GRASS RIVER ADAPTIVE MANAGEMENT PLAN

September 2023

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Section 1: Brief Watershed Characterization

GEOGRAPHY AND HYDROGRAPHY

As part of the Elk River Chain of Lakes (ERCOL) in the northwestern region of Michigan's Lower Peninsula, Grass River flows in a southwesterly direction between Lake Bellaire and Clam Lake. Much of the land immediately surrounding the Grass River has been protected as Grass River Natural Area (GRNA), which totals 1,492 acres in size. Water flowing through the Grass River eventually ends up in Grand Traverse Bay, and because the ERCOL provides 60% of the surface water inputs to Grand Traverse Bay, the pristine and intact wetlands protected as GRNA are critical for maintaining high water quality throughout the region.

The Grass River watershed (hereafter "sub-watershed") is a sub-watershed of the Elk River Chain of Lakes consisting of the Grass River, its three tributaries (Finch Creek, Cold Creek, and Shanty Creek), and several sub-tributaries.

SUB-WATERSHED DELINEATION AND SUB-BASINS

The sub-watershed is 17.36 mi^2 in area, covering portions of Helena, Custer, Forest Home, and Kearny Townships in Antrim County and a small portion of Rapid River Township in Kalkaska County (Figure 1).

The Grass River is a slow river, with an elevation gradient of no more than 0.01%, measuring about 2.5 miles long (Kendall et al. 2014). The average navigable depth of the river is 3-5 feet, with an average thalweg of 5-9 feet. Finch Creek, the largest of the tributaries, is about 6.5 miles long, with stretches approaching 1.5% gradient (Kendall et al. 2014). Its discharge close to its confluence with Grass River (but before a distributary channel) is 1.44 m^3/s (Kendall et al. 2014). Cold Creek is about 2.5 miles in length with a discharge just before its confluence with Grass River at 1.00 m^3/s, though it has a relatively shallow gradient at below 0.5% (Kendall et al. 2014). Shanty Creek is about 2.75 miles long with a discharge just before its mouth of 0.28 m^3/s, though it does have a relatively steep gradient of 1.5% (similar to Finch Creek) (Kendall et al. 2014). All three tributaries are groundwater-fed coldwater streams.

Finch Creek's and Cold Creek's creeksheds are both much larger than that of Shanty Creek, at 6.87 mi2 and 7.34 mi2, respectively. Finch Creek's creekshed includes two named sub-tributaries: Crow Creek and Scrabble Creek. Shanty Creek's creekshed is the smallest at 2.04 mi^2. (Figure 2).

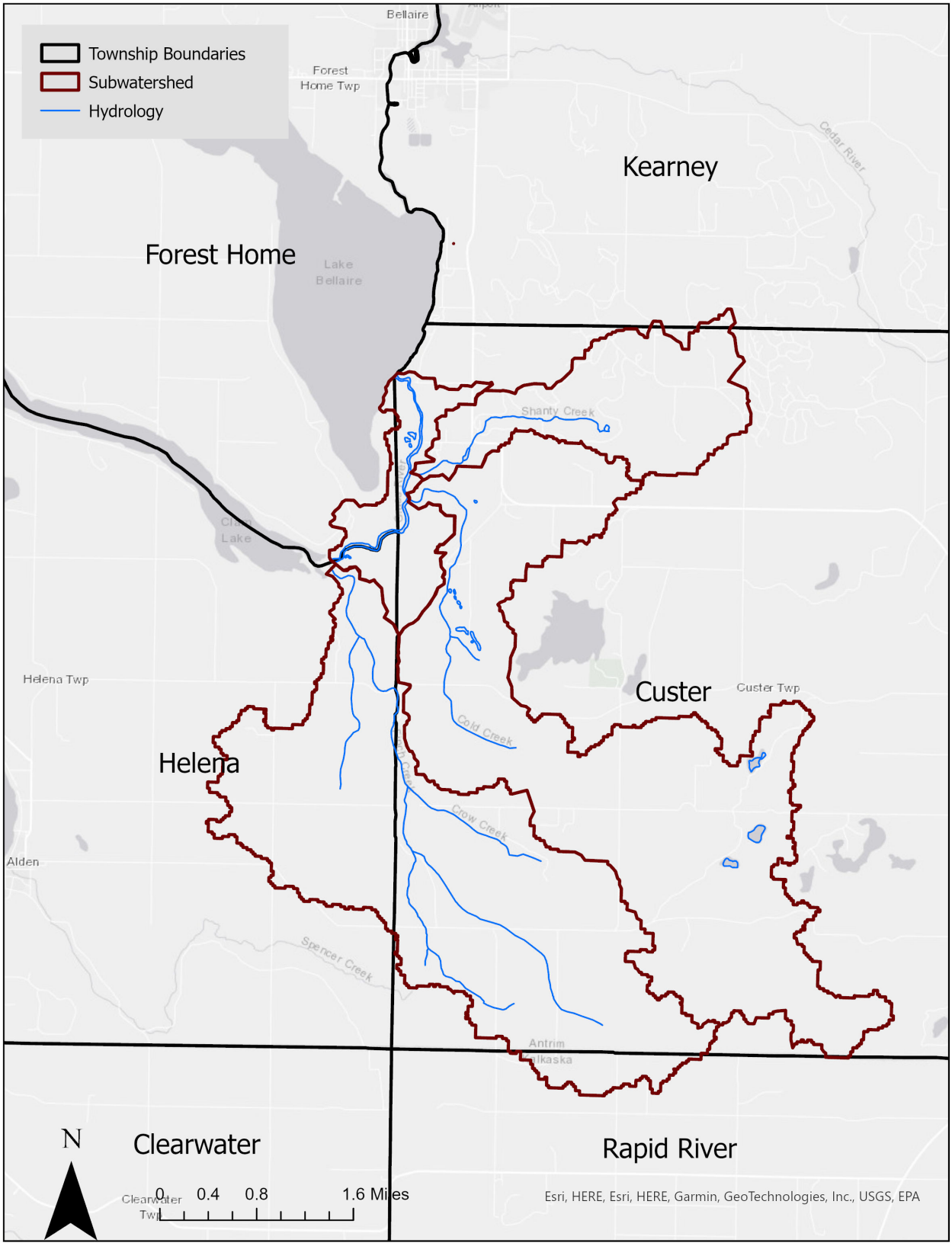

Figure 1. Townships within the sub-watershed.

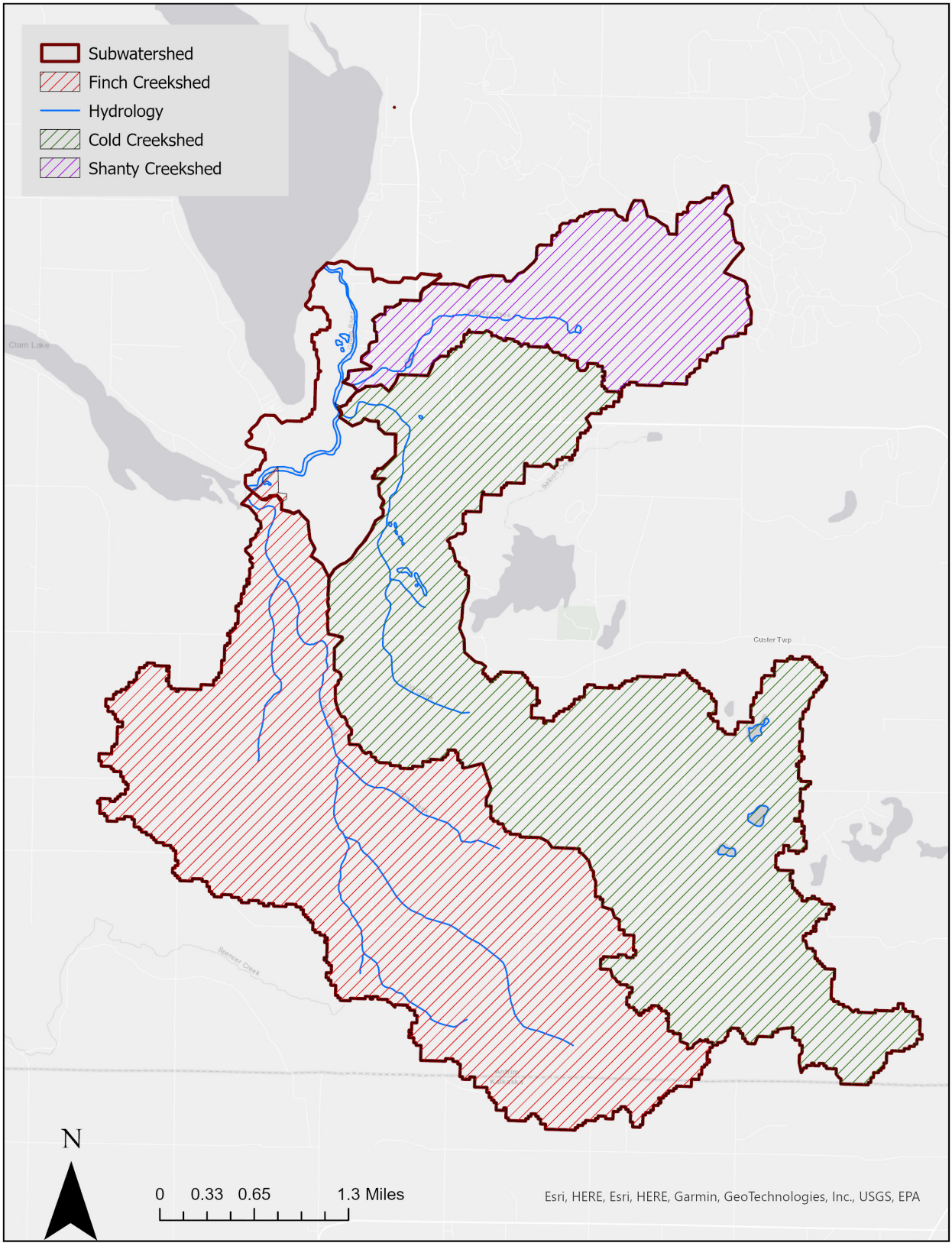

Figure 2. Creeksheds of the sub-watershed.

NATURAL FEATURES

The sub-watershed is home to species listed in the state of Michigan as threatened and endangered, making it important to protect the resources these species depend on. No federally listed species are known to occur in the sub-watershed, but the federally threatened pitcher's thistle (*Cirsium pitcheri*) occurs in Antrim County as a whole, the federally endangered rusty-patched bumble bee (*Bombus affinis*) occurs in Kalkaska County, and the federally endangered northern long-eared bat (*Myotis septentrionalis*) and federally threatened Eastern massasauga (*Sistrurus catenatus*) occur in both counties. (These are the only federally listed species found in the two-county area). Using wildlife species records from GRNA and the Michigan Natural Features Inventory Rare Species Explorer, the species in Table 1 were identified as particularly needing protection.

Common Name	Scientific Name	Taxon	State Status	Observed at GRNA	Observed in Antrim Co.	Observed in Kalkaska Co.
Common loon	*Gavia immer*	Bird	Threatened	Yes	Yes	Yes
Northern goshawk	*Accipiter gentilis*	Bird	Threatened	Yes	Yes	Yes
Pumpelly's bromegrass	*Bromus pumpellianus*	Plant	Threatened	No	Yes	No
Calypso	*Calypso bulbosa*	Plant	Threatened	No	Yes	No
Voss's goldenrod	*Solidago vossii*	Plant	Endangered	No	No	Yes
Pitcher's thistle	*Cirsium pitcher*	Plant	Threatened	No	Yes	No
False violet	*Dalibarda repens*	Plant	Threatened	No	Yes	No
Whorled pogonia	*Isotria verticillata*	Plant	Threatened	No	No	Yes
Vasey's rush	*Juncus vaseyi*	Plant	Threatened	No	No	Yes
Ginseng	*Panax quinquefolius*	Plant	Threatened	No	Yes	Yes
Canada rice grass	*Piptatherum canadense*	Plant	Threatened	No	No	Yes
Hill's pondweed	*Potamogeton hillii*	Plant	Threatened	No	No	Yes
Pinedrops	*Ptersospora andromedea*	Plant	Threatened	No	Yes	No

New England violet	*Viola novae-angliae*	Plant	Threatened	No	No	Yes
Rusty-patched bumble bee	*Bombus affinis*	Insect	Endangered	No	No	Yes
Kirtland's warbler	*Setophaga kirtlandii*	Bird	Endangered	No	No	Yes
Eastern whip-poor-will	*Antrostomus vociferus*	Bird	Threatened	No	No	Yes
Spotted turtle	*Clemmys guttata*	Reptile	Threatened	No	No	Yes
Lake herring	*Coregonus artedi*	Fish	Threatened	No	Yes	Yes
Wood turtle	*Glyptemys insculpta*	Reptile	Threatened	No	No	Yes
Little brown bat	*Myotis lucifugus*	Mammal	Threatened	No	Yes	Yes
Northern long-eared bat	*Myotis septentrionalis*	Mammal	Threatened	No	Yes	Yes
Grizzled skipper	*Pyrgus centaureae wyandot*	Insect	Threatened	No	Yes	No
Eastern massasauga	*Sistrurus catenatus*	Reptile	Threatened	No	Yes	Yes
Lake Huron locust	*Trimerotropis huroniana*	Insect	Threatened	No	Yes	No
Golden-winged warbler	*Vermivora chrysoptera*	Bird	Threatened	No	Yes	No

Table 1. State threatened and endangered species found in the sub-watershed and Antrim and Kalkaska Counties.

FISHERIES

The diverse stream and river habitats of the sub-watershed support a wide diversity of fish species. All three tributaries to Grass River, as well as Grass River itself, are designated as coldwater trout streams. Table 2 displays the species observed during fish surveys conducted during 1981 throughout the sub-watershed by consultant Thomas M. Kelly.

Waterbody	Date	Species
Cold Creek	7-11-81	Bluntnose minnow
Finch Creek	7-10-81	Slimy sculpin
Finch Creek	7-10-81	Slimy sculpin, brown trout
Finch Creek	7-10-81	Slimy sculpin, brook trout, central mudminnow,
Grass River		Yellow perch, largemouth bass,
Grass River	7-21-81	Bluntnose minnow, white sucker, log perch, rockbass

Table 2. Fish species observed in the sub-watershed.

LAND COVER

A wide variety of land cover types exist in the sub-watershed, and though forests and wetlands dominate, anthropogenic landscapes like hay/pasture, developed land, and barren land are also present (Figure 3). Hay/pasture is concentrated in the Finch Creek sub-basin, developed land occurs mostly in the Shanty Creek and Cold Creek sub-basins, and there are areas of barren land in the Cold Creek sub-basin (Table 3).

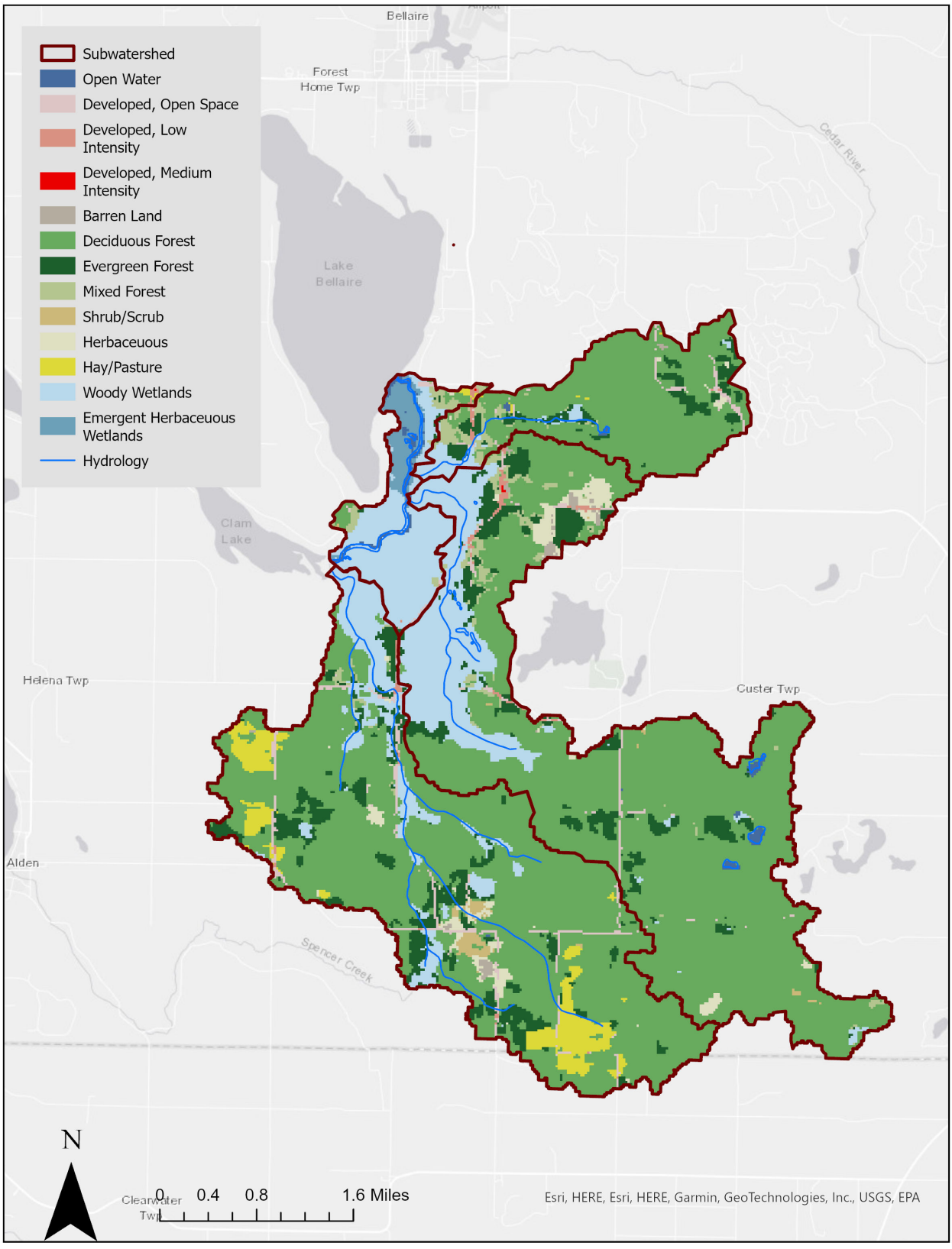

Figure 3. Land cover of the sub-watershed.

Land Cover	Area (mi^2)	Percentage of sub-watershed area
Woody Wetlands	2.46	14.17%
Herbaceous Wetlands	0.19	1.12%
Deciduous Forest	11.66	67.19%
Evergreen Forest	1.40	8.06%
Mixed Forest	0.31	1.78%
Shrub/Scrub	0.08	0.43%
Herbaceous	0.27	1.54%
Hay/Pasture	0.45	2.61%
Barren Land	0.06	0.34%
Developed, Open Space	0.29	1.67%
Developed, Low Intensity	0.08	0.43%
Developed, Medium Intensity	0.0	0%
Open Water	0.11	0.66%

Table 3. Land cover in the sub-watershed by area and percentage.

GEOLOGY & SOILS

The bedrock geology of the sub-watershed is comprised of several types of shale, including Coldwater Shale, Sunbury Shale, Berea Sandstone/Bedford Shale, Antrim Shale, and Ellsworth Shale. The glacial topography is chiefly a flat lake plain with sandy soil, but also includes moraine ridges and narrow outwash channels near the headwaters of the tributaries, as well as broad moraine ridges, till plains, and drumlins in the southwestern part of the Finch Creek sub-basin. Soils in the sub-watershed are comprised of Tawas-Roscommon-Cathro surrounding the Grass River and the downstream portions of the tributaries, Kalkaska-Leelanau-Emmet near the headwaters of the three tributaries, and a section of Emmet-Montcalm-Kalkaska in the southwestern portion of the Finch Creek sub-basin. Tawa-Roscommon-Cathro is characterized by poorly drained, nearly level mucky, loamy, and sandy soils in depressions on plains that are neutral to slightly acidic. Kalkaska-Leelanau-Emmet is characterized by well-drained and loamy soils that persist on level to steep areas and are usually neutral or slightly acidic in pH, while Emmet-Montcalm-Kalkaska consists of well-drained sandy loams and loamy sands ranging from neutral to acidic that are found on gently sloping to steep land. See the maps on pages 31-33 of the ERCOL plan for details on the bedrock geology, glacial topography, and soils.

TOPOGRAPHY

Elevation ranges from 174 – 358 m above sea level throughout the sub-watershed. The highest elevations occur in the eastern section, near the headwaters of the three tributaries, while the lowest elevations are found in the northwestern section along the Grass River (Figure 4).

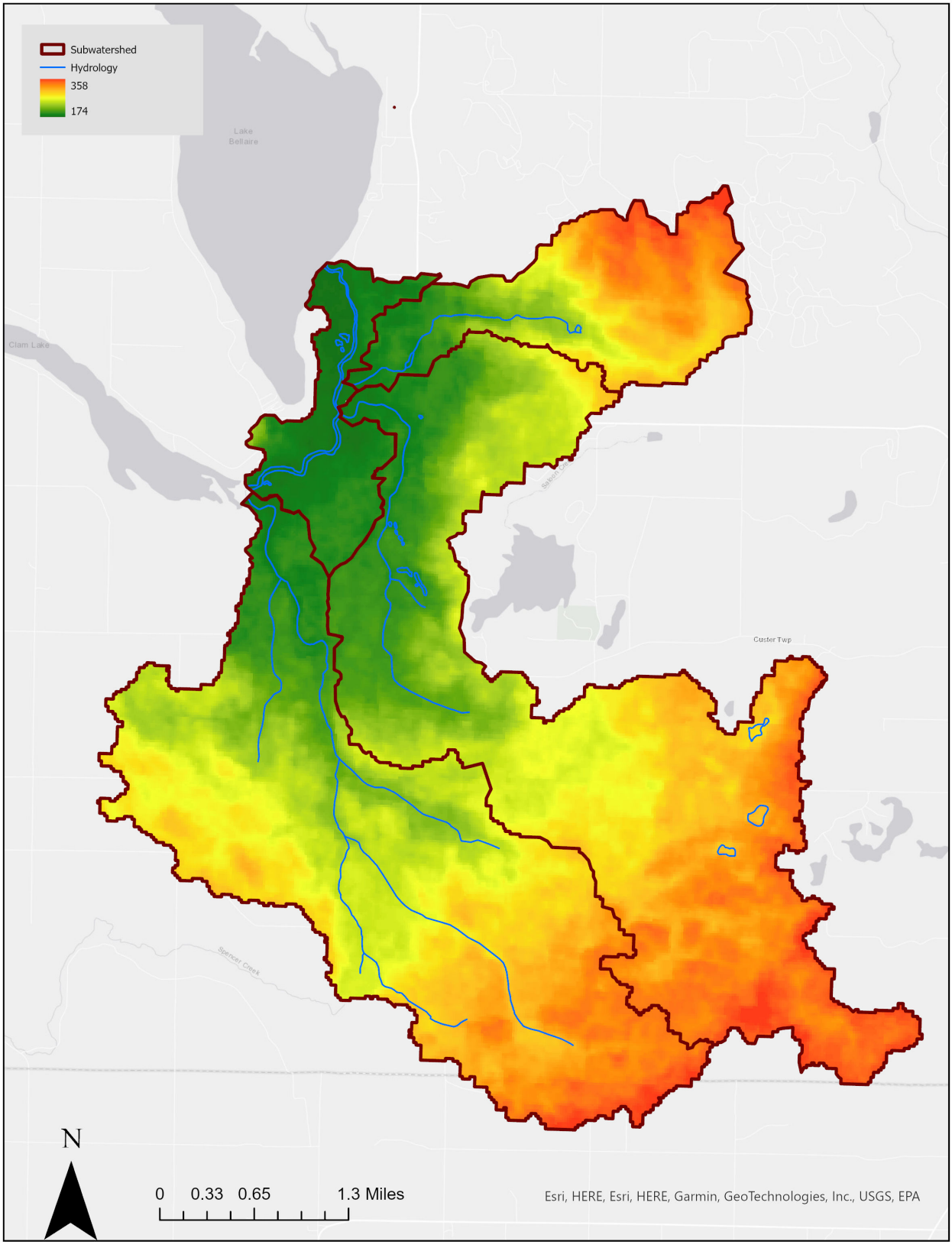

Figure 4. Elevation of the sub-watershed in meters above sea level.

PEOPLE

The sub-watershed is sparsely populated without any incorporated municipalities. The population of the five townships that comprise the sub-watershed totaled 4,537 in 2020 according to U.S. Census Bureau data, meaning the population density of all four townships is below 50 people per square mile (Table 4).

Township	County	2020 Population	Area (mi^2)	Population Density (people/mi^2)
Helena	Antrim	937	23.1	40.7
Custer	Antrim	1,150	35.2	32.7
Forest Home	Antrim	1,205	33.5	36.0
Kearny	Antrim	1,197	35.3	33.9
Rapid City	Kalkaska	1,245	35.2	35.4
Total		4,537	127	35.7

Table 4. Population, area, and population density of townships within the sub-watershed.

The populations of Helena, Forest Home, and Kearny Townships decreased from 2010 to 2020, while the population of Custer and Rapid City Townships experienced increases during the same period (U.S. Census Bureau). Overall, the population of all four townships together has decreased (Table 5).

Township	County	2010 Population	2020 Population	Percent Change (2010 – 2020)
Helena	Antrim	1,001	937	-6.4%
Custer	Antrim	1,136	1150	1.2%
Forest Home	Antrim	1,720	1205	-29.9%
Kearny	Antrim	1,765	1,197	-32.3%
Rapid River	Kalkaska	1,145	1,245	8.7%
Total		6,767	5,734	-15.3%

Table 5. Population change in townships within the sub-watershed.

GOVERNMENTS

There are five townships within the sub-watershed – Helena, Custer, Forest Home, Kearny, and Rapid City – with each township having varying degrees of land area within the sub-watershed (Table 6). The majority of the sub-watershed is made up by Custer Township. The western portion of the Finch Creek creekshed is located within Helena Township, while a small portion of Forest Home Township drains directly into Grass River, a small portion of Rapid City Township is included in the headwaters of the Finch Creek sub-basin, and a very small portion of Kearny Township is in the Shanty Creek sub-basin headwaters.

Township	Total Area (mi^2)	Total Area in Sub-watershed (mi^2)	% of Sub-watershed in Township
Helena	23.1	2.84	16.37%
Custer	35.2	13.90	80.05%
Forest Home	33.5	0.24	1.39%
Kearny	35.3	0.03	0.16%
Rapid City	35.2	0.35	2.03%

Table 6. Land area by township within the sub-watershed.

Antrim County does not have a county-wide zoning ordinance; instead, individual township and village governments have zoning authority. Helena, Forest Home, and Kearny townships have a zoning ordinance that includes riparian buffer strip provisions, and Forest Home and Kearny township also includes a setback provision. Custer Township does not have zoning. In Kalkaska County, Rapid River Township does not fall under the Kalkaska County zoning ordinance that covers some other townships, but it does have its own zoning ordinance. Rapid City Township has a setback provision as well as a riparian buffer strip provision. The extent to which the provisions in the three townships in which they exist are enforced is uncertain, which is addressed in Section 5: Implementation Strategy.

USES

The Grass River is a vital asset to the community for its ecological, recreational, and economic values, with the freshwater resources and water recreation opportunities of this area playing both an important role in the identity of the residents but also as a draw for tourists. The Grass River in particular is both a popular destination for water recreation due to the majority of its length flowing through the pristine GRNA, but it's also an important travel corridor for boaters, particularly tourists, between the town of Bellaire (and the very popular Shorts Brewing Company) and Torch Lake.

In a survey administered to attendees of several stakeholder meetings, over 50% of respondents reported that they engage in each of the following three behaviors at least once a month during the warm season: observing nature, sitting near the river and watching the water/passersby, and visiting the river with guests. Other important uses include paddling, boating, and fishing. Appendix B provides more details on survey responses. See Section 3: Education/Outreach, Grass River Connects Meetings for a detailed review of these stakeholder meetings.

The sub-watershed has a variety of designated uses. For a full description of designated uses for surface waters in the state of Michigan, see Table 51 on page 154 of the ERCOL plan. All three tributaries, as well as Grass River, are designated trout streams in the state of Michigan according to Fisheries Order 210.23. There are no designated use impairments within the sub-watershed.

Though there are no official designated use impairments, the sub-watershed remains vulnerable to nonpoint source pollution and other environmental stressors. The ERCOL plan identified the creeksheds of the three tributaries to Grass River as a critical area:

> These creeks have problems resulting from development pressures, water control infrastructure, and road stream crossing infrastructure. A significant acreage within these creeksheds has been converted from forest to human landscapes such as lawns, roads, and golf courses. Clearing of vegetation within the riparian buffer on residential properties leads to increased sediment and nutrient loading. Four small dams are in this area, two of which were found to be nearly completely failing while the other two each had structural integrity issues. The breaking or leaking of these dams also contributes to increased sediment loading. Five severe impact road stream crossings are in this area, with undersized culverts limiting fish passage. All three of these creeks are designated as coldwater fisheries, but sediment loading and fish habitat fragmentation put this use at high risk (page 175).

The combination of the steep gradients of the tributaries, severe road stream crossings, removal of riparian buffers, land use conversion (particularly the presence of Shanty Creek Resort – a large complex of golf courses and deforested ski slopes – surrounding Shanty Creek), and failing private dams have caused extreme sediment loading in Grass River. This sediment input has begun to impact the ability of boats to navigate the river, a situation that is exacerbated by a subset of boaters failing to comply with the no-wake regulation; besides being a safety issue, boats traveling at wake speed negatively erode the river banks, as the sedge-dominated vegetation is not adapted for wave action, effectively depositing more sediment into the river. Additionally, the relatively new practice of pulling boats up onto the fragile riparian vegetation along the river has created several denuded areas of bare soil, further contributing to the sedimentation issue. While sedimentation is the most pressing and holistic threat facing the sub-watershed, a full list of threats also includes irresponsible boating, invasive species, flow alterations to the tributaries, septic systems, land use changes, and climate change. Each of these threats are described in detail in Section 2.

Section 2: Nonpoint Source Pollution and Other Ecological Stressors

SEDIMENTATION

An increased sediment load in the Grass River and the lower reaches of its tributaries is likely the biggest ecological stressor in the sub-watershed. Sedimentation covers up important aquatic habitat that many of our fish and macroinvertebrate species need to thrive, threatens the navigability of the Grass River, and paves for the way for establishment by some invasive species like purple loosestrife and narrowleaf cattail.

The hydrologic factor underlying this sedimentation problem is the low elevation gradient of Grass River compared to the higher gradients of the tributaries. Essentially, sediment washing into the tributaries is carried downstream to the river, where it contributes to significant deposition. The river, in turn, has little capability to continue to carry that sediment downstream. Some of the sediment from the tributaries is normal, though much of it is washed into the creeks due to development like poor road-stream crossings, streambank erosion sites, removal of riparian buffers, stormwater from impervious surfaces, and land conversion into ski hills and golf courses.

Paul Richards of The College at Brockport applied the Soil Water Assessment Tool (SWAT) to the Grass River sub-watershed. The SWAT is a model that incorporates land use, topography, road-stream crossing traits, evaporation, snowmelt, and groundwater flow to estimate sedimentation and other stressors like nutrient run-off. According to this model, more than 620 tons of sediment wash into the Grass River every year, which is the equivalent of 13 dump trucks (Richards 2011). Finch Creek is the largest contributor, likely due in part to the fact that it's also the largest tributary (Table 7).

Richards also broke the sub-watershed into sub-basins and mapped them onto land use types (Figure 5). From there, sediment yields – as well as organic nitrogen, organic phosphorus, soluble phosphorus, and mineral phosphorus – for each sub-basin of the three tributaries and Grass River were calculated (Table 8). Additionally, sediment loads were mapped onto the sub-basins both per unit watershed area (Figure6) and in individual stream reaches (Figure 7). The maps indicate that the sub-basins associated with Finch Creek are of greatest concern, which makes sense because Finch Creek was predicted by the model to be the largest contributor to sediment of the three tributaries.

An important input of SWAT is stream flow. When Richards compared the model's predictions of the flow of Cold Creek to actual observed discharges of the stream from Endicott 2007, he found that the model underpredicted the average monthly flow during the months of April, May, and June by 26% and the months of July, August, and September by 75%, as depicted in Table 9 (Richards 2011). This discrepancy led the author to conclude that "whatever conclusions this study draws on sedimentation, the truth is probably much, much worse" (Richards 2011).

Another study by Dr. Anthony Kendall of Michigan State University and colleagues attempting to assess sedimentation in the Grass River system involved a field survey of the Grass River's bathymetry, as well as elevation measurements along its length and discharge and elevation measurements of the three tributaries. The study found that Finch and Shanty Creek

have higher gradients than Cold Creek, as depicted in Figure 8, suggesting that they have more potential to transport sediment, all other things being equal. However, as shown in Figure 9, the discharge of Finch and Cold Creeks peak in excess of 1 cubic meter per second, while Shanty Creek peaked at less than 0.3 cubic meters per second, meaning that overall, Finch Creek is most likely contributing the highest sediment loads of the three creeks, a finding that confirms the conclusion of the SWAT analysis (Kendall et al. 2014).

The results of the field survey on the river revealed that the elevation gradient is very shallow – no more than 0.01%, as depicted in Figure 10 and as compared to sections of Finch and Shanty Creeks that approach 1.5% (Kendall et al. 2014). In addition to the river having a low elevation gradient, the average navigable depth of the Grass River – in 50 m increments – was frequently only 3-3.5 ft, and occasionally the depth was less than 3 ft (Figure 11), meaning that navigational difficulties occasionally occur, which the authors noted they experienced personally during the course of the study (Kendall et al. 2014). Furthermore, the channel depth was shallower at the tributary outlets to the river as compared to the rest of the river, suggesting that the tributaries are a source of sediment (Figure 12).

Kendell et al. also compared the channel widths calculated during field surveys to aerial images from 1938, 1950s, 1960s, 1970s, 1980s, and the early 1990s in order to determine if the channel had widened, finding that the river has widened on average about 25 feet from 1938 to the early 1990s (Figure 13). This width increase is likely due to the river getting shallower due to sediment inputs.

Tributary	Sediment Load (tons/year)
Finch Creek	401.0
Cold Creek	166.8
Shanty Creek	50.0
Total	617.8

Table 7. Modeled sediment Loads per year by creekshed.

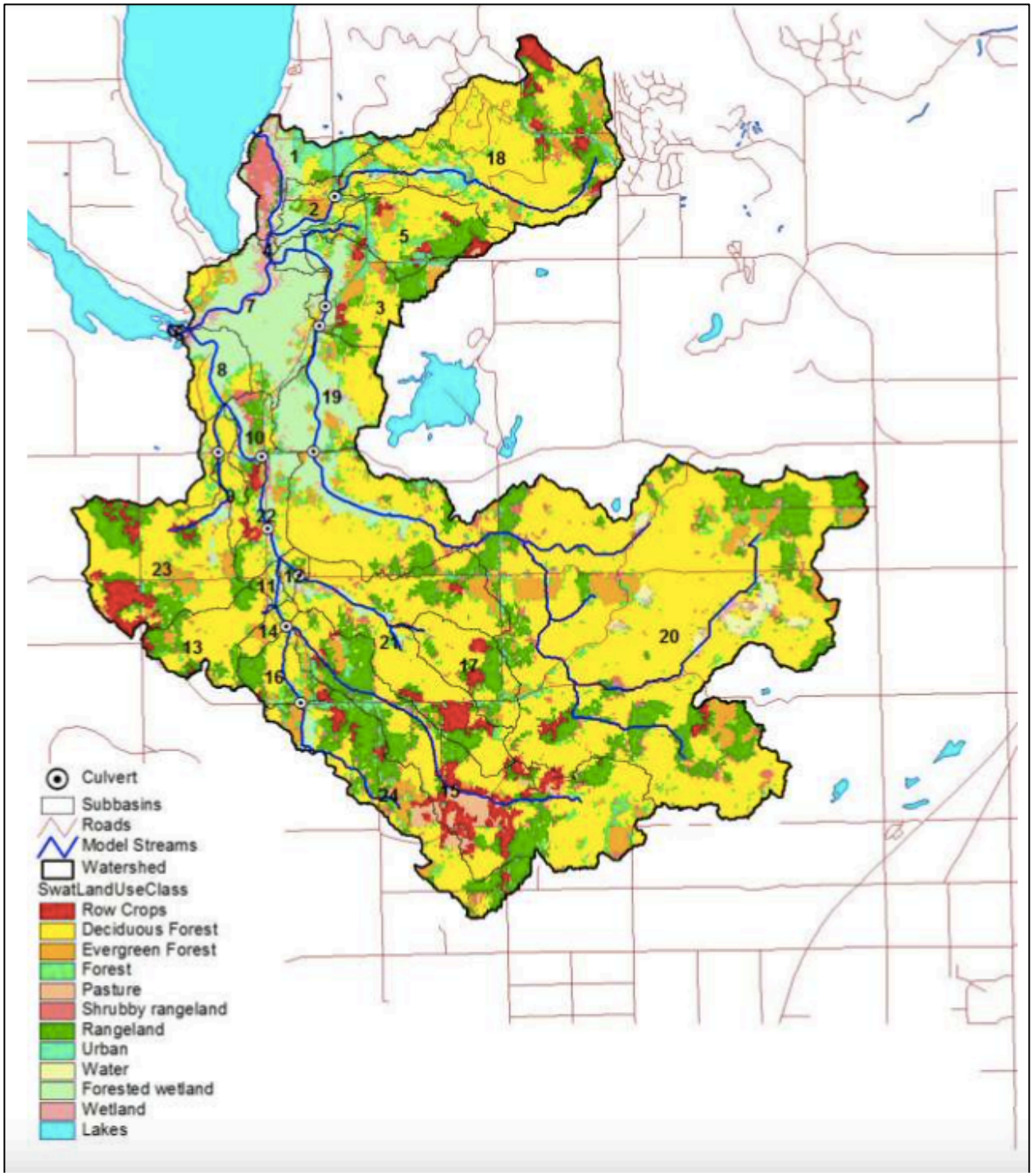

Figure 5. Sub-basins mapped onto land cover. Map provided by Richards 2011.

Sub-basin ID	Drainage Point	Sediment (tons/yr/km^2)	Organic Nitrogen (kg/yr/km^2)	Organic Phosphorus (kg/yr/km^2)	Soluble Phosphorus (kg/yr/km^2)	Mineral Phosphorus (kg/yr/km^2)
1	Grass River	4.9	43.5	7.5	3.7	0.3
2	Shanty Creek	3.9	16.9	3.8	1.6	0.1
3	Cold Creek	53.7	302.4	44.7	1.5	2.8
4	Cold Creek	0.6	15.4	2.1	0.2	0.1
5	Cold Creek	6.6	45.5	7.0	1.6	0.6
6	Grass River	0.8	22.3	3.0	0.2	0.2
7	Grass River	1.3	28.5	3.6	0.3	0.2
8	Finch Creek	0.7	16.1	2.0	0.1	0.1
9	Finch Creek	1.4	11.3	1.4	0.7	0.2
10	Finch Creek	4.4	25.8	5.0	1.7	0.2
11	Finch Creek	16.6	43.8	5.5	1.9	1.9
12	Finch Creek	7.4	27.3	3.5	0.8	0.9
13	Finch Creek	24.7	64.3	8.3	2.5	2.7
14	Finch Creek	6.3	17.4	2.2	1.7	0.8
15	Finch Creek	205.7	331.3	49.6	0.8	9.3
16	Finch Creek	15.9	42.6	5.5	1.9	1.8
17	Finch Creek	102.5	195.6	29.1	0.9	5.5
18	Shanty Creek	35.9	70.2	9.3	1.2	1.3
19	Cold Creek	2.5	57.0	7.0	0.2	0.3
20	Cold Creek	5.2	19.7	2.5	0.8	0.7
21	Finch Creek	119.7	215.8	32.2	0.8	6.1
22	Finch Creek	109.1	285.8	41.9	1.5	4.8
23	Finch Creek	438.5	386.8	60.7	2.2	15.3
24	Finch Creek	107.8	201.1	29.8	0.8	5.7

Table 8. Predicted Sediment and Nutrient Loads by Sub-Basins of Grass River and Tributaries.

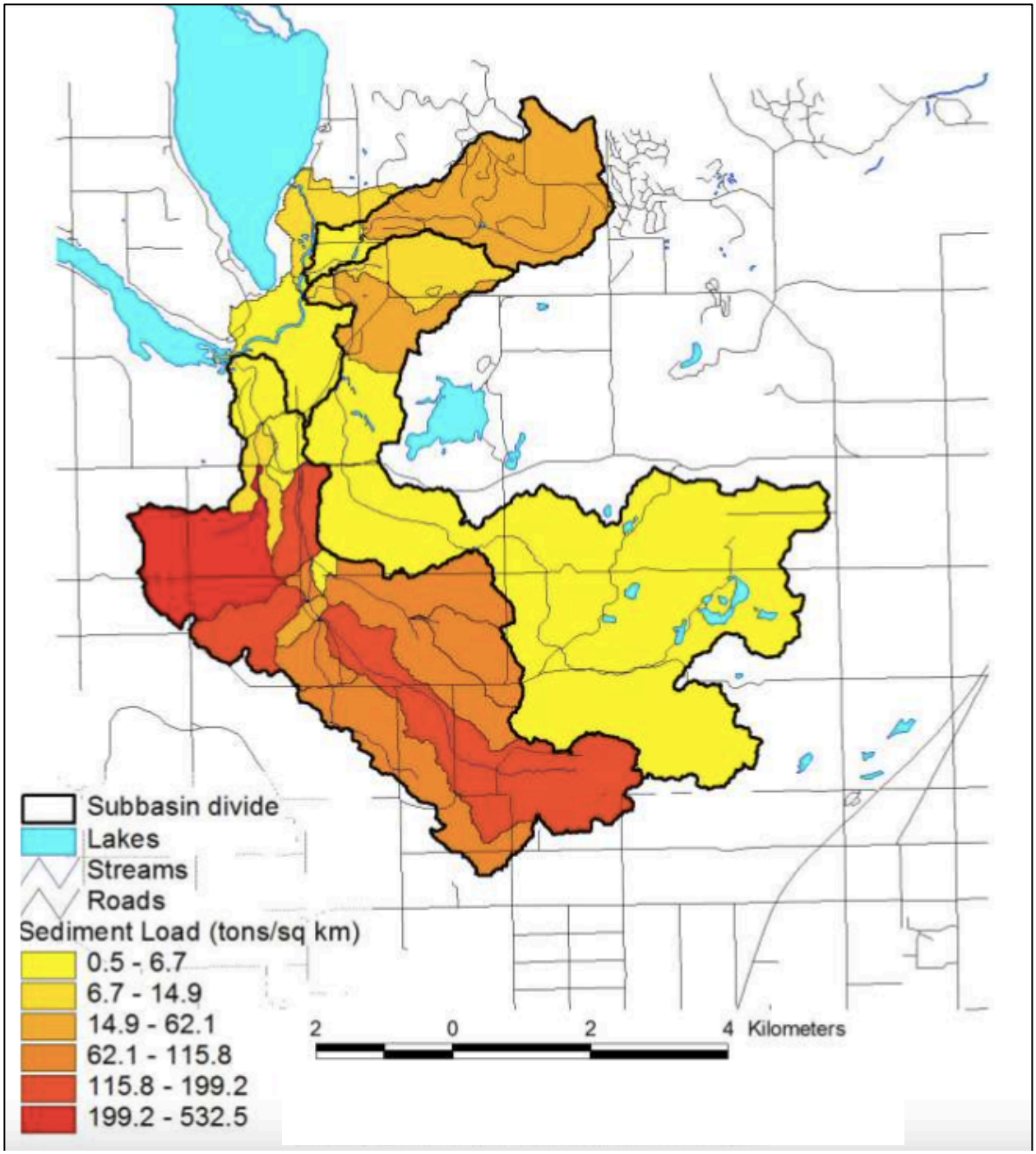

Figure 6. Modeled sediment loads per unit area by sub-basin. Map provided by Richards 2011.

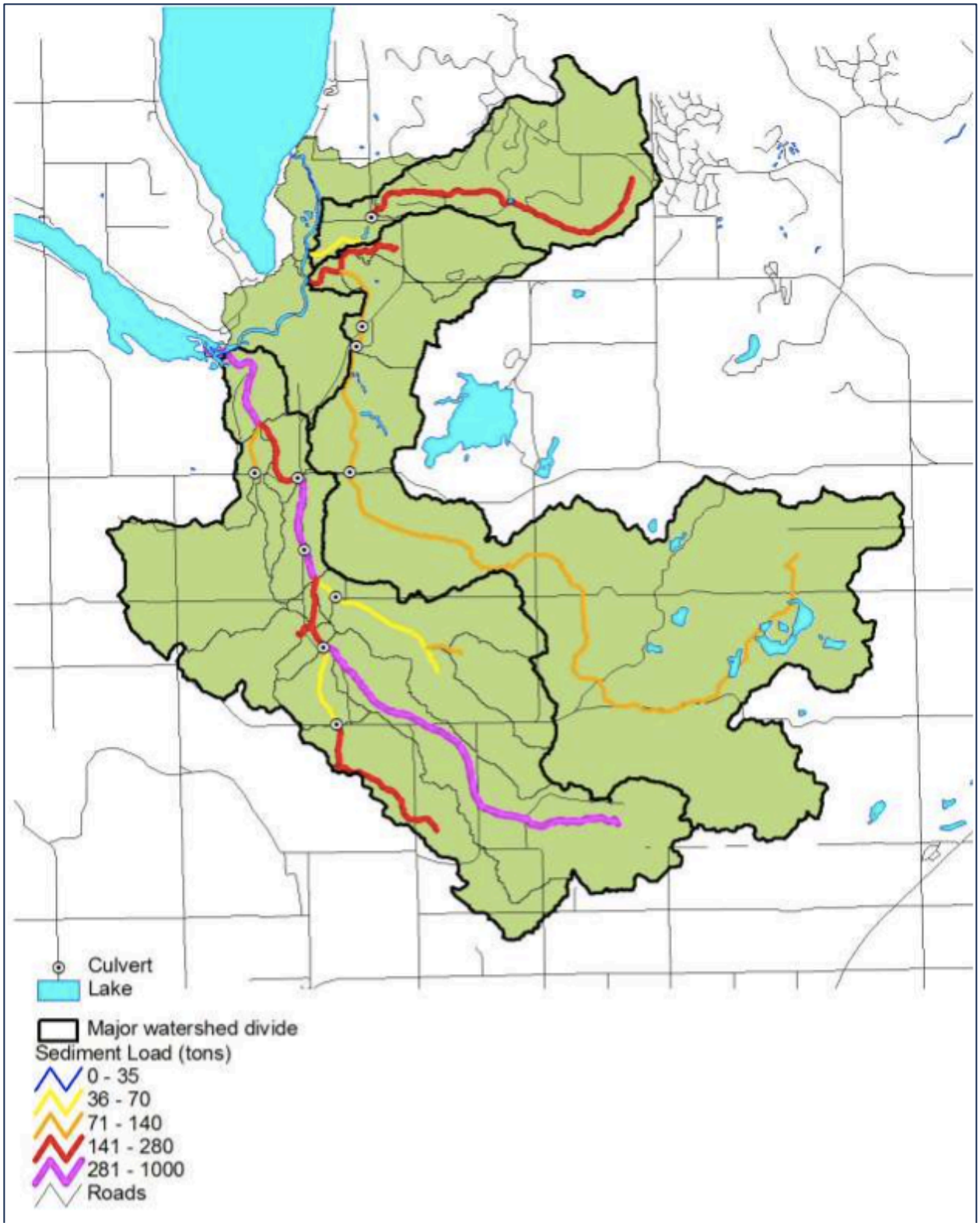

Figure 7. Sediment loads in individual stream reaches. Map provided by Richards 2011.

Month	Monthly Averaged Observed Flow (cubic ft/sec)	Monthly Averaged Modeled Flow (cubic ft/sec)
April 2006	29.64	21.9
May 2006	29.0	20.8
June 2006	28.1	21.8
July 2006	28.4	10.4
August 2006	28.3	6.9
September 2006	28.5	4.4

Table 9. Modeled versus observed flow in Cold Creek.

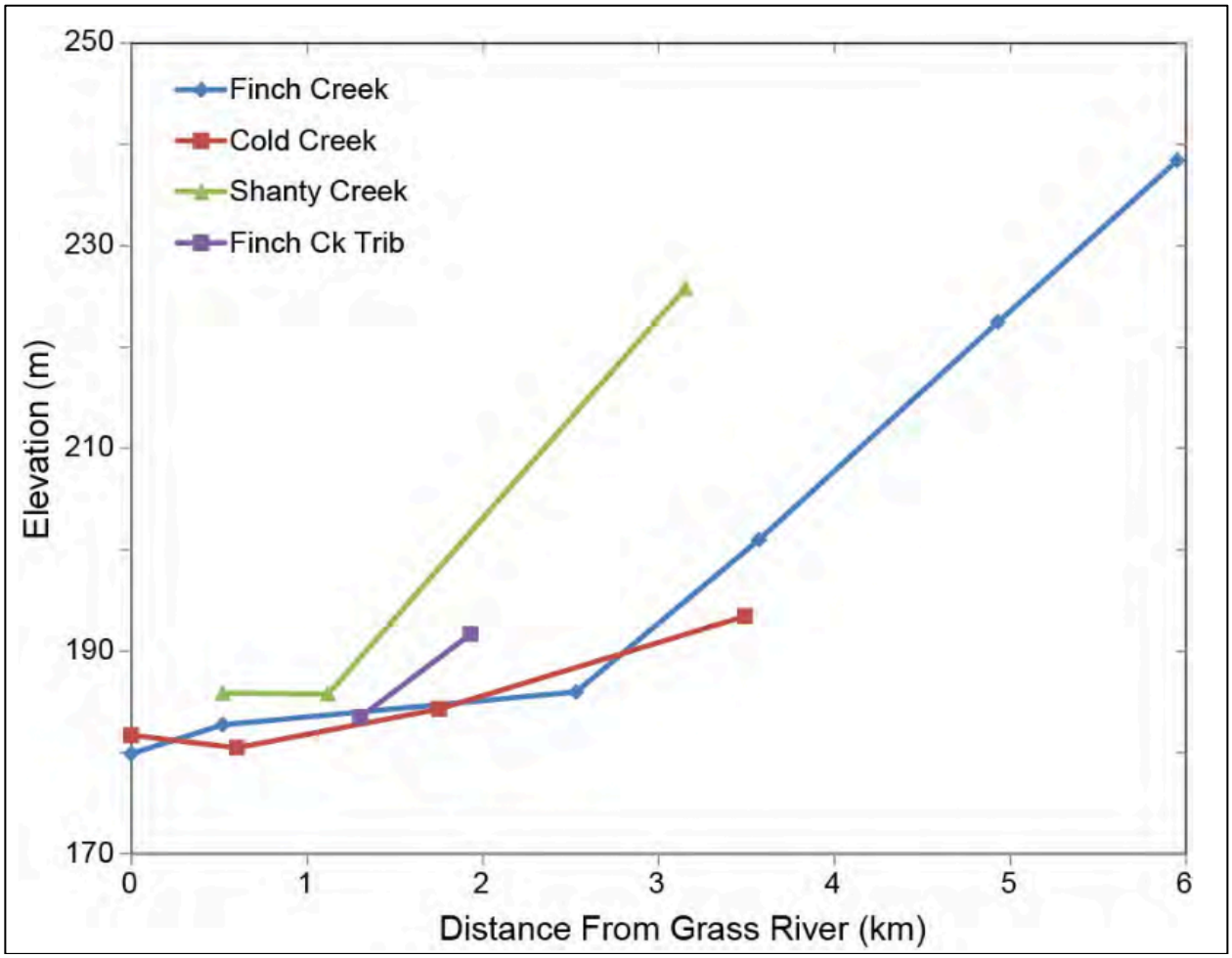

Figure 8. Gradients of the three tributaries. Finch Ck Trib refers to Scrabble Creek. Figure provided by Kendall et al. 2014.

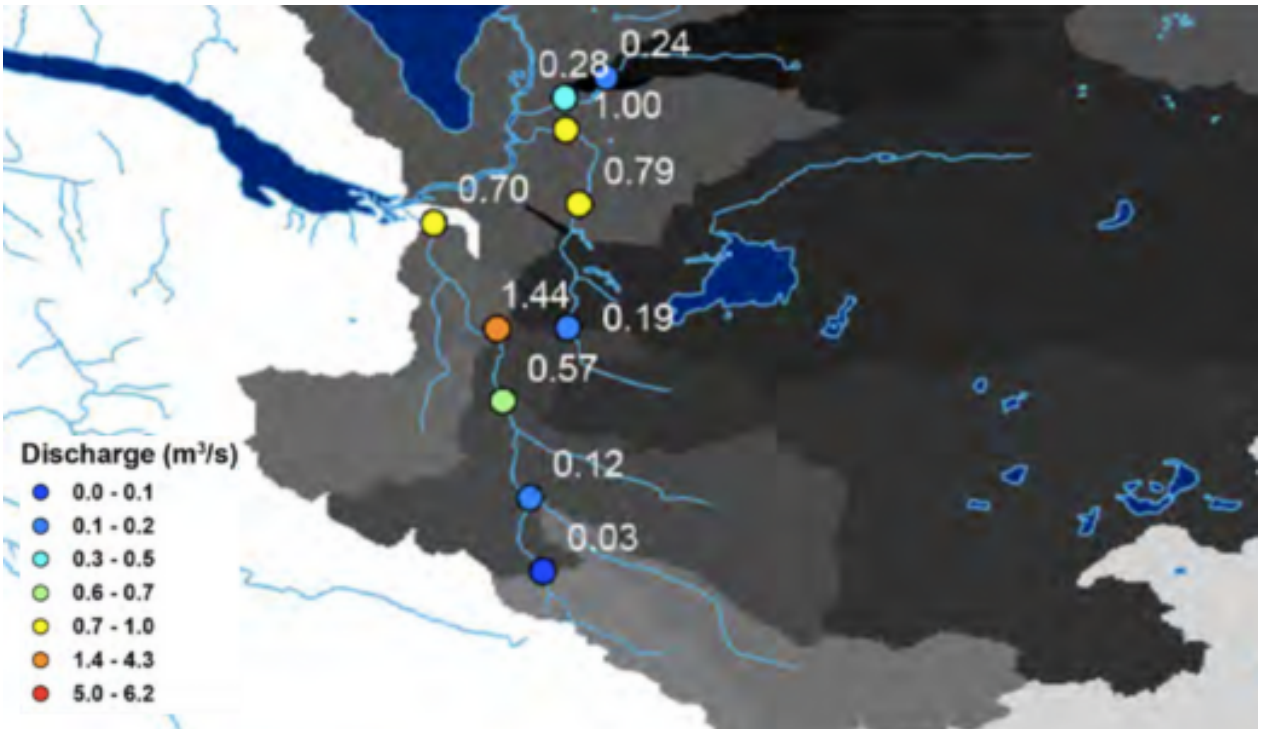

Figure 9: Discharge values throughout the sub-watershed. Map provided by Kendall et al. 2014.

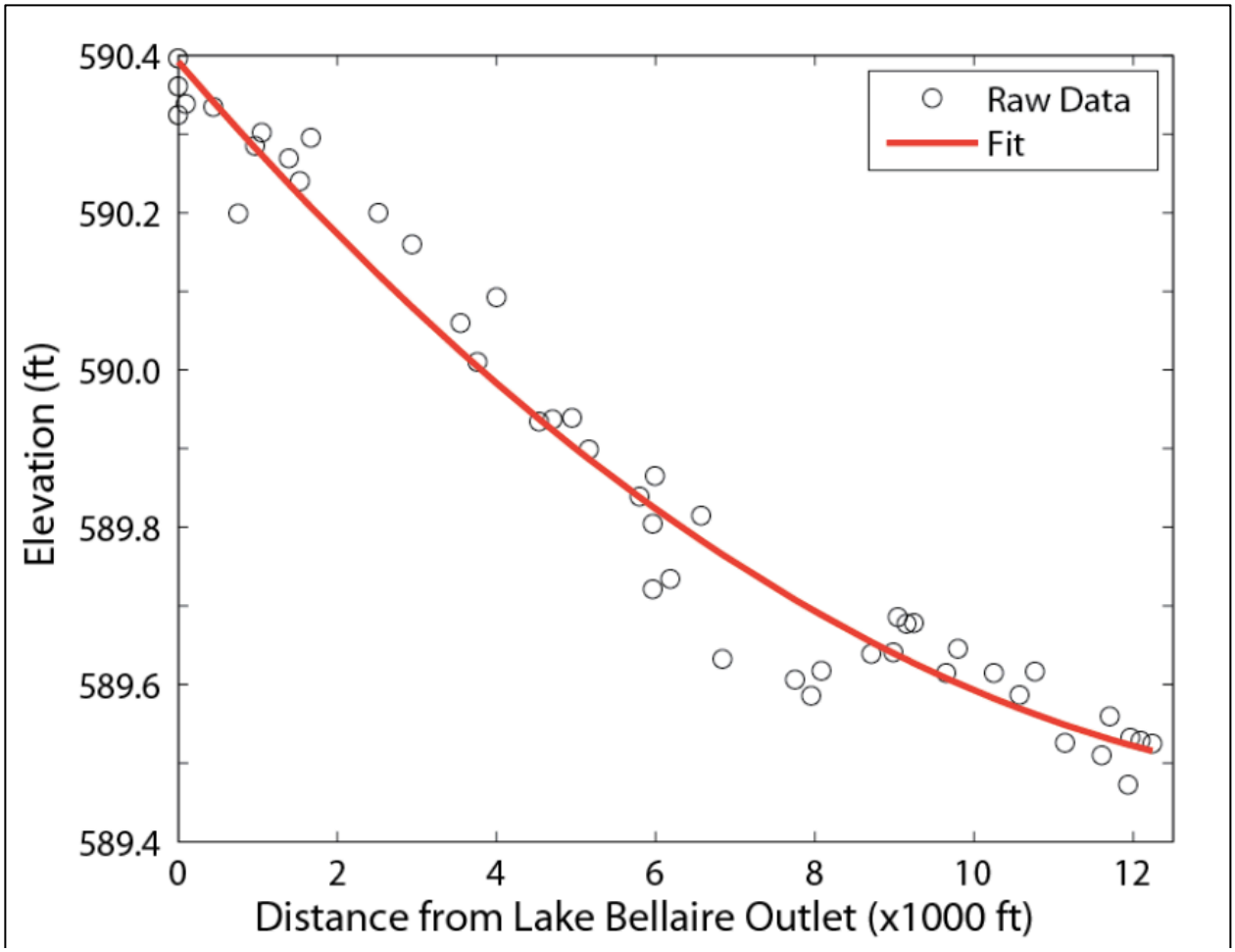

Figure 10. Elevation along Grass River with a best fit line. Figure provided by Kendall et al. 2014.

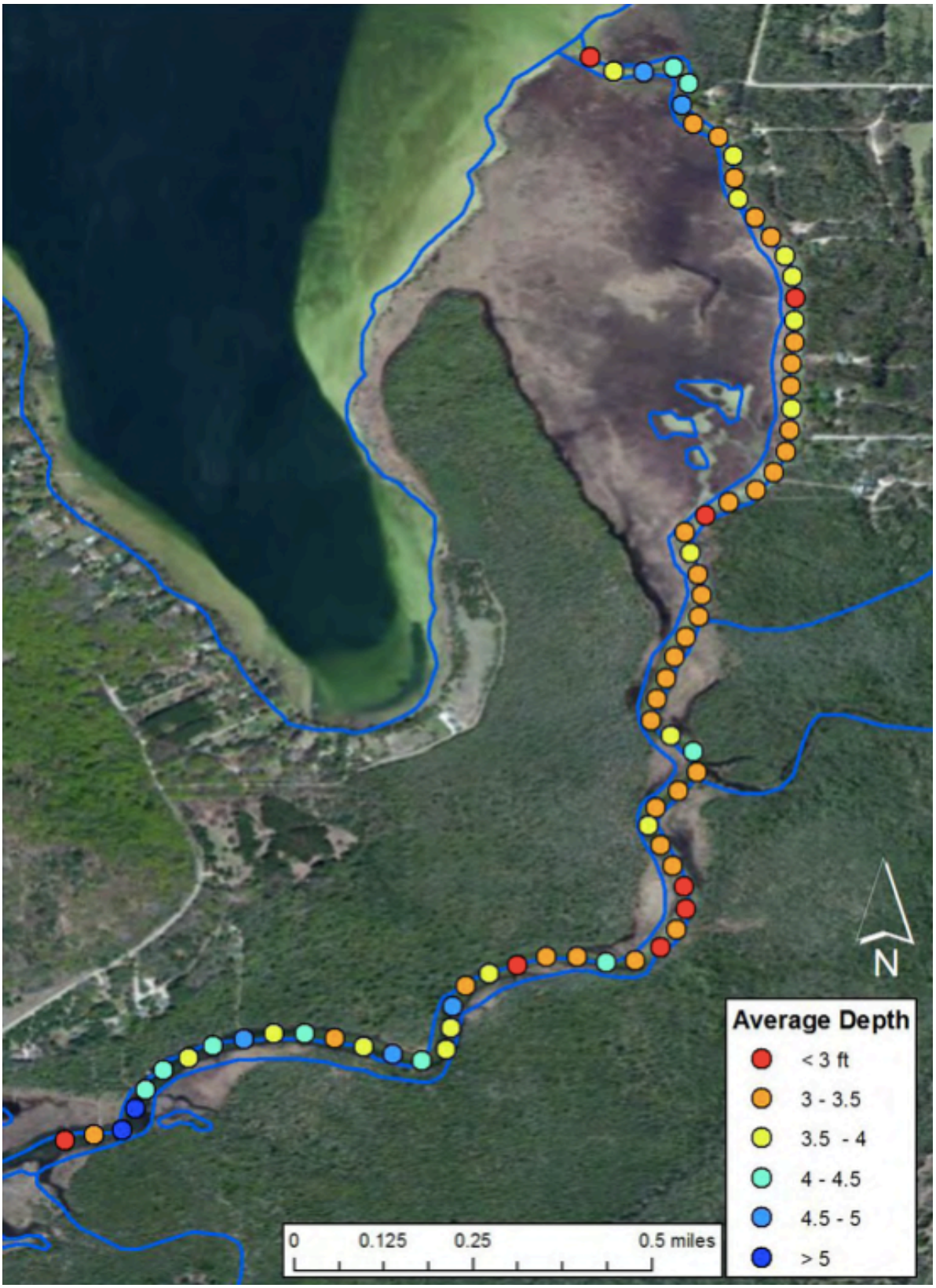

Figure 11. Average navigable depth along Grass River in 50 m increments. Map provided by Kendall et al. 2014.

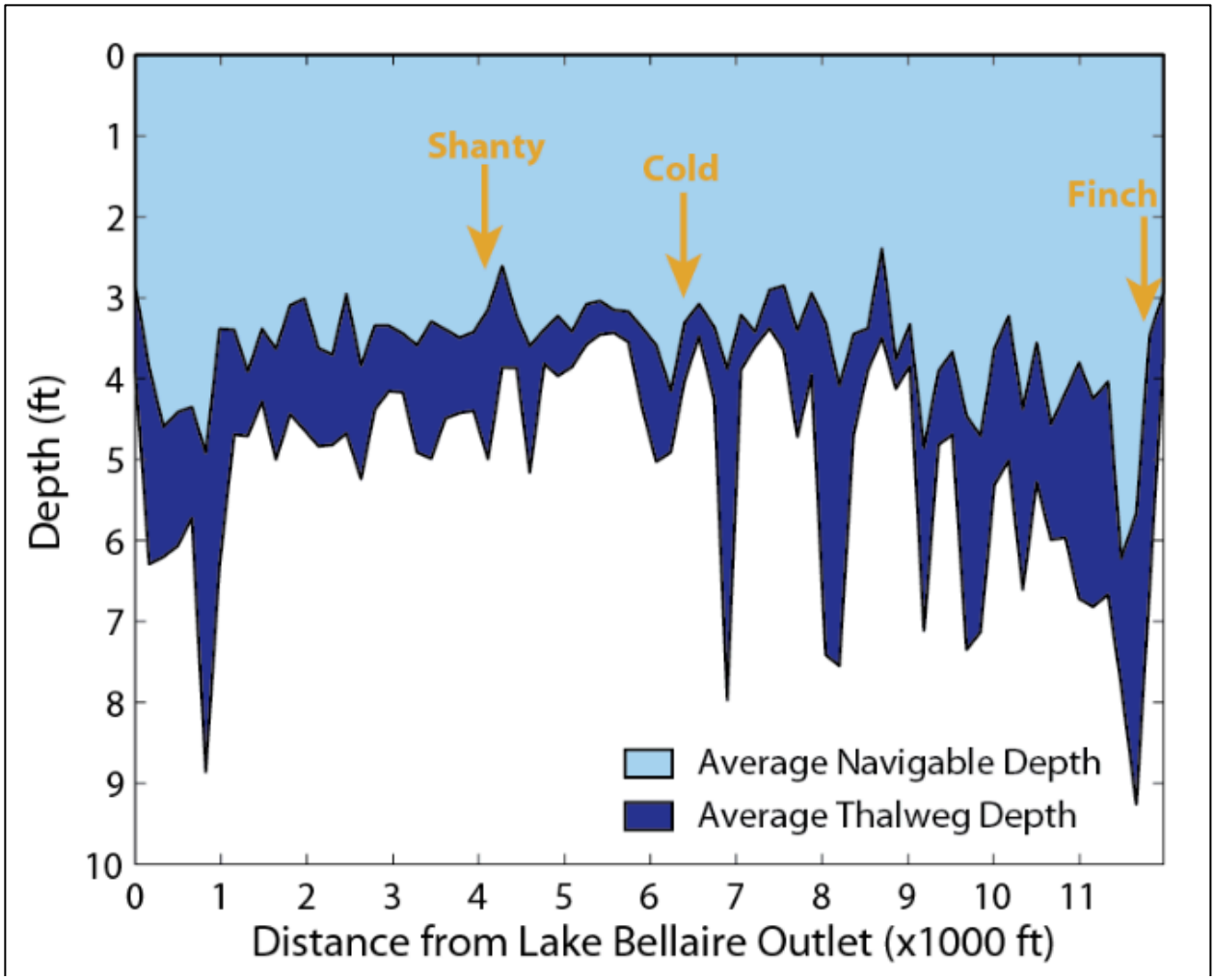

Figure 12. Average navigable depth and average thalweg depth in 50 m increments along Grass River. Figure provided by Kendall et al. 2014.

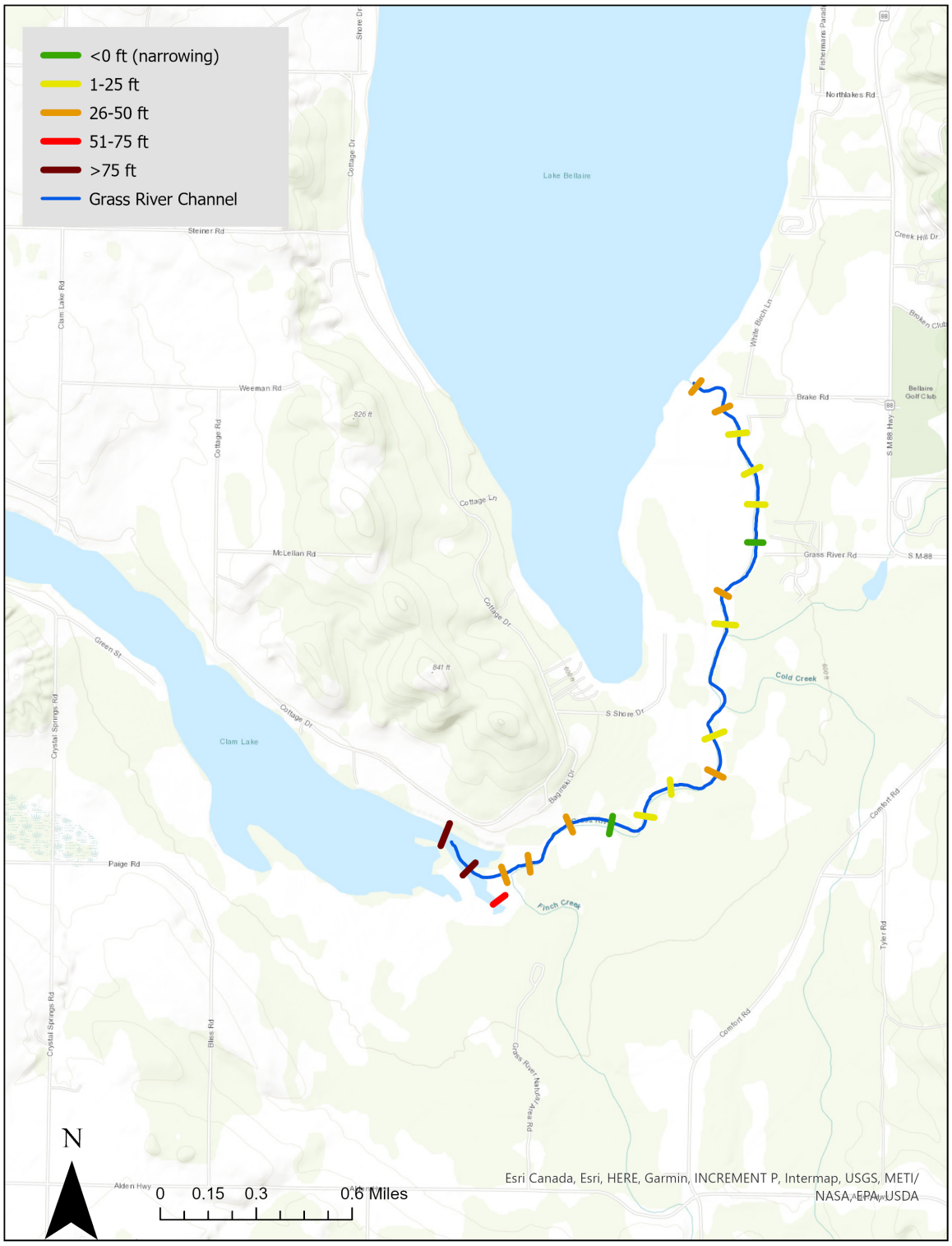

Figure 13. Changes in river width at select transects along the Grass River from 1938 to the 1990s.

IRRESPONSIBLE RECREATION

A statute in the Michigan Administrative Code Section R. 281.705.1 establishes certain rivers and channels in Antrim County on which "no operator of any motorboat shall exceed a slow-no wake speed," including "Grass River from Clam Lake to Lake Bellaire." However, multiple conversations and workshops with riparian landowners; GRNA staff, board, volunteers, and donors; recreators, both boaters and quiet water enthusiasts; and members of other nonprofit organizations have demonstrated that the lack of compliance with the no-wake statute is a threat to the Grass River. In addition to damaging docks and other infrastructure, wakes can cause bank erosion and undermine the stabilizing force of riparian vegetation, thereby exacerbating the issues of sedimentation and river widening. This is especially true given that the vegetation along the Grass River, which is dominated by sedges, is not adapted for wave action or fast current due to the river's low elevation gradient. Lessening the impact of boat wakes is critical not only for the aquatic habitat but also because much of Grass River's shoreline and riparian area has been classified as an A/B ranked northern fen by Michigan Natural Features Inventory – meaning it is a large, intact natural community highly deserving of protection but vulnerable to disturbances like human incursions that can cause changes in hydrology.

There is signage at either end of the river – along with one in the middle of its length – advising boaters that the river is a no-wake zone (Figure 14). While no formal assessment of the variety of variables that contribute to the lack of compliance has been conducted, based on anecdotal observations, at least some of it seems to stem from confusion around what a "no-wake" speed means, particularly with boat renters who may not be very familiar with motorboat operations. As the popularity of boating the Grass River has increased in recent years – partly due to the rise of popularity of Torch Lake and the town of Bellaire as tourist destinations – the effects of wakes in the Grass River have become more impactful.

In addition to the rise in boats traveling at wake speed, boaters have also begun pulling their boats up onto the bank at various locations along the river. In conversations with riparian landowners, this appears to be a relatively new cultural practice, but areas of denuded riparian vegetation can now be seen along the river from this practice (Figure 15). There is currently no regulation at the state or local level banning this practice.

Figure 14. No wake sign in the middle of Grass River.

Figure 15. An example of an area along Grass River where boats have pulled up onto the banks.

INVASIVE SPECIES

Invasive plants can alter aquatic and riparian habitats, outcompete native species, and impede the view of and access to the water, as species like narrow-leaf cattail and non-native phragmites often grow in very dense monocultures. While no comprehensive invasive species survey of the entire Grass River sub-watershed has been conducted, several efforts have documented species and population occurrences. These efforts include a 2017 meander survey by Michigan Natural Features Inventory throughout GRNA; a 2017 survey of the entire lengths of Finch and Scrabble Creeks by GRNA; a 2021 survey of the length of all three tributaries within GRNA by GRNA; purple loosestrife and phragmites surveys by CAKE CISMA in 2019, 2020, and 2021 along the length of Grass River; and meander parcel monitoring surveys throughout 64 of GRNA's 69 parcels conducted by GRNA during 2018, 2020, and 2021. Other opportunistic observations by GRNA staff have also been recorded.

Multiple invasive plants have been found within the Grass River sub-watershed (Table 10), including three of the species listed by CAKE CISMA on their Top 5 Least Wanted list: non-native phragmites, purple loosestrife, and knotweed spp., as well as another priority species, garlic mustard (Figure 16). However, the populations of purple loosestrife are sparse, and of the few known populations of non-native phragmites within the sub-watershed, none occur along the river or the tributaries but instead primarily occur in ditches along trails and roads. The

phragmites and purple loosestrife populations within GRNA were treated with herbicides in both 2020 and 2021, and GRNA continues to monitor these populations annually to determine the effectiveness of those treatments and to coordinate re-treatment if necessary.

There are several known locations of knotweed species (both Japanese and giant) in the sub-watershed, and the one occurring within GRNA was treated with herbicide in 2021. Just as with the phragmites and purple loosestrife, GRNA continues to monitor this population. The other populations occur outside of GRNA on private land.

There are only three known population of garlic mustard in the sub-watershed, and all are in the Finch Creek creekshed. The small population occurring within GRNA (along the border of the parking lot) is pulled annually, but the other two populations occur on private land.

Besides these three species, another riparian or shoreline plant of concern is narrow-leaf cattail, which occurs in a very dense patch near the outlet of the river. Additionally, there are populations of European marsh thistle and autumn olive along portions of the tributaries.

In terms of aquatic invasive species, none of the aquatic invasive plants that have been found in other parts of the Elk River Chain of Lakes watershed – like Eurasian water milfoil or curly leave pondweed – have been found in the Grass River sub-watershed. However, in May of 2021, a population of New Zealand mudsnails was discovered near the mouth of Shanty Creek and have since been found at another location on Shanty Creek and a location on Cold Creek (Figure 17). These invasive snails can reach high densities, alter aquatic food webs, outcompete native macroinvertebrates, and negatively impact the health of fish populations, as fish may turn to eating them as they increase in number and replace the fishes' normal macroinvertebrate prey base.

Common Name	Scientific Name	Physiogomy	Coefficient of Wetness	Duration
Autumn olive	*Eleagnus umbellata*	Shrub	3	Perennial
Bull thistle	*Cirsium vulgare*	Forb	3	Biennial
Canada thistle	*Cirsium arvense*	Forb	3	Perennial
Common speedwell	*Veronica officinalis*	Forb	3	Perennial
European marsh thistle	*Cirsium palustre*	Forb	-3	Biennial
Forget-me-not	*Myosotis scorpiodes*	Forb	-5	Perennial
Garlic mustard	*Alliaria petiolate*	Forb	3	Biennial
Giant knotweed	*Fallopia sachalinensis*	Forb (but looks like a shrub)	5	Perennial
Hybrid honeysuckle	*Lonicera x bella*	Shrub	3	Perennial
Japanese barberry	*Berberis thunbergii*	Shrub	3	Perennial
Japanese knotweed	*Fallopia japonica*	Forb (but looks like a shrub)	3	Perennial
Leafy spurge	*Euphorbia virgata*	Forb	5	Perennial
Moneywort	*Lysimachia nummularia*	Forb	-3	Perennial
Morrow honeysuckle	*Lonicera morrowii*	Shrub	3	Perennial
Multiflora rose	*Rosa multiflora*	Shrub	3	Perennial
Narrow-leaved cat-tail	*Typha angustifolia*	Forb	-5	Perennial
Non-native phragmites	*Phragmites australis australis*	Grass	-3	Perennial
Purple loosestrife	*Lythrum salicaria*	Forb	-5	Perennial
Reed canary grass	*Phalaris arundinacea*	Grass	-3	Perennial
Spotted knapweed	*Centaurea stoebe*	Forb	5	Biennial
Yellow flag iris	*Iris pseudacorus*	Forb	-5	Perennial

Table 10. Invasive plants observed within the Grass River sub-watershed.

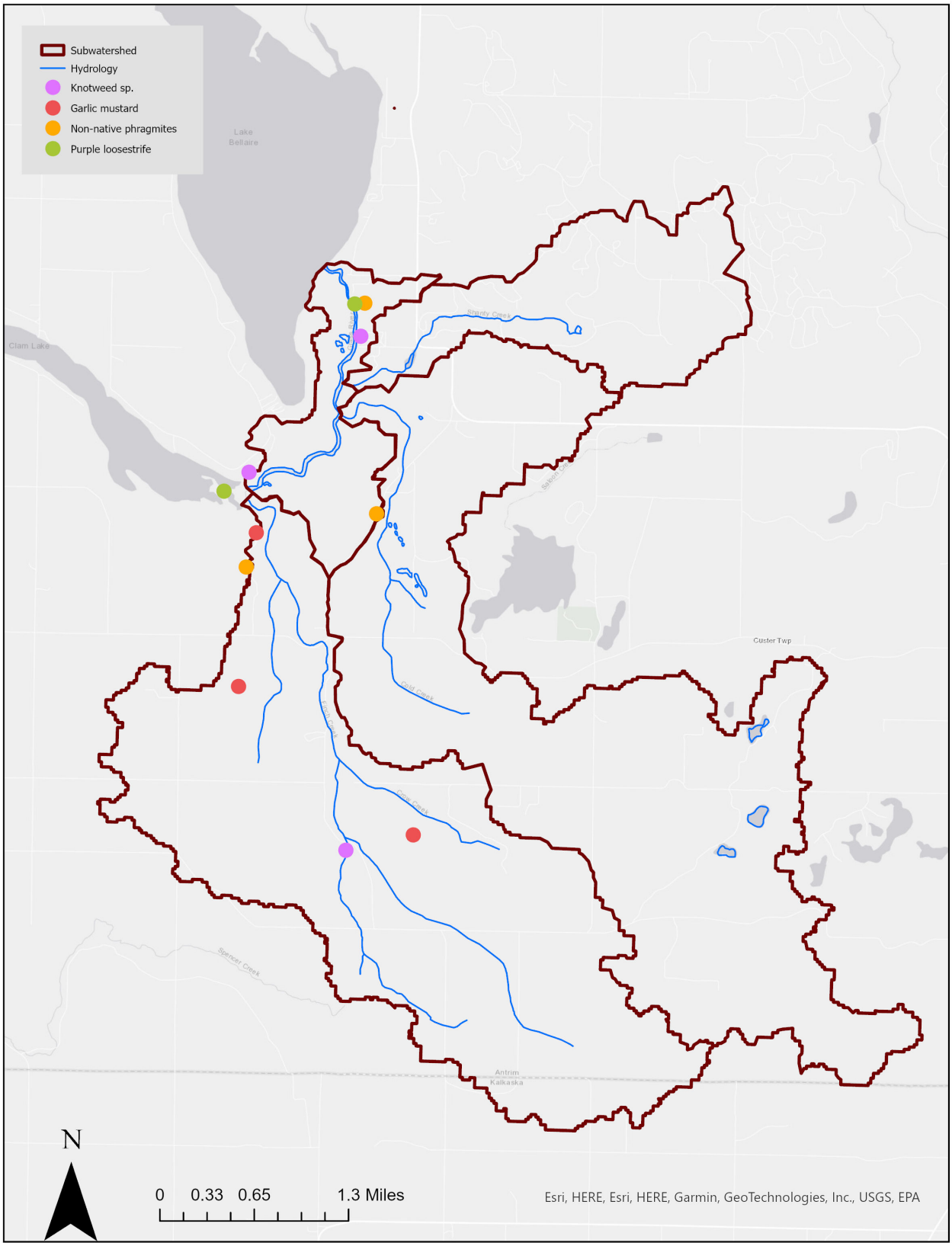

Figure 16. Priority invasive plants within the sub-watershed.

Figure 17. Locations of observed New Zealand mudsnail (NZMS) populations.

FLOW ALTERATION STRUCTURES

Though there are no structures that alter the natural flow of water along the Grass River, these structures are abundant along the three tributaries. Because these structures impact flow regimes and stream connectivity, they can often contribute to sedimentation, aquatic habitat fragmentation, and thermal pollution of streams. Broadly, these structures can be split into two categories: road-stream crossing infrastructure and dams.

ROAD STREAM CROSSINGS

Multiple roads cross the three tributaries, resulting in 20 road-stream crossings in the sub-watershed (Figure 18). While there has never been a comprehensive inventory of all of these crossings, 7 were surveyed during Tip of the Mitt Watershed Council's 2015 inventory that utilized the standardized procedure known as the Great Lakes Road Stream Crossing Inventory developed by the Great Lakes Connectivity Workgroup. During the same study, another 4 were spot checked, which involved a visual analysis for significant issues, but did not include flow or erosion measurements. (Table 11). According to the results of the inventory, the Crow Creek (a tributary of Finch Creek) crossing under Elder Road was one of the top 10 most severe crossings in the whole ERCOL, out of 149 crossings visited. The top three most severe crossings in the Clam Lake watershed included this crossing as well as Finch Creek/Elder Road and Cold Creek/Comfort Road.

DAMS

A comprehensive inventory of dams within the watershed has never been completed, but we are aware of four private dams within the sub-watershed from a combination of local knowledge and a partial small dam inventory conducted in 2013-2014 by The Watershed Center Grand Traverse Bay and Antrim Conservation District throughout the ERCOL. At the time of the inventory, one dam had failed, one was near failure, and two had structural integrity issues. In 2021, another one of the four failed, and both failures – one on Cold Creek and one on Shanty Creek – likely released large volumes of sediment. At least one functional dam still exists on Shanty Creek, with an additional non-functional dam on Shanty Creek (Figure 19). Both functional and defunct dams create spillways that likely act as fish passage barriers throughout the sub-watershed. From conversations with private landowners along the tributaries, it's very likely that more of these structures exist in the area.

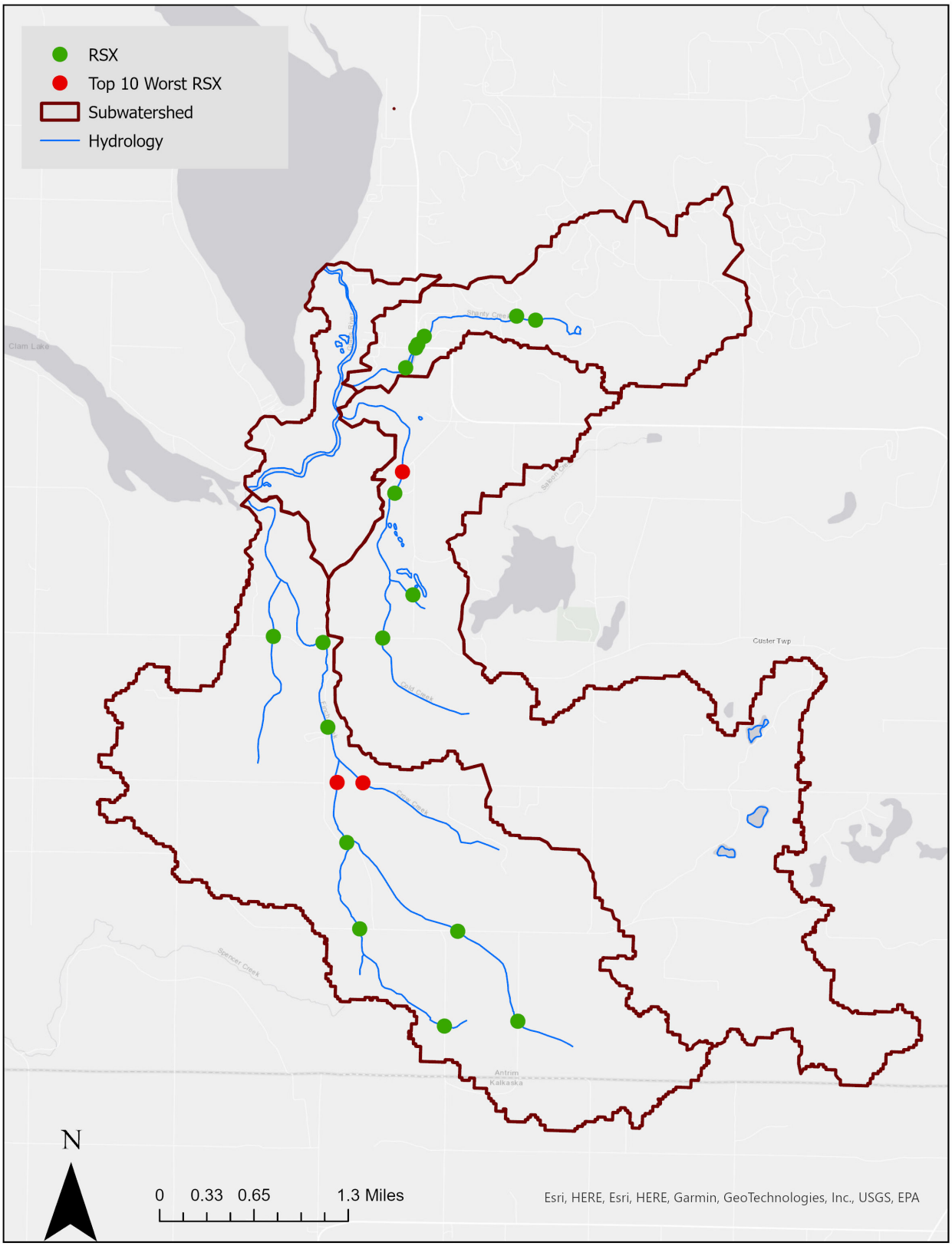

Figure 18. Road stream crossings (RSX), including those rated as top 10 worst in the Clam Lake sub-watershed, within the Grass River sub-watershed.

Stream Name	Road Name	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
Shanty Creek	M-88	Culvert(s)	0.0522	0.0522	0.9	Minor	10
Shanty Creek	Grass River Rd.	Culvert(s)	0.0382	0.0382	0.9	Minor	
Cold Creek	Comfort Rd	Culvert(s)	1.1002	1.1002	0	Severe	135
Finch Creek	Alden Hwy	Culvert(s)	0.0738	0.1687	0	Severe	110
Finch Creek	Finch Creek Rd N	Culvert(s)	0.125	0.3252	0.5	Moderate	70
Finch Creek	Elder Rd	Culvert(s)	0.0362	4.1282	0	Severe	240
Finch Creek	Finch Creek Rd S	Culvert(s)	0.0141	0.0982	0	Severe	100
Finch Creek	Bebb Rd	Culvert(s)					
Finch Creek	Bebb Rd						
Cold Creek	Alden Hwy				0	Severe	
Crow Creek	Elder Rd						

Table 11. Results of 2015 partial road stream crossing inventory in the sub-watershed. Sites highlighted in gray were spot-checked.

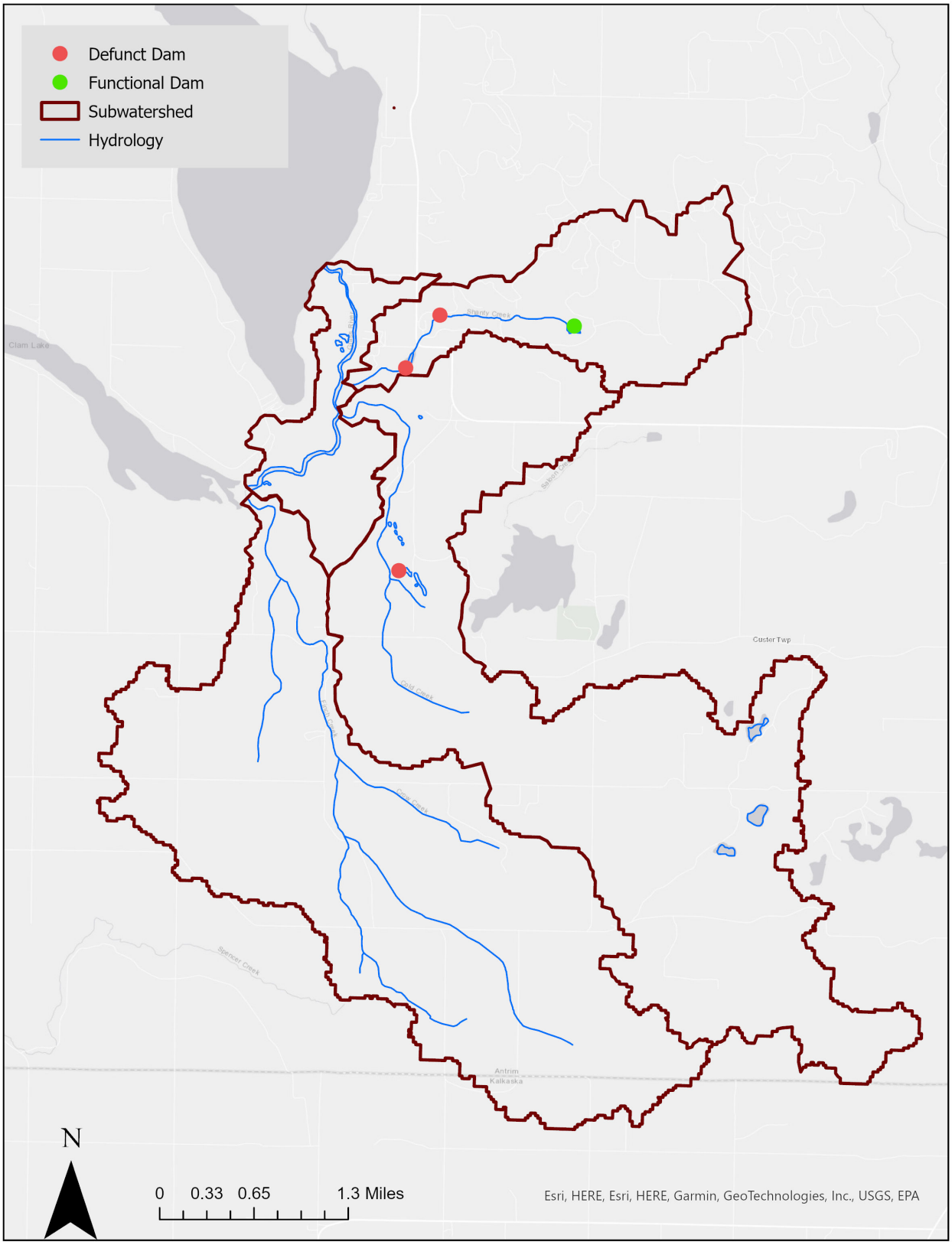

Figure 19. Defunct and functional dams within the sub-watershed.

SEPTIC SYSTEMS

No comprehensive analysis of septic systems has been conducted within the sub-watershed. However, there is no established sewer system in any area of the sub-watershed and many of the homes in the area are older family cottages, making outdated, unmaintained, or undersized septic systems a major concern for water quality.

LAND USE

Much of the land cover in the sub-watershed is classified as wetlands, and the majority of these wetlands are within Grass River Natural Area, which boasts more than 1,000 acres of seven types of wetlands, including emergent marsh, northern wet meadow, northern fen, northern shrub thicket, rich conifer swamp, poor conifer swamp, and hardwood-conifer swamp (Michigan Natural Features Inventory 2017). These wetlands provide vital ecological services like water filtration, flood mitigation, and wildlife habitat. GRNA also has over 300 acres of upland forests, including mesic northern forest and dry-mesic northern forest. See Figure 23 for a map of GRNA's natural communities.

However, upstream of GRNA, a significant portion of the sub-watershed has been converted from wetlands and forests to anthropogenic landscapes like lawns, roads, cropland, pastureland, and golf and ski resorts. While there are no major towns in the sub-watershed, Shanty Creek Resort (within the Shanty Creek creekshed) contains a significant amount of impervious surfaces and sloped deforested areas used as golf courses and ski hills. This area is a potential source of nutrient- and sediment-laden stormwater runoff into Shanty Creek.

In 2013 and 2014, staff from The Watershed Center Grand Traverse Bay and Antrim Conservation District conducted a stormwater runoff assessment and developed a stormwater action plan for the area surrounding Shanty Creek Resort and Golf Course, among other urbanized areas in Antrim and Kalkaska Counties. The team found several instances of erosion throughout the development, including roof runoff from the main resort building, runoff paths to the creek, a lack of buffer along the creek at points throughout the golf course, gravel input from adjacent roads, and multiple operable and defunct gravel road stream crossing structures.

Besides land use practices around Shanty Creek Resort, deforested pastureland within the Finch Creek creekshed and the removal of riparian buffers on private property upstream of GRNA are other areas of concern pertaining to land use.

CLIMATE CHANGE

While there hasn't been any modeling work on the projected impacts of climate change in the Grass River sub-watershed specifically, a 2016 study by scientists at Michigan State University, along with input from The Watershed Center Grand Traverse Bay, evaluated the projected impacts of climate change on the Grand Traverse Bay region and watershed (Hyndman et al. 2016). The report found that, in the last 100 years, the climate in the Grand Traverse Bay watershed has become warmer and wetter, with less snow overall but with more frequent extreme precipitation events, and that this trend is expected to continue into the future. Specifically, based on the standard scenario RCP 6.0 – which assumes that greenhouse gas emissions will continue to increase through 2080 before they start to decline – the Grand Traverse Bay watershed is projected to increase in temperature by about 5-7° F from 1990 to 2090 and to experience a 10% increase in precipitation during the same period. The water is

projected to also become warmer, with lower baseline summer flows but with more intense periods of rain, which is expected to worsen problems related to nutrient and sediment run-off during heavy rain events, including more *E. coli* issues.

Much of the infrastructure in the Grass River sub-watershed is aging and not designed for these projected changes. For example, in 2021, a major storm event caused the Finch Creek/Alden Highway crossing to completely blow out due to an undersized culvert and caused a small private dam on Shanty Creek to burst. A few years earlier, a series of private dams on a tributary to Cold Creek failed. All of these failures released significant amounts of sediment downstream.

Section 3: Previous Efforts in the Sub-watershed

This section discusses all previous work in the sub-watershed in the past 15 years, including both structural and non-structural best management practices (BMPs).

STRUCTURAL BMPS

LARGE WOODY DEBRIS PROJECT

In September 2013, Three Lakes Association contracted with Ken Reed to install seven large woody debris structures in the Grass River. The goal of this project was to improve the navigability of the river and to determine if large woody debris was a viable strategy for reducing sediment in the ERCOL system. Five of the structures were installed on the second bend downstream from Cold Creek (upstream site), with two additional structures installed on the next bend (downstream site) (Figure 20).

While the structures are still in place today, data on the river depth and macroinvertebrate community was only collected at two of the seven sites before installation. Post-installation, river depth measurements were taken at these same two sites, but no macroinvertebrate sampling was completed. This paucity of pre- and post-installation data limits the ability to draw conclusions on the effectiveness of the project, though anecdotal comparisons at those two sites before and after installation seem to indicate that deposition occurred on the inside of the meander (Hershey 2014). (Figures 21 and 22). However, the structures were installed on the deposition (inside) side of river bend, which, if sediment reduction and channel narrowing are goals of the project, doesn't seem to be the correct design, given the tendency of rivers to flow the fastest and carry the most scour potential on the outside of a meander. Indeed, both graphs indicate that the outside bank (east bank) of the river appears to have eroded, inputting more sediment into the system.

Figure 20. Large woody debris sites along Grass River.

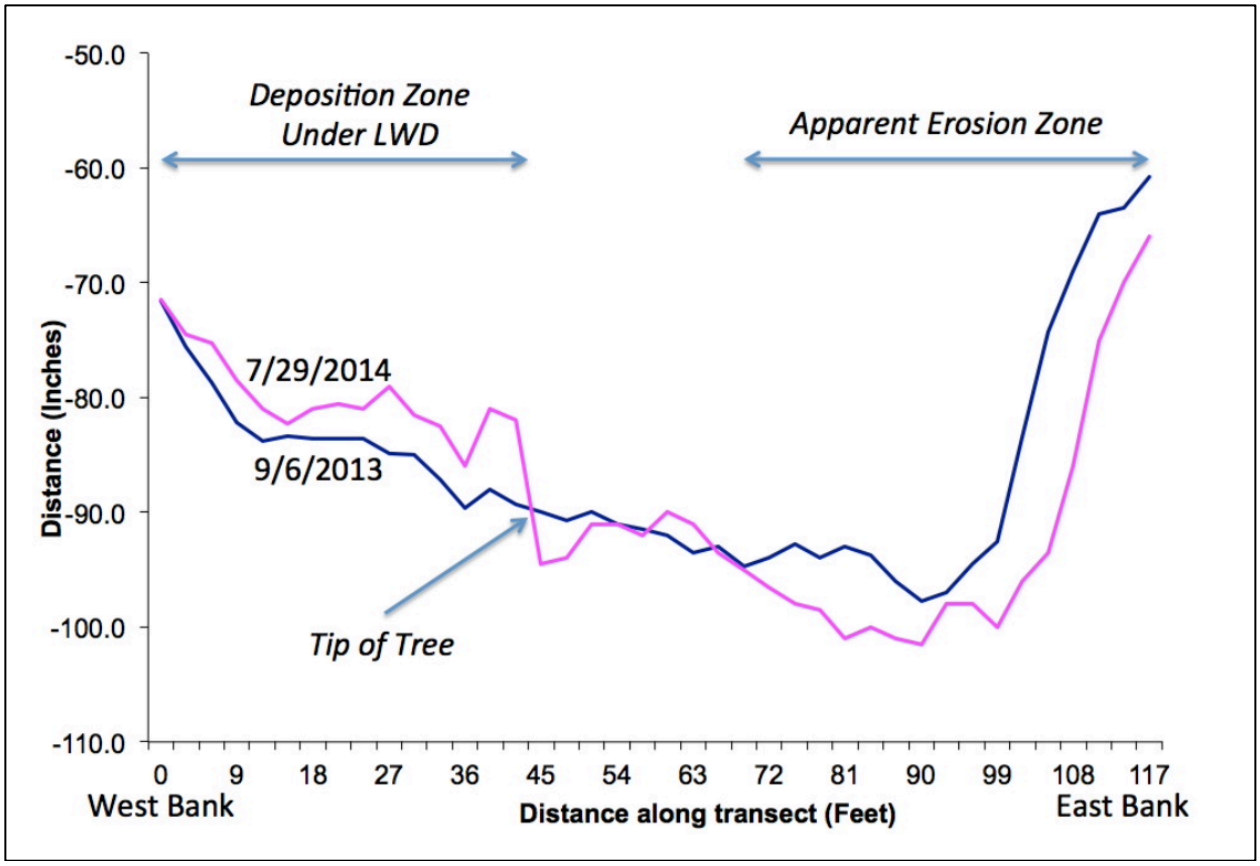

Figure 21. Grass River bottom cross section at upstream site, structure 3. Figure provided by Hershey 2014.

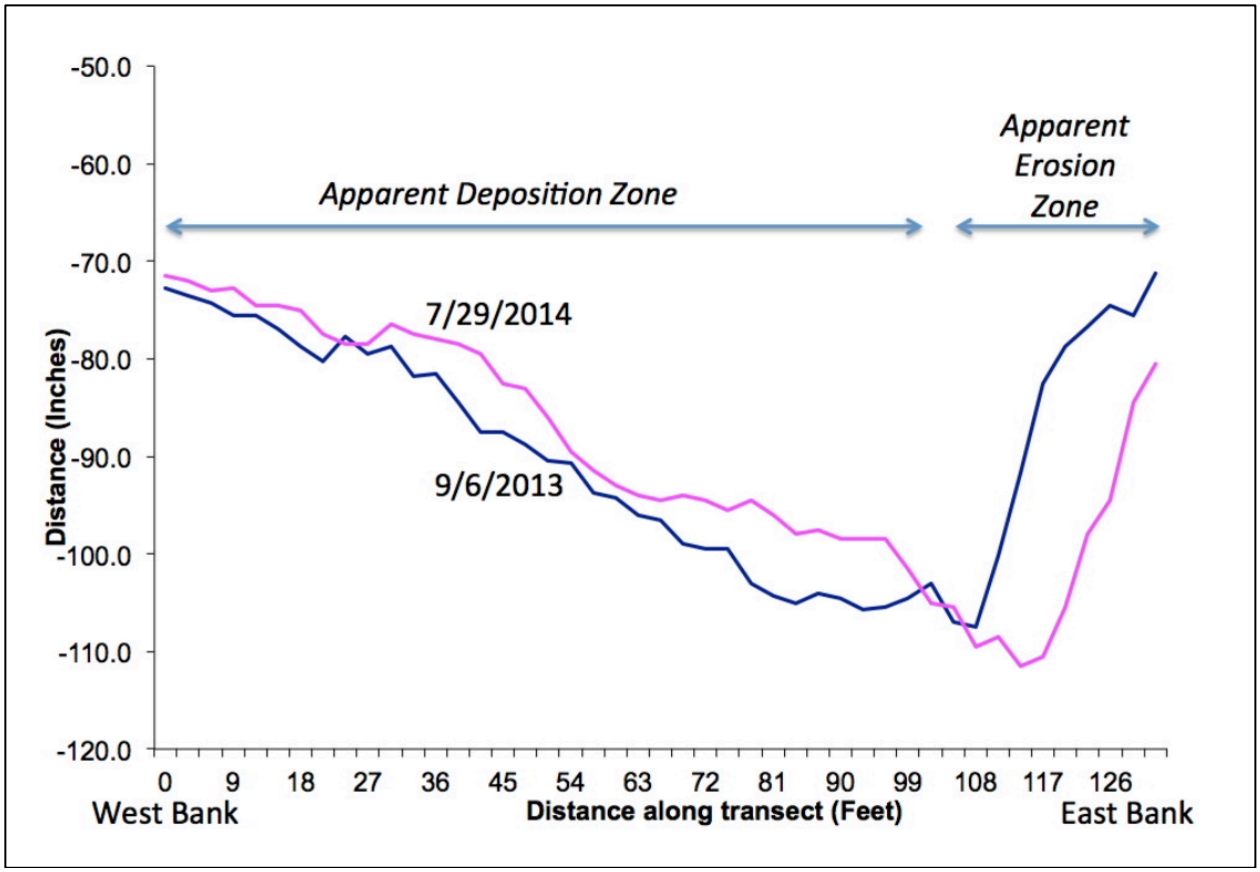

Figure 22. Grass River bottom cross section at upstream site, structure 5. Figure provided by Hershey 2014.

ROAD STREAM CROSSING IMPROVEMENTS

In 2021, the Finch Creek/Alden Highway crossing structure was improved following a road failure incident caused by a heavy rain event and an undersized crossing structure. The initial structure was a pair of 48" diameter culverts, which was replaced with a single 224" diameter corrugated elliptical culvert with a natural stream bottom in October 2021.

NON-STRUCTURAL BMPS

EDUCATION/OUTREACH

GRASS RIVER NATURAL AREA CLASSES

Grass River Natural Area (GRNA) hosts a wide selection of nature education programs and events for all ages. Past programs include guided kayak tours, maple tree tapping, wildflower walks, bird and tree identification, and nature art for diverse audiences, from elementary school students to Northwestern Michigan College Extended Education students and the general public.

GRASS RIVER NATURAL AREA RIPARIAN GATHERINGS

GRNA hosts an annual gathering for Grass River riparian landowners and residents who own land along the three tributaries. The goal of these gatherings is to update these important stakeholders on our river protection initiatives, to provide a forum for them to communicate their concerns and experiences, and to build relationships and trust.

GRASS RIVER CONNECTS MEETINGS

In addition to meeting with riparians and tributary landowners each year, GRNA and Three Lakes Association (TLA) hosted a series of community engagements meetings – called Grass River Connects – that educated various subsets of stakeholders on the threats to the sub-watershed and gathered input on what to include in the management plan. This effort was funded by an EGLE Watershed Council Support grant in 2022. We held five of these meetings from the fall of 2021 to the spring of 2023, including meetings to engage local governments (both townships and the county), local business owners, riparian and tributary landowners, conservation partner organizations, and the general public. Surveys were completed at the end of each meeting (with the exception of the meetings with conservation partner organizations and township boards, which occurred prior to the start of a Department of Environment, Great Lakes, and Energy Watershed Council Support grant to GRNA, part of which involved the development of the survey instrument that was employed at all subsequent meetings). The purpose of the surveys was to measure participants' use of and attitudes toward the river, as well as their concern for the various threats facing the river (Appendix A). We collected surveys from 7 county commissioners, 16 members of the local business community, 10 riparian and tributary landowners, and 25 members of the general public. Overall, meeting attendees used the river at high rates, had positive attitudes toward the river, and were concerned about threats to the river. The top three important river characteristics important to respondents were high water quality, natural beauty of the river, and presence of/observing wildlife; the top three uses in the warm season were observing nature, sitting near the river and watching the water, and visiting the river with guests; and the top three respondent concerns were irresponsible or unsafe boating practices, leakage from septic systems, and erosion of riverbanks. See Appendix B for full results.

SOCIAL MEDIA CAMPAIGN

As part of GRNA's and TLA's effort to pave the way for public support for future projects to improve the health of the Grass River, the organizations developed and implemented a social media campaign in 2022. The goal of the campaign – who's tagline was "If you know, you know. This place is special" – was to drum up local pride for the river. The campaign ran on Facebook for 90 days from December 2022 to March 2023 and was served to accounts originating within a 20-mile radius of GRNA. The campaign reached over 115,000 users and generated 3,980 post engagements, including 2,288 link clicks, which redirected users to a webpage about the threats to the river and the creation of the management plan.

MICHIGAN PADDLE STEWARDS CLASSES

In 2023, GRNA has partnered with Paddle Antrim and Charlevoix, Antrim, Kalkaska, and Emmet County Cooperative Invasive Species Management Area to host MI Paddle Stewards

classes. These programs train paddlers in how to identify and report invasive species, as well as how to prevent their spread.

ONGOING MONITORING

MiCORPS STREAM MONITORING

In 2013, GRNA received a grant from the Michigan Clean Water Corps (MiCorps), a statewide network of water quality monitoring programs created by EGLE, to start a stream monitoring project on the three tributaries. For the past 10 years, every spring and fall, GRNA staff and trained volunteers survey several sites along one of the tributaries, rotating creeks each year so each creek is surveyed twice (once in the spring and once in the fall) every three years. These surveys follow the standardized MiCorps protocol to collect benthic macroinvertebrates. Each spring, staff and volunteers also conduct a full stream habitat assessment according to the standardized MiCorps protocol. Taken together, the results of these surveys allow GRNA to regularly evaluate the overall health of its streams and provide an important long-term dataset. The most recent scores for the 11 sites are represented in Table 12.

Creek	Location	MiCorps Site ID	Date	Numerical Score	Categorical Score
Finch Creek	Beaver Bridge	FCBB	9-24-22	4.00	Very good
Finch Creek	Rail Trail	FCRT	9-24-22	4.46	Very good
Finch Creek	Finch Creek Rd	FCFC	9-24-22	3.86	Very good
Finch Creek	Bebb Rd	FCBR	9-24-22	3.75	Very good
Cold Creek	Grass River	CCGR	5-13-23	3.80	Very good
Cold Creek	Rail Trail	CCRT	5-13-23	3.87	Very good
Cold Creek	Rob Fleet's	CCRF	5-13-23	4.09	Very good
Cold Creek	Alden Hwy	CCAH	5-13-23	3.72	Very good
Shanty Creek	Grass River	SCGR	9-25-21	4.46	Very good
Shanty Creek	Rail Trail	SCRT	9-25-21	7	Fairly poor
Shanty Creek	Pinebrook	SCPB	9-25-21	4.46	Very good

Table 12. Most recent MiCorps macroinvertebrate sampling results.

GRNA PARCEL MONITORING

GRNA staff and volunteers launched an ongoing parcel monitoring project in 2018, the goal of which is to conduct meander surveys on each of the 69 parcels that make up the natural area on a rotating basis to document occurrences of invasive species, illegal dumping, shoreline erosion, signs of ATV usage, or other human disturbances. Observations are uploaded to a map in ArcGIS Pro, and the team tries to monitor each parcel at least once every three years, though staff turnover, the COVID-19 pandemic, and access disputes with neighboring property owners have made this goal difficult to reach. Observations are then prioritized for remediation

activities. To date, we have monitored 64 of the 69 parcels in the last five years and intend to continue this project in the summer of 2023.

PREVIOUS STUDIES/REPORTS/MODELS

ECOLOGICAL INVENTORY OF GRNA

In 2017, Michigan Natural Features Inventory (MNFI) conducted an ecological inventory of GRNA, including a natural community delineation and floristic quality assessments of each natural community (Figure 23). Nine types of natural communities were identified (Table 13), which included the inclusion of the northern fen areas as a new A/B-ranked natural community element occurrence for the MNFI Biotics database. Rich conifer swamp, northern fen, and northern wet meadow each have floristic quality indices (FQI) over 50, indicating that they are of considerable biodiversity value to the state, and poor conifer swamp, hardwood-conifer swamp, and mesic northern forest have FQIs greater than 35, meaning they are floristically important (Hackett et al. 2017)

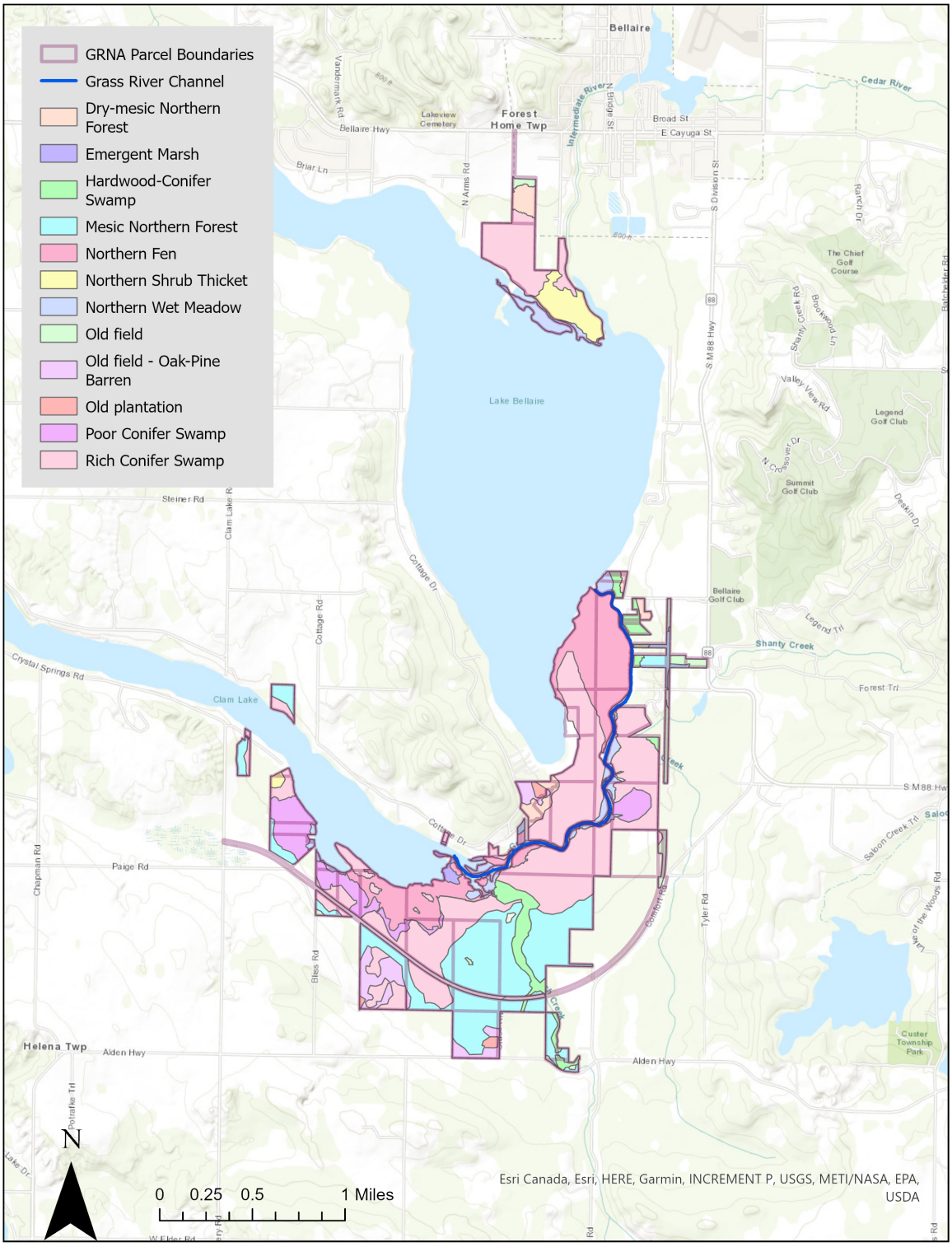

Figure 23. Natural community delineation of GRNA.

Community Type	Acres within GRNA*	Floristic Quality Index
Emergent marsh	6	22.7
Northern wet meadow	49	55.5
Northern fen	185	68.7
Northern shrub thicket	41	26.5
Poor conifer swamp	82	46.0
Rich conifer swamp	503	69.1
Hardwood-conifer swamp	53	32.4
Dry-mesic northern forest	40	39.2
Mesic northern forest	283	19.4

Table 13. Natural communities by acreage and floristic quality index at GRNA. *GRNA has acquired an additional 49 acres since this assessment, bringing the total acreage to 1,492.

STORMWATER ASSESSMENT OF SHANTY CREEK RESORT

In 2013 and 2014, staff from The Watershed Center Grand Traverse Bay and Antrim Conservation District conducted a stormwater runoff assessment of Shanty Creek Resort (SCR). Shanty Creek flows through SCR, so inputs into the creek from runoff over the golf course, impervious surfaces, and other anthropogenic landscapes were a concern. The assessment identifies major points of runoff, priority sites for improvement, and erosion sites along Shanty Creek. It also proposes low-impact development techniques for stormwater retention and filtration. Maury Creek, which also runs through SCR, was included in the assessment as well, but is not a concern for the Grass River sub-watershed because it drains into Lake Bellaire. See Appendix J of the ERCOL watershed management plan for the full stormwater action plan based on the assessment.

GRNA INVASIVE SPECIES SURVEYS

In the summers of 2016 and 2017, GRNA staff walked the length of Finch Creek and its tributary Scrabble Creek, surveying approximately 20 feet on either side of the streambank for 18 target invasive plants (Table 14). Six of the 18 target species were observed, including autumn olive, bull thistle, European swamp thistle, Canada thistle, giant knotweed, and multiflora rose (Luta 2018a and Luta 2018b).

In the summer of 2021, GRNA staff conducted surveys along the length of Grass River, the length of the three tributaries through, the Clam Lake and Lake Bellaire shorelines within, and the length of three unnamed streams through GRNA for invasive plants. Autumn olive, purple loosestrife, non-native phragmites, narrow-leaf cattail, bull thistle, and European marsh thistle were observed.

Common Name	Scientific Name
Autumn olive	*Eleagnus umbellata*
Dame's Rocket	*Hesperis matronalis*
Non-native phragmites	*Phragmites australis*
Garlic mustard	*Alliaria petiolate*
Glossy buckthorn	*Frangula alnus*

Japanese barberry	*Berberis thunbergia*
Japanese stiltgrass	*Microstegium vimineum*
Giant knotweed	*Polygonum schalinense*
Japanese knotweed	*Polygonum cuspidatum*
Mile-a-minute	*Polygonum perfoliatum*
Multiflora rose	*Rosa multiflora*
Narrow-leaf bittercress	*Cardamine impatiens*
Narrow-leaf cattail	*Typha angustifolia*
Purple loosestrife	*Lythrum salicaria*
Reed canarygrass	*Phalaris arundinacea*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
European swamp thistle	*Cirsium palustre*

Table 14. Invasive plants surveyed for during 2016-2017 surveys along Finch and Scrabble Creeks, with species that were observed highlighted in gray.

ROAD STREAM CROSSING INVENTORIES

In 2011, an inventory of some of the road stream crossings in the Grass River sub-watershed was completed by volunteers from Three Lakes Association and Friends of Clam Lake. The inventory focused on a qualitative assessment of crossing structures and potential concerns like if the structure was undersized or would be a potential fish passage barrier (Barber et al. 2011).

In 2015, a team of graduate students under the supervision of Tip of the Mitt Watershed Council assessed 149 road stream crossings through the ERCOL. 116 full surveys were conducted according to the standardized and widely-used Great Lakes Road Stream Crossing Inventory, and an additional 33 spot checks were conducted. Spot checks didn't include quantitative measurements of flow or erosion, but rather visually checked for significant issues like erosion features, culverts with high flows or perched openings, nearby impoundments, and poor road or structure conditions. Within the Grass River sub-watershed, which consists of 19 crossings, 7 crossings were fully inventoried, while another 4 were spot checked. Full results are presented in Appendix C of the ERCOL watershed management plan.

STREAMBANK EROSION SURVEYS

In 2015, streambank erosion surveys were conducted by a team of graduate students trained and guided by the ERCOL-WPIT. These surveys only took place within 500 feet of a road stream crossing. At each erosion feature, measurements like height, width, depth, and severity were taken to calculate the sediment erosion load at each site. Four sites within the Grass River sub-watershed were surveyed during this effort, each with low severity (Table 15).

Also in 2015, streambank erosion features were identified and measured during road stream crossing inventories. These features were also sites that were visible within a line of site when standing at the crossing, typically within 30-70 feet of the crossing. Erosion features were measured in three dimensions, eroded material was noted, and a total sediment erosion load was calculated using the Great Lakes Road Stream Crossing Inventory database. Four sites

within the Grass River sub-watershed were surveyed during this effort, with varying degrees of severity, though some of the data is incomplete (Table 16). Figure 24 depicts the location of the erosion sites from both 2015 surveys.

Because both of these surveys took place at or near road stream crossings, the degree and impact of streambank erosion between crossings is largely unknown.

Site ID	CL08_D1	CL09_U2	CL12_D1	CL12_U1
Stream	Cold Creek	Finch Creek	Finch Creek	Finch Creek
Crossing	Comfort Rd	Alden Hwy	Finch Creek Rd	Finch Creek Rd
Latitude	44.91953	44.90173	44.88317	44.88175
Longitude	-85.2003	-85.2107	-85.2081	-85.2074
Length of eroded bank (ft)	57.5	0	10	56
Soil texture	Loam		Sand	Sand
Severity	Low	Low	Low	Low
Erosion load (tons/yr)	1.66911	0	0.09676	0.541856
Load category	2	1	1	1

Table 15. Streambank erosion features and sediment loads observed during 2015 streambank erosion surveys.

Site ID	CL09	CL10	CL11	CL12
Stream	Finch Creek	Finch Creek	Finch Creek	Finch Creek
Crossing	Alden Hwy	Finch Creek Rd N	Elder Rd	Finch Creek Rd S
Latitude	44.90246	44.893985	44.88841	44.882464
Longitude	-85.21107	-85.21049	-85.20781	-85.207653
Length of eroded bank (ft)	15	6.5	8	4
Soil texture	Loam	Loam	Sand	Gravelly loam
Severity	Minor		Severe	
Erosion load (tons/yr)	0.095	-.2002	4.092	0.084
Severity ranking	1	1	3	1

Table 16. Road stream crossing inventory sediment erosion features and loads.

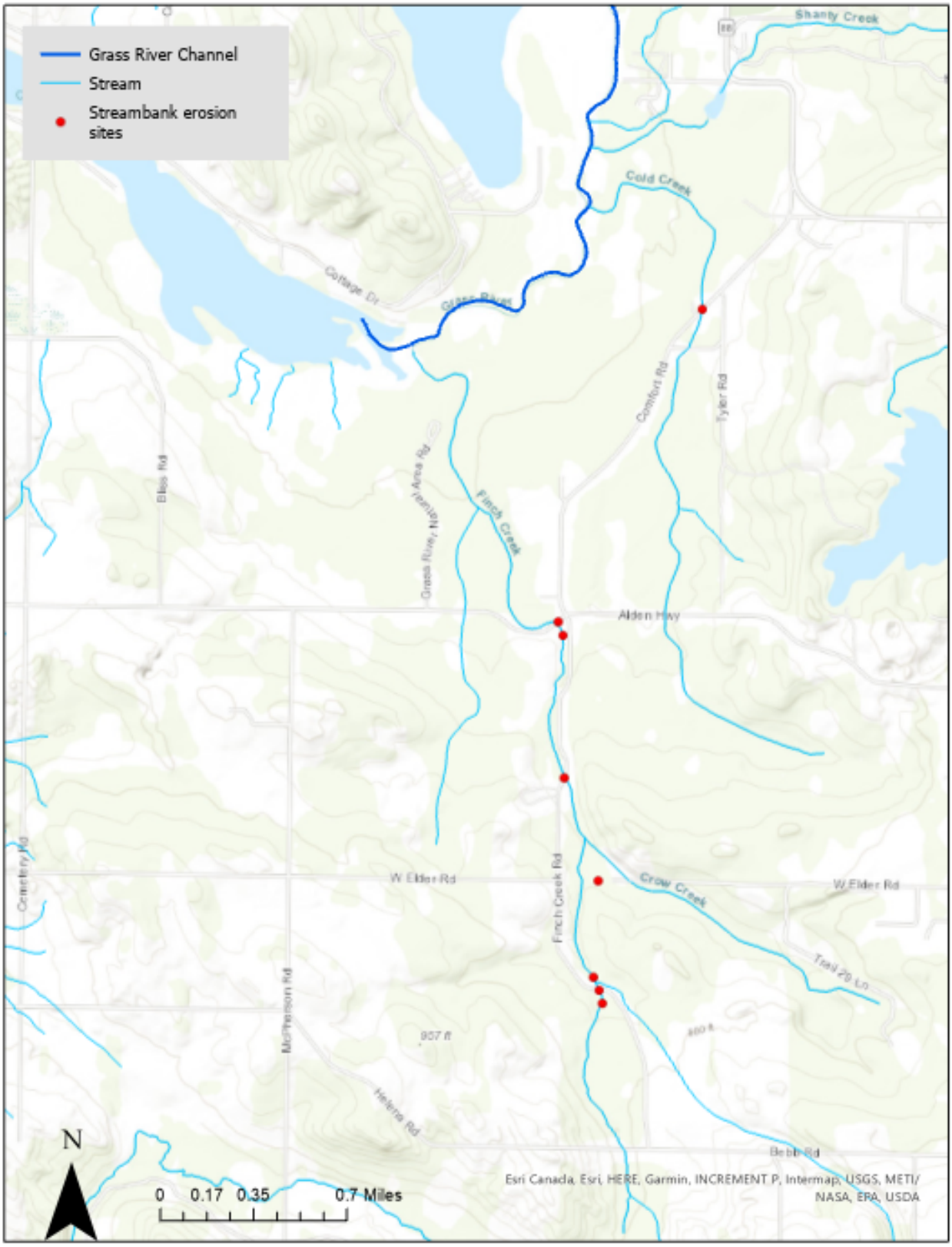

Figure 24. Streambank erosion locations.

PRIVATE DAM INVENTORY

In 2014, The Watershed Center Grand Traverse Bay completed a partial small dam inventory in the Chain of Lakes on both public and private property. Dam measurements and characteristics, habitat types, and water velocity were noted at each site. Because this was not a comprehensive inventory, some dams were likely omitted or missed.

PUBLIC LAND RIPARIAN SURVEY

In 2008, The Watershed Center Grand Traverse Bay and Grand Traverse Conservation District characterized riparian buffers on all of the public lands in the ERCOL, including GRNA.

HYDROLOGY MODEL

The Army Corps of Engineers has contracted Spicer Group to develop a hydrology model for the Chain of Lakes in order to assess the results of different management options for changing water levels. This work is ongoing, and in 2023, the team was working to add the influence of the dam in Elk Rapids into the model.

GRASS RIVER SOIL WATER ASSESSMENT TOOL

In 2011, Dr. Paul Richards of The College at Brockport was commissioned by The Watershed Center Grand Traverse Bay, Three Lakes Association, Tip of the Mitt Watershed Council, and Elk-Skegemog Lake Association to apply the Soil Water Assessment Tool (SWAT) to the Grass River watershed. The SWAT is a model that incorporates land use, topography, road stream crossing characteristics, evaporation, snowmelt, and groundwater flow information to estimate run-off, sedimentation, and nutrient inputs. Richards also tested the SWAT model against actual flow measurements collected at Cold Creek to see how well it predicted observed conditions. See Section 2 for a detailed review of the results of this project.

ASSESSMENT OF SEDIMENT SOURCES IN GRASS RIVER WATERSHED

In 2014, Dr. Anthony Kendall of Michigan State University and colleagues were contracted to quantify sedimentation in Grass River, Rapid River, and Torch River. This work involved a field survey of the rivers' bathymetry, as well as elevation, width, and stream discharge measurements; comparing the findings of the field survey to aerial images from 1938 to the early 1990s to quantify changes in channel widths; and taking GPS-tagged photos of the channels, road crossings, and erosional features. See Section 2 for a detailed review of the results of this project.

SEDIMENT TRANSPORT INDEX

In 2023, GRNA contracted with Dan Ariza, an independent GIS consultant, to run a stream transport index (STI) within the sub-watershed. The STI predicts where sediment is likely to be deposited in a watershed based on topography (including elevation, slope, and aspect) on a scale of 1 to 9, with 1 representing areas with the least deposition and 9 representing areas with the most deposition. The model assigns a 9 to the lower portion of Grass River, an 8 to middle portions of the river, and a 7 to the most downstream portions of Finch and Cold Creeks. Other areas of the sub-watershed are assigned values of 6 or less (Figure 25). This

analysis reflects the on-the-ground situation well, with the lower portions of the creeks and Grass River representing areas of significant sediment deposition.

OTHER

GRNA LAND ACQUISITION

In 2016, Antrim County added a 40-acre parcel to GRNA. This parcel comprises rich conifer swamp and mesic northern forest, is adjacent to existing GRNA land, and drains directly into Grass River.

INVASIVE SPECIES TREATMENTS

In addition to invasive species surveys, GRNA and CAKE CISMA have completed multiple invasive species control efforts in recent years, utilizing both mechanical and chemical (herbicidal) control methods, with a focus on controlling priority species like garlic mustard, purple loosestrife, non-native phragmites, and Japanese knotweed. See Appendix C for a full list of invasive species treatments within GRNA since 2018.

PRIORITY PARCEL ANALYSES

Grand Traverse Regional Land Conservancy developed a priority parcel analysis framework for their entire service region, which encompasses the Grass River sub-watershed. This framework involved assigning each parcel a score of one through four, with parcels scoring as a one being those most important to conserve, either through acquisition or conservation easements. Scores were based on several metrics, involving parcel size, adjacency to protected lands, size and contiguity of wetlands, length of shoreline, and habitat fragmentation. Figure 26 shows scores for the parcels within the Grass River sub-watershed. The last iteration of this work was completed in 2016, and GTRLC is working on updating this with a new parcel map and by incorporating The Nature Conservancy's climate change resiliency metrics into the algorithm in 2023.

Tip of the Mitt Watershed Council conducted a separate priority parcel analysis for the ERCOL. This framework involved assigning a score of 0-33 to each parcel in the watershed, with higher scores denoting parcels that are higher priority for protection. Variables included in the analysis include parcel size, ground water recharge potential, proportion of wetlands, lake and stream shoreline length, slope, adjacency to protected land, model predictions for occurrence of threatened and endangered species or natural communities, proximity to development, percentage of natural land cover, wellhead protection areas, and adjacency to trout streams, old growth forests, and undeveloped lakes. Figure 27 shows scores for the parcels within the Grass River sub-watershed.

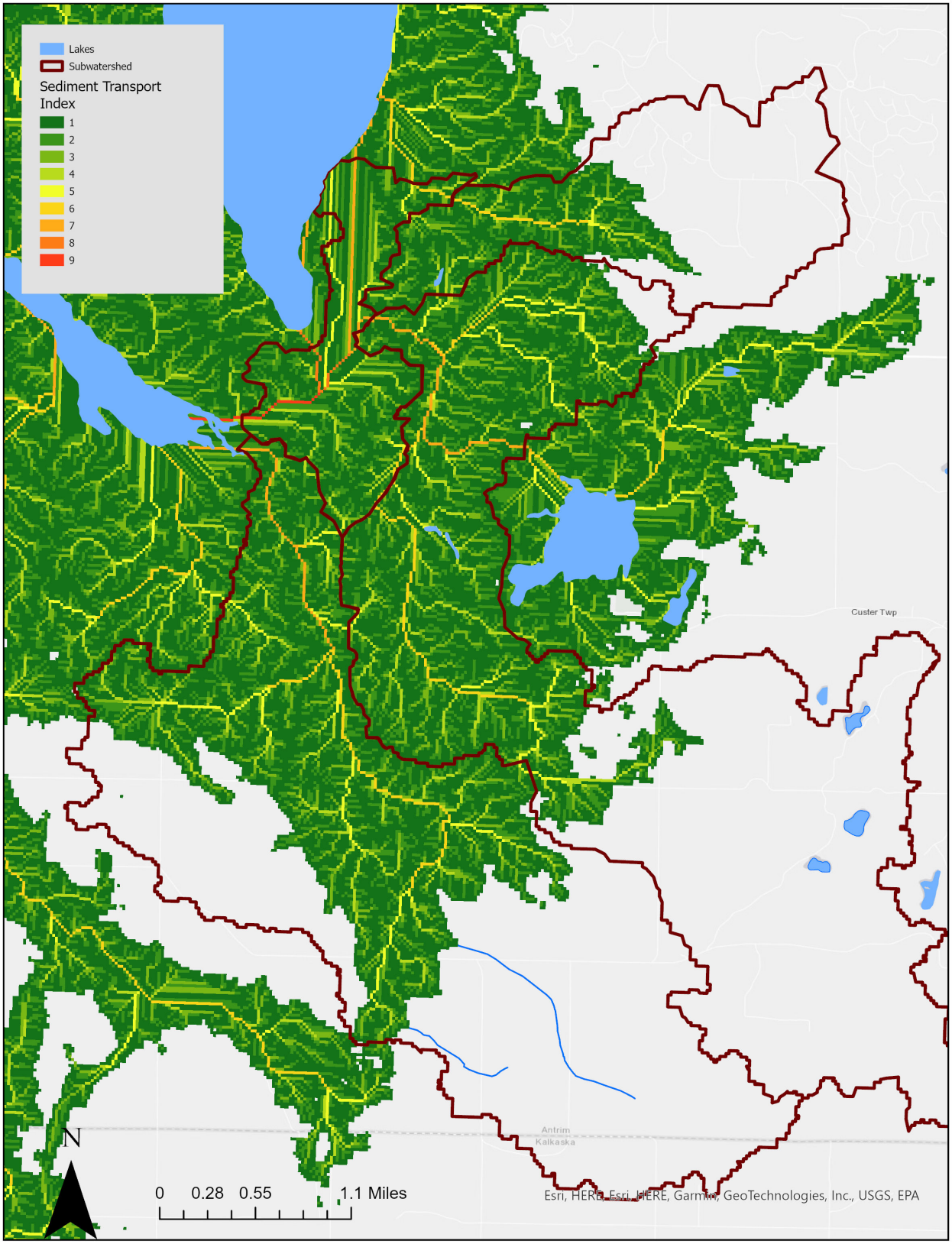

Figure 25. Sediment transport index. Lower indices are the least likely to accumulate sediment. The model only covers the portion of the sub-watershed with year-round flows.

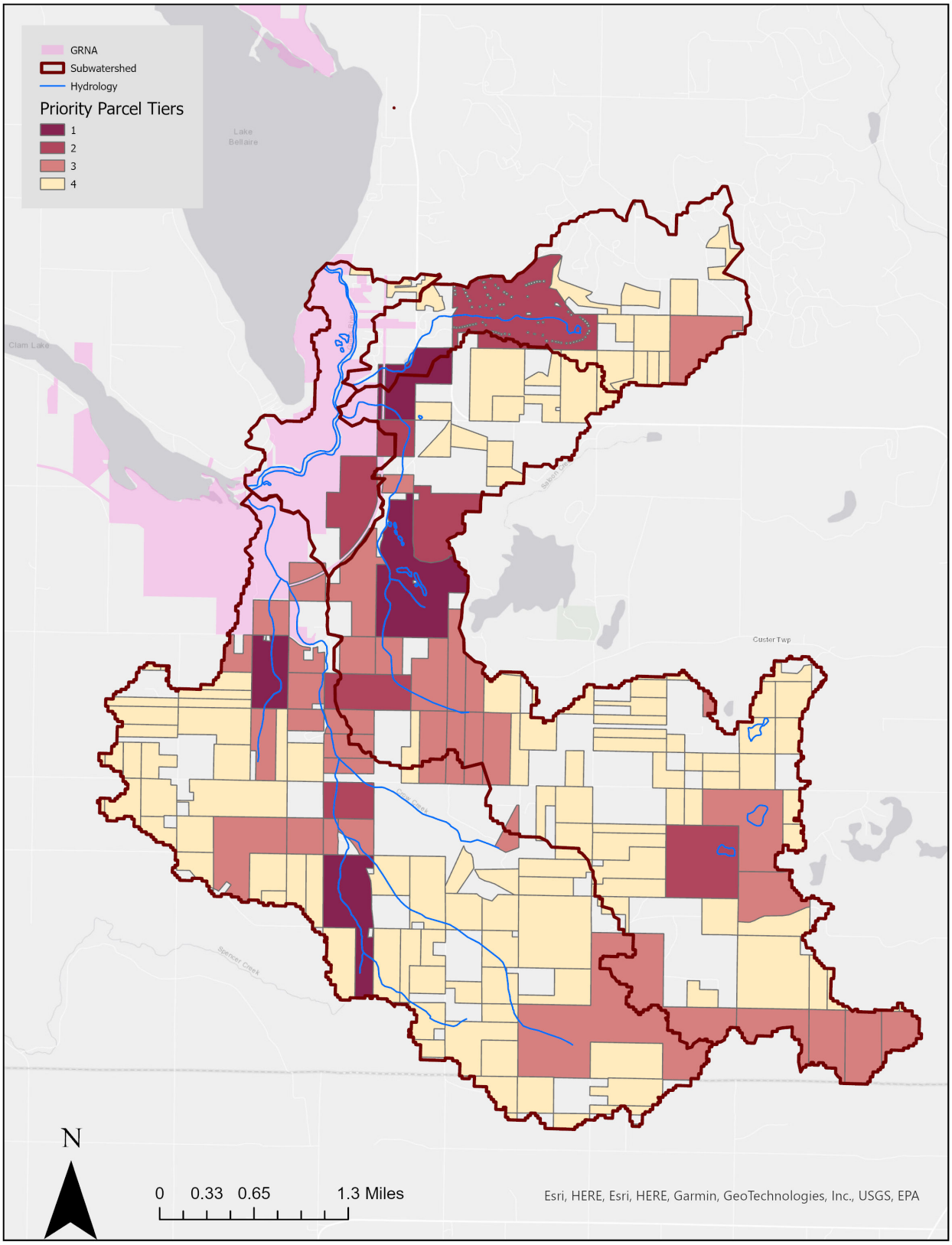

Figure 26. Priority parcel analysis for land protection. Tier 1 indicates parcels of the highest priority. Not all parcels are included, as included parcels must meet baseline requirements.

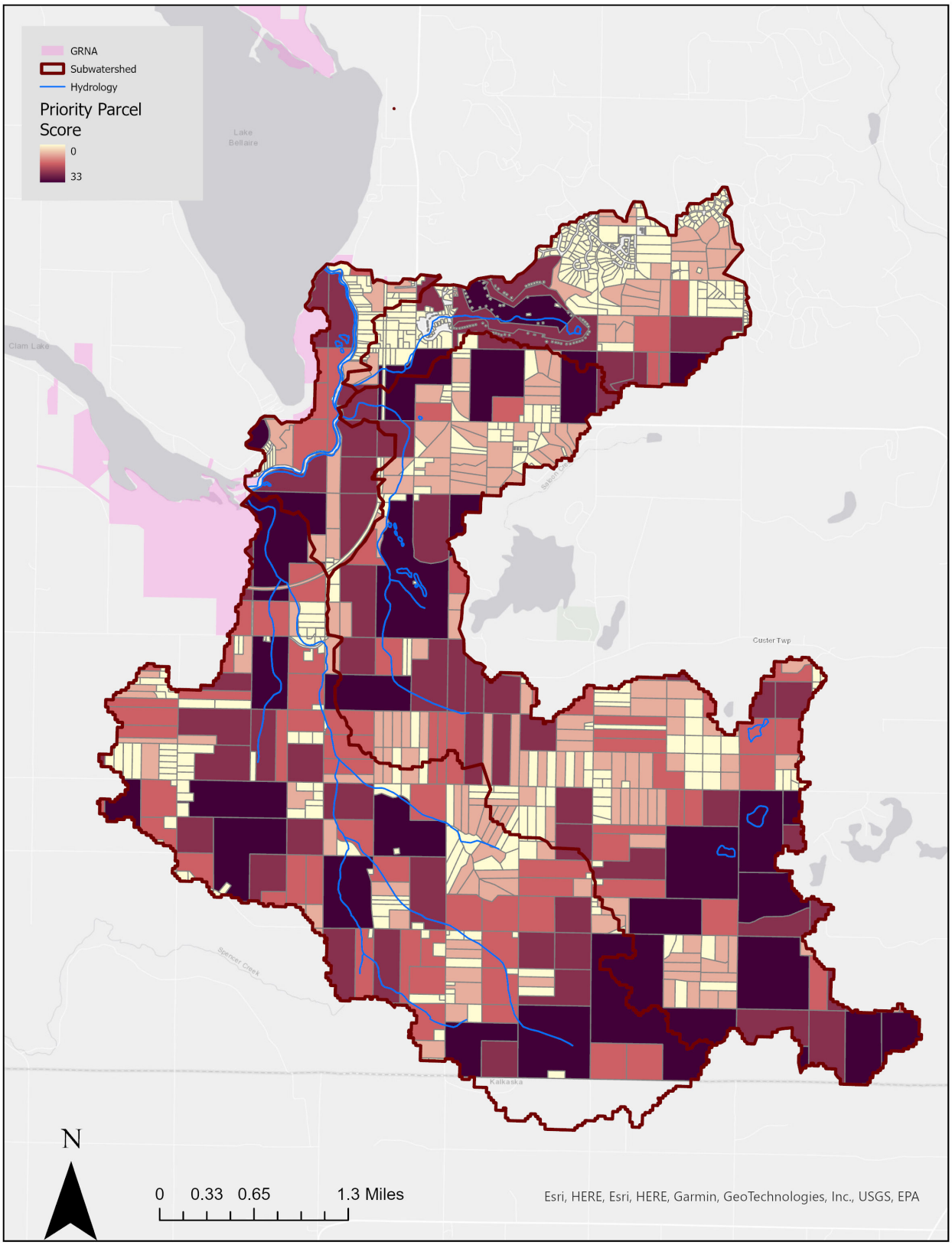

Figure 27. Priority parcel analysis for water protection. Parcels with higher scores are higher priority.

Section 4: Vision, Goals, and Objectives

VISION

The goals and objectives of this plan have been designed to support the long-term vision for the sub-watershed, which is as follows: We envision a future in which the Grass River and its tributaries are a thriving ecosystem, characterized by excellent water quality; healthy, free-flowing streams; and pristine habitats that sustain diverse native plants and wildlife. Individual and community actions work to protect and restore the vibrant Grass River, and residents and visitors alike cherish its immense natural, economic, and recreational value.

GOALS

In order to ensure alignment with the larger ERCOL plan, the goals of the Grass River Adaptive Management Plan match the goals of the ERCOL plan. These goals serve as the overarching framework for subsequent sections detailing implementation tasks (Section 5) and evaluation (Section 6). The goals are as follows:

Implementation goals

1. Protect the diversity of aquatic habitats.
2. Protect and improve water quality.
3. Enhance and maintain recreational opportunities that preserve water quality and support the local economy.
4. Promote sustainable land management practices that conserve and protect the natural resources, character, and heritage of the sub-watershed.
5. Integrate climate-resilient practices and efforts throughout the sub-watershed.
6. Develop and maintain effective education and outreach efforts to support sub-watershed protection.

Because the Grass River and its watershed is a sub-set of the ERCOL with unique hydrology, threats, and data needs, some of the objectives for the protection of the sub-watershed are unique. However, most are analogous to or based on those included in the ERCOL plan. The following table details the objectives of this plan as well as their alignment to the ERCOL plan objectives.

Goal	Objective Code	Objective	Analogous ERCOL plan objective
1: Protect the diversity of aquatic habitats	1a	Inventory and monitor aquatic habitats to document conditions and changes	1.1
	1b	Protect and restore diverse river and stream habitats	1.2
	1c	Protect and restore riparian corridors, floodplains, and wetland areas	1.3
	1d	Protect and restore natural hydrologic connectivity and integrity	1.5
	1e	Monitor and manage invasive species populations to promote the integrity of native populations	1.6
	1f	Protect and restore critical habitat for threatened/endangered species, species of special concern, or species of regional significance	1.4
2: Protect and improve water quality	2a	Establish effective, standardized water quality monitoring procedures	2.1
	2b	Reduce sediment inputs to surface waters	2.3
	2c	Reduce chemical, thermal, nutrient, bacterial, and other harmful inputs to surface waters and groundwater	2.2, 2.4, 2.6, 2.7
3: Enhance and maintain recreational opportunities that preserve water quality and support the local economy	3a	Maintain boating navigability	3.1
	3b	Create, maintain, and promote protocols or infrastructure to help limit spread of invasive species	3.3
	3c	Create infrastructure, promote regulations, and develop a culture that encourages stewardship through recreation	3.5
	3d	Maintain open space, parks, greenways, and natural areas for public enjoyment	4.3
4: Promote sustainable land management practices that conserve and protect the natural resources, character, and heritage of the watershed	4a	Maintain natural beauty and wilderness character of the river corridor	4.1, 4.2
	4b	Protect priority areas to preserve ecological integrity and watershed quality	4.4
	4c	Promote low impact development techniques and green infrastructure throughout the watershed	4.5
	4d	Increase local governmental awareness as to the impacts of development on natural resources and biological communities	4.6
	4e	Promote regulatory tools that prevent or reduce environmental degradation in riparian zones, drainage areas, and sensitive landscapes	4.7

	4f	Promote voluntary best management practices that prevent or reduce environmental degradation in riparian zones, drainage areas, and sensitive landscapes	4.8
5: Integrate climate-resilient practices and efforts throughout the watershed	5a	Develop adaptive management strategies based on climate predictions and observed patterns	5.2
	5b	Develop infrastructure resilient to increased storm severity and climate variability	5.3
	5c	Promote and sustain biodiversity and ecological integrity in light of changing environmental conditions	5.4
6: Develop and maintain effective education and outreach efforts to support watershed protection	6a	Maintain a working knowledge of current and emerging issues affecting the Grass River sub-watershed	6.1
	6b	Regularly inform public about research, projects, and opportunities for contribution/collaboration within the watershed	6.2
	6c	Engage stakeholders in actions that prevent and mitigate current and emerging issues in the watershed	6.3, 6.4
	6d	Maintain place-based learning and organized citizen science opportunities	6.5
	6e	Develop a culture of community pride and stewardship of the river	
	6f	Develop a network of river ambassadors who are committed to and engaged in protecting the watershed	

Table 17. Goals, objectives, and alignment of objectives with those included in the ERCOL plan.

Section 5: Implementation Strategy

Recommended implementation tasks are organized in Table 20. Each task is aligned to the plan's objectives; is assigned a priority level based on urgency for mitigation or prevention, availability of capacity in terms of partners and funding, and practical time constraints; is assigned milestones when possible that can be used as benchmarks of progress, and is assigned an estimated cost, potential project partners, and potential funding sources. GRNA and TLA will be partners on all projects. Lists of abbreviations for potential project partners and potential fundings sources are listed in Tables 18 and 19, respectively.

Potential Project Partners	Abbreviation
Antrim Conservation District	ACD
Antrim County	AC
Antrim County Road Commission	ACRC
Charlevoix, Antrim, Kalkaska, Emmet Cooperative Invasive Species Management Area	CAKE CISMA
Michigan Department of Environment, Great Lakes, and Energy	EGLE
Friends of Clam Lake	FoCL
Grand Traverse Regional Land Conservancy	GTRLC
Michigan Department of Natural Resources	MDNR
Paddle Antrim	PA
Shanty Creek Resort	SCR
Tip of the Mitt Watershed Council	TOMWC
The Watershed Center Grand Traverse Bay	TWC

Table 18. Abbreviations for potential project partners in implementation strategy table.

Potential Funding Source	Abbreviation
Private foundation	PF
State grant	SG
Federal grant	FG
Partner organization	PO
Local government	LG
Private cost-share	CS
Local business	LB

Table 19. Abbreviations for potential funding sources in implementation strategy table.

Priority	Aquatic Habitat	Objectives Addressed	Milestone 2024-2025	Milestone 2026-2027	Milestone 2028-2032	Estimated Cost	Potential Partners	Potential Funding Sources
High	Conduct a full RSX inventory on all RSXs in the sub-watershed	1a, 6a	Conduct inventory			$7,000	ACD, TOMWC, TWC, ACRC	PF, SG, PO
	Improve priority RSXs for better hydrology, erosion control, and fish passage	1b, 1d, 1f, 2b, 2c, 3a, 5a, 5b, 5c		Improve	Improve	$500,000	ACD, TOMWC, TWC, ACRC	PF, SG, FG, PO, LG
	Remove priority small dams and other water control infrastructure	1b, 1d, 1f, 2b, 2c, 3a, 5a, 5b, 5c, 6c			Remove	$200,000	TOMWC, TWC	SG, FG, PO, CS
Medium	Strategically install large woody debris to naturally scour channel and facilitate sediment transport	1b, 1f, 3a, 5c	Determine locations	Installation	Monitor	$100,000	ACD	SG, PF, PO
	Compile known information about small dams and water control infrastructure and work to fill in gaps with remotely gathered data	1a, 6a	Compile data			$2,000	TOMWC, TWC	SG, FG, PO
	Develop and implement outreach and education strategy targeting owners of small dams, focusing on the benefits of removing dams and water control infrastructure	4f, 5c, 6c, 6e		Develop campaign	Implement campaign	$3,000	TOMWC, TWC	PF, SG, FG, PO
Low	Conduct a fish survey in Grass River and the three tributaries to determine if the species assemblage has	1a, 6a		Conduct survey		$2,000	MDNR, EGLE	CS, PF

	changed since the last survey in 1981							
Priority	**Invasive Species**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	Continue controlling priority invasive species on an annual basis throughout GRNA	1b, 1c, 1e, 1f, 3a, 3d, 4a, 5c	Continue annually	Continue annually	Continue annually	$8,000	CAKE CISMA	CS, PO, PF, SG, LG
	Continue New Zealand mudsnails qualitative surveys annually during stream monitoring	1a, 1e, 6a	Continue annually	Continue annually	Continue annually	$1,000	CAKE CISMA, MDNR, EGLE	PO
Medium	Continue regular monitoring of shoreline invasive plants throughout GRNA and along Grass River	1a, 1e, 6a	Continue annually	Continue annually	Continue annually	$5,000	CAKE CISMA	PO, PF, LG
	Continue to report introductions and spread of invasive species to MISIN	1e, 6a	Continue annually	Continue annually	Continue annually	$5,000	CAKE CISMA	PF, SG, LG, PO
Low	Stay up-to-date on emerging invasive species threats through webinars, conferences, and workshops	1e, 6a				$2,000	CAKE CISMA, MDNR, EGLE	PO
	Work with CAKE CISMA to provide assistance, resources, and support to landowners to manage invasive species within the sub-watershed outside of GRNA	1b, 1c, 1e, 1f, 3b, 4a, 4f, 6b, 6c, 6e, 6f		Implement		$30,000	CAKE CISMA	PO, PF, CS, SG

	Work with CAKE CISMA and Paddle Antrim to host annual Michigan Paddle Stewards class on Grass River	1a, 1e, 3b, 3c, 4f, 6b, 6c, 6d, 6e, 6f	Continue annually	Continue annually	Continue annually	$7,000	CAKE CISMA, PA, EGLE, MDNR	PO, SG
Priority	**Land Protection**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
Medium	Work with GTRLC to protect private priority parcels with conservation easements	1b, 1c, 1f, 4b, 4f, 6c, 6f				$100,000	GTRLC	CS, PO, PF
Low	Work with Antrim County to acquire appropriate adjacent/nearby priority parcels as part of GRNA	1b, 1c, 1f, 3d, 4a, 4b				$1,000,000	AC	PO, PF, LG
Priority	**Land Use**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	Work with Shanty Creek Resorts and various HOAs along Shanty Creek to establish agreements related to land management practices and grounds maintenance (i.e., using phosphorus-free fertilizers on the golf course) according to recommendations in stormwater action plan (See ERCOL plan Appendix J)	1c, 2b, 2c, 3b, 4f, 6b, 6c, 6e, 6f	Establish agreements			$40,000	SCR, TOMWC, TWC, ACD	PF, SG, PO, CS, LB

	Work with Shanty Creek Resorts and various HOAs along Shanty Creek to install green infrastructure for stormwater management according to recommendations in stormwater action plan (See ERCOL plan Appendix J)	2b, 2c, 4c, 4f, 5a, 5b, 6c, 6e, 6f		Install infrastructure	Install infrastructure	$150,000	SCR, TOMWC, TWC, ACD	PF, SG, FG, PO, CS, LB
Medium	Physically restrict motorized vehicle access in "problem areas" of GRNA where the potential impact to water quality is high	1c, 2b, 3b, 3c	Implement			$3,000	AC, ACD	PO, PF, LG
Low	Work with Antrim Conservation District to support agricultural producers implementing agricultural BMPs	2b, 2c, 4c, 5a, 5c, 6c, 6e, 6f				$15,000	ACD	SG, FG, CS, PF
Priority	**Planning and Zoning**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	When GRNA's ordinance with Antrim County is redone, add provision that bans boats from pulling up onto banks and add a no-wake ordinance	1b, 1c, 1f, 2b, 3c, 4e, 6c, 6e, 6f	Implement			$1,000	AC	LG, PO
Medium	Educate townships on the advantages of riparian buffer and setback ordinances	4d, 4e, 6c, 6e, 6f	Implement			$2,000	TWC, TOMWC	PF, LG, PO

	Work with The Watershed Center Grand Traverse Bay to educate townships on how to better enforce their existing riparian buffer and setback ordinances	4a, 4d, 4e, 6c, 6e, 6f		Implement		$2,000	TWC, TOMWC	PF, LG, PO
	Educate local township officials on the option to create a Grass River overlay district	4d, 4e, 6c, 6e, 6f	Implement			$2,000	TWC	PF, LG, PO
Priority	**Recreation**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	Develop and implement a boating education campaign encouraging stewardship through recreation on Grass River	3c, 3d, 4a, 6c, 6e	Partners & funding	Implement		$25,000	PA, FoCL	LB, PF, SG, PO, LG
	Establish a river ambassador program to conduct outreach to boaters during the busy summer season on the importance of stewardship through recreation	3c, 3d, 4a, 4f, 6c, 6e, 6f		Implement		$30,000	PA, FoCL, AC	PO, PF, SG, LG
	Engage marinas and boat rental companies as another avenue to educate recreators on the importance of stewardship	3c, 3d, 4a, 6c, 6e, 6f		Implement		$10,000	PA, FoCL, marinas and boat renters	LB, LG, PF, SG, PO
Medium	Work with the Sheriff Department's Marine Patrol to better enforce	3c, 3d, 4a	Implement			$30,000	AC	LG, PO, PF

	no-wake infractions on Grass River							
Priority	**Septic Systems**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
Medium	Work with Tip of the Mitt Watershed Council and The Watershed Center Grand Traverse Bay to pass time of transfer septic inspection ordinances	2c, 4d, 4e, 5b, 6c, 6e				$10,000	TOMWC, TWC	PO, LG, PF
	Work with Northwest Michigan Health Department and other organizations to promote best management practices related to septic systems	2c, 4e, 4f, 5b, 6c, 6e				$25,000	Health Department, TOMWC, TWC, townships	PF, SG, LG, PO, CS, LB
Priority	**Streambank Protection**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	Conduct streambank erosion inventory on the three tributaries and the river	1a, 6a	Conduct inventory			$5,000	ACD, TOMWC, TWC	PF, SG, FG, PO
	Restore priority streambank erosion sites on the tributaries and Grass River	1c, 1f, 2b, 2c, 3a, 4a, 5c, 6c, 6e			Restore	$40,000	ACD, TOMWC, TWC	PF, SG, FG

Medium	Conduct outreach and provide resources to landowners on the importance of protecting and restoring riparian buffers and shorelines	4c, 4f, 6c, 6e, 6f		Conduct outreach		$10,000	ACD, TOMWC, TWC	PF, SG, FG, PO
Priority	**Water Quality Monitoring**	**Objectives Addressed**	**Milestone 2024-2025**	**Milestone 2026-2027**	**Milestone 2028-2032**	**Estimated Cost**	**Potential Partners**	**Potential Funding Sources**
High	Create water quality monitoring program in the sub-watershed to collect baseline data	1a, 2a, 6a	Create program			$8,000	TOMWC, TWC, EGLE	PF, SG, FG, PO
Medium	Continue twice-annual macroinvertebrate and stream habitat monitoring on the three tributaries through MiCorps' Volunteer Stream Monitoring Program	1a, 6a, 6b, 6c, 6d, 6e, 6f	Continue twice-annually	Continue twice-annually	Continue twice-annually	$12,000	ACD, TOMWC, TWC	SG, PO

Table 20. Implementation strategy.

Section 6: Evaluation

INTRODUCTION

Evaluating progress is critical to measuring the success of this plan and its goals, objectives, and implementation tasks. Our evaluation strategy will focus on the same three measurable categories as the ERCOL plan (numbers 1-3) and a fourth category that builds on our focus on and success at engaging the community in our efforts (number 4):

1. Progress in completing recommended implementation tasks
2. Effectiveness in improving and maintaining water quality throughout the sub-watershed
3. Effectiveness in improving and protecting land resources and habitat throughout the sub-watershed
4. Amount of community engagement and community pride in caretaking the river

COMPLETING IMPLEMENTATION TASKS

Progress toward completing implementation tasks included in Section 5 will be reviewed quarterly by the Grass River Adaptive Management Plan advisory committee (hereafter "advisory committee"), which includes staff and board members of GRNA, Three Lakes Association, and Wayfinder Facilitation. Milestones will be tracked for completion, and implementation tasks will be adapted as needed.

IMPROVING AND MAINTAINING WATER QUALITY

The advisory committee will utilize the results of the ongoing benthic macroinvertebrate sampling on 11 sites on Finch Creek, Cold Creek, and Shanty Creek to assess water quality trends on an annual basis. Sites on each creek are measured in the spring and the fall every 3 years, so single creeks will be evaluated each year based on the monitoring results from that year.

One of the high priority implementation tasks in this plan is to create a water quality monitoring program in the sub-watershed to collect baseline data, with a targeted milestone to create the program in 2024-2025. While the monitoring parameters are yet to be finalized, this project is expected to at least monitor total nitrogen, total phosphorus, and total suspended solids. Once this program is implemented and baseline data is collected, we will then also be able to evaluate water quality trends going forward by comparing ongoing results of the monitoring to the baseline data.

IMPROVING AND PROTECTING LAND RESOURCES AND HABITAT

The advisory committee will utilize the results of various ongoing surveys and monitoring projects to assess the health of terrestrial and aquatic habitats.

HABITAT

GRNA will continue its stream habitat assessments at the established 11 sites throughout the sub-watershed on Finch, Cold, and Shanty Creeks. These assessments follow the MiCorps standardized procedure and are collected at each site once every three years in the spring. Results will be reviewed annually to determine trends.

GRNA is also launching a fen monitoring project in the summer of 2023 to document the hydrologic conditions, nutrients, and flora of the two large fen complexes within GRNA. On-the-ground surveys will be conducted every 5 years and aerial imagery will be captured with a drone annually to check for changes in hydrology between the on-the-ground surveys. The 2023 results will serve as baseline data that can then be compared to future surveys to assess the ongoing health of this important habitat.

INVASIVE SPECIES

GRNA will continue monitoring for invasive species through its parcel monitoring project and during annual surveys for riparian invasive plants along GRNA's shorelines (including the river, the three tributaries, and the shorelines of Lake Bellaire and Clam Lake that fall within the natural area). Results will be used to assess progress made in habitat protection and improvement.

GRNA will also continue its New Zealand mudsnail surveys at the established 11 sites used for macroinvertebrate sampling and stream habitat assessments. Presence and absence of mudsnails will be used to assess progress in habitat protection.

RIPARIAN ZONES

One of the high priority tasks in the implementation strategy is conducting full streambank erosion surveys throughout the sub-watershed. The results of this inventory will be compared with results from the 2015 survey, and at sites that were not surveyed during the partial 2015 inventory, results will be used as baseline data that can be compared to future surveys. Streambank erosion surveys should be conducted every 5 years, according to the ERCOL plan.

ROAD STREAM CROSSINGS

A high priority task in the implementation strategy is conducting a full road stream crossing inventory throughout the sub-watershed. The results will be compared to the results of the partial inventory that was conducted in 2015, and for sites that were not surveyed in 2015, results will be used as baseline data. Road stream crossing surveys should be completed every 10 years according to the ERCOL plan, so this baseline data can be compared to the results of future inventories.

STORMWATER

Progress on stormwater will be assessed through the installation of green infrastructure, particularly as to the degree to which installation reflects the recommendations of the Shanty Creek Stormwater Action Plan, included as Appendix J in the ERCOL plan.

LAND PROTECTION AND MANAGEMENT

The priority parcel analyses detailed in Section 3 will serve as the basis for assessing the success of this metric. Specifically, the acreage of parcels protected (either privately as conservation easements or publicly as part of GRNA or a Grand Traverse Regional Land Conservancy preserve), along with the priority score of those parcels, will be used to measure success in protecting land.

COMMUNITY ENGAGEMENT

Because the Grass River is such a beloved asset in the local community – providing vital ecosystem services, opportunities for recreation, and a tourism draw that boosts the local economy – the effort to create a management plan for the sub-watershed has involved the local community from the beginning through our Grass River Connects stakeholder engagement meetings. Taking the community's experiences, needs, and concerns into account during the creation of the plan has created buy-in and support for our efforts, and the continuation of this support will be crucial to the ability of the advisory committee to implement tasks identified in this plan.

Additionally, the continuation of our efforts will require the community as a whole to know and value the Grass River sub-watershed as a refuge for wildlife, as an intact wild ecosystem, and as a place of beauty and rejuvenation. Regular engagement with the community around the river's protection will be required to build and sustain a group of stakeholders who act, as a matter of course, on behalf of Grass River.

We will therefore continuously evaluate several metrics of community engagement, specifically:

1) The advisory committee will host an annual community meeting to update stakeholders on progress toward implementation tasks and will use attendance numbers and attendee comments to evaluate engagement,

2) The number of community members participating in volunteer monitoring activities like GRNA's twice-annual stream monitoring will be evaluated,

3) The number of local landowners engaged in voluntary best management practices on their land will be evaluated to the extent possible, and

4) Community attendance at public meetings like TLA's annual meeting, report-out meetings from the Chain of Lakes hydrology study, and local government meetings related to the health of the sub-watershed will be monitored.

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Appendices

Appendix A: Grass River Connects Meetings Survey Tool

1. How important is each of these to you?

Natural beauty of the river	very important	somewhat important	not important
Ability to float/paddle down the river	very important	somewhat important	not important
Ability to motorboat on the river	very important	somewhat important	not important
Presence of/observing wildlife	very important	somewhat important	not important
Quiet on the river	very important	somewhat important	not important
Attraction for tourists/visitors	very important	somewhat important	not important
High water quality along the river	very important	somewhat important	not important
Other: _____	very important	somewhat important	not important

2. How do you interact with the river in the warm months?

Sitting near it/watching the water and passers-by:

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Paddling or floating on the river

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Motor boating on the river

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Fishing or hunting on the river

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Observing nature (i.e. plants, animals)

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Collecting data for water quality, plant surveys, or other systematic observation of the river

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Visiting the river with guests/visitors, or encouraging guests/visitors to visit the river

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

Other: _____

many times per week	1-4 times per month	1-4 times per year	once every 2-4 years	once every 5+ years	not at all

I don't interact with the Grass River directly; I appreciate it from afar

3. How concerned are you about each of the following:

Invasive species expansion on the Grass River and tributaries	high concern	moderate concern	mild concern	no concern	don't know enough about it
Decrease in biodiversity due to increased sedimentation	high concern	moderate concern	mild concern	no concern	don't know enough about it
Reduction in navigability due to increased sedimentation	high concern	moderate concern	mild concern	no concern	don't know enough about it
Widening of the Grass River	high concern	moderate concern	mild concern	no concern	don't know enough about it
The impacts of climate change on the river and tributaries	high concern	moderate concern	mild concern	no concern	don't know enough about it
Development along river or tributary edges	high concern	moderate concern	mild concern	no concern	don't know enough about it
Development on the land surrounding the Grass River (the watershed)	high concern	moderate concern	mild concern	no concern	don't know enough about it
Irresponsible or unsafe boating practices on the Grass River	high concern	moderate concern	mild concern	no concern	don't know enough about it
Leakage from septic systems	high concern	moderate concern	mild concern	no concern	don't know enough about it
Fertilizer and pesticide pollution from lawn and farming practices	high concern	moderate concern	mild concern	no concern	don't know enough about it
Boater overcrowding on the river	high concern	moderate concern	mild concern	no concern	don't know enough about it
Erosion of riverbanks and river edges	high concern	moderate concern	mild concern	no concern	don't know enough about it

Tributary discontinuity (i.e. existing dams, poor/inadequate road-stream crossings)	high concern	moderate concern	mild concern	no concern	don't know enough about it
Other: _____	high concern	moderate concern	mild concern	no concern	don't know enough about it

4. **What surprised you here today? What did you learn? (about the river, the community, your neighbors, etc.)**

5. **<u>Let's flag the best ideas from today:</u> What is your favorite idea or a way to move forward that came up today? Why do you like it so much?**

Appendix B: Quantitative Results of Grass River Connects Meetings Survey

Question 1 Results

Natural Beauty					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	93.8%	85.7%	100.0%	100.0%	96.5%
Somewhat important	6.2%	14.3%	0.0%	0.0%	3.5%
Not important	0.0%	0.0%	0.0%	0.0%	0.0%
Paddling					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	93.8%	42.9%	90.0%	84.0%	82.8%
Somewhat important	6.2%	42.9%	10.0%	12.0%	13.8%
Not important	0.0%	14.2%	0.0%	4.0%	3.4%
Boating					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	66.7%	28.6%	90.0%	41.7%	55.4%
Somewhat important	20.0%	71.4%	10.0%	33.3%	30.4%
Not important	13.3%	0.0%	0.0%	25.0%	14.2%
Observing Wildlife					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	100.0%	71.4%	100.0%	95.8%	94.7%
Somewhat important	0.0%	28.6%	0.0%	4.2%	5.3%
Not important	0.0%	0.0%	0.0%	0.0%	0.0%
Quiet on the River					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	87.5%	42.9%	90.0%	83.3%	80.7%
Somewhat important	12.5%	57.1%	10.0%	16.7%	19.3%
Not important	0.0%	0.0%	0.0%	0.0%	0.0%
Attraction for Tourists					

Stakeholder Group	Businesses	Board of Commissioners	Riparians	General Public	Total
Very important	56.3%	28.6%	30.0%	28.0%	36.2%
Somewhat important	37.5%	57.1%	40.0%	52.0%	46.6%
Not important	6.2%	14.3%	30.0%	20.0%	17.2%
High Water Quality					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Very important	100.0%	85.7%	100.0%	100.0%	98.3%
Somewhat important	0.0%	0.0%	0.0%	0.0%	1.7%
Not important	0.0%	14.3%	0.0%	0.0%	0.0%

Question 2 Results

Sitting near the water					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	25.0%	14.3%	66.7%	16.7%	26.8%
1-4 times per month	25.0%	14.3%	22.2%	45.8%	32.1%
1-4 times per year	31.3%	42.9%	11.1%	25.0%	26.8%
Once every 2-4 years	12.5%	0.0%	0.0%	0.0%	3.6%
Once every 5+ years	0.0%	0.0%	0.0%	0.0%	0.0%
Not at all	6.2%	28.5%	0.0%	12.5%	10.7%
Paddling					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	18.7%	0.0%	33.3%	4.0%	12.3%
1-4 times per month	31.3%	14.2%	0.0%	32.0%	24.5%
1-4 times per year	31.3%	28.6%	55.6%	44.0%	40.4%
Once every 2-4 years	12.5%	28.6%	0.0%	4.0%	8.8%
Once every 5+ years	0.0%	0.0%	0.0%	0.0%	0.0%
Not at all	6.2%	28.6%	11.1%	16.0%	14.0%

Boating					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	18.8%	0.0%	55.6%	4.0%	15.8%
1-4 times per month	37.5%	28.5%	11.1%	24.0%	28.1%
1-4 times per year	18.7%	0.0%	22.2%	44.0%	26.2%
Once every 2-4 years	0.0%	14.3%	0.0%	8.0%	5.3%
Once every 5+ years	18.7%	14.3%	0.0%	4.0%	8.8%
Not at all	6.3%	42.9%	11.1%	16.0%	15.8%
Fishing or Hunting					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	6.3%	0.0%	11.1%	0.0%	3.5%
1-4 times per month	18.7%	28.5%	11.1%	28.0%	22.8%
1-4 times per year	12.5%	14.3%	44.5%	12.0%	17.6%
Once every 2-4 years	0.0%	14.3%	33.3%	0.0%	7.0%
Once every 5+ years	0.0%	0.0%	0.0%	0.0%	0.0%
Not at all	62.5%	42.9%	0.0%	60.0%	49.1%
Observing Nature					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	31.3%	14.3%	66.7%	24.0%	31.6%
1-4 times per month	25.0%	14.3%	22.2%	40.0%	29.8%
1-4 times per year	31.2%	42.8%	11.1%	24.0%	26.2%
Once every 2-4 years	12.5%	0.0%	0.0%	4.0%	5.3%
Once every 5+ years	0.0%	14.3%	0.0%	0.0%	1.8%
Not at all	0.0%	14.3%	0.0%	8.0%	5.3%
Collecting Data					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	0%	0%	0%	4.0%	1.8%
1-4 times per month	0%	0%	0%	4.0%	1.8%

1-4 times per year	0.0%	14.3%	11.1%	0.0%	3.5%
Once every 2-4 years	6.3%	0.0%	11.1%	8.0%	7.0%
Once every 5+ years	0.0%	0.0%	0.0%	0.0%	0.0%
Not at all	93.7%	85.7%	77.8%	84.0%	85.9%
Visiting with guests or encouraging guests to visit					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
Many times per week	31.3%	14.3%	11.1%	12.5%	17.9%
1-4 times per month	31.3%	0.0%	33.3%	41.7%	32.1%
1-4 times per year	18.7%	57.1%	44.5%	41.7%	37.5%
Once every 2-4 years	18.7%	0.0%	11.1%	0.0%	7.1%
Once every 5+ years	0.0%	0.0%	0.0%	0.0%	0.0%
Not at all	0.0%	28.6%	0.0%	4.1%	5.4%

Question 3 Results

Invasive species					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	53.3%	85.7%	40.0%	70.8%	62.5%
Moderate Concern	26.7%	0.0%	50.0%	29.2%	28.6%
Mild Concern	13.3%	14.3%	10.0%	0.0%	7.1%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	6.7%	0.0%	0.0%	0.0%	1.8%
Decrease in biodiversity					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	43.8%	57.1%	70.0%	75.0%	63.2%
Moderate Concern	50.0%	28.6%	30.0%	20.8%	31.6%
Mild Concern	6.2%	0.0%	0.0%	4.2%	3.5%
No Concern	0.0%	14.3%	0.0%	0.0%	1.7%

Don't know enough	0.0%	0.0%	0.0%	0.0%	0.0%
Reduction in navigability					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	56.3%	42.9%	60.0%	37.5%	47.4%
Moderate Concern	31.2%	42.9%	30.0%	41.7%	36.8%
Mild Concern	12.5%	14.2%	10.0%	20.8%	15.8%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	0.0%	0.0%	0.0%	0.0%	0.0%
Widening of Grass River					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	56.3%	42.9%	60.0%	29.2%	43.9%
Moderate Concern	31.2%	14.2%	40.0%	50.0%	38.6%
Mild Concern	12.5%	42.9%	0.0%	20.8%	17.5%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	0.0%	0.0%	0.0%	0.0%	0.0%
Impacts of climate change					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	43.8%	42.9%	40.0%	50.0%	45.6%
Moderate Concern	31.3%	28.5%	40.0%	29.2%	31.6%
Mild Concern	18.7%	14.3%	20.0%	16.7%	17.5%
No Concern	6.2%	14.3%	0.0%	4.1%	5.3%
Don't know enough	0.0%	0.0%	0.0%	0.0%	0.0%
Development along river or tributary edges					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	31.3%	42.9%	50.0%	70.8%	52.6%
Moderate Concern	43.8%	28.6%	20.0%	25.0%	29.8%
Mild Concern	18.7%	28.6%	30.0%	0.0%	14.0%
No Concern	6.2%	0.0%	0.0%	0.0%	1.8%

Don't know enough	0.0%	0.0%	0.0%	4.2%	1.8%
Development along land surrounding river					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	56.3%	28.6%	50.0%	79.2%	61.4%
Moderate Concern	12.5%	28.6%	10.0%	16.7%	15.8%
Mild Concern	25.0%	14.3%	40.0%	0.0%	15.8%
No Concern	6.2%	14.3%	0.0%	0.0%	3.5%
Don't know enough	0.0%	14.2%	0.0%	4.1%	3.5%
Irresponsible or unsafe boating					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	87.5%	42.9%	80.0%	95.8%	84.2%
Moderate Concern	6.2%	28.5%	10.0%	4.2%	7.0%
Mild Concern	6.3%	14.3%	10.0%	0.0%	7.0%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	0.0%	14.3%	0.0%	0.0%	1.8%
Leakage from septic systems					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	68.8%	57.1%	70.0%	83.3%	73.6%
Moderate Concern	18.7%	14.3%	20.0%	12.5%	15.8%
Mild Concern	6.2%	14.3%	10.0%	4.2%	7.0%
No Concern	6.3%	0.0%	0.0%	0.0%	1.8%
Don't know enough	0.0%	14.3%	0.0%	0.0%	1.8%
Fertilizer and pesticide pollution					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	56.3%	42.9%	60.0%	87.5%	68.4%
Moderate Concern	37.5%	28.5%	30.0%	12.5%	24.5%
Mild Concern	6.2%	0.0%	10.0%	0.0%	3.5%
No Concern	0.0%	14.3%	0.0%	0.0%	1.8%

Don't know enough	0.0%	14.3%	0.0%	0.0%	1.8%
Boater overcrowding					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	75.0%	28.6%	70.0%	58.4%	61.4%
Moderate Concern	6.2%	14.3%	30.0%	33.3%	22.8%
Mild Concern	12.5%	28.5%	0.0%	8.3%	10.5%
No Concern	6.3%	14.3%	0.0%	0.0%	3.5%
Don't know enough	0.0%	14.3%	0.0%	0.0%	1.8%
Erosion of riverbanks					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	81.3%	33.3%	60.0%	75.0%	69.6%
Moderate Concern	12.5%	33.3%	40.0%	20.8%	23.3%
Mild Concern	6.2%	33.4%	0.0%	4.2%	7.1%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	0.0%	0.0%	0.0%	0.0%	0.0%
Tributary discontinuity					
Stakeholder Group	**Businesses**	**Board of Commissioners**	**Riparians**	**General Public**	**Total**
High Concern	50.0%	0.0%	30.0%	54.2%	42.9%
Moderate Concern	25.0%	33.3%	50.0%	37.5%	35.7%
Mild Concern	12.5%	50.0%	20.0%	8.3%	16.1%
No Concern	0.0%	0.0%	0.0%	0.0%	0.0%
Don't know enough	12.5%	16.7%	0.0%	0.0%	5.3%

Appendix C: Invasive Plants in the Sub-watershed

Latitude	Longitude	Species	Size or Extent	Date of Discovery	Treatment Status
44.88273	-85.20736	Canada Thistle	6-10 individuals		Not treated
44.88323	-85.20815	Canada Thistle	Fewer than 5 individuals		Not treated
44.88372	-85.20893	Canada Thistle	11-20 individuals		Not treated
44.88387	-85.20905	Canada Thistle	6-10 individuals		Not treated
44.88474	-85.20887	Canada Thistle			Not treated
44.88474	-85.20909	Canada Thistle			Not treated
44.88485	-85.20903	Canada Thistle			Not treated
44.88633	-85.20962	Canada Thistle	6-10 individuals		Not treated
44.88644	-85.20962	Canada Thistle	6-10 individuals		Not treated
44.88832	-85.20885	Canada Thistle			Not treated
44.8887	-85.20829	Canada Thistle	11-20 individuals		Not treated
44.88887	-85.20823	Canada Thistle			Not treated
44.88927	-85.20839	Canada Thistle			
44.89362	-85.21039	Canada Thistle			Not treated
44.89452	-85.21108	Canada Thistle	Fewer than 5 individuals		Not treated
44.8951	-85.21089	Canada Thistle	6-10 individuals		Not treated
44.89514	-85.21079	Canada Thistle	11-20 individuals		
44.90024	-85.2107	Canada Thistle			Not treated
44.90097	-85.21088	Canada Thistle	6-10 individuals		Not treated
44.90225	-85.21081	Canada Thistle			Not treated
44.90233	-85.21082	Canada Thistle	6-10 individuals		Not treated
44.90247	-85.21078	Canada Thistle	6-10 individuals		Not treated
44.90243	-85.21091	Canada Thistle			Not treated

44.90257	-85.2114	Canada Thistle	6-10 individuals		Not treated
44.90321	-85.21194	Canada Thistle			Not treated
44.90303	-85.21462	Canada Thistle	51-100 individuals		Not treated
44.90336	-85.21485	Canada Thistle			Not treated
44.92379823	-85.2183443	Common speedwell		8/15/17	Not treated
44.91386723	-85.2327766	Eurasian water-milfoil		8/14/18	Not treated
44.93490822	-85.2142455	European marsh thistle		8/15/17	Not treated
44.93522042	-85.2059018	European marsh thistle		7/22/20	Not treated
44.92460998	-85.2045256	European marsh thistle	51-100 individuals	6/16/21	Not treated
44.92780285	-85.2058677	European marsh thistle	51-100 individuals	6/16/21	Treated - manually pulled
44.92620665	-85.2066697	European marsh thistle	21-50 individuals	6/16/21	Not treated
44.96916755	-85.2208012	European marsh thistle	21-50 individuals	6/25/21	Not treated
44.90587	-85.21451	European marsh thistle	21-50 individuals		Not treated
44.91287827	-85.2311489	European marsh thistle		8/10/17	Not treated
44.91490604	-85.2204596	European marsh thistle	Fewer than 5 individuals	7/20/20	Treated - other
44.92779045	-85.2062578	European marsh thistle	More than 100 individuals	6/16/21	Treated - manually pulled
44.92627085	-85.2500813	Garlic mustard	Fewer than 5 individuals	4/20/21	Treated - manually pulled
44.92742408	-85.2501664	Garlic mustard	More than 100 individuals	6/25/21	Treated - manually pulled
44.92717036	-85.250111	Garlic mustard	21-50 individuals	6/25/21	Treated - manually pulled
44.9268811	-85.2500694	Garlic mustard	11-20 individuals	6/25/21	Treated - manually pulled

44.92666354	-85.2499278	Garlic mustard	6-10 individuals	6/25/21	Treated - manually pulled
44.92663064	-85.250124	Garlic mustard	6-10 individuals	6/25/21	Treated - manually pulled
44.92617115	-85.2501523	Garlic mustard	21-50 individuals	6/28/21	Treated - manually pulled
44.926067	-85.2503448	Garlic mustard	Fewer than 5 individuals	6/28/21	Treated - manually pulled
44.92608117	-85.2500663	Garlic mustard	Fewer than 5 individuals	6/28/21	Treated - manually pulled
44.88168	-85.20779	Giant knotweed			Not treated
44.90350435	-85.2216384	Honeysuckle	Fewer than 5 individuals	7/10/18	Not treated
44.9075492	-85.2266421	Japanese barberry	Fewer than 5 individuals	6/1/18	Treated - other
44.9220294	-85.2160054	Japanese barberry		11/2/18	Treated - manually pulled
44.92746213	-85.2498646	Japanese barberry	Fewer than 5 individuals	6/25/21	Treated - manually pulled
44.92713171	-85.2498442	Japanese barberry	Fewer than 5 individuals	6/25/21	Treated - manually pulled
44.96919034	-85.2191972	Japanese barberry	Fewer than 5 individuals	8/15/17	Treated - manually pulled
44.96499542	-85.2148285	Japanese barberry	Fewer than 5 individuals	8/15/17	Treated - manually pulled
44.9285999	-85.2066181	Japanese barberry		8/15/17	Treated - manually pulled
44.92993987	-85.2457251	Japanese barberry		8/15/17	Treated - manually pulled

44.91929904	-85.2219426	Japanese knotweed	Fewer than 5 individuals	9/24/20	Treated - chemicals applied
44.91929904	-85.2219426	Japanese knotweed			
44.95977838	-85.2143547	Leafy spurge		8/15/17	Not treated
44.94099845	-85.2085059	Moneywort		8/15/17	Not treated
44.96319728	-85.213792	Moneywort		7/1/21	Not treated
44.90419573	-85.223371	Morrow honeysuckle		8/15/17	Not treated
44.90984852	-85.2336285	Morrow honeysuckle		8/15/17	Not treated
44.90350435	-85.2216384	Multiflora rose	Fewer than 5 individuals	7/10/18	Not treated
44.90382303	-85.2264235	Multiflora rose	Fewer than 5 individuals	7/10/18	Not treated
44.90813832	-85.2314464	Multiflora rose		6/1/18	Not treated
44.90810811	-85.2314174	Multiflora rose			
44.90672991	-85.2317448	Multiflora rose		6/1/18	Not treated
44.90827897	-85.2362023	Multiflora rose		6/1/18	Not treated
44.93667351	-85.2057551	Multiflora rose	Fewer than 5 individuals	9/25/20	Not treated
44.88282	-85.20736	Multiflora rose	Fewer than 5 individuals		Not treated
44.91438555	-85.2163545	Multiflora rose		8/15/17	Not treated
44.91356531	-85.2281629	Narrow-leaved cat-tail	More than 100 individuals		Not treated
44.96510235	-85.2191441	Narrow-leaved cat-tail		8/15/17	Not treated
44.91687466	-85.2225327	Narrow-leaved cat-tail	More than 100 individuals	8/15/17	Not treated
44.91550089	-85.2259022	Narrow-leaved cat-tail		8/15/17	Not treated
44.96169454	-85.2171952	Narrow-leaved cat-tail		7/1/21	Not treated
44.96112172	-85.2165665	Narrow-leaved cat-tail		7/1/21	Not treated
44.96049135	-85.2147535	Narrow-leaved cat-tail	More than 100 individuals	7/1/21	Not treated
44.96061553	-85.2156145	Narrow-leaved cat-tail		7/1/21	Not treated

44.93625081	-85.2059217	Non-native phragmites		9/25/20	Not treated
44.91139293	-85.2322996	Non-native phragmites			
44.91185166	-85.233539	Non-native phragmites			
44.91528	-85.20395	Non-native phragmites		8/22/19	Treated - chemicals applied
44.91960669	-85.2273349	Other		10/26/18	Not treated
44.91938717	-85.2420716	Purple loosestrife	21-50 individuals	8/15/17	
44.91934275	-85.2421402	Purple loosestrife	Fewer than 5 individuals	8/12/20	Treated - manually pulled
44.91736	-85.2254	Purple loosestrife		8/27/20	Treated - chemicals applied
44.9185	-85.22644	Purple loosestrife		8/27/20	Treated - chemicals applied
44.936167	-85.207318	Purple loosestrife		8/25/20	Treated - chemicals applied
44.96427	-85.21466	Purple loosestrife	Fewer than 5 individuals	8/7/19	Treated - chemicals applied
44.96446	-85.21472	Purple loosestrife		8/7/19	Treated - chemicals applied

44.96463	-85.21474	Purple loosestrife	Fewer than 5 individuals	8/7/19	Treated - chemicals applied
44.9258191	-85.2494782	Reed canary grass		8/15/17	Not treated
44.9264466	-85.2067315	Reed canary grass		8/15/17	Not treated
44.92975309	-85.2447109	Reed canary grass		8/15/17	Not treated
44.91607748	-85.2217999	Reed canary grass		8/15/17	Not treated
44.91441643	-85.2330603	Reed canary grass		8/15/17	Not treated
44.91405629	-85.225854	Reed canary grass		8/15/17	Not treated
44.93452304	-85.2023569	Spotted knapweed	More than 100 individuals	7/7/20	Not treated
44.92825309	-85.2136699	Spotted knapweed	More than 100 individuals	7/29/20	Not treated
44.90817994	-85.2146132	Spotted knapweed		9/15/20	Not treated
44.90309212	-85.2213949	Spotted knapweed	6-10 individuals	9/29/20	Not treated
44.90328055	-85.2224138	Spotted knapweed		9/29/20	Not treated
44.97202184	-85.2206526	Spotted knapweed	More than 100 individuals	6/25/21	Not treated
44.97111284	-85.2181781	Spotted knapweed		8/15/17	Not treated
44.92458554	-85.2086673	Unidentified cat-tail		6/16/21	Not treated
44.93924583	-85.207985	Unidentified thistle		6/2/20	Not treated
44.91036736	-85.2286051	Unidentified thistle	Fewer than 5 individuals		Not treated
44.90671256	-85.2324072	Unidentified thistle		6/1/18	Not treated
44.90671206	-85.2331253	Unidentified thistle		6/1/18	Not treated
44.92329817	-85.2161629	Unidentified thistle		11/2/18	Not treated
44.92561266	-85.2111704	Unidentified thistle		10/2/20	Not treated
44.91914561	-85.2141324	Unidentified thistle	11-20 individuals	10/6/20	Not treated
44.91906841	-85.2131802	Unidentified thistle	Fewer than 5 individuals	10/6/20	Not treated
44.91936714	-85.2128747	Unidentified thistle		10/6/20	Not treated

44.91949098	-85.2128474	Unidentified thistle		10/6/20	Not treated
44.92027741	-85.2093304	Unidentified thistle	6-10 individuals	10/6/20	Not treated
44.91926157	-85.2087827	Unidentified thistle	21-50 individuals	10/6/20	Not treated
44.91782596	-85.2092197	Unidentified thistle	6-10 individuals	10/6/20	Not treated
44.91867907	-85.2125131	Unidentified thistle	Fewer than 5 individuals	10/6/20	Not treated
44.91798957	-85.2160454	Unidentified thistle		10/6/20	Not treated
44.92469342	-85.2038896	Unidentified thistle	21-50 individuals	6/16/21	Not treated
44.9278635	-85.205611	European marsh thistle	Fewer than 5 individuals	6/16/21	Treated - manually pulled
44.92755387	-85.2066536	European marsh thistle		6/16/21	Treated - manually pulled
44.94005665	-85.2083404	Bull Thistle		6/2/20	Not treated
44.94003604	-85.2083562	Unidentified thistle			
44.93810698	-85.2029825	Spotted knapweed	More than 100 individuals	7/22/20	Not treated
44.93334694	-85.2137471	Unidentified thistle		7/29/20	Not treated
44.91616643	-85.2240421	Narrow-leaved cat-tail		7/14/21	Not treated
44.91609187	-85.2234095	Narrow-leaved cat-tail		7/14/21	Not treated
44.9156983	-85.2232502	Narrow-leaved cat-tail		7/14/21	Not treated
44.91639324	-85.2232548	Narrow-leaved cat-tail	More than 100 individuals	7/14/21	Not treated
44.91719283	-85.2227414	Narrow-leaved cat-tail		7/14/21	Not treated
44.90790472	-85.2164144	Autumn olive	Fewer than 5 individuals	9/15/20	Treated - manually pulled
44.90773918	-85.2203543	Autumn olive	Fewer than 5 individuals	9/15/20	Not treated
44.90790472	-85.2164144	Autumn olive			
44.90790472	-85.2164144	Autumn olive			
44.90801737	-85.2155893	Autumn olive	Fewer than 5 individuals	9/15/20	Not treated
44.90825559	-85.2143931	Autumn olive	Fewer than 5 individuals	9/15/20	Not treated

44.90833878	-85.2141477	Autumn olive	Fewer than 5 individuals	9/15/20	Not treated
44.90771013	-85.2186598	Autumn olive	Fewer than 5 individuals	9/15/20	Treated - manually pulled
44.90671206	-85.2331253	Autumn olive		6/1/18	Not treated
44.90672115	-85.2340183	Autumn olive	Fewer than 5 individuals	6/1/18	Not treated
44.90678347	-85.2362708	Autumn olive		6/1/18	Not treated
44.90752737	-85.2361403	Autumn olive		6/1/18	Not treated
44.90939523	-85.236157	Autumn olive		6/1/18	Not treated
44.9155732	-85.2389638	Autumn olive	Fewer than 5 individuals	6/15/18	Not treated
44.91494799	-85.2391893	Autumn olive	Fewer than 5 individuals	7/15/18	Not treated
44.92124548	-85.2155827	Autumn olive	Fewer than 5 individuals		Not treated
44.9346546	-85.2030187	Autumn olive	Fewer than 5 individuals	7/22/20	Not treated
44.93449832	-85.2019859	Autumn olive	Fewer than 5 individuals	7/7/20	Not treated
44.92927342	-85.2137279	Autumn olive		7/29/20	Not treated
44.93162429	-85.2457884	Autumn olive		8/19/20	Not treated
44.93629997	-85.2061015	Autumn olive	Fewer than 5 individuals	9/25/20	Not treated
44.90325754	-85.2215575	Autumn olive	Fewer than 5 individuals	9/29/20	Not treated
44.90362295	-85.2259986	Autumn olive	6-10 individuals	9/29/20	Not treated
44.90356981	-85.2262269	Autumn olive		9/29/20	Not treated
44.92457042	-85.2076878	Autumn olive	Fewer than 5 individuals	6/16/21	Not treated
44.97180076	-85.2182478	Autumn olive	6-10 individuals	6/25/21	
44.97442652	-85.2206026	Autumn olive	Fewer than 5 individuals	6/25/21	Not treated
44.9271326	-85.2499376	Autumn olive	21-50 individuals	5/25/21	Treated - manually pulled
44.87316	-85.20533	Autumn olive			Not treated
44.88478	-85.20928	Autumn olive	Fewer than 5 individuals		Not treated

44.88598	-85.20982	Autumn olive	Fewer than 5 individuals		Not treated
44.88628	-85.20975	Autumn olive	Fewer than 5 individuals		Not treated
44.89309	-85.20999	Autumn olive	Fewer than 5 individuals		Not treated
44.90253	-85.21345	Autumn olive	Fewer than 5 individuals		Not treated
44.90249	-85.2139	Autumn olive	Fewer than 5 individuals		Not treated
44.9029	-85.21454	Autumn olive			
44.90334	-85.21474	Autumn olive	Fewer than 5 individuals		Not treated
44.90374	-85.21478	Autumn olive	Fewer than 5 individuals		Not treated
44.903877	-85.21468	Autumn olive	Fewer than 5 individuals		Not treated
44.90399	-85.21487	Autumn olive	Fewer than 5 individuals		Not treated
44.90399	-85.214977	Autumn olive	Fewer than 5 individuals		Not treated
44.90423	-85.21486	Autumn olive	Fewer than 5 individuals		Not treated
44.90426	-85.215	Autumn olive	Fewer than 5 individuals		Not treated
44.90493	-85.21484	Autumn olive	Fewer than 5 individuals		Not treated
44.90501	-85.21484	Autumn olive	Fewer than 5 individuals		Not treated
44.90557	-85.21458	Autumn olive	Fewer than 5 individuals		Not treated
44.90500031	-85.2148739	Autumn olive		8/15/17	Not treated
44.90482231	-85.2152258	Autumn olive		8/15/17	Not treated
44.91522303	-85.2159161	Autumn olive		8/15/17	Not treated
44.92599784	-85.249883	Autumn olive		8/15/17	Not treated
44.91182556	-85.2342257	Autumn olive		8/15/17	Not treated
44.91195904	-85.2341042	Autumn olive		8/15/17	Not treated
44.91290743	-85.2334094	Autumn olive		8/15/17	Not treated
44.9258191	-85.2494782	Autumn olive		8/15/17	Not treated
44.90838911	-85.2140452	Autumn olive			
44.90840814	-85.213957	Autumn olive			

44.90842327	-85.2138133	Autumn olive			
44.90853701	-85.2133515	Autumn olive			
44.90766894	-85.218446	Autumn olive			
44.90786872	-85.2162318	Autumn olive	Fewer than 5 individuals	7/6/21	Treated - manually pulled
44.90827897	-85.2362023	Bull Thistle	Fewer than 5 individuals	6/1/18	Not treated
44.87401	-85.20586	Bull Thistle			Not treated
44.87426	-85.20589	Bull Thistle			Not treated
44.8764	-85.20803	Bull Thistle	Fewer than 5 individuals		Not treated
44.87646	-85.20813	Bull Thistle	Fewer than 5 individuals		Not treated
44.88056	-85.20804	Bull Thistle	Fewer than 5 individuals		Not treated
44.88243	-85.20725	Bull Thistle	6-10 individuals		Not treated
44.88887	-85.20827	Bull Thistle			Not treated
44.88904	-85.20821	Bull Thistle			Not treated
44.88926	-85.20829	Bull Thistle			Not treated
44.89031	-85.2089	Bull Thistle	11-20 individuals		
44.89062	-85.20919	Bull Thistle			Not treated
44.89075	-85.2093	Bull Thistle			Not treated
44.89082	-85.20937	Bull Thistle			Not treated
44.891	-85.2093	Bull Thistle			Not treated
44.89251	-85.21	Bull Thistle			Not treated
44.89299	-85.21014	Bull Thistle	11-20 individuals		Not treated
44.89286	-85.2099	Bull Thistle	11-20 individuals		Not treated
44.89298	-85.20991	Bull Thistle	6-10 individuals		Not treated
44.89331	-85.21027	Bull Thistle	11-20 individuals		Not treated
44.89361	-85.21043	Bull Thistle			Not treated

44.894	-85.21062	Bull Thistle	6-10 individuals		Not treated
44.894	-85.21072	Bull Thistle	Fewer than 5 individuals		Not treated
44.89557	-85.21085	Bull Thistle	11-20 individuals		Not treated
44.89601	-85.21091	Bull Thistle	Fewer than 5 individuals		Not treated
44.89679	-85.21092	Bull Thistle	Fewer than 5 individuals		Not treated
44.89712	-85.21099	Bull Thistle	Fewer than 5 individuals		Not treated
44.89724	-85.21094	Bull Thistle	Fewer than 5 individuals		Not treated
44.89782	-85.21101	Bull Thistle	Fewer than 5 individuals		Not treated
44.89863	-85.21112	Bull Thistle	Fewer than 5 individuals		Not treated
44.89883	-85.21117	Bull Thistle	21-50 individuals		Not treated
44.89887	-85.21111	Bull Thistle	6-10 individuals		Not treated
44.89901	-85.2112	Bull Thistle			Not treated
44.89906	-85.21112	Bull Thistle			Not treated
44.90078	-85.21094	Bull Thistle	6-10 individuals		Not treated
44.90123	-85.21074	Bull Thistle	11-20 individuals		Not treated
44.90139	-85.21067	Bull Thistle	6-10 individuals		Not treated
44.90152	-85.21061	Bull Thistle	Fewer than 5 individuals		Not treated
44.90166	-85.21061	Bull Thistle	Fewer than 5 individuals		Not treated
44.90172	-85.21055	Bull Thistle			Not treated
44.90194	-85.21066	Bull Thistle	6-10 individuals		Not treated
44.90233	-85.21086	Bull Thistle	Fewer than 5 individuals		Not treated
44.90254	-85.21127	Bull Thistle	Fewer than 5 individuals		Not treated
44.90318	-85.21208	Bull Thistle	21-50 individuals		Not treated
44.9032	-85.21199	Bull Thistle	11-20 individuals		Not treated
44.90297	-85.21235	Bull Thistle			Not treated
44.90295	-85.21225	Bull Thistle			Not treated

44.90289	-85.21229	Bull Thistle	Fewer than 5 individuals		Not treated
44.90276	-85.21249	Bull Thistle	Fewer than 5 individuals		Not treated
44.90256	-85.21287	Bull Thistle			Not treated
44.90256	-85.2129	Bull Thistle			Not treated
44.90253	-85.21328	Bull Thistle	6-10 individuals		Not treated
44.90246	-85.21363	Bull Thistle			Not treated
44.9026	-85.21416	Bull Thistle	Fewer than 5 individuals		Not treated
44.90271	-85.21428	Bull Thistle			Not treated
44.90271	-85.21424	Bull Thistle	Fewer than 5 individuals		Not treated
44.90369	-85.21483	Bull Thistle			Not treated
44.90392	-85.21474	Bull Thistle			Not treated
44.90427	-85.21495	Bull Thistle	6-10 individuals		Not treated
44.90447	-85.21489	Bull Thistle			
44.90458	-85.21478	Bull Thistle			Not treated
44.90527	-85.21468	Bull Thistle			Not treated
44.90525	-85.21455	Bull Thistle			Not treated
44.90626	-85.21459	Bull Thistle			Not treated
44.9063	-85.21473	Bull Thistle			Not treated
44.9065	-85.21497	Bull Thistle			Not treated
44.92626327	-85.2062615	Bull Thistle		8/15/17	Not treated
44.91410799	-85.2256763	Bull Thistle		8/15/17	Not treated
44.91216226	-85.2261306	Canada Thistle	Fewer than 5 individuals		Not treated
44.91266007	-85.231511	Canada Thistle	21-50 individuals	8/14/18	Not treated
44.90672991	-85.2317448	Canada Thistle	Fewer than 5 individuals	6/1/18	Treated - manually pulled
44.90662233	-85.2353453	Canada Thistle		6/1/18	Not treated

44.91461577	-85.2391472	Unidentified thistle	21-50 individuals	6/15/18	Not treated
44.87353	-85.20565	Canada Thistle			Not treated
44.87237	-85.20554	Canada Thistle	Fewer than 5 individuals		Not treated
44.87297	-85.20549	Canada Thistle			Not treated
44.87428	-85.20636	Canada Thistle			Not treated
44.87531	-85.2069	Canada Thistle			Not treated
44.87642	-85.20799	Canada Thistle	11-20 individuals		Not treated
44.87648	-85.20808	Canada Thistle	Fewer than 5 individuals		Not treated
44.92617626	-85.2045376	European marsh thistle	51-100 individuals	8/3/21	Not treated
44.92619139	-85.2050913	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.92635417	-85.2054744	European marsh thistle	11-20 individuals	8/3/21	Not treated
44.92645157	-85.205733	European marsh thistle	11-20 individuals	8/3/21	Not treated
44.92641536	-85.206329	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92626247	-85.2064969	European marsh thistle	11-20 individuals	8/3/21	Not treated
44.92605087	-85.2067193	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92584132	-85.206755	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.92575645	-85.2068319	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92538744	-85.2071607	Unidentified cat-tail	Fewer than 5 individuals	8/3/21	Not treated
44.9248624	-85.2075244	European marsh thistle	Fewer than 5 individuals	8/3/21	Treated - manually pulled
44.92488951	-85.2082893	Unidentified cat-tail	Fewer than 5 individuals	8/3/21	Not treated
44.92677171	-85.2082909	European marsh thistle	11-20 individuals	8/3/21	Not treated
44.92830665	-85.2077139	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.92835795	-85.2075811	Bull Thistle	Fewer than 5 individuals	8/3/21	Treated - manually pulled
44.92835853	-85.2075212	European marsh thistle	11-20 individuals	8/3/21	Not treated

44.92842127	-85.2073496	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92855513	-85.2071731	European marsh thistle	6-10 individuals	8/3/21	Not treated
44.92855513	-85.2071731	Bull Thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92863643	-85.2069202	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.92867793	-85.2065624	European marsh thistle	6-10 individuals	8/3/21	Not treated
44.92868853	-85.2062652	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92873907	-85.2061493	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.92878023	-85.2059764	European marsh thistle	Fewer than 5 individuals	8/3/21	Not treated
44.9288368	-85.2057971	European marsh thistle	11-20 individuals	8/3/21	Not treated
44.92913453	-85.2056453	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.9292857	-85.2055047	European marsh thistle	21-50 individuals	8/3/21	Not treated
44.92930389	-85.2053032	European marsh thistle	6-10 individuals	8/3/21	Not treated
44.92913361	-85.204927	Bull Thistle	Fewer than 5 individuals	8/4/21	Treated - manually pulled
44.92929332	-85.2051035	European marsh thistle	6-10 individuals	8/4/21	Not treated
44.92932287	-85.2057417	European marsh thistle	Fewer than 5 individuals	8/4/21	Not treated
44.92927216	-85.206029	European marsh thistle	21-50 individuals	8/4/21	Not treated
44.92919773	-85.2062286	European marsh thistle	11-20 individuals	8/4/21	Not treated
44.9291922	-85.2063893	European marsh thistle	6-10 individuals	8/4/21	Not treated
44.92924102	-85.2064877	European marsh thistle	21-50 individuals	8/4/21	Not treated
44.92946197	-85.2069978	European marsh thistle	6-10 individuals	8/4/21	Not treated
44.92949721	-85.2071528	European marsh thistle	21-50 individuals	8/4/21	Not treated
44.92970982	-85.2075943	European marsh thistle	Fewer than 5 individuals	8/4/21	Not treated
44.92969339	-85.2079668	European marsh thistle	21-50 individuals	8/4/21	Not treated
44.93038234	-85.208432	European marsh thistle	Fewer than 5 individuals	8/4/21	Not treated
44.92994246	-85.2078261	European marsh thistle	11-20 individuals	8/4/21	Not treated

44.92979825	-85.2075052	European marsh thistle	6-10 individuals	8/4/21	Not treated
44.90276024	-85.2125449	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.9025732	-85.2127815	European marsh thistle	21-50 individuals	8/10/21	Not treated
44.90265681	-85.2129481	Purple loosestrife	Fewer than 5 individuals	8/10/21	Not treated
44.90242874	-85.2132879	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.90304007	-85.214428	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.90303471	-85.2144941	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.90325725	-85.2148196	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.90332258	-85.2148699	European marsh thistle	11-20 individuals	8/10/21	Not treated
44.90367462	-85.2148838	European marsh thistle	21-50 individuals	8/10/21	Not treated
44.9038035	-85.2148797	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.90423026	-85.214846	European marsh thistle	11-20 individuals	8/10/21	Not treated
44.90450523	-85.2148159	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.90886583	-85.2171392	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.9169723	-85.222161	Narrow-leaved cat-tail	More than 100 individuals	8/10/21	Not treated
44.91549457	-85.2197885	European marsh thistle	11-20 individuals	8/10/21	Not treated
44.9153551	-85.2188349	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.9151427	-85.2188557	European marsh thistle	6-10 individuals	8/10/21	Not treated
44.91367687	-85.2188985	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.91196801	-85.2193936	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.91134163	-85.2195622	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.91118548	-85.2193819	Autumn olive	Fewer than 5 individuals	8/10/21	Not treated
44.90997593	-85.2187188	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.90991084	-85.2184579	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated
44.90934201	-85.2178425	European marsh thistle	6-10 individuals	8/10/21	Not treated
44.90905685	-85.2176586	European marsh thistle	Fewer than 5 individuals	8/10/21	Not treated

44.90759861	-85.2208147	Spotted knapweed	More than 100 individuals	8/11/21	Treated - manually pulled
44.90835344	-85.2247658	Spotted knapweed	Fewer than 5 individuals	8/11/21	Treated - manually pulled
44.9085741	-85.2260493	Spotted knapweed	Fewer than 5 individuals	8/11/21	Treated - manually pulled
44.90880506	-85.2266662	Autumn olive	Fewer than 5 individuals	8/11/21	Not treated
44.9089608	-85.2273877	Spotted knapweed	More than 100 individuals	8/11/21	Not treated
44.91016192	-85.2299302	Autumn olive	Fewer than 5 individuals	8/11/21	Not treated
44.91118653	-85.2322394	Bull Thistle	Fewer than 5 individuals	8/11/21	Not treated
44.91145135	-85.2326724	Non-native phragmites	More than 100 individuals	8/11/21	Treated - chemicals applied
44.91158789	-85.2328489	Bull Thistle	Fewer than 5 individuals	8/11/21	Not treated
44.91236511	-85.2344687	Narrow-leaved cat-tail	More than 100 individuals	8/11/21	Not treated
44.91274791	-85.2352465	Narrow-leaved cat-tail	More than 100 individuals	8/11/21	Not treated
44.91295381	-85.2356411	Narrow-leaved cat-tail	More than 100 individuals	8/11/21	Not treated
44.91323188	-85.2359979	Narrow-leaved cat-tail	More than 100 individuals	8/11/21	Not treated
44.91338179	-85.2362734	Autumn olive	Fewer than 5 individuals	8/11/21	Not treated
44.91349805	-85.236463	Narrow-leaved cat-tail	More than 100 individuals	8/11/21	Not treated
44.91214341	-85.2335544	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91362847	-85.2366306	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91423373	-85.2378122	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91435946	-85.2381115	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91489627	-85.2390048	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.9159239	-85.2410735	Autumn olive	6-10 individuals	8/12/21	Not treated

44.91584745	-85.2409436	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91551519	-85.2402862	Autumn olive	6-10 individuals	8/12/21	Not treated
44.91545753	-85.2401624	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91531227	-85.2398715	Autumn olive	6-10 individuals	8/12/21	Not treated
44.91501253	-85.2394026	Autumn olive	6-10 individuals	8/12/21	Not treated
44.91460555	-85.2386032	European marsh thistle	Fewer than 5 individuals	8/12/21	Not treated
44.91451624	-85.2383918	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91396584	-85.2373059	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91376891	-85.23693	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91385797	-85.2364939	Autumn olive	Fewer than 5 individuals	8/12/21	Not treated
44.91482612	-85.2355575	Unidentified cat-tail	51-100 individuals	8/12/21	Not treated
44.91365441	-85.2363515	European marsh thistle	6-10 individuals	8/12/21	Not treated
44.9171785	-85.2266097	Purple loosestrife	Fewer than 5 individuals	8/12/21	Treated - manually pulled
44.91715687	-85.2252028	Purple loosestrife	11-20 individuals	8/12/21	Treated - manually pulled
44.90848822	-85.2172143	Autumn olive	6-10 individuals	8/17/21	Not treated
44.90815052	-85.2174638	Autumn olive	Fewer than 5 individuals	8/17/21	Not treated
44.9079828	-85.2178774	Autumn olive	Fewer than 5 individuals	8/17/21	Not treated
44.9072493	-85.2185274	Bull Thistle	Fewer than 5 individuals	8/17/21	Not treated
44.90858675	-85.2132545	Autumn olive	Fewer than 5 individuals	7/6/21	Not treated
44.9088451	-85.2130185	Autumn olive	Fewer than 5 individuals	7/6/21	Not treated
44.91514361	-85.2190274	Bull Thistle	Fewer than 5 individuals	7/23/21	Treated - manually pulled
44.9175394	-85.2148928	Autumn olive	Fewer than 5 individuals	7/23/21	Treated - other

44.91923851	-85.2148959	Autumn olive	Fewer than 5 individuals	8/25/21	Treated - chemicals applied
44.91919731	-85.2145679	Autumn olive	Fewer than 5 individuals	8/25/21	Treated - chemicals applied
44.9597738	-85.2106085	Purple loosestrife		8/26/21	Treated - chemicals applied
44.96003003	-85.2136891	Purple loosestrife		8/26/21	Treated - chemicals applied
44.95951001	-85.2104832	Purple loosestrife		8/26/21	Treated - chemicals applied
44.96142906	-85.2119833	Purple loosestrife		8/26/21	Treated - chemicals applied
44.90844	-85.21737	Autumn olive	Fewer than 5 individuals		Not treated
44.90832	-85.21738	Autumn olive	Fewer than 5 individuals		Not treated
44.90827	-85.2175	Autumn olive	Fewer than 5 individuals		Not treated
44.89417	-85.21967	Canada Thistle	More than 100 individuals		Not treated
44.90722	-85.2185	Bull Thistle	Fewer than 5 individuals		Not treated
44.90608	-85.21892	Bull Thistle	Fewer than 5 individuals		Not treated
44.89417	-85.21967	Canada thistle	Area = 1,000 sq ft - 0.5 acres; density = patchy		Not treated
44.90856	-85.21728	Autumn olive	11-20 individuals		Not treated

44.90637	-85.21901	Autumn olive	Fewer than 5 individuals		Not treated
44.90606	-85.21898	Autumn olive	Fewer than 5 individuals		Not treated
44.90574	-85.21896	Autumn olive	Fewer than 5 individuals		Not treated
44.89127	-85.22009	Autumn olive	Fewer than 5 individuals		Not treated
44.89587	-85.21927	Autumn olive	Fewer than 5 individuals		Not treated
44.90608	-85.21892	Bull thistle	1		Not treated
44.9045	-85.21854	Bull Thistle	Fewer than 5 individuals		Not treated
44.89417	-85.21967	Canada thistle	Area = 1,000 sq ft - 0.5 acres; density = patchy		Not treated
44.90581	-85.21885	Multiflora rose	Fewer than 5 individuals		Not treated
44.90449	-85.2184	Multiflora rose	Fewer than 5 individuals		Not treated
44.90034	-85.21075	Canada Thistle	6-10 individuals		Not treated
44.90790597	-85.2220051	Multiflora rose	21-50 individuals	3/15/22	Not treated
44.92621822	-85.250256	Autumn olive	Fewer than 5 individuals	5/20/22	Not treated
44.9264571	-85.2503003	Garlic mustard	21-50 individuals	5/20/22	Treated - manually pulled
44.9267569	-85.2502541	Garlic mustard	21-50 individuals	5/20/22	Treated - manually pulled
44.92690323	-85.2498719	Garlic mustard	More than 100 individuals	5/20/22	Treated - manually pulled
44.92688279	-85.2499185	Autumn olive	11-20 individuals	5/20/22	Not treated
44.9270161	-85.2498366	Multiflora rose	Fewer than 5 individuals	5/20/22	Treated - manually pulled
44.92723603	-85.2498166	Garlic mustard	6-10 individuals	5/20/22	Treated - manually pulled

44.92723853	-85.249848	Japanese barberry	Fewer than 5 individuals	5/20/22	Treated - manually pulled
44.92730775	-85.2498066	Autumn olive	Fewer than 5 individuals	5/20/22	Treated - manually pulled
44.91486159	-85.2182581	Honeysuckle	Fewer than 5 individuals	6/7/22	Treated - manually pulled
44.92708371	-85.2502868	Garlic mustard		6/7/22	Treated - manually pulled
44.927063	-85.2499175	Garlic mustard		6/7/22	Treated - manually pulled
44.92678666	-85.2499281	Garlic mustard	More than 100 individuals	6/8/22	Treated - manually pulled
44.9260333	-85.249845	Garlic mustard	Fewer than 5 individuals	6/10/22	Treated - manually pulled
44.91945609	-85.2417351	Autumn olive	Fewer than 5 individuals	6/16/22	Not treated
44.91937222	-85.2419624	Autumn olive	Fewer than 5 individuals	6/16/22	Not treated
44.91935935	-85.2420836	Autumn olive	Fewer than 5 individuals	6/16/22	Not treated
44.91934759	-85.2422086	Autumn olive	Fewer than 5 individuals	6/16/22	Not treated
44.91919979	-85.2422031	Autumn olive	Fewer than 5 individuals	6/16/22	Not treated
44.91804133	-85.2439573	Autumn olive	6-10 individuals	6/16/22	Not treated
44.92989962	-85.2455116	Autumn olive	6-10 individuals	6/21/22	Treated - manually pulled
44.90989941	-85.2292941	Autumn olive	Fewer than 5 individuals	6/30/22	Not treated
44.90804985	-85.2232809	Autumn olive	Fewer than 5 individuals	6/30/22	Not treated
44.90869141	-85.2262282	Autumn olive	Fewer than 5 individuals	6/30/22	Not treated
44.93612488	-85.2138546	Non-native phragmites		8/15/17	Not treated

44.91948198	-85.2273236	Non-native phragmites		8/15/17	Not treated
44.90983993	-85.2221994	Non-native phragmites	21-50 individuals	7/7/22	Treated - chemicals applied
44.90772612	-85.2183844	Autumn olive	Fewer than 5 individuals	7/18/22	Treated - manually pulled
44.90761537	-85.2198051	Autumn olive	Fewer than 5 individuals	7/19/22	Not treated
44.90764293	-85.2190848	Multiflora rose	Fewer than 5 individuals	7/19/22	Treated - manually pulled
44.90774784	-85.2178659	Autumn olive	Fewer than 5 individuals	7/19/22	Treated - manually pulled
44.90824614	-85.214621	Autumn olive	Fewer than 5 individuals	7/19/22	Not treated
44.90869118	-85.21295	Autumn olive	21-50 individuals	7/19/22	Not treated
44.90909906	-85.211781	Autumn olive	Fewer than 5 individuals	7/19/22	Not treated