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# Evolution of Modeling Tools to Support Management and Restoration of the Great Lakes

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LimnoTech
Water | Environment | Scientists | Engineers

# Presentation Outline

- Perspective on Integrated Decision Support Modeling in the Great Lakes
- Case Studies
  - Maumee River sediment and nutrient Management
  - Lower Don River, Toronto Redevelopment Design
  - Great Lakes water level regulation Policies
- The Future

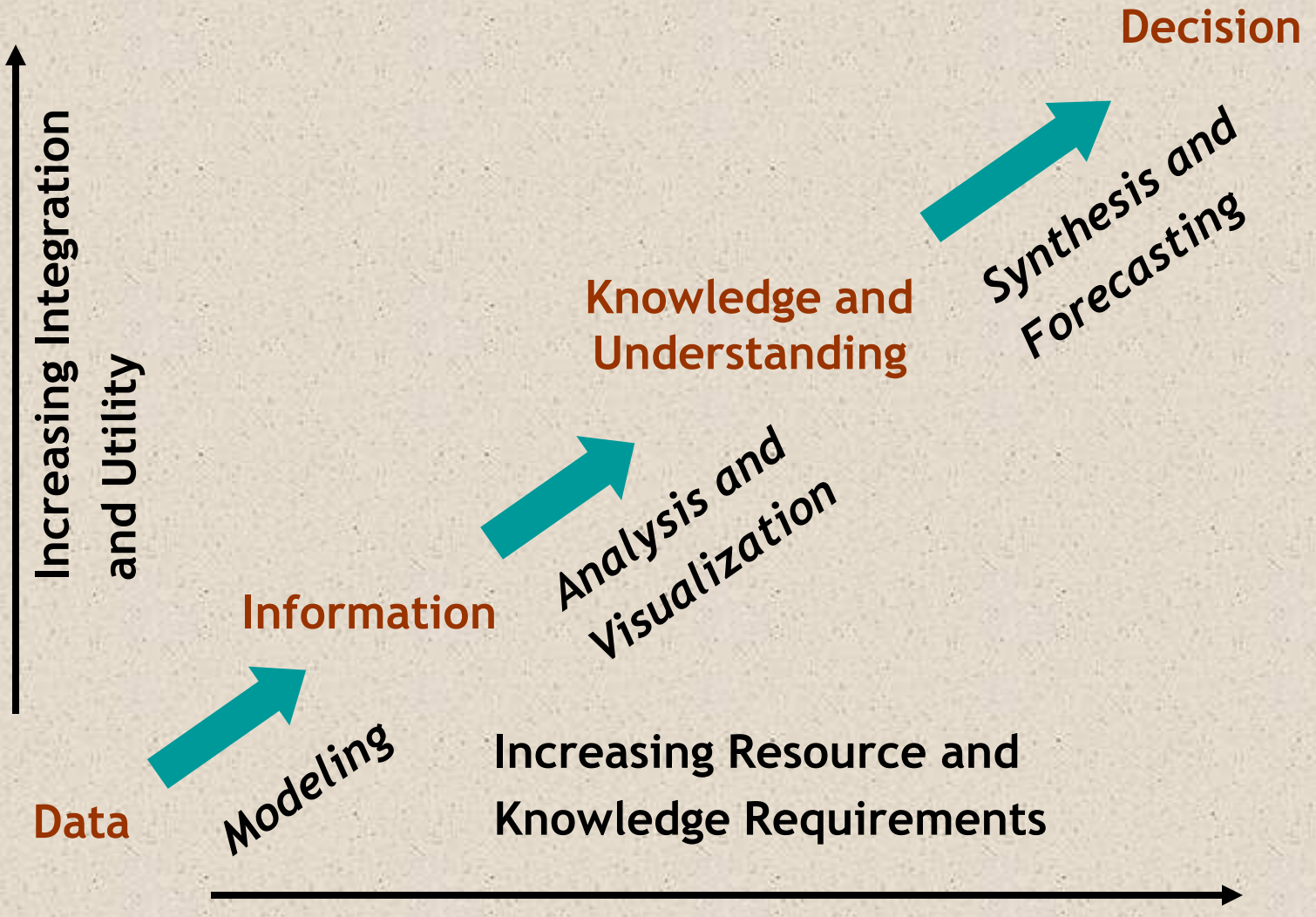
# Modeling for Great Lakes Management – whole lake models

- **1960 – 1980**
  - **Focus on nutrient – eutrophication modeling**
    - Models used to establish P as limiting nutrient in Great Lakes
    - Models used to set targets loads for phosphorus to lakes – Lake Erie
- **1980 – present**
  - **Focus on persistent, bioaccumulative, toxics**
    - Models used to assess exposure to PBTs
    - Models used to quantify time-dependent load – response relationships
  - **Fish bioenergetics and population dynamics models**
    - Models help understand the upper food web of each Great Lake
    - Models used to support stocking and harvest decisions

# Drivers for Development of Integrated Decision Support Models in Great Lakes (1990 - present)

- Concern about relative impacts of multiple stressors acting in concert to produce multiple ecosystem responses
  - issue feedback models (e.g., impact of ANS invasions on trophic conditions; effects of trophic conditions on toxics exposure, effects of water levels on coastal ecosystems)
- Concern about nearshore impacts (link fine-scale physical models to nutrient-eutrophication models)
- Quantify linkage between land use/watershed actions and lake trophic state (link watershed models to lake models)
- Ecosystem Forecasting needed to support *Ecosystem Restoration in the Great Lakes*

# Integrated Decision Support Modeling: Converting Data to a Decision



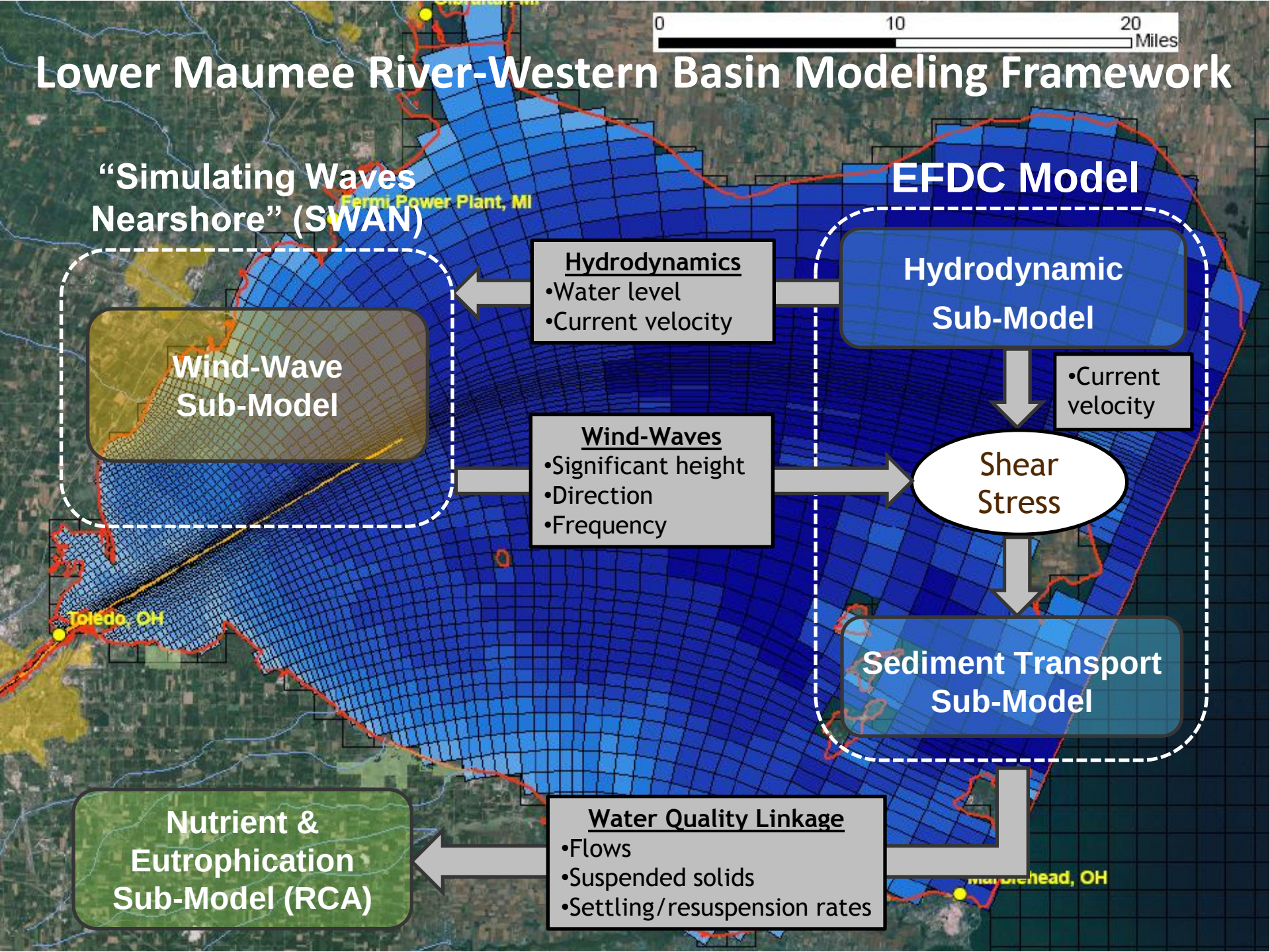
# Lower Maumee River - Lake Erie western basin Model (LMR-MB)

Example of Integrated Decision Support Modeling for Management Decisions: Regional sediment management and rivermouth harmful algal bloom management

# LMR-MB Model Project Objectives

- **Model ecological response to external (Maumee Watershed) and internal (wind-driven resuspension) sources:**
  - **Sediment ⇨sedimentation and turbidity**
    - Annual navigation channel dredging
      - ~640,000 $yd^3$ (~$5M/yr)
      - >70% open-lake disposal
  - **Nutrients ⇨nuisance & harmful algal blooms**

- **Support USACE management decisions:**
  - **Minimize need for dredging and associated impacts**
  - **Beneficial reuse of dredged material for habitat enhancement**
  - **Nutrient – Eutrophication problems**
- **LMR-MB model is one component of a linked watershed-receiving water model to support comprehensive system management planning:**
  - **Sediment management**
  - **Nearshore water quality management (GLRI - WLEBP)**
  - **Navigation**
  - **Coastal erosion**
  - **Flood control**


0
10
20
Miles
Lower Maumee River-Western Basin Modeling Framework
"Simulating Waves Nearshore" (SWAN)
Fermi Power Plant, MI
EFDC Model
Hydrodynamics
•Water level
•Current velocity
Hydrodynamic Sub-Model
Wind-Wave Sub-Model
•Current velocity
Wind-Waves
•Significant height
•Direction
•Frequency
Shear Stress
Toledo, OH
Sediment Transport Sub-Model
Nutrient & Eutrophication Sub-Model (RCA)
Water Quality Linkage
•Flows
•Suspended solids
•Settling/resuspension rates
Marblehead, OH

# WinModel - Data Analysis and Visualization Tool

- Comprehensive framework for model processing and visualization
  - Spatial and temporal profiles
  - Map-based; animations
  - Scenario comparisons
- Configured for use with multiple modeling tools
- Significantly improves model management and calibration/application efficiency
- Provides user-friendly tools for evaluating model results and regulatory and management alternatives

# WinModel Visualization Tools

Water quality and sediment sub-model results

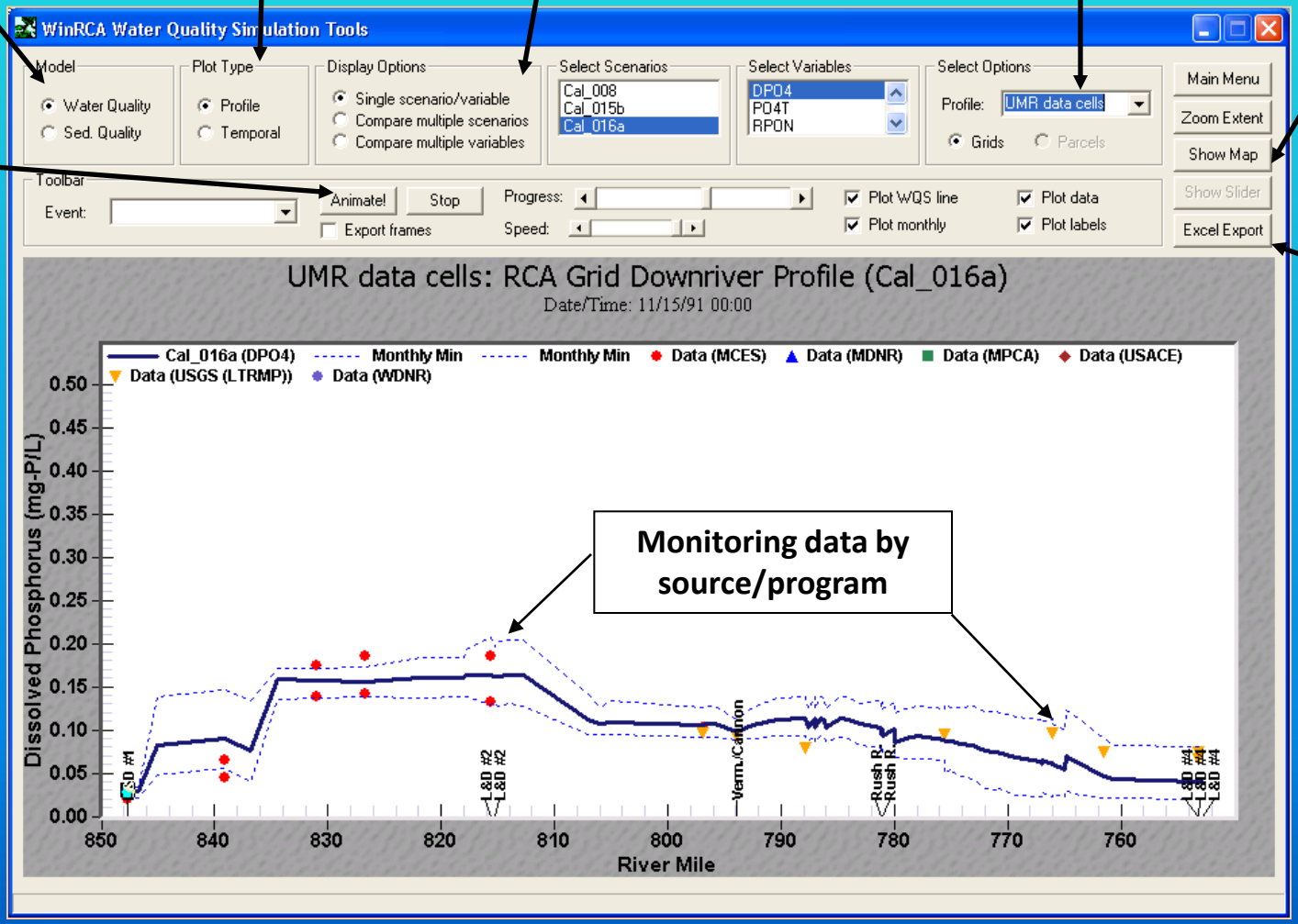
Spatial and temporal plots

Compare multiple scenarios/variables

View different longitudinal profiles / maps

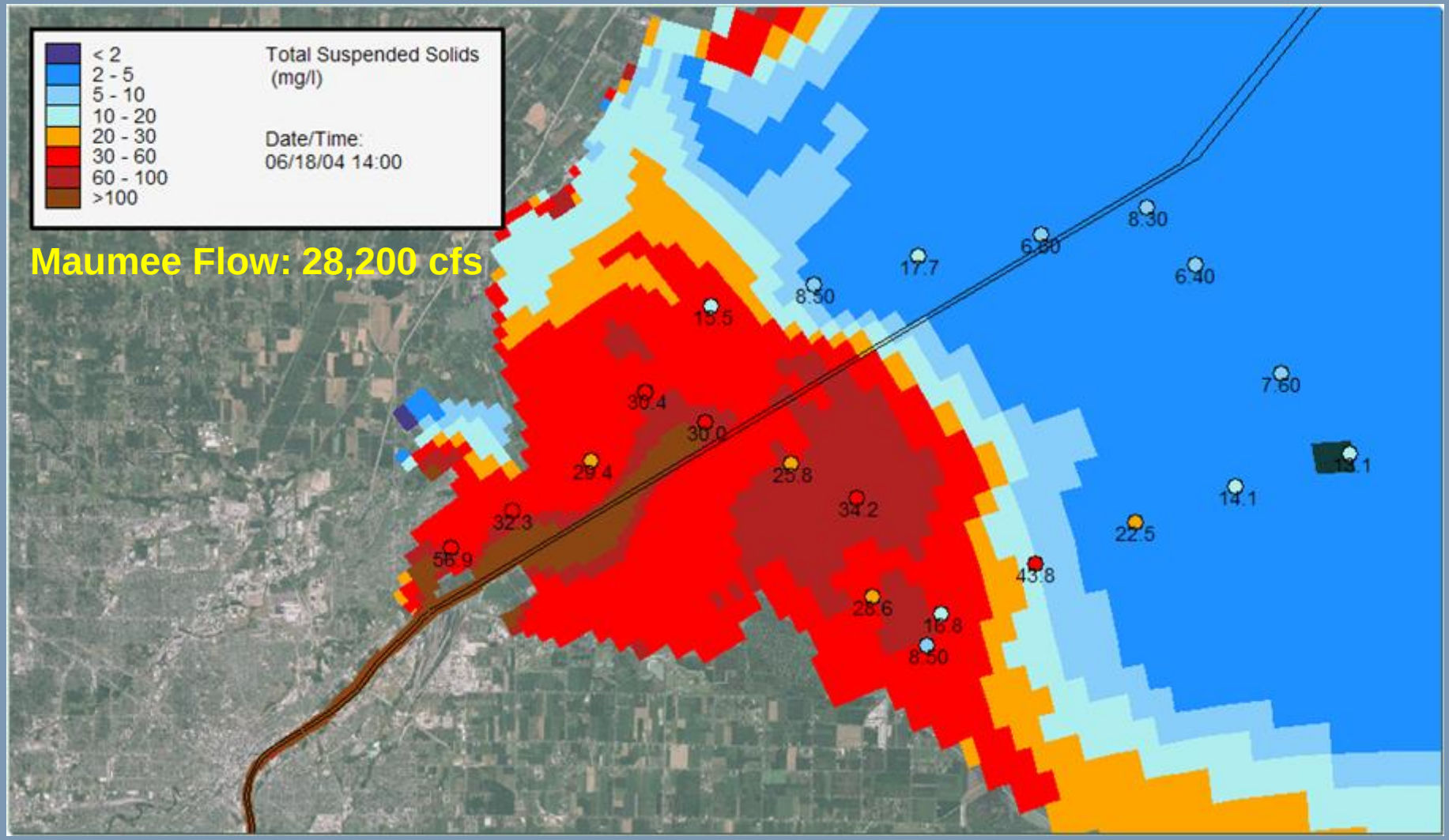
Display results on the model grid/map

Animate through time/space



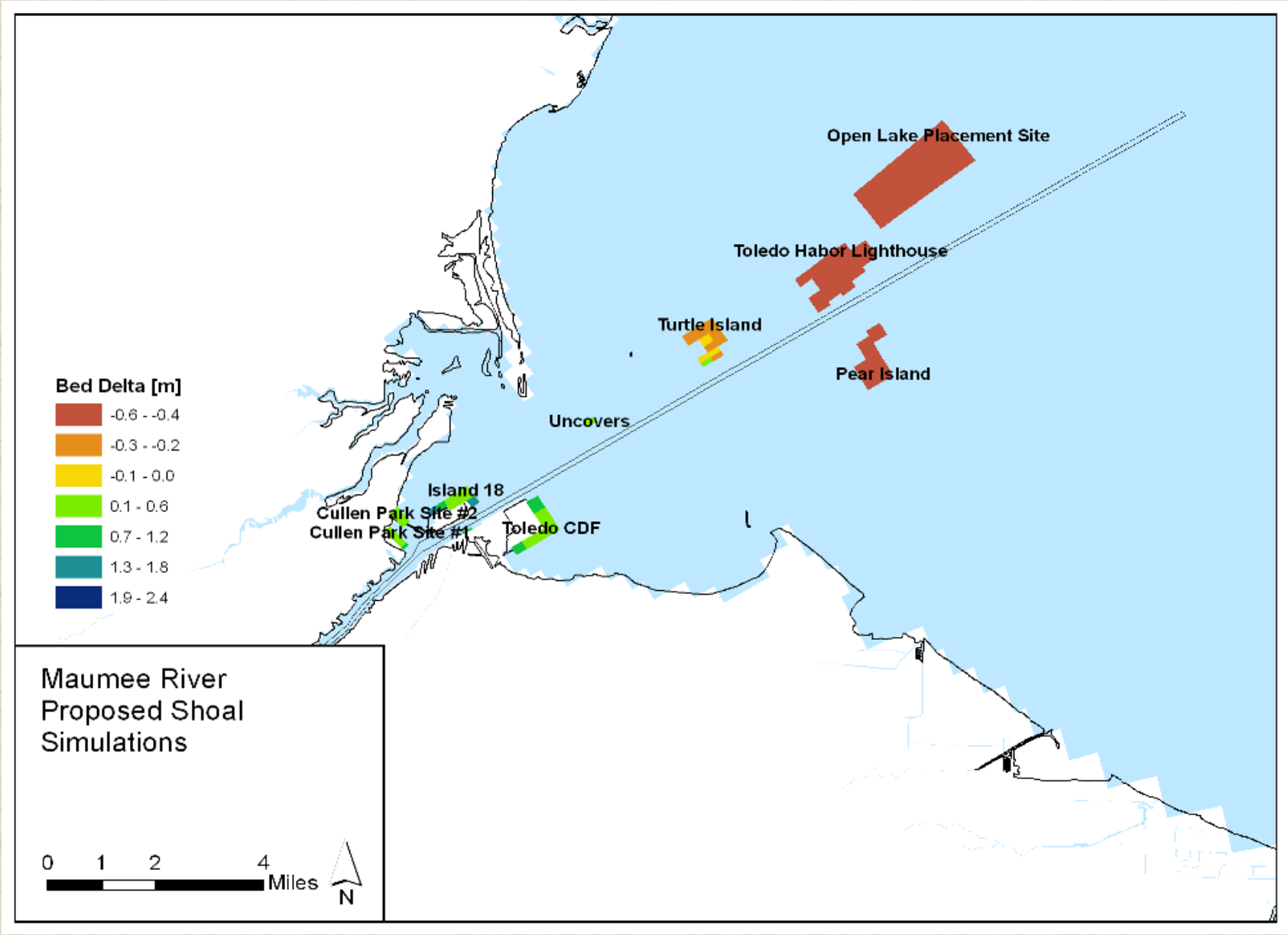

Export Results

# Model-Data Comparison for Total Suspended Solids (6/18/2004)




Data provided by Tom Bridgeman, University of Toledo

# Simulation of Bed Elevation Changes in Proposed Shoal Areas During 2004-05



# Lower Don River, Toronto hydraulic-sediment transport model

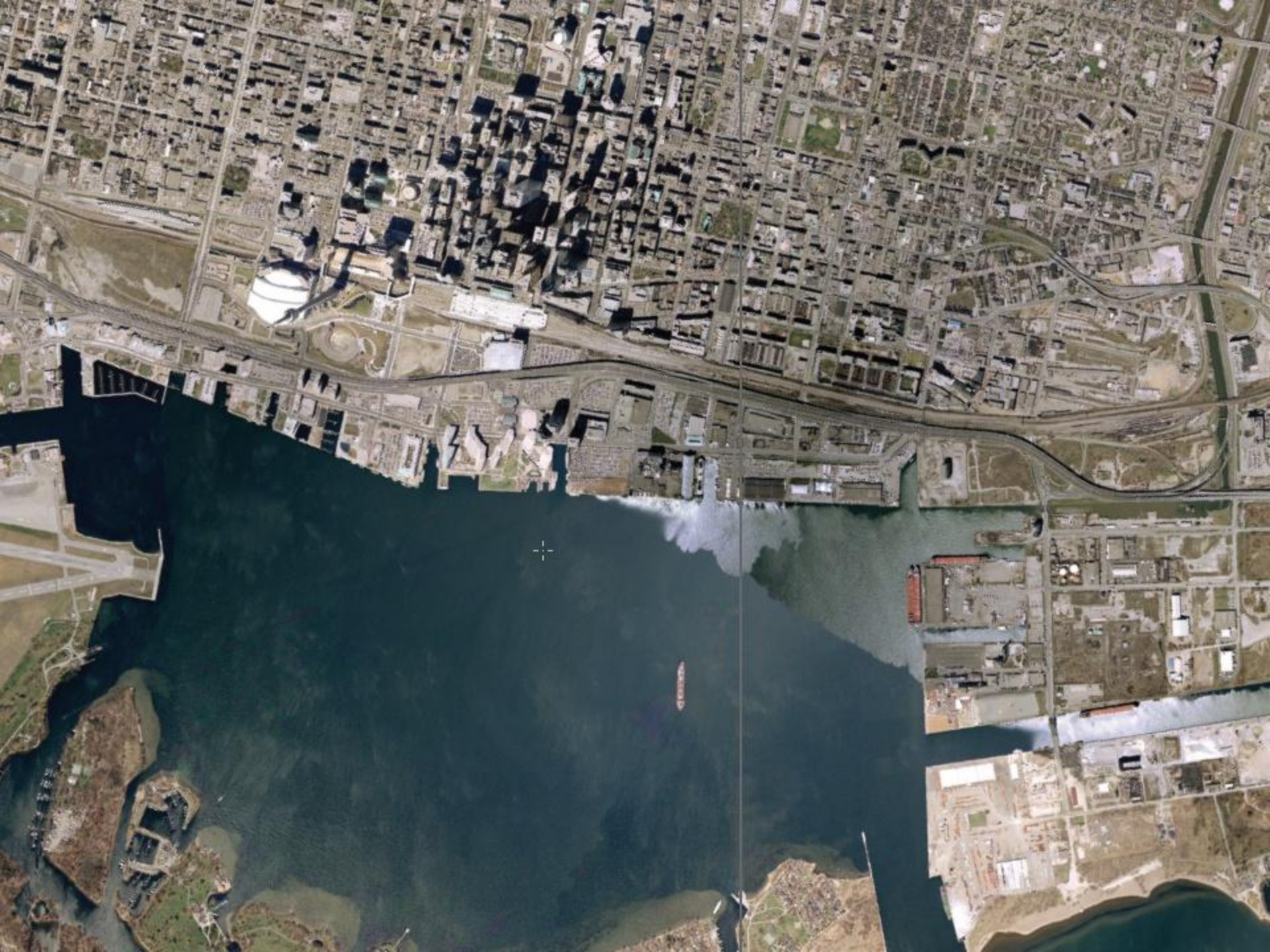
**Example of Integrated Decision Support Modeling for Restoration Design Decisions:**
Redesign river channel to support multiple ecosystem services

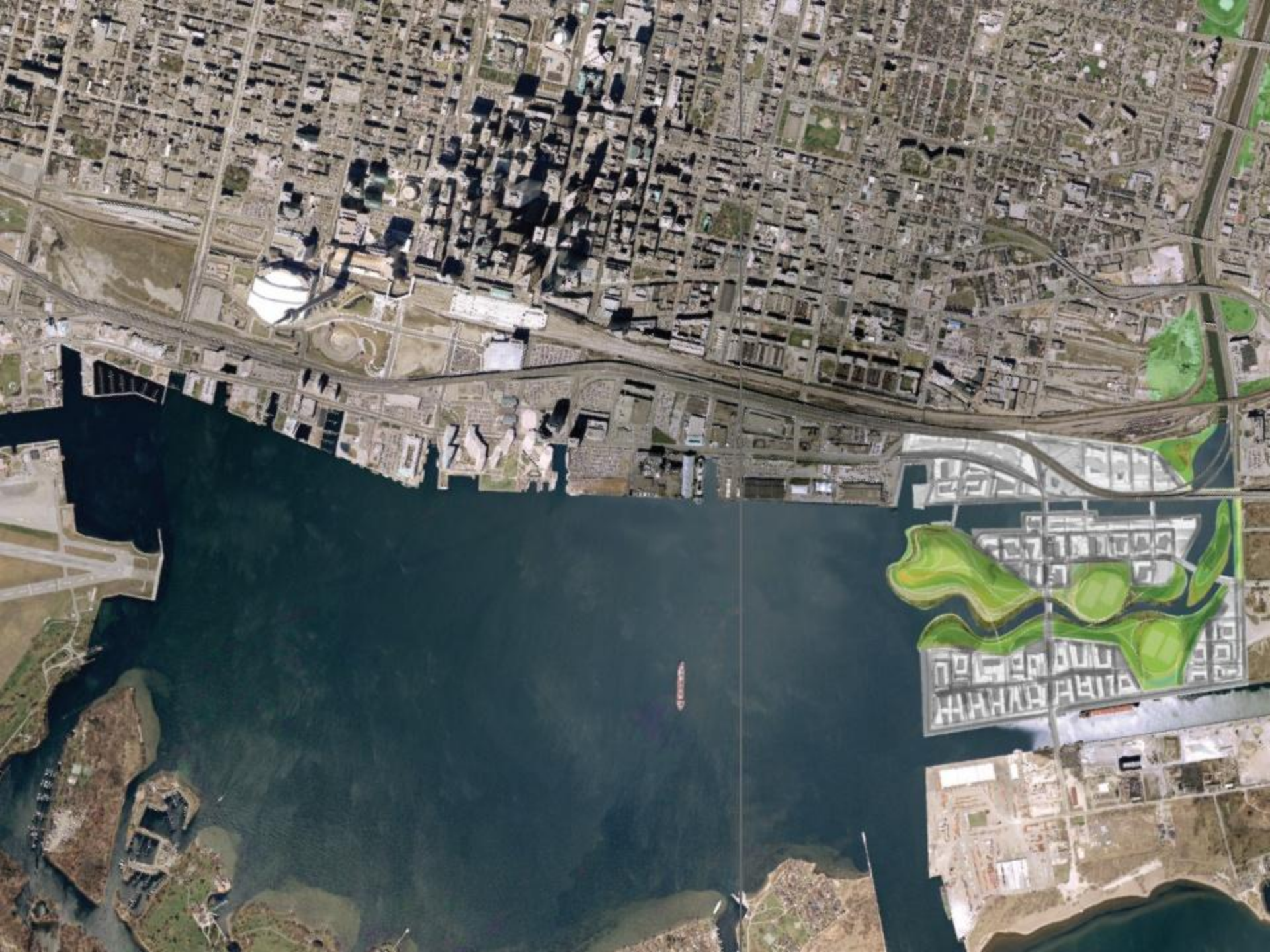
# Lower Don River, Toronto

- Toronto Waterfront Revitalization Corporation (now Waterfront Toronto) supported a design project “to produce a bold and compelling concept for the Lower Don River”
- LimnoTech worked with Michael Van Valkenburgh Assoc. and Applied Ecological Services to produce a re-development design

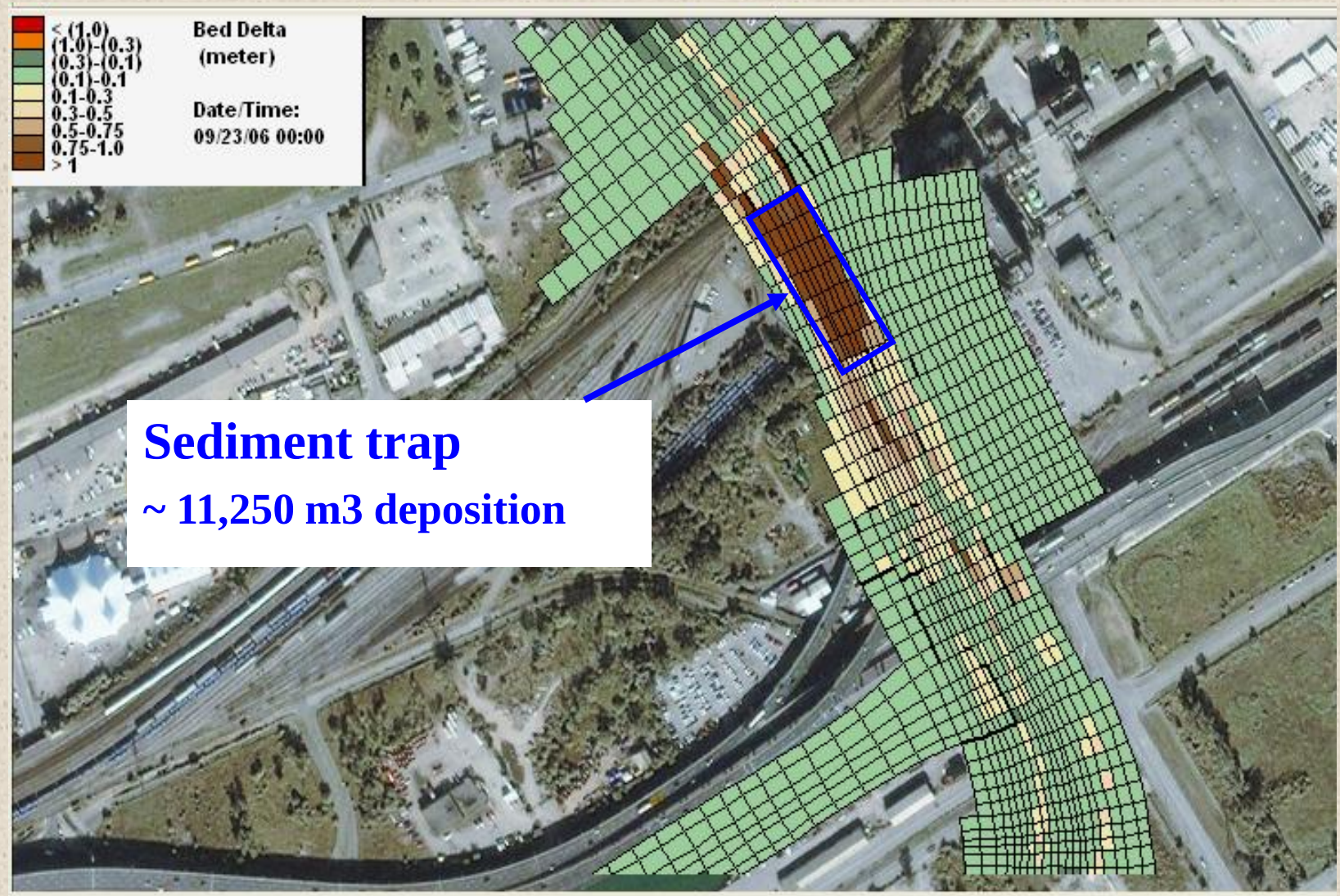
# Donlands Design Drivers

- Provide a restored, sustainable rivermouth ecosystem at the mouth of the Don River
- Create a continuous riverfront park system
- Provide for harmonious new development
- Connect waterfront neighborhoods
- Prioritize public transit
- Develop a gateway into the port lands
- Promote sustainable development
- Expand opportunities to interact with the water
- Manage floodwaters and sediment load





# Bed Elevation Change for 5-year Event Design Simulation



# Maintenance Schedule: Baseline Trap (71 m elevation, ~ 15,000 m3)

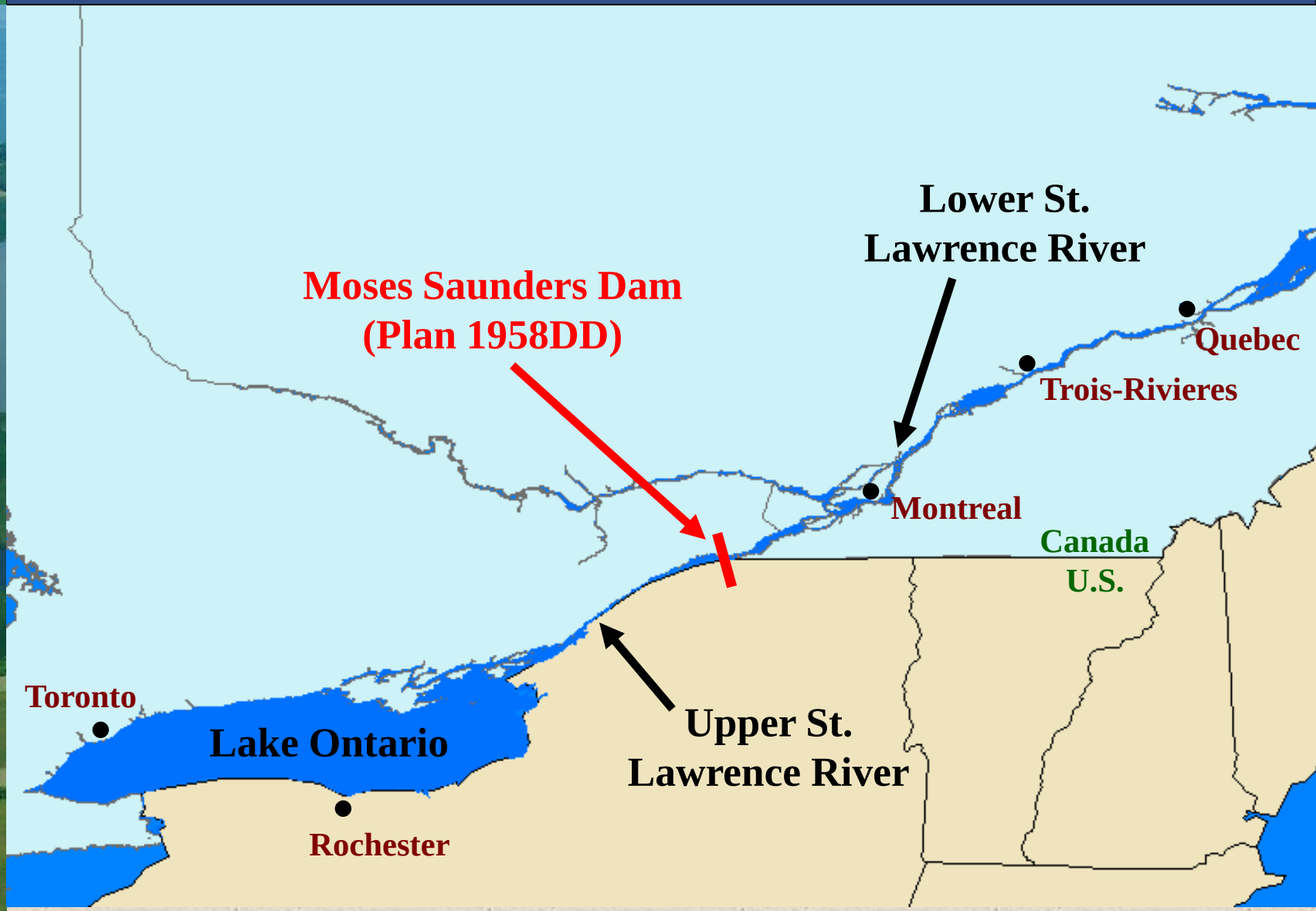
- For a “typical” year:
  - Anticipate dredging trap at least twice per year: Expect drop in trap efficiency at ~ 60 - 75% full (~9,000 - 11,250 m3). Similar to the deposition in the 39-day simulation and the 2-yr design event.
  - Dredging when 33% full (~ 5,000 m3) would leave enough capacity for a 2-yr event and would require dredging approximately four times per year.
- Events:
  - 2-yr event and larger expected to necessitate maintenance.
  - 5-yr event captured only if trap starts empty.
  - 25-yr event overfills trap.


Riverdale Park
Regent Park
Riverdale
Leslieville
South of Eastern
Corktown
West Don Lands
FilmPort
Distillery District
East Baytrout

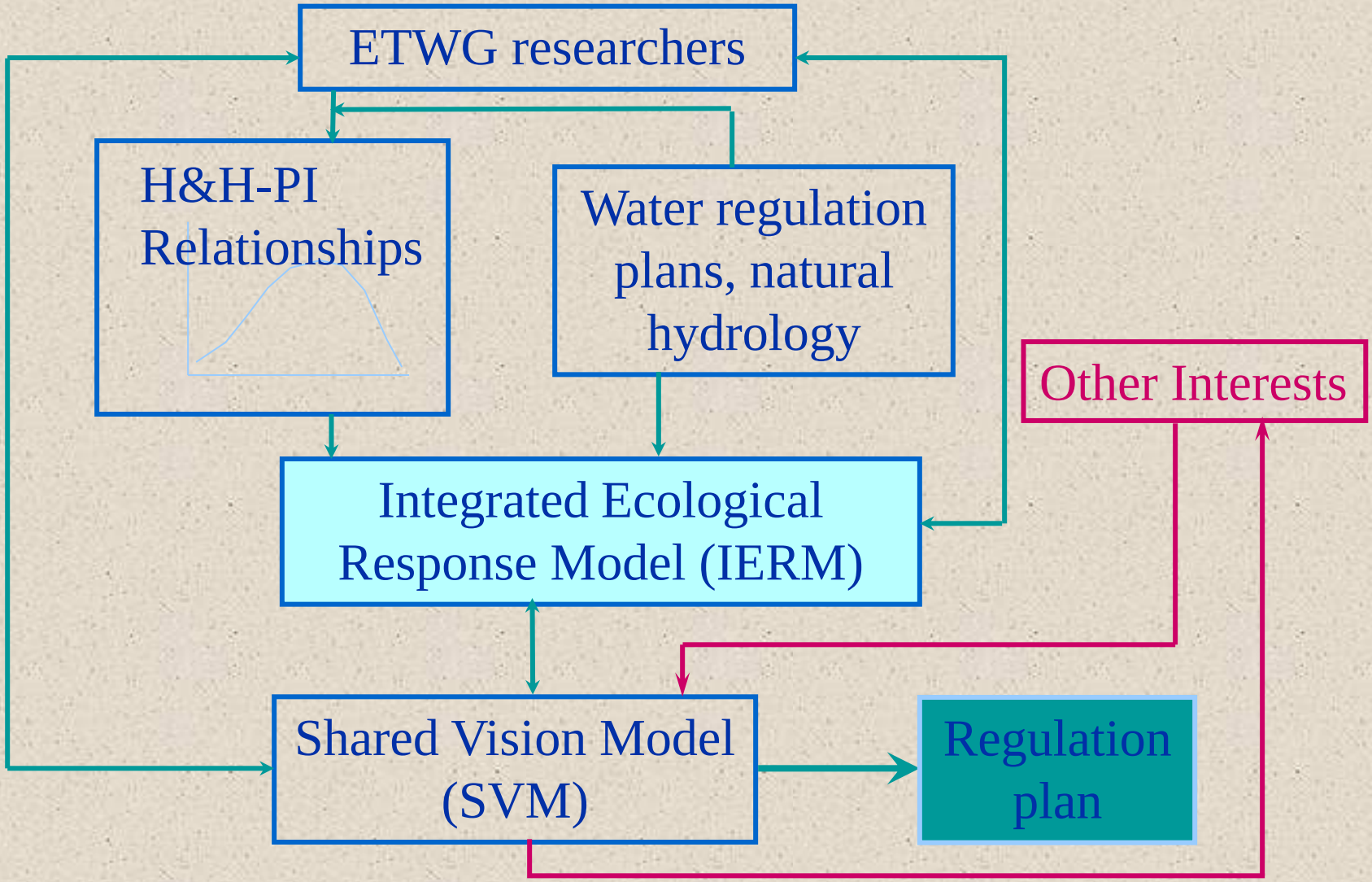
# Integrated Ecological Response Models

Example of Integrated Decision Support Modeling for Policy Decisions: Evaluation of water level and flow regulation plans for Lake Ontario and St. Lawrence River (LOSL-IERM) and for Upper Great Lakes (IUGLS-IERM2)

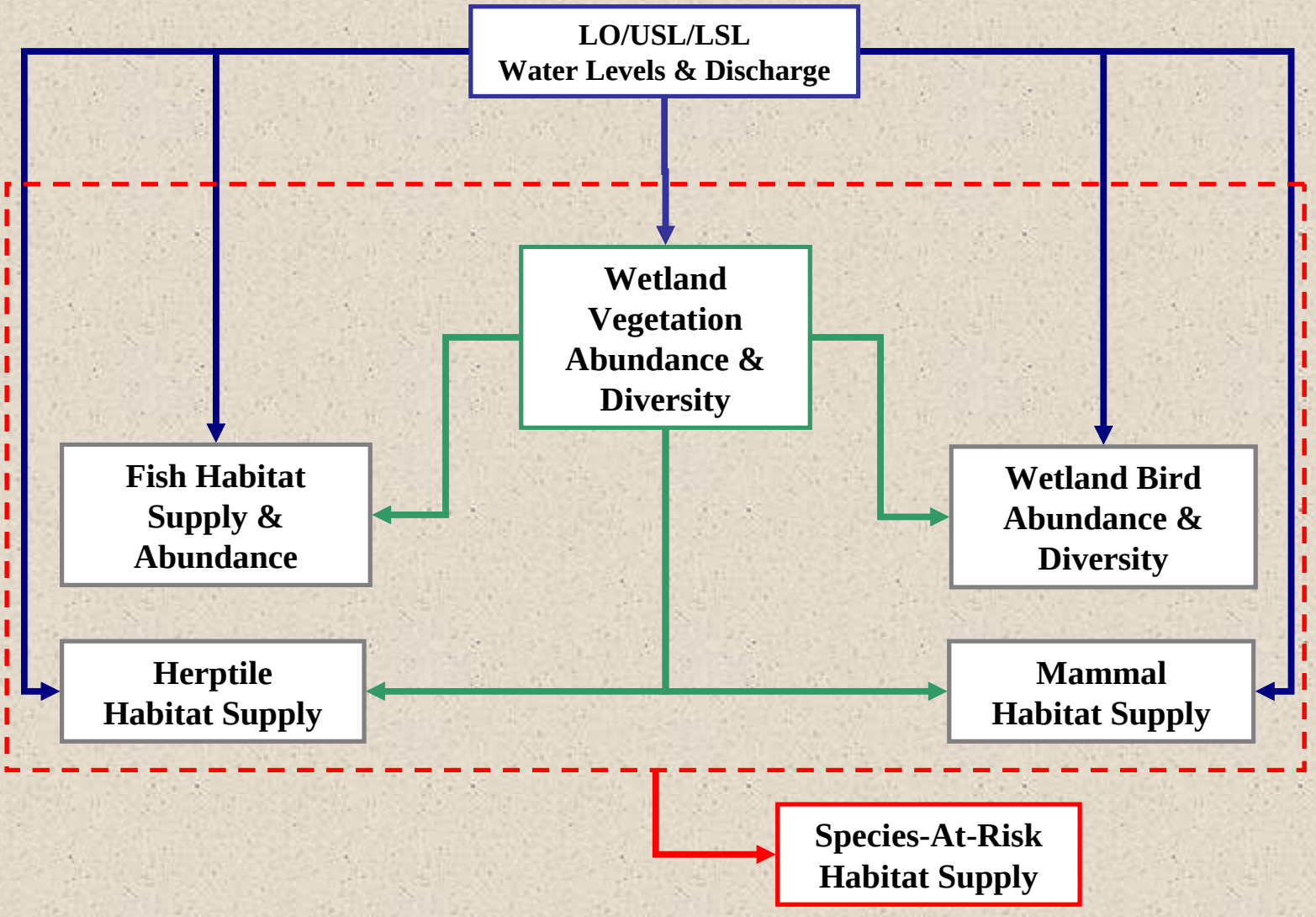
# LOSL Regulation Study Area



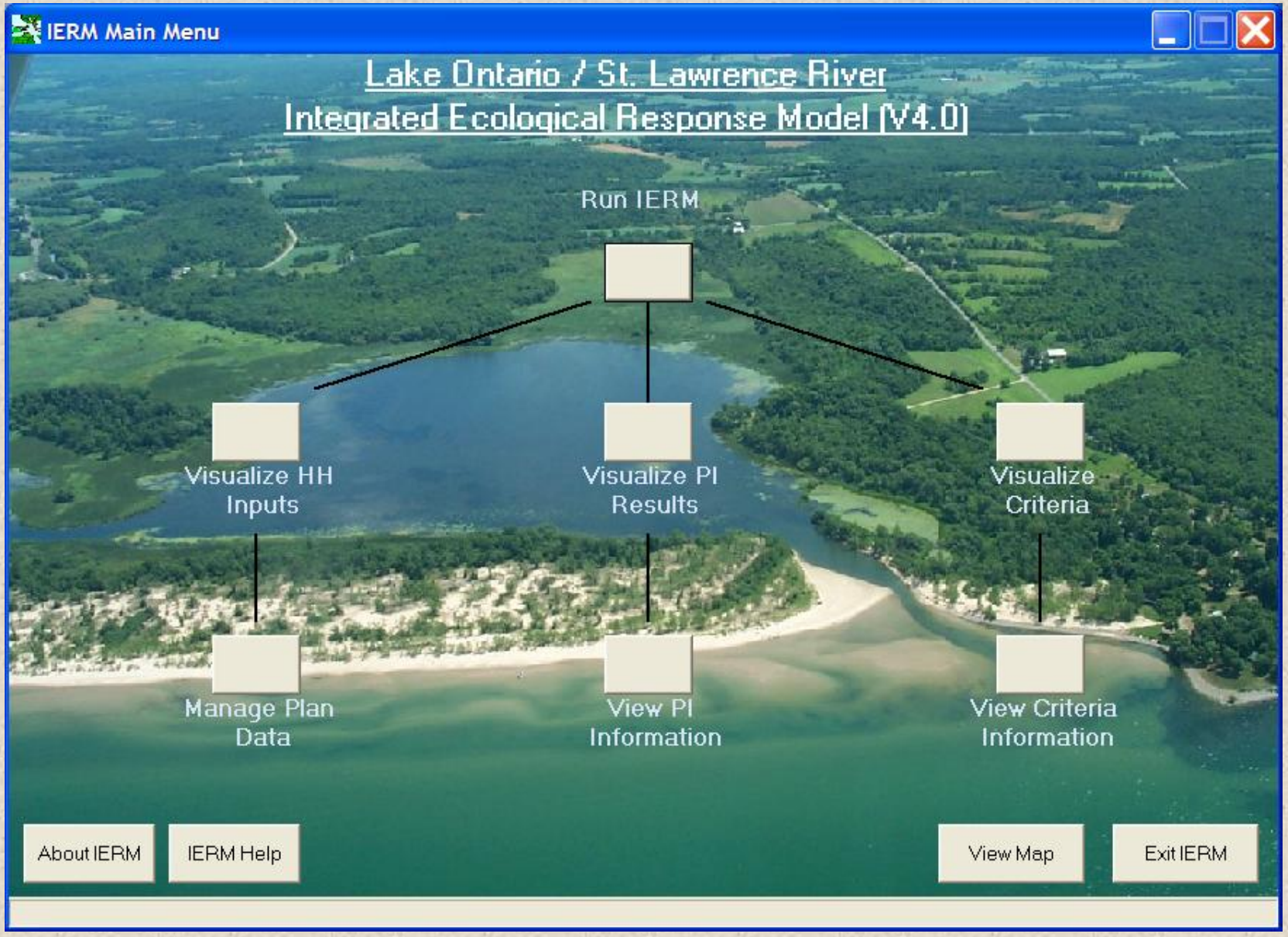
# Role of IERM in Study

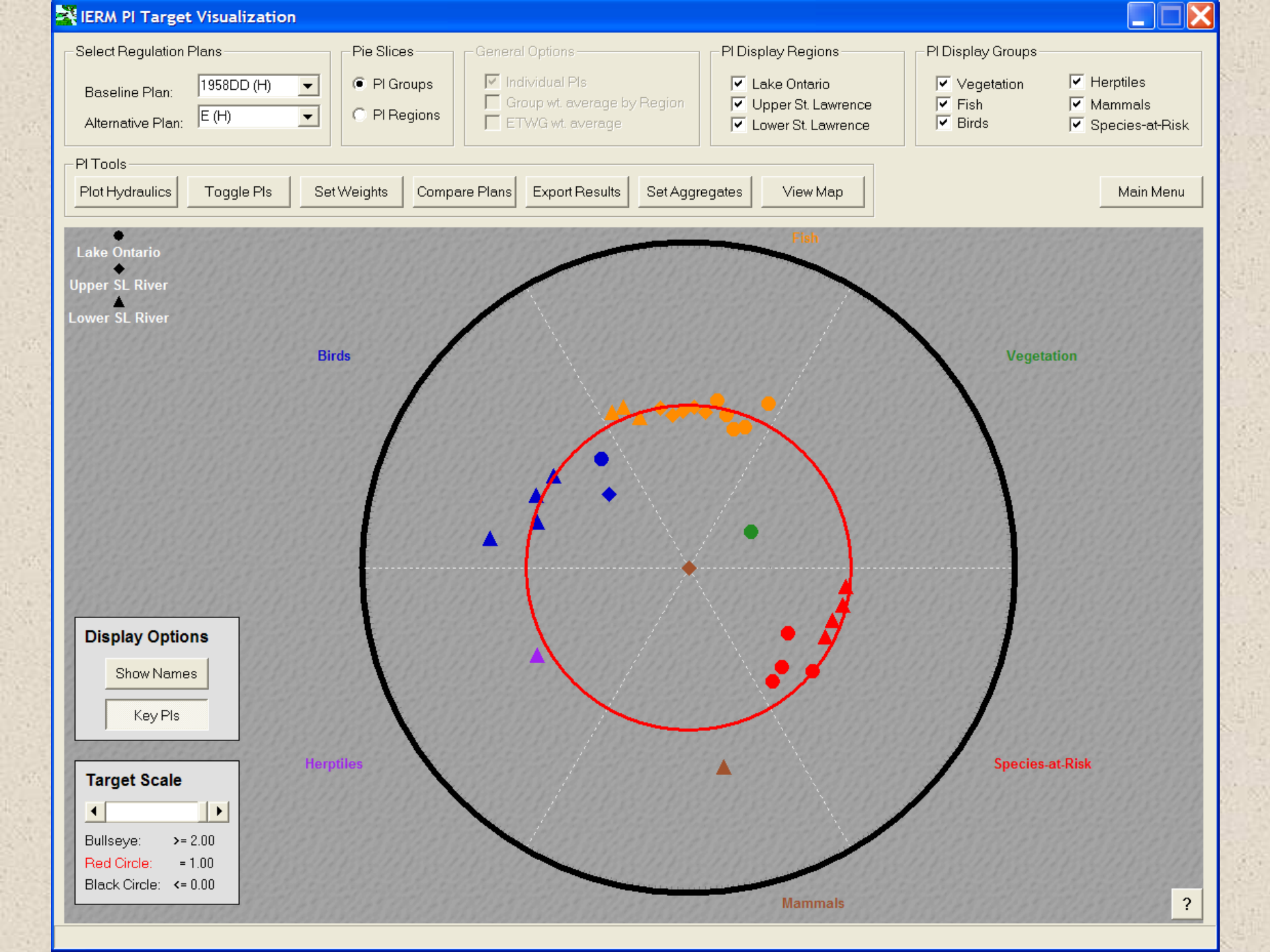


# IERM Conceptual Model



# IERM Decision Support Tool




IERM PI Target Visualization
Select Regulation Plans
Baseline Plan:
1958DD (H)
Alternative Plan:
E (H)
Pie Slices
PI Groups
PI Regions
General Options
Individual PIs
Group wt. average by Region
ETWG wt. average
PI Display Regions
Lake Ontario
Upper St. Lawrence
Lower St. Lawrence
PI Display Groups
Vegetation
Fish
Birds
Herptiles
Mammals
Species-at-Risk
PI Tools
Plot Hydraulics
Toggle PIs
Set Weights
Compare Plans
Export Results
Set Aggregates
View Map
Main Menu
Lake Ontario
Upper SL River
Lower SL River
Fish
Birds
Vegetation
Herptiles
Species-at-Risk
Mammals
Display Options
Show Names
Key PIs
Target Scale
Bullseye: >= 2.00
Red Circle: = 1.00
Black Circle: <= 0.00
?

IERM Performance Indicator Time Series Results

Select Regulation Plans

Baseline Plan: 1958DD (H) Plot

Alternative Plan: E (H) Plot

PI Overview

Region: Group:

**Least Bittern (IXEX) - reproductive index (Lake Ontario) (index)**

PI Aggregate Scores

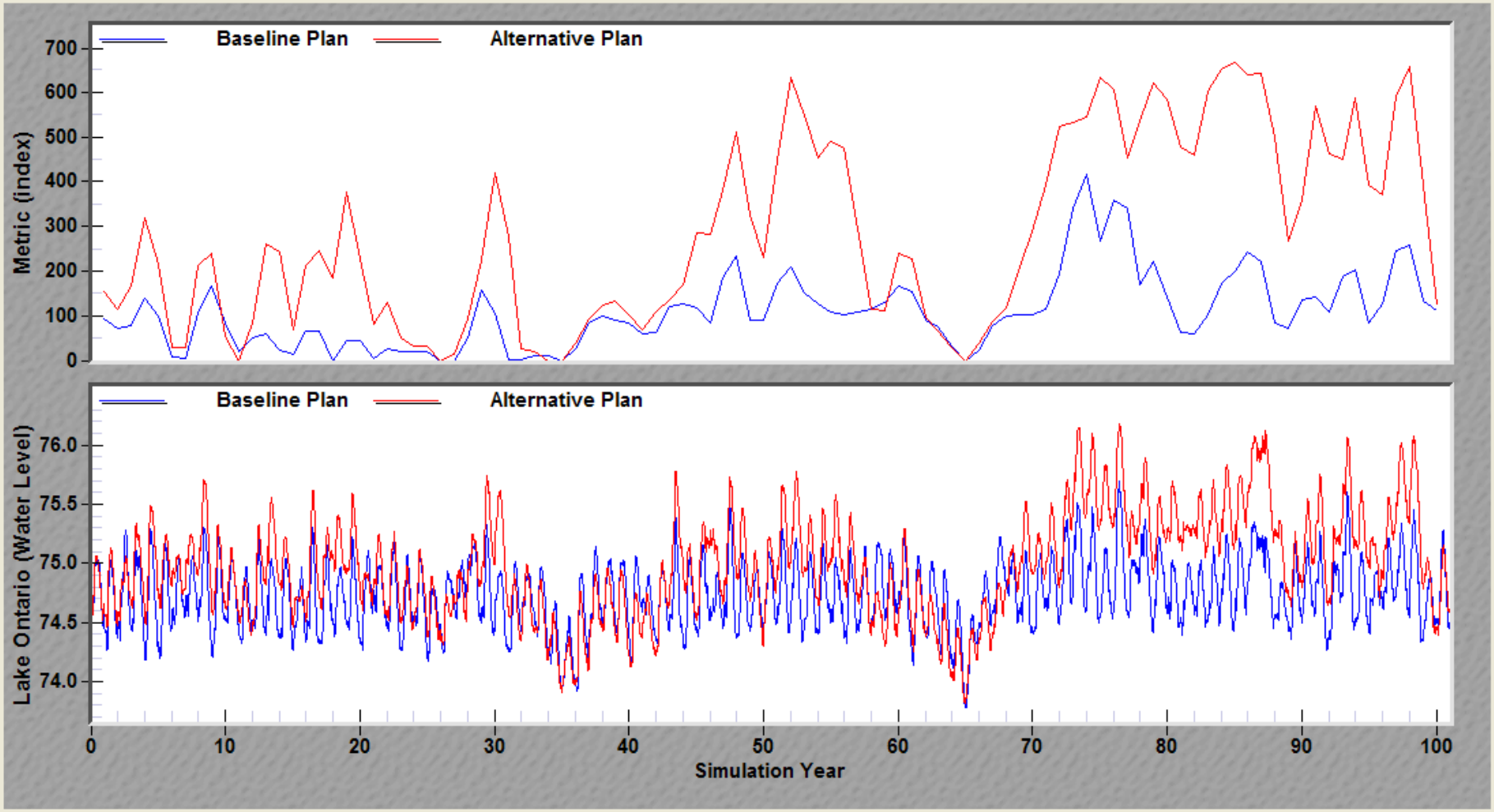
**Ratio:** 1.133

Baseline: 0.750

Alternative: 0.850

Zoom

Zoom Extent




PI Tools

Plot Group | Export Results | PI Browser

?

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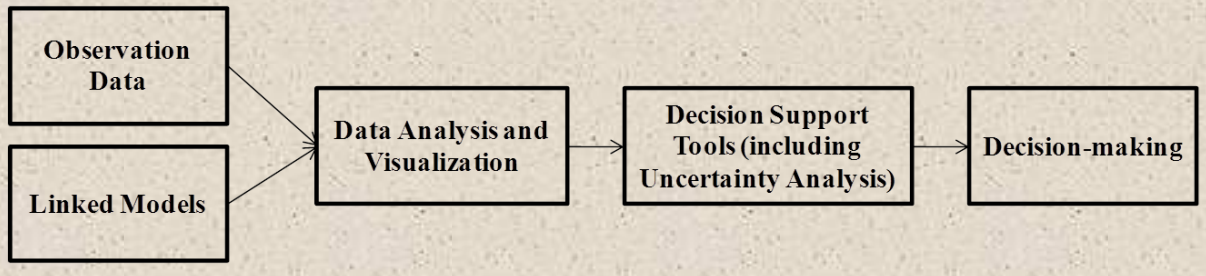
# Environmental Performance for Plan Selection
## (Ratio relative to no regulation based on historical supplies)

| | Performance Indicators | Current Plan | New Plan |
|---|---|---|---|
| Lake Ontario | Wetland Meadow Marsh Community | 0.64 | 0.91 |
| | Least Bittern reproductive index | 0.88 | 1.01 |
| | Virginia Rail reproductive index | 0.87 | 1.03 |
| | Black Tern reproductive index | 0.86 | 1.03 |
| | King Rail preferred breeding habitat | 0.79 | 0.94 |
| Upper St. Lawrence River | Northern Pike YOY net productivity | 0.48 | 0.67 |
| | Virginia Rail reproductive index | 0.75 | 0.89 |
| | Muskrat house density | 0.07 | 0.18 |
| Lower River | Muskrat surviving houses | 0.95 | 0.90 |

- Out of the 19 environmental performance indicators examined on the Lake and Upper River, those listed above showed a significant difference between the current and new plan.
- None of the 13 PIs on the Lower River showed any significant difference including the muskrat.

# The Future - Continued Development of:

- Multi-stressor, multi-response aquatic ecosystem models
- Multi-media models, including linked watershed - receiving water models
- Fine-spatial scale linked hydrodynamic - sediment transport - water quality models
- Integrated Models with Decision Support Systems




- Integrate ecological systems with human systems models
- Downscaling of GCMs to Great Lakes region and analysis of climate change impacts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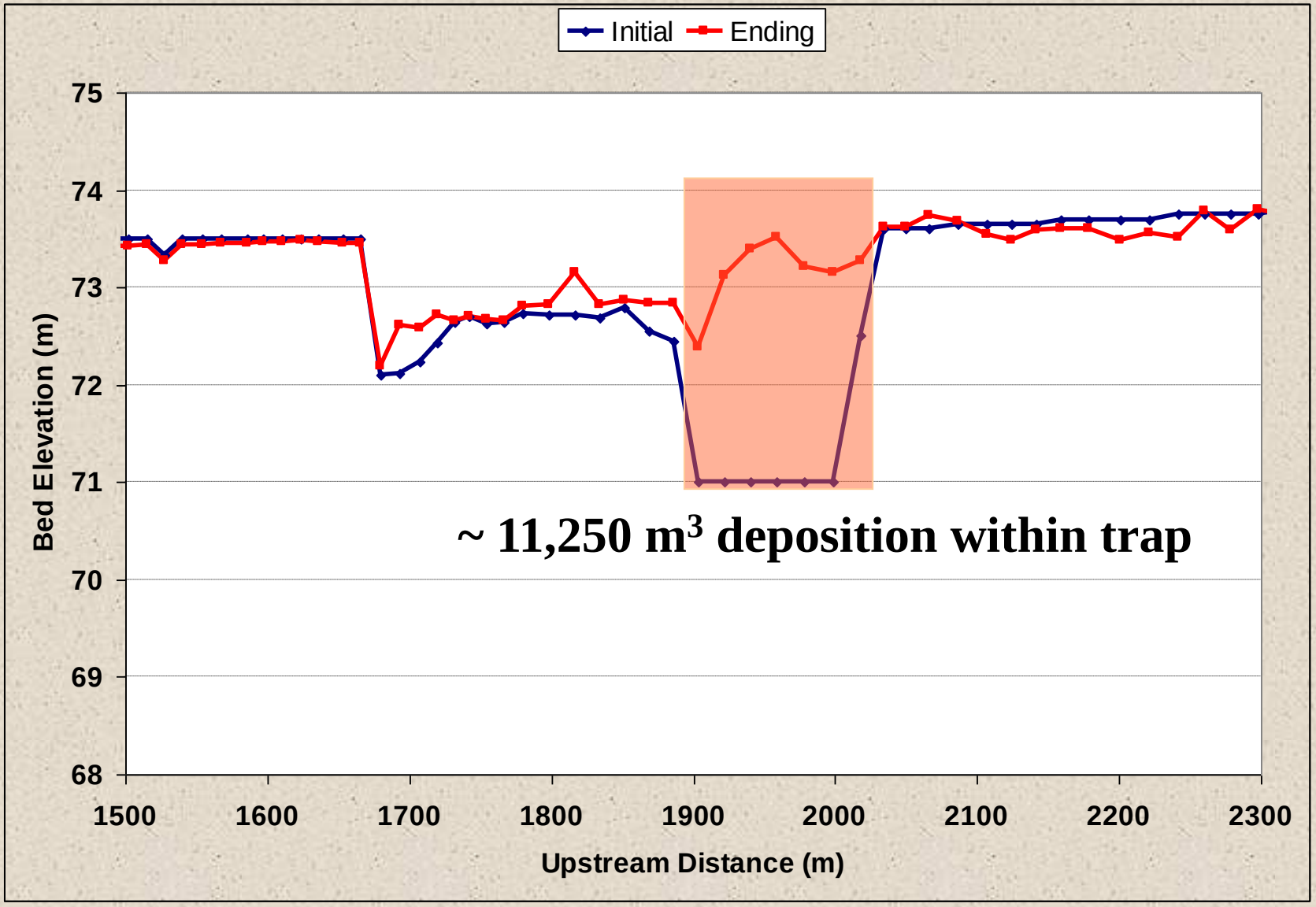
# Great Lakes Restoration Initiative

- Largest investment in the Great Lakes in over two decades.
- Task force of 11 federal agencies developed an action plan for 2010-2014.
- Addresses five urgent issues (themes):
  - Cleaning up toxics and areas of concern;
  - Combating invasive species;
  - Promoting nearshore health by protecting watersheds from polluted run-off;
  - Restoring wetlands and other habitats; and
  - Tracking progress and working with strategic partners.
- 596 projects funded in 2010 (>$400M)


2. Secondary Channel
3. Regulatory flood spillway
1. Primary Channel

# Initial and Ending Bed Elevation Profiles: 5-yr Event Design Simulation



# LOSL Technical Working Groups