

## Lake Profile Brief

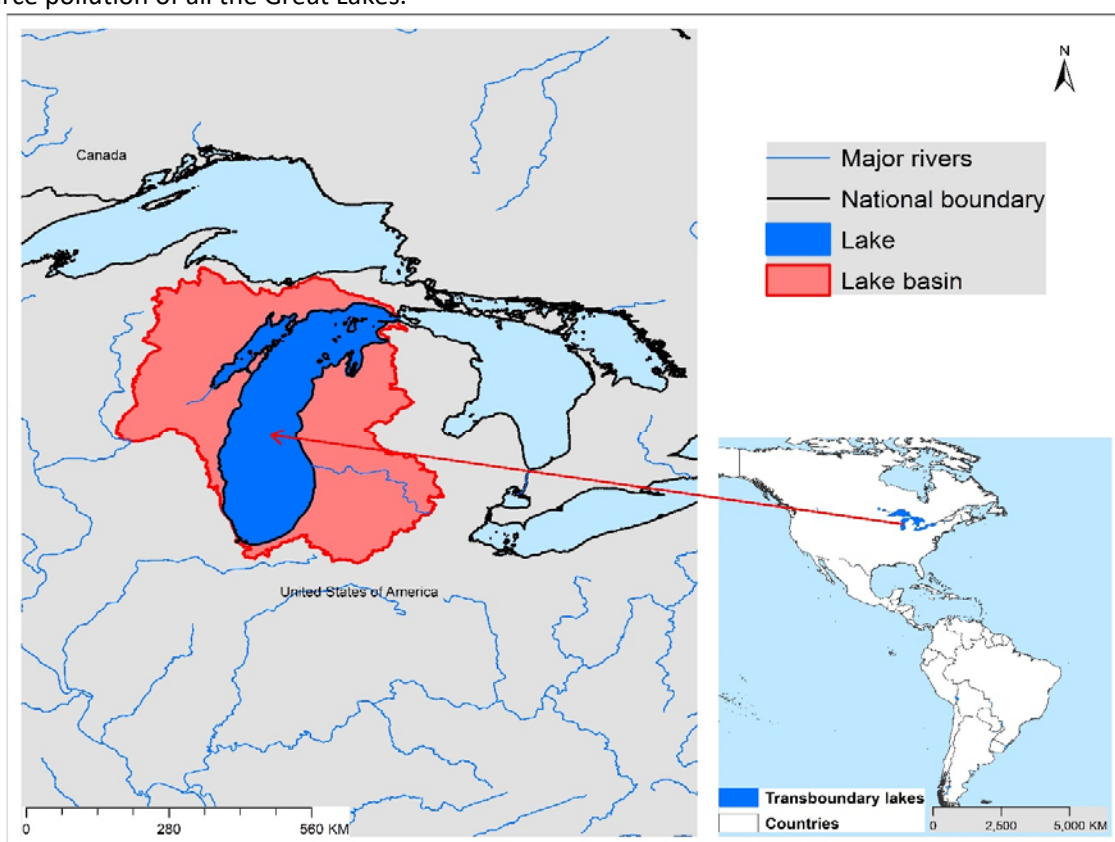
This is based on the results of Multiple Lake Threat Assessment and its Scenario Analysis. Refer to the Technical Report for details.



### Lake Michigan

### Geographic Information

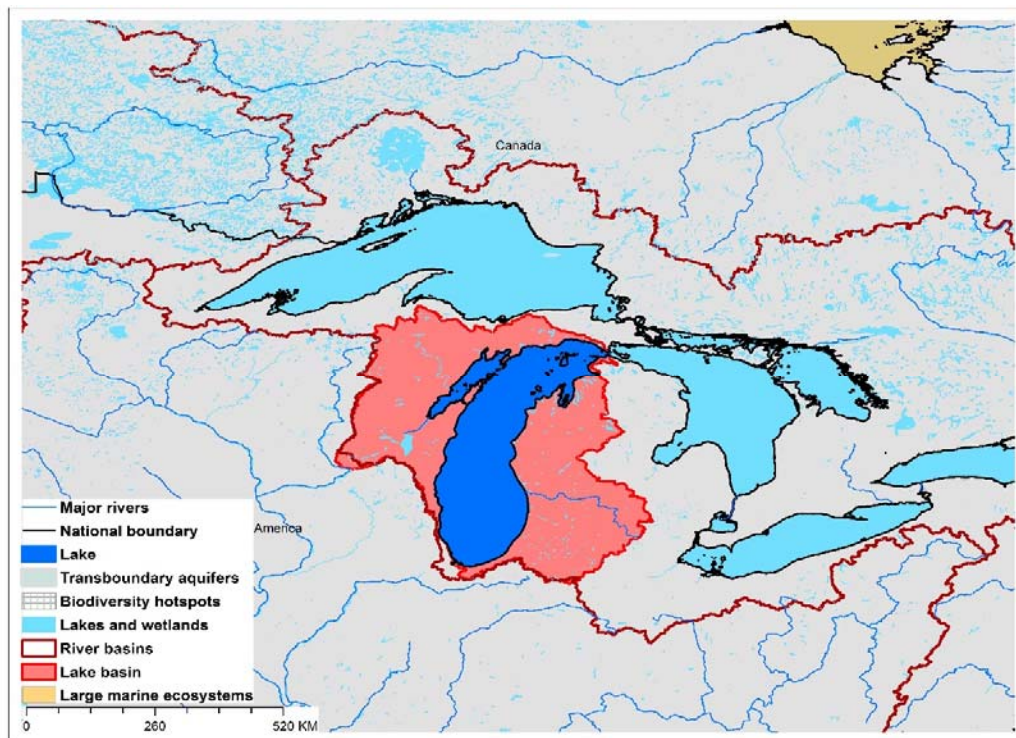
Lake Michigan is the second largest (by volume), and third largest of the Laurentian Great Lakes and sixth largest of the world's lakes (by area). Lying entirely within the USA, it is the largest lake lying entirely in one country (by area), although part of the transboundary Great Lakes system under the Boundary Waters Treaty of 1909 between the USA and Canada. With a volume of 4,920 km<sup>3</sup>, it is hydrologically connected to Lake Huron by the Straits of Mackinac, lying at the same water level. If both lakes were considered an aggregated waterbody, it would be the world's largest freshwater lake. It also became a part of the waterways leading the Great Lakes to the Mississippi River and ultimately to the Gulf of Mexico. It has many sandy beaches, often being referred to as the 'Third Coast' of the USA after the Atlantic and Pacific Oceans. It nevertheless suffers from multiple environmental stresses, including pollution, invasive species and eutrophication. It is included in the Great Lakes Water Quality Agreement between the two countries, including concerted efforts directed to controlling non-point source pollution of all the Great Lakes.



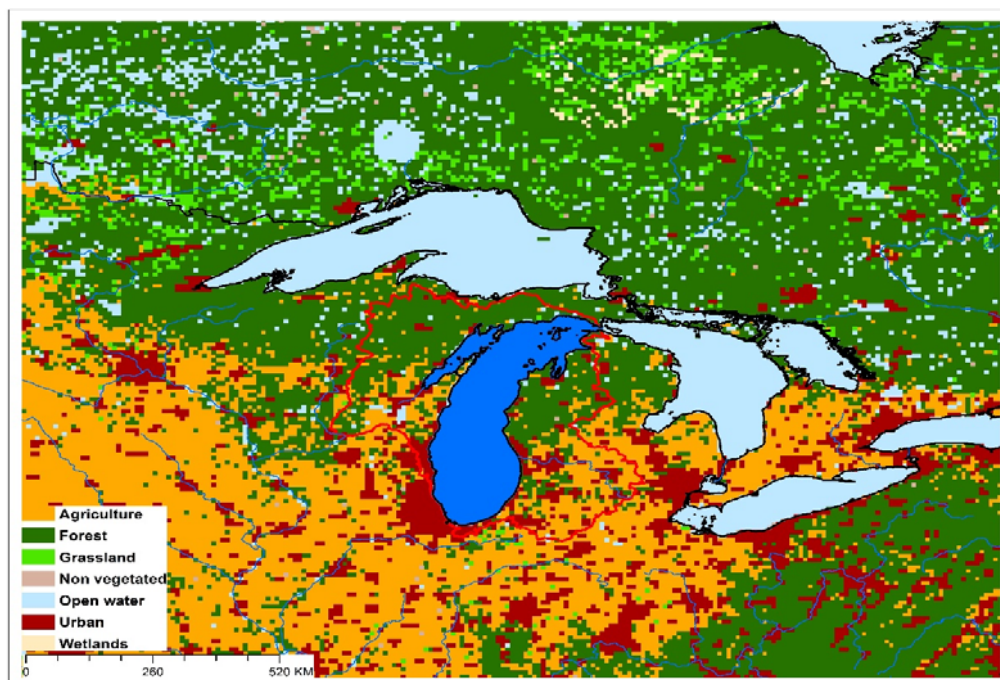
<b>TWAP Regional Designation</b>	Northern, Western & Southern America	<b>Lake Basin Population (2010)</b>	8,365,188
<b>River Basin</b>	St. Lawrence	<b>Lake Basin Population Density (2010; # km<sup>-2</sup>)</b>	48.7
<b>Riparian Countries</b>	USA, Canada	<b>Average Basin Precipitation (mm yr<sup>-1</sup>)</b>	828.2
<b>Basin Area (km<sup>2</sup>)</b>	175,435	<b>Shoreline Length (km)</b>	2,367
<b>Lake Area (km<sup>2</sup>)</b>	58,535	<b>Human Development Index (HDI)</b>	0.94
<b>Lake Area:Lake Basin Ratio</b>	0.334	<b>International Treaties/Agreements Identifying Lake</b>	Yes



## Lake Michigan Basin Characteristics



(a) Lake Michigan basin and associated transboundary water systems



(b) Lake Michigan basin land use

## Lake Michigan Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Michigan and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Michigan threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Michigan and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

**Table 1. Lake Michigan Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score**

*(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)*

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank	Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank	Human Development Index (HDI) Score	Relative HDI Rank
0.44	50	0.44	48	0.94	53

It is emphasized that the Lake Michigan rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Michigan indicates a low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Michigan, which is meant to describe its biodiversity sensitivity to basin-derived degradation, also places the lake in a low threat rank, compared to the other



transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Michigan basin in a low threat rank in regard to its health, educational and economic conditions.

**Table 2. Lake Michigan Threat Ranks, Based on Multiple Ranking Criteria**  
(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Threat Rank	Sum Adj-HWS + HDI	Relative Threat Rank	Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
50	53	48	98	52	103	52	151	53

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Michigan in the lower quarter of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Michigan exhibits a low threat ranking.

Further, a series of parametric sensitivity analyses of the ranking results also was performed to determine the effects of changing the importance of specific criteria on the relative transboundary lake rankings. This analysis involved increasing or decreasing the weights applied to the threat ranks derived from multiple ranking criteria to reassess the relative impacts of the weight combinations on the threat ranks. For example, in determining the sensitivity of the Adjusted Human Water Security (Adj-HWS) and Biodiversity (BD) ranking criteria, the threat rank associated with the first was assumed to be of complete (100%) importance (i.e., rank weight of 1.0), while the other was assumed to be of no (0%) importance (i.e., rank weight of 0.0). The relative importance of the two ranking criteria was then successively changed, with weight combinations of 0.9 and 0.1, 0.8 and 0.2, etc., until the first ranking criteria (Adj-HWS) was assumed to be of no importance (rank weight of 0.0) and the second (BD) was of complete importance (rank weight of 1.0). In the case of Lake Michigan, the 0.5 and 0.5 weight combinations for three cases of parametric analysis for Lake Michigan resulted in respective threat rankings of 6<sup>th</sup>, 6<sup>th</sup> and 2<sup>nd</sup>, respectively, among the total of 7 North American transboundary lakes in the TWAP study (see Technical Report, Section 4.3.3, pp44-48 and Appendix 6(2)).

In essence, therefore, identifying potential management intervention needs for Lake Michigan must be considered on the basis of both educated judgement and accurate representations of its situation. A fundamental question to be addressed, therefore, is how can one decide that a given management

intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Michigan basin? Accurate answers to such questions for Lake Michigan, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and context, the anticipated improvements from specific management interventions, and its interactions with water systems to which the lake is linked.