

Lower Four Mile Creek Rapid Geomorphic Assessment



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AHYDTECH GEOMORPHIC
ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

APRIL 2026



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1 INTRODUCTION

AHYDTECH Geomorphic Ltd. was retained by the Niagara Peninsula Conservation Authority (NPCA) to complete a Rapid Geomorphic Assessment of Lower Four Mile Creek, which flows northward from the Niagara Escarpment to Lake Ontario. The assessment was conducted in accordance with applicable Provincial and Federal guidelines to support the delineation of erosion hazard limits for land development purposes. As part of this study, Meander Belt Width and erosion hazard analyses were completed for the reaches of Lower Four Mile Creek.

To assess fluvial geomorphology of the study area, AHYDTECH completed the following tasks:

- Collected and reviewed background information related to stream morphology, topography, and historical channel change.
- Conducted field reconnaissance and surveying to document existing channel conditions and stream crossings.
- Collected topographic, bathymetric, cross-sectional, and hydraulic structure data required to support the assessment.
- Completed reach delineation, Rapid Geomorphic Assessment (RGA), and Rapid Stream Assessment (RSA) of the existing stream network within the study area in accordance with established protocols.
- Identified bankfull channel indicators and estimated key bankfull parameters through field measurements.
- Reviewed available historical aerial imagery and completed Meander Belt Width assessments to evaluate lateral channel stability and potential migration, incorporating field observations and analytical results.
- Delineated erosion hazard limits in accordance with Ministry of Natural Resources and Forestry (MNRF) and Conservation Authority guidelines.
- Identified and confirmed drainage patterns within the study area to support hydrologic and geomorphic analyses.
- Identified priority erosion hazard areas and potential mitigation opportunities based on channel sensitivity, erosion potential, and hydraulic considerations.
- Developed conceptual mitigation options and geomorphic design recommendations, including order-of-magnitude cost estimates, were required.
- Prepared this report to summarize the assessment findings, mapping, and recommendations in support of project planning and erosion mitigation strategies.

This report has been prepared in an AODA-compliant format in accordance with WCAG 2.0 Level AA.

2 PROJECT OVERVIEW

2.1 Project Site Location

The study area encompasses the lower portion of Four Mile Creek, located within the jurisdiction of the Niagara Peninsula Conservation Authority (NPCA). Four Mile Creek flows northward from the Niagara Escarpment and discharges into Lake Ontario. The project limits extend from the creek outlet at Lake Ontario upstream (southward) to a point immediately north of Line 5, where the channel transitions to a regulated municipal drain.



The Virgil Reservoir corridor, located between Line 2 and Line 4, was excluded from the assessment. As a result, actively studied portion of the creek comprises approximately 10 kilometers of channel length. Within this extent, the creek includes an upstream segment of approximately 1.9 kilometers located above the Virgil Reservoir and a downstream segment of approximately 8.1 kilometers extending from the reservoir to the Lake Ontario outlet.

The study corridor traverses a range of land use settings, including agricultural, residential, and transportation corridors, and includes multiple roadways, railway, and utility crossings. These features influence local channel conditions and represent key locations for geomorphic assessment, particularly with respect to erosion susceptibility, channel stability, and infrastructure interaction. A plan view of the study area and project limits is provided in **Figure 2-1**.

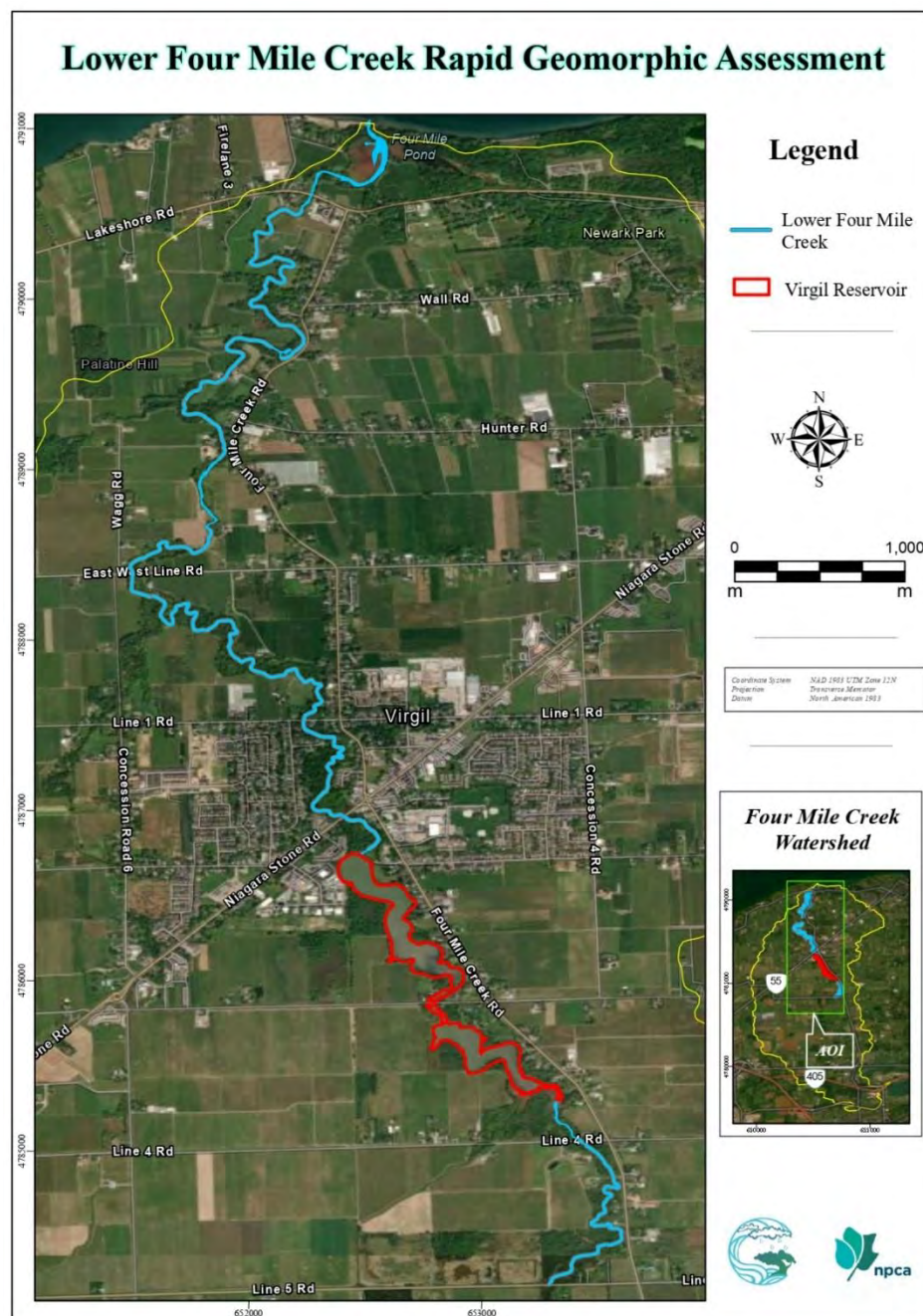


Figure 2-1: Study Area



2.2 Project Area Physiography

The Lower Four Mile Creek study area is situated within the Niagara Peninsula and extends from the Lake Ontario shoreline upstream to just north of Line 5, excluding the Virgil Reservoir corridor. The creek flows northward from the Niagara Escarpment and traverses a gently sloping lowland landscape before discharging into Lake Ontario. This physiographic setting exerts a strong influence on channel form, substrate composition, and dominant fluvial processes observed along the study corridor.

Land use within the project area is predominantly rural and agricultural, with interspersed natural woodlands, wetlands, and localized areas of low-density residential development. The degree of riparian corridor integrity varies considerably along the creek. Portions of the study area exhibit well-vegetated riparian buffers with forested cover and wetland fringe, while other sections are characterized by narrow, fragmented, or highly manicured riparian zones adjacent to private properties and agricultural lands. These variations in riparian conditions represent primary control on bank stability and strongly influence erosion susceptibility and the feasibility of different restoration or stabilization approaches.

Surficial geology within the study area is spatially variable and reflects the transition from escarpment-influenced terrain to the Lake Ontario plain. Upstream reaches influenced by the Niagara Escarpment are characterized by coarser glaciolacustrine sands and gravels, while downstream reaches generally transition to finer silts and clays. Locally, the presence of bedrock or cobble substrate creates grade controls that influence channel slope, bed stability, and sediment transport processes. This heterogeneity in substrate composition, combined with variable riparian cover, contributes to differences in channel response, including localized bank erosion, channel migration rates, and sediment deposition patterns.

Hydrologically, Lower Four Mile Creek functions as a primary drainage pathway conveying both baseflow and storm runoff to Lake Ontario. No visible evidence of groundwater upwelling, seepage discharge, or spring-fed inflow was identified during the reconnaissance and field survey based on surface indicators observed at the time of assessment. The creek provides important hydrologic connectivity and supports aquatic and riparian ecosystem functions throughout the study area. The lower reaches are generally characterized by a meandering planform, variable bank conditions, and localized erosion hazards, particularly in areas influenced by channel confinement, infrastructure crossings, and changes in land use or riparian management.

3 BACKGROUND DATA REVIEW AND DESKTOP ANALYSIS

3.1 Review of the Existing Data

NPCA has provided a GIS database developed as part of a broader, NPCA-wide initiative to standardize surface water datasets and delineate hierarchical drainage areas (e.g., Hierarchical Drainage Area Dataset and Surface Water Inventory geodatabases). This dataset establishes a consistent baseline for understanding watershed connectivity, drainage routing, and sub-catchment structure across the NPCA jurisdiction and provides an appropriate starting point for developing project specific hydrologic model schematization.

As illustrated in **Figure 3-1**, NPCA provided a HEC-HMS model and associated drainage delineation that encompass the Lower Four Mile Creek study corridor within two broad drainage areas, or subbasins. This delineation is appropriate for authority-wide screening,



high-level watershed management, and regional reporting; however, the scale is too coarse for the current assignment. In particular, it does not provide the spatial resolution required to support reach-based hydrologic attribution or detailed geomorphic interpretation.

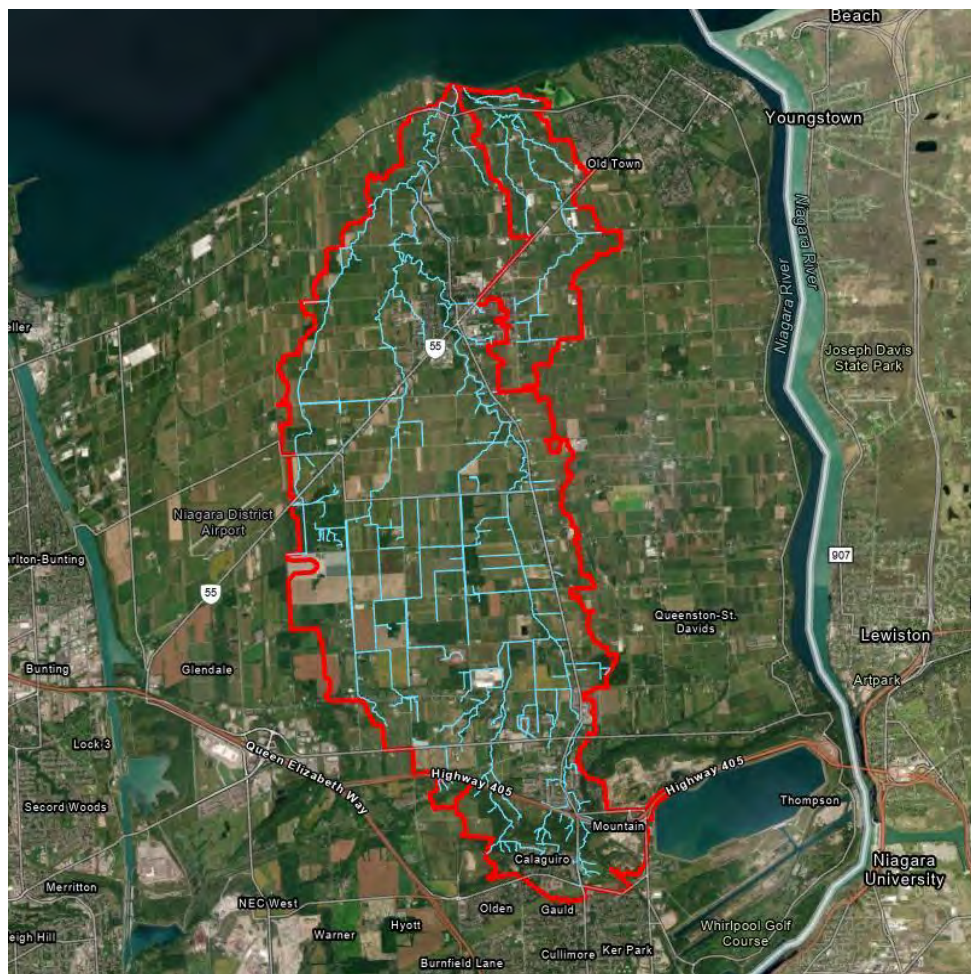


Figure 3-1: Available Subbasin Coverage

3.2 Review of the Existing HEC-HMS Model

3.2.1 Overview of the Existing Model (HEC-HMS)

The files provided comprise a legacy HEC-HMS project titled “4MC” (Four Mile Creek) configured as an event-based design-storm model. The project metadata show it was built using HEC-HMS Version 3.0.0 and last executed in December 2006, with basin/meteorology edits dated April 2006. The existing HEC-HMS model configurations have been summarized in **Table 3-1** below:

Table 3-1: Summary of Existing HEC-HMS Model Configuration (as provided)

Item	Existing Model (From provided files)	What it Means for This Assignment
Software Version	HEC-HMS 3.0.0 (project/basin/met files)	Legacy software version; higher risk of compatibility issues with current workflows and limited support for modern continuous-simulation capabilities.



Item	Existing Model (From provided files)	What it Means for This Assignment
Model type	Event-based design-storm project	Designed to simulate discrete storms, not long-term watershed response.
Unit system	Metric	Consistent with typical engineering deliverables.
Basin models	Two: “4MC-design storm model” and “4MC-draft base model”	Primary computations appear centered on the design-storm basin; the “draft base” is an alternate configuration.
Basin schematization	34 Subbasins, 41 Junctions, 19 Reaches, 2 Reservoirs	Adequate network complexity for event routing may require restructuring for reach-specific continuous outputs.
Reservoirs	Virgil Dam-Upper and Virgil Dam-Lower	Reservoir routing is included (important control), but operations/curves must be verified for present-day use.
Loss method (subbasins)	SCS Curve Number (CN) with % impervious + initial abstraction	It is appropriate for event runoff estimation, but not sufficient alone for continuous soil moisture accounting without additional components.
Transform method (subbasins)	SCS Unit Hydrograph using lag time	Event hydrograph shaping method; not a continuous process model.
Baseflow	None	Major limitation for geomorphic work (no low-flow regime / recession representation).
Reach routing	Muskingum-Cunge, “8-point channel” definition per reach	Suitable for event routing; requires validation of reach geometry/slopes/roughness and does not replace hydraulic model needs.
Meteorology	Specified Average precipitation method	Uniform precipitation forcing across subbasins (no spatial variability).
Storm inputs	2-, 5-, 10-, 25-, 100-year storms	Design-event oriented (useful for peak screening, not for long-term regime metrics).
Hyetograph definition	12-hour AES incremental storms (St. Catharines)	Short-duration synthetic events; not representative of multi-year climatic sequencing.
Time step	5-minute computational interval	Good temporal resolution for event response.
Simulation window	24 hours (Feb 16–17, 2006)	Confirms event focus (storm + recession), not continuous simulation.
Data storage	HEC-DSS (4MC.dss)	Contains precipitation series and routing/curve tables referenced by the HMS model.

3.2.2 Limitations of the Existing Model

The existing model is not suitable for detailed geomorphic assessment primarily because it is configured as a legacy, design-storm, event-based framework and does not produce the continuous flow information required to characterize the flow regime that drives channel adjustment and stability analysis.

- **Legacy platform and vintage:** The model was developed in **HEC-HMS 3.0.0** with last execution metadata in **2006**. This introduces practical drawbacks: potential conversion/compatibility challenges, limited alignment with current continuous simulation workflows, and reduced confidence that parameterization reflects present



watershed conditions (land use, stormwater controls, and current drainage connectivity).

- **Design-storm orientation:** The model uses discrete AES storms (2- to 100-year) and runs over a single 24-hour window. This configuration is appropriate for peak flow screening but cannot support long-term geomorphic interpretation because it does not represent inter-event variability, seasonal patterns, or cumulative hydrologic forcing.
- **No baseflow representation:** Baseflow is set to “None” throughout. For geomorphology, absence of baseflow prevents representation of recession behavior, low-flow regime, sustained wet-season discharges, and persistence of flows that influence bank saturation, toe scour susceptibility, and sediment transport continuity.
- **Limited treatment of antecedent moisture and event sequencing:** As the model is event-based and without a continuous soil-moisture accounting framework, it does not simulate evolving watershed wetness over weeks/months. As a result, runoff sensitivity to seasonal evapotranspiration effects, and antecedent precipitation conditions is not captured, yet these are often critical drivers of erosion effectiveness and reach response.
- **Spatially uniform precipitation forcing:** Precipitation is applied using **Specified Average** with the same St. Catharines incremental hyetograph assigned across subbasins. This can misrepresent spatial rainfall variability and may distort timing/magnitude of tributary contributions, particularly important when attributing flows to specific reaches.
- **Routing and structure parameter verification requirements:** Muskingum-Cunge routing relies on reach parameterization (lengths, slopes, Manning's n, and referenced tables) and reservoir routing relies on storage-outflow tables. For current application, these inputs require confirmation against current conditions and operational assumptions before they can be relied upon quantitatively.

4 FIELD SURVEY

Field surveys were undertaken to verify desktop findings, document existing channel conditions, and collect the geomorphic and topographic data required to support the fluvial geomorphic assessment of Lower Four Mile Creek. The field program included site reconnaissance, detailed topographic and bathymetric surveying, and systematic photographic documentation of geomorphic hazards and opportunities.

4.1 Site Reconnaissance

An initial site reconnaissance was conducted on October 12, 2025, prior to the detailed survey program. The purpose of this reconnaissance was to obtain an overall understanding of channel morphology, riparian conditions, and site accessibility throughout the study area. The reconnaissance confirmed access points verified the locations of road, rail, and utility crossings, and identified areas requiring special consideration for safety and survey logistics.

During reconnaissance, the creek was observed to contain numerous fallen and broken trees, exposed root systems, and significant in-channel woody debris accumulations. These features are indicative of ongoing bank erosion, toe scour, and localized channel instability in several reaches. In many locations, exposed roots and undercut banks suggest active lateral adjustment processes. Indicators of geomorphic adjustment, including bank undercutting, localized slumping, and erosion-prone banks, were identified along several reaches. These

observations were used to refine the detailed survey plan and ensure that subsequent data collection focused on geomorphologically relevant locations. Extensive photographic documentation was completed during the reconnaissance survey; a representative subset of these photographs is presented in **Figure 4-1** to **Figure 4-4**.



Figure 4-1: Crossing Over the Creek



Figure 4-2: Fallen Tree



Figure 4-3: Broken Tree at the Bank



Figure 4-4: In Channel Woody Debris

4.2 Topographic, Bathymetric and Cross Section Survey

Detailed topographic, bathymetric, and cross-section surveys were conducted between October 18, 2025, and October 26, 2025, to characterize channel geometry, floodplain form, and in-stream conditions. Surveying was completed using Real-Time Kinematic (RTK) GPS equipment to obtain accurate, georeferenced elevation data along channel banks, the channel bed, and adjacent floodplain areas. The collected field data during the survey are presented in **Figure 4-5**.

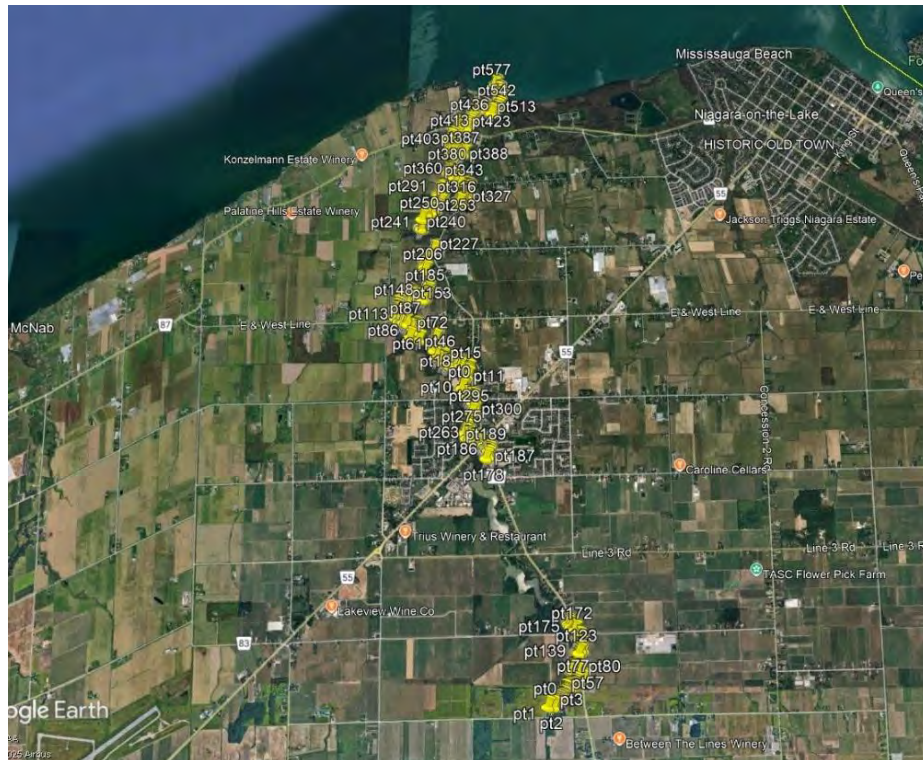


Figure 4-5: Collected Field Data Points by AHYDTECH

Cross sections were surveyed at representative intervals (shown in **Figure 4-6**) along each geomorphic reach and at key locations, including upstream and downstream of hydraulic structures, at channel bends, confluences, and areas exhibiting active or potential instability. Bankfull indicators were identified at each cross section based on field observations such as breaks in slope, changes in vegetation, water marks on banks, and sediment texture, and were surveyed using RTK equipment.

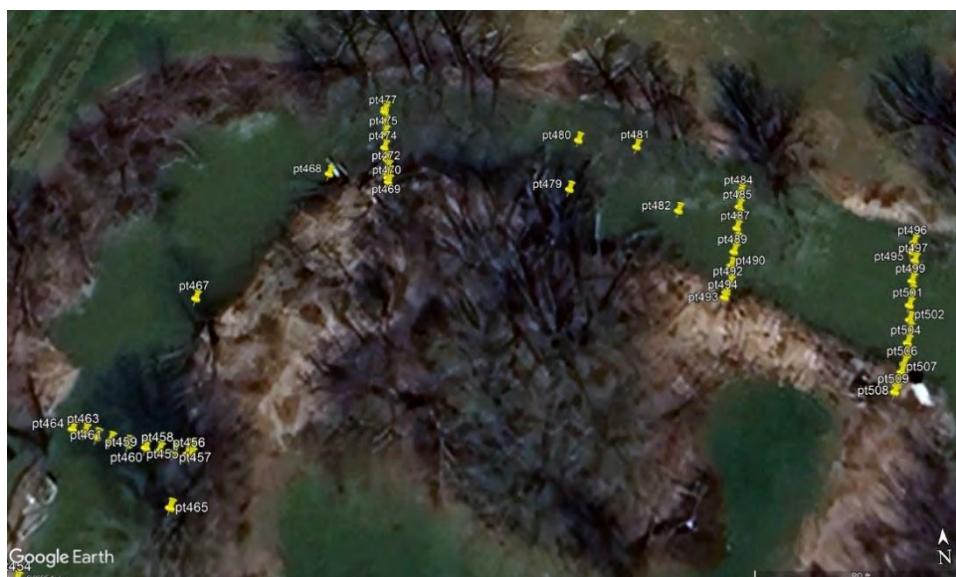


Figure 4-6: Cross-section Data Points collected by AHYDTECH

Survey equipment was deployed as required to capture channel bed profiles within riffle and pool sections of the creek. Structural information at identified crossings was also collected to



support geomorphic assessment, including channel alignment, evidence of scour or deposition, and potential impacts on channel stability.

4.3 Collection of Photographs of Hazards and Opportunities

Photographic documentation was completed systematically across the study area to record existing channel conditions, geomorphic hazards, and potential restoration or mitigation opportunities. Photographs were taken at representative locations within each reach and at all identified erosion-prone areas, infrastructure crossings, and zones of geomorphic interest. The photographs were sorted by reach (shown in **Figure 4-7**). **Figure 4-8** presents the reach-wise organized images, and a selection of representative photographs for each reach is provided in **APPENDIX A: Site Photos**.

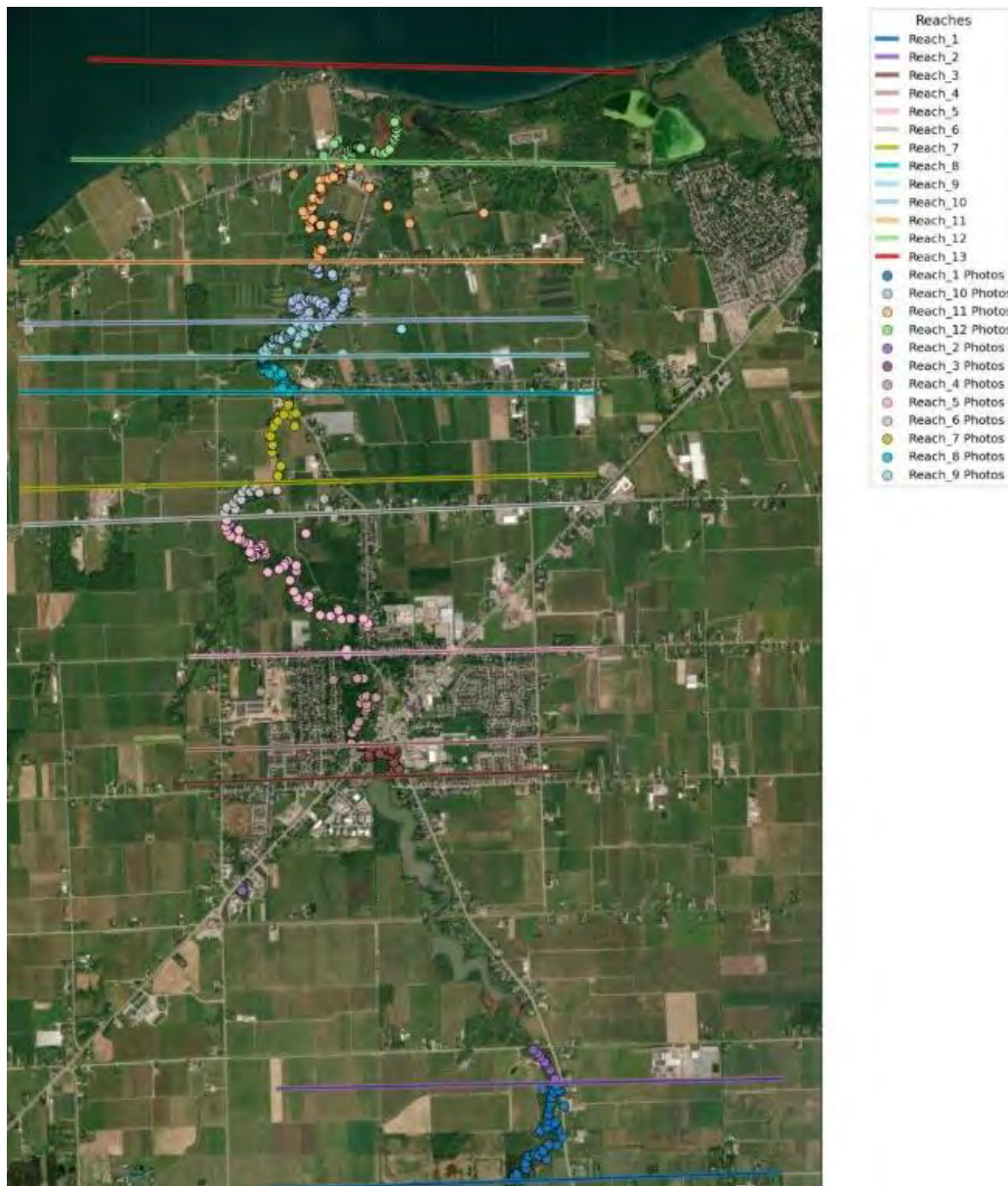


Figure 4-7: Reach Wise Photo Location

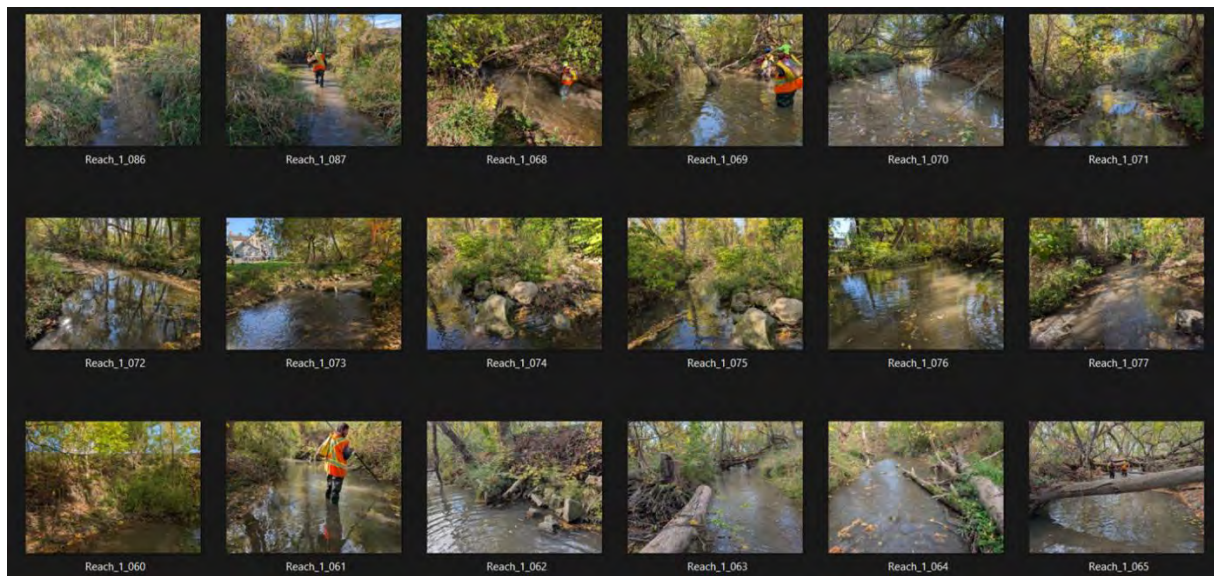


Figure 4-8: Reach Wise Sorted Images

Photographs captured evidence of bank erosion, exposed roots, fallen trees, woody debris accumulation, channel obstructions, riparian condition variability, and interactions between the channel and adjacent land uses or infrastructure. Each photograph was georeferenced and catalogued to support mapping, interpretation, and future reference. This photographic record provides visual context for the geomorphic assessment findings and supports communication of the site conditions and identified issues.

5 FIELD GEOMORPHIC INVESTIGATIONS

A field investigation was conducted by AHYDTECH between October 18, 2025, and October 26, 2025, to evaluate the existing geomorphic conditions of Lower Four Mile Creek. The fluvial geomorphic assessment for this study focused on characterizing localized channel form and active fluvial processes at locations where the creek crosses or flows adjacent to roadway infrastructure. Attention was given to identifying indicators of geomorphic stability, assessing erosion susceptibility, and understanding the interaction between channel morphology and existing or proposed infrastructure constraints.

As part of the field investigation, the study area was delineated into a series of discrete geomorphic reaches to support a structured and consistent assessment framework. Following reach segmentation, two standardized field-based evaluation methods were applied: The Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT). These assessments provided a systematic basis for documenting channel conditions, identifying areas of instability, and supporting subsequent geomorphic interpretation and management recommendations.

5.1 Reach Delineation

AHYDTECH undertook a systematic reach delineation for Lower Four Mile Creek using a two-stage methodology that integrated desktop geomorphic assessment with detailed field verification. This approach ensured that the reach boundaries accurately reflected current channel conditions and provided a foundation for subsequent Meander Belt Analysis and fluvial geomorphic interpretation.

The delineation process began with a detailed review of available spatial datasets, including high-resolution aerial imagery, the most recent LiDAR-derived Digital Elevation Models (DEMs), and Google Earth Pro resources. These datasets were used to interpret channel planform characteristics and identify key geomorphic features influencing channel form and adjustment. Control points such as tributary confluences, major meander bends, infrastructure crossings, and other natural or anthropogenic features affecting flow and sediment transport were identified during this phase.

Based on the desktop geomorphic interpretation, the Lower Four Mile Creek corridor was subdivided into twelve (12) distinct reaches, including two (2) reaches upstream of the Virgil Reservoir and ten (10) reaches downstream. Reach boundaries were established at locations where observable transitions in channel morphology and controlling conditions occurred. These transitions included changes in valley setting, channel confinement, sinuosity, gradient, bank stability, substrate composition, riparian vegetation cover, surrounding land use, and evidence of active geomorphic processes such as erosion or deposition.

Following the preliminary reach segmentation, field investigations were undertaken to confirm the channel boundaries and verify the reach break locations. Site reconnaissance allowed for direct observation of channel form, flow conditions, bank characteristics, and geomorphic stability indicators. Field verification also provided an opportunity to assess the accuracy of the remote sensing datasets and to identify any recent channel changes, sediment accumulation, erosion features, or land development activities not captured in the available imagery or elevation models.

Field observations were incorporated into the final reach delineation, and the reach boundaries were refined where necessary to ensure consistency with actual site conditions. The resulting reach framework therefore reflects a combination of geomorphic interpretation from available resources and confirmation through field-based evidence, ensuring that each reach represents a relatively homogeneous channel segment with similar form, function, and governing fluvial processes. The finalized reach delineation is illustrated in **Figure 5-1**. The longitudinal profile of each reach has been presented in **Figure 5-2** to **Figure 5-13**.

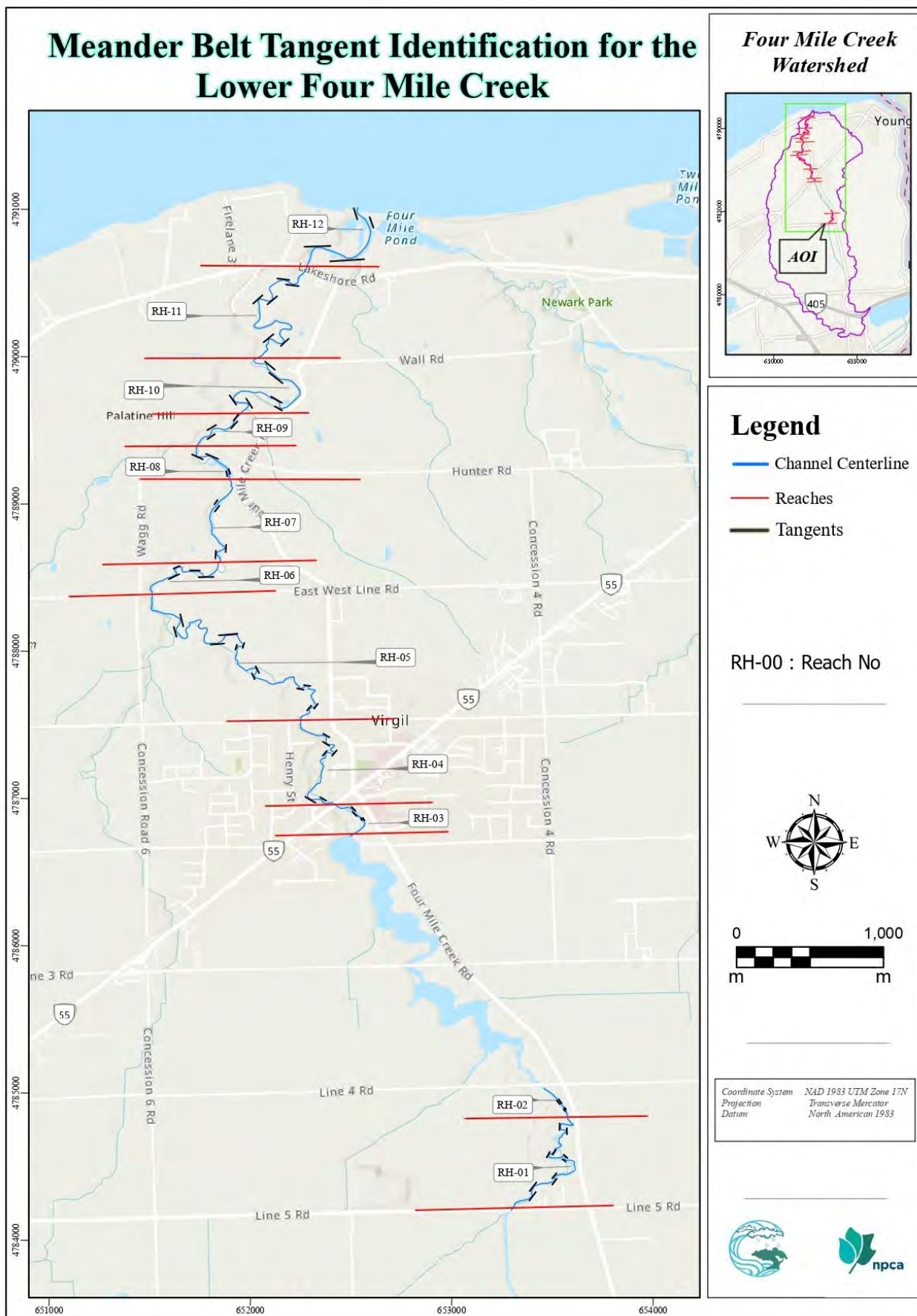


Figure 5-1: Overall Reach Delineation of Four Mile Creek

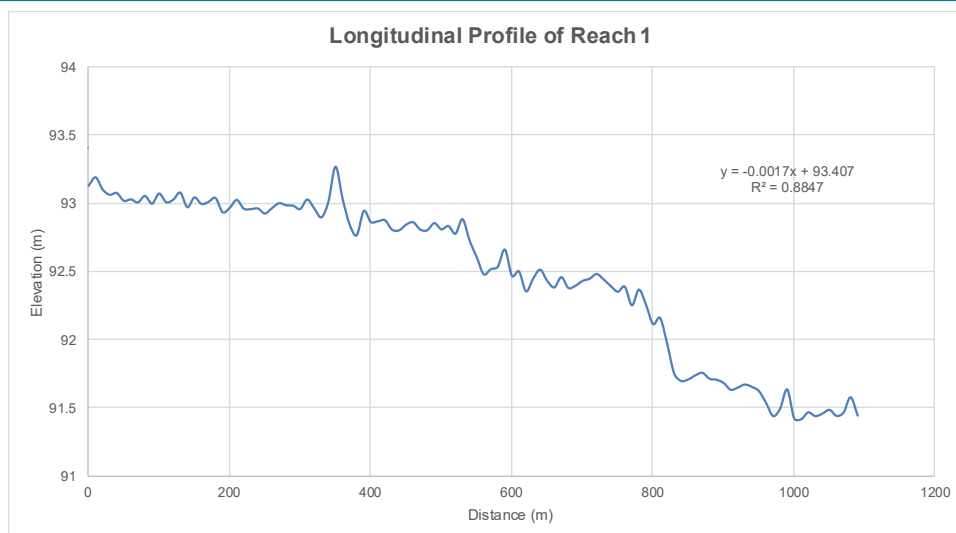


Figure 5-2: Longitudinal Profile of Reach 1

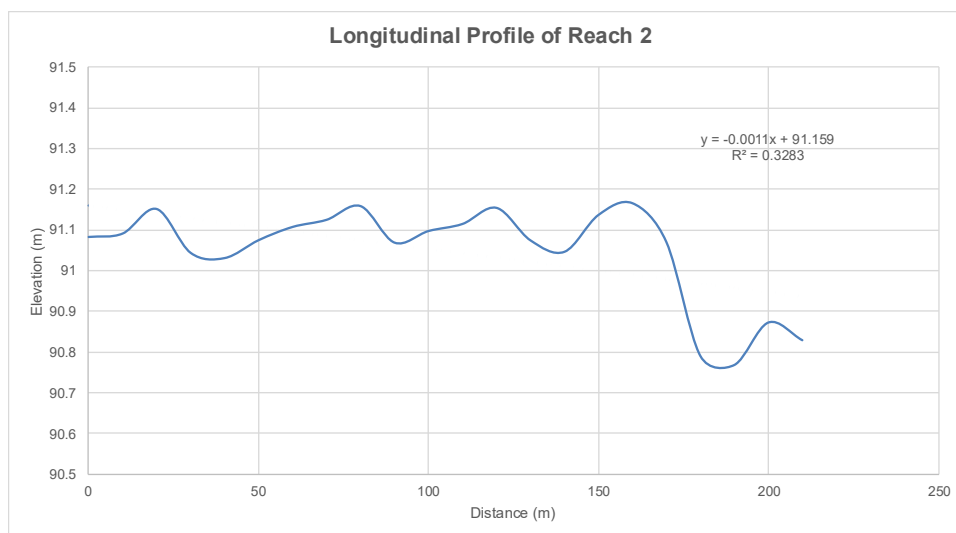


Figure 5-3: Longitudinal Profile of Reach 2

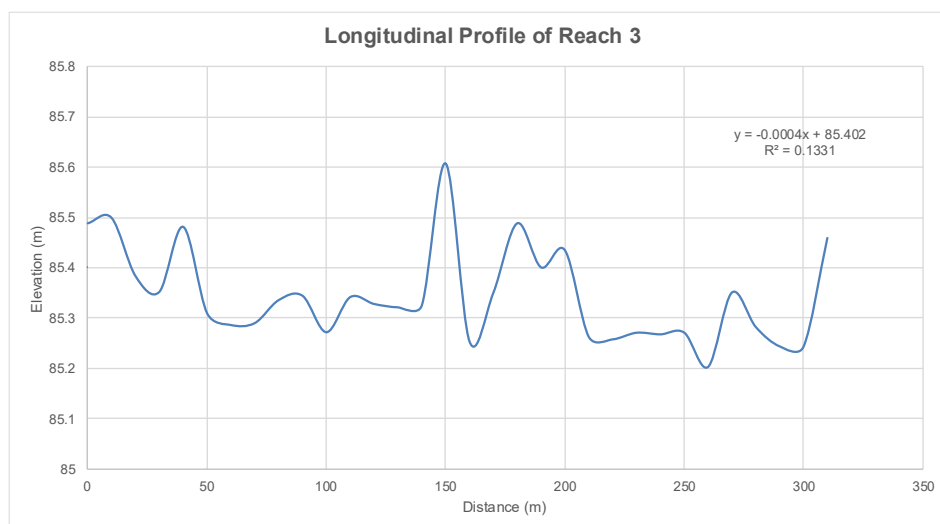


Figure 5-4: Longitudinal Profile of Reach 3

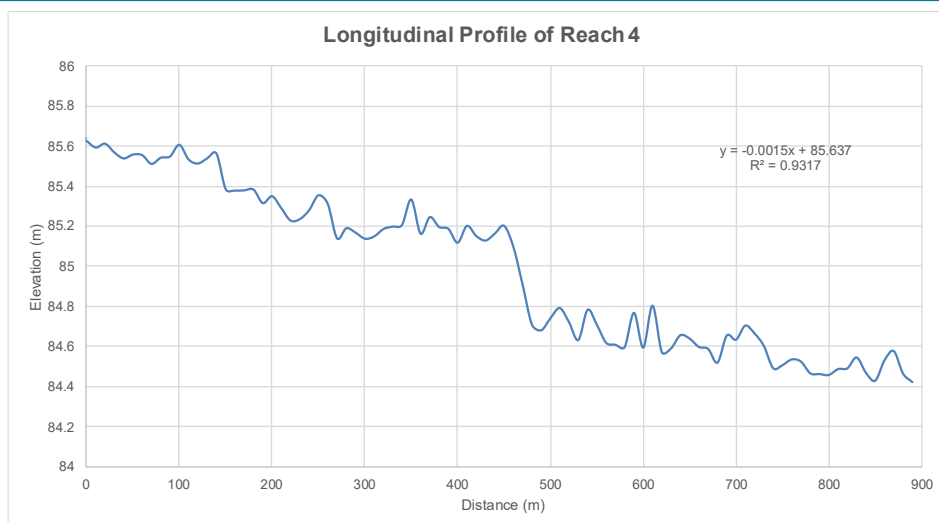


Figure 5-5: Longitudinal Profile of Reach 4

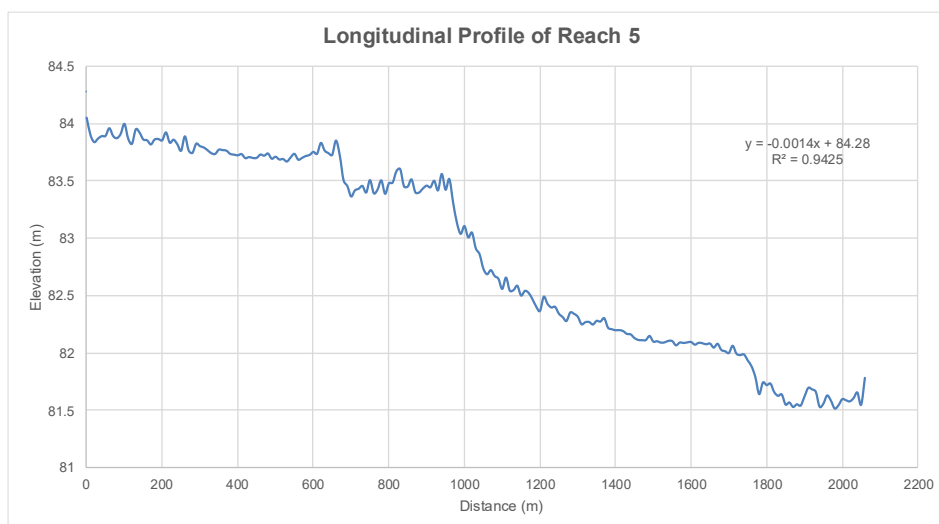


Figure 5-6: Longitudinal Profile of Reach 5

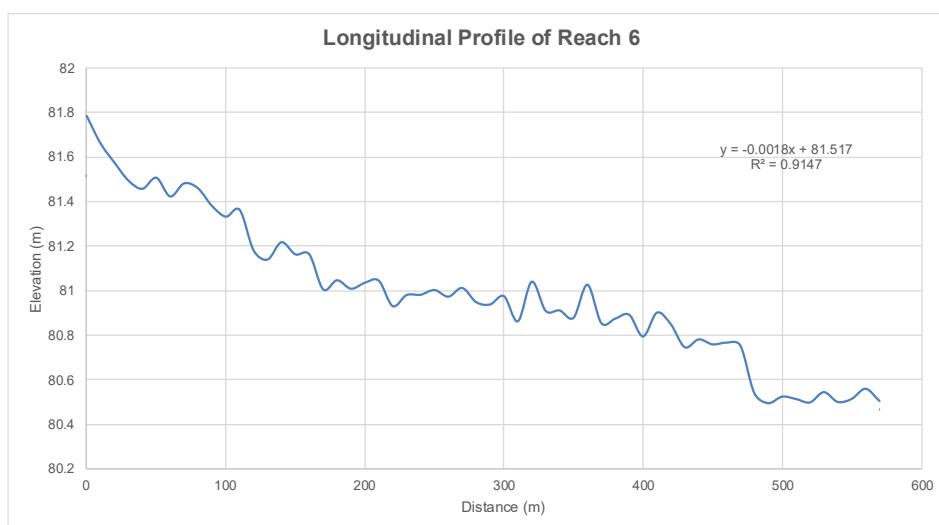


Figure 5-7: Longitudinal Profile of Reach 6

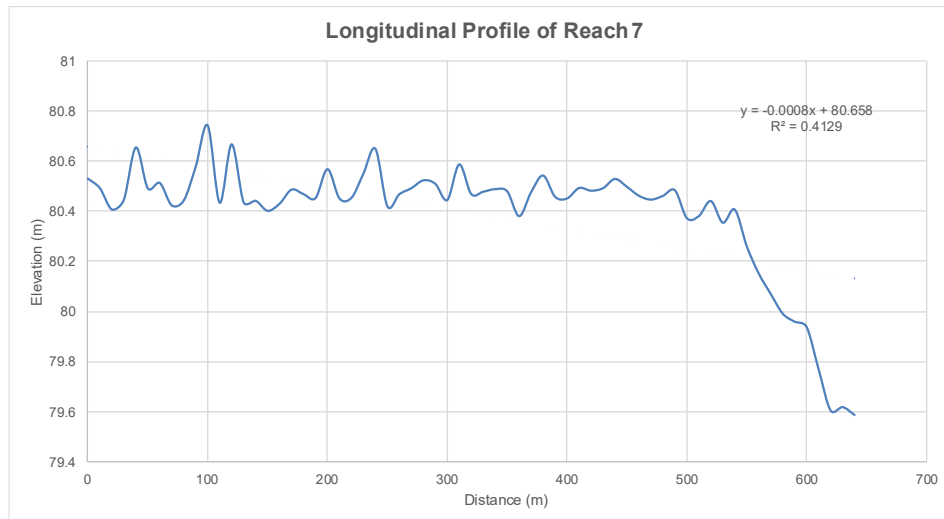


Figure 5-8: Longitudinal Profile of Reach 7

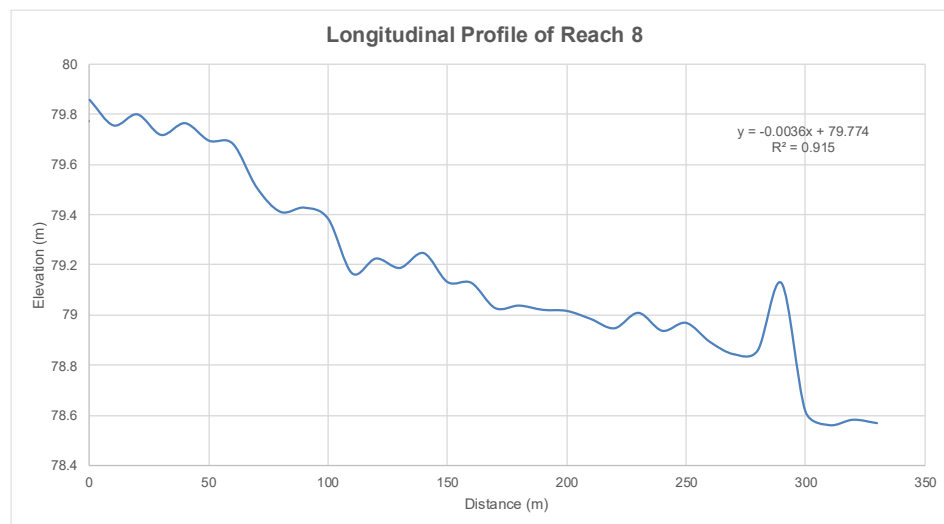


Figure 5-9: Longitudinal Profile of Reach 8

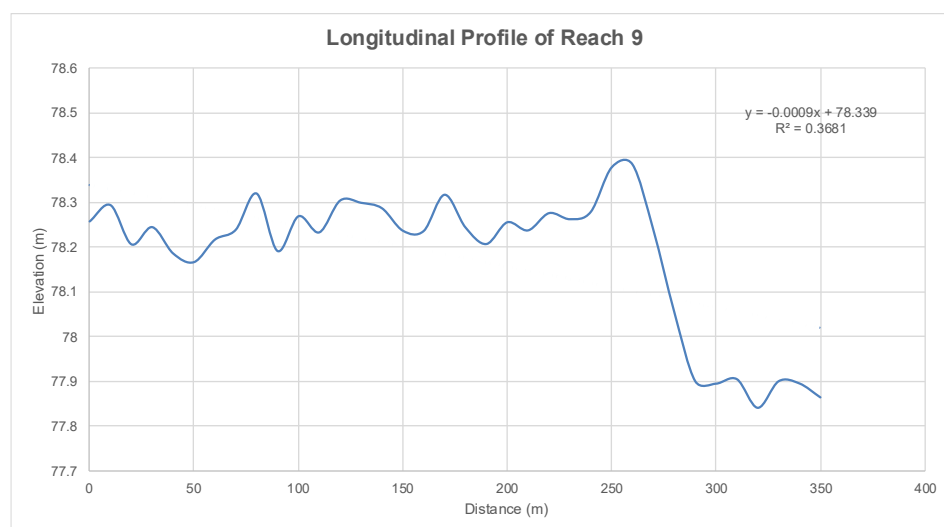


Figure 5-10: Longitudinal Profile of Reach 9

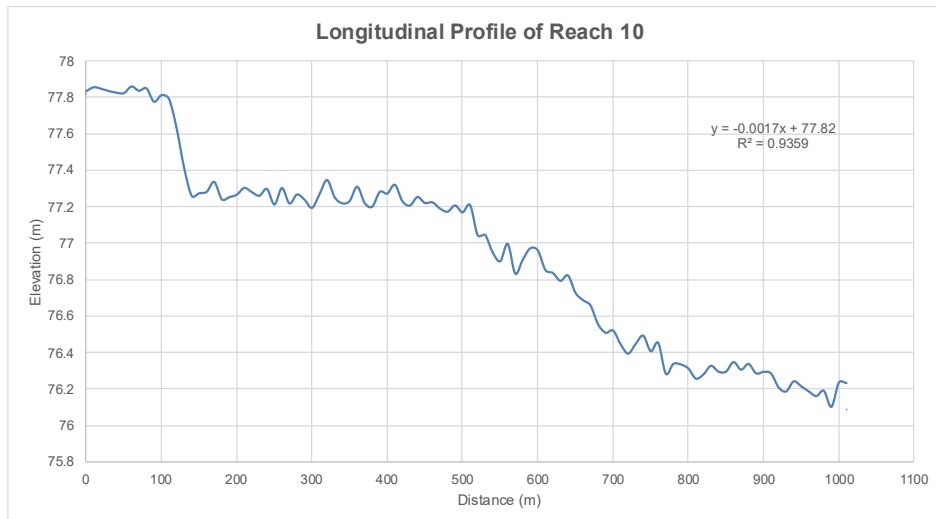


Figure 5-11: Longitudinal Profile of Reach 10

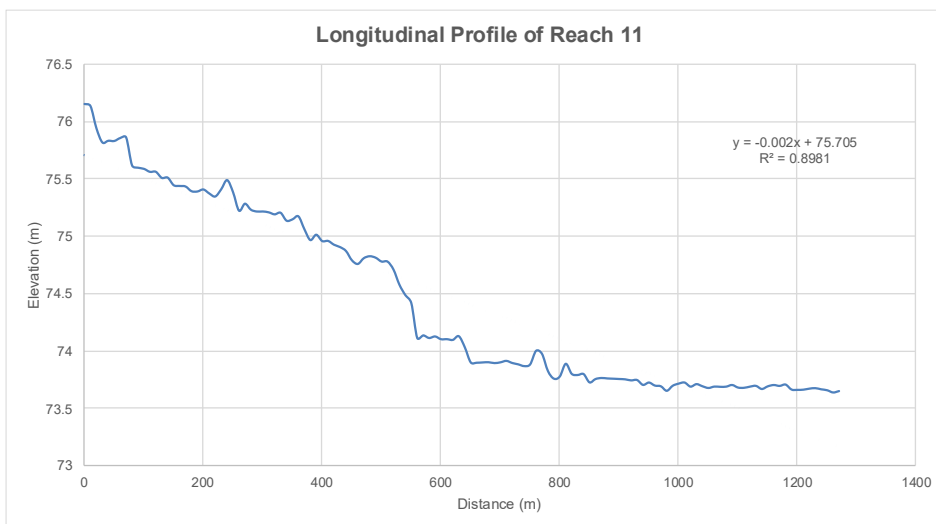


Figure 5-12: Longitudinal Profile of Reach 11

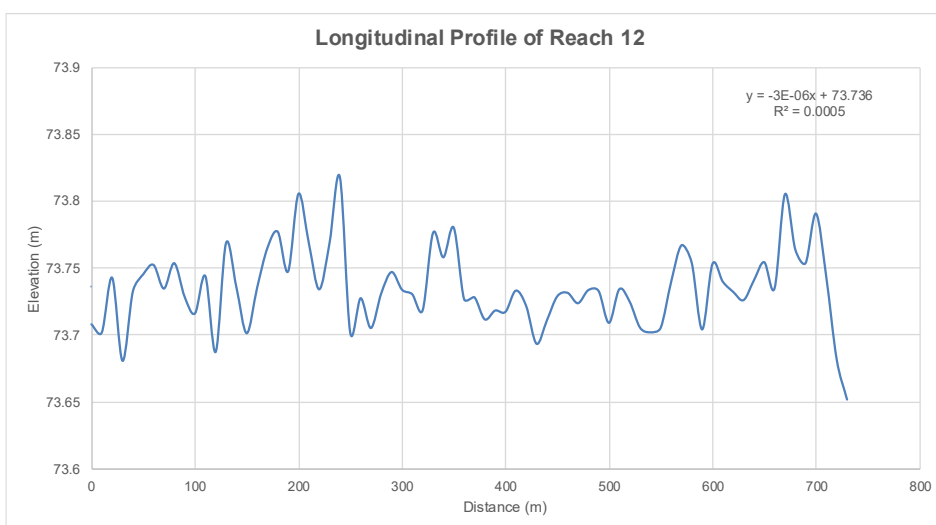


Figure 5-13: Longitudinal Profile of Reach 12



5.2 Rapid Geomorphic Assessment

The RGA (Rapid Geomorphic Assessment) observes stream stability based on processes of aggradation, degradation, channel widening or planimetric form adjustment (Vermont Agency of Natural Resources, 2009). These processes are quantified using an index that specifies whether the stream is stable (0.00-0.20), stressed (0.21-0.40), or in adjustment (>0.41). **Table 5-1** below interprets RGA classification:

Table 5-1: Rapid Geomorphic Assessment Classification

Stability Index	Classification	Interpretation
≤ 0.20	Stable or In Regime (Least Sensitive)	No indication of active channel morphological adjustment in process; evidence of instability is isolated or associated with normal river meander propagation processes
$0.21 - 0.40$	Transitional or Stressed (Moderately Sensitive)	Channel morphological adjustment is within the range of variance for streams of similar hydrographic characteristics, but the evidence of instability is frequent
≥ 0.41	In Adjustment (Most Sensitive)	Channel morphological adjustment is not within the range of variance for streams of similar hydrographic characteristics and evidence of instability is widespread

The Rapid Geomorphic Assessment (RGA) results of the reaches summarized in Table 5-2 indicate that a majority of reaches are classified as Transitional (Stressed), suggesting measurable but not severe channel adjustment across the study area. The predominance of Transitional (Stressed) classifications indicates that while the channel is not undergoing catastrophic adjustment, measurable and recurring instability processes are active throughout much of the study corridor. These include localized bank erosion, widening tendencies, and planform adjustment, particularly in reaches with higher sinuosity and limited riparian buffering.

Reaches 01, 02, 05, 07, and 12 were classified as In Regime, with Stability Index values at or below 0.20, indicating that these segments are generally stable and exhibit limited evidence of active morphological adjustment beyond natural meander progression. In contrast, reaches 03, 04, 06, 08, 09, 10, and 11 were categorized as In Transition, with Stability Index values between 0.23 and 0.34. These reaches display more frequent indicators of channel adjustment, primarily associated with localized aggradation, widening, and planform modification. Details of the RGA are provided in **APPENDIX B: Rapid Geomorphic Assessment**.

Table 5-2: Summary of RGA

Reach	Factor Value				Stability Index	Condition
	Aggradation	Degradation	Widening	Planform Adjustment		
Reach 01	0.14	0	0.40	0.14	0.17	In Regime
Reach 02	0.29	0	0.40	0.14	0.20	In Regime
Reach 03	0.43	0	0.40	0.14	0.24	In Transition
Reach 04	0.43	0.10	0.40	0.14	0.27	In Transition
Reach 05	0.29	0	0.40	0.14	0.20	In Regime
Reach 06	0.43	0	0.40	0.29	0.28	In Transition
Reach 07	0.29	0	0.20	0.14	0.16	In Regime



Reach	Factor Value			Planform Adjustment	Stability Index	Condition
	Aggradation	Degradation	Widening			
Reach 08	0.14	0.10	0.40	0.29	0.23	In Transition
Reach 09	0.29	0.10	0.40	0.14	0.23	In Transition
Reach 10	0.57	0	0.50	0.29	0.34	In Transition
Reach 11	0.57	0.10	0.40	0.14	0.30	In Transition
Reach 12	0.14	0	0.40	0	0.14	In Regime

5.3 Rapid Stream Assessment Technique

An RSAT (Rapid Stream Assessment Technique) provides a broader overview of the system by considering the ecological functions of the stream (Galli, 1996). Observations include instream habitat, water quality, riparian conditions and biological indicators. Additionally, the RSAT approach includes semi-quantitative measures of bankfull channel dimensions, types of substrates, vegetative covers and channel disturbance. This technique applies visual estimates of stream conditions and numerical scoring of stream parameters using six categories:

- Channel Stability
- Erosion and Deposition
- Instream Habitat
- Water Quality
- Riparian Conditions
- Biological Indicators

RSAT scores rank the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (34-42) degree of stream health. The present study performed RSAT on the twelve (12) reaches of the Lower Four Mile Creek. The summary of Rapid Stream Assessment Technique of Reaches is provided in **Table 5-3**.

Table 5-3: Summary of RSAT

Reach	Total Overall Score (0-42)	Ranking	Key Notes
Reach 01	31	Good	Overall good; moderate habitat complexity.
Reach 02	31	Good	Overall good; moderate habitat complexity.
Reach 03	30	Good	Strong riparian score; lower stability/scour vs R1-R2.
Reach 04	30	Good	Water quality is slightly lower.
Reach 05	31	Good	High water quality + riparian.
Reach 06	32	Good	Highest total; strongest channel stability.
Reach 07	29.5	Good	Habitat score lower; good scour/deposition.
Reach 08	29	Good	Habitat score lower; good water + riparian.
Reach 09	31	Good	Strong riparian score.
Reach 10	22	Fair	Lowest rank: channel stability scored Fair on form.
Reach 11	26	Good	Fair channel stability + scour reduce total.
Reach 12	16	Fair	Low habitat + water quality scores drive low total.

Details of the RSAT are shown in **APPENDIX C: Rapid Stream Assessment Technique**.



6 REACH-BY-REACH FLUVIAL GEOMORPHIC ANALYSIS

6.1 Historical Aerial Imagery Analysis

A historical aerial imagery analysis was completed to evaluate long-term planform changes, bank migration patterns, and channel stability along Lower Four Mile Creek. Aerial photographs from 1934, 1954, 2000, and 2015 were reviewed to identify shifts in left and right bank positions and to assess the degree of lateral channel adjustment over time, as shown in **Figure 6-1** to **Figure 6-4**.



Figure 6-1: Banklines in 1934 Aerial Imagery



Figure 6-2: Banklines in 1954 Aerial Imagery



Figure 6-3: Banklines in 2000 Aerial Imagery *Figure 6-4: Banklines in 2015 Aerial Imagery*

Banklines were digitized consistently for each image set and compared across the four periods. The analysis indicates that the creek has generally maintained a sinuous planform, with localized lateral migration occurring primarily along outer meander bends. Several bends show gradual bank retreat over time, while other sections exhibit relatively stable bank positions with minimal change between the imagery years.

Overall, the imagery suggests that channel migration has occurred progressively rather than abruptly, with no evidence of widespread avulsion or rapid realignment. Areas with more pronounced bank movement correspond to zones of higher sinuosity and reduced floodplain confinement. These observations provide important context for interpreting current geomorphic conditions and support subsequent analyses of bankfull channel geometry, meander belt width, and erosion hazard limits.

6.2 Bankfull Channel Geometry Analysis

Bankfull channel geometry was analyzed for the twelve (12) delineated reaches of Lower Four Mile Creek to characterize channel form, hydraulic capacity, and spatial variability along the study area. Bankfull parameters were derived using a combination of field survey data, longitudinal profile analysis, water level (WL), channel invert (CH) elevations, and reach-scale geometric measurements. Bankfull elevations were identified based on consistent field indicators, including breaks in bank slope, changes in vegetation density, sediment texture, and alignment with longitudinal water surface profiles.

For each reach, average bankfull width, average bankfull depth, channel slope, sinuosity, velocity, and estimated bankfull discharge were calculated. These parameters were used to evaluate reach-scale differences in channel size, flow capacity, and potential geomorphic response. The results of the reach-by-reach bankfull channel geometry analysis are summarized in **Table 6-1**.


Table 6-1: Bankfull Channel Geometry of All Reaches

Reach	Reach Length (m)	Average Bankfull Width (m)	Average Bankfull Depth (m)	Channel Slope	Sinuosity	Velocity (m/s)	Discharge (m ³ /s)
R1	1090	6.43	0.14	0.0017	1.62	0.48	0.42
R2	210	9.12	0.89	0.0011	1.02	1.34	10.91
R3	310	10.00	0.34	0.0004	1.41	0.43	1.45
R4	890	8.44	0.31	0.0015	1.52	0.76	1.98
R5	2060	9.38	0.46	0.0014	1.83	0.97	4.14
R6	570	9.67	0.42	0.0018	1.47	1.03	4.19
R7	640	13.69	0.83	0.0008	1.16	1.08	12.24
R8	330	10.89	0.71	0.0036	1.19	2.08	16.16
R9	350	13.37	0.47	0.0009	1.12	0.79	5.01
R10	1010	11.28	0.46	0.0017	2.65	1.06	5.48
R11	1270	10.92	0.84	0.0020	1.89	1.73	15.95
R12	730	21.33	0.76	0.000003	1.55	0.06	1.02

The analysis shows notable variability in bankfull channel geometry across the assessed reaches. Average bankfull widths range from approximately 6.43 m to 21.33 m, with wider sections generally associated with lower channel slopes and greater flow conveyance. Bankfull depths range from 0.14 m to 0.89 m, indicating differences in channel incision, sediment storage, and hydraulic efficiency.

Estimated bankfull discharges vary from less than 1 m³/s in smaller, low capacity reaches to greater than 15 m³/s in wider and more hydraulically efficient sections. Reaches with higher slopes and velocities exhibit increased erosive potential, while higher sinuosity values indicate greater lateral adjustment and meander development. Variations in bankfull width and depth also suggest differences in width-to-depth relationships, with wider and shallower sections generally exhibiting a higher potential for lateral instability. These bankfull geometry characteristics provide key input for erosion hazard assessment and directly support the meander belt width analysis and erosion hazard limit delineation.

6.3 Meander Belt Width Assessment

A meander belt width assessment was conducted for each delineated reach of Lower Four Mile Creek to evaluate the extent of lateral channel migration and to support erosion hazard limit delineation. The assessment was completed using recent aerial imagery and the field observations, with individual meander bends identified and measured within each reach.

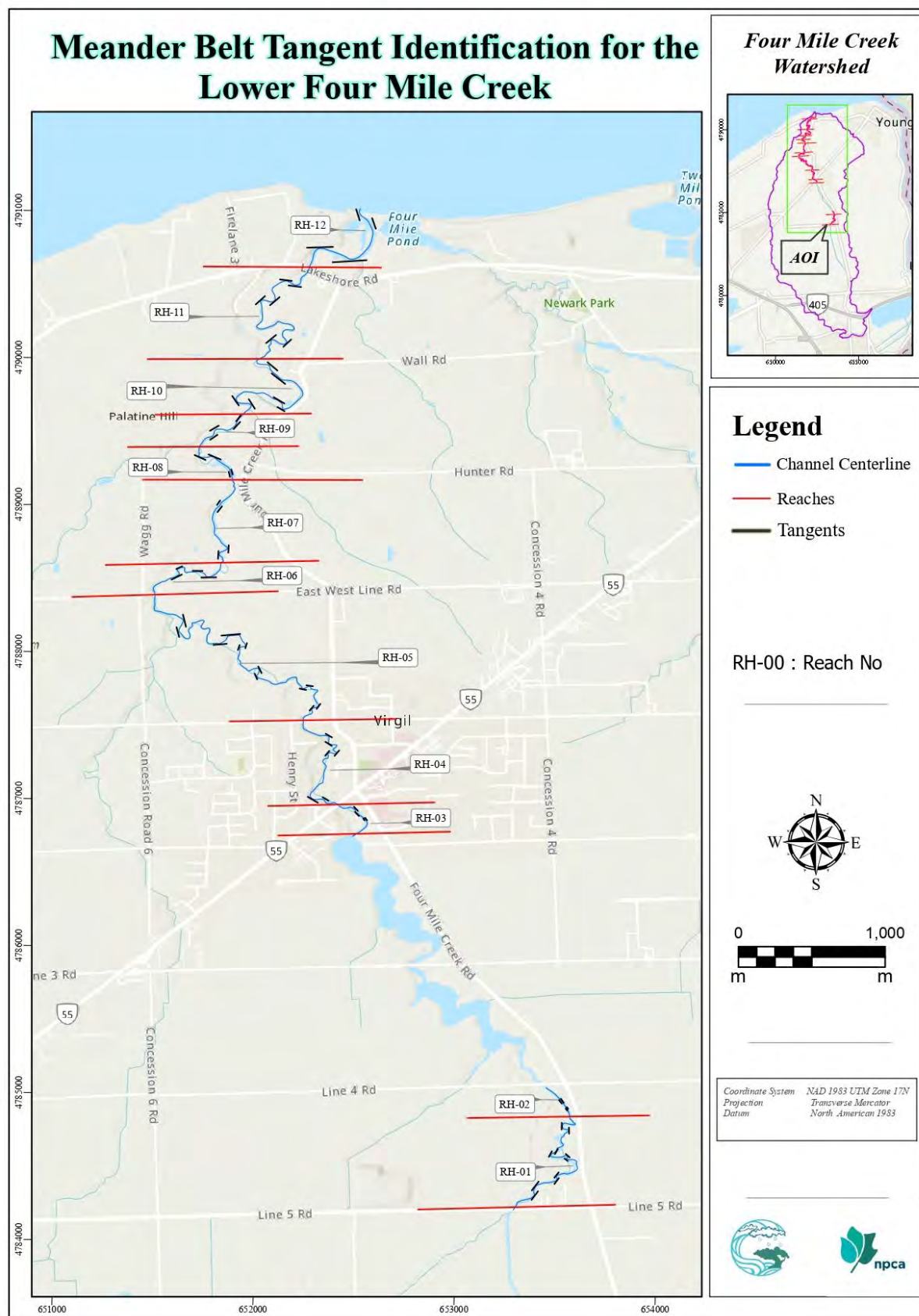


Figure 6-5: Meanderbelt Tangent Identification

Meander belt width was measured as the maximum lateral extent of successive bend apices (shown in **Figure 6-5**), consistent with standard TRCA (2004) meander belt delineation



technique and geomorphic assessment practice. Where multiple bends were present within a reach, meander belt widths were measured for each bend and summarized to determine an average meander belt width and the maximum meander belt width representative of that reach. The results of the meander belt width analysis are presented in **Table 6-2**.

Table 6-2: Calculation of Meander Belt Widths of All Reaches

Reach No.	Bend No.	Bend Width (m)	Average Bend Width (m)	Maximum Bend Width (m)
Reach 1	Bend 1	29.63	25.85	36.48
	Bend 2	21.29		
	Bend 3	23.73		
	Bend 4	18.14		
	Bend 5	36.48		
Reach 2	Bend 1	8.95	10.24	11.52
	Bend 2	11.52		
Reach 3	Bend 1	10.55	13.23	15.91
	Bend 2	15.91		
Reach 4	Bend 1	43.60	41.22	43.60
	Bend 2	40.05		
	Bend 3	40.00		
Reach 5	Bend 1	22.90	37.02	57.10
	Bend 2	30.50		
	Bend 3	31.95		
	Bend 4	32.80		
	Bend 5	57.10		
	Bend 6	46.84		
Reach 6	Bend 1	47.70	46.02	47.70
	Bend 2	44.34		
Reach 7	Bend 1	48.74	37.29	48.74
	Bend 2	25.83		
Reach 8	Bend 1	15.36	27.73	40.09
	Bend 2	40.09		
Reach 9	Bend 1	43.69	31.32	43.69
	Bend 2	18.94		
Reach 10	Bend 1	61.80	45.29	61.80
	Bend 2	39.70		
	Bend 3	34.36		
Reach 11	Bend 1	80.11	57.11	80.11
	Bend 2	58.75		
	Bend 3	32.48		
Reach 12	Bend 1	98.11	80.68	98.11
	Bend 2	63.25		

The calculated average meander belt widths vary across the study area, reflecting differences in channel planform, sinuosity, and local geomorphic controls. Reaches with higher sinuosity and well-developed meanders generally exhibit wider meander belts, indicating greater

potential for lateral channel adjustment. In contrast, reaches with lower sinuosity or increased confinement display narrower meander belt widths and more limited lateral movement.

Maximum bend widths were also considered to account for localized areas of enhanced migration potential, particularly along outer bends. These values provide a conservative representation of possible future channel adjustment under prevailing geomorphic conditions.

The meander belt width assessment, when considered alongside historical aerial imagery analysis and bankfull channel geometry, provides a basis for defining the lateral extent of channel movement. These results are used directly in the delineation of erosion hazard limits.

6.4 Erosion Hazard Limit Delineation

Under typical conditions, erosion hazard limits are established using long-term lateral migration rates to estimate an erosion setback. However, at this site, dense vegetation cover, limitations in the resolution of historical imagery, and the scale and geomorphic characteristics of the channel prevented reliable estimation of reach-specific migration rates.

Accordingly, a conservative approach was adopted using the maximum measured meander belt width as the primary indicator of lateral channel adjustment potential.

To account for future bank erosion, valley wall adjustment, and potential changes in hydrologic and sediment regimes, an erosion allowance equal to 10 percent of the maximum meander belt width was applied on each side of the channel. This results in a total factor of safety of 20 percent added to the maximum measured meander belt width.

For clarity, the erosion hazard limit for each reach was calculated as follows:

- The maximum meander belt width was first identified for the reach.
- An additional allowance equal to 10 percent of that width was added to each side.
- The resulting total width (maximum meander belt width + 20 percent) was then divided by two to determine the erosion hazard limit measured outward from the channel centerline.

Accordingly, the erosion hazard limit on each side of the channel from the channel centreline was calculated as follows:

$$\text{Erosion Hazard Limit} = (\text{Maximum Meander Belt Width} \times 1.20) / 2$$

The calculated erosion hazard limits for all reaches are summarized in **Table 6-3**.

Table 6-3: Erosion Hazard Limit Delineated for All Reaches

Reach No.	Maximum Meander Belt Width (m)	Erosion Access Allowance (m)	Erosion Hazard Limit at each Side of Channel from Channel Centerline (m)
Reach 1	36.48	7.30	21.89
Reach 2	11.52	2.30	6.91
Reach 3	15.91	3.18	9.55
Reach 4	43.60	8.72	26.16
Reach 5	57.10	11.42	34.26
Reach 6	47.70	9.54	28.62
Reach 7	48.74	9.75	29.24



Reach No.	Maximum Meander Belt Width (m)	Erosion Access Allowance (m)	Erosion Hazard Limit at each Side of Channel from Channel Centerline (m)
Reach 8	40.09	8.02	24.05
Reach 9	43.69	8.74	26.21
Reach 10	61.80	12.36	37.08
Reach 11	80.11	16.02	48.07
Reach 12	98.11	19.62	58.87

Figure 6-6 Shows the overall meander belt width and erosion hazard limit of Lower Four Mile Creek. The detailed reach wise meander belt width and erosion hazard limit is presented in **Figure 6-7** to **Figure 6-16**.

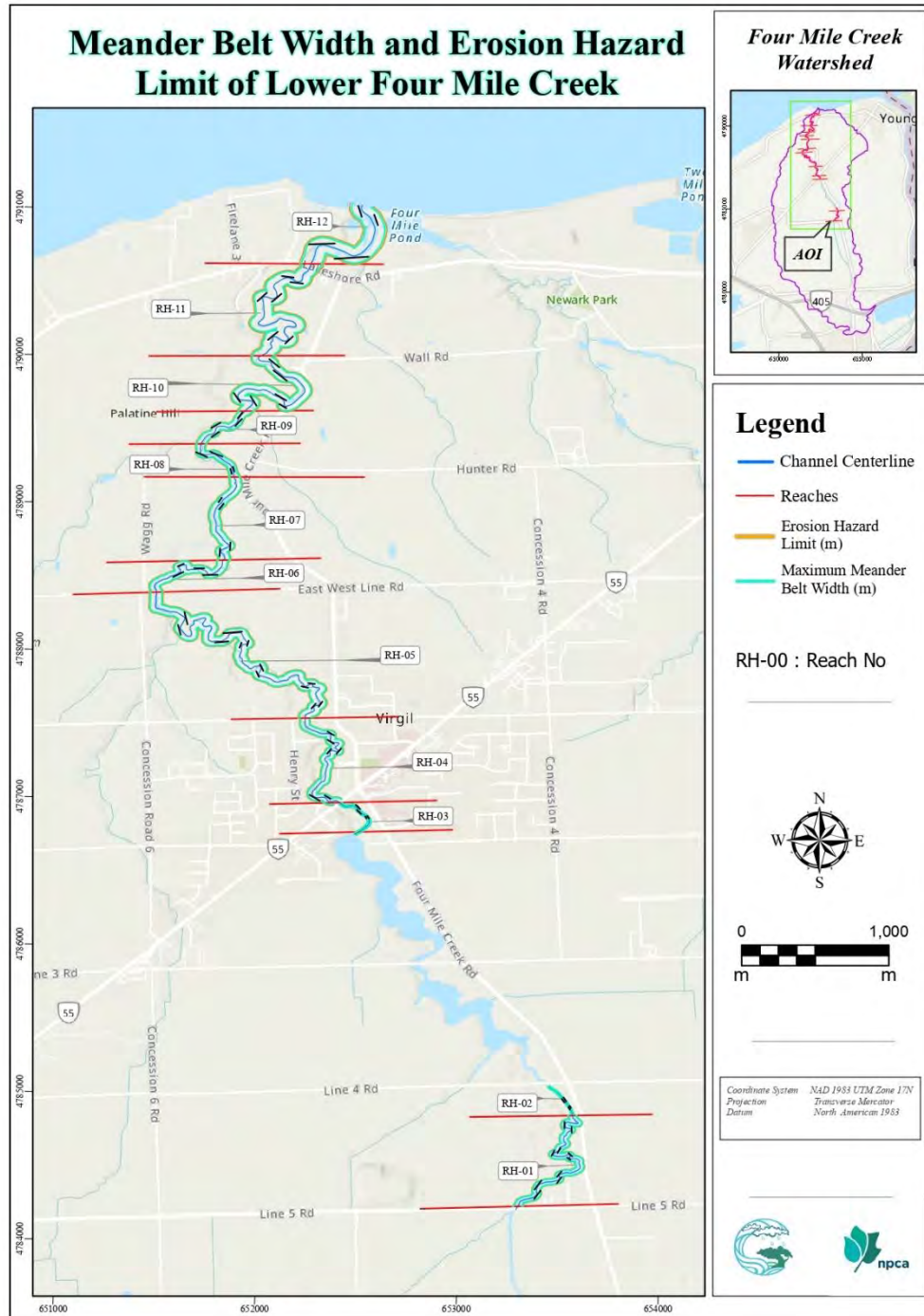


Figure 6-6: Overall Meander Belt Width and Erosion Hazard Limit

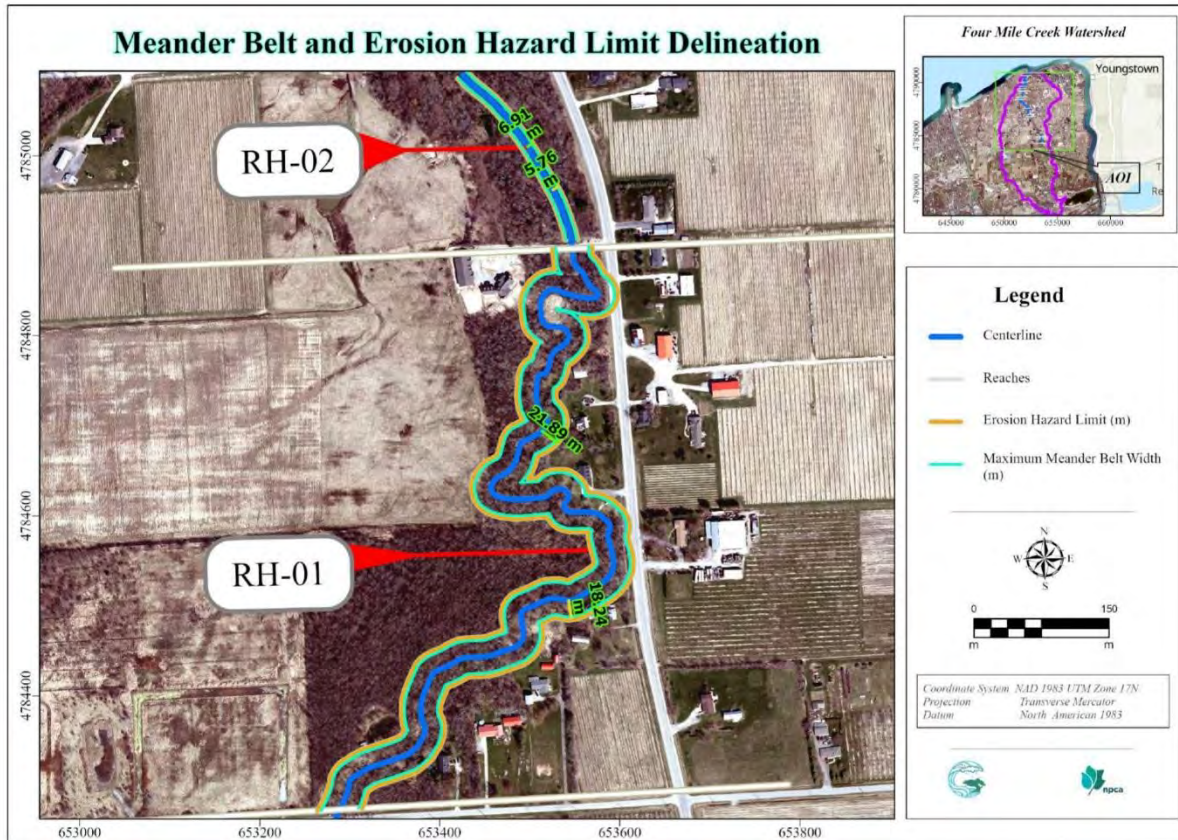


Figure 6-7: Meander Belt Width and Erosion Hazard Limit of Reach 01 and 02

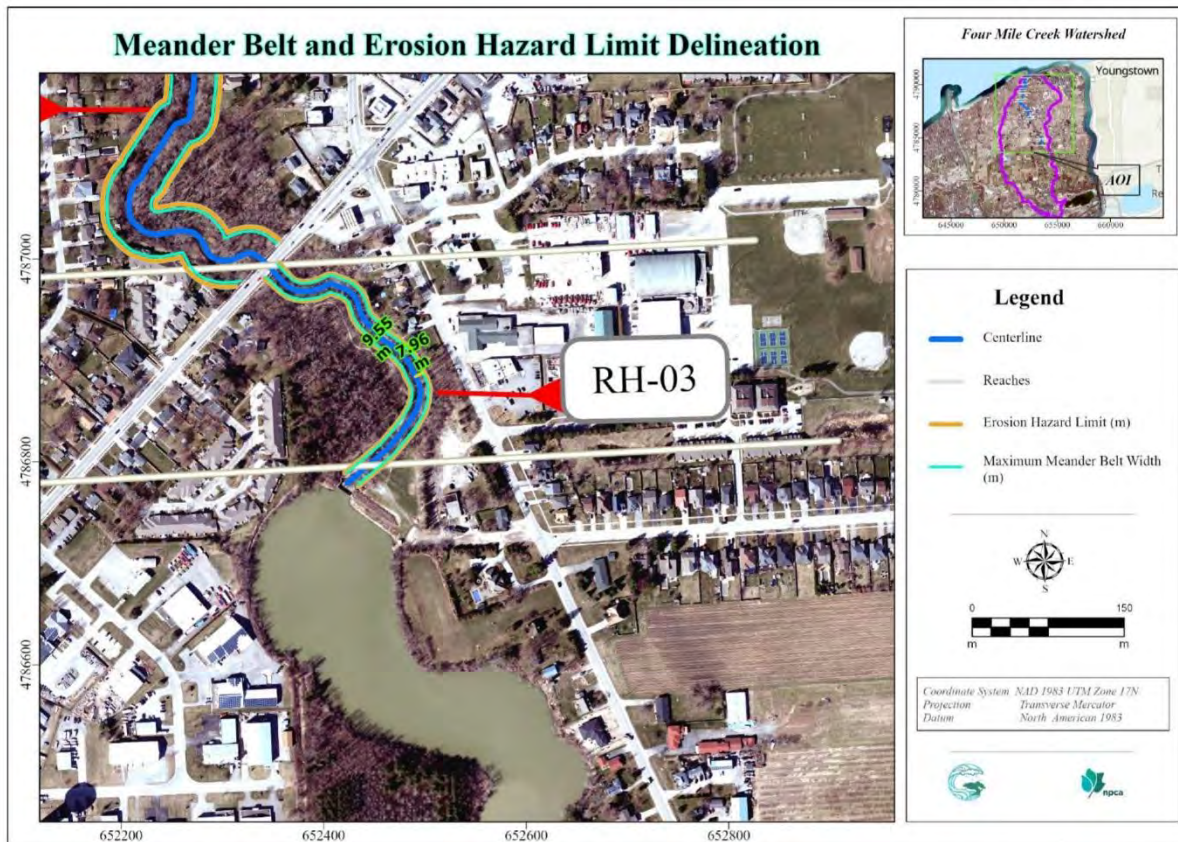


Figure 6-8: Meander Belt Width and Erosion Hazard Limit of Reach 03

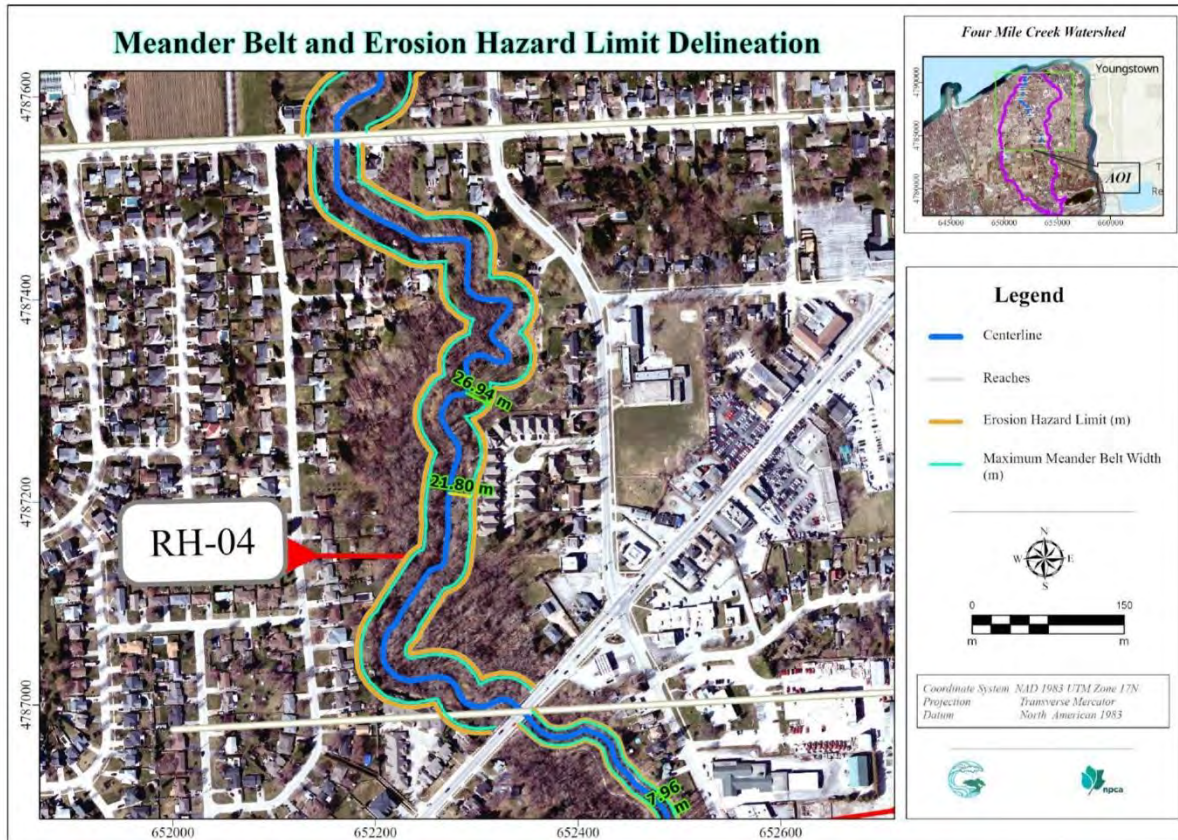


Figure 6-9: Meander Belt Width and Erosion Hazard Limit of Reach 04

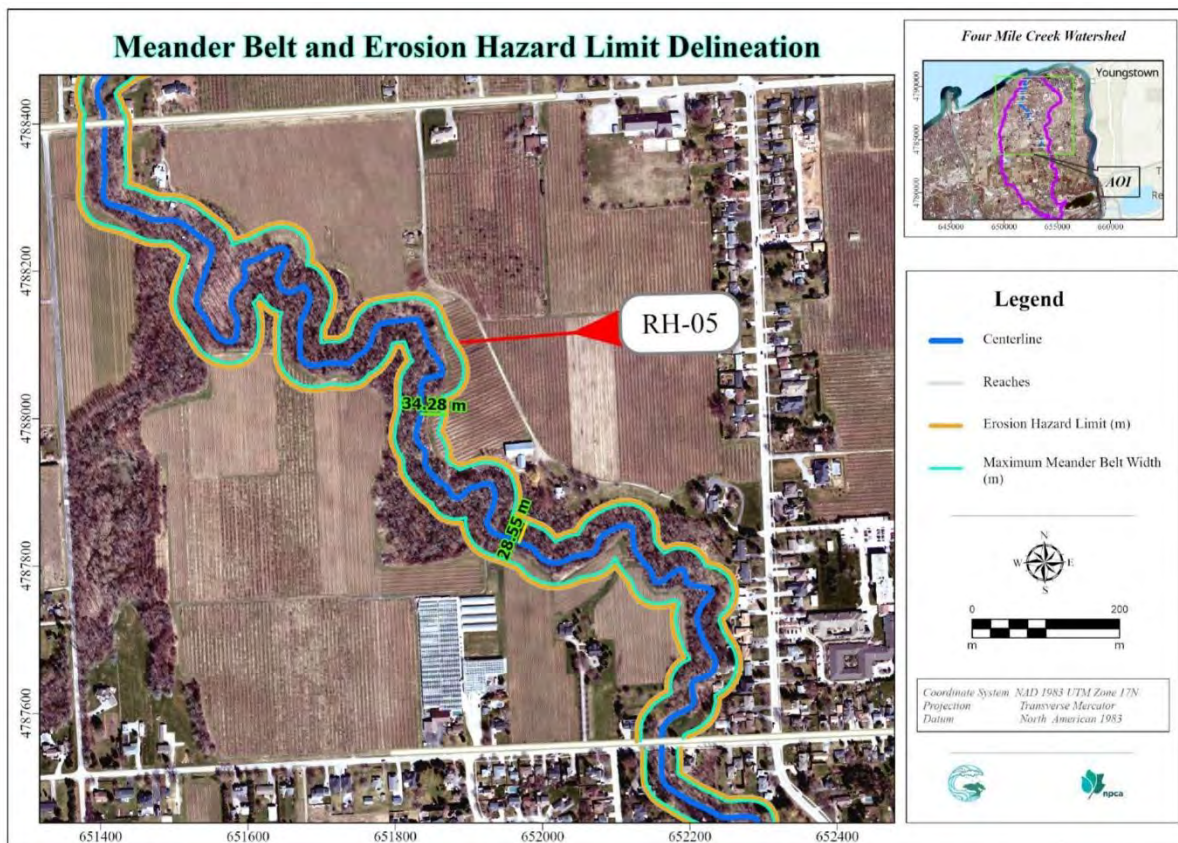


Figure 6-10: Meander Belt Width and Erosion Hazard Limit of Reach 05

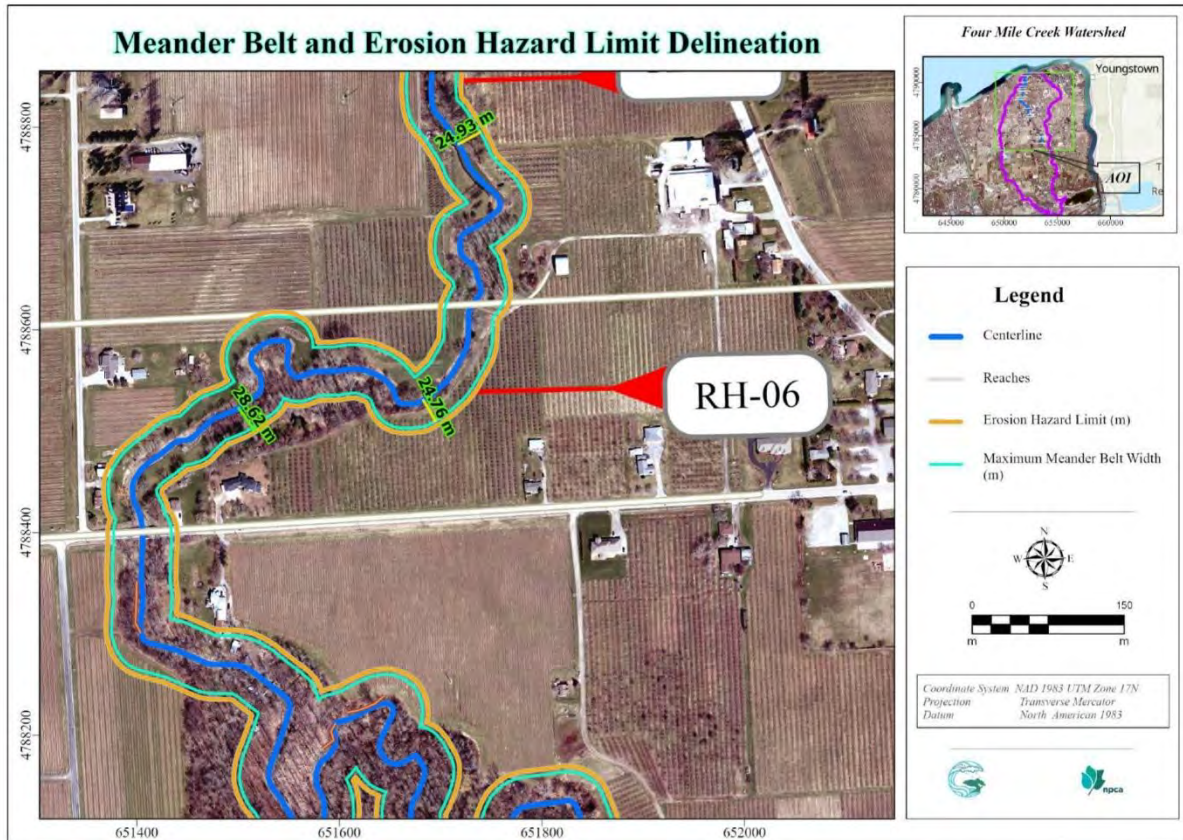


Figure 6-11: Meander Belt Width and Erosion Hazard Limit of Reach 06

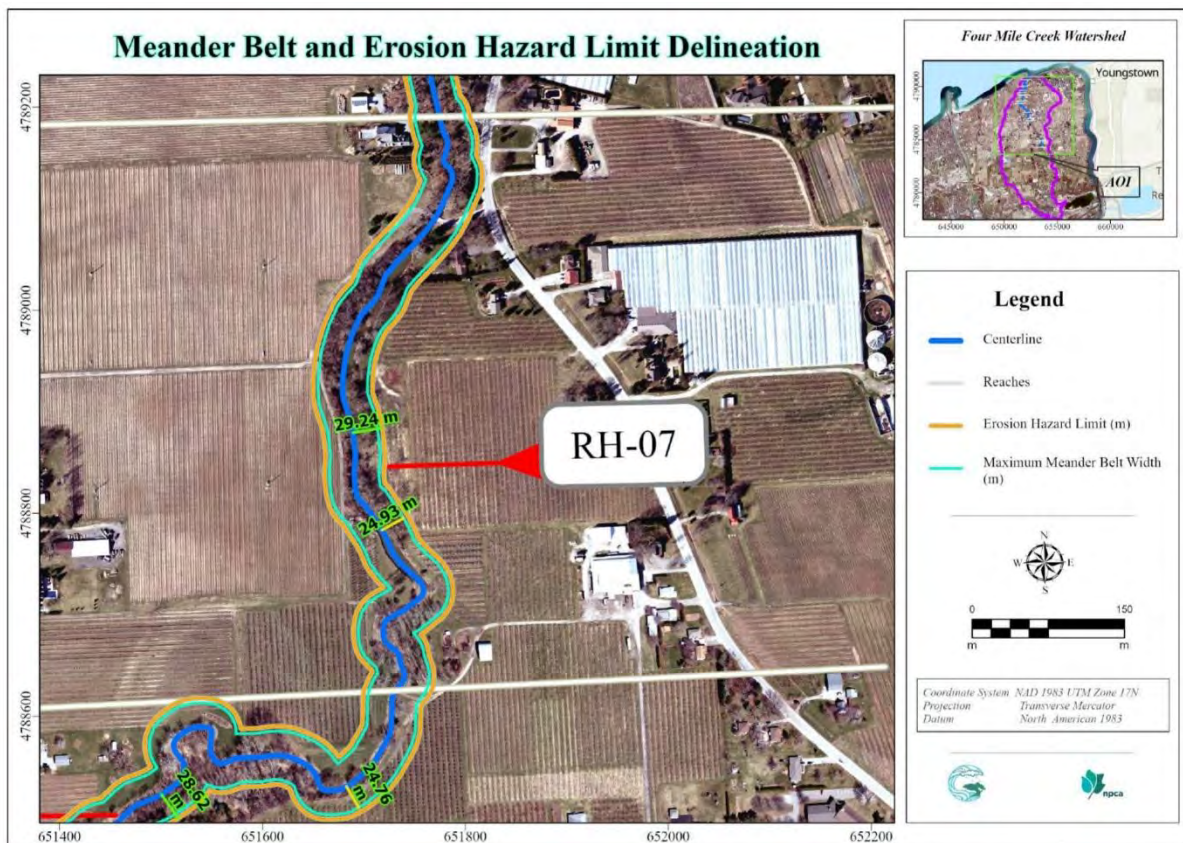


Figure 6-12: Meander Belt Width and Erosion Hazard Limit of Reach 07

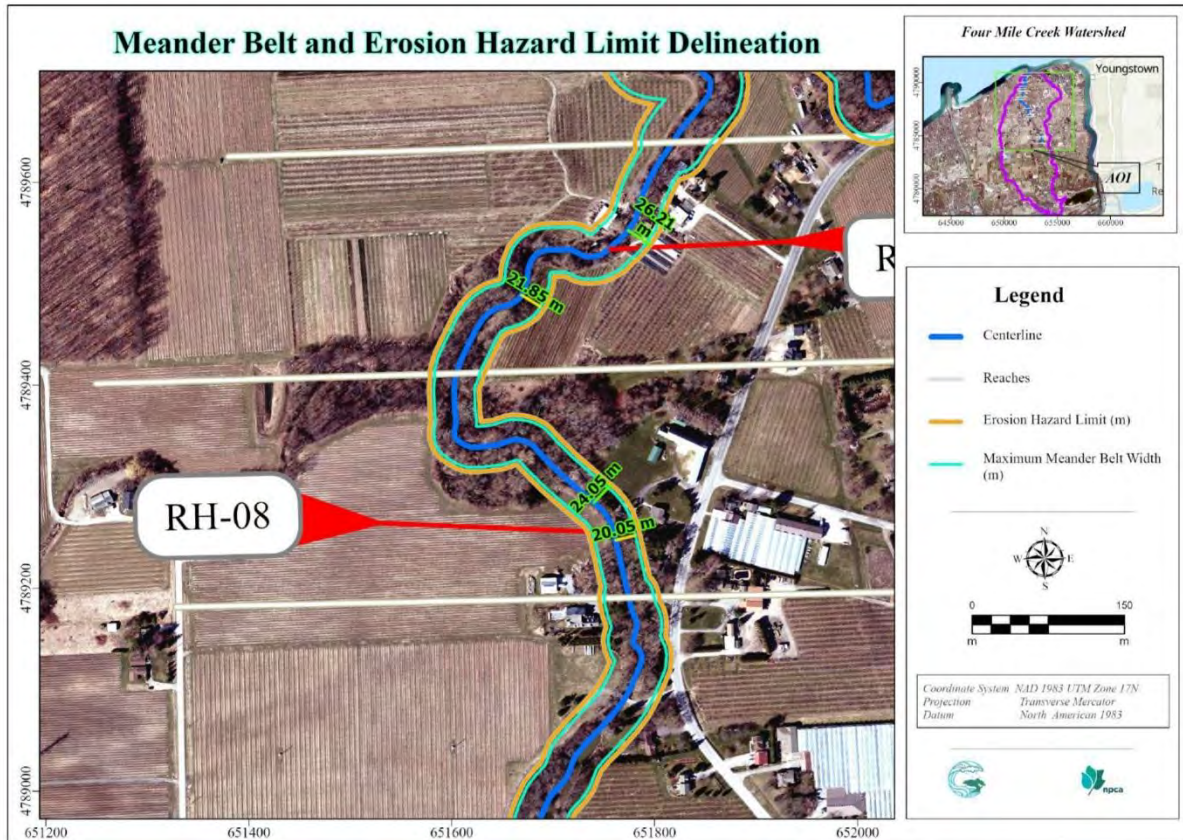


Figure 6-13: Meander Belt Width and Erosion Hazard Limit of Reach 08

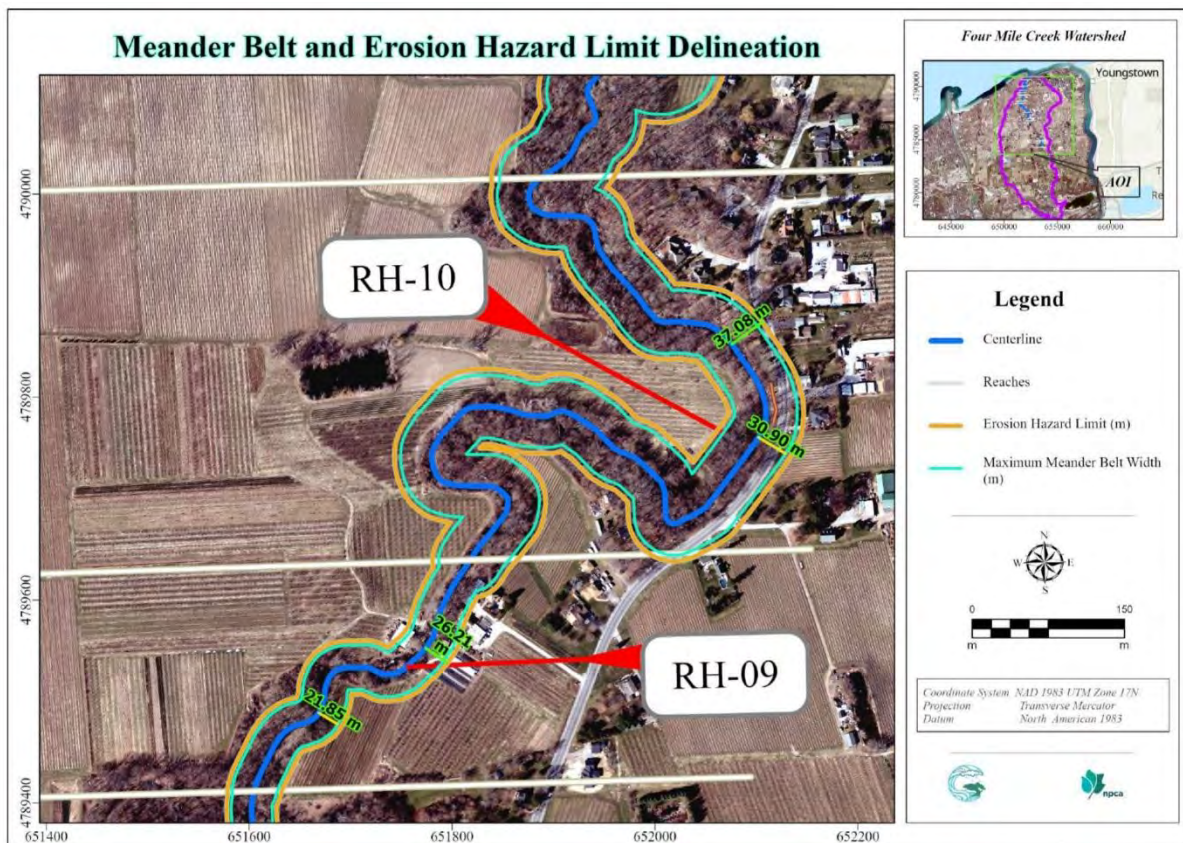


Figure 6-14: Meander Belt Width and Erosion Hazard Limit of Reach 09 and 10

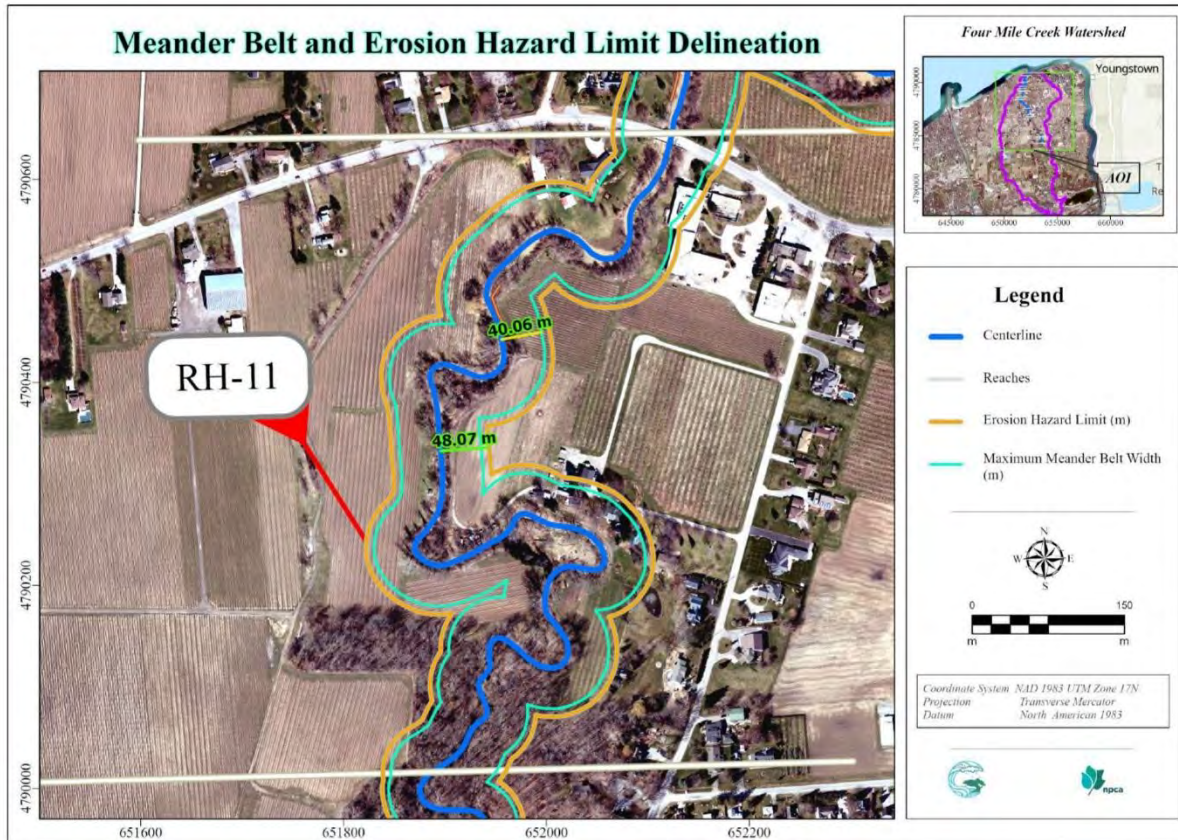


Figure 6-15: Meander Belt Width and Erosion Hazard Limit of Reach 11

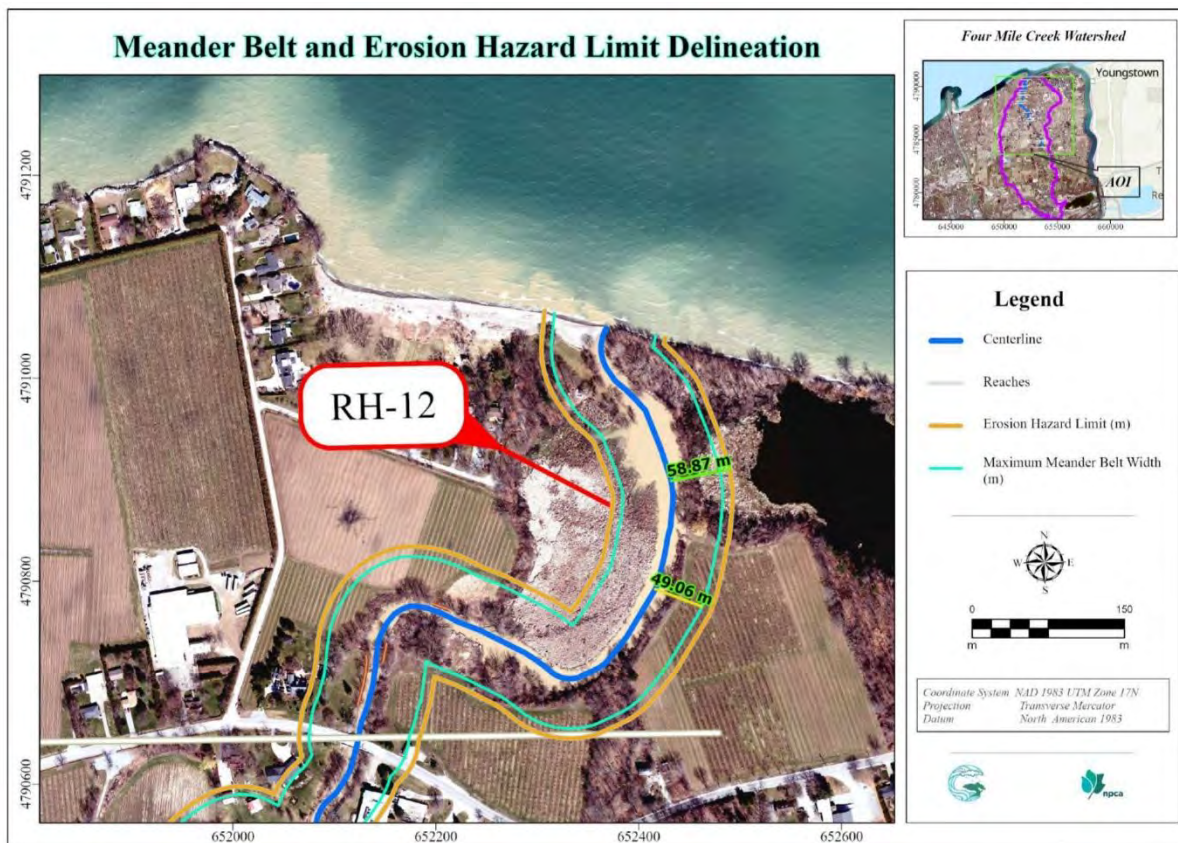


Figure 6-16: Meander Belt Width and Erosion Hazard Limit of Reach 12

6.5 Requirement of Detailed Fluvial Geomorphic Assessment

The requirement for a detailed fluvial geomorphology assessment was determined based on the results of the Rapid Geomorphic Assessment, the calculated **Stability Index (SI)**, the dominant and secondary forms of channel adjustment, and field-confirmed indicators of instability. Reaches were identified for further detailed assessment where the Stability Index exceeded 0.20 and where widening, lateral adjustment, bank erosion, infrastructure proximity, or other field-confirmed instability indicators suggested an elevated need for additional investigation.

Based on this screening approach, Reaches R3, R4, R8, R9, and R10 were identified as requiring detailed fluvial geomorphic assessment. These reaches exhibit transitional geomorphic conditions and show evidence of active or potential adjustment processes, including localized aggradation, channel widening, planform adjustment, and field-observed erosion indicators. The selected reaches are summarized in **Table 6-4**

Table 6-4: Reaches Recommended for Detailed Geomorphic Assessment

Reach	Stability Index (SI)	Rationale for Detailed Assessment
R3	0.24	Transitional condition with measurable adjustment indicators and field-confirmed erosion sensitivity.
R4	0.27	Transitional condition with aggradation, widening indicators, and localized bank instability.
R8	0.23	Transitional condition with widening and planform adjustment indicators.
R9	0.23	Transitional condition with localized instability and erosion/deposition indicators.
R10	0.34	Highest SI among the selected reaches, with strong aggradation and widening indicators and elevated erosion sensitivity.

For the identified reaches, a detailed fluvial geomorphic assessment is recommended to further evaluate channel stability and erosion processes and to support refinement of erosion hazard limits and development setback considerations. A detailed geomorphic analysis typically includes the following assessments:

- i. Field measurement of channel geometry.
- ii. Sediment particle size.
- iii. Desktop analysis of erosion thresholds.
- iv. Continuous hydrologic modeling; and
- v. Determination of erosion indices.

At this stage, the study area does not have a continuous hydrologic model, which can provide flow hydrograph for the reaches. As a result, the detailed geomorphic assessment was not



completed under the current scope. It is, therefore, recommended that continuous hydrologic modeling be performed, followed by detailed fluvial geomorphology assessments for the selected erosion-prone reaches to adequately evaluate channel stability and erosion risk.

7 IDENTIFICATION AND/OR CONFIRMATION OF DRAINAGE AREA OF INTEREST

The drainage characteristics of the Lower Four Mile Creek study area were identified and confirmed using existing watershed delineation datasets of the Four Mile Creek watershed. These datasets provide a consistent and reliable framework for understanding watershed connectivity, contributing drainage areas, and flow routing within the study corridor.

Available drainage delineation prepared as part of a broader Niagara Peninsula Conservation Authority initiative defines hierarchical drainage areas and subwatersheds across the Four Mile Creek watershed. This delineation confirms that the Lower Four Mile Creek study corridor lies within the Four Mile Creek watershed, which has a total drainage area of approximately 51 km², and drains toward Lake Ontario.

For the purposes of geomorphic assessment, drainage confirmation focused on ensuring that surface runoff and contributing areas to the assessed reaches were accurately represented. The watershed analyses indicate that the Lower Four Mile Creek corridor is influenced by multiple upstream contributing areas, including local sub-catchments and tributary inflows, as well as flow regulation effects associated with upstream control features such as the Virgil Reservoir. The delineated drainage areas have been depicted in the **Figure 7-1**.

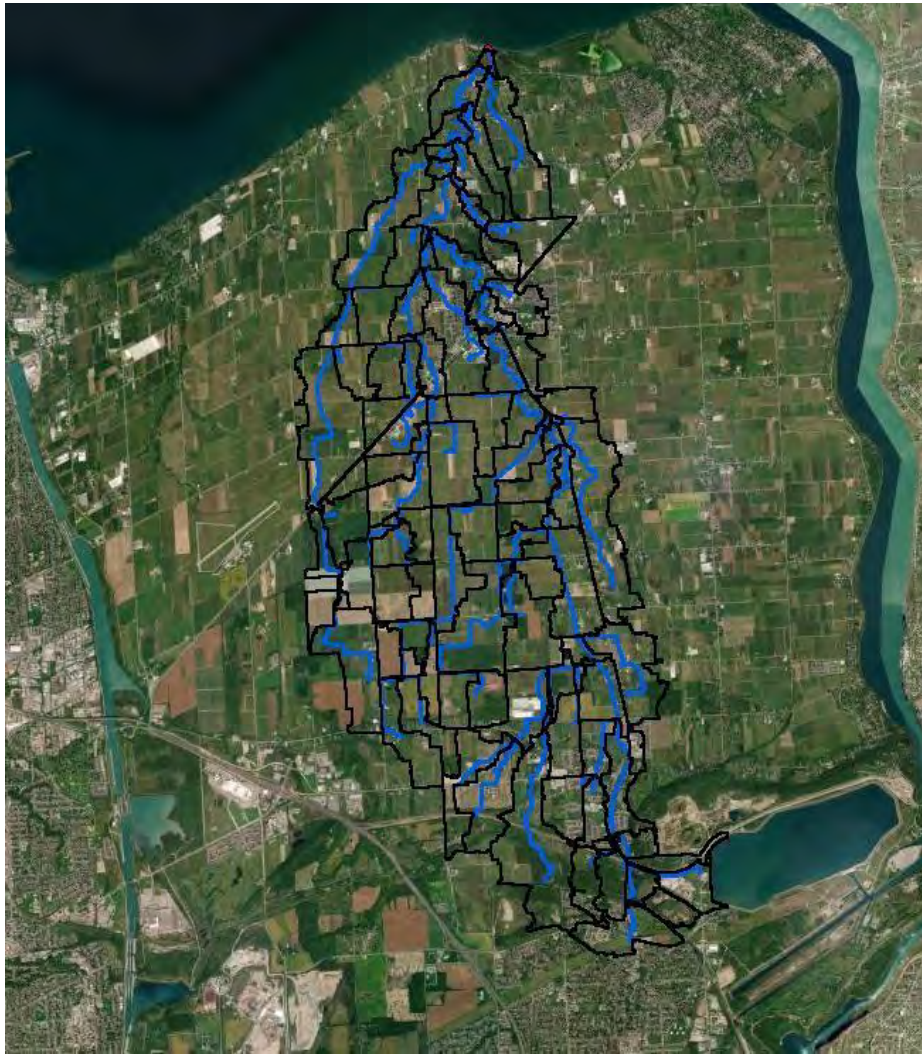


Figure 7-1: Study-Specific Drainage Area Refinement and Subbasin Delineation

AHYDTECH has refined watershed and sub-watershed boundaries within the Four Mile Creek watershed using high-resolution digital elevation data and GIS-based hydrologic tools. This refinement confirms that drainage to the study area is well-defined, hydraulically connected, and consistent with observed channel alignment, valley form, and surface topography. The delineated drainage framework supports reach-scale interpretation of flow contributions and geomorphic processes along the Lower Four Mile Creek corridor.

Based on the available watershed delineation and prior hydrologic work, no anomalous drainage conditions or undocumented contributing areas were identified within the area of interest. The confirmed drainage framework provides a sound basis for the reach-by-reach geomorphic assessment, erosion hazard evaluation, and identification of erosion-prone areas presented in this report.

8 IDENTIFICATION OF POTENTIAL EROSION HAZARDS AND RESTORATION OPPORTUNITIES

An evaluation of potential erosion-related risks to adjacent properties and infrastructure was undertaken as part of the integrated geomorphic assessment of Lower Four Mile Creek. This evaluation builds upon the findings of the field reconnaissance, detailed topographic and

bathymetric surveys, Rapid Geomorphic Assessment (RGA), Rapid Stream Assessment Technique (RSAT), historical aerial imagery analysis, bankfull channel geometry assessment, and meander belt width evaluation.

The study corridor was systematically traversed, where access permitted, to document observable indicators of channel instability, including bank undercutting, exposed root systems, fallen and leaning trees, in-channel wood debris accumulations, localized bank slumping, and active outer bend erosion. Attention was given to locations where channel processes interact with the existing infrastructure, including road crossings, utilities, adjacent properties, and areas of structural intervention.

In addition to identifying erosion-related hazards, the field program also documented opportunities for channel stabilization, riparian enhancement, debris management, and aquatic habitat improvement. These opportunities are intended to inform future mitigation strategies and to support a proactive approach to long-term channel stability and corridor management.

8.1 Identification of Potential Risk and Opportunities

8.1.1 Methodology for Risk Identification and Classification

Potential erosion hazard locations along Lower Four Mile Creek were identified through an integrated multi-parameter assessment incorporating:

- Direct field evidence of instability (fallen trees, exposed roots, bank undercutting, slumping, debris accumulation)
- Dominant geomorphic adjustment processes identified through RGA (aggradation, degradation, widening, planform adjustment)
- RSAT channel stability and erosion/deposition scores
- Meander belt width and lateral adjustment potential
- Proximity to infrastructure (roads, crossings, utilities) and adjacent private property
- Historical planform migration patterns
- Detailed Geomorphic Assessment (Not completed this task)

This integrated approach ensured that erosion hazards were not identified solely on the basis of isolated field observations, but rather through correlation between observed channel conditions, documented geomorphic processes, and long-term planform behavior. Emphasis was placed on reaches exhibiting widening as the dominant adjustment process, as widening increases the potential for lateral migration and encroachment toward adjacent land uses and infrastructure.

Field investigations confirmed that fallen trees, exposed root systems, and localized bank undercutting are recurring indicators throughout portions of the corridor. In several areas, these conditions are consistent with measurable lateral adjustment identified through RGA and meander belt analysis. While many of these features represent natural channel evolution processes, their presence in proximity to infrastructure or private property elevates their significance from a geomorphic observation to a potential erosion risk.

Based on the severity of observed geomorphic indicators and the potential consequence to adjacent infrastructure or property, erosion severity locations were categorized using a five-level classification system as shown below:



- **Level 1 – Extreme Erosion Severity:** Active bank failure, significant widening, or instability posing immediate or near-term risk to infrastructure or property. Typically associated with dominant widening processes, visible bank retreat, and direct infrastructure proximity.
- **Level 2 – High Erosion Severity:** Active or progressing instability with strong geomorphic indicators such as undercutting, exposed roots, and leaning or fallen trees, representing elevated sensitivity to continued lateral adjustment.
- **Level 3 – Moderate Erosion Severity:** Localized instability with measurable widening tendencies and visible erosion indicators but limited immediate consequence to infrastructure.
- **Level 4 – Low Erosion Severity:** Minor or early-stage instability indicators, generally occurring within reaches that are otherwise stable at the reach scale.
- **Level 5 – Minimal Erosion Severity:** Stable channel conditions with limited evidence of active adjustment beyond natural meander progression.

Mapped locations corresponding to these severity levels are identified as L1 through L5 on **Figure 8-1**. Detailed reach-wise illustrations of the potential erosion hazards are presented in **Figure 8-2** through **Figure 8-8**. Selected photographs of the identified potential erosion hazard locations are provided in **APPENDIX D: Images of Potential Erosion Hazard Locations**.

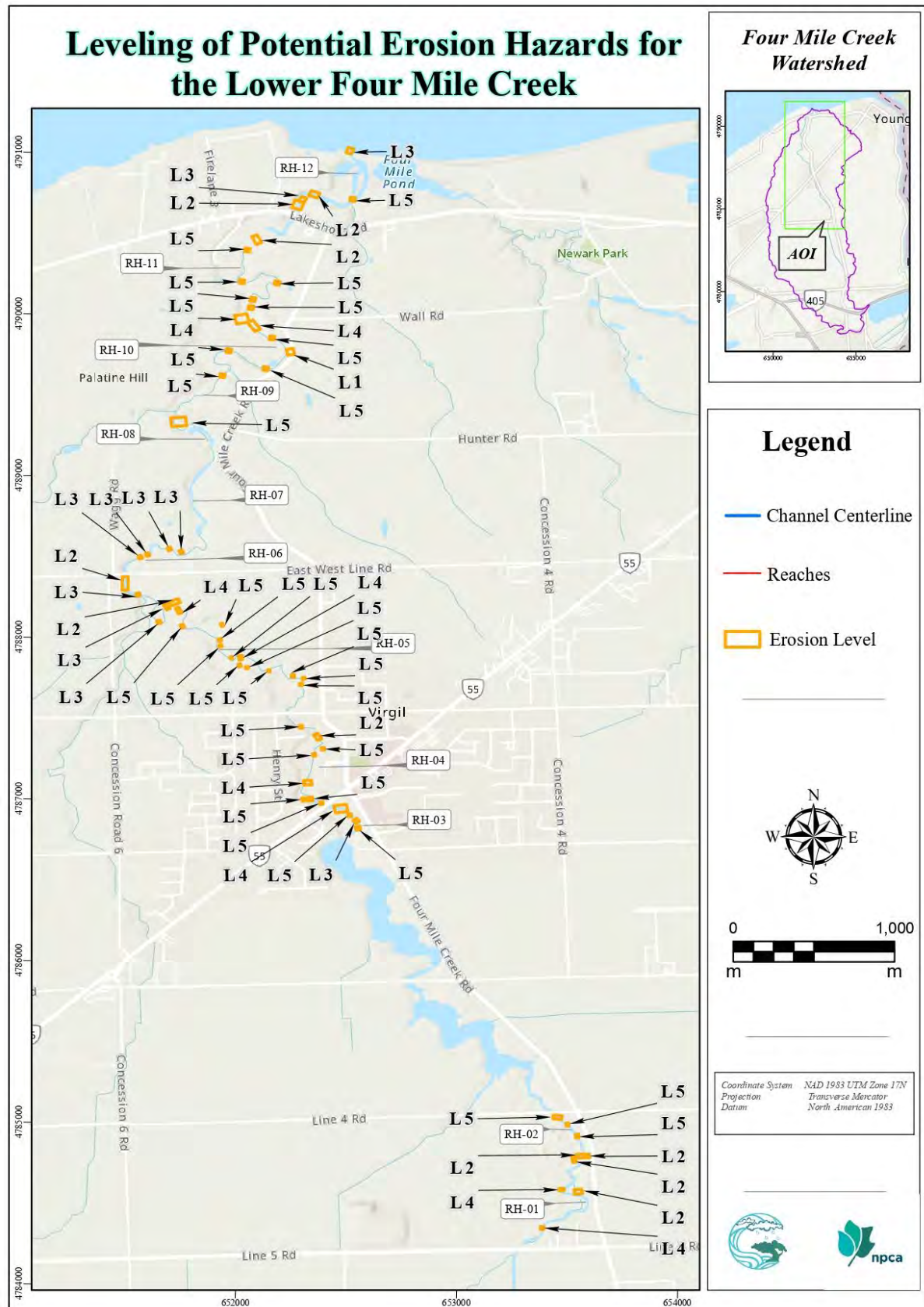


Figure 8-1: Potential Erosion Hazards Locations

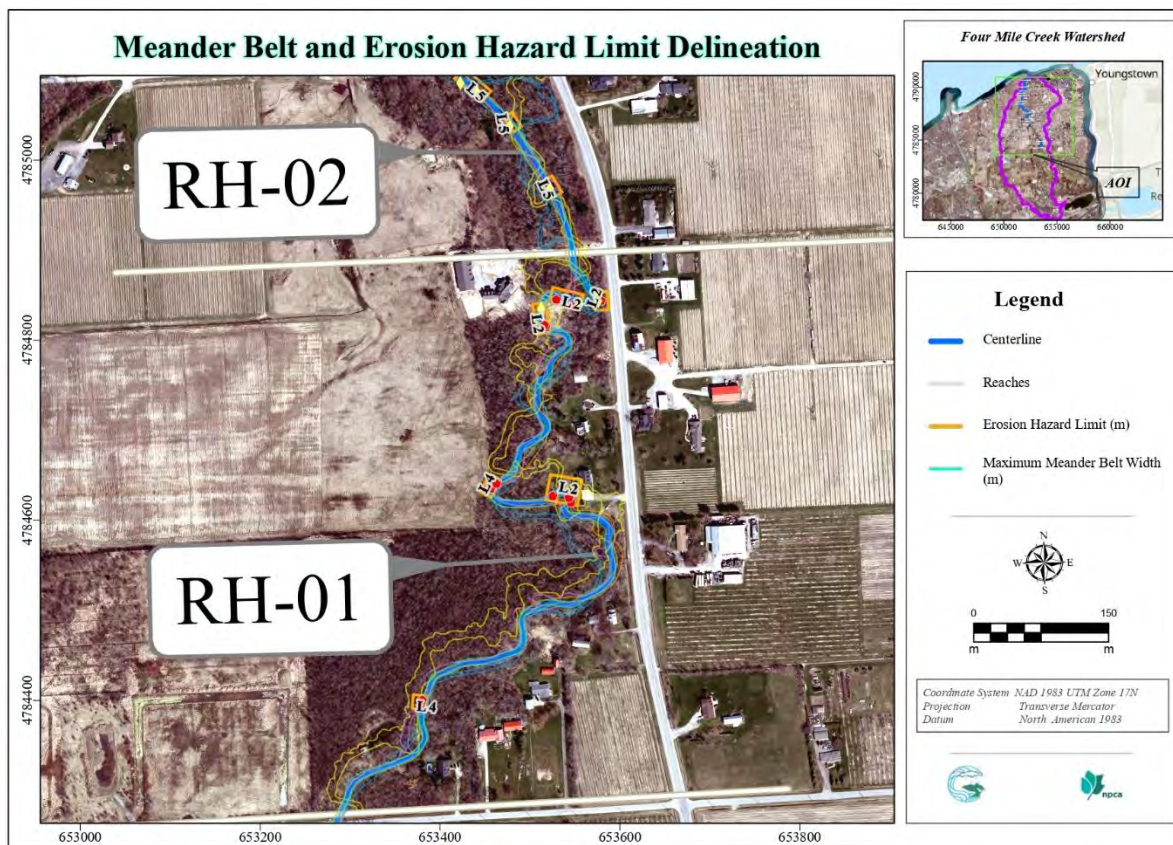


Figure 8-2: Potential Erosion Hazards Locations of Reach 01 and 02

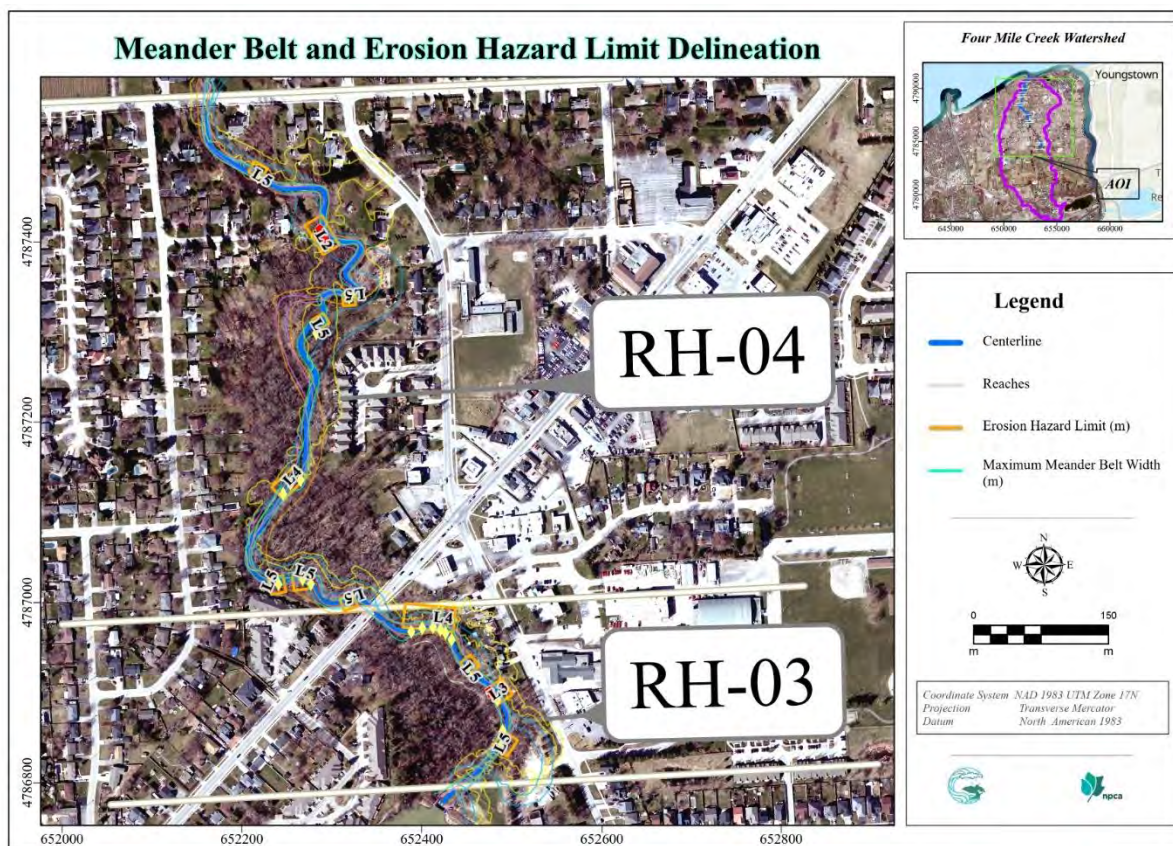


Figure 8-3: Potential Erosion Hazards Locations of Reach 03 and 04

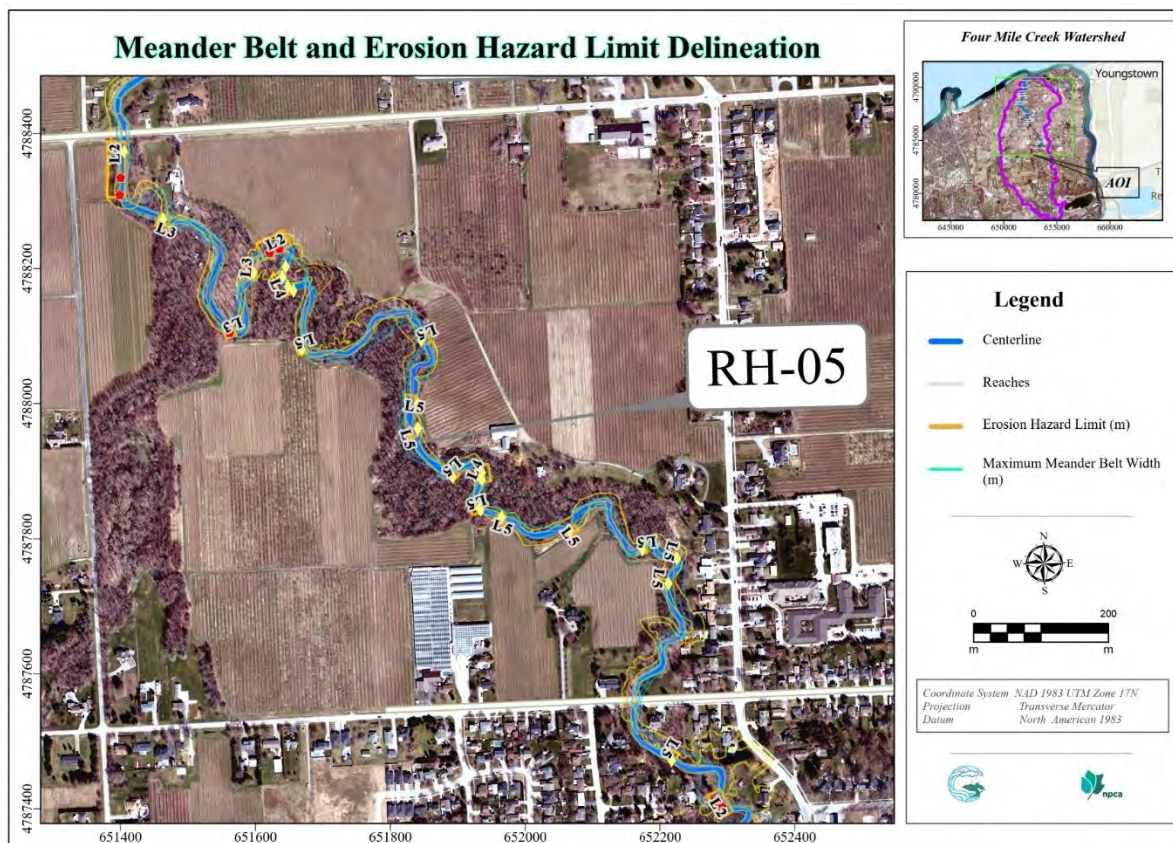


Figure 8-4: Potential Erosion Hazards Locations of Reach 05

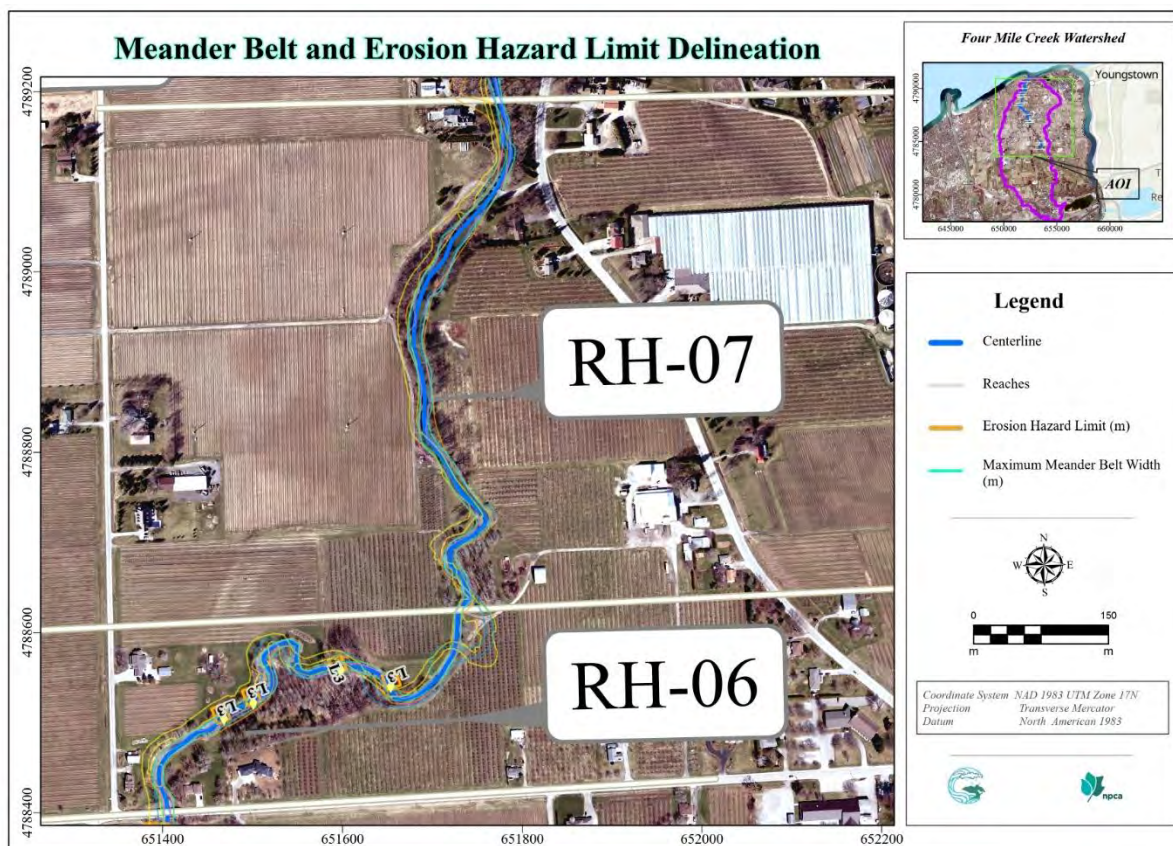


Figure 8-5: Potential Erosion Hazards Locations of Reach 06 and 07

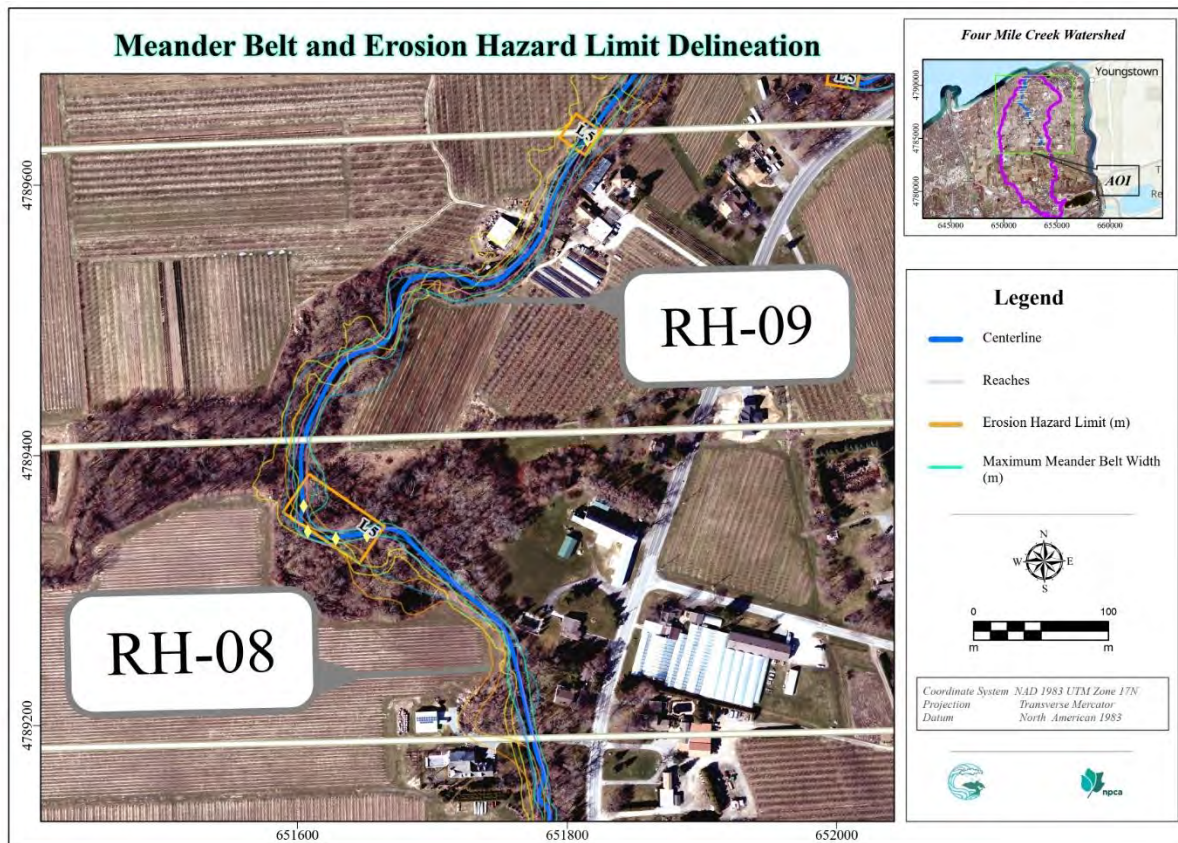


Figure 8-6: Potential Erosion Hazards Locations of Reach 08 and 09

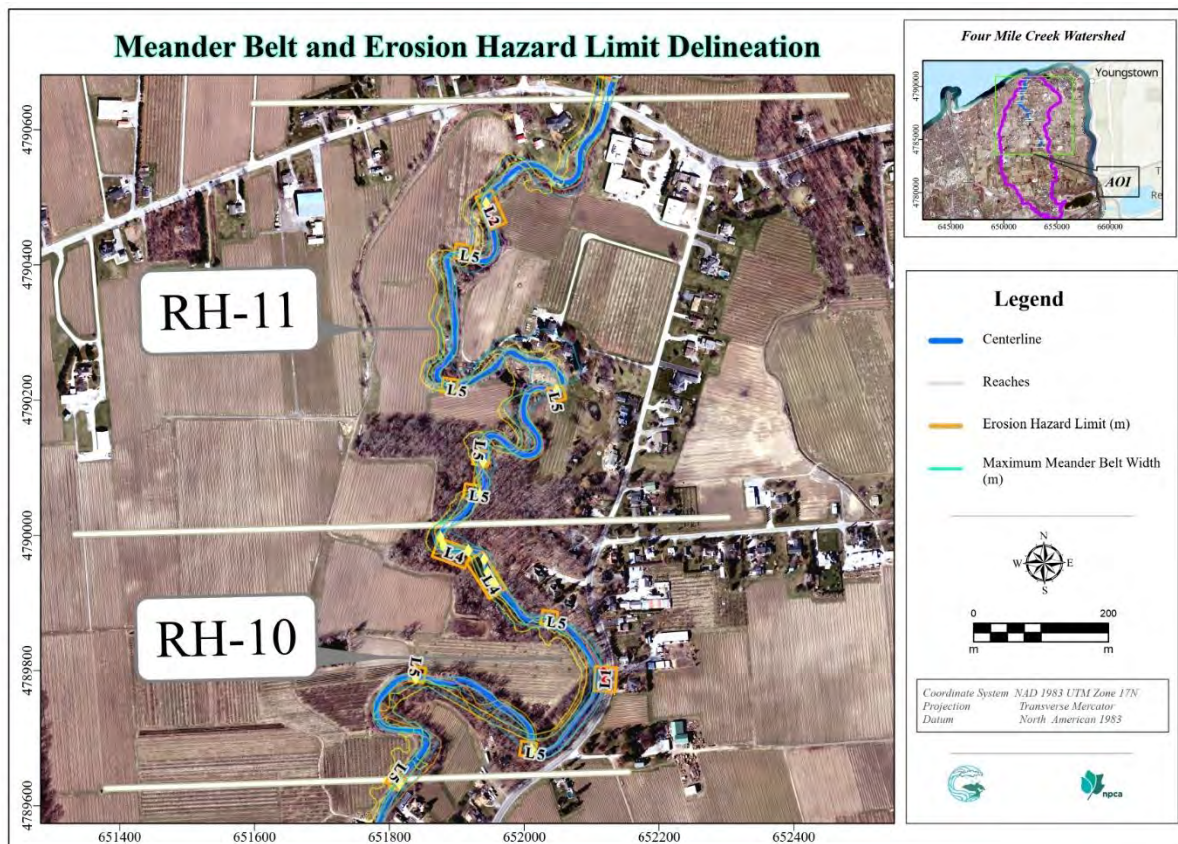


Figure 8-7: Potential Erosion Hazards Locations of Reach 10 and 11

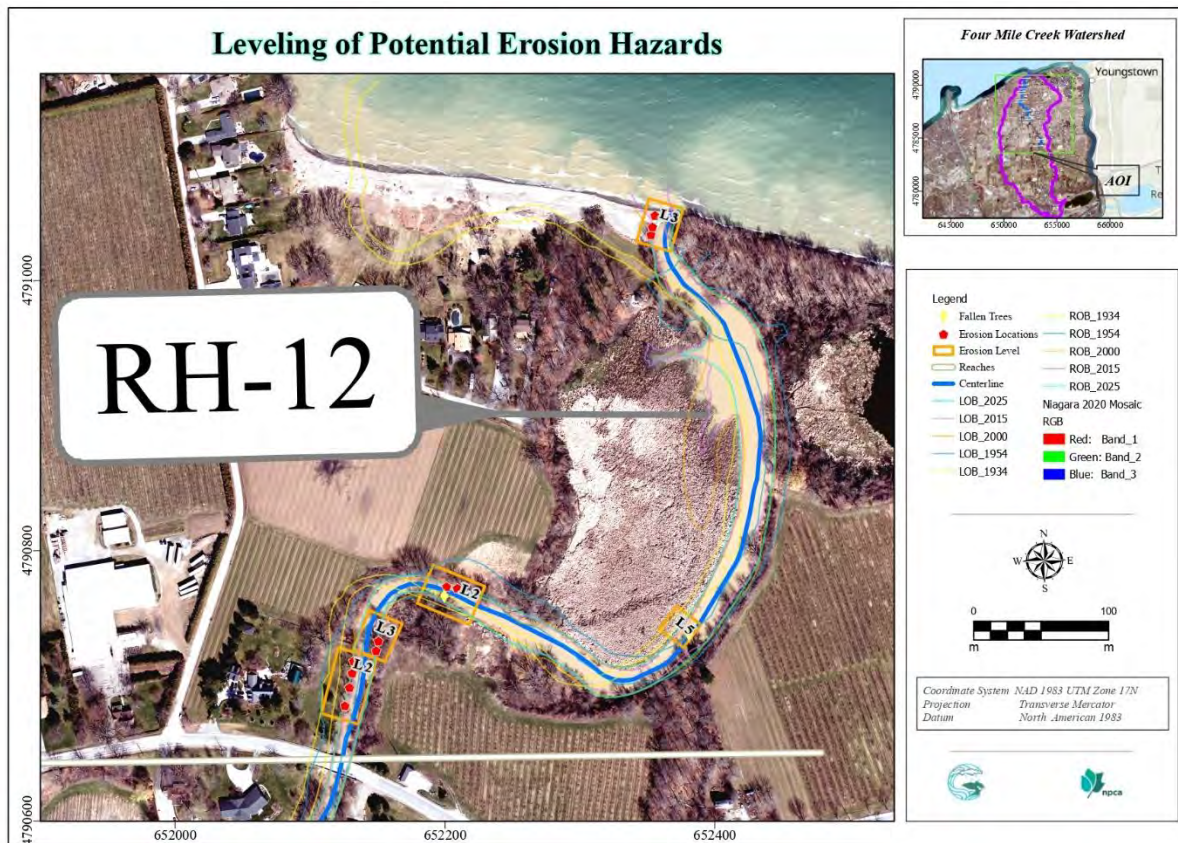


Figure 8-8: Potential Erosion Hazards Locations of Reach 12

8.1.2 Summary of Erosion Severity Across the Study Area

The overall erosion severity along Lower Four Mile Creek is characterized as spatially variable and generally moderate, with localized areas of elevated concern. The integrated assessment indicates that widening is the most common dominant geomorphic adjustment process throughout the corridor. This widening tendency is reflected in both the RGA results and the field-documented indicators of bank instability, including exposed root systems, fallen and leaning trees, and outer bend erosion.

Reaches classified as Transitional (Stressed) under the RGA framework correspond closely with areas where widening, localized degradation, and measurable bank retreat were observed in the field. In contrast, reaches classified as In Regime generally exhibit stable channel form at the reach scale; however, even within these segments, isolated locations of root exposure and fallen vegetation indicate localized toe scour and early-stage lateral adjustment.

The most elevated erosion severity is associated with areas where active bank erosion coincides with infrastructure proximity, including roadway crossings and developed properties. Overall, the erosion severity mapping reflects a corridor that is undergoing ongoing geomorphic adjustment primarily through widening processes, with localized areas of heightened sensitivity where infrastructure interaction increases potential consequence.

8.1.3 Restoration and Mitigation Opportunities

In addition to identifying erosion severity locations, the assessment identified opportunities to enhance channel stability and riparian function through targeted restoration measures. A



summary of selected priority areas, including the corresponding reach, representative photographs, key issues, and recommended restoration or mitigation opportunities, is provided in **Table 8-1**.

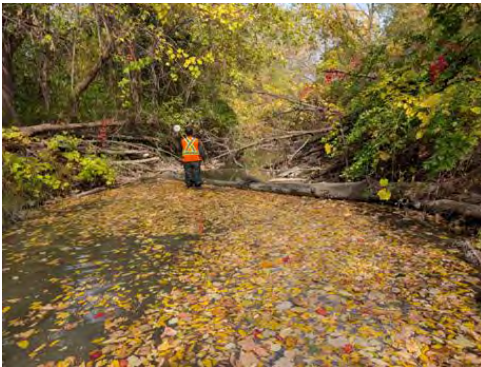
Table 8-1: Identified Potential Hazard Areas and Restoration or Mitigation Opportunities

Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 01	Level 2		Bank erosion accompanied by exposed root systems, contributing to ongoing bank instability.	Removal of obstructing debris and targeted vegetative reinforcement could help stabilize the affected section.
Reach 01	Level 2		Localized soil loss with exposed roots, suggesting moderate instability	Reinforcing the area with vegetation and supportive plantings is recommended to enhance bank stability.
Reach 01	Level 5		A fallen tree creating minor disruption to the channel	Removal of the tree and incorporation of natural woody elements could support habitat and channel stability.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 01	Level 2		Significant bank erosion accompanied by broken trees and branches, contributing to severe instability	Removal of debris and targeted structural stabilization is recommended to protect the bank and adjacent areas.
Reach 02	Level 5		A fallen tree spanning the channel, with branches and accumulated debris, is disrupting flow and exacerbating bank erosion	Removal of the obstruction and reinforcement of the adjacent bank with vegetation or structural support is recommended.
Reach 02	Level 3		Fallen trees and exposed roots within the channel are obstructing flow and contributing to localized instability	Clearing of obstructions followed by establishment of riparian vegetation is recommended to restore channel function.
Reach 03	Level 3		Significant bank erosion with extensive exposed roots, contributing to localized instability	Stabilization through vegetation and supplemental planting is recommended to reduce further soil loss.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 03	Level 4		Fallen tree, branches, and debris are present within the creek channel without noticeable bank erosion	Removal of obstructing material and integration of natural woody elements could enhance habitat and flow conditions.
Reach 04	Level 5		Minor bank erosion observed due to localized exposure	Stabilizing the affected area with natural vegetation or structural support could help limit further deterioration.
Reach 04	Level 4		Fallen trees with intense debris and branches	Removal of obstructive material followed by installation of natural structural elements could help stabilize the area.
Reach 04	Level 2		Bank erosion associated with exposed root systems, contributing to localized instability	Stabilization through vegetative reinforcement and bioengineering measures is recommended.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 05	Level 5		Fallen tree and exposed root along the bank, causing minor local disruption	Opportunities exist to enhance stability and habitat through natural vegetation and root-based structures.
Reach 05	Level 4		Branches and uprooted trees along the channel margin, contributing to localized obstruction	Removal of unstable material and reinforcement with natural root structures could help stabilize the area.
Reach 05	Level 3		Bank slump with localized soil loss and instability	Implementing vegetative reinforcement and bio-stabilization could help reduce further erosion.
Reach 05	Level 2		Bank instability with exposed roots and partially fallen trees	Removal of obstructing debris followed by targeted vegetation and structural reinforcement is recommended to stabilize the slope.

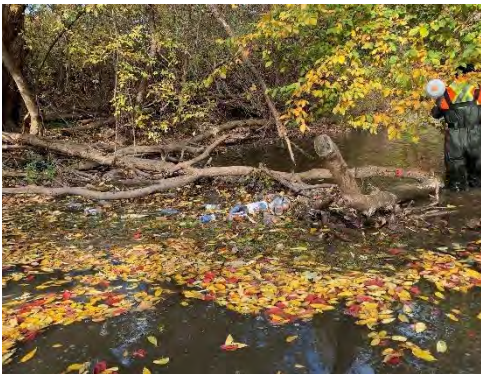


Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 05	Level 2		Bank exhibiting significant erosion with exposed roots and standing trees	Removal of unstable soil and debris is recommended, followed by stabilization and vegetative reinforcement to limit further bank retreat.
Reach 06	Level 2		Bank showing erosion with scattered fallen trees, exposed roots, and vegetation	Removal of obstructing debris is advised, followed by vegetative or structural measures to stabilize the bank.
Reach 06	Level 3		Erosion observed on both banks, though subsequent dense vegetation provides some natural stabilization	Reinforcing vegetation and selective planting could further reduce ongoing erosion.
Reach 06	Level 3		Bank erosion associated with exposed roots of standing trees, indicating localized instability	Supplemental vegetation and natural stabilization measures could help reinforce the bank.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 06	Level 3		Minor erosion observed along both banks, suggesting early-stage instability	Natural vegetation and bio-stabilization measures could help reinforce these areas.
Reach 07	Level 3		Branches present within the creek accompanied by minor bank erosion, indicating moderate instability	Targeted vegetation and natural structural measures could help stabilize the affected section.
Reach 08	Level 4		Minor bank erosion accompanied by a fallen tree, suggesting localized instability	Removal of debris and establishment of vegetative support could help restore stability.
Reach 08	Level 5		Uprooted trees have fallen into the creek, contributing to debris accumulation and localized flow disruption	Clearing the obstruction and encouraging natural vegetation growth along the banks could help re-stabilize the area.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 08	Level 5		Broken trees have fallen into the creek, contributing debris and minor flow disruption	Clearing the debris and encouraging natural vegetation growth along the banks may help maintain channel stability.
Reach 08	Level 5		Broken tree lies across the creek, accompanied by accumulated debris	Removal of the obstructing material and support for bank vegetation can help restore local channel
Reach 09	Level 5		Minor displacement of riprap observed due to long-term exposure and root growth	Consider gentle stabilization measures that integrate natural materials and vegetation.
Reach 10	Level 1		Significant bank erosion accompanied by fallen trees and scattered branches in the creek	Immediate removal of debris is recommended, followed by stabilization measures to address ongoing bank instability.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 10	Level 4		Fallen tree with minor soil loss along the bank	Removal of the tree is advised, followed by vegetation-based stabilization to support gradual bank recovery.
Reach 10	Level 5		Several broken and fallen trees with accumulated debris	Removal of obstructing material is suggested, complemented by low-impact natural habitat or stabilization features.
Reach 11	Level 5		Minor bank erosion observed	maintain natural stabilization and allow for gradual vegetation recovery.
Reach 11	Level 2		Bank erosion with broken and fallen tree observed	Removal of obstructing debris and reinforcement with vegetation is recommended.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 12	Level 5		Fallen trees observed along the creek bank	Clearing the debris.
Reach 12	Level 2		Bank erosion with uprooted and broken trees and exposed roots	Removal of unstable debris and reinforcement with vegetation is recommended.
Reach 12	Level 2		Severe bank and soil erosion with exposed bank face	Immediate stabilization and protective intervention are recommended.
Reach 12	Level 3		Broken tree within the creek with minor bank erosion	Removal of debris and localized stabilization measures are recommended.



Reach	Priority/ Severity	Image	Issues	Opportunities for Restoration
Reach 12	Level 3		Creek widening with minor visible bank erosion	targeted vegetation or natural stabilization measures could help reduce further lateral adjustment.

Opportunities include selective bioengineering stabilization along outer bends exhibiting root exposure and toe scour, riparian buffer enhancement in areas with fragmented or narrow vegetative cover, and strategic management of woody debris where accumulations are influencing local hydraulics and contributing to localized bank erosion. Monitoring is recommended within widening-dominant reaches to track lateral migration trends and to inform adaptive management strategies. Particular consideration should be given to more detailed geomorphic and hydraulic assessment within the higher priority segments identified in **Table 8-1** to refine mitigation approaches and confirm design requirements.

Priority Level-specific conceptual mitigation approaches for the identified erosion hazard locations are further discussed in “Section 9: Conceptual Plans”, where representative stabilization concepts and associated preliminary cost considerations are presented in accordance with the severity classification framework.

9 CONCEPTUAL PLANS

9.1 Purpose of Conceptual Planning and Typical Mitigation Options

Potential hazard locations were identified using an integrated assessment approach that considered field evidence of instability, dominant geomorphic adjustment processes (from RGA), RSAT scores, meander belt width / lateral adjustment potential, proximity to infrastructure and private property, and historical planform behavior. The corridor is characterized by spatially variable erosion severity and is generally undergoing ongoing adjustment primarily through widening processes, with localized areas of elevated concern where infrastructure proximity increases consequence. **Table 9-1** Shows the typical mitigation options by erosion severity level.

Table 9-1: Typical Mitigation Options by Erosion Severity Level

Erosion severity level	Typical drawing / Concept	Primary function	Typical triggers / Application
Level 1 – Extreme	Armour stone vertical wall	Immediate bank protection with minimal footprint; resist toe scour and prevent rapid retreat	Active bank failure near infrastructure/property; limited corridor width; need near-term risk reduction



Erosion severity level	Typical drawing / Concept	Primary function	Typical triggers / Application
Level 2 – High	Vegetated buttress (Type 1)	Toe and lower-bank protection with vegetation reinforcement; reduce widening tendency	Active undercutting/exposed roots/leaning trees; elevated sensitivity; some room for regrading
Level 3 – Moderate	Vegetated buttress (Type 2)	Targeted toe protection + soft bank reinforcement; reduce localized instability	Localized erosion indicators with limited immediate consequence; opportunity for nature-based stabilization
Level 4 – Low	Root wad with footer section	Habitat + toe roughness; localized toe scour control; encourage deposition	Early-stage toe scour/root exposure; stable reach-scale conditions; habitat benefit desired
Level 5 – Minimal	Root wad habitat structure	Habitat enhancement + bank roughness; minor flow deflection/cover	Stable conditions; minor woody debris / habitat opportunities; monitoring-focused

9.1.1 Structure 1 – Armour Stone Vertical Wall (Hard Bank Protection)

This is a bank erosion protection structure with a hard-armoured, near-vertical bank protection system comprising stacked armour stones on a prepared foundation, backed by a graded riprap / granular transition zone and separated from native soils by a geotextile filter layer. It has large, embedded boulders at the toe to provide a robust launchable foundation and improve resistance to toe scour. **(Figure 9-1)**

Primary purpose: Arrest active retreat and provide immediate protection where bank failure or rapid widening poses near-term risk to infrastructure or property.

Key components: (i) toe boulders partially embedded into the channel bed; (ii) stacked armour stones forming a vertical or steep face; (iii) riprap / granular backfill; and (iv) non-woven geotextile filter to prevent piping and loss of fine soils.

Design considerations: Embedment depth and toe keying should account for expected scour depth and bed mobility; tie-ins upstream and downstream should be flared and keyed to avoid end-around erosion; transitions to adjacent natural bank should be graded and vegetated where space allows; and the wall height should be limited to the minimum required to address the risk driver (e.g., infrastructure offset and bank height).

Maintenance: Annual inspection and post-event inspection should focus on toe displacement, void development, stone breakage, and evidence of flanking at the upstream/downstream tie-ins.

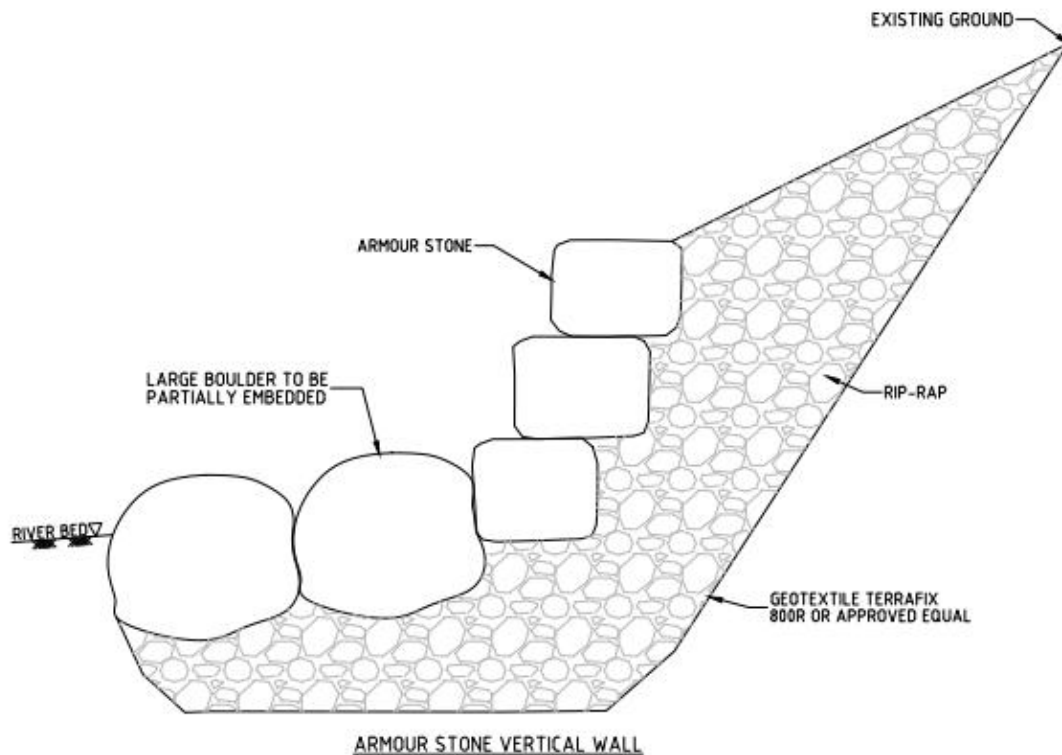


Figure 9-1: Armour stone vertical wall typical cross-section (Structure 1).

9.1.2 Structure 2 – Vegetated Buttress (Type 1)

Vegetated Buttress (Type 1) is a hybrid stabilization measure that combines a rock buttress (key stones and a well-graded gradation mix) with live shrub planting and live staking to reinforce the upper bank. The buttress provides toe protection and a stable, roughened bank surface while allowing a vegetated bankline to establish over time. **(Figure 9-2)**

Primary purpose: Reduce widening and lateral migration potential at actively eroding banks by addressing toe scour and improving near-bank roughness, while restoring riparian function.

Key components: (i) key stones at the toe and lower bank; (ii) graded rock (gradation mix) placed on a graded bank surface; (iii) topsoil cap in the upper bank zone; and (iv) live shrub plantings / live stakes integrated into the bank face and top-of-bank.

Design considerations: Rock sizing and thickness should be selected for expected near-bank shear stresses; the buttress crest should remain below or near bankfull where feasible to promote vegetation establishment; planting zones should be protected from high-velocity concentration by maintaining roughness and avoiding local flow constriction; and irrigation/temporary watering may be required in the first growing season.

Maintenance: Inspect after spring freshet and major storm events for stone displacement and loss of planted materials; replace failed plantings and re-compact/repair localized slumps as needed.

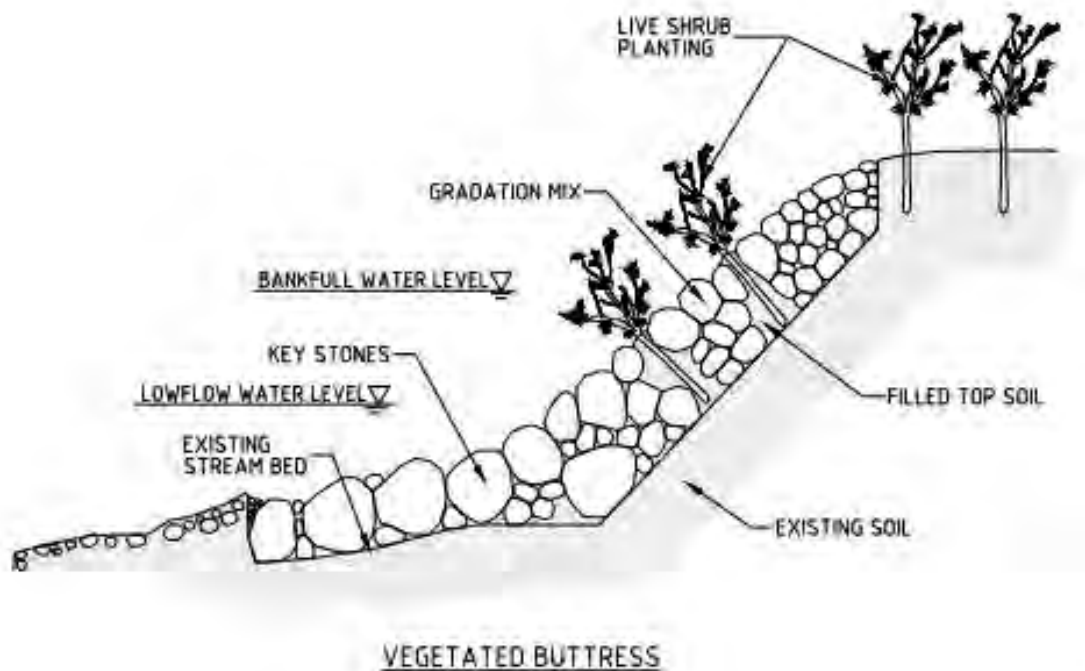


Figure 9-2: Vegetated buttress typical cross-section (Type 1) (Structure 2).

9.1.3 Structure 3 – Vegetated Buttress (Type 2)

Vegetated Buttress (Type 2) is a moderated version of the vegetated buttress that retains key stones and a smaller rock buttress, while emphasizing vegetated reinforcement along the mid-bank and upper bank. The concept is suited to localized instability where full structural protection is not required. (*Figure 9-3*)

Primary purpose: Treat discrete erosion indicators (localized undercutting, root exposure, minor slumping) and improve bank resistance without over-hardening otherwise stable reaches.

Key components: (i) toe key stones; (ii) gradation mix along the lower bank; (iii) a vegetated lift or coir/fiber matting zone (as shown by the shaded band) to support live staking and rapid surface stabilization; and (iv) topsoil and shrubs at the crest.

Design considerations: Ensure the toe is keyed into the bed to prevent undercutting; limit buttress footprint to minimize channel narrowing; integrate bank grading to remove over-steepened faces; and prioritize native species selection to match site moisture and shade conditions.

Maintenance: Similar to Level 2, with particular focus on early vegetation establishment and localized toe scour.

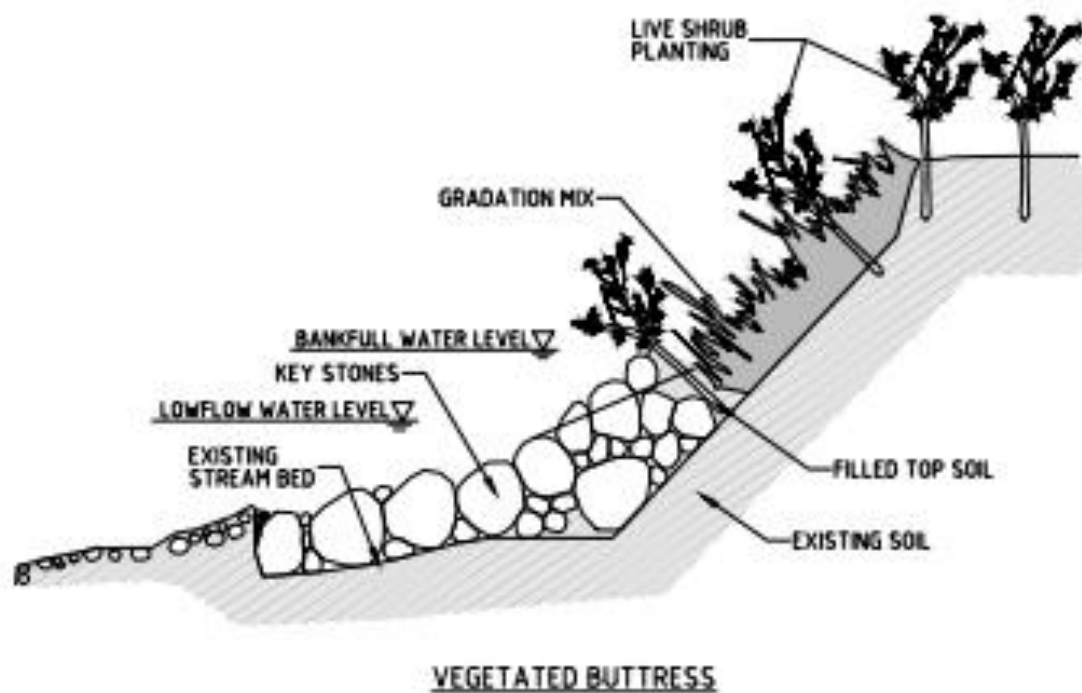


Figure 9-3: Vegetated buttress typical cross-section (Type 2) (Structure 3).

9.1.4 Structure 4 – Root Wad with Footer Section

This is a habitat-forward stabilization detail that uses embedded woody material (root wad) keyed into the bank toe and tied to a footer log and/or boulder cluster. Geotextile fabric and live posts in the bank provide soil retention and vegetative reinforcement above the structure. (Figure 9-4)

Primary purpose: Address minor or early-stage toe scour and localized instability, while enhancing cover and hydraulic complexity at the bank toe.

Key components: (i) root wad extending into the low-flow channel to provide roughness and habitat; (ii) footer log at the toe to anchor the root wad and resist displacement; (iii) boulders to provide mass and scour resistance; (iv) geotextile fabric (or biodegradable coir where appropriate) to retain fines; and (v) live posts at the crest to reinforce the soil mass and support vegetation establishment.

Design considerations: Root wads should be keyed into the bank and ballasted/anchored to resist buoyancy and drag; embedment depth should anticipate bed mobility; orientation should avoid creating excessive local scour at adjacent untreated areas; and upstream/downstream transitions should include smaller woody elements or light rock to avoid flanking.

Maintenance: Inspect after high flows for displacement of the root wad or footer log, undermining at the toe, and damage to live posts; replace or re-secure woody elements as needed.

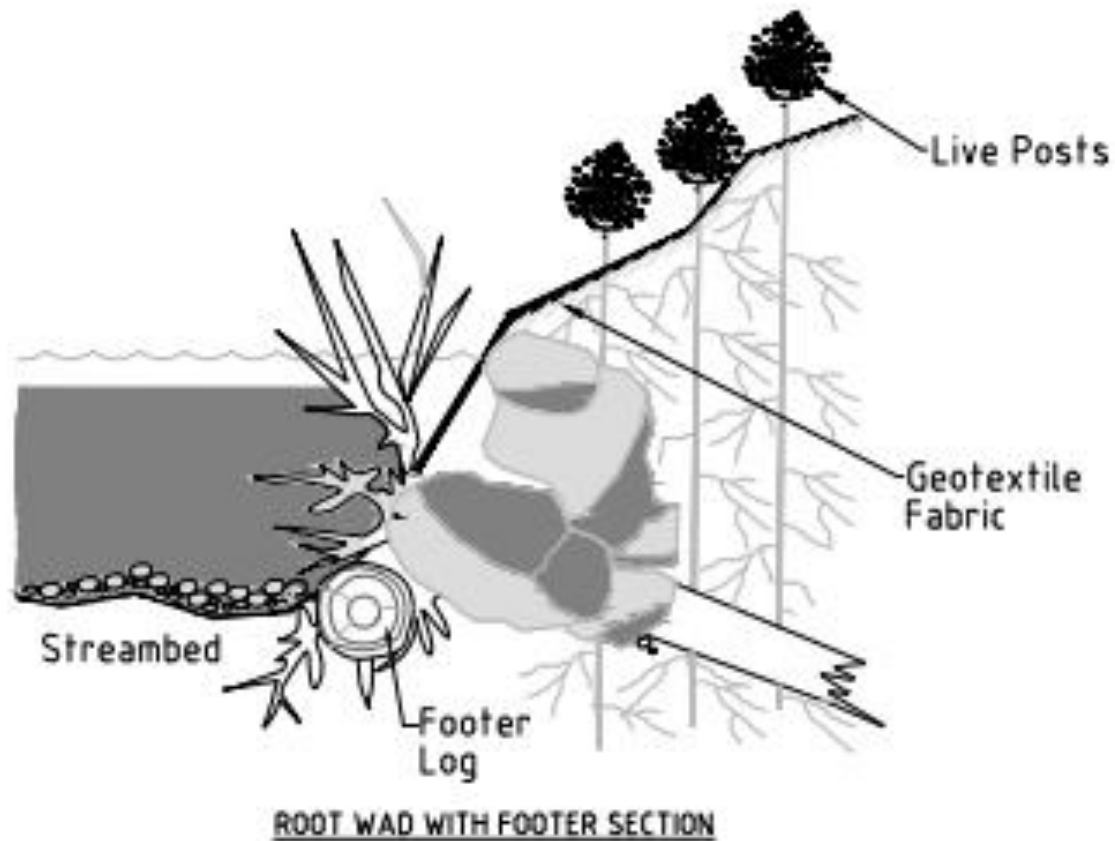


Figure 9-4: Root wad with footer section typical detail (Structure 4).

9.1.5 Structure 5 – Root Wad Habitat Structure

A habitat structure consisting of placed woody material along the bank margin (logs/root elements) anchored to the bank (soil anchor) to provide cover, near-bank roughness, and minor flow deflection. (**Figure 9-5**)

Primary purpose: Enhance aquatic habitat and provide a low-intensity measure appropriate for stable reaches where active adjustment is limited and the primary management approach is monitoring rather than structural intervention.

Key components: (i) placed logs / root elements along the waterline; (ii) anchoring system (soil anchor) to secure the structure; and (iii) riparian plantings on the upper bank/floodplain to improve long-term bank resistance.

Design considerations: Locate structures where they will not redirect flow toward the opposite bank or infrastructure; avoid installation in locations prone to ice jamming or debris accumulation unless the intent is to promote controlled wood retention; and ensure anchoring capacity is adequate for design flow drag forces.

Maintenance: Periodic inspection for loosening anchors or mobilized wood; reposition or remove elements if they pose a blockage risk at crossings.

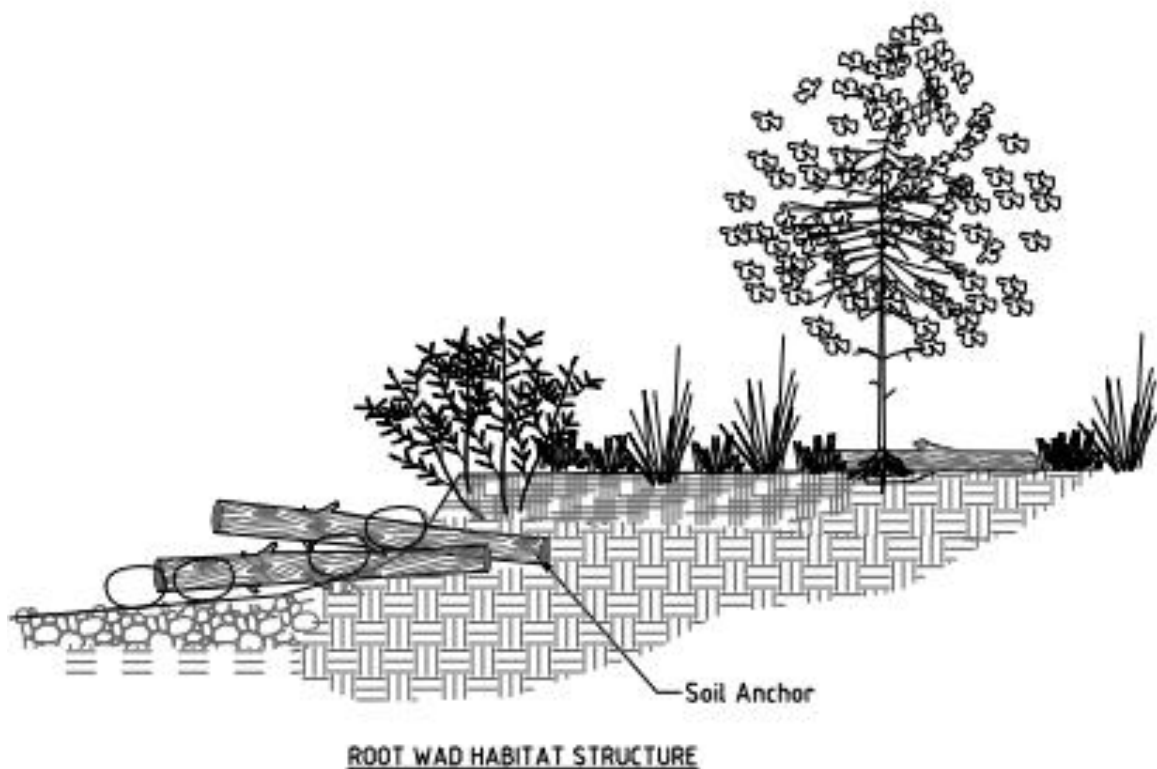


Figure 9-5: Root wad habitat structure typical detail (Structure 5).

9.2 Class D Cost Estimation for Conceptual Mitigation Options

A Class D indicative cost estimate was prepared for the conceptual erosion mitigation and restoration opportunities identified along Lower Four Mile Creek. The purpose of this estimate is to provide an order-of-magnitude planning-level cost for the recommended conceptual mitigation structures identified in **Section 9.1**. The estimate is based on the erosion severity classification framework, the corresponding conceptual mitigation structure assigned to each severity level, and the number of identified treatment locations within each reach.

The five conceptual mitigation structures used for the cost estimate are consistent with the mitigation hierarchy presented in **Section 9.1**. Structure 1 corresponds to the highest severity locations requiring hard bank protection, while Structures 2 and 3 correspond to vegetated buttress treatments for high and moderate erosion severity areas. Structures 4 and 5 represent lower-impact root-wad-based treatments intended for localized toe support, habitat enhancement, and management of minor erosion or woody debris-related instability. These treatment types are consistent with the typical mitigation options presented for each erosion severity level in **Table 9-1**.

For costing purposes, each identified treatment location was assumed to represent a typical 10 m treatment length. This assumption provides a consistent conceptual basis for comparing costs across reaches and erosion severity levels. The estimate should therefore be interpreted as a planning-level cost based on typical treatment locations, rather than a final construction quantity take-off. Final costs will require confirmation through detailed design, site-specific field verification, refined treatment lengths, access assessment, construction staging, and permitting requirements.



The adopted unit prices are summarized in **Table 9-2**. These unit prices were developed using typical planning-level costs for similar erosion protection, vegetated buttress, and root-wad-based stabilization treatments. The rates were applied on a per-metre basis and converted to a typical cost per 10 m treatment location.

Table 9-2: Typical Unit Price for Each Mitigation Structure

Structure	Typical Solution	Pricing Basis Used	Assumed Unit for Estimate	Adopted Typical Price
Structure 1	Armour Stone Vertical Wall	\$4,000/m adopted from a planning range of \$3,500–\$4,000/m for hard bank protection works	10 m treatment location	\$40,000 / 10 m treatment
Structure 2	Vegetated Buttress Type 1	\$3,000/m adopted from a planning range of \$2,500–\$3,500/m for vegetated buttress/bioengineered bank protection	10 m treatment location	\$30,000 / 10 m treatment
Structure 3	Vegetated Buttress Type 2	\$2,500/m adopted from a planning range of \$2,000–\$3,000/m for lower-intensity vegetated buttress treatment	10 m treatment location	\$25,000 / 10 m treatment
Structure 4	Root Wad with Footer Section	\$2,000/m adopted for a root-wad treatment zone with footer support, anchoring, and localized bank treatment	10 m treatment location	\$20,000 / 10 m treatment
Structure 5	Root Wad Habitat Structure	\$2,000/m adopted for a low-impact root-wad habitat treatment zone	10 m treatment location	\$20,000 / 10 m treatment

The number of conceptual treatment locations identified within each reach is summarized in **Table 9-3**. A total of **62 conceptual treatment locations** were identified across the study corridor. Structure 5 is the most frequently identified treatment type, reflecting the large number of low-severity locations where habitat enhancement, woody debris management, and minor stabilization measures are considered appropriate. Structure 1 is required at only one location, indicating that the majority of identified opportunities can be addressed through softer or nature-based stabilization approaches rather than extensive hard protection.


Table 9-3: Number of Solutions Recommended in Each Reach

Reach	Structure 1	Structure 2	Structure 3	Structure 4	Structure 5	Total
Reach 01	0	4	0	2	0	6
Reach 02	0	0	0	0	3	3
Reach 03	0	0	1	1	2	4
Reach 04	0	1	0	1	6	8
Reach 05	0	2	3	2	11	18
Reach 06	0	0	4	0	0	4
Reach 07	0	0	0	0	0	0
Reach 08	0	0	0	0	1	1
Reach 09	0	0	0	0	1	1
Reach 10	1	0	0	2	3	6
Reach 11	0	1	0	0	5	6
Reach 12	0	2	2	0	1	5
Total	1	10	10	8	33	62

The direct conceptual construction cost was calculated by multiplying the number of treatment locations for each structure type by the adopted typical cost per 10 m treatment. A **20% Class D allowance** was then applied to the direct subtotal to account for the uncertainty normally associated with conceptual-level design, preliminary quantities, site access requirements, construction staging, and detailed design refinement.

The cost calculation was completed as follows:

Direct Subtotal = Structure 1 count × \$40,000 + Structure 2 count × \$30,000 + Structure 3 count × \$25,000 + Structure 4 count × \$20,000 + Structure 5 count × \$20,000

Class D Allowance = Direct Subtotal × 20%

Class D Total = Direct Subtotal + Class D Allowance

The resulting reach-by-reach Class D cost estimate is presented in **Table 9-4**.


Table 9-4: Summary of Cost D Estimation

Reach	S1 Cost	S2 Cost	S3 Cost	S4 Cost	S5 Cost	Direct Subtotal	Class D Allowance 20%	Class D Total
Reach 01	0	120,000	0	40,000	0	160,000	32,000	192,000
Reach 02	0	0	0	0	60,000	60,000	12,000	72,000
Reach 03	0	0	25,000	20,000	40,000	85,000	17,000	102,000
Reach 04	0	30,000	0	20,000	120,000	170,000	34,000	204,000
Reach 05	0	60,000	75,000	40,000	220,000	395,000	79,000	474,000
Reach 06	0	0	100,000	0	0	100,000	20,000	120,000
Reach 07	0	0	0	0	0	0	0	0
Reach 08	0	0	0	0	20,000	20,000	4,000	24,000
Reach 09	0	0	0	0	20,000	20,000	4,000	24,000
Reach 10	40,000	0	0	40,000	60,000	140,000	28,000	168,000
Reach 11	0	30,000	0	0	100,000	130,000	26,000	156,000
Reach 12	0	60,000	50,000	0	20,000	130,000	26,000	156,000
Grand Total	40,000	300,000	250,000	160,000	660,000	1,410,000	282,000	1,692,000

Based on the conceptual treatment locations and adopted unit prices, the total direct conceptual construction subtotal is estimated at **CAD \$1,410,000**. With the 20% Class D allowance applied, the total Class D cost estimate for the identified conceptual mitigation and restoration opportunities is **CAD \$1,692,000**.

Reach 05 represents the highest estimated cost, with a Class D total of **CAD \$474,000**, due to the large number of identified treatment locations, including multiple Structure 2, Structure 3, Structure 4, and Structure 5 treatments. Reaches 04, 01, 10, 11, and 12 also represent notable cost contributions due to the number and/or type of conceptual mitigation measures identified. Reach 07 has no assigned conceptual treatment cost under the current assessment because no specific treatment locations were identified for that reach in the current mitigation count.

This cost estimate is intended to support conceptual planning, prioritization, and budget-level decision-making. It should not be interpreted as a final construction estimate. Prior to implementation, each proposed treatment location should be reviewed through detailed design, including confirmation of treatment length, bank height, toe condition, substrate,

hydraulic loading, property constraints, construction access, environmental permitting requirements, and restoration planting needs. The estimate should be updated once detailed design drawings and quantity take-offs are prepared.

10 CONCLUSION

This fluvial geomorphic assessment of Lower Four Mile Creek was undertaken to characterize channel condition, evaluate channel stability, identify erosion hazards, and support the delineation of erosion hazard limits within the study corridor. The assessment integrated desktop data review, historical aerial imagery interpretation, field reconnaissance, topographic and bathymetric surveying, Rapid Geomorphic Assessment (RGA), Rapid Stream Assessment Technique (RSAT), erosion hazard evaluation, and review of available hydrologic modelling resources. Collectively, the results provide a comprehensive understanding of the fluvial processes governing channel behaviour within the Lower Four Mile Creek corridor and establish a defensible screening-level framework for erosion hazard management and land-use planning.

Field observations confirmed that although the creek generally maintains a sinuous meandering planform, multiple reaches exhibit localized bank erosion, exposed root systems, woody debris accumulation, and channel widening, indicating ongoing geomorphic adjustment processes. Reach delineation subdivided approximately 10 kilometers of channel into twelve geomorphologically distinct reaches based on channel form, gradient, sinuosity, substrate characteristics, riparian condition, and land-use influences. This reach-based framework enabled consistent geomorphic interpretation and hazard evaluation across the study area. RGA results indicate that the creek is predominantly in a transitional or stressed condition, reflecting measurable but not catastrophic channel adjustment. Reaches R1, R2, R5, R7, and R12 were classified as In Regime, demonstrating generally stable channel form with adjustment largely limited to natural meander evolution. Conversely, Reaches R3, R4, R6, R8, R9, R10, and R11 exhibited transitional conditions characterized by localized aggradation, degradation, planform modification, and channel widening tendencies. RSAT results further confirmed that overall ecological and geomorphic health of the corridor is generally moderate to good, although reduced channel stability and habitat complexity were observed in selected reaches, particularly R10 and R12.

Historical aerial imagery analysis demonstrated that Lower Four Mile Creek has maintained a relatively consistent sinuous planform for over multiple decades, with lateral migration occurring progressively along outer meander bends. No evidence of large-scale avulsion or abrupt channel realignment was identified. Migration patterns correlate strongly with areas of reduced floodplain confinement, increased sinuosity, and localized riparian disturbance, confirming that channel evolution is governed by both natural fluvial processes and anthropogenic influences.

Bankfull channel geometry analysis revealed substantial variability in channel dimensions and hydraulic capacity throughout the study area. Bankfull widths ranged from approximately 6 metres to over 21 metres, while bankfull depths ranged from approximately 0.20 metres to 0.89 metres. Estimated bankfull discharges vary significantly among reaches, reflecting differences in watershed drainage contributions, channel slope, and hydraulic efficiency. Reaches exhibiting higher velocities and slopes demonstrate increased erosive potential, whereas wider, shallower channels exhibit greater susceptibility to lateral migration and planform adjustment.

Meander belt width assessments confirmed that lateral channel migration represents a dominant geomorphic process along Lower Four Mile Creek. Meander belt widths varied considerably between reaches, with downstream reaches generally exhibiting wider belts and increased migration potential due to reduced confinement and increased sinuosity. Due to dense riparian vegetation, historical imagery resolution limitations, and channel scale, reliable long-term migration rates could not be derived. Accordingly, erosion hazard limits were conservatively delineated using maximum measured meander belt widths combined with a 20 percent safety allowance to account for future erosion potential, valley wall adjustment, and possible hydrologic or sediment regime changes. The resulting erosion hazard limits provide a precautionary and defensible basis for development setback planning.

A key component of this study was the review of the existing HEC-HMS hydrologic model ("4MC"), originally developed in 2006 using HEC-HMS Version 3.0.0. The review determined that the model is configured as a legacy event-based design-storm framework intended primarily for peak flow estimation under discrete AES storm events. Although the model incorporates detailed basin schematization and accepted event-routing methodologies, it does not generate the continuous flow regime information required for geomorphic interpretation. The absence of baseflow representation, reliance on spatially uniform precipitation forcing, use of short-duration synthetic storms, and limited simulation period restrict the model's ability to characterize long-term hydrologic variability, antecedent moisture conditions, flow duration characteristics, and cumulative erosive processes.

Based on geomorphic stability thresholds and dominant adjustment processes, Reaches R3 (SI = 0.25), R4 (SI = 0.27), R8 (SI = 0.23), R9 (SI = 0.23), and R10 (SI = 0.34) were identified as priority locations requiring detailed fluvial geomorphic assessment. However, a comprehensive detailed geomorphic assessment of these reaches was not completed within the scope of the current assignment. The primary limitation encountered by AHYDTECH was the absence of a continuous hydrologic modelling framework capable of generating multi-year discharge records required to evaluate erosion thresholds, channel-forming flow recurrence, flow duration characteristics, and sediment transport competence. Without continuous flow simulation, quantitative determination of erosion indices, regime-based stability interpretation, and predictive channel response modelling could not be robustly completed.

Refinement of erosion hazard limits for the identified priority reaches therefore remains contingent upon completion of additional hydrologic, hydraulic, and geomorphic investigations. Development of a continuous hydrologic model reflecting updated watershed conditions and current modelling platforms is required to generate long-term flow duration data. Hydraulic model development and calibration using surveyed channel geometry and available monitoring data are also recommended to quantify shear stress distributions, velocity patterns, and water surface elevations under varying flow conditions.

It is recommended that:

- The legacy HEC-HMS model is updated and converted to a continuous simulation platform reflecting current watershed conditions and modelling standards.
- Continuous multi-year flow series be generated to support geomorphic regime and erosion threshold analysis.
- Detailed fluvial geomorphic assessments, including sediment transport and bank stability investigations, be completed for priority reaches R3, R4, R8, R9, and R10.



-
- Hydraulic modelling and calibration be undertaken to refine erosion hazard limits and development setback requirements.
 - Erosion hazard limits and mitigation recommendations be refined based on the results of detailed hydrologic, hydraulic, and geomorphic analyses.
 - Conceptual mitigation cost estimates be updated following detailed design, site-specific quantity take-offs, and agency review.

Sincerely,

Dr. Bahar SM, *APEGA, P.Geo.(Ltd), P.Eng.*

Managing Director

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11 REFERENCES

- Galli, J. (1996). *Rapid Stream Assessment Technique, Field Methods*. 36 pp. . Metropolitan Washington Council of Governments.
- Global Watersheds. (2021). *MERIT Hydro: Global Hydrography Datasets*. Retrieved from https://mghydro.com/watersheds/?fbclid=IwZXh0bgNhZW0CMTEAAR0O4pbb2ssoOMhFN__IZDCsFbCUoCdxpWWMyOv8YG719HnDC0mEXF9yNbM_aem_-kDcnS90-v8XJsEDnFvllw
- Klumpp, C., & Baird, D. (1992). *University of Nebraska - Lincoln*. Retrieved from United States Bureau of Land Management: Staff Publications.
- MNRF, M. (n.d.). *DEDSFM Huron-Georgian Bay 2022 - Package 38*. Retrieved from Ontario Digital Terrain Model (Lidar-Derived): <https://geohub.lio.gov.on.ca/maps/mnrf::ontario-digital-terrain-model-lidar-derived/explore?location=44.302626%2C-79.506133%2C8.84>
- MNRF, O. (2002). *Technical Guide River & Stream Systems: Erosion Hazard Limit*. Ontario Geological Survey. (2010). MRD128-REV, Ontario Geological Survey, Geology Ontario Online Database, Ministry of Mines, Website URL: <https://mndm.maps.arcgis.com/apps/mapviewer/index.html?layers=4cb9a34cacc04633bb85c708239877e0>. Ontario. Retrieved from Ontario Geological Survey.
- Ontario Geological Survey. (2011). MRD126-REV1, Ontario Geological Survey, Geology Ontario Online Database, Ministry of Mines, Website URL: <https://mndm.maps.arcgis.com/apps/webappviewer/index.html?id=66ee0efe4d3c4816963737dbdb890708>.
- Parish Geomorphic Ltd. (2004). *Belt Width Delineation Procedures*. Toronto and Region Conservation Authority.
- USACE, U. (1980). *Engineering and Design, Engineer Manual 1110-2-1611: Layout and Design of Shallow-Draft Waterways*.
- USDA. (1996). National Engineering Handbook: Chapter 16 - Streambank and Shoreline Protection. In U. S. (USDA), *Part 650 - Engineering Field Handbook* (pp. 11-16). Natural Resources Conservation Service (NRCS).
- USDOT, U., Richardson, E., & Davis, S. (1995). *Evaluating Scour at Bridges. Hydraulic Engineering Circular No. 18*. U. S. Department of Transportation, Federal Highway Administration.
- Vermont Agency of Natural Resources. (March 2009). *Vermont Stream Geomorphic Assessment Phase 2 Handbook: Rapid Stream Assessment*. 38 pp.
- WDWF, W. (2003). *Integrated Streambank Protection Guidelines, Chapter 6*. Washington Dept. of Transportation and Washington Dept. of Ecology.



APPENDIX A: Site Photos



Site Photos (Reach 1)



Site Photos (Reach 2)





Site Photos (Reach 3)



Site Photos (Reach 4)



Site Photos (Reach 5)

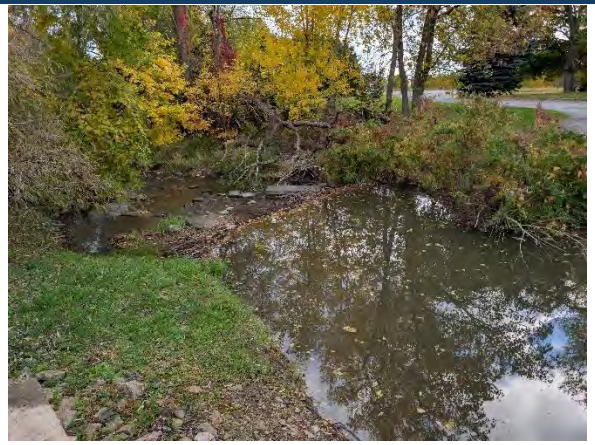




Site Photos (Reach 6)



Site Photos (Reach 7)





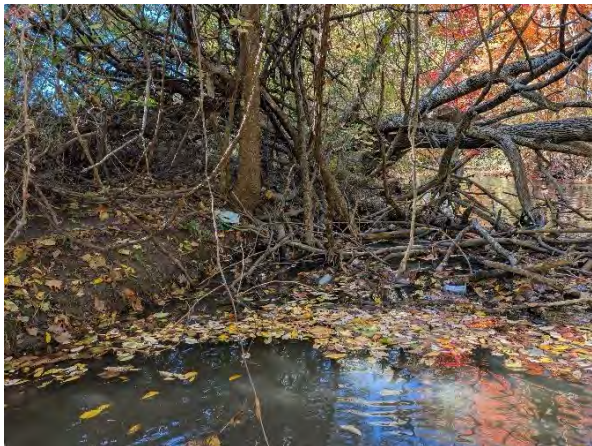
Site Photos (Reach 8)



Site Photos (Reach 9)



Site Photos (Reach 10)





Site Photos (Reach 11)



Site Photos (Reach 12)







APPENDIX B: Rapid Geomorphic Assessment



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 18, 2025 Weather: Sunny Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach-1 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			1/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds			
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials			
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			1/7
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI): <u>0.17</u>		
<u>Reach 1 is mostly stable. However, there are fallen trees and exposed roots in the reach. Widening is dominant process at the reach.</u>			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☒ In Regime (0.00-0.20) ☐ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 18, 2025 Weather: Sunny Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach 2 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			2/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials			
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			1/7
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:		Stability Index (SI):		0.2	
Reach 2 is marginally stable. But there are fallen trees and exposed roots in channel. It has widening dominant process.		[SI = (AI+DI+WI+PI)/4]			
		Condition:			
		☒ In Regime (0.00-0.20) ☐ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)			
Photos Taken:		Checked by:			



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: 04/19/2025 Weather: Sunny Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach 3 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			3/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaving trees / fence posts / etc.		✓	4/10
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends			
	5	Basal scour in both sides of channel through riffle		✓	
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			1/7
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI): <u>0.247</u>		
<u>Reach 3 is in transition. There are fallen trees and exposed roots. It has widening as a dominant process.</u>			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20) ☒ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 19, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach 4 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			3/7 =0.428
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			7/10 =0.70
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaving trees / fence posts / etc.		✓	4/10 =0.40
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			7/7 =1.00
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI):		0.267
This reach is in transition/stress. Fallen trees and exposed roots in the reach. Widening is dominant process.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20) ☒ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 25, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach 5 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			2/7 = 0.285
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials			
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10 = 0
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer out/all(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaving trees / fence posts / etc.		✓	4/10 = 0.40
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour > 50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			1/7 = 0.14
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes: <u>Reach 5 is a marginally stable channel. The dominant process is widening. There are fallen trees and tree roots exposed.</u>			Stability Index (SI): <u>0.20</u> [SI = (AI+DI+WI+PI)/4]		
			Condition: ☒ In Regime (0.00-0.20) ☐ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 25, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
 Stream/Reach: Reach 6 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			3/7 =0.428
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10 =0.4
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			2/7 =0.285
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes: <u>Reach 6 is in transition/stress. there are fallen trees</u>			Stability Index (SI): <u>0.28</u> [SI = (AI+DI+WI+PI)/4]		
			Condition: ☐ In Regime (0.00-0.20) ☒ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 25, 2025 Weather: Cloudy Crew: Dr. Bahar SM

Stream/Reach: Reach 7 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			2/7 =0.285
	2	Coarse materials in riffles embedded			
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer out/all(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaving trees / fence posts / etc.		✓	2/10 =0.2
	2	Occurrence of large organic debris			
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends			
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			1/7 =0.143
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes: <u>Reach 7 has several pools. It has comparatively less fallen trees and exposed tree roots. RGA score shows a stable channel.</u>			Stability Index (SI): <u>0.16</u> [SI = (AI+DI+WI+PI)/4]		
			Condition: ☒ In Regime (0.00-0.20) ☐ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct. 26, 2025 Weather: Sunny Crew: Dr. Bahar Sh.
 Stream/Reach: Reach 8 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			1/7 =0.14
	2	Coarse materials in riffles embedded			
	3	Siltation in ponds			
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			4/10 =0.10
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer out/all(s)			
	4	Undermined gabion baskets / concrete aprons / etc.		✓	
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10 =0.4
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends			
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked		✓	
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			2/7 =0.285
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI):		0.23
Reach 8 has fallen trees and root exposure. This reach is in transition/stress. The dominant geomorphic process is widening.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20) ☒ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr. Bahar SM

Stream/Reach: Reach 9 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			4/7 = 0.286
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials			
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			4/10 = 0.1
	2	Exposed sanitary / storm sewer / pipeline / etc.		✓	
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10 = 0.4
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			4/7 = 0.43
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI):		0.232
Reach 9 is in stress condition. Its stress is mostly due to fallen trees and exposed roots. The reach has widening dominant process.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20)		
			☒ In Transition/Stress (0.21-0.40)		
			☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr. Bahar SM
 Stream/Reach: Reach 10 Watershed/Subwatershed: Lower Four Mile Creek
 Location: _____ Project Code/Phase: _____
 UTM Coordinates: Upstream E _____ N _____ WP# _____
 (Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar		✓	4/7 = 0.57
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10 = 0
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer out/all(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaving trees / fence posts / etc.		✓	5/10 = 0.5
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			2/7 = 0.286
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed		✓	
Sum of Indices:					
Additional Notes:			Stability Index (SI): <u>0.34</u>		
In the study area Reach 10 is the most stress and unstable channel. There are bank erosion which are very close to Four Mile Rd. Widening is the most dominant fluvial process.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20) ☒ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr Bahar SM

Stream/Reach: Reach 11 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar		✓	4/7 = 0.571
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in ponds		✓	
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			4/10 = 0.4
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10 = 0.4
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			4/7 = 0.571
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form			
	4	Cutoff channel(s)			
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI):		0.38
This Reach has "aggradation" dominant process. It is in Transition/stress condition. There are fallen trees and roots exposed.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☐ In Regime (0.00-0.20)		
			☒ In Transition/Stress (0.21-0.40)		
			☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Rapid Geomorphic Assessment (RGA)

Date: Oct. 26, 2025 Weather: Sunny Crew: Dr. Bahar SM

Stream/Reach: Reach 12 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

PROCESS	GEOMORPHIC INDICATOR		PRESENT?		FACTOR VALUE
	Number	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lobate bar			1/7 = 0.142
	2	Coarse materials in riffles embedded			
	3	Siltation in ponds			
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone			
Sum of Indices:					
Evidence of Degradation (DI)	1	Exposed bridge footings			0/10 = 0
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut-face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armour layer visible in bank			
	10	Channel worn into undisturbed overburden / bedrock			
Sum of Indices:					
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	4/10 = 0.4
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour in both sides of channel through riffle			
	6	Gabion baskets / concrete walls / etc. outflanked			
	7	Length of basal scour >50% through subject reach			
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
Sum of Indices:					
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)			0/7 = 0
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form			
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed			
Sum of Indices:					
Additional Notes:			Stability Index (SI):		0.135
Reach 12 is located in most of the creek discharging to Lake Ontario. It dominant process is Widening.			[SI = (AI+DI+WI+PI)/4]		
			Condition:		
			☒ In Regime (0.00-0.20) ☐ In Transition/Stress (0.21-0.40) ☐ In Adjustment (>0.41)		
Photos Taken:			Checked by:		



APPENDIX C: Rapid Stream Assessment Technique



Rapid Stream Assessment Technique (RSAT)

Date: Oct 18, 2025 Weather: Sunny Partly Cloud Crew: D Baker SM
Stream/Reach: Reach 1 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	- Walled perimeter <40% of bottom width (<45% 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)	- Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas) - Few Pools present; riffles and runs dominant; velocity and depth generally slow and shallow (for large mainstem areas, runs ad depth diversity intermediate)	- Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas) - Good mix between riffles, runs, and pools - Relatively diverse velocity and depth of flow	- Walled perimeter >85% of bottom width (>90% for large mainstem areas) - Riffles, runs and pool habitat present - Diverse velocity and depth of flow present (i.e. slow, fast, shallow, ad deep water)
	- Riffle substrate composition predominantly gravel with high percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	- Substrate fouling level: High (>50%) - TDS: >150mg/L; Brown	- Substrate fouling level: Moderate (21-50%) - TDS: 101-150mg/L; Grey	- Substrate fouling level: Very Light (11-20%) - TDS: 50-100mg/L; Slightly grey	- Substrate fouling level: 0-10% (Rock underside) - TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area - Canopy coverage: <50% shading (30% for large mainstem areas)	- Riparian area predominantly wooded but with major localized gaps - Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	- Forested buffer generally >3m wide along major portion of both banks - Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	- Wide (>60m) mature forested buffer along both banks - Canopy coverage: >80% shading (>60% for large mainstem areas)
Point Range	0 1	2 3	4 5	6 7

Total Overall Score (0-42): 31

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 18, 2025 Weather: Sunny Partly Cloudy Crew: Dr. Bahar SM
Stream/Reach: Reach 2 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	Riparian area mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) mature forested buffer along both banks
	- Narrow riparian area - 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): 31

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 19, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
Stream/Reach: Reach 3 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bend areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	- Walled perimeter <40% of bottom width (<45% 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)	- Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas) - Few Pools present; riffles and runs dominant; velocity and depth generally slow and shallow (for large mainstem areas, runs and depth diversity intermediate)	- Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas) - Good mix between riffles, runs, and pools - Relatively diverse velocity and depth of flow	- Walled perimeter >85% of bottom width (>90% for large mainstem areas) - 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	- Substrate fouling level: High (>50%) - TDS: >150mg/L; Brown	- Substrate fouling level: Moderate (21-50%) - TDS: 101-150mg/L; Grey	- Substrate fouling level: Very Light (11-20%) - TDS: 50-100mg/L; Slightly grey	- Substrate fouling level: 0-10% (Rock underside) - TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 30

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 19, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
Stream/Reach: Reach 4 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	Riparian area mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) mature forested buffer along both banks
	- Narrow riparian area - 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): 30

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 25, 2025 Weather: Partly cloudy Crew: Dr Bahar SM
Stream/Reach: Reach 5 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	Riparian area mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) mature forested buffer along both banks
	- Narrow riparian area - 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): 31

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: April 25, 2025 Weather: Partly Cloudy Crew: Dr. Bahar SM
Stream/Reach: Reach 6 Watershed/Subwatershed: Four Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 ad 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, ad deep water)
	- Riffle substrate composition predominantly gravel with high percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 32

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 25, 2025 Weather: Cloudy Partly Crew: Dr. Benhar SM
Stream/Reach: Reach 7 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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	



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1, 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	Riparian area mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) mature forested buffer along both banks
	- Narrow riparian area - 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): 29.5

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct. 26, 2025 Weather: Sunny Crew: Dr. Bahar SM

Stream/Reach: Reach 8 Watershed/Subwatershed: Lower Four Mile Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bend areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 ad 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, ad deep water)
	- Riffle substrate composition predominantly gravel with high percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 29

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr. Bahar SM
Stream/Reach: Reach 9 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas <u>unstable</u> - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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 <u>7</u> 8	9 10 11

Evaluation Category	Poor	Fair	Good	Excellent
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% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- Fresh, large sand deposits uncommon 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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 <u>6</u>	7 8



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	- Walled perimeter <40% of bottom width (<45% 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)	- Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas) - Few Pools present; riffles and runs dominant; velocity and depth generally slow and shallow (for large mainstem areas, runs and depth diversity intermediate)	- Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas) - Good mix between riffles, runs, and pools - Relatively diverse velocity and depth of flow	- Walled perimeter >85% of bottom width (>90% for large mainstem areas) - 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	- Substrate fouling level: High (>50%) - TDS: >150mg/L; Brown	- Substrate fouling level: Moderate (21-50%) - TDS: 101-150mg/L; Grey	- Substrate fouling level: Very Light (11-20%) - TDS: 50-100mg/L; Slightly grey - Objects visible to depth 0.5-1m below surface	- Substrate fouling level: 0-10% (Rock underside) - TDS: <50mg/L; Clear flow - Clear water - Objects visible to depth >1m below surface
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	- Riparian area predominantly wooded but with major localized gaps - Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	- Forested buffer generally >3m wide along major portion of both banks - Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	- Wide (>60m) mature forested buffer along both banks - Canopy coverage: >80% shading (>60% for large mainstem areas)
Point Range	0 1	2 3	4 5	6 7

Total Overall Score (0-42): 31

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr. B. B. B. SM

Stream/Reach: Reach 10 Watershed/Subwatershed: Lower Fawn Mule Creek

Location: _____ Project Code/Phase: _____

UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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)	Rifle embeddedness <25% sand-silt (<35% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool-substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- Fresh, large sand deposits uncommon 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or enlargement
	- Riffle/pool ratio: 0.49:1< ; <1.51:1 - Summer afternoon H₂O temperature >80°F	- Riffle/pool ratio: 0.5-0.69:1; 1.31-1.5:1 - Summer afternoon H₂O temperature 75-80°F	- Riffle/pool ratio: 0.9-0.89:1; 1.11-1.3:1 - Summer afternoon H₂O temperature 68-75°F	- Riffle/pool ratio: 0.9-1:1 - Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 22

Ranking: ☐ Poor (<13) ☒ Fair (13-24) ☐ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct 26, 2025 Weather: Sunny Crew: Dr. Bahar SM
Stream/Reach: Reach 11 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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)	Rifle embeddedness <25% sand-silt (<35% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	Walled perimeter <40% of bottom width (<45% for large mainstem areas)	Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas)	Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas)	Walled perimeter >85% of bottom 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 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	Substrate fouling level: High (>50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very Light (11-20%)	Substrate fouling level: 0-10% (Rock underside)
	TDS: >150mg/L; Brown	TDS: 101-150mg/L; Grey	TDS: 50-100mg/L; Slightly grey	TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 26

Ranking: ☐ Poor (<13) ☐ Fair (13-24) ☒ Good (25-34) ☐ Excellent (35-42)



Rapid Stream Assessment Technique (RSAT)

Date: Oct. 26, 2025 Weather: Sunny Crew: Dr. Bahar SM
Stream/Reach: Reach 12 Watershed/Subwatershed: Lower Four Mile Creek
Location: _____ Project Code/Phase: _____
UTM Coordinates: Upstream E _____ N _____ WP# _____
(Ends of Reach) Downstream E _____ N _____ WP# _____

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 1.2m above stream (2.1m above stream for large mainstem areas) - Overhang >0.8-1.0m	- Stream bend areas unstable - Outer bank height 0.9-1.2m above stream (1.5-2.1m above stream for large mainstem areas) - Bank overhang 0.8-0.9m	- Stream bends areas stable - Outer banks height 0.6-0.9m above stream bank (1.2-1.5m above stream banks for large mainstem areas) - Overhang 0.6-0.8m	- Stream bend areas very stable - Height <0.6m above stream (<1.2m above stream for large mainstem areas) - Bank overhang <0.6m
	- 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

Evaluation Category	Poor	Fair	Good	Excellent
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)	Rifle embeddedness <25% sand-silt (<35% for large mainstem areas)
	- Few, if any, deep pools - Pool substrate >81% sand-silt	- Low to moderate number of deep pools - Pool substrate 60-80% sand-silt	- Moderate number of deep pools - Pool substrate 30-59% sand-silt	- High number of deep pools >61cm (>122cm for large mainstem areas) - Pool substrate <30% sand-silt
	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits common	Streak marks and/or "banana" deposits uncommon	Streak marks and/or "banana" deposits absent
	- Fresh, large sand deposits very common in channel - Moderate to heavy sand deposition along major portion of overbank area very common	- 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 in channel rare or absent - No evidence of fresh sediment deposits on overbank
	Point bars moderate to large and unstable with high amount of fresh sand present at most stream bends	Point bars moderate to large and unstable with high amount of fresh sand common	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



AHYDTECH GEOMORPHIC

ADVANCED HYDROLOGY HYDRAULIC GEOMORPHOLOGY

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	- Walled perimeter <40% of bottom width (<45% 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)	- Walled perimeter 40-60% of bottom width (45-65% for large mainstem areas) - Few Pools present; riffles and runs dominant; velocity and depth generally slow and shallow (for large mainstem areas, runs and depth diversity intermediate)	- Walled perimeter 61-85% of bottom width (66-90% for large mainstem areas) - Good mix between riffles, runs, and pools - Relatively diverse velocity and depth of flow	- Walled perimeter >85% of bottom width (>90% for large mainstem areas) - 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 percentage of sand <5% cobble	- Riffle substrate composition predominantly small cobble, gravel and sand 5-24% cobble	- Riffle substrate composition has 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 <10cm for large mainstem areas	Riffle depth 10-15cm for large mainstem areas	Riffle depth 15-20cm for large mainstem areas	Riffle depth >20cm for large mainstem areas
	Large pools generally <30cm deep (<60cm for large mainstem areas) and devoid of cover/structure	Large pools generally 31-45cm deep (61-90cm for large mainstem areas) with little or no cover/structure	Large pools generally 46-60cm deep (91-122cm for large mainstem areas) with some cover/structure	Large pools generally >61cm deep (>122cm for large mainstem areas) with good overhead cover/structure
	Extensive channel alteration or point bar formation/enlargement	Moderate increase in point bar and/or amount of channel modification	Slight increase in point bar formations/enlargement or slight amount of channel modification	No channel alteration or significant point bar formation or 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: 0.9-0.89:1; 1.11-1.3:1	Riffle/pool ratio: 0.9-1:1
	Summer afternoon H₂O temperature >80°F	Summer afternoon H₂O temperature 75-80°F	Summer afternoon H₂O temperature 68-75°F	Summer afternoon H₂O temperature <68°F
Point Range	0 1 2	3 4	5 6	7 8

Evaluation Category	Poor	Fair	Good	Excellent
Water Quality	- Substrate fouling level: High (>50%) - TDS: >150mg/L; Brown	- Substrate fouling level: Moderate (21-50%) - TDS: 101-150mg/L; Grey	- Substrate fouling level: Very Light (11-20%) - TDS: 50-100mg/L; Slightly grey	- Substrate fouling level: 0-10% (Rock underside) - TDS: <50mg/L; Clear flow
	Objects visible to depth <0.15m below surface	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1m below surface	Clear water - Objects visible to depth >1m 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

Evaluation Category	Poor	Fair	Good	Excellent
Riparian Habitat Conditions	- Riparian area mostly non-woody vegetation - Narrow riparian area	Riparian area predominantly wooded but with major localized gaps	Forested buffer generally >3m wide along major portion of both banks	Wide (>60m) 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): 16

Ranking: ☐ Poor (<13) ☒ Fair (13-24) ☐ Good (25-34) ☐ Excellent (35-42)



APPENDIX D: Images of Potential Erosion Hazard Locations



Figure 1: Images of Potential Erosion Hazard Locations Reach 01 and 02



Figure 2: Images of Potential Erosion Hazard Locations Reach 03 and 04



Figure 3: Images of Potential Erosion Hazard Locations Reach 05



Figure 4: Images of Potential Erosion Hazard Locations Reach 06 and 07



Figure 5: Images of Potential Erosion Hazard Locations Reach 08 and 09

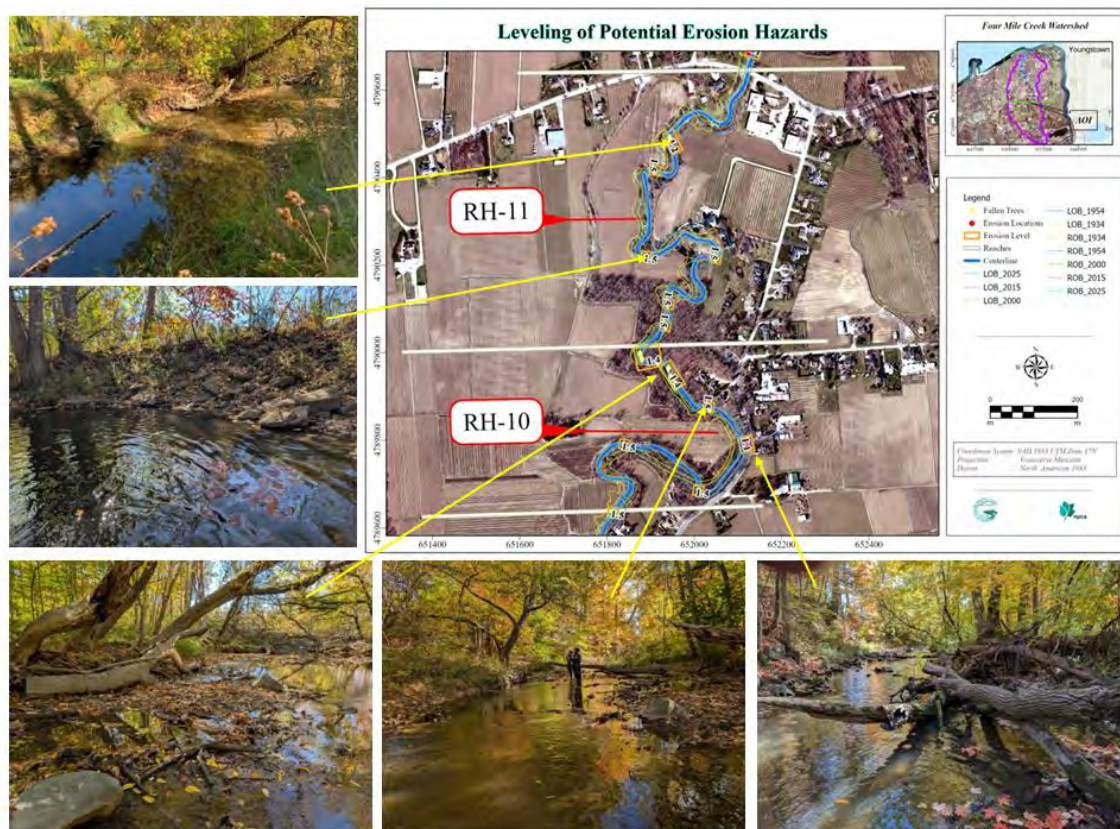


Figure 6: Images of Potential Erosion Hazard Locations Reach 10 and 11



Figure 7: Images of Potential Erosion Hazard Locations Reach 12