

Flooding Performance Indicator Summary

Performance indicator: Flooding impacts on riparian property for Lake Ontario and the Upper St. Lawrence River

Technical Workgroup: Coastal TWG

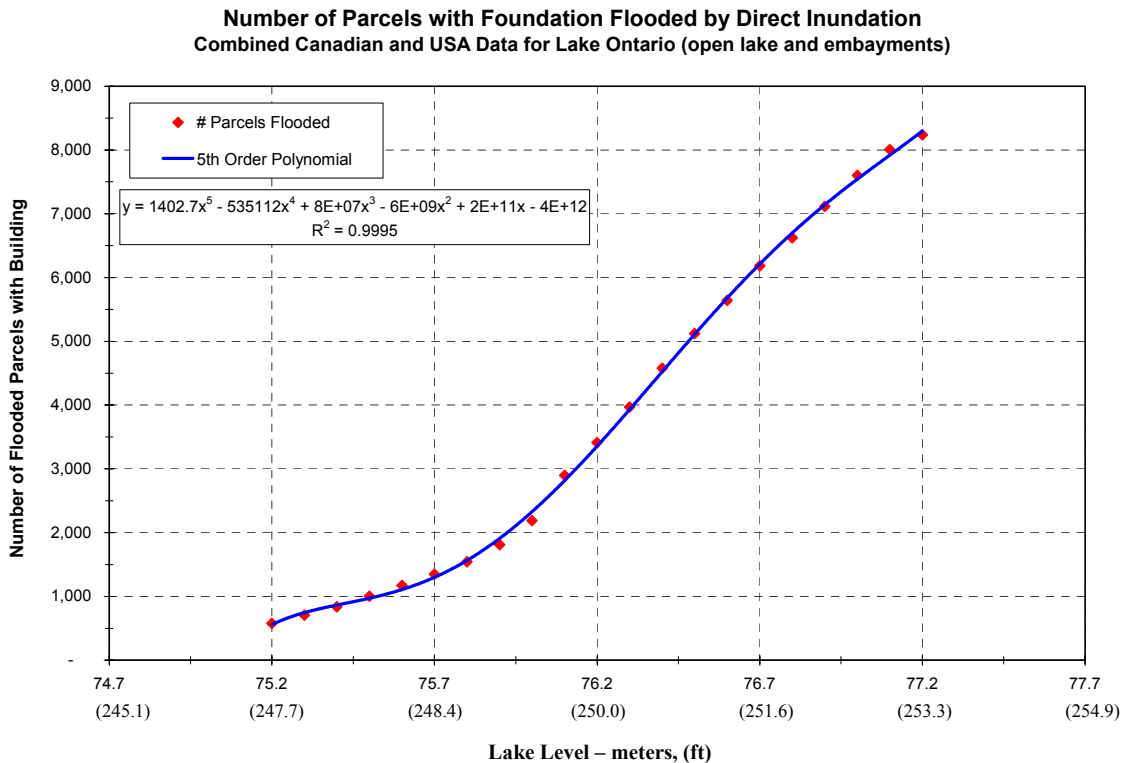
Research by: Baird & Associates

Modeled by: Complex algorithm in Flood and Erosion Prediction System (FEPS) linked directly to the Shared Vision Model



Activity represented by this indicator: Flooding of riparian property

Link to water levels: There is a direct link between lake levels and flooding. Simply, the higher the lake gets the more flood damages that occur. The graph below was generated from data in the property parcel database of the FEPS. As the lake level rises, an increasing number of homes are threatened by flood damage. For example, if the lake reaches 75.7 m (248.3 ft), water may reach the foundation of 1,300 homes across the lake. The number of homes at risk to flooding increases to 3,400 if the lake reaches 76.2 m (249.9 ft). Interestingly, a fifth order polynomial provides a very good line of best fit for the points in the graph



Importance: The parcel database in the FEPS indicates that there are approximately 25,000 riparian properties on Lake Ontario and the Upper St. Lawrence River susceptible to coastal hazards. Of these, 7,905 have land elevations at the building foundation less than 77.2 m (253.3 ft), which was established as the upper limit of flood damages for this study. Further, almost 800 of these parcels have land elevations at or below the current upper limit for the operating range of Lake Ontario 75.37 m (247.3 ft). In summary, flooding is a very real and dangerous coastal hazard for many communities on Lake Ontario and the Upper St. Lawrence River.

Performance Indicator Metric: Maximum monthly mean lake level is the metric for the Flooding PI on Lake Ontario. The table below summarizes the upper threshold for monthly lake levels (recommendations current as of spring 2004):

Upper	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Meters	74.70	74.70	74.87	75.04	75.20	75.20	75.20	75.20	75.04	74.87	74.7	74.7
Feet	245.1	245.1	245.6	246.2	246.7	246.7	246.7	246.7	246.2	245.6	245.1	245.1

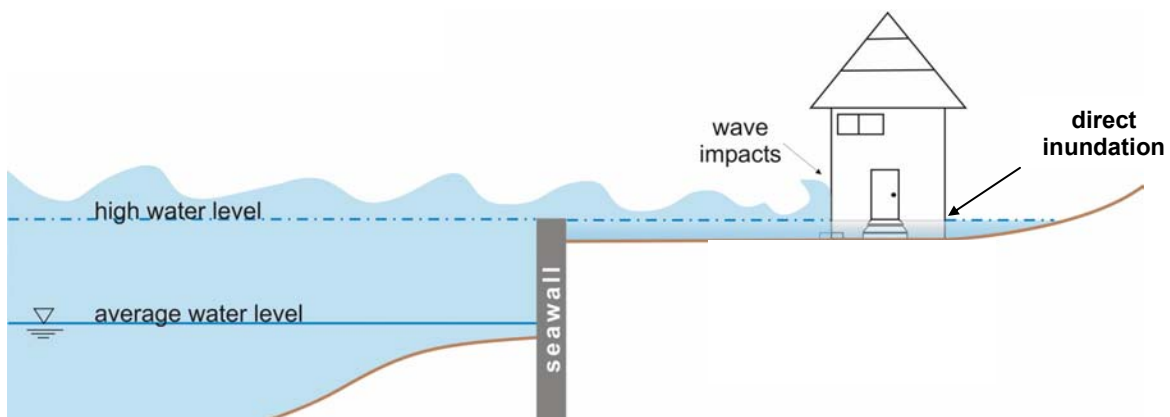
Recommendations are in progress for the Upper St. Lawrence River.

Temporal validity: The metric is valid throughout the year.

Spatial validity: The monthly water levels presented above are valid for Lake Ontario.

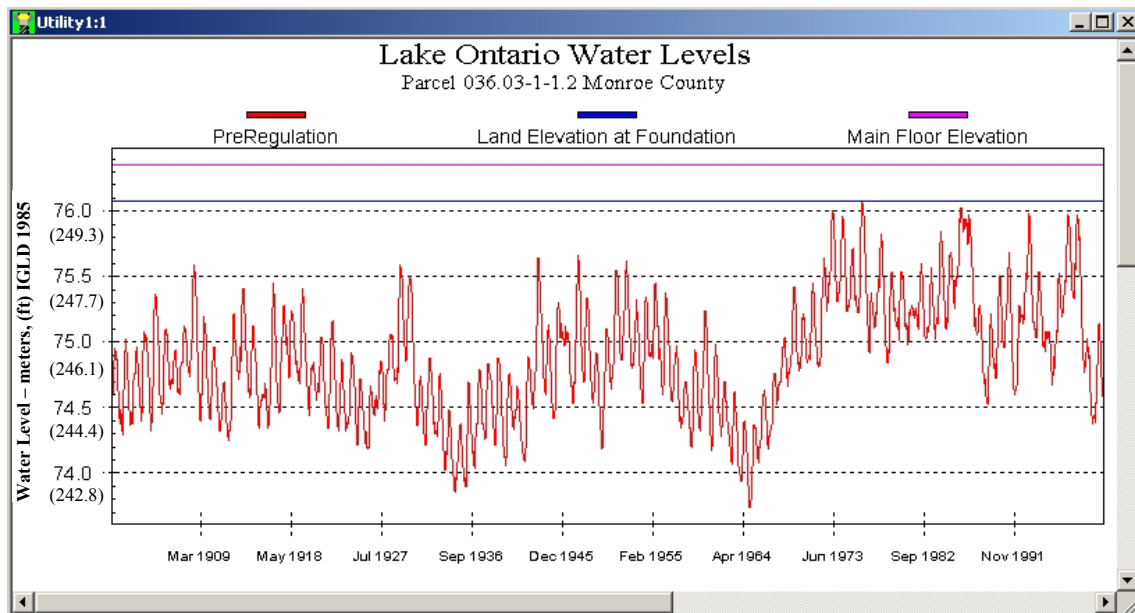
Links with hydrology used to create the PI algorithm: The flooding investigation began with a detailed literature review of previous investigations completed for the IJC, such as the 1992 Levels Reference Study. Methodologies and reports from the Federal Emergency Management Agency (FEMA) and the United States Army Corps of Engineers (USACE) were also reviewed. Several detailed study sites were investigated to assess historical flood events on Lake Ontario and model hypothetical damages for alternative regulation plans. For more information on the detailed numerical modeling, refer to the study sites report (Baird, in preparation).

The culmination of this work is the Flooding PI algorithm described in the next section and summarized visually in the graphic below. There are two principal types of flood damage during high water levels: 1) direct inundation above the main floor elevation, and 2) structural damage due to wave forces impacting directly on the buildings. These two processes are described in further detail below.



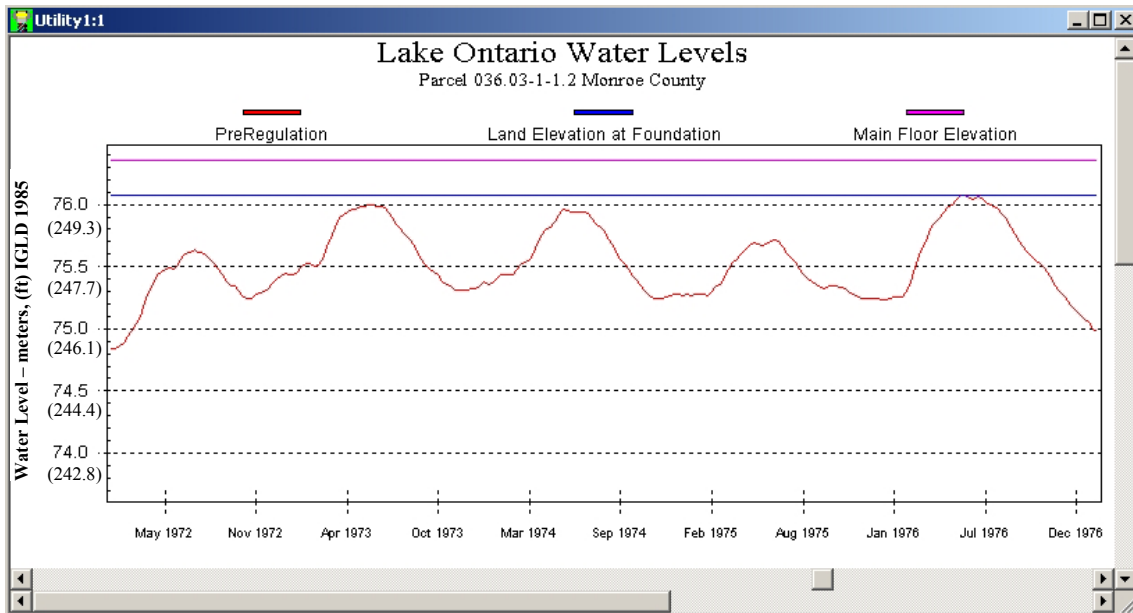
The Algorithm: The Flooding PI algorithm was developed, tested, calibrated and verified in the FEPS. Refer to the May 2004 report for a complete reference (Baird, 2004c). Several key components of the algorithm will be discussed, including: application during simulation time, flooding damages due to inundation (structural and contents) and flood damage due to wave forces directly on the structure (i.e. buildings in the velocity zone).

The Flooding PI algorithm is applied to the entire parcel database for the duration of a simulation in the SVM, commonly 101 years. Since flood damages are event driven, the algorithm must move through simulation time and look for lake levels that could cause flooding damages at each parcel individually. An example is presented for Parcel 036.03-1-1.2 in Reach 938, Monroe County, NY. The land elevation at the base of the building is 76.08 m, the main floor elevation is 76.35 m (250.5 ft), and the home is located 5.6 m (18.4 ft) from the edge of the lake. The lake levels for the Pre-Project condition are plotted in the graphic below along with the land and main floor elevation



for Parcel 036.03-1-1.2.

Prior to the 1970's, there is no flood risk for the parcel as lake levels are at least 0.5 m (1.6 ft) below the foundation of the home. However, in the early 1970's, flooding damages are predicted with the algorithm. To understand why, a second zoomed view of the lake levels is provided below for the period of 1972 to 1976. A storm occurs on May 1, 1973 and the resulting storm surge above the static lake level in Monroe County was approximately 0.2 m (0.6 ft). This additional water was sufficient to cause standing water at the building foundation. The maximum wave height for the event was 1.1 m (3.6 ft). The combination of standing water, the close proximity of the building to the lake and a 1.1 m (3.6 ft) offshore wave height resulted in a prediction of structural damage to the foundation of the building. The methodology used for the damage calculation was based on the published data for the wave energy flux reaching a building and the associated damage in a joint publication from Environment Canada and the



1973 to 1976 lake levels for Pre-Project conditions



Example of structural damage to a home foundation due to wave forces

Ministry of Natural Resources (EC and MNR, 1981). The lake level with surge wasn't high enough to reach the main floor of the building and thus there was no damage predicted to the interior of the home or the contents. The damage calculations for this type of flooding (interior and contents) are based on the FEMA depth damage curves. Refer to Baird (2004c) for additional details. The algorithm keeps track of the estimated damage for the May 1, 1973 event and continues to move through the time series to look for combinations of lake levels and wave heights that could damage the structure.

Validation: The predictive capabilities of the Flooding PI algorithm were extensively tested during Baird's internal Quality Control – Quality Assurance review. The predicted flood events for the historic time series from 1960 to present corresponded to years when flood damages were actually reported (1973, 1992, etc.).

Unfortunately, there is no damage data to verify flooding impacts and the associated economic damages for lake levels above 76.0 m (249.3 ft) on Lake Ontario because the lake has never reached these elevations. However, during the high supply conditions of the 1970s, 1980s, and 1990s, the modeled water levels for Pre-Project and 1958D without Deviations both feature water levels above 76.0 m (249.3 ft). In the absence of real damage data to verify the function for these high lake levels, we have used our professional judgment to evaluate the predicted flooding damages and they are reasonable.

Documentation and References:

Baird, (in preparation). *Lake Ontario and Upper St. Lawrence River Detailed Study Sites*. Prepared for the Coastal TWG.

Baird, 2004b. *Flooding Performance Indicator: Methodology and Shared Vision Model Application*. Prepared for the Coastal TWG, May 2004.

Environment Canada and Ontario Ministry of Natural Resources, 1981. *Great Lakes Shore Management Guide*.

Risk and uncertainty assessment: As discussed above, there is when with lake levels exceed 76.0 m (249.3 ft), as these levels have never occurred on the lake during the current settlement period. Consequently, there is no recorded damage data to verify the algorithm.