Shallow Lake Management Report

to the

2012 Minnesota Legislature

Submitted January 9, 2012, by the Minnesota Department of Natural Resources

FISCAL DISCLOSURE

Pursuant to Minnesota Statutes, Section 3.197, it is estimated that it cost approximately $8,000 in Minnesota Department of Natural Resources staff time to produce this report.

SHALLOW LAKES MANAGEMENT REPORT

Executive Summary

The 2011 Minnesota Legislature required the commissioner of natural resources to submit a report covering the ecology, importance, management, and regulatory framework for shallow lakes along with recommendations for statutory changes to better manage the shallow lake resource.

Shallow lakes are described as those lakes 15 feet or less in depth and at least 50 acres in size. Shallow lake ecology is a relatively new science investigating the differences that distinguish shallow lakes from deeper ones. Shallow lakes do not thermally stratify, are subject to internal loading of nutrients, and are dominated by rooted aquatic vegetation when healthy. Shallow lakes tend to occur in one of two stable conditions. One is a clear water condition with abundant rooted aquatic vegetation and high fish and wildlife habitat value. The other is a turbid condition with few aquatic plants and low fish and wildlife habitat value.

Shallow lakes bring essential economic and social benefits for recreation, hunting and fishing, migratory species use, and many other values. When healthy, shallow lakes are particularly valuable for waterfowl, shorebirds, and aquatic furbearers, as well as over 20 species identified as in greatest conservation need by the Minnesota state wildlife plan *Tomorrow's Habitat for the Wild and Rare.* These lakes are at serious risk due to the loss of a great percentage of wetlands in their watersheds and sweeping changes in how water is managed on the landscape. Many continue to lose some of their most important functions that benefit the quality of life in Minnesota.

There are more than 4,000 shallow lakes in Minnesota relatively evenly distributed between the prairie, transition, and forest landscapes. While the majority are less than 100 acres, 115 are more than 1,000 acres and nearly 50 are over 2,000 acres in size. Forty-seven shallow lakes have been formally designated specifically for wildlife management. The 2006 DNR *Duck Recovery Plan* identifies the need for 1,800 shallow lakes to be managed for wildlife habitat benefits. Specific strategies for achieving this goal are identified in the Department's Shallow Lake Program Plan, *Managing Minnesota's Shallow Lakes for Waterfowl and Wildlife* completed in 2010.

The quality of shallow lakes is negatively impacted by high water, modified watersheds, invasive species, undesirable fish, surface water disturbance, shoreline development, and changing climatic conditions. Shoreline protection, water level management, and removal of undesirable fish are the primary management strategies to improve the quality of shallow lakes for wildlife. The Department of Natural Resources (DNR) has demonstrated the effectiveness of these strategies in restoring clear water and abundant rooted aquatic vegetation to shallow lakes degraded with turbid conditions. Other regulatory approaches may be used to manage disturbance of migratory and breeding birds on these areas.

Shallow lakes are sensitive to changes in nutrients and the impacts of land use changes in the watersheds that have delivered more nutrients and sediment and more water more quickly. These changes create water quality and habitat impairments, and it is becoming impossible for public agencies and partner organizations to manage healthy fish and wildlife populations for the many ecological benefits that are being demanded by society without additional tools to facilitate management.

The state of Minnesota's authority to protect and manage shallow lakes in the public interest has been well established in statute and case law. This report recommends two two specific statute language changes to further facilitate shallow lake management. These specific recommendations can be found on pages 35-37 of the report.

One recommendation would broaden the authority of the commissioner under Minnesota Statutes (MS) 103G.408 to initiate periodic temporary (typically no more than two growing seasons) water level draw downs of public waters. The other recommendation would allow the Commissioner to initiate proceedings to designate Waterfowl Feeding and Resting Areas and Waterfowl Sanctuaries under MS 97A.095 subd. 1 and 2. It would also provide greater latitude in applying the restrictions beyond the waterfowl hunting season.

SHALLOW LAKES MANAGEMENT REPORT

LEGISLATIVE MANDATE

Laws of 2011, Chapter 107, Section 100
SHALLOW LAKES MANAGEMENT REPORT

By January 1, 2012, the commissioner of natural resources shall submit a report to the senate and house of representatives committees and divisions with jurisdiction over natural resources policy that includes:

(1) a summary of the science and ecology of shallow lakes;

(2) a summary of the significance of shallow lakes to continental and state waterfowl populations and Minnesota's waterfowl heritage;

(3) examples and documented results of previous temporary water-level management activities;

(4) a list of current statutes and rules applicable to shallow lakes including, but not limited to, water-level management of shallow lakes; and

(5) a list of any changes to statute necessary that would allow the commissioner of natural resources, through shallow lake management, to better achieve the state's wildlife habitat and clean water goals and address the threats of invasive species.

List of Tables and Figures

SUMMARY OF SCIENCE AND ECOLOGY OF SHALLOW LAKES

Shallow Lake Definition

Minnesota's shallow lake resource has been described in different ways. Many of the terms used are interpreted differently by different people. For the purposes of this report a shallow lake is a water basin 50 acres or greater in size and 15 feet or less in maximum depth. Most of these lakes have average depths of less than 6 feet. As a result, healthy shallow lakes are dominated by rooted aquatic plants. Figure 1 shows the distribution of shallow lakes in Minnesota.

The following background is provided to put the proposed management of shallow lakes into a scientific, ecological, and wildlife habitat context. The science of shallow lake ecology is a relatively new area of study. Only in the last 20 years has shallow lake ecology become a distinct topic within the broader fields of limnology and ecology.

The key to understanding and managing shallow lakes is defining what makes them unique from deep lakes. During the summer months, deep lakes thermally stratify or separate into layers based on water temperature. The epilimnion, the layer nearest the surface, is isolated for most of the summer from the nutrients contained in the sediments of the lake bottom due to this stratification.

On the other hand, shallow lakes do not form stable, distinct thermal layers during the summer months. The water column is mixing throughout the summer, and there is an exchange of nutrients between the water and lake sediments (Scheffer, 2004). This frequent water-sediment interaction results in a nutrient rich environment. A shallow lake compared with a deep lake of the same size and same watershed will have higher nutrient concentrations because of the greater internal nutrient cycling. The Minnesota Pollution Control Agency (PCA) has recognized the difference in natural fertility between shallow lakes and deep lakes and, therefore, has different impairment standards for shallow lakes (Heiskary and Lindon, 2005).

Another difference between shallow and deep lakes is the abundance and importance of rooted aquatic plants. Aquatic vegetation growth is limited to the areas of a lake where sunlight can penetrate to the bottom. In deep lakes that depth may only be a few feet to more than 20, depending on water clarity. Aquatic plants can grow over the entire bottom of a healthy shallow lake. Because aquatic vegetation can have such extensive coverage in these lakes, it is a key component of a shallow lake ecosystem.

Alternative Stable States Theory and Shallow Lakes

There is evidence that shallow lakes can exist in either of two conditions: one of clear water and abundant vegetation, or one of turbid water, little or no aquatic vegetation but abundant algae (Scheffer et al. 1993). While such shifts in condition can also occur in deeper lakes, it is uncommon and the effect not nearly as dramatic. Each condition is relatively stable depending upon nutrient concentrations.

Clear Water State

In the clear water state, aquatic plants serve to keep the water clear by protecting sediments from wind suspension (Van den Berg et al. 1997), providing habitat for filter-feeding invertebrates (Lauridsen et al. 1997), and storing nutrients (Van den Berg et al. 1997). Lakes in the clear water condition also support a greater diversity of wildlife and waterfowl. Aquatic vegetation directly provides habitat for waterfowl and furbearers and aquatic invertebrates associated with aquatic vegetation are important food sources for waterfowl.

Plants protect the bottom sediments from wind re-suspension just as terrestrial vegetation protects soils from erosion. Aquatic vegetation also enhances water clarity by competing with planktonic algae for nutrients (Sondergaard and Moss 1997).

Turbid Water State

In the turbid water condition, algae and suspended sediments prevent the growth of aquatic plants and the water stays turbid. Lakes in this turbid condition provide little or no habitat for wildlife and waterfowl.

Changes in the fish community of a shallow lake can cause deterioration from clear water to turbid water. Lakes dominated by bottom feeding fish and other planktivorous fish tend toward the turbid water condition. Bottom feeding fish (carp, bullheads) stir-up bottom sediments and uproot aquatic vegetation but, more importantly, increase internal nutrient loading through their metabolic activities (Lamarra 1975, Braband et al. 1990, Persson 1997, Zimmer et al. 2006). Planktivorous fish consume small invertebrates that filter feed on algae. These invertebrates play a significant role in reducing algae.

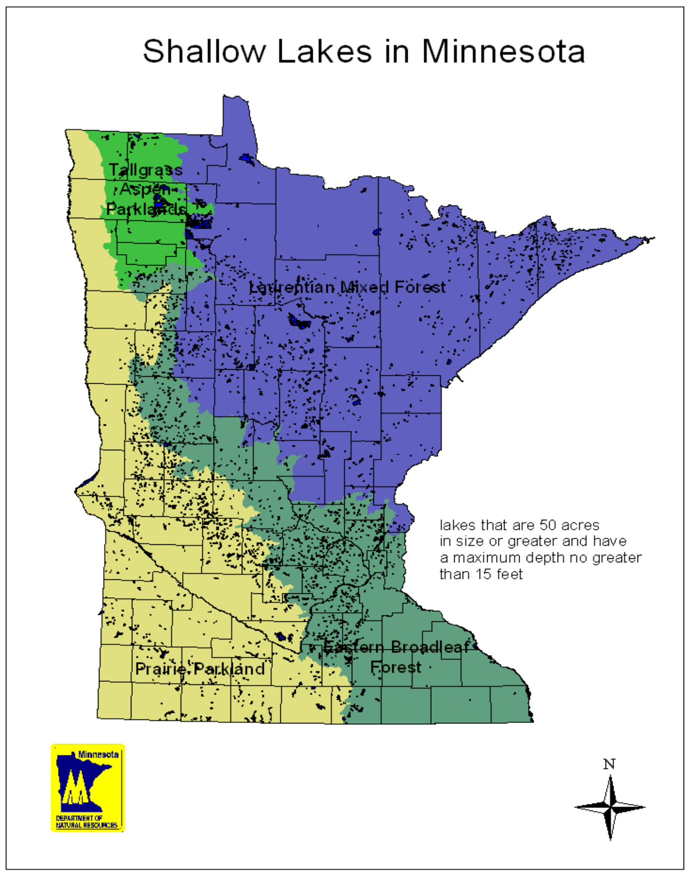

Figure 1. Shallow lakes are distributed through the forest, transition, and prairie portions of the state.

A lake's susceptibility to turbid conditions is strongly influenced by its contributing watershed. Changes in the watershed that increase runoff, sediment, and nutrients will increase eutrophication and the likelihood that a lake will be turbid. However, simply reducing the nutrient flow will not convert the lake back to a clear water condition once it is turbid (Scheffer 2004, Moss et al. 1997). It is important to recognize that reducing nutrients coming into a lake may improve the long-term results of in-lake management techniques (Hansson et al. 1998).

Biomanipulation

Due to stabilizing interactions, once a lake is in the turbid condition it is difficult to restore a clear water regime. Watershed management alone will not be able to reverse the lake back to the clear water condition in part due to the internal loading of nutrients from suspended sediments (Scheffer 2004, Moss et al. 1997). Additionally, in large watersheds, it is not feasible to restore pre-settlement conditions to the extent that would be required to see noticeable changes in habitat quality in a lake. Some type of in-lake management is required to change the cycling of nutrients already in the lake.

Changing how nutrients are cycled in a lake and where they are stored requires dramatic manipulations of the biological interactions occurring among fish, invertebrates, and algae. Common techniques to switch a lake from the turbid to the clear state include drawing down lake levels (drawdowns), changing the fish community through chemical treatments, stocking predator fish to reduce planktivorous fish; or through other means (winter drawdown).

These manipulations are referred to as "biomanipulations" which means manipulating the biology of a system. Biomanipulation can allow a brief window of low fish abundance. Without predation pressure from planktivorous fish, invertebrate populations flourish, grazing on algae and improving water clarity, and allowing aquatic plants to grow. The plants then stabilize the clear water in the lake. It is often easier to manipulate the fish communities than it is to manage other components of lake ecosystems (Lammens 1999).

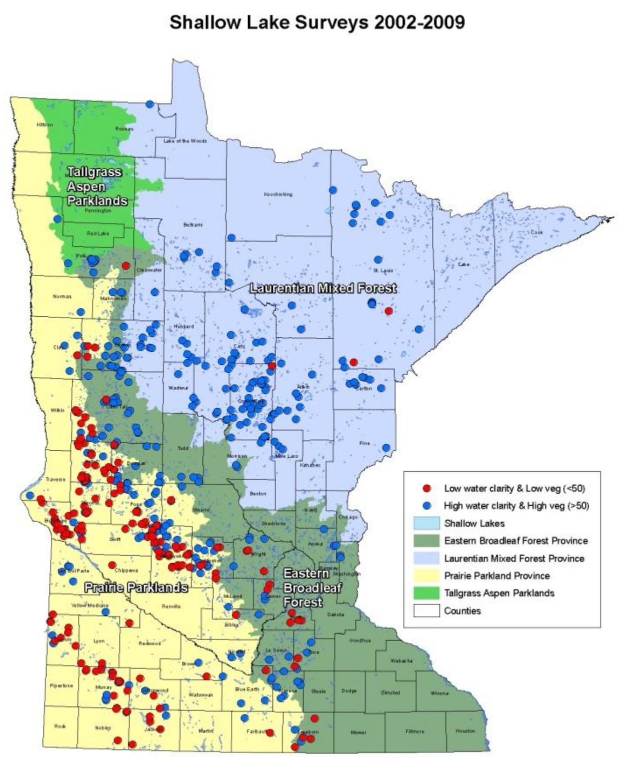

Figure 2. Distribution and condition of shallow lakes in Minnesota. Red dots indicate lakes in poor condition, blue those that are in good condition based on water clarity and vegetation abundance.

If carp are present in the lake or connected waters and are able to repopulate after a partial winterkill or incomplete kill from a chemical treatment, improvements in water clarity and habitat may be short-lived. Partial winterkills can create reproductive opportunities for carp by reducing competition and predation on eggs (Bajer and Sorensen 2009). Such partial winterkills are common in shallow lakes, even those with aeration systems.

While biological interactions in shallow lakes can cause switches from the clear to the turbid state and vice versa, underlying nutrient levels in a lake also influence the likelihood that a lake will be turbid or clear. At low nutrient levels, a shallow lake is more likely to be clear, at mid-levels of nutrients a lake can switch between both states, and at high nutrient levels, a lake is more apt to have turbid water. Many things can influence the underlying nutrient levels in lakes, including watershed size, soil type, topography, and watershed development (Moss et al. 1997). Such factors need to be considered when choosing shallow lakes to manage and when formulating expectations for management.

Those lakes with watersheds that have higher percentages of native vegetation and intact wetlands should be high priority for protection (both lake and watershed). Lakes with impacted watersheds are going to require more aggressive in-lake management and also restorative measures in their watersheds. Even with aggressive management, it may be difficult to maintain high water clarity in some lakes, although improvements in habitat are likely possible. For example, active management of a highly eutrophic system may not result in long-term improvements in water clarity, but increases in tolerant species of aquatic plants (ie sago pondweed) may be attainable. In those cases, repeated management is necessary to maintain quality habitat.

Minnesota Shallow Lake Resource Base

Minnesota has a resource of over 4,000 shallow lakes. The majority of these lakes fall between 50 and 100 acres in size; 115 are over 1,000 acres, and nearly 50 exceed 2,000 acres. Examples of large lakes include Minnesota’s most famous waterfowl hunting lakes such as Swan Lake in Nicollet Co. (9,346 acres), Heron Lake in Jackson Co. (8,251 acres), Lake Christina in Douglas Co. (3,978 acres), Pelican Lake in Wright Co. (2,793 acres), Thief Lake in Marshall Co. (7,430 acres), and Big Rice Lake in Cass Co. (2,717 acres). Approximately 1,700 shallow lakes have been drained prior to the 1970s, and most of those remain lost. Table 1 provides a summary of general information on numbers and uses of shallow lakes in Minnesota.

While shallow lakes are distributed throughout the state (Figure 1), habitat characteristics vary among and within regions. Habitat and water quality tend to be poor where watersheds have been dramatically altered by agricultural or urban development.

Data from DNR shallow lake surveys (Figure 2) suggest that the majority of prairie region shallow lakes have poor water clarity and consequently poor conditions for submerged aquatic plants and invertebrates, the primary sources of food for migrating and breeding ducks.

Total Existing Shallow Lakes, or lakes 50 acres or greater in size with maximum depths of 15 feet or less (there are still many lakes with unknown/unrecorded water depths)	~4069
Shallow Lakes Lost to or affected by drainage (according to Bulletin 25)	1752
Designated Wildlife Lakes under M.S. 97A.101 (2011)	47
Shallow Lakes Managed for Game Fish	754
Shallow Lakes Used for Aqua Culture	199
Shallow Lakes associated with public lands (State, Co., and USFWS)	2186
Shallow Lakes with public access but no other public land	244
Shallow Lakes with Wild Rice	559
Shallow Lakes with migratory waterfowl feeding and resting areas (MWFRAs)	37

Table 1. General shallow lake information. There is overlap in lakes in each category, for example, wild rice lakes may also be counted in lakes associated with public lands, or a Designated Wildlife Lake could also have a MWFRA.

Shallow Lakes and Wild Rice in Minnesota

Minnesota ranks first in the nation among states for natural wild rice production. Minnesota has over 1,000 (Figure 2) lakes containing stands of wild rice. Over half of these wild rice lakes are also shallow lakes. Wild rice provides important brood and migration habitat for ducks in the forest and portions of the transition zone. Many of these wild rice stands have deteriorated due to high water caused by ill advised dams or lake outlet blockages by beaver dams and dense growths of hybrid or narrow-leaf cattail. Managing wild rice remains an ongoing project for the DNR. In recent years, Ducks Unlimited, tribal governments, and lake associations have been important partners in these efforts. A complete report on the threats to wild rice in Minnesota was submitted by the DNR to the legislature on February 8, 2008.

SUMMARY OF FACTORS AFFECTING HABITAT AND WATER QUALITY IN SHALLOW LAKES IN MINNESOTA

Water Levels and Water Quality

More than a century and half of agricultural and urban development has taken its toll on Minnesota's shallow lakes. The prairie area of the state is substantially drained with fewer than 10% of the original wetlands remaining. Row crops such as corn, soybeans, and sugar beets dominate the landscape. Runoff is much greater due to loss of wetlands and reduced soil porosity due to loss of perennial grass cover. Remaining shallow lakes are often the receiving waters for much of this drainage and runoff. The result of decreased watershed storage and increased drainage is lakes with more hydrological "bounce" in water levels (flashy hydrographs) and increased levels of dissolved nutrients.

In addition to increased drainage, parts of the state have also experienced a trend of increased average annual precipitation in recent decades. Figure 3 shows how annual precipitation has increased in Otter Tail County in the last 20 years compared to the two decades prior. Similar patterns are evident in many other counties of the state. This increased precipitation has resulted in increased lake water levels.

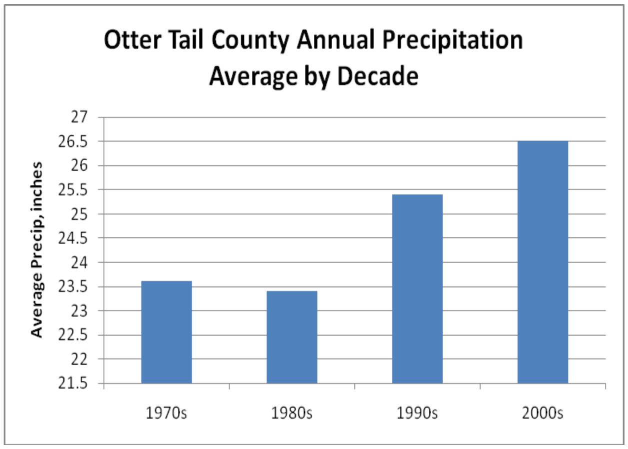

Figure 3. Precipitation data for Otter Tail County, MN from 1973-2009. Annual average by decade based on all available data in Otter Tail County from Minnesota State Climatology records.

Deeper water combined with mild winters, earlier ice-out on lakes, and increased connectivity (Figure 4) has decreased frequency of fish winterkill. Many of these lakes were important waterfowl lakes, but they now sustain abundant fish populations. Recent research predicts further reductions in the frequency and extent of winterkill in temperate lakes due to climate change. Duration, volume, and temporal extent of anoxia (lack of oxygen) are predicted to decrease in northern temperate lakes (Fang and Stefan 1997, 2000). When winterkills do occur, undesirable fish often re-infest the lake quickly through the enhanced connectivity provided by drainage networks.

Increased numbers and types of fish in shallow lakes have added to water quality problems. Carp and other benthivorous (bottom feeding) fish increase nutrient levels in basins through their foraging activity and through excreted nutrients (Lougheed et al. 1998). These nutrients contribute to algal blooms that decrease water clarity and submerged aquatic plants. Research has clearly documented poor habitat quality in basins with high densities of undesirable fish, including such native species as black bullheads and fathead minnows (Hanson et al. 2005, Herwig et al. 2006, Zimmer at al. 2006).

Increases in nutrients, higher water levels, suspension of bottom sediments, invasive species, algal blooms, and shoreline disturbance have combined to eliminate aquatic plants and invertebrates and decrease water clarity and quality in many basins. Nearly two-thirds of the shallow prairie lakes surveyed by Minnesota DNR Shallow Lakes Program have poor water clarity and quality.

Continuing research has led to a better understanding of the intricacies of these relationships among fish, invertebrates, water clarity, and lake nutrient levels. Although much remains to be learned, it is clear that lake management approaches cannot ignore biological interactions occurring in lakes if the management goal is related to waterfowl, fish, or water quality.

Invasive Species

Invasive fish, particularly carp, pose a serious challenge to maintaining water quality, desirable aquatic plants, and invertebrates (Parkos et al. 2003). Documentation of problems with the regulated invasive common carp in Minnesota date back at least to the 1940s and are generally limited to the southern half of the state (Sharp 1942). This fish was recognized as problematic in other parts of the country by the early 1900s.

Four new species of prohibited invasive Asian carp that could invade Minnesota are silver (*Hypophthalmichthys molotrix)*, black (*Mylopharyngodon piceus*), big head (*Hypophthalmichthys nobilis*), and grass (*Ctenopharyngodon idella*). These fish species have been raised commercially and used experimentally in aquaculture ponds in many southern and Midwestern states and escaped into the wild. They have since been expanding in the Mississippi and Illinois rivers and their tributaries. Grass carp feed directly on aquatic vegetation, silver and big head carp focus on plankton, and black carp feed on snails and clams.

Their impact on invertebrates and aquatic ecosystems will be devastating to Minnesota's aquatic habitats and fisheries, if they become established. They could reach the state from the Mississippi River or potentially through the Great Lakes (spread from the Illinois River). Currently, a temporary electric barrier in Illinois is the only protection from further invasion toward Minnesota via the Great Lakes. However, at least one carp has been found above this barrier already.

There is no barrier (other than existing dams) on the Mississippi to prevent upstream spread into Minnesota. As of 2008, no known viable populations of these fish exist in the state; however, a grass carp was caught in the St. Croix River in the spring of 2006, a big head carp was caught by a commercial fisherman in the fall of 2007 on Lake Pepin, and two grass carp, one bighead carp, and one silver carp were caught by a commercial fisherman in the Mississippi River near LaCrosse, Wisconsin, in November

2008 (Associated Press). There has been recent DNA evidence of Asian carp in the Metro area of the Mississippi River.

The prohibited invasive Zebra mussel (*Dreissena polymorpha*) is a small clam that is native to the Caspian Sea region of Eastern Europe. The small bivalves were introduced into the Great Lakes through ballast water from ships. They were first found in Minnesota in 1989 in the Duluth Harbor of Lake Superior and have since spread to over three-dozen other water bodies in the state, including the Mississippi River near Brainerd (Minnesota invasive species website). It seems likely that these mussels will eventually be introduced into shallow lakes in the state. In some of the Great Lakes, zebra mussels have attracted large numbers of diving ducks (Petrie and Schummer 2002). However, these filter-feeding mussels also harbor environmental contaminants. The contaminants accumulate in the mussels' fatty tissues.

High concentrations of methyl mercury and polychlorinated biphenyls (PCBs) were found in zebra mussels in Minnesota and Iowa after only one growing season. There is great concern that these mussels could be a source for translocation of contaminants into higher trophic levels of the food web including waterfowl (Cope et al. 1999, MacIsaac 1996). There is evidence from many lakes, including Lake Erie, that water clarity increases after introduction of zebra mussels due to their filter feeding. They have been intentionally introduced into lakes in the Netherlands as a tool to improve water clarity (MacIsaac 1996). Submerged aquatic vegetation could increase in lakes where these mussels become established.

Other invertebrate invasive species are cause for concern as well. Recent scaup die-offs in Lake Winnibigoshish have been linked to the invasive faucet snail *(Bithynia tentaculata*). These small snails are native to Europe and were mostly introduced into the Great Lakes via ballast water. They are intermediate hosts to trematode parasites. Diving ducks, particularly scaup, consume the snails in large quantities and are killed by the trematodes as they infest their bodies. Although faucet snails have not been documented in any Minnesota shallow lakes yet, they may already be present in some and would survive if introduced, as their preferred native habitats are freshwater ponds and shallow lakes with abundant aquatic plants (Kipp and Benson 2008).

Shallow lakes have been degraded by other invasive species such as hybrid cattail, reed canary grass, and the prohibited invasive purple loosestrife. These invasive plants have displaced desirable native vegetation (bulrush, wild rice, broad-leaf cattail) in some lakes and have altered the hydrology in many. Hybrid cattail, in particular, can clog outlet channels and increase sedimentation in these areas, ultimately affecting lake water levels. Additionally, this plant can completely fill in all of the open water areas of lakes and wetlands if it is not managed. Once it has filled in a basin, it is very difficult to remove, especially if it forms a floating mat. Hybrid cattail can be beneficial in some lakes that are degraded such that they are the only emergent species that will tolerate the siltation and nutrient rich conditions. In these instances some emergent vegetation, even if hybrid cattail, is better than having no emergent vegetation. It prevents shoreline erosion and does provide some habitat.

An invasive European genotype of common reed grass (*Phragmites australis)* has displaced native forms of the plant in New England states. This invasive form of reed grass has expanded across the southern Great Lakes states and has been found in isolated locations in Minnesota (Saltonstall 2002). This plant has the tendency to form monocultures. It also has the potential to alter hydrology and reduce open water habitats in many of the state's shallow lakes. It could further displace native vegetation across the state and could be particularly threatening to native wild rice stands.

At least two species of submerged prohibited invasive aquatic plants, Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) are found in the state and have spread to some shallow lakes. These plants can displace native submerged plants that are more desirable for waterfowl habitat. The timing of curly-leaf pondweed's growth and die-back affects internal nutrient cycling in lakes resulting in mid-summer algal blooms. Once these plants are in a lake they are nearly impossible to eliminate. Management focuses on reducing nuisance conditions and is expensive. Attempts at control usually involve multiple herbicide applications, although drawdowns can be used to reduce both of these species. There are several other submerged invasive aquatic plants present in other states that would also be troublesome if introduced to Minnesota's shallow lakes; the prohibited invasive hydrilla *(Hydrilla verticillata)* is one example.

There is evidence that climate change affects an ecosystem's susceptibility to invasive species. Warming lake environments may lead to a change in species composition of plants, invertebrates, and fish. If conditions become less than ideal for native species, an opening is created for biological invasions. Some scientists suggest that under these circumstances, it may be necessary to view new species as a part of these changing systems rather than trying to eradicate them (Walther 2009).

Fish Rearing

Loss of wetland quantity and quality has created a scarcity of wetlands in some parts of the state resulting in competition for remaining wetlands and shallow lakes. Competing uses include fish rearing for the bait industry and game fish stocking in lakes. The bait and aquaculture industry are economically and socially important in Minnesota. Current statutes support the use of public programs to promote aquaculture (MS 17.49) and the use of wetlands for commercial purposes (MS 103B.3355). Bait dealers can catch baitfish from wild stock in lakes and wetlands, and they can also raise baitfish in public waters with a permit. There is little regulation on the actual harvest of bait from public waters. The bait harvesters must be licensed but then can trap in almost any basin on which they have legal access.

The Legislature has also appropriated funds for increased levels of walleye stocking. Walleye stocking involves use of both fry and fingerlings. The fingerlings to support this stocking are raised in natural wetlands and shallow lake basins. More than 2,000 basins are currently approved for fish rearing activities; 199 of these are shallow lakes (greater than 50 acres in size). In some shallow lakes, walleye rearing has been beneficial to temporarily reduce fathead minnows and improve aquatic invertebrate abundance along with water clarity (Herwig et al. 2004). Walleye fry feed on fathead minnow fry and have effectively controlled fathead minnows during the years of fry stocking. In the absence of winter kill, wetlands or shallow lakes are treated with rotenone, usually by DNR Fisheries, to remove bullheads and or carp and then the water bodies are used for walleye rearing activities. Current DNR fish rearing methods and activities do not include stocking of fathead minnows or other forage fish to increase production.

Recent concerns over the impact of fish rearing has led to additional research by the DNR and increased interest by the state Legislature. As a result, in 2006, the DNR unsuccessfully proposed a moratorium on the use of additional basins for fish rearing until ecological criteria could be established to measure the impact of rearing activities on individual wetlands and shallow lakes. The 2007 Legislature required the DNR to submit a report on the effects of fish rearing, and this report was submitted in January of 2008.

Physical Disturbance

Disturbance to waterfowl by watercraft often accompanies increasing human populations and shoreline development. Negative impacts to waterfowl caused by motorized surface use of lakes has been documented both during spring and fall migration (Kahl 1991, Havera et al. 1992). Waterfowl often take flight when approached by motorboats. Boating activity related to fishing, hunting, and general recreation can decrease the amount of time the ducks have to forage and increase energy expenditure. Kahl (1991) quantified the time and energetic impacts of boating disturbance for canvasbacks on a Wisconsin lake. Boating disturbance accounted for 50% of the time canvasbacks spent away from feeding areas during the spring migration in this study. Several other studies have documented negative impacts of motor boat activities on migrating and breeding waterfowl (Korschgen and Dalhgren 1992, Liddle and Scorgie 1980). Currently under Minnesota law, specific lakes can be designated MWFRAs, which restrict motorized use only during the waterfowl-hunting season. Recreational fisheries and high water have impacted some MWFRAs. Without opportunities to rest and refuel undisturbed, waterfowl move through the state quickly.

The DNR recently completed a statewide survey of refuges and rest areas and found significant gaps in the statewide quantity and quality of sites available to migrating flocks. This was especially true for water-based rest areas and refuges. Although the process for establishing refuges and rest areas differs by ownership and type, it is usually dependent on citizen initiation and support.

In addition to direct disturbance of birds, power boating can also directly and indirectly impact aquatic vegetation (Asplund, 2000, Asplund and Cook, 1997). Motors directly impact aquatic plants by uprooting and cutting them. They can indirectly impact plants with their wakes by disturbing bottom soils and increasing phosphorus concentrations in the water column. This increase in turbidity is particularly true for shallow lakes with soft bottom substrates (Anthony and Downing, 2003, Wagner 1991, Yousef et al. 1980).

Increased Shoreline Development

Ever increasing demand for shoreline property has resulted in development on lakes that historically would not have been considered suitable for lake homes. In addition to increased surface use, which can lead to waterfowl disturbance, shoreline development usually results in loss of shoreline vegetation and submerged vegetation. Both types of aquatic vegetation are valuable for wildlife and waterfowl habitat. Increased development can also result in increased pressure to manage lakes for sport fishing, which can lead to further habitat changes and increased conflicts between fishermen and waterfowl hunters. Management based on the ecological function of a shallow lake may become more difficult in these situations.

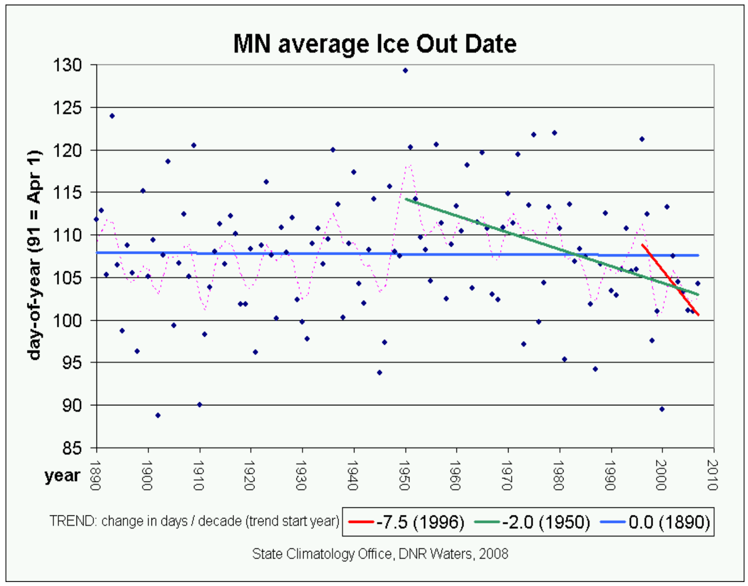

Figure 4. Average date of lake ice out from historical data on several lakes across the state. Pink dashed line represents short term trends.

Increased shoreline development can indirectly impact management potential of a basin. Drawdowns have long been recognized as valuable management tools for wetlands and shallow lakes, not only for waterfowl and wildlife benefits, but also for water quality improvements. This tool, however, is controversial and often not viewed as beneficial by shoreline owners. As shoreline development increases on a particular shallow lake, it becomes politically difficult to perform managed drawdowns.

Climate Change

In the next 100 years, average temperatures are predicted to increase by 5-12^{o}F in winter and even more in summer (Kling et al. 2003). Precipitation patterns are also predicted to change with the frequency of extreme weather events increasing by 50-100% of current values (Kling et al. 2003). The impacts of these changes on shallow lakes are unknown. However, one likely impact that may already be occurring is decreased winterkill of fish populations. Many studies have shown that fishless basins provide the best waterfowl habitat but are increasingly rare (Hanson and Riggs 1995, Bouffard and Hanson 1997). Fishless basins tend to be small and isolated. Drainage and tiling have led to direct loss of these basins or connected them to other water bodies with fish. Frequent winterkill is one of the mechanisms that eliminate fish from a lake or wetland. Recent research (Fang and Stefan 2000) indicates that the likelihood of winterkill is strongly reduced in northern states under several predicted climate change scenarios. Ice out data from Minnesota also indicates a trend of shorter duration of ice cover on Minnesota Lakes (Figure 9). Shorter duration of ice cover would contribute to reduced frequency of winterkill.

There are several other potential effects of climate change that are less well understood including the impacts of warmer temperatures on invertebrate populations and aquatic vegetation. Models indicate that rainfall amounts and timing of rainfall events will be more variable in Minnesota. More rainfall would have negative impacts on aquatic vegetation in shallow lakes. The increased runoff associated with more severe rain events is expected to increase pollution of the state's surface waters (Carstensen et al. 2008). This added pollution would also have negative impacts on aquatic vegetation and waterfowl habitat. Increased warming may lead to increased summer water temperatures which could exacerbate internal phosphorus loading in lakes (Malmaeus et al. 2006). Management strategies to deal with or reduce internal nutrient loading will continue to be needed.

SIGNIFICANCE OF MINNESOTA'S SHALLOW LAKES TO CONTINENTAL AND STATE WATERFOWL POPULATIONS

Quality shallow lakes are critical habitats for waterfowl production and migration. These lakes play three important roles in waterfowl production. The first is providing abundant food energy in the form of aquatic invertebrates for breeding hens. Diving ducks, particularly lesser scaup, depend on shallow lakes for these invertebrates while dabbling ducks often frequent small, shallow marshes in the spring. The second contribution is in providing high quality duckling brood habitat for all ducks. Thirdly, shallow lakes can provide nesting habitat for species of ducks that nest over water on floating mats of vegetation or in dense stands of emergent vegetation.

Favored nesting habitats are those that have partial basin coverage with thick stands of emergent vegetation including bulrush, cattail, phragmites, or sedge. Redheads, canvasbacks, scaup, ring-necked ducks, mallards, and ruddy ducks are all species that will nest over-water in emergent vegetation (Bellrose 1980, Baldassarre and Bolen, 2006). This valuable breeding habitat has decreased with higher water levels in lakes and wetlands over the last two decades. For some wetlands the reverse is true when the invasive hybrid cattail completely covers a lake.

Minnesota's breeding populations for these species ranges greatly from year to year but can be tens of thousands to over 100,000 birds in any given year (Waterfowl breeding population survey for Minnesota, 2011). Canvasbacks, redheads, and ring-necked ducks are the most likely species to nest overwater in shallow lakes or on floating bogs at the edges of shallow lakes (Bellrose 1980). In 2011, there were over 6,700 breeding redheads in the state and over 22,000 breeding ring-necked ducks in Minnesota. Breeding canvasbacks are considerably less common.

Shallow lakes are important brood habitats to most if not all species of ducks that nest in Minnesota. High quality brood habitat leads to increased ducking survival rates. Duckling survival is a critical component to improving duck populations. Emergent aquatic plants such as rushes, wild rice, and rooted common cattail enhance brood habitat by providing protective cover from weather and predators. Aquatic invertebrates such as insects, amphipods, and snails are critical for duckling growth and survival. An abundance of invertebrates reduces the time ducklings spend foraging, which increases their survival rates.

The quality of shallow lakes providing brood habitat has dramatically declined due to a combination of factors including prolonged periods of high water that favor winter survival of undesirable fish, such as bullheads and carp. These fish reduce the invertebrates and aquatic plants necessary for brood survival (Buoffard and Hanson 1997, Hanson and Riggs 1995).

Diving ducks (canvasbacks, redheads, lesser scaup, and ring-necked ducks) rely on lakes especially for both spring and fall migration habitat (Korschgen 1989). In the spring, it is important that these lakes provide abundant invertebrates to support female ducks that are preparing to breed and nest. For example, lipid and mineral reserves are important determinants of nest initiation and clutch size in lesser scaup (Anteau and Afton 2004). There is evidence that the quality of spring migration habitat in Minnesota has declined, particularly in the abundance of important invertebrates such as amphipods. Anteau and Afton (2006) attribute the decrease in lipid reserves to a corresponding decrease in the amount of amphipods in the diets of scaup during spring migration. Both invertebrates and plants are important nutrient sources to diving ducks in the fall. Ducks need to feed on these food sources relatively undisturbed to gain weight for the remaining migration (Korschgen 1989); thus, it is important that shallow lakes provide both invertebrates and aquatic plants in order to meet waterfowl migration needs.

Minnesota's shallow lakes are also important to continental waterfowl populations during the fall migration period. Waterfowl that breed in Canada and North Dakota will migrate through Minnesota on their way to the east coast or to the Gulf coast. A large portion of the continental canvasback population has historically migrated through Minnesota to stage on the Mississippi River near LaCrosse, WI, and also near Keokuk, IA, (Bellrose 1980); Heron Lake and Lake Christina were famous for their canvasback concentrations in the fall.

Ducks are driven primarily by their need for food and rest during fall migration. Temporary and seasonal wetlands sometimes fill these needs for dabbling ducks during extremely wet falls, particularly within the prairie region of the state. However, these ponds are usually dry during the average fall. Typically it is the larger, more permanent wetlands and shallow lakes that provide the most important fall habitat. Unfortunately in Minnesota, the quality of this habitat has declined markedly due to shoreline development, drainage, excessive runoff, sedimentation, and dominance by invasive plant and fish species.

The worst loss of habitat for waterfowl has occurred within the prairie and transition portions of the state (Figure 1). For example, the impacts of wetland drainage include the direct loss of habitat for wetland dependant species, increased nutrients and siltation in remaining wetlands and lakes, altered hydrology including loss of flood storage, increases in water levels, and altered food webs (Blann et al. 2009). While “modernizing” existing drainage systems to incorporate controlled drainage technology can reduce the downstream flow of some nutrients, subsurface drainage tile can also divert ground water into surface drainage, further adding water that would normally go to ground water recharge.

Restoration of wetland and grassland complexes within the watersheds of these lakes will help reduce excessive runoff and improve water quality in the long-term. However, watershed work alone will not resolve in-lake degradation problems nor restore invertebrate populations related to high populations of undesirable fish species including carp and bullheads. It is not completely understood how much conservation and management will be needed to show improvement in the condition of aquatic systems in these impacted landscapes (Blann et al. 2009).

Importance of Shallow Lakes to Other Wildlife and Species of Greatest Conservation Need

Shallow lakes provide important habitat to many environmentally sensitive species such as those listed as having the “Greatest Conservation Need” by the DNR in the state wildlife plan *Tomorrow’s Habitat for the Wild and Rare*. Over 20 species listed as a species of greatest conservation need (SGCN) utilize shallow lake habitats. They include many water bird species that nest on shallow lakes including grebes and terns. Their habitats have been negatively impacted by the loss of emergent vegetation or increases in water level bounce caused by watershed changes or constricted lake outlets. Shorebirds also utilize shallow lake habitat, especially those that are in a natural or managed drawdown during their migration. Several species of frogs, toads, and turtles are also found in shallow lakes, particularly for wintering habitat.

Shallow lakes were listed specifically as “key habitats for species of greatest conservation need” in six of the state’s 25 ecological subsections. Those six subsections were located in the Prairie Parklands and Eastern Broadleaf Forest provinces. Management options to support SGCN in the report include preventing loss and degradation of shallow lakes, focus on protecting larger shallow lakes and wetland complexes, managing shallow lakes to mimic natural water regimes, managing infestations of invasive plants and animals in shallow lakes, and protecting known nesting areas for Forster’s terns.

IMPORTANCE OF SHALLOW LAKES TO MINNESOTA'S WATERFOWL HERITAGE

Despite substantial losses in the quantity and quality of the state's shallow lakes, Minnesota remains one of the most important waterfowl production and harvest states in the Mississippi Flyway. Minnesota typically fields close to 100,000 waterfowl hunters and 400,000 waterfowl watchers/birders a year, one of the highest in the nation. Annual trip and equipment expenditures by these enthusiasts in 2001 totaled more than $224 million and generated more than $20 million in state tax receipts.

The number and diversity of shallow lake habitats that provide hunting opportunities for waterfowl are great. Lakes like Swan, Christina, Heron, and Thief have been known as important waterfowl hunting lakes even prior to European settlement as indicated by archeological evidence. Waterfowl hunting camps have existed on these lakes since the turn of the last century. Heron Lake was known once as the "Chesapeake of the West" due to the numbers of canvasbacks that staged on the lake during migration. Hunters would take trains from Minneapolis/St. Paul to places like Heron Lake or the Fergus Falls area specifically to hunt ducks. Lakes like Big Rice in Cass County also have a history rich in waterfowl hunting traditions.

The importance of waterfowl hunting in the state has resulted in organizations that are particularly active in conservation of waterfowl habitats in the state. The Minnesota Waterfowl Association (MWA) was founded in Albert Lea in 1967 to protect important shallow lakes for waterfowl and for waterfowl hunting. The organization rallied for the passing of legislation for the State Waterfowl Duck Stamp in 1977. MWA also supported the legislation that allows the DNR to manage designated lakes for waterfowl and wildlife purposes and supported the recent Legacy Amendment. The fact that Minnesota has a state organization dedicated to preservation and improvement of waterfowl habitat illustrates the importance of this activity to the citizens of the state.

Ducks Unlimited (DU), a national waterfowl organization also has a strong presence and membership in Minnesota with over 38,000 members. DU and MWA have been strong partners with the DNR in shallow lake management projects over several decades. DU's Living Lakes Initiative is an important effort to protect and manage Minnesota's shallow lakes for waterfowl.

In 2005 waterfowl hunters of the state were instrumental in organizing a rally at the state capitol to bring attention to the decline in wetland habitat and waterfowl numbers in Minnesota. Over 5,000 people attended the rally in the first year and a second rally was held in 2006. These rallies served to solidify numerous conservation organizations that eventually helped pass the Legacy Amendment to the State's constitution in 2008.

Declines in shallow lake quality directly affect waterfowl hunting opportunities. Places to hunt and see waterfowl are critical elements leading to hunter satisfaction (Schroeder et al. 2007). Restoring and protecting the habitat needed by migrating ducks is obviously beneficial for hunters as well. Access to some shallow lakes can be physically intimidating for many hunters and impossible for those challenged by age or physical ability. Balancing the issue of increased disturbance with appropriate access will be a challenge for the DNR, particularly as the population ages.

SHALLOW LAKE MANAGEMENT FOR WILDLIFE IN MINNESOTA

In Minnesota, there are approximately equal numbers of shallow lakes in the forest, transition, and prairie areas (Figure 1), but the characteristics and conditions of the lake resources differ considerably among the ecological zones. Management strategies must differ accordingly.

Many of the shallow lakes of the prairie and western portions of the transition zone are large semi-permanent and permanent water bodies. They have traditionally been dominated by cattails and bulrushes along the shorelines and dense stands of submerged food plants, such as sago pondweed, throughout the basins. Reflecting the rich prairie landscape, the lakes are inherently nutrient-rich and can support an abundance of invertebrates and food plants.

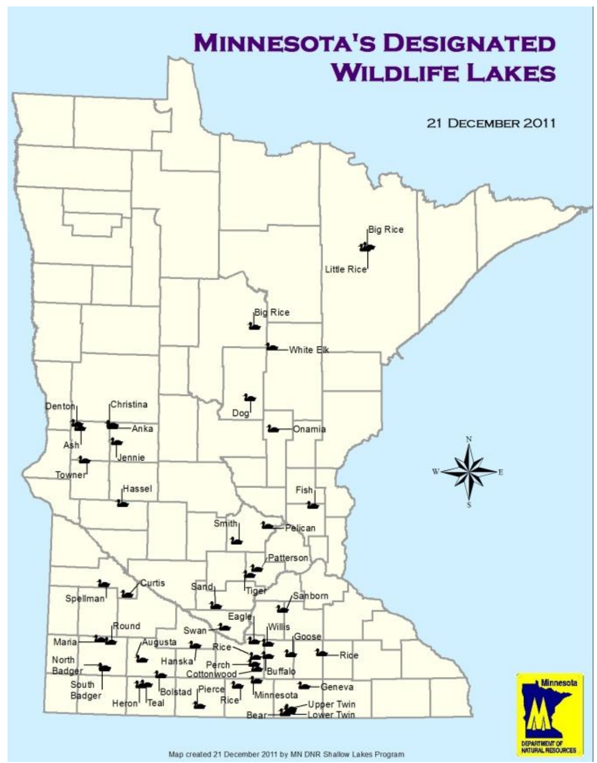

Figure 5. Minnesota's Designated Wildlife Lakes under M.S. 97A.101.

The quality of waterfowl habitat in prairie lakes is highly influenced by water clarity, abundance of aquatic plants, and invertebrates. Often, excessive nutrients and undesirable fish can cause degradation of water clarity and these lakes shift to turbid, algae-dominated basins with few plants and invertebrates. Lakes in this condition have little value for waterfowl. Historically, frequent winterkills, low water cycles, and isolation from other water bodies limited fish populations and maintained good quality habitat in prairie lakes and wetlands.

Productivity of lakes and soils decreases as one moves north and eastward in the state. Lakes in the forested area of the state are less likely to have problems with excessive nutrient inputs. This area has also been less impacted by wetland drainage. The best waterfowl lakes in the forest are wild rice lakes. As mentioned earlier, wild rice stands provide important brood and migration habitat for waterfowl, but many of these wild rice stands have deteriorated due to high water caused by lake outlet blockages by beaver dams and other obstructions. Managing wild rice is an ongoing project for the DNR and other partners, including Ducks Unlimited, tribal governments, and lake associations. For example, in 2010, over 240 lakes were managed for wild rice.

One of the primary tools the DNR has available for shallow lake management for wildlife is Wildlife Lake Designation through Minnesota Statute (MS) 97A.101. This statute allows lakes to be designated specifically for wildlife management through a formal public hearing process. Such designation provides DNR wildlife managers with authority to manage water levels and control motorized use. Only 47 (Figure 6) of the more than 4,000 shallow lakes have been formally designated for wildlife management through this process. In comparison, about 754 shallow lakes have or are managed for recreational fishing in Minnesota by DNR Fisheries. An additional 199 lakes are licensed for private aquaculture activities. The lakes with recreational fisheries are evenly distributed throughout the state, but most shallow lakes used for aquaculture are located in the prairie and transition areas of the state (Figure 6).

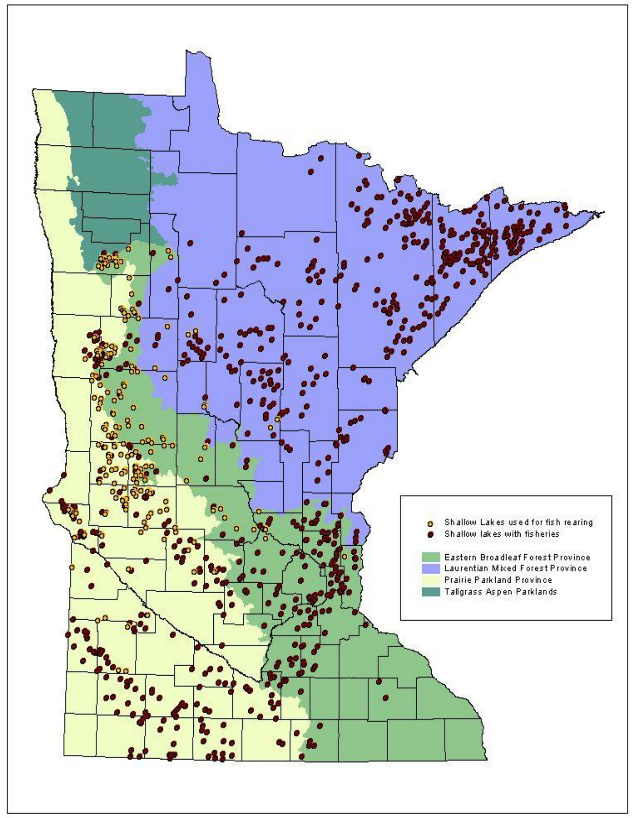

Figure 6. Shallow lakes with recreational fisheries or with aquaculture use.

OPPORTUNITIES AND MANAGEMENT APPROACHES

The multiple problems affecting shallow lakes require a variety of tools to address those problems. Some of the most common tools are summarized below. Each managed lake requires an individual management plan that includes multiple strategies and tools to deal with specific impacts or threats. Shallow lake management requires ingenuity and creativity; therefore, this list is not comprehensive and new tools may be developed. The tools in this summary can be divided into three basic categories: direct protection, habitat and water quality improvement, and regulatory and policy protections.

Direct Protection

Some shallow lakes in the state are in good condition both with respect to waterfowl habitat and water quality. The primary management objective for these lakes should be to maintain and protect that existing habitat. The likely reason some of these lakes remain in good condition is absence of invasive species, small contributing watersheds with little loss of native vegetation and wetlands, and lack of extensive shoreline development. For such lakes surface use restrictions could be implemented to protect the aquatic plants, maintain water clarity, and minimize disturbance. Watershed and shoreline protection can be done through direct acquisition from willing sellers and through conservation easements available through various programs and non-profit organizations (Reinvest In Minnesota, Wetland Reserve Program, US Fish and Wildlife Service, Natural Resources Conservation Service, Soil and Water Conservation Districts, DNR, and Ducks Unlimited). Additionally, new programs providing incentives for conservation easements or acquisitions targeted for shallow lake watersheds and lakeshores could be developed. All of the above tools require working cooperatively with various partners.

Criteria to consider for targeting lakes for direct protection are: quality of existing habitat, size of watershed (smaller the better), waterfowl use, water level management potential, and proximity to features that would contribute to a wetland habitat complex.

Such tools can also be applied to degraded lake systems as a part of a comprehensive habitat restoration plan that includes in-lake management. Research on shallow lakes demonstrates that while watershed restoration is not sufficient to restore in-lake habitat quality due to internal nutrient loading, reducing the external sources of nutrients can aid and extend the benefits of in-lake management. In addition, wetland and grassland restoration and protection provides additional benefits by forming habitat complexes of shallow lakes, wetlands and grasslands. These complexes are a key component of achieving the goals of the 2006 *Duck Recovery Plan*.

Habitat and Water Quality Improvement Tools

Shallow prairie lake ecosystems evolved under climatic conditions that featured periodic droughts of varying degrees of intensity. Severe droughts typically occurred every 8-15 years with mild droughts occurring about twice as often. The result was basins with good quantities of emergent vegetation such as bulrush and open areas with lush submerged vegetation. The periodic droughts combined with severe winters to limit fish populations. Lakes with flowing outlets often harbored game fish that moved upstream in the spring. The surrounding uplands were typically dense prairie grass that enhanced infiltration of rain, minimizing the amount of run-off into lakes and streams. The changes highlighted earlier (climate change, altered hydrology) have reduced or eliminated natural drought cycles.

Drawdown

The most effective management technique mimics historical droughts through temporary water level manipulation known as a “drawdown”. A drawdown is an effective and relatively inexpensive shallow lake management tool that addresses both problems with internal nutrient loading and loss of aquatic plants. This temporary water level manipulation restores aquatic vegetation, improves water clarity, removes fish or temporarily reduces fish abundance and increases invertebrate abundance. Sediments are consolidated when they are subjected to drying, reducing wave re-suspension thereby increasing water clarity when the basin is re-flooded. Sediments are also aerated, reducing release of phosphorus into the water column. Additionally, many aquatic plant seeds, especially bulrush, need to be dried or need mud flats to germinate. A temporary drawdown typically lasts through one or, at most, two growing seasons. Since natural droughts occur periodically and that is what most shallow lake aquatic vegetation and wildlife is adapted to, drawdowns will also need to be repeated over time as habitat conditions change.

Partial drawdowns can effectively mimic annual seasonal cycles of water levels. Typically water levels are highest in the spring and early summer with lower water levels occurring as precipitation declines in late summer and fall. Dabbling ducks and shorebirds particularly benefit from wetland habitat with less than a foot of water. The reduced water levels as winter approaches helps insure winterkill of undesirable fish.

Fish Management

On many basins, drawdowns are not possible. Some lakes do not have outlets, or the outlets lack sufficient change in topography to lower water levels. Lakes with large watersheds are difficult to drawdown. For these basins, other tools need to be considered including rotenone treatments, fish barriers, and predator fish stocking. These tools need to be appropriately applied to identified problems in conjunction with individual lake management plans. Like drawdowns, fish management in shallow lakes is an on-going process; the results of any single treatment will not last indefinitely. Management and treatments will need to be repeated if habitat quality is to be maintained.

Fish barriers are installed to prevent or reduce carp populations. Barriers come in several different types and configurations including physical barriers, mechanical barriers, and electric barriers. These barriers reduce or prevent upstream movement of fish. Preventing downstream movement is more difficult. The site and budget will determine which barrier is best suited to a particular site. Ideally, these barriers are placed prior to drawdowns or chemical treatments aimed at reducing fish populations. Basins that have limited connections to other water bodies are the best candidates for fish barriers. In many situations, however, it is difficult to find an effective fish barrier or means of removing fish above a barrier.

Rotenone is a piscicide derived from plants from the *Derris* genus. It has been used as a fisheries management tool for decades. Wildlife managers in Minnesota and elsewhere use this chemical primarily to manage carp in shallow lakes. Due to the cost and overall desire to limit chemical treatments, this tool is usually used when full drawdowns are not possible as a means of fish control. Rotenone can be most effective when applied to isolated water bodies, those either naturally isolated or through means of fish barriers. However, due to the difficulty of obtaining effective treatments in shallow, nutrient rich systems, treatments may need to be repeated or combined with some level of drawdown. It typically, but not always, is applied in the late fall. Each individual basin will have a specific treatment plan.

Predator fish stocking has been studied as a management tool for degraded systems, including wetland systems in Minnesota. The concept is that predators can control undesirable fish that reduce zooplankton and the ultimate result is reduced algal biomass. An example of predator stocking in Minnesota has involved experimental stocking of walleye fry to control fathead minnows in wetland systems (Herwig et al. 2004). In the simplest explanation, walleye fry eat fathead fry, and fathead minnow populations drop due to their short lifespan. Zooplankton populations are then able to increase and reduce algae abundance through their filter feeding activities.

Another example is the stocking of largemouth bass and walleye in Lake Christina following the first rotenone treatment in 1987 to apply additional predation pressure on planktivores and benthivores. More recently, special angling restrictions have been applied to the lake to increase the abundance and size class of northern pike and other predator fish.

Northern pike have been used in other states to try to reduce carp recruitment (Cunningham, personal communication). Carp reach a large enough size by their second year of growth to escape significant predation pressure by other fish, including adult pike. As with fathead minnows, the best opportunities to reduce carp through predation likely occur very early in the life cycle. Research has also shown that this tool is usually not effective when used alone but should be combined with other management treatments (Scheffer 2004). More recent research has documented predation pressure on carp eggs by sunfish (Bajer and Sorenson, 2009).

Fish populations can naturally occur in shallow lakes. Historically, they have been periodically limited by winter-kill, although less so more recently as discussed earlier. Popular game species including northern pike, largemouth bass, sunfish, perch, and crappies can all naturally occur in some shallow lakes. Given the natural occurrence of these species, it may be appropriate to use fish as a management tool in some situations. In fact, it will be necessary in many shallow lakes to manage them in part for recreational fishing opportunities.

Game fish may provide some competition and control, as mentioned above, of less desirable species. Conflicts between waterfowl hunters and fishermen, however, often occur when management of fish and waterfowl interests do not align. For example, recreational fishing can be provided through aeration and stocking even when water quality and aquatic plant abundance has deteriorated along with wildlife habitat. When fish are present or used as a management tool in shallow lakes, expectations of both resource managers and the public are necessary. Winter aeration is most often considered as a tool to maintain game fish populations in deeper shallow lakes with maximum depths greater than 10 feet. While maintaining these populations may provide some predation pressure on undesirable fish the dynamic nature of these systems must be recognized and appreciated in considering successful outcomes.

The general public often perceives some of these in-lake tools, including drawdowns and rotenone treatments, as being overly drastic. Research on management of degraded shallow lakes indicates that these “drastic” measures are exactly what is needed to overcome the multiple stressors (loss of plants, abundant algae, suspended sediments, internal nutrient loading from fish) that are maintaining the poor habitat and water quality conditions.

In-lake strategies should be supported by restoration and protection of the contributing watershed. Key watershed tools are best agricultural management practices, and wetland and grassland protection, and restoration. Biomanipulation attempts are more likely to be successful in improving water clarity in those cases where watersheds have more grassland (Reed 2006).

Restoration and protection of watersheds could also make these shallow lakes more resistant and resilient to impacts caused by many different stressors. Loss of biodiversity and function makes systems less resistant to impacts including pollution and climate change (Folke et al. 2004). The resilience of ecosystems can be reduced by anthropegenic (human caused) pressures and ultimately affect ecosystem function. An ecosystem's capacity to absorb changes and "repair" itself is not a certainty; thus, adaptive management will be necessary to maintain ecosystem function or desired ecological states (Folke et al. 2004).

Habitat Management for Wild Rice

Management of lakes for wild rice has been focused on the forested part of the state. Historically, the native range of this plant extended well beyond the boundaries of Minnesota into the prairies of Iowa and the Dakotas. While there are currently a very few scattered examples remaining on the prairie, wild rice is much more likely to occur in the forest and forest transition zones.

Lakes in the forested region have been less impacted by wetland drainage. Management for wild rice has included removal of beaver dams or cattail bogs that have obstructed lake outlets. This management is relatively inexpensive, yet effective. Removing outlet obstructions minimizes both high water and rapid water level changes, which can damage wild rice.

In some instances, water levels on historic wild rice lakes have been raised or stabilized by installation of dams, or the outlets were impacted by road culverts. Simply modifying the dam or outlet structure to allow historical water levels and natural fluctuations can be enough to restore wild rice. Lake Onamia is an example of wild rice restoration by outlet dam modification.

There are some lakes that historically have produced wild rice, but it is unlikely a viable seed bank remains due to the number of years since it has grown. Seeding may be considered if the reason for the original loss of wild rice has been mitigated. Restoring wild rice to its historical range is an ongoing effort.

EXAMPLES AND DOUCMENTED RESULTS OF PREVIOUS WATER-LEVEL MANAGEMENT ACTIVITIES

It is important to make the distinction between shallow lake management and shallow lake restoration. Unfortunately the two terms are often are used interchangeably. Management is periodic manipulation in an effort to obtain a desired condition (ie good waterfowl habitat). Restoration should be defined as restoring previously drained lakes. True restoration is rare for shallow lakes as all the owners of the drained basin have to be in agreement. Management is an ongoing process, restoration is a one-time activity. The temporary water level drawdowns the DNR does to enhance waterfowl habitat in shallow lakes is *management*. It will have to be repeated, just as management is necessarily repeated in other ecosystems. Examples include prescribed burns to maintain quality prairie habitat or managed harvest to maintain aspen forests.

The DNR Section of Wildlife manages shallow lakes across the state with various tools. Full temporary drawdowns are done only on a few lakes each year. Partial drawdowns are much more common. A full drawdown is often physically difficult to obtain due to weather, watershed size, and outlet configuration. In addition, a full drawdown may not be necessary to obtain the desired habitat management. Full drawdowns typically last through one or, at most, two growing seasons. Partial drawdowns may be conducted seasonally. On some lakes it is not possible to do either a full or a partial drawdown. On those lakes management options are more limited and often involve the use of rotenone, a piscicide.

In recent years the DNR has made a concerted effort to manage results of full drawdowns and other management techniques. Figures 7 through 9 provide a summary of monitoring data before and after management actions took place on several recently managed shallow lakes. It often takes several years for the management results to be apparent. For example, year one the lake receives a pre-management assessment. In years two-three the lake is in drawdown and not accessible for surveys. There is often a lag in the submerged vegetation response, especially if the lake had been in poor condition for many years prior to the management action, thus post-treatment results are often not collected until years five-six. The lake will typically continue to receive periodic monitoring to determine when management actions need to be repeated.

All of the data in the graphs are from lakes in the prairie areas of western and southern Minnesota. Agriculture is the dominate land use and carp are often present. These areas are also very important for waterfowl production and migration.

The goal of most drawdowns is to improve waterfowl and wildlife habitat through improvements in abundance of submersed and/or emergent aquatic vegetation, invertebrate abundance, water clarity, and water quality. To determine if these goals were met vegetation, water clarity, and water chemistry is monitored through point-intercept surveys. A grid of points is overlain on a lake using geographic information system (GIS) software. These points are navigated to by boat with the aid of a global positioning system (GPS) unit. Species of aquatic vegetation present, water depth, and water clarity are recorded at each point. A water sample is also collected from the middle of the lake and sent to the Department of Agriculture for analysis.

In almost every instance above, aquatic vegetation abundance dramatically increased after the management action. The exceptions were on Swan Lake where the management occurred immediately after carp were detected rather than waiting for the carp to negatively impact habitat. On Teal Lake, habitat conditions did not improve after a rotenone treatment. In this case a drawdown was not feasible at the time, so only a chemical treatment to remove fish was conducted. The reasons for lack of improvement after the treatment are not clear as test netting indicated the fish kill was effective. The lake had a large population of crayfish, and it is possible that these invertebrates prevented aquatic plants from re-establishing. Very recently the DNR has obtained authority to conduct drawdowns on Teal Lake so management options will be greater once a water control structure is installed.

When management is successful, the changes in habitat are dramatic. For example, in Lake Geneva, the lake went from having almost no submerged vegetation to being completely covered in either submerged or emergent vegetation after the drawdown combined with a rotenone treatment. Waterfowl and furbearer use of the lake has greatly increased. This lake was also stocked with northern pike in an effort to control carp. The lake outlets into a ditch with a fish barrier; however, some carp remain in the lake, but three years after the treatment, the lake remains in good condition. The lake will likely need future drawdown if carp present in the lake have a good reproduction year.

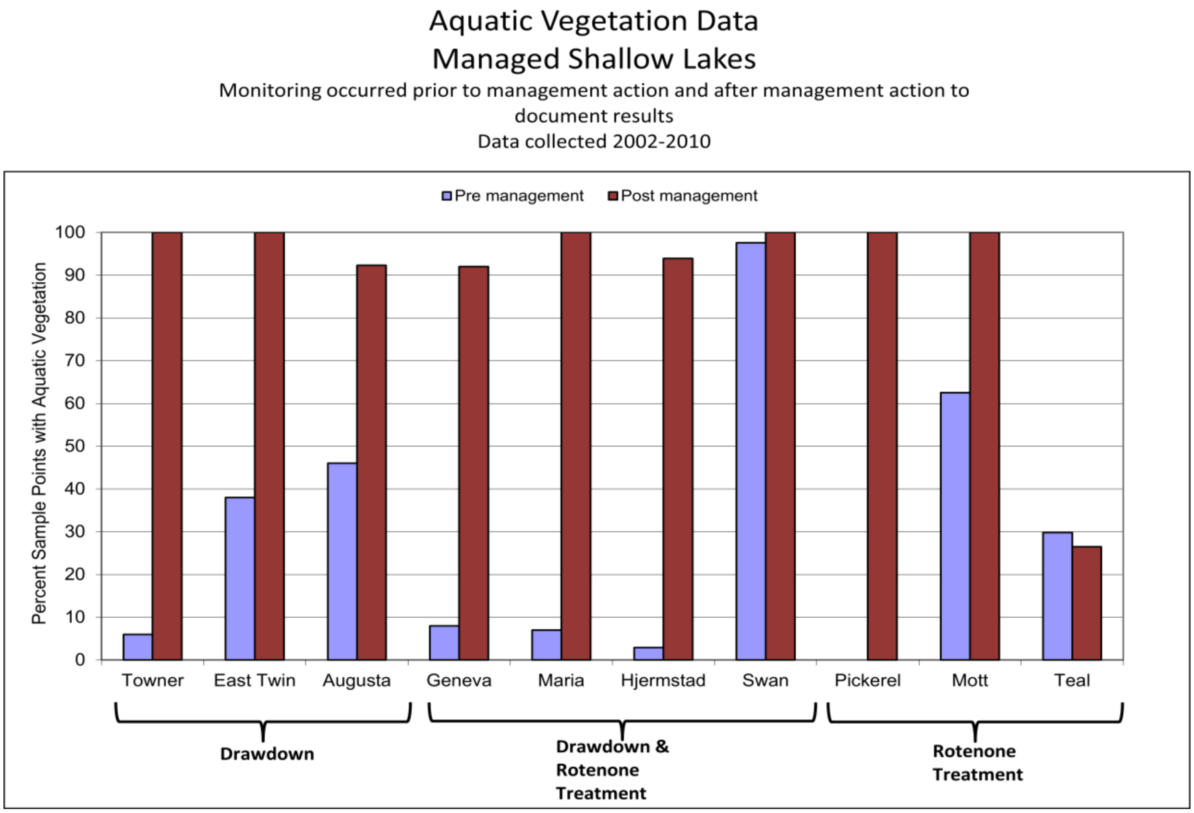

Figure 7. Aquatic vegetation changes in managed shallow lakes.

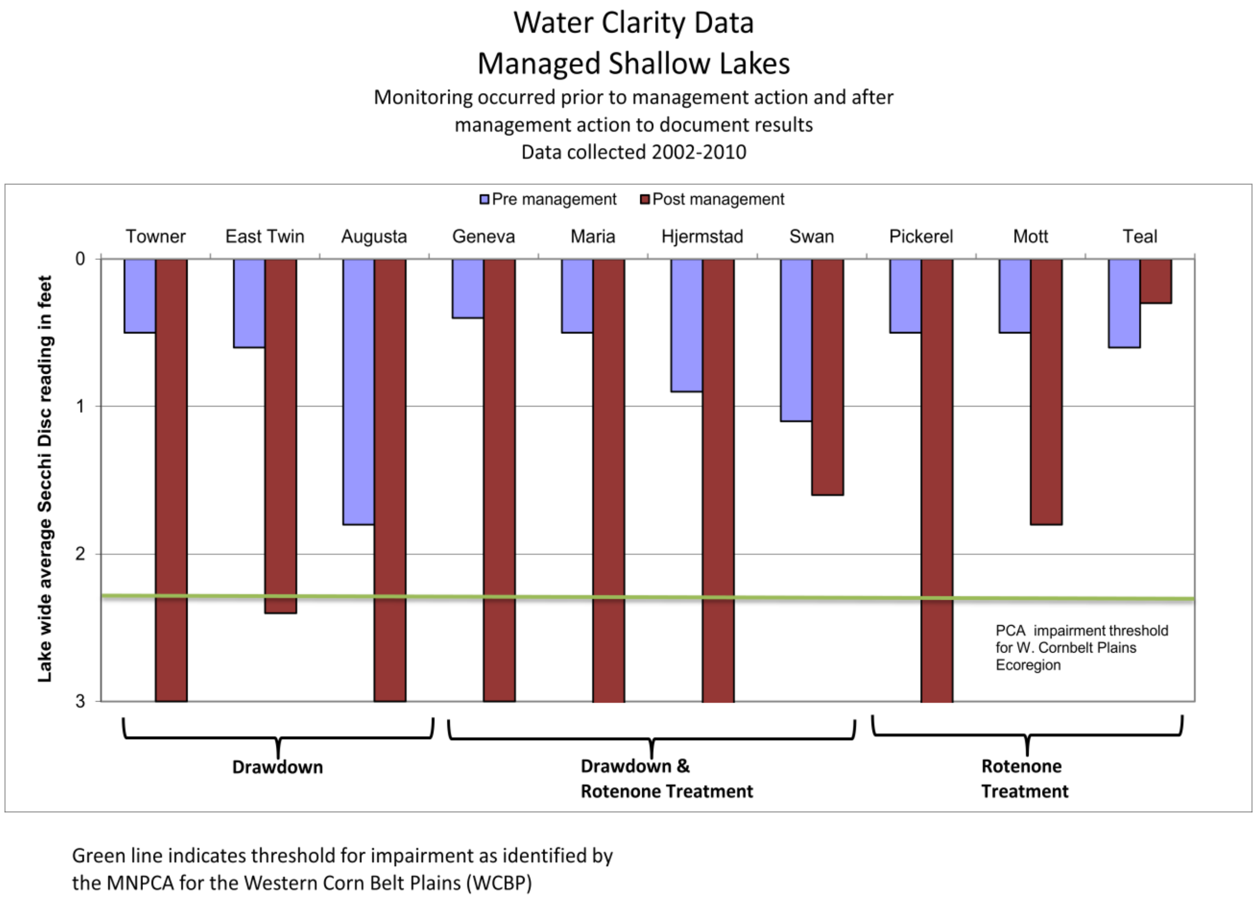

Figure 8. Water clarity changes in managed shallow lakes.

Water clarity improvements usually go hand-in-hand with improvements in aquatic vegetation abundance. In almost every case above, water clarity improved after the management treatment. The only exception again was Teal Lake. While Secchi disk depth readings are somewhat crude, they are inexpensive and easy to collect. However, they tend to underestimate water clarity. For example, in many of the lakes above the Secchi disk is clearly visible on the bottom of the lake. Given the clarity of the water, if the lakes were deeper the Secchi readings would be greater.

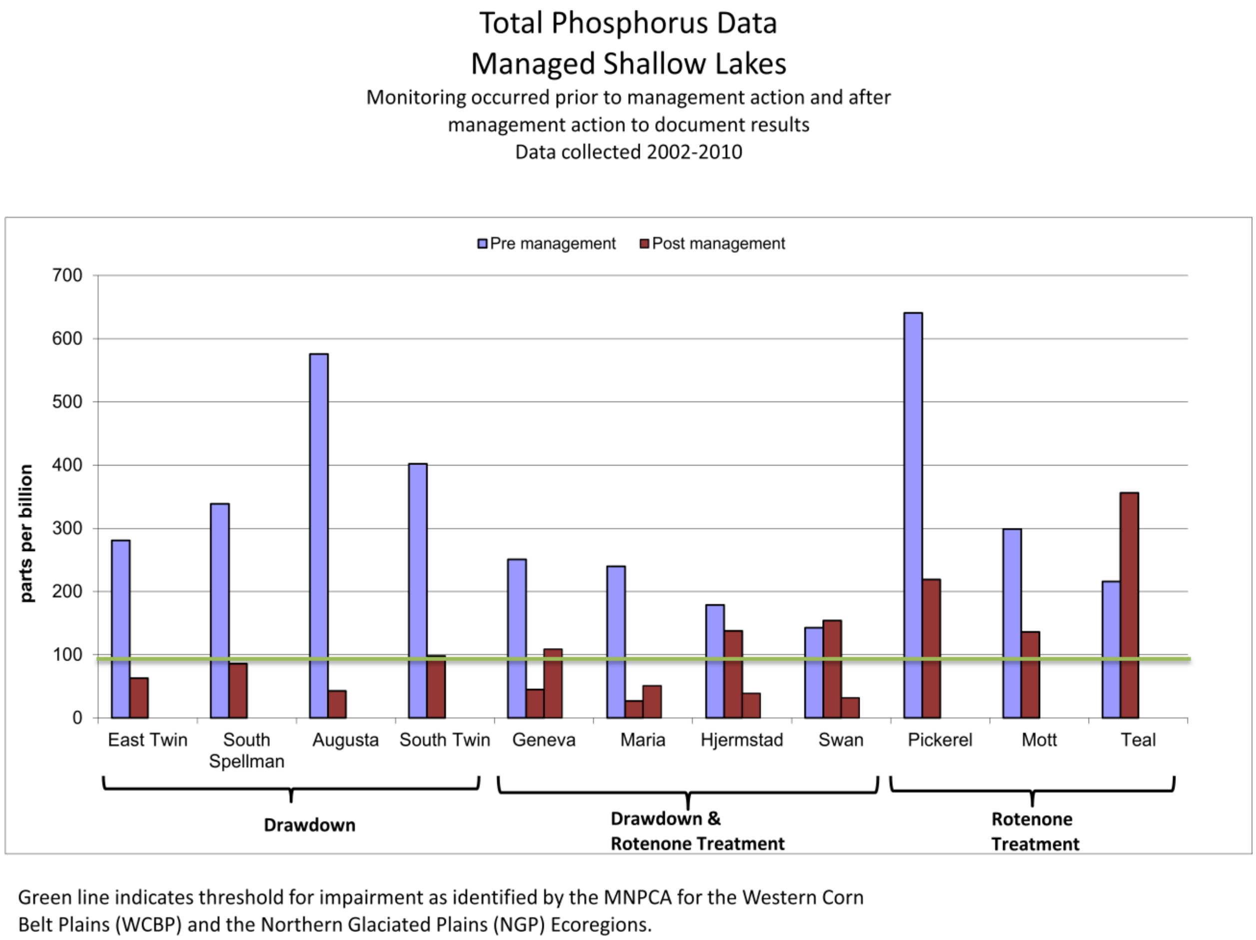

Figure 9. Total phosphorus in managed shallow lakes.

Such dramatic improvements in total phosphorus were somewhat of a surprise. For example, the improvement in total phosphorus in Lake Maria, Murray County, go from well over 200 ppb to 27 ppb after the drawdown. This lake is in a fertile and agriculturally dominated watershed. Lake Maria was fully drawn down for an entire growing season. The lake sediments were consolidated and aerated. Consolidation resulted in reduction of wind suspension of sediments and the exposure of the bottom soils to air; this reduced the internal phosphorus loading from the sediments. The drawdown and rotenone treatment of refuge areas also reduced the fish populations which contributed to internal nutrient loading.

These improvements in water quality and habitat are not easy to obtain on Lake Maria. The contributing watershed is dominated by agricultural cropland. Few wetlands remain. It is directly connected to Lake Sarah, a larger and slightly deeper lake that is managed for a walleye fishery. Lake Sarah also contains a large carp population. In an effort to keep carp out of Maria, an electric fish barrier was installed between the two lakes. These barriers are very effective, but occasionally fish do get through and repeated drawdowns on Maria will be necessary. Because it is not possible to do a gravity drawdown of Lake Maria without also lowering Lake Sarah, drawdowns of Maria are done via an electric pump. The entire system to manage Lake Maria was several years in the development and cost hundreds of thousands of dollars. Land adjacent to the lake has been purchased, and wetlands and grasslands will be restored to further enhance waterfowl habitat and somewhat reduce nutrient flows into the lake. Waterfowl use and hunting opportunities have improved after management actions have occurred on Lake Maria and other similar shallow lakes across the prairie portions of the state.

REGULATORY TOOLS FOR PROTECTION AND MANAGEMENT OF SHALLOW LAKES

Public Trust Doctrine

The roots of the public trust doctrine lie in English common law. The Crown decreed that tidal waters (the shoreland area between low and high tide) would be held in trust for the public. In the United States the concept was expanded in the Northwest Ordinance of 1787 to include all navigable waters leading into the Mississippi and St. Lawrence rivers. Although federal statutes have evolved over time legislatively and in case law, navigability remains a key concept for application to water bodies.

The Minnesota state constitution further expands the Public Trust Doctrine to include all navigable waters leading into the Mississippi River and all other border waters (Article 2 Section 2). The intent focuses on the role of these waters for travel.

The public interest in waters continued to evolve. In 1867, the Legislature passed a law that made it illegal to drain a meandered lake (Laws of 1867, Chapter 40). In 1883, the Legislature authorized county commissioners to drain “shallow, grassy, meandered lakes under four feet in depth”, but only with the concurrence of all riparian landowners (Laws of 1883, Chapter 139). It clearly established that the Counties could act only with this authorization from the State. Requiring approval from all the riparian owners clearly reflects recognition of the rights of landowners. Presumably these rights are derived from the state constitution under Article 1, Section 13. This section notes that private property shall not be taken, destroyed or damaged for public use without just compensation.

In 1933, the authority to permit drainage was assigned to the Commissioner of the Department of Conservation (later called the Department of Natural Resources). Four years later the Legislature designated as public waters all streams, lakes, and water bodies regardless of whether or not they were meandered as long as they were “navigable in fact” (Laws of 1937, Chapter 468). Yet another expansion occurred in 1946 when the legislation included “beneficial public use” in addition to navigability (Laws of 1946, Chapter 142).

Further clarification came in 1957 (Laws of 1957, Chapter 502) with the legislative decree:

"Subject to existing rights all waters in streams and lakes within the state which are capable of substantial beneficial public use are public waters subject to the control of the state. The public character of water shall not be determined exclusively by the proprietorship of the underlying, overlying, or surrounding land or on whether it is a body or stream of water which was navigable in fact or susceptible of being used as a highway for commerce at the time this state was admitted to the union."

In 1990, the state's interest was reaffirmed in the recodification of state water law:

103A.201 Regulatory Policy

*Subdivision 1.**Policy.***

To conserve and use water resources of the state in the best interests of its people, and to promote the public health, safety, and welfare, it is the policy of the state that:

(1) subject to existing rights, public waters are subject to the control of the state;

(2) the state, to the extent provided by law, shall control the appropriation and use of waters of the state; and

(3) the state shall control and supervise activity that changes or will change the course, current, or cross section of public waters, including the construction, reconstruction, repair, removal, abandonment, alteration, or the transfer of ownership of dams, reservoirs, control structures, and waterway obstructions in public waters.

State statutes have been upheld by the courts in a number of notable cases: See: *Lamprey v. State, 52 Minn. 1981, 53 NW 1139 [1893]; and United States v. Holt State Bank, 270 U.S. 49 [1926]; Sanborn v. People's Ice Co. 82 Minn 43, 84 NW 641 [1900]; Johnson v. Seifert 257 Minn 159, 100 NW 2d 689 [1960]; Petraborg v. Zontelli, 217 Minn 536, 15 NW 2d 174 [1944]); and Flynn v. Beisel, 257 Minn. 531, 102 N.W .2d 284 [1960].*

Legal Issues Associated with Water Level Management and Lake Designation Through M.S. 97A.101

Table 2 specifically summarizes the statutes that relate to active shallow lake management including those statutes that affect regulation of hunting on shallow lakes and those statutes that affect water level management of shallow lakes. Changes to statutes to provide additional shallow lake management authority are recommended later in this report. Table 3 summarizes the administrative rules that affect shallow lake management for the purposes of wildlife habitat.

Water levels and water management are governed through MS 103G and associated rules in Chapter 6115. Changes in water levels or active management of water levels in lakes are difficult to achieve in many cases due to requirements in rule and statute. Water level management is permitted following statutory and rule procedures and requirements.

A limitation of MS 103G is that regulatory authority is limited to below a lakes Ordinary High Water (OHW) level. It does not regulate some practices in lakesheds that can significantly impact lake water levels and water quality. For example, a field can be tiled and out-letted into a protected water body as long as the tile outlet is above the OHW level. Mitigation of such water level impacts involves work below the OHW level, thus requiring sometimes multiple permits and regulatory approvals. This results in the scales being tipped against managers desiring to protect and improve habitat or water quality in shallow lakes.

Management of water levels in lakes and wetlands is governed by many laws and levels of government which makes implementing new water level management projects a complicated and lengthy process. Such management is regulated by the state through the DNR, the PCA, and the Board of Water and Soil Resources through MS 103A-G (and the Wetland Conservation Act rules found in MN Rules, Chapter 8420). The U.S. Army Corps of Engineers also has regulatory authority over some of these projects through Section 404 of the Clean Water Act. Any water management project involves coordination with multiple entities and agencies that may have regulartory authority over a particular aspect of a project, resulting in a long and usually complicated process toward implementation.

MS 97A.101 is one of the strongest legal management tools available to the DNR Section of Wildlife for shallow lake management purposes. This authority was originally passed by the Legislature in 1969. This additional authority to manage water levels for the benefit of wildlife was added due to the support from the Southern Minnesota Waterfowl Association and other sportsmen's groups. The new statutory language gave the DNR the authority to manage water levels on designated lakes for the benefit of wildlife without obtaining written permission or flowage easements from all riparian landowners. Legal requirements include legal notice and a public hearing on the proposed management.

Originally the statute applied to the portion of the state south of US Highway 12. In 1975, the statute was modified to apply to the entire state. Further modifications have occurred to the statute including the prohibition of airboat use on designated lakes and the addition of authority to restrict motorized surface use.

Other legal mechanisms to manage water levels in lakes are also available and include: obtaining flowage easements from all riparian landowners, acquiring all shorelines through fee-title purchase, or obtaining signatory permission for one-time drawdowns. Wildlife Lake Designation is the most public of these options as an extensive review process is required. Through this statute, drawdowns can be conducted without permission from all landowners, making it the only viable option for water level management authority in some cases. One-time signatures are not often used to gain management permission, as a capital investment in a water control structure would not be made without long-term management authority. In 2009, additional language was passed (MS 103G.408) by the Legislature allowing drawdowns if 75% of riparian owners signed off on the proposed management and a public hearing was held. This new language may offer expanded water level management opportunities beyond those for wildlife benefits. Further changes in statute that regulate drainage surrounding lakes and water level management may be needed to fully achieve goals of this plan or to deal with problems of water quality in lakes beyond the scope of this report.

The lake designation process is long and can be controversial. Survey and feasibility studies are often needed to determine management potential. Legal access and control of the lake outlets are required in order to construct structures. Landowners and local units of government are involved in the process and review of draft management plans. As of December of 2011, 47 lakes have been designated for wildlife management purposes.

Shoreline Classification

Shallow lakes have few regulations and statutes that apply specifically to wildlife and waterfowl habitat. These lakes receive protection under shoreline rules, as do all public waters. Many shallow lakes fall under the zoning classification of Natural Environment Lakes, which have the most stringent shoreline development standards of the current classifications. Statewide shoreline management standards may soon undergo revision with options to increase protection of sensitive shorelines/areas, many of which would likely be on shallow lakes. Current standards urge local units of government to use special protection districts to manage and preserve areas having special natural or biological characteristics, such as shallow lakes. Some Counties have implemented special standards on lakes with sensitive habitats including some shallow lakes. Current Aquatic Plant Management Rules also limit aquatic vegetation removal on all protected water bodies.

Surface Use and Hunting Regulation

There are options to limit surface use of shallow lakes in order to reduce disturbance to waterfowl and/or protect aquatic vegetation from damaged caused directly by motorboats or indirectly from increased turbidity caused by motor-boating activities. Wildlife lake designation statutes including MS 97A.101 provides the authority to restrict motorized surface use on Designated Wildlife Lakes. This is the only tool available for limiting motor-boating activity outside of the waterfowl-hunting season for the benefit of waterfowl.

The intent of the following regulations is to protect migrating waterfowl. These regulations apply only during the waterfowl-hunting season and do not protect the lake habitats that waterfowl are using.

MWFRAs can be used to minimize boating disturbance but only during the waterfowl season. MWFRAs are open to hunting, but not motorized boat use (MS 97A.095). Refuges can be used to limit hunting-related disturbance during the waterfowl-hunting season. Lakes within refuges are closed to hunting but not other forms of surface use. Surface use is not restricted during the rest of the year. (MS 97A.085 and 97A.095).

Migratory waterfowl sanctuaries can be used to prevent all surface use, including hunting, during the waterfowl-hunting season. Lakes within sanctuaries are open to surface use the rest of the year (MS 97A.095).

STATUTE CHANGE RECOMMENDATIONS

A requirement of the 2011 session law mandating this report was to provide a list of any changes to statute necessary that would allow the commissioner of natural resources, through shallow lake management, to better achieve the state's wildlife habitat and clean water goals, and address the threats of invasive species. The analysis of existing authorities in this report has resulted in two specific recommended statute changes.

One recommended change is to increase the authority of the commissioner under MS 103G.408 regarding temporary drawdowns of public waters. Currently the State does not have broad authority to do temporary drawdowns. The Commissioner does have limited authority to do so for wildlife purposes under MS 97A.101, but that authority is specific to wildlife habitat. Due to changes in hydrology and climate conditions impacting water regimes in shallow lakes that have caused eutrophication and contributed to increased problems with invasives, additional authority is necessary to improve habitat and ecological conditions of the state’s shallow lakes.

Drawdowns are a beneficial tool to manage carp and internal nutrient loading in these lakes. Language changes to MS 103G.408 that would give the Commissioner authority to do temporary water level drawdowns on shallow lakes for the purposes of ecological, or fish and wildlife habitat are recommended. These changes would still require a public hearing, but not landowner approval for drawdowns initiated by the DNR.

These statute changes would give the Commissioner broader authority to manage shallow lakes for a broader range of purposes without designation under MS 97A.101. Such statutory modifications are recommended and justified to address degraded conditions of many of these lakes. Temporary drawdowns should not be considered “takings” from riparian landowners because they would be of relatively short duration and conducted for the purposes of improving ecological or habitat conditions in shallow lakes. Adding a specific definition for shallow lakes should also be included in MS 103G.005. The specific suggested language change follows:

103G.005 Definitions

Subd. 11. ***Meandered lake.***

"Meandered lake" means a body of water except streams located within the meander lines shown on plats made by the United States General Land Office.

Subd. 11a. Shallow Lake.

"Shallow lake" means a body of water except streams that is greater than 50 acres in size and less than 15 feet maximum depth.

103G.408 Temporary Drawdown of Public Waters

(a) The commissioner, upon consideration of recommendations and objections as provided in clause (~~4~~5) and paragraph (c), may issue a public waters work permit for the periodic temporary drawdown of a public water when:

(1) the lake is a shallow lake to be managed for fish, wildlife, or ecological purposes by the Department; or

(~~1~~2) the permit applicant is a public entity;

(~~2~~3) the commissioner deems the project to be beneficial and makes findings of fact that the drawdown is in the public interest;

(~~3~~4) the permit applicant has obtained permission from at least 75 percent of the riparian landowners; and

(~~4~~5) the permit applicant or the Department has conducted a public hearing presenting a comprehensive management plan outlining how and when periodic temporary drawdowns would be conducted according to paragraph (d).

103G.408 Temporary Drawdown of Public Waters

(f) Periodic temporary drawdowns conducted under (a) will not be considered takings from riparian landowners.

A second recommended change would expand the options for the Commissioner to initiate proceedings to designate WFRAs and waterfowl sanctuaries under MS 97A.095 subdivisions 1 and 2 and provide greater latitude in applying restrictions. Language changes would allow the Commissioner to initiate the proceedings for establishing these protection areas without a petition from ten local licensed waterfowl hunters. Local waterfowl hunters could still initiate the process by petition. The rest of the process would remain the same.

In addition, language changes would allow the Commissioner to apply the restrictions under these designations to time periods other than the open migratory waterfowl season.

The statutory language infers that local hunters are the authority on where feeding and resting areas and sanctuaries are needed, but this authority should also be afforded to the DNR as well. Under the recommendation the DNR is still bound to follow the statute with regard to public notification and comment through a public hearing. The specific suggested language change follows:

97A.095 Waterfowl Protected Areas
Subdivision 1. ***Migratory waterfowl sanctuary.***

The commissioner may designate by rule any part of a state game refuge or any part of a public water that is designated for management purposes under section 97A.101, subdivision 2, as a migratory waterfowl sanctuary ~~if there is presented to the commissioner a petition signed by ten resident licensed hunters describing an area that is primarily a migratory waterfowl refuge~~. The commissioner must consider areas for designation if there is presented to the commissioner a petition signed by ten licensed hunters describing an area that is primarily a migratory waterfowl refuge. The commissioner shall post the area as a migratory waterfowl sanctuary. A person may not enter a posted migratory waterfowl sanctuary during the open migratory waterfowl season or other dates prescribed by the Commissioner unless accompanied by or under a permit issued by a conservation officer or wildlife manager. Upon a request from a private landowner within a migratory waterfowl sanctuary, an annual permit must be issued to provide access to the property during the waterfowl season. The permit shall include conditions that allow no activity which would disturb waterfowl using the refuge during the waterfowl season.

Subd. 2. ***Waterfowl feeding and resting areas.***

The commissioner may, by rule, designate any part of a lake as a migratory feeding and resting area if there is adequate, free public access to the area. Before designation, the commissioner must describe the area in a public notice and receive comments for 30 days ~~receive a petition signed by at least ten local resident licensed hunters describing the area of a lake that is a substantial feeding or resting area for migratory waterfowl, and find that the statements in the petition are correct, and that adequate, free public access to the lake exists near the designated area~~. The commissioner must consider areas for designation if there is presented to the commissioner a petition signed by ten licensed hunters describing an area that is a substantial feeding or resting area for migratory waterfowl. The commissioner shall post the area as a migratory waterfowl feeding and resting area. Except as authorized in rules adopted by the commissioner, a person may not enter a posted migratory waterfowl feeding and resting area, *during a period when hunting of migratory waterfowl is allowed , with watercraft or aircraft propelled by a motor, other than an electric motor with battery power of 12 volts or less. The commissioner may, by rule, further restrict the use of electric motors in migratory waterfowl feeding and resting areas.*

TABLE 2. SUMMARY OF STATE STATUTES APPLICABLE TO SHALLOW LAKE MANAGEMENT

Statute #	Summary
17.4981 (c)	Aquaculture Best Management Practices.
84.091	State owns aquatic vegetation growing in public waters. Fees for harvesting wild rice are included.
97A.095	Allows the creation of Waterfowl Feeding and Resting Areas and Migratory Waterfowl Sanctuaries
97A.101	Allows the Commissioner to formally designate lakes for wildlife management and manage water levels to benefit wildlife. This statute also gives authority to restrict motorized surface use on designated wildlife lakes. Fishing may not be restricted with the exception of minnow harvest.
97C.325(d)	Restrictions on taking fish. To protect water quality or improve habitat for fish or wildlife, the commissioner may prescribe restrictions on fishing seasons, limits or methods on specific bodies of water.
103G.005	Definitions for the remainder of the 103G statute. Various definitions may apply to shallow lake work under 103G.
103G.201	Commissioner shall maintain a map for each county that shows the public waters. Specific standards for updating and classifying public waters are included.
103G.205	Designation of public waters does not grant public additional right of access, diminish the right of ownership of the lake bed…
103G.211	Drainage of public water is generally prohibited without replacement.
103G.215	A property owner may use the bed of public water for agricultural purposes during a drought if such use does not drain the public water and tiles, ditches and buildings cannot be constructed.
103G.221-2374	Water law regarding specific wetland protections, wetlands cannot be drained without replacement
103G.255-298	Gives the commissioner the authority to administer use and allocation of waters of the state. Includes water appropriation of both surface and ground water.
103G.301-315	General permit procedure including required documents for a permit application and cost of permits. State and federal agencies are exempt from permit fees. Statute language includes details on denying and issuing permits. The commissioner has the right to cancel or amend a permit to protect public interests.
103G.401-407	Water level establishment and control. The commissioner has the authority to establish and maintain levels of public waters. Specific language regarding water level controls for landlocked lakes is included. Control elevation established for landlocked lakes must not be more than 1.5 feet below the ordinary high water level if a LGU files a written objection. For lakes with an existing outlet, the commissioner may issue a permit to establish a control elevation that is different from an existing control elevation when all the property owners abutting the OHW have given permanent flowage easements, the commissioner finds the change is in the public interest has minimal adverse environmental impacts.
103G.408	Allows temporary drawdowns of public waters by public entities if 75% of riparian landowners give permission and a public hearing has been held. This requirements do not apply to designated wildlife management lakes under M.S. 97A.101
103G.501-561	Addresses construction of private dams and construction of dams by the state. Dams owned by the state or built on property controlled by the state must be maintained and operated by or under the direction of the commissioner. Dams used only for water level regulation-if a dam has been affecting water levels continuously for at least 15 years then the state has a prescriptive flowage easement from all the riparian owners. Certain criteria have to be met for the statute to be applicable.
103G.611	Details permit costs for winter aeration permits and that such sites must be posted with details on posting requirements.
103G.615	The commissioner may issue permits to gather or harvest and transplant aquatic plants. The commissioner may stop the illegal gathering or destroying of aquatic plants and may issue restoration orders.

TABLE 3. SUMMARY OF RULES APPLICABLE TO SHALLOW LAKE MANAGEMENT

Rule #	Summary
6115.0170	Includes definitions for water rules. Drawdown is defined as a temporary lowing of water levels, for a maximum duration of two years.
6115.0201	Specific standards for allowed excavation of a public water, establishes requirements for excavating in basins for benefits to the public interest including improving navigation, swimming, recreation and reducing winter fish kill potential. Addresses excavations to improve fish and wildlife habitat. There must be no feasible or practical alternative to excavation. Outlet must be adequate as to not increase downstream or overbank flooding or downstream erosion. Watercourse channel excavations to restore or improve fish and wildlife habitat require plans that show nature and degree of habitat benefited and showing the project will not create flooding, erosion, sedimentation or obstruct navigation.
6115.0210	Structures in public waters. Goal of the department to limit structures in public waters to preserve natural character and prevent navigation obstructions, structures are prohibited that will be detrimental to fish and wildlife habitat, construction is prohibited in posted fish spawning areas. No permits are required to construct or reconstruct a floating temporary structure under certain conditions and certain boat ramps.
6115.0215	Specific standards for restoration of public waters. It is the goal of the department to encourage restoration of public waters to improve and protect fish and wildlife habitat and for other reasons listed. No permit is required to construct, reconstruct or abandon a water level control structure in a public water course of a contributing watershed of 300 acres or less if the structure does not qualify as a dam under parts 6115.0300-.0520. Criteria for permits required and granting of permits if listed conditions are met.
6115.0220	Water Level Controls-goal of the department to limit artificial manipulation with certain exceptions. Water level control solely to satisfy private interests is prohibited. Lists when permits are required for water level controls.
6115.0221	Specific Standards for water level controls. Specific standards for permanent water level controls are listed. Fish and wildlife management under 97A.101 is referenced including such drawdowns are temporary, “appropriate” easements or fee title is obtained.
6115.0270	Drainage of Public Waters-permanent drainage of pubic waterbasins and public water wetlands are prohibited.
6280.0250 Subp. 2	Lists actions requiring an Aquatic Plant Management (APM) permit
6280.0250 Subp. 3a	Specific criteria for issuing APM permits

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