Fremont Lake
Fisheries Survey Report

Newaygo County (T12N, R14W, Sections 2, 3, 4, 9, 10, 11)
Muskegon River Watershed
2009

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Introduction

Fremont Lake is located in west, central Michigan in the southern portion of Newaygo County (Figure 1). It is part of the Muskegon River watershed and has several small tributary streams and discharges through Brooks Creek. The principal tributary is Darling (Daisy) Creek that drains from First, Second, Third and Fourth Lakes and then flows through the City of Fremont before entering Fremont Lake. Another tributary flows from the outlet of Lorden Lake and there are a few other small tributaries that have portions of them designated as county drains. The lake is approximately 790 acres in size with a shoreline length of approximately 5.1 miles (determined using ArcView 3.2) and a maximum depth of 86 feet (Figure 2). The watershed is approximately 19.1 mi^2 in size and is primarily developed into agricultural land (67%) and urban area (28%), with a small portion of forested land (6%; DNR 1893). There is a City of Fremont boat ramp and park on the north side of the lake and a Sheridan Township boat ramp on the southeast corner of the lake.

The Department of Natural Resources (DNR), Fisheries Division has had extensive involvement in the management of this lake. The first survey was conducted in 1892 by the Michigan Fish Commission that evaluated some of the game fish species in the lake and made several transects of water depths.

A summary list of DNR activities and other information contained in DNR-Fisheries Division files is provided in Table 1. Reference to information in Table 1 will be used throughout this survey report. Trimberger (1982) described the history of Fremont Lake in relation to fisheries management from the 1800s through 1982. This is a summary of his report with added information.

The City of Fremont was initially settled in 1854, became the Village of Fremont in 1875, and became the City of Fremont in 1911. Fremont Lake received significant quantities of pollution that significantly changed the water quality and fisheries of Fremont Lake. The entire area within the watershed was stripped of lumber during the 1800s and runoff likely resulted in water quality changes at that time. The 1892 survey of the lake recorded lake herring (cisco) present so water quality apparently was still suitable for this coldwater species. Apparently common carp were present in sufficient numbers as early as 1924 to initiate removal programs by the Fremont Fish and Game Club and these continued through the mid-1960s. A legal lake was established in 1945 (dam built in 1947), by the Fremont Lake Association, apparently for the purpose of increasing northern pike spawning to combat the increasing common carp population. By 1952, poor water quality from pollutants resulted in a fish community dominated by common carp and this continued through 1982.

Reports of significant fish mortalities began in 1947 and continued through 1975 (Table 1). Complaints of floating and filamentous algal blooms began in the 1950s and copper sulfate treatments began in the early 1960s and continued through 2009. DNR water quality studies were conducted in 1952 and 1969. Spot treatments with rotenone to control common carp began in 1957 but were not successful.

Gerber Baby Food was one of the largest contributors of industrial waste to Fremont Lake. In 1952, they established their own sewage treatment system that greatly reduced organic and nutrient inputs. Other industrial wastes were mostly diverted to waste treatment systems in 1974. Municipal waste from the City of Fremont was diverted to a land treatment system in 1974, and Sheridan Township made final connection to this system in 1981. A DNR report in 1983 showed that phosphorous and nitrogen had declined steadily since 1974, and that ammonia had declined from 95% to only 5% at spring turnover. Dissolved oxygen below the thermocline continued to be very low.

In 1981, Fisheries Division attempted a netting program to remove a significant number of common carp from Fremont Lake. This effort failed so a whole lake treatment using rotenone was proposed to remove all fish from the lake. This plan was approved and enacted in December 1982. The project was considered successful in removing most fish from the lake. Restocking fish began in April 1983. Trout were stocked for an interim period and provided very popular fisheries for a short period of time. Trout stocking was discontinued in 1991 due to poor survival possibly resulting from predation from the expanding northern pike population or water quality issues. Good fishing reports for bass, walleye, crappie, rock bass and northern pike have continued from 1990 through the present time.

The purpose of the 2009 survey was to evaluate the fish community and habitat characteristics of Fremont Lake. Information acquired included fish community composition, catch per unit effort, size range, and growth rates along with some physical habitat and water quality components. This information will be compared and discussed in relation to relevant historical information.

Methods and Materials

Fish were collected using variable mesh gill nets, trap nets, seines and a boat mounted electro-fishing unit. Fish sampling was conducted at random locations around the lake (Figures 3 & 4). All fish, zooplankton, structural habitat, and water quality sampling was conducted using standard DNR Fisheries Division Status and Trends Protocols (Wills et al. 2008). Water transparency, total phosphorous, and chlorophyll-a samples were collected through the DNR Inland Lakes Cooperative Monitoring Program in 2008 and 2009. Zooplankton samples were not analyzed at the time this report was written.

Structural habitat and water quality parameters were compared to statewide and regional values gathered through the Status and Trends Sampling Program. The box plots of statewide and regional values represent minimum, maximum, 25th and 75th percentile, and median values for lakes in Michigan.

Results and Comparisons

The number of dwellings per mile of shoreline on Fremont Lake was 32 in 2009. This value was average for Lower Peninsula Michigan Lakes (Figure 5). In 1952, there were 15 dwellings per mile on Fremont Lake indicating shoreline development has doubled over the past 57 years. About 47% of the shoreline of the lake has artificial armor. This level of armoring is relatively high for Michigan Lakes (Figure 5). Artificially high lake-levels maintained by the dam in the outlet of the lake most likely effects the high level of artificial shore armor. Submerged tree densities in Fremont Lake were typical for lakes in the Northern Lower Peninsula (Figure 5).

Alkalinity was not measured in the 2009 survey but eight measurements had been collected from 1952 through 1987. Alkalinity during this period ranged from moderate to high when compared to other Northern Lower Peninsula Michigan lakes (Figure 6; Table 2). Total phosphorous measured in 2008 and 2009 was about average when compared to other Northern Lower Peninsula Michigan lakes (Figure 6; Table 2). Total phosphorous levels indicated mesotrophic productivity conditions in Fremont Lake in 2008 and 2009. Total phosphorous levels measured in years from 1972 through 2006 were higher and indicated eutrophic productivity conditions in the lake. Chlorophyll-a was measured in 2008 and 2009 and was about average when compared to other Northern Lower Peninsula Michigan lakes (Figure 6; Table 2). Chlorophyll-a levels indicated mesotrophic productivity conditions in Fremont Lake in 2008 and 2009. Chlorophyll-a levels measured in years from 1972 through 2006 were higher and indicated eutrophic productivity conditions occurring in 1972 and 1974, and mesotrophic productivity conditions in later years. The nitrogen-phosphorous ratio indicated phosphorous was the limiting nutrient for plant growth in 1976, 1982, and 2006.

Water transparencies were about average when compared to other Northern Lower Peninsula lakes from 1983 through 2009, and indicated mesotrophic productivity conditions (Figure 7; Table 2). Water transparencies measured between 1952 and 1982 were lower and indicated eutrophic productivity conditions.

Water temperature and dissolved oxygen profiles were measured in Fremont Lake on August 11, 2009 (Figure 7). A distinct thermocline (indicated by an abrupt drop in temperature with greater depth) was present between the 24 foot and 34 foot depths. Dissolved oxygen levels fell below 5 ppm at a depth of 19 feet.

Summer water temperature and dissolved oxygen profiles were collected during 10 different years from 1952 through 1991 (Figures 9 & 10). The highest water temperatures and the sharpest thermoclines were always present in July. Dissolved oxygen depletion in the water column was always at the greatest depth in August and September. Dissolved oxygen was present within the thermocline on 8/30/1974, 9/11/1984, 7/13/1987, and 7/22/1991, but only at water temperatures of ≤ 69F in July 1991. These data indicate that a cool (≤ 69F), well oxygenated (≥ 5 ppm) thermocline has seldom been maintained throughout the summer months in Fremont Lake from 1952 through 2009.

In 1952, an aquatic plant survey was conducted in Fremont Lake by Fisheries Division. This survey found seven species of submersed plants, three species of floating-leaved plants, and four species of emergent plants (Table 3). Non-indigenous macrophytes were not found at that time. In 1980 and 1985, herbicide permits were issued to treat curly-leaf pondweed (Table 1). From 1986 through 1990, herbicide permits were issued to treat a broad range of aquatic plants, including native species. These treatments were discontinued due to angler concerns and fishing apparently improved by 1993 (Table 1). An herbicide permit was issued for treatment of aquatic macrophytes again in 2009. Recent aquatic plant surveys have not been conducted in Fremont Lake. Eurasian water-milfoil was present in Fremont Lake during the 2009 survey.

A DNR study in 1952 found that Fremont Lake had very high concentrations of planktonic algae (Purdy 1952). Complaints of algal blooms began in 1958. In 1959, heavy filamentous and floating algal growth with blue-green algae was found in the lake. Aerial applications of copper sulfate for algae control occurred from 1962 through 1968. Copper sulfate treatments of varying degrees continue today for both algae and swimmers itch control.

Sixteen species of fish were collected during the 2009 survey (Tables 4 & 5). Known stocking of fish in Fremont lake began in 1930 (Table 6). The 1892 and 1926 surveys should indicate species of fish native to Fremont Lake if stocking did not begin until 1930. Based on this premise, species of fish present in 2009 that were not native to Fremont Lake were common carp, walleye and fathead minnow. Common carp are an invasive species that were not stocked into the lake and were first found in surveys in 1952. Walleye were first stocked in 1939 and then extensively from 1983 through 2009. Fathead minnows were stocked once, in 1985, following the whole lake rotenone treatment in 1982. It is uncertain if both yellow bullhead and brown bullhead were both native to the lake since the early surveys only indicate bullhead were present. Three species of fish were stocked but were not found in the lake shortly after stocking discontinued because they were unable to reproduce. These include emerald shiners that were stocked in 1934, and rainbow trout and brown trout that were stocked from 1983 through 1990. The most extensive stocking of fish that occurred during any period was from 1983 through 1985, following the 1982 whole lake rotenone treatment.

Species not found during the 2009 survey that were present in the original fish community, included the lake herring and fourteen species of forage fish (Tables 4 & 5). The lake herring was present in the late 1800s and early 1900s then was not found in later surveys or reported by anglers. Lake herring require high quality coldwater habitat and were likely extirpated from the lake during the early 1900s as pollution increased. The fourteen species of forage fish that appear to have been extirpated were native species found in surveys between 1892 and 1952. Many of these fish were present in the lake in 1935 and 1952 indicating that pollution may not have caused their demise. The 1982 rotenone treatment conducted to remove all fish from the lake, and possibly the extensive chemical treatments for algae using copper since the 1960s, most likely caused the decline in forage species in the lake. Very few (only three) minnows were collected during the 2009 survey and this may indicate minnow populations remain depressed in Fremont Lake. Lake residents also reported seeing few, if any, minnows along the shoreline of the lake for the past 10 years or longer.

The prevalent fish species collected in 2009, by biomass and number, were walleye, northern pike, smallmouth bass, bullhead, largemouth bass, rock bass, yellow perch, black crappie, bluegill, and pumpkinseed. The catch rates in trap nets were highest for black crappie, bullhead, bluegill, and rock bass (Table 7). The catch rates for bluegill and pumpkinseed were not very high for Michigan Lakes, indicating relatively low populations of these two species in Fremont Lake. Black crappies were not efficiently sampled with our gear as these fish are often suspended in deep water and difficult to catch. Anglers were catching many nice size crappies during our survey period. The catch rate of rock bass was relatively high indicating good numbers of this species present in the lake. Walleye had the highest gill net catch rate. The catch rate for walleye in gill nets was relatively high for an inland lake in Michigan indicating a good population of walleye is present in this lake. Northern pike had moderate catch rates in both trap and gill nets. Smallmouth bass and largemouth bass had relatively low catch rates. Some common carp were also collected indicating their presence in the fish community, but they do not dominate the fish community as they did prior to the 1982 rotenone treatment.

With the exception of pumpkinseed and yellow perch, the size distribution of game species was favorable for anglers, with good numbers of large fish present in the catch (Table 8). Pumpkinseeds larger than 6 inches were not collected and only a few yellow perch larger than 7 inches were collected in any gear. Most yellow perch were collected with electrofishing gear along the shoreline of the lake and the greatest numbers were from 3 to 5 inches in length.

Growth rates were above state average for bluegill, largemouth bass, rock bass and walleye in 2009 (Table 9). Growth rates were about state average for black crappie, northern pike, pumpkinseed and yellow perch. Growth rates between 1952 and 2009 were variable for bluegill, black crappie, northern pike, and yellow perch. Growth rates were fairly consistent for largemouth bass between 1981 and 2009, and for walleye between 1984 and 2009. All species collected in 1984 and 1985, following the 1982 rotenone treatment, had relatively high growth rates, but slower growth for some species was again present by 1987. Yellow perch growth rates were high during 1952, declined by 1981, increased in 1985 following the rotenone treatment, and has been fairly consistent near the state average since.

Bluegill growth and size structure was used to classify the population in Fremont Lake using methods provided by Schneider (1990). The bluegill population was ranked satisfactory based on this method (Table 10). Bluegills are not very abundant in Fremont Lake but they have satisfactory growth and a good number of fish larger than 6 inches, but few fish larger than 7 inches.

Schneider (2002) provided methods for assessing the habitat quality of lakes based on fish, limnological parameters, aquatic plants, and alteration of the shoreline. Fremont Lake scored 40.5 of a possible 50-53 (Table 11). This is a moderate score indicating some degradation of habitat and fisheries. Habitat scores were diminished due to the introduction of common carp and walleye, low dissolved oxygen in the thermocline and hypolimnion, productivity enrichment, and extensive shoreline alteration resulting from the presence of a lake-level control structure and elevated lake levels.

Discussion

Significant changes in fishery habitat and the fish community of Fremont Lake have occurred since the first survey was conducted in 1892. Fisheries habitat was probably affected by extensive logging in the watershed during the 1800s, but was likely still relatively good in 1892 based on the presence of lake herring. Lake herring require a continuous layer of water with temperatures of $\leq$ 68F and dissolved oxygen levels of at least 3-4 ppm (Latta 1995). This layer usually occurs in the thermocline in mesotrophic stratified lakes, but can go to greater depths in oligotrophic lakes. Extensive inputs of industrial and municipal sewage occurred during the early 1900s and fish mortalities and algal blooms were common occurrences from the 1940s through the 1970s. Diversion of industrial and municipal sewage began in 1952 and was mostly completed by 1981. A DNR report in 1983 indicated that nitrogen and phosphorous levels had declined steadily since 1974 and spring ammonia levels had declined significantly, but dissolved oxygen levels in the water column had not improved. Samples of water transparency, phosphorous, nitrogen and chlorophyll-a collected from 2006 through 2009 indicates Fremont Lake has mesotrophic to eutrophic productivity conditions and phosphorous continues to be the limiting nutrient for plant growth. Dissolved oxygen conditions in the thermocline have not improved and remain low.

The DNR study in 1983 summarized existing and potential future water quality conditions in Fremont Lake, and provided an estimated nutrient budget for the lake. Several factors affect nutrient inputs into Fremont Lake. The size of the watershed is about 15.5 times the size of the lake (about normal for Michigan) and 95% of land-use is agricultural and urban. Darling Creek, the main tributary of the lake, has four other lakes upstream of Fremont Lake that affect movement of nutrients through the system. Another issue not mentioned in the report is the added ditching and drain extensions of the other tributaries of the lake that add more nutrients to the lake. The detention time of water moving through the lake is 1.9 years. This indicates it will take several years before any changes in nutrients might affect water quality in the lake. Also, the high nutrient loading rates have inundated bottom sediments in the lake, and this may delay the potential effects of nutrient reductions even longer.

A range of estimates for post-waste diversion were provided for the phosphorous budget of Fremont Lake because general land-use values were used due to lack of actual sample data (Table 12). Most of the phosphorous inputs to Fremont Lake were estimated to be coming from non-point sources in the watershed. This report projected that Fremont Lake should be a good quality eutrophic lake or mesotrophic lake by the mid to late 1980s, but dissolved oxygen conditions were unlikely to change. This projection was correct in that various water quality parameters have indicated mesotrophic productivity conditions since the mid-1980s (Table 2).

The 1952 aquatic plant survey found only native species in the lake. In 1980 and 1985, permits were issued to treat curly-leaf pondweed although it is uncertain if this exotic species actually existed in the lake. Permits for treating a broad range of aquatic plants were issued from 1986 through 1990. These treatments stopped due to anglers and Fisheries Division’s concerns about effects on the fishery. Permits for treatments of various locations have again been issued in 2009. Filamentous algae continue to be pervasive in the lake and were present during the 2009 survey. It was expected that rooted aquatic plants would increase following nutrient decreases and the resulting increases in water clarity. However, this lake has a relatively narrow shallow shelf around the lake that limits macrophyte distribution and macrophytes are considered important fishery habitat. Bryan and Scarnecchia (1992) found that species richness and total fish abundance were consistently greater in naturally vegetated sites compared to developed sites in both nearshore (0–3.3 feet) and intermediate (3.3–6.6 feet) depth zones. Both emergent and submerged vegetation protect and reduce erosion on the shorelines of lakes (Cotel et al. 2009). Full protection of native vegetation should be provided in all areas of the lake to protect important fish and wildlife habitat and to control shoreline erosion. Eurasian water-milfoil was present in different areas of the lake during the 2009 survey. This plant should be controlled only where necessary in Fremont Lake, and only with methods that do not harm native vegetation. The limited amount of rooted vegetation in Fremont lakes makes Eurasian water-milfoil an important habitat component for fish.

The lake-level control structure in Brooks Creek was originally constructed in 1947, presumably for the intent of helping fisheries in the lake by increasing northern pike spawning to aid in common carp control. However, maintaining artificially high lake levels is the primary cause of shoreline erosion in inland lakes. The artificially high lake-levels are likely the cause of the very high level of hardened shoreline in Fremont Lake. Removing the lake-level control structure is an important step towards improved shoreline habitat for fish, amphibians, and reptiles in the Fremont Lake.

The number of submerged trees along the shoreline of Fremont Lake (28/mile) was about average for inland lakes in the northern Lower Peninsula. These densities are relatively low when compared to undeveloped lakes in northern Wisconsin where submerged trees ranged from 470 to 1,545 per mile (Christensen et. al. 1996). The long term effects of logging and development along the shoreline of Fremont Lake has likely resulted in low submerged tree densities in the lake. Deadwood provides an important substrate for plants and animals in the littoral zone of lakes (France 1997), provides spawning habitat for fish, and serves as cover and a predation refuge for fish (Hanson and Margenau 1992; Rust et al. 2002) Saas et al. (2006) found that yellow perch were reduced to extremely low densities and largemouth bass growth rates decreased after wood habitat was removed from a lake. Providing additional wood habitat (whole trees) to Fremont Lake should be considered to improve growth rates and population size structure of fish.

Dwelling densities in Fremont Lake were 32/mile in 2009 and about average when compared to other northern Lower Peninsula Lakes sampled in the Status and Trends Program. In 1952, dwelling densities were about 15/mile indicating that shoreline development has increased substantially during the past 57 years. Dwelling densities are a good indicator of how human development affects fisheries resources in lakes. Christiansen (1996) found that deadwood was significantly greater in undeveloped than in developed lakes in northern Wisconsin and Michigan. He found that deadwood within the lake was positively correlated with levels of riparian tree density and negatively correlated with dwelling density. Radomski and Geoman (2001) found that developed shorelines had substantially less emergent and floating-leaf vegetation than undeveloped shorelines in Minnesota lakes. Significant aquatic vegetation losses were visible at dwelling densities of 9.6/mi. Woodford and Meyer (2002) found that adult green frog populations were significantly lower in lakes with developed shorelines (average dwelling densities = 21.0/mi) than lakes with little or no development (average dwelling density = 2.9/mi). Bryan and Scarnecchia (1992) evaluated species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of Iowa’s 6,000-acre Spirit Lake. Young-of-the-year fish communities in naturally vegetated sites were compared with those inhabiting nearby sites where lakeshore development (i.e., homes, boat docks, and beaches) reduced nearshore macrophyte species richness and abundance. Species richness and total fish abundance were consistently greater in natural sites compared to developed sites in both nearshore (0–1m) and intermediate (1–2m) depth zones, but differed little between natural and developed sites in the offshore (2–3m) zone. Nearly 50% of the species sampled, including yellow perch and bluegill, inhabited limnetic areas as larvae before migrating inshore as juveniles. Eighteen of the twenty species collected as juveniles were greater in abundance in natural sites compared to developed sites. Smallmouth bass and darters were found in equal or greater abundance in developed sites. Longnose gar, northern pike, yellow bullhead, banded killifish, green sunfish, black crappie, yellow perch, largemouth bass, bluegill, spottail shiner, bluntnose minnow, and black bullhead were scarce or absent from developed sites. Schindler et al. (2000) evaluated patterns of fish growth along a residential development gradient in north temperate lakes. Bluegill and largemouth bass growth was studied in 14 lakes located in northern Wisconsin and northern Michigan. Size-specific growth rates for both species were negatively correlated with the degree of lakeshore development, although this trend was not statistically significant for largemouth bass. On average, annual growth rates for bluegill were 2.6 times lower in heavily developed lakes than in undeveloped lakes. Bluegill populations were approximately 2.3 times less productive in highly developed lakes than in undeveloped lakes. They concluded that extensive residential development of lakeshores may reduce the fish production capacity of aquatic ecosystems. Dwelling densities in Fremont Lake are substantially greater than threshold levels affecting the various resources found in these studies and this should be considered in management of fisheries resources of the lake.

The sport fishery in Fremont Lake is generally favorable for anglers at this time. The best fisheries are for black crappie, northern pike, walleye, rock bass, and largemouth bass, with more moderate fisheries for smallmouth bass, bluegill, pumpkinseed, yellow perch and bullheads. With the exception of yellow perch and pumpkinseed, these species have sufficient numbers of large individuals present in the population to provide good fishing. Growth rates are reasonable in that all species are growing near or above the state average. Although common carp dominated the fish community during much of the period from the 1940s through the 1970s they form only a portion of the fish community at this time. Water quality has improved sufficiently to provide suitable habitat for native fish species.

Originally, there was a very diverse minnow assemblage in Fremont Lake. In 2009, only one of the original minnow species was found and a few individuals of an introduced minnow. Residents on the lake indicate that few, if any minnows have been visible along the shoreline for the past 10 years or more. A diverse forage fish community would be beneficial to the stability of the overall fish community and reestablishing some of the native minnows should be a management objective for this lake.

During the period from the 1940s through the 1970s there were a number of comments in the file indicating the yellow perch fishery was fair with good size fish in the catch. This was one of the concerns with conducting the rotenone treatment on the lake. After the rotenone treatment in 1982, yellow perch exhibited a growth rate above state average for a few years and then growth rates declined. A significant yellow perch fishery has not developed in recent years. The 2009 survey found fairly large numbers of yellow perch from 3-7 inches, and only two 8-9 inch fish. They were growing slightly slower than state average so it does not appear yellow perch were slow growing. There is a very good predator fish population in Fremont Lake and it is likely the yellow perch are one of the primary food items. Reestablishing minnows in the lake would provide a broader forage base for predator fish in the lake and provide a buffer for the yellow perch population. Reestablishing the minnow populations may also increase yellow perch growth rates because minnows are a primary food item of yellow perch.

The reintroduction of lake herring should also be a fishery management objective as they provide both a fishery and forage for predatory fish species. Additional improvements in water quality may be necessary before reintroduction of this species because they require cold water temperatures and sufficient dissolved oxygen to survive. They were extirpated from Fremont Lake due to pollution and poor water quality in the early 1900s. Trout have similar temperature and dissolved oxygen requirements as lake herring. Trout were stocked in Fremont Lake for a nine year period (1983-1991) following the rotenone treatment in 1982. They had relatively good survival for 3-4 years then declined substantially in later years. Several issues may have resulted in poor trout survival including a greater abundance of northern pike following the rotenone treatment, the beginning of aquatic macrophyte control with chemicals, and continued low dissolved oxygen concentrations within the thermocline. It is uncertain if one or all of these may have resulted in the decline of trout survival in Fremont Lake. Any potential plan to reintroduce lake herring in the lake should include additional evaluation of water quality conditions in the lake.

Recommendations

1) Additional improvements to the fisheries of Fremont Lake will require restoration of fisheries habitat conditions in the lake. Water quality conditions have improved since the 1980s but low dissolved oxygen conditions within the water column persist and filamentous algal growth remains high. Nutrient inputs most likely continue to be high and studies will be required to determine the existing nutrient budget for the lake. Lake-level manipulation continues and is causing shoreline erosion conditions in the lake and extensive artificial shoreline armoring that is detrimental to fisheries habitat. Development of the shoreline is very high causing low levels of submerged wood habitat and reductions in aquatic macrophyte abundance. Aquatic macrophyte distribution in the lake is low and macrophytes should be protected from removal. These habitat issues are broad in scope involving both biological and social issues on a watershed scale. Development of a lake management plan involving both stakeholder organizations and agencies is the best way to address watershed issues.
2) Reintroduction of some of the native minnow species would provide a broader and more stable forage base for predatory fish in Fremont Lake. Appropriates sources and disease issues will need to be considered as required by Michigan Fish Stocking Guidelines.
3) Reintroduction of lake herring should be considered. Improvements in water quality conditions will be required before this can occur.
4) The walleye stocking program should continue. The stocking program has established a walleye population and fishery in Fremont Lake.

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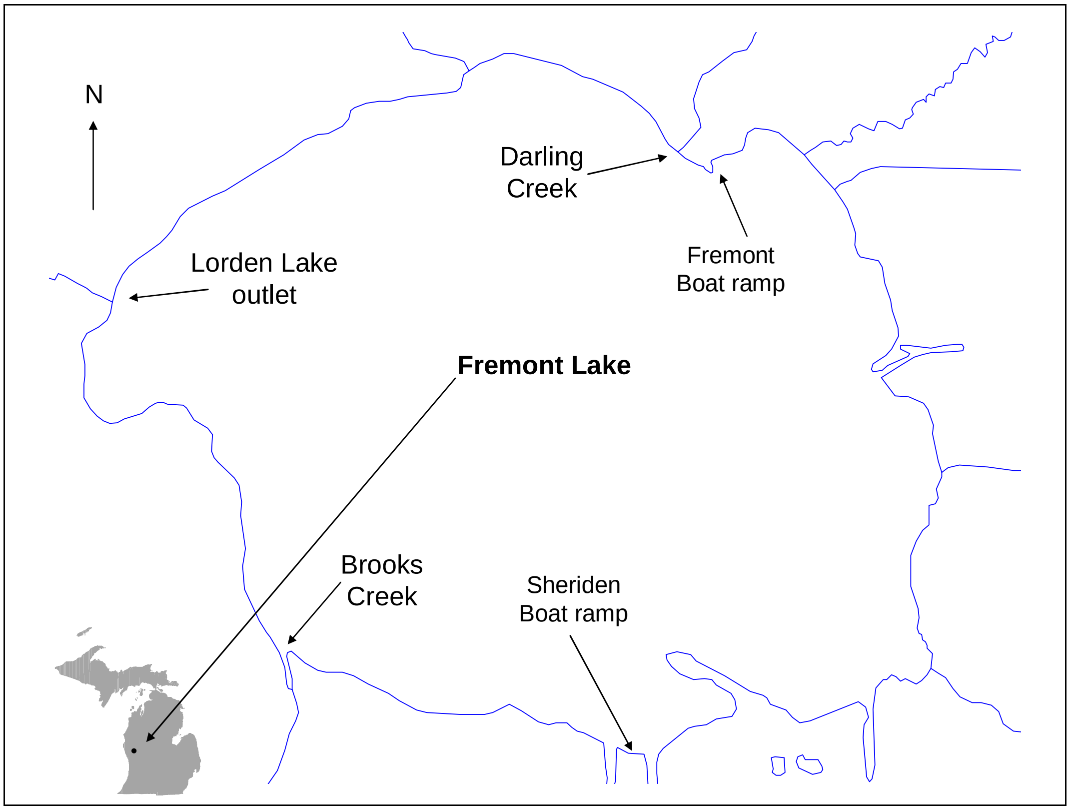


Figure 1. Map of Fremont Lake, Newaygo County, with public boat launches.

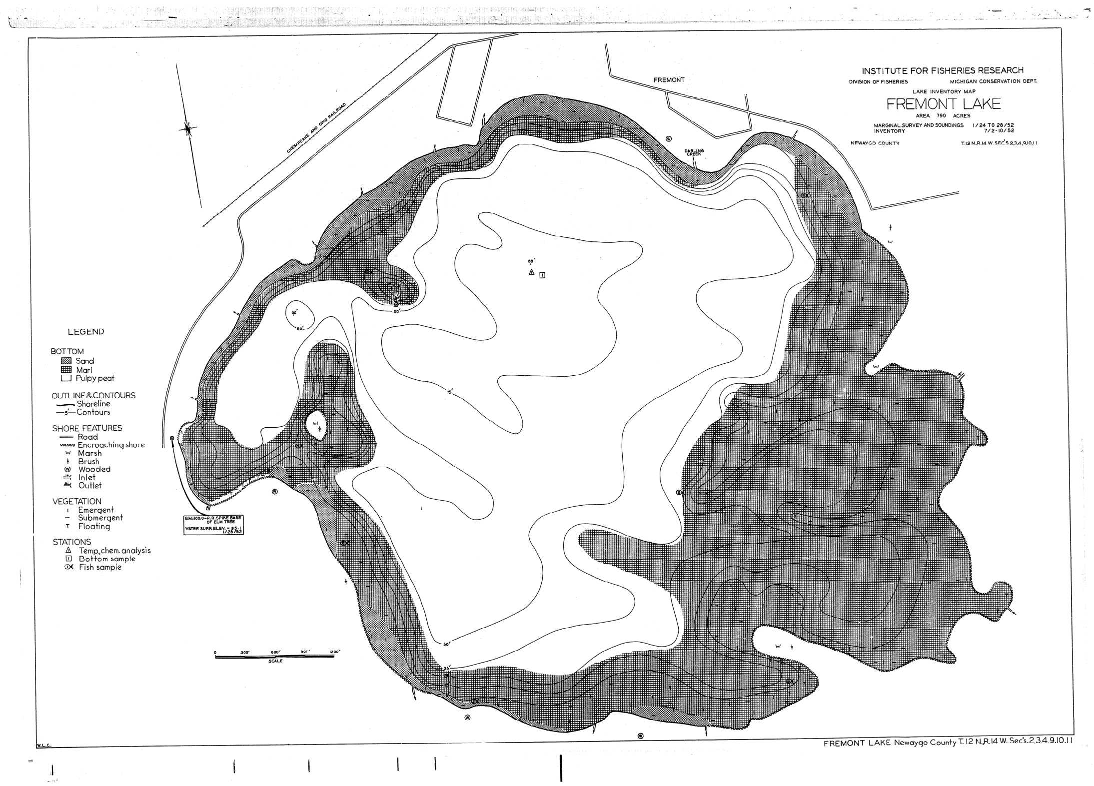


Figure 2. Inventory map of Fremont Lake, Newaygo County, 1952. Fremont Lake has a surface area of approximately 790 acres and shoreline length of 5.1 miles.

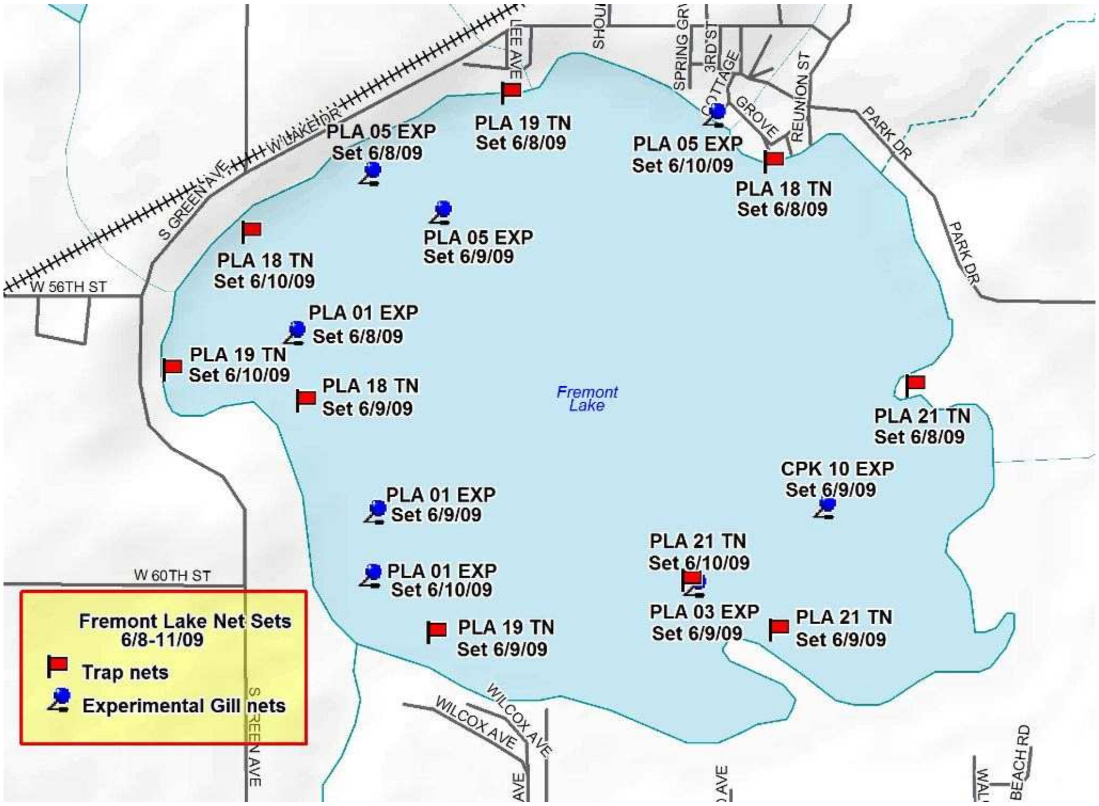


Figure 3. Fremont Lake trap net and gill net sampling sites during 2009.

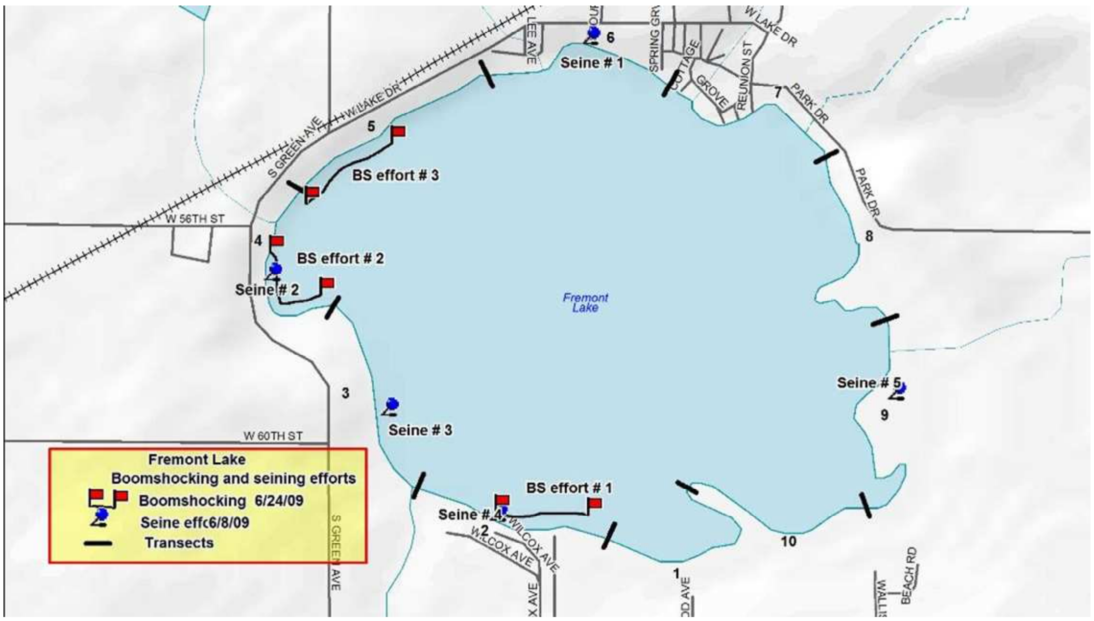


Figure 4. Fremont Lake electro-fishing and seine sampling sites during 2009.

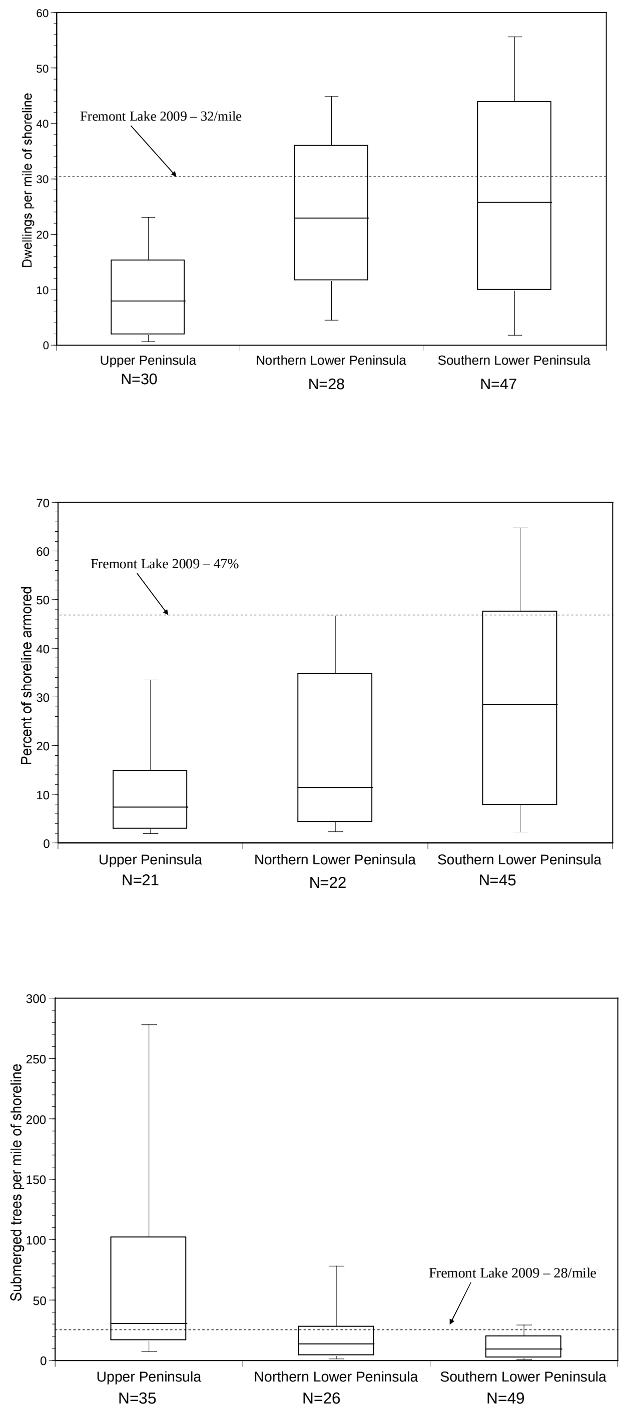


Figure 5. Density of shoreline dwellings (upper graph), percentage of shoreline with artificial armor (middle graph), and submerged tree densities for Fremont Lake in 2009. The box plots represent minimum, maximum, 25th and 75th percentile, and median values for lakes in the northern, middle, and southern regions of Michigan.

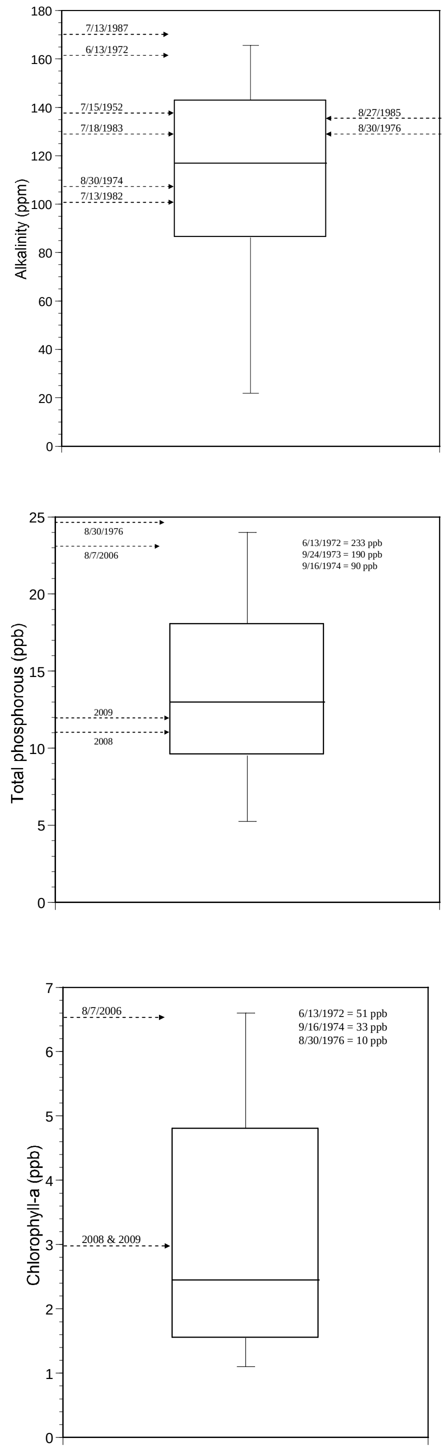


Figure 6. Comparison of Fremont Lake chemical parameters to other Northern Lower Peninsula Michigan lakes. The box plots represent minimum, maximum, 25th and 75th percentile, and median values for alkalinity (n=27, upper graph), total phosphorous (n=25, middle graph), and chlorophyll-a (n=22, lower graph).

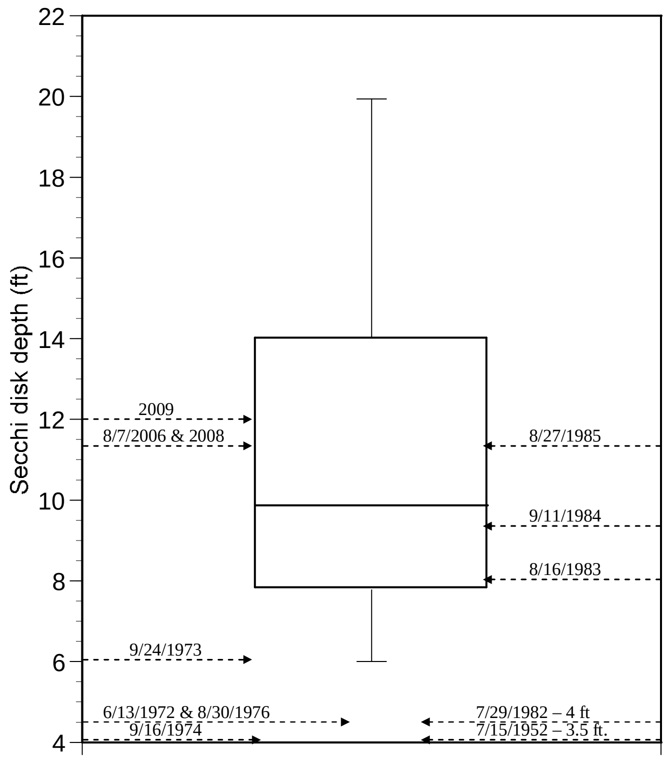
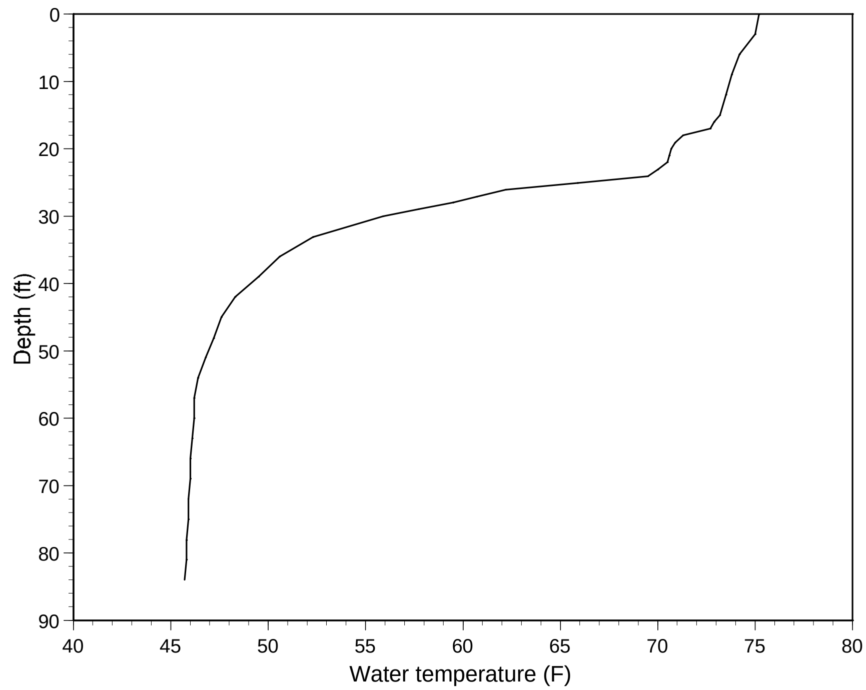


Figure 7. Comparison of Fremont Lake water transparency to other Northern Lower Peninsula Michigan lakes. The box plot represents minimum, maximum, 25^{th} and 75^{th} percentile, and median values for water transparency (n=43).



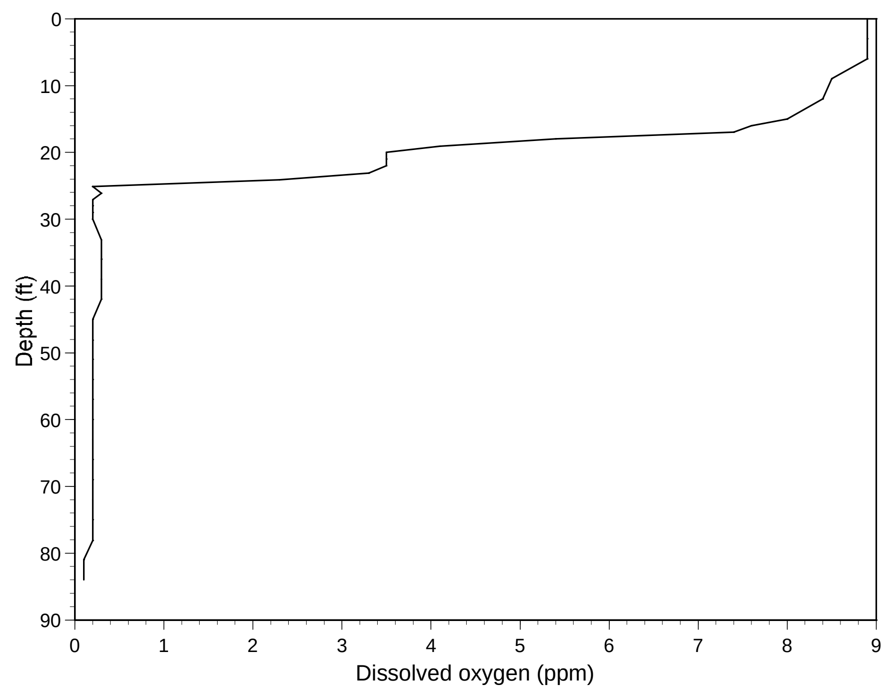
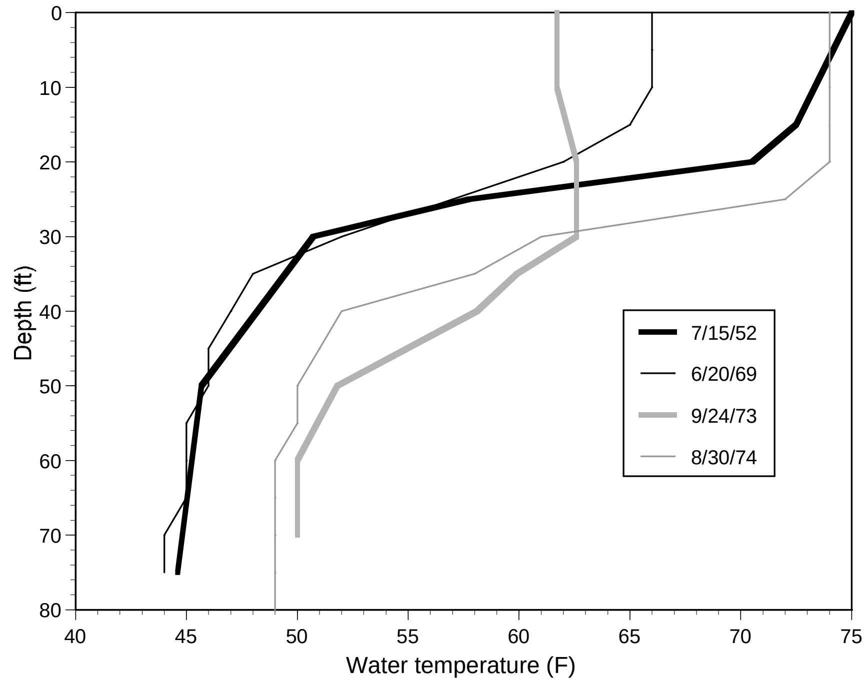


Figure 8. Fremont Lake water temperature profile (upper graph) and dissolved oxygen profile (lower graph) on August 11, 2009.



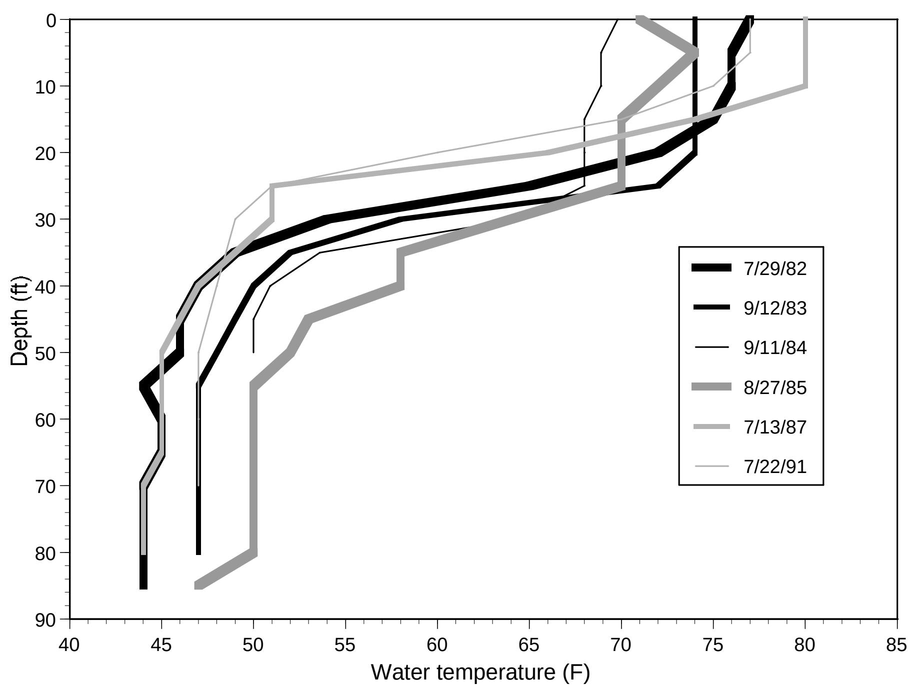
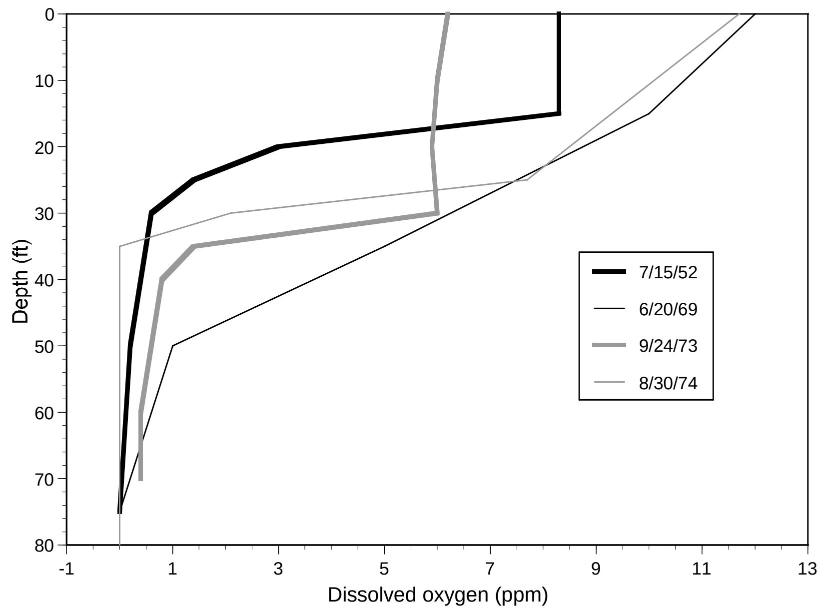


Figure 9. Water temperature profiles collected in Fremont Lake from 1952 through 1991.



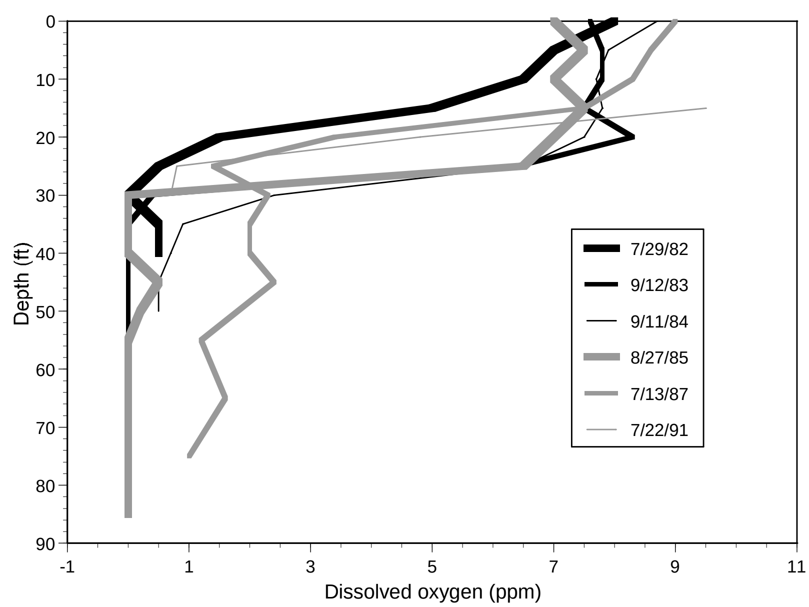


Figure 10. Dissolved oxygen profiles collected in Fremont Lake from 1952 through 1991.

Table 1. Summary list of DNR Fisheries Division files for Fremont Lake.

Date	Comments
1892	Fish and lake depth survey
9/1926	DNR fisheries survey
11/19/1934	DNR fisheries survey
4/10/1935	DNR fisheries survey
8/30/1938	DNR fisheries survey
8/8/1941	DNR fisheries survey
1946	Reported a popular fishing lake good for yellow perch
1/31/1947	Report fish kills estimated near 10,000 crappie and bluegill subsequent to complete ice cover, note of historical pollution with continued significant industrial and sewage inputs
1947	Dam constructed in Brooks Creek at lake outlet by the Fremont Lake Association ($18,000), court ordered 12 month lake-level elevation of 746.59 feet (in 1945?), no appointed authority for maintenance of lake-level or structure. Top of dam elevation at 749.5 feet
10/1/1948	DNR Conservation Officer reported 30-40 dead walleye in lake
1950s	Many complaints of too many common carp and poor fishing
1952	Fish Survey, aquatic plant survey, and lake bottom contour mapped by the DNR
6/25/1952	Black crappie fish kill reported in the lake, lab analyses indicated significant levels of the bacteria *Cytophaga columnaris* and *Saprolegnia spp*. were present on fish samples in mouth and gill areas.
9/1952	DNR Michigan Water Resources Commission report on bottom fauna, algae and nutrients in Fremont Lake
11/18/1953	DNR note that Fisheries Biologist recommends lake level be maintained at 746.59 feet to insure of good northern pike spawning.
1954-1956	Permit issued to Fremont Lake Conservation Club to remove common carp with seine
10/9/1956	Request for information on killing aquatic vegetation, “Pamphlet provided on the use of sodium arsenite.
1957	Several areas spot treated with rotenone for common carp control with poor results
1958	Permit issued to Fremont Lake Conservation Club to remove common carp with seine
10/14/1958	Complaints of heavy algal blooms
1959	Permit issued to Fremont Lake Conservation Club to remove common carp with seine
5/28/1959	Heavy filamentous and floating algal growth reported, blue-green algae found, indication that control was not practical due to sewage inputs especially through Daisy Creek.
4/27/1962	Fremont Lake Association requested DNR to rotenone common carp
1962, 1965, 1966 & 1968	Aerial application of copper sulfate within 1000 feet of shore around lake
6/20/1969	DNR fisheries survey

Table 1. Continued

8/14/1969	DNR recommend use of Hydrothol-47 for algal control due to concerns with copper applications
10/28/1969	DNR Michigan Water Resources Commission report on sources of algal nutrients in Fremont Lake (Robinson 1969)
10/6/1971	Rainbow trout mortality, possibly due to water temperatures
5/4/1972	DNR fisheries survey
7/7/1975	Fish kill in Daisy Creek due to discharge of muriatic acid
6/8/1977	Court allowed a temporary 12 inch reduction for winter lake-level, Drain Commissioner assigned to raise lake-level to 746.59 no earlier that March 1 and no later than April 15
1980 & 1981	Granular Aquathol used to treat curly-leaf pondweed
1981	DNR fisheries survey and common carp netting removal project that was not effective in removing sufficient quantities of common carp from the lake
12/1981	DNR proposal to kill most of the fish in Fremont Lake with rotenone
7/1982	DNR Fisheries Management Plan for Fremont Lake completed
12/14/1982	Fremont Lake, First Lake, and Lorden Lake were treated with rotenone
4/1983	Fremont Lake, First lake, and Lorden Lake fish restocking program started
6/1983	Copper sulfate treatment in 1.5 miles of Fremont Lake
10/20/1983	DNR fisheries survey
1/1984	Good ice fishing pressure for trout reported
5 & 6/1984	DNR fisheries survey
12/2/1985	Letter from City of Fremont thanking the DNR for the fishery improvements and indicating upcoming park and boat ramp projects
6 & 10/1985	DNR fisheries survey
1985	Copper applied to shoreline areas for algae and swimmer's itch control, Aquathol-K applied for curly-leaf pondweed
1/18/1986	News report indicating hundreds of anglers fishing the lake for trout
1986	Aquathol-K applied to kill watermilfoil, duckweed, algae and coontail
10/13/1987	DNR fisheries survey
1987& 1988	Copper sulfate, hydrothol 191, 2,4-D, Aquathol-K, and Diquat used to kill algae, milfoil, pondweeds, and waterweed
1/26/1988	Report that winter trout fishing has declined substantially
12/7/1988	DNR fisheries survey
1989 & 1990	Copper sulfate, hydrothol 191, 2,4-D, Aquathol-K, and Diquat used to kill algae, milfoil, pondweeds, and waterweed
1990	Bass fishing reported low compared to 1989
10/25/1990	DNR fisheries survey
7/23/1991	DNR fisheries survey
12/12/1990	DNR internal letter discussing concerns with expanding aquatic vegetation treatments on fisheries in Fremont Lake
4/1993	DNR Inland Lake Management Unit Report on water quality and nutrient budget for Fremont Lake
9/3/1993	Report by an angler that perch fishing has improved since weed treatments have been stopped on the lake

Table 1. Continued

1994 & 1996	Good fishing reports for walleye
6-9/1997	DNR fisheries survey
4/12/2004	Note in file that lake level control structure had shut off all flow to Brooks Creek
2005	Good fishing reports for walleye
9/12/2005	DNR fisheries survey
2007	Good fishing reports for walleye
5/14/2007	Lake Association meeting attended and there were good reports of fishing for walleye, largemouth bass, smallmouth bass, rock bass, crappie and northern pike
5/31/2007	Report of heavy filamentous algae growth in the lake
2009	Copper sulfate, Reward, and Nautique used to treat aquatic vegetation at various locations
6-8/2009	DNR fisheries survey

Table 2. Limnological parameters evaluated in Fremont Lake, Newaygo County, from 1952 through 2006. All values are in ppm unless indicated otherwise. N/P indicates total nitrogen-total phosphorous ratio. Water transparency measured with a Secchi disk.

Date	07/15/1952	06/13/1972	09/24/1973	09/16/1974	08/30/1976	09/21/1982	08/27/1985	08/07/2006	2008 & 2009A
Water transparency (ft)	3.5	4.5	6	4	4.5	5.5	11.5	11.3	11.4 & 12.0
Alkalinity		162		125	127	138			
Chlorophyll-a		0.051		0.033	0.01	0.012		0.007	0.003
Total phosphorous		0.233	0.19	0.09	0.025	0.023		0.023	.011 & .012
Nitrite & nitrate		0.02	0.02	0.02	0.01	0.01		0.004	
Total nitrogen				1.08	0.61	0.75		0.59	
N/P ratio				12	24	33		25	
<u>Trophic status</u>									
Water transparency	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic
Chlorophyll-a		Eutrophic		Eutrophic	Mesotrophic	Mesotrophic		Mesotrophic	Mesotrophic
Phosphorous		Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic		Eutrophic	Mesotrophic
Nutrient limiting plant growth					Phosphorous	Phosphorous		Phosphorous	

A. The measurements provided for 2008 and 2009 were collected through the DNR Inland Lakes Cooperative Monitoring Program. Water transparency was the summer mean value, phosphorous was measured in late summer, and chlorophyll-a was the median summer value.

Table 3. Aquatic plants found in Fremont Lake in 1952.

Common name	Scientific name
Coontail	*Ceratophyllum demersum*
Eel grass	*Vallisneria americana*
Flat-stemmed pondweed	*Potamogeton zosteriformis*
Fries' pondweed	*Potamogeton friesii*
Sago pondweed	*Potamogeton pectinatus*
White-stemmed pondweed	*Potamogeton praelongus*
Robbins pondweed	*Potamogeton robbinsii*
Sweet-scented waterlily	*Nymphaea odorata*
Yellow pond-lily	*Nuphar advena*
Small duckweed	*Lemna minor*
Softstem bulrush	*Schoenoplectus tabernaemontani*
Broad-leaved cat-tail	*Typha latifolia*
Swamp loosestrife	*Decodon verticillatus*
Arrowhead	*Sagittaria spp.*

Table 4. Sport fish species collected in Fremont Lake from 1894 through 2009. Collection methods are indicated by GN = gill net, TN = trap net, SE = seine, EL = electrofishing, and A = angling. Bowfin reported caught by anglers in 1952.

Common name	Scientific name	1892	1926	1935	1952	1969-1981	1983-1991	2009
Method		GN, A	SE	SE	SE, GN	TN,GN	TN, GN, E	TN, GN, SE, E
Black crappie	*Pomoxis nigromaculatus*	X	X	X	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X	X	X	X
Brown bullhead	*Ameiurus nebulosus*				X			X
Brown trout	*Salmo trutta*						X	
Bullhead	*Ameiurus spp.*	X						X
Common carp	*Cyprinus carpio*				X	X	X	X
Lake herring (cisco)	*Coregonus artedi*	X						
Largemouth bass	*Micropterus salmoides*	X	X	X	X	X	X	X
Longnose gar	*Lepisosteus osseus*					X		
Northern pike	*Esox lucius*	X		X	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X		X	X
Rainbow trout	*Onchorynchus mykiss*						X	
Rock bass	*Ambloplites rupestris*	X	X		X	X	X	X
Smallmouth bass	*Micropterus dolomieu*		X			X	X	X
Walleye	*Sander vitreus*					X	X	X
Warmouth	*Lepomis gulosis*							
White sucker	*Catostomus commersonii*	X		X	X	X	X	X
Yellow bullhead	*Ameiurus natalis*						X	X
Yellow perch	*Perca flavescens*	X	X	X	X	X	X	X

Table 5. Forage fish species collected in Fremont Lake from 1894 through 2009. Collection methods are indicated by GN = gill net, TN = trap net, SE = seine, EL = electrofishing, and angling.

Common name	Scientific name	1892	1926	1935	1952	2009
Method		GN, A	SE	SE	SE, GN	TN, GN, SE, E
Blackchin shiner	*Notropis heterodon*		X		X	
Blacknose shiner	*Notropis heterolepis*		X		X	
Bigmouth shiner	*Notropis dorsalis*			X	X	
Bluntnose minnow	*Pimephales notatus*		X	X	X	X
Common shiner	*Luxilus cornutus*			X		
Creek chub	*Semotilus atromaculatus*			X		
Emerald shiner	*Notropis atherinoides*			X		
Fathead minnow	*Pimephales promelas*					X
Golden shiner	*Notemigonus crysoleucas*	X	X	X		
Iowa darter	*Etheostoma exile*		X	X	X	
Johnny darter	*Etheostoma nigrum*		X	X	X	
Mimic shiner	*Notropis volucellus*			X		
Redbelly dace	*Phoxinus spp.*					
Rosyface shiner	*Notropis rubellus*			X		
Sand shiner	*Notropis stamineus*			X	X	
Western banded killifish	*Fundulus diaphanous menona*		X	X	X	
Western blacknose dace	*Rhinicthys obtusus Agassiz*			X		

Table 6. Numbers of fish stocked into Fremont Lake from 1930 through 2010. Stocked fish were fingerlings unless indicated as fry (F), yearling (Y) or adult (A). An unreported number of emerald shiners were stocked in 1934.

Year	Walleye	Largemouth bass	Smallmouth bass	Bluegill	Yellow perch	Pumpkinseed	Black crappie	Rainbow trout (Y)	Brown trout(Y)	Fathead minnow
1930				4000	500					
1931		450		5400	7200	2400				
1939	278A		1500	10000	7500					
1940	122A		1350		6A					
1941		1000	1288	10000						
1942		1,500	1,000	1,000						
1944		1,500								
1983	700 & 2,965,700F	388A	765A	1,580A	61A		4A	13,375	27,375	
1984	21,381		410A					9,700	10,606	
1985	3,273							13,000	10,130	345,245
1986	51,684							20,000	10,573	
1987	24,600							20,000	10,800	
1988	1,276							20,006	12,000	
1989	30,814							20,000	12,000	
1990								20,000	12,000	
1991	60,803							18,313	11,900	
1992	93,597									
1994	83,088									
1996	82,131									
1997	72,787									
1999	81,068									
2001	101,319									
2003	79,098									
2005	79,384									
2008	39,444									
2010	41,343									

Table 7. Catch per unit effort of fish collected in trap nets and gill nets during 2009 from Fremont Lake. These data exclude two partial gill net sets (efforts 18 and 19).

Method & Species	Number collected	Catch per unit effort
Trap nets	**9 lifts**	
Black crappie	39	4.3
Bluegill	30	3.3
Bullhead	34	3.8
Largemouth bass	6	0.7
Northern Pike	5	0.6
Pumpkinseed	13	1.4
Rock bass	29	3.2
Smallmouth bass	1	0.1
Walleye	1	0.1
Yellow perch	5	0.6
Gill nets	**6 lifts**	
Black crappie	3	0.4
Bluegill	0	0
Bullhead	2	0.2
Largemouth bass	0	0
Northern Pike	8	1.3
Pumpkinseed	0	0
Rock bass	6	0.7
Smallmouth bass	1	0.2
Walleye	46	7.7
Yellow perch	0	0

Table 8. Length distributions of fish collected with trap and gill nets in Fremont Lake during 2009.

Length (inches)	Black crappie	Bluegill	Bullhead	Largemouth bass	Northern pike	Pumpkinseed	Rock bass	Smallmouth bass	Walleye	Yellow perch
4	5	4				4	1			
5	18	2				3	2			8
6	3	18	1			6	6			9
7		6					9	1		1
8	10						13			1
9			4				3			
10	5		17				1			
11			9							
12	1		2	1						
13			3	1					2	
14				2				1	3	
15								1	8	
16								2	1	
17				1				2	1	
18									5	
19									9	
20				1	2				16	
21					1				8	
22					3				3	
23					1					
24									1	
25					2					
26					2					
27										
28					1					
29					2					
30					1					
31										
32					1					

Table 9. Growth rates of fish, relative to state averages, for fish collected in Fremont Lake from 1952 through 2009. Sample sizes are designated in parentheses.

Year	Bluegill	Black crappie	Largemouth bass	Northern pike	Pumpkinseed	Rock bass	Walleye	Yellow perch
1952	1.6 (7)	-0.3 (30)						1.8 (113)
1981	0.2 (26)	0.0 (36)	1.3 (34)					-0.3 (31)
1983	0.4 (5)							
1984							1.5 (6)	0.8 (5)
1985	3.6 (39)	1.2 (16)	1.5 (18)				3.8 (10)	3.8 (37)
1987		0.0 (23)					-0.2 (32)	-0.2 (53)
1990							2.8 (12)	
1991		0.9 (5)		-0.9 (11)			4.1 (8)	1.0 (17)
1997	0.6 (39)			-5.1 (13)	0.5 (16)		3.0 (5)	0.2 (10)
2005							0.5 (21)	
2009	1.7 (23)	0.2 (52)	1.6 (6)	0.2 (11)	0.2 (22)	1.3 (25)	2.2 (54)	-0.6 (48)

Table 10. Bluegill growth and size structure classification for Fremont Lake in 2009. Refer to Schneider (1990) for methods[1]. The ranking for the 2009 average growth rate of 1.7 inches above state average was superior.

Sample method	Average length (in)	%>6"	%>7"	%>8"	Average score	Rank
Trap net data	6.4	80.0	20.0	0.0		
Trap net score	4	5	4	2	4	Satisfactory

1. Scores and ranks are as follows: 1=very poor, 2=poor, 3=acceptable, 4=satisfactory, 5=good, 6=excellent, and 7=superior.

Table 11. Habitat quality scores for Fremont Lake based on fish community composition[1]. Several other variables were used to determine scores including limnological parameters, aquatic plant abundance, and alteration of the shoreline (Schneider 2002).

Metric		Possible score	Score	Comments
1	Native fish fauna	1-5	3.5	Demote a point for introduction of common carp & ½ point for stocked walleye
2	Winterkill	1-5	5	Winterkill intolerant species = 81% of biomass of sample
3	Acidity	1,2,3,5	5	pH>5, acid tolerant and other species present
4	Thermocline/hypolimnion DO	1-5	3	No indicator species present
5	Productivity/enrichment	1-5	2	Common carp = 9% of sample biomass
6	Turbidity	1-4	2	Turbidity intolerant species not present
7	Silt	1-4	4	Silt intolerant walleye and northern pike present
8	Macrophytes	1,2,3,5	5	Bluegill growth above average, 4 macrophyte dependent species present (northern pike, bluegill, largemouth bass, yellow bullhead)
9	Edge modification	1-5	3	Shoreline armor = 47%, high dwelling densities, one edge modification intolerant species present (northern pike)
10	Level stabilization	1-5	3	Lake-level control dam and northern pike present
11	Predation/competition	2,3,5	5	Natural dominant species present
	Total		40.5	

1. The range of possible scores is 12-53. A maximum score would be achieved in a deep, oligotrophic, non-acidic lake with moderate densities of aquatic macrophytes, which was unaffected by species introductions, low DO (dissolved oxygen), eutrophication, or modifications of edge or water levels. Typical shallow, mesotrophic, Michigan lakes with no DO below the thermocline would score a maximum of 50. Natural Michigan lakes that are shallow, productive and have fish kills due to low DO in winter would score a maximum of 31. Most lakes in Michigan presently will not have maximum scores due to human alterations.

Table 12. Theoretical nutrient budget for Fremont Lake after nutrient diversion. Loadings are in pounds per year. The information provided is from DNR (1983).

Source	Low loading	Most likely loading	High loading
Watershed (non-point sources)	1,188	2,791	3,430
Septic systems	30	60	120
Precipitation	117	234	469
Point sources	8	23	43
Total	1,343	3,108	4,062