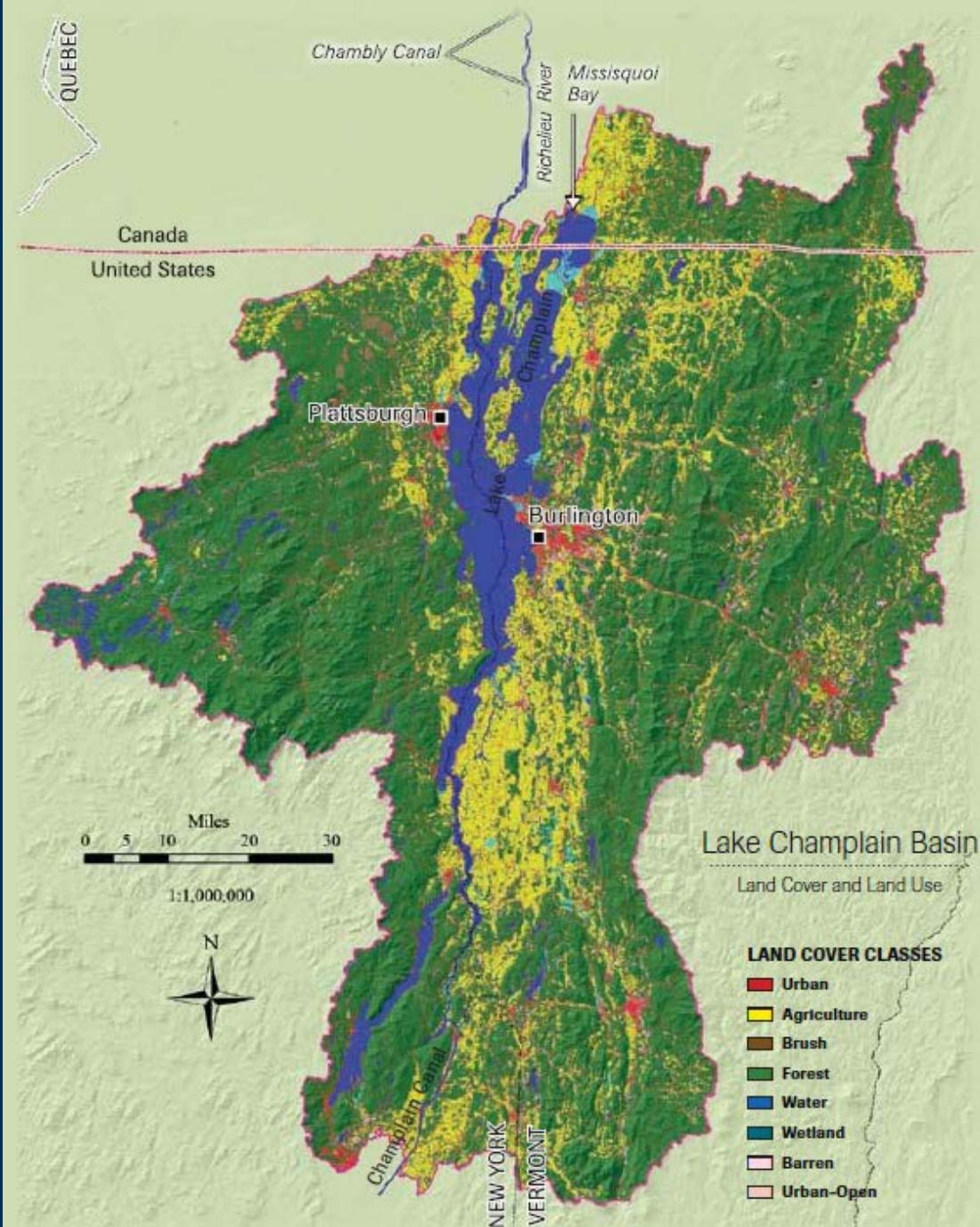# Improving Operational Real-Time Flood Forecasting and Flood Inundation mapping in the Lake Champlain-Richelieu River Watershed:

A Cooperative Effort between Canada and the US for Lake Champlain and the Richelieu River

Robert Flynn – US Geological Survey New England Water Science Center, NH/VT Office, Pembroke, NH

William Saunders – National Weather Service, Northeast River Forecast Center, Taunton, MA

Lake Champlain Basin
Land Cover and Land Use

LAND COVER CLASSES
- Urban
- Agriculture
- Brush
- Forest
- Water
- Wetland
- Barren
- Urban-Open

Short History

- **Spring 2011 Flooding - Lake Champlain & Richelieu River**
  - **Lake Peaked at 103.2 ft**
  - **Wind Exacerbated Flooding Conditions**
- **2012 - LCBP Flood Resilience Conference**
- **2012 - IJC LCRR Technical Workshops**
- **2014 - IJC Plan Of Study**
  - **3 Potential Approaches for Work to Mitigate Future Flooding Effects**
    - **~$5 Million to ~$14 Million**

Photo courtesy of Vermont Governor's Office

IJC Technical Working Group

- **USGS, NOAA, VT DEC, NY DEP**
- **Environment Canada, CEHQ, MDDELCC**

FY2015 Tasks

- Assess quality of Wind, Precipitation, Temperature forecasts
- Develop 2D Lake Model
- Establish Data Exchange Mechanism
- Recommend Pragmatic Approach for Future
- Collect/Process Lake Champlain LiDAR
- Address Border Vertical Datum Differences

- Establish new Lake Gages
- Assess/collect Aquatic Plant Distributions in Upper Richelieu
- Consolidation/Harmonization of US Data
- Create Quality-Controlled DEM using Champlain/Richelieu LiDAR
- Set Up 2-D River Model
- Create Static Inundation Maps along the lake/river Shoreline

Static Flood-Inundation Mapping – FY15

- **Component of International Joint Commission (IJC) directive**

- **Production of flood inundation maps for those communities with recently acquired LiDAR and linked to 5 USGS lake elevation gages and NWS prediction site (Rouses Point, NY).**

- **10 Static maps were produced starting at 100.0 (NGVD29) and then at 0.5-ft intervals from 101.0 to 104.0 ft and 1-ft intervals from 104.0 to 106.0 ft as referenced to the USGS lake gage 04295000, Richelieu River (Lake Champlain) at Rouses Point, N.Y.**

- **In addition, the May 2011 flood-inundation area for elevation 103.20 ft (102.77 ft, North American Vertical Datum [NAVD] 88) was determined.**

- **USGS maps posted on a IJC web site (http://www.ijc.org/en_/) and a USGS web site (http://water.usgs.gov/osw/flood_inundation) along with a USGS Scientific Investigations Report on Lake Champlain flood-inundation mapping**

Collection of Data to Assist with Flood Forecasting and Future Inundation Mapping

5 USGS Lake Elevation streamgages – for online Flood Inundation Mapping application:

- Richelieu River (Lake Champlain) at Rouses Point, N.Y. (lake gage 04295000) – NWS Prediction Site,

- Lake Champlain at Burlington, Vt. (lake gage 04294500),

- Lake Champlain North of Whitehall, N.Y. (lake gage 04279085),

- Lake Champlain at Port Henry, N.Y. (lake gage 04294413),

- Lake Champlain near Grand Isle, Vt. (lake gage 04294620)
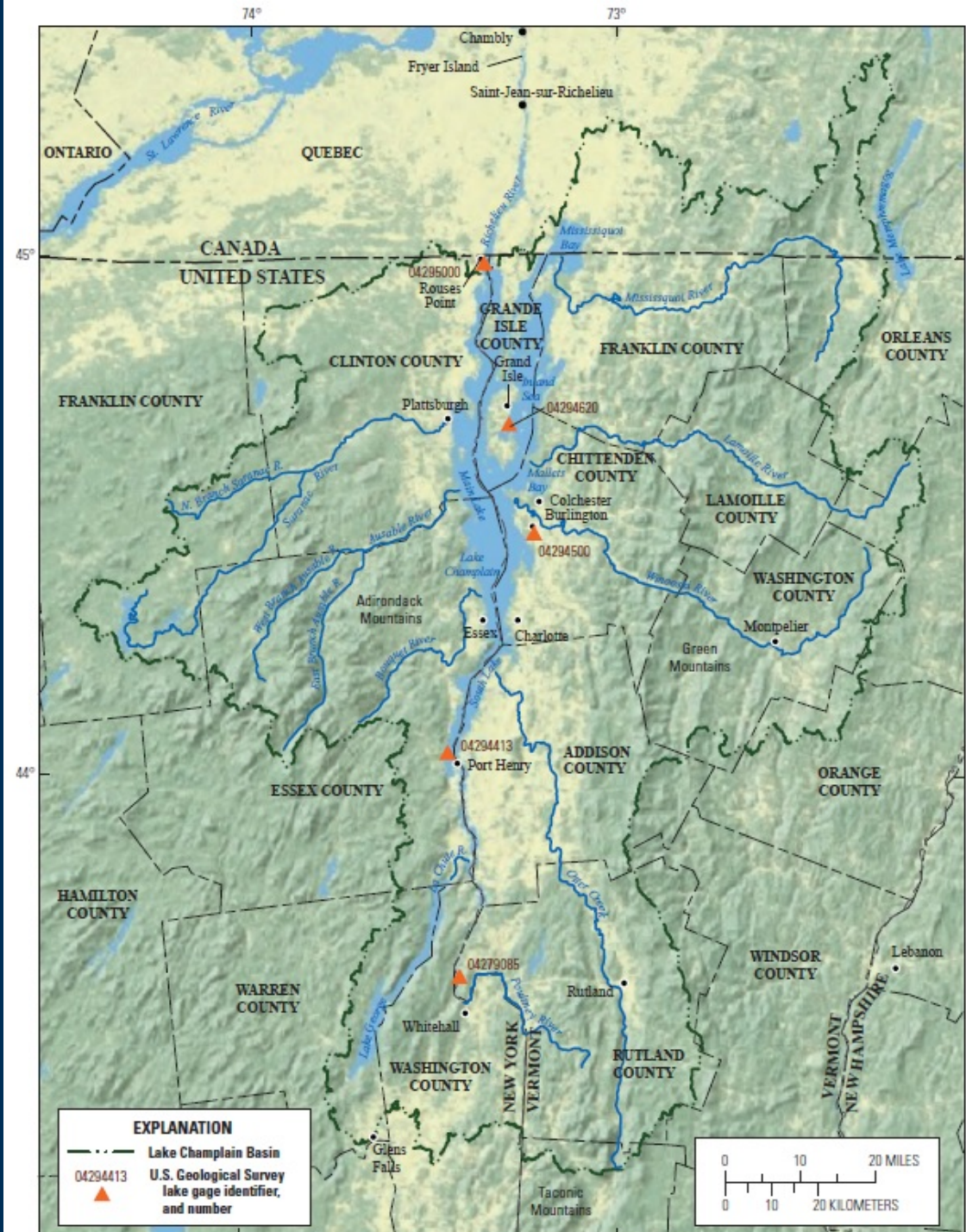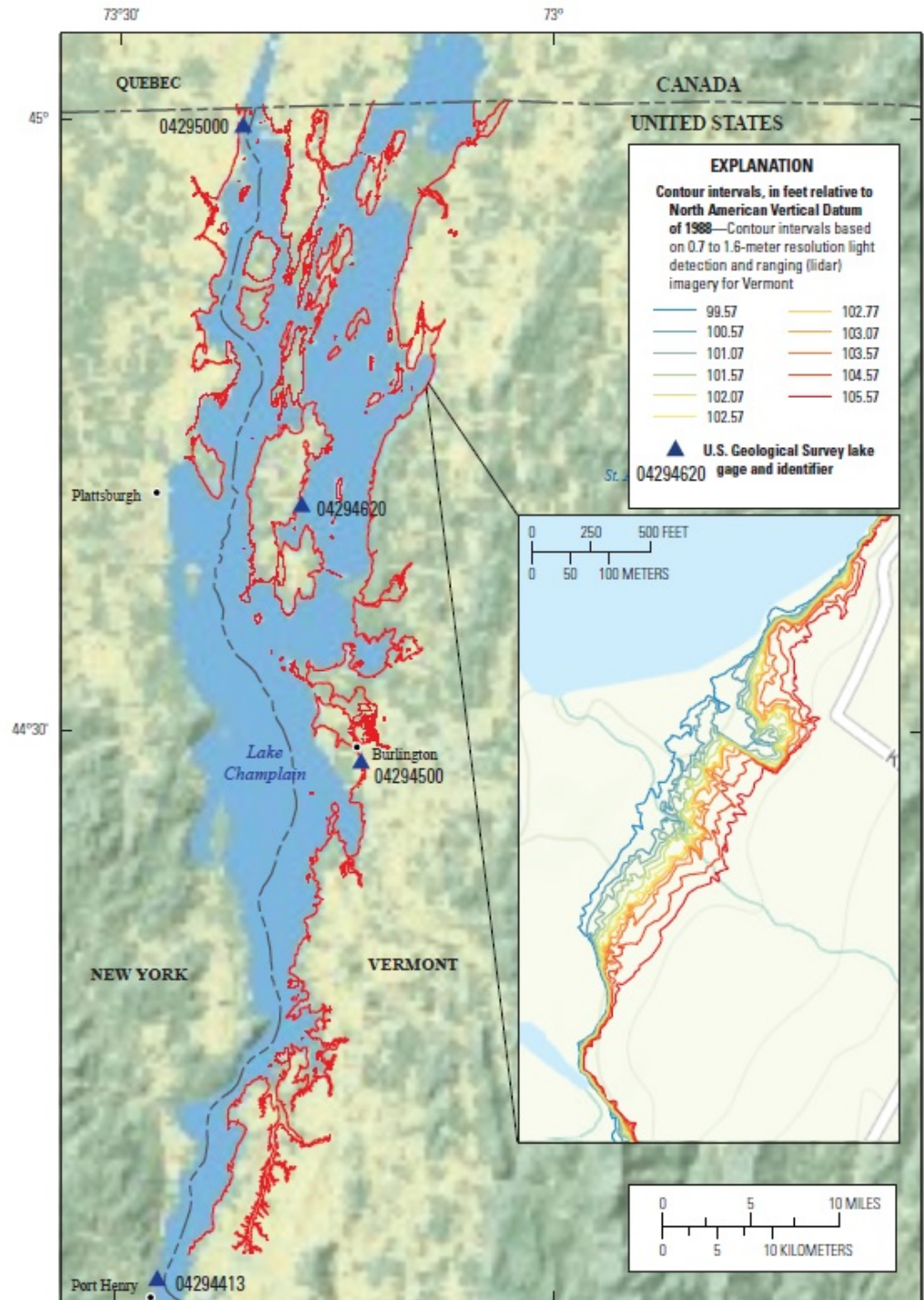
Using Flood Inundation Maps

Choose Lake Location

- **USGS stage information available at 5 lake elevation gages**
- **NWS Flood Forecast information available for USGS Rouses Point, NY streamgage**
- **Elevation and Structure Information**
- **Flood Impact Locations**
    - **Critical infrastructure**
   - **Routes of egress**
    - **Population locations**

Example flood inundation map for Lake Champlain (106.0 ft NGVD 29, 105.57 ft NAVD88)

- Eastern side of the Lake from the Rutland/Addison County line in Vermont north to the Canada/United States border

- Western side of the Lake from the northern part of Clinton County (Cumberland Bay, north of Plattsburgh) in New York north to the Canada/United States border
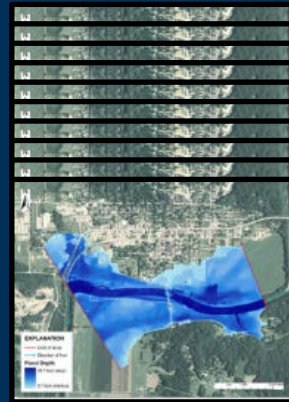
USGS Flood Inundation Mapper (FIM) website: Flood Inundation Maps translate hydrograph into operational maps that communicate risk and consequences
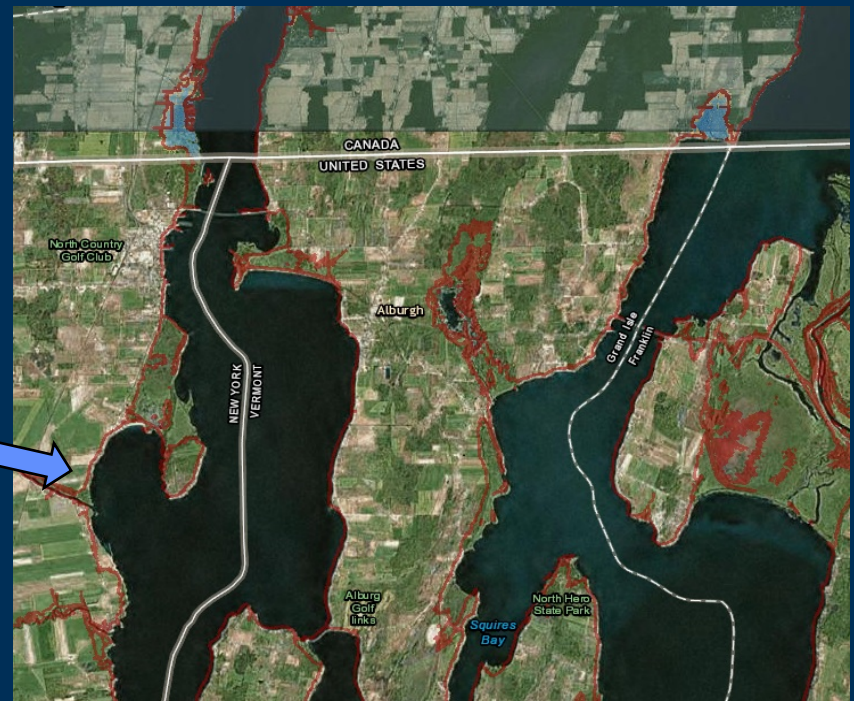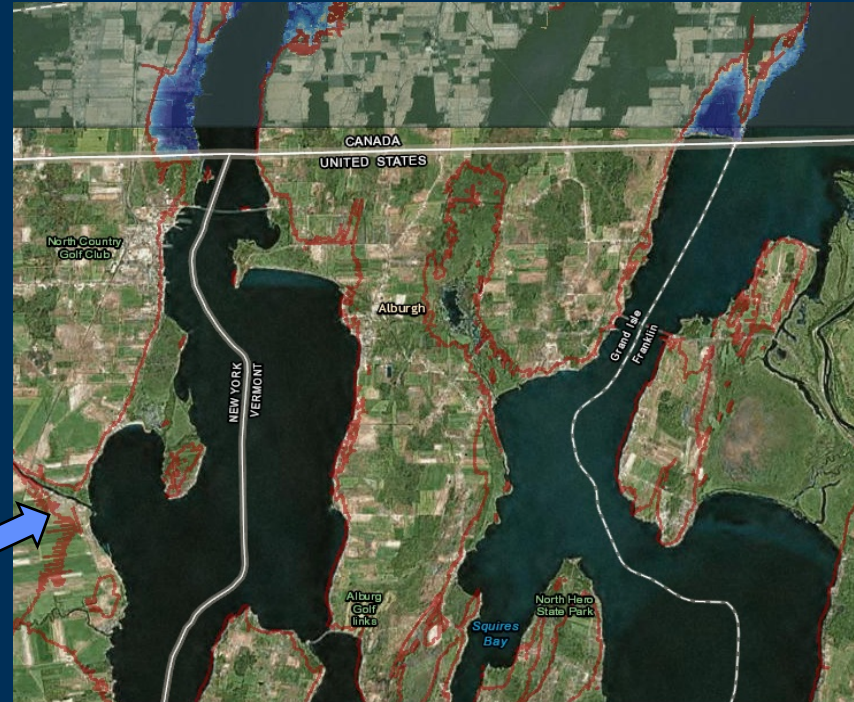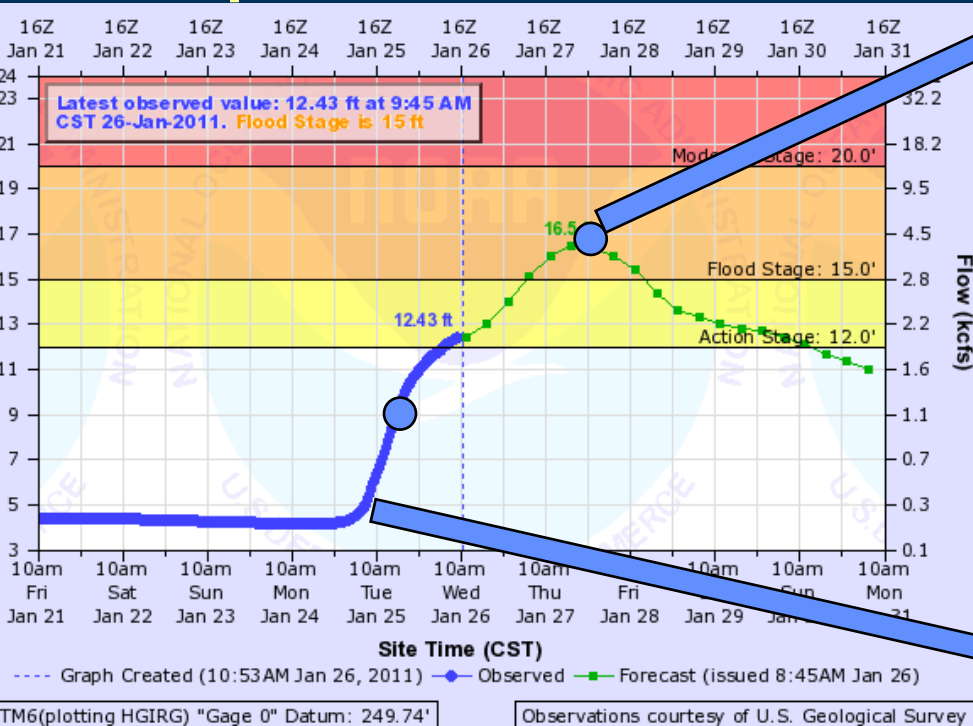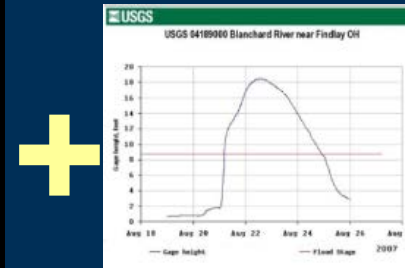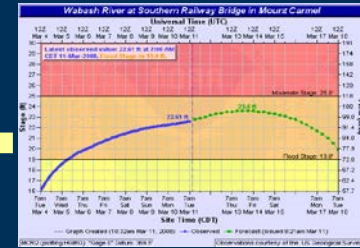
FIM Mapper – more than just maps

Turns the map data into an operational tool by combining data together with tools that enhance the utility and don't require any modeling or GIS software or skills
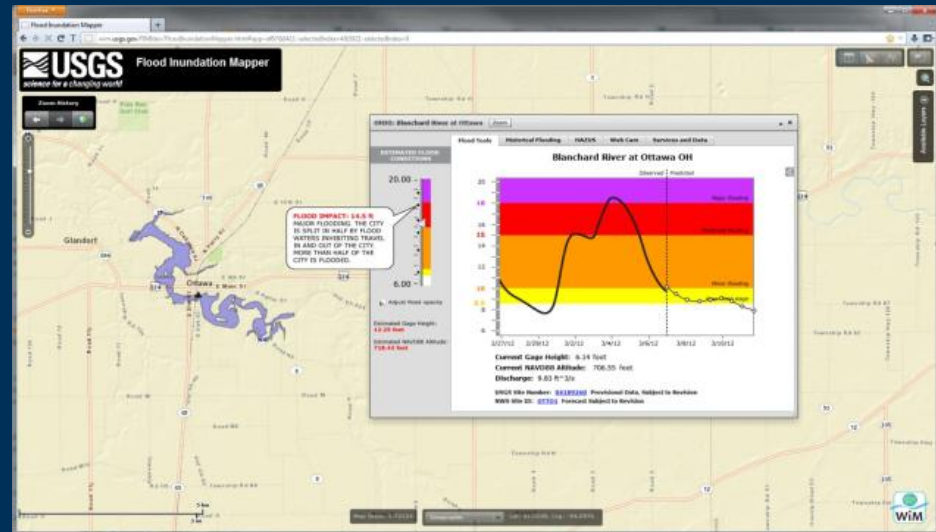

Flood Library

USGS Real-time streamgage

NWS Flood Forecast

http://wim.usgs.gov/FIMI/

Lake Champlain Flood-Inundation Mapping Sites

- **International Joint Commission :** **http://ijc.org/en_/LCRRTWG**

- **USGS : http://wimcloud.usgs.gov/apps/FIM/FloodInundationMapper.html**

- **Results of Flood-Inundation Mapping presented in a USGS Scientific Investigations Report (SIR 2016-XXXX, in review) entitled, Flood-Inundation Maps for Lake Champlain in VT and in Northern Clinton County, NY**

Global Navigation Satellite Systems (GNSS) survey for Datum Harmonization in Lake Champlain Basin in US and Canada

- Datum discrepancy at international border

- Single datum determined by GNSS surveys at 9 locations

- USGS and Canadian government staffs coordinated for surveys

- OPUS (NOAA Online Positioning User Service) Projects Network Adjustment performed on data

- Results presented in a USGS Scientific Investigations Report (USGS SIR 2016-5009)

"Network Global Navigation Satellite System Surveys to Harmonize American and Canadian Datums for the Lake Champlain Basin"

https://pubs.er.usgs.gov/publication/sir20165009
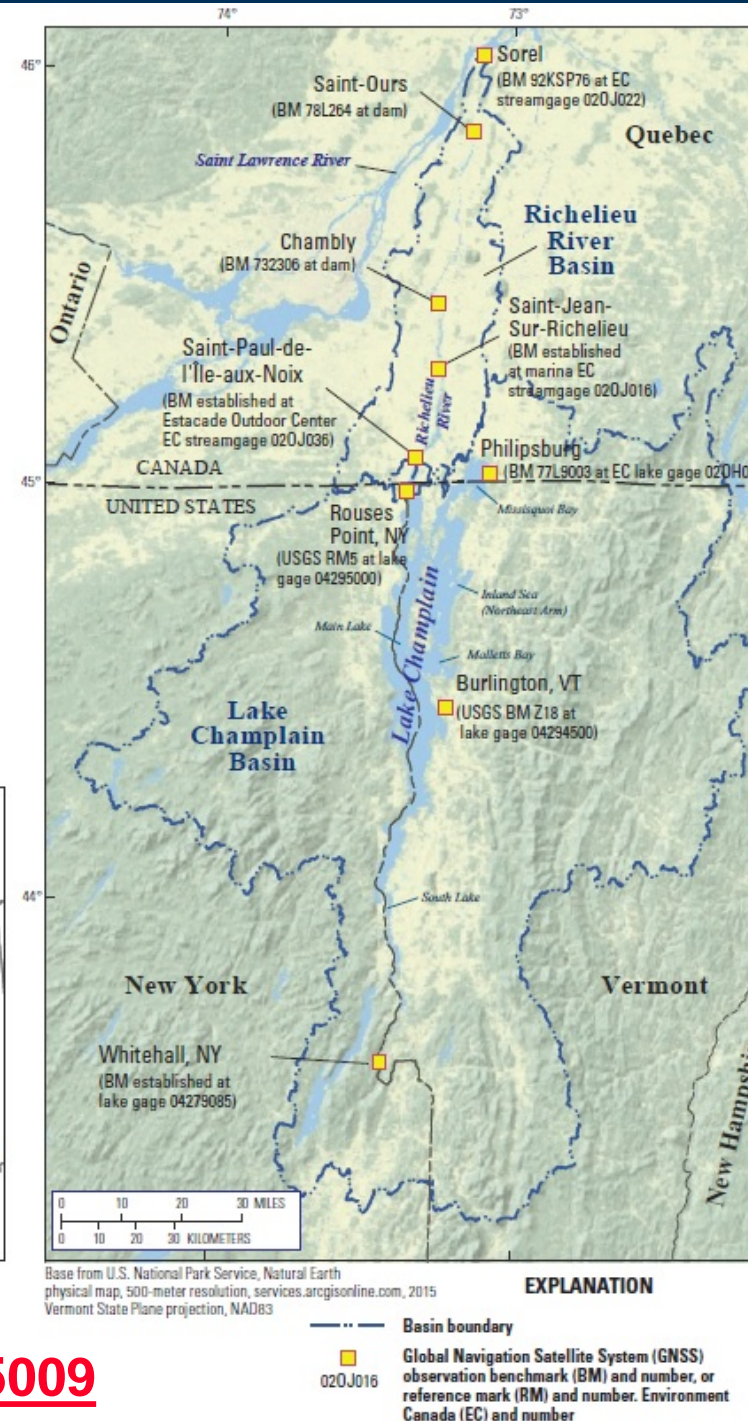
2-D Model of Lake Champlain

- Developed by Environment Canada
- Experimental Model using H2D2 software (INRS-ETE)
- Model Domain from Whitehall NY to Fryers Dam (Richelieu)
- Used to establish lake outflows for each inundation scenario
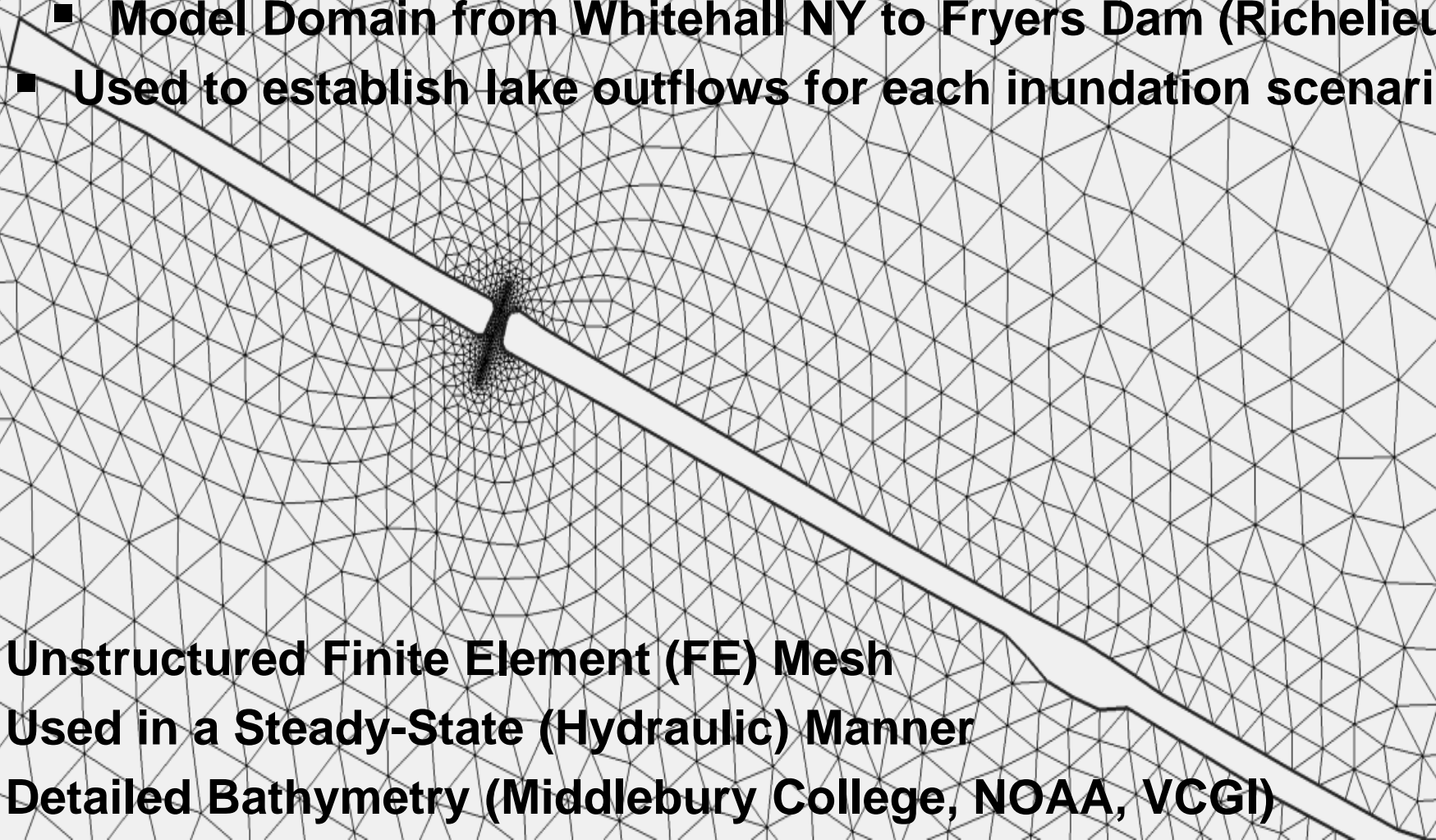
- Unstructured Finite Element (FE) Mesh
- Used in a Steady-State (Hydraulic) Manner
- Detailed Bathymetry (Middlebury College, NOAA, VCGI)

Richelieu River 2-D Model

- Developed by Environment Canada'
- H2D2 with Finite Element Mesh
- Model Domain – Fryers Rapids to Sorel
- 7 Tributary Inflows
- Steady State Application
- Bathymetry from
  - LiDAR (shorelines)
  - CHS (lower river)
  - Parks Canada x-sects (mid river)
  - Lake Model (upper river)
- Model could not converge at Chambly Dam
  - Split into 2 segments
  - Stage-Discharge established for the dam
- Downstream Bathymetry Errors up to 0.5 m
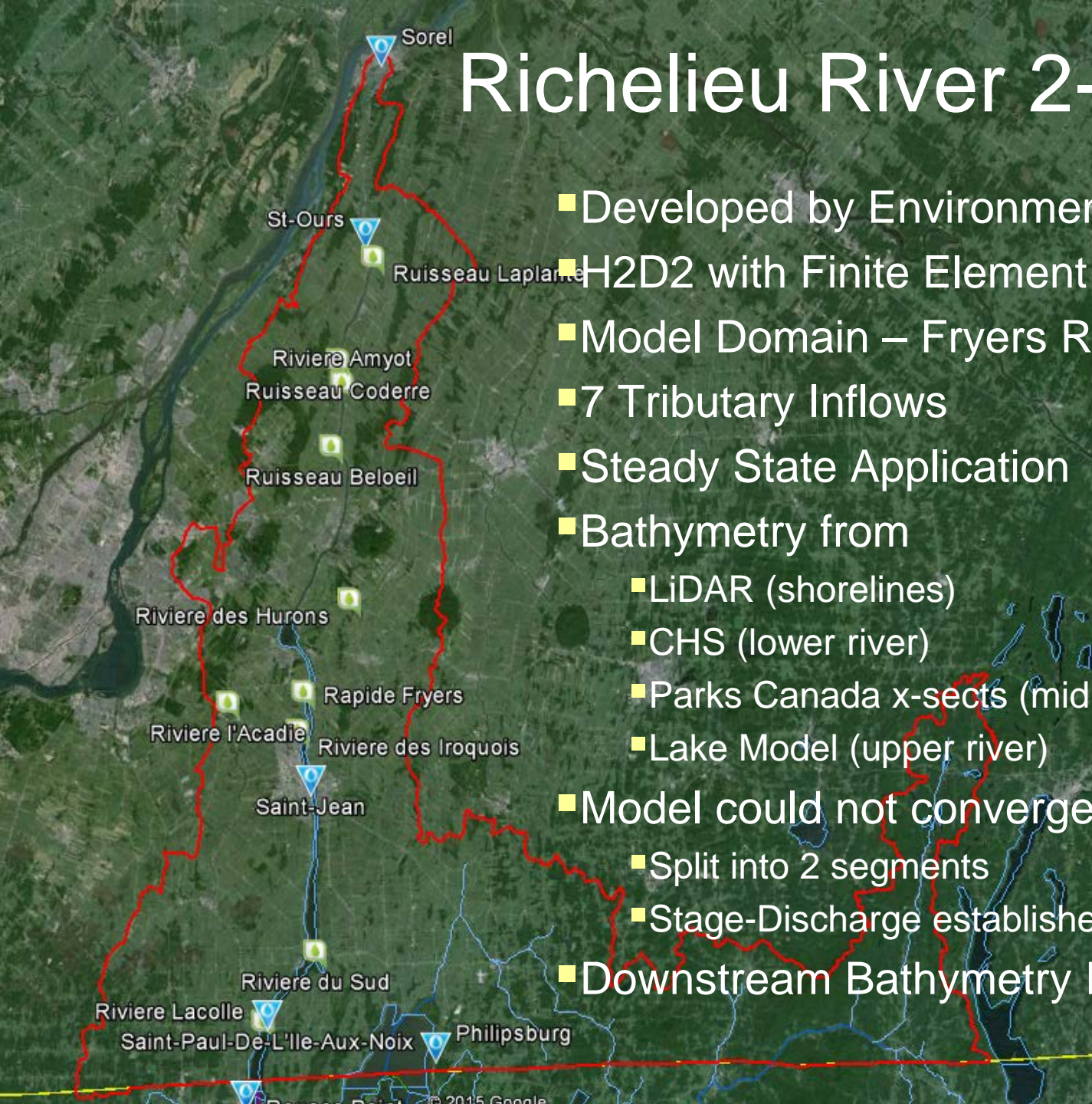
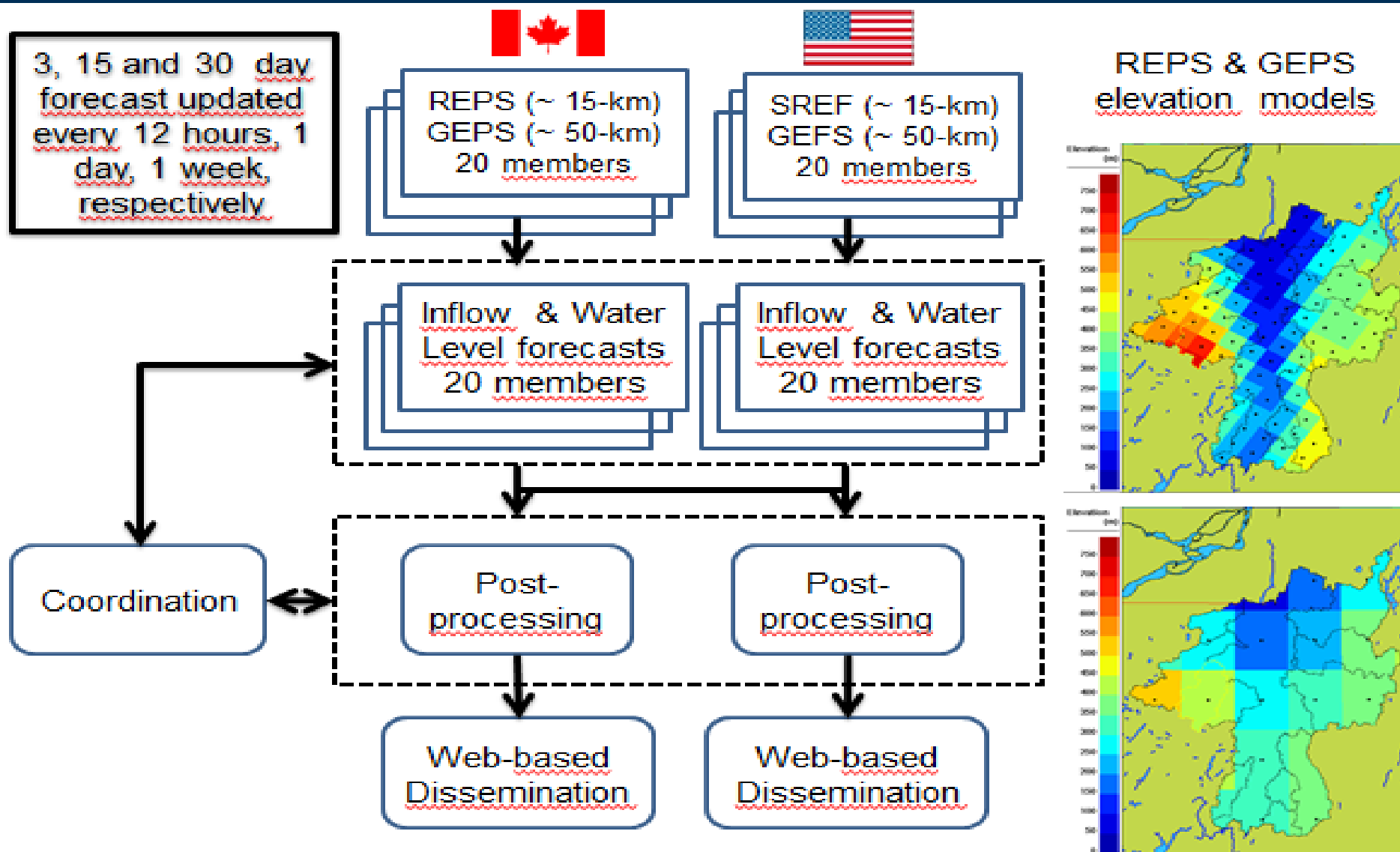# 2-D Modeling Work To Be Done

- **River Model**
  - **Collect new Richelieu Bathymetry**
    - **Chambly to Sorel**
  - **Combine segments into single river model**
  - **Extension of River Model to Rouses Point**

- **Both Models**
  - **Transition from Hydraulic to Hydrodynamic**
    - **Required for Forecasting**
  - **Incorporate Effects of Wind**
  - **Calibrate/Verify to High/Low Flow Conditions**

Pragmatic Approach for Future Forecasting/Inundation Mapping

3, 15 and 30 day forecast updated every 12 hours, 1 day, 1 week, respectively

REPS (~ 15-km)
GEPS (~ 50-km)
20 members

SREF (~ 15-km)
GEFS (~ 50-km)
20 members

Inflow & Water Level forecasts 20 members

Inflow & Water Level forecasts 20 members

Coordination

Post-processing

Post-processing

Web-based Dissemination

Web-based Dissemination

REPS & GEPS elevation models

Questions ?

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http://water.usgs.gov/osw/flood_inundation/
http://newengland.water.usgs.gov/
http://www.weather.gov/nerfc/