Petition to the Agency of Natural Resources to Amend the Vermont Use of Public Water Rules to Adopt a Rule to Prohibit the Use of Wakesports on Shadow Lake in Glover, Vermont

Petitioners
Town of Glover
Shadow Lake Association Board

Jenifer Andrews, President
slgvtpresident@gmail.com
802-585-4286

Phil Young, Chair, Glover Select Board

Denise Sawan Caruso, Secretary

Submitted on April 29, 2024

LAKE ASSOCIATION SHADOW

P.O Box 135

Glover, Vermont 05839

www.shadowlakeassociation.org

April 29, 2024

To: Peter LaFlamme
Director, Watershed Management Division
Vermont Department of Environmental Conservation
Davis Building - 3rd Floor
One National Life Drive Montpelier, Vermont 05620-3522

Re: Petition For Prohibition of Wakesports on Shadow Lake

Dear Director LaFlamme,

Attached is a petition submitted by the Town of Glover and the Shadow Lake Association Board seeking an amendment to the Vermont Use of Public Waters Rules that would prohibit wakesports on Shadow Lake. The recently adopted statewide rule makes Shadow Lake eligible for wakesports activities, which the SLA membership believes would be antithetical to the lakes' unique character and long-standing traditional, normal uses.

After you have had a chance to review our petition and accompanying materials, we would welcome the opportunity to address any concerns you may have about the completeness of our submission. Our expectation is that this will be concluded in time for the requested amendments to take effect for the 2025 Vermont boating season.

Very Truly Yours,

Jenifer Andrews

Shadow Lake Association, by Jenifer Andrews, President.
PO Box 168, Glover, Vermont 05839
802-585-4286; slgvtpresident@gmail.com

Cc:
Julie Moore, Secretary, Vermont Agency of Natural Resources
julie.moore@vermont.gov

Jason Batchelder, Commissioner, Vermont Department of Environmental Conservation
jason.batchelder@vermont.gov

Sgt. Jacob Metayer, Vermont Department of Public Safety, Marine Division
jacob.metayer@vermont.gov

Town of Glover, Vermont, Town Clark
c/o Cindy Epinette, tcglover@comcast.net

Town of Glover, Vermont. Planning Commission
c/o Randy Williams, gloverplanningcommission@gmail.com

Orleans County Conservation District Northeastern Vermont Development Association, St. Johnsbury, Vermont c/o Sarah Damsell, info@nvda.net

Table of Contents

The Town of Glover and the Shadow Lake Association Board Co-Petitioners hereby petition the Vermont Department of Environmental Conservation (DEC), a department within the Vermont Agency of Natural Resources (ANR), to exercise rulemaking authority in accordance with 10 V.S.A. § 1424 to adopt rules to prohibit Wakesports on Shadow Lake located in the town of Glover, Orleans County, Vermont

EXECUTIVE SUMMARY

Vermont's Use of Public Waters Rules (UPW) state in 2.2(b) under General Criteria, "The public waters shall be managed so that various uses may be enjoyed in a reasonable manner, considering safety and best interest of both current and future generations…"

Further, Vermont's Use of Public Waters rules state in 2.3 under Recreation Related Criteria "In evaluating normal recreational and other uses, the following uses shall be among those considered: fishing, swimming, boating, water skiing, fish and wildlife habitat, wildlife observation, the enjoyment of aesthetic values, quiet solitude of the water body, and other water-based activities."

NATURE and PURPOSE

The arguments presented in this petition support the prohibition of wakesports on Shadow Lake due to the strong likelihood of irreconcilable conflict of use. Myriad adverse impact issues result from wakesports artificially created enhanced wakes that turbulently churn the lake water and harm the lake environment. The most compelling reason to prohibit wakesports on Shadow Lake is to prevent safety-related incidents caused by wake surf boats and their powerfully enhanced wakes that could result in severe injury or loss of life.

Shadow Lake is a small 217-acre inland lake with a limited flow of navigable water on which the normal uses of fishing, swimming, paddling (kayaks/paddleboard/canoes), sailing, water skiing and tubing is available.

The first organizational meeting of the Shadow Lake Improvement Association was held in 1947 to unite lake community members in the long-term stewardship of the lake. Our Association is a member-supported non-profit 501(c)(4) tax-exempt organization dedicated to improving the understanding and management of Shadow Lake for its long-term environmental health. The mission of the Shadow Lake Association "shall be to collaborate with lake residents, the Town of Glover, and the State of Vermont, to learn, educate, and foster best management practices around Shadow Lake, in order to preserve and promote the healthy ecology of the lake and to ensure pristine water quality for the benefit of current and future generations."

Over the decades, volunteer water stewards have contributed innumerable hours of gathering data recorded at the state level for water quality. The Shadow Lake Association has participated in the Lay Monitoring program for 45 years since the program began in 1979. We also participate in the LaRosa stream monitoring data collection and cyanobacteria monitoring,

and a lake volunteer assists the Loon monitoring program for the Vermont Center for Ecostudies. The SLA, in collaboration with the Town of Glover, the Northwoods Stewardship Center, and the DEC Lake Wise program, has proactively installed rain gardens at the Glover public beach to reduce the impact of stormwater runoff from the road, to prevent beach erosion, and minimize the associated pollutants from entering the lake.

The Town of Glover is improving the roads around the lake upgrading culverts, and adding rock rip-rap to protect the lake from stormwater impacts. Every year, the town repaints the crosswalks on the lakeside road to ensure pedestrians' safety. The town also sets out buoys to mark the public beach swim zone, warning boaters not to enter the area to ensure swimmers' safety.

The Shadow Lake Association operates a Greeter station at the Fish and Wildlife fishing access, which provides aquatic invasive species watercraft inspection and free boat wash services. Established in 2003, the Greeter station is the oldest in the state and the first to implement a hot water pressurized decontamination station. Weather permitting, we operate seven days a week, 12 hours a day, from May through September. The initiative is funded by the Department of Environmental Conservation and generously supported by the town of Glover.

The Shadow Lake Association, in conjunction with the Natural Resource Conservation District, Town of Glover ARPA funds, and its “sister lake”, Lake Parker, in West Glover, received funding in 2023 to present two public workshops—Lake Wise and Wastewater. These funds have allowed us to post educational signage at the lakes and ponds in Glover that shares information on our watershed and ways to promote healthy lakes.

The Glover Select Board and the DEC also support the Shadow Lake Association’s A(1) Reclassification Petition, which will more closely align our pristine water quality designation to its natural state. Due to their well-documented destructive impacts, wakesports are antithetical to our efforts to protect this lake's outstanding water quality. Ballasted boats are a significant risk for transporting AIS, and their presence on the lake will inevitably harm the lake environment over time. Allowing wakesports on this lake may, in all likelihood, obliterate the chances for Shadow Lake Association's petition for an A(1) status filed with ANR.

With the help of DEC scientists' expertise guiding our Eurasian watermilfoil (Myriophyllum spicatum) management and control efforts over many years, Shadow Lake was restored to an AIS-free status and removed from the state’s infested water bodies list in July 2022. We have spent tens of thousands of dollars and innumerable volunteer hours eradicating Eurasian watermilfoil from Shadow Lake. SLA-hired divers and lake volunteers continue our proactive, regular surveying of the lake's littoral zone for aquatic invasive species all summer.

The Town of Glover and the Shadow Lake Association are committed to maintaining, improving, and preserving Shadow Lake's outstanding water quality, ensuring public recreational safety, and protecting wildlife. This petition is supported by the Town of Glover, its citizens,

the Shadow Lake Association, its board of directors, and its members.

- Discussions regarding wake sports and wake boats occurred at the Shadow Lake Association membership annual meeting on July 8, 2023. Participants agreed to approve that SLA shall submit an individual lake petition to prohibit wake boats and wakesports on Shadow Lake if the DEC regulation passes at a 500-foot distance from shore.
- Shadow Lake Association Board discussion and motion to prohibit wakesports boats, approved August 2023.
- Local community members discussed wakesports at the Glover Select board meeting, and the board voted to prohibit wakesports on all 3 Glover Lakes in August 2024.

Wakesports can negatively impact the lake environment and conflict with long-established normal uses on the lake and create unique public safety risks during water recreation. The new UPW Rule § 3.8, "Wakesports," fails to address safety concerns that threaten the well-being of Shadow Lake users. Therefore, the Town of Glover and the Shadow Lake Association request that wakesports be prohibited on Shadow Lake. Our petition provides reasoning and explanations to support this request.

Proposal to change the Vermont use of Public Water Rules for Shadow Lake, Glover, Vermont

STATUTORY AUTHORITY

This Petition is submitted pursuant to 10 V.S.A .§1424(e) and seeks to add lake-specific rules to Appendix A of the Vermont Use of Public Waters Rules (UPW). In accordance with published guidance provided by DEC, the content and service requirements governing this petition are as set forth in i) the Vermont Agency of Natural Resources (ANR) Procedures for Evaluating Petitions to Adopt, Amend or Repeal Surface Water Rules and ii) the Rules of Procedure formerly applicable to petitions filed with the Vermont Natural Resources Board (VNRB), but now applicable to petitions filed with DEC. (In 2012, the Vermont Legislature transferred UPW rulemaking authority from the VNRB to ANR, and ANR has designated DEC as the starting point for UPW petitions.) These Rules of Procedure further provide that the rulemaking requested by this petition be undertaken in accordance with the Vermont Administrative Procedure Act, 3 V.S.A. § 800 et. seq.

PROPOSED RULE

Shadow Lake Association requests to amend Appendix A of the Vermont Use of Public Water rules by adding a lake-specific rule for Shadow Lake, Town of Glover as follows:

"b. Wakesports *are* prohibited."

Prohibiting wakesports on Shadow Lake is necessary to protect lake users, maintain normal use recreational activities, and maintain the lake's clean water quality and healthy ecosystem as an AIS-free lake and continue our loon conservation efforts. This petition is supported by the Town of Glover, the citizens of Glover, the Shadow Lake Association, its board of directors and members and others.

EXISTING RULE

The recently concluded Agency of Natural Resources rulemaking responding to the rapid growth of wakesports in Vermont resulted in a new UPW rule 3.8, “Wakesports”, are prohibited on lakes, ponds, and reservoirs that do not have a defined wakesports zone and shall not take place outside the boundaries of a wakesports zone. The requirements for such a zone are: wakesports on Vermont’s inland lakes to operate at least 500 feet from the shoreline and in water at least 20 feet deep, provided the area on a given lake meets those two criteria and is at least 50 contiguous acres. In addition, the rule seeks to mitigate the spread of aquatic invasive species (AIS) by requiring Vermont-registered wake boats to declare a “Home Lake”, and to undergo decontamination of their ballast tanks at a state-certified facility prior to launching in another water body within Vermont.

This new rule will make Shadow Lake eligible for wakesports. The Shadow Lake Association and those individuals and entities who have submitted attached letters of support maintain that wake boats and wakesports will significantly impact the shoreline, near-shore habitat, water quality, and public safety. According to the Shadow Lake Association’s mission statement, it is our responsibility “...to preserve and promote the healthy ecology of the lake and to ensure pristine water quality for the benefit of current and future generations.” Our mission statement supports the DEC’s mission statement: “...to preserve, enhance, restore, and conserve Vermont’s natural resources and protect human health for the benefit of this and future generations.”

NARRATIVE SUMMARY

Use of Public Waters (UPW) rules were developed to avoid and resolve conflicts and to protect normal or designated uses on all lakes, ponds, and reservoirs. They were established with consideration of the interests of current and future generations of lake users and to ensure that the natural resource values of public waters are fully protected.

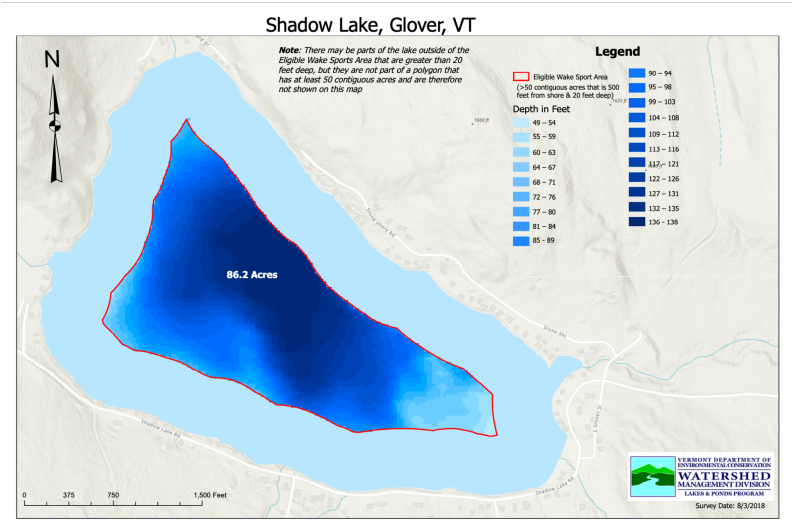
During the rulemaking process, the Agency of Natural Resources (ANR) acknowledged that its staff **lacks a fine level of expertise on safety and recreation at the intersection of uses and chose not to prioritize public safety in developing its new statewide rule,** preferring to defer public safety issues for consideration on a lake-by-lake basis. **The UPW Rules require ANR to consider the "safety and best interests of both current and future generations" of Vermont citizens when managing the state's public waters.**

The DEC Commissioner stated on February 15, 2024, during the Legislative Committee on Administrative Rules meeting and boats operating in wakesports mode to our view do not meet the definition under the UPW of a normal use. Since wakesports are *not normal use* under the UPW and have never occurred on a regular, frequent, consistent basis prior to January 1, 1993, and especially on a relatively small lake like Shadow Lake, are not safely compatible with normal use recreation, they should not be allowed to occur alongside the predominant and traditional long-standing normal-use recreation activities such as swimming, water skiing, tubing, cruising,

sailing, kayaking, canoeing, rowing, paddleboarding, pedal boating, fishing, wildlife observation, the enjoyment of aesthetic values and quiet solitude of being on the lake that take place throughout the entire lake surface as enjoyed by many generations on Shadow Lake prior to the ANR's wake boat regulation.

Wakesports have never occurred on Shadow Lake, and there are no resident wake boats on the lake. Thus, the conflict of use between wakesports and normal-use recreation has yet to exist on the lake. However, there was one instance where a wake boat operating only in cruising mode toured the lake for one afternoon and exited, but only after the operator violated the 200’ rule and recklessly ran the boat too fast and too close to shore, causing a frightening safety incident that endangered a person and damaged property. We petitioners and our supporters are deeply concerned that introducing wakesports on this small lake will undoubtedly lead to serious safety issues and conflicts of use that would severely interfere with the lake’s historically normal use recreational activities.

1.1 Size: Shadow Lake is a beautiful body of water spanning 217 acres with a maximum depth of 139 feet. It is one of the most crystal clear lakes in the state and one of the most peaceful spots to relax. A DEC-designated 86.2-acre wake sports zone covers nearly the entire lake except the 500' buffer, occupying almost half the lake area.



1.2 Public Safety: Ensuring public recreational safety is paramount at all times on Shadow Lake. **The new UPW Rule § 3.8, "Wakesports," fails to address safety concerns that threaten the well-being of the lake users**. It is imperative that we take necessary measures to ensure that everyone can enjoy the lake and its surroundings without endangering themselves or others.

Wakesports, especially on small lakes, are not an appropriate mix of water-based recreation and are fundamentally incompatible with the safety of traditional normal-use activities. The intersection of the recreational use of wakesports with traditional normal

use recreation on this small lake poses an unreasonable and unacceptable threat to the public's safety while engaging in normal use recreational activities. The proposed DEC-designated 86.2-acre wake sports zone will cover the entire mid-lake region. This zone will take up almost half of the lake and usurp the deep-water space, historically used for a mix of traditional normal use recreation activities and should not be monopolized by a single interest niche sport. The powerful wake energy generated by wakesports will render the lake unsafe for all normal recreational activities, which take priority over the non-normal recreation use of niche wakesports.

Wake boats are specifically designed to artificially create large and powerful ocean-like-sized wakes that present unique safety issues. Wakes consist of a series of individual waves referred to as a “wave packet” or a “wave train.” The most important wave train parameters include maximum wave height, total wave train energy, and peak wave train power. Power is considered the most important parameter because of its harmful and destructive impact on the shoreline, other boaters, swimmers, water quality, wildlife.

When wake boats operate in wake surf mode, the boat's large bow is raised to "plow" the water, limiting the operator's forward visibility and line of sight, creating blind spots, and increasing the risk of accidents and injuries for people in or on the water. There have been numerous reports from Vermont residents on different Vermont lakes and across the country who have voiced alarm after a wake boat almost hit or ran over them because the boat operator did not see them in the water!

Due to Shadow Lake's limited size, the 86.2-acre wakesport zone covers the entire mid-lake area and takes up almost half the lake, allowing wakesports high-energy activities to dominate this lake and usurp the deep-water space that has always been traditionally used and enjoyed by normal recreational activities for generations of lake goers.

Throughout the summer, Shadow Lake residents and visitors enjoy heading to and actively using the middle of the lake for recreation. Many people revel in their ritual swims across the lake and back, sailors tack through the wind, paddlers quietly crisscross the lake at random, and most boaters stop to drift in mid-lake to savor the calm water

and tranquility, take in the beautiful scenery, listen to and observe the Loons, watch the Osprey and Bald eagles fishing or soaring overhead, soaking up some sun, and take a resplendent deep-water swim. Shadow Lake is a popular destination for many open-water swimmers training for marathons, and rowing shells often practice on the lake due to its relatively calm waters. Wake sports activities with powerful waves will disturb the pleasant enjoyment of these relaxing and fun summertime-honored lake pastimes. Wakesports' intense surf wakes and resulting wave train energy and power can easily endanger highly vulnerable swimmers, swamp or capsize lightweight paddle craft and small boats, hinder or disrupt other recreational activities, and crowd out or entirely exclude all normal-use recreation. Therefore, wakesports activities are not shared or equitable and will constitute an irreconcilable use conflict on Shadow Lake. UPW Rules 2.6(a) Use conflicts shall be managed in a manner that provides for all normal uses to the greatest extent possible consistent with the provisions of Section 2.2 of these Rules.

A single wakesurf sports activity would create unsafe conditions across most of Shadow Lake and an imbalance of equity for lake users' safe access to and enjoyment of normal use recreation. *(See Appendix A; Illustration of Shadow Lake Map Wakesports and Public Safety)*

When two or more wake sports occur on the lake simultaneously and in proximity of each other their wakes can intersect and combine in an additive effect *(constructive interference)*, creating enormous, high-power magnitude waves that are more hazardous than the waves generated by a single wake surf boat.

Vermont law requires all motor boats to stay 200 feet away from other boats or people in the water unless operating at "no-wake speed" (<5 mph). The 200-foot rule was written long before wake sports became popular, with boats specially designed and operated to make the biggest wake possible. The new UPW Rule § 3.8 (d) requires wake sports to operate 500 feet from shore and yet permits the operation of these extraordinarily heavy, ballast-laden watercraft with an inordinate capacity to hydraulically displace large volumes of water to generate 3-5-foot height surf wakes and their resulting unrelenting barrage of powerful kinetic energy wave trains in the wake sports zone to take place at a dangerously close distance of only 200 feet from other vulnerable boaters and people in the water, which creates a significant hazard to public safety and makes no common sense.

The kinetic energy associated with water waves grows exponentially in response to increases in wave height. A wave that crests at a height of 8 inches, for example, has four times greater kinetic energy than a 4-inch wave and sixteen times greater kinetic energy than a 2-inch wave. (Brown, 2021) *from Exploring Our Fluid Earth - Teaching Science as Inquiry.*

In deep water, the waveform is unaffected by water depth, causing waves to react more forcefully than they would on gradually sloping lake beds. Surf wakes have more extended wave periods and, therefore, have more wave energy. Wave packet power, the biggest wave in deep water, moves faster and is stronger in deep water than in shallow water because there is no friction with the lake bed, which causes waves in the water to slow down and lose energy (Goudy and Girod, 2015).

According to the University of Minnesota Saint Anthony Falls Laboratory (SAFL) (Marr, et al., 2022) study, at 200 feet, wake surf boats exert more destructive power than a typical water ski boat.

- The surf wake height was 13-inches at 200 feet,
- 500 feet was needed for the height of wake surfing waves to be equivalent to 200 feet for a typical cruiser or ski boat,
- Over 600 feet (the maximum distance in which the study measured waves) was needed for their power to be equivalent, and
- The waves produced by wake boats were 2–3 times higher, had 3–9 times more energy, and were 6–12 times more powerful than a typical motorboat.

Per p. 88-90 https://conservancy.umn.edu/bitstream/handle/11299/226190/BoatGeneratedWakeWaveReport_Feb12022_Final.pdf?sequence=1&isAllowed=y

Even the boating industry's Water Sports Industry Association (WSIA), which funded Goudey and Girod's (2015) study's data from (p. iii and iv), is similar to that of the University of Minnesota. At 200 feet, the wake height is almost 16-inches. https://www.wsia.net/wpcontent/uploads/2020/03/WSIA_draft_report_Rev_II.pdf

		Maximum wave height (in)			
Distance from track (FT)		0	100	200	300
Cruising	Shallow	15.42	10.16	8.83	5.09
Cruising	Deep	14.54	9.95	7.19	6.32
Wakeboard	Shallow	21.82	11.18	9.13	6.93
Wakeboard	Deep	22.46	13.63	10.10	9.87
Wakesurf	Shallow	27.83	11.75	9.63	5.91
Wakesurf	Deep	26.14	19.88	15.89	12.92

Wake surfing in deep water is the exception and it takes 300 feet for the wave height to drop by half of its original 26" height.

(The above Goudey and Girod's table include wakesurf deep water wave height is almost 16" at 200 feet away. The study's shallow water lake data is not applicable; all their boat runs were done in water just 8 to 10 feet deep, so most of the wave energy went to friction with the lakebed. Shadow Lake profiles better match Goudey's deeper lake.)

It is important to note that the SAFL and Goudey studies only measured the wake height of a single wake surf boat and did not measure several wake boats when operating concurrently in the same area. Both studies also used older wake boat models that were

lighter, carried less ballast, had only four passengers onboard, and ran less powerful engines than the boats currently being sold.

Gregor Macfarlane Report 18WW01 wave study found that wave energy from ballasted wake-surfing craft was 5–17 times higher than a benchmark speedboat. MacFarlane, et al., 2018 per p.18
https://static1.squarespace.com/static/5a0ba0f9e5dd5bce46ef4ed2/t/5c01dec34d7a9cb0b6f25937/1543626456377/AMC+Wave+Wake+Study_HB4099+Motorboat+Working+Group+REPORT.pdf

Based on the State's own safety rule of "no-wake-speed" within 200 feet of other vessels, plus the fact that more than 500 feet for surfing is equivalent to 200 feet for other boating, it is reasonable to expect that when wakesurfing, they need to stay more than 500 feet from other boats and people in the water when operating in the DEC wake sports zone on Shadow Lake. However, this is not even possible on a lake as small as Shadow Lake; as shown on the attached illustration map, there is nowhere else that another boater could be safe from the large, dangerous waves of one surfboat.

Other boaters anywhere on the lake would experience waves more dangerous than those 200' from a non-surf boat:

	200' from non-surf boat	*200' from surfing boat*	*500' from surfing boat*
Wake height	*6"*	*13"*	*7"*
Total wake energy, J/meter	*1000*	*4000*	*1800*
Max wake power, J/m/sec	*30*	*260*	*80*

When wake boats in surf mode pass close to the shoreline safety zone, nearshore swimmers and paddle craft will encounter larger waves than usual, especially when 13-inch-high wake surf waves at the 200-foot mark and their wave packet action hit them. These wave heights could be enough to swamp or capsize many. Even if kayakers, paddleboarders, and row boats for safety hug the shore from being crowded out by this dangerous sport, they will still be hit with more powerful waves than if a ski boat was 200 feet away.

UPW Rules 2.2(b) ***"The public waters shall be managed so that the various uses may be enjoyed in a reasonable manner, considering safety*** *and the best interests of both current and future generations of citizens of the State and the need to provide an appropriate mix of water-based recreational opportunities on a regional and statewide basis."*

Lake residents and the general public frequent Shadow Lake's public beach, a popular summer gathering place for locals and tourists alike to enjoy the Lake's clean water and scenic beauty. On any day during the summer, as many as 80 people can use the beach

and recreate in the Lake. The safety of vulnerable individuals such as children or inexperienced lake users, older people, and those with disabilities is a major concern. As the surf wake arrives at the beach swim zone and travels towards the shore, they still have enough energy and power to cause someone in the water to lose their balance or overpower a child swimming.

Due to certain variables, not all wake sports boats will be able to maintain the 500-foot buffer requirement. There may be situations, especially when the lake is crowded, where a wake surf boat needs to go beyond the boundaries of the wake sports zone to avoid collisions or individuals in the water. As the number, size, and power of wake boats steadily increase, the safe distance from other people on the lake will also need to increase.

The only rational way to protect people from exposure to the hazardous waves generated by wakesports and huge, heavy wake boats and the probability of safety risks is to prohibit wakesports activity on Shadow Lake. Nobody wants their kids on a paddle board out in the middle of the lake when wakesports start up.

1.3 PWC Rule: A state rule enacted by the Vermont Department of Environmental Conservation on May 1, 1995, prohibited personal watercraft (PWC) from operating on inland lakes with fewer than 300 acres due to noise and public safety issues.

Shadow Lake, at only 217 acres, has prohibited PWC/jet skis for over two decades and is one of only 6 lakes out of the 30 designated with a wakesports zone that is free from aquatic invasive species and prohibits jet skis. The design of a wake boat is unlike any other vessel used on inland lakes when the original boating laws were adopted. There was no way to predict the need for changes, much like when personal watercraft became popular and needed specific regulation.

The Shadow Lake Association Board and the Glover Select Board, as petitioners, strongly believe that when state officials deem the use of PWCs as incompatible with the traditional normal recreation uses, aesthetic values, and quiet solitude of this lake, the same priority principle should also apply to prohibiting wake sports and their huge, dangerous wakes as an incompatible use on Shadow Lake. Wake surf boats with loud, oversized 350 to 650 hp engines are much noisier and more disruptive to the lake's natural, peaceful tranquility than a jet ski. Furthermore, wake sports have a well-documented range of adverse impacts on the lake environment and near-shore habitat ecology; they damage property and disturb wildlife, and their ballast tanks are at high risk for transferring AIS. Besides, and most importantly, the powerfully enhanced wakes generated by wake surf boats pose more significant public safety risks that conflict with normal use recreation.

1.4 Dam Condition: Glover's dam at Shadow Lake dates to the 1800s. The 1927 flood caused the dam to breach, and its condition has significantly deteriorated over the decades. The dam has undergone thirteen inspections since 1952, with the most recent in 2023. The SLA Dam Safety Committee estimated that the 2023 water level was 4 inches above the auxiliary spillway, meaning the lake rose 22.2 inches above the normal pool of 1,394.6 feet. This extra volume takes additional time to leave the lake and is a stressor on the shorefront and its structures. The main concern about the dam's impact is the continued high water levels during springtime and summer, which negatively affect the shoreline stability and lakeshore properties.

The State of Vermont conducted 7 dam safety inspections from 1984 to 2017. The majority of the inspections rated the dam as “in poor condition.” Three hydrologic and hydraulic assessments of the dam, in 1991, 2019, and 2023, were also conducted to assign a "Class 2-Significant Hazard Potential" rating. If the dam were to breach, it could cause economic loss, environmental damage, destruction of property, disruption of lifeline facilities, or impact other concerns, the most crucial of which is the safety threat to people living downstream of the dam.

The dam does not meet the DEC’s dam safety program for hydraulic adequacy and repairs are recommended. These concerns include maintenance problems with vegetation, seepage under the auxiliary spillway, and the need for an Emergency Action Plan (EAP). The last inspection suggested three conceptual alternatives to address the hydraulic deficiencies. These options deal with altering the dam spillway to address the excessive volume during springtime conditions. Due to the deficiencies, the gate valve should be fixed so it is fully open. It is currently stuck at 40% open. The debris rack should also be redesigned as it obstructs 50% of the opening at the water level below the dam building. *(See Appendix B; Dubois & King, H&H Shadow Lake Dam Assessment) (See Appendix C; DEC Shadow Lake Dam Inspection Report)*

Climate change, increased rainfall, fluctuating lake high water levels, higher ice out height, and flooding have all put additional pressure on the dam. Additionally, wakesports wakes and resulting wave train action create intense energy and power water flow that can exert pressure on the dam to potentially further compromise the dam's integrity.

1.5 Water Quality: Shadow Lake is a pristine, oligotrophic lake that is considered one of the most beautiful lakes in the state. This lake is known for its clear water and is eligible to be classified as an A(1) lake. Water clarity is an important indicator of the lake's trophic status and plays a critical role in supporting the aquatic ecosystem. The 2023 summer average for Secchi Transparency Summary for inland lakes in Vermont revealed that Shadow Lake is the fourth clearest lake in the state.
The transparency of a lake’s water is directly related to the amount of materials

suspended in the water. When wake surf waves hit the lakebed as they dissipate toward shore, the shoaling action can still cause lake bottom disturbance and turbidity through sediment resuspension, releasing nutrients and pollutants that harm the lake environment and ecology. Sediment deposition and accumulation contribute to the degradation of desirable natural features such as firm sandy bottoms situated in shallow, gradually sloping beach areas of inland lakes such as designated for public swimming of phosphorus in the lake, which can result in or exacerbate cyanobacteria blooms, to potentially harm public health, pets, wildlife, and the lakes' diverse array of insects, mussels, amphibians, and fish.

Shadow Lake has two lake volunteers trained to monitor for cyanobacteria with the Lake Champlain Committee which performs weekly testing. This program provides critical data on where and when blooms are happening and helps inform public health officials as to whether the water is safe for swimming or household use. In the summer of 2023, Shadow Lake experienced its first-ever cyanobacteria bloom, recorded as a Level 2 alert. If the bloom had persisted or worsened, this could have resulted in cautions for lake recreation or the closing of the public beach. If the trend of cyanobacteria bloom persists, it could lead to water quality degradation and lake water contamination to restrict swimming and household use. Climate change, environmental conditions, and lake-stressor activities, such as wakesports resuspending sediments, can increase the potential for future blooms.

1.6 Aquatic Invasive Species: After a costly and lengthy concerted effort, Shadow Lake has become one of the few Vermont lakes that have successfully eradicated Eurasian watermilfoil. As one of the few remaining lakes in Vermont with exceptionally clear water quality with an AIS-free status we ask for greater state protection.

Wake boat ballast tanks are considered high-risk vectors for containing, transporting and potentially spreading numerous aquatic organisms, pathogens and a destructive array of AIS. There are no nationwide standards for decontaminating ballast tanks. The DEC's current decontamination plan for ballast tanks involves rinsing with hot water for only 3 minutes, and it's doubtful whether this protocol is as effective as a full flush for each tank. The DEC initially proposed enlisting more well-equipped marinas and sophisticated car washes to perform decontamination. Instead, the DEC's plan now burdens and strains the small boat wash operations available at only a few lakes. Now, the responsibility rests solely on our local Greeters, who will need a relatively in-depth understanding of the anatomy of wake boats and various types of ballast tanks, advanced decontamination techniques and a high level of expertise. Despite all best intentions, there is no guarantee of a 100% kill rate for all AIS stowaways in ballast tanks.

Spiny water fleas *(Bythotrephes longimanus)* will be right at home in Shadow Lake to outcompete small fish for zooplankton, posing a threat to the lake's ecosystem and altering the aquatic food web.

There is currently no known effective method of human control for spiny water fleas or the Dressenid mussels.

Photo Credit
Emily Debott

photo credit Wyoming
Game and Fish Dept.

Different states and regions outside Vermont lack comprehensive sampling programs focused on early AIS detection and have varying standards of decontamination protocols. Wake boats arriving to access Vermont lakes and ponds with an out-of-state proof of decontamination receipt may not ensure all ballast tanks are 100% AIS-free.

We do not know which lakes in other states are or are not infested; many have AIS not yet found in Vermont, and their decontamination procedures could be outdated. Literally, anything that is small enough to pass through the ballast water intake pump of wake boats, including bacteria, invertebrates, and/or the eggs, cysts, larvae, and veligers of a diverse and potentially destructive array of exotic aquatic species are capable of surviving for long periods of time in ballast water, and of eventually being released into un-invaded waters where they are often capable of flourishing in their new environments (Surangi, 2019).

Our boat wash station is now designated as a DEC wake boat decontamination station that will draw wake boats and wil likely increase the prevalence of wake boats entering Shadow Lake. **It only takes 1 wake boat with insufficient ballast decontamination to cause an AIS infestation and ruin this lake for current and future generations.**

1.7 Fishing: One of the many normal uses popular at Shadow Lake is fishing.
The petitioners strive to protect the lake's fisheries and trout population. Shadow hosts a Vermont State Fish and Wildlife fishing access. Shadow Lake is a 139-foot deep, cold, clean lake that supports Lake and Rainbow trout. Native lake trout flourish in the deepest and cleanest lakes and are commonly referred to as bio-indicators, meaning they require high water quality to survive and increase their population.

Some of the lake's best fishing areas are within the designated DEC wakesport zone. Wakesports waves and turbulent wave train action will disturb the quiet lake surface and negatively affect fishing and directly conflicting with trout fishing. Anglers who slowly troll for trout often fish from one end of the lake to the other, right where the

wakesport zone is, and will be exposed to enhanced wake dangers to likely drive them from the water. The small 12 and 14-foot aluminum fishing boats preferred by many anglers and commonly found on the lake could easily be swamped or capsized. Wakesports waves will make fishing unpleasant and prevent the enjoyment of good fishing on Shadow Lake.

Even with the 500-foot distance from shore, wakesports wave train power can still affect the lakebed's shallow water habitat which is a critical nursery zone for all lake life, by churning up sediment, releasing legacy phosphorous and decreasing water clarity. Turbidity can harm fish habitats. It can reduce fish's ability to spawn and find food, clog their gills, cover their eggs with silt, and negatively affect their overall health. Moreover, the long-term effects of the loud sound of wakesports motors and powerful waves on fish populations are still unknown.

1.8 Loons: Shadow Lake is a critical habitat that supports loons, a much-beloved beautiful bird for its iconic haunting calls, intriguing behaviors and longevity as returning sentinels of their chosen lakes.

Lorna Kane-Rohloff from Glover captured this photo during a mid-afternoon rowboat ride on a nearby lake.

The Shadow Lake Association proudly supports the Vermont Center for Ecostudies (VCE) Loon Conservation Project. Loon biologist Eric Hanson and a dedicated volunteer from the lake teamed up to construct and install a loon-nesting platform anchored in a quiet cove to provide a suitable nesting location for our resident pair of mating loons. Human recreation and large waves causing water fluctuation can disturb mating loon pairs' nest sites and cause them to flush from the nest, leaving vulnerable eggs to predators or overheating. Wake surf disturbance may also cause them to abandon their nests, resulting in the death of their eggs or chicks. Wake surf waves have been shown to violently rock loon platforms, which can dislodge their eggs and cause them to roll into the water and die. Loon chicks out on the open water are particularly vulnerable to being washed over and overcome by oversized waves easily.

1.9 Shoreline Erosion: Shadow Lake's shoreline stability is compromised by continued high water levels well above normal pool during spring and summer due to limited dam functionality and the recent impacts of the 2023 flood. Frequent high-velocity

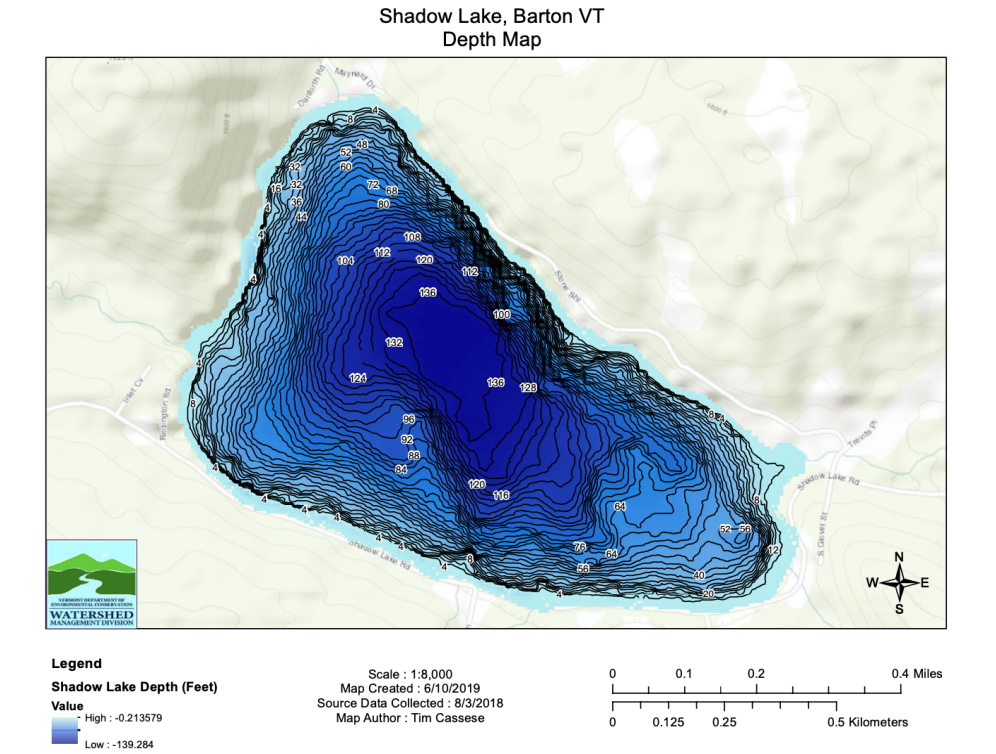
stormwater events and inadequate stormwater management have caused severe erosion and cumulative sediment deposition along several shoreline areas, leading to significant shoreline impairment.

The largest of the severely aggrading deltaic mounds of exposed gravel, sand, mud, and silt measures over 75' X 75' from the culvert daylighting at the shoreline, and the plume of muck and silt extends well over 100 feet outward beneath the lake's surface and laterally. The sediment volume is unstable and will be easily disturbed by the wakesports wave trains power exceeding 100 j/s/m as they hit that vulnerable area. Strong wave disturbance will easily cause the sediments to resuspend, exacerbating phosphorus, heavy metals and pollutants released, that can contaminate the lake and contribute to our rising phosphorous trend, leading to water-quality problems and eutrophication.

Lake Watershed Action Plan Phase 1 for Shadow Lake - drone photo of shoreline area identified as a priority restoration project

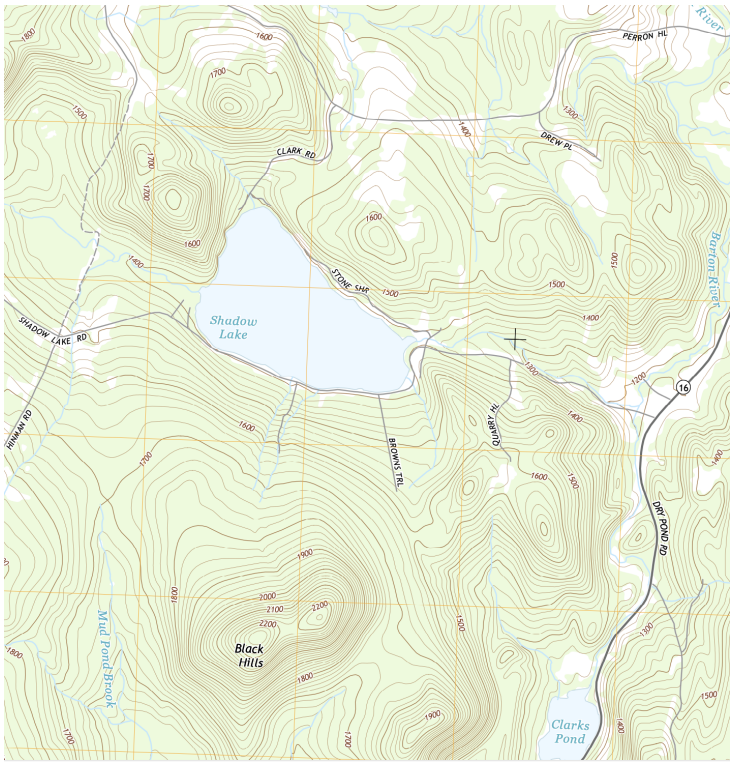
The lake's shoreline is also generally in poor condition because of the high population density of houses close to the water. *(see Vermont Inland Lake Scorecard for Shadow Lake)* Due to Shadow Lake's relatively small size, wake sports wave trains multiply the wave energy and power that crashes into the shoreline, which can accelerate erosion. The characteristics of the shoreline itself influence the impact of waves on shorelines, and relevant for shore erosion is the maximum wave power.

Waves react more forcefully when they encounter steeply rising shorelines, as opposed to gradually sloping lake beds. When wakesurf energy and power crash into a steep shoreline, it reflects back into the lake and laterally towards neighboring properties.



Mercier-Blais and Prairie (2014) concluded that significantly more enhanced wake energy dissipates before it reaches the shore in lakes defined by gently sloping bottom contours, in contrast to the greater amount of wake energy that reaches the shore on lakes characterized by steeply sloping contours. Shadow Lake has areas of gentle slope and steeply sloping contours, with approximately a half mile of very steep shoreline along the north shore. Additionally, most of the lakeshore properties have boats, docks, and rafts, and several camps and boat houses are built on piers extending into the lake that are especially vulnerable to oversized wake action. Frequent exposure to wakesports, high-impact waves, and turbulence will likely intensify shoreline erosion issues and potentially cause property damage.

1.10 Topography: Shadow Lake is surrounded by high hills on all sides, resulting in sound retention. The loud, throaty sound of wake boat 350-650 hp engines and wakesports often loud music will bounce off the hills and reverberate across the lake, causing increased noise pollution that will disturb the peace and tranquility of our small lake, which has been cherished and enjoyed for generations.



USCS Topo map detail Shadow Lake

1.11 Enforcement: Most lakes in the Northeast Kingdom are rarely patrolled. Shadow Lake only has one game warden responsible for enforcing fish and wildlife, boat, ATV, traffic regulations, and general criminal laws for 11 towns in the Northeast District. Consequently, response times for enforcement calls to Shadow are typically slow unless the warden is nearby. If wake sports are prohibited, the need to call for enforcement for wake sports safety and or distance violation becomes zero, thereby relieving the strain on game wardens, sheriffs, or the State Police marine division.

1.12 Economy: The value of the lake is in its water quality, the health of its ecosystem, and its beauty as a natural feature. Maintaining the economic benefits of Shadow Lake's healthy ecosystem and shorelands is crucial for Glover, the State of Vermont, and its citizens. The residents of Shadow Lake support several businesses in the region. These include grocery stores, restaurants, and shopping venues. Allowing wake sports on Shadow Lake, which are known to cause an array of adverse impacts on small water bodies, will likely contribute to the degradation of the lake's clean water quality and negatively affect the value of lake properties. High-powered enhanced wakes can cause shoreline property damage, and the adverse effects of wake sports will occur over time, leading to a compromised lake ecosystem in the long run. These negative impacts will reduce the use of the lake by residents, surrounding communities, and our many visitors for normal-use recreational activities. If swimmers, water skiers, pleasure boaters,

sailors, kayakers, anglers, and others can no longer safely enjoy recreating on Shadow Lake, or the water quality degrades, the property values and local business income will plummet. The 110 homes and camps on Shadow and other properties around this lake significantly contribute to town taxes. If the lake community properties become compromised, their values will decrease, resulting in less tax revenue for the town of Glover, for which the town's local homeowners and businesses must compensate.

Wakesports represents the fastest-growing and most profitable segment of the recreational boating industry. The boating industry aggressively markets new boat designs with advanced technology to create the largest wave possible. As the upsurge of these more powerful wake surf boats arrive and damage the lake, there is more potential for detrimental economic effects.

ECONOMIC IMPACT ANALYSIS

Shadow Lake's natural environment is a uniquely valuable and important resource of unspoiled natural beauty within the Northeast Kingdom. If the rule requested by this petition is adopted, the petitioners and the Town of Glover believe that there would be no economic impact because the rule would result in a continuation of the status quo. Restrictions on boating activities, such as the PWC rule, have not negatively impacted property values around the lake or tourism, primarily when those restrictions, like a wakesports prohibition, will protect the waterbody and its ecosystem.

If the proposed rule of this petition is not adopted, wakesports may have severe consequences for Shadow Lake and its neighboring community. The petitioners strongly believe that allowing enhanced wakes on this small lake would pose a hazardous risk to public safety, put additional pressure on an already compromised dam, jeopardize shoreline property structures, cause adverse impacts to shoreline and shoreline restoration efforts, damage near-shore habitat, cause sediment dispersal, and potentially release phosphorus into the lake. Wakesports may increase algal and Cyanobacteria blooms, and the introduction of aquatic invasive species will cause irreparable harm to the lake's ecosystem.

Preserving Shadow's clear, clean water quality will be at risk, and wakesports may disrupt wildlife and threaten loons' safety and conservation efforts. The loud motor noise will ruin the tranquility of the lake, diminishing the lake's attraction for trophy fishing and driving away tourists. The hazards of wakesports will preclude all traditional normal-use water activities. The lake will lose appeal as more wakeboats will be drawn to the lake due to the proximity of our boat wash as a wakeboat decontamination station. Property values will eventually decrease, and the local business community will see economic loss. The magnitude of the negative impacts of enhanced wakes on Shadow Lake cannot be overstated. This lake community, well-known for being very friendly and supportive, will lose its sense of place and may turn to confrontation. We need to make sure we consider the environmental and social impacts thoroughly so there is no reduced enjoyment or lasting damage to our lakes.

Seasonal Residents. If wakesports are allowed on Shadow Lake, the petitioners anticipate that the wakesports activities will significantly harm the lake environment, ecosystem, shoreline, and water quality. The lake's aesthetics and traditional recreation uses would diminish, and the lakeshore properties would lose market value. Purchasers of waterfront property have long been drawn to Shadow Lake's clean water quality and peaceful quietude, including the absence of jet skis.

Permanent Residents. Glover is a small town. The current year-round population is estimated at 1114. If wakesports are allowed on Shadow Lake, petitioners anticipate the well-documented array of adverse impacts resulting from wakesports activities would inevitably harm the lake environment, eventually reducing the value of lakefront properties and likely resulting in a relative shift of the property tax burden to the town residents.

Visitors. If wakesports are allowed on Shadow Lake, the petitioners anticipate wakesport activities would be very loud and disrupt the quiet solitude of the lake. The hazardous enhanced wakes would create turbulence throughout the lake and threaten public safety while recreating on the water and swimming at the public beach, making the lake unpleasant. Visitors won't flock to the beach with their kids anymore, afraid of the giant waves or take the drive to unload paddlecraft that could easily be swamped, won't be able to fish quietly, canoe, or sail, enjoy the scenery and listen to the loons, leading to fewer visitors to the area resulting in an economic negative impact on the following local businesses:

Busy Bee Diner

Currier's Quality Market

Parker Pie Restaurant

Red Sky Trading

Local Air B&Bs

Labor of Love Landscaping

C & C grocery store

Copper Plate

River's Edge Farmstand

Parsons Dinner House

E.M. Brown & Sons Hardware

Taylor Automobile Service

Produce farms and farmer markets

Orleans County Fair

State Agencies.

Vermont Department of Public Safety. If wakesports are allowed to operate on Shadow Lake, their oversized enhanced wakes and wave train energy and power would create dangerous conditions and a recreation conflict of use covering almost the entire lake surface, warranting calls to public safety enforcement and likely straining the wardens available in the Northeast Kingdom.

Department of Environmental Conservation. If wakesports are allowed, petitioners anticipate the introduction of AIS from ballast tanks despite the best decontamination efforts. The myriad adverse ecological impacts—several of which are yet to be fully understood and require further study—will degrade Shadow Lake's ecosystem and clear water quality, likely requiring expensive mitigation and demands on DEC staff time, increasing the budgeting woes and efficiency of the lakes and ponds programs.

CONCLUSION

Shadow Lake is irrefutably too small to accommodate a wakesports zone. Adding wakesports to the recreational mix is inappropriate and will create a high level of conflict of use. The associated safety risks of injury or fatal accident due to a wakeboat or its force of wake or waves are not worth taking. We can never undo a wakesports tragedy or bring back a lost life.

As the trustee of Vermont's inland lakes, the Agency of Natural Resources is required to promote public health, safety, convenience, and the general welfare of Vermont's waters for the best interests of all Vermont citizens. Similarly, under Vermont's Water Quality Standards, the Agency must "protect the quality, character, and usefulness of Vermont's surface waters," by supporting their "designated and existing uses."

To fulfill this mandate, the Agency must manage public waters to ensure that current and future generations of Vermonters may **reasonably and safely** enjoy an appropriate mix of water-based recreational opportunities.

The undersigned, along with our supporters, strongly urge the Agency of Natural Resources to recognize the critical importance of responsibly managing recreation to ensure public safety at Shadow Lake while also protecting the quality, character, and usefulness of the lake's designated and long standing existing uses and preserve the integrity of this lake's aquatic ecosystem for the long term and in the best interests of both current and future generations of the citizens of the state and insuring that natural resource values of the public waters are fully protected.

For the foregoing reasons, petitioners request the Vermont Agency of Natural Resources to exercise its rulemaking authority and grant this petition, as it has previously done with PWC, and adopt a rule to prohibit wakesports on Shadow Lake in Glover, Vermont.

Respectfully submitted,

Phil Young
Phil Young, Glover Selectboard Chair
Town of Glover
51 Bean Hill Rd, Glover, VT 05839

Jenifer Andrews
Jenifer Andrews, President
slgvtpresident@gmail.com
PO Box 168, Glover, VT 05839
802-585-4286

Denise M. Caruso
Denise Sawan Caruso, Secretary
dmscaruso@yahoo.com
463 Stone Shore Road, Glover, VT 05839

ATTACHMENTS

Appendix A; Illustration of Shadow Lake Map Wakesports and Public Safety
Appendix B; Dubois & King, H&H Shadow Lake Dam Assessment 2022
Appendix C; DEC Dam Safety Inspection Report 2023
Appendix D; SLA Participation in State Lake Protection Programs

Appendix E; Letters of Support:

1. The Federation of Vermont Lakes and Ponds, President Pat Suozzi, letter, 2024
2. Vermont Loon Conservation biologist Eric Hanson, letter, 2024

RESOURCES

The following documents provided information that assisted in creating this petition.

- Vermont Use of Public Water Rule (UPW) https://dec.vermont.gov/sites/dec/files/documents/Use_of_Public_Waters_Rules.pdf
- USGS Topographical of Shadow Lake https://prdtnm.s3.amazonaws.com/StagedProducts/Maps/USTopo/PDF/VT/VT_Crystal_Lake_20150706_TM_geo.pdf
- Vermont Department of Environmental Conservation Lay Monitoring Program https://anrweb.vt.gov/DEC/IWIS/ReportViewer2.aspx?Report=LakesScorecardLinksTable&ViewParms=True)
- Vermont Department of Environmental Conservation (VT DEC), 2023b. Vermont Lake Score Card: Shadow Lake https://anrweb.vt.gov/PubDocs/DEC/WSMD/Lakes/Lake_Score_Cards/SHADOW%20(GLOVER).HTML
- Secchi Transparency Summary 2023 for Shadow Lake https://anrweb.vt.gov/DEC/IWIS/ReportViewer.aspx?Report=WQSummarySecchi&LocationID=504915
- Goudey and Girod (2015). Characterization of wake-sport wakes and their potential impact on shorelines. The Wave Sports Industry Association funded the report https://www.wsia.net/wpcontent/uploads/2020/03/WSIA_draft_report_Rev_II.pdf.
- Marr J. et al., (2022). A Field Study of Maximum Wave Height, Total Wave Energy, and Maximum Wave Power Produced by Four Recreational Boats on a Freshwater Lake. The University of Minnesota Digital Conservancy from the University of Minnesota Digital Conservancy https://conservancy.umn.edu/bitstream/handle/11299/226190/BoatGeneratedWakeWaveReport_Feb12022_Final.pdf?sequence=1&isAllowed=y
- Mercier-Blais S., and Prairie H. (2014). Impact assessment project waves created by type boats wake boat on the shore of the lakes Memphremagog and Lovering. University of Montreal. 6/2014 https://www.gencourt.state.nh.us/statstudcomm/committees/1434/documents/Impact%20of%20Waves%20Created%20by%20Wake%20Boats-%20Canada.pdf
- New England Chapter North American Lake Management Society, A Scientific Literature Based Review of What is Currently Known About the Adverse Impacts Attributed to the Operation of Wake Enhanced Boats on Inland Lake Ecosystems-by W. Scott Brown (2021) https://www.mcnalms.org/__static/5fc50b1413053eb4c0272d8921161238/adverse-impacts-attributed-to-the-operation-of-wake-enhanced-boats-on-inland-lake-ecosystems.pdf?dl=1
- Michigan Department of Natural Resources, Fisheries Division, Fisheries Report 37, A literature review of wake boat effects on aquatic habitat. Francis, et al., (2023) https://mymlsa.org/wp-content/uploads/2023/07/Fisheries-Report-37-Wake-Boat-Study-Official-Version-Released-on-7.28.2023.pdf
- Gregor Macfarlane, et al., Report 18WW01, 2018 https://static1.squarespace.com/static/5a0ba0f9e5dd5bce46ef4ed2/t/5c01dec34d7a9cb0b6f25937/1543626456377/AMC+Wave+Wake+Study_HB4099+Motorboat+Working+Group+REPORT.pdf

- Lake Watershed Action Plan Phase 1 for Shadow Lake Final Report - Jan 2024.pdf (with drone photo of Shadow Lake shoreline deposition) https://storymaps.arcgis.com/stories/f2da679206a4420b8bb96382f24a963b

- Exploring Our Fluid Earth - Teaching Science as Inquiry https://manoa.hawaii.edu/exploringourfluidearth/physical/waves

Re: Petition to Amend the Vermont Use of Public Waters Rules
for Shadow Lake in Glover, Vermont

as Filed on April 29, 2024 with
Peter LaFlamme, Director, Watershed Management Division
Vermont Department of Environmental Conservation

CERTIFICATE OF SERVICE

I, Jenifer Andrews, the undersigned do hereby certify that the persons and entities listed below have been duly served with a copy of the above-referenced Petition and attachments, either by U.S. mail or electronic means, on April 29, 2024, as required by Section 16 of the Vermont Natural Resources Board Rules of Procedure:

Julie Moore, Secretary, Vermont Agency of Natural Resources
julie.moore@vermont.gov

Jason Batchelder, Commissioner, Vermont Department of Environmental Conservation
jason.batchelder@vermont.gov

Sgt. Jacob Metayer, Vermont Department of Public Safety, Marine Division
jacob.metayer@vermont.gov

Town of Glover, Vermont, Town Clerk
c/o Cindy Epinette, tcglover@comcast.net

Town of Glover, Vermont. Planning Commission,
c/o Randy Williams, gloverplanningcommission@gmail.com

Orleans County Conversation District Northeastern Vermont Development Association,
St. Johnsbury, Vermont % Sarah Damsell, info@nvda.net

Jenifer Andrews

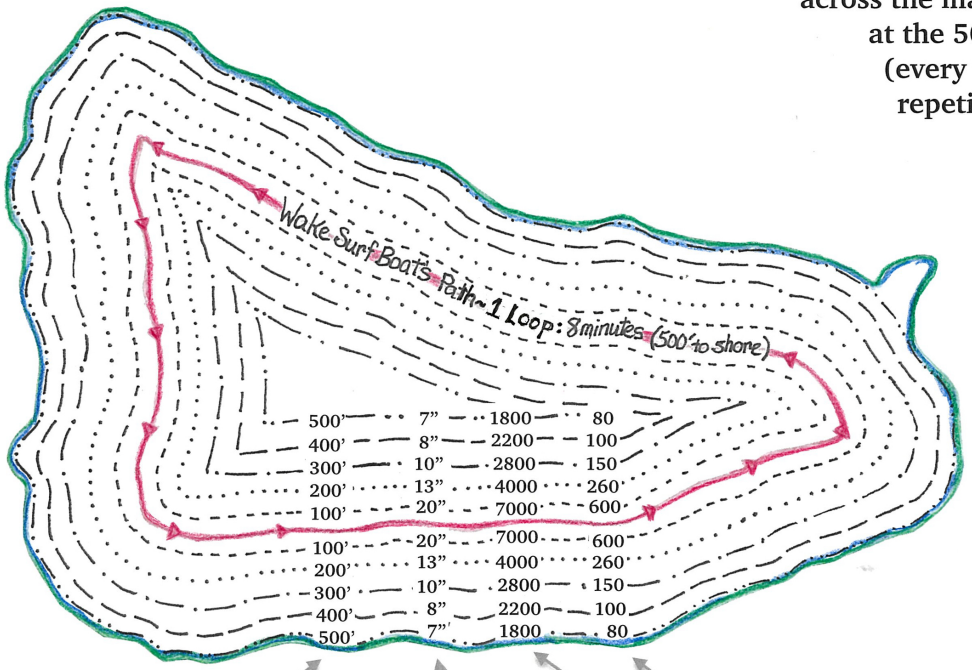
Jenifer Andrews
Shadow Lake Association
By: Jenifer Andrews, SLA President
PO Box 168, Glover, Vermont 05839
802-585-4286
slgvtpresident@gmail.com

Appendix A- Illustration of Shadow Lake Map Wakesports and Public Safety

Vermont law requires all motor boats to stay 200 feet away from other boats or people in the water unless operating at "no-wake speed" (<5 mph). The 200-foot rule was written before wakesports became popular, with boats designed and operated to make the largest wake possible (3-5' H). When intentionally magnifying the wake, the distance from others must be over 500 feet to equate to a traditional motor boat at 200 feet.

Shadow Lake, Glover

Small 217-acre deep lake, total shoreline measures about 2.58 mi. wakesports zone: 86.2-acres/the entire area inside the red loop (500' from shore) occupying almost half the lake and intended for all recreational uses making traditional "normal use" recreation unpleasant and unsafe.



Distance from wake surf boat's path

Wake height inches, compare to 6" for non-surf at 200'

Wake total energy, joules/per meter, compare to 1000 for non-surf at 200'

Wake maximum power, joules/second/meter, compare to 30 for non-surf at 200'

Data: University of Minnesota SAFL study (Marr, J., et al., 2022) p. 88 - 90

A single wake surf boat will create unsafe wakes & wave train action across the majority of this 217-acre lake when wakesurfing (11-12 mph) at the 500' buffer from shore circling the lake every 8 minutes (every 4 minutes for two wake surf boats sharing the loop): repetitive boat passes with frequent powerful wake force, creating a barrage of dangerous waves.

Paddlers and sailors would not be able to cross the lake safely before the wake surf boat loops back.

Nearly the entire lake surface will experience these waves with wake surf boats:

*Higher than 6" waves from non-surf boat 200' away

*Almost twice as much energy as the 1000 joules meter from non-surf boat 200' away

*Almost 3 times as much maximum power as the 30 j/s/m from non-surf boat 200' away

When wake surf boats are out, where is any other boater or person on/in the water Safe?

N

500' 1000'

TECHNICAL MEMORANDUM

(127862)

Date: December 5, 2022

From: Andy Hoak, PE, PG

Ali Farid, PhD, EIT, CFM

To: Andrew Sampsell, PE (VT DEC - Dam Safety Program)
Ben Green, PE (VT DEC - Dam Safety Program)

Cc: Town of Glover / Shadow Lake Association

Subject: **Shadow Lake Dam Hazard Potential Classification and IDF Selection Summary**

DuBois & King, Inc. (D&K) has completed a hydrologic and hydraulic (H&H) analysis, dam breach assessment, flood inundation maps, and evaluation of dam hazard classification of Shadow Lake Dam in Glover, VT. The dam is owned and operated by the Town and is identified by the Vermont Department of Environmental Conservation, Dam Safety Section as No. 81.02.

D&K conducted an H&H analysis of the dam in 2019 for the Town, which included an updated assessment of the hydraulic capacity using modern hydrologic and hydraulic modeling techniques and current climatology data. This analysis provided suitable technical information for use in this subsequent dam breach analysis and inundation mapping project. D&K found the hydraulic capacity of the dam and its spillway, based on the dam's current SIGNIFICANT hazard classification, and did not meet the intended performance of the Vermont Dam Safety Regulations and USACE guidelines. In 2021 the dam safety program (DSP) performed a simplified DSS-WISE Lite dam failure analysis to verify/determine if the SIGNIFICANT hazard potential classification was still appropriate due to changes in the hazard classification definitions which implemented as part of the Administrative Dam Safety Rules put into effect August 1st, 2020. The simplified DSS-WISE Lite dam failure analysis was showing that the dam was borderline SIGNIFICANT/HIGH and that a more detailed study without the limitations of DSS-WISE Lite was warranted. The DSP secured FEMA funding's to pay for the more detailed study.

The FEMA funded analysis is currently underway, and as of date, the following analyses have

been completed; dam failure evaluation of downstream impacts, hazard potential classification determination, and selection of the dam's inflow design flood (IDF). The hazard potential classification and inflow design flood selection are necessary to determine appropriate dam rehabilitation alternatives to bring the dam into compliance with dam safety design criteria.

Hazard Potential Classification Determination

D&K completed storm-day and sunny-day dam breach modeling of Shadow Lake Dam using HEC-RAS and a variety of breach parameters. The breach model covered a study area from the dam to just past the VT Route 5 bridge located near the intersection of Kinsey Rd and VT Route 5 in the Town of Barton. The breach model relied on the previously developed HEC-HMS Shadow Lake Dam watershed model for estimating unsteady hydrograph inflows at the dam and relied on USGS Stream Stats data for estimating steady state peak discharge inflows from tributaries downstream of the dam.

D&K performed the hazard potential classification assessment following the methodology described in US Bureau of Reclamation (USBR) ACER Technical Memorandum No. 11 "Downstream Hazard Classification Guidelines" (1988).

D&K evaluated potential loss of life, property damage, and environmental impacts to evaluate the hazard potential classification for Shadow Lake Dam for several storm events. Dam failure events were analyzed using storm events including the Probable Maximum Flood (PMF), 0.75 PMF, and 0.5 PMF, 0.25 PMF, 1000-yr, and 500-yr. The hazard potential classification is selected based on the storm event that results in the largest observed differential between dam failure flooding impacts, and natural (without dam failure occurring flood affects) following the methodology described in USBR ACER-11. In accordance with the DSP hazard potential classification definitions, in order for Shadow Lake Dam to be considered HIGH hazard potential the analysis would have to determine that loss of life is considered probable as a result of the dam failure flooding impacts.

Upon reviewing the results of the dam failure analysis, it was determined that during the Sunny Day dam failure event that loss of life was not considered probable, and that the controlling Storm Day failure event (the event which had the greatest incremental difference between the dam failing and the dam not failing) was failure under the 1000-yr storm. When comparing the results of the 1000-yr Storm Day failure event to the 1000-yr Storm Day non-failure event it was concluded that loss of life because of the incremental flooding difference cause by the dam failing was not probable. A summarized reasoning for this determination is provided below. However, it is first important to note that the following interpretations consistent with current DSP application of the USBR ACER-11 guidance were applied when evaluate the results.

- Loss of life is primarily evaluated at structures such as commercial business and residential homes with the thought that in all likely hood that persons standing outside will seek shelter or evacuate to higher ground. Exceptions may be applied in areas with unique circumstances such as campgrounds next to streams, or heavily populated city areas, but for the Shadow

Lake Dam failure analysis no such unique circumstances were identified.

- It is assumed by default that structures with foundations have a first-floor elevation of at least 1 foot higher than the adjacent native grade (represented by LIDAR DEM elevation data). In unique circumstances first floor elevations higher than 1-foot can be applied if it is possible to verify the data in the field. Depths used in the loss of life evaluation take first floor elevation into account.
- If the depth velocity relationship measured at an impacted structure (commercial building or home) plot with the LOW danger zone, then loss of life is assumed to be not probable.
- If the depth velocity relationship measured at an impacted structure plots within the lower half of the JUDGEMENT zone, loss of life is considered not probable, unless the application of engineering judgment indicates otherwise.
- If the depth velocity relationship measured at an impacted structure plots within the upper half of the JUDGMENT zone, loss of life is considered probable, unless the application of engineering judgment advocates for otherwise.
- If the depth velocity relationship measured at an impacted structure plots within the HIGH danger zone, loss of life is considered probable.

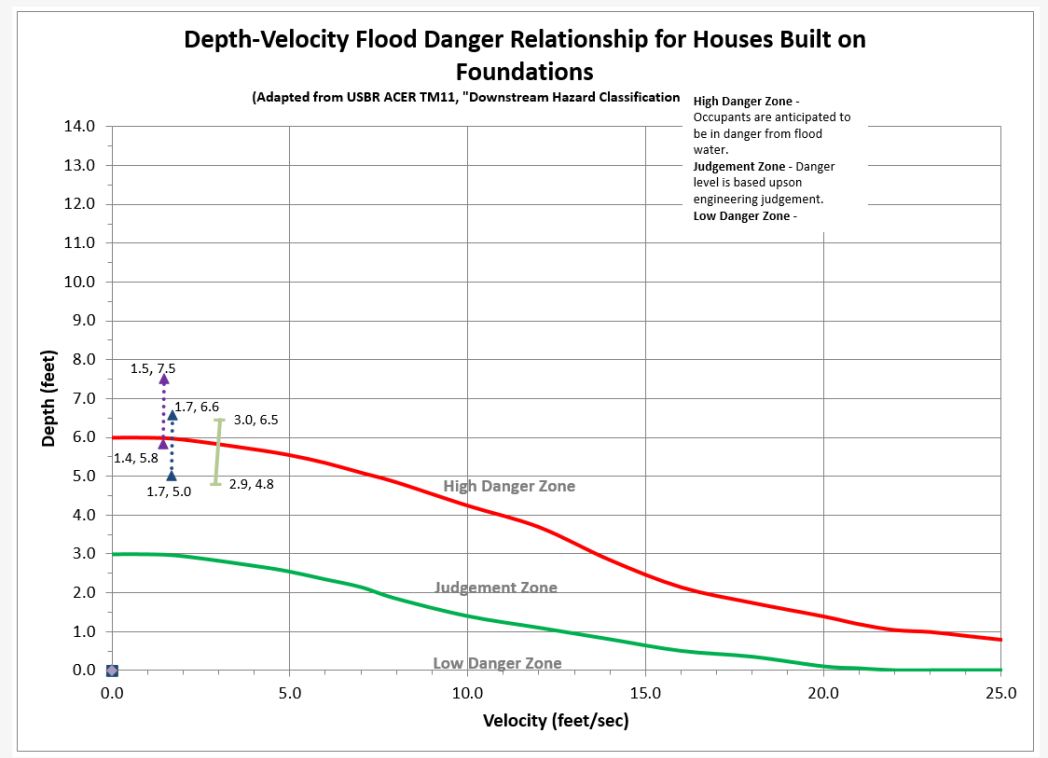
In addition, when evaluating storm day dam failure vs storm day non-failure results, in order for loss of life to be considered probable as a result of the dam failing, the incremental rise in flooding depth needs to be 2 feet or greater for structures with foundations, and 1 foot or greater for structures without foundations. This interpretation is applied to address fringe cases where insignificant increases in flooding such as a 0.1 ft rise result in loss of life being considered probable because the without dam failure depth-velocity relationship was sitting just below the dividing line between loss of life being considered probable and loss of life being considered not probable. The significance of 1 – 2 feet of incremental rise is consistent with federal guidance such as the guidance provided in the Federal Energy Regulatory Commission (FERC) Engineering Guidelines for the Evaluation of Hydropower Projects - Chapter 2 “Selecting and accommodating Inflow Design Floods for Dams” (2015).

Summarized loss of life evaluation results:

1. During the 1000-yr dam failure vs 1000-yr no dam failure comparison, three (3) structures transition from being in the JUDGEMENT zone (Yellow) to the HIGH danger zone (Red) on the USBR ACER- 11 chart. These structures, summarized in the table below, were already located within the upper half of the JUDGEMENT zone which generally indicates that the loss of life is likely. In addition, the increase in flooding depth at these structures’ ranges from 1.58 to 1.68 ft which is less than the applied 2-foot threshold for structures with foundations. Furthermore, the incremental increase in flood velocity was only 10% to 20%.

Address	Structure type	1000-yr Failure			1000-yr No Failure			Rise
		Hazard	Depth (ft)	Velocity (ft/s)	Hazard	Depth (ft)	Velocity (ft/s)	(ft)
29 Elm St, Barton, VT 05822	House	Red	7.59	1.71	Yellow	6.01	1.68	1.58
32 Glover Rd, Barton, VT 05822	House	Red	7.46	3.03	Yellow	5.80	2.90	1.66
15 S Glover St, Glover, VT 05839	Church	Red	8.51	1.47	Yellow	6.83	1.44	1.68

*Listed depth values not adjusted to account for first floor elevation.

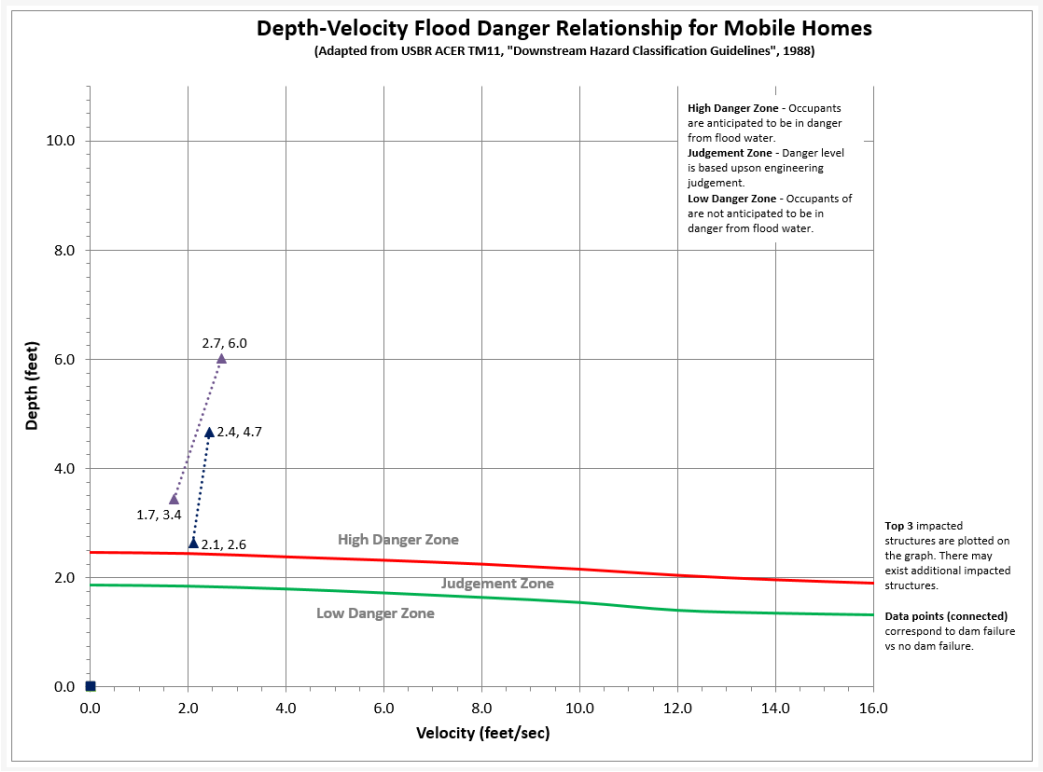


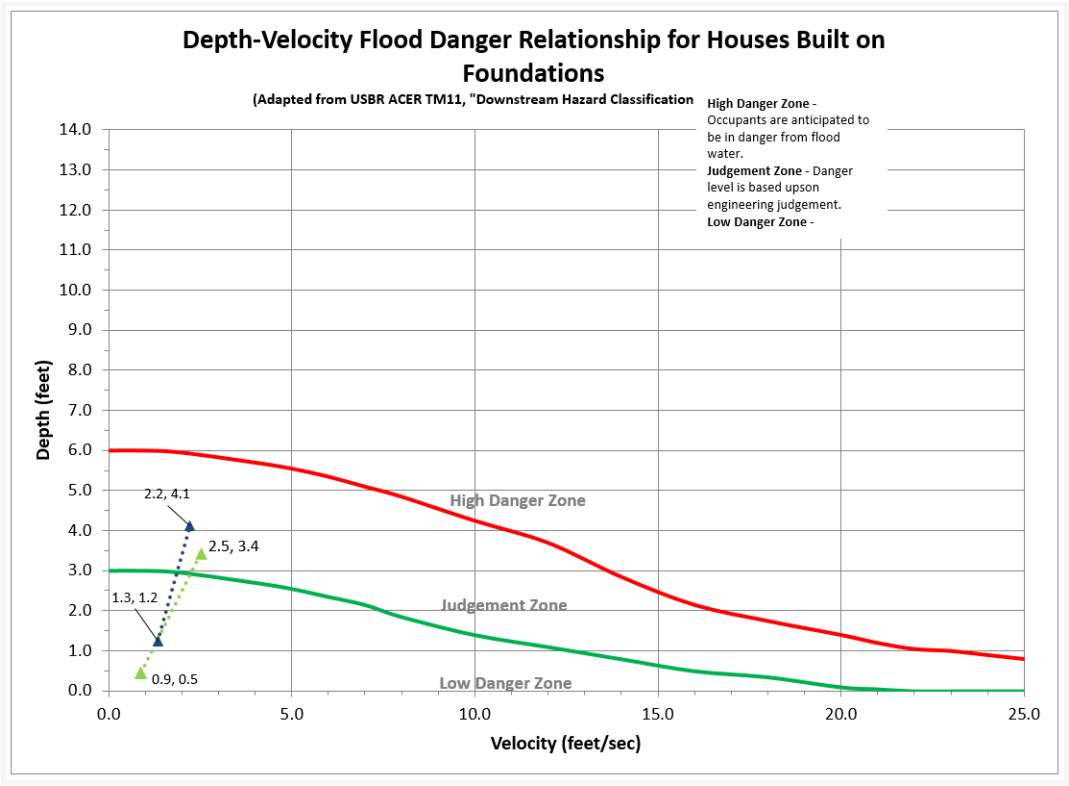
*Listed depth values show on the chart are taking into account first floor elevation.

2. During the 1000-yr dam failure vs 1000-yr no dam failure comparison, four (4) structures were identified that experience incremental flooding rises greater than 2 feet (maximum of 2.98 feet). Of these four structures, two (2) structures plotted in the HIGH danger zone (Red) with and without dam failure. The remaining two (2) structures transition from the LOW danger zone (Green) to the Judgment Zone (Yellow), but both structures end up plotting in the middle to lower half of the JUDGMENT zone, and therefore loss of life was not considered probable. See table below.

Address	Structure type	1000-yr Failure			1000-yr No Failure			Rise
		Hazard	Depth (ft)	Velocity (ft/s)	Hazard	Depth (ft)	Velocity (ft/s)	(ft)
1770 Glover Rd, Barton, VT 05822	Mobile Home	Red	4.67	2.44	Red	2.63	2.10	2.04
2513 Glover Rd, Glover, VT 05839	House	Yellow	5.13	2.22	Green	2.24	1.34	2.89
26 Talbot Ln, Glover, VT 05839	Mobile Home	Red	6.02	2.69	Red	3.44	1.71	2.58
9 Bean Hill Rd, Glover, VT 05839	House	Yellow	6.43	2.52	Green	3.45	0.89	2.98

*Listed depth values not adjusted to account for first floor elevation.





*Listed depth values show on the chart are taking into account first floor elevation.
** The two connected green dots are 9 bean hill road. This is the structure which has a first floor elevation 3 ft plus higher than native grade (by counting steps when looking at google street view). By accounting for a 3 ft above native grade the dam failure point will no longer plot in the upper half of the judgement zone.

Inflow Design Flood (IDF) Selection

The IDF is the flood flow above which the incremental increase in water surface elevation due to failure of the dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life and property (FERC, 2015). Currently in the State of Vermont the IDF is the flood at which the dam needs to be able to safely convey while maintaining a minim of 1.5 feet of freeboard, unless with measures to address overtopping. Currently the State of Vermont applies federal guidance found in FEMA P-94 “Selecting and Accommodating Inflow Design Floods for Dams” (2013) for determining the IDF for dams. FEMA P-94 outlines the following prescriptive IDFs based on a dam’s hazard potential classification.

Hazard Potential Classification	Prescriptive IDF
HIGH	Probable Maximum Flood (PMF)
SIGNFICANT	1000-yr Flood (0.1% Annual Chance Exceedance)
LOW	100-yr Flood (1% Annual Chance Exceedance)

The starting point for a dam's IDF is the prescriptive IDF outlined in the table above (1000-yr for Shadow Lake Dam). FEMA-94 then goes on out describe how the IDF can be reduced from the prescriptive IDF based on performing one of three analyses. These analyses include the following:

1. A site specific probable maximum precipitation study,
2. Incremental Consequence Analysis,
3. Risk-Informed Hydrologic Hazard Analyses.

The FEMA P-94 document states that for HIGH hazard potential dams the lower allowable threshold for the IDF is the 500-yr flood. FEMA P-94 states that the lower allowable threshold for a SIGNIFICANT hazard potential dam is the 100-yr flood. For this study, an incremental consequence analysis was performed to determine if the IDF could be reduced. This involved comparing dam failure vs no dam failure impacts for the following commonly used design flood events 1000-yr, 500-yr, 200-yr, and 100-yr. The results of the incremental consequence analysis indicated that the IDF could not be reduced to a flood frequency lower than the 1000-yr flood. This determination was made based on the incremental flooding difference between the dam failing and not failing being greater than the generally applied 2-foot allowable threshold by various federal agencies.

Existing Conditions Dam Performance

D&K re-evaluated the performance of the existing dam in reference to the IDF, and additional storm events to determine the hydraulic adequacy of the existing structure. The existing conditions hydraulic performance evaluation utilized the HEC-HMS model developed as part of the prior 2019, and 2020 analysis work. The HEC-HMS model was updated to account for the flow restriction of the wooden debris rack in front of the principal spillway structure, and also the contraction of the slide gate which partially blocks the outlet of the principal spillway. The results of this analysis are summarized in the table below. The key takeaway being that the dam is unable to maintain 1.5 feet of freeboard during the IDF, and therefore by State of Vermont standards is considered hydraulically inadequate.

Event	Annual Chance Exceedance	Precipitation Depth (in)	Peak Inflow to Dam (cfs)	Peak Outflow from Dam (cfs)	Starting WSEL (NAVD88 ft)	Peak WSEL (NAVD88 ft)	Rise in Water Surface Elevation from Normal Pool (ft)	Freeboard (+) or Overtopping (-) (ft)
24-hr PMF	-	26.00	11631	11163	1394.6	1407.8	13.2	-8.0
24-hr 1000-yr	0.1%	7.92	4728	343	1394.6	1400.0	5.4	-0.2
24-hr 500-yr	0.2%	7.08	4284	274	1394.6	1399.5	4.9	0.3
24-hr 200-yr	0.5%	6.88	3796	264	1394.6	1399.4	4.8	0.4
24-hr 100-yr	1%	5.40	3272	155	1394.6	1398.3	3.7	1.5
24-hr 50-yr	2%	4.82	2875	117	1394.6	1397.9	3.3	1.9
24-hr 25-yr	4%	4.28	2496	84	1394.6	1397.5	2.9	2.3
24-hr 10-yr	10%	3.55	1983	44	1394.6	1397.0	2.4	2.8
24-hr 5-yr	20%	3.02	1617	21	1394.6	1396.6	2.0	3.2
24-hr 2-yr	50%	2.38	1171	9	1394.6	1396.1	1.5	3.7

Preliminary ideas/concepts on the alternatives

Now that the dam hazard potential classification, inflow design flood, and hydraulic performance have been established. The task remains to develop conceptual alternatives to address design deficiencies such as the inability of the dam to safely convey the IDF. Additional concerns have been voiced about the dam's ability to pass smaller, more frequent flood events such as springtime snow/ice melt/rain events, which result in lake level rises and damage to lakefront properties. In 2021, D&K performed a study for the Shadow Lake Association which evaluated the ability of the dam to handle springtime snow/ice melt/rain events. The study found that principal spillway had a limited discharge capacity/ability to drawdown the lake level back to the normal pool elevation, making the dam and surrounding lake front properties susceptible to extended duration or back-to-back flood events. The conceptual alternatives are to address

hydraulic performance concerns while attempting to balance the downstream consequences of releasing water, and the upstream impacts of storing water. Some preliminary ideas regarding the alternatives are listed below:

1) Lowering the auxiliary spillway crest to the principal spillway crest to make the dam "run of river": D&K estimated the increased hydraulic capacity of a widened spillway from its current 15-ft to 40-ft would be approximately 1190.3 cfs at 1.5-ft of freeboard (peak elevation of 1398.3 ft). Also, the principal spillway should be redesigned (removing the operated gate/rack and increasing discharge capacity for both inlet and outlet controls). As such, lowering the auxiliary spillway crest level and increasing discharge capacity for the principal spillway during the IDF is considered practical and would likely achieve the needed results. Figure 1 depicts this option. This configuration is using an Ogee weir with a discharge coefficient of 3.8.

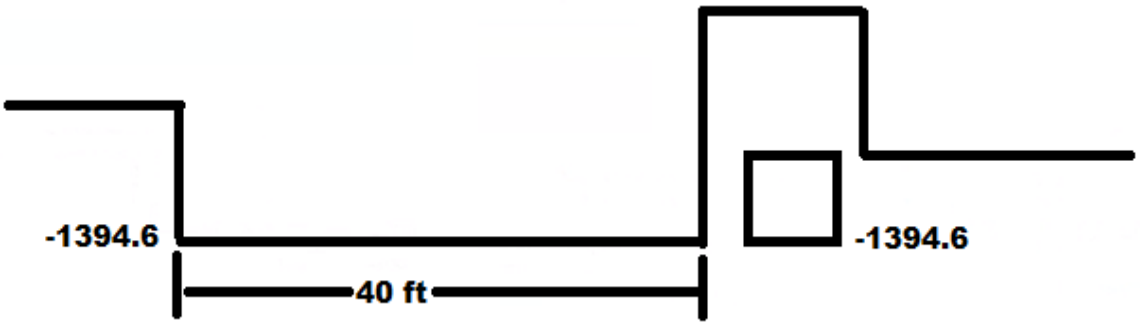


Fig.1. Alternative 1

2) The stepwise shape of the auxiliary spillway crest: D&K estimated the increased hydraulic capacity of a widened spillway from its current 15-ft to 105-ft would be approximately 1614.4 cfs at 1.5-ft of freeboard (peak elevation of 1398.3 ft). The auxiliary spillway consists of three parts (Figure 2). These sections are middle (Width: 15-ft, Elevation: 1395.0 ft), right, and left sides (Width: 45-ft, Elevation: 1395.5 ft). In addition, the principal spillway should be redesigned (removing the operated gate/rack and increasing discharge capacity for both inlet and outlet controls). Figure 2 illustrates this alternative. This configuration is using an Ogee weir with a discharge coefficient of 3.8 for middle part and a broad crested weir with a discharge coefficient of 2.7 for right and left sections of the auxiliary spillway.

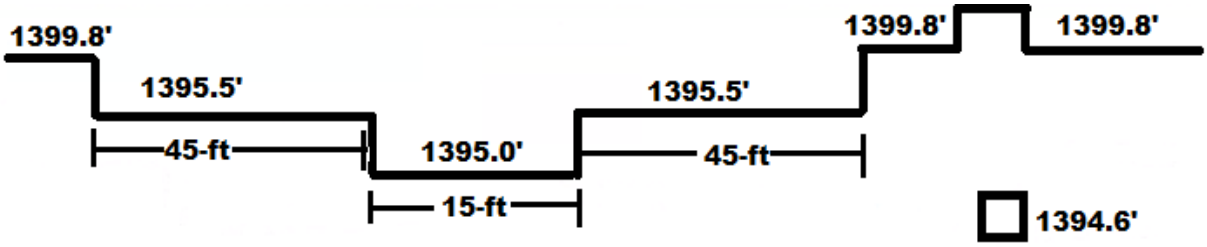


Fig.2. Alternative 2

3) Keeping the auxiliary spillway crest elevation and width (Width: 15-ft, Elevation: 1396.2 ft) as existing and modifying the principal spillway by removing the operated gate/rack and increasing discharge capacity of widened inlet and outlet controls from its current 5.2-ft to 6.7-ft and lowering the principal spillway crest from its existing 1394.6 ft to 1392.5 ft (Figure 3). Lowering the principal spillway crest level and increasing discharge capacity for the principal spillway by increasing the size of inlet and outlet controls during the IDF results in 0.2-ft of overtopping depth. This alternative considers overtopping discharge that touches the left and right abutment of the dam. Therefore, overtopping protection to protect the earthen portions of the dam and abutments from erosion and scour during an overtopping event should be installed. This configuration is using a broad crested weir with a discharge coefficient of 2.7.

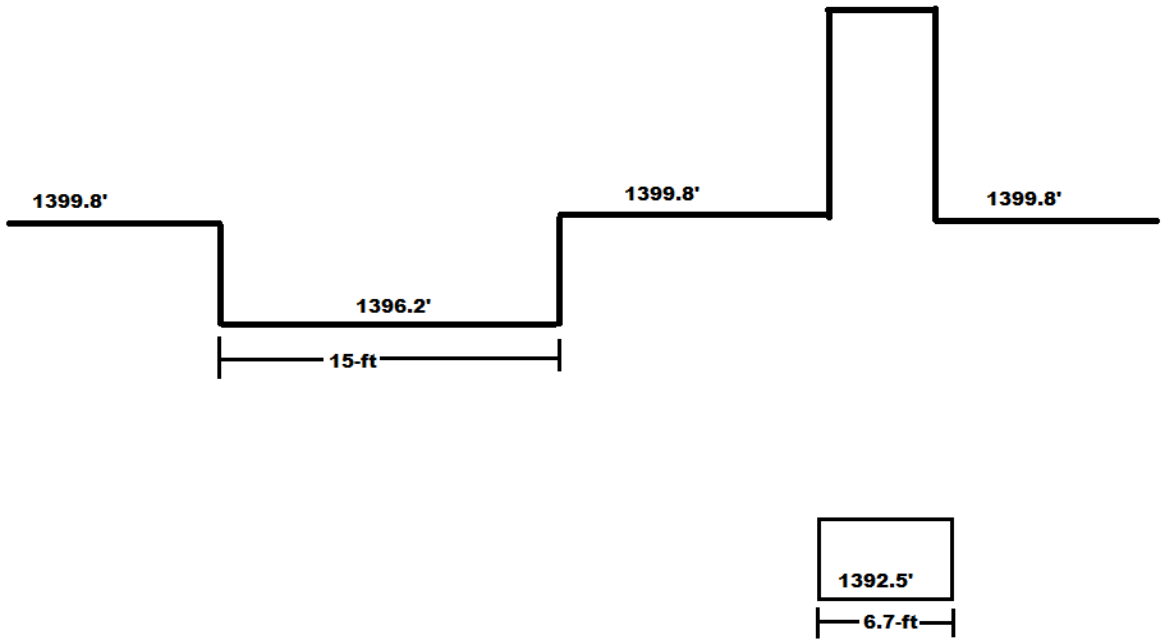


Fig.3. Alternative 3

The results of this Preliminary ideas/concepts on the alternatives are summarized in the tables 1, 2, and 3 below.

Event	Annual Chance Exceedance	Precipitation Depth (in)	Peak Inflow to Dam (cfs)	Peak Outflow from Dam (cfs)	Starting WSEL (NAVD88 ft)	Peak WSEL (NAVD88 ft)	Rise in Water Surface Elevation from Normal Pool (ft)	Freeboard (+) or Overtopping (-) (ft)
24-hr 1000-yr	**0.1%**	**7.92**	**4728**	**1190**	1394.6	**1398.3**	**3.7**	**1.5**
24-hr 100-yr	**1%**	**5.40**	**3272**	**651**	1394.6	**1397.1**	**2.5**	**2.7**
24-hr 2-yr	**50%**	**2.38**	**1171**	**144**	1394.6	**1395.5**	**0.9**	**4.3**

Table 1: Alternative 1

Event	Annual Chance Exceedance	Precipitation Depth (in)	Peak Inflow to Dam (cfs)	Peak Outflow from Dam (cfs)	Starting WSEL (NAVD88 ft)	Peak WSEL (NAVD88 ft)	Rise in Water Surface Elevation from Normal Pool (ft)	Freeboard (+) or Overtopping (-) (ft)
24-hr 1000-yr	**0.1%**	**7.92**	**4728**	**1614**	1394.6	**1398.3**	**3.7**	**1.5**
24-hr 100-yr	**1%**	**5.40**	**3272**	**852**	1394.6	**1397.3**	**2.7**	**2.5**
24-hr 2-yr	**50%**	**2.38**	**1171**	**138**	1394.6	**1395.9**	**1.3**	**3.9**

Table 2: Alternative 2

Event	Annual Chance Exceedance	Precipitation Depth (in)	Peak Inflow to Dam (cfs)	Peak Outflow from Dam (cfs)	Starting WSEL (NAVD88 ft)	Peak WSEL (NAVD88 ft)	Rise in Water Surface Elevation from Normal Pool (ft)	Freeboard (+) or Overtopping (-) (ft)
24-hr 1000-yr	**0.1%**	**7.92**	**4728**	**690**	1392.5	**1400.0**	**7.5**	**- 0.2**
24-hr 100-yr	**1%**	**5.40**	**3272**	**403**	1392.5	**1398.5**	**6**	**1.3**
24-hr 2-yr	**50%**	**2.38**	**1171**	**152**	1392.5	**1396.5**	**4**	**3.3**

Table 3: Alternative 3

* Top of Dam Elevation: 1399.8’ (NAVD 88).

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Dam Safety Inspection Report

Dam Safety Program
One National Life Drive
Montpelier, VT 05620-3510
(802) 622-4093
benjamin.green@vermont

Name: **Shadow Lake**
State ID: **81.02** NID ID: **VT00070**
Hazard Class: **Significant**

Town: **Glover**
Watershed: **Barton River**
Stream: **Barton River-TR**

Inspection Details

Inspection date: 06/28/2023 10:56	**Last inspection date:** 7/19/2017
Inspection type: Periodic	**Weather:** Cloudy, Recent Rainfall
Inspected by: Hannah Kuleba, Andrew Sampsell	**Others present:** Town Selectboard Member

Dam Safety Recommendations

The following recommendations and remedial measures describe the recommended approach to address current deficiencies at the dam. Maintenance level activities can be performed by the Owner, while Studies and Analyses and Remedial Repair Recommendations will require the services of a qualified professional engineer registered in the State of Vermont who is experienced in dam safety engineering design, permitting, and construction. Remedial repairs will likely require obtaining a Dam Order from the Dam Safety Program.

Overall dam condition:

☐ Satisfactory ☐ Fair ☑ Poor ☐ Unsatisfactory ☐ Not Rated

**See General Information section at the end of report for further details*

Maintenance level recommendations	
General	• On a regular basis and following the application of unusual or extreme loading conditions, perform monitoring of the dam and its appurtenances. Report any unsafe condition to the Dam Safety Program.
General embankment	• Establish and maintain vegetation clearing limits a minimum of 15 feet from all portions of the dam. Annually cut and remove grass, weeds, brush, and woody vegetation (but leave stumps) from the dam crest, upstream and downstream slopes, abutments, and downstream areas to near ground surface. • Mow/brush the grass surfaces of the embankment at least once to twice annually.

Maintenance level recommendations	
Crest	• Cut tall vegetation on dam crest. • A sinkhole was observed in the dam crest during a rapid post flood inspection which took place on 7/18/2023. The inspectors indicated that the sinkhole was located between the gate house and the auxiliary spillway and was approximately 4 feet long and a stick could be inserted 3.5 feet deep. Backfill the sinkhole with compacted granular fill and monitor the sinkhole area and areas upstream and downstream for signs of subsidence. If the sinkhole begins to redevelop or other adverse conditions are observed, contact the Dam Safety Program.
Downstream slope area	• Cut tall vegetation on downstream slope. • Regularly monitor seepage, leakage, and/or wet areas for changes in flow, turbidity, or size.
Spillways	• Maintain the principal and/or auxiliary spillway free of debris to ensure free-flow conditions. • Cut vegetation in front of, around, and below auxiliary spillway. • Monitor the condition of the auxiliary spillway concrete, and perform minor surficial repairs as needed. • See additional comments under the principal spillway section regarding the principal spillway trash rack and knife gate. • See additional comments under the auxiliary spillway section about previously observed seepage.
Low-level outlets	• Periodically monitor and inspect the condition of the stoplogs and take measures to reduce leakage as necessary.
Embankment walls	• Cut vegetation in front of the masonry wall.

Studies and analysis	
General	• Perform necessary analyses to support either the design of repairs to bring the dam into compliance with current dam safety rules and guidelines, or alternately, dam removal.
Hydrology and hydraulics/hazard classification	• Identify alternatives to make the dam hydraulically adequate or capable of safely being overtopped during the Inflow Design Flood.
Emergency Action Planning	• Develop an Emergency Action Plan for the dam using the dam safety program's significant hazard potential EAP template, and the inundation mapping produced by the 2022 H&H study.
Operation and maintenance	• Develop an Operations and Maintenance Manual for the dam and provide a copy to the Dam Safety Program for record keeping purposes.

Remedial repair recommendations
• Based on the studies and analysis recommended above, repair, rehabilitate, or replace the dam to bring it into compliance with current dam safety rules and guidance. Alternatively, consider pursuing dam removal.

Dam Information

Type: Earth **Purpose:** Recreation	**Status:** In Service **Height:** 12 ft **Length:** 130 ft	**Construction date:** 1800s, 1929
Owner/Contact/Operator: Town of Glover *email:* glovertc@comcast.net *phone:* (802) 525-6227 *Address:* 51 Bean Hill Road Glover, VT 05839		
Normal storage: 1709 ac-ft	**Max storage:** 2,866 ac-ft	Dam has capability to impound **more than** 500k cubic feet (11.48 ac-ft)
Normal surface area: 220 ac	**Drainage area:** 5.3 sq mi	**Max surface area:** 321 ac
Pool elevation during inspection: approx. couple inches of flow over principal spillway stoplogs	**Tailwater elevation during inspection:** normal, no backwater	**Normal pool elevation:** 1394.6 (NAVD88 feet)
Dam **has not** been breached or overtopped.		
Dam **does not** have public road on crest.	Dam **does not** have public bridge.	Dam **does not** have associated dike.
Reservoir shape: Round	**Reservoir average depth (ft):** Unknown	**Reservoir observations:**
Shoreline development: ☐ Undeveloped ☐ Semi-developed ☑ Developed ☐ Unknown		
Reservoir slopes: ☑ Mild ☐ Moderate ☐ Steep ☐ Unknown		
Inspection history: The dam was last inspected in 2017 and was rated in FAIR condition.		
Notes: Increased vegetation growth, encroachment of woody vegetation.		

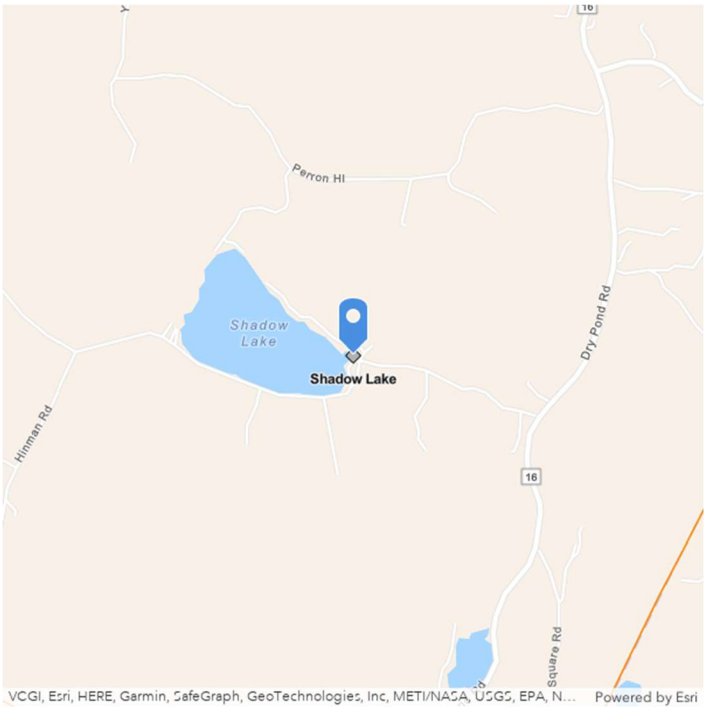
Access road to dam		
Type: Paved Road	**Road name:** Shadow Lake Road	**Distance from access road to dam:** 230 ft
Seasonal access: ☐ Plowed winter ☐ Sanded winter ☐ Maintained in mud season ☑ Passable in all weather conditions ☐ Need high clearance vehicle		
Access of emergency/construction equipment: Fair, requires passing through neighboring properties not owned by the Town of Glover.		
Action required: ☑ None ☐ Monitor ☐ Maintenance ☐ Engineer		

Security
Device type(s): The principal spillway gate house is locked.
Action required: ☑ None ☐ Monitor ☐ Maintenance ☐ Engineer

Public/Inspection team safety at dam	
Confined space entry required: No	Fall protection required: No
Other safety required: No	Public safety consideration: None
Action required: ☑ None ☐ Monitor ☐ Maintenance ☐ Engineer	

Dam Description/Background
Shadow Lake Dam is an earth embankment dam with a principal spillway and auxiliary spillway. The dam is currently classified as a SIGNIFICANT hazard potential. According to file information, the dam is approximately 130 feet long with a reported structural height of 12 feet. The upstream face of the dam consists of a granite block wall with some riprap placed in front of the wall. The crest is about 8 feet wide and surfaced with grass. The downstream slope is earthen and surfaced with grass. The principal spillway is a cast-in-place concrete drop inlet-style spillway with a single stoplog section that controls elevation. A series of timbers in front of the stop logs act as a trash rack. Flow is released through a 36-inch diameter opening with a knife gate located on the upstream face of the opening. The maximum open position of the knife gate partially blocks a small portion of the 36-inch diameter opening. The stop logs and knife gate are housed in a timber gate house building which the owner keeps locked. The auxiliary spillway is a 15 feet wide broad crested weir with a concrete chute. The drainage area of the dam is reportedly 5.3 square miles. Shadow Lake at normal pool is approximately 220 acres and the normal and maximum storage capacity of the dam are approximately 1,708 acre-feet and 2,866 acre-feet, respectively. The dam's original construction dates to the 1800s and the auxiliary spillway was constructed to its current configuration in 1929.

Dam Location



Emergency Action Plan

EAP **on** file

EAP date:
June 7, 1991
Revised date: January 1, 2015

As the dam is a SIGNIFICANT Hazard potential dam, an up-to-date EAP with dam failure flood hazard inundation map is required.

Has the EAP been exercised? ☐ Yes ☑ No

What issues are present with the EAP?	**Action**
☐ None ☑ Revisions required ☐ Not approved ☐ No plan available ☐ Inundation study required ☐ Format out of date ☐ Under review	☐ None ☐ Monitor ☑ Maintenance ☐ Engineer

Notes: EAP should be updated using 2022 hydrologic and hydraulic analysis results and mapping. Emergency contacts and procedures should be reviewed and revised as appropriate.

Operation & Maintenance Manual

O&M Manual **not on** file

Accessibility to outlets or low-level outlet (LLO): Stop logs can be accessed from principal spillway gate house.	**Frequency of outlet or LLO discharge:** One stop log is removed for winter and replaced in spring.
Frequency of mowing: Annually	**Seasonal drawdown?** ☑ Yes ☐ No **Amount lowered:** 11”
Frequency of dam owner surveillance: Frequent	**Owner surveillance during storm events:** ☑ Yes ☐ No
Operating problems since last inspection: None reported	**History of repairs since last inspection:** None reported

What issues are present with the O&M Manual?	Action
☐ None	
☐ Revisions required	☐ None
☐ Not approved	☐ Monitor
☑ No plan available	☐ Maintenance
☐ Format out of date	☑ Engineer
☐ Under review	

Hazard Potential Classification

Current classification: Significant

Current classification appears appropriate, and an inundation map was used to determine the classification. There appears to be **no** significant changes in land use or habitation since the last inspection.

Hydrologic/Hydraulic Data

Since Shadow Lake Dam is a SIGNFICANT hazard potential dam, the Inflow Design Flood (IDF) is the 1000-yr event according to federal guidance currently applied in the State of Vermont.

Based on file review, the most recent hydrologic and hydraulic assessment of the dam was performed by Dubois & King, Inc. (D&K) in 2022. As part of this work, D&K confirmed the elevations of key hydraulic features at the dam in NAVD88 in feet:

- Principal Spillway Stoplogs/Normal Pool: El. 1,394.6
- Auxiliary Spillway Weir: El. 1,396.2
- Dam Crest: El. 1,399.8

The hydrologic and hydraulic analyses by D&K provided the following results:

Storm Event	Precip. (in.)	Inflow (cfs)	Outflow (cfs)	Attenuation of Peak Inflow (%)	Peak WS El.	Freeboard (+) or Overtopping (-) (feet)
10-yr	3.55	1,983	44	97.8	1,397.0	+2.8
50-yr	4.82	2,875	117	95.9	1,397.9	+1.9
100-Year	5.40	3,272	155	95.3	1,398.3	+1.5
1000-yr	7.92	4,728	343	92.7	1,400.0	-0.2
PMF	26.0	11,631	11,163	4.0	1,407.8	-8.0

Based on the above results, the dam has approximately 5.2 feet of freeboard to the lowest portion of the dam crest under normal pool conditions, which exceeds the lower allowable freeboard threshold (3 feet) according to State requirements.

Based on the available analysis, it appears the dam has adequate freeboard during the 100-year storm but will overtop during the 1000-yr event. Since the dam cannot safely pass the IDF while maintaining 1.5 feet of freeboard in accordance with State requirements, the dam is considered hydraulically inadequate.

Upstream Slope

Not applicable, see upstream wall section below.

Crest

Length: 130 ft **Width:** 8 ft

Freeboard:

Principal spillway to dam crest: 5.2 ft
Auxiliary spillway to dam crest: 3.6 ft

Additional comments: none

Crest issues	Action
Other vegetation Description: Tall grass Quantity: Dense Location: Left End	☐ None ☐ Monitor ☑ Maintenance ☐ Engineer
Additional comments: Vegetation to the left of the auxiliary spillway is too tall and needs to be cut.	
Sinkhole Description: Approximately 4 feet long, and max 3.5 feet deep Location: Crest, between gate house and auxiliary spillway	☐ None ☑ Monitor ☑ Maintenance ☐ Engineer
Additional comments: A sinkhole was observed in the dam crest during a rapid post flood inspection which took place on 7/18/2023. The rapid inspectors indicated that the sinkhole was located between the gate house and the auxiliary spillway and was approximately 4 feet long and a stick could be inserted 3.5 feet deep. Backfill with compacted granular fill and monitor the sinkhole area and areas upstream and downstream for signs of subsidence. If the sinkhole begins to redevelop or other adverse conditions are observed, contact the Dam Safety Program.	

Crest images

This photo was taken on 7/18/2023 as part of the rapid inspection program (sinkhole).

Downstream Slope

General slope inclination: 3H:1V (slopes **are** within generally accepted stable inclinations).
Downstream slope appears stable based on visual observation under current loading conditions.

Additional comments: none

Downstream slope protections				Action
Vegetation Condition:				☐ None ☐ Monitor
☐ Adequate	☐ Bare	☑ Too tall		☑ Maintenance
☐ Improper	☐ Sparse	☐ Too short		☐ Engineer
Comments: Vegetation prevented a thorough inspection of the downstream slope. The previous 2017 periodic inspection observed seepage and iron staining near the right side (looking downstream) toe of the dam.				

Downstream slope issues	Action
No downstream slope issues were observed during the inspection.	None

Seepage Collection Systems	Number
No seepage collection systems were observed during the inspection.	None

Downstream slope images

Instrumentation

No instrumentation found.

Principal Spillway

Spillway type: Gate house, drop inlet, stop logs.

Primary material: Concrete - Rectangular

Spillway location: Near right abutment

Gate: Knife gate

Water level measured against principal spillway crest: approximately 2-inches above stop log crest

Erosion control structures: Drop sill, riprap

Spillway components:

☐ Anti-vortex plate	☐ Filter Diaphragm	☐ Training Walls
☐ Flashboard	☑ Trashrack	☐ Other:

Additional comments: A timber trash rack sits in front of the principal spillway stop logs to prevent debris from clogging the spillway. The limited spacing in between the vertical bars results in head loss/flow restriction as indicated in the 2022 H&H study. While the purpose of the trash rack is to limit the potential for debris to get into and clog the spillway, it is recommended that the owner test an alternative debris rack configuration or remove some of the vertical bars to reduce the head loss. A dam order (permit) would not be required to perform this work.

The 2022 H&H study also notes that the slide gate partially blocks the outlet of the principal spillway gate house even with gate stem cranked fully open. This does not appear to influence normal flow conditions, but it may limit outflows under high flow events.

It is the Departments understanding that the Owner periodically closes this gate to equalize water pressure on the stop logs for installation/removal/maintenance. Elimination of this gate is not recommended since it serves an important operation and maintenance function, but the Owner should investigate why the gate does not fully open, and whether maintenance level modifications can be made to fix this issue, or alternatively pursue replacement.

There is no standalone low-level-outlet, removal of the principal spillway stop logs would allow for a partial drawdown of the impoundment. The stop logs could not be thoroughly inspected. Observable portions appeared to be in fair condition.

Principal spillway issues			Action
Trash rack Type: Timber Opening size: Too Small Condition: ☑ Good ☐ Broken bars	☐ Collapsed ☐ Rusted	☐ Missing sections	☐ None ☐ Monitor ☑ Maintenance ☐ Engineer
Slide Gate Type: Metal, Gate Stem, Handwheel Opening size: Too Small Condition: ☑ Good ☐ Broken	☐ Leakage ☐ Rusted	☐ Missing Sections	☐ None ☐ Monitor ☐ Maintenance ☑ Engineer

Principal spillway drains	Number
No drains were observed during inspection.	None

Principal spillway images

Principal spillway images

Principal spillway images

Auxiliary Spillway

Spillway type: Weir	**Primary material:** Concrete	**Weir:** Broad-Crested
Spillway location: Left abutment		
Water level measured against principal auxiliary crest: Not measured		**Erosion control structures**: Riprap

Spillway components:

☐ Anti-vortex plate	☐ Filter Diaphragm	☑ Training Walls
☐ Flashboard	☐ Trashrack	☐ Other:

Additional comments: On April 28. 2023, approximately 20 gallons per minute of seepage was previously observed near the left (looking downstream) bottom corner of the auxiliary spillway. At the time of this inspection the pool elevation was measured to be 3-inches below the dam's auxiliary spillway crest (approximately 16 inches above normal pool).

At the time of this June 28, 2023 inspection above-mentioned seepage was not observed. The water level at the time of this inspection was observed approximately 2-inches above normal pool. Some water was pooled below the base of the auxiliary spillway. It had recently rained, and it was unclear if this water was from seepage or not. The pooled water did not appear to be actively flowing**.**

While the seepage path potentially could have self-healed, it should be noted that the pool elevation during the April 28, 2023 site visit was approximately 14 inches higher than during this June 28, 2023 inspection.

It is recommended that the owner continue to periodically monitor this area for seepage paying special attention to elevated pool conditions and keeping an eye out for any changing conditions. Cutting the tall vegetation will make it easier to monitor for seepage.

Auxiliary spillway issues	**Action**
Other Description: Vegetation growth, too tall Location: in front of, below, and beside	☐ None ☐ Monitor ☑ Maintenance ☐ Engineer
Undermining/Seepage Description: Over the years the channel below the auxiliary spillway has experienced erosion from turbulent flow. The end of the spillway slab has been partially undermined. Voids range from 6 to 18 inches deep. Large stones have been placed along the base of the spillway to help reduce the potential for further erosion to occur, however this is not an engineered design, and it is unclear if this measure will perform satisfactory under the inflow design flood loading condition. This is the same location where seepage unearth the spillway slab has been historically observed. Location: End of spillway, below slab	☐ None ☑ Monitor ☐ Maintenance ☑ Engineer

Auxiliary spillway issues	Action
Concrete deterioration Description: There are visible signs of wear and deterioration along the entirety of the auxiliary spillway. The concrete has been patched/repaired in some places along the training walls. Concrete is in fair condition for its age.	☐ None ☑ Monitor ☐ Maintenance ☐ Engineer

Auxiliary Spillway Drains	Number
No drains were observed during inspection.	None

Auxiliary spillway images

Auxiliary spillway images

Upstream Wall

Wall type: Stone Masonry
Length: 130 ft

Wall height (exposed):	**Horizontal wall alignment:**	**Vertical wall alignment:**
5.2 ft above normal pool	Good	Good

Unusual wall movement: ☐ Yes ☑ No

Additional comments: Stone/riprap has been placed in front of the wall; tall vegetation is growing on the stone/riprap which prevented thorough inspection.

Surface condition: Fair to Good

Joint condition: Good

Abutment contact condition: Good

Upstream wall issues			**Action**
Vegetation			☐ None
Condition:			☐ Monitor
☐ Adequate	☐ Bare	☑ Too tall	☑ Maintenance
☐ Improper	☐ Sparse	☐ Too short	☐ Engineer
Comments: none			

Upstream wall images

Upstream wall images

GENERAL INFORMATION

Website: https://dec.vermont.gov/water-investment/dam-safety

The Dam Safety Program conducts periodic safety inspections of non-federal, non-power dams to determine their condition and the extent to which they pose a potential or actual threat to life, property, and the environment. The condition rating reported herein was based on available data and visual inspection. Detailed investigations/analyses were beyond the scope of this report. It should be realized that the reported condition was based on observations of field conditions at the time of inspection, along with data available to the inspection team. The condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam in the future. Only through continued care and inspection can there be any chance that unsafe conditions are detected.

Hazard Potential Classifications:

HIGH: Dams where failure or mis-operation will probably cause loss of human life.
SIGNIFICANT: Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
LOW: Dams where failure or mis-operation results in no probable loss of human life and low economic and environmental losses.
MINIMAL: A dam that meets the LOW hazard definition, above, but is only capable of impounding less than 500,000 cubic feet.

Condition Ratings:

SATISFACTORY: No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
FAIR: No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
POOR: A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. POOR may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.
UNSATISFACTORY: A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.
NOT RATED: The dam has not been inspected, is not under state jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Definitions:

Upstream: The side of the dam that borders the impoundment located up gradient of the dam.
Downstream: The side of the dam opposite the upstream side, located down gradient of the dam.
Right: The area to the right when looking in the downstream direction (also known as “river right”).
Left: The area to the left when looking in the downstream direction (also known as “river left”).
Structural Height-of-Dam: The vertical distance from the lowest point in the stream bed or native ground surface at the downstream toe of the dam to the elevation of the lowest non-overflow section of the dam crest.
Embankment: An artificially constructed feature usually consisting of earth and rock with sloping sides and a flat crest, intended to provide a permanent barrier that impounds or is capable of impounding water.
Dam Crest: The top of the non-overflow portion of the dam.
Abutment: The part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed at the interface with a concrete gravity section.
Normal Pool: The water elevation, reservoir surface area, and reservoir storage capacity that is prevalent at the site or typical under normal, non-storm conditions. Typically, this level is controlled by the principal spillway.

Maximum Pool: The highest water elevation, reservoir surface area, and reservoir storage capacity that could be impounded by the dam, including accumulated sediments, with the water or liquid level at the top of the lowest non-overflow part of the structure or dam crest.
Principal spillway: A structure that maintains normal pool conditions and over which daily non-storm related and flood flows are discharged. Also called a primary or service spillway.
Auxiliary Spillway: The secondary spillway not in use under normal conditions but used when needed to pass flood flows that exceed the capacity of the principal spillway.
Low-level outlet or "LLO": An installed pipe and operable gate or valve typically located in or near the foundation of a dam that can be used to alter water levels, drain the reservoir, or otherwise meet operational or safety needs. Also called a pond drain.
Inflow Design Flood or "IDF": The storm event which the dam is designed and required to safely pass. Dam safety rules under development are considering the following prescriptive IDF's, Low and Minimal = 100-year Storm, Significant = 1,000-year storm, High = PMF. The use of incremental consequence analysis or risk-informed decision making to evaluate the potential of selecting a smaller/site specific IDF is permitted.
Emergency Action Plan (EAP): A written plan that identifies the area that would likely be inundated by the failure of a dam and identifies the actions that should be taken by the Owner to protect life, property, lifelines, and the environment in the event of a dam failure or threatening condition at the dam. The plan is usually implemented in cooperation with the local, regional, and state emergency personnel.
Operation and Maintenance Plan or "O&M": A plan that provides guidelines for the necessary, regular operation and maintenance activities at a dam.

Complete list of definitions from the Vermont Dam Safety Rule:
https://anrweb.vt.gov/DEC/IronPIG/DownloadFile.aspx?DID=185352&DVID=0

Appendix D - State-sponsored lake protection programs that Shadow Lake Association participates in:

- Access Greeter Program and hot pressure wash station
- Vermont Invasive Patrollers including Invasive Animals
- Lay Monitoring
- LaRosa Tributary Testing
- Lake Wise Program
- Lake Champlain Committee Cyanobacteria monitoring
- Lake Watershed Action Plan – Phase 1

The Federation of Vermont Lakes and Ponds, Inc.
P.O. Box 766
Montpelier, VT 05601
www.vermontlakes.org

April 3, 2024

Jason Batchelder
Commissioner, Vermont Department of Environmental Conservation
1 National Life Dr.
Montpelier, VT 05602

RE: Shadow Lake Association petition to Modify the Wake Sports Rule

Dear Commissioner Batchelder,

The Federation of Vermont Lakes and Ponds, a coalition of volunteer lake associations, is dedicated to fostering environmental quality standards and to the protection and preservation of Vermont's lakes and ponds.

Shadow Lake is a small lake of 217 acres. It is one of the state's cleanest, most pristine lakes and is eligible to be classified to A1 status. It has no aquatic invasive species, low nutrient levels, and very high quality waters. Due to its small size and the safety hazard they pose, personal watercraft are prohibited on the lake. However, under the current Wake Sports Rule, wake boats will be allowed on the lake and will be able to operate in a majority of this small lake.

Even under the current rule, the large wakes that these boats create along with their ballast tanks raise concerns especially for small and pristine lakes such as Shadow. These include:

- posing safety hazards to other boaters, anglers, people in the water or near-shore, on docks or moored boats;
- significantly increasing the risk of lake-to-lake aquatic invasive species spread due to large capacity ballasts that cannot be fully drained of water and are effectively impossible to inspect or decontaminate;
- eroding shorelines, undercutting trees and other vegetation, resulting in nutrient and sediment influxes that degrade water quality;
- inundating the nests of loons and other waterfowl; and,
- disrupting wildlife habitats and wetlands.

Every lake is unique. As the DEC website states: *"Each Vermont lake and pond formed under unique conditions in diverse locations; no two lakes and ponds are alike."* For this reason, it is important to allow modifications of the wake sports rule based on the unique characteristics of particular lakes. While a "one size fits all" rule can set a minimum standard, it does not necessarily work for all, given the many differences among lakes and ponds.

In its petition the Shadow Lake Association (SLA) describes the unique characteristics of this lake and explains how permitting wake sports on such a lake would lead to irreparable damage to the aquatic ecosystem and would endanger the safety of other lake users.

The Federation supports the SLA in its efforts to protect this very special lake, ensure the safety of lake users, and protect this pristine aquatic ecosystem. We urge the DEC to review this petition expeditiously and grant the modifications requested.

Sincerely,

Pat Suozzi
President
Federation of Vermont Lakes and Ponds

VERMONT CENTER FOR ECOSTUDIES
Uniting People and Science for Conservation

Wakesports and Loons on Shadow Lake April 1, 2024

I am writing regarding concerns about wakesports, loons, and water quality on Shadow Lake in Glover, Vermont. A "potential territorial loon pair" has recently formed, as both pair-like activity has been well-documented and copulation was observed in 2023. In 2023, we placed a nesting raft in the northwest corner, so that if the loons nest on the raft, it would be away from cottages and human activity. Almost the entire shoreline around Shadow Lake is highly exposed to any boating activity. Loon nests are usually located from 2-8 inches vertically from the water. At 500 feet, a wakeboat could produce a wave that is 5-6 inches tall. The 15 or so current loon nests in Vermont that are directly exposed to where wakesports will occur could be at risk. I am concerned about the intentional or unintentional wakeboater who ends up 300 feet from shore with an occupied loon nest nearby. It only takes one boat to flood out a nest. Waves created 300 to 400 feet from shore could produce waves in excess of eight to ten inches, which will wash out loon nests and will definitely contribute to more erosion, sedimentation, turbidity, and overall decrease in water quality. Even at 500 feet, a wake boat has the equivalent impact (wave force) of a standard motorboat at less than 50 feet.

My long-term concerns about wakesports will be the degradation of lake shorelines and riparian areas and the resulting decline in water quality, especially in sections of lakes that are not naturally conditioned for larger wave action. The results of higher wave action are more erosion, increased sedimentation, and higher turbidity, which contribute to higher nutrient loads in the water column, and decreased visibility. From a recent study in Wisconsin, loon chick productivity has declined over the past 25 years due in part to decreases in water clarity (Piper, et al. 2020, loonproject.org 2023). Adult male and chick weights have declined during this same period. Loons need clear lakes for successful feeding, and declines in weight contribute to declines in a loon's overall fitness and ability to raise young successfully. We have not seen this decline in Vermont, but it is something we'll be monitoring closely. Despite phosphorous levels increasing over the past two decades, secchi disk readings are also increasing demonstrating that water clarity is currently good. Healthy riparian areas are critical for the base of a lake's foodweb, which plants, aquatic insects, fish, and loons all depend on.

There are many effects of wave action that we do not know because of the newness of wakeboats. How will larger wakes affect small loon chicks who do not have the waterproofing that adult loons do? Non-breeding and breeding loons often congregate in the middle of larger lakes. How will hours of large wakes affect these important social gatherings? We do not know the effects of continued excessive rocking of a raft nest on incubating loons. Wakesports will be an additional stressor on wildlife and lake water quality. The Vermont Center for Ecostudies supports the petition by the Shadow Lake Association to prohibit wakesports from operating on Shadow Lake.

Sincerely,
Eric Hanson
Vermont Loon Conservation Project Biologist
Vermont Center for Ecostudies

Piper, W., J. Grear, B. Hoover, E. Lomery, L. Grenzer (2020). Plunging floater survival causes cryptic population decline in the Common Loon. Ornithological Applications. Volume 122, Issue 4, 2 November 2020, duaa044, https://doi.org/10.1093/condor/duaa044