

Executive Summary

In the one year from October 1, 2014 to September 30, 2015 a number of federal and state/provincial agencies worked together to enhance flood preparedness and warnings for Lake Champlain and the Richelieu River (LCRR). This effort was the result of a Directive of the Canadian and United States governments led by the International Joint Commission (IJC) in response to severe flooding in the area in 2011 and a subsequent 2013 Plan of Study (PoS) that identified measures to mitigate flooding and flood impacts in the LCRR watershed.

On July 24 and July 31, 2014 the governments of the US and Canada, in accordance with Article IX of the Boundary Waters Treaty, requested that the IJC assist the two governments in:

1. Addressing and closing data gaps through data collection and harmonization of topographic, bathymetric, aquatic vegetation, soil texture, LiDAR and observed climate and hydrometric data collection (per section 3.1, p. 34 of the July 2013 PoS) as are necessary as a basis for the earliest possible initiation of a real-time flood forecasting and inundation mapping system. This system would consist of the development of new real-time LCRR hydrologic and hydraulic models for predicting lake and river levels, and a precise DEM of the flood plain to delineate the contours of corresponding inundated areas.
2. Creation of static flood inundation maps using a combination of existing and new data and modeling to provide practical information to communities. These maps would show which areas would be affected if LCRR water levels hit different heights.

Under the guidance of the International Lake Champlain-Richelieu River (ILCRR) Technical Working Group (TWG) gaps in specific aspects of the required elements for a future forecasting system were addressed, a suggested pragmatic approach for a future flood forecasting system was developed, and a series of static maps of flood inundation under specific scenarios in response to component 2 of the directive were prepared.

Accomplishments from this collective Canadian-United States effort include:

1. **New LiDAR data** were collected for drainage to Lake Champlain in New York State. When this LiDAR data along with new LiDAR data for Vermont is released, a complete LiDAR data set will be available of the entire LCRR basin.
2. **Hydrologic and watershed data** for areas of the LCRR basin were collected and used to create an experimental two-dimensional hydro-dynamic model of Lake Champlain and the Richelieu River.
3. **Meteorological data evaluation** to assess current abilities to predict short- and long-term precipitation, wind and temperatures for the LCRR basin. Data and predictions from a variety of US and Canadian sources were used in this evaluation. Results indicates it is possible to forecast the North-South component of the wind for three day out periods for flood forecasting purposes, but a calibration/downscaling procedure will be required before wind forecasts can be used by hydrodynamic models. Precipitation forecasts to the 5-day lead-time also provide reliable forecasts for flood modeling purposes.
4. **Vertical datum corrections** were developed for critical lake and river water level measuring points so that a common vertical datum could be used on both sides of the

international border. This has been a previous issue when comparing observed Lake Champlain and Richelieu River water levels. This problem is now solved.

5. **Experimental 2-dimensional hydrodynamic lake modeling for Lake Champlain and Richelieu River** was performed using existing and new data collected for this study. Results of the modeling found that high lake levels on Lake Champlain could be reasonably simulated with this model and that the model provides a good foundation for future modeling of the lake and Richelieu River to Chambly. Additional bathymetric data of the Saint-Jean-sur-Richelieu sill and from Chambly downstream to Sorel will be needed to simulate river flows and flooding accurately.
6. **Static Flood Inundation maps for portions of the Lake Champlain shoreline and the Richelieu River above Chambly** were created for 11 flood level scenarios. These maps are designed to show what land areas would be flooded during the 11 scenario, and are hoped, to be a valuable product for local and state emergency responders and local officials. The maps will be available on the web so locals can get quick access to them. These maps are static and therefore do not reflect actual wind and wave conditions that could influence the extent of flooding. A complete LiDAR Digital Elevation Model available in Canada also allowed for the representation of inundation depths for the 11 flood scenarios.
7. **Future Improved and Coordinated Flood Forecasting** is possible and a pragmatic approach is described. The approach is based on using a probabilistic approach to the modelling system and an international coordination body to issue the best possible joint flood forecast to the agencies responsible for flood warnings and flood plain mapping.

The study also provides specific recommendations for future flood forecasting and preparedness; these recommendations include:

1. To generate flood forecasts and real-time flood mapping system, the TWG recommends that the proposed U.S. - Canada two-pronged probabilistic approach presented in section 5 for the forecasting of floods should be adopted and implemented operationally, including the modelling of wind set-up and wave action.
2. To calibrate and validate a future forecasting system, the TWG recommend that the both the Port Henry and the Grand Isle water level stations installed to support this Study, be kept in operation at a minimum to collect data covering a representative range of water levels supporting the calibration of the hydraulic model, recognising that those stations may or may not be required in the context of an operational system. The TWG also recommends, at least during the calibration phase of a wave model, the installation of wave buoys in both the main part of the lake and in the inland sea.
3. The TWG recommends that a binational coordination body under the auspices of the IJC be instituted to conduct the coordination among agencies involved in real-time forecasts, namely on the development and maintenance of the models, availability of observation data, quality control of the ensemble predictions and generate the bi-national water level predictions and a consistent message to emergency responders and public regarding the bi-national water level predictions for distribution to agencies responsible for dissemination.
4. To allow for a better flood forecasting capacity of the entire LCRR, the TWG recommends that the acquisition of new bathymetric data of the Richelieu River between Sorel and the natural control section near Saint-Jean-sur-Richelieu, and that updated

maps of substratum and aquatic plant assemblages be completed.

5. To generate flood forecasts and real-time flood mapping products for the entire Lake Champlain Richelieu River system, as well as static maps, the TWG recommends that a single consistent DEM be created for the entire LCRR basin once all LiDAR and bathymetric data acquisition and quality control is completed.
6. The TWG recommends that the static flood inundation maps be generated for the entire Lake Champlain Richelieu River system.