Aquatic Plant Survey Report and Management Alternatives

For

Sandstone Flowage

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Sandstone Flowage
Aquatic Plant Survey Report
and
Management Recommendations

Sandstone Flowage is a 153-acre impoundment on the Peshtigo River. The flowage is located 2.5 miles west of Crivitz in Marinette County, Wisconsin (figure 1).

The shoreline of Sandstone flowage is heavily developed with many permanent and seasonal dwellings, one resort, and one private campground on the shoreline. Public access is available at a boat landing on Hideaway Lane, a walk-in access at Sandstone Dam, and at several access points in the Peshtigo River State Forest immediately upstream from the flowage.

Sandstone Flowage Association formed in 2002 to preserve and protect Sandstone Flowage. Membership in the Association is voluntary and is open to all landowners within one mile of Sandstone Flowage. The association currently has 117 members representing 72 waterfront and 6 non-waterfront properties. In the process of forming the association excessive aquatic plant growth and the spread of Eurasian water milfoil (EWM) were identified as a major concern.

The purpose of this report is to further explore issues and concerns of association members, gather and summarize existing water quality and fisheries data on Sandstone Flowage, conduct a detailed aquatic plant survey of the flowage, and make recommendations for managing aquatic plants.

Overview of Physical & Chemical Characteristics of Sandstone Flowage

Sandstone flowage is formed by The Sandstone Rapids dam, owned and operated by the Wisconsin Public Service Corporation (WPS). The dam is used for electricity generation and maintains a head of 42 feet. The dam is operated in run-of-the-river mode per Federal Energy Regulatory Commission (FERC) license. Run-of-the-river means that water is passed through the dam at the same rate it enters the flowage, limiting the amount of water level fluctuation in the flowage. The FERC license requires WPS to maintain the water level in Sandstone Flowage between 723.7 feet and 724.2 feet above sea level.

Where it enters Sandstone Flowage the Peshtigo River has a watershed, or drainage area, of approximately 643 square miles. According to WPS the average flow through Sandstone Flowage is

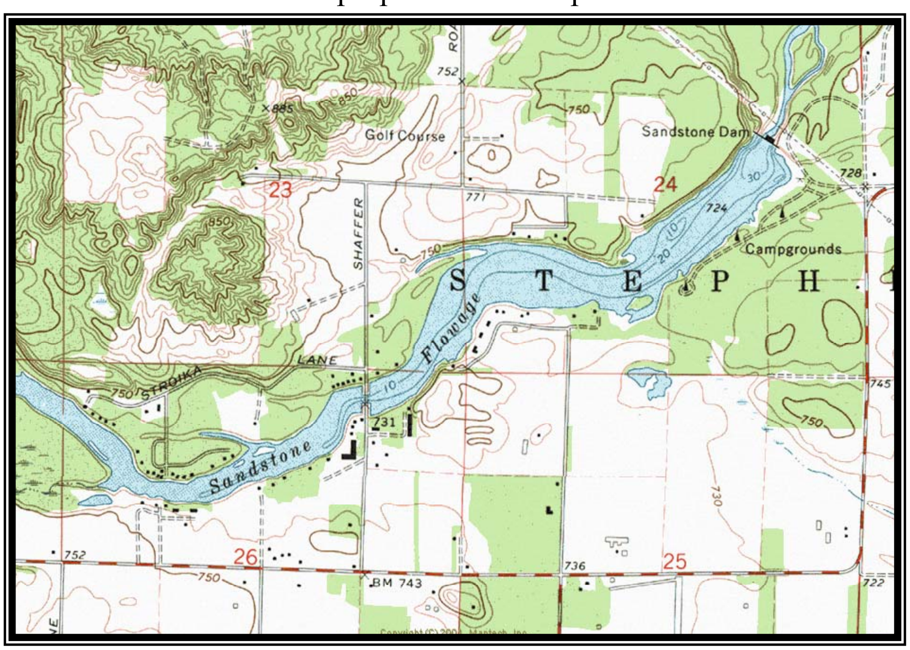

Figure 1. Sandstone Flowage and surrounding area

approximately 615 cubic feet per second (cfs). The Flowage is approximately 2.4 miles long with a maximum width of 850 feet (0.16 miles). According to the Department of Natural Resources (DNR) the Flowage has a maximum depth of 39 feet and holds 2,230 acre-feet of water.

Using this data the flushing rate of Sandstone Flowage can be calculated. Flushing rate, or retention time, is amount of time it takes incoming water to replace the entire volume of a lake. Flushing rate is important because it impacts nutrient dynamics (how nutrients are stored, flushed, and recycled) within a lake or flowage. While most lakes have a flushing rate measured in years, the calculated flushing rate for Sandstone Flowage is only 1.8 days! That is, under normal conditions it takes less than two days to replace the entire volume of Sandstone Flowage with "new" water from the Peshtigo River.

Reservoirs with a high flushing rate typically behave much more like a river than a lake. This usually means high turbidity and increased nutrient levels from runoff. Waters with a high flushing rate also tend to have less algae than would otherwise be supported by their elevated nutrient levels.

Water chemistry data for Sandstone Flowage is rather limited. A search of DNR records found a single DNR monitoring event in the summer of 2003 and four sample sets collected during the fall of 1989 and summer of 1990 by WPS as part of their re-licensing process. From this limited data the water quality of Sandstone Flowage appears to be very good with an average total phosphorus concentration of 18 ug/l. This level is well below the average for Wisconsin impoundments (65 ug/l) and reflects the excellent water quality of the Peshtigo River. Without major changes in the upstream drainage area water quality in Sandstone Flowage should continue to remain good.

Alkalinity, or hardness is often the most important water chemistry measure determining aquatic plant growth and species composition. Alkalinity is a measure of the amount of calcium and magnesium ions in the water and is closely related to pH, or acidity. Waters with a low pH (acidic) and low alkalinity often support few rooted aquatic plants. Hard water lakes, like Sandstone Flowage, are less acidic and are capable of supporting more types and increased quantities of plants.

Sandstone Flowage Landowner Survey

A survey of waterfront property owners and association members was conducted to examine how people use Sandstone Flowage, what they perceive to be the problems facing the flowage, and to gauge support for management actions.

The survey was mailed to all waterfront property owners on Sandstone Flowage and any association members who do not own waterfront property. Of the 108 surveys mailed, 68 were completed and returned for a response rate of 63%. No follow up correspondence was used to increase response rate. A complete listing of survey results can be found in Appendix A.

Flowage Use Patterns
A series of questions was asked to try and determine some basic history of the respondents, their familiarity with Sandstone Flowage, and how they use the flowage. Of the respondents, permanent residents slightly outnumbered those who use the flowage as a vacation & weekend retreat (52% permanent, 48% weekend). This is a much higher percentage of permanent residents than reported in surveys conducted on other Marinette County Lakes. The average respondent has been living on or coming to the flowage for more than 30 years, the longest has been coming to Sandstone for 86 years.

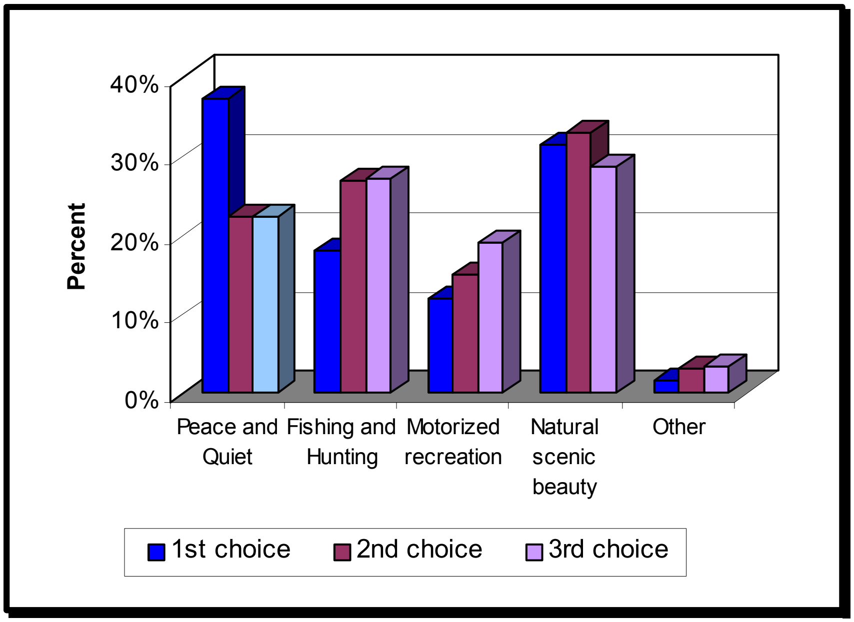

Figure 2. Why survey respondents enjoy Sandstone Flowage.

Respondents were also asked why the enjoy Sandstone Flowage (figure 2). The top ranking answer was Peace and Quiet (37%) followed closely by natural scenic beauty (31%). Fishing & hunting was the third at 18%. This same question has been asked in three other Marinette County lake user surveys and in statewide lake user surveys. In each survey the answer is the same, peace & quiet and natural scenic beauty top the list. These responses are reinforced by the fact that canoes and kayaks are the most common watercraft owned by respondents (27%) followed by rowboats (21%), powerboats (19%) and pontoon boats (17%). Only 9% of boats were personal watercraft.

Perception of fish & Water Quality Conditions

The survey contained nine questions designed to explore how landowners perceive the condition of Sandstone Flowage and how conditions have changed over time. When asked about the water quality of Sandstone Flowage, 50 percent believe water quality is good or excellent. Only 16% think water quality is poor. When asked how water quality has changed, exactly half thought it has gotten worse compared to 5% who feel it has improved. 45% think water quality has remained unchanged.

When the questions focus on aquatic plants the results are striking. Asked how to best describe the level of aquatic plant growth in the flowage 91% find the current level of aquatic plant growth diminishes attractiveness and limits uses such as swimming and boating. Nearly half are unhappy with plant growth in front of their frontage. On the question of trends in aquatic plant growth 71% feel it has gotten worse, 29% think it has stayed the same and none reported that it has declined.

On the question of fishing, only 20% feel it is good while nearly half consider fishing only fair. Regarding trends there is more agreement. In the experience of nearly 80% of respondents fishing has worsened in recent years.

Asked about the severity of shoreline erosion on their individual lots, more than 75% of respondents reported minimal erosion or none at all. Eighteen percent described shoreline erosion as moderate, with undercutting banks and 3" to 5" of shoreline lost per year. The balance (7%) described their shorelines as retreating at a rate in excess of 5" per year.

Issues of Concern

Respondents were asked to list the top three problems or concerns regarding Sandstone Flowage (figure 3). Excessive aquatic plant growth topped the list with nearly 60% choosing it as their primary concern. Poor fishing was the most often reported second and third choice. Compared to all other reported concerns, excessive aquatic plants and poor fishing account for more than half of the responses.

Opinions are equally split on whether failing septic systems add to the aquatic plant problem in Sandstone Flowage. Sixteen percent were not sure.

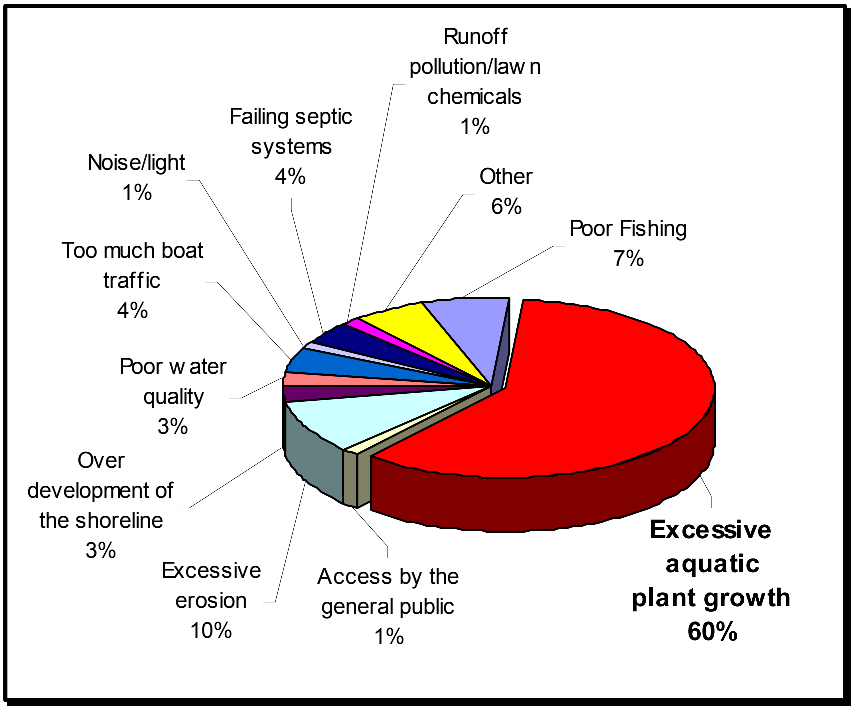

Figure 3. Landowners top ranked concern for Sandstone Flowage

When asked about the enforcement of zoning, boating, and sanitary regulations 21% to 40% professed a lack of knowledge about the specific requirements. Enforcement of sanitary regulations was rated as poor by 14% of respondents while enforcement of boating regulations was rated poor by 13%. Only 3% rated shoreland zoning enforcement as poor. The majority rated enforcement of these regulations as fair to good.

Asked to list additional concerns that need to be addressed, 6 respondents listed a need to address boat and/or personal watercraft use. Other responses included increasing flow at the dam (3), issues with WPS campground boaters (2), and the need to address shoreline erosion (2).

User Identified Solutions to Problems
Respondents were also asked several questions regarding solutions to the problems they identified. A majority (72%) felt the association should be working on improving the fishery.

Asked about specific improvement measures, stocking fish was the most popular response (27) followed closely by building fish cribs (20). Controlling weeds and improving fish habitat (other than cribs) were also recommended.

As for aquatic plants, 76% of respondents were in favor of the association working on aquatic plant control. Asked which control measures should be explored, 16% listed chemical treatment and 19% harvesting. Many people (44%) chose "whatever is appropriate". This indicates that many are unfamiliar with the available control options.

Respondents were also asked an open-ended question regarding what they would like to see done to correct problems they had identified. Answers were grouped into several broad categories. The most popular responses (34%) dealt with controlling aquatic plant growth. The next most popular category consisted of controlling boat wake, speed, or type. Figure 4 shows the most popular responses by category.

Overview of Sandstone Flowage Fish Community

The Wisconsin DNR has conducted fish surveys on Sandstone Flowage several times in the past 30 years including 1977, 1983, 1990 and 2003. The two most recent surveys included both spring fyke netting and summer electrofishing. In both surveys fish were tagged to help gain insight into angler harvest and growth rates. Although population estimates have not yet been completed for the 2003 survey, length frequencies for selected fish were graphed and are included in appendix B.

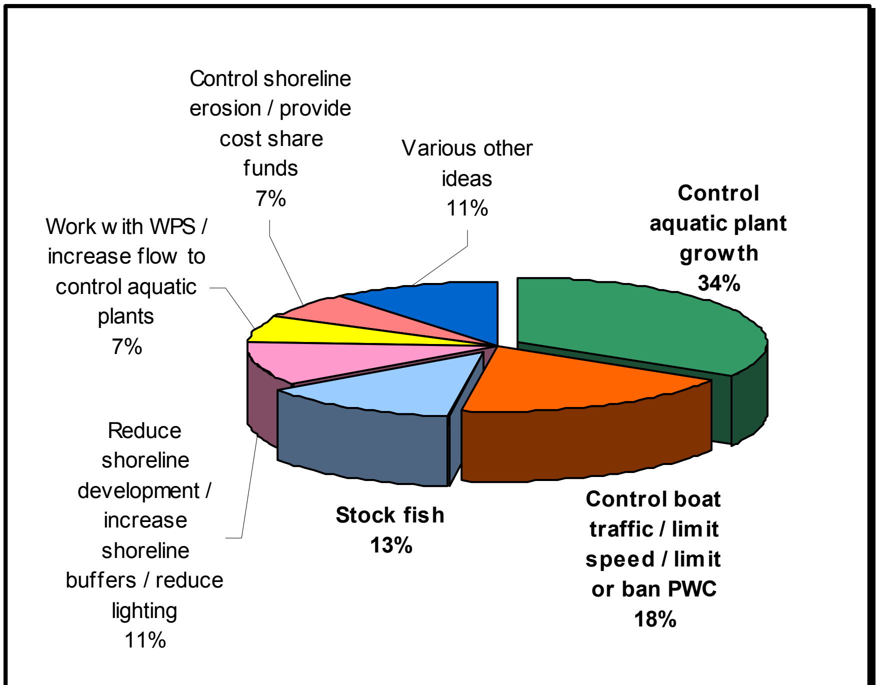

Figure 4. Favored responses to landowner identified concerns.

Preliminary results from the 2003 fish survey indicate little change in the northern pike fishery with good numbers but few large fish in the population. As in the 1990 survey largemouth bass continue to outnumber smallmouth bass. The walleye population appears to have fallen significantly since the 1990 survey and the DNR has recommended stocking to supplement the population. The 2003 survey appears to show a marked improvement in the bluegill population with good numbers and an improved size structure.

Muskellunge were found in both the 1990 and 2003 fish surveys. In each of the surveys fewer than 5 musky were captured but most of the fish were between 36 and 43 inches. Musky are not stocked in Sandstone but are likely coming from High Falls and Caldron Falls Flowages. Both have naturally reproducing populations and receive stocked fish as well.

The 1990 fish survey report found that Sandstone Flowage had a generally good fishery with self-sustaining populations of walleye, smallmouth bass, largemouth bass, northern pike, bluegill, crappie and perch. It was noted that the walleye fishery had good numbers of large fish but that some year classes of fish were poorly represented, indicating poor reproduction in those years. The northern pike population had good numbers of fish but only 14% were over 30 inches long. It was also noted that fewer smallmouth bass were captured compared to earlier surveys while largemouth bass had increased greatly in number. It was theorized that the increase in largemouth bass might have been due to recent draught conditions and warmer water.

During the 1990 survey black crappie had a quality size structure and growth rates were good. This was not the case with bluegill, perch and other panfish that had smaller size structures and growth rates below the area average.

A few rainbow trout were also captured in the 2003 survey. Trout likely spend winters in Sandstone Flowage and head up-river into the fly-fishing area when water temperatures climb in the summer.

Maintaining healthy self- sustaining fish populations requires habitat protection, particularly spawning habitat and nursery areas used by newly hatched fry. Spawning habitat for bass, bluegill and other nest builders consists primarily of shallow water habitat with nearby overhead cover consisting of overhanging shoreline vegetation or downed trees in the water. Many studies have shown the importance of large woody habitat to bass reproduction in particular.
Walleye spawn on gravel and cobble size rock along wave washed shores or in riffle areas in streams. Upstream from Sandstone Flowage

walleye spawning habitat is abundant. Northern pike spawn primarily in flooded wetland vegetation. This habitat type should be in adequate supply in backwater areas of the flowage and in streamside wetlands. It is important to protect these wetland areas for spawning habitat and for its importance as nursery areas for juvenile fish of many species.

Aquatic Plant Survey

Sandstone Flowage landowners have become increasingly concerned about the level of aquatic plant growth in the flowage. The main focus of the lake management planning grant and this report is to accurately describe the aquatic plant population of Sandstone flowage and lay out various management alternatives. To that end, a detailed aquatic plant survey was completed during the summer of 2005.

Survey Methodology

The aquatic plant survey of Sandstone Flowage was completed over a four day period between the 15th and 18th of August, 2005. The survey used a point intercept sampling protocol as recommended by the Wisconsin DNR. Jennifer Hauxwell of the Wisconsin DNR provided coordinates for a 35-meter (115-foot) sample grid. Coordinates for each of the 504 sample points were loaded onto a Garmin Vista handheld GPS unit for navigation in the field.

At each sample location a special double-headed garden rake on an extendable aluminum pole was used to determine the water depth and sediment type and to sample aquatic plants. Plants were collected for identification by dragging the rake across the bottom for approximately 1-meter and bringing it to the surface. Each species of plant found on the rake was recorded as being present. For Eurasian water milfoil, a density measure indicating the amount of plant material on the rake was also recorded.

The field survey was completed using a team of two individuals, a “driver” and a “sampler”. The driver navigated to each sample point using the GPS receiver and recorded field data. When a sample point was reached the “sampler” would call out the depth and bottom type then take the vegetation sample. Typically the sampler could sort and call out the vegetation data before the next sample point was reached.

Data was recorded on field data sheets and later entered into an Excel spreadsheet. Data analysis and graphing was completed in Excel and is reported in full in Appendix C. The location of each sample point and associated aquatic plant data was also mapped in the Marinette County Geographic Information Systems (GIS) database. Plant distribution maps for each species were created and can also be found in Appendix C.

Sediment Type

As part of the aquatic plant survey sediment type was determined for each sample location shallower than the maximum depth of plant colonization. Sediment type was determined by “feel” using the metal rake head attached to an aluminum pole. Data was recorded as muck, sand & gravel, or rock. Soft unconsolidated sediment was recorded as muck. Rock included everything from cobble size rock (2-3 inches) to boulders or limestone bedrock. Sand and gravel are often mixed and difficult to distinguish by feel so they were grouped together. A GIS sediment map was produce and can be found in Appendix C.

Analysis of the data shows that 37% of the sample points had sand & gravel followed closely by muck at 36%. Rock was found at 27% of the sample points. It should be noted that muck is probably under-represented since there were several areas where the vegetation was so dense we could not get the boat in to sample. These areas, indicated on the maps, typically had a muck bottom.

Sediment type is largely determined by water flow. Sand and rock are typically found in areas with more water flow and along wave washed shores. A review of the sediment map indicates that upstream from Shaffer Road, where there is more current, sand is the dominant sediment type. Throughout the flowage rock is found scattered in very shallow areas and along the edge of the old river channel where scouring is greatest. Muck is typically found in shallow areas with minimal current. The inside bends of river channels are typically deposition areas and most large areas of muck sediment correspond to the inside bends and secondary channels of the original river.

Aquatic Plant Community Structure

Sandstone Flowage supports an abundant and diverse aquatic plant population. Twenty different species of aquatic plants were identified during the aquatic plant survey. However, the following five plants account for nearly 75% of vegetation in the flowage (figure 5). Aquatic plant descriptions are taken from *Through the Looking Glass, a Field Guide to Aquatic Plants* (Boreman 1997), a publication of the Wisconsin Lakes Partnership.

Wild Celery
Wild celery (*Valisneria americana*) is the most abundant aquatic plant found in Sandstone Flowage. It was found growing at nearly 70% of the survey points shallower than 10 feet deep and is the plant is primarily responsible for the nuisance conditions found throughout Sandstone Flowage (figure 6).

Wild celery is a native plant found throughout Wisconsin. It has long ribbon shaped leaves ¼ to ½ inch wide and up to 7 feet long. The leaves have a prominent central stripe and a cellophane-like consistency. The leaves emerge from a central rosette on the bottom and grow up until the leaf tips trail out just under the surface. Late in the summer water celery produces tiny male flowers under water that break free and float up to the surface. The white female flowers are found at the end of a long coiled stalk that extends the flower up to the surface where it is pollinated. After pollination it is withdrawn below the surface and a long narrow seed capsule develops. Water celery prefers hard substrate and is quite tolerant of turbid water. The plant is common in flowing water.

Wild celery is a perennial plant that spreads primarily by vegetative means, not by seed. Wild celery produces abundant tubers just under the sediment surface each summer. These

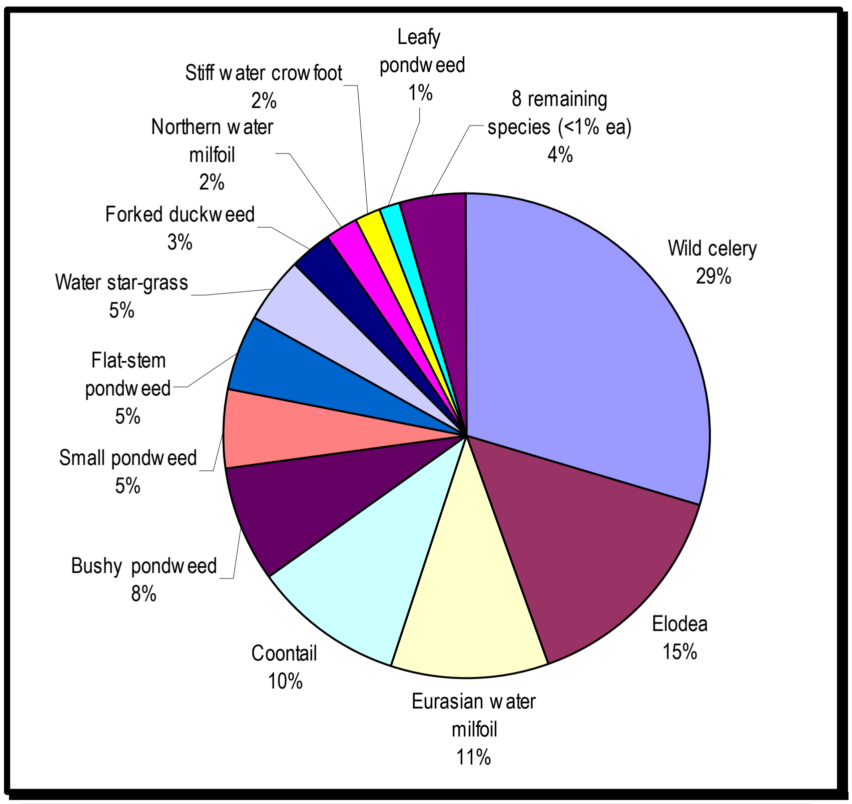

Figure 5. Relative frequency of aquatic plants in Sandstone Flowage

tubers lie dormant during the winter and resume growth in the spring. While waterfowl eat all parts of the plant, these starchy tubers are especially prized. Canvasback ducks are almost completely dependent on the tubers of wild celery during their migration flights. Wild celery also provides important fish habitat.

Despite its habit of growing to the surface, water celery is not commonly seen as a nuisance plant. In fact, due to its value as a waterfowl food source it is often encouraged to grow.

Elodea

Elodea (*Elodea canadensis*) was the next most abundant plant, found growing at 35% of the vegetated sample points. Elodea has much branching slender stems with small lance shaped leaves attached in whorls of three. Leaves are typically spread out at the bottom of the plant and crowded together near the top.

Elodea prefers soft sediment with lots of organic matter. Elodea produces small white flowers at the surface during early summer but typically produces few fruit. Like many aquatic plants, Elodea spreads primarily by stem fragments that settle to the bottom and take root.

Elodea can overwinter green and begin growing again soon after ice out. It is used by waterfowl as a food source and provides general fish habitat. Elodea typically does not grow to the surface in deep water so its nuisance potential is limited to very shallow water areas.

Eurasian Water Milfoil

Eurasian water milfoil (*Myriophyllum spicatum*), an invasive exotic species, was found at 25% of the sites (figure 7). It was most abundant immediately west of the boat landing in 2 to 5 feet of water where it replaces water celery as the primary nuisance plant.

Eurasian milfoil has soft feather like leaves arranged in groups of four along a long thin stem. The plant can grow more than 6 feet long. When the stems reach the surface they branch profusely and spread out to form a canopy that shades the water beneath. Eurasian water milfoil is considered invasive since it has a habit of expanding rapidly and eliminating or drastically suppressing other plants

Eurasian milfoil can overwinter green or survive as sprouts on the rootstock. The plant begins rapid growth at a low water temperature and quickly reaches the surface. The rapid growth, along with its canopy forming habit, allows it to out compete many of the slower growing native pondweeds.

While Eurasian milfoil provides some fish and wildlife habitat, studies show that native pondweed stands have a higher diversity and numbers of insects (Engel 1990).

Coontail

Coontail (*Ceratophyllum demersum*) is the most common aquatic plant in Wisconsin. In Sandstone it was found at more than 23% of vegetated sites. Like milfoil, coontail has long stems with leaves arranged in whorls around the stem. Unlike milfoil the leaves of coontail are very stiff and tend to be dense near the ends of the stem, giving them the appearance of a bushy raccoon tail.

Coontail has no true roots but anchores to the sediment by modified stems wherever it touches the bottom. Due to its poor “rooting” ability, coontail prefers soft organic sediment. It rarely produces seed but spreads by fragmentation.

Coontail is important for fish habitat since it is slow to decompose and often stays alive under the ice. This habit makes it excellent winter habitat, attracting aquatic insects and the fish that feed on them.

Bushy Pondweed

Bushy pondweed (*Najas flexilis*), found at 18% of vegetated sites, rounds out the five most common aquatic plants in Sandstone Flowage. Bushy pondweed varies greatly in growth form. In shallow water it is very compact and bushy while in deep water the stems are often elongated with leaves widely scattered. The leaves are very narrow (1/16th inch wide) with a broad base where they attach to the stem. Plants generally grow no more than 3 feet tall and prefer a hard substrate.

Bushy pondweed is rather unique in that it's one of the few annual aquatic plants. It dies completely each winter and depends on seed to grow new plants each year. The plants and the seeds, which are produced in great number each year, are important food for waterfowl.

Bushy pondweed is relatively intolerant of turbidity. Due to its short stature bushy pondweed is seldom reported as a nuisance plant.

Minor species
Twelve additional aquatic species were found at fewer than 10% of the sample locations. Many of these plants have specialized habitat requirements, such as long-leaf pondweed which prefers flowing water or are found scattered widely throughout the flowage.

Floristic Quality Index
One measure of the "health" of a lake and its plant population is the Floristic Quality Index (FQI). The FQI assigns a "coefficient of conservatism" to every aquatic plant found in Wisconsin. The coefficient represents how typical the plant is in pristine conditions. The FQI is based solely on the presence of a plant, not its abundance or dominance. Statewide, the average FQI for lakes is 22.2. The FQI for Sandstone Flowage was 28. This indicates good water quality and a high quality aquatic plant population.

Aquatic Plant Distribution

Each species of aquatic plant has habitat preferences that determine where it grows or potentially can grow. These include such factors as depth, light exposure, sediment type and water flow. A discussion of these factors and their effect on the plant community of Sandstone Flowage follows.

Depth
Field investigation reveals that the maximum depth of plant colonization is approximately 10 feet (figure 8). Between 8 and 10 feet deep the number of species is limited and overall plant density is sparse.

The maximum depth of plant colonization is determined by how deep light can penetrate (transparency). Light penetration in-turn is controlled by water clarity and algae growth. In Sandstone Flowage color, not suspended sediment or algae is responsible for limiting light penetration. The light brown color is typical in the Peshtigo River and all its flowages and is caused by tannins. Tannins are naturally occurring dissolved organic compounds resulting from decomposing plants in wetlands throughout the drainage area.

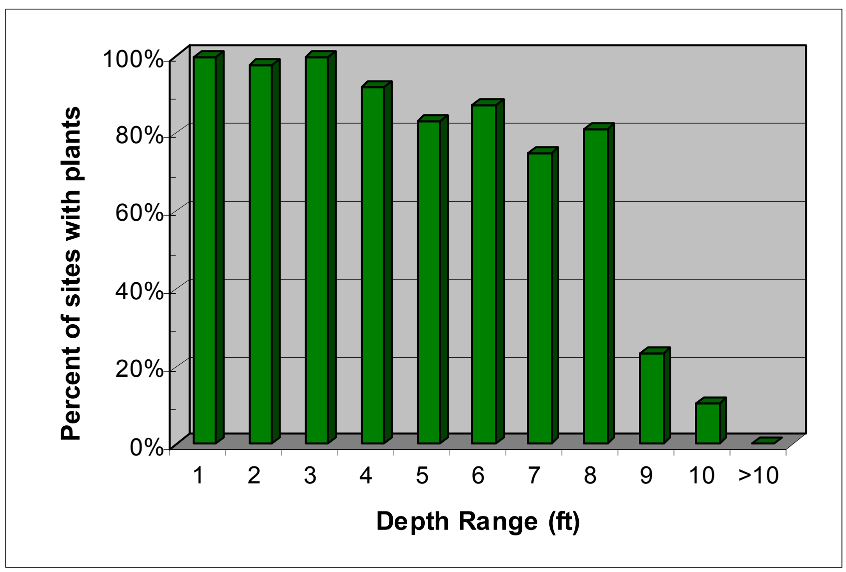

Figure 8. Aquatic plant colonization by depth.

Within the range of depths at which aquatic plants can grow, each species of plant has a depth preference. Some plants are limited by depth because of growth form such as water lilies that have floating leaves attached at the end of long underwater stalks, or cattails that must get their oxygen from above the water surface. Other plants are limited not so much by depth, but by the amount of light that reaches the sediment surface.

Most aquatic plants are perennials that die back to the roots each year, or sprout anew from specialized plant fragments (winter buds) lying on the lake bottom. These plants use energy stored in the roots or winter buds to extend upward towards the light each year. They must grow high enough and fast enough to reach the sunlight then grow and export nutrients to the roots to start next year's growth. Different species vary in their ability to grow in low light conditions and fewer species are typically found at greater depth. Of the major species, Eurasian water milfoil shows the strongest preference for shallow water with nearly 85% of the milfoil found in water less than 5 feet deep. Coontail, Elodea, and water celery have a more uniform distribution. For all species there is a sharp decline in aquatic plant abundance beyond the 8-foot depth as seen in figure 8.

Sediment

Sediment type also plays a major role in aquatic plant distribution and abundance. These sediment preferences can be related to physical properties of the sediment (coarseness, grain size, compaction) or in the chemical properties of the sediment such as pH, or nutrient availability.

Most rooted aquatic plants get their nutrients from the sediment, not the overlying surface water. Because of this, even lakes with low to moderate nutrient levels in the water column can support abundant aquatic plants if sediment nutrient levels and water clarity is sufficient. Sediment that erodes from upland sources is typically high in nutrients. Flowages, with their large watersheds, typically receive abundant nutrient rich sediment in incoming water. Even the relatively undisturbed watershed above Sandstone will deliver sufficient nutrients to support ample aquatic plant growth.

Nutrient availability is closely tied to sediment coarseness. What most people refer to as muck is typically silt with a high percentage of organic particles from decomposing plant material. Organic sediment is typically high in nutrients. Sand, by itself can be very nutrient poor, however there is typically sufficient fine silt and organic matter mixed in to provide good growing medium for plants. Rock by itself will not support plant growth but it is often found mixed with sediment that will.

The graph in Figure 9 shows the sediment preference of the four most abundant plants in the flowage. The graph shows that coontail and elodea show a strong preference for growing in muck. Eurasian water milfoil, although reported in the literature to prefer hard substrate, shows a preference for muck as well. Wild celery, the most abundant plant in the flowage, is found growing in sand and gravel almost as often as it is found in muck. Literature reports indicate that water celery has a preference for hard substrates. No plants are especially abundant in rocky areas.

Water flow

Aquatic plants also differ in their response to flowing water. Some plants are very intolerant of flowing water while others prefer it. When water flow is very high sediment scouring is so great that no plants will grow even if sediment conditions would otherwise support it. In the

upper flowage the effects of water flow can be seen on the distribution of plants. The center of the channel where current is greatest is often

free of plants event though the water is often less than 5 feet deep. Long-leaf pondweed (*Potamogeton nodosus*) was found exclusively in the upper reaches of the flowage. This plant

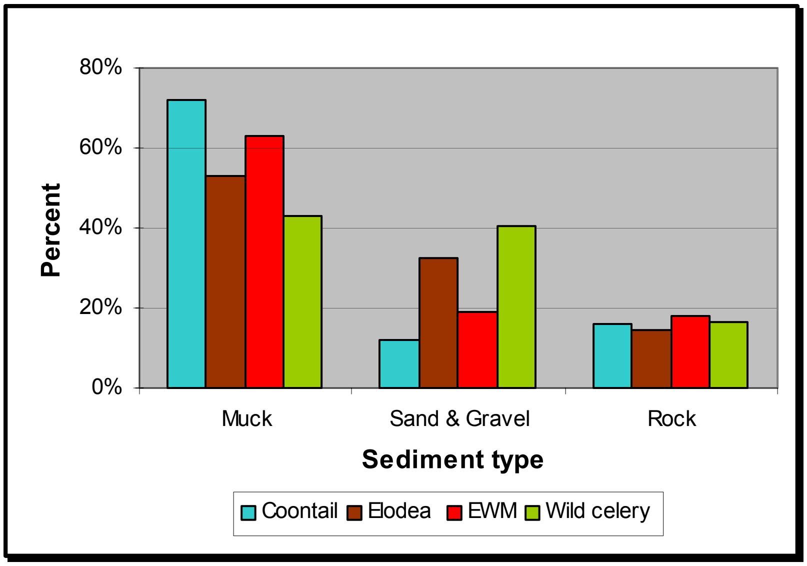

Figure 9. Sediment preference of major aquatic plants

is adapted to growing in flowing water and is most often found in rivers. Water celery, the most abundant aquatic plant in the flowage, is also well adapted to flowing water and is the dominant plant west of the Schaffer Road Bridge where the flowage is more "riverine" (like a river).

The effects of flow and sediment type can be hard to separate. Generally where there is considerable flow the sediment will consist of sand & gravel or rock. The fact that Eurasian water milfoil and coontail are rare upstream from the bridge may be a function of flow or it may be a lack of the preferred sediment (muck).

Aquatic plant stand density

The aquatic plant survey methodology recommended by the Wisconsin DNR determines the frequency with which different species occur in the flowage. While the data clearly shows if a plant can be found at a certain location in the flowage it says nothing about how densely it is growing at that spot. This is unfortunate a plant can be present but be of little concern if its growth is sparse. In Sandstone Flowage frequency of occurrence certainly does not tell the whole story and understanding plant density is critical to comprehending the scope of the aquatic plant problem.

To complement the point-intercept survey, areas with significant aquatic plant growth were mapped and plant density described. Plant beds were mapped using a Trimble Geo XT Explorer GPS receiver. Plant density was mapped by slowly navigating the edge of plant stands with a motorboat. Individual plant stands were described as moderate in density where plants only intermittently reached the surface and it would be possible to boat through them. Dense plant beds had complete coverage of aquatic plants, were difficult if not impossible to boat through, and could best be described as weed choked. Areas with sparse plant growth were not mapped.

Figure 10 shows the results of the aquatic plant stand mapping. Approximately 74 acres of plant beds were mapped. Of this, seventy percent (52 acres) was described as dense. These areas were typically shallow with muck bottom on the inside bends of the old river channel. The outer edge of these dense plant beds typically ended abruptly at the 7 or 8-foot contour interval. During grid sampling it was nearly impossible to navigate within the dense plant beds with a gas motor. The only method of propulsion that worked was rowing or using a "weedless" electric motor and cleaning it often.

Moderate plant growth accounted for only thirty percent (22 acres) of the mapped plant beds. Many of these areas consisted of a narrow band outside of the dense plant beds or in shallow sandy areas with increased flow or wave action. Moderate density beds were navigable but still required extra cleaning of the motor.

Recent Changes in the Aquatic Plant Community

There are no previous aquatic plant surveys of Sandstone Flowage with which we can compare current survey data. However, in the landowner survey almost 70% of respondents reported that aquatic plant growth had increased in their experience. With such widespread agreement it is very likely that the aquatic plant community has been changing.

As mentioned previously, based on the aquatic plant sampling effort it's clear that water celery is the primary nuisance species in Sandstone Flowage. The exception is west of the boat landing where the exotic Eurasian water milfoil is dominates the population.

Eurasian water milfoil is a relatively recent addition to the plant community in Sandstone and the upriver flowages. In many lakes the introduction and domination of Eurasian water milfoil follows a very typical sequence. Often the plant persists in a lake a relatively low level for a few years after introduction then expands rapidly into all areas of suitable habitat. At this point the plant has reached its maximum nuisance level. Studies have shown that after a period of domination the milfoil has often declined on its own. Carpenter (1980) reported that the duration of peak abundance in many lakes is approximately 10 years before any significant decline. While some report a lack of definite cause for these declines, other studies have attributed it to a native milfoil weevil. Since Eurasian water milfoil is relatively new in Sandstone Flowage it may not have yet reached its peak abundance and may become more of a nuisance in areas downstream from Shaffer Road. Upstream from the bridge water flow and sediment type will likely limit Eurasian water milfoil to more protected backwater areas.

The more challenging question is why there has been an expansion of water celery in Sandstone Flowage. In most lakes and flowages water celery does not grow at nuisance levels. In fact, its more often seen as one of the more desirable native plants due to its high wildlife value.

Several landowners have questioned whether the change in operating mode of Sandstone Dam might be responsible for increasing aquatic plant density in the flowage. Prior to November 1998 the dam was operated in a peaking mode. In the peaking mode water is preferentially stored in the flowage during off periods of electrical use (mid day and at night) and released in the morning and late afternoon during periods of peak electricity use.

When the Sandstone dam was re-licensed in 1998 the operation was changed to run-of-the-river mode. In Run-of-the-river water is passed through the dam at the same rate at which enters the flowage while maintaining a surface water elevation between 723.7 and 724.2 feet. The change in operation was required by the DNR to protect downstream fisheries that are harmed by the rapid fluctuations in flow and water level associated with peaking.

The change in operating mode has resulted in more stable water levels within the flowage. Under the current license requirements the water level should fluctuate by no more than 6 inches. There are also limits on how fast the water level can change. The change in operating mode would be most noticeable in the upper reaches of the flowage where there would be fewer periods of low water and difficult navigation.

While Wisconsin Public Service Corporation was unable to provide water level records during the period of peaking operation, long-time cottage owners claim the water level fluctuate by less than a foot on a daily basis.

A search of the scientific literature failed to turn up any studies that addressed the effect of changing flow regimes on aquatic plants. Considering the growth habits of the most common plants in Sandstone Flowage, however, it appears unlikely that daily fluctuations of this magnitude would have much effect on aquatic plants growing in deep water. In very shallow water (2-feet deep or less) it is conceivable that the daily fluctuations may have suppressed some species.

If the change to run-of-the-river has its greatest impact on flow and water level in the upper part of the flowage it would follow that the greatest change in aquatic plants would have occurred there as well. However, the aquatic plant survey shows that water celery dominates the population and is found in nuisance levels throughout the flowage. Wild celery is also most abundant in water between 2 and 6 feet deep where changing water levels should have less effect.

Recent studies and personal communication with aquatic biologists show that wild celery populations have been known to experience large swings plant frequency and density in some lakes. In 1980 in Lake Onalaska wild celery was found in 100 percent of sample points with a mean plant density of 90.5 plant tubers/0.33 m^2. By 1991 the population had crashed and wild celery was found in only 5 percent of the sites with an average density of 2.7 tubers/0.33 m^2 (Seitz, 2004). By 2003 the population had largely recovered. The report concluded that a relatively minor increase in water depth played a critical role in the population recovery. It was reported that wild celery increased when the mean annual depth of the reservoir was at or above 1.26 meters (4.1 feet). The report also theorized that other factors such as turbidity, water clarity, and ecological succession may be effecting the population in Lake Onalaska.

Correspondence with other North American Lake Management Society Certified Lake Mangers (CLM's) led to some interesting insights into wild celery population changes. Several CLM's work on reservoirs, estuaries and large river systems where water levels fluctuate widely with the season and due to weather events. All of these systems contain wild celery. It was the lake managers experiences that minor fluctuations in water level had no effect on wild celery.

The consensus of the CLM's who responded to the request for information was that changes in flow and water level would not lead to large changes in wild celery populations. Several experts pointed to the fact that wild celery populations fluctuate a lot in large river systems. This may be due in part to changes in the quantity of runoff. In the Peshtigo River system dry years lead to clearer water (less tannins in the runoff) and warmer water temperatures.

It was also interesting that in Lake Montello in southern Wisconsin there was an unheard of increase in wild celery in 2005. The lake is usually dominated by Eurasian water milfoil but even that was suppressed by the unusually dense wild celery.

The only other theory offered was that wild celery is susceptible to hydrogen sulfide (H2S) in the sediment. A decrease in H2S could allow for wild celery expansion and growth. Typically H2S is found in deep organic sediment with poor water flow and little oxygen exchange. Changes in dam operation that leads to more stable water levels and dry weather with low river discharge should favor increased H2S buildup in the sediment and reductions in wild celery.

Without more information or further study it is difficult to point to the changes in dam operations as the cause of increased aquatic plant growth in Sandstone Flowage. It seems more likely that natural population dynamics, and local weather patterns and water conditions are the cause of plant community changes.

Aquatic Plant Management Goals

Setting aquatic plant management goals is an important and necessary step in aquatic plant management. The Sandstone Flowage

Association should go through the process of setting realistic and achievable goals before undertaking any serious aquatic plant management program.

Given the results of the landowner survey, it is reasonable to assume that any goals achieved through consensus of the members will include reducing nuisance levels of aquatic plant growth where it interferes with recreation, and controlling the spread of Eurasian water milfoil. Improving the fishery also ranked very high in the survey. These concerns should be addressed in any management program.

Aquatic Plant Management Alternatives

Any aquatic plant management strategy must be tailored to the plants and water body in question. Typically the management program will include multiple control practices and a process to review and update the management plan as needed.

A comprehensive review of aquatic plant management alternatives follows. While each of the alternatives may be beneficial in certain situations, not all will be applicable to managing aquatic plants in Sandstone Flowage.

Do Nothing

Doing nothing is inexpensive, easy to do, and relatively uncontroversial. In rare cases it is also an effective alternative.

Lakes and flowages are complicated ecosystems and aquatic plant populations fluctuate within them due to a variety of factors. Large-scale climactic conditions and local weather cycles can impact water temperature, flow, and clarity, all of which effect aquatic plant growth. Plant populations also vary because of disease, species introduction, competition and other internal processes. Left to its own devices the plant community in Sandstone Flowage will continue to change over time.

In the case of Eurasian water milfoil doing nothing has, on occasion, led to long-term benefits. Studies have shown that Eurasian milfoil infested lakes have "recovered" and milfoil growth declined without active management. The mechanism for decline is not entirely clear but it is thought that it may be due to a native weevil that feeds on Eurasian milfoil. Unfortunately this natural decline has not been seen everywhere and has taken many years to occur on most lakes.

The downside to doing nothing is that the result may be nothing. This option may only result in a continuation of the problem and might lead to worsening of the situation.

Chemical Control

When properly planned and executed, chemical control of aquatic plants can be effective. However, if care is not taken in the selection timing, and application of aquatic herbicides the results can be less than desirable or worse, have unintended consequences.

Chemicals can generally be applied in a targeted manner to control plants in specific areas. The exception to this is in flowing water. Chemical action typically depends on achieving a specific concentration of chemical in contact with the plant for a minimum period of time. Flowing water dilutes the chemical and transports it out of the treatment area. For this reason chemical treatment is often not allowed in areas with significant water flow.

There are several herbicides approved for aquatic use in Wisconsin and each differs in its mode of action and the species it controls. Contact herbicides kill exposed plant material but can leave the root system intact. Plant re-growth can be problem with these types of herbicides. Systemic herbicides are transported to the roots and kill the entire plant. Systemic herbicides provide longer-term control but may act slower than contact herbicides.

Herbicides can also be grouped into two general groups, “broad-spectrum” and “selective”. Broad-spectrum herbicides control a broad range of plants. Selective herbicides, as the name implies, are relatively selective and control fewer species while leaving many others unharmed. Often selectivity is a function of timing of application or concentration of the herbicide.

A review of the literature reveals that water celery, the most abundant plant in Sandstone Flowage, is one of the more difficult species to control with approved aquatic herbicides. In fact, some resources do not list chemical control as a viable management alternative. Other literature list Hydrothol 191 as controlling water celery. Hydrothol is a formulation of Endothol, a broad-spectrum contact herbicide. Since it is less effective at killing the extensive root system and reproductive tubers plants re-growth will be a concern.

Unlike water celery, Eurasian water milfoil (EWM) is very susceptible to several common aquatic herbicides. The plant is especially susceptible to formulations of 2,4-D. Since most pondweeds and other native aquatic plants are resistant or only slightly susceptible to 2,4-D the chemical can be used to selectively control milfoil while protecting native species (Parsons, 2001). Chemical control of EWM is a popular and effective control measure where the goal is to shift the plant community to a more natural mix of native species.

Chemical treatment, even with systemic herbicides, will seldom completely eradicate aquatic plants from an area. Plant seeds are generally unaffected by herbicides and plant fragments from outside the treatment area can quickly re-colonize a site. In the case of Sandstone Flowage upstream reservoirs will continue to provide EWM fragments and eradication will not be possible. Like most management alternatives chemical control is a temporary measure that needs to be repeated on a regular basis.

Improper or excessive use of aquatic herbicides can have unintended consequences. Widespread use of broad-spectrum herbicides can leave large areas of soft sediment exposed to wave action and colonization by nuisance exotic species. Many of the more common nuisance plants are aggressive pioneer species that can quickly invade disturbed areas. The decomposition of tons of aquatic plants also releases large amounts of nutrients to the water column. These nutrients can trigger algae blooms and fuel additional aquatic plant growth. Sandstone Flowage’s the high flushing rate minimizes the potential for algae blooms following herbicide treatment.

Chemical treatment of aquatic plants in Wisconsin always requires a permit from the Wisconsin DNR. This is to ensure that the proposed chemical treatment will use appropriate chemical(s), at the correct concentration and at the proper time of the year. In almost all situations the chemical applicator must be certified by the Wisconsin Department of Agriculture Trade and Consumer Protection.

Chemical treatment cost depends primarily on the chemical formulation and application rate, the distance a certified applicator has to travel, and the time and equipment involved. Current costs for EWM treatment with 2,4-D could be expected to cost from $400 to $600 per acre (DNR Pers. Com.). In some instances the State of Wisconsin can provide funding for chemical treatment of Eurasian water milfoil or other lake restoration activities recommended in a lake management plan approved by the DNR.

Benthic Barriers

Benthic, or sediment barriers cover the sediment and prevent the growth of aquatic plants. The barriers work by physically disrupting plant growth or eliminating light at the sediment surface. When installed properly benthic barriers are very effective at eliminating all plant growth. However the difficulty of installing and maintaining these barriers prevent their widespread use.

Benthic barriers can be made of naturally occurring materials (sand and gravel) or artificial (synthetic plastic sheeting). Sand or pea gravel is commonly used to create weed free swim areas. However, there are several common problems with sand and gravel benthic barriers. In areas with significant flow the barrier can wash away. If deposited on soft sediment it can sink in and mix with the native sediment. Also, over time new sediment is deposited on top of the barrier. All of these factors will lead to failure of the barrier.

Artificial barriers typically consist of sheets of polypropylene, polyethylene, fiberglass or nylon (Wagner 2004). All must be weighted to hold them in place against water currents, waves, and boat wake. If constructed of non-porous material benthic barriers will be subject to billowing and may float free of the sediment as gasses from decomposition build up beneath them. Porous barriers are less subject to billowing but plant fragments that settle on top are better able to root through them. Both types of barriers require annual maintenance since sediment accumulation on top of the barriers will build up and support new aquatic plant growth.

Artificial benthic barriers are also relatively expensive and difficult to install and maintain. Maintenance consists primarily of annually removing accumulated sediment, which typically requires removal and replacement of the barrier.

The use of any type of benthic barrier requires a DNR permit.

Dyes and Floating Covers
Dyes are liquid chemicals that are applied to change the color of the water. Covers physically cover the water surface. Both control aquatic plants by reducing the amount of light reaching the sediment.

Dyes typically color the water a deep blue or even black. For small ponds they are relatively inexpensive, long lasting, and effective. Effectiveness is limited in shallow water (2 feet or less) where the light reduction is seldom enough to prevent plant growth. Dyes must stay in the water throughout much of the growing season. Because of their dark color, dyes increase light absorption and can result in higher water temperatures. The increase water temperature can in-turn result in stronger stratification, lower dissolved oxygen and widespread changes in the aquatic community (Wagner 2004). Dyes are not an option in larger lakes and those with significant outflow.

Floating covers also disrupt plant growth by reducing light levels at the sediment surface. However, unlike dyes the floating covers prevent virtually all water use while they are in place. Floating covers can be difficult to install and effectively anchor.

Both dyes and floating covers require DNR permits. The main permitting issue with floating covers is the disruption of public water rights (fishing and navigation) that they cause while installed.

Harvesting
Aquatic plant harvesting is a widely accepted aquatic plant management alternative that can be effective on a large or small scale. Individual landowners often manually clear small areas around their dock or swim area. Typically this is accomplished by using one of several specially designed aquatic plant rakes and/or hand-held cutting implements. Under current Wisconsin Law this type of harvesting requires no permit if the plant removal is not in a DNR

designated sensitive area and is limited to a 30-foot wide area measured parallel to shore. The control area must be around existing piers, boat lifts, and swim rafts and the cut plants must be removed from the water.

Large scale harvesting is typically accomplished using specially designed aquatic plant harvesters that cut and collect aquatic plants in one operation. The size and capacity of these harvesters varies greatly but the largest can cut a 10-foot wide swath up to 6 feet deep and hold more than 16,000lbs of cut plants.

Like most aquatic plant management alternatives harvesting seldom eliminates plants. Much like cutting your lawn, harvesting leaves the root system intact and plants will re-grow. In some cases repeated harvesting close to the sediment surface can stress plants enough to cause mortality. Species that depend on seed production for their spread may be partially controlled by harvesting if seeds are repeatedly removed through harvesting. Plants that spread by fragmentation such as milfoil and coontail can actually be spread through harvesting when cut fragments escape the harvester and drift to other areas of the lake.

Repeated harvesting can have impacts on the aquatic plant community that go beyond the initial cutting. In Lake Noquebay repeated harvesting has led to measurable shifts in the aquatic plant community. When harvesting began in 1978 the lake was dominated by a variable water milfoil, a native milfoil with growth habits similar to the Eurasian variety. After 28 years of harvesting the plant community has changed noticeably. Harvesting tonnage has gone down and the new dominant species in Lake Noquebay is bushy pondweed, a low growing native that typically stays below the maximum cutter depth of 5.5 feet.

As a management method harvesting is not selective and is best used where invasive or nuisance species dominate. Plant re-growth depends on the species present, timing of harvest, and cutting depth. Studies have shown that very deep cutting with specialized harvesters can even have multiple year effects on milfoil and other aquatic plants. In Lake Noquebay re-growth was greatest early in the harvesting program but has slowed and most areas are now cut only once each year.

Large Scale mechanical harvesting can be an expensive proposition. Commercial harvesting is available in Wisconsin and can range from $300 to $500 per acre plus travel costs. As with many services the unit cost is typically lower when the harvest area is larger. The Wisconsin Association of Lakes website has information regarding private commercial harvesting vendors.

Typically when a lake undertakes a long term harvesting program they purchase and operate their own equipment. Initial costs for a new harvester can range from $50,000 to $100,000 depending on the size of machine. Typically a truck is also required to transport plants to a disposal site and a shoreline conveyor to transfer cut plants from the harvester to the truck. Operating and maintenance costs vary depending on the amount of use and the labor source. While volunteer operators are of course free, in the long run it may be best for the equipment and for the harvesting program to hire a dedicated harvesting crew to operate and maintain such expensive and complicated equipment.

Of course undertaking such an expensive program requires a dependable funding source. Most lakes that own and operate harvesters have formed a Lake District with taxing powers to fund the program. Unlike most other aquatic plant management alternatives, the State of Wisconsin does provide financial assistance for harvester and related equipment purchases through the Wisconsin Waterways Commission. Grants are awarded on a competitive basis and cover 50% of equipment purchase price.

Any mechanical harvesting requires a Wisconsin DNR approved aquatic plant management plan and permit. The approved management plan is also a requirement for receiving a Waterways Commission grant for equipment purchase.

Dredging

Typically a practice known for increasing depth to aid in navigation, dredging can also be a very effective aquatic plant control technique. As a plant control measure dredging has two primary modes of action: changing sediment type, and increasing the depth to sediment.

Where a layer of nutrient rich organic sediment overlies a nutrient poor layer of mineral soil the organic layer can be removed to expose the sand or gravel layer that is less capable of supporting plant growth. Typically such removal will change the plant community structure, not eliminate all plant growth. Removing the upper layers of sediment also eliminates plant roots and most viable seeds. Unfortunately, the results of organic sediment removal are seldom long lived since very little organic matter is needed to support dense plant growth. In flowing water the buildup of fine organic sediment is especially rapid in depositional areas.

Eliminating all submersed aquatic plants requires dredging the lake to a depth where light availability limits plant growth. In Sandstone Flowage the lower limit of aquatic plant growth is 10 feet with sparse plant growth beyond the 8-foot depth.

There are two major types of dredging, hydraulic and mechanical. Hydraulic dredging is accomplished by mixing sediment with a large volume of water and pumping it to a disposal/dewatering area. Hydraulic dredging is best suited to loose organic sediment. Mechanical dredging employs heavy equipment deployed on barge or shore to dig out the sediment and transfer it to trucks for removal. Mechanical dredging can be simplified if done n conjunction with a drawdown since less water is moved and conventional dry land excavating equipment can be used.

Any type of dredging will require, at a minimum, a Wisconsin DNR and US Army Cops of Engineers permit. Permits must describe in detail the scope of the proposed dredging, dewatering and disposal of spoils, and the effects the project will have on fish, wildlife, and public water rights. In addition, contaminant testing of the spoils may be required.

It should come as no surprise that dredging is typically a very expensive alternative. Rough estimates for mechanical dredging range from $8.00 to $25.00 for each cubic yard (Wagner 2004). Much depends on the type of sediment, accessibility and disposal costs.

Drawdown

Drawdown can be an effective aquatic plant management tool in impoundments such as Sandstone Flowage where the water levels can be easily controlled. While drawdown can control many plant species, it is ineffective against some and actually stimulates others to grow. Of the species found in Sandstone Flowage, according to Cooke (2005), bushy pondweed and leafy pondweed both increase as a result of drawdown while milfoil and coontail are controlled. Some sources report that water celery also increases in response to winter drawdown (Beard, 1973). For many plants there is little or no data regarding response to drawdown.

Drawdown effectiveness depends on the amount of sediment drying achieved, the season, and duration of the drawdown. With organic sediment drying is often difficult to achieve and plant roots and fragments that remain moist may not be controlled. A winter drawdown is typically more effective than a summer drawdown, especially in organic sediment, since sediment freezing further injures exposed roots.

Eurasian water milfoil is particularly susceptible to winter drawdown. The Wisconsin Public Service Corporation (WPS) conducted a drawdown of High Falls Flowage during the winter of 2001 specifically for the purpose of Eurasian water milfoil control. In a plant survey conducted in 2002 no EWM was observed in 14 test plots that previously contained the plant. By 2005 the milfoil had re-colonized 5 of the plots but was still much reduced.

The primary drawbacks to drawdown include loss of recreational use during the low water period and unintended effects of fish and aquatic life including insects and mollusks that are important elements in the food chain. A permit from the Wisconsin DNR is required to complete a drawdown. Any drawdown would also require cooperation from WPS, owner of the Sandstone dam. Depending on how far the impoundment elevation is lowered, electricity generation would be seriously reduced or even eliminated during the drawdown period.

Control/Reduce Nutrient Inputs
Aquatic plant response to nutrient inputs varies by species and source of nutrients. For the most part, rooted aquatic plants absorb their nutrients through the root system so nutrient additions to the sediment are more important than dissolved nutrients in the water column. Dissolved nutrients however can become sediment bound nutrients when they fuel algae growth that dies and sinks to the bottom.

Studies have shown that many aquatic plants are particularly stimulated by nitrogen additions to the sediment. Rogers (1995) reported that nitrogen additions to sediment significantly increased wild celery growth. Nitrogen is a water soluble nutrient. Septic systems intensive irrigation and excessive nitrogen fertilizer use have all been shown to cause increased nitrogen concentrations in groundwater. The Landowner survey showed that many landowners who fertilize their lawns are applying excessive amounts of nitrogen. If fertilizer must be used the recommended amount is 3-4 lbs of 27% nitrogen fertilizer per 1000 square feet of lawn. Since phosphorus is rarely in short supply in lawns, phosphorus free fertilizer should be used.

Flow Regime Change
Currently the Sandstone Dam in operated in run-of-the-river mode as required by their Federal Energy & Regulatory Commission (FERC) license. The current operating license was granted in 1997 after a long and difficult re-licensing process during which the Wisconsin DNR and other state and federal agencies made recommendations to reduce the impact of hydropower generation on fish and wildlife. The change to run-of-the-river operation was made based on the benefits to the downstream fish community of a more natural flow regime.

Without solid evidence that recent operational changes at the dam are harming fish and wildlife in Sandstone Flowage it is very unlikely that the operating license could be changed to alter the flow regime. Even with proof that the changes have impacted the aquatic plant community of Sandstone Flowage it would then come down to the weighing the benefits to the flowage against the damage done to downstream fish and wildlife.

Biological Plant Control
Biological control typically utilizes bacteria, fungi, or insects to control an unwanted plant. Biological control of exotic species often involves finding the natural control mechanism in the exotic plants country of origin and importing it to the US. Since there is always a risk that introducing a new organism may lead to unintended impacts to non-target species a lot of study is required to approve the use of new biological control agents.

In a rather unusual twist, the most promising biological control agent for Eurasian water milfoil is a native insect. The milfoil weevil (*Euhrychiopsis lecontei*) is a native species that normally feeds on northern water milfoil where it burrows into the stems and new shoots. The stout stems of northern water milfoil typically show little damage from this feeding activity. Eurasian water milfoil however has relatively weak stems that are readily damaged by weevil feeding activity. Studies have shown that milfoil weevils actually prefer the Eurasian milfoil and increase in population when Eurasian milfoil is the dominant food source (Lillie, 1997). It's believed that the natural decline in Eurasian milfoil infestations in some lakes may be due to the milfoil weevil.

Since its discovery as a control agent "stocking" milfoil weevils to control Eurasian water milfoil has been marketed as a control strategy by EnviroScience Inc. a lake management firm in Ohio. However, studies have since shown that the native weevil is already widespread in Wisconsin lakes (Jester, 1998).

Several studies have been conducted to determine the effectiveness of weevils as a milfoil control method. The results of these studies have been mixed. In Wisconsin it was found that in twelve lakes where weevils were stocked a few experienced large-scale milfoil declines while others saw little or no change (Jester 1999). The same study concluded that stocking weevils would be most effective in lakes where Eurasian milfoil has already reached its maximum distribution. The study also found that weevil density was positively correlated with increasing water temperature, distance of plant beds from shore (closer was better), and the percent of natural shoreline. The amount of natural shoreline is important because the adult weevils overwinter in leaf litter on the forest floor along the waters edge.

A second biological control agent may be of interest in Sandstone Flowage is a beetle that feeds on purple loosetrife, an exotic wetland plant that has been found in the flowage and can take over wetlands and crowd out the beneficial native plants. The beetle (*Galerucella sp.)* has proven to be very effective at controlling purple loosetrife infestations and can be easily raised with a minimum of equipment and effort. The Marinette County LWCD can assist in setting up a beetle raising operation.

Neither of these control methods is likely to eliminate an exotic species. Indeed most biological control methods simply control or reduce exotic populations so native species can better compete.

Exotic Species Monitoring and Prevention
As is often the case, an ounce of prevention is worth a pound of cure. With exotic species this is doubly true. In most lakes, and for most exotic species the primary mode of introduction is by boat, boat trailer, or bait bucket. While public access points are particularly susceptible, many exotic have been introduced on lakes without any public access. Unfortunately, flowages are even more at risk for exotic species introduction since the exotics can come from upstream sources.

Preventing exotic species introduction requires education. Besides posting signs at boat landings, the DNR offers exotic species control grants to qualified lake groups. The grants provide cost sharing for education programs and to conduct boat trailer inspection at public landings.

Once established in a water body it is extremely difficult to eradicate an exotic species. In the few cases where eradication has been successful the introduction was detected early. Regular monitoring to detect new invasive species is an important step in any aquatic plant management effort. The Wisconsin DNR and University of Wisconsin Extension have many good publications and websites to help the layperson identify exotic species. Periodically these agencies also offer exotic species identification and control training to landowners.

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