

APPENDIX C6

Geomorphology

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APPENDIX C6.1

Upper East Patterson Creek Geomorphic Assessment

This page intentionally left blank for 2-sided printing purposes 348 Bronte Street South, Unit 2 Milton, Ontario L9T 5B6 T 416.920.0926

e balance@geomorphix.com

Rizmi Property City of Vaughan, Ontario

Upper East Patterson Creek Geomorphic Assessment



Prepared for: Rizmi Holdings Limited 11333 Dufferin Street PO Box 663 Maple, Ontario L6A 1S5

Prepared by: GEO Morphix Ltd.

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1 Introduction

A Municipal Class Environment Assessment is proposed by the City of Vaughan to determine the preferred alternative to extend Kirby Road to Gamble Road in the Town of Richmond, between Dufferin and Bathurst Streets. The ultimate alignment of this arterial road will be determined with consideration to numerous factors as required in the Class EA process. One consideration is East Patterson Creek, which is addressed in this report.

The east tributary of Patterson Creek originates in a wetland located near the north part of the Rizmi Stone & Aggregates property at 11333 Dufferin Street in the community of Maple. A significant portion of channel within the property limits has apparently been modified in the past. The alterations, however, do not affect fish habitat due to a significant barrier to fish passage along the southern property line. The watercourse currently conveys flows to the south property line where it terminates in a wetland. The following report provides a geomorphic assessment of East Patterson Creek to fulfill a Class EA requirement to document natural heritage features, as well as to support the decision-making process with respect to actions that affect the watercourse.

It is understood that the future of the channel within the property has yet to be determined as it is not considered to be direct fish habitat. Potential outcomes include removal, retain in its current alignment, realignment, enhancement, or a combination of these alternatives. GEO Morphix will provide appropriate support once the preferred solution has been determined in the Class EA study.

2 Historical Conditions

A series of 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. Historical aerial photographs from 1946 (scale 1:20,000) and 1954 (scale 1:63,360), and orthophotography from 1970, 1999, 2002, 2005, 2007, 2011, 2012 and 2013, and Google Earth Pro satellite imagery from 2015 were reviewed to complete the historical assessment.

In 1946, the upper East Patterson Creek drainage area was largely forested, with the exception of a clearing for agriculture at the upper extent of the drainage area. At the current location of the Rizmi Stone & Aggregates field operations, there was a clearing but no apparent activity. The drainage route within the subject property could not be identified due to tree cover, but there was an intermittently-forested corridor with a watercourse that extended in a southeasterly direction from the subject property towards Bathurst Street. The channel planform could not be determine on the aerial photography. Outside of the forested area to the north beyond the drainage area, the land was used exclusively for agriculture. The area beyond the property to the south was also used for agriculture.

There were no significant changes in land use through 1954. The surrounding land to the south, however, was transformed to a golf course, Maple Downs Golf Course. By 1970, Rizmi operations extended approximately 0.4 km to the east from the previously cleared area, as suggested by the heavily disturbed landscape and the access road connecting the disturbed area to Dufferin Street. Also between 1954 and 1970, the TransCanada Pipeline was constructed along the south property boundary and across the channel. The watercourse is visible along the east side of an internal road at the eastern end of the disturbed area, but the Pipeline clearly prevents flow conveyance

beyond the property as evidenced by the ponded water at the Pipeline crossing. The lack of tree cover along the section of channel along the internal road as well as its linear alignment also suggest that it was channelized to enhance drainage function. East of the Rizmi property along the north side of the Pipeline was a private runway.

Rizmi operations appeared to have slowed by 1999. The channel alignment was the same as it was in 1970, but the pond at the Pipeline had visual characteristics of a wetland. Another notable change within the property was a linear clearing through the forest leading to the general area of the channel origin, north of the cleared aggregate extraction area. There was also limited clearing on the east side of the internal road and channel, as well as a culvert in the channel next to this recently cleared area for access the east side. Southeast of the property, the land was developed for residential use.

Surrounding land use remained generally unchanged in 2011. Between 2007 and 2011, a portion of the channel within the Rizmi property was again realigned to travel along the margin of the cleared area. The previously installed culvert was removed due to the channel realignment, and a new culvert was constructed at the new channel crossing location. Activity within the property also appears to have increased during this period. There were no notable changes in 2012 and 2013.

Overall, the portion of East Patterson Creek within the Rizmi property experienced significant changes over the period covered by historical imagery. These changes include realignment and straightening (i.e., channelization), removal of tree cover, and the disruption of channel and flow continuity as a result of the TransCanada Pipeline.

3 Existing Conditions

3.1 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 are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

East Patterson Creek is situated in the Upper East Don Subwatershed. The channel within the property limits is a headwater feature that originates from a generally linear wetland feature located mostly within the property. In total, the channel travels in a southerly direction for approximately 6 km, where it joins West Patterson Creek, then continues for another 1.5 km to the confluence with the East Don River.

The subject site is located in a southward extending lobe of the Oak Ridges Moraine physiographic region, which is bounded by the South Slope physiographic region to the west, south and east. Beyond the South Slope is the Peel Plain (Chapman and Putnam, 1984), where Patterson Creek joins the East Don River. With respect to surficial geology, the subject area is characterized by ice-contact stratified deposits consisting of sand and gravel, minor silt, clay and till (OGS, 2010). The surficial geology generally changes in the downstream direction in concert with the physiographic regions: the South Slope is comprised of clay to silt-textured till (derived from glaciolacustrine deposits or shale) and the Peel Plain is generally characterized by glaciolacustrine deposits (OGS, 2010). The predominantly sand and gravel composition of the surficial material

allows the channel to readily adjust, although the degree of adjustment would also be influenced by the flow regime as well as other factors such as vegetation control.

The catchment area for the channel within the subject property is largely forested with the exception of the area cleared for the Rizmi Stone & Aggregates operations. Downstream of the property to Bathurst Street, the channel travels through a forested corridor surrounded by low-density residential dwellings. The forested channel corridor continues beyond Bathurst Street, although housing density increases.

3.2 Reach Delineation

Rivers and streams are frequently segmented into reaches to provide meaningful lengths of channel for study. Reaches are delineated based on changes such as hydrology, channel gradient, confinement, planform (i.e., channel pattern), geology, surrounding land use and anthropogenic disturbances (e.g., crossing structures, dams, straightening/channelization, armouring). Each reach can then be studied as a unit that is expected to function in generally uniform manner throughout its length.

Within the Rizmi property, East Patterson Creek was divided into three reaches. The downstream channel reach (EPC-1) is approximately 100 m in length, the middle reach (EPC-2) is 130 m, and the upstream reach (EPC-3) is 200 m. Forest cover was one consideration when delineating the reaches: the Reach EPC-1 channel lies just within the west forest margin, while Reaches EPC-2 and EPC-3 are just outside the west forest margin. Despite the apparently limited differences between reaches, tree cover is a significant factor that governs channel form and function, and hence the two reaches. Reaches EPC-2 and EPC-3 are differentiated primarily by channel morphology. Wetland features are located downstream of Reach EPC-1 and upstream of Reach EPC-2. The reach delineation was verified in the field, as discussed below.

3.3 Reach Assessments

Site observations and channel measurements were collected on November 2, 2015. The field investigation was completed for the full length of channel between the wetland at the upstream extent of the channel and the south property limit. A photographic record of site conditions is provided in Appendix A. On the day of the site visit, the temperature was 10°C and there was no precipitation. There was, however, 7 mm of rain from October 31 to November 1.

3.3.1 General Observations

Within the Rizmi property, East Patterson Creek originates in a wetland feature located in a forested area to the north just beyond an open, disturbed area created by site activities. The channel travels along the perimeter of the clearing before entering the forested area. It continues just within the forest boundary to a wetland feature at the south limit of the property. The reaches identified in Section 3.2 were confirmed to be correct. The following is a description of each reach from upstream to downstream.

The wetland at the upstream end of the section of channel under study is comprised of a dense thicket of shrubs (red-osier dogwood). There was no define flow pattern within the wetland.

Reach EPC-3 is in a constructed valley feature containing a low-flow channel. The valley had a V' shape except towards the downstream end of the reach. The channel had no bankfull indicators

and there was limited evidence of a stable channel morphology. The bed was composed of mostly silt and sand, and its morphology was partly controlled by vegetation. Three knickpoints were observed, which suggests that the channel gradient is high relative to those of the two downstream reaches. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the wetland contributed to total flow. Wetted flow width varied due to the high degree of channel confinement, ranging from 0.1 to 1.5 m. The channel characteristics were largely governed by the composition of the valley materials, which was sand. The northeast embankment (left embankment viewed in the downstream direction) was comprised of exposed sand with limited woody vegetation. Due to the unstable nature of the embankments, in particular that to the northeast, the channel will likely continue to adjust according to the sediment supply. Mature trees lied beyond the sandy embankment. The southwest side of the channel was open with primarily grasses.

Reaches EPC-3 and EPC-2 were divided by a partly embedded 1200 mm CSP culvert, constructed for access across the channel. Reach EPC-2 continues as a constructed valley feature, but with appreciably different physical characteristics. Here, the valley top width was roughly 3.9 m wide and the valley depth was 1.5 to 2.0 m. The east side of the valley was populated by mature trees, while the east side was dominated by grasses within an open (i.e., cleared) area.

The Reach EPC-2 channel likely formed naturally following valley excavation. The low-flow channel is considered to be the bankfull channel, although it still may be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. There was a 0.22 m high knickpoint mid-reach that cut into till. Upstream of the knickpoint, the bed was characterized by sand, gravel and small cobbles, while downstream of the knickpoint, the bed was comprised of mostly sand, but also exposed till. This longitudinal change in bed characteristics can be explained by differences in bed gradient.

At the downstream end of Reach EPC-2, the channel turns at nearly a right angle to travel south into Reach EPC-1. There was evidence of the former channel location (before the realignment of Reaches EPC-3 and EPC-2), in the form of a linear depression across the cleared area, that aligned with Reach EPC-1. Although the former channel was decommissioned, surface runoff apparently continued to enter the Reach EPC-1 channel at the upstream end of this reach as indicated by the minor erosion and headcutting.

Reach EPC-1 travels in a southerly direction and continues as a constructed valley feature approximately 5 m wide and just over 1 m deep. Both sides of the valley was vegetated with mature trees; however, the woody riparian buffer on the west side was limited. Tree cover over the channel was dense, and there were frequent observations of woody debris within the constructed valley, mostly as broken individual tree limbs that did not significantly affect flow pattern. The low-flow channel had no riffle-pool development, and averaged 1.90 m wide and 0.15 m deep. The increase in width-to-depth ratio, relative to that of Reach EPC-2, can be explained by the decrease in channel gradient and the increase in discharge. Both the bed and banks were comprised of sand, which would be expected due to the lower gradient and the typical downstream fining found in natural watercourses.

At the downstream end of the Reach EPC-1 channel was a wetland feature. This wetland was contained in a basin (roughly 70 wide and 50 m wide) that was bounded in the downstream (south) end by a raised natural gas pipeline corridor (i.e., TransCanada Pipeline), which was essentially a large berm. The top of the Pipeline was approximately 1.5 to 2.0 m above the wetland bed, and therefore a considerable volume of water would be required for flows to spill

over the Pipeline corridor. There was no evidence of a flow path over the Pipeline, although it would clearly be located across the lowest point. The impact of the lack of surface flow continuity to the watercourse downstream (south) of the Pipeline corridor could not be assessed due to property constraints.

3.3.2 Rapid Field Assessments

Rapid field assessments were completed as reconnaissance-level evaluations to determine the condition of each reach with respect to channel stability and general stream health:

- Channel instability was semi-quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.41).
- The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and consider the ecological functioning of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34) or excellent (35-42) degree of stream health.

A summary of the rapid assessments is provided in Table 1. Completed field sheets are found in Appendix B.

		RGA	*	RSAT**			
Reach	Score	Condition	Dominant Form of Adjustment	t Form tment Score Condition		Limiting Feature(s)	
EPC-1	0.11	In regime	Aggradation	26	Good	Physical instream habitat	
EPC-2	0.12	In regime	Degradation	28	Good	Riparian habitat conditions	
EPC-3	0.09	In regime	Degradation	22	Fair	Riparian habitat conditions	

Table 1: Rapid field assessment summary

* Ontario Ministry of the Environment (2003)

** Galli (1996)

3.3.3 Detailed Geomorphic Assessment

Within the property limits, Reach EPC-1 was determined to be relatively natural and certainly the most aged since realignment. As such, this reach was selected for further investigation – i.e., detailed geomorphic assessment. This detailed assessment serves as the basis for any required channel modifications such as realignment or stabilization.

The detailed assessment involved temporarily setting up eight representative cross sections for the purpose of determining average bankfull channel dimensions (e.g., width, average bankfull depth, maximum depth, and bank angles). The bankfull level was determined using standard protocols and accepted field indicators. A survey of the bed profile was also completed to determine slope and compute bankfull hydraulics. A modified Wolman (1954) pebble count was completed to characterize the bed materials. A summary of measured and computed values is presented in Table 2.

Channel parameter	Results
Measured	
Average bankfull channel width (m)	1.89
Average bankfull channel depth (m)	0.15
Average width-to-depth ratio	14.7
Channel gradient (%)	0.42
D ₅₀ (mm)	<2
D ₈₄ (mm)	<2
Manning's n roughness coefficient	0.034
Computed	
Bankfull channel discharge (m ³ /s) *	0.14
Average bankfull velocity (m/s)	0.53
Unit stream power at bankfull discharge (W/m ²)	3.2
Tractive force at bankfull (N/m ²)	5.98
Critical shear stress (N/m ²) **	1.46
Flow competency for D ₅₀ (m/s) ***	0.27
Flow competency for D ₈₄ (m/s) ***	0.27

Table 2: Bankfull parameters of the reference channel

* Based on Manning's equation

** Based on Shields diagram from Miller et al. (1997)

*** Based on Komar (1987)

The Reach EPC-1 reference channel has a lower width-to-depth ratio than the two upstream reaches due to the lower channel gradient. Despite the relatively low unit stream power, the bed (comprised of sand) is fully mobile under bankfull flow conditions. It is expected that the Reach EPC-1 channel length would decrease slowly over time as the bed material is transported and deposited in the wetland. The receiving wetland would consequently increase in size, but only in the upstream direction due to the raised pipeline crossing.

4 Conclusions

East Patterson Creek within the Rizmi property has been significantly altered, and impacted both directly and indirectly, over the period covered by historical imagery. It also no longer functions



as potential fish habitat as a result of the construction of the TransCanada Pipeline. In-channel flows now therefore infiltrate and contribute to groundwater.

If the preferred alternative solution, resulting from the Class EA study, is assessed to be restoration, realignment or enhancement, we would be pleased to provide design services. Concurrently or independently, we can also investigate potential hazards associated with a dynamic channel.

5 References

Chapman, L.S. and Putnam, D.F. 1984. The Physiography of Southern Ontario. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources, Toronto.

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Ministry of the Environment (MOE). 2003. Ontario Ministry of the Environment. Stormwater Management Guidelines.

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Appendix A Photographic Record of Site Conditions













Appendix B Rapid Assessment Field Sheets



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Keach Chara	cteristics	Project Co	de/Phase: PMINU	90	Observations	1
Date:	NOU 3. 2015	Stream/Reach:	EPC-1			
Weather:	AN + 10°C	Location:	KINDY RO	* DUFFR	rinst.	
Field staff:	UH/FIS	Watershed/Subwatershed:	East / Potte	rson orl		
UTM (Upstream)		UTM (Downstream))		
Land Use (Table 1)	alley Type Channel Type Channel 2 (Table 2) (Table 2) (Table 3)	Zone Zone Flow Type (Table 5)	2 KGroundwater	Evidence:	deroress	
Riparian Vegetation		Aquatic/Instream Ve	sgetation	Water Quality		
Dominant Type: Cov (Table 6) 1 1 1	erage: ^{channel} Age Class (yrs) : Encroachmen Vone 🗌 1-4 🔲 Immature (<5) (Table Fragmented 😿 4-10 👷 Established (5-30) 🗾	nt: Type (Table8) Woody Debris Present in Cutban Present in Channe Not Present	Coverage of Reach (%) Density of WD: k V Low WDJ/50m: el 🗆 Moderate 1 High		dour (Table 16)	
Channel Characteristi	91					
Sinuosity (Type)	Sinuosity (Degree) Gradient Num	nber of Channels	Clay/Silt Sand Gra	ivel Cobble Bo	ulder Parent Ro	otle
(Table 9)	(Table 10) 1 (Table 11) 1 (Tab	ble 12) 1 Rittle Substr	ate D X I			
Entrenchment	Type of Bank Failure Downs's Classification	Pool-Substr	ate			þ
(Table 13)	(Table 14) (Table 15) (Table 15)	Bank Materia				
	See of the lead	ASSESSMAN	-B obnot And	nk Fracion		
Bankfull Width (m)	Wetted Width (m)	/			es:	
Bankfull Depth (m)	Wetted Depth (m)			5 - 30%		
Riffle/Pool Spacing (n	1) NA % Riffles: NA % Pools: N	A Meander Amplitude:		60 - 100%		
Pool Depth (m)	NA Riffle Length (m) NA Undercuts (m)	Nore Comments: NO	riffie - pools,	Door		
Veloctity (m/s)	Wiffle ball / ADV	(/Estimated) SF in	directors.			

/

Date:	NI	2112 2015	EDC	-1				
Weather:	C	in iner		Location	L'L	0-	1	
weather.	3	n ~ 10°C Location: Kirby P						
Field Staff:	(HIER	Watershed/Subwatershed: E. Patters					
		Geomorphic Indicator				sent?	Facto	
Process	No.	Description			Yes	No	Value	
	1	Lobate bar			1	1	-	
	2	Coarse materials in riffles embedde	d		MA		-	
Evidence of	3	Siltation in pools			NA		1 14.	
Aggradation	4	Medial bars				V	1 14	
(AI)	5	Accretion on point bars			NA		1	
	6	Poor longitudinal sorting of bed ma	terials		V		1	
	7	Deposition in the overbank zone			1	V		
	_			Sum of indices =		3	0.25	
	1	Exposed bridge footing(s)			ND		1	
	2	Exposed sanitary / storm sewer / pi	peline / etc.		NA		1	
	3	Elevated storm sewer outfall(s)			NA		-	
Evidence of	4	Undermined gabion baskets / concr	ete aprons / etc.		NA		1	
Degradation	5	Scour pools downstream of culverts	s / storm sewer outlet	s	NA		OI	
(DI)	6	Cut face on bar forms			NA		-13	
	7	Head cutting due to knick point mig	1011	V				
	8	Terrace cut through older bar mater	rial		NA			
	9	Suspended armour layer visible in b	ank			V		
	10	Channel worn into undisturbed over	rburden / bedrock		-	V		
				Sum of indices =	0	3	O	
	1	Fallen / leaning trees / fence posts /	/ etc.			V		
	2	Occurrence of large organic debris			~			
	3	Exposed tree roots				5	10	
Evidence of	4	Basal scour on inside meander bends					1/2	
Widening	5	Basal scour on both sides of channe	l through riffle		NA		., , , , , ,	
(WI)	6	Outflanked gabion baskets / concre	NA		4			
	7	Length of basal scour >50% through subject reach				-		
	8	Exposed length of previously buried pipe / cable / etc.					4	
-	9	Fracture lines along top of bank				~	-	
	10	Exposed building foundation		Sum of Indiana	NH	4	0.2	
	-	T		Sum of indices =		17	0.2	
1.000	1	Formation of chute(s)				~		
Evidence of	2	Single thread channel to multiple ch	nannel		-	V	1	
Planimetric	3	Evolution of pool-riffle form to low bed relief form			-	~		
Form	4	Cut-off channel(s)				~	16	
Adjustment	5	Formation of island(s)				-	- 0	
(PI)	6	Thalweg alignment out of phase me	ander form			~	4	
	7	Bar forms poorly formed / reworked	d / removed	Cum of tadtes	NA	1	0	
				Sum of indices =	0	6	10	
dditional notes:			-	Stability Index (SI) =	(AI+DI+W	/I+PI)/4 =	0.11	
			Condition	In Regime In T	ransition/St	ress In	Adjustme	
			the second secon	/				

Completed by: _____ Checked by:

PN15080 **Project Number:** Rapid Stream Assessment Technique Date: Stream/Reach: 2015 20 Weather: Location: Kirnu Field Staff: Watershed/Subwatershed: HersonCric Evaluation Poor Fair Good Excellent Category · > 80% of bank network stable < < 50% of bank network stable · 50-70% of bank network 71-80% of bank network Recent bank sloughing, stable stable No evidence of bank sloughing, slumping or failure slumping or failure frequently Recent signs of bank Infrequent signs of bank observed sloughing, slumping or failure sloughing, slumping or failure fairly common · Stream bend areas unstable · Stream bend areas highly Stream bend areas stable · Stream bend areas very stable Outer bank height 0.9-1.2 m Outer bank height 0.6-0.9 m Height < 0.6 m above stream unstable • Outer bank height 1.2 m above stream bank above stream bank (< 1.2 m above stream bank

(1.5-2.1 m above stream

bank for large mainstem

Bank overhang 0.8-0.9 m

Young exposed tree roots

4-5 recent large tree falls per

areas)

common

material

low banks

fresh sand

Point bars common,

moderate to large and

unstable with high amount of

/Plant/soil matrix

stream mile

· Bottom 1/3 of bank is

generally highly erodible

(1.2-1.5 m above stream bank

predominantly old and large,

2-3 recent large tree falls per-

smaller-young roots scarce

Bottom 1/3 of bank is

generally highly resistant

plant/soil matrix or material

for large mainstem areas)

Bank overhang 0.6-0.8 m

Exposed tree roots

stream mile

for large mainstem areas)

Exposed tree roots old, large

· Generally 0-1 recent large tree

Bank overhang < 0.6 m

falls per stream mile

Bottom 1/3 of bank is

generally highly resistant

plant/soil matrix or material

and woody

above stream bank

Channel

Stability

large mainstem areas)

Bank overhang > 0.8-1.0 m

> 6 recent large tree falls per

Bottom 1/3 of bank is highly

Plant/soil matrix severely

portion of overbank area

Point bars present at most

amount of fresh sand

Point range

stream bends, moderate to

large and unstable with high

Young exposed tree roots

abundant

stream mile

erodible material

compromised

(2.1 m above stream bank for

		compromised				
	Channel cross-section is generally trapezoidally- shaped	Channel cross-section is generally trapezoidally- shaped	Channel cross-section is generally V- or U-shaped	 Channel cross-section is generally V- or U-shaped 		
Point range		030405	060708	□ 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 S1% 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	Fresh, large sand deposits	Fresh, large sand deposits	Fresh, large sand deposits rare		

or absent from channel ery common in channe ommon in channel uncommon in channe Small localized areas of fresh Small localized areas of fresh No evidence of fresh sediment Moderate to heavy sand sand deposits along top of deposition along major sand deposits along top of deposition on overbank

low banks

fresh sand

· Point bars small and stable,

armoured with little or no

well-vegetated and/or

· Point bars few, small and stable, well-vegetated and/or armoured with little or no

fresh sand

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Evaluation Category	Poor	Fair	Good	Excellent	
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40-60% of bottom channel width (45- 65% for large mainstem areas) 	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 	
Physical Instream Habitat	 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) 	
Habitat	 Riffle substrate composition: predominantly gravel with high percentage of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: 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 	
oint range		□ 3 □ 4	□ 5 □ 6	0708	

	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)
Water	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
Quality	 Objects visible to depth < 0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	Objects visible to depth 0.5-1.0 m below surface	Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	+ Slight organic odour	No odour
Point range		□ 3 □ 4	□ 5 □ 6	7 8

Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian wooded localized 	area predominantly but with major gaps	 Forested buffer get > 31 m wide along portion of both bar 	nerally + Wide (major foreste nks banks	> 60 m) mature ed buffer along both
Conditions	 Canopy coverage: < 50% shading (30% for large mainstem areas) 	Canopy coverage: 50-60% shading (30-44% for large mainstem areas)		 Canopy coverage: 60-79% shading (4) large mainstem are 	5-59% for eas) Canop > 80% mainst	y coverage: shading (> 60% for large em areas)
Point range				5	6 0 7	
Additional no	tes:			Total	overall score (0 -	42) =
		Ranking Poor (<13)		Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: _____ Checked by: _

Wether: Arrive 10 Lotter:	Date:	2100 SIDE E NON	Stream/Reach:	EPC-2	
Red acti: CH, FR Moreofond/submatricities: Each Hart Chart Chart For Chart Chart UN (Upstream) Unit (Densitiend) Unit (Densitiend) Unit (Densitiend) Unit (Densitiend) Table UB Unit (Densitiend) Unit (Densitiend) Unit (Densitiend) Unit (Densitiend) Remain Vegetation Table UB Controls 1.14 Controls Unit (Densitiend) Remain Vegetation Table UB Controls 1.14 Controls Unit (Densitiend) Remain Vegetation Table UB Controls 1.14 Controls Unit (Densitiend) Remain Vegetation Table UB More (SS) Table UB More (Density (Densitiend) Controls Unit (Density (Density (Densit)) Controls Unit(D	Weather:	SUN + 10°C	Location:	Kirhu Rol + NUR	erin St.
Utrikling University Utrikling Utri	Field staff:	CH/FR	Watershed/Subwatershed:	East patterso	h Ork
Lund Use Lund Use Lund Use Channel Zone Flow Vype Channel Zone Flow Vype Channel Zone Lund Use Lund Use<	UTM (Upstream)		UTM (Downstream)		
Repartien Vegetation Aqualit/Instream Vegetation Dominant Type: Coverage: 1.4 Atomicant Type: Aqualit/Instream Vegetation Dominant Type: Dominant Type: Aqualit/Instream Vegetation Aquality (Table 5) Table 7) Trable 6) Image: 1.4 Transmiture (s) Table 7) Table 7) Aquality (Table 5) Aduality (Table 5) Species: Fragmented 2/4.10 Established (5.30) 2) Present in Channel Image: Aquality (Table 13) Species: 7 Fragmented 2/4.10 Established (5.30) 2) Present in Channel Image: Image: Image: Channel Characteristic Channel 1 Table 11 2 Table 11 1 Aduality (Table 11) Image: Image: <td< th=""><th>Land Use [H] Vi (Table 1)</th><th>illey Type Channel Type Channel Z (Table 2) (Table 2) (Table 3)</th><th>Cone A Flow Type 2 (Table 5)</th><th>Eviden</th><th>En stenning</th></td<>	Land Use [H] Vi (Table 1)	illey Type Channel Type Channel Z (Table 2) (Table 2) (Table 3)	Cone A Flow Type 2 (Table 5)	Eviden	En stenning
Dominant Yper Coverage Coverage Oddun (Table 15) Trable (1) Instant (1) Instant (1) Instant (1) Species: Instant (1) Instant (1) Instant (1) Species	Riparian Vegetation		Aquatic/Instream Ve	getation Wa	ter Quality
Channel Characteristics Channels Channels Clay(sit) Savel Coble Boulder Parent Rootlet Files 9) 1 Table 10) 1 Table 11) 1 Table 12) 1 Table 11) 1 Table 12) 1 Table 12) 1 1 Table 12) 1	Dominant Type: Cove (Table 6) 2 0 1 1 Species: 2 0	srage: channel widths Age Class (yrs) : Encroachment Ione 1-4 Immature (<5)	t: Type (Table8)	Coverage of Reach (%) Density of WD: Density of WD: Densit	Odour (Table 16)
Sinuosity (Type) Sinuosity (Degree) Gradient Number of Channels Clay/Silt Sand Gravel Cobble Boulder Parent Route (Table 19) (Table 10) (Table 11) (Table 11) (Table 12) (Channel Characteristic				
Snuosity (Degree) Gradient Number of channels CapNsit Sand Gravel Cobble Boulder Parent Notifie Table 10) 1 Table 11) 2 Table 11) 1 1 1	-		1.1.2.10 P. 1.4		1
Entrenchment Type of Bank Failure Down's Classification Pool-Gubstrate Image: Classification Pool-Gubstrate Image: Classification Pool-Gubstrate Image: Classification Image: Clas	(Table 9)	(Table 10) Table 11) (Table 11) (Table 11) (Table	ber of Channels le 12) 1 Riffle Substra	the D to the D to the D to the D	Dolle Boulder Parent Kooti
(Table 13) (Table 14) (Table 15) Emk Material Emk Material Emk Material Emk Material Image: Second Secon	Entrenchment	Type of Bank Failure Downs's Classification	Pool-Substra	#e	
Bankfull Width (m) I.3 I.0 Wetted Width (m) O.3 O.35 Bank Angle Bank Erosion Notes: Bankfull Depth (m) O.4 O.45 Wetted Depth (m) O.1 O.1 O.3 0.5% 0.5% Bankfull Depth (m) O.4 O.45 Wetted Depth (m) O.1 O.1 O.1 O.5 0.5% 0.5% Riffle. N.A % Riffles: N.A % Pools: N.A Meander Amplitude: N.I/A D.0	(Table 13)	(Table 14) 1 (Table 15)	Bank Material	Real way	
Bankfull Depth (m) 04 045 wetted Depth (m) 01 015 30-60 5-30% CSP COCOCADE-1 Riffle/Pool Spacing (m) NA % Riffles: NA % Pools: NA % Riffles: NA % Pools: NA % Riffles: NA % Pools: NA <td< td=""><td>Bankfull Width (m)</td><td>1.3 L.O Wetted Width (m)</td><td>0.3 0.25</td><td>Bank Angle Bank Erosion □ ∩ − 3∩ □ < 5%</td><td>Notes:</td></td<>	Bankfull Width (m)	1.3 L.O Wetted Width (m)	0.3 0.25	Bank Angle Bank Erosion □ ∩ − 3∩ □ < 5%	Notes:
Rifle/Pool Spacing (m) NI % Rifles: NI % Pools: NI Meander Amplitude: NI 0 Indercut 60 - 100% Pool Depth (m) NI Rifle Length (m) NI Undercuts (m) NI Undercuts (m) NI 10 Indercut 60 - 100% Undercuts (m) Vielocity (m/s)	Bankfull Depth (m)	0 4 0.45 Wetted Depth (m)	510 1.0	□ 30 - 60 □ 5 - 30% □ 360 - 90 □ 330 - 60%	CSP (Crossing= 1
Pool Depth (m) NA Riffle Length (m) NA Undercuts (m) Comments: KP Exposed Lill Velocitity (m/s) V V V Velocity (m/s) Velocity (u/s) Velocit	Riffle/Pool Spacing (m)	NG % Riffles: NG % Pools: NF	Meander Amplitude:	J//2 □ Undercut □ 60 – 100%	2
Velocity (m/s) Veloci	Pool Depth (m)	NA Riffle Length (m) NA Undercuts (m)	Comments: KP	+ EXDOSED Lill	
Porture A 3.9 M P 7 1.5 + 0.2 cm Completed by: Checked by:	Veloctity (m/s)	Wiffle ball / ADV	/ Estimated	molerial uls of KP	
	valley Dorture	4 W6.5 V	2+02012	Completed by:	Checked by:

Date:	No	12 2015		Stream/Reach	EPC	-2	
Dute.	IVO	Valadis		Location	KICI	VO	Rd
Weather:	Sui	1+ 10 C	Watershe	d/Subwatershee	FACE	Dalle	AND.
Field Staff:	CH	ER	Watershe	u/Subwatershee	Last	FARL	. 301 0
· · · · · ·	-	Geomorph	ic Indicator		Pres	ent?	Factor
Process	No	Description			Yes	No	value
	1	Lobate bar				V	
	2	Coarse materials in riffles embedde	ed		N	(A)	-
vidence of	3	Siltation in pools			N	A	-
ggradation	4	Medial bars				V,	0/5
(Δ1)	5	Accretion on point bars				V	13
(en)	6	Poor longitudinal sorting of bed ma	aterials			V	
0	7	Deposition in the overbank zone				V	-
		Deposition in any		Sum of indices	= 0	5	0.0
	_				NI	IA	
	1	Exposed bridge footing(s)	ta-line / ato			IA	
	2	Exposed sanitary / storm sewer / 1	openne / etc.		N	VA	7
	3	Elevated storm sewer outfall(s)	ante enrons / otc		.1	YA	1
Evidence of	4	Undermined gabion baskets / con	crete aprons / etc.			11	121
egradation	5	Scour pools downstream of culver	ts / storm sewer outlet.	3		V	16
(DI)	6	Cut face on bar forms	f		1/	1	
(0.)	7	Head cutting due to knick point m	igration		V	V.	
	8	Terrace cut through older bar man	terial		-	1V	
	9	Suspended armour layer visible in	Dank		1/		
	10	Channel worn into undisturbed of	Verburden / bedrock	Sum of indice	s= 2	H	0.33
						1.1	-
	1	Fallen / leaning trees / fence post	s / etc.			1 7	-
	2	Occurrence of large organic debr	S		-	1	-
	3	Exposed tree roots				1/0	-
	4	Basal scour on inside meander be	ends			11A	- 41-
Evidence of	5	Basal scour on both sides of chan	nel through riffle			11-1	- 0/5
Widening	6	Outflanked gabion baskets / cond	crete walls / etc.		1	111	
(001)	7	Length of basal scour >50% throu	igh subject reach		-	110	
	8	Exposed length of previously bur	ied pipe / cable / etc.		0	1 m	-
	9	Fracture lines along top of bank			4	ILA	-
-	10	Exposed building foundation				16	0
				Sun or mare		1	
	1	Formation of chute(s)				-V	-
Evidence of	2	Single thread channel to multipl	e channel			NIA	11
Planimetric	3	Evolution of pool-riffle form to l	ow bed relief form		-	YIT	-1/1
Form	4	Cut-off channel(s)				V	6
Adjustment	5	Formation of island(s)				V	-
(PI)	6	Thalweg alignment out of phase	meander form			IV	
V7	7	Bar forms poorly formed / rewo	rked / removed		Y	-	2 1-
				Sum of indi	ces =	12	10 1 -
Additional not	es:			Stability Index	(SI) = (AI+D	I+WI+PI)/4	= 0.13
			Condition	In Regime	In Transition	/Stress	In Adjustme
							[] 0 44

Completed by: KT KK Checked by: _

Date:	NOV 2,2015		Stream/Reach: CPC-2			
Weather: Sun + 10°C Field Staff: CHIER			Location: KINDY Rd			
		Watersh	Watershed/Subwatershed: East Patterson			
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 0.8-0.9 m 	 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		

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		□ 3 □ 4	□ 5 □ 6	₫ 7 🗆 8

A

EPC-2 PH ISOBO GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width (45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
Physical Instream Habitat	Dominated by one habitat type (dsually 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 percentage 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 0.49:15; >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
1/4	 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
oint range		☑ 3 □ 4		

Water	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
Quality	 Objects visible to depth < 0.15 m below surface 	 Objects visible to depth 0.15-0.5 m below surface 	Objects visible to depth 0.5-1.0 m below surface	• Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	 Slight organic odour 	No odour
Point range		□ 3 □ 4	□ 5 1 6	0708

Riparian Habitat	Narrow riparian area of mostly non-woody vegetation	 Riparian a wooded b localized 	area predominantly out with major gaps	 Forested buffer ger > 31 m wide along portion of both bar 	nerally major nks	 Wide (> forestea banks 	60 m) mature d buffer along both
Conditions	Canopy coverage: < 50% shading (30% for large mainstem areas)	 Canopy c 50-60% s large mai 	overage: hading (30-44% for nstem areas)	Canopy coverage: 60-79% shading (45 large mainstem are	5-59% for eas)	 Canopy > 80% s mainster 	coverage: hading (> 60% for large :m areas)
Point range			2 🗆 3	040	5	E	6 🗆 7
Additional no	tes:			Total	overall s	core (0 - 4	42)= 27
		Ranking	Poor (<13)	Fair (13-24)	Good	(25-34)	Excellent (>35)
					1	/	

Completed by: KILE Checked by:

Date:	SIDE CONT	Stream/Reach:	EPC-3		
Weather:		Location:	KINDU ROL		
Field staff:	CHIER	Watershed/Subwatershed:	Fast Potterson Cr	C	
UTM (Upstream)		UTM (Downstream)			
Land Use H Vall (Table 1)	ley Type 2 Channel Type (Table 2) (Table 2) (Table 3) (Table 3)	one 1 Flow Type 24) (Table 5)	Evidence:	wherevess	
Riparian Vegetation]	Aquatic/Instream Veg	getation Water 0	Quality	
Dominant Type: Cover (Table 6) D Cover Species: Cover Co	age: Channel widths Age Class (yrs) : Encroachment one 1-4 Immature (<5)	t: Type (Table8) 2 Woody Debris Present in Cutbank Present in Channel	Coverage of Reach (%) 네이 Density of WD: - Low WDJ/50m ⁴ - Moderate High	Odour (Table 16)	
Channel Characteristics					
Sinuosity (Type) (Table 9)	Sinuosity (Degree) Gradient Num (Table 10) 1 (Table 11) 2 (Table Table 11) Type of Bank Failure Downs's Classification	ber of Channels le 12)	clay/Silt Sand Gravel Cobble ate	e Boulder Parent Rootlets	a_ +
(Table 13)	(Table 14) 1 (Table 15)	Bank Material			
Bankfull Width (m) Bankfull Depth (m)	1. Ц Image: Constraint of the second secon		Bank Angle Bank Erosion Bank Angle Bank Erosion 0 - 30 30 - 60 5 - 30% 0 - 100% 0 - 100%	Notes: Samply VUS	
Riffle/Pool Spacing (m) Pool Depth (m) Dら cf KP	NA % Kinnes: NA % FOUS: MA 0.3 Riffle Length (m) MA Undercuts (m)	comments: 3	knick ponts, no	C DS & Xterr	0
Veloctity (m/s)	Wiffle ball / ADV	/Estimated	pool development	KletIma ups of	MIN
feature	4 Sion b	1.3m @ DIS Exte	A + Completed by: CH	Checked by:	
		NID SCILLA			

Date:	No	12,2015		Stream/Reac	FPI	5-2			
Weather:	S.	1000		Location		- 0			
Tille: #	ou	HIER Watershed/Subwatershed			KICK	24 K	d		
Field Staff:	Ct	H E K Watershed/Subwatershed:			East	r Pat	tersor		
Process		Geomorp	phic Indicator		Pre	sent?	Facto		
FIOCESS	No.	Description			Yes	No	Value		
[]	1	Lobate bar				11			
and second	2	Coarse materials in riffles embedo	ded		-		-		
Evidence of Aggradation	3	Siltation in pools				1.7			
	4	Medial bars				1.1	DL		
(AI)	5	Accretion on point bars	-		1.	17	-97		
	6	Poor longitudinal sorting of bed m	naterials		1	Y			
	7	Deposition in the overbank zone							
				Sum of indices	= 0	7	0.0		
	1	Exposed bridge footing(s)			1 1/	1A			
Evidence of	2	Exposed sanitary / storm sewer / r	pipeline / etc		18	12			
	3	Elevated storm sewer outfall(s)	pipeinte y etc.		N	NIA NIA NA 1/5			
	4	Undermined gabion baskets / con	crete aprons / etc.		- /V				
	5	Scour pools downstream of culver	rts / storm sewer outle	ts	- pl				
Degradation	6	Cut face on bar forms			/V.				
(DI)	7	Head cutting due to knick point migration				V			
	8	Terrace cut through older bar material				1	1		
	9	Suspended armour layer visible in bank				17	1		
	10	Channel worn into undisturbed overburden / bedrock				11			
	-			Sum of indices	= /	4	0.20		
	1	Fallen / leaning trees / fence posts	s/etc.		1	1.7	1		
	2	Occurrence of large organic debris	5		-	1 X	-		
	3	Exposed tree roots				17	-		
Fuidau as af	4	Basal scour on inside meander ber	nds		IN I	IA	-		
Widening	5	Basal scour on both sides of chann	nel through riffle		N	1.00			
(MAIL)	6	Outflanked gabion baskets / concr	rete walls / etc.		NA 0				
(001)	7	Length of basal scour >50% throug	gh subject reach		1	N/A 75			
	8	Exposed length of previously burie	ed pipe / cable / etc.		M				
	9	Fracture lines along top of bank							
	10	Exposed building foundation			N	1A			
	-			Sum of indices	0	5	0.0		
	1	Formation of chute(s)			1	. /			
Evidence of	2	Single thread channel to multiple of	channel		-	1	-		
Planimetric	3	Evolution of pool-riffle form to low	v bed relief form		1	1.7	-		
Form	4	Cut-off channel(s)				17	11_		
Adjustment	5	Formation of island(s)				1.7	- 17		
(PI)	6	Thalweg alignment out of phase meander form			1	1	1		
	7	Bar forms poorly formed / reworke	ed / removed		1/		1		
				Sum of indices	: /	6	0.14		
dditional notes				Stability Index (CI)		/L+DI)/4	0		
internal notes.			Condition	In Paging Index (SI)		1+r1)/4 =	0.07		
			Condition	in Regime In T	ransition/St	ress In a	Adjustmer		
			SI score =	월 0.00 - 0.20	0.21 - 0.4	0	0.41		

Completed by: KI/ER Checked by: _

Rapid Stream Assessment Technique Project Number: PNIS080

Date:	NOV 2, 2015	Stream/Reach:	EPC-3
Weather:	SUN+ 10°C	Location:	Kirby Rd
Field Staff:	CHIER	Watershed/Subwatershed:	East Patterson

Evaluation Category	Poor	Fair	Good	Excellent
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% 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
ALA	 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 0.8-0.9 m 	 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
Channel Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed 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		□ 3 □ 4 □ 5	060708	□ 9 □ 10 □ 11

	 > 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)
Channel Scouring/ Sediment Deposition	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		□ 3 □ 4	□ 5 10 G	0708



Evaluation Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width (45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
Physical Instream Habitat	 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 ryms 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 percentage 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 peols 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
NIF	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		□ 3 ☑ 4	□ 5 □ 6	0708

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 < 0.15 m below surface 	 Objects visible to depth 0.15-0.5 m below surface 	Objects visible to depth 0.5-1.0 m below surface	 Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour
Point range		□ 3 □ 4		₫ 7 🗆 8

Riparian Habitat	Narrow riparian area of mostly non-woody vegetation	 Riparian a wooded b localized 	area predominantly out with major gaps	 Forested buffer ger > 31 m wide along portion of both bar 	nerally • Wide major forest oks banks	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	Canopy coverage: < 50% shading (30% for large mainstem areas)	 Canopy coverage: 50-60% shading (30-44% for large mainstem areas) 		Canopy coverage: 60-79% shading (45 large mainstem are	5-59% for > 80% mains	 Canopy coverage: > 80% shading (> 60% for large mainstem areas) 	
Point range					5	6 7	
Additional no	otes:			Total	overall score (0	-42) = 22	
		Ranking	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)	
			1 - 1 - C - 1				

Completed by: KT/ER Checked by:


APPENDIX C6.2

Planning Level Meander Belt Width Delineation, 100-Year Erosion Limits, and Preliminary Crossing Recommendations

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Head Office 2800 High Point Drive, Suite 100A Milton, Ontario, Canada L9T 6P4

T 416.920.0926

Ottawa Office PO Box 336 Woodlawn PO Dunrobin, Ontario, Canada K0A 1T0

T 613.979.7303

June 4, 2018

Schaeffers Consulting Engineers 6 Ronrose Drive Concord, Ontario L4K 4R3

Attention: Mr. Leonid Groysman, Class EA Lead

Re: Planning Level Meander Belt Width Delineation, 100-Year Erosion Limits, and Preliminary Crossing Recommendations for the Kirby Road Extension Environmental Assessment Upper East Patterson Creek, Vaughan, Ontario GEO Morphix Project No. 15080

A geomorphological assessment was previously completed by GEO Morphix Ltd. (2016) for the Upper East Patterson Creek in the vicinity of the proposed Kirby Road Extension in Vaughan, Ontario. Our 2016 assessment involved both desktop and field activities including reach delineation, reach-by-reach rapid assessments, and a detailed geomorphological assessment.

Our understanding is that the Toronto and Region Conservation Authority (TRCA) has requested additional information including meander belt widths, 100-year erosion limits, and preliminary recommendations regarding the potential crossing location (Scott Smith, email dated May 3, 2018).

To address this request we completed additional desktop analysis to: supplement the findings of our original report; provide planning level meander belt widths; calculate 100-year erosion limits; and develop crossing recommendations.

General Reach Characteristics

Our previous work identified three reaches. A reach map is included in **Appendix A**. Reaches **EPC-1**, **EPC-2**, and **EPC-3** of Upper East Patterson Creek were assessed in Fall 2015 (GEO Morphix Ltd., 2016). Reach **EPC-1** was forested, while Reaches **EPC-2** and **EPC-3** flowed just outside the forest margin, along the perimeter of a disturbed area. An additional reach, **EPC-4**, was considered in the present desktop analysis to address all potential road alignment options and possible crossing locations. Reach **EPC-4** was identified as a wetland feature in a forested area upstream of Reach **EPC-3**. No significant tributaries were observed flowing into the main channel within the study area.

According to our observations in Fall 2015, the majority of the channel was at least partially confined or fully realigned. Reach **EPC-1** was a constructed valley feature, approximately 5 m wide and just over 1 m deep. The low-flow channel had no riffle-pool development, and averaged 1.89 m wide and 0.15 m deep. Reach **EPC-2** was also within a constructed valley feature, whose channel was likely formed naturally following valley excavation. The low-flow channel was considered to be the bankfull channel, although it may still be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. Reach **EPC-3** continued as a low-flow channel within a constructed valley feature, but with appreciably different physical characteristics than Reach **EPC-2**. The Reach **EPC-3** channel had no bankfull indicators and limited evidence of a stable channel morphology. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the upstream wetland (Reach **EPC-4**)

contributed to total flow. Further reach descriptions and observations are provided in our previous report, which has been included as **Appendix B**.

Planning Level Meander Belt Width Delineation and 100-Year Erosion Limits

In support of crossing recommendations and to provide context, meander belt widths and 100-year erosion limits were calculated for the four reaches within the study area.

Meander belt widths for Reaches EPC-1, EPC-2, EPC-3 and EPC-4 were estimated using two methods.

The first method used two modified Williams (1986) models with the addition of a 20% factor of safety.

Modified Williams (1986) Area,	$B_W = 18A^{0.65} + W_b \dots$	(Eq.1)
Modified Williams (1986) Width,	$B_{W} = 4.3 W_{b}^{1.12} + W_{b} \dots$	(Eq.2)

Where B_W is meander belt width (m), A is cross-sectional area (m²), and W_b is bankfull channel width (m).

Previous clearing and other historical site activities have resulted in a disturbed study area with few natural references. Reach **EPC-1** was determined to have the most natural characteristics and was the most aged since realignment (GEO Morphix, 2016). As such, this reach was selected for detailed assessment to determine average bankfull channel dimensions (Fall 2015) and was used as a reference reach to model a representative meander belt width for all reaches in the present analysis. The average bankfull channel width for Reach **EPC-1** was 1.89 m, and the average bankfull channel depth was 0.15 m.

The modelled meander belt widths (including a 20% factor of safety) based on the detailed assessment were 11.8 m (Eq.1) and 12.8 m (Eq.2).

The second method for determining meander belt widths required measuring the largest meander amplitude observed within each reach. Again, previous site activities and watercourse realignments had erased any previously natural meanders from the planforms of Reaches **EPC-2** and **EPC-3**. The forest cover of Reaches **EPC-1** and **EPC-4** also prevented us from identifying drainage routes and channel planforms using aerial photography.

As a surrogate, we measured the largest meander amplitude within the study extent, as observed along the Ontario Hydro Network (MNR) watercourse. This was the most accurate delineation of the watercourse available for the present study. A 20% factor of safety was added to the measured value to determine a meander belt width of 20.6 m, which was applied for all reaches. This meander belt width was delineated along the observed central tendency of the watercourse within the study extent, and is illustrated in **Appendix C**.

The calculated meander belt widths are conservative, given that the studied reaches are in confined, or partially-confined systems. These meander belt widths can be further refined at detailed design, if required.

A 100-year erosion limit was estimated for all the reaches in the study area based on geology, level of erosion, and channel size according to the MNR's erosion hazard technical guidelines (MNR, 2001).

Where the reaches were not controlled by the presence of vegetation, the bank materials were a mix of clay, silt, and sand, with only limited evidence of active erosion. As such, based on MNR guidance we suggest an erosion limit of 5 m be applied to delineate the lateral erosion hazard.

Geomorphological Crossing Recommendations

Our preferences with regards to road alignment are based solely on geomorphological and erosion considerations. We have also considered TRCA's Crossing Guideline for Valley and Stream Corridors (2015), which recommends using siting and design to avoid damage to the infrastructure and minimizing channel contact with the crossing infrastructure to reducing erosion hazards.

We recommend that the sizing and location of the proposed crossing consider potential future channel erosion and/or migration. We suggest that the crossing be located at a fair distance from any upstream meanders. The crossing should also maintain velocity differentials and sediment transport processes for frequent storm events through and adjacent to the crossing. The installed structure should have an open bottom and be positioned within a reasonably stable length of channel.

Road Alignment Options 4 and 5 are not preferred as they both could potentially result in disturbance of well-established riparian cover. Clearing the riparian cover would negatively influence creek function. If this crossing location is proposed, we recommend spanning the meander belt width and limiting vegetation removal/impact. In that case, the potential impacts can likely be mitigated.

Road Alignment Options 6 and 6A are preferred as they cross the existing watercourse at a perpendicular angle through a previously disturbed area where the reach has been realigned and channelized. Erosion was noted along the valley walls in the crossing location associated with Road Alignment Options 6 and 6A. A crossing at this location would likely provide an opportunity for stabilization.

We recommend two possible approaches to crossing sizing at 6 or 6A. The first is calculated as three times the bankfull channel width. The second is calculated as bankfull width plus two times the erosion limit. Based on the average bankfull channel width of 1.9 m, these approaches provide crossing sizes of 5.7 m and 11.9 m, respectively. Note these values are a significant portion of the modelled meander belt width estimates.

If disturbance of riparian vegetation is anticipated, we also advocate installation of a channel reinforced with hydraulically sized materials to stabilize the channel under the crossing allowing for fish passage across a wide range of conditions. With regards to hydraulic sizing, MTO Highway Drainage Design Standards (2008) would suggest 100-year event scour protection per standards WC-1/WC-3 for 'local road' conditions with FS=1. Detailed design HEC-RAS results can be utilized for the 100-year event velocity determination.

These recommendations reflect the geomorphological considerations. Other disciplines will also need to be considered including terrestrial and aquatic biology, ecology, hydrogeology, and hydrology.

We trust this memo meets your requirements.

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., Can-CISEC Director, Principal Geomorphologist

Cara Hutton

Cara Hutton, M.Sc. Senior Environmental Technician

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Appendix A



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Appendix B



This page intentionally left blank for 2-sided printing purposes 348 Bronte Street South, Unit 2 Milton, Ontario L9T 5B6 T 416.920.0926

e balance@geomorphix.com

Rizmi Property City of Vaughan, Ontario

Upper East Patterson Creek Geomorphic Assessment



Prepared for: Rizmi Holdings Limited 11333 Dufferin Street PO Box 663 Maple, Ontario L6A 1S5

Prepared by: GEO Morphix Ltd.

Project No.: 15080

Date: January 18, 2016

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Appendices

Appendix APhotographic Record of Site ConditionsAppendix BRapid Assessment Field Sheets

1 Introduction

A Municipal Class Environment Assessment is proposed by the City of Vaughan to determine the preferred alternative to extend Kirby Road to Gamble Road in the Town of Richmond, between Dufferin and Bathurst Streets. The ultimate alignment of this arterial road will be determined with consideration to numerous factors as required in the Class EA process. One consideration is East Patterson Creek, which is addressed in this report.

The east tributary of Patterson Creek originates in a wetland located near the north part of the Rizmi Stone & Aggregates property at 11333 Dufferin Street in the community of Maple. A significant portion of channel within the property limits has apparently been modified in the past. The alterations, however, do not affect fish habitat due to a significant barrier to fish passage along the southern property line. The watercourse currently conveys flows to the south property line where it terminates in a wetland. The following report provides a geomorphic assessment of East Patterson Creek to fulfill a Class EA requirement to document natural heritage features, as well as to support the decision-making process with respect to actions that affect the watercourse.

It is understood that the future of the channel within the property has yet to be determined as it is not considered to be direct fish habitat. Potential outcomes include removal, retain in its current alignment, realignment, enhancement, or a combination of these alternatives. GEO Morphix will provide appropriate support once the preferred solution has been determined in the Class EA study.

2 Historical Conditions

A series of 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. Historical aerial photographs from 1946 (scale 1:20,000) and 1954 (scale 1:63,360), and orthophotography from 1970, 1999, 2002, 2005, 2007, 2011, 2012 and 2013, and Google Earth Pro satellite imagery from 2015 were reviewed to complete the historical assessment.

In 1946, the upper East Patterson Creek drainage area was largely forested, with the exception of a clearing for agriculture at the upper extent of the drainage area. At the current location of the Rizmi Stone & Aggregates field operations, there was a clearing but no apparent activity. The drainage route within the subject property could not be identified due to tree cover, but there was an intermittently-forested corridor with a watercourse that extended in a southeasterly direction from the subject property towards Bathurst Street. The channel planform could not be determine on the aerial photography. Outside of the forested area to the north beyond the drainage area, the land was used exclusively for agriculture. The area beyond the property to the south was also used for agriculture.

There were no significant changes in land use through 1954. The surrounding land to the south, however, was transformed to a golf course, Maple Downs Golf Course. By 1970, Rizmi operations extended approximately 0.4 km to the east from the previously cleared area, as suggested by the heavily disturbed landscape and the access road connecting the disturbed area to Dufferin Street. Also between 1954 and 1970, the TransCanada Pipeline was constructed along the south property boundary and across the channel. The watercourse is visible along the east side of an internal road at the eastern end of the disturbed area, but the Pipeline clearly prevents flow conveyance

beyond the property as evidenced by the ponded water at the Pipeline crossing. The lack of tree cover along the section of channel along the internal road as well as its linear alignment also suggest that it was channelized to enhance drainage function. East of the Rizmi property along the north side of the Pipeline was a private runway.

Rizmi operations appeared to have slowed by 1999. The channel alignment was the same as it was in 1970, but the pond at the Pipeline had visual characteristics of a wetland. Another notable change within the property was a linear clearing through the forest leading to the general area of the channel origin, north of the cleared aggregate extraction area. There was also limited clearing on the east side of the internal road and channel, as well as a culvert in the channel next to this recently cleared area for access the east side. Southeast of the property, the land was developed for residential use.

Surrounding land use remained generally unchanged in 2011. Between 2007 and 2011, a portion of the channel within the Rizmi property was again realigned to travel along the margin of the cleared area. The previously installed culvert was removed due to the channel realignment, and a new culvert was constructed at the new channel crossing location. Activity within the property also appears to have increased during this period. There were no notable changes in 2012 and 2013.

Overall, the portion of East Patterson Creek within the Rizmi property experienced significant changes over the period covered by historical imagery. These changes include realignment and straightening (i.e., channelization), removal of tree cover, and the disruption of channel and flow continuity as a result of the TransCanada Pipeline.

3 Existing Conditions

3.1 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 are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

East Patterson Creek is situated in the Upper East Don Subwatershed. The channel within the property limits is a headwater feature that originates from a generally linear wetland feature located mostly within the property. In total, the channel travels in a southerly direction for approximately 6 km, where it joins West Patterson Creek, then continues for another 1.5 km to the confluence with the East Don River.

The subject site is located in a southward extending lobe of the Oak Ridges Moraine physiographic region, which is bounded by the South Slope physiographic region to the west, south and east. Beyond the South Slope is the Peel Plain (Chapman and Putnam, 1984), where Patterson Creek joins the East Don River. With respect to surficial geology, the subject area is characterized by ice-contact stratified deposits consisting of sand and gravel, minor silt, clay and till (OGS, 2010). The surficial geology generally changes in the downstream direction in concert with the physiographic regions: the South Slope is comprised of clay to silt-textured till (derived from glaciolacustrine deposits or shale) and the Peel Plain is generally characterized by glaciolacustrine deposits (OGS, 2010). The predominantly sand and gravel composition of the surficial material

allows the channel to readily adjust, although the degree of adjustment would also be influenced by the flow regime as well as other factors such as vegetation control.

The catchment area for the channel within the subject property is largely forested with the exception of the area cleared for the Rizmi Stone & Aggregates operations. Downstream of the property to Bathurst Street, the channel travels through a forested corridor surrounded by low-density residential dwellings. The forested channel corridor continues beyond Bathurst Street, although housing density increases.

3.2 Reach Delineation

Rivers and streams are frequently segmented into reaches to provide meaningful lengths of channel for study. Reaches are delineated based on changes such as hydrology, channel gradient, confinement, planform (i.e., channel pattern), geology, surrounding land use and anthropogenic disturbances (e.g., crossing structures, dams, straightening/channelization, armouring). Each reach can then be studied as a unit that is expected to function in generally uniform manner throughout its length.

Within the Rizmi property, East Patterson Creek was divided into three reaches. The downstream channel reach (EPC-1) is approximately 100 m in length, the middle reach (EPC-2) is 130 m, and the upstream reach (EPC-3) is 200 m. Forest cover was one consideration when delineating the reaches: the Reach EPC-1 channel lies just within the west forest margin, while Reaches EPC-2 and EPC-3 are just outside the west forest margin. Despite the apparently limited differences between reaches, tree cover is a significant factor that governs channel form and function, and hence the two reaches. Reaches EPC-2 and EPC-3 are differentiated primarily by channel morphology. Wetland features are located downstream of Reach EPC-1 and upstream of Reach EPC-2. The reach delineation was verified in the field, as discussed below.

3.3 Reach Assessments

Site observations and channel measurements were collected on November 2, 2015. The field investigation was completed for the full length of channel between the wetland at the upstream extent of the channel and the south property limit. A photographic record of site conditions is provided in Appendix A. On the day of the site visit, the temperature was 10°C and there was no precipitation. There was, however, 7 mm of rain from October 31 to November 1.

3.3.1 General Observations

Within the Rizmi property, East Patterson Creek originates in a wetland feature located in a forested area to the north just beyond an open, disturbed area created by site activities. The channel travels along the perimeter of the clearing before entering the forested area. It continues just within the forest boundary to a wetland feature at the south limit of the property. The reaches identified in Section 3.2 were confirmed to be correct. The following is a description of each reach from upstream to downstream.

The wetland at the upstream end of the section of channel under study is comprised of a dense thicket of shrubs (red-osier dogwood). There was no define flow pattern within the wetland.

Reach EPC-3 is in a constructed valley feature containing a low-flow channel. The valley had a V' shape except towards the downstream end of the reach. The channel had no bankfull indicators

and there was limited evidence of a stable channel morphology. The bed was composed of mostly silt and sand, and its morphology was partly controlled by vegetation. Three knickpoints were observed, which suggests that the channel gradient is high relative to those of the two downstream reaches. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the wetland contributed to total flow. Wetted flow width varied due to the high degree of channel confinement, ranging from 0.1 to 1.5 m. The channel characteristics were largely governed by the composition of the valley materials, which was sand. The northeast embankment (left embankment viewed in the downstream direction) was comprised of exposed sand with limited woody vegetation. Due to the unstable nature of the embankments, in particular that to the northeast, the channel will likely continue to adjust according to the sediment supply. Mature trees lied beyond the sandy embankment. The southwest side of the channel was open with primarily grasses.

Reaches EPC-3 and EPC-2 were divided by a partly embedded 1200 mm CSP culvert, constructed for access across the channel. Reach EPC-2 continues as a constructed valley feature, but with appreciably different physical characteristics. Here, the valley top width was roughly 3.9 m wide and the valley depth was 1.5 to 2.0 m. The east side of the valley was populated by mature trees, while the east side was dominated by grasses within an open (i.e., cleared) area.

The Reach EPC-2 channel likely formed naturally following valley excavation. The low-flow channel is considered to be the bankfull channel, although it still may be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. There was a 0.22 m high knickpoint mid-reach that cut into till. Upstream of the knickpoint, the bed was characterized by sand, gravel and small cobbles, while downstream of the knickpoint, the bed was comprised of mostly sand, but also exposed till. This longitudinal change in bed characteristics can be explained by differences in bed gradient.

At the downstream end of Reach EPC-2, the channel turns at nearly a right angle to travel south into Reach EPC-1. There was evidence of the former channel location (before the realignment of Reaches EPC-3 and EPC-2), in the form of a linear depression across the cleared area, that aligned with Reach EPC-1. Although the former channel was decommissioned, surface runoff apparently continued to enter the Reach EPC-1 channel at the upstream end of this reach as indicated by the minor erosion and headcutting.

Reach EPC-1 travels in a southerly direction and continues as a constructed valley feature approximately 5 m wide and just over 1 m deep. Both sides of the valley was vegetated with mature trees; however, the woody riparian buffer on the west side was limited. Tree cover over the channel was dense, and there were frequent observations of woody debris within the constructed valley, mostly as broken individual tree limbs that did not significantly affect flow pattern. The low-flow channel had no riffle-pool development, and averaged 1.90 m wide and 0.15 m deep. The increase in width-to-depth ratio, relative to that of Reach EPC-2, can be explained by the decrease in channel gradient and the increase in discharge. Both the bed and banks were comprised of sand, which would be expected due to the lower gradient and the typical downstream fining found in natural watercourses.

At the downstream end of the Reach EPC-1 channel was a wetland feature. This wetland was contained in a basin (roughly 70 wide and 50 m wide) that was bounded in the downstream (south) end by a raised natural gas pipeline corridor (i.e., TransCanada Pipeline), which was essentially a large berm. The top of the Pipeline was approximately 1.5 to 2.0 m above the wetland bed, and therefore a considerable volume of water would be required for flows to spill

over the Pipeline corridor. There was no evidence of a flow path over the Pipeline, although it would clearly be located across the lowest point. The impact of the lack of surface flow continuity to the watercourse downstream (south) of the Pipeline corridor could not be assessed due to property constraints.

3.3.2 Rapid Field Assessments

Rapid field assessments were completed as reconnaissance-level evaluations to determine the condition of each reach with respect to channel stability and general stream health:

- Channel instability was semi-quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.41).
- The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and consider the ecological functioning of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34) or excellent (35-42) degree of stream health.

A summary of the rapid assessments is provided in Table 1. Completed field sheets are found in Appendix B.

	RGA*			RGA* RSA				RSAT	**
Reach	Score	Condition	Dominant Form of Adjustment	Score	Condition	Limiting Feature(s)			
EPC-1	0.11	In regime	Aggradation	26	Good	Physical instream habitat			
EPC-2	0.12	In regime	Degradation	28	Good	Riparian habitat conditions			
EPC-3	0.09	In regime	Degradation	22	Fair	Riparian habitat conditions			

Table 1: Rapid field assessment summary

* Ontario Ministry of the Environment (2003)

** Galli (1996)

3.3.3 Detailed Geomorphic Assessment

Within the property limits, Reach EPC-1 was determined to be relatively natural and certainly the most aged since realignment. As such, this reach was selected for further investigation – i.e., detailed geomorphic assessment. This detailed assessment serves as the basis for any required channel modifications such as realignment or stabilization.

The detailed assessment involved temporarily setting up eight representative cross sections for the purpose of determining average bankfull channel dimensions (e.g., width, average bankfull depth, maximum depth, and bank angles). The bankfull level was determined using standard protocols and accepted field indicators. A survey of the bed profile was also completed to determine slope and compute bankfull hydraulics. A modified Wolman (1954) pebble count was completed to characterize the bed materials. A summary of measured and computed values is presented in Table 2.

Channel parameter	Results
Measured	
Average bankfull channel width (m)	1.89
Average bankfull channel depth (m)	0.15
Average width-to-depth ratio	14.7
Channel gradient (%)	0.42
D ₅₀ (mm)	<2
D ₈₄ (mm)	<2
Manning's n roughness coefficient	0.034
Computed	
Bankfull channel discharge (m ³ /s) *	0.14
Average bankfull velocity (m/s)	0.53
Unit stream power at bankfull discharge (W/m ²)	3.2
Tractive force at bankfull (N/m ²)	5.98
Critical shear stress (N/m ²) **	1.46
Flow competency for D ₅₀ (m/s) ***	0.27
Flow competency for D ₈₄ (m/s) ***	0.27

Table 2: Bankfull parameters of the reference channel

* Based on Manning's equation

** Based on Shields diagram from Miller et al. (1997)

*** Based on Komar (1987)

The Reach EPC-1 reference channel has a lower width-to-depth ratio than the two upstream reaches due to the lower channel gradient. Despite the relatively low unit stream power, the bed (comprised of sand) is fully mobile under bankfull flow conditions. It is expected that the Reach EPC-1 channel length would decrease slowly over time as the bed material is transported and deposited in the wetland. The receiving wetland would consequently increase in size, but only in the upstream direction due to the raised pipeline crossing.

4 Conclusions

East Patterson Creek within the Rizmi property has been significantly altered, and impacted both directly and indirectly, over the period covered by historical imagery. It also no longer functions



as potential fish habitat as a result of the construction of the TransCanada Pipeline. In-channel flows now therefore infiltrate and contribute to groundwater.

If the preferred alternative solution, resulting from the Class EA study, is assessed to be restoration, realignment or enhancement, we would be pleased to provide design services. Concurrently or independently, we can also investigate potential hazards associated with a dynamic channel.

5 References

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Miller, M.C., McCave, I.N., and Komar, P.D. 1977. Threshold of sediment motion under unidirectional currents. Sedimentology, 24: 507-528.

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Appendix A Photographic Record of Site Conditions













Appendix B Rapid Assessment Field Sheets



Reach Charact	eristics	Project Lo					1
Date:	NON 2015	Stream/Reach:	EPC-1				
Weather:	9 × + 10°C	Location:	Kivby Rd	+ DU	PERIN	5	
Field staff:	CH/FR	Watershed/Subwatershed:	East Portfe	WEDD C	XIL		
UTM (Upstream)		UTM (Downstream)					
(Table 1)	ev Type 2 Channel Type (Table 2) (Table 2) (Table 2) (Table 2)	Zone 2 Flow Type 1 (Table 5)	2 Keroundwater	Evidence:	woter	cress	1
Riparian Vegetation		Aquatic/Instream Ve	igetation	Water Q	uality		
Dominant Type: Cover (Table 6) 1 0 No Species: 6 6 0	age: Channel Age Class (yrs) : Encroachmer ne 1 1-4 1 Immature (<5) (Table gmented X 4-10 X tstablished (5-30) 2 ntinuous 1 > 10 1 Mature (>30)	tt: Type (Table8) Woody Debris Present in Cuthan Present in Channe Not Present	Coverage of Reach (%) Density of WD: k \vee VD: A \vee VD!/50m I \vee Moderate 1		Odour (Ta 1 Turbidity (T	ble 16) able 17)	
Channel Characteristics							
Sinuosity (Type)	Sinuosity (Degree) Gradient Nun	her of Channels	Clay/Silt Sand G	ravel Cobble	Boulder	Parent R	tootlets
(Table 9)	(Table 10) 1 (Table 11) 1 (Tal	He 12) 1 TRIFfic Substr	ate 🛛 🕅			0	
Entrenchment	Type of Bank Failure Downs's Classification	Peol-Substr	ate C D			þ	þ
(Table 13)	(Table 14) (Table 15) S	Bank Materia				0	
Bankfull Width (m)	Wetted Width (m)		Bank Angle	Bank Erosion	Notes:		
Bankfull Depth (m)	Wetted Depth (m)		09-00	0 2 - 30%			
Riffle/Pool Spacing (m)	NP % Riffles: NR % Pools: N	Meander Amplitude:	NA Durdercut	0 = 100%			
Pool Depth (m)	N.A. Riffle Length (m) N.A. Undercuts (m)	Nore comments: NO	riffle - pools,	poor			
Veloctity (m/s)	Withe ball / ADV	(Estimated) BF (D	diccitors.				

Date:	NV	2015	Stream/Rea	ch: EDA	2-1	-		
Weather	- N	1000	Jacobi	CPU	0-	4		
weather.	Z	A + 10 C	LUCAU	ON: KIVE	NY KO	X		
Field Staff:	(HIER	Watershed/Subwatersh	ed: E. Pa	atters	son Cri		
Desease		Geomorphic In	dicator	Pre	sent?	Facto		
Process	No.	Description		Yes	No	Value		
	1	Lobate bar			1	-		
	2	Coarse materials in riffles embedded		NA		-		
Evidence of	3	Siltation in pools				1 17.		
Aggradation	4	Medial bars			V	- 14		
(AI)	5	5 Accretion on point bars				_		
	6	Poor longitudinal sorting of bed material	V					
	7	Deposition in the overbank zone		V	1			
	Sum of indices					0.25		
	1	Exposed bridge footing(s)		110	1			
	2	Exposed sanitary / storm sewer / pipelin	e / etc.	NIQ.				
-	3	Elevated storm sewer outfall(s)	.,	NIA	-			
Evidence of Degradation (DI)	4	Undermined gabion baskets / concrete a	NA	-	-			
	5	Scour pools downstream of culverts / sto	MA	1	01			
	6	Cut face on bar forms	110		- 12			
	7	Head cutting due to knick point migratio	- Nin	1	_			
	8	Terrace cut through older bar material	NA	1				
[9	Suspended armour layer visible in bank		V				
	10	Channel worn into undisturbed overburg	ien / bedrock		V	1		
			Sum of indice	es = 0	3	C		
	1	Fallen / leaning trees / fence posts / etc.			V			
	2	Occurrence of large organic debris		V				
[3	Exposed tree roots		V				
Euidonco of	4	Basal scour on inside meander bends				11/		
Widening	5	Basal scour on both sides of channel three	NA		1/5			
(WII)	6	Outflanked gabion baskets / concrete wa	NA	-				
()	7	Length of basal scour >50% through subj		1				
Į	8	Exposed length of previously buried pipe	NA					
	9	Fracture lines along top of bank		V				
	10	Exposed building foundation	NA		1			
			Sum of indice	25 =	4	02		
	1	Formation of chute(s)			1~			
	2	Single thread channel to multiple channel	1		V			
Evidence of	-	3 Evolution of pool-riffle form to low bed relief form			1			
Evidence of Planimetric	3	4 Cut-off channel(s)			-	OI		
Evidence of Planimetric Form	3	Cut-off channel(s)			1			
Evidence of Planimetric Form Adjustment	3 4 5	Cut-off channel(s) Formation of island(s)				- 16		
Evidence of Planimetric Form Adjustment (PI)	3 4 5 6	Evolution of pool-riffie form to low bed r Cut-off channel(s) Formation of island(s) Thalweg alignment out of phase meanded	er form		15	16		
Evidence of Planimetric Form Adjustment (PI)	3 4 5 6 7	Cut-off channel(s) Formation of island(s) Thalweg alignment out of phase meande Bar forms poorly formed / reworked / re	r form moved	NA	111	16		
Evidence of Planimetric Form Adjustment (PI)	3 4 5 6 7	Evolution of pool-riffie form to low bed r Cut-off channel(s) Formation of island(s) Thalweg alignment out of phase meande Bar forms poorly formed / reworked / re	er form moved Sum of indice	NA 15= Ø	112 6	0		
Evidence of Planimetric Form Adjustment (PI) dditional notes:	3 4 5 6 7	Evolution of pool-riffie form to low bed r Cut-off channel(s) Formation of island(s) Thalweg alignment out of phase meande Bar forms poorly formed / reworked / re	r form moved Sum of indice Stability Index (S	NA 25 = Ø	6 WI+PI]/4 :	0.11		
Evidence of Planimetric Form Adjustment (PI)	3 4 5 6 7	Evolution of pool-riffie form to low bed r Cut-off channel(s) Formation of island(s) Thalweg alignment out of phase meande Bar forms poorly formed / reworked / re	r form moved Sum of indice Stability Index (S Condition In Regime II	es = Ø	6 WI+PI]/4 : itress In	0.11 Adjustmer		

Completed by: _____ Checked by: _

Rapid Stream	Assessment	Technique	
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Project Number: PN15080

Date:	Nov 2,2015		Stream/Reach: EP	C-1	
Weather:	SUN + 10°C		Location: Kirloy Rd		
Field Staff: CH / ER		Watersh	Watershed/Subwatershed: E. Patterson		
Evaluation Category	Poor	Fair	Good	Excellent	
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	71-80% 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) Rank wasthane 0.9-0.9 m	Stream bend areas stable Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) Bank overhang 0.6-0.8 m	Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m	
Stability	Young exposed tree roots abundant S recent large tree fails 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		3 4 5	06,0708	□ 9 □ 10 □ 11	

	 >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) 	NĄ
	Few, if any, deep pools. Pool substrate complexition S1% 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-slit	
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak-marks and/or "banana"-shaped sediment deposits uncommon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	Fresh, large sand deposits 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 	NI
Point range	0 0 1 0 2	□ 3 □ 4 ~	0506	0708	

P

GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted-perimeter 40-60% of bottom channel width (45-) 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
Physical Instream	 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)
Habitat	Biffle substrate composition: predominantly gravel with high percentage of sand < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and sand S-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 mainstern 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 om 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
oint range		□ 3 □ 4	0506	0708

	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)
Water	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
Quality	 Objects visible to depth <0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	Objects visible to depth 0.5-1.0 m below surface	Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	+ Slight organic odour	No odour
Point range		□ 3 □ 4	0506	7 8

Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	Biparian wooded localized	area predominantly- but with major gaps	Forested buffer ge > 31 m wide along portion of both bar	nerally + Wide (major nks banks	> 60 m) mature d buffer along both
Conditions	 Canopy coverage: < 50% shading (30% for large mainstern areas) 	Canopy of 50-60% s large ma	overage: hading (30-44% for instem areas)	Canopy coverage: 60-79% shading (4) large mainstem are	5-59% for sas) Canopy > 80% : mainst	v coverage: shading (> 60% for large em areas)
Point range			2 🗆 3	0 4 ^L 0	5 0 0	6 0 7
Additional no	tes:		_	Total	overall score (0 -	42) =
		Ranking	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)
					26	

Completed by: _____ Checked by:__

Weather: Field staff: UTM (Upstream) Land Use [Table 1)	NON & GOID	eam/Reach:	EPC-2			
Field staff: UTM (Upstream) Land Use [Table 1) H	SUN + 10°C	cation:	Kirbu Rol:	DUFFer	12 U	
UTM (Upstream) Land Use H Va (Table 1)	CH /FR	atershed/Subwatershed:	East pat-	Ferson (Ork	
Land Use H Va (Table 1)	5	M (Downstream)				
	Iley Type Channel Type Channel Zona (Table 2) (Table 3) (C Channel Zona	Flow Type 2	AGroundwater	Evidence:	iron stein	6
Riparian Vegetation		Aquatic/Instream Veg	etation	Water Qu	iality	
Dominant Type: Cove (Table 6) 2 0 N Species: 5	rage: Obvious weaters Age Class (yrs) : Encroachment: one 1.4 M Immature (<5)	Type (Table8) Woody Debris Present in Cutbank	Coverage of Reach (%) < Density of WD: Low WDJ/56 Moderate High	V = -	Odour (Table 16)	
Channel Characteristics						
			and the second			
Sinuosity (Type) (Table 9)	Sinuosity (Degree) Gradient Number (Table 10) 1 (Table 11) 2 (Table 1	of Channels 2) 1 Aiffile Substrai	te D to the te	Gravel Cobble	Boulder Parent	Rootlets
Entrenchment	Type of Bank Failure Downs's Classification	Pool-Substra	te			#
(Table 13) 2	(Table 14) 1 (Table 15)	Bank Material	went up		0	
Bankfull Width (m)	1.3 [L.O] Wetted Width (m) O.	3 0.25	Bank Angle	Bank Erosion	Notes:	
Bankfull Depth (m)	○ ↓ Ø, Ч Wetted Depth (m) Õ	510	09-00	0 5 - 30%	CSPCOLOSS	100 - 1 ar
Riffle/Pool Spacing (m)	NA & Riffles: NA & Pools: NA	Meander Amplitude:	1/17 Dudercut	00-100%		0
Pool Depth (m)	NP Riffle Length (m) NP Undercuts (m)	Comments: KP	· exnosed	1117		
Veloctity (m/s)	Wiffle ball / ADV / Es	timated COONEY	haterial uls	OF KP		
valley -	4 wiss v		Completed by:	M	Checked by:	1
lecture	1.3M	6)		

Date:	Mai	12 2015		Stream/Reach	EPO	2-2	
Date.	110	Valadis		Location	EVI	bu	Rd
Weather:	Sur	1+ 10°C		1/C. huntarchar	L. L. oct	Daile	C MA
Field Staff:	CH	IER	Watershe	d/Subwatershet	CON	Patric	noort
	-	Geomorph	nic Indicator		Pr	esent?	Factor
Process	No	Description			Yes	No	Value
	1	Lobate bar				.V	
	2	Coarso materials in riffles embedd	ed		1	VA	
widence of	2	Situation in peols			1	VA_	-
agradation	3	Medial bars				V,	-015
(AI)	5	Accretion on point bars			-	V	- 12
180	6	Poor longitudinal sorting of bed m	aterials			V	4
	7	Deposition in the overbank zone				Y	10.0
		L'OP		Sum of indices	· 0	5	0.0
		s the day facting(s)			N	I IA	
	1	Exposed bridge tooting(s)	nineline / etc		0	IA	
	2	Exposed sanitary / storm sewer /	pipenne / eve			JA	
	3	Elevated storm sewer outraits/	crete aprons / etc.			I KA	
Evidence of	4	Undermined gabion baskets / con	rts / storm sewer outlet	5		V	2/
Degradation	5	Scour pools downstream of coive	its f storing of the			V	10
(DI)	6	Luci face on bar forms	nigration		V	/	_
	1	Testana cut through older har ma	terial			V.	
	8	Ferrace cut an ough order out ma	n bank			V	
	9	Channel worn into undisturbed o	verburden / bedrock		V		-
	1 10	Chamiler World like Chamile		Sum of indice	s= 2	14	0.3
	1.4	sulla - Usersian trans / fance pos	te / etc.			V	
	1	Fallen / leaning trees / fence pos	ic .			V	
	2	Occurrence of large organic debi	15			V	
	3	Exposed tree roots	ande			NIA	
Evidence of	4	Basal scour on inside meander of	anel through riffle			MA	61
Widening	5	Basal scour on both sides of char	crete walls / etc.			NHE	175
(WI)	6	Outlianked gabioil baskets / com	ugh subject reach			V	5.1
	1	Elength of basar scour a some time	ried nine / cable / etc.			NA	
	0	Exposed religen of previously of	Contract of the second s			V	
	10	Exposed building foundation				NA	-
	10	Exposed building rounderbar		Sum of indic	es= O	15	0
	-	I south a state				V	
	1	Formation of chute(s)	to distance!			V	
Evidence of	f 2	Single thread channel to multip	le channel			NA	11
Planimetric	3	Evolution of pool-riffle form to	low bed relief form			17	710
Form	4	Cut-off channel(s)				V	
Adjustmen	t 5	Formation of island(s)	manderlar			1 1	1
(PI)	6	Thalweg alignment out of phase	e meander form		1	1	
	7	Bar forms poorly formed / rewo	orked / removed	Sum of Indi	ces =	5	Dil
			-		101 - 101	+DI+WI+PI1/	4 = 0 12
Additional no	tes:			Stability Index	[51] = [A0		In Adjuste
			Condition	In Regime	In Transit	ion/Stress	in Adjustin
			SI score =	10 0.00 - 0.20	0.2	21 - 0.40	0.4

Completed by: $\underline{\leftarrow \top \mu \leq}$ Checked by: _

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Date:	NOV 2,2015		Stream/Reach: CP	C-2		
Weather:	Sun + InªC		Location: KIRDY Rd			
Field Staff:	CHIER	Watershed/Subwatershed: East Patterson				
Evaluation Category	Poor	Fair	Good	Excellent		
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	SO-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 0.8-0.9 m	Stream bend areas stable Outer bank height 0.5-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) Bank overhang 0.6-0.8 m	Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m		
Stability	Young exposed tree roots abundant > 6 recent large tree falls per stream mile	Young exposed tree roots common 4-5 recent large tree falls per stream mile	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 fails 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 #/3 of bank1s 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		

	 >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	00102		0506	0708
EPC-2 PH ISOBO GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent	
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width)(45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 	
Physical Instream Habitat	Dominated by one habitat type (dsually 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 percentage of sand < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and sand S-24% cobble	Riffle substrate composition: good mix of gravel, cobble, and rubble material 25–49% cobble	 Riffle substrate composition: cobble, gravel, rubble, boulder mtx 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	
	Battle/Pool ratio 0.49:1 S; S1.51:1	 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	
ALA	Summer afternoon water temperature > 27°C temperature 24-27°C		Summer afternoon water temperature 20-24°C	 Summer afternoon water temperature < 20°C 	
oint range		⊠ 3 □ 4	□ 5 □ 6	0708	

Water	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 TOS: 50-100 mg/L	Clear flow TDS: < 50 mg/L
Quality	 Objects visible to depth < 0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	 Objects visible to depth 0.5-1.0 m below surface 	Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	Slight to moderate organic odour	Slight organic odour	+ No odour
Point range		□ 3 □ 4	0506	0708

Riparian Habitat Conditions	Narrow riparian area of mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps		 Forested buffer generally > 31 m wide along major portion of both banks. 		Wide (> 60 m) mature forested buffer along both banks	
	Canopy coverage: < 50% shading (30% for large mainstern areas)	+ Canopy c 50-60% s large mai	overage: hading (30-44% for nstem areas)	+ Canopy coverage: 60-79% shading (45 large mainstem are	5-59% for sas)	Canopy > 80% s mainste	coverage: hading (> 60% for large em areas)
Point range	0 0 1		2 🗆 3	040	5	0	6 🗆 7
Additional no	ites:			Total	overall se	core (0 - 4	42)= 27
		Ranking	Poor (<13)	Fair (13-24)	Good	(25-34)	Excellent (>35)
						/	

Completed by: <u>FT/ER</u> Checked by: _

Date: LIAU 2 2015	Stream/Reach:	EPC-3		
Weather:	Location:	KINDU ROL		
Field staff: CH / ER	Watershed/Subwatershed:	FAST PATIENSO	n cric	
UTM (Upstream)	UTM (Downstream)			
Land Use H Valley Type Channel Type Channel Type (Table 1) H (Table 2) Channel (Table 3)	Zone 1 Flow Type 2 bie 4) 1 (Table 5) 2	ZGroundwater E	vidence: Which of Cross	
Riparian Vegetation	Aquatic/Instream Veg	etation	Water Quality	
Dominant Type: Coverage: Cannel Age Class (yrs) : Encroachme (Table 6) 0 0 1.4 0 Immature (<5)	nt: Type (Table8) 2 7) Woody Debris Dresent in Cutbank	Coverage of Reach (%) 40 Density of WD: 10w WD1/50m/ 10w WD1/50m/ 10k	Odour (Table 16)	
Channel Characteristics				
Sinuosity (Type) Sinuosity (Degree) Gradient Nu (Table 9) 1 (Table 10) 1 (Table 11) 1 Entrenchment Type of Bank Failure Downs's Classification	nber of Channels ble 12) 1 and another Peel-Substra	te D X X	Cobble Boulder Parent Rootlet	n 1
(Table 13) 2 (Table 14) 1 (Table 15)	Bank Material			
Bankfull Width (m) [나니 [Wetted Width (m) Bankfull Depth (m) 0.35 [Wetted Depth (m) 0.35 [Wetted Depth (m) Riffle, Pool Spacing (m) NA % Riffles: NA % Pools: NA	0.8 0.1 Meander Amplitude:	Bank Angle Bank E Bank Angle Bank E 0 - 30 30 - 50 30 - 50 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 -	nosion Notes: Comply VLUY 30% -60% -100% Supplieds in Chro	างเชื
Pool Depth (m) U.S. Kinte Lengu (m) U.S. Kinte Lengu (m) U.S. KP DIS of KP Veloctity (m/s) Veloctity (m/s)	v/Estimated V. STE-	pool developin	with with the use	-Vic
volley s.cm b	1.3me ols exter + asine CIS ext	+ completed by: OH	Checked by:	

Date:	No	V2.2015		Stream/Re	ach:	FPC	5-1				
Weather:	C.	10 1 1005		Local	lan	L.		1			
Theorement.	DL	INFIUL		LOCA	ion:	KICK	24 1	20			
Field Staff:	Cł	f EK	Water	shed/Subwaters	hed:	East	-Pat	tersor			
Dracore		Geomorph	nic Indicator			Pres	sent?	Factor			
Process	No.	Description			-	Voc	No	Value			
	1	Lobate bar			-	160	1/	1 1 1 1 1 1			
	2	Coarse materials in riffles embedde	ed		-	1	V	-			
Evidence of	3	Siltation in pools					1.7	-			
Aggradation	4	Medial bars					1.1	- nh			
(AI)	5	Accretion on point bars					17	-97			
	6	Poor longitudinal sorting of bed ma	aterials			1	-				
	7	7 Deposition in the overbank zone					11				
	_			Sum of india	es =	0	7	0.0			
	1	Exposed bridge footing(s)			-	17	L A				
	2	Exposed sanitary (storm source (p	inalina / ata		_	MI	12	-			
Evidence of	3	Elevated storm sever outfall(c)	ipenne / etc.		_	N	IM	-			
	4	Undermined rahigs backets / cons	toto antono Late		-	N	14	1/5			
	5	Scour pools downstream of culvert	rete aprons / etc.		_	PI	1A				
Degradation	6	Cut face on har forms	sy storm sewer out	ets	-	A/	11				
(DI)	7	Head cutting due to knick point mis	ration		- V						
	8	Terrace cut through older bar material Suspended armour layer visible in bank					1	-			
	9						1	-			
	10	Channel worn into undisturbed over	whurden / hedrock		-		14	-			
			inducerty bearbex	Sum of India	- 29	1	4	1 10			
		Paller (basharan (b						Die			
-	1	Fallen / leaning trees / tence posts /	/ etc.		_		LV,	_			
-	2	Occurrence of large organic debris				V					
	3	Basal scour on inside meander bends					V	-			
Evidence of	** E	Basal scour on inside meander bends Basal scour on both sides of channel through sittle					1A				
Widening	5	Dasai scour on both sides of channel through riffle Outflanked gabion baskets / concrete walls / etc.					14	- 01-			
(WI) -	7	Outflanked gabion baskets / concrete walls / etc.					H	- 75			
-	8	Length of basal scour >50% through subject reach				A.(X	-			
1	9	Exposed length of previously buried pipe / cable / etc.					T	-			
	10	Exposed building foundation	acture lines along top of bank					-			
		Exposed building roundation		Sum of indic	ac =	N	5	00			
		er and a state of the		ount of side		0		1.0.10			
	1	Formation of chute(s)			_		V	_			
vidence of	2	Single thread channel to multiple ch	sannel		-		V,				
Flanimetric	3	Evolution of pool-riffle form to low bed relief form Cut-off channel(s)			-		V,	- 11			
Form	4				_	-	V	- 17			
(DI)	5	Formation of island(s)					V,	- '			
(PI)	6	Thalweg alignment out of phase meander form				-/	\sim	_			
	7	Bar forms poprly formed / reworked	d / removed		-	V	1	10.111			
A Real Property in the				Sum of indic	es =	1	6	0.19			
iditional notes:			1	Stability Index (S	51) =	(AI+DI+W	I+PI)/4 =	0.09			
			Condition	In Regime	n Tra	nsition/Str	ress In	Adjustment			
			Si contra a	TV 0.00 0.00	-	1202000000000					

Completed by: <u>FI/ER</u> Checked by: _

Rapid Stream Assessment Technique Project Number: PMISO80

Date:	NOV 2, 2015	Stream/Reach:	EPC-3
Weather:	SUN+ 10°C	Location:	Kirby Rd
Field Staff:	CHIER	Watershed/Subwatershed:	East Patterson

Evaluation Category	Poor	Fair	Good	Excellent
	 < 50% of bank.network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% 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
Alu	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 unsta Outer bank height 0.9-1. above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9 m		Stream bend areas stable Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) Bank overhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	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 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 b generally V- or U-shaped
Point range	00102	030405	60708	□ 9 □ 10 □ 11

	 > 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 mainstern 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
Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common Streambed streak mar and/or "banana"-shap sediment deposits common		 Streambed streak marks and/or "banana"-shaped sediment deposits uncommon 	Streambed streak marks and/or "banana"-shaped sediment deposits absent
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks	Fresh, large sand deposits 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-wegetated and/or armoured with little or no fresh sand 	 Point bars few, small and stable, well-vegetated and/or armouned with little or no fresh sand
Point range		3 0 4	□ 5 t 6	0708

EPC-3 PN 150BC GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent	
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width (45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 	
Physical Instream	 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, hiffles and runs dominant, velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mb 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) 	
Habitat	Riffle substrate composition: predominantly gravel with high percentage of sand < 5% cobble Since the substrate composition: predominantly small cobble, stand sand < 5% 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 S0% 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 Section 2015 Section 2015		 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 	 Riffie/Pool ratio 0.7-0.89;1; 1.11-3.3:1 	Riffle/Pool ratio 0.9-1.1:1	
NIF	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	00102	□ 3 ☑ 4	0506	0708	

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 < 0.15 m below surface	Objects visible to depth 0.15-0.5 m below surface	Objects visible to depth 0.5-1.0 m below surface	Objects visible to depth > 1.0-m below surface	
	Moderate to strong organic odour	Slight to moderate organic odour	Slight organic odour	No odour	
Point range		□ 3 □ 4	0506	7 0 8	

Riparian Habitat	Narrow riparian area of mostly non-woody vegetation	Riparian a wooded b localized	irea predominantly iut with major gaps	Forested buffer ger > 31 m wide along portion of both bar	nerally + Wide major fores nks bank	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	Canopy coverage: < 50% shading (30% foc large mainstem.areas)	Canopy coverage: 50-60% shading (30-44% for large mainstem areas)		Canopy coverage: 60-79% shading (45 large mainstem are	5-59% for > 80 nas) main	Canopy coverage: > 80% shading (> 60% for large mainstem areas)	
Point range			2 🗆 3	040	5	6 7	
Additional no	ites:			Total	overall score (0	-42)= 22	
		Ranking	Poor (<13)	Fair (13-24)	Good (25-34) Excellent (>35)	

Completed by: KT/ER Checked by:

Appendix C







APPENDIX C6.3

Reponse to TRCA Comments dated September 12, 2018

GEO Morphix Ltd.

Head Office 2800 High Point Drive, Suite 100A Milton, Ontario, Canada L9T 6P4

T 416.920.0926

Ottawa Office PO Box 336 Woodlawn PO Dunrobin, Ontario, Canada KOA 1TO

MORPHIX

T 613.979.7303

November 28, 2018

Schaeffers Consulting Engineers 6 Ronrose Drive Vaughan, ON L4K 4R3

Attention: Leonid Groysman

Re: Kirby Road Extension Crossing for East Patterson Creek Response to TRCA Comments dated September 12, 2018 City of Vaughan, Ontario GEO Morphix Project No. PN15080

This letter is in response to several comments received from the Toronto Region Conservation Authority (TRCA, September 12, 2018) regarding the Kirby Road Extension between Dufferin and Bathurst Streets in the City of Vaughan. Specifically, we address comments related to the geomorphic assessment completed by GEO Morphix (report dated January 18, 2016 and letter dated June 4, 2018). We have provided each comment in italics below as well as a subsequent written response. Supporting materials have also been included as attachments.

Response to TRCA Comments

• Comment #4 - For example: S3.2.3.2:

o a) Please provide a drawing showing the location of the different reaches.

A reach map was included under the GEO Morphix letter dated June 4, 2018. Reaches are also outlined on the new figure included in this letter (**Attachment A**).

- o b) Please provide a figure showing the location of the observed watercress in the channel.
- o c) Please identify all wetland features on a figure with their size in hectares.
- d) Please provide a figure showing the location of observed groundwater staining and the area described as "basin-like".

The locations of watercress, wetlands, and iron staining were not specifically mapped as part of the geomorphological assessment. These were general, reach level observations collected during the field reconnaissance. The exact locations were not mapped, as they were not significant with respect to the geomorphological assessment.

• Comment #18 – Please provide a location map.

A location map was included under the GEO Morphix letter dated June 4, 2018. The location is also outlined on the new figure included in this letter (**Attachment A**).

Comment #19 – Please provide a figure showing the location of all observations: e.g. barrier to fish
passage and referenced wetlands, knick points, culverts and pipeline. Historical photos are
recommended to improve clarity.

geomorphix.com | The science of earth + balance.

The new figure included in this letter (**Attachment A**) shows the location of knick points and one (1) observed culvert. It should be noted that knick points in this case are small in scale and, as such, are not a relevant constraint with respect to proposed crossing locations. The locations of fish barriers were not specifically mapped as part of the geomorphological assessment. These were general observations collected during the field reconnaissance. Although these items may be of interest to other disciplines, they are not significant from a geomorphological perspective. The term wetland was used to indicate wet areas without a defined channel/vegetation controlled. Further, the location of the pipeline was not specifically mapped as it was located immediately downstream of the study site. As requested, historical photographs of the site have been included under **Attachment B**.

• Comment #20 – Please note that TRCA has not yet concluded that this channel does not constitute fish habitat.

Noted.

• Comment #21 – Please provide a figure showing the breakdown of reaches within the watercourse.

A reach map was included under the GEO Morphix letter dated June 4, 2018. Reaches are also outlined on the new figure included in this letter (**Attachment A**).

• Comment #22 – In the second last paragraph, please revise the text to clarify the meaning of "fining".

Fining is a common term used in geomorphological assessments. We have not revised the report text, but instead provide a description here to clarify. Downstream fining of sediment is observed in most creek systems as a result of collective sediment sorting (i.e. smaller grains are transported farther downstream while larger grains are deposited preferentially upstream). The finer sediments observed along reach EPC-1 were therefore expected given that it was the farthest downstream reach.

• Comment #23 – Please provide a figure identifying the location of the referenced 8 cross sections.

The new figure included in this letter (Attachment A) shows the location of the eight (8) cross-sections.

• Comment #24 – Please note that the construction of the Trans Canada Pipeline doesn't necessarily preclude the possibility that the channel constitutes fish habitat.

Noted.

• Comment #25 – Please note that TRCA's Crossing Guideline for Valley and Stream Corridors recommends that new crossings are designed to span the meander belt width or the 100-year channel migration limit. These limits must be identified to support an assessment of crossing alternatives.

The new figure included in **Attachment A** shows the extent of the meander belt width and/or erosion hazard setback in relation to the proposed crossing locations.

Additional field work was completed on November 16, 2018 to verify the location of the channel centreline in the vicinity of each crossing location. Specifically, a RTK and Total Station survey was completed to field-truth the MNRF stream layer (see figure in **Attachment A**).

We understand that crossing Option 5 has been selected as the preferred approach. It should be noted that in the vicinity of the Option 5 crossing, a channel centreline could not be mapped by Total Station or RTK GPS survey. The existing MNRF stream layer shown near Option 5 (**Attachment A**) also does not accurately characterize this particular section. Based on our field observations, the area is vegetation controlled with a low-gradient, evidence of aggradation, and no defined low-flow channel. As such, there is limited erosion potential.

From a geomorphological perspective, there is no future concern of erosion in the vicinity of crossing Option 5. Still, we have provided a meander belt width in this area based on the largest channel meander amplitude measured upstream of the Option 5 crossing using the MNRF stream layer. Given that the feature is vegetation controlled and lacks defined bed and banks in this section, the meander belt width is an extremely conservative estimate of the erosion hazard. For further discussion on the application of the meander belt width and erosion hazard, please refer to our June 4, 2018 memo.

Option 5 is an appropriate approach for the future road crossing. If required at detailed design, a low-flow channel could be created as part of the crossing design.

If you have any questions or concerns, please contact the undersigned.

Respectfully submitted,

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

Attachment A





Attachment B



























APPENDIX C6.4

Recommendations for Alignment 5A

GEO Morphix Ltd.

Head Office 2800 High Point Drive, Suite 100A Milton, Ontario, Canada L9T 6P4

T 416.920.0926

Ottawa Office PO Box 336 Woodlawn PO Dunrobin, Ontario, Canada KOA 1TO

T 613.979.7303

April 15, 2019

Schaeffers Consulting Engineers 6 Ronrose Drive Concord, Ontario L4K 4R3

Attention: Mr. Leonid Groysman, Class EA Lead

Re: Recommendations for the Kirby Road Extension Environmental Assessment Proposed Crossing Alignment 5A Upper East Patterson Creek, Vaughan, Ontario GEO Morphix Project No. 15080

A geomorphological assessment was previously completed by GEO Morphix Ltd. for Upper East Patterson Creek in the vicinity of the proposed Kirby Road extension in the City of Vaughan, Ontario. The geomorphological assessment included both desktop and field activities including reach delineation and reach-by-reach rapid assessments. The Toronto and Region Conservation Authority (TRCA) also requested additional information related to meander belt widths, 100-year erosion limits, and preliminary recommendations for the potential Kirby Road crossing location. As such, additional desktop analysis was completed to support planning level meander belt width delineation and determination of a 100-year erosion limit for the creek.

Several alignments have been proposed for the Kirby Road extension. The current alignment proposed for the road crossing (Option 5A) is outlined on the map provided in **Appendix A**. This letter provides a summary of the geomorphological assessment completed in support of the Kirby Road extension and outlines recommendations with regards to crossing design and implementation in the context of the preferred Option 5A alignment.

General Reach Characteristics

Three watercourse reaches were identified for East Patterson Creek in the vicinity of the proposed road crossing. A reach map is included in **Appendix A**. Reaches **EPC-1**, **EPC-2**, and **EPC-3** of Upper East Patterson Creek were assessed in Fall 2015. Reach **EPC-1** was forested, while Reaches **EPC-2** and **EPC-3** flowed just outside the forest margin, along the perimeter of a disturbed area. An additional reach, **EPC-4**, was considered in the desktop analysis to address all potential road alignment options and possible crossing locations. Reach **EPC-4** was identified as a wetland feature in a forested area upstream of Reach **EPC-3**. No significant tributaries were observed flowing into the main channel within the study area.

Based on our 2015 field observations, the majority of the channel was at least partially confined or fully realigned. Reach **EPC-1** was a constructed valley feature, approximately 5 m wide and just over 1 m deep. The low-flow channel had no riffle-pool development and averaged 1.89 m wide and 0.15 m deep. Reach **EPC-2** was also within a constructed valley feature, whose channel was likely formed naturally following valley excavation. The low-flow channel was considered to be the bankfull channel, although it may still be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. Reach **EPC-3** continued as a low-flow channel within a constructed valley feature, but with appreciably different physical characteristics than Reach **EPC-2**. The Reach **EPC-3** channel had no bankfull indicators and limited evidence of channel morphology. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the upstream wetland (Reach **EPC-4**) contributed to total flow. Given that Reach **EPC-3** is located immediately downstream of the wetland, it can also be

characterized as a reasonably low-energy system. This is supported by the lack of definition and limited evidence of a defined bankfull channel. However, minor evidence of erosion was noted along the straightened section of Reach EPC-3 in the area associated with the proposed road and watercourse crossing.

Planning Level Meander Belt Width Delineation and 100-Year Erosion Limits

In support of crossing recommendations and to provide context, meander belt widths and 100-year erosion limits were calculated for the four reaches within the study area. Meander belt widths for Reaches EPC-1, EPC-2, EPC-3 and EPC-4 were estimated using a combination of empirical models, historical aerial photographs, and the Ontario Base Mapping stream layer. A full summary of our methodology and approach is outlined in our June 4, 2018 letter included in Appendix B: *Planning Level Meander Belt Width Delineation, 100-Year Erosion Limits, and Preliminary Crossing Recommendations for the Kirby Road Extension Environmental Assessment.*

A meander belt width of 20.6 m was determined for the four reaches of East Patterson Creek and included a 20% factor of safety. This meander belt width was delineated along the observed central tendency of the watercourse within the study extent, and is illustrated in **Appendix A**. The meander belt width is conservative, given that the studied reaches are in confined, or partially-confined systems. As such, the meander belt width can be further refined at detailed design, if required.

A 100-year erosion limit was also estimated for all the reaches in the study area based on geology, level of erosion, and channel size according to the MNRF's erosion hazard technical guidelines (MNR, 2001). Where the reaches were not controlled by the presence of vegetation, the bank materials were a mix of clay, silt, and sand, with only limited evidence of active erosion. As such, based on MNR guidance an erosion limit of 5 m was applied to delineate the lateral erosion hazard.

Geomorphological Crossing Recommendations

Our recommendations with regards to the proposed road alignment are based solely on geomorphological and erosion considerations. We have also considered TRCA's Crossing Guideline for Valley and Stream Corridors (2015), which recommends using siting and design to avoid damage to the infrastructure and minimizing channel contact with the crossing infrastructure to reducing erosion hazards.

We recommend that the sizing and location of the proposed crossing consider potential future channel erosion and/or migration. As such, we suggest that the road be aligned perpendicular to the channel. Also, the crossing should also maintain velocity differentials and sediment transport processes for frequent storm events through and adjacent to the crossing. The installed structure should have an open bottom and be positioned within a reasonably stable length of channel.

Road alignment Option 5A is appropriate, given that it will cross the existing watercourse at a nearly perpendicular angle through a previously disturbed area where the reach has been realigned and channelized. Minor erosion was noted along the valley walls in the watercourse crossing location associated with Option 5A; however, a crossing at this location would likely provide an opportunity for stabilization.

We recommend two possible approaches to crossing span sizing at 5A. The first is calculated as three times the bankfull channel width. The second is calculated as bankfull width plus two times the erosion limit. Based on the average bankfull channel width of 1.9 m, these approaches provide crossing sizes of 5.7 m and 11.9 m, respectively. Note these values are a significant portion of the meander belt width estimate.

If disturbance of riparian vegetation is anticipated, we also advocate installation of a channel reinforced with hydraulically sized materials to stabilize the channel under the crossing allowing for fish passage across a wide range of conditions. With regards to hydraulic sizing, MTO Highway Drainage Design Standards (2008) would suggest 100-year event scour protection per standards WC-1/WC-3 for 'local road' conditions with FS=1. Detailed design HEC-RAS results can be utilized for the 100-year event velocity determination.

The Option 5A alignment also includes a retaining wall on the north side of the road. On the west side of the creek, the retaining wall is adjacent to a meander bend that separates Reach **EPC-3** and **EPC-4**. As documented through our field assessment, this section of channel is in a transition area between the upstream wetland the defined channel downstream. As such, it is a low-energy and stable location with limited channel definition and no evidence of erosion. Most of the erosion associated with Reach **EPC-3** is located along the straight section farther downstream. The retaining wall sits approximately 1 to 1.5 m outside of the meander belt width in this area. Given the limited potential for erosion in this area and the factor of safety included in the meander belt width delineation, we suggest that the proposed retaining wall location is appropriate. For additional erosion protection, we recommend minor bioengineering treatments or offset protection be installed.

These recommendations only reflect geomorphological considerations for the proposed Kirby Road extension alignment Option 5A. Other disciplines will also need to be considered including terrestrial and aquatic biology, ecology, hydrogeology, and hydrology.

We trust this memo meets your requirements.

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., Can-CISEC Director, Principal Geomorphologist

Kat Woodrow, M.Sc. Environmental Scientist

References

Ontario Ministry of Natural Resources (MNR). 2001. Technical Guide-River & Stream Systems: Erosion Hazard Limit.

Ontario Ministry of Transportation (MTO). 2008. Highway Drainage Design Standards.

Toronto and Region Conservation Authority. 2015. Crossings Guideline for Valley and Stream Corridors.

Appendix A




Appendix B





Head Office 2800 High Point Drive, Suite 100A Milton, Ontario, Canada L9T 6P4

T 416.920.0926

Ottawa Office PO Box 336 Woodlawn PO Dunrobin, Ontario, Canada K0A 1T0

T 613.979.7303

June 4, 2018

Schaeffers Consulting Engineers 6 Ronrose Drive Concord, Ontario L4K 4R3

Attention: Mr. Leonid Groysman, Class EA Lead

Re: Planning Level Meander Belt Width Delineation, 100-Year Erosion Limits, and Preliminary Crossing Recommendations for the Kirby Road Extension Environmental Assessment Upper East Patterson Creek, Vaughan, Ontario GEO Morphix Project No. 15080

A geomorphological assessment was previously completed by GEO Morphix Ltd. (2016) for the Upper East Patterson Creek in the vicinity of the proposed Kirby Road Extension in Vaughan, Ontario. Our 2016 assessment involved both desktop and field activities including reach delineation, reach-by-reach rapid assessments, and a detailed geomorphological assessment.

Our understanding is that the Toronto and Region Conservation Authority (TRCA) has requested additional information including meander belt widths, 100-year erosion limits, and preliminary recommendations regarding the potential crossing location (Scott Smith, email dated May 3, 2018).

To address this request we completed additional desktop analysis to: supplement the findings of our original report; provide planning level meander belt widths; calculate 100-year erosion limits; and develop crossing recommendations.

General Reach Characteristics

Our previous work identified three reaches. A reach map is included in **Appendix A**. Reaches **EPC-1**, **EPC-2**, and **EPC-3** of Upper East Patterson Creek were assessed in Fall 2015 (GEO Morphix Ltd., 2016). Reach **EPC-1** was forested, while Reaches **EPC-2** and **EPC-3** flowed just outside the forest margin, along the perimeter of a disturbed area. An additional reach, **EPC-4**, was considered in the present desktop analysis to address all potential road alignment options and possible crossing locations. Reach **EPC-4** was identified as a wetland feature in a forested area upstream of Reach **EPC-3**. No significant tributaries were observed flowing into the main channel within the study area.

According to our observations in Fall 2015, the majority of the channel was at least partially confined or fully realigned. Reach **EPC-1** was a constructed valley feature, approximately 5 m wide and just over 1 m deep. The low-flow channel had no riffle-pool development, and averaged 1.89 m wide and 0.15 m deep. Reach **EPC-2** was also within a constructed valley feature, whose channel was likely formed naturally following valley excavation. The low-flow channel was considered to be the bankfull channel, although it may still be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. Reach **EPC-3** continued as a low-flow channel within a constructed valley feature, but with appreciably different physical characteristics than Reach **EPC-2**. The Reach **EPC-3** channel had no bankfull indicators and limited evidence of a stable channel morphology. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the upstream wetland (Reach **EPC-4**)

contributed to total flow. Further reach descriptions and observations are provided in our previous report, which has been included as **Appendix B**.

Planning Level Meander Belt Width Delineation and 100-Year Erosion Limits

In support of crossing recommendations and to provide context, meander belt widths and 100-year erosion limits were calculated for the four reaches within the study area.

Meander belt widths for Reaches EPC-1, EPC-2, EPC-3 and EPC-4 were estimated using two methods.

The first method used two modified Williams (1986) models with the addition of a 20% factor of safety.

Modified Williams (1986) Area,	$B_W = 18A^{0.65} + W_b $	(Eq.1)
Modified Williams (1986) Width,	$B_{W} = 4.3 W_{b}^{1.12} + W_{b} \dots$	(Eq.2)

Where B_W is meander belt width (m), A is cross-sectional area (m²), and W_b is bankfull channel width (m).

Previous clearing and other historical site activities have resulted in a disturbed study area with few natural references. Reach **EPC-1** was determined to have the most natural characteristics and was the most aged since realignment (GEO Morphix, 2016). As such, this reach was selected for detailed assessment to determine average bankfull channel dimensions (Fall 2015) and was used as a reference reach to model a representative meander belt width for all reaches in the present analysis. The average bankfull channel width for Reach **EPC-1** was 1.89 m, and the average bankfull channel depth was 0.15 m.

The modelled meander belt widths (including a 20% factor of safety) based on the detailed assessment were 11.8 m (Eq.1) and 12.8 m (Eq.2).

The second method for determining meander belt widths required measuring the largest meander amplitude observed within each reach. Again, previous site activities and watercourse realignments had erased any previously natural meanders from the planforms of Reaches **EPC-2** and **EPC-3**. The forest cover of Reaches **EPC-1** and **EPC-4** also prevented us from identifying drainage routes and channel planforms using aerial photography.

As a surrogate, we measured the largest meander amplitude within the study extent, as observed along the Ontario Hydro Network (MNR) watercourse. This was the most accurate delineation of the watercourse available for the present study. A 20% factor of safety was added to the measured value to determine a meander belt width of 20.6 m, which was applied for all reaches. This meander belt width was delineated along the observed central tendency of the watercourse within the study extent, and is illustrated in **Appendix C**.

The calculated meander belt widths are conservative, given that the studied reaches are in confined, or partially-confined systems. These meander belt widths can be further refined at detailed design, if required.

A 100-year erosion limit was estimated for all the reaches in the study area based on geology, level of erosion, and channel size according to the MNR's erosion hazard technical guidelines (MNR, 2001).

Where the reaches were not controlled by the presence of vegetation, the bank materials were a mix of clay, silt, and sand, with only limited evidence of active erosion. As such, based on MNR guidance we suggest an erosion limit of 5 m be applied to delineate the lateral erosion hazard.

Geomorphological Crossing Recommendations

Our preferences with regards to road alignment are based solely on geomorphological and erosion considerations. We have also considered TRCA's Crossing Guideline for Valley and Stream Corridors (2015), which recommends using siting and design to avoid damage to the infrastructure and minimizing channel contact with the crossing infrastructure to reducing erosion hazards.

We recommend that the sizing and location of the proposed crossing consider potential future channel erosion and/or migration. We suggest that the crossing be located at a fair distance from any upstream meanders. The crossing should also maintain velocity differentials and sediment transport processes for frequent storm events through and adjacent to the crossing. The installed structure should have an open bottom and be positioned within a reasonably stable length of channel.

Road Alignment Options 4 and 5 are not preferred as they both could potentially result in disturbance of well-established riparian cover. Clearing the riparian cover would negatively influence creek function. If this crossing location is proposed, we recommend spanning the meander belt width and limiting vegetation removal/impact. In that case, the potential impacts can likely be mitigated.

Road Alignment Options 6 and 6A are preferred as they cross the existing watercourse at a perpendicular angle through a previously disturbed area where the reach has been realigned and channelized. Erosion was noted along the valley walls in the crossing location associated with Road Alignment Options 6 and 6A. A crossing at this location would likely provide an opportunity for stabilization.

We recommend two possible approaches to crossing sizing at 6 or 6A. The first is calculated as three times the bankfull channel width. The second is calculated as bankfull width plus two times the erosion limit. Based on the average bankfull channel width of 1.9 m, these approaches provide crossing sizes of 5.7 m and 11.9 m, respectively. Note these values are a significant portion of the modelled meander belt width estimates.

If disturbance of riparian vegetation is anticipated, we also advocate installation of a channel reinforced with hydraulically sized materials to stabilize the channel under the crossing allowing for fish passage across a wide range of conditions. With regards to hydraulic sizing, MTO Highway Drainage Design Standards (2008) would suggest 100-year event scour protection per standards WC-1/WC-3 for 'local road' conditions with FS=1. Detailed design HEC-RAS results can be utilized for the 100-year event velocity determination.

These recommendations reflect the geomorphological considerations. Other disciplines will also need to be considered including terrestrial and aquatic biology, ecology, hydrogeology, and hydrology.

We trust this memo meets your requirements.

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., Can-CISEC Director, Principal Geomorphologist

Cara Hutton

Cara Hutton, M.Sc. Senior Environmental Technician

References

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Appendix A





Appendix B



348 Bronte Street South, Unit 2 Milton, Ontario L9T 5B6 T 416.920.0926

e balance@geomorphix.com

Rizmi Property City of Vaughan, Ontario

Upper East Patterson Creek Geomorphic Assessment



Prepared for: Rizmi Holdings Limited 11333 Dufferin Street PO Box 663 Maple, Ontario L6A 1S5

Prepared by: GEO Morphix Ltd.

Project No.: 15080

Date: January 18, 2016

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Appendices

Appendix APhotographic Record of Site ConditionsAppendix BRapid Assessment Field Sheets

1 Introduction

A Municipal Class Environment Assessment is proposed by the City of Vaughan to determine the preferred alternative to extend Kirby Road to Gamble Road in the Town of Richmond, between Dufferin and Bathurst Streets. The ultimate alignment of this arterial road will be determined with consideration to numerous factors as required in the Class EA process. One consideration is East Patterson Creek, which is addressed in this report.

The east tributary of Patterson Creek originates in a wetland located near the north part of the Rizmi Stone & Aggregates property at 11333 Dufferin Street in the community of Maple. A significant portion of channel within the property limits has apparently been modified in the past. The alterations, however, do not affect fish habitat due to a significant barrier to fish passage along the southern property line. The watercourse currently conveys flows to the south property line where it terminates in a wetland. The following report provides a geomorphic assessment of East Patterson Creek to fulfill a Class EA requirement to document natural heritage features, as well as to support the decision-making process with respect to actions that affect the watercourse.

It is understood that the future of the channel within the property has yet to be determined as it is not considered to be direct fish habitat. Potential outcomes include removal, retain in its current alignment, realignment, enhancement, or a combination of these alternatives. GEO Morphix will provide appropriate support once the preferred solution has been determined in the Class EA study.

2 Historical Conditions

A series of 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. Historical aerial photographs from 1946 (scale 1:20,000) and 1954 (scale 1:63,360), and orthophotography from 1970, 1999, 2002, 2005, 2007, 2011, 2012 and 2013, and Google Earth Pro satellite imagery from 2015 were reviewed to complete the historical assessment.

In 1946, the upper East Patterson Creek drainage area was largely forested, with the exception of a clearing for agriculture at the upper extent of the drainage area. At the current location of the Rizmi Stone & Aggregates field operations, there was a clearing but no apparent activity. The drainage route within the subject property could not be identified due to tree cover, but there was an intermittently-forested corridor with a watercourse that extended in a southeasterly direction from the subject property towards Bathurst Street. The channel planform could not be determine on the aerial photography. Outside of the forested area to the north beyond the drainage area, the land was used exclusively for agriculture. The area beyond the property to the south was also used for agriculture.

There were no significant changes in land use through 1954. The surrounding land to the south, however, was transformed to a golf course, Maple Downs Golf Course. By 1970, Rizmi operations extended approximately 0.4 km to the east from the previously cleared area, as suggested by the heavily disturbed landscape and the access road connecting the disturbed area to Dufferin Street. Also between 1954 and 1970, the TransCanada Pipeline was constructed along the south property boundary and across the channel. The watercourse is visible along the east side of an internal road at the eastern end of the disturbed area, but the Pipeline clearly prevents flow conveyance

beyond the property as evidenced by the ponded water at the Pipeline crossing. The lack of tree cover along the section of channel along the internal road as well as its linear alignment also suggest that it was channelized to enhance drainage function. East of the Rizmi property along the north side of the Pipeline was a private runway.

Rizmi operations appeared to have slowed by 1999. The channel alignment was the same as it was in 1970, but the pond at the Pipeline had visual characteristics of a wetland. Another notable change within the property was a linear clearing through the forest leading to the general area of the channel origin, north of the cleared aggregate extraction area. There was also limited clearing on the east side of the internal road and channel, as well as a culvert in the channel next to this recently cleared area for access the east side. Southeast of the property, the land was developed for residential use.

Surrounding land use remained generally unchanged in 2011. Between 2007 and 2011, a portion of the channel within the Rizmi property was again realigned to travel along the margin of the cleared area. The previously installed culvert was removed due to the channel realignment, and a new culvert was constructed at the new channel crossing location. Activity within the property also appears to have increased during this period. There were no notable changes in 2012 and 2013.

Overall, the portion of East Patterson Creek within the Rizmi property experienced significant changes over the period covered by historical imagery. These changes include realignment and straightening (i.e., channelization), removal of tree cover, and the disruption of channel and flow continuity as a result of the TransCanada Pipeline.

3 Existing Conditions

3.1 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 are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

East Patterson Creek is situated in the Upper East Don Subwatershed. The channel within the property limits is a headwater feature that originates from a generally linear wetland feature located mostly within the property. In total, the channel travels in a southerly direction for approximately 6 km, where it joins West Patterson Creek, then continues for another 1.5 km to the confluence with the East Don River.

The subject site is located in a southward extending lobe of the Oak Ridges Moraine physiographic region, which is bounded by the South Slope physiographic region to the west, south and east. Beyond the South Slope is the Peel Plain (Chapman and Putnam, 1984), where Patterson Creek joins the East Don River. With respect to surficial geology, the subject area is characterized by ice-contact stratified deposits consisting of sand and gravel, minor silt, clay and till (OGS, 2010). The surficial geology generally changes in the downstream direction in concert with the physiographic regions: the South Slope is comprised of clay to silt-textured till (derived from glaciolacustrine deposits or shale) and the Peel Plain is generally characterized by glaciolacustrine deposits (OGS, 2010). The predominantly sand and gravel composition of the surficial material

allows the channel to readily adjust, although the degree of adjustment would also be influenced by the flow regime as well as other factors such as vegetation control.

The catchment area for the channel within the subject property is largely forested with the exception of the area cleared for the Rizmi Stone & Aggregates operations. Downstream of the property to Bathurst Street, the channel travels through a forested corridor surrounded by low-density residential dwellings. The forested channel corridor continues beyond Bathurst Street, although housing density increases.

3.2 Reach Delineation

Rivers and streams are frequently segmented into reaches to provide meaningful lengths of channel for study. Reaches are delineated based on changes such as hydrology, channel gradient, confinement, planform (i.e., channel pattern), geology, surrounding land use and anthropogenic disturbances (e.g., crossing structures, dams, straightening/channelization, armouring). Each reach can then be studied as a unit that is expected to function in generally uniform manner throughout its length.

Within the Rizmi property, East Patterson Creek was divided into three reaches. The downstream channel reach (EPC-1) is approximately 100 m in length, the middle reach (EPC-2) is 130 m, and the upstream reach (EPC-3) is 200 m. Forest cover was one consideration when delineating the reaches: the Reach EPC-1 channel lies just within the west forest margin, while Reaches EPC-2 and EPC-3 are just outside the west forest margin. Despite the apparently limited differences between reaches, tree cover is a significant factor that governs channel form and function, and hence the two reaches. Reaches EPC-2 and EPC-3 are differentiated primarily by channel morphology. Wetland features are located downstream of Reach EPC-1 and upstream of Reach EPC-2. The reach delineation was verified in the field, as discussed below.

3.3 Reach Assessments

Site observations and channel measurements were collected on November 2, 2015. The field investigation was completed for the full length of channel between the wetland at the upstream extent of the channel and the south property limit. A photographic record of site conditions is provided in Appendix A. On the day of the site visit, the temperature was 10°C and there was no precipitation. There was, however, 7 mm of rain from October 31 to November 1.

3.3.1 General Observations

Within the Rizmi property, East Patterson Creek originates in a wetland feature located in a forested area to the north just beyond an open, disturbed area created by site activities. The channel travels along the perimeter of the clearing before entering the forested area. It continues just within the forest boundary to a wetland feature at the south limit of the property. The reaches identified in Section 3.2 were confirmed to be correct. The following is a description of each reach from upstream to downstream.

The wetland at the upstream end of the section of channel under study is comprised of a dense thicket of shrubs (red-osier dogwood). There was no define flow pattern within the wetland.

Reach EPC-3 is in a constructed valley feature containing a low-flow channel. The valley had a V' shape except towards the downstream end of the reach. The channel had no bankfull indicators

and there was limited evidence of a stable channel morphology. The bed was composed of mostly silt and sand, and its morphology was partly controlled by vegetation. Three knickpoints were observed, which suggests that the channel gradient is high relative to those of the two downstream reaches. Groundwater input, evidenced by the watercress towards the upstream end of the reach, as well as water from the wetland contributed to total flow. Wetted flow width varied due to the high degree of channel confinement, ranging from 0.1 to 1.5 m. The channel characteristics were largely governed by the composition of the valley materials, which was sand. The northeast embankment (left embankment viewed in the downstream direction) was comprised of exposed sand with limited woody vegetation. Due to the unstable nature of the embankments, in particular that to the northeast, the channel will likely continue to adjust according to the sediment supply. Mature trees lied beyond the sandy embankment. The southwest side of the channel was open with primarily grasses.

Reaches EPC-3 and EPC-2 were divided by a partly embedded 1200 mm CSP culvert, constructed for access across the channel. Reach EPC-2 continues as a constructed valley feature, but with appreciably different physical characteristics. Here, the valley top width was roughly 3.9 m wide and the valley depth was 1.5 to 2.0 m. The east side of the valley was populated by mature trees, while the east side was dominated by grasses within an open (i.e., cleared) area.

The Reach EPC-2 channel likely formed naturally following valley excavation. The low-flow channel is considered to be the bankfull channel, although it still may be adjusting to the annual range of flows given that the valley was constructed between 2007 and 2011. The bankfull channel was on average 1.15 m wide and 0.42 m deep. There was a 0.22 m high knickpoint mid-reach that cut into till. Upstream of the knickpoint, the bed was characterized by sand, gravel and small cobbles, while downstream of the knickpoint, the bed was comprised of mostly sand, but also exposed till. This longitudinal change in bed characteristics can be explained by differences in bed gradient.

At the downstream end of Reach EPC-2, the channel turns at nearly a right angle to travel south into Reach EPC-1. There was evidence of the former channel location (before the realignment of Reaches EPC-3 and EPC-2), in the form of a linear depression across the cleared area, that aligned with Reach EPC-1. Although the former channel was decommissioned, surface runoff apparently continued to enter the Reach EPC-1 channel at the upstream end of this reach as indicated by the minor erosion and headcutting.

Reach EPC-1 travels in a southerly direction and continues as a constructed valley feature approximately 5 m wide and just over 1 m deep. Both sides of the valley was vegetated with mature trees; however, the woody riparian buffer on the west side was limited. Tree cover over the channel was dense, and there were frequent observations of woody debris within the constructed valley, mostly as broken individual tree limbs that did not significantly affect flow pattern. The low-flow channel had no riffle-pool development, and averaged 1.90 m wide and 0.15 m deep. The increase in width-to-depth ratio, relative to that of Reach EPC-2, can be explained by the decrease in channel gradient and the increase in discharge. Both the bed and banks were comprised of sand, which would be expected due to the lower gradient and the typical downstream fining found in natural watercourses.

At the downstream end of the Reach EPC-1 channel was a wetland feature. This wetland was contained in a basin (roughly 70 wide and 50 m wide) that was bounded in the downstream (south) end by a raised natural gas pipeline corridor (i.e., TransCanada Pipeline), which was essentially a large berm. The top of the Pipeline was approximately 1.5 to 2.0 m above the wetland bed, and therefore a considerable volume of water would be required for flows to spill

over the Pipeline corridor. There was no evidence of a flow path over the Pipeline, although it would clearly be located across the lowest point. The impact of the lack of surface flow continuity to the watercourse downstream (south) of the Pipeline corridor could not be assessed due to property constraints.

3.3.2 Rapid Field Assessments

Rapid field assessments were completed as reconnaissance-level evaluations to determine the condition of each reach with respect to channel stability and general stream health:

- Channel instability was semi-quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.41).
- The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and consider the ecological functioning of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34) or excellent (35-42) degree of stream health.

A summary of the rapid assessments is provided in Table 1. Completed field sheets are found in Appendix B.

	RGA*			RSAT**			
Reach	Score	Condition	Dominant Form of Adjustment	Score	Condition	Limiting Feature(s)	
EPC-1	0.11	In regime	Aggradation	26	Good	Physical instream habitat	
EPC-2	0.12	In regime	Degradation	28	Good	Riparian habitat conditions	
EPC-3	0.09	In regime	Degradation	22	Fair	Riparian habitat conditions	

Table 1: Rapid field assessment summary

* Ontario Ministry of the Environment (2003)

** Galli (1996)

3.3.3 Detailed Geomorphic Assessment

Within the property limits, Reach EPC-1 was determined to be relatively natural and certainly the most aged since realignment. As such, this reach was selected for further investigation – i.e., detailed geomorphic assessment. This detailed assessment serves as the basis for any required channel modifications such as realignment or stabilization.

The detailed assessment involved temporarily setting up eight representative cross sections for the purpose of determining average bankfull channel dimensions (e.g., width, average bankfull depth, maximum depth, and bank angles). The bankfull level was determined using standard protocols and accepted field indicators. A survey of the bed profile was also completed to determine slope and compute bankfull hydraulics. A modified Wolman (1954) pebble count was completed to characterize the bed materials. A summary of measured and computed values is presented in Table 2.

Channel parameter	Results
Measured	
Average bankfull channel width (m)	1.89
Average bankfull channel depth (m)	0.15
Average width-to-depth ratio	14.7
Channel gradient (%)	0.42
D ₅₀ (mm)	<2
D ₈₄ (mm)	<2
Manning's n roughness coefficient	0.034
Computed	
Bankfull channel discharge (m ³ /s) *	0.14
Average bankfull velocity (m/s)	0.53
Unit stream power at bankfull discharge (W/m ²)	3.2
Tractive force at bankfull (N/m ²)	5.98
Critical shear stress (N/m ²) **	1.46
Flow competency for D ₅₀ (m/s) ***	0.27
Flow competency for D ₈₄ (m/s) ***	0.27

Table 2: Bankfull parameters of the reference channel

* Based on Manning's equation

** Based on Shields diagram from Miller et al. (1997)

*** Based on Komar (1987)

The Reach EPC-1 reference channel has a lower width-to-depth ratio than the two upstream reaches due to the lower channel gradient. Despite the relatively low unit stream power, the bed (comprised of sand) is fully mobile under bankfull flow conditions. It is expected that the Reach EPC-1 channel length would decrease slowly over time as the bed material is transported and deposited in the wetland. The receiving wetland would consequently increase in size, but only in the upstream direction due to the raised pipeline crossing.

4 Conclusions

East Patterson Creek within the Rizmi property has been significantly altered, and impacted both directly and indirectly, over the period covered by historical imagery. It also no longer functions



as potential fish habitat as a result of the construction of the TransCanada Pipeline. In-channel flows now therefore infiltrate and contribute to groundwater.

If the preferred alternative solution, resulting from the Class EA study, is assessed to be restoration, realignment or enhancement, we would be pleased to provide design services. Concurrently or independently, we can also investigate potential hazards associated with a dynamic channel.

5 References

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Appendix A Photographic Record of Site Conditions













Appendix B Rapid Assessment Field Sheets



Reach Charact	eristics						1
Date:	NON 2 2015	Stream/Reach:	EPC-1				
Weather:	9 x + 10°C	Location:	Kubu Rd	* DUY	FERIN	5	
Field staff:	CH/FR	Watershed/Subwatershed:	East Potte	NECO C	111		
UTM (Upstream)		UTM (Downstream)					
(Table 1)	ev Type 2 Channel Type (Table 2) (Table 2) (Table 2) (Table 2)	Zone Zone Flow Type Jie 4) [Table 5]	2 Keroundwater	Evidence:	woter	ores	1
Riparian Vegetation		Aquatic/Instream Ve	getation	Water Q	uality		
Dominant Type: Cover (Table 6) 1 0 No Species: 7 6	age: Channel Age Class (yrs) : Encroachmei ne 🗆 1-4 🔲 Immature (<5) (Table gmented 😿 4-10 📡 tstablished (5-30) 🔽 ntinuous 🗆 > 10 🗂 Mature (>30)	tt: Type (Table8) Woody Debris Present in Cutban Present in Channe	Coverage of Reach (%) Density of WD: k %Low WDJ/50m: i		Odour (Ta 1 Turbidity (T	ble 16) able 17)	
Channel Characteristics							
Sinuosity (Type)	Sinuosity (Degree) Gradient Nur	nber of Channels	Clay/Silt Sand Gr	avel Cobble	Boulder	Parent 1	Rootlets
(Table 9) 1	(Table 10) 1 (Table 11) 1 (Ta	ble 12) 1 THING Substr	ate D X			0	۵
Entrenchment	Type of Bank Failure Downs's Classification	Peol-Substr	ate E E			P	þ
(Table 13)	(Table 14) (Table 15) S	Bank Materia	X				
Bankfull Width (m)	Wetted Width (m)		Bank Angle B	tank Erosion	Notes:		
Bankfull Depth (m)	Wetted Depth (m)		09-08] 5 - 30%			
Riffle/Pool Spacing (m)	NP % Riffles: NA % Pools: N	A Meander Amplitude:	NA Dundercut L	%00T - 09 E			
Pool Depth (m)	NA Riffle Length (m) NA Undercuts (m)	Nore Comments: NO	riffie - pools .	Door			
Veloctity (m/s)	Ø Niffle ball / ADV	(/Estimated) BF in	dico.tors				

Date:	NV	2112 2015		Stream/Read	h: EDC	-1	-			
Weather	Ci	1000		Location	CFC	0-	4			
weather.	A	A + 10 C	KIND	KINDY KOL						
Field Staff:	(H/EK	Watershed/Subwatershed: E. Patterso							
Desease		Geomorph	hic Indicator		Pres	Present? Fa				
Process	No.	Description			Yes	No	Value			
	1	Lobate bar				1	-			
	2	Coarse materials in riffles embedde	ed		NA		-			
Evidence of	3	Siltation in pools			NG		1 17.			
Aggradation	4	Medial bars			1011	V	- 14			
(AI)	5	Accretion on point bars			NA		_			
	6	Poor longitudinal sorting of bed ma	V							
	7	Deposition in the overbank zone				V				
				Sum of indices	=	3	0.25			
	1	Exposed bridge footing(s)			110	1				
	2	Exposed sanitary / storm sewer / p	ipeline / etc.		NA		-			
	3	Elevated storm sewer outfall(s)			ALA	-	-			
nation of	4	Undermined gabion baskets / cond	rete aprons / etc.		NA					
Evidence of	5	Scour pools downstream of culvert	ts / storm sewer outlets		NA	JA O				
/pil	6	Cut face on bar forms			NA					
(0)	7	Head cutting due to knick point mi	- Nord	V	_					
1	8	Terrace cut through older bar mate	NA							
[9	Suspended armour layer visible in	bank			V				
	10	Channel worn into undisturbed overburden / bedrock				V	1			
	_			Sum of indices	= 0	3	C			
	1	Fallen / leaning trees / fence posts	/ etc.			V				
	2	Occurrence of large organic debris			V					
	3	Exposed tree roots				V				
Evidence of	4	Basal scour on inside meander bends			NA		1/2			
Widening	5	Basal scour on both sides of channel through riffle					0			
(WI)	6	Outflanked gabion baskets / concrete walls / etc.			NA		_			
	7	Length of basal scour >50% through subject reach			-	V				
	8	Exposed length of previously buried pipe / cable / etc.			NA	-	_			
	9	Fracture lines along top of bank				V	-			
	10	Exposed building foundation								
	_	1		Sum of indices	=	9	02			
	1	Formation of chute(s)				~				
Evidence of	2	Single thread channel to multiple c	hannel		-	V				
Planimetric	3	Evolution of pool-riffle form to low bed relief form				~	1			
Form	4	4 Cut-off channel(s)				1	1%			
Adjustment	5	5 Formation of island(s)				~	6			
(PI)	6	Thalweg alignment out of phase meander form				~				
	7	Bar forms poorly formed / reworke	ed / removed		NA					
				Sum of indices	= 0	6	0			
Additional notes:				tability laday (CI)	- (AL+DL+M	JI-DIL/A -	0 11			
dditional notes:				stability moex (5i)	= (HITDITY	ALAL MA .	0.11			
dditional notes:			Condition I	n Regime In	Transition/St	tress In	Adjustme			

Completed by: _____ Checked by: _

Rapid Stream	Assessment	Technique	
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Project Number: PN15080

Date:	Nov 2,2015		Stream/Reach: EP	C-1	
Weather:	SUN + 10°C	Location: KITDU Rd			
Field Staff:	CH/ER	Watersh	Watershed/Subwatershed: E. Patterson Cr		
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 	70% of bank network ble ent signs of bank ughing, slumping or failure hy common		
	 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 0.8-0.9 m	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 S recent large tree fails 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		□ 3 □ 4 □ 5	06,0708	□ 9 □ 10 □ 11	

	 >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) 	NĄ
	Few, if any, deep pools. Pool substrate complexition S1% 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-slit	
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak-marks and/or "banana"-shaped sediment deposits uncommon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	Fresh, large sand deposits 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 	NI
Point range	0 0 1 0 2	□ 3 □ 4 ~	0506	0708	

P
GEO MORPHIX

Evaluation Category	Poor	Poor Fair		Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted-perimeter 40-60% of bottom channel width (45-) 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
Physical Instream	 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)
Habitat	Biffle substrate composition: predominantly gravel with high percentage of sand < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and sand S-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 mainstern 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 om 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		iffle/Pool ratio 0.49:1≤; 1.51-1 · Riffle/Pool ratio 0.5-0.59:1; · Riffle/Pool ratio 0.7-0.89:1; · Riffle/Pool ratio 1.11-1.3:1	
	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
oint range		□ 3 □ 4	0506	0708

	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)
Water	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
Quality	 Objects visible to depth <0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	 Objects visible to depth 0.5-1.0 m below surface 	Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	+ Slight organic odour	No odour
Point range		□ 3 □ 4	0506	7 8

Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	Biparian wooded localized	area predominantly- but with major gaps	Forested buffer ge > 31 m wide along portion of both bar	nerally + Wide (major nks banks	> 60 m) mature d buffer along both
Conditions	 Canopy coverage: < 50% shading (30% for large mainstem areas) 	Canopy of 50-60% s large ma	overage: hading (30-44% for instem areas)	Canopy coverage: 60-79% shading (4) large mainstem are	5-59% for sas) Canopy > 80% : mainst	v coverage: shading (> 60% for large em areas)
Point range			2 🗆 3	0 4 ^L 0	5 0 0	6 0 7
Additional no	tes:		_	Total	overall score (0 -	42) =
		Ranking	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)
					26	

Completed by: _____ Checked by:__

Weather: Field staff: UTM (Upstream) Land Use [Table 1)	Nov 2, 3015	eam/Reach:	EPC-2			
Field staff: UTM (Upstream) Land Use H va (Table 1)	SUN + 10°C	cation:	Kirbu Rol.	· DUFFer	10 CT	
UTM (Upstream) Land Use H Va (Table 1)	CH /FR	atershed/Subwatershed:	East pat-	Ferson (Ork	
Land Use H Va (Table 1)	5	'M (Downstream)				
	Iley Type Channel Type Channel Zona (Table 2) (Table 3) (C Channel Zona	Flow Type 2	Seroundwater	Evidence:	iron stein.	6
Riparian Vegetation		Aquatic/Instream Veg	etation	Water Qu	ality	
Dominant Type: Cove (Table 6) 2 0 N Species: 5	rage: Obvious weaters Age Class (yrs) : Encroachment: one 1.4 M Immature (<5)	Type (Table8)	Coverage of Reach (%) Density of WD:	M . T	Odour (Table 16)	
Channel Characteristics						
			and the second s			
Sinuosity (Type) (Table 9)	Sinuosity (Degree) Gradient Number (Table 10) 1 (Table 11) 2 (Table 1	of Channels 2) 1 Aiffile Substra	te 🗆 🖄	Gravel Cobble	Boulder Parent	Rootlets
Entrenchment	Type of Bank Failure Downs's Classification	Pool-Substra	e			ł
(Table 13) 2	(Table 14) 1 (Table 15)	Bank Material	Weitt up		0	
Bankfull Width (m)	1.3 [L.O] Wetted Width (m) O.	3 0.25	Bank Angle	Bank Erosion	Notes:	
Bankfull Depth (m)	○ ↓ Ø, Ч Wetted Depth (m) Õ	510	09-00	05-30%	CSPCCross	100 - 1.ar
Riffle/Pool Spacing (m)	NA & Riffles: NA & Pools: NA	Meander Amplitude:	1/2 Dudercut	00 - 100%		0
Pool Depth (m)	NP Riffle Length (m) NP Undercuts (m)	Comments: KP	+ exnosed	11.1		
Veloctity (m/s)	Wiffle ball / ADV / Es	timated COONEY	haterial uls	OF KP		
valley -	4 wiss v		Completed by:	CH	Checked by:	1
lecture	1.3M	0.00)		

Date	Mai	12 2015		Stream/Reach	EP	C-2	
Date.	110	Valadis	EVI	(by	Rd		
Weather:	Sur	1+ 10°C	1.1.00	Dail	- CRA		
Field Staff:	CH	IER	Watershe	d/Subwatershet	. ICas	r rated	21 JUN
	-	Geomorph	nic Indicator		P	resent?	Factor
Process	No	Description			Yes	No	Value
	1	Lobate bar				.V	
	2	Coarso materials in riffles embedd	ed			NA	_
widence of	2	Situation in peols			1	VA	-
agradation	3	Medial bars			-	V	- 0/6
(AI)	5	Accretion on point bars				V	1/2
180	6	Poor longitudinal sorting of bed m	aterials			V	4
	7	Deposition in the overbank zone				Y	10.0
		Deposition		Sum of indices	· 0	5	0.0
		5			1	VIA	
	1	Exposed bridge tooting(s)	nineline / etc			NA	
	2	Exposed sanitary / storm sewer /	pipenne / eve			NA	
	3	Elevated storm sewer outrail(s)	crete aprons / etc.			J KA	
Evidence of	4	Undermined gabion baskets / con	rts / storm sewer outlet	5		V	2/
Degradation	5	Scour pools downstream of coive				V	10
(DI)	6	Luct face on bar forms	aigration		V	7	
	1	Head cutting due to knick point in	terial			V	
	8	Terrace cut through order bar me	n bank			V	
	9	Suspended armour layer visible of	werburden / bedrock		V	·	-
	10	Channel Worr and Channel Con		Sum of indice	1s# 2	4	0.3
	1		te late			V	/
	1	Fallen / leaning trees / fence pos	is to the second			V	
	2	Occurrence of large organic debr	15		-	V	
	3	Exposed tree roots	ande			NVA	
Evidence of	4	Basal scour on inside meander of	enus			MA	61.
Widening	5	Basal scour on both sides of char	crote walls / etc.			NIF	1
(WI)	6	Outrianked gabion baskets / com	ugh subject reach			V	C 1
	1	Length of basal scour >50% thro	ried nine / cable / etc.			NA	
	8	Exposed length of previously bu	lied hime I control			V	
	9	Fractore milding foundation				NA	
	10	Exposed boliding roundation		Sum of indic	es= C	5	0
	_	1				V	
	1	Formation of chute(s)			-	V	
Evidence of	f 2	Single thread channel to multip	le channel			NA	11
Planimetric	3	Evolution of pool-riffle form to	low bed relief form		-	-17.	11
Form	4	Cut-off channel(s)				V	
Adjustmen	t 5	Formation of island(s)	de la marcina de la marcin				1
(PI)	6	Thalweg alignment out of phase	e meander form		1	1	
	7	Bar forms poorly formed / rewo	orked / removed	Sum of indi	ces =	14	5 0.1
	-		-	Juni of high	1015 141		14 = 1 10
Additional no	tes:		-	Stability Index	(SI) = (A)	HDI+WI+PI]	14 - 0-13
			Condition	In Regime	In Transi	tion/Stress	In Adjustn
			01	TTV 0.00 0.20		21 - 0.40	0.4

Completed by: $\underline{\leftarrow \top \mu \leq}$ Checked by: _

£.

Date:	NOV 2,2015		Stream/Reach: CP	C-2	
Weather:	Sun + Inac	Location: Ki			
Field Staff:	CHIER	Watersh	ed/Subwatershed: E.a.	st Patterson	
Evaluation Category	Poor	Fair	Good	Excellent	
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	SO-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 0.8-0.9 m	Stream bend areas stable Outer bank height 0.5-0.9 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 manetem areas) Bank overhang < 0.6 m	
Stability	Young exposed tree roots abundant > 6 recent large tree falls per stream mile	Young exposed tree roots common 4-5 recent large tree falls per stream mile	Exposed tree roots predominantly old and large, smaller young roots scarce 2-3 recent large tree fails per stream mile	Exposed tree roots old, large and woody Generally 0-1 recent large tree fails 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 bank1s 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	

	 >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	 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
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks	 Fresh, large sand deposits 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		□ 3 □ 4	0506	0708

EPC-2 PH ISOBO GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width)(45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstern areas)
Physical Instream	Dominated by one habitat type (dsually 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)
Habitat	Riffle substrate composition: predominantly gravel with high percentage of sand < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and sand S-24% cobble	Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble	Riffle substrate composition: cobble, gravel, rubble, boulder mtx 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 	 targe 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
	Battle/Pool ratio 0.49:1 S; S1.51:1	 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
ALA	 Summer afternoon water temperature > 27°C 	 Summer afternoon water temperature 24-27°C 	Summer afternoon water temperature 20-24%	 Summer afternoon water temperature < 20°C
oint range		⊠ 3 □ 4	□ 5 □ 6	0708

	Substrate fouling level: High (> 50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)
Water	Brown colour TDS: > 150 mg/L	Grey colour TDS: 101-150 mg/L	Slightly grey colour TOS: 50-100 mg/L	Clear flow TDS: < 50 mg/L
Quality	 Objects visible to depth < 0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	 Objects visible to depth 0.5-1.0 m below surface 	Objects visible to depth > 1.0 m below surface
	 Moderate to strong organic odour 	Slight to moderate organic odour	Slight organic odour	+ No odour
Point range		□ 3 □ 4	0506	0708

Riparian Habitat	Narrow riparian area of mostly non-woody vegetation	Riparian a wooded is localized	area predominantly out with major gaps	 Forested buffer ger > 31 m wide along portion of both bar 	nerally major nks	Wide (> 60 m) mature forested buffer along both banks	
Conditions	Canopy coverage: < 50% shading (30% for large mainstern areas)	+ Canopy c 50-60% s large mai	overage: hading (30-44% for nstem areas)	+ Canopy coverage: 60-79% shading (43 large mainstem are	5-59% for sas)	Canopy > 80% s mainste	coverage: hading (> 60% for large em areas)
Point range	001		2 🗆 3	040	5	0	6 🗆 7
Additional no	ites:			Total	overall se	core (0 - 4	42)= 27
		Ranking	Poor (<13)	Fair (13-24)	Good	(25-34)	Excellent (>35)
						/	

Completed by: <u>FT/ER</u> Checked by: _

Date: LIAU 2 DOIS	Stream/Reach:	EPC-3		
Weather:	Location:	Kinbu Rd		
Field staff: CH / CR	Watershed/Subwatershed:	Fast Potter sc	sh Critc	
UTM (Upstream)	UTM (Downstream)			
Land Use H Valley Type Channel Type Channel: (Table 1) H (Table 2) 2 (Table 3) (C (Table 3)	zone 1 Flow Type 2 bie 4) 1 (Table 5) 2	XGroundwater	ividence: Which cress	
Riparian Vegetation	Aquatic/Instream Veg	etation	Water Quality	
Dominant Type: Coverage: Cannot withs Age Class (yrs) : Encroachmer (Table 6) 0 0 None 1.4 0 Immature (<5)	nt: Type (Table8) 2 7) Woody Debris Present in Cutbank	Coverage of Reach (%) 40 Density of WD: Low WD1/50m/ Mgderate Mgderate	Odour (Table 16)	
Channel Characteristics				
Sinuosity (Type) Sinuosity (Degree) Gradient Nun (Table 9) 1 (Table 10) 1 (Table 11) 1 Entrenchment Type of Bank Failure Downs's Classification	ble 12) 1 Actine Substra	te D X Sand Savel	Cobble Boulder Parent Rootte	n (
(Table 13) 2 (Table 14) 1 (Table 15)	Bank Material			200
Bankfull Width (m) 나니 wetted Width (m) Bankfull Depth (m) 0.35 Wetted Depth (m) Riffles: NA % Pools: NA	0.8 Meander Amplitude:	Bank Angle Bank 0 - 30 - 5 30 - 60 - 5 5< 0 - 5 0 - 30 0 - 5 0 - 30 0 - 30 0 - 5 0 - 5	Frosion Notes: Comply VULY 30% OLONG US; -60% OLONG US; -100% Sorpliads in Chin	า.เฮ
Pool Depth (m) 0.3 Riffle Length (m) NA Undercuts (m 외동 야 KP Veloctity (m/s) Viffle ball / AD	V/Estimated V. R. I.	knick ponts, r	nent kietimol uls ol	EVIC
rolley sicm by	71.3m e DIS exter + a.s.me U/S ext	1+ Completed by: CH	Checked by:	

Date:	No	V7.2015		Stream/Re	ach:	FPC	2-3	
Weather:	SI	Lo + 10°C						1.1
Field Ctoff	01						24 15	0
Field Staff:	Ct	TEK	Waters	shed/Subwaters	hed:	East	- Pat	terson
Process		Geomorph	hic Indicator			Pres	sent?	Factor
riocess	No.	Description				Yes	No	Value
	1	Lobate bar			- 1		V	
	2	Coarse materials in riffles embedde	ed			1	V	
Evidence of	3	Siltation in pools					V	3
Aggradation	4	Medial bars					11/	0/2
(AJ)	5	Accretion on point bars					17	777
	6	Poor longitudinal sorting of bed ma	aterials			1	V.	7
	7 Deposition in the overbank zone						1	7
	_			Sum of indi	ces =	0	7	0.0
	1	Exposed bridge footing(s)			-	N	LA.	
	2	Exposed sanitary / storm sewer / p	ipeline / etc.		-	N	TA	-
	3	Elevated storm sewer outfall(s)					1.5	-
Cuidones of	4	Undermined gabion baskets / conc	rete aprons / etc.			(A)	10	-
Evidence or	5	Scour pools downstream of culvert	s / storm sewer outl	ets	-	01	1A	- 1/5
(DI)	6	Cut face on bar forms			-	15	1V	- 10
(0)	7	Head cutting due to knick point mig	gration		1	1/	1	-
	8	Terrace cut through older bar mate	erial			V.	1	1
	9	Suspended armour layer visible in I	bank				17	-
	10	Channel worn into undisturbed over	erburden / bedrock				1	1
	-			Sum of Indi	ces =	1	4	0.20
	1	Fallen / leaning trees / fence posts	/ etc.				1	
	2	Occurrence of large organic debris					V	-
	3	Exposed tree roots					Y	-
Euldenes of	4	Basal scour on inside meander ben	ds		-	n/	IA	-
Widening	5	Basal scour on both sides of channel	el through riffle			N	1A	-
(WI)	6	Outflanked gabion baskets / concre	ete walls / etc.			N	A	19/5
(with	7	Length of basal scour >50% through	h subject reach				V	1 2
	8	Exposed length of previously buried	d pipe / cable / etc.			N	IA .	1
	9	Fracture lines along top of bank					V	1
	10	Exposed building foundation				N	IA .	1
	_			Sum of India	ces =	0	5	0.0
	1	Formation of chute(s)					./	T
Evidence of	2	Single thread channel to multiple cl	hannel		-		1	-
Planimetric	3	Single thread channel to multiple channel Evolution of pool-riffle form to low had reliaf form					V	-
Form	4	Cut-off channel(s)		1	- 11_			
Adjustment	5	Formation of island(s)					1	- 17
(PI)	6	Thalweg alignment out of phase me	ander form			1	1	-
	7	Bar forms poprly formed / reworke	d / removed			1	~	-
				Sum of india	es =	1 I	6	0.14
ditional poter-				Stability Inde	CI1.	(4)-01-30	1.011/4	
and the second second	-		Cantral	stability index (511 =	UNI+DI+W	HP1)/4 =	0.07
			Condition	in Regime	in tra	nsition/Str	ess In	Adjustment
			Si score =	L1 0.00 - 0.20		021-04	0	C1 0 44

Completed by: <u>FI/ER</u> Checked by: _

Rapid Stream Assessment Technique Project Number: PMISO80

Date:	NOV 2, 2015	Stream/Reach:	EPC-3
Weather:	SUN+ 10°C	Location:	Kirby Rd
Field Staff:	CHIER	Watershed/Subwatershed:	East Patterson

Evaluation Poor Category		Fair	Good	Excellent	
	< < 50% of bank.network stable Recent bank sloughing, slumping or failure frequently observed	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% 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 	
Alu	 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 0.8-0.9 m	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 	
Channel Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	Exposed 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 eradible 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 b generally V- or U-shaped	
Point range	00102	030405	60708	□ 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 mainstern 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 	itreambed streak marks ind/or "banana"-shaped ediment deposits common uncommon	
	 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	esh, large sand deposits immon in channel nall localized areas of fresh ind deposits along top of w banks localized areas of fresh sand deposits along top of low banks	
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point bars small and stable, well-wegetated and/or armoured with little or no fresh sand 	 Point bars few, small and stable, well-vegetated and/or armouned with little or no fresh sand
Point range		3 0 4	□ 5 10 6	0708

EPC-3 PN 150BC GEO MORPHIX

Evaluation Category	Poor	Fair	Good	Excellent	
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	Wetted perimeter 40-60% of bottom channel width (45- 65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66- 90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 	
Physical Instream Habitat	 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, hiffles and runs dominant, velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mb between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
	Riffle substrate composition: predominantly gravel with high percentage of sand + < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and saul S-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 S0% 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		
	 Riffle/Pool ratio 0.49:1 ≤ : ≥ 1.51:1 	 Riffle/Pool ratio 0.5-0.69:1; 1.31-1.5:1 	 Riffie/Pool ratio 0.7-0.89;1; 1.11-3.3:1 	Riffle/Pool ratio 0.9-1.1:1	
NIF	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	00102	□ 3 ☑ 4	0506	0708	

Water Quality	Substrate fouling level: High (> 50%)	Substrate fouring 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 < 0.15 m below surface 	Objects visible to depth 0.15-0.5 m below surface	Objects visible to depth 0.5-1.0 m below surface	Objects visible to depth > 1.0-m Delow, surface	
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour	
Point range		0304	0506	₫ 7 🗆 8	

Riparian	Narrow riparian area of mostly non-woody vegetation	Riparian area predominantly wooded but with major localized gaps		 Forested buffer ger > 31 m wide along portion of both bar 	nerally + Wide major fores nks bank	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	Canopy coverage: < 50% shading (30% foc large mainstem.areas)	Canopy coverage: 50-60% shading (30-44% for large mainstem areas)		Canopy coverage: 60-79% shading (45 large mainstem are	-59% for > 80 main	Canopy coverage: > 80% shading (> 60% for large mainstem areas)	
Point range			2 🗆 3	040	5	6 7	
Additional no	tes:			Total	overall score (0	-42)= 22	
		Ranking	Poor (<13)	Fair (13-24)	Good (25-34) Excellent (>35)	
			a dia 12 dia				

Completed by: KT/ER Checked by:

Appendix C



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