

## **Eurasian Watermilfoil in Lake Leelanau Report on Field Activities in 2022**



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## **Executive Summary**

The summer field season of 2022 marked the third full season of efforts by the Lake Leelanau Lake Association and the Grand Traverse Band of Ottawa and Chippewa Indians to bring Eurasian Watermilfoil (EWM) under control in Lake Leelanau using non-chemical methods. The program continues to rely primarily on use of biodegradable benthic barriers.

A total of approximately 2.4 acres of lake bottom was covered in 2022, some adjacent to and in conjunction with previously treated sites, and some in locations not previously treated with large barriers.

Major effort was put into covering virtually all the visible EWM at each site treated, primarily by using “micro-barriers” to eliminate any EWM in gaps or along the edges of large burlap barriers. This effort was prompted in response to observations in previous years that any remaining EWM left untreated would re-invade around and over the burlap barriers. Increased efforts using SCUBA divers to hand-pull and clean barriers of any EWM fragments were prioritized to ensure re-colonization of the barriers did not occur. Of seven large EWM infestations in the lake, by summer’s end four had received extensive treatment such that almost all visible EWM was gone.

By mid-summer of 2022, burlap barriers deployed in 2020 were rapidly disintegrating and often sediment covered.

Hand-pulling by SCUBA divers was again employed in smaller and scattered sites, many first identified and treated in 2021. In general, sites treated only by hand-pulling were often reduced in size but not completely eliminated.

An important research partnership was established with Grand Valley State University (GVSU) and Prof. Dr. Mark Luttenton to study the impact of large benthic barriers on the lake environment, including non-target aquatic vegetation, benthic organisms, fish community, and water chemistry. Five research locations

were chosen, and sites were sampled both before and after barrier deployment. Previous year’s barriers as well as control sites were also sampled for comparison.

Aerial drone imagery was used to select barrier locations and precisely guide the deployment of large barriers. In late summer, a complete survey of rooted macrophytes was conducted via aerial drone and in the fall a final assessment of all EWM infestations was conducted. For the first time, autonomous flight paths were used, so exact replicability will allow future surveys to very accurately assess the effectiveness of control efforts.

## **Activities of 2022 Field Season**

Orthomosaic drone photography of large EWM sites at the end of the 2021 Field Season allowed partners to determine the configuration of barriers needed to treat remaining large sites in Lake Leelanau. Accordingly, burlap was custom ordered in 20', 30', and 40' widths. 2.7 acres of burlap was ordered in February and delivered in April.

In May, the LLLA barrier boat was fitted with removable extensions which allowed 40' material to be stacked for deployment (Figure 1).



Figure 1: The boat used for barrier deployment with extensions for deployment of burlap up to 40' wide.

A late spring prevented water warm-up and plant growth until early June. In addition, the need to complete sampling protocols and site selection in conjunction with GVSU research delayed barrier deployment for several additional weeks. All research sites and protocols were finalized in a meeting on June 10, and sampling on selected sites was completed by June 20.

Large barriers were set beginning on June 8 at Grant's Point (a non-2022-research site) and continued over the next three weeks as weather permitted, until all large barriers were deployed.

A dedicated 24' long pontoon boat for use by the dive crew was available beginning June 28. New divers were then trained and began daily work assisting in deployment of barriers and hand-pulling from existing barriers as EWM fragments

landed on them and attempted to take root. (See summary of locations in Appendix A)

During the field season, much effort was put into deploying relatively small burlap barriers ("micro-barriers") on gaps and along edges of the large barriers. These "micro-barriers" were usually cut to fit specific locations where EWM grew along edges of larger barriers. Often single plants or small stands of EWM were covered by the micro-barrier to more precisely target isolated infestations around the perimeter of the larger barrier. These micro-barriers can be more easily manufactured on shore and stored on the boat for use by divers.

After all large barriers were deployed and most micro-barriers in place, a second round of sampling on all GVSU research sites was conducted in mid-September. Additional sampling on the 2020 and 2021 barriers was completed in mid-August. Personnel from all three partner organizations (LLLA, GTB, GVSU) conducted the sampling.

Hand-pulling by the dive crew was conducted at EWM sites that had not been identified as potential barrier sites in the MDNR approved 2022 Workplan. In most of these smaller sites, divers pulled all visible EWM. Some locations had a dense "core" area of EWM that was passed over by the divers in favor of deploying a biodegradable barrier constructed to fit the site in 2023. This reflects our observation that barriers are far more effective than hand-pulling. A further advantage is that barriers do not create additional fragments, an inevitable product of hand-pulling.

Aerial drone imagery was used to help guide placement of barriers in the early summer. In mid-summer aquatic macrophyte beds in the entire littoral zone of the lake were assessed. A final set of flights in September/October assessed season-end status of all EWM infestations. Drone imagery was evaluated at a meeting following conclusion of the field season on November 5. A more precise estimate of the amount of EWM in Lake Leelanau will be

available in the coming months, as the time-consuming data is analyzed and quantified.

### **Key Findings**

The strategy of treating each infestation as a separate and discrete entity, usually through a first intensive treatment followed by maintenance efforts in successive visits until the infestation is eradicated, remains the overall guiding strategy of control efforts in the lake. Observations of EWM's ability to re-invade burlap barriers from any untreated edges underscored the need to do multiple follow-up maintenance visits and refine techniques of deploying micro-barriers at chosen treatment sites.

- 1. Biodegradable benthic barriers are effective in eliminating infestations of EWM when virtually all visible EWM is covered in a first intensive treatment. Some EWM that is not initially visible or that is not covered by the initial large barrier requires follow-up micro-barriers and continued monitoring.**
- 2. Burlap barriers deployed in early summer of 2020 were nearly completely disintegrated by late summer of 2022, some 26 months after placement in Lake Leelanau.**
- 3. Recolonization of burlap barriers by native plants was observed in multiple locations. As burlap continued to decay into the second summer and sufficient time for natural recolonization had occurred, macroalgae and vascular flowering plants were observed growing through or on the burlap and newly deposited sediments.**
- 4. As biomass of EWM is reduced in the lake, multiple observers noted the reduction in fragments floating at the surface by late summer. However, we know of no accurate way to quantify this reduction.**
- 5. We have seen no flowering of EWM plants and believe that there is no seed bed built up in Lake Leelanau.**

- 6. Use of drone imagery, including detailed ortho-mosaic photography for major infestations, and autonomous flight for replicable surveys annually, holds great promise for pinpointing new infestations and gauging the effectiveness of treatment.**
- 7. Hand-pulling by divers can generally retard the expansion of EWM in smaller and scattered locations, but root fragments left behind will generally prevent elimination by hand-pulling alone. Therefore, hand-pulling offers only a temporary solution.**
- 8. Widespread use of much smaller micro-barriers holds great promise for eliminating very small and scattered infestations, while facilitating the effort to approach 100% elimination of EWM on large infestations treated with large barriers.**

## **Discussion**

**1. Biodegradable benthic barriers are effective in eliminating infestations of EWM when virtually all visible EWM is covered in a first intensive treatment. Some EWM that is not initially visible or that is not covered by the initial large barrier requires follow-up micro-barriers and continued monitoring.**

In 2020, large burlap barriers were first deployed over dense beds of EWM in Lake Leelanau. While some native aquatic plants were covered by the barrier as well as the targeted EWM, every effort was made to avoid damage to non-target species, including stopping barriers short when EWM graded into areas where the plant community was composed of a majority of native species.

As part of the initial intensive treatment as envisioned in 2020, areas of EWM around the margins of the barriers were to be attacked primarily by DASH diving to remove as much EWM as possible. To that end, much effort was put toward DASH treatment at sites that received large barriers in the summer of 2020. By 2021, EWM had returned in great abundance at most sites that had been treated by DASH. In response, the partners began to look for more effective ways to approach 100% elimination of EWM in the initial intensive treatment that researchers on Lake Tahoe and elsewhere considered the key to success.

The Narrows South site, given its strategic location close to the boat channel connecting North and South Lake Leelanau, its isolation from other EWM infestations, and its modest size, was chosen in 2021 for another effort to completely eliminate EWM from the site.

On 7/30/21 two 66'x30' burlap barriers were placed over the Narrows South infestation. In the following days divers made sure that there was no gap between the two adjacent barriers. Additional micro-barriers of about 150 sq ft each were placed along the edges. Remaining EWM

stems that were visible near the barrier were pulled. Follow-up visits were made twice in 2021 and again three times in 2022. A total of only two pounds (estimated 60 stems) were found at the site in 2022. By mid-summer of 2022, native plants were observed rapidly reclaiming the barrier, apparently growing from the native plant seed bed below or by fragmentation. No additional EWM was visible on or off the barrier by late-summer 2022 (Appendix B).

The decision to try to replicate this apparent success at larger and more complex sites was made prior to the 2022 field season. Steps were taken to try to assure maximum coverage in the initial set of large barriers, with an understanding that immediate follow-up would be necessary, but this time exclusively with micro-barriers, rather than reliance on DASH diving or hand-pulling. Divers adjusted the large barriers to ensure overlap and to guide the exact placement of patch barriers. Maintenance on existing barriers was prioritized to ensure no nearby fragments could settle and recolonize the barrier (Appendix B).

Six separate overlapping large barriers ranging from 40'x140' down to 30'x80' were placed on the large infestation at **Otto Road** on 6/22, 6/29, and 7/5. Every attempt was made to prevent any gaps during barrier deployment, but divers still needed to make minor adjustments to the barriers after deployment.

By late summer, EWM that had been invisible to the drone in June began growing in significant areas around the edges of the large barriers. In response, much effort was put into deploying over 22 additional micro-barriers on the edges of the large barriers. This work was carried out over parts of more than a dozen days by diving crews from GTB, LLLA, and volunteers.

Otto Rd. Estimated EWM coverage: 95%

At **Mebert Creek** barrier placement went smoothly. An unusual site for Lake Leelanau, very dense EWM was growing in shallow water



studded with many stumps from a drowned cedar swamp. Three large barriers were applied. Overlapping the edges was simple in the shallow water. Within a week several micro-barriers were applied where infestations occurred that were separated from the main body of EWM. Eight follow-up visits over the course of two months were made to retrieve re-rod, install sandbags, put down micro-barriers, and hand-pull EWM plants that were found as far as 100' from the main infestation.

Mebert Creek Estimated EWM Coverage: 99%

**Grant's Point** was challenging. Unlike the previous three locations, steep banks limited EWM to a fairly narrow band, with the original infestation not more than 50' wide but extending over more than 1000' in a N-S orientation. In 2020, a 40'x700' burlap barrier was placed on the main infestation that was visible at the time. The aquatic plant bed extended both north and south of the applied barrier, but on each end the plants graded into a majority of native plants, so barriers were cut off to avoid extending over these areas of mixed vegetation. In addition, almost the entire east edge of the large barrier was lined by EWM plants that occurred in water that was about 6' deep. Unwilling to set large barriers that shallow, we opted to follow-up with DASH and hand-pulling.

Considerable effort in 2021 was put into DASH and hand-pulling to contain spread back onto the barrier, but drone survey work showed that the effort was ineffective, and that EWM was rapidly reinvading the barrier from the east. In addition, EWM which had seemed sparse on both ends of the barrier was rapidly replacing native plants.

On June 8, a 40'x510' barrier was set along the eastern edge of the 2020 barrier. On 6/27, an additional barrier (30'x350') was placed off the north end of the barriers and overlapped to prevent any gap. This barrier largely covered the

area where EWM had rapidly replaced most native plants.

On 7/12, an additional 30'x100' barrier was added to the south end as dense EWM became visible.

On 7/12-13 and 7/15, divers added multiple micro-barriers along the entire length of the Grant's Point large barriers to try to ensure full coverage of EWM. Micro-barriers included long strips of burlap in 6' or 12' widths, along with micro-barriers over separate clumps.

Grant's Point Estimated EWM Coverage: 95%

Overall, it is believed that improvements in barrier deployment techniques coupled with the commitment to treat all the EWM at a barrier site by covering all EWM and cleaning all fragments from the barrier will yield similar results to those achieved at the Narrows South site.

**2. Burlap barriers deployed in early summer of 2020 were nearly completely disintegrated by late summer of 2022, some 26 months after placement in Lake Leelanau.**

Divers working to clear by hand-pulling any EWM on the barriers set in 2020 found that by mid-summer the 26-month-old burlap had nearly completely disintegrated. It was difficult to tell where the 2020 barrier was located, and much of the remaining deteriorating material was covered by silt.

Barriers set in 2021 (approximately 14 months old) were intact, easy to find, and beginning to degrade. There were no known issues with transport of barrier material to any other location by currents or other means. Burlap naturally deteriorates in place and joins the substrate.

**3. Recolonization of burlap barriers by native plants was observed in multiple locations. As burlap continued to decay into the second**

**summer and time for natural recolonization occurred, macroalgae and vascular flowering plants were observed growing through or on the burlap and newly deposited sediments.**

While significant growth of native plants over one-year-old barriers was noted in the 2021 field report, this growth was mixed with EWM (pulled by divers). In diving on the Narrows South site in mid-June, divers noted very significant healthy growth of native plants, and only a handful of EWM over the barrier (Figure 2). Other barrier sites also saw natural recolonization of native plants, but at a lesser extent than that of the Narrows South site.

We believe that the rate of recolonization by native plants is dependent on three factors: 1) the ability to eliminate competition from EWM, 2) presence prior to the EWM invasion of a healthy native plant community, and thus the existence of a native plant seed bed, and 3) the presence of a native plant community near the EWM infestation that could possibly fragment and promote recovery.

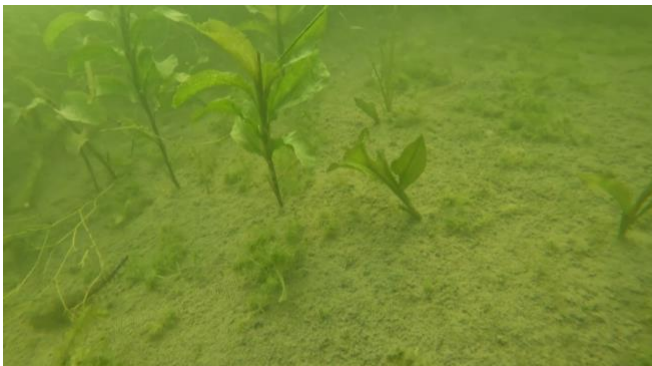


Figure 2: Native vegetation growing up through the barrier placed in 2021 at the Narrows.

Without competition from EWM, native plants appear to be capable of rapidly recolonizing a barrier site. When recolonization is slower, we surmise that physical and chemical factors may play a role, but the rate of recolonization is almost certainly affected by the presence or absence of a native plant seed bed. Because the weave of the barrier material includes gaps that sprouts can push through as the barrier

biodegrades, seeds located under the barrier appear capable of rapidly establishing new sprouts. It seems likely that this is the main mode of recolonization, as plant growth in the middle of the barrier achieved densities similar to that near the edges.

If confirmed over several growing seasons, and native plants are capable of rapidly reclaiming barrier sites with a mix of species representing the pre-EWM flora of the area, then the need to transplant desired native plants onto the barrier is called into question.

**4. As biomass of EWM is reduced in the lake, multiple observers noted the reduction in fragments floating at the surface by late summer. However, we know of no accurate way to quantify this reduction.**

Multiple observers noticed that far fewer fragments were floating in the lake, especially in late summer when EWM auto-fragments. Unlike the two previous years, we received no calls from lakefront cottage owners about large amounts of EWM fragments washed up on their beach following onshore winds.

We know of no method to quantify these observations but nevertheless think that this is one important measure of progress. Reduced fragments in the lake can in some part be explained by lessening our reliance on DASH and hand-pulling, two activities that, despite precautions taken, add to the amount of fragments in the lake. But overall, biomass is closely correlated with fragments in late summer, and the lack of fragments indicates reduction in overall biomass.

**5. We have seen no flowering of EWM plants and believe that there is no seed bed built up in Lake Leelanau.**

As noted from previous years, we have not seen any flower spikes that produced flowers. However, at one location (Mebert Creek) flower



spikes were noted just prior to the deployment of barriers. This location was the shallowest (max 5 ft) and probably densest infestation of EWM in the lake. A few days later, long before flowers had set seed, the entire location was covered by barriers. One other location (Gordon's Point), where EWM was seen growing near the surface was closely monitored, but no flower spikes were observed.

These observations are significant because the effectiveness of burlap barriers, which allow for new sprouts to poke up through the material, would likely be greatly compromised if an EWM seed bed existed under the barrier. And while further genetic testing is not planned until 2023, no hybridization can occur within the lake without sexual reproduction.

**6. Use of drone imagery, including detailed ortho-mosaic photography for major infestations, and autonomous flight for replicable surveys annually, holds great promise for pinpointing new infestations and gauging the effectiveness of treatment.**

In 2021, drone imagery was used to assess the effectiveness of barriers, and to locate the size and configuration of known EWM infestations that would likely require barrier treatment. In addition, some limited scouting was done to determine how effective drone imagery would be in finding unknown, small, and scattered infestations.

In 2022 three major drone imagery projects were undertaken. In addition, ZeroGravity Aerial LLC was called upon to pinpoint anchor locations and sometimes guide the barrier boat as it attempted to set large barriers with the proper overlaps between strips of burlap.

1. In June, prior to planned barrier deployment, ortho-mosaic drone imagery allowed careful adjustments to get the best "coverage" with the material available. It

was noted at this time that EWM beds had expanded in size in the ensuing six months after fall assessment flights. This potential "spread" is most likely due to small invading EWM plants among and below larger native plants but growing up toward the canopy in their second season. This "spread" is a greater problem when EWM is not confined by a steep bank.

2. Over the course of two weeks in late summer, a full survey of all macrophyte beds in Lake Leelanau was undertaken as part of a contract between ZeroGravity Aerial/Freshwater Solutions and LLLA. This was followed up with a survey targeted only at areas with EWM infestations. These surveys will create a baseline of macrophyte bed location and provide key information for future planning and precise placement of micro-barriers.
3. The fall end-of-season EWM survey was conducted in a similar fashion to 2021 with one key exception. Flights in 2022 were flown using autonomous navigation technology, allowing the exact same locations to be surveyed every year. This should prove invaluable in determining the effectiveness of the program.

Preliminary reports have been issued to GTB and LLLA by ZeroGravity Aerial/Freshwater Solutions, but more thorough drone imagery analysis will be performed in 2023 to get a more accurate estimate of the amount of EWM in Lake Leelanau after the 2022 treatments. We continue to believe that such imagery is the best way to quantify the scope of the problem and document the extent of control.

**7. Hand-pulling by divers can generally retard the expansion of EWM in smaller and scattered locations, but root fragments left behind will generally prevent elimination by hand-pulling alone. Therefore, hand-pulling offers only a temporary solution.**

Reliance on DASH and hand-pulling to eliminate relatively small infestations yielded mixed results, as reported at the end of 2021. We continue to see some limited effectiveness but have confirmed the difficulty of removing all the root fragments no matter how carefully the diver operates.

In 2022, divers followed up on sites that were previously hand-pulled, visiting 11 sites during the summer that had also been treated in 2021 (Appendix A). At most sites, less EWM was present after repeated treatments. However, after four or more visits over three full summers, EWM was not eliminated at any individual site by hand-pulling alone.

The partners conclusion: hand-pulling may be an effective stopgap, but actual elimination of EWM from any specific site is unlikely unless the plant and all its root fragments are killed. Hand-pulling remains useful as a method of removing fragments that land on barriers and send roots down through gaps in the material.

**8. Widespread use of much smaller micro-barriers holds great promise for eliminating very small and scattered infestations, while facilitating the effort to approach 100% elimination of EWM on large infestations treated with large barriers.**

Techniques of hand-pulling were completely ineffective when used to eliminate EWM from the margins of large barriers. Previous years' failures to prevent reinvasion of EWM at the Narrows South, Otto Road, Grant's Point, and Gordon's Point sites all pointed to the need to develop a method of eliminating EWM along any gaps or margins in or along the barriers. In 2021 some experimentation with much smaller barriers showed promising initial results. A decision was made to use similar small micro-barriers to extend the coverage of large barriers, rather than hand-pulling.

Over the course of the field season in 2022, several designs for small barriers were developed. Very small micro-barriers were usually fashioned with re-rod bent into 3' or 6' diameter circles, with the burlap material stapled over the re-rod to spread the material and to make it sink over the target EWM. A small sandbag was tossed in the middle after adjustment by divers.

Larger patches required sewing several panels together to achieve widths up to 12', with lengths up to 40'. The micro-barriers were unrolled either by divers in the water or by crew on the boat and maneuvered into position. Often divers could tuck any stems protruding from the edges back under the barrier.

Preliminary results look very promising. We observed no ability for EWM to send out lateral shoots under the barrier that might come up around the edges. Also, small barriers set in late spring or early summer at several locations were engulfed by native vegetation several months later (Figure 3).

Because GTB's Workplan for 2022 did not include use of barriers beyond the larger planned barrier locations identified specifically in the plan, micro-barriers were not deployed widely except around the perimeter at identified large barrier sites.



Figure 3: A 6' diameter micro-barrier placed on a small infestation of EWM on day of deployment 7/17/22 (top) and after four months on 11/17/22 (bottom) in which native vegetation quickly re-colonized the site of the previous EWM infestation.

## **Research Priorities for 2023**

While much has been learned about the use of large benthic barriers to control EWM in Lake Leelanau, much remains to be learned about how to improve deployment techniques and accurately determine the amount of EWM in the lake post-treatment. Research priorities for 2023 include:

### **Grand Valley State University research:**

Sampling of barrier sites before and after deployment began in June of 2022 with the following goals:

- Evaluate recolonization of treatment areas by native/non-native species, including evaluation of planting strategies (if appropriate).
- Determine nutrient concentrations above, below, and outside barrier treatment areas.
- Evaluate macroinvertebrate communities on vegetation in barrier treatment areas and on barriers.
- Evaluate the response of fish to the use of burlap benthic barriers.

The multi-year study began with the initial sampling before barriers were set in June of 2022. Initial samples were taken for water, fish, macroinvertebrates, temperature, and macrophytes at randomly selected sample locations at five “research barrier sites” prior to barrier deployment. In addition, recognizing that sites with pre-existing large barriers should be sampled as well, all research parameters were sampled on all the barriers deployed in previous years. The 2022 barriers were sampled for the same parameters about two months after they were deployed.

Fieldwork for this research is expected to continue over several years and is designed to yield publishable results that can be made available to the research community.

**Continue to improve techniques that precisely target barriers over EWM sites and ensure complete coverage in a first intensive treatment.**

Each year has brought changes and improvements to barrier deployment techniques, but technical challenges still remain. Areas for improvement include:

- Using drone imagery, guide buoys in the water, or other techniques to apply overlapping burlap barriers more precisely to large and complex sites.
- Scouting by divers immediately prior to barrier deployment to determine and mark the true extent of EWM at targeted sites, including small EWM plants that may not be visible to drone imagery.
- Continued development of techniques for application of micro-barriers.

With continued improvement in deployment of barriers, we should continue to come closer to the goal of 100% elimination of targeted EWM sites in an initial intensive treatment.

**Continue to improve design and deployment of micro-barriers, including use on smaller sites and on sites that have widely scattered EWM plants.**

Initial observations of experimental micro-barriers placed in 2022 showed that not only did such barriers kill the targeted EWM, but they also were rapidly reinvaded by native plants. After five months in place, observations of several 6' diameter barriers showed only bare burlap in the middle of the barrier as native plants moved in from the edges. Several 3' diameter barriers placed over single strands of EWM were difficult to locate after 5 months.

We are working to create micro-barriers that can be easily deployed by divers and that incorporate only biodegradable materials (wood or bamboo, burlap, sand, etc.). Micro-barrier construction and deployment strategies, along with efforts to determine the most effective timing for deployment during the EWM seasonal

growth cycle will be the subject of experimentation going forward.

**Continue to improve techniques to assess EWM coverage and biomass in the lake.**

Improvements to drone survey techniques have already greatly expanded our ability to pinpoint small EWM infestations and determine the extent of larger EWM sites. In 2022 all macrophyte beds were surveyed to establish a better baseline for future reference. We expect drone surveys will be invaluable in improving effectiveness of treatment and documenting the results.

## **Summary**

Much has been learned about deploying large biodegradable benthic barriers, how effective they are in killing EWM, and how long they last before disintegration. After three full field seasons, we have confirmed the importance of a truly thorough and effective initial treatment of chosen sites, and steps will need to be taken to prevent barriers sites from being recolonized by EWM rather than native plants. Opportunities to observe the response of native plants to a truly effective initial treatment are very encouraging and point the way to continued refinements in techniques.

Long term research with our academic partner is expected to yield publishable results that can be shared with the community of practitioners who may be searching for non-chemical, effective, and economical control techniques.

The EWM control program initiated by the Grand Traverse Band of Ottawa and Chippewa Indians and the Lake Leelanau Lake Association has reduced both the biomass and surface coverage area of EWM in Lake Leelanau. Throughout its first three years, the program has enjoyed outstanding community support from local governing bodies and the community of riparians. Many generous donors and grant funders will allow us to carry on this work well into the future.

## **Acknowledgements**

**Darren and Jennie Keller** who have allowed for this important work to continue by committing to fund our Aquatic Invasive Species Remediation program from 2022-2024.

**Bureau of Indian Affairs – Great Lakes Restoration Initiative** for providing grant funding contributing to the first three years of monitoring, control, and restoration, as well as additional grant funds supporting future prevention measures including boat washing stations and public outreach and communication.

This work would not have been possible without the partnership between the **Grand Traverse Band of Ottawa and Chippewa Indians (GTB)** and the **Lake Leelanau Lake Association (LLA)**. This project's success is a result of the steadfast support by LLA's board of directors, and especially Tom Hiatt (Board President) and Kathy Birney (Treasurer/Vice President). Similarly, the **Natural Resources Department of the GTB**, and its Tribal Council, played an essential role in all phases of planning, fundraising and execution of this project. Both parties are immensely grateful for this partnership.

**Darlene Doorlag**, who offered us the exclusive use of her landing on Lake Leelanau, allowing us to keep boats and equipment in a secure location that greatly improved the efficiency of our operations. "Dar" provided that one essential thing: the perfect location from which to conduct our work.

**Centerville Township and Supervisor Jim Schwantes**, for allowing our team to use the road end adjacent to the Township Park on Lake Leelanau to prep barriers for deployment and then load them onto our workboat.

**Volunteers and staff** made important contributions to our work throughout the summer. Some of the volunteers include:

- **Divers** who spent, collectively, over 100 hours of dive time hand pulling EWM, documenting the recolonization of plants over barriers, and adjusting newly set benthic barriers. The divers include:
  - **Contracted Dive Team Members: Catherine Dunn and Austin O'Connor** cheerfully worked under water every day under the direction of **Annalise Povolo**.
  - **Volunteers: Mike Downs** who greatly assisted us when our contracted divers were unavailable.
- **Jim Wysor**: Principal operator of our Trident ROV underwater drone. Jim and volunteers took on the responsibility of monitoring all North Lake Leelanau for any sign of EWM presence.
- **Dan Harkness**: for help in scouting EWM infestations and working with our divers, installing dock at our base on Lake Leelanau and anything else we asked him to do.
- **Josh Jackiewicz and Nate Campbell**: GTB staff members, Josh and Nate were part of the field crew and greatly assisted with data collection, boat operations and benthic barrier deployments.
- **Lonnie Rademacher**: for leading the LLA Lake Stewardship Committee, assisting dockage removal and new dockage for 2023, and wholeheartedly supporting our efforts.

**Dennis Wiand** of ZeroGravity Aerial LLC was endlessly inventive and available to help us in our work.



**Grand Valley State University Professor Dr. Mark Luttenton and Grad Student Anna Briem** for their partnership in the scientific study to evaluate the impacts of benthic barriers on the lake, and for their many hours of planning and data collection.

**Lindsay Chadderton and Andrew Tucker**, of the Nature Conservancy's Aquatic Invasive Species program made many observations and suggestions that set us off on productive lines of inquiry. **Dan Shaw** and **Dan Wick** offered invaluable insights from their EWM control programs in Lake Tahoe and Lake George, respectively.

**Reid Swanson** of the Great Lakes Fishery Commission for his expert assistance with Geographical Information Systems that was utilized for planning in our additional data collection.

## **Appendix A – 2022 EWM Control Efforts in Lake Leelanau**

### **Narrows South**

First observed: 7-8-19

Location: 44 58.40 N, 85 42.36W

2022 Treatment: Divers applied several micro-barriers along the NW and S edge of this barrier on 7/11. Hand-pulling of EWM that had settled on the barriers yielded a small number of stems totaling less than 5lbs. total in visits on 6/28, 7/11, and 8/17. Vast recolonization of native plants to the barrier was observed on all visits, especially late summer.

### **DNR Launch North (AKA Laskey)**

First observed: 8-12-19

Location: 44 55.079N, 85 43.431 W about ¼ mile north of Hohnke Road

2022 Treatment: On July 20 divers pulled 36lbs. of EWM in about 90 minutes. Comments noted patch was “large, amorphous, and very tall, in 15 ft. of water.” The central core of the site was not pulled, awaiting a barrier and follow-up treatment in 2023.

### **DNR Launch South (Willow Point North)**

First Observed: 8-12-19

Location: 44 5.28N, 85 43.04W about ¼ south of DNR boat launch

2022 Observations: The 30x80’ barrier set over the core of this infestation in 2021 was difficult to locate as rapid sedimentation made the barrier hard to see. The barrier did not provide sufficient coverage at this site, and it is highly likely that a further large barrier or micro-barriers will need to be deployed. 13lbs. of EWM were harvested in short time. There are also many smaller and scattered EWM clumps and larger patches within 200 ft. This a complex area and will require considerable effort to eliminate EWM while favoring abundant native plant species.

### **Willow Point South**

First Observed: 8-9-19

Location: 44 54.28N, 85 43.04W Just south of point with large willow, about ½ mile south boat launch

2022 Treatment: Site was visited on 5 occasions in July and once in August. The barrier itself was relatively clean, yielding only 2lbs. of EWM. Drone surveys revealed the existence of a string of smaller EWM sites south of Site 4, and several of these were hand-pulled on 7/22 when 18lbs. were harvested. At least several of these smaller sites will require micro-barriers, along with one dense site north between the two Willow Point barrier.

### **Kozelko**

First Observed: 8-12-19

Location: 44 53.56N, 85 42.50W. Off Rice Creek

2022 Observations: Hand pulled in 2020 and monitored in 2021. No visible EWM present in 2022.

### **Kelenske Pt (North)**

First Observed: 8-12-19

Location: 44 53.25N, 85 42.36 W 100 yd north of Kelenske Pt

2022 Observations: DASHed in 2020 and hand-pulled in 2021. BP marked the site, but divers did not find any EWM on 7/22 despite considerable searching.

### **Cedar River**

First Observed: 8-10-19

Location: 44 50.49N, 85 45.01W off river mouth

2022 Observations: Mid-summer drone survey turned up several spots with clumps of EWM, including one unusual small but dense spot surrounding a “hole” where perhaps a spring provides nutrients. RR and BP did follow-up ground truthing in August and found that a number of the sites identified as possible EWM were in fact other native plants, although small amounts of EWM were sometimes mixed in. Observation only in 2022.

### **Sanborn**

First Observed: 7-3-19

By: Jeff Sanborn and Brian Price

Location: 44 50 03N, 85 43.12W just north of former Sanborn house N of Birch Pt.

2022 Observations: Small stand was hand pulled in 2020 and 2021. Site was not visited in 2022.

### **Gordon Point and Reed Bed**

First Observed: 7-8-19

Location: 44 54.07N northward for about 2000 feet. About 85 42.34W

2022 Treatment: Three large barriers were set in the immediate vicinity north and south of Gordon's Point. Immediately south of the point a 40'x270' barrier was set following research sampling on 6/29. After a gap of about 100 ft another small 30'x80' barrier was set after sampling. On 7/15 a 30'x300' barrier was placed beginning about 80 feet north of the northernmost research barrier, running to the north over an area covered by a double string of 22 LBB's in 2022. EWM had completely overtaken this site following removal of synthetic barriers. There will need to be a great deal of effort put into this area in 2023 to add barriers further north, along the eastern edge of the 300 ft barrier, and between and around all the barriers. Detailed drone imagery will help guide these efforts.

### **Grant's Point**

First Observed: 7-8-19

Location: 44 55.40N to 44 55.87N, at approximately 85 42W (from 1<sup>st</sup> house N Mebert NA to Grants Pt.)

2022 Treatment: Much effort was put into this site as incomplete coverage of the barriers deployed in 2020, coupled with ineffective DASH treatment, had led to rapid recolonization of EWM to the shallower side of a 700 ft barrier. In addition, to the north and south of the barrier EWM that was relatively sparse in 2020 was rapidly replacing native plants. Barriers of 40x510', 20x310', and finally 40x350' were set at this site. At least five days of follow up treatment included multiple additional micro-barriers and repairing two large rips caused by apparent anchor strikes. Hand pulling was limited in favor of micro-barriers in the vicinity of the larger barriers. The Farber Sites, located about 2000 ft south of the main Grant's Point sites had received three large 30' wide barriers in 2021 and were visited in 2022 to remove re-rod, to hand-pull on top of the barrier on two occasions, and for research sampling. While these sites have patches of EWM in the gaps between the barriers and along the eastern edges, they were judged to be in pretty good shape with little EWM reinvading the barriers which were cleaned twice by divers. In 2023, micro-barriers should be applied to this site to try to achieve close to 100% elimination.

### **Mebert Shoal**

First observed: 6/14/20 Also observed by RLS survey

Location: 44 54.58N 85 42.54W

2022 Observations: Site was visited twice by divers, who observed that the original undersized barrier had been largely engulfed by both EWM and native plants. The original barrier seemed to be completely disintegrated and was not observed. Drone imagery will be used accurately determine current size, but it appears significantly larger than the original estimate of 50x100. A larger barrier will need to be applied in 2023, covering the original 2020 barrier site and extending for some distance beyond. Several other EWM sites to the north are separated from this site and should receive micro-barriers in 2023.

### **Otto Road**

First Observed: RLS crew mapped as single larger site during fieldwork in late June 2020. Confirmed by BP and DH as medium size, dense, about 50 x 100 feet solid EWM. 6ft of water. Source of many floating fragments

Location: 44 56.18N 85 42.40W

2022 Treatment: Six separate large barriers ranging from 40'x140' down to 30'x80' were placed on the large infestation at Otto Road on 6/22, 6/29, and 7/5. Every attempt was made to overlap the barriers to prevent any gaps, but divers still needed to adjust the barriers after placement. Many additional micro-barriers were set to fill a gap between the 2<sup>nd</sup> and 3<sup>rd</sup> barrier set, and to add additional coverage along edges.

As the summer progressed, EWM that had not previously been visible came up on all sides of the barrier, and required extra micro-barriers, sometimes up to 10' wide and up to 100' in length. Barriers included sizeable extensions of 30x40, 20x30, 6x120, 6x25, 20x25, and 20x20, along with numerous smaller pieces. All were hand placed by divers. By September, little EWM was observed although it is certain that micro-barriers will need to be again set in 2023.

This site is not located along a steep bank, so not confined to a relatively narrow band restricted by depth. In this case, and probably others like it, additional careful scouting needs to be done to make sure that barriers planned for a site are not too small. It is obvious that planning based on drone imagery from Sept of 2021 underestimated the size of the site by a considerable factor.

### **Otto Road North Sites**

First Observed by RLS. Follow up by BP and Dan Harkness on July 6, 2020.

Location: 44 56.25N to 44 56.44N at approximately 85 42.38W.

2022 Observations: Drone imagery and observation showed many relatively small beds of aquatic plants, with varying amounts of EWM mixed in. Many beds, in fact, have only a few stems of EWM. The beds are generally discrete and separated from each other by areas with little or no rooted plants. Efforts to hand-pull these areas in 2021 did seem to change the overall character in 2022. No barriers were set because these sites were not specifically listed on the work plan as submitted and approved. Micro-barriers applied only to stems and clumps of EWM would be the most effective approach in 2023.

### **Kelenske Point South**

Observed: RLS survey June 2020, confirmed by BP on July 6.

Location: 44 53.15N 85 42.36W

2022 Treatment: Hand pulled in 2020 and 2021. The site was visited twice in 2022, with less than 2lbs. of EWM hand pulled.

### **Billman's Beach**

Observed: RLS survey, confirmed by BP and DH on July 6.

Location: 44 52.18N 85 43.23W

Waypoint: 78, LLLA 15

2022 Treatment: On 7/25 divers visited the site and pulled 8lbs. of EWM, leaving in place a relatively small (est. 300 sq ft) core area of relatively thick EWM. While some EWM is scattered out to the N and S from this core among significant native plants, efforts to contain seem to be working relatively well based on observations. A small barrier on the "core" area along with micro-barriers elsewhere could get close to eliminating this infestation.

### **Dunklow Farm SE (Dar's Landing)**

Observed: RLS Survey June 2020, confirmed by BP and DH on July 6, 2020.

Location: 44 56.17N 85 43.16W

2022 Observations: Past hand-pulling did not seem to have any impact on this site. On 7/28 divers noted that the patch was larger than previous estimates (50x50'). Like the Narrows South and Otto Road sites, this infestation is not bounded by water depths inhospitable to EWM and should become a high priority before it continues to spread. Both drone imagery and careful assessment by divers should be used to determine the true extent of EWM (see comments re: Otto Road).

### **Mebert Creek Natural Area**

Observed: On October 6 by BP, following up on suspicious weed bed in 2017 shoreline drone survey. A check of 2017 drone survey shows that infestation was well established in 2017.

Location: 44 54.45N 85 42.30W about 200 yds south of Gauthier camp

2022 Treatment: Barriers set on 6/23 were very effective in covering this site. Barriers set stopped short of clusters and stems of EWM that were up to 50' beyond the edge of main infestation. About 20lbs. of EWM were pulled around the perimeter of the barrier, but larger clusters received small barriers hand-placed by divers. In September, only a few stems were visible (none on the barrier).

### **DNR Boat Launch**

Observed: August of 2020

Location: 44 54.50N 85 43.26W

2022 Observations: Observed with no treatment. No EWM present since 2019.

### **North Lake Leelanau**

Observed: Late May of 2021

Location:

2022 Treatment: Hand pulled in 2021, this site was re-visited by divers in 2022 on 7/7 and 7/11. Earlier visits did not show any EWM, but by July a few clumps were visible. Follow up visits were hampered by poor visibility, and sometimes by high boat traffic, and no further EWM was observed. In 2023, micro-

barriers should be used to eliminate this infestation, the only known foothold of EWM in North Lake Leelanau.

#### **Lake Leelanau Narrows Sites**

Observed: 2021

Location:

2022 Treatment: EWM was not observed at sites carefully hand-pulled in 2021, except at the Narrows Yacht Club, where not only EWM but curly-leaf pondweed was found. At the end of the season, a couple of clumps of EWM and a few separate stems were still visible. Very small barriers set in 2023 could eliminate EWM from this site. One additional site was observed by drone imagery and follow-up inside a shallow boat basin about 50 meters north of the Consumers Power line. No treatment was attempted as a small barrier would be the best treatment, and this site was not listed in the 2022 workplan.

#### **Saint Mary's Bay and South Channel**

Observed: 2021

Location:

2022 Treatment: The site was visited on 7/1 and 7/14 with a total of 7lbs. of EWM harvested. The site is very compact, and hand-pulling seems to be effective so far. The South Channel site, only 15' from the SW entry channel marker was visited on 7/14 but only a few stems were found and pulled.

#### **Haring's Point**

Observed: 2021

Location:

2022 Treatment: EWM was found on both sides of the point in 2021. On 7/28 divers thoroughly searched the site on the north side of the point, finding less than 1lbs. of scattered stems. The site south of the point yielded about 3lbs. of EWM.

#### **Channel South**

Observed: 2021

Location:

2022 Treatment: Hand-pulled in 2021 and again in 2022. In 2022, divers pulled 43 lbs. of EWM off several sites along the west shore south of the channel. EWM at this location may have expanded since 2021, and should be treated with micro-barriers in 2023.

#### **Fountain Point South**

Observed: 2021

Location:

2022 Treatment: Hand-pulled in 2021 and again in 2022. Little treatment was done in 2022. There are about 5 separate infestations. The northern 3 sites were hand-pulled and yielded less than 10lbs. EWM. The two southern infestations will require micro-barriers of about 300 – 600 sq. ft. Both sites were relatively small but dense infestations that would be best treated by micro-barriers.

#### **Bingham Boat Launch North and South**

Observed: 2021

Location:



2022 Observations: None of these sites were treated in 2022, although they were observed by drone and from a boat on 8/24. Most sites seem to be slowly expanding N – S along a steep bank, mixed with sparse native vegetation. Drone imagery has pinpointed these sites precisely, and a combination of micro-barriers applied in 2023 would be effective in preventing further spread.

**Paradise Cove**

Observed: 2021

Location:

2022 Treatment: Sites were hand-pulled by 3 divers on 7/19 and 7/25, with a total of 55lbs. of EWM collected. Hand pulling over two years has not had much effect here. An infestation in a broad bay widely separated from other EWM sites should be a very high priority for placement of multiple micro-barriers over clumps and stems in 2023.

**SE SLL between Lakefront and Birch Point Road**

Observed: 2021

Location:

2022 Treatment: Hand pulled in 2021, but not treated in 2022.

**Skeba Point**

Observed: 2021

Location:

2022 Treatment: Hand pulled in 2021 and again in 2022. On 7/25/22, the site was hand-pulled yielding only a few stems.

## **Appendix B – List of Barrier Site Treatments**

Divers hand pulled EWM on and around the barriers on the following dates:

<b>Site Name</b>	<b>Year Deployed</b>	<b>Date(s) Visited in 2022</b>	<b>Notes</b>
Gordon's Point North	2020		Visited from the boat but did not dive on it other than for research sampling.
Mebert Shoal	2020		Was not visited in 2021 and has thus been overtaken by vegetation, making it impossible to locate. Divers searched in the area but were unable to find the barrier.
Grant's Point South	2020	7/19/22	No new fragments observed growing through the 2020 barrier, but a lot of dense EWM off the edges of the barrier.
Narrows	2021	6/28/22, 7/11/22, 9/9/22	Fragments pulled from on and around the edges of the barrier (6/28, 7/11, 9/9). After three visits, 100% of EWM was cleaned off the barrier.
Farber Point	2021	7/14/22, 8/11/22	Some EWM pulled, noted that patch and micro-barriers would be more effective (7/14). Barrier cleaned of any fragments and noted that most edges have patches of EWM (8/11).
Willow Point	2021	7/13/22, 7/21/22, 9/2, 9/9	2 lbs. pulled from site, mostly off barrier (7/13). 13 lbs. EWM pulled from on and off the barrier. 14 lbs. pulled from on and around the edges of the barrier, a lot of EWM observed growing on top of the barrier it was not cleaned in 2021, the EWM on the edges of the barrier likely encroached onto the barrier (9/2). Cleaned more fragments from the barrier, some still remained (9/9).
Mebert Creek	2022	8/12/22, 8/15/22	Cleaned any fragments off the barrier, observed very little around the edges of the barrier, which was hand-pulled (8/12). Final check on fragments on the barrier and hand-pulled small clumps/single stems from the nearby area (8/15).
South Gordon's Point 1N	2022	8/31/22	7 lbs. of fragments and EWM pulled on and around the barrier, final check showed the barrier clear of EWM, though still some remaining on the edges (8/31).
South Gordon's Point 2S	2022	8/31/22	1.5 lbs. of fragments and EWM pulled on and around the barrier, final check showed the barrier clear of EWM, though still some remaining on the edges (8/31).

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Grant's Point North	2022	7/15/22, 7/19/22, 7/26/22, 8/4/22, 8/5/22, 8/9/22, 8/11/22	10 lbs. pulled from around barrier but not on barrier (7/15). From northern half of the barrier, no new fragments observed growing through, but areas missed off the barrier (7/26). Southern half of the barrier, 11 lbs. EWM pulled from around the barrier, other edge infestations measured for patches. Micro-barriers placed (8/4, 8/5). Finished laying micro-barriers on 8/9 and noted that just a few strands of EWM remained on the edges. Final check to clean any fragments on the barrier from nearby infestations (8/11).
Otto Road	2022	8/2/22, 8/10/22, 8/12/22, 9/1/22, 9/7/22	No EWM observed growing on the barrier but around the edges where the barrier did not cover everything. Areas for micro-barriers measured (8/2). Micro-barriers placed (8/10, 8/12, 9/1, 9/7).