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RUNYAN LAKE
LAKE MANAGEMENT STUDY REPORT

August 1996

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August 1996

Project No: 9503-26

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INTRODUCTION

PROJECT BACKGROUND

Runyan Lake is a medium-sized, relatively deep lake located at the northeast corner of Livingston County adjacent to the U.S. 23 expressway (T.4N;R.6E; Figure 1). In July of 1995, Runyan Lake Inc. retained Progressive Architecture Engineering Planning to conduct a study of Runyan Lake to evaluate management alternatives to preserve and protect lake water quality. During the course of study, previous studies of Runyan Lake were compiled and reviewed, the physical characteristics of Runyan Lake and its watershed were evaluated, an opinion survey of lake residents was completed, samples were collected to determine the present condition of the lake, and the type and distribution of aquatic plants was determined. The purpose of this report is to discuss study findings, recommendations, and conclusions.

LAKE AND WATERSHED CHARACTERISTICS

A summary of the physical characteristics of Runyan Lake and its watershed is provided in Table 1. Runyan Lake has a surface area of 174 acres, a maximum depth of 55 feet, and a mean or average depth of 32.8 feet. A map depicting approximate depth contours in the lake is shown in Figure 2. Runyan Lake contains about 5,721 acre-feet of water, a volume which would cover over 9 square miles to a depth of 1 foot. The lake has a shoreline 2.5 miles long and a shoreline development factor of 1.9. The shoreline development factor indicates the degree of irregularity in the shape of the shoreline. That is, compared to a perfectly round lake that has the same surface area as Runyan Lake (i.e., 174 acres), the shoreline of Runyan Lake is 1.9 times longer because of its convoluted shape. Runyan Lake receives water from a number of small streams, the largest being Denton Creek which enters at the north end of the lake. Water flows from Runyan Lake's outlet into Hoisington, Bennett, and Lobdell lakes before emptying into the Shiawassee River which flows to the Saginaw River and eventually into Lake Huron via Saginaw Bay.

The land area surrounding a lake that drains to the lake is called the watershed, or drainage basin. The Runyan Lake watershed comprises 7,471 acres, a land area 43 times the size of the lake. The watershed boundary and watershed land uses are depicted in Figures 3. In order to effectively manage Runyan Lake over the long term, steps must be taken in conjunction with in-lake improvements to identify and reduce pollution inputs to the lake from the surrounding watershed.

Figure 1. Project location map.

TABLE 1
RUNYAN LAKE
PHYSICAL CHARACTERISTICS[1]

Lake Surface Area	174 Acres
Maximum Depth	55 Feet
Mean Depth	32.8 Feet
Lake Volume	5,721 Acre-Feet
Shoreline Length	3.6 Miles
Shoreline Development Factor	1.9
Lake Elevation	893 Feet
Watershed Area	7,471 Acres
Ratio of Lake Area to Watershed Area	1:43

Watershed Land Uses	Acres	Percent Of Total
Agriculture	1,957	26%
Residential Development	887	12%
Wooded	1,492	20%
Undeveloped	2,390	32%
Wetlands	745	10%
	7,471	100%

[1] Shoreline length, lake elevation, watershed and lake areas were determined by examining a United States Geological Survey topographic map of the Runyan Lake area (scale: 1" = 2000'). Lake volume, maximum and mean depths were derived from a depth contour map of Runyan Lake (Jude and Ervin 1986). Digital data derived from the Michigan Department of Environmental Quality Michigan Resource Information System (MIRIS) was utilized to delineate land use types (MDEQ 1978).

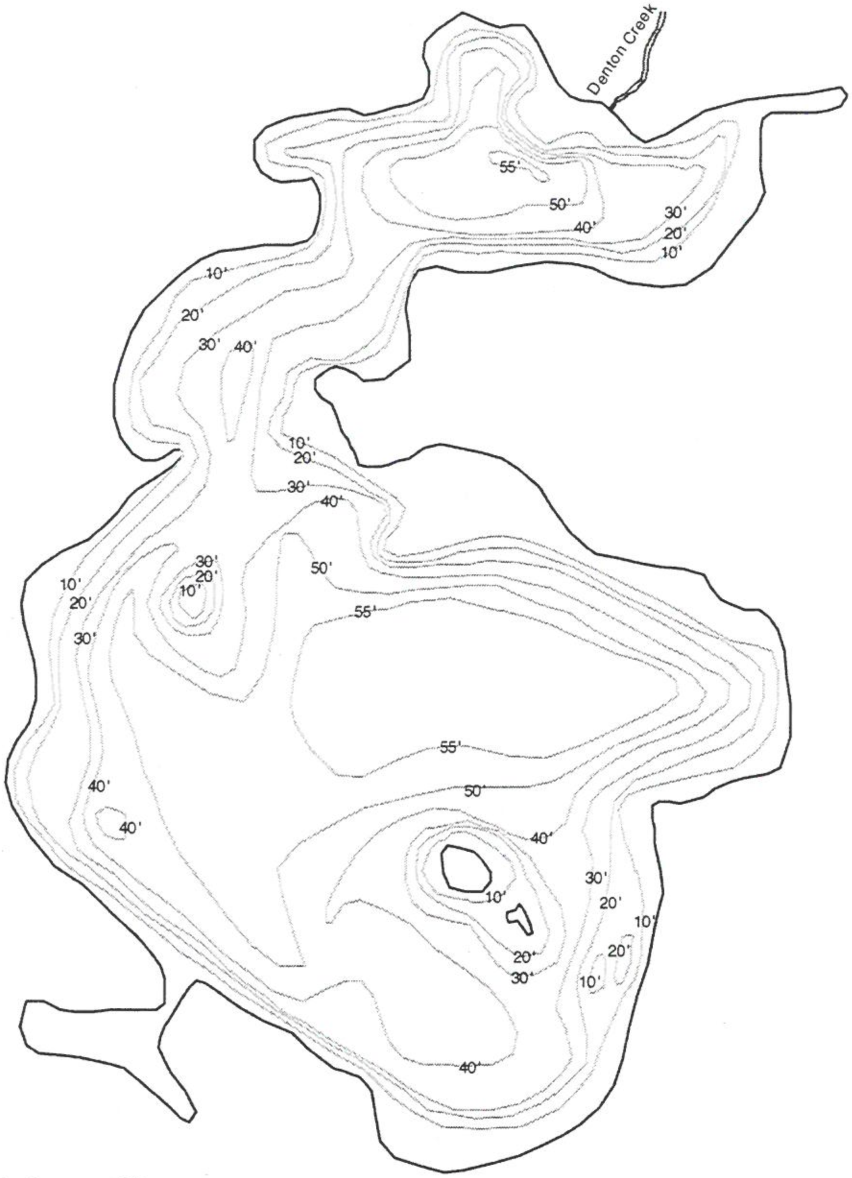


Figure 2. Lake Depth Contour Map.

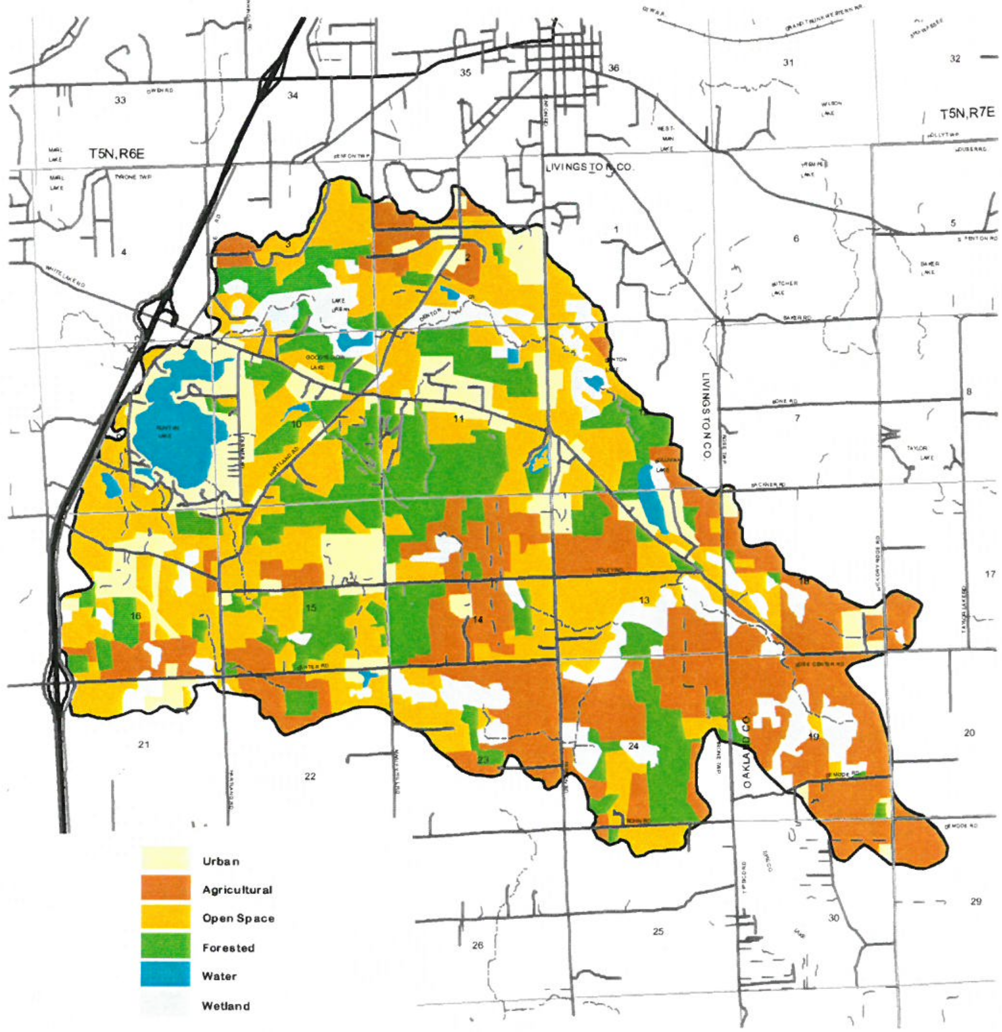


Figure 3. Watershed Map.

QUESTIONNAIRE RESULTS

In order to obtain information on area residents' perspective of Runyan Lake, a questionnaire was distributed to all lake residents. Approximately 250 questionnaires were mailed and a total of 90 were returned. A complete tabulation of questionnaire responses is provided in Appendix A. Responses to key questions are summarized as follows:

- A majority of respondents (48%) had observed the lake for 20 or more years.
- A majority of respondents (60%) felt that excessive rooted plant growth was the major problem in Runyan Lake.
- Residential runoff was listed as the largest single source of pollution to Runyan Lake (48%).
- A majority of respondents were year-round residents (72%).
- Ninety-five percent of respondents favor at least moderate regulations for protecting wetlands and would support a program that promotes the use of phosphorus-free lawn fertilizer around the lake.

Many lake residents commented that excessive boat traffic was becoming a problem on Runyan Lake.

LAKE WATER QUALITY

Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact of drainage from the surrounding watershed.

Lakes are commonly classified as **oligotrophic**, **mesotrophic**, or **eutrophic**. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The aging process in lakes is called "**eutrophication**" and may take anywhere from a few hundred to several thousand years, generally depending on the size of the lake and its watershed. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from sources such as septic seepage, lawn fertilization, and agricultural runoff. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as "**cultural eutrophication.**" The problem of cultural eutrophication can be managed by identifying sources of sediment and nutrient loading (i.e., inputs) to the lake and developing strategies to halt or slow the inputs. Thus, in developing a management plan, it is necessary to determine the limnological (i.e., the physical, chemical, and biological) condition of the lake and the physical characteristics of the watershed as well.

Key parameters used to evaluate the limnological condition of a lake include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency. A brief description of these water quality measurements is as follows:

TEMPERATURE

Temperature is important in determining the type of organisms which may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as "spring turnover" because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the "thermocline." The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as "fall turnover." As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated.

DISSOLVED OXYGEN

An important factor influencing lake water quality is the quantity of **dissolved oxygen** in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because the oxygen has been consumed, in large part, by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

PHOSPHORUS

Oxygen is also important in that it influences the distribution of nutrients in the lake. The quantity of **phosphorus** present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, lake sediments act as a phosphorus trap, retaining phosphorus and, thus, making it unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus will be released from the sediments and may be available to promote aquatic plant growth. In some lakes, the internal release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input).

By reducing the availability of phosphorus in a lake, it is often possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration of 20 μg/L (micrograms per liter, or parts per billion) or greater are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.

CHLOROPHYLL-*A*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-*a* concentration greater than 6 μg/L is considered characteristic of a eutrophic condition.

SECCHI TRANSPARENCY

A **Secchi disk** is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line. The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of at least twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

Ordinarily, as phosphorus inputs (both internal and external) to a lake increase, the amount of algae will also increase. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria developed by the Michigan Department of Environmental Quality is shown in Table 2.

TABLE 2
LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (μg/L)[1]	Chlorophyll-*a* (μg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

SAMPLING RESULTS AND DISCUSSION

Samples were collected from the surface to the bottom at each of the three deep basins of Runyan Lake on March 28, June 21, and August 14, 1995 (Figure 4). These sampling periods corresponded with spring turnover, early-summer stratification, and late-summer stratification, respectively.

During the March 28 sampling period, Runyan Lake's temperature was uniform from the surface to bottom due to the mixing of the water column during spring turnover (Table 3). Dissolved oxygen concentrations were near saturation levels, that is, near the maximum amount of oxygen that the water can hold at a given temperature. By

[1] μg/L = micrograms per liter = parts per billion.

[1] μg/L = micrograms per liter = parts per billion.

June 21, Runyan Lake's temperature profile was quite different from the earlier sampling period in that water temperatures were much warmer in the upper surface layer of the lake than in the deeper water. The temperature data indicate that the thermocline (i.e., the zone where the temperature drops rapidly with depth) was located about 20 feet below the surface. By August 14, the thermocline had descended to approximately 25-30 feet below the surface. The water near the bottom of the lake was nearly devoid of oxygen, thus, the deeper portions of Runyan Lake had become unsuitable for most fish.

Phosphorus concentrations in Runyan Lake were quite variable during the period of sampling (Table 3). The average total phosphorus concentration measured during spring turnover was 16 μg/L although phosphorus levels in the lake increased somewhat by June and August. During the summer sampling periods, elevated phosphorus levels were measured near the thermocline. (Algae [free-floating microscopic plants] often concentrate at or near the thermocline, thus, the higher phosphorus concentrations observed might be attributed to this phenomenon.) In August, no significant build-up of phosphorus was observed in the deeper waters of the lake despite the fact that dissolved oxygen levels at the lake bottom were nearly depleted. This data indicates that internal phosphorus loading may not be significant in Runyan Lake. A graphic comparison of historical and recent phosphorus data indicates a substantial decline in spring phosphorus levels in recent years (Figure 5). This decline may be the result of the construction of the sewer system in the late 1980's that eliminated a major source of phosphorus loading to Runyan Lake.

The average chlorophyll-*a* concentration measured during the period of sampling was 4.5 μg/L while Secchi transparency readings ranged from 8 to 11 feet. (Table 4) Applying the Department of Environmental Quality lake classification criteria in Table 2 to the spring total phosphorus, chlorophyll-*a*, and Secchi transparency data collected during the course of study, Runyan Lake is mesotrophic. The lake maintains relatively low spring phosphorus levels, moderate amounts of algae growth in the open waters, and reasonably good transparency. Information on other parameters sampled during the study is included in Appendix B.

In addition to samples collected over the deep basins of Runyan Lake, fecal coliform bacteria samples were collected from Denton Creek and several minor tributaries to the lake (Figure 6) on June 21 and September 12, 1995. Bacteriological sampling results are listed in Table 5. The new State of Michigan standard for fecal coliform bacteria requires that the geometric mean of five or more sampling events representatively spread over a 30-day period not exceed 130 *E. coli* bacteria per 100 milliliters of sample. A single sampling event standard of 300 *E. coli* bacteria per 100 milliliters has also been established. (A sampling event includes a minimum of three samples collected at representative locations within a defined area). Several of the samples analyzed during the course of study had slightly elevated bacteria levels. However, given the fact that the Runyan Lake area has been served for several years by a sanitary sewer system, it is likely that the elevated bacteria levels are the result of bird and wildlife activity in the area. Bacteria levels in Runyan Lake are well within the state standard for total body contact recreational activities.

LAKE WATER QUALITY

In addition to the bacteriological sampling, measurements were made of flow and total phosphorus concentration in Denton Creek on June 21, August 14, and September 12, 1995 (Table 6). Although flow in the creek was relatively low, elevated phosphorus levels were measured during each sampling period.

Monitoring should be continued on Runyan Lake to better discern water quality conditions. Samples should be collected from over the deep basins in the lake during both spring turnover and late summer stratification. Samples collected should be analyzed to determine temperature, dissolved oxygen, total phosphorus, and chlorophyll-*a* levels. In addition, measurements should be made of Secchi transparency during each sampling period. Sampling of the deep basins of the lake should be conducted on a 3- to 4-year basis. In order to better evaluate the impact of Denton Creek on the water quality of Runyan Lake, monitoring of the creek should be conducted monthly on an annual basis during ice free periods to determine flow, total phosphorus concentration, dissolved oxygen and bacteria levels.

Figure 4. Deep Basin Sampling Location Map.

TABLE 3
RUNYAN LAKE
DEEP BASIN WATER QUALITY DATA

Station	Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L)
			March 28, 1995			
1	1	43.0	12.0	14	8.4	210
1	10	42.5	12.0			
1	20	42.5	12.0			
1	30	42.5	12.5	14	8.4	213
1	40	42.5	12.0			
1	50	42.5	12.4	15	8.4	220
2	1	42.0	12.8	14	8.4	207
2	10	42.0	12.8			
2	20	42.0	13.0			
2	30	42.0	13.0	22	8.4	216
2	40	42.0	12.6			
2	50	42.0	11.6	14	8.3	225
3	1	43.0	11.6	14	8.4	212
3	10	42.5	12.4			
3	20	42.5	10.8	22	8.3	211
3	30	42.5	12.8			
3	40	42.5	11.8	14	8.2	192

[1] mg/L = milligrams per liter = parts per million.

[2] µg/L = micrograms per liter = parts per billion.

[3] S.U. = standard units.

TABLE 3 (Continued)
RUNYAN LAKE
DEEP BASIN WATER QUALITY DATA

Station	Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L)
			June 21, 1995			
1	1	77.0	8.4	15	8.7	200
1	10	74.0	8.3	89		
1	20	66.0	7.5	16		
1	30	55.0	6.2	56	8.5	210
1	40	52.0	5.1	63		
1	50	50.0	2.5	26	8.3	228
2	1	78.0	8.6	21	8.5	206
2	10	75.0	8.7	12		
2	20	60.0	8.5	15		
2	30	56.0	8.3	60	8.4	218
2	40	53.0	7.0	29		
2	50	50.5	4.6	17	8.3	221
3	1	78.0	8.5	52	8.6	198
3	10	75.0	8.5	21		
3	20	63.0	8.5	46	8.5	205
3	30	56.0	6.2	36		
3	39	53.0	4.8	20	8.0	226

[1] mg/L = milligrams per liter = parts per million.

[2] μg/L = micrograms per liter = parts per billion.

[3] S.U. = standard units.

TABLE 3 (Continued)
RUNYAN LAKE
DEEP BASIN WATER QUALITY DATA

Station	Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L)
			August 4, 1995			
1	1	82.5	8.1	14	9.0	172
1	10	82.0	8.0	14		
1	20	73.0	8.7	36		
1	30	58.0	7.4	24	8.6	183
1	40	54.0	1.2	25		
1	55	49.0	0.6	15	8.1	203
2	1	81.5	8.1	15	8.9	165
2	10	81.0	8.0	10		
2	20	72.0	8.6	15		
2	30	55.0	7.6	68	8.4	181
2	40	54.0	7.0	24		
2	55	49.0	0.2	38	8.1	201
3	1	82.0	8.0	36	8.9	156
3	10	81.5	7.6	23		
3	20	72.0	10.0	42	8.5	173
3	30	56.0	8.3	22		
3	40	53.0	3.8	38	8.2	182

[1] mg/L = milligrams per liter = parts per million.

[2] μg/L = micrograms per liter = parts per billion.

[3] S.U. = standard units.

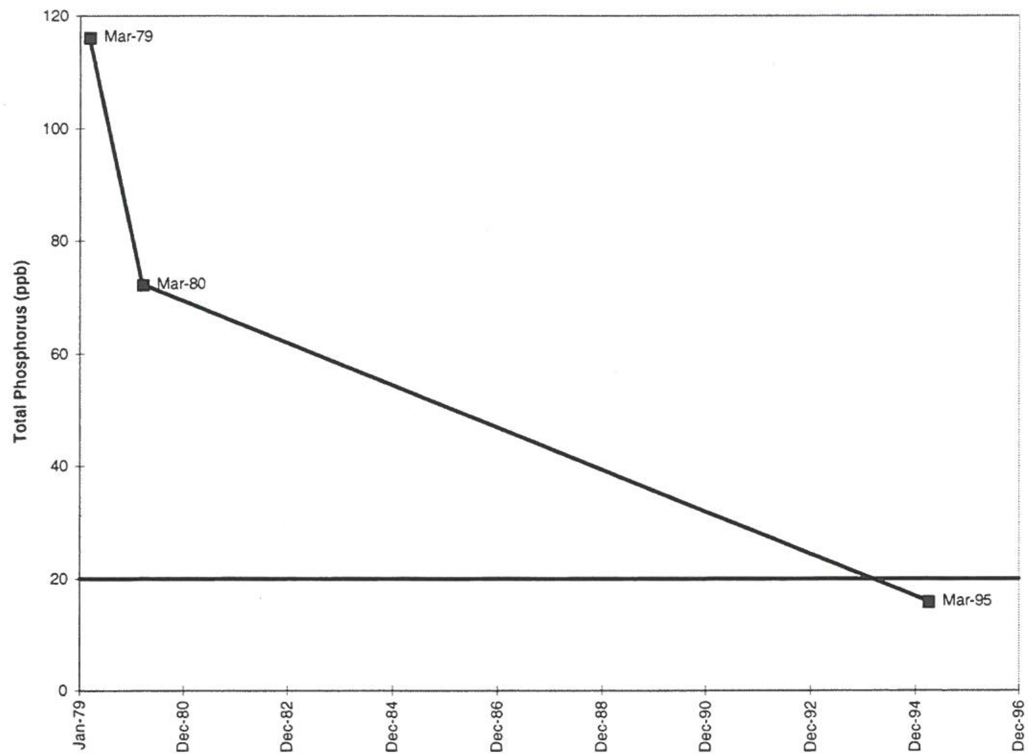


Figure 5. Runyan Lake spring phosphorus data - past and present. Source for 1979 and 1980 data: Jude and Ervin 1980, 1981.

TABLE 4
RUNYAN LAKE
SURFACE WATER QUALITY DATA

Station	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[1]
	March 28, 1995	
1	10.0	5
2	8.5	4
3	9.0	4
	June 21, 1995	
1	11.0	0
2	8.5	0
3	9.5	0
	August 4, 1995	
1	8.0	4
2	8.0	7
3	8.0	3

[1] µg/L = micrograms per liter = parts per billion.

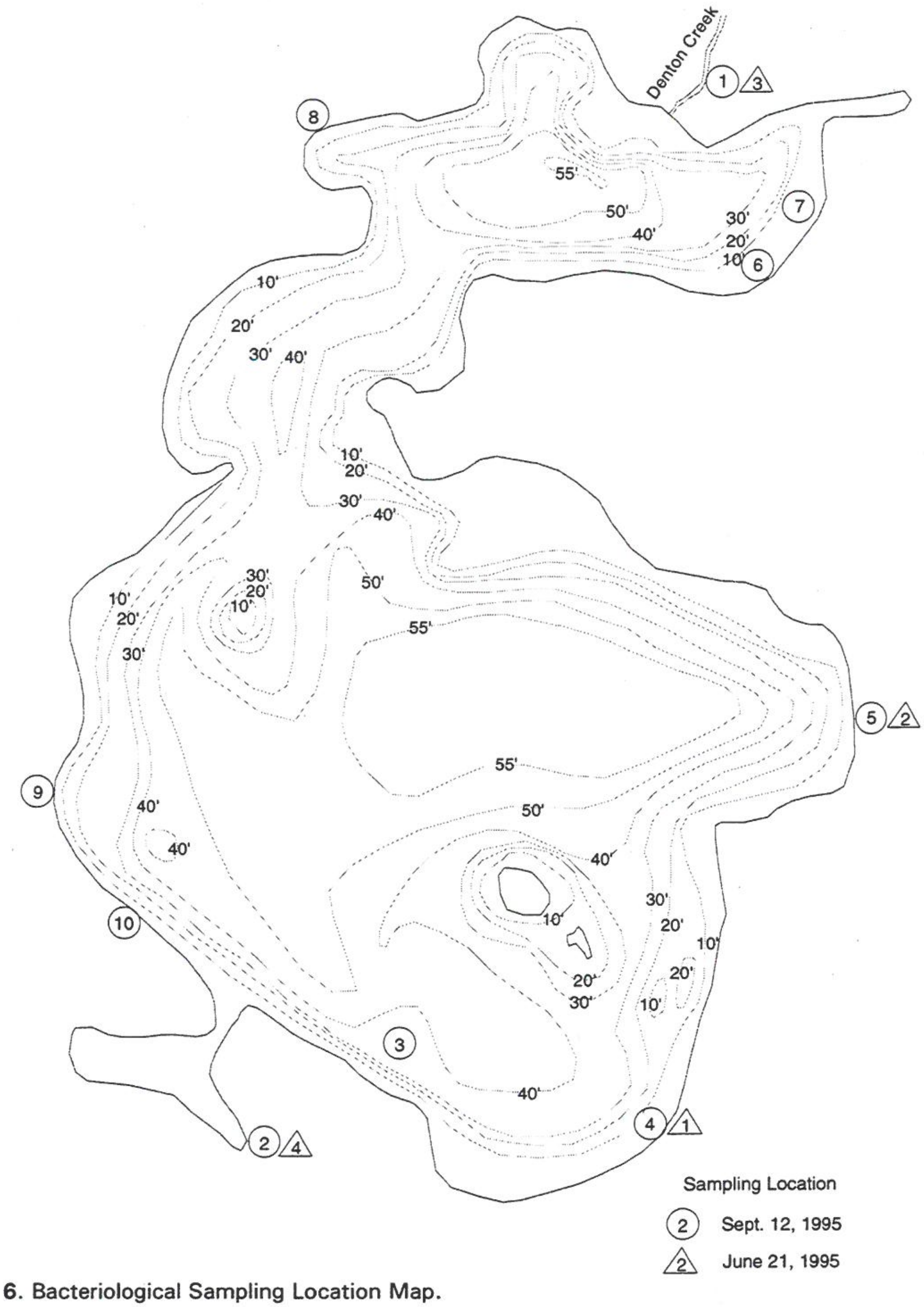


Figure 6. Bacteriological Sampling Location Map.

TABLE 5
RUNYAN LAKE
BACTERIOLOGICAL DATA

Site No.	No. Fecal Coliform/100 mL[1]
June 21, 1995	
1	334
2	167
3	0
4	234
5	23
September 12, 1995	
1	168
2	9
3	0
4	396
5	43
6	4
7	0
8	19
9	29
10	2

[1] mL = milliliters.

TABLE 6
DENTON CREEK
WATER QUALITY DATA

Date	Discharge (Cubic Feet per Second)	Total Phosphorus (μg/L)[1]
June 21, 1995	1.3	391
August 14, 1995	1.1	54
September 12, 1995	0.3	99

[1] μg/L = micrograms per liter = parts per billion.

AQUATIC PLANT CONTROL

Although an overabundance of undesirable plants can limit enjoyment of a lake, it is important to realize that aquatic plants are a vital component of aquatic ecosystems. They produce oxygen during photosynthesis, provide food and habitat for fish and other organisms, and help stabilize shoreline and bottom sediments. The objective of a sound aquatic plant control program is to remove plants only from problem areas where nuisance growth is occurring. Under no circumstance should an attempt be made to remove all plants from the lake.

The distribution and abundance of aquatic plants are dependent on several variables, including light penetration, bottom type, temperature, water levels, and the availability of plant nutrients. The term "aquatic plants" includes both the algae and the larger aquatic plants or macrophytes. The macrophytes can be categorized into four groups: the emergent, the floating-leaved, the submersed, and the free-floating.

Mechanical harvesting (i.e., plant cutting and removal) and chemical herbicide treatments are methods commonly employed to control aquatic plant growth. For large-scale aquatic plant control, harvesting may be advantageous over herbicide treatments since plants removed from the lake will not sink to the lake bottom and add to the buildup of organic sediments. In addition, some nutrients contained within the plant tissues are removed with the harvested plants. With the use of herbicides, treated plants die back and decompose on the lake bottom while bacteria consume dissolved oxygen reserves in the decomposition process. Since the plants are not removed from the lake, sediment buildup on the lake bottom continues, often creating a bottom substrate ideal for future aquatic plant growth.

In evaluating plant control alternatives, it should be noted that attempts to control certain plant types, such as Eurasian milfoil (*Myriophyllum* spicatum), by harvesting alone may not prove entirely effective due to the fact that the plant may proliferate and spread via vegetative propagation (small pieces break off, take root, and grow) if the plant is cut. Eurasian milfoil is especially problematic in that it often becomes established early in the season and can grow at greater depths than most plants. Once introduced into a lake system, Eurasian milfoil may out-compete more desirable plants and become the dominant species.

AQUATIC PLANT CONTROL

Aquatic plant surveys of Runyan Lake were conducted on June 21, August 14, and September 12, 1995. Plant types observed during the surveys included:

Common Name	Scientific Name
Native milfoil	*Myriophyllum heterophyllum*
Curly-leaf pondweed	*Potamogeton crispus*
Thin-leaf pondweed	*Potamogeton* sp.
Broad-leaf pondweed	*Potamogeton amplifolius*
Waterweed	*Elodea canadensis*
Bladderwort	*Utricularia vulgaris*
Richardson's pondweed	*Potamogeton richardsonii*
Illinois pondweed	*Potamogeton illinoensis*
Coontail	*Ceratophyllum demersum*
Sago pondweed	*Potamogeton pectinatus*
Southern naiad	*Najas flexilis*
Flat-stem pondweed	*Potamogeton zosteriformis*
Wild celery	*Vallisneria americana*
Muskgrass	*Chara* sp.

A diagram of many of the above-listed plants is included in Appendix C. It is noteworthy that Eurasian milfoil was not observed in Runyan Lake during the summer of 1995 although it was detected in an earlier survey of the lake (Freshwater Physicians 1979). (As discussed previously, Eurasian milfoil is a problem plant in that it has the ability to spread rapidly by fragmentation and often forms thick mats at the lake surface.) With the exception of the cove at the southwest end of the lake and the canal at the north end, nuisance plant growth in Runyan Lake is limited to a narrow shelf immediately adjacent to the shoreline, an area comprising approximately 25 acres. (The cove and canal areas are excavated wetlands which now create ideal substrate and conditions for aquatic plant growth.) In recent years, herbicide treatments of the lake have been performed for aquatic plant control. Assuming that Eurasian milfoil does not become reestablished in the lake, it is recommended that mechanical harvesting of vegetation (in conjunction with limited herbicide treatments of shallow water areas) be considered for Runyan Lake. This approach would help to maximize the amount of plant biomass removed from the lake and would slow the rate of sedimentation at the lake bottom. Contract harvesting generally ranges from $150 to $200 per acre. It is further recommended aquatic plant surveys be conducted on an annual basis during spring and summer to determine the type and location of plants in the lake. This information would allow infestations of Eurasian milfoil (and other nuisance species) to be detected and would allow appropriate plant control alternatives to be evaluated.

BEACH CONSTRUCTION

Currently, conditions along much of the near-shore bottomlands of Runyan Lake are less than ideal for swimming and other recreational activities. Near-shore conditions and recreational activities afforded by the lake could be markedly improved if lakefront property owners opted to construct swimming beach areas adjacent to their respective properties. Beaches could be constructed by cleaning, stabilizing, and possibly placing sand at select swimming locations. It is important to remember that shoreline areas are vital for fish and wildlife. Residents should limit beach size in order to preserve and protect as much natural area as possible--both on shore and in the lake.

Areas being considered for beach construction should first be cleared to remove accumulated debris. Once adequately cleaned, the beach area can be overlain by a gas-permeable filter fabric to stabilize the bottom and to provide a relatively firm bottom substrate. (The filter fabric must be gas-permeable so that gasses naturally produced in the lake sediments do not float the fabric to the surface.) Once secured in place, the filter fabric may be covered with clean, washed beach sand; or, in some instances, the fabric is left uncovered to inhibit aquatic plant growth. Depending on the extent of use of the beach areas, periodic maintenance may be required to ensure optimum conditions are maintained.

Pursuant to provisions of P.A. 451 of 1994, the Natural Resource and Environmental Protection Act, Part 301, Inland Lakes and Streams, a permit must be acquired from the Department of Environmental Quality (DEQ) for beach construction. If the proposed beach area is less than approximately 2,500 square feet, requires less than 300 cubic yards of fill sand, and is constructed in less than four feet of water, the DEQ may classify the work as a minor activity. The minor activity classification can expedite the usual four-month to six-month DEQ permit acquisition process.

Cost estimates for the construction of beach areas as described above range from $1.50 to $1.75 per square foot. It is recommended that lake residents who desire to implement beach improvements develop site specific construction plans and submit the appropriate permit application to the DEQ.

WATERSHED MANAGEMENT

Effective management of the Runyan Lake watershed to reduce pollution inputs is critical to improving and protecting lake water quality over the long term. It is important to note that, once introduced into a lake, phosphorus can generate several hundred times its weight in plant biomass. Given the fact that Runyan Lake has a relatively long water residence time (i.e., it takes several years for the volume of water in the lake to be flushed by incoming waters), the lake is very sensitive to pollution inputs. Once a pollutant such as phosphorus is introduced into the lake, it will take several years for the pollutant to be flushed out and perhaps many more years for the lake to show signs of recovery. Watershed management, by its nature, is an ongoing process which requires continued vigilance and effort.

A review of historical aerial photographs of the Runyan Lake area (Figures 7 thru 9) reveals that development around the lake increased dramatically between 1940 and 1980. In 1940, Runyan Lake had only about 75 homes around the lake and the Fenton Highway (west of lake) was still under construction. By 1955, the lake perimeter contained approximately 120 homes and in 1957, U.S. 23 was constructed immediately west of the lake. The construction of U.S. 23 greatly increased the accessibility of Runyan Lake and thus made it more attractive for residential development. The excavation of the cove at the southwest end of the lake and the canal at the northeast corner of the lake occurred between 1955 and 1963. By 1980, approximately 180 homes bordered the lake and, at present, 226 homes abut the lake. Thus, in a 56-year period, shoreline development around Runyan Lake increased by 200 percent. As natural groundcover and wetlands in the area were replaced by roof tops, roads, and other impervious surfaces, water runoff to the lake increased as the quality decreased. Clearly, this has had a direct impact on the quality of Runyan Lake especially in the near-shore areas where excessive aquatic vegetation is most prevalent.

The construction of a sewer system around Runyan Lake was an important first step in curbing nutrient inputs to the lake. However, given the density of development immediately adjacent to the lake, runoff from residential lands appears to be the major controllable source of phosphorus loading to Runyan Lake. The amount of phosphorus transported to the lake in residential runoff could be substantially reduced if vegetative buffer strips (i.e., greenbelts) were established around the lake perimeter and the use of lawn fertilizers containing phosphorus was curtailed by area residents.

Sediment and nutrient inputs resulting from future development and construction activities in the Runyan Lake watershed are another potential source of pollution to the lake. A review of the Tyrone Township Comprehensive Plan (Planning and Zoning Center, 1993), revealed that much of the lake's watershed is designated as suburban residential in the Future Land Use Plan. Given the proximity of the City of Fenton and the rate of urbanization regionally, this designation could lead to a substantial increase in residential construction in the watershed, which in turn, could adversely impact the water quality of Runyan Lake. Part 91 of Act 451 of 1994, the Natural Resources and Environmental Protection Act, requires a permit from the local Soil Erosion Control Officer, for construction activities which disturb one acre or more or are within 500 feet of a lake or stream. The local Soil Erosion Control Officer for Livingston County is the Livingston County Drain Commissioner. Although this act is intended to provide regulatory protection against soil erosion and sedimentation, it is important for area residents to monitor area development for potential violations of the act. If suspicious activity is observed within the watershed, the Soil Erosion Control Officer should be contacted immediately.

Stormwater emanating from future development sites in the watershed is another major cause of concern. Often, as part of the subdivision review process, the drain commissioner will critique stormwater management proposals to ensure proper facilities are in place to protect receiving waters and properties. As new developments are proposed within the watershed, lake residents should inquire specifically about the stormwater management measures that will be employed to protect the quality of Runyan Lake. Another means of curbing nutrient and sediment loading to the lake would be for lake residents to request the establishment of riparian corridors or conservation easements along Denton Creek and other significant tributaries as development proposals are submitted. These areas would remain in an undeveloped state and act as buffers which would decrease the amount of pollutants entering Runyan Lake and its tributaries.

Wetlands within the Runyan Lake watershed are an essential component of the lake system. They provide valuable fish and wildlife habitat, and act to purify and filter pollutants from incoming waters. Pursuant to provisions of Part 303 of the Natural Resources and Environmental Protection Act (P.A. 451 of 1994), regulations exist that restrict the development and destruction of wetlands. However, lake residents should monitor development in the Runyan Lake watershed to help ensure excessive encroachment of area wetlands and the loss of valuable wetland functions does not occur.

Since no regulations are in place, either locally or state-wide, which specifically address the issue of eutrophication from watershed runoff, a watershed management program for Runyan Lake must rely largely on the efforts of area residents. In order to achieve the greatest level of effectiveness, a program should be established to promote the dissemination of information on watershed management practices and concepts. The program should address sources of pollution from existing development as well as potential sources of pollution from future development. The program is proposed to include:

- The publication of a lake protection guidebook for mailing to all lake residents. The guidebook would focus on watershed management issues and would contain the following:
    - Information regarding proper lakeside lawncare and landscaping practices.

  - Information on wetland locations, functions, values, and regulations.
  - Information on Runyan Lake's water quality.
  - Guidance on how to limit the introduction of invader species such as Zebra mussels and Eurasian milfoil.

- Active involvement by representatives of Runyan Lake in local land use planning and zoning. As development proposals are submitted to the Township for review, issues such as retention of vegetative ground cover along stream corridors, stormwater management, and soil erosion control should be examined and discussed.
- Monitoring of development within the watershed to ensure compliance with environmental protection statutes.

Figure 7. Runyan Lake area, 1940.

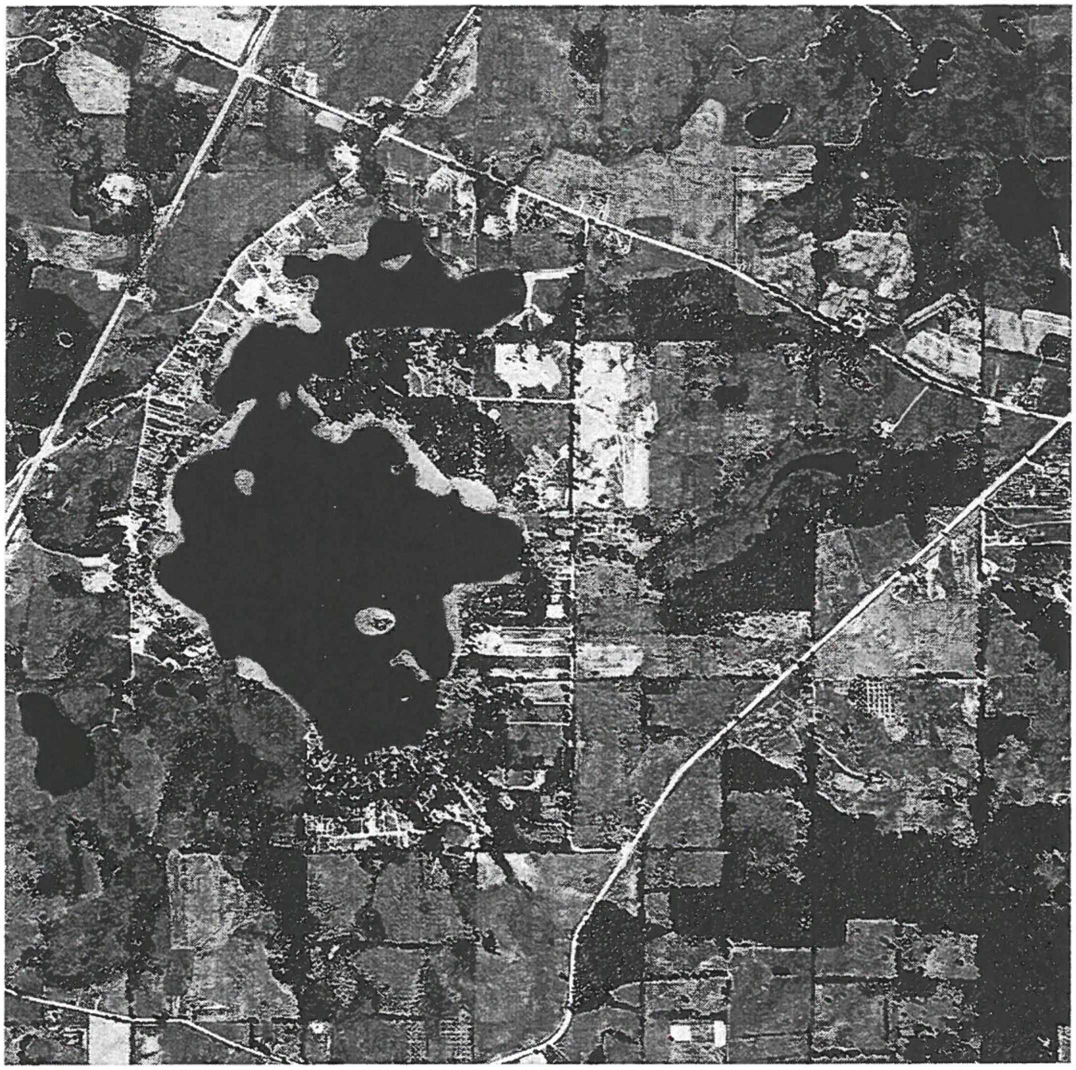


Figure 8. Runyan Lake area, 1955.

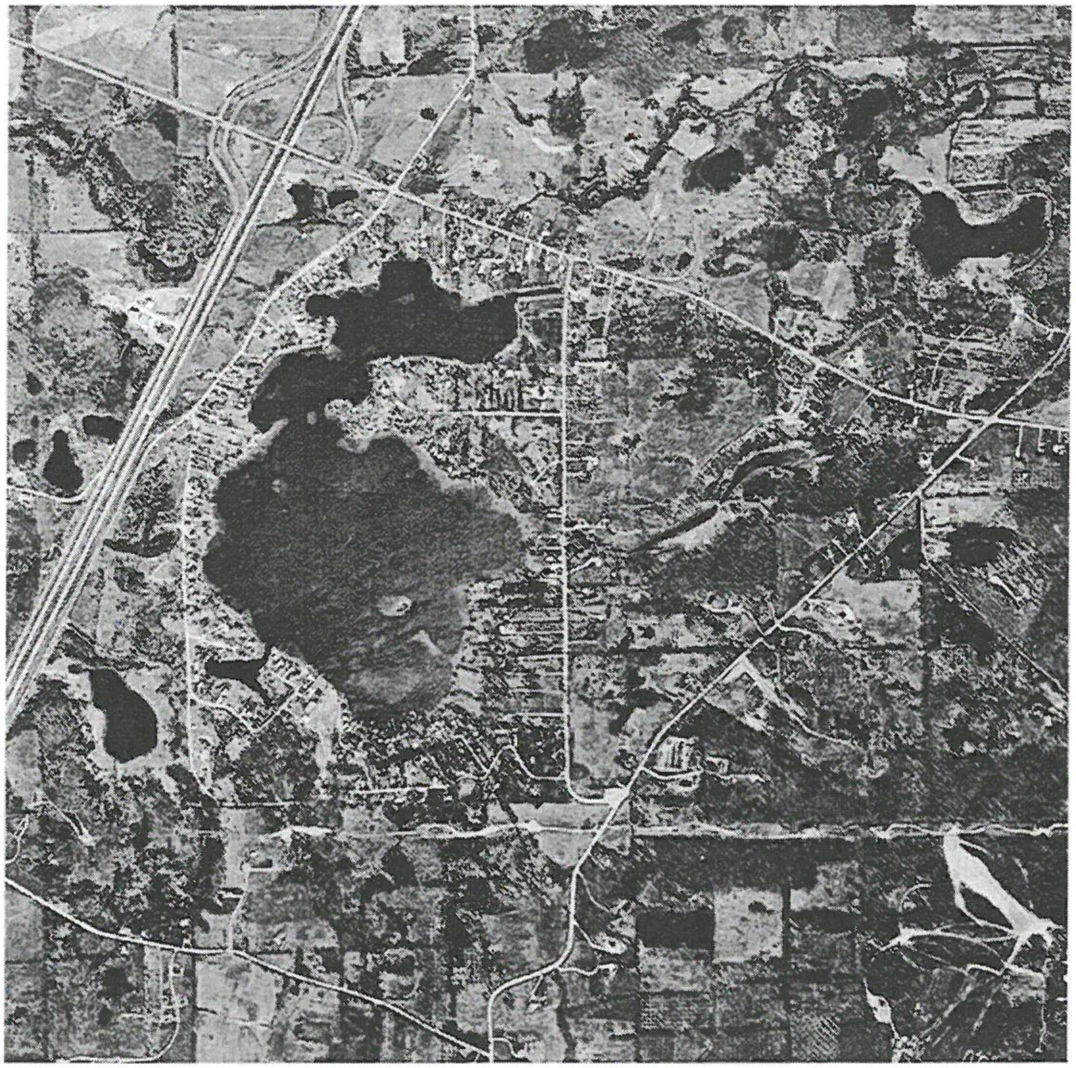


Figure 9. Runyan Lake area, 1980.

LAKE CARRYING CAPACITY

In order to avoid multi-use conflicts and the safety problems associated overcrowding, the concept of a lake's carrying capacity should be consid addressing lake access and lake use issues. For the purpose of this r discussion of lake carrying capacity will focus on the lake's ability to acc boats without compromising safe recreational use.

In recent years, keyhole or funnel development has become a conce communities. Funneling occurs when a waterfront lot is used to permit a larger development located away from the lake. Funneling allows a large individuals to gain access to the lake through a small corridor of lake Unregulated funnel development has the potential to create a number o including land use conflicts; unsafe and inadequate access; boating accide lake congestion; degradation of the environment; and decreased proper Recently, two Michigan Supreme Court decisions supported local control rights (e.g., boat dockage). Square Lake Condominium Assoc. v Bloomfield 437 Michigan 310 (1991) upheld local control through police power (n ordinances while Hess v Charter Township of West Bloomfield, MSC Case N filed May 22, 1992, upheld local control through zoning.

In estimating the carrying capacity of a lake, a number of variables considered. Key factors to be evaluated include lake surface area, wa existing development pressure, the number and type of access sites, and t of riparian property owners. Currently, 226 homes border Runyan Lake. 1995, 218 motorized boats (including personal watercraft) and 122 non boats were moored on Runyan Lake.

For every lake, there is a portion of the lake that is not suitable for high-spe and, therefore, this area should be removed from the carrying capacity c What remains is the useable lake area. In accordance with the Marine Safet 303 of 1967:

> A person shall not operate a motorboat on the waters of this state speed greater than slow no-wake speed or the minimum speed neces for the motorboat to maintain forward movement *when within 100 of the shoreline where the water depth is less than 3 feet*, as determ by vertical measurement, except in navigable channels not other posted (Section 72a(3); emphasis added).

> Persons operating vessels on the waters of this state...*shall mainta distance of 100 feet from any dock, raft, buoyed or occupied bat area, or vessel moored or at anchor*, except when the vessel is procee at a slow-no wake speed or when water skiers are being picked u dropped off... (Section 75; emphasis added).

In the case of Runyan Lake, the area within 100 feet of the shoreline is 44 acres. Therefore, the remaining useable area of Runyan Lake is 130 acres.

Despite widespread interest in lake carrying capacity, there have been very few scientific studies to determine optimum boating density. Most reported figures are based on the authors' personal opinions, though many may be considered expert. In a study of carrying capacity and lake user attitudes for Cass, Orchard, and Union Lakes in Oakland County, Ashton (1971) determined optimum boating density ranges of five to nine acres per boat, four to nine acres per boat, and six to 11 acres per boat for the three lakes, respectively. Jaakson et al. (1989) studied three lakes in north-central Saskatchewan and determined the following boating densities: 20 acres each for motorboat cruising and water skiing; ten acres for fishing (from a boat); and eight acres each for canoeing, kayaking, and sailing. Warbach et al. (1994) concluded that approximately 30 acres per motor boat (greater than five horsepower) is an appropriate boat density. Based on these findings, a density of 10 acres per boat appears appropriate as the optimum boating density for Runyan Lake. With a useable lake area of 130 acres, Runyan Lake can safely accommodate a maximum of 13 boats at any given time.

Although it is possible to determine an optimum boating density as described above, all of the boats that can use the lake do not use the lake at the same time. In other words, only a fraction of the maximum number of boats that have access use the lake at any given time. For example, on peak use days such as the Fourth of July, a lake may be utilized for boating by 25 percent of the area homeowners at the same time. Or, on weekdays, the lake may be utilized by only a small fraction of area homeowners at a given time. Thus, in evaluating carrying capacity, the lake use rate must be considered. According to a study by the Lake Charlevoix County Planning Commission, peak lake use rate is estimated at 10 percent of the total number of boats that have access to the lake. For Runyan Lake, the current peak boating density is estimated to be 10 percent of 226 households at 1.5 boats per household, or a total of 34 boats potentially using the lake during peak use periods such as summer holidays and weekends. Thus, for Runyan Lake, the estimated peak boating density of 34 boats greatly exceeds the carrying capacity of 13 boats.

In light of these considerations, it is strongly recommended that lake residents continue to work with Tyrone Township to adopt ordinances or zoning provisions that regulate funnel-type development and the number of boats moored on Runyan Lake. These activities can be regulated pursuant to provisions of P.A. 246 of 1945, the Township Ordinance Act or P.A. 184 of 1943, the Township Rural Zoning Act. Restrictions on lake use (such as limiting hours of high speed boating) are generally adopted in accordance with the P.A. 303 of 1967, the Marine Safety Act.

RECOMMENDED MANAGEMENT PLAN

Study findings indicate the water quality of Runyan Lake is generally good. The lake maintains a healthy diversity of aquatic plants although there are isolated areas in which nuisance plant growth is occurring. The construction of the sewer system around the lake in the late 1980's has had a positive impact on overall water quality conditions.

Since the initial settlement of Runyan Lake as a resort area began in the 1940's, most of the land adjacent to the lake has been converted to residential development. Today, over 225 cottages and year-round homes border the lake. Currently, surface water drainage from developed shoreland areas appears to be the largest controllable source of lake pollution. Proper management of these lands to control pollution runoff is critical to long-term water quality protection. As additional development occurs in the Runyan Lake watershed, wetland protection and stormwater management issues will take on greater importance.

With the advent of high-speed boats and personal watercraft, congestion on the lake is becoming a problem. Steps need to be taken to ensure future development in the area does not overburden the lake.

In light of these considerations, the management plan for Runyan Lake is proposed to include the following:

- A water quality monitoring program to better discern water quality conditions.
- The control of nuisance aquatic vegetation via the limited use of herbicides and mechanical harvesting.
- The construction of swimming beaches by individual property owners.
- The preparation of a lake protection guidebook for lake residents which would include information on Runyan Lake and its watershed, lake water quality, lakeside landscaping and lawn care, wetland protection, invader species control, and watershed management techniques to protect water quality.
- Active involvement by representatives of Runyan Lake in local planning and zoning decisions.
- The enactment of an ordinance to regulate future access to the lake.

APPENDIX A

QUESTIONNAIRE RESULTS

RUNYAN LAKE

QUESTIONNAIRE RESULTS

1. HOW LONG HAVE YOU HAD AN OPPORTUNITY TO OBSERVE THE LAKE?

	TOTAL RESPONSES	PERCENT
Less than 1 year	3	4
1 to less than 5 years	11	13
5 to less than 10 years	16	20
10 to less than 15 years	10	12
15 to less than 20 years	3	4
20 or more years	39	48

2. WHAT PROBLEMS EXIST ON THE LAKE THAT YOU WOULD LIKE TO SEE ADDRESSED IN THE STUDY?

	TOTAL RESPONSES	PERCENT
Excessive rooted plant growth	49	60
Excessive algae growth	26	32
Poor water clarity	20	24
Congestion on the lake	24	30
Submerged objects	3	4
Soft sediments	32	39
Other	10	12

3a. DO YOU FEEL THE LAKE IS BEING POLLUTED?

	TOTAL RESPONSES	PERCENT
Yes	39	48
No	18	22
Don't know	25	30

3b. WHAT DO YOU THINK ARE THE MAJOR SOURCES OF POLLUTION?

	TOTAL RESPONSES	PERCENT
Agricultural runoff	17	21
Residential runoff	39	48
Storm sewer discharges	16	20
Other	17	21

4. WHAT USES DO YOU MAKE OF THE LAKE?

	TOTAL RESPONSES	PERCENT
Swimming	77	94
Fishing	56	68
Boating	82	100
Water skiing	51	62
Other	10	12

5. WHEN IS YOUR HOME USUALLY OCCUPIED?

	TOTAL RESPONSES	PERCENT
All year	59	72
Part of the year	22	27
Other	1	1

6a. DO YOU FERTILIZE YOUR LAWN?

	TOTAL RESPONSES	PERCENT
Yes	28	34
No	54	66

6b. HOW OFTEN DO YOU APPLY FERTILIZER?

	TOTAL RESPONSES	PERCENT
Seldom (2 to 5 years)	5	18
Once a year	14	50
More than once a year	9	32

7. WHAT TYPE OF REGULATIONS DO YOU FAVOR FOR PROTECTING WETLAND AREAS AROUND THE LAKE?

	TOTAL RESPONSES	PERCENT
No regulations	4	5
Moderate regulations	41	50
Strict regulations	37	45

8. WOULD YOU SUPPORT A PROGRAM THAT PROMOTES THE USE OF PHOSPHORUS-FREE LAWN FERTILIZERS AROUND THE LAKE?

	TOTAL RESPONSES	PERCENT
Yes	78	95
No	4	5

9. WOULD YOU SUPPORT A VOLUNTARY PROGRAM THAT PROMOTES THE ESTABLISHMENT OF SHORELINE VEGETATIVE BUFFERS IN APPROPRIATE LOCATIONS AROUND THE LAKE PERIMETER?

	TOTAL RESPONSES	PERCENT
Yes	58	71
No	24	29

10. ARE YOU A FISHERPERSON?

	TOTAL RESPONSES	PERCENT
Yes	48	59
No	34	42

APPENDIX B

WATER QUALITY

APPENDIX C

COMMON AQUATIC PLANTS

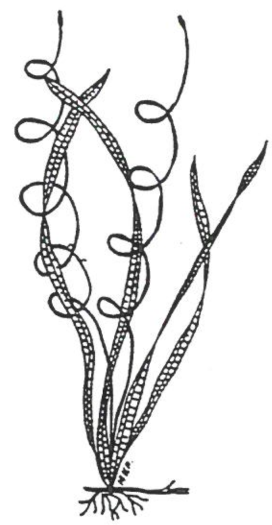
Chara

Clasping-leaf Pondweed

Coontail

American elodea

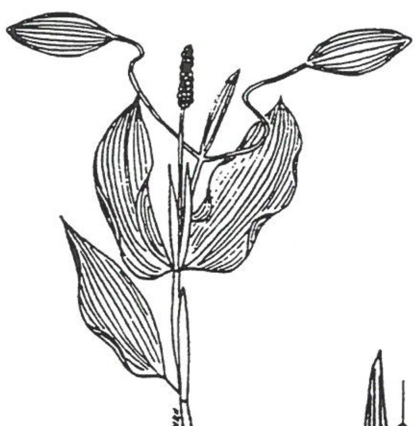
Watermilfoil



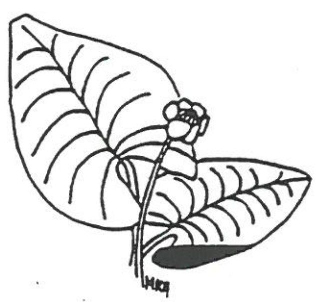
Wild Celery

Floating-leaf Pondweed

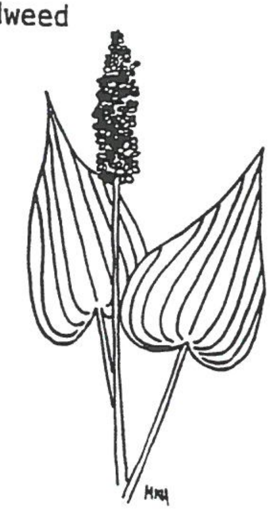
Curly-leaf Pondweed



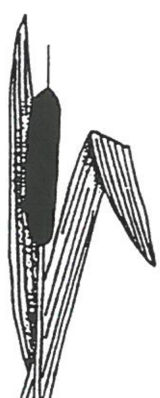
Large-leaf Pondweed



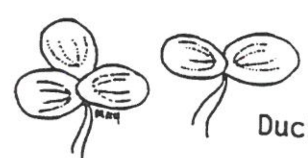
Yellow Water Lily



Pickerelweed



Cattail



Duckweed
3x actual size

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