Jock River, Barrhaven Conservancy

Erosion Hazard Assessment and Erosion Threshold Analysis

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Table of Contents

List of Tables

Appendices

1 Introduction

This report provides support in addressing meander belt width requirements for the Jock River and its tributaries and erosion threshold analyses for the Fraser Clark, Foster Ditch, and O'Keefe municipal drains. The property of the assessed reaches is located between Highway 416 to the west, Greenbank Road to the east, Strandherd Drive to the north, and Jock River to the South.

To delineate the hazard land associated with Jock River and the three (3) municipal drains and to determine the erosion thresholds analysis in support of the proposed stormwater management, the following activities were completed:

- Background review of existing documents related to the study area, including topography, physiography, and geology mapping;
- Review of the meander belt widths associated with the subwatershed study and subsequent analysis on the adjacent tributaries;
- Updated and confirm reach delineation for all three drains;
- Review of historical and recent aerial photographs;
- Completion of rapid geomorphic assessments of the three drains to document channel condition;
- Delineation of the hazard area adjacent to the Jock River and 3 drains based on the results of the updated belt width assessment where warranted;
- Complete a detailed geomorphic assessment of each municipal drain to determine a critical discharge or confirm existing erosion thresholds; and
- Modelling of erosion indices based on post- to pre-development synthetic storage or continuous modelling.

2 Background Review

A review of the meander belt widths and erosion threshold analyses from previous studies were completed for the Jock River and the three adjacent municipal drains. The following studies were reviewed:

- CH2M Hill Canada Limited. 2013. O'Keefe Drain Environmental and Stormwater Management Plan. Prepared for the City of Ottawa;
- CH2M Hill Canada Limited. 2013. Foster Stormwater Management Facility Environmental Study Report. Prepared for the City of Ottawa;
- Parish Aquatic Services, A Division of Matrix Solutions. 2016. Clarke Drain Erosion Threshold Assessment. Prepared for Minto Communities Inc.; and
- Stantec Consulting Ltd. 2007. Jock River Reach One Subwatershed Study Final Report: Volume 1 of 2. Prepared for the City of Ottawa.

3 Historical Assessment

Historical aerial photographs were reviewed to determine changes to the channel and surrounding land use/cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. The 1976 and 1991 aerials were provided by the City of Ottawa and the 2016 was provided by Google Earth Pro. A summary of the historical changes to the three drains are provided in **Table 1**. Historical aerial photographs are provided in **Appendix A**.

Table 1. Historical assessment

Watercourse	1976	1991	2014
Fraser Clark Drain	Agricultural fields surround associated reaches with little to no riparian buffer. Land use within the study site remains consistent to 2014. Reaches FCD2 and FCD3 consist of wetland features. Reach FCD3-3 was not present on the aerial photograph. Reaches FCD3-1, FCD3-2, and FCD5 consist of swale features.	Residential development extends to McKenna Drive and Borrisokane Road. A localized residential property present adjacent to Reach FCD4. Tree growth within the narrow riparian areas. Reach FCD5 was ditched and straightened. No changes to the form of the remainder of the reaches since 1976. Two elongated storm water ponds are constructed, extending east from McKenna Drive parallel to Reach FD1-1.	Residential development extends to Strandherd Drive. Residential and commercial properties present along Strandherd Drive. Riparian buffers increase in width and an increase in tree cover. No changes to the form of the reaches since 1991. A storm water pond was constructed between Strandherd Drive and Reach FCD4**.** Reach FCD4-1 was built to convey flows from the pond to FCD4.
Foster Ditch	Agricultural fields surround associated reaches with no riparian buffer. Land use within the study site remains consistent to 2014. Reaches FD1, FD2, FD3 are narrow features. Reach FD3 was ditched, Reaches FD1 and FD2 were unmodified.	Residential properties extend to the east side of Borrisokane Road. Riparian buffers are narrow and fragmented. Reaches FD1, FD2, FD3, and upstream of Reach FD3 have been noticeably widened. A stormwater pond and Reach FCD1-1 was constructed adjacent to Reach FD1. A flow structure was present at the pond inlet and an access road crosses Reach FD1.	Riparian buffers widen slightly and some tree establishment was noted. Residential areas extend west to Strandherd Drive and north towards Fallowfield Road. Stormwater pond along reach FD1 was reshaped, given a new outlet flowing into Jock River. The flow structure and access road are removed Upstream of the study site stormwater ponds were constructed. Reaches FD4 and FD5 were created as inlet and outlet reaches to the ponds. Further upstream, reaches FD6 to FD14 were re-aligned for development purposes.

Watercourse	1976	1991	2014
O'Keefe Drain	Agricultural fields surround associated reaches. Land use within the study site remains consistent to 2014. A narrow, established riparian buffer zone was only present along Reach OKD1. All other reaches possess little to no riparian area. All reaches were previously straightened and ditched	No notable changes to land use, riparian coverage, and channel formation since 1976.	Riparian tree growth noted upstream of the study site. No changes to riparian coverage and channel formation to reaches OKD1 and OKD2. Commercial development extends east of Strandherd Drive. Reaches OKD3 to OKD8 were re-aligned. Stormwater ponds were constructed along reaches OKD3, and OKD5.
Jock River	Agricultural fields surround associated reaches. Narrow riparian zones along both banks of all reaches. Reach JR-4 more sinuous than reach JR-3. No other morphology apparent in aerial.	No notable changes to land use, riparian coverage, and channel formation since 1976.	No notable changes to riparian coverage and channel formation since 1991. Residential development just south of reach JR-3. Highway 416 was built intersection reach JR-4.

4 Existing Conditions

4.1 Watershed Characteristics

Channel morphology and planform are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. Physiography, riparian vegetation and land use also physically influence the channel. These factors provide insight into existing conditions and perception to the future potential changes as they relate to a proposed activity.

Physiographically, the project site is located within an area dominated by glaciofluvial deposits comprised of alluvial deposits and topset facies. Within the project site, surficial deposits also include modern alluvium ranging from clay to gravel with organic deposits as well as glaciolacustrine sediments composed of massive to laminated silt and clay with minor sand and gravel (OGS, 2010).

4.2 Confirmation of Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. They are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This 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 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; and
- Certain types of anthropogenic channel modifications.

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), Brierley and Fryirs (2005), and the Toronto and Region Conservation Authority (2004).

Thirteen reaches were delineated within the study area in a desktop exercise using available data and background reports. These reaches were then field verified. Seven reaches of Fraser Clark Drain (FCD), two reaches of O'Keefe Drain (OKD), and four reaches of Foster Ditch (FD) were defined in the subject lands. The reaches for the Jock River remain the same from the Subwatershed Study (Stantec, 2007). A reach map is provided in **Appendix B**. Reach mapping extends north of the study site.

4.3 Channel Characteristics

Reach observations and channel measurements were collected in June 2017. These field investigations were used to gain insight into the conditions and general characteristics of each reach in the subject property. A photographic record is included in **Appendix C** and documents the conditions from all observed reaches. Field notes and observations are provided in **Appendix D**.

Rapid geomorphological assessments were completed and included the following reach-by-reach observations:

- Characterization of stream form, process, and evolution using the Rapid Geomorphological Assessment (RGA) (MOE, 2003, VANR, 2007);
- Assessment of the ecological function of the watercourse using the Rapid Stream Assessment Technique (RSAT) (Galli, 1996);
- Stream classification following a modified Downs (1995) and a modified Brierley and Fryirs (2005) River Styles Classification approach;
- Reach-scale habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow behaviour, geomorphological units, and riparian vegetation on the day;
- Instream estimates of bankfull channel dimensions; and
- Bed and bank material composition and structure.

4.4 Rapid Geomorphological Assessments

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). The RGA evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The end result 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 change 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 watercourses (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.

Reaches were also classified according to a modified Downs (1995) Channel Evolution Model and the River Styles Framework (Brierley and Fryirs, 2005). The Down's 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 (Brierley and Fryirs, 2005) provides a geomorphological approach to examining river character, behaviour, condition, and recovery potential.

Field observations are provided in **Table 2** and **Table 3** below.

4.4.1 Fraser Clark Drain

Reach FCD2 exists as an unconfined wetland between agricultural fields. The reach flows south east with low gradient and entrenchment to the Jock River. Riparian vegetation was comprised of trees and grasses. In the upstream portion of the reach, riparian cover was continuous and tree dominated. The downstream was grass dominated and entirely encroached with reeds. Average feature width and depth were 9.3, and 0.4 m, respectively. Bed and bank material were soft and comprised of clay, silt, and sand. There was no development of geomorphic units. Approximately 0.30 to 0.40 m deep of loose bed material and organics were present on the bed at the time of assessment.

Reach FCD3 exists as an unconfined wetland. Riparian vegetation was fragmented containing scattered trees and dominated by grasses. Approximately 75% of upstream is heavily encroached with reeds, containing no notable flow. Bed and bank materials consisted of clay, silt, and sand. Average feature width and depth were 12.3 m, and 0.2 m, respectively. There was no riffle-pool development throughout the reach.

Reach FCD3-1 is an unconfined swale feature surrounded by active agricultural fields. The riparian zone was fragmented and consisted of grasses with scattered trees and shrubs. The swale was heavily encroached with grasses and reeds. The reach had no defined channel banks and no riffle-pool features. Bed material consisted of clay, silt, and sand.

Reach FCD3-2 starts approximately 25 m east of Borrisokane Road and flows intermittently over a low gradient. There was no surface water present at the time of assessment. The riparian area was grass dominated, with reeds fully encroaching the bed. The reach had no defined channel banks and no riffle-pool features. Bed material consisted of clay, silt, and sand.

Reach FCD3-3 was not present at the time of assessment.

Reach FCD5 exists as an unconfined swale feature with a low gradient. The reach begins on the western side of Borrisokane Road, and concludes at a culvert at Borrisokane Road. No surface water was present at the time of assessment. The bank angles were low with no evidence of erosion. Riparian vegetation consisted of mainly grasses with scattered trees. Bed and bank material consisted of clay, silt, sand. The reach was absent of geomorphic development.

4.4.2 Foster Ditch

Reach FD1 consists as a sinuous, unconfined channel that perennially flows into Jock River. The reach flows over a low gradient surrounded by agricultural fields. Riparian coverage was dominated by grass, with trees present at the upstream and downstream breaks. The banks were highly entrenched and undercutting was present in the downstream portion of the reach. Bank angles were high and extent of bank erosion included 30-60% of the reach. Bankfull width and depth were 4.7 m and 0.7 m, respectively. No riffle-pool features were present. Grasses encroached minimally into the channel and a low density of woody debris was present. The bed and banks of the channel were both comprised of clay and silt, with sand and scattered rip rap present in the heavily modified areas. Bed materials were soft and were 0.05 to 0.20 m deep.

Reach FD2 consisted of a low gradient, perennial channel surrounded by agricultural fields. The reach exhibits a sinuous planform and was slightly entrenched. The riparian area was narrow and consisted of trees, shrubs, and grasses. Reeds were extensively encroaching the channel at the downstream reach break. A moderate density of woody debris was present. High bank angles at 60-90 degrees and undercutting up to 0.10 m was present. Average bankfull width and depth were 7.6 m and 0.6 m, respectively. No riffle-pool features were present. The bed and banks were composed of clay and silt.

Reach FD3 is straight, ditched, and unconfined channel with a low gradient. The reach was surrounded by a narrow riparian buffer dominated by grasses with scattered trees. Reeds were moderately encroaching the channel. The banks had high angles of 60-90 degrees and were highly entrenched. A large woody debris jam at the downstream portion of the reach was causing substantial backwatering. Undercutting was present upstream and downstream of a large woody debris jam. Average bankfull width and depth were 6.9 m and 0.5 m, respectively. The reach was absent of riffle-pool features. Bed and bank material consisted of clay, silt, and sand. Approximately 0.3 to 0.4 m deep of fines were present on the bed upstream of the woody debris jam.

4.4.3 O'Keefe Drain

Reach OKD1 is a previously straightened and ditched channel flowing between agricultural fields. The reach had a low gradient and was unconfined. Riparian vegetation was continuous and dominated by trees and grasses. The channel was highly entrenched, with high bank angles between 60-90 degrees. Fluvial entrainment and exposed tree roots were commonly observed, with an extent of 60-100% of the reach exhibiting erosion. Encroachment was minimal. Woody debris was high in density with two woody debris jams per 50 m. Average bankfull width and depth were 4.6 and 0.7 m, respectively. The reach had no riffle-pool features. Substrate of the bed and bank ranged between clay, silt, sand, and organics. At the time of assessment, approximately 0.2 – 0.3 m of loose bed material was present on the bed.

Reach OKD2 was previously straightened and ditched. Riparian vegetation was narrow and consisted of grasses. Reed encroachment was moderate. The banks were highly entrenched with high angles of 60-90 degrees. Erosion was present in 30-60% of the reach. Two erosion scars were observed along the right bank. Average bankfull width and depth were 4.4 m and 0.7 m, respectively. Riffle-pool features were not observed. Bed and bank material included clay and silt. A low density of woody debris was present in the channel.

General reach characteristics are summarized below in **Table 2**, and results from the rapid assessments are summarized in **Table 3**.

Table 2. General reach characteristics

Reach	Average Bankfull Width (m)	Average Bankfull Depth (m)	Substrate		Valley Type	Riparian Vegetation	Notes
			Riffle	Pool			
FCD2	N/A: wetland feature		No riffle-pool development: clay, silt, organics		Unconfined	Trees and grasses, fragmented	Wetland feature. Heavy reed encroachment. Soft bed materials.
FCD3	N/A: wetland feature		No riffle-pool development: clay, silt, organics		Unconfined	Trees and grasses, fragmented	Wetland feature. Heavy reed encroachment. No flow.
FCD3-1	N/A: swale feature		No riffle-pool development: clay, silt, organics		Unconfined	Trees and grasses, fragmented	Swale feature. Channel dry at time of assessment. Heavy reed encroachment.
FCD3-2	N/A: swale feature		No riffle-pool development: clay, silt, organics		Unconfined	Trees and grasses, fragmented	Swale feature. Channel dry at time of assessment. Heavy reed encroachment.
FCD3-3	N/A: no feature at the time of assessment						
FCD5	N/A: swale feature		No riffle pool development: clay, silt, sand		Unconfined	Trees and grasses, fragmented	Swale feature. Channel dry at time of assessment. Heavy reed encroachment.
FD1	4.3	0.4	No riffle pool development: clay, silt		Unconfined	Trees and grasses, fragmented	Sinuous and entrenched. Undercutting. Soft bed materials.
FD2	7.6*	0.4	No riffle pool development: clay, silt		Unconfined	Trees shrubs and grasses, continuous	Sinuous and slightly entrenched. Undercutting. Heavy reed encroachment.
FD3	6.9*	0.4	No riffle pool development: clay, silt, sand		Unconfined	Trees and grasses, fragmented	Straightened and ditch feature. Backwatering due to a large woody debris jam.
OKD1	4.6	1.0	No riffle pool development: clay, silt, sand, organics		Unconfined	Trees shrubs and grasses, fragmented	Straightened and ditch feature. Highly entrenched. Soft bed materials.
OKD2	4.4	0.7	No riffle pool development: clay, silt		Unconfined	Trees and grasses, fragmented	Straightened and ditch feature. Highly entrenched. Erosion scars observed.

*feature width

Table 3. Rapid assessment results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Down's Channel Evolution Model (1995)	River Styles Framework (Brierley and Fryirs, 2005)
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Features		
FCD2	0	In Regime	N/A	31	Good	Riparian Habitat	S – stable	Straight, suspended load
FCD3	0	In Regime	N/A	29.5	Good	Riparian Habitat	S – stable	Straight, suspended load
FCD3-1	0	In Regime	N/A	N/A	N/A	N/A	S – stable	Meandering, suspended load
FCD3-2	0	In Regime	N/A	N/A	N/A	N/A	S – stable	Meandering, suspended load
FCD3-3	N/A, Channel non-existent at time of assessment.							
FCD5	0	In Regime	N/A	N/A	N/A	N/A	S – stable	Straight, suspended load
FD1	0.09	In Regime	Evidence of Aggradation	30.5	Good	Riparian Habitat	S – stable	Meandering, suspended load
FD2	0.12	In Regime	Evidence of Widening	31	Good	Riparian Habitat	S – stable	Meandering, suspended load
FD3	0.11	In Regime	Evidence of Widening	30	Good	Riparian Habitat	S – stable	Straight, suspended load
OKD1	0.12	In Regime	Evidence of Widening	30	Good	Channel Stability	e - enlarging	Straight, suspended load
OKD2	0	In Regime	N/A	29	Good	Riparian Habitat	C – Compound	Straight, suspended load

4.4.4 Jock River

Reach JR-2 is just downstream and east of the study site. Site reconnaissance was completed at the Borrisokane Road crossing at the reach break between JR-3 and JR-4. Photographs are provided in **Appendix C**. Both reaches are unconfined with narrow riparian buffer zones. Bank erosion was not observed in the vicinity of the crossing. This was consistent with Stantec's observations.

4.5 Detailed Geomorphological Assessments

A detailed geomorphological assessment was completed for each drain: OKD1, FD1, and FCD2 in June 2017. As these reaches are downstream of the proposed SWM facility, Wet Ponds, and Oil and Grit Separator. The extent of the detailed assessments areas are provided in **Appendix F**. As such, defining an erosion threshold is necessary to mitigate negative post-development impacts.

The detailed assessment includes the following:

- Longitudinal profile of the channel;
- Eight detailed cross-sectional surveys of the watercourse;
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density;
- Bed material sampling at each cross-section following a modified Wolman's (1954) Pebble Count Technique or substrate sample; and
- Velocity, discharge and observations of active/inactive sediment transport at select representative cross-sections.

Bankfull characteristics, based on the results of the detailed assessments for each drain are presented in **Table 5** in **Section 6.1**. A summary of the detailed assessment results for Reach OKD1, FCD1, and FCD2 are provided in **Appendix G**.

5 Meander Belt Width Assessment

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

When defining the meander belt width for a creek system, the Ministry of Natural Resources and Forestry (MNRF) treats unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well-outside where the channel could realistically migrate. Confined systems are those where the watercourse in contained within a defined valley, where valley wall contact is possible.

In unconfined systems, the meander belt width can be graphically defined using orthorectified aerial imagery by determining the channel centreline and the channel's central tendency (i.e. meander belt axis). In cases where the channel has been previously modified or the location cannot be determined in the imagery – due to tree cover or poor photograph resolution, for example – a modelling approach is employed. More specifically, empirical models by Williams (1986). These models are scientifically-defensible and have been verified in past projects as suitable for use in southern Ontario. This modelling approach also serves as a preliminary, or planning level, meander belt width assessment.

All watercourses within the study site are within unconfined valley systems. Since the drainage features have been heavily modified, the meander belt width cannot be determined using orthorectified aerial imagery. Therefore, the modelling approach was used for all the drainage feature within the study site.

Meander belt widths were calculated using empirical models, as these reaches showed signs of previous modification. The results are outlined in **Table 4** and a map is provided in **Appendix H**.

Meander belt widths were proposed using a modified Williams (1986) model, based on field measurements of channel geometries. The modified model also accounts for the average bankfull width of a given reach and an additional 20% factor of safety. These empirical relations are outlined below:

$$B_w = 4.3{W_b}^{1.12} + W_b \quad \text{[Eq. 1]}$$

where B_w is meander belt width (m) and W_b is bankfull channel width (m).

Table 4. Meander belt width estimates

Reach	#CH2MHILL (2013)	##Stantec (2007)	GEO Morphix Ltd.	
			*Williams – Width (1986) (m)	Proposed Meander Belt Width (m)
FCD2	No previous meander belt widths given for the Fraser Clark Drain		N/A: wetland feature; no erosion hazard	
FCD3			N/A: wetland feature; no erosion hazard	
FCD3-1			N/A: wetland feature; no erosion hazard	
FCD3-2			N/A: wetland feature; no erosion hazard	
FCD3-3			N/A: wetland feature; no erosion hazard	
FCD5			N/A: wetland feature; no erosion hazard	
FD1	18.9	32.7	32	32
FD2	18.9		32^	32
FD3	Not determined		32^	32
OKD1	45.6	28.8	34	34
OKD2	45.6		32	32

*includes a 20% factor of safety

#O'Keefe and Foster Drain Report

##No reach specified, average given

^Using the bankfull width from reach FD1

The Fraser Clark Drain, reaches FCD2 and FCD3, consisted of a wetland feature with no channel centreline. Therefore, there is no erosion hazard associated with these features. The same applies to the swale features for reaches FCD3-1, FCD3-2, and FCD5.

Since the Foster Ditch was previously ditched, the bankfull dimensions are comprised. The detailed assessment completed at reach FD1 has more accurate bankfull dimension measurements. Therefore, the meander belt with calculation for reach FD1 are used for reaches FD2 and FD3.

The Jock River meander belt widths within the Subwatershed Study (Stantec, 2007) were reviewed to assess suitability. The meander belt widths provided by the Subwatershed Study for reaches JR-3 and JR-4 are 218 and 231 m, respectively (Stantec, 2007). These meander belt widths include a 10% buffer. We are generally in agreement with the scale of the meander belt widths. The central tendency of the watercourse generally follows the overall trend of the channel passing through riffles or runs. Although there may be an opportunity for minor adjustments to the central

tendencies for reaches JR-3 and JR-4. This does not fundamentally adjust the meander belt width from the location illustrated in the subwatershed study.

We have a minor refinement for the downstream reach, JR-2. The geologic feature at Half Moon bay is not technically a meander. Half Moon bay was formed by reworking the underlying glaciomarine deposits (OGS, 2010). Therefore, the meander belt width for reach JR-2 is 130 m plus a 10% buffer plus a 7 m setback. The proposed meander belt width for reach JR-2 is 150 m. This is smaller than that proposed in the subwatershed study.

6 Erosion Analysis

6.1 Erosion threshold Analysis

Erosion threshold analyses were completed for reaches OKD1, FD1, and FCD2 to determine the flow conditions under which channel bed and bank materials can potentially be entrained and transported. Erosion thresholds are established to provide targets for the proposed SWM facility, Wet Ponds, and Oil and Grit Separator discharges to ensure that post-development erosion rates into the receiving watercourses do not exceed natural pre-development rates.

The erosion threshold analysis provides a depth, velocity, or discharge at which sediments of a particular size may potentially be entrained. The results of the detailed geomorphic assessments were used to inform the erosion threshold analysis. Detailed geomorphic assessment locations were completed downstream of the proposed SWM facility, Wet Ponds, and Oil and Grit Separators. We note that even under the most typical conditions, due to natural variability of channel morphology and sediment characteristics within the reach, the computed flow characteristics would only provide first approximations of erosion thresholds.

Erosion thresholds are determined using different methods that are dependent on channel and sediment characteristics. For example, erosion thresholds for non-cohesive sediments may be estimated using either a shear stress or a velocity approach. An erosion threshold, in the form of a critical discharge, is then calculated based on the bed and bank materials and local channel geometry. Theoretically, above this discharge, entrainment and transport of sediment can occur.

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. An erosion threshold was quantified based on the bed and bank materials and local channel geometry in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. The velocity, *U* (m/s) is iteratively calculated at various depths, until the average velocity in the cross section slightly exceeds the critical velocity of the bed material. The velocity is determined using a Manning's approach, where the Manning's *n* value is visually estimated, a method proposed by Cowan (1956). This is mathematically represented as

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

where, *d* is depth of water (m), *S* is channel slope, and *n* is the Manning's roughness. The discharge is then calculated using the area of a typical cross section at that depth. Results of the erosion threshold analysis are provided below in **Table 5**.

Table 5. Erosion thresholds for each drain

Channel parameter	O'Keefe Drain Reach OKD1	Foster Ditch Reach FD1	Fraser Clark Drain Reach FCD2
Measured			
Average bankfull channel width (m)	4.59	4.69	9.33
Average bankfull channel depth (m)	0.98	0.70	0.39
Bankfull channel gradient (%)	0.05	0.17	0.0001
D_{50} (m)	0.000002	0.000002	0.000002
Average bankfull velocity (m/s)	0.51	0.52	0.05
Bankfull discharge (m^3/s)	1.69	1.21	0.10
Bankfull shear stress (N/m^2)	3.53	8.33	1.46
Calculated for Bed Materials			
Critical velocity (m/s)	0.53*	0.53*	0.15
Critical discharge (m^3/s)	0.80	0.68	0.33
Apparent shear stress (N/m^2)	3.80	11.60	2.5
Conditions at Time of Assessment			
Water depth (m)	0.14	0.21	0.23
Average velocity (m/s)	0.26	0.20	0.05
Average discharge (m^3/s)	0.08	0.13	0.04
Sediment Transport Observations	No transport	No transport	No transport
Critical Discharges from Previous Reports			
Critical discharge (m^3/s)	1.86[#] (Stantec, 2007) 0.08[##] (CH2MHILL, 2013)	0.79[#] (Stantec, 2007) 0.82 (CH2MHILL, 2013)	1.70 (PARISH, 2013)

* Based on Fischenich (2001) for sandy loam
[#] Not given for a specific reach
[##] calculated for reach OKD2

Since both bed and bank material are similar in all three reaches and bank erosion thresholds are a proportion of thresholds for bed material, erosion thresholds for bank materials would be higher. Therefore, using the thresholds for bed materials would keep the bank erosion thresholds values conservative.

The critical discharge of the bed and bank materials for the O'Keefe Drain at reach OKD1 is 0.80 m^3/s. The critical discharge of the bed and bank materials for the Foster Ditch at reach FD1 is 0.68 m^3/s. The critical discharge of the bed and bank materials for the Fraser Clark Drain at reach FCD2 is 0.33 m^3/s.

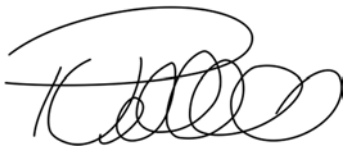
7 Summary and Conclusions

The purpose of this report was to provide support in addressing meander belt width requirements and erosion threshold analyses for the Frazer Clark drain, the Foster Ditch, and the O'Keefe Drain. To delineate the limit of development, the meander belt width was calculated for the 2 reaches of the O'Keefe Drain and the 3 reaches of the Foster Ditch. The Frazer Clark Drain does not have a centre line of channel as the drain consisted of a wetland feature and therefore does not require and meander belt width. The meander belt widths for the O'Keefe Drain are 34 m for reach OKD1 and 32 m for reach OKD2. The meander belt widths for the reaches within the Foster Ditch are 32 m. The meander belt widths for the Jock River reaches JR-2, JR-3, and JR-4 are 150 m, 218 m, and 231 m, respectively.

The erosion threshold analyses provide targets for the proposed SWM facility, Wet Ponds, and Oil and Grit Separator discharge to ensure that post-development erosion rates into the receiving drains do not exceed the natural pre-development rates. The critical discharge of the bed and bank materials for reach OKD1, FD1, and FCD2 are 0.80 m^3/s, 0.68 m^3/s, and 0.33 m^3/s respectively.

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

Respectfully submitted,



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Appendix A Historical Aerial Photographs

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Location: Barrhaven, ON (denoted by red circle)
Year: 1976
Source: City of Ottawa, Teranet

Location: Barrhaven, ON
Year: 1991
Source: City of Ottawa, Teranet

Location: Barrhaven, ON
Year: 2016
Source: Google Earth Pro

Appendix B Reach Delineation

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Reach Delineation

Jock River,
O'Keefe Drain, Foster Drain,
and Fraser-Clarke Drain

Barrhaven, Ottawa

Legend

1:12,000

N

Reach break

Drainage Feature

O'Keefe Drain (OKD)

Foster Drain (FD)

Fraser-Clarke Drain (FCD)

Not present at time of assessment

Reach break: Stantec, 2007, PARISH Geomorphic Ltd., 2013, and GEO Morphix Ltd., 2017.
Drainage Feature: MNRF, 2010, City of Ottawa, 2016, and GEO Morphix Ltd., 2017.
Imagery: Google Earth Pro, 2016.

Appendix C Photographic Record

Photo 1 Reach FCD2	
	Photograph taken facing west. Bed material was 30 to 40cm deep consisted of fines and organics.
Photo 2 Reach FCD2	
	Photograph taken facing east. Wetland feature fully encroached with reeds.

Photo 3 Reach FCD3	
	Photograph taken facing east. Heavily encroaching reeds in the wetland feature was observed.
Photo 4 Reach FCD3	
	Photograph taken facing east. Fragmented riparian buffer was dominated by grass.

Photo 5 Reach FCD3-1	
	Photograph taken facing east. Riparian buffer composed of trees, grasses and shrubs.
Photo 6 Reach FCD3-1	
	Photograph taken in the middle of the feature, facing east. Swale was primarily composed of reeds and was dry at the time of assessment.

Photo 7 Reach FCD3-2	
	Photograph taken facing south east. Center of swale was encroached with reeds, with a primarily grass buffer.
Photo 8 Reach FCD3-2	
	Photograph taken facing south east. No water was present in the feature at the time of assessment.

Photo 9 Reach FD3-3	
	Photograph taken facing south east. Feature not present at time of assessment.

Photo 10 Reach FCD5	
	Photograph taken facing downstream towards left bank. Channel dry at time of assessment.
Photo 11 Reach FCD5	
	Photograph taken facing upstream. Heavy encroachment of tall reeds was observed.

Photo 12 Reach FD1	
	Photograph taken facing downstream towards left bank. Channel was entrenched. Rip rap was observed along the banks in some areas.
Photo 13 Reach FD1	
	Photograph taken facing downstream towards right bank. Minor undercutting observed on right bank.

Photo 14 Storm-water Pond at FD1	
	Photograph taken facing south from Reach FD1.
Photo 15 Reach FD1-1	
	Photograph taken facing west from overflow channel FD1-1.

Photo 16 Reach FD2	
	Photograph taken facing upstream. The channel was slightly entrenched and large woody debris was observed.
Photo 17 Reach FD2	
	Photograph taken facing upstream from Reach FD1 break. Reeds heavily encroached the channel near the downstream reach break.

Photo 18 Reach FD3	
	Photograph taken facing upstream towards left bank. Channel was a straightened and ditched feature.
Photo 19 Reach FD3	
	Photograph taken facing downstream. Extensive backwatering observed upstream of large woody debris jam.

Photo 20 Reach OKD1	
	Photograph taken facing downstream. Channel was a straightened and ditched feature.
Photo 21 Reach OKD1	
	Photograph taken facing left bank. Channel was highly entrenched, woody debris was commonly observed.

Photo 22 Reach OKD2	
	Photograph taken facing upstream. Channel exists as a highly entrenched, straightened and ditched feature.
Photo 23 Reach OKD2	
	Photograph taken facing right bank. Erosion scarring was observed.

Photo 24 Reach JR-4	
	Photograph taken facing upstream, west, from Borrisokane Road.
Photo 25 Reach JR-4	
	Photograph taken facing right bank, south, from Borrisokane Road. The reach was unconfined.

Photo 26 Reach JR-3	
	Photograph taken facing downstream, east, from Borrisokane Road.
Photo 27 Reach JR-3	
	Photograph taken facing the left bank, north, from Borrisokane Road. The reach was unconfined with a narrow riparian buffer zones.

Appendix D Field Observations

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FCD2
Field Staff:	LG BM2	Watercourse:	Foster Drain
Weather:	Rain 18C	Watershed:	Jock River

Location

lat=45.260226245331054, long=-75.75114652679375, alt=94.27012027340467, accuracy=48.0

General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	11 - Straight suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees, Grasses
Dominant Species:	Grass dominant in downstream portion, trees dominant upstream portion
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Moderate

Notes: Fully encroached in downstream portion of reach.

Aquatic / Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	70
Presence of Woody Debris:	Present in Channel
Density of Woody Debris:	Low
Number of WDJs per 50 m:	0

Notes:

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Low (>2.2)
Bank Failures (Brierley and Fryirs, 2005):	None
Downs Model of Channel Evolution (1995):	S - stable
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt, Organics
Bank Material:	Clay, Silt, Sand
Bank Angle:	0 - 30
Extent of Bank Erosion:	< 5%

Notes:

Channel Measurements

Additional Measurements

Is riffle-pool development absent?	yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes:

Water Quality

Odour:	None
Turbidity:	Clear
Notes:	

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General Site Characteristics

Project Code: 17071

Date:	June 21 2017	**Stream/Reach:**	FCD2
Weather:	Sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

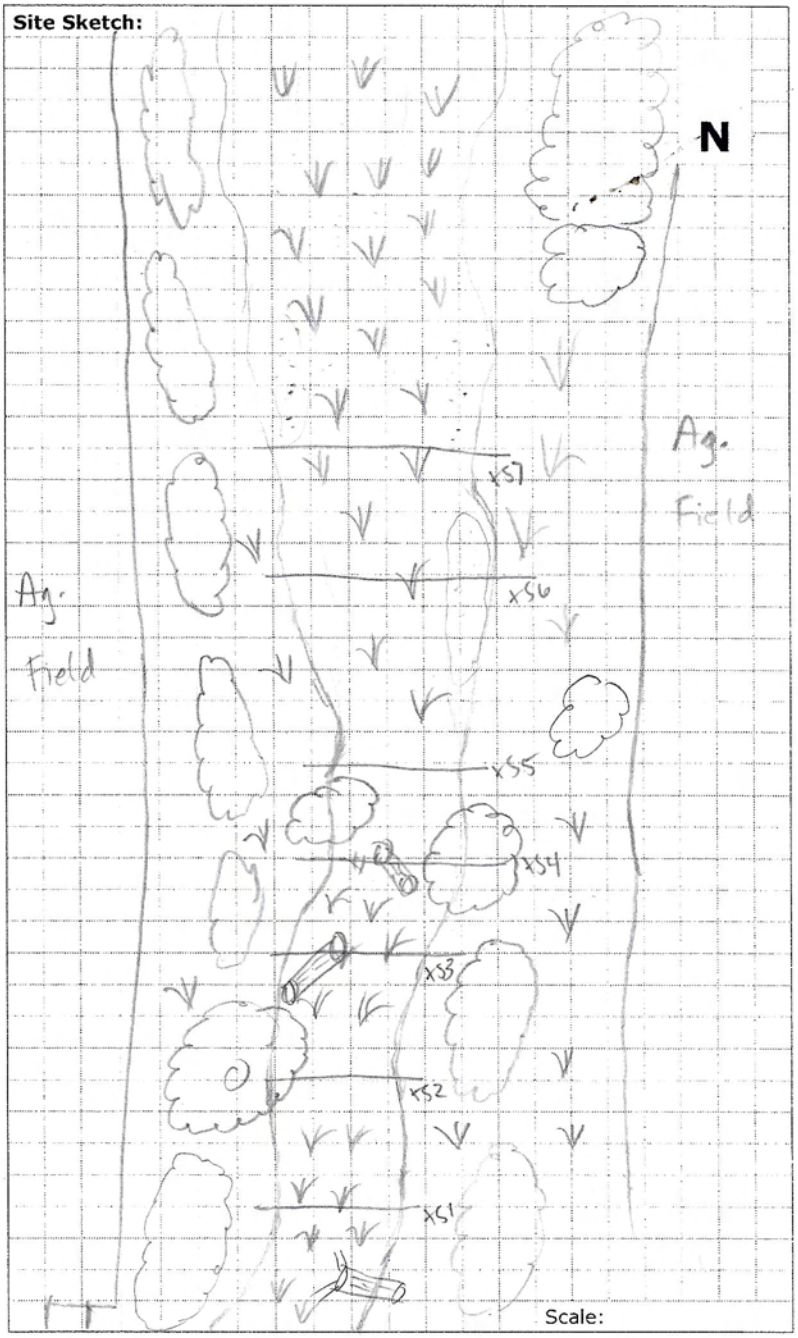
Substrate

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

Other

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

Site Sketch:



Additional Notes:

~40 cm of sediment/organics build up before bed

Completed by: BM2 Checked by: _____

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Rapid Geomorphic Assessment **Project Code:** 17071

Date:	June 22/17	**Stream/Reach:**	FCD2
Weather:	Sunny 25°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG, BM2	**Watershed/Subwatershed:**	

Process	Geomorphic Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		X	0/4
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools		N/A	
	4	Medial bars		X	
	5	Accretion on point bars		N/A	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	4	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			N/A
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut face on bar forms			
	7	Head cutting due to knick point migration		X	0/3
	8	Terrace cut through older bar material		N/A	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	0	3	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		2/7
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots		X	
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		N/A	
		Sum of indices =	2	5	0.28
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0/5
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		N/A	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		N/A	
	7	Bar forms poorly formed / reworked / removed		X	
		Sum of indices =	0	5	0

- riffle pool absent
- point bars absent
- infrastructure absent
- bar forms absent

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.07

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

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Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 21 / 17	**Stream/Reach:**	FCD2
Weather:	sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability — no roots seen	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☐ 7 ☐ 8	☒ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition — N/A	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
N/A	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☒ 8

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

Total overall score (0–42) = 31	**Poor (<13)**	**Fair (13-24)**	**Good (25-34)**	**Excellent (>35)**

Completed by: LG Checked by: _____

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FCD3
Field Staff:	LG BM2	Watercourse:	Frazer Clark Drain
Weather:	Rain 18C	Watershed:	Jock River

Location

lat=45.25976031175945, long=-75.75790180828797, alt=1.5463331083301004, accuracy=12.0

General Characteristics

Land Use:	Agricultural,Residential
Valley Type:	Unconfined
Channel Type:	11 - Straight suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees,Grasses
Dominant Species:	Grass
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Heavy
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	100
Presence of Woody Debris:	Present in Channel
Density of Woody Debris:	Low
Number of WDJs per 50 m:	0
Notes:	

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Low (>2.2)
Bank Failures (Brierley and Fryirs, 2005):	None
Downs Model of Channel Evolution (1995):	S – stable
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt, Organics
Bank Material:	Clay, Silt, Sand
Bank Angle:	0 - 30
Extent of Bank Erosion:	< 5%

Notes:

Channel Measurements

Cross Section #1:

Bankfull Width (m):	11.5	Wetted Width (m):	4
Bankfull Depth (m):	N/A	Wetted Depth (m):	0.12
Velocity (m/s):	0.02	Measurement Type:	Wiffle ball

Cross Section #2: Run

Bankfull Width (m):	12	Wetted Width (m):	3.5
Bankfull Depth (m):	N/A	Wetted Depth (m):	0.11
Velocity (m/s):	N/A	Measurement Type:	N/A

Cross Section #3:

Bankfull Width (m):	13.5	Wetted Width (m):	4
Bankfull Depth (m):	N/A	Wetted Depth (m):	0.15
Velocity (m/s):	N/A	Measurement Type:	N/A

Additional Measurements

Is riffle-pool development absent?	yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes: Height of left bank: 0.60. No notable velocity at cross section 1.

Water Quality

Odour:	None
Turbidity:	Slightly Turbid
Notes:	

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD3
Weather:	rainy, 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM²	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

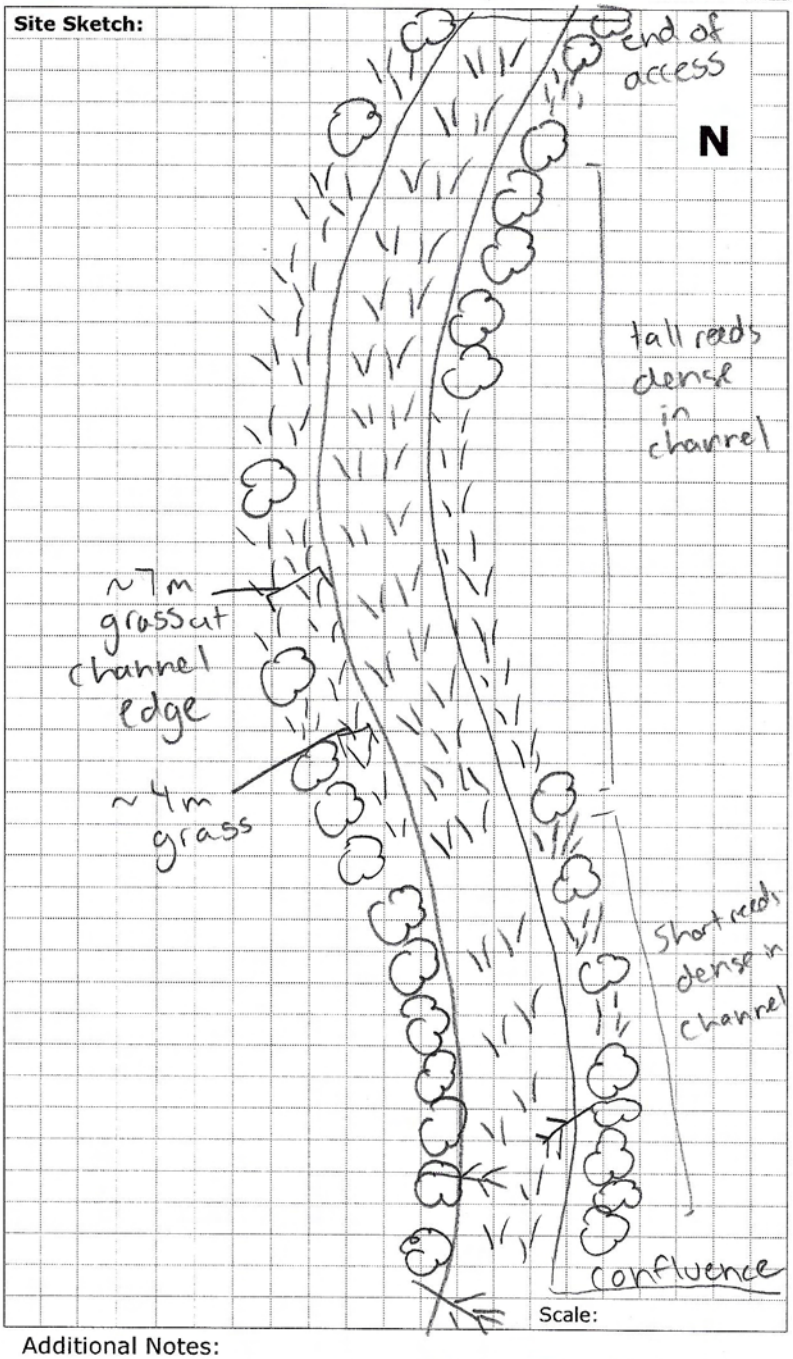
Substrate

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

Other

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

Site Sketch:



Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FC03
Weather:	rainy 20°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG BM²	**Watershed/Subwatershed:**	

Process	No.	Geomorphic Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0.14
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools		N/A	
	4	Medial bars		X	
	5	Accretion on point bars		N/A	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	4	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			0.13
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut face on bar forms			
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		N/A	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	0	3	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		X	1/7
	2	Occurrence of large organic debris	Y		
	3	Exposed tree roots		X	
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		N/A	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		X	
		Sum of indices =	1	6	0.14
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0.15
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		N/A	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed		X	
		Sum of indices =	0	5	0

- no bars
- riffle pool absent
- infrastructure absent
- ask

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.035

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD3
Weather:	rainy 20°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

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

Date:		Reach:		Project Code:	

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

Total overall score (0–42) = 29.5	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FCD3-1
Field Staff:	LG BM2	Watercourse:	Frazer Clark Drain
Weather:	Rain 18C	Watershed:	Jock River

Location

lat=45.25719582508419, long=-75.76280598993611, alt=49.93364386812506, accuracy=12.0

General Characteristics

Land Use:	Agricultural,Residential
Valley Type:	Unconfined
Channel Type:	12 - Sinuous suspended load
Flow Type:	Intermittent
Groundwater:	No
Notes:	No flow . Channel fully encroached by reeds and grasses. Only small puddles of water found .

Riparian Vegetation

Dominant Vegetation Type:	Trees,Grasses
Dominant Species:	Reeds and grasses
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Heavy
Notes:	Grasses and reeds fully encroach channel . Scattered trees present , trees denser at the upstream confluence with FCD3-1 AND FCD4-1

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	100
Presence of Woody Debris:	Not Present
Density of Woody Debris:	None
Number of WDJs per 50 m:	0
Notes:	There may have been debris present , grasses to thick to see anything on the ground

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Low (>2.2)
Bank Failures (Brierley and Fryirs, 2005):	None
Downs Model of Channel Evolution (1995):	S - stable
Riffle Substrate:	N/A
Pool Substrate:	Clay, silt
Bank Material:	Clay,Silt,Sand
Bank Angle:	0 - 30
Extent of Bank Erosion:	< 5%

Notes:

Channel Measurements

Cross Section #1:

Bankfull Width (m):	12	Wetted Width (m):	N/A
Bankfull Depth (m):	N/A	Wetted Depth (m):	N/A
Velocity (m/s):	N/A	Measurement Type:	N/A

Cross Section #2:

Bankfull Width (m):	8	Wetted Width (m):	N/A
Bankfull Depth (m):	N/A	Wetted Depth (m):	N/A
Velocity (m/s):	N/A	Measurement Type:	N/A

Additional Measurements

Is riffle-pool development absent?	yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes:

Water Quality

Odour:	N/A
Turbidity:	N/A
Notes:	No flow

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD3-1
Weather:	rainy 20°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

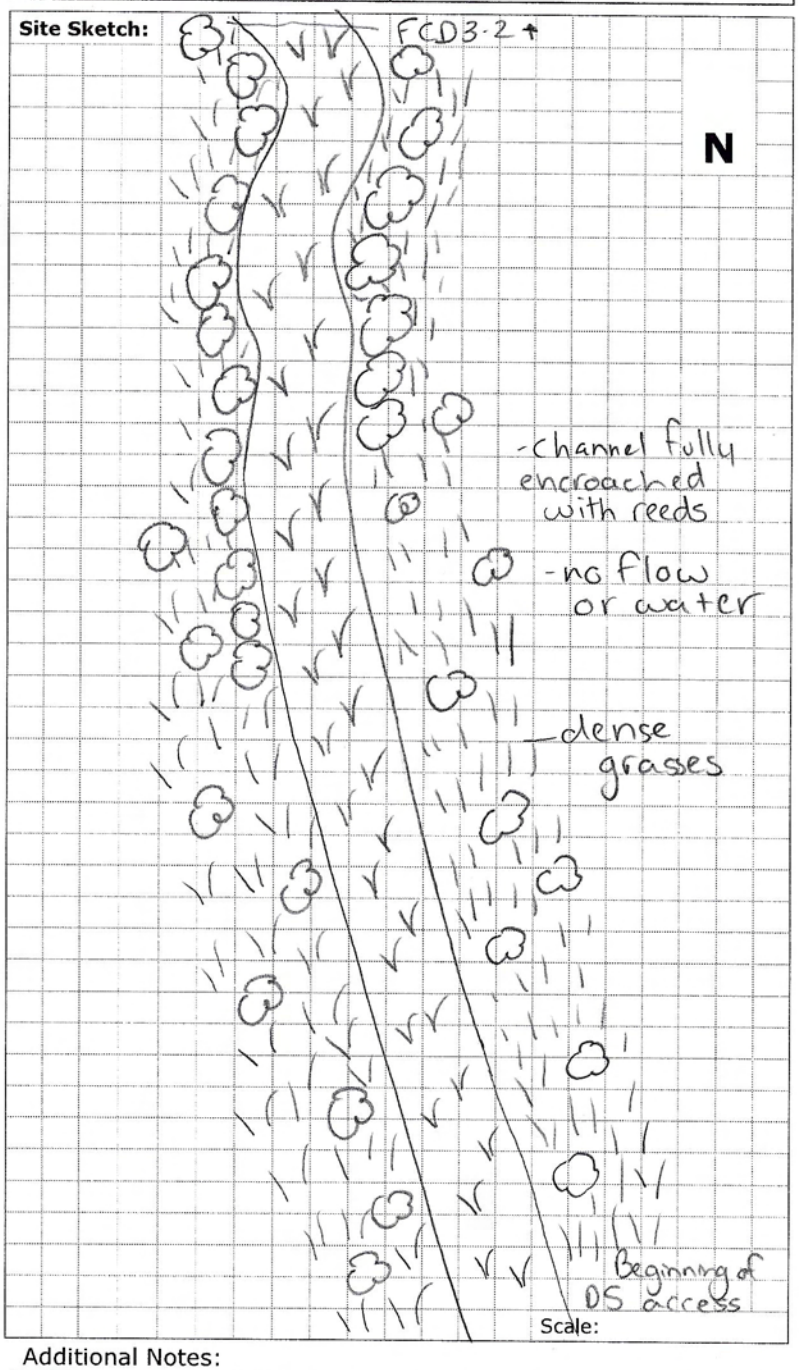
Substrate

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

Other

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

Site Sketch:



Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23 / 17	**Stream/Reach:**	FCD3-1
Weather:	Cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG, BM2	**Watershed/Subwatershed:**	

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

- no flow
- reed / grass encroached
- no bars present
- riffle pool absent
- no infrastructure present

Additional notes:

- no flow
- heavy reed / grass encroachment

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23 17	**Stream/Reach:**	FCD3-1
Weather:	cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BMR	**Watershed/Subwatershed:**	

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

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

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Date:	June 23/17	Reach:	FC03-1	Project Code:	17071

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

Total overall score (0–42) = 30	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LC Checked by: _____

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FCD3-2
Field Staff:	LG BM2	Watercourse:	Frazer Clark Drain
Weather:	Rain 18C	Watershed:	Jock River

Location

lat=45.25550095657881, long=-75.76600135181351, alt=66.9408353150523, accuracy=24.0

General Characteristics

Land Use:	Agricultural, Residential
Valley Type:	Unconfined
Channel Type:	12 – Meandering suspended load
Flow Type:	Intermittent
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Grass, Trees
Dominant Species:	Grass
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Heavy
Notes:	

Aquatic / Instream Vegetation

Type of Instream Vegetation:	Reeds
Coverage of Reach (%):	90%
Presence of Woody Debris:	None
Density of Woody Debris:	N/A
Number of WDJs per 50 m:	N/A
Notes:	

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Low sinuosity
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Slightly
Bank Failures (Brierley and Fryirs, 2005):	N/A
Downs Model of Channel Evolution (1995):	S - stable
Riffle Substrate:	N/A
Pool Substrate:	Silt, organics
Bank Material:	Clay, Silt,
Bank Angle:	0 - 30
Extent of Bank Erosion:	<5%

Notes:

Channel Measurements

Cross Section #1:

Bankfull Width (m):	5.3	Wetted Width (m):	N/A
Bankfull Depth (m):	N/A	Wetted Depth (m):	N/A
Velocity (m/s):	N/A	Measurement Type:	N/A

Cross Section #2:

Bankfull Width (m):	4	Wetted Width (m):	N/A
Bankfull Depth (m):	N/A	Wetted Depth (m):	N/A
Velocity (m/s):	N/A	Measurement Type:	N/A

Cross Section #3:

Bankfull Width (m):	2.9	Wetted Width (m):	N/A
Bankfull Depth (m):	N/A	Wetted Depth (m):	N/A
Velocity (m/s):	N/A	Measurement Type:	N/A

Additional Measurements

Is riffle-pool development absent?	Yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes:

Water Quality

Odour: N/A

Turbidity:	N/A
Notes:	

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General Site Characteristics

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FC302
Weather:	rainy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG, BM²	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

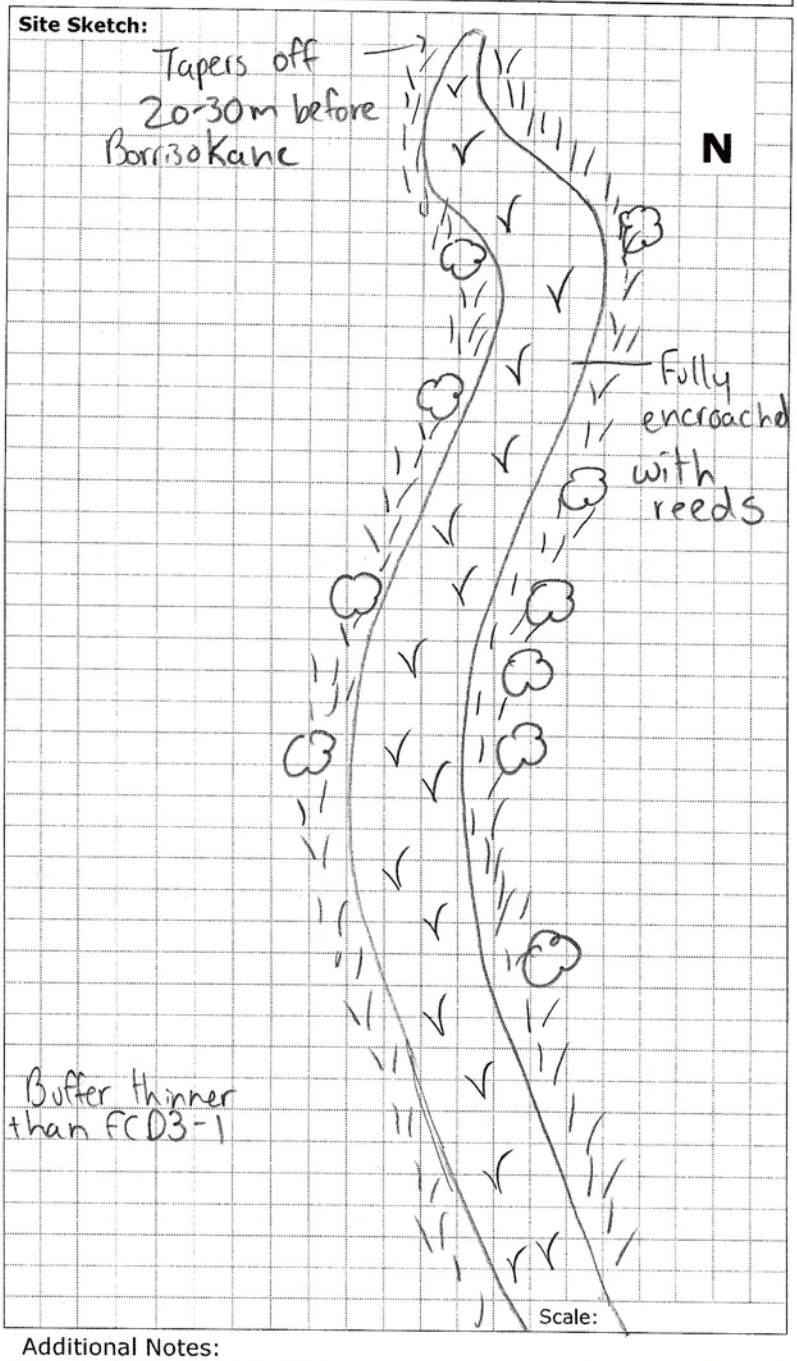
Substrate

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

Other

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

Site Sketch:



Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD3-2
Weather:	rainy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

Additional notes:
- no flow
- reed / grass encroached

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD3-2
Weather:	rainy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BMZ	**Watershed/Subwatershed:**	

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

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

Date:		Reach:		Project Code:	

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

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

Completed by: LG Checked by: _____

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FCD5
Field Staff:	LG BM2	Watercourse:	Frazer Clark Drain
Weather:	Cloudy 20 degrees	Watershed:	Jock River

Location

General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	11 – Straight suspended load
Flow Type:	Intermittent
Groundwater:	No
Notes:	No water present.

Riparian Vegetation

Dominant Vegetation Type:	Grasses, Trees
Dominant Species:	Grass
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 – 4Widths
Riparian Age Class:	Established
Extent of Encroachment into channel:	Heavy
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Reeds
Coverage of Reach (%):	100%
Presence of Woody Debris:	Not present
Density of Woody Debris:	None
Number of WDJs per 50 m:	0
Notes:	

Channel Characteristics

Type of Sinuosity:	N/A
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Slightly Entrenched
Bank Failures (Brierley and Fryirs, 2005):	N/A
Downs Model of Channel Evolution (1995):	S – stable
Riffle Substrate:	N/A
Pool Substrate:	N/A
Bank Material:	Clay, Silt, Sand
Bank Angle:	0 – 30
Extent of Bank Erosion:	<5%

Notes:

Channel Measurements

Additional Measurements

Is riffle-pool development absent?	Yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes:

Water Quality

Odour:	N/A
Turbidity:	N/A
Notes:	

GEO MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD5
Weather:	Cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

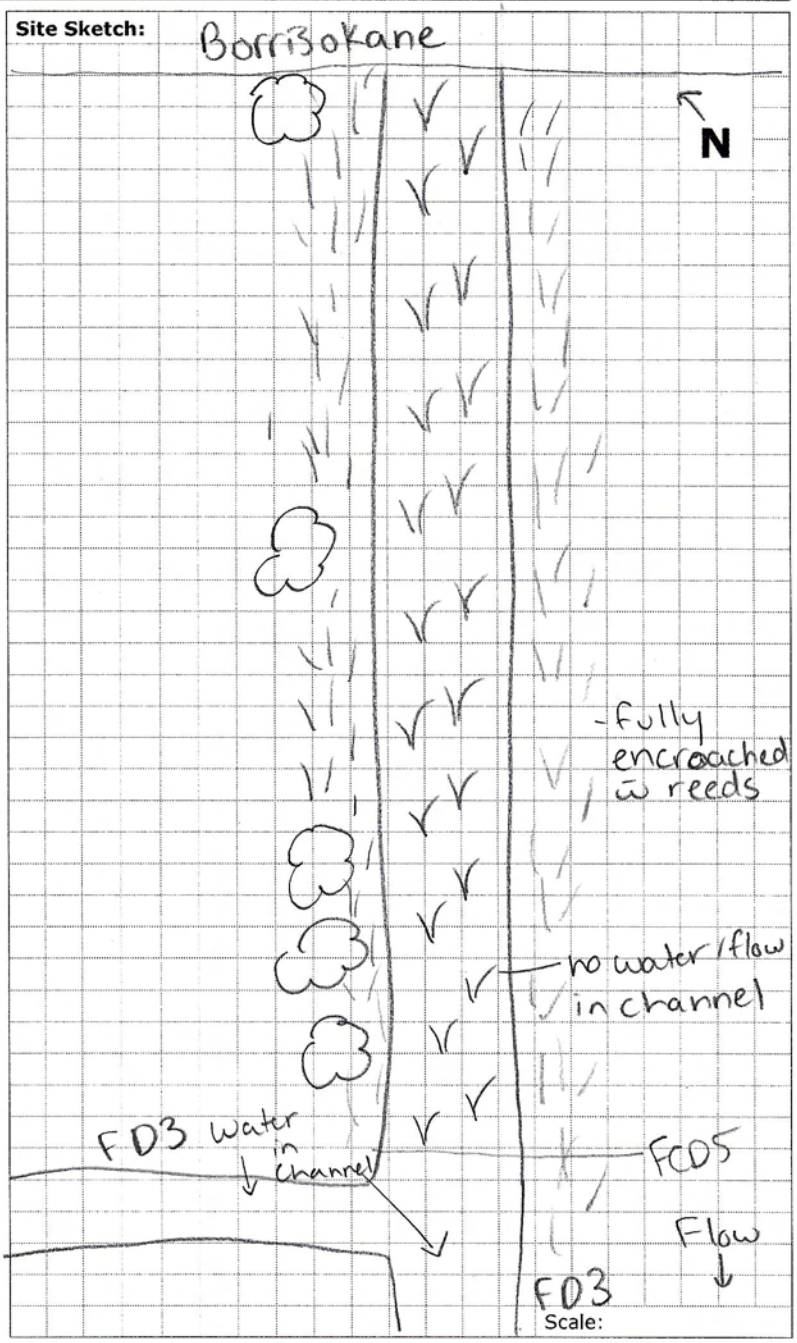
Substrate

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

Other

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

Site Sketch:



Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD5
Weather:	Cloudy 20°	**Location:**	Ottawa - Borrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

- no water
- riffle/pool absent
- no infrastructure
- no bars

Additional notes:

- no water
- reeds fully encroached

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

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Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FCD5
Weather:	cloudy 20°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

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

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Date:	June 23/17	Reach:	FCD5	Project Code:	17071

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

Total overall score (0–42) = 28.5	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

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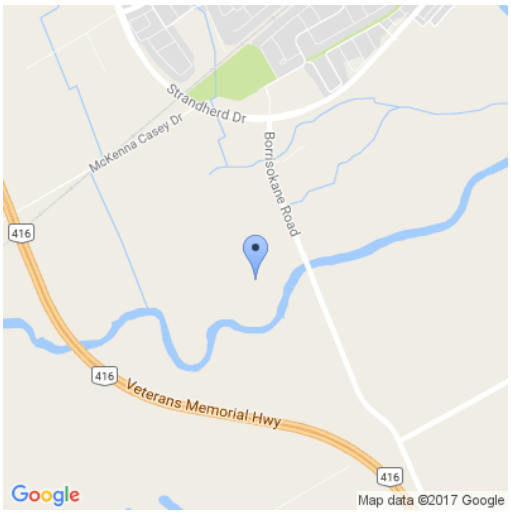
Project Number: PN17071

Reach Characteristics

Date:	2017-06-22	Reach:	FD1
Field Staff:	LG BM2	Watercourse:	Foster Drain
Weather:	Sunny 25 degrees	Watershed:	Jock River

Location



lat=45.25182925690391, long=-75.768392678713, alt=61.008241515689946, accuracy=12.0

General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	12 - Sinuous suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees,Grasses
Dominant Species:	Grasses
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Minimal
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Submergent
Coverage of Reach (%):	80
Presence of Woody Debris:	Present in Channel
Density of Woody Debris:	Low
Number of WDJs per 50 m:	0
Notes:	Rooted emergent and submergent veg.

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Straight
Gradient:	Low
Number of Channels:	Single
Entrenchment:	High (<1.4)
Bank Failures (Brierley and Fryirs, 2005):	Undercutting (Hydraulic Action)
Downs Model of Channel Evolution (1995):	S – Stable – no observable morphological change
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt
Bank Material:	Clay, Silt
Bank Angle:	60 - 90
Extent of Bank Erosion:	30 - 60%

Notes: Riffle pool sequence absent .

Channel Measurements

Additional Measurements

Is riffle-pool development absent?	Yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	0.20,

Notes: 50-75% erosion extent along reach .

Water Quality

Odour:	None
Turbidity:	Clear
Notes:	Slightly turbid to opaque, appears clear because of bed sediment being close to surface

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General Site Characteristics

Project Code: 17071

Date:	June 22/17	**Stream/Reach:**	FD1
Weather:	Cloudy 20°	**Location:**	
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

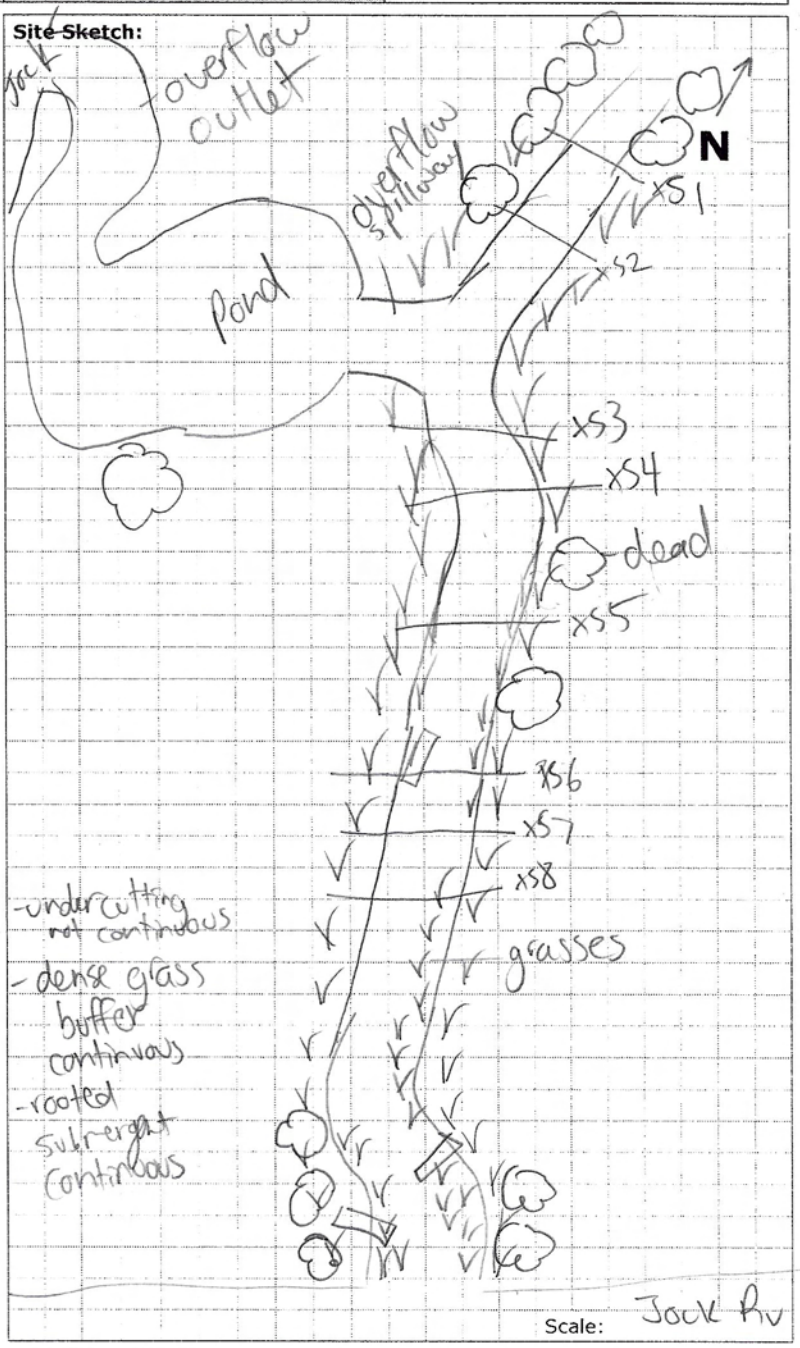
Substrate

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

Other

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

Site Sketch:



Scale:

Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment **Project Code:** 17071

Date:	June 22 / 17	**Stream/Reach:**	FD1
Weather:	cloudy 20°	**Location:**	Nepean/Ottawa
Field Staff:	BM2 LG	**Watershed/Subwatershed:**	

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

b/c of riprap

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

Rapid Stream Assessment Technique

Project Code: 1707

Date:	June 22/17	**Stream/Reach:**	FD1
Weather:	Cloudy 20°	**Location:**	Nepean / Ottawa
Field Staff:	BMZ LG	**Watershed/Subwatershed:**	

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure 10
	• 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 8
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 10 clay in OS
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped 8	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☐ 7 ☐ 8	☑ 9 ☐ 10 ☐ 11

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

Date:		Reach:		Project Code:	
Evaluation Category	**Poor**	**Fair**	**Good**	**Excellent**
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 8
	• 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) 1	• 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)
	N/A • 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
	N/A • 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
	N/A • 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 8
	N/A • 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 8
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4**	☐ **5** ☐ **6** 1	☐ **7** ☐ **8**
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4**	☐ **5** ☒ **6**	☐ **7** ☐ **8**
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ **0** ☒ **1**	☐ **2** ☐ **3**	☐ **4** ☐ **5**	☐ **6** ☐ **7**

Total overall score (0–42) = 30.5	**Poor (<13)**	**Fair (13-24)**	**Good (25-34)**	**Excellent (>35)**

Completed by: LG Checked by: _____

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Project Number: PN17071

Reach Characteristics

Date:	2017-06-22	Reach:	FD2
Field Staff:	LG BM2	Watercourse:	Foster Drain
Weather:	Cloudy 20 degrees	Watershed:	Jock River

Location

lat=45.25212204614041, long=-75.7685473728085, alt=69.52584001778119, accuracy=16.0

General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	12 – Sinuous, suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees, Shrubs, Grasses
Dominant Species:	Grass
Riparian Coverage:	Continuous
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Minimal
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	55
Presence of Woody Debris:	Present in Cutbank, Present in Channel
Density of Woody Debris:	Moderate
Number of WDJs per 50 m:	2
Notes:	Extensive reed encroachment in channel, rooted submergent plants, algae

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Low sinuosity (1.06-1.30)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	Slightly
Bank Failures (Brierley and Fryirs, 2005):	Undercutting (hydraulic action)
Downs Model of Channel Evolution (1995):	S - Stable – no observable morphological change
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt
Bank Material:	Clay, Silt
Bank Angle:	60 - 90
Extent of Bank Erosion:	0 – 30%

Notes:

Channel Measurements

Cross Section #1: Run

Bankfull Width (m):	7.7	Wetted Width (m):	5.7
Bankfull Depth (m):	1.15	Wetted Depth (m):	0.14
Velocity (m/s):	0.2	Measurement Type:	Wiffle Ball

Cross Section #2: Run

Bankfull Width (m):	7.5	Wetted Width (m):	5
Bankfull Depth (m):	1.2	Wetted Depth (m):	0.11
Velocity (m/s):	0.14	Measurement Type:	Wiffle Ball

Additional Measurements

Is riffle-pool development absent?	yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	0.10

Notes: Cross Section 1 near culvert at upstream break.
Cross Section 2 downstream at bend near woody debris.

Water Quality

Odour:	None
Turbidity:	Clear
Notes:	Slightly organic smell

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General Site Characteristics

Project Code: 17071

Date:	June 22/17	**Stream/Reach:**	FD2
Weather:	cloudy 20°	**Location:**	Nepean, Ottawa
Field Staff:	BMZ LG	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

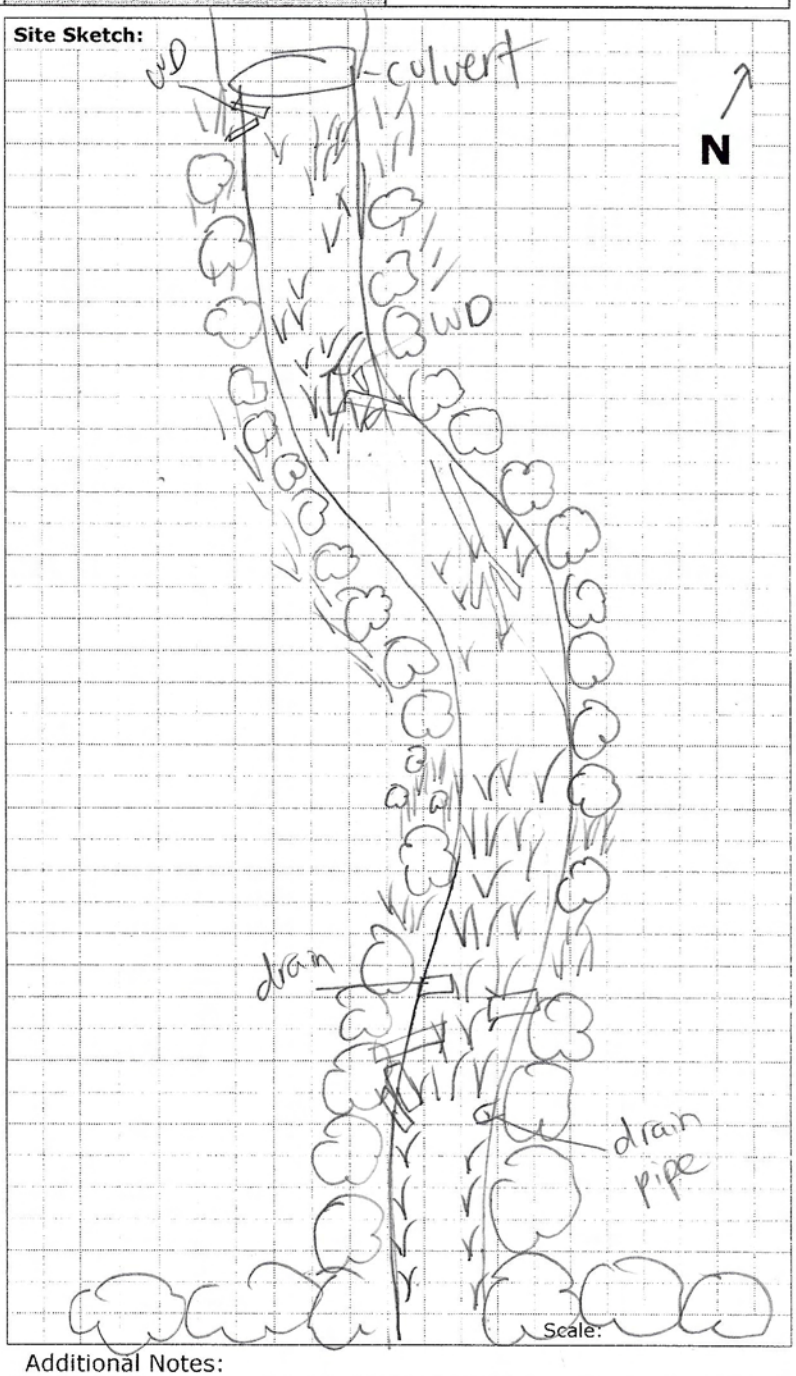
Substrate

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

Other

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

Site Sketch:



Additional Notes:

pic 379 start

last pic 403

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FD2
Weather:	cloudy 20	**Location:**	Ottawa-Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Process	No.	Geomorphic Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0/4
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools		N/A	
	4	Medial bars		X	
	5	Accretion on point bars		N/A	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	4	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		↓	N/A
	2	Exposed sanitary / storm sewer / pipeline / etc.		↓	
	3	Elevated storm sewer outfall(s)		↓	
	4	Undermined gabion baskets / concrete aprons / etc.		↓	
	5	Scour pools downstream of culverts / storm sewer outlets		X	0/4
	6	Cut face on bar forms		N/A	
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		N/A	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	0	4	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		4/7
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.	X		
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		N/A	
		Sum of indices =	4	3	0.57
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0/4
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		N/A	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form			
	7	Bar forms poorly formed / reworked / removed		N/A	
		Sum of indices =	0	4	0

- riffle pool absent - bars absent

drain pipe but we think it was placed like that

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.14

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

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Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	ED2
Weather:	Cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG, BM2	**Watershed/Subwatershed:**	

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

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

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Date:	June 23/17	Reach:	FD2	Project Code:	17071

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

Total overall score (0–42) = 31	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

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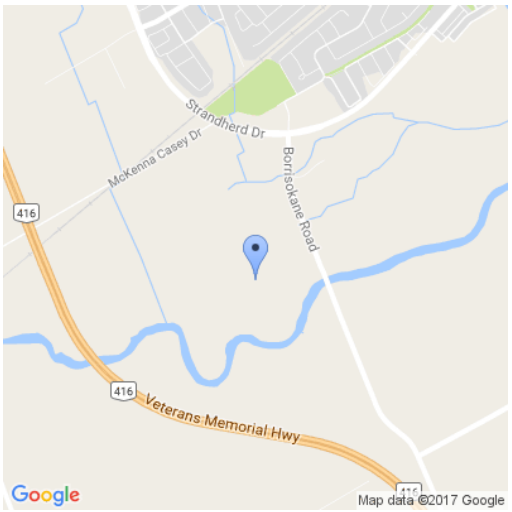
Project Number: PN17071

Reach Characteristics

Date:	2017-06-23	Reach:	FD3
Field Staff:	LG BM2	Watercourse:	Foster Drain
Weather:	Cloudy 20 degrees	Watershed:	Jock River

Location



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General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	11 - Straight suspended load
Flow Type:	Perennial
Groundwater:	no
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees,Grasses
Dominant Species:	Grass
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Minimal
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Submergent
Coverage of Reach (%):	75
Presence of Woody Debris:	Present in Channel
Density of Woody Debris:	Low
Number of WDJs per 50 m:	0.25
Notes:	1 large WDJ causing extensive back watering Rooted submergent dominant, emergent also moderately present

Channel Characteristics

Type of Sinuosity:	N/A
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	High (<1.4)
Bank Failures (Brierley and Fryirs, 2005):	Undercutting (Hydraulic Action)
Downs Model of Channel Evolution (1995):	S – Stable – no observable morphological change
Riffle Substrate:	N/A
Pool Substrate:	N/A
Bank Material:	Clay, Silt, Sand
Bank Angle:	60 - 90, Undercut
Extent of Bank Erosion:	30 - 60%

Notes:

Channel Measurements

Cross Section #1: Run

Bankfull Width (m):	8.2	Wetted Width (m):	5.4
Bankfull Depth (m):	N/A	Wetted Depth (m):	0.31
Velocity (m/s):	0.22	Measurement Type:	Wiffle Ball

Cross Section #2:

Bankfull Width (m):	5.5	Wetted Width (m):	4.3
Bankfull Depth (m):	N/A	Wetted Depth (m):	0.48
Velocity (m/s):	0.15	Measurement Type:	Wiffle Ball

Additional Measurements

Is riffle-pool development absent?	Yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	0.08 , most likely higher in some areas

Notes: Upstream of culvert bank height ~1.4

Water Quality

Odour:	None
Turbidity:	Opaque
Notes:	Turbid/ opaque

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Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FD3
Weather:	cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

Substrate

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

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
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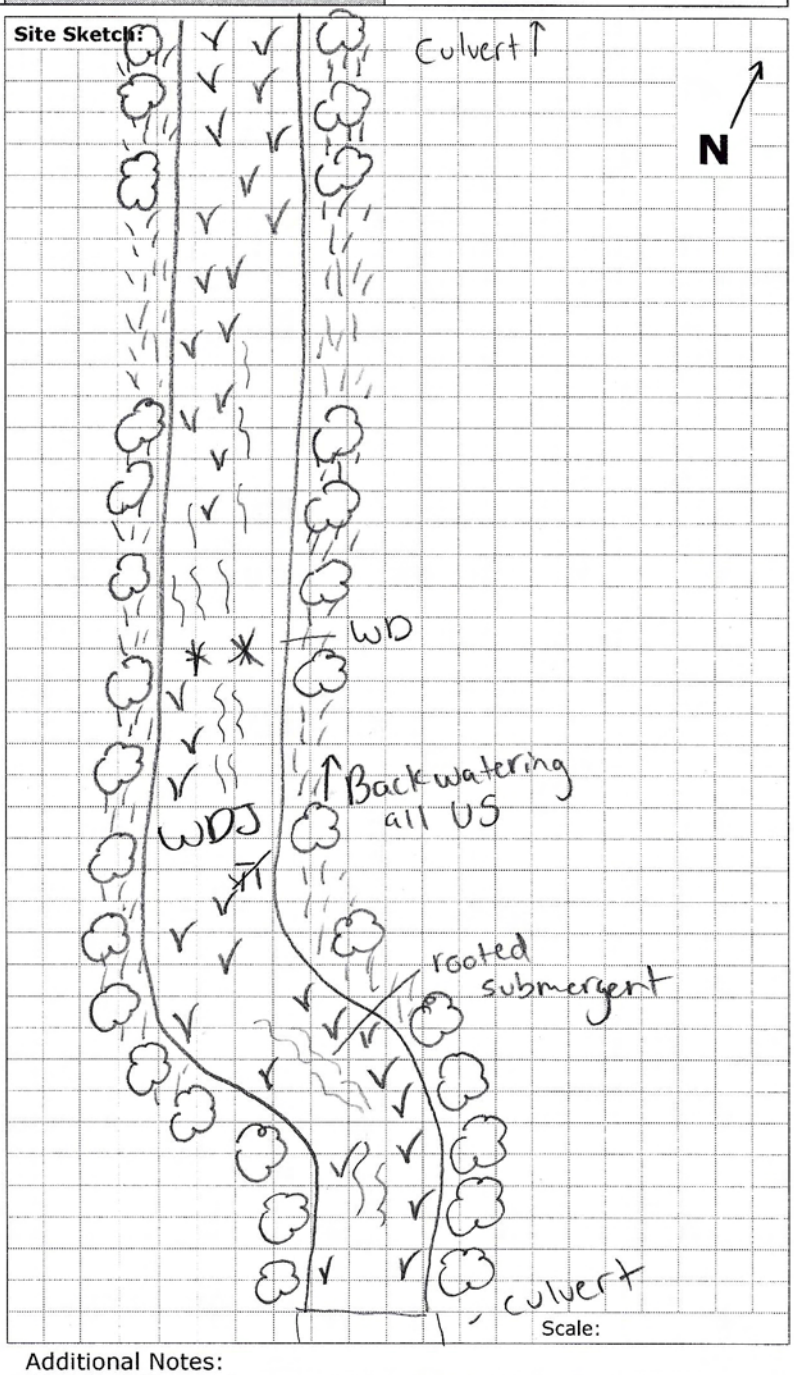
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Additional Notes:

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 23 / 17	**Stream/Reach:**	FD3
Weather:	cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM²	**Watershed/Subwatershed:**	

Process	No.	Geomorphic Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0/4
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools		N/A	
	4	Medial bars		X	
	5	Accretion on point bars		N/A	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	4	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		↓	N/A
	2	Exposed sanitary / storm sewer / pipeline / etc.		↓	
	3	Elevated storm sewer outfall(s)		↓	
	4	Undermined gabion baskets / concrete aprons / etc.		↓	
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		N/A	0/4
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		N/A	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	0	4	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		3/7
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		N/A	
		Sum of indices =	3	4	0.42
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0/5
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		N/A	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		N/A	
	7	Bar forms poorly formed / reworked / removed		X	
		Sum of indices =	0	5	0

-riffle pool absent
-bars absent

causing backwater + large WOD

at lower end before backwater

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.11

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

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Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 23/17	**Stream/Reach:**	FD3
Weather:	Cloudy 20°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

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

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Date:	June 23/17	Reach:	FD3	Project Code:	17071

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

Total overall score (0–42) = 30	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

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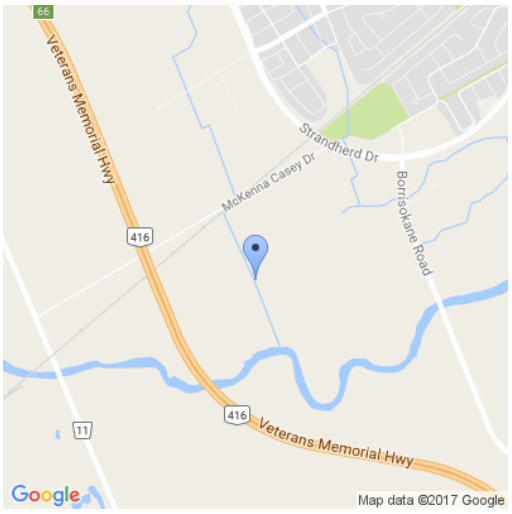
Project Number: PN17071

Reach Characteristics

Date:	2017-06-20	Reach:	OK D1
Field Staff:	BM2, LG	Watercourse:	O'Keefe Drain
Weather:	Sunny and cloudy 25 degrees	Watershed:	Jock River

Location



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General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	11 - Straight suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Trees,Shrubs,Grasses
Dominant Species:	Trees, shrubs, some grasses
Riparian Coverage:	Continuous
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Minimal
Notes:	

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	5
Presence of Woody Debris:	Present in Channel
Density of Woody Debris:	High
Number of WDJs per 50 m:	2
Notes:	

Channel Characteristics

Type of Sinuosity:	Sinuous
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	High (<1.4)
Bank Failures (Brierley and Fryirs, 2005):	Fluvial Entrainment (Hydraulic Action), Undercutting
Downs Model of Channel Evolution (1995):	e - intiation of continuous erosion
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt, Sand, Organics
Bank Material:	Clay, Silt
Bank Angle:	60 - 90, Undercut
Extent of Bank Erosion:	60 - 100%

Notes: Extensive undercutting and exposed roots.

Channel Measurements

Cross Section #1: Run

Bankfull Width (m):	N/A	Wetted Width (m):	2.5
Bankfull Depth (m):	1.4	Wetted Depth (m):	0.14
Velocity (m/s):	0.2	Measurement Type:	Wiffle ball

Cross Section #2: Run

Bankfull Width (m):	N/A	Wetted Width (m):	2.4
Bankfull Depth (m):	1.6	Wetted Depth (m):	0.19
Velocity (m/s):	0.14	Measurement Type:	Wiffle ball

Cross Section #3: Run

Bankfull Width (m):	N/A	Wetted Width (m):	1.5
Bankfull Depth (m):	2	Wetted Depth (m):	0.12
Velocity (m/s):	0.2	Measurement Type:	Wiffle ball

Additional Measurements

Is riffle-pool development absent?	yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	0.30, 0.80, 0.40,

Notes:

Water Quality

Odour:	None
Turbidity:	Turbid
Notes:	

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General Site Characteristics

Project Code: 17071

Date:	June 20/17	**Stream/Reach:**	OKD1
Weather:	Sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BMZ	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

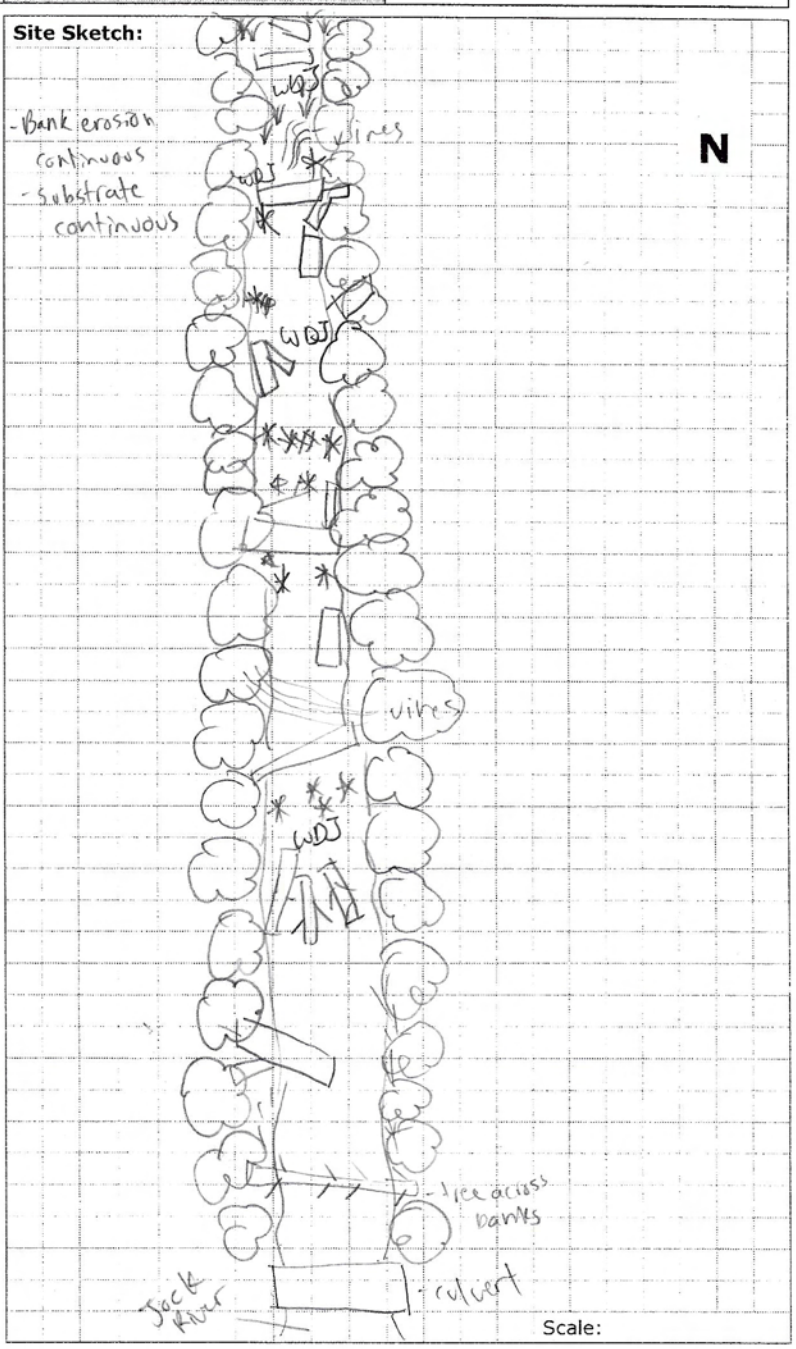
Substrate

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

Other

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

Site Sketch:



Additional Notes:

pictures 12 - 100 reach

Completed by: LG Checked by: _____

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Rapid Stream Assessment Technique

Project Code: 17071

Date:	Jun 20/17	**Stream/Reach:**	OKD1
Weather:	Sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

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

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Date:	June 20/17	Reach:	OK01	Project Code:	17071

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

Total overall score (0–42) = 30	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

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Rapid Geomorphic Assessment **Project Code:** 17071

Date:	June 2017	**Stream/Reach:**	OK01
Weather:	Sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BMZ	**Watershed/Subwatershed:**	

Process	No.	Geomorphic Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0.14
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools		N/A	
	4	Medial bars		X	
	5	Accretion on point bars		N/A	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	0	4	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			N/A 0.13
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut face on bar forms			
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		N/A	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	0	3	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		straight channel 3.16
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		N/A	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		N/A	
		Sum of indices =	3	3	0.5
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0.14
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		N/A	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		N/A	
	7	Bar forms poorly formed / reworked / removed		N/A	
		Sum of indices =	0	4	0

- riffle pool absent
- infrastructure absent
- bars absent

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.125

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: LG Checked by: _____

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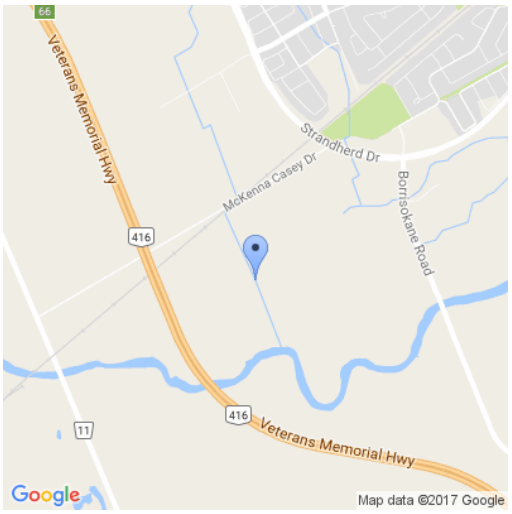
Project Number: PN17071

Reach Characteristics

Date:	2017-06-21	Reach:	OKD2
Field Staff:	LG BM2	Watercourse:	O'Keefe Drain
Weather:	Sun and cloud 18C	Watershed:	Jock River

Location



lat=45.253683882781495, long=-75.77752606140785, alt=57.03539215789929, accuracy=6.0

General Characteristics

Land Use:	Agricultural
Valley Type:	Unconfined
Channel Type:	11 - Straight suspended load
Flow Type:	Perennial
Groundwater:	No
Notes:	

Riparian Vegetation

Dominant Vegetation Type:	Grasses, trees
Dominant Species:	Grass
Riparian Coverage:	Fragmented
Width of Riparian Zone:	1 - 4 Channel Widths
Riparian Age Class:	Established (5-30 years)
Extent of Encroachment into channel:	Moderate
Notes:	A few trees scattered along banks.

Aquatic/Instream Vegetation

Type of Instream Vegetation:	Rooted Emergent
Coverage of Reach (%):	100
Presence of Woody Debris:	Not Present
Density of Woody Debris:	None
Number of WDJs per 50 m:	0
Notes:	Top half of reach heavily encroached with reeds.

Channel Characteristics

Type of Sinuosity:	N/A
Degree of Sinuosity:	Straight (1 - 1.05)
Gradient:	Low
Number of Channels:	Single
Entrenchment:	High (<1.4)
Bank Failures (Brierley and Fryirs, 2005):	Fall/Sloughing (Mass Failure)
Downs Model of Channel Evolution (1995):	C – Compound – aggradation of channel bed with erosion of channel banks
Riffle Substrate:	N/A
Pool Substrate:	Clay, Silt
Bank Material:	Clay, Silt
Bank Angle:	60 - 90,Undercut
Extent of Bank Erosion:	30 - 60%

Notes:	Two erosion scars, potentially from sloughing brought on by undercutting photos 191-192 Significant erosion on the sides of the upstream culvert photos 183-185

Channel Measurements

Additional Measurements

Is riffle-pool development absent?	Yes
Riffle-pool Spacing (m):	N/A
% Riffles:	N/A
% Pools:	N/A
Meander Amplitude (m):	N/A
Pool Depth (m):	N/A
Riffle Length (m):	N/A
Undercuts (m):	N/A

Notes:

Water Quality

Odour:	None
Turbidity:	Opaque
Notes:	

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Environmental Geology, Earth Science Observations

General Site Characteristics

Project Code: 17071

Date:	June 21	**Stream/Reach:**	OK-D2
Weather:	cloudy 20°	**Location:**	Ottawa-Barrhaven
Field Staff:	LG, BMP	**Watershed/Subwatershed:**	

Features

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

Flow Type

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

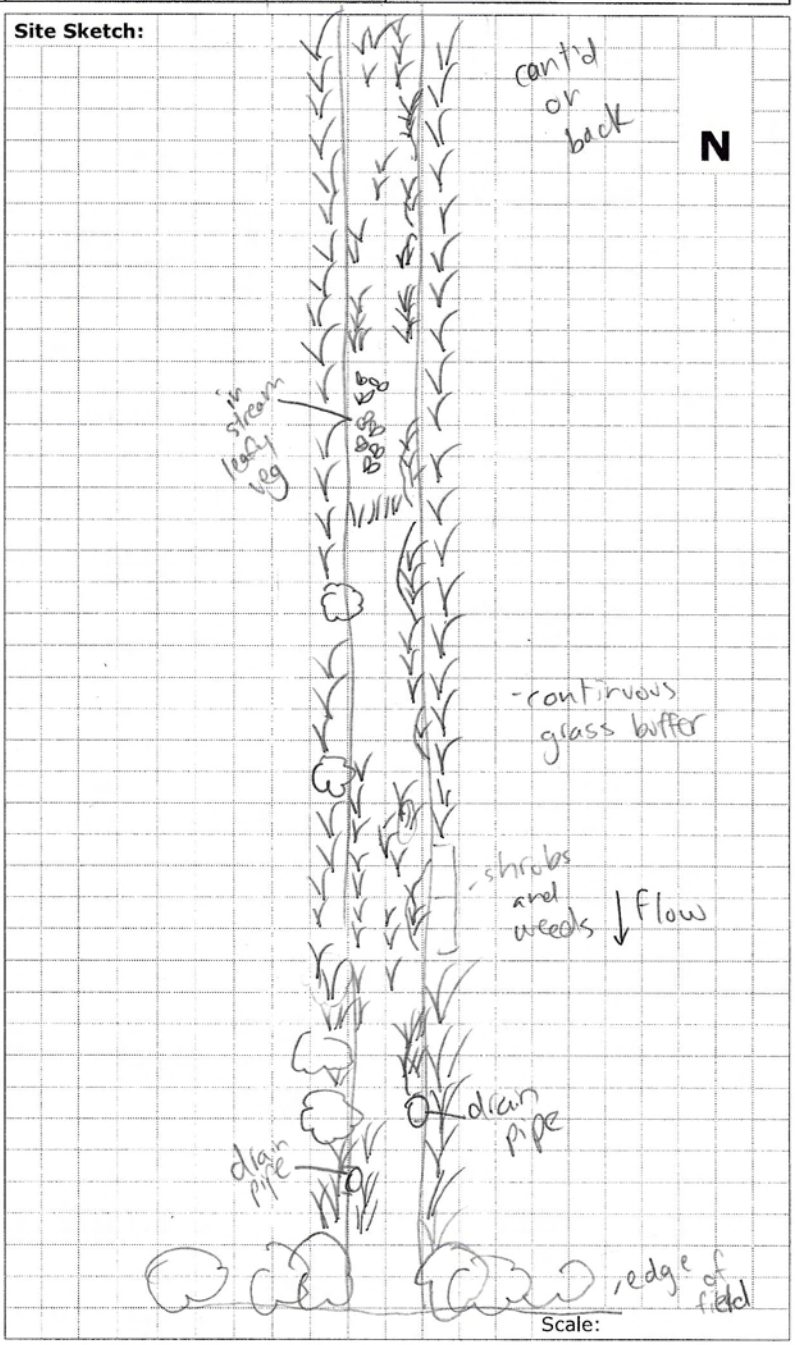
Substrate

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

Other

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

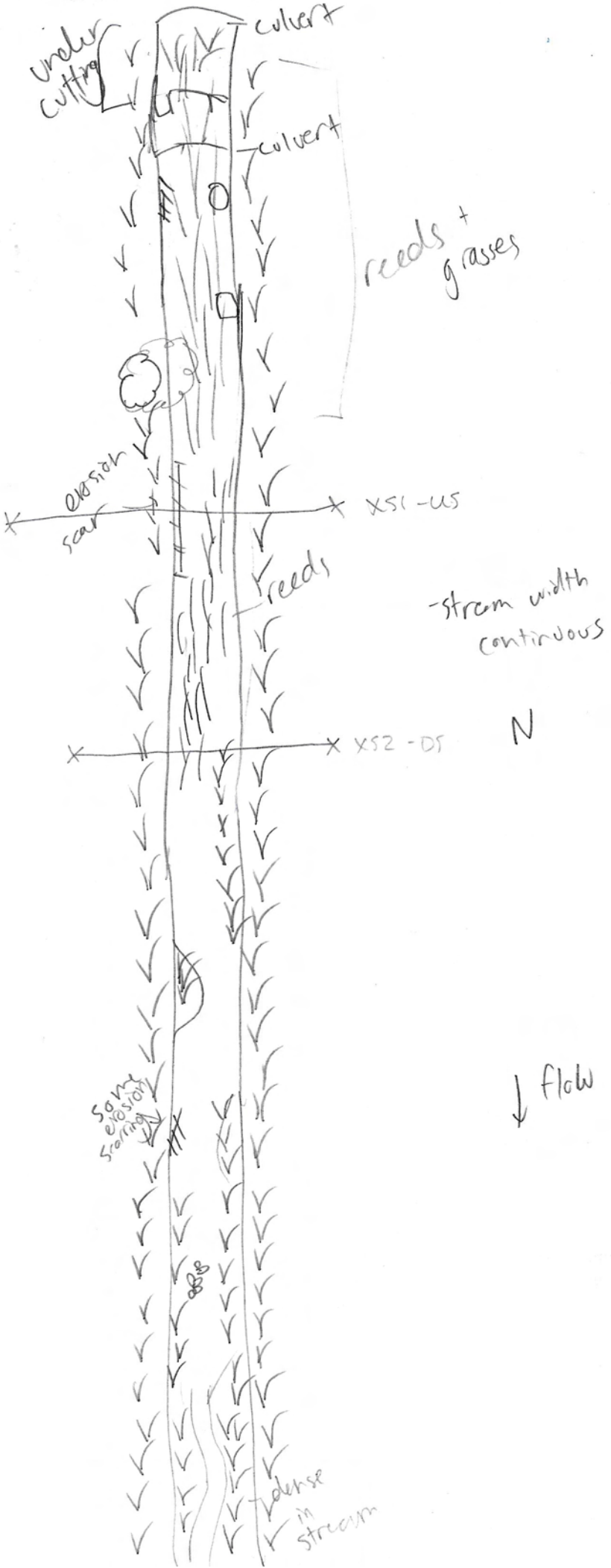
Site Sketch:



Additional Notes:

Photos #142 - 187

Completed by: LG Checked by: _____


culvert
undercutting
culvert
reeds + grasses
erosion scar
XS1 - US
reeds
-stream width continuous
XS2 - DS
N
some erosion scarring
flow
dense in stream

GEO | MORPHIX

Rapid Stream Assessment Technique

Project Code: 17071

Date:	June 21/17	**Stream/Reach:**	OKD2
Weather:	sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM²	**Watershed/Subwatershed:**	

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure 7	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure → erosion scars
N/A straight	• 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
no roots seen	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile 11
	• 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 8	• 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 8	• Channel cross-section is generally V- or U-shaped
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4** ☐ **5**	☐ **6** ☐ **7** ☐ **8**	☐ **9** ☐ **10** ☐ **11**

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

Date:		Reach:		Project Code:	

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

Total overall score (0–42) = 29.5	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: LG Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: 17071

Date:	June 21 / 17	**Stream/Reach:**	OK D2
Weather:	sunny 25°	**Location:**	Ottawa - Barrhaven
Field Staff:	LG BM2	**Watershed/Subwatershed:**	

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

- riffle pool absent
- bars absent
- infrastruc absent

erosion around culvert - its exposed row @ US break

- ask

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Completed by: _____ Checked by: _____

Appendix E RGA and RSAT Results

GEO MORPHIX

RGA Results

O'Keefe Drain, Foster Drain, and Fraser-Clarke Drain

Barrhaven, Ottawa

Legend

1:12,000

N

Reach break

Drainage Feature

O'Keefe Drain (OKD)

Foster Drain (FD)

Fraser-Clarke Drain (FCD)

Not present at time of assessment

RGA Condition

In Regime

Reach break: Stantec, 2007. PARISH Geomorphic Ltd., 2013, and GEO Morphix Ltd., 2017.
Drainage Feature: MNRF, 2010, City of Ottawa, 2016, and GEO Morphix Ltd., 2017.
RGA Condition: GEO Morphix Ltd., 2017. Imagery: Google Earth Pro, 2016.

GEO MORPHIX

RSAT Results

O'Keefe Drain, Foster Drain, and Fraser-Clarke Drain

Barrhaven, Ottawa

Legend

1:12,000

N

Reach break

Drainage Feature

- O'Keefe Drain (OKD)
- Foster Drain (FD)
- Fraser-Clarke Drain (FCD)
- Not present at time of assessment

RSAT Condition

- Good
- N/A

Reach break: Stantec, 2007. PARISH Geomorphic Ltd., 2013, and GEO Morphix Ltd., 2017.
Drainage Feature: MNRF, 2010, City of Ottawa, 2016, and GEO Morphix Ltd., 2017.
RSAT Condition: GEO Morphix Ltd., 2017. Imagery: Google Earth Pro, 2016.

Appendix F Detailed Assessments Locations

GEO MORPHIX

Detailed Assessments

O'Keefe Drain, Foster Drain, and Fraser-Clarke Drain

Barrhaven, Ottawa

Legend

1:12,000

N

Reach break

Drainage Feature

- O'Keefe Drain (OKD)
- Foster Drain (FD)
- Fraser-Clarke Drain (FCD)
- Not present at time of assessment

Detailed Assessment

- GEO Morphix Ltd. (2017)

Reach break: Stantec, 2007, PARISH Geomorphic Ltd., 2013, and GEO Morphix Ltd., 2017.
Drainage Feature: MNRF, 2010, City of Ottawa, 2016, and GEO Morphix Ltd., 2017.
Detailed Assessment: GEO Morphix Ltd., 2017. Imagery: Google Earth Pro, 2016.

Appendix G Detailed Assessment Summaries

Detailed Geomorphological Assessment Summary

Reach FCD2

Project Number:	PN17071	Date:	June 20/ 2017
Client:	David Schaeffer Engineering Ltd.	Length Surveyed (m):	99.4
Location:	Barrhaven, Ottawa	# of Cross-Sections:	7

Reach Characteristics

Drainage Area:	Not measured	Dominant Riparian Vegetation Type:	Shrubs and grasses
Geology/Soils:	Clay Plains	Extent of Riparian Cover:	Fragmented
Surrounding Land Use:	Agricultural, Residential	Width of Riparian Cover:	1 - 4 Channel widths
Valley Type:	Unconfined	Age Class of Riparian Vegetation:	Established (5-30 years)
Dominant Instream Vegetation Type:	Rooted emergent	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	70%	Density of Woody Debris:	Low

Hydrology

Measured Discharge (m^3/s):	0.04	Calculated Bankfull Discharge (m^3/s):	0.42
Modelled 2-year Discharge (m^3/s):	Not modelled	Calculated Bankfull Velocity (m/s):	0.19
Modelled 2-year Velocity (m/s):	Not modelled		

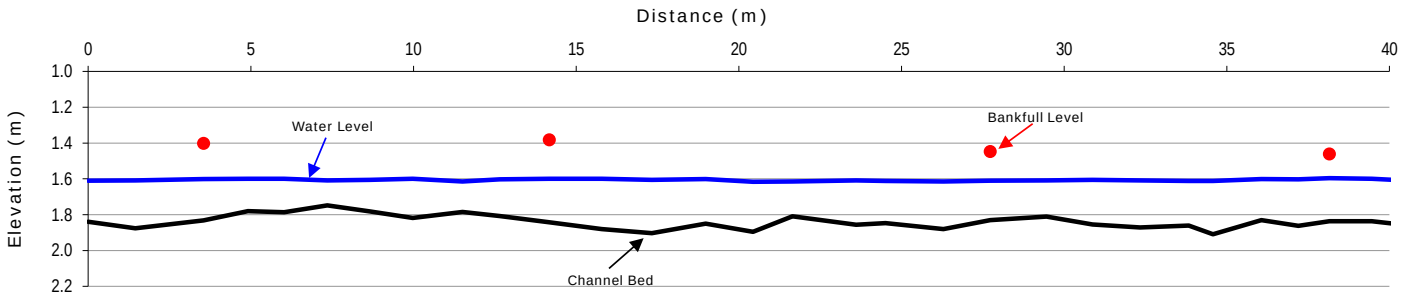
Profile Characteristics

Bankfull Gradient (%):	0.17
Channel Bed Gradient (%):	0.12
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.79
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.3	0.60	0.46
Bank Angle (deg):	15	25	19
Root Depth (m):	0.10	0.10	0.10
Root Density (%):	50	100	90
Bank Undercut (m):		N/A: no undercuts	

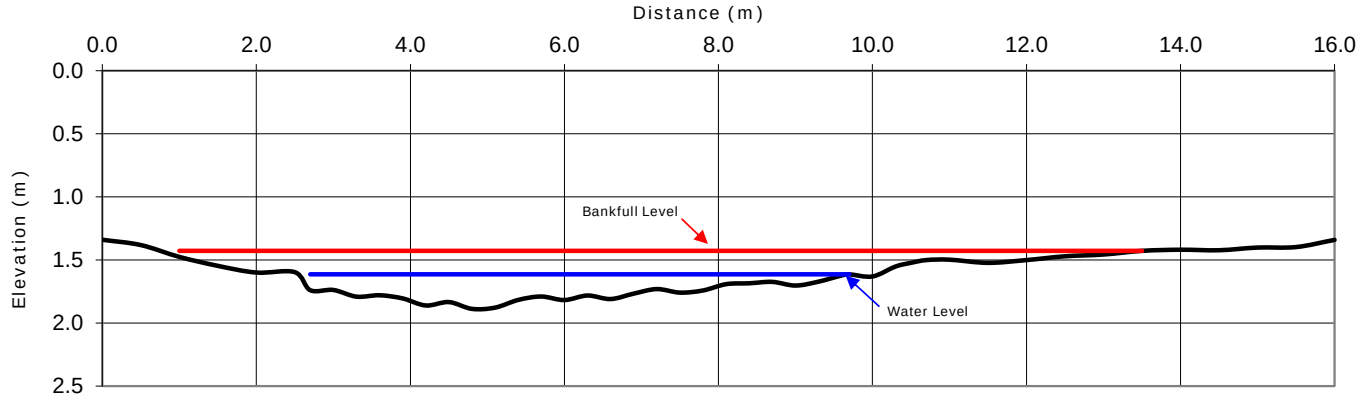
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Sandy Loam	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	5.10	12.50	9.33
Average Bankfull Depth (m):	0.19	0.26	0.23
Bankfull Width/Depth (m/m):	21	50	40
Wetted Width (m):	1.80	10.40	5.54
Average Water Depth (m):	0.02	0.22	0.13
Wetted Width/Depth (m/m):	19	86	54
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.01	0.28	0.22
Manning's *n*:		0.080	

Photograph at cross section 2 (facing upstream)

Representative Cross-Section 2



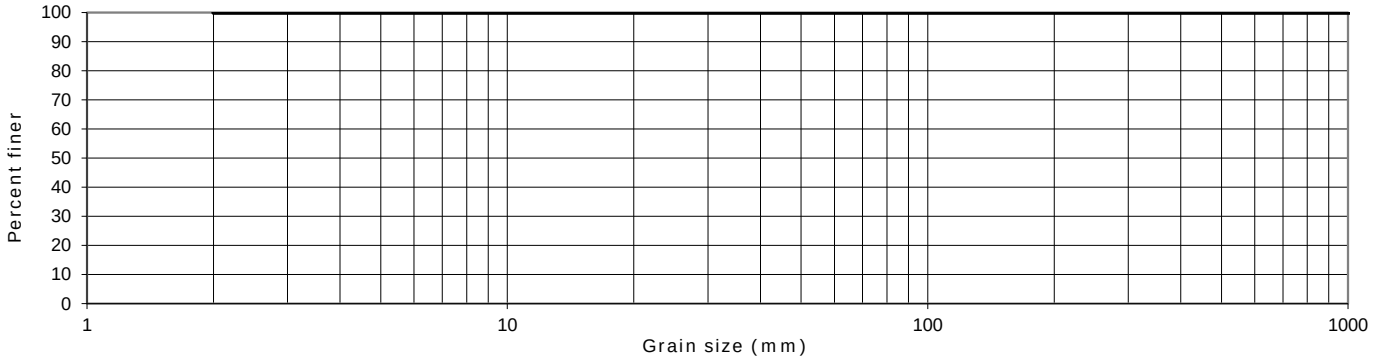
Substrate Characteristics

Particle Size (mm)

D_{10} :	<	2.0
D_{50} :	<	2.0
D_{84} :	<	2.0

Subpavement:	Clay
Particle shape:	N/A: fine sediment
Embeddedness (%):	N/A: fine sediment
Particle range (riffle):	N/A: riffle-pool sequence absent
Particle Range (pool):	N/A: riffle-pool sequence absent

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	3.76
for D_{50}:	0.27	Tractive Force at 2-year flow (N/m^2):	Not modelled
for D_{84}:	0.27	Critical Shear Stress (D_{50}) (N/m^2):	1.46
Unit Stream Power at Bankfull (W/m^2):	0.72		

General Field Observations

Channel Description

This channel runs between agricultural fields before flowing into Jock River. The channel is straight, slightly entrenched, and has a low gradient. Riffle-pool sequences are absent within this reach, only run features are present. Bank erosion was not present. Woody debris is present in the channel at a low density. Average bankfull width and depth are 9.23 m and 0.23 m, respectively. Bank material consists of sandy loam, bed material consists of fine sediment and organics. Depth of fine sediment on the bed at the time of assessment was approximately 0.30 - 0.40 m.

Cross Section 4 - Facing Downstream

Detailed Geomorphological Assessment Summary

Reach FD1

Project Number:	PN 17071	**Date:**	June 22/ 2017
Client:	David Schaeffer Engineering Ltd.	**Length Surveyed (m):**	110.0
Location:	Barrhaven, Ottawa	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	Not measured	**Dominant Riparian Vegetation Type:**	Grasses
Geology/Soils:	Clay Plains	**Extent of Riparian Cover:**	Fragmented
Surrounding Land Use:	Agricultural	**Width of Riparian Cover:**	1 - 4 Channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Established (5-30 years)
Dominant Instream Vegetation Type:	Rooted submergent	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	80%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.13	**Calculated Bankfull Discharge (m^3/s):**	0.77
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.45
Modelled 2-year Velocity (m/s):	Not modelled		

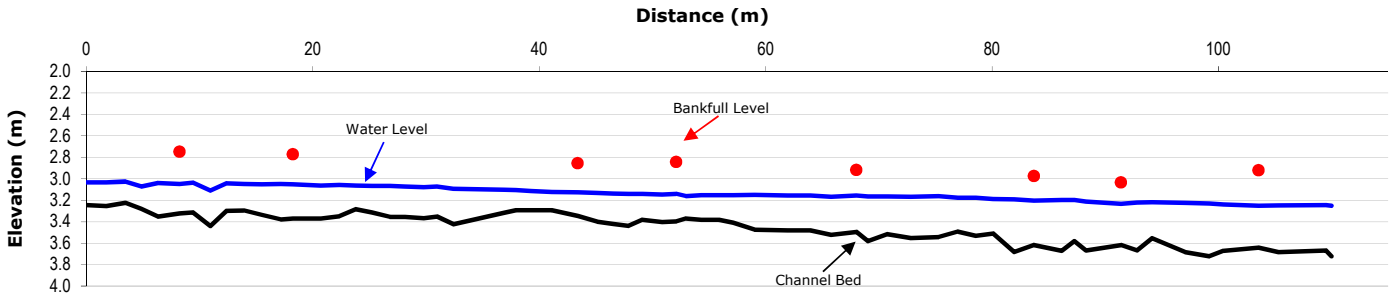
Profile Characteristics

Bankfull Gradient (%):	0.17
Channel Bed Gradient (%):	0.40
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.22
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	1.3	1.75	1.48
Bank Angle (deg):	45	70	53
Root Depth (m):	0.10	0.10	0.10
Root Density (%):	40	90	84
Bank Undercut (m):	0.05	0.30	0.13

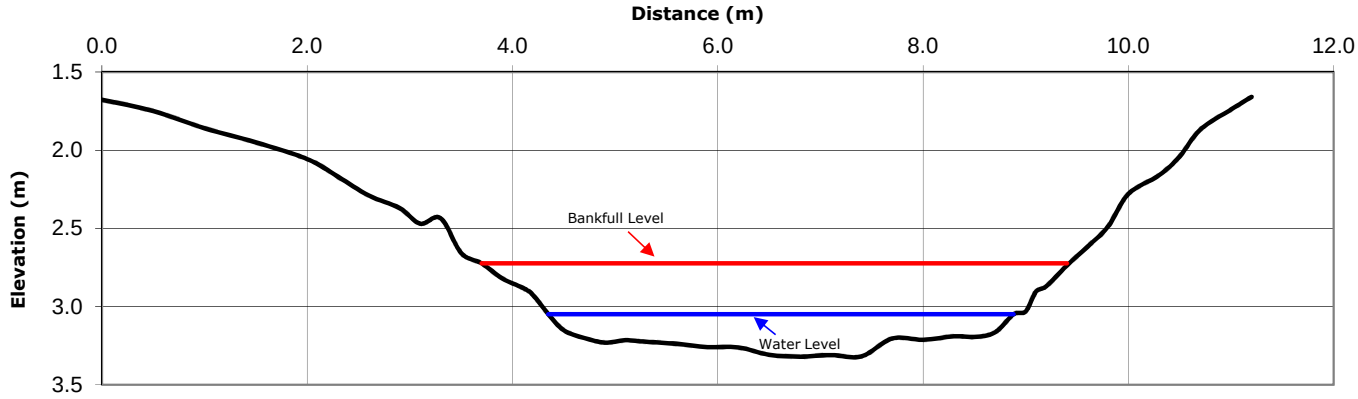
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay, Silt, Sand, some Rip-Rap present	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	3.30	5.70	4.29
Average Bankfull Depth (m):	0.34	0.48	0.40
Bankfull Width/Depth (m/m):	9	14	11
Wetted Width (m):	2.17	4.95	3.34
Average Water Depth (m):	0.15	0.27	0.21
Wetted Width/Depth (m/m):	11	24	16
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.22	0.41	0.31
Manning's *n*:		0.050	

Photograph at cross section 6 (looking at the right bank)

Representative Cross-Section 2



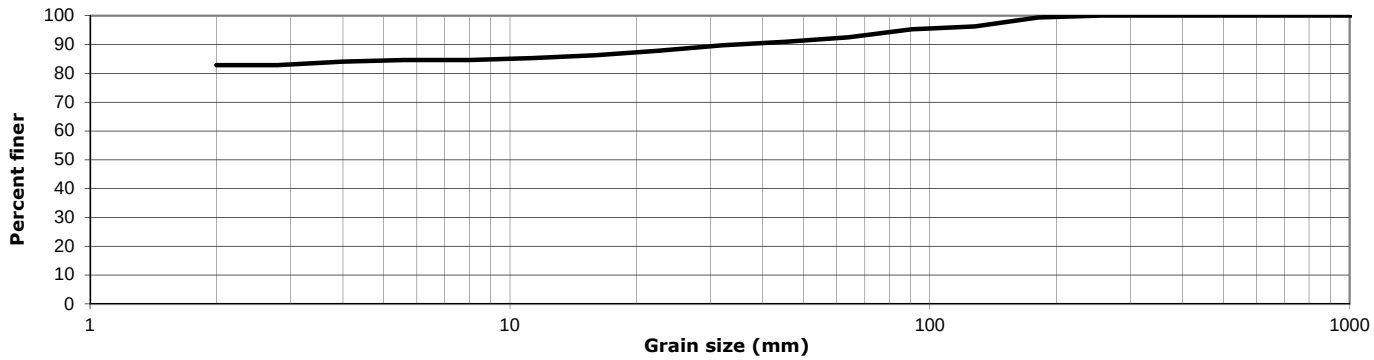
Substrate Characteristics

Particle Size (mm)

D_{10} :	<	2.0
D_{50} :	<	2.0
D_{84} :		4.0

Subpavement:	Clay
Particle shape:	Rip-rap: Subangular
Embeddedness (%):	Rip-rap: 0-50%
Particle range (riffle):	N/A: riffle-pool sequence absent
Particle Range (pool):	N/A: riffle-pool sequence absent

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	6.70
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.37	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	3.01		

General Field Observations

Channel Description

This channel runs between agricultural fields before flowing into Jock River. The channel is sinuous with a low gradient, and highly entrenched. Riffle-pool sequences are absent within this reach, only run features are present. Undercutting is present in the downstream portion of the reach. A low density of woody debris is present in the channel. Average bankfull width and depth are 4.69 m and 0.50 m, respectively. Bank material consists of clay, silt and sand, with rip-rap between cross sections 2 and 5. Bed material consists of clay, and sporatic rip-rap. Depth of fine sediment on the bed at time of assessment was approximately 0.05 - 0.20 m.

Cross Section 4 - Facing Downstream

Detailed Geomorphological Assessment Summary

Reach OKD1

Project Number:	PN 17071	Date:	June 20, 2017
Client:	David Schaeffer Engineering Ltd.	Length Surveyed (m):	82.0
Location:	Barrhaven, Ottawa	# of Cross-Sections:	8

Reach Characteristics

Drainage Area:	Not measured	Dominant Riparian Vegetation Type:	Trees and Grasses
Geology/Soils:	Clay Plains	Extent of Riparian Cover:	Continuous
Surrounding Land Use:	Agricultural	Width of Riparian Cover:	1 - 4 Channel widths
Valley Type:	Unconfined	Age Class of Riparian Vegetation:	Established (5-30 Years)
Dominant Instream Vegetation Type:	Rooted emergent	Extent of Encroachment into Channel:	Minimal
Portion of Reach with Vegetation:	5%	Density of Woody Debris:	High

Hydrology

Measured Discharge (m^3/s):	0.08	Calculated Bankfull Discharge (m^3/s):	1.69
Modelled 2-year Discharge (m^3/s):	Not modelled	Calculated Bankfull Velocity (m/s):	0.51
Modelled 2-year Velocity (m/s):	Not modelled		

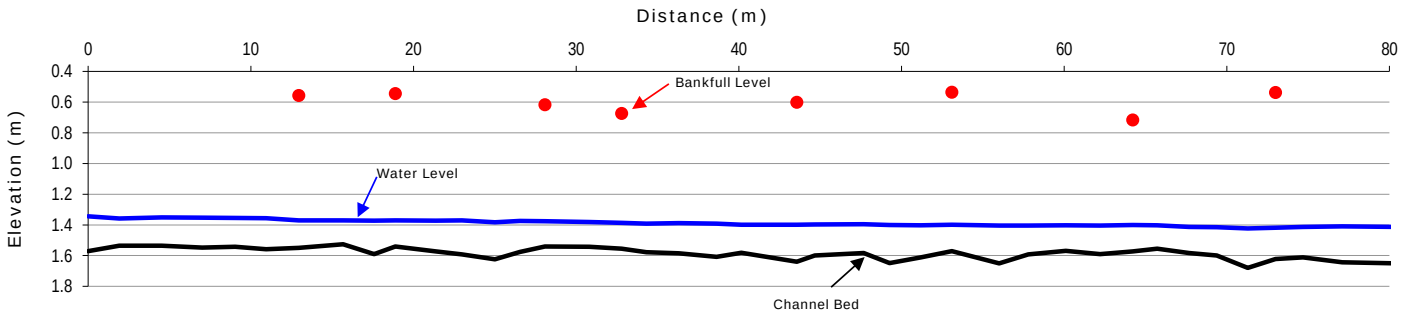
Profile Characteristics

Bankfull Gradient (%):	0.05
Channel Bed Gradient (%):	0.10
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.00
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	1.4	1.70	1.59
Bank Angle (deg):	50	80	67
Root Depth (m):	0.20	1.00	0.53
Root Density (%):	5	25	13
Bank Undercut (m):		N/A: no undercuts	

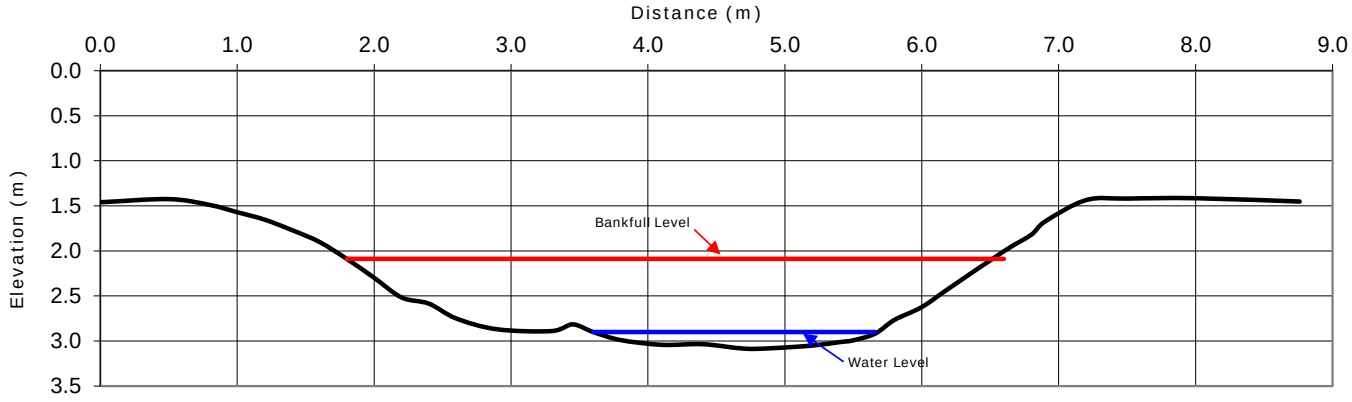
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay, Silt	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	4.30	4.83	4.59
Average Bankfull Depth (m):	0.62	0.81	0.72
Bankfull Width/Depth (m/m):	5	8	6
Wetted Width (m):	1.95	2.61	2.29
Average Water Depth (m):	0.13	0.16	0.14
Wetted Width/Depth (m/m):	14	20	16
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.17	0.24	0.19
Manning's *n* :		0.035	

Photograph at cross section 6 (looking at the right bank)

Representative Cross-Section 2



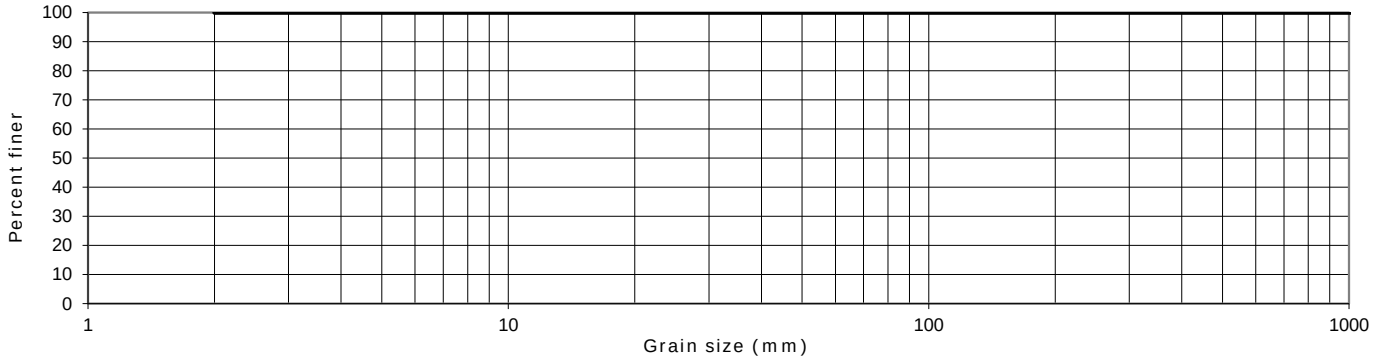
Substrate Characteristics

Particle Size (mm)

D_{10} :	0.002
D_{50} :	0.002
D_{84} :	0.002

Subpavement:	Clay
Particle shape:	N/A : Fine Sediment
Embeddedness (%):	N/A : Fine Sediment
Particle range (riffle):	N/A : Riffle pool sequence absent
Particle Range (pool):	N/A : Riffle pool sequence absent

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		Tractive Force at Bankfull (N/m^2):	3.53
for D_{50}:	0.01	Tractive Force at 2-year flow (N/m^2):	Not modelled
for D_{84}:	0.01	Critical Shear Stress (D_{50}) (N/m^2):	0.00
Unit Stream Power at Bankfull (W/m^2):	1.81		

General Field Observations

Channel Description

This channel runs between agricultural fields before flowing into Jock River. The channel is straight and highly entrenched, with a low gradient. This reach did not contain riffle-pool sequences, only run features were present. Average bankfull width and depth are 4.6 m and 0.7 m, respectively. Bank erosion was evident. Woody debris was commonly observed in the channel. Both bed and bank material consisted of a sandy loam. Depth of fines on the bed were approximately 0.2 - 0.3 m at time of assessment.

Cross Section 5 - Facing Upstream

Appendix H Meander Belt Widths

GEO MORPHIX

Meander Belt Widths

Jock River,
O'Keefe Drain, Foster Drain,
and Fraser-Clarke Drain

Barrhaven, Ottawa

Legend

1:12,000

N

Reach break

Drainage Feature

- O'Keefe Drain (OKD)
- Foster Drain (FD)
- Fraser-Clarke Drain (FCD)
- Not present at time of assessment

Meander Belt Width

- Stantec (2007)
- GEO Morphix Ltd. (2017)

Reach break: Stantec, 2007, PARISH Geomorphic Ltd., 2013, and GEO Morphix Ltd., 2017.
Drainage Feature: MNRF, 2010, City of Ottawa, 2016, and GEO Morphix Ltd., 2017.
MBW: Stantec, 2007, and GEO Morphix Ltd., 2017. Imagery: Google Earth Pro, 2016.