Physical and Numerical Modelling

National Research Council

Ocean, Coastal and River Engineering Research Centre (OCRE)

December 2025

NRC at a glance

Government of Canadas largest research and development organization

Mandate:

- Advance scientific & technical knowledge
- Strengthen the resilience and sustainability of Canadian communities
- Support business innovation
- Support government policy objectives

NRC – Ocean, Coastal & River Engineering (OCRE) Research Centre

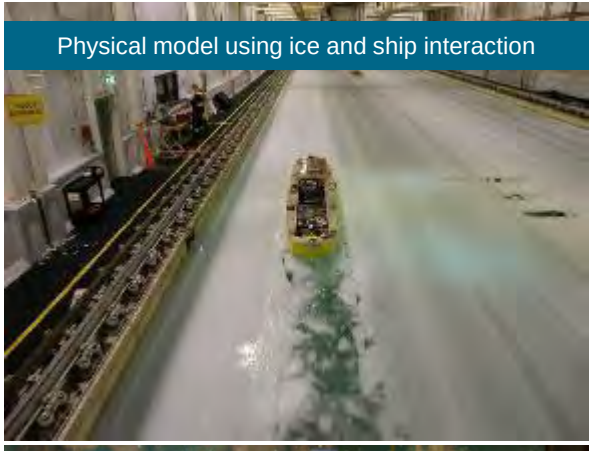
2 locations – St. John's & Ottawa

115 people

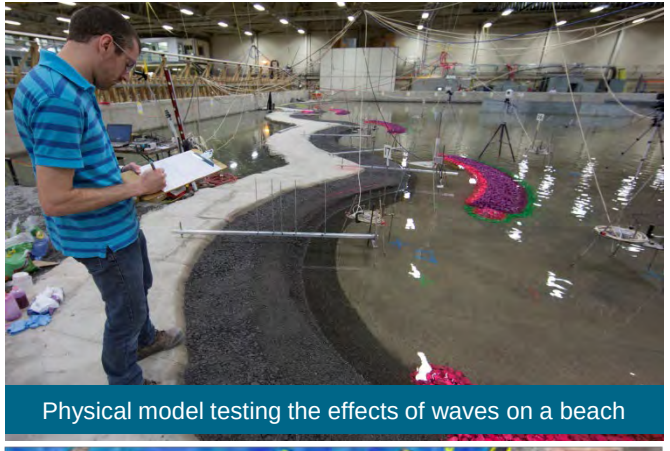
Extensive research & testing facilities

St. John's
- Marine Operations, Autonomy & Safety
- Marine Performance & Evaluation
- Arctic Marine Engineering

Ottawa
- Coastal Engineering
- Coastal & River Systems
- Northern Rivers and Shorelines
- Water Resources
- Data Science & AI

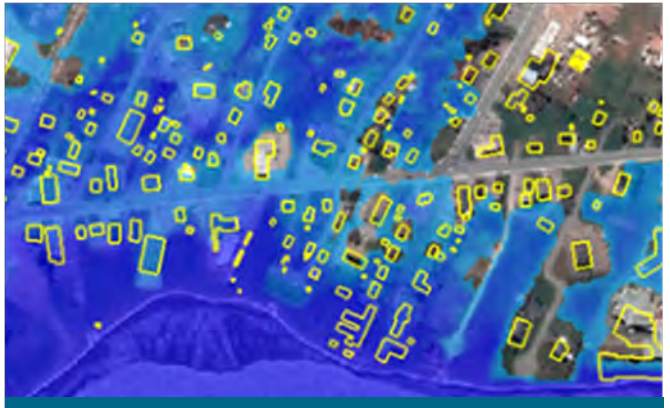


Physical model using ice and ship interaction



Physical model testing the effects of waves on a beach

Physical model testing vegetation effects on waves



Numerical model simulating flood inundation

Modelling

- Helps us understand how things work or how future events might unfold
- Allows us to test different situations and see possible outcomes
- Helps us make better decisions
- Improves designs

Two main types:

- Physical Models
- Numerical Models

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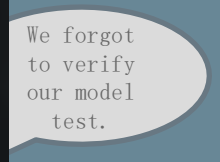

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Two main types:

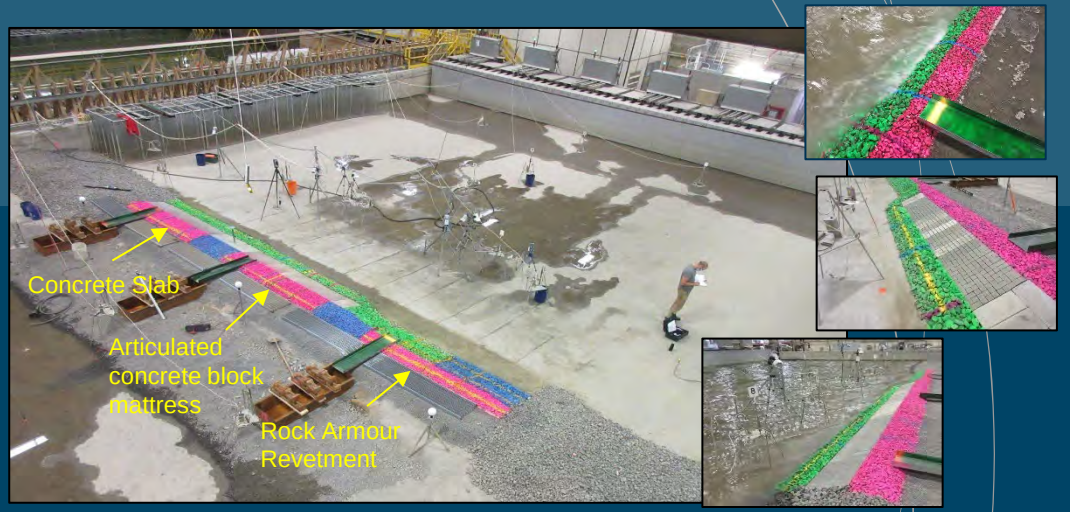
- Physical Models
- Numerical Models

Physical Models

- Real-life, hands-on version of existing or planned structures or events
- Built with existing materials and use actual water
- Usually built at a smaller scale
- Allow testing under different conditions
- Can be costly

Physical Models

- Hamlet of Tuktoyaktuk
- Proposed shoreline protection
- Verify designs – various storm conditions
- Optimized the final design for constructability, performance and cost



Courtesy of Baird & Associates

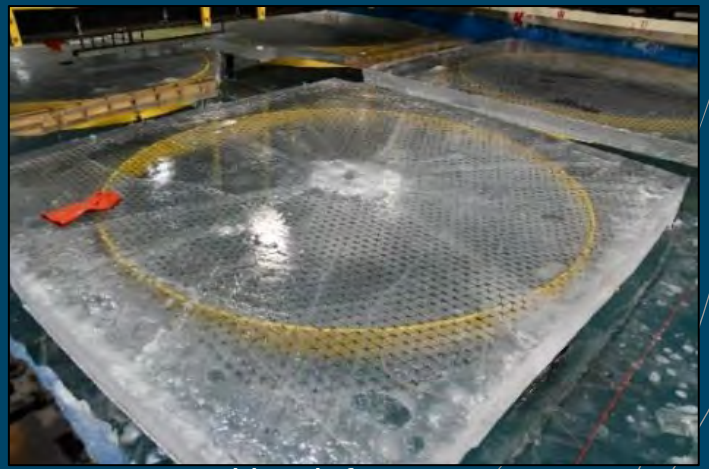
Physical Models

- Bow River in Calgary
- Study of flooding events and impacts to deposition of gravel from upstream erosion
- More to come – tomorrow!

Physical Models

2016 incident near Deline, NWT

Without reinforcement



With reinforcement

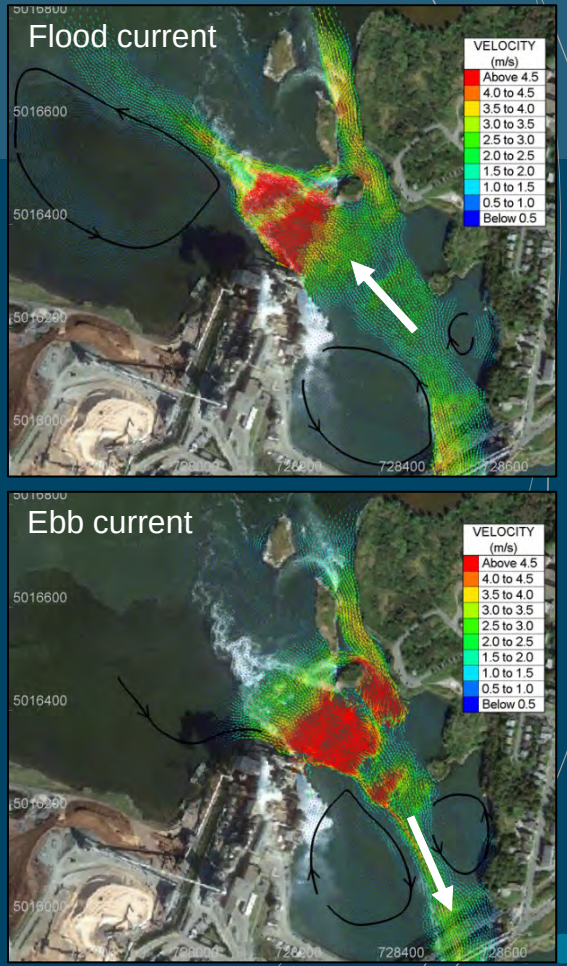
Ice Road Safety:
Solutions to extend the ice road season

Numerical Models

- Computer-based version of real-world systems or events
- Built using numbers and equations instead of physical materials
- Can be very simple or complex
- We can run 1000s of simulations to test many different scenarios
- Results can be quick - alerts and warnings
- Complexity determines cost

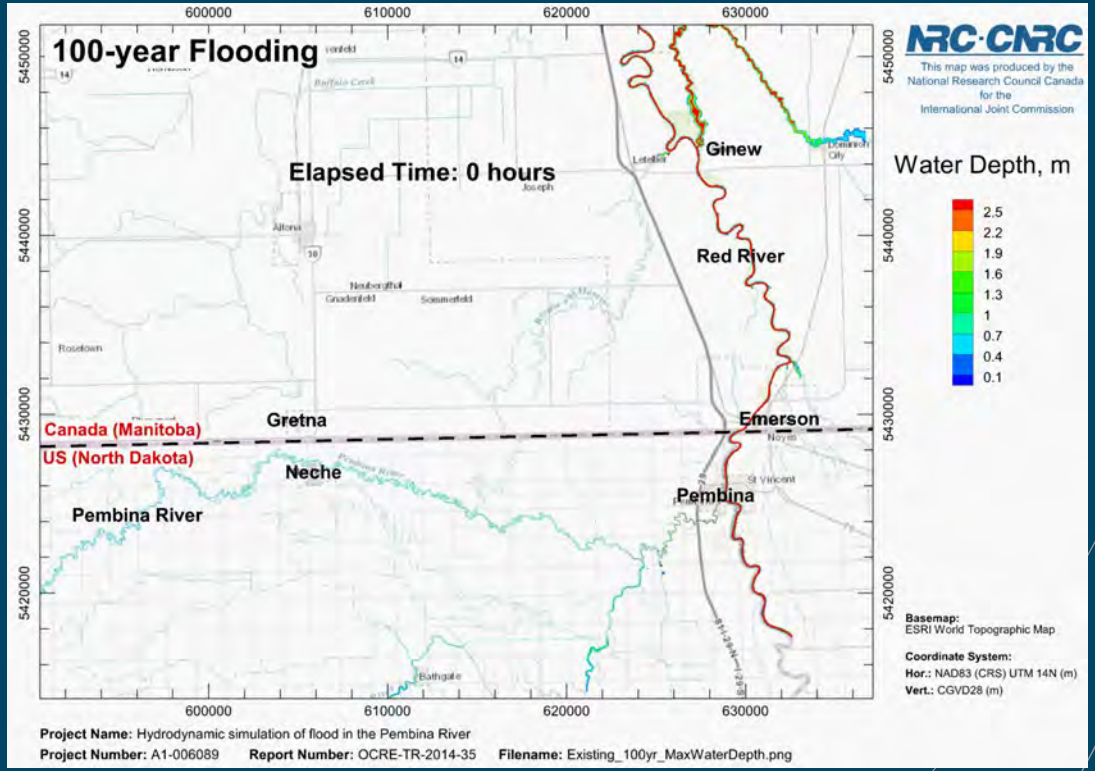
Numerical Models

- Saint John River in New Brunswick at Reversing Falls
- Tidal River – changing conditions
  - Locations of high turbulence
  - High river currents
  - Circulation fields
- Water quality – impacts on fish and aquatic ecosystems



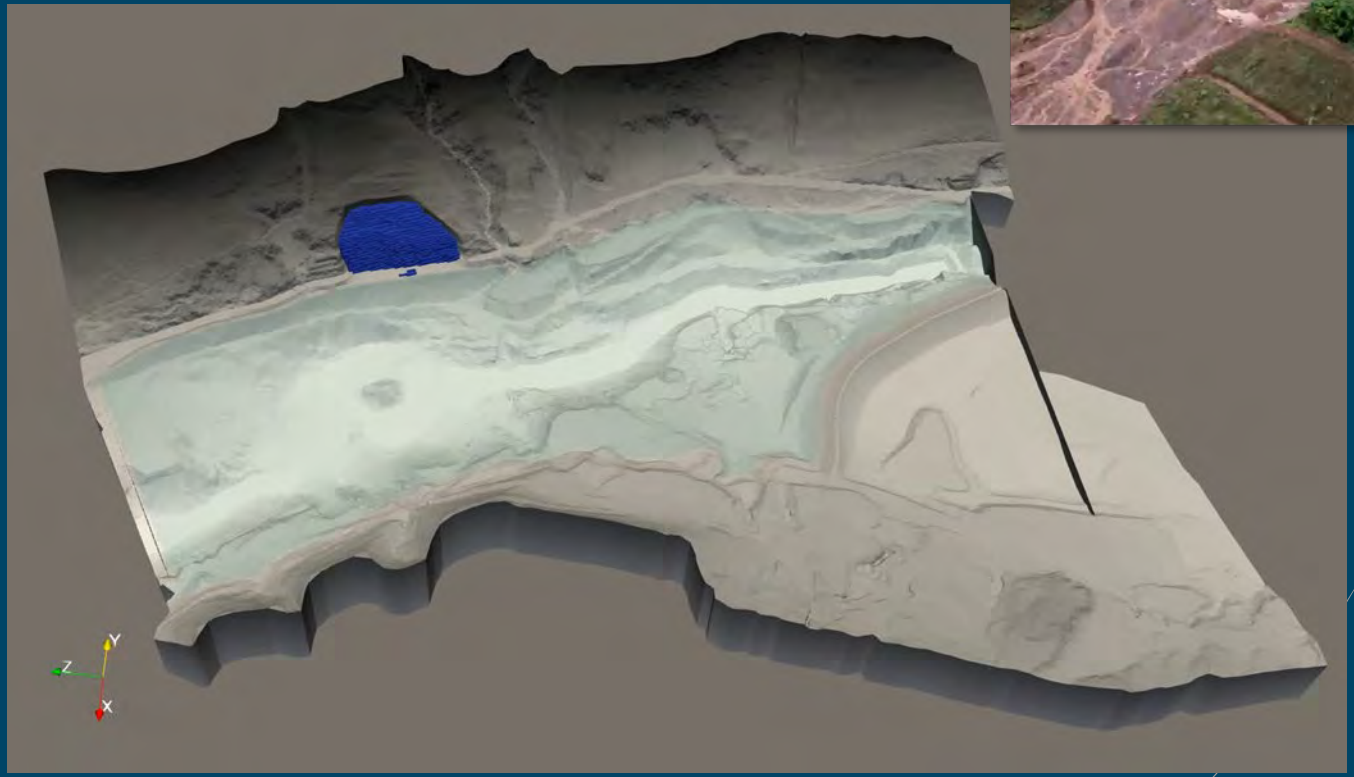
Numerical Models

Riverine Flooding



Numerical Models

Mud slide

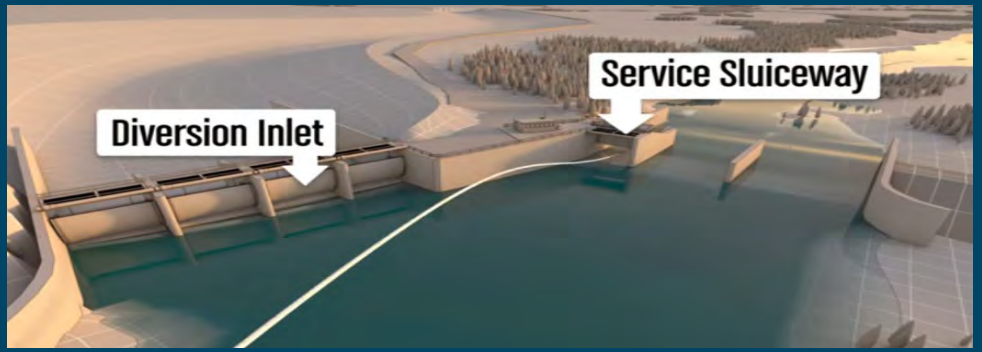


Numerical Models

Moving particles in the Mackenzie R.

Micro-plastics research

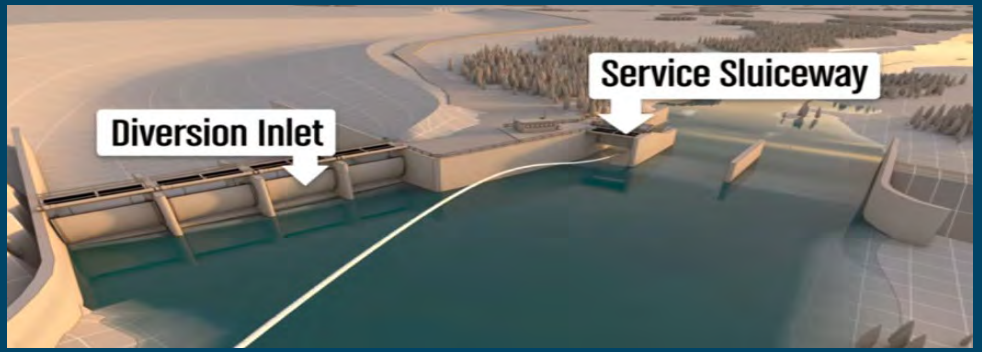
Example: Debris Interaction with Structures
Physical Model



- 2014 AB flood
- Extensive damages

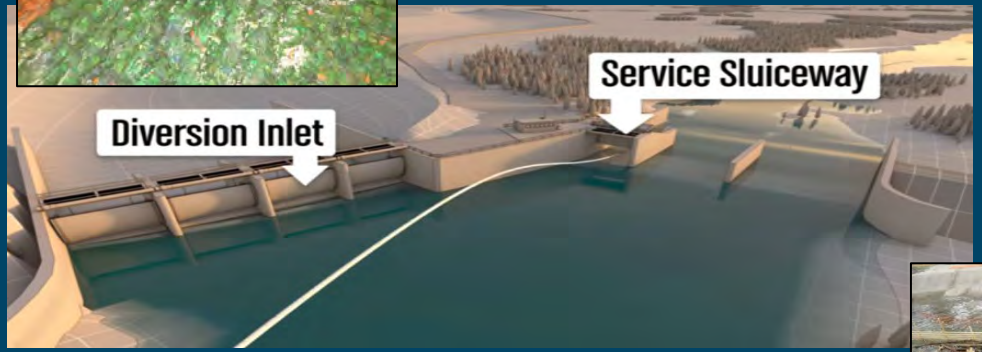
- Diversion to hold back and store upstream floodwaters until downstream levels fall

Example: Debris Interaction with Structures
Physical Model



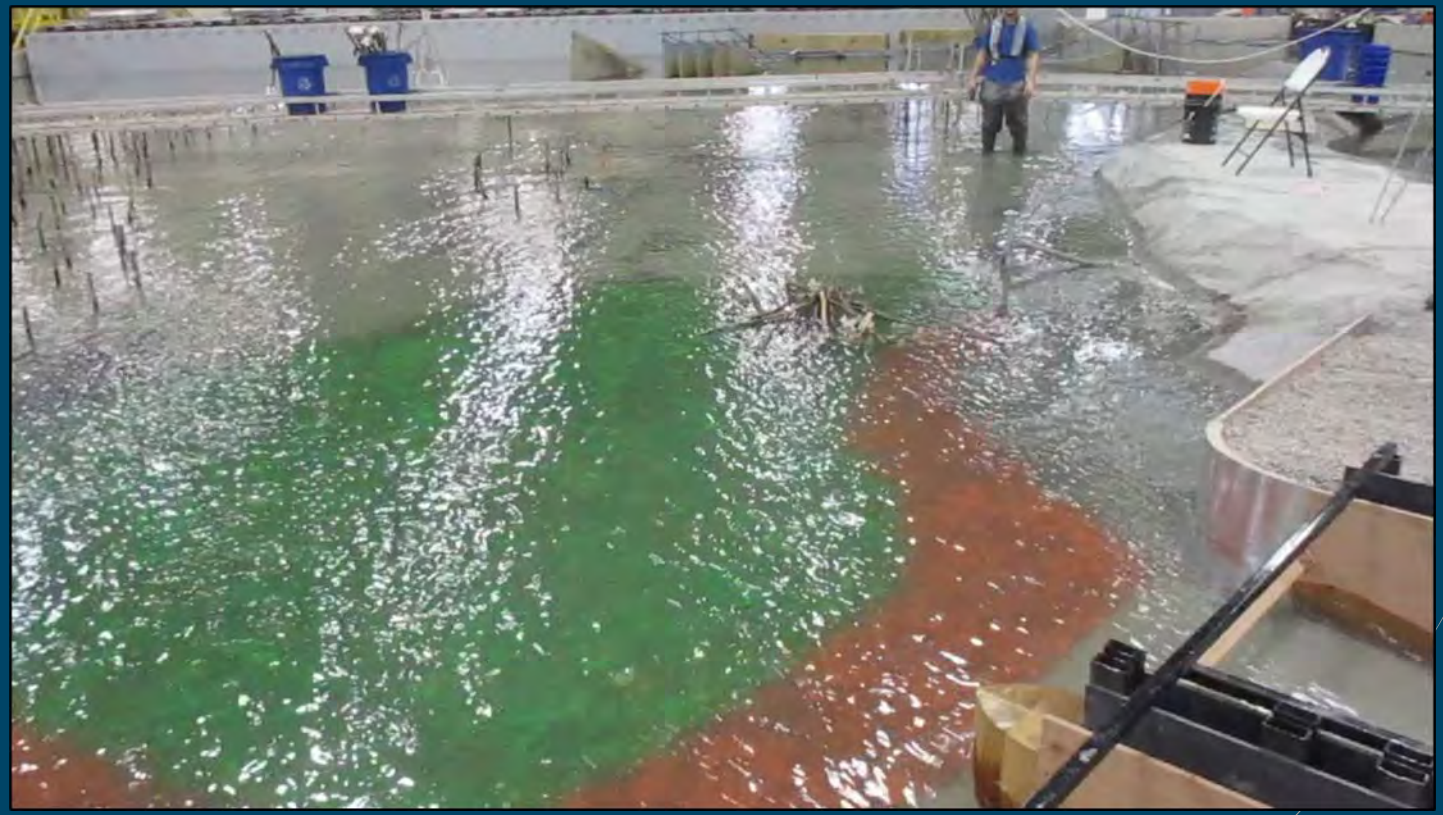
- Testing impact of woody debris
  - Potential to block flow through structures

Example: Debris Interaction with Structures
Physical Model



- Testing impact of woody debris
  - Design that allows safe passage of debris

Example: Debris Interaction with Structures Physical Model



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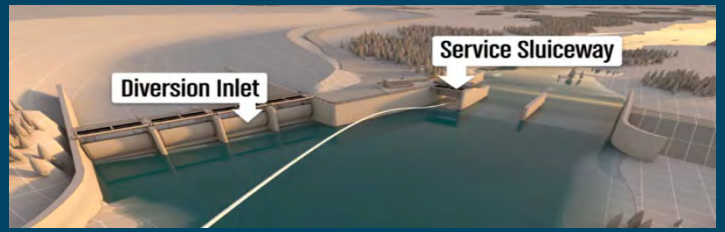

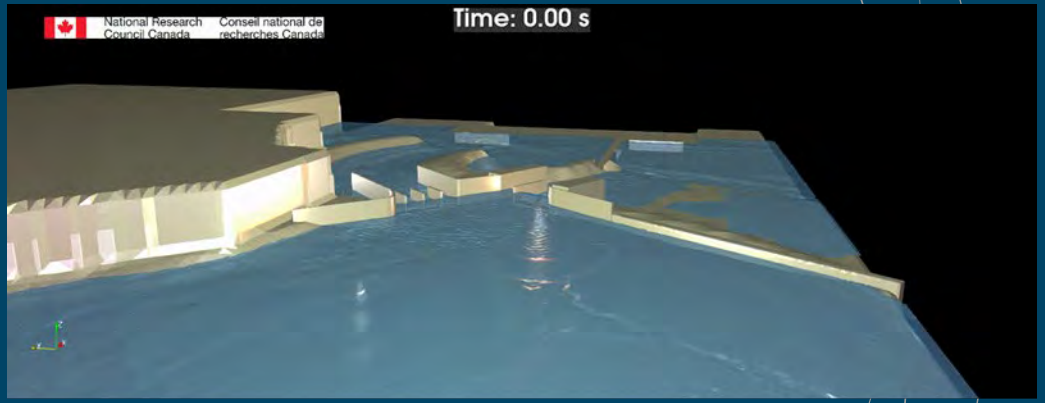

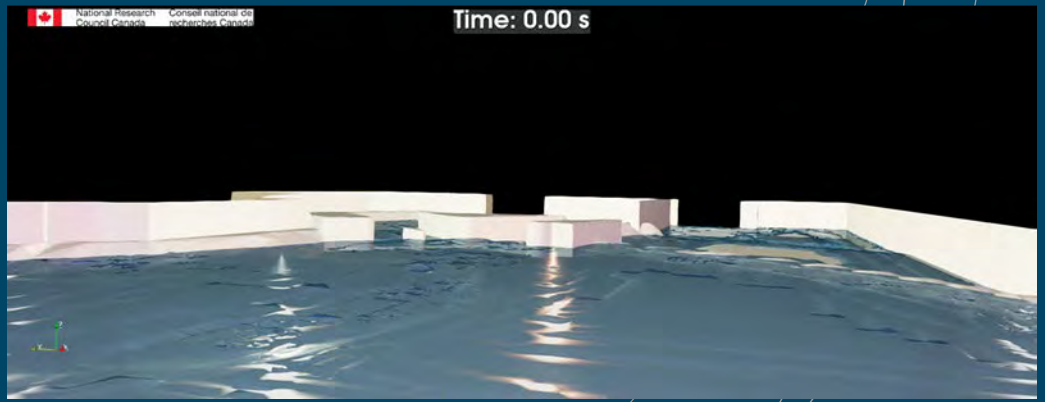

When to use a model?

The use of a model and model complexity depend on the needs of the project and **may not** always be required.

In general **large**, more **complex**, or **high-risk** projects justify the cost of using a model – small compared to potential damage or redesign costs if something goes wrong later.

Small, low-cost projects might be better to rely on existing data and knowledge, simplified calculations or design guidelines instead of developing a potentially expensive model.

Concluding Thoughts

Models help us predict future events and improve design.

Models are best used when the stakes are high – inform safer designs, reduce uncertainty and avoid costly mistakes during construction or future operation.

But beyond the technical side, models play an important role in helping communities. They can show how different designs protect homes, roads and infrastructure from risks of flooding and erosion. They help decision-makers choose safer, more effective solutions.

Using models early in the planning process can save time, reduce costs, and ultimately make communities more resilient to future events.

THANK YOU

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