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TRIECA
March 22, 2018

To Pipe or Not to Pipe - Erosion Issues and Solutions in an Urban Watercourse in Edmonton

Heather Amirault

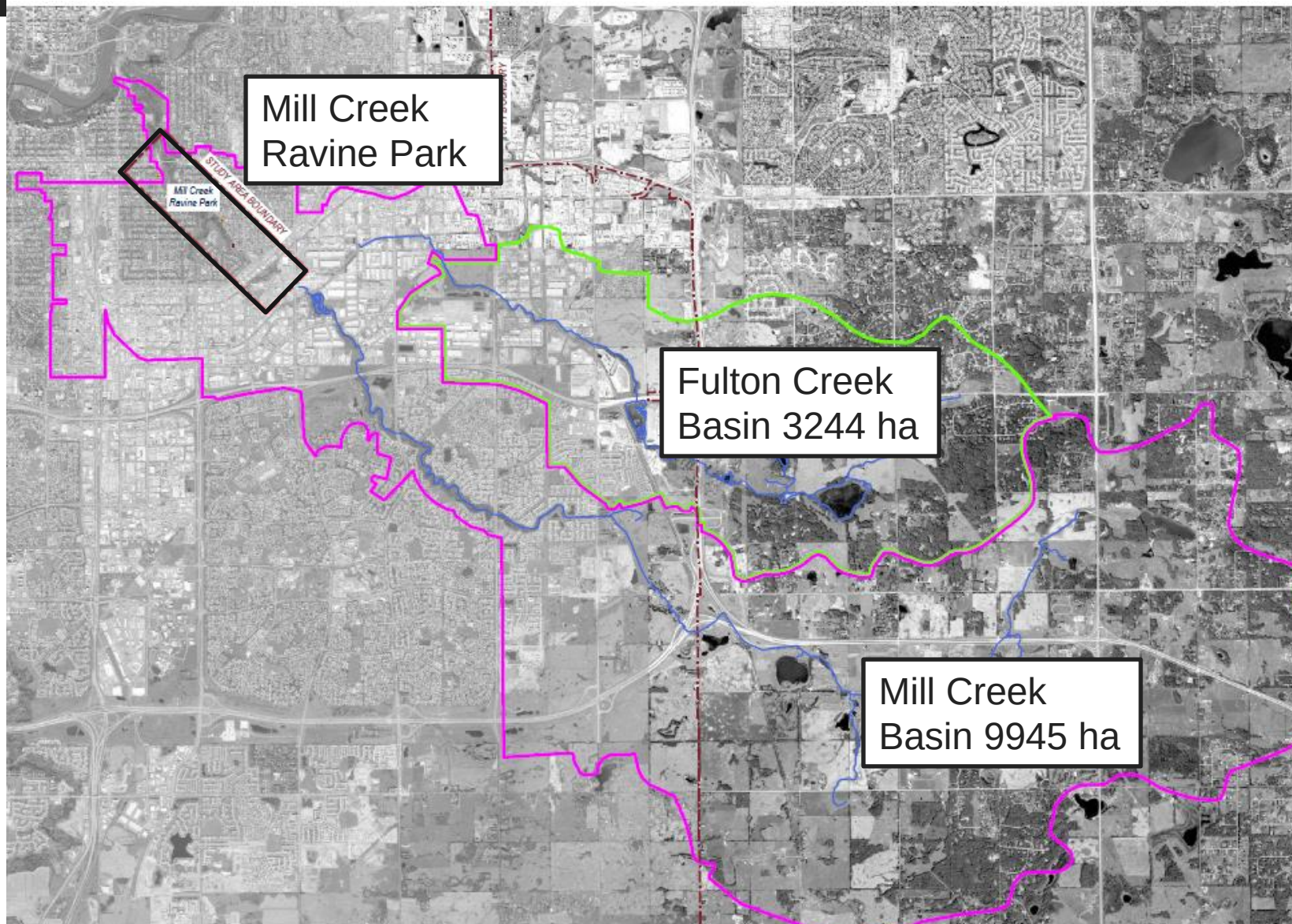
Agenda

1. Mill Creek
2. Creek Impacts
3. Erosion Assessment
4. Outcomes

How it all started

Mill Creek

Creek Impacts



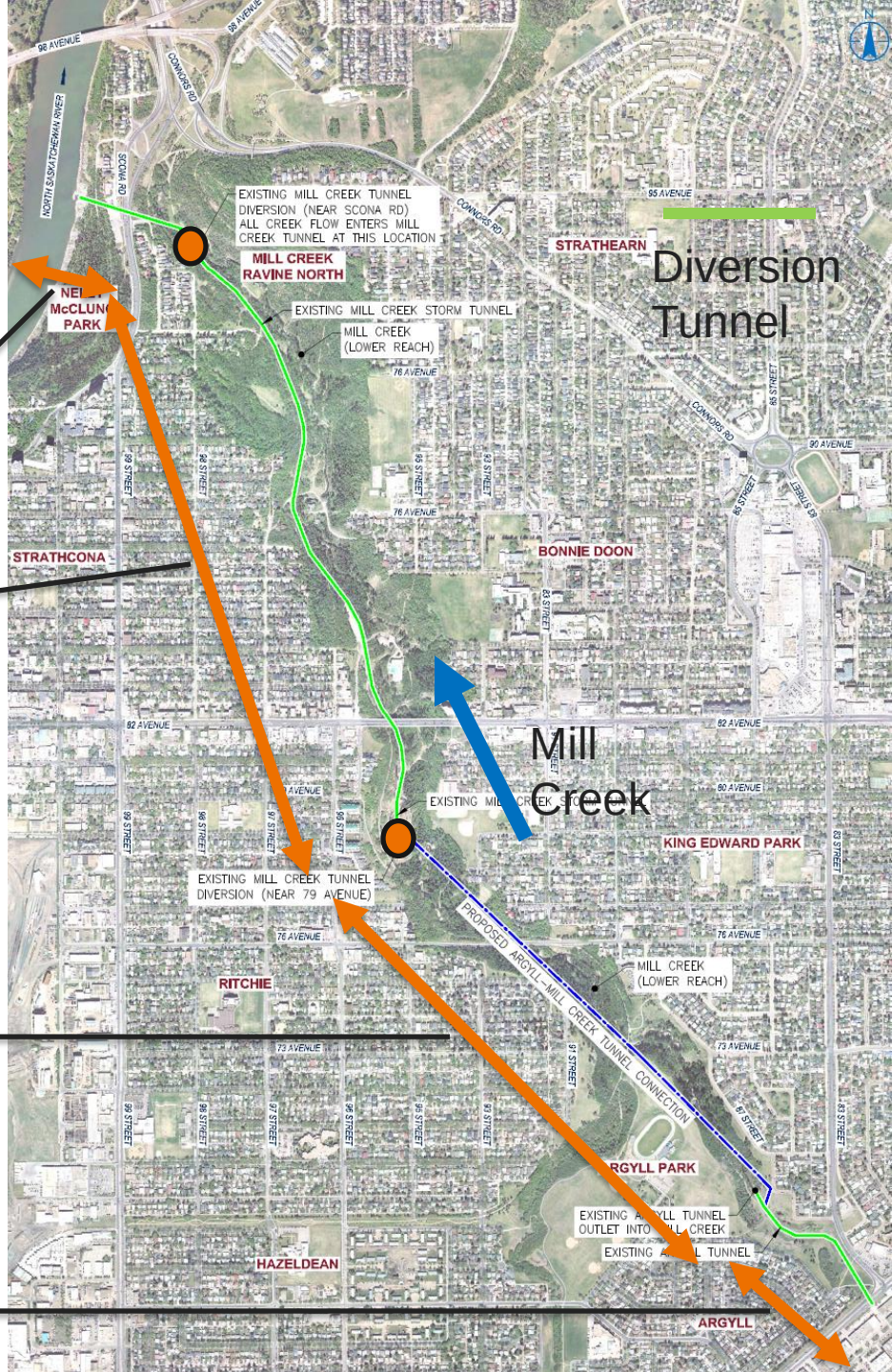
Site Conditions

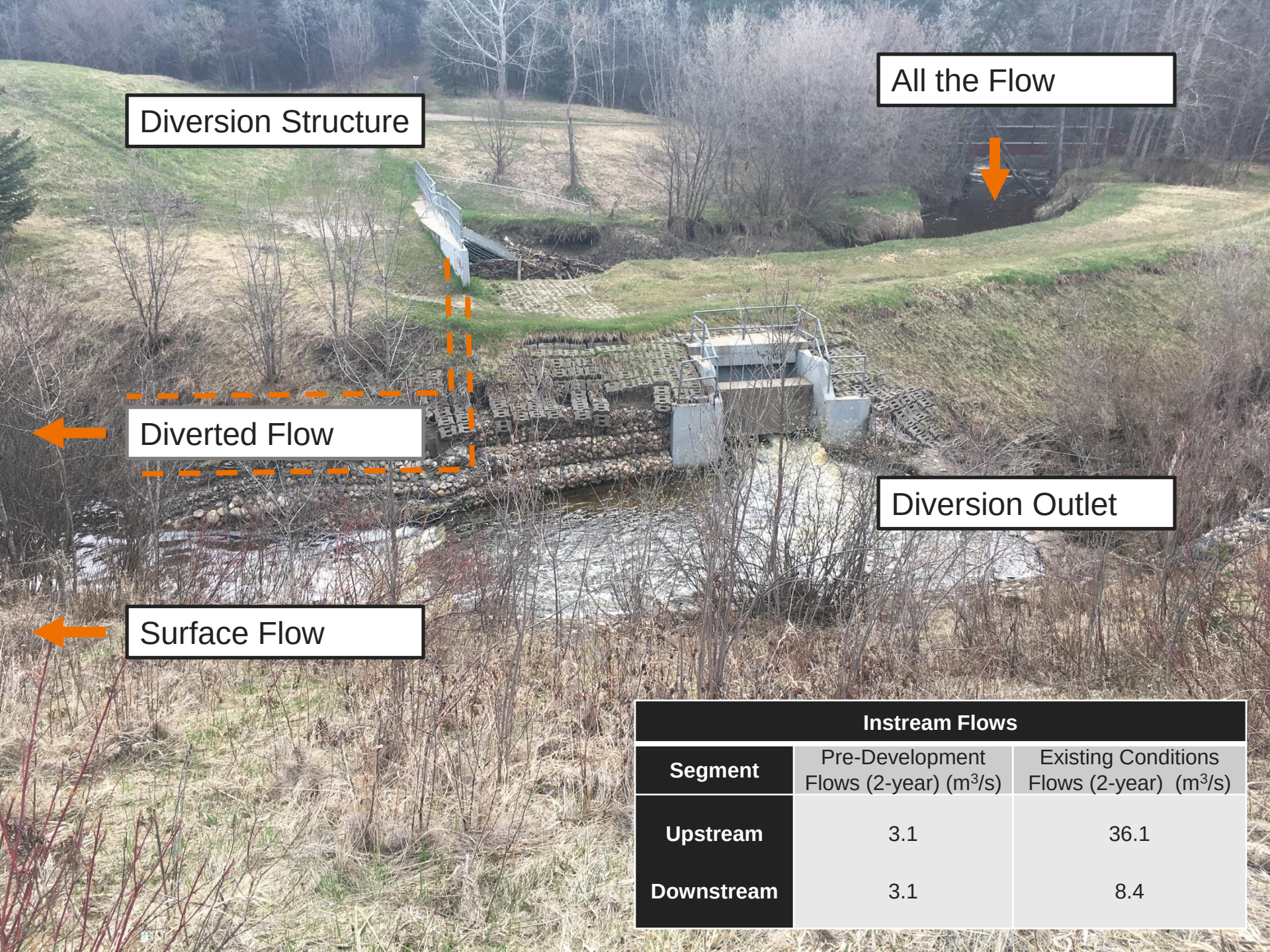
Flows fully piped to North Sask. River

Flows partially piped, partially surface

Flows fully surface

Flows fully piped





Instream Flows		
Segment	Pre-Development Flows (2-year) (m^3/s)	Existing Conditions Flows (2-year) (m^3/s)
Upstream	3.1	36.1
Downstream	3.1	8.4


Diversion Structure
All the Flow
Issues downstream of diversion

What happened

Creek Impacts

Creek Impacts

- Incision
- Over widening
- Bank Erosion
- Utility Exposure
- Public Safety Risk
- Infrastructure Damage

Gabions and Bank Erosion

Downcutting and Widening

Creek Impacts

- Consulting report evaluating erosion sites
- 64 erosion sites with $74M of repair works in study reach
- Permanent options listed as:
    1. Grade control structures
    2. Diversion tunnel extension ($30M)

What's happening

Erosion Assessment

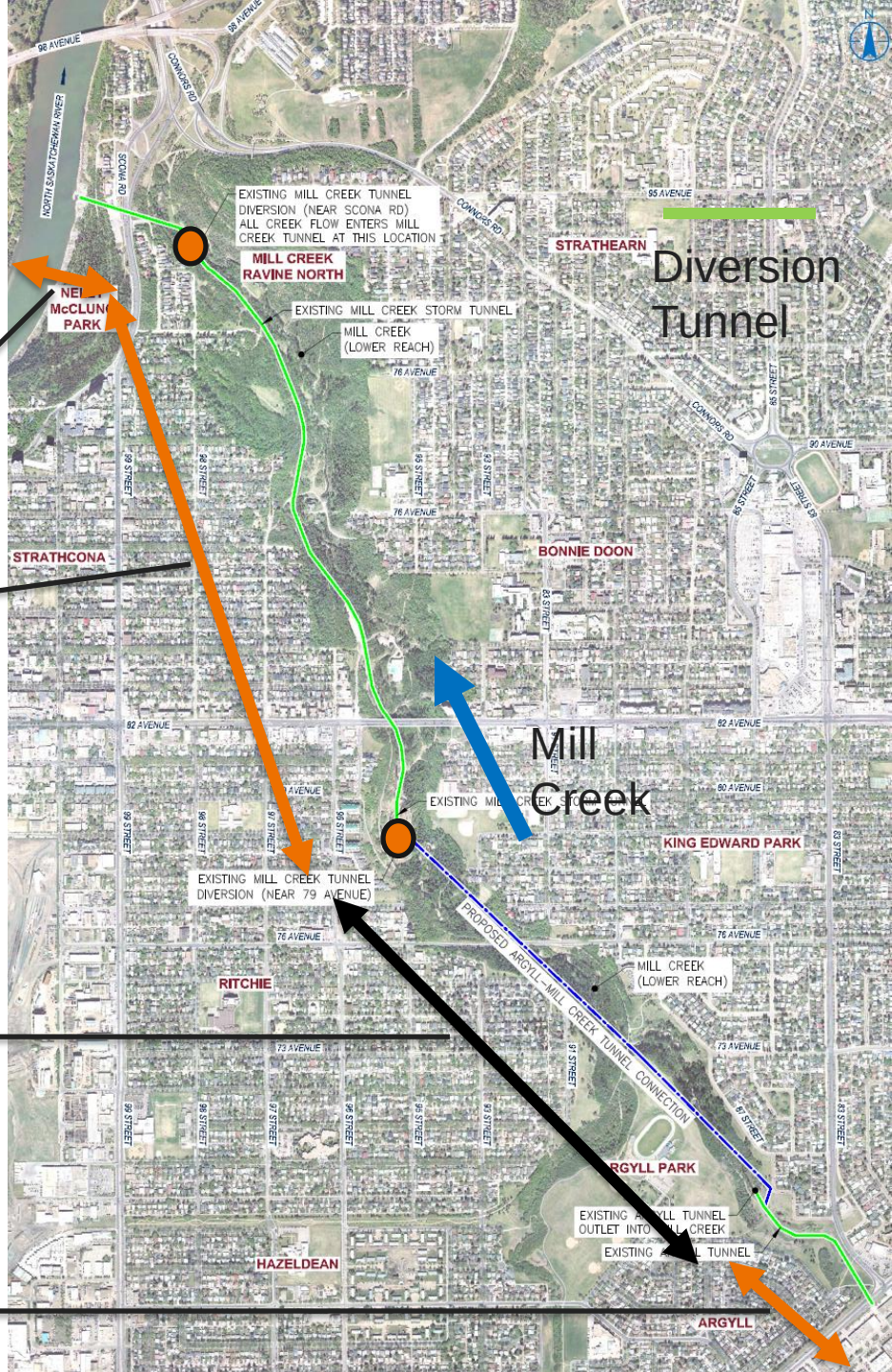
New Diversion

Flows fully piped to North Sask. River

Flows partially piped, partially surface

FUTURE
Flows partially piped, partially surface

Flows fully piped



Study Goals

- Understand erosion mechanisms
- Determine Mill Creek ‘stable’ flow capacity
- Examine diversion tunnel extension approach and consider alternatives
- Review erosion site priorities from previous study

Study

Historical Planform

Stantec
300 Hagey Blvd. Suite 100
Waterloo, ON, N2L 0A4
Tel. 519.579.4410
www.stantec.com

Legend
Creek Planform 2014
Creek Planform 1982
Creek Planform 1949
Reach Break
DIRECTION OF FLOW

Notes

1:5000 0 50 150 250m

Client/Project
CITY OF EDMONTON
MILL CREEK

Figure No.
5

Title
Mill Creek Planform
Reaches MC-1, MC-2 and MC-3

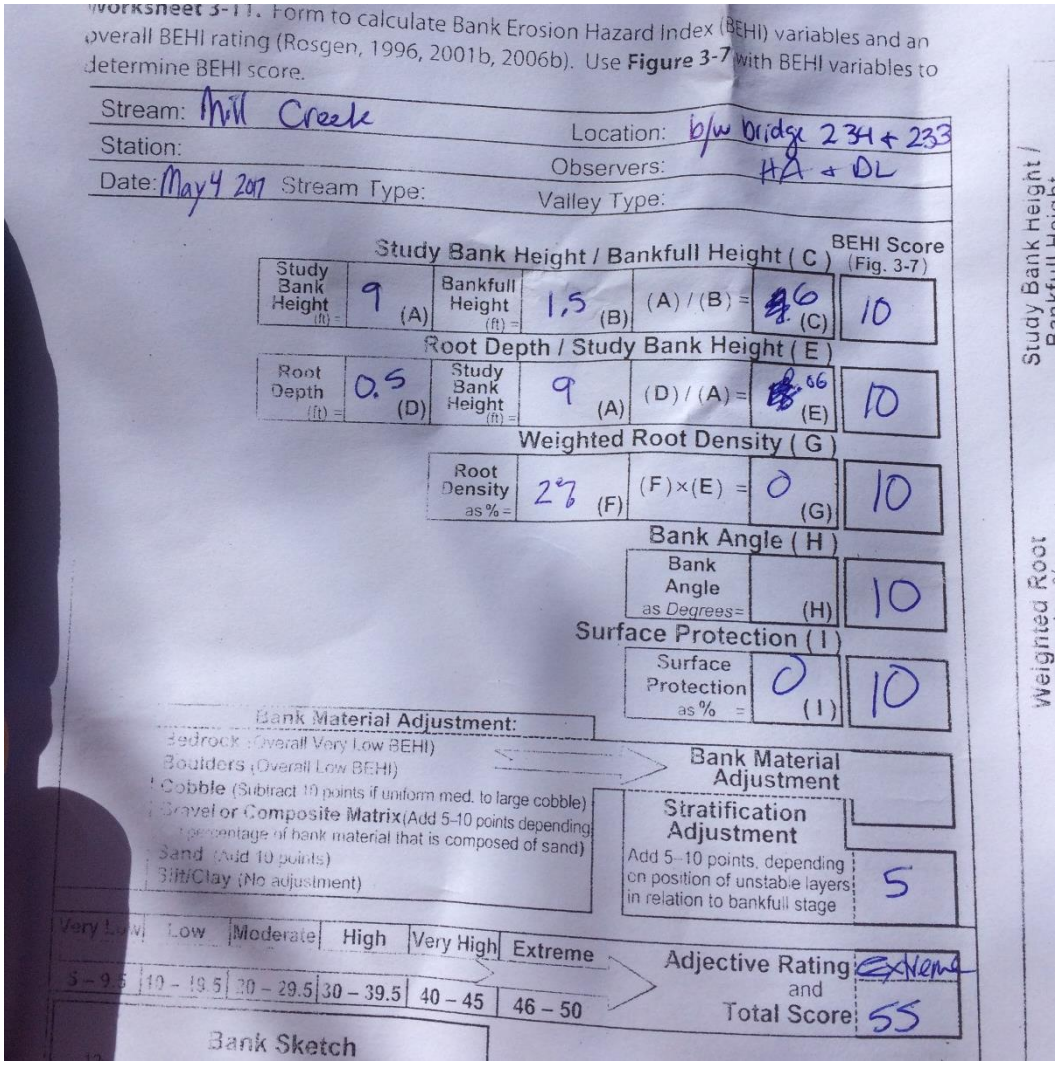
Creek Erosion

- Upstream of Diversion Tunnel
  - Erosion rates 0.12 m/yr

- Downstream of Diversion Tunnel
  - Erosion rates 0.09 m/yr

Bank Erosion Hazard Index - BEHI

- Bank height ratio
- Root depth / Bank height
- Root density
- Bank Angle
- Surface Protection
- Bank materials / stratification



Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001b, 2006b). Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Mill Creek Location: b/w bridge 234 + 233

Station: Observers: HA + DL

Date: May 4 2017 Stream Type: Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	9 (A)	Bankfull Height (ft) =	1.5 (B)	(A) / (B) =	6 (C)	10
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0.5 (D)	Study Bank Height (ft) =	9 (A)	(D) / (A) =	.06 (E)	10
Weighted Root Density (G)						
Root Density as % =	2% (F)	(F) × (E) =	0 (G)			10
Bank Angle (H)						
Bank Angle as *Degrees* =	(H)					10
Surface Protection (I)						
Surface Protection as % =	0 (I)					10

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform med. to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (No adjustment)

→ **Bank Material Adjustment**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 5

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

→ **Adjective Rating** and **Total Score**: Extreme 55

Bank Sketch

Study Bank Height / Bankfull Height

Weighted Root

Near Bank Shear Stress- NBS

- NBS based on proximity of thalweg to the bank – the closer the thalweg the higher the near bank shear stress
- Use graph to determine bank erosion rate

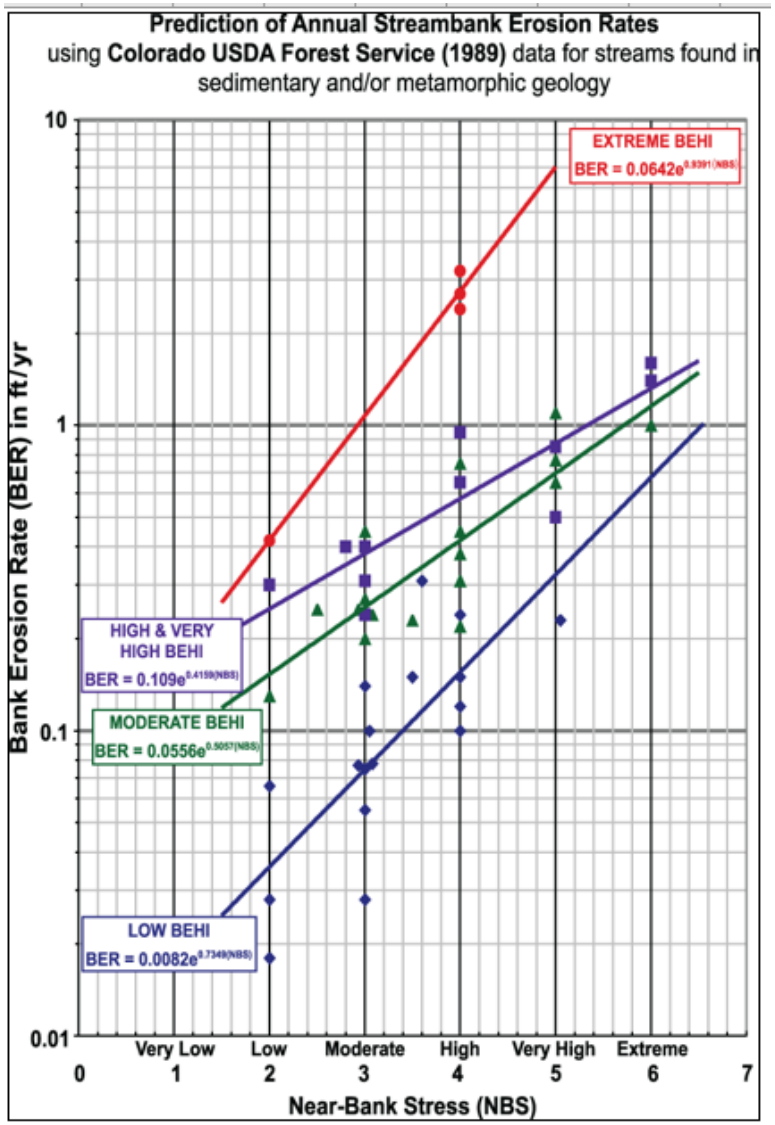


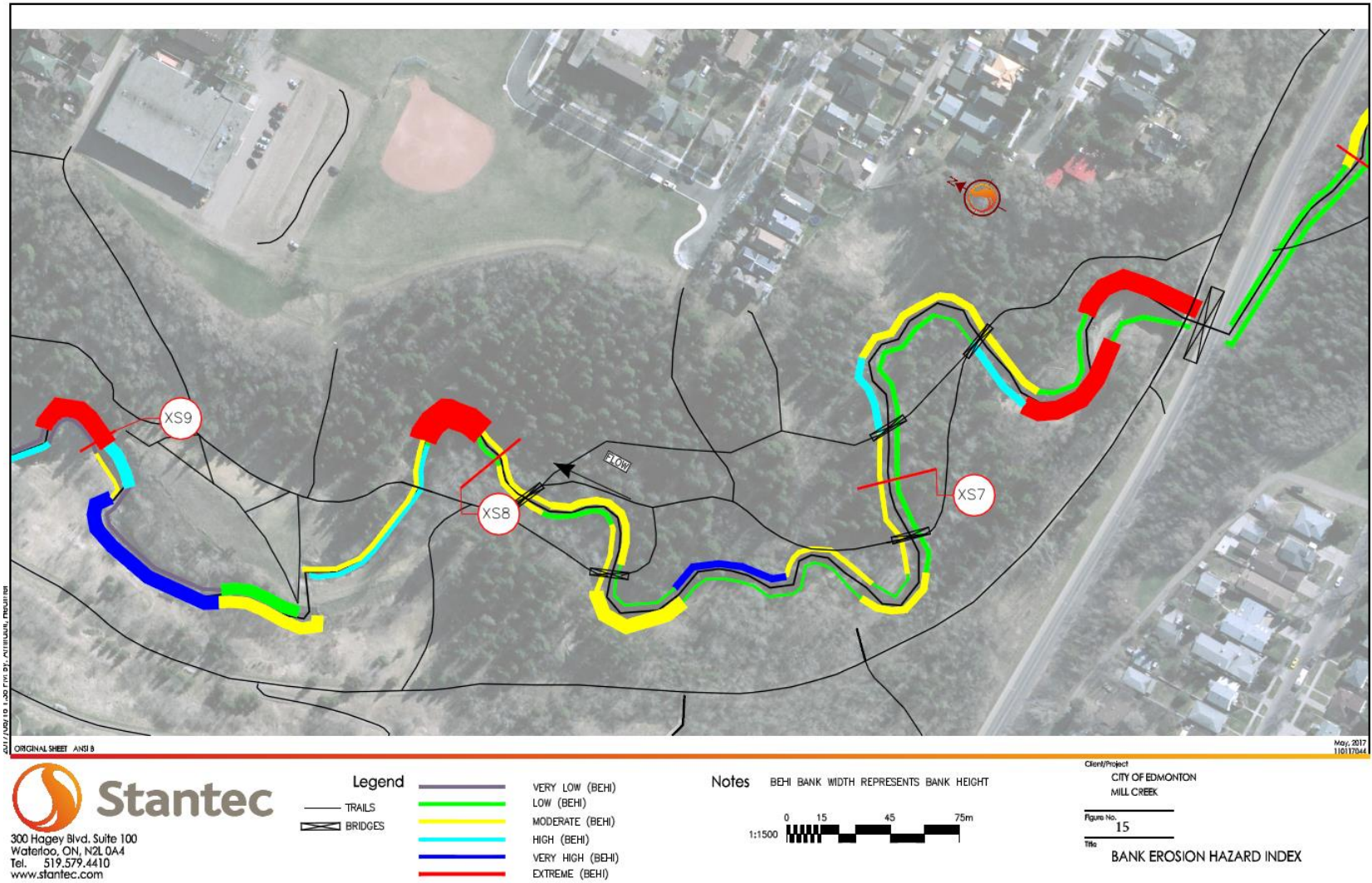
Figure 3-9. Relationship of BEHI and NBS to predict annual streambank erosion

Source: WARSSS (Rosgen 2009)

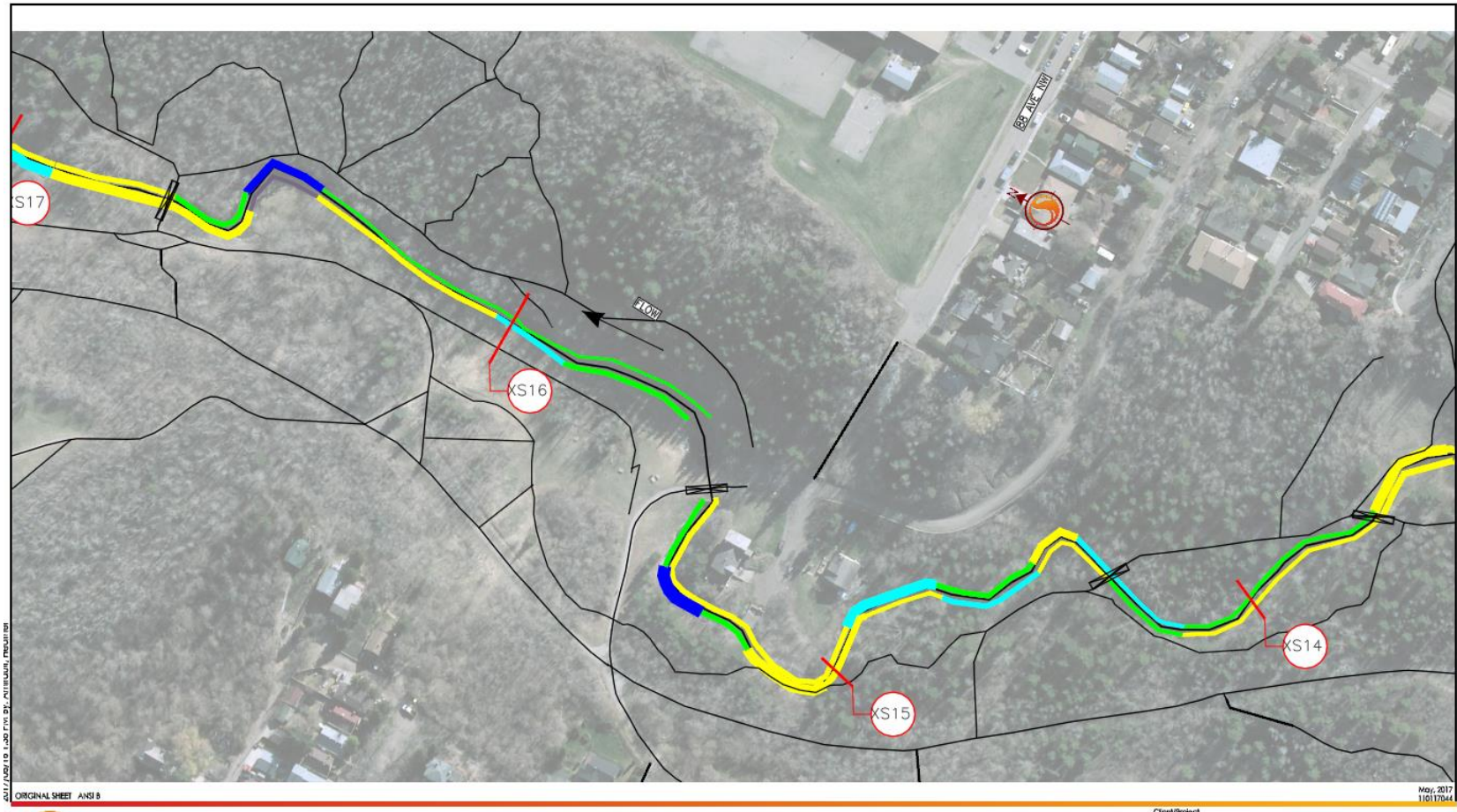
Study

Bank Erosion Hazard Index – field notes

Bank Erosion Hazard Index – upstream of diversion



Bank Erosion Hazard Index – downstream of diversion



BEHI / NBS Results

- Upstream Reach
  - 3.0 m^3 sediment/ m of bank /year
- Downstream Reach
  - 1.7 m^3 sediment/ m of bank /year
- Upstream reach losing 184% more sediment

Hydraulic Analysis

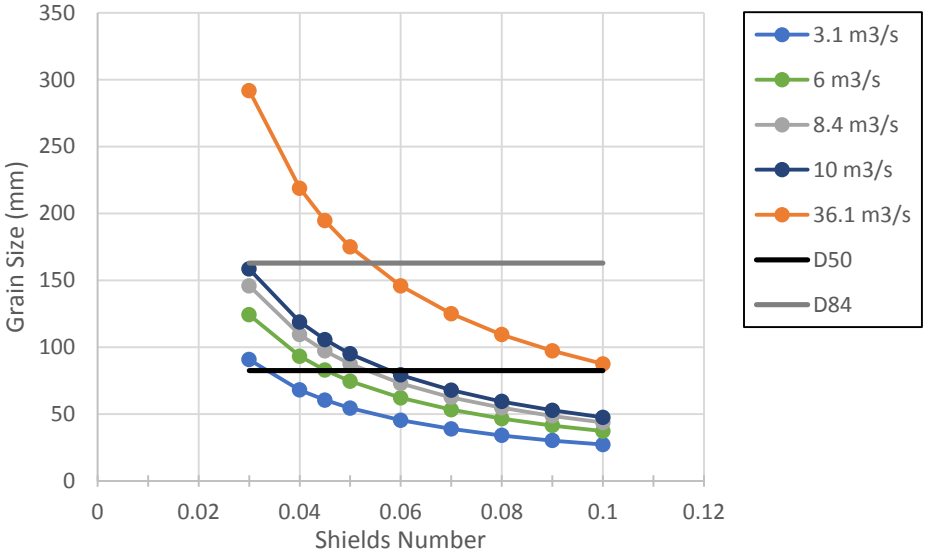
	Parameter	Upstream Reach	Downstream Reach
Pre-Development	Flow Rate (2-year) (m^3/s)	3.1	3.1
	Average Flow Depth (m)	0.55	0.56
	Average Shear Stress (Pa)	42	33
Existing Conditions	Flow Rate (2-year) (m^3/s)	36.1	8.4
	Average Flow Depth (m)	1.72	0.91
	Average Shear Stress (Pa)	130	53

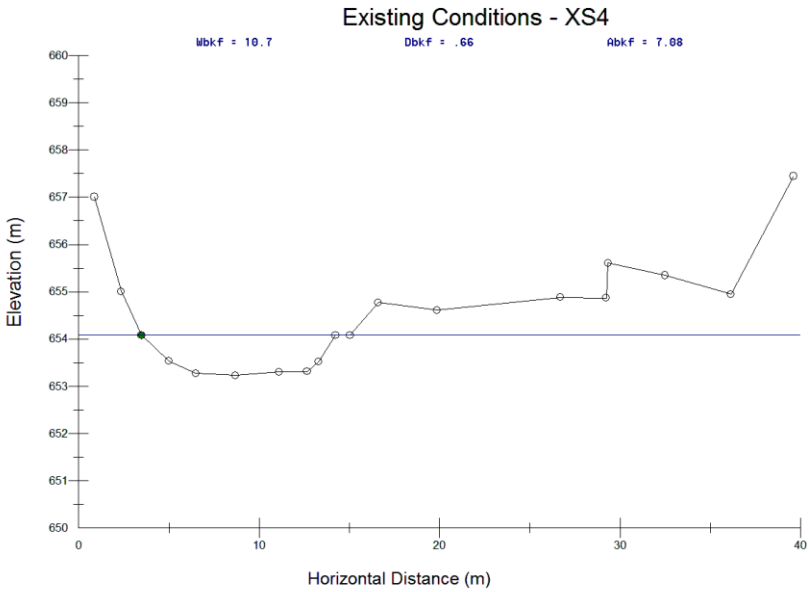
Pre-Development Flows < Existing Conditions Flows

Upstream Depth and Shear > Downstream Depth and Shear

Bed Stability Analysis

Cross-Section 4 Shields Numbers and Grain Mobility



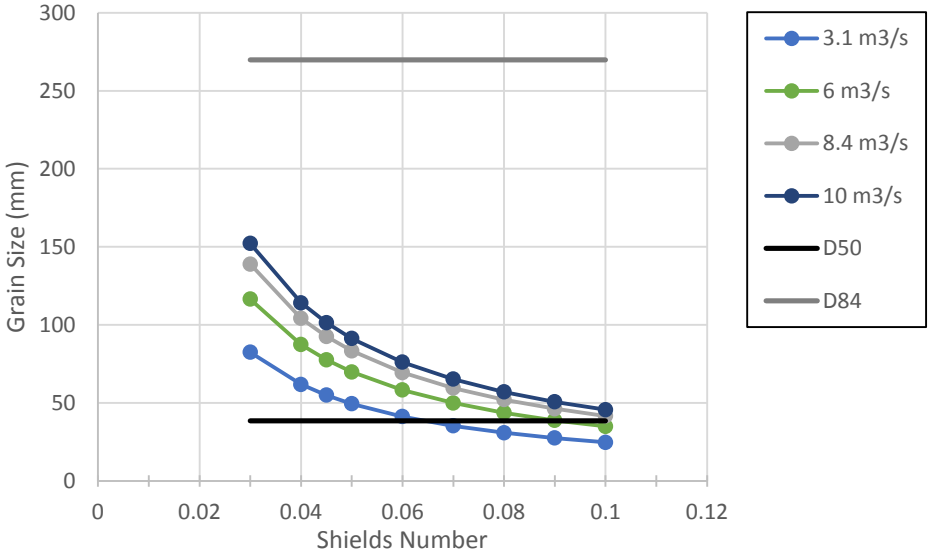


Discharge (m^3/s)	Sediment Size Range (mm)	D50 Stable (Y/N)*	D84 Stable (Y/N)*
3.1	27.2 – 90.7	Y	Y
6	37.3 – 124.2	Y	Y
8.4	43.7 – 70.8	N	Y
10	47.5 – 158.4	N	Y
36.1	87.5 – 291.8	N	N

*Assumes Shields Number of 0.045

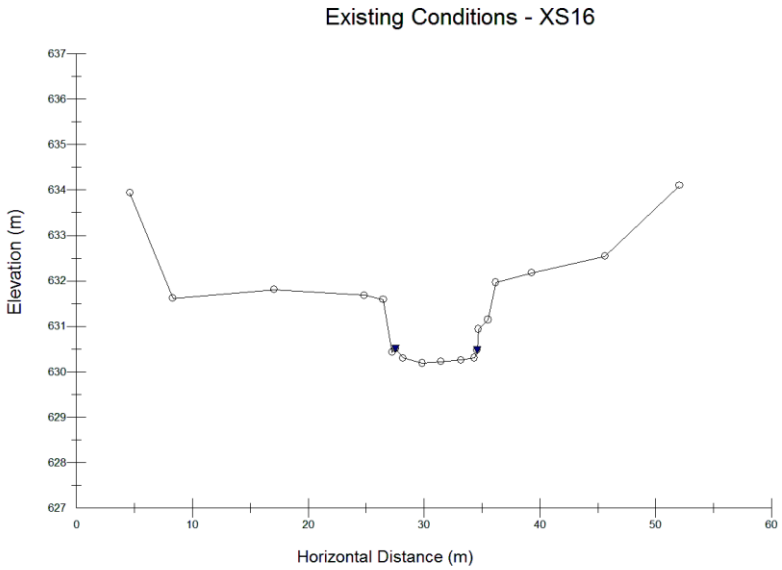
Bed Stability Analysis

Cross-Section 16 Shields Numbers and Grain Mobility



Discharge (m^3/s)	Sediment Size Range (mm)	D50 Stable (Y/N)*	D84 Stable (Y/N)*
3.1	24.7 – 82.5	N	Y
6	35.0 – 116.5	N	Y
8.4	41.7 – 138.93	N	Y
10	45.7 – 152.2	N	Y

*Assumes Shields Number of 0.045



Bed Stability Analysis

Discharge (m^3/s)	Sediment Size (mm)	Cross-Section 3	Cross-Section 4	Cross-Section 9	Cross-Section 12	Cross-Section 14	Cross-Section 16	Cross-Section 19
3.1	D50	Y	Y	N	Y	Y	N	N
	D84	Y	Y	N	Y	Y	Y	Y
6	D50	Y	Y	N	N	N	N	N
	D84	Y	Y	N	Y	Y	Y	Y
8.4	D50	Y	N	N	N	N	N	N
	D84	Y	Y	N	Y	Y	Y	Y
10	D50	Y	N	N	N	N	N	N
	D84	Y	Y	N	Y	Y	Y	Y
36.1	D50	Y	N	-	-	-	-	-
	D84	Y	N	-	-	-	-	-

D84 bed material largely stable at flows up to 10 m^3

What are we going to do

Outcomes

Recommendations

Creek Conveyance

- Obtain more flow data – use gauges
- Implement the proposed Tunnel Connection, reduce creek flows to between 3.1 m^3/s and 10 m^3/s
- Implement channel restoration to address existing bank erosion sites
- Consider options for increasing floodplain access

Recommendations

Creek Restoration

- Implement a pilot stabilization project in the reach downstream of the diversion structure
- Bank stabilization works to stabilize the watercourse and reduce erosion rates - After construction of tunnel
- Consider more natural, measures to stabilize the watercourse (less gabion)
- Remove existing diversion structure and restore channel between upper and lower reach

Thanks and Acknowledgments

- The City of Edmonton

- Stantec colleagues in Edmonton and Burnaby

Questions

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