US Army Corps of Engineers
Detroit District

Great Lakes Update

Volume 194: 2015 Annual Summary

Background

The U.S. Army Corps of Engineers (USACE) tracks and forecasts the water levels of each of the Great Lakes. This report summarizes the hydrologic conditions of the Great Lakes basin in 2015.

Great Lakes water levels generally remained above average in 2015. The Great Lakes, particularly Lakes Superior and Michigan-Huron, surged upward in 2013 and 2014, following a prolonged period of below average water levels that culminated in record and near record low levels in 2012 and January 2013. The levels of Lakes Superior and Michigan-Huron surpassed long term average water levels in 2014, and remained above average throughout all of 2015. A summary of 2015 Great Lakes water levels is discussed below in the lake-by-lake sections.

Official water levels are based on monthly lake-wide means, and the period of record used for each of the lakes includes the years 1918 to 2015. These data have been coordinated between the United States and Canada through 2014. All 2015 water levels will be officially coordinated and added to the historical record in the spring of 2016. The elevations used are referenced to the 1985 International Great Lakes Datum. The water level of each lake is averaged from a network of individual 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.

The Great Lakes are large and behave differently from smaller, inland lakes. In general, Great Lakes water levels do not rise and fall dramatically with individual storms, but rather significant water level fluctuations require multiple months, seasons, or years of wet or dry conditions.

Each year, the Great Lakes experience a seasonal rise and a seasonal decline due to changes in weather patterns. The seasonal rise, typically starting in the spring, is caused primarily by an increase in precipitation, increased runoff due to melting of accumulated snow, and low evaporation rates. The typical seasonal decline of the water levels in the fall and winter is primarily caused by an increase in evaporation, a decrease in precipitation, and the accumulation of snowpack on the land area.

The term net basin supply (NBS) is used to describe the amount of water that is contributed to or lost from a lake within the confines of its natural drainage basin. USACE uses the residual method to compute NBS, shown below:

Residual Method Net Basin Supply:

$$NBS = WL - I - D + O$$

WL: Water Level Change
I: Connecting Channel Inflow
O: Connecting Channel Outflow
D: Diversion into (+) or out (-) of lake

Net basin supply includes water a lake receives from precipitation on its surface and runoff from land making up its drainage basin, less the

evaporation of water from the lake's surface. The higher the quantity of precipitation and runoff, the higher the NBS will be. Conversely, the higher the quantity of evaporation, the lower the NBS will be. NBS is far and away the main driver of water levels, and is discussed in more detail in the following sections.

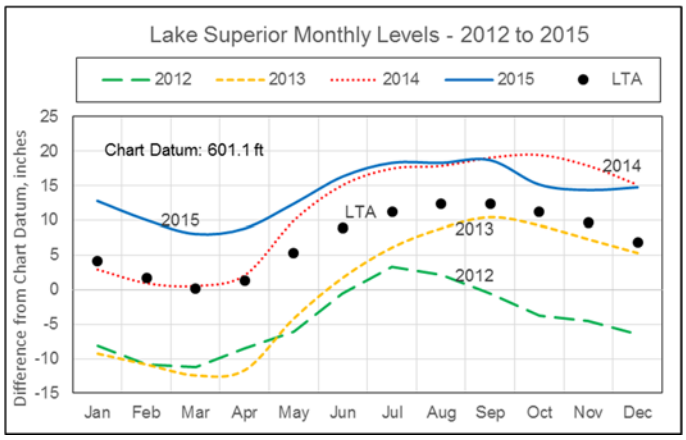

Figure 1: Lake Superior Water Levels

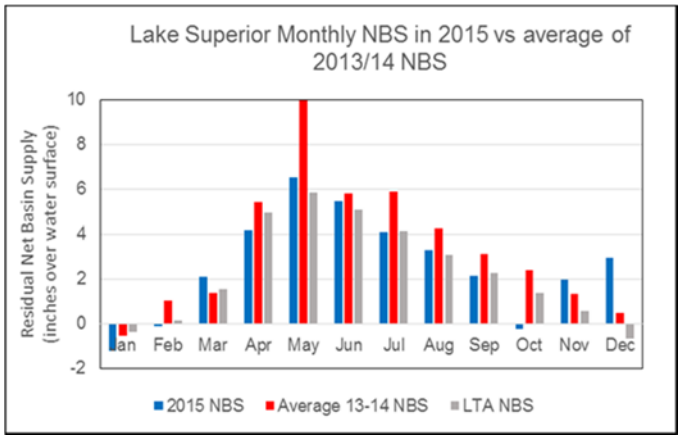

Figure 2: Lake Superior Residual Net Basin Supply

Lake Superior

Figure 1 shows the 2015 water levels of Lake Superior compared with the 2012 through 2014 levels and the monthly long-term average (LTA) levels. A similar figure is shown for each lake in the following sections. Each lake's data has been plotted relative to chart datum (a.k.a. low water datum), which represents the horizontal line at a value of zero. Chart datum for Lake Superior is 601.1 ft.

Lake Superior water levels remained above average for all of 2015. Lake Superior started the year at a level of 602.17 ft, 10 inches higher than at the beginning of 2014, 9 inches above its Long Term Average (LTA) in January, and 21 inches higher than January 2012. At the end of 2015, the lake was less than an inch below its level in December 2014, but still 10 inches above LTA.

The lake's seasonal climb of 11 inches in 2015 was near its historical average. However, this seasonal rise was small in comparison to the previous year's rise of 23 inches, and Lake Superior did not reach its 2014 peak level. Nevertheless, the net basin supply to the lake in December 2015 was historically high and caused the level of the lake to rise from November to December for only the 3rd time since 1918. This small rise nearly brought the lake to its December 2014 level.

Figure 2 shows the Lake Superior NBS for each month in 2015 compared to the average of the monthly 2013 and 2014 NBS and the historical average NBS. Precipitation that fell within the lake's basin was near average in 2015, with only 3 months of above average precipitation.

December saw particularly high precipitation at 42% above average. The NBS to the lake was the highest NBS ever recorded for December dating to 1918. December was also warmer than average, which allowed most of the precipitation to fall as rain rather than snow, which increased runoff. Moreover evaporation in late fall and early winter was 38% below average. This is because the temperature difference between the air and lake surface was less than normal due to the above average air temperatures.

Lake Michigan-Huron

Following record low water levels in late 2012 and January 2013, Lake Michigan-Huron's level soared in 2013 and 2014, reaching its long term average in September 2014 for the first time since 1998. Lake Michigan-Huron's rises during 2013 and 2014 led to levels being more than 3 feet higher in January 2015 than January 2013. Levels were also 7 inches above average in January 2015. Water levels in Figure 3 are relative to the Lake Michigan-Huron chart datum level of 577.5 ft.

Lake Michigan-Huron declined just 2 inches in the winter of 2014/2015; the average fall is 11 inches. Because of the substantial rise in 2014 and the small seasonal decline in fall/winter 2014-2015, Lake Michigan-Huron's level in March 2015 was 21 inches higher than it was 12 months before. The lake peaked at 579.79 ft. in July, its highest level since August 1998.

Lake Michigan-Huron's seasonal rise in 2015 was only 8 inches, or 3 inches lower than average. The lake's seasonal decline in 2015 began in July, and by November it had declined 7 inches. October's net basin supply was particularly low due to extremely low precipitation. The smaller-than-average seasonal rise coupled with a July-to-November decline of 7 inches resulted in the lake falling to its 2014 level in November. However, the lake level experienced a slight increase from November to December, only the 12th time that has happened since 1918. This small increase was the result of the highest net basin supply that the lake has received in December dating back to 1918.
Figure 4 shows the 2015 NBS for Lake Michigan-Huron compared to the average of the 2013 and 2014 NBS and the historical averages. The Net Basin Supply to Lake Michigan-Huron was below average 5 of the first 7 months of 2015, but was above average in 4 of the last 5 months of 2015. Above average NBS in September, November, and December corresponded with below average evaporation. Just as with Lake Superior, the December 2015 NBS was a record high. Precipitation was 66% above average that month. Total precipitation to the lake was 91% of average in 2015.

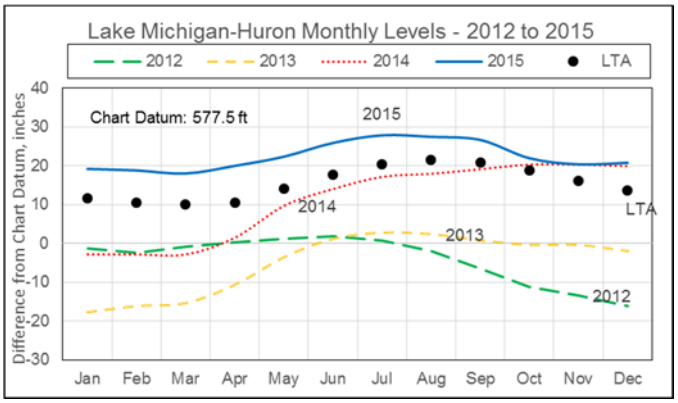

Figure 3: Lake Michigan-Huron Water Levels

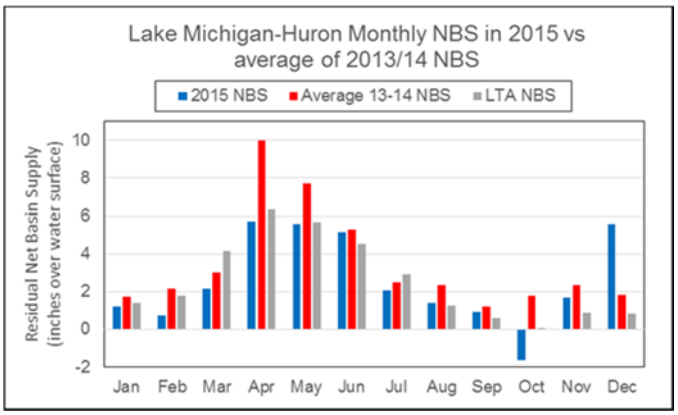

Figure 4: Lake Michigan-Huron Residual Net Basin Supply

Lake St. Clair

Heart-shaped and shallow Lake St. Clair is the smallest lake in the Great Lakes system. As seen in Figure 5, Lake St. Clair water levels exhibit more short-term fluctuations than lakes Superior, Michigan-Huron, Erie, or Ontario because of its smaller size. Because of the smaller size, the connecting channels (the St. Clair River upstream

and the Detroit River downstream) have a large influence on the Lake St. Clair water levels.

Wind, ice, and other climate variations can cause fluctuations in the hydraulic behavior through the St. Clair River, Lake St. Clair, and Detroit River system. A representative example of the significant impact the connecting channels and ice have on the lake's level is the sharp 8-inch decline in water level that occurred from January to February 2015. Ice build-up reduced flow in the St. Clair River, which decreased the amount of water discharging into Lake St. Clair. Ice formation began affecting the St. Clair River flow around January 7th. Photo 1 shows significant ice in the St. Clair River in January 2015.

Daily St. Clair River flow from January 1 to January 7 averaged 203,299 cfs, and the daily flow from January 8th to January 31st averaged 143,920 cfs, indicating a reduced amount of water discharging into the lake.

Photo 1: Ice on the St. Clair River at Marine City, MI on 25-January-2015

In 2015, with the exception of February, the level of Lake St. Clair was above average. In January 2015, Lake St. Clair was 11 inches above its January 2014 monthly mean level and 5 inches above LTA. By year's end, the lake was still above LTA by 9 inches but had dropped slightly below its December 2014 level. The lakes' 2015 seasonal rise of 32 inches was 6 inches was higher than its 2014 rise. The 2015 seasonal rise was buoyed by precipitation in June that was over 50% above average. Lake St. Clair peaked in July at 575.98 ft., its highest level since June 1998. A quicker than average decline occurred during the fall of 2015 due to dry conditions, especially in October.

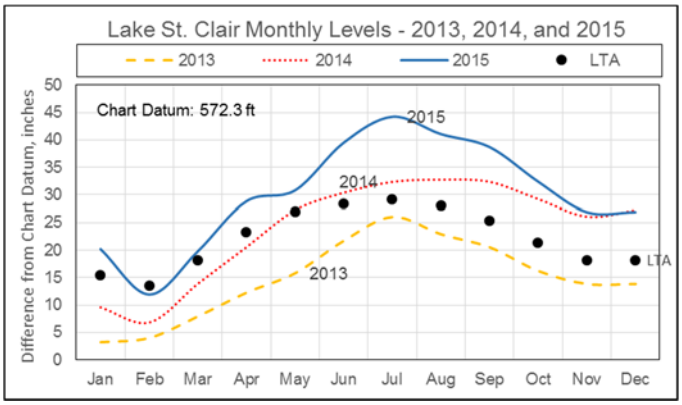

Figure 5: Lake St. Clair Water Levels

Lake Erie

In 2015, Lake Erie's water level was above LTA in 11 of 12 months. Lake Erie began 2015 by dropping a total of 6 inches in January and February, a time period in which the lake historically rises an average of 3 inches. Below average precipitation and above average evaporation driven by extreme cold in January and February contributed to the water level decline. In addition, the ice formation that clogged the St. Clair River and reduced the inflow into Lake St. Clair in January and February also reduced inflow to Lake Erie and contributed to lower its level. The US Geological Service's gage on the Detroit River at Fort Wayne showed the average discharge in the river was 205,667 cfs in December, while the average discharge in January was 145,229 cfs and 134,536 cfs in February.

Figure 6 shows Lake Erie water levels relative to the chart datum of 569.2 ft. The lake's level climbed 30 inches from March to July, more than double the lake's average seasonal rise of 14 inches. This was the lake's largest seasonal rise since 1947 when it rose 33 inches. The lake's July monthly mean level of 573.29 ft. was its highest since June 1998. In June, the lake was about 24 inches higher than it was in July 2012. Lake Erie's monthly mean level rose the highest, 8 inches, from June to July, a time period when it usually begins declining. This large rise was due to the record rainfall in June 2015. By December 2015, water levels had fallen to those of the previous December, but remained 7 inches above LTA.

Precipitation within the Lake Erie basin was 94% of average in 2015. On a monthly basis, precipitation was below average in 9 months in 2015. A notable exception to the below average precipitation in 2015 was June when Lake Erie received 6.75 inches of rain. This rainfall was the highest recorded amount of precipitation that the lake has received in June. The 6.75 inches was almost double its June average. In addition, this rainfall had a significant impact on the total amount of precipitation that Lake Erie received in 2015. If the lake had received just an average amount of rainfall in June, about 3.5 inches, than the total precipitation to the lake in 2015 would have been just 84% of average.

Corresponding with the fall in water level in January and February, Lake Erie NBS was below average the first 3 months of the year. However, the lake's 30 inch seasonal rise was fed by above average NBS from April to July. Due to the record rainfall in June, NBS to Lake Erie was the highest on record for the lake in the month of June dating back to 1900.

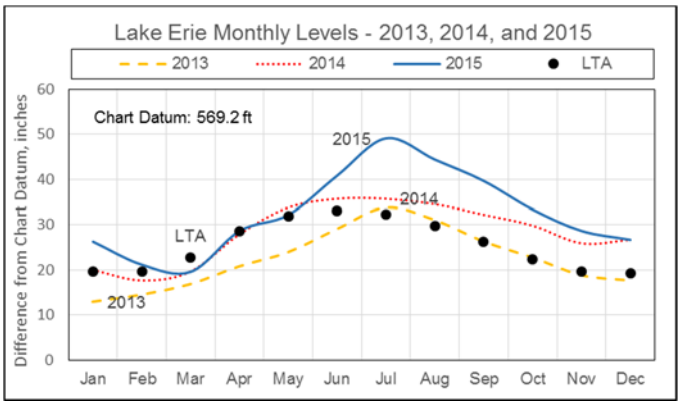

Figure 6 Lake Erie Water Levels

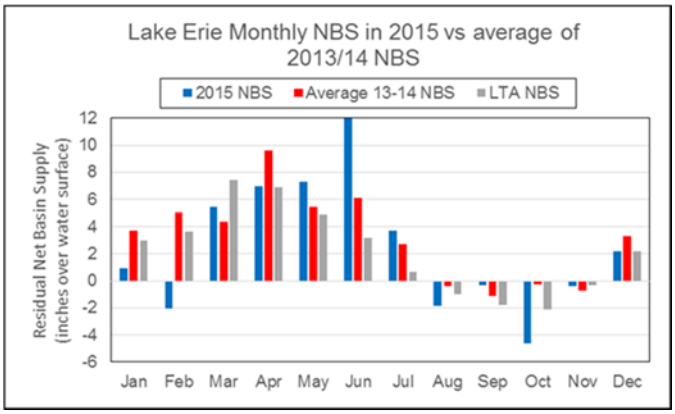

Figure 7: Lake Erie Residual Net Basin Supply

Lake Ontario

In December 2014, Lake Ontario was 2 inches below LTA. Similar to Lake Erie, Lake Ontario's monthly level fell 6 inches in January and February. Precipitation in January and February was well below average. This contributed to the lake's water level being below average the first 6 months of the year. Figure 8 shows Lake Ontario water levels relative to the chart datum of 243.3 ft. The lake was more than 10 inches below average by March. Lake Ontario's seasonal rise began in March and was 31 inches high, 8 inches higher than its average seasonal rise. A catalyst of the lake's above average rise was the nearly 6 inches of rain the lake received in June. The lake's level climbed to 8 inches higher than LTA in July and

remained above average until December, when it nearly matched its December 2014 level. The lake's peak level of 246.75 ft. in July was its highest level since June 2011.

Figure 9 shows the average of the 2013 and 2014 NBS and LTA NBS for Lake Ontario. Similar to Lake Erie, Lake Ontario experienced below average NBS the first 3 months of the year. The low NBS in January and February was the result of below average precipitation and above average evaporation. Fueled by precipitation that was 79% above average in June, the NBS to Lake Ontario was its highest in June since 1947 and the 3rd highest since 1900 according to USACE calculations. Despite the considerable rainfall in June, precipitation was below average for 8 months of 2015, and the total rainfall to the lake's basin in 2015 was 11% below average. In addition, evaporation was below average the first 2 months of 2015, but at or above average in 9 of the final 10 months of the year.

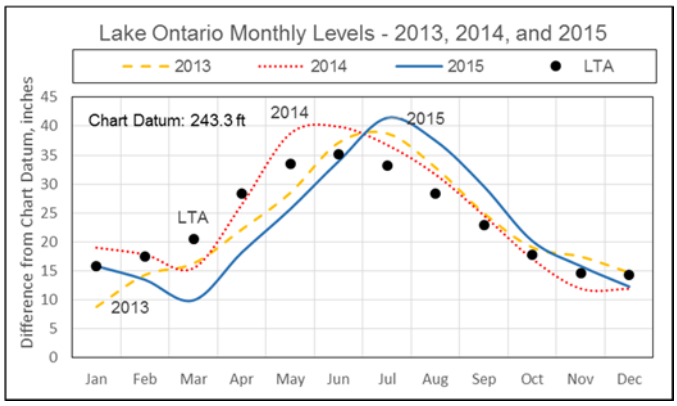

Figure 8: Lake Ontario Water Levels

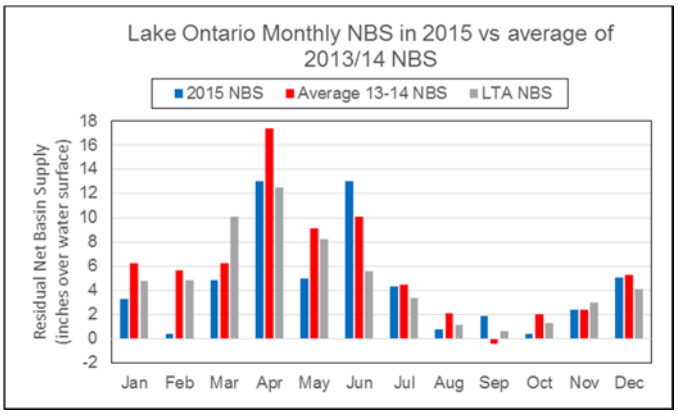

Figure 9: Lake Ontario Residual Net Basin Supply

Coastal erosion

With the recent rise in water levels, coastal bluffs are beginning to erode again after over a decade of low water and apparent stability. It is important, however, to understand that lake levels do not cause erosion – waves cause erosion. The lake level merely concentrates the wave energy onto a particular section of the coastal profile. During the last decade plus of low water, the offshore portion of the coastal profile has been quietly eroding. This is of little immediate concern since little to none of society's infrastructure is on the lake bed. However, with the recent rise in lake levels, the waves now have access to the bluffs and dunes, which host much infrastructure. Increased erosion has been observed over the last two years on the Great Lakes. Photo 2 shows an example of coastal erosion on Lake Superior.

Photo 2: Coastal Erosion on
Lake Superior at Paradise, MI

The extent of coastal erosion in the Great Lakes is a delicate balance between the supply of sand to the beaches and the rate at which waves carry it away. There is currently no evidence that the wave climate has changed, yet erosion seems to be increasing. The sand supply to the beaches, however, has been steadily reduced over the last few decades due to the proliferation of coastal shore protection. A study is currently underway to assess the effects of the reduced sand supply and mitigation options. Expect a report highlighting findings of this study is to be complete later in 2016, but it is hoped that data collection and analysis will continue for the foreseeable future.

More Information

Starting in 2016, Update Articles will be included in various editions of the *Monthly Bulletin.* Topics will rotate between Great Lakes hydrology and lake levels and other less technical pieces relevant to the Great Lakes as a whole. February's *Monthly Bulletin* will typically include an annual summary from the year before.

The next Update Article will likely be in June and will cover a unique group of Federal agencies from both the United States and Canada. This group, called the Coordinating Committee on Basic Great Lakes Hydraulic and Hydrology Data meets twice per year and will have just celebrated its 100th meeting in May. All of our past Update Articles can be read online here:

http://www.lre.usace.army.mil/Missions/GreatLakesInformation/NewsandInformation/GreatLakesUpdateArticles.aspx

Some of the past topics include:

Water level forecasting techniques
A Guide to the Monthly Bulletin
Frequently Asked Questions
Winter Work at the Soo Locks
100th Anniversary of the Boundary Waters Treaty

The *Monthly Bulletin* is sent by postal mail. To be added to the postal mailing list, please send an email to hhpm@usace.army.mil or call 1-888-694-8313 and select option 1. Alternatively, the Monthly Bulletin can be viewed on our website. The home page is: http://www.lre.usace.army.mil. In addition to the *Monthly Bulletin*, the Detroit District issues the *Weekly Great Lakes Water Level Update* and the *Weekly Great Lakes Connecting Channels Water Levels and Depths*. Both products are updated each Thursday and can be located here:

http://www.lre.usace.army.mil/Missions/GreatLakesInformation/GreatLakesWaterLevels/WaterLevelForecast.aspx

A new product developed and issued by the USACE this year is the Great Lakes Water Level Outlook. It is a longer term look at potential water levels based on specific NBS scenarios. These scenarios are developed using climate projections and current conditions in the Great Lakes basin. The outlook can be found here:

http://www.lre.usace.army.mil/Missions/GreatLakesInformation/GreatLakesWaterLevels/WaterLevelForecast/WaterLevelOutlook.aspx

The Detroit District also has a Facebook page which can be found here:

https://www.facebook.com/pages/Detroit-District-US-Army-Corps-of-Engineers/144354390916

The District plans on posting water level and other relevant Great Lakes information on a more frequent basis in 2016, so please like us on Facebook to keep current on the ups and downs of Great Lakes water levels and other Great Lakes gee-whiz items.

The Detroit District welcomes comments on all of our forecast products. Please email questions and comments to hhpm@usace.army.mil. To contact the District by phone call toll free 1-888-694- 8313 and select option 1. The Detroit District's mailing address is:

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