Reacting to Extreme High Water Levels on Lakes Michigan-Huron

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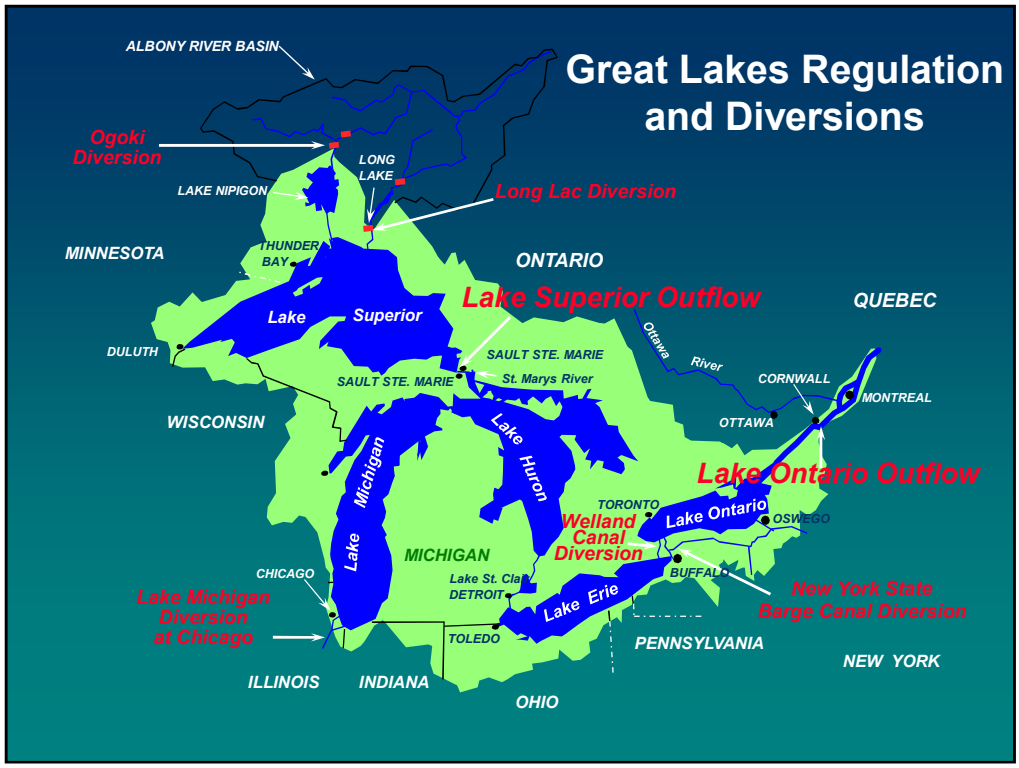
Great Lakes Regulation and Diversions
ALBONY RIVER BASIN
Ogoki Diversion
LONG LAKE
LAKE NIPIGON
Long Lac Diversion
MINNESOTA
THUNDER BAY
ONTARIO
QUEBEC
Lake Superior Outflow
Lake Superior
DULUTH
SAULT STE. MARIE
SAULT STE. MARIE
St. Marys River
Ottawa River
CORNWALL
MONTREAL
OTTAWA
WISCONSIN
Lake Michigan
Lake Huron
Lake Ontario Outflow
TORONTO
Welland Canal Diversion
Lake Ontario
OSWEGO
MICHIGAN
Lake St. Clair
DETROIT
BUFFALO
Lake Erie
CHICAGO
Lake Michigan Diversion at Chicago
New York State Barge Canal Diversion
TOLEDO
PENNSYLVANIA
NEW YORK
ILLINOIS
INDIANA
OHIO

Hydrologic Principles

Magnitude: The extremes of a range of occurrences

Duration: Length of time that a phenomenon persists

Sequence: The order that differing phenomenon occur

Extreme Water Level Periods

This slide shows all the years in red where water levels were below the “crisis action level” for more than 6 months of the year. This level is the trigger for measures that should be implemented to hold water back on Lakes Michigan-Huron, per recommendations of the IJC Levels Reference Study in their Annex 6 report published in 1993. For the years in blue, extreme high water levels should cause implementation of crisis measures to increase outflows from the lakes and reduce inflows into them from the Long Lac and Ogoki Diversions.

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The previous longest sustained low water period occurred between 1932-1938 during the “Dust Bowl” era, a long-running drought across much of central North America. You can see that our current extreme low water level period is more than twice as long as the previous longest duration event.

Recent Hydrology

US Army Corps of Engineers

PRECIPITATION (INCHES)								
BASIN	June				12-Month Comparison			
	2019	Average (1900-2016)	Diff.	% of Average	Average Last 12 Months	Average (1900-2016)	Diff.	% of Average
Superior	2.85	3.30	-0.45	86	29.72	30.58	-0.86	97
Michigan-Huron	3.59	3.18	0.41	113	34.84	32.55	2.29	107
Erie	4.33	3.50	0.83	124	37.96	35.62	2.34	107
Ontario	3.88	3.20	0.68	121	39.00	35.87	3.13	109
Great Lakes	3.54	3.25	0.29	109	34.25	32.77	1.48	105

LAKE	June WATER SUPPLIES[1] (cfs)		June OUTFLOW[2] (cfs)	
	2019	Average (1900-2008)	2019	Average[3] (1900-2008)
Superior	125,000	155,000	101,000	77,000
Michigan-Huron	306,000	204,000	246,000	192,000
Erie	79,000	31,000	283,000	216,000
Ontario	72,000	42,000	360,000	260,000

Notes: Values (excluding averages) are based on preliminary computations; cfs denotes cubic feet per second.

[1] Net basin supply is the net result of precipitation falling on the lake, runoff from precipitation falling on the land which flows to the lake, and evaporation from the lake. Negative net basin supply denotes evaporation exceeded runoff and precipitation. The net total supply can be found by adding the net basin supply and the outflow from the upstream lake.

[2] Does not include diversions.

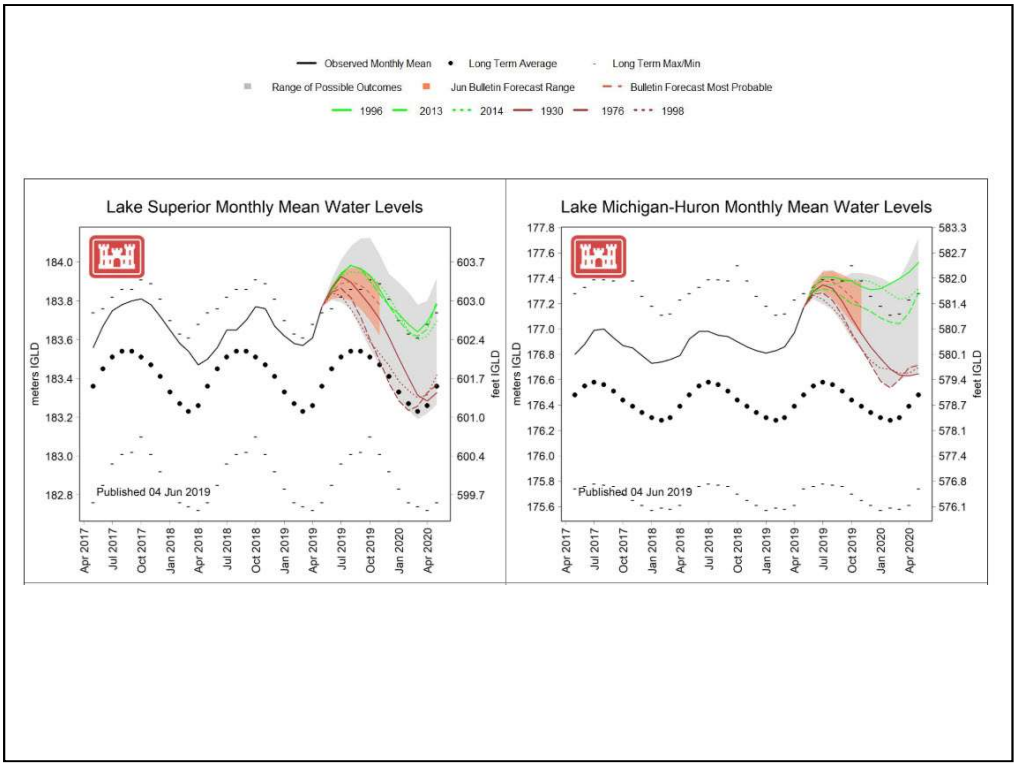
[3] Lake Ontario average water supplies and average outflows are based on period of record 1900-2005

Over the period July 2018 through June 2019, all of the Great Lakes drainage basins except Lake Superior have received precipitation significantly above normal. All interconnecting rivers (St. Marys, St. Lclair, Detroit and Niagara) and the St. Lawrence Seaway have been discharging water well above their long term averages.

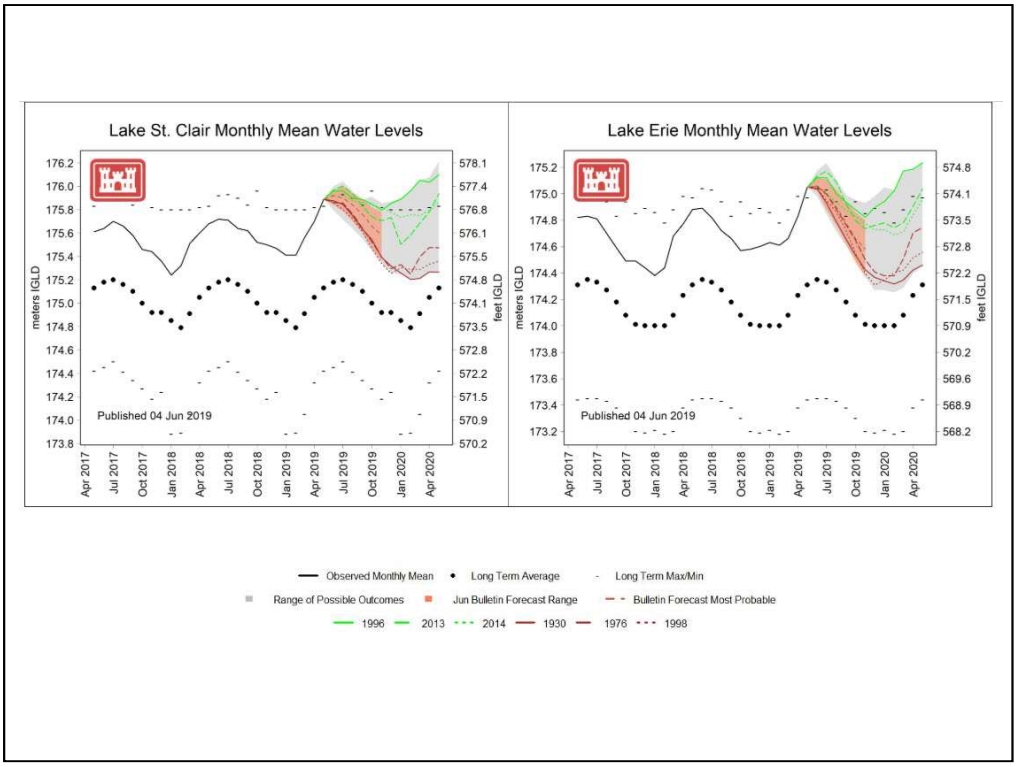
Water Level Forecasts

	SUPERIOR	MICH-HURON	ST. CLAIR	ERIE	ONTARIO
Forecasted Water Level for Jul 5, 2019 (feet)	603.22	581.96	577.59	574.70	248.98
Chart Datum (feet)	601.10	577.50	572.30	569.20	243.30
Difference from chart datum (inches)	+25	+54	+63	+66	+68
Difference from average water level for Jun 5, 2019 (inches*)	+1	+4	+4	+2	-1
Difference from average water level for Jul 5, 2018 (inches*)	+9	+15	+12	+11	+30
Difference from long-term monthly average of Jul (inches)	+14	+31	+33	+33	+35
Difference from highest monthly average of record for Jul (inches)	+2	0	+5	+6	+8
Year of highest recorded monthly mean	1950	1986	1986	1986	2017
Difference from lowest monthly average of record for Jul (inches)	+35	+63	+61	+68	+69
Year of lowest recorded monthly mean	1926	1964	1934	1934	1934
Projected net change in levels for Aug 5, 2019 (inches)	+3	+2	0	-2	-10

U.S. Army Corps of Engineers weekly water level forecast as of July 5, 2019. Lake Michigan-Huron is expected to peak 2” inch higher by August 5, 2019, being near a new record high level. Lake Superior is expected to also rise during the next month and will likely establish a new record high. Lakes Erie and Ontario are expected to start declining over the next month.



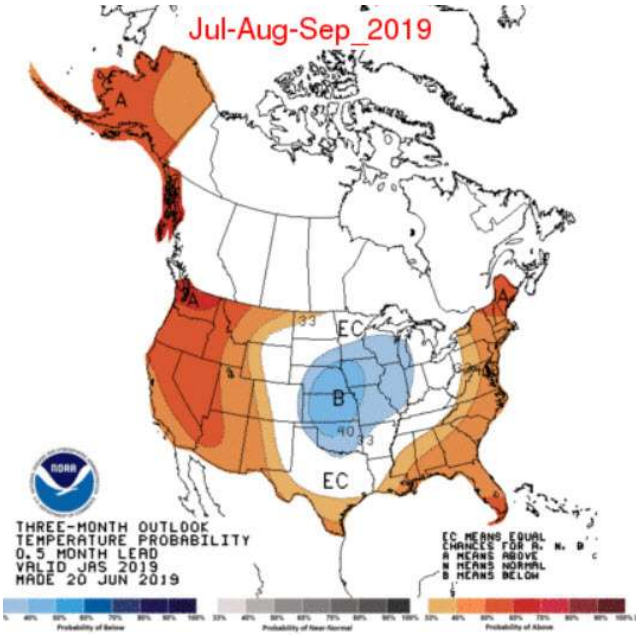
These graphs show that water levels over the next twelve months for Lake Superior could continue to set new record highs if water supplies are well above long term averages. Lakes Michigan and Huron also could see higher water levels for the rest of the calendar year if supplies are well above average. If supplies are lower than average, Michigan and Huron could drop below 2018 levels but would still remain well above long-term water level averages.



Lakes St. Clair and Erie are expected to continue with extreme high water levels over the next twelve months, owing largely to substantially above average inflows from the upstream lakes (Superior and Michigan-Huron).

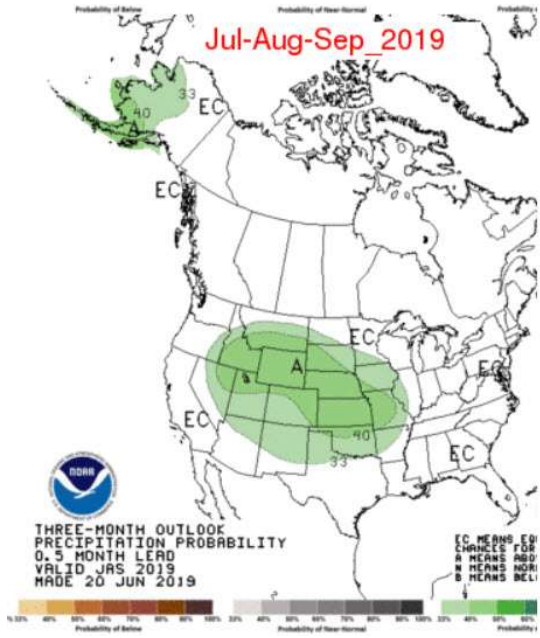
Weather Outlooks

90-Day Temperature Outlook



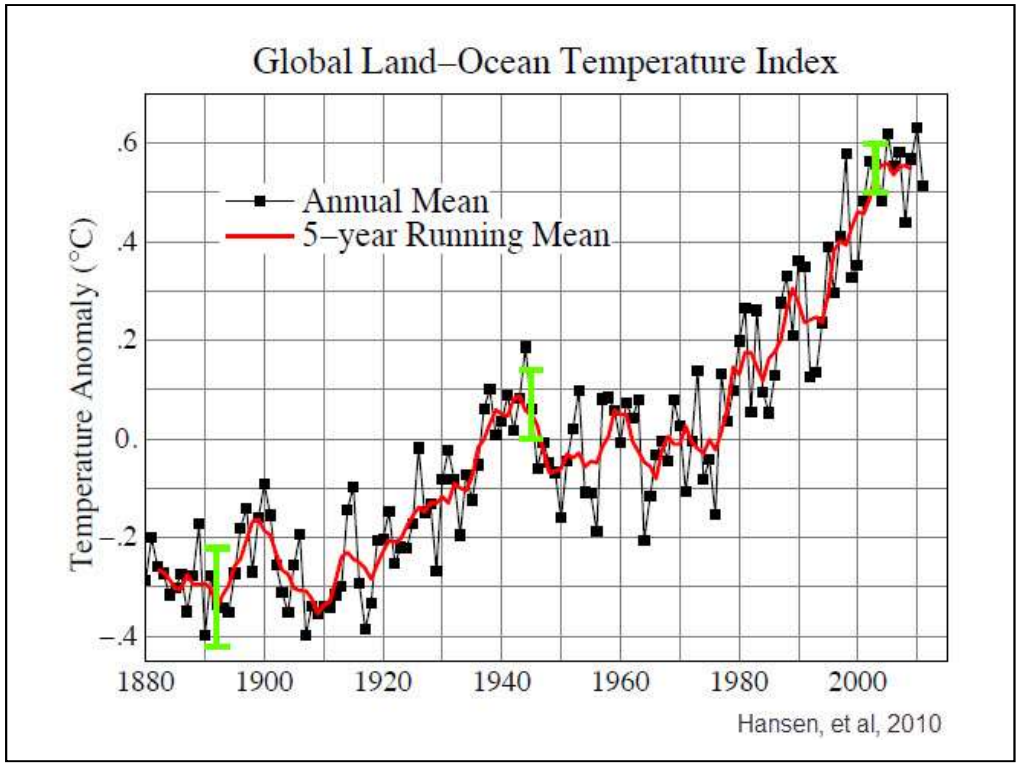
The late summer temperature conditions are expected to be near normal for most of the Great Lakes.

90-Day Precipitation Outlook



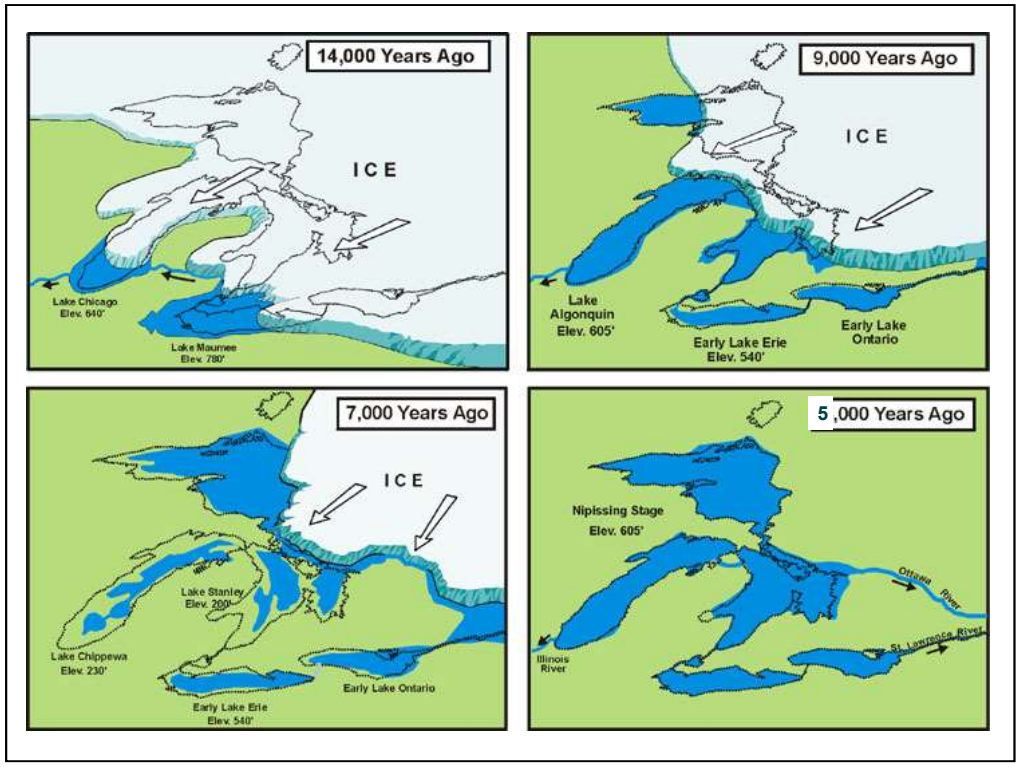
Precipitation across the entire Great Lakes basin over the next 90 days is expected to be at or near average.

Global Climate



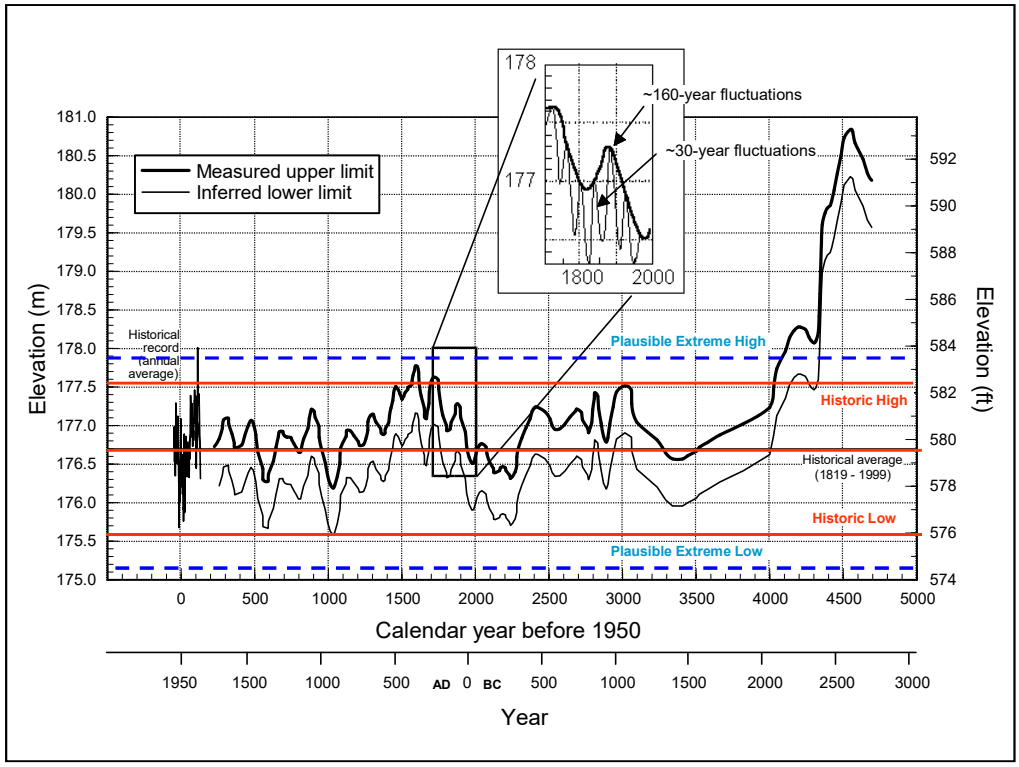
This graph showcases the average annual global temperatures since 1880. Beginning in the mid 1970s global temperature averages have risen steadily by almost .6 of a degree (Celsius). Global warming is a reality and has caused substantially greater climate variability across the Great Lakes region.

Paleo-geologic Climate



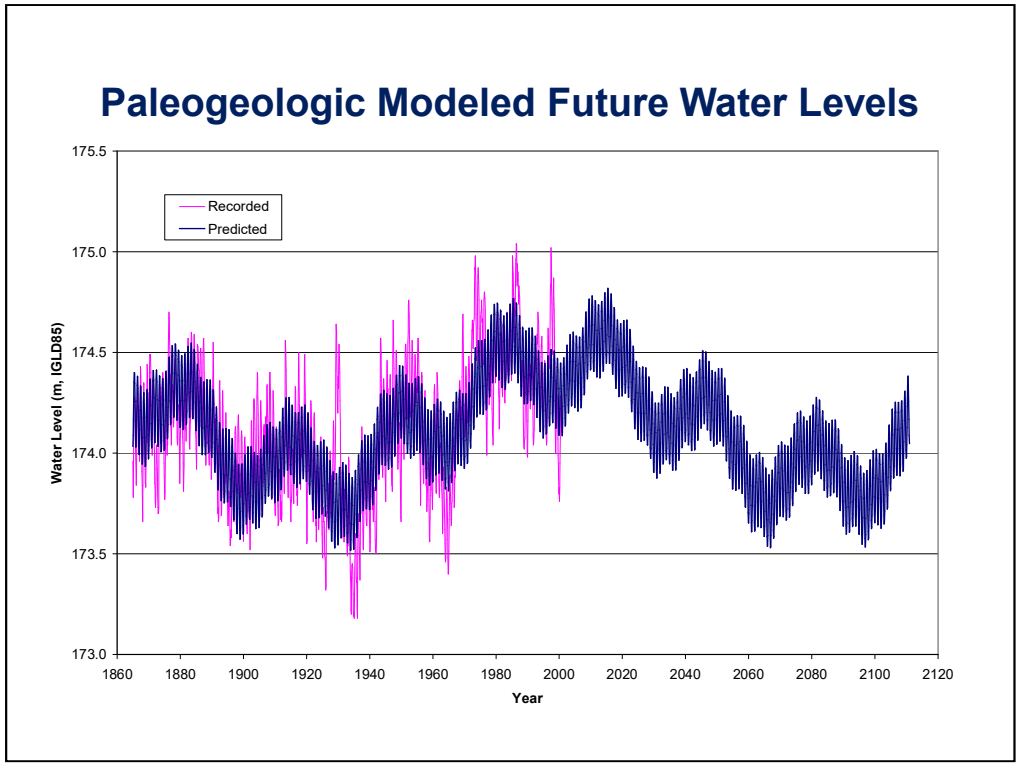
These graphics show the best estimates of glacial positions across the Great Lakes region, with massive changes in water levels on each of the current five Great Lakes.

This aerial photo shows concentric beach ridges along the Lake Michigan shoreline. Each ridge contains evidence of past extreme high water level position.



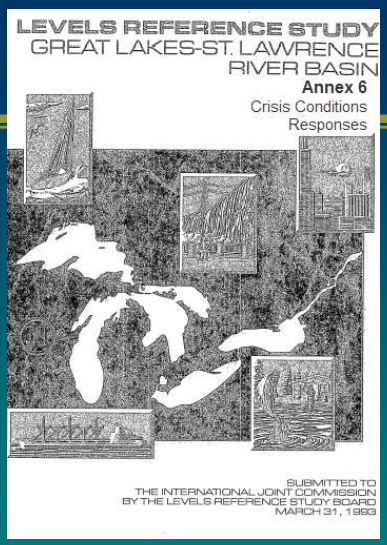
This graph shows the reconstructed extreme high water levels on Lakes Michigan and Huron derived by Dr. Todd Thompson of the Indiana Geological Survey. These reconstructed levels agree with the range of levels recorded on the lakes since 1865. The plausible extreme highs and lows were derived by stochastic statistical methods, showing that these lakes could be 9" higher than the record high recorded in 1986 and 21 inches lower than the record low that occurred in 2014.

Dr. Thompson's research indicates that there is a "quasi periodicity" of extreme high water levels on these lakes that occur every 150-160 years, with a subordinate frequencies of 30-35 years.



Dr. Thompson generated a predictive model using the prior frequency analysis. This graph shows his projected water levels for Lakes Michigan and Huron from 1860 through 2120 in dark blue. The magenta lines overprinting the graph are recorded water levels for the lakes from 1860 through 2000. Generally the recorded water levels track the modeled predicitions.

Crisis Response Measures



1993 IJC Levels Reference Study Annex 6 – Crisis Conditions Responses

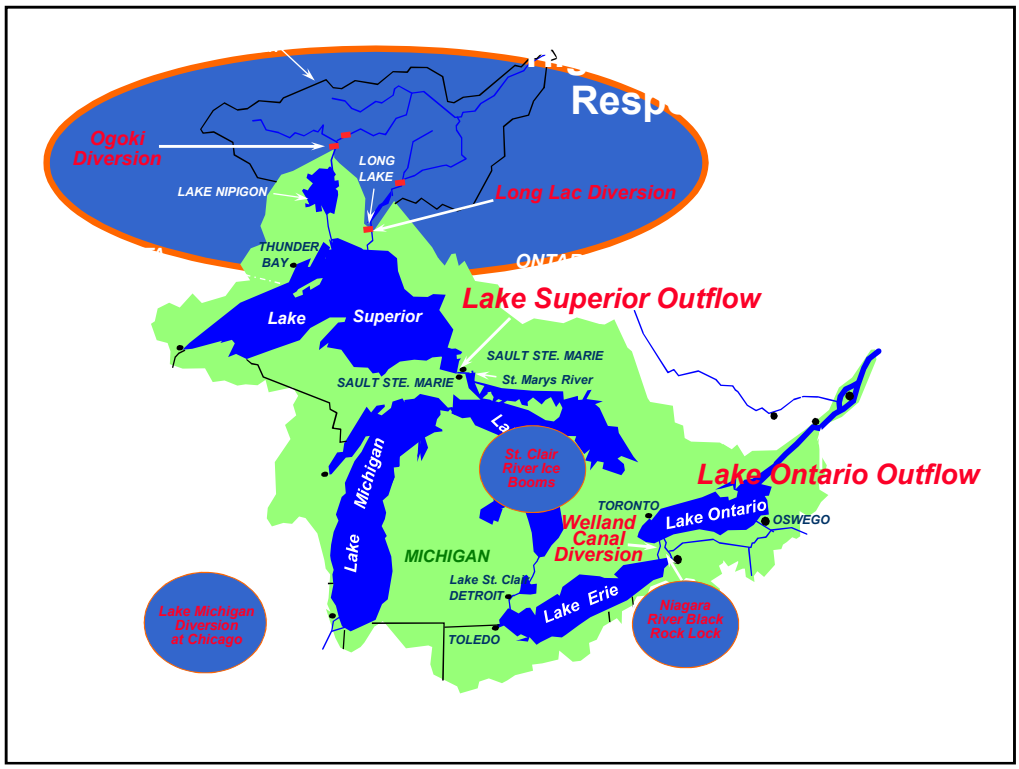
- Established Alert and Action Levels for both High and Low Water Extremes for each Great Lake

- Includes non-capital cost measures and capital cost measures AND combinations

Endorsed by the International Joint Commission, the U.S. State Department and Canadian Ministry of Foreign Affairs

In 1993, the International Joint Commission recommended that the governments of the U.S. and Canada work toward implementation of a series of “Crisis Response Measures”. In turn, our federal Governments endorsed this strategy. Unfortunately, no progress has been made on this front over the last twenty-five years.

On the next few slides, we will examine what these “crisis measures” are.”



The four crisis response measures that should be implemented include 1) cutting back inflows from the Long Lac and Ogoki Diversion to their natural levels (from 160 cubic meters per second on average to a maximum of 30 cubic meters per second), 2) doubling the outflows through the Lake Michigan Diversion at Chicago; 3) stabilizing the ice cover on the St. Clair-Detroit rivers to allow for more discharge during winter months; and 4) opening up the Black Rock Lock in the Niagara River to increase outlfows from Lake Erie.

Cumulative Human Impacts on Lakes Michigan - Huron Water Levels

Modification	Dates	Estimated Effect on Lakes M-H Water Level (inches)
Long Lac - Ogoki Diversions (inflow)	1943 to present	+ 4.3
Chicago Diversion (outflow)	1887 to present	- 2.4
Welland Canal (outflow)	1824 to present	- 2.4
Detroit-St Clair Rivers Modifications	1855 to present	-19.7
Niagara River Outlet Constriction	unknown to present	+ 1.2
Consumptive Uses	unknown through 1993	- 2.0
NET EFFECT	1855 to present	21 inches lower

Each of the Great Lakes are affected by modifications to its inflows and outflows through diversions and changes in river channels. Lake Michigan and Huron has had the biggest cumulative impact of human modifications to its water balance.

This table showcases that the inflows from Long Lac – Ogoki Diversion into Lake Superior has increased Michigan-Huron by 4.3 inches, while outflows through the Chicago Diversion have lowered the lakes by 2.4 inches. If the Long Lac –Ogoki Diversion was reduced to its natural level and the Chicago Diversion was doubled, it would be theoretically possible to reduce water levels on Lakes Michigan and Huron by at least 6 inches.

Adaptive Measures

Adaptive Measures

Shoreline Armoring – Examples already deployed

Vegetation Planting – Guidance exists for low dunes

Beach Nourishment – Not extensively used

Zoning Restrictions – In-place but could be strengthened

Erosion Insurance – Explored but never implemented

Tax Credits for Losses – More investigation warranted

Reactions to extreme high water levels across the Great Lakes region could include any of the measures listed here.

Comments / Questions