Kalamazoo Lake Levels- Past, Present and Future

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Introduction: Saugatuck and Douglas have experienced high Kalamazoo Lake and River water levels and flooding this past spring and summer and most recently experienced a major flooding event right before Thanksgiving. Many folks are asking what is going on and will the Lake level ever go down? I will try to address these questions with this discussion, but note the predictions on future lake level are educated guesses by NOAA and USCOE scientists and engineers based on modeling Mother Nature.

First point to understand: Kalamazoo Lake and Lake Michigan are hydrostatically connected! This means that as Lake Michigan rises so does the Kalamazoo Lake and River. Kalamazoo Lake is what is referred to as a drowned river mouth.

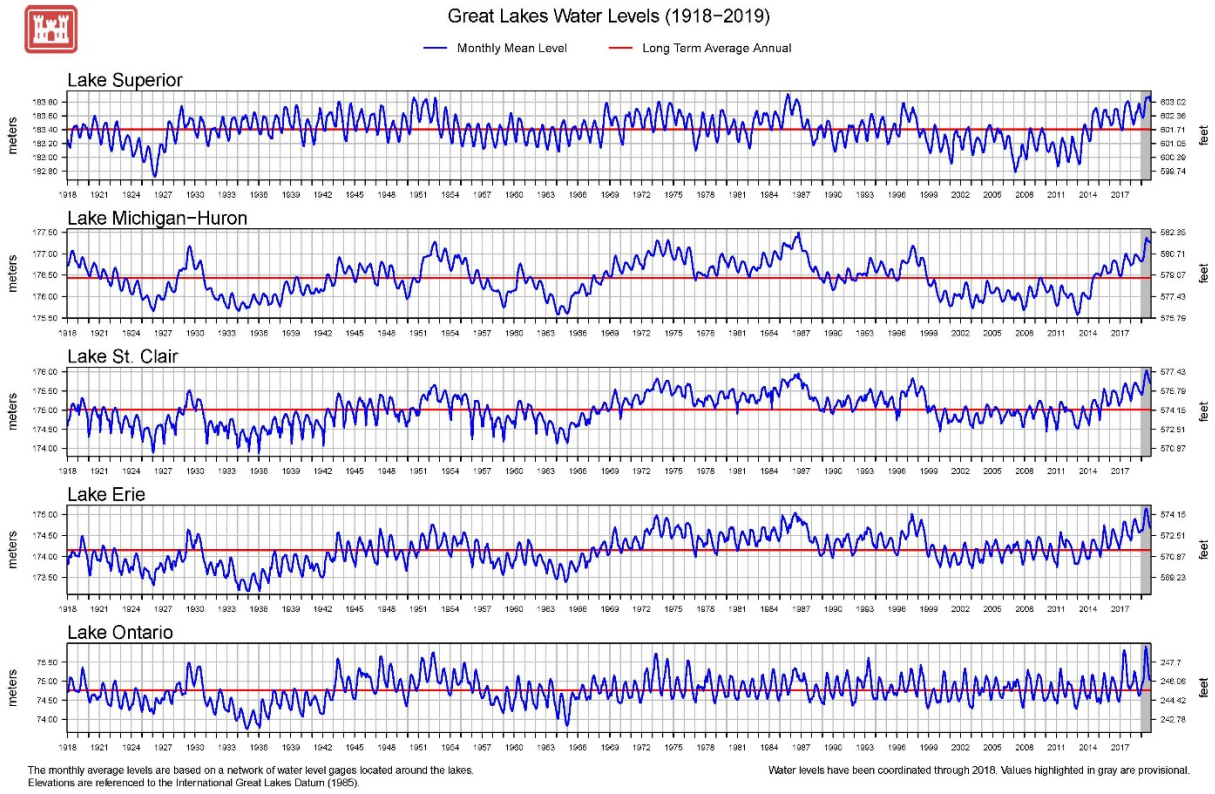


Figure 1: *Historical Lake Michigan Lake Levels*

Historical Lake Levels: Let's look at the historical Lake Michigan water levels going back to the year 1918 (Figure1). Note Lakes Michigan and Huron are also hydrostatically connected by the Straits of Mackinac. The time history in Figure 1 shows at least six periods of high water and five low water level events, with a near record low occurring in 2013 (remember all the dredging concerns). Some modelers see a periodicity in high to low water levels of eight to fifteen years, but suffice to say the water level goes up and it goes down at least each decade. The other noteworthy value on the figure is the 582.5 ft

msl. In 1986 Lake Michigan reached that record high water mark. This summer we approached within an inch or two that record level and during the last storm we were well above the 582.5 ft value.

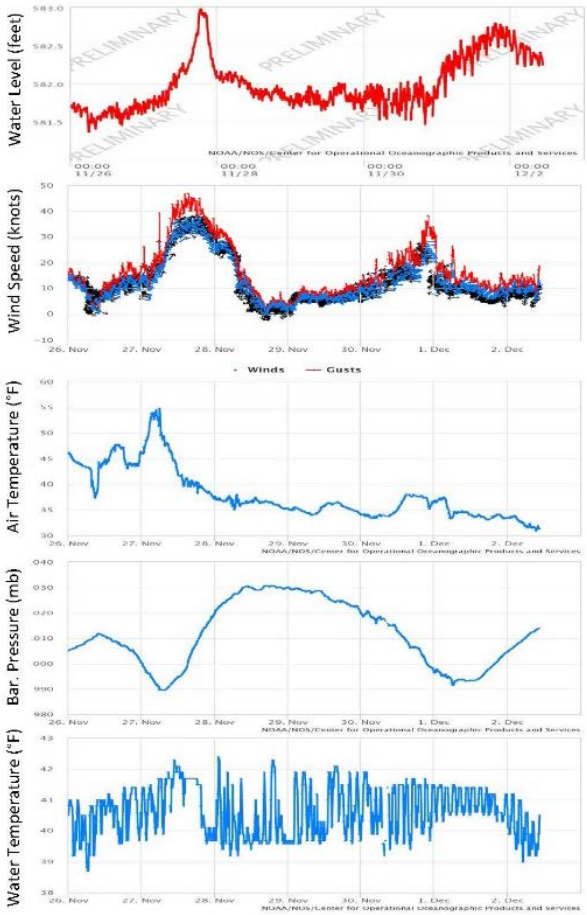


Figure 2: *Holland Lake Michigan water level gauge for 26 November to 3 December 2019*

Thanksgiving 2019 Storm: A Lake Michigan water level gauge (www.ndccurrents.noaa.gov-9087031) is located in Holland and I use it to tell me when water level will match the height of the sea wall at ESHC in Saugatuck. Figure 2 are the records for the Holland gauge starting November 26 before the big storm which created the storm surge and ending 3 December after the second flooding event which was caused by a seiche. The first event on figure 2 produced a Lake Michigan water level of approximately 583ft well about the highest recorded water level. This storm surge was caused by sustained winds of 35kt and the flooding on Lake Kalamazoo was enhanced by wind generated waves in excess of 3ft. The second event shown on Figure 2 is a seiche event set up by a dramatic change in the barometric pressure along with a sudden decrease in a 20 kt wind. A seiche, a French word meaning "to sway back and forth", is a standing wave that oscillates in a lake as a result of seismic or atmospheric disturbances creating huge fluctuations of water levels in just moments. The standing waves slosh back and forth between shores of the lake basin (Typically 3-4 times with decreasing amplitude), often referred as tide-like changes of the Great Lakes, by many. Most seiches on the Great Lakes are results of atmospheric disturbances and a cease in wind, not seismic activity or huge tidal forces. For the geeks see http://geo.msu.edu/extra/geogmich/seiches.htm for additional details. Note the duration of the storm surge was a shorter time period than the seiche.

Future Lake Levels: The US Army Corps of Engineers, NOAA , and various Canadian govt organizations all monitor the water level in the Great Lakes and make predictions as to future water levels. Some predictions look a few months into the future while others predict next year or five and ten years out. For this discussion I am presenting the USACE Great Lakes Water Level Outlook for a 12 month period from Oct 2019 (see attached again for the more geek inclined). Three factors determine lake level; precipitation, evaporation, and runoff which is referred to as the

Figure 3: *Prediction of Lake Level for Lake Michigan*

Net Basin Supply (NBS). Figure 3 shows the range of predicted water level for Lake Michigan. The gray area represents the range of possible modeling scenarios, from a level below 580 ft (~2 ft below the present level) to approximately 583 ft, a new record high water event. The purple curve represents a normal precipitation year while yellow would indicate below average precipitation. If the 2019 spring weather repeats itself we will have water level similar to this year. Don't shoot the messenger!

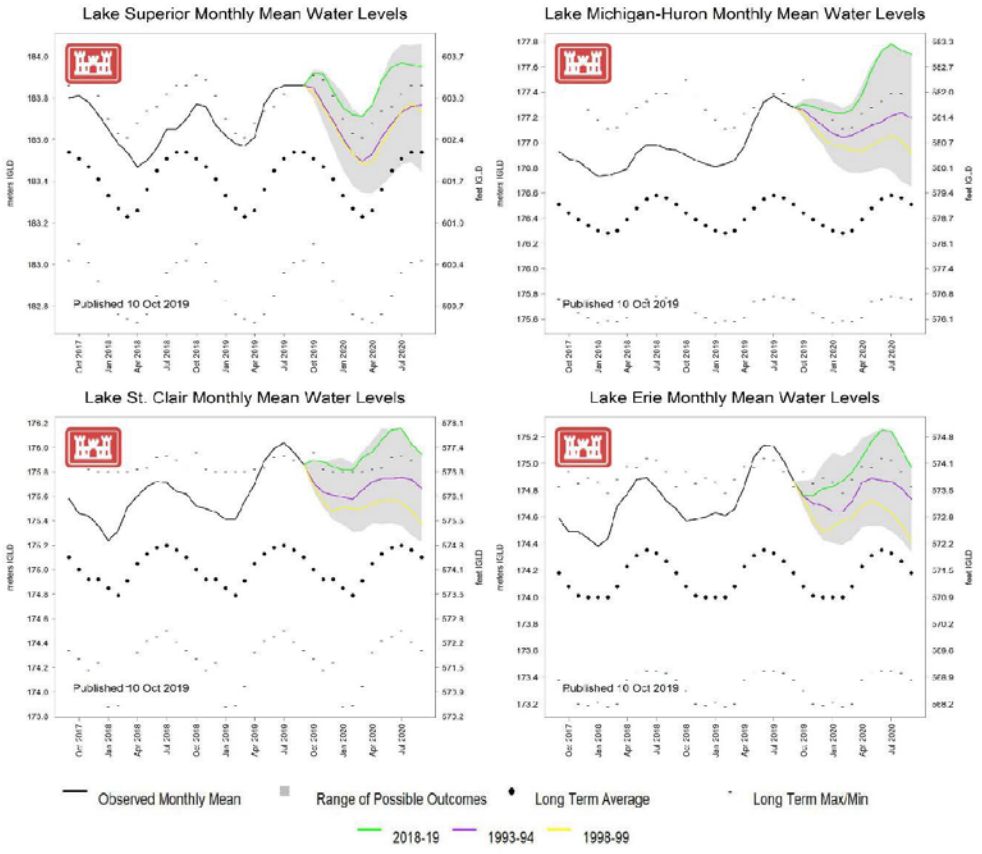
Summary: A lot of information has been presented. The take a ways are:

1) Kalamazoo Lake and Lake Michigan are hydrostatically connected, if Lake Michigan rises so does Kalamazoo Lake and River.
2) Remember the number 582.5 ft msl, the highest recorded level in Lake Michigan. When the gauge at Holland reads 582.5 or higher we are going to get flooding.
3) Storm surge and seiche events are a big problem due to the high water, in normal times we barely notice these occurrences.
4) The future lake level is all about NBS, really it translates into rain and snow fall. Above average precipitation in the Great Lakes Basin spells trouble.

US Army Corps of Engineers
Detroit District

Great Lakes Water Level Outlook

Volume 17: October 2019 12-Month Outlook



*At this time, water level outlooks for Lake Ontario are still under development due to complexities of its weekly regulation process. For the official 6-month forecast of all lakes, including Lake Ontario, see the Monthly Bulletin of Great Lakes Water Levels.

Overview

Monthly mean water levels continued to set records in September with Lake Superior tying its monthly record high and Lakes St. Clair and Erie setting new record high September levels. On Lakes Michigan-Huron and Ontario water levels remain well above average and near record levels. These record high water levels have been a result of persistent wet conditions that have existed over the past several months to years, which continued with high precipitation and runoff this past spring that led to rapid water level rises. Recently in July and August, conditions were generally dry as the lakes began their seasonal declines, however, September was relatively wet for the western half of the basin. In the fall, the lakes generally decline due to an increase in evaporation as temperatures cool off and the cold air moves over the relatively warm lake waters. During the spring, the lakes typically rise due to increased precipitation and increased runoff as a result of snowmelt. We refer to the combined effect of precipitation over the lake, evaporation from the lake, and runoff to the lake as Net Basin Supply (NBS).

Over the past year, the cumulative NBS we've seen across the Great Lakes basin has been well above normal. This edition of the Water Level Outlook incorporates the projection of water levels if the cumulative NBS over the next 12 months is a repeat of last year (high), near average, or a lower cumulative NBS scenario. The lower NBS sequence represents a time when water levels were transitioning from a high water period to a low water period. The green line represents the 2018-19 scenario, which is characterized by high cumulative NBS over the next 12 months (Oct.-Sep.). The purple line represents the 1993-94 scenario, which is characterized by near average NBS throughout the next 12 months. Lastly, the yellow line shows the 1998-99 scenario, which represents a lower cumulative NBS scenario that was characterized by a transition from high to low water periods.

2018-19 Scenario

The 2018-2019 scenario depicts water levels under a condition of high cumulative NBS for the next 12 months (Oct-Sep) and is shown by the blue line. It was developed using historical NBS data from 2018-19. The total NBS for the Great Lakes basin over this 12 month period was the highest on record. In 2018, the precipitation was very high in October for Lakes Superior, Michigan-Huron, and St. Clair, while in November precipitation was quite high in the Lakes Erie and Ontario basins. This led to well above average NBS in the respective months for each lake basin. December of 2018 was rather warm, which led to decreased evaporation during a time of year where evaporation is a large component of the total NBS. The low evaporation rates resulted in above average NBS across all of the lake basins. NBS during the first 3 months of 2019 (Jan-Mar) were close to average with February slightly on the wetter side as some areas throughout the basin set record snowfall and total precipitation records. For example, in Sault Ste. Marie Michigan 45.2" inches of snow fell in February, which was a new record for the month. A decent snowpack from the winter, on top of saturated soils from a wet fall of 2018, contributed to increased runoff from April to June, which was combined with above average rainfall, leading to rapid rises in lake level across the Great Lakes. The end of summer was drier in the region, but with water levels above or near records little relief was noticed. The beginning of fall in September was again wet for the western half of the basin. In this scenario in which we would have similar NBS over the next 12 months as was seen in 2018-2019, water levels on Lake Superior would be above record high water levels throughout next year. On Lake Michigan-Huron, water levels would remain below record high levels until December and then be above record high levels for the rest of the period. Lake St. Clair would also be above record high levels for most of the next 12 months, with October being the only month below record high levels. Lake Erie would be below record high levels through January 2020 and surpass records beginning in February throughout the rest of the period.

1993-94 Scenario

The 1993-94 scenario depicts water levels under a condition of near average cumulative NBS for the

next 12 months (Oct-Sep) and is shown by the purple line. It was developed using the historical NBS data from 1993-1994. The temperatures from October to December in the Great Lakes basin were just slightly below normal and evaporation stayed near average during these months of seasonal decline. Precipitation was generally near average in October for all lakes, but slightly below average in November and December for Lakes Superior, Michigan-Huron, and St. Clair. Precipitation and NBS on Lake Erie was above average in November and below average in December. From January through March, there was some fluctuation in precipitation, but overall NBS was near average. April and June precipitation was generally above average, but May was slightly drier throughout the basin and runoff during these three months was predominantly below average. In the late summer, Lakes Superior and Michigan-Huron experienced above average precipitation, which led to slightly above average NBS. On Lakes St. Clair and Erie, July was slightly drier, while August was on the wetter side and total NBS was near average. In September, precipitation was below average throughout the basin, but warmer than normal temperatures caused evaporation to be well below average leading to near average NBS. Under the scenario in which the basin receives similar NBS as was seen in 1993-1994, all of the lakes would remain below record high water levels throughout the next 12 months. However, water levels would continue to be well above long-term average levels.

1998-99 Scenario

The 1998-99 NBS scenario depicts water levels under the conditions of low cumulative NBS over the next 12 months (Oct-Sep) and it represents a time when water levels were transitioning from a period of high water to low water. This scenario is shown with the yellow line and was developed using historical NBS data from 1998-1999. Temperatures in the summer were closer to average, and increased evaporation began on the lakes in the summer, which continued throughout the fall and into the early winter. On Lake St. Clair and Lake Erie, high evaporation during the fall was also coupled with below average precipitation, while on Lake Superior and Lake Michigan-Huron precipitation was near average during the fall. During the spring, Lake Superior experienced above average runoff in April likely from snowmelt and also had above average precipitation in May. However, a drier spring was experienced on the other lakes. Precipitation for the other lakes during the late winter and spring of 1999 was generally near to below average, which led to decreased runoff during this time. In the summer of 1999, Lake Superior had an exceptionally wet July, which led to well above average NBS and a rise in water levels. However on the other lakes, from June to September, precipitation was near to below average. August was particularly dry as below normal temperatures brought well above average evaporation on the lake surfaces and contributed to NBS being below average throughout the entire basin. In the scenario in which the basin receives similar NBS to what was experienced in 1998-1999, water levels would drop significantly in the fall and winter months across each of the lake basins. Also, the dry conditions leading to below average NBS on Lakes Michigan-Huron, St. Clair, and Erie would result in small water level rises in the spring. In the Lake Superior basin, conditions would be wetter during the spring and would experience more of a typical rise during the spring months in this scenario. Although this scenario is near the bottom of the range of possible outcomes, water levels would remain well above long-term average water levels.

Climatic Outlook as of October 2019

The recent 1-month climate forecast updated by the Climate Prediction Center (CPC) shows a likelihood of above average temperatures in the month of October for the majority of the Great Lakes basin. The 1-month precipitation outlook shows the likelihood of above average precipitation for the entire Great Lakes basin in the month of October, as a wet beginning to the month is expected in the region. The seasonal three-month outlooks for temperatures in the fall and early winter indicate a continuation of above average temperatures throughout the Great Lakes basin. The seasonal three month outlooks for

precipitation in the fall show equal chances of above, below, or normal precipitation forecasted for the Great Lakes basin, but during the winter forecasts are indicating a likelihood of above average precipitation. One of the climatic factors that influences the outlooks are teleconnections, such as the El Niño Southern Oscillation (ENSO). Currently, ENSO neutral conditions exist, which occurs when sea surface temperatures in the eastern and central equatorial Pacific Ocean are near average. With ENSO neutral conditions favored for the upcoming winter it's likely that other teleconnections such as the Arctic Oscillation (AO) could have a larger impact this year on temperature and precipitation.