The potential impact of climate change on the Lake Huron shoreline at Goderich

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Lake Huron water levels have been declining due to a combination of lower precipitation, higher air temperatures, and increased evaporation over the past three years. Further, warmer winter temperatures and below average precipitation in 1999-2000 reduced the amount of snow required to replenish lake levels in the spring (GLERL, 2000). Although summer precipitation levels were above average, water levels continue to decline, and are currently approaching their record low set in 1964. As cold, dry air masses pass over warmer Lake Huron waters this fall and winter, the potential exists for lake levels to reach their lowest point in 36 years.

Figure 1. Georgian Bay, 1964 and Grand Traverse Bay, Lake Michigan, 2000 (Sources: Dr. Daniel Scott, Adaptation and Impacts Research Group (left) and Dale G. Young, The Detroit News (right). Note: due to the Straits of Mackinac, Lakes Michigan and Huron share the same lake level.)

At present, water levels are 10 cm below chart datum at 175.90 m. The reference point for measuring Great Lakes water levels, chart datum for Lake Huron is 176.0 m above sea level (International Great Lakes Datum, 1985). Based on an average level between several measurement stations, current levels are 32 cm above the all time low level for Lake Huron of 175.58 m recorded in March of 1964.

Although lake level fluctuations are natural and occur in annual and long-term cycles, climate change could have a significant impact on Lake Huron water levels should temperature and evaporation increase and seasonal precipitation patterns become more variable and extreme. Recent studies have indicated that Lake Huron water levels are projected to decline by as much as 1 m by 2050 (Mortsch et al, 2000). To date, little research has focussed on the potential impact this change may have on the socioeconomic and biophysical systems of the Lake Huron shore.

Figure 2. Goderich study area, shown in a 1965 air photo following 1964 record low levels.

This article outlines a joint research project between the University of Waterloo's Department of Geography, Environment Canada's Adaptation and Impacts Research Group and the Lake Huron Centre for Coastal Conservation. A methodology to explore, assess, and quantify the potential impacts of declining water levels on the Lake Huron shore at Goderich, Ontario is presented. A prominent tourist destination and the site of a major Great Lakes shipping port and the world's largest salt mine, Goderich represents a unique and ideal study area for a climate change impact assessment. Shown below, the study area covers an approximate area of 2.5 km^2 along the Lake Huron shoreline at Goderich.

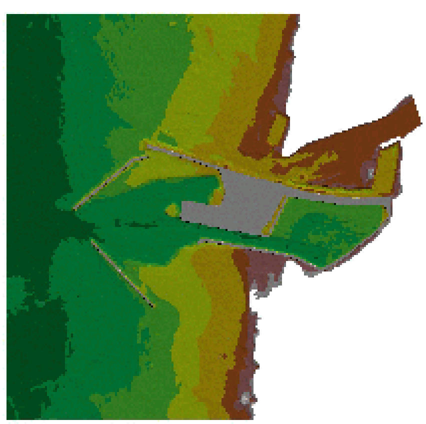

Figure 3. GIS surface representation of the Goderich harbour and near shore area.

The methodology utilizes a geographic information system (GIS) to produce a shoreline elevation model that incorporates bathymetric, topographic, and water level scenario data sets. A continuous digital elevation surface of the shore and near shore areas is produced upon which projected water level scenarios are plotted.

Water level scenarios from the combined results of atmospheric general circulation models (GCMs) and hydrologic models can be plotted on the elevation surface to produce hypothetical shorelines. Arbitrary scenarios of lake level decline can also be plotted on the model depending on local stakeholder interests and concerns. For example, 10 cm, 25 cm, and 50 cm decreases in Lake Huron levels could be mapped as new shorelines.

Since water levels are referenced to a known elevation (chart datum), water level scenarios can be plotted at their corresponding lake bed elevation. Contour lines representing water level elevations can be extracted from the elevation model to represent hypothetical shorelines. The following example represents an arbitrary water level decline of 1 m from 176.0 m to 175.0 m at Goderich.

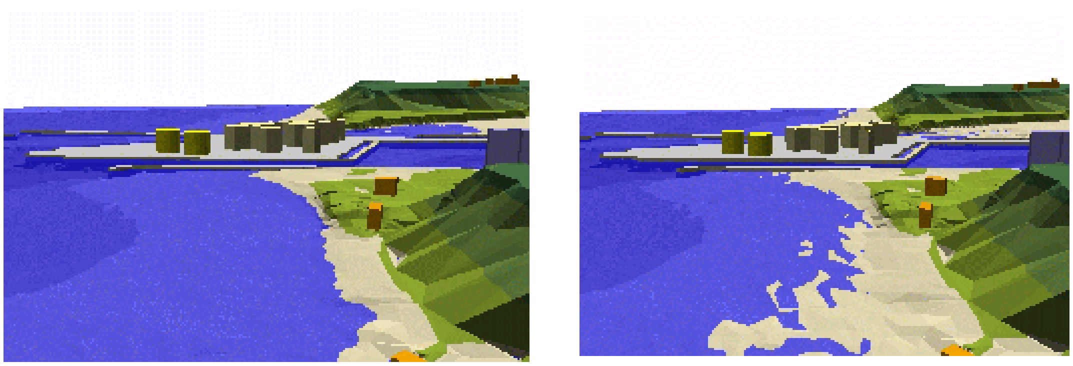

Figure 4. Example 1 m water level decline from 176 m to 175 m along the Goderich shoreline. Shoreline change will vary with water depth and slope of the near shore, and will be more pronounced along shallow and gradually sloping shore areas.

Due to the uncertainty surrounding projected changes in climate and water levels, several scenarios will be used to produce a range of hypothetical shorelines. By creating a series of shorelines at Goderich, a range of sensitivities, impacts and costs can be identified for the Goderich harbour. The model can be used to estimate volumes of material that may require dredging, identify potential navigation hazards, calculate surface areas of newly exposed lake bed, and determine the lakeward extent of shoreline movement. The model could ultimately be used to assess the utility of the Goderich harbour under altered climate and water level scenarios.

Although decreasing water levels at Goderich may produce impacts for the harbour and surrounding marinas with respect to shipping and navigation, several opportunities may be presented as well. For example, declining water levels will produce wider beaches and may reduce shoreline erosion and destruction of homeowner property. Should climate change induced lake level decline occur, a range of impacts and opportunities will depend on current shoreline use and stakeholder interests.

The results expected from the shoreline model are envisaged to be used as a first estimate for potential socioeconomic and biophysical impacts at Goderich. With refinement, the shoreline elevation model could generate estimates of potential economic impacts and opportunities, provide both researchers and local decision and policy makers with a valuable future planning tool, and support further shoreline management and climate impact and variability studies in other Great Lakes. Depending on data quality and availability, the methodology could be expanded along the entire Lake Huron shore in an attempt to explore the implications of changes in climate and water levels on the tourism and recreation, shipping and navigation and shoreline development sectors of Ontario's economy.

References

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Mortsch, L. D., H. Hengeveld, M. Lister, B. Lofgren, F. Quinn, M. Slivitzky and L. Wenger. 2000. Climate change impacts on the hydrology of the Great Lakes-St. Lawrence system. *Canadian Water Resources Journal* 25(2): 153-179.