## Newly-recognized lowstands of the Laurentian Great Lakes signal their sensitivity to changed climate

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Today the Great Lakes are collectively ranked as North America's largest freshwater reservoir. Their five basins support a total population of >33 million persons, and host well-developed activities and facilities for shipping, industry, power production, fishing, recreation, and municipalities. Their monthly mean levels have varied little more than ± 1 m during 150 years of instrumental measurement, and thus appear relatively stable. Together, the lakes contain 23,000 km$^3$ of water, and their watersheds add about 1 % of this volume annually, derived from precipitation and runoff. Overflow from this positive water balance sustains major rivers and shipping canals between lakes, and discharges to the St. Lawrence River. In a similar way, geologists and paleo-hydrologists have always considered the

 

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paleo-Great Lakes to have been overflowing bodies of water since their formation during retreat of the last (Laurentide) ice sheet. This paradigm of continuous abundant water supply is shown to be false by recent findings of early Holocene lowstands, indicated by submerged tree stumps, beaches, and spillways, buried erosion surfaces, infilled river valleys, and a new analysis of differential glacio-isostatic uplift.

Comparison of the early Holocene lake level, based on the original elevations of all dated lake-level indicators, with the uplift history of possible outlets, revealed an episode of low water level tens of meters below outlets about 7,900 $^{14}C$ (8,800 cal) BP, possibly a few centuries long. Lakes without outflow can only be explained by a dry climate in which water losses by evaporation exceeded water additions by precipitation and runoff.

The discovery that the Great Lakes entered a phase of negative water balance in a dry climate with low water levels below outlets, and hence without connecting rivers, signals the sensitivity of these lakes to climate change, and that significant reductions in lake level relative to current societal usage should be expected as climate in the Great Lakes Basin warms in future. Modeling and prediction of future levels requires confident knowledge of the sensitivity of the Great Lakes hydrology to climate change. An opportunity to add to this knowledge is possible by further research and quantification of this new phase of early Holocene climate and closed lakes.