Aquatic Enhancement
& Survey, Inc.

Aquatic Vegetation Management Plan 2008-2012

Atwood Lake, LaGrange County

Prepared for the Atwood Lake Association
By
Aquatic Enhancement & Survey, Inc.
Angola, Indiana

December 7, 2008

Aquatic Enhancement
& Survey, Inc.
P.O. Box 1036
Angola, IN 46703

1-888-867-5253
260-665-8226
www.aquaticenhancement.com

Acknowledgements

This work was made possible through cost-share funding provided by a grant from the Indiana Department of Natural Resources, Division of Fish and Wildlife, Lake and River Enhancement (LARE) Program and the Atwood Lake Association. I would like to thank the following persons who contributed time, data, and literature necessary for the preparation of this update: Ted A. Kirschner, John Lordier and the other officers and members of the Atwood Lake Association, Neil Ledet, Larry Koza and Gwen White of the Indiana Department of Natural Resources Division of Fish and Wildlife, Ronald Hellmich of the Indiana Department of Natural Resources Division of Nature Preserves, Dr. Robin Scribailo and Mitchell Alix of Purdue University North Central and The Sportsman's Connection. Field work for this document was performed by Scott Banfield and Joseph Closson of Aquatic Enhancement & Survey, Inc.

Scott Banfield, Aquatic Enhancement & Survey, Inc.

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Executive Summary

Atwood Lake is a kettle lake of approximately 170 acres located in South Central LaGrange County Indiana. The lake is roughly oval in shape and is relatively shallow with an average depth of nine feet and a maximum depth of 33 feet. The lake exhibits low to moderate summertime water clarity with a Secchi depth of 4.3 feet recorded in August of 2008. In 2003 water quality data collected gave the lake a "mesotrophic" status indicating a moderate amount of nutrient enrichment and average water quality. The general public gains access to Atwood Lake through an IDNR launch ramp located on a channel in the lake's southwest corner. The majority of the lake's shoreline has been developed with cottages, single family homes, and a campground. Atwood Lake has a watershed area of approximately 521 acres with the primary land-uses being agriculture (54%) followed by residential (15%) and woodlands (14%). The primary lake-related activities occurring at Atwood Lake include; enjoying the aesthetics of the lake-environment, swimming, boating, and fishing. Residents of Atwood Lake have been represented by the Atwood Lake Association, Inc. (ALA) since about 1990. The association serves as the local advocate for the protection and health of the lake and its surrounding community. Various general fish surveys performed on Atwood by the Indiana Department of Natural Resources (IDNR) in 1965 through 1988 have shown problems with lagging growth of panfish species such as Bluegills and Redear sunfish. In 1967 through 1972 partial fish eradication projects helped somewhat with the problems but results were not long lasting. Problems with panfish growth rates persist to this current day. Many residents are, however, satisfied enough with the Largemouth bass fishery at the lake to forgo further attempts at partial eradications in the present day. At some point in the past the non-native potentially invasive aquatic plants Eurasian watermilfoil *Myriophyllum spicatum* and Curlyleaf pondweed *Potamogeton crispus* found their way into Atwood Lake. By 2004 the invasive milfoil had heavily colonized much of the lake's littoral zone creating a major hindrance for recreational activities and threatening the ecological integrity of the lake's plant community. Curlyleaf pondweed has also been hindering recreational use in some shoreline and channel areas until mid-summer after which the plants naturally decline for the remainder of the season. In 2004 it was necessary for the A.L.A. to fund the treatment of 28 acres of dense milfoil growth. For the 2005 season the A.L.A. applied to the IDNR Lake and River Enhancement Program (LARE) for cost-share funding to develop an aquatic plant management plan and perform a "whole lake" treatment with a fluridone herbicide. Weed Patrol Inc. was contracted for both tasks. The "whole lake" treatment performed well controlling both exotic plants by the end of the 2005 season. The plan developed by Weed Patrol did not, however, gain full approval by IDNR. In 2006 and 2007 no treatment was needed for either Eurasian watermilfoil or Curlyleaf pondweed. Another consultant was retained to complete a plant plan utilizing ALA and LARE funding in 2007 but the plan was not completed. Activities in 2008 were cost-share funded by the ALA and LARE and included plant surveys, treatment of 4 acres of Eurasian watermilfoil, and other activities performed to prepare this plan drafted to supplant the one done in 2005. This plan establishes the following primary goals for Atwood Lake: 1. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality. 2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species. 3. Provide reasonable public recreational access while minimizing the negative impacts on plant, fish, and wildlife resources. To work toward these goals it is recommended that the ALA apply to the IDNR LARE program for assistance to continue management of non-native aquatic plants in 2009 and continue to work toward educating lake users and residents about the options available for managing the lake. It is estimated that the active plant management at Atwood in 2009 will entail the treatment of up to 8 acres of Curlyleaf pondweed and 8 acres of Eurasian watermilfoil. The total cost of treatments in 2009 is estimated to be $6400.00. It is also recommended that this plan be updated in 2009. The total update cost for 2009 is estimated to be $4050.00.

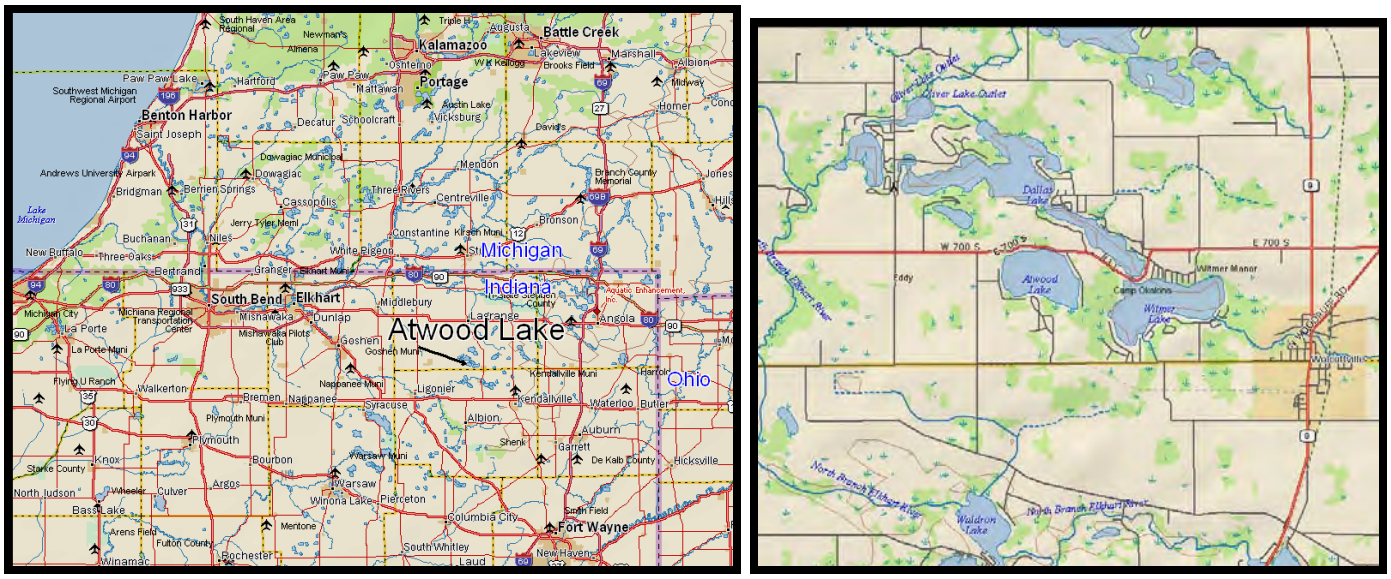


Figure 1 1,200,000 (left) and 68,750 (right). Scale maps showing general location of Atwood Lake

1. Problem Statement

At some point in the past the non-native, potentially invasive, aquatic plant Eurasian watermilfoil *Myriophyllum spicatum* found its way into Atwood Lake. In a 1998 Indiana Department of Natural Resources (IDNR) analysis, Eurasian water milfoil was reported from 173 lakes or 56 percent (33,006 acres) of the total lake surface area in Indiana. (White 1998) In the analysis Eurasian milfoil was noted in 24 of 62 total lakes in LaGrange County (39%). Because Eurasian can be spread by fragments carried on boat trailers it's no surprise that Eurasian watermilfoil ended up in Atwood Lake. There is an IDNR public access ramp located in the southwest corner of the lake where many area residents launch boats. By 2004 the invasive milfoil had heavily colonized much of the lake's littoral zone creating a major hindrance for recreational activities like swimming, fishing, and boating. When colonization of a lake is extensive, boaters tend to hasten spread by creating new plant fragments trying to navigate through thick milfoil growth with outboard motors. Eurasian milfoil often outgrows native species, sometimes developing a thick shading canopy by growing laterally at the surface. This threatened to affect the diversity and health of Atwood Lake's beneficial native plant community, radically changing aquatic habitat and negatively affecting its value to fish and wildlife. Curlyleaf pondweed, another non-native invasive plant is also present in Atwood Lake, hindering navigation and recreational use in some shoreline and channel areas until mid-summer.

2. Management History and Goals

In 2004 the Atwood Lake Conservation Club sought and was granted assistance with the problem through the INDR Division of Fish and Wildlife's Lake and River Enhancement (LARE) program. Cost-share funds were provided to develop an aquatic plant management plan. For the original plant management plan draft for Atwood Lake see ***Atwood Lake Aquatic Plant Management Plan 2005-2008*** **(Weed Patrol Inc. 2005)**

The initial plant plan established the following goals for exotic plant management at Atwood Lake (specified by IDNR):

1. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality.

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

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

After receiving additional assistance for exotic plant control in 2005 the Atwood Lake Association hired Weed Patrol Inc. to perform a whole lake treatment with Sonar® aquatic herbicide (fluridone). In whole lake fluridone treatments doses of a persistent herbicide is applied to the lake's waters and allowed to mix throughout the water body. Various plant species uptake the active ingredient of the herbicide (fluridone) over a period of 60 -90 days and respond in accordance with their respective sensitivity to the herbicide. Typically Eurasian watermilfoil and Curlyleaf pondweed respond to these treatments by dying back and decomposing with most native plant species remain largely unaffected. In this way selective pressure is applied to the lake's plant community to push it back toward dominance by beneficial native aquatic plants. Often two to three seasons of control can be achieved with this method with the invasive milfoil gradually returning. Localized treatments with herbicides can often be effective in delaying the return of major problem milfoil growth if reappearing plants are spotted and treated carefully.

Since Curlyleaf usually produces turions in April, before the whole lake treatments take place, this plant often sprouts at the same growth levels in the season following these treatments. Turions are small reproductive buds that grow on the Curlyleaf plant. Each of these is typically fully formed and viable early in the season and destined to drop from the plant and settle into the lake sediments sprouting as a new plant at some point in the future. Once the turions are viable they typically remain even after their parent plants are killed by an herbicide application. The parent plants simply drop and decompose leaving viable turions to produce the following season's growth.

Eurasian watermilfoil in Atwood Lake was under control by the end of 2005. In 2006 and 2007 the Atwood Lake Association applied for and received cost-share funding from the LARE program to commence treatment of localized Eurasian watermilfoil with 2, 4-D granular herbicide to control returning plants on a small area of the lake. Weed Patrol, Inc. performed the treatments. Because the plan developed by Weed Patrol, Inc. in 2005 was never approved by IDNR the association also applied for funding to redevelop the plan in 2007 and hired a consultant. Work was begun in 2007 on redeveloping the plan but was never completed. In 2008 the Atwood Lake Association was again granted funding for Eurasian water milfoil control and plan redevelopment. Treatment of Eurasian watermilfoil was needed on approximately five acres in 2008 and was completed by Weed Patrol Inc. A small area of the lake was also treated for Curlyleaf pondweed with private funding (IDNR did not provide Curlyleaf pondweed control funding in 2008). To establish measurements of success in working toward the Atwood Lake Association's three primary goals the Atwood Lake Association is advised to continue exotic plant management control that will seek a late-season Tier II Plant Survey sampling site occurrence of five percent or less for both Eurasian watermilfoil and Curlyleaf pondweed.

Year	Consultant Activity	funding	Treatment Activity	Date	funding	Results
2004	Exotic plant survey by applicators (Not LARE funded)	A.L.A.	28 acres Eurasian watermilfoil (Navigate 2,4-D granular 100 lbs per acre)	6/2/04	A.L.A.	Good, no significant milfoil growth observed post-treatment
2005	Surveys and Plan development (Weed Patrol, Inc.) (not approved by IDNR)	LARE/A.L.A.	6 bump 6 whole lake fluridone treatment (170 acres)	5/27/05 initial 6/16/05 bump	LARE/A.L.A	Good, O% occurrence of milfoil in 9/7/05 Tier II sampling
2006	None	LARE/A.L.A.	1.25 acres treated twice for misc. natives	7/5/06 7/12/06	A.L.A.	Good, treatment achieved control of target natives
2007	Surveys and Plan development (Kennedy) Not completed	None, work not completed	4.65 acres treated for misc. natives	7/9/07	A.L.A.	Good, treatment achieved control of target natives
2008	Surveys and Plan developed (Aquatic Enhancement, Inc.)	LARE/A.L.A.	4 Acres Eurasian watermilfoil treated, (2,4-D granular) 7.5 acres of Curlyleaf pondweed treated (Aquathol K) 4.42 acres treated for misc. natives (Reward/Hydrothol191 1 gal/ac. each/Cygnet plus surfactant)	6/9/08 6/9/08 6/19/08	LARE/A.L.A. A.L.A. A.L.A.	Good, milfoil occurrence at 6% of sites in late season Tier II sampling Good, Curlyleaf plants eliminated in treated areas Good, treatment achieved control of target natives

Table 1 Five year aquatic plant management history for Atwood Lake

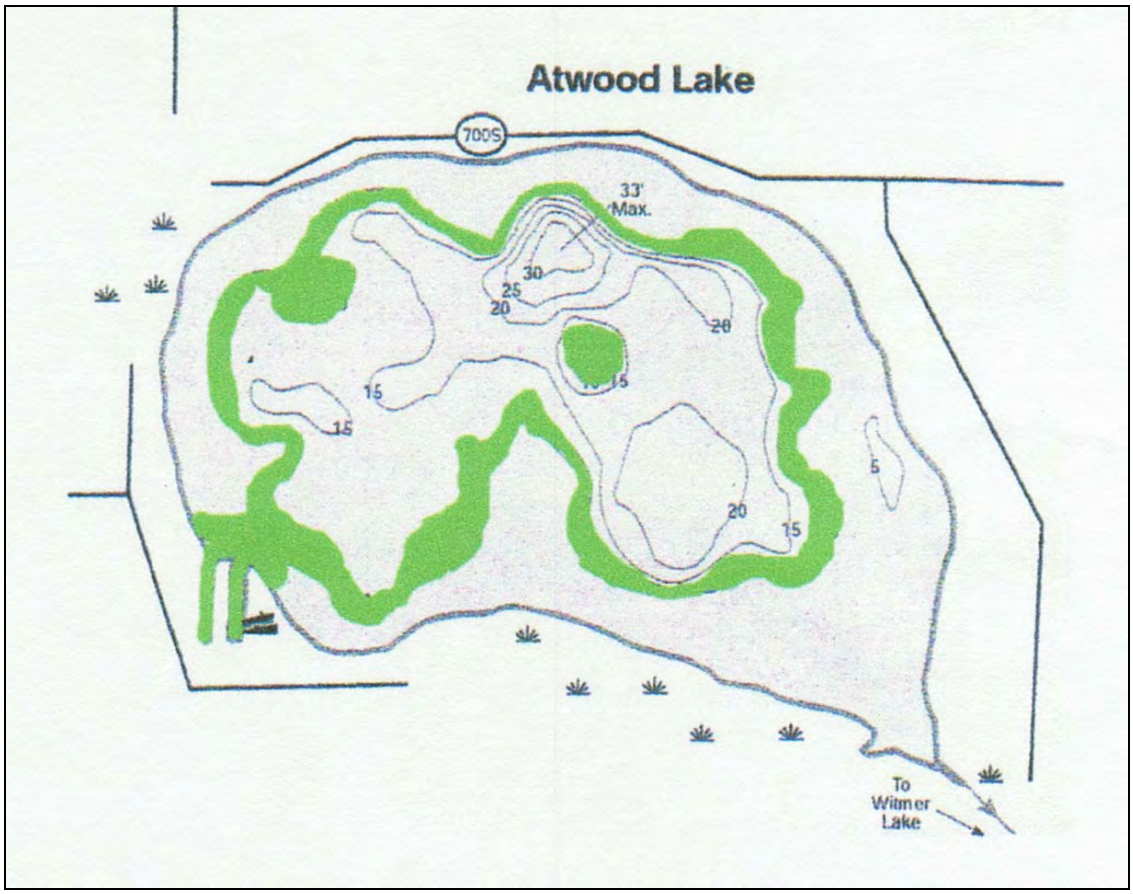


Figure 2 2004 Treatment/milfoil growth map for Atwood Lake (Weed Patrol, Inc.)

Figure 3 Whole lake fluridone treatment area 2005

Figure 4 5/19/08 Curlyleaf pondweed growth area map

Figure 5 6/9/08 Curlyleaf pondweed treatment area map

Figure 6 5/19/08 Eurasian watermilfoil growth area map

Figure 7 6/9/08 Eurasian watermilfoil treatment area map

3. Watershed and Water Body Characteristics

3.1 General Morphometry and Physical Characteristics

Atwood Lake is glacial "kettle" lake of approximately 170 acres located in LaGrange County in Northeast Indiana. Like most LaGrange County lakes Atwood Lake was probably formed during the late Pleistocene era approximately 10,000 years ago by a large glacial ice-block left in the landscape as glaciers that extended over the northern half of Indiana receded northward and melted. The lake is roughly oval in shape lying in an East-West orientation just south of county road East 700 South in South Central LaGrange County Indiana.

Atwood Lake is a fairly shallow lake with a maximum depth of 33 feet in a small hole located offshore in the north-central part of the lake (see contour map below). Atwood has an average depth of nine feet. A shallow littoral flat extends to approximately 300 feet from shore around most of the lakes basin with a drop to a mostly 10-15 foot deep central basin taking place beyond that. A small submersed island extends upward near the center of the lake to a depth of approximately five feet and a second deep hole (20 ft) approximately 8 acres in area is located offshore in the southeast portion of the lake. There are no major tributary streams or ditches that flow into Atwood Lake. The lake contains approximately 1530 acre-feet of water equating to 499,851,000 (just under one half billion) gallons of water.

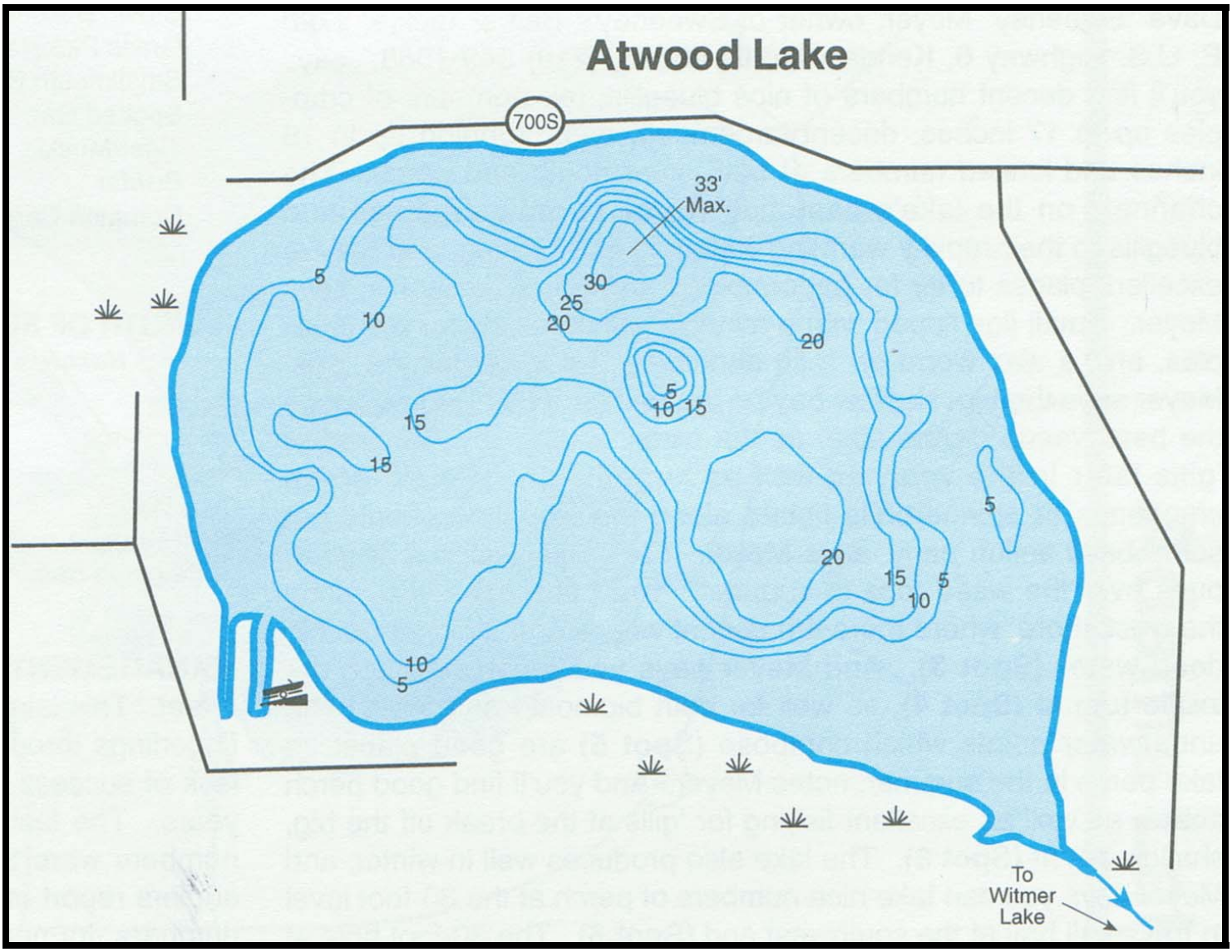


Figure 8 Contour map of Atwood Lake, Data Source IDNR, (Reproduced with permission of Sportsman's Connection)

For this plan an estimate was calculated for the lake's hydraulic residence time. The hydraulic residence (retention) time is the average time that a given drop of water finding its way to Atwood Lake would spend in the lake before passing through the outflow stream. Using annual precipitation data from the Midwestern Regional Climatic Center and data collected from a United States Geological Survey (USGS) operated stream flow gauging station stream in adjacent Steuben County a general runoff coefficient was calculated to provide an estimate of the average inches of runoff entering the lake from its 691 acre watershed. This figure is then used to calculate the volume of estimated runoff entering the lake each year. Dividing the volume of water in the lake by the volume of water flowing into it each year produces a rough estimate of the average time that water spends in the lake.(see figures in table 2 below) The estimated residence time for waters in Atwood Lake is 4.26 years. Because runoff or direct rainfall entering the lake during the summer warm season when the lake is thermally stratified is not likely to mix with the lower waters of the lake, but rather flow through the upper 10 feet of the lake, a more conservative estimate for retention time can be produced assuming the lake to only be comprised of it's upper ten feet of volume. In this case the retention time estimate produced is

3.26 years. When "whole lake" type herbicide treatments are performed it's typically required that the applied herbicide be retained in the waters of the lake for an extended period of time. The estimates for Atwood Lake indicate that even in an especially wet year where an unusually large amount of runoff flows into the lake, the residence time of the lake's waters will be long enough to insure sufficient herbicide retention.

Atwood Hydraulic Residence time Calculation	
Watershed Acres	691
Est. Runoff Coefficient	0.16
Est. Annual Precip. (in)	38.89
Est. Annual Precip. (ft)	3.24
Annual Runoff (ft) (Ann. Precip.)*(runoff coeff)	.52
Ann. Runoff Vol. (ac-ft) (Ft. runoff)*(ac. watershed)	359
Lake Volume (170 ac @ 9 foot avg. depth)	1530
Residence time (yrs) (Lk vol/ann. Runoff)	4.26
Upper 10 ft Lake Volume (170 ac @ 6.9 foot depth)	1173
Residence time of upper ten feet (yrs) assuming no mixing of rainfall/runoff below 10 feet	3.26

Table 2 Estimated residence time calculation for Atwood Lake.

3.2 Water Quality

Atwood Lake generally exhibits low to moderate midsummer water clarity and moderate to good water quality. Lakes are often classified by the amount of nutrients present in their waters, especially phosphorus. Low nutrient waters generally exhibit good water clarity, good oxygen levels, and a moderate to low growths of aquatic plants while waters richer in phosphorus often have lower oxygen levels at depth in deeper water, and poor water clarity, growing large amounts of planktonic algae or aquatic plants. The amount of nutrient enrichment a lake has undergone is sometimes referred to as its degree of eutrophication. Eutrophication occurs naturally as part of an overall aging process experienced by lakes. Over time organic sediments, soil particles, and their associated nutrients are carried by rain runoff and winds naturally settling into the depressions on the landscape. As this occurs waters can become shallower, plant and aquatic animal communities shift and overall productivity can increase. With extensive development or agricultural activity in a lake's watershed or riparian the process is often accelerated drastically over the natural rate of eutrophication. This leads to unstable ecological conditions or pronounced water-quality problems. Lakes that are highly enriched with nutrients tend to have poor plant community diversity in general. Usually highly turbid waters in these cases exclude all species except those that can adapt well to low light conditions. In some cases this can give invasive exotic plants an edge, applying selective pressure away from a diverse native plant

community toward one of low diversity and dominance by undesirable invasives. Because the eutrophication process can affect the ecological health and recreational viability of Indiana's lakes the Indiana Department of Environmental Management collects data on the water quality of our lakes to keep track of statewide trends in this process. Part of this sampling includes the collection of data which is used in a mathematical index (the Indiana Trophic State Index) to produce a numeric score for lake water quality or "eutrophication". Data collected from Atwood Lake in 1993 (See table 3 below) gave the lake an Indiana Trophic State Index (ITSI) score of 18.

Year	ITSI Points	Mean total phos. (ppm) (epilimnion/hypolimnion)	Secchi depth (ft)
1982 (Fish survey)	-	-	7
1988 (Fish survey)			6.5
1993	18	.041	5.9
2000	19	.070	4.3
2003	26	.038	3.6
2008	No data	No data	4.3

Table 3 Basic water quality data from Atwood Lake (IDEM 1993, 2000, 2003, and 2006)

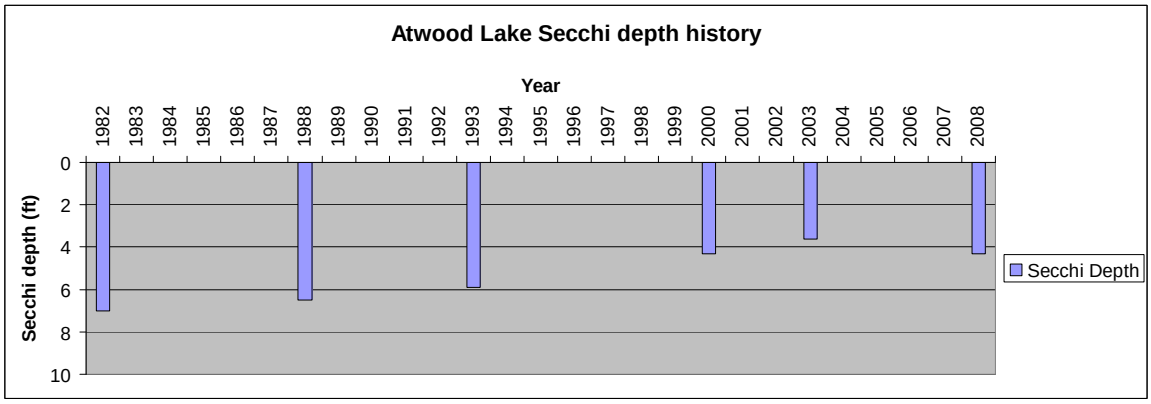


Figure 9 Atwood Lake Secchi depth history

With the ITSI a total score of zero to 25 points represents generally oligotrophic conditions (Class I), 26-50 points generally represent mesotrophic conditions (Class II), and 51 to 75 points generally represents eutrophic conditions (Class III). This places Atwood as a Class I Lake under Indiana's classification system in 1993 and 2000 indicating it is "oligotrophic" with a low amount of nutrient enrichment. This indicated it was above 90% of Indiana's lakes in terms of water quality. In 2003 the lake scored 26 pushing it slightly into the Class II or "mesotrophic" category indicating a moderate level of nutrient enrichment. A Secchi disk was used to measure water clarity during the 2008 season work on Atwood Lake. A Secchi disk is a black and white disk lowered into the water with the observer recording the depth at which the disk can no longer be seen. Secchi readings of 4.3 feet recorded in June and also in August of 2008. The available water clarity history (see fig. 9 above) does suggest a trend may be occurring toward lower water clarity on Atwood Lake. The initiation of a volunteer monitoring program could help generate a more complete water quality record for Atwood Lake and make detection of emerging problems easier. A lake/watershed diagnostic study could also be utilized to help the Atwood Lake Association spot problem areas that can be addressed by the residents, local, landowners and local resource agencies. No other preexisting water quality studies are known to have been compiled for Atwood Lake.

3.3 Public Access and Riparian Land Uses

The general public gains access to Atwood Lake through an IDNR launch ramp in the lake's southwest corner. The lake is bordered by approximately 38 acres of riparian emergent and scrub-shrub wetlands, most of which lie within a marsh at the outlet in the southeast corner of the lake. (See fig. 10 below) Nearly all riparian uplands around Atwood Lake have been developed with approximately 80 acres of homes, cottages, and businesses located around the lake. There are approximately 123 homes and cottages on the lake. Of Atwood's 13435 feet of shoreline 76 percent has been developed. There is also a campground with a large swimming beach and boat mooring area that operates on the lake's south shore. Upland frontage has been extended somewhat with the excavation of three small channels. Two are located in the southwest corner of the lake forming a circle around a small wetland island. The westernmost of these is developed while the easternmost provides the frontage for the IDNR public access site. The third small channel is located along the northwest shore of the lake and is developed.

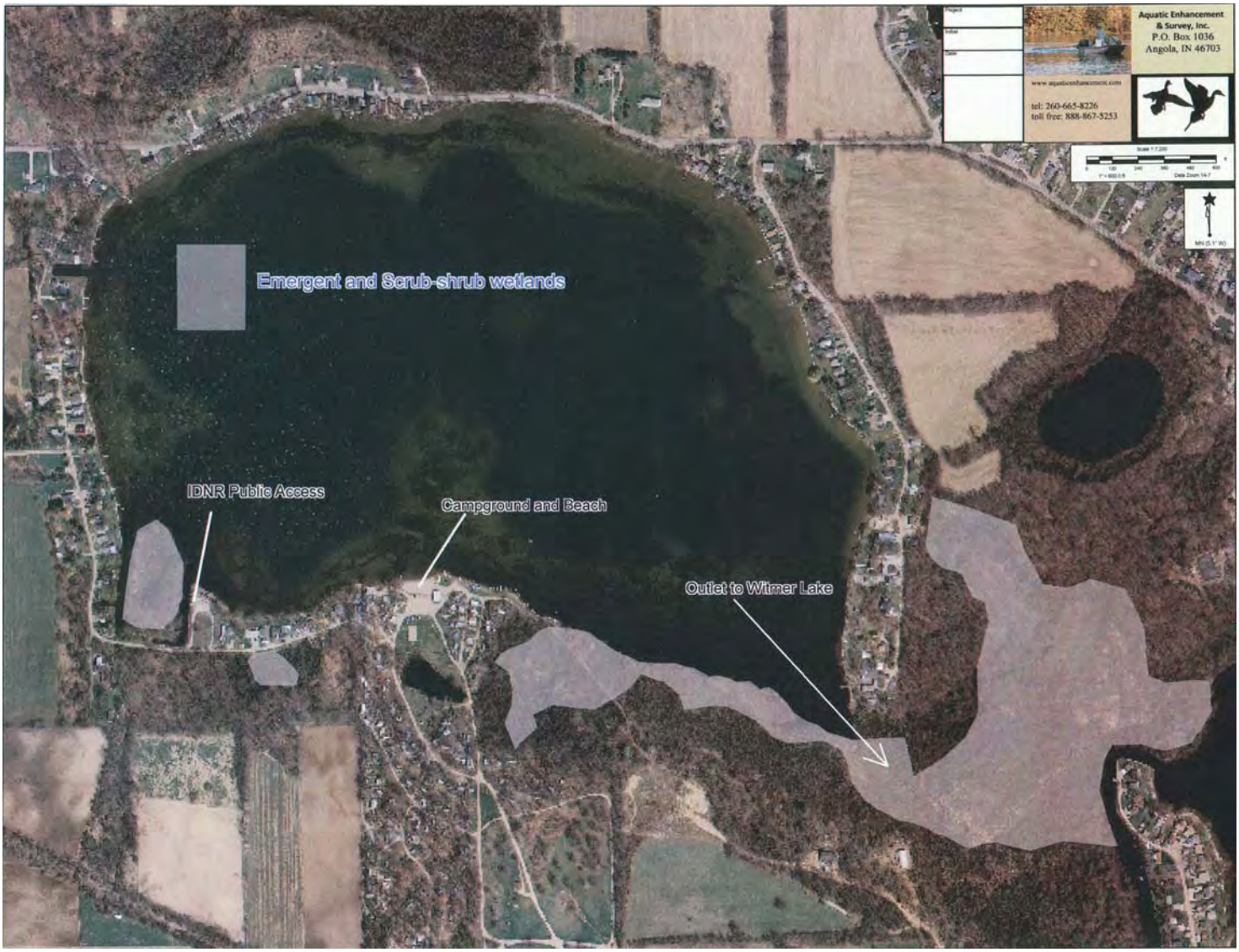


Figure 10 Atwood Lake general characteristics

3.4 Watershed

Atwood Lake has a relatively small watershed for its size (approx. 521 acres) (see fig. 11 below). The land area is dominated by agricultural use (54%) with extensive acreage also in residential areas (15%), woodlands (14%), and grasslands (13%). Wetlands comprise approximately four percent of the watershed and included wooded, emergent, and scrub shrub areas. There are no major tributary streams or ditches that flow into Atwood Lake, but two small intermittent inlets, one flowing into the channel system that the IDNR access site is on and one flowing into the small excavated channel on the northwest shoreline of the lake. Because a lake's watershed plays a key part in determining the nature of the lake, and ultimately the amount of plant and algae growth in the lake, the ALA should remain aware of potential nutrient and sediment runoff sources in the watershed such as construction sites and livestock feeding areas. Atwood's small watershed means the lake has a rather long hydraulic residence time, so nutrients accumulated in the lake's waters and sediments may take a long time to leave the lake via the outflow, but the small watershed will also prove more feasible for the ALA to manage and asses on an ongoing basis, potentially leading to a healthier lake and more manageable plant community. ALA members can work with the LaGrange County Soil and Water Conservation District and USDA Natural Resources Conservation Service to see if agricultural best management practices (BMP's) have been implemented to help limit nutrient and sediment runoff from cultivated fields within the watershed. With a small watershed the ALA will need to make contact with a relatively small number of landowners to address any noted problem areas.

Watershed land use/land cover	Acres	Percentage of land area
Agriculture	280	54
Residential	80	15
Woodlands	71	14
Grassland/pasture	69	13
Wetlands	21	4
Open water	170	
Total watershed area	691	
Total Watershed land area	521	

Table 4 Atwood Lake watershed land use/land cover figures

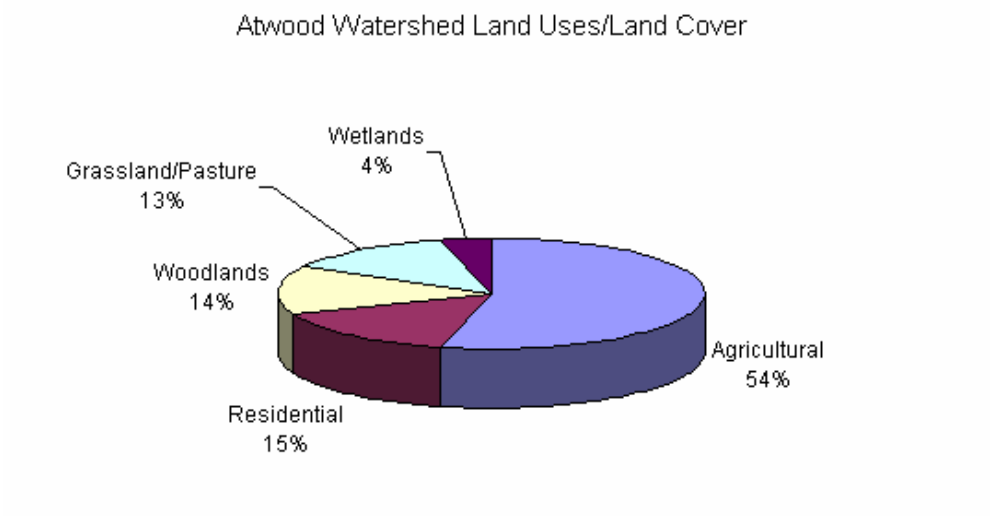


Figure 11 Land Use/Land Cover Pie Chart for the Atwood Lake Watershed

Figure 12 Atwood Lake watershed

4. Present Water Body Uses

Fishing, swimming, and boating are the most common recreational uses of Atwood Lake. The Atwood Lake community includes a sizeable campground with a beach, boat mooring area, and a covered pavilion. Because Atwood is an Indiana public freshwater lake less than 200 acres, Indiana law maintains a 10 mile per hour/no wake speed limit on the lake. This effectively prohibits many activities such as water skiing, tubing, and personal watercraft. This is beneficial because it somewhat limits the fragmentation and spread of Eurasian watermilfoil likely to occur if the passage of fast powerboats and associated wave action were allowed to batter the shallows and shorelines at Atwood. Maintaining enforcement of this limit will benefit plant management efforts. Residents and visitors who operate watercraft on the lake should also be informed that avoiding contact with the Milfoil plants is critical to the management of the lake. This should be stressed at public meetings held regarding plant management at Atwood Lake as well as at all private Atwood Lake Association meetings. While ideally all significant growth of invasive exotic plants should be controlled, extra care should be taken at Atwood Lake to target "high use" areas for control. This will not only minimize the problems the plants present to lake users, but also help prevent the spread of Eurasian watermilfoil from being hastened by the production of plant fragments where swimmers and watercraft damage the plants. These high use areas would include the channel/pubic access site in the southwest corner of the lake, the beach and campground on the south shore of the lake, and the areas immediately in front of developed frontages where swimming and boat mooring take place (see fig. 13 below). The signatures of outboard motor travel visible on the shallow bottom of the lake on the submersed peninsula extending from the south shore also suggests that this is an area of potential spread if invasive plants are allowed to grow there. All areas containing native submersed plants and including areas of emergent plants such as White water lilies and Spatterdock (Yellow lily) should be considered beneficial and worthy of protection from both disturbance and invasion by non-native plants

Figure 13 "High Use" areas of Atwood Lake

4.1 The Atwood Lake Fishery

Fishing is a popular activity at Atwood Lake for the lake and campground residents and also the general public which gains access to the lake via the IDNR access ramp. To keep track of public fishery resources Indiana Department of Natural Resources fisheries biologists conduct surveys periodically on public freshwater lakes. To collect fish for these surveys the biologists use a combination of gill-netting, trap netting, and nighttime D.C. electrofishing. This gives IDNR information about the fish species present, growth rates, and general condition. IDNR has performed general fish surveys on Atwood Lake in 1965, 1970, 1975, 1982 and 1988. In 2002 a Largemouth bass population survey was conducted utilizing electrofishing equipment. This survey generated a total population estimate for stock sized (8 inch or larger) Largemouth Bass in Atwood Lake. Data from the 1982, 1988, and Largemouth surveys were available for inclusion in this report.

4.1.1 The 1982 Fish Survey

The introduction to the 1982 report document (IDNR 1982) indicates that when the lake was initially surveyed in 1965 an overpopulation of slow-growing Bluegill and Redear sunfish was noted. A partial fish eradication project was recommended and carried out in the fall of 1967 to thin panfish numbers thus allowing for more food per fish and increasing growth. A follow-up survey conducted in July of 1970 indicated that the three species sought by anglers most (Bluegill, Redear, and Largemouth) had seen an improvement. The rate of growth and number of fish of catchable size had increased. It was recommended that further thinning be performed. Partial eradications along with Largemouth bass stockings took place in 1971 and 1972. Results were considered excellent with large numbers of young-of-the-year bluegill and Redear sunfish being removed. A second follow-up survey was conducted in 1975. A noticeable increase in

Bluegill and Redear growth had resulted from the eradication projects; however the Largemouth bass population remained small. Fisherman reported an improvement in the sport fishery overall but reported that large numbers of eight to ten inch bass were being caught and kept, especially during the winter ice fishing season. In 1975 IDNR recommended the lake users adopt a "self-imposed" 14 inch size limit on Largemouth bass maintain a better predatory influence in the lake to control Bluegill and Redear populations.

The 1982 survey was conducted in response to the Atwood Lake Association reporting that the fishing at the lake was poor. During the survey 1788 fish of 20 different species were collected. Basic fish collection results are contained in Table six below. It was reported that Bluegills weights were average but growth rates were far below the average for northeast Indiana lakes. The Bluegill population had declined 19% by number, 15% by weight, and 54% in harvestable sized fish since the 1975 survey.

Species Common Name	Number collected	% by number	Length Range (inches)
Bluegill	965	54.0	2-7.1
Redear	377	21.1	3-9
Pumpkinseed	83	4.6	2-6.5
Warmouth	73	4.1	2.5-7.5
Lake chubsucker	61	3.4	2.5-10.5
Yellow bullhead	60	3.4	7-12.5
Spotted gar	30	1.7	15.5-30
Yellow perch	28	1.6	3.5-9.5
Black crappie	22	1.2	7-11.5
Largemouth bass	21	1.2	2-19.5
Grass Pickerel	18	1.0	8.5-14.4
Bowfin	17	1.0	10.6-22.2
Golden shiner	10	.6	5.5-8.4
Hybrid sunfish	6	.3	5.4-7.0
Green sunfish	6	.3	2.8-5.4
Brown bullhead	4	.2	10.2-10.4
Carp	4	.2	23.7-29.7
Longnose gar	2	.1	31.3-32.5
Central mudminnow	1	.1	2.6
Brook silversides	Abundant		-

Table 5 Species and relative abundance by number for 1982 Atwood fish data.

Redear abundance had increased, but the percent of catchable fish had declined. Redear 6.4 inches and smaller had average weights while those 6.5 inches and larger had weights above average. Growth rates on all sizes of Redears were below average. It was reported that growth and weight per length for Largemouth bass were above average but only five percent of the bass were of catchable size (14 inches or larger) and the abundance of Largemouth bass in Atwood lake remained low.

It was summarized that the overpopulation problem with Bluegills and Redears had deteriorated since 1975 and the quality of fishing was poor. It was also noted that water quality was good and aquatic vegetation was abundant in certain areas but did not present a problem or seem to be a factor in the stunting situation. Since the benefits of the partial eradications had been short lived it was recommended 10 inch Tiger Muskies be stocked at the rate of seven per acre. This was to create a Muskie fishery, but also to evaluate the effect the additional predators would have on the stunted Bluegill population. The stockings were to be evaluated in 1983 and 1984 with further recommendations to be made at that time.

4.1.2 The 1988 Fish Survey

During the 1988 survey 2686 fish of 18 different species were collected. Basic fish collection results are contained in Table six below. Bluegill remained the most numerically abundant (70.9 percent). Only 15.7 percent of the Bluegill collected were of harvestable size (6 inches or longer). Bluegill growth rates remained well below average and were similar to those observed in 1982. Bluegill weights per length were now below average. In 1982 they had been average. Redear sunfish were the second most abundant (6.1 percent). Redear growth rates and weights per length were both below average. Of 163 Redears collected 44.8 percent were of harvestable size. This was down from 65 percent in the 1982 survey. Numerically Largemouth bass comprised 1.6 percent of the fish collected (1.2 percent in 1982). Growth rates and weights per length were average (in 1982 they had been above average). Harvestable bass comprised 11.4 percent of the sample. In 1982 the harvestable bass had been five percent. Although 14 Tiger muskies had been collected it was concluded that the overall survival rate of the Tiger muskies stocked in Atwood Lake had been poor.

It was summarized that the overpopulation problem with Bluegills and Redears had persisted at Atwood Lake. It was also noted that the Largemouth bass population and percent harvestable bass remained small and growth rates and weights per length had declined. The overall assessment was made that Atwood Lake was not providing good quality sport fishing. Water quality was deemed to be good with aquatic vegetation abundant in some areas but still not considered a serious problem. It was recommended that the fish population in Atwood Lake be totally eradicated with the eradication occurring prior to ice-up in late December 1990 with restocking with Largemouth bass and bluegill in late April 1990. It was further recommended that two brush pile fish attractors be constructed in the lake basin to help concentrate fish and improve angling success. The Atwood Lake Association or other interested groups were advised to contact district fisheries personnel for permit applications and assistance. IDNR fisheries personnel have since indicated that the lake residents were reasonably satisfied with the existing Largemouth bass fishing at Atwood Lake at the time and chose not to pursue the eradication.

A Largemouth bass survey was conducted at Atwood Lake in 2002. Night time D.C. electrofishing was used exclusively to collect Largemouth bass on three separate nights. Bass caught were marked with a fin clipping and successive recapture rates were used to mathematically estimate the total stock size (6 inch or above) population. The population was estimated to be 2514 and falls within the normal range for northeast Indiana lakes.

Plant management at Atwood Lake may have implications for the fishery. In a lake that has experienced continual problems with stunting of Bluegill and Redear sunfish a plant community dominated by dense stands of Eurasian watermilfoil could make a preexisting problem worse. Typically in lakes with stunting problems species like Bluegill tend to produce too many offspring. Without the predatory influence of larger fish species too many of these fish survive to recruitment, competing with each other for limited forage. With less food available per fish growth rates lag. It's been shown that a more complex aquatic environment with regard to plant cover and mass can decrease the ability of predatory fish to capture prey. (Savino and Stein 1992) In a lake like Atwood where increasing predation of Bluegills and Redear sunfish by Largemouth Bass and other predators is likely to be beneficial domination of the lake by extremely dense stands of Eurasian watermilfoil is not desirable. Seeking to hold the lake in a balance that provides a moderate amount of native plant cover may provide long term benefits to the fishery.

Species Common Name	Number collected	% by number	Length Range (inches)
Bluegill	1904	70.9	2.0-8.3
Redear	163	6.1	3.9-8.2
Bluegill x Redear (hybrid)	151	5.6	3.7-8.0
Black crappie	123	4.6	4.3-13.3
Lake chubsucker	71	2.6	5.0-11.3
Largemouth bass	44	1.6	5.8-19.8
Warmouth	41	1.5	2.6-8.1
Yellow perch	40	1.5	4.1-10.0
Pumpkinseed	36	1.3	2.8-7.1
Yellow bullhead	26	1.0	5.6-12.1
Brown bullhead	24	0.9	6.1-11.9
Grass Pickerel	21	0.8	8.2-14.4
Golden shiner	14	0.5	5.7-8.3
Tiger Muskie	14	0.5	11.7-23.1
Spotted gar	6	0.2	20.9-29.3
Bowfin	5	0.2	16.2-21.6
Carp	2	0.1	25.2-26.6
Green sunfish	1	Less than 1%	2.0

Table 6 Species and relative abundance by number for 1988 Atwood fish data.

5.0 Plant Community Characterization

5.1 Methods

Two primary methods of observation were used to characterize the Atwood Lake's plant community during the 2008 season. Exotic plant growth was mapped mainly by visual observation from the boat. Extensive time was spent running a zigzag pattern over the lake's littoral zone to establish the boundaries for dense exotic plant growth. This was complimented by Tier II quantitative survey plant collection data, prior knowledge of typical plant growth patterns, and a contour map. A handheld WAAS Enabled GPS unit was also helpful in marking the general boundaries of exotic plantbeds for mapping. To characterize the lake's plant community quantitatively and produce objective data for analysis and tracking of overall plant community composition, Tier II Plant surveys were utilized as described in the next section.

5.1.1 Tier II

Tier II stratified random sampling was utilized on June 14th and August 19th 2008 to establish random plant sampling points on Atwood Lake and quantify approximate species biomass at each respective point. The Tier II aquatic plant sampling protocol used was established by INDR and is available in full in *Tier II Aquatic Vegetation Survey Protocol, May 2007* (IDNR 2007). In Tier two sampling, data collection points are established within given depth strata of the lake according to lake size and trophic status listing. INDR has listed Atwood with the "mesotrophic" status and directed sampling be done to a depth of 10 feet. The 2008 sampling complied with this, however Chara and Flatstem pondweed were noted to a depth of 13.5 feet so an increase in sampling depth to 15 feet may be appropriate in future seasons. A toss and retrieval of a specially fabricated two sided rake (See fig.14 below) on a rope is used to sample vegetation from the lake bottom at each point. After retrieval of the rake a score is assigned to each recovered plant species by separating the species and placing them back on the rake. Thickness of the plants when placed back on the rake is recorded as measured by equally spaced marks on the rake tines. This measurement assigns a rake score of one, three, or five to each species as a basic

measure of biomass. Plants seen but not recovered on the rake are marked as "observed only". Filamentous algae is recorded only as "present" if recovered on the rake. Location data for sampling points was collected using a WAAS enabled GPS unit. Data points were then downloaded to geographic information system (GIS) software for placement on a map. Because aquatic plant species vary in their prominence during various part of the growing season sampling is performed in both the late and early season during plant plan development. In treatment seasons the two survey regime can also allow for a pre-treatment and post-treatment comparison of the lake's plant community. Data collected during the Tier II survey is then used to calculate a set of statistical descriptors developed by IDNR to help characterize plant communities in Indiana waters (Pearson 2004). The Tier II sampling points (50 in Atwood Lake) for the early and late season surveys in 2008 are displayed in table 8 below.

Figure 14 Two sided sampling rake

Figure 15 Tier II sampling points for Atwood Lake

5.2 6/14/08 (early season) Tier II Survey Results

The early season Tier II survey for Atwood Lake was conducted on June 14 in good weather conditions. A summary of results is contained in table seven below. Water clarity was considered to be relatively low with a Secchi depth of 4.3 feet recorded. Surprisingly plants were found to a depth of 13.5 feet. Future data collection at Atwood Lake may be enhanced if the maximum sampling depth is increased to 15 feet. Nine species were identified in the survey including Whitestem pondweed *Potamogeton praelongus* a state "threatened" species. This is slightly above the average number of 8 species for a set of 21 other northern Indiana lakes compiled by IDNR.(Pearson 2004) The highest occurrence was Chara (54 percent) followed by Sago pondweed (32 percent) and Variable pondweed (30 percent). Curlyleaf pondweed occurrence was 18 percent and Eurasian watermilfoil was ten percent. Overall the Atwood Lake plant community appeared to be of slightly above average diversity in the early season survey and was dominated by native species. Plant maps for Chara, Sago pondweed, Whitestem pondweed, Curlyleaf pondweed, and Eurasian watermilfoil are in figures 16 through 19 below.

Occurrence and abundance of submersed aquatic plants in Lake Atwood.						
County:	LaGrange	Sites with plants:	46	Mean species/site:		1.92
Date:	6/14/2008	Sites with native plants:	45	Standard error (ms/s):		0.14
Secchi (ft):	4.3	Number of species:	9	Mean native species/site:		1.63
Maximum depth (ft):	13.5	Number of native species:	7	Standard error (mns/s):		0.14
Trophic status:	Mesotrophic	Maximum species/site:	4	Species diversity:		0.83
Total sites:	50			Native species diversity:		0.79

All depths (0 to 20 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Chara	54.0	46.0	32.0	4.0	18.0	26.8
Sago pondweed	32.0	68.0	28.0	2.0	2.0	8.8
Variable pondweed	30.0	70.0	24.0	4.0	2.0	9.2
Curlyleaf pondweed	18.0	82.0	12.0	0.0	6.0	8.4
Whitestem pondweed	18.0	82.0	10.0	4.0	4.0	8.4
Flatstem pondweed	12.0	88.0	12.0	0.0	0.0	2.4
Coontail	10.0	90.0	6.0	2.0	2.0	4.4
Eurasian milfoil	10.0	90.0	10.0	0.0	0.0	2.0
Spiny naiad	4.00	96.0	4.0	0.0	0.0	0.8

All depths (0 to 5 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Chara	61.5	38.5	38.5	2.6	20.5	29.7
Sago pondweed	33.3	66.7	30.8	0.0	2.6	8.7
Variable pondweed	30.8	69.2	23.1	5.1	2.6	10.3
Coontail	10.3	89.7	5.1	2.6	2.6	5.1
Curlyleaf pondweed	10.3	89.7	7.7	0.0	2.6	4.1
Eurasian milfoil	10.3	89.7	10.3	0.0	0.0	2.1
Flatstem pondweed	10.3	89.7	10.3	0.0	0.0	2.1
Whitestem pondweed	7.7	92.3	5.1	2.6	0.0	2.6
Spiny naiad	5.1	94.9	5.1	0.0	0.0	1.0

All depths (5 to 10 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Whitestem pondweed	60.0	40.0	30.0	10.0	20.0	32.0
Curlyleaf pondweed	50.0	50.0	30.0	0.0	20.0	26.0
Chara	30.0	70.0	10.0	10.0	10.0	18.0
Sago pondweed	30.0	70.0	20.0	10.0	0.0	10.0
Variable pondweed	30.0	70.0	30.0	0.0	0.0	6.0
Flatstem pondweed	20.0	80.0	20.0	0.0	0.0	4.0
Coontail	10.0	90.0	10.0	0.0	0.0	2.0
Eurasian milfoil	10.0	90.0	10.0	0.0	0.0	2.0

Table 7 Summary of 6/14/08 Tier II data for Atwood Lake

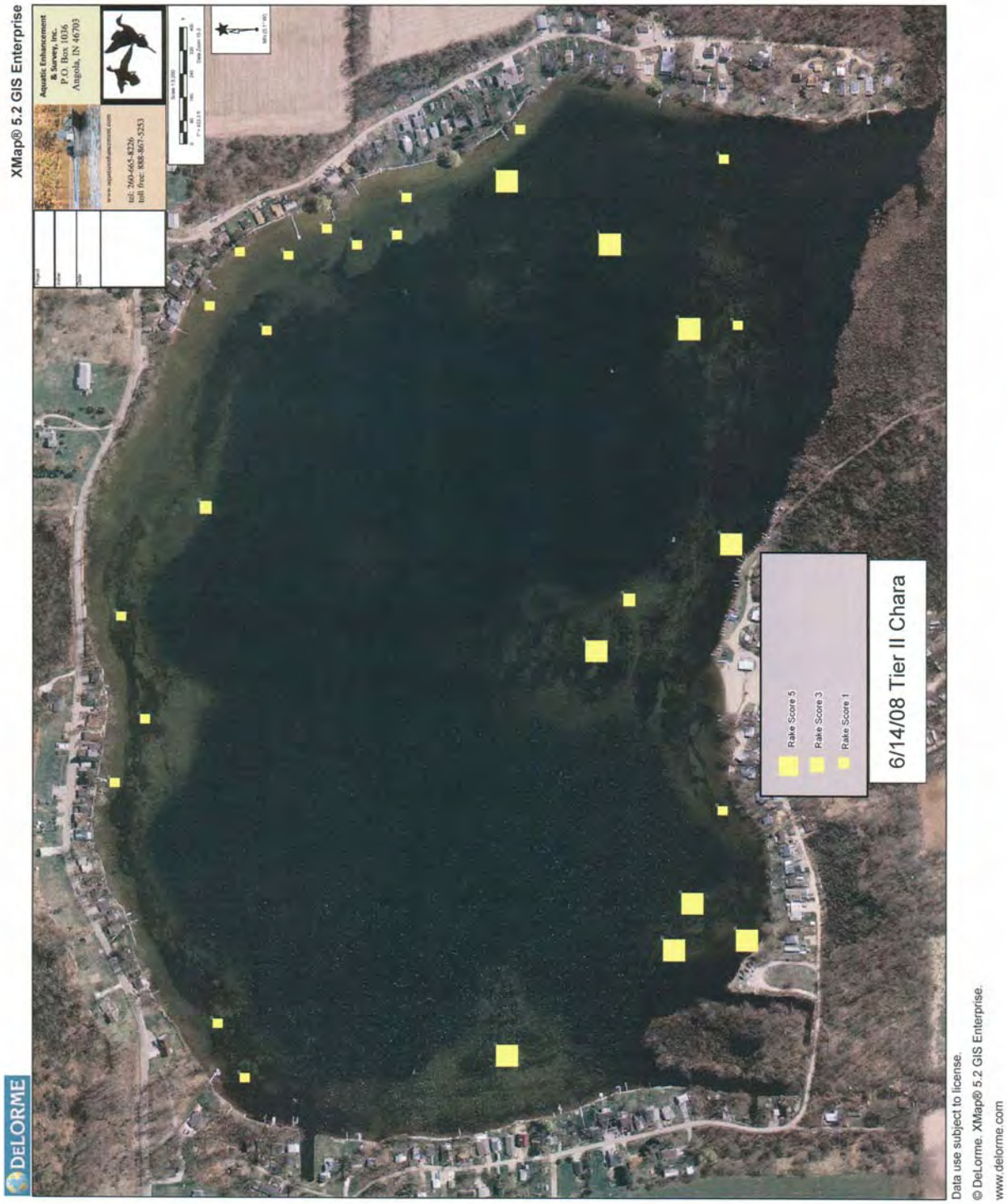


Figure 16 6/14/08 Chara map

Figure 17 6/14/08 Sago pondweed

Figure 18 6/14/08 Whitestem pondweed map

Figure 19 6/14/08 Eurasian milfoil map

5.3 8/19/08 (late season) Tier II Survey Results

The late season Tier II survey for Atwood Lake was conducted on August 19th in good weather conditions. A summary of results is contained in table eight below. Water clarity was considered to be relatively low with a Secchi depth of 4.3 feet again recorded. Plants were found to a depth of 10 feet. Fourteen species were identified in the survey including Richardson's pondweed *Potamogeton richardsonii* a state listed "rare" species. Fourteen plant species were sampled. This is well above the average of 8 species for a set of 21 other northern Indiana lakes compiled by IDNR.(Pearson 2004) The highest occurrence was Spiny naiad (50 percent) followed by Chara (44 percent) and Slender (Common) naiad (18 percent). Curlyleaf pondweed did not occur in the late season sampling. Eurasian watermilfoil occurrence was six percent. Overall the Atwood Lake plant community appeared to be well above average diversity in the late season survey and was dominated by native species. Plant maps for Spiny naiad, Chara, Whitestem pondweed, Richardson's pondweed and Eurasian watermilfoil are in figures 20 through 24 below.

Occurrence and abundance of submersed aquatic plants in Lake Atwood.							
County:	LaGrange	Sites with plants:	44	Mean species/site:			1.92
Date:	8/19/2008	Sites with native plants:	44	Standard error (ms/s):			0.15
Secchi (ft):	4.3	Number of species:	14	Mean native species/site:			1.86
Maximum depth (ft):	10	Number of native species:	13	Standard error (mns/s):			0.15
Trophic status:	Mesotrophic	Maximum species/site:	4	Species diversity:			0.85
Total sites:	50			Native species diversity:			0.84

All depths (0 to 20 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Spiny naiad	50.0	50.0	34.0	2.0	14.0	22.0
Chara	44.0	56.0	18.0	0.0	26.0	29.6
Slender naiad	18.0	82.0	8.0	4.0	6.0	10.0
Variable pondweed	16.0	84.0	10.0	2.0	4.0	7.2
Illinois pondweed	16.0	84.0	14.0	2.0	0.0	4.0
Sago pondweed	12.0	88.0	12.0	0.0	0.0	2.4
Richardson's pondweed	6.0	94.0	4.0	2.0	0.0	2.0
Eurasian milfoil	6.0	94.0	6.0	0.0	0.0	1.2
Small pondweed	6.0	94.0	6.0	0.0	0.0	1.2
Coontail	4.0	96.0	2.0	0.0	2.0	2.4
Whitestem pondweed	4.0	96.0	2.0	2.0	0.0	1.6
Water stargrass	4.0	96.0	2.0	2.0	0.0	1.6
Flatstem pondweed	4.0	96.0	4.0	0.0	0.0	0.8
Elodea	2.0	98.0	0.0	0.0	2.0	2.0

All depths (0 to 5 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Chara	47.5	52.5	17.5	0.0	30.0	33.5
Spiny naiad	45.0	55.0	32.5	2.5	10.0	18.0
Variable pondweed	20.0	80.0	12.5	2.5	50.0	9.0
Slender naiad	17.5	82.5	10.0	5.0	2.5	7.5
Illonois pondweed	15.0	85.0	12.5	2.5	0.0	4.0
Sago pondweed	10.0	90.0	10.0	0.0	0.0	2.0
Small pondweed	7.5	92.5	7.5	0.0	0.0	1.5
Coontail	5.0	95.0	2.5	0.0	2.5	3.0
Elodea	2.5	97.5	0.0	0.0	2.5	2.5
Richardson's pondweed	2.5	97.5	0.0	2.5	0.0	1.5
Eurasian milfoil	2.5	97.5	2.5	0.0	0.0	0.5
Flatstem pondweed	2.5	97.5	2.5	0.0	0.0	0.5
Water stargrass	2.5	97.5	2.5	0.0	0.0	0.5

All depths (5 to 10 ft)	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
Species		0	1	3	5	
Spiny naiad	70.0	30.0	40.0	0.0	30.0	38.0
Chara	30.0	70.0	20.0	0.0	10.0	14.0
Slender naiad	20.0	80.0	0.0	0.0	20.0	20.0
Whitestem pondweed	20.0	80.0	10.0	10.0	0.0	80.0
Eurasian milfoil	20.0	80.0	20.0	0.0	0.0	40.0
Illinois pondweed	20.0	80.0	20.0	0.0	0.0	40.0
Richardson's pondweed	20.0	80.0	20.0	0.0	0.0	40.0
Sago pondweed	20.0	80.0	20.0	0.0	0.0	40.0
Water stargrass	10.0	90.0	0.0	10.0	0.0	60.0
Flatstem pondweed	10.0	90.0	10.0	0.0	0.0	2.0

Table 8 Summary of 8/19/08 Tier II data for Atwood Lake

Figure 20 8/19/08 Spiny naiad map

Figure 21 8/19/08 Chara map

Figure 22 8/19/08 Whitestem pondweed map

Figure 23 8/19/08 Richardson's pondweed map

Figure 24 8/19/08 Eurasian milfoil map

Atwood Lake Summary 2008

Summary of Season's Treatments

Eurasian watermilfoil	Flurid. 6 ppb (28 ac.)	2,4-D (4 acres)		2,4-D (28 acres)	Flurid. 6 ppb (28 ac.)	Flurid. 6 ppb (28 ac.)		2,4-D (4 acres)
Curlyleaf pondweed	Flurid. 6 ppb (unk.ac.)	Aquathol K, 7.5 acres			Flurid. 6 ppb (unk.ac.)	Flurid. 6 ppb (unk.ac.)		Aquathol K, 7.5 ac.
Atwood Lake	**WPI**	**AES**		**WPI**	**IDNR**	**WPI**	**IDNR**	**AES**
Date	**5/5/05**	**6/14/08**		**8/9/04**	**8/3/05**	**9/7/05**	**8/9/06**	**8/19/08**
IDNR protocol 1 or 2	1	2		1	1	1	2	2
Depth range (ft)	0-12	0-10		0-20	0-20	0-10	0-20	0-10
Sample sites (n)	43	50		50	50	43	50	50
Secchi (ft)	6.6	4.3		6.6	9.0	5.7	5.0	4.3
Littoral depth (ft)	12.0	13.5		13.0	15.0	6.0	15.0	10.0
Occurence (%)	81.4	92.0		84.0	84.0	63.0	64.0	88.0
Species (N)	6	9		10	7	4**	9	14
Native species (N)	4	7		9	6	4	7	13
Species/site (max)	5	4		5	3	4	5	4
Mean species/site	1.71	1.92		1.44	1.02	1.11	1.68	1.92
Mean Native species/site	1.26	1.63		1.08	0.94	1.11	1.60	1.86
Species diversity	n/d	0.83		n/d	0.60	n/d	0.74	0.85
Native diversity	n/d	0.79		n/d	0.53	n/d	0.71	0.84
Species occurrence								
Chara	72.1	54.0		72.1	59.2	39.5	50.0	44.0
Coontail		10.0		4.7	4.1			4.0
Eurasian watermilfoil	27.9	10.0		20.9	8.2		2.5	6.0
Flatstem pondweed		12.0		2.3	2.0	7.0		4.0
Sago pondweed	7	32.0		2.3	2.0	37.2	7.5	12.0
Water Bulrush					2.0		2.5	
Illinois pondweed					24.5		25.0	16.0
Spiny naiad		4.0		34.9*			62.5	50.0
Curlyleaf pondweed	9.3	18.0					7.5	
Whitestem pondweed		18.0		18.6			2.5	4.0
Slender naiad							5.0	18.0
Variable pondweed		30.0						16.0
Richardson's pondweed				2.3				6.0
Small pondweed								6.0
Water Stargrass								4.0
Elodea	2.3							2.0
Nitella				4.7				
Bladderwort				2.3				
* Naiad species not specified, assumed to be Spiny naiad								
n/d denotes no data								
** Stats listed for 3 species, 4th is unknown								
Algae occurrence (%)								
Species dominance* **								
Chara		26.8			22.0		19.0	29.6
Coontail		4.4			1.2			2.4
Eurasian watermilfoil		2.0			2.4		0.5	6.0
Flatstem pondweed		2.4			2.0			0.8
Sago pondweed		8.8			0.4		1.5	2.4
Water Bulrush					0.8		0.5	
Illinois pondweed					4.9		6.0	4.0
Spiny naiad		0.8					27.0	22.0
Curlyleaf pondweed		8.4					1.5	
Whitestem pondweed		8.4					0.5	1.6
Slender naiad							1.0	10.0
Variable pondweed		9.2						7.2
Richardson's pondweed								2.0
Small pondweed								1.2
Water Stargrass								1.6
Elodea								2.0
Nitella								
Bladderwort								
*** Dominance is not provided for WPI data								

Table 9 Summary of Tier II data for Atwood Lake

5.3.1 2008 Tier II Seasonal Changes

Aquatic plant communities are expected to change over the course of a season. Various species complete the bulk of their growth and reproduction at different times of the growing season. This is usually reflected in the Tier II plant survey occurrence frequencies for various species. Changes in frequencies of occurrence are also expected for target species treated between the early season survey and late season survey. The occurrence of Eurasian watermilfoil declined from 10 percent to six percent, presumably in response to treatment which took place less than a week before the June 14 survey. Curlyleaf pondweed, present at 18 percent of sampling sites in June was not collected in the August sampling. This is expected as most Curlyleaf plants tend to complete their life cycle and drop out of the water column in July naturally. Treatment for Curlyleaf also took place and likely contributed to it's disappearance as well. Other notable changes included an increase in Spiny naiad *Najas marina* from four percent in the early season to 50 percent of sites in the late season survey. Slender (Common) naiad *Najas flexilis* also increased from zero occurrences in the early season to 18 percent occurrence in the late season sampling. This is to be expected as Naiads are typically a plant that grows most heavily during the latter part of the season.

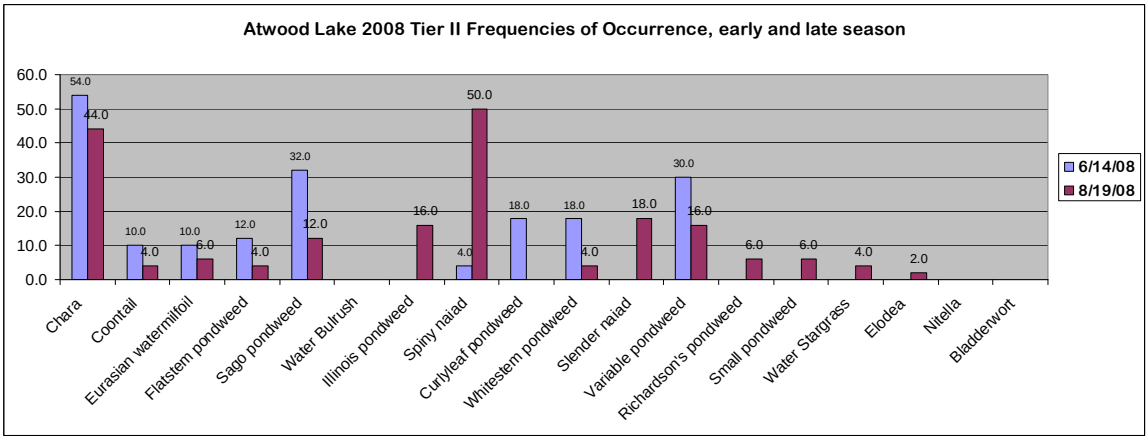


Figure 25 2008 Early and late season Tier II occurrences for Atwood Lake species

5.4 Overall Plant Community History

5.4.1 Species Number Changes over Time

Figure 26 below contains a summary of Tier II plant survey data collected from Atwood Lake since 2004. Species number, especially native species number, can be a useful indicator of diversity. In general a larger number of species indicates a healthier or more stable system. The total number of native species noted in all five late season surveys performed on Atwood from 2004 through 2008 has varied from 4 to 13 with an all survey average of 7.8. Overall it appears that diversity in terms of native species number is in line with other northern Indiana lakes. The average native species number for a set of 21 Northern Indiana Lakes surveyed (Pearson 2004) is 8. After the 28 acre treatment for Eurasian watermilfoil with 2, 4-D in 2004 the number of Tier II native species noted was nine. After the whole lake fluridone treatment in 2005 this number dropped to 4 in the Weed Patrol, Inc. (WPI) data and 6 in the IDNR data. It is possible that this is a result of the effects of the fluridone treatment on non-target native species. In the 2006 IDNR data this had increased to seven native species and by the time of the 2008 late season survey by

Aquatic Enhancement & Survey, Inc. (AES) 13 native species were noted in the Tier II sampling. This pattern suggests that the extensive milfoil colonization had degraded diversity somewhat, followed by the whole lake treatment eliminating the milfoil, but also suppressing diversity via non-target effects. As the lake's plant community later recovered free of the influence of the extensive milfoil colonization it reached a point of diversity that exceeded the 2004 season diversity. Overall it appears that the lake's plant community has benefited from the course of plant management followed thus far. In terms of diversity one major step to be taken is to work toward preventing the increased presence of nutrients in the lake by working toward a healthy watershed. Lower nutrient levels typically mean better water clarity and more available light to spur the development of the lake's plant community. Persistent poor water clarity over time will limit the lakes plant community to the support of low-light tolerant species that thrive in high nutrient environments.

5.4.2 Eurasian Watermilfoil Growth Trends

By 2004 Eurasian milfoil appears to have heavily colonized nearly all of the Atwood Lake littoral area between the six and ten foot depth contours arriving at the 28 acre area of dense colonization (Fig. 2 page 8). This is a typical growth pattern for Eurasian watermilfoil colonization and dense plant growth in glacial lakes in general. Submersed aquatic vegetation growth, especially Eurasian watermilfoil, favors fine-textured inorganic sediments with an intermediate sediment density while plants grow more poorly both on sands with a high sediment density and on highly organic sediments with a low sediment density (Barko and Smart 1985). Many of the shallowest areas of Atwood Lake have the mechanical influence of wave action continually influencing their substrate, sweeping finer soil particles and organic materials into deeper or quieter areas of the lake. Sandy substrates dominate the sediment's surface in the shallowest areas. It follows that the preferred intermediate substrate densities are present in deeper areas such as the lake's central basin or the dredged channels off of the lake. Beyond the ten foot contour lack of light begins to restrict plant colonization. With a lack of available light limiting growth on the deep side and less favorable substrates limiting growth on the shallow side the plant growth is naturally confined to this five to ten foot "weedline" zone. As recolonization occurs this zone (including dredged areas such as channels) has naturally been the location of new colony start-ups. Because this will continue it will be important to check these areas most carefully for exotic plant growth. The colonization by Eurasian milfoil in 2004 resulted in a Tier II survey occurrence of 20.9 sites in the late-season Tier II, even after treatment with 2,4-D. Because residents have reported good results this is likely the result of scattered low-grade colonization outside the areas of dense growth that were treated or a result of short plants re-growing in and near the treatment areas. Milfoil Tier II occurrence peaked in the spring of 2005 survey (WPI) at 27.9 percent. In 2005 after the whole lake treatment, occurrence had dropped to 8.2 by August 3, 2005 (IDNR) and did not occur at all in a Tier II survey performed on September 7, 2005. In August of 2006 Tier II sampling site occurrence remained very low at 2.5 percent. (IDNR) In the spring of 2008 the Tier II milfoil occurrence was 10 percent (AES). Treatment was then performed on four acres of noted growth in 2008 resulting in a Tier II occurrence of 6 percent in a post treatment survey on August 19, 2006. Obviously the whole lake treatment provided much more complete control than treating all of the noted dense growth with 2, 4-D as was done in 2004 and 2008. This control was also obviously longer lasting, producing extensive control over three seasons. The data collected so far suggests that the ALA may be able to continue effective control of Eurasian watermilfoil with systemic herbicide spot treatments for a number of seasons, enjoying good plant diversity during those seasons, but eventually another whole-lake treatment will likely be needed to provide the most beneficial and efficacious management.

5.4.3 Curlyleaf Pondweed Growth Trends

Curlyleaf pondweed has colonized Atwood Lake to a much lesser extent than Eurasian watermilfoil, but its occurrence did prompt a targeted treatment of 7.5 acres by the ALAs in 2008. Curlyleaf pondweed is largely an early-season plant. Most of the plants complete their annual life cycle and drop out of the water column in July. Despite this its occurrence in Tier II surveys can be substantial in the late season on lakes where the level of growth is high. Two early-season Tier II surveys have been done on Atwood Lake. In a May 5, 2005 survey Curlyleaf pondweed occurred in the sampling at 9.3 percent of sites (WPI). The highest Tier II aquatic plant survey occurrence for Curlyleaf pondweed on Atwood lake was 18 percent on June 14 of 2008 (AES). Curlyleaf pondweed only occurred in one of the five late-season Tier II surveys performed on Atwood Lake. It was recovered at 7.5 percent of sites in an IDNR survey on August 9, 2006. It is possible that Curlyleaf pondweed is capitalizing on early season resources made available by the control of Eurasian watermilfoil and using its early season growth pattern to gain an advantage over native plants. The level of growth noted in 2008 may also simply be part of a natural season to season variation in growth. Erratic seasonal changes in growth area and density have been known to occur with this invasive plant. Ideally early-season treatment of all significant Curlyleaf pondweed growth should be performed when water temperatures are approximately 55 degrees Fahrenheit (F). This would work toward limiting the number of turions in the Atwood Lake sediments and prevent the emergence of a serious problem. If funding is not available to target Curlyleaf, careful observation and mapping of dense Curlyleaf pondweed growth should still be made each season to determine if problems with this plant may become more pronounced.

Atwood Lake Summary 2008

Summary of Season's Treatments

Eurasian watermilfoil	Flurid. 6 ppb (28 ac.)	2,4-D (4 acres)		2,4-D (28 acres)	Flurid. 6 ppb (28 ac.)	Flurid. 6 ppb (28 ac.)		2,4-D (4 acres)
Curlyleaf pondweed	Flurid. 6 ppb (unk.ac.)	Aquathol K, 7.5 acres			Flurid. 6 ppb (unk.ac.)	Flurid. 6 ppb (unk.ac.)		Aquathol K, 7.5 ac.
Atwood Lake Date	**WPI 5/5/05**	**AES 6/14/08**		**WPI 8/9/04**	**IDNR 8/3/05**	**WPI 9/7/05**	**IDNR 8/9/06**	**AES 8/19/08**
IDNR protocol 1 or 2	1	2		1	1	1	2	2
Depth range (ft)	0-12	0-10		0-20	0-20	0-10	0-20	0-10
Sample sites (n)	43	50		50	50	43	50	50
Secchi (ft)	6.6	4.3		6.6	9.0	5.7	5.0	4.3
Littoral depth (ft)	12.0	13.5		13.0	15.0	6.0	15.0	10.0
Occurence (%)	81.4	92.0		84.0	84.0	63.0	64.0	88.0
Species (N)	6	9		10	7	4**	9	14
Native species (N)	4	7		9	6	4	7	13
Species/site (max)	5	4		5	3	4	5	4
Mean species/site	1.71	1.92		1.44	1.02	1.11	1.68	1.92
Mean Native species/site	1.26	1.63		1.08	0.94	1.11	1.60	1.86
Species diversity	n/d	0.83		n/d	0.60	n/d	0.74	0.85
Native diversity	n/d	0.79		n/d	0.53	n/d	0.71	0.84
Species occurrence								
Chara	72.1	54.0		72.1	59.2	39.5	50.0	44.0
Coontail		10.0		4.7	4.1			4.0
Eurasian watermilfoil	27.9	10.0		20.9	8.2		2.5	6.0
Flatstem pondweed		12.0		2.3	2.0	7.0		4.0
Sago pondweed	7	32.0		2.3	2.0	37.2	7.5	12.0
Water Bulrush					2.0		2.5	
Illinois pondweed					24.5		25.0	16.0
Spiny naiad		4.0		34.9*			62.5	50.0
Curlyleaf pondweed	9.3	18.0					7.5	
Whitestem pondweed		18.0		18.6			2.5	4.0
Slender naiad							5.0	18.0
Variable pondweed		30.0						16.0
Richardson's pondweed				2.3				6.0
Small pondweed								6.0
Water Stargrass								4.0
Elodea	2.3							2.0
Nitella				4.7				
Bladderwort				2.3				
* Naiad species not specified, assumed to be Spiny naiad								
n/d denotes no data								
** Stats listed for 3 species, 4th is unknown								
Algae occurrence (%)								
Species dominance* **								
Chara		26.8			22.0		19.0	29.6
Coontail		4.4			1.2			2.4
Eurasian watermilfoil		2.0			2.4		0.5	6.0
Flatstem pondweed		2.4			2.0			0.8
Sago pondweed		8.8			0.4		1.5	2.4
Water Bulrush					0.8		0.5	
Illinois pondweed					4.9		6.0	4.0
Spiny naiad		0.8					27.0	22.0
Curlyleaf pondweed		8.4					1.5	
Whitestem pondweed		8.4					0.5	1.6
Slender naiad							1.0	10.0
Variable pondweed		9.2						7.2
Richardson's pondweed								2.0
Small pondweed								1.2
Water Stargrass								1.6
Elodea								2.0
Nitella								
Bladderwort								
*** Dominance is not provided for WPI data								

Figure 26 Summary of available Tier II plant survey data from Atwood Lake

6. Threatened and Endangered Species Surveys

In December 2008 personnel from the Indiana Department of Natural Resources Division of Nature Preserves check the National Heritage database for any known rare, threatened, or endangered species or high quality natural communities present at Atwood Lake. The following was reported:

1. Atwood Lake: There is a historical record of the state species of special concern fish *Coregonus artedi*, Cisco, documented from Atwood Lake in 1955.

Since 1955 IDNR fisheries biologist have sampled Atwood Lake for Cisco, a type of inland-lake Whitefish, and tested water quality at the lake to determine if suitable habitat for the fish still exists in Atwood Lake. Because no Cisco were recovered and the lake was deemed to no longer contain suitable summertime habitat for the fish it is now listed as extirpated from Atwood Lake.

Whitestem pondweed *Potamogeton praelongus* was noted during both the June 14, 2008 and August 19, 2008 Tier II surveys. Whitestem pondweed is listed on the IDNR Division of Nature Preserves list of Rare, Threatened, and Endangered species with a "threatened" status. Richardson's pondweed was collected during the August 19, 2008 survey. Richardson's pondweed is listed as a "Rare" species. No voucher specimen's of these plants were collected for preservation during 2008. The ALA may wish to collect samples of each for preservation and documentation as part of their 2009 management activities. Both these native pondweeds can be considered to provide beneficial habitat in Atwood Lake. Because these plants are not generally tolerant of a high amount of cultural disturbance preserving and improving water quality, managing invasive competing species, and generally maintaining stable aquatic habitat and good water clarity at Atwood Lake will be key in preserving the presence of these species.

7. Description of Beneficial and Problem Areas

Since the biological integrity of Atwood Lake will be maximized if native aquatic plants are preserved and allowed to dominate areas of native plant growth are beneficial. Unfortunately these are often the same areas where invasive non-native plants like Eurasian watermilfoil and Curlyleaf pondweed tend to colonize. Typically drop off areas where the littoral shelf angles down into deep water support much of a lake's plant growth so selectively controlling the growth of exotics in these areas to allow native plants to thrive will be a key to maintaining a healthy plant community.

8. Aquatic Plant Management Alternatives

8.1 General Options for Controlling Invasive Exotic Aquatic Plants

•Insect Biological Control:

A North American Weevil *Euhrychiopsis lecontie*, may be associated with natural declines in Eurasian milfoil at northern lakes (Sheldon 1994, Bratager et al. 1996, Weinberg 1995). In recent years the weevils have been marketed and stocked as a biological control agent with varying results. Historically associated with the native milfoils, the insects are capable of grazing on Eurasian milfoil as well, while not affecting the majority of native vegetation. A control program involves breeding the weevils in captivity, collecting them and then physically attaching the insects to the target plants in the field. The stocked weevils sometimes produce a modest reduction in milfoil biomass among targeted plants during the first season. In most cases restocking must occur every year to maintain control, in many cases no reduction in plants is noted at all after stocking. Interest in the use of the milfoil weevils has been high. They are often viewed as a natural control method that will be less environmentally damaging than more effective forms of control. At present, the high cost and relatively low reductions in plant biomass associated with weevil stocking programs has severely limited their popularity as a control mechanism.

•Harvesting:

There are several models of machines produced for cutting and removal of aquatic vegetation from lakes. Contractors who own the machines generally hire on to cut plants on an hourly basis with organizations that can provide a set minimum hours of work to cover mobilization costs. Most harvesters are constructed like a floating combine. The floating machine is driven and steered with paddle wheels. An underwater cutting bar cuts plant stems and a driven belt carries the cuttings to the back of the machine where they are deposited in a hopper. When the machines hopper is full the machine operator offloads the aquatic cuttings in a designated area or into the back of a truck for disposal. One advantage of harvesting is the actual removal of plant material and associated nutrients from the lake. Unfortunately, only a very small percentage of a lakes nutrient load is invested in plant biomass at any given time. In most cases the cutting will have to

be repeated each season and often multiple cuttings per season are needed to control plant regrowth. This has been experienced at Atwood Lake in the past when the Lake Association owned its own harvester for a time. A major disadvantage of harvesters is the amount of biological disturbance introduced to the lake during the cutting process. Eurasian watermilfoil maintains the ability to recover very quickly from cutting. Native plants which cannot recover as readily from the harvesting encounter a selective disadvantage. The end result can be a shift in plant biomass away from more beneficial native plants, toward Eurasian watermilfoil. Whereas Eurasian milfoil can reproduce through fragmentation, the potential for free floating cut plants to spread growth by settling in other parts of the lake also must be considered. Aquatic plant cutters also tend to entrain a large number of small fish, turtles, and other aquatic organisms which will be removed from the lake if not screened out by the operator. Because of these problems weed harvesting has become subject to regulation and permitting by the Indiana Department of Natural Resources. Harvesters are often the only effective option for controlling excessive growths of stout native plants that do not respond well to other control methods. They are also often employed in areas where regulatory permitting excludes the use of pesticides.

•Control of Eurasian watermilfoil and Curly-leaf Pondweed with Aquatic Contact Herbicides:
Several aquatic contact herbicides are available for use in Indiana lakes. Aquatic pesticide applications on Indiana public lakes are subject to review and permitting on a seasonal basis with the Indiana Department of natural Resources. In addition aquatic applicators for hire must be licensed through the office of the Indiana State Chemist. In aquatic herbicide applications chemical products are typically dispersed over target plants as liquid or granular formulations using specialized boat-mounted equipment. Most contact herbicides function by eroding the cell membranes of plant tissue disrupting plant functioning. Control is usually achieved quickly with susceptible plant species often dropping out in less than one week. Aquatic herbicide choices are somewhat limited as EPA approved products must not cause damage to untargeted organisms, provide a hazard to lake users, or leave harmful residues in the environment. Because of these requirements most contact herbicides have a short half-life in an aquatic environment, being lost to soil adhesion, photodegradation, or bacterial decomposition shortly after application. By both accident and design, most aquatic contact herbicides are selectively effective against obnoxious exotic species with Eurasian milfoil, and Curly-leaf pondweed being especially susceptible. Stout native species such as some of the larger native pondweeds and most of the native milfoils largely remain unaffected by marginal applications on larger lakes. This provides the advantage of allowing selective control, dropping out invasive exotics and leaving the native plant community to recover and capitalize on available light. Selective susceptibility needs to be considered when making herbicide choices so that appropriate plant community effects occur. Contact herbicides tend to leave plant root structures intact so regrowth often begins shortly after treatment. Multiple treatments can be needed in some cases to maintain full-season control. Use of some herbicides requires that lake activities such as swimming or lawn irrigation be restricted near the treatment area during a post treatment waiting period. Water-use restrictions generally apply within 100 feet of the application area. Waiting periods for swimming and other water-uses vary between zero and 120 days depending on the product used.

•Aquatic Plant Control with 2-4-D Granular Translocated Aquatic Herbicide:
Granular formulations of 2-4-D herbicide have been used for many years to control Eurasian watermilfoil. In lawn, agricultural and aquatic applications 2-4-D is used to selectively control plants which are biologically classified as “broadleaves”. Aquatic plants in this category include Eurasian and Native milfoils and Coontail *Ceratophyllum echinatum*. 2-4-D is a translocated or “systemic” aquatic herbicide. It is absorbed by target plants and transported through their vascular systems, affecting remote parts of the plant including the root structure. This offers the theoretical advantage of actually killing more plants and providing longer term control. Well-timed 2-4-D applications in some cases provide seasonal control of Eurasian watermilfoil with

regrowth occurring the following season. Occasionally reapplication is needed within the same season. With milfoil infestations, 2-4-D offers the advantage of being highly selective for milfoil with the pondweeds, and most other native plants remaining completely unaffected. Because granular pellets sink into plant foliage or to the lake bottom and slowly release their active ingredients they can sometimes be more effective than liquid formulations in deepwater applications. Granular 2-4-D use typically restricts swimming near the treatment area for one day, and requires a waiting period on the use of lake water for lawn irrigation, so ornamental and garden plants will not be damaged.

•Aquatic Plant Control with Trichlopyr Translocated Aquatic Herbicide:
Available in a liquid formulation or granular flake (OTF) as Renovate 3® aquatic herbicide, trichlopyr offers broadleaf specific systemic control of aquatic plants in a liquid herbicide. This offers the advantage of easier handling and application over 2-4-D. Results have been similar to the use of 2-4-D. Improved application techniques and the use of adjuvants show some promise of possible multi-seasonal control with the use of Trichlopyr. The current labels allows the restricted use of dosed lake water to be adjusted in accordance with lake-water assay results, greatly reducing the time of restriction in most cases. The label application rates for Renovate 3® can make deep water applications rather expensive when compared with label rates for granular 2, 4-D applications. The Renovate 3® On Target Flake should be considered as an alternative control at Atwood if 2, 4-D does not achieve desired control.

•Aquatic Plant Control with Fluridone Translocated Aquatic Herbicide:
Two aquatic herbicide formulations containing fluridone are currently available. Fluridone is an extremely effective aquatic herbicide at very small concentrations in lakes and ponds, while it displays a relatively low toxicity to fish and mammals. Unlike most other aquatic herbicides it's also environmentally persistent, often remaining in the dosed waterbody in minute, but measurable amounts over the course of several months. Fluridone is absorbed by plant shoots from water, and from hydrosoil by the roots of aquatic vascular plants. In susceptible plants, fluridone inhibits the formation of carotene. In the absence of carotene chlorophyll is rapidly photodegraded causing plants to become chlorotic (whitish) and eventually drop out. Like many other herbicides fluridone is capable of a high degree of selective control at proper dosages. Within the assemblage of plants in most Indiana lakes, Curly-leaf pondweed and Eurasian watermilfoil are most susceptible. For control of Eurasian milfoil fluridone is introduced into a lake at the calculated rate of six to twelve parts-per-billion. Assays are often performed within the first two weeks after initial dosing to assess a hit or miss on a target concentration. A second dosage is often used to maintain the target concentration for a period of 60 to 90 days as the product is allowed to work. At a 6 PPB dosage rate fluridone is highly selective for Eurasian watermilfoil and Curly-leaf pondweed. Fluridone was utilized at Atwood Lake in the 2005 season to provide control of Eurasian watermilfoil. Control typically lasts the entire season with occasional carryover effects during the second season. At dosages of 10 to 12 PPB Eurasian watermilfoil control is typically complete by the end of the first season and often extends through the second season, but a variety of native plants may be impacted. One major advantage of Fluridone use is its persistence and slow activity. During the extended treatment period the product mixes throughout the upper strata of the entire lake basin, allowing it to reach all exotic target plants in contact with the water. This also means that consideration must be given to possible impacts downstream from the target lake. Because of its slow rate of activity fluridone also offers the advantage of providing for gradual breakdown of target plants, providing a more gradual release of nutrients than faster acting herbicides. This decreases the chances of developing oxygen deficits or excessive algal blooms in shallow lakes. Because of the high cost of fluridone herbicides, their use is often reserved for lakes with extensive littoral areas showing profound mat-forming infestations and severely impaired recreational use. The only water-use

restriction associated with fluridone is a wait on the use of lake water for lawn and garden irrigation of 14 to 30 days depending on dose rate.

•Aquatic Plant Control with Triploid Grass Carp (White Amur):
The Asiatic Grass Carp *Ctenopharyngodon idella* has become popular as an introduced exotic biological control for rooted aquatic plants in ponds and southern U.S. lakes. Grass Carp are native to river systems of Russia and China. The species was first imported to the southern United States in 1963. Like most biological controls herbivorous grass carp have remained extremely popular despite some problems associated with their use. Stocking of grass carp was initially illegal in many states including Indiana. Because grass carp are a possibly detrimental exotic species, resource managers feared a destructive establishment of viable wild populations. This process had already occurred with the common carp which remains a destructive influence in our aquatic habitats. Proponents of the plant-eating fish argued that viable breeding habitat for the carp was not present in the United States. That argument was refuted when viable reproduction was noted in the 1980's in tributaries to the Mississippi. When a technique was developed for producing genetically altered triploid grass carp stock with greatly reduced fertility, laws in many states including Indiana were changed to allow stocking of the sterile fish in private waters. The possibility still exists for fish producers to bypass the necessary hatchery process and market fertile fish. Illegally stocked fertile grass carp have been found in some locations. Use of any grass carp remains illegal in twelve states including Michigan.

Despite remaining controversy, some regulatory agencies encourage their use in ponds and lakes publishing stocking guidelines and even offering the fish for sale. Grass carp have been introduced into thousands of private ponds and many larger reservoirs in the southern United States with mixed results. Often stockings in large water bodies bring either complete eliminations of vegetation or very little decline at all (Cassani 1995). Grass Carp are selective feeders and unfortunately tend to prefer most native plant species over Eurasian watermilfoil. Results of grass carp stocking vary with the plant species assemblage present in stocked waters and variations in lake morphometry. In general, stocking at low rates can be expected to produce a shift in plant biomass away from preferred species food plants, toward unpreferred. At high stocking rates the fish will consume all rooted aquatic vegetation in the system. This causes a shift in plant biomass toward planktonic and filamentous algae as fish waste and feeding activity boosts lake nutrient levels. At sustained high numbers, the fish will consume filamentous algae, emergent aquatic plants, and even terrestrial vegetation within their reach at the lake's edge. Shoreline erosion can become a problem when this occurs. At the end result of sustained high stocking rates lake plant biomass will be maintained in planktonic algae, which the fish are unable to utilize as a food source. This can obviously lead to water clarity problems and unstable oxygen levels, especially in the temperate northern U.S. Successful use of grass carp on ponds and in large southern lakes often trades water clarity for alleviation of rooted plant problems. This technique can be effectively employed where water clarity and high oxygen levels are not a priority. In the case of most Indiana natural lakes where water quality and clarity is a high priority, use of herbivorous fish as a management technique would not be wise or legal.

•Benthic Barriers for Aquatic Plant Control
Sheets of plastic or rubber material have been used to exclude aquatic plant growth. Usually owners of small ponds or swimming areas will employ this technique by placing the liner on the bottom and depositing sand or pea gravel on the liner. One drawback with this technique is the tendency for gasses to build up beneath impermeable liner material pushing it up from the bottom. This occurs as decomposition in the lake sediments produces hydrogen sulfide and carbon dioxide gasses. Using mesh liners or permeated liners can alleviate this problem somewhat, but obviously will allow plants to grow through the liner. Bottom liners also

effectively exclude areas of benthic habitat and are generally not permitted by IDNR in public lakes for this reason.

Option	Benefits	Drawbacks
No Control	No dollar cost, No water-use restrictions	Further loss of plant diversity, degraded fish & wildlife value, possible further Sportfish stunting, Impeded recreational use, aesthetic problems
Biocontrol Weevils	No swimming restrictions, No watering restrictions	Often ineffective, Cost prohibitive
Biocontrol Grass Carp	No water-use restrictions, possible multi-season control	Results not-predictable, illegal in Indiana public waters, may cause water clarity/quality problems, limited selectivity
Harvesting	No water-use restrictions, Removes some nutrients from lake	May hasten spread Eurasian milfoil through fragmentation and hydrosoil disturbance, Expensive, May result in regrowth within same season, Requires plant disposal site, Non-selective
Benthic liners	No water-use restrictions, possible multi-seasonal control	Impairs benthic habitat, Not generally permitted in Indiana Public Waters, Not feasible in deep water, Inherent maintenance problems
Aquatic Pesticides (2-4-D)	Highly selective control, Very effective	Intermediate expense, difficult application, Swimming and irrigation restrictions, Generally provides one season's control
Aquatic Pesticides(Renovate)	Highly selective control, Very effective	Expensive- materials expense, Swimming and irrigation restrictions, Generally provides one season's control,
Aquatic Pesticides (Sonar a.s.)	Highly selective control, Very effective, Multi-seasonal control	Expensive product, irrigation restriction, possible damage to non-target vegetation
Aquatic Pesticides (contact herbicides) (diquat dibromide or endothols)	Some selectivity, Very effective, fast acting, least expensive application	Generally provides on season's control, Possible regrowth in late season, Swimming, Irrigation, and possible fish consumption restrictions

Table 10 General Aquatic Plant Control Alternatives, Advantages, and Drawbacks

In the case of Atwood Lake that application of aquatic herbicides is currently the most suitable alternative because of the legality, relatively low cost, and selectivity of control. Native plant growth needs to be encouraged at Atwood Lake so non-selective controls are not a good option. As long as Milfoil and Curlyleaf growth acreages remain small systemic herbicides (contact herbicides for Curlyleaf) will remain the best option. If the acreage of milfoil increases significantly another whole-lake treatment will be the best option because of the selectivity that is possible as well as the completeness of control.

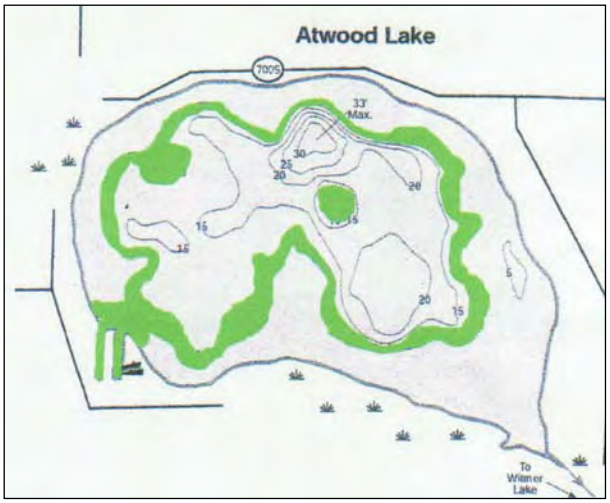


Figure 27 Atwood Lake. extent of dense E. milfoil (28ac.) prior to the 2005 whole lake treatment

Figure 28 Approx. extent of dense E. milfoil growth in 2008

Atwood Lake has responded well to its 2005 season whole-lake treatment. Typically lakes dosed at six parts-per-billion with fluridone will see complete control of Eurasian watermilfoil by the end of the first season with significant growth returning in the second or third season after treatment. Atwood Lake had probably achieved a relatively stable level of Milfoil colonization in 2005 at 28 acres of dense growth. (Figure 27 above) No treatments for milfoil were needed in 2006 or 2007 with only a small treatment taking place at Atwood in 2008. Obviously the pattern of colonization was still comparatively minimal during 2008 (figure 28 above). Only four acres ended up needing treatment in 2008. Many factors may have contributed to the excellent duration of control achieved on Atwood. Because watercraft speeds are limited to 10 miles-per-hour or "no wake" plant fragmentation and transport by watercraft has probably been less than would be experienced on a lake were water skiing and personal watercraft operation are popular. Contributions of new fragments brought into the lake from outside sources are probably also minimal at Atwood. The lake is located in a relatively rural area away from population centers. Atwood also has several other popular fishing lakes located nearby that my draw much of the angler traffic away. Since there are no large streams flowing from other water bodies into Atwood, it is not subjected to constant contributions of plant fragments. Tributaries that flow into fluridone treated lakes can also provide a constant source of untreated water that dilutes in-lake fluridone levels in the immediate vicinity of the inflow. On some lakes this may have a protective effect, preserving milfoil plants near the inlets of these steams that then act as a sources of fragments to quickly recolonize the lake. Because the tributaries flowing into Atwood are very small and intermittent, this effect has probably been minimal. It is reasonable to expect that Atwood will gravitate back toward approximately 28 acres of dense milfoil colonization if no control measures are taken. Treating all noted Eurasian watermilfoil growth with systemic aquatic herbicides each season can help slow this process, but the acreage of growth may still increase each season as unobserved low grade growth may be present in many areas of the lake in any given season. Assuming that the growth area for Eurasian watermilfoil could easily double each season the 28 acre colonization could return by 2012. The Atwood Lake plant community responded well to fluridone treatment, experiencing a near-eradication of Eurasian watermilfoil, elimination of Curlyleaf pondweed in the season of treatment, and a rapid rebound in native diversity in the seasons after treatment, so the decision about when another fluridone treatment is advisable becomes largely a matter of financial efficacy.

It's estimated that a 6 ppb fluridone treatment could cost up to $22,800.00. If this treatment results in another three seasons without additional milfoil treatment needed the cost per season for milfoil control would be approximately $7600.00 per season. At $450.00 per acre for seasonal treatment with 2, 4-D this equates to approximately 17 acres of treatment. Considering that the lakewide level of control achieved is typically greater with the fluridone treatment than with 2, 4-D, and other factors such as the water-use restrictions imposed by seasonal 2, 4-D treatments and possible inflation in treatment costs for 2, 4-D it appears that another whole-lake treatment would be wise if the seasonal growth of milfoil is expected to occupy 15 acres or more. An additional benefit of performing another whole lake treatment includes the added control it will provide for Curlyleaf pondweed in the season of the application. With an estimated 8 acres of Eurasian milfoil treatment needed in 2009 and up to twice that (16 acres) possibly needed in 2010 the Atwood Lake Association is advised to plan another whole lake treatment for 2010. The pattern of growth in 2009 can be expected to be close to that experienced in 2008 (Fig. 30 below).

The ALA is advised to control this milfoil growth with Navigate granular 2,4-D in the 2009 season. To prevent Curlyleaf pondweed from becoming a serious secondary problem annual early season treatments with contact herbicides should be performed when water temperatures reach approximately 50-55 degrees F. This early season treatment is intended to stop the production of turions that initiate growth into adult plants in future seasons. It's been demonstrated experimentally that treatments with contact herbicides such as the endothalls (Aquathol K®, Hydrothol 191®) during early or mid-spring can decrease turion production by over 90 percent, while late spring treatments may not (Poovey, Skogerboe, and Owens 2002).

In field studies depletion of Curlyleaf turions has occurred after multiple seasons of repeated early Curlyleaf treatments to the point where treatment was unnecessary for one to two seasons. Additionally performing these treatments early can minimize the effects of the treatment on non-target species like the native pondweeds. Curlyleaf plants are typically emerged and actively growing and thus susceptible to treatment at this time while most native plants are not. It is advised that the ALA plan to treat up to eight acres of Curlyleaf pondweed in the 2009 season using Aquathol K® liquid herbicide at the application rate of 1 ppm. Growth areas for Curlyleaf pondweed can vary greatly from year to year, but the growth pattern exhibited in 2008 will be a good starting point for planning purposes (Fig 29 below). Sampling and mapping should adjust this as needed prior to treatment.

The ALA may wish to continue with small treatments of native plants in high-use areas where they provide a hindrance to recreational activities so long as the treatment areas are not extensive enough to provide significant damage to the lake's native floral community. Because the management of the lake's shoreline, riparian wetlands, and watershed are crucial to maintaining a healthy aquatic plant community the Atwood Lake Association should consider seeking funding from the LARE program for a Lake Diagnostic Study. The disappearance of Cisco from Atwood indicates that some nutrient enrichment has occurred in the past. Trophic state index scores and available water clarity data also suggest that changes toward a more nutrient-rich system may be occurring. A Lake Diagnostic Study would help establish a set of directives toward improving and protecting the water quality of the lake. Local County Soil and Water Conservation District and USDA NRCS Personnel may also be helpful in indicating possible changes in watershed land-management practices that may be helpful. It would also be helpful for the ALA to implement volunteer monitoring of water clarity through the Indiana Clean Lakes Program. This can help establish and maintain a more complete record of water clarity to track trends accurately and help with future decision making.

Figure 29 2008 Curlyleaf growth areas (also approximate areas of estimated growth for 2009)

Figure 30 Eurasian watermilfoil treatment map for 2008, also approximate estimated growth pattern for 2009

9. Public Involvement

A public meeting for discussion of aquatic plant management at Atwood Lake was incorporated into the regular meeting of the Atwood Lake Association held on June 14, 2008 at the Atwood Lake Campground pavilion. Each year the ALA holds a meeting in June and another in August. Approximately 44 persons were in attendance on June 14. This was considered to be a well-attended meeting of the ALA. Survey results indicate that all were Atwood Lake property owners or their family members. Of approximately 123 households on the lake this represented 22 percent. Of 75 association member households it represented 36 percent. Information about ongoing plant management and monitoring efforts was presented by Aquatic Enhancement & Survey, Inc. A discussion was held about the status and goals of the Atwood Lake Plant Management Plan and opportunity was provided for lake residents to ask questions and provide input regarding the plant management and water-use restrictions involved. Samples of Curlyleaf pondweed and Eurasian watermilfoil were provided to help the lake users to recognize these invasive plants. The Lake Use Survey below was distributed to those present, filled out (one per household), and collected. Twenty-seven surveys were completed and returned. The survey form and results are provided below. All 27 respondents indicated that they were lake property owners and association members. When asked how long they had resided at the lake eight respondents indicated they were 20+ year residents, four were 11-20 year residents, five had been at the lake 6-10 years, and seven were relatively new to the lake having resided there 0-5 years. Twelve residents indicated that the growth of aquatic plants had detracted from their enjoyment of the lake at some point, eleven said it had not. When asked to mark activities they participate in at the lake 25 marked “enjoy view and atmosphere”, 24 marked “swimming”, 24 marked “boating”, 21 marked “fishing”, 16 marked “view wildlife”, and 7 marked “irrigation”. When asked whether the lakes contained aquatic plants in nuisance quantities at the current time (post treatment) 15 respondents marked “yes” nine marked “no”. When asked whether they felt that the level of aquatic vegetation at the lake can negatively affect their property value 22 indicated it could, while only four said it could not. All 26 respondents said they were in favor of continued vegetation control, none marked that they were not in favor. When asked to mark which items on a list of 12 common lake problems were current problems on Atwood Lake 17 respondents marked “Canada Geese”, two marked too many aquatic plants, two marked “poor water clarity”, one marked “dredging needed”, and one marked “additional speed enforcement needed”. Opportunity was provided for other problems to be indicated or other input to be written on the back of the form. One respondent indicated “no duck hunting!” as a problem, one requested that more structure besides aquatic plants be provided for fish, one indicated “stunted fish” as a problem, one indicated “geese out of control”. Overall the meeting attendants were very interested in continuing efforts to manage exotic plants at the lake and were pleased with plant management results thus far. This was also indicated by comments made verbally at the meeting. Support for continued exotic plant management was not surprising considering that enjoying the view, boating, and swimming, were the most popular activities.

Atwood Lake User Survey 6/14/08

1. Are you an Atwood Lake property owner? Yes___**27**_____ No_____

2. How many years have you been at the lake? (circle one) 0-5 years **7**
6-10 years **5**
11-20 years **4**
More than 20 years **8**

3. Has the growth of aquatic plants on Atwood Lake ever negatively affected your enjoyment of the lake? Yes__**12**___ No___**11**____

4. How do you use the lake? (mark all that apply)
24_Swimming **7**__Irrigation (including lawn) **25**_Enjoy View and Atmosphere
24_Boating **21**_Fishing **_16**__View Wildlife
Other _____

5. Do you feel that there are Aquatic plants in nuisance quantities on Atwood Lake at this time (2008 after treatment)?
Yes _**15**__ No _**9**__

6. Do you feel the level of vegetation in the lake can negatively affect your property value?
Yes _**22**__ No _**4**__

7. Are you in favor of your lake association initiating efforts to control vegetation on the lake?
Yes _**26**__ No ___

8. Are you a member of your lake association? Yes___**27**__ No_____

9. Mark any of these you think are problems on your lake:
___ Too much fishing
_17__ Canada Geese
___ Excessive boat traffic
_1__ Dredging needed
_2__ Too many aquatic plants
___ Not enough aquatic plants
_2__ Poor water clarity
_1__ Additional Speed enforcement needed

Other_____

Please add any additional comments on the back:

10. Implementation Strategy, Timeline, and Cost Estimates

2009 ●**Success Benchmarks** Elimination of all densely growing Curlyleaf stands within two weeks of treatment. A late-season Tier II occurrence of Eurasian watermilfoil of 5% or less	**2010** ●**Success Benchmarks** Elimination of all densely growing Curlyleaf stands by mid-May. A late-season Tier II occurrence of Eurasian watermilfoil of 5% or less.	**2011** ●**Success Benchmarks** Elimination of all densely growing Curlyleaf stands within two weeks of treatment. A late-season Tier II occurrence of Eurasian watermilfoil of 5% or less	**2012** ●**Success Benchmarks** Elimination of all densely growing Curlyleaf stands within two weeks of treatment. A late-season Tier II occurrence of Eurasian watermilfoil of 5% or less
Month/Activity	**Month/Activity**	**Month/Activity**	**Month/Activity**
April, Map Curlyleaf pondweed And Eurasian watermilfoil growth 700.00	April, Map Curlyleaf pondweed And Eurasian watermilfoil growth 700.00	April, Map Curlyleaf pondweed And Eurasian watermilfoil growth 700.00	April, Map Curlyleaf pondweed And Eurasian watermilfoil growth 700.00
April/May (H2O temp app. 50-55 F or soon after emergence) Treat Curlyleaf pondweed 8ac.as needed (1 ppm Aquathol K) 2800.00	May apply Fluridone at 6 ppb with a bump back to 6 ppb as needed at two weeks 22,800.00	April/May (H2O temp app. 50-55 F or soon after emergence) Treat Curlyleaf pondweed 8ac.as needed (1 ppm Aquathol K) 2800.00	April/May (H2O temp app. 50-55 F or soon after emergence) Treat Curlyleaf pondweed 8ac.as needed (1 ppm Aquathol K) 2800.00
May, Eurasian treatment (approx. 8 ac.) 3600.00		May, Eurasian treatment (approx. 2 ac.) 900.00	May, Eurasian treatment (approx. 4 ac.) 3600.00
July, Tier II Survey 1200.00	July, Tier II Survey 1200.00	July, Tier II Survey 1200.00	July, Tier II Survey 1200.00
As arranged, Public Meeting 350.00	As arranged, Public Meeting 350.00	As arranged, Public Meeting 350.00	As arranged, Public Meeting 350.00
October/November, Permit Meeting 200.00	October/November, Permit Meeting 200.00	October/November, Permit Meeting 200.00	October/November, Permit Meeting 200.00
December, Plan Update Document Due 1600.00	December, Plan Update Document Due 1600.00	December, Plan Update Document Due 1600.00	December, Plan Update Document Due 1600.00
Total Cost **10,450.00**	**Total Cost** **27,150.00**	**Total Cost** **7750.00**	**Total Cost** **10,450.00**

11. Integrated Management Action Plan

Exotic plant management at Atwood Lake should take an approach consisting of three tiers of action working toward this plan's primary goals:

Tier 1. Nutrient and Sediment control.
The ALA should be vigilant in spotting and addressing nutrient and sediment sources in the watershed, stopping pollutants at their source before water quality can be impacted.

Tier 2. Public Education.
The educational points in the section below can potentially prevent a very costly infestation of new exotic plants and animals at the lakes, saving resources that can be utilized to address current problems. This information should be shared with as many lake residents as possible.

Tier 3. Exotic Plant Control.
Addressing the submersed aquatic non-native plants present on a lakewide basis with professional applications of EPA approved aquatic pesticides and monitoring results closely can potentially limit their spread, and preserve the native plant community while providing relief to lake users. The proposed treatment regime is detailed in the budget and timeline above. A treatment response benchmark of a reduction in Eurasian watermilfoil late-season Tier II occurrence to five or below should be pursued for 2009. For Curlyleaf pondweed a goal of having all notable dense

growth areas treated, with plants dropping out within two weeks of an early-season treatment is reasonable for Atwood Lake. To reduce turion production this should take place when water temperatures are approximately 50-55 degrees F. This course of action appears to be agreeable to Atwood Lake Association and IDNR at this time. Whereas funding requests for LARE exceed available funding every applicant lake will not be funded each season. It is important for the ALA to remember that it may be necessary to plan alternate sources of funding for plant management activities during season's in which no funding is available.

Important program dates for the ALA in the 2009 season are below. These dates are based on a timeline needed if the ALA intends to have an early-season Curlyleaf treatment done. There is considerably more flexibility in timing if only a milfoil treatment is being performed as milfoil treatments generally do not begin until May.

March 1	Send in treatment permit form to IDNR
March 15	IDNR funding decisions
March 20	Send a request for proposals to planning and application contractors due in one week
March 27	Receive bids from contractors
March 31	Select and notify contractor(s) and call IDNR to have application contractor noted on permit (260-244-6805)
April 10	Obtain signed contract
May 15	Schedule Lake Association Meeting with contractor (s)
November 1	Last day for contractors to provide maps for management plan or plan updates and schedule a meeting with DNR Fisheries and LARE biologists
December 15	First draft of management plan or plan updates due from contractors
January 15	Grant application due for current year funding
March 1	Final copy of revised plan or update due from contractors

12. Public Education

The ALA should set reasonable goals for increasing awareness among lake users about lake health issues. The association's summer meetings held in June and again in August can serve as the primary vehicles for disseminating information. An association newsletter could also help reach those who do not attend. An association website might be another way that relevant information can be shared. The following areas should be addressed:

●Prevention of the spread of Exotic Invasive Aquatic and Wetland Species
An effort should be made to make lake users aware that their own boat trailers could have introduced Curlyleaf pondweed or Eurasian watermilfoil to Atwood Lake or could spread these plants to other lakes if care is not taken to remove vegetative debris at pull-out. Basic plant identification should be addressed including Hydrilla *Hydrilla verticillata,* so new invasive species appearing can be spotted early on by the lake users. Information on Hydrilla is presented in the next report section.

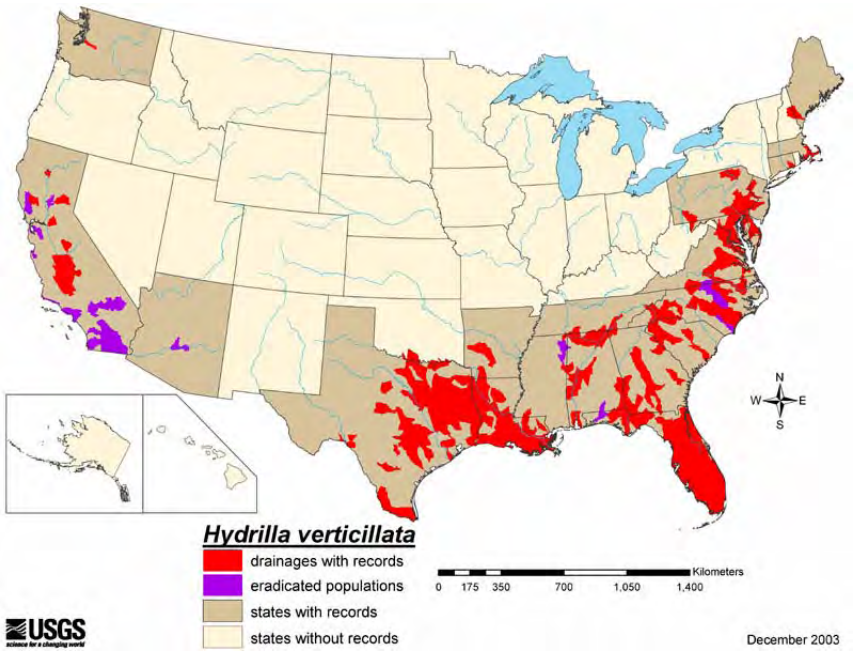
●Prevention of lake nutrient enrichment.
An effort should be made to encourage all lake residents to switch to no-phosphorus lawn fertilizers. Residents should also be made aware that soils lost through erosion in the watershed carry nutrients into the lake's waters as do sediments mobilized from the lake's bottom and

shoreline by watercraft. Area residents should be aware of proper erosion control techniques needed at construction sites within the watershed. Residents should be aware that water quality can change with changes in the use of watershed lands. Local County Soil and Water Conservation District personnel could be a good source of information regarding farming and land-use practices in the watershed.

●Expectations and water use restrictions associated with Plant Management
Residents should be made aware that LARE funds are intended to address only Exotic species of aquatic plants and control of plants will not occur throughout the whole lake. It is also important that residents understand and obey the posted water use restrictions associated with any chemical treatments performed.

12.1 Hydrilla and its Implications for Atwood Lake

Keeping lake residents and users aware of the possibility of bringing in new invasive species in to the lake on watercraft trailers will be especially important now that Hydrilla has been found in Indiana. Hydrilla *Hydrilla verticillata* is an invasive submersed aquatic plant thought to be native to Africa, Australia, and parts of Asia. As a hearty growing plant Hydrilla was used in aquariums and this led to its introduction into Florida waters in 1960. Since then Hydrilla has spread to become the single most problematic plant in the United States. (See USGS map below) In Florida alone millions are spent in controlling the growth of Hydrilla each year. The potential exists for the same type of damage on Indiana waterways if Hydrilla is allowed to spread. Like many invasive aquatic plants Hydrilla can form dense surface mats depriving native plant communities of light, decreasing plant community diversity, and causing serious impairment of recreational activities including fishing, swimming, and boating.



Known occurrences of Hydrilla in the U.S. in 2003. From the USGS website, http://nas.er.usgs.gov/taxgroup/plants/docs/hy_verti.html

Hydrilla mats clog the surface of Lake Conroe Texas. Photo courtesy of Earl Chilton, Texas Parks and Wildlife Department

Hydrilla can spread by fragmentation or the production of seeds, tubers (root structures), or turions (seed-like plant buds). Because of the potential for spread through fragmentation, plant material hitching a ride on watercraft trailers is probably a major mechanism of introduction. Tubers and turions can be very hearty, surviving dry periods or herbicide treatments and remaining hidden in the lake bottom for extended periods of time. Because of these characteristics great ecological damage and recreational impairment can occur in watersheds colonized by Hydrilla. In 2006 Hydrilla was discovered in Lake Manitou and its outlet stream in Rochester Indiana (Fulton County). This is the first known occurrence of this plant in the Midwest. The Indiana Department of Natural Resources is carrying out a plan for eradicating and controlling the Hydrilla to prevent spread to other water bodies. Checks of other lakes in close proximity to Lake Manitou have not located any Hydrilla, so it is possible that the plant is only in and immediately downstream of Lake Manitou at this time. However, it's also possible that other lakes contain young Hydrilla infestations that have yet to be recognized so it's important that associations and lake residents learn to identify this plant. Acting early in spotting Hydrilla can help prevent spread and ultimately save a huge cost to the ecology and recreational value of Indiana lakes. At some point other infestations may occur as a result of plants being transported to Indiana from out-of-state. Whereas Atwood Lakes has a public access site and is a popular fishing destination, there is a definite possibility that this plant could appear in the Lake in the future. Information on Hydrilla identification should be presented to the Lake users at meetings as a regular part of the lake resident educational program.

Hydrilla is similar in appearance to the native plant Elodea and also Brazilian elodea, an exotic (also recently found in Indiana). It forms long stems containing many whorls of short leaves. Photo Courtesy of Dr. John H. Rodgers, Jr.

12.1.1 Hydrilla Identification

Hydrilla strongly resembles the native aquatic plant Elodea *Elodea canadensis* and the introduced species Brazilian elodea *Egeria Densa*. Both these species can be found in Indiana although the occurrence of Brazilian elodea has been very limited thus far. Hydrilla is a long slender plant that sometimes branches and has short leaves arranged around the stem in a star-like (whorled) pattern. Characteristics which differentiate Hydrilla from Elodea and Brazilian elodea include a typical leaf count of five in the whorl. Brazilian elodea typically has four to six leaves but never three, and native Elodea usually has three (Fig. 31). Small teeth are also present on the midrib of Hydrilla leaves and may give the plant a “rough” feel. Hydrilla also has small serrations along the leaf edges (Fig. 32). Another distinguishing characteristic of Hydrilla is the presence of tubers (.2 to .4 inch long off-white structures attached to the root) (Fig. 33).

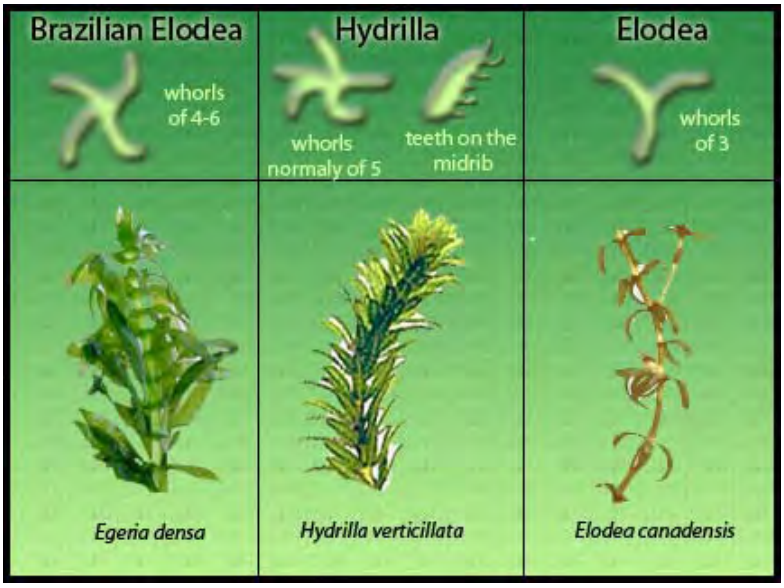


Figure 31 Brazilian elodea has a typical leaf count of 4-6, while Hydrilla is usually 5, and Elodea's 3. Drawing courtesy of Rob Nelson at ExploreBiodiversity.com

Figure 31 Edges of Hydrilla leaves have fine serrations visible upon close examination. Photo Courtesy of Dr. John H. Rodgers, Jr.

Figure 32 Hydrilla plants with tubers attached. Photo courtesy of King County Natural Resources and Parks, Water and Land Resources Division.

Anyone noting the presence of Hydrilla or Brazilian elodea is asked to immediately contact Doug Keller, Invasive species coordinator for the Indiana Department of Natural Resources at 317-234-3883, email: **dkeller@dnr.in.gov**. If you have questions about the identity of aquatic plants found, photos of the plants can be e-mailed to Doug for basic identification to determine if further action is required. More information on stopping the spread of invasive aquatic species is available online at **http://www.protectyourwaters.net/.**

13.0 Monitoring and Plan Update Procedures

The Atwood Lake Association's aquatic plant management program should be monitored and updated on an annual basis. Monitoring will consist of monitoring not only the lake's plant community, but the thoughts and opinions of the lake's users. To monitor the lake's exotic growth remapping of growth should occur each spring with a comparison made with the previous season's growth pattern. A tier II survey in the late season after treatment has been initiated will serve to characterize the lake's overall plant community statistically and also gage if treatment success bench marks from the implementation strategy have been attained. In addition to seeking a late-season Tier II occurrence of five percent or less for Eurasian watermilfoil and seasonal elimination of dense stands of Curlyleaf pondweed the ALA should seek to maintain a late-season Tier II occurrence of at least 6 native species. This will provide a good basic indicator of plant community diversity. If treatment response bench marks are not attained changes in the treatment timing, chemical(s) used, or integrated approach will all be options for setting a new course toward success. To monitor the thoughts and opinions of lake users at least one public meeting should be held annually and a survey distributed. An open forum at the meeting should exist to allow for discussion of water-use restrictions associated with treatments, new problems arising at the lake, or treatment effectiveness.

14. Literature Cited

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Appendix A
IDNR Aquatic Vegetation Permit Application

APPLICATION FOR AQUATIC VEGETATION CONTROL PERMIT

State Form 26727 (R / 11-03)
Approved State Board of Accounts 1987

[ ] Whole Lake [x] Multiple Treatment Areas
Check type of permit

INSTRUCTIONS: Please print or type information

FOR OFFICE USE ONLY
License No.
Date Issued
Lake County

Return to:
DEPARTMENT OF NATURAL RESOURCES
Division of Fish and Wildlife
Commercial License Clerk
402 West Washington Street, Room W273
Indianapolis, IN 46204

FEE: $5.00

Applicant's Name: Ted Kirchner	Lake Assoc. Name: Atwood Lake Association	
Rural Route or Street: 7160 S. 080E		Phone Number: 260-854-2919
City and State: Wolcottville, IN		ZIP Code: 46795
Certified Applicator (if applicable)	Company or Inc. Name	Certification Number
Rural Route or Street		Phone Number
City and State		ZIP Code
Lake (One application per lake): Atwood	Nearest Town	County: LaGrange
Does water flow into a water supply		[ ] Yes [x] No

Please complete one section for *EACH* treatment area. Attach lake map showing treatment area and denote location of any water supply intake.

Treatment Area # 1	LAT/LONG or UTM's see map	
Total acres to be controlled: up to 12	Proposed shoreline treatment length (ft): n/a	Perpendicular distance from shoreline (ft): n/a
Maximum Depth of Treatment (ft): 8 ft	Expected date(s) of treatment(s): 5/25/2009	

Treatment method: [x] Chemical [ ] Physical [ ] Biological Control [ ] Mechanical

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. general seek and destroy of Eurasian watermilfoil, 2,4-D gran.

Plant survey method: [x] Rake [x] Visual [ ] Other (specify)

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community
Eurasian watermilfoil	x	10%
Chara		70%
Curlyleaf		10%
Sago		10%

Treatment Area # 2	LAT/LONG or UTM's general seek and destroy		
Total acres to be controlled up to 10	Proposed shoreline treatment length (ft) n/a	Perpendicular distance from shoreline (ft) n/a	
Maximum Depth of Treatment (ft) 9ft	Expected date(s) of treatment(s) 4/25/2009		

Treatment method: [x] Chemical [ ] Physical [ ] Biological Control [ ] Mechanical

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. Aquathol K (general seek and destroy)

Plant survey method: [x] Rake [x] Visual [ ] Other (specify)

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community
Eurasian watermilfoil		10%
Chara		70%
Curlyleaf	x	10%
Sago		10%

INSTRUCTIONS: Whoever treats the lake fills in "Applicant's Signature" unless they are a professional. If they are a professional company who specializes in lake treatment, they should sign on the "Certified Applicant" line.

Applicant Signature	Date
Certified Applicant's Signature	Date

FOR OFFICE ONLY

[ ] Approved [ ] Disapproved	Fisheries Staff Specialist
[ ] Approved [ ] Disapproved	Environmental Staff Specialist

Mail check or money order in the amount of $5.00 to:

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
COMMERCIAL LICENSE CLERK
402 WEST WASHINGTON STREET ROOM W273
INDIANAPOLIS, IN 46204

XMap® 5.2 GIS Enterprise
DeLORME
Aquatic Enhancement & Survey, Inc.
P.O. Box 1036
Angola, IN 46703
tel: 260-665-8226
toll free: 888-867-5253
Areas 1 and 2, entire littoral zone seek and destroy
Area 1 up to 1/2 acres, Area 2 up to 10 acres
(areas exceed APMP prediction in case growth has been underestimated)
Atwood Lake 2009 permit map
Data use subject to license.
© DeLorme. XMap® 5.2 GIS Enterprise.
www.delorme.com

Appendix B
Tier II Plant Survey Data Sheets

Aquatic Vegetation Random Sampling (Tier 2)

Waterbody Cover Sheet

Surveying Organization: Aquatic Enhancement & Survey, Inc.

Contact Information: (260) 665-8226

Waterbody Name: Atwood Lake

Lake ID:

County(s): Lagrange

Date: 6-14-2008

Habitat Stratum:

Avg. Lake Depth (ft):

Lake Level:

Crew Leader: Scott Banfield

GPS Metadata

Datum: Zone: Accuracy:

Recorder: Joseph Closson

Method:

Secchi Depth (ft):

Total # of Points Surveyed:

Total # of Species:

Littoral Zone Size (acres):

- ☐ Measured
- ☐ Estimated

Littoral Zone Max. Depth (ft):

- ☐ Measured
- ☐ Estimate (historical Secchi)
- ☐ Estimated (current Secchi)

Notable Conditions:

Note: Between 0-5 = ~~29~~ 40
5-10 = ~~17~~ 10

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

Page 1 of 2

WATERBODY NAME: Atwood Lake	DATE: 6-14-08
COUNTY: Lagrange	SECCHI DEPTH (FT): 4.5
SITE ID:	MAX PLANT DEPTH (FT):
SURVEYING ORGANIZATION: Aquatic Enhancement	WEATHER: 76°, light Southwest wind, sunny – water = 72.2°
CREW LEADER: Scott Bantfield	COMMENTS (Include voucher codes - V1, V2...):
RECORDER: Joseph Closson	
CONTACT INFO: (260) 665-8226	

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

Species Codes:

Point #	R/T	Latitude	Longitude	Depth (ft)	MYRSPI	POTCRI	CHARA	CERDEM	STUPEC	ALGA	POTZOS	POTGRA	POTPRA	POTZOS	NAS MAR	~~[illegible]~~	Notes
2				4.5			5		1								
3				4.8		5			5		1						
5				2								1					
6				4			5										
7				10		1			3				5				
8				4					1			1					
9				9.5		5							1	1			
10				4			1					1			1		
11				4			1										
12				9.8	1								3				
13				5					1								
14				5.5				1	1								
15				4.8				3	1			1					
16				3.8			1					1		1			
17				4.8								1					
18				4.5			1					1					
19				8.5								1					
20				4.5			1	1	1							+	
21				3				1	1							+	
22				3.5													
23				6			3		1								
24				4.2													
25				3		1											
26				3			1					1					
27				6.5		1	1				1	1					
28				2	1		1										
29				4.5		1	1										
30				3			1					3					
31				4.5			1					1					
32				5			1										

0-5	5-10
~~[illegible]~~	~~[illegible]~~
411	11

Other plant species observed at lake: ~ plants grew at 13.5 feet (Chara & flatstem).
~Lake was treated on June 9, 2008

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

WATERBODY NAME: Atwood Lake
DATE: 6-19-08
COUNTY: Lagrange
SECCHI DEPTH (FT):
SITE ID:
MAX PLANT DEPTH (FT):
SURVEYING ORGANIZATION: Aquatic Enhancement
WEATHER:
CREW LEADER: Scott Banfield
COMMENTS (Include voucher codes - V1, V2...):
RECORDER: Joseph Closson
CONTACT INFO: (260) 665-8226

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

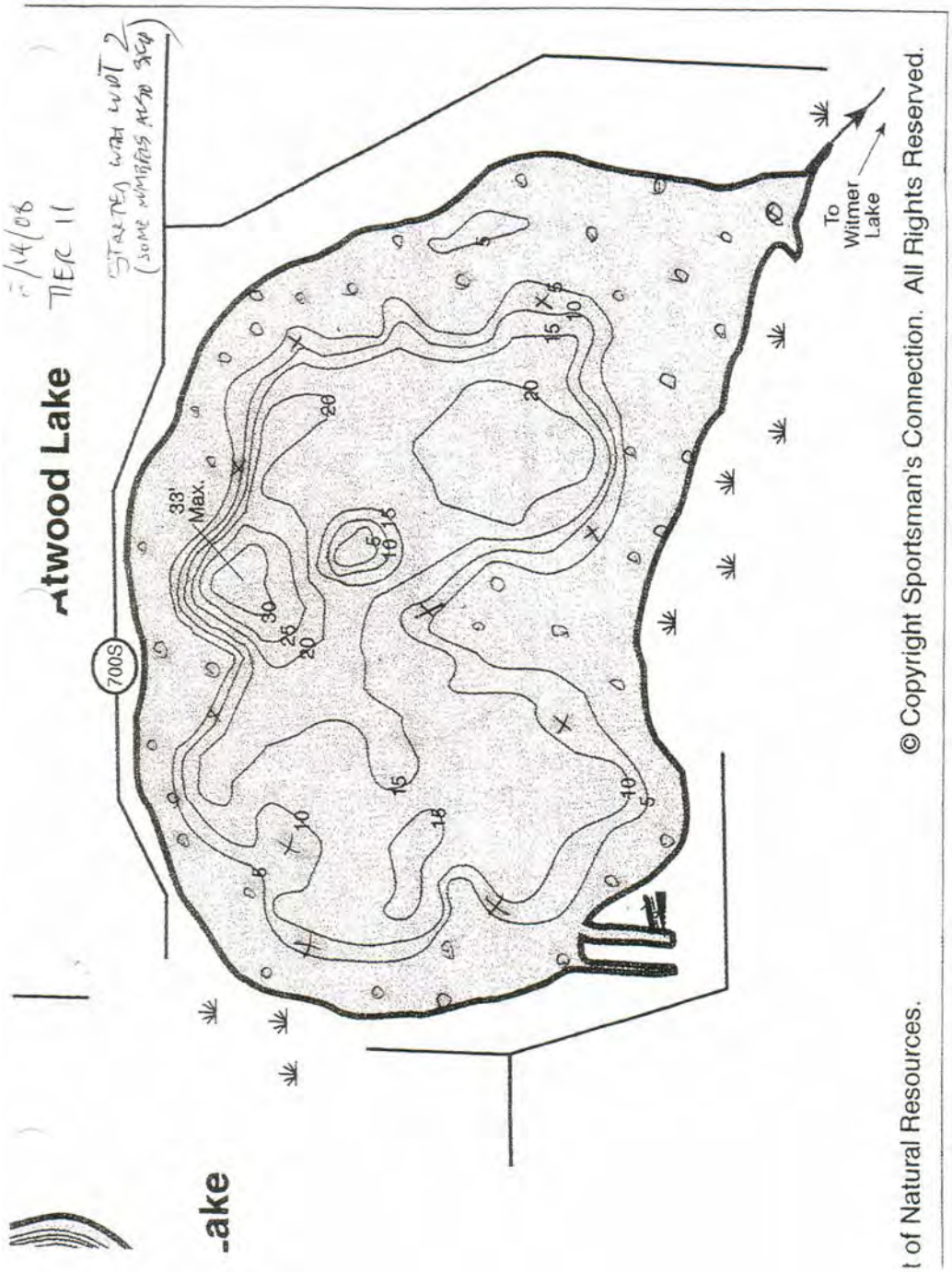
Species Codes:

Point #	R/T	Latitude	Longitude	Depth (ft)	MYSPIC	POTCRI	CHARA	CERDEM	STUPEC	ALGA	POTZOS	POTGRA	POTPRA	POTZOS	NASMAR	Voucher #1	Notes
33				3.5			1										
34				4.5			5				1						
35				1.8			1										
36				4.9					1								
37				4.5			5										
38				4			1		1						1		
39				3.5	1								3				
40				4													
41				4			1		1				1		1		
42				4.8			5		1			1					
43				9.2		1							1				
44				2	1	1		5									
45				3.5			5										
46				4.5			3		1							1	
47				~~5.5~~ 4			5		1				+				
48				~~4~~ 4.5	1												
49				9		5							1				
50				3			1					3					
51				7			5					1	5				
52				2.5			5					5		1			

voucher specimen collected wp # 4 @ 4.5 feet

0-5	5-10
24	7
~~1111~~	17
~~1111~~	1
1111	

Other plant species observed at lake:


Atwood Lake
700S
33' Max.
To Witmer Lake
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t of Natural Resources.
77

Aquatic Vegetation Random Sampling (Tier 2)

Waterbody Cover Sheet

Surveying Organization: Aquatic Enhancement & Survey, Inc.

Contact Information: (260) 665-8226

Waterbody Name: Atwood Lake

Lake ID:

County(s): La Grange

Date: 8-19-08

Habitat Stratum:

Avg. Lake Depth (ft):

Lake Level: 9.86

Crew Leader: Scott Banfield

GPS Metadata

Datum: Zone: Accuracy:

Recorder: Joseph Closson

Method:

Secchi Depth (ft): 4'4"

Total # of Points Surveyed:

Total # of Species:

Littoral Zone Size (acres):

- ☐ Measured
- ☐ Estimated

Littoral Zone Max. Depth (ft):

- ☐ Measured
- ☐ Estimate (historical Secchi)
- ☐ Estimated (current Secchi)

Notable Conditions:

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

Page 1 of 2

WATERBODY NAME: Atwood Lake	DATE: 8-19-08
COUNTY: Co Orange	SECCHI DEPTH (FT): 4' 4"
SITE ID:	MAX PLANT DEPTH (FT):
SURVEYING ORGANIZATION: Aquatic Enhancement	WEATHER: Sunny 85° Light South
CREW LEADER: Scott Banfield	COMMENTS (Include voucher codes - V1, V2...):
RECORDER: Joseph Closson	V1 POTRIC WPTS
CONTACT INFO: (205) 665-8226	

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

Point #	R/T	Latitude	Longitude	Depth	LHARA	NAJMAR	~~CERDEM~~	~~ELOCAN~~	POTRIC	POTILL	POTGRA	STUPEC	ZOS DUB ~~Notes~~	POTZOS	POTPUS	NAJGUT
					Species Codes:		POTBRA	MYRSPE								
2		ELOCAN	CERDEM	4.5	5	1										
3		5	1	4.8									1	1		
5				2					3	1						
6				4	5					1	1					
7				10	1	5						1				
8				4		5				1						
9				9.5									3	1		
10				4		5										
11				4	5	5										
12				9.8		1	1	1								
13				5	1	1						1				
14				5.5		5				1						
15				4.8	5							1		1		
16				3.8												
17				4.8	1						1	1				1
18				4.5	1	1				1						5
19				8.5		1				1		1				
20				4.5		1						1				
21				3		1		1								
22				3.5												
23				6	1									1		
24				4.2												
25				3												
26				3												
27				6.5		1	3									
28				2												
29				4.5		1								1	1	
30				3												
31				4.5		1										
32				5	1											
33				3.5		1										
34				4.5	5											
35				1.8		1										

Other plant species observed at lake:

Submersed Aquatic Vegetation Survey (Tier II) Datasheet

Page 2 of 2

WATERBODY NAME: Atwood Lake	DATE: 8-19-08
COUNTY: Carroll	SECCHI DEPTH (FT):
SITE ID:	MAX PLANT DEPTH (FT):
SURVEYING ORGANIZATION: Aquatic Enhancement	WEATHER:
CREW LEADER: Scott Banfield	COMMENTS (Include voucher codes - V1, V2...):
RECORDER: Joseph Closson	
CONTACT INFO: (260) 665-8226	Rake score (1, 3, 5). 9 = algae, emergent or species observed but not sampled.

Species Codes: POTPRA MYRSPI

Point #	R/T	Latitude	Longitude	Depth	CHARA	NASMAR	~~CERDEM~~	~~ELOCAN~~	NASFLE	STUPEC	POTFUS	POTGRA	POTRI ~~Notes~~	CERDEM	POTILL
36				4.9	5										
37				4.5	1	3									
38				4	5	5									
39				3.5	5 ~~5~~				~~5~~		+	1			
40				4	5				5		1				
41				4	1	1									
42				4.3	1							5			
43				9.2		1							1		
44				2	~~5~~	~~1~~						1		5	
45				3.5	5	1									
46				4.5		1						3		3	
47				4	5									1	
48				4.5											
49				9		5	+	1					1		
50				3								~~3~~ 5			
51				7	5							~~3~~			
52				2.5	5	1						1			
					CHARA	NASMAR	CERDEM	ELOCAN							
*	4			4			1	1							

Other plant species observed at lake: MYRSPI in front of Swim Area

Appendix C
Tier II Plant Survey Waypoint Coordinates

Deg. Lattitude	Deg. Longitude		Waypoint #
41.535114	-85.417385	Atwd t2 6-14-08	001
41.535249	-85.417162	Atwd t2 6-14-08	002
41.535818	-85.418270	Atwd t2 6-14-08	003
41.536716	-85.419255	Atwd t2 6-14-08	005
41.536824	-85.418500	Atwd t2 6-14-08	006
41.537241	-85.418058	Atwd t2 6-14-08	007
41.537585	-85.418968	Atwd t2 6-14-08	008
41.538247	-85.418547	Atwd t2 6-14-08	009
41.539300	-85.418788	Atwd t2 6-14-08	010
41.539556	-85.418103	Atwd t2 6-14-08	011
41.539181	-85.417578	Atwd t2 6-14-08	012
41.540258	-85.416533	Atwd t2 6-14-08	013
41.540286	-85.415905	Atwd t2 6-14-08	014
41.540322	-85.415369	Atwd t2 6-14-08	015
41.540527	-85.415042	Atwd t2 6-14-08	016
41.540385	-85.414412	Atwd t2 6-14-08	017
41.540242	-85.414240	Atwd t2 6-14-08	018
41.539719	-85.413841	Atwd t2 6-14-08	019
41.540468	-85.412949	Atwd t2 6-14-08	020
41.540791	-85.412159	Atwd t2 6-14-08	021
41.540403	-85.411181	Atwd t2 6-14-08	022
41.539671	-85.411566	Atwd t2 6-14-08	023
41.539933	-85.410128	Atwd t2 6-14-08	024
41.539839	-85.409425	Atwd t2 6-14-08	025
41.539635	-85.409022	Atwd t2 6-14-08	026
41.539096	-85.409329	Atwd t2 6-14-08	027
41.539348	-85.408333	Atwd t2 6-14-08	028
41.538890	-85.408374	Atwd t2 6-14-08	029
41.538529	-85.408035	Atwd t2 6-14-08	030
41.538245	-85.408239	Atwd t2 6-14-08	031
41.537866	-85.408114	Atwd t2 6-14-08	032
41.537778	-85.407639	Atwd t2 6-14-08	033
41.536829	-85.407434	Atwd t2 6-14-08	034
41.536705	-85.406785	Atwd t2 6-14-08	035
41.536425	-85.407758	Atwd t2 6-14-08	036
41.535856	-85.408234	Atwd t2 6-14-08	037
41.534785	-85.407155	Atwd t2 6-14-08	038
41.533467	-85.406975	Atwd t2 6-14-08	039
41.533714	-85.408097	Atwd t2 6-14-08	040
41.534655	-85.409257	Atwd t2 6-14-08	041
41.535107	-85.409306	Atwd t2 6-14-08	042
41.535549	-85.409836	Atwd t2 6-14-08	043
41.534308	-85.411477	Atwd t2 6-14-08	044
41.534713	-85.412019	Atwd t2 6-14-08	045
41.535679	-85.412724	Atwd t2 6-14-08	046
41.535984	-85.413380	Atwd t2 6-14-08	047
41.535076	-85.413903	Atwd t2 6-14-08	048
41.535330	-85.415255	Atwd t2 6-14-08	049
41.534797	-85.415378	Atwd t2 6-14-08	050
41.535076	-85.416569	Atwd t2 6-14-08	051
41.534561	-85.417036	Atwd t2 6-14-08	052
END			

Appendix D
National Heritage Databases Request and Response

Aquatic Enhancement
& Survey, Inc.

P.O. Box 1036
Angola, IN 46703

Attn: Ronald Hellmich
Division of Nature Preserves
Indiana Dept. of Natural Resources
402 W. Washington St., Rm W267
Indianapolis, IN 46204
Fax # 317-233-0133

RE: National Heritage Database Request for known state endangered, threatened, and rare species, high quality natural communities, and significant natural areas at the following lakes and their immediate riparian areas:

Atwood Lake, LaGrange County, Johnson Township, Section 31, N41° 32.24639' W85° 24.82376'

Meserve Lake, Steuben County, Steuben Township, Section 14, N41° 34.40997' W84° 59.84679'

Please return fax as soon as possible to 260-665-9785 or email to sbanfield@aquaticenhancement.com

Thank you,

Scott Banfield
off. 260-665-8226
mobile 260-668-5062

DNR

Indiana Department of Natural Resources

December 11, 2008

Mr. Scott Banfield
Aquatic Enhancement & Survey, Inc.
PO Box 1036
Angola, IN 46703

Dear Mr. Banfield:

I am responding to your request for information on the endangered, threatened, or rare (ETR) species, high quality natural communities, and natural areas documented from Atwood Lake, LaGrange County and Meserve Lake, Steuben County, Indiana. The Indiana Natural Heritage Data Center has been checked and enclosed you will find information on the ETR species documented from these lakes and immediate riparian areas.

1. Atwood Lake: There is a historical record of the state species of special concern fish *Coregonus artedi*, cisco, documented from Atwood Lake in 1955.
2. Meserve Lake:
   a. The state species of special concern fish *Coregonus artedi*, cisco, was documented from Meserve Lake in 1992.
   b. There is a historical record of the state rare plant *Triglochin palustris*, marsh arrow grass, documented from Meserve Lake in 1932.

For more information on the animal species mentioned, please contact Christie Stanifer, Environmental Coordinator, Division of Water, 402 W. Washington Room W264, Indianapolis, Indiana 46204, (317)232-4160.

The information I am providing does not preclude the requirement for further consultation with the U.S. Fish and Wildlife Service as required under Section 7 of the Endangered Species Act of 1973. You should contact the Service at their Bloomington, Indiana office.

U.S. Fish and Wildlife Service
620 South Walker St.
Bloomington, Indiana 47403-2121
(812)334-4261

At some point, you may need to contact the Department of Natural Resources' Environmental Review Coordinator so that other divisions within the department have the opportunity to review your proposal.

For more information, please contact:

Department of Natural Resources
attn: Christie Stanifer
Environmental Coordinator
Division of Water
402 W. Washington Street, Room W264
Indianapolis, IN 46204
(317)232-4160

Please note that the Indiana Natural Heritage Data Center relies on the observations of many individuals for our data. In most cases, the information is not the result of comprehensive field surveys conducted at particular sites. Therefore, our statement that there are no documented significant natural features at a site should not be interpreted to mean that the site does not support special plants or animals.

Due to the dynamic nature and sensitivity of the data, this information should not be used for any project other than that for which it was originally intended. It may be necessary for you to request updated material from us in order to base your planning decisions on the most current information.

Thank you for contacting the Indiana Natural Heritage Data Center. You may reach me at (317)232-8059 if you have any questions or need additional information.

Sincerely,

Ronald P. Hellmich

Ronald P. Hellmich
Indiana Natural Heritage Data Center

enclosure: invoice