GEIST RESERVOIR, HAMILTON AND MARION COUNTIES AQUATIC VEGETATION MANAGEMENT PLAN 2009-2013

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MARCH 1, 2010

Executive Summary

V3 was contracted by the Upper White River Watershed Alliance (UWRWA) to develop a five-year aquatic vegetation management plan for Geist Reservoir. The UWRWA is working in cooperation with the Geist Watershed Alliance in the development of this management plan. Funding was provided by the Geist Watershed Alliance and the Indiana Department of Natural Resources (IDNR) through the Lake and River Enhancement (LARE) Program. This management plan is the first LARE project for Geist Reservoir. The purpose of an aquatic vegetation management plan is to identify aquatic weed problem areas, describe management objectives, prescribe management strategies, and determine funding needs and sources necessary for the control of invasive aquatic vegetation. The Geist Reservoir Aquatic Vegetation Management Plan will serve as a tool to track changes in the vegetative community, update action plans and budget, and continue eligibility for future LARE funds for aquatic species control.

Geist Reservoir is a 1,900-acre drinking water reservoir located in Hamilton and Marion Counties, Indiana, near the town of Fishers. The only nuisance exotic species within Geist Reservoir is Eurasian watermilfoil (*Myriophyllum spicatum*). Aquatic vegetation is an important component of lake ecosystems in Indiana; however as a result of many factors, aquatic vegetation can develop to a nuisance level. Nuisance quantities of aquatic vegetation are described as plant growth that negatively impacts lake uses such as swimming, boating, and fishing. Exotic species typically reach nuisance quantities as they outcompete native species and proliferate rapidly.

A Tier II vegetation survey was conducted during the Spring of 2009 (May 15 to June 15), and summer of 2009 (July 15 to August 30) to assess the vegetative communities within Geist Reservoir. The Tier II survey data is used to document the vegetative community composition at different times throughout the growth season. All surveys followed IDNR Tier II Aquatic Vegetation Survey Protocol.

V3 conducted the spring survey on June 9, 2009. The spring survey identified 4 species within Geist Reservoir, 3 of which were native species. Thirty-four of the 100 sampling locations were vegetated; however, native species were only represented at three sampling locations. The Spring secchi disk depth measurement was 4 feet. Eurasian watermilfoil was present at 31% of sampling locations sites at depths ranging from 1 to 6 feet during the June 2009 survey. Three native species were collected during the June survey which included coontail (*Ceratophyllum demersum*), chara (*Chara sp.*), and elodea (*Elodea canadensis*).

Aquatic Control completed two treatments on Geist Reservoir in 2009 for control of Eurasian watermilfoil. The June treatment was a total of 2.09 acres and the July treatment was a total of 5.25 acres. Renovate OTF was used in June, and Renovate3 was used in July. Treatments were completed with a target triclopyr concentration of 1.5 ppm within treatment areas. ASAP Aquatics treated 5 acres of Eurasian watermilfoil within the Intracoastal Marina using 7 gallons of Reward diquat on June 23, 2009. They also treated 1.25 acres in the Breakwater Marina of Geist reservoir using Reward diquat and copper sulfate. ASAP Aquatic's Breakwater Marina treatments were conducted on June 23 and August 19 of 2009.

V3 performed the summer Tier II vegetation survey on August 18, 2009 and collected 5 species up to a depth of 8 feet. Vegetation was present at 26 of the 100 sampling locations; however native species were only represented at 3 sampling locations. Eurasian watermilfoil had a site frequency of 25% and was present at depths ranging from 2 to 8 feet.

The goals outlined in this management plan were created based on the results of vegetation surveys and interaction with the Upper White River Watershed Alliance, Veolia Water, Watershed Stakeholders and IDNR biologists. The Geist Reservoir Vegetation Management Plan was created as a proactive measure to effectively propose exotic species management and to help reach the management goals established by the IDNR for all public lakes in Indiana. The three IDNR goals for all Indiana Public Lakes are listed below:

1. Develop or maintain a stable, diverse aquatic vegetative community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species;
2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species; and
3. Provide reasonable public recreational access while minimizing the negative impacts on plant and wildlife resources.

It is important to note that all management actions proposed are related to invasive exotic species within Geist Reservoir. The 2009 Tier II results have identified Eurasian watermilfoil as the only exotic species currently present within Geist Reservoir and is really the only vegetation providing any sort of habitat structure currently. Based on these findings, our next step for the Geist Reservoir Vegetation Management Plan is to provide no treatment or management at this time. It should be noted that the Geist Reservoir/Upper Fall Creek Watershed Management Plan is in the process of being completed with an expected approval date of late summer 2010. Establishing water quality improvements that will reduce the amount of sediments and nutrients entering the reservoir along with a solid public education program will assist in decreasing the invasive species and increasing the native species in the reservoir. Selective mechanical removal is already taking place within the reservoir and will continue on an as needed basis in the high recreation areas and areas deemed necessary by Veolia for drinking water purposes.

At this time, based on the use of the reservoir, status of the existing aquatic vegetation, competition with blue-green algae and ongoing preparation of the Watershed Management Plan no action is the recommended management for the existing vegetation in the reservoir. The exotic vegetative species abundance may remain stable, or it may increase from year to year. This uncertainty coupled with the known issue of blue-green algae in the reservoir leaves the recommendation of no action as the appropriate plan.

Acknowledgements

We would like to acknowledge Angela Sturdevant and Greg Biberdorf with IDNR's LARE program for providing funding and assistance in completion of this study. We would like to recognize Rhett Wisener, IDNR District Fisheries Biologist, for consultation and information. We would like to acknowledge the Upper White River Watershed Alliance as the local sponsor that provided assistance and guidance including: Jill Hoffman and Lenore Tedesco. We would like to recognize Nathan Long of Aquatic Control and Ryan Schowe with ASAP Aquatics for their mapping, recommendations and consultation. Finally, we would like to acknowledge V3 staff involved in the research, sampling, and document preparation including: Scott Brejcha, Carrie Pintar, Jessica Spurlock, Amy Halsall, Phil Rezin, Nick Vansomeran, and Jessica Dunn.

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Introduction and LARE Background

V3 was contracted by the Upper White River Watershed Alliance (UWRWA) to develop a five-year aquatic vegetation management plan for Geist Reservoir. The UWRWA is working in cooperation with the Geist Watershed Alliance in the development of this management plan. Funding was provided by the Geist Watershed Alliance and the Indiana Department of Natural Resources (IDNR) through the Lake and River Enhancement (LARE) Program. This management plan is the first LARE project for Geist Reservoir. Items covered within this management plan include watershed characteristics, water body uses, 2009 vegetation control efforts, 2009 Tier II vegetation survey results, a summary of the public meeting, discussion of management options and an action plan. The Geist Reservoir Aquatic Vegetation Management Plan will serve as a tool to track changes in the vegetative community, update action plans and budgets, and continue eligibility for future LARE funds.

Geist Reservoir is located in Hamilton and Marion Counties, near Fishers, Indiana (Exhibit 1). Construction of Geist Reservoir was completed in 1944. The primary purpose of the reservoir was to provide a consistent source of water supply to the Indianapolis Water Company's Fall Creek Water Treatment Facility. In the early 1980's real estate development began around the reservoir, resulting in development along most of its 35 miles of shoreline. The reservoir has a maximum depth of approximately 48 feet, a storage capacity of 6.9 billion gallons, and a surface area of approximately 1,900 acres. In addition to water supply, Geist Reservoir is currently widely used for recreation purposes including swimming, boating, and fishing.

Geist Reservoir has a large watershed that can affect the chemical and biological characteristics of the water body as it has the potential to receive more pollutants such as sediments, nutrients, and pesticides. Geist Reservoir has a large watershed to water body ratio as the reservoir represents 1% of the total watershed size. In response to toxic blue green algal blooms during the summer of 2007, a number of concerned residents came together to form the Geist Watershed Alliance (GWA). As a means for achieving the goals of public awareness and improved water quality, the GWA is operating in partnership with the UWRWA, and other community watershed groups for the development of the Geist Reservoir Watershed Management Plan which is currently being developed.

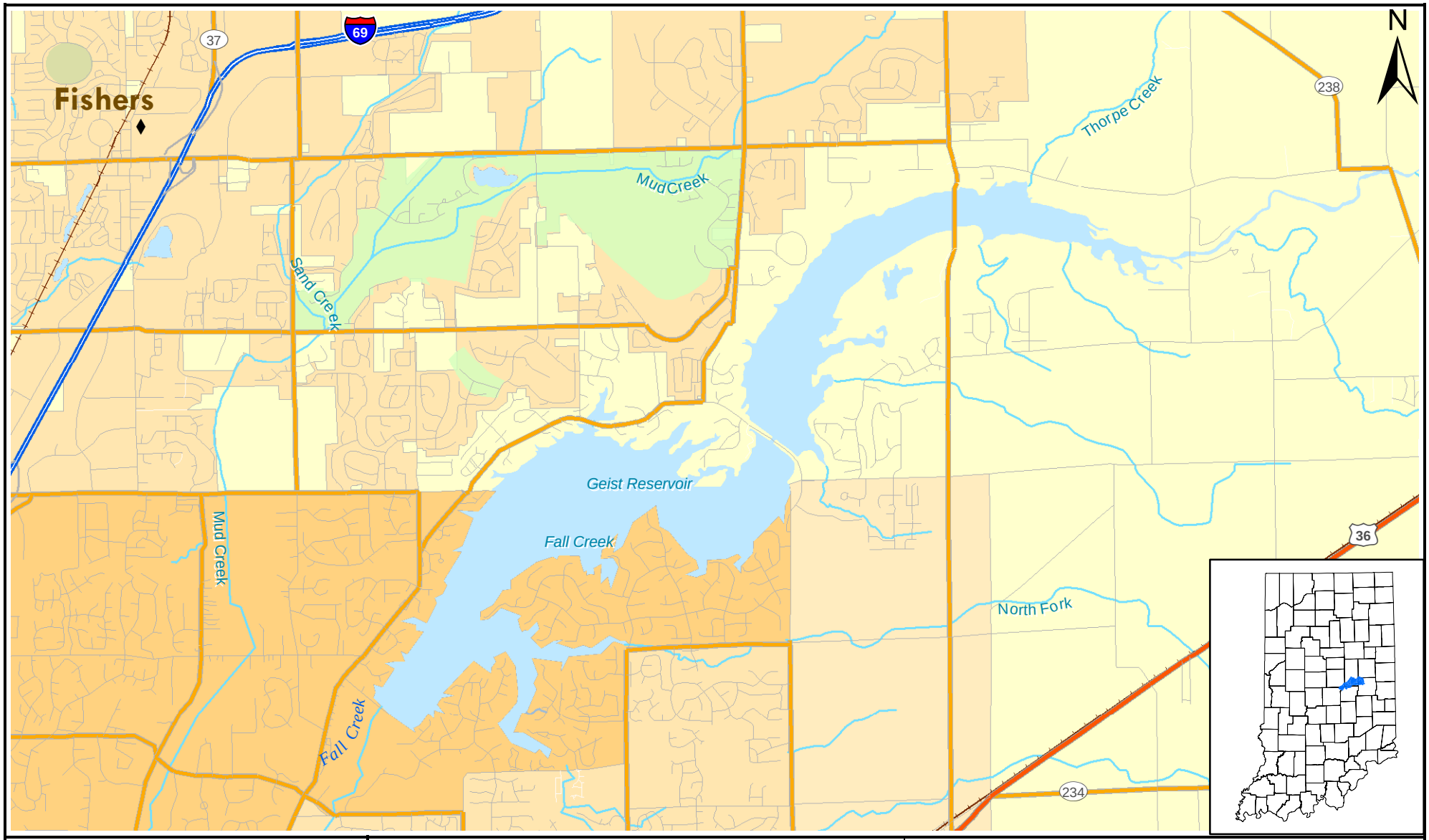
Native aquatic vegetation provides fish habitat, stabilizes the shoreline, and prevents the establishment and/or spread of exotic species. Eurasian watermilfoil *(Myriophyllum spicatum)* is the only exotic vegetative species within Geist Reservoir. The purpose of this aquatic vegetation management plan is to identify aquatic weed problem areas, describe management objectives, develop management strategies, and determine funding needs and sources necessary for the future control of exotic aquatic vegetation.

The following actions were taken during the development of the Geist Reservoir Vegetation Management Plan.

- June 8, 2009; 2.09 acres of Eurasian watermilfoil were treated by Aquatic Control near the Geist Marina
- June 9, 2009; V3 conducted spring Tier II aquatic vegetation survey
- June 23,2009; 1.25 acres of Eurasian watermilfoil in the Breakwater Marina and 5 acres of Eurasian watermilfoil in the Intracoastal Marina were treated by ASAP Aquatics

- July 17, 2009; 5.25 acres of Eurasian watermilfoil were treated near the Geist Marina by Aquatic Control
- August 17, 2009; V3 conducted late summer Tier II aquatic vegetation survey
- August 19, 2009; 1.25 acres of Eurasian watermilfoil in the Breakwater Marina was treated by ASAP Aquatics
- January 27, 2010; Public meeting to discuss 2009 treatment, aquatic vegetation survey results, and recommended 2010 management strategy

The overall goal of the LARE program is to ensure the continued viability of public-access lakes and streams by utilizing a watershed approach to reduce non-point source sediment and nutrient pollution of Indiana's and adjacent states' surface waters to a level that meets or surpasses state water quality standards. To accomplish this goal, the LARE program provides technical and financial assistance to qualified projects. These include: a) studies, management plans, sediment removal, and design and construction activities involving specific lakes and streams; b) land treatment practices or management plans for designated watersheds; and c) management plans and control of exotic plants and animals in targeted lakes. Funding for the LARE program is provided by an annual fee charged to Indiana boat owners.



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TITLE: **Geist Reservior Vicinity Map**	PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**		
BASE LAYER: StreetMap USA	PROJECT NO.: 09006	EXHIBIT: 1	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance, 723 West Michigan Street, Indianapolis, Indiana 46202	QUADRANGLE: N/A	DATE: 11/18/09	SCALE: 1" = 4,500'

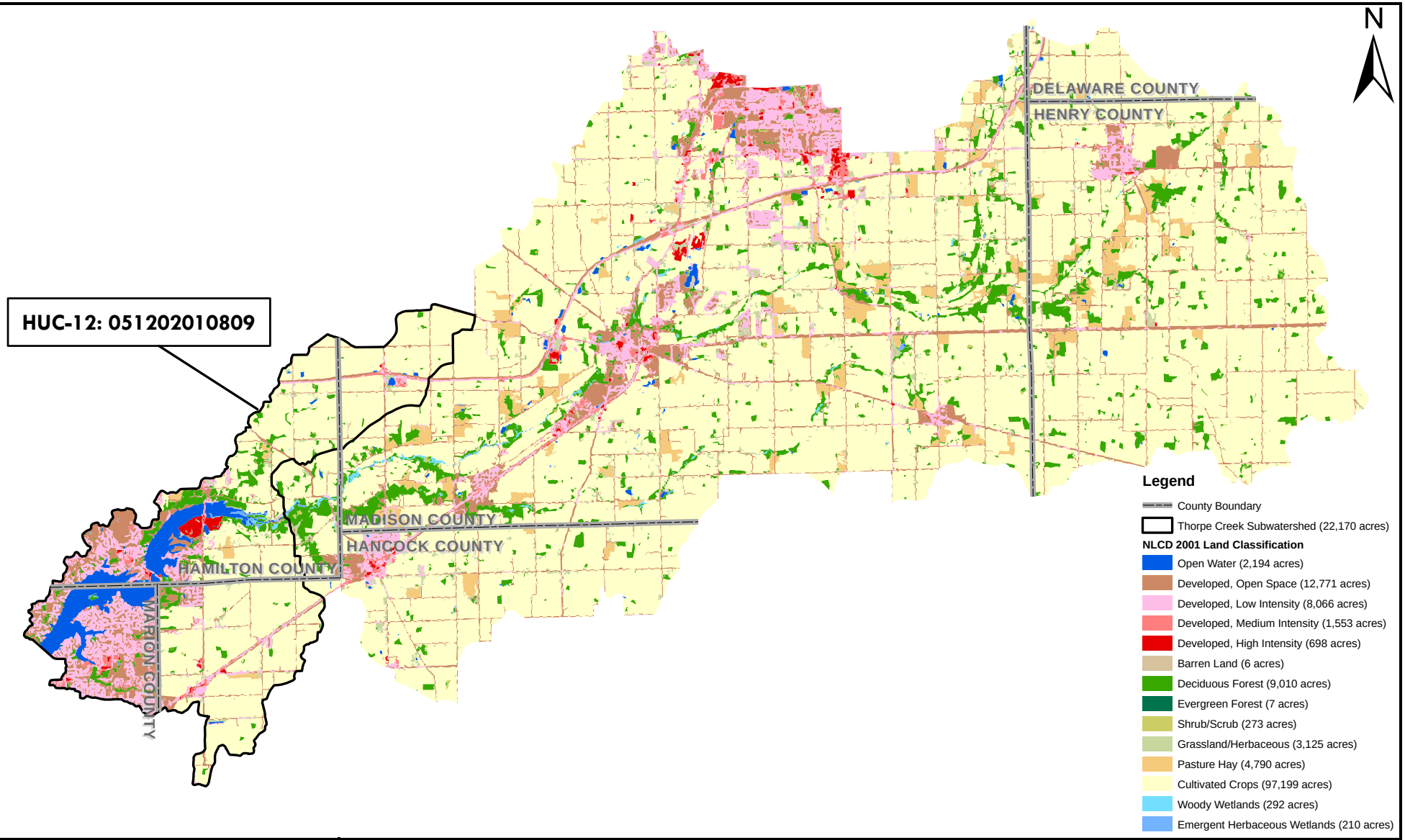
Watershed Characteristics

Geist Reservoir is part of the Geist Reservoir/Upper Fall Creek Watershed which has its origins in northwest Henry County and flows southwest through Madison, Hamilton, and Marion Counties (Exhibit 2). The watershed also encompasses portions of Delaware and Hancock Counties. The Geist Reservoir/Upper Fall Creek Watershed consists of approximately 140,194 acres of mixed land use of which approximately 70% consists of cultivated crops (Table 1). Approximately 140.5 linear miles of cumulative waterways are contained in the Geist Reservoir/Upper Fall Creek Watershed. The principal bedrock formations in the Geist Reservoir/Upper Fall Creek Watershed are associated mainly with rocks of Silurian and Devonian age, and consist mainly of limestone and dolomites with some shale or argillaceous zones, whereas the Silurian material consists of limestone, dolomite, and much more argillaceous material than in the Devonian age rock. The topography of Upper Fall Creek, which lies in the Tipton Till Plain physiographic unit, consists of a flat to slightly rolling plain.

Table 1: Geist Reservoir/ Upper Fall Creek Watershed Landuse (NLCD, 2001).

Landuse Classification	Acres	Percentage
Open Water	2,194	1.56%
Developed, Open Space	12,771	9.11%
Developed, Low Intensity	8,066	5.75%
Developed, Medium Intensity	1,553	1.11%
Developed, High Intensity	698	0.50%
Barren Land	6	0.005%
Deciduous Forest	9,010	6.43%
Evergreen Forest	7	0.005%
Shrub/Scrub	273	0.19%
Grassland/Herbaceous	3,125	2.23%
Pasture Hay	4,790	3.42%
Cultivated Crops	97,199	69.33%
Woody Wetlands	292	0.21%
Emergent Herbaceous	210	0.15%

The Geist Reservoir/Upper Fall Creek Watershed is divided into nine subwatersheds. Geist Reservoir is located in the eastern portion of the Thorpe Creek Subwatershed (HUC 12 – 051202010809) and is approximately 22,170 acres (Exhibit 2). Landuse within the Thorpe Creek Subwatershed consists primarily of agricultural uses, however significant development is also present in the subwatershed. Medium and high intensity development concentrated in the western portion of the subwatershed is associated with Indianapolis, Fishers, McCordsville, and Lawrence. In the early 1980's, residential development began around the reservoir. Currently, the majority of the 42.92 miles of Geist Reservoir's shoreline consists of residential development.



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TITLE: **Geist Reservoir/Upper Fall Creek Watershed Land Use Map**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: N/A		PROJECT NO.: 09006	EXHIBIT: 2	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance, 723 West Michigan Street, Indianapolis, Indiana 46202		QUADRANGLE: N/A	DATE: 11/18/09	SCALE: 1" = 16,000'

Water Body Characteristics

Geist Reservoir is a 1,900-acre reservoir that is used as a drinking water resource within the Central Indiana region. Geist Reservoir was formed by an impoundment of Fall Creek. Fall Creek flows from the reservoir at the southwestern end and empties into the White River, 17.6 miles downstream (Newhouse and Stahl, 2000). The tributaries for Geist Reservoir are Thor Run, Thorpe Creek, Mount Zion Branch, Bee Camp Creek, Bills Branch, North Fork, Middle Fork and Dry Branch. Geist Reservoir has a maximum depth of 48 feet, an elevation of 785.41 with water level fluctuates based on water supply needs. The Indianapolis Water Company provides a daily water level reading of the reservoir and can be accessed at the following link: http://www.indianapoliswater.com/check-reservoir-levels.html. The Geist Reservoir dam height is 40 feet above valley, approximately 1,900 feet in length, and 26 feet deep at the dam (Center for Earth and Environmental Science, IUPUI, 2008). The outlet structure for Geist Reservoir is an open crest spillway and tainter gates.

Geist Reservoir has a large watershed that can affect the chemical and biological characteristics of the water body as it has the potential to receive more pollutants such as sediments, nutrients, and pesticides. Geist Reservoir has a large watershed to water body ratio as Geist Reservoir represents 1% of the total watershed size. In response to toxic blue green algal blooms during the summer of 2007, a number of concerned residents came together to form the Geist Watershed Alliance (GWA). As a means for achieving the goals of public awareness and improved water quality, the GWA is operating in partnership with the UWRWA, and other community watershed groups for the development of the Geist Reservoir Watershed Management Plan which is currently being developed. A list of existing studies for Geist Reservoir is provided in Table 2.

Figure 1: Seawall at Geist Reservoir.

Geist Reservoir is characterized as a shallow turbid water body and has an average depth of 11 feet. Geist Reservoir is elongate with many branches representing the tributaries of the former stream or river. Geist Reservoir is a popular recreational lake due to its size and fishing opportunities. There is a privately owned public access with a concrete ramp and large parking lot located on the northeast shore off of Olio Rd (Exhibit 3). This ramp is operated on a daily fee basis and the fee varies based on the type of watercraft as well as day of the week. The

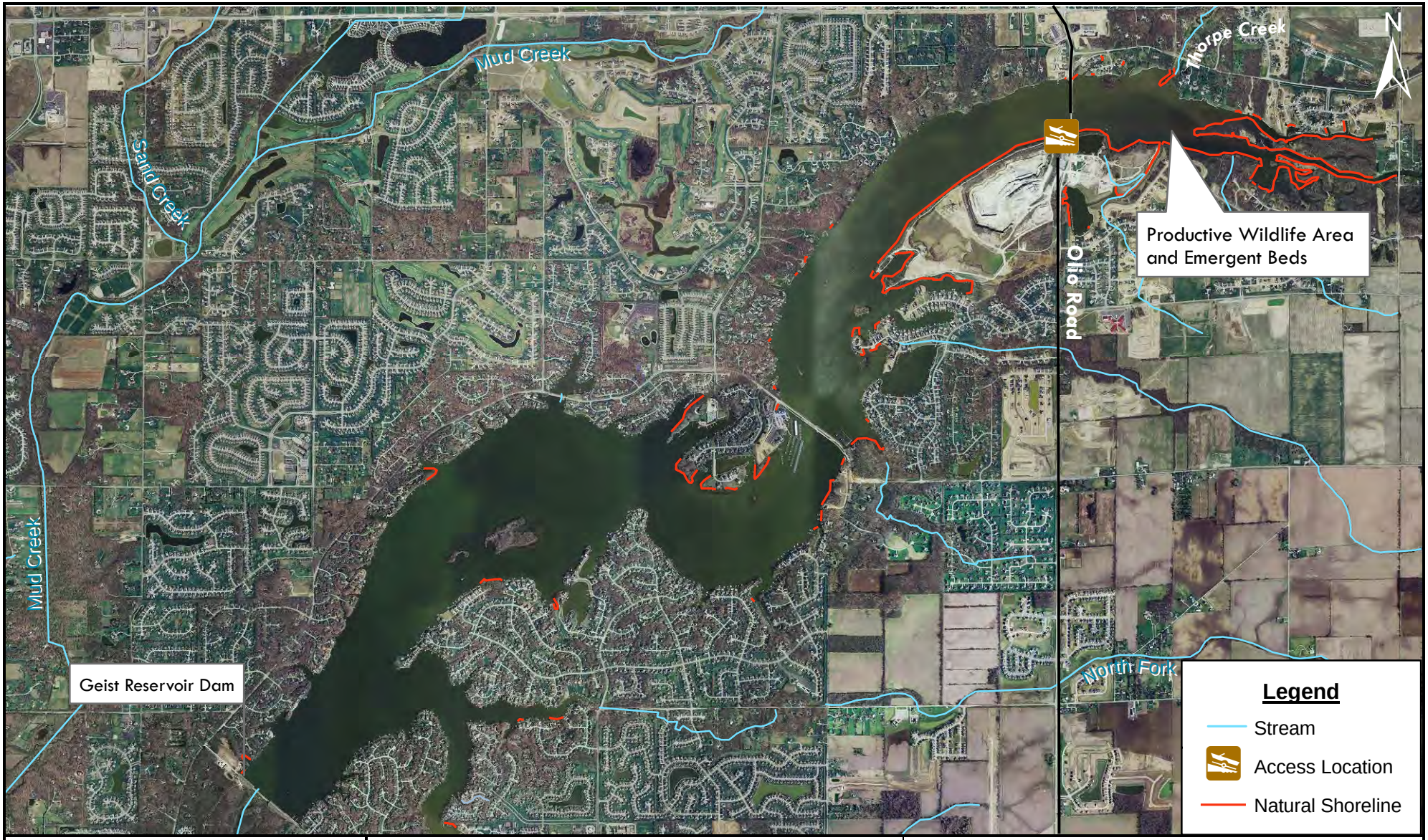
majority of Geist Reservoir's shoreline is developed with a concrete, sheet pile seawall, or rock wall utilized for shoreline protection (Figure 1). While seawalls provide erosion control along shorelines, they cannot provide the natural functions of a shoreline plant community. Wave energy that is reflected off seawall structures can create significant turbulence in the shoreline zone which negatively impacts the growth and establishment of aquatic vegetation. A shoreline survey was conducted in June of 2009 and identified areas that were natural or not structurally protected. Shoreline areas that were unprotected were typically undeveloped lakeshore lots (Exhibit 3). Geist Reservoir is a man made water body, as it was formed by an impoundment of Fall Creek, and as such has upland soils that are not typically found as lake bottom substrates which also impacts the ability of aquatic vegetation to establish.

Table 2: Existing studies for Geist Reservoir and the surrounding watershed.

Study	Author, Date
Geist Reservoir 1983 Fish Management Report.	Kingsley, 1984
Bathymetric Surveys of Morse and Geist Reservoirs in Central Indiana Made with Acoustic Doppler Current Profiler and Global Positioning System Technology. U.S. Geological Survey Water Resources Division.	Morlock, and Baker, 1996.
A comparison of the Mid-water planktonic invertebrate communities of Eagle Creek, Geist and Morse Reservoirs in Central Indiana using underwater light trapping.	Newhouse and Stahl, 2000
Clean Lakes Program Data Summary	Indiana Clean Lakes Program, 2002
Water Quality and Nutrient Cycling in Three Indiana Watersheds and Their Reservoirs: Eagle Creek/Eagle Creek Reservoir, Fall Creek/Geist Reservoir, and Cicero Creek/Morse Reservoir.	Central Indiana Water Resources Partnership Studies (CIWRP) and IUPUI's Center for Earth and Environmental Sciences (CEES), 2003
Indiana Lake Water Quality Assessment Report for 1994 - 1998	School of Public and Environmental Affairs, Indiana University, 2005
303(d) List of Impaired Waters (PCB's and mercury in fish tissue).	IDEM, 2008
IDEM water quality sampling 1996 – 2009.	IDEM, 2009
Geist Reservoir Blue-Green Algae Sampling/Reporting	Indiana Department of Environmental Management (IDEM), Center for Earth and Environmental Science (CEES), 2008-Ongoing
Geist Reservoir/Upper Fall Creek Watershed Management Plan	V3 Companies, 2009-Ongoing

Water Body Uses

Geist Reservoir does not have a motor or speed restriction outside of idle zones which makes it a popular boating site. Aquatic vegetation is sparse throughout the reservoir but fishing is popular in the northern channels. As part of its Central Indiana initiative, the Center for Urban Policy and the Environment surveyed more than 6,400 people from Central Indiana households in the summer of 2000 about their perceptions of outdoor water recreational opportunities. Results indicate that nearly five in 10 households visited a regional water recreation site and that regional water recreation areas attract people from throughout the region. Geist Reservoir was noted as the most popular destination by 4.9% of participants that represented 13 of the 44 central Indiana counties (Center for Urban Policy and Environment, 2000). Dredging boats were also present during both Tier II vegetation surveys in 2009 in the central area of Geist Reservoir (Exhibit 3). Geist Reservoir's northern area is characterized by emergent vegetation and lotus lily beds that offer wildlife viewing opportunities as it draws a diverse group of avian species.



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TITLE: **Geist Reservoir Priority Use Areas**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 3	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/11/09	SCALE: 1" = 3100'

2009 V3 Water Quality Data

Geist Reservoir is rated as eutrophic by the Indiana Department of Environmental Management (IDEM). Eutrophic lakes are characterized by water transparency that is less than 6 feet, high concentrations of nutrients (total phosphorus > 35 µg/L), abundant algae and weeds, and lack of dissolved oxygen in the hypolimnion during the summer (Jones and Medrano, 2006).

Although not specifically required as part of the aquatic vegetation sampling protocol, V3 collected water quality data during the 2009 vegetation sampling. Representative water quality data was collected from the surface waters (1 m) over the deep well-mixed portion of the reservoir. Water quality data was collected in the field using a YSI 63 pH, YSI Model 55 Dissolved Oxygen Meter, conductivity/Salinity/Temperature Meter, LaMotte 2020 turbidity meter, and secchi disk. V3 performed water quality measurements for the following parameters: water temperature, pH, conductivity, specific conductance, salinity, dissolved oxygen, and turbidity (Table 3). The water quality parameter descriptions are provided following Table 3.

Table 3. Surface Water Quality Data in 2009 at Geist Reservoir.

Date	H2O Temp. (°C)	pH	Cond. (µmhos)	SpC (µmhos)	Salinity (ppt)	DO (mg/L)	Turbidity (NTU)	Secchi (ft)
6/11	24.4	8.66	516	522	0.3	8.24	3.79	4
8/17	27.6	8.7	495	471	0.2	6.47	5.99	2

Temperature. The ecological effects of light and temperature on the photosynthesis and growth of algae are inseparable because of the interrelationships in metabolism and light saturation. One commonly observed change in the rate of respiration of planktonic algae is an increase of the rate with increasing temperature. Additionally, the ability of water to hold oxygen decreases as temperatures increase. When water is oxygen saturated, warmer water has the ability to possess lower amounts of oxygen when compared to colder water that is likewise oxygen saturated. In 2009, the water temperature was 24.4°C in June and increased to 27.6°C in late August.

Conductivity. The conductance of lake water is the reciprocal of its resistance to electrical flow. The resistance of a water solution to electrical current or electron flow is reduced with increasing content of ionized salt. Distilled water has a conductivity of zero. The purer the water is, the lower its conductivity. Temperature also affects conductivity as warm water has a higher conductivity. Some pollution discharges and polluted runoff into water bodies can cause changes in conductivity especially if the pollutants include inorganic dissolved solids. The conductivity at Geist Reservoir ranged from 516 to 495 µmhos.

Specific Conductance. Specific Conductance is the conductance of water at 25°C. This reading is important because conductivity readings are directly linked to temperature and can change up to 3% for a change of one degree Celsius. Typical conductivity and specific conductance readings for lakes in Indiana are approximately 400 µmhos, with readings over 1,000 µmhos being indicative of excessive metal or salt inputs. The specific conductance ranges for Geist Reservoir in 2009 were 471 µmhos in August and 516 µmhos in June. The specific conductance values for Geist Reservoir taken during Tier II vegetative sampling were considered to be in normal range.

Salinity. Salinity is a measure of the total salts that are dissolved in water, in parts per thousand (ppt). Salinity will be variable based on location and time of year. Plants are adversely affected by high salinity, which can cause stunted growth, leaf burn, and defoliation. The ocean's salinity is approximately 35 ppt. Urban influences of salt distribution during the winter create unnatural salt inputs in aquatic systems. The most commonly used road salt is sodium chloride (NaCl). NaCl dissociates in aquatic systems into chloride ions (Cl^-) and sodium cations (Na^+). This also results in a higher conductivity reading. Elevated sodium and chloride levels create osmotic imbalances in plants, which inhibit water absorption and reduce root growth. Various species of fish, amphibians and aquatic macroinvertebrates are adversely impacted by increased levels of sodium and chloride. Geist Reservoir had a salinity reading of 0.3 ppt in June and 0.2 ppt in August sampling and does not indicate water quality impairment related to salinity.

pH (Acidic and Alkaline). The pH of a water body reflects the concentration of hydroxide (OH^-) in the water body. A low pH signifies an acidic medium (lethal effects of most acids begin to appear at pH = 4.5) while a high pH signifies an alkaline medium (lethal effects of most alkalis begin to appear at pH = 9.5). Neutral pH is 7. The actual pH of a water sample indicates the buffering capacity of that water body. The pH at Geist Reservoir was 8.66 in June and 7.6 in August which is within a healthy range for aquatic systems.

Dissolved Oxygen. Dissolved oxygen is the gaseous form of oxygen and is essential for respiration of aquatic organisms (i.e. fish and plants). Dissolved oxygen enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Oxygen saturation in water would equal 100% if equilibrium were reached. Values greater than 100% saturation indicate photosynthetic activity within the water. Large amounts of dissolved oxygen in the water indicate excessive algae growth. Dissolved oxygen is consumed by respiration of aquatic organisms and during bacterial decomposition of plant and animal matter. The Indiana Administrative Code lists a minimum standard of 4.0 mg/L for dissolved oxygen. Dissolved oxygen at the surface of Geist Reservoir was 8.24 mg/L in June 2009 and was in normal range for Indiana lakes in August (6.47 mg/L). Fish need at least 3 - 5 mg/L of D.O. to survive.

Turbidity. The waters transparency can be affected by two primary factors: algae and suspended particulate matter. An increase in the density of the phytoplankton or suspended particles signifies an increase in the waters turbidity. The typical range for turbidity is 0 to 173 Nephelometric Turbidity Unit (NTU), with an average turbidity value of 36 NTU. The 2009 turbidity results taken during vegetative sampling were within the typical turbidity range for Indiana lakes. The June 2009 turbidity value was 3.79 NTU and the August turbidity value was 5.99 NTU. Turbidity varies seasonally, and in larger bodies of water with depth, in response to natural and human-caused physical, chemical and biological changes. Turbidity can also be measured using a Secchi disk. A Secchi disk is an 8-inch diameter disk with alternating black and white quadrants that is lowered into the water column until it can no longer be seen from the surface to obtain a water clarity value. Secchi disk depth measurements were taken on June 9 and August 18 of 2009 during Tier II vegetative sampling. The Secchi disk depth measurement was 4 feet in June and 2 feet in August. The low Secchi depths are related to high turbidity within Geist Reservoir.

Geist Reservoir Fisheries

Currently, the Indianapolis Water Company controls the water in Geist Reservoir and its level is determined by municipal needs. The use of Geist Reservoir as a water supply precludes fisheries management techniques such as chemical treatment, drainage or drawdown. Due to the lack of management alternatives and the limited public access, there has been limited fish management by the state at Geist Reservoir. As summarized from personal communications with Rhett Wisener, IDNR District 5 Fisheries Biologist, the IDNR does not actively manage the reservoir because access fees are considered excessive. A fisheries survey was conducted in 1983 at Geist Reservoir and the species results are comparable to what species may currently be in the Reservoir. The species results for the 1983 Fish Management Report by Douglas Kingsley is presented in Table 4.

Table 4. Fisheries data from July 5 – 12, 1983 fisheries survey at Geist Reservoir.

Scientific Name	Common Name	Number	(%)	Length Range (inches)	Total Weight (pounds)	(%)
Dorosoma cepedianum	gizzard shad	1,403	47.4	1.5 – 14.5	295.78	30.9
Pomoxis annularis	white crappie	477	16.1	4.5 – 13.0	63.93	6.7
Lepomis macrochirus	bluegill	462	15.6	1.0 – 7.5	58.33	6.1
Ictalurus punctatus	channel catfish	150	5.1	8.0 – 31.0	162.58	17.0
Perca flavescens	yellow perch	78	2.6	4.5 – 8.0	8.26	0.9
Lepomis megalotis	longear sunfish	74	2.5	2.0 – 7.0	5.78	0.6
Micropterus salmoides	largemouth bass	67	2.3	1.5 – 2.1	81.21	8.5
Ameiurus melas	black bullhead	61	2.1	7.0 – 11.0	25.11	2.6
Catostomus commersoni	white sucker	41	1.4	6.5 – 17.0	43.69	4.6
Poxmois nigromaculatus	black crappie	38	1.3	5.5 – 8.0	6.45	0.7
Cyprinus carpio	carp	32	1.1	14.0 – 27.5	173.84	18.1
Notemigonus crysoleucas	golden shiner	24	0.8	5.5 – 7.0	1.95	0.2
Lepomis gibbosus	pumpkinseed	14	0.5	2.5 – 5.5	1.25	0.1
Labidesthes sicculus	brook silverside	13	0.4	1.1 – 4.2	0.12	-
Lepomis cyanellus	green sunfish	6	0.2	4.0 – 6.0	0.58	-
Minytrema melanops	spotted sucker	5	0.2	9.0 – 16.0	7.27	0.8
Carpoides cyprinus	quillback carpsucker	4	0.1	19.0 – 20.5	14.8	1.5
Ictalurus natalis	yellow bullhead	3	0.1	7.5 – 9.0	0.87	0.1
Percina caprodes	logperch	3	0.1	4.6 – 5.3	0.11	-
Ictiobus cyprinellus	bigmouth buffalo	1	-	15.9	2.35	0.2
Moxostoma erythrurum	golden redhorse	1	-	17.8	2.27	0.2
Micropterus dolomieui	smallmouth bass	1	-	12.2	0.92	0.1
Pylodictis olivaris	flathead catfish	1	-	10-.7	0.45	-
Total	**23 species**	**2,959**	**-**	**-**	**957.85**	**-**

Summary of the Geist Reservoir 1983 Fish Management Report

The following is a summary of the IDNR fisheries survey conducted from July 5 – 12, 1983 at Geist Reservoir. V3 would like to thank District 5 Fisheries Biologists Rhett Wisener for providing the fisheries data for this management plan.

The July 5 – 12, 1983 fisheries survey consisted of five hours and 47 minutes of electrofishing, 352 hours of experimental mesh gill netting and 201 hours of trap netting. A total of 2,959 fish were collected which had a combined weight of 957.85 pounds and represented 23 species (Table 4).

Gizzard shad were the most abundant species collected by number and weight. The 1,403 shad collected weighed a total of 295.78 pounds and comprised 47.4% of the sample by number and 30.9% by weight. Scale samples indicated that the gizzard shad were all age II, spawned in 1981. Average weights for gizzard shad were slightly below normal, indicating that competition for food was occurring.

White crappie was the second most abundant species collected with 477 individuals comprising 16.1% of the sample. White crappie were collected from a wide range of sizes 4.5 to 13.0 inches long and weighed up to 1.22 pounds. The population measures all indicated fairly uniform white crappie reproduction and recruitment. Bluegill was the third most numerous species by number (15.6%) and 6th by weight. Growth rates and average weights for bluegill were average for central Indiana and is important because of the large gizzard shad population. Often times the large populations of gizzard shad will cause for competition for food and space and often causes a decline in growth and average weight of other prey species such as bluegill.

The fishery at Geist Reservoir is characterized by an abundance of forage fish such as gizzard shad and bluegill. Gizzard shad accounted for almost half of the species collected and nearly a third of the total pounds collected. Other young and small prey species which provide forage for the reservoir's predators included: yellow perch, longear sunfish, black bullhead, white sucker, carp, golden shiner, pumpkinseed and brook silverside. Together, these species in addition to the shad comprise approximately 75% of the total sample.

Consideration should be given to a future stocking of top-level predator species as prey species are so abundant. Species considered for stocking at Geist Reservoir should be a pelagic feeder that is capable of surviving high temperature and low dissolved oxygen conditions. The predator species best suited for Geist Reservoir would be White Bass. Stocking 500 – 1,000 adult white bass in the early spring of 1985 was recommended for Geist Reservoir. Despite stocking recommendations, there are no records that the stocking recommended for 1985 occurred at Geist Reservoir.

Problem Statement

Geist Reservoir has low native plant diversity as a result of many factors. Geist Reservoir's shoreline consists largely of seawalls that reflect wave energy and virtually eliminate the transitional shoreline area where vegetation typically establishes. Geist Reservoir's bottom substrate is primarily rocky and sandy as it was formed through an impoundment. Water clarity is significantly reduced in Geist Reservoir as a result of sediments and organic matter suspended in the water column. Turbid or cloudy water impacts native species growth as they require higher levels of light for photosynthesis. Geist Reservoir's primary use is water supply and water levels fluctuate based on municipal water supply needs. In general, a fluctuating water table may expose roots of native species and decrease survivorship. The desirable level of aquatic vegetation varies based on the recreational user. Swimmers and power boaters desire a low amount of aquatic vegetation, whereas anglers favor water bodies with established submergent vegetation as it provides good cover for fish. It is imperative that stakeholders have a realistic expectation of the level of vegetation that is the most sustainable for Geist Reservoir when developing the aquatic vegetation management plan.

Eurasian watermilfoil (*Myriophyllum spicatum*) is an exotic vegetative species that is abundant throughout Geist Reservoir. Eurasian watermilfoil is typically considered to be a high management priority as it is an aggressive, exotic aquatic species that can have a detrimental effect on the native aquatic plant community. This exotic species grows and spreads rapidly through fragmentation, forming dense weed beds that outcompete native species for light and nutrients. The biology and life cycle of Eurasian watermilfoil provide it with a significant advantage over native species. Eurasian watermilfoil lies dormant during the winter months, instead of dying back completely like many native species. As spring arrives, the dormant Eurasian watermilfoil is able to grow earlier and reach the surface faster than other native species. It then grows horizontally across the water surface to form a canopy and effectively shade out other plants.

Eurasian watermilfoil was collected at 31% of sampling locations from depths ranging from 1 to 6 feet during the spring survey in June 2009. The lack of vegetation is a problem within Geist Reservoir and although Eurasian watermilfoil is an exotic species, it is currently providing the majority of submergent plant structure. The summer Tier II vegetation survey was conducted on August 18, 2009 by V3. Eurasian watermilfoil's site frequency of 25% in August demonstrates a decrease in abundance from the spring results and is likely in effect of the treatments that occurred. Twenty-six percent (26%) of sampling locations were vegetated during the summer sampling and native vegetation was present at 3 sampling locations.

Aquatic Vegetation Management Goals and Objectives

The following management goals have been established by the IDNR for all lakes applying for LARE funding. Any management practices implemented at Geist Reservoir must facilitate the achievement of these three goals.

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species;

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species; and

3. Provide reasonable public recreational access while minimizing the negative impacts on plant and wildlife resources.

Specific objectives are proposed to facilitate the success of the actions listed below to achieve the overall LARE management goals for Geist Reservoir.

1. **Increase Educational Outreach.** Reduce spread of Eurasian watermilfoil to other water bodies by increasing awareness of preventative actions. Geist Reservoir's access is widely used by surrounding counties and is a popular recreational water body. Increasing signage educating recreational users on how exotics are spread and instructions to prevent the spread of exotics is needed at Geist Reservoir. Stop Aquatic Hitchhikers! is a campaign aiming to inform recreational users about actions they can make to reduce the spread of exotic species. Figure 2 provides an example of educational signage. More information can be found at the website: http://www.protectyourwaters.net/.

Figure 2: Educational signage on preventative actions for the spread of exotic species.

2. **Maintain and Enhance Diversity of the Native Aquatic Plant Community.** Reduce the spread of Eurasian watermilfoil through educational outreach and selective management in high traffic areas should it become a significant impact to recreational use which would

increase the potential for native plants to establish. The type of substrate affects a lake's ability to support aquatic vegetation. Lakes that have mucky, organic, nutrient-rich substrates have an increased potential for plant growth compared to lakes with gravelly, rocky substrates. The substrate of Geist Reservoir consists largely of sand although areas of muck and clay exist as well. While sandy substrates typically support healthy aquatic plant communities, this is only true when sufficient organic material is mixed in with the sand to provide a nutritional base for the rooted plants. (Giolitto and Olyphant, 2002). In addition to Eurasian watermilfoil reduction, watershed activities to improve the water clarity will benefit the native aquatic plant communities' ability to establish.

Specific actions are proposed as follows to facilitate achievement of the overall LARE management goals for Geist Reservoir.

1. **Promote and Maintain the Diversity of Native Aquatic Plant Species.** A diverse native aquatic vegetative community is important in Geist Reservoir as they provide fish habitat, stabilize the shoreline, and prevent the establishment and/or spread of Eurasian watermilfoil and other invasive species. Due to these multiple benefits, one of the specific goals of this plan is to promote and maintain a healthy diversity of native aquatic plant species, while recognizing that some vegetation management may be necessary to provide reasonable public access for recreation. Geist Reservoir has a low native species diversity which is attributed to lack of shoreline, substrate composition and turbid water. Watershed activities to improve the water quality within Geist Reservoir may help promote the growth of native vegetative species. Due to the complexities of the watershed and its relationship to the reservoir with regards to algae and other invasive species, no treatment actions are proposed for management at this time.

Exotic Species Management Efforts at Geist Reservoir

Herbicide treatments have primarily been privately funded and conducted within the coves and shoreline areas of Geist Reservoir over the past ten years. Treatments have been applied as a measure for lake front access. Geist Reservoir 2009 treatment records were obtained through the IDNR and herbicide application details are provided in table 5. The total acreage of treatment that occurred in Geist Reservoir in 2009 was 14.84 acres.

Table 5. Herbicide treatments at Geist Reservoir for Eurasian watermilfoil in 2009.

Date	Acreage	Herbicide Applicator	Herbicide Type	Location
6/8/09	2.09	Aquatic Control	Renovate OTF	Geist Marina
6/23/09	1.25	ASAP Aquatics	Reward and Copper Sulfate	Breakwater Marina
6/23/09	5.0	ASAP Aquatics	Reward	Intracoastal at Geist
7/17/09	5.25	Aquatic Control	Renovate 3	Geist Marina
8/19/09	1.25	ASAP Aquatics	Reward and Copper Sulfate	Breakwater Marina

Aquatic Control completed two treatments on Geist Reservoir in 2009 for control of Eurasian watermilfoil (Exhibit 4). The June treatment was a total of 2.09 acres and the July treatment was a total of 5.25 acres. Renovate OTF was used in June, and Renovate3 was used in July. Treatments were completed with a target triclopyr concentration of 1.5 ppm within treatment areas. Treatments effectively controlled targeted Eurasian watermilfoil within 14 days and little to no re-growth was recorded in late summer to early fall. Treatment area 2 received complaints in September due to the influx of native vegetation, primarily coontail (*Ceratophyllum demersum*).

ASAP Aquatics treated 5 acres of Eurasian watermilfoil within the Intracoastal Marina on June 23, 2009 using 7 gallons of Reward (diquat) (Exhibit 5). In addition to the Intracoastal Marina treatment, ASAP Aquatics completed two treatments in the Breakwater Marina of Geist reservoir for a total of 1.25 acres. The June 23, 2009 Breakwater Marina treatment required 2 gallons of Reward diquat and 25 lbs of copper sulfate (Exhibit 6). The second Breakwater Marina treatment was conducted August 19, 2009 and required 1.5 gallons of Reward diquat and 15 lbs of copper sulfate.

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TITLE: **Aquatic Control 2009 Eurasian watermilfoil Herbicide Treatment Locations**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 4	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/8/09	SCALE: NTS

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TITLE: **ASAP Aquatics 2009 Eurasian watermilfoil Herbicide Treatment in Intracoastal Marina**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 5	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/23/09	SCALE: NTS

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TITLE: **ASAP Aquatics 2009 Eurasian watermilfoil Herbicide Treatment within Breakwater Marina**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 6	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/23/09	SCALE: NTS

Tier II Sampling Methods

Tier II aquatic sampling protocols were established by the IDNR to accurately describe and characterize the aquatic plant community of any particular water body, in a repeatable, consistent and analytical manner. Tier II sampling provides quantitative data on the occurrence, distribution, and abundance of aquatic plants within a water body. This sampling protocol is intended to:

1. Document the distribution and abundance of submersed and floating-leaved aquatic vegetation within selected areas and at a lake-wide scale, and

2. Compare present distribution and abundance of particular aquatic plants with past distribution and abundance within select areas and at a lake-wide scale.

LARE Tier II aquatic plant monitoring consists of a spring and summer sampling effort. Spring sampling is typically conducted between May 15 and June 15, and summer sampling typically occurs between July 15 and August 31. Tier II sampling efforts at Geist Reservoir in 2009 were within the designated sampling windows.

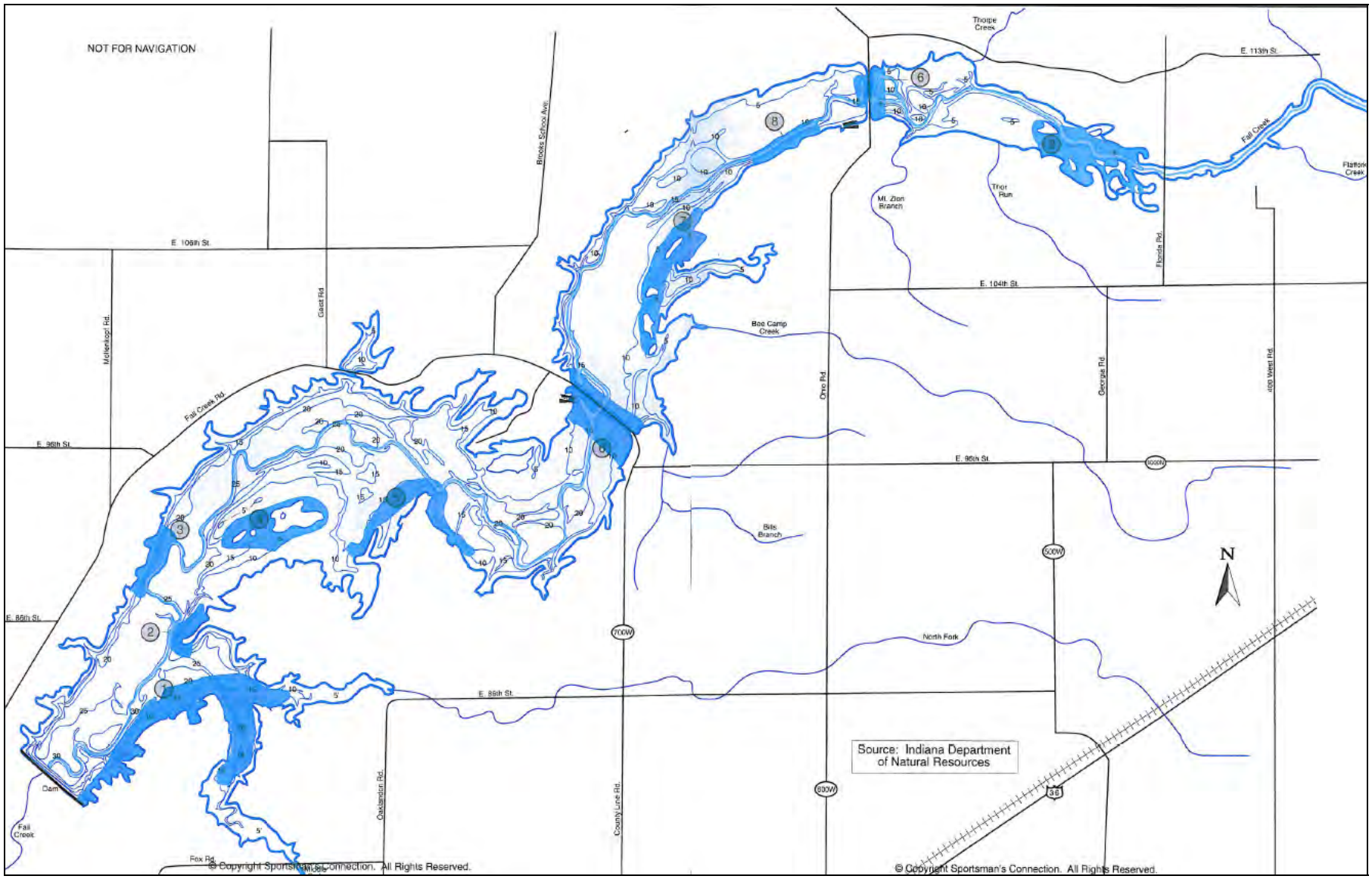
The number and depth of sampling locations are determined by lake size, trophic status and apportioned by depth class (Table 6). The following table was used to determine the number and depths of sampling locations (note: table excludes hypereutrophic status).

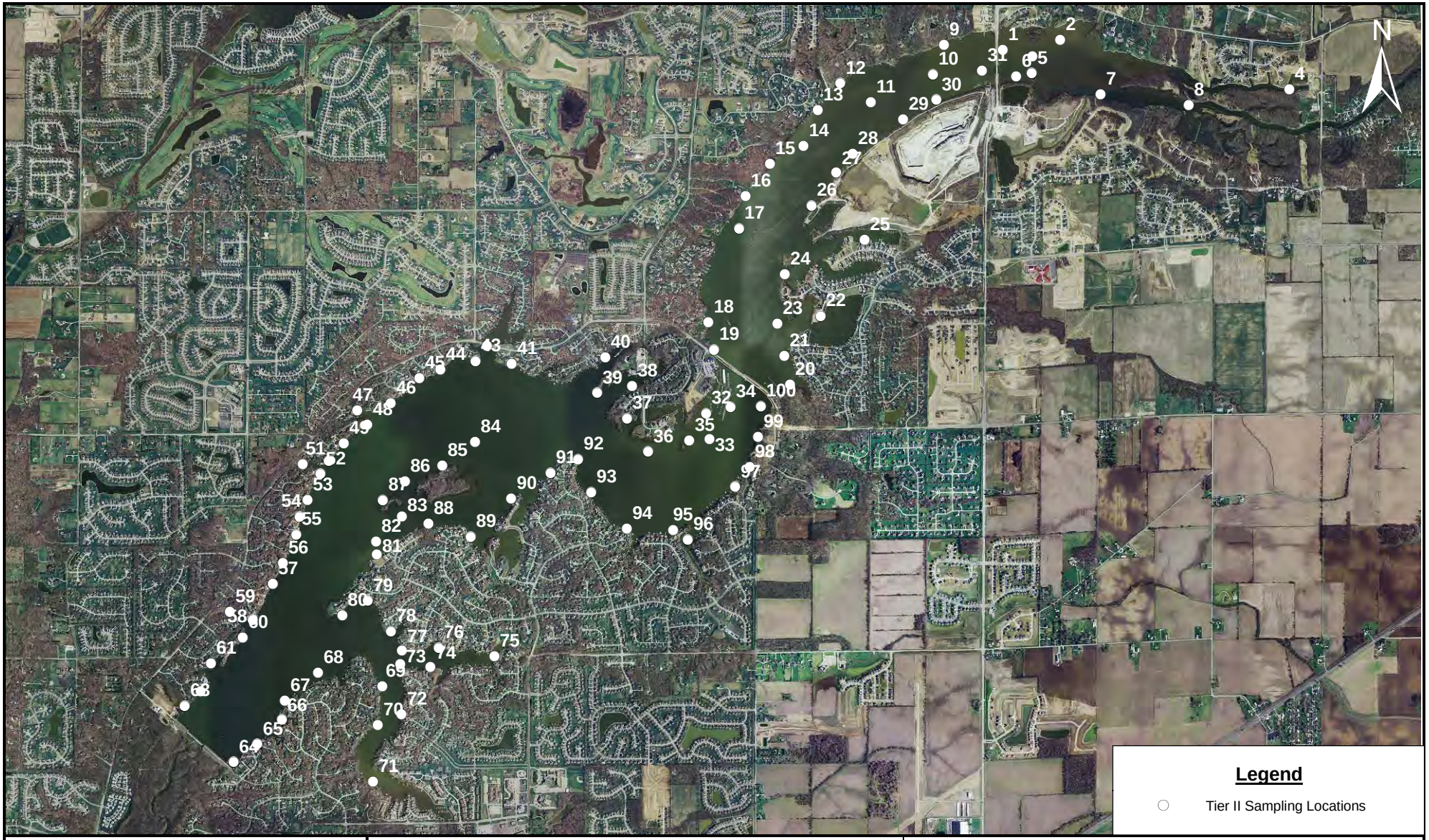
Table 6. Sample Size Requirements for Tier II Sampling (IDNR 2007).

		Eutrophic			Mesotrophic				Oligotrophic				
Lake Acres	Total # Sites	0-5'	5-10'	10-15'	0-5'	5-10'	10-15'	15-20'	0-5'	5-10'	10-15'	15-20'	20-25'
<10	20	10	7	3	10	5	3	2	10	4	3	2	1
10-49	30	10	10	10	10	10	7	3	10	10	5	3	2
50-99	40	17	13	10	10	10	10	10	10	10	10	7	3
100-199	50	23	17	10	14	14	12	10	10	10	10	10	10
200-299	60	30	20	10	18	16	16	10	14	12	12	12	10
300-399	70	37	23	10	22	20	18	10	17	15	14	14	10
400-499	80	43	27	10	25	23	22	10	19	18	17	16	10
500-799	90	50	30	10	29	27	24	10	22	21	19	18	10
≥ 800	**100**	**57**	**33**	**10**	33	31	26	10	25	23	22	20	10

Geist Reservoir has a surface area of 1,900 acres and is rated as eutrophic, therefore, 100 sampling locations were required at the depth distribution shown in bold in Table 6. Approximate sample site locations were randomly spaced on a bathymetric map based on the depth categories (Figure 3). The blue shaded areas with a corresponding number in Figure 3 represent areas that Sportsman Connection identified as a productive fishing location. Pre-designated sample site locations were navigated to based on visual markers. The depth category in the vicinity was found using a Humminbird 383c depth finder. The location of each sampling point was recorded using a WAAS-enable GPS unit (estimated accuracy ± 3m) (Exhibit 7).

Figure 3: Geist Reservoir Bathymetric Map (Courtesy of Sportsman Connection).





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TITLE: Geist Reservoir 2009 Tier II Sampling Locations		PROJECT: Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 7	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/9/09	SCALE: 1" = 3250'

Tier II Sampling Methodology

A double-headed thatch rake with attached nylon rope was used to sample the aquatic vegetation at each sampling location. The rake was lowered to the bottom of the reservoir, and an extra ten feet of slack was let out in the rope as the boat drifted. Then the rake was dragged along the reservoir bottom for a few feet and pulled up through the water column. All vegetation retrieved on the teeth of the rake was gathered into the boat and separated by species. Plants of each species were piled onto one side of the rake for a score of 1-5, based on the following table (Table 7). Visible "holes" in the rake teeth were filled without overly packing plants onto the rake. In addition to recording the density of each species, the overall density was recorded of all plants at a sampling location.

Table 7. Vegetation Abundance Ratings for Tier II Sampling.

Rake Teeth Filled (%)	Abundance Rating
100+	5
21-99	3
1-20	1
No plants retrieved	0

After the Tier II data was collected, it was imported into a Microsoft Excel spreadsheet to calculate plant community metrics used by IDNR (IDNR 2007). Site frequency measures how often a species was collected at the Tier II sampling locations. It is calculated by the following equation:

$$\text{Site Frequency} = \frac{\text{(\# of sites where the species was collected)}}{\text{Total \# of sample sites}} \times 100$$

Relative density is calculated as the sum of the rake scores for a species divided by the total number of sample sites in the survey. In contrast, mean density measures the abundance of a species in areas where it is growing. These values are calculated by the following equations:

$$\text{Mean Density} = \frac{\text{(Sum of all rake scores for a species)}}{\text{(Total \# of sites where the species was collected)}}$$

$$\text{Relative Density} = \frac{\text{(Sum of all rake scores for a species)}}{\text{(Total \# of sample locations)}}$$

The dominance index of each species is a metric that combines the frequency of occurrence and relative density to reflect the relative dominance of a species within the aquatic plant community. It is calculated as:

$$\text{Dominance Index} = \frac{\text{(Sum of all rake scores for a species)}}{\text{(Total \# of sample locations X 5)}} \times 100$$

Tier II 2009 Sampling Results

The Tier II Aquatic Vegetation Survey Protocol, designated by the IDNR, serves as a standardized method to document the occurrence, distribution, and abundance of aquatic vegetation. Spring and late summer Tier II vegetation surveys were conducted on Geist Reservoir in 2009. The information collected is useful to monitor changes in the vegetative community over time and identify success or failure of the exotic species control techniques implemented. A table outlining the scientific and common names of species collected or observed during the 2009 sampling surveys in Geist Reservoir is listed below (Table 8).

Table 8. Scientific and common names of species collected or observed for both June and August Tier II vegetative sampling within Geist Reservoir.

Scientific Name	Common Name	Spring survey 6/9/09	Late summer survey 8/18/09
Ceratophyllum demersum	Coontail	x	x
Chara spp.	Chara species	x	
Elodea canadensis	Elodea	x	x
Myriophyllum spicatum	Eurasian watermilfoil*	x	x
Najas gracillima	Northern naiad		x
Potamogeton pusillus	Small pondweed		x

**Indicates exotic species*

Results of Spring Tier II Survey- June 9, 2009

A total of 4 species were identified up to a maximum depth of 6 feet. The secchi disk depth measurement was 4 feet during the June Tier II survey. Emergent species observed during the sampling effort include spatterdock (*Nuphar advena*), white water lily (*Nymphaea oderata*), and water willow (*Justicia americana*). Water willow is the most dominant emergent species throughout Geist Reservoir and is able to establish near seawalls. Geist Reservoir's spring sampling results from depth ranges of 0 to 10 feet are provided below (Table 9a – 9c). The depth range of 10 to 15 feet was excluded as plants were not retrieved at these depths.

Table 9a: Geist Reservoir Spring Tier II survey results all depths (0 – 15 feet).

County:	Hamilton/Marion	Total Sites:	100	Mean species/site:	0.35
Date:	6/9/2009	Sites with plants:	34	SE Mean species/site:	0.05
Secchi (ft):	4.0	Sites with native plants:	3	Mean native species/site:	0.04
Maximum Plant Depth (ft):	6.0	Number of species:	4	SE Mean natives/site:	0.02
Trophic Status:	Eutrophic	Number of native species:	3	Species diversity:	0.21
		Maximum species/site:	2	Native species diversity:	0.63

All Depths (0 to 15 ft)		Frequency of Occurrence	Rake score frequency per species				Plant
Species	Common Name	(%)	0	1	3	5	Dominance
Myriophyllum spicatum	Eurasian watermilfoil	31.0	69.0	16.0	12.0	3.0	13.4
Ceratophyllum demersum	Coontail	2.0	98.0	2.0	0.0	0.0	0.4
Chara sp.	Chara sp.	1.0	99.0	1.0	0.0	0.0	0.2
Elodea canadensis	Elodea	1.0	99.0	1.0	0.0	0.0	0.2

Hamilton/Marion
6/9/2009
4.0

6.0
Eutrophic

Common Name
Eurasian watermilfoil
Coontail
Chara sp.
Elodea

Table 9b: Geist Reservoir Spring Tier II survey results 0 to 5 foot depth zone.

County:	Hamilton/Marion	Total Sites:	57			Mean species/site:	0.58
Date:	6/9/2009	Sites with plants:	32			SE Mean species/site:	0.07
Secchi (ft):	4.0	Sites with native plants:	2			Mean native species/site:	0.05
Maximum Plant Depth (ft):	6.0	Number of species:	4			SE Mean natives/site:	0.04
Trophic Status:	Eutrophic	Number of native species:	3			Species diversity:	0.17
		Maximum species/site:	2			Native diversity:	0.67
Depth: 0 to 5 ft		**Frequency of Occurrence**	**Rake score frequency per species**				**Plant**
Species	**Common Name**	(%)	**0**	**1**	**3**	**5**	**Dominance**
Myriophyllum spicatum	Eurasian watermilfoil	52.6	47.4	26.3	21.1	5.3	23.2
Ceratophyllum demersum	Coontail	1.8	98.2	1.8	0.0	0.0	0.4
Chara sp.	Chara sp.	1.8	98.2	1.8	0.0	0.0	0.4
Elodea canadensis	Elodea	1.8	98.2	1.8	0.0	0.0	0.4

Table 9c: Geist Reservoir Spring Tier II survey results 5 to 10 foot depth zone.

County:	Hamilton/Marion	Total Sites:	33			Mean species/site:	0.06
Date:	6/9/2009	Sites with plants:	2			SE Mean species/site:	0.04
Secchi (ft):	4.0	Sites with native plants:	1			Mean native species/site:	0.03
Maximum Plant Depth (ft):	6.0	Number of species:	2			SE Mean natives/site:	0.03
Trophic Status:	Eutrophic	Number of native species:	1			Species diversity:	0.50
		Maximum species/site:	1			Native diversity:	0.00
Depth: 5 to 10 ft		**Frequency of Occurrence**	**Rake score frequency per species**				**Plant**
Species	**Common Name**	(%)	**0**	**1**	**3**	**5**	**Dominance**
Ceratophyllum demersum	Coontail	3.0	97.0	3.0	0.0	0.0	0.6
Myriophyllum spicatum	Eurasian watermilfoil	3.0	97.0	3.0	0.0	0.0	0.6

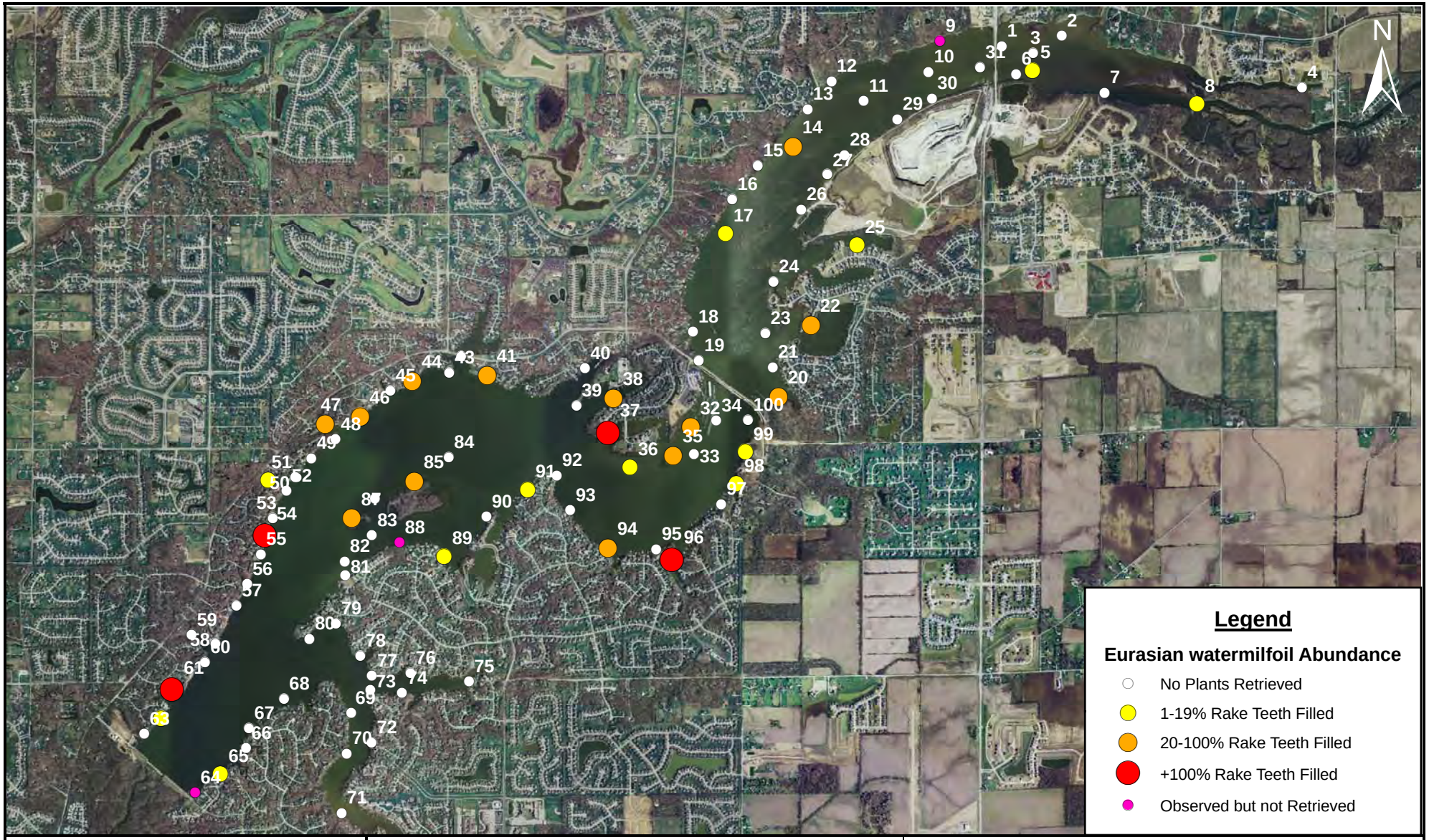
The Tier II results for the depth range of 0 to 15 feet identified Eurasian watermilfoil at the highest percentage of sample sites (31%). Distribution and abundance of Eurasian watermilfoil is presented in Exhibit 8. Eurasian watermilfoil was present at depths ranging from 1 to 6 feet. Eurasian watermilfoil was collected with a rake score of 1 (1-19% rake teeth filled) at 16 sampling locations, a rake score of 3 (20-100% rake teeth filled) at 12 sampling locations, and a rake score of 5 (+100% rake teeth filled) at three locations. Eurasian watermilfoil was observed within the vicinity of 3 sampling locations. The maximum number of species collected at a sampling location was 2 and the average number of species collected was 0.35. Three native species were collected during the spring survey which included coontail, chara, and elodea (Exhibit 9).

The 0 to 5 foot depth zone represented all species collected during the spring survey effort. The 0 to 5 foot depth zone had vegetation at 32 of the 57 sampling locations. Native species were collected at 2 sampling locations. The maximum number of species collected at a sampling location was 2 with an average of 0.58 species per site. The most dominant species within this depth zone was Eurasian watermilfoil and occurred at 52.6% of sampling locations. Coontail, chara and elodea all had a frequency of occurrence of 1.8% and were collected with a rake score of 1.

Two species were collected within the 5 to 10 foot depth zone. Vegetation was present at 2 of the 33 sampling locations within this depth zone. The maximum number of species collected at a sampling location was 1 and the average number of species collected at a sampling location was 0.06. Eurasian watermilfoil and coontail had the same frequency of occurrence (3.0%) and were collected with a rake score of 1. Eurasian watermilfoil has a lower light requirement compared to native species but does not appear to be dominating the deeper zone of Geist Reservoir.

Water Willow (*Justicia americana*) is an emergent aquatic species that is not included in the Tier II Survey Protocol. Its presence throughout Geist Reservoir was noted during spring sampling due to the lack of vegetative structure present within Geist Reservoir (Figure 4). This species is common throughout Geist Reservoir and provides vegetative cover for many aquatic species and is an important native species to protect (Exhibit 10).

Figure 4: Stand of water willow being utilized as cover by waterfowl.



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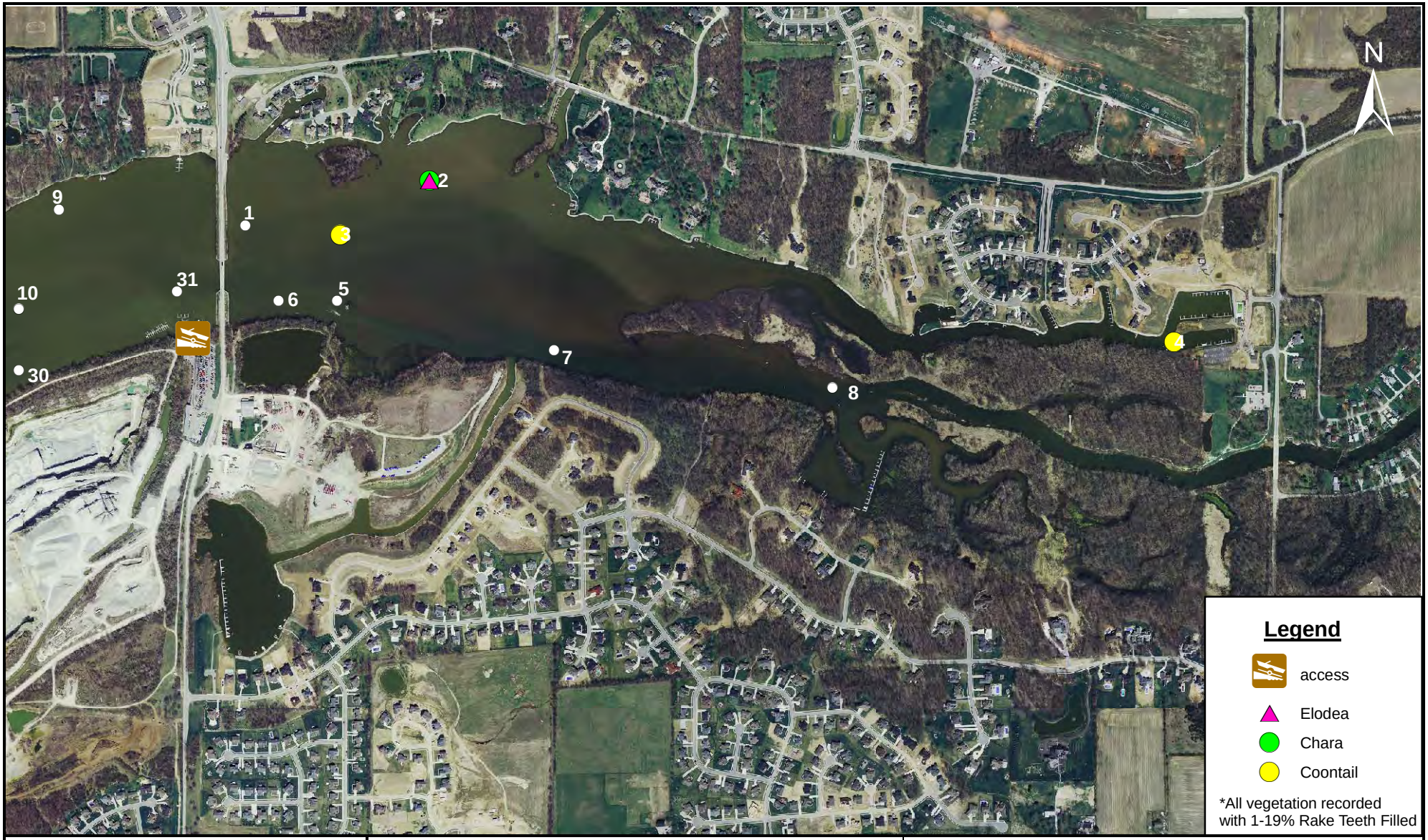
TITLE: **Pre-treatment Eurasian watermilfoil Distribution and Abundance**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 8	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/11/09	SCALE: 1" = 3,100'



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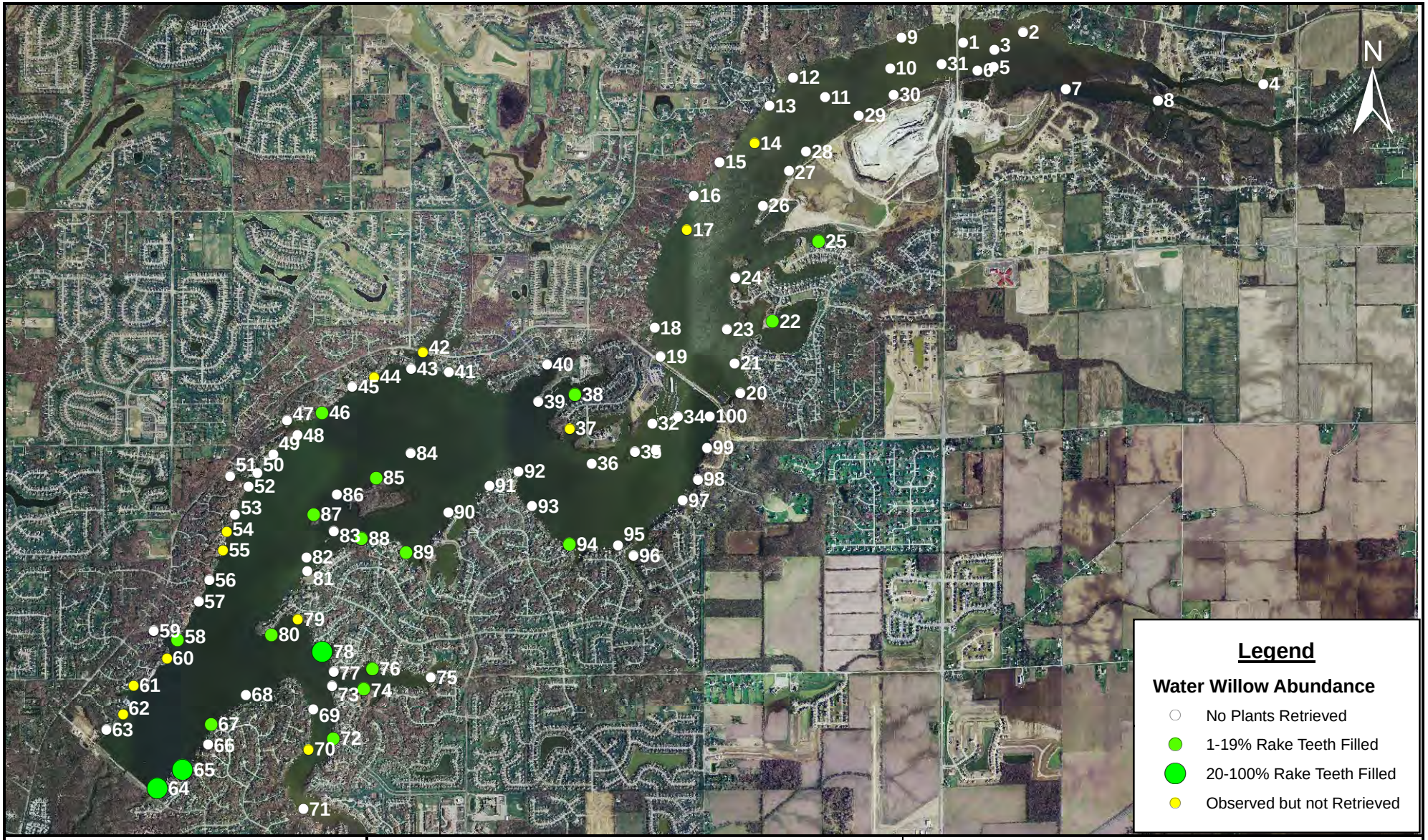
TITLE: **Pre-treatment Distribution and Abundance of Chara, Coontail, and Elodea**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 9	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/11/09	SCALE: 1" = 1,000'



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TITLE: Pre-treatment Water Willow Distribution and Abundance		PROJECT: Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 10	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 6/11/09	SCALE: 1" = 3100'

Results of Late Summer Tier II Survey- August 19, 2009

A total of 5 species were identified up to a maximum depth of 8 feet among the 100 Tier II sampling locations during the August 19, 2009 survey. Geist Reservoir's sampling results from depth ranges of 0 to 15 feet are provided below (Table 10a – 10c). The secchi disk depth measurement was taken after completion of vegetation sampling efforts and was recorded at 2 feet. The depth range of 10 to 15 feet was excluded as plants were not retrieved at these depths.

Table 10a: Geist Reservoir Late Summer Tier II survey results all depths (0 – 20 feet).

County:	Hamilton/Marion	Total Sites:	100	Mean species/site:	0.30
Date:	8/18/2009	Sites with plants:	26	SE Mean species/site:	0.06
Secchi (ft):	2.0	Sites with native plants:	3	Mean native species/site:	0.05
Maximum Plant Depth (ft):	8.0	Number of species:	5	SE Mean natives/site:	0.03
Trophic Status:	Eutrophic	Number of native species:	4	Species diversity:	0.30
		Maximum species/site:	3	Native species diversity:	0.72

All Depths (0 to15 ft)		Frequency of Occurrence	Rake score frequency per species				Plant
Species	Common Name	(%)	0	1	3	5	Dominance
Myriophyllum spicatum	Eurasian watermilfoil	25.0	75.0	14.0	5.0	6.0	11.8
Ceratophyllum demersum	Coontail	2.0	98.0	2.0	0.0	0.0	0.4
Elodea canadensis	Elodea	1.0	99.0	1.0	0.0	0.0	0.2
Najas gracillima	Northen naiad	1.0	99.0	1.0	0.0	0.0	0.2
Potamogeton pusillus	Small pondweed	1.0	99.0	1.0	0.0	0.0	0.2

Table 10b: Geist Reservoir Late Summer Tier II survey results 0 to 5 foot depth zone.

County:	Hamilton/Marion	Total Sites:	57	Mean species/site:	0.44
Date:	8/18/2009	Sites with plants:	23	SE Mean species/site:	0.08
Secchi (ft):	2.0	Sites with native plants:	2	Mean native species/site:	0.05
Maximum Plant Depth (ft):	8.0	Number of species:	4	SE Mean natives/site:	0.04
Trophic Status:	Eutrophic	Number of native species:	3	Species diversity:	0.22
		Maximum species/site:	2	Native diversity:	0.67

Depth: 0 to 5 ft		Frequency of Occurrence	Rake score frequency per species				Plant
Species	Common Name	(%)	0	1	3	5	Dominance
Myriophyllum spicatum	Eurasian watermilfoil	38.6	61.4	19.3	8.8	10.5	19.6
Ceratophyllum demersum	Coontail	1.8	98.2	1.8	0.0	0.0	0.4
Elodea canadensis	Elodea	1.8	98.2	1.8	0.0	0.0	0.4
Najas gracillima	Northen naiad	1.8	98.2	1.8	0.0	0.0	0.4

Table 10c: Geist Reservoir Late Summer Tier II survey results 5 to 10 foot depth zone.

County:	Hamilton/Marion	Total Sites:	33	Mean species/site:	0.15
Date:	8/18/2009	Sites with plants:	3	SE Mean species/site:	0.10
Secchi (ft):	2.0	Sites with native plants:	1	Mean native species/site:	0.06
Maximum Plant Depth (ft):	8.0	Number of species:	3	SE Mean natives/site:	0.06
Trophic Status:	Eutrophic	Number of native species:	2	Species diversity:	0.56
		Maximum species/site:	3	Native diversity:	0.50

Depth: 5 to 10 ft		Frequency of Occurrence	Rake score frequency per species				Plant
Species	Common Name	(%)	0	1	3	5	Dominance
Myriophyllum spicatum	Eurasian watermilfoil	9.1	90.9	9.1	0.0	0.0	1.8
Ceratophyllum demersum	Coontail	3.0	97.0	3.0	0.0	0.0	0.6
Potamogeton pusillus	Small pondweed	3.0	97.0	3.0	0.0	0.0	0.6

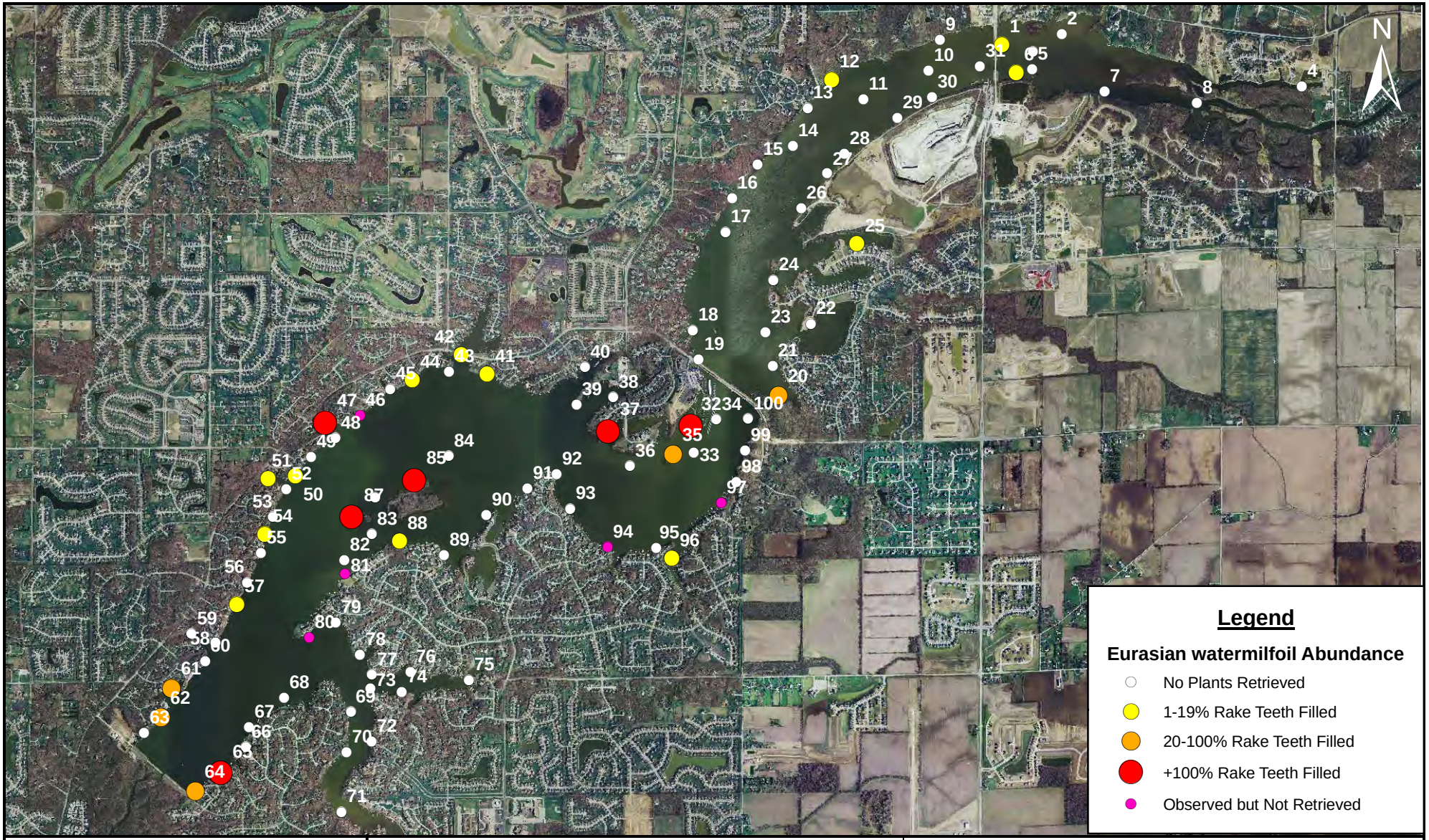
The results of the August Tier II survey (0 – 15 feet) identified Eurasian watermilfoil at the highest percentage of sample sites (25%). Eurasian watermilfoil was present at depths ranging from 2 to 8 feet (Exhibit 11). Eurasian watermilfoil was collected with a rake score of 1 (1-19% rake teeth filled) at 14 sampling locations, a rake score of 3 (20-100% rake teeth filled) at 5 sampling locations, and a rake score of 5 (+100% rake teeth filled) at 6 locations. The maximum number of species collected at a sampling location was 3 and the average number of species collected was 0.3.

The 0 to 5 foot depth zone consisted of 3 native species and 1 exotic species. The 0 to 5 foot depth zone had vegetation at 23 of the 57 sampling locations. The maximum number of species collected at a sampling location was 2 with an average of 0.44 species per site. The most dominant species within this depth zone was Eurasian watermilfoil and occurred at 38.6% of sampling locations. Coontail, Elodea and Northern naiad had a site frequency of 1.8% and were collected with a rake score of 1.

Three species were collected within the 5 to 10 foot depth zone. Vegetation was present at 3 of the 33 sampling locations within this depth zone. The maximum number of species collected at a sampling location was 3 species and the average number of species collected at a sampling location was 0.15. Eurasian watermilfoil was the most frequently occurring species and was present at 9.1% of sampling locations within the 5 to 10 foot depth zone.

Significant natural areas within Geist Reservoir are located east of Olio Road in the northeastern portion of Geist Reservoir. A large lotus bed provides foraging area for many bird species such as great blue herons (*Ardea herodias*) and white egrets (*Ardea alba)*. These emergent bed areas are popular fishing areas for anglers and can provide a wildlife viewing opportunity for naturalists (Figure 5). Turtles are commonly found basking in shallow areas of Geist Reservoir. Protection of these emergent beds is important as it sustains a high percentage of the vegetative structure within Geist Reservoir.

Figure 5: Shallow areas within Geist Reservoir provide productive wildlife areas.



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TITLE: **Post-treatment Eurasian watermilfoil Distribution and Abundance**		PROJECT: **Geist Reservoir Aquatic Vegetation Management Plan 2009 - 2013**	
BASE LAYER: Indiana Data Spatial Portal 2006 Orthophotography		PROJECT NO.: 09006	EXHIBIT: 11	SHEET: 1 OF: 1
CLIENT: Upper White River Watershed Alliance 723 West Michigan Street Indianapolis, IN 46202		QUADRANGLE: McCordsville	DATE: 8/18/09	SCALE: 1" = 3,100'

Threatened and Endangered Species

The Indiana Natural Heritage Data Center database provides information on the presence of rare species, threatened and endangered species, and high quality natural communities and areas. The database serves as a tool for setting management priorities in areas where these species are encountered. There were no encounters of threatened or endangered species during the Tier II sampling. No voucher specimens were collected during the efforts of this project. There are no anticipated adverse impacts to any state or federally protected threatened or endangered species as it relates to the use of the vegetation control herbicides recommended within this plan. The Indiana Natural Heritage Data Center's list of threatened and endangered species for Hamilton and Marion Counties are provided in Appendix II.

Aquatic Plant Management Alternatives

At the present time, the health of Geist Reservoirs aquatic vegetative community is poor. Native plant diversity is low and many areas of Geist Reservoir are not vegetated. Eurasian watermilfoil has a high frequency of occurrence throughout Geist Reservoir (25% site frequency) as it is able to tolerate the water conditions compared to the presence of native species. Targeting large acreages of Eurasian watermilfoil can be problematic as it is currently the dominant vegetative structure within the Reservoir. Additionally, watershed activities to improve the water quality of Geist Reservoir are important to protect the native plant diversity and to decrease the input of nutrients and sediments that feed the invasive species.

Many management strategies have been used to control Eurasian watermilfoil in Indiana lakes. A management strategy should be chosen based on its selectivity to the target species, its long-term effectiveness, and potential for detrimental side-effects (i.e., effects on non-target species). The foremost objective is to choose a management strategy that will effectively control the Eurasian watermilfoil population with minimal negative effects on non-target plants or fish species.

Although dense beds of native aquatic plants can be a nuisance where they inhibit water body access, aquatic vegetation is important in maintaining a healthy ecosystem. Aquatic plants provide habitat for plankton, insects, crustaceans, fish, and amphibians. They take nutrients such as phosphorus and nitrogen out of the water column, increase water clarity, prevent harmful algal blooms, produce oxygen, and provide food for waterfowl. Aquatic plants can also remove pollutants from contaminated water and prevent the suspension of particulate matter by stabilizing sediment and preventing erosion from wave action or current.

Because of the overall importance of beneficial aquatic vegetation, one of the goals of the LARE aquatic vegetation program is to maintain healthy aquatic ecosystems by maintaining or improving biodiversity in Indiana lakes, which includes protecting beneficial aquatic vegetation. As such, it is recognized that competing uses of the water body, including access for boating and maintaining plant beds to provide habitat for juvenile fish, must be incorporated into an overall management strategy for the reservoir.

Different types of aquatic plant management alternatives are discussed below. One or more of these alternatives may be implemented to help meet the objectives of Geist Reservoir.

1 No Action

At this time, based on the use of the reservoir, status of the existing aquatic vegetation, competition with blue-green algae and ongoing preparation of the Watershed Management Plan no action is the recommended management for the existing vegetation in the reservoir. The exotic vegetative species abundance may remain stable, or it may increase from year to year. This uncertainty coupled with the known issue of blue-green algae in the reservoir leaves the recommendation of no action as the appropriate plan.

Eurasian watermilfoil spreads by fragmentation; when the plant is cut, the fragment has the ability to form an entirely new plant. Eurasian watermilfoil also over-winters as an adult plant and sprouts early in the spring. These reproductive characteristics cause exotic vegetative species to become dense over time, creating a monoculture that out-competes and eliminates native

species. A major goal of this aquatic vegetation management plan is to prevent Eurasian watermilfoil from becoming a monoculture, and to maintain and enhance the current diversity of native aquatic plants. Therefore, it is imperative that Eurasian watermilfoil be monitored. It should be noted that Eurasian watermilfoil has a history of re-establishing after treatments, and diligent treatment of re-sprouts over several years is needed to provide longer-term control. Taking no action may allow the Eurasian watermilfoil population to expand after the 2009 treatment and reach a problematic level.

2 Institutional Protection of Beneficial Vegetation

Recreational users can play an important role in the protection of beneficial aquatic vegetation. Aquatic invasive species often gain a foothold in an ecosystem in areas disturbed by human activity or natural processes. In many cases, boating may be restricted in certain areas of a water body to prevent harm to native plants, especially many emergent species. Boating lanes have been established in the northeastern portion of Geist Reservoir and serve as a navigational path through the shallow areas. This functions as a protective measure for existing aquatic plant beds and ecological zones. Shallow areas of Geist Reservoir are also marked with buoys to prevent injury to boaters.

3 Environmental Manipulation

Lower water levels expose the Eurasian watermilfoil roots to freezing and thawing, which may kill milfoil root systems. However, a reservoir drawdown will not only kill Eurasian watermilfoil but all native plants as well. Also, reducing the water level may allow new areas of the reservoir to become available habitat for vegetative growth, and Eurasian watermilfoil may have an advantage in the colonization of newly created habitat. Geist Reservoir is used as a water source and fluctuations in water level are necessary based on water supply needs. The results of the Tier II sampling efforts do not indicate Eurasian watermilfoil is disadvantaged by the fluctuating water level. Environmental Manipulation is not a management option for Eurasian watermilfoil as Geist Reservoir's priority is to maintain water supply.

4 Nutrient Reduction

An overabundance of nutrients can greatly increase the possibility for an invasive species to proliferate in a body of water. Limiting factors for plant growth include light, lake morphometry and depth, substrate, and the availability of nutrients like phosphorus and nitrogen. While lake morphometry is most highly correlated with plant biomass, the availability of phosphorus and nitrogen have a significant impact on the amount of plant growth in a body of water. If the vast majority of phosphorus in a system is tied up in plant matter, it may be difficult for an invasive species to become established and spread rapidly in a reservoir. If phosphorus is constantly being added to the system and is readily available in the water, invasive species can use the nutrient excess and take over an aquatic system within a few growing seasons. Additionally, herbicide applications to native plant beds can cause a single large release of nutrients as the killed vegetation decomposes, coupled with available space for the germination of new species. This combination of conditions presents a ripe opportunity for the establishment of an invasive species such as Eurasian watermilfoil and may exacerbate algal bloom problems in the reservoir.

Phosphorus and nitrogen are added to aquatic systems by natural sources, such as the decomposition of plant material and animal waste. Human activity, however, is often responsible

for excessive phosphorus loading that contributes to blue-green algal blooms, overabundant vegetation growth, and a general decline in water quality. Major contributions of excess phosphorus come from sources such as combined sewer overflows, septic system inputs, agricultural runoff, storm water drainage, lawn fertilizer applications, and improper disposal of grass clippings and tree leaves. Owners of water front property can reduce the amount of phosphorus entering the reservoir by taking actions outlined in the public education section of this report.

5 Mechanical Cutting and Harvesting

Mechanical harvesting involves using a large machine to cut and collect unwanted aquatic plants. The machine picks up the cut weeds but leaves small fragments behind. Since Eurasian watermilfoil is able to reproduce from cut fragments, mechanical harvesting can spread this invasive species. Additionally, mechanical harvesting is not selective and will cut both native and exotic plant species. Where both native and non native species are growing together, mechanical harvesting will give an advantage to Eurasian watermilfoil over any native species that are present, given its growth and reproductive characteristics. Each fragment clipping of Eurasian watermilfoil is capable of becoming reestablished as a complete plant. For these reasons, mechanical harvesting is not recommended in any area inhabited by Eurasian watermilfoil. Harvesting can be accomplished by individual owners around their dock areas. A lake property owner can legally harvest a 625 square foot area (25 feet by 25 feet).

6 Hand-Pulling, Cutting, Raking

Manual controls such as hand pulling, cutting, and raking can be effective ways to control unwanted plants in certain situations. In very shallow clear water, small areas of vegetation can be identified and cleared by hand. Large areas of vegetation, especially those in deeper water, can be extremely difficult to control using these methods. Many of the harvested weeds will break apart, leaving the root system in the lake bottom. Failure to remove root structures will result in re-growth.

Plants such as Eurasian watermilfoil, that possess the ability to reproduce through fragmentation, can seldom be effectively controlled by these methods if they are distributed throughout a lake. Identifying every area of infestation would be difficult, as would harvesting the plants without causing fragmentation of plant parts. Any plant fragments not removed from the water can form new plants, meaning that hand pulling and cutting can facilitate the spread of unwanted plant species such as Eurasian watermilfoil. The infestation of Eurasian watermilfoil has been too large in recent years within Geist Reservoir and shown too high of a potential for expansion for hand-pulling, cutting, or raking to be viable options.

7 Bottom Barriers

Bottom barriers prevent the growth of aquatic plants by lining the bottom of a lake or pond with a material that prohibits light from reaching the lake bottom, and prohibits penetration of aquatic vegetation. Often, plastic or concrete barriers are installed during construction of a lake or pond to prevent subsequent growth of aquatic vegetation. This form of control is best implemented during construction of a new pond or reservoir. Placing a bottom barrier in an existing reservoir would involve significant logistical challenges and would be extremely expensive. A draw down of the reservoir may be necessary to install the barrier. Once in place, the barrier would prevent plant growth of both invasive and native species, and would deprive the ecosystem of the

benefits provided by native aquatic plants. Sediment would gradually accumulate on top of the barrier, and aquatic plant growth would return as plants begin to take root in the sediment on top of the barrier; bottom barriers generally do not provide effective long-term control. Bottom barriers may not be placed without a permit for shoreline construction from the IDNR Division of Water. The complex ownership of this waterbody would also require permission from the City of Indianapolis. Bottom barriers are not a management option for Geist Reservoir as the priority is to maintain function a drinking water supply.

8 Biological Controls – Water Milfoil Weevil

The water milfoil weevil is a native North American insect that consumes Eurasian watermilfoil and northern milfoil. The milfoil weevil burrows into the stem and consumes tissue of the plant. Holes in the milfoil stem bored by weevil larvae allow disease an entrance pathway. These same holes also cause a release of the plant's gases, which reduces buoyancy and causes the plant to sink. All biological controls, including water milfoil weevil stocking, may not be implemented without an aquatic plant control permit from the IDNR Division of Fish & Wildlife.

Studies conducted to evaluate the effectiveness of the water milfoil weevil have not yielded consistent results. Factors influencing the weevil's success or failure in a body of water are not well documented. In 2003, Scribailo and Alix conducted a weevil test on Round Lake in Indiana and found no conclusive evidence that Eurasian watermilfoil populations were reduced. In addition to this potential ineffectiveness, a large population of Eurasian watermilfoil must be present to support the weevil population. For both of these reasons, using the water milfoil weevil as a biological control for Eurasian watermilfoil is not recommended at Geist Reservoir.

9 Biological Controls – Grass Carp

The Asian grass carp (*Ctenopharyngodon idella*) is an herbivorous fish that is native to eastern Russia and China. This fish has been introduced into the U.S. to help control aquatic vegetation. To prevent their uncontrolled proliferation, all fish stocked in Indiana must be triploid, meaning that they are sterile and cannot reproduce. Stocking is restricted to privately owned bodies of water, and suppliers must obtain a special permit from the IDNR. All biological controls, including grass carp stocking, may not be implemented without an aquatic plant control permit from the IDNR Division of Fish & Wildlife.

Grass carp are completely vegetarian feeding on many species of submersed plants, in addition to some floating plants such as duckweed. Hydrilla, a highly invasive plant found in many southern states, is a preferred food of grass carp, and efforts to control hydrilla with grass carp have been successful. However, grass carp avoid Eurasian watermilfoil and show strong preferences for many native plants in addition to hydrilla. Therefore, since Eurasian watermilfoil dominates the aquatic vegetative community, grass carp are not recommended for Geist Reservoir.

10 Chemical Controls – Aquatic Herbicides

There are two major categories of aquatic herbicides: contact and systemic. Contact herbicides are not selective, and thus are best used to control plants around piers and in navigation channels. Given the lack of selectivity and their inability to eliminate the root systems of treated plants,

contact herbicides have the potential to cause unnecessary damage to native species. Additionally, there is potential for re-infestation of Eurasian watermilfoil.
Although contact herbicides generally are not selective, timing and dosage can be adjusted to make them affect the target species with less damage to non-target species. The phenological timing method of contact herbicide treatment for Eurasian watermilfoil has shown some success. Recent tests have shown that by adjusting the dosage higher and timing the treatment exactly, a systemic effect on Eurasian watermilfoil can be achieved with contact herbicides. This method involves treating the plants very early in the spring when carbohydrate reserves of Eurasian watermilfoil have left the root structure, promoting rapid growth in the other plant structures. Since Eurasian watermilfoil is growing more actively earlier in the spring than other species, the risk to non-target plants is relatively low if timed properly.

Systemic herbicides are absorbed by the plant and transported to the root systems where they kill both the roots and the plant. Systemic herbicides effectively kill Eurasian watermilfoil plants and roots.

The public's primary concern with the use and application of aquatic herbicides is safety. Each chemical registered for aquatic applications has undergone extensive testing prior to becoming available for use. It is imperative that any aquatic herbicide be approved for drinking water supplies and are applied by a licensed professional in accordance with its label to minimize potential side-effects. Geist Reservoir is a drinking water reservoir and therefore treatment with chemical controls should be thoroughly evaluated. Permits from IDNR and IDEM are required for any chemical application proposed for the reservoir.

Public Involvement and Education

A public meeting was held January 27, 2010 at the Geist Elementary School in Fortville, Indiana. Approximately twenty individuals attended the meeting which represented Geist Reservoir property owners, surrounding businesses, Geist Watershed Alliance members, herbicide applicators, and representatives from Veolia Water Company. V3 discussed current plant management activities, the LARE program, results of the Tier II vegetation surveys, and future management options. A waterbody use survey was handed out after the meeting and ten individuals participated. Summary totals from the completed waterbody use survey are shown in Figure 6. Half of the survey participants were reservoir property owners. Two of the survey participants were members of the Geist Watershed Alliance and one participant indicated on the survey form their intent to join the group. Six of the survey participants were members of a homeowners association which consisted of Breakwater, Geist Property Homeowners Association, Grey Eagle Homeowners Association, Masthead and Timberstone. Three of the participants had been at the reservoir for 10 years or more and two participants had been at the reservoir between five to ten years. Two participants had been at the reservoir for five years or less. Questions concerning reservoir use found that the main uses among those surveyed were boating and drinking water (7 and 5 participants respectively). Four participants indicated they used the reservoir for swimming and three indicated they used the lake for fishing. Nobody surveyed used the reservoir for irrigation. Questions concerning problems with the lake identified five of the participants had nuisance quantities of aquatic vegetation at their shoreline yet only 2 participants currently participate in a weed control project. Seven participants felt the level of aquatic vegetation did not interfere with their enjoyment of the reservoir. The question regarding the level of aquatic vegetation affecting property values was split with 3 participants feeling property values were affected and 3 participants feeling property values weren't affected. Seven of those surveyed were aware of LARE contributions for controlling invasive exotic vegetative species. Five participants were in favor of continuing efforts to control vegetation in the reservoir. The main issues identified by participants for Geist Reservoir were poor water quality, not enough aquatic plants, and dredging needed (7, 6, and 5 participants respectively). Two participants felt that too many boats accessing the lake and excess nutrients are a problem.

Overall individuals that attended the meeting expressed concern over Eurasian watermilfoil abundance and lack of native species within the reservoir. Lenore Tedesco of IUPUI was present for the public meeting and answered many of the questions attendees had concerning the toxic algae problem at Geist Reservoir. The relationship between algae growth and Eurasian watermilfoil abundance was discussed until attendee's questions were satisfied.

Aquatic Vegetation Management Plan
Waterbody Use Survey for Geist Reservoir

Are you a reservoir property owner? Yes 5 No 5

Are you currently a member of the Geist Watershed Alliance? Yes 2 No 8

Are you currently a member of a homeowners association? Yes 6 No 4
If yes which one: Breakwater, Geist Property Homeowners Association (2), Grey Eagle Homeowners Association, Masthead, Timberstone

How many years have you been at the reservoir?

2 or less	1	5-10 years	2
2-5 years	1	Over 10 years	3

How do you use the reservoir (mark all that apply)

4	Swimming	0	Irrigation
7	Boating	5	Drinking water
3	Fishing	0	Other_____

Do you have aquatic plants at your shoreline in nuisance quantities? Yes 5 No 1

Do you currently participate in a weed control project on the reservoir? Yes 2 No 5

Does aquatic vegetation interfere with your use or enjoyment of the reservoir? Yes 1 No 7

Does the level of vegetation in the reservoir affect your property values? Yes 3 No 3

Are you in favor of continuing efforts to control vegetation in the reservoir? Yes 5 No 1

Are you aware that the LARE funds will only apply to work controlling invasive exotic species, and more work may need to be privately funded? Yes 7 No 3

To assess the overall problems associated with your reservoir, please mark any you feel are issues.

2	Too many boats access the reservoir	1	Overuse by nonresidents
1	Use of jet skiis on the reservoir	0	Too many aquatic plants
0	Too much fishing	6	Not enough aquatic plants
0	Fish population problem	7	Poor water quality
5	Dredging need	4	Other: excess nutrients (2), toxic algae, lack of natural areas

Please add any comments:

_____

Figure 6: Summary totals from the 2009 Waterbody Use Survey.

People within the Geist watershed play an important role in establishing and maintaining a healthy aquatic community. The Geist Watershed Alliance is a non-profit organization focused on the improvement and protection of Geist Reservoir's water quality. Its membership consists of many types of stakeholders seeking to ensure that the lake will remain a healthy recreational and drinking water resource within the Central Indiana region. Joining a group that is active in water quality issues related to Geist Reservoir is a great way to gain information about management practices and current issues.

The stakeholders of the Geist Reservoir/Upper Fall Creek Watershed have many important partners in conservation including:

- Geist Watershed Alliance (GWA),
- Upper White River Watershed Alliance (UWRWA),
- Indiana University Purdue University Indianapolis- Center for Earth and Environmental Science (IUPUI-CEES),
- Indiana Department of Natural Resources (IDNR) ,
- Indiana Department of Environmental Management (IDEM),
- Hamilton County Soil and Water Conservation District,
- Hancock County Soil and Water Conservation District,
- Henry County Soil and Water Conservation District,
- Madison County Soil and Water Conservation District,
- Marion County Soil and Water Conservation District, and
- Veolia Water Indianapolis, LLC.

The Geist Watershed Alliance has a website that provides resources for more information on water quality and other partnerships which can be accessed at the following link: http://atgeist.com/water/ .

Public involvement and educational needs are critical with respect to a new threat to Indiana lakes from an invasive aquatic plant called Hydrilla (*Hydrilla verticillata*). In 2006, on Lake Manitou (adjacent to Rochester in Fulton County), an area infested with this problematic aquatic plant was identified. Efforts are currently underway to resolve the problem, but it is critical if this plant is seen at Geist Reservoir for the state to be notified as soon as possible.

Hydrilla can be differentiated from the native elodea in that there are typically 3 leaves per whorl on the native elodea and there are as many as eight leaves per whorl in Hydrilla. Elodea is also smooth to the touch where as Hydrilla is rough. Figure 7 (Michigan Sea Grant 2007) demonstrates a means of comparative identification.

Additional information can be found from the national campaign to *Stop Aquatic Hitchhikers!* at http://www.protectyourwaters.net/

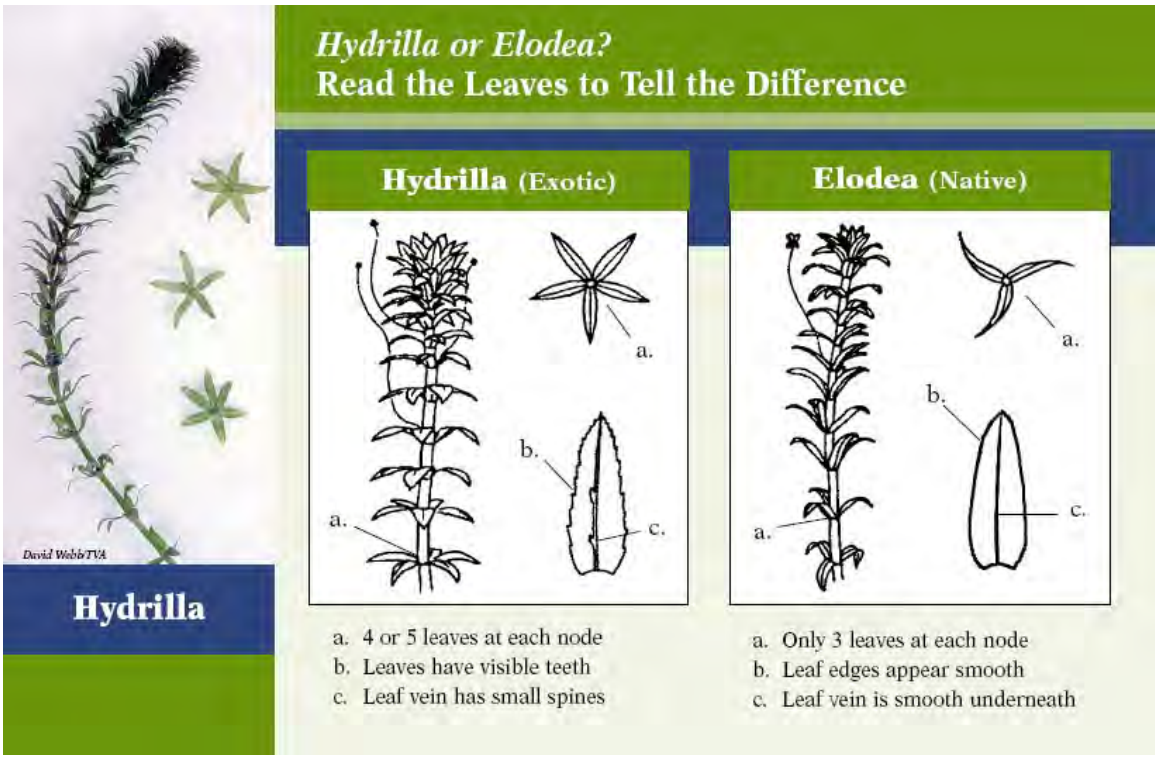

Figure 7: Illustration of Hydrilla compared to native elodea. (Illustrations provided by Michigan Sea Grant)

In addition to these state and aquatic ecosystem issues, stakeholders can be educated regarding practical steps that can reduce nutrient loading and improve the Geist Reservoir ecosystem, when such practices are implemented collectively. These best management practices are also beneficial in promoting a desirable native plant community.

1. **Proper Maintenance of Boat Motors.** Improperly maintained boats may leak gasoline or oil directly into the waterbody, which is detrimental to aquatic ecosystems. Educating waterbody users about the importance of properly maintaining their boat motors is an easy and effective step to improve water quality.

2. **Limit Lawn Fertilizer Use Adjacent to Reservoir.** If a fertilizer application must be applied, avoid spreading fertilizer directly into the reservoir, on sidewalks, or seawall where it will wash into the reservoir. Choose phosphorus free fertilizers or have the soil tested for fertilizer needs prior to application. Fertilizer application should be avoided within 30 feet of the waterbody if possible. In addition, a buffer strip of native vegetation along the waterbody allows runoff to be filtered before it enters the reservoir.

3. **Promote Agricultural Best Management Practices.** Work with farmers within the upstream watershed to increase filtration and purification of agricultural runoff before water reaches the waterbody. Indiana offers incentives for farmers to address soil and water concerns through the U.S. Department of Agriculture. The Indiana Conservation Reserve Program (CRP) provides technical and financial aid to reduce soil erosion, reduce sediment in lakes and streams, and improve overall water quality. Farmers owning highly erodible land or property adjacent to tributary streams, lakes or reservoirs may be

eligible for funding to implement practices that increase water quality. Further information is available from the Indiana Natural Resources Conservation Service (NRCS).

4. **Disposal of Grass Clippings**. Avoid blowing grass clippings and tree leaves into the reservoir. Grass clippings blown into a waterbody can quickly turn into a floating mat of algae because cut and decaying vegetation rapidly releases nutrients into the water.

5. **Urban Stormwater Best Management Practices**. Prevent or reduce urban and industrial runoff flowing directly into the reservoir. Urban runoff can be one of the most detrimental factors influencing water quality. Nutrients and sediment are conveyed into the waterbody through storm sewers and overland flow. Additionally, oil, antifreeze, gasoline, road salt, and other pollutants are washed from pavement through the storm sewer system, and are detrimental to aquatic ecosystems. The following are practical steps recommended by the U.S. Environmental Protection Agency to reduce urban runoff.

a) Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss,
b) Limit land disturbance such as clearing and grading and cut and fill to reduce erosion and sediment loss,
c) Limit disturbance of natural drainage features and vegetation,
d) Place bridge structures so that sensitive and valuable aquatic ecosystems are protected,
e) Prepare and implement an approved erosion control plan,
f) Ensure proper storage and disposal of toxic material,
g) Incorporate pollution prevention into operation and maintenance procedures to reduce pollutant loadings to surface runoff, and
h) Develop and implement runoff pollution controls for existing road systems to reduce pollutant concentrations and volumes.

6. **Protect Wetlands**. Establish ecological zones to protect existing wetlands and emergent vegetation from turbulence caused by boats. Wetlands are valuable components of aquatic ecosystems because they filter water and stabilize shoreline areas. Submersed and emergent vegetation can be eliminated by heavy wave action, which destabilizes the shoreline.

Action Plan

At this time, based on the use of the reservoir, status of the existing aquatic vegetation, competition with blue-green algae and ongoing preparation of the Watershed Management Plan no action is the recommended management for the existing vegetation in the reservoir. The exotic vegetative species abundance may remain stable, or it may increase from year to year. This uncertainty coupled with the known issue of blue-green algae in the reservoir leaves the recommendation of no action as the appropriate plan.

In the following years aquatic vegetation surveys should be continued to monitor the exotic species population. The abundance and distribution of Eurasian watermilfoil will be recorded using the current IDNR Tier II sampling protocol. The survey will also document whether native plants remain protected. The new data analysis results will be incorporated into the current aquatic vegetation management plan. This will provide property owners, applicators, and the IDNR with detailed records describing the changes within the vegetative communities of Geist Reservoir.

Project Budget

There is no project budget at this time as we have recommended no action until the management plan is complete.

Timeline for LARE Grant Applications

LARE grants are available on a competitive basis for actions that can address the ecology and management of public lakes and their watersheds. The UWRWA must comply with IDNR grant deadlines to remain eligible for funding assistance with management of invasive aquatic plants such as Eurasian watermilfoil.

Associations must apply for funding assistance by January 15 and grant application forms can be obtained through the LARE website (www.in.gov/dnr/fishwild/3302.htm). Aquatic vegetation control permits should ideally be completed by January 31st and submitted to DNR Division of Fish and Wildlife commercial license clerk. Award notices are announced in March. If a lake has received funding, a request for proposals that is prepared by LARE staff should ideally be submitted to contractors by the end of March. Contractor qualifications and experience should be thoroughly reviewed before a final selection is made. Contracts for a planning consultant and herbicide treatment contractor should ideally be signed by the month of April to accommodate early spring treatments and spring surveys if applicable.

Monitoring and Plan Updates

This vegetation management plan should be evaluated annually to assess the progress made as well as to revise the plan, if appropriate, based on the progress achieved. As an action plan is implemented, aquatic vegetation surveys will help to monitor the effectiveness of the management strategy. The abundance and distribution of Eurasian watermilfoil will be recorded using the current IDNR Tier II sampling protocol.

Additional Funding Sources

Identifying additional funding sources for improvement of Geist Reservoir's watershed is important as State funding is limited. In addition to the LARE Program, there are many other sources of potential funding to help improve the quality of Indiana Lakes and water resources such as Geist Reservoir. Many government agencies assist in projects designed to improve environmental quality.

The Environmental Protection Agency, the Indiana Department of Environmental Management, and the U.S. Forest Service also have numerous programs for funding. A few of these are listed below. More information can be found at www.in.gov/idem and www.fs.fed.us/.

- U.S Environmental Protection Agency Environmental Education Program (EPA)
- Community Forestry Grant Program (U.S. Forest Service)

The USDA has many programs to assist in environmental improvement. More information on the following programs can be found at www.usda.gov.

- Watershed Protection and Flood Prevention Program
- Wetlands Reserve Program
- Grasslands Reserve Program
- Wildlife Habitat Incentive Program
- Small Watershed Rehabilitation Program

The following programs are offered by the U.S Fish and Wildlife Service. More information about the Fish and Wildlife Service can be found at www.fws.gov.

- Partners for Fish and Wildlife Program
- Bring Back the Natives Program
- Native Plant Conservation Program

References

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APPENDIX I.

DATA SHEET, TIER II LATITUDE/LONGITUDE

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Geist Reservoir	**DATE:** 6-9-09
COUNTY: Hamilton & Marion	**SECCHI DEPTH (FT):**
SITE ID:	**MAX PLANT DEPTH (FT):**
SURVEYING ORGANIZATION: V3 Companies	**WEATHER:** Partly Sunny
CREW LEADER: Jessica Dunn	**COMMENTS (Include voucher codes - V1, V2...):**
RECORDER: Phil Rezin	
CONTACT INFO: Jdunn@v3co.com	

Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.

Species Codes:

GPS #	Point #	R/T	Latitude	Longitude	Depth	ALGA	ELOCAN	CHARA	CERDEM	MYRSPI	JUSAME			Notes
794	1				3	9								
	2				1	9	1	1						filamentous
	3				6	9			1					
797	4				7				1					
798	5				4					1				
799	6				6									MYRSPI w/ Algae in channel
800	7				7									NO VEG
	8				1					1				NO VEG
2nd section	9				3					9				
	10				7									NO VEG
	11				6									NO VEG
	12				4									NO VEG
	13				9									NO VEG
	14				3									NO VEG
808	15				8									
	16				2					3	9			Milfoil bed & JUSAME
	17				7									NO VEG
811	18				4									NO VEG
	19				3					1	9			JUSAME 9
	20				4					3				
	21				6									NO VEG
	22				4					3	1			
816	23				1									NO VEG
	24				7									NO VEG
	25				2					1	1			
	26				2									No Veg
820	27				6									NO veg
	28				14									No veg
	29				4									No veg
	30				2									No veg
	31				1									No veg
825	32				2					3				milfoil bed
	33				7									NO VEG

Other plant species observed at lake:

emergent: pickeral,

JUSAME- Water willow

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Geist Reservoir	**DATE:** 6/11/09
COUNTY: Hamilton & Marion county	**SECCHI DEPTH (FT):**
SITE ID: 1	**MAX PLANT DEPTH (FT):**
SURVEYING ORGANIZATION: V3 Companies	**WEATHER:** Cloudy/Rainy
CREW LEADER: Jessica Dunn	**COMMENTS (Include voucher codes - V1, V2...):**
RECORDER: Jessica Dunn	
CONTACT INFO: JDunn@V3co.com	***Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.***

	Point #	R/T	Latitude	Longitude	Depth	Species Codes: MYRSPI	USAME							Notes
827	34	R			12									NO VEG
	35	R			3	3								MYRSPI
829	36	R			9	1								NO VEG
	37	R			4	5	9							MYRSPI bed
	38	R			1.5	3	1							
832	39	R			6									NO VEG
	40	R			4									NO VEG
	41	R			3	3								MYRSPI
	42	R			2		9							NO VEG ROCKY
	43	R			[illegible]	[illegible]	[illegible]							NO VEG
837	44	R		4 → [illegible]		3	9							Up to 7 ft MYRSPI
	45	R			6									NO VEG
839	46	R			3	3	1							
	47	R	photo not	MYRSPI-bed	4	3								[illegible]
	48	R	bank	[illegible]	7									NO VEG
	49	R			14									NO VEG
843	50	R			2									
	51	R			2	1								
	52	R			7									NO VEG
	53	R			3									NO VEG ROCKY
	54	R			2	5	9							
848	55	R			6		9							NO VEG
	56	R			4									NO VEG ROCKY
850	57	R			8									NO VEG
	58	R			3		1							
852	59	R			4									NO VEG
	60	R			6		9							NO VEG
	61	R			3	5	9							
	62	R			2	1	9							
856	63	R			8									NO VEG
	64	R			2	9	3							water smartweed
	65	R			3	1	3							
859	66	R			9									No veg, Rocky Substrate

Other plant species observed at lake:

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Geist Reservoir	DATE: 6/11/09
COUNTY: Hamilton & Marion	SECCHI DEPTH (FT): 4
SITE ID:	MAX PLANT DEPTH (FT):
SURVEYING ORGANIZATION: V3 Companies	WEATHER: cloudy / partly sunny
CREW LEADER: Jessica Dunn	COMMENTS (Include voucher codes - V1, V2...):
RECORDER: Jessica Dunn	
CONTACT INFO: jdunn@v3co.com	Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.

	Point #	R/T	Latitude	Longitude	Depth	Species Codes: JUSAME	ALGA	MYRSPI						Notes
860	67	R			4	1								
	68	R			11									No veg
	69	R			8									No veg
	70	R			3	9	9							
864	71	R			4									No veg
865	72	R			1	1								
	73	R			7									No veg
	74	R			2	1								JUSAME bed
	75	R			3									No veg
	76	R			2	3								
870	77	R			13									No veg
	78	R			4	3								
	79	R			6	9								No veg
873	80	R			3	1								JUSAME stand
	81	R			3									
	82	R			8									no veg
876	83	R			12									no veg
877	84	R			14									no veg
878	85	R			3	1		3						
	86	R			6									
	87	R			3	1		3						
881	88	R			2	1		9						
	89	R			3	1		1						
	90	R			7									NO VEG
	91	R			4			1						MYRSPI bed
	92	R			7									NO VEG
886	93	R			14									NO VEG
887	94	R			3	1		3						
888	95	R			7									NO VEG
890	96	R			4			5						
891	97	R			6									NO VEG
	98	R			4			1						
	99	R			2			1						
	100	R			8									NO VEG

Other plant species observed at lake:

temp. 24.4, 522 us, .3 ppt, 8.6 pH, 516 us cond
Sp. cond

889 → dense milfoil bed

* Hummingbird 01

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Geist Reservoir	**DATE:** 8-17-09
COUNTY: Hamilton & Marion	**SECCHI DEPTH (FT):**
SITE ID:	**MAX PLANT DEPTH (FT):**
SURVEYING ORGANIZATION: V3 Companies	**WEATHER:** Cloudy
CREW LEADER: Jessica Dunn	**COMMENTS (Include voucher codes - V1, V2...):**
RECORDER: "	
CONTACT INFO: Jdunn@v3co.com	***Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.***

Species Codes: MYRSPI, Algae, ELOCAN, NELLUT, NAJGRA, CERDEM, POTSPI (NARROW LEAVED), JUSAME

GPS#	Point #	R/T	Latitude	Longitude	Depth	MYRSPI	Algae	ELOCAN	NELLUT	NAJGRA	CERDEM	POTSPI	JUSAME	Notes
794	1				3	1	9							Very little/brown
	2				2			1	9	9				NAJGRA - found in channel
796	3				6		9							filamentous/Noveg
798	4				3									NOVEG
799	5				4									NOVEG
	6				6	1	9				1	1		
	7				8									Noveg
	8				3		9							Noveg
	9				4									Noveg
	10				7									Noveg
	11				6									Noveg
	12				4	1							9	brown
	13				3		9							Noveg
	14				9									Noveg
	15				3									Noveg → rocky
	16				4									Noveg
	17				9									Noveg
	18				2								9	Noveg
	19				9									Noveg
	20				4	3							9	brown
	21				6									Noveg
	22				4	1	9						9	
	23				11									NOVEG
	24				7									NOVEG
	25				3	1							9	
	26				2									Noveg
	27				6								1	
	28				14									Noveg
	29				4									Noveg
	30				3		9						9	Noveg
	31				11									Noveg
	32				2	5								MYRSPI Brown
	33				7									NOVEG

Other plant species observed at lake:

NAJGRA - Bushy Naiad Creeping water primose in N lobe

Erosion near station 4

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Geist Reservoir	**DATE:** 8-18-09
COUNTY: Hamilton & Marion	**SECCHI DEPTH (FT):**
SITE ID:	**MAX PLANT DEPTH (FT):**
SURVEYING ORGANIZATION: V3 Companies	**WEATHER:** Sunny
CREW LEADER: Jessica Dunn	**COMMENTS (Include voucher codes - V1, V2...):**
RECORDER: "	
CONTACT INFO: Jdunn@v3co.com	***Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.***

Point #	R/T	Latitude	Longitude	Depth	Species Codes: MYRSPI	JUSAME							Notes
34	R			13									NOVEG
35	R			3	3	9							MYRSPI Bed
36	R			8									NOVEG
37	R			3	5	9							brown MYRSPI
38	R			2		9							NOVEG
39	R			6									NOVEG
40	R			4									NOVEG
41	R			3	1								
42	R			2	1	9							
43	R			8									NOVEG
44	R			4	1	1							
45	R			8									NOVEG
46	R			3	9	9							
47	R			4	5								
48	R			7									NOVEG
49	R			14									NOVEG
50	R			2	1	9							
51	R			3	1								
52	R			7									NOVEG
53	R			3									NOVEG
54	R			2	1	9							
55	R			6									NOVEG
56	R			4									NOVEG
57	R			8	1								
58	R			3		9							NOVEG
59	R			4		9							NOVEG
60	R			6									NOVEG
61	R			3	3	9							
62	R			2	3	9							
63	R			8									NOVEG
64	R			2	3	1							
65	R			3	5	9							
66	R			8									NOVEG

Other plant species observed at lake:

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Beist Reservoir	**DATE:** 8-18-09
COUNTY: Hamilton & Marion	**SECCHI DEPTH (FT):** 2
SITE ID:	**MAX PLANT DEPTH (FT):**
SURVEYING ORGANIZATION: V3 Companies	**WEATHER:**
CREW LEADER: Jessica Dunn	**COMMENTS (Include voucher codes - V1, V2...):**
RECORDER: Jessica Dunn	
CONTACT INFO: JDunn@v3co.com	***Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.***

Point #	R/T	Latitude	Longitude	Depth	Species Codes: JUSAME	MYRSPI	CERDEM						Notes
67	R			4	1								
68	R			11									NOVEG
69	R			8									NOVEG
70	R			3	9								NOVEG
71	R			4									NOVEG
72	R			2	9								NOVEG
73	R			7									NOVEG
74	R			2	9								NOVEG
75	R			3	9								NOVEG
76	R			2	1								
77	R			13									NOVEG
78	R			4	1								
79	R			6									NOVEG
80	R			3	3	9							
81	R			3	5	9							
82	R			8									NOVEG
83	R			12									NOVEG
84	R			18									NOVEG
85	R			2	9	5							
86	R			7									NOVEG
87	R			3		5							
88	R			2		1							
89	R			3									NOVEG
90	R			8									NOVEG
91	R			4									NOVEG
92	R			7									NOVEG, ROCKY
93	R			13									NOVEG
94	R			3	9	9							
95	R			7									NOVEG
96	R			4	9	1	1						
97	R			6	9	9							NOVEG
98	R			4	1								
99	R			2	5								LARGE MYRSPI bed
Other plant species observed at lake:													
100	R			8									NOVEG

• turbidity 5.99 • temp 27.6 • .2 ppt salinity

• Secchi 2ft • 495 conductivity • 8.7 pH

• do 6.47, 79.4% sat • 471 specific cond

Geist Reservoir 2009 Tier II Sampling Locations

Sampling Location	LAT	LON
1	39.9522	-85.9174
2	39.9528	-85.9126
3	39.9517	-85.9149
4	39.9497	-85.8933
5	39.9507	-85.9150
6	39.9504	-85.9163
7	39.9493	-85.9092
8	39.9486	-85.9018
9	39.9525	-85.9224
10	39.9506	-85.9233
11	39.9488	-85.9285
12	39.9482	-85.9330
13	39.9459	-85.9342
14	39.9426	-85.9390
15	39.9405	-85.9396
16	39.9344	-85.9421
17	39.9327	-85.9416
18	39.9447	-85.9370
19	39.9500	-85.9311
20	39.9304	-85.9352
21	39.9323	-85.9357
22	39.9349	-85.9327
23	39.9344	-85.9363
24	39.9376	-85.9357
25	39.9398	-85.9290
26	39.9420	-85.9335
27	39.9442	-85.9314
28	39.9454	-85.9300
29	39.9476	-85.9258
30	39.9489	-85.9230
31	39.9508	-85.9192
32	39.9285	-85.9423
33	39.9269	-85.9420
34	39.9289	-85.9402
35	39.9268	-85.9437
36	39.9260	-85.9471
37	39.9282	-85.9489
38	39.9303	-85.9485
39	39.9298	-85.9514
40	39.9322	-85.9508
41	39.9317	-85.9586
42	39.9329	-85.9607
43	39.9319	-85.9617
44	39.9313	-85.9646
45	39.9307	-85.9664
46	39.9291	-85.9688
47	39.9286	-85.9716
48	39.9277	-85.9708
49	39.9265	-85.9727
50	39.9254	-85.9740

Sampling Location	LAT	LON
51	39.9252	-85.9762
52	39.9245	-85.9747
53	39.9228	-85.9758
54	39.9217	-85.9764
55	39.9206	-85.9767
56	39.9187	-85.9778
57	39.9174	-85.9787
58	39.9150	-85.9803
59	39.9156	-85.9823
60	39.9139	-85.9812
61	39.9122	-85.9838
62	39.9104	-85.9847
63	39.9095	-85.9860
64	39.9058	-85.9819
65	39.9070	-85.9799
66	39.9086	-85.9778
67	39.9098	-85.9776
68	39.9116	-85.9748
69	39.9108	-85.9694
70	39.9083	-85.9698
71	39.9046	-85.9702
72	39.9090	-85.9678
73	39.9122	-85.9679
74	39.9120	-85.9654
75	39.9128	-85.9600
76	39.9133	-85.9647
77	39.9131	-85.9678
78	39.9143	-85.9687
79	39.9163	-85.9707
80	39.9154	-85.9728
81	39.9193	-85.9699
82	39.9202	-85.9700
83	39.9218	-85.9678
84	39.9266	-85.9617
85	39.9251	-85.9644
86	39.9241	-85.9676
87	39.9228	-85.9694
88	39.9213	-85.9656
89	39.9205	-85.9620
90	39.9230	-85.9586
91	39.9246	-85.9553
92	39.9255	-85.9530
93	39.9234	-85.9519
94	39.9210	-85.9489
95	39.9210	-85.9450
96	39.9209	-85.9437
97	39.9203	-85.9438
98	39.9238	-85.9398
99	39.9251	-85.9386
100	39.9270	-85.9379

APPENDIX II.

THREATENED AND ENDANGERED SPECIES WITHIN HAMILTON AND MARION COUNTIES

Indiana County Endangered, Threatened and Rare Species List

County: Hamilton

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Fish					
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Amphibian					
Necturus maculosus	Common mudpuppy		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Certhia americana	Brown Creeper			G5	S2B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Thryomanes bewickii	Bewick's Wren			G5	S1B
Mammal					
Lynx rufus	Bobcat	No Status		G5	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Armoracia aquatica	Lake Cress		SE	G4?	S1
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Drosera intermedia	Spoon-leaved Sundew		SR	G5	S2
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G3	S1
High Quality Natural Community					
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3

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State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana County Endangered, Threatened and Rare Species List

County: Marion

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Alasmidonta viridis	Slippershell Mussel			G4G5	S2
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Epioblasma triquetra	Snuffbox		SE	G3	S1
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma parvum	Lilliput			G5	S2
Venustaconcha ellipsiformis	Ellipse		SSC	G3G4	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Insect: Neuroptera					
Sisyra sp. 1	Indiana Spongilla Fly		ST	GNR	S2
Fish					
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Percina evides	Gilt Darter		SE	G4	S1
Amphibian					
Rana pipiens	Northern Leopard Frog		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Clonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Thamnophis butleri	Butler's Garter Snake		SE	G4	S1
Bird					
Aimophila aestivalis	Bachman's Sparrow			G3	SXB
Ardea alba	Great Egret		SSC	G5	S1B
Ardea herodias	Great Blue Heron			G5	S4B
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Certhia americana	Brown Creeper			G5	S2B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Falco peregrinus	Peregrine Falcon	No Status	SE	G4	S2B
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SE	G5	S2
Helmitheros vermivorus	Worm-eating Warbler		SSC	G5	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Mniotilta varia	Black-and-white Warbler		SSC	G5	S1S2B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Pandion haliaetus	Osprey		SE	G5	S1B
Rallus elegans	King Rail		SE	G4	S1B
Sitta canadensis	Red-breasted Nuthatch			G5	S1B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Lutra canadensis	Northern River Otter			G5	S2
Lynx rufus	Bobcat	No Status		G5	S1
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Deschampsia cespitosa	Tufted Hairgrass		SR	G5	S2
Hydrastis canadensis	Golden Seal		WL	G4	S3

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Indiana County Endangered, Threatened and Rare Species List

County: Marion

Species Name	Common Name	FED	STATE	GRANK	SRANK
Juglans cinerea	Butternut		WL	G3G4	S3
Melanthium virginicum	Virginia Bunchflower		SE	G5	S1
Panax quinquefolius	American Ginseng		WL	G3G4	S3
Poa wolfii	Wolf Bluegrass		SR	G4	S2
Rubus odoratus	Purple Flowering Raspberry		ST	G5	S2
Trifolium stoloniferum	Running Buffalo Clover	LE	SE	G3	S1
High Quality Natural Community					
Forest - flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Forest - floodplain mesic	Mesic Floodplain Forest		SG	G3?	S1
Forest - floodplain wet	Wet Floodplain Forest		SG	G3?	S3
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Wetland - fen	Fen		SG	G3	S3

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