



**US Army Corps
of Engineers
Detroit District**



Great Lakes Update

Volume 191: 2014 January through June Summary

The U.S. Army Corps of Engineers (USACE) monitors the water levels of each of the Great Lakes. This report provides a summary of the Great Lakes water levels and basin conditions from January through June 2014, and discusses the hydrologic conditions behind the recent significant water level rises on Lakes Superior and Michigan-Huron.

The primary drivers of water level changes are precipitation falling on the lake surface, runoff draining to the lake, evaporation from the lake surface, diversions into or out of the lake, and connecting channel inflows and outflows. The combined effects of the first three hydrologic factors – precipitation, runoff, and evaporation – are referred to as the Net Basin Supply (NBS) to the lake. The NBS is an important quantity for understanding the amount of water supplied to the lake. USACE uses the residual method to calculate NBS, which is equal to the water level change, minus the inflow from an upstream lake, plus the outflow, and plus any diversions out of (+) or into (-) the lake. Net Basin Supply is the most significant driver of water level change.

All water levels mentioned in this article are monthly mean surface elevations in feet referenced to the 1985 International Great Lakes Datum. The period of record used for each of the lakes includes the years 1918 to 2013 and this data has been coordinated between the United

States and Canada. All 2014 water levels are considered provisional and will be officially coordinated in the spring of 2015. The water level of each lake is averaged from a network of individual water level gages around each lake. Also of note is that Lake Michigan and Lake Huron are hydraulically treated as one lake due to their connection at the Straits of Mackinac.

2014 Overview: January - June

In January 2014, the only Great Lake above its long-term average was Lake Ontario. Lakes Superior, Michigan-Huron, and St. Clair were 1, 13, and 6 inches, respectively below their long-term averages (LTA), while Lake Erie was near its LTA. By June 2014, however, all of the Great Lakes, with the exception of Lake Michigan-Huron, were above their LTAs. Although Lake Michigan-Huron was the only lake below LTA, it was only 6 inches lower than average, in contrast to its level in June 2013 when it was 19 inches below LTA.

All of the Great Lakes were above their levels of a year ago in June 2014. In fact, Lakes Superior and Michigan-Huron were over a foot higher than they were in June 2013. Moreover, during the first 6 months of 2014, all of the Great Lakes were above their levels of a year ago, with the exception of Lake Ontario in March 2014.

These higher water levels were bolstered by above average NBS. All of the Great Lakes experienced above average Net Basin Supplies in April, May, and June 2014. Precipitation, a primary contributor to NBS, was also higher than average on all of the Great Lakes in April, May, and June, except for Lake Erie in May.

These 3 months of above average precipitation were preceded by 5 consecutive months of average to below average precipitation on all of the Great Lakes, excluding Lake Michigan-Huron in November 2013, and Lake Erie in December 2013 and February 2014.

As there was record and near-record snowfall last winter in several cities within the Lakes Michigan-Huron basin, it is notable that the lake's estimated precipitation was below average in the first 3 months of the year. Precipitation in the winter in cold weather regions is often under-recorded due to data collection limits. USACE Detroit uses measurements from a network of rain gauges around the Great Lakes to estimate lake basin-wide precipitation. These rain gauges are sometimes unable to collect all of the snowfall because winds can blow the falling snow away from the gauges. Because of this, the precipitation data from the winter months is not given much weight in this summary.

Seasonal changes in the weather patterns typically cause an annual pattern of rising and falling water levels. In general, each of the Great Lakes exhibits a seasonal rise in the spring primarily caused by an increase in precipitation, the melting of accumulated snow, and an increase in runoff. The seasonal decline of the water level in the fall and winter is primarily caused by an increase in evaporation and the accumulation of snowpack on the land area.

In table 1, the water level rise from January to June in 2014 is compared with each January to June rise in the historical record, which dates

back to 1918. The January to June time period does not represent each lake's total seasonal rise, because the timing of seasonal maximums and minimums varies from lake to lake. This analysis is simply highlighting what has happened so far in 2014.

Water Level Rise (June monthly mean minus January monthly mean), inches			
Lake	2013	2014	Historical Average Rise
Superior	11	8	5
Michigan-Huron	19	11	9
St. Clair	18	13	13
Erie	16	10	13
Ontario	28	13	19

Table 1: Great Lakes Water Level Changes from January to June (inches)

For a second straight year, the rise in Lakes Superior and Michigan-Huron water levels were higher than their typical amounts, but not to the extent as they were in 2013. The 2014 rise of Lakes Superior and Michigan were 3 and 2 inches, respectively, above their historical average rises. In addition, the rise in Lake St. Clair was equal to the historical average rise, but the rise on Lakes Erie and Ontario were actually lower than average, and much lower than they were in 2013.

Lake Superior Summary

In June 2014, Lake Superior's water level was 13 inches higher than it was a year before, and 6 inches higher than LTA. Lake Superior reached its long-term average in March which ended a 15 - consecutive year period in which the lake was below LTA, the longest stretch of below average levels in Lake Superior's period of record dating back to 1918. Below is a graph of the Lake Superior water levels from January to June for 2013 and 2014.

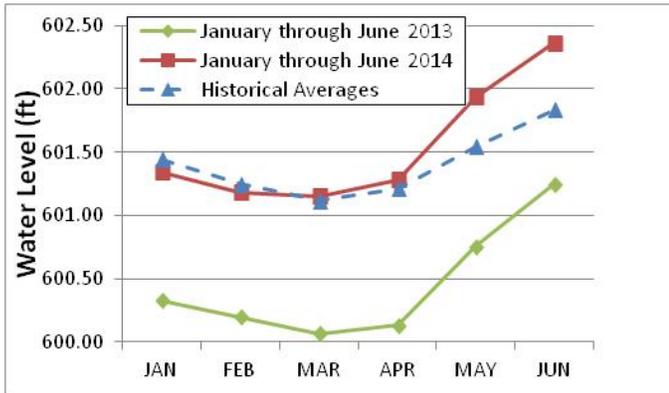


Figure 1: 2013 and 2014 Lake Superior Water Levels

Figure 1 shows the considerable water level increase on Lake Superior since last year and its rise above LTA in the spring and early summer of 2014. In fact, these recent relatively higher levels are indicative of a longer trend in which the level of Lake Superior has generally been rising relative to its LTA since the low water levels of 2012. Figure 2 demonstrates this trend.

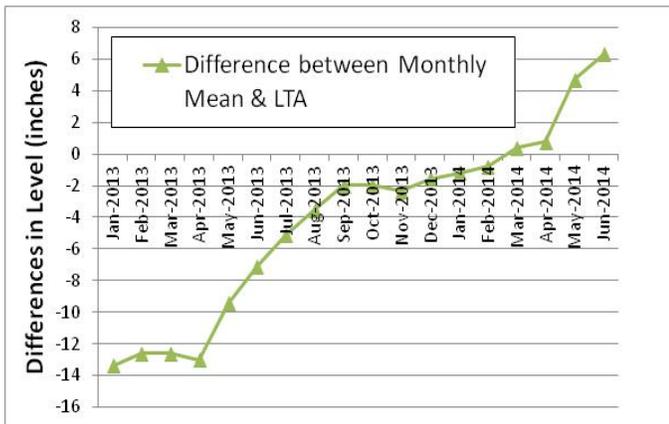


Figure 2: Rise in Lake Superior Level relative to LTA since January 2013

The 14-month time period in which the monthly mean levels rose relative to the LTA (May 2013 to June 2014), closely coincides with the time period in which the Net Basin Supply of water to Lake Superior was above average in 13 of those months. Figure 3 below illustrates this trend in above average NBS.

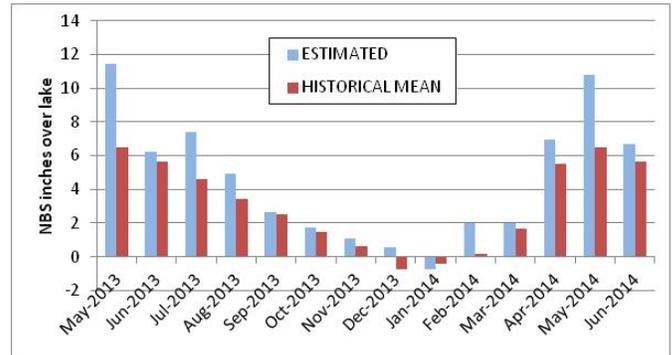


Figure 3: Lake Superior Monthly Net Basin Supply

The 2013 and 2014 NBS values are preliminary. Based on the coordinated NBS data record, which includes data from 1900 to 2008, the NBS received by Lake Superior in May 2013 and May 2014, were the 2nd and 3rd highest NBS ever received by the lake in May.

As stated earlier, the precipitation on Lake Superior was above average in April, May, and June, but near or below average the first 3 months of the year. Figure 4 shows the recent trend in the above average precipitation. Given the difficulty of accurately measuring snowfall, we are skeptical of the basin-wide precipitation estimates for the winter months.

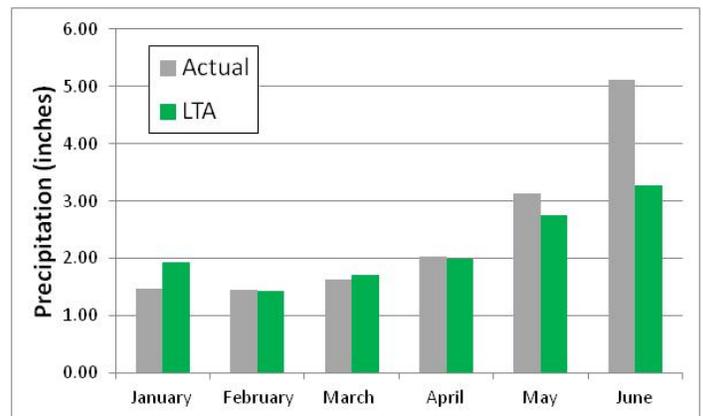


Figure 4: Lake Superior Precipitation in 2014

The precipitation in April was only minimally above average by 0.04 inches; however, the

precipitation that fell in June was almost 2 inches above average.

The water level of Lake Superior will continue its seasonal rise until August and then begin its seasonal decline. The lake is forecasted to range from 3 to 6 inches above LTA from August through January.

The historic ice cover of the winter 2013-2014 may affect the water levels in the fall. The ice coverage on Lake Superior peaked at nearly 96% in March, and was still over 40% at the beginning of May. The longer ice cover has had a cooling effect on the lake's surface water temperature. Figure 4 is a plot created by NOAA's Great Lakes Environmental Research Laboratory that shows Lake Superior's surface temperature has been below average all year.

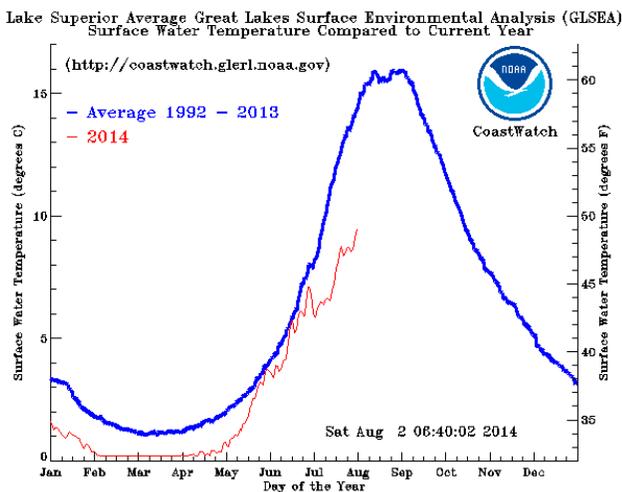


Figure 5: Lake Superior's surface temperature in 2014 compared to average (NOAA)

The water surface temperature was 10 degrees below average temperatures from 1992-2013 at the time of this printing. Evaporation from the lake surface is directly related to the difference in temperature between the air and lake surface. If these cooler temperatures persist into fall, the lake surface will be closer in temperature to fall/winter air that is already predicted to be milder due to El Nino. This smaller temperature

difference may lead to lower than usual evaporation this fall and winter.

Lake Michigan-Huron Summary

From January to June 2014, Lake Michigan-Huron continued a 15 consecutive year stretch of below average levels, the longest in its period of record. However, by June 2014, Lake Michigan-Huron's water level was only 6 inches lower than its LTA. In contrast, the lake was 13 inches below LTA in January 2014, and 19 inches below LTA in June 2013. In addition, the lake's level from January to June 2014 was consistently more than a foot above its level of a year ago. Figure 6 demonstrates these trends.

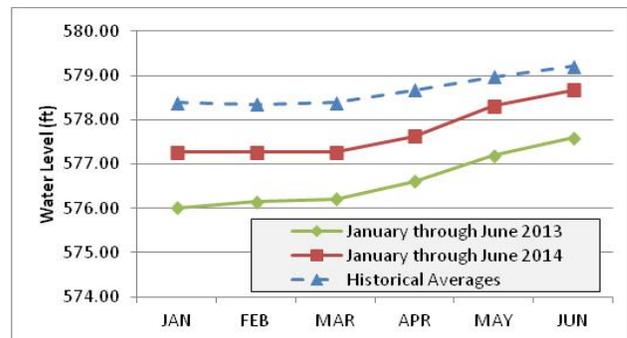


Figure 6: Lake Michigan-Huron Water Levels

Figure 6 shows that Lake Michigan-Huron's level was flat during the first 3 months before it began rising in April. In addition, the above figure shows the gap between Lake Michigan-Huron's level and its LTA decreased from January to June 2014. This is part of a longer trend of Lake Michigan-Huron inching closer to its LTA ever since the lake dropped to its record low level in January of 2013. See Figure 7 below.

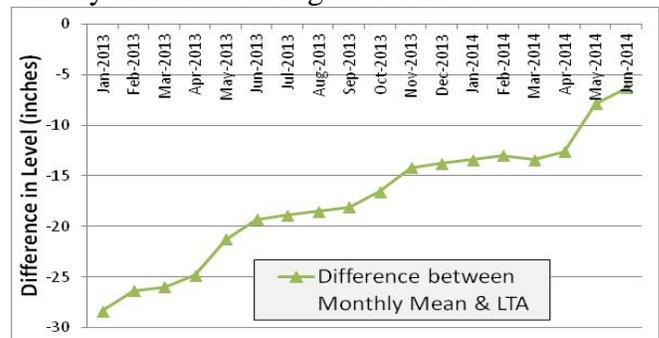


Figure 7: Rise in Lake Michigan-Huron Level relative to LTA since January 2013

This remarkable rise in Lake Michigan-Huron was buoyed by a trend of generally above average NBS to Lake Michigan-Huron in the past year and a half since the historic low water levels. Figure 8 highlights this trend.

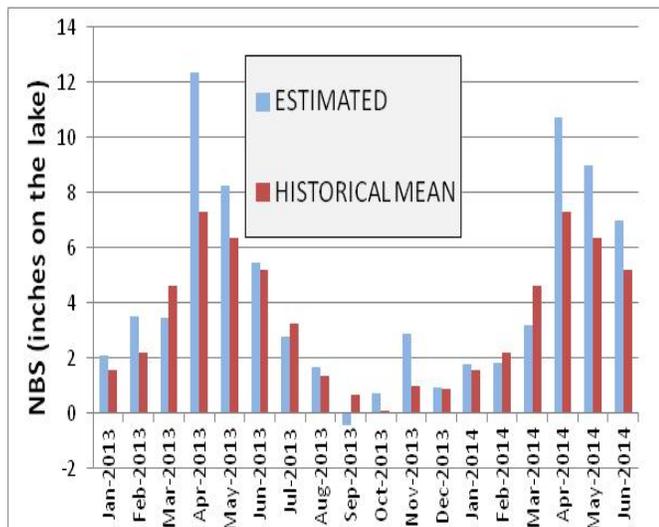


Figure 8: Lake Michigan Net Basin Supply by month since January 2013

Figure 8 shows that in the 18 month period beginning January 2013, the NBS to Lake Michigan-Huron was above average in 12 of those months. The 2013 and 2014 NBS values are preliminary. Based on the coordinated NBS data record (1900-2008) the NBS received by Lake Michigan-Huron in April 2013 and April 2014 were the 3rd and 8th highest NBS ever received by the lake in April.

The considerable differences between estimated NBS and Historical mean NBS in April through June 2014 can largely be explained by the above average precipitation during those 3 months. In the first 3 months of 2014, however, the precipitation was below average. Figure 9 shows the precipitation trend of the last 6 months.

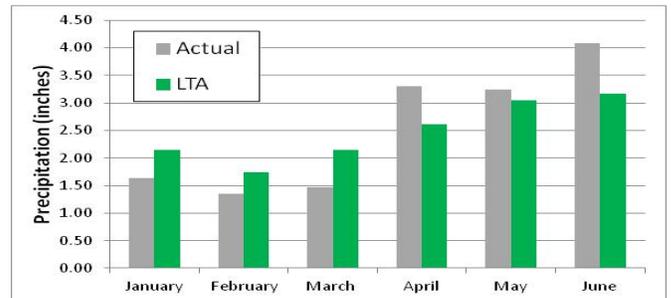


Figure 9: Lake Michigan-Huron Precipitation

It is somewhat surprising that the estimated precipitation was not above average in the first 3 months of 2014. During the 2013-2014 winter season, Chicago, IL received the third-highest snowfall in its history, and the cities of Grand Rapids, MI; Milwaukee, WI; Green Bay, WI; and Saginaw, MI experienced snowfall that was 55%, 35%, 40%, and 45%, respectively, above average. As alluded to earlier in this article, the accuracy of the basin-wide precipitation values is questionable, and we suspect near average or above average precipitation on Lake Michigan-Huron during the winter months.

The historically high snowfall of winter 2013-2014, however, is reflected in the Snow Water Equivalent (SWE) computed for the Lake Michigan and Huron basins. SWE is the depth of liquid precipitation that would result if the snowpack melted instantaneously. Figures 10a and 10b shows this past winter's peak SWE estimates on the Lakes Michigan and Huron sub-basins compared to the peaks of recent winters.

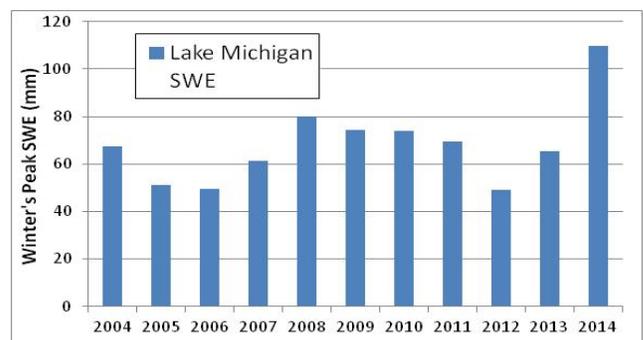


Figure 10a: Lake Michigan sub-basin Peak SWE

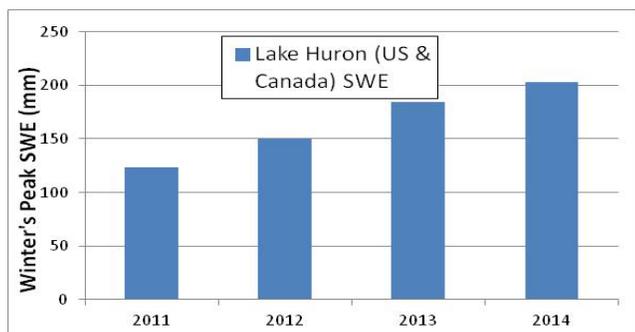


Figure 10b: Lake Huron sub-basin Peak SWE

Figure 10 shows the peak SWE in the Lake Michigan sub-basin was 37% higher than the peak SWE in any of the previous ten winters, while the Lake Huron peak SWE was over 10% higher than the peak SWE of the previous 3 years. The Lake Huron analysis is only 4 years long, because only 4 years of SWE data for the Canadian side of the Lake Huron sub-basin exist.

Another factor which has contributed to Lake Michigan-Huron's considerable water level rise is the above average inflow from the St. Mary's River. The St. Mary's river flow, regulated by the International Lake Superior Board of Control in accordance with Regulation Plan 1977-A, was above average every month from January to June 2014 as shown in Figure 9, and has been above average since July 2013. This trend is shown in Figure 11 below.

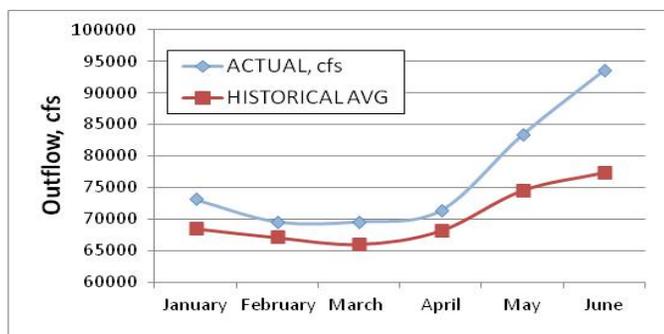


Figure 11: Lake Michigan-Huron inflow through the St. Mary's River

The difference between the observed outflow and historical average significantly increased in May

and June 2014, which is due to higher outflow being released from Lake Superior due to the rise in water level on that Lake.

While inflow through the St. Mary's River was above average during the first six months of 2014, Lake Michigan-Huron's outflow through the St. Clair River was below average in four of the 6 months. Figure 12 illustrates these conditions.

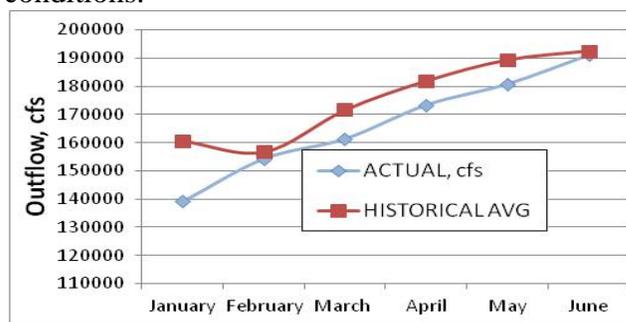


Figure 12: Lake Michigan-Huron outflow through the St. Mary's River

Figure 12 shows the outflows through the St. Clair River were near average in February and June, and that the historical monthly average outflows were not exceeded from January to June 2014. Lake Michigan-Huron outflows were generally below average in part due to the lake remaining below LTA.

Lake Michigan-Huron is predicted to begin its seasonal decline in September. The lake level is forecasted to continue to get closer to LTA, and reach LTA by November 2014.

Lake St. Clair Summary

The water level of Lake St. Clair in June 2014 was 9 inches above the level of one year ago and 2 inches above the LTA. The lake's rise from January to June 2014 was 13 inches, equaling its historical average rise. Lake St. Clair started its seasonal rise in February. Figure 13 shows the Lake St. Clair water levels thus far in 2014 compared to average and last year.

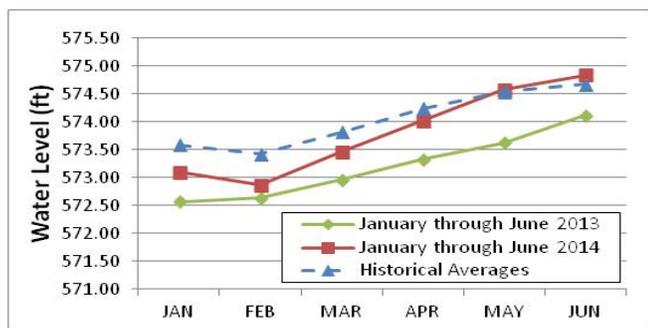


Figure 13: Lake St. Clair Water Levels

Lake St. Clair ranged from 2 to 4 inches below LTA before reaching the LTA in May. In addition, Lake St. Clair was consistently above its level of year ago during the first 6 months of 2014 – ranging from 3 to 11 inches above. The Lake began its seasonal rise in March, as it typically does.

Lake St. Clair experienced above average NBS from March to June 2014. Above average precipitation occurred from April to June 2014, preceded by 3 months of below average precipitation.

Lake St. Clair is expected to follow the typical seasonal decline for the remainder of 2014. From July’s mean water level to January, the lake is predicted to fall 12 inches.

Lake Erie Summary

In June 2014, Lake Erie was 3 inches above LTA and 7 inches above its level in June 2013. Figure 14 shows the water levels through the first six months of 2014.

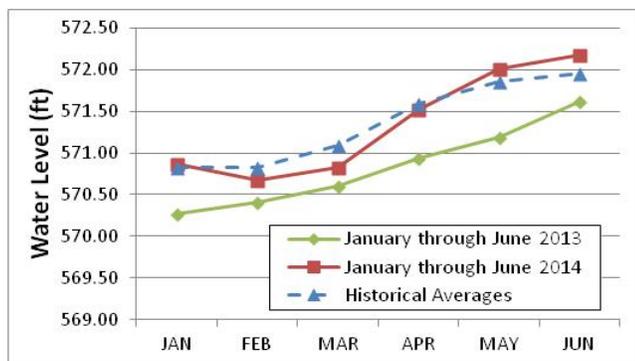


Figure 14: Lake Erie Water Levels

The lake’s January to June rise in 2014 was 10 inches, three inches less than normal. Also, the Lake Erie’s level began rising in February. The Lake has ranged from 3 to 10 inches above last year’s levels in the first half of 2014. It was near its LTA in January, below LTA in February and March, regained its LTA in April, and exceeded LTA in May and June.

Inflow from the Detroit River was near average from March to June 2014, and outflow through the Niagara River was near average from February to June. Since inflow and outflow to Lake Erie were generally near average, they probably did not influence the seasonal rise substantially.

There has been no trend in the NBS to Lake Erie during the first half of 2014. The NBS has been above average in 3 different months, near average in two non-consecutive months, and below average in March. Several cities in the Lake Erie basin received record high snowfall in the winter of 2013-2014. Detroit, MI, and Toledo, OH, experienced their highest snowfall on record, while Fort Wayne, IN saw its 2nd highest snowfall.

The level of Lake Erie has plateaued for the year. The latest six month forecast shows Lake Erie’s beginning its seasonal decline in August and will fall 11 inches during the next 6 months.

Lake Ontario Summary

Typically, Lake Ontario begins rising in January. However, the lake began 2014 by dropping the first two months, before beginning its seasonal climb in April. The lake rose just 13 inches from January to June 2014, far below the 19-inch average. Figure 15 shows the lake’s water levels from January to June 2014.

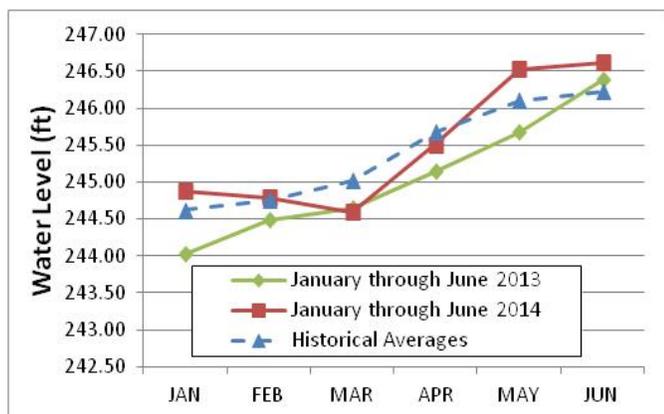


Figure 15: Lake Ontario Water Levels

The water level of Lake Ontario was 3 inches above the level of one year ago and 5 inches above LTA in June 2014. Lake Ontario hovered within 5 inches of its LTA through the first 6 months of 2014. Also, besides February, it was above its levels of a year ago in every other month.

The NBS to Lake Ontario was above average from April to June 2014. The NBS was certainly boosted by precipitation that was also above average during those 3 months as well.

Lake Ontario began its seasonal decline in July. The latest 6 month forecast shows Lake Ontario continuing to fall into December. Its December mean level will be 26 inches lower than its mean level was in July.

More Information

Detroit District recently changed the links to the PDF documents for its Monthly Bulletin of Great Lakes Water Levels. Below is a list of the new links for the Bulletin PDFs:

Combined Bulletin and Backpage

http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-combined_bulletin_and_backpage.pdf

Superior Bulletin

<http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-superior.pdf>

Michigan-Huron Bulletin

http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-mich_hrn.pdf

St. Clair Bulletin

<http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-stclair.pdf>

Erie Bulletin

<http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-erie.pdf>

Ontario Bulletin

<http://w3.lre.usace.army.mil/hh/ForecastData/MB/UGLWL-ontario.pdf>

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