within the area have undergone a long history of agricultural and urban modification. This continues today as channel restoration works are undertaken; for instance, restoration has been recently completed at Applewood Creek near Lakeshore Road and Serson Creek is being realigned downstream of Lakeshore Road. The erosion assessment took this into consideration by estimating both existing urban corridor and unmanaged natural corridor widths, to reflect both current management and historic conditions, respectively. Based on an erosion risk framework, the existing bridge and culvert crossings structures at Lakeshore Road are considered to be at moderate risk from long-term erosion hazards. The proposed replacement culvert at Serson Creek is also considered to be at moderate risk, although this risk may be slightly reduced compared to existing conditions. Given the evaluation of erosion risks, erosion mitigation works are recommended in association with the widening of Lakeshore Road and the culvert extensions and replacements. The proposed extension of the Applewood Creek culvert to the south and the replacement of the Serson Creek culvert will require channel tie-in works which are recommended to include re-instatement of the existing outlet pools and cobble-lined channels. The extent of required channel tie-ins and associated grading limits and tree removals should be determined at detailed design.

6 REFERENCES

AECOM Canada Ltd. (AECOM). 2018. *Replacement of the Lakeshore Road East Culvert Over Applewood Creek Including Creek Improvements*. Contract Drawings (As Built). December 2018.

AECOM Canada Ltd. (AECOM). 2015. *Class Environmental Assessment Culvert and Creek Improvements on Lakeshore Road East over Applewood Creek*. Prepared for the City of Mississauga. Kitchener, Ontario. June 2015.

Aquafor Beech Limited (Aquafor Beech). 2011. *Lake Ontario Integrated Shoreline Strategy Background Review and Data Gap Analysis*. Appendix B, Fluvial Geomorphology Final Report. Prepared for Credit Valley Conservation. Mississauga, Ontario. May 5, 2011.

Armstrong D.K. and J.E.P. Dodge. 2007. *Paleozoic Geology of Southern Ontario*. Project Summary and Technical Document. Sedimentary Geoscience Section, Ontario Geological Survey. Miscellaneous Release Data 219. 2007. http://maps.niagararegion.ca/Metadata/md/DocumentUpload/2007-08-08%2014-44-38.pdf

Beacon Environmental Limited (Beacon Environmental). 2020. *Serson Creek Geomorphic Assessment and Rehabilitation Design Lakeview Village, City of Mississauga*. Prepared for Lakeview Community Partners Limited. December 2020.

Chapman L.J. and D.F. Putnam. 1984. *The Physiography of Southern Ontario*. Third Edition. Ontario Geological Survey, Special Volume 2. Accompanied by Map 2715 (coloured), scale 1:600,000. Ontario Ministry of Natural Resources. Toronto, Ontario. July 9, 1984, 270 p. 1984. https://open.canada.ca/data/en/dataset/d22354e8-cb01-5262-aed5-1de48d1ffb0a

City of Toronto. 2021. *Aerial Photographs*. Accessed September 2021. https://www.toronto.ca/city-government/accountability-operations-customer-service/access-city-information-or-records/city-of-toronto-archives/whats-online/maps/aerial-photographs/

Collinson J.D. 1977. "Vertical Sequence and Sand Body Shape in Alluvial Sequences." Canadian Society of Petroleum Geologists. *Fluvial Sedimentology - Memoir 5* pp. 577–586. 1977.

Credit Valley Conservation (CVC). 2019a. *Fluvial Geomorphic Guidelines: Factsheet VI Scour Analysis*. Mississauga, Ontario. December 2019.

Credit Valley Conservation (CVC). 2019b. *Technical Guidelines for Watercourse Crossings - Version 1.0*. Mississauga, Ontario. September 2019.

Credit Valley Conservation (CVC). 2019c. *Serson Creek HEC-RAS Model*. Compiled by Credit Valley Conservation. 2019.

Credit Valley Conservation (CVC). 2019d. *Applewood Creek HEC-RAS Model*. Compiled by Credit Valley Conservation. 2019.

Credit Valley Conservation (CVC). 2015. *Fluvial Geomorphic Guidelines*. Mississauga, Ontario. April 2015. 2015.

Credit Valley Conservation (CVC). n.d. *Jim Tovey Lakeview Conservation Area, Transforming Our Waterfront*. n.d. https://peelregion.ca/pama/morphology/pdf/lakeview-conservation-area-transformation-fact-sheet.pdf

Dunne T. and L.B. Leopold. 1978. *Water in Environmental Planning*. San Francisco, CA. 1978.

Galli J. 1996. "Rapid Stream Assessment Technique (RSAT) Field Methods." Draft memorandum. Metropolitan Washington Council of Governments. Washington, DC, USA. 36 pp. 1996.

Guy K. 2005. "50 Years Later...Hurricane Hazel's Legacy at the mouth of Etobicoke Creek." Toronto and Region Conservation Authority. *Creek Time 7* (*1*) Spring 2005.

HRD Corporation (HDR). 2019. "Lakeshore Road Transportation Master Plan (TMP) and Implementation Strategy DRAFT Final Report." Draft prepared for the City of Mississauga. 2019.

Ontario Ministry of Natural Resources and Forestry (MNRF). 2021. *Ontario Flow Assessment Tool*. Powered by Land Information Ontario Accessed September 2021. 2021. https://www.lioapplications.lrc.gov.on.ca/OFAT/index.html?viewer=OFAT.OFAT&locale=en-ca

Ontario Ministry of Natural Resources (MNR). 2002. *Technical Guide, River & Stream Systems: Erosion Hazard Limit*. Water Resources Section. Peterborough, Ontario.

PARISH Geomorphic Ltd. (PARISH). 2004. *Belt Width Delineation Procedures - REVISED*. Prepared for the Toronto and Region Conservation Authority. September 2001. Revised January 2004. 2004.

Toronto and Region Conservation Authority (TRCA). 2021. *Etobicoke & Mimico Creek*. Copyright 2021. https://trca.ca/conservation/watershed-management/etobicoke-mimico-creek/

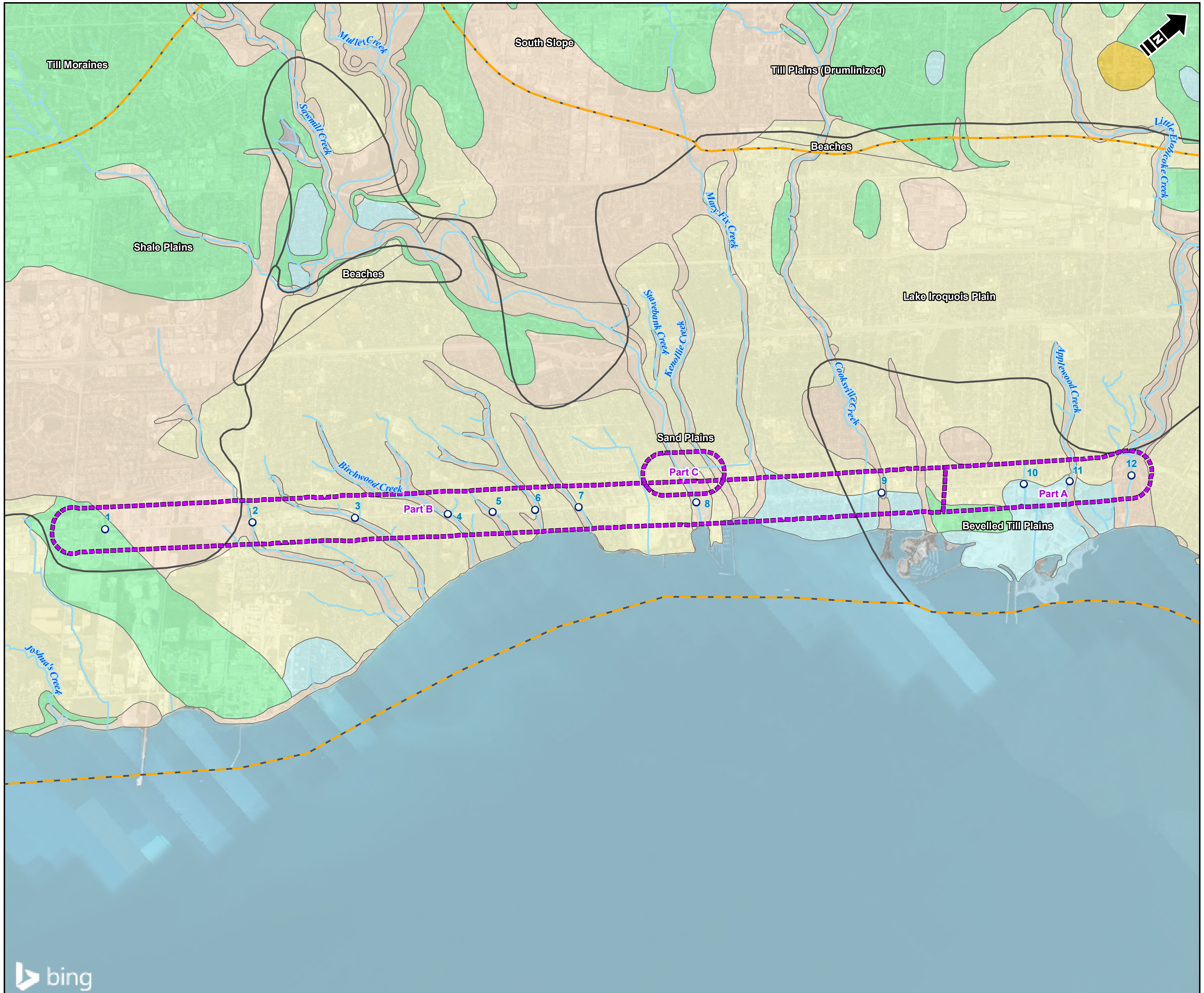
Toronto and Region Conservation Authority (TRCA). 2015a. *Crossing Guidelines for Valley and Stream Corridors*. September 2015.

Toronto and Region Conservation Authority (TRCA). 2015b. *Etobicoke Creek HEC-RAS Model*. Compiled by Toronto and Region Conservation Authority. 2015.

Toronto and Region Conservation Authority (TRCA). 2010. *Etobicoke and Mimico Creek Watersheds, Technical Update Report*. 2010.

Ward A. et al. 2002. "Sizing Stream Setbacks to Help Maintain Stream Stability." In: *2002 ASAE Annual International Meeting/CIGRX XVth World Congress*. Sponsored by ASAE and CIGR. Chicago, IL, USA. July 28-31, 2002. August 2002.

Williams G.W. 1986. "River meanders and channel size." *Journal of Hydrology 88*: 147–164. 1986.



Study Area

Physiographic Landforms

Physiographic Region - Boundary between South Slope and Iroquois Plain

Water Body

Watercourse

Watercourse Crossing

Surficial Geology Unit

1 - Bedrock: limy mudrock and clastic sedimentary rock

4 - Glacial Deposits (till): clayey silt to silt

5 - Moraine Deposits: fine sand to gravel

7 - Glacial Lake Deposits: sand and clay

8 - Glacial Lake Deposits: sand and gravel

9 - Organic Deposits: peat, muck, and marl

10 - River Deposits: sand and gravel

Study Areas

Part A: Lakeshore Bus Rapid Transit (BRT) Study
Part B: Lakeshore Complete Streets Study
Part C: New Credit River Active Transportation (AT) Bridge Study

Watercourse Crossings

1: Avonhead Creek Crossing
2: Sheridan Creek Crossing
3: Turtle Creek Crossing
4: Birchwood Creek Crossing
5: Moore Creek Crossing
6: Lornewood Creek Crossing
7: Tecumseh Creek Crossing
8: Credit River Crossing
9: Cooksville Creek Crossing
10: Serson Creek Crossing
11: Applewood Creek Crossing
12: Etobicoke Creek Crossing

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1:50,000 Kilometers
0.5 0 0.5 1
NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

HDR Corporation
Lakeshore Bus Rapid Transit

Surficial Geology and Physiography Lakeshore Transportation Studies

Date:	Project:	Submitter:	Reviewer:
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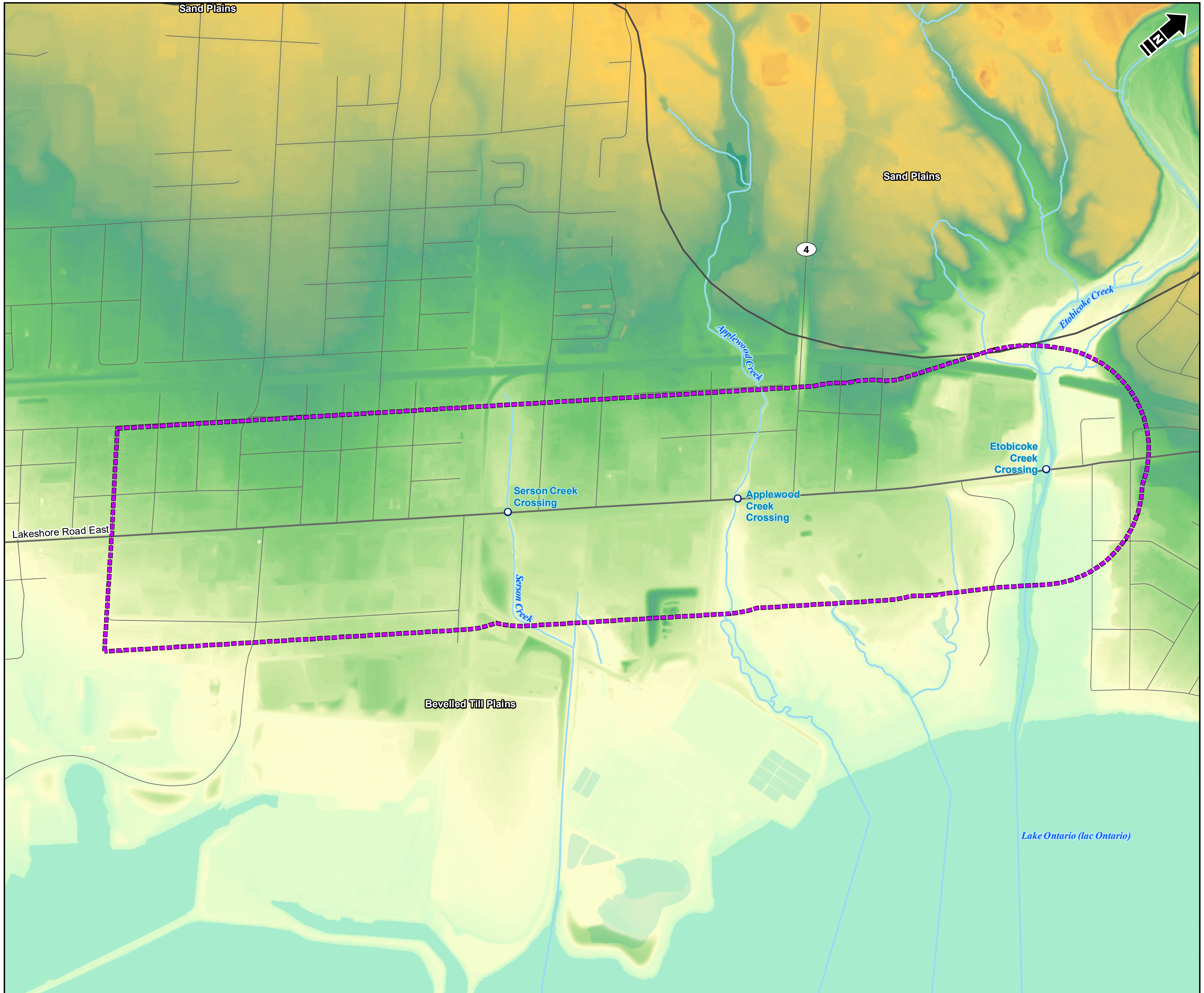
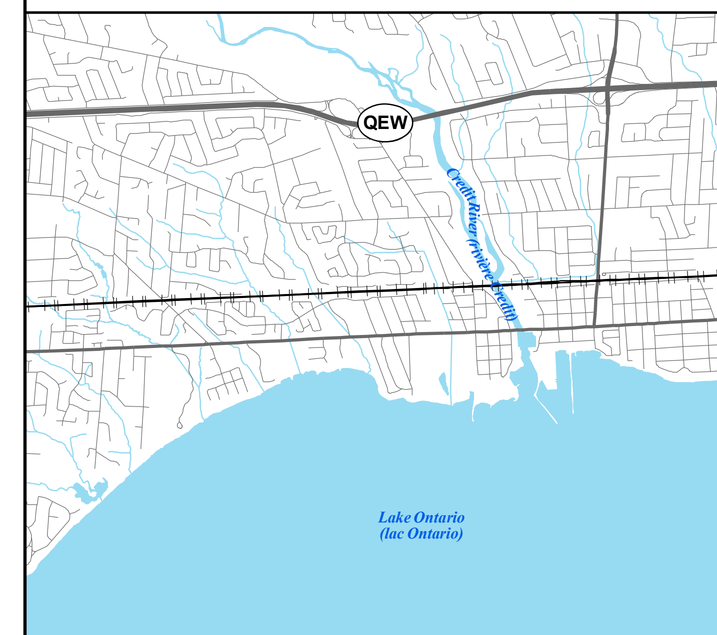
Figure 1



Study Area
Physiographic Landforms
Water Body
Watercourse
Highway
Road
Watercourse Crossing
Digital Elevation Model (masl)
High : 140
Low : 70



1:10,000
Meters
100 0 100 200
NAD 1983 UTM Zone 17N

Reference: Contains information licensed under the Open Government Licence – Ontario.

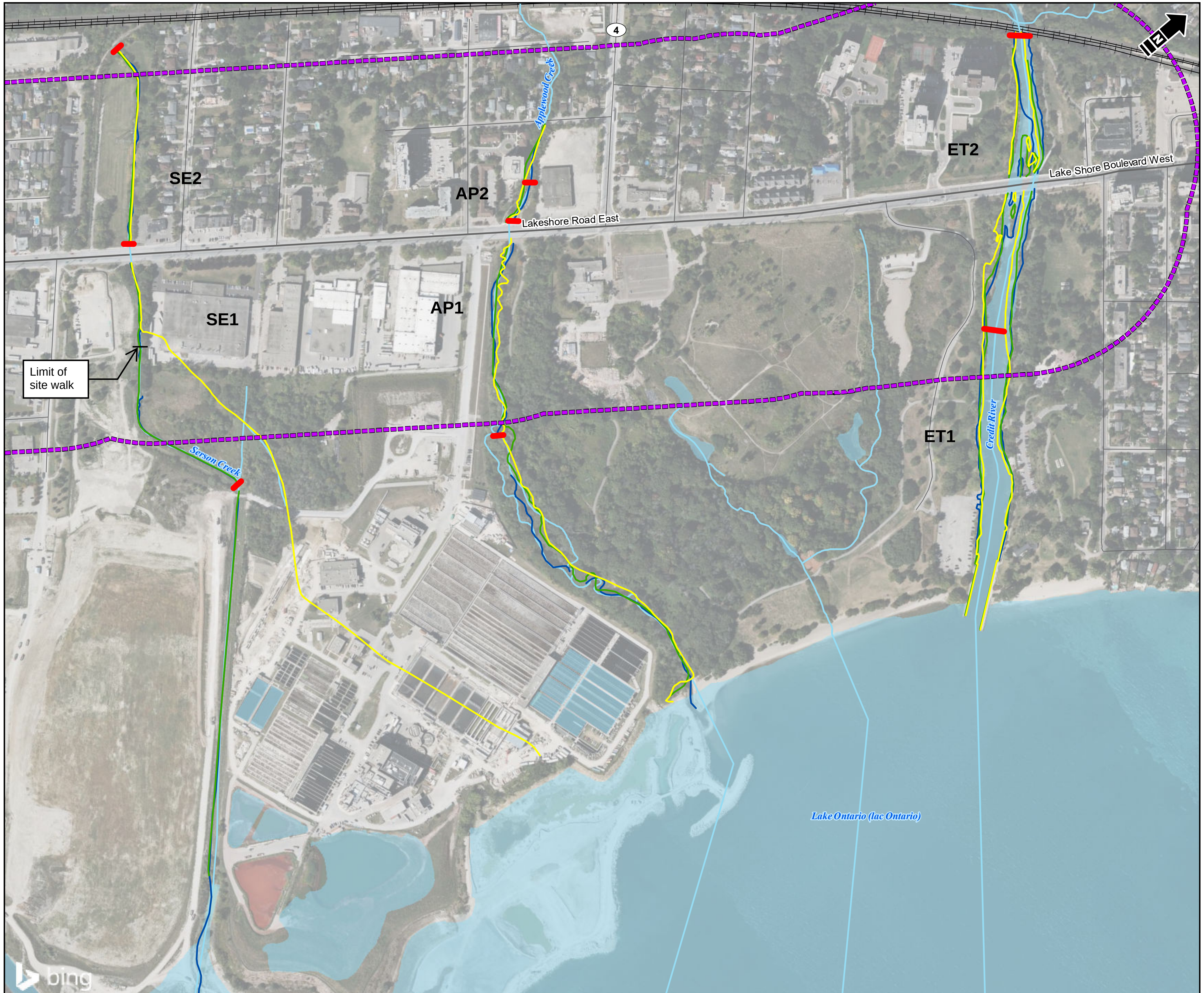
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

HDR Corporation
Lakeshore Bus Rapid Transit

Topography

Date:	Project:	Submitter:	Reviewer:
November 2021	33023	A. Nicoll	R. Phillips

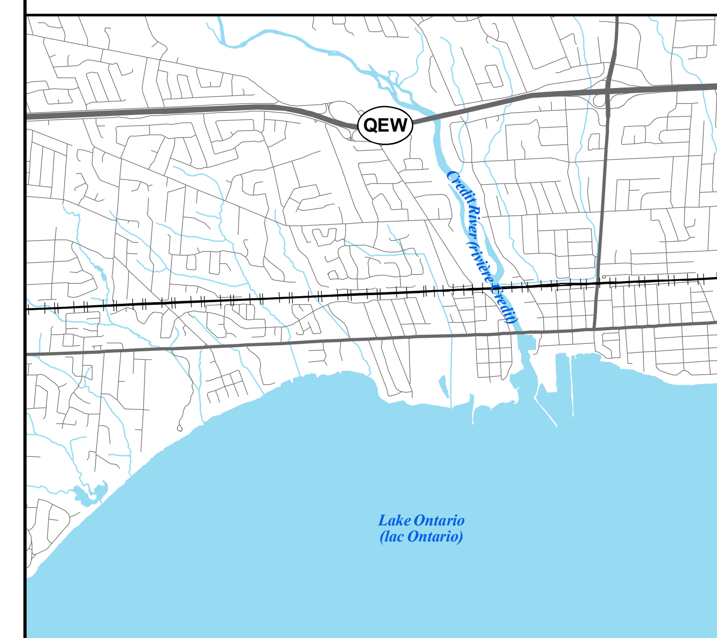
Figure 2



Study Area
Water Body
Watercourse
Railway
Highway
Road
Reach Break

Historic Traces

1960
1978
2020



Reference: Contains information licensed under the Open Government Licence – Ontario. Imagery © 2021 Microsoft Corporation © 2021 Maxar ©CNES (2021) Distribution Airbus DS

1:6,000 Meters
60 0 60 120
NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

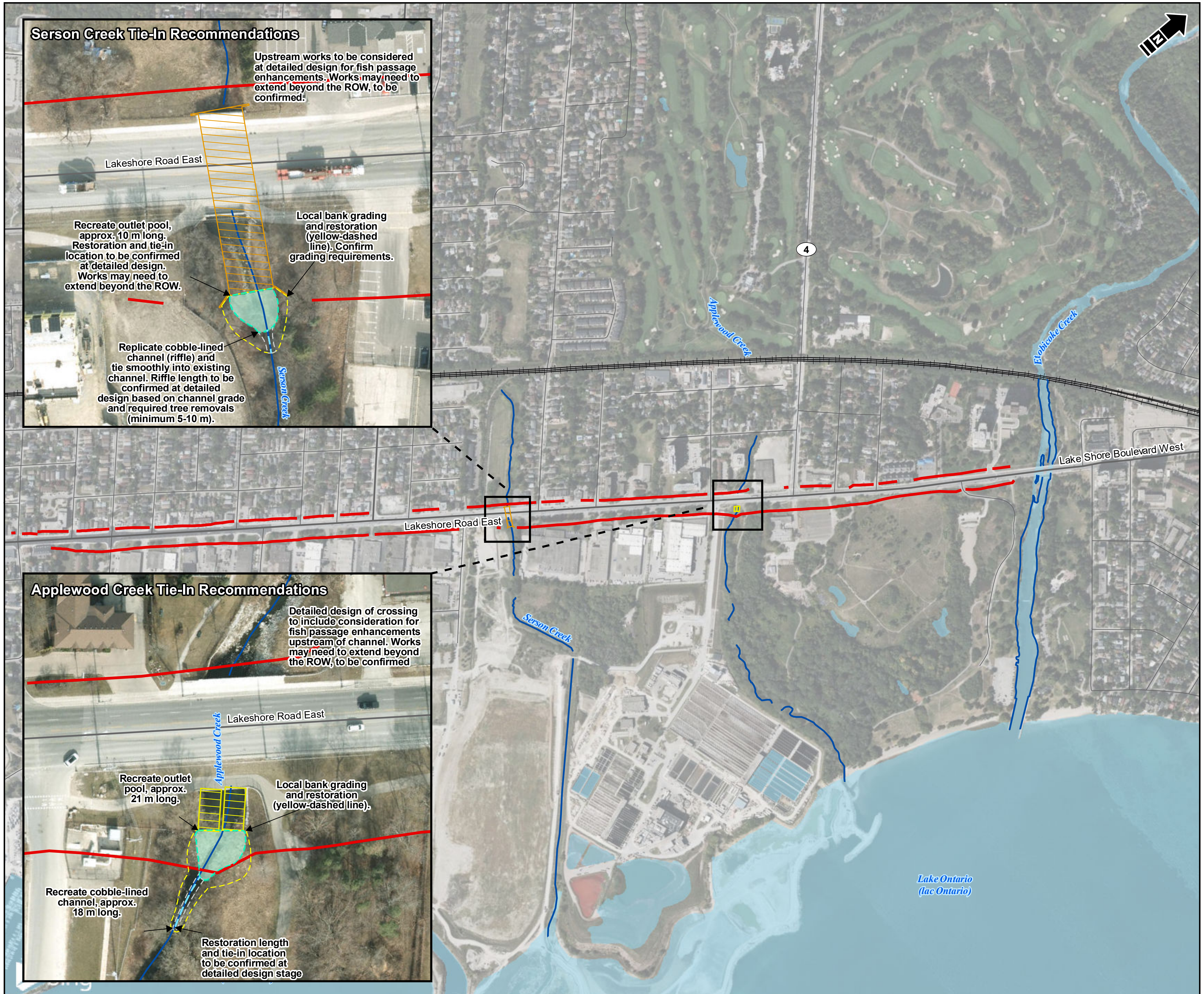
HDR Corporation
Lakeshore Bus Rapid Transit

Reach Breaks & Historic Traces

Date:	Project:	Submitter:	Reviewer:
November 2021	33023	A. Nicoll	R. Phillips

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

Figure 3

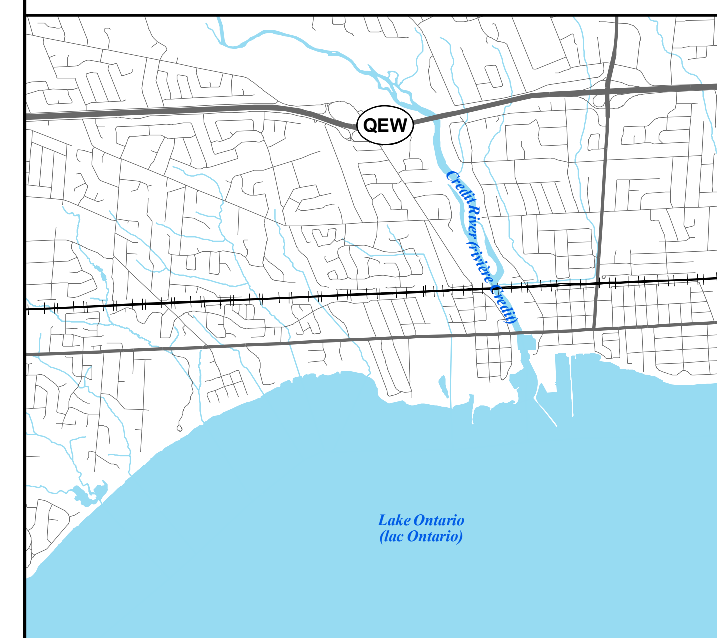


- Culvert Extension
- New Culvert
- Watercourse
- Railway
- Highway
- Road
- Proposed Construction Boundary Limits

Potential Channel Tie-In Recommendations

- Cobble-Lined Channel
- Local Bank Grading and Restoration
- Restoration Length

Note: Sketches of potential channel tie-in works shown are schematic



Reference: Contains information licensed under the Open Government Licence – Ontario. Imagery © 2023 Microsoft Corporation © 2023 Maxar ©CNES (2023) Distribution Airbus DS
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

1:10,000 Meters
100 0 100 200
NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

HDR Corporation
Lakeshore Bus Rapid Transit

Proposed Works

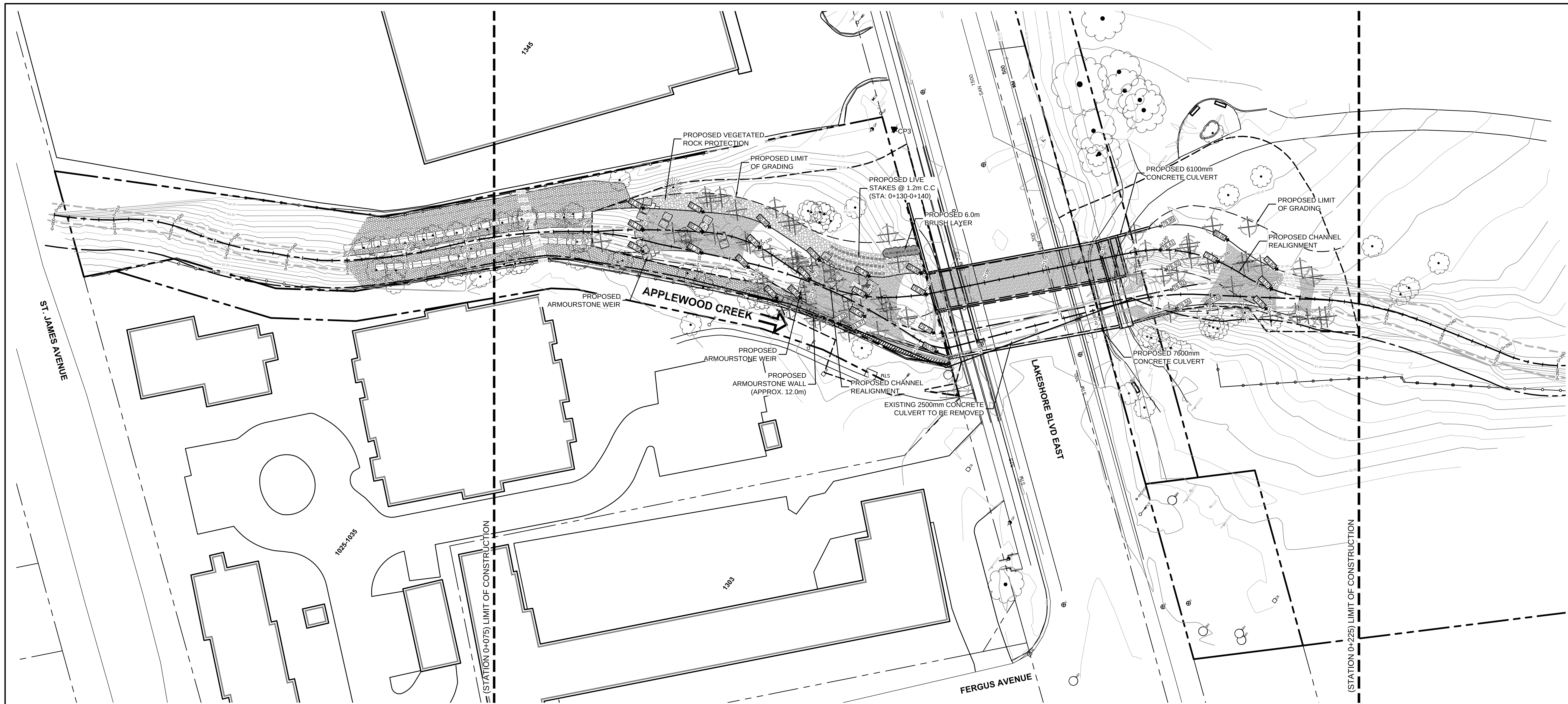
Date:	Project:	Submitter:	Reviewer:
April 2023	33023	A. Nicoll	R. Phillips

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

Figure 4

APPENDIX A
Excerpted Design Drawings

APPENDIX A1
Replacement of the Lakeshore Road East Culvert Over Applewood Creek Including Creek Improvements As-built Drawings (AECOM 2018)



SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN. SEWERS			GAS MAINS		
STM. SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
M.O.E.			ROGERS U/G CABLE		

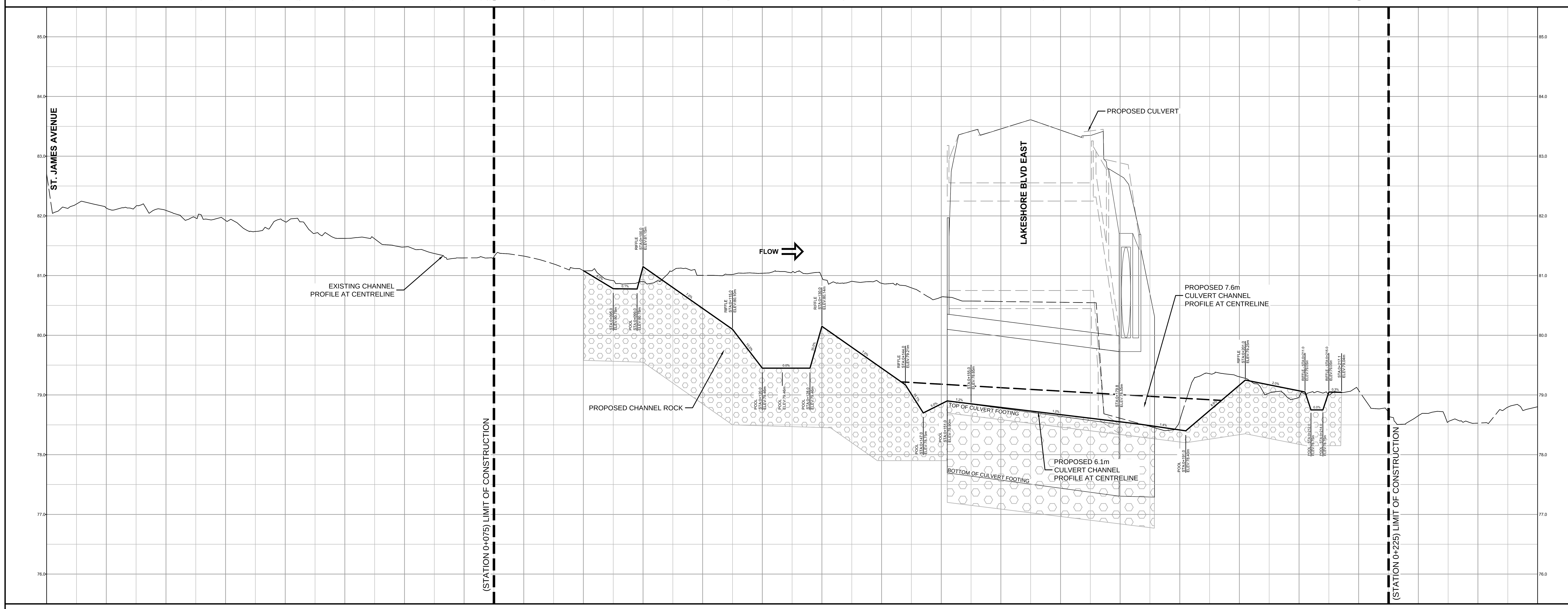
REVISIONS

DATE	DETAILS	INIT.
MAR. 2019	AS BUILT	W.K.

NORTH

LEGEND

- CREEK CENTRELINE
- 0+160 CHAINAGE
- EXISTING EDGE OF WATER
- PRIVATE PROPERTY LIMIT
- EASEMENT LIMIT
- FENCE LINE
- SAN SANITARY LINE
- WM WATERMAIN
- STM STORM SEWER
- MH SANITARY SEWER
- HYDRANT
- CB CATCHBASIN
- LAMP POST
- WATER VALVE
- HP HYDRO POLE
- EXISTING BUILDING
- TREES
- CONTOUR
- TREE REMOVALS
- EXISTING GABIONS
- EXISTING ARMOURSTONES
- PROPOSED ARMOURSTONE
- PROPOSED RIFFLE
- PROPOSED LIMIT OF GRADING



FINAL RD. GR.
EXIST RD. GR.
CHAINAGE: 0+000 0+010 0+020 0+030 0+040 0+050 0+060 0+070 0+080 0+090 0+100 0+110 0+120 0+130 0+140 0+150 0+160 0+170 0+180 0+190 0+200 0+210 0+220 0+230 0+240

ALL DIMENSIONS AND INFORMATION SHALL BE CHECKED AND VERIFIED ON THE JOB AND ANY DISCREPANCIES MUST BE REPORTED TO THE CONSULTANT BEFORE COMMENCING THE WORK. DO NOT SCALE THIS DOCUMENT. ALL DIMENSIONS MUST BE OBTAINED FROM STATED DIMENSIONS.
IT IS THE RESPONSIBILITY OF THE CONTRACTORS TO INFORM THEMSELVES OF THE EXACT LOCATION OF, AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES, SERVICES AND STRUCTURES WHETHER ABOVE GROUND OR BELOW GRADE BEFORE COMMENCING THE WORK. SUCH INFORMATION IS NOT NECESSARILY SHOWN ON THE DRAWING, AND WHERE SHOWN, THE ACCURACY CANNOT BE GUARANTEED.
WITH THE SOLE EXCEPTION OF THE BENCHMARK(S) SPECIFICALLY DESCRIBED FOR THIS PROJECT, NO ELEVATION INDICATED OR ASSUMED HEREON IS TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.

AECOM

PROPOSED PLAN AND PROFILE

DESIGN BY	APPROVED BY
C.E.T.	
DEPARTMENTAL APPROVAL	
SILVIO CESARIO P.ENG.	JEFF PRINCE P.ENG.

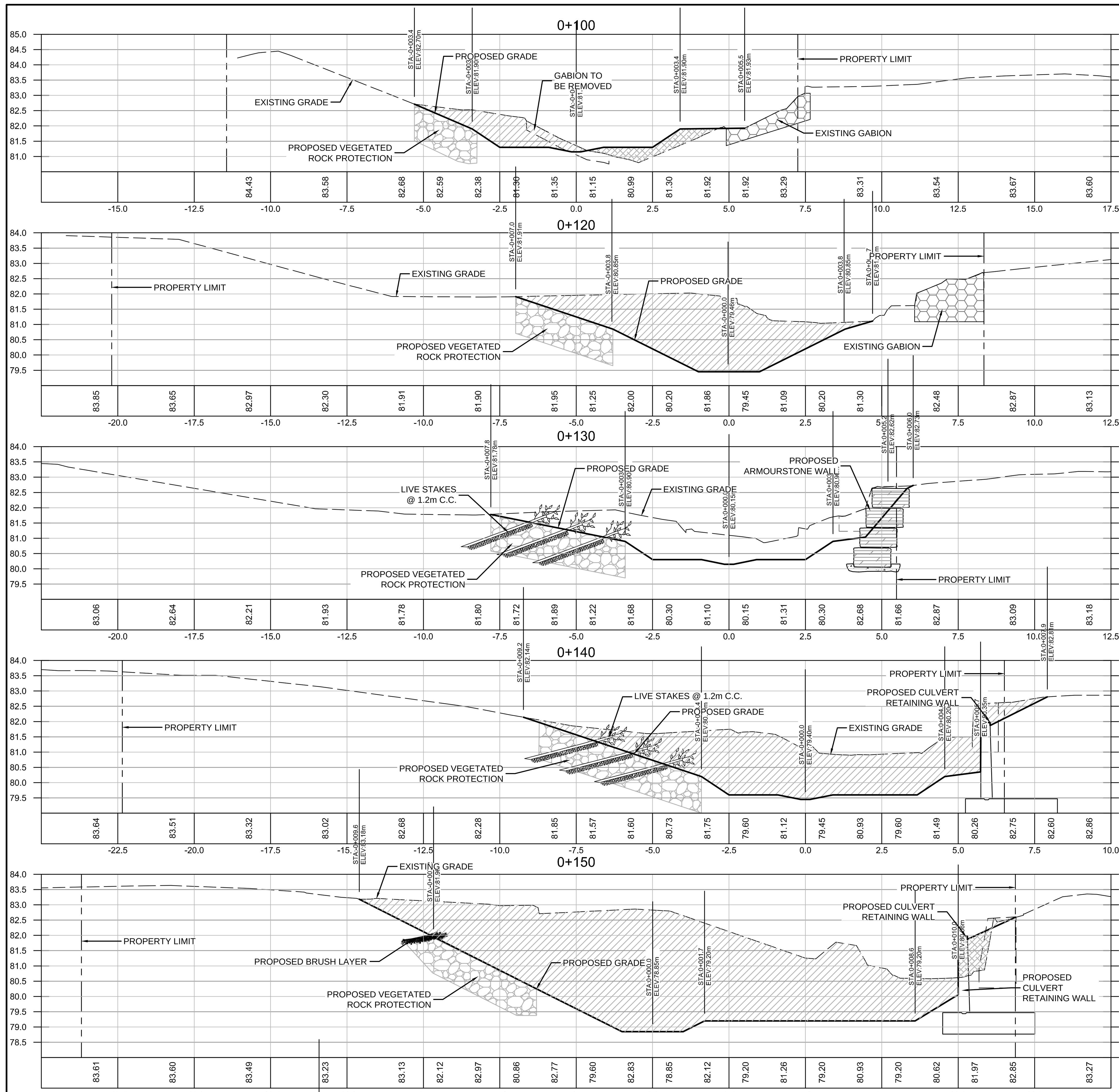
MISSISSAUGA

PRODUCED FOR – T&W, ENGINEERING AND WORKS

LAKESHORE ROAD EAST

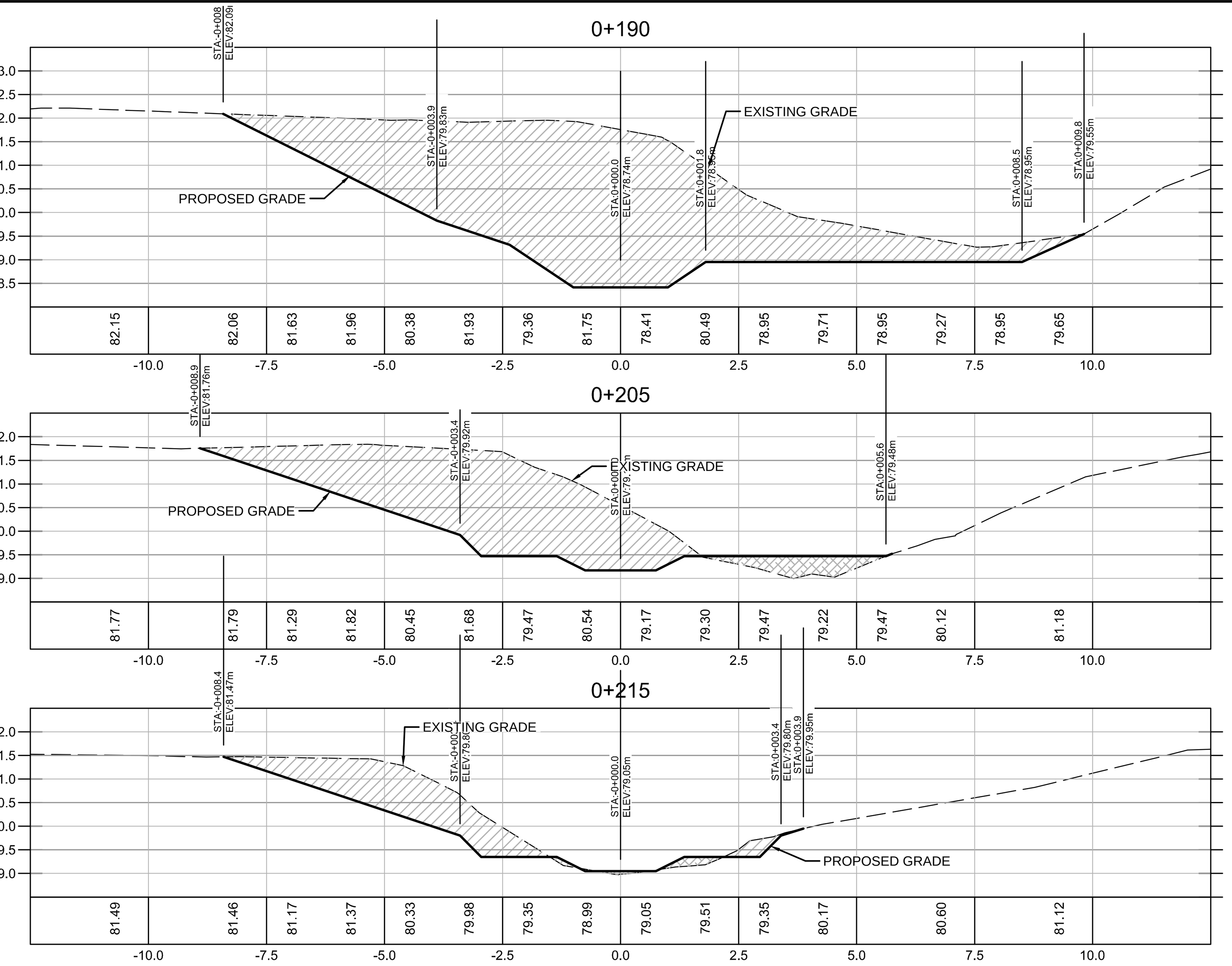
APPLEWOOD CREEK RESTORATION

SCALE: H:1:400 V:1:40	AREA: Z1\Z5\Z6	P.N. 11 154, 14 136
DRAWN BY: K.V.	CHECKED BY: J.P.	PLAN No.
DATE: JUNE 2016	SHEET 19 OF 21	C



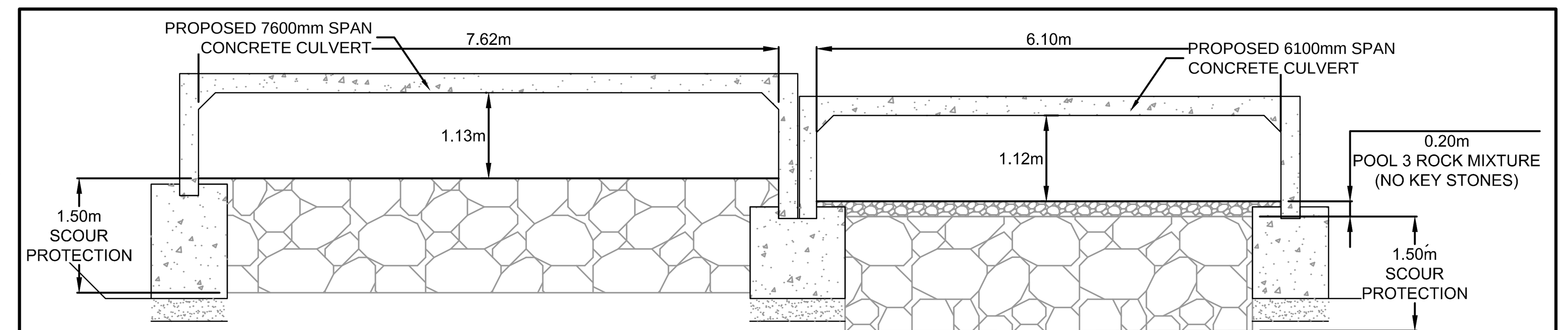
PROPOSED SECTIONS UPSTREAM (U/S) OF CULVERT

SCALE: 1:100



PROPOSED SECTIONS DOWNSTREAM (D/S) OF CULVERT

SCALE: 1:100

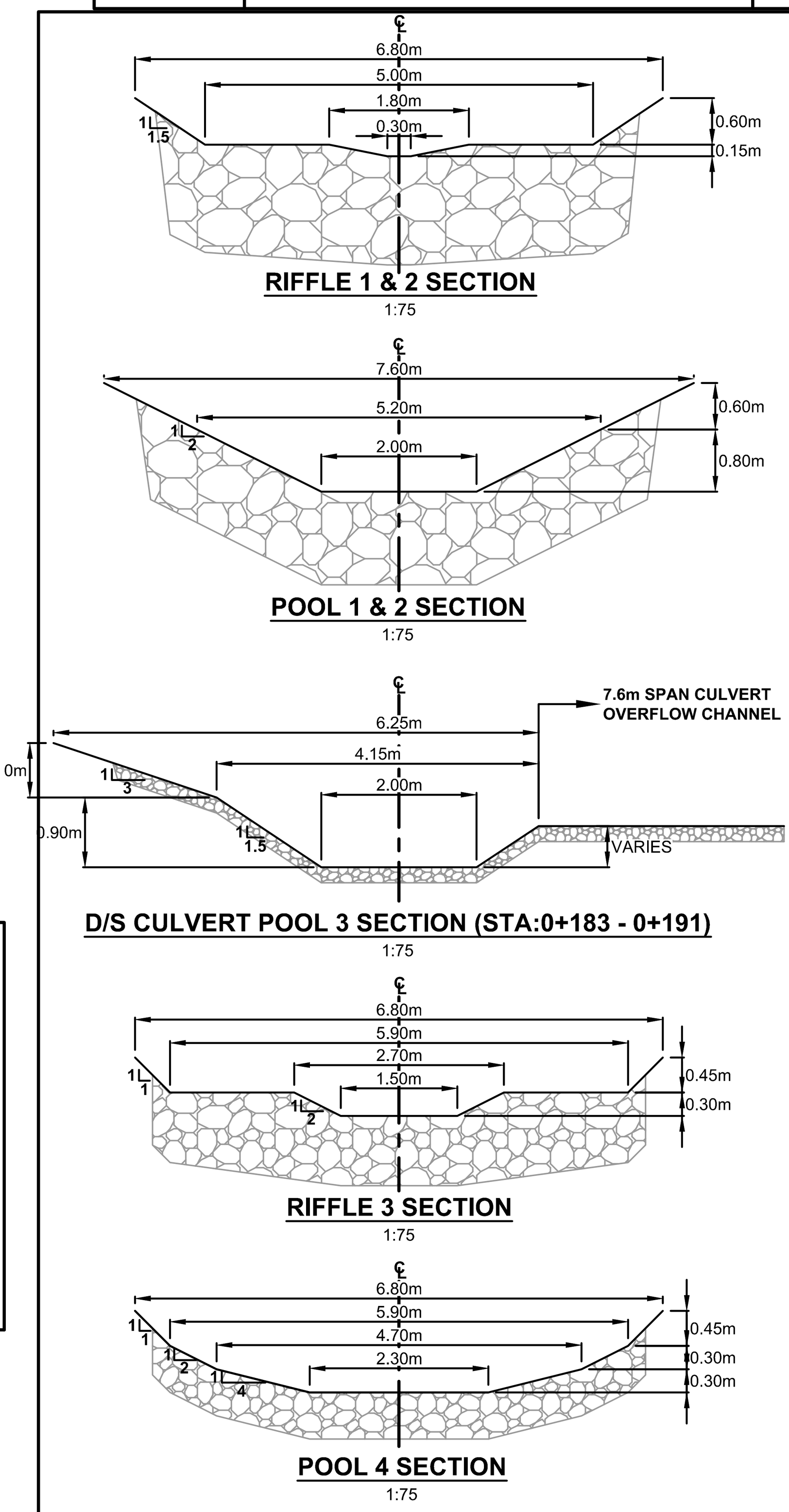


TYPICAL CHANNEL SECTION THROUGH CULVERTS

SCALE 1:75

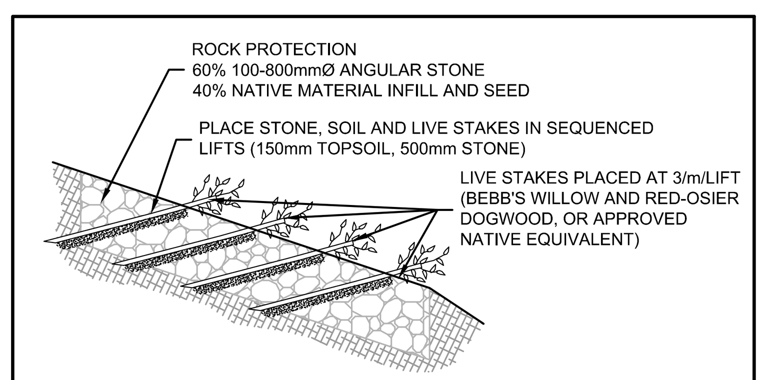
TABLE 1: ROCK SIZE TABLE

Rock Size	Riffle 1	Riffle 2	Riffle 3	Pool 1	Pool 2	Pool 3	Scour Protection	Pool 4
	0+100 to 0+115	0+130 to 0+144	0+201 to 0+211	0+095 to 0+100	0+115 to 0+128	0+144 to 0+191	0+144 to 0+180	0+212 to 0+215
Gran B	5	5	10	5	10	20	5	10
10-50mm	5	10	25	5	70	75	5	25
50-75mm	5	10	25	5	15		5	30
75-150mm	10	15	30	5				25
150-300mm	10	20	10	5			10	10
300-400mm	30	20		40	5 (Key Stones)	5 (Key Stones)		
400-600mm	20	15		20			15	
600-800mm	15	5		15			30	
800-1000mm							30	
Rock Depth	1600mm	1600mm	900mm	1200mm	1000mm	200mm	1500mm	600mm



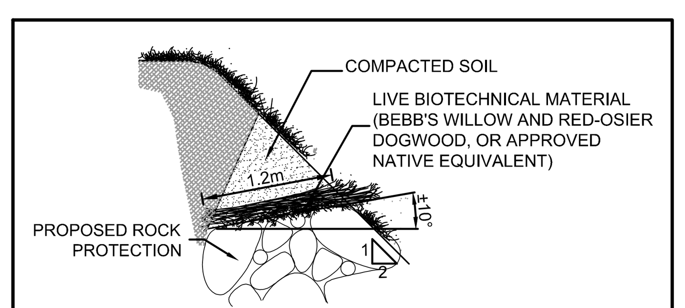
TYPICAL CHANNEL SECTION DETAILS

SCALE 1:75



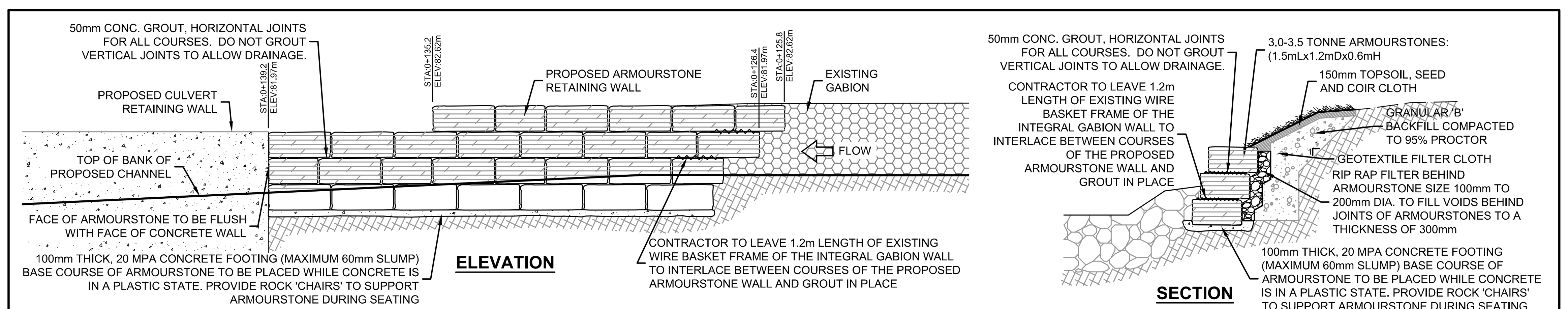
VEGETATED ROCK PROTECTION

SCALE 1:100



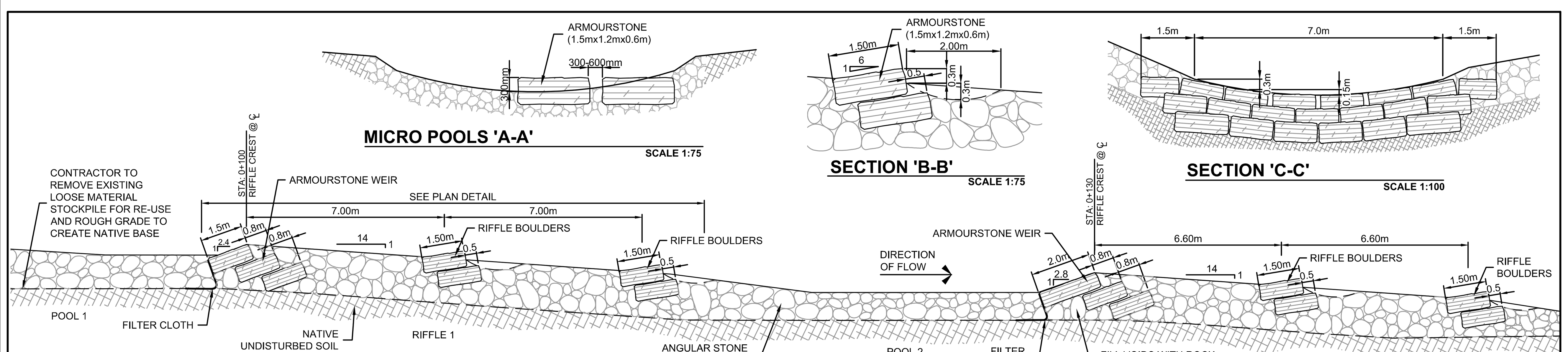
DETAIL :BRUSH LAYER

SCALE 1:50



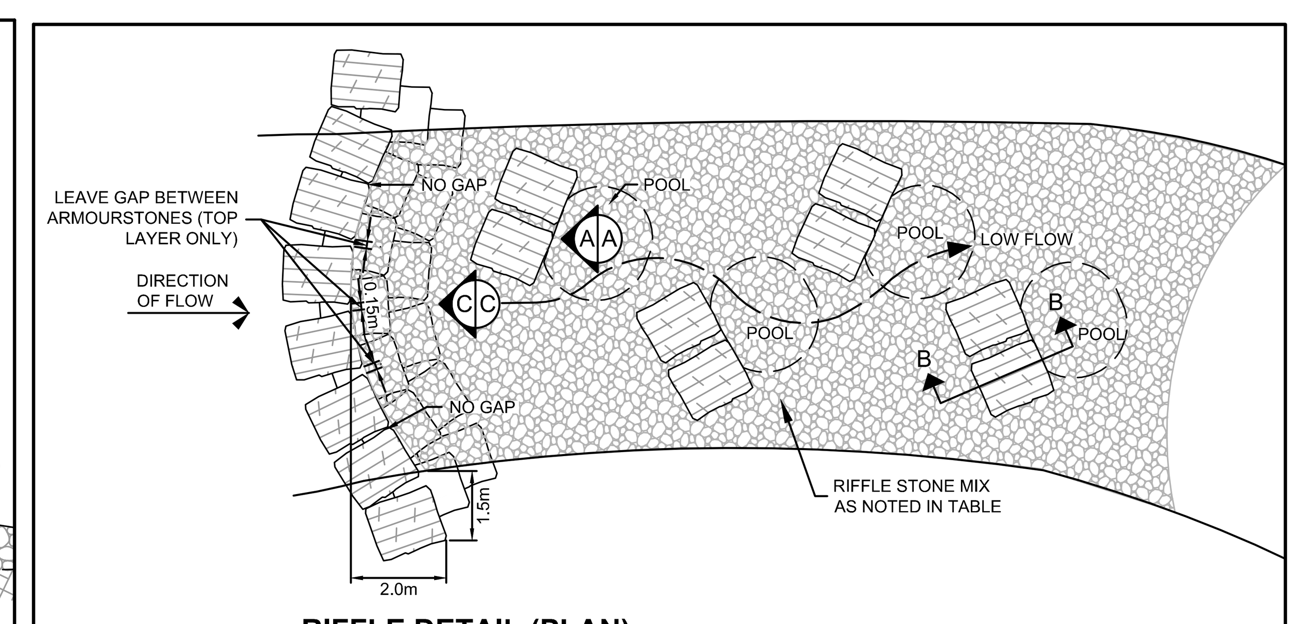
ARMOURSTONE WALL DETAILS

SCALE 1:100



RIFFLE PROFILE

SCALE 1:125



RIFFLE DETAIL (PLAN)

SCALE 1:125

SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN. SEWERS			GAS MAINS		
STM. SEWERS			BELL U/G CABLE		
WATERMAINS			HYDRO U/G CABLE		
M.O.E.			ROGERS U/G CABLE		

REVISIONS

DATE	DETAILS	INIT.
MAR. 2019	AS BUILT	W.K.

AECOM

PROPOSED SECTIONS AND DETAILS

DESIGN BY	APPROVED BY
C.E.T.	
DEPARTMENTAL APPROVAL	
SILVIO CESARIO P.ENG.	JEFF PRINCE P.ENG.

MISSISSAUGA

PRODUCED FOR – T&W, ENGINEERING AND WORKS

LAKESHORE ROAD EAST

APPLEWOOD CREEK RESTORATION

SCALE: AS NOTED	AREA: Z1\Z5\Z6	P.N. 11 154, 14 136
DRAWN BY: K.V.	CHECKED BY: J.P.	PLAN No.
DATE: JUNE 2016	SHEET 20 OF 21	C

APPENDIX A2
Serson Creek Ultimate Floodplain Mapping
(Urbantech 2019)

	EXISTING CONDITION		ULTIMATE CONDITION	
	LENGTH (m)	AREA (ha)	LENGTH (m)	AREA (ha)
OPEN CHANNEL	250	0.20	1142	2.39
OPEN DITCH	158	0.17	0	0
DISCONNECTED CHANNEL	520	0.72	0	0
CONNECTED CHANNEL	0	0	0	0

	EXISTING FLOODLINE AREA (ha)	ULTIMATE FLOODLINE AREA (ha)
Lakeview Village	1.29	1.17
Plaster Form Inc.	1.06	1.00
G.E.BOOTH WWTP	1.42+Spill	0.00
Total	3.77+Spill	2.17

urbantech
Urbantech Consulting, A Division of Leighton-Zec Ltd.
3760 14th Ave, Suite 301, Markham, Ontario L3R 3T7
tel: 905.946.9461 fax: 905.946.9595
www.urbantech.com

LAKEVIEW COMMUNITY PARTNERS LTD.

CITY OF MISSISSAUGA

ULTIMATE FLOODPLAIN MAPPING

PROJECT No.	DATE	SCALE	DWG No.
17-549	DEC. 2019	1:1250	FP-3

APPENDIX B
Historic Aerial Photographs

1960 Aerial Photograph

Roll Number: A16995 | Photo: 37 | Scale: 25,000

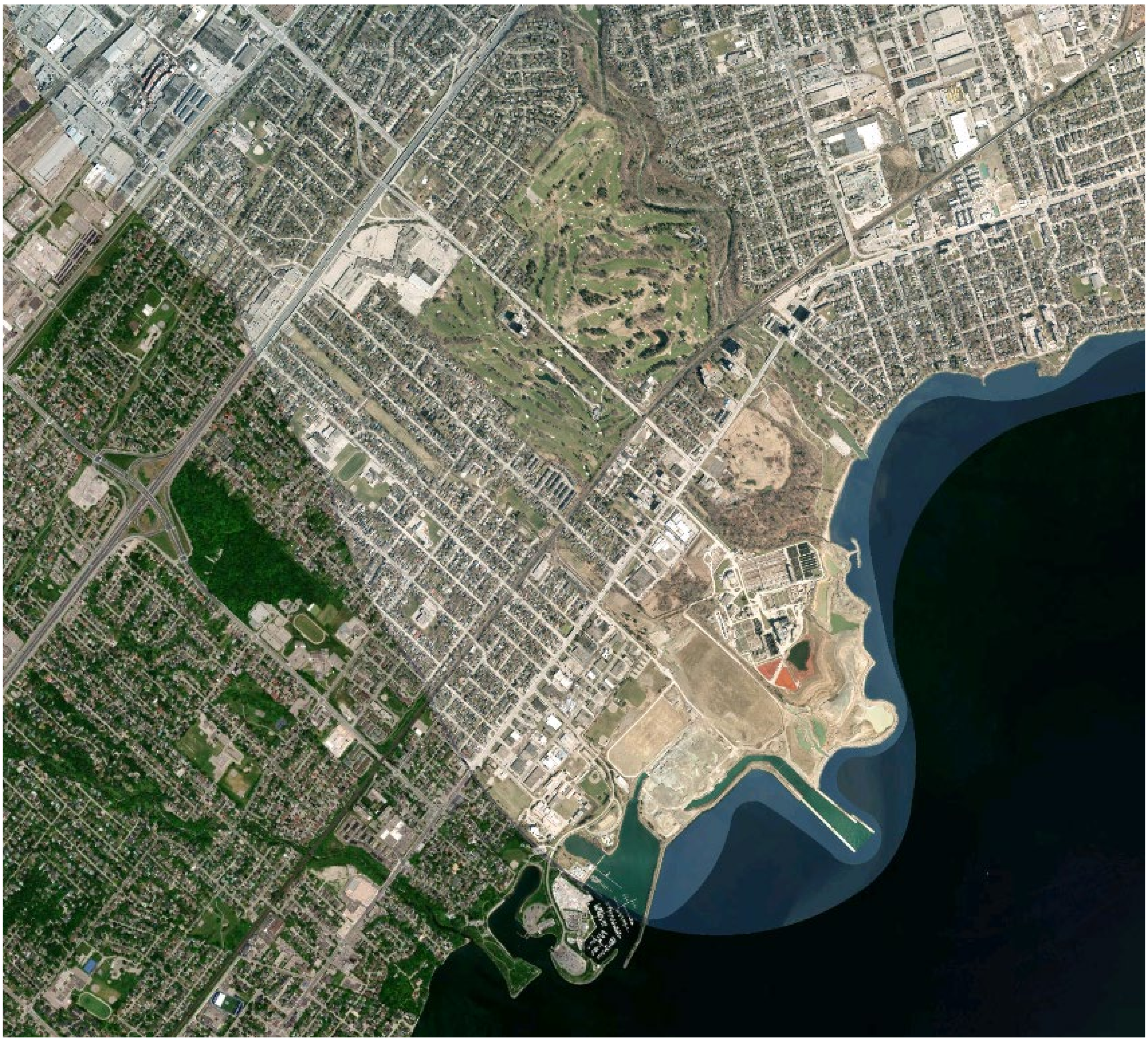
Disclaimer:
The photographs as shown are not georectified.
Photograph source:: National Air Photo Library (NAPL). Satellite imagery source: Bing Maps, 2021.

1978 Aerial Photograph

Roll Number: A24842 Photo: 90 Scale: 25,000

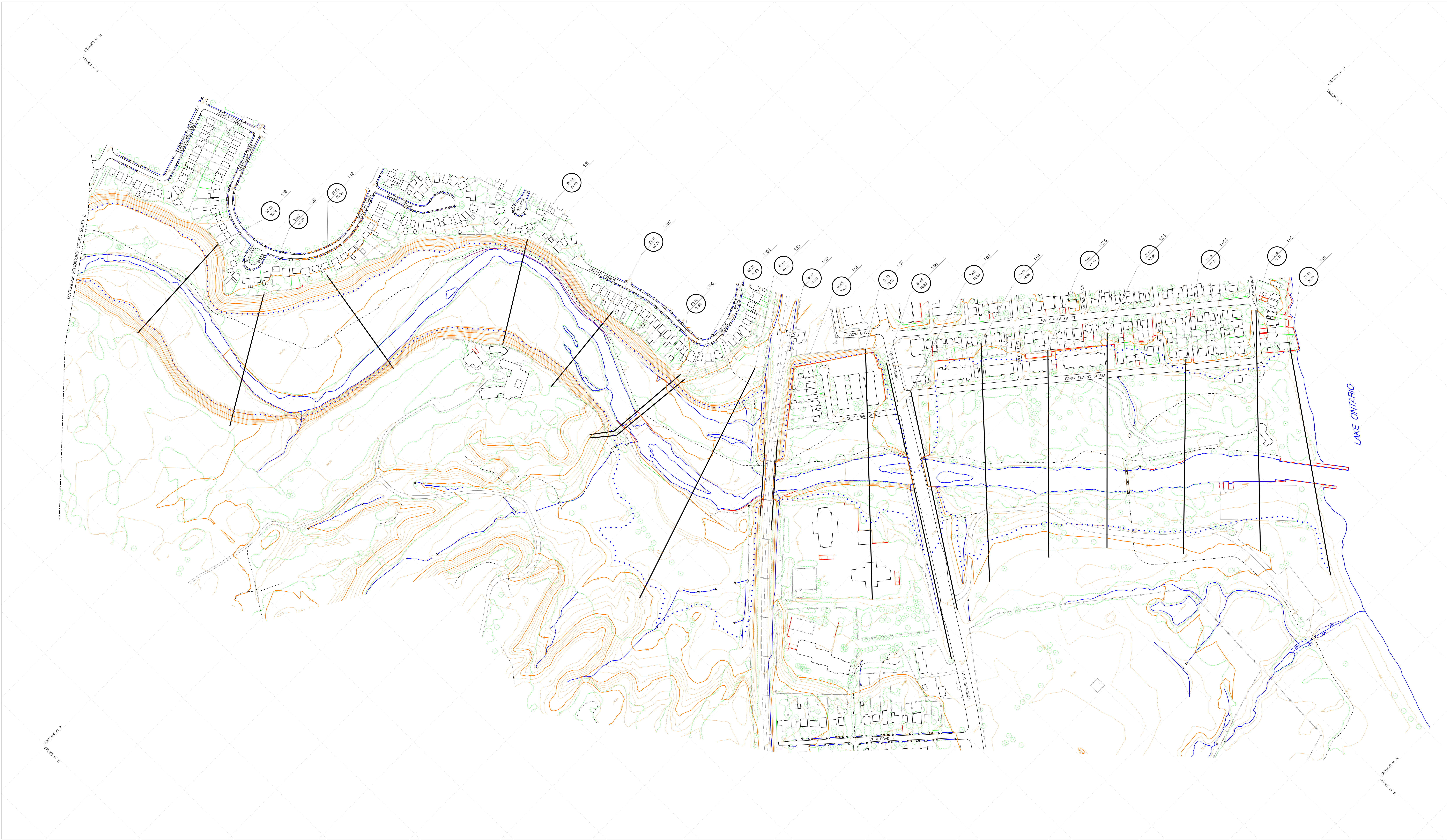
Disclaimer:
The photographs as shown are not georectified.
Photograph source:: National Air Photo Library (NAPL). Satellite imagery source: Bing Maps, 2021.

2020 Satellite Imagery



Disclaimer:
The photographs as shown are not georectified.
Photograph source:: National Air Photo Library (NAPL). Satellite imagery source: Bing Maps, 2021.

APPENDIX C
Floodline Mapping Provided by Conservation Authorities



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND

Cross–Section Label

Cross–Section Leader Line

Regional Flood Elevation (m)

Cross–Section Number 14.060 172.00 / 172.00

100 Year Existing Flood Elevation (m)

Cross–Section Length

REGULATORY FLOOD ELEVATION IS THE HIGHER OF THE TWO ELEVATIONS DISPLAYED

LEGEND

Contour Index
Contour Intermediate
Contour Auxiliary
Contour Depression
Contour Text 100.20
Spot Height . 100.10
Road
Parking Lot
Race Track
Wall
Retaining Wall
Rail Line
Runway
Silo, Smoke, Tank
Marsh Symbol
Marsh Boundary
Township Fabric
Hydro Tower
Trail
Bridge
Wooded Area
Tree
Hedge
Fence
Water Feature
Culvert Symbol
Culvert to Scale
Dam
Pool
Building
Pit
Pile
Regulatory Flood Line

This map was compiled photogrammetrically from 1/10000 aerial photography flown in 2002.

The vertical datum is mean sea level as established by the Geodetic Survey of Canada. CGVD 1928-1978 Ontario Adjusted Version

The horizaontal datum is North American Datum 1983, U.T.M. 6° projection Zone 17, Central Meridian 81° W.

Grid Interval 100 metres.

PLEASE NOTE:
FLOODLINE ELEVATIONS ARE SUBJECT TO CHANGE DUE TO REVISED INFORMATION.

J.D.BARNES LIMITED
SURVEYING MAPPING GIS
MARKED BY INNOVATION . MEASURED BY REPUTATION™
145 RENFREW DRIVE SUITE 160
MARKHAM, ONTARIO L3R 9R6
TEL. (905) 477-3600
FAX (905) 477-3882

DATE ISSUED
JUNE 17, 2004

PLEASE NOTE:
THE ONTARIO LAND SURVEYOR STAMP VERIFIES ONLY THE TOPOGRAPHIC AND PLANIMETRIC DATA, NOT THE CADASTRAL DATA, UNLESS OTHERWISE NOTED

ASSOCIATION OF ONTARIO LAND SURVEYORS CR99

Aquafor Beech Limited
#6-202-2600 SKYMARK Ave,
MISSISSAUGA, ONTARIO, L4W 5B2
PHONE: (905) 629-0099, FAX: (905) 629-0089

PLEASE NOTE:
THE PROFESSIONAL ENGINEER'S STAMP VERIFIES THE FLOOD LINE AND ASSOCIATED DATA NOT THE MAP DATA UNLESS OTHERWISE NOTED

LICENSED PROFESSIONAL ENGINEER G.R. FREW PROVINCE OF ONTARIO

FLOOD PLAIN MAPPING PROGRAM

FLOODLINE APPROVED DATE: 2015–04–24

Toronto and Region Conservation for The Living City®

5 Shoreham Drive Downsview Ontario M3N 1S4 (416) 661–6600

Scale 1:2000

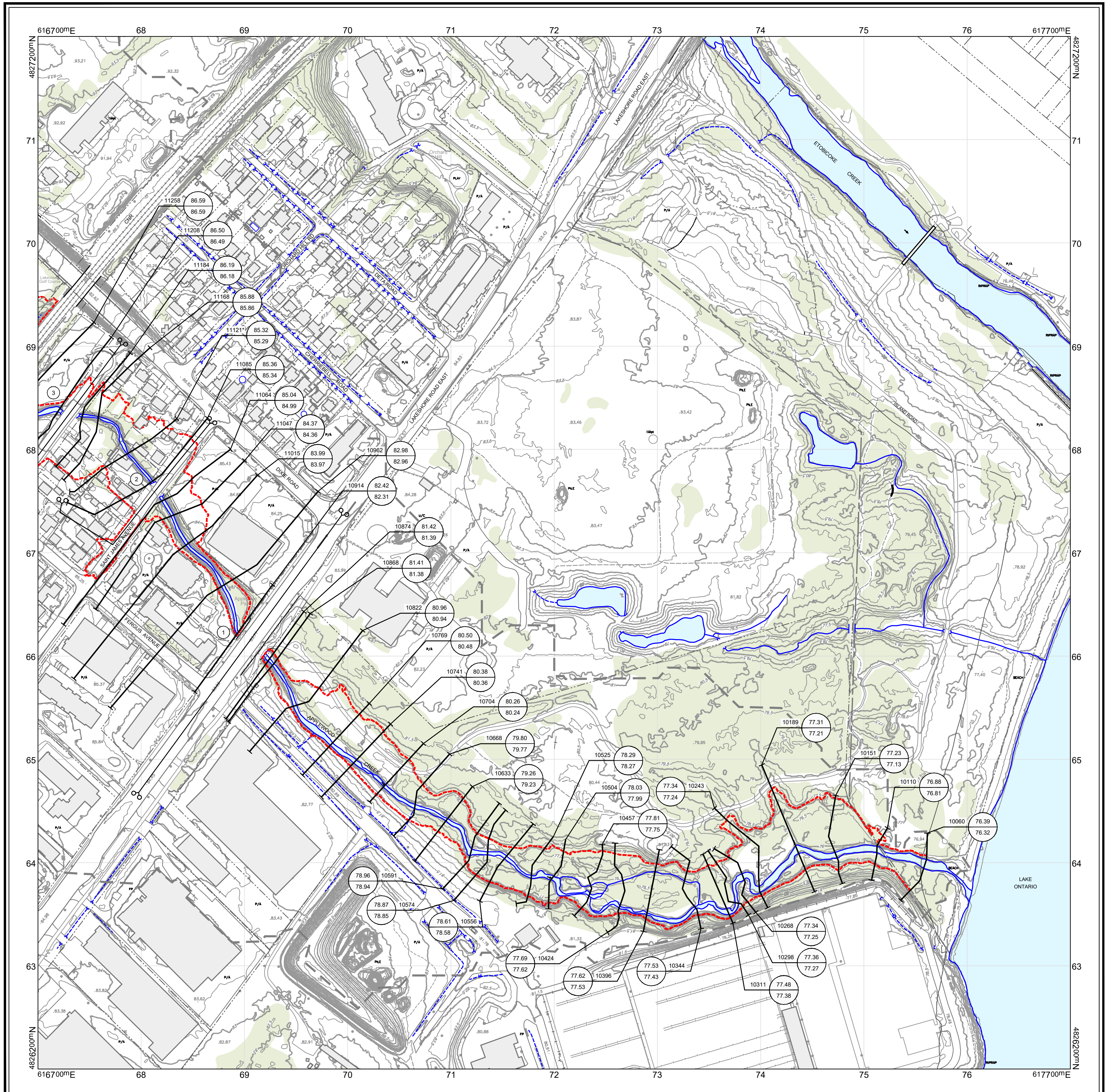
100 Metres 0 100 200 Metres

200 Feet 0 200 400 600 800 1000 Feet

CONTOUR INTERVAL 1.0 METRE

ETOBICOKE CREEK

SHEET No. 1



Credit Valley Conservation
inspired by nature

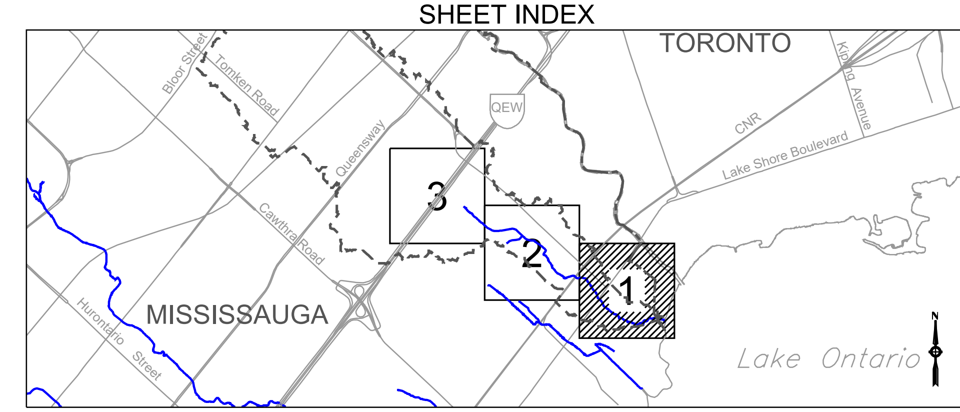
FLOOD HAZARD MAP
APPLEWOOD CREEK WATERSHED

LEGEND

- Bridges
- Building
- Building Ruin
- Building Under Construction
- Contour Index (172)
- Contour Intermediate (172.5)
- Culvert Symbol
- Culvert to Scale
- Dam
- Ditch
- Dock, Wharf, Pier
- Driveway
- Falls, Rapids (Rapid, Falls)
- Flow Direction
- Footbridge
- Guiderail
- Headwall
- Hedge
- Marsh
- Municipal Boundary
- Overhead Walkway
- Parcel Fabric
- Parking Lot (P/A)
- Pile
- Pipe
- Pit
- Playground (PLAY)
- Pole
- Pool
- Railway
- Railway Abandoned
- River, Creek, Shoreline
- Road
- Road Understruction (UC)
- Sidewalk
- Silo
- Spot Height (•123.45)
- Trail
- Wall
- Watershed Boundary
- Waterbody Elevation (•97.5)
- Wooded Area
- Regulatory Floodline
- Regulatory Floodplain (2D Model)
- 1D–2D Model Limits (1D, 2D)
- Two-Zone Policy Area
- Section
- Overflow Section
- Structure ID (10)
- Spill
- Regional Flood Elevation / Section Number / 100 Year Flood Elevation (15426; 98.75; 98.25)

Note: The Regulatory flood elevation and floodline is the greater of the Regional and 100 Year storms. See General Note 6 concerning Section Numbers marked with an *.

SHEET INDEX



SCALE 1:4000

Metres 100 0 100 200 METRES

CONTOUR INTERVAL 0.5 METRE

General Notes:

1. Contourlines on this map were generated by Airborne Imaging using the Spring of 2015 LiDAR point cloud, breaklines and hydrologic enforcement at bridges. The vertical accuracy of the original points is 0.10 metres RMSE.
2. The planimetric data was obtained from the City of Mississauga in 2017.
3. The vertical datum is mean sea level established by the CGVD 28, 1978 Southern Ontario adjustment.
4. The horizontal datum is North American Datum 1983 CSRS (Epoch 2010) UTM Zone 17.
5. To obtain City of Mississauga datum, add 0.121 metres to elevation data.
6. Where section numbers are marked with an * the Regulatory flood elevations drop moving upstream. The flood elevation for Regulatory purposes shall be calculated by linearly interpolating between the upstream and downstream sections that are adjacent to the sections marked with an *. In no case shall interpolation extend through a structure. For additional clarification please contact Credit Valley Conservation.

N

ASSOCIATION OF ONTARIO LAND SURVEYORS
PAUL FRANCIS
CR 21

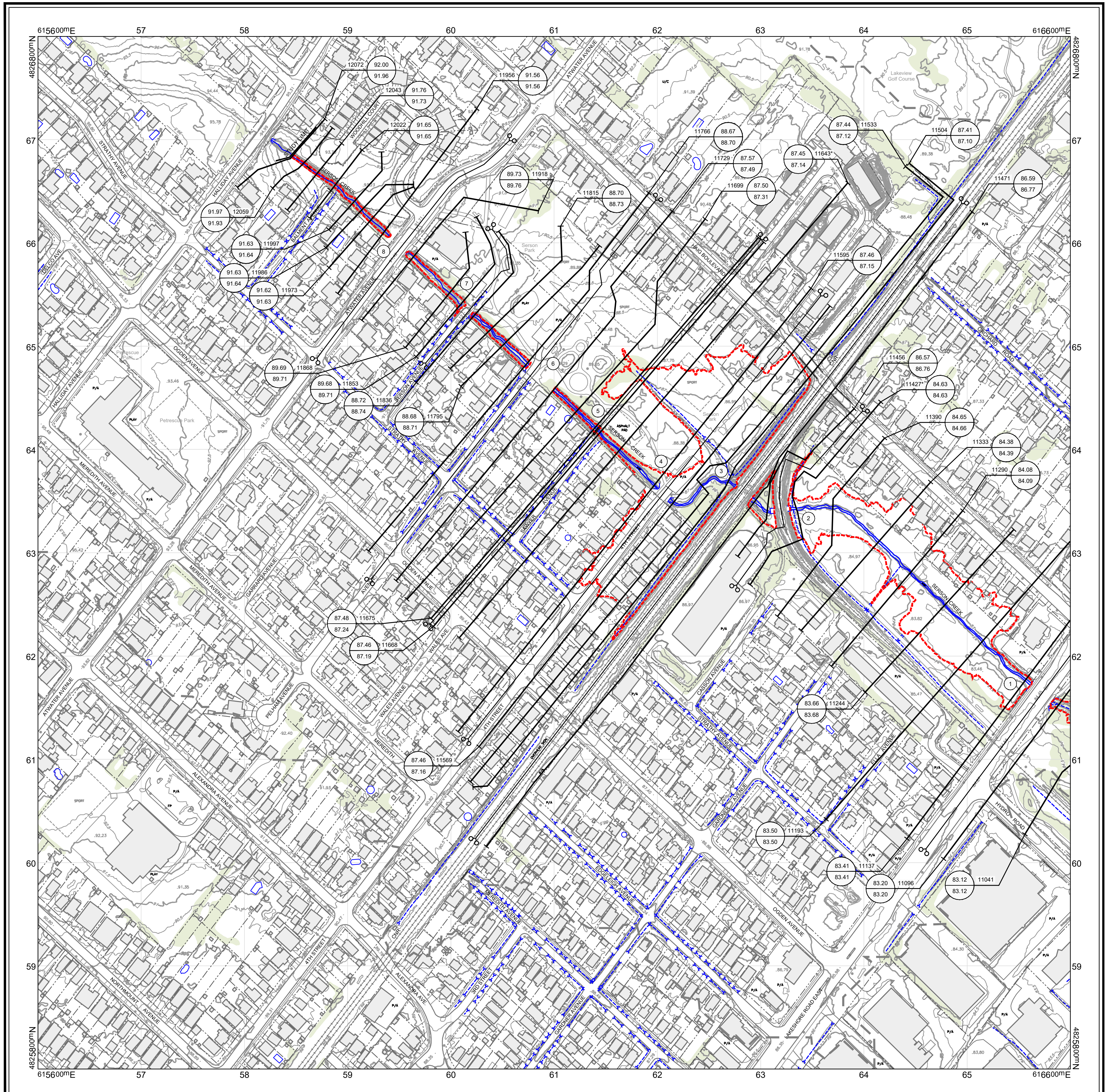
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

AIRBORNE IMAGING
A Clean Harbors Company

MISSISSAUGA

No	Amendment/Revision	By	Date

SHEET No 1 of 3



FLOOD HAZARD MAP

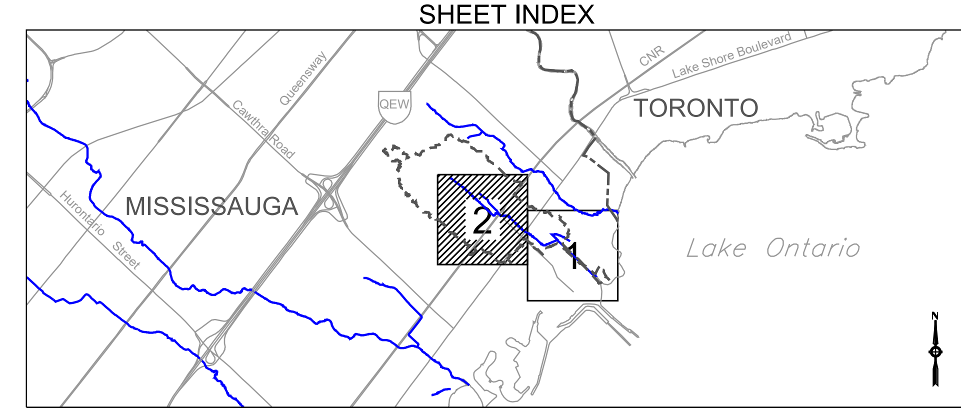
SERSON CREEK WATERSHED

LEGEND

- Bridges
- Building
- Building Ruin
- Building Under Construction
- Contour Index — 172
- Contour Intermediate — 172.5
- Culvert Symbol
- Culvert to Scale
- Dam
- Ditch
- Dock, Wharf, Pier
- Driveway
- Falls, Rapids — Rapid / Falls
- Flow Direction
- Footbridge
- Guiderail
- Headwall
- Hedge
- Marsh
- Municipal Boundary
- Overhead Walkway
- Parcel Fabric
- Parking Lot — P/A
- Pile
- Pipe
- Pit
- Playground — PLAY
- Pole
- Pool
- Railway
- Railway Abandoned
- River, Creek, Shoreline
- Road
- Road Understruction (UC) — UC
- Sidewalk
- Silo
- Spot Height — •123.45
- Trail
- Wall
- Watershed Boundary
- Waterbody Elevation — •97.5
- Wooded Area
- Regulatory Floodline
- Regulatory Floodplain (2D Model)
- 1D-2D Model Limits — 1D / 2D
- Two-Zone Policy Area
- Section
- Overflow Section
- Structure ID — 10
- Spill
- Regional Flood Elevation / Section Number / 100 Year Flood Elevation — 15426, 98.75, 98.25

Note: The Regulatory flood elevation and floodline is the greater of the Regional and 100 Year storms. See General Note 6 concerning Section Numbers marked with an *.

SHEET INDEX



SCALE 1:4000

Metres 100 0 100 200 METRES

CONTOUR INTERVAL 0.5 METRE

General Notes:

1. Contourlines on this map were generated by Airborne Imaging using the Spring of 2015 LiDAR point cloud, breaklines and hydrologic enforcement at bridges. The vertical accuracy of the original points is 0.10 metres RMSE.
2. The planimetric data was obtained from the City of Mississauga in 2017.
3. The vertical datum is mean sea level established by the CGVD 28, 1978 Southern Ontario adjustment.
4. The horizontal datum is North American Datum 1983 CSRS (Epoch 2010) UTM Zone 17.
5. To obtain City of Mississauga datum, add 0.121 metres to elevation data.
6. Where section numbers are marked with an * the Regulatory flood elevations drop moving upstream. The flood elevation for Regulatory purposes shall be calculated by linearly interpolating between the upstream and downstream sections that are adjacent to the sections marked with an *. In no case shall interpolation extend through a structure. For additional clarification please contact Credit Valley Conservation.

ASSOCIATION OF ONTARIO LAND SURVEYORS — PAUL FRANCIS — CR 21

LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

N

No	Amendment/Revision	By	Date

SHEET No 2 of 2

APPENDIX D
Site Photographs

Matrix Solutions Inc.
July 30, 2021

1. Etobicoke Creek- Reach ET2 – Upstream of Lakeshore Rd – Railway bridge upstream of Lakeshore Road.

Matrix Solutions Inc.
July 30, 2021

2. Etobicoke Creek – Reach ET2 – Upstream of Lakeshore Rd – Looking upstream from vegetated bar.

Matrix Solutions Inc.
July 30, 2021

3. Etobicoke Creek – Reach ET2 – Upstream of Lakeshore Rd – View of toward Lakeshore Road bridge. Vegetated bar in foreground.

Matrix Solutions Inc.
July 30, 2021

4. Etobicoke Creek – Reach ET2 – Western opening of Lakeshore Rd Bridge looking upstream. Vegetated bar in foreground.

Matrix Solutions Inc.
July 30, 2021

5. Etobicoke Creek – Reach ET2 – Eastern opening of Lakeshore Rd Bridge looking upstream. Pedestrian crossing passes below bridge by east abutment.

Matrix Solutions Inc.
July 30, 2021

6. Etobicoke Creek – Reach ET2 – Upstream of Lakeshore Rd – Vegetated bar upstream of Lakeshore Rd bridge in foreground.

Matrix Solutions Inc.
July 30, 2021

7. Etobicoke Creek – Reach ET2 – Lakeshore Rd bridge pier footings and eastern bridge opening, looking downstream.

Matrix Solutions Inc.
July 30, 2021

8. Etobicoke Creek – Reach ET2 – Downstream of Lakeshore Rd – View of West bridge abutment and watermain. Vegetated bar in foreground.

Matrix Solutions Inc.
July 30, 2021

9. Etobicoke Creek – Reach ET2 – Downstream of Lakeshore Rd – View of main channel downstream of Lakeshore Rd bridge. Main channel passes through the eastern bridge opening. Wide, shallow channel with platey substrate derived from local shale bedrock.

Matrix Solutions Inc.
July 30, 2021

10. Etobicoke Creek – Reach ET1-ET2 transition – Downstream of Lakeshore Rd – View of Lakeshore Rd bridge. Channel gradually deepens and becomes backwatered as it approaches Lake Ontario.

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11. Etobicoke Creek – Reach ET1 – Looking downstream toward Lake Ontario.

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12. Etobicoke Creek – Reach ET1 – Looking upstream.

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13. Applewood Creek– Reach AP2 - Upstream of Lakeshore Rd– Channel is lined with gabion basket (bed) and armourstone (banks) upstream of constructed riffle-pool sequence .

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14. Applewood Creek - Reach AP2 – Upstream of Lakeshore Rd – View looking upstream of constructed riffle-pool system.

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15. Applewood Creek - Reach AP2 – View of downstream towards Lakeshore Road, constructed riffle-pool system.

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16. Applewood Creek- Reach AP2 – Upstream of Lakeshore Rd – View looking upstream from Lakeshore Road culvert.

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17. Applewood Creek - Reach AP2 – Lakeshore Road culvert inlet.

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18. Applewood Creek - Reach AP1 – Lakeshore Road culvert outlet.

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19. Applewood Creek - Reach AP1 – Downstream of Lakeshore Rd – View looking downstream from Lakeshore Road.

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20. Applewood Creek - Reach AP1 – Downstream of Lakeshore Rd – View of constructed riffle downstream of outlet pool.

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21. Applewood Creek - Reach AP1 – Downstream of Lakeshore Rd – View of constructed pool downstream of culvert.

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22. Applewood Creek - Reach AP1 – Downstream of Lakeshore Rd – View of woody debris downstream.

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23. Serson Creek – Reach SE2 – Upstream of Lakeshore Rd – both banks eroding.

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24. Serson Creek – Reach SE2 – Upstream of Lakeshore Rd – Typical channel.

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25. Serson Creek – Reach SE2 – Lakeshore Road inlet. Embankment slopes were densely vegetated.

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26. Serson Creek – Lakeshore Road culvert - Deposition along West side of culvert near culvert inlet.

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27. Serson Creek – Lakeshore Road Culvert looking downstream.

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28. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – View of Lakeshore Road culvert outlet, taken from East bank.

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29. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – Lakeshore Road culvert outlet. A bar has formed at the outlet along the East side of the culvert.

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30. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – View looking downstream where the channel narrows into a constructed cobble-lined channel downstream of the outlet pool.

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31. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – View of constructed cobble riffle.

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32. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – Downstream of constructed cobble riffle. Channel bed has incised creating shallow terracing.

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33. Serson Creek – Reach SE1– Downstream of Lakeshore Rd – Exposed roots on the west creek bank.

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34. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – Eroding western creek bank, with meter stick for scale.

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35. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – View of entrenched channel looking upstream. Channel is entrenched and semi-confined.

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36. Serson Creek – Reach SE1 – Downstream of Lakeshore Rd – Typical bed material.