

Summary
Highs and Lows: Western Lake Superior Water Levels Conference
11 December, 2019, Duluth, Minnesota
Objectives 1 and 2 prepared by the University of Minnesota Sea Grant Program

The objectives of the Highs and Lows of Lake Superior workshop held in Duluth, Minn., on 11 December 2019, were to:

1. Recognize the history, trends and drivers of water levels in Lake Superior over the last 100 years.
2. Share examples of how lake levels have impacted local resources and communities.
3. Identify challenges and opportunities to improve local resilience to fluctuating lake levels.

History, Trends and Drivers of Water Levels in Lake Superior

Melissa (Missy) Kropfreiter¹ and Brandon Krumwiede² reviewed the history, trends and drivers of water levels in Lake Superior.

Kropfreiter gave an overview of the Great Lakes basin and explained how the [Boundary Waters Treaty Act of 1909](#) committed Canada and the United States to cooperatively manage the Great Lakes. To aid this management, the two countries have maintained a system of water level gauges since 1918 and have had at least one gauge operating on each of the Great Lakes since 1860. The National Oceanic and Atmospheric Administration's (NOAA) [National Ocean Service](#) and the [Canadian Hydrographic Service](#) are the agencies currently maintaining this coordinated system of water level gauges.

Kropfreiter said the U.S. Army Corps of Engineers (USACE) calculates Lake Superior's average water level based on data from [five gauges](#) that are accurate down to a centimeter. Accurate monthly average water level records span the last 100 years and are expressed as an elevation above sea level. The reference level, [International Great Lakes Datum](#) (IGLD) is recalibrated every 30-35 years to compensate for the rebounding of the Earth's crust after the last ice age.

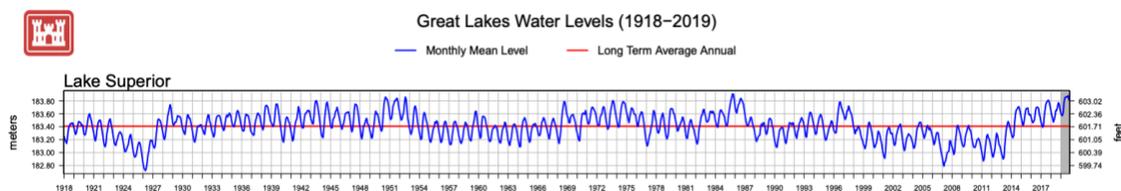
Kropfreiter explained from 1918 - 2019, Lake Superior's monthly average ranged 3.9 feet (1.19 m)(Figure 1) while in just the last 13 years, it ranged 3.57 feet (1.09

¹ Kropfreiter is a hydrology engineer with the [U.S. Army Corps of Engineers, Detroit District Office](#).

² Krumwiede is the Great Lakes regional geospatial coordinator through a [CCS](#) contract with the National Oceanic and Atmospheric Administration's [Office of Coastal Management](#).

m). She said that lake level fluctuations are primarily due to forces of nature. “Forces of nature can change Lake Superior’s water level by feet whereas human influences can only change it by inches,” she said. Forces of nature include precipitation, runoff, evaporation, inflow, outflow, wind, seiches, crustal movement, ice and vegetation. Human influences include diversions, regulations, dredging and consumption. The International Joint Commission (IJC) regulates the flow of water out of Lake Superior through the Soo Locks while the USACE and Canadian Hydrographic Service executes the IJC’s orders.

Figure 1: Lake Superior’s monthly average water level from 1918-2019 compared to the lake’s long-term average water level. Credit: USACE, <http://lre-wm.usace.army.mil/ForecastData/GLBasinConditions/LTA-GLWL-Graph.pdf>.



“The hydrologic cycle is really what we concentrate on in the USACE office,” said Kropfreiter. “The net basin supply is a focus.” The net basin supply is the volume of water entering the lake through precipitation and runoff minus evaporation over a specified time. It represents the total contribution of water to each lake, excluding inflows from upstream lakes, outflows to downstream lakes and diversions.³

Kropfreiter said Lake Superior’s current high water level reflects the last five years, which have been the wettest on record for the Great Lakes basin. “Our basin is saturated,” she said, adding that substantial ice cover in the winters of 2017/18 and 20/19 limited evaporation rates, which kept lake levels high going into the respective summers.

Conversely, a decade ago, Lake Superior experienced the longest sustained period of low water recorded in the last century. Kropfreiter said that this was partially due to a lack of winter ice cover, which allowed more evaporation.

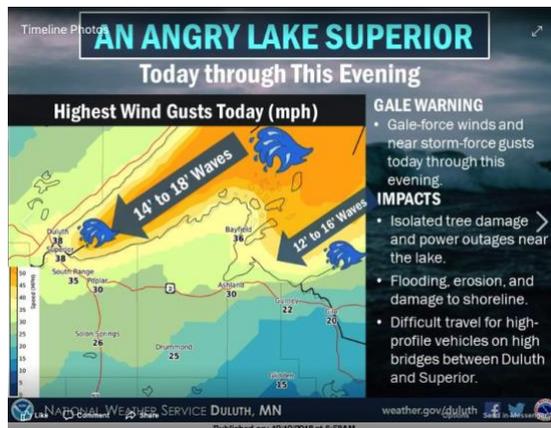
“These water level fluctuations have everything to do with natural factors that we don’t control,” said Kropfreiter. “Even at the USACE, we have to adapt to varying levels.”

³ <https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information-2/Basin-Conditions/Basin-Conditions/>

Kropfreiter said that all shorelines, rock-faced ones included, are at risk of eroding during periods of high water. She said the outlook for the Lake Superior basin is that it's likely to remain wet and that the water level will remain high in 2020.

Krumwiede added perspectives on Lake Superior's monthly average water levels over the past 100 years. He talked about the 30-year averages used by NOAA and the upward swings after lake level lows in 1926 and 2012. He said the 2012 to 2018 rise in lake level (See Figure 1) added 41+ trillion gallons of water to Lake Superior and that such a rise can damage the success of wild rice in connected wetlands.

Figure 2: Wind and wave graphic prepared by NWS-Duluth and shared on Twitter.



Krumwiede talked about the consequence of high water levels when coupled with high winds, showing a National Weather Service Duluth, Minn., graphic from October 10, 2018. He said this illustration of how gale-force winds were poised to push 12-18 foot waves onto shorelines from Duluth to Ashburn, Wisc., could easily have been used again during this year's October storm.

Krumwiede reminded participants that storm surges inundating Canal Park, Minn., happen. He showed a photograph of a 1975 blizzard that sent water over the road and talked about the October

2019 storm surge that pushed the Duluth water level gauge to a new high. Krumwiede said that seiches change lake levels at particular points along Great Lake's shorelines and contribute to the spikes recorded at Lake Superior water level gauges in Minnesota.

Krumwiede talked about how the slope of the lake bed influences what sort of wave develops. Waves develop due to friction as surface water reaches and moves across the lake bed, he said. Wave action can alter river mouths, cause river inflooding and increase the sediment and nutrients entering the lake. Furthermore, wave action can damage coastal infrastructure as evidenced by recent damage a McQuade Safe Harbor, Brighton Beach and the Duluth Lakewalk. Krumwiede said the sidewalk bumpers from McQuade washed up on Brighton Beach, 4.3 miles away.

Kropfreiter and Krumwiede prompting participants to:

1. Learn more about Great Lakes water levels through the USACE - <https://www.lre.usace.army.mil/Missions/Great-Lakes-Information>

2. Explore options for managing shorelines through the free 50-page book, [Living on the Coast: Protecting Investments in Shore Property on the Great Lakes](#), co-produced by Wisconsin Sea Grant and USACE.
3. Visit NOAA's Digital Coasts for information about [adaptation strategies](#).
4. Read about coastal processes on the website [Coastalwiki.org](#).
5. Find [LIDAR data](#) and [aerial oblique imagery](#) for Lake Superior through the NOAA Office of Coastal Management. (Note: New Lake Superior LIDAR data should be available soon.)
6. Find out where the impacts of high and low water levels are poised to be most severe through NOAA's [Lake Level Viewer](#) tool.
7. Fill out the International Joint Commission's Great Lakes-St. Lawrence River shoreline landowners and businesses 2019 high water impacts questionnaire - <https://ijc.org/en/glam/watershed/questionnaire/high-water-levels-2019>.

Questions about history, trends and drivers of water levels in Lake Superior included:

How does the USACE use elevation above sea level as a measure when the sea level is rising due to climate-change?

Kropfreiter: Sea level doesn't really influence Great Lakes level calculations because the baseline (IGLD) is set by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. The IGLD is a standardized level that is recalibrated every 30-35 years to compensate for the rebounding of the Earth's crust after the glaciers retreated.

What can we do more to mitigate water levels?

Kropfreiter: IJC [Great Lakes Adaptive Management Committee](#) member, said that this committee is looking into ways to adapt and alterations to the regulations. Altering flow through the St. Marys Rapids must not strand fish or wash out eggs and fry. The IJC's questionnaire, which is helping to collect information to answer this question, was mainly driven by the devastating floods along Lake Ontario.

Do you agree with the predictions that Lake Superior will experience similar or even greater fluctuations in water levels in the future?

Kropfreiter: Climate and hydrology experts are expecting higher variability in Great Lakes water levels over shorter timeframes.

Why isn't the USACE considering human activity as a driver of climate change and therefore a driver of natural forces?

Kropfreiter and Krumwiede: Studies along these lines are being conducted but that they are not ready to be factored into lake level regulations or mitigation/adaptation strategies at this time.

How often are you seeing changes in bathymetry data? Per year? Per decade?

Krumwiede: The amount of change depends on the shoreline. NOAA's [National Coastal Mapping Program](#) aims toward collecting data every five years to quantify changes in nearshore and bathymetry.

Is the Lake Level Viewer going to be updated?

Krumwiede: NOAA is in the process of inventorying the data being collected, including aerial and LIDAR (Light Detection and Ranging - a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to the Earth). Much of the data can be found on the [NOAA Data Access Viewer](#) that is housed within [NOAA's Digital Coast](#).

Instead of saying, "the gales of November," should we be saying, "the gales of October?"

Krumwiede: Maybe we should be saying, "the Gales of fall." Lake Superior has had major storms in September but the severity of storms in recent Octobers has, indeed, been notable.

Can you see a way to integrate science, managers, engineers and others to better mitigate the changes we see?

Krumwiede: I think events like this are important. Getting ideas pulled together will help. Video are a powerful way to communicate. One of my favorites shows the importance of mangroves in reducing wave energy and protecting natural beach. It is also important to make resources publically available in a timely manner.

Are there enough financial resources available to collect data such as the LIDAR imagery?

Krumwiede: The U.S. Geological Survey recently launched [3D Nation](#) to collect and share U.S. mapping data about the U.S. [NOAA's Coastal Resilience grants](#) are available for data collection. Along the North Shore of Lake Superior, [Great Lakes Restoration Initiative](#) funds helped fill a data gap.

Examples of Lake Superior's Water Level Impacts

Neva Maxwell⁴, Michelle Shriders⁵, Kari Hedin⁶ and Jim Filby Williams⁷ participated in a panel discussion moderated by Todd Breiby, the coordinator of the Wisconsin Coastal Management Program. Together they addressed the second conference objective by sharing examples of how lake levels have affected their constituents and communities, focusing primarily on the situation which prompted the conference: Lake Superior's high water level.

⁴ Maxwell represented Lake County Planning and Zoning.

⁵ Shrider represented Washburn Marina.

⁶ Hedin represented the Fond du Lac Band of Lake Superior Chippewa.

⁷ Filby Williams represented the City of Duluth.

Maxwell, a county land use specialist, spoke about property loss along the eroding shorelines and cliff faces of Minnesota’s coast. She said that, in some cases, Highway 61 prevents buildings from being moved to safety. In addition to erosion, she reported that some Lake County residents and property owners are frustrated by the escalating volume of shoreline debris associated with higher water levels and cost of its removal.

“People are asking, ‘What are we supposed to be designing for? Up or down?’” said Maxwell. “The county needs to be able to give people some direction and some hope. Right now we’re lacking that.”

Maxwell said the number of shoreline restoration projects being pursued in 2019 exceeds average and suggested better tracking of coastal erosion rates will help property owners make better decisions. “It baffles me that tracking coastal erosion hasn’t been addressed earlier,” she said.

Figure 3: A hazard mapping project identifies areas of high erosion along Minnesota’s north shore. <https://ardc.org/cehm/>.

COASTAL EROSION HAZARD MAPPING
LAKE SUPERIOR'S NORTH SHORE

Project Outcomes

- Develop a tool that can be used to identify the suitability for development.
- Create a resource for property owners living along the coast
- Provide recommendations for property owners regarding conservation concerns/hazard erosion areas.

Why map erosion?

- Although data for Lake Superior's coastal region does exist, current mapping efforts do not directly address coastal erosion along the dynamic North Shore.
- Past efforts to map erosion on the North Shore occurred 30 years ago, rendering them outdated considering increased water levels and storm cycles – it's time for an update!

Who will benefit?

Property owners, public officials, local decision makers, realtors, developers, and researchers will all benefit from this mapping tool.

Erosion Facts

- Shoreline erosion affects landowner property values and structures, yet also impacts water quality and the habitat for critical species.
- At an average increase of 2 degrees per decade, Lake Superior's rising water temperatures are leading to more storm events causing erosion which put a stress on community infrastructure, economy, and resiliency.
- The Great Lakes Coastal Flood Study conducted by FEMA from 2010 found that Lake Superior's water levels are increasing which leads to increased wave action causing erosion on the North Shore.

Who is involved?

Partners involved with this project include:

- North Shore Management Board
- Lake and Cook County's Soil and Water Conservation Districts
- Arrowhead Regional Development Commission
- University of Minnesota Duluth
- Minnesota's Lake Superior Coastal Program
- Cook and Lake Counties

For more information: [ARDC.ORG/CEHM](https://ardc.org/cehm)

The [coastal erosion hazard mapping project](#) (figure 3) and its associated [north shore erosion mapping tool](#) is being developed by partners to assist decision making along Minnesota’s coast. Maxwell said, “Updating the erosion hazard maps will be an uphill battle as lines are changing from 40 feet setbacks to 125 feet along some stretches of Minnesota’s coast.” Minnesota shorelines other than Lake Superior’s typically have setbacks of 75 feet.

Although affluent people tend to own the shoreline property, Maxwell said that most are not so well off that they can repeatedly spend millions of dollars fixing property damaged by high water and waves. She reported that [FEMA maps](#) showing splash overtopping zones were available but have been withdrawn, which makes planning more difficult.

She told a story of a structure that was recently built a legal 40 feet from the shoreline but within the splash overtopping zone. The structure was half-covered with ice at the time of the conference. “Our regulations are not doing what they should be,” said Maxwell. “There are lots of unaware people who are purchasing property,” said Maxwell. “We need to educate people.”

Shrider spoke about high-water challenges faced by marina operators, which include damage to infrastructure as ice forms and the costs associated with aerators to keep ice from forming. Acknowledging that high waters and cold winters have been a boon to aeration system manufacturers, she said, “The initial cost of the aerators doesn’t even come close to costs of keeping them running.”

High water levels also can damage breakwater structures important to safe boating, marinas and communities. Shrider reported that a storm in October 2014 ripped off the top timbers from a breakwall in Washburn, Wisc., which dated back to the late 1800s. She said emergency funding made it possible to repair the damage by adding a cement cap over the lower timbers. Bayfield, Wisc., has experienced similar breakwall troubles. Shrider commented on the difficulties of finding money to repair storm damage to harbors and marinas. She said these funds are also allocated to repair roads, sewers and other public assets. It took three years to reopen Saxon Harbor, Wisc., after it was destroyed by a powerful storm on July 11, 2016.

Shrider said the recreation marine industry is affected by higher water and winds, in part because the average age of boaters is increasing and older people are less willing take vessels out in windy or stormy weather. Shrider said the marinas are full and many boats don’t leave. She suggested there might be a correlation to what she hears from the local lodging industry, which reports been down 10-15% over the last two years. Shrider surmised that people are sleeping on their boats and bringing fewer friends to the area. “There is a large trickle-down impact,” she said, “though the shoreline restoration business is booming,

In addition to boaters and business owners, Shrider said that low income families have been affected by flooding in community playgrounds, beaches, and play areas adjacent and near to Lake Superior. She said the fishing pier in Bayfield is underwater and the Washburn pier was destroyed. “There’s no money to shore-up or replace these public assets in small municipalities,” she said. Shrider reported that raw sewage from Ashland, Wisc., entered Chequamegon Bay three times in 2019 as a result of high water and that these events led to beach closures.

Shrider relies on networking among marina operators to help mitigate the impacts of high water. At higher levels, she said it is important to work with municipal facilities and other organizations to develop a long-term strategic plan that addresses the fluctuation of Lake Superior’s water level. “You need a strong strategic plan to get federal funding,” she said.

Hedin talked about the impacts of fluctuating water levels on wild rice (manoomin) stands. Wild rice is important from an indigenous perspective and grows in some rivers and wetlands connected to Lake Superior. High water levels are not ideal for wild rice, an annual plant that also does poorly when water levels dramatically fluctuate during the growing season, like some did in 2012.

Hedin said having a water control plan and trained crews to managing water control structures will likely improve wild rice harvests. To this end, the Fond du Lac tribe is working with U.S. Geological Survey and U.S. Army Corps of Engineers watershed models, and using water level gauge data provided by the U.S. Army Corps of Engineers. The U.S. Geological Survey awarded a tribal grant to Fond du Lac so that they could also install more water level gauges. Monitoring water levels is part of the tribe's climate change monitoring strategy supported by the U.S. Environmental Protection Agency.

Hedin said the tribe is also working with University of Minnesota researchers to develop a holistic understanding of wild rice. This includes managing beaver. She said that there has been a decrease in number of people who trap beavers and a corresponding rise in water levels on tribal territory because of the active beaver dams. She also spoke of the spiritual, cultural and mental health of band members, for whom wild rice is sacred, citing that Wild Rice Lake hasn't supported wild rice for 20 years. Understanding wild rice cycles also involves hydrology and the geochemistry of mercury methylation. Hedin briefly talked about the ties between water levels, mercury availability, wild rice productivity and fish consumption.

Filby Williams spoke about managing water level-related challenges in the City of Duluth, Minn., from Park Point to the Lake County line. He said the biggest practical challenge the city has encountered during the last two years of high water is reconstructing assets in a resilient way before next storm hits.

"Ironically, the Lakewalk is where we are in the best position to succeed," he said, referencing the recent reconstruction adjacent to the Fitger's building. "Still," he said, "the damage created by Lake Superior's high waters coupled with severe storms has been a drain on city's time and human resources." Filby Williams commended the heroic efforts of city employees over the last two years in response to severe storms and high water levels.

"The City of Duluth made an economic decision to face the lake," said Filby Williams. This means that it is a priority for the city to maintain the Lakewalk and publically accessible shoreline while managing erosion and revetment failure. He said that proactively reconstructing assets to endure future storms is critical, citing the infrastructure protecting the water pumping plant as an example.

He noted that residents on Park Point, though small in number, had immediate concerns. The community's buried stormwater and sanitary systems are flooded, causing problems in private homes.

Filby Williams said that the local government's need for partnerships has been exponentially compounded by Lake Superior's high water. Technical help, assistance understanding the FEMA process, and conversations with the U.S. Army Corps of Engineers, Sea Grant, researchers and community planners have been important.

Filby Williams said, “There is a surplus of expertise but it’s hard for our small team to take full advantage of that. It’s hard to be as responsive and appreciative as we wish we could be. We really appreciate our federal and state partnerships!”

Duluth is pulling on multiple funding sources to deal with the effects of high water, including FEMA and hazard mitigation grants. He said the challenge is understanding how to best approach reconstructing public and private assets with the future in mind. “It is also important to understand how forces will impact those assets if we don’t take action,” he said. “The floodplain management services offered through the U.S. Army Corps of Engineers could help us understand the long game. The long game is the toughest one.”

Conference participants asked several questions:

What do you see as mechanisms that can enable us to live differently on the coasts? How do we change the way we live, because we might need to?

Shrider: Education is critical. The dissemination of information seems easy but it’s not. We’ve got live webcams and send messages out monthly but most people don’t read them. One of the bigger challenges is education.

Maxwell: I’m excited about the FEMA maps because they will allow us to bring up a particular parcel and show people the splash zone. They’ll help us make sure people are knowledgeable about their property.

Hedin: One-on-one communications are important. If people are open to learning, bringing the weight of evidence to bear could change hearts and minds.

Filby Williams: A managed retreat for a public access site such as Brighton Beach is easy. We’ll need to armor the heck out of our potable water plant. We need to pay attention to national lessons to dodge bitter political stalemates about zoning around coastal zones. We might look to the Twin Cities zoning for multiple families. At some point we’ll have to be pretty heavy handed.

As the integrity of homes, recreation and habitat degrades. Do you think people’s sense of place is evolving?

Maxwell: Property owners are seeing pink Iona’s Beach rock washing up and saying, “Huh!?! That’s strange!” Some think there are changes in the wind and/or the current. They’re having more “aha” moments. Some are selling their properties.

Shrider: I think boaters are taking the ostrich approach. The last two summers were eye-opening because of damage to equipment.