Report on the Elimination of Chronic High Water Issues on Moose Lake by the Restoration of a Drainage Outlet from Moose Lake in Waukesha County, Wisconsin

Prepared by
Greg O'Hearn

of the
Moose Lake Advancement Association

June, 2019

June 12, 2019

Mr. Paul Farrow
County Executive
Waukesha County
515 W. Moorland Blvd.
Waukesha, Wisconsin 53188

Re: High Water – Moose Lake

Dear Mr. Farrow:

Moose Lake, in the Town of Merton, has had chronic high, damaging water for three consecutive summers, and now going into the fourth summer. It has also had high damaging water in prior years, resulting in damages due to flooded property, erosion, costly damage to retaining walls, siltation of the lake and shoreline damage due to the loss of large shoreline trees (and their roots) falling into the water. The Board of the Moose Lake Advancement Association has prepared a report documenting the issues, the solution and estimated cost to implement said solution.

In 1836, Moose Lake flowed into the Oconomowoc River. Subsequent to that time, the roadway which is now Highway C was constructed, essentially creating an earthen dam without an outlet control structure. The Board of the Moose Lake Advancement Association, representing 72% of the riparian owners on Moose Lake wants the County to upgrade the dam that it created (or inherited), to include an outlet control structure for the dam on Moose Lake. We simply want parity with the other downstream lakes that have dams to be able to attenuate Moose Lake excess water flow.

Enclosed find our report documenting the issues on the lake associated with this matter and proposed solution and estimated costs.

On behalf of the residents of Moose Lake, we much appreciate your early attention towards movement on a solution to this matter.

Sincerely,

Greg O'Hearn
President, Moose Lake Advancement Association
A Wisconsin Non-Stock Corporation

enc: Report

cc: Paul Decker, Chairman, Waukesha County Board, w/enc
Richard Morris, District 3 Waukesha County Supervisor, w/enc
Allison Bussler, Director Waukesha County Department of Public Works, w/enc

Donna Hann, Clerk, Town of Merton, w/enc
Tim Klink, Chairman, Town of Merton, w/enc

Heidi Bunk, Sr. Water Resources Management Specialists, DNR, w/enc
Darsi Foss, Division Administrator of Environmental Management, DNR, w/enc

Tom Slawski, Southeastern Wisconsin Regional Planning Commission (SEWRPC), w/enc
Carol Wilson, Chair, Okauchee Lake Management District, w/enc

Chris Kapenga, State Senator, w/enc
Cindi Duchow, State Representative, w/enc

Moose Lake Advancement Association Board:
Greg O'Hearn
Charlie Harkins
Sue Laabs
Kyle Strigenz
Gery Sawall
Yvonne Lindl
Dave Hartleip
Nick Rakich
Gerry Dolphin

Joe Mattano, past President of the Moose Lake Advancement Association

/glo

Approval and Signatory Page

This report has been reviewed and approved by the Moose Lake Advancement Association Board of Directors this 5th day of June, 2019:

Greg O'Hearn, President

Charlie Harkins, Vice-President

Sue Laabs, Treasurer

Kyle Strigenz, Secretary

Gery Sawall, Board Member

Yvonne Lindl, Board Member

Dave Hartleip, Board Member

Nick Rakich, Board Member

Gerry Dolphin, Board Member

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Executive Summary and Recommendation

Moose Lake, in the Town of Merton, Waukesha, County, Wisconsin is an 83 acre lake which has had significant, chronic, damaging flooding for four consecutive years and in many prior years going back to 2008. This directly affects 121 riparian properties and 116 owners. This report further details the effects of this flooding. Moose Lake has a small watershed, only 309 acres, and its flooding is related to Moose Lake being a "bathtub without an overflow drain." Currently the only outflow from Moose Lake is groundwater flow moving from a generally east to west direction as documented in the "Inland Lakes of Wisconsin" report (see References) and from surface evaporation.

That was not always the case. In 1836 there was a naturally flowing stream starting at the southwest shore of Moose Lake that flowed west to the Oconomowoc River, which now is encompassed by Okauchee Lake. See Appendix 1 for a copy of original US Land Survey notes and map and the interpretation by staff of the Southeastern Wisconsin Regional Plan Commission of the small stream emanating from Moose Lake, then known as "Lake No. 5" in the US Land Survey notes and maps.

County Highway C currently acts as a dam to the original naturally flowing stream outflow from Moose Lake. Waukesha County either created the dam, or inherited the dam that is County Highway C. That dam has no spillway nor water elevation control structure, thus being the primary cause to the impounded high water and flooding issues on Moose Lake.

We have a written eyewitness account from a person very familiar with the area of water running over Hwy C from Moose Lake in the 1950's and that Hwy C was much lower in elevation at that time. (See Appendix 3). So truly Hwy C has acted as a dam without a spillway.

It is the desire of the Board of the Moose Lake Advancement Association which has 72% of riparian owners as members that Waukesha County re-establish a controlled water flow outlet on Moose Lake and install an overflow control structure on Moose Lake with a spillway elevation no lower than 882.42 which is the Ordinary High Water Mark elevation for Moose Lake as established by the DNR. The controlled water flow outlet would be limited to a flow of 6 acre-ft in a 24 hour period, which would limit the receiving water elevation increase on Okauchee Lake to 0.005 ft, or 1/16th of an inch, the thickness of a penny. It is our understanding this would be within the requirements of not impacting Okauchee Lake by more than 0.01 ft during a 100 year frequency occurrence rainfall/flood event. With the controlled outflow, Moose Lake would continue to act as a detention basin and retain excess flow to it (and rise approximately 10 inches during a 100 yr occurrence rainfall event) and only discharge the max flow of 6 acre-ft per day.

This outlet can be constructed for an estimated cost of $80,000 including engineering, construction of a small overflow pipe and the cost of an easement. **We request Waukesha County do the necessary engineering for the design of this outlet to Moose Lake in 2019 and construct the outlet in 2020.**

Key points:

- There have been chronic, damaging high water issues on Moose Lake going back to 2008
- Moose Lake is a "bathtub without an overflow drain"
- Moose Lake previously had a natural stream drainage outlet
- County Highway C blocks that natural stream outlet, acts as a dam, and that dam has no overflow control structure
- The Moose Lake Advancement Association represents 72% of the riparian owners of Moose Lake and on September 26, 2018 the membership voted overwhelmingly "that the Moose Lake Advancement Association Board focus its energies on pursuing a solution to the high water issues on Moose Lake and that all riparian owners be informed of the findings."
- Members from the Moose Lake Advancement Association board have met at least three times with the Wisconsin Department of Natural Resources and once with the Waukesha County Engineering Department to discuss high water issues. We also had discussions with the Southeastern Regional Plan Commission.
- A technical solution is to construct an excess flow, "overflow only" pipe between Moose and Okauchee Lakes
- Moose Lake will still act as a detention basin, and only bleed off excess flow in a manner that does not adversely impact Okauchee and other downstream lakes
- The outflow design from Moose Lake would only raise the height of Okauchee Lake the thickness of a penny, 1/16", when Moose Lake had an excess water condition.
- The estimated cost for the solution is $80,000
- Request is for Waukesha County engineering to start in 2019 and construction of the solution to be completed in early 2020

Overview

The Moose Lake Advancement Association is a Wisconsin non-stock corporation that was formed in 1939 and represents the riparian owners of Moose Lake. It is not a governmental entity and therefore not a taxing authority. It is a membership group. It currently has 72% of the 116 riparian owners as members.

At its September 26, 2018 meeting the membership voted overwhelmingly "that the Moose Lake Advancement Association Board focus its energies on pursuing a solution to the high

water issues on Moose Lake and that all riparian owners be informed of the findings." The vote was 52 to 3 in favor of pursuing a solution.

This report is the sum of the actions of the Board to date towards a solution to the high water issues on Moose Lake, including proposing a technical solution.

History of Moose Lake

Moose Lake is an 83 acre oval lake with two long bays at its southern end situated in Sections 19, 20, 29 and 30 in the Town of Merton in Waukesha County, Wisconsin. It is immediately east of County Highway C and south of County Highway K. It is part of "Lake Country" with Okauchee Lake immediately to the west (within 300 ft) and North Lake a half mile to the northeast, and Pine Lake one mile to the east and Beaver Lake less than 2 miles to the east.

It is a very clean, clear lake that is a seepage lake. It has no rivers or streams feeding it. The Oconomowoc River runs just to the west of Moose Lake, to Okauchee Lake. Moose Lake is classified as an oligotrophic lake, defined as characterized by a low accumulation of dissolved nutrient salts, supporting but a sparse growth of algae and other organisms, and having a high oxygen content owing to the low organic content. The drainage basin of Moose Lake is quite small, at 309 acres, and has little runoff from farm fields. There are a few wetlands to the east and northeast of Moose Lake, separated by land, that provide sand, gravel and other soil filtration for surface water seeping into Moose Lake via the wetlands.

Moose Lake and surrounding area were a part of the US Government Land Surveys in 1836. The lake was surveyed and on the original survey maps was simply noted as "Lake No. 5." At a later time, it was noted as "Mouse Lake." Eventually it was renamed to Moose Lake.

In the late 1800's there was a resort on the west side of the lake known as the Oaks Resort. That property today is Carl Schurz Park, a private membership association that provides cottage and recreational facilities on Moose Lake for 300 member families.

Oral history indicates that resort goers were transported via carriage or wagons from the Nashotah train station to the resort via a road which is now Highway 83, and that later a roadway was built along the west side of Moose Lake, which is now Highway C, making a more direct route to the resort. On the southeast side of Moose Lake was the Evergreen's Resort which changed hands in 1922 to the well-known Hasslinger's Resort which was in operation until 1998.

There were a lot of small cottages around Moose Lake. Over the years, Moose Lake has transitioned to mostly year around homes. The 2018 assessed value of the riparian owner property around Moose Lake is $64.8 million and the 2.1 mil rate of the county would indicate approximately $136,000 annual county tax revenue from the lake riparian owners. Being a public access lake, many other users within Waukesha County and beyond are able to enjoy the lake.

The Moose Lake Advancement Association was established in 1939 and actively supports lake management, especially in recent years by annually handling aquatic invasive plants on Moose Lake with chemical treatment under DNR permit. The Moose Lake Advancement Association has also aided the Southeastern Regional Plan Commission crews in their sampling for a chloride study on the lake. Moose Lake Advancement Association volunteers have taken water quality readings on Moose Lake since 1993.

About 2002, the Wisconsin Department of Natural Resources purchased property at the south end of Moose Lake and spent over $1 million to provide a boat launch for Moose Lake and insure the accessibility of the lake to the broader public. The improvements were completed in 2007.

Today, there are 116 riparian property owners on the lake, and due to the public access provided by the boat launch, the lake is also enjoyed by many fisherman, canoers, kayakers and other water sport enthusiasts from Waukesha County and beyond.

Hydrology of Moose Lake

Moose Lake is a "seepage lake" or spring fed lake. This means that its water source is groundwater flow, and rainwater and a limited amount of surface water drainage to Moose Lake from its limited drainage basin. Moose Lake currently has no surface water outflow, so it currently is dependent upon groundwater flow and surface evaporation for moderating changes to lake elevation. This groundwater and evaporation process has been problematic over the years because Moose Lake is essentially "a bath tub without an overflow drain."

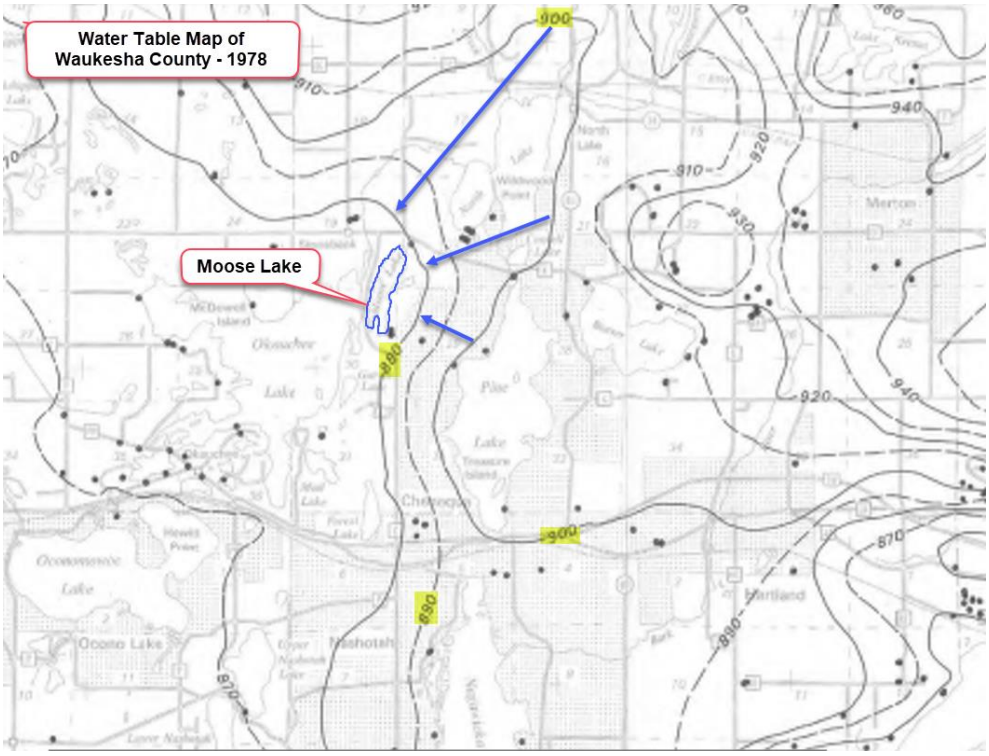
In 1836, Moose Lake had a naturally regulating outflow stream, allowing for normalization of lake elevation over relatively short periods of time after heavy rains or unusually wet periods. Apparently in the 1850's a roadway was built that is now County Highway C. It is likely the road was built with a dip in the road to stream level and wagons and carriages traversed the stream. Sometime prior to the 1970's it appears that the stream was obliterated and/or county Highway C raised in the area of the naturally occurring stream

outflow of Moose Lake causing Highway C to become a dam for Moose Lake. There is an eyewitness report of Moose Lake water overtopping Hwy C in the 1950's.

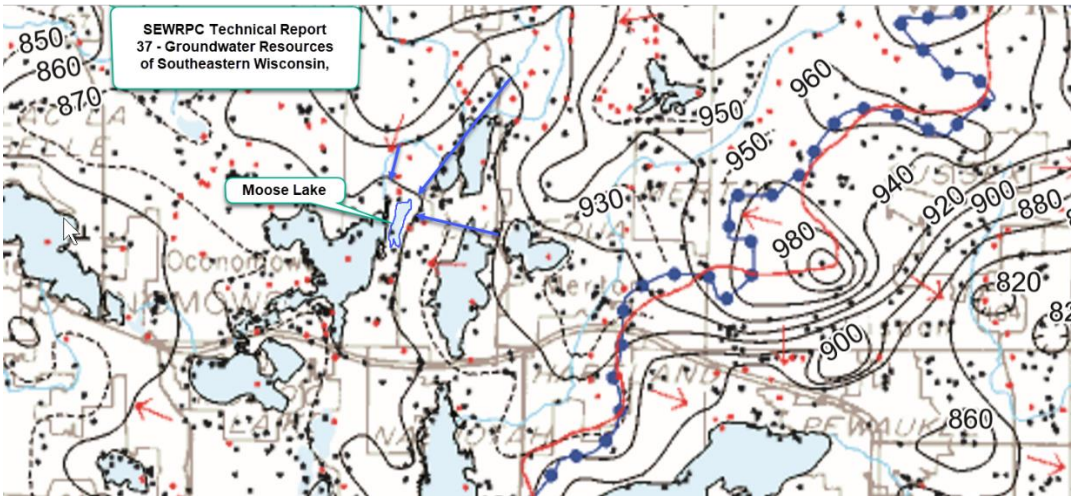
Residents in the area of Robin Lane report that the detention basin for the subdivision does not appear to work properly and may adversely impact Moose Lake.

Per the report entitled "Inland Lakes of Wisconsin: the Hydrography and Morphometry of the Lakes," it states that Pine Lake is a mile east and its water elevation is about 25 ft higher than that of Moose Lake and that much of the spring water entering Moose Lake is likely derived from Pine Lake groundwater flow. Additionally, it is stated that the water level of Moose Lake is about 5 ft higher than Okauchee Lake (at the time) and that the water of Moose Lake passes westerly to Okauchee by seepage and as a result, there are many springs on the east side of Okauchee Lake.

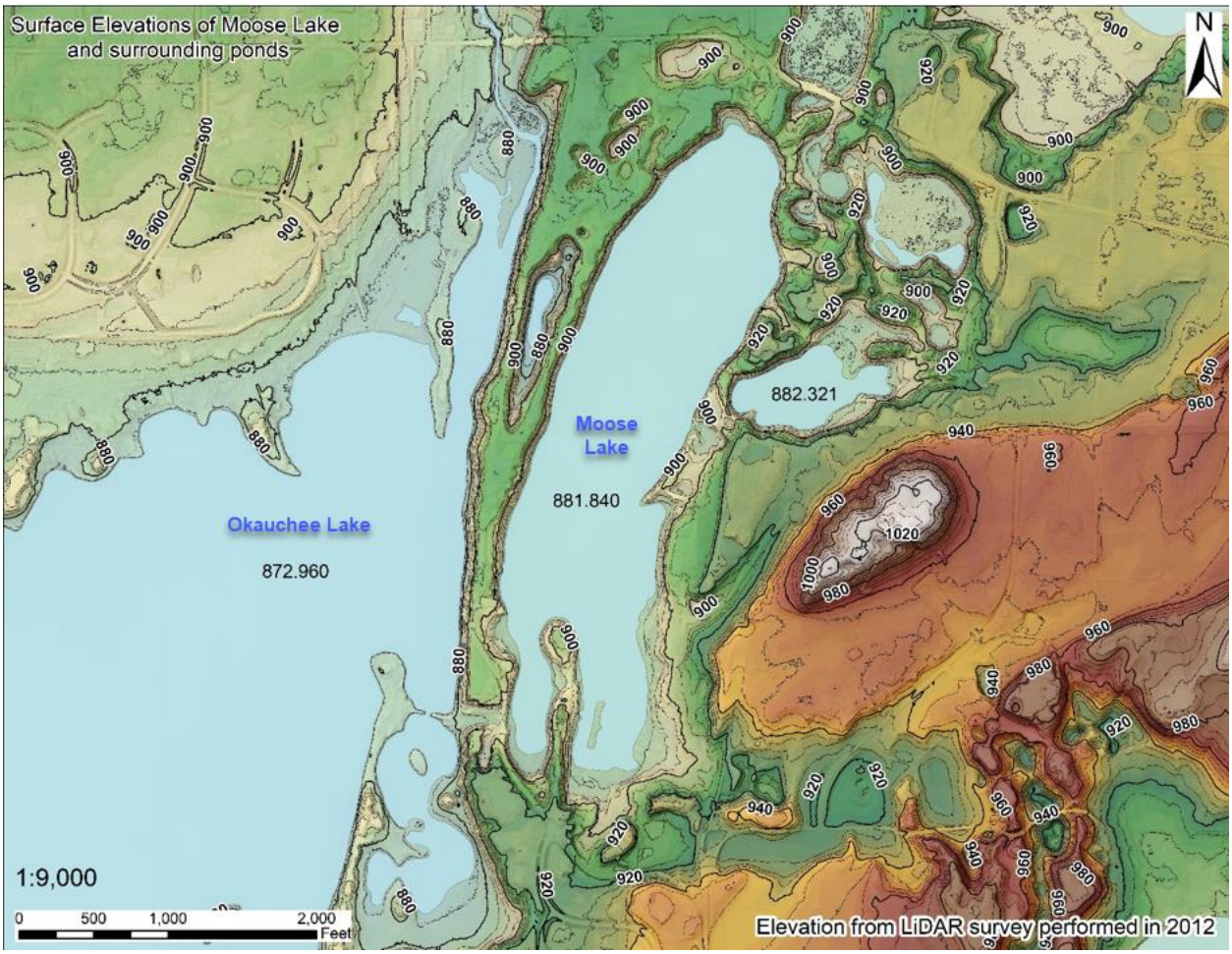
From the 1978 USGS Report entitled "Water-Table map of Waukesha County Wisconsin" the groundwater table gradient clearly indicates that groundwater flows from Pine Lake and North lake towards Moose Lake and Okauchee Lake. Additionally, the groundwater table gradient is relatively steep in this area dropping approximately 20 feet in a mile. Due to the groundwater gradient, groundwater consistently flows into Moose lake from the east and continues to flow west to Okauchee Lake. Map excerpt follows.



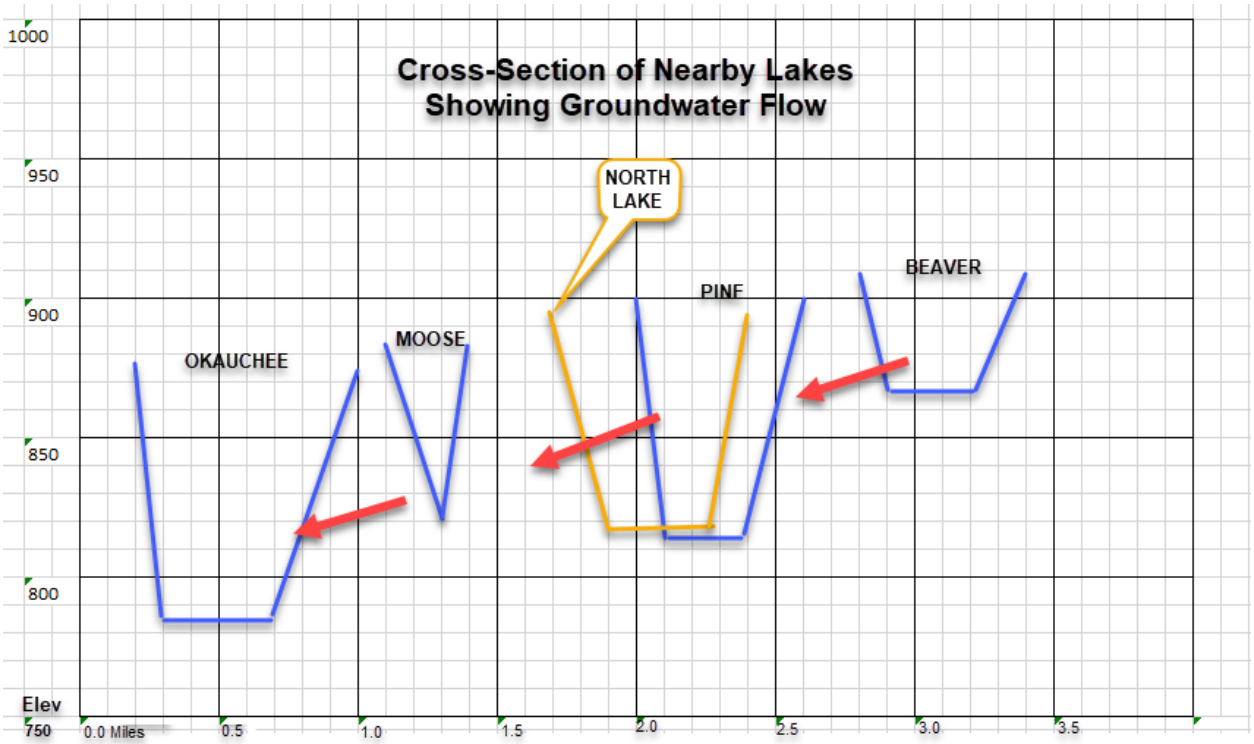
Similar groundwater flows from Pine Lake and North Lake and a 20 foot groundwater gradient drop between Pine Lake and Moose Lake and Okauchee Lake is found in a 2002 SEWRPC report. Map excerpt follows.



Mapping done from LIDAR survey in 2012 indicates ponds east of Moose Lake are higher than Moose Lake and pond between Moose Lake and Okauchee Lake is lower than Moose Lake water elevation in 2012, again indicating an east to west groundwater flow.



The distance between Moose and Okauchee Lake is separated by a narrow isthmus approximately 300 feet in width. Okauchee Lake is 8 to 9 feet lower than Moose Lake, and the "Inland Lakes of Wisconsin: the Hydrography and Morphometry of the Lakes" report indicates there are springs discharging on the east shore of Okauchee Lake, which would indicate evidence of the east-west water flow. The significant drop between Moose and Okauchee Lakes would indicate there is likely seepage directly from Moose to Okauchee Lake.



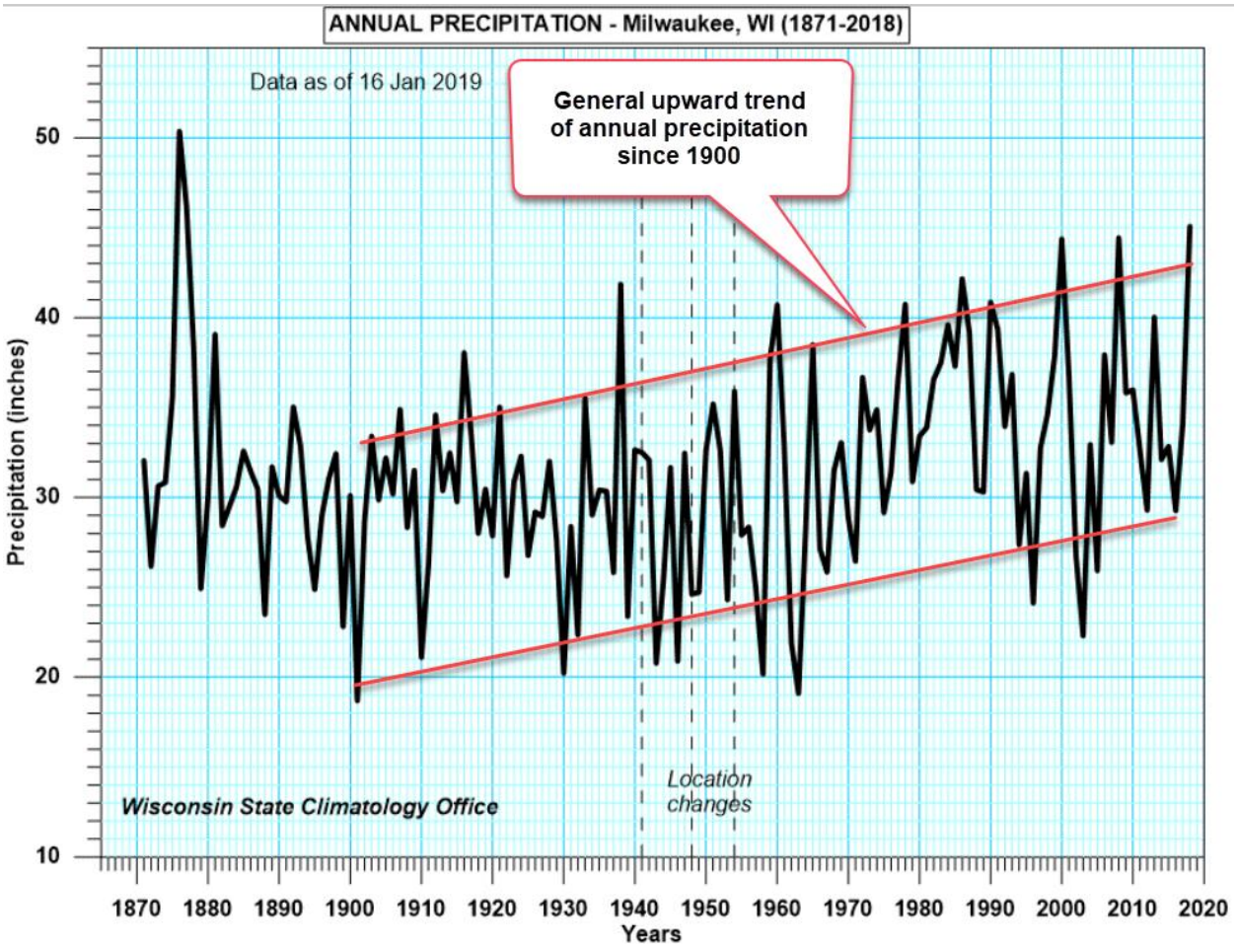
The spillway elevation of the dam on Okauchee Lake is 872.60 which is **9.8 feet lower** than the proposed outlet elevation of (no lower than) 882.42 on Moose Lake. Moose and Okauchee Lakes are 245 feet apart at their closest and this is through a ridge 28 feet in height. In the area where the original 1837 stream flowed from Moose Lake to Okauchee Lake, the highest point is County Hwy C at *8.1 ft. above* the proposed Moose Lake overflow elevation of 882.42. It is obvious that at some point in the past, fill has been placed to establish the current County Hwy C road height in the location where Hwy C right-of-way touches or encroaches Moose Lake and the original area of the stream to the west has been filled in. We have an eyewitness account of Moose Lake water overtopping the County Hwy C in the 1950's when the roadway was at an obvious lower elevation. County Hwy C is a minimum of 4 feet higher than the ground at the west right-of-way and a minimum of 8 feet on the east right-of-way in the area of the original stream flowing out of Moose Lake. Moose Lake lies approximately 18 feet east of the east pavement edge of Hwy C during high water. The ground naturally slopes east to west in the area of the original 1837 stream, (except for the obvious fill at roadway).

Precipitation

The mean annual precipitation for Milwaukee is 34.8" for 1981-2010, from NOAA reporting. (See References).

The chart below shows the annual precipitation totals (in inches) for Milwaukee Wisconsin 1871 – 2018 from Wisconsin State Climatology Office. (See References). From 2000 to 2018 there were 3 years in which the precipitation was 9-10" above the mean. The trend since 1900 has generally been towards increasing annual precipitation, which, if the trend continues, will *exacerbate the high water situation on Moose Lake*, a lake currently without an overflow drain.

Chart 1 – Annual Precipitation – Milwaukee, Wisconsin (1871-2018)



Evaporation

Evaporation from Moose Lake varies based on the levels of sun and wind. Using the NOAA Technical Report NWS 34, (see References), the expected mean evaporation from Moose Lake is approximately 70% of 42"annually or 29" of evaporation from Moose Lake annually. The 70% evaporation figure is based on this information in the report: "It has been found that evaporation from a shallow lake, wet soil, or other moist natural surfaces is roughly 70 percent of the evaporation from a Class A pan for the same meteorological conditions." The Class A pan evaporation values are found in Table II below utilizing Milwaukee and Madison data.

Table II – Monthly Mean Estimate "Pan Evaporation" Computed From Meteorological Measurements Using a Form of the Penman Equation

TABLE II -- MONTHLY MEANS OF ESTIMATED "PAN EVAPORATION" COMPUTED FROM METEOROLOGICAL MEASUREMENTS USING A FORM OF THE PENMAN EQUATION*

	State No.	Station Index No.**	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May-Oct***	Nov-Apr***	Annual***	Record Began Mo/Yr	Last Data Mo/Yr
WEST VIRGINIA (continued)																			
Elkins WSO 38° 55', 79° 49'	46	2718	0.99 10 24	1.21 10 25	2.23 10 19	3.14 10 14	4.33 11 12	4.39 11 10	4 8 ****	4 9 ****	3 9 ****	2 9 ****	1 9 ****	1 9 ****	22 **** ****	10 **** ****	32 **** ****	1/56	6/68
WISCONSIN																			
Green Bay WSO 44° 28', 88° 7'	47	3269	0.62 14 24	0.81 15 29	1.70 15 30	3.46 15 18	5.17 15 12	6.15 15 12	6.64 15 12	5.33 15 12	3.38 15 12	2.34 15 25	1.16 15 19	0.63 15 25	29.02 7	8.37 13	37.30 7	1/56	12/70
La Crosse WSO 43° 52', 91° 15'	47	4370	0.74 13 24	1.03 13 33	1.99 13 30	4.31 13 16	6.15 13 12	6.95 13 12	7.26 12 7	6.11 13 8	3.85 13 12	3.20 12 18	1.45 12 19	0.80 12 24	33.43 5	10.08 12	43.36 5	1/56	9/68
Madison WSO 43° 7', 89° 19'	47	4961	0.74 14 27	1.00 15 24	1.99 15 25	3.75 15 14	5.34 15 25	6.69 15 14	6.86 15 8	5.80 15 10	3.63 15 13	2.71 15 20	1.28 15 14	0.69 15 30	31.03 6	9.43 12	40.46 6	1/56	12/70
Milwaukee WSO 42° 56', 87° 53'	47	5479	0.85 15 24	1.09 15 26	2.01 15 30	3.82 15 14	5.57 15 18	6.70 15 13	7.25 15 13	5.96 15 12	4.04 15 11	2.88 15 19	1.55 15 13	0.90 15 19	32.39 7	10.22 12	42.62 6	1/56	12/70

Above from: http://www.dynsystem.com/netstorm/docs/NWS34EvapTables.pdf

Overall, the flow into the lake from direct precipitation is approximately 35" annually (Milwaukee mean precipitation figures). Drainage from the small Moose Lake drainage basin into Moose Lake is estimated at 12.2 acre-ft per inch of rainfall. See Table 3 in this report for more detail. A measurement of the groundwater flows into and out of Moose Lake is beyond the scope of this report, however, as noted earlier in this report there is a significant groundwater gradient and groundwater feed flowing east to west from Pine and North Lakes towards Okauchee Lake.

A sampling of historic water elevations of Moose Lake can be found in Table 1, following. The lowest recorded water elevation that has been documented from a reliable source is 879, which can be found on the 1959 USGS mapping. There is oral history from long time lake residents of other low water periods.

Table 1 - A Sampling of Historic Water Elevations of Moose Lake (See Appendix 9)

Lake Elevation	**Code**	**Date or Year**	**Subjective Elevation Measure-ments Lindl & Leidinger**	**Comments**
883.72		5/27/2019		Lake very high
883.64		5/1/2019		
883.62		4/24/2019		
883.55		4/19/2019		
883.82		3/3/2019		(ice elevation) – **Apparent record high water (as ice) elevation**
883.61		3/30/2019		
883.68		12/2/2018		
883.73		11/7/2018		
883.69		10/9/2018		
883.39		8/31/2018		
		2018	High	
883.58		8/1/2017		
		2017	High	
		2016	High	
		From 8/10/15	Low	
		Thru 7/21/15	Normal	
		From 7/15/14	Normal	
		From 7/1/14	High	
		Thru 6/30/14	Normal	
		2013	High	
		From 7/4/12	Low	
		Thru 6/17/12	Normal	
881.84		2012		From 2012 LIDAR survey/mapping – specific date within year unknown
		From 8/25/11	Normal	
		Thru 8/24/11	High	

>882.75		at least through 4/26/2011		Letter from Town of Merton to DNR 4/26/2011: "Moose Lake has been Slow No Wake since the floods of 2008."
>882.75		2010		Letter from Town of Merton to DNR 4/26/2011: "Moose Lake has been Slow No Wake since the floods of 2008."
		2010	High	
		7/10/2009	High	
>882.75		2009		Letter from Town of Merton to DNR 4/26/2011: "Moose Lake has been Slow No Wake since the floods of 2008."
		5/3/2009	High	
>882.75		Late June, 2008		Letter from Town of Merton to DNR 4/26/2011: "Moose Lake has been Slow No Wake since the floods of 2008."
		2008	High	
882.5		2/14/08		Ice elevation as noted on Certified Survey Map #10558
		8/31/07	High	
		Thru 7/22/07	Normal	
		8/3/06	Low	
		7/9/06	Normal	
		6/4/06	High	
		7/10/2005	Low	
		Thru 6/26/05	Normal	
		6/20/04	High	
		6/6/04	Normal	
		8/3/03	Low	
		From 8/11/02	Normal	
		6/10/02	High	
		Thru 5/26/02	Normal	
		2001	High	
		From 6/18/00	High	
		5/21/00	Normal	
		5/8/00	Low	

		From 8/14/99	Normal	
		Thru 7/25/99	High	
		From 8/16/98	Normal	
		Thru 7/26/98	High	
879		1959		From USGS map - **Possible record low water elevation**

Note: Proposed overflow elevation for Moose Lake is (no lower than) 882.42

Comparison of Moose and Okauchee Lake Drainage Basins

The drainage basin feeding Okauchee Lake is 80.70 sq. miles. The Moose Lake drainage basin is approximately 0.5 sq. miles (309 acres). The drainage basin of Moose Lake is 0.6% that of Okauchee Lake.

Environmental

Per Wisconsin DNR references, Moose Lake is an 83 acre oligotrophic lake. It is home to largemouth bass, northern pike and panfish. It has invasive species of Banded Mystery Snail, Freshwater Jellyfish, Zebra Mussel, Eurasian Water-Milfoil, Purple Loosestrife and Spiney Naiad.

The high water the last number of years has caused shore erosion to the point that a number of very large trees have fallen into the lake, reducing the soil erosion mitigation of the tree roots, and causing siltation of the lake.

The Moose Lake Advancement Association, in conjunction with the Town of Merton has established a "slow-no-wake" elevation ordinance of water elevation 882.75 ft. in which boats are not allowed to speed and cause a wake when the water elevation is at or above that level in order to mitigate the damaging effects of boat waves on shoreline erosion and piers. The slow no-wake lake elevation has been exceeded for almost 100% of the last three summers and at the beginning of spring of 2019. It appears the water elevation in the spring of 2019 will start about 10 inches above the slow no-wake elevation.

The possible all time high water (ice) recording was March 3, 2019 at 883.82 which is 1.4 ft (more than 16-3/4") above the proposed Moose Lake overflow elevation of (no lower than) 882.42.

The chronic high water causes property and environmental issues for Moose Lake and its owners. High water and associated wave action from wind continue to erode the shoreline of Moose Lake as demonstrated by the water eroding the soil from around the roots of large trees, causing them to fall in the water. Continued high water erosion leads to additional siltation of the lake.

Properties on the south and north end of the lake are flooded, causing damage to property and use issues which will require costly retaining wall repair or retaining wall construction, fill adjacent to the lake, and additional stone rip-rap along the shoreland. Boat houses and sheds are being damaged by the chronic high water and high ice elevations. This past winter is noted as a record high ice elevation by members of Carl Schurz Park and they never recall ice in the bath house as they saw this past winter. High water in late Fall 2018 has brought high water and significant ice formation behind various lakeshore retaining walls, causing retaining walls to shift and lean towards the lake. This is significant damage and a costly repair. Currently there is no known flooding of residential structures.

At Carl Schurz Park, the bath house and beach facility has been flooded for the last three years, requiring Carl Schurz Park to spend considerable sums of money to make adjustments related to the high water elevation. The high water has made the bath house dressing rooms unusable. This past winter the water was high for the first time in the winter, causing significant structural concerns for the bath house and beach structure due to ice.

The high water at the south end of Moose Lake is within 18 feet of the edge of pavement of County Highway C on a regular basis.

The National Weather Service has recently adjusted their rainfall-intensity charts for southeastern Wisconsin, indicating a likelihood of higher rainfall totals and more intense rainfall events, which are likely to exacerbate the flooding situation on Moose Lake because of the damming of its natural outflow. Chart 1 shows this increasing precipitation tendency over the last 119 years of an additional 10 inches of rainfall per year.

Photos

See photos in Appendix 4, showing high water and flooding issues on Moose Lake.

Economic Impact

Moose Lake is a recreational lake that is used for fishing, swimming, boating of all sorts and other water sports. The persistent multi-year high water situation on the lake has been perceived to have a negative economic impact by a few home sellers on the lake.

Because of the tight working conditions, from land for anything related to shoreline improvements or repair, any significant improvements or repairs that involve shoreline rip-rap, retaining walls or shoreline fill can easily cost in the tens of thousands of dollars per property owner. Shoreline improvements or repair utilizing marine contractors if necessary can typically be more costly. With continued water elevation increase, shoreline improvements may have to be done multiple times. Installation of the overflow drain is a permanent solution.

The high water is eroding the embankment along Highway C where Highway C is at its lowest elevation in the area of the former outlet stream of Moose Lake. There is concern that continued erosion of the embankment will affect the integrity of the road.

The proposed construction of a simple, controlled overflow drain for Moose Lake is much more cost-effective than each property owner doing their own work to accommodate chronic high-water conditions.

Transport of Water Between Moose and Okauchee Lake

This report proposes the movement of excess waters permanently between Moose and Okauchee Lakes as was occurring in 1836 and later. The waters of Moose Lake are cleaner (or the same) as the waters of Okauchee Lake with the exception of the Spiney Niad as noted below:

Table 2 – Invasive Species and Water Quality of Moose and Okauchee Lakes

Invasives	**Moose Lake**	**Okauchee Lake**
Banded Mystery Snail	Yes	Yes
Freshwater Jellyfish	Yes	Yes
Zebra Mussel	Yes	Yes
Eurasian Water-Milfoil	Yes	Yes
Hybrid Eurasian/Northern Water-Milfoil		
Purple Loosestrife	Yes	Yes
Spiney Naiad	Yes	No
Chinese Mystery Snail	No	Yes
Rusty Crayfish*	No	Yes
Curly-Leaf Pondweed*	No	Yes
Trophic State	Oligotrophic	Mesotrophic

* = not verified on Okauchee Lake
Data from: https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx

All of the lakes in the Oconomowoc River basin have mixed waters. Moose Lake was historically tributary to the Oconomowoc River/Okauchee Lake basin. Local lake waters are still known to be mixed by boats being transported and used between lakes. The addition of the DNR public boat launch has caused more mixing of waters to Moose Lake from other lakes via boats used on multiple lakes.

It is proposed the outlet from Moose Lake have a filter to eliminate issues of the Spiney Niad. It is also proposed to have a physical drop of a least a foot at the outlet structure discharging to Okauchee Lake so there is a vertical drop of water flow to insure there is no practical way for any Okauchee Lake invasive aquatic creatures to go upstream in the outlet pipe. An outlet grate is proposed to eliminate large mammals such as beaver or muskrat from using the pipe as a conduit between lakes.

Proposed Drainage Outlet from Moose Lake

The chronic high water issues of Moose Lake can be readily and permanently resolved by the restoration of a drainage outlet from Moose Lake along the relatively short path and low (filled in) ground area where the original small stream flowed between Moose and Okauchee Lakes in 1836.

Downstream Impact

Restoration of the drainage outlet from Moose Lake would mean excess waters from Moose Lake would (occasionally) directly flow from surface waters (as opposed to just groundwater flow) to Okauchee Lake, and proposed to be designed for a controlled volume of flow, so as to not adversely impact the receiving waters of Okauchee Lake and further downstream.

It is understood that flows added to the Okauchee Lake/Oconomowoc River drainage basin cannot impact the elevation of those receiving waters by more than 0.01 ft. Because of the large size differences between Moose Lake and Okauchee lake, the drainage of one inch depth of excess waters of Moose Lake would impact the Okauchee Lake/Oconomowoc River receiving waters by approximately 0.006 ft. vertically, well within the 0.01 ft. limit.

Okauchee Lake is 1,210 acres. Assuming a maximum receiving volume of 0.01 ft. vertical to the 1,210 acres of Okauchee Lake per day equals 12.1 acre-ft per day of volume. This converts to a potential inflow of 6.1 cu ft/sec. from Moose Lake with a very limited impact, approximately 1/8th inch vertical on Okauchee Lake.

A more conservative overflow volume from Moose Lake would be half of the above value or 6 acre-ft per day, and that volume is utilized in further analysis in this report. If detailed analysis of the hydraulics of the Okauchee Lake/Oconomowoc River receiving waters concluded the receiving volume of only half of the above, or 0.005 ft. vertical to the 1,210 acres of Okauchee Lake in a day, this would be a potential inflow of only 6 acre-ft per day, or 3 cu ft./sec. from Moose Lake with a negligible impact of 1/16th inch vertical rise on Okauchee Lake, or *the thickness of a penny.*

An analysis was made of the Moose Lake Drainage Basin utilizing one-foot contour interval mapping, and the direct runoff drainage basin flowing to Moose Lake is 309 acres. This is less than the 553 acres found in a 1997 sediment study report. The 309 acre calculation is believed to be more accurate.

For the 309 acre drainage basin, the runoff coefficient utilized for precipitation volume finding its way to Moose lake is as noted below and the volume runoff to Moose Lake per 1-inch of precipitation is calculated as follows. (Ignores groundwater flow and evaporation).

Table 3 – Calculation of Rainfall Runoff for Moose Lake Drainage basin

Land Type	**Acres**	**Runoff Coefficient**	**1-inch Rainfall Vol Flow to Moose Lake (in acre-ft)**
Lake	83	1.0	6.9
Housing and farmland	226	0.28	5.3
Total	**309**		**12.2**

Table 4 - Discharge Times of Excess Water From Moose Lake If Okauchee Lake Receiving Volume Is 6 Acre-Ft Per Day

Rainfall	**Volume Drainage to Moose Lake (in acre-ft)**	**Expected Lake Rise (inches)**	**Drainage Time (days) @ 6 acre-ft per day**	**Comments**
0”	0.0	0.0	0.0	
1 “	12.2	1.77	2.0	
2”	24.4	3.54	4.1	
3”	36.6	5.31	6.1	
4”	48.8	7.08	8.1	
5”	61.0	8.85	10.2	
6”	**73.2**	10.62	12.2	**Approximate 100 yr 24 hr frequency rainfall**, or 10 yr 7-day frequency rainfall
7”	85.4	12.39	14.2	

Hydraulics

A *detailed* analysis of the hydraulics of the relatively small flow from Moose Lake is beyond the scope of this report, however it is understood that flows added to the Okauchee Lake/Oconomowoc River drainage basin cannot impact the elevation of those receiving waters by more than 0.01 ft. Because of the large size differences between Moose Lake

and Okauchee lake, the drainage of one inch depth of water of Moose Lake drainage basin would impact the Okauchee Lake/Oconomowoc River receiving waters by approximately 0.006 ft. vertically, well within the 0.01 ft. limit.

It is *very feasible to design a limiting overflow structure on Moose Lake* that would do two important things:

1. Limit the elevation of Moose Lake at which water would flow out of the lake, similar to a bath tub overflow drain set at a specific elevation in the tub. Proposed at no lower than 882.42.
2. Limit the rate of flow out of Moose Lake so that the effect on the downstream receiving waters of the Okauchee/Oconomowoc River basin are not impacted more than 0.01 ft. (or alternatively 0.005 ft.) vertically.

With a properly designed overflow structure on Moose Lake, Moose Lake can act as a detention basin and hold rainwater flow during large rainfall events, and slowly bleed off the *excess* precipitation *at a controlled rate* to the Okauchee/Oconomowoc River basin, without detrimental downstream effects. See Table 4 for the number of days of detention of excess waters on Moose Lake, for the noted design parameters.

A 12-inch pipe, 255 ft in length and 150 ft of shallow ditch starting at the west shore of Moose Lake and extending to the east shore of Okauchee Lake would accommodate the discharge of one inch of rainfall in Moose Lake drainage basin in two days at 6 acre-ft per day.

A map showing the proposed location of the pipe and ditch is shown in Exhibit 1. An easement would be necessary however the construction would be relatively shallow and would not be close to any residences.

The Okauchee Lake/Oconomowoc River has an available hydraulic model that could be utilized to further analyze the effect of a “small controlled bleed” of excess water from Moose Lake to Okauchee Lake, so as not to disrupt any of the Okauchee Lake nor Oconomowoc River basins.

There are three potential ways suggested to consider for practical construction of an outlet pipe (“overflow drain”) for Moose Lake:

1. Construct between 255 – 405 ft. of shallow open cut 8”, 10” or 12” pipe and 0 - 150 ft. of shallow ditch to be constructed in the natural low area between the lakes, where the original outlet stream flowed from Moose to Okauchee Lakes.
2. Same as No 1, except use shallow depth horizontal directional pipe boring construction for 405 ft.

3. Use deep depth horizontal directional pipe boring construction for 275 ft. in the narrow isthmus between Moose and Okauchee Lakes.

The above construction requires an easement.

Exhibit 1 - Topographic Plan View of Proposed Pipe from Moose Lake to Okauchee Lake

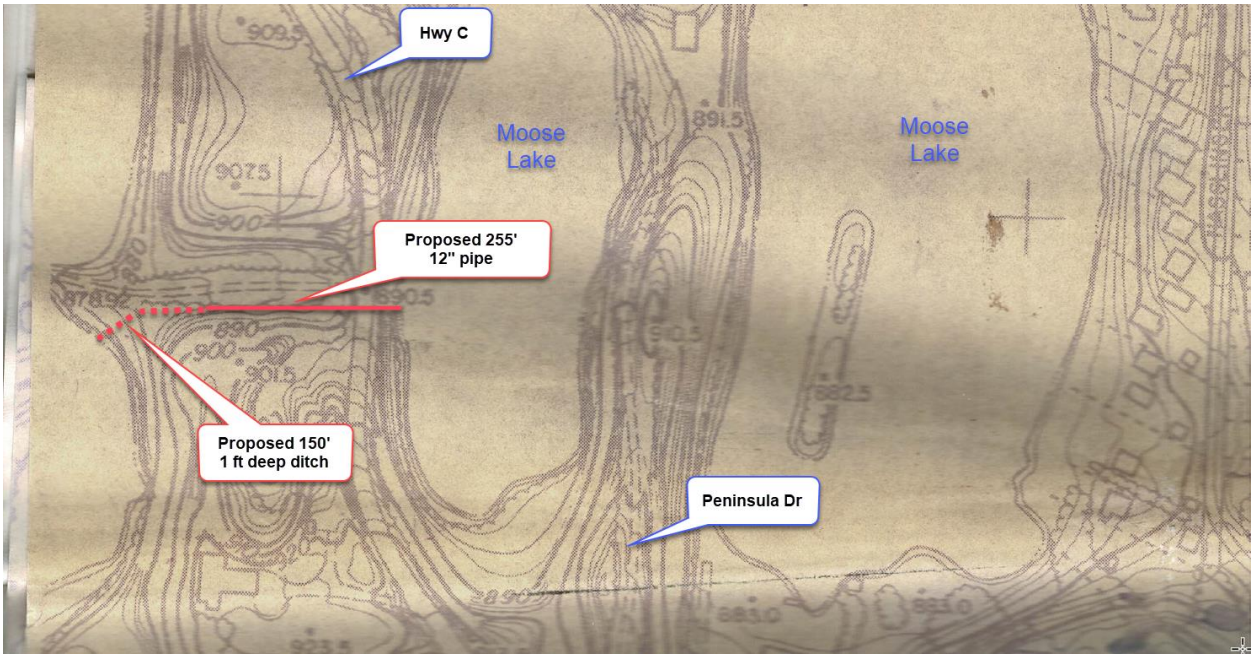


Exhibit 2 - Profile of Proposed Outlet Pipe From Moose to Okauchee Lake

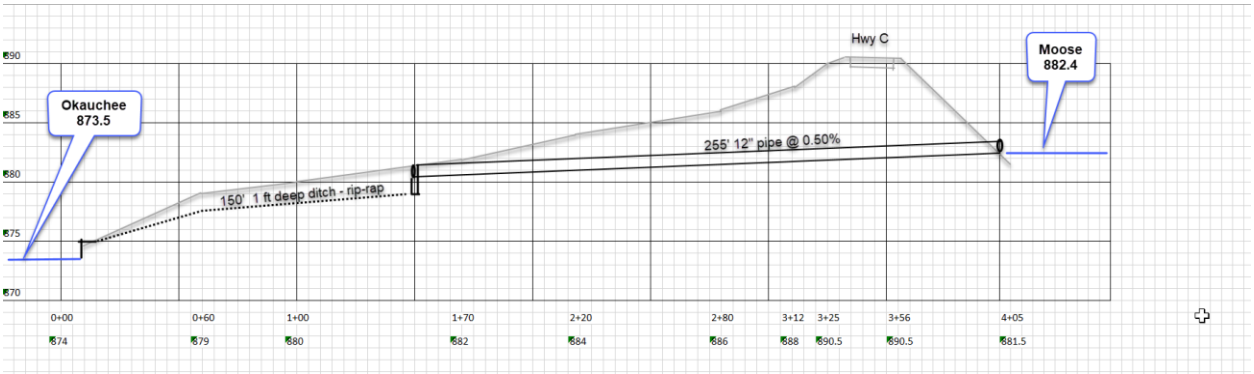
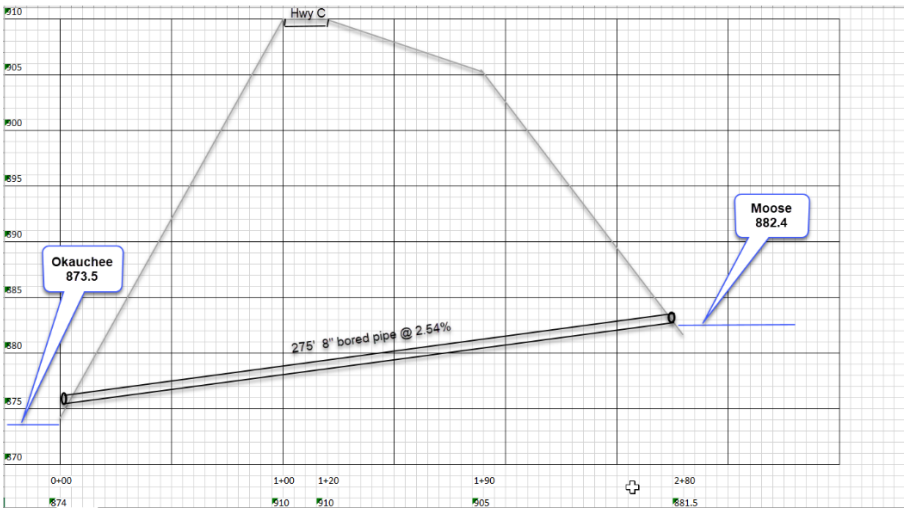


Exhibit 3 – Generic Profile of Proposed Outlet Pipe From Moose to Okauchee Lake Utilizing Deep Horizontal Directional Boring at Narrow Isthmus



Estimated Costs

The estimated cost to construct the pipe and ditch from Moose Lake to Okauchee Lake in the low area where the original outlet stream flowed between the lakes is $40,000 based on bid prices for the Waukesha County airport drainage project in 2018. This does not include the cost of engineering for the project nor the cost for an easement. It is anticipated that an additional $40,000 would cover those costs, for a total project cost of $80,000.

If it were determined that boring a pipe in the isthmus between Moose and Okauchee Lakes is the most feasible alternative, then the estimated cost to construct an 8" pipe via boring from Moose Lake to Okauchee lake for 275 feet is $50,000 based on discussion with a pipe boring contractor familiar with the area's soil conditions and length and depth of boring, as well as the potentially tight working constraints that may require marine mobilization of boring equipment during construction. This does not include the cost of engineering for the project nor the cost for an easement. It is anticipated that an additional $40,000 would cover those costs, for a total project cost of $90,000.

Implementation

This report is the result of the vote by the Moose Lake Advancement Association membership on September 26, 2018, in which the Board was directed by its membership to "focus their energies on finding a solution to high water issues on Moose Lake."

The Moose Lake Advancement Association Board approved this report on June 5, 2019.

This report is being circulated to Waukesha County, as primary recipient, because of their ownership of County Highway C, which is acting as a dam (without an overflow structure) from Moose Lake. Other entities being copied on this report are the Town of Merton, the Wisconsin Department of Natural Resources and the Southeastern Wisconsin Regional Planning Commission and Okauchee Lake Management District.

It is the request of the Moose Lake Advancement Association board, that the Waukesha County Department of Public Works initiate engineering in 2019 and do construction in early 2020 to restore a controlled outlet to Moose Lake, in order to mitigate chronic high water issues on Moose Lake.

Appendix 1

Interpretation by Southeastern Wisconsin Regional Plan Commission (SEWRPC) staff of stream outlet from Moose Lake as found in original 1837 U.S. Public Land Survey

Email from Thomas Slawski, SEWRPC:

From: **Slawski, Thomas M.** <TSlawski@sewrpc.org>
Date: Thu, Aug 23, 2018 at 9:26 AM
Subject: RE: Chloride sampling help request
To: MLAA-Greg OHearn <mooselakewis@gmail.com>
Cc: Buser, Dale J <dbuser@sewrpc.org>

Hello Greg,

Sorry I did not get back to you earlier on your question of a historical connection on Moose Lake. Yes indeed, I agree that this is very convincing evidence that there used to be an outlet connection to the Oconomowoc River. In fact, we checked the original survey meander notes (see attached). These notes clearly identify an outlet for Lake#5 (Moose Lake) and it indicates it was 4 links wide. This translates to a 32 inch wide stream outlet channel, but there was no mention of water depth. It seems that Okauchee Lake grew (presumably due to an outlet dam) as did Moose Lake. So, the original outlet is either under water or obliterated by road fill. The forerunner of CTH C was already present in 1857, so the fill was placed earlier than 1857.

So, I think that it would be important to share this new information with WDNR staff and begin discussions for potentially re-establishing an outlet on Moose Lake.

Sincerely,

Tom

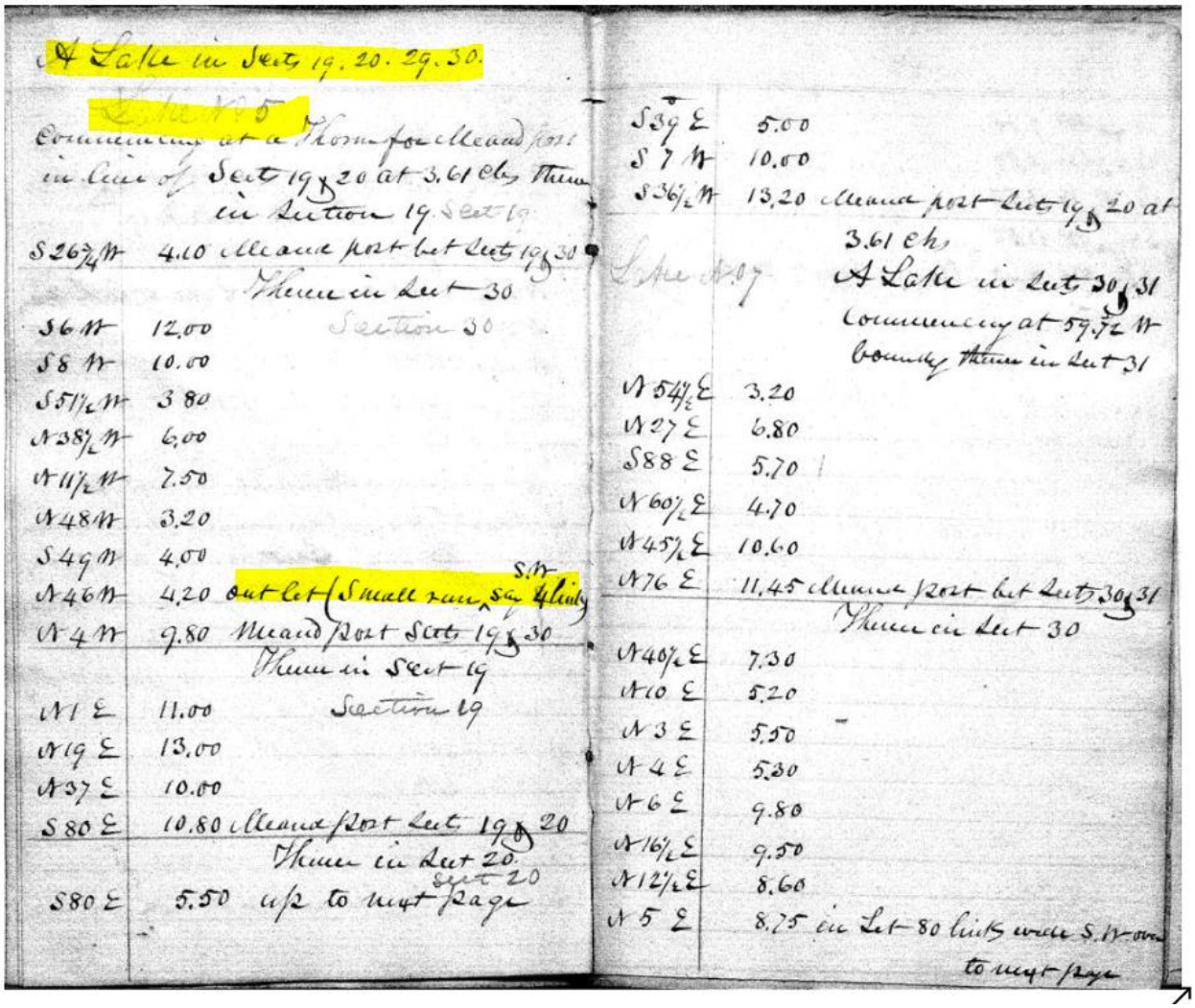
Southeastern Wisconsin Regional Planning Commission
SEWRPC

Thomas Slawski | PhD, Chief Biologist

tslawski@sewrpc.org | 262.953.3263

sewrpc.org/news

Original U.S. Public Land Survey Meander Notes for Sections, 19, 20, 29, 30 – Lake No 5 (Moose Lake)



A Lake in Sects 19. 20. 29. 30.

Lake No 5

Commencing at a Thorn post Meand for: in Line of Sect 19 & 20 at 3.61 chs Thence in Section 19 Sect 19

S 26¾ W 4.10 Meand post Set Sect 19 & 30

Thence in Set 30 Section 30

S 6 W 12.00
S 8 W 10.00
S 51½ W 3.80
N 38½ W 6.00
N 11½ W 7.50
N 48 W 3.20
S 49 W 4.00
N 46 W 4.20 out Set (Small run S.W. 4 links)
N 4 W 9.80 Meand Post Sect 19 & 30

Thence in Sect 19 Section 19

N 1 E 11.00
N 19 E 13.00
N 37 E 10.00
S 80 E 10.80 Meand Post Sect 19 & 20

Thence in Sect 20. Sect 20

S 80 E 5.50 c/s to next page

S 39 E 5.00
S 7 W 10.00
S 36½ W 13.20 Meand post Sect 19 & 20 at 3.61 chs

Lake No 7 A Lake in Sects 30 & 31 Commencing at 59½ W bounds Thence in Sect 31

N 54½ E 3.20
N 27 E 6.80
S 88 E 5.70
N 60½ E 4.70
N 45½ E 10.60
N 76 E 11.45 Meand Post Set Sect 30 & 31

Thence in Sect 30

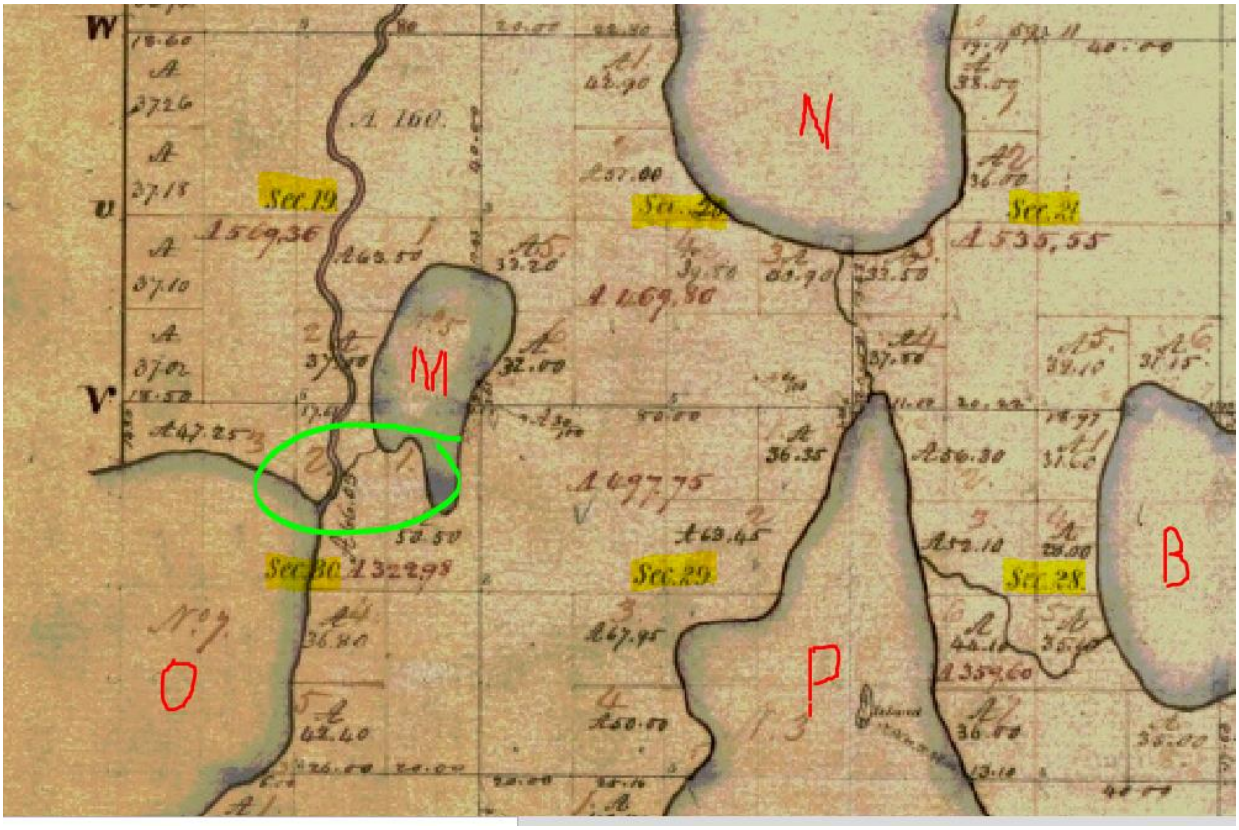
N 40½ E 7.30
N 10 E 5.20
N 3 E 5.50
N 4 E 5.30
N 6 E 9.80
N 16½ E 9.50
N 12½ E 8.60
N 5 E 8.75 in Set 80 links west S.W. cor to next page

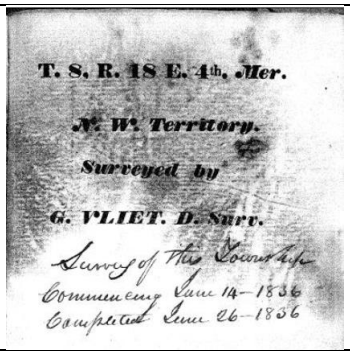
Source of notes: Board of Commissioners of the Public Lands
Link: http://digicoll.library.wisc.edu/cgi-bin/SurveyNotes/SurveyNotes-idx?type=turn&issueid=SurveyNotes.INT170E03&entity=SurveyNotesINT170E000117&isize=M&twp=T008NR018E

U.S. Public Land Survey map of 1837 showing connection between Lake No. 5 (Moose Lake) and Lake No. 7 (Okauchee Lake)

(Part of) Town of Merton: Township 8 North, Range 18 East.

Note Section 30 drainage from Lake #5





Within a Township, sections are numbered like this:

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

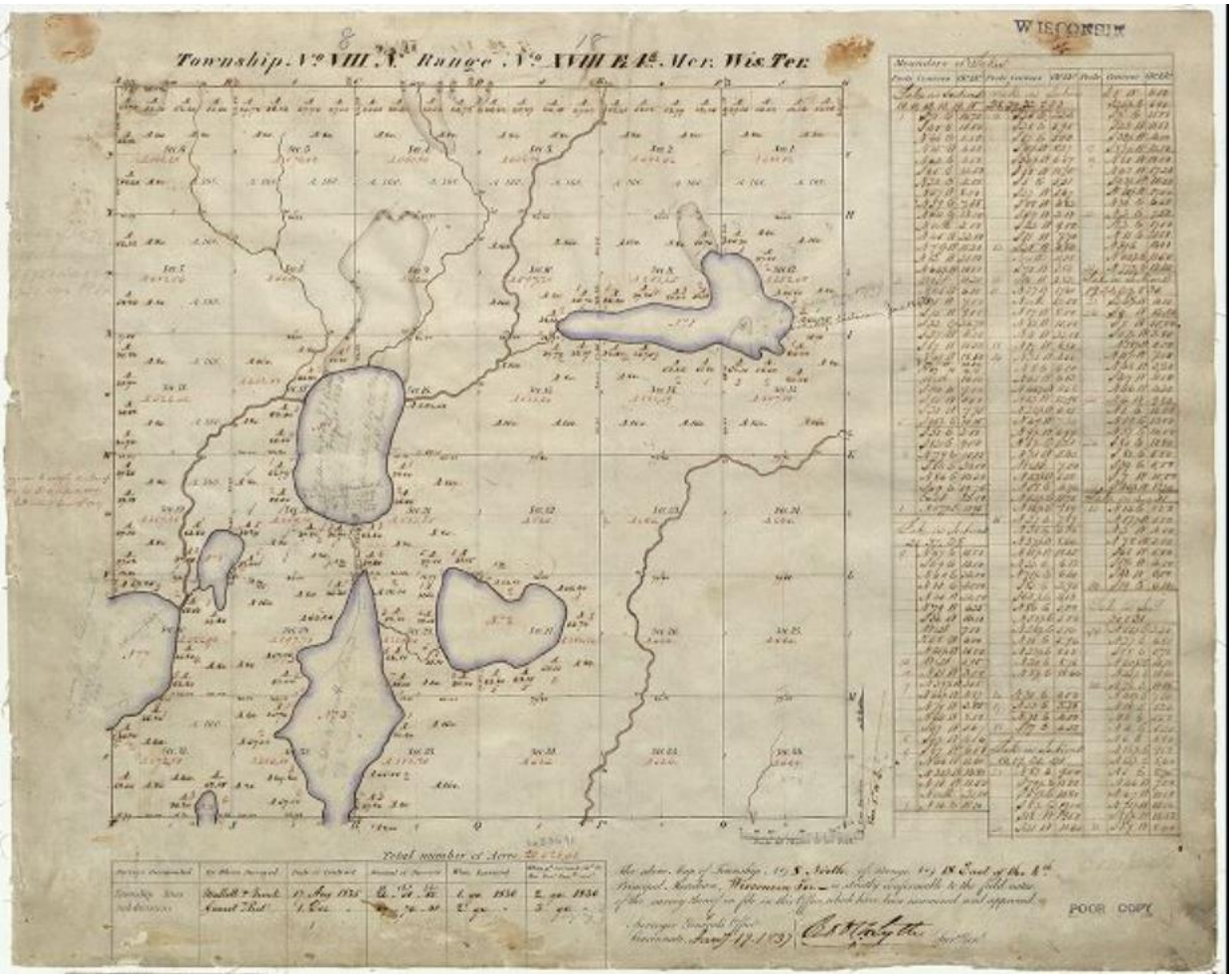
Index indicates approved/accepted Jan 19, 1837

Source: http://digicoll.library.wisc.edu/SurveyNotes/Search.html

Original U.S. Public Land Survey Map: January 19, 1837 – Town of Merton

Source Links:
https://glorecords.blm.gov/details/survey/default.aspx?dm_id=101619&sid=t0tpx3eu.jsg#surveyDetailsTabIndex=1 and

http://images.library.wisc.edu/awareImageServer/SurveyNotesImageNav.jsp?collection=SurveyNotes&resource=PlatMaps/TN08/reference/000818EA.jp2&title=Plat+Map+for+T8N+R18E%20%28original%29



Appendix 2

Generalized Summary of State Common-Law
as
It Relates to Drainage

Excerpted From the U.S. Department of Transportation
Urban Drainage Design Manual

Excerpts from https://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf follow. The following is verbatim from the noted source with the exception of the red text highlights.

“2.5.2 State Regulations[10]

In addition to the above mentioned federal laws, the design of storm drainage systems must also comply with state laws and regulations. State drainage law is derived from both common and statutory law. A summary of applicable state drainage laws originating from common law, or court-made law, and statutory law follow. It is noted that this is a generalized summary of common state drainage law. Drainage engineers should become familiar with the application of these legal principles in their states.

The Civil Law Rule of Natural Drainage is based upon the perpetuation of natural drainage. A frequently quoted statement of this law is:

> "... every landowner must bear the burden of receiving upon his land the surface water naturally falling upon land above it and naturally flowing to it therefrom, and he has the corresponding right to have the surface water naturally falling upon his land or naturally coming upon it, flow freely therefrom upon the lower land adjoining, as it would flow under natural conditions. From these rights and burdens, the principle follows that he has a lawful right to complain of others, who, by interfering with natural conditions, cause such surface water to be discharged in greater quantity or in a different manner upon his land, than would occur under natural conditions....." *(Heier v. Krull. 160 Cal 441 (1911))*

This rule is inherently strict, and as a result has been modified to some degree in many states.

Stream Water Rules are founded on a common law maxim which states "water runs and ought to run as it is by natural law accustomed to run." Thus, as a general rule, any interference with the flow of a natural watercourse to the damage of another will result in liability. Surface waters from highways are often discharged into the most convenient watercourse. The right is unquestioned if those waters were naturally tributary to the watercourse and unchallenged if the watercourse has adequate capacity. However, if all or part of the surface waters have been diverted from another watershed to a small watercourse, any lower owner may complain and recover for ensuing damage

Appendix 3

Letter From John Tauscher Regarding Moose Lake Water Flowing Over Hwy C

To: Greg O'Hearn, MLAA President May 31, 2019

From: John Tauscher

RE: High water levels on Moose Lake

My grandmother purchased a summer cottage on Moose Lake in 1956…I was 7 years old. The address was 4330 Hasslinger Drive. The property was in our family until 1992.

At that time, most of the lake front properties were summer cottages. The water level fluctuated year to year. However, I could always swim to the little island in the south bay and walk up the dry shore of the island and sit on the concrete edging that surrounds the island. That concrete apron is still there but it is currently under at least 12 inches of water. Another favorite swimming spot was the "stone pier" at the north end of the peninsula.

There were a few years in the early 60's when the water level on Moose Lake was above average. At that time, after a hard rain, the lake water from Moose Lake would be over highway C. It appeared to be flowing to the West. I remember this because dad would slow down to drive through the water.

I have attached an aerial photograph that I found in the UW school of Geography archives. This photo was taken in the 1930's…UW can verify the date. One can plainly see Moose Lake and Highway "C". The resolution is very good and the photo can be magnified. There is an obvious road going from Highway "C" to Okauchee Lake near the south end of Moose Lake. If you look closely on the north side of that road, you can see a little stream or clearing that the water would take after it crossed the road to flow West. This outlet might be the reason why we never had serious high water issues on Moose lake in the past.

Today, the roadbed of Highway "C" is much higher that it was 60 years ago. The low spot that would fill with lake water was raised. Also, the road has been repaved many times. The elevated road and our increase in annual rainfall could be why Moose Lake is now at a record high level that is causing property damage.

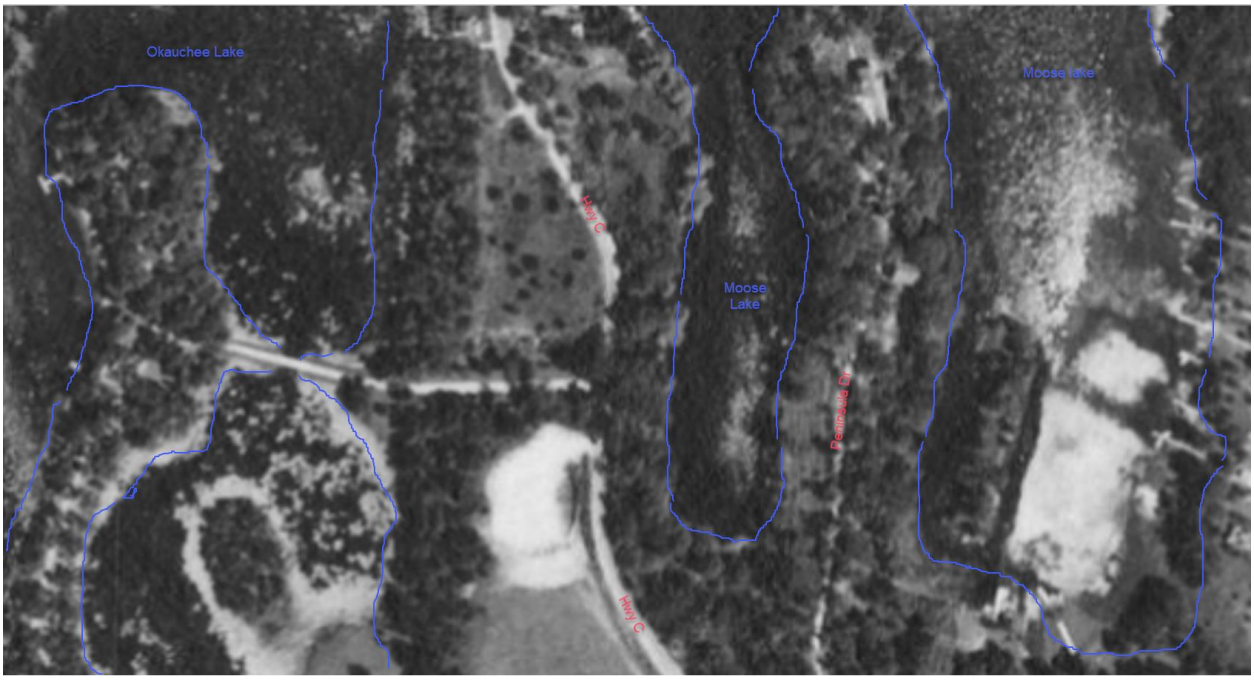
John Tauscher, Representing Carl Schurz Memorial Park

Associated photo referenced by John Tauscher is from US Department of Agriculture aerial photography, dated 8/4/1937, (Roll 19, Exposure 1702) available from the Arthur H. Robinson Map Library at the University of Wisconsin – Madison. Link to map viewer: https://maps.sco.wisc.edu/WHAIFinder/#15/43.1290/-88.3809

A portion of that 1937 aerial photo image is shown below:

US Department of Agriculture aerial photography, dated 8/4/1937, (Roll 18, Exposure 1687) available from the Arthur H. Robinson Map Library at the University of Wisconsin – Madison. Link to map viewer:
https://maps.sco.wisc.edu/WHAIFinder/#15/43.1290/-88.3809

A portion of that 1937 aerial photo image (with additional annotation) is shown below:



Appendix 4

Photos Showing High Water
and
Flooding Issues on Moose Lake

"Permanent" *Temporary* (3+ years) Emergency High Water sign
posted at Moose Lake boat launch
by the Town of Merton

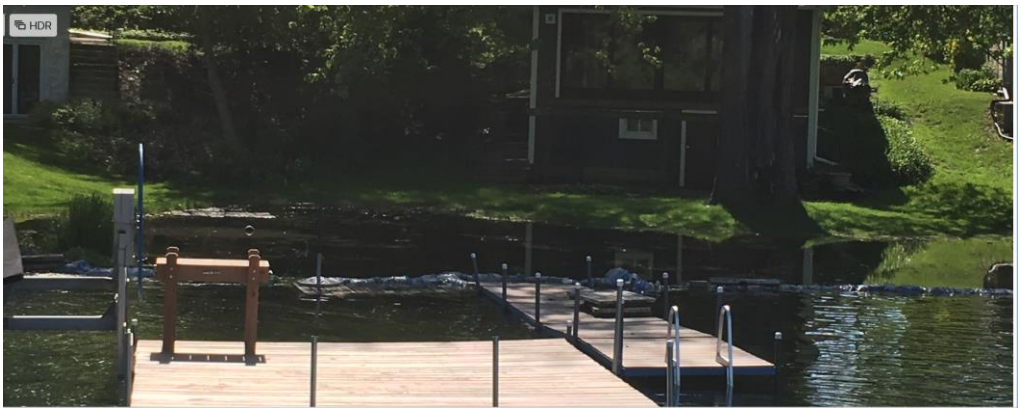
Note many of the photos shown here are not just of occasional flooding,
but a *chronic situation by and large for 3 plus continuous years on Moose Lake.*

Flooding Carl Schurz Park swim platforms and changing rooms west shoreline – September 10, 2018

Flooding Carl Schurz Park swim platforms and changing rooms west shoreline – September 10, 2018

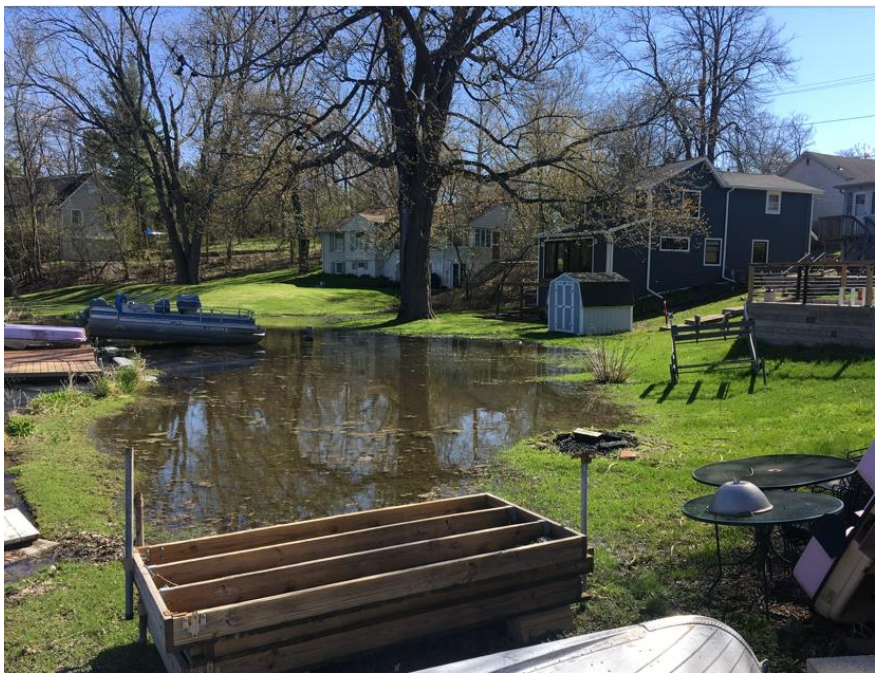
Top: Flooding Carl Schurz Park swim platforms and changing rooms west shoreline – April 22, **2019** (Plus it rained 1.5" a day after this photo was taken)
Bottom: Carl Schurz Park swim platform May 28, **1999** with water elevation about 12" below concrete platform.

May 25, 2019 photo - Flooding close to Hwy C



May 25, 2019 photo – Property flooding near house. Property owner attempted sand bagging.

May 10, 2019 photo – Flooding east shore of peninsula. Shore rip-rap under water.



April 26, 2019 photo – Flooded yards southwest shore.

April 26, 2019 photo – Flooded shoreline southwest shore.

Pier and yard flooding north shoreline – October 8, 2018

Tolbolski **2008** photo – pier and yard flooding southwest shoreline

Tolbolski November 11, 2018 photo - pier and yard flooding southwest shoreline. "I "I measured the depth of water today. It is **21 inches higher than it was in 1975**." - Sharon Tolbolski November 11, 2018

Tolbolski November 11, 2018 photo – neighbor boathouse surrounded by water – southwest shoreline

May 10, 2019 photo – boathouse surrounded by water – southwest shoreline

Trees standing in water east shore – north - August 30, 2018

Flooded boat-launch southeast bay – October 31, 2018
Note concrete walkway under water leading to (removed) floating launch pier.

Flooded boat-launch southeast bay – April 24, **2019**
Note concrete walkway under water leading to floating launch pier.

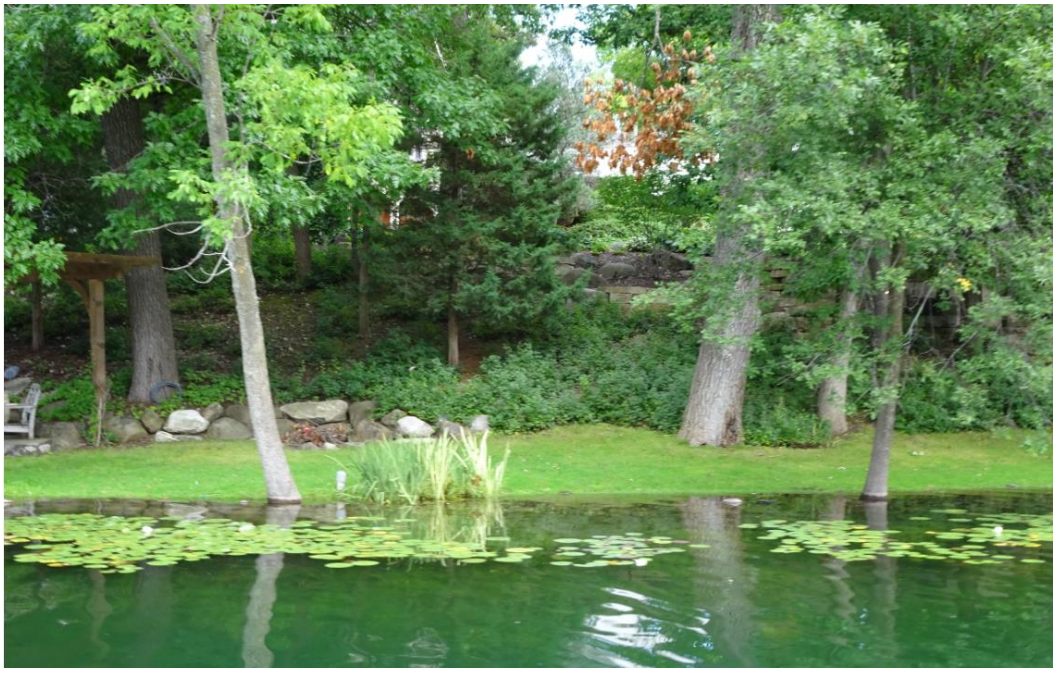
High water northeast shoreline – August 30, 2018
Note erosion control stone rip-rap no longer effective height as to wave action.

Flooded island southeast bay – August 30, 2018

Yard and shed flooding north shore of Moose Lake November 6, 2018

Trees falling in water – west shoreline – August 30, 2018

Flooded pier and shoreline southwest shoreline – August 30, 2018

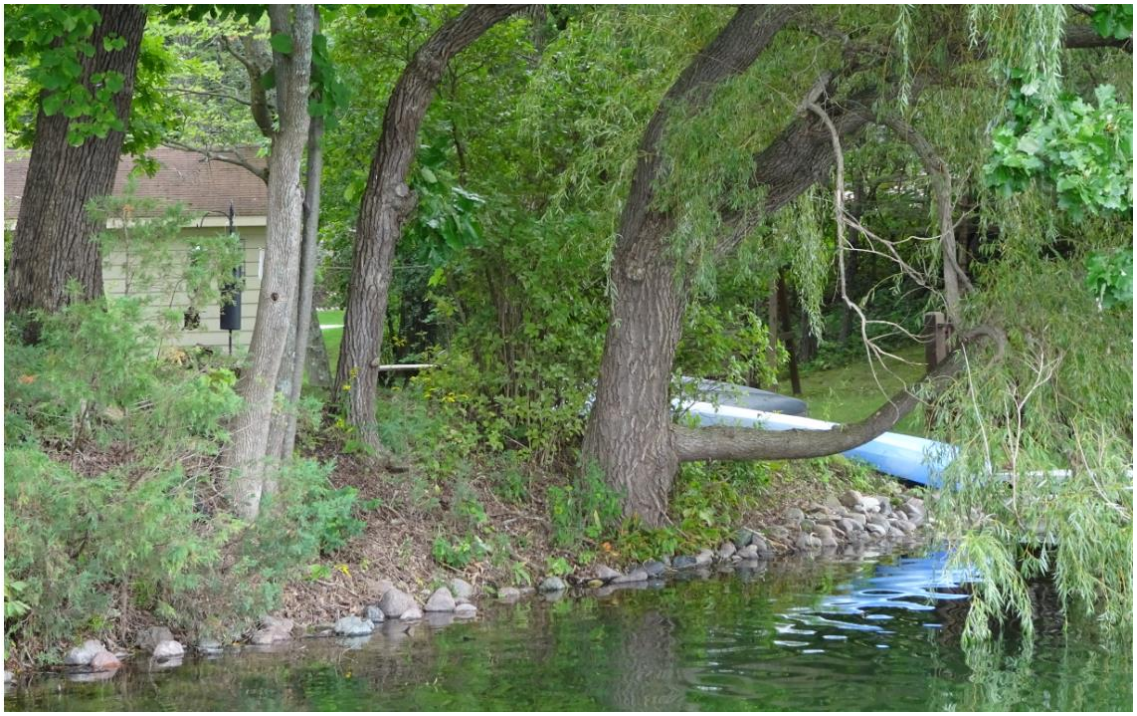


Yard flooding southwest bay, west shore of peninsula – August 30, 2018
Note aquatic plants that have taken hold in what is normally lawn.

Trees in water and flooded yard southwest bay, west side peninsula – August 30, 2018

Flooded yard southwest bay, west side peninsula – August 30, 2018

High water southeast bay, east side peninsula – August 30, 2018
Note erosion control stone rip-rap no longer effective height as to wave action.

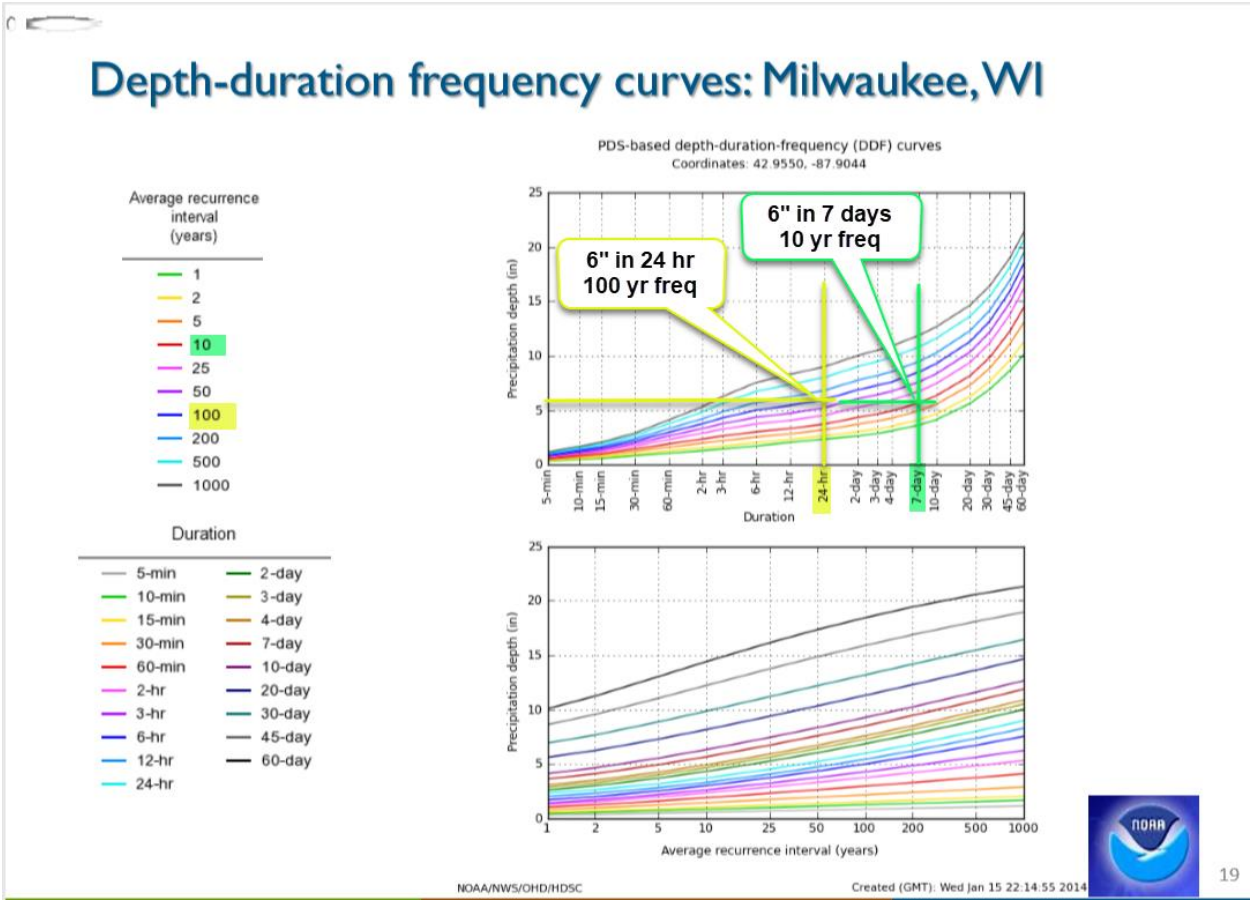


High water east shoreline – August 30, 2018
Note erosion control stone rip-rap no longer effective height as to wave action.

Flooded pier and shoreline southwest bay – April 19, **2019**

Appendix 5

Rainfall Depth-Duration Frequency Curves for Milwaukee, Wisconsin

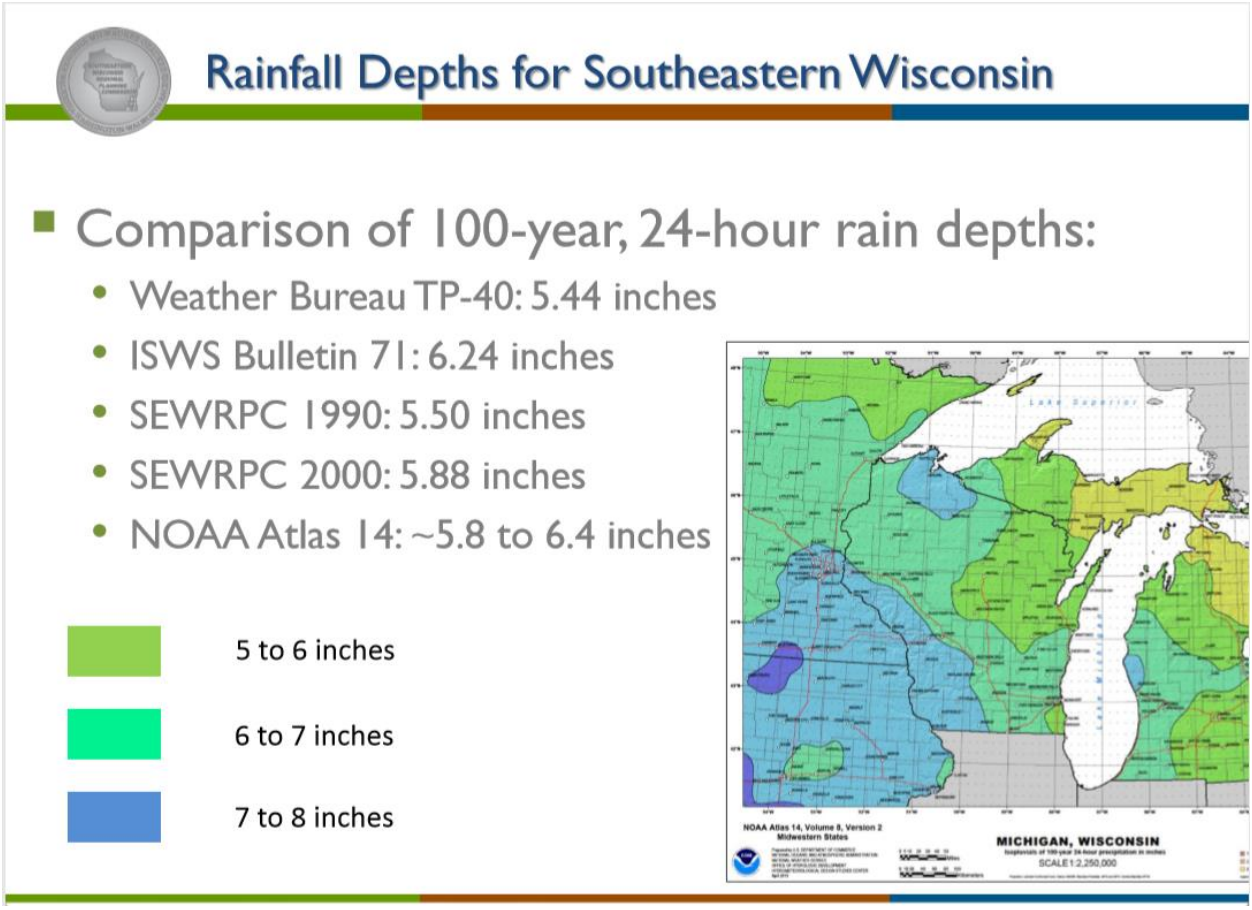


Excerpt from: http://www.sewrpc.org/SEWRPCFiles/Environment/Rainfall/NOAA-atlas14-sewrpc-nrcs-presentation.pdf

The above curves indicate that approximately 6" of rainfall can be expected to fall on the Moose Lake drainage basin in a 24-hour period, once every 100 years on average. Furthermore, 6" of rainfall can be expected to fall on the Moose Lake drainage basin in a *7-day period*, once every 10 years on average.

Appendix 6

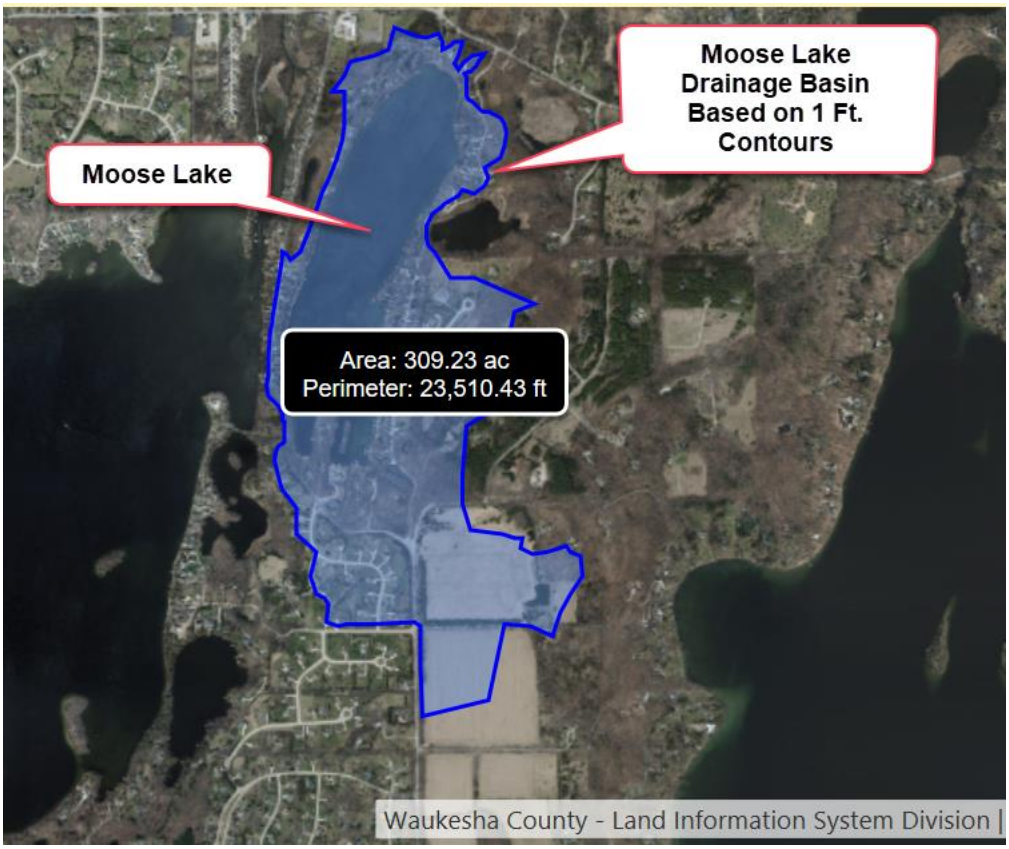
Rainfall Depths for Southeastern Wisconsin
for
100 Year 24-hour Frequency Rain Event



Excerpt from: http://www.sewrpc.org/SEWRPCFiles/Environment/Rainfall/NOAA-atlas14-sewrpc-nrcs-presentation.pdf

Appendix 7

Moose Lake Drainage Basin – Based on One Foot Contour Interval Mapping



Appendix 8

Documentation of Boat Launch
Elevation Benchmark on Moose Lake

Offices in Kenosha & Waukesha, Wisconsin.
surveyor@execpc.com

BENCHMARK
LAND SURVEY TECHNOLOGY
Full Land Surveying Services
N80W28352 Keesus Rd. Hartland, WI 53029
(262) 658-1686 e-fax (866) 262-0621

>Architectural Surveys
>Topographic Maps
>Official Surveys
>Land Divisions
>Land Planning
>City Properties
>County Properties
>Construction Staking

Prepared for: Moose Lake Advancement Association
Joe Mattano
W332N6288 Cr C
Nashotah, WI 53058

To whom this may concern

On August 1, 2016, I personally measured the existing "Benchmark" on Tax Key parcel number MRTT0405948 presently owned by the State of Wisconsin. This "Benchmark is a chiseled square on the NE corner of the bulkhead for the pier.

August 1, 2016 measured 883.37 USGS datum
On this day the water elevation measured 882.69 USGS datum

It is my understanding that Moose Lake has a "NO WAKE" when the water elevation is at 882.75 USGS datum or higher by local ordinance.

CONCLUSION:
The above described "Benchmark" present measured elevation = 883.37
Present "No Wake" ordinance = 882.75 or higher
Measuring from the "Benchmark" down/lower to the "No Wake Elevation"= 0.62 feet (7 7/16") or less.

USGS-Benchmark Used;
Located west of the Stone Bank Presbyterian Cemetery
The East ¼ corner of Section 19, Town 8 North, Range 18 East
Concrete monument with SEWRPC brass cap
420,457.21(N) 2,426,802.63(E) Elevation 913.984 USGS datum

August 1, 2016
Dated

Michael R. Kotlarek,
Professional Land Surveyor WI # S-1677

Appendix 9

Data Collection of Moose Lake Water Elevations

Table 1 – "A Sampling of Historic Water Elevations of Moose Lake" is excerpted primarily from measurements made by Mike Popp and Greg O'Hearn between June 30, 2016 and April 24, 2019. The sampling density is greater than reported in this table. The elevations noted are representative.

The Comments column in that table provides notes to the origin of other recorded elevation data on Moose Lake.

The table "Code" column is color coded as follows:

- Red – 882.75 or greater, or subjective "High"
- Green subjective "Normal"
- Yellow subjective "Low"

The table column noted as "Subjective Elevation Measurements Lindl & Leidinger," is the subjective recordings of normal/high/low water readings by Yvonne Lindl and her husband between 2011 and 2018. Similarly, subjective recordings of normal/high/low water readings by Connie or Al Leidenger were done between 1998 and 2010.

Email from Yvonne Lindl documenting the history of subjective readings of normal/high/low water on Moose lake between 1998 and 2018:

From: Yvonne Lindl
Sent: Monday, May 6, 2019 8:15 AM
To: Greg OHearn
Cc: CHARLES HARKINS; Susan Laabs; Kyle Strigenz; Glenda; Nick Rakich; dave hartleip; Gery Sawall
Subject: Historic water levels - table on page 17

Greg,
Since 2011, my husband and I have done the clarity levels for the lake and, as part of that reporting, we assess the level of the water. We don't actually measure the lake level, but do report whether the water level is high, normal or low. We've reported high levels if the no-wake restrictions are in effect (>882.75). We report normal if it is below that level, and report low if it seems low based upon the level on our steps to our pier - definitely subjective, but it does give an idea as to the water levels in recent years and it may help to add this reported data to your table on page 17 to help fill in the gaps. We've reported the following:

- 2018 - high water all summer
- 2017 - high water all summer

- 2016 - high water all summer
- 2015 - normal level through 7/21/2015; low level from 8/10/2015 through the end of summer
- 2014 - normal level through 6/30/2014; high level from 7/1/2014 through 7/14/2014; normal level for the rest of the summer
- 2013 - high water all summer
- 2012 - normal level through 6/17/2012; low level from 7/4/2012 through the rest of the summer
- 2011 - high water through 8/24/2011; normal level from 8/25/2011 through the rest of summer

Prior to 2011, the readings were done by Connie or Al Leidinger. I do have their reports dating back to 1998 so we can also add this data. Certainly their subjective assessments may be different than what we would make, but again, they do provide some reported data. Also, prior to 2008, we did not have the no-wake restrictions as a reference point for high water, so that assessment was also subjective. The following levels were reported to the DNR:

- 2010 - high water all summer
- 2009 - only two readings were done (5/3 & 7/10) but both reported high water
- 2008 - high water all summer
- 2007 - normal water through 7/22/2007; high water as of 8/31/2007
- 2006 - high water as of 6/4/2006; normal level as of 7/9/2006; low level as of 8/3/2006
- 2005 - normal level through 6/26/2005; low level as of 7/10/2005
- 2004 - normal level as of 6/6/2004; high water as of 6/20/2004
- 2003 - only 1 reading was taken (8/3/2003) when the water level was low
- 2002 - normal water level through 5/26/2002; high water level as of 6/10/2002; normal water level as of 8/11/2002 through the end of summer
- 2001 - water level high all summer
- 2000 - water level low as of 5/8/2000; normal as of 5/21/2000; high as of 6/18/2000 through the end of summer
- 1999 - water level high through 7/25/1999; normal from 8/14/1999 through the end of summer
- 1998 - water level high through 7/26/1998; normal from 8/16/1998 through the end of summer

Again, this data is subjective but at least it provides some history as to the fluctuations in the water levels during the past 20 years.

Yvonne

Notes and References:

1. Moose Lake Advancement Association set a local elevation benchmark at the Moose Lake boat launch at 883.37 (mean sea level). This benchmark was set by Benchmark Land Survey on August 1, 2016.

2. The slow-no-wake elevation on Moose Lake is 882.75 set by the Merton Town Board on April 26, 2011. (This elevation is 7-7/16th" below the benchmark set at the boat launch).

3. Moose Lake surface area is 83 acres per the DNR web site. Okauchee Lake is 1,210 acres per that same web site. https://dnr.wi.gov/lakes/findalake/

4. The mean annual precipitation for Milwaukee is 34.8" for 1981-2010, from NOAA reporting found here: http://www.aos.wisc.edu/~sco/clim-history/sta-data/mke/MKE-Monthly/GHCND_USW00014839_2010-1-1.pdf and excerpted below:

04/06/2015

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service

Summary of Monthly Normals 1981-2010

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: MILWAUKEE MITCHELL INTERNATIONAL AIRPORT, WI US

GHCND:USW00014839
Elev: 670 ft. Lat: 42.955° N Lon: 87.904° W

Precipitation (in.)

	Totals	Mean Number of Days				Precipitation Probabilities Probability that precipitation will be equal to or less than the indicated amount		
	Means	Daily Precipitation				Monthly Precipitation vs. Probability Levels		
Month	Mean	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.25	.50	.75
1	1.76	11.4	5.1	0.8	0.1	0.91	1.49	2.57
2	1.65	9.7	4.0	0.9	0.3	0.91	1.41	2.30
3	2.27	11.4	5.4	1.5	0.2	1.21	2.01	3.21
4	3.56	12.1	6.6	2.6	0.9	2.41	3.67	4.42
5	3.40	11.4	7.0	2.3	0.8	2.48	2.91	3.76
6	3.90	10.4	6.5	2.7	1.0	2.23	3.10	4.97
7	3.67	9.8	6.1	2.4	0.8	2.33	3.23	4.35
8	3.97	9.5	6.5	2.5	0.9	2.23	4.00	5.17
9	3.18	8.8	5.4	2.1	1.0	1.89	2.85	4.16
10	2.65	10.0	5.6	1.8	0.4	1.45	2.64	3.18
11	2.71	11.3	5.8	1.5	0.5	1.47	2.56	3.65
12	2.04	10.9	5.1	1.1	0.3	1.04	1.56	2.69
Summary	34.76	126.7	69.1	22.2	7.2	20.56	31.43	44.43

5. Annual Precipitation Totals for Milwaukee Wisconsin 1871 – 2018 from Wisconsin State Climatology Office (http://www.aos.wisc.edu/~sco/clim-history/stations/mke/MKE-TS-ANN-R.gif).

6. NOAA Technical Report NWS 34, further titled: "Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States" published December, 1982. https://www.nws.noaa.gov/oh/hdsc/PMP_related_studies/TR34.pdf Cover excerpt follows:

NOAA Technical Report NWS 34

Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States

Washington, D.C.
December 1982

7. Detailed information for Okauchee Lake dam and drainage basin from DNR web site address: https://dnr.wi.gov/damsafety/damsearch.aspx with search entry of Okauchee Lake. Excerpts follow:

Detailed Information for Dam Okauchee Lake

Dam Key Seq No	220	Field File No	67.42
Size	LARGE	NID	222
Popular Name	Upper Oconomowoc	Former Name	

Location

County	Waukesha		
Latitude	43.108536	Longitude	-88.453869
Permitted TRS		**Located TRS**	
QQQ:NW QQ:NW Q:SE - Sec:35 T:08N R:17E			

Contacts

Owner		**Alternate**	
Organization	TOWN OF OCONOMOWOC	Organization	VILLAGE OF OCONOMOWOC LAKE
Name	Town Clerk	Name	

Waterbody

Drainage Basin (sq mi)	80.70		
Stream		**Impoundment**	
Local Name	OCONOMOWOC	Local Name	OKAUCHEE LAKE
Row and Official Name	OCONOMOWOC RIVER	Row and Official Name	OKAUCHEE L
Navigable?	not determined	Size (acres)	1,187.00
When was navigability determined?		Maximum Depth (ft)	94.00

Regulatory/Inspection

NR 333 Years	EAP:2013 IOM:2013 HYD:1992 STAB:1992 ZONE:1992		
Auth. Approval Desc	2WP1438	Regulatory Agency	WIDNR
Hazard Rating	Low	Estimated Hazard Rating	Low
Ferc. No		Exempt Issue Date	
Ferc. Inspection Year		License Expiration Year	

Construction Characteristics

Normal Storage (acre-ft)	11,000.00	Max Storage (acre-ft)	15,000.00
Structural Height (ft)	18.00	Hydraulic Height (ft)	12.00
Crest Length (ft)	450.00	Spillway Type	Controlled
Discharge Through Principal Spillway (cfs)	1,011.00	Width/Diameter of Principal Spillway (ft)	46.00
Total Discharge Through All Spillways (cfs)	1,589.00	Total Width/Diameter of All Spillways (ft)	54.00
Core Type		Position	
Foundation Type		Foundation Certainty	
Purposes	RECREATION	Structural Types	GRAVITY EARTH

Detailed Information for Dam Okauchee Lake

Water Levels

	Normal		Winter	
	MSL	Datum	MSL	Datum
Minimum	872.60	NGVD 29		
Normal				
Maximum	873.71	NGVD 29		

Construction History

Designer	Construction Firm	Complete Year
HARZA ENGINEERING CO		1961
		1992
		1999

Outlet Gates

No data found.

8. Public Service Commission of Wisconsin – 12-WP-625 – Order in the Matter of the Operation of the Several Dams in the Outlet Streams of Lakes Okauchee, Oconomowoc, Fowler and La Bell, March 10, 1945.

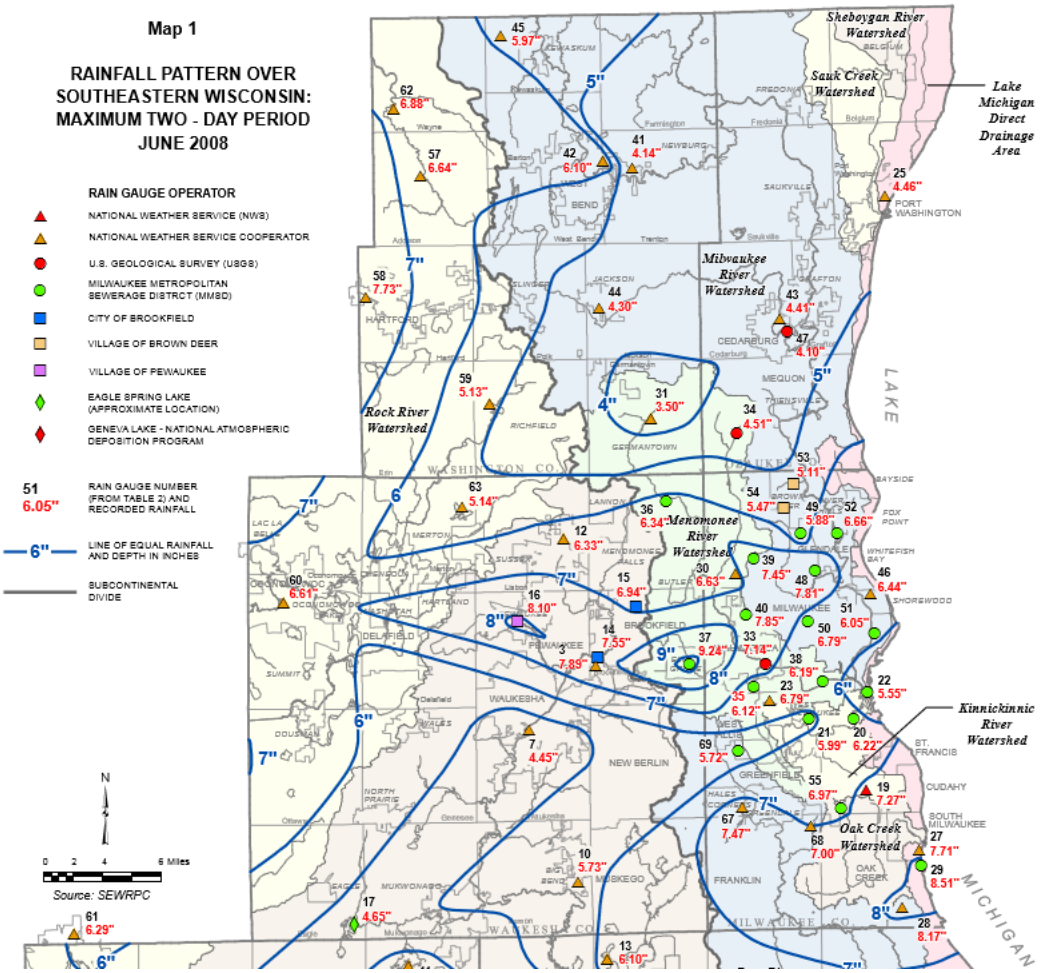
   Received a copy of the above Public Service Commission Order from Michelle Hasse, P.E of the Wisconsin DNR on November 11, 2018. She indicated the operation of the noted dams is controlled by this Public Service Commission Order.

9. Inland Lakes of Wisconsin – "Inland Lakes of Wisconsin: The Hydrography and Morphometry of the Lakes" (Chapter IV) – published 1914. http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=article&did=EcoNatRes.WGB27Sci9.i0010&id=EcoNatRes.WGB27Sci9&isize=M

10. USGS Report entitled "Water-Table Map of Waukesha County Wisconsin" published in 1978 https://pubs.usgs.gov/wri/1979/0043/plate-1.pdf

11. Similar groundwater flows from Pine Lake and North Lake and a 20 foot groundwater gradient drop between Pine Lake and Moose Lake and Okauchee Lake is found in a 2002 SEWRPC report. Map excerpt follows.
    A Paleolimnological Study of the Water Quality Trends in Moose Lake, Waukesha County [PDF 507 KB]

12. Map of maximum two day rainfall in June, 2008, Southeastern Wisconsin



http://www.sewrpc.org/SEWRPCFiles/Environment/Rainfall/RainfallPatternMaps.pdf

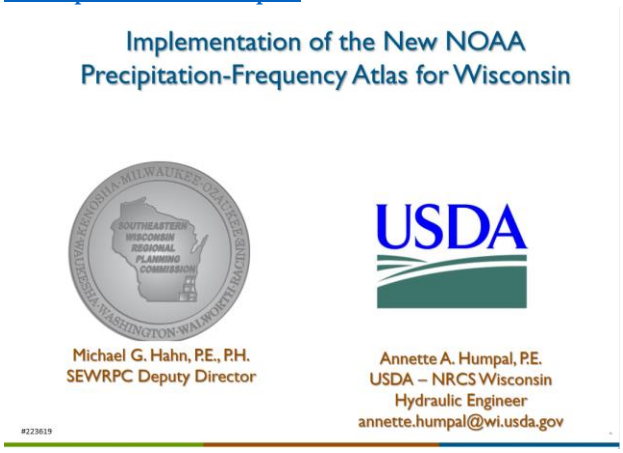
13. Precipitation runoff coefficients for sandy and loamy soils

	Runoff Coefficient, C					
	Soil Group A			Soil Group B		
Slope :	< 2%	2-6%	> 6%	< 2%	2-6%	> 6%
Forest	0.08	0.11	0.14	0.10	0.14	0.18
Meadow	0.14	0.22	0.30	0.20	0.28	0.37
Pasture	0.15	0.25	0.37	0.23	0.34	0.45
Farmland	0.14	0.18	0.22	0.16	0.21	0.28
Res. 1 acre	0.22	0.26	0.29	0.24	0.28	0.34
Res. 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36
Res. 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39
Res. 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42
Res. 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44
Industrial	0.85	0.85	0.86	0.85	0.86	0.86
Commercial	0.88	0.88	0.89	0.89	0.89	0.89
Streets: ROW	0.76	0.77	0.79	0.80	0.82	0.84
Parking	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.65	0.67	0.69	0.66	0.68	0.70

Rational Method Runoff Coefficients - Part I

14. Rainfall Frequency in the Southeastern Wisconsin Region – Technical Report No. 40, Southeastern Wisconsin Planning commission, April, 2000 http://www.sewrpc.org/SEWRPCFiles/Publications/TechRep/tr-040_rainfall_frequency.pdf

15. Presentation: Implementation of the New NOAA Precipitation-Frequency Atlas for Wisconsin, Southeastern Wisconsin Regional Planning Commission and United States Department of Agriculture, 2014 http://www.sewrpc.org/SEWRPCFiles/Environment/Rainfall/NOAA-atlas14-sewrpc-nrcs-presentation.pdf



16. Wisconsin Administrative Code: NR116 – Wisconsin's Floodplain Management Program http://docs.legis.wisconsin.gov/code/admin_code/nr/100/116/

17. In a short meeting with Waukesha Counter Planner, Ben Greenberg of the Department of Parks and Land Use Planning and Zoning Division on May 30, 2019, he confirmed the Ordinary High Water Mark elevation for Moose Lake is **882.42**. He found documentation of that on Certified Survey Map (CSM) #10558 and that it indicates the Ordinary High Water Mark elevation was established by the DNR.

[END]