Fluvial Geomorphological Assessment, Erosion Hazard Delineation, and Channel Realignment

12035 Dixie Road, Caledon, ON

Prepared for:

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GEO MORPHIX
Geomorphology
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Observations

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1 Introduction

GEO Morphix Ltd. was retained to complete a fluvial geomorphological assessment, erosion hazard delineation, and channel realignment at 12035 Dixie Road, in the Town of Caledon, Ontario. The subject site is bounded by Dixie Road to the south/west, privately owned lands to the north, and Mayfield Road to the south/east. There are two (2) watercourse features within the subject property, including the main branch of the West Humber River which traverses the northern extent of the property, as well as a tributary of the West Humber River which traverses through the center of the property. Each watercourse feature generally flows in a northwest to southeast direction. The geomorphological assessment and erosion hazard delineation was completed to support a proposed industrial development, including associated buildings and road networks. Additionally, the tributary of the West Humber River was proposed for realignment to accommodate the proposed development footprint.

For the fluvial geomorphological assessment and erosion hazard delineation, the following activities were completed:

- Review available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Complete watercourse reach delineation through a desktop assessment
- Review of recent and historical aerial photographs of the site to understand historical changes in channel form and function
- Complete rapid geomorphological assessments on a reach basis to document channel conditions and verify the desktop assessment where possible
- Document any areas of significant erosion, collect instream measurements of bankfull channel dimensions, and characterize bed and bank material composition and structure
- Delineate limits of the erosion hazard on a reach basis using field observations

Specific to the channel realignment design, the following activities were completed:

- Complete a detailed geomorphological assessment along **Reach 1**
- Provide details for the channel design including planform, cross sections, and necessary bioengineering details
- Hydraulic sizing of the channel materials
- Recommendations for design implementation including construction timing, stabilization, and best management practices

2 Background Review and Desktop Assessment

2.1 Background Information

The subject section of West Humber River is situated within the Toronto and Region Conservation Authority (TRCA) jurisdiction and further, the Humber River watershed. The Humber River watershed originates in the Oak Ridges Moraine, outlets to Lake Ontario, and encompasses approximately 911 square kilometers (TRCA, 2021). The West Humber River specifically originates in Caledon (South Slope) and flows over 45 km (crossing Peel Plain) in Brampton prior to its confluence with the Main Humber River in Toronto (TRCA, 2021).

Several stream layer datasets were reviewed to understand existing drainage features on site. The review included data from MNRF's Ontario Hydro Network (OHN) stream layer, Peel Region's stream layer, and the TRCA Regulation Area stream layer. It should be noted that the three layers were in agreement in terms of the watercourse features present on site.

Within the subject property, the main branch of the West Humber River flows generally northwest to southeast, traversing the northern corner of the property. This watercourse has a meandering planform with irregular meanders and flows through a partially confined valley system. The tributary of the West Humber River flows generally northwest to southeast, bisecting the subject property through the center. This watercourse is generally straightened with a low degree of sinuosity and flows through an unconfined valley system.

It is important to note that at least one additional drainage feature was observed through a desktop assessment of recent aerial imagery from Google Earth Pro. Recent aerial photographs indicate that there is at least one small headwater drainage feature on site that extends through an existing agricultural field. It should be noted that the feature is only visible through aerial photograph interpretation and is not included in any available stream layer datasets reviewed through the desktop assessment.

2.2 Geology and Physiography

Geology and physiography act as constraints to channel development and tendency. These factors determine the nature and quantity of the availability and type of sediment. Secondary variables that affect the channel include land use and riparian vegetation. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

Within the subject property, the West Humber River and associated tributary are dominated by the Till Plains (drumlinized) physiographic region of Ontario (Chapman and Putnam, 2007). In terms of surficial geology, the subject lands are characterized by till (OGS, 2010). Soils within these areas include clay to silt-textured clay derived from glaciolacustrine deposits or shale (OGS, 2010). Evidence of till exposure and shale were observed on site during field investigations. Additionally, underlying the main branch of the West Humber River, soils were characterized by modern alluvial deposits, including clay, silt, sand, gravel, and organic remains (OGS, 2010). A geotechnical assessment was completed by MTE Consultants (2021) that included borehole analysis across the site. Results of the geotechnical study confirm the presence of modern alluvium materials and various glacial deposits.

2.3 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity.

Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs

- Soil type and surficial geology
- Historical channel modifications

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004) as well as others.

Several watercourse layers were reviewed to identify watercourses on site, which included those available through TRCA, Peel Region, and MNRF. Based on the existing channel conditions and the linear extent of the watercourses within the subject property, two (2) reaches were delineated. All reaches are graphically defined in **Appendix A**. It should be noted that the watercourse layer included in **Appendix A** is a combination of TRCA and Peel Region linework, which was verified through field observations or confirmed to be the most accurate based on our desktop assessment.

An additional drainage feature was observed on site through a desktop assessment of recent aerial imagery from Google Earth Pro. Recent aerial photographs indicate that there is at least one small headwater drainage feature on site that extends through an existing agricultural field. It should be noted that the feature is only visible through aerial photograph interpretation and is not included in any available stream layer datasets reviewed through our desktop assessment. As such, it has not been included as part of the reach delineation exercise outlined here. We note that a preliminary review of headwater features was completed by WSP Canada in 2020. The results of that assessment are documented in their report (WSP, 2021).

2.4 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics.

Various aerial photographs and satellite images from 1960 to 2018 were retrieved to complete the historical assessment and inform the erosion hazard delineation. Specifically, aerial photographs from 1960, 1974 (National Air Photo Library), and satellite images from 2005 and 2018 (Google Earth Pro) were reviewed. All historical aerial photographs are provided in **Appendix B** for reference. The watercourse reaches outlined as part of the historical assessment are graphically presented on the map in **Appendix A**.

In 1960, the subject lands and surrounding properties were dominated by agricultural activities. Few residential dwellings were constructed along major road networks, including Dixie Road and Mayfield Road. The main branch of the West Humber River was visible and generally flowing northwest to southeast, with reaches upstream and downstream from the subject property also flowing through agricultural lands. The planform was meandering with irregular meanders. A limited riparian buffer was observed, consisting of grasses and few large trees. The tributary of the West Humber River was difficult to discern through available aerial imagery. The furthest downstream extent of the tributary was visible crossing Mayfield Road, and demonstrated a straightened planform with low sinuosity. In addition to the watercourses identified on site, a small drainage feature was also observed running through the subject property.

There were no changes in land use or the extent of development at the subject lands in 1974. The Town of Caledon remained largely occupied by agricultural activities, with few small woodlots and wetland/pond features. The change in colour at the northern corner of the subject property suggests a change in topography in this location. With respect to the main branch of the West Humber River, the channel displays greater sinuosity near the break in slope. In comparison, the downstream extent of the watercourse displays a more straightened, less sinuous planform, and is closer to Bramalea Road than the break in slope. The riparian buffer is not visible, which may be due to the time of year in which the aerial photograph was taken. Consistent with the aerial photograph from 1960, the tributary of the West Humber River was vaguely discernable. The downstream extent of the channel appeared straightened with a low sinuosity. Further, there was no change in topography noted, indicating the system is likely characteristic of an agricultural swale. In this aerial photograph, several drainage networks were pronounced on the landscape.

Between 2005 and 2018, there was a substantial increase in residential development surrounding the subject property. Particularly to the southeast, residential developments and linear infrastructure occupied the majority of lands. The floodplain associated with the West Humber River was more defined, and the meandering planform was more sinuous in comparison to 1974 and 1960. The riparian buffer surrounding the West Humber River remained minimal, with few trees established along the break in slope. The tributary of the West Humber River was more defined bisecting the subject lands through the center of the agricultural field. The planform was generally straight with limited sinuosity. The riparian zone associated with this feature was occupied by agricultural grasses, with no larger shrub or tree species visible through aerial photography.

Despite the change in land use from agricultural to residential in the Town of Caledon, the watercourse characteristics associated with the West Humber River and tributary were largely unchanged.

3 Watercourse Characteristics

3.1 General Reach Observations

Field investigations were completed on November 26, 2020 for **Reaches 1** and **3**, and included the following:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

These observations and measurements are summarized below. The descriptions are supplemented and supported with representative photographs, which are included in **Appendix C**. Field sheets, including those completed for rapid assessments, are provided in **Appendix D**. General reach characteristics for each reach are summarized below in **Table 1**.

Table 1. General reach characteristics

Reach	Average Bankfull Width (m)	Average Bankfull Depth (m)	Substrate		Riparian Vegetation	Notes
			Riffle	Pool		
Reach 1	6.36*	0.13*	No riffle-pool formation, clay and silt		Fragmented grasses and herbaceous species	Unconfined system, characteristic of an agricultural swale with limited morphology and evidence of erosion
Reach 3	3.22	0.87	Sand, gravel, cobble (clay/silt banks)	Sand and gravel (clay/silt banks)	Continuous grasses and tree species	Confined system, valley wall contacts, evidence of erosion, leaning and fallen trees

*Dimensions based on poor bankfull indicators (swale was heavily modified with encroachment of vegetation)

Reach 1 flows generally northwest to southeast through agricultural lands, crossing through the center of the property. The reach was characteristic of a swale through the subject lands. **Reach 1** was situated within an unconfined valley setting. The channel demonstrated a straightened planform with a low sinuosity that ranged from 1.00 – 1.05. The surrounding land use consisted of agricultural land and the channel was in a headwater zone. The riparian buffer zone was approximately 1 to 4 channel widths beyond the watercourse and had fragmented coverage. The dominant type of riparian vegetation was immature (less than 5 years) grasses and herbaceous species. There was extreme encroachment of vegetation into the channel. The reach had intermittent flow with a low gradient and low entrenchment. Bed material was composed of entirely clay and silt. There was no development of geomorphic units (i.e., riffles or pools). Approximately 90% of the reach was occupied by rooted emergent aquatic vegetation, and woody debris was not present in the cutbank or channel.

Average feature width and depth were approximately 6.36 m and 0.13 m, respectively. It is important to note that banks were poorly defined and bankfull indicators were absent on the day of assessment. Additionally, the reach was heavily modified and there was extreme encroachment of vegetation. Bank angles ranged from 0° to 60° and consisted of entirely clay/silt. Evidence of erosion was observed through less than 5% of the channel.

Reach 1 is subject to realignment to accommodate the proposed industrial development. As such, a detailed geomorphic assessment was completed through the reach.

Reach 3 flows northwest to southeast through a semi-confined valley system located at the northern extent of the subject property. Moving downstream, **Reach 3** enters a woodlot and traverses through adjacent agricultural lands, prior to crossing Mayfield Road. **Reach 3** was situated within a partially confined valley setting. The channel exhibited a meandering planform with irregular meanders. The surrounding land use consisted of agricultural land to the north and south of the floodplain and the channel was in a transfer zone. The riparian buffer zone was approximately 4 to 10 channel widths beyond the watercourse and had continuous coverage. The dominant type of riparian vegetation was immature grasses with few, established and mature (5 to >30 years) tree species. There was minimal encroachment of vegetation into the channel. The reach had perennial flow with a moderate gradient and moderate entrenchment. Bed material was composed of sand, gravel, and cobble at riffles and sand and gravel within pools. Approximately 10% of the reach was occupied by rooted submergent aquatic vegetation and there was a low density of woody debris present in the cutbank and channel.

Average bankfull width and depth were approximately 3.22 m and 0.87 m, respectively. Bank angles ranged from 60° to 90° and consisted of clay/silt, sand, gravel, and exposed till. Evidence of erosion was observed through 30 to 60% of the channel, with bank undercuts measuring up to 0.40 m in depth.

3.2 Rapid Assessment

Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

These observations and measurements are summarized below. The descriptions are supplemented and supported with representative photographs, which are included in **Appendix C**. Field sheets, including those completed for RGA and RSAT assessments, are provided in **Appendix D**. RGA and RSAT results for **Reach 3** are summarized in **Table 2**. Given the absence of defined morphology , it was not applicable to assess **Reach 1** using the RGA or RSAT protocols. **Reach 1** is more characteristic of an agricultural swale feature.

Reach 3 was assigned an RGA score of 0.23, indicating the reach was in transition/stress. The dominant geomorphological indicator was evidence of planimetric form adjustment by the observation of formation of chutes, formation of islands, and poorly formed/reworked/removed bar forms. The secondary geomorphological indicator was evidence of widening, based on observations of exposed tree roots, basal scour on inside meander bends, and basal scour on both sides of the channel through riffles. These characteristics influence the delineation of erosion risk in terms of overall channel stability. **Reach 3** had an RSAT score of 27, or *good*. There were two limiting factors, including physical instream habitat and riparian habitat conditions. This was due to the limited geomorphological units, limited diversity in habitat types, and a narrow riparian area of mostly non-woody vegetation. It is important to note that the time of the field investigation (late fall) likely impacted the overall RSAT score in terms of habitat conditions.

Table 2. Summary of Rapid Assessment Results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)		
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)
Reach 1	Agricultural swale feature – RGA/RSAT not appropriate					
Reach 3	0.23	In Transition/Stress	Planimetric Form Adjustment	27	Good	Physical instream habitat and riparian habitat

3.3 Detailed Assessment

Obtaining detailed geomorphological measurements and observations allows for a more complete characterization of channel geometry, flow and sediment characteristics. The data obtained were used to inform the natural corridor design for **Reach 1**. The detailed field assessment was completed on November 26, 2020 and included a survey of eight representative cross sections to determine average channel dimensions. A survey of the bed profile was also completed to determine slope and compute channel hydraulics. A summary of data collected as part of the detailed assessment and a site sketch showing the relative locations of surveyed cross-sections is contained in **Appendix D**. Measured and computed values are presented in **Table 3**, below.

Table 3. Measured bankfull channel parameters according to existing conditions

Channel Parameter	Reach 1
Measured	
Average bankfull channel width (m)	6.36*
Average bankfull channel depth (m)	0.13*
Average cross-sectional area (m^2)	0.82*
Bankfull channel gradient (%)	0.48
D_{50} (mm)	< 2
D_{84} (mm)	< 2
Manning's n roughness coefficient	0.04

*Dimensions based on visible feature width and depth (poor bankfull indicators and swale was heavily modified with encroachment of vegetation)

Approximately 160.7 m of the reach was surveyed and consisted of a relatively straight channel with extensive vegetation encroachment. Flow conditions at the time of the survey were relatively minimal. A Manning's n of 0.040 was assigned to the surveyed section of the reach. Channel bed substrate consisted predominantly of fine-grained sediments (<2 mm), and as such, a pebble was not completed as part of the field assessment. Monumented monitoring cross sections were not installed as part of the assessment as this reach is to be realigned.

4 Erosion Hazard Assessment

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width or erosion hazard assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a watercourse.

When defining the erosion hazard for a watercourse, Ministry of Natural Resources and Forestry (MNRF, 2002) guidelines treat unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible.

When a meandering channel is confined, erosion of the valley wall needs to be considered. The Ontario Ministry of Natural Resources and Forestry (MNRF) outlines an approach for establishing the erosion hazard for confined valley systems. This approach defines an appropriate erosion setback or toe erosion allowance from the channel bank where the creek is within 15 m from the toe of slope (MNRF, 2002). A toe erosion allowance can be determined in several ways: use of an average annual recession rate; use of a delineated toe erosion allowance in areas where the channel is within 15 m of the toe of slope; or use of soil information and field observations of geomorphic processes (MNRF, 2002).

In unconfined systems, the limit of the erosion hazard and migration potential can be delineated based on the meander amplitude. Meander amplitude is defined by Leopold et al. (1964) as the lateral distance between tangential lines drawn to the center channel of two successive meander bends. This differs from meander belt, which is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends (TRCA, 2004). Both the meander belt width and amplitude quantify the lateral extent of a river's occupation on the floodplain (TRCA, 2004).

At the subject property, an erosion hazard assessment was completed for **Reach 3** to identify the extent of possible erosion and delineate a natural hazard limit in support of development at the subject property. **Reach 3** was identified as a partially confined system with observations of valley wall contact. As such, both a meander belt width delineation and toe erosion allowance determination based on MNRF (2002) guidelines were completed for delineating the natural erosion hazard.

Where **Reach 3** was within a confined valley system or flowed within 15 m of the toe of slope (based on the topographic break in slope) through the subject property, a toe erosion allowance was determined to address the erosion hazard. Based on the type of bed and bank material (i.e., clay/silt, tills) and evidence of active erosion, a 5 m toe erosion was deemed appropriate using MNRF (2002) guidelines.

It is important to note that the total erosion hazard for confined valley systems is based on a combined influence of the toe erosion allowance and the stable slope. For confined systems, a stable slope is identified as 3:1 (H:V) or as determined by a study using accepted geotechnical principles (MNRF, 2002). A geotechnical investigation and slope stability analysis was completed for **Reach 3** by MTE Consultants (2021) to identify the stable top of slope. The geotechnical study confirmed that the slope is relatively stable under current conditions. The stable top of slope documented by MTE (2021) includes the 5 m toe erosion allowance, and as such, adequately characterizes the erosion hazard associated with **Reach 3**. The erosion setback delineation is provided in **Appendix E.**

Where **Reach 3** was within an unconfined valley system or flowed beyond 15 m from the toe of slope (based on the topographic break in slope), meander amplitude was applied to delineate the erosion hazard. Using recent aerial photographs from Google Earth Pro, the amplitude of three meander bends was measured. This measurement was used to inform the meander belt width delineation and address natural erosion hazard. Meander amplitudes were measured using an aerial photograph from 2005 (GEP) where the channel planform was discernable and unobstructed by vegetation. Meander amplitudes ranged from 11.8 m to 23.5 m. Further, a 20% factor of safety was applied to the largest meander amplitude (23.5 m) to account for changes in creek morphology over time. With a 20% factor of safety, the hazard limit is approximately 28.2 m. The meander belt width delineation is provided in **Appendix E.** The meander belt width associated with **Reach 3** was also applied to **Reach 2** within the subject property. Although **Reach 2** was located beyond the subject property, the meander belt width (28.2 m) extends into the subject property in one location. This is illustrated in **Appendix E**.

It was determined that **Reach 3** of the West Humber River contains regulated (occupied) Redside Dace habitat, a species classified as endangered both provincially and nationally. As such, to satisfy the requirements of the Provincial Policy for development activities in Redside Dace protected habitat, a 30 m buffer from the toe of slope within the confined valley system, and a 30 m buffer from the meander belt width within the unconfined valley system, is also required (MNRF, 2016).

5 Conceptual Natural Corridor Design

5.1 Design Objectives

Given **Reach 1** is proposed for realignment there is opportunity to replace the existing agricultural swale with a dynamically stable channel containing naturalized riffle and pool system, with cross sectional dimensions closer to that of a naturalized watercourse conveying similar flows. The natural corridor design will offer significant improvements to aquatic and terrestrial habitat through an open channel with riffle-pool sequences and wetland features.

From a habitat perspective, the important contributions of the watercourse include the provision of aquatic habitat, organic inputs to the system, provision of a more complex corridor system with elements that have a wide range of hydroperiods, and aquatic and terrestrial habitat elements. The inclusion of a riffle-pool system with offline wetland features provides a wide range of hydroperiods.

The proposed design provides a single thread channel with riffle-pool sequences that aim to reinstate and enhance channel form and function, provide habitat variability, improve sediment transport, and provide greater substrate and morphological variability.

The primary objectives of the design are to:

- Reinstate a more natural physical form, including planform and instream characteristics
- Restore the function of the channel and promote interaction with the floodplain
- Improve water quality by extending detention of water through offline and online wetland features
- Restore aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows
- Improve riparian habitat by installing woody plantings and floodplain features

In the development of a natural channel design, the length of the watercourse proposed to be realigned is typically replicated or exceeded, to provide an overall gain in habitat. The existing length of **Reach 1** proposed for realignment is approximately 1000 m. The realigned corridor will provide a total linear distance of approximately 1385 m. It is important to note that the existing watercourse is a heavily modified, agricultural swale, with extreme encroachment of vegetation. As such, it is not an ideal reference reach to inform the realignment design. To produce a system more similar to what would occur in nature, a sinuosity of 1.13 was applied to the realigned channel, resulting in an increased channel length of 1570 m. The proposed channel will therefore result in a significant increase in the area of restored and enhanced habitat. The proposed conceptual design is included in **Appendix F** and described in further detail below.

5.2 Channel Planform

The initial channel planform layout was created using the modelled radius of curvature value (*Rc*) as a guide. The radius of curvature (*Rc*) of meanders can be used to evaluate channel stability. For example, stable meanders typically exhibit larger *Rc* values as opposed to lower values that indicate increased channel bank erosion and avulsion. Bankfull width is often an appropriate indicator for this instability. Hickin and Nanson (1983) note that channel avulsions are common when meander *Rc* is approximately 1-2 times the channel bankfull width. For larger *Rc* (e.g., >5), the upstream limb of the meander will migrate more rapidly than the downstream limb (Hooke, 1975). Williams (1986) was used to derive values for the channel radius of curvature, using the following equation (Eq. 1):

$$Rc = 2.43 \times w \qquad \text{[Eq. 1]}$$

where *Rc* is the radius of curvature and *w* is the average bankfull width.

Empirical models derived by Hey and Thorne (1986) were followed to determine riffle spacing. Hey and Thorne's (1986) modelled values are often applied in larger watercourses. As such, multiple methods (Eq. 2-4) were considered in order to provide a range of riffle spacing values. These are:

$$Z = 6.31 \times w \qquad \text{[Eq. 2]}$$

$$Z = 9.1186 \times w^{0.8846} \qquad \text{[Eq. 3]}$$

$$Z = 7.36 \times w^{0.896} \times S^{-0.03} \qquad \text{[Eq. 4]}$$

where *Z* represents riffle spacing.

Stream power and unit stream power were calculated as a function of bankfull discharge and channel gradient (Eq. 5). Stream power values are important to determine the need for mitigating channel bank and bed erosion. Stream power is given by:

$$\Omega = \rho \times g \times d \times S \qquad \text{[Eq. 5]}$$

where ρ is the density of water (kg/m^3), *g* is the acceleration due to gravity (m/s^2), and *Q* and *S* are discharge (m^3/s) and channel gradient, respectively.

Stream power per unit width (Eq. 6), is given by:

$$\omega = \frac{\Omega}{w} \qquad \text{[Eq. 6]}$$

where as before, Ω and *w* are stream power and bankfull width, respectively.

The final channel planform was established through an iterative process. First, a cross-section with defined bankfull geometry was developed to calculate parameters for the planform (i.e., radius of curvature). The cross-section was then further refined, and riffle and pool lengths were determined based on channel gradient.

5.3 Bankfull Channel

The recommended restoration design focuses on a riffle-pool channel system that will provide significant improvements to not only the channel, as it essentially mimics a natural system, but also to aquatic habitat. The proposed channel design will provide a self-maintaining low-flow channel and provide connection to the floodplain. The channel carries the bankfull discharge, equivalent to the 1.25-year return post-development flow. A riffle-pool geometry will be incorporated in the channel design, and given the small gradient and limited discharge, there will be a level of vegetation encroachment. The extent of vegetation encroachment will also limit the potential erosion hazard of the realigned watercourse. When it is assessed to be an appropriate channel type, a riffle-pool system offers numerous benefits, namely:

- Channel bed relief for flow variability
- Relatively quiescent flows in pool sections to provide refuge for fish during high flows
- Instream energy dissipation
- Tortuous meanders to increase scour and pool depth, providing potential over wintering habitat for fish species

Channel dimensions are determined by bankfull discharge, as this represents what is generally considered the channel-forming discharge or the dominant discharge. Several methods can be applied to select an appropriate bankfull discharge. Hydraulic modelling was used to determine an appropriate bankfull discharge. The discharge used to size the bankfull channel was assumed to be equivalent to the 1.25-year flow, estimated using 60% of the modelled 1.5 year flow. As such, the bankfull discharge was defined as 0.18 m^3/s for Reach D1, 0.20 m^3/s for Reach D2, 0.22 m^3/s for Reach D3, 0.26 m^3/s Reach D4, and 0.40 m^3/s for Reach D5. Bankfull capacity for channels generally have a range from the 1- to 2-year return events. The channel has been subdivided into five separate design reaches based on changes in flow magnitude.

Riffle and pool geometries, as well as anticipated bankfull conditions, are provided in **Table 4**. A simple Manning's approach was used to iteratively back-calculate bankfull dimensions for the proposed channel. Since pools are designed to contain ineffective space, this model over-predicts the amount of discharge that they convey. However, the modelled values for the riffles give a better prediction of the channel capacity.

The design has an overall gradient of 0.38% for 1570 m. Reach D1 bankfull width and depth range from 1.70 m to 2.35 m, and 0.20 m to 0.35 m. Average riffle gradient for Reach D1 is 1.90%. Reach D2 bankfull width and depth range from 1.85 m to 2.45 m and 0.20 m to 0.35 m. Average riffle gradient for Reach D2 is 1.90%. Reach D3 bankfull width and depth range from 2.00 m to 2.60 m and 0.20 m to 0.35 m. Average riffle gradient for Reach D3 is 1.90%. Reach D4 bankfull width and depth range from 1.90 m to 2.45 m and 0.25 m to 0.40 m. Average riffle gradient for Reach D4 is 1.60%. Reach D5 bankfull width and depth range from 2.20 m to 2.70 m and 0.30 m to 0.45 m. Average riffle gradient for Reach D5 is 1.55%.

Table 4. Bankfull parameters for the proposed channel (Reach D1 and Reach D2)

Channel parameter	Reach D1		Reach D2	
	Riffle	Pool	Riffle	Pool
Bankfull width (m)	1.70	2.35	1.85	2.45
Average bankfull depth (m)	0.15	0.22	0.15	0.23
Maximum bankfull depth (m)	0.20	0.35	0.20	0.35
Bankfull width-to-depth ratio	8.50	6.71	9.25	7.00
Channel gradient (%)	1.90	0.38	1.90	0.38
Bankfull gradient (%)	0.38		0.38	
Radius of curvature (m)*	15		16	
Riffle-pool spacing (m)**	6		5	
Manning's roughness coefficient, *n*	0.05	0.04	0.05	0.04
Mean bankfull velocity (m/s) †	0.69	0.51	0.71	0.51
Bankfull discharge (m^3/s) †	0.18	0.27	0.20	0.29
Discharge to accommodate (m^3/s)	0.18	0.18	0.20	0.20
Tractive force at bankfull (N/m^2)	37	13	37	13
Stream power (W/m)	33	10	37	11
Unit stream power (W/m^2)	22	4	20	4
Froude Number (unitless)	0.58	0.34	0.58	0.34
Maximum grain size entrained (m) ††	0.04	0.01	0.04	0.01
Mean grain size entrained††	0.03	0.01	0.03	0.01

* Based on Williams (1986)
** Based on Hey and Thorne (1986)
† Based on Manning's equation
†† Based on Shields equation assuming Shields parameter equals 0.06 (gravel)

Table 5. Bankfull parameters for the proposed channel (Reach D3 and D4)

Channel parameter	Reach D3		Reach D4	
	Riffle	Pool	Riffle	Pool
Bankfull width (m)	2.00	2.60	1.90	2.45
Average bankfull depth (m)	0.15	0.23	0.19	0.25
Maximum bankfull depth (m)	0.20	0.35	0.25	0.40
Bankfull width-to-depth ratio	10.00	7.43	7.60	6.11
Channel gradient (%)	1.90	0.38	1.60	0.38
Bankfull gradient (%)	0.38		0.38	
Radius of curvature (m)*	17		16	
Riffle-pool spacing (m)**	6		5	
Manning's roughness coefficient, *n*	0.05	0.04	0.05	0.04
Mean bankfull velocity (m/s) †	0.72	0.52	0.73	0.54
Bankfull discharge (m^3/s) †	0.22	0.32	0.26	0.32
Discharge to accommodate (m^3/s)	0.22	0.22	0.26	0.26
Tractive force at bankfull (N/m^2)	37	13	39	15
Stream power (W/m)	41	12	40	12
Unit stream power (W/m^2)	20	5	25	7
Froude Number (unitless)	0.59	0.35	0.54	0.34
Maximum grain size entrained (m) ††	0.04	0.01	0.04	0.02
Mean grain size entrained††	0.03	0.01	0.03	0.01

* Based on Williams (1986)
** Based on Hey and Thorne (1986)
† Based on Manning's equation
†† Based on Shields equation assuming Shields parameter equals 0.06 (gravel)

Table 6. Bankfull parameters for the proposed channel (Reach D5)

Channel parameter	Reach D5	
	Riffle	Pool
Bankfull width (m)	2.20	2.70
Average bankfull depth (m)	0.22	0.28
Maximum bankfull depth (m)	0.30	0.45
Bankfull width-to-depth ratio	7.33	6.00
Channel gradient (%)	1.55	0.38
Bankfull gradient (%)	0.38	
Radius of curvature (m)*	18	
Riffle-pool spacing (m)**	6	
Manning's roughness coefficient, *n*	0.05	0.04
Mean bankfull velocity (m/s) †	0.81	0.58
Bankfull discharge (m^3/s) †	0.40	0.43
Discharge to accommodate (m^3/s)	0.40	0.40
Tractive force at bankfull (N/m^2)	46	17
Stream power (W/m)	61	16
Unit stream power (W/m^2)	33	9
Froude Number (unitless)	0.55	0.35
Maximum grain size entrained (m) ††	0.05	0.02
Mean grain size entrained††	0.04	0.01

* Based on Williams (1986)
** Based on Hey and Thorne (1986)
† Based on Manning's equation
†† Based on Shields equation assuming Shields parameter equals 0.06 (gravel)

5.4 Corridor Requirements

As part of the design, a meander belt width was calculated based on design bankfull dimensions to ensure that the planform has a meander belt width that falls within the proposed corridor. Given the scale of the watercourse and limited migration potential for the system, the hazard limits calculated can be considered conservative. The meander belt widths provided are based on modelled relations from Williams (1986) which were modified to include channel width and a factor of safety, and applied using the bankfull channel dimensions such that:

$$B_w = (4.3{W_b}^{1.12} + W_b) \times 1.2 \qquad \text{[Eq. 7]}$$

where Bw is meander belt width (m), and Wb is bankfull channel width (m). An additional 20% buffer, or factor of safety, was applied to the computed belt width values. This addresses issues of under prediction and provides a factor of safety.

The bankfull channel dimensions of the proposed channel have an average width of 2.03 m for Reach D1, 2.15 m for Reach D2, 2.30 m for Reach D3, 2.18 m for Reach D4 and 2.45 m for Reach D5. The resulting meander belt width estimates are provided in **Table 7**.

Table 7. Meander belt width estimate

Tributary of West Humber River	Meander Belt Width (m)*	Corridor Bottom Width (m)
Design Reach D1	14	17
Design Reach D2	15	17
Design Reach D3	16	17
Design Reach D4	15	17
Design Reach D5	17	17

*Based on modified Williams (Width) method (Eq. 1)

The predicted meander belt width for the realigned reaches ranges from 14 m to 17 m. It is anticipated that this channel will be stable given the low gradient and vegetation control and will unlikely migrate or adjust its channel planform within the bounds calculated. All meander belt width calculations are based on channels where instream energy is greater than potential resistance of the bank materials. As such, they over predict the potential extent of meandering of vegetation-controlled channels and the erosion hazard. The proposed valley bottom width of 17 m adequately addresses any potential erosion hazard.

5.5 Hydraulic Substrate Sizing

The sizing of the proposed substrate materials was guided by a review of hydraulic conditions (i.e., tractive force, flow competence) in the typical channel cross sections. The channel bed substrate is derived by balancing the average shear stress acting on the bed with the critical shear stress for the material. When the critical shear stress slightly exceeds the average shear stress acting on the bed, sediment transport is initiated.

To provide for a stable bed and level of sorting, 60% 50 mm – 100 mm diameter riverstone, 20% granular 'B', and 20% native material is proposed for the riffles. For the pools, the substrate will be comprised of 50% granular 'B' and 50% native material. Granular 'b' consists of a mix of stone where approximately 20% - 50% of the stone is greater than 0.005 m in diameter, but nothing larger than 0.15 m in diameter. These materials will always have a core of sediment that is not entrained under bankfull flow conditions. This material maintains the character of the native material, while providing slightly higher stability and opportunity for sediment sorting.

5.6 Design Elements

5.6.1 Corridor Wetland Features

Online and offline wetland features will be constructed in addition to the channel to provide formalized wetlands. To provide for elongated periods of floodplain inundation, the channel was sized to the 1.25-year return flow. As such, the proposed valley corridor has the potential to maintain wetland habitat and wetland tolerant species. This approach ensures replication of the existing riparian wetlands within the property.

These features enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits such as short-term water retention and sediment banking. They will be irregularly shaped to maximize the perimeter for a given area, which increases the potential for edge effects. Submerged and dry mounds are proposed within the offline wetlands to provide a topographically complex bottom to increase habitat heterogeneity. The short-term water retention function of these wetland types helps to polish water and moderate the discharge of water into the channel. These features will address the proposed wetland replication due to the removal of the existing meadow marsh feature along the existing drainage feature.

The proposed wetlands have depths ranging from 0.20 m to 0.30 m with deeper areas of up to 0.60 m provided for habitat variability. The wetlands were designed with mounds of variable heights to allow for a range of wetland vegetation to establish. We have provided variability to assure that from year-to-year a range of water depths and hydroperiods are provided. The proposed restoration planting plan will be completed by others and will include the appropriate plant species.

5.7 Site Restoration Recommendations

Newly constructed features can be vulnerable to erosion. This is particularly true before vegetation has established along the channel banks. While low-flow events should not intensify erosion, the concern for erosion occurs when there are high flows or precipitation events during construction.

For immediate erosion protection, mechanical stabilization in the form of biodegradable erosion control blankets (i.e., coir cloth, jute mat, etc.) should be used. As the blankets will biodegrade over time, this serves as a short-term stabilization measure.

For long-term stability, implementation of a planting plan is recommended. This includes deep rooting native grasses and other herbaceous species seeded along and within channel sections, prescription of flood tolerant native shrub and tree species, and use of seed banks within the local soil. Shrubs should be planted close to the channel margins to provided maximum benefit with respect to stabilization and channel cover.

Potential erosion locations (i.e., along the outside meander bends, immediately downstream of wetland features, etc.) should be anticipated, and should be reflected in the planting plan. Live staking and shrub stock should be used adjacent to the channel bank to provide immediate benefit as well as long-term infilling. If appropriate live staking methods are followed, this method should provide greater benefits than simple potted or bare root shrub plating. This is because of the potential for higher densities with live staking. At tortuous meander bends, root wads are proposed to provide additional channel stability.

6 Monitoring Plan Recommendations

6.1 Geomorphological Monitoring Plan

We have also assumed that a level of monitoring would be required for the site, specifically with regards to watercourses where hydrology changes are anticipated as a result of the proposed development. Geomorphological monitoring should include monumented cross section surveys and longitudinal profiles of the channel centre line at each site, channel substrate characterization, installation and documentation of erosion pins, and a collection of monumented photographs. Pre-construction monitoring should be completed prior to development to document baseline conditions. Monitoring should also continue through construction and the post-construction period, ending two-years following build-out of the site.

Results of the geomorphological monitoring should be summarized in annual reports for submission to regulatory agencies that include a comparison of pre- and post-development instream conditions and evaluate any changes in the context of anticipated natural variability in the system. These recommendations for monitoring are preliminary in nature. We have assumed that the monitoring program will be coordinated and finalized through consultation with TRCA and the Town as part of conditions of approval.

6.2 Monitoring During Channel Design Construction

Construction activities should be overseen by a qualified professional with experience in in-water works. Field fitting and adjustments are often required due to the dynamic nature of natural systems, and it is therefore beneficial to have an experienced inspector that can provide proper direction when necessary. A basic understanding of hydrodynamics and sediment transport is also beneficial, as an ill-conceived field adjustment could result in unintended consequences such as the redirection of flow that later creates erosion issues elsewhere.

6.3 Post-Construction Channel Design Monitoring

A post-construction monitoring program is recommended to assess the performance of the implemented channel design. Monitoring observations can also be used to determine the need for remedial works. The following activities should be undertaken by a fluvial geomorphologist and completed on a seasonal basis (i.e., spring and fall), unless otherwise indicated, for a period of two (2) full years following the year of construction.

The following tasks would be completed as part of the post-construction monitoring program:

- Collection of general observations of the channel works after construction and after the first large flooding event to identify any potential areas of erosion concern
- Completion of bi-annual visual inspections along the restored corridor to observe and document any areas of concern
- Collection of a monumented photographic record of site conditions during each visit
- Completion of a total station survey of the longitudinal profile and monumented cross sections following construction to serve as the as-built reference condition for use in comparing surveys completed in subsequent monitoring years
- Re-survey of the longitudinal profile and monumented cross sections annually during the fall and spring following construction
- Installation of erosion pins at monumented cross sections to be remeasured seasonally
- Characterization of bed material using a modified Wolman (1954) pebble count or bed sample, as appropriate, during each monitoring event
- Completion of an annual general vegetation survey

- Preparation of year-end reporting summarizing construction activities (i.e., design implementation), and subsequent year-end reports for the duration of the monitoring period

7 Summary and Recommendations

This report details the fluvial geomorphological assessment and conceptual corridor design completed in support of the proposed industrial development. The fluvial assessment included a review of previous studies, the completion of a historical assessment, rapid and detailed field reconnaissance, the development of a conceptual corridor design for **Reach 1** and monitoring program recommendations.

Two (2) watercourse features, including the main branch of West Humber River and one tributary of the West Humber River, traverse the subject property at 12035 Dixie Road in the Town of Caledon, Ontario. The subject property is occupied by agricultural lands, a small wetland feature to the north, and a small woodlot feature to the northeast. The main branch of the West Humber River flows within a partially confined valley system, whereas the smaller tributary occupies an unconfined valley system.

Reach 1 flowed generally northwest to southeast through agricultural lands, crossing through the center of the property. The reach was characteristic of a swale and was situated within an unconfined valley setting. There was extreme encroachment of vegetation into the channel and no development of geomorphic units (i.e., riffles or pools). Evidence of erosion was observed through less than 5% of the channel. **Reach 1** was subject to realignment to accommodate the proposed industrial development. As such, a detailed geomorphic assessment was completed through the reach.

Reach 3 flowed northwest to southeast through a semi-confined valley system located at the northern extent of the subject property. **Reach 3** was situated within a partially confined valley setting. The channel exhibited a meandering planform with irregular meanders. Evidence of erosion was observed through 30 to 60% of the channel, with bank undercuts measuring up to 0.40 m in depth. In locations where **Reach 3** was within 15 m from the toe of slope within the subject property, a toe erosion allowance was determined to address the erosion hazard. Based on the type of bed and bank material (i.e., clay/silt, tills) and evidence of active erosion, a 5 m toe erosion was deemed appropriate. The 5 m toe erosion allowance was also applied to the stable top of slope (MTE, 2021) to delineate the total erosion hazard. In locations where **Reach 3** was beyond 15 m from the toe of slope, or flowed through an unconfined valley system, a meander belt width was delineated to address the erosion hazard. To delineate the meander belt width, the amplitude of three (3) meander bends were measured. With a 20% factor of safety, the hazard limit was approximately 28.2 m. This delineation was applied to **Reach 2** where it approached the subject property boundary.

An additional drainage feature was observed on site through a desktop assessment of recent aerial imagery from Google Earth Pro. It is understood that a review of headwater channels was completed separately by WSP in 2020 to address features within the areas of active agriculture on site. To update and refine the findings of the 2020 assessment, a headwater drainage feature assessment should be completed in 2021 in accordance with the TRCA/CVC (2014) guidelines for headwater drainage feature evaluation.

A conceptual corridor design has been developed for the portion of **Reach 1** within the subject lands that will enhance seasonal aquatic habitat and provide a diverse channel and floodplain morphology. The proposed design includes a riffle and pool system that aims to improve channel form and function, increase habitat variability, increase low flow habitat, improve sediment transport, and provide greater substrate and morphological variability. To provide a self-maintaining low-flow channel while also providing a connection to the floodplain, a nested channel is proposed.

To assist with the detailed design and ensure proper implementation of the channel design, the following additional recommendations are provided:

- Confirm valley and channel gradients
- Confirm locations and requirements for outlet treatments from stormwater management facilities
- Develop a native planting plan for the proposed corridor that will complement the bioengineered treatments, wetland features, and riparian live stake plantings
- Establish site access routes, staging and storage areas for construction
- Prepare an erosion and sediment control plan to facilitate implementation

7.1 Report Considerations

This report was completed for the sole use of the Client. This report is not intended to be exhaustive in scope and may not address all aspects potentially applicable to the site. Further, this report may not address all aspects which may be of interest to the reader.

The results of analyses presented in this report are based on conditions as they existed during the period of work. The material in the report reflects our best judgement using the information available at the time of report preparation.

It is important to note that seasonality and/or year-to-year conditions can impact observations and interpretation of observations. Further, it should be recognized that the characterization of features, conclusions, and recommendations in this report may be affected over time, as site conditions and regulatory requirements change.

All design details were not known at the time of submission of this report. Refinements or changes to the design could impact our interpretation or recommendations related to the site.

Any use which another party makes of this report, or any reliance on, are the responsibility of such parties. GEO Morphix accepts no responsibility for liabilities incurred by, or damages by another party, as a result of decisions made or actions taken, based on this report.

We trust this report meets your current requirements. Should you have any questions or concerns, please contact the undersigned.

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., CAN-CISEC, EP, CERP
Director, Principal Geomorphologist

Josie Mielhausen, M.Sc.
Junior Environmental Scientist

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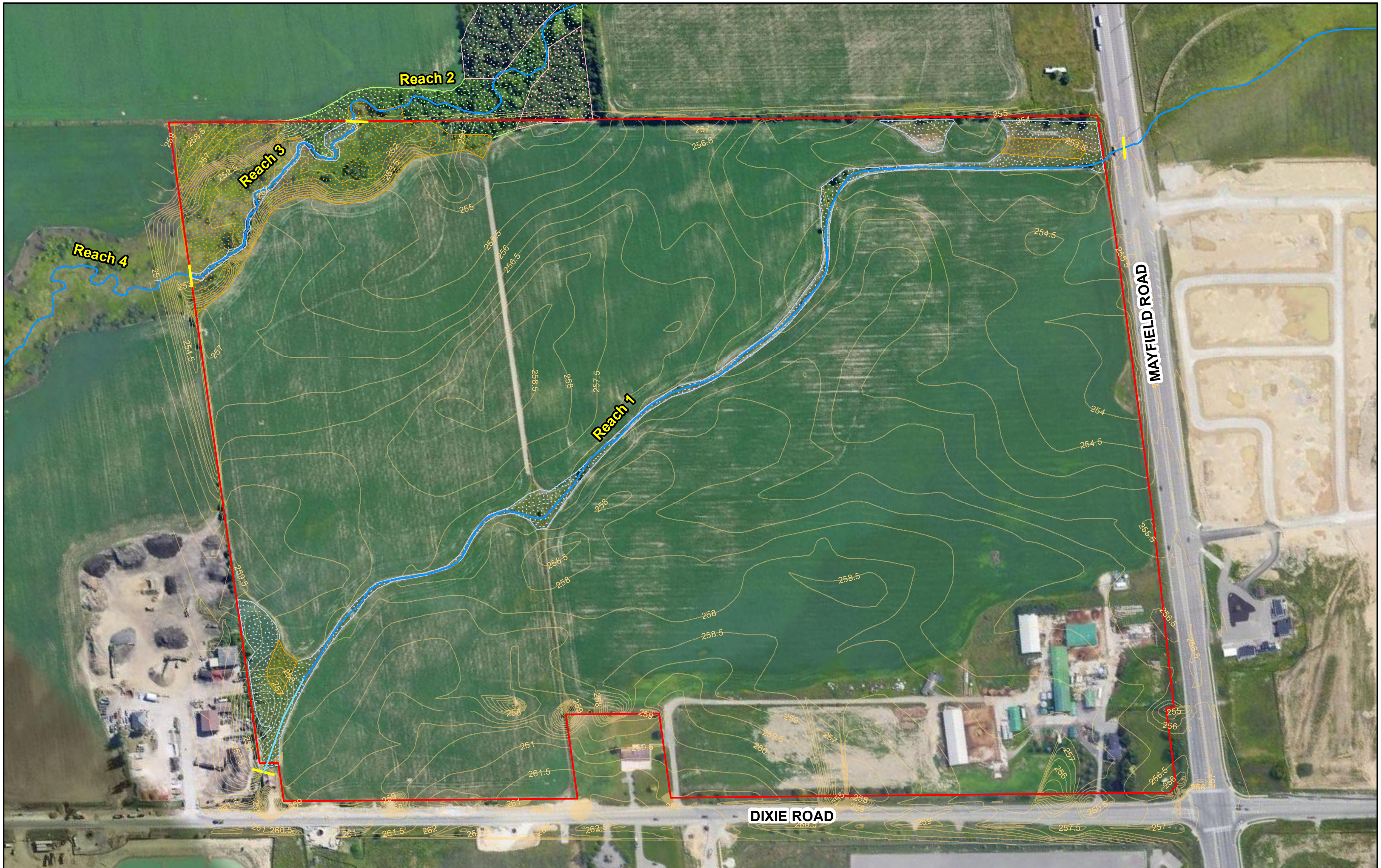
Appendix A
Study Site Map and Reach Delineation



Legend

- Reach Break and Label
- Watercourse (TRCA)
- Watercourse (Peel - Modified)
- Subject Land Boundary
- 0.5 m Contour

Ecological Land Classification

- CUM1-1
- FOD5
- FODM7-7
- MAMM3-1

12035 Dixie Road

Study Site and Reach Delineation

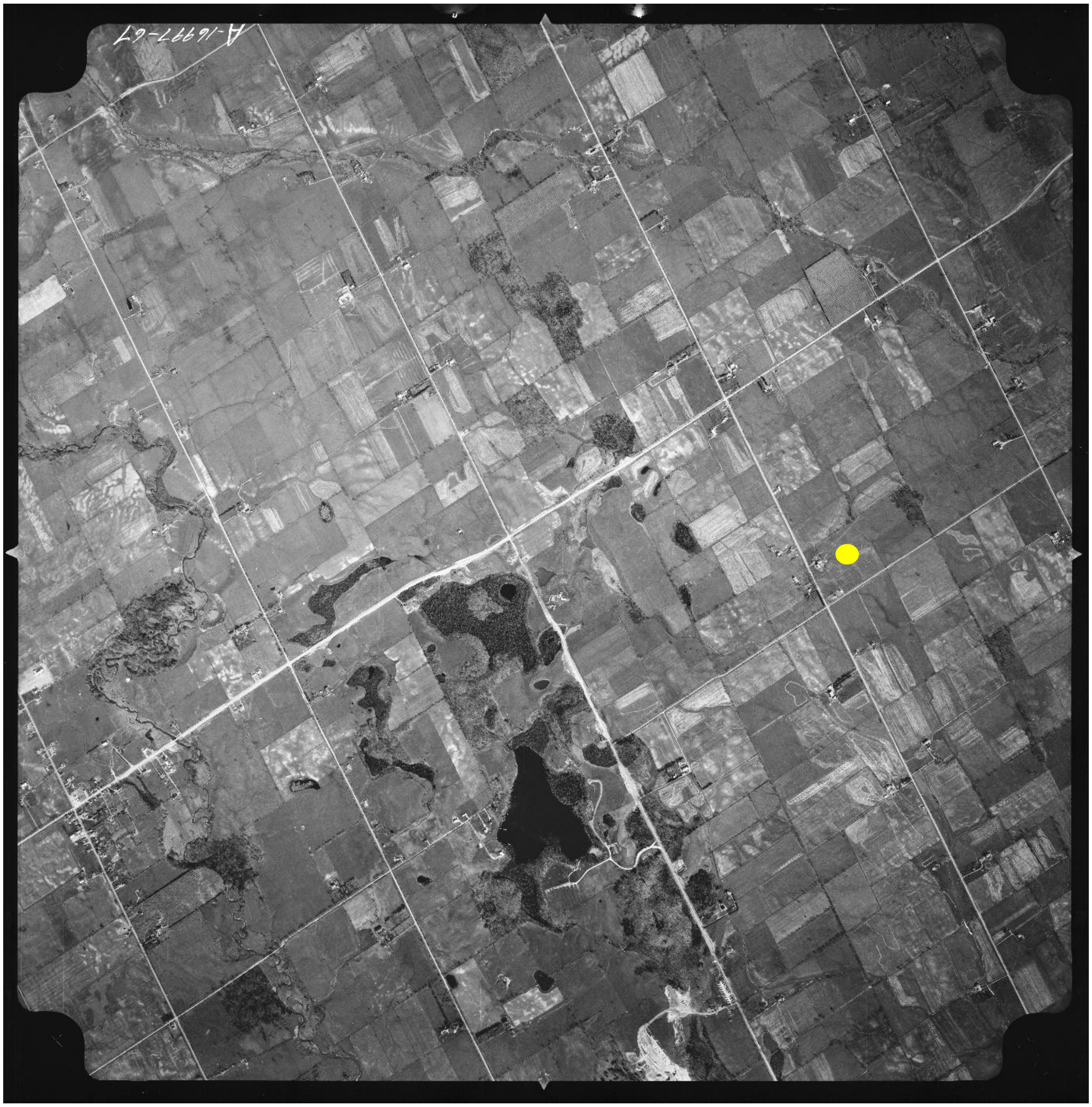
Caledon, Ontario

GEO MORPHIX™

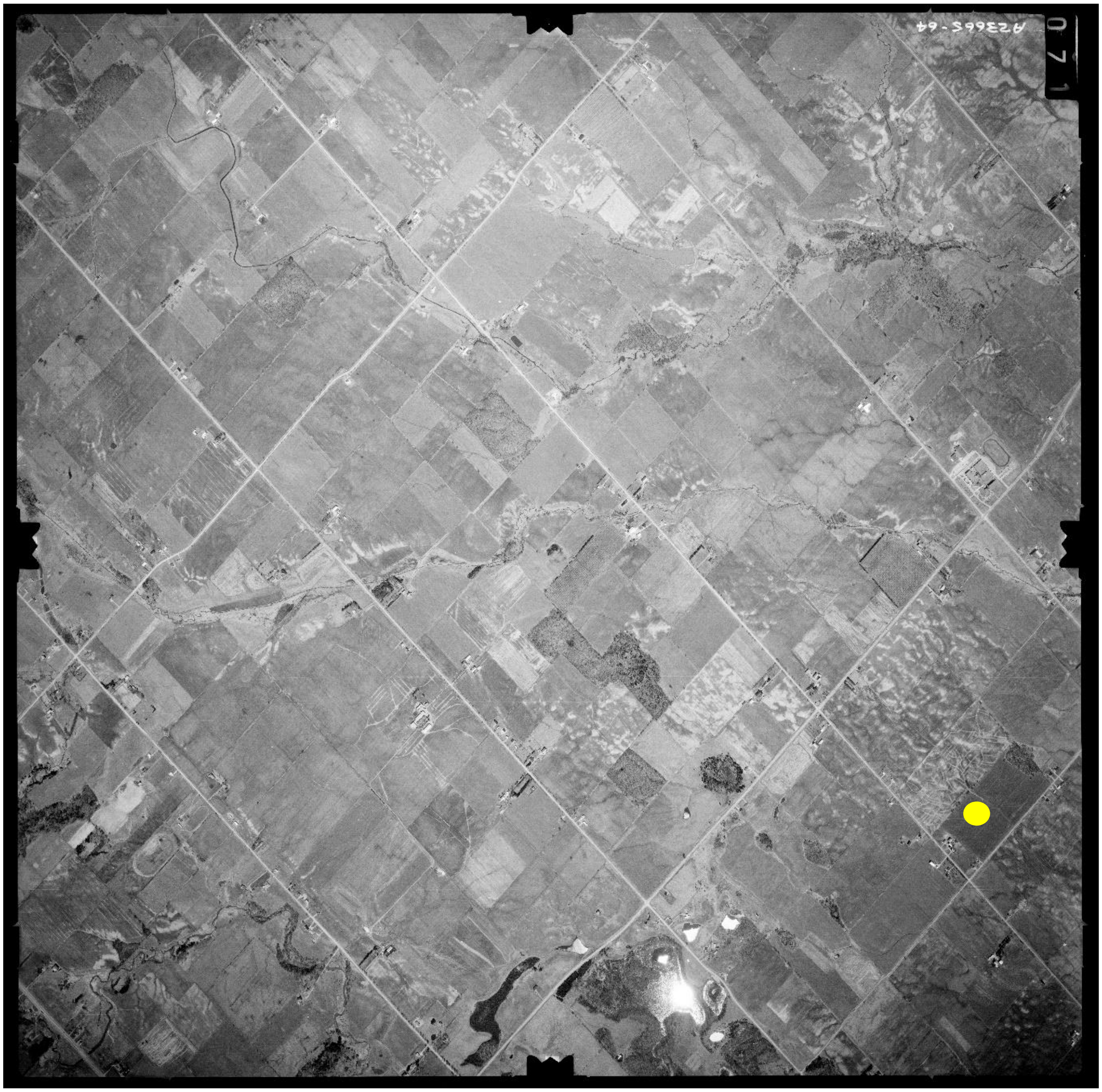
0 50 100
Metres

Imagery: Google Earth Pro, 2018.
Subject Land Boundary, and 0.5 m Contour: R. Avis Surveying Inc., 2021.
Reach Break and Label: GEO Morphix Ltd., 2021.
Watercourse: TRCA, 2021 / Region of Peel, 2020 and GEO Morphix Ltd., 2021.
Printed: March 2021. PN20109. Drawn by M.H., J.M., P.V.

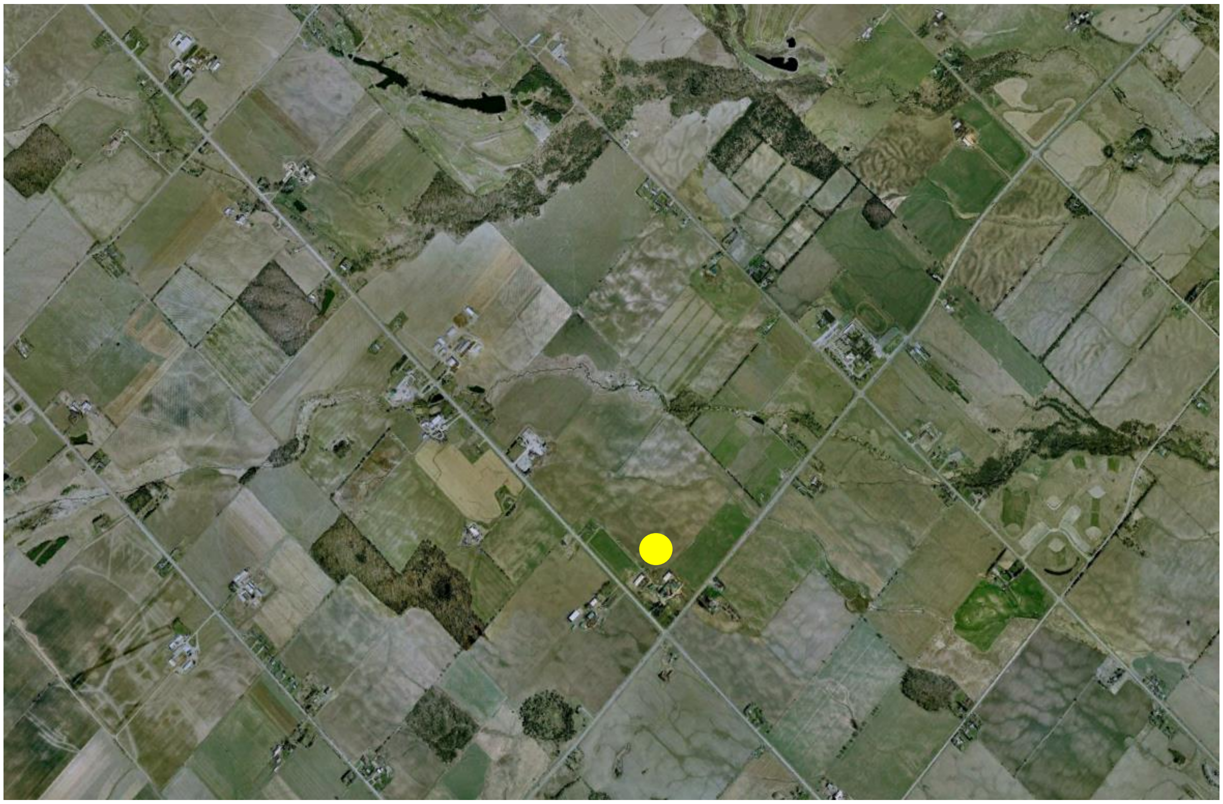
Appendix B
Historical Aerial Photographs



Location: 12035 Dixie Road, Caledon, ON (yellow dot)
Year: 1960
Scale: 25,000
Source: National Air Photo Library



Location: 12035 Dixie Road, Caledon, ON (yellow dot)
Year: 1974
Scale: 25,000
Source: National Air Photo Library



Location: 12035 Dixie Road, Caledon, ON (yellow dot)
Year: 2005
Source: Google Earth Pro

Location: 12035 Dixie Road, Caledon, ON (yellow dot)
Year: 2018
Source: Google Earth Pro

Appendix C
Photographic Record

Photo 1 Reach 1 – Tributary of West Humber River	 Upstream view towards the upstream extent of the subject lands. Extreme vegetation encroachment was observed through the upstream segment of the feature.
Photo 2 Reach 1 – Tributary of West Humber River	 Photograph taken mid-reach looking downstream where the channel gains definition. The tributary of the West Humber River flows generally west to east through agricultural lands.

Photo 3 Reach 1 – Tributary of West Humber River	 The fragmented riparian buffer zone was 1 to 4 channel widths. Riparian vegetation was comprised of a mix of immature (<5 years) grasses and herbaceous species.
Photo 4 Reach 1 – Tributary of West Humber River	 Photograph taken looking downstream. Riffle-pool sequencing was not observed, and bed materials consisted of entirely clay and silt.

Photo 5
Reach 1 – Tributary of West Humber River

Downstream view of the watercourse. Rooted emergent aquatic/instream vegetation was observed through approximately 90% of the reach.

Photo 6
Reach 1 – Tributary of West Humber River

Reach 1 flowed through an unconfined valley system. The watercourse was poorly defined through sections and characterisitic of an agricultural swale.

Photo 7 Reach 3 – West Humber River		
	Photograph looking upstream at the furthest downstream extent of Reach 3 within the subject lands. The channel was single-thread, meandering, with irregular meanders.	
Photo 8 Reach 3 – West Humber River		
	Reach 3 flowed through a partially confined valley system with valley wall contact observed (pictured here). Leaning trees were observed along the valley wall (arrows).	

Photo 9 Reach 3 – West Humber River	
	Photograph taken looking towards the right bank (facing upstream). Bank erosion was present through 30 to 60% of the reach and was observed through scouring of the channel banks. Basal scour was observed on the inside of meander bends and through riffles.
Photo 10 Reach 3 – West Humber River	
	Average bankfull width and depth were 3.22 and 0.87 m, respectively. The riparian zone was 1 to 4 channel widths and dominated by grasses.

Photo 11
Reach 3 – West Humber River

Photograph taken looking upstream. The reach had a narrow riparian area of mostly non-woody vegetation. Riparian habitat conditions were limited with <50% canopy coverage.

Photo 12
Reach 3 – West Humber River

Formation of chutes (pictured here) were observed throughout the reach. This provided evidence of planimetric form adjustment.

Photo 13
Reach 3 – West Humber River

Formation of islands were also noted and provided further evidence of planimetric form adjustment processes.

Photo 14
Reach 3 – West Humber River

Leaning and fallen trees (circled), as well as exposed tree roots, provided evidence of channel widening. Exposed tree roots were old, large, and woody improving channel stability.

Photo 15 Reach 3 – West Humber River	 Photograph taken looking upstream. There was limited development of geomorphic units. Reach 3 was dominated by riffles and runs, with few pools present, limiting physical instream habitat.
Photo 16 Reach 3 – West Humber River	 Bank materials consisted of clay/silt, sand, gravel, and occasionally exposed till. Undercuts up to 0.40 m were measured.

Photo 17
Reach 3 – West Humber River

Riffle substrate consisted of primarily sand, gravel, and cobble. Moving upstream, larger materials including boulders were observed.

Photo 18
Reach 3 – West Humber River

Photograph taken facing the valley wall. Approximately 71 to 80% of the bank network was considered stable with infrequent signs of bank slumping or failure (pictured here).

Photo 19
Reach 3 – West Humber River

Photograph taken looking upstream. Rooted submergent aquatic/instream vegetation was observed through approximately 10% of the reach.

Photo 20
Reach 3 – West Humber River

Upstream view of the watercourse at the furthest upstream extent of the subject lands. Evidence of planimetric form adjustment and widening were the key geomorphic indicators of channel stability through the reach.

Appendix D
Field Assessment Sheets

GEO | MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 1
Weather:	OVERCAST 11°C	**Location:**	12035 DIXIE RD, CALEDON
Field Staff:	LVM BB	**Watershed/Subwatershed:**	

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

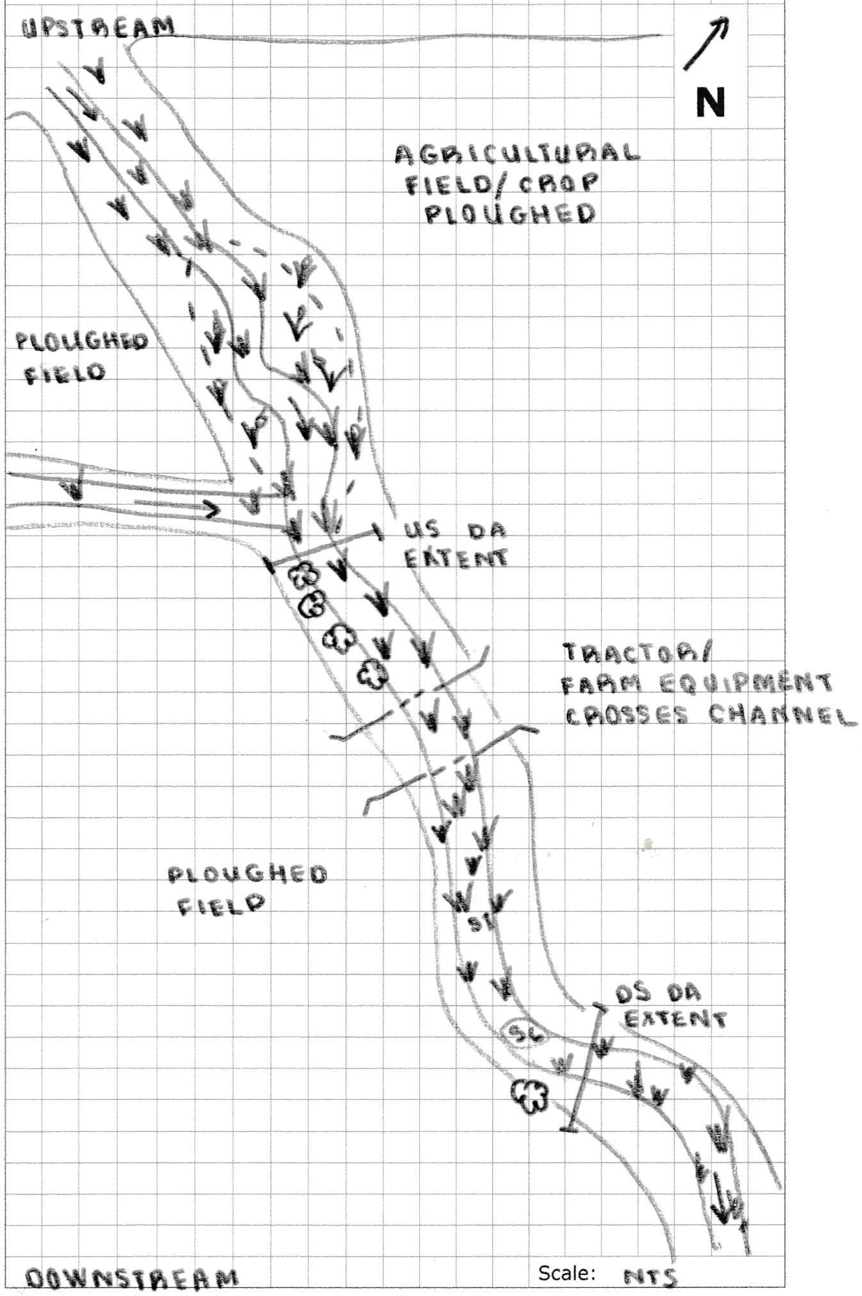
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch:



Scale: NTS

Additional Notes:

Completed by: BB Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 1
Weather:	OVERCAST 11°C	**Location:**	12035 DIXIE RD, CALEDON
Field Staff:	CVM BB	**Watershed/Subwatershed:**	
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 3 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 11 | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 2 | ☒ Groundwater | Evidence: WATERCRESS

Riparian Vegetation

Dominant Type: (Table 6) 3/4

Species: GRASS + HERBACEOUS MIX

Coverage:
- ☐ None
- ☒ Fragmented
- ☐ Continuous

Channel widths:
- ☒ 1-4
- ☐ 4-10
- ☐ > 10

Age Class (yrs):
- ☒ Immature (<5)
- ☐ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7) 5

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 90

Woody Debris
- ☐ Present in Cutbank
- ☐ Present in Channel
- ☒ Not Present

Density of WD:
- ☒ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9): 1 | **Sinuosity (Degree)** (Table 10): 1 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): 1 | **Downs's Classification** (Table 15): 5

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☒	☐	☐	☐	☐	☐	☐
Pool Substrate	☒	☐	☐	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☐

* SEE DETAILED ASSESSMENT

Bankfull Width (m) *: \ | \ | \
Wetted Width (m) *: \ | \ | \
Bankfull Depth (m) *: \ | \ | \
Wetted Depth (m) *: \ | \ | \

Bank Angle
- ☒ 0 – 30
- ☒ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☒ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Riffle/Pool Spacing (m): N/A | % Riffles: 0 | % Pools: 0 | Meander Amplitude: N/A

Pool Depth (m): N/A | Riffle Length (m): N/A | Undercuts (m): 0 | Comments: NO MEANDERS

Velocity (m/s): \ | \ | \ | Wiffle ball / ADV / Estimated → SEE DETAILED ASSESSMENT

Notes:

- NO RIFFLE POOL SEQUENCING
- VEGETATED SWALE
- RGA/RSAT NOT APPLICABLE
- BANKS NOT WELL DEFINED

Completed by: BB

Checked by:

GEO | MORPHIX
Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 3
Weather:	OVERCAST 11°C	**Location:**	12035 DIXIE RD, CALEDON
Field Staff:	CVM BB	**Watershed/Subwatershed:**	

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

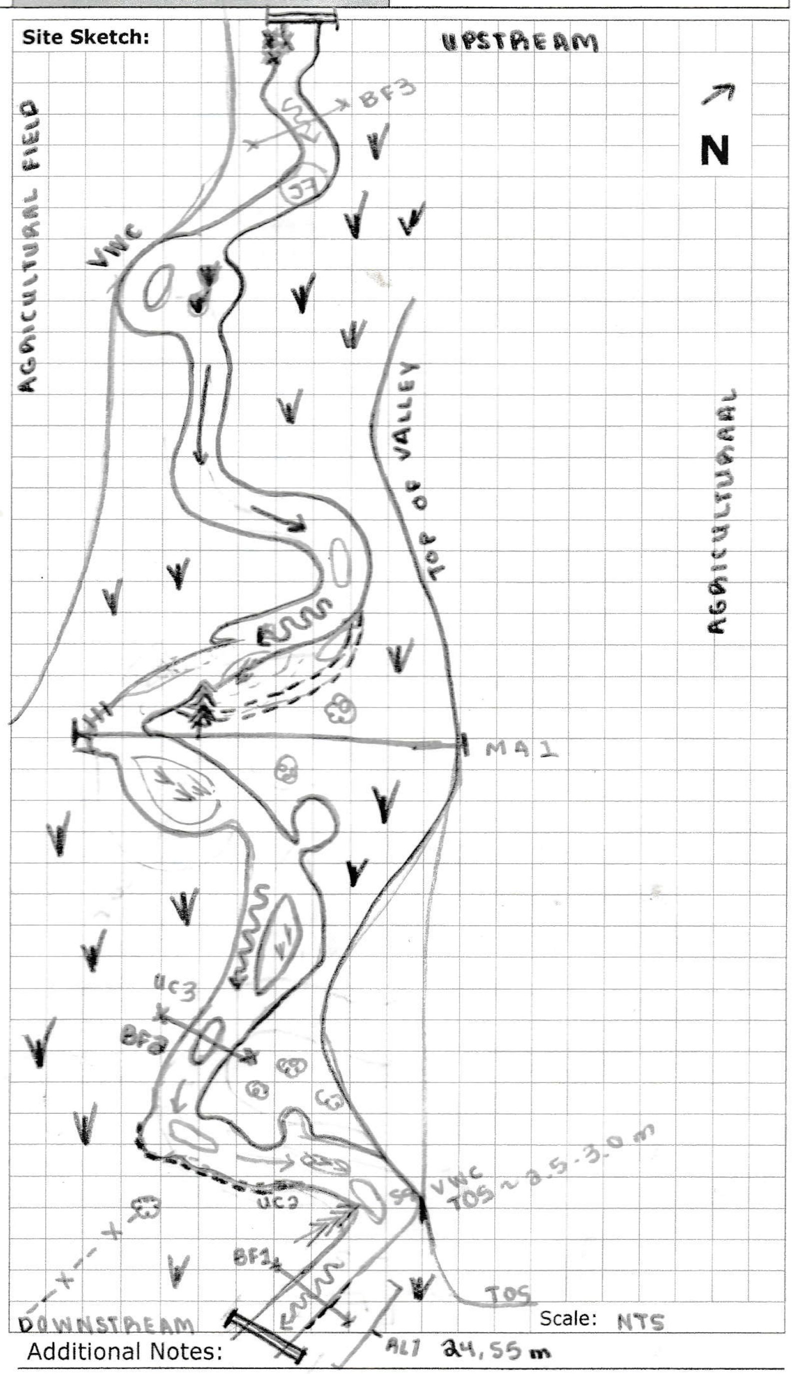
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch:



Scale: NTS

Additional Notes: ALT 24.55 m

- UC2 : 0.20 m
- UC3 : 0.40 m
- MA = 52 m

Completed by: BB Checked by: ________

GEO | MORPHIX

Rapid Geomorphic Assessment **Project Code:** PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 3
Weather:	OVERCAST 11°C	**Location:**	13035 DIXIE RD, CALEDON
Field Staff:	BB CVM	**Watershed/Subwatershed:**	

Process	No.	Description	Yes	No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0/7
	2	Coarse materials in riffles embedded		X	
	3	Siltation in pools		X	
	4	Medial bars		X	
	5	Accretion on point bars		X	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	7	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		1/9
	2	Exposed sanitary / storm sewer / pipeline / etc.		X	
	3	Elevated storm sewer outfall(s)		X	
	4	Undermined gabion baskets / concrete aprons / etc.		X	
	5	Scour pools downstream of culverts / storm sewer outlets		X	
	6	Cut face on bar forms		X	
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock	X		
		Sum of indices =	1	8	0.11
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		X	3/8
	2	Occurrence of large organic debris		X	
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends	X		
	5	Basal scour on both sides of channel through riffle	X		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation	N/A		
		Sum of indices =	3	5	0.38
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	X		3/7
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		X	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)	X		
	6	Thalweg alignment out of phase with meander form		X	
	7	Bar forms poorly formed / reworked / removed	X		
		Sum of indices =	3	4	0.43

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =				0.23
Condition	**In Regime**	**In Transition/Stress**	**In Adjustment**	
SI score =	☐ **0.00 - 0.20**	☒ **0.21 - 0.40**	☐ **0.41**	

Completed by: BB Checked by: ________

Rapid Stream Assessment Technique **Project Code:** PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 3
Weather:	OVERCAST 11°C	**Location:**	12035 DIXIE RD, CALEDON
Field Staff:	CVM BB	**Watershed/Subwatershed:**	

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☐ 7 ☒ 8	☐ 9 ☐ 10 ☐ 11

Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8

Date:	2020-11-26	Reach:	REACH 3	Project Code:	PN20109

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
N/A	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☒ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 27	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: BB Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: PN20109

Date:	2020-11-26	**Stream/Reach:**	REACH 3
Weather:	OVERCAST 11°C	**Location:**	12035 DIXIE RD, CALEDON
Field Staff:	CVM BB	**Watershed/Subwatershed:**	
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 3 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 13 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☒ Groundwater | Evidence: WATERCRESS

Riparian Vegetation

Dominant Type: (Table 6) 3

Species: GRASS/ HERBACEOUS SP.

Coverage: ☐ None ☐ Fragmented ☒ Continuous

Channel widths: ☒ 1-4 ☐ 4-10 ☐ > 10

Age Class (yrs): ☐ Immature (<5) ☒ Established (5-30) ☐ Mature (>30)

Encroachment: (Table 7) 2

Aquatic/Instream Vegetation

Type (Table8): 2 | Coverage of Reach (%): 10

Woody Debris: ☒ Present in Cutbank ☒ Present in Channel ☐ Not Present

Density of WD: ☒ Low ☐ Moderate ☐ High

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9): 5 | **Sinuosity (Degree)** (Table 10): 3 | **Gradient** (Table 11): 2 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 2 | **Type of Bank Failure** (Table 14): 6 | **Downs's Classification** (Table 15): C *

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☒	☒	☒	☐	☐	☐
Pool Substrate	☐	☒	☒	☐	☐	☐	☐
Bank Material	☒	☒	☒	☐	☐	☒	☐

	BF1	BF2	BF3		MH = 100 mm		30
Bankfull Width (m)	3.40	3.30	2.95	**Wetted Width (m)**	1.90	2.60	1.35
Bankfull Depth (m)	0.60	1.30	0.70	**Wetted Depth (m)**	0.14	0.48	0.26

Riffle/Pool Spacing (m): >15 | **% Riffles:** 20 | **% Pools:** 40 | **Meander Amplitude:** 52.0

Pool Depth (m): 0.50 | **Riffle Length (m):** 16.3 | **Undercuts (m):** 0.13 \0.20\ 0.40

Comments:

Velocity (m/s): 0.74 | \ | \ | Wiffle ball / ADV / Estimated

Bank Angle: ☐ 0 – 30 ☐ 30 – 60 ☒ 60 – 90 ☒ Undercut

Bank Erosion: ☐ < 5% ☐ 5 – 30% ☒ 30 – 60% ☐ 60 – 100%

Notes:

Completed by: BB Checked by: ______

Detailed Geomorphological Assessment Summary

Reach 1

Project Number:	PN20109	**Date:**	2020-11-26
Client:	Tribal Partners Canada Inc.	**Length Surveyed (m):**	160.7
Location:	12035 Dixie Road, Caledon	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses
Geology/Soils:	Silty to clayey till	**Extent of Riparian Cover:**	Fragmented
Surrounding Land Use:	Agricultural	**Width of Riparian Cover:**	1 to 4 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Immature (<5 years)
Dominant Instream Vegetation Type:	Rooted emergent	**Extent of Encroachment into Channel:**	Heavy
Portion of Reach with Vegetation:	90%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.00	**Calculated Bankfull Discharge (m^3/s):**	Not calculated
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	Not calculated
Modelled 2-year Velocity (m/s):	Not modelled		

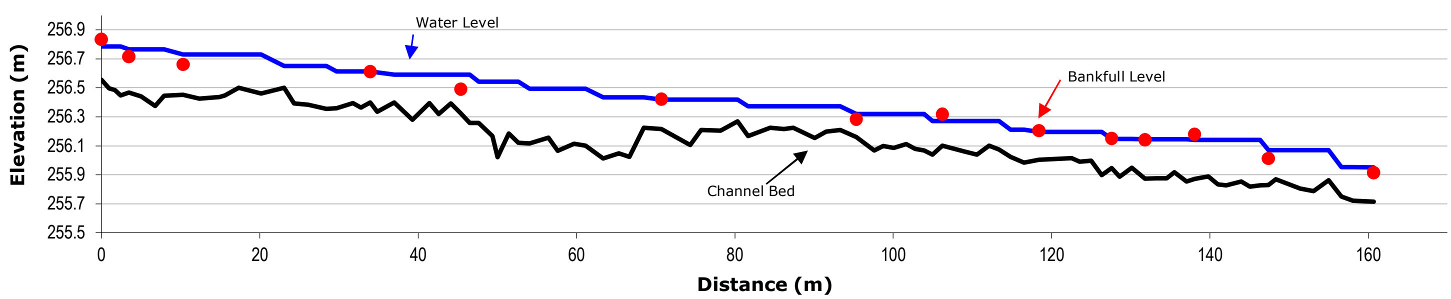
Profile Characteristics

Bankfull Gradient (%):	0.48
Channel Bed Gradient (%):	0.43
Riffle Gradient (%):	N/A
Riffle Length (m):	N/A
Riffle-Pool Spacing (m):	N/A

Planform Characteristics

Sinuosity:	1.04
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.20	0.42	0.32
Bank Angle (deg):	15	30	23
Root Depth (m):	0.05	0.05	0.05
Root Density (%):	5	5	5
Bank Undercut (m):	0.00	0.00	0.00

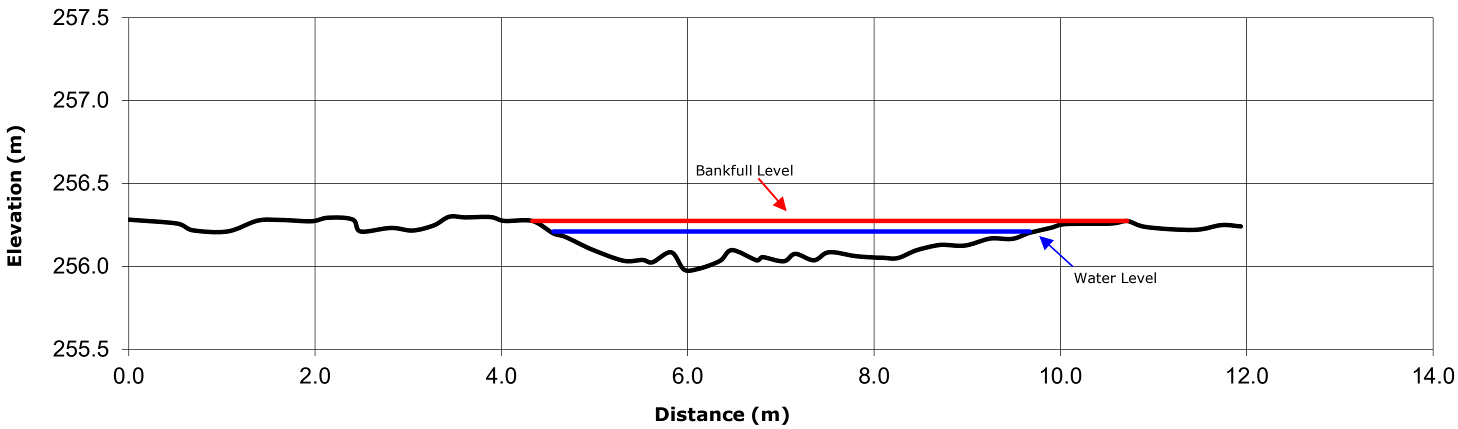
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to silt	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	4.65	8.28	6.36
Average Bankfull Depth (m):	0.10	0.18	0.13
Bankfull Width/Depth (m/m):	26	72	51
Wetted Width (m):	5.09	7.99	6.43
Average Water Depth (m):	0.08	0.17	0.12
Wetted Width/Depth (m/m):	30	76	58
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.18	0.37	0.25
Manning's *n*:		N/A	

Photograph at Cross-Section 6 (looking downstream)

Representative Cross-Section 6



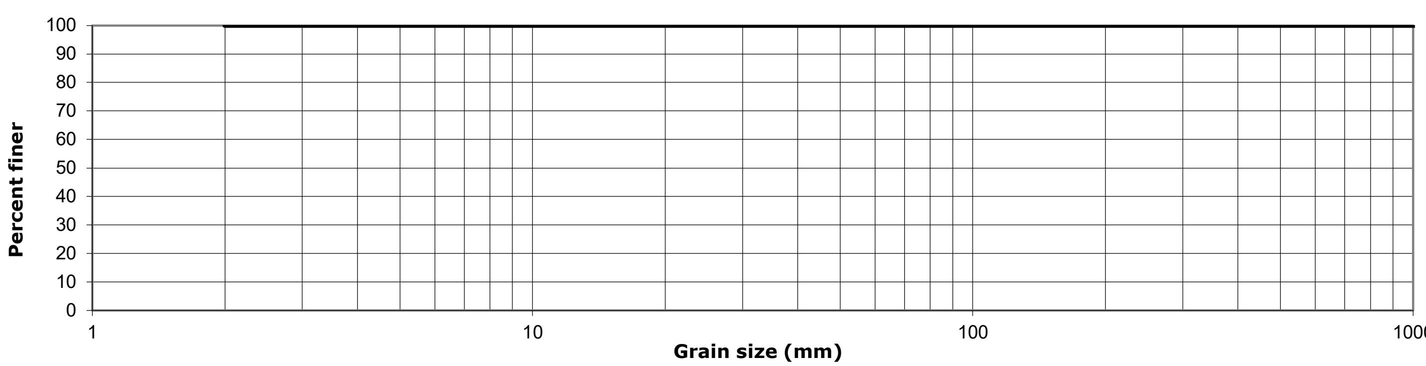
Substrate Characteristics

Particle Size (mm)

D_{10} :	0.0
D_{50} :	0.0
D_{84} :	0.0

Subpavement:	Till
Particle shape:	Platy
Embeddedness (%):	0
Particle range (riffle):	No riffles
Particle Range (pool):	No pools

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	6.30
for D_{50}:	0.00	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.00	**Critical Shear Stress (D_{50}) (N/m^2):**	0.00
Unit Stream Power at Bankfull (W/m^2):	N/A		

General Field Observations

Channel Description

Reach 1 generally flows northwest to southeast across the subject property through active agricultural fields. The unconfined single channel exhibited a straight planform with a low gradient and low entrenchment. The riparian buffer zone spanned 1 to 4 channel widths and was fragmented. Riparian vegetation was comprised of immature (less than 5 years) grasses and herbaceous species. A low degree of woody debris was noted within the channel and cutbank. Aquatic vegetation consisted of rooted emergent species such as cattails and covered approximately 90% of the reach. Banks were poorly defined. Bed and bank materials consisted of entirely fine materials, ranging from clay to silt. Overall, Reach 1 was characteristic of a vegetated agricultural swale.

Cross-Section 8 - Facing Downstream

Appendix E
Erosion Setback Mapping

Legend

- Erosion Setback Point
- Stable Top of Slope (3:1)
- 5 m Toe Erosion Setback
- 10 m Erosion Access Allowance
- Meander Belt Width
- Watercourse Central Tendency
- Toe of Slope
- Top of Slope
- Watercourse
- Subject Land Boundary
- 0.5 m Contour

12035 Dixie Road

Preliminary Erosion Setback and Meander Belt Width

Caledon, Ontario

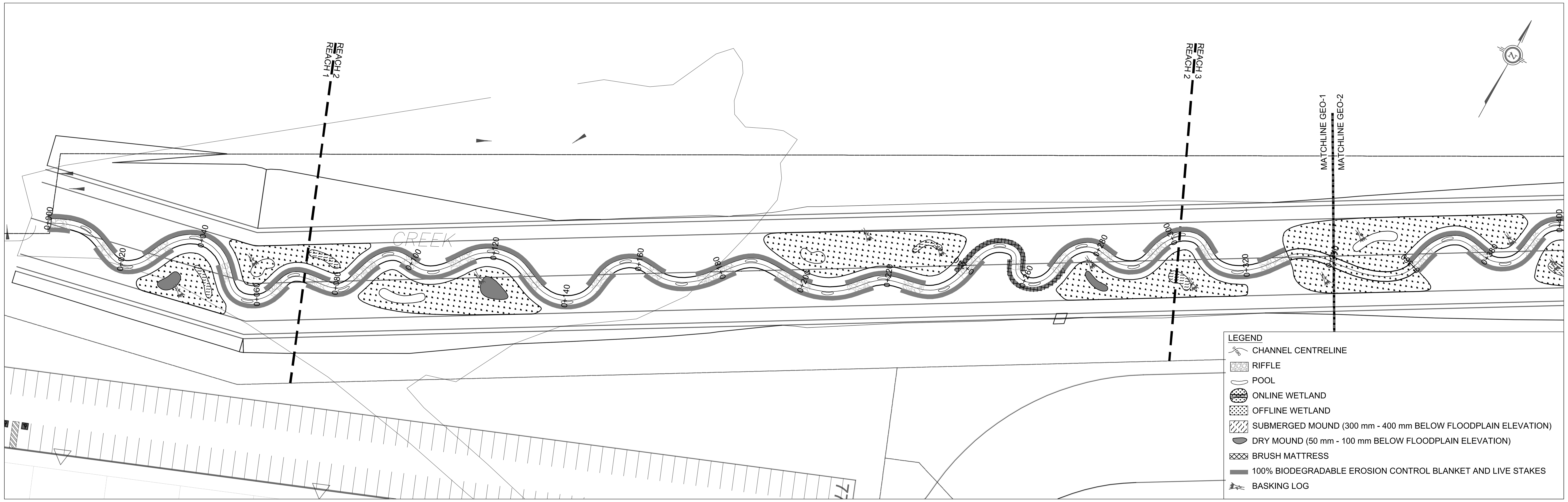
GEO MORPHIX™

0 20 40
Metres

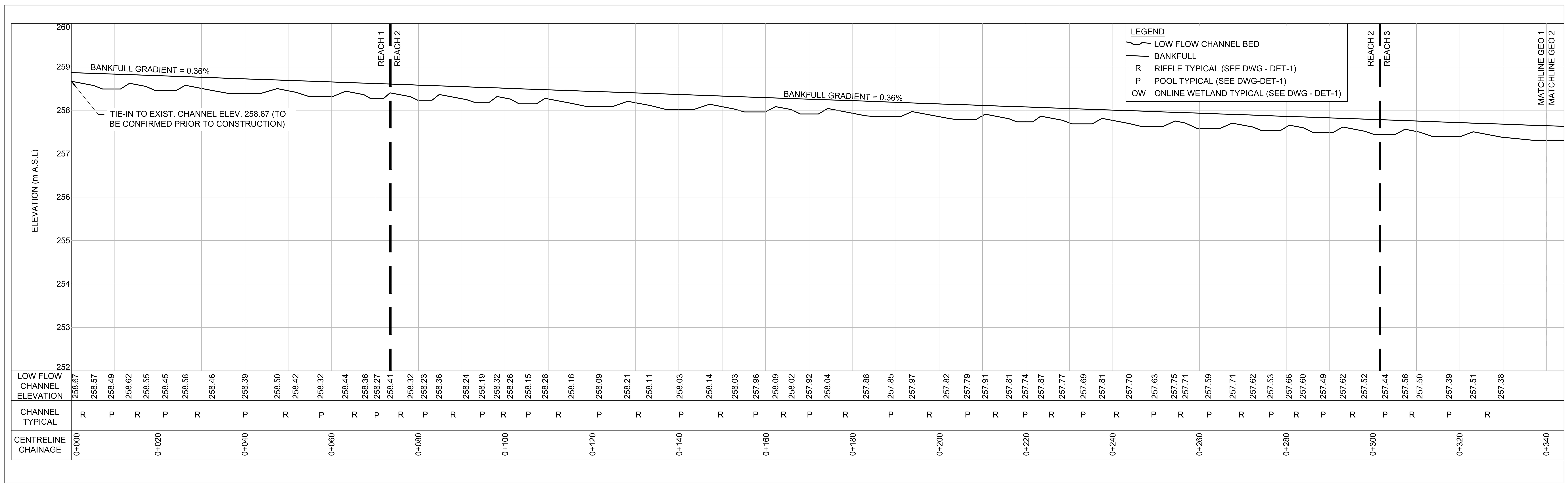
N

Imagery: Google Earth Pro, 2018.
Top of Slope, Subject Land Boundary, and 0.5 m Contour: R. Avis Surveying Inc., 2021.
Erosion Setback Point/ Line / Allowance, Stable Top of Slope, Watercourse Central Tendency, MBW, and Toe of Slope: GEO Morphix Ltd., 2020.
Watercourse: Region of Peel, 2020 and GEO Morphix Ltd., 2021.
Printed: March 2021. PN20109. Drawn by M.H., J.M., P.V.

Appendix F
Conceptual Natural Corridor Design



PLANFORM
1:500



PROFILE
H = 1:500; V=1:50

DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

KEY MAP
N.T.S.

GENERAL NOTES

1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.
5. DESIGNER OR REPRESENTATIVE SHALL BE PRESENT DURING CONSTRUCTION TO PROVIDE GUIDANCE ON INSTALLATION OF THE FEATURES.

TIMING OF WORKS

1. WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
2. TREE CLEARING SHOULD BE COMPLETED OUTSIDE THE BIRD NESTING SEASON TO COMPLY WITH THE FEDERAL MIGRATORY BIRDS CONVENTION ACT. ANY TREES THAT REQUIRE REMOVAL OUTSIDE OF THIS TIMING WINDOW MUST FIRST BE INSPECTED BY A QUALIFIED BIOLOGIST TO DETERMINE THE PRESENCE OF NESTING BIRDS.
3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
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DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

1. PREVENT THE RELEASE OF SEDIMENT, SEDIMENT-LADEN WATER, RAW CONCRETE, CONCRETE LEACHATE OR ANY OTHER DELETERIOUS SUBSTANCES INTO ANY WATERBODY, RAVINE OR STORM SEWER SYSTEM.
2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
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	DATE	BY	REVISIONS

DESIGNED BY: LD	CHECKED BY: PV
DRAWN BY: GM/AS	DATE: MARCH 2021

PROFESSIONAL GEOSCIENTIST
PAUL V. VILLARD
PRACTISING MEMBER
0957
ONTARIO
21/03/17

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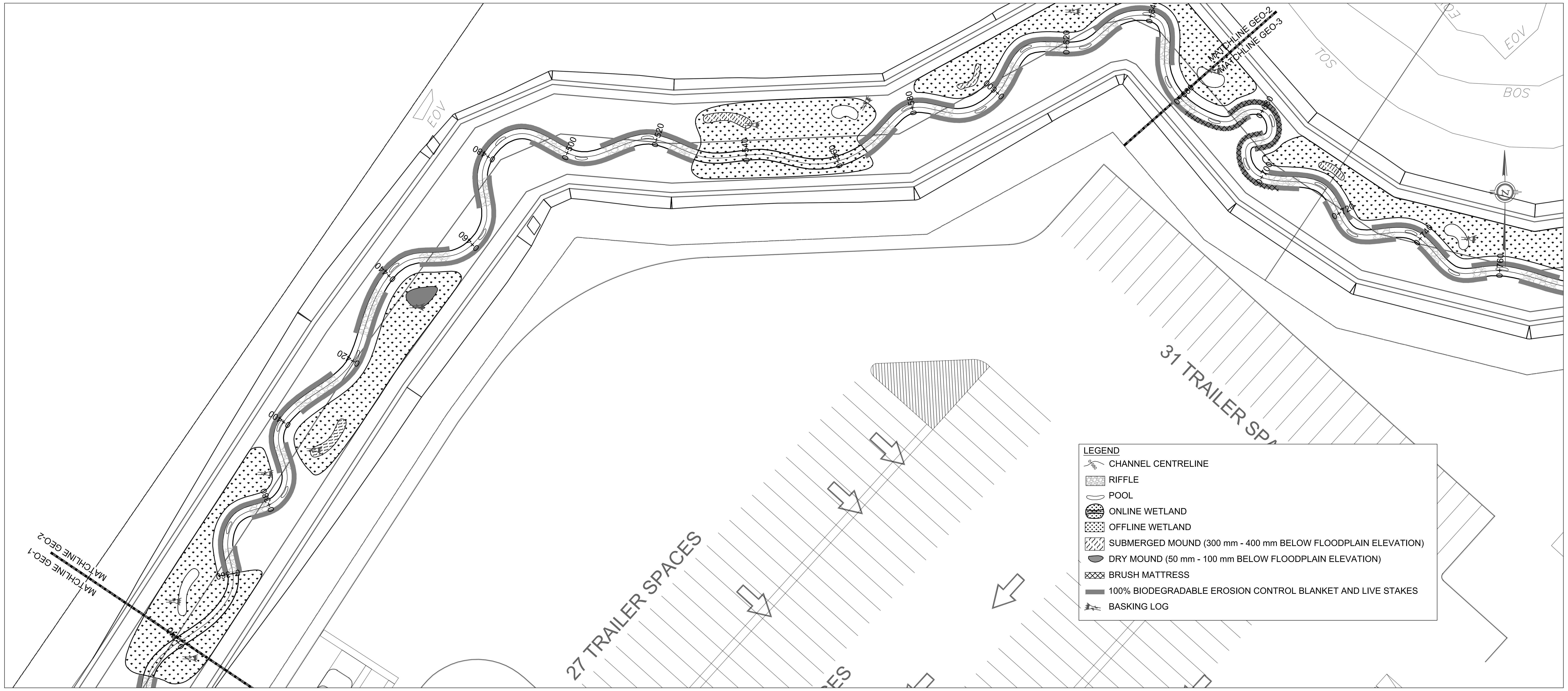
www.geomorphix.com

TRIBAL PARTNERS CANADA INC.

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 20109	DRAWING No.: GEO-1
SCALE: AS NOTED	SHEET 1 OF 7



PLANFORM
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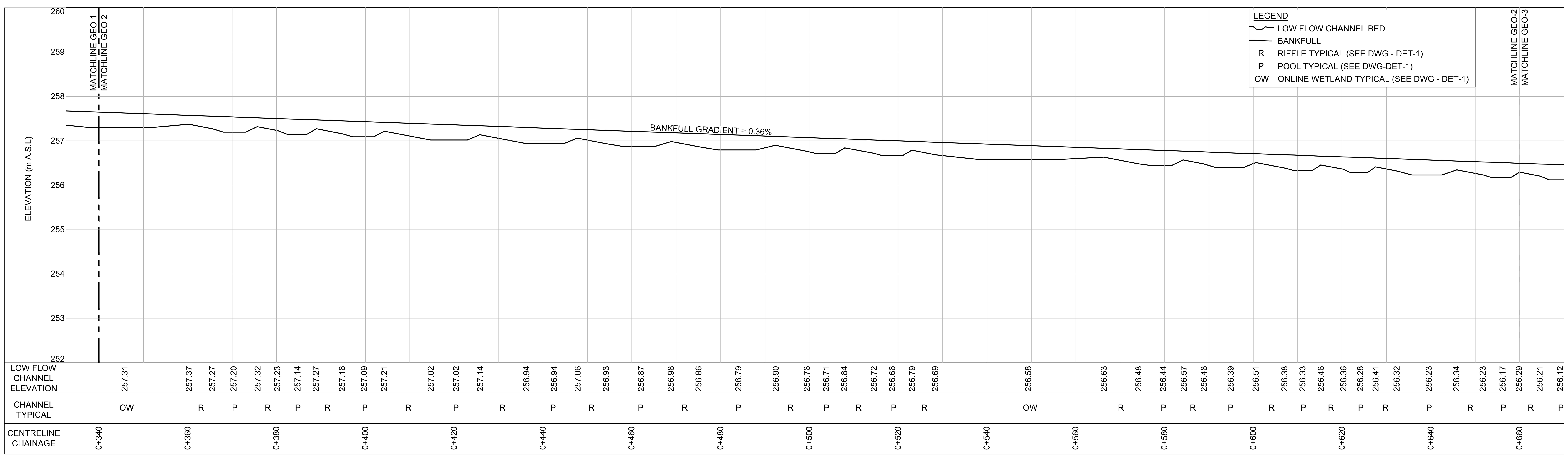

PROFILE
H = 1:500; V=1:50

DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

KEY MAP
N.T.S.

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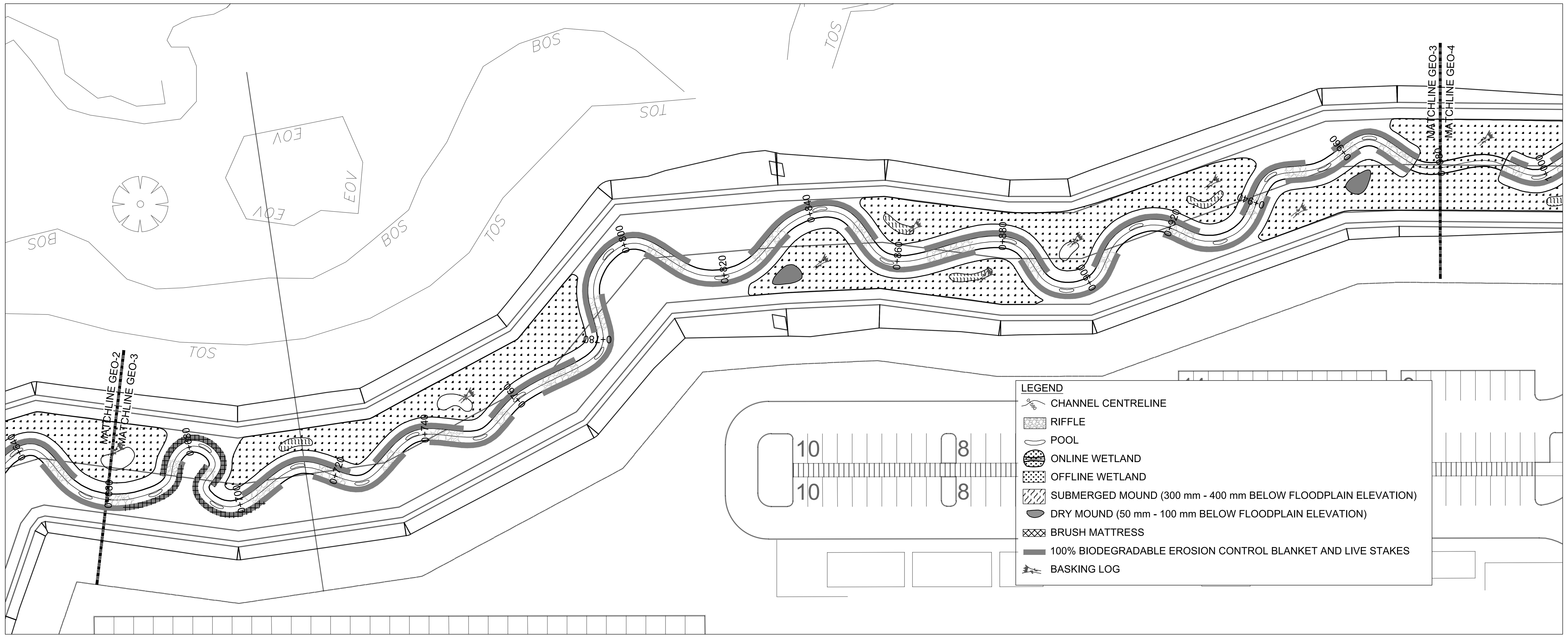
TRIBAL PARTNERS
CANADA INC.

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 20109 | DRAWING No.: GEO-2
SCALE: AS NOTED | SHEET 2 OF 7



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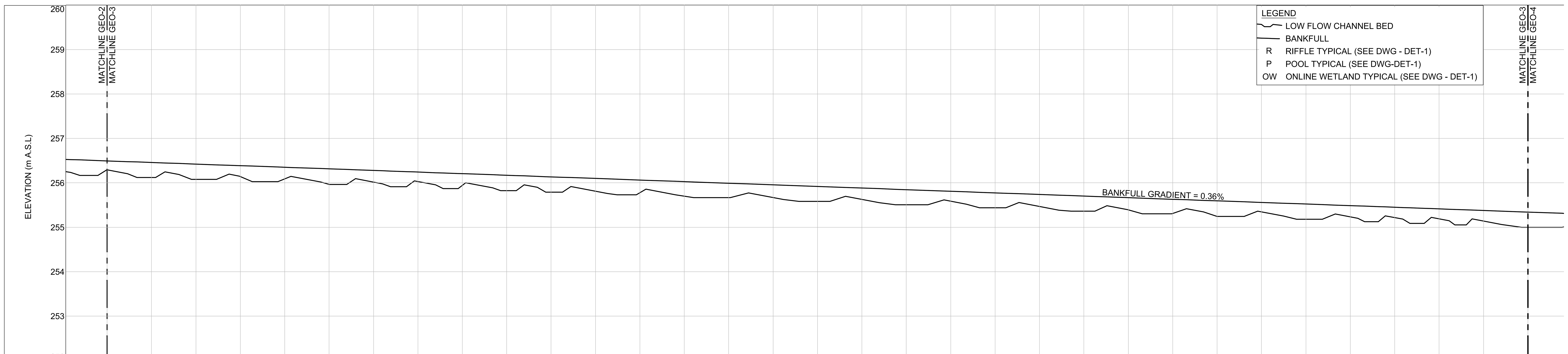

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CHANNEL TYPICAL	P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R P R OW
CENTRELINE CHAINAGE	0+660, 0+680, 0+700, 0+720, 0+740, 0+760, 0+780, 0+800, 0+820, 0+840, 0+860, 0+880, 0+900, 0+920, 0+940, 0+960, 0+980

PROFILE
H = 1:500; V=1:50

DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

KEY MAP
N.T.S.

N
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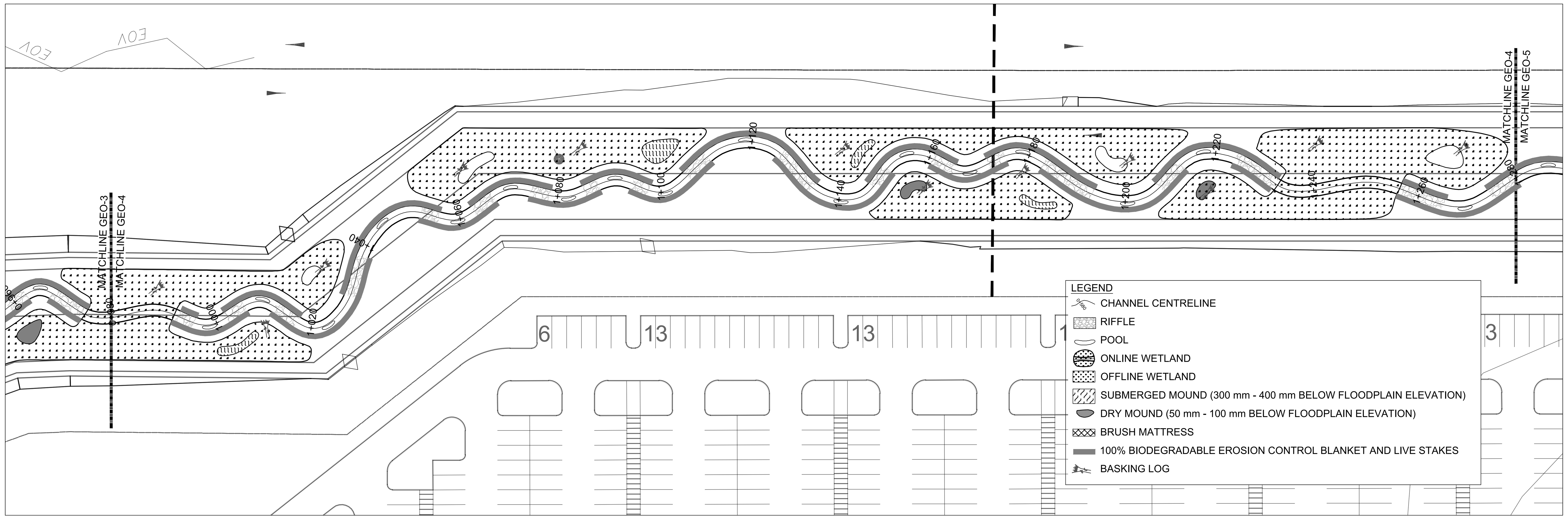
TRIBAL PARTNERS
CANADA INC.

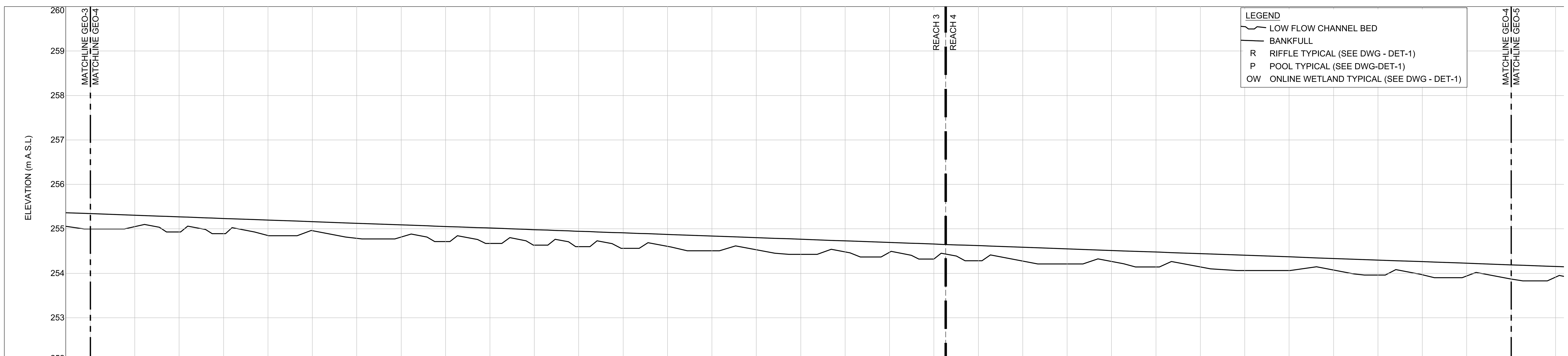
CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 20109 | DRAWING No.: GEO-3

SCALE: AS NOTED | SHEET 3 OF 7



PLANFORM
1:500



LOW FLOW CHANNEL ELEVATION	255.00, 255.10, 255.03, 254.93, 255.06, 254.99, 254.89, 255.03, 254.93, 254.85, 254.96, 254.82, 254.77, 254.88, 254.81, 254.71, 254.84, 254.76, 254.67, 254.80, 254.73, 254.63, 254.77, 254.71, 254.60, 254.73, 254.67, 254.56, 254.69, 254.59, 254.51, 254.62, 254.45, 254.43, 254.54, 254.46, 254.37, 254.49, 254.41, 254.32, 254.45, 254.39, 254.28, 254.41, 254.21, 254.21, 254.33, 254.22, 254.14, 254.27, 254.10, 254.06, 254.15, 253.99, 253.96, 254.08, 253.98, 253.90, 254.02, 253.87, 253.83, 253.95
CHANNEL TYPICAL	OW, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, P, R, OW, R, P, R, P, R, P
CENTRELINE CHAINAGE	0+980, 1+000, 0+340, 1+020, 1+040, 1+060, 1+080, 1+100, 1+120, 1+140, 1+160, 1+180, 1+200, 1+220, 1+240, 1+260, 1+280

PROFILE
H = 1:500, V = 1:50

PROFILE
H = 1:500; V = 1:50

DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

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3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
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1.	21/03/17	LD	FIRST CONCEPTUAL DESIGN SUBMISSION
	DATE	BY	REVISIONS

DESIGNED BY: LD | CHECKED BY: PV

DRAWN BY: GM/AS | DATE: MARCH 2021

PROFESSIONAL GEOSCIENTIST
PAUL V. VILLARD
PRACTISING MEMBER
0957
ONTARIO
21/03/17

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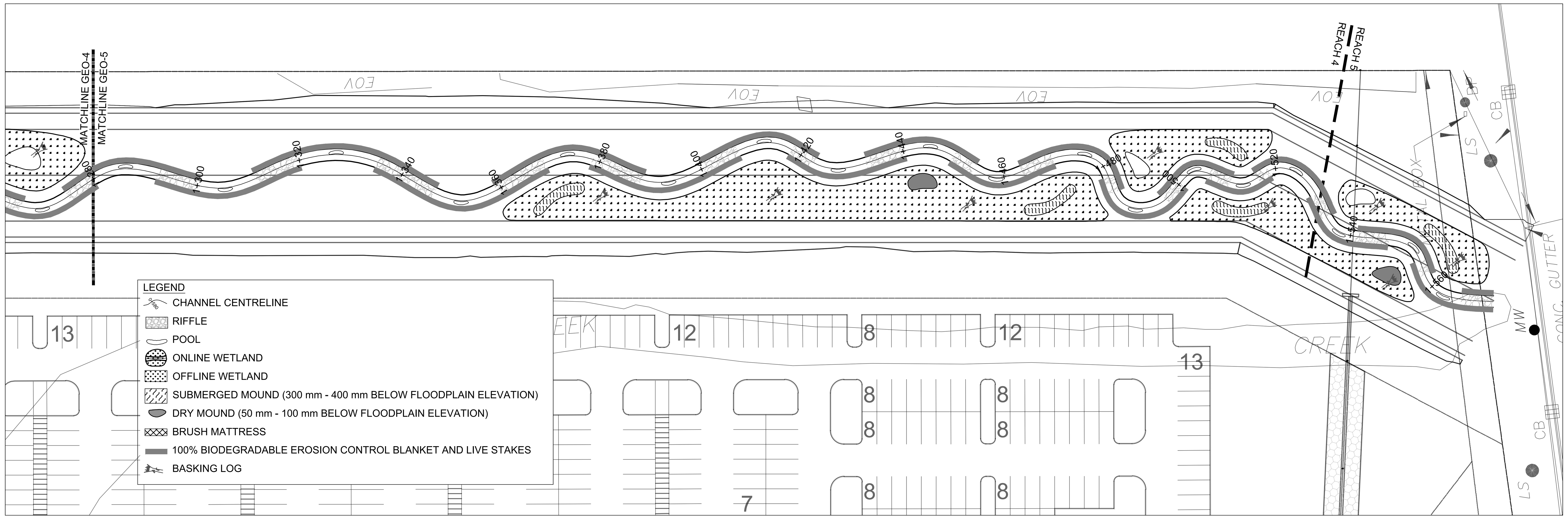
TRIBAL PARTNERS
CANADA INC.

CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 20109 | DRAWING No.: GEO-4

SCALE: AS NOTED | SHEET 4 OF 7



PLANFORM
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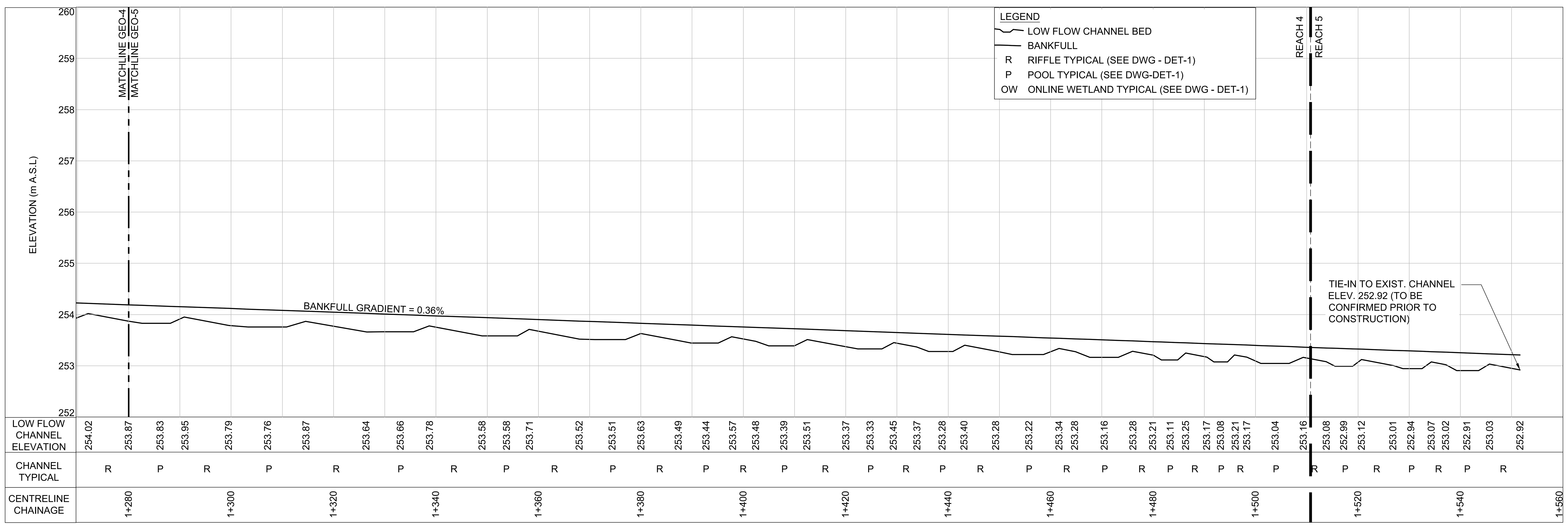

PROFILE
H = 1:500; V=1:50

DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

KEY MAP
N.T.S.

N
N.T.S.

GENERAL NOTES

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3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
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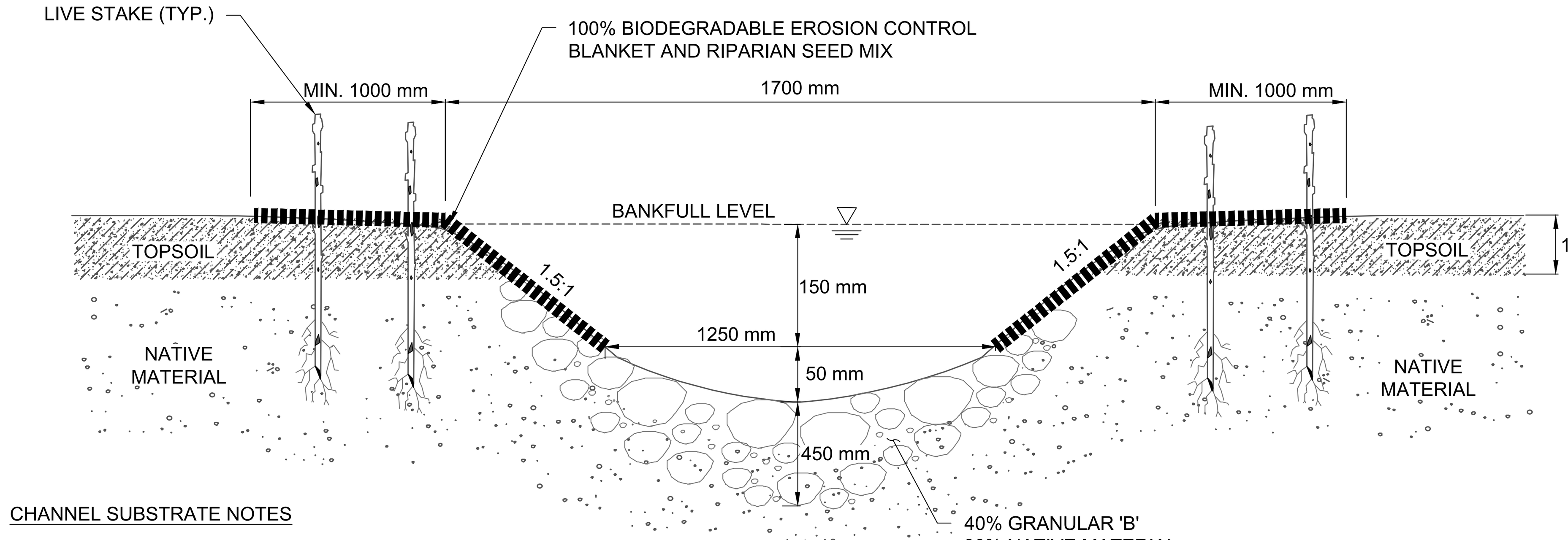
CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: 20109	DRAWING No.: GEO-4
SCALE: AS NOTED	SHEET 4 OF 7



CHANNEL SUBSTRATE NOTES

1. SUBSTRATES TO BE COMPACTED TO 90% SPD TO PREVENT PIPING/FLOW-THROUGH.
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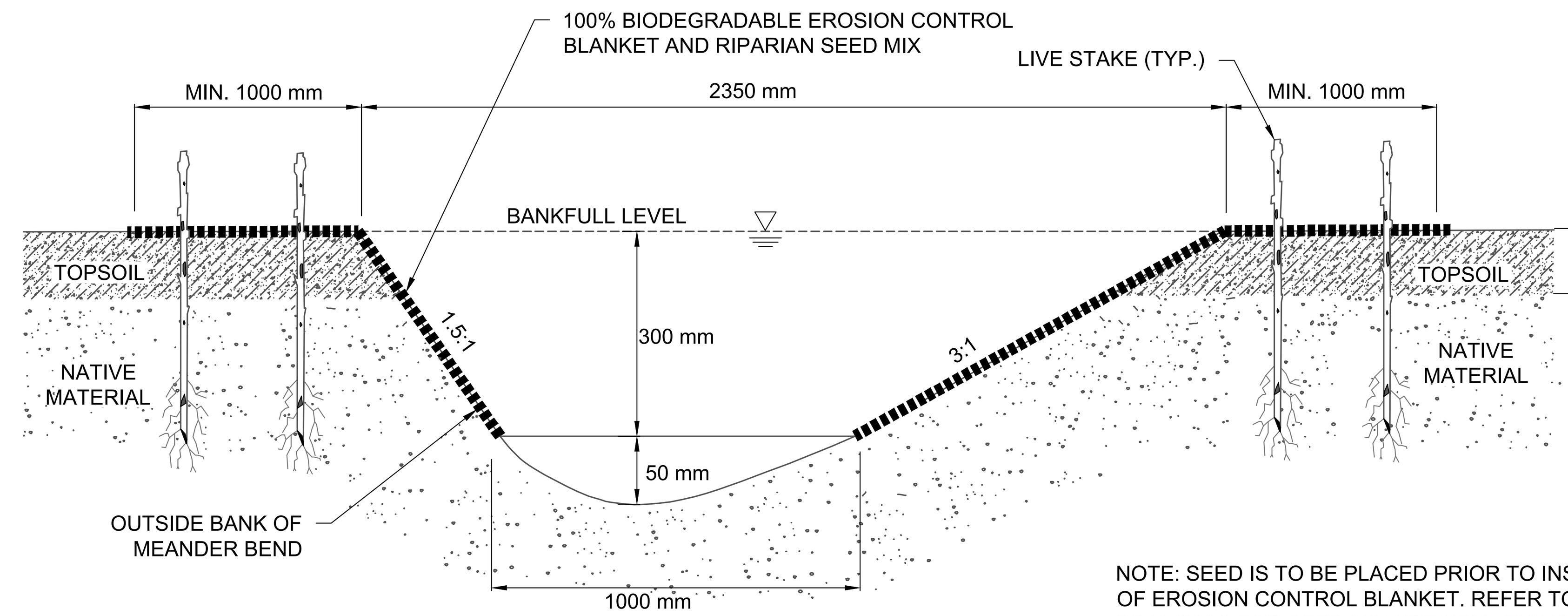
TYPICAL RIFFLE



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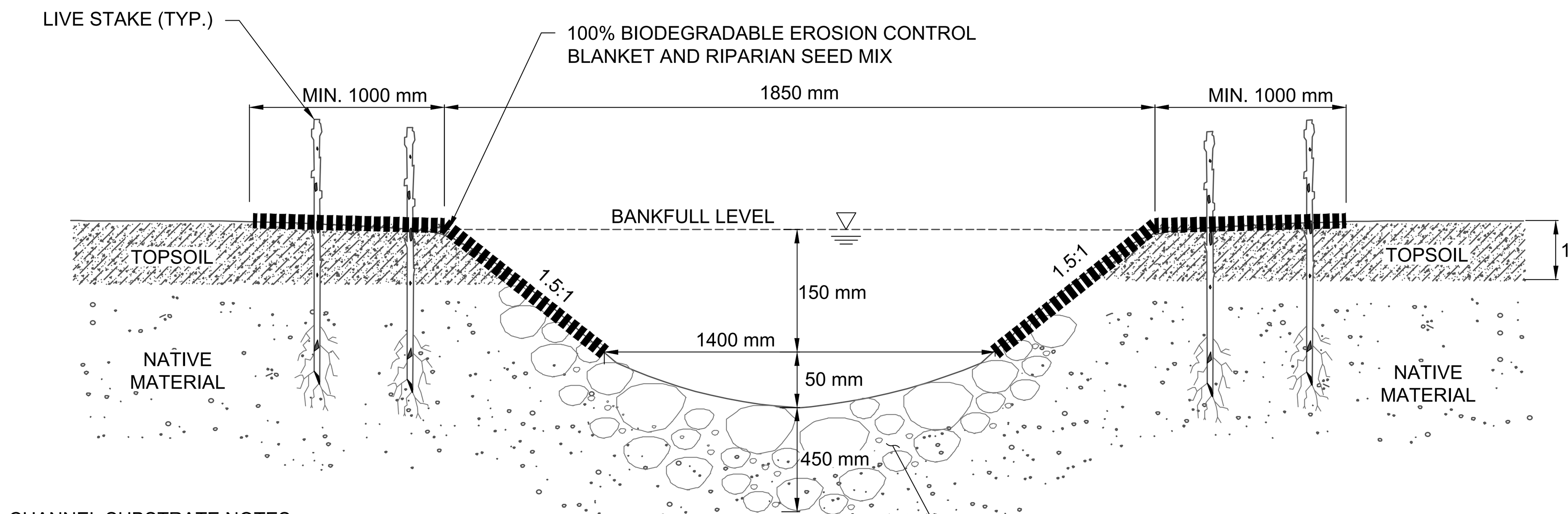
CHANNEL CROSS SECTIONS - REACH 1
N.T.S.



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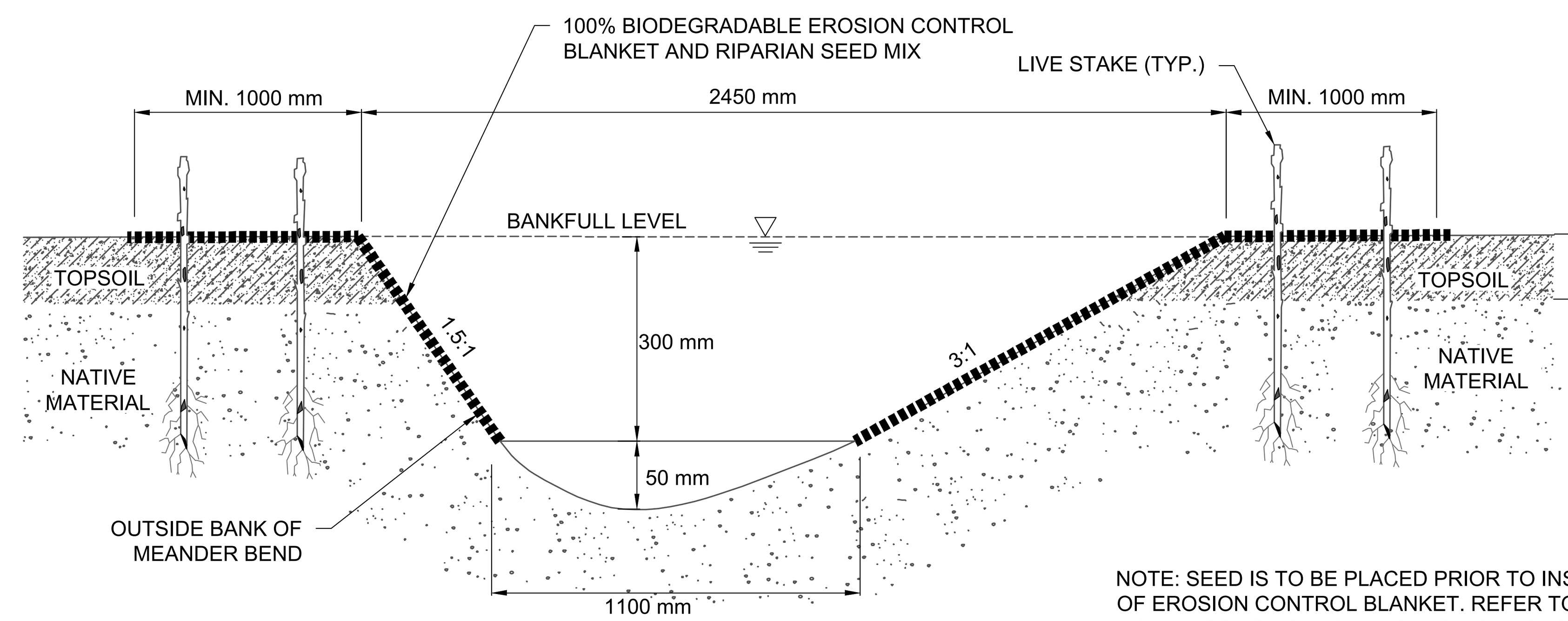

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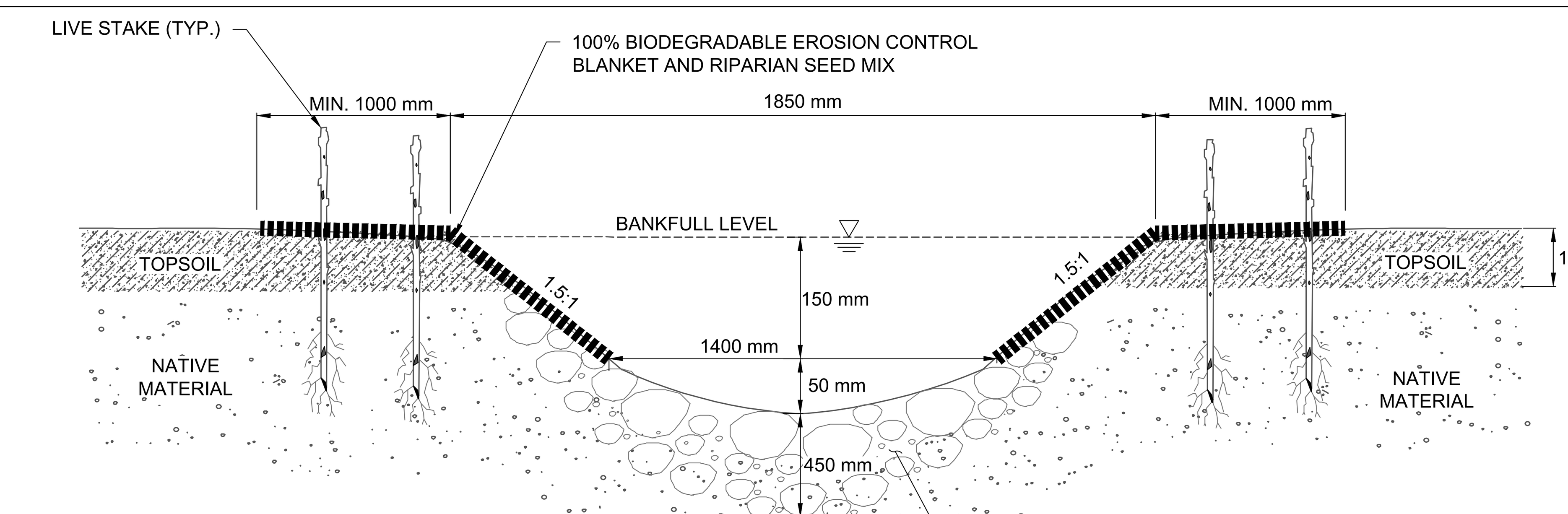

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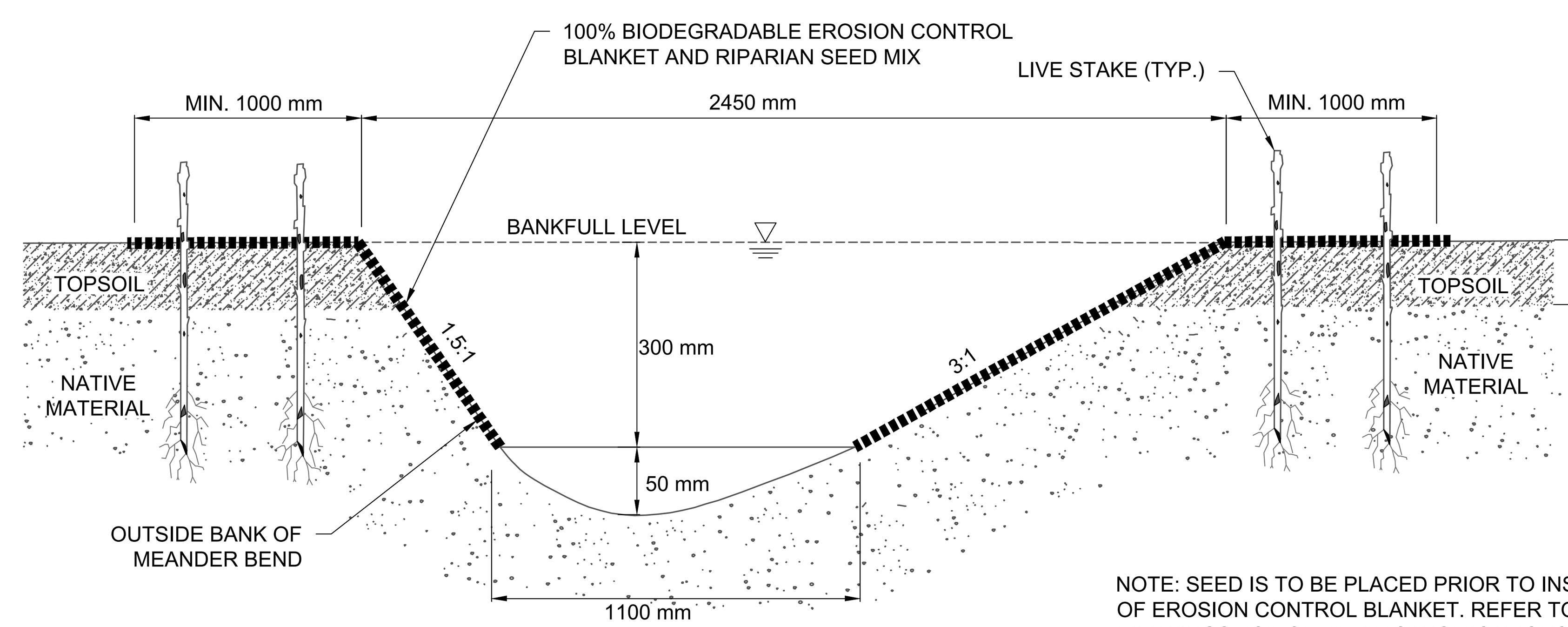

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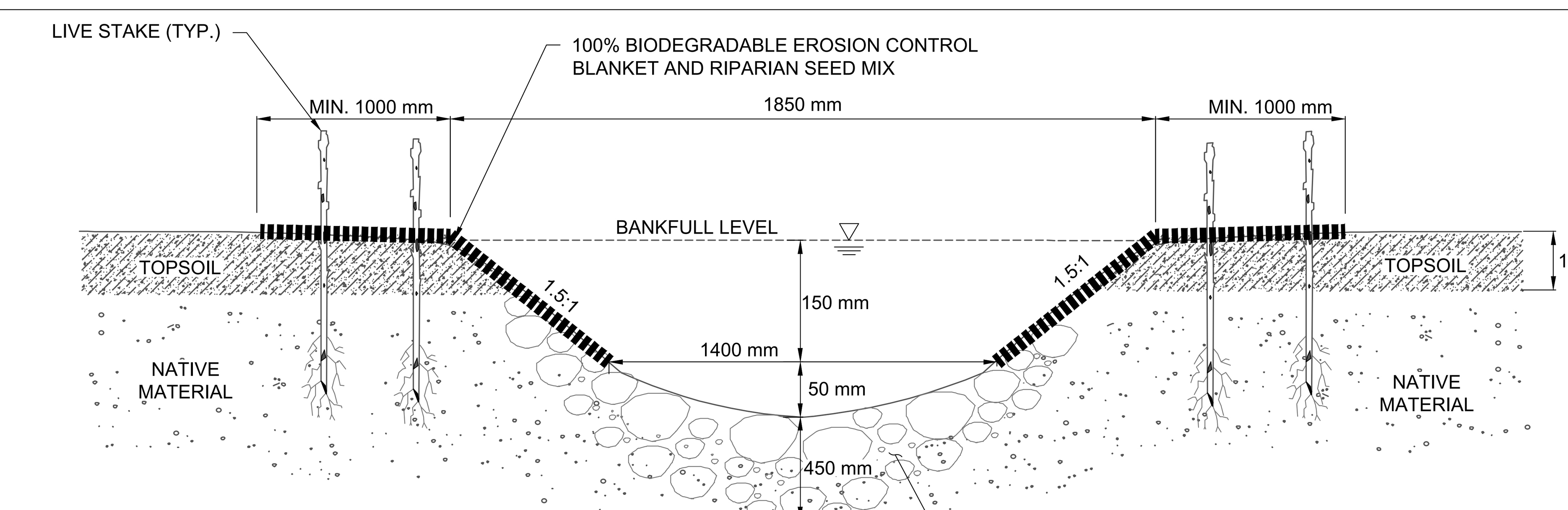

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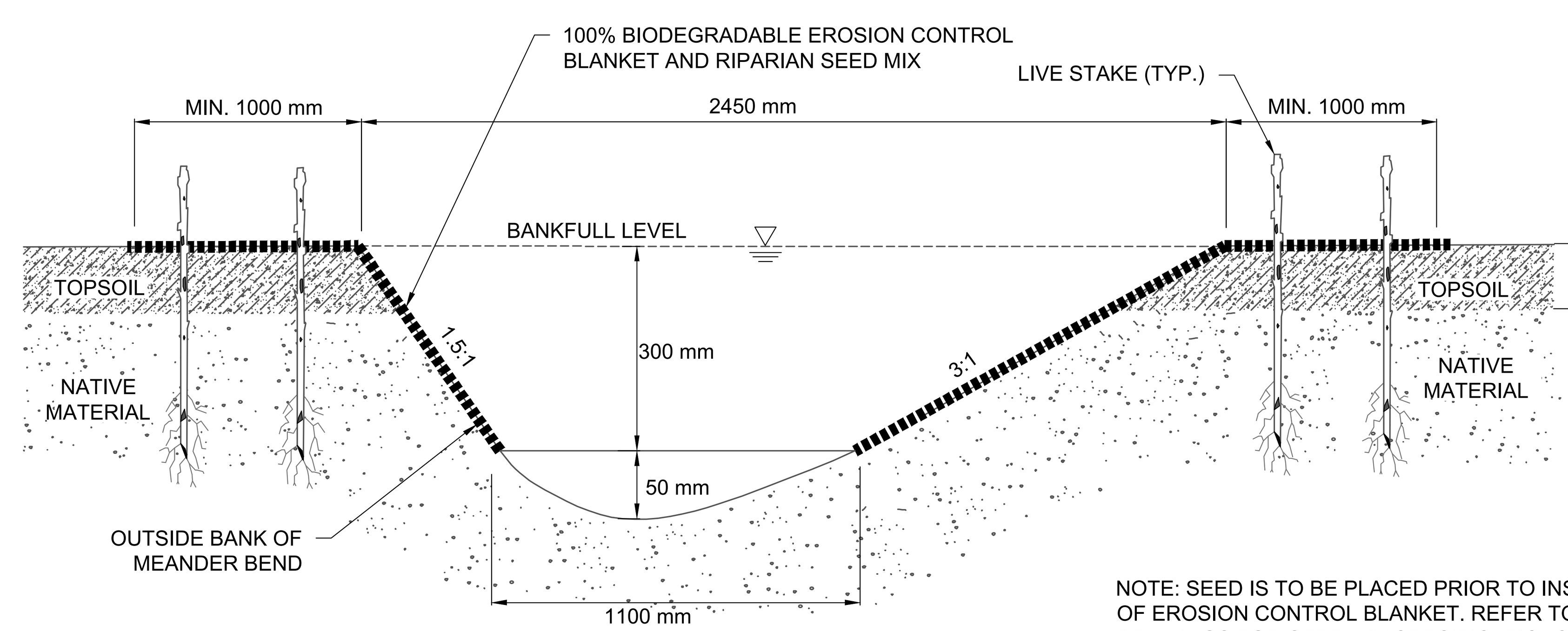

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DRAFT FOR DISCUSSION

SCALED FOR PLOT ON 'ARCH D'

N
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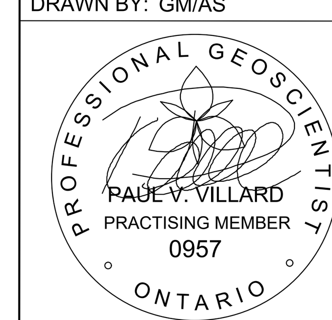

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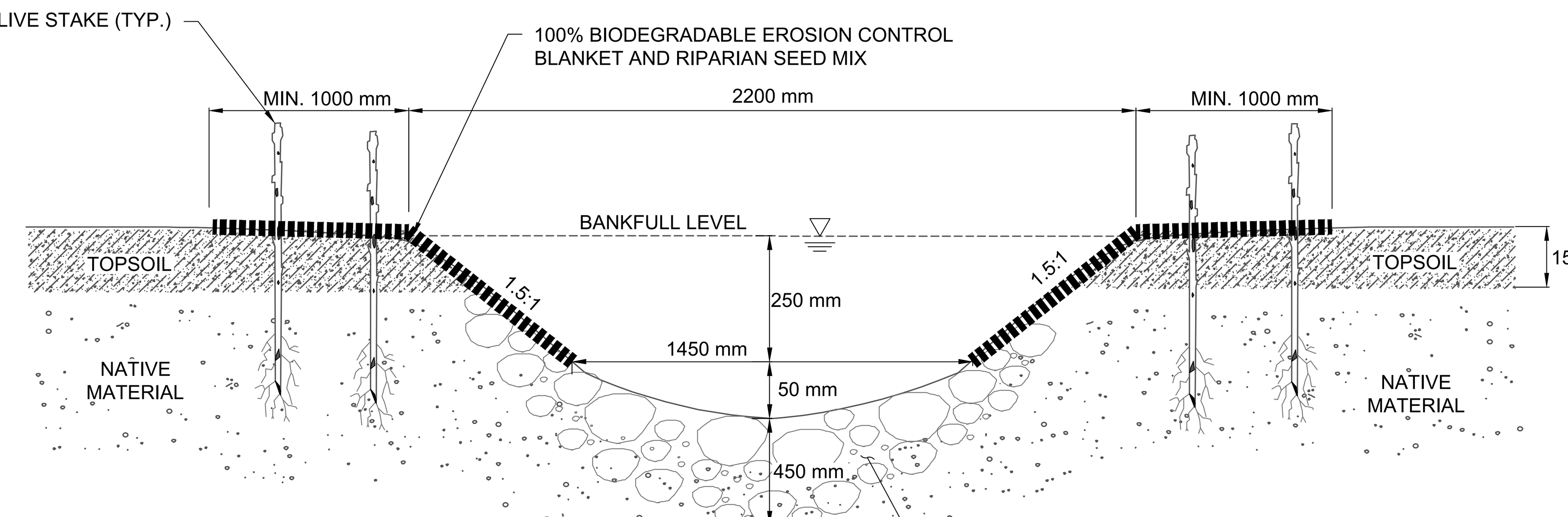
CONCEPTUAL CHANNEL DESIGN RESTORATION DETAILS

PROJECT No.: 20109	DRAWING No.: DET-1
SCALE: AS NOTED	SHEET 6 OF 7



TYPICAL RIFFLE

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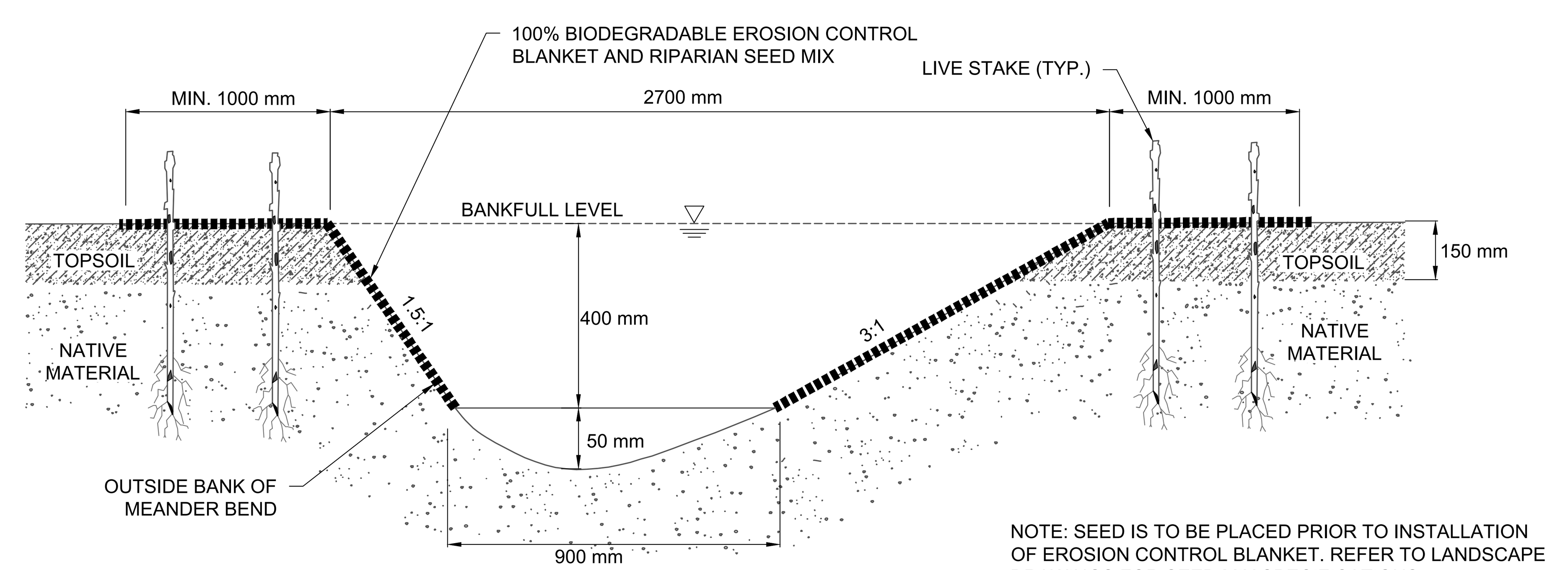

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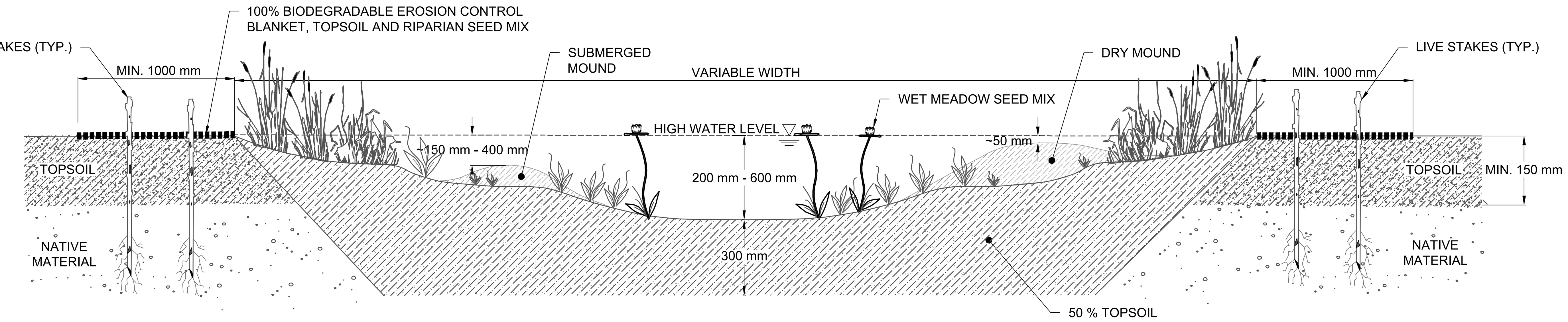
CHANNEL CROSS SECTIONS - REACH 5
N.T.S.



WETLAND CROSS SECTION
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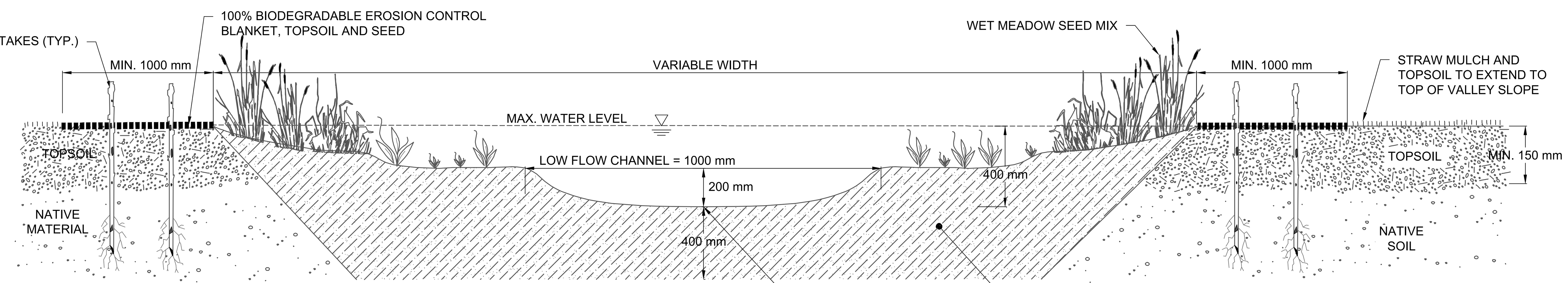

ONLINE WETLAND CROSS SECTION
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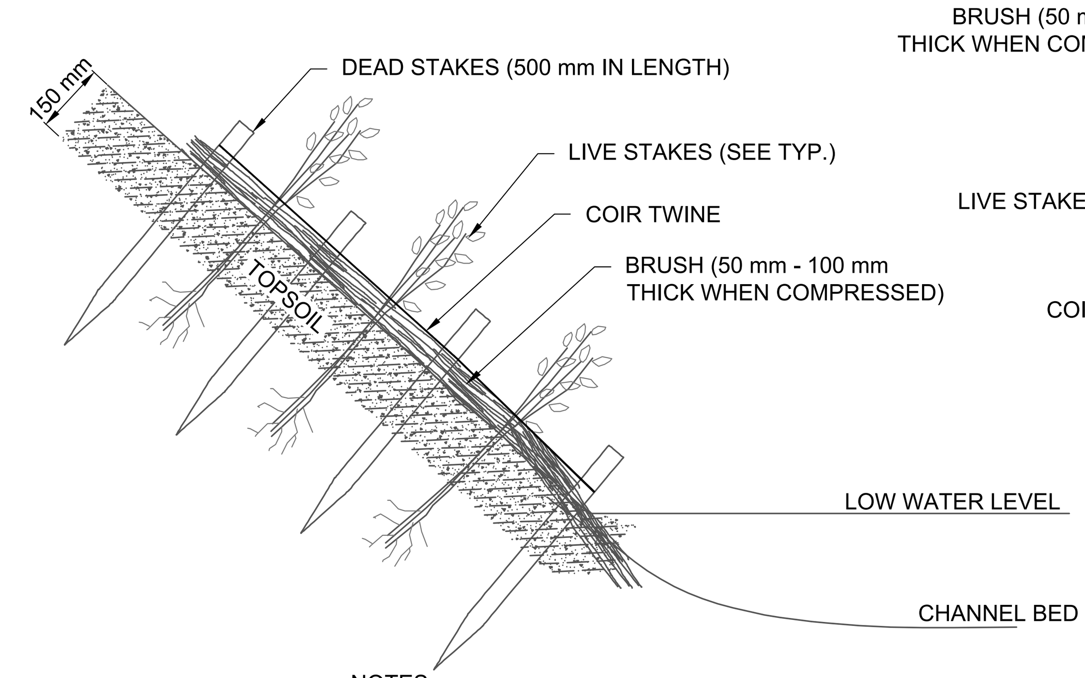
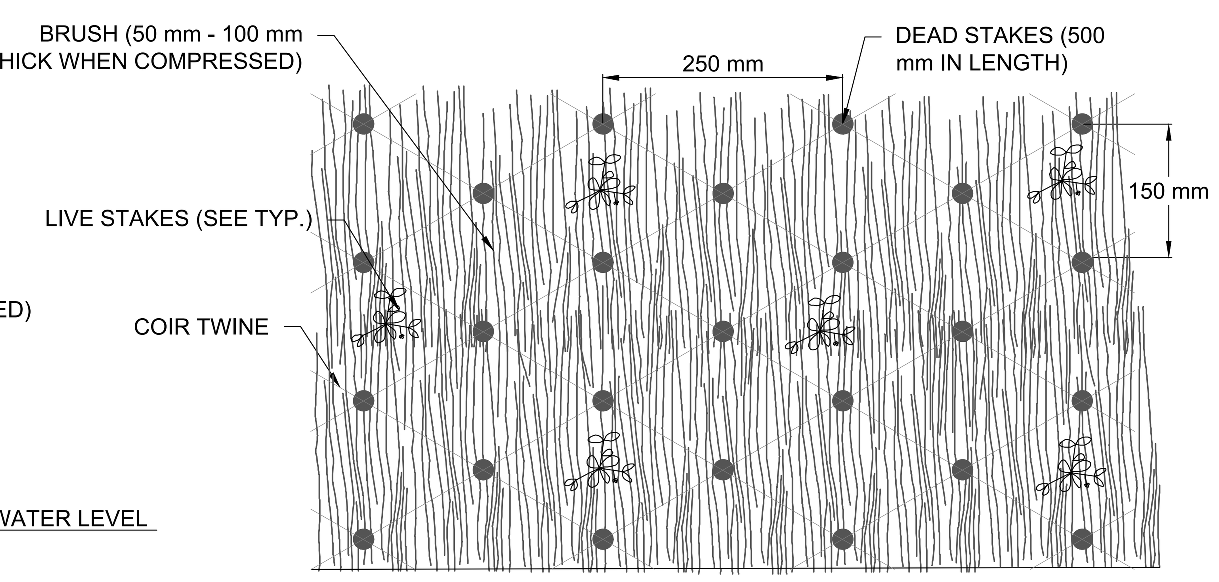
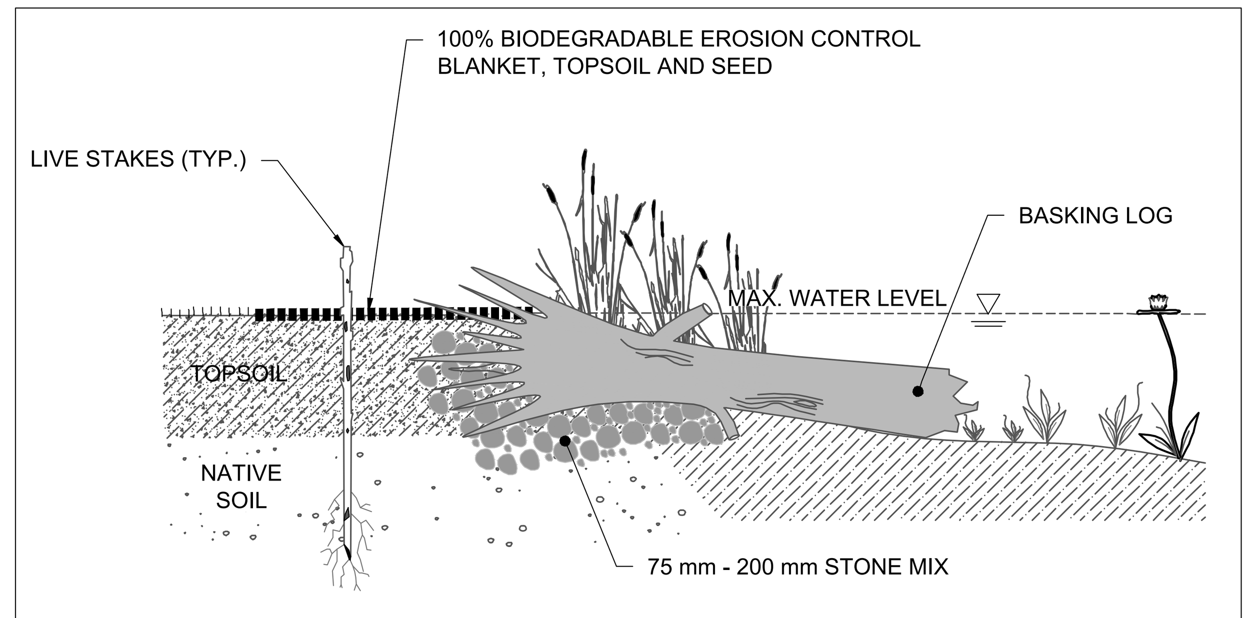




NOTES
1. LIVE BRANCHES TO CONSIST OF WILLOW AND DOGWOOD SPECIES, APPROXIMATELY 1 m IN LENGTH AND 50 mm - 100 mm IN WIDTH.
2. SOURCE MATERIAL FOR BRUSH MATTRESS SHOULD BE CONFIRMED BY THE DESIGNER OR REPRESENTATIVE.
3. BRANCHES TO BE KEPT IN MOIST AND COLD UNTIL INSTALLATION.
4. BRUSH MATTRESS TO BE INSTALLED WHILE BRANCHES ARE DORMANT.
5. BRANCHES TO BE PLACED ON SLOPE WITH BUTT END TOWARDS VALLEY FLOOR AND PUSHED INTO SOIL.
6. BRANCHES MUST BE FLEXIBLE ENOUGH TO CONFORM TO THE SLOPE SURFACE IRREGULARITIES.
7. POUND DEAD STAKES TO HALF THEIR LENGTH INTO SOIL BETWEEN BRANCHES. TIE COIR TWINE AROUND DEAD STAKES AND TIGHTLY OVER BRANCHES. USE A CLOVE HITCH TO SECURE STAKES. POUND STAKES INTO SLOPE TO COMPRESS BRANCHES AGAINST GROUND.
8. TAMP LIVE STAKES BETWEEN DEAD STAKES.
9. FILL VOIDS BETWEEN BRANCHES OF THE BRUSH MATTRESS WITH SOIL TO PROMOTE ROOTING.

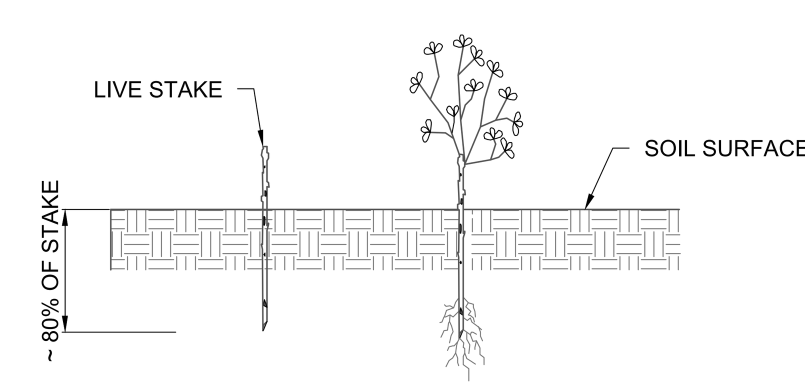
BRUSH MATTRESS
N.T.S.

DRAFT FOR DISCUSSION



NOTES
1. ANCHOR AND SUPPORT BASKING LOGS WITH 75 mm - 200 mm STONE MIX.
2. FIRMLY COMPACT STONE MIX TO PREVENT THROUGH FLOW.
3. BURY 1/3 OF LOG INTO SOIL.
4. LENGTH OF BASKING LOGS ARE TO BE INSTALLED 1000 - 1500 mm INTO WET AREA.
5. BASKING LOGS TO BE A MINIMUM 500 mm IN DIAMETER AND 2000 - 2500 mm IN LENGTH.
6. BASKING LOGS SHOULD BE ANGLED TO PROMOTE TURTLE BASKING.
7. BASKING LOGS SHOULD BE A MIXTURE OF SUITABLE HARDWOOD AND SOFTWOOD SPECIES.

BASKING LOG
N.T.S.



SPECIES AND QUANTITIES

COMMON NAME	SPECIES	SIZE
RED OSIER DOGWOOD	*Cornus stolonifera*	1 m
PUSSY WILLOW	*Salix discolor*	1 m
SANDBAR WILLOW	*Salix exigua*	1 m

NOTES
1. QUANTITY TO BE DETERMINED BASED ON AREA OF DISTURBANCE TO BE RESTORED
2. LIVE STAKES SHOULD BE FROM AT MINIMUM 2-YEAR OLD STOCK.
3. LIVE STAKES ARE TO BE INSTALLED AT A DENSITY OF 3 STAKES PER SQUARE METRE.
4. LIVE STAKES SHOULD BE PRE-SOAKED (SUBMERGED IN WATER) FOR AT LEAST 24 HOURS AFTER HARVESTING AND IMMEDIATELY BEFORE INSTALLATION.
5. LIVE STAKES SHOULD NOT BE STORED FOR A PERIOD LONGER THAN 2 DAYS, UNLESS THEY ARE BEING SOAKED.
6. THE CONTRACTOR SHALL PROTECT PLANT MATERIALS FROM DRYING FROM THE TIME OF HARVEST UNTIL INSTALLED.
7. LIVE STAKES ARE TO BE A MINIMUM OF 25 mm IN DIAMETER AND CUT TO A LENGTH OF 1000 mm.
8. CUT ANGLE AT THE BOTTOM OF THE STAKE AND FLAT ON THE TOP.
9. TRIM ALL SIDE BRANCHES WHILE TAKING CARE NOT TO DAMAGE THE BARK.
10. INSTALL STAKES WITH BUDS POINTING UPWARDS AND THICKER STEM IN THE BED.
11. LIVE STAKES SHOULD BE INSTALLED USING A LARGE RUBBER MALLET.
12. 80% OF THE STAKE IS TO BE BELOW SURFACE.
13. TAMP THE LIVE STAKE INTO THE GROUND AT RIGHT ANGLE TO THE SURFACE.
14. IN COMPACT SOIL A PILOT HOLE SHOULD BE USED TO LIMIT DAMAGE TO THE STAKES.
15. IF USING A PILOT HOLE REPACK SOIL AROUND THE LIVE STAKE.
16. LIVE STAKES SHOULD STAND FIRM FROM THE SOIL FOLLOWING INSTALLATION.
17. ALL STAKES NOT PLANTED TO THE SPECIFICATIONS ABOVE WILL BE REPLACED AT THE CONTRACTOR'S EXPENSE.

LIVE STAKE
N.T.S.

SCALED FOR PLOT ON 'ARCH D'

N
N.T.S.

KEY MAP
N.T.S.

GENERAL NOTES

1. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
2. THE CONTRACTOR MUST NOTIFY THE CONTRACT ADMINISTRATOR AND CONSERVATION AUTHORITY OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
3. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
4. LAYOUT MUST BE REVIEWED AND APPROVED BY THE CONTRACT ADMINISTRATOR.
5. DESIGNER OR REPRESENTATIVE SHALL BE PRESENT DURING CONSTRUCTION TO PROVIDE GUIDANCE ON INSTALLATION OF THE FEATURES.

TIMING OF WORKS

1. WORKS SHALL BE COMPLETED BETWEEN JULY 1ST TO MARCH 31ST.
2. TREE CLEARING SHOULD BE COMPLETED OUTSIDE THE BIRD NESTING SEASON TO COMPLY WITH THE FEDERAL MIGRATORY BIRDS CONVENTION ACT. ANY TREES THAT REQUIRE REMOVAL OUTSIDE OF THIS TIMING WINDOW MUST FIRST BE INSPECTED BY A QUALIFIED BIOLOGIST TO DETERMINE THE PRESENCE OF NESTING BIRDS.
3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE STOCKPILED SOILS THAT ARE STORED FOR PROLONGED PERIODS WITH THE APPLICATION OF A NURSE CROP AT A RATE OF 60 kg/ha.
5. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW. ON SOILS THAT WILL BE EXPOSED FOR PROLONG PERIODS, TEMPORARILY INSTALL A BIODEGRADABLE EROSION CONTROL BLANKET ON EXPOSED SOILS, OR APPLY A NURSE CROP AT A RATE OF 60 KG/HA.
6. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE.
7. ALL VEGETATION, ADJACENT TO THE WORK AREA, MUST BE PROTECTED AND DELINEATED WITH CONSTRUCTION FENCING OR TREE PROTECTION BARRIERS.
8. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.

EROSION AND SEDIMENT CONTROL

1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
2. SEDIMENT CONTROLS MUST BE INSPECTED DAILY TO ENSURE THAT THEY ARE IN GOOD REPAIR AND FUNCTIONING AS INTENDED.
3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
5. ANY CHANGES TO THE EROSION AND SEDIMENT CONTROL PLAN BEYOND MINOR ADJUSTMENTS MUST BE APPROVED BY THE CONTRACT ADMINISTRATOR.
6. ADDITIONAL EROSION AND SEDIMENT CONTROL SUPPLIES MUST BE KEPT ON SITE IN ORDER TO FACILITATE IMMEDIATE REPAIRS AND/OR UPGRADES AS NEEDED.
7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.

DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

1. PREVENT THE RELEASE OF SEDIMENT, SEDIMENT-LADEN WATER, RAW CONCRETE, CONCRETE LEACHATE OR ANY OTHER DELETERIOUS SUBSTANCES INTO ANY WATERBODY, RAVINE OR STORM SEWER SYSTEM.
2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE.

WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 M FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
3. FISH MUST BE REMOVED FROM THE WORK AREA ONCE ISOLATED. FISH SALVAGE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY.

1.	21/03/17	LD	FIRST CONCEPTUAL DESIGN SUBMISSION
	DATE	BY	REVISIONS

DESIGNED BY: LD	CHECKED BY: PV
DRAWN BY: GM/AS	DATE: MARCH 2021

PROFESSIONAL GEOSCIENTIST
PAUL V. VILLARD
PRACTISING MEMBER
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21/03/17

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CONCEPTUAL CHANNEL DESIGN
RESTORATION DETAILS

PROJECT No.: 20109	DRAWING No.: DET-2
SCALE: AS NOTED	SHEET 7 OF 7