Geomorphological and Erosion Assessment, Tributary of Bear Brook

6160 Thunder Road and 5368 Boundary Road City of Ottawa



Prepared for: Thunder Road L.P. 801-250 City Centre Avenue Ottawa, Ontario K1R 6R7

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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained by Thunder Road Limited Partnership to complete a fluvial geomorphology assessment in support of a proposed development at 6160 Thunder Road and 5368 Boundary Road in Ottawa, Ontario (herein referred to as "subject land"). The subject land is located west of the intersection of Thunder Road and Boundary Road within the Bear Brook watershed and is bordered in the north by low-density, forested residential properties, and by forest to the west and south. The subject land is currently undeveloped, and the land cover is comprised of planted tree cover in the north and a fallow field in the south, with straightened drainage channels throughout. The subject land drains to a tributary of Bear Brook that flows westward along the northern border of the site through a forested area. The tributary proceeds through forest and beaver meadow towards a crossing with Thunder Road, downstream of which it drains into Bear Brook. The tributary appears to be straightened for a length of approximately 200 m along the northern border of the subject land, then downstream of this it transitions to an irregularly meandering pattern, which it maintains until its confluence with Bear Brook approximately 1.4 km downstream of the subject land. A map of the watercourse and subject land is presented in **Appendix A**.

Based on the information provided, the current design for the proposed development within the subject land includes a 12.78 ha industrial park primarily comprised of warehouses, loading bays, parking lots, a drainage swale, and three (3) stormwater management facilities, one of which (Pond 1) will discharge to the tributary of Bear Brook in the northwest corner of the subject land. Pond 1 is proposed to be located along the northwestern boundary of the subject land between the proposed building and associated outdoor shed, and a straightened section of the watercourse that flows parallel to the northwestern site boundary. It is proposed to outlet to the downstream end of this straightened section of the watercourse. It is our understanding that fluvial geomorphological services are required to inform stormwater mitigation strategies for the tributary to Bear Brook. We have developed a work plan to assess existing fluvial geomorphological conditions associated with the watercourse and conduct erosion threshold and exceedance analyses to understand potential erosive impacts downstream due to stormwater discharge.

The following activities were completed as part of the fluvial geomorphological assessment:

- Review of available background reports and mapping (i.e., watershed/subwatershed reporting, geology, topography, etc.) related to channel form and function and controlling factors related to fluvial geomorphology
- Historical site assessment using aerial photograph records to identify changes to the system due to land use and past channel modifications within the primary and extended study areas
- Delineate watercourse reaches along the receiving watercourses through a desktop exercise
- Rapid geomorphological field assessment to verify the background review and desktop assessment results and identify the most erosion-sensitive reach in the receiving watercourse
- Detailed geomorphological field assessment along the most erosion-sensitive reach to support and inform erosion threshold modelling and erosion exceedance analysis
- Erosion threshold assessment based on the detailed assessment results for the most erosionsensitive reach to determine the limiting erosion threshold value to inform the erosion exceedance analysis
- Erosion exceedance analysis of the most erosion-sensitive reach using the previously determined erosion threshold value to compare pre- and post-development conditions to inform stormwater mitigation strategies and SWM pond sizing and release rates to address erosion mitigation requirements

2 Existing Site Conditions

2.1 Background Review

A review of pertinent background material was completed to inform and provide context regarding local hydrology and stream morphology. Material reviewed includes site plans, historical aerial photographs, publicly available surficial geological mapping, physiological region and landform mapping, and watershed reports published by SNCA.

2.2 Watershed Characteristics

The subject site is located within the Bear Brook Watershed, southeast of the City of Ottawa. The main channel of Bear Brook flows generally eastwards through agricultural lands and fragmented forest to outlet into the South Nation River and is approximately 40 kilometers long. The total Bear Brook drainage area is approximately 488 km² and extends south and east of Ottawa (SNCA, 2016). The Bear Brook main channel begins near the community of Edwards within the municipal boundaries of the City of Ottawa and flows generally northwards in a meandering pattern until a crossing with the railway near Russell Road north of Highway 417. Downstream of the railway crossing, the main channel alignment turns to flow generally eastwards, an alignment it maintains until its confluence with the South Nation River near the community of Ettyville within Prescott-Russell County.

The tributary adjacent to the subject land is within the headwaters of Bear Brook south of Highway 417. The tributary flows westward from a crossing under the north-south segment of Thunder Road, which curves 90° in the vicinity of the subject land to intersect the tributary twice. The tributary proceeds along the northern extent of the subject land in a straightened ditch bordered by forest to the south and an abandoned residential property to the north. It then meanders irregularly in a northwestward alignment through forest and beaver meadow before crossing again under the east-west segment of Thunder Road. Downstream of the second growing it continues to meander irregularly in a northwestward alignment but is confined by a distinct valley in this section until its confluence with Bear Brook, where it enters the confined valley in which the main channel flows.

2.3 Surficial Geology and Physiography

Surficial geology and physiography act as primary controls regarding channel development, as they greatly influence the hydrological and sediment characteristics of a given drainage system. Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments within the stream corridor. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity. A map showing the surficial geology is presented in **Appendix B**.

The subject land is located within a Sand Plains physiographic region that covers much of the South Nation River watershed (Chapman and Putnam, 1984). The surficial geology of the subject land is comprised of fine- to medium-grain sands (surficial geology unit 11a), that originate from fluvial and marine processes operating in in the ancient delta and estuary environments of the Champlain Sea. These sediments are non-cohesive with high permeability. The sandy sediments are underlain by red and grey stratified clay thought to originate from weathering of local granitic rock (Chapman and Putnam, 1984).

2.4 Historical Assessment

A series of historical aerial photographs and publicly available LiDAR data were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an

understanding of the historical factors that have contributed to current channel morphodynamics and is used to inform erosion hazard assessments. Aerial photographs for the years 1965, 1976, 1991, 2008, and 2021 from GEO Ottawa (<u>https://maps.ottawa.ca/geoottawa/</u>) were reviewed. Imagery is provided in **Appendix C** for reference. Remote-sensing bare-earth digital elevation models (DEMs) derived from airborne LiDAR surveys (OMNRF, 2020) were also reviewed for a detailed, broad-scale analysis of geomorphic features along the watercourse and adjacent land. The bare-earth elevation raster dataset was used to generate a hillshade model useful for the analysis. A figure showing the hillshade model for the area surrounding the length of watercourse assessed is provided in **Appendix C** for reference.

Land cover visible in the 1965 imagery within the subject land and the surrounding area was comprised of agricultural fields and fragmented forest intersected by linear drainage ditches. Boundary Road and Thunder Road were established at this time, and a few residential and agricultural buildings were present along both roads. The upstream extent of the Bear Brook Tributary was straightened and bounded by agricultural fields. Approximately 400 m southwest of Boundary Road the watercourse transitioned to a section with low sinuosity, which continues towards Thunder Road. Riparian vegetation was sparse along the straightened portion of the tributary before transitioning to fragmented forest and fallow fields to the Thunder Road crossing. Headwater tributaries appear to have drained the forest and fallow fields in the south. An area with backwatering is visible immediately upstream of the Thunder Road crossing. The watercourse enters a confined valley downstream of the crossing, and another instance of backwatering caused by a berm that spans the valley approximately 60 m northwest of the road is visible. The tributary downstream of this appears to have been straightened in an alignment that mirrors that of the valley.

Minor changes in land use in the area surrounding the subject land occurred between 1965 and 1976. Active agriculture is visible in the 1976 imagery within the upstream portion of the tributary and several additional residential buildings were established along Thunder Road north of the subject site. Highway 417 had been constructed by this time to bisect the land north of the subject land. Although it is not possible to comment on small-scale changes to the watercourse due to the low resolution of the 1976 imagery, the watercourse alignment appears identical throughout the length of the tributary. Forest cover within riparian areas has matured and expanded since 1965. Backwatering throughout the middle section of the tributary upstream of Thunder Road is evident, likely caused by the historic beaver dams observed during field assessments. Backwatering observed upstream and downstream of Thunder Road in the 1965 imagery appears to have dissipated.

Land use surrounding the subject land underwent continued changes between 1976 and 1991 with agricultural land north of the straightened section of tributary having been developed into residential properties and a fuel station having been established at the intersection of Thunder Road and Boundary Road adjacent to the subject land. South of the straight section within the subject land, it appears a tree plantation had been established. Forest cover within riparian areas continued to mature and expand, providing a buffer along a large proportion of the tributary. Backwatering caused by historic beaver dams appears to have decreased in volume, as it covers less surface area. Areas that were previously backwatered have wide, open floodplains with forest setback from the watercourse. Low-sinuosity channels are visible in the locations previously backwatered upstream and downstream of the Thunder Road crossing. A remnant of the berm observed in the 1965 imagery is visible in the 1991 imagery and no backwatering is present upstream of it. The channel form downstream of this within the valley includes regular meanders that transition to a straightened planform as the tributary enters the wider valley of Bear Brook and drains into the larger watercourse.

Between 1991 and 2008, development continued in the area surrounding the subject land, including clearing and expansion of several commercial lots along Boundary Road east of the subject area. Land east of the Thunder Road and Boundary Road intersection was partially cleared of forest and fallow field

for the beginning stages of a warehouse facility. The tree plantation within the subject land had matured, as had the riparian buffer along the entire extent of the tributary. Backwatering through the middle section of tributary had further receded, leaving a wide floodplain. Higher resolution imagery provided in 2008 aid in observing the planform of the downstream extent which was difficult to observe in previous years. The channel exhibits a meandering planform with variable sinuosity and regularity from its middle section through to the Thunder Road crossing and towards the Bear Brook confluence, in contrast with the straighter planform visible in the same sections in the 1965 imagery. A channel crossing is now apparent at the location of the berm initially noted in the 1965 imagery, as there is a break in the visible watercourse at the same location with no backwatering upstream of this feature.

Construction of the warehouse facility located east of the subject land across Boundary Road was completed between 2008 and 2021. Other commercial properties south of the warehouse continued to expand, with two properties hosting piled fill. Riparian vegetation surrounding the entire tributary continued to mature and trees appear to have begun encroaching upon the wide floodplain left by the historic beaver dam. The channel appears wider through its downstream half, particularly downstream of the Thunder Road crossing, where some changes in meander bend shape are also observable. The culvert conducting flow below Thunder Road was replaced between 2008 and 2021. The crossing/berm noted approximately 60 m downstream of Thunder Road is somewhat obscured by maturing tree cover in the 2021 imagery. Based on sections of the watercourse that are observable upstream and downstream of its location, it does not appear to be causing a backwater effect as was observed on previous historical images.

As revealed on the bare-earth hillshade model derived from 2020 LiDAR data, the section of watercourse adjacent to the subject land is a straightened channel. A T-shaped confluence with two other straightened drainage channels is visible at the westernmost corner of the proposed development area. Forms suggesting debris piles are evident north of this confluence along the right channel bank. Downstream of this confluence there is a short section that appears to have been historically straightened within a meandering alignment and a levee or piled debris visible along the length of the northern bank. Approximately 225 m downstream of the subject site the watercourse flows into an area where the channel is poorly defined on the DEM hillshade model. Here the watercourse is situated within a wide, low-lying floodplain that leads to a backwatered pond upstream of an apparent beaver dam located approximately 395 m downstream of the subject site. The gradient marginally increases from an average of < 0.01% upstream to an average of approximately 0.2% downstream of the beaver dam. The watercourse through this section meanders irregularly in an approximately northwestward alignment through a slightly more well-defined channel with the floodplain showing some evidence of historic beaver activity. At approximately 660 m downstream of the subject lands the watercourse turns towards the southwest where both the channel and floodplain become more well-defined as the channel gradient increases to approximately 0.2%. Here the planform alternates between relatively straight and irregularly meandering sections. At approximately 950 m downstream from the subject site the form of another historic beaver dam is present on the hillshade model. Downstream of this the channel turns towards the northwest before crossing under the east-west segment of Thunder Road (1060 m downstream of the subject site). The observations made through analysis of the 2020 high-resolution bare-earth DEM Hillshade model are consistent with the conclusions of the Historical Assessment (detailed above) in which historical beaver and human modifications to the floodplain and channel were identified. Observations of beaver activity were noted upstream of the Thunder Road crossing, where the floodplain was wider and poorly defined, the gradient was less than 0.4%, and the channel was also poorly defined for approximately 25% of its length.

Downstream of Thunder Road the channel gradient increases to approximately 0.5% and the watercourse flows in an irregularly meandering planform confined by a valley until it enters the wider valley of the main Bear Brook channel approximately 215 m downstream of Thunder Road. The valley

walls from the Thunder Road crossing to that point are approximately 3 m above the channel floodplain. The location of the former crossing/berm noted in the Historical Assessment is evident in the hillshade model with the channel breaching the feature 60 m downstream from Thunder Road. The gradient both upstream and downstream of the feature is approximately 0.5%.

3 Watercourse Characterization

3.1 Reach Delineation

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

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), the Toronto and Region Conservation Authority (2004) and others. Several watercourse reaches were delineated within the immediate zone of impact associated with each SWM facility based on a desktop assessment of available data (e.g., MNRF stream layer, surficial geology, historical and recent aerial photographs, topographic data).

A total of eight (8) reaches were identified within the subject property, from upstream to downstream: **BBT-1**, **BBT-2**, **BBT-3**, **BBT-4**, **BBT-5**, **BBT-6**, **BBT-7**, and **BBT-8**. Reach mapping is provided in **Appendix A**, for reference.

3.2 General Reach Observations

A site visit was completed by GEO Morphix Ltd. on November 8th 2023, to document existing channel conditions. Photographs of site conditions are provided in **Appendix D** and field observations are included in **Appendix E**, for reference.

The site visits included the following activities and reach observations:

- Habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow patterns, geomorphological units (e.g., riffle, run, pool), and riparian vegetation for the extent of each reach assessed
- Descriptions of riparian conditions
- Documentation of culvert crossing conditions
- Estimates of bankfull channel dimensions
- Bed and bank material composition and structure
- Observations of erosion, scour or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures



• Completion of rapid channel assessments following the Rapid Geomorphological Assessment (RGA) (MOE, 2003; VANR, 2007) and Rapid Stream Assessment Technique (RSAT) (Galli, 1996) methodologies

General channel characteristics for all assessed reaches are summarized below in **Table 1**.

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Notes
BBT-1	5.55	1.1	Clay/Silt	Clay/Silt	Trees/Shrubs	 Straightened planform Relatively uniform U-shaped cross-sectional morphology throughout (i.e., no pool-riffle sequence)
BBT-2	6.75	1.15	Clay/Silt/ Sand	Clay/Silt/ Sand	Trees/Herbaceous	 Evidence of historical agricultural activity along both sides of reach Historically straightened Woody and organic debris in channel
BBT-3	21	1.3	Clay/Silt/ Sand	Clay/Silt/ Sand	Herbaceous	 Upstream of historic beaver dam Reach flows through drained beaver meadow with wide floodplain Some backwatering and pool present upstream of beaver dam
BBT-4	0.6*	0.53*	Clay/Silt/ Sand	Clay/Silt/ Sand	Herbaceous	 Downstream of historic beaver dam Flow path poorly defined and obscured by vegetation Backwatering due to channel constrictions in some locations
BBT-5	1.43*	0.5*	Clay to Gravel	Clay to Gravel	Trees/ Herbaceous	 Riparian area transitions from wide meadow to forested area High density of woody and organic debris Meandering planform
BBT-6	1.28*	0.59*	Clay to Gravel	Clay to Gravel	Trees/ Herbaceous	 Upstream Thunder Rd crossing Planform mostly straight Forest transitions to meadow with herbaceous vegetation that heavily encroaches on channel
BBT-7	3.57	0.51	Clay to Gravel	Clay to Gravel	Trees/ Herbaceous	 Downstream Thunder Rd crossing Confined in forested valley Meandering planform
BBT-8	1.38*	0.63*	Clay to Gravel	Clay to Gravel	Trees/ Herbaceous	 Reach flows through herbaceous meadow Planform mostly straight with some irregular meanders Heavy vegetation encroachment

Table 1: General Reach Observation Summary

*Indicates measurement is representative of bank width rather than bankfull width due to poor bankfull definition or a wide floodplain

BBT-1 begins at a concrete culvert near 6146 Thunder Road. The culvert outlets to a T-shaped intersection where ditches parallel to Thunder Road meet the watercourse. Reach **BBT-1** flows approximately southwest for 220 m through a straightened channel with relatively uniform U-shaped

cross-sectional morphology throughout the reach. The reach is bordered by forest comprised of coniferous trees planted in rows along the left (south) bank and an abandoned residential property with a mix of grass, herbaceous vegetation, and tree cover along the right (north) bank. The upstream end of the reach that lacks tree cover is populated by emergent aquatic vegetation and some attached algae. Fallen trees across the channel were observed throughout the reach. The bed and bank materials are generally comprised of clay and silt-sized materials, with soft silt deposits on the bed up to 0.20 m deep in some locations. The average bankfull width and depth are 5.55 m and 1.1 m, respectively. The reach ends at another T-shaped confluence with two straightened tributary channels connecting from the north and south. There was a relatively large pool (0.56 m deep) observed at the confluence and a constriction where the watercourse continues and the next reach begins. The Bear Brook Tributary continues in an approximately westward direction downstream of this confluence.

BBT-2 begins at the channel constriction at the downstream end of **BBT-1** and continues downstream for approximately 225 m. The channel appears to have been historically straightened within a meandering alignment, as the channel corridor proceeds westward before meandering slightly north, then back towards the south before a wider bend northward. Further evidence of historical alteration included a levee built up along the right (north) bank setback approximately 5-10 m. The riparian area is comprised of forest with herbaceous vegetation along the channel banks. The average bankfull width and depth are 6.75 and 1.15 m, respectively. Channel bed and banks were comprised of clay to sand-sized particles. Rooted emergent and rooted submergent aquatic vegetation was observed throughout the reach. Woody and organic debris within the channel created a somewhat sinuous thalweg within the straightened alignment that resulted in a mix of narrow, rapid flow sections and slower, wider flow sections. The watercourse continues in an approximately northwest alignment after the wide bend northward, the downstream end of which is where the next reach begins.

BBT-3 continues to meander with low-sinuosity for approximately 170 m towards a breached beaver dam. There was no evidence of contemporary beaver activity observed during the field assessment. The majority of the reach flows through a wide floodplain with herbaceous vegetation cover and emergent aquatic vegetation. Several pools of standing water and side-channels were observed adjacent to the channel within the low-lying floodplain. The average bankfull width and depth were 21 m and 1.3 m, respectively. The channel bed and banks are comprised of clay to sand-sized substrate. Rooted submergent vegetation was observed in the pool on the upstream side of the historic beaver dam. Slumping was observed in some locations along the banks.

BBT-4 begins downstream of the breached beaver dam with a section of poorly defined channel heavily obscured by herbaceous and emergent aquatic vegetation. The channel flows towards the northwest for approximately 265 m in an irregularly meandering pattern through a wide, low-lying floodplain that narrows with distance downstream. Riparian vegetation is comprised of herbaceous species with a forested area setback from the edge of the low-lying floodplain. Channel dimensions were measured, as bankfull dimensions were not estimated due to the breadth of the floodplain. Channel bank width and depth are 0.6 m and 0.53 m, respectively. The channel bed and banks are comprised of clay to sand-sized substrate. Scour and undercuts (0.05-0.15 m) were observed along the banks throughout the reach. An area of backwatering due to a constriction in the channel was observed approximately halfway downstream within the reach. At the downstream end of the reach, the floodplain transitions to a forested area where the next reach begins.

BBT-5 continues downstream in a meandering planform for approximately 200 m. An unmaintained earthen berm, approximately 1 to 2 m height and 2 m in width, spans the floodplain perpendicular to the watercourse at the upstream end of the reach with the berm breached and eroded at the location of the channel. The watercourse continues towards the northwest at first, then approximately 30 m

downstream of the break between **BBT-4** and **BBT-5** it turns towards the southwest and continues in that alignment for the remainder of the reach. The riparian area is comprised of forest with herbaceous vegetation where there are gaps in the trees and along the channel banks. Bankfull dimensions were estimated at 11.7 m wide and 1 m in depth at one location but were otherwise poorly defined. Channel dimensions were measured instead. Bank width and depth are 1.43 m and 0.5 m, respectively. Banks are comprised of clay to sand-sized material overlying a compact red and gray mottled clay till base. The channel bed is comprised of loose clay to small gravel-sized material. Bank angles ranged from 30-90 degrees. Bank undercuts ranging from 0.06-0.20 m and basal scour were observed throughout the reach along both sides of meander bends. J-hooked and leaning trees immature to established in age were also frequently observed along the banks. Woody and organic debris were also frequently observed within the channel.

BBT-6 begins where there is a transition from a forested riparian area to an area dominated by herbaceous meadow with scattered trees and a forest setback at the margins of the low-lying floodplain. There are some straight sections with infrequent and irregular meanders through the upstream end of the reach, which continues in a southwestern alignment for approximately 70 m. The channel then turns towards the northwest and proceeds to meander for approximately 135 m until it meets another Thunder Road crossing. The channel bed elevation notably drops throughout the reach and the bank angles are steeper than the reach upstream. Channel dimensions were measured, as bankfull was poorly defined due to the breadth of the low-lying floodplain. Bank width and depth are 1.28 m and 0.59 m, respectively. Bed and bank composition are identical to reach **BBT-5** and basal scour and undercuts (0.05-0.20 m) were observed along both sides of the channel throughout the reach. J-hooked trees were observed along the banks, and woody and organic debris were observed within the channel.

BBT-7 begins downstream of the Thunder Road crossing and enters a confined valley. The channel flows for approximately 200 m through a forest primarily composed of mature trees and herbaceous vegetation. The watercourse travels westward towards the Bear Brook corridor through irregular meanders. Approximately 60 m downstream of the Thunder Road crossing there is a degraded crossing. There is a corrugated steel pipe culvert situated in the centre of the channel, which has outflanked it to the west and flows through it as well as around it. Riffles and pools were observed throughout the reach, however primarily forced due to the presence of woody debris throughout the channel. Channel dimensions were measured and bankfull width and depth were 3.57 m and 0.51 m, respectively. The channel bed substrate was composed of primarily silt-sized particles with some particles up to coarse sand-size, while small pebbles were also observed within the upstream extent, all overlying a layer of compact red and gray mottled clay. Channel bank angles ranged from 60-90° and erosion was observed along 60-100% of the reach. Bank undercuts ranging from 0.06 m - 0.12 m were observed and scour was noted along both sides of the channel. J-hooked trees and exposed tree roots were prevalent.

BBT-8 begins at a transition from the confined, forested valley of **BBT-7** towards the channel corridor of the mainstem of Bear Brook. Herbaceous vegetation heavily encroached the channel which was generally straight with exception of a few tortuous meanders immediately upstream of the confluence with Bear Brook. Channel dimensions were measured, however bankfull was poorly defined, although it was estimated at 1.38m wide and 0.63 deep. The channel bed and banks were composed of clay to sand-sixed substrate and ranged from 30-90°. Scour was prevalent along the reach and an undercut of 0.06m was recorded at one location. Bank erosion was observed along 30-60% of the reach.

3.3 Rapid Field Assessments

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment (MOE; 2003) Rapid Geomorphic Assessment (RGA) technique. The

RGA evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The purpose of the RGA is to produce a score, or stability index, which evaluates the degree to which a stream has departed from its equilibrium condition. A stream with a score of less than 0.20 is in regime, indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that a stream is in transition or stress and is experiencing major changes to process and form outside the natural range of variability. A score of greater than 0.41 indicates that a stream is in extreme adjustment, exhibiting a new stream type, or in the process of adjusting to a new equilibrium (MOE, 2003; VANR, 2007).

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

The reaches were also classified according to the Downs (1995) Model of Channel Evolution and a modified version of the River Styles Framework (Brierley and Fryirs, 2005). The Downs (1995) model describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system. The River Styles Framework is a set of procedures that are applied to describe and explain channel forms and processes and assess channel response and potential future behaviour. These procedures are integrated into our geomorphic field assessment protocol.

Rapid assessments were completed during the site visit on November 8th, 2023. Photographs of channel conditions for all reaches are provided in **Appendix D** and field observations are included in **Appendix E**, for reference. **Table 2**, below, summarizes the results of the rapid field assessments.

Table 2: Reach Classification Summary

Deceb		RGA (MOE, 20	01)	RSAT (Galli, 1996)			
Name	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
BBT-1	0.178	In Regime	Widening	30	Good	Riparian Habitat Conditions	
BBT-2	0.178	In Regime	Widening	33	Good	Physical Instream Habitat	
BBT-3	0.107	In Regime	Aggradation	31	Good	Physical Instream Habitat	
BBT-4	0.214	In Transition	Planimetric Adjustment	31	Good	Channel Stability	
BBT-5	0.371	In Transition	Widening	29	Good	Physical Instream Habitat	
BBT-6	0.363	In Transition	Widening	25	Good	Physical Instream Habitat	
BBT-7	0.394	In Transition	Widening	25	Good	Physical Instream Habitat	
BBT-8	0.214	In Transition	Widening	27	Good	Physical Instream Habitat	

Reach **BBT-1** scored 0.178 on the RGA, indicating that the channel is in regime. The dominant systematic adjustment observed was evidence of widening, as a few fallen and leaning trees as well as occurrence of organic debris in the channel was observed. The reach received an RSAT score of 30, or good. The limiting factor was predominantly riparian habitat conditions due the lack of variation in vegetation and low canopy coverage along the riparian corridor.

Reach **BBT-2** received a score of 0.178 on the RGA, indicating that the channel is in regime. This was similarly due to the dominant systematic adjustment being evidence of widening. Occurrence of woody debris in the channel, and leaning trees contributed to the score. The reach received an RSAT score of 33, or good. The limiting feature along the reach was physical instream habitat due to the lack of riffle-pool features and variety of substrate sizes.

Reach **BBT-3** scored a 0.107 on the RGA, indicating that the channel is in regime. Occurrences of siltation in the pools and deposition along the overbank zone suggested the observed dominant systematic adjustment be evidence of aggradation. The reach received an RSAT score of 31, or good. The limiting factor was physical instream habitat due to the lack of riffle-pool features and variety in substrate sizes.

Reach **BBT-4** received a score of 0.214 on the RGA, indicating that the channel is in transition. It was determined that the dominant systematic adjustment was planform adjustment. This was due to observations of cut-off channels, islands, and the thalweg alignment out of phase. The reach received an RSAT score of 31 or good, with the limiting factor identified as poor channel stability. This was due to observations of bank failure and recent signs of slumping.

Reach **BBT-5** scored 0.371 on the RGA, indicating that the channel is in transition. The dominant systematic adjustment was channel widening, as fallen and leaning trees, exposed roots, large organic debris and basal scour throughout the reach was observed. The reach received an RSAT score of 29 or good. The limiting factor was identified as the physical instream habitat due to the lack of riffle-pool features and variety of substrate sizes.

Reach **BBT-6** was given an RGA score of 0.363, indicating that the channel is in transition. Due to observations of fallen and leaning trees, organic debris in the channel, and basal scour on both banks throughout the reach, it was determined that the dominant systematic adjustment was channel widening. The reach received an RSAT score of 25, or good. The limiting factor was identified as physical instream habitat again, due to a lack of riffles and pools, and a lack or variability in channel substrate sizes.

Reach **BBT-7** scored 0.394 on the RGA, indicating that the channel is in transition. The dominant systematic adjustment was evidence of widening as observations of leaning trees, exposed roots, organic debris in the channel and basal scour along both banks throughout the reach were made. The reach received an RSAT score of 25, or good. The limiting factor was identified as poor physical instream habitat due to shallow riffle and pool depths and channel alteration

Reach **BBT-8** received an RGA score of 0.214, indicating that the channel is in transition. The dominant systematic adjustment observed was channel widening due to observations of organic debris in the channel, fracture lines, and basal scour on both banks throughout the reach. An RSAT score of 27, or good was assigned. The limiting factor was physical instream habitat due to the lack of riffle and pool features.

3.4 Detailed Geomorphological Assessment

A detailed geomorphological assessment was completed for reach **BBT-7** on November 15th, 2023. This reach was selected for detailed assessment based on the results of the desktop assessment (see Section 2.4) and rapid field assessment (see Section 3.2) of the receiving watercourse. The results of these broader scale assessments indicated that reach **BBT-7** was the reach most susceptible to changes in erosion potential associated with the proposed development. This determination was based on multiple factors including evidence of active channel bank scour along the reach, and the reach being both confined and with a steeper channel gradient relative to upstream reaches. Consistent with this assessment were RGA scores which were higher and RSAT scores that were lower relative to the other assessed reaches along the receiving watercourse. Higher RGA scores indicate a greater degree of channel instability whereas lower RSAT scores indicate poorer quality stream conditions (i.e., RSAT includes an evaluation of ecological indicators as well as channel stability and scour).

The detailed assessment included measurements and observations of channel form (i.e., planform, bedconfiguration, slope, and cross-sectional form), bed and bank materials, erosion indicators (i.e., undercutting, exposed roots, mass movement), bankfull indicators, and aquatic and riparian vegetation. Measurements of water velocity and observations of sediment transport were also made along the reach. Detailed measurements and observations were at collected at eight representative cross sections and a longitudinal survey of the channel was completed to determine reach slope. For reference, photographs of channel conditions are provided in **Appendix D** and a comprehensive summary of the channel measurements is included in **Appendix F**. In the following section, channel characteristics relevant for the erosion threshold analysis are presented in **Table 3**.

4 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia, 2008; Villard and Parish, 2003). As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Erosion thresholds were modelled from detailed field observations of reach **BBT-7**. This reach was selected for the assessment, as it was determined to be the most erosion-sensitive reach within the potential zone of impact within the receiving watercourse (see details provided in preceding section). The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the morphology of the channel and characteristics of the bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate of erosion potential.

4.1 Methods

Erosion thresholds are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. Alternatively, a velocity-based approach can be applied. For fine grained sediments, empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994), can be applied.

An erosion threshold, defined in terms of a critical discharge, is quantified based on the bed and bank materials and local channel geometry. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, U, or Shear Stress, t, is calculated at various depths for a representative cross section until the average velocity or shear stress in slightly exceeds the critical threshold of the bed material. The velocity is determined using a Manning's approach, where the Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2}$$
 [Eq. 1]

where, *d* is depth of water, *S* is channel slope, and n is the Manning's roughness.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

$$\tau = d\rho g S_{hed}$$
[Eq. 2]

Where, τ is shear stress, d is the water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Because only 75% of bed shear stress and velocities applies to channel banks in uniform cross sections (Chow, 1959), the erosion threshold is scaled appropriately for these materials.

A Manning's roughness value of 0.040 was adopted for the critical discharge calculations, based on the framework described by Acrement and Schneider (1989).

4.2 Results

Banks within **BBT-7** were composed of soils with particles ranging from clay to sand in size. Fresh sandy overbank deposits were observed on top of the soil comprising the banks throughout the reach. Compact clay till underlying the soil was observed to be exposed along the base of the bank at several locations where scour had occurred. Based on field observations, the bank materials were classified as silty loam using the criteria of Fischenich (2001). Using the empirically derived values from Fischenich (2001) a critical velocity of 0.53 m/s for the erosion of silty loam was used for the bank material which yielded a critical discharge estimate of 0.808 m³/s based on the average cross-sectional area of the channel.

Bed materials within **BBT-7** were composed largely of particles ranging from silt to coarse sand in size, with the addition of small pebble-sized materials observed at 2 of the 7 surveyed cross-sections and loose clay-sized materials with cohesive properties observed at 1 of the 7 surveyed cross-sections. Compact clay till was exposed on the bed at 1 of the 7 surveyed cross-sections. Based on field observations, the bed materials were classified as silty loam (i.e., a mixture of predominantly silt sized particles with some sand and some clay). This classification was considered the most appropriate to capture the range of bed material sizes and properties observed throughout the reach. Using the empirically derived values from Fischenich (2001), a critical velocity of 0.53 m/s for the erosion of silty loam was used for the bed material, yielding a critical discharge estimate of 0.203 m³/s based on the average cross-sectional area of the channel.

The final, modelled erosion threshold is the lesser of the bed and bank materials, and in this instance was determined to be 0.203 m3/s for the bed materials. A pre-development drainage area of 148.64 ha was provided by JFSA (2024) and used to calculate the unitary erosion threshold of 0.00136 m3/s/ha. The results of the erosion threshold assessment are provided in **Table 3** below.

Channel Parameter		BBT-7							
Channel Characteristics									
Average bankfull width (m)		3.57							
Average bankfull depth (m)		0.31							
Channel gradient (%)		0.47							
D ₅₀ (mm)		<2.0							
D ₈₄ (mm)		<2.0							
Manning's n roughness coefficient	0.04								
Average bankfull discharge (m ³ /s)	0.733								
Average bankfull velocity (m/s)	0.737								
	Bed	Banks							
Material	Silt loam	Silt loam	Compact clay						
Reference	Fischenich, 2001	Fischenich, 2001	Chow, 1959						
Critical velocity at the bed (m/s)	0.53	0.53	0.54						
Apparent shear stress (N/m ²)	8.28	10.74	10.77						
Critical discharge (m ³ /s)	0.203	0.808	0.876						
Unitary threshold (m ³ /s/ha)*	0.00136	0.00544	0.00589						
Limiting critical discharge (m ³ /s)		0.203							

Table 3: Reach BBT-7 detailed assessment and erosion threshold analysis results

* Determined using a 148.64 ha drainage area provided by JFSA (2024)

5 Pre- to Post-Development Erosion Exceedance Analysis

In support of the proposed Stormwater Management (SWM) plan, an erosion exceedance analysis was completed for the receiving watercourse (CVC, 2015; TRCA, 2012). An outlet is proposed to drain a SWM pond that will release flows to the upstream end of the subject tributary at **BBT-1**. Ultimately, flows drain downstream into reach **BBT-7**, which was determined through rapid assessments to be the most erosion sensitive reach downstream of the proposed outlet located within the potential zone of impact.

Using the results of the erosion threshold analysis and hydrological simulation modelling provided by JFSA (2024) for pre- and post-development conditions, an erosion exceedance analyses to evaluate the potential for changes in the amount of erosion within the watercourse were completed with our in-house Erosion Exceedance Model. The most relevant erosion exceedances indices are summarized below:

- 1) Cumulative time of exceedance
- 2) Number of exceedance events
- 3) Cumulative effective discharge and volume
- 4) Cumulative effective work index (i.e. cumulative effective stream power)

These indices have been applied elsewhere in numerous jurisdictions, such as Conservation Halton and Toronto and Region Conservation Authority and have been widely accepted by Ontario Conservation Authorities. They provide an evaluation of the number, duration, and magnitude of exceedance events

(CVC, 2015). We note that the most relevant indicator is the cumulative effective work index, as this value reflects both the duration and magnitude of erosion exceedance events (TRCA, 2012).

Time of exceedance, number of exceedances, and cumulative effective discharge and volume can be calculated from the discharge record and established critical discharge value (i.e., erosion threshold). The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold, and the number of exceedances is the count of erosion exceedance events throughout the discharge record. The cumulative effective discharge represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event, whereas the cumulative effective volume represents the total discharge volume that exceeds the erosion threshold throughout the modelled discharge record. Specific details about how each of these key erosion metrics are calculated is provided in the following subsection.

For more relevant indicators, namely the cumulative effective work index, hydraulic information is required. Our model applies the discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-section, and channel roughness. This provides analysis that is appropriate to the specific site conditions.

Flow data for reach **BBT-7** was provided by JFSA (2024) in 5-minute increments for a 40-year period from 1968 to 2007. The hydrological modelling reflects local rainfall data from that period; with the yearly data spanning the period spring to fall. The years 2001 and 2005 are not represented in the data, however, as rainfall data for those years was not available in the historic climate record used for the hydrological simulation. The hydrological simulation data for pre- and post-development conditions was analyzed to calculate the aforementioned erosion indices. The pre- and post-development hydrographs, overlain with the respective erosion threshold and bankfull discharge, are provided in **Appendix G**, for reference.

5.1 Methods

To calculate erosion indices, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using the Manning's approach. This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i , such that:

$$Q_{T=}\sum Q_i$$

 Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i$$

where, w_i and d_i are width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{max}}$ based on:

[Eq. 3]

[Eq. 4]



 $au_{o_{\max}} = d_{\max}
ho g S_{\text{bed}}$

where, d_{\max} is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\text{max}}} . U_{\text{avg}} . \Delta t$$
 [Eq. 6]

where, U_{avg} is average velocity (Q_{tot}/A_{tot} , where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr} \cdot U \cdot \Delta t, \quad \omega < 0 = 0$$
[Eq. 7]

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$t_{\rm ex} = \sum \Delta t \text{for} (Q_T > Q_{\rm threshold})$	[Eq. 8]
where, $Q_{ ext{threshold}}$ is the discharge at the erosion threshold.	

The cumulative effective discharge volume (CEV) is defined as:

$CEV = \sum Q \text{ (for } Q > Q_{threshold} \text{)} $	q. 9	9]
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Similarly, the cumulative effective discharge (CED) is defined as:

 $CED = CEV/t_{ex}$ [Eq. 10]

5.2 Results

Modeling results indicate an insignificant post-development increase in erosion indices. We note that the cumulative effective work index (∞ eff; CEWI) is considered the most relevant index with respect to erosion potential, as it reflects both the flow magnitude and exceedance duration of a given erosion event. Results indicated a 3.86% increase in post development CEWI. Results within +/-5% are not considered to be significant enough to result in a detectable change in erosion potential. Therefore, the results indicate that the erosion potential of the receiving watercourse, expressed in this case by CEWI, is maintained post-development. Of secondary relevance is the cumulative effective discharge (CED) indicator, representing the total discharge volume that exceeds the established critical discharge throughout the modelling record. The erosion exceedance modeling was completed using one set of hydrological simulation data that reflects local rainfall data spanning the years 1968 to 2007 (provided by JFSA). The pre-development and post-development hydrographs are included in **Appendix G. Table 4** provides the results of the assessment based on the flow data provided by JFSA (2024).

Table 4:	Reach	BBT-7	cumulative	pre- an	id p	ost-developme	nt erosion	exceedance	analysis
results				-	_	-			-

Simulation		CED (m ³ /s)	ര _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
	(PRE)	459,259	3,682	492	112
Cumulative	(POST)	453,223	3,825	540	120
	Change (%)	-1.31	3.86	9.70	7.14

[Eq. 5]

The cumulative effective discharge (CED) represents the total volume of flow exceeding the threshold during a given year. The pre-development CED estimate for all years is approximately 459,259 m³/s, while the post-development CED estimate is approximately 453,223 m³/s, which amounts to a negligible decrease of 1.31%. The cumulative effective work index (ω_{eff}) reflects both the duration and magnitude of erosion events. The pre-development ω_{eff} estimate summed for all years is approximately 3,682 N/m², while the post-development ω_{eff} estimate is approximately 3,825 N/m², which amounts to a slight increase of 3.86%.

The cumulative time of exceedance (t_{ex}) represents the cumulative time for which flow exceeds the established erosion threshold. The pre-development t_{ex} estimate summed for all years is approximately 492 hrs, while the post-development t_{ex} estimate is approximately 540 hrs, which amounts to 9.70% increase. The number of exceedances also increased by 7.14%, from 112 pre-development, to 120 under post-development conditions.

The percent change estimates for CED and ω_{eff} fall within the +/-5% range of variability expected in natural channels. The estimated percent change for cumulative effective work, defined as the most relevant index in terms of erosion potential, is approximately 4%. As such, the proposed stormwater management plan adequately addresses concerns relating to potential erosion impacts of the development on the receiving watercourse.

6 Summary

GEO Morphix Ltd was retained by Thunder Road Limited Partnership to complete a fluvial geomorphology assessment in support of a proposed development at 6160 Thunder Road and 5368 Boundary Road in Ottawa, Ontario. This report summarizes the existing geomorphic conditions of the channel and provides erosion threshold and exceedance analysis to understand potential erosion impacts to the receiving watercourse associated with the proposed development.

Activities completed for the assessment included a detailed desktop review of available geology, topography, drainage area characteristics and watercourse reach confirmation and delineation. General channel observations, rapid stream assessments, and a detailed geomorphological assessment along the most sensitive reach were completed on November 8th and 15th, 2023. These assessments documented existing channel characteristics and assessed relative erosion-sensitivity of each channel reach. The results of the rapid assessments informed the location of the detailed geomorphological assessment, which was completed at reach **BBT-7**.

The results of the detailed geomorphological assessment provided information relevant to the erosion threshold analysis. An erosion threshold, expressed as a critical discharge was determined for both the bed and bank materials within reach **BBT-7**. An erosion threshold of 0.203 m³/s was defined for the subject reach. Using a drainage area of 148.64 ha provided by JFSA (2024) a corresponding unitary erosion threshold was defined as 0.00136 m³/s/ha. The results from a site-wide continuous hydrological simulation model were used to calculate pre- and post-development erosion exceedance indices for the site. Modeling results demonstrate that the proposed stormwater management strategy for the development is effective in mitigating potential downstream erosion impacts to the receiving watercourse.



We trust this report meets your requirements at the time. Should you have any questions please contact the undersigned.

Respectfully submitted,

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Appendix A: Reach Delineation



Appendix B: Surficial Geology



Appendix C: Historical Aerial Photographs and Terrain Map





geomorphix.com







Location: 6150 Thunder Road, Ottawa, ON Year: 2008 Source: GEO Ottawa Red Arrow: Thunder Road crossing Yellow Arrow: Upstream extent



Year: 2021 Source: GEO Ottawa Red Arrow: Thunder Road crossing Yellow Arrow: Upstream extent

Appendix D: Photographic Record




























Appendix E: Field Observations

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Last e	dited: 21/02/2023					1		complete	

Page ____ of ____

Project Number: 23111 **Reach Characteristics** Watershed/Subwatershed: BEAR BROOK **Field Staff:** KS KM 08-11-2023 Date: UTM (Upstream): 11:00 Stream: BEAR BROOK TRIB Time: O'C SUNNY UTM (Downstream): BBT-**Reach:** Weather: **Channel Type Channel Zone** Flow Type Valley Type Land Use 1,7 Evidence of Groundwater Location: Photo: (Table 4) (Table 5) (Table 2) (Table 3) (Table 1) Water Quality **Aquatic & Instream Vegetation Riparian Vegetation** WD Density Odour Turbidity Woody Debris **Channel Widths** Age (yrs) Coverage Type **Dominant Type** 1,2 ,2 WDJ/50m: (Table 16) (Table 17) (Table 8) (Table 6) □ In Cutbank Low □ None №1-4 ▶ Immature (<5) 2 In Channel Mod Nod Established (5-30) □ Fragmented ▶ 4 - 10 Encroachment Reach 20 □ Not Present □ High □ Mature (>30) Continuous $\Box > 10$ (Table 7) Coverage % **Channel Characteristics** Parent Rootlets Cobble Boulder (Table 19) Clay/Silt Sand Gravel **Bank Angle Bank Erosion** Sinuosity Degree **Sinuosity Type** NA X Bank (Table 10) ⊠ 0 - 30 5% (Table 9) Π Π Riffle \Box 5 - 30% □ 30 - 60 # of Channels Gradient Π (Table 12) (Table 11) $\Box 60 - 90$ \Box 30 - 60% Pool □ Undercut $\Box 60 - 100\%$ Bed **Bank Failure** Π Entrenchment M Π \Box (if no riffle-pool NA (Table 14) (Table 13) morphology) **Bankfull Width** Bankfull Indicators Down's Model 5.6 Wetted Width (m) 2.5 S 3 3.3 5.5 (m) (Table 18) (Table 15) Sediment Transport **Bankfull Depth** Sed Sorting 1.1 Wetted Depth (m) 0.215 0,54 🗆 Yes 🖾 No 🗆 Not Visible .1 WS **Observed?** (m) (Table 20) Transport Velocity (m/s) 0,135 0.024 % of Bed Active 0 Undercuts (m) NIA NIA Mode (Table 21) **Velocity Estimate Pool Depth** Mass Movement Geomorphic WB WB NA 8 Method (Table 23) (m) Units (Table 22) Meander Amplitude **Riffle-Pool** % Riffles: O % Pools: 0 Riffle Length (m) NIA NA (m) Spacing (m): PLANFORM 15 0:20 M DEEP IN SOME LOCATIONS. BED COMPRISED OF SOFT SILTY DEPOSITS, UP TO Notes: CHANNEL STRAIGHT, CROSS-SECTION IS GENERALLY U-SHAPED. NO RIFFLE-POOL FORMATION, MORPHOLOGY UNIFORM THROUGHOUT. REACH ENDS AT T- SHAPED CONFLUENCE W OTHER STRAIGHTENED CHANNELS; A LARGE DEEP POOL 15 PRESENT WHERE THE 3 CHANNELS INTERSECT, WHICH THEN FEEDS INTO A SLIGHTLY NARROWER AND HIGHER GRADIENT REACH (BBT-2) IN THE SAME ALIGNMENT BBT - 1. LAND COVER AC RESIDENTIAL LABANDONED SINGLE FAMILY HOME ALONG THE RB AND 19 SURROUNDING BBT-1 REFORESTED / TREE PLANTATION ALONG THE LB. Photos:

Senior staff sign-off (if required): _____ Checked by: <u>KM</u> Completed by: <u>KS</u>

Rapid Geomorphic Assessment

Project Number: 23111

Data:	~~	11-2022	Stream:		BF	AR BRO	OK 1	RIB		_
	08.	-11-7072	Boach		PE	T-1				
Time:	11:	MA OO	Reach;		DE	51-1	. 1556	000	A. 170	
Weather:	0.0	- SUNNY	Location:		01	50 I FIU	nyer	1 1103	1 L	
Field Staff:	KS	KM	Watershed/Subw	atershed:	BI	EAR BI	200K			
		G	eomorphological Indicato	r			Pres	sent?		Factor
Process	No.	Description					Yes	No		Value
	1	Lobate bar								
	2	Coarse materials in riffl	es embedded				-	1		1
Evidence of	3	Siltation in pools		_			>			1/2
Aggradation	4	Medial bars								
(AI)	5	Accretion on point bars								
	6	Poor longitudinal sortin	g of bed materials							
	7	Deposition in the overb	ank zone							a . 18 a
				S	um o	f indices =	1	6	(0.142
	1	Exposed bridge footing	(s)					NIA		
	2	Exposed sanitary / stor	m sewer / pipeline / etc.				1			
	3	Elevated storm sewer of	outfall(s)					NIA		
	4	Undermined gabion bas	skets / concrete aprons /	etc.				NIA		1/-
Evidence of	5	Scour pools downstream	m of culverts / storm sew	er outlets				NN		17
(DI)	6	Cut face on bar forms								
	7	Head cutting due to kn	ickpoint migration							
	8	Terrace cut through old	ler bar material				1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -			
	9	Suspended armour lay	er visible in bank	1						
	10	Channel worn into und	isturbed overburden / bec	drock	ium c	findicos -	1	1		A 147
[T								0.1-16
	1	Fallen / leaning trees /	fence posts / etc.							
	2	Occurrence of large or	janic debris							
2	3	Exposed tree roots				· · · · · · · · · · · · · · · · · · ·				
Evidence of	4	Basal scour on inside n	neander bends	flo						21
Widening	5	Basal scour on both sid	les of channel through the	,				NIA		-1-1
(WI)	6	Uutrianked gabion basi	50% through subject rea	ach					•	T
	/	Eveneed longth of prev	viously buried pipe / cable					NI	2	
	0	Exposed length of prev	n of bank	7 000				1	~	
	10	Exposed building found	ation			-		NIA	1	
		Exposed building round		S	Sum o	of indices =	2	5		0.285
	1	Formation of chute(s)								
		Single thread channel	to multiple channel							
Evidence of	2	Single thread channel	form to low bed relief for	m			/			1/
Planimetric		Cut-off channel(s)	Torrit to fow bed relier for	and a second						7
Adjustment	5	Formation of island(s)		·····				1		
(PI)	6	Thalweg alignment out	t of phase with meander f	form				1		
	7	Bar forms poorly form	ed / reworked / removed					/		
		Frank Service			Sum	of indices =	١	6		0.142
Notes:				Stability In	ndex	(SI) = (AI-	+DI+W	I+PI)/	4 =	0.177
				In Regim	ne	In Transi	tion/St	ress 1	n Ad	justment
×			anan kanan ang manang manan	⊠ 0.00 - 0	0.20	□ 0.2	1 - 0.4	0		0.41

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS____

Rapid Stream Assessment Technique Project Number: 2311

Date:	08-11-2023	Stream:		BEAR BROOM	K TRIB					
Time:	IL:00 AM	Reach:		BBT-1						
Weather:	O'C SUNNY	Location:	and the	6150 THU	6150 THUNDER ROAD					
Field Staff:	KS KM	Watershed/Subwater	shed:	BEAR BROOK						
Category	Poor	Fair		Good	Excellent					
an o service angle of an o service angle o agus de al service a	 < 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% stable Infreque sloughir failure 	of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 					
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer b m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) rerhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 					
Stability	 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 predom large, s scarce 2-3 reconstruction 	Ltree roots inantly old and maller young roots ent large tree falls am 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 general plant/so	1/3 of bank is ly highly resistant bil 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 	 Channe general 	I cross-section is Iy V- or U-shaped	Channel cross-section is generally V- or U-shaped					
Point range		030405		5 0 7 0 8	A 9 0 10 0 11					
8 88 1 - 1 - 1 1 - 1 - 1 1 - 1 - 1 1 - 1 - 1	 > 75% embedded (> 85% embedded for large mainstem areas) 	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% er mainste	6 embedded (35- nbedded for large em areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)					
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	 Moderate number of deep pools Pool substrate composition 30-59% sand-silt High number (> 61 cm dee (> 122 cm de mainstem an - Pool substrate 							
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Stream and/or sedime uncom 	 Streambed streak marks and/or "banana"-shaped sediment deposits uncommon Streambed strea and/or "banana" sediment deposits 						
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area Fresh, large sand deposits common in channel Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 				 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 					
0 3 84 (938)	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point b well-ve armoun fresh s 	ars small and stable, getated and/or red with little or no and	Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand					
Point range				5 6	英7 🗆 8					

Date: 02	8-11-2023	PN: 23111	Location:	THUNDER ROAD	
Category	Poor	Fair	Good	Excellent	
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 	NIA
Habitat	Riffle depth < 10 cm for large mainstem areas	Riffle depth 10-15 cm for large mainstem areas	Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas 	NIF
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	 Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure 	 Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure 	
	Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 	 Slight amount of channel alteration and/or slight increase in point bar formation/enlargement 	 No channel alteration or significant point bar formation/enlargement 	
	• Riffle/Pool ratio 0.49-1 ; ≥1.51:1	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1	
	Summer afternoon water temperature > 27°C	 Summer afternoon water temperature 24-27°C 	Summer afternoon water temperature 20-24°C	 Summer afternoon water temperature < 20°C 	NIA
Point range	00102	0304	₽ 5 □ 6		
	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Quality	 Brown colour TDS: > 150 mg/L 	 Grey colour TDS: 101-150 mg/L 	Slightly grey colour TDS: 50-100 mg/L	Clear flow TDS: < 50 mg/L	
	Objects visible to depth < 0.15m below surface	 Objects visible to depth 0.15-0.5m below surface 	 Objects visible to depth 0.5-1.0m below surface 	 Objects visible to depth > 1.0m below surface 	
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour	
Point range	00102		5 6	0708	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	 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	001	□ 2 □ 3	0,4□5	0607	
Total overall so	core (0-42) = 3	Poor (<13) F	air (13-24) Good (25-3	(>35) Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: $\underline{\hspace{0.5cm}} \mathrel{\hspace{0.5cm}} \mathrel{\hspace{0.5cm$

2211

	2023-11-08	Stream:	REAK BROOK THIR
Time:	11:4Sam	Reach:	BBT-2
Weather:	SUNNU DOG	Location:	THINDER PAAD
Field Staff:	KS KM	Watershed/Subwatershed	: BEAR BROOKE
Features	Monitoring	Site Sketch	Compass
Reach break	Long-profile		BFW TIZO
Station location	Monumented XS	FUE KING AL	K BFM : 213M
× Cross-section	O Monumented photo	END	WP OIT (-TN)
Flow direction	Monumented photo	of BBI-9. M.M.	
Riffle	▼ direction		
	Sediment sampling		IN BERM
Sediment bar		m g v g	
Eroded bank/slope	0 Scour chains		MOT CONSISTION
WWW Bank stabilization	Additional Symbols	OLD SULF	THINK IG HALT
		BEDEC U CON	INKANUIDAI
xxx Fence		VPmr	W REACH.
Culvert/outfall			
Swamp/wetland		W D VV	TRIR
₩₩₩ Grasses	· ·		E man martil
🗂 Tree			OLD FOOTPHINI HAB
Instream log/tree			W VITESTICT
≭ ≭ ∦ Woody debris		5 Ng M	\sim
Beaver dam		St a Charles	V t
Vegetated island		P W W PHI	i () is
Flow Type		OV VK JUL	2
H1 Standing water H1	A Back water	m WV N H	ET COW
H2 Scarcely perceptible	e flow	N AN I	V W
H4 Unwelling	v	VKABUN	
H5 Rippled		C VI AV	
H6 Unbroken standing	wave	CO WANTE	U (.
H7 Broken standing wa	ve		WPSON BOTH
H8 Chute			SIDES OF CHANNEL
H9 Free fall H9	A Dissipates below free fall	V. VE	$\left(\mathbf{V} \right)$
Substrate		VEG NO T	\sim
S1 Silt	S6 Small boulder	BAR SAR	
S2 Sand	S7 Large boulder	NO Y	BFW: Leisin
SA Small cohbin	So Bimodal	DXA NOS	OFD LIM
ST Large cobble	Sy Bearock/till	WOSHING W	D WW. Sittm
Other		BOTH BANNS	U 100,0,20m
BM Benchmark	EP Erosion nin	VIADUARE) W. OU	- NEGENCROPACHMENT
BS Backsight	RB Rebar	FLOW CD VI V	CO THE CHILE OF THE CONTENT OF THE
DS Downstream	US Upstream	PHITEPIS (VA'V	SMALL
WDJ Woody debris jam	TR Terrace	Antaba	-SMD2
VWC Valley wall contact	FC Flood chute	DEAINAGE PITCIT BET-1	
Bottom of slope	FP Flood plain	Photos:	
TOS Top of slope	KP Knick point	Notes: "CHANNEL COUNCA	TENER MAND EFINDER
		UNI OLLIGADORE CALLORIT	PO BONDER WE WE DE
		IN UNHNIEL COMPANY	LEV NUMPERTICIALLY COU
	0.0	MUDILOUS LIGH ANTHE	HUNGRANTE PAUCINIC MAL
- CHANNEL BED	SAMD, COARSESILT	VARIABLE FLOW PATHS	/ VELOCITIES, CAUSING ZON

Page _____ of ____

Reach Chara	cteris	tics P	roject	Number:	23111														MORPHIX
Date:		08-11-	-2023		Field S	taff:		KS KN	Λ			Wate	ershe	d/Subw	atershe	ed: B	EARE	ROOK	
Time:		11:30	AM		Stream	1:		BEAR	BRO	OK	TRIB	UTM	(Ups	tream):					
Weather:		o'c su	rnni		Reach:			BBT-	2			UTM	(Dov	vnstrea	m):				
Land Use (Table 1)	Va (T	alley Type able 2)	1	Channel (Table 3)	Туре	12 (t han Table	nel Zone e 4)	1] Fi	ow Type able 5)	1		vidence o	f Ground	water L	ocation:	<u> </u>	Photo:
Riparian Vege	tation							Aquatic 8	k Instr	eam	Vegetati	on			V	/ater Q	uality		
Dominant Type (Table 6)	1,4	Coverage	Chann	el Widths /	Age (yrs) I Immature	(<5)		Type (Table 8)	1,2	w o	ody Debris In Cutbank	WD De	ensity v	WDJ/50m	1:	Od (Tab	our le 16)	T (1	urbidity Table 17)
Encroachment (Table 7)	3	□ Fragment S.Continuo	ted 🖪 🕯	4-10 1 >10 [Establishe Mature (>	ed (5-30) ·30)		Reach Coverage %	20		In Channel Not Present	⊠ Moo	d h	<u> </u>					2
Channel Chara	cteris	tics																	
Sinuosity Type (Table 9)	NIA	Sinuos	sity Degr (Table 1	ee 0)	Bank /	Angle 30	B	Bank Erosion ∃ < 5%	1	((Table 19) Bank	Clay/	Silt	Sand	Gravel	Cobble	Boulde	r Parent	Rootlets
Gradient (Table 11)]] # c	of Channe (Table 1	2)	□ 30 - □ 60 -	60 90		∃ 5 – 30% ∃ 30 – 60%			Riffle Pool								
Entrenchment (Table 13)		B	ank Failu (Table 1	4) N/A	🗆 Unde	ercut	C	∃ 60 - 100%		(ii	Bed f no riffie-pool morphology)	0	•						
Down's Model (Table 15)	S	Bankfull	Indicato (Table 1	rs 8) 1,3				Bankfull Wie (dth m) 6	.5	8			Wette	ed Width	(m) 🗧	3.7	2.3	
Sed Sorting (Table 20)	WS	Sediment	t Transpo Observe	d? 🗆 Yes	🖾 No 🗆 N	ot Visible		Bankfull Dej (m)	.1	1.2			Wette	ed Depth	(m) (0.2	517	
Transport Mode (Table 21)	NIA	% of	Bed Acti	ve 🔿				Undercuts (m)	-				v v	elocity (I	m/s) (099	0.149	
Geomorphic Units (Table 22)	5,8	Mass	Moveme (Table 2	nt 3) N/A	% RUN	US 10		Pool De (m)	-				Vel	ocity Esti Me	mate	WB	WB	
Riffle-Pool Spacing (m):	20		% Riffle	s: 10	% Pools	: 80	Ri	ffle Length (m)	2				Meand	er Ampli	tude (m)	VIA		
Notes: CHANN	iel,	APPEARS	5 415	FORICAL	LY STR	AIGH	TER	NED, EV	IDEN	JCE	OF HI	ISTO	RIC	AGRIC	ULTU	IRAL	ACTIN	ITY A	LONG
BOTH SI	265	THROUG	SHOU	- WS	PORTI	ON OF	= r	REACH .	CHAN	JNE	EL COR	RIDO	DR	SOME	WHAT	F"IN	IANDEI	RE" IN	STEAD
OF MEAN	IDEF	RING C	I.E.	IT MA	1 HAV	E BEI	EN	THANA	ICALL	CR	EATE	HEN	ED	NUME	TUTI	HAL	NEG	WIIN	STRAIGHT
ALIGNMEN	51.	VODDI	AND AL	ID RAC	C DEE	CHAL	Ze	ONES .	I.E.	RIT	FFLES)	ARE	= CF	HUSEL	> BY	WOO	DYA	ND OI	RGANIC
DEPRIS	THE	RE AP	PEAR	S TO	REA	MAN	-M	ADE LI	EVPE	=	BUILT	UP	AL	ONG	THE	RE	3 THR	OUGHO	JHT THE
REACH	SETE	BACK A	PPRC	X. 5-	10 M	FRO	M	CHAN	NEL	E	SANK.								
									-				construction and a second						
						2011-0 (mail - 1997)										******			
Photos:																			
					2														

Version #4 Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS_

GEO

Project Number: 23111 **Rapid Geomorphic Assessment** Stream: Date: BEAR BROOK TRIB 08-11-2023 Reach: Time: BBT-2 11:30 AM Weather: O'C SUNNY Location: THUNDER FORD Watershed/Subwatershed: BEAK BROOK Field Staff: KS KM Present? Factor Geomorphological Indicator Process Value Yes No Description No. 1 1 Lobate bar 2 Coarse materials in riffles embedded 2/7 Siltation in pools 3 Evidence of Aggradation Medial bars 4 (AI) 5 Accretion on point bars Poor longitudinal sorting of bed materials 6 Deposition in the overbank zone 7 2 5 0.285 Sum of indices = NIA Exposed bridge footing(s) 1 NIA Exposed sanitary / storm sewer / pipeline / etc. 2 NIA 3 Elevated storm sewer outfall(s) 0/5 NIA Undermined gabion baskets / concrete aprons / etc. 4 Evidence of Scour pools downstream of culverts / storm sewer outlets NIA 5 Degradation Cut face on bar forms 6 (DI) Head cutting due to knickpoint migration 7 8 Terrace cut through older bar material Suspended armour layer visible in bank 9 Channel worn into undisturbed overburden / bedrock 10 ()0 Sum of indices = Fallen / leaning trees / fence posts / etc. 1 2 Occurrence of large organic debris Exposed tree roots 3 Basal scour on inside meander bends 4 Evidence of Basal scour on both sides of channel through riffle 5 Widening NIA Outflanked gabion baskets / concrete walls / etc. 6 (WI)7 Length of basal scour >50% through subject reach NIA Exposed length of previously buried pipe / cable / etc. 8 9 Fracture lines along top of bank NIA Exposed building foundation 10 0.285 2 Sum of indices = 1 Formation of chute(s) Single thread channel to multiple channel 2 Evidence of Evolution of pool-riffle form to low bed relief form 3 Planimetric 1/7 4 Cut-off channel(s) Form Adjustment Formation of island(s) 5 (PI) Thalweg alignment out of phase with meander form 6 Bar forms poorly formed / reworked / removed 7 0.142 6 Sum of indices = Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.178 Notes: In Transition/Stress In Adjustment **In Regime** 0.21 - 0.40 0.41 ☑ 0.00 - 0.20

Rapid Stream Assessment Technique Project Number: 23111

Date:	08-11-2023	Stream:		BEAR BROD	KTRIB			
Time:	11:30 AM	Reach:		BBT-2				
Weather:	O'C SUNNY	Location:	an Herdener	THUNDER R	RCAD			
Field Staff:	KS KM	Watershed/Subwater	rshed:	BEAR BROOK				
Category	Poor	Fair		Good	Excellent			
n y ska denth A (19 - dane An (19 - dane	 < 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% stable Infrequ sloughin failure 	6 of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer b m abov 1.5 m a for larg Bank ov 	bend areas stable bank height 0.6-0.9 re stream bank (1.2- above stream bank e mainstem areas) verhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 			
Stability	 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 	Expose predom large, s scarce 2-3 rec per stree	 Exposed tree roots Exposed tree root arge, smaller young roots Generally 0-1 recent ree falls Generally provide tree falls 				
	 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 general plant/se	1/3 of bank is lly highly resistant oil 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 	 Channe genera 	el cross-section is lly V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range	000102	030405		6 0 7 0 8	0 9 10 0 11			
	 > 75% embedded (> 85% embedded for large mainstem areas) 	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% er mainste	% embedded (35- mbedded for large em areas)	 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 			
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	 Modera pools Pool su 30-59% 	Moderate number of deep pools Pool substrate composition 30-59% sand-silt Pool substrate composition 30-59% sand-silt Pool substrate composition				
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Stream and/or sedime uncom 	reambed streak marks d/or "banana"-shaped diment deposits common				
υεροςιτιοη	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area Fresh, large sand deposits common in channel Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks Fresh, large sand dep uncommon in channel Small localized areas of fresh sand deposits along top of low banks 						
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point b well-ve armout fresh s 	ars small and stable, egetated and/or red with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 			
Point range		0304		0506	7 0 8			

Date: C	18-11-2023	PN: 23111	Location:	THUNDER ROAD
Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channe width (45-65% for larg mainstem areas) 	Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffl and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble
Habitat	 Riffle depth < 10 cm for large mainstem areas 	Riffle depth 10-15 cm f large mainstem areas	for • Riffle depth 15-20 cm for large mainstem areas	Riffle depth > 20 cm for large mainstem areas
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 3 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structu 	 60- Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure 	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	 Extensive channel alteration and/or point bar formation/enlargement 	 Moderate amount of channel alteration and/ moderate increase in point bar formation/enlargement 	• Slight amount of channel or alteration and/or slight increase in point bar formation/enlargement	 No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1
	Summer afternoon water temperature > 27°C	 Summer afternoon wat temperature 24-27°C 	• Summer afternoon water temperature 20-24°C	Summer afternoon water temperature < 20°C
Point range		0304	5 0 6	0708
	 Substrate fouling level: High (> 50%) 	 Substrate fouling level: Moderate (21-50%) 	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)
Water Quality	Brown colour TDS: > 150 mg/L	Grey colourTDS: 101-150 mg/L	Slightly grey colour TDS: 50-100 mg/L	Clear flow TDS: < 50 mg/L
2	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surfact 	Objects visible to depth 0.5-1.0m below surface	 Objects visible to depth > 1.0m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour
Point range			0506	0708
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks
Conditions	 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 0 1	0203	0405	6 0 7
Total overall	score (0-42) = 33	Poor (<13)	Fair (13-24) Good (25-	B4) Excellent (>35)

Version #2 Last edited: 10/02/2023

General Site Characteristics

Project Number: 23111

Date: 20 & 3 - 11 - 0 S Stream: Inter Time: 13 :30 pm Reach: B BT-3 Weather: SUNNY 0 °C Location: THUMDE P Field Staff: K S KA Watershed/Subwatershed: BET-3 Reach break ↔ Long-profile Monumented photo direction Imounented photo direction State Sketch Pool Imounented photo direction Imounented photo direction Imounented photo direction State Sketch Image: Sediment bar Himmer Eroded bank/slope Scour chains Additional Symbols Image: Sediment bar Himmer Eroded bank/slope Scour chains Image: Sediment bar Himmer Eroded bank/slope Additional Symbols Image: Sediment bar Himmer Eroded bank/slope Additional Symbols Statistication Additional Symbols Image: Scour chains Additional Symbols Image: Scour ch	0.0
Time: 1A 30pm Reach: B bl-5 Weather: SUNNY 0 °C Location: THUNDE P Field Staff: F S KA Watershed/Subwatershed: EFRE From Reach break Station location Imonumented photo Site Sketch Reach Imonumented photo Monumented photo Imonumented photo Pool Imonumented photo Sour chains Memme Erode bank/slope Sour chains Sour chains Memme Erode bank/slope Sour chains Additional Symbols Stating ree Sour chains Charter chains Memme Erode bank/slope Sour chains Additional Symbols Image: Stating ree Sour chains Sour chains Memme Erode bank/slope Sour chains PRAU Memme Erode bank/slope Sour chains PRAU Memme Erode bank/slope Sour chains PRAU Weather thank Erosing pins Sour chains Memme Erode bank/slope Sour chains PRAU Weather thank Erosing pins Provide thains Swamp/wetland Provide thains Provide thains Weather thank Erosing pins Provide thains Stating ree fail HA Dissipates below free fail Provide thains <th>5 RBOOKE</th>	5 RBOOKE
Weather: SUMNY Cocation: THUNDER Field Staff: KS KA Watershed/Subwatershed: Ether E too Features Monitoring Station location Ether E too Ether E too Reach break Station location Immuneted photo Monumented photo Monumented photo Immuneted bank/slope Scalenet sampling Scalenet sampling Scalenet sampling Station location Immuneted bank/slope Scalenet sampling Scalenet sampling Scalenet sampling Station location Immuneted bank/slope Scalenet sampling Scalenet sampling Station location Scalenet sampling Immuneted bank/slope Scalenet sampling Scalenet sampling Scalenet sampling Station location Immuneted bank/slope Scalenet sampling Station location Scalenet sampling Station location Station location tartare mody/ree Immuneted sampling Station location Station location Station location VV VV Grasses Immuneted sampling Station location Station location Station location Station location VV VV Grasses Immuneted saming wave Immuneted sampling	
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DS Downstream US Upstream TO GRAMSSES Description DEG WDJ Woody debris jam TR Terrace TO GRAMSSES Terrace	
WDJ Woody debris jam TR Terrace	
VWC Valley wall contact FC Flood chute	
BOS Bottom of slope FP Flood plain Photos:	
TOS Top of slope KP Knick point Notes: -NO EIFFLE - POOLS	
- CHOSE TO BEANER DOND, VEG ENCRONCHMENT BECOMES EXTREME COMMANDE RED	n Pront
- EVIDENCE OF SOME DE-WATERING, LOW BANKS, SILTY BED, WIDE PLOOPPI	MAN VER
N2: 7 15(110) (OHRE CUT (TINK CHND BUL RED 10.20)	

Version #4 1/2; 14,240 (1m) Last edited: 21/02/2023

Page _____ of _____

Reach Charac	terist	ics Pr	oject Nu	umber:	23111										100000			MORPHIX
Date:		08-11-	2023		Field S	Staff:	KS KM	1			Wat	tershe	d/Subwa	atershed	1: BE	AR BR	COK	
Time:		12:15	PM		Stream	n:	BEAR	BR	OOK .	TRIB	UTN	4 (Ups	stream):					
Weather:		o'c su	NNY		Reach	:	BBT-	3			UTN	1 (Dov	wnstrean	n):				
Land Use (Table 1)	Va (Ta	able 2)	۲ с	hannel [•] Table 3)	Туре [اع <mark>د</mark> ا ۱۲ (۱	hannel Zone Table 4)		Flo (Ta	w Type ble 5)			vidence of	Groundw	ater Loo	ation:	<u> </u>	hoto:
Riparian Veget	ation						Aquatic 8	& In	stream	Vegetat	ion			Wa	ater Qu	ality		
Dominant Type (Table 6)	4	Coverage	Channel V	Widths A 4 C	Age (yrs) I Immatur	re (<5)	Type (Table 8)	1,	2 woo	ody Debris n Cutbank n Channel	WDD Lo	ensity w	WDJ/50m	:	Odou (Table	ur 16)	Tu (Ta	rbidity ible 17)
Encroachment (Table 7)	4	Continuou	s □>1	.0 C] Mature (>30)	Reach Coverage %	8		lot Presen	t 🗆 Hig	gh					L	
Channel Chara	cterist	ics																
Sinuosity Type (Table 9)	Z	Sinuosi	ity Degree (Table 10)	1	Bank □ 0 -	Angle 30	Bank Erosion ₪ < 5%	ı	()	Table 19) Bank	Clay	/Silt 3.	Sand	Gravel		Boulder	Parent	
Gradient (Table 11)	1	# o1	f Channels (Table 12)	1	⊠ 30 □ 60	- 60 - 90	□ 5 - 30% □ 30 - 60%			Riffle Pool								
Entrenchment (Table 13)	1	Ba	nk Failure (Table 14)	NA	🗆 Un	dercut	□ 60 - 100%		(if	Bed no riffle-pool morphology)	2	3						
Down's Model (Table 15)	D	Bankfull J	Indicators (Table 18)	1,5			Bankfull Wi	idth (m)	12	30	>		Wette	d Width	(m)],'	85	5	
Sed Sorting (Table 20)	WS	Sediment	Transport Observed?	□ Yes	🕅 No 🗆	Not Visible	Bankfull De	epth (m)	1.1	1.5	>		Wette	d Depth	(m) (),	17	0.285	
Transport Mode (Table 21)	NIA	% of	Bed Active	6			Undercuts	(m)	\sim				Ve	elocity (m	n/s) 0,	139	0,07	
Geomorphic Units (Table 22)	8	Mass	Movement (Table 23)	NIA	%RUN	15 100	Pool De	epth (m)					Vele	ocity Estin Met	nate thod	IB	WB	
Riffle-Pool Spacing (m):	NIA		% Riffles:		% Poo	ls:	Riffle Length	(m)					Meand	er Amplit	(m)	< _		
Notes: BBT -	-3 15	S IMMER	DIATEL	Y WIS	OF	A HIS	TORIC BEA	AVE	R DI	AM TH	AT	HAS	BEEN	BRE	ACHEI	DINA	PAST	SEASON
(I.E. NO E	VIDE	NCE OF	ONGO	ING	BEAV	ER AS	TIVITY, E	UT	EVIC	DENCE	<u>= of</u>	Pr	RESEN	CE I	DA	IU TEI	TRO OF	REACH
HISTORIC	DAN	M CAUS	SES F	BACKU	NATE	RING	AND FORM	AS	P00	LAT	DI	ATT	NU C	PAG	CACHI AT	TING	LAND	SURFACE
FLOWS TH	ROU	GH WID	PE FLC	DODPL	AIN	W HE	REACEOL	12	POOL	AT	DAI	M.		PUP	MLA	11.001		
SUBMERG	ENT	AQUAT	TC VE	G MO	STLY	ouu	KS W/IN	3	FUEL	<u>e A1</u>	211							

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Photos:												. i		•				
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Version #4	100 mm 200 mm							Seni	or staff	sign-off ((if requ	ired):		Checke	d by:	CM (Completed	by: KS

Version #4 Last edited: 04/04/2023

GEO

Rapid Geomorphic Assessment

Project Number: 23111

Date:	0%-	11-2023	Stream:	BR	EAR BA	200K	TRIB	
Time:	12:	IS DM	Reach:	BI	BT-3			_
Weather:	n'C	SUDIN	Location:	774	UNDER	RON	D	
Field Staff	Ke	SWINN T	Watershed/Subwat	ershed: Br	EAR BR	SCOK		
	110		Coomorphological Indicator			Pres	ent?	Factor
Process	Nie	Description	Geomorphological Indicator			Yes	No	Value
411	1	Lebate bar					~	
	1	Lobate bai	riffler ombedded					
	2	Coarse materials in i	Times embedded			-		21
Evidence of	3	Siltation in pools					1	1 The
Aggradation (AI)	4	Mediai bars	2.42					
(/)	5	Accretion on point b	dis				-	
	6	Poor longitudinal sor						
	7	Deposition in the over	erbank zone	Sum o	f indices =	2	-	0.285
[1		· · / · >				NIA	
	1	Exposed bridge foot	ing(s)			-	NIA	
	2	Exposed sanitary / s	storm sewer / pipeline / etc.				NIA	
	3	Elevated storm sewe	er outrall(s)	~			NILA	
Evidence of	4	Undermined gabion	baskets / concrete aprons / et	outlots		<u> </u>	NIA	0.
Degradation	5	Scour pools downsti	ream of culverts / storm sewer	outiets			14/11	15
(DI)	6	Cut face on bar forn	ns					and
	7	Head cutting due to	knickpoint migration					
	8	Terrace cut through	older bar material				1	
	9	Suspended armour	layer visible in bank					
	10	Channel worn into u	indisturbed overburden / beard	Sum c	f indices =	0	5	0
	1	E-llas (leaning trop	ac / fonco nosts / etc		1		1	
	1	Fallen / leaning tree						4
	2	Occurrence of large	organic debris				1	
	3	Exposed tree roots	le meander bonds					
Evidence of	4	Basal scour on insid	ie meander bends				1	1
Widening	5	Basal scour on both	sides of channel through time				NIA	0/-
(WI)	6	Outflanked gabion i	baskets / concrete waits / etc.					1 '+
	1	Length of basal sco	ar >30% through subject reac	etc			NIA	1
	8	Exposed length of p	stop of bank				1	
	9	Fracture lines along					NA	1
	10	Exposed building to		Sum	of indices =	0	7	6
	<u> </u>		(a)					T
		Formation of chute	(5)					-
Evidence of	2	Single thread chan	file forms to low had relief form					-
Planimetric	3	Evolution of pool-ri	file form to low bed relier form					11
Form Adjustment	4	Cut-off channel(s)	1(0)					17
(PI)	5	Formation of Island	i(s)	m			1	
	6	I naiweg alignment	out of phase with meanuer for					-
	7	Bar forms poorly fo	Jimeu / reworkeu / removeu	Sum	of indices =	1	17	0,142
]	Stability Index	(ST) = (AT	+DI+W	I+PI)/4 :	- 0.107
Notes:				The Bogimo	In Tranci	tion /St	ress In	Adjustmer
						21 - 0 /		0.41
				PA 0.00 - 0.20	L 0.4	L - U.4	<u> </u>	

Senior staff sign-off (if required): _____ Checked by: $\underline{\mathsf{KM}}$ Completed by: $\underline{\mathsf{KS}}$

Rapid Stream Assessment Technique Project Number: 23111

Date:	08-11-2023	Stream:		BEAR BROK	OK TRIB			
lime:	12:15 PM	Reach:		BBT-3				
Weather:	O'C SUNNY	Location:	ected in a	THUNDER 1	ROAD			
Field Staff:	KS KM	Watershed/Subwater	shed:	BEAR BROOK				
Category	Poor	Fair	ere slos	Good	Excellent			
	 < 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% stable Infreque sloughir failure 	o of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer b m aboventiation 1.5 m a for largentiation Bank on 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) verhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 			
Stability	 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 predom large, s scarce 2-3 rec per stree 	d tree roots inantly old and maller young roots ent large tree falls eam 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 general plant/se	1/3 of bank is Ily highly resistant oil 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 	 Channe genera 	el cross-section is lly V- or U-shaped	 Channel cross-section is generally V- or U-shaped 			
Point range		030405		5 0 7 8	09010011			
an a	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% ei mainste	6 embedded (35- mbedded for large em areas)	 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 			
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	Modera pools Pool su 30-59%	ate number of deep Ibstrate composition % sand-silt	 High number of deep pools 61 cm deep) 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits 		nbed streak marks "banana"-shaped ent deposits mon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 				
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, uncom Small I fresh s top of 	large sand deposits mon in channel localized areas of and deposits along low banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 			
0) . 	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point b well-ve armou fresh s 	pars small and stable, egetated and/or red with little or no sand	Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand			
Deinterange		0304		D 5 0 6				

Senior staff sign-off (if required): _____ Checked by: __KS__ Completed by: __KS__

GFO

Date: 0	8-11-2023	PN: 23111		Location: THUNDER ROAD		
Category	Poor	Fair		Good	Excellent	Ī
	Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)		0- nnel large bottom (66-90%) mainstem	rimeter 61-85% channel width for large areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, run and pools dominant, velocity and depth diversity intermedia 	riffles • Good mix runs and p • Relatively and depth runs • (between riffles, bools diverse velocity of flow	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 		Riffle subs composition gravel, col material • 25-49% co	trate on: good mix of oble, and rubble obble	Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble	
Tablat	 Riffle depth < 10 cm for large mainstem areas 	Riffle depth 10-15 ci large mainstem area	m for • Riffle dept large main	h 15-20 cm for stem areas	 Riffle depth > 20 cm for large mainstem areas 	NIA
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generall 46 cm deep (61-91 of for large mainstem areas) with little or r overhead cover/stru 	y 30- • Large pool cm cm deep (9 large main no some over cture cover/strue	s generally 46-61 91-122 cm for stem areas) with head cture	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	
	 Extensive channel alteration and/or point bar formation/enlargement 	 Moderate amount of channel alteration ar moderate increase ir point bar formation/enlargement 	 Slight amo alteration a increase in formation/ 	unt of channel and/or slight point bar enlargement	 No channel alteration or significant point bar formation/enlargement 	
	• Riffle/Pool ratio 0.49.1 ; ≥1.51+1	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ; 1.11-1.3:	ratio 0.7-0.89:1 1	• Riffle/Pool ratio 0.9-1.1:1	
	 Summer afternoon water temperature > 27°C 	 Summer afternoon w temperature 24-27°C 	vater • Summer af temperatur	ternoon water e 20-24°C	 Summer afternoon water temperature < 20°C 	NIA
Point range		0304	X:	5 🗆 6	0708	
	 Substrate fouling level: High (> 50%) 	 Substrate fouling lev Moderate (21-50%) 	el: • Substrate f Very light (ouling level: 11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Quality	Brown colour TDS: > 150 mg/L	Grey colourTDS: 101-150 mg/L	Slightly gre TDS: 50-10	ey colour 00 mg/L	Clear flow TDS: < 50 mg/L	
, , , , , , , , , , , , , , , , , , ,	Objects visible to depth < 0.15m below surface	 Objects visible to dep 0.15-0.5m below sur 	oth • Objects visi face 0.5-1.0m b	ible to depth elow surface	 Objects visible to depth > 1.0m below surface 	
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	 Slight organ 	nic odour	No odour	
Point range	0 0 1 0 2			6	0708	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly woode but with major localiz gaps 	• Forested bu > 31 m wid portion of b	iffer generally e along major oth banks	• Wide (> 60 m) mature forested buffer along both banks HEKBACEOUS MERDOW	1
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50 60% shading (30-44% for large mainstem areas) 	• Canopy cov % 60-79% sha for large ma	erage: ading (45-59% ainstem areas)	Canopy coverage: >80% shading (> 60% for large mainstem areas)	-
Point range			□ 4	□ 5	607	
Total overall so	core (0-42) = 3	Poor (<13)	Fair (13-24)	Good (25-3	(>35) Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: _KM_ Completed by: _KS___

General Site Characteristics Project Number: 2311 Date: 2023-11-08 Stream: BEHAR BROOK TRIB Time: 1:150m **Reach:** BBT-U Weather: SUNNU 000 Location: THUNDER ROAD **Field Staff:** MY Watershed/Subwatershed: BEAR BROOK Features Monitoring Site Sketch ENDOF BBF-4 Compass WW', 1.2 BANE WD:055 HEIGT: aleo -Reach break -0-0-0- Long-profile underat both Banks 못 Station location Monumented XS 1 KHEIGH: 0.65M Cross-section X Monumented photo 0 continus Flow direction ED BALLACUT Monumented photo INEILING POINT VTVP Riffle direction (0.05) UN DOWNCUT Pool 11 Sediment sampling BANKHEIGHO.60m) CONTRO O Sediment bar Erosion pins WP5- CREATING PIETE underect ННННН Eroded bank/slope 8 Scour chains 10.15m ----Undercut bank **Additional Symbols** JEG BELOMES XXXXXX Bank stabilization DENSE AGAIN Leaning tree WIDE FLOORPLAIN X----X Fence SCONF MINOR BANKWIDTH: 0,200m 1 Culvert/outfall SCOUPING Swamp/wetland BED: U.USM underato 14m 52M VVV Grasses D:0,14m 3 Tree Instream log/tree HANNEL BECOMES DE FINED * * * Woody debris OPIC BEAVERDAN -XXXXXX Beaver dam MMM VV Vegetated island **Flow Type** OFETE FUODY H1 Standing water H1A Back water H2 Scarcely perceptible flow FORFSIED Smooth surface flow H3 H4 Upwelling PAISHUN H5 0 Rippled Unbroken standing wave H6 H7 Broken standing wave 9 W0:0.25m **H8** Chute WW;0.90m H9 Free fall H9A Dissipates below free fall 3010 Substrate **S1** Silt Small boulder 56 EFFAILE I OWADA **S2** Sand **S7** Large boulder 00 \$3 Gravel 58 Bimodal 54 orb Small cobble **S9** Bedrock/till 00 **S**5 Large cobble Other MULTIPLEFLOWPA BM Benchmark EP Erosion pin BS Backsight RB Rebar INTERSTITIAL FLOW DS Downstream US Upstream WDJ Woody debris jam TR Terrace BEAVER VWC Valley wall contact FC Flood chute NAG BOS Bottom of slope FP Flood plain Photos: TOS Top of slope KP Knick point Notes: HOTE PLOWPATHY IN DRAWING NOT EXACT : 2,92(Im) - SANDISILT ON CHANNELBED 0.10+0120m -SCOURS/UNDERWITING MORE DEFCENT DC

Senior staff sign-off (if required): _____ Checked by: _K Completed by:

Page _ of _ I

Reach Characte	ristics Project N	umber: 23111			T		MORPHIA	
Date:	08-11-2023	Field Staff:	KS KM Watershed/Subwat			rshed: BEAR E	3rock	
Time:	1:00 PM	Stream:	BEAR BROOK TRIB UTM (Upstream):				an a	
Weather:	O'C SUNNY	Reach:	BBT-4	BBT - A UTM (Downstream)			ander men der eine eine eine der eine der eine der eine der eine der	
Land Use Valley Type Channel Type Channel Type (Table 1) (Table 2) (Table 3) 12			annel Zone able 4)	Flow Type (Table 5)	oundwater Location:	Photo:		
Riparian Vegetati	on		Aquatic & In	stream Vegetati	Water Quality	Water Quality		
Dominant Type (Table 6)	Coverage Channel V	Widths Age (yrs) 4 □ Immature (<5)	Type (Table 8)	Woody Debris	WD Density Low WDJ/50m:	Odour (Table 16)	Turbidity (Table 17)	
Encroachment (Table 7)	$\begin{array}{c} \square \ \text{Fragmented} & \square 4 - \\ \blacksquare & \square \\ \blacksquare & \square \\ \end{array}$	10 Image: Second state Image: Second state <th imag<="" td=""><td>Reach C Coverage %</td><td>In Channel</td><td>Mod High</td><td></td><td>2</td></th>	<td>Reach C Coverage %</td> <td>In Channel</td> <td>Mod High</td> <td></td> <td>2</td>	Reach C Coverage %	In Channel	Mod High		2
Channel Characte	eristics							
Sinuosity Type (Table 9)	2 Sinuosity Degree (Table 10)	2 Bank Angle □ 0 - 30	Bank Erosion □ < 5%	(Table 19) Bank	Clay/Silt Sand Gra	vel Cobble Bould	er Parent Rootlets	
Gradient (Table 11)	# of Channels (Table 12)	2 ¹ 30 − 60 □ 60 − 90	⊠ 5 – 30% □ 30 – 60%	Riffle Pool				
Entrenchment (Table 13)	Bank Failure (Table 14)		□ 60 - 100%	Bed (if no riffle-pool morphology)				
Down's Model (Table 15)	A Bankfull Indicators (Table 18)	5	Bank fall Width (m)	0.6	Wetted W	idth (m) 0.90	0.52 1.20	
Sed Sorting (Table 20)	Sediment Transport Observed?	🗆 Yes 🔍 No 🗆 Not Visible	Bankf uil Depth (m)	0.4		epth (m) 0,25	0.14 0.55	
Transport Mode (Table 21)	MA % of Bed Active	0	Undercuts (m)	0.12 0.15	0.05 Veloci	ty (m/s)	0.342	
Geomorphic Units (Table 22) 5	, 5 Mass Movement (Table 23)	NIA % RUNS 60	Pool Depth (m)		Velocity	Estimate Method	WB	
Riffle-Pool Spacing (m):	//A % Riffles:	<u> </u>	Riffle Length (m)		Meander A	mplitude (m)		
Notes: BBT-4	BEGINS IMMED	IATELY DIS OF HIS	STORIC BEA	VER DAM T	A SECTION O	F UNDEFINE	D FLOW PATH.	
DIS OF THIS	THE CHANNEL	MEANDERS IRREG	ULARLY TH	ROUGH A V	NIDE FLOODPLAIN	W HERBACED	ous + SEMI-	
AQUATIC)	EG BORDERED	34 FOREST LIKE	BBT-3.7	THE CHANN	EL IS HEAVILY	OKSCURED	BY VEG	
ENCROACH	MENT, MAKING	DIMENSION MEA	GUREMEN	TS DIFFICK	READER ADDEAD	EN SIGHTIY	STERDED TUAN	
DUE TO T	THE LANGE WID	TH (LIKELY 7 30	M). GRADIE	DANUINATERS	D DIE TO CHA	NNEL CONST	RICTIONS	
UND REACH	ED. DOME SECT	IONS OF THE R	ATVIL TIME	DIVEWALCES			P. Serve No. 1. L. Sort I. Stef Sand &	
				1				
Photos:								

Version #4 Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: __KS___

GEO

GEO MORPHIX*

Rapid Geomorphic Assessment

Project Number: 2311

Date:	08-	11-2023	Stream:		BEAR BR	200K	TRIB						
Time:	1:00	> PM	Reach:		BBT-A		2						
Weather:	0.0	SUNNY	Location:		THUNDER	HUNDER ROAD							
Field Staff:	KS	KS KM Watershed/Subwatershed: BEAR BROOK											
			Geomorphological Indicator			Pres	sent?	Factor					
Process	No.	No. Description					No	Value					
· · · · · · · · · · · · · · · · · · ·	1	Lobate bar					1						
	2	Coarse materials in	riffles embedded				>						
Evidence of	3	Siltation in pools				1		.					
Aggradation	4	Medial bars				-	/	6/7					
(AI)	5	Accretion on point b	oars				/						
	6	Poor longitudinal so	rting of bed materials				1						
	7	Deposition in the ov	1										
				Su	m of indices =	2	5	0.285					
	1	Exposed bridge foot	ing(s)				NIA						
	2	Exposed sanitary /	storm sewer / pipeline / etc.				NIA]					
	3	Elevated storm sew	er outfall(s)				NIA						
	4	Undermined gabion	baskets / concrete aprons / et	c.			NIA]					
Evidence of	5	Scour pools downst	ream of culverts / storm sewer	r outlets			NIA	A					
Degradation	6	Cut face on bar form	ns				-	~/~					
	7	Head cutting due to	knickpoint migration										
	8	Terrace cut through older bar material											
	9												
	10	Channel worn into u	undisturbed overburden / bedr	ock			1						
				Su	m of indices =	0	6	0					
	1	Fallen / leaning tree	es / fence posts / etc.	-			-	_					
	2	Occurrence of large		1									
	3	Exposed tree roots					Summer of						
	4	Basal scour on insid		1									
Evidence of	5	Basal scour on both sides of channel through riffle						1,					
(WI)	6	Outflanked gabion baskets / concrete walls / etc.					NIA	17					
	7	Length of basal scour >50% through subject reach					>	4					
	8	Exposed length of previously buried pipe / cable / etc.					NIA						
	9	Fracture lines along top of bank						4					
	10	Exposed building for		NIA									
		And the second		Su	m of indices =	1	6	0,142					
	1	Formation of chute	(s)				~						
	2	Single thread channel to multiple channel						2					
Evidence of Planimetric	3	Evolution of pool-riffle form to low bed relief form					~						
Form	4	Cut-off channel(s)						177					
Adjustment	5	Formation of island(s)						_					
(P1)	6	Thalweg alignment out of phase with meander form						_					
	7	Bar forms poorly formed / reworked / removed											
				Su	m of indices =	3	4	0.428					
Notes:				Stability Ind	ex (SI) = (AI	+DI+W	I+PI)/4 :	01214					
				In Regime	In Transi	tion/Sti	ress In	Adjustment					
				0.00 - 0.2	20 🖾 0.2	21 - 0.40	0	0.41					

Senior staff sign-off (if required): _____ Checked by: _KM_ Completed by: _KS___

Rapid Stream Assessment Technique Project Number: 2311

Date:	08-11-2023	Stream:		BEAR BROOK TRIB		
lime:	1:45 PM Reach:			BBT-4		
Weather:	O'SUNNY Location:			THUNDER ROAD		
Field Staff:	KS KM	Watershed/Subwater	rshed: BEAR BROO)K	
Category	Poor	Poor Fair Good		Good	Excellent	
ting, Brind, Johnson Gao (E. y. 2004) Attornet, Als	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 50-70% of bank network stable 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 71-80% of bank network stable 71-80% of bank network stable Infrequent signs of bank sloughing, slumping or failure 		of bank network ent signs of bank ig, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 		
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream bend areas stable Outer bank height 0.6-0.9 m above stream bank (1.2- 1.5 m above stream bank for large mainstem areas) Bank overhang 0.6-0.8 m 		 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 	
Stability	 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 Scarce 2-3 recent		I tree roots inantly old and maller young roots ent large tree falls am 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		030405			□ 9 □ 10 □ 11	
8 8 1992 - 1993 - 1993 1993 - 1993 - 1994 1993 - 1994 - 1994	> 75% embedded (> 85% embedded for large mainstem areas)	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% embedded (35- 59% embedded for large mainstem areas)		 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 	
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	rate number s• Moderate number of deep pools•se• Pool substrate composition 30-59% sand-silt•d-silt• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon•sand omon in ed areas of eposits along inks• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks•ommon, large and n high esh sand• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand•		 High number of deep pools 61 cm deep) 122 cm deep for large mainstem areas) Pool-substrate composition <30% sand-silt 	
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Streambed streak marks and/or "banana"-shaped sediment deposits common 			 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 			 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 	
5 2 8 800 (23.27)	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 			 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 	
Point range			1	5 0 6	2708	

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Date: 09	-11-2023	PN: 23111	Location:	THUNDER READ	
Category	Poor	Fair	Good	Excellent	Ì
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	Wetted perimeter 40- 60% of bottom channe width (45-65% for larg mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas) 	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riff and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and san 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 	NIA
Habitat	 Riffle depth < 10 cm for large mainstem areas 	Riffle depth 10-15 cm large mainstem areas	for • Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas	NIA
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 3 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structu 	 80- Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure 	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	h
	 Extensive channel alteration and/or point bar formation/enlargement 	 Moderate amount of channel alteration and/ moderate increase in point bar formation/enlargement 	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	No channel alteration or significant point bar formation/enlargement	
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1	
	Summer afternoon water temperature > 27°C	 Summer afternoon wat temperature 24-27°C 	• Summer afternoon water temperature 20-24°C	 Summer afternoon water temperature < 20°C 	NIA
Point range		□ 3 □ 4	05 6	0708	
	 Substrate fouling level: High (> 50%) 	 Substrate fouling level: Moderate (21-50%) 	Substrate fouling level Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	Slightly grey colour TDS: 50-100 mg/L	 Clear flow TDS: < 50 mg/L 	
()	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surface 	Objects visible to depth 0.5-1.0m below surface	Objects visible to depth > 1.0m below surface	
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	• No odour	
Point range			D 5 2 6	0708	
Riparian Habitat Conditions	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	Forested buffer generally > 31 m wide along major portion of both banks	Wide (> 60 m) mature forested buffer along both banks HERPACEOUS MEADOW	
	 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	001		0405	6 0 7	
Total overall s	core (0-42) = 31	Poor (<13)	Fair (13-24) Good (25-3	34) Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____KS___

Page 2 of 2

General Site Characteristics Project Number: 23/11

Date:		20	23-11-02		Stream:	Viell	RENG Range 1000	
Time: 2:00:000			Peach		RET-F			
Weather:					p61-5			
Field Staffi		Location:		1	THUNDER ROAD			
KS KM			Watersh	ed/Subwatershed:	BEARBROOK			
Features Monitoring		Site	Sketch	that poor i	Compass			
	Reach break	-0-0-0-	Long-profile	pune	17	W (10.25m)		
<u> </u>	Station location		Monumented XS		\wedge	MILOS V	NEG ()	
~~~~	Cross-section	0	Monumented photo	1.00	CER	W/ W BRE	ENCRONCH	
	Flow direction		Monumented photo	Etto	out 1	TOTE	S A	
	Riffle		direction	1 Yu		INN - SIFC		
atten	POOI Sodimont hav		Sediment sampling			1 OV NXVX	BANKHEIGHT: O.SOM	
	Sediment bar	Q	Erosion pins	-		ANGUNA	BFW: II7M	
	Undercut bank		Scour chains		/	WYYYY	WW: J.OSM	
XXXXXX	Bank stabilization	Auditio	onal Symbols	All coloris	and -	XTT-	PFINESICI WD.0117m	
	Leaning tree			BACEWA	fitt-	V Viex Fore	IV A SIMPLEBOLES	
XX	Fence			2011	6	W /silk ve	:0.00	
	Culvert/outfall			CA.		TATON.	· · · · · · · · · · · · · · · · · · ·	
	Swamp/wetland			0 46	SCOUL	the way	· .	
VVV	Grasses			(H)		V WH WW		
C	Tree			2		V V KAN	A DEC ADENCLUD	
	Instream log/tree			SK .		W WHERE W	NEW	
***	Woody debris			T L		Ville Ve	BANK 9 IN HEFORICOUS	
***	Beaver dam					XXUX	EENCE DETUNE	
V	Vegetated island			L		1 THE	CULCO POINTIN	
Flow T	уре						× /	
H1 Standing water H1A Back water						10 -W		
H2	Scarcely perceptible	flow				A CON CO	10	
НЗ	Smooth surface flow					all ave	(0.05-0.10 (M)	
H4	H4 Upwelling					P17 2 P06	1 10,20cm Deep	
H5	Rippled					3' W WENT	REES GROWING HURDSSCHANNEL	
H6	Unbroken standing w	ave			~	1 and a	20	
H/	Broken standing way	e			0	J JOY DJ		
ПО	Erec fall	Disela		·		in XX ai	ound J' HOOKEN	
Substr	rice idii <b>ny</b>	I Dissip	bates below free fall	UNDE	spaut	XX	TREE	
S1	Silt	56	Small bouldor	a 0,201	11	L. h/ov+		
S2	Sand	57	Large boulder	H POOL DE	CIM .	12 A - main in C	HANNEL	
S3	Gravel	58	Bimodal	N N		DEBERS IN	Ω	
<b>S</b> 4	Small cobble	S9	Bedrock/till	206	5	Ciq al Mar		
<b>S</b> 5	Large cobble			4 R	2 12		A DATION DE P (VADI)	
Other				X	RA	2916018	PENNI HAM	
вм	Benchmark	EP	Erosion pin		11	WWW.	BFH 0.80-100m	
BS	Backsight	RB	Rebar			K KHAK	WW:1120M	
DS	Downstream	US	Upstream			N SIX	wp:oilem	
WDJ	Woody debris jam	TR	Terrace	2		Wal Sorth		
VWC	Valley wall contact	FC	Flood chute			W11 266 2	Exception Exception	
BOS	Bottom of slope	FP	Flood plain	Photo	5:	<u> </u>		
TOS	Top of slope	КР	Knick point	Notes	-MORF	STONES /UP ALANIA	MEANDER	
TRANSITIONS INTO REFINED CHANNEL - BEGIN					ANDING	h contra	LIDE DOOD BINLOF	
-7 (HA	- CHANNEL RED. COMPERCIET / TIME CAND -> STILL WIDE FLUODPLATIN/BE							
Vilb	(1m) N 1 3.201	Im )	THE SHIND -7 M	inney .	KVIYI +	FUULS		
Varcia	2 +1 12, 11051		Sopior staff size	off (if an a	ined).	V		
last er	1#4 1ited: 21/02/2023		Senior starr sign-	on (ir requ	irea):	Checked by:	Completed by: <u>KM</u>	

Page  $_$  of 2

#### **General Site Characteristics**

### Project Number: 33111

Date: 2023-11-08 Stream: BEAR BROOK TRIB Time: 2:00pm **Reach:** (LONT) 5 nor Weather: UNNV Location: HINDER ROHD ( M **Field Staff:** KC Watershed/Subwatershed: 2 R 200K Features Monitoring Site Sketch Compass -0-0-0- Long-profile Reach break 只 Station location Monumented XS Cross-section O Monumented photo Flow direction Monumented photo BBT-6 SEE ~~ Riffle direction RIPARIAN Pool P Sediment sampling NEX ZONE CONSISTS CONTRO O Sediment bar Erosion pins of Gransses CHEE 8 HHHHHH Eroded bank/slope Scour chains HEPBIACEOUS END OF BBF-C ----Undercut bank Additional Symbols hno hhpo X XXXXXX Bank stabilization WOODS Leaning tree - WDJ - DOWN TREES IN NEGETATE SLUMID x----x---x Fence CHANNEL Culvert/outfall WDSt HOOKED Swamp/wetland Grasses VVV 115.025 03 Tree BED Instream log/tree ve' COHESINE * * * Woody debris Sm SILTY - ANY NORT 50 FINET Beaver dam 1.05m COMESE VV Vegetated island 0.23m SAND NO * Flow Type DEBRIS H1 Standing water H1A Back water MAH) MI SLUMP XDOWN TREE SLIMIERED H2 Scarcely perceptible flow H3 Smooth surface flow THROUGHER S Upwelling H4 DEPOSITION P H5 Rippled 9 B H6 Unbroken standing wave H7 Broken standing wave DEBRIS P H8 Chute IN CHANNEL 2 FLOW PATHS THROWING 2 Free fall H9 H9A Dissipates below free fall WOODT THALWEG DUT Substrate 0 OFLINE/CHUSING **S6** Small boulder **S1** Silt Q' VC S(FLOOD PININ)  $\mathfrak{I}$ 8C039 SCOL **S2** Sand **S7** Large boulder () **S**3 Gravel **S8** Bimodal **S**4 Small cobble **S9** Bedrock/till RIFFLE FROM  $(\mathbf{p})$ **S**5 Large cobble 51/52 Other BANKS BELOME POINT BM Benchmark Erosion pin EP NEEFINED P BS Backsight RB Rebar Upstream DS Downstream US WDJ Terrace 2 Woody debris jam TR TREES ACCROSS BBT VWC Valley wall contact FC Flood chute LONT CHANNEL BOS Bottom of slope FP Flood plain Photos: Notes: - INCREASE IN SCOURS (CONSENTRATED P/S), BASAC TOS Top of slope KP Knick point CHANNEL CREATING UNDEPCUTS. STILL SCOUR PRESENT ROTH BHNKS 680 OEBBIR IN SOME TORTUOUS MEANDERS WOOLS / QUNK FEW RIFFLES Not111

Senior staff sign-off (if required): _____ Checked by: KS____ Completed by: KM

Page 2 of 2
																			GE	0
Reach Chara	cteris	tics P	Project I	Number	: 23111	f													MORP	• H I X™
Date:		08-11-	2023		Field Staff:		KS KM				Wate	ershe	d/Subv	vatersh	ed: B	FAR	BRO	OK		
Time:		1:30 P	°M		Stream:		BEAR	BRCO	K TRIB	3	UTM	(Ups	tream)	:						
Weather:		o'c SI	YNNY		Reach:		BBT - 5	5			UTM	(Dov	vnstrea	m):					*****	
(Table 1)	7 (1	alley Type Fable 2)	1	Channel (Table 3)	I Type 7	Chan (Table	n <b>el Zone</b> e 4)	l	Flow Ty (Table 5)	pe	1	□ E [,]	vidence	of Ground	water L	ocation			hoto:	-
<b>Riparian Vege</b>	tation						Aquatic 8	k Instr	eam Vege	tatio	n			N	/ater Q	uality				
<b>Dominant Type</b> (Table 6)	1,4	Coverage	Channe	l Widths - 4	Age (yrs)		Type (Table 8)	[]	Woody Deb	oris ank	WD Der	nsity	WDJ/50n	<u>n:</u>	Od (Tabl	<b>our</b> e 16)		<b>T</b> u (T)	able 17)	
Encroachment (Table 7)	3	□ Fragment	.ed ⊠(4 us ⊠(>	- 10 10	I Mature (>30) ■	0)	Reach Coverage %	20	In Chan	nel sent	⊠, Mod ⊠, High		2		1			L	2	
<b>Channel Chara</b>	acteris	tics												L						
Sinuosity Type (Table 9)	2	Sinuos	ity Degree (Table 10	2	Bank Angle □ 0 - 30	B	Bank Erosion □ < 5%		(Table 19 Ban	9) nk	Clay/S	lit	Sand	Gravel	Cobble	Boul	ider Pa	arent	Rootle	ets
Gradient (Table 11)	2	# of	f Channels (Table 12	s	🖾 30 - 60 🖾 60 - 90		∃ 5 – 30% ∎30 – 60%		Riff	le ol							]			
Entrenchment (Table 13)	l	Ba	nk Failure (Table 14	2	🔍 Undercut		∃ 60 <b>-</b> 100%		Be (if no riffle-po morpholog		8			8		C	]			
Down's Model (Table 15)	m	Bankfull I	Indicators (Table 18)	1,3		1	Bankfull Wid (1	lth m)   ,=	T Noisn	7	NSION	.15	Wette	ed Width	(m) ),	2	1.01	5	1.05	
Sed Sorting (Table 20)	PS	Sediment C	Transport )bserved?	🗆 🗆 Yes	🔊 No 🗆 Not Visib	le	Bankfull Dep (1	m)	BANH	5	DIME	».5	Wette	ed Depth	(m) (),	16	0.17	7	0.23	
Transport Mode (Table 21)	NIA	% of E	Bed Active	0			Undercuts (r	<b>n)</b> 017	20 0.	06	0	113	Ve	elocity (n	n/s) 0,(	095	0.25	9	6.199	
Geomorphic Units (Table 22)	5,6,8	Mass N	(Table 23)	NIA	% RUNS 60	5	Pool Dep (r	n) ບາລ	20 0	120	0	125	Velo	ocity Estin Mei	nate thod W	IB	WE	3	WB	
Riffle-Pool Spacing (m):	20		% Riffles:	15	% Pools: 2	S Rif	fle Length (r	m) 5					Meand	er Amplit	ude (m)	-				
Notes: BBT-	5 BI	EGINS	AT TH	KANSI'	TION FROM	1 B	GROAD H	ERE	ACEOU	SN	AEAD	NOC	) TO	FORE	STEI	SR	PARI	AN	ARFA	
FLOODPLAN	U NA	RROWS	SLIGI	ATLY	AND CHAR	INE	L MEAN	JDER	S GON	NEU	OHAT	TRE	EGUL	ARLY	FOR	SH	ORT	STE	ETCH	ES
BETWEE	N ST	RAIGHT	AND	IRREE	ULAR SE	CTIC	ons, Hi	GHD	ENSIT	4_	OF	WC	YOON	AND	ORG	ANIC	DEF	BRUS	3 WAS	5
OF J-HO	DK Y	REEC I	IMMAT	TIPE	TO ECTAR	ADE	W LAH	ACE	LIN	50	ME	SEC	STION	S. VE	RY	FRES	RUEN	TG	CCURE	INCE
-OUT REF	ictt.	PEACH-	COLOU	RED	CLAY OBS	V A	LONG F	ZASE	OF I	FOI	MILLA	G 1	BAAN	BADA	LSC	DUK	OBS	SV T	HROUG	an
						х.,м/ \.				Sand Sand	UNE	9	C27414	10 IL		HN	7 10(	ATT	UNS.	
										4										
Photos:								7												
						·····														

Version #4 Last edited: 04/04/2023 Senior staff sign-off (if required): _____ Checked by: _KS___

# GEO MORPHIX*

# **Rapid Geomorphic Assessment**

# Project Number: 23111

Date:	08.	-11-2023	Stream:		BEAR BR	DOK 7	RIB	n an di minali paparat di manangin
Time:	1:3	BO PM	Reach:		BBT-5			
Weather:	0.0	SUNNY	Location:		THUNDE	RRO	AD	
Field Staff:	KS	KM	Watershed/Subv	vatershed:	BEAR RI	RUUK		
			Geomorphological Indicate	)r	001111 01	Dro	cont2	
Process	No.	Description	Cecimor photogical maleate			Vec	No	Factor Value
	1	Lobate bar		****		165		
	2	Coarse materials in r	iffles embedded					
Evidence of	3	Siltation in pools			· • ••••••••••••••••••••••••••••••••••	~		
Aggradation	4	Medial bars				~		- 5/2
(AI)	5	Accretion on point ba	ars	****		~		T
	6	Poor longitudinal sor	ting of bed materials		·····			
	7	Deposition in the over	erbank zone					
				um of indices =	3	4	0:428	
	1	Exposed bridge footi	na(s)				L NILA	100
	2	Exposed sanitary / st	form sewer / nineline / etc				MA	
	3	Elevated storm sewe	r outfall(s)	****			NIM	
	4	Undermined gabion t	paskets / concrete aprons /	etc.			NIA	
Evidence of	5	Scour pools downstre	eam of culverts / storm sew	er outlets			NIA	
Degradation (DI)	6	Cut face on bar form	S				1514	- 1/-
()	7	Head cutting due to I	knickpoint migration				-	- 5
	8	Terrace cut through a	older bar material					
	9	Suspended armour la	ayer visible in bank					
	10	Channel worn into ur	ndisturbed overburden / bec	lrock		1		
				Su	m of indices =	1	4	0.20
	1	Fallen / leaning trees	/ fence posts / etc.			/		
	2	Occurrence of large of	organic debris			-		
x	3	Exposed tree roots				~		
	4	Basal scour on inside	meander bends			~	1	
Evidence of Widening	5	Basal scour on both s	sides of channel through riff	le		~		5,
(WI)	6	Outflanked gabion ba	skets / concrete walls / etc				NIA	7 7
	7	Length of basal scour	>50% through subject rea	ch		1		
	8	Exposed length of pre	eviously buried pipe / cable	/ etc.			NIA	
	9	Fracture lines along t	op of bank					
	10	Exposed building four	ndation				NIA	1
				Su	m of indices =	5	2	0.714
	1	Formation of chute(s	)				1	
Evidence of	2	Single thread channe	l to multiple channel				1	
Planimetric	3	Evolution of pool-riffle	e form to low bed relief form	n			1	
Form	4	Cut-off channel(s)					1	-)/-
Adjustment (PI)	5	Formation of island(s	)				1	T
()	6	Thalweg alignment or	ut of phase with meander fo	orm		1		
	7	Bar forms poorly forn	ned / reworked / removed				/	
				Su	m of indices =	١	6	0.142
Notes:				Stability Inde	ex (SI) = (AI+	-DI+WI	+PI)/4	= 0.297
				In Regime	In Transit	ion/Stre	ess Ir	Adjustment
				0.00 - 0.2	0 🖾 0.2	1 - 0.40		0.41

Senior staff sign-off (if required): _____ Checked by:  $\underline{\mathcal{K}}$  Completed by:  $\underline{\mathcal{K}}$ 

# Rapid Stream Assessment Technique Project Number: 2311

Date:	08-11-2023	Stream:		BEAR BROOK TRIB					
Time:	1:30	Reach:		BBT 5	Lond				
Weather:	O'C SUNNY	Location:		THUNDER	RAAD				
Field Staff:	KS KM	Watershed/Subwate	rshed:	BEAR BRO	>0K				
Category	Poor	Fair		Good	Excellent				
n Barne (n. 1999). 1860 - J. J. Statu 1979 - Barne	<ul> <li>&lt; 50% of bank network stable</li> <li>Recent bank sloughing, slumping or failure frequently observed</li> </ul>	<ul> <li>50-70% of bank network stable</li> <li>Recent signs of bank sloughing, slumping or failure fairly common</li> </ul>	<ul> <li>71-80%</li> <li>stable</li> <li>Infreque sloughin failure</li> </ul>	of bank network ent signs of bank ig, slumping or	<ul> <li>&gt; 80% of bank network stable</li> <li>No evidence of bank sloughing, slumping or failure</li> </ul>				
Channel	<ul> <li>Stream bend areas highly unstable</li> <li>Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang &gt; 0.8-1.0 m</li> </ul>	Stream bend areas unstable • Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	<ul> <li>Stream</li> <li>Outer bandle</li> <li>m above</li> <li>1.5 m all for large</li> <li>Bank ov</li> </ul>	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) erhang 0.6-0.8 m	<ul> <li>Stream bend areas very stable</li> <li>Height &lt; 0.6 m above stream (&lt; 1.2 m above stream bank for large mainstem areas)</li> <li>Bank overhang &lt; 0.6 m</li> </ul>				
Stability	<ul> <li>Young exposed tree roots abundant</li> <li>&gt; 6 recent large tree falls per stream mile</li> </ul>	Young exposed tree roots common     4-5 recent large tree fails per stream mile	<ul> <li>Exposed predomi large, sr scarce</li> <li>2-3 rece per streat</li> </ul>	l tree roots nantly old and naller young roots ent large tree falls am mile	<ul> <li>Exposed tree roots old, large and woody</li> <li>Generally 0-1 recent large tree falls per stream mile</li> </ul>				
	<ul> <li>Bottom 1/3 of bank is highly erodible material</li> <li>Plant/soil matrix severely compromised</li> </ul>	<ul> <li>Bottom 1/3 of bank is generally highly erodible material</li> <li>Plant/soil matrix compromised</li> </ul>	• Bottom generall plant/so	1/3 of bank is y highly resistant il matrix or material	<ul> <li>Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material</li> </ul>				
	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	Channel     generall	cross-section is) y V- or U-shaped	<ul> <li>Channel cross-section is generally V- or U-shaped</li> </ul>				
Point range		030405	Å 6	0708	□ 9 □ 10 □ 11				
3 8 10 10 10 10 10 10 10 10 10 10	<ul> <li>&gt; 75% embedded (&gt; 85% embedded for large mainstem areas)</li> </ul>	<ul> <li>50-75% embedded (60- 85% embedded for large mainstem areas)</li> </ul>	• 25-49% 59% em mainstei	embedded (35- bedded for large m areas)	<ul> <li>Riffle embeddedness &lt; 25% sand-silt (&lt; 35% embedded for large mainstem areas)</li> </ul>				
	<ul> <li>Few, if any, deep pools</li> <li>Pool substrate composition &gt;81% sand- silt</li> </ul>	<ul> <li>Low to moderate number of deep pools</li> <li>Pool substrate composition 60-80% sand-silt</li> </ul>	<ul> <li>Moderat pools</li> <li>Pool sub 30-59%</li> </ul>	e number of deep strate composition sand-silt	<ul> <li>High number of deep pools (&gt; 61 cm deep) (&gt; 122 cm deep for large mainstem areas)</li> <li>Pool substrate composition &lt;30% sand-silt</li> </ul>				
Channel Scouring/ Sediment Deposition	Streambed streak marks and/or "banana"-shaped sediment deposits common	<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits common</li> </ul>	Streamb and/or " sedimen uncomm	ed streak marks banana"-shaped t deposits on	<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits absent</li> </ul>				
	<ul> <li>Fresh, large sand deposits very common in channel</li> <li>Moderate to heavy sand deposition along major portion of overbank area</li> </ul>	<ul> <li>Fresh, large sand deposits common in channel</li> <li>Small localized areas of fresh sand deposits along top of low banks</li> </ul>	<ul> <li>Fresh, la uncomm</li> <li>Small loo fresh san top of lo</li> </ul>	rge sand deposits on in channel calized areas of nd deposits along w banks	<ul> <li>Fresh, large sand deposits rare or absent from channel</li> <li>No evidence of fresh sediment deposition on overbank</li> </ul>				
ین ۲۰ (1.1 = ) هر دهنو	<ul> <li>Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bars common, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bai well-veg armoure fresh sar</li> </ul>	rs small and stable, etated and/or d with little or no nd	<ul> <li>Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand</li> </ul>				
Point range		0304	· · · · · · · · · · · · · · · · · · ·	5 0 6	0708				

Senior staff sign-off (if required): _____ Checked by: _KS____

# GEO

MORPHIX

Date: 09-	-11-2023	PN: 23111	Location: T	TUNDER ROAD
Category	Poor	Fair	Good	Excellent
	<ul> <li>Wetted perimeter &lt; 40% of bottom channel width (&lt; 45% for large mainstem areas)</li> </ul>	<ul> <li>Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)</li> </ul>	<ul> <li>Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)</li> </ul>	<ul> <li>Wetted perimeter &gt; 85% of bottom channel width (&gt; 90% for large mainstem areas)</li> </ul>
	<ul> <li>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)</li> </ul>	<ul> <li>Few pools present, riffles and runs dominant.</li> <li>Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)</li> </ul>	<ul> <li>Good mix between riffles, runs and pools</li> <li>Relatively diverse velocity and depth of flow</li> </ul>	<ul> <li>Riffles, runs and pool habitat present</li> <li>Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)</li> </ul>
Physical Instream	<ul> <li>Riffle substrate composition: predominantly gravel with high amount of sand</li> <li>&lt; 5% cobble</li> </ul>	<ul> <li>Riffle substrate composition: predominantly small cobble, gravel and sand</li> <li>5-24% cobble</li> </ul>	<ul> <li>Riffle substrate composition: good mix of gravel, cobble, and rubble material</li> <li>25-49% cobble</li> </ul>	<ul> <li>Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand</li> <li>&gt; 50% cobble</li> </ul>
Habitat	<ul> <li>Riffle depth &lt; 10 cm for large mainstem areas</li> </ul>	Riffle depth 10-15 cm for large mainstem areas	Riffle depth 15-20 cm for large mainstem areas	<ul> <li>Riffle depth &gt; 20 cm for large mainstem areas</li> </ul>
	<ul> <li>Large pools generally &lt; 30 cm deep (&lt; 61 cm for large mainstem areas) and devoid of overhead cover/structure</li> </ul>	Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	Large pools generally 46-61     cm deep (91-122 cm for     large mainstem areas) with     some overhead     cover/structure	<ul> <li>Large pools generally &gt; 61 cm deep (&gt; 122 cm for large mainstem areas) with good overhead cover/structure</li> </ul>
	Extensive channel alteration and/or point bar formation/enlargement	<ul> <li>Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement</li> </ul>	<ul> <li>Slight amount of channel alteration and/or slight increase in point bar formation/enlargement</li> </ul>	<ul> <li>No channel alteration or significant point bar formation/enlargement</li> </ul>
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	<ul> <li>Riffle/Pool ratio 0.7-0.89:1</li> <li>; 1.11-1.3:1</li> </ul>	• Riffle/Pool ratio 0.9-1.1:1
	<ul> <li>Summer afternoon water temperature &gt; 27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 24-27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 20-24°C</li> </ul>	<ul> <li>Summer afternoon water temperature &lt; 20°C</li> </ul>
Point range	0 0 1 0 2	0304	5 0 6	0708
	• Substrate fouling level: High (> 50%)	<ul> <li>Substrate fouling level: Moderate (21-50%)</li> </ul>	Substrate fouling level: Very light (11-20%)	<ul> <li>Substrate fouling level: Rock underside (0-10%)</li> </ul>
Water Quality	<ul> <li>Brown colour</li> <li>TDS: &gt; 150 mg/L</li> </ul>	<ul><li>Grey colour</li><li>TDS: 101-150 mg/L</li></ul>	<ul> <li>Slightly grey colour</li> <li>TDS: 50-100 mg/L</li> </ul>	<ul><li>Clear flow</li><li>TDS: &lt; 50 mg/L</li></ul>
water Quality	<ul> <li>Objects visible to depth &lt; 0.15m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.15-0.5m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.5-1.0m below surface</li> </ul>	<ul> <li>Objects visible to depth</li> <li>&gt; 1.0m below surface</li> </ul>
	<ul> <li>Moderate to strong organic odour</li> </ul>	<ul> <li>Slight to moderate organic odour</li> </ul>	<ul> <li>Slight organic odour</li> </ul>	No odour
Point range		□ 3 □ 4	056	0708
Riparian Habitat	<ul> <li>Narrow riparian area of mostly non-woody vegetation</li> </ul>	<ul> <li>Riparian area predominantly wooded but with major localized gaps</li> </ul>	<ul> <li>Forested buffer generally</li> <li>&gt; 31 m wide along major portion of both banks</li> </ul>	• Wide (> 60 m) mature forested buffer along both banks
Conditions	<ul> <li>Canopy coverage: &lt;50% shading (30% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 60-79% shading (45-59% for large mainstem areas)</li> </ul>	Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	001	0203	0405	6 7

Total overall score (0–42) = $29$	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Senior staff sign-off (if required): _____ Checked by: KS____

Page 2 of 2

NIA

### **General Site Characteristics**

### Project Number: 23111

Date: Stream: 2023-11-08 BEAR BROOK TRIB Time: **Reach:** BBT-10 a'.45pm SUNNIV DOC Weather: Location: THUNDER ROAD **Field Staff:** V AA Watershed/Subwatershed: BROOK BEAR Features Monitoring Site Sketch THUNDER ROAD Compass Reach break -o-o-o- Long-profile _____ F 19 只 Station location Monumented XS DENSE Cross-section 0 Monumented photo VEG Flow direction Monumented photo VS OF ~ direction Riffle CROSSING Pool Sediment sampling N3:1/51485 W BW: 1.6m CHILDO mm Sediment bar Erosion pins BH: O.LOm SAND-8 WL ннннн Eroded bank/slope Scour chains WW: 0.95m SMALL **Additional Symbols** Undercut bank ----2 NOOKEd WP: 0.145m WOJ PERSIES 11C: 0120LB XXXXXX Bank stabilization exp. Roonse 0.00 RB 11 Leaning tree LEANING DEPOSITION Fence X ..... X TREES Culvert/outfall 1 1 UC: DIOSRB  $\bigcirc$ Swamp/wetland BH = O.SOM WWW Grasses BW: 1,20m G Tree WW: 1,05m Instream log/tree CHANNEL BED SILT-SAMULE WP: 0.12m *** Woody debris PEBBLES 1 12:1/0.375 *** Beaver dam VV Vegetated island **Flow Type** 53 SLOUP H1 Standing water H1A Back water ON BOTH H2 Scarcely perceptible flow (0 RHWK. H3 Smooth surface flow Upwelling H4 5 H5 Rippled PI V.: 1/ 4.195 Unbroken standing wave H6 BH: O. loton H7 Broken standing wave BW: 1.05m EANING H8 Chute TREE WW: 0.95m H9 Free fall H9A Dissipates below free fall WD: DISM Substrate CHANNEL UC: 0.05 40 BED CONFISE **S1** Silt **S6** Small boulder DIDGLB SILT **S2** Sand **S7** Large boulder UNDERLEAF **S**3 **S**8 Gravel Bimodal SLOVES BELOME LITTER **S4** Small cobble **S9** Bedrock/till PRESENT ON BOTH BHNKS **S**5 Large cobble HROUGHOUT DEBRIS Other UNDERCUT CHUSINGUC 0.15m BM Benchmark EP Erosion pin BS Backsight RB Rebar DS Downstream US Upstream BEGINS ING DEBRISIN WDJ Woody debris jam TR Terrace CHANNE RBT VWC Valley wall contact FC Flood chute KP BOS Bottom of slope FP Flood plain Photos: NOTES: BBT-S TRANSITIONS TO THE CHANNEL EXHIBITING TOS Knick point Top of slope KP NEPTICHE BHNKS + CHANNELBEGINS TO DOWN CUT - SCOUR THPOUGHOUT ON BOTH BANKS

Version #4 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: _K_ Completed by: _KM

Page_1 of \

Reach Charac	terist	tics Project N	umber	23111		5						1			8	MORPHIX
Date:		08-11-2023		Field Sta	aff:	KS KM			Wate	ershe	d/Subv	vatershed	: BE	ear e	ROOK	
Time:		2:15 PM		Stream:		BEAR BR	OOK TA	UB	UTM	(Ups	tream)	:				
Weather:		O'C GUNNY		Reach:		BBT-6			UTM	(Dow	Instrea	m):				
(Table 1)	<b>V</b> a (T	alley Type C able 2)	hannel Table 3)	Туре	7 Ch (Ta	annel Zone	Flor (Tal	<b>v Type</b> ble 5)	1		/idence o	of Groundwa	ater Loc	ation:		Photo:
<b>Riparian Veget</b>	ation					Aquatic & Ir	stream \	/egetati	on			Wa	ter Qua	ality		
Dominant Type (Table 6)	1,4	Coverage Channel V	Vidths 4 Ì	<b>Age (yrs)</b> Immature (	<5)	Type (Table 8)	│ Wood	<b>iy Debris</b> Cutbank	WD De	ensity /	WDJ/50n	n:	Odou (Table	16)	<b>ד</b> ו דו (ד	arbidity able 17)
Encroachment (Table 7)	4	□ Fragmented □ 4 - S Continuous   S > 1	10 T 0 [	Established Mature (>3	(5-30) 0)	Reach Coverage %		Channel ot Present	⊠ Moc	d h	1					2
<b>Channel Chara</b>	cterist	tics														
Sinuosity Type (Table 9)	Z	Sinuosity Degree (Table 10)	1	<b>Bank An</b> □ 0 - 30	gle	Bank Erosion □ < 5%	(Ta	ble 19) Bank	Clay/	Silt	Sand	Gravel C	obble	Boulder	r Parent	Rootlets
<b>Gradient</b> (Table 11)	Z	# of Channels (Table 12)	1	⊠ 30 - 6 □ 60 - 9	0 0	⊠ 5 - 30% □ 30 - 60%		Riffle Pool								
Entrenchment (Table 13)	1	Bank Failure (Table 14)	2,5	🗆 Under	cut	□ 60 - 100%	(if no	Bed oriffle-pool orphology)			ß	Z				
Down's Model (Table 15)	u	Bankfull Indicators (Table 18)	3,5			Bank <b>tui</b> Width (m)	1.05	1.20		1.6	Wett	ed Width (I	n) 0,9	15	1.05	0,95
Sed Sorting (Table 20)	MS	Sediment Transport Observed?	□ Yes	🔊 No 🗆 Not	Visible	Bank <b>full</b> Depth (m)	0.67	0,50		0.60	Wett	ed Depth (I	n) (0,1	5	0.12	0.145
Transport Mode (Table 21)	NIA	% of Bed Active	0		[]	Undercuts (m)	0.15	0.05		0120	v	elocity (m/	s) 0.2	39	0.157	0.185
Geomorphic Units (Table 22)	5,6,8	Mass Movement (Table 23)	N/A			Pool Depth (m)					Vel	ocity Estima Meth	od WE	3	WB	WB
Riffle-Pool Spacing (m):	10-20	% Riffles:	15	% Pools:	30	Riffle Length (m)	3-5				Meand	ler Amplitu (I	de n)	•		
Notes: BBT-6 DOMINATE THE STRA AREA ALS	D BE	GINS AS THE SY STRAIGHT S T SECTIONS T RANSITIONS FO	E CHI DECTI THERI ROM	ANNEL ONS W E ARE FORES	TRAM STE INTR T TO	A HERBA	C EOUS	A ME	AND SCOL	UR	ALON N H	PLANE ONG E IG BOT EAVY	ORM OTH H B /EG	I TO SIDE ANKS ENCK	ONE S. BE	RIPARIAN
ENDS AT	THE	LUSSIDE	OF T	HE CU	LVER	T CROSSIN	JG UI	JDER	TH	UN	DER	ROAL	),			
Photos																
FIIVUS:					and the second second											
lorsion #1		A				Soni	or staff sid	m_off (if	roquire	ad).		Chocked	K	M	Completed	by KS

Last edited: 04/04/2023

GEO

# GEO MORPHIX

### Rapid Geomorphic Assessment

### Project Number: 2311

Date:	08	-11-2023	Stream:		BEAR B	RCOK	TRIB	
Time:	2:	15 PM	Reach:		BBT-6			
Weather:	0.0	SUNNY	Location:		THUNDE	RRA	AN	
Field Staff:	K	5 KM	Watershed/Subw	atershed:	BEAR B	ROOK		a lan dan sekara kanan
	1	G	eomorphological Indicate	r		Pre	sent?	Eactor
Process	No.	Description		•		Yes	No	Value
	1	Lobate bar						
	2	Coarse materials in riff	es embedded				~	-
Evidence of	3	Siltation in pools	and the second	en la desta de la desta de la dela de la desta de la desta de la dela dela dela dela dela dela de				- I.
Aggradation	4	Medial bars					~	1 1/4
(AI)	5	Accretion on point bars						+
	6	Poor longitudinal sorting	g of bed materials				1	-
	7	Deposition in the overb	ank zone			1		
				Su	m of indices =	١	6	0,142
	1	Exposed bridge footing	(s)	t di anna di su provint provinsi na provinsi di spragon di spragon di spragon di spragon di spragon di spragon			NIA	
	2	Exposed sanitary / stor	m sewer / pipeline / etc.				NIA	-
	3	Elevated storm sewer o	utfall(s)				NIA	-
	4	Undermined gabion bas	kets / concrete aprons /	etc.				-
Evidence of	5	Scour pools downstrear	n of culverts / storm sew	er outlets			NIA	1
(DI)	6	Cut face on bar forms					~	111
	7	Head cutting due to kni	ckpoint migration			1	16	
	8	Terrace cut through old			~			
	9	Suspended armour laye	r visible in bank					
	10	Channel worn into undis	sturbed overburden / bec	rock		1		
				Su	m of indices =	<u> </u>	5	0.167
	1	Fallen / leaning trees /	fence posts / etc.			/		
	2	Occurrence of large org	anic debris		a	~		
	3	Exposed tree roots				~		
Evidence of	4	Basal scour on inside m	eander bends			~		
Evidence of Widening	5	Basal scour on both side	es of channel through riff	le		~		61
(WI)	6	Outflanked gabion bask	ets / concrete walls / etc				NIA	- 7
	7	Length of basal scour >	50% through subject rea	ch		1	<u> </u>	- '
	8	Exposed length of previ	ously buried pipe / cable	/ etc.			NIA	_
	9	Fracture lines along top	of bank				<u> </u>	-
	10	Exposed building founda	ation				NIA	0.000
[	<u></u>			Su	m of indices =	0		0.85+
	1	Formation of chute(s)					~	
Evidence of	2	Single thread channel to	o multiple channel				~	_
Planimetric	3	Evolution of pool-riffle f	orm to low bed relief forr	n				
Form Adjustment	4	Cut-off channel(s)						2/2
(PI)	5	Formation of island(s)						
	6	Thalweg alignment out	of phase with meander fo	orm				-
		Bar forms poorly formed	d / reworked / removed			2		6.00r
	ag,			Su	III OF INDICES =	4	<u> </u>	01685
Notes:	ere arra alta a	ж 		Stability Inde	ex (SI) = (AI-	+DI+WI	+PI)/4 =	10:363
· · · · · · · · · · · · · · · · · · ·				In Regime	In Transit	sition/Stress In Adjustmen		
				0.00 - 0.2	:0 🖾 0.2	1 - 0.40		0.41

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

# GEO

Date: 08	-11-2023	PN: 2311	Location:	HUNDER ROAD
Category	Poor	Fair	Good	Excellent
	Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)	Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	<ul> <li>Few pools present, riffles and runs dominant.</li> <li>Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)</li> </ul>	<ul> <li>Good mix between tiffles, runs and pools</li> <li>Relatively diverse velocity and depth of flow</li> </ul>	<ul> <li>Riffles, runs and pool habitat present</li> <li>Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)</li> </ul>
Physical Instream	<ul> <li>Riffle substrate composition: predominantly gravel with high amount of sand</li> <li>&lt; 5% cobble</li> </ul>	<ul> <li>Riffle substrate composition: predominantly small cobble, gravel and sand</li> <li>5-24% cobble</li> </ul>	<ul> <li>Riffle substrate composition: good mix of gravel, cobble, and rubble material</li> <li>25-49% cobble</li> </ul>	<ul> <li>Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand</li> <li>&gt; 50% cobble</li> </ul>
Habitat	<ul> <li>Riffle depth &lt; 10 cm for large mainstem areas</li> </ul>	• Riffle depth 10-15 cm for large mainstem areas	<ul> <li>Riffle depth 15-20 cm for large mainstem areas</li> </ul>	<ul> <li>Riffle depth &gt; 20 cm for large mainstem areas</li> </ul>
	<ul> <li>Large pools generally &lt; 30 cm deep (&lt; 61 cm for large mainstem areas) and devoid of overhead cover/structure</li> </ul>	Large pools generally 30     46 cm deep (61-91 cm     for large mainstem     areas) with little or no     overhead cover/structure	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	<ul> <li>Large pools generally &gt; 61 cm deep (&gt; 122 cm for large mainstem areas) with good overhead cover/structure</li> </ul>
	<ul> <li>Extensive channel alteration and/or point bar formation/enlargement</li> </ul>	Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	<ul> <li>Slight amount of channel alteration and/or slight increase in point bar formation/enlargement</li> </ul>	<ul> <li>No channel alteration or significant point bar formation/enlargement</li> </ul>
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	<ul> <li>Riffle/Pool ratio 0.7-0.89:1</li> <li>; 1.11-1.3:1</li> </ul>	Riffle/Pool ratio 0.9-1.1:1
	<ul> <li>Summer afternoon water temperature &gt; 27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 24-27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 20-24°C</li> </ul>	<ul> <li>Summer afternoon water temperature &lt; 20°C</li> </ul>
Point range		<b>3 4</b>	0506	0708
	<ul> <li>Substrate fouling level: High (&gt; 50%)</li> </ul>	<ul> <li>Substrate fouling level: Moderate (21-50%)</li> </ul>	Substrate fouling level: Very light (11-20%)	<ul> <li>Substrate fouling level: Rock underside (0-10%)</li> </ul>
Mator Quality	<ul> <li>Brown colour</li> <li>TDS: &gt; 150 mg/L</li> </ul>	<ul><li>Grey colour</li><li>TDS: 101-150 mg/L</li></ul>	Slightly grey colour     TDS: 50-100 mg/L	<ul> <li>Clear flow</li> <li>TDS: &lt; 50 mg/L</li> </ul>
vater Quality	<ul> <li>Objects visible to depth</li> <li>&lt; 0.15m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.15-0.5m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.5-1.0m below surface</li> </ul>	<ul> <li>Objects visible to depth</li> <li>&gt; 1.0m below surface</li> </ul>
an (tekstopeda) Stil	<ul> <li>Moderate to strong organic odour</li> </ul>	<ul> <li>Slight to moderate organic odour</li> </ul>	Slight organic odour	• No odour
Point range	00102	0304	05/06	0708
Riparian Habitat	<ul> <li>Narrow riparian area of mostly non-woody vegetation</li> </ul>	<ul> <li>Riparian area predominantly wooded but with major localized gaps</li> </ul>	<ul> <li>Forested buffer generally</li> <li>&gt; 31 m wide along major portion of both banks</li> </ul>	• Wide (> 60 m) mature forested buffer along both banks
Conditions	<ul> <li>Canopy coverage: &lt;50% shading (30% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)</li> </ul>	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	<ul> <li>Canopy coverage: &gt;80% shading (&gt; 60% for large mainstem areas)</li> </ul>
Point range	□ 0 □ 1	0203	0405	607

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS

### Rapid Stream Assessment Technique Project Number: 23

Date:	08-11-2023	Stream:		BEAR BROOK TRIB					
Time:	2:15 PM	Reach:		BBT-6					
Weather:	O'C SUNNY	Location:		THUNDER	ROAD				
Field Staff:	KS KM	Watershed/Subwater	rshed:	BEAR BRO	OK	]			
Category	Poor	Fair		Good	Excellent	]			
	<ul> <li>&lt; 50% of bank network stable</li> <li>Recent bank sloughing, slumping or failure frequently observed</li> </ul>	<ul> <li>50-70% of bank network stable</li> <li>Recent signs of bank sloughing, slumping or failure fairly common</li> </ul>	<ul> <li>71-80% stable</li> <li>Infreque sloughin failure</li> </ul>	of bank network ent signs of bank g, slumping or	<ul> <li>&gt; 80% of bank network stable</li> <li>No evidence of bank sloughing, slumping or failure</li> </ul>				
Channel	<ul> <li>Stream bend areas highly unstable</li> <li>Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang &gt; 0.8-1.0 m</li> </ul>	<ul> <li>Stream bend areas unstable</li> <li>Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang 0.8-0.9m</li> </ul>	<ul> <li>Stream</li> <li>Outer ba m above</li> <li>1.5 m al for large</li> <li>Bank ov</li> </ul>	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) erhang 0.6-0.8 m	<ul> <li>Stream bend areas very stable</li> <li>Height &lt; 0.6 m above stream (&lt; 1.2 m above stream bank for large mainstem areas)</li> <li>Bank overhang &lt; 0.6 m</li> </ul>				
Stability	<ul> <li>Young exposed tree roots abundant</li> <li>&gt; 6 recent large tree falls per stream mile</li> </ul>	<ul> <li>Young exposed tree roots common</li> <li>4-5 recent large tree falls per stream mile</li> </ul>	<ul> <li>Exposed predomi large, sr scarce</li> <li>2-3 rece per stream</li> </ul>	I tree roots nantly old and naller young roots ent large tree falls am mile	<ul> <li>Exposed tree roots old, large and woody</li> <li>Generally 0-1 recent large tree falls per stream mile</li> </ul>				
	<ul> <li>Bottom 1/3 of bank is highly erodible material</li> <li>Plant/soil matrix severely compromised</li> </ul>	<ul> <li>Bottom 1/3 of bank is generally highly erodible material</li> <li>Plant/soil matrix compromised</li> </ul>	• Bottom generall plant/so	1/3 of bank is y highly resistant il matrix or material	<ul> <li>Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material</li> </ul>				
	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	<ul> <li>Channel generall</li> </ul>	cross-section is y V- or U-shaped	Channel cross-section is generally V- or U-shaped				
Point range	00102	030405		0708	0 9 0 10 0 11	]			
	<ul> <li>&gt; 75% embedded (&gt; 85% embedded for large mainstem areas)</li> </ul>	<ul> <li>50-75% embedded (60- 85% embedded for large mainstem areas)</li> </ul>	• 25-49% 59% en mainste	embedded (35- bedded for large m areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)	NI			
	<ul> <li>Few, if any, deep pools</li> <li>Pool substrate composition &gt;81% sand- silt</li> </ul>	Low to moderate number of deep pools     Pool substrate composition 60-80% sand-silt	<ul> <li>Moderat pools</li> <li>Pool sub 30-59%</li> </ul>	e number of deep ostrate composition sand-silt	<ul> <li>High number of deep pools (&gt; 61 cm deep) (&gt; 122 cm deep for large mainstem areas)</li> <li>Pool substrate composition &lt;30% sand-silt</li> </ul>				
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	Streambed streak marks and/or "banana"-shaped sediment deposits common	<ul> <li>Streamt and/or " sedimer uncomm</li> </ul>	oed streak marks banana"-shaped at deposits non	Streambed streak marks and/or "banana"-shaped sediment deposits absent				
Deposition	<ul> <li>Fresh, large sand deposits very common in channel</li> <li>Moderate to heavy sand deposition along major portion of overbank area</li> </ul>	<ul> <li>Fresh, large sand deposits common in channel</li> <li>Small localized areas of fresh sand deposits along top of low banks</li> </ul>	<ul> <li>Fresh, karala</li> <li>Small lo fresh sa top of lo</li> </ul>	arge sand deposits non in channel calized areas of nd deposits along w banks	<ul> <li>Fresh, large sand deposits rare or absent from channel</li> <li>No evidence of fresh sediment deposition on overbank</li> </ul>				
	<ul> <li>Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bars common, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point ba well-veg armoure fresh sa</li> </ul>	rs small and stable, getated and/or ed with little or no nd	<ul> <li>Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand</li> </ul>	NI			
Point range		□ 3 □ 4	R	5 0 6	0708				

### **General Site Characteristics**

### Project Number: 2311

Date: 2023-11-08 Stream: BEAR BROOK TRIB Time: 3:30 pm **Reach:** BBT-7 Weather: THUNDER ROAD SUNNA DOG Location: **Field Staff:** BEHR BROOK NY KS Watershed/Subwatershed: BW: 216M WW:200 DEBRIS Features Monitoring Site Sketch Compass BH: 0155m wp:017 UC: 0112LB V: 1/2.935 CHANNEC ----- Long-profile = Reach break = BED SILT-只 Station location ____ Monumented XS Cross-section 0 Monumented photo PEB MHA FLOW 200% 118 Flow direction Monumented photo REIGHT INDICHTOR ~ direction Riffle DEPOSITION @ 1.05m CXD. TV & & Pool Sediment sampling V COMBO (TTTTTT Sediment bar Erosion pins 8 GROUNDWHTER ######## Eroded bank/slope Scour chains **Additional Symbols** MEHNER ----Undercut bank WDJ -1331 P XXXXXX Bank stabilization RMPLITUDE a Leaning tree 3m Fence x----x J-hooked DEPOSITION Culvert/outfall 1 STOUR ON OUTSIDE  $\bigcirc$ Swamp/wetland REMOS POINT VVV Grasses BAR WDJ 3 Tree 1 1 Instream log/tree 9 DEPOSITION DISTANCE BETWEEN ALL * * * Woody debris POOLT RIFFLE > RIFFLELENADA PTP --Beaver dam VV Vegetated island 40.0m DEPOSITION 670 4479 417 (739) Flow Type EROSION Standing water H1A Back water H1 CULYERT/OLD CROSSING H2 Scarcely perceptible flow (010) H3 Smooth surface flow Upwelling H4 11) H5 Rippled CHANNEL H6 Unbroken standing wave LEANING W BED' H7 Broken standing wave TREES LAG DEB K VI H8 Chute COHESIVE SILT SUB-DAN PRIVATE H9 Free fall H9A Dissipates below free fall :113.15 Substrate V G BW: 23m S1 Silt **S6** Small boulder BH: DISSM C Nº1,45M Stouk 1 **S2** Sand **S7** Large boulder :0.10501 th M O **S**3 **S8** Gravel Bimodal 0.06KB DENSE VEG-**S4** Small cobble **S9** Bedrock/till **S**5 Large cobble 1 ENCROACH 12 Other CHANNEL CHANNEL 1 Ex BM Benchmark FP Erosion pin 2 5 RIR BS Backsight RB Rebar -CONSTRUCTED Tess DS Downstream US Upstream RIFFLE WDJ Woody debris jam TR Terrace VWC Valley wall contact FC Flood chute THUNDERROHD BOS Bottom of slope FP Flood plain Photos: TOS Top of slope KP Knick point Notes: SLOUP ON MANY BENDG+DEPOSITION -EXPOSED TREE & DOTS+ WD5+'J'HOOKOD TREES COMMON. - MOSTLY TREES ON LB 4ND ITEP48HCEOUS ON -MEANFRING, SOME YOOL-RIFFIE FORMATIONS KS Completed by: KM

Senior staff sign-off (if required): _ Checked by:

Page of

# GEO MORPHIX"

# General Site Characteristics Project Number: 23111

Date:		20'	23-11-08		Stream:		BEAR BROOK TRIB
Time:		3:2	Opm		Reach:		BBT-7 (Cont) + BBT-8
Weath	er:	CU	DOD VOU		Location:		THUNDER ROAD
Field S	itaff:	KG	KM		Watershed/Subwate	rshed:	BFAR GROOX
Footur		Manita			Chatah		
	es Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree Woody debris Beaver dam Vegetated island	Monitor	ring Long-profile Monumented XS Monumented photo direction Sediment sampling Frosion pins Scour chains nal Symbols	BH BH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH HJWONCH	CHANNEL BED AND-SILT MARCE PEB	X X X X X X X X X X X X X X X X X X X	Compass N TORTLOVS / D MEHNDEPS BEFORE CONFILENCE CONFILENCE CONFILENCE WITH/REPREBEDOF WITH/REPREBEDOF 0.400 12 0.400 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12 0.50 12
H1 H2 H3 H4 H5 H6 H7 H8 H9	Standing water H1/ Scarcely perceptible Smooth surface flow Upwelling Rippled Unbroken standing wav Broken standing wav Chute Free fall H9/	A Back v flow vave e A Dissip	vater ates below free fal		All EV Ling	XXX XXX XXX XXX XXX XXX XXX XXX XXX XX	BW: 1.80m N:1/470 BH: 0.100m SULT- WW: 1.25m SMHLL WP: 0.100m PEB UC: 0.006LB 1 BBT-8 1 LEACH BPEME- BBT-7
Substr	ate				(Art	18 (	V
S1 S2 S3 S4 S5 Other	Silt Sand Gravel Small cobble Large cobble	S6 S7 S8 S9	Small boulder Large boulder Bimodal Bedrock/till	UN ALL	LEANING THEES	- no - X	EPOSITION U-1/4.925 WDJ BH:0150m WW:1115m WD:0114m
BM	Benchmark	EP	Erosion pin	0.5F	A HADRAN	1 ×	THANKEDTREES
DS	backsignt	KB US	Upstream	VEF	USITION A	Bit	2-HORSEEN HEER
WDJ	Woody debris jam	TR	Terrace		i w D/	1 S	
vwc	Valley wall contact	FC	Flood chute			ただ	
BOS	Bottom of slope	FP	Flood plain	Phot	os:		
TOS	Top of slope	KP	Knick point	Note	S: -TRIANSITION TO	BIST-8	3 - HEMYY VEG ENCROMCH -
FIPHY - FIF CCN Versio Last e	21191 2011 BE(0) FLE-POOL FOR IFLUEN(E WIT n #4 dited: 21/02/2023	MIES I MIATO TY BE	HEPRH(EOUS N ABSENT AR BROOK Senior staff sig	<u>91 TRIB</u> IN BBT gn-off (if re	ENTERS BEHR BF - & , LESS MEANDER quired): Check	<u>400€ (C0</u> 41N6 FX1 ≪ed by:	ECPT DIS EXTENT BEFORE ES_ Completed by: <u>EM</u> Page <u>1</u> of <u>1</u>

<b>Reach Chara</b>	cteris	tics Pro	oject Nu	ımber	23111													MORPHI
Date:		08-11-2	023		Field S	taff:	KS KM				Wat	tershe	d/Subv	vatersh	ed: 🤅	BEAR	BROOK	
Time:		2:45 P	M		Stream	1:	BEAR B	BROO	KT	RIB	UTN	1 (Ups	tream)	:				
Weather:					Reach:		BBT-7				UTN	1 (Dow	Instrea	m):				
(Table 1)	<b>۲</b>	alley Type	2 CI	hannel able 3)	Туре	8 (	<b>hannel Zone</b> Table 4)	2	<b>Flov</b> (Tab	<b>v Type</b> ole 5)	1	ĘΩ E	vidence o	of Ground	lwater L	ocation: <u>/</u>	MUDTPLE	Photo: YES
<b>Riparian Vege</b>	tation						Aquatic 8	Instra	am V	/egetatio	on			V	Vater <b>Q</b>	uality		
Dominant Type (Table 6)	1, A	Coverage	Channel W	/idths 1	<b>Age (yrs)</b> ⊐ Immature	(<5)	Type (Table 8)	1	Wood In	<b>ly Debris</b> Cutbank	WD D	ensity W	WDJ/50n	n:	Od (Tab	lour le 16)		Turbidity (Table 17)
Encroachment (Table 7)	N	□ Fragmented	1 🔍 4 - 1 1 🔍 > 10	LO 1 D 1	및 Establishe 및 Mature (>	d (5-30) 30)	Reach Coverage %	20	™ In □ No	Channel ot Present	™ Mo	od gh						2
Channel Chara	octeris	tics																
Sinuosity Type (Table 9)	4	] Sinuosit	<b>y Degree</b> Table 10)	З	<b>Bank A</b> □ 0 - 3	Angle 30	Bank Erosion □ < 5%		(Ta	ble 19) Bank	Clay	/Silt \$	Sand	Gravel	Cobble	e Bould	er Pare	nt Rootlets
Gradient (Table 11)	2	] # of (	Channels Table 12)	1	□ 30 - □ 60 -	60 90	□ 5 - 30% □ 30 - 60%			Riffle Pool		] ]						
Entrenchment (Table 13)		Ban (	<b>k Failure</b> (Table 14)	2	🗆 Unde	ercut	□ 60 - 100%		(if no m	Bed riffle-pool orphology)	15	1	Z	A				
Down's Model (Table 15)	Μ	Bankfull In (	dicators Table 18)	1,3			Bank <b>tuli</b> - Wid (1	m) 2	5	2,6		3.0	Wett	ed Width	(m) \	.45	2.0	1.15
Sed Sorting (Table 20)	MS	Sediment T Ot	ransport oserved?	□ Yes	No 🗆 No	ot Visible	Bank <b>ieli.</b> Dep (1	m) 0.5	55	0.55		0,50	Wett	ed Depth	n (m) (	1,105	F1.0	0.14
Transport Mode (Table 21)	NIA	% of Be	ed Active	0			Undercuts (	<b>m)</b> 0,0	0	0.12			v	elocity (	m/s)	1317	0.341	0.203
Geomorphic Units (Table 22)	5,6	Mass M (	ovement Table 23)	NIA			Pool Dep	m)	-				Vel	locity Est Mo	imate ethod	NB	WB	WB
Riffle-Pool Spacing (m):	5-7	o,	% Riffles:	10	% Pools:	30	Riffle Length (	m) 3-	·S				Meand	ler Ampl	itude (m)		3	
Notes: BBT-	7 B	EGINS	IMMED	ATE	LY DIS	70	THE CULVER	et ci	ROSS	SING	UNI	DER	THUN	JDER	ROA	D. TH	EVAL	EY TYPE
IS CONFINE	DU	NLIKE TH	te re	ACHE	SWS	RESI	DENTIAL P	ROPE	RT	TES E	SORI	ALLE	THE	VALL	EY	TOP N	ORTH	OF
IN HERR	ACEC	AD. LAN	DIE	C4LAI	INFL 1	JAS A	MEANDER	DING	PID	NFOR	AA -	THRO	LAHOU	UT T	HE K	REACH	, THE	SAME
PEACH - CO	SLOU	RED CI	AYV	VAS	OBSV	ALON	JG THE	BASI		FSCO	UR	ED	BANI	KS. A	SIN	J BE	T-5	A
														1				
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Photos:										an balance and the second								
7																langer of a star star		
															*****			<b></b>

Version #4 Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _KS___

GEO

# GEO PHIX

### **Rapid Geomorphic Assessment**

### Project Number: 23111

Date:	08	-11-2023	Stream:		BEAR B	ROOK	TRIB			
Time:	2:	45 PM	Reach:		BBT-7	<b>1</b> 0				
Weather:	0.	C SUNNY	Location:		THUNDE	RRO	AD			
Field Staff:	KS	KM	Watershed/Subw	atershed:	BEAR E	BROOK	6			
	 		Geomorphological Indicator	, ,		Pre	sent?	Factor		
Process	No.	Description				Yes	No	Value		
	1	Lobate bar								
	2	Coarse materials in rif	fles embedded		an han di cara di cara di sa chana		1	1		
Evidence of	3	Siltation in pools				1	_	21		
Aggradation	4	Medial bars	inan da sina 1996 et al contra de la contra de la contra de la formada de				~	2/7		
(IA)	5	Accretion on point bars	5			/				
	6	Poor longitudinal sorti	ng of bed materials				1	]		
·	7	Deposition in the over	bank zone	a. 1917 (* 19. 1942) (* 19. 19. 19. 19.			-			
				Su	m of indices =	3	4	0,428		
	1	Exposed bridge footing	ı(s)				NIA			
	2	Exposed sanitary / sto	rm sewer / pipeline / etc.				<hr/>			
	3	Elevated storm sewer	outfall(s)			<b></b>	~	1		
	4	Undermined gabion ba	skets / concrete aprons / e	etc.	a antonio del contra del s		~	1		
Evidence of	5	Scour pools downstrea	m of culverts / storm sewe	er outlets			~	1/0		
Degradation (DI)	6	Cut face on bar forms						19		
	7	Head cutting due to kr	nickpoint migration			~				
	8	Terrace cut through ol	der bar material	1		~	1			
	9	Suspended armour lay	er visible in bank				1	1		
	10	Channel worn into und	listurbed overburden / bed	rock		1		1		
				Su	m of indices =	1	8	0.1112		
	1	Fallen / leaning trees /	' fence posts / etc.			/				
	2	Occurrence of large or	ganic debris			1	-			
	3	Exposed tree roots				1		4		
	4	Basal scour on inside r	meander bends				1			
Widence of	5	Basal scour on both si	des of channel through riffl	е		1		61		
(WI)	6	Outflanked gabion bas	kets / concrete walls / etc.	CULVER	1	~		-18		
	7	Length of basal scour	>50% through subject read	ch		~		-		
	8	Exposed length of prev	viously buried pipe / cable ,	/ etc.			NIA			
	9	Fracture lines along to	p of bank				-	4		
	10	Exposed building found	dation	وروان والمراجع والمراجع المراجع			NIA	1		
				Su	m of indices =	6	2	0.75		
	1	Formation of chute(s)					~			
Evidence of	2	Single thread channel	to multiple channel				1			
Planimetric	3	Evolution of pool-riffle	form to low bed relief form	n			/			
Form	4	Cut-off channel(s)					~	2/2		
Adjustment	5	Formation of island(s)					~			
	6	Thalweg alignment ou	t of phase with meander fo	rm		~		_		
-	7	Bar forms poorly form	ed / reworked / removed			1				
				Su	m of indices =	2	5	0,285		
Notes:	. Supplicements of the			Stability Inde	ex (SI) = (AI	+DI+WI	+PI)/4 =	0.394		
				In Regime	In Transi	tion/Str	ess In /	djustment		
				0.00 - 0.2	0 10 0.2	21 - 0.40		<b>0.41</b>		

Senior staff sign-off (if required): _____ Checked by: <u>KS</u> Completed by: <u>KS</u>

### Rapid Stream Assessment Technique Project Number: 23111

Date:	08-11-2023	Stream:	Stream: BEAR BROOK			
Time:	2:45 PM	Reach:		BBT-7		
Weather:	O'C SUNNY	Location:	nder de la c	THUNDER R	GAD	
Field Staff:	KS KM	Watershed/Subwater	shed:	BEAR BROX	JK	
Category	Poor	Fair		Good	Excellent	
<ul> <li>&lt; 50% of bank network stable</li> <li>Recent bank sloughing, slumping or failure frequently observed</li> </ul>		<ul> <li>50-70% of bank network stable</li> <li>Recent signs of bank sloughing, slumping or failure fairly common</li> </ul>	<ul> <li>71-80% stable</li> <li>Infreque sloughir failure</li> </ul>	o of bank network ent signs of bank ng, slumping or	<ul> <li>&gt; 80% of bank network stable</li> <li>No evidence of bank sloughing, slumping or failure</li> </ul>	
Channel	<ul> <li>Stream bend areas highly unstable</li> <li>Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang &gt; 0.8-1.0 m</li> </ul>	<ul> <li>Stream bend areas unstable</li> <li>Outer bank height 0.9- 1.2 m above stream pank (1.5-2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang 0.8-0.9m</li> </ul>	<ul> <li>Stream bend areas stable</li> <li>Outer bank height 0.6-0.9 m above stream bank (1.2- 1.5 m above stream bank for large mainstem areas)</li> <li>Bank overhang 0.6-0.8 m</li> <li>Bank overhang</li> </ul>		<ul> <li>Stream bend areas very stable</li> <li>Height &lt; 0.6 m above stream (&lt; 1.2 m above stream bank for large mainstem areas)</li> <li>Bank overhang &lt; 0.6 m</li> </ul>	
Stability	<ul> <li>Young exposed tree roots abundant</li> <li>&gt; 6 recent large tree falls per stream mile</li> <li>Young exposed tree roots</li> <li>Young exposed tree roots</li></ul>		d tree roots inantly old and maller young roots ent large tree falls eam mile	<ul> <li>Exposed tree roots old, large and woody</li> <li>Generally 0-1 recent large tree falls per stream mile</li> </ul>		
<ul> <li>Bottom 1/3 of bank is highly erodible material</li> <li>Plant/soil matrix severely compromised</li> </ul>		<ul> <li>Bottom 1/3 of bank is generally highly erodible material</li> <li>Plant/soil matrix compromised</li> </ul>	Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material		<ul> <li>Bottom 1/3 of bank is generally highly resistant plant/soil matrix or materia</li> </ul>	
	Channel cross-section is generally trapezoidally- shaped	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	<ul> <li>Channe general</li> </ul>	l cross-section is ly V- or U-shaped	Channel cross-section is generally V- or U-shaped	
Point range		030405	060708		<b>0</b> 9 <b>0</b> 10 <b>0</b> 11	
1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1996 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	<ul> <li>&gt; 75% embedded (&gt; 85% embedded for large mainstem areas)</li> </ul>	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% en mainste	embedded (35- nbedded for large em areas)	Riffle embeddedness <     25% sand-silt (< 35%     embedded for large     mainstem areas)	
<ul> <li>Few, if any, deep pools</li> <li>Pool substrate composition &gt;81% sand- silt</li> </ul>		Low-to moderate number of deep pools Pool substrate composition 60-80% sand-silt	to moderate number eep pools substrate position 0% sand-silt • Moderate nu pools • Pool substra 30-59% sar		<ul> <li>High number of deep pools (&gt; 61 cm deep) (&gt; 122 cm deep for large mainstem areas)</li> <li>Pool substrate composition &lt;30% sand-silt</li> </ul>	
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	Streambed streak marks and/or "banana"-shaped sediment deposits common	<ul> <li>Stream and/or sediment uncomm</li> </ul>	bed streak marks) "banana"-shaped nt deposits non	• Streambed streak marks and/or "banana"-shaped sediment deposits absent	
	<ul> <li>Fresh, large sand deposits very common in channel</li> <li>Moderate to heavy sand deposition along major portion of overbank area</li> </ul>	<ul> <li>Fresh, large sand deposits common in channel</li> <li>Small localized areas of fresh sand deposits along top of low banks</li> </ul>	<ul> <li>Fresh, I uncomr</li> <li>Small lo fresh sa top of lo</li> </ul>	arge sand deposits non in channel ocalized areas of and deposits along ow banks	<ul> <li>Fresh, large sand deposits rare or absent from channe</li> <li>No evidence of fresh sediment deposition on overbank</li> </ul>	
0 (211) ) Jasib	<ul> <li>Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bars common, moderate to large and unstable with high amount of fresh sand</li> </ul>	Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand		<ul> <li>Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand</li> </ul>	
Point range		0304		5 0 6	0708	

Senior staff sign-off (if required): _____ Checked by: _KS___

# GEO

MORPHIX

Date: 68	-11-2023	PN: 23111	Location:	THUNDER ROAD	
Category	Poor	Fair	Good	Excellent	
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	<ul> <li>Wetted perimeter 40- 60% of bottom channe width (45-65% for larg mainstem areas)</li> </ul>	Wetted perimeter 61-85%     of bottom channel width     (66-90% for large     mainstem areas)	<ul> <li>Wetted perimeter &gt; 85% of bottom channel width (&gt; 90% for large mainstem areas)</li> </ul>	
	<ul> <li>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)</li> </ul>	<ul> <li>Few pools present, riffle and runs dominant.</li> <li>Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)</li> </ul>	<ul> <li>es • Good mix between riffles, runs and pools</li> <li>• Relatively diverse velocity and depth of flow</li> </ul>	<ul> <li>Riffles, runs and pool habitat present</li> <li>Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)</li> </ul>	
Physical Instream	<ul> <li>Riffle substrate composition: predominantly gravel with high amount of sand</li> <li>&lt; 5% cobble</li> </ul>	<ul> <li>Riffle substrate composition: predominantly small cobble, gravel and sand</li> <li>5-24% cobble</li> </ul>	<ul> <li>Riffle substrate composition: good mix of gravel, cobble, and rubble material</li> <li>25-49% cobble</li> </ul>	<ul> <li>Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand</li> <li>&gt; 50% cobble</li> </ul>	
Habitat	<ul> <li>Riffle depth &lt; 10 cm for large mainstem areas</li> </ul>	<ul> <li>Riffle depth 10-15 cm f large mainstem areas</li> </ul>	• Riffle depth 15-20 cm for large mainstem areas	<ul> <li>Riffle depth &gt; 20 cm for large mainstem areas</li> </ul>	
- 	<ul> <li>Large pools generally &lt; 30 cm deep (&lt; 61 cm for large mainstem areas) and devoid of overhead cover/structure</li> </ul>	<ul> <li>Large pools generally 3 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structu</li> </ul>	0 ⁻ • Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead re cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	
	<ul> <li>Extensive channel alteration and/or point bar formation/enlargement</li> </ul>	<ul> <li>Moderate amount of channel alteration and/ moderate increase in point bar formation/enlargement</li> </ul>	<ul> <li>Slight amount of channel alteration and/or slight increase in point bar formation/enlargement</li> </ul>	<ul> <li>No channel alteration or significant point bar formation/enlargement</li> </ul>	
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1	
	<ul> <li>Summer afternoon water temperature &gt; 27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 24-27°C</li> </ul>	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C	
Point range		03 4	0506	0708	
	<ul> <li>Substrate fouling level: High (&gt; 50%)</li> </ul>	<ul> <li>Substrate fouling level: Moderate (21-50%)</li> </ul>	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Quality	<ul> <li>Brown colour</li> <li>TDS: &gt; 150 mg/L</li> </ul>	<ul><li>Grey colour</li><li>TDS: 101-150 mg/L</li></ul>	Slightly grey colour     TDS: 50-100 mg/L	Clear flow     TDS: < 50 mg/L	
match quality	<ul> <li>Objects visible to depth &lt; 0.15m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.15-0.5m below surface</li> </ul>	Objects visible to depth     0.5-1.0m below surface	Objects visible to depth     > 1.0m below surface	
	<ul> <li>Moderate to strong organic odour</li> </ul>	<ul> <li>Slight to moderate organic odour</li> </ul>	<ul> <li>Slight organic odour</li> </ul>	No odour	
Point range	0 0 1 0 2	□ 3 □ 4	05/26	0708	
Riparian Habitat	<ul> <li>Narrow riparian area of mostly non-woody vegetation</li> </ul>	<ul> <li>Riparian area predominantly wooded but with major localized gaps</li> </ul>	<ul> <li>Forested buffer generally</li> <li>31 m wide along major portion of both banks</li> </ul>	Wide (> 60 m) mature forested buffer along both banks	
Conditions	<ul> <li>Canopy coverage: &lt;50% shading (30% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 60-79% shading (45-59% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: &gt;80% shading (&gt; 60% for large mainstem areas)</li> </ul>	
Point range	001	0203	0405	6 0 7	
Total overall s	core (0-42) = 25	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)	

Version #2 Last edited: 10/02/2023 Senior staff sign-off (if required): _____ Checked by:  $\underline{\mathcal{KN}}$  Completed by:  $\underline{\mathcal{KS}}$ 

Date:		08-11-2	023	1	Field Sta	aff:	KS KM			Wa	tershe	d/Subv	vatershed	I: BE	ARE	ROCK	
Time:		3:20 PM			Stream:		BEAR B	ROOK.	TRIB	UTI	M (Ups	tream)					
Weather:		O'C OVER	RCAST		Reach:		BBT-8			UTI	M (Dov	vnstrea	m):				
Table 1)		alley Type	יין ב(י ד(1	n <b>annei</b> able 3)	Туре	12 (Ta	annel Zone able 4)	1	Flow Type (Table 5)	e		vidence c	of Groundw	ater Loc	ation:	~	Photo:
Riparian Vege	tation						Aquatic &	Instrea	m Vegeta	ition			Wa	iter Qua	ality		
<b>Dominant Type</b> (Table 6)	1,4	Coverage	Channel W □ 1 - 4	vidths v	Age (yrs) Nmmature ( Established	<5)	<b>Type</b> (Table 8)	\	Voody Debri	s WDD ik □Lo	<b>Density</b> W	WDJ/50m	1:	Odou (Table 1	16)	т ()	able 17)
Encroachment (Table 7)	4	Continuous	₩2 > 10	) [	] Mature (>3	0)	Reach Coverage %	801	Not Prese	nt □ Hi	gh 						4
Channel Chara	cteris	tics															
Sinuosity Type (Table 9)	1	Sinuosity (	<b>/ Degree</b> Table 10)	1	Bank An □ 0 - 30	gle	Bank Erosion □ < 5%		(Table 19) Bank	Clay	/Silt }	Sand	Gravel (	Cobble	Boulder	Parent	
Gradient (Table 11)	2	# of (	<b>Channeis</b> Table 12)	١	⊠ 30 - 6 ⊠ 60 - 9	0 0	□ 5 - 30% ⊠_30 - 60%		Riffle Pool		]						
Entrenchment (Table 13)	1	Bani (	<b>k Failure</b> Table 14)	2	🛛 Undero	cut	□ 60 - 100%		(if no riffle-poo morphology)	5	1	Z	R				
Down's Model (Table 15)	e	Bankfull In	<b>dicators</b> Table 18)	3,5			Bankf <b>uf</b> l Widt (n	:h 1) 1.8	04	70	1.45	Wette	ed Width (	m) 1.2	5	0.50	0.60
Sed Sorting (Table 20)	MS	Sediment Tr Ob	ansport served?	□ Yes	🔊 No 🗆 Not	Visible	Bankf 🗰 Dept (n	n) 0.60	0.6	20	0.70	Wette	ed Depth (	m) 0,1	6	0.50	0.17
Transport 1ode (Table 21)	NA	% of Be	d Active	0			Undercuts (n	0.06		_		Ve	elocity (m/	(s) 0.2	13	0.327	0,289
Geomorphic Jnits (Table 22)	8	Mass Mo	<b>ovement</b> Table 23)	NIA			Pool Depi (n	:h		_		Vele	ocity Estima Meth	od WE	3	WB	WB
Riffle-Pool Spacing (m):		%	Riffles:	~	% Pools:	~	Riffle Length (n	"				Meand	er Amplitu (	de - m)			
otes: BBT-	S BE	EGINS AT	ATE	RANSI	TION F	ROM	A MEAL	VDER	ING, F	ORES	STED	> SEC	TION	TG A	MOR	LE OPI	EN
HERBACES	SUS 2001	MEHDOV	U. THE	VAL	LEY B	EGIN	S TO WIE	A NJA	ND T	HE C	HANI	SAA	ENTER	STA	HE M	UCH E	ROADER
AND ISOL	ATEI	BENDS	, SCO	URI	S PRE'	VALEN	T. THE CH	ANNE	LIS	LARG	ELY	DIRS	UKED	BY	THE	HERE	ACECUS
AND SEN	1-40	DUATTC V	EG D	UE	TO HE	AVEY	ENCROAD	HME	NT. C	HANI	NEL	DIME	ENSION	15 C	HANG	EAS	THE
CONFLUE	NCE	W BEAR	BRO	3/4 15	5 APPR	DACHE	D; WIDTT	DEC	REASE	SW	HILE	DE	PTH 1	NCRE	ASE	1.0 1.0	
notos:						••••	· · · · · · · · · · · · · · · · · · ·										

Version #4 Last edited: 04/04/2023

# GEO

### **Rapid Geomorphic Assessment**

# Project Number: 2311

Date:	08-	-11-2023	Stream:		BEAR B	RCOK	TRIE	,		
Time:	3:	20 PM	Reach:		BBT-9		20			
Weather:	0'0	OVERCAGT	Location:		THUNDE	RR	OAD	ang ang pang pang pang pang pang pang pa		
Field Staff:	KS	5 KM	Watershed/Subw	vatershed:	BEAR E	SROCH	K			
		Ġ	Geomorphological Indicato	nr		Pre	sent?	Factor		
Process	No.	Description	Yes	No	Value					
	1	Lobate bar		2						
	2	Coarse materials in riff	les embedded	and a subscription of the second s				-		
Evidence of	3	Siltation in pools								
Aggradation	4	Medial bars		1	6/					
(IA)	5	Accretion on point bars		1	1 '+					
	6	Poor longitudinal sortin			1					
u:	7	Deposition in the overb		1	]					
				Sur	n of indices =	0	7	G		
	1	Exposed bridge footing	(s)				NIA			
	2	Exposed sanitary / stor	m sewer / pipeline / etc.	ana ang ang ang ang ang ang ang ang ang			NIA	1		
	3	Elevated storm sewer of	outfall(s)			5	NIA	1		
	4	Undermined gabion bas	skets / concrete aprons /	etc.			NIA			
Evidence of	5	Scour pools downstream		NIA	] .					
(DI)	6	Cut face on bar forms					-			
	7	Head cutting due to kn	ickpoint migration					15		
	8	Terrace cut through old	ler bar material				1			
	9	Suspended armour laye	er visible in bank				~			
	10	Channel worn into undi	sturbed overburden / bec	Irock			-			
				Sur	n of indices =	0	5	0		
	1	Fallen / leaning trees /	fence posts / etc.							
	2	Occurrence of large organic debris								
	3	Exposed tree roots						4		
Evidence of	4	Basal scour on inside meander bends						antifere-		
Widening	5	Basal scour on both sides of channel through riffle						51		
(WI)	6	Outflanked gabion baskets / concrete walls / etc.					NIA	1 1		
	7	Length of basal scour >50% through subject reach					1	4		
	8	Exposed length of previously buried pipe / cable / etc.					NIA	-		
	9	Fracture lines along top of bank						4		
	10	Exposed building found	ation			(m)	NIA	0 710		
[		T		Sur	n of indices =	0	2	0,714		
	1	Formation of chute(s)					Concerne of the second	4		
Evidence of	2	Single thread channel t	o multiple channel				~	-		
Planimetric	3	Evolution of pool-riffle	form to low bed relief form	n						
Form Adjustment	4	Cut-off channel(s)						1/7		
(PI)	5	Formation of island(s)								
	6	I nalweg alignment out	1		-					
	/	Bar forms poorly forme	a / reworked / removed	<u> </u>	o of indiana	1		0140		
				Sur	n or indices =	-		0.142		
Notes:				Stability Inde	x (SI) = (AI·	+DI+WI	+PI)/4 =	01214		
				In Regime	In Transi	tion/Str	ess In A	djustment		
				0.00 - 0.20	0.2	1 - 0.40		] 0.41		

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: ______



# Rapid Stream Assessment Technique Project Number: 2311)

Date:	08-11-2023	Stream:		BEAR BRO	OK TRIB	
Time:	3:20 PM	Reach:		BET - 8		
Weather:	O'C OVERCAST	Location:		THUNDER	POAD	
Field Staff:	ks KM	Watershed/Subwate	rshed:	BEAR BRO	GK	
Category	Poor	Fair		Good	Excellent	
	<ul> <li>&lt; 50% of bank network stable</li> <li>Recent bank sloughing, slumping or failure frequently observed</li> </ul>	<ul> <li>50-70% of bank network stable</li> <li>Recent signs of bank sloughing, slumping or failure fairly common</li> </ul>	<ul> <li>71-80% of bank network stable</li> <li>Infrequent signs of bank sloughing, slumping or failure</li> <li>Stream bend areas stable</li> <li>Outer bank height 0.6-0.9 m above stream bank (1.2- 1.5 m above stream bank for large mainstem areas)</li> <li>Bank overhang 0.6-0.8 m</li> <li>&gt; 80% of b stable</li> <li>No evidence sloughing, si stoughing, si stable</li> <li>Stream bend stable</li> <li>Stream bend stable</li> <li>Stream bend stable</li> <li>Bank overhang 0.6-0.8 m</li> </ul>		<ul> <li>&gt; 80% of bank network stable</li> <li>No evidence of bank sloughing, slumping or failure</li> </ul>	
Channel Stability	<ul> <li>Stream bend areas highly unstable</li> <li>Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang &gt; 0.8-1.0 m</li> </ul>	<ul> <li>Stream bend areas unstable</li> <li>Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas)</li> <li>Bank overhang 0.8-0.9m</li> </ul>			<ul> <li>Stream bend areas very stable</li> <li>Height &lt; 0.6 m above stream (&lt; 1.2 m above stream bank for large mainstem areas)</li> <li>Bank overhang &lt; 0.6 m</li> </ul>	
	<ul> <li>Young exposed tree roots abundant</li> <li>&gt; 6 recent large tree falls per stream mile</li> </ul>	<ul> <li>Young exposed tree roots common</li> <li>4-5 recent large tree falls per stream mile</li> </ul>	<ul> <li>Exposed tree roots predominantly old and large, smaller young roots scarce</li> <li>2-3 recent large tree falls</li> </ul>		<ul> <li>Exposed tree roots old, large and woody</li> <li>Generally 0-1 recent large tree falls per stream mile</li> </ul>	
	<ul> <li>Bottom 1/3 of bank is highly erodible material</li> <li>Plant/soil matrix severely compromised</li> </ul>	<ul> <li>Bottom 1/3 of bank is generally highly erodible material</li> <li>Plant/soil matrix compromised</li> </ul>	Bottom 1     generally     plant/soi	L/3 of bank is v highly resistant I matrix or material	Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	
	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	<ul> <li>Channel cross-section is generally trapezoidally- shaped</li> </ul>	Channel cross-section is generally V- or U-shaped		<ul> <li>Channel cross-section is generally V- or U-shaped</li> </ul>	
Point range		<b>3 4 5</b>	X 6	0708	09010011	
	<ul> <li>&gt; 75% embedded (&gt; 85% embedded for large mainstem areas)</li> </ul>	<ul> <li>50-75% embedded (60- 85% embedded for large mainstem areas)</li> </ul>	-75% embedded (60- % embedded for large instem areas) + 25-49% em 59% embed mainstem ar		<ul> <li>Riffle embeddedness &lt; 25% sand-silt (&lt; 35% embedded for large mainstem areas)</li> </ul>	VIA
	<ul> <li>Few, if any, deep pools</li> <li>Pool substrate composition &gt;81% sand- silt</li> </ul>	<ul> <li>Low to moderate number of deep pools</li> <li>Pool substrate composition 60-80% sand-silt</li> </ul>	Moderate pools • Pool subs 30-59%	e number of deep strate composition sand-silt	<ul> <li>High number of deep pools (&gt; 61 cm deep) (&gt; 122 cm deep for large mainstem areas)</li> <li>Pool substrate composition &lt;30% sand-silt</li> </ul>	
Channel Scouring/ Sediment Deposition	<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits common</li> </ul>	<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits common</li> </ul>	<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits uncommon</li> </ul>		<ul> <li>Streambed streak marks and/or "banana"-shaped sediment deposits absent</li> </ul>	
Deposition	<ul> <li>Fresh, large sand deposits very common in channel</li> <li>Moderate to heavy sand deposition along major portion of overbank area</li> </ul>	<ul> <li>Fresh, large sand deposits common in channel</li> <li>Small localized areas of fresh sand deposits along top of low banks</li> </ul>	<ul> <li>Fresh, large sand deposits uncommon in channel</li> <li>Small localized areas of fresh sand deposits along top of low banks</li> </ul>		<ul> <li>Fresh, large sand deposits rare or absent from channel</li> <li>No evidence of fresh sediment deposition on overbank</li> </ul>	
	<ul> <li>Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bars common, moderate to large and unstable with high amount of fresh sand</li> </ul>	<ul> <li>Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand</li> </ul>		<ul> <li>Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand</li> </ul>	
Point range		0304		5 6	□ 7 □ 8	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

Date: 0%	-11-2023	PN: 23111	Location:	THUNDER ROAD	
Category	Poor	Fair	Good	Excellent	
	<ul> <li>Wetted perimeter &lt; 40% of bottom channel width (&lt; 45% for large mainstem areas)</li> </ul>	<ul> <li>Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)</li> </ul>	<ul> <li>Wetted perimeter 61-85% of bottom channel width</li> <li>(66-90% for large mainstem areas)</li> </ul>	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	<ul> <li>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)</li> </ul>	<ul> <li>Few pools present, riffle and runs dominant.</li> <li>Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)</li> </ul>	<ul> <li>Good mix between riffles, runs and pools</li> <li>Relatively diverse velocity and depth of flow</li> </ul>	<ul> <li>Riffles, runs and pool habitat present</li> <li>Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)</li> </ul>	
Physical Instream Habitat	<ul> <li>Riffle substrate composition: predominantly gravel with high amount of sand</li> <li>&lt; 5% cobble</li> </ul>	<ul> <li>Riffle substrate composition: predominantly small cobble, gravel and sand</li> <li>5-24% cobble</li> </ul>	diversity intermediate)         Riffle substrate         composition:         predominantly small         cobble, gravel and sand         5-24% cobble    • Riffle substrate composition: good mix of gravel, cobble, and rubble • A standard stand • 25-49% cobble		
- a breac	Riffle depth < 10 cm for large mainstem areas	Riffle depth 10-15 cm for large mainstem areas	<ul> <li>Riffle depth 15-20 cm for large mainstem areas</li> </ul>	• Riffle depth > 20 cm for large mainstem areas	
	<ul> <li>Large pools generally &lt; 30 cm deep (&lt; 61 cm for large mainstem areas) and devoid of overhead cover/structure</li> </ul>	Large pools generally 30     46 cm deep (61-91 cm     for large mainstem     areas) with little or no     overhead cover/structure	<ul> <li>Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead</li> <li>cover/structure</li> </ul>	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	
	<ul> <li>Extensive channel alteration and/or point bar formation/enlargement</li> </ul>	Moderate amount of channel alteration and/o moderate increase in point bar formation/enlargement	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	No channel alteration or significant point bar formation/enlargement	
<	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	<ul> <li>Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1</li> </ul>	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1	
	<ul> <li>Summer afternoon water temperature &gt; 27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 24-27°C</li> </ul>	<ul> <li>Summer afternoon water temperature 20-24°C</li> </ul>	Summer afternoon water temperature < 20°C	
Point range	<b>0 0 1 0 2</b>	₹3 □ 4	□ 5 □ 6	0708	
	<ul> <li>Substrate fouling level: High (&gt; 50%)</li> </ul>	<ul> <li>Substrate fouling level: Moderate (21-50%)</li> </ul>	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Ouality	<ul> <li>Brown colour</li> <li>TDS: &gt; 150 mg/L</li> </ul>	<ul><li>Grey colour</li><li>TDS: 101-150 mg/L</li></ul>	Slightly grey colour     TDS: 50-100 mg/L	Clear flow     TDS: < 50 mg/L	
. ,	<ul> <li>Objects visible to depth</li> <li>&lt; 0.15m below surface</li> </ul>	<ul> <li>Objects visible to depth 0.15-0.5m below surface</li> </ul>	<ul> <li>Objects visible to depth</li> <li>0.5-1.0m below surface</li> </ul>	Objects visible to depth     > 1.0m below surface	
-	<ul> <li>Moderate to strong organic odour</li> </ul>	<ul> <li>Slight to moderate organic odour</li> </ul>	Slight organic odour	• No edour	
Point range	00102	□ 3 □ 4	□ 5 □ 6	₹7 □ 8	
Riparian Habitat	Narrow riparian area of mostly non-woody vegetation bitat     Narrow riparian area of predominantl but with majo gaps		<ul> <li>Forested buffer generally</li> <li>&gt; 31 m wide along major portion of both banks</li> </ul>	• Wide (> 60 m) mature forested buffer along both banks	
Conditions	<ul> <li>Canopy coverage: &lt;50% shading (30% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)</li> </ul>	<ul> <li>Canopy coverage: Ø0-79% shading (45-59% for large mainstem areas)     </li> </ul>	<ul> <li>Canopy coverage: &gt;80% shading (&gt; 60% for large mainstem areas)</li> </ul>	
Point range	□ 0 □ 1	□ 2 □ 3	0405	6 0 7	
otal overall so	core (0-42) = J7	Poor (<13)	Fair (13-24) Good (25-3	Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS_

Page 2 of 2

# Appendix F: Detailed Assessment Summary

MORPHIX

Geomorpholo Earth Science

# **Detailed Geomorphological Assessment Summary**

### Reach: BBT-7

Project Number:	PN23111	Date:	15-11-23
Client:	Thunder Road Limited Partnership	Length Surveyed (m):	115.4
Location:	Bear Brook Tributary, Thunder Rd	# of Cross-Sections:	7

Reach Characteristics				
Drainage Area:		148.65 ha	Dominant Riparian Vegetation Type:	Trees, shrubs
Geology/Soils:	Glaciofluvial and	glaciomarine sands	Extent of Riparian Cover:	Continuous
Surrounding Land Use:		Forest	Width of Riparian Cover:	4-10 channel widths
Valley Type:		Confined	Age Class of Riparian Vegetation:	Established
Dominant Instream Vegeta	tion Type:	Rooted emergent	Extent of Encroachment into Channel:	Minimal
Portion of Reach with Vege	etation:	5%	Density of Woody Debris:	High

Hydrology			
Measured Discharge (m ³ /s):	0.0297	Calculated Bankfull Discharge (m ³ /s):	0.86
		Calculated Bankfull Velocity (m/s):	0.78

Profile Characteristics		Planform Characteristics		
Bankfull Gradient (%):	0.40	Sinuosity:	1.28	
Channel Bed Gradient (%):	0.47	Meander Belt Width (m):	N/A - Con	
Riffle Gradient (%):	1.55	Meander Amplitude (m):	3 m	
Riffle Length (m):	N/A			
Riffle-Pool Spacing (m):	N/A			

### Longitudinal Profile



### Bank Characteristics

	Minimum	Maximum	Average	e	Average
Bank Height (m):	0.35	0.75	0.63		
Bank Angle (deg):	20	90	67	Torvane Value (kg/cm ² ):	0.75
Root Depth (m):	0.10	0.20	0.14	Penetrometer Value (kg/cm ³ ):	1.04
Root Density (%):	20	70	47	Bank Material (range):	Clay to sand sized
Bank Undercut (m):	0.00	0.17	0.05		

### **Cross-Sectional Characteristics**

	Minimum	Maximum	Average
Bankfull Width (m):	2.31	8.89	3.57
Average Bankfull Depth (m):	0.27	0.36	0.31
Bankfull Width/Depth (m/m):	6.90	30.73	11.83
Wetted Width (m):	0.79	2.12	1.60
Average Water Depth (m):	0.05	0.13	0.09
Wetted Width/Depth (m/m):	12.59	38.89	19.47
Maximum Water Depth (m):	0.12	0.20	0.16
Manning's <i>n</i> :		0.040	



Photograph at cross section 4 (looking downstream) Representative Cross-Section 4 72.5 72.0 Bankfull Level **Elevation (m)** 71.5 71.0 Channel Bed Elevation Water Level Elevation 70.5 0.0 1.0 2.0 3.0 4.0 5.0 6.0 Distance (m)



Channel Thresholds			
Flow Competency (m/s):		Tractive Force at Bankfull (N/m ² ):	14.25
for D ₅₀ :	0.09	Tractive Force at 2-year flow (N/m ² ):	Not modelled
for D ₈₄ :	0.09	Critical Shear Stress (D ₅₀ ) (N/m ² ):	0.15
Unit Stream Power at Bankfull (W/m ² ):	11.16		

### **General Field Observations**

### **Channel Description**

Reach BBT-7 begins downstream of a large culvert crossing under Thunder Road. The watercourse is confined in a valley through this reach and residential properties border the top of the valley slope. Land cover within the valley is primarily forested with some open areas covered in herbaceous vegetation. The channel has an irregular meandering planform through BBT-7. Exposed tree roots and hooked and leaning trees were frequently observed. Some point bar deposition combined with outside bend scour was observed along meanders. The geomorphic units were predominantly runs, with some riffles and pools. A high density of woody debris within the channel created the conditions for many of the geomorphic units observed, such as backwatering forming a pool.

### Facing Downstream at cross-section 1



# Appendix G: Erosion Modelling Hydrographs








































## **Reach BBT-7**

