TESTIMONY BY PROFESSOR WILLIAM BANHOLZER
IN OPPOSITION TO VERMONT'S 500-FOOT WAKE BOAT SETBACK RULE

TO: The Honorable Members of the Vermont Legislature's Committee on Legislative Apportionment and Reapportionment (LCAR) and Relevant Oversight Committees

FROM: Professor William Banholzer

AFFILIATION: Professor of Practice, University of Wisconsin–Madison

RESIDENT OF: Madison, WI

DATE: 2026

RE: OPPOSITION to Vermont's 500-Foot Wake Boat Setback — The Most Restrictive Policy in the United States, Unsupported by Science

Executive Summary

This testimony reflects my extensive background in engineering, including fluid mechanics, as a Professor of Practice at the University of Wisconsin-Madison. I have published research on the motion of particles in fluid — the same physics governing shore erosion and sediment resuspension — in a peer-reviewed journal. I am one of only 250 chemical engineers elected to the U.S. National Academy of Engineering and hold a Certified Six Sigma Master Black Belt designation in statistical analysis. I meet the professional criteria to assess both the quantitative data and the methodological rigor of studies examining wake boat impacts. For detailed critiques of the various studies and review papers on the science of wake boat impacts, I maintain a publicly accessible website at: https://gn844xhd8f.wixsite.com/wake-surf-defense. The site includes analysis of methodological shortcomings in studies commonly cited by wake boat opponents, as well as reviews of the peer-reviewed science supporting a 200-foot standard.

Vermont's 500-foot wake boat setback is the most restrictive policy of any state in the United States. No other state has adopted a 500-foot setback. This policy is not supported by peer-reviewed science.

Of the 48 continental U.S. states, 46 either have no specific statewide restrictions or adhere to a 200-foot (or shorter) setback standard. Maine, the next most restrictive state, requires only 300 feet. Vermont's 500-foot rule stands alone — an extreme outlier with no scientific basis.

Fact: The scientific evidence demonstrates that wake boats operating at 200 feet from shore in water depths exceeding 10–15 feet pose no unique or disproportionate threats compared to ski boats and fishing boats. Arguments for setbacks beyond 200 feet are

based on fundamentally flawed comparisons that ignore basic physics and misapply data. I provide extensive research support for this fact in the pages that follow.

A statewide 200-foot standard for wake surfing would be supported by science and would protect Vermont's lakes. Vermont's current 500-foot rule provides no additional environmental protection beyond what a 200-foot setback achieves — it simply eliminates lawful recreational activity on a large share of Vermont's lakes without scientific justification.

States such as Tennessee, Alabama, Georgia, South Carolina, and Virginia — where wake surfing takes place *year-round* on environmentally sensitive reservoir systems — have adopted 200-foot standards based on scientific evidence. Even Midwestern states with ecosystems similar to Vermont's, including Minnesota, Michigan, and Indiana, have not adopted extreme setbacks. Vermont's current rule imposes on its citizens and visitors the most restrictive wake boating regulation in the nation, without the scientific foundation to justify it.

(I) WAKE BOATS ARE NOT UNIQUELY HARMFUL

- When boats are compared under equivalent conditions and speeds, wake boats 200 feet from the shoreline produce waves indistinguishable from fishing boats, ski boats, or other watercraft operating at slow speed (8–18 mph).
- There is no scientific basis for singling out wake boats and ignoring other slow-speed activities that produce comparable waves, including casual tubing, teaching novices to ski, and cruising.

(II) SHORELINE EROSION IS DRIVEN BY WIND

- Dominant causes of shoreline erosion are wind, fluctuating water levels, ice, storm runoff, and overdevelopment — not recreational boats.
- A single wake boat pass affects a sliver of shoreline for less than 60 seconds, whereas wind delivers wave energy continuously over hours or days across a much larger area — accounting for more than 95% of total shoreline wave exposure over a boating season.
- To match the total energy delivered to shore by a 20-mph wind over six hours, a wake boat would need to pass at 200 feet every minute.
- Extending a setback from 200 feet to 500 feet does not reduce wind-driven wave energy at all. It eliminates wake boating while leaving the dominant source of shoreline energy entirely unchanged.

(III) SEDIMENT AND WATER QUALITY: A DEPTH QUESTION, NOT A BOAT QUESTION

- Sediment resuspension is a function of water depth and boat speed, not boat type. Rigorous field studies show that no boat type — wake boats included — disturbs lake sediments at depths greater than 10–15 feet, but all boats can disturb sediments in 3–8 feet.
- A 2022 study in Indiana's largest natural lake directly measured nutrients, suspended solids, and turbidity before and after multiple boat types passed at various depths. It found that after 10–15 feet, a ballasted wake boat creates no measurable disturbance of the lake bed, even for fine sediment.
- A 2015 study measured water velocity at varying depths as wake boats passed overhead. Water 10–15 feet below the wake boat does not move fast enough to mobilize fine silt particles.
- Claims that wake boats uniquely degrade water clarity or phosphorus levels are not supported by direct measurement. The most-cited study used to justify extreme restrictions has significant methodological flaws and was not subject to a formal peer-review process.
- Long-term water quality data from lakes with heavy wake boat use show stable or improving conditions, directly contradicting claims of ecological harm.

(IV) AQUATIC INVASIVE SPECIES (AIS) RISK IS NOT WAKE-BOAT-SPECIFIC

- All watercraft retain water that can transport invasive species.
- Modern wake boats retain less residual water than stern-drive boats, and they are typically used on a single home lake.
- Fishing boats — which make up the large majority of watercraft and frequently travel between multiple bodies of water — carry far greater AIS risk.
- AIS is a serious concern, but any policy addressing it should account for the magnitude of the risk factors. Vermont's 500-foot setback does not address the primary AIS vectors.

(V) VERMONT'S 500-FOOT RULE IS AN EXTREME OUTLIER WITH NO SCIENTIFIC BASIS

Vermont has the most restrictive wake boat policy of any state in the nation. No other state has adopted a 500-foot setback. This is not a distinction to be proud of — it reflects policy that has outrun the science.

Of the 48 continental U.S. states:

- **46 states:** 200-foot setback, 100-foot setback, or no specific statewide restriction
- **Vermont:** 500 feet (the most restrictive in the country, with a "home lake rule" and decontamination requirements)
- **Maine:** 300 feet (the second most restrictive)

Southern states where wake surfing occurs *year-round* on environmentally sensitive reservoirs have found 200 feet to be adequate:

- **Tennessee:** 200 feet, banned on lakes under 50 acres
- **Alabama:** 200 feet, banned on lakes under 50 acres
- **Georgia:** 200 feet
- **South Carolina:** 200 feet, banned on lakes under 50 acres
- **Virginia:** 200 feet (advisory)

These states have more wake boat activity and more vulnerable ecosystems than Vermont, yet they have found 200 feet to be sufficient based on scientific evidence. **No peer-reviewed study documents unique or disproportionate harm from wake boats operated at 200 feet and in water deeper than 10–15 feet.** Vermont's 500-foot rule is a policy choice that goes far beyond what any scientific evidence supports.

Statistical analysis of six independent studies (Welch's t-tests) demonstrates that **wake boats at 200 feet produce waves that are statistically indistinguishable from fishing or ski boats at 100 feet**, operating at comparable speeds. Adding another 300 feet of setback (to reach Vermont's 500-foot standard) provides no demonstrable environmental protection beyond what is already achieved at 200 feet. The site-classification framework developed by Knutson et al. (1990) from U.S. Army Corps of Engineers research confirms that on typical inland lakes, shorelines are already adapted to wind-wave energy that far exceeds the contribution of any recreational boat at any practical setback distance.

Important Context for Evaluating Wake Boat Opponents' Studies

Vermont's LCAR will likely receive claims of evidence that wake boats pose a great threat. **However, most studies cited by wake boat opponents do not meet the level of scientific rigor necessary to support calls for extreme setbacks.**

The claims that wake boats pose special dangers to lakes rest on a fundamental error: every cited study compares wake boats traveling at slow speed — where all boats generate their largest waves — to boats traveling at high speed "on plane," where waves are minimal. This comparison is invalid and explains why most studies cited by opponents are self-published technical reports rather than peer-reviewed journal articles. They lack fundamental elements of sound research, including proper sensor calibration, replication, transparent statistical analysis, and independent editorial oversight.

For example, the widely referenced 2022 St. Anthony Falls Laboratory wake study is often described as "peer reviewed," but it did not undergo a formal peer-review process in which reviewer critiques were fully addressed and revisions re-evaluated prior to release. The study has excessive (100%) data variability, inconsistent energy

calculations, and failure to reconcile findings with established prior research; these deficiencies raise serious questions about its reliability as a basis for public policy.

Detailed Technical Appendix

(I) The Fundamental Problem: Inappropriate Benchmarking and Misunderstanding of Hydrodynamic Regimes

1. Understanding Operating Regimes

The single most critical flaw in every study cited by anti-wake-boat advocates is the comparison of boats operating in fundamentally different hydrodynamic regimes. This is not a minor methodological issue — it invalidates the entire analytical framework.

Boats operate in three distinct regimes characterized by their volumetric Froude number (Fr_v), which relates a vessel's speed to the cube root of its displacement volume. This dimensionless number relates a boat's speed to the speed of the gravity waves it creates.

- **Displacement regime ($Fr_v < 1.0$):** The boat moves through the water, pushing it aside. Waves are minimal.
- **Semi-displacement regime ($Fr_v = 1.0–2.5$):** The boat begins to climb its own bow wave, creating maximum wave height and energy. This is where wake surfing occurs (typically 10–12 mph for 20–23 foot boats).
- **Planing regime ($Fr_v > 2.5$):** The boat rises onto the water surface, significantly reducing wave height. High-speed skiing (24–34 mph) occurs in this regime.

2. The Flawed Comparison

All studies cited by wake boat opponents compare:

- **Wake boats at 10–12 mph** (semi-displacement, maximum wave generation)
- **To ski boats at 24–32 mph** (planing regime, minimal wave generation)

This comparison is **scientifically invalid.** It is analogous to comparing the fuel efficiency of a car accelerating uphill in second gear to one cruising downhill in overdrive — the vehicles are operating under completely different physical conditions.

MacFarlane's 2025 peer-reviewed study provides definitive evidence. A Ski Nautique 200 operating at 30 mph (planing) produces a 5–7 inch wave at 100 feet from the boat. The same boat at 10 mph (semi-displacement) produces a 17-inch wave at 100 feet — exceeding the average wake boat wave at 200 feet of 11–12 inches.

3. The Appropriate Benchmark

The appropriate benchmarks for wake boats surfing at 10–12 mph are other boats in the same hydrodynamic regime:

- **Fishing boats at 10–12 mph at 100 feet:** Average wave height 11.4 inches
- **Ski boats at 10–12 mph at 100 feet:** Average wave height 11.4–17 inches
- **Tubing with children** (recommended speeds 8–12 mph per industry guidelines)
- **Teaching children to water ski** (10–15 mph)
- **Cruising** (10–15 mph)

All of these common, widely accepted activities generate waves of similar magnitude to those of wake surfing at 200 feet from shore, because they occur in the same hydrodynamic regime. The data provides **no scientific basis** for singling out wake boats as a unique threat at 200 feet, let alone for imposing a 500-foot setback.

4. Statistical Analysis: Wake Boats at 200 Feet Are Not Significantly Different

Formal statistical analysis (Welch's t-tests) on wave height data from six independent studies yields the following results:

- **Wake boats (no ballast, 10–12 mph, 100 ft) vs. Wake boats (with ballast, 10–12 mph, 200 ft):** p-value 0.012 (AMC only) or 0.545 (all six studies combined). Wake boats WITHOUT ballast at 100 feet produce statistically LARGER waves than wake boats with ballast at 200 feet.
- **Fishing/Ski boats (10–12 mph, 100 ft) vs. Wake boats (surfing, 10–12 mph, 200 ft):** p-value 0.359 (AMC) or 0.645 (all studies). No statistically significant difference. The waves are indistinguishable.

These results demonstrate that wake boats at 200 feet produce waves no larger — and in some cases smaller — than other common boating activities at 100 feet. Vermont's 500-foot setback provides zero additional environmental benefit over a 200-foot standard.

(II) Wave Energy and Shoreline Impact

1. Rapid Energy Dissipation

More than 70% of a wake boat's initial wave energy is dissipated within the first 200 feet due to breaking, geometric spreading, and frequency dispersion. At 200 feet from the boat, the average maximum wave height from wake boats across all studies is 12 inches with a period of approximately 2 seconds.

2. Wind Dominates Shoreline Energy Exposure

Wind-generated waves deliver continuous energy over hours or even days, while a wake boat affects any given shoreline for only 45–60 seconds per pass. To match the total energy delivered by a 20-mph wind in six hours, a wake boat would need to pass 200 feet from shore every minute — an absurd and unrealistic scenario.

Over an entire boating season, wind-generated waves contribute more than **95% of total wave energy** impacting shorelines. Vermont's 500-foot rule does nothing to address this dominant energy source.

3. Wave Period and Erosion Potential

Wave erosion is not solely a function of wave height — wave period is equally or more important. Nanson et al. (1994) identified erosion thresholds for protected cohesive shorelines at approximately 0.25 m (9.8 inches) with a 2.7-second period. Field measurements indicate that wake-surf waves at 200 feet generally fall below this height and have shorter periods (1.8–2.2 seconds), implying lower deep-water penetration and lower energy per crest length than the Nanson threshold condition.

(III) Sediment Resuspension and Water Quality: The Definitive Evidence

1. The Gold Standard: Daeger et al. (2022)

The most rigorous experimental study of sediment resuspension was conducted by Daeger, Bosch, and Johnson (2022) at Lake Wawasee, Indiana's largest natural lake. This study directly measured nutrients, suspended solids, and turbidity before and after multiple boat types passed over instrumented sites at various depths.

- **All boat types** (wake boats, fishing boats, pontoons, PWCs) can resuspend sediment in 3–5 feet of water
- **No boat type** caused measurable sediment resuspension at depths of 10–15 feet or greater
- Sediment disturbance is **depth-dependent, not boat-type dependent**

At depths of 10–15 feet, none of the measured parameters (total phosphorus, total nitrogen, ammonia, silica, suspended solids) showed statistically significant increases after boat passage, regardless of boat type or operating mode.

2. Supporting Evidence: Water Velocity Measurements

Raymond and Galvez-Cloutier (2015) measured water velocities at various depths as wake boats passed overhead. At 10 feet depth, maximum velocities of 10 cm/s (0.22 mph) were recorded — below the threshold (12 cm/s) required to mobilize fine silt

particles. A diver observing the lakebed during testing reported he did not notice any material suspended as a result of the passage of the boats.

3. Claims of Wake Boats Degrading Water Quality Are Unsupported

If wake boats were significantly degrading lake water quality, we would expect to see measurable declines in water clarity and increases in phosphorus concentrations over the past 15 years as wake boats became popular. **This has not occurred.** Long-term water quality monitoring data from lakes with substantial wake boat use show stable or improving water quality metrics, increased species diversity, increased maximum plant depth, and improved floristic quality indices.

(IV) Aquatic Invasive Species: Wake Boats Are Not the Primary Risk

The concern about wake boats spreading aquatic invasive species (AIS) stems from their internal ballast systems. However, this concern applies to **all watercraft**, not uniquely to wake boats.

- **Wake boats (modern rigid tanks):** ~0.1 gallons (~2 quarts) of residual water
- **Stern-drive boats (inboard/outboard):** ~4 quarts — twice as much as wake boats
- **Fishing boats (live wells, bilges):** Variable, often several gallons

A quantitative risk assessment considering both likelihood (frequency of use) and severity (residual water volume, cross-lake travel) reveals that fishing boats carry an 11–17 times higher AIS risk than wake boats, and runabouts carry a 4–5 times higher risk. Wake boats are typically used on a single home lake, dramatically reducing cross-lake transfer risk.

(V) Vermont's 500-Foot Rule: What the National Record Shows

Vermont stands completely alone. No scientific evidence justifies a 500-foot setback.

The table below summarizes state laws across the country. Vermont is the sole outlier at 500 feet. The next most restrictive state is Maine at 300 feet. All other states with regulations use 200 feet or less.

State	Distance	Min. Depth	Lake Size	Comments
Vermont (VT)	**500 ft**	20 ft	50 acres	MOST RESTRICTIVE IN THE NATION. "Home Lake Rule"; decontamination before switching lakes. Not supported by peer-reviewed science.

State	Distance	Min. Depth	Lake Size	Comments
Maine (ME)	300 ft	15 ft	Lakes may opt out	Civil fine up to $100; may escalate to Class E crime
Pennsylvania (PA)	200 ft	None	None	No-wake speed within 200 ft
New Jersey (NJ)	200 ft	None	None	Treated like water skiing
Alabama (AL)	200 ft	None	Lakes <50 acres banned	Applies to certain named reservoirs
Georgia (GA)	200 ft	None	None	Night surfing prohibited
Tennessee (TN)	200 ft	None	Lakes <50 acres banned	Based on WSIA model law
South Carolina (SC)	200 ft	None	Lakes <50 acres banned	WSIA model law
Virginia (VA)	200 ft (advisory)	None	None	
Minnesota (MN)	None statewide	None	None	Recommendation of 200 ft only
Michigan (MI)	None	None	None	No statewide rule
Indiana (IN)	Proposed: 200 ft	None	Lakes >300 acres	Pending
Wisconsin (WI)	100 ft (statewide)	None	Lakes <50 acres	30+ local ordinances creating confusion

Recommendations

Wake surfing provides significant recreational and accessibility benefits, particularly for older adults and individuals with physical limitations who cannot participate in traditional water skiing. It is a safe, inclusive activity that expands access to Vermont's waters.

Based on comprehensive scientific analysis, I urge Vermont to replace its current 500-foot setback with a **consistent, science-based 200-foot standard** for wake surfing:

- **Minimum 200-foot setback from shore** for all wake-producing boats operating in semi-displacement mode (including tubing, teaching water skiing, cruising)
- **AIS decontamination requirements** for all boats traveling between water bodies

These standards align with:

- Scientific evidence from peer-reviewed studies
- National precedents (46 states use 200 feet or no restriction)
- Equal treatment (applies the same standard to all boats in the same operating regime)

Vermont's current 500-foot rule is the most restrictive wake boat policy in the United States. It is not supported by peer-reviewed science. No other state has found it necessary to go beyond 300 feet, and the overwhelming weight of scientific evidence supports a 200-foot standard as both protective and proportionate. I respectfully urge Vermont's LCAR and relevant oversight committees to align Vermont's standards with the scientific evidence and with the national consensus.

Author Biography

My name is William Banholzer, and I am a Professor of Practice at the University of Wisconsin-Madison, a position I have held since 2014. My extensive background in engineering, including fluid mechanics, equips me with the technical expertise to critically evaluate the scientific literature on wake boats and their environmental impacts. I am one of only 250 chemical engineers elected to the US National Academy of Engineering and am a Certified Six Sigma Master Black Belt in statistical analysis. I have published research in a peer-reviewed journal on the movement of particles in a flow field, which involves the same physics as shore erosion and sediment resuspension.

I have thoroughly reviewed the peer-reviewed literature, regulatory studies, and technical reports on wake boats, including work by MacFarlane (2025, 2018), the University of Minnesota St. Anthony Falls Laboratory (SAFL), Daeger et al. (2022), Goudey and Girod (2015), and numerous other sources. My analysis focuses on scientific rigor, appropriate benchmarking, statistical validity, and adherence to fundamental hydrodynamic principles.

For detailed critiques of the various studies and review papers on the science of wake boat impacts, I maintain a publicly accessible website at: https://gn844xhd8f.wixsite.com/wake-surf-defense. The site includes analysis of methodological shortcomings in studies commonly cited by wake boat opponents, as well as reviews of the peer-reviewed science supporting a 200-foot standard.

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