Avon River Aboiteau Replacement Design

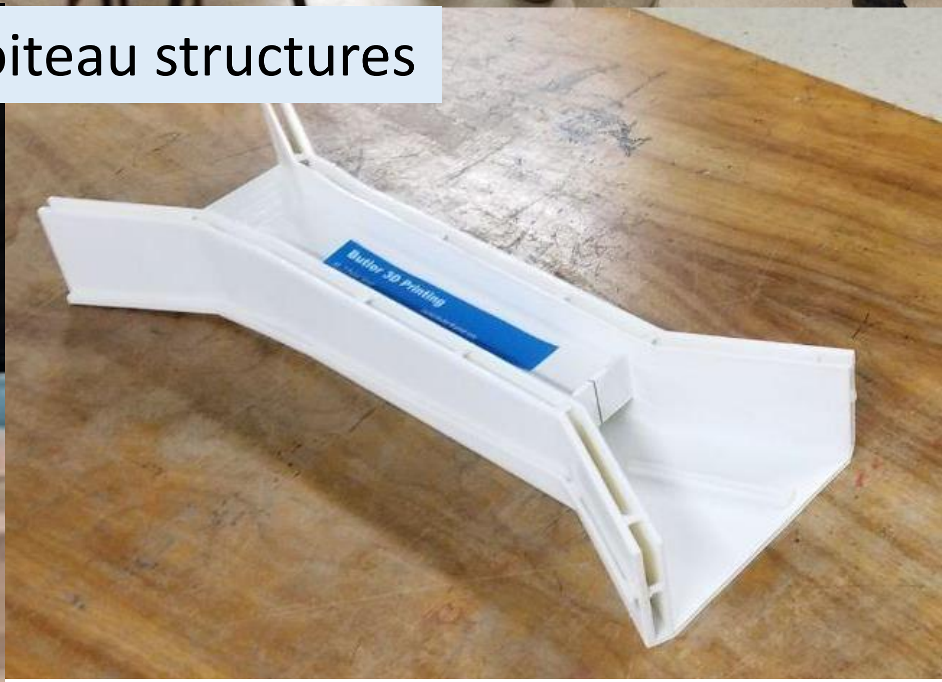
Open House

Nova Scotia / Nouvelle-Écosse · CBCL · Dalhousie University · Golder · Saint Mary's University Since 1802 · Acadia University

WELCOME

Open House at the Windsor Legion on October 10th, 2018

Models of historic, typical and proposed aboiteau structures



Avon River Aboiteau Replacement Design

➡ Project Overview

Goals of the project:

- Provide corridor over the Avon River for twinned Highway 101
- Ensure continuity of rail, trail and utility services
- Protect communities and agricultural land from the effects of sea level rise and climate change
- Achieve all the above safely and cost effectively

Avon River Aboiteau Replacement Design

→ Life of the Aboiteau Project

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Planning, Scientific Investigatons, Measurements	Project Initiation, Funding	Engineering Design	Construction	Testing, Operation, Measurements	Operational Procedure Management Committee	Maintenance	End of Life Planning for Future Steps / New Approach
--- 20+ years ago ---	---- ~1 year ago ----	--------- Now ---------	----- ~4-5 years -----	------- 5 years -------	----------------- 100 years ---------------		

Pre - Design → Options Development → Concept Development → Detailed Design → Tendering and Construction

Pre - Design

Start January 2018

- Gather existing information:
  - Drawing
  - Data reports
  - Literary review
- Topographic surveys
- Geotech study
- Constructability review
- Preliminary dam safety assessment
- Sea level rise study
- Preliminary hydrology and hydraulic models
- Regulatory requirements review
- Analysis of project requirements

Options Development

WE ARE HERE

- Public engagement
- Develop design criteria
- Preliminary geometric design (general arrangement):
  - 3 location options
- Fish passage design
- Structure foundation options.
- Water management scenarios.
- Develop and test hydrotechnical models for options:
  - Water levels/discharge/velocity (storms and tide)
  - Sediment
  - Salinity (salt concentration)
- Mechanical and electrical requirements
- Cost estimates
- Construction schedule review

Concept Development

- Refine and confirm concept selected:
  - Hydrotechnical model refinement/confirmation detailed.
  - Geotechnical investigation
  - Site design refinement
  - Structures design concept
  - Fish passage design concept
- Present concept to stakeholders
- Identify critical design issues
- Refine cost estimate
- Mechanical and electrical
- Building concept
- Constructability review
- Develop Phase 2 design scope and schedule

Detailed Design

- Finalize design criteria
- Finalize operational requirements
- Develop construction drawings:
  - Causeway
  - Aboteau
  - Fishways
  - Bridges
  - Mechanical, Electrical, Instrumentation
  - Buildings
  - Demolition and Staging

Avon River Aboiteau Replacement Design

Stakeholder Comments

We met with various local groups in advance of this open house:

- June, 2017 — Joint Council West Hants- Windsor
- January 16, 2018 — Community Liaison Committee
- January 24, 2018 Commercial, Recreational and Aboriginal Fisheries representatives
- February 15, 2018 — Sipekne'katik First Nation
- May 7, 2018 — MCG and KMKNO First Nation Representatives
- May 30, 2018 — NSE
- June 25, 2018 — Commercial, Recreational and Aboriginal Fisheries representatives
- August 15, 2018 — Farmers
- September 11, 2018 — Windsor and West Hants CAOs
- September 11, 2018 — Ski Martock
- September 11, 2018 — Pisiquid Canoe Club
- September 17, 2018 — DFO, NSE
- September 19, 2018 — Community Liaison Committee
- September 26, 2018 — Sipekne'katik First Nation
- September 27, 2018 — Joint Council West Hants- Windsor
- October 9, 2018 — KMKNO First Nation Representatives

Here are various comments we heard throughout those meetings

- The causeway should be fully reopened for fish, boats and the ecosystem
- The canoe club is at the heart of the community
- Kilometers of fencing will be required if the water turns to brackish
- The lake is an essential part of our community
- Personal interests should not take priority over the long term health of the ecosystem
- Recreation needs to be on the same level as DFO and flood protection
- We want to see fish passage 24/7, 365 days a year
- We need the lake as a potential water supply to help against climate change
- Downtown businesses will be impacted if the lake becomes tidal
- Some people prefer the tidal marsh views more than the lake

Avon River Aboiteau Replacement Design

→ History

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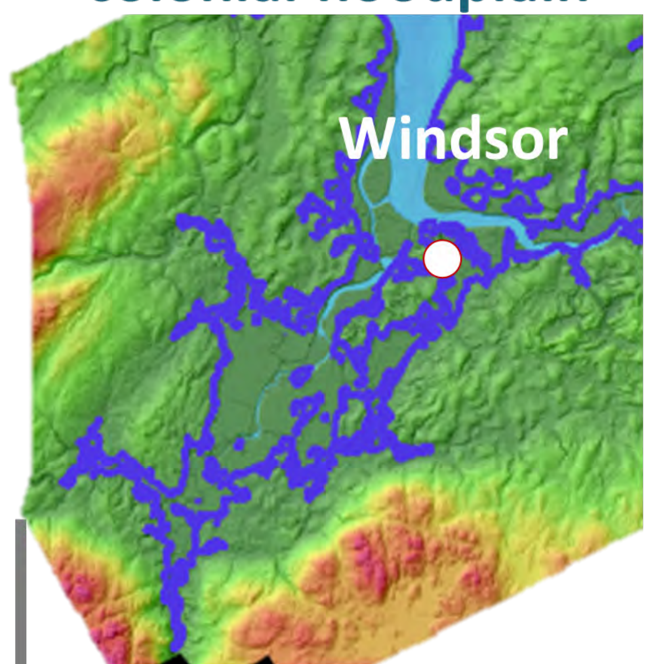
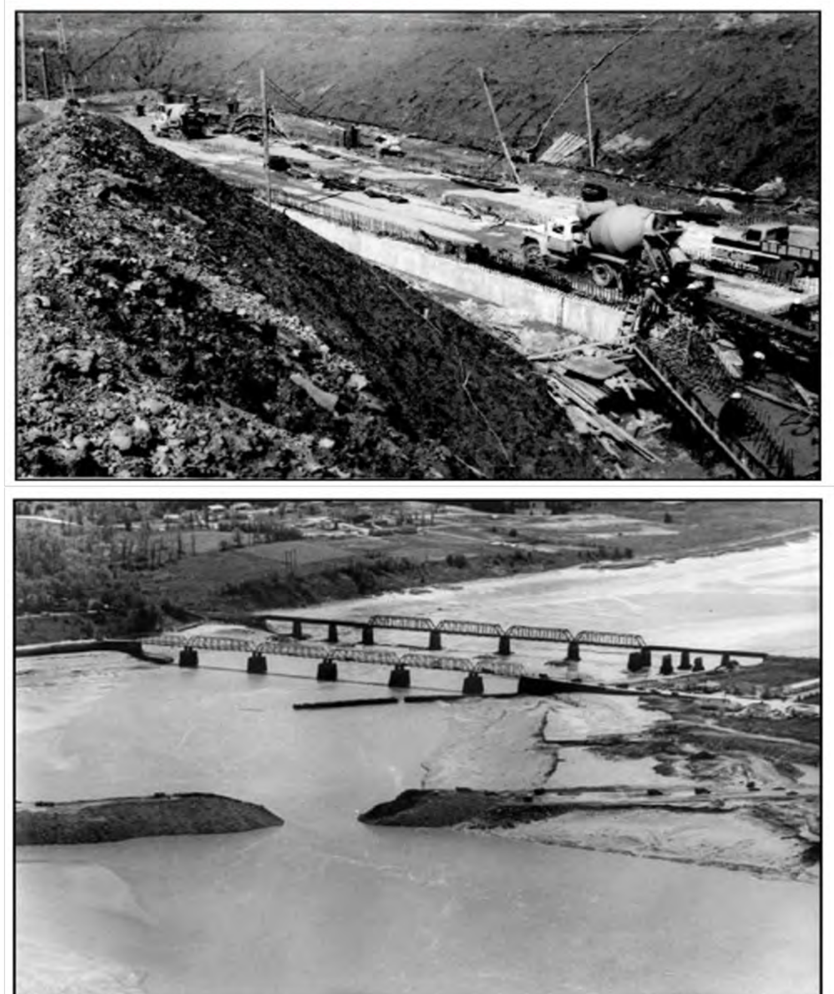
Approximate pre-colonial floodplain

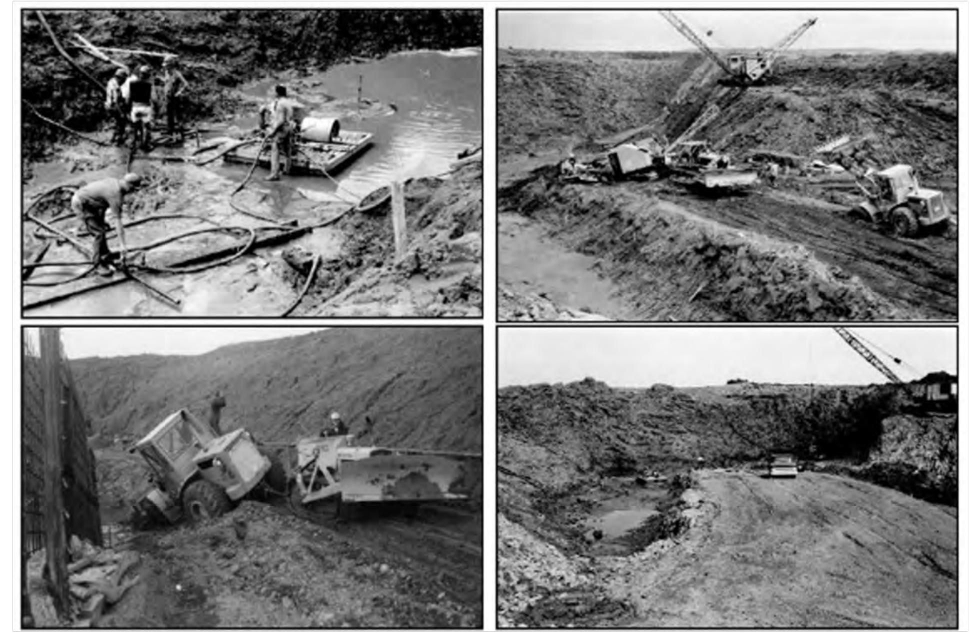


Approximate post-colonial floodplain

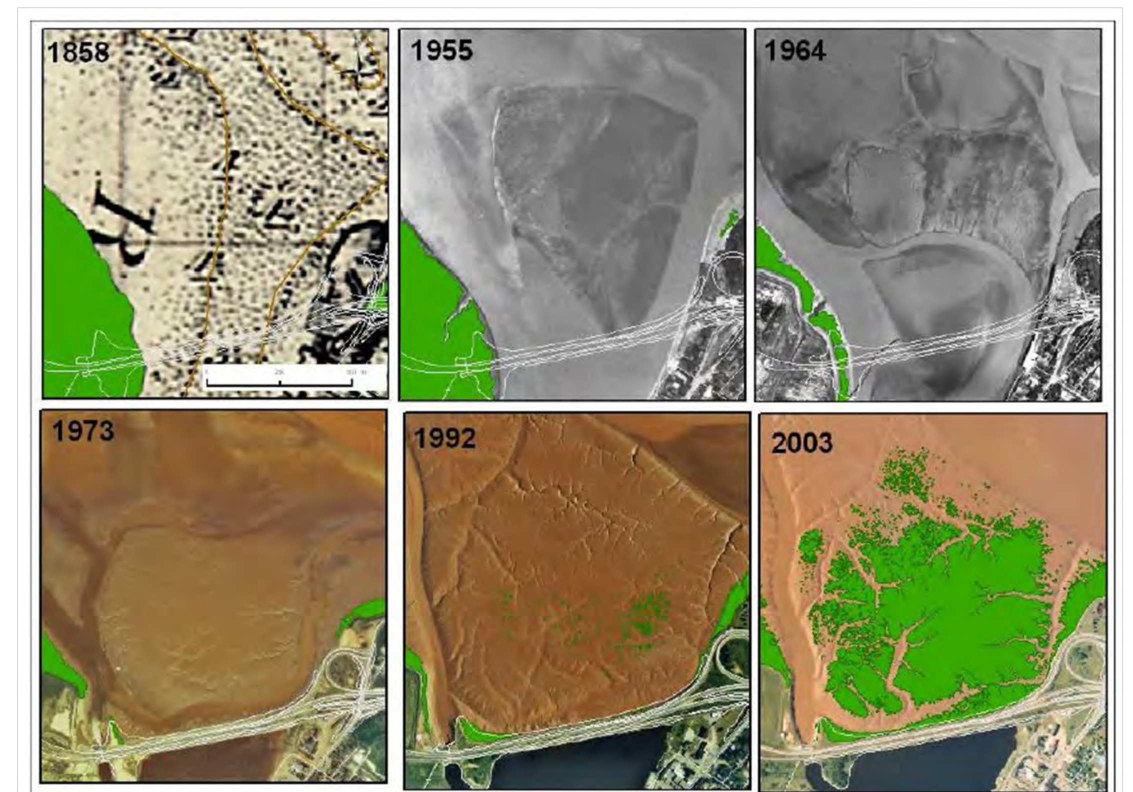
Ship building became prominent along the Avon

Construction of the dike (bottom) and aboiteau (top and right)





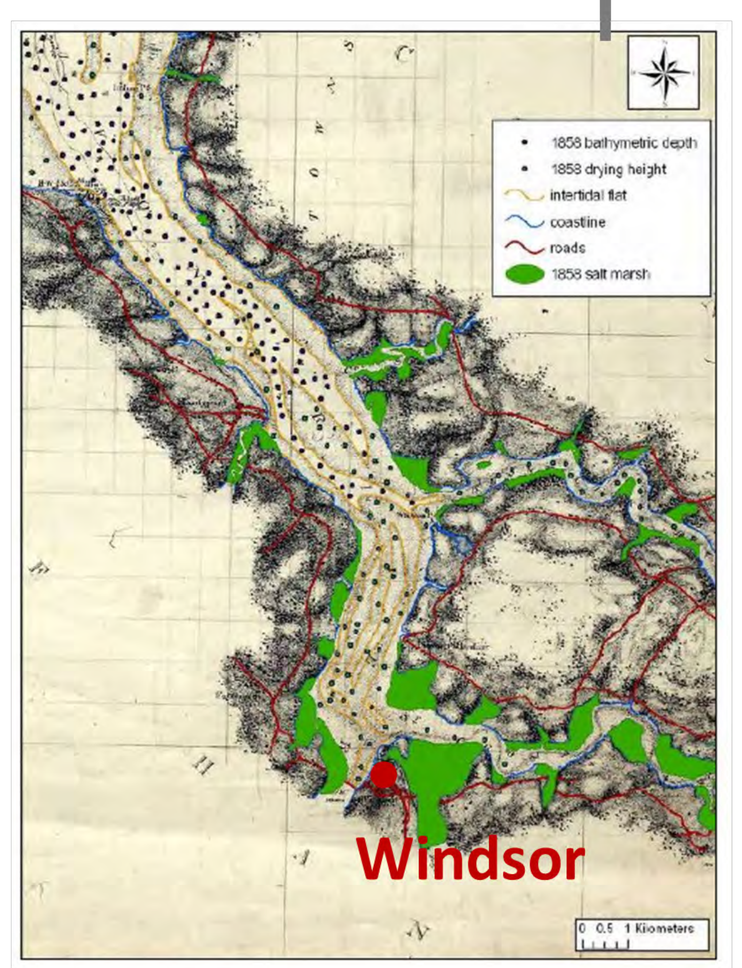
View of causeway in 1971



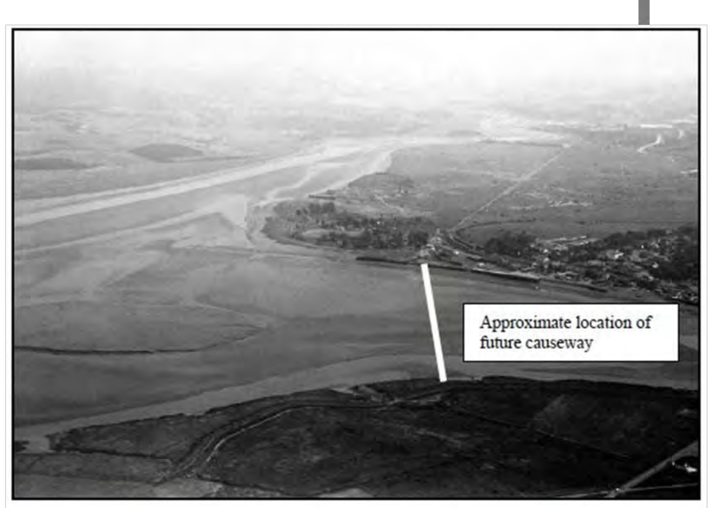
Evolution of the Windsor mudflat showing increase in vegetation

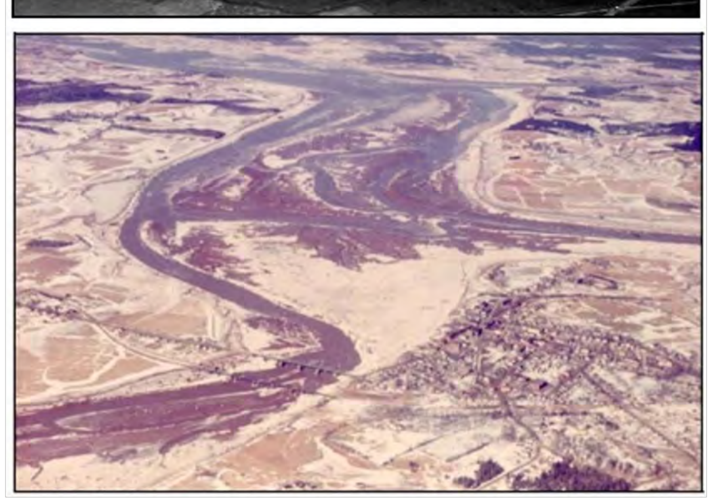
Current gate management:
- Goal of maintaining water level at target of 2.7m (9ft)
- DFO has required that levels be drawn down in Spring to improve fish passage
- levels are drawn down each time a heavy rainfall is forecast to reduce flooding risks
- DFO has put pressure on Department of Agriculture to lower water levels in the fall as well

Pre-Colonial · 1840 - 1890 · 1858 · 1963 · 1969 · 1970 · 1971 · 2002 · 2003 · 2010



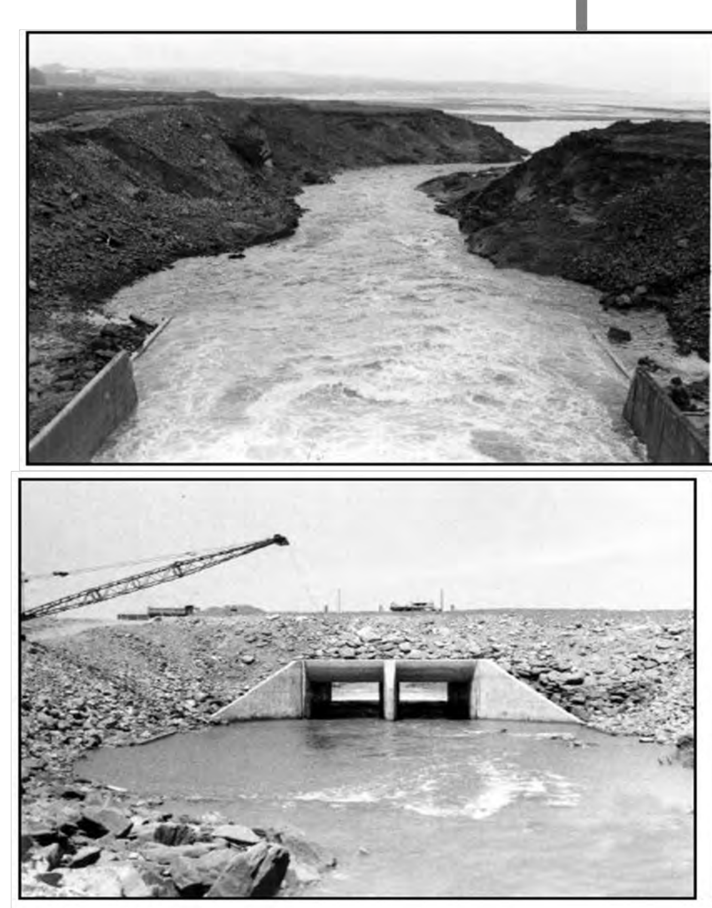
1858 salt marshes





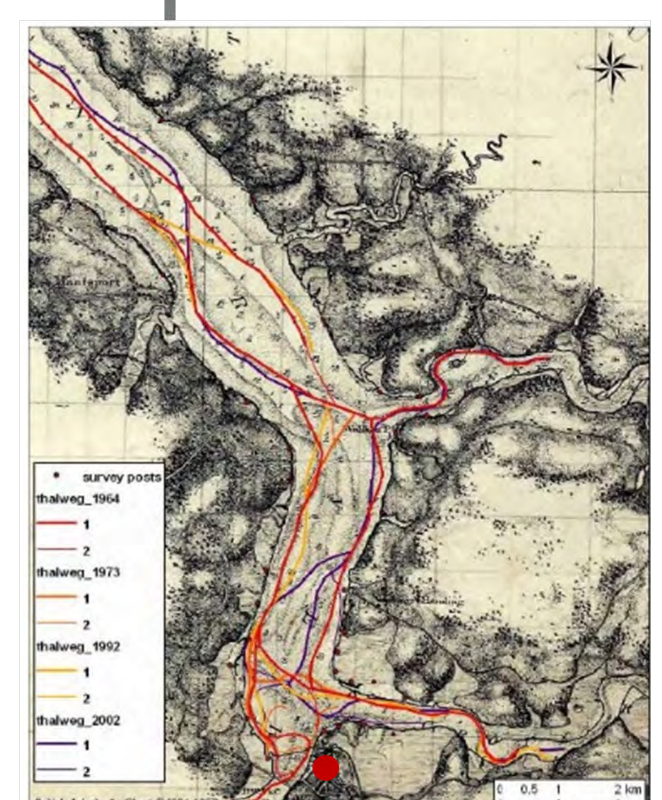
Natural conditions showing the natural bar that forms where the causeway was built

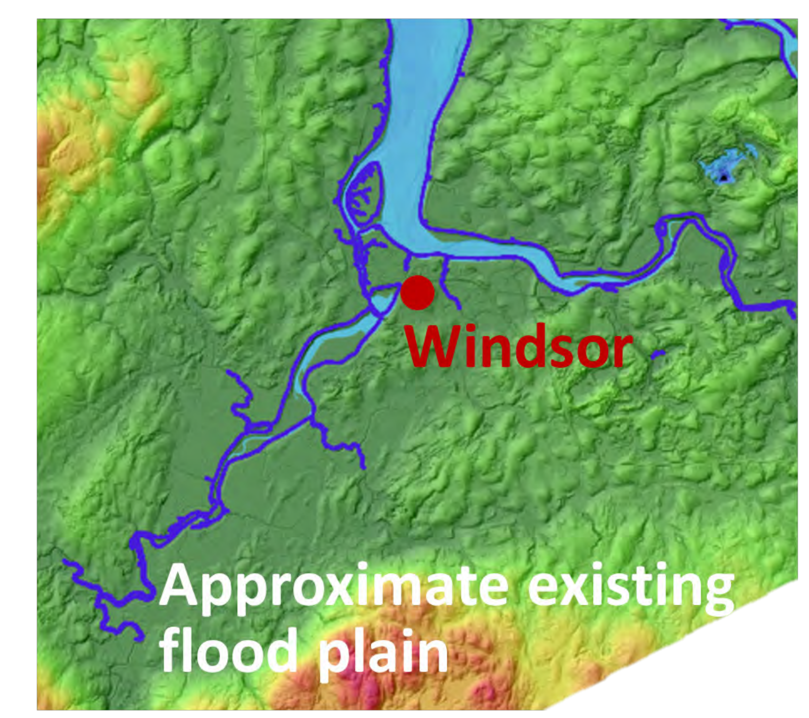
Construction of the aboiteau

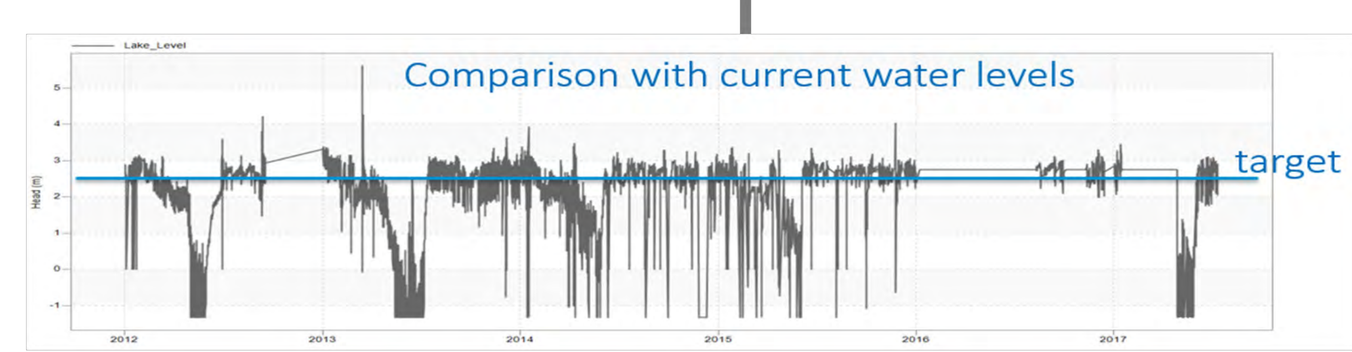


Current view from aboiteau

Changes in river thalweg over time







Measured historical lake levels: water levels are drawn down regularly for maintenance of the structure

Avon River Aboiteau Replacement Design

➡ Conductivity Measurements in Existing Lake Pesaquid

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1

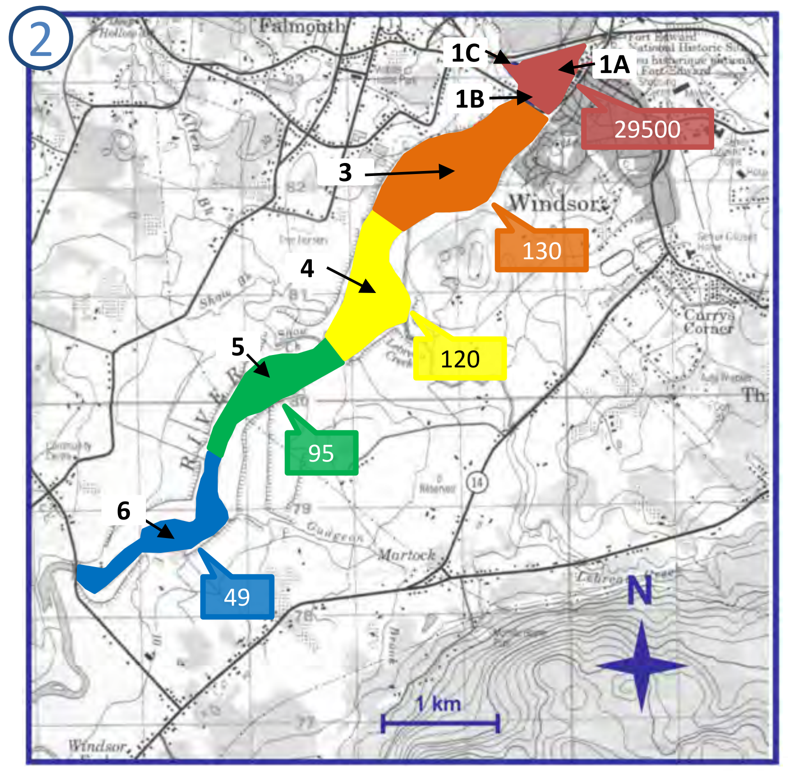
This poster reports on conductivity measurements obtained in Lake Pesaquid. Conductivity is a measure of water's capability to pass electrical flow (as a result of conductive ions from dissolved salts and inorganic materials). Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related. Conductivity is also affected by temperature (see table at right).

Conductivity is reported here in millisiemens.
1 millisiemens [mS] = 1000 microsiemens [µS]

Temperature				Salinity
15°C	20°C	25°C	30°C	ppt
1.700	2.000	2.200	2.400	1
3.300	3.700	4.100	4.500	2
4.700	5.300	5.900	6.500	3
6.100	6.900	7.600	8.400	4
7.500	8.400	9.300	10.300	5
8.800	9.900	11.000	12.100	6
10.100	11.300	12.600	13.900	7
11.400	12.800	14.200	15.700	8
12.700	14.200	15.800	17.400	9
13.900	15.600	17.300	19.100	10
15.200	17.000	18.900	20.800	11
16.500	18.900	20.400	22.500	12
17.600	19.700	21.900	24.100	13
18.700	21.100	23.400	25.800	14
20.100	22.400	24.900	27.400	15
21.200	23.800	26.400	29.100	16
22.400	25.100	27.800	30.700	17
23.600	26.400	29.300	32.300	18
24.800	27.700	30.700	33.900	19
25.900	29.000	32.200	35.500	20
27.100	30.300	33.600	37.000	21
28.300	31.600	35.000	38.600	22
29.400	32.900	36.500	40.100	23

Data derived from the equation of P.K. Weyl, Limnology and Oceanography; 9,75 (1964).

2

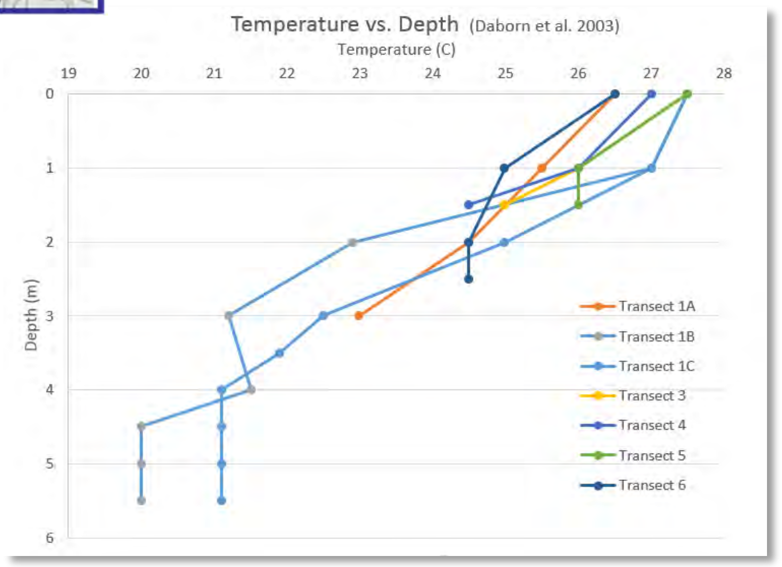


2

Daborn et. al. (2003) measured conductivity in Lake Pesaquid as part of the "Ecological Studies of the Windsor Causeway and Pesaquid Lake". The measurement locations are shown at left (black numbering). Measurements were obtained in mid-August.

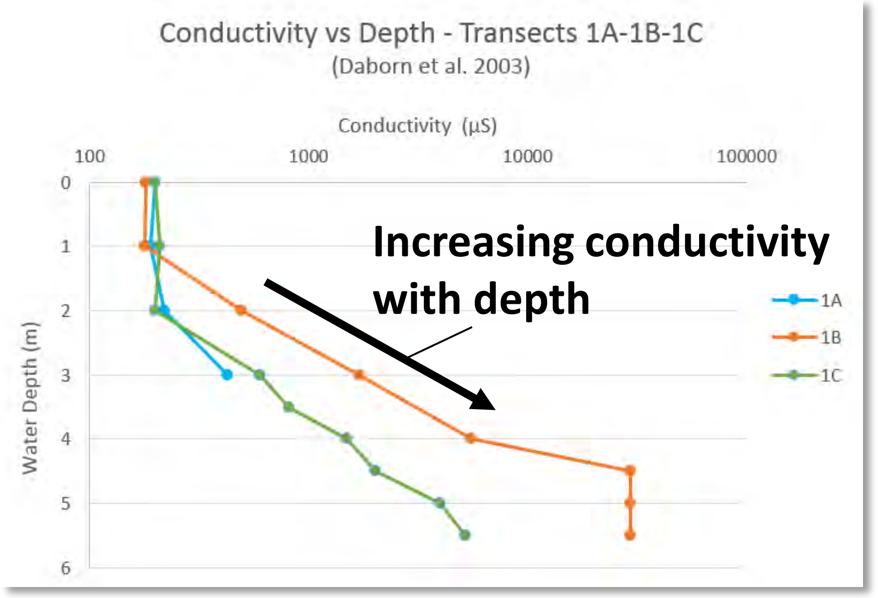
3

Since conductivity is affected by temperature, temperature measurements from Daborn et al. (2003) are provided as a reference (at right).



4

Daborn et al. (2003) found that transects located between the highway 2 bridge and the causeway (Transects 1A, 1B, and 1C) had the highest conductivities, with values up to 29500 µS. It was found that these conductivities increased with depth.



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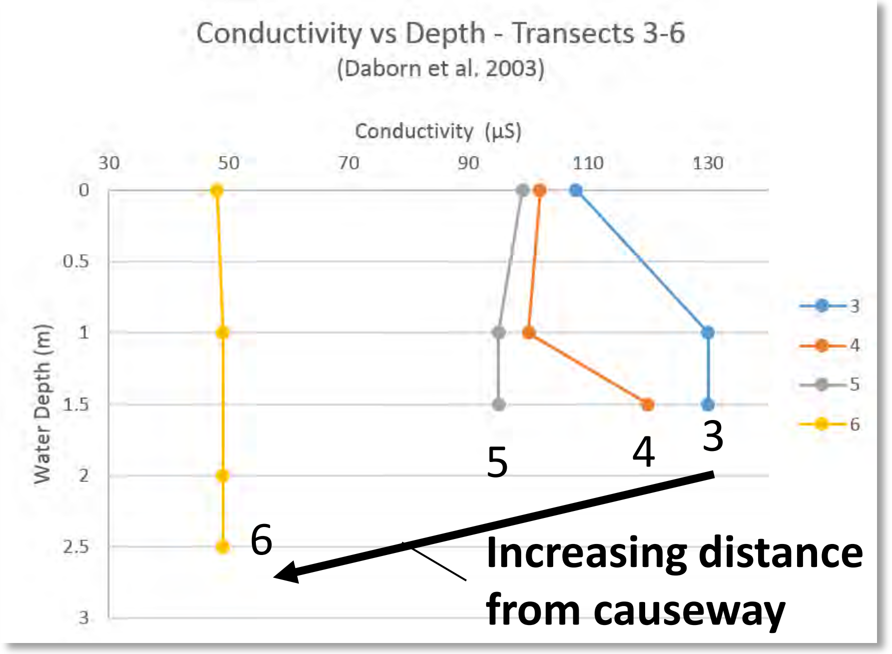
Conductivities further upstream were much lower (< 150 µS). These conductivities further decreased with increasing distance from the causeway. The same trend is shown with the colouring in Figure 2, where the coloured boxes depict maximum conductivities measured.

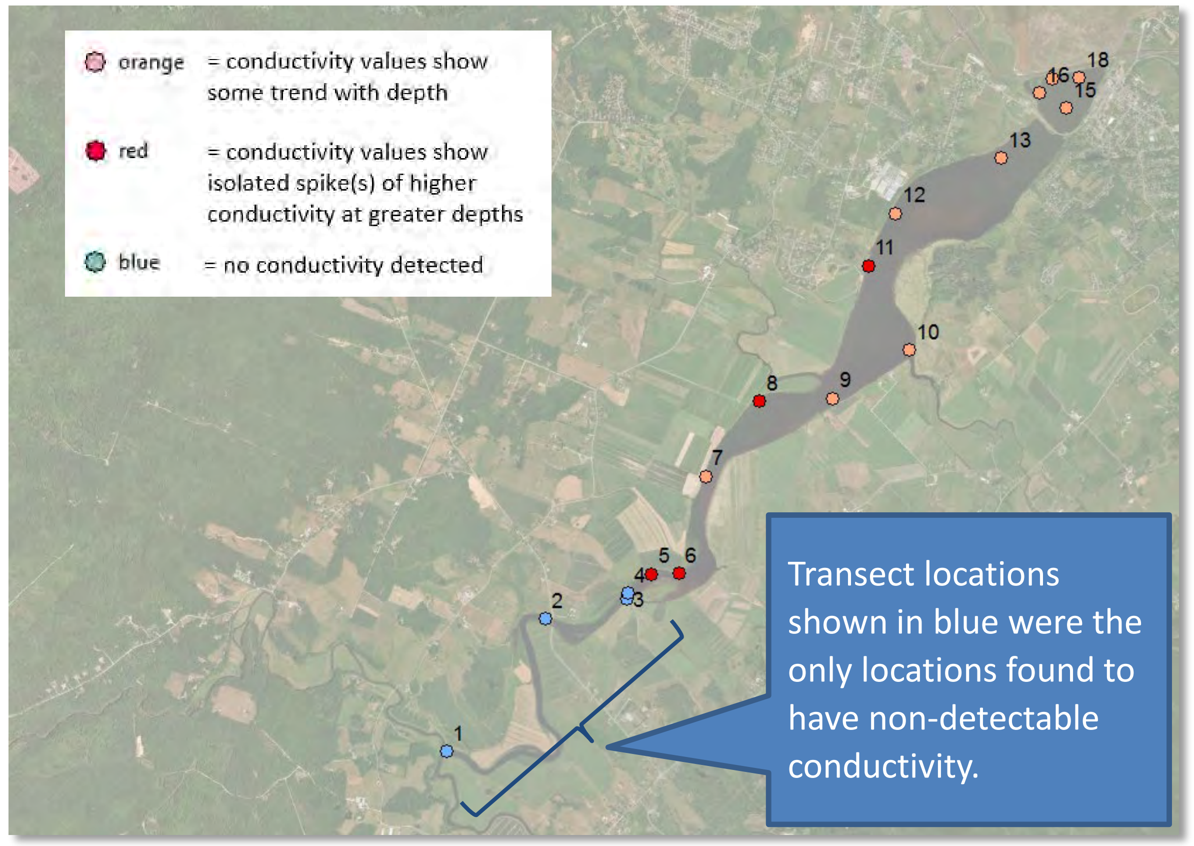


6

From these measurements, Daborn et al. (2003) concluded that the lake was "a stratified impoundment, with a saline layer underlying the top 2-3 m".

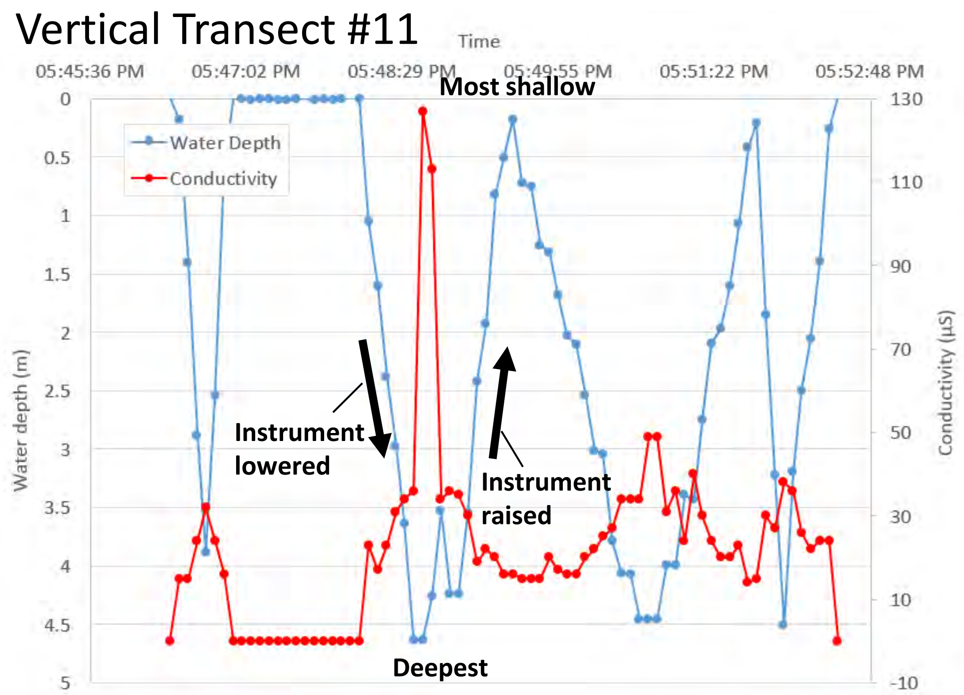
7

As part of this project, CBCL also measured conductivity with depth (measurement locations shown below). Despite high measurement variability, half of the transects showed a pattern of higher conductivities at higher depths.



8

Some locations were found to have higher conductivities at depth. Measurements from Vertical Transect #11 are shown as an example. The figure shows the variation of water level (blue) and conductivity (red) over time. The instrument was lowered into the water four times, which is why both parameters increase and decrease four times.



Avon River Aboiteau Replacement Design

➡ Existing Ecosystem

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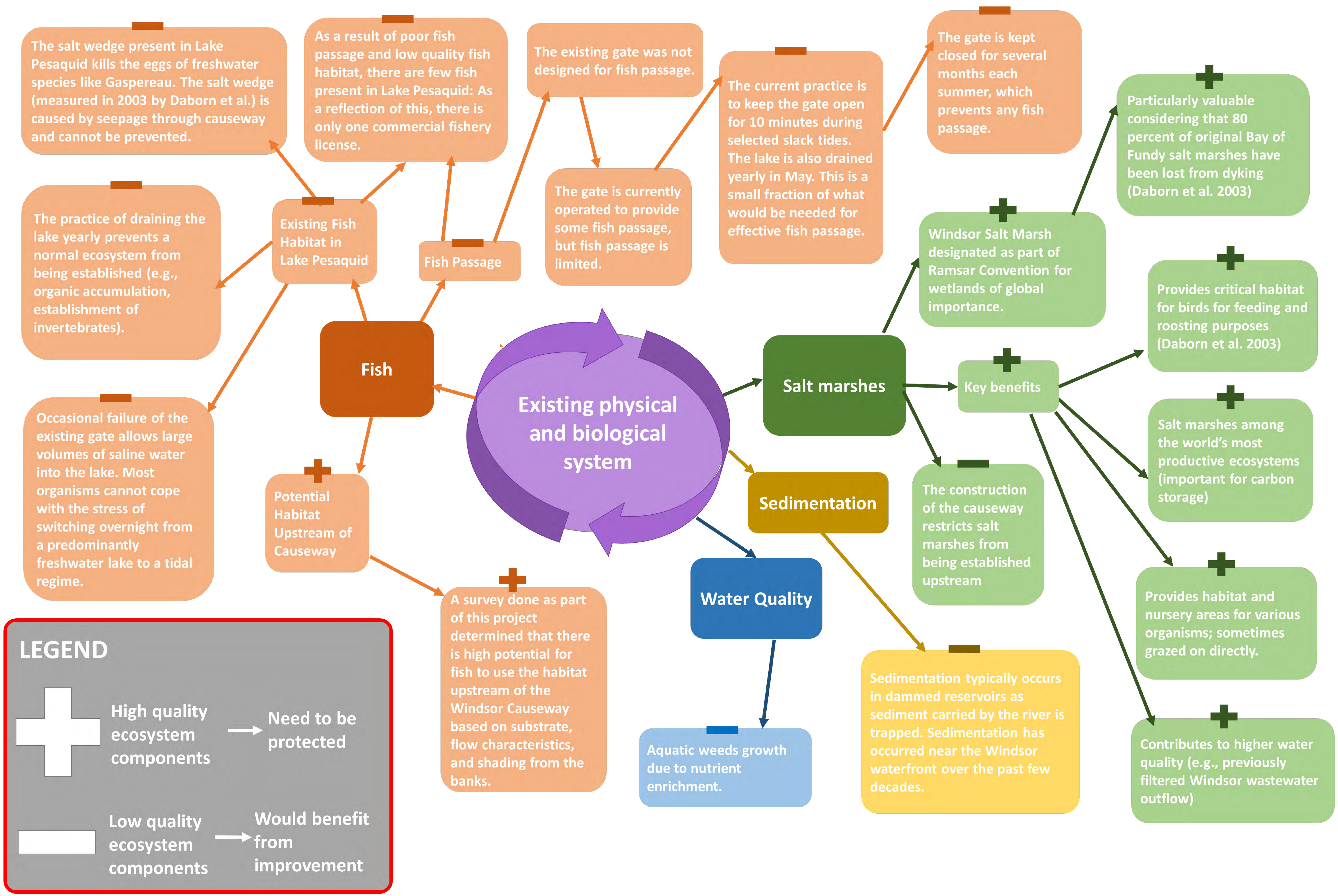

Avon River Aboiteau Replacement Design

➡ Avon River Fish Species

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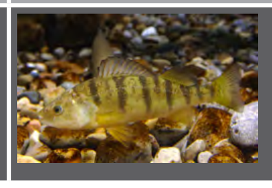
Common Name		Habitat
Alewife / Blueback Herring		• Habitat is good up in north branch, south branch blocked by NSP; • Pisiquid Lake would be habitat if it were pure fresh water and not drained during spawning season.
American Eel		• Avon habitat is good
American Shad		• Spawns in slow moving freshwater lower reaches of the north branch
Atlantic Salmon		• Avon has some spawning habitat observed on north branch and south branch habitat needs restoration
Atlantic Silverside		• Spawn in brackish water
Atlantic Sturgeon		• Potential to use the Avon River for feeding runs
Atlantic Tomcod		• Spawn just above head of tide in Avon River in late January into February
Banded Killifish		• Mainly freshwater
Brook Trout		• Avon River has good habitat
Dogfish Shark		• Feeding runs
Fourspine /Ninespine/ Threespine Stickleback		• Spawns in Avon River
Lake Chub		• Avon River has suitable habitat.
Northern Redbelly Dace		• Avon River has suitable habitat
Rainbow Smelt		• Anadromous Avon habitat early spring run

Common Name		Habitat
Smallmouth Bass		• Avon River has suitable habitat
Striped Bass (Bay of Fundy Pop.)		• Feeding runs to Avon River
Winter and Smooth Flounder		• Feeding and overwintering opportunities
White Perch		• Avon River offers possible habitat
White Sucker		• Avon River offers possible habitat
Yellow Perch		• Avon River offers possible habitat

Avon River North Branch

Spawning/Breeding	Good
Rearing/Nursery/Juvenile	Good
Overwintering	Moderate
Migration	Good
Foraging/Feeding	Good

Avon River South Branch

Spawning/Breeding	Moderate
Rearing/Nursery/Juvenile	Moderate
Overwintering	Moderate
Migration	Good
Foraging/Feeding	Good

Avon River Aboiteau Replacement Design

Fish Passage

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The species, age classes, size, body shape, group behaviour and level of fatigue of fish may affect their swimming behaviour and requirements during migration. Fish typically have requirements relating to the following non-exhaustive list of physical river flow characteristics:

Criteria	Fish migration requirements
Velocity	• Velocities will typically be in the range of 1.5 to 2 body lengths per second. • Many fish need covered areas of slower flows (less than 0.5 m/sec) where they can rest. • Some fish are limited by their burst speeds (e.g., salmon and trout) whereas other fish are limited by their sustained swimming speeds (e.g., smelt and shad).
Depth, cover, and timing	• The minimum water depth is typically 1/3 of the body length. • Depth requirements are related to needs for suitable cover with (e.g., turbid water shielding fish from birds). Pelagic fish will typically swim with their dorsal fin at one secchi disc depth. Benthic fish will choose to swim on the bottom (e.g., adult eels). • Requirements for cover (and thus depth) also vary with the time of day (e.g., salmon prefer to migrate at dawn and dusk).
Flow patterns	• The shape of the fish will affect the pattern of flow that it requires. • For example, a laterally compressed fish (e.g., alewife, shad) cannot handle turbulent flows from the side.
Passage width	• Group behaviour also affects requirements for passage characteristics. • Schooling fish typically require larger passageways in order to move upstream successfully. Different species can tolerate different levels of crowding, but all species reach a point where crowding limits migration.
Height	• Some fish are capable of jumping while others are not.

Notes

- This variation in fish preferences results in trade-offs for a given structure's ability to be favourable for different types of fish (species, age, etc.).
- Although there are a wide range of species that need to pass the Avon River Aboiteau, most of them have not been the subject of fish passage design or studies. Hence, assumptions will need to be made as to their swimming ability, based on characteristics such as body shape, size, and behaviour.
- Therefore, an understanding of the fish behaviours described above is required for the successful design of fish passage.

Fish Habitat Potential Assessment

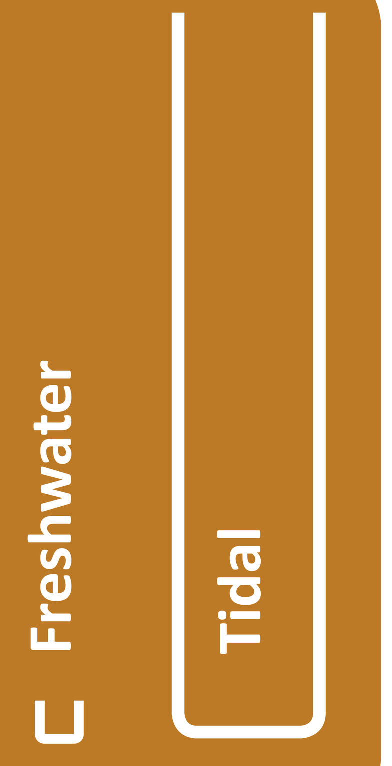
Fish Species	Lake Option		Tidal Option		Option that provides the Greatest Potential Increase in Population	
Fish Species	Fish Habitat Potential: Lake	Fish Passage Percentage:	Fish Habitat Potential: Tidal	Fish Passage Percentage:	Lake	Tidal
Gaspereau/ Bluebacks	Low	Low	High (1,200,000	High		●
Atlantic Salmon	Low	Low-Moderate	Moderate	High		●
Sea Run Brook Trout	Low-Moderate	Low-Moderate	High	High		●
American Eel	Low-Moderate	Low-Moderate	High	High		●

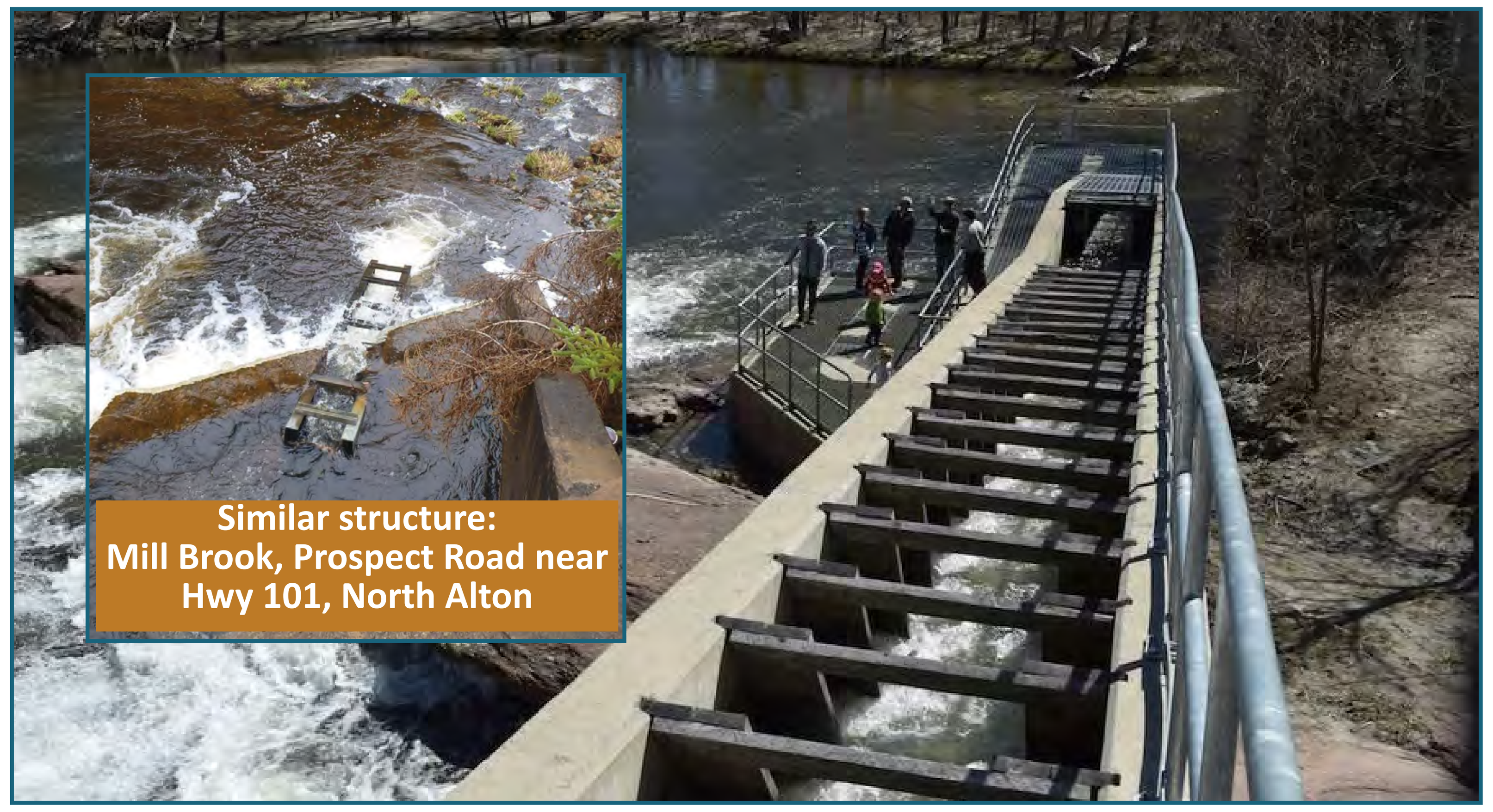
Tidal Fishway Characteristics

- Denil Fishway (16m high, 1.8m wide, with baffles);
- Permanent opening below the gates will be 6m wide x 1.5m high (creates pressure differences, not great for fish passage under every stage ofthe tide).

Freshwater Fishway Characteristics

- Denil Fishway with vertical baffles;
- 300mm wide and 400mm high;
- Fishway would have water in it when the lake level would be higher than 2.7m.





Similar structure:
Mill Brook, Prospect Road near Hwy 101, North Alton

Spawning Times of Avon River Fish Species

Fish Species	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct	Nov.	Dec.
Alewife					■	■						
Atlantic Salmon										■	■	■
American Eel					■			■	■			
American Shad				■	■	■						
Atlantic Tomcod	■	■										
Brook Trout									■	■	■	
Rainbow Smelt			■	■								
Fourspine Stickleback					■	■	■					
Threespine Stickleback						■	■					
White Perch					■	■						

Avon River Aboiteau Replacement Design

➡ Inspection Report

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- 49 years old
- Inspected every 1-2 years
- Difficult and costly to dewater
- Last inspection June 2018

Main Gates

- Mechanical components on life support
- Manually operated for the tides and fish passage
- Gate malfunction is continuous concern


Main Gates


Main Gates

Aboiteau Barrel

- Good condition considering age
- Some typical cracks, minimal reinforcing exposed
- No signs of movement in overall structure
- Floor inspection limited by dewatering constraints

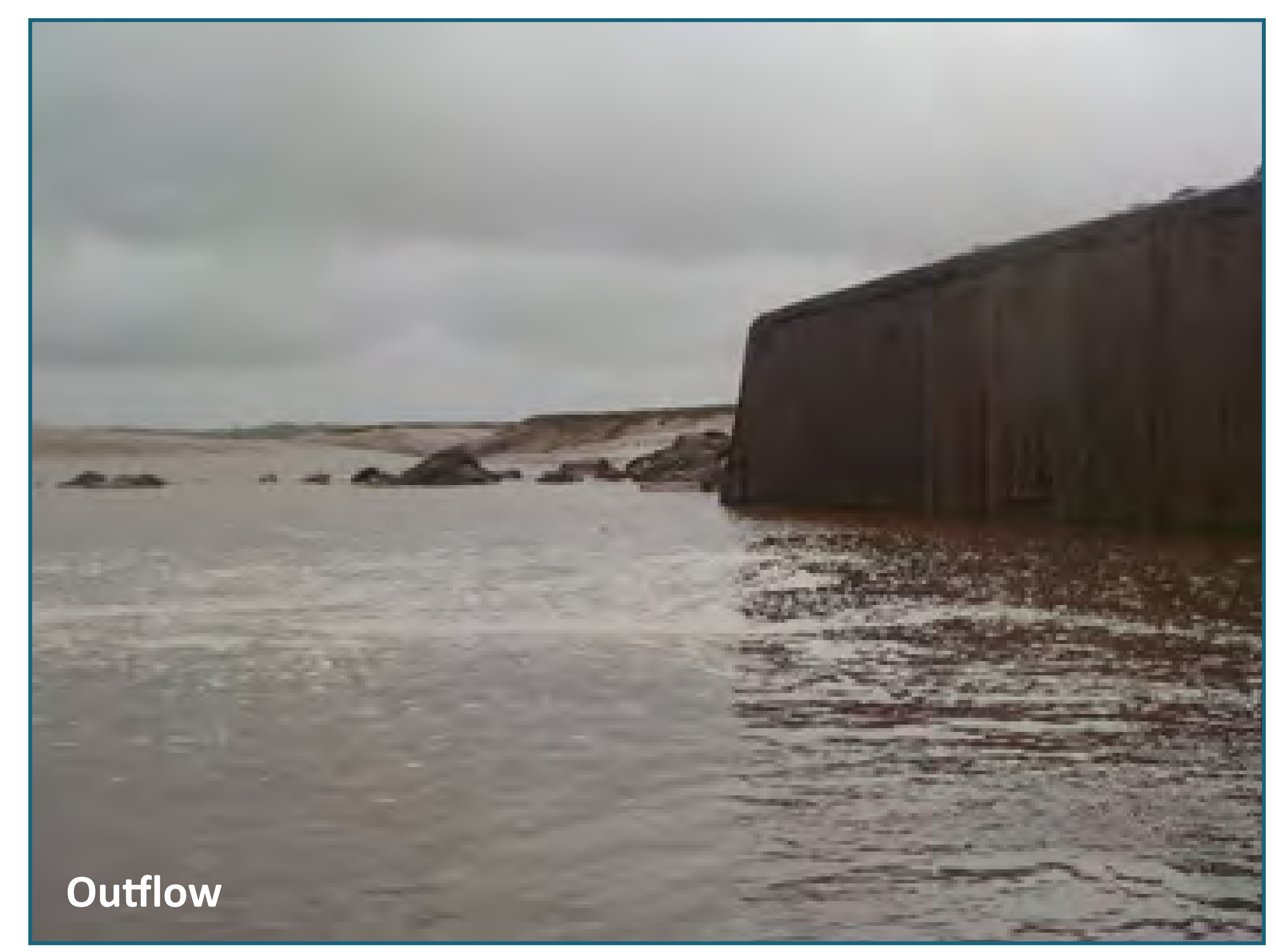

Aboiteau Barrel


Aboiteau Barrel

Outflow (Downstream)

- Visible portions in poor condition / collapsing wingwall
- Estimated remaining life substantially less than barrel
- Voids detected by sonar D/S of apron
- Condition of apron (under water) is unknown, but assumed to be poor


Outflow


Outflow

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Location Analysis

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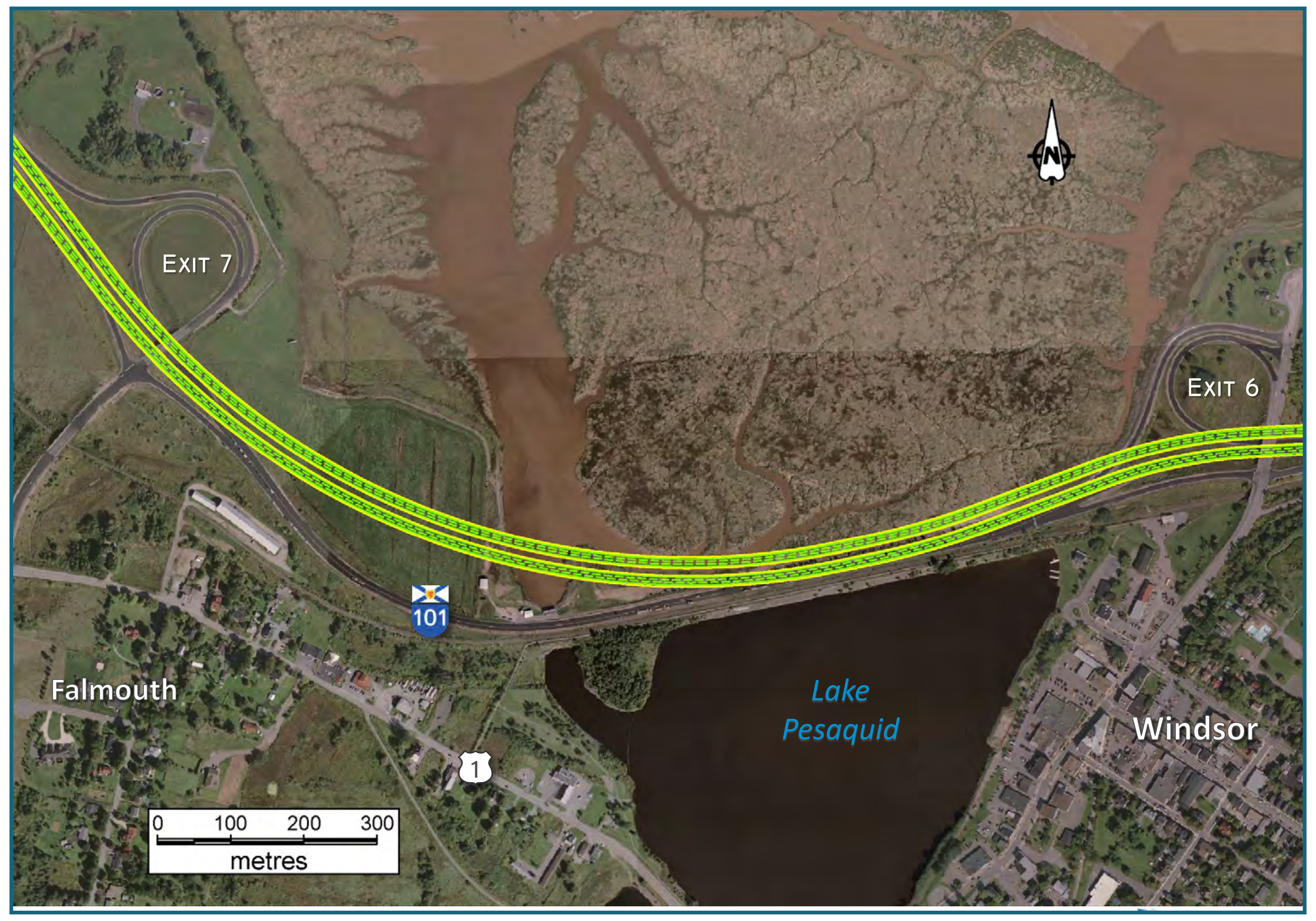
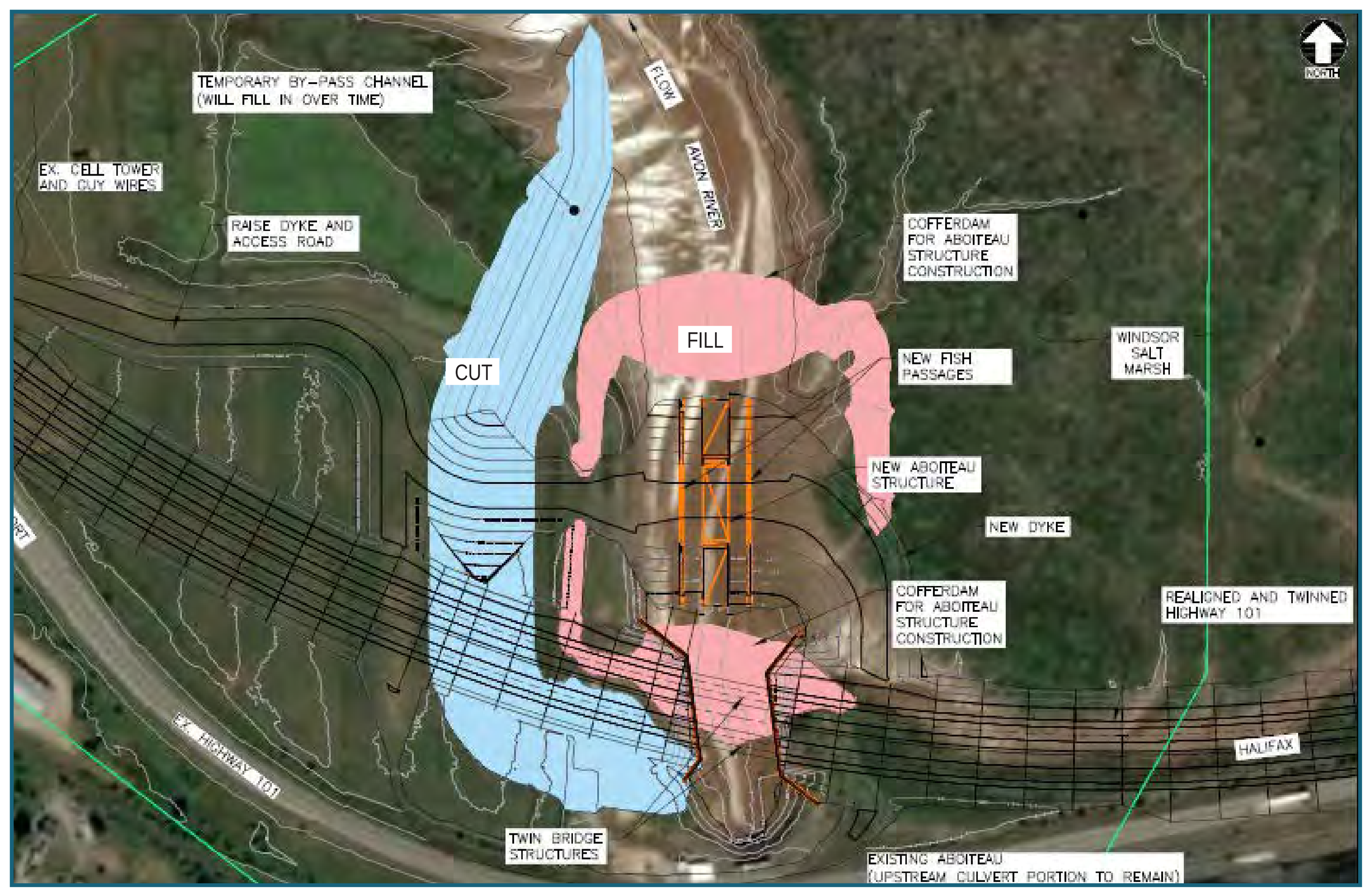
Proposed Highway Alignment



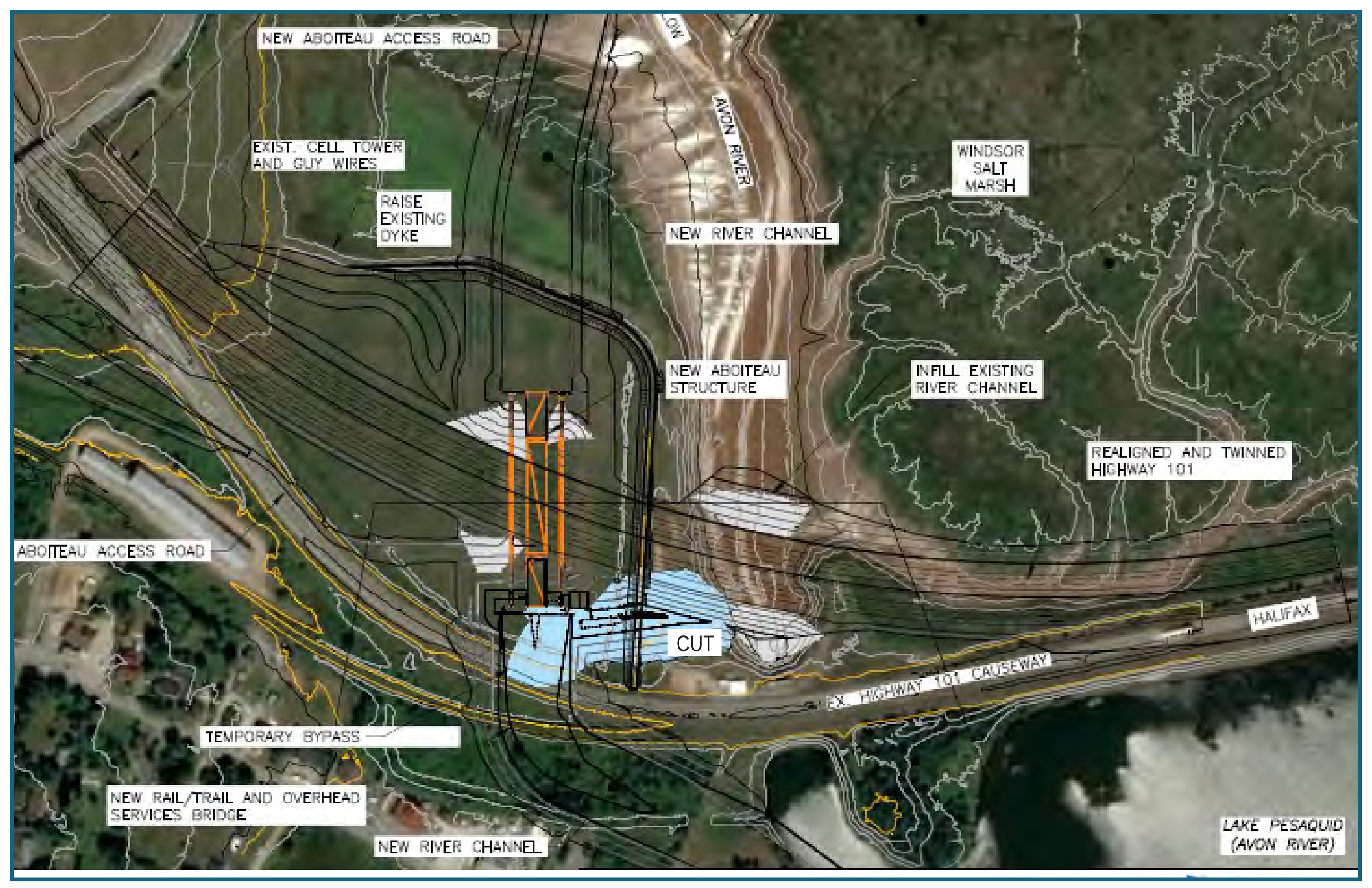
Aboiteau Option 1

Location analysis compares options against one another. Pros and cons are weighed before proceeding with best possible option.

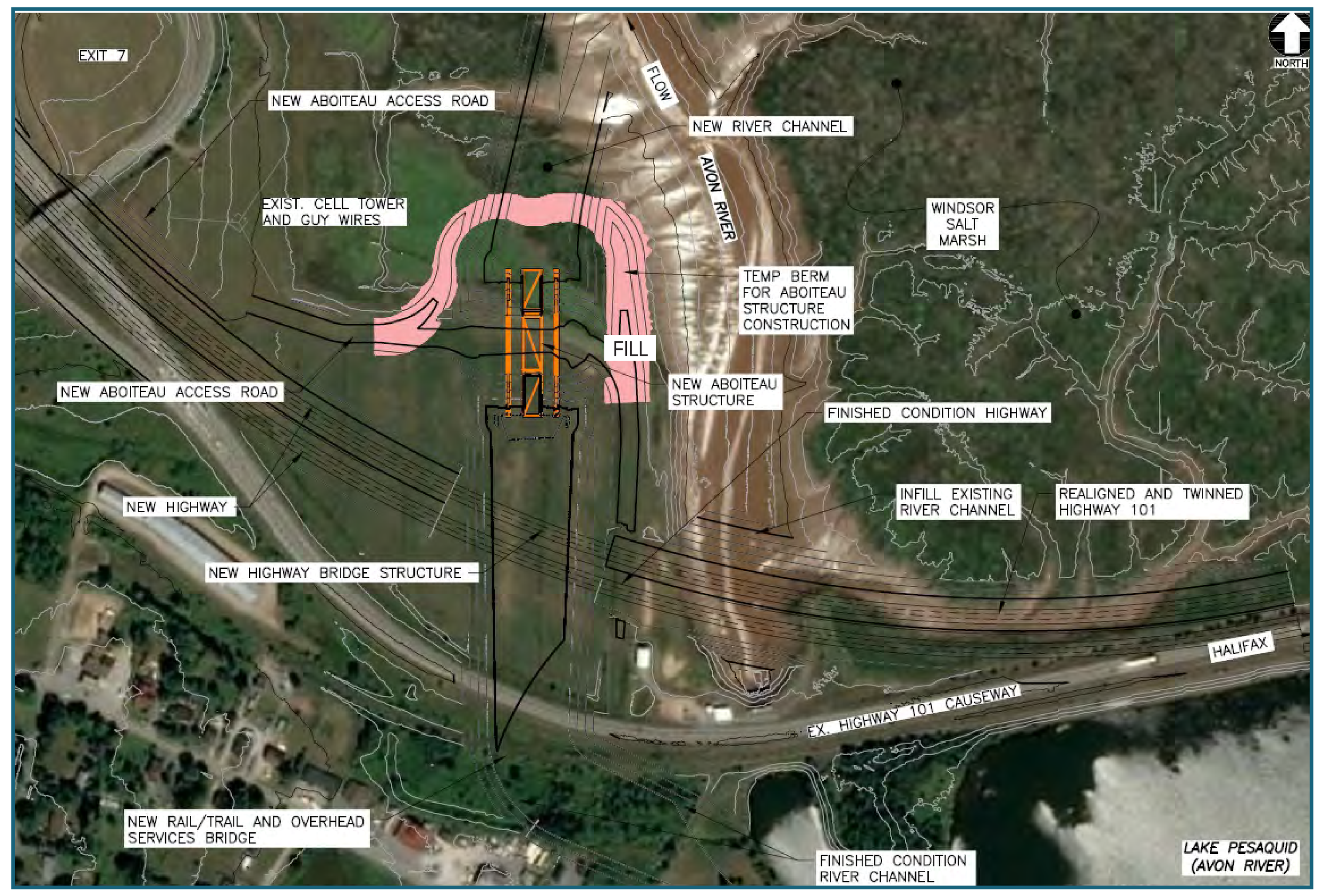
Aboiteau Option 1



Aboiteau Option 2



Aboiteau Option 2a



Aboiteau Option 1
New Aboiteau in Existing Channel
Downstream of Highway
Avoids need for new channel to South
Uses existing structure for rail and trail
Better alignment for temporary diversion
Minimal anticipated impact to salt marsh
Lowest cost

Aboiteau Option 2
New aboiteau in new channel
Aboiteau under Highway (longer/bigger)
Requires new channel to South, impacts park
New bridges for rail and trail
Poor alignment for temporary diversion
Unknown impact to salt marsh
Higher cost

Aboiteau Option 2a
New aboiteau in new channel
Aboiteau downstream of highway
Requires new channel to South, impacts park
New bridges for highway, rail and trail
Poor alignment for temporary diversion
Unknown impact to salt marsh
Highest cost

Avon River Aboiteau Replacement Design

➡ Model set-up and calibration (Part 1)

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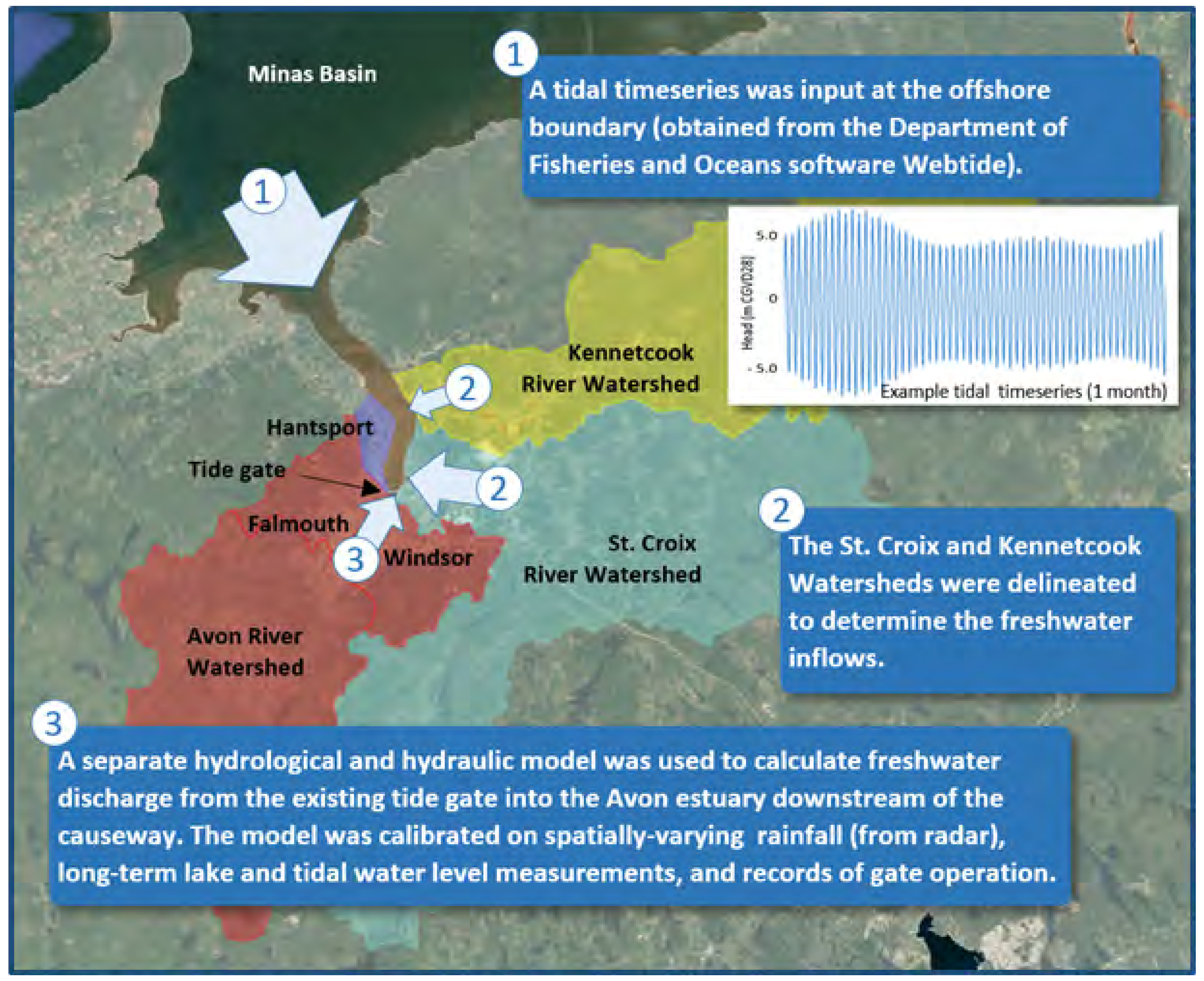
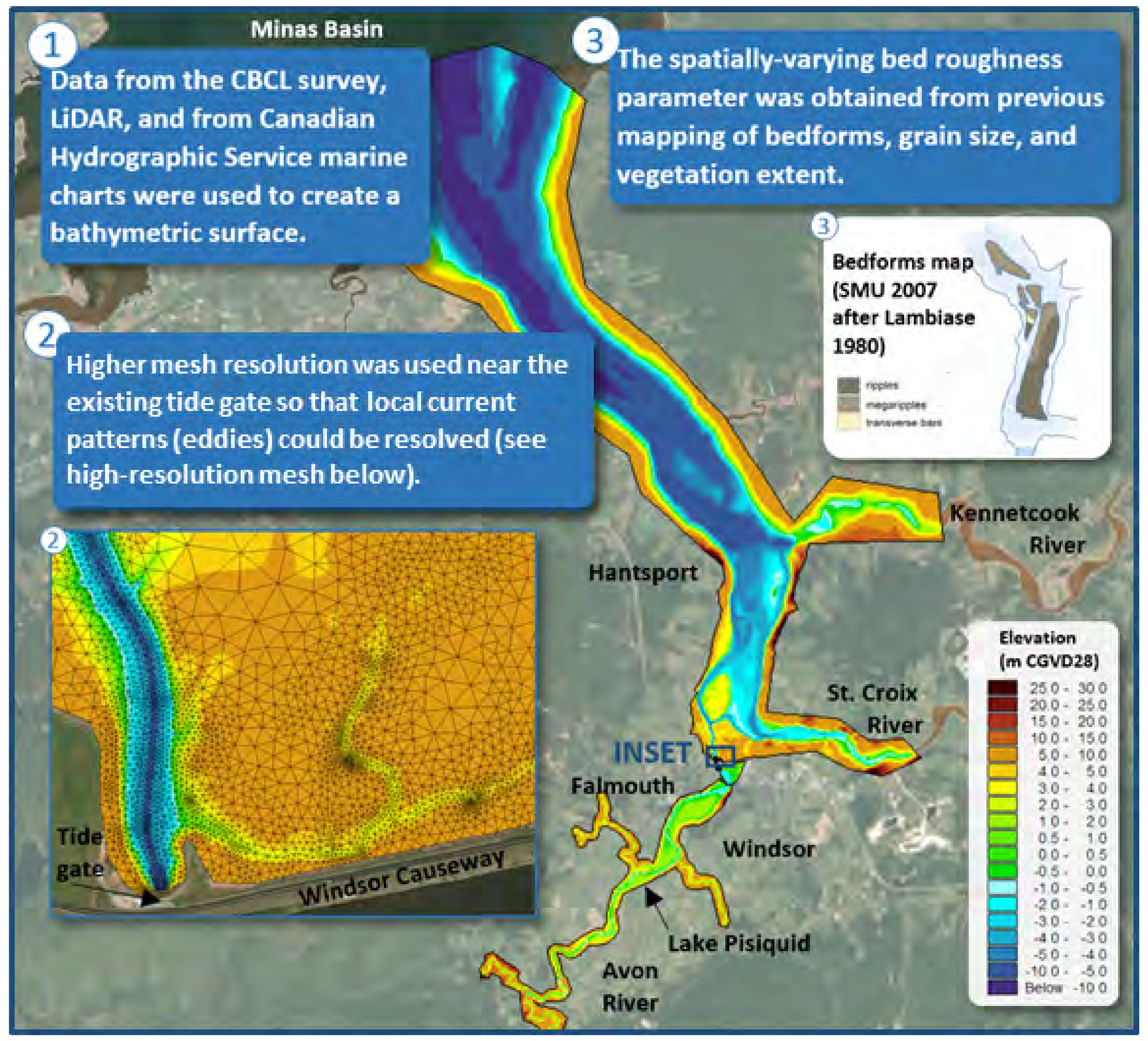
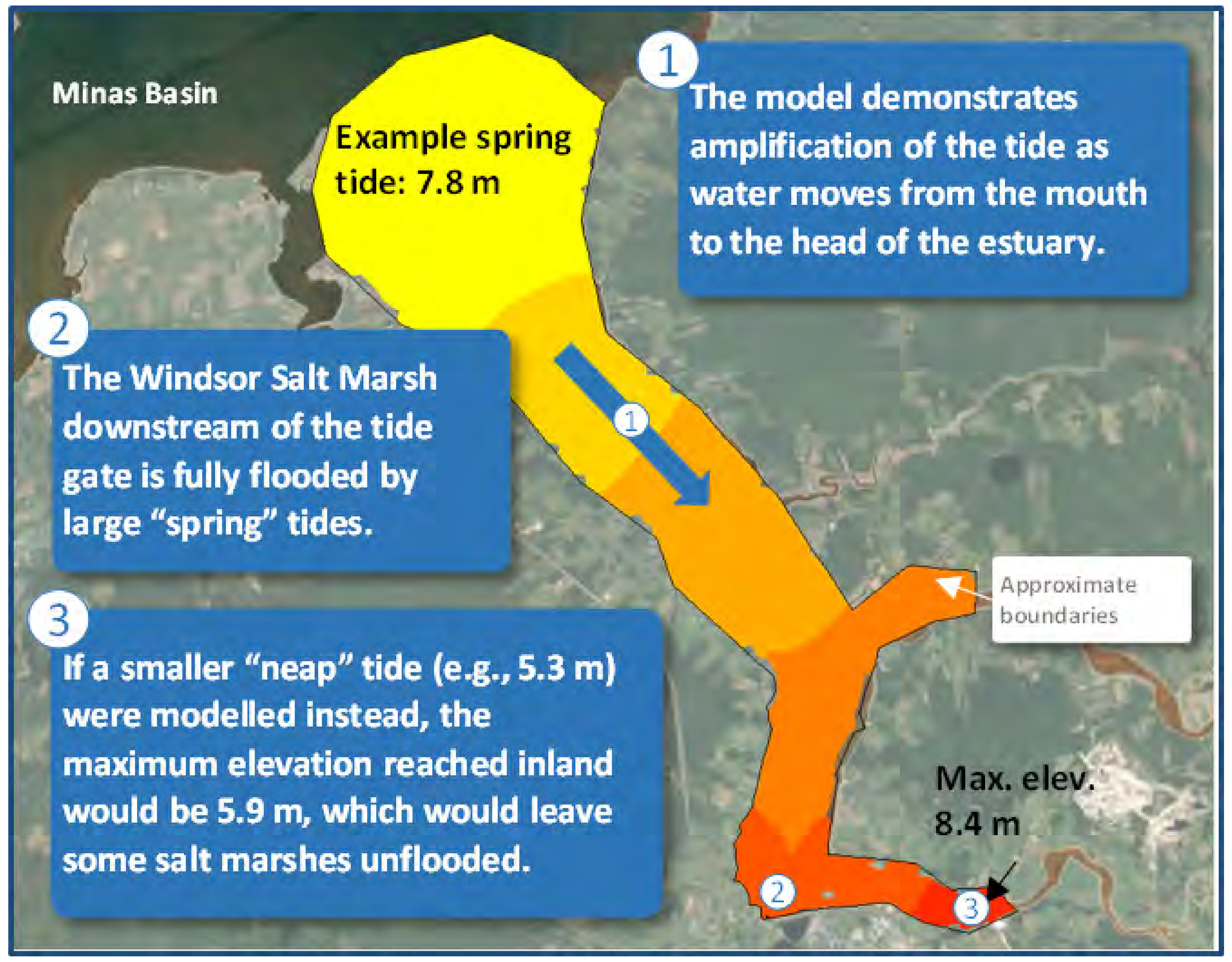
Drivers of water movement: Tides and Rivers.



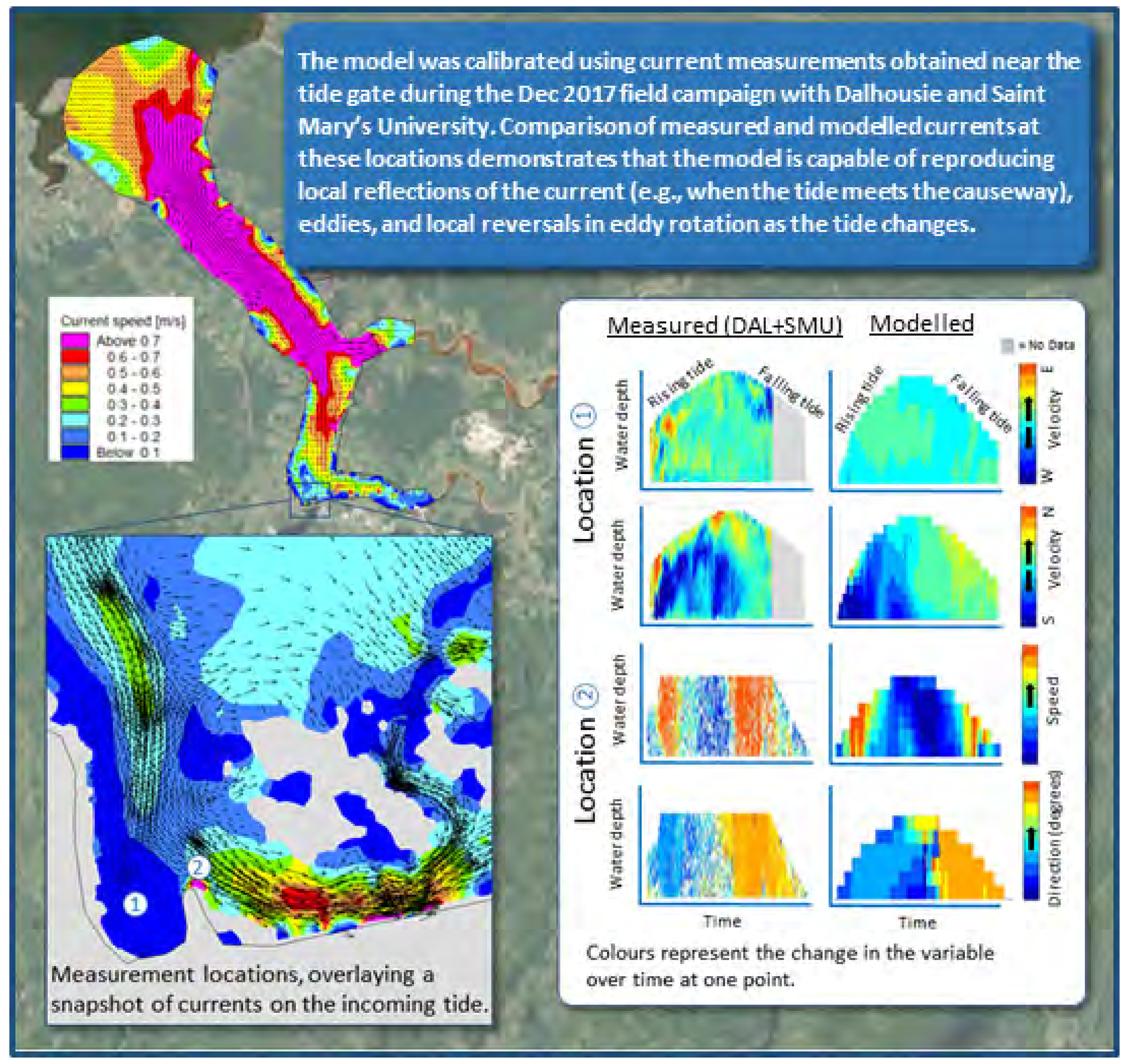
Bathymetry and resistance to flow.



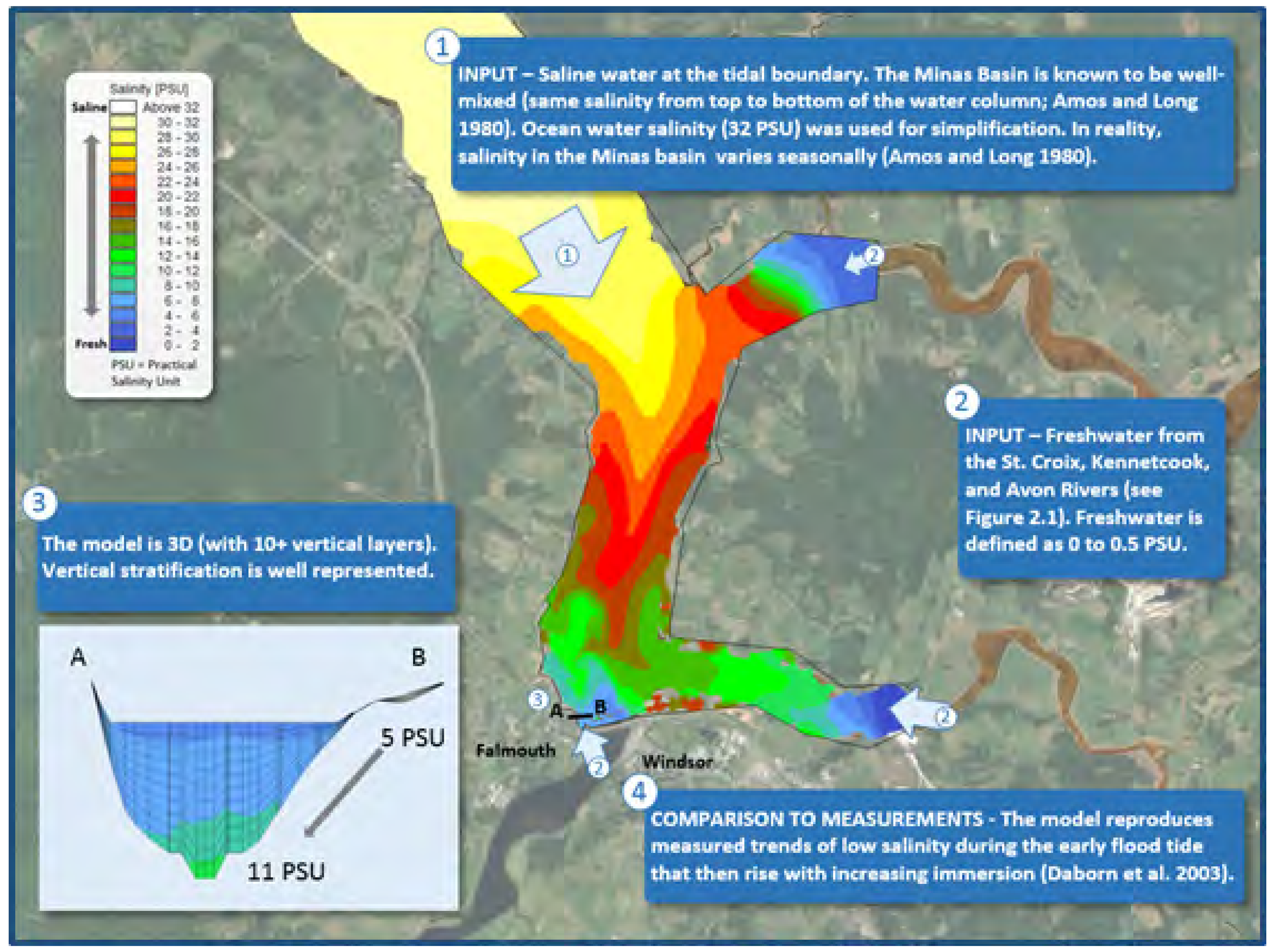
Water Level Processes



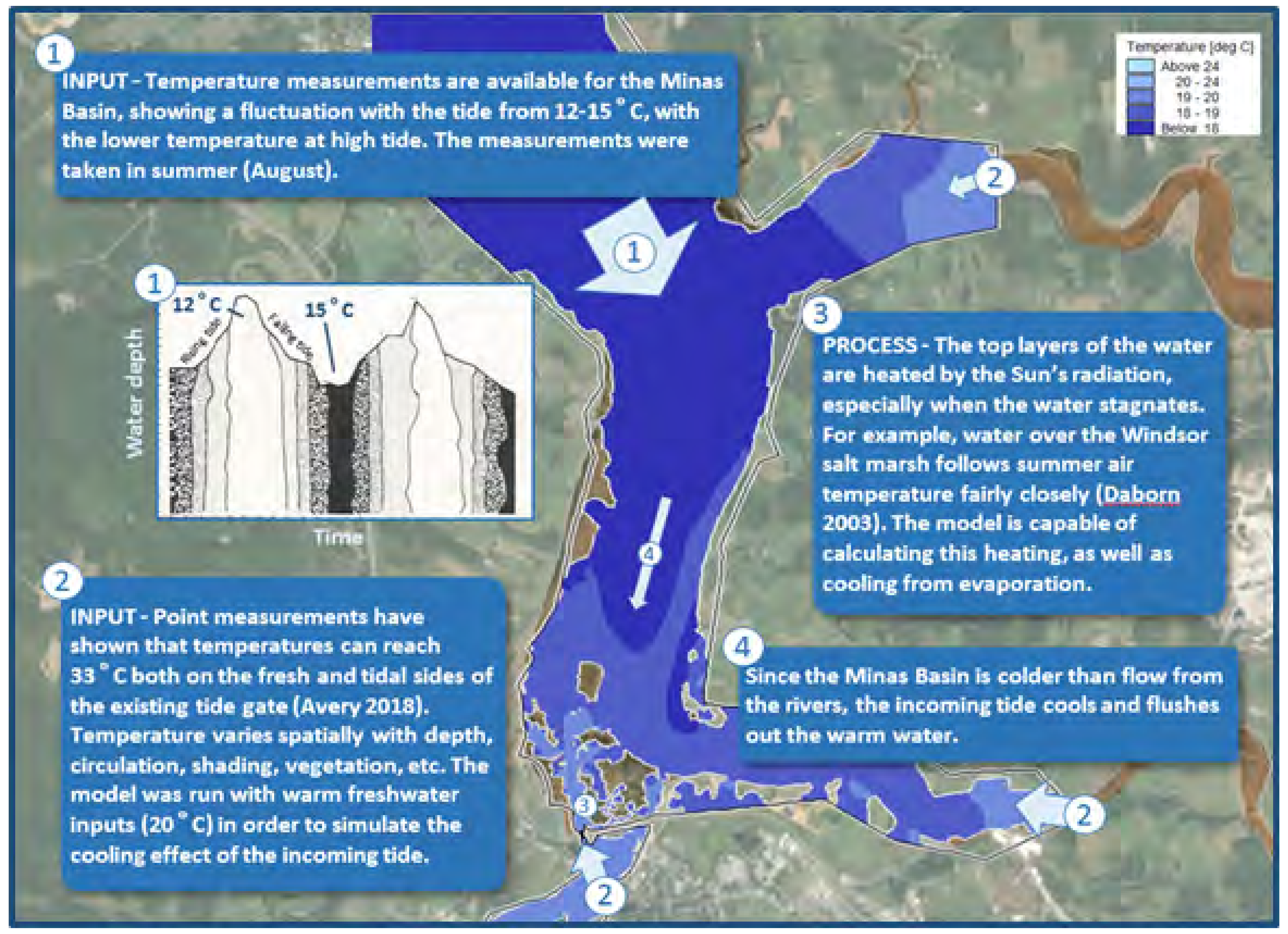
Current Processes



Salinity Model



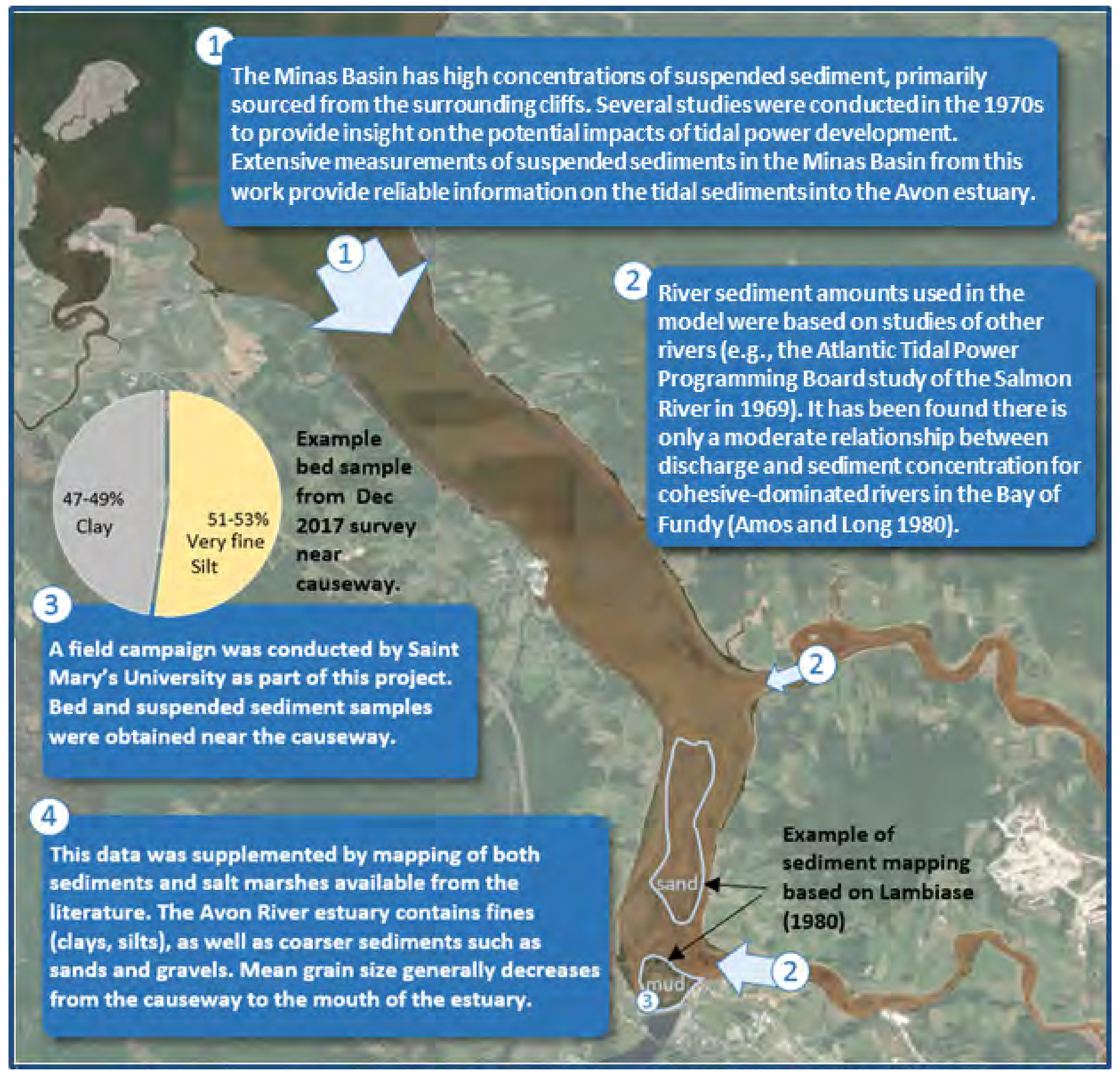
Temperature Model

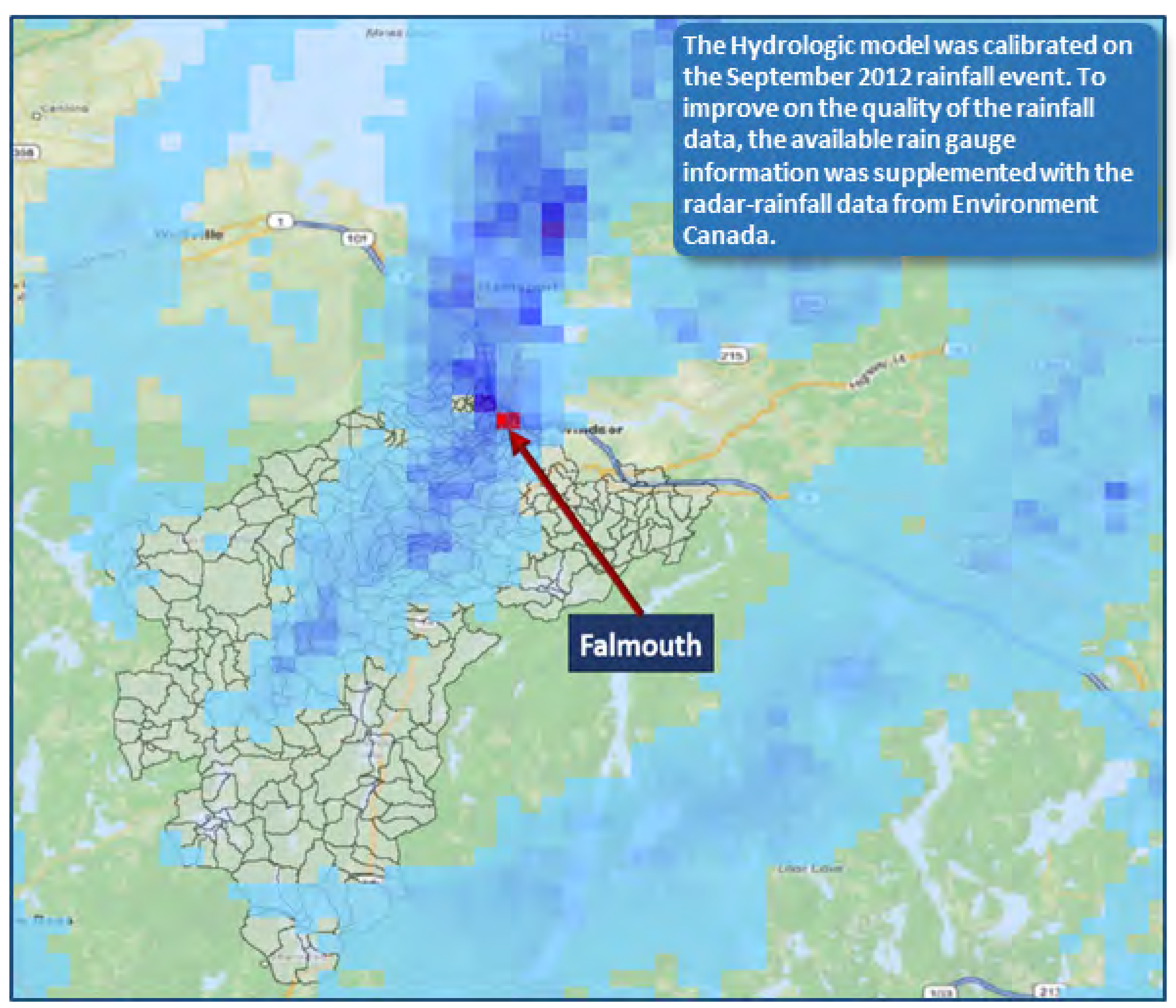


Avon River Aboiteau Replacement Design

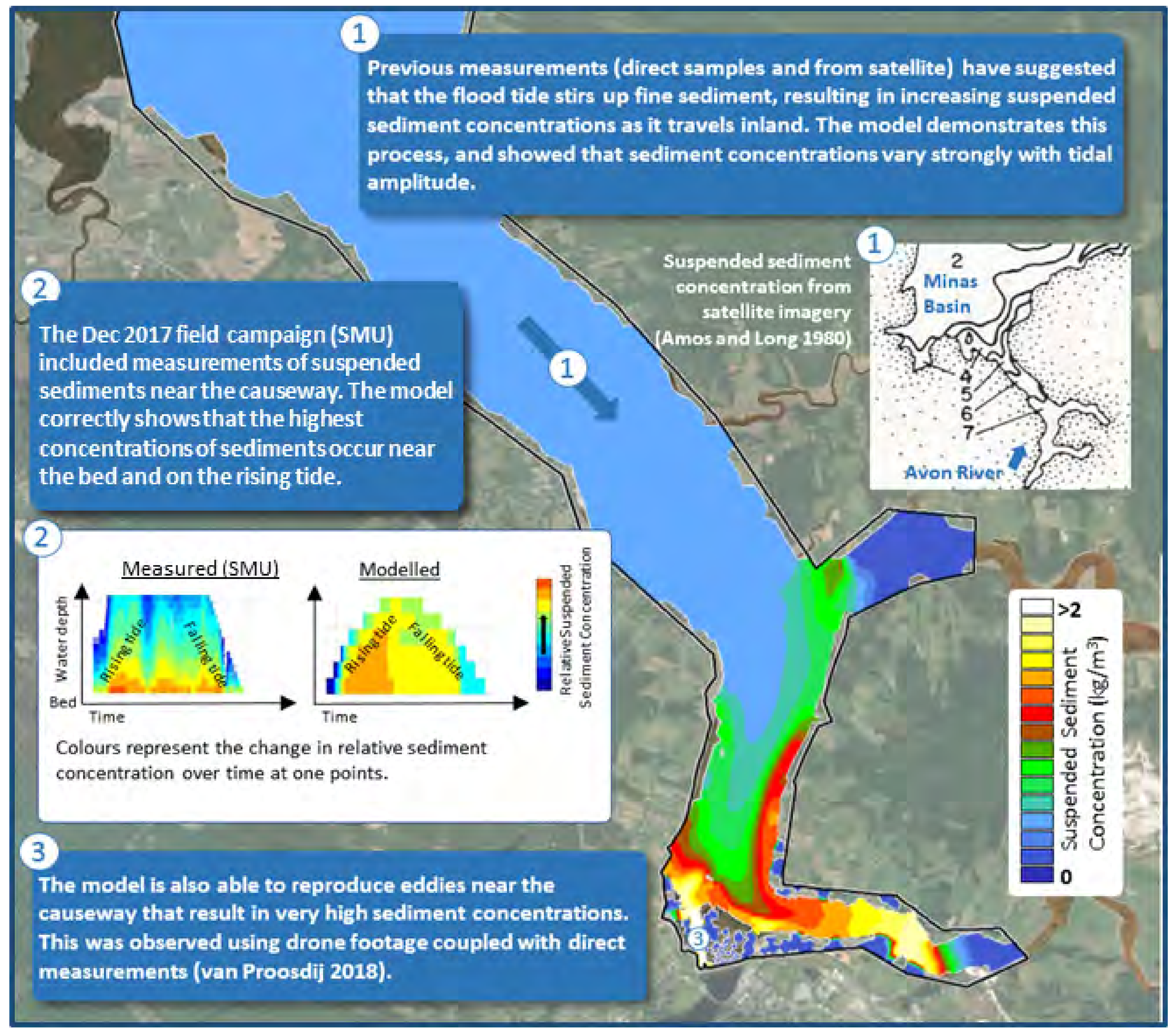
➡ Model set-up and calibration (Part 2 - Sediment Model)

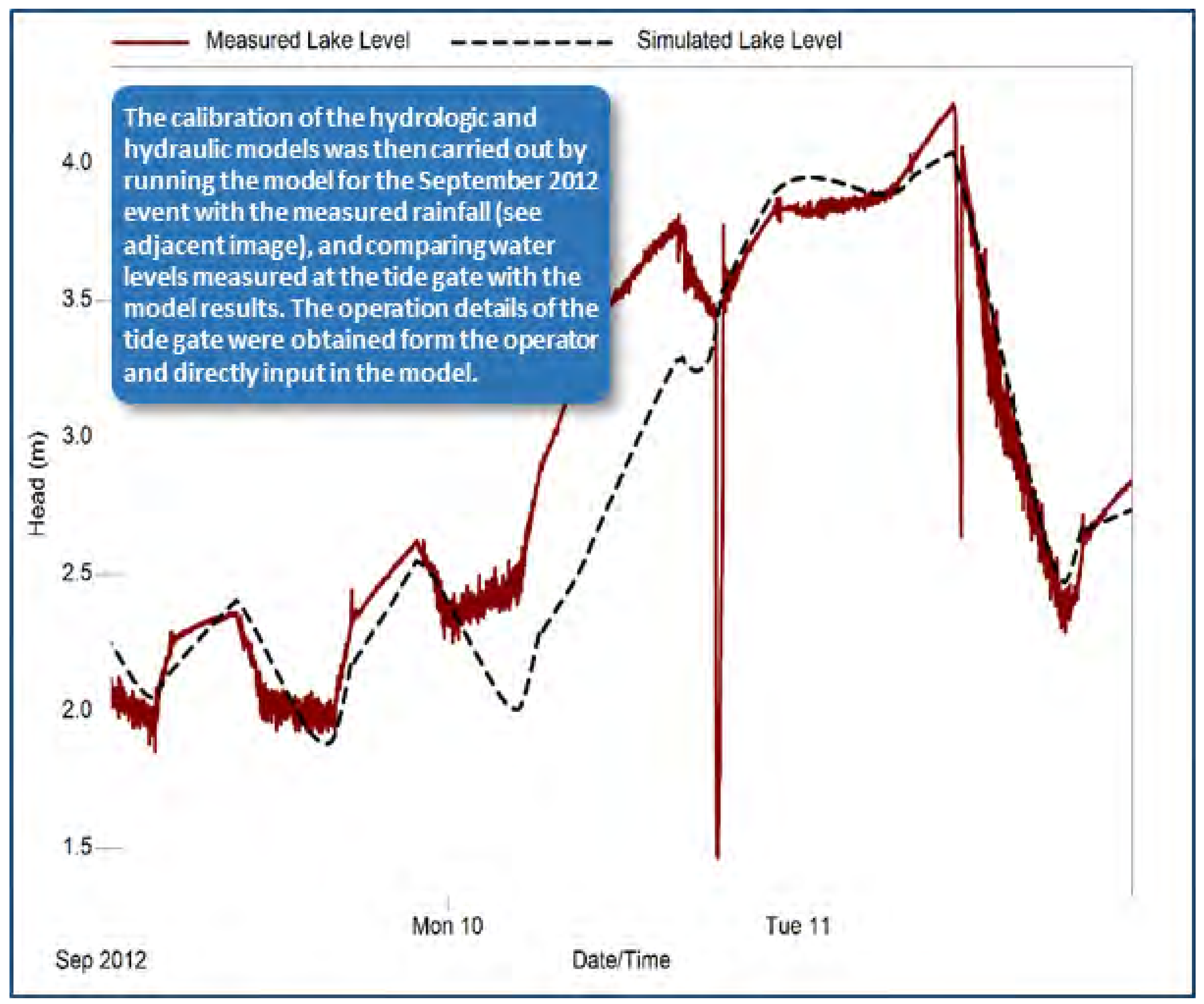
Sediment Model Set-up



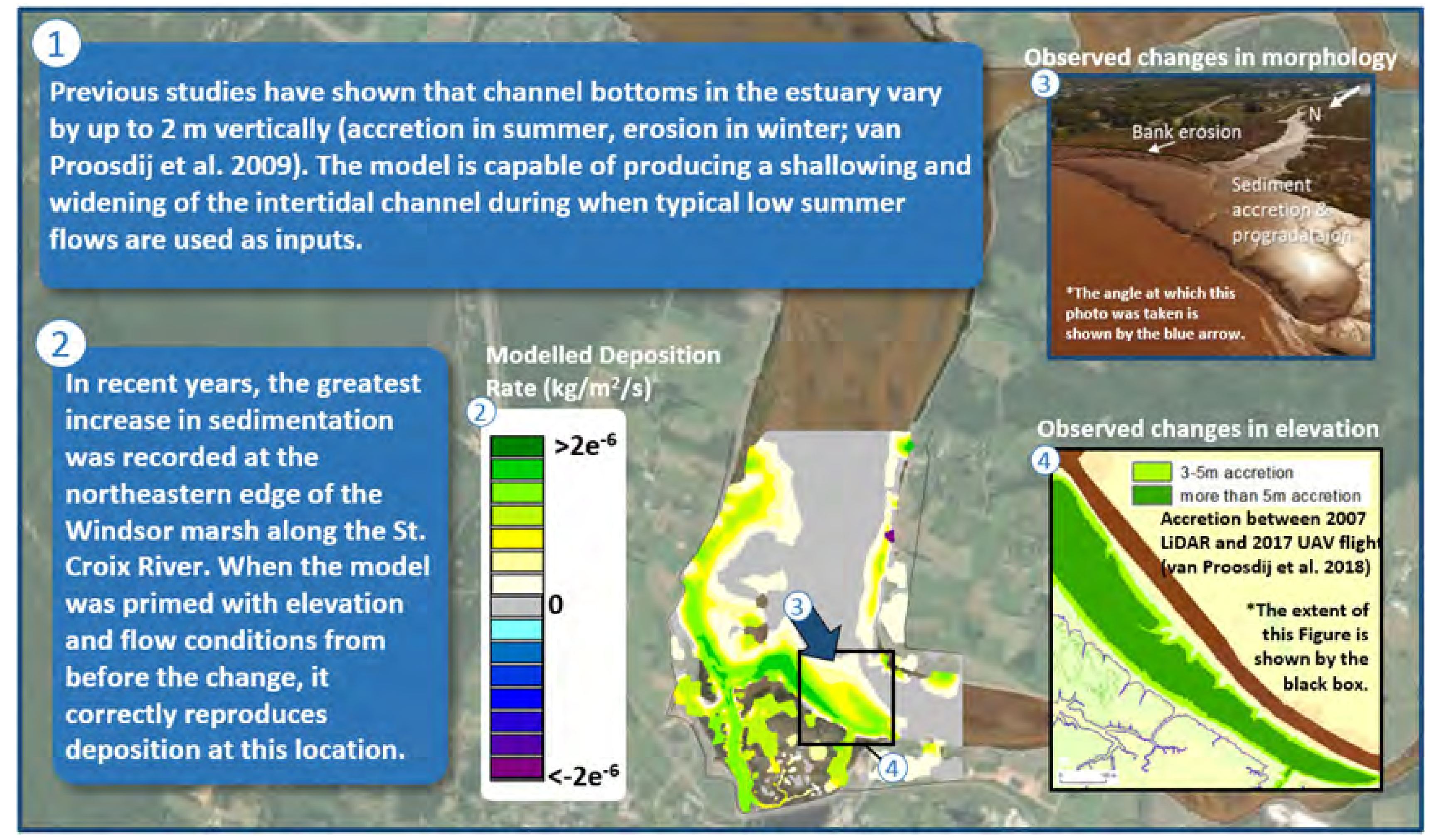


Suspended sediment concentration





Erosion and Accretion



Avon River Aboiteau Replacement Design

➡ Upstream conditions under Tidal Passage Scenario (Part 1)

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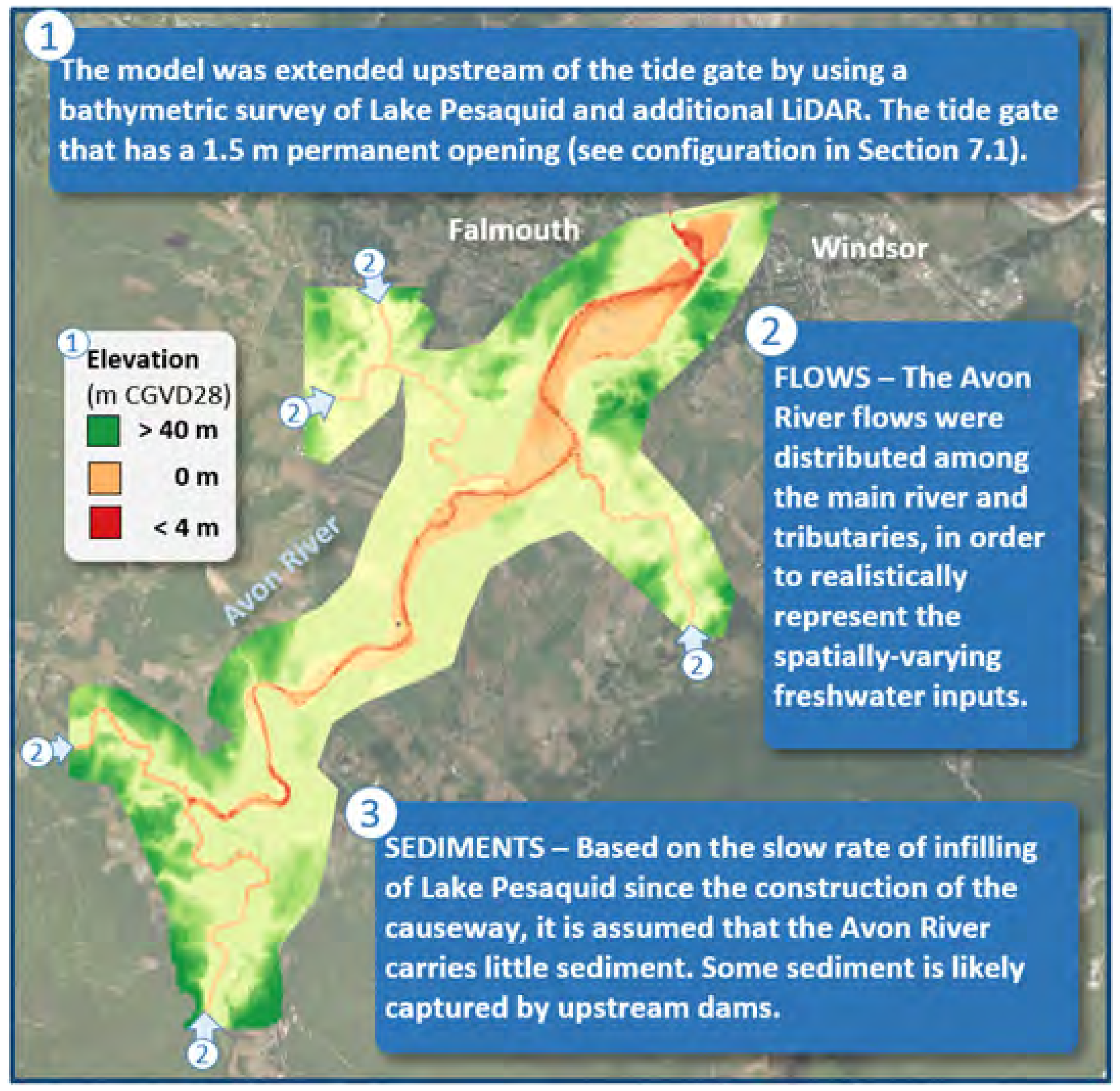
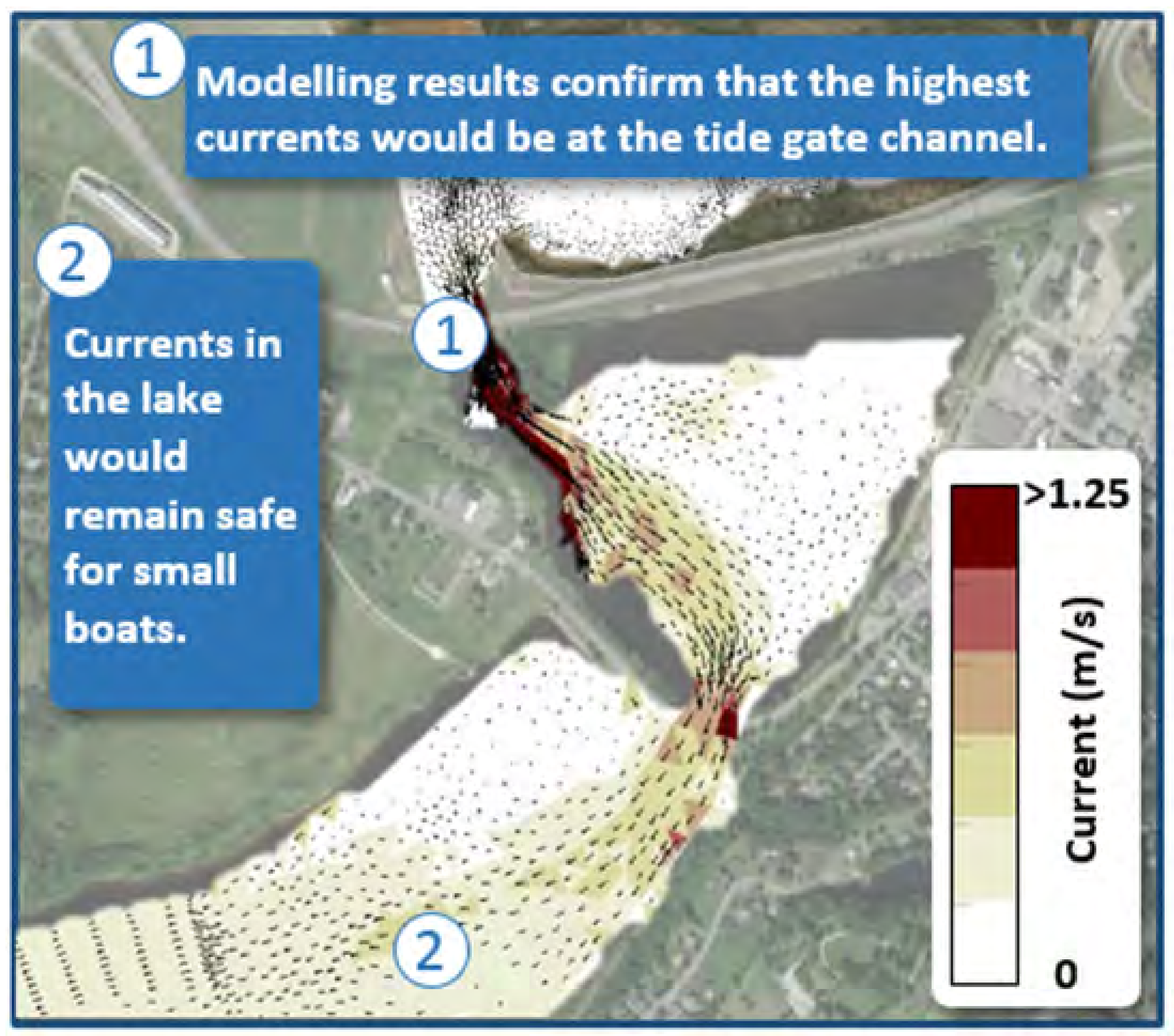
GOLDER
SAINT MARY'S UNIVERSITY SINCE 1802
ACADIA UNIVERSITY

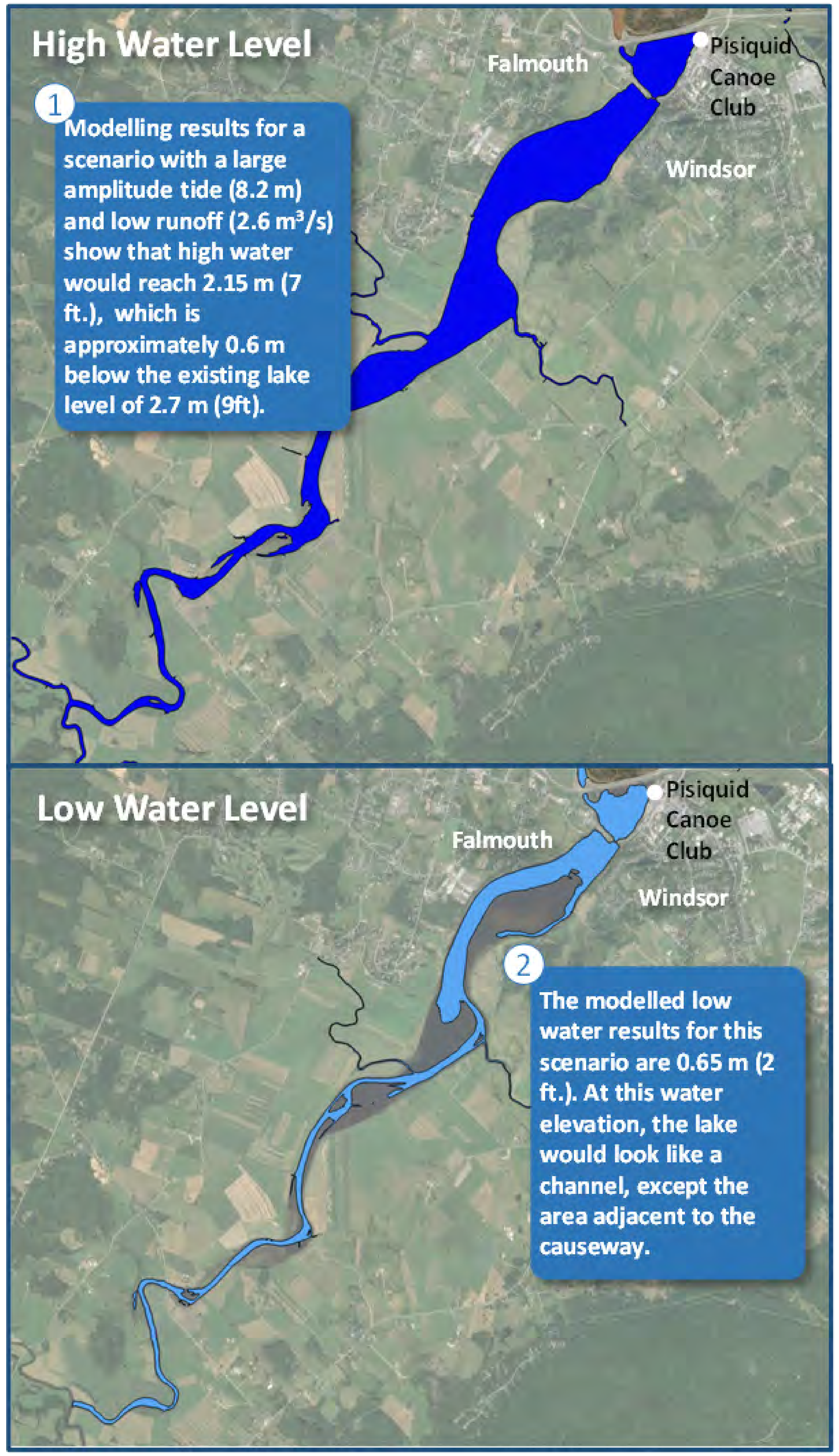
Tidal Exchange Model Upstream of the Tide Gate.



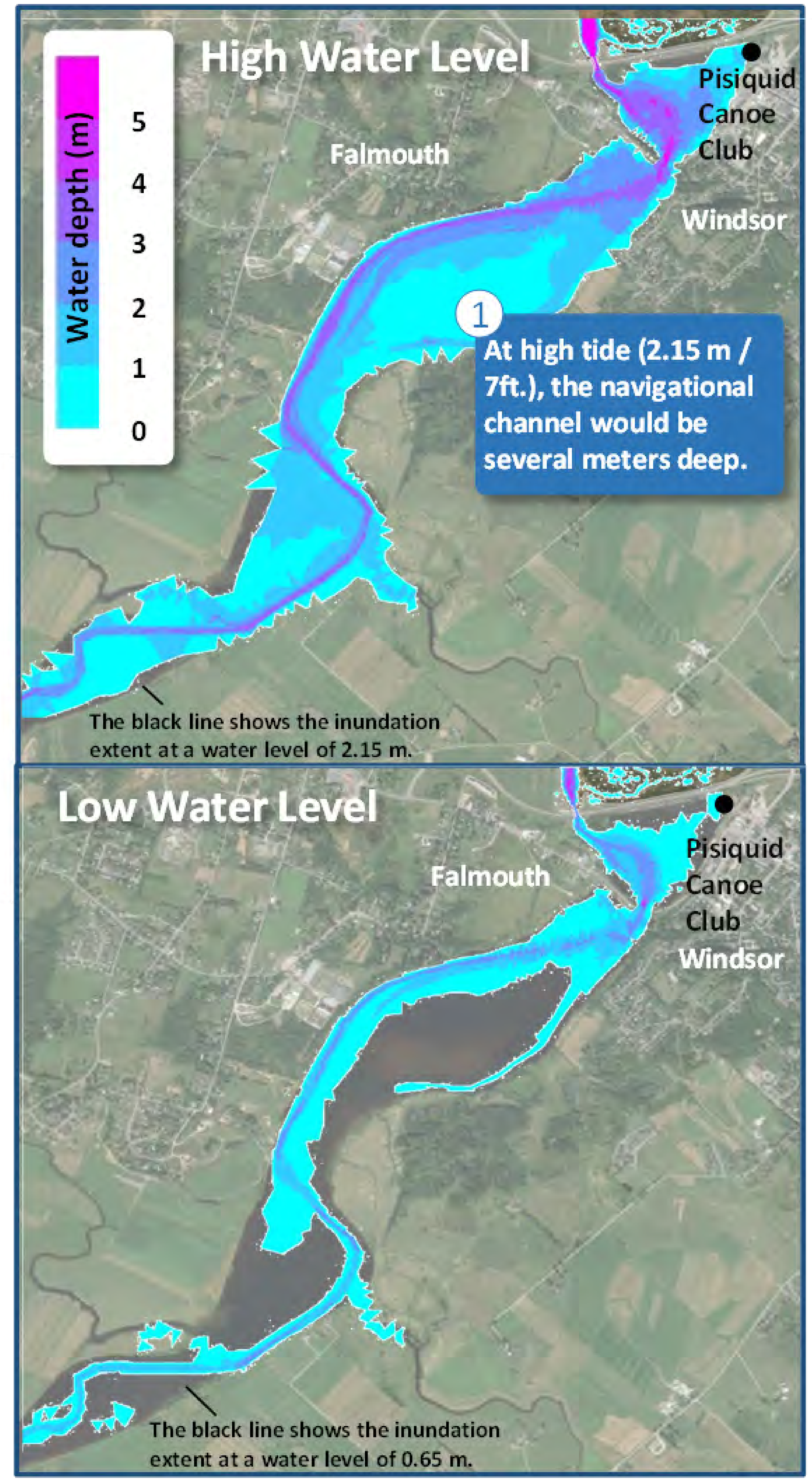
Currents



Water Levels



Water Depths

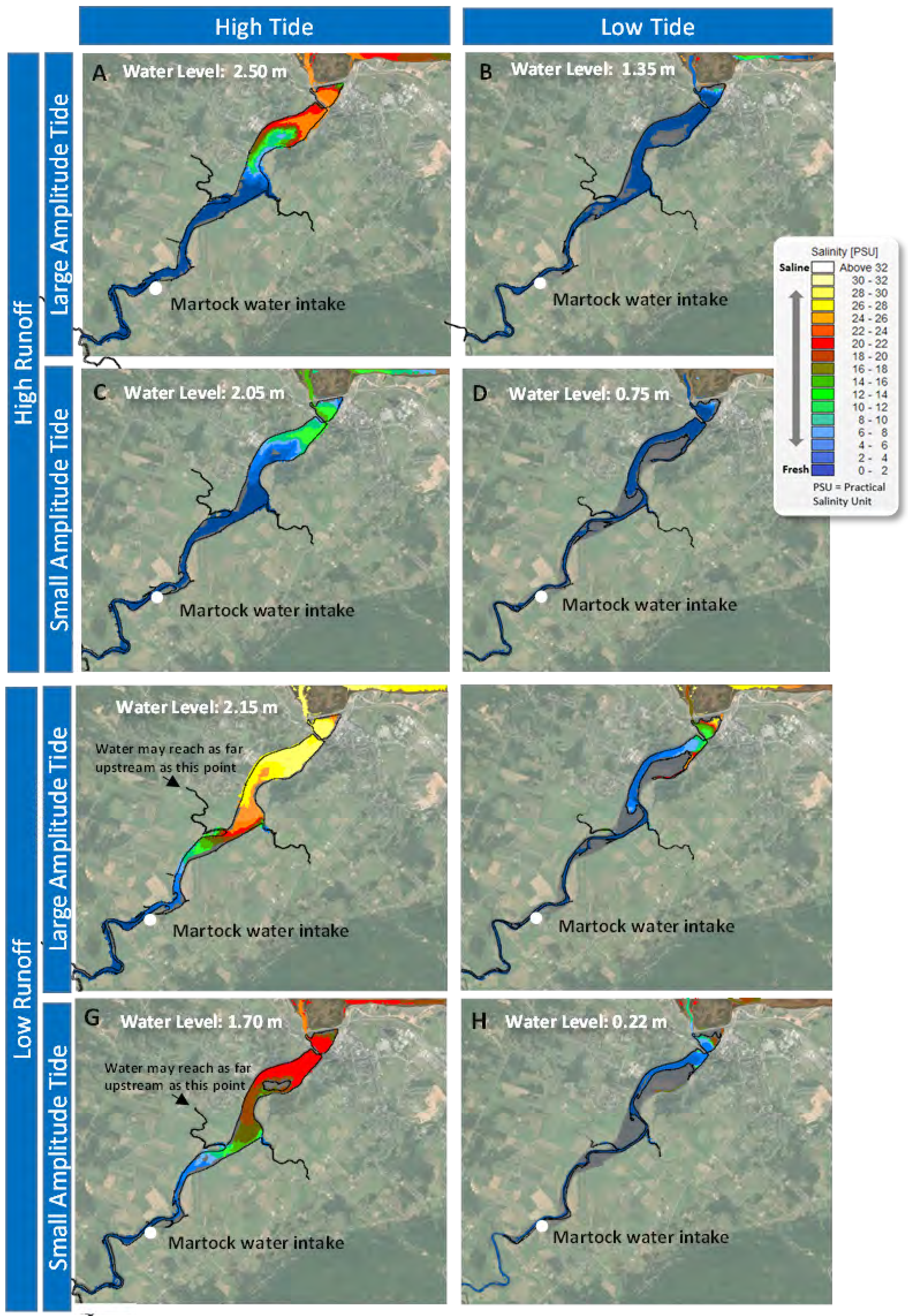


Avon River Aboiteau Replacement Design

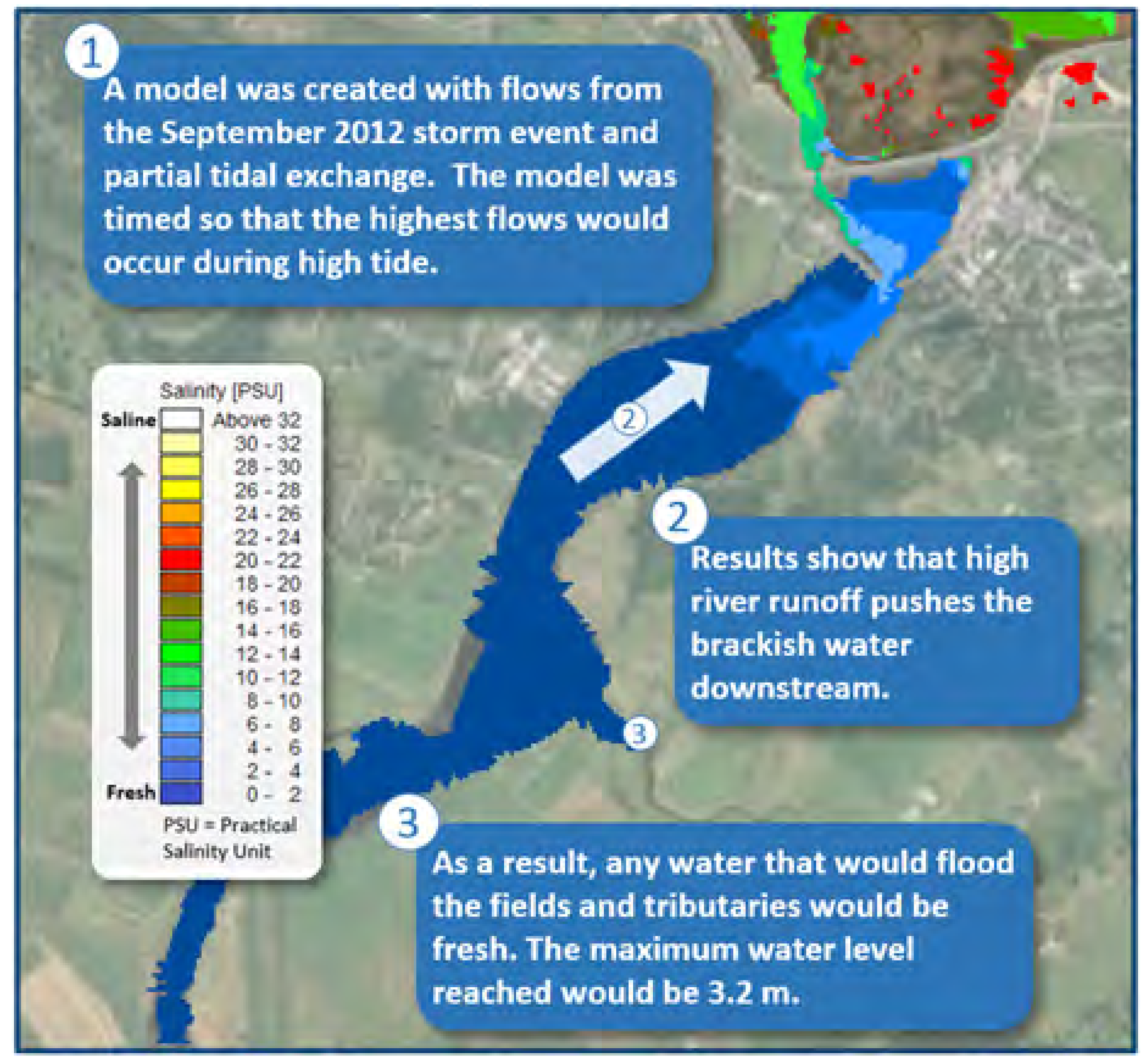
➡ Upstream conditions under Tidal Passage Scenario (Part 2)

Nova Scotia / Nouvelle-Écosse · CBCL · Dalhousie University · Golder · Saint Mary's University · Acadia University

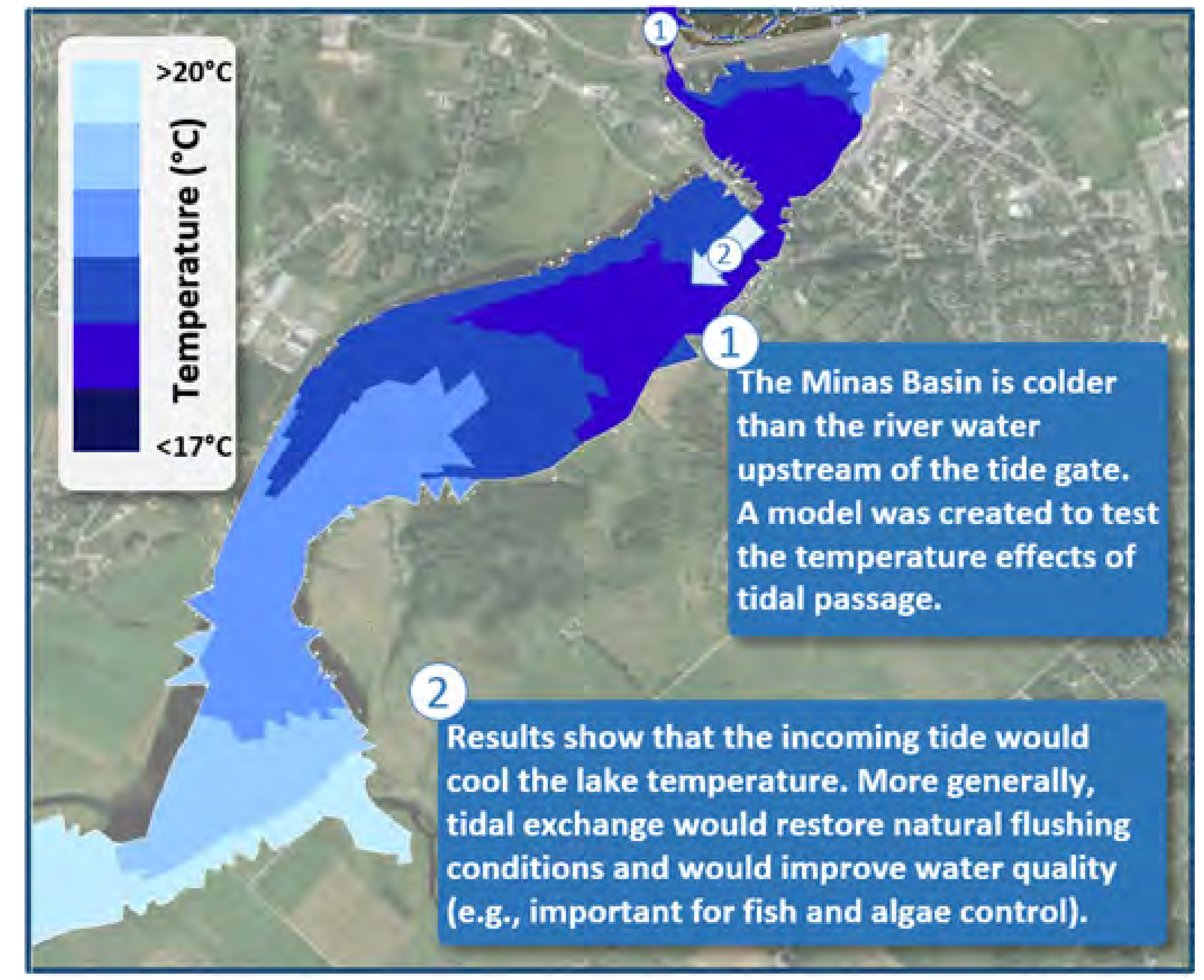
Salinity



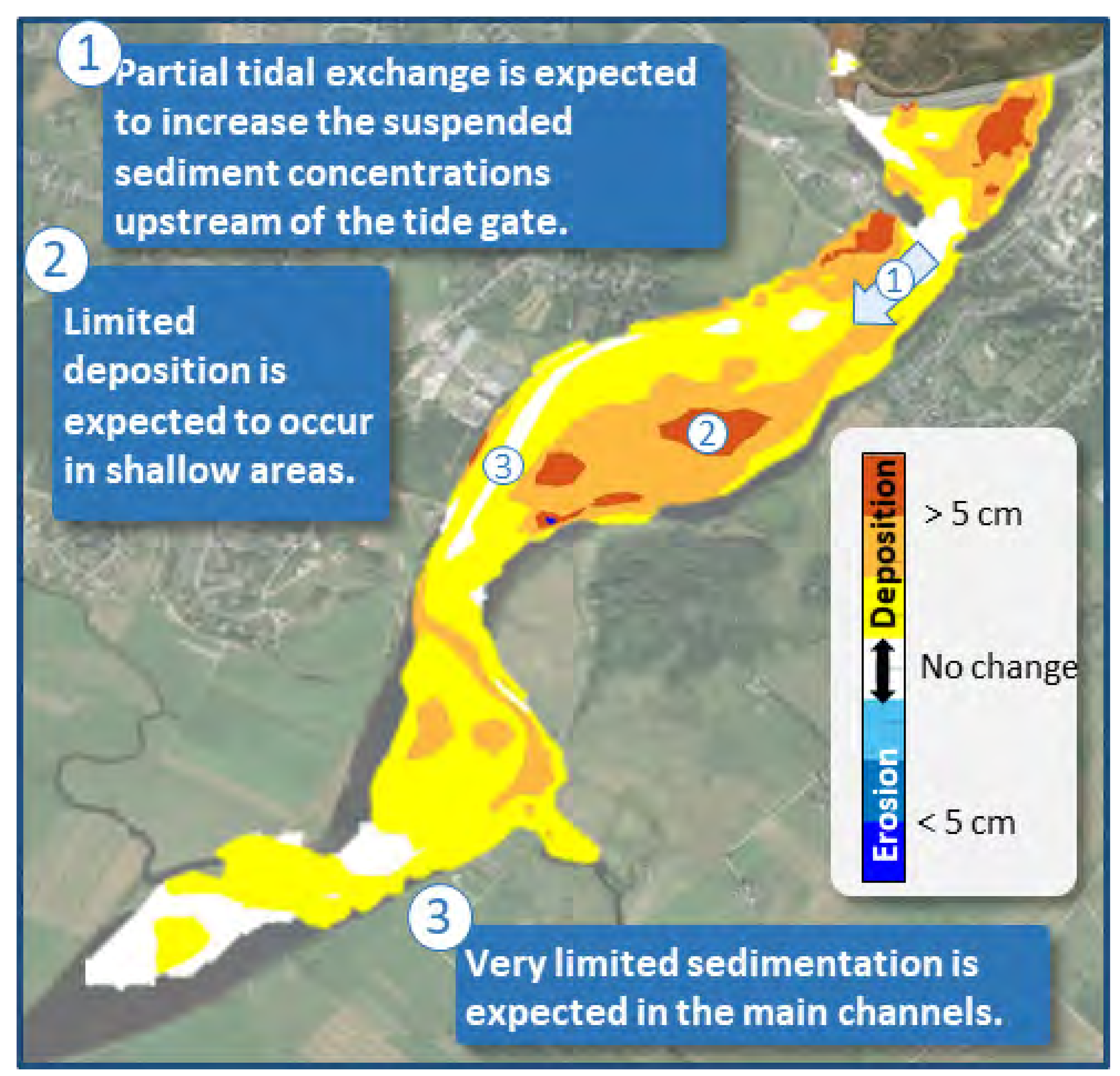
Salinity during a Large Storm event.



Temperature



Sedimentation



Avon River Aboiteau Replacement Design

➡ High-Resolution Model of Tidal Denil Fishway

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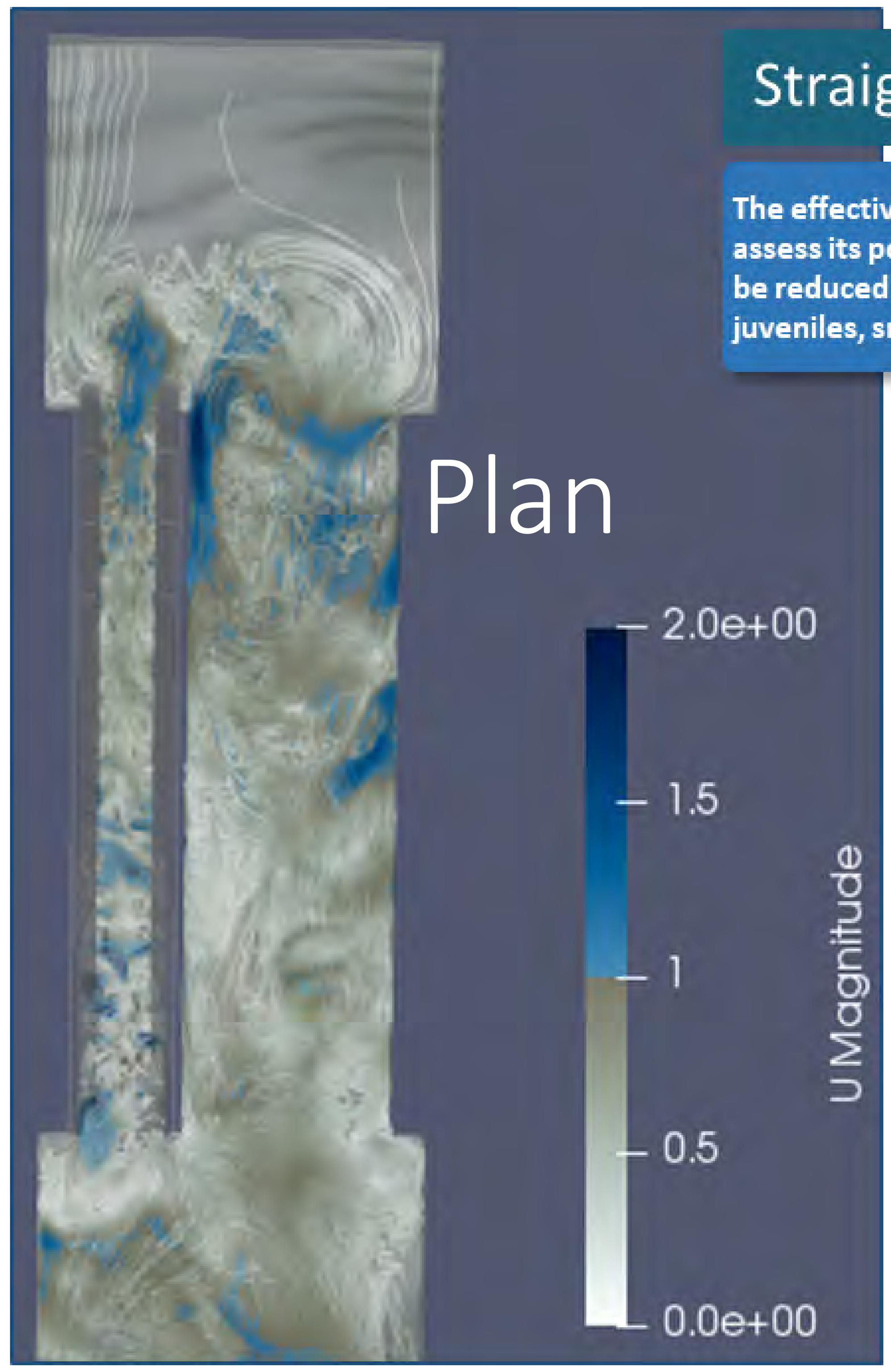
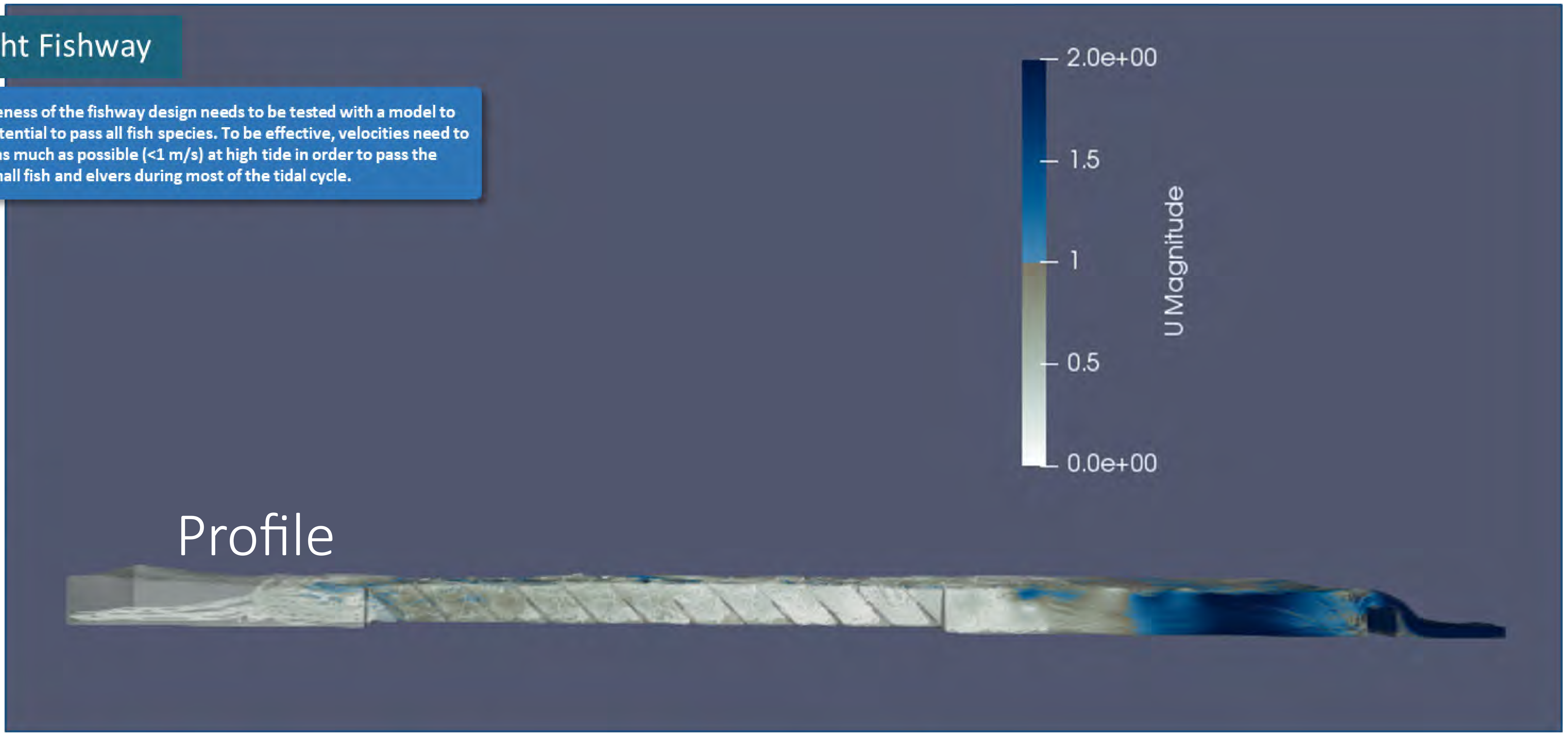
Straight Fishway

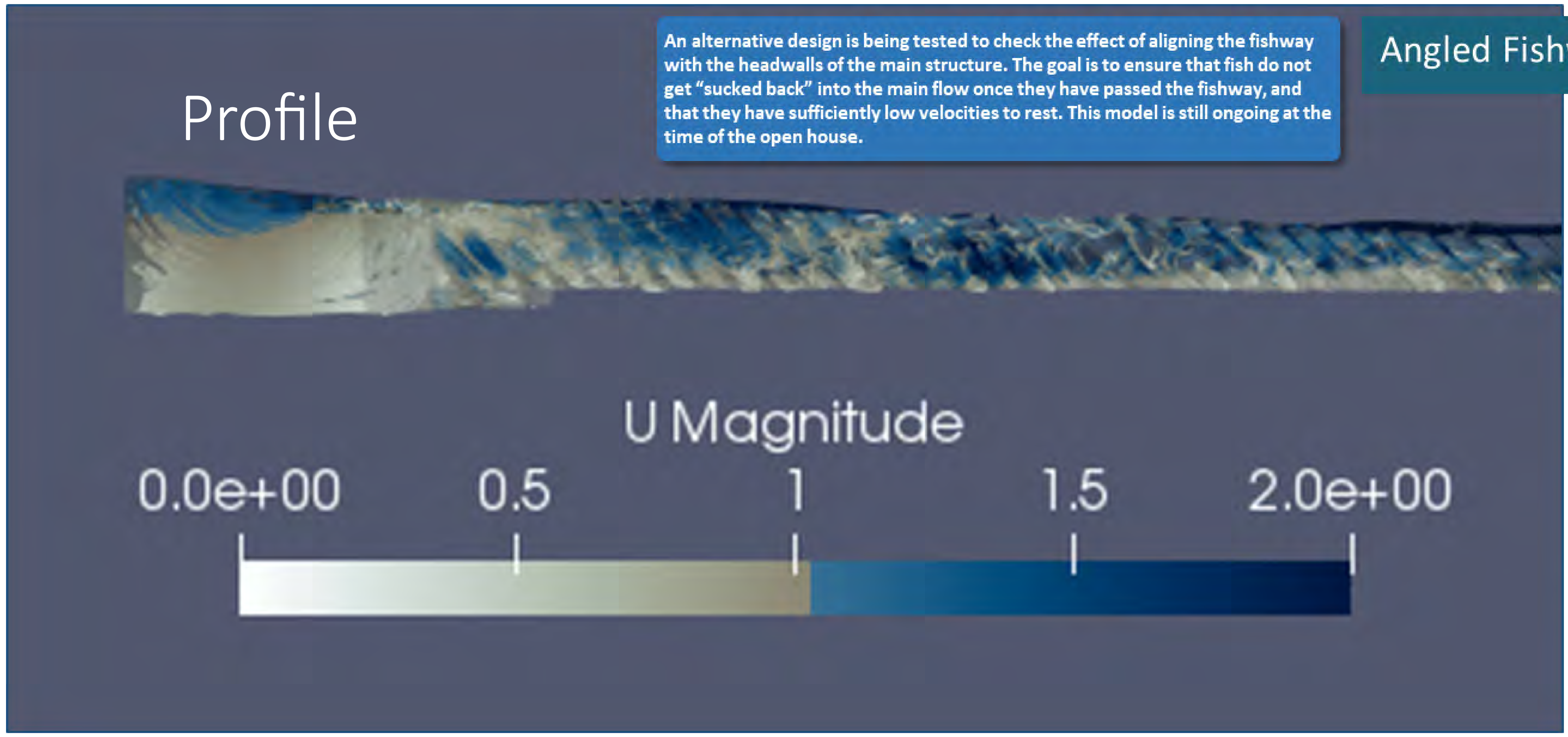
The effectiveness of the fishway design needs to be tested with a model to assess its potential to pass all fish species. To be effective, velocities need to be reduced as much as possible (<1 m/s) at high tide in order to pass the juveniles, small fish and elvers during most of the tidal cycle.

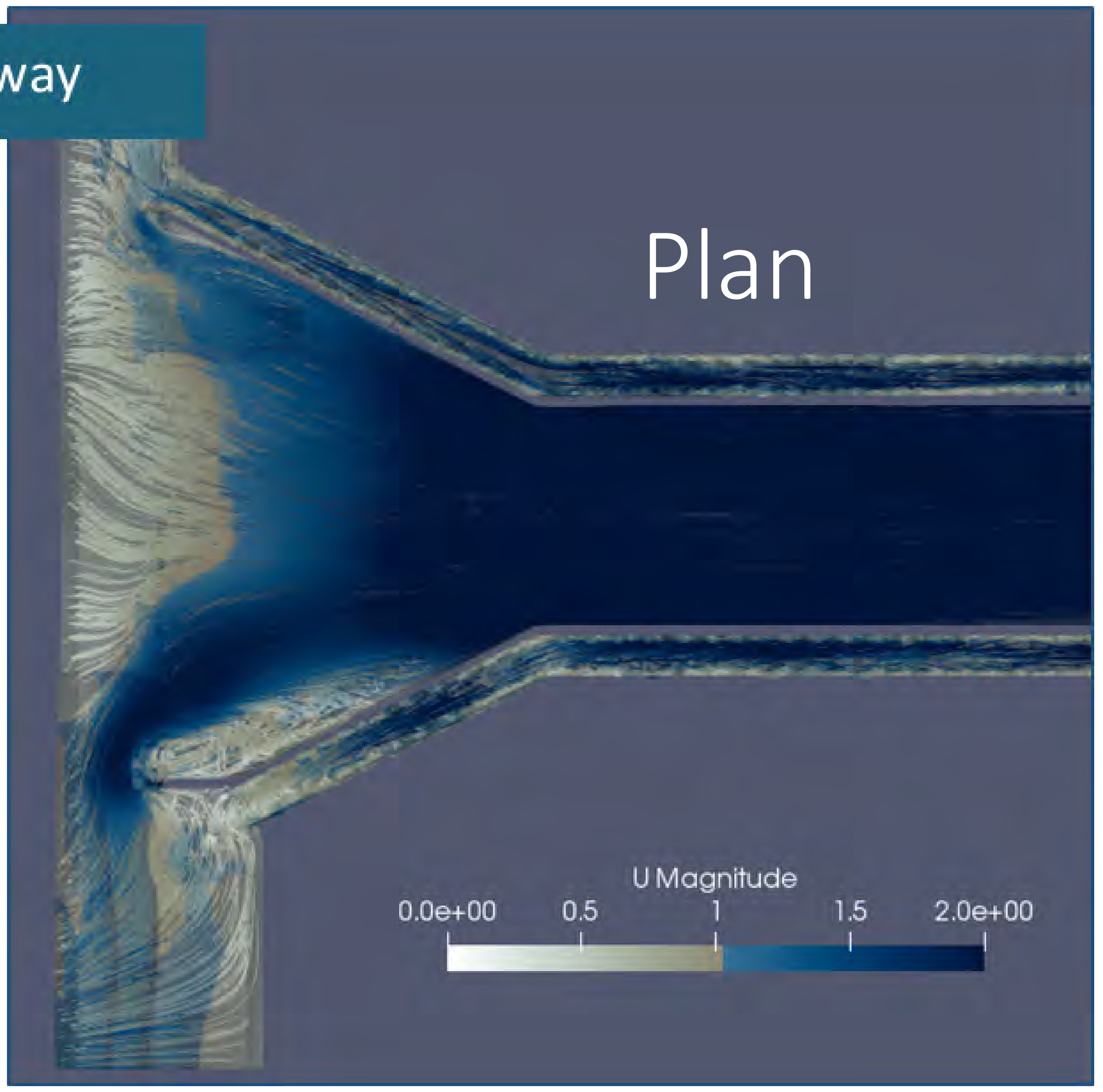




Angled Fishway

An alternative design is being tested to check the effect of aligning the fishway with the headwalls of the main structure. The goal is to ensure that fish do not get "sucked back" into the main flow once they have passed the fishway, and that they have sufficiently low velocities to rest. This model is still ongoing at the time of the open house.





Avon River Aboiteau Replacement Design

➡ Water Management Scenario A&B

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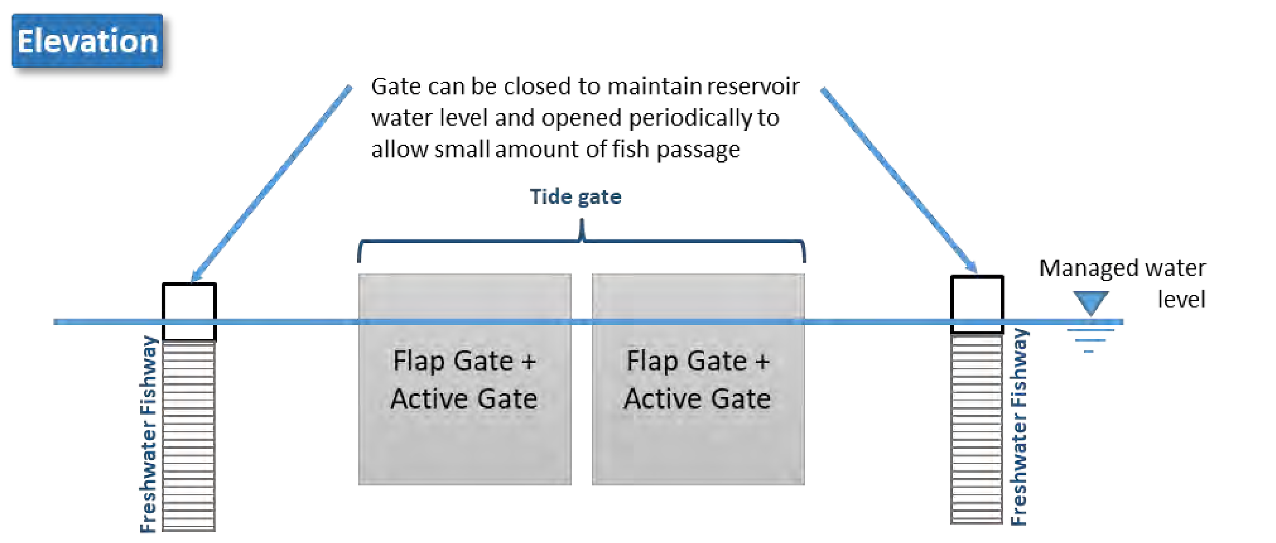
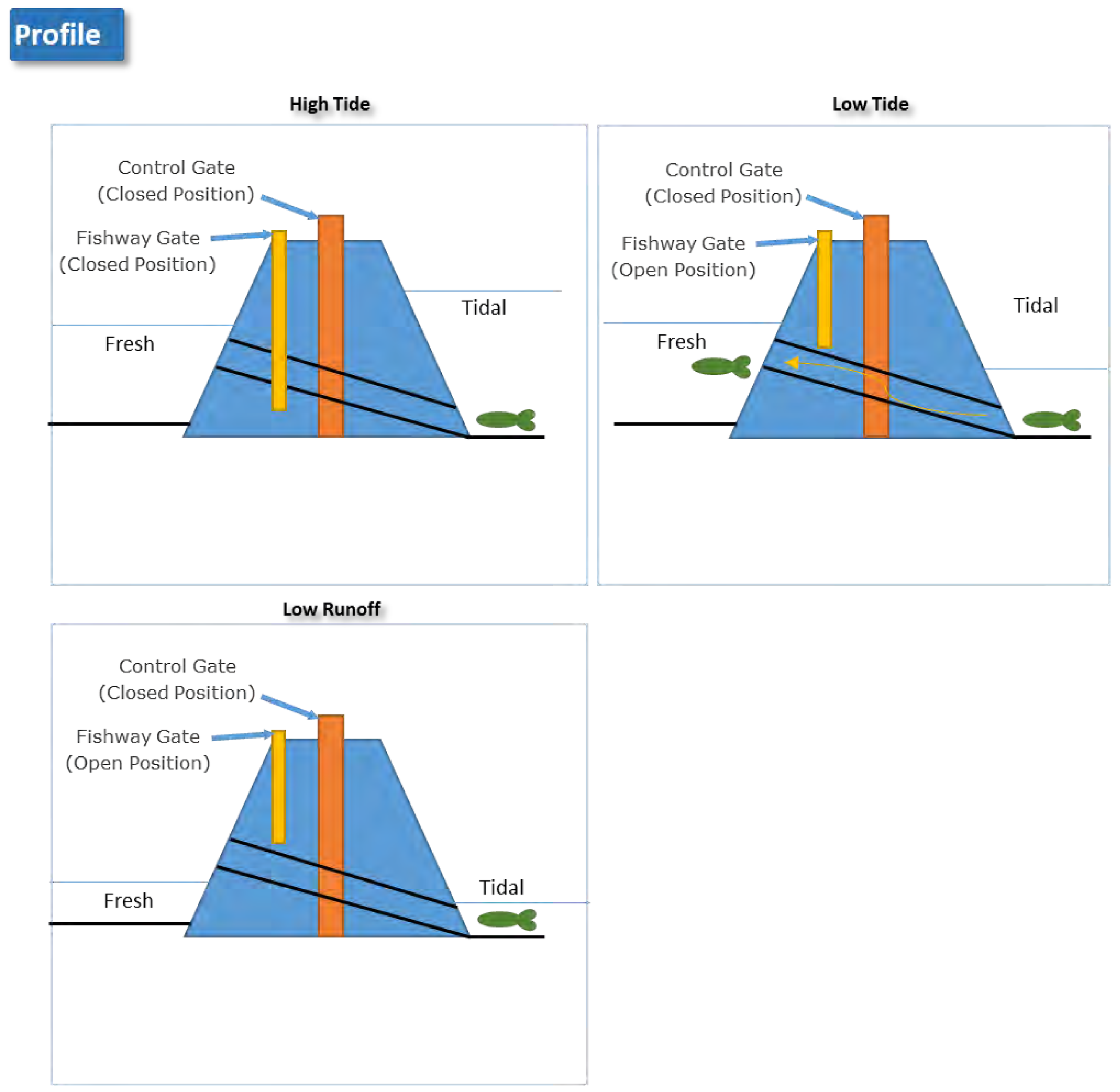
Scenario A – Maintain Freshwater Reservoir
Priority: Lake (Reservoir) Level



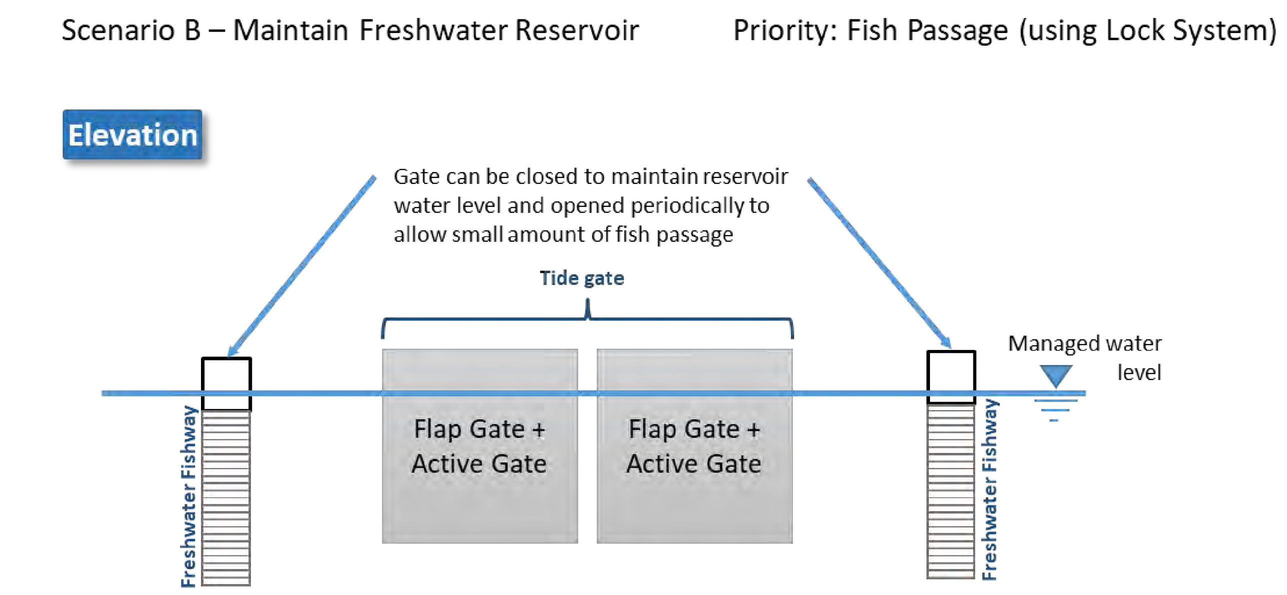


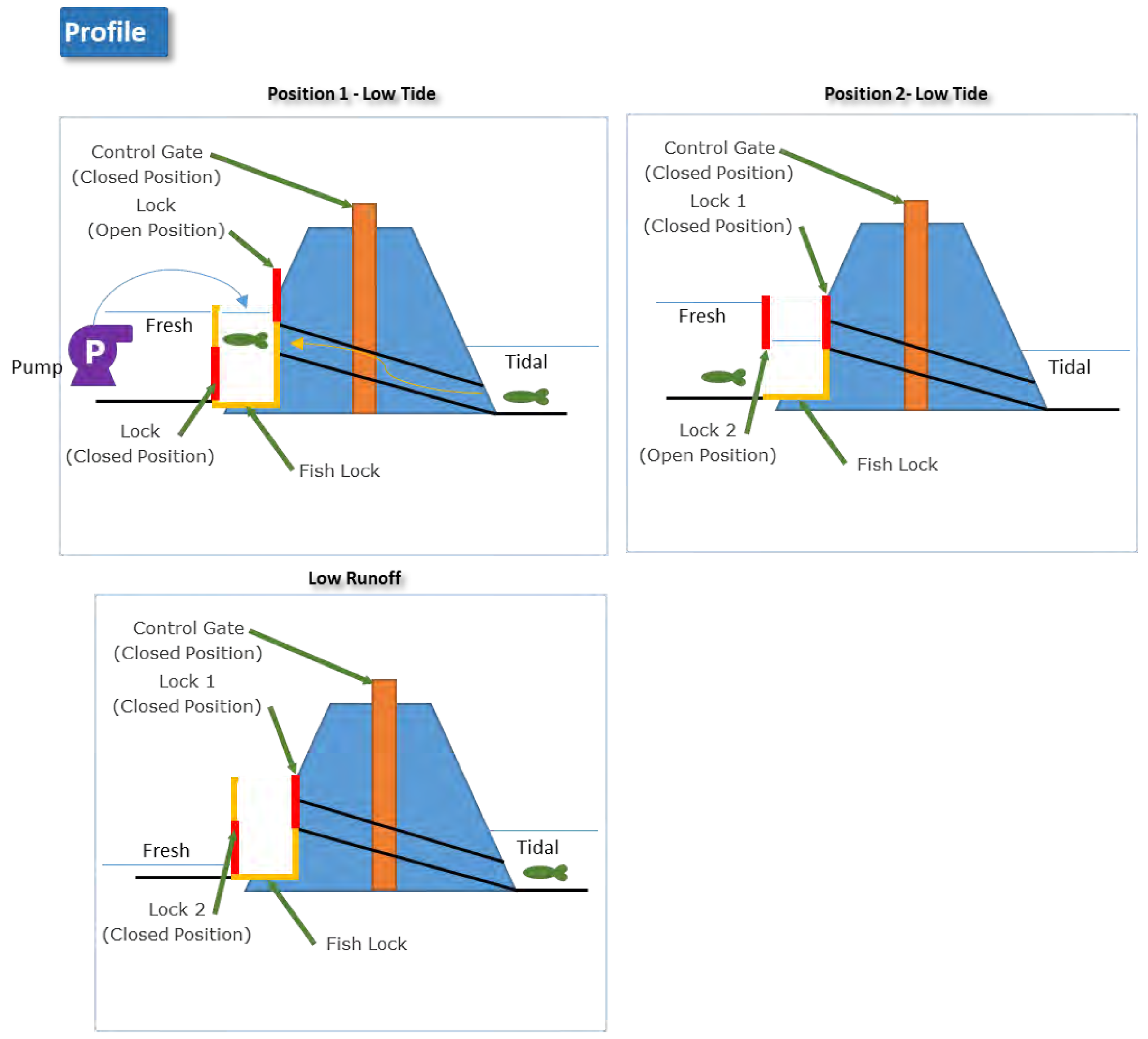
Scenario A
Main Freshwater Reservoir

Priority
Maintain upstream Water Level

Impacts
- Fish passage limited by water availability during low flow periods (summer) and may not meet the Fisheries Act
- Fishway size prevents juveniles, and small fish, as well as large fish species from swimming up the fishway
- Concerns from First Nations, CRA fisheries groups, other advocacy groups
- More complex gate needed, with flood warning and forecasting systems
- Continued sedimentation of lake, water quality degradation
- Impossible to fully prevent seepage through causeway (saltwater seepage will limit freshwater biota and fish habitat to current level)
- Preferred option of: boat clubs, Ski Martock, farmers

Scenario B – Maintain Freshwater Reservoir
Priority: Fish Passage (using Lock System)





Scenario B
Maintain Freshwater Reservoir

Priority
Keep fishway active and lake as freshwater

Impacts
Upstream Water Levels (from modelling results)
- If we pump the lake water into the fishway to keep it fully active as long as possible and reduce sedimentation, the lake level will be drawn down by the fishway.
- The level would be completely drawn down (no water left) 36 days per year on average.
- Climate change (drier summer) is expected to further decrease water available
- Higher potential for flood risk (more complex gate)

Fish Passage
- Fishway size prevents juveniles, and small fish, as well as large fish species from swimming up the fishway
- The fishway would be closed half the time to prevent tides from flowing upstream.
- Fish passage limited by water availability during low flow periods (summer) and may not meet the Fisheries Act
- Sedimentation management will be required to prevent blockage of the fishway
- Impossible to fully prevent seepage through causeway (saltwater seepage will limit freshwater biota and fish habitat to current level)

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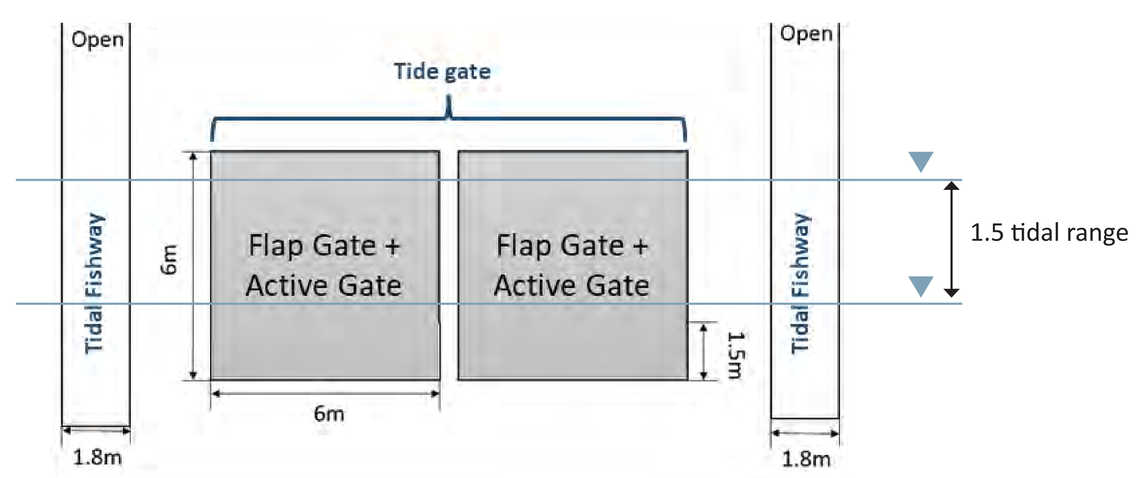
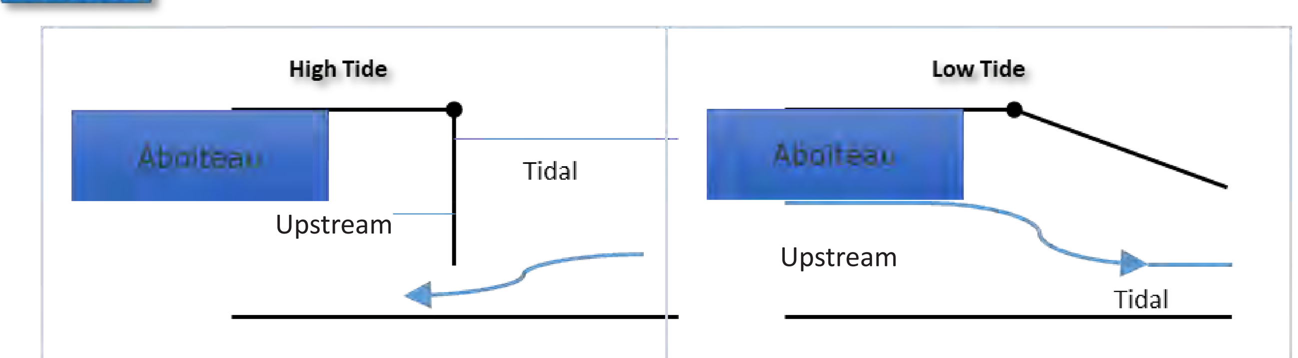
➡ Water Management Scenario C&D

Scenario C – Controlled Tidal Exchange
Priority: Fish Passage and Restoration to More Natural Conditions

Elevation



Profile



Scenario C

Controlled Tidal Exchange

Priority

Fish Passage and Restoration to More Natural Conditions

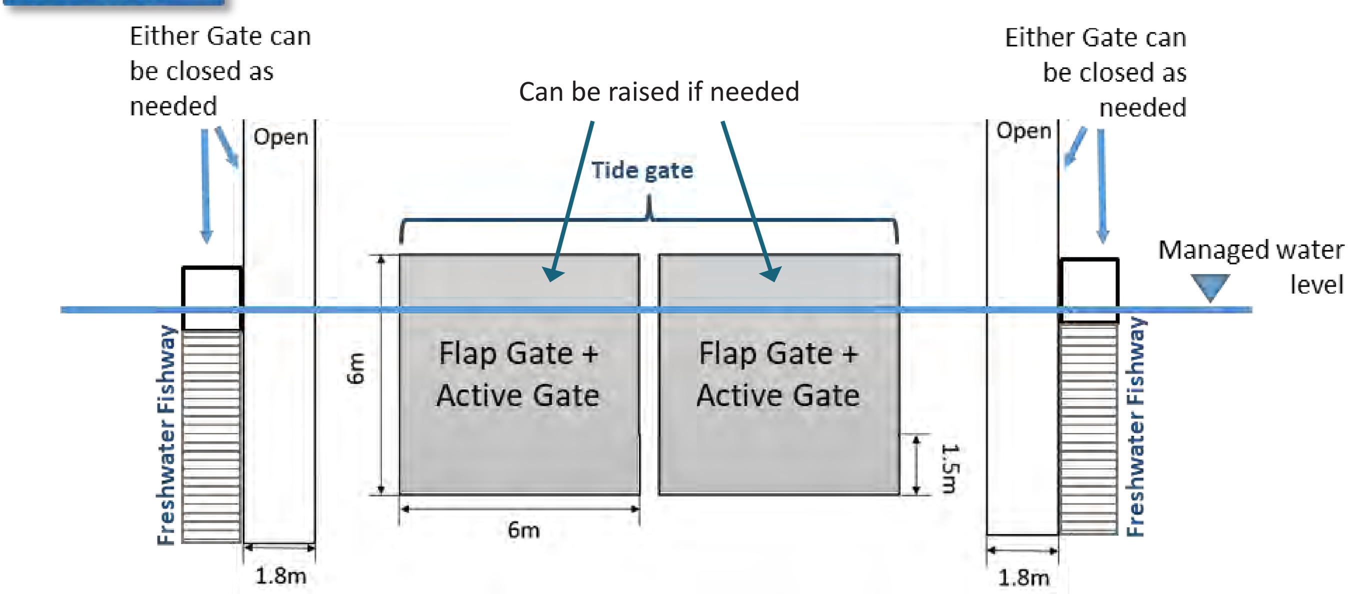
- Provides controlled partial exchange of tidal water allowing salt water intrusion.
- Year-round fish passage for all species
- Adaptive design for anticipated climate change and sea-level rise
- The intention is that such a configuration can be adjusted as needed. It is able to function safely and effectively with minimal operation, but can be adjusted to meet various needs, such as allowing water levels to rise in the lake for specific events.
- Ease of Operation and maintenance

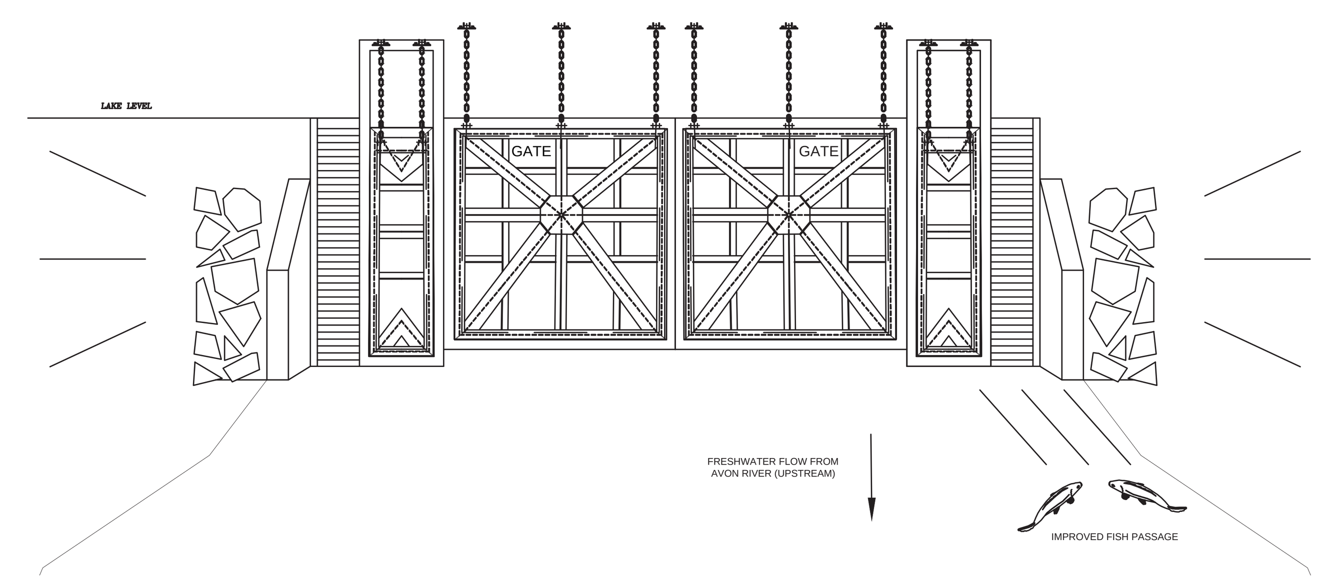
Anticipated Impacts based on modelling results

- Flooding - Provides more reliable flood protection, does not require operation in advance of storms
- Fish Passage –Significantly greater fish passage and habitat potential
- Water level -The water level would be approx. 0.6m to 2.1m (2-7 ft.) below the existing target water level. This is intentional, to protect the farming ditches from saltwater intrusion.
- Currents-Currents would change but still remain safe for canoeing / boating.
- Salinity (salt) -Would enter the upstream area. Not expected to impact current farming operations. Salt would not reach Martock water intake except during a combination of extreme low runoff and high tides in late summer. This can be monitored and gate operation can be adjusted to ensure no impact if necessary.
- Temperature -Tidal exchange would cool the reservoir, restore natural flushing, and improve water quality.
- Sediments-Minor sediment deposition would occur in shallow areas; no sedimentation is expected in the main channels. Water color would change on the causeway side
- Improved Ecosystem health: Daily Tidal Flushing would result in a more naturally functioning river ecosystem.
- Water levels would be reduced between .6m (2ft) and 2.1m (7ft) below existing water levels
- Competitive canoeing would no longer be possible at this location

Scenario D – Hybrid of Scenario A & C
Priority: Fish Passage and Reservoir Water Level

Elevation





Scenario D

Hybrid of Scenario A & C

Priority

Able to maintain upstream water level and upstream freshwater, able to provide improved fish passage.

Impacts

- More complex gate management system.
- Reduced potential for flood risk (more complex gate operation)
- Regular maintenance required to clean sediment blockages in fresh water fishway development

This option is still under development, to be refined during next phase of development.

Avon River Aboiteau Replacement Design

➡ Proposed Aboiteau Management

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Needs & Options

↓

Consultation

↓

Management Plan

↓

Independent Monitoring

↓

Adaptation

Prior to commissioning the new aboiteau, a Working Group (WG) would summarize the needs and interests, and demonstrate to the public how the diverse interests can be accommodated and meet regulatory, community and opportunity criteria (i.e., an education process).

- Government (municipal, provincial and federal)
- Mi'kmaq
- Local farmers
- Business community
- NS Power
- Ski Martock
- Paddling
- Boating and other recreational users
- Fishers
- Environmental advocates

An integrated lake management plan would then be developed by the WG and implemented by NS Agriculture staff to balance the diverse interests.

In the future, the new structure will require operational reviews for public safety, regulatory compliance (including environmental monitoring), and changing conditions.

Regulatory criteria	Community criteria	Opportunity criteria
Mi'kmaq Rights and Treaties	Interests the community defines	Business development opportunities
Flood Protection	Lake levels for recreation (on or near the lake)	Community Planning
EA Requirements: Environmental Protection	Protection of business interests (i.e. Martock, downtown businesses)	
DFO Requirements for Fish Passage - must be met as it is law	NS Power	
Agricultural Lands Protection - Legal Responsibilities Of NSA	Tourism	

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Open House

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Tell us what you think!

or email us at: info@hwy101windsor.ca