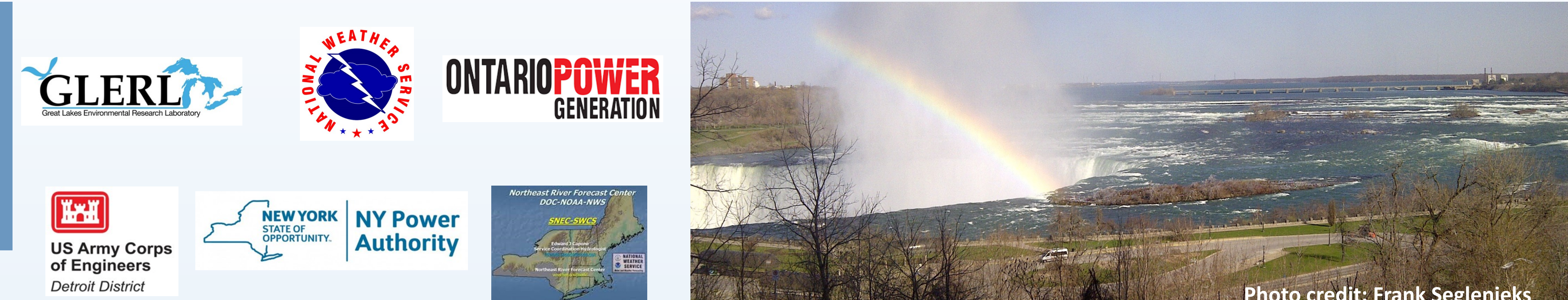# An Operational Short-Term Forecasting System for Regional Hydropower Management

Authors: Katherine Labuhn[1], Tim Calappi[1], Drew Gronewold[2], Eric Anderson[2], Alison MacNeil[3]   H43B-1643

GLERL NATIONAL WEATHER SERVICE ONTARIO POWER GENERATION

US Army Corps of Engineers Detroit District   NEW YORK STATE OF OPPORTUNITY NY Power Authority

Photo credit: Frank Seglenieks

Introduction

Since 1893 people have used the Niagara River for power generation. Currently, two agreements govern the sharing of the Niagara River between the Unites States and Canada.

Boundary Waters Agreement of 1909
This agreement requires an equitably sharing of water between the United States and Canada.

The 1950 Niagara Treaty
This treaty controls the flow over Niagara Falls by regulating when the hydropower companies can divert water from the Chippawa-Grass Island Pool (CGIP). The regulations were developed to maintain a minimum flow over the Falls to maintain their natural beauty and tourism value.

Niagara River Control Center (NRCC)
The Niagara River Control Center operates the control structure on the CGIP and regulates water Withdrawals by the hydropower entities.

A New Niagara River Forecast System

The NRCC has historically generated Niagara River forecasts using a simple 1-D river model with upstream boundary conditions dictated by experimental runs from the Lake Erie component of the NOAA-GLERL Great Lakes Coastal Forecasting System. In 2015, a collaborative partnership was formed between NRCC, NOAA-GLERL, USACE and NWS NERFC to develop a new forecasting system that leverages advancements in Lake Erie water level forecasting, Niagara River routing models and the operational forecasting capabilities of regional RFC.
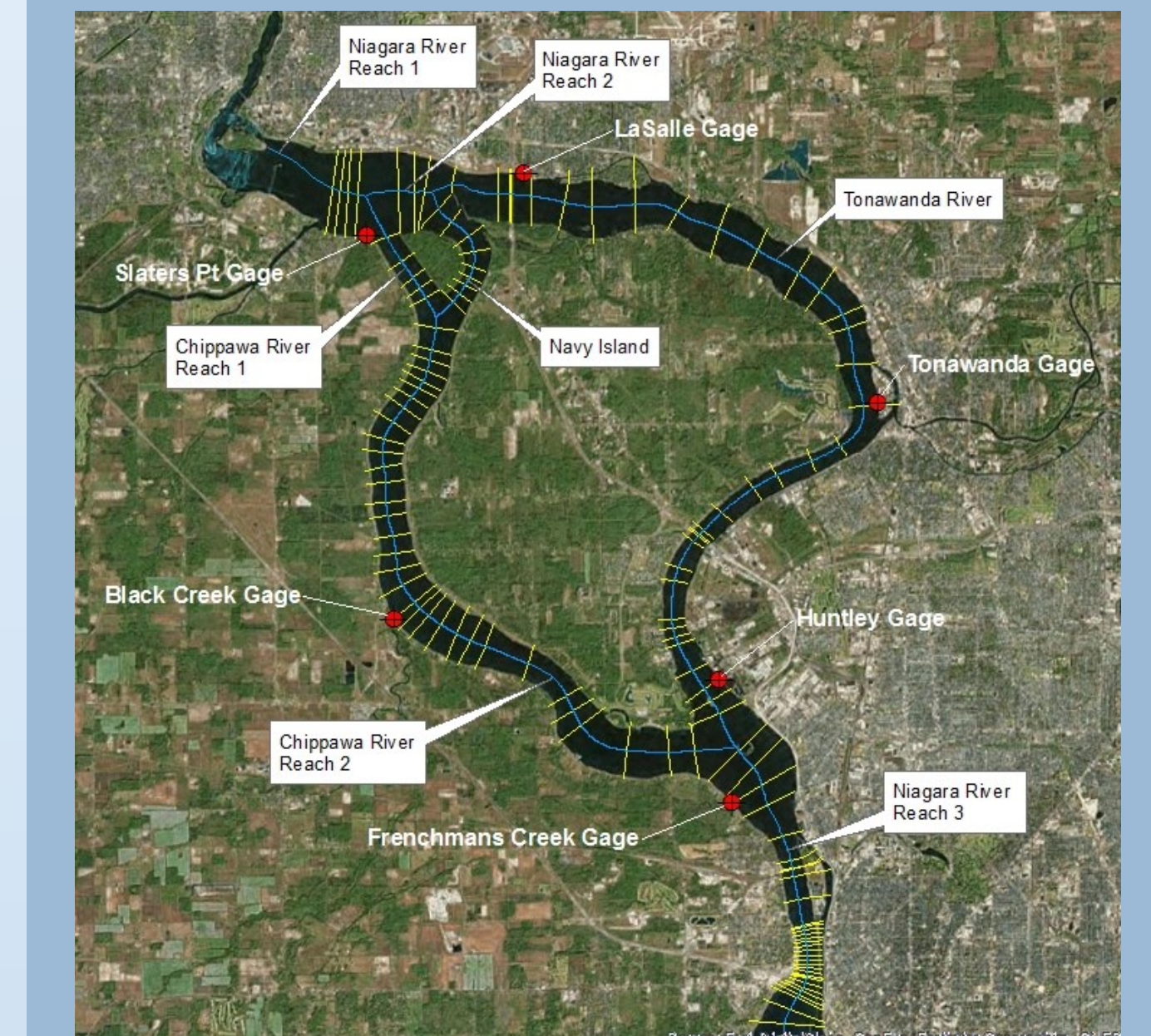
Niagara River Control Structure

Upstream Boundary Condition

The Lake Erie Operational Forecast System (LEOFS) provides the upstream boundary condition while HEC-RAS routes the flow to the CGIP. LEOFS is an FVCOM model of Lake Erie and consists of 11,500 elements and 20 vertical layers. The model applies a forecasted wind field to the lake and produces a water level forecast for up to 120 hours. The model is run multiple times per day and provides regularly updated conditions at a point near Buffalo, NY to the HEC-RAS model.

Lake Erie Water Level Above LWD (173.5 m)
2016 349 20:00 GMT
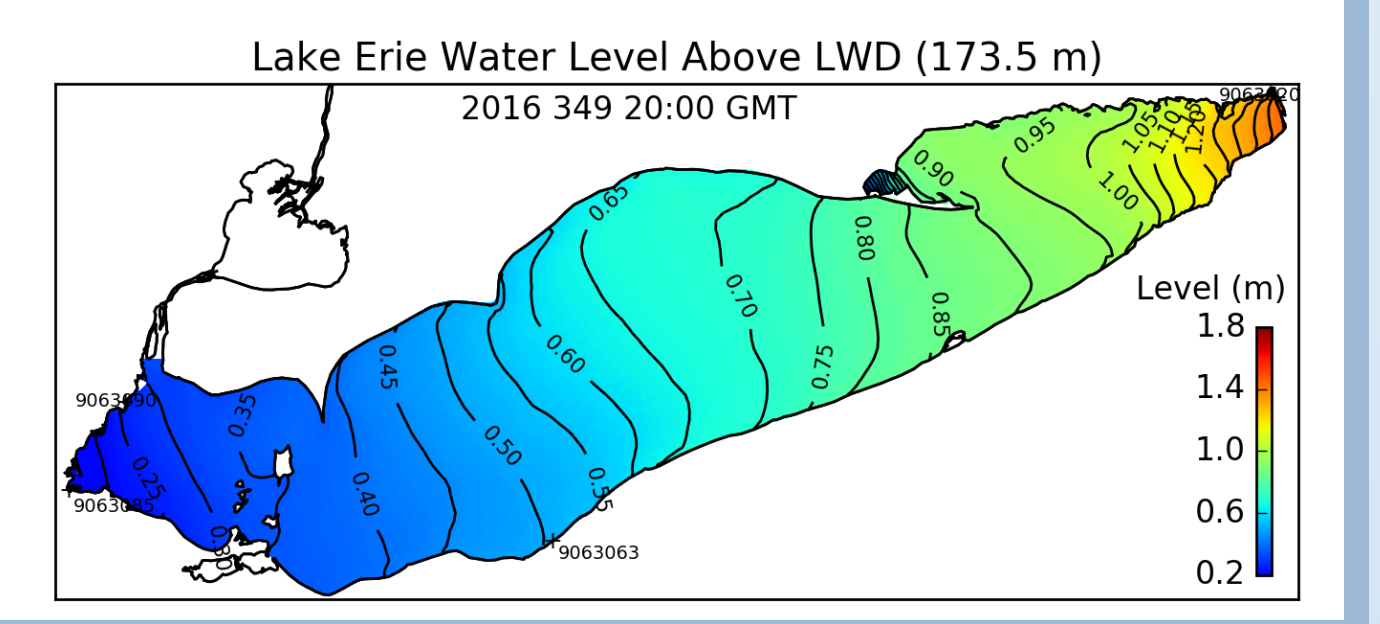
HEC-RAS — River Routing

- Niagara splits into Chipawa and Tonawanda
- Channels converge to form CGIP
- Updated existing HEC-RAS
- Converted to unsteady model
- Made boundary conditions forecastable
- 7 reaches
- 124 cross sections
- 6 bridges

Downstream Boundary Condition

The downstream boundary of the model was challenging due to the complexity of activities—water withdrawals, gate changes at the control structure, treaty requirements for flow over Niagara Falls for both tourist and non-tourist season.

Three boundary conditions were considered:
- the long term average of the CGIP
- normal depth and a
- planned water level developed each month by the NRCC—best option

Water Level at the Upstream End of the Grass Island Pool April 2016
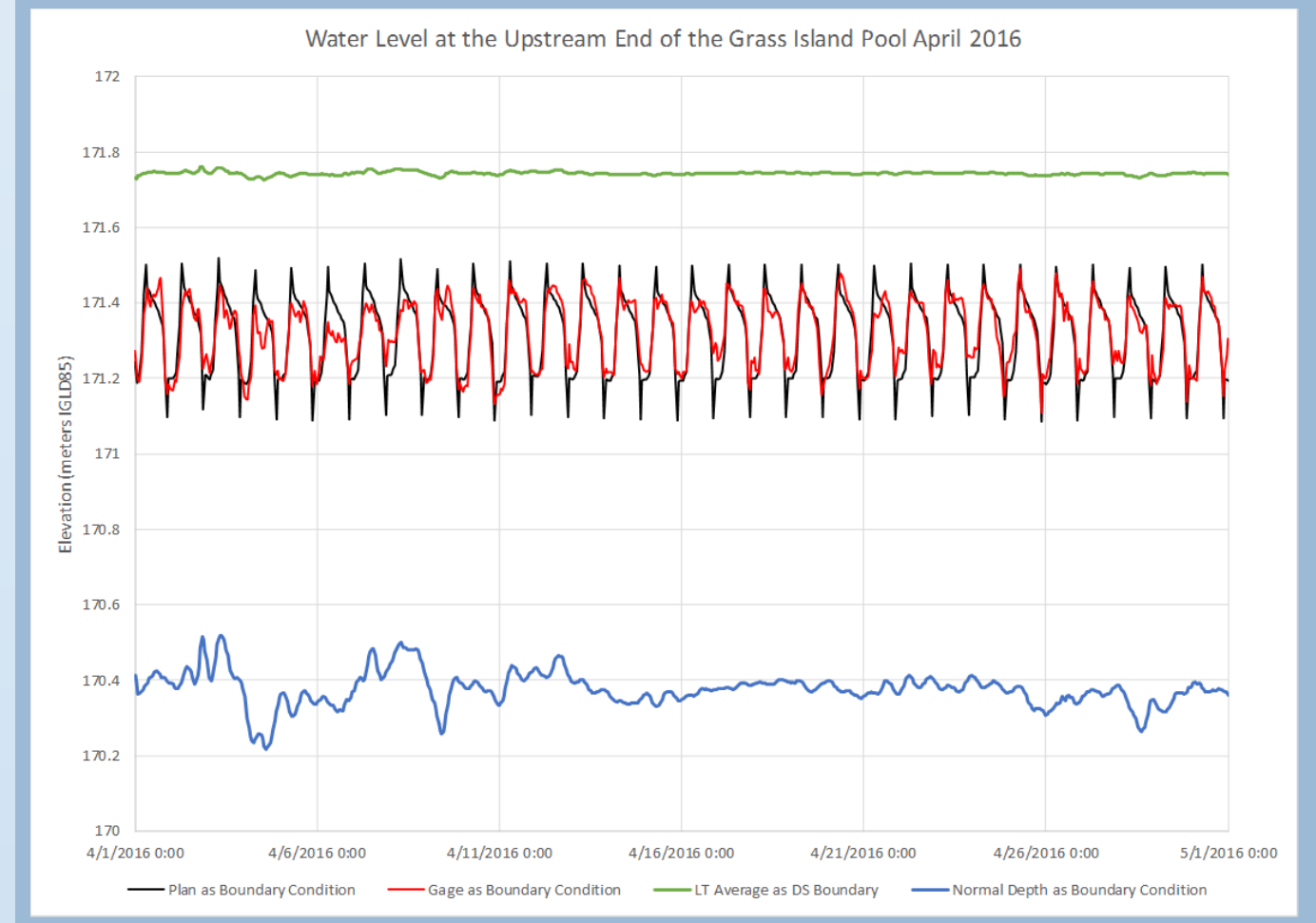
Calibration

There were six water levels gages with data available for calibration and the automated roughness calibration tool in HEC-RAS was used to optimize the Manning's n value for each month and year from April to November. Due to river ice, the gage data was unreliable from December to March so those Manning's n values were based on the values calculated for April and December.

April Results Model - Gage

April 2004 - LaSalle Model vs Gage
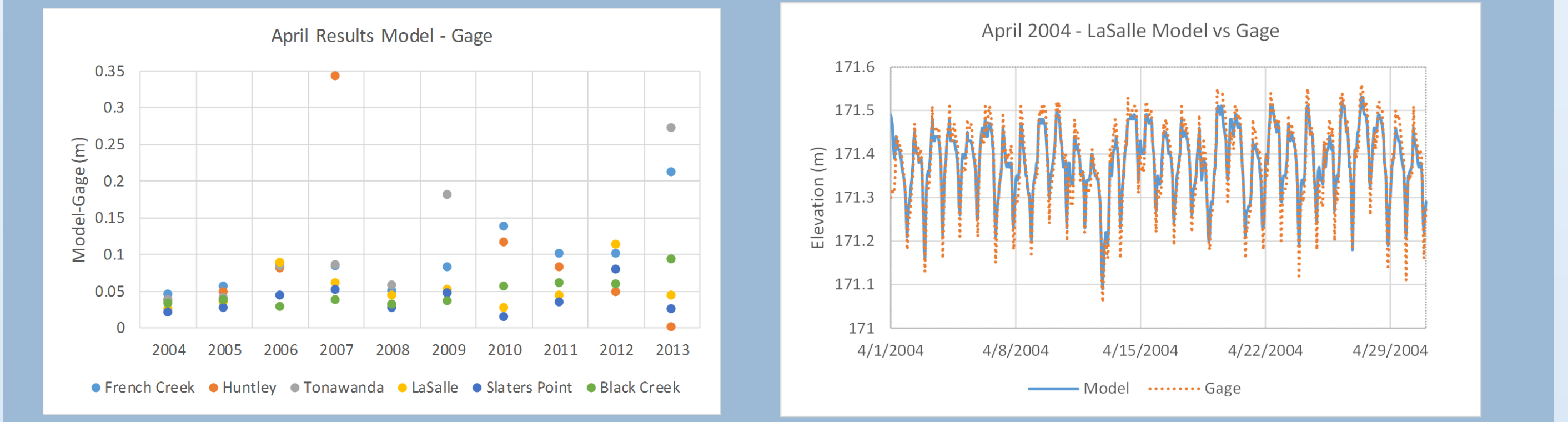
Operational Forecast

- All models must fit into NOAA's operational framework
- Lake Erie model runs at NOAA Center for Oceanographic Operation Products
- Routing model—HEC RAS is required to fit into the River Forecast Center operational system
- Forecasts currently made once per day and will increase to four times daily to provide consistency with other forecasted products

Operations in the Chippawa – Grass Island Pool

- hydropower intake
- forecasted flow
- water level gauge
- flow direction

City of Niagara Falls, NY
NYPA intake
LaSalle
Chipawa-Grass Island Pool
Niagara River Control Structure
OPG intake
Material Dock
Slaters Point

The Niagara River: An Ice Age Legacy

The Niagara River and the entire Great Lakes Basin are a legacy of the last ice age. Approximately 12,500 years ago the last glacier retreated, leaving the Niagara Peninsula free of ice and the meltwaters started flowing from Lake Erie, through the Niagara River, over Niagara Falls and on to Lake Ontario.

The Drop over the Falls

The Horseshoe Falls drops about 188 feet while the American Falls drop varies between 70 and 100 feet.

Current Use of the Niagara River

The waters of the Niagara River are used jointly by the United States and Canada and serve a population of over 1 million people for:
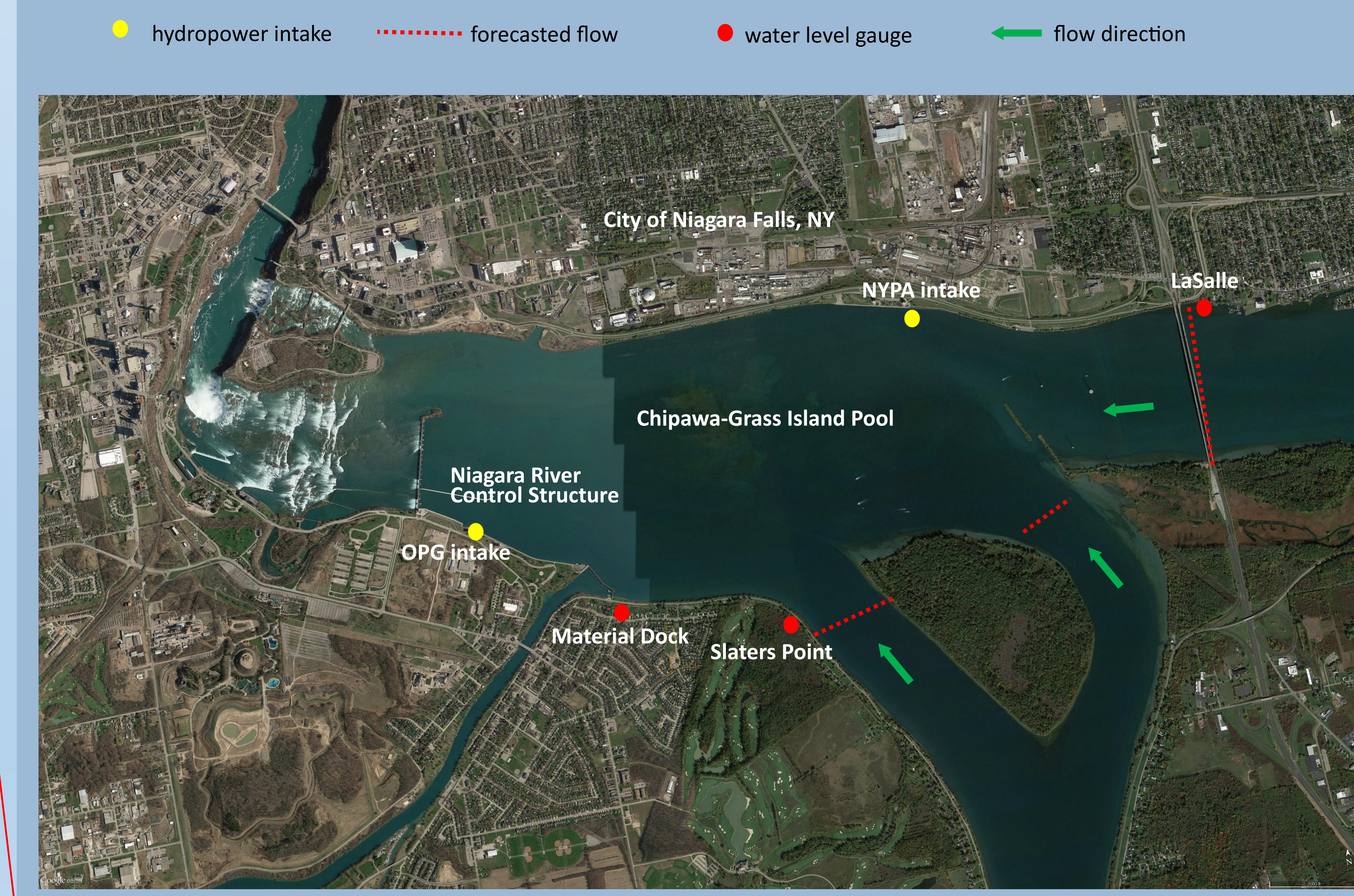◊ Drinking water
◊ Recreation
◊ Fishing
◊ Industrial cooling water supply
◊ Hydropower generation

Hydropower Generation

Power generation from the falls started on the Canadian side in 1893 to power an electric railway. Since that time use of the falls for power generation has greatly expanded.

There are currently three power plants on the Canadian Side, downstream of the Falls, the Sir Adam Beck Niagara Generating Station Nos. 1 and 2 and a nearby pumping-generation stations.

There are two power plants on the American side, downstream of the Falls, the Robert Moses Niagara River Power Plant and the Lewiston Pump Generating Plant.
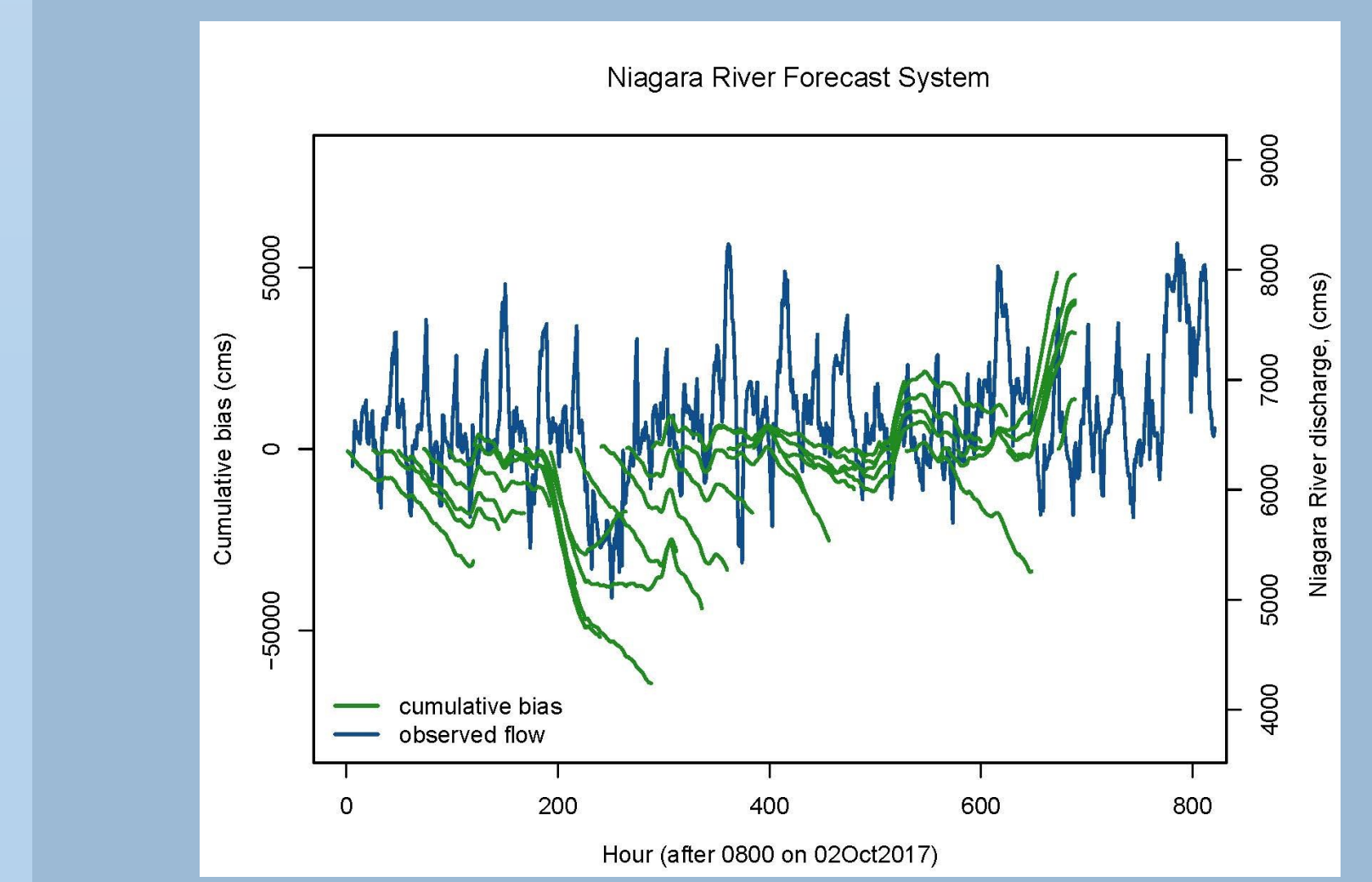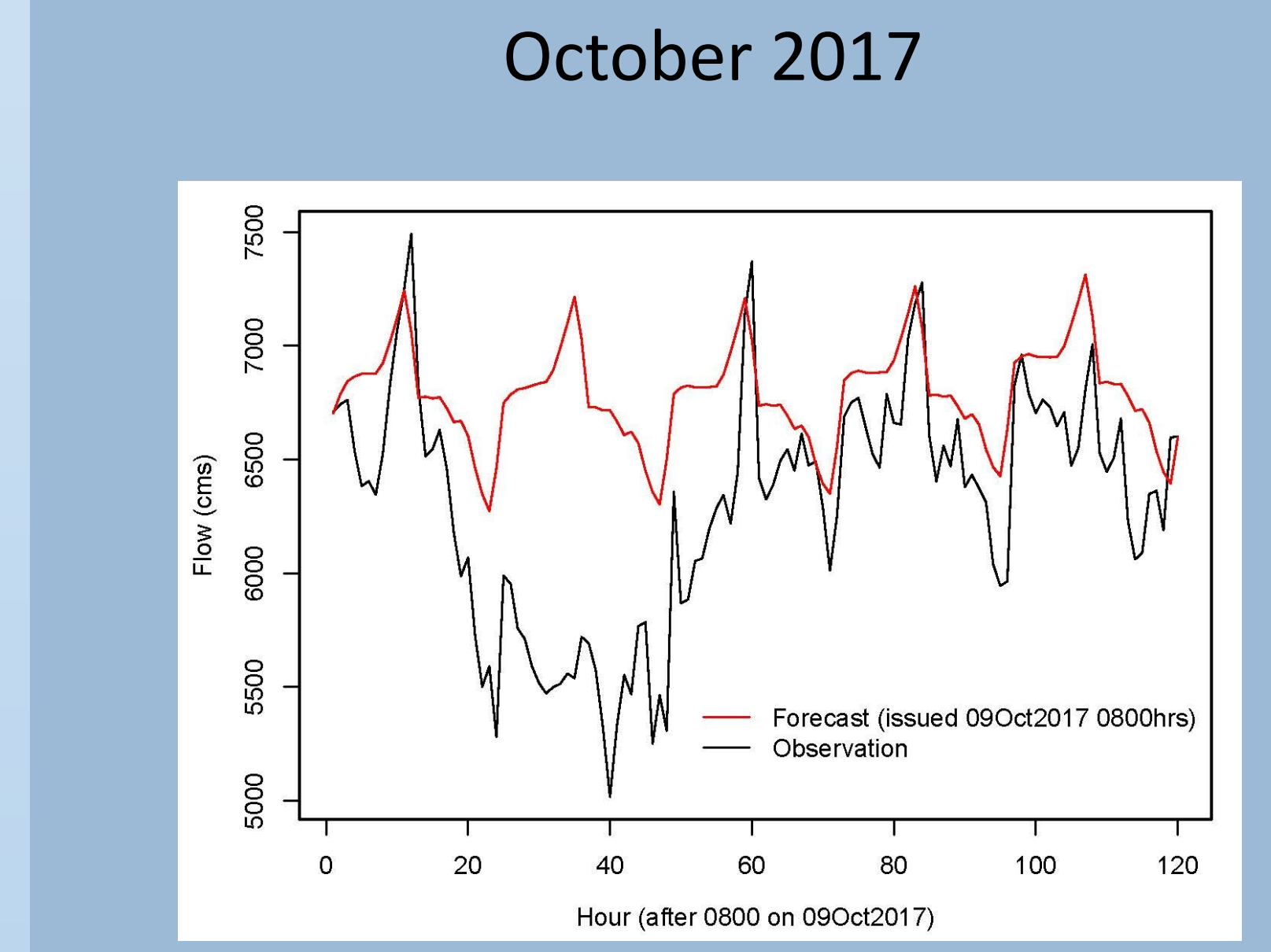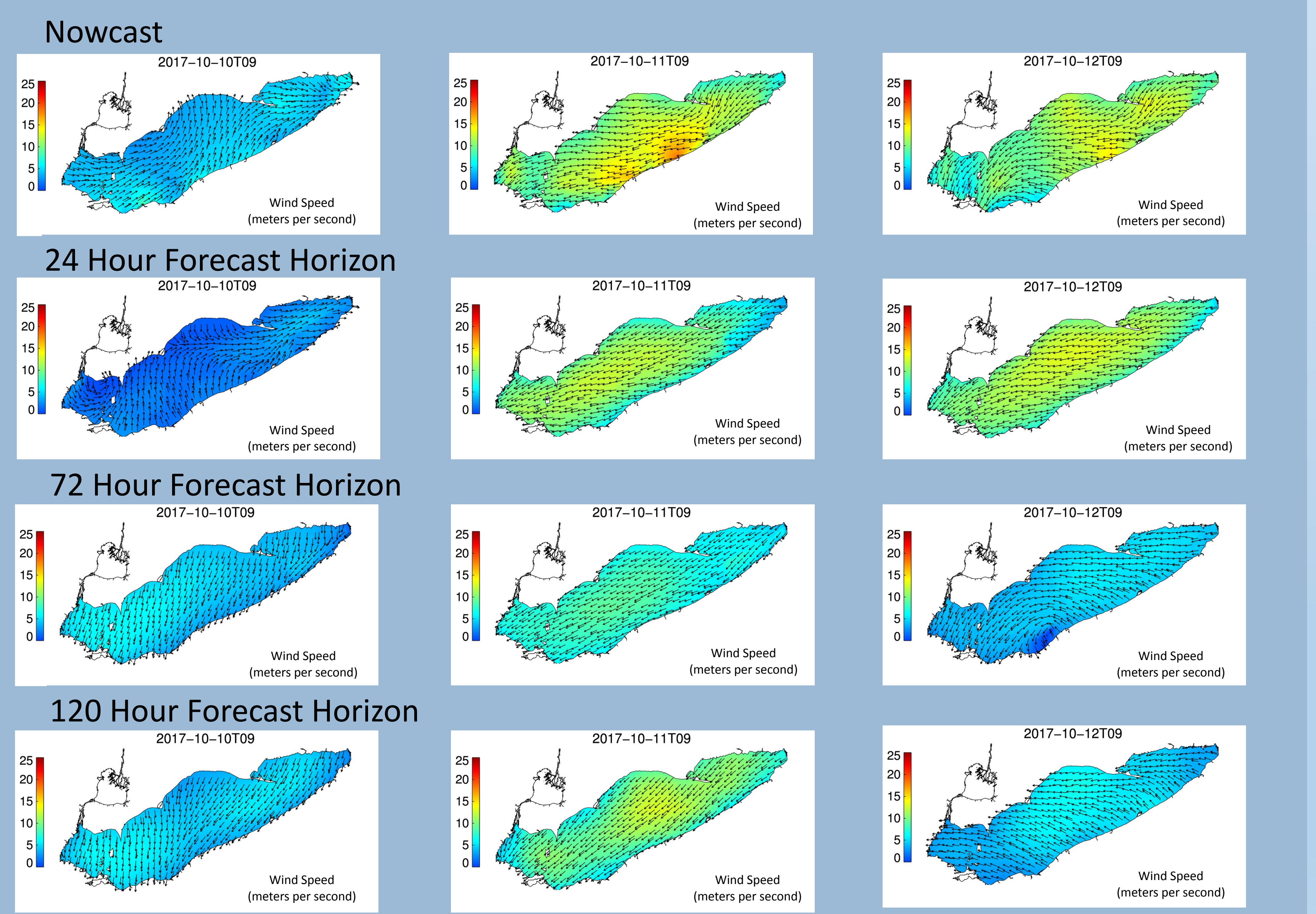
Authors:
1—US Army Corps of Engineers, Detroit District
2—NOAA Great Lakes Environmental Research Laboratory
3—National Weather Service Northeast River Forecast Center

Forecast Performance

October 2017

Niagara River Forecast System

Forecast (issued 09Oct2017 0800hrs)
Observation

cumulative bias
observed flow

Wind Forecast Assessment Over Three Forecast Horizons

Nowcast
2017-10-10T09 2017-10-11T09 2017-10-12T09

24 Hour Forecast Horizon
2017-10-10T09 2017-10-11T09 2017-10-12T09

72 Hour Forecast Horizon
2017-10-10T09 2017-10-11T09 2017-10-12T09

120 Hour Forecast Horizon
2017-10-10T09 2017-10-11T09 2017-10-12T09

Wind Speed (meters per second)

American Geophysical Union Fall Meeting 2017 New Orleans, LA

Conclusions/Future Work:

The Niagara River Control Center has a new tool, developed by three federal partners, to help meet treaty requirements and optimize water withdrawals from the Chippawa-Grass Island Pool. These models have shown to perform well when the meteorological forcings are appropriately forecasted. Future work includes further field verified velocities, updates to bathymetry and roughness values. Once fully operational, additional forecast ensembles are envisioned based on different rating curves and Lake Erie outflow forecasts.