

## **CONDITION REPORT TO SUPPORT AN ORDINANCE RESTRICTING ARTIFICIALLY ENHANCED WAKES IN LAKES PARTIALLY WITHIN THE TOWNS OF MANITOWISH WATERS AND BOULDER JUNCTION, VILAS COUNTY**

### **INTRODUCTION**

Wisconsin's inland lakes are among the state's most critical natural resources and have incalculable aesthetic, environmental and economic value. Vilas County's concentration of 1300 natural lakes and 73 streams and rivers is recognized as an important global resource. The quality of our waters makes the lakes of Manitowish Waters and Boulder Junction a major destination for tourists and second homeowners from across the country. Residential waterfront property values account for 75% of the total assessed property in Vilas County. In recent years, the increased presence of artificially enhanced wake surfing has generated many comments to both town boards about concerns for personal safety, damage to shorelines and personal property, harm to wildlife, and the threat of an increase of aquatic invasive species. Through consequent town meetings and public hearings, the town of Boulder Junction has passed, and the Town of Manitowish Waters is in the process of passing, substantially identical ordinances to prohibit the activity of wake surfing on lakes wholly within their boundaries. This left two lakes that lie partially in each town unregulated. The town boards of both Manitowish Waters and Boulder Junction have since worked cooperatively to regulate these "border lakes" with the same prohibitions on wake surfing as recently proposed in ordinances applying to lakes wholly within their borders. The result of this cooperation is that each town has submitted to the DNR identical ordinances for approval, to prohibit the activity of wake surfing on Island and Clear Lakes. In the interest of public health, safety and/or welfare, including the public's interest in preserving natural resources and protection of the environment and outdoor recreation, the Towns of Manitowish Waters and Boulder Junction have the authority to cooperatively enact ordinances covering shared waters that lie partially in their jurisdictions, if the ordinances are identical and not contrary to or inconsistent with Chapter 30, Wis. Stats., and they relate to the equipment, use, or operation of boats or to any activity regulated by Wis. Stats. Sections. 30.60 to 30.71 and 30.77 (3)(a).

### **PURPOSE OF THE ORDINANCE**

The proposed ordinance applies to the two "border lakes" larger than 50 acres in size and that lie partially within the Town of Manitowish Waters and partially within the town of Boulder Junction (Island Lake and Clear Lake). See Appendix 1 for greater detail on these two lakes.

The purpose of this ordinance is to:

- (1) extend the current prohibitions on wake surfing pertaining to lakes wholly within their borders recently enacted by Boulder Junction, and in the process of being enacted in Manitowish Waters, to these two “border lakes,” providing consistent rules for boaters to follow and law enforcement to enforce, and to eliminate the concern of increased wake surfing congestion on these lakes, if they were left unregulated;
- (2) prevent property damage from artificially enhanced wakes impacting privately owned shorelines, docks, shoreline structures and moored boats;
- (3) prevent damage from artificially enhanced wakes impacting publicly owned shorelines;
- (4) protect and improve public safety;
- (5) prevent the transfer of aquatic invasive species occurring through ballast water intake and subsequent discharge when boats travel between non-connected lakes;
- (6) prevent enhanced wake activities discouraging other recreational lake users from using the lakes;
- (7) protect the nesting sites of loons and other water birds from the impact of artificially enhanced wakes;
- (8) protect fish spawning grounds from artificially enhanced wakes; and
- (9) protect water quality and prevent algae bloom from resuspension of lake bed sediments.

## **PROPOSED ORDINANCE RESTRICTIONS**

Specifically, the proposed ordinance would prohibit the use of ballast tanks, ballast bags or fins to cause a boat to operate in a bow-high manner or which increase or artificially enhance a boat's wake. It also would prohibit continuously operating a boat in an artificially bow-high manner having the effect of increasing the boat's wake; this would include prohibiting wake enhancement using ballast tanks, ballast bags, mechanical fins or continuous operation at transition speed (the speed below planing speed in which a boat is operating in plowing mode). In no event would any of the following operations be deemed a violation of the ordinance, provided such operations do not use ballast tanks, wave shapers or electro-mechanical fins: 1) water skiing, 2) tubing, 3) wakeboarding using a tow rope, 4) brief transition operation to empty a boat of bilge water, or 5) brief transition operation of a boat accelerating into a planing condition. Restrictions on water skiing and other tow rope activities are not within the intended scope of the proposed ordinance.

Nothing in the proposed ordinance would preclude the use of wake boats with ballast tanks if the ballast tanks and other features intended to create artificially enhanced wakes or cause the boat to operate in a bow-up orientation are not deployed. These boats could continue to be used for cruising, water skiing and other activities provided the ballast tanks and other wave-enhancing features are not deployed.

#### **LOCAL CONDITIONS NECESSITATING AN ORDINANCE**

Clear and Island Lakes are part of a prominent watershed system in Vilas County. It is characterized by glacially formed lakes with clear water and sandy, rocky or silty shorelines. The watershed serves as a critical ecological, recreational and economic resource for the region, supporting diverse wildlife and human activities.

- Island and Clear Lakes are designated Priority Navigable Waterways (PNW) for Musky and Walleye. These are waters that are self-sustaining for musky populations or waters self-sustaining for walleye populations in ceded territories. Please see Appendix 1 for citation.
- The lakes of Manitowish Waters contain sensitive cultural resources spanning more than 9000 years. Prehistoric indigenous sites, historic indigenous sites, and logging and pioneering sites have been documented by numerous archeological surveys. Several cultural sites found along the shores of Clear and Island Lakes and associated streams qualify as unique and are located on both private and public lands. Several of these sites are susceptible to degradation or destruction from the erosive action of artificially enhanced waves. Please see Appendix 3 for citations.
- Wild rice (Manoomin) is a unique and culturally important source of food for the Anishinaabe (Ojibwe) people. The plants are rooted loosely in soft bottom sediments along the parts of the shorelines where streams enter the lake and the soft-bottomed bays, and may be particularly susceptible to damage from artificially enhanced wave action, especially during the floating leaf stage, generally considered the most critical when large waves could uproot or drown entire beds. Wild rice beds are scattered throughout lakes of both towns. Island Lake is designated as a regulated Manoomin (wild rice) Lake per the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). Island Lake is also designated Priority Navigable Waterways (PNW) by the State of Wisconsin as Areas of Special Natural Resources Interest (ASNRI) as “Wild Rice Lakes.” Please see Appendix 3 for citation.
- Island Lake has an average depth of 13 feet. Clear Lake has an average depth of 16 feet. Recent research has concluded the deleterious effects of downward propwash from wake surfing exceeds 30 feet. Please see Appendices 1 and 4 for citations.
- Eurasian watermilfoil has not yet been detected in either Island or Clear Lakes, however, it has been detected in six other lakes that are physically connected by channel: Manitowish Lake, Little Star Lake, Spider Lake, Fawn Lake, Stone Lake and Alder Lake. Eurasian

watermilfoil can reproduce via fragmentation when a segment of the plant leaves the parent plant and roots elsewhere in a connected water body. Currently, there is a local fundraising project to raise \$250,000 to supplement Town funding and state grants to control and remove Eurasian watermilfoil. Both Clear and Island Lakes have or have had curly-leaf pondweed. There has been some success in combating curly-leaf pondweed; not all of the populations of curly-leaf pondweed still exist, but those lakes with and those without are interconnected waterways. Curly-leaf pondweed can reproduce when plant turions drop from a plant and take root in water. Reports of weed beds dislodged by the downward propwash from wake surfing is a cause for concern. Spiny water fleas are another serious concern; to date no detections have been recorded yet in the lakes wholly within Manitowish Waters, but they have been detected in Trout Lake in Boulder Junction, which lies upstream from the Manitowish Waters chain of lakes, connected via the Trout River and eventually to both Island and Clear Lakes. Spiny water fleas are able to be transported by ballast water in ballast tanks, as well as by other means. Please see Appendix 3 for citations.

- As a result of artificially enhanced wakes, property owners have reported numerous incidents, complaints and concerns (please see Appendix 2 for specific comments):
  - Damage to docks, piers, seawalls and boats as well as moored boats breaking their ties due to enhanced wakes;
  - Shoreline damage, severe erosion and high turbidity with clear lakes turning murky as sediment re-enters the water column;
  - Fish and habitat damage, including significant amounts of weeds floating on the water and washing up on shore;
  - Disturbance of nesting sites for loons and other waterfowl; and
  - Lake users also report they are unable to use their lake as they have been accustomed to out of concerns for safety when just one or two boats are out operating in wake-surf mode. For example:
    - Kayakers and paddlers not going out on lakes when wake surfing activity is occurring for fear of being swamped.
    - Boats towing skiers or tubers returning to their docks unable to safely navigate due to safety concerns for those being towed.
    - Anglers having to move to other areas of the lake to ensure they can safely fish, being unable to safely stand and fish in their boats, and reporting near misses with boats being operated in the bow-up manner for surfing, severely obstructing the view of the wake boat driver.
    - Pontoon boats getting swamped or completely re-routed to avoid entire areas of the lake when a wake boat is generating artificially enhanced wakes.

- Small children not being able to play in the shallows, or even at risk of drowning, from the intense size and energy of waves created by passing wake surfing activities.
- Because it is not possible to fully empty or inspect the ballast tanks of wake surf boats, bringing a wake surf boat from a lake with aquatic invasive species populations to either Clear or Island Lakes represents a potential violation of state statute NR 19.055.
- There is no practical way in Manitowish Waters or Boulder Junction to inspect the ballast tanks of boats coming to Clear or Island Lakes from other lakes.
- There are no existing decontamination centers in Manitowish Waters or Boulder Junction, nor is there a registration process, or agency to oversee and certify decontamination of undrainable ballasts tanks.

Manitowish Waters has an experienced Water Safety Patrol that currently patrols both Island and Clear Lakes per a Memorandum of Understanding with the Town of Boulder Junction. However, prohibitions on wake surfing in both towns have not been in force in prior years, and, therefore, there have not yet been any citations specific to wake surfing.

#### **HOW AN ORDINANCE WOULD SOLVE THE ABOVE ISSUES FOR THE TOWNS OF MANITOWISH WATERS AND BOULDER JUNCTION**

An ordinance prohibiting boats from generating artificially enhanced wakes would result in the following benefits to both the towns of Manitowish Waters and Boulder Junction:

- Since both towns have already passed, or are in the process of passing, substantially identical ordinances prohibiting the activity of wake surfing on lakes wholly within each town, this ordinance would extend the same restrictions to these two “border lakes,” reducing confusion for law enforcement and increased wake surfing congestion on these lakes, if they were left unregulated.
- The negative environmental impacts from boats generating artificially enhanced wakes, noted above, would be prevented.
- The safety risks associated with boats generating artificially enhanced wakes, noted above, would be eliminated. Other lake users would be able to return to using the lakes as they have been accustomed to.
- Costly shoreline and shore structure damage from artificially enhanced waves caused by wake surfing would be eliminated.
- The possibility of ballast tanks to transfer aquatic invasive species from one lake to another would be reduced or eliminated, as well as the associated costs related to ecological degradation. Currently, there is a strong movement among property owners, local organizations (the Manitowish Waters Lakes Association, the Manitowish Waters Alliance Foundation and the Manitowish Waters Lions Club with support from the North

Lakeland Discovery Center) and other lake users to address the threat that the spread of aquatic invasive species poses to the lakes of Manitowish Waters, including both Clear and Island Lakes.

- Significant cultural and historical resources being degraded by artificially enhanced wakes would be eliminated.
- The Manitowish Waters Town's Water Safety Patrol would have clear guidance on enforcing the prohibition of the activity of wake surfing on both Clear and Island Lakes, as it would be the same prohibition proposed in the ordinances already passed, and in the process of being passed, on the rest of the lakes in Manitowish Waters and Boulder Junction.

#### **POSSIBLE NEGATIVE EFFECTS OF ADOPTING THE ORDINANCE**

Both the towns of Manitowish Waters and Boulder Junction have had town meetings and public hearings over the past year regarding the issue of wake surfing on the lakes wholly within their borders. The result was that both towns have passed, or are in the process of passing, identical ordinances to prohibit the activity of wake surfing on these lakes. The wake surfing community has been looking at Clear and Island Lakes as waters they would be able to continue to wake surf on because they were not controlled wholly by either town, therefore leaving them outside the scope of any ordinance covering only internal lakes. However, Wisconsin statutes allow for ordinances covering border lakes shared between two towns to be passed, if they are substantially identically written. The leadership of both towns have agreed to this process.

The negative effect of adopting this ordinance to further restrict wake surfing on Clear and Island Lakes is that, going forward, wake surfing enthusiasts will be forced to trailer their boats to unregulated waters to pursue their sport. Please see Appendix 2 for specific comments from Manitowish Waters and the Boulder Junction Condition Report for comments from Boulder Junction.

#### **PEOPLE OR GROUPS WHO MAY BE NEGATIVELY AFFECTED BY ADOPTION OF THE PROPOSED ORDINANCE**

- Owners of wake boats who are not able to use their boats for the activity of wake surfing
- Other wake surfers who do not own boats but enjoy the activity
- Boat dealers that sell wake surf boats
- Lake users on other bodies of water that have concerns about the deleterious effects of wake surfing as wake surfers flock to their lakes in response to not being allowed to perform their activity on the growing number of other regulated lakes.

## **SUMMARY OF THE ARGUMENTS OF THE INTERESTS OPPOSED TO REGULATION**

The wake surfing community has been well represented and have made public comments at Town meetings and Public Hearings in both towns on the issue. They have been very vocal about the negative effects resulting from adopting an ordinance prohibiting wake surfing. In summary, their concerns and claims have been:

- An ordinance would be “taking away one of their rights.”
- The guidelines for the “safe” practice of wake surfing suggested by the broad scientific community were biased, incorrect and unfair, and that the guidelines suggested by the marine sport industry were unbiased, correct and fair.
- Prohibiting the activity of wake surfing would have a negative effect on the family life of those families who come to our chain specifically to wake surf.
- An ordinance would negatively affect the sales of new boats, leading to economic hardship for area boat dealers.
- That any regulation pertaining to enhanced wakes would be a violation of the Public Trust Doctrine.
- That ballast tanks of wake surf boats are no more likely to transfer invasives than live wells.
- See Appendix 2 for specific comments from Manitowish Waters and the Boulder Junction Condition Report for comments from Boulder Junction.

## **IMPACT ON PUBLIC HEALTH, SAFETY OR WELFARE IF THE ORDINANCE IS NOT ADOPTED**

Since both the towns of Manitowish Waters and Boulder Junction have recently passed, or are in the process of passing, ordinances to prohibit the activity of wake surfing on lakes wholly within their borders, Island and Clear Lakes, which lie partly in each town, remain as two unregulated lakes for the sport of wake surfing. If this ordinance is not adopted, these two lakes will become highly vulnerable to increased congestion from wake surfers newly restricted on other lakes. The majority of property owners and other lake users on these lakes have made it clear to the leaders of both towns that they are opposed to wake surfing on these lakes as well.

If the ordinance is not adopted, the impacts caused by wake surfing regarding human safety and property and lake health will become increasingly difficult to manage. The health and well-being of the public will be abandoned in favor of an activity for the relatively few. Allowing wake surfing will increase the economic and ecological burden that will fall to all community members but will have been generated by a very small minority. The quality of the lakes and shorelines will decrease, and the attractiveness of the area for tourists on which both towns and their businesses depend will decrease. This does not serve the best interest of the majority of people using the lakes in Manitowish Waters or Boulder Junction.

Ordinances to prohibit wake surfing have recently been passed in several towns surrounding Manitowish Waters and Boulder Junction (Presque Isle, Plum Lake and Winchester), and by the Lac du Flambeau Band of Lake Superior Chippewa Indians on all tribal waters. If wake surfing remains unregulated on these two lakes, they will most certainly experience increased traffic from wake surfers who are no longer allowed to wake surf on other connected lakes. This increase will greatly magnify the myriad of concerns about property damage, safety, ecological degradation and the spread of aquatic invasive species discussed above.

Both towns have received public input, listened to the experiences of lake users, learned from science-based studies (please see Appendix 4), and concluded that public safety and protection of its valued resources are best served by adopting the proposed ordinance.

### **PLACEMENT OF SIGNAGE**

Upon adopting the proposed ordinance, appropriate signage would be placed at all public landings, in accordance with Wisconsin law. Based on the experiences of other Wisconsin municipalities that have adopted ordinances regulating the creation of artificially enhanced wakes, such signage and general education regarding the ordinance will help ensure compliance. The town of Manitowish Waters is fortunate to have a very experienced and active, town-supported Water Patrol that patrol both Clear and Island Lakes. By prohibiting the activity of wake surfing on Clear and Island Lakes, our patrol will have a uniform enforcement code for all the lakes in the area.



## **APPENDIX 1**

## APPENDIX 2

### EXAMPLES OF IMPACT OF WAKE SURFING ON THE ENVIRONMENT, PROPERTY AND OTHER LAKE USERS

**Note: statements have been pulled from longer emails and edited slightly for clarity and grammar. We have included comments from both sides of this issue.**

We have personally witnessed an incident where a wake boat wave endangered a small fishing boat. These waves can endanger the safety of swimmers, kayakers, canoers and other boaters.

I had to rebuild my seawall at a cost of \$150,000. While this may have happened anyway over a long period of time, the significant force caused by large waves exacerbated the erosion of my wall and necessitated repair much sooner than needed.

I had my two 2 ½-year grandsons getting reasonably comfortable in the 6 inches of water they were playing in. I was facing the shore, my back to the lake. Out of nowhere, tremendous wake surf waves roared in. When the first wave hit the little boys, I grabbed the one who was closer. Got him slightly stable. By then, the other one was rolling around, under water, and the 2nd wave hit!! He was completely out of control. When I fished him out, he was very frightened. He wanted out of the water immediately.

I was crossing Manitowish Lake early afternoon on my wave runner, going half speed, when I hit cross waves from two wake surfers. I did a deep dive into a swell. The front of my boat got caught under the water, and my face and chest were slammed into the steering column. I lost my breath and thought I lost my front teeth. Turns out I didn't lose my teeth but the inside of my mouth was bleeding pretty good. My face and chest were bruised and swollen.

The erosion that this activity has created has significantly impacted our lake frontage. The negative impacts include wet docks all summer that used to be dry, causing rot and now dock replacement. The bank being undercut and threatening trees that are now leaning toward the lake, and our applying for a permit and having to spend literally tens of thousands to put rip rap on the shoreline to limit the erosion.

All of the other towns around us have outlawed them. If we don't, we will be the town with all the wake boats on our waters. The wake boats can function just fine as ski boats.

Shore erosion, the introduction of invasive species and simply threats to safety to anyone in smaller craft are hard to overlook. Even our 19' ski boat has not been immune to swamping with significant amounts of water over the bow when one of these behemoths are operating on our lakes. The introduction of invasive species and pollution from harmful chemicals in their ballast tanks are difficult or impossible to effectively monitor without a total ban.

My hope for a settlement allowing wake boats with ballast has faded due to the facts regarding water quality danger and the inability to ensure wake boats will honor any regulations.

Lakes on the MW chain, like Alder, are far too small to mitigate the damaging effects of artificially enhanced wakes. I have gone wake surfing many times in New Mexico, and I get the appeal. It is a blast. The big difference is that in New Mexico we are surfing on very large, deep reservoirs with rocky shores that bounce the waves back toward the middle. By comparison, the MW lakes are small and shallow with sensitive shorelines.

One of the reasons we moved up here is to enjoy the peaceful surrounds, especially when we are kayaking. A number of times the stability of our kayaks has been compromised due to high waves. The folks on pontoons, fishing boats, kayaks and boards far outnumber those who wish to see an ordinance passed to allow wake surfing. Shouldn't majority rule?

To open our lakes to this type of boating when surrounding communities and lakes have imposed bans would target our waterways for use/abuse. I urge the board to follow the example of other areas that have banned the use of wake boats.

It has gotten so bad that we have had our decking on our dock actually lifted out of the dock frame. We don't dare tie our boats to our dock and are forced to always keep them on our boatlifts.

Just because someone has created a boat that can do such tricks, doesn't mean that everyone should have to be witness to the destruction, the noise and the lack of respect for the environment and the safety of others on the lakes. I agree that these boats should be allowed to pull skiers and tubers in a normal fashion, but wake surfing is not reasonable, nor safe.

It is unfair to have a small percentage of folks disrupt the opportunity for the rest of us to enjoy our lakes. I'm a fisherman and I am sick of constantly having to reposition my boat so I don't get swamped - the fact of them has completely changed how, where and when I fish and that is not fair. My wife is a kayaker, and she is having a similar effect on her. Our neighbor's pier was wrecked from their waves.

I have no issues when these wake boats are pulling tubers or skiers, but I have a big issue when they operate in wake board mode. Besides the exceedingly loud music that we can easily hear even when on the other end of the lake, the waves frequently dislodge sections of my metal frame dock which I have to retrieve or replace if I can't find them.

The original owner of the home on our property built a 100-foot length of seawall to preserve the area that was cleared for access to the lake. Wave action requires regular maintenance of the wall and soil surface abutting the wall. Large waves flow over the top of the seawall washing away soil in spite of a healthy coat of grass. One can get wet from the splashes that reach heights of 10 or more feet above the water surface.

I am sure there are some responsible wake boat owners that respect the delicate ecosystem of the lakes but what is more important for the Manitowish chain: a sustainable lake system or a minority of people that like to surf in a place that was never meant for 10-foot waves to crash on the shores and disturb wildlife or perhaps even displace it?

Proposals to allow enhanced wakes at certain distances from shore and in certain depths of water are just asking for a disaster in enforcing those rules.

Besides damaging the environment, wake surfing is extremely disruptive to other lake activities, and literally chase us off the water with their unnatural wave activity.

I know in this world we would like to accommodate everyone's interests, but with wake boarding, you negatively affect shorelines, other boaters, fishermen, kayakers, swimmers and loon reproduction, which is on the decline as it is. In reality, we are talking about less than 5% of lake users dictating to the majority that they have to endure these negative effects in order to be fair.

We have seen further impacts from weed growth and invasive species entering our lakes largely due to these boats. I scuba dive in the lake and I see the impact on the bottom and the weed growth that wasn't there to this extent only a few years back.

This recommendation to ban is a draconian response to a vital activity for the economy and for the enjoyment of a huge population of families.

As a frequent boater on these waters, I believe this ban would have a detrimental impact on our community, the local economy, and the recreational opportunities available to both residents and visitors.

While I recognize the concerns raised by some regarding wake surfing and ballast use, I believe that a ban on such activities is unwarranted and unsupported by scientific evidence.

Considering the enormous expense and upkeep of these craft and the apparent unpopularity among non-surf boaters, this may well calm down of its own accord without the need to anger those who have already made the investment.

The arguments presented by proponents of the ban on wake surfing are based on studies that have been thoroughly debunked. Contradictory research and engineering experts have demonstrated that wake surfing, when practiced in designated areas, does not pose the environmental or safety risks claimed by the opposition.

This issue has gained particular significance, especially with the growing involvement of activist groups in Wisconsin. While I deeply respect the intentions of those advocating for environmental and recreational regulations, it is important to remember that the Manitowish

chain is part of the Public Trust Doctrine, which guarantees the right for all boats, including wake boats with ballasts, to use these lakes.

My family of six has greatly enjoyed the water recreation that wakeboarding provides. It is a fantastic activity that is easier on the body compared to water skiing.

To completely ban wake boarding on the chain is not prudent nor will it make the lakes and shoreline any better. It will lead to litigation which no one wants or has time for.

### APPENDIX 3: CITATIONS

The following citations support the cultural point referenced on page 3:

Bokern, James K.

1987

The History and Primary Canoe Routes of the Six Chippewa Bands From the Lac du Flambeau District. Unpublished Master's thesis, University of Wisconsin-Stevens Point.

Bokern, James K. and Cynthia M. Stiles

1993

Report of the 1992 Shoreline Survey, Manitowish Waters Chain of Lakes, Vilas County, Wisconsin. Nicolet National Forest, State Region 2 Archaeological Center, Report of Investigations No.1, Rhinelander.

1995

Report of the 1993-94 Shoreline Survey, Manitowish Waters Chain of Lakes, Vilas County, Wisconsin. Nicolet National Forest, State Region 2 Archaeological Center, Report of Investigations No.5, Rhinelander.

Salzer, Robert J.

1966

Northern Wisconsin Archeological Progress Report: 1966. Unpublished Report of research under the auspices of the National Science Foundation (Grant GS 839) and Logan Museum of Anthropology, Beloit College, Beloit.

1969

An Introduction to the Archaeology of Northern Wisconsin. Unpublished PhD. Dissertation, Southern Illinois, Carbondale.

1974

Wisconsin Northern Lakes Project: A Preliminary Report. In Aspects of Upper Great Lakes Anthropology, Papers in Honor of Lloyd A. Wilford. Edited by Elden Johnson. Minnesota Prehistoric Archeological Series No.11, Minnesota Historical Society, St. Paul.

The following citations support the points made in this report on Aquatic Invasive Species:

Milfoil:

<https://dnr.wisconsin.gov/topic/Invasives/fact/EurasianWatermilfoil>

Curlyleaf Pondweed

<https://dnr.wisconsin.gov/topic/Invasives/fact/CurlyLeafPondweed>

The following citation supports the Manitowish Waters lakes information in the report and Appendix 1:

Wisconsin Surface Waters Data Viewer:

<https://dnr.wisconsin.gov/topic/SurfaceWater/swdv>

Wisconsin Find A Lake: <https://apps.dnr.wi.gov/lakes/lakepages/>

The following citation supports the wild rice information found on page 3:

Great Lakes Indian Fish and Wildlife Commission:

- [https://glifwc.org/publications/pdf/Wildrice\\_Brochure.pdf](https://glifwc.org/publications/pdf/Wildrice_Brochure.pdf)
- <https://data.glifwc.org/manoomin.harvest.info/>

## APPENDIX 4

### RELEVANT RESEARCH STUDIES AND SURVEYS

- Several studies contributing to the facts in this condition report were completed in recent years. Since that time, boats generating enhanced wakes have gotten more powerful and their wakes bigger (e.g., increasing in height from 2-4 feet to 4-5 feet, and more) and more powerful. Therefore, the figures cited in this report are likely conservative. More studies are underway and in review.
- **General literature study of the impacts of wake surfing:** “The Effects of Wake Boats on Lake Ecosystem Health: A Literature Review.” Wisconsin Green Fire (May 2024)  
<https://wigreenfire.org/wake-boats-lakes-update-may-2024/>
- **Ballast tank water retention and invasive species:** “Volume and contents of residual water in recreational watercraft ballast systems,” Management of Biological Invasions (2016) Volume 7, Issue 3: 281-286, first published online 04/18/2016, [https://www.reabic.net/journals/mbi/2016/3/MBI\\_2016\\_Campbell\\_etal.pdf](https://www.reabic.net/journals/mbi/2016/3/MBI_2016_Campbell_etal.pdf).
- **Study showing that residual water in ballast tanks transfer live zebra mussel veligers:** Doll, A. 2018. *“Occurrence and survival of Zebra Mussel (Dreissena polymorpha) veliger larvae in residual water transported by recreational watercraft.”* Master’s thesis. University of Minnesota, St. Paul.  
<https://conservancy.umn.edu/server/api/core/bitstreams/da582b1c-7880-4adb-af31-5303491ed1a6/content>
- **Wave height, power and energy:** *“A Field Study Of Maximum Wave Height, Total Wave Energy, And Maximum Wave Power Produced By Four Recreational Boats On A Freshwater Lake,”* St. Anthony Falls Laboratory, College of Science & Engineering, University of Minnesota, SAFL Project Report No. 600, 02/02/2022, <https://conservancy.umn.edu/handle/11299/226190>.
- **Wave size, power and turbidity:** *“A Phased Study Of The Water Quality And Wave Propagation Dynamics Currently Impacting A Small Southeast Wisconsin Freshwater Lake: Waukesha,”* Terra Vigilis Group, as contained in Responsible Wakes for Vermont Lakes (see pp 16-37 of linked presentation where study is embedded), <https://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/Additional%20supporting%20Information%20submitted%2007292022.pdf>



- **Vilas County public sentiment support for regulating artificially enhanced wakes to lakes of greater than 1500 acres, 700 feet from shore, and 20-foot depth**-Page 21  
Response #43: *"2023 Spring Hearing Statewide Results by County,"* Wisconsin Conservation Congress and Department of Natural Resources, 04/26/2024, [https://dnr.wisconsin.gov/sites/default/files/topic/About/WCC/2024/SpringHearing/2024\\_StatewideResultsByCounty.pdf](https://dnr.wisconsin.gov/sites/default/files/topic/About/WCC/2024/SpringHearing/2024_StatewideResultsByCounty.pdf)
- Wisconsin Green Fire May 2024 survey of available studies regarding the environmental impacts of wake surfing.  
[https://wigreenfire.org/2019/wp-content/uploads/2024/05/WakeBoatsLakeEcosystemHealth\\_WGF-May2024\\_Final.pdf](https://wigreenfire.org/2019/wp-content/uploads/2024/05/WakeBoatsLakeEcosystemHealth_WGF-May2024_Final.pdf)
- **Wave size, shoreline impact, depth of lakebed impact and phosphorus increase from lakebed impact:** *"Lake Waramaug Wave Impact Study, Final Report,"* Nov 15 2024, Terra Vigilis Environmental Impact Services Group, prepared for the Lake Waramaug, Conn. Inter-Local Commission  
[https://www.warrenct.gov/sites/g/files/vyhlif3991/f/uploads/lake\\_waramaug\\_final\\_report.pdf](https://www.warrenct.gov/sites/g/files/vyhlif3991/f/uploads/lake_waramaug_final_report.pdf)
- **Wave Impact and Prop Wash Impact, Recommending Surf Boats operate in minimum 8 Meter (26 feet) depth.** *"Lake Windermere (B.C.) Recreational Impact and Sediment Quality Assessment,"* Ecoscape Environmental Consultants Ltd. August 22, 2024  
<https://www.lakeambassadors.ca/lwawp/wp-content/uploads/2024/08/Lake-Windermere-Recreational-Carrying-Capacity-Study-Public-Release-Version.pdf>
- **The boat industry's own study showing that a surf boat operating in 20' water depths makes a wave 20" high at 100' from the boat, 16" high at 200' from the boat and a wave 13" high a full 300' from the boat –** *"Characterization of Wake-Sport Wakes and their Potential impact on Shorelines,"* November 2015, commissioned and paid for by the Water Sports Industry Association  
[https://www.wsia.net/wp-content/uploads/2020/03/WSIA\\_draft\\_report\\_Rev\\_II.pdf](https://www.wsia.net/wp-content/uploads/2020/03/WSIA_draft_report_Rev_II.pdf)