Using a scaled model to assess the performance of the Penticton Creek restoration project, British Columbia

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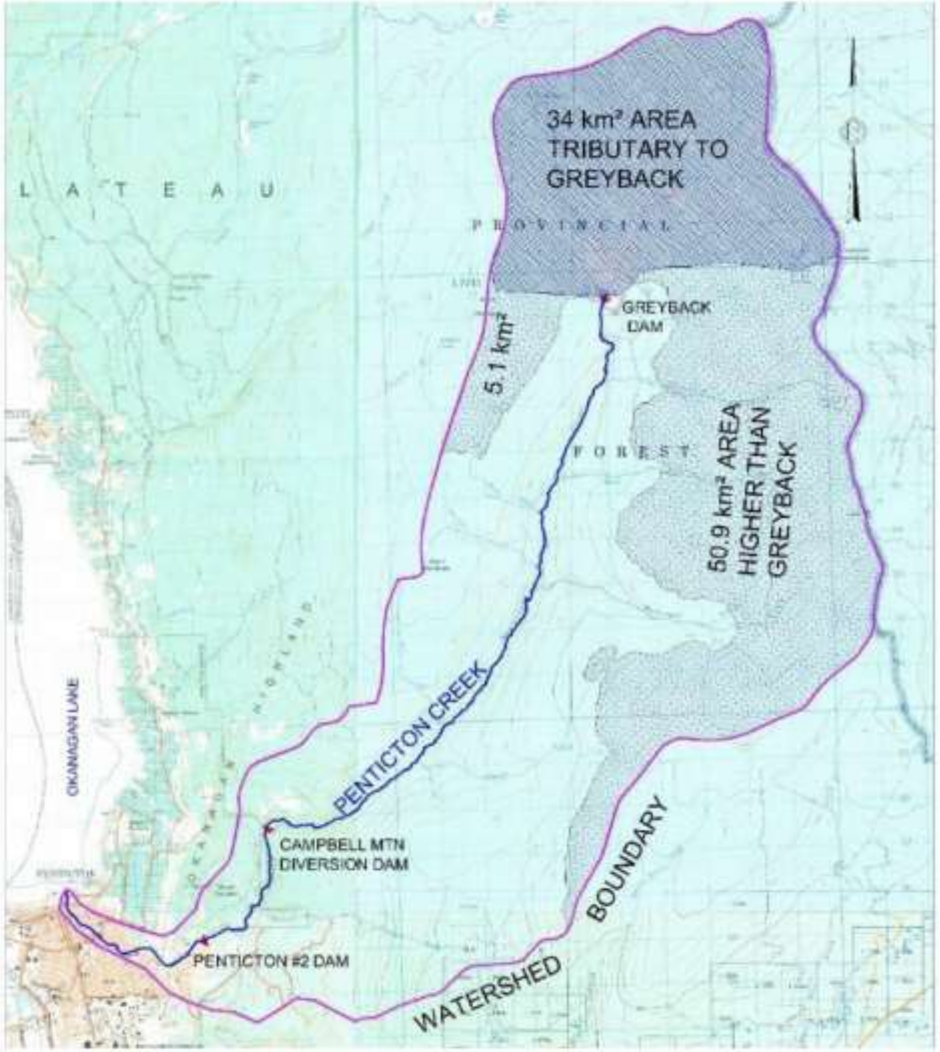
Penticton Creek, British Columbia



Penticton Creek History

- Flooding in 1942 and 1948 caused significant issues for the city
- Creek was channelized and concrete lining installed
- Narrowing from ~ 16 m to ~ 6 m wide at bankfull

Construction of the channel lining (date unknown)

City of Penticton (2017)

The Penticton Creek Restoration Project

- Penticton Creek Master plan in 2017
- 13 different reaches to be designed and restored
- Showcase section was built in 2015

PENTICTON CREEK: WE HAVE A PLAN

Restore flood protection. Restore fish habitat. Good design lets us do both.

CITY OF Penticton

City of Penticton (2017)

Reach 3A (upper) and 3B

Restoration purpose: stabilize channel with natural materials to mitigate flooding and improve fish habitat and restore fish passage

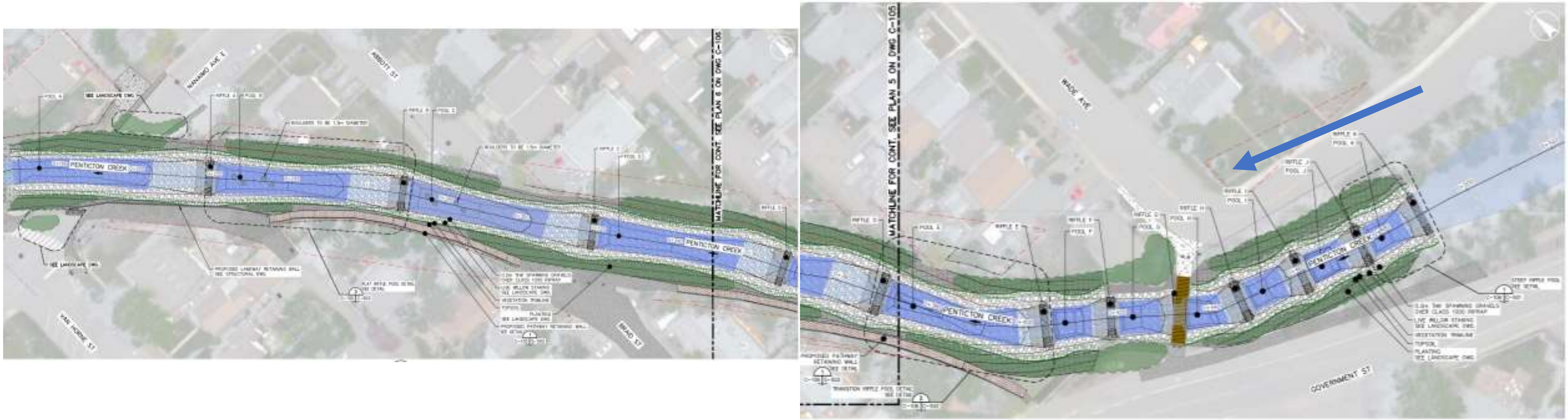
Specific Objectives

- Remove existing concrete, rubble, and curbs
- Remove existing structure and fish ladder
- Re-grade channel to contain 200-year design flow
- Provide resiliency from erosion up to 200-year design flow
- Include hydraulic controls and channel features to improve fish passage, habitat, and spawning
- Include vegetation for fish habitat and aesthetic benefits

Design Flow	Discharge [m^3/s]
Minimum channel Flow	0.23
200-year Maximum Daily Design Q	48
200-year Instantaneous Maximum Design Q	60

Stantec (2019)

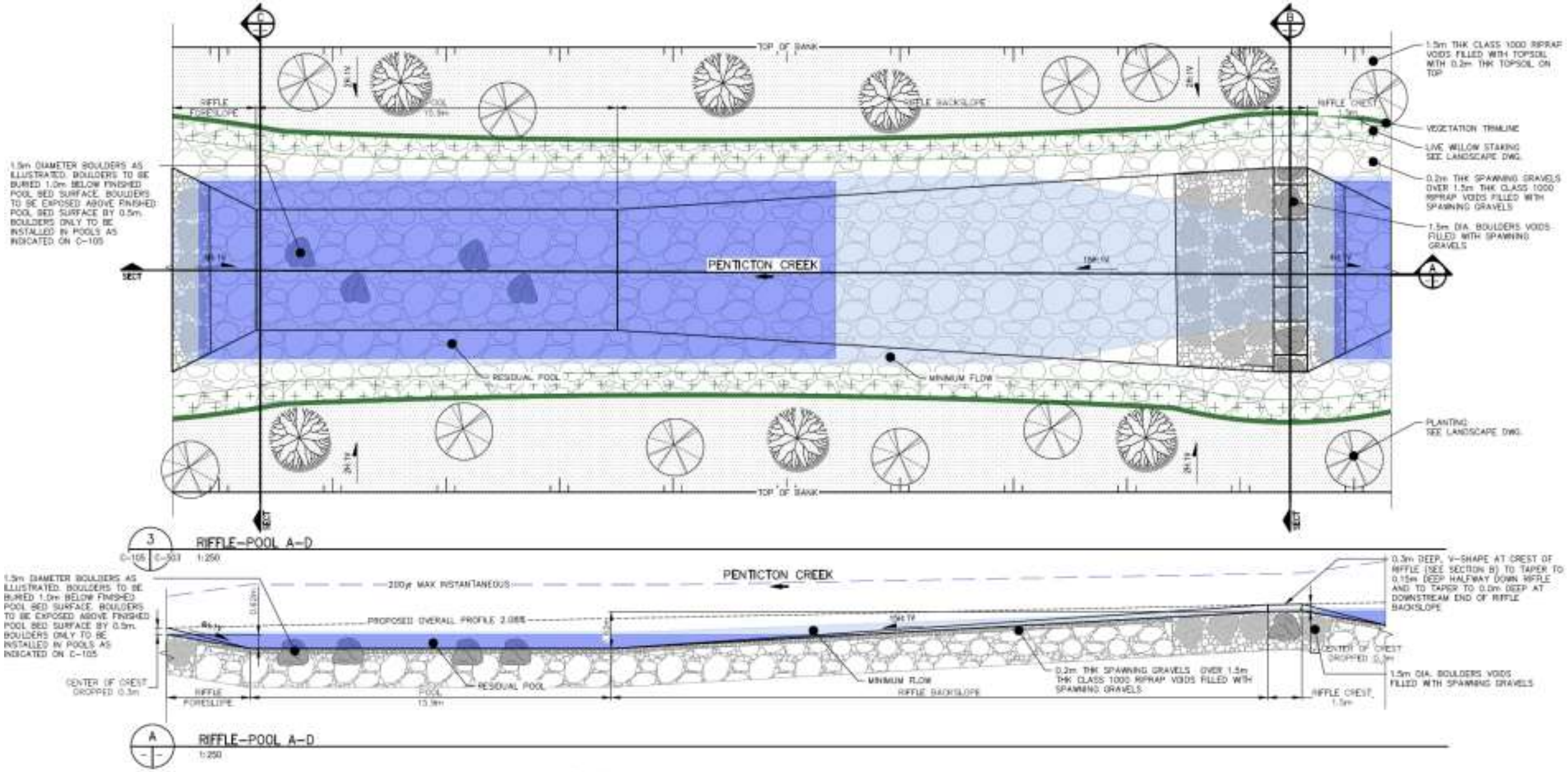
Design



Lower section	Deep Pool	Upper section
Lower section Series of 5 riffle-pool sequences at 2.1%	**Deep Pool**	**Upper section** Series of 6 steep step-pool structures at 3.6%

Design

- Based on 1-D and 2-D models
- Designed to meet flooding, erosion, and fish habitat needs



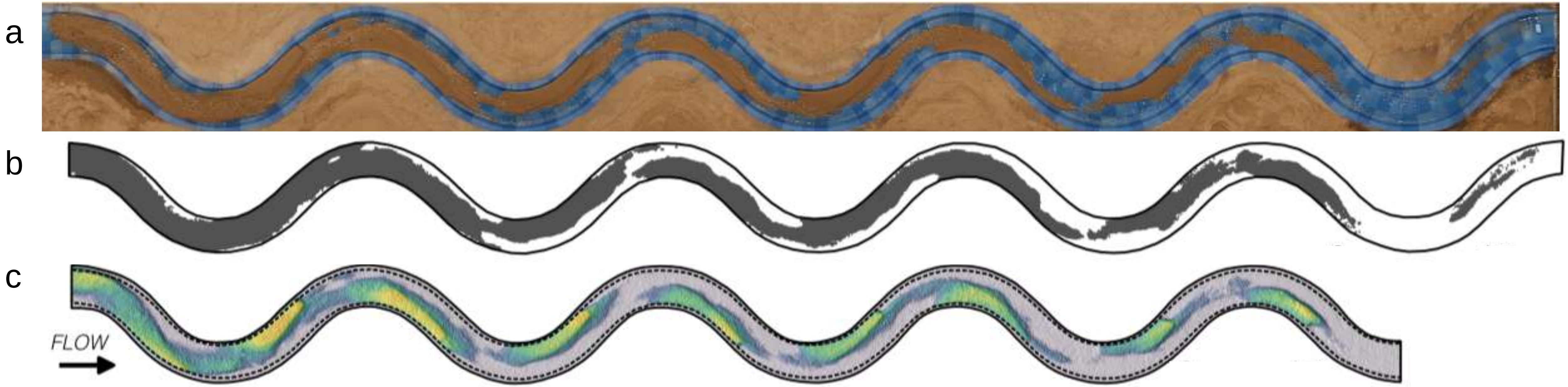
Flume Experiments

- Popular tools for research into river hydraulics and sediment transport
- Allow for many variables to be controlled very precisely (flow, sediment feed rate, topography)
- Many types and sizes of flumes (e.g. stream tables, recirculating, flow-through)

Flume Experiments

Can measure:

- Sediment transport and storage rates
- Evolution of channel morphology (in 3D)
- Small-scale hydraulic structures
- Effects of vegetation

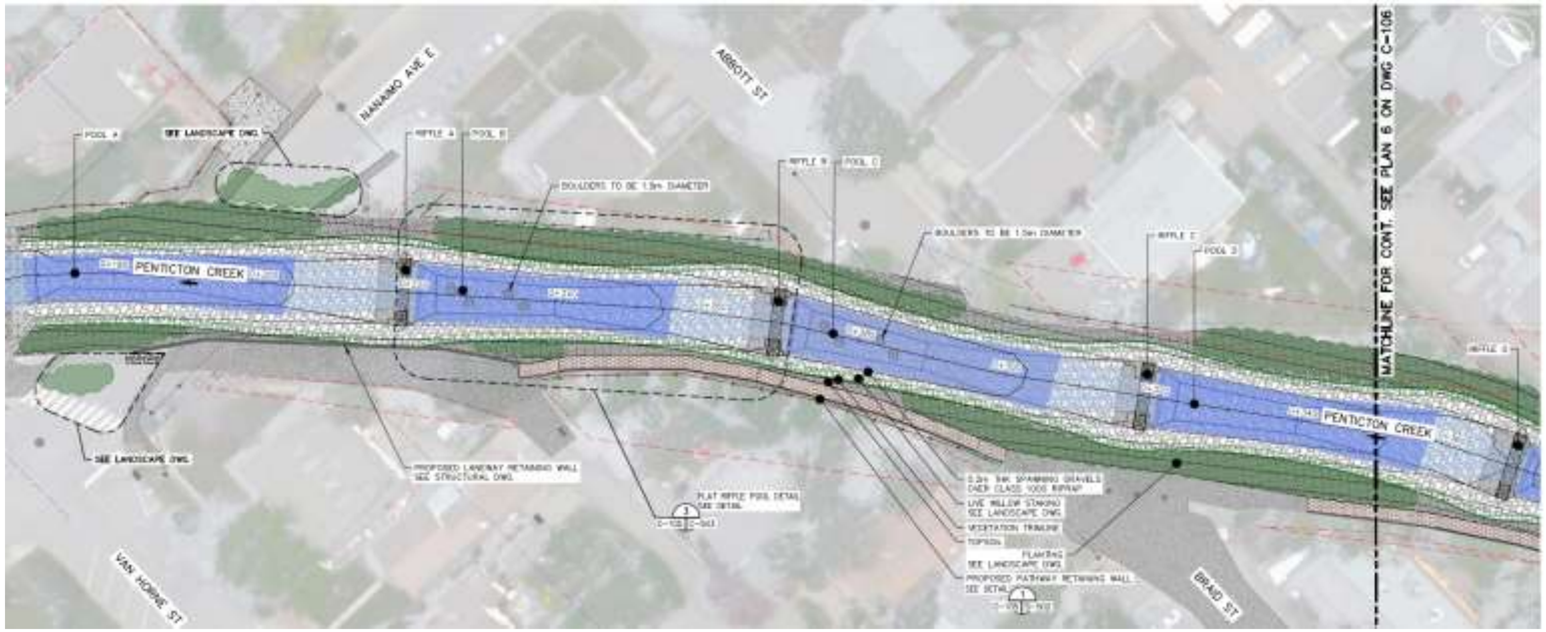


Froude Scaling

- Set of scaling relationships meant to preserve fluid forces (Froude number, shear stress, shear velocity)
- Reynolds numbers can differ from full-scale

Parameter	Units	Scaling Factor
Length	m	λ^1
Density	kg/m^3	λ^0
Mass	kg	λ^3
Pressure (including **τ**)	N/m^2	λ^1
Velocity	m/s	$\lambda^{0.5}$
Time	s	$\lambda^{0.5}$

Model Scaling at 1:30



Return [yrs]	Penticton Q [m³/s]	Model Q_m [l/s]
2	11	2.23
5	18	3.65
10	22	4.46
20	26	5.27
50	32	6.49
100	36	7.30
200	40	8.11
200+cc	48	9.74
200 MI	60	12.03

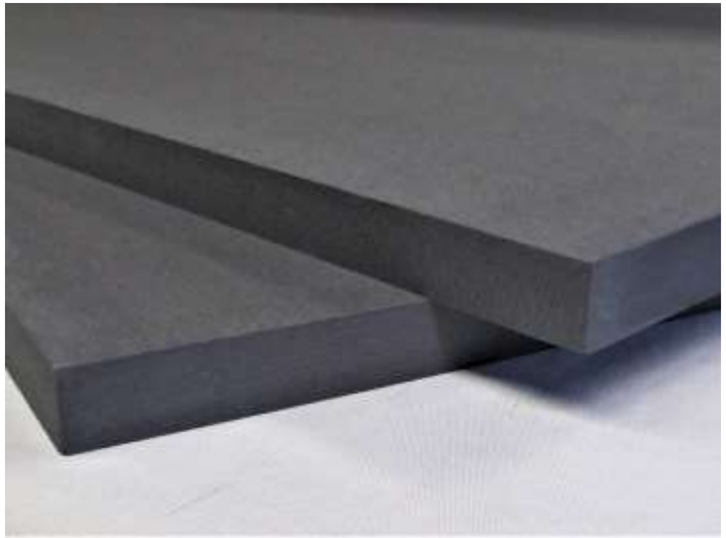
	Length [m]	Bed Slope %	Avg. Bed Width [m]	Riff. Spacing [m]	Pool Depth [m]
Penticton	141.3	2.1	9.0	50	0.62
Model	4.71	2.1	0.3	1.667	0.021

	Penticton [m]	Model [mm]
Riffles	1.5	50
Roughness	4.71	2.1
Spawning	0.2	6.7

Model Construction

Materials & Costs

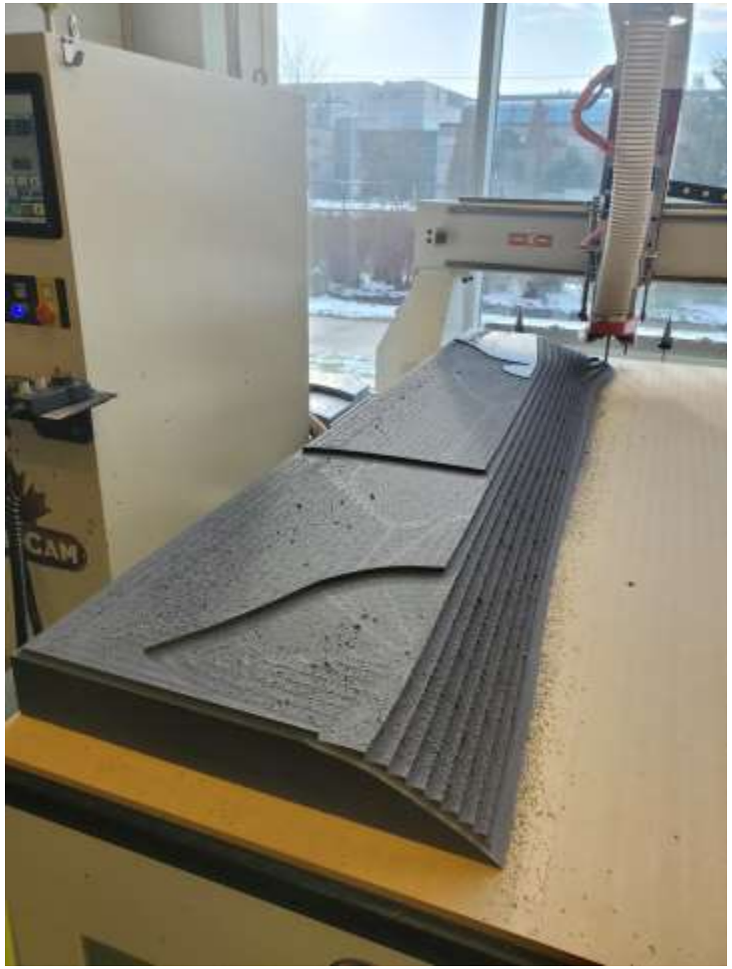
Item	Unit Cost [CAD]	Total Cost [CAD]
Foam Boards (XPS Insulation Boards)	56.44	959.54
CNC Machine Time	30/hr	840
Misc. Items (silicone sealant, construction adhesive)	-	200
Stones for roughness	9.39	75.12
		2,074.7



Model Construction

CNC Machining

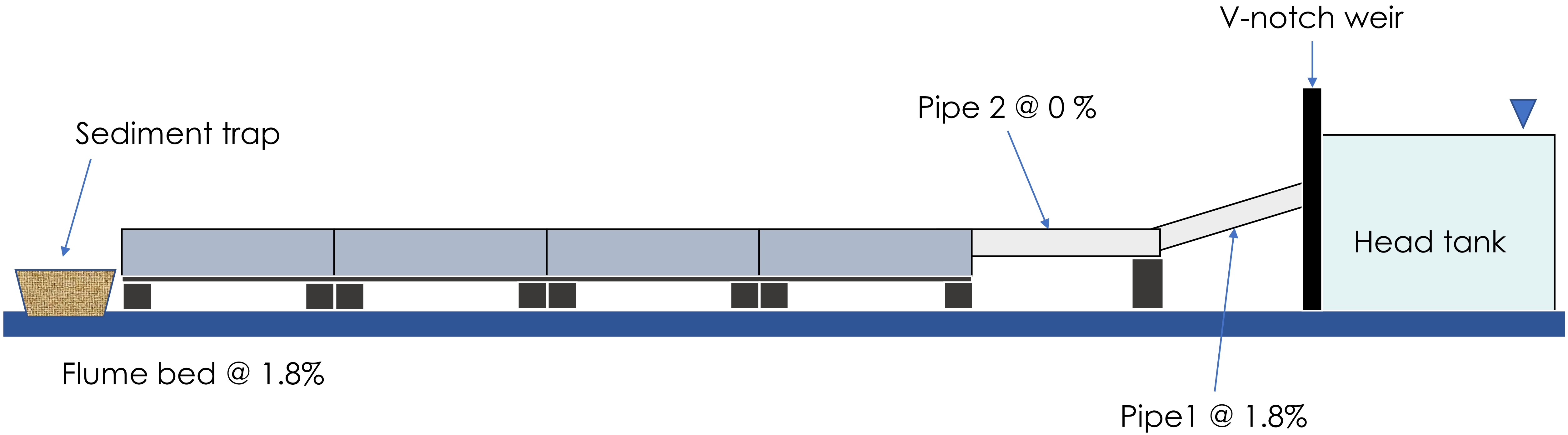
- Total time: 3 days



Model Construction

Comparison to Showcase Reach:

Model Assembly



Final Model

City of Penticton (2017)

Next Steps

- **Run the experiments!**
  - Run different Q scenarios
  - Monitor spawning gravel movement and evacuation

Final Thoughts

Benefits of using scaled models of restoration projects:

- Low-cost and quick using new construction methods (e.g. CNC machining, 3D printing)
- Ability to test the performance of designs under extreme events
- Ability to validate hydraulic models at high flows
- Test novel designs and unanswered questions

Benefits of industry-academic partnerships:

- Shared cost
- Test designs risk-free
- Model validation
- Student training

Thank you!

Questions?

Stantec

Mitacs

UNIVERSITY OF WATERLOO

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