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Water

EPA

Environmental Impact Statement

Final

Moose Lake-Windemere Sanitary District Wastewater Treatment System Pine and Carlton Counties, Minnesota

EPA-5-MN-PINE/CARLTON-MOOSE LAKE-SAWS-83

FINAL ENVIRONMENTAL IMPACT STATEMENT

on the

PROPOSED WASTEWATER TREATMENT SYSTEM

for the

MOOSE LAKE-WINDEMERE SANITARY DISTRICT

PINE and CARLTON COUNTIES, MINNESOTA

Prepared by the

United States Environmental Protection Agency

Region V

Chicago, Illinois

and

WAPORA, Inc.

Chicago, Illinois

October 1983

Approved by:

Alan Levin

ALAN LEVIN

ACTING REGIONAL ADMINISTRATOR

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ABSTRACT

The Moose Lake-Windemere Sanitary District (MLWSD) has proposed constructing collection sewers around Island and Sturgeon Lakes, Windemere Township, Pine County, Minnesota. The wastewater would be treated in the Moose Lake wastewater treatment plant. Both lakes currently have surrounding residential development served by on on-site treatment systems. The US Environmental Protection Agency (USEPA) determined that an Environmental Impact Statement was needed for the proposed project because of the potential environmental impacts associated with the construction of collection sewers, the possible financial burden resulting from the proposed project on low and fixed-income residents, and the possibility for the proposed wastewater collection systems to induce growth. The operation of existing on-site systems was investigated. Of the 151 on-site systems in use around Island Lake, 45 were classified as either "definitely" or "probably" failing. For Sturgeon Lake, 13 of the 143 total systems were classified as probably failing. Two lake sampling programs were conducted to investigate the relationship between lake water qualty and nutrient inputs from failing or inadequately operating on-site systems. Surface water, groundwater, and lake sediment core samples were obtained and analysed. Phytoplankton species composition and abundance was documented. Historical land use characteristics within the lake watersheds also were investigated. Analysis of the data indicated that the nutrient contributions of on-site systems to the lakes were insignificant compared to other non-wastewater sources. Seven wastewater treatment alternatives, including a no-action alternative were evaluated for cost-effectiveness and environmental impact. Each action alternative consisted of various combinations of design components including on-site systems upgrades, collection system options, and treatment plant options. The selected EIS alternative is the full on-site system upgrade alternative which has an estimated present worth cost of $1.01 million. In comparison, the EIS alternative of constructing collection sewers around Island and Sturgeon Lakes with treatment provided at an upgraded Moose Lake treatment plant had a present worth cost of $4.61 million.

SUMMARY OF THE EIS

1.0. PURPOSE AND NEED FOR ACTION

The project area encompasses an area surrounding Island Lake, Sturgeon Lake, Rush Lake, and Passenger Lake in Windemere Township, Pine County, and in Moose Lake Township, Carlton County, Minnesota. This project area is located within a larger planning area that includes the City of Moose Lake and the City of Barnum.

Wastewater collection and treatment within the planning area is provided by the two cities and by the Moose Lake-Windemere Sanitary District (MLWSD). The Sanitary District's boundaries include the unincorporated portion of Moose Lake Township and Windemere Township (Figure 1-1). The project area addressed in this report is within the MLWSD's boundaries. The residential development around the four lakes within the project area (Island, Sturgeon, Rush, and Passenger) now relies exclusively on on-site systems for wastewater treatment. Residential growth around these project area lakes, particularly Island and Sturgeon Lakes, has led to increased recreational use of the lakes and, consequently, increased concern over lake water quality. Specifically, area residents have indicated a concern over water quality degradation and blue-green algae blooms as a result of on-site systems around the lakeshores.

In 1979, the MLWSD contracted with Consoer, Townsend & Associates LTD. to prepare a "201 Step 1" Facilities Plan for overall wastewater collection and treatment facilities within the District. Funding for this planning effort was shared 75% by the Federal government (through USEPA), 15% by the State of Minnesota (through the Minnesota Pollution Control Agency [MPCA]), and 10% by the District. Among the wastewater management component options considered were the construction of collection sewers around Island and Sturgeon Lake; interceptor sewers and pump stations to bring Island Lake and Sturgeon Lake into the Moose Lake sewer system; a new pump station; a wet weather overflow pond; and expansion of the existing City of Moose Lake wastewater treatment facility.

In 1980, the City of Barnum contracted with Howard A. Kuusisto Consulting Engineers to prepare a "201 Step 1" Facilities Plan for the City. The City of Barnum contributed 10% of the total cost of the Facilities Plan and the remainder was shared by USEPA and MPCA in the same proportions as for the MLWSD. The Barnum Facilities Plan evaluated seven alternatives and recommended construction of a stabilization pond with controlled discharge to Gillespie Brook west of the City of Barnum.

USEPA reviewed the MLWSD Facilities Plan in accordance with Federal regulations (40 CFR, Part 6) and determined that the preparation of an Environmental Impact Statement (EIS) was warranted because of the:

- Possible impact of the project on water quality
- Potential adverse socioeconomic impacts
- Potential for centralized collection and treatment systems to induce growth with attendant secondary impacts.

These issues were identified in the 11 July 1980 Notice of Intent to prepare an EIS. Specifically, USEPA determined that an EIS is needed because there was inadequate documentation in the Facilities Plan supporting the need to provide sewers around Island Lake and Sturgeon Lake and the high probability that the project proposed in the Facility Plan could have significant adverse socioeconomic impacts because of the number of families in the service area with fixed or low incomes.

In order to expedite the EIS process, USEPA determined that the preparation of the EIS would be in two phases. Phase I culminated in March 1981 with the publication of two reports: A Current Situation Report and a Regional Alternatives Analysis. The Regional Alternatives Analysis Report examined the alternatives presented in the MLWSD and Barnum Facilities Plans and evaluated the cost effectiveness of including the City of Barnum and the corridor between the Cities of Moose Lake and Barnum as a component of a regional collection and treatment alternative. The Current Situation Report described those aspects of the natural and man-made environment likely to be affected by the various facilities planning alternatives proposed in the MLWSD and Barnum Plans.

Following the completion of Phase I of the EIS Process, a Citizens Advisory Committee (CAC) meeting and a public information meeting were held to review the two reports. Area residents expressed concern with the quality of the published data used to develop the reports, as well as other issues which they felt were not adequately supported or addressed in the Phase I reports.

Phase II (completion of the EIS) addresses these public concerns and data deficiencies which were identified in the review of the Phase I reports. Phase II includes the preparation of Draft and Final Environmental Impact Statements (DEIS and FEIS) on the proposed wastewater management alternatives for the area of most critical need within the Moose Lake-Windemere Sanitary District.

2.0. EXISTING CONDITIONS

Natural Environment

The EIS includes very detailed information on the surface water resources and aquatic biota of the project area. During EIS preparation, a sampling program was conducted to provide additional data on water quality in the four lakes and to provide information for evaluating alternative wastewater management proposals. Water quality was measured in Island, Sturgeon, Rush, and Passenger Lakes.

The water quality sampling data from the summer and fall of 1982 and winter of 1982 were used to evaluate the existing fertility and trophic status of the lakes and to determine the cause of observed blue-green algae blooms. Sediment sampling data were used to evaluate the historic fertility and trophic status of the lakes and to evaluate whether there is a historical correlation between shoreline development and the algae bloom problems in Island Lake. The following conclusions were drawn concerning the water quality and trophic status of Island Lake, Sturgeon Lake, Rush Lake and Passenger Lake:

- Island Lake and Sturgeon Lake both are eutrophic and may be in need of management to improve or to protect existing water quality. Rush and Passenger Lakes are mesotrophic and do not require management to maintain or improve water quality.

- The significant sources of phosphorus to the four lakes are not associated with on-site wastewater systems. The amount of phosphorus moving into any of the four lakes from failing septic systems is probably only a small fraction of what is being delivered to those failing systems by domestic wastewater.

- During the summer, Island Lake was found to have significantly higher phytoplankton productivity, more severe blue-green algae blooms, and lower hypolimnetic dissolved oxygen than Sturgeon Lake. It was concluded that these conditions in Island Lake were due to a large nutrient load originating from non-wastewater sources in the watershed, and that these problems are amplified by the Lake's shallowness and variable wind fetch. Biotic interactions resulting from changes in the population of plankton-eating fish in Island Lake also may have contributed to algal bloom problems.

Because of public concerns about blue-green algae blooms in the lakes, and the possibility of algal toxicity, a special report on phytoplankton populations was included in the Phase I study. Topics covered included phytoplankton ecology in late summer and early fall, the potential presence of toxicity producing blue-green algal species, a description of the location of beds of aquatic macrophytes, and a summary of MDNR fish management survey data for Island and Sturgeon Lakes.

Based on phytoplankton sampling data collected during the lake sampling, and a review of existing public health data, the following conclusions were made:

- As with all eutrophic lakes in Minnesota, Island Lake has the potential to develop a health hazard associated with blooms of blue-green algae. However, the dominant blue-green algae in Island Lake in 1982 was Anabaena macrospora, which a review of the literature indicates is not directly associated with toxicity.

- Blue-green algae do not appear to pose a potential threat to public health in Sturgeon, Passenger, or Rush Lakes. These lakes were found to support lower overall concentrations of blue-green algae and did not experience blue-green growth to bloom proportions.

- Island Lake had the highest algae density of the four lakes and also had the poorest water clarity. In August non-blue-green algae was dominant. In early September, the concentrations of non-blue-green algae species declined while two species of blue-green algae increased in number and achieved total dominance.

- Sturgeon Lake had better water clarity than Island Lake, primarily because blue-green algae were much less abundant. However, blue-green algae were the dominant phytoplankton group in Sturgeon Lake throughout September.

- Passenger Lake had relatively low volumes of algae and, in particular, very low volumes of blue-green algae compared to both Island and Sturgeon Lakes. The relatively low clarity of Passenger Lake was attributed to other factors such as dissolved and suspended organic matter.

- Rush Lake had the lowest abundance of phytoplankton of the four lakes tested and had the greatest water clarity.

- Local citizens have not reported problems with swimmers itch in Sturgeon, Rush or Passenger Lakes. One instance was reported on Island Lake in 1981. Health officers, physicians, and veterinarians contacted reported no public health problems related to swimming in or drinking from the project area lakes.

Man-made Evironment

The EIS presents information on the man-made environment in the project area including population, land use, economics, public finance, transportation, energy, recreation and tourism, and cultural resources. The major element of the man-made environment that will affect decisions concerning wastewater management is the existing and future population for the project area.

Existing (1980) and historic population and housing data was obtained from US Bureau of the Census. Prior to 1960, population growth in Windemere Township and in Moose Lake Township was erratic. Since 1960, however, the number of housing units in the two townships increased steadily, often at a greater rate than population growth. For example, between 1960 and 1970 the number of housing units in Windemere Township increased by 89.2%

while the population increased by only 36.6%. The substantial increase in the number of housing units is indicative of the high local demand for recreational homes because of the amenities associated with the lakefront property in the Township. Between 1970 and 1980, the number of housing units in Windemere Township increased by 59.3% while the population increased by 79.1%. This reversal of the preceeding decade's trend (1960 to 1970) appears to be indicative of the recent national trend of net migration from urban to rural areas. Rural areas were attractive during the 1970s for a variety of reasons that have been widely documented, including lower land values, the amenities of "country life," and an absence of "urban" problems. This current trend of population increase is expected to continue in the project area, at similar or somewhat reduced rates for the reasons cited, and because of the area's perceived quality among retired people.

The population projections for the project area were made based on 1960, 1970, and 1980 census data and were developed from projections of the number of additional housing units that will be built in the project area by the year 2000. A housing unit projection methodology was used because the available data on housing units are of a similar quality as the available data on populations and because fewer extrapolations are required to estimate the future seasonal population than with a population projection methodology. The available census data on population within the Townships is for year-round residents only. Thus, estimates of the peak population (seasonal plus year-round) were derived by assigning an average household size of seasonal dwellings to the number of seasonal dwellings and combining the result with the projected number of year-round residents. The existing (1980) and year 2000 projected populations are presented in Table 1.

The individual Island Lake and Sturgeon Lake area population projections are significantly lower than the population estimates which are presented in the Draft MLWSD Facilities Plan. The "population equivalents" for the year 1995 that are presented in the Facilities Plan are 931.0 for the Island Lake vicinity and 1,382.5 for the Sturgeon Lake vicinity. The year 2000 population projections used in this report are 579 for the Island

Table 1. Seasonal and permanent population projections within Census Enumeration District 504-Windemere Township, 1980 to 2000

	1980			2000		
	Permanent	Seasonal	Total	Permanent	Seasonal	Total
Island Lake	153	261	414	200	333	579
Sturgeon Lake	100	465[a]	565	131	615[a]	802
Outlying Areas	76	51	127	98	63	174
Total ED 504	329	777	1,106	429	1,017	1,555

[a]An additional 120 seasonal residents are projected for the YMCA Boys Camp.

Lake area and 922 for the Sturgeon Lake area (including the YMCA Boys Camp summer population). The sources of the discrepancies between the Facilities Plan and these projections are thought to be:

- The year 2000 projections used in this EIS are based on detailed 1980 census data for the local area not available at the time the MLWSD Facilities Plan was prepared.
- The assumptions used to develop the projections in the EIS reflect a direct assessment of vacant, buildable lots in the lakeshore areas and interviews with local real estate sales offices.

3.0. WASTEWATER MANAGEMENT ALTERNATIVES

Needs Documentation

Wastewater treatment within the EIS project area currently is handled exclusively by on-site systems. Information on existing systems was gathered by a review of public tax rolls, USGS topographic maps and aerial photographs; by reference to information in the MLWSD Facilities Plan; and by two property owner surveys. Within the project area there are approximately 400 existing on-site systems. Septic tanks with soil absorption systems are the most common type of system in use (80%), followed by privies (10%), holding tanks (5%), and combination or "hybridized" systems (2%).

On-site systems that fail to function properly can cause backups in household plumbing, ponding of effluent on the ground surface, groundwater contamination that may affect water supplies, and excessive nutrients and coliform levels in surface water. USEPA Guidance requires that documented pollution problems be identified and traced back to the causal factors. Projects may receive USEPA grants only where a significant proportion of residences can be documented as having or causing problems. Eligibility for USEPA grants is limited to those systems for which there is direct evidence that indicates they are causing pollution or those systems that are virtually identical in environmental constraints and in usage patterns to documented failing systems.

USEPA determined from the Phase I reports and from review comments made by MPCA and the Citizens Advisory Committee that additional information was required prior to assessment of on-site waste treatment systems. The sources of information used in Phase II for evaluation of on-site systems include:

- A soil survey of the EIS project area.
- Information provided in the MLWSD Facilities Plan and by the MLWSD.
- Mailed questionnaire responses from property owners.
- A field survey of septic leachate sources to the lakes.
- A tabulation of Minnesota Department of Public Health well water quality data for critical lakeshore areas.
- Two color-infrared aerial photographic surveys of lakeshore areas designed to locate obvious septic leachate break throughs.
- Data contained in the permit files of the Pine County Sanitarian on recent on-site system construction and maintenance.
- A follow up survey to answer questions unanswered by the other surveys, including telephone interviews with property owners and site visits to assess current land use and development patterns.

Analysis of this information resulted in the classification of each existing on-site system into one of three categories:

- "Obvious problem"-Direct evidence of failure including such problems as backups, ponding, or ground or surface water contamination.
- "Potential problem"-Indirect evidence indicating that future failure is probable including high water table and tight soils where failures of older systems are documented.
- "No problem."

A thorough analysis of the available information indicated that certain shoreline areas around the lakes had a commonality of conditions which resulted in concentrations of systems with problems. In general, such areas were characterized by a high water table, tight soil, on-site system backups or ponding, groundwater moving toward the lake, and permit records documenting frequent system replacements. The number of existing onsite systems exhibiting obvious or potential problems is summarized below:

Area	1980 Residences	Obvious Problem	Potential Problem	No Problem
Island Lake	151	18	27	106
Sturgeon Lake	198	0	13	185
Rush and Passenger Lakes	19	0	0	19
Wild Acres and Hogans Acres	48	0	0	48

Wastewater Management Alternatives

Feasible and compatible sets of collection and treatment options were developed into project alternatives for the proposed EIS project area. The project alternatives represent combinations of on-site system options, centralized collection system options, and effluent treatment and disposal options. Seven project alternatives were developed and evaluated for technical feasibility, cost-effectiveness, and environmental concerns. These alternatives also include a No-Action Alternative (Alternative 1). Project Alternatives 2 through 7 are consecutively less comprehensive in providing major on-site system upgrades and consecutively more comprehensive in providing hookups of residences to centralized collection systems.

The EIS process must evaluate the consequences of not taking action. The No-Action Alternative implies that neither USEPA or MPCA would provide funds to build, upgrade, or expand existing wastewater treatment systems. If the No-Action Alternative is "implemented", existing on-site systems in the project area would continue to be used in their present conditions. Any changes or improvements in malfunctioning systems would be at the initiative and expense of either the property owner or a local government. Under the No-Action Alternative, additional holding tanks would be used on lots with site limitations, and existing problems would continue.

Alternatives 2 through 7 each consist of one or more component options including on-site system upgrades, cluster drainfields and centralized collection and treatment. Alternative 2 consists solely of upgrading on-site systems for the entire service area, Alternatives 3 through 6 include progressively fewer on-site upgrades and Alternative 7 includes very few on-site upgrades. Alternative 7 is almost exclusively a centralized wastewater management alternative.

The appropriate technology for upgrading existing on-site systems with obvious and potential problems was selected based on the best available information on soil characteristics, depth to groundwater, landscape slope, and lot size. The preferred major upgrade, where conditions permit, is the septic tank-soil absorption system with a serial-parallel trench system. Depending on lot limitations, the appropriate alternative on-site system would be selected. Alternative on-site systems include septic tank seepage beds, septic tank mound systems, and wastewater segregation. Where wastewater segregation was recommended, the graywater would continue to be treated with an existing or upgraded septic tank and soil absorption system. The blackwater treatment components would include a new low-flow toilet and a holding tank.

Alternatives 3 through 6 include cluster drainfields for limited lakeshore areas. These were designed based on soil conditions and on documented on-site system problems. Each cluster collection system would employ septic tank effluent pumps and pressure and/or gravity sewers for collection. Each cluster treatment system would consist of a dosing tank or pump station, and three drain fields to allow two of the fields to be used during the year while the third field was being rested.

Alternatives 4 through 7 include centralized collection and off-site treatment for: a portion of the Island Lake shoreline (Alternatives 4 and 5); the entire shoreline of Island Lake (Alternative 6); and the entire shoreline of both Island Lake and Sturgeon Lake (Alternative 7).

Conventional gravity, septic tank effluent gravity and septic tank effluent pressure collection systems were evaluated, and the most cost-effective selected for each alternative. Septic tank effluent gravity sewers were the most cost-effective for Alternatives 4 and 7, and septic tank pressure sewers were the cost-effective for other alternatives (Alternatives 5 and 6). Conventional gravity sewers were not cost-effective for any alternative.

The MLWSD Facility Plan evaluated three centralized treatment alternatives: upgrading the existing City of Moose Lake WWTP; construction of a new activated sludge WWTP; and construction of a new oxidation ditch WWTP. The MLWSD Facility Plan concluded that upgrading the existing Moose Lake WWTP was the most cost-effective alternative. The existing Moose Lake WWTP consists of seven facultative lagoons: 6 primary lagoons (43 acres total) and one secondary lagoon (15.2 acres). The existing permitted design capacity of the lagoon system is 444,000 gpd. However, because the centralized treatment proposed in the EIS alternatives would add significant flows to the system, MPCA has indicated that the maximum calculated capacity of the lagoon system would have to be reduced to 316,100 gpd to meet updated requirements (By telephone, Mr. Zdon, MPCA, to WAPORA, Inc., 15 July 1982). Costs for the EIS alternatives are based on the revised design criteria. There is adequate additional land adjacent to the site for a major expansion of the lagoon system.

Off-site wastewater treatment options considered in the EIS alternatives include upgrading the existing Moose Lake WWTP (Alternatives 4, 6, and 7), and a bog treatment system (Alternative 5).

The treatment of wastewater by a bog or peatland system is similar in approach to treatment by a cluster drainfield in that solids are retained in a septic tank and primary effluent is taken off-site and treated by a "soil" absorption system. In this case, peat is used rather than soil for treatment. Extensive areas of peatland are present in the project area. Some of these areas are in an unaltered or relatively "natural" state and others have been partially drained in an attempt to move water off surrounding lands. The peat bog area considered in Alternative 5 has previously been channelized for other drainage purposes to a depth of 1 to 2 feet.

The estimated total present worth costs for the build alternatives are presented in Table 2. Alternative 2, upgraded on-site systems, is the least cost alternative.

4.0. ENVIRONMENTAL AND FINANCIAL IMPACTS OF THE PROJECT ALTERNATIVES

The No-Action Alternative would entail almost no construction impacts. The significant environmental impacts of the six action alternatives would primarily be short-term impacts on the local environment due to construction.

The implementation of the on-site system component of Alternatives 3, 4, 5, 6, and 7 or the full on-site upgrade alternative (Alternative 2), would have direct impacts on those lots where upgraded on-site systems are necessary. Disruption of backyard vegetation and vacation schedules would be the primary concern.

Cluster drainfield and cluster mounds (Alternatives 3, 4, 5, and 6) would involve construction on the drainfield sites of a similar nature to that of the onsite upgrades.

The construction of centralized collection facilities (Alternatives 3, 4, 5, 6, and 7) would have considerable impacts on the right-of-way where the sewers are located. Dewatering for deep sewer excavations and pump stations could affect wells in the vicinity. WWTP construction (Alterna-

Table 2 Summary of the estimated costs for Project Alternatives 1 through 7 in March 1982 dollars.

	Total Present Worth[a]								
Alternative Number and Name	On-Site Upgrade	Cluster Drainfield[b]	Centralized Collection	Centralized Treatment[c]	Sub Total	Administrative[f]	Total	Average Annual Equivalant Costs	Cost Ranking
1 No-Action in EIS service area	-	-	-	-	-	-	-	-	NA
2 Upgrade on-site systems within EIS service area	726,100	-	-	-	726,100	286,790	1,012,890	100,300	1
3 Cluster drainfield for limited areas and on-site system upgrading elsewhere in EIS service area	575,000	985,220	-	-	1,560,220	286,790	1,847,010	182,900	2
4B Island Lake-limited area collection by STE gravity sewers and treatment at upgraded Moose Lake WWTP; Sturgeon Lake-cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	400,880	498,370	815,300	268,340	1,982,890	286,790	2,269,680	224,760	3
5B Island Lake-limited area collection by STE pressure sewers and peat bog treatment; Sturgeon Lake - cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	400,880	498,370	815,940	327,170	2,042,360	286,790	2,329,150	230,650	4
6C Island Lake entire shoreline STE pressure collection and treatment at upgraded Moose Lake WWTP; Sturgeon Lake - cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	271,010	498,370	1,475,590[d]	394,100	2,639,070	286,790	2,925,860	289,740	5
7B Island Lake and Sturgeon Lake shorelines STE gravity collection and treatment at upgraded Moose Lake WWTP; on-site system upgrading elsewhere in EIS service area.	89,710	-	3,616,080[e]	625,080	4,330,870	286,790	4,617,660	457,270	6

[a]Includes costs for on-site or off-site treatment of wastewater from existing and future residences in the EIS project area to the year 2000. See Appendix E for a description of cost development methodology.

[b]Includes STE pressure and gravity collection system

[c]Includes upgrading of existing lift station to Moose Lake WWTP

[d]For comparison, the estimated present worth cost of conventional gravity collection is $1,705,950 ($2,866,430 subtotal, $3,153,220 total, $312,250 Equiv. Ann.).

[e]For comparison, the estimated present worth cost of conventional gravity collection is $3,846,980 ($4,561,770 subtotal, $4,848,560 total, $480,140 Equiv. Ann.).

[f]Includes annual personnel and overhead costs for administration and billing.

tives 4, 6, and 7) would irretrievably convert prime agricultural lands to treatment plant use. Construction of a bog treatment system (Alternative 5) would have significant adverse construction and operational impacts on the biota of the site.

Discharges from the expanded Moose Lake WWTP to the Moose River would be required to meet the effluent requirements established by MPCA. Water quality would be altered, but not seriously degraded.

The centralized collection, treatment and disposal facilities would have a limited positive effect on groundwater quality by eliminating existing failing on-site systems. On-site upgrades and the continuing proper management of on-site systems would replace failing on-site systems with appropriate new systems or holding tanks through the 20 year design period.

Project Alternative 7 is a high cost system that could pose a significant financial burden on users even if State and Federal grants are available. Project Alternative 2 is the only alternative that would not pose a significant financial burden on users if no grants are available.

Project Alternatives 3 through 7 could have a significant secondary impact on low income families with residences on the shorelines of Island and Sturgeon Lakes. These families may be displaced from the project area if they are unable to afford user charges.

Based on a review of historical population trends and current and historical land use patterns, induced growth is not anticipated to be a significant trend with any of the project alternatives.

THE SELECTED PROJECT ALTERNATIVE

The Draft EIS, published March 1983, contained an evaluation of existing wastewater management needs. Centralized collection and treatment alternatives were re-evaluated. Several new wastewater collection and treatment modes were developed in an attempt to devise cost effective service for portions of the project area with the greatest need. Considerable emphasis was devoted to design and cost estimation for on-site waste management options because the potential to reduce costs was great.

Subsequent to issuance of the Draft EIS, a public hearing was convened before USEPA representatives at the Moose Lake High School on 10 June 1983. The hearing was held to take comments on the Draft EIS. Sufficient time was available at the hearing to answer most of the questions raised and to record responses. A public hearing record was taken by USEPA. The post-hearing comment period was extended to receive written comments.

This Final EIS was prepared in response to the comments received. It presents a selected EIS alternative. Most of the oral and written comments received called for additional explanation of facts used by USEPA in the decision making. Many oral comments were in regard to the possibilities for funding the recommended EIS alternative. Following consideration of the hearing record and the written responses from citizens and agencies, USEPA determined the Final EIS recommended action would be Alternative #2, the full on-site system upgrade project, with no additional centralized collection and treatment.

All the action alternatives will eliminate any existing impact on the lakes by eliminating failing on-site systems. However, evaluation of the existing data on the natural and man-made environment in the project area indicates that water quality impacts due to on-site systems are inconsequential in comparison with other manageable and unmanageable nutrient sources which influence the lakes. Thus, it is concluded that none of the action alternatives will significantly benefit the quality of the lakes or the groundwater.

The least cost alternative from both an economic and environmental perspective is Alternative #2 - on-site system upgrades for the entire project area. The beneficial environmental impacts of Alternative 2 include elimination of any phosphorus loads to the lakes that might be coming from failing on-site systems. Compared with the alternatives that include centralized collection and treatment, Alternative #2 is expected to have fewer construction impacts because extensive construction within road right-of-ways is not required. Alternative #2 is not expected to have impacts on the groundwater or lakes that are significantly different than the other action alternatives. Adverse construction impacts that might result in disturbance and erosion on individual lots can be mitigated with proper construction management practices. Alternative #2 is recommended as the selected project alternative because it is the least costly means of achieving the benefits cited. Alternative #2 has an estimated total present worth cost of $1,012,890.

The MLWSD Facilities Plan recommended gravity sewers be constructed around Island Lake and Sturgeon Lake with treatment at the Moose Lake WWTP upgraded to meet the additional demand. This recommendation is equivalent to EIS project option 7A (not an EIS project alternative). Option 7A was estimated on an EIS population served basis to have a total present worth cost of $4.8 million.

Another alternative under discussion by MLWSD is a gravity collection system for Island Lake only, with treatment at the Moose Lake WWTP upgraded to meet the additional demand. This is equivalent to project option 6A (also not an EIS project alternative). Option 6A has an estimated total present worth cost of $3.2 million to serve the EIS population equivalent for that area only and provide adequate treatment at the Moose Lake WWTP.

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1.0. PURPOSE OF AND NEED FOR ACTION

1.1. Project Background

The planning area for this EIS involves three adjacent townships in northeastern Minnesota: Windemere Township in Pine County, and Moose Lake and Barnum Townships in Carlton County (Figure 1-1). The City of Moose Lake (population 1490) is situated centrally in Moose Lake Township. The City of Barnum (population 493) is situated to the northeast of Moose Lake Township. Windemere Township, on the south end of the planning area, has no incorporated villages or cities but encompasses the greater portion of the area's surface water resources. The Moose River and the Willow River flow through the planning area, carrying surface water to the southwest where confluence is made with the Kettle River. Thirteen lakes of greater than 100 acres in size lie within the area and the majority of the residential development outside the Cities of Moose Lake and Barnum is concentrated around several of these lakes. Sewer service currently is provided to the residents of the Cities of Moose Lake and Barnum and to residents living around Moosehead Lake, Coffee Lake, and Sand Lake. On-site wastewater treatment systems are utilized by the remainder of the population.

The City of Barnum was included in the planning area in order to consider regional alternatives that could increase the overall cost-effectiveness of wastewater treatment in the cities of Barnum and Moose Lake. Consideration of regional collection and treatment alternatives for Barnum and Moose Lake area residents was made initially in the facilities plan completed in 1979 by the Moose Lake-Windemere Sanitary District (MLWSD). This EIS has built upon that initial review of regional alternatives by evaluating all parts of the planning area where sanitary service improvements may be needed and then developing a wide range of alternatives for serving the identified needs. This was done in two phases (identified as Phase I and Phase II).

The studies conducted in Phase I resulted in the determination that the wastewater management alternative most appropriate for Barnum was the one that had already been identified in that city's facilities plan. A

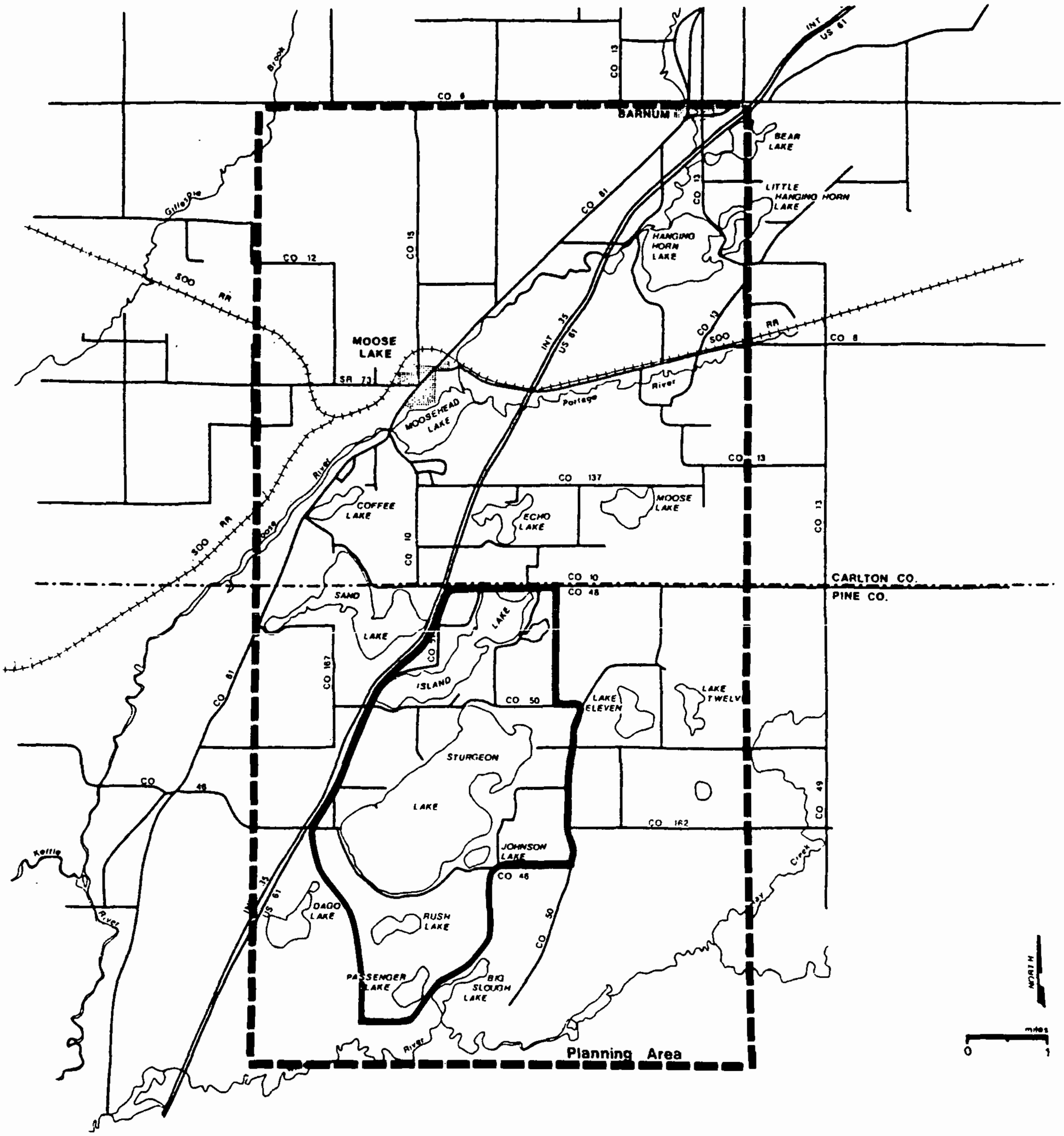

Figure 1-1. Planning area and project area boundaries.

report on Phase I was submitted to EPA as a separate document, as detailed in Section 1.3. below. The present volume documents Phase II, in which wastewater management alternatives were examined for a limited "project area" inside the MLWSD. This project area encompasses Island Lake, Sturgeon Lake, Rush Lake, and Passenger Lake in Windemere Township. The unincorporated parts of the planning area that are concentrated around these four lakes have recently experienced the greatest population growth in Windemere Township. This area also is the area defined in the MWLSD facilities plan as having the greatest need for improved sanitary service. Background information on the facilities planning efforts for both the MLWSD and the City of Barnum, and further discussion of how this EIS 'project area' (Figure 1-1) was selected, are presented in the following paragraphs.

The existing sewage collection and treatment system in the City of Moose Lake was completed in 1965. After completion of that project, significant residential growth took place on unsewered lakeshore lots in Windemere and Moose Lake Townships. Increased growth in this unsewered lakeshore community led to public concern with restrictions in water use where on-site systems are located in tight soils. Public concern also centered on the presence of blue-green algae blooms in the lakes. The perceived need to deal with these problems gave rise to the belief that improved means of wastewater management were needed around the lakes. This resulted in the formation in 1975 of a special purpose unit of local government to plan for improved wastewater treatment. This unit of government, the MLWSD, raised funds for the planning and design of collection sewers in portions of the lakeshore community within the District through the levy of special tax assessments. As a result of the efforts of the MLWSD, sewers were constructed around Coffee Lake in 1976 (1.5 miles southwest of the City of Moose Lake), and by 1979 sewers also were constructed around Sand Lake (approximately 0.5 miles south of Coffee Lake). Construction of these lakeshore area sewers, as well as of the sewers constructed from the City of Moose Lake to Interstate Highway 35 during 1979, was supported in part by Federal loans obtained from the Farmers Home Administration (FMHA). Treatment of the wastewater from these outlying service areas is provided at the City of Moose Lake treatment plant through a service agreement between the City and the MLWSD.

In 1979, the MLWSD contracted with Consoer, Townsend & Associates Ltd. (now PRC-Consoer Townsend, Inc.), consulting engineers of Duluth, Minnesota, to prepare a "201 Step 1" Facility Plan for overall wastewater collection and treatment facilities within the District. Funding for this planning effort was shared 75% by the Federal government (through USEPA), 15% by the State of Minnesota (through the Minnesota Pollution Control Agency [MPCA]), and 10% by the District. The Facility Plan was prepared to serve as the basis for selecting a specific wastewater management project from among various alternatives for detailed design and construction. The cost of detailed design ("Step 2") and construction ("Step 3") also may be shared among USEPA, MPCA, and the District. Because of the financial and regulatory involvement by the Federal government, USEPA is charged with the responsibility to determine whether an Environmental Impact Statement (EIS), in accordance with the National Environmental Policy Act of 1969, should be prepared.

The purpose of the District's Facility Plan, dated March 1980, was to:

- Examine the adequacy of existing wastewater treatment and collection facilities.
- Assess existing water quality conditions and wastewater system needs.
- Recommend future action to protect the District's diverse water resources.

The Facility Planning Area (FPA) had included the Moose Lake-Windemere Sanitary District, the Cities of Barnum and Moose Lake, and the corridor along County State Aid Highway (CSAH) 61 between the Cities of Barnum and Moose Lake, encompassing approximately 60 square miles. Among the alternatives considered were the construction of collection sewers around Island and Sturgeon Lakes, interceptor sewers and pump stations to bring Island and Sturgeon Lakes into the Moose Lake sewer system, a new pump station, a wet-weather overflow pond, and expansion of the existing wastewater treatment facility.

An infiltration/inflow (I/I) analysis was conducted in the City of Moose Lake in the autumn of 1979 by Consoer, Townsend and Associates as part of the Facility Plan. The cost-effectiveness analysis in the Facility Plan recommended correction of the excess I/I originating in the collection system of the City of Moose Lake. The sewers in the Coffee Lake and Sand Lake areas were not included because they had recently passed infiltration tests during construction. In order to define the construction required to correct the I/I, a Sewer System Evaluation Study (SSES) was authorized. PRC-Consoer Townsend, Inc. currently is performing this task. Initial monitoring was performed in the autumn of 1981. An interim report was issued in March 1982 identifying areas of the system requiring cleaning, televising, and smoke testing. The final SSES is expected in August 1982.

The City of Barnum contracted with Howard A. Kuusisto Consulting Engineers to prepare a "201 Step 1" Facility Plan for the wastewater system in Barnum. The City of Barnum contributed 10% of the total cost of the Facility Plan and the remainder was shared by USEPA and MPCA in the same proportions as for the MLWSD. The Barnum Facility Plan, completed in May 1980, evaluated seven alternatives and recommended construction of a stabilization pond with controlled discharge to Gillespie Brook, west of the City of Barnum.

A public hearing was held on the MLWSD Facility Plan in March 1980, at which time public support was expressed for the recommended alternative and testimony was presented showing widespread belief that improved wastewater treatment around Island Lake would result in substantial improvements in water quality.

1.2. Legal Basis for Action and Project Need

The National Environmental Policy Act of 1969 (NEPA) requires a Federal agency to prepare an EIS on "...major Federal actions significantly affecting the quality of the human environment ..." In addition, the Council on Environmental Quality (CEQ) has established regulations (40 CFR Part 1500-1508) to guide Federal agencies in determinations of whether Federal funds or Federal approvals would result in a project that would significantly affect the environment. USEPA has developed its own regulations (40

CFR Part 6) for the implementation of the EIS process. As noted above, USEPA Region V determined that pursuant to these regulations, an EIS was required for the MLWSD Facility Plan, and should include consideration of the City of Barnum Facility Plan. Specific issues were identified in the 11 July 1980 Notice of Intent to prepare an EIS (Section 1.3).

The Federal Water Pollution Control Act of 1972 (FWPCA, Public Law 92-500), as amended in 1977 by the Clean Water Act (CWA, Public Law 95-217), and as amended in 1981 by the MWW Construction Grants Amendments (PL 97-117) establishes a uniform, nationwide water pollution control program according to which all state water quality programs must operate. MPCA has been delegated the responsibility and authority to administer this program in Minnesota, subject to the approval of USEPA.

Federal funding for wastewater treatment projects is provided under Section 201 of the FWPCA. For projects initiated prior to the 1981 FWPCA Amendments, USEPA will fund 75% of the grant-eligible costs for conventional sewers and treatment. For alternative collection systems and treatment systems (e.g., pressure sewers, septic tank effluent sewers, septic tanks, and soil absorption systems), the funding level increases to 85% of the eligible costs. The costs for conventional sewers that USEPA will not assist in funding are land and easement costs, sewers for which less than two-thirds of the planned flow originated before 28 October 1972, pipes in the street or easements for house connections, and the building of sewers for connection to the system. The costs for alternative systems that the USEPA will not assist in funding are easement costs and the building of sewers for connection to septic tanks. The grant eligibility of the on-site portions of alternative systems varies depending on their ownership and management. Publicly- and privately-owned systems constructed after 27 December 1977 are not eligible for Federal grants. Presently, MPCA can provide grants of 60% of the funds required in excess of the Federal share for both conventional sewers and for alternative collection and treatment systems.

The dispersal of Federal funds to local applicants is made via the Municipal Wastewater Treatment Works Construction Grants Program administered by USEPA. Prior to the amendments of 1981, the program consisted of a three-step process: Step 1 included wastewater facilities planning; Step 2 involved the preparation of detailed engineering plans and specifications; and Step 3 covered construction of the pollution control system.

The Municipal Wastewater Treatment Construction Grants Amendments of 1981 became law (PL 97-217) on 29 December 1981, and significantly changed the procedural and administrative aspects of the municipal construction grants program. The changes reflected in these amendments have been incorporated into Construction Grants-1982 (CG-82) Municipal Wastewater Treatment (Draft), (USEPA, March 1982); and an interim final rule implementing the 1981 Amendments was issued by USEPA on 12 May 1982 (Federal Register (4792). Under the 1981 Amendments, separate Federal grants are no longer provided for facilities planning and design of projects. However, the previous designation of these activities as Step 1, facilities planning, and Step 2, design, are retained in the CG-82. The term "Step 3, grant" refers to the project for which grant assistance will be awarded. The Step 3 grant assistance is comprehensive and will include an allowance for the planning (Step 1) and design (Step 2) activities.

The CG-82 states that projects which received Step 1 and/or Step 2 grants prior to the enactment of the 1981 Amendments should be completed in accordance with the terms and conditions of their grant agreements. Step 3 grant assistance will include an allowance for design of those projects which received Step 1 grants prior to 29 December 1981. A municipality may be eligible, however, to receive an advance of the allowance for planning and/or design if the population of the community is under 25,000, and the state reviewing agency (MPCA) determines that the municipality otherwise would be unable to complete the facilities planning and design to qualify for grant assistance. The MLWSD and the City of Barnum currently are in Step 1.

Communities also may choose to construct wastewater treatment facilities without financial support from the state or Federal governments. In such cases, the only requirements are that the design be technically sound and that the MPCA is satisfied that the facility will meet discharge standards.

If a community chooses to construct a wastewater collection and treatment system with USEPA grant assistance, the project must meet all requirements of the Grants Program. The CWA stresses that the most cost-effective alternative be identified and selected. USEPA defines the cost-effective alternative as the one that will be environmentally sound and result in minimum total resource costs over the life of the project, as well as meet Federal, state, and local requirements. However, the cost-effective alternative is not necessarily the lowest cost proposal. The analysis for choosing the cost-effective alternative is based on both the capital costs and the operation and maintenance costs for a 20-year period, although only the capital costs are eligible for funding. Non-monetary costs also must be considered, including social and environmental factors.

Minnesota was required by the Federal Clean Water Act (PL 92-500) to establish water quality standards for lakes and streams, and effluent standards for discharge to them. Federal law stipulates that, at a minimum, discharges must meet secondary treatment requirements. In some cases, even stricter effluent standards are subject to USEPA approval and must conform to Federal guidelines.

Wastewater treatment facilities also are subject to the requirements of Section 402 of the FWPCA, which established the National Pollutant Discharge Elimination System (NPDES) permit program. Under the NPDES regulations, all wastewater discharges to surface waters require an NPDES permit and must meet the effluent standards identified in the permit. USEPA has delegated the authority to establish effluent standards and to issue discharge permits to the MPCA. USEPA, however, maintains review authority. Any permit proposed for issuance is subject to a state hearing if requested by another agency, the applicant, or other groups and individuals. A hearing on an NPDES permit provides the public with the opportunity to comment on a proposed discharge, including the location of the discharge and the level of treatment.

1.3. Study Process and Public Participation

Participants in wastewater management planning for the project area during the past four years have included: US Environmental Protection Agency, Region V; Minnesota Pollution Control Agency; WAPORA, Inc. (EIS consultant); PRC-Consoer Townsend, Inc. and Howard A. Kuuisisto Consulting Engineers (facility planners); Moose Lake-Windemere Sanitary District; the City of Moose Lake, the City of Barnum; and other Federal, State and local agencies and organizations.

As previously mentioned, USEPA reviewed the MLWSD Facility Plan in accordance with the criteria established under 40 CFR, Part 6, and determined that the preparation of an EIS was warranted because of the project's impacts in the following areas:

- Water quality (40 CFR 6.506 (a) (7)).
- Socioeconomic factors (40 CFR 6.506 (a) (4)).
- Secondary impacts and induced growth (40 CFR 6.506 (a) (1)).

These issues were highlighted in the 11 July 1980 Notice of Intent (NOI) to prepare an EIS (Appendix A). Specifically, USEPA determined that an EIS was needed because the Facility Plan did not adequately document the need to provide sewers around Island and Sturgeon Lakes, and that additional documentation was needed to determine that the deterioration of the quality of the lakes was related to inadequate on-site treatment systems. USEPA's decision to require an EIS also was based on its finding that there is a high probability that the proposed project could have significant adverse socioeconomic impacts on a number of families in the service area who have fixed or low incomes. In the NOI, USEPA indicated the need to determine the probable induced growth and the changes in land use which would be caused by the project and the resultant effects on future demand for public services.

In order to expedite the EIS process, USEPA determined that the preparation of the EIS would be in two phases. The initial phase involved reviewing published and unpublished information to determine its adequacy in addressing the identified facility planning issues (Section 1.4.). Additionally, the initial phase of EIS preparation involved consideration of regionalized collection and treatment alternatives which would include service areas outside the MLWSD: specifically, the City of Barnum and the adjacent Hanging Horn Lakes area. A Citizen's Advisory Committee was founded during the initial phase of EIS preparation (July 1980) to keep local citizens informed and to obtain the benefit of their critical review. Additionally, public meetings were held on 10 September 1980 and 21 January 1981 to evaluate public concerns in regard to the facility planning.

Phase I culminated in March 1981 with the publishing of two reports: a Current Situation Report and a Regional Alternatives Analysis. The Current Situation Report described aspects of the natural and man-made environment likely to be affected by the various Facility Planning alternatives proposed in the MLWSD and Barnum Plans. The report also initiated an analysis of need for additional wastewater treatment facilities in the planning area and presented a brief discussion of the question of whether the need for sewers around Island Lake was so great that immediate sewering of the lake was justified. The Regional Alternatives Analysis Report examined the alternatives presented in the MLWSD and Barnum facilities plans, and presented altered costs to determine whether it was cost-effective to include the City of Barnum and the corridor between the Cities of Moose Lake and Barnum as components of a regional collection and treatment alternative. The report also addressed the possibility of including the Hanging Horn Lakes area adjacent to Barnum in the alternatives.

The Phase I Environmental Report (USEPA 1981) concluded that:

- Available information was unreliable and insufficient to address the issues identified in the 11 July 1980 NOI and therefore the second phase, completion of the full EIS, was recommended.

- Separate consideration of the proposed sewering of Island Lake would not be made in this EIS, since decentralized alternatives were to be evaluated. A determination of the cost-effectiveness of implementing Island Lake sewers alone could be made later if the centralized collection and treatment alternative was found, on completion of the EIS, to be the most cost-effective approach for the planning area.

- Barnum should be excluded from further study in the EIS since the regional alternative does not provide a cost advantage over the separate treatment plant alternative for Barnum.

- The Hanging Horn Lake area would not be studied further in the EIS. The preliminary analysis revealed no categorical need for improved sewage treatment in the Hanging Horn Lake area. This area was included only for the purpose of evaluating a regional alternative, and did not affect the recommendation for Barnum.

Following the completion of Phase I of the EIS process, a Citizens' Advisory Committee (CAC) meeting was held on 10 April 1981 and a public information meeting was held on 24 April 1981 to review the two reports. These meetings were the culmination of the public participation program conducted throughout Phase I. At the CAC meeting and at the public meeting, area residents expressed concern about the quality of published data and other issues which they felt were not adequately supported or addressed in the Phase I reports. Their major concerns were:

- Detailed soil surveys should be made that include the lakeshore community and the entire development corridor around the lakes.

- More accurate assessment of land use in the lakeshore community and development corridor should be made.

- The contribution of septic tank effluent to lake pollution should be quantified.

- Public health risks associated with whole-body contact recreation should be studied.

- The trophic conditions of the lakes should be further studied.

- Public participation during the second phase of EIS preparation should include a Citizens' Advisory Committee, which would provide comments on preliminary and draft reports.

Complete investigation of the public health concerns and the trophic conditions of the lakes is beyond the scope of most rural lakes EISs. However, in response to public expectations expressed in the meetings, these investigations were performed.

Phase II (completion of the EIS) addresses public concerns, as above, and describes the data gaps and deficiencies which were identified in reviewing the Phase I reports. Phase II includes the preparation of Draft and Final Environmental Impact Statements (DEIS and FEIS) on the proposed wastewater management alternatives for the area of most critical need within the Moose Lake-Windemere Sanitary District.

1.4. Issues

Based on a review of USEPA's Notice of Intent to prepare an EIS, the conclusions of the Phase I Reports, and the MLWSD Facility Plan, the following issues have been determined to be significant and are addressed in this Environmental Impact Statement:

- Additional documentation is required to evaluate the need for sewers around Island and Sturgeon Lakes, as proposed in the Facility Plan.
- An evaluation of the relationship between documented failures of septic syptems and water quality in the lakes was not made in the MLWSD Facility Plan, and is needed, as is an evaluation of the causes and effects of blue-green algal blooms.
- An evaluation of the need for improved wastewater treatment for residences in the Rush and Passenger Lakes area was not presented in the Facility Plan. Additional needs documentation is required for those areas.
- The recommended facilities planning alternative (the installation of sewers around Island Lake), if implemented, could have significant adverse socioeconomic impacts on a number of households in the service area which have low or fixed incomes.
- The MLWSD facilities planning alternative could induce additional development.
- The existing wastewater treatment facility of the City of Moose Lake currently has a limited capacity to accept additional wastewater flows.

2.0. WASTEWATER MANAGEMENT ALTERNATIVES

2.1. Description of Existing Wastewater Collection and Treatment Facilities

The City of Moose Lake owns and operates the facilities which treat the wastewater collected by the Moose Lake city sewer system and by the Moose Lake-Windemere Sanitary District (MLWSD) sewer system. Wastewater is conveyed from the City and Sanitary District systems to a pumping station located immediately northwest of the County Highway 61 bridge over the Moose River. From this point, the wastewater is pumped via a force main 8,730 feet southwest to a lagoon treatment system located in Section 30 of Moose Lake Township. The lagoon system provides secondary treatment and effluent from the lagoon is discharged via a small channel to the Moose River.

Sewage Collection System

The areas served by the wastewater collection system described above are shown in Figure 2-1. The collection system in the City of Moose Lake consists of vitrified clay pipes sized as follows:

Diameter	Length	
24" diameter	2,450'	
21"	1,350'	
15"	4,700'	(State hospital sewer)
12"	200'	
10"	2,070'	(State hospital sewer)
8"	21,560'	
6"	3,670'	

The oldest sewers were constructed in 1916 and are located in the downtown business district and in the southeast portion of the town along Moose Lake.

A substantial amount of extraneous groundwater infiltration and stormwater inflow (commonly referred to as infiltration and inflow, or I/I) enters this wastewater collection system. This situation necessitates frequent bypassing of wastewater at the main pumping station into the Moose Horn River.

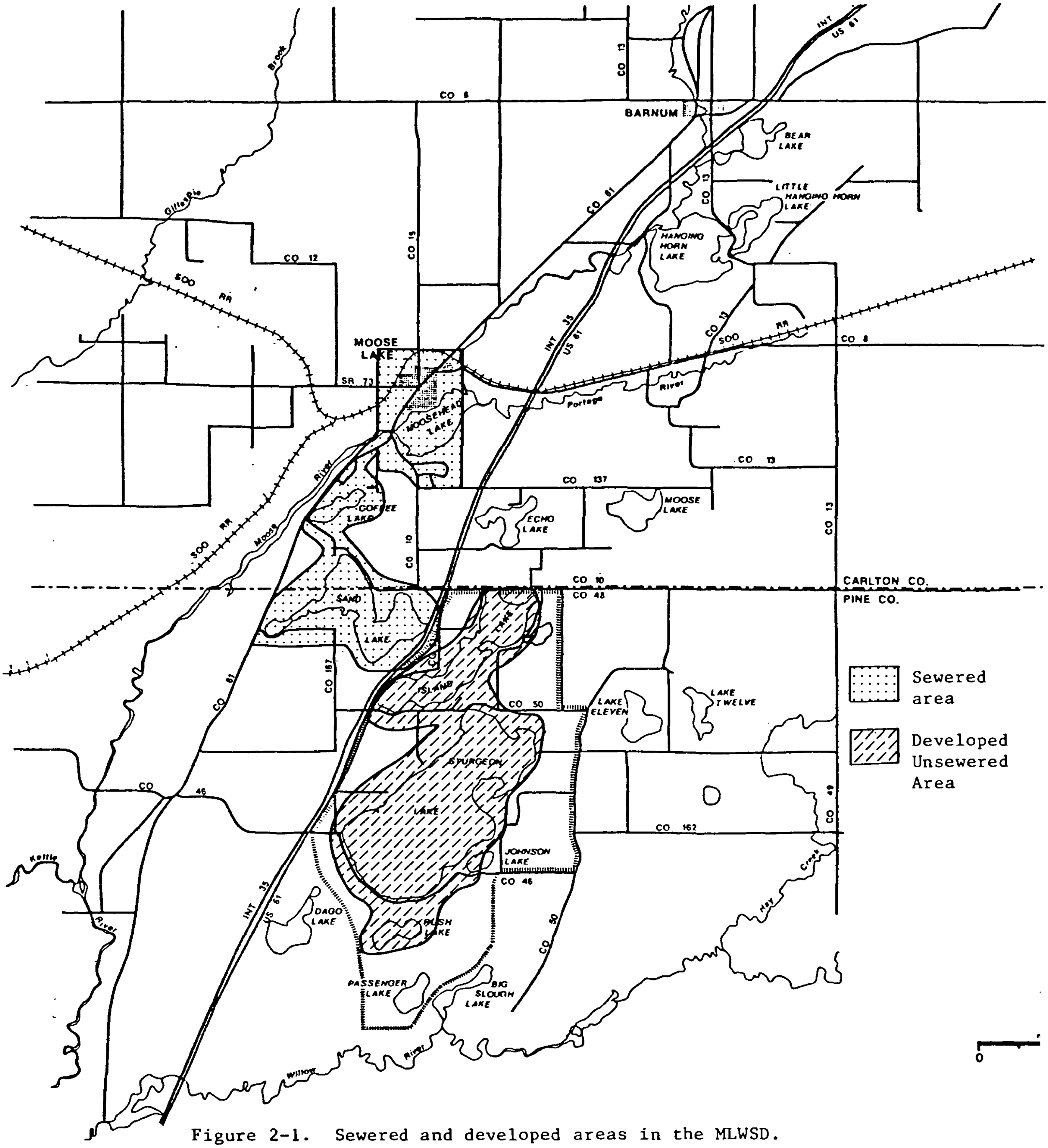

Figure 2-1. Sewered and developed areas in the MLWSD.

The Facility Plan (PRC Consoer Townsend and Associates Ltd 1980) reports that the peak monthly wastewater flow in the period from January 1977 to November 1979 occurred during August 1978, when the daily average flow was 877,000 gallons per day (gpd) (including a 210,000 gpd base flow). The amount of wastewater bypassed into the Moose Horn River is included as part of the 877,000 gpd, because flow was determined from wastewater pumping records. The facility planners have estimated that 1,330,000 gallons of wastewater were bypassed over a 3-day period during August 1978. Furthermore, the facility planners note that there are other bypasses reported in the monthly reports to the Minnesota Pollution Control Agency (MPCA), and express the suspicion that other bypasses occurred which were reported. Because of the excessive I/I, the existing Moose Lake system is incapable of accepting additional wastewater flow.

Wastewater Pumping Station

The Moose Lake wastewater pumping station and lagoon system were built in 1965. Wastewater entering the station first passes through manually cleaned bar screens, then enters a wet well. Screened wastewater is pumped from the well by three alternating 585 gallons per minute (gpm) capacity pumps. The station was originally equipped with flow measuring equipment and recorders. This monitoring equipment is no longer operable. Flows through the station currently are estimated by reading the elapsed-time meters on the pumps. The pumps appear to be in good working order. However, peak wastewater flows exceed the current capacity of the pumping station and force main. During periods of peak flow, wastewater is bypassed directly to the Moose Horn River from the station.

There are three bypasses at the main pumping station as described below:

- A bypass is located outside the pumping station in a manhole. It has a manually operated shear gate which is opened when the interceptor sewer is sufficiently surcharged.
- The second bypass, located in the pumping station, is always open. There is no evidence that bypassing has occurred here, because the bypass is located 7 feet above the interceptor.

- The third bypass also is located outside the pumping station, in the manhole serving the forcemain to the lagoons. This bypass is utilized when the pumping station cannot accommodate the wastewater flow even when the first bypass is opened.

Wastewater Treatment Lagoons

A plan view of the existing lagoon system is presented in Figure 2-2. Except for repair work done to one of the lagoon dikes in 1981, the system has remained essentially unchanged since its construction in 1965, when it replaced a treatment plant which had been built in 1935.

The 10-inch diameter force main from which the pumping station discharges, exits into a distribution hub that regulates the flow into each of the six primary treatment lagoons, which total 43 acres. Effluent from the primary lagoons flows to a 15.2-acre secondary treatment lagoon, from which it is discharged semi-annually to the Moose River. All seven of these lagoons are facultative (containing both aerobic and anaerobic zones) and no mechanical aeration is provided. The existing permitted design capacity of the lagoon system is 444,000 gpd, with a detention time of 196 days. However, MPCA has indicated that if significant new flows are connected to the system, there will be a requirement that the lagoons be upgraded to meet newer restrictive design criteria (By telephone, Mr. Larry Zdon, MPCA, to WAPORA, Inc. 15 July 1982). Based on the new design criteria, MPCA calculates the capacity of the lagoon system at 316,100 gpd, with a detention time of 180 days, based on an active storage depth of 3 feet and a sludge storage depth of 2 feet (Section 2.3.4). There is adequate additional land adjacent to the site for a major expansion of the lagoon system.

2.1.1. Existing Centralized Treatment System Discharge Characteristics

The National Pollutant Discharge Elimination System (NPDES) permit for the City of Moose Lake lagoon system was issued on 27 February 1980. The effluent limitations listed in NPDES permit (MN0020699) are shown in Table 2-1.

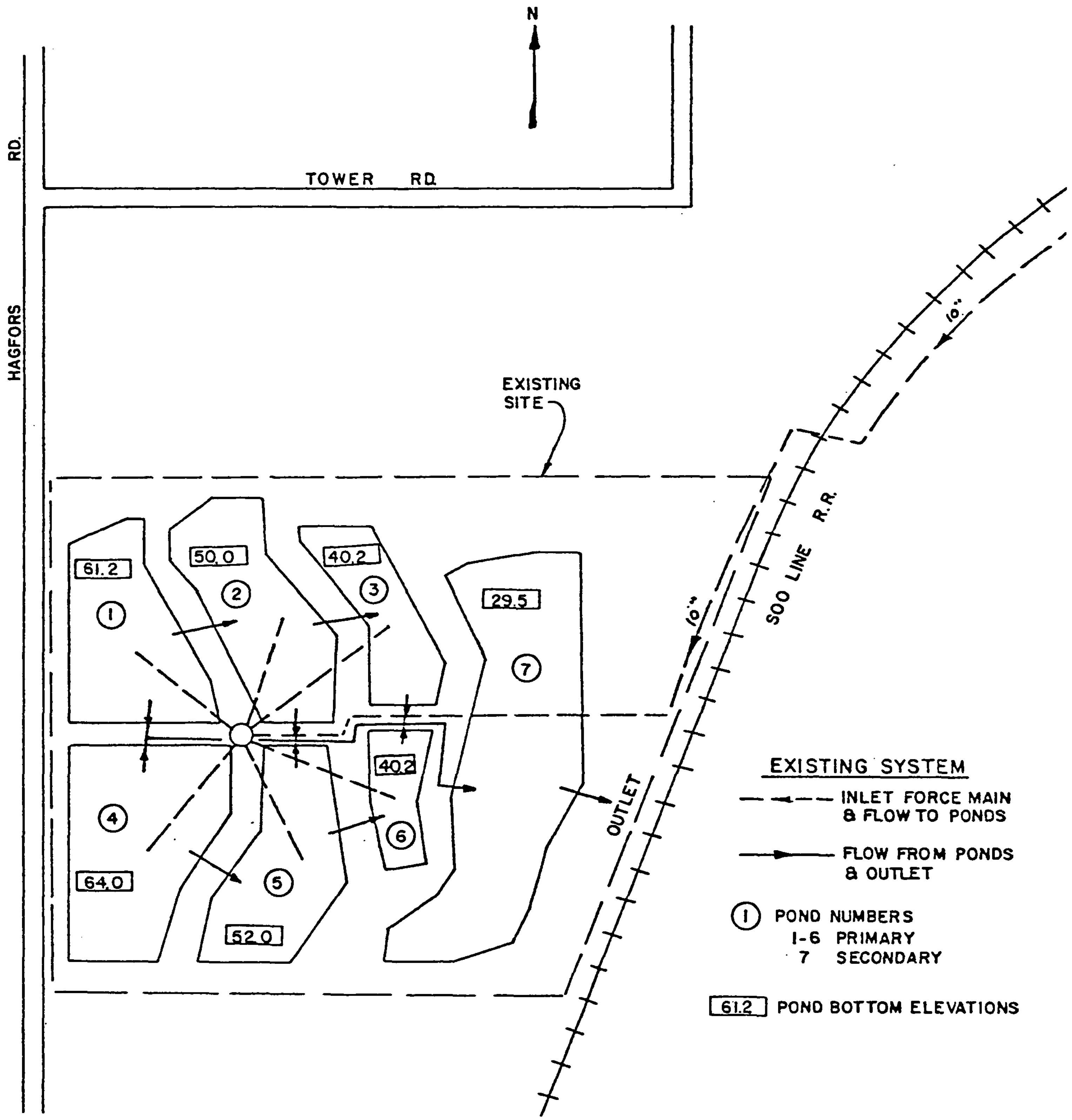

Figure 2-2. Plan view of existing wastewater treatment lagoons for the City of Moose Lake treatment plant.

Table 2-1. NPDES effluent limitations for the City of Moose Lake wastewater lagoon system.

The discharge is limited as specified below using a maximum drawdown rate of 6 inches per day from the secondary cell for calculating pounds and kilograms:

EFFLUENT CHARACTERISTICS	CONTROLLED DISCHARGE LIMITATIONS		
	Average During Discharge Period *		Notes
5-day biochemical oxygen demand (BOD_5)	25 mg/l	513 lbs/day, 233 kg/day	(1) (3)
Total suspended solids (TSS)	30 mg/l	615 lbs/day, 279 kg/day	(1)
Fecal coliform bacteria	200 MPN/100 ml		(2)
Turbidity	25 NTU		(1)

The pH shall not be less than 6.5 nor greater than 8.5. These upper and lower limitations are not subject to averaging and shall be met at all times.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

The discharge shall not contain oil or other substances in amounts sufficient to create a visible color film on the surface of the receiving waters.

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* In addition, the seven consecutive day average shall not exceed 45 mg/l BOD_5, (923 lbs day, 419 kg/day), 45 mg/l TSS, (923 lbs/day, 419 kg/day), and 400 MPN/100 ml fecal coliform bacteria.

Notes: (1) Arithmetic mean (2) Geometric mean (3) For the average during the discharge period, the effluent concentration shall not exceed the stated value or 15% of the arithmetic mean of the average value for influent samples collected during the related treatment period (most restrictive value).

2.1.2. Operation and Maintenance of Existing Facilities

Under dry weather conditions, the existing lagoon treatment system is capable of adequately treating all the wastewater it receives. The water quality of representative samples taken from the secondary treatment lagoon is presented in Table 2-2. This information was obtained from the City of Moose Lake's operating records. No records exist for the quality of the effluent when it was being discharged into the Moose River. In accordance with the NPDES permit, the operation of the pond system, insofar as is practical, is to avoid effluent discharge to the Moose Horn River during low stream flow periods. Furthermore, prior approval of any discharge is required by MPCA. The effluent discharge velocity is limited to avoid shock loads and to avoid disturbing bottom sediments of the Moose Horn River. The maximum drawdown of secondary cells is 6 inches per day.

However, past inspections by the MPCA (Compliance Monitoring Surveys) have found that unauthorized discharges were occurring and that system maintenance was inadequate (excessive vegetation was observed on dikes, in addition to apparent seepage through one of the dikes of the secondary cells). The MPCA has issued a Citation for Violation. The limited influent wastewater quality data that are available are listed in Table 2-3.

2.1.3. Problems Caused By Centralized Treatment Plant Discharges

Water quality in the secondary treatment lagoon exceeded NPDES limits on 29 April 1980, probably as a result of operational problems. The most recent water quality data (autumn, 1981) indicates that the plant was capable of achieving 5-day biochemical oxygen demand (BOD_5) and suspended solids (SS) treatment which brings effluent quality below limits in the NPDES permit for the facility. A compliance schedule directs that the bypasses/overflows be eliminated or controlled.

2.1.4. Existing Wastewater Management

The MLWSD includes Moose Lake Township in Carlton County and Windemere Township in Pine County (Figure 2-3). Although the MLWSD geo-

Table 2-2. Water quality in the secondary treatment lagoon of the City of Moose Lake wastewater treatment facility.

Date	BOD_5 (mg/1)	Suspended Solids (mg/1)	Turbidity (NTU)
29 April 1980	27	70	17
17 May 1980	11	18	7
15 May 1980	24	22	7
20 May 1980	5	25	8
22 May 1980	15	4	5
08 Sept. 1980	17	7	8
30 Sept. 1980	14	5	6
02 Oct. 1980	7	4	6
06 Oct. 1980	5	7	6
09 Oct. 1980	3	2	6
10 July 1981	4	3	6
29 July 1981	7	9	6
14 Sept. 1981	5	2	3
02 Oct. 1981	4	3	3
09 Oct. 1981	6	2	4
NPDES Limits	25	30	25

Table 2-3. Influent wastewater quality to the City of Moose Lake wastewater treatment facility

Date	BOD_5 mg/1	SS mg/1	pH
07-15-81	95	92	6.8
10-23-80	107	216	7.7
04-01-80	93	102	7.5

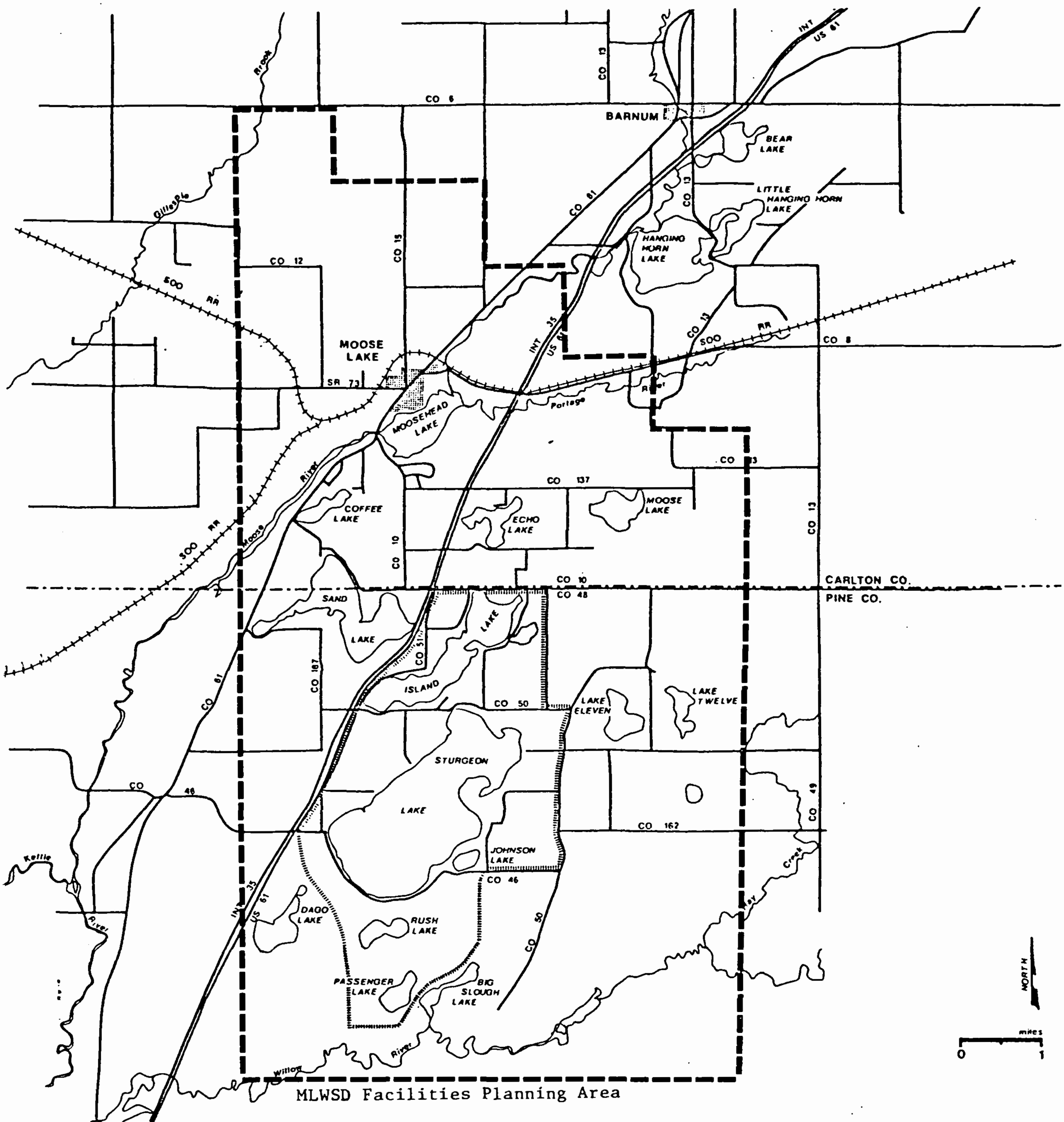


Figure 2-3. Facilities planning area for the MLWSD.

graphical boundaries include the City of Moose Lake, the City is a separate political jurisdiction. The MLWSD has sewered the areas around Coffee Lake and Sand Lake. The wastewater from these lakeshore areas is treated at the City of Moose Lake wastewater treatment lagoon system. Two areas within the MLWSD that have significant populations are the areas around Island and Sturgeon Lakes. These areas both utilize on-site wastewater management systems.

2.1.5. Wastewater Management Planning

A separate wastewater Treatment Facility Plan has been prepared for the MLWSD. This wastewater management planning study was funded under the 201 Construction Grants Program. The Federal government (through USEPA) provided 75% of the funding; the State government (through the Minnesota Pollution Control Agency [MPCA]) contributed 15%; and each local jurisdiction paid for 10%. The Facility Plan recommends specific actions for design and construction to remedy existing problems and to provide adequate wastewater management for the next 20 years. However, before USEPA commits additional funds to implement these measures, it must ensure that the recommended actions are cost-effective, environmentally sound, and implementable. USEPA's decision to prepare an EIS for the MLWSD reflects these concerns.

Consoer, Townsend & Associates Ltd. prepared the Facility Plan for the MLWSD. The plan recommended the following major actions:

- Construction of collection sewers around Island and Sturgeon Lakes.
- Construction of interceptor sewers and wastewater pumping stations to convey wastewater from the Island Lake and Stúrgeon Lake areas to the existing Moose Lake wastewater collection system.
- Modifications to the existing Moose Lake interceptor sewers.
- Removal of some extraneous flows (infiltration/inflow [I/I] corrections to the Moose Lake wastewater collection system in accordance with the recommendations of a Sewer System Evaluation Survey [SSES]).

- Construction of an overflow pond for short-term storage (i.e., storm events) of the extraneous flows (I/I) that cannot be removed economically from the wastewater conveyance system.

- Renovation or construction of a new main wastewater pumping station.

- Modification and expansion of the existing Moose Lake lagoon wastewater treatment system.

2.2. Description of Existing On-site Waste Treatment Systems

Information on the number of on-site waste treatment systems, the types of systems in use, and problems with their design and performance has been obtained from eight area-specific sources. The necessary literature reviews, file searches, and original data gathering efforts were made between August 1981 and May 1982. This research reflects current published and unpublished information and was done to provide the background information on on-site systems introduced in the following section (2.2.1.). Determination of need for waste treatment alternatives will be based on this information.

Enumeration of the on-site systems in the project area was accomplished by the review of public tax rolls, USGS topographic maps (1979), and aerial photographs (USEPA 1981); by reference to information in the MLWSD Facility Plan (Consoer Townsend Associates Ltd. 1980); and by direct investigation through the use of two property owner survey techniques. These information sources also were utilized to determine the types of systems in use and problems with those systems.

An overview of this combined data base, as identified in the following eight sections, reveals that currently there are approximately 400 on-site waste treatment systems in the area surrounding Island, Sturgeon, Rush, and Passenger Lakes. The boundary of this land area, hereafter referred to as the "project area", is presented in Figure 2-4. Available data indicate that within the service area septic tanks are the most common type of system in use (80%), followed by privies (10%), holding tanks (5%), and combination or "hybridized" systems (2%). Existing information also in-

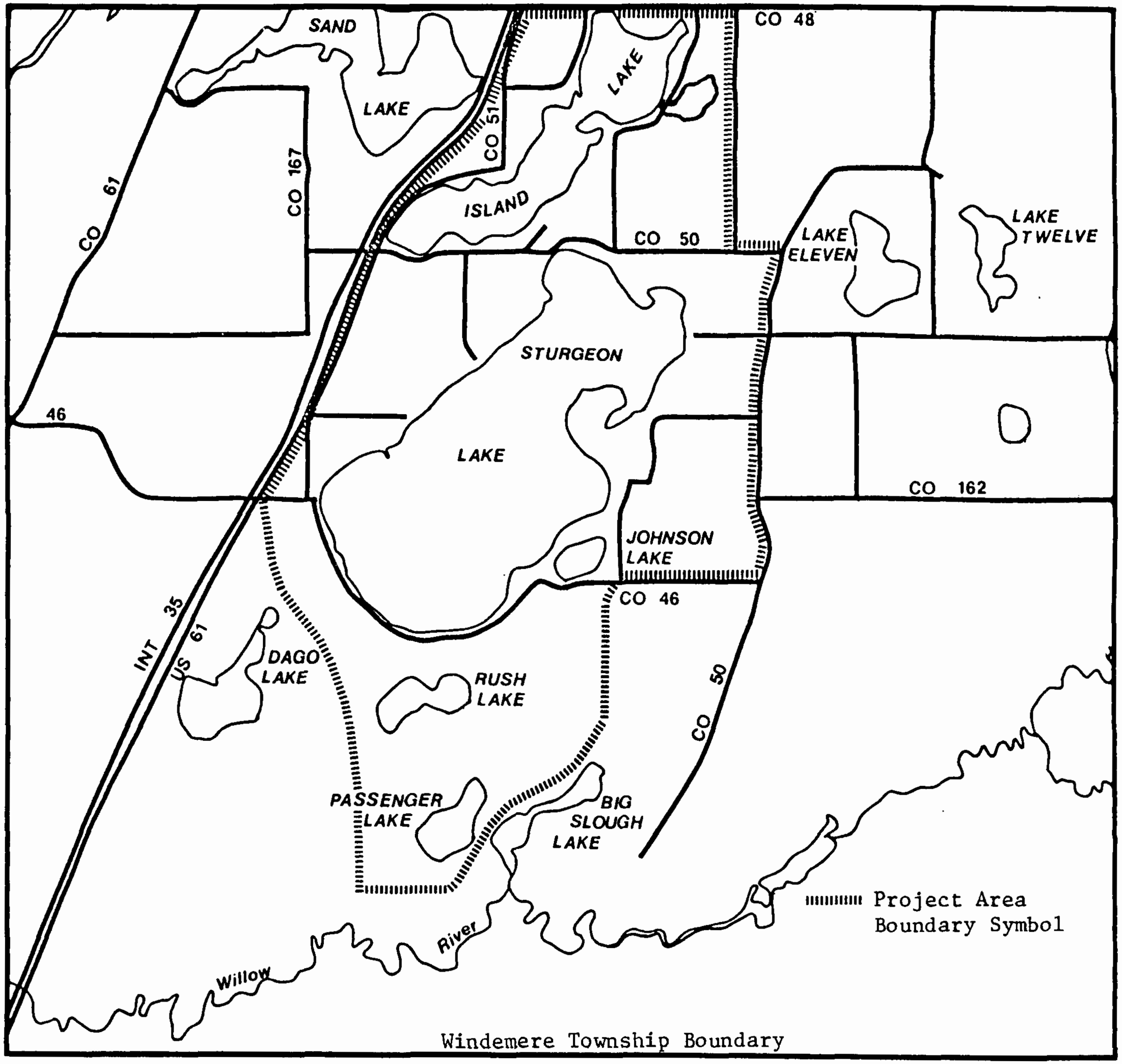


Figure 2-4. The EIS project area. Boundary of the project area is delineated by hatched line. Windemere Townships, the larger area, is delineated by the solid line.

dicates that most on-site waste treatment systems in use are functioning properly. The types of problems currently being encountered and the frequency and severity of those problems, are discussed in detail in Sections 2.2.2. and 2.2.3. Additional data on the distribution of developed lots within the service area are presented in Section 3.2.1.

2.2.1. Data Pertinent to the Assessment of On-site Waste Treatment Systems

USEPA determined from the the report on Phase I of this EIS, and from review comments made by the Minnesota Pollution Control Agency and the Citizens Advisory Committee that additional information was required for preparation of the balance of the EIS. Much of the requisite effort involved gathering new data pertinent to the assessment of on-site waste treatment systems. The new sources of information were:

- A soil survey of a portion of Pine County inclusive of the land adjacent to Island, Sturgeon, Rush, and Passenger Lakes.
- Information in the MLWSD Facility Plan and related data provided by the MLWSD.
- Mailed questionnaire responses from property owners within the service area.
- A field survey of septic leachate sources to the lakes.
- A tabulation of well water quality data for critical lakeshore areas, based on the well-log files of the Minnesota Department of Public Health.
- Two color-infared aerial photographic surveys of lakeshore areas designed to locate obvious septic leachate breakthroughs.
- The data contained in the permit files of the Pine County Sanitarian on recent on-site system construction and maintenance.
- A follow up survey to answer questions unanswered by the other surveys, including telephone interviews with property owners and site visits to assess current land use and development patterns.

Each source of information will be referred to in the analysis of the need for wastewater management alternatives. A complete description of the available data is provided in the following sections.

2.2.1.1. Soil Survey of a Portion of Windemere Township

Accurate soil data are necessary to assess on-site system performance and to assess the design prerequisites for sewage collection and treatment facilities. In preparation of this EIS, soil properties in areas with significant amounts of unsewered residential development were determined by making a comprehensive soil survey of a portion of Windemere Township, and by analyzing the particle size distribution of representative soils. The soil survey encompassed approximately 7,000 acres of land around Island, Sturgeon, Rush, and Passenger Lakes, and was conducted during the period of 14 September to 6 November 1981. As a result of the soil survey, soils were identified and classified, a soils map was prepared, and interpretations of the limitations of the soils were made in regard to on-site wastewater treatment.

Development of the Soil Survey

Prior to preparation of this EIS, a modern comprehensive soil survey had not been developed for Pine County, which includes the surveyed Windemere Township area. To obtain the needed soils data, soil mapping and sample collection were done by a certified professional Soil Scientist with previous field experience in the region. USDA Soil Conservation Service (SCS) classifications and terminology were used in the development of the project area soil survey. The boundaries of the survey were semi-rectangular in shape and were entirely within Windemere Township. The surveyed area (Figure 2-5) was bounded by Carlton County to the north, Interstate Highway 35 on the west, and non-linear boundaries approximately 0.5 miles to the east and south of the four lakes. These boundaries were selected to include all platted lakeshore properties and contiguous, unplatted areas within the drainage basins of the four project area lakes. Access to private property was not obtained on one parcel adjacent to the northeast shore of Sturgeon Lake.

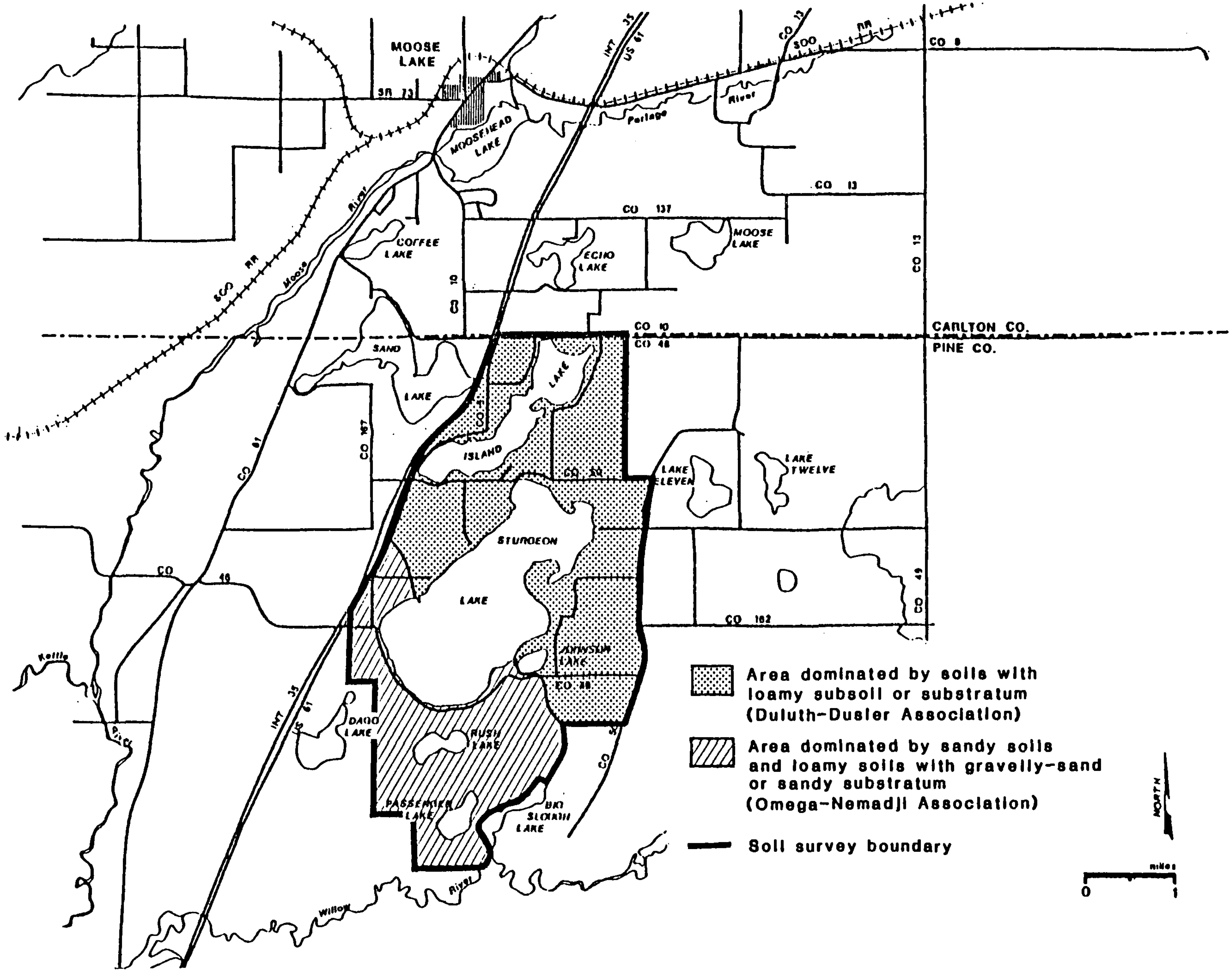


Figure 2-5.Soil survey boundaries and major soil associations. Derived from the soil survey results (Finney 1981) and from the Pine County General Soil Map (SCS 1975).

The soil survey findings are presented in detail in Appendix B of this EIS. The map produced as a result of the field survey was prepared at a scale of approximately 6 inches to the mile. This original soil map was re-photographed at approximately the same scale, in a series of 12 overlapping plates, and also is included in Appendix B. A copy of the original soils map is held by USEPA, Region V.

General Soil Associations

The surveyed area includes two distinct soil associations which are adjacent to each other. The soils surrounding Island Lake and the northern and eastern parts of Sturgeon Lake (Figure 2-5), were formed in glacial till and contain relatively high proportions of silt and clay (e.g., Duluth series). The soils surrounding Rush and Passenger Lakes and the southern shores of Sturgeon Lake were formed in glacial outwash and are primarily sandy in texture (e.g., Omega series). These zones are characterized as soil associations: the Duluth-Dusler association to the north, and the Omega-Nemadji association to the south (USDA, General Soil Map, Pine County, 1978).

The soil associations of the surveyed area can be characterized superficially by two types of associated vegetation. The soils of the Omega-Nemadji association, which were formed in glacial outwash sands, are somewhat acidic as a result of the processes of weathering and leaching. Field observations of the surveyed area and inspection of aerial photographs indicate that coniferous forests dominate on the sandy, more acid soils of the southern association while deciduous forests dominate the more clayey soils of the northern association. The transition zone between the two soil associations has no distinct vegetative type that is apparent by visual inspection. However, the soil survey provided additional information on the transition zone between these two major soil associations. A previously unclassified, intermediate soil series was identified in this transition zone and was named Duluth Variant. It is characterized by a substratum of loamy soils similar to the Duluth series, overlain by a mantle of sandy soils similar to the Omega series.

2.2.1.2. Information Contained in the Moose Lake-Windemere Sanitary District Facility Plan

During preparation of the Facility Plan, the MLWSD conducted a lot-by-lot survey around Island and Sturgeon Lakes to determine the problems with existing on-site systems. This survey was conducted in 1980 by MLWSD staff and commission members with the help of interested local residents. The methodology used and the results obtained from this survey were discussed in detail in the Phase I Environmental Report (USEPA 1981). A summary of the information contained in the Facility Plan which characterized problems with on-site systems is presented in Table 2-4.

Table 2-4. Summary of MLWSD lot-by-lot survey findings.

Type of Problem	Number of Lots With Problems: Island Lake	Number of Lots With Problems: Sturgeon Lake
Total lots surveyed	156	173
Surface failures	42	6
Sewer back-up	0	5
Tight soil	154	90
Groundwater table	71	82
Distance from the lake (75 feet)	54	51
Lot size	11	21
Restricted water use	10	4
Lot floods	6	0
Well isolation	35	101
Frequent rehabilitation	2	ND
Holding tanks	15	17
Privies	40	39

ND - not determined.

The MLWSD survey of on-site problems did not encompass lots in the vicinity of Rush and Passenger Lakes or in the Wild Acres and Hogan's Acres subdivisions. The types of problems enumerated in the Facility Plan are categorically not identical to those used by the Minnesota Pollution Control Agency and the US Environmental Protection Agency to evaluate the need for improved waste management in an area. The two problem categories evaluated by the MLWSD which are most directly comparable to state and federal needs documentation guidelines and to the questionnaire results cited in Section 2.2.1.3 are:

- Ponding or surface failures associated with the leachate field and
- Sewer backups within the residence.

The lots cited as having these types of problems during the 1980 MLWSD survey were also surveyed through the questionnaire and followup surveys in 1982. Comparisons between these data sources are made in Section 2.2.3.

2.2.1.3. Mailed Questionnaire Survey

To obtain current information on existing on-site systems, a questionnaire was mailed to each property owner in Windemere Township. The objective of the questionnaire was to determine the types of on-site systems that are in use in the project area, the kinds of problems or malfunctions that residents have experienced with those systems, and the frequency of system maintenance. The questionnaire was not designed to provide detailed information on the design and functioning of every aspect of the on-site systems. The survey results were evaluated in conjunction with information derived from Sanitary District records and from field investigations to identify problems associated with on-site systems in specific segments of the Sanitary District.

Methodology

In October 1981, a four-page questionnaire and a cover letter were mailed to all property owners in Windemere Township. The first mailing went to property owners with land on or near the four project area lakes, and a subsequent mailing was sent to property owners in subdivisions and outlying areas. The mailing list was developed from County property tax records for Windemere Township, and contained a total of 587 names. To facilitate responses, a self-addressed, stamped envelope was included with each questionnaire.

facilitate response. The cover letter stressed that all responses would be confidential and would be combined with other responses for the purposes of analysis.

Although the tax records documented 587 property owners within the township, 31 of the questionnaires sent to tax record addresses were returned as undeliverable. In addition, not all of the properties listed on the tax rolls are developed. A building count based on parallel review of 1974 USGS maps and November 1980 USEPA Environmental Monitoring Systems Laboratory (EMSL) remote imagery indicated a total of 475 housing units within Windemere Township (USEPA 1981). Accordingly, this figure can be used as a basis for determining the Township response rate to the questionnaire. A total of 249 valid questionnaires were received out of a possible 475, for an overall response rate of approximately 52%. A copy of the questionnaire and cover letter are included in Appendix C.

Results of the Questionnaire by Individual Lake or Subdivision

Island Lake

There are an estimated 151 housing units on the platted land area surrounding around Island Lake. A total of 89 questionnaires were received from property owners in this area. Eight of those respondents indicated that their land currently is not developed. The remaining 81 respondents reported developed lots with homes or cabins and on-site systems. Of the 151 housing units around Island Lake, 64 are estimated to be used on a year-round (permanent) basis and 87 are used seasonally. Responses to the questionnaire were received from 58% of the permanent households (37 responses) and 51% of the seasonal households (44 responses).

Most of the Island Lake area respondents reported septic systems as the primary method of on-site treatment. Of the 81 systems for which questionnaire responses were received, 54 are septic tanks, 15 are privies, and 12 are holding tanks. Six of the respondents using septic systems also indicated that secondary treatment or "backup" systems also are used.

These included two holding tanks and four cess pools used in conjunction with septic systems.

Most of the on-site systems described by Island Lake area respondents discharge to a seepage field (41; 66%). Two respondents have systems that discharge to a seepage field plus surface discharge, 4 respondents have systems that discharge through a tile line, and 15 respondents reported that discharge is by other means. (There were 62 responses to this question.)

Based on the questionnaire responses, the on-site systems in use around Island Lake range in age from 2 years to more than 20 years. Although 27 of the 71 responses to this question (38%) reported systems less than 10 years old, there were 31 responses (44%) indicating systems greater than 15 years old. The remaining 13 systems (18%) are between 10 and 14 years old.

Problems with septic systems were reported by 32 of the 54 septic system owners. None of the property owners using privies reported problems, but 4 of the 12 property owners using holding tanks reported problems. The problems reported by septic system owners included backup of wastes into the house (11), odorous water surfacing at the tile field (3), backup of wastes and odorous water (15), and 3 other responses that do not encompass any of these problems. Most of the reported problems were solved by pumping the septic tank, by fixing a broken pipe, or by allowing a frozen drainfield to thaw. Few of the responses indicated chronic problems requiring frequent maintenance. Of the 75 responses pertaining to the questions on system maintenance, 25 reported that regular maintenance was performed on the system, 26 reported that the system was maintained only when a problem occurred, and 14 reported that maintenance has never been undertaken with the on-site system.

Sturgeon Lake

There are an estimated 197 housing units around Sturgeon Lake. A total of 98 questionnaires were received from property owners with lots near or adjacent to Sturgeon Lake. Ten of the property owners indicated that their land currently is not developed or used. Two property owners provided no information other than that their property is used during the year. Five property owners indicated that they do not have houses on their property, but that the land is used during the year and on-site systems, primarily privies, are present. The remaining 81 respondents (41%) reported developed lots with homes or cabins and on-site systems. Of the 197 housing units around Sturgeon Lake, 42 are estimated to be used on a year-round basis and 155 are used seasonally. Responses to the questionnaire were received from 57% of the permanent households (24 responses) and from 37% of the seasonal households (57 responses). The property owners who do not have houses on their property, but do have on-site systems, accounted for five responses. Questionnaire response rate for the Sturgeon Lake area property owners was much less than for the Island Lake area in the seasonal use category (37% versus 51%, respectively).

Septic systems used alone are the predominant on-site system used by Sturgeon Lake area residents; 42 of the 86 systems (49%) identified by Sturgeon Lake respondents are septic systems. Combination systems also are used; 18 of the respondents (21%) indicated that a combination of on-site systems are used to treat their wastewater. Among the combinations reported by the respondents are septic tank-cess pool combinations (8), septic system-privy combinations (2), septic tank-holding tank combinations (1), and other combinations of holding tanks, privies, and cess pools. The remaining systems in use are privies (13; 15%), holding tanks (9;11%), and cesspools (4; 5%).

With few exceptions, the on-site systems of the Sturgeon Lake area survey respondents discharge to a seepage field only. One respondent indicated that the system utilizes a seepage field plus surface discharge and four respondents indicated that surface discharge through a tile line is used.

The on-site systems in use around Sturgeon Lake were reported to range in age from less than 1 year to more than 20 years. Sixteen of the 80 responses (20%) listed their systems as less than 5 years old, 39 (49%)

indicated systems between 5 and 10 years old and 25 (31%) indicated that their systems are greater than 15 years.

Problems were reported by 25 of the respondents who used septic systems. The problems indicated by septic system owners included: the backup of wastes into the house (15), odorous water surfacing at the tile field (2), backups and odorous water surfacing (4), and other problems (4). In general these problems were solved by either pumping the septic tank, by fixing a broken pipe, or by allowing a frozen drainfield to thaw. There were few responses that indicated chronic problems requiring frequent maintenance. In many reported cases (43%), maintenance of on-site systems was undertaken only after a problem developed.

Rush and Passenger Lakes

A total of 24 questionnaires were received from property owners with lots within the land area immediately surrounding Rush and Passenger lakes. Nine of the respondents indicated that their property is not developed or used. The remaining 15 respondents have developed lots with homes or cabins and on-site systems. Of these 15 respondents, 13 indicated that their property is used on a seasonal basis and 2 indicated that they are permanent residents.

Privies and septic systems were reported as the predominant on-site systems used by the Rush and Passenger lakes respondents; 6 of the 15 systems identified are privies and are 5 septic tanks. The remaining systems reported are either cess pools (3) or cess pool-holding tank combinations (1). The septic tanks and cess pools all discharge to a seepage field (7) or to a tile line (1).

Most of the respondents indicated that systems in use around Rush and Passenger Lakes are less than 10 years old (6 of the systems are between 5 and 10 years old). Four respondents, though, reported systems greater than 20 years old, including one privy reported as 52 years old and another reported as 45 years old.

All of the respondents reported that they had never had problems with their on-site systems, although 4 of the respondents reported that maintenance is done on the system "after a problem develops." Most of the systems are maintained on a regular basis (8 of 14 responses). Two respondents indicated that their systems are never maintained.

Wild Acres and Hogan's Subdivisions

A total of 36 questionnaires were received from property owners in two adjacent subdivisions just northeast of Rush and Passenger Lakes. Fifteen property owners indicated that their lots currently are undeveloped. The remaining 21 respondents reported having developed lots where on-site systems are present. All but 3 of these 21 property owners indicated that they are seasonal residents.

The on-site systems reported include 9 septic systems, 6 privies, 3 holding tanks and 1 cess pool. Two combination systems also were reported, both septic tank-cess pool combinations. All but 3 of the systems (excluding the privies and holding tanks) discharge to seepage fields. The other 3 discharge to tile lines.

Because these are relatively new residential subdivisions, most of the systems are less than 5 years in age. Two respondents indicated that their systems are between 5 and 10 years in age.

None of the respondents reported having problems with their on-site systems. Most of the responses also indicated that the systems are regularly maintained; 7 of the 16 responses to this question reported regular maintenance and 6 reported that maintenance has never been performed. One respondent indicated that maintenance was performed after a problem develops and 2 reported other maintenance arrangements.

Outlying Properties

Within the service area there are a number of residences not having riparian access and not located in the Hogan's or Wild Acres subdivisions.

These rural residences are principally farm houses or other permanent local dwellings located on main roads. There are approximately 50 outlying residences within the service area. Two questionnaire responses were received from these outlying residences, indicating no problems with on-site systems.

2.2.1.4. EMSL Aerial Survey

The USEPA Environmental Monitoring Systems Laboratory acquired remote sensing imagery of the project area in late 1980. False-color infrared aerial photography and multispectral scanner imagery were collected on 21 October 1980. Additional color aerial photography was collected over the project area on 10 November 1980. The color and false-color infrared aerial photography were stereoscopically examined for evidence of apparent on-site septic system malfunctions, for indications of algal blooms on area lakes, and for land use/land cover data in the project area (USEPA 1981). Multispectral scanner imagery was computer-analyzed to determine relative surface water temperature differences near the shorelines of the project area lakes. The temperature differences were evaluated as a possible indication of the entrance of warm wastewater or septic tank effluent into a lake.

The analyses of on-site septic leachate field malfunctions with remote sensing imagery requires detection of variations in color tones of vegetation which may result from septic effluent rising to or near the soil surface. With the use of color infrared photography, vegetation appears in varying red tones which may represent different plant species and growth stages as well as plant vigor. The October fly-over should have captured remnants of vegetative growth that may have resulted from drainfield surface failures.

Results of the analyses described above identified only seven on-lot septic tank-drainfield systems that appeared to have vegetative "signatures" which indicated a surface failing on-lot system. A subsequent field trip to the area for ground truth verification was not conducted due to snow cover. The photo interpretation indicated that three systems around

Island Lake and four systems around Sturgeon Lake were potential failures, with no indicated failures around Passenger or Rush lakes. The accuracy of associating an aerially detected system failure with ground-truth verified problems has been marginally successful in other studies (Rural Lake Projects 1-6, USEPA 1978-1981).

For Island Lake, the EMSL remote sensing data indicated three probable system failures along the northwest shore where, coincidentally, problems were also described by the lot-by-lot survey and by the septic leachate survey. The aerial photography did not indicate any probable system failures along the north shore of Island Lake, a problem area as determined by other sources.

For one isolated segment of Sturgeon Lake (Sturgeon Island) there was a general concurrence of information on probable failing systems from the lot-by-lot survey, the septic leachate survey, and the remote sensing imagery analysis. The two problems detected by the analysis of the aerial photography of the Sturgeon Island segment of Sturgeon Lake were not associated with specific problem lots defined by the other surveys, but were in the general area of other identified problem lots. The other two cases of aerially detected probable failures on Sturgeon Lake were not at all corroborated by other information.

Analysis of the Passenger and Rush Lake aerial surveys indicated no probable system failures. This is consistent with other collected information indicating few, if any, problems with on-site systems for these two lakes.

The discrepancy between the larger number of problems indicated from ground based surveys and the relatively few problems indicated from the combined methods of aerial survey could be attributed to one or several of the following factors:

- Portions of lots where the septic system is located were obstructed by shadows and could not be stereoscopically analyzed.

- Some seasonal residences may not have been in use for several months prior to the time of the fly over, allowing the drainfield to recuperate, lowering the groundwater level, and resulting in a loss of vegetative vigor.

- The drainfields of some residences were obscured by brush or other small woody bushes and some residences have gardens planted over the drainfields. These gardens could mask potential drainfield failures.

Imagery information collected from this aerial survey was used in other sections of this EIS. For example, the multi-spectral scanner imagery gave evidence for general groundwater flow directions into the lakes, and was utilized to help resolve differences found in the highly specific groundwater flows measured during the septic leachate survey. Imagery used to formulate lakeshore area land use maps in the EMSL survey also was used in conjunction with other data sources to map land uses in the watershed of each lake. These maps were used as the basis for projecting nutrient export values from the land. No algal blooms were indicated on the four lakes by the false color infrared or by the color photography.

2.2.1.5. Septic Leachate Survey of Island, Sturgeon, Rush, and Passenger Lakes

Interviews with lakeshore residents, visual inspections, and remote sensing imagery can detect obvious backups and surface malfunctions of on-site wastewater treatment systems. However, these techniques do not detect poorly treated effluents that may enter lakes or streams via soil infiltration and groundwater transport. Because of the highly variable nature of the slopes and soils around the surveyed lakes, the location of such below ground effluent sources would be difficult to predict based on conventional sanitary survey techniques. In the septic leachate survey, on-site waste treatment system effluent plumes were located and monitored directly utilizing instrumentation designed specifically for that purpose.

Potential effluent plumes entering Island, Sturgeon, Rush, and Passenger lakes were located with an ENDECO Type 2100 Septic Leachate Detector System. Baseline or "ambient" water quality of the lakes was first measured in mid-lake to calibrate the response of the instrument to natural conductivity (a reflection of ionized mineral salts) and to dissolved organic matter (fluorescence). Shorelines were then surveyed to locate areas with relatively high conductivity and fluoresence, these being areas where inadequately treated wastewater may be emerging. Small areas of the lake bed where elevated amounts of organic matter and conductivity are found to be emerging into the water are termed "suspected effluent plumes". The 9 suspected wastewater or effluent plumes which appeared to be the strongest of the 39 such plumes detected were sampled as they emerged. These samples were then analyzed in a laboratory for the water quality parameters of interest. In addition, at the nine plumes where instrument signals of relatively high amplitude were recorded, groundwater was sampled at close intervals in a shoreline transect made perpendicular to the estimated direction of plume movement. These groundwater samples were tested with the leachate detector to locate the approximate plume centers through which leachate moved from the failing system toward the lake. The groundwater was then sampled at the plume center for subsequent laboratory analysis.

Sources other than septic tank effluent also can produce strong leachate detector responses which can either mask or falsely indicate the detection of septic leachate plumes where evaluated amounts of natural organic substances are present. Seven water quality samples were collected where runoff water or intermittent streams entered the lakes to identify such potential interference problems.

A discussion of the methods employed and the results of the septic leachate survey are presented in Appendix C of this report.

Conclusions and Observations Based on the Leachate Survey

The more important conclusions and observations made based on the septic leachate survey of Island Lake are that:

- The septic leachate survey of this lake was performed under ideal conditions of calm weather and insignificant wave activity.

- Fifteen suspected wastewater plumes were identified. All of them were found on the northwest shoreline between flow stations 1 and 13 (Figures 2-6 through 2-9). The influx of the nutrients from the four suspected septic plumes sampled for phosphorus and nitrates was very low as indicated by the low levels measured at the point of plume emergence into the lake.

- Background fluorescence and conductivity values are significantly higher in the northern basin than in the southern basin. This may be associated with the fact that sizeable tributary streams enter the northern basin only.

- Six distinct stream plumes were located, and four of these were in the northern basin. Moderate levels of fecal coliform bacteria were detected in five of the streams and non-human sources are indicated by them.

- No potential public health problems associated with septic sources of fecal coliform organisms in the surface waters of Island Lake were indicated.

- Both surface water and groundwater were found to be recharging the northern basin and discharging from the southern basin.

The more important conclusions and observations made based on the septic leachate survey of Sturgeon Lake are that:

- The survey of Sturgeon Lake was performed under less than ideal conditions due to the prevailing wind and wave action along the downwind shores. This may have resulted in an underestimation of the pollutional significance of on-site systems at seasonally used residences.

- Groundwater was found to be discharging from Sturgeon Lake along the southern shoreline between flow stations 35 and 39, accounting for the absence of septic leachate plumes along this lake segment.

- Groundwater recharges Sturgeon Lake along the segment between flow stations 28 and 34. Six emergent plumes were detected in this segment, indicating an area of possible concern with regard to small waste flows management. Homes along this segment were observed to be closer generally to the shoreline than at other areas around the lake. However, the water quality samples taken in the two suspected effluent plumes on this shoreline do not indicate a significant influx of nutrients to the lake. Additionally, no high concentrations of fecal coliform organisms were found.

- Homes along the shoreline segment between stations 24 through 26 are located very close to the lake. No septic plumes could be identified there, however, possibly because of high ambient interference levels caused by two adjacent runoff sources.

The more important conclusions and observations made based on the septic leachate surveys of Rush and Passenger Lakes are that:

- Both Rush and Passenger Lakes are surrounded by highly permeable, sandy soils. These soils are ideal for the percolation of septic tank effluent from the standpoint of wastewater movement, but would also exhibit the passage of effluent plumes.

- Most of the homes near Rush Lake are built on a sand ridge located between flow stations 48 and 51. Another sand ridge extends from stations 44 to 46. The northeast corner of this lake is swampland underlain by a mucky peat layer about five feet thick.

- A total of three suspected plumes were located on Rush Lake, and a total of four suspected plumes located on Passenger Lake. In spite of the high soil permeability associated with the sandy soils of this area no significant nutrient influx was detected at emerging plumes and no elevated fecal coliform levels were detected.

During the periods of 11-25 September 1981 and 2-9 October 1981, groundwater flow velocity and direction were measured at points along the shorelines of Sturgeon Lake, Island Lake, Passenger Lake, and Rush Lake. The objective of these measurements was to support the analysis of the leachate survey by characterizing shoreline segments in terms of groundwater flow patterns. By identifying subsurface flow vectors, it is possible to estimate the direction of groundwater effluent plume movement and to identify those shoreline areas where failing septic systems can cause the greatest impacts on lake water quality.

A Groundwater Flowmeter System (Model 20) was used to evaluate the direction and velocity of groundwater flow at selected locations on the shorelines of the four project area lakes. The Flowmeter has a cylindrical probe with radially projecting thermistor "spikes." Flow measurements were obtained by inserting the probe in saturated soil at or slightly below the water table surface. Access to the water table was achieved by digging shallow holes with a narrow-nosed shovel, 3-10 feet inland from the lake shorelines. Prior to measurement of flow a minimum of 30 minutes was allotted to permit the water table and thermistor array to achieve equilibrium.

A standardizing method was used to improve the correlation between laboratory instrument calibration and collected field data. A large sample of sand was collected from a beach area on Island Lake. This sand was thoroughly mixed and placed in a laminar flow tube of known cross-section and flow. In this way the probe was calibrated to local soil having specific average pore size and permeability. Enough sand was collected to backfill the holes dug at each flow station. Thus, all flow measurements were made in soil matrices having uniform properties.

The groundwater flow vector data collected for the stations around the shoreline of each lake are presented in Table 2-5. Locations of the groundwater flow measurement stations are presented in Figures 2-6, 2-7, and 2-8 and 2-9.

During the initial survey in September 1981, groundwater flow measurements around the four lakes were made during a period of little or no precipitation; there had been no significant rainfall in the area for 1 month preceeding the study. Therefore, the measured groundwater flow data are probably representative of low to average water table conditions in the unconfined water table aquifer. Nine flow measurement stations were established at the estimated plume centers during a subsequent period (early October). The subsequent measurements were made after several days of rainfall and provide information about groundwater flow when the water table is at or above average height. Flow conditions in the confined aquifer systems (below the unconfined water table) were not measured.

Conclusions and Observations Based on the Groundwater Flow Data

Groundwater apparently discharges from Island Lake along the shoreline, west of a hypothetical line drawn through flow stations 15 and 9 (Figure 2-6). The anomalously high flow velocity recorded at Station 10

Table 2-5. Groundwater flow velocities and directions as measured at "flow stations" established on the shorelines of Island, Sturgeon, Rush, and Passenger Lakes.

Island Lake

Station #	Apparent Velocity (ft./day)	Azimuth Direction (degrees)
1	1.2	321
2	4.1	200
3	4.7	250
4	1.6	270
5	1.5	184
6	2.0	254
7	2.0	300
8	1.5	345
9	3.0	188
10	39.4	177
11	2.0	035
12	2.0	249
13	7.4	315
14	2.0	350
15	6.7	009
16[1]	2.0	221
17	0.7	067
18	0.7	230
19[1]	2.0	160
20[1]	4.5	185
21	1.2	218
22	0.7	254
23	1.8	237
23a[1]	2.4	231

Sturgeon Lake

Station #	Apparent Velocty (ft./day)	Azimuth Direction (degrees
24	1.4	260
25	3.2	212
26	1.4	170
27	1.6	122
28	8.0	220
29[1]	1.9	355
30	1.7	151
31	1.2	185
32	2.4	233
33[1]	2.3	329
34	3.2	324
35	3.7	173
36	6.4	196
37	1.8	272
38	2.4	230
39	2.2	222
40	2.8	341
41	2.7	248
42	1.9	028
43	2.3	273

Rush Lake

Station #	Apparent Velocity (ft./day)	Azimuth Direction (degrees)
44	1.2	235
45	2.3	015
45a[1]	3.1	317
46	7.6	147
47	3.0	228
48	1.2	256
49	2.0	147
50[1]	11.1	012
51	2.4	210

Passenger Lake

Station #	Apparent Velocity (ft./day)	Azimuth Direction (degrees)
52	1.9	179
53	1.8	140
54	2.2	223
55	2.2	320
57	1.4	350
58	3.8	145
59[1]	3.5	289

[1] Measured during period of above average precipitation (2-9 October, 1981). All other measurements taken during period of low precipitation (11-25 September, 1981).

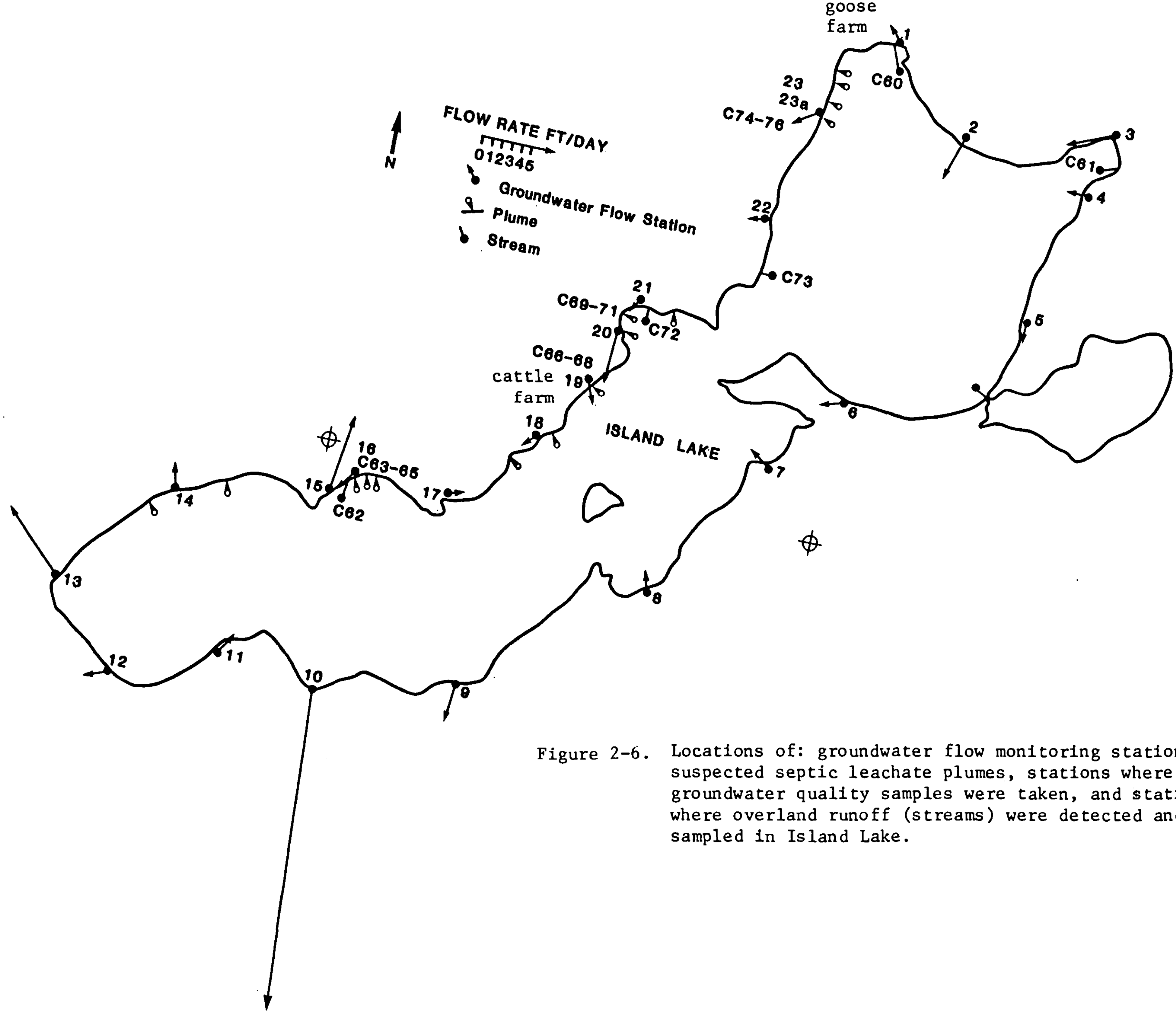
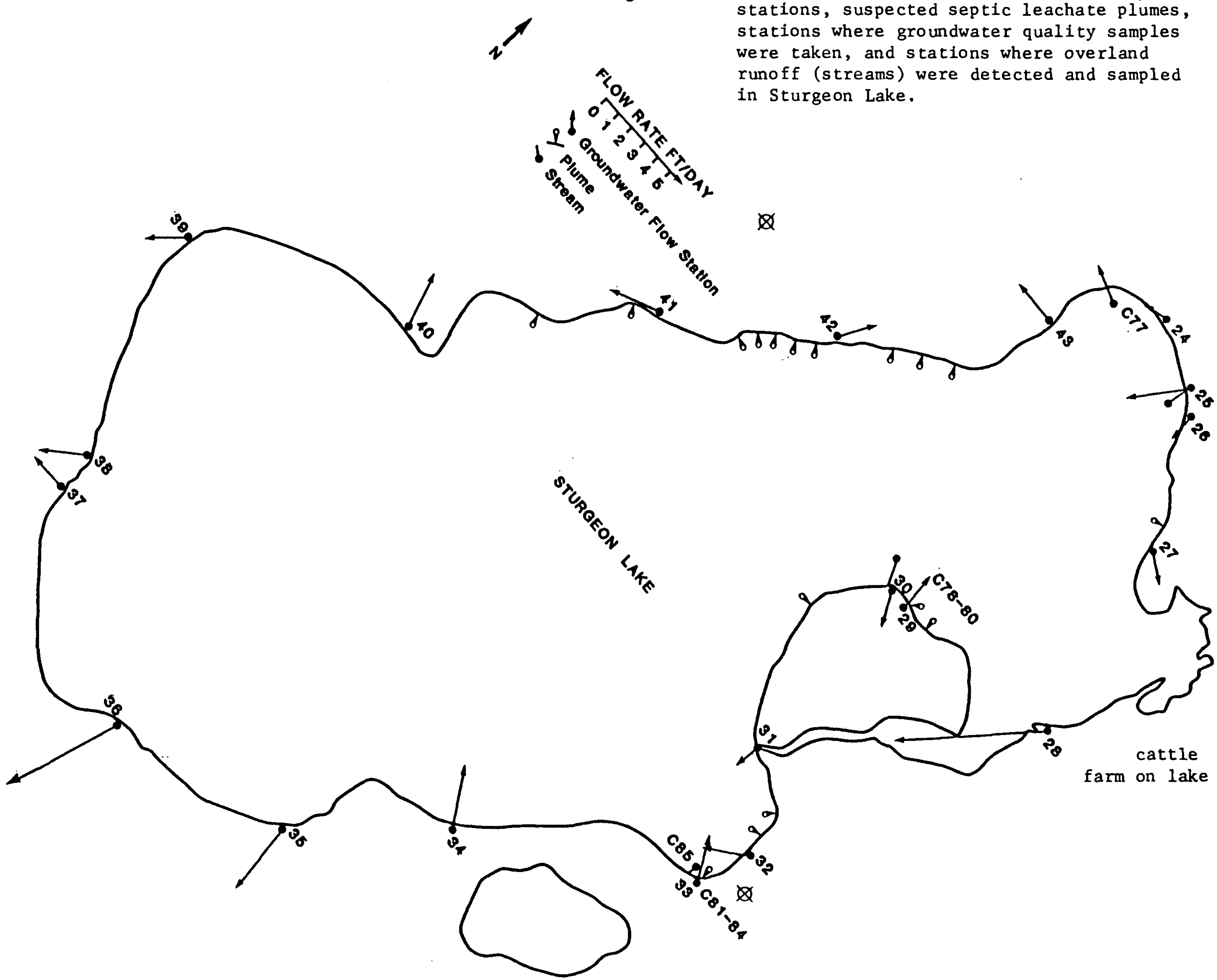


Figure 2-6. Locations of: groundwater flow monitoring stations, suspected septic leachate plumes, stations where groundwater quality samples were taken, and stations where overland runoff (streams) were detected and sampled in Island Lake.

Figure 2-7. Locations of: groundwater flow monitoring stations, suspected septic leachate plumes, stations where groundwater quality samples were taken, and stations where overland runoff (streams) were detected and sampled in Sturgeon Lake.



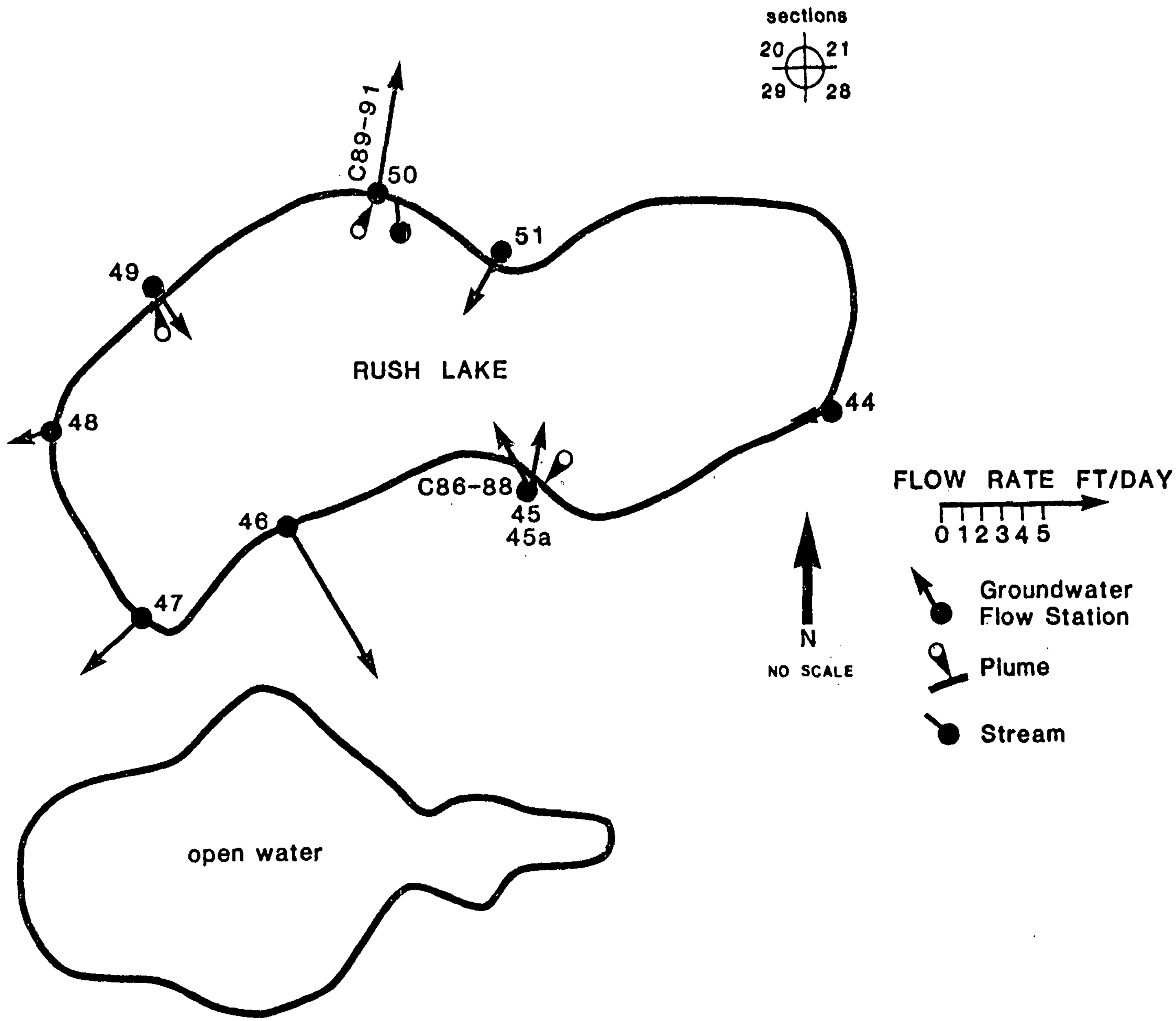


Figure 2-8. Locations of: groundwater flow monitoring stations, suspected septic leachate plumes, stations where groundwater quality samples were gathered, and locations of stations where overland runoff(streams) were detected in Rush Lake.

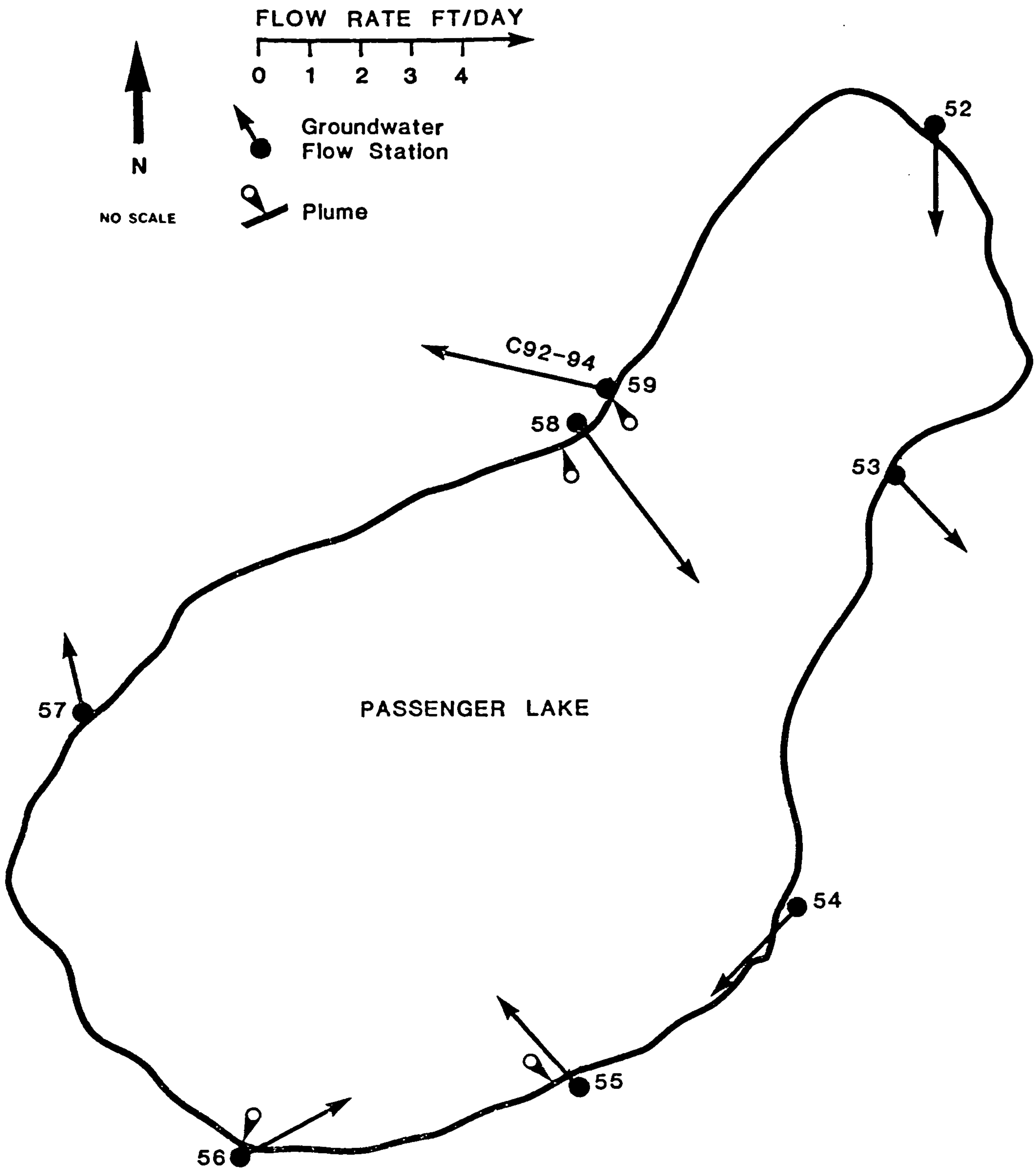


Figure 2-9. Locations of: groundwater flow monitoring stations, suspected septic leachate plumes, stations where groundwater quality samples were gathered.

(40 feet per day [ft/day]) was confirmed by additional measurements on successive days. This high outflow from Island Lake occurs through a sand and cobble zone at the base of a steep slope which overlooks the beach area.

Based on the flow vectors measured in September 1981, groundwater recharges Island Lake along the shoreline between flow stations 8 and 2. Between flow stations 15 and 1, the groundwater vectors displayed no consistent trends. This latter segment contains the highest concentration of lakefront homes and it is possible that under average water table conditions, volumes of water percolating from on-site systems may be sufficient to affect the overall flow pattern of groundwater movement due to localized artificial recharge of the water table by domestic wastewater.

Based upon the association and distribution of soils in the region, it appears that the southern and southwestern shores of Sturgeon Lake are underlain by a glacial till which is veneered with a thick deposit of outwash sands. These sands comprise a highly permeable, unconfined aquifer underlain by the glacial till aquitard. The slopes along the southern shoreline of Sturgeon Lake also are much less than on the till-covered landscape surrounding the rest of the Lake. Geologic and topographic characteristics result in complete groundwater discharge from Sturgeon Lake along the shoreline between stations 35 and 40.

Groundwater flows into Sturgeon Lake along the beach area between stations 31 and 33. Numerous homes have been built around this embayment in close proximity to the beach. The lakeward groundwater flow conditions observed would contribute to the emergence of septic plumes there.

The highest flow velocity measurement recorded on Sturgeon Lake was at station 28 (8 ft/day). This flow station is located at the juncture of an inland swale with the shoreline. A surface water flow does not normally exit from the swale, but surface waters may be discharging intermittently during storm events. The significance of this depression is that it drains an area presently in use as a dairy farm and groups of cows were seen standing in the water. The shoreline segment between flow stations 40 and

43 is characterized by narrow beach areas at the base of relatively steep till slopes. Groundwater flow patterns along this segment appeared diffuse. Distinct landward flow was not indicated.

The topography of the land surrounding Rush Lake indicates that it was considerably larger in recent geologic history and may have been part of Sturgeon Lake. Large swamplands demarcated by relict shorelines occur northeast and south of Rush Lake, and are probably the result of eutrophication processes in parts of the former lake.

Surface water flowing from a broad swampland enters Rush Lake along its northeastern and eastern shorelines. Surface water is discharged from Rush Lake through a single small culvert to another broad swampland to the south. Under base flow conditions, groundwater recharges Rush Lake along its northern and eastern shores. Groundwater is discharged along the southwest shoreline in a direction analogous to surface flows.

Flow stations 45 and 50 were established during the septic leachate survey which followed a period of rainy weather (October 1981). The increased flow rate at station 45a reflects this. Normally, increased precipitation can be expected to increase groundwater flow toward a lake. Rush Lake might not display this property because the relatively large watershed area on the northeast may, under rainy conditions, introduce more water than can be carried away by the single culvert. Rising lake levels would then induce groundwater discharge along much of the remaining shoreline, which would account for the outward flow recorded at station 50 and the deflected flow direction at station 45a, relative to earlier flow data at these stations (September 1981).

Surface water discharges from Passenger Lake into Big Slough Lake via a small creek, the inlet of which lies approximately 100 feet south of station 54. No sources of surface water influx to Passenger Lake were observed. Passenger Lake is apparently recharged by groundwater along its northern and southern shores. The flows observed at station 53 indicate that subsurface flow toward Big Slough Lake to the southeast may occur along the eastern shore of Passenger Lake. The measured easterly flow vector is analogous to this surface water flow trend. Flow station 59 was established during the high water table conditions in October 1981. The measured landward flow is probably a result of rising lake levels caused by rapid groundwater influx to Passenger Lake along other shoreline segments. The data from station 52 indicate that under average water table conditions the groundwater vector in the vicinity of station 59 probably is lakeward.

The overall regional groundwater flow direction in the project area is southerly. The effect of this southerly flux is to enhance the emergence of septic leachate plumes on the northern shores of the lakes and inhibit emergence on the southern lake shores (Septic Leachate Survey, Section 2.2.1.5.) There are isolated exceptions to this overall southerly direction of groundwater flux, expecially during periods of high precipitation.

Of the four lakes that were investigated, only Sturgeon and Rush Lakes were shown to exhibit distinct groundwater interconnections. Lake water is discharged to the outwash sands along the southern shore of Sturgeon Lake, and some of this water eventually reaches Rush Lake by means of a marsh. Surface water and groundwater discharged from the southwest shoreline of Rush Lake flow in a south westerly direction, and ultimately drain into the Willow River.

Groundwater entering Passenger Lake from the north, west, and south ultimately flows east via a small creek to Big Slough Lake and then on to the Willow River. Of the four lakes studied, Passenger Lake has the smallest watershed area and is the most isolated in terms of regional groundwater flow patterns.

2.2.1.6. Private Water Well Information

The leachate survey described in the previous section (2.2.1.5) developed a limited amount of water quality data to characterize the water table aquifer in the vicinity of nine lakeshore residences. The results, labeled as "background samples" of groundwater in the data tables prepared for the leachate survey, indicate no extraordinary amounts of nitrate or fecal coliforms (Appendix C). However, these limited groundwater data are insufficient for the purpose of determining whether private wells in lakeshore homes are currently being contaminated with pollutants originating from on-site waste treatment systems. To determine if well contamination is a serious problem and that as a result improved wastewater management is necessary, a series of questions should be addressed such as:

- How deep are the wells?
- How permeable are the soils around the wells?
- Does groundwater at the aquifers being tapped move from the leachate field toward wells?
- Are naturally dissolved groundwater constituents already at levels which constitute a potential public health problem?
- Is there documentation of private well contamination from wastewater?
- Can fertilizer or animal waste in feedlots be a source of groundwater contamination?

Using the information presented in this report, a number of deductions can be made, a priori, to focus on lakeshore segments where private water well contamination is most likely to be occurring. The aforementioned questions can then be addressed for private wells in identified critical lakeshore segments to determine if further investigation is warranted. For example, it is assumed that tight soils which may preclude satisfactory performance of septic systems also generally preclude the recharge of groundwater with septic leachate (USEPA 1978, pc-60). This assumption applies in much of the northern portion of the service area, where Duluth Series soils predominate.

The predominance of Duluth soils around most of Island Lake and also around the northern half of Sturgeon Lake was discussed in the Soil Survey prepared as a portion of this EIS. The testing of soil particle size distributions as documented in the Soil Survey, indicates that the Duluth soils found around Island and Sturgeon Lakes are especially clayey and that their clay content tends to increase with depth. This situation results in very low rates of downward permeability for leachate and makes contamination of groundwater to a depth greater than 20 feet extremely unlikely.

The inverse situation is found in an isolated area of sandy soils located adjacent to the northwest shoreline of Island Lake and in the remainder of the service area wherever sandy soils predominate. Shallow domestic water wells located in sandy soils are the wells most likely to be contaminated by septic leachate recharging the water table aquifer (USEPA, 1978, pc-69). The shallow "sand point" wells which are sometimes used to tap the water table or "glacial drift" aquifer often are associated with older or seasonal residences. A concentration of residences with shallow wells located on lakeshore segments with sandy soils should be examined critically for the potential of well contamination.

The Omega sandy loam soil series and Lake Beach soils of the project area can practicably support seasonal development because of the incidental ease with which well water may be withdrawn from shallow wells, and also because of the ease with which septic leachate percolates through drain fields. This coincidence of favorable leachate percolation characteristics and water table aquifer accessibility may be associated with many of the older lakeshore residences in the area. Where water use has been drastically increased by year round residence in dwellings which still rely on the original "sand point" well, this may increase the potential of well contamination by septic leachate. However, a broad determination of the need for better wastewater management in such situations must be made with caution. Older wells may also be experiencing contamination by non-wastewater sources such as surface water intrusion due to improper well vent protection or due to cracked well casings, or other design faults. Additionally, rapid development of a small land area where many shallow wells are being used could induce upward movement of groundwater of objectionable quality. In the final analysis, the discovery of objectionable well water quality or even of the potential of septic leachate contamination in a few isolated cases may more properly constitute a need for new, deeper wells than for another means of waste treatment.

The mailed questionnaire responses, as described in Section 2.2.1.3., provide information on well depth for one third to one half of the residences within the service area (depending on locale). This information allows an analysis to be made of the depths of wells at lakeshore residences in areas with Omega sandy loam soils or sandy Lake Beach soils. Table 2-6 presents the well depth information taken from questionnaire responses received from homeowners living in these sandy-soil areas.

Based on the questionnaire responses on well depth for the portions of the service area defined in Table 2-6 as having sandy soils, the following observations are made:

- Most residences located on the sandy soils along the northwest shore of Island Lake have well depths in excess of 40 feet. This is perhaps because the accessible groundwater is at or just above the 40-foot level.
- A large proportion of wells located on the sandy Lake Beach soils near the neck of Sturgeon Island are less than 30 feet in depth. This indicates the need to further investigate the potential for well contamination by septic leachate.
- Shallow wells are uncommon in the sandy Omega series soils along the south shore of Sturgeon Lake.
- A large proportion of the residences located on the sandy Omega series soils surrounding Rush and Passenger Lakes have wells less than 30 feet in depth. This indicates the need for further investigation of the potential for well contamination by septic leachate.
- Few private water wells in the Hogan's and Wild Acres developments are less than 30 feet in depth. The median well depth in this area is 40 feet, perhaps because the accessible groundwater is at or just above this level.

Based on these observations, it appears that the potential for well contamination by septic leachate is greatest in the land area just south of the neck of Sturgeon Island and in the land area immediately surrounding Rush and Passenger Lakes. Questionnaires received from property owners in these two critical areas were re-examined and a total of 14 residences with wells of less than the median depth were identified as suitable for study in a follow-up well sampling program. Of the 14 residences thus identified, only one was in use as a permanent dwelling, and the other 13 seasonal-use dwellings were owned by persons not living in the project area. Since the summer season was over when this analysis was performed, it was assumed that additional well sampling would not be feasible until the

Table 2-6. Information on well depth in the portions of the service area having permeable, sandy soils.

Area	Number of Questionnaire Respondents Reporting on Depth of Well	Number of Wells > 30 ft. in Depth	Median Well Depth	Range of Depths Reported
Northwest Shoreline of Island Lake (Omega series soils)	8	0	45 ft.	40-60 ft.
Neck of Sturgeon Island on Southeast Shore of Sturgeon Lake (Lake beach soil)	9	4	32 ft.	20-199 ft.
Southern Shore of Sturgeon Lake (Omega series soils)	19	4	57 ft.	7-190 ft.
Rush and Passenger Lakes Area (Omega series soils)	13	9	28 ft.	8-175 ft.
Hogan's and Wild Acres Area (Omega series soils)	17	3	40 ft.	20-70 ft.

summer of 1983, when the seasonal dwellings were occupied and their wells functioning.

Further evaluation of the potential for well contamination in these areas was attempted based on review of Minnesota Department of Public Health well sampling data. In Minnesota, well water samples are collected and analyzed after a new well has been drilled. Data from the Health Department were obtained for 60 recently drilled wells (1979-1981) in Pine and Carlton Counties (presented in Appendix C). Eleven of the 60 tested wells are in Windemere Township, Pine County. Based on the 60 well samples, the groundwater quality in the project area appears to be very good. Most of the reported cases of coliform contamination in these samples are thought to be due to inadequate disinfection following well completion (written communication to WAPORA, Inc. by Mr. Michael Convery, 1982). Most of the tested wells were greater than 50 feet in depth, with the deepest listed at 538 feet. The tested wells are finished in either sand/gravel deposits or sandstone (Minnesota Dept. of Health Well Records 1979-1981).

Based on the available well sampling data, it appears that the deeper wells of the project area have no water quality problems. However, data from the recently tested wells in the project area were insufficient for the purpose of analyzing the potential of water table aquifer contamination by septic leachate. Too few shallow wells were sampled and none in the critical sandy-sand areas were sampled.

Woodward and others (1961; as cited in USEPA 1978p. C-60) reported on an extensive survey of over 63,000 private water supply wells in 39 communities which were served by individual septic tank systems. Eleven percent of the wells tested had total nitrate concentrations which were greater than the drinking water quality standard of 10 mg/l-N. The results were attributed to differences in soil characteristics, well depth, population density, and hydrogeology. Because sufficient groundwater quality sampling data for shallow wells were not available in the project area, the water table aquifer quality in critical lakeshore areas cannot be fully evaluated at this time. The above referenced study does, however, point out the possibility that shallow aquifer nitrate contamination can occur under comparable circumstances. Groundwater quality is influenced by numerous independent variables and a full scale study to outline problems and trace their causes would be cost prohibitive even if sufficient time were available. Because documented well contamination problems associated with septic systems are not common in the area, according to the State Department of Health, it is presumed that no broad degree of need for improved waste treatment exists as a result of well water contamination.

2.2.1.7. Local Permit File Information

The County Sanitary Codes of Minnesota require that permits be obtained by individual property owners for replacement or for new installation of on-site waste treatment systems. The Pine County Zoning Administrator maintains a file of the permit applications made in Pine County each year. The file was reviewed for this EIS to determine which portions of the project area were being developed with on-site systems and to locate any recent on-site system upgrades. In addition, federal grant eligibility for sewers and for on-site system upgrades can be determined according to the date of on-site system installation. A summary of the information obtained from the local permit file is presented in Table 2-7.

Records of on-site system upgrades in the Island Lake area were available for the period of 1974 - 1982. These upgrades are discussed in more detail in Section 2.2.3.1. For the period of 1980 - February 1982, the most common type of new system permitted around Island Lake was the holding tank (5 installed) followed by the the privy (3 installed). No septic systems were installed around Island Lake after February 1980. The Zoning Administrator has stated that septic tanks are sometimes recommended by his office for persons planning to construct new homes in the Island Lake vicinity, but that people have usually elected to apply for holding tanks instead (Personal communication to WAPORA, Inc. by Mr. Wayne Golly, 1982).

2.2.1.8. Follow-up Survey

The information described in the preceding sections, when initially reviewed, revealed data gaps which required that a follow-up survey be

Table 2-7. Summary of County permit file data for the period February 1974 through February 1982 (File of the Zoning Administrator, Pine County, Pine City, MN.)

	Permit Applications 1974 through 1980			Permit Applications 1981 through 1982		
	Island	Sturgeon	Rush/ Passenger	Island	Sturgeon	Rush/ Passenger
New septic tanks with soil absorption systems	14	14	7	0	3	0
New holding tanks	17	26	1	5	1	0
New Privies	6	9	6	3	2	0
Upgrades of soil absorption systems	6	0	0	0	0	0
Sub-area totals	43	49	14	8	6	0
Project area totals		106			14	

made. The follow-up survey, conducted in March-April 1982, consisted of telephone contacts with property owners and a field reconnaissance to inventory existing structures in the Wild and Hogan's Acres subdivisions.

The telephone survey was conducted to obtain additional original information from property owners or to clarify discrepancies found in the existing information. For example, on-site systems which had been reported to have problems in the mailed questionnaires or lots which had been qualitatively described as having serious site limitations or failing systems in the Facility Plan were re-evaluated through this telephone survey of owners. In the approximately 35 telephone contacts made, specific questions were asked about the cause of and seriousness of any problems cited.

Through the direct telephone conversations with property owners, it was determined that many of the problems previously reported with septic systems had been maintenance-related instead of design or site limitation related. Normal maintenance had, in most instances, already solved the problems. In several cases the problems were ongoing and appeared to require a more permanent and extensive solution. The details of what was learned from the follow-up telephone survey are presented in Table 2-10 (Section 2.2.3.) where problems in specific lakeshore or subdivision areas are identified.

A field visit was made to the Wild and Hogan's Acres subdivisions during February 1982. The purpose of this visit was to determine the number of lots with residences or trailers on-site. It was assumed that mobile units on-site at that time of the year were present year round. Summer and early fall use of the lots in these subdivisions had previously been observed to include hard-top and tent camper trailers which are seasonally moved on and off-site. (Late fall use includes residence in the area through the hunting season according to several of the questionnaire respondents). During the February visit, 74 lots with structures inplace were counted. The majority of these structures were mobile homes. The total number of privately owned lots in the two subdivisions may exceed 155, based on tax records, but the actual trailer occupancy rate in the warm season is unknown. It is assumed, however, that a large proportion of the trailers are not connected to on-site systems because their waste holding facilities are self contained. The telephone follow-up survey did not cover all owners of lots in these subdivisions because of the aforementioned uses of the lots and because no on-site system problems were reported for them in the questionnaire responses, in the public well water records, or in the Zoning Administrator's file. Additionally, local septage haulers reported no excessive septic tank pumping taking place at homes within those subdivisions (personal communication to WAPORA, Inc. by Mr. Dale Heaton, April 1982).

2.2.2. Problems Caused by Existing On-Site Systems

On-site waste treatment systems may fail to function properly for a variety of reasons, including improper design and installation, failure of the owner to perform proper maintenance or unsuitable site characteristics. The symptoms of on-site treatment system failure may include:

- Backups of wastewater in household plumbing;
- Ponding of effluent on the ground surface (surface failures);
- Groundwater contamination; and
- Surface water contamination.

In this section, some of the information presented in Section 2.2.1 is used to define and quantify the extent of several symptoms of system failures found in the project area. Additionally, an overview is provided of the existing scientific literature and of locally gathered data regarding the potential impact of such failing on-site systems on public health and on water quality. Indirect evidence to be utilized for anticipation of future problems with on-site systems is also defined in this section. Where the perspective of this section is on the entire project area and on each lake's set of problems, the perspective of the subsequent section (2.2.3.) is on the problems in particular lakeshore segments or subdivisions. This latter perspective provides a basis for the development of project alternatives which serve the real needs of the people owning property within the project area.

Published Federal guidance directs that on-site system pollution problems affecting groundwater or surface water be identified and traced to the causal factors. Facility planning projects will only receive federal funding where a significant proportion of residences are so documented as causing problems. The Federal documents being utilized for the analysis of causal factors and for quantifying and categorizing failures include:

- USEPA Region V; Guidance on Site Specific Needs Determination and Alternative Planning for Unsewered Areas.
- USEPA Region V, Guidance and Program Requirements Memoranda 78-9 and 79-8.
- Minnesota Pollution Control Agency, Site Specific Needs Determination and Alternative Planning for Unsewered Areas.

Additionally, the USEPA Region V staff have interpreted the regulations to mean that eligibility for USEPA grants be limited to providing improved waste treatment only for those on-site system which have been demonstrated with direct evidence to be polluting and to those systems which have site characteristics and usage patterns identical to those associated with the polluting systems.

2.2.2.1 Backups

Backup of sewage in household plumbing constitutes direct evidence of need if it is caused by a design problem such as an undersized drainfield or by site limitations such as extremely tight, clayey soil or a high groundwater table which results in the filling of the leachate field with groundwater. Pipes or drain tiles that are clogged or broken or septic tanks which are filled with solids due to a lack of normal maintenance pumping are not considered evidence of direct need for a system upgrade or replacement.

The number of septic systems in the project area which have backup problems was determined by review of the MLWSD survey, of the responses from the mailed questionnaire survey, and of the follow-up telephone survey results. Initially, this information indicated that fewer than 20 residences had experienced problems with backup of sewage into the household.

Contacts with homeowners made during the follow-up survey documented that 7 of the 20 backup problems reported were chronic and attributable to design problems or site characteristics.

2.2.2.2. Ponding or Surface Failure

The ponding of septic tank effluent at and around a soil absorption system constitutes direct evidence of need for improved waste treatment. The impacts of ponding may include objectionable odors and public health risk to the property owner and to the neighbors. If runoff carries ponded septic tank effluent into a lake or stream the pollutional impact of associated pathogenic organisms and of nutrients may be significant. Soft or wet soil above the leachate field also provides direct evidence of need if it occurs regularly.

The number of septic systems which demonstrated direct evidence of surface failures was determined by a review of the MLWSD survey, of the mailed questionnaire survey, of the EMSL aerial survey, and by the follow-up telephone survey. The follow-up survey was utilized to contact all owners reporting ponding problems in order to determine whether the drainfield was consistently wet or had standing water over it. Cumulatively, fewer than 30 chronic ponding problems were identified in the project area. These chronic problems were associated principally with systems located on tight, clayey soils around Island Lake.

Chronic problems with ponding may be completely exclusive of problems reported with sewage backups in the home. The exception is in the case where both occur simultaneously due to natural flooding of the system.

2.2.2.3. Groundwater Contamination

This section presents a summary of the information regarding the impact of septic leachate on the groundwater aquifers being pumped by private water wells within the project area. Section 2.2.2.6. addresses the impact of nutrients originating from on-site waste treatment systems moving with the groundwater and discharging into surface waters.

Contamination of groundwater with septic leachate, resulting in elevated levels of nitrite and nitrate (in excess of 10 mg. per liter) or in elevated levels of fecal coliform organisms (in excess of 100 organisms per milliliter) in private water wells constitutes direct evidence of the need for improved waste management.

Lakeshore segments where sandy soils predominate and where shallow aquifers are commonly tapped for drinking water supplies were identified in Section 2.2.1.6. Also in that section, well sampling and testing records maintained by the Minnesota Department of Public Health were reviewed to determine the quality of groundwater being tapped by the wells in such areas. No problems with well contamination by fecal coliform organisms or nitrates were documented for any of the wells in areas having a high potential for water well contamination.

Well drilling records for recent drillings in the project area indicate that a hydraulically limiting horizon or "aquitard" is generally present within 20 feet of depth from the land surface. This relatively impermeable layer would protect most of the area's wells of greater than 20 foot depth from bacterial intrusion via the groundwater. In addition, environmental reports on similar rural lake facility plans have addressed groundwater contamination potential through broadly scoped well sampling programs. In comparable settings, septic leachate intrusion into wells via the groundwater was not found to be a significant problem (USEPA 1978, 1979, 1979, 1980,).

2.2.2.4. Surface Water Contamination

Surface water quality problems directly attributable to on-site systems can be serious enough to warrant system rehabilitation or replacement. The two categories of problems for surface waters which qualify as direct evidence of need are high fecal coliform counts, which may imply a public health risk and high nutrient inputs which may be detrimental to water quality.

The septic leachate survey was the primary data source used to determine if there was direct surface water contamination by fecal coliform organisms originating from septic tank effluent. Surface water "contamination" is an accurate description of wastewater impact when used to indicate a substantial public health risk posed by disease causing (pathogenic) organisms originating from human fecal matter. Such contamination should be a matter of concern for the riparian property owner and constitutes a need for improved waste treatment. However, demonstration of the degree of health risk being posed by a failing on-site system is, unfortunately, not straight forward.

The conventional laboratory test used to estimate the density of fecal coliform organisms in water can be used to indicate the probability of actual disease causing bacteria and viruses being present. However, the fecal coliform test can only be construed to indicate a probability of pathogenic contamination if it is also established that the organisms being counted are indeed of human origin (USEPA 1980, Goldreich 1965). This is difficult to do in on-site system field studies because wild animals, pets, and domestic stock also can produce large numbers of fecal coliforms in excreta. Domestic pets and waterfowl can easily obscure the meaning of a coliform count by introducing non-human fecal material to surface water or groundwater. The result is that the probability of human pathogens being present is indicated only when a series of coliform counts are made over a period of time, under controlled conditions, and in situations where direct discharge of septic effluent is being made and where soil/leachate contact is minimal. In other words, the fecal coliform test alone can scientifically prove that pathogenic contamination exists only where this is already obvious to the public or to public health officials making a sanitary survey. With the above as background, it is noted that during the Septic Leachate Survey no overland flows or direct discharges of septic tank effluent were observed on the shorelines of any of the lakes being surveyed.

Based on all the available information sources listed in Section 2.2.1. it was estimated that fewer than 30 soil absorption systems may currently be experiencing surface failure problems out of an an estimated total of 260 soil absorption systems in use within the project area (Section 2.2.2.2.). Based on this, the potential of surface water contamination with disease causing pathogens does not appear to be widespread or serious. However, under future conditions, with additional development taking place on less suitable lots and with increases in water use attendant to further conversions of seasonal to permanent residences, the contamination problem caused by surface failures could become more serious.

A more positive assessment of the potential for contamination of the surface water of Island, Sturgeon, Rush, and Passenger Lakes may be gained from examination of the counts of fecal coliform made in suspected groundwater plumes versus counts made at the point of groundwater emergence into the lake (Section 2.2.1.5.). Based on the groundwater sampling data for situations where fecal coliform numbers in the groundwater plumes were high, no emergence of fecal coliforms through sub-surface groundwater plumes was found. Thus, it appears that adequate treatment of pathogens is taking place in sub-surface effluent plumes, even where certain other dissolved and colloidally suspended effluent constituents may be entering the lakes. This is supported by the published literature on fecal coliform-groundwater transport which suggests that because most bacteria are quite large compared to the colloidal organic substances that are located by the Septic Leachate Detector, that they (the coliform bacteria) are easily filtered out of the leachate by soils (Jones and Lee 1977).

Domestic wastewater may in some instances contribute a large load of nutrients to a lake or stream. The impact on water quality of this kind of nutrient enrichment may range from favorable to seriously adverse, depending on chemical and biological factors in each water body. For example, a trout stream can become far more productive and have a more viable fishery with the introduction of moderate levels of nutrient enrichment from sewage treatment plant effluent (WDNR 1975). On the other hand, lakes and streams can become over-enriched by nutrients from wastewater and can, as a result, show symptoms of environmental degradation ranging from partial or complete loss of dissolved oxygen in deep water to becoming choked with weeds and covered with mats of blue-green algae. Where a scientific assessment can support the notion that abatement of nutrient loads from on-site systems will actually limit or reverse the process of nutrient enrichment in a seriously degraded lake or stream, there is a demonstrated need to provide some kind of improved wastewater management.

The assessment of need based on nutrient enrichment or "eutrophication" is still more difficult and costly to make than the assessment of contamination by pathogenic organisms. The reason for this is that for each lake's eutrophication problem there is no generic assessment of cause. No two lakes are exactly the same and very few in a given region will be quite similar in terms of such factors as volume, shape, types of nutrient loads, flushing rate and so on. As a corollary to this, no single nutrient abatement step is universally prescribed to improve problem lakes. Thus, each lake's management needs must be individually assessed to determine if significant benefit will accrue from an expenditure of public money for better management of failing on-site systems. Island, Sturgeon, Rush, and Passenger Lakes each have unique physical and biological characteristics and illustrate this point well. The information used to determine the appropriate management strategies for these lakes and establish the need for improved wastewater management will draw largely on data gathered during preparation of the Environmental Report.

Phosphorus loads to Island, Sturgeon, Rush and Passenger Lakes were evaluated based on watershed land use and appropriate export rates selected from the literature. The impact of the estimated phosphorus nutrient loads on lake trophic status was then modeled in two steps (Section 3.1.3.3.). It was concluded, beginning with an assumed worst-case (total failure of all existing, on-site systems) for residential wastewater sources along the lakeshores that:

- Island Lake and Sturgeon Lake are both eutrophic and may be in need of management to improve water quality. Rush and Passenger Lakes are mesotrophic and do not require management to maintain or improve water quality.
- On-site systems at their assumed worst-case failure rate constitute a small proportion (less than 11%) of the annual phosphorus load to Island Lake and to Sturgeon Lake.
- On-site systems at their assumed worst-case failure rate constitute a sizable proportion of the annual phosphorus

load to both Rush and to Passenger Lakes (30% and 23%, respectively).

- The modeling of trophic status, assuming no phosphorus loads from on-site systems, projected no substantial improvement in the trophic status of Island and Sturgeon Lakes over the trophic status modeled with the assumed "worst case" on-site system loads.

The reason for the "no gain" situation portrayed by the two-step evaluation of the trophic status of Island and Sturgeon Lakes is related to the historic and existing use of the land in their watersheds as described in Section 3.2.2. Based on the land use data, agricultural and other non-septic system related phosphorus sources were estimated to provide the dominant historic and contemporary inputs of phosphorus to Island and Sturgeon Lakes Section 3.1.3.4.). In terms of model sensitivity then, the reason that sizeable improvements were not projected for Island and Sturgeon Lake trophic status by removal of the on-site system load is the relative insignificance of the phosphorus load from on-site systems even at the assumed "worst-case" failure rate. The two-step modeling of trophic status for Rush and Passenger Lakes indicated a shift toward improved trophic state assuming elimination of failing systems at their worst-case phosphorus contribution. However, existing information indicates that on-site systems around Rush and Passenger Lakes are already performing quite satisfactorily (Section 2.2.3.3.). In fact, for all four lakes, the assumed worst case failure rate for on-site systems results in a serious over estimatation of phosphorus loads. This assumption must therefore be modified to develop realistic classifications of trophic status. A realistic estimate of on-site system failure rates, and the implications of this estimate for classification of trophic status are discussed in the following paragraphs.

As indicated by the number of reported absorption field surface failures (less than 30) combined with the number of suspected subsurface groundwater plumes (less than 10), it was estimated that fewer than 40 septic systems out of the estimated 260 in operation currently have the potential to adversely affect the surface waters of the project area (Section 2.2.1.). This is an estimated overall maximum numerical failure rate of about 15% for combined surface and subsurface failures. The potential water quality impact of the 15% overall numerical failure rate is much less than the assumed "worst-case" (100%) failure rate. However, the implication of this estimated failure rate for classification of trophic state may be very different for each lake depending on circumstantial factors. The water quality impact of failed on-site systems will in each case depend on the actual number and nature of shoreline lot on-site system failures, but also on lake shape and volume and on the proportion of other nutrient loads as are related to land use, agricultural practices, and soils in the watershed. These combined factors were determined to affect the trophic state of each lake in the following ways:

- The amount of phosphorus moving into any of the four lakes from failing septic systems is probably only a small fraction of the phosphorus being delivered to those failing systems by domestic wastewater.

- Rush and Passenger Lake area residences have on-site systems which all appear to be adequately treating wastes. These two lakes do not have serious water quality problems principally because agricultural use of the land is so rare in their respective watershed areas.

- Under summer conditions, Island Lake was documented as having significantly higher phytoplankton productivity, more severe blue-green algae blooms and lower hypolimnetic dissolved oxygen than Sturgeon Lake. It was concluded that Island Lake's problems were due to a large nutrient load originating from non-wastewater sources in the watershed and that these problems are amplified by the Lake's shallowness and variable wind fetch. Biotic interactions stemming from changes in the plankton eating fish populations of Island Lake are also thought to have contributed to algal bloom problems.

- Total phosphorus concentrations in Island and Sturgeon Lake waters were found to be similar under winter conditions.

- The concentration of non-apatite phosphorus (NAI-P) was measured in 16 surficial sediment samples taken from Island, Little Island, and Sturgeon Lakes. The highest concentration of NAI-P was found in Little Island Lake, a shallow water body contiguous to Island Lake but having no shoreline residential development. This finding emphasized the significance of non-wastewater phosphorus sources.

Supporting information for the aforementioned conclusions are discussed and cited in the following paragraphs.

Support for the assertion that little phosphorus moves out of groundwater plumes from failing on-site systems and into the surface waters of these lakes is provided in the literature. In other studies, phosphorus inputs into lakes from septic systems have been found to represent a low percentage of the total annual phosphorus load, typically less than 15% (USEPA Rural Lake Projects 1-6, 1978-1981; Kerfoot and Skinner 1981). Jones and Lee (1977) found that most phosphorus associated with septic leachate is removed from the leachate by soils within a short distance from the drainfield. There is a general consensus among researchers that soils having even a small percent of clay with iron and aluminum present will remove most of the phosphorus from groundwater (Viraghavan and Warnock 1976, Tofflemire and others 1977, Reneam and Pettry 1975). These findings are important because numerous researchers have established that phosphorus is the key to controlling eutrophication (USEPA 1980).

The results of the nutrient analyses of groundwater plumes found to be entering the lake (Section 2.2.1.5) indicated no elevated nutrient concentrations were emerging. One explanation of this finding is that when groundwater plumes enter a lake the high nutrient levels rapidly become diluted and thus undetectable but examination of groundwater and plume samples, collected onshore and upgradient of where nutrients might enter the lake, also showed instances where background phosphorus levels in groundwater were just as high as plume levels. The explanation for high phosphorus levels in both plume and background groundwater samples is perhaps related to land use. Agricultural practices, application of lawn fertilizer, or the presence of nearby bog areas may contribute elevated levels of nutrients to groundwater moving toward a lake. For example, in the Rush and Passenger Lake vicinity, dissolved organics originating from surrounding bog areas appeared to be contributing to the overall high fluorescence detected in those lakes by the septic leachate detector. Sturgeon Lake appeared to have a pattern of emergent ground plumes along the northwest shore originating from bogs in the immediate drainage area just north of the shoreline. Thus, the field studies indicate that organic material and nutrients moving with groundwater toward lakes may be associated with sources other than on-site systems and that such sources reduce the significance of suspected effluent plumes in the context of the total amount of nutrients moving lakeward with groundwater.

During March 1982, a water quality sampling visit was made to Island and Sturgeon Lakes to determine the total phosphorus levels present in the water under winter conditions, when no runoff was carrying nutrients from the respective watersheds. Under the ice cover conditions and with more than 56 inches of snow cover present, light penetration was reduced and hence biological productivity was low in both lakes. Therefore, it can be hypothesized that total phosphorus in the water column would reflect a singularly large number of on-site system failures on one lake versus the other.

The detection limit assigned to the laboratory method used for total phosphorus analysis was 0.01 milligrams per liter. The average total phosphorus concentration in Island Lake was 0.04 milligrams P per liter. The average concentration in Sturgeon Lake was 0.02 milligrams P per liter. A greater number of on-site systems failures have been reported around Island Lake than around Sturgeon Lake (Section 2.2.3.), but the in-lake phosphorus data gathered in March 1982 do not reflect a strong influence by on-site system failures. This was corroborated by the results of additional sampling in February 1982 of NAI-P phosphorus in the surficial littoral sediments of Island and Sturgeon Lakes (Section 3.1.3.2.). NAI-P levels in littoral lake sediments varied widely in concentration in both Island and Sturgeon Lakes and sediment characteristics showed no correlation with the nature and degree of residential development on the shorelines. These findings are in contrast with elevated phosphorous concentrations reported for Island Lake and Sturgeon Lake in sampling conducted by the MLWSD (referenced in USEPA 1981c).

Water quality and biotic conditions for the four lakes also were observed under warm season conditions. Explanations for the differences in water quality and biological characteristics found between all four project area lakes, as observed in the summer and fall of 1981, are given in detail in Sections 3.1.3. and 3.1.4. and in "The Report on Algae" prepared as a technical support document for this EIS (Appendix H). A compendium of the warm season biotic and water quality characteristics observed for these lakes is given in the following paragraphs.

Based on the literature review and data gathering conducted in preparation of the Report on Algae, it was concluded that the three genera of blue-green algae most often associated with mammalian toxicity were found in bloom proportions in Island Lake. However, the dominant blue-green species found in Island Lake, Anabaena macrospora, while belonging to one of the toxicity-producing genera, is a species that has not been associated with toxic effects. Therefore, while there is a potential for a public health problem associated with blue-green algae in Island Lake, there is no direct evidence that toxic species of blue-green algae are present; hence, there appears to be no imminent health threat to swimmers or other recreational users. Sturgeon, Rush and Passenger Lakes were not found to be supporting blue-green algae growth to bloom proportions, nor were the genera of blue-greens associated with toxicity dominant in them. As with Island Lake, toxicity producing blue-green algae species were not found in Sturgeon, Rush, or Passenger Lakes. Additionally, State of Minnesota and local health officers, physicians, and veterinarians who were contacted reported that no health related or toxicological problems were known to have developed due to swimming in or drinking from any of the project area lakes. Based on this information, it was concluded that existing blue-green algal populations in the 4 service area lakes do not constitute strong evidence of need for improved waste management.

Overall water clarity, as indicated by a series of Secchi disk measurements, was found to be poorest in Island Lake and best in Rush Lake. The water clarity measurements for both Sturgeon and Passenger Lakes were greater than for Island Lake, with Sturgeon Lake having somewhat greater clarity than Passenger Lake (Section 3.1.3.2.).

Mats of floating blue-green algae were observed on Island Lake in the late summer and early fall of 1981. The wind blown accumulations of blue-green algae observed during a September sampling visit were greatest along Island Lake's south-facing shorelines under the prevailing southerly winds. These accumulations would pose aesthetic problems to riparian owners and recreational users of Island Lake (Section 3.1.4.1.).

No accumulations of algae or of emergent or submergent rooted aquatic plants were found to be strongly associated with areas having suspected leachate plumes.

In the context of the aforementioned findings on the biological characteristics of the four project area lakes, it was concluded that no immediate danger to public health nor unusually severe nuisance conditions are being caused by nutrient enrichment of any of the four lakes. The algae blooms in evidence on Island Lake may be regarded, however, as a factor contributing to the degradation of Island Lake's fishery, and a nuisance problem that reduces the recreational quality of the lake's waters. The nature of the degradation and nuisance problem is discussed in the following paragraphs.

Water quality surveys conducted in mid-September 1981, and historic data from water quality surveys conducted by the Minnesota Department of Natural Resources (1938, 1954, 1955, 1967, 1969, 1970, 1975 unpublished) indicate that the portion of the water column of Island Lake in excess of 20-foot depth periodically experiences severe oxygen depletion (Section 3.1.3.2.). Absence of oxygen in the deeper (hypolimnetic) waters of Island Lake is thought to be a transitory condition that occurs in periods of sunny, calm and warm weather when density stratification takes place and algae blooms are severe. Based on the series of oxygen and temperature profiles made from the data obtained in late summer of 1981, and based on calculations of wind induced mixing characteristics, Island Lake was classified as "polymictic" (Section 3.1.3.2.). This means that the water column goes through cycles of mixing (stratification and destratification) more than twice a year, perhaps several times each summer as the weather changes repeatedly from warm and calm to cool and windy. A lack of dissolved oxygen at depth when chemical (oxygen) stratification is prolonged reduces biological productivity and places fish under stress because of the reduction in available fish habitat that results. A periodic lack of hypolimnetic oxygen may also mobilize phosphorus into the upper water column after destratification takes place.

Based on a comparable water quality data base, Sturgeon Lake appears to remain well mixed and to maintain adequate oxygen levels throughout the water column in summer. Oxygen levels in its deeper waters therefore remain adequate for fish and aquatic life and phosphorus is probably not mobilized from the sediment of Sturgeon Lake. Rush and Passenger Lakes stratify thermally and experience oxygen depletion below the 20-foot depth levels but are dimictic, remaining stratified through the summer. Phosphorus cycling to surface layers from the sediments and from hypolimnetic waters probably does not take place during summer in Rush and Passenger Lakes (Section 3.1.3.2.).

Documentation of Need for Improved Wastewater Management

Based on the above referenced information, it was concluded that of the four lakes, Island Lake alone exhibits symptoms of advanced eutrophication and that these symptoms have degraded its quality as a recreational lake. These symptoms seem to indicate a need for management of controllable phosphorus sources to Island Lake. However, as discussed above and in Sections 3.1.3.3. and 3.1.3.4., the shift of Island Lake from a mesotrophic to a eutrophic state is thought to have begun in the 1930's, well before the development of a significant lakeshore residential community. Island Lake's current problems are primarily due to a large nutrient load stemming from non-wastewater sources within the watershed. The fertility of Island Lake waters is further enhanced by phosphorus cycling from sediments and low-lying waters to the upper water layers where algal blooms take place (Section 3.1.3.2.). The observed late-summer dominance of blue-green algae in Island Lake may also be partly the result of recent dominance of zooplankton-eating fish such as perch and bluegill in the fish community (Section 3.1.4.3.).

Also based on the above referenced information, it was concluded that Sturgeon, Rush, and Passenger Lakes do not have water quality problems or trophic conditions which indicate a serious need for improved wastewater management or for other means of nutrient control in their respective watersheds. Although the paleo-limnological investigation (Section 3.1.3.4.) did indicate that the phosphorus load to Sturgeon Lake had increased substantially since 1945, no parallel increase in the rate of eutrophication was indicated by other parameters. Sturgeon Lake appears to have remained essentially unchanged in trophic status over the last century and no evidence was found which indicates that serious eutrophication problems are imminent for Sturgeon Lake.

Management Opportunities for Island Lake

Improvment of Island Lake's quality would call for an extensive watershed management program. Island Lake is a shallow and fertile (nutrient rich) water body giving, in accordance to its elongate shape, changing opportunity for the wind to mix and aerate (Section 3.1.3.2.). Island Lake's shallowness and variable wind mixing characteristics make its hypolimnion subject to periodic anoxia during summer. This enhances the bio-availability of phosphorus. Increased availability of phosphorus during the summer months will continue to aggravate Island Lake's blue-green algae bloom problem for as long as present levels of fertility are sustained. Based on the annual watershed phosphorus loading regime (Section 3.1.3.3.) and on evidence that relatively high fertility and productivity levels have existed in Island Lake for over a century (Section 3.1.3.4.), it appears that the lake's blue-green algae blooms will continue to occur as long as current land use characteristics and management practices in the watershed are sustained. Abatement of phosphorus from a single, small source category such as on-site systems is not likely to result in improved water quality for Island Lake. Management of the game fish populations of Island Lake may also be a prerequisite to reduction of blue-green algal blooms, regardless of the degree of phosphorus abatement that could be achieved with a comprehensive watershed management program (Section 3.1.4.3.).

2.2.2.5. Indirect Evidence of Problems

Indirect evidence that correlates with known failures can be used as an initial screening device for locating areas where failures are probable. Site limitations that infer failures are:

- Seasonal or permanent high water table;

- Lack of sufficient isolation distance for water wells (depending on well depth and presence or absence of hydraulically limiting layers);

- Documented groundwater flow from a soil absorption system to a water well;

- Slowly permeable soils with percolation rates greater than 60 minutes per inch;

- Bedrock proximity (within three feet of soil absorption system where bedrock is permeable);

- Rapidly permeable soil with percolation rates less than 0.1 minutes per inch;

- Presence of holding tanks as evidence that site limitations prevent installation of soil absorption systems;

- On-site treatment systems that do not conform to accepted practices or current sanitary codes including, but not limited to, cesspools, the "55 gallon drum" septic tank, and other inadequately sized components; and

- On-site systems in an area where local data indicate excessive failure rates or excessive maintenance costs.

All eight sources of information discussed in Section 2.2.1 were used to assess the indirect evidence for problems. The final classification of on-site performance status used a combination of direct and indirect evidence. This classification is given in the next section.

2.2.3. Identification of Problems in Specific Areas

One of the principal purposes of collecting information in the project area was to classify on-site systems into one of three categories: "obvious problem," "potential problem," or "no problem." In this EIS, an on-site system is classified as an "obvious problem" if at least one criterion of direct evidence of need is satisfied. Examples of direct evidence (given in Sections 2.2.2.1. to 2.2.2.4) include problems such as backups, or ponding, or of ground or surface water contamination. "Potential problem" systems are those systems which do not yet exhibit direct evidence of failure but which can reasonably be expected to fail in the future. Justification of expected future failures relies on detailed analysis of the causes for failure of similar systems in the project area. The "no problem" category consists of lots where there is no direct evidence of need indicating that the present system is inadequate or malfunctioning. Sites may be categorized as "no problem" if older systems operating in identical soil or groundwater conditions are functioning properly (USEPA 1981).

The analysis of the available information indicated that in certain shoreline areas around the lakes the problems encountered shared similar characteristics. In general, such areas were characterized by a high water table, tight soil, on-site system backups or ponding, groundwater moving toward the lake, and system upgrading. The number of systems per lake and the number of sites exhibiting direct evidence of need are summarized in Table 2-8. The onsite systems are classified into one of the three groups, obvious problem, potential problem, or no problem. The correlation of on-site problems with various soil types is presented in Table 2-9. Specific lakeshore or subdivision areas are addressed in further detail in the following sections.

2.2.3.1. Island Lake Segments I., II., and III.

The information gathered for Island Lake area on-site systems indicates some problems are present. Currently, 151 lots with on-site systems are estimated to be around Island Lake. Of the total number of systems, 12% (18 systems) were classified as having obvious problems, and 17% (27 systems) were classified as potential problems. To facilitate a discussion of the data for on-site systems, the Island Lake shoreline was divided into three segments. The segments were delineated based on natural breaks in shoreline development patterns or on changes in shoreline configuration. Obvious or potential problems with on-site systems in each of the Island Lake segments are presented in Figure 2-10.

Segment I., Island Lake

Segment I includes the island Lake shoreline perimeter extending around the northern end of Island Lake, then southward along the north-

Table 2-8. Summary of the analysis of problems with on-site waste treatment systems in the project area.

	Existing Residences with On-Site Systems			Number of Existing On-Site Systems[a]			Number of Reported Backups		Analysis of Problems According to Specific USEPA Criteria for Needs Documentation: Surface Malfunctions			Surface Water Contamination		Classification According to On-Site System Problem Categories		
	Seas.	Perm.	Total	Septic tanks	Holding tanks	Privies	Lot-by-lot	Quest.	Lot-by-lot	Quest.	EMSL Aerial	Nutrients	Coliforms	Obvious Problem	Potential Problem	No Problem
Island Lake																
Segment I	27	16	(43)	23	7	13	0	5	10	8	0	0	0	6	5	32
Segment II	38	30	(68)	51	3	15	0	12	26	7	2	12	2	8	13	47
Segment III	22	18	(40)	24	9	13	0	7	10	3	1	0	0	4	9	27
Sub-total	87	64	(151)	98	19	41	0	24	46	18	3	12	2	18	27	106
Sturgeon Lake																
Segment I	45	10	(56)	36	7	15	1	0	0	1	0	11	0	0	3	53
Segment II	55	20	(74)	52	10	16	1	4	3	3	1	0	0	0	2	72
Segment III	55	12	(67)	55	9	3	3	5	3	4	3	6	0	0	8	59
Sub-total	155	42	(197)	143	26	34	5	9	6	8	4	17	0	0	13	185
Rush and Passenger Lakes	17	2	(19)	8[b]	1[b]	6[b]	ND	0	ND	0	0	7	0	0	0	19
Wild Acres and Hogan's Acres	40	8	(48)	10[c]	3[c]	7[c]	ND	0	ND	0	0	ND	ND	0	0	48

[a]Some lots have more than one system

[b]Based on 15 questionnaire responses

[c]Based on 21 questionnaire responses

ND - No data, information not collected

Table 2-9. Correspondence of on-site system problem classifications with soil types. Soil types for lots with problem systems were determined from the soil survey (Section 2.2.1).

Island Lake Shoreline Lot Soils	Number of Systems With Obvious Problems	Number of Systems With Potential Problems
Duluth loam	12	17
Duluth Variant	4	4
Blackhoof muck	0	3
Omega sandy loam	2	3
Sturgeon Lake Shoreline Lot Soils		
Duluth loam	0	8
Duluth variant	0	3
Omega sandy loam	0	1
Altered soil (fill)	0	1
Rush and Passenger Lakes Shoreline Lot Soils		
Omega sandy loam	0	0
Lake Beach soil	0	0
Hogan's and Wild Acres Subdivision Soils		
Omega sandy loam	0	0
Lake Beach soil	0	0

eastern side of the lake to Swanson's Point (Figure 2-10). Out of 43 lots in this segment, 6 lots were classified as having obvious problems and 5 lots were classified as having potential problems. The northern end of the lake was the area where most of the segment's on-site problems were concentrated. Although the groundwater flow direction throughout the segment is estimated to be toward the lake, no groundwater septic leachate plumes were detected during the septic leachate survey. Ponding was the problem reported most frequently, especially during wet weather.

Permit records from the Pine County Zoning Administrator's Office indicate that 13 lots in Segment I have had new systems installed or have had repairs made since 1973. Five of these permits were issued to upgrade

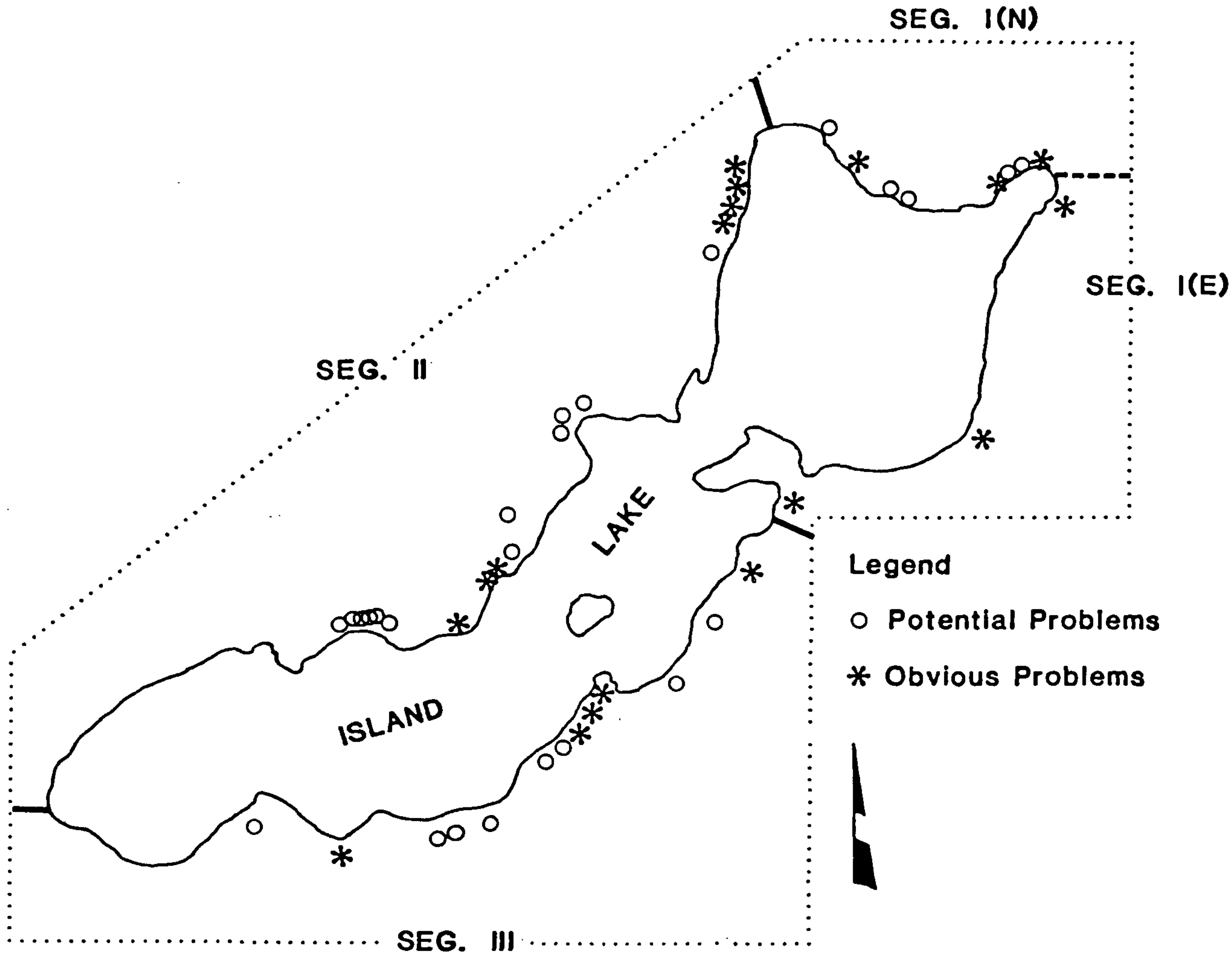


Figure 2-10. Island Lake segments and locations of on-site systems with obvious and potential problems.

existing septic tank system. All 5 upgrades concerned systems installed prior to 1974. Of the 8 new systems installed, 1 was a ST-SAS and 7 were holding tanks. Installation of all but 2 of the new systems was initiated prior to 1977.

Segment II., Island Lake

Segment II. includes the shoreline area from the southern end of the Sunrise Bay subdivision northward to the northernmost tip of Island Lake (Figure 2-10). Including all forms of survey information, Segment II had the highest proportion of reported problems for the number of residences of all Segments. The reported problems were associated with a variety of factors, including high groundwater, lot flooding caused by temporarily high lake levels, small lot size, and tight soils. Out of a total of 68 lots in Segment II., 8 obvious and 13 potential problem classifications were made. Most of the problems were concentrated in three shoreline sections of Segment II. Portions at the north end of Segment II were problem-free, possibly because of sandy soils present.

Groundwater in Segment II. generally flows toward the lake, although along the northerly extent the flow directon is indeterminate or variable. Of the 12 suspected septic leachate plumes located around Island Lake the only 2 groundwater plumes with fecal coliform counts above background levels were found in this segment.

Permit records from the Pine County Zoning Administrator's Office indicate that 17 lots in Segment II have had new on-site treatment systems installed or have had repairs made since the latter part of 1973. One of the permits was issued to upgrade (replace) an existing septic tank system. In this case, the original ST-SAS, installed in 1975, was replaced by a new system in 1976. Of the new systems installed in Segment II., 1 is a mound system, 9 are ST-SAS, 3 are holding tanks, and 4 are privies. Installation of all but 4 of these systems was initiated prior to 1977.

Segment III., Island Lake

Segment III includes the northeast shoreline section from just below Swanson's Point south to the outlet at the southwestern tip of Island Lake (Figure 2-10). Segment III had several areas where problems appeared to be concentrated. Four obvious and 9 potential problem classifications were made out of a total of 40 on-site systems in the segment. The general groundwater flow direction in Segment III is out of the lake, which may partially explain why no groundwater plumes were found entering the lake. Although tight soils are prevalent in this segment, most problems associated with maintenance problems described by the mailed questionnaire responses or by the results of the MLWSD lot-by-lot survey had been solved by fixing broken pipes or by pumping out full septic tanks.

Permit records from the Pine County Zoning Office indicate that a number of lots in Segment III have had new systems installed or repaired since the latter part of 1973. One permit was issued to upgrade an existing septic tank-soil absorption system (ST-SAS). Of the 12 new systems installed, 4 are ST-SAS, 7 are holding tanks, and 1 is a privy. Installation of all but 3 of these systems was initiated prior to 1977.

2.2.3.2. Sturgeon Lake Segments I., II., and III.

The information for Sturgeon Lake indicates few problems with on-site systems other than those associated with the Sturgeon Island area (Segment I.). A total of 197 lots with on-site systems were identified around Sturgeon Lake. Of the total number of systems, 6% (13 systems) were classified as having potential problems, and no systems were classified as having obvious problems (Table 2-9). Problem locations within Sturgeon Lake segments are presented in Figure 2-11.

Segment I., Sturgeon Lake

Segment I encompasses most of the northern portion of the Sturgeon Lake shoreline, from the YMCA camp on the west shore, north to the public boat launch site and southward to a point just above Sturgeon Island on the

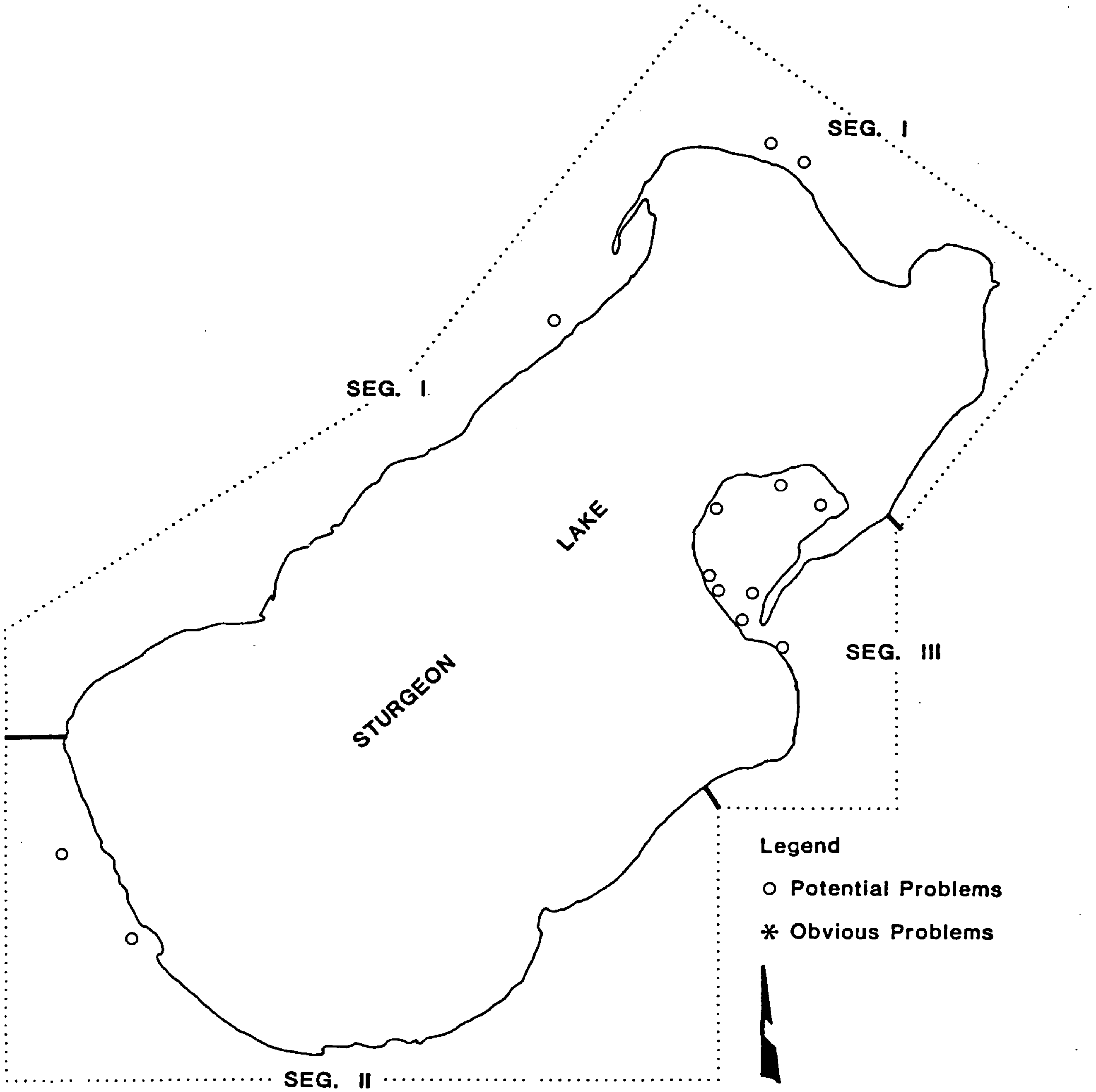


Figure 2-11. Sturgeon Lake segments and locations of on-site systems with obvious and potential problems.

east shore (Figure 2-11). Segment I contains 56 lots with on-site systems, 3 of which were classified as having potential problems. Two of these lots with problems were located on the northern shoreline on soils mapped as Duluth loam, a very tight clayey soil.

No other on-site systems in Segment I were classified as having problems, in spite of the location of 11 suspected plumes along the northwest shore of the lake during the septic leachate survey. These suspected plumes (11) where characterized by high fluorescence and not by high conductivity, indicating that other (non-human) biogenic sources of fluorescence were involved. It is thought that dissolved organics leaching out of the large peat bog area located immediately behind the shoreline ridge are the source of the fluorescence. No corroborating evidence of septic leachate movement toward the lake was provided by the water quality sampling or by other survey information for homes in the vicinity of these suspected plumes. Therefore, it was assumed that the plumes located along the northwest shore do not represent direct evidence of the entrance of septic leachate into Sturgeon Lake.

Permits obtained from the Pine County Zoning Administrator's file records indicate that 15 lots in Segment I have had new on-site systems installed since 1973. No upgrades of ST-SAS were reported in the permit file for this period. Of the 15 new systems installed, 3 are mound systems, 8 are holding tanks, and 4 are privies. No ST-SAS have been installed since 1973. Installation of 5 out of 15 systems was initiated prior to 1977.

Segment II., Sturgeon Lake

Segment II. includes approximately the southern half of Sturgeon Lake (Figure 2-11). Relatively few problems were found in Segment II. Out of an estimated 74 lots, only 2 lots were classified as having potential problems. The relatively sandy soils probably are the main reason for few backup or ponding problems in this segment. In addition, the groundwater flow is out of the lake in this area, which may explain why no suspected groundwater plumes were located.

Permit records from the Pine County Zoning Administrator's Office records indicate that 24 lots have had new systems installed since 1973. No upgrades of ST-SAS were made in this period. Of the 24 new systems installed, 11 are ST-SAS, 7 are holding tanks, and 6 are privies. Installation of 10 out of 24 systems was initiated prior to 1977.

Segment III, Sturgeon Lake

Segment III, which includes Sturgeon Island, has 67 lots with on-site systems. A total of 8 of those systems were classified as having potential problems. The majority of these problems occur at the neck of Sturgeon Island and south of the point where the access road connects to the mainland. This region is low-lying with tight soils and a high groundwater table, and portions are susceptible to temporary flooding. The EMSL aerial survey located 3 of the 4 probable failing systems in this segment. The septic leachate survey located six suspected groundwater plumes in this segment. Saturated soils in drainfields are probably the most significant factor in causing this area's problems.

Permit records from the Pine County Zoning Administrator's Office indicate that 13 parcels have had new on-site systems installed since 1974. No ST-SAS systems were reported as being upgraded since 1973 although some privies were replaced with holding tanks. Of the 13 new on-site systems installed, 1 is an ST-SAS, 10 are holding tanks, 1 is a privy over a holding tank, and 1 is a chem-toilet. Installation of 2 out of the 13 new systems was initiated prior to 1977.

2.2.3.3. Rush and Passenger Lakes

The residences surrounding Rush and Passenger Lakes are few and therefore are being considered together. Problems associated with on-site systems around both lakes are minimal. No obvious or potential problem classifications were made for the 19 on-site systems located around Rush or Passenger Lakes. All 15 questionnaire responses indicated no problems. The soil survey found that the soils were predominantly Omega sands with some organic soils in wet areas. Permit records indicate no repairs or upgrades have been needed since 1974. Local septage haulers indicated that only routine service calls have been made in the area. The EMSL aerial survey detected no surface failures.

The septic leachate survey detected 3 potential leachate plumes entering Rush Lake and 4 potential groundwater plumes in Passenger Lake. The exact source of the elevated fluorescence measured in these plumes, whether from septic tanks or from wetlands, was not determined, although the water quality sampling indicated negligible movement of nutrients lakeward from these plumes.

2.2.3.4. Hogan's and Wild Acres Subdivisions

These adjacent subdivisions are located immediately east of Rush Lake and south of Sturgeon Lake. Lot owners have access to a launch site on Rush Lake, but there are no waterfront lakeshore lots. No problems have been reported for the Hogan's or Wild Acres subdivisions. Approximately 74 lots currently have some form of existing structures, typically mobile homes, many of which may have built-in holding tanks, with waste disposal undertaken by the owners. The number of functioning on-site systems is uncertain. Based on a review of available information it was assumed that there are 48 existing on-site systems. Review of permit records, interviews with local septage haulers, and mailed questionnaire responses indicate there are few problems, if any, in the area. The soil survey shows the area to be dominated by the Omega sandy loam soils. The Zoning Administrator for Pine County stated that there have been few problems with installation of on-site systems in the area under his jurisdiction (by telephone, W. Golley to WAPORA, May 4, 1982).

2.2.4. Septage Disposal Practices

Septage is the residual solids generated in septic tanks. Septic tanks are pumped when homeowners contract with a septage hauler for service. Holding tanks containing raw sewage are also pumped by private haulers. The haulers dispose of septage at sewage treatment plants or on land disposal areas. For the Moose Lake area, the septage is introduced to the Moose Lake Treatment system via a manhole (by telephone, Heaton's Sewer Service, April 14, 1982). In the busiest time of the year (spring and fall), up to 4500 gallons per day of septage and holding tank wastes are introduced to the Moose Lake System. Wastes are collected from a 40-mile radius of the City of Moose Lake, and depending on seasonal pumping requirements Island and Sturgeon Lake area wastes can make up a large percentage of the load.

2.3. Identification of Wastewater Management System Options

2.3.1. Design Factors

Three categories of factors must be considered in the design of a wastewater treatment system: the present and projected wastewater flows in the study area, the effluent requirements established by Federal and State authorities, and economic cost criteria (duration of the planning period, interest rate, service factor, and service life of facilities and equipment). Each of these factors is discussed in Appendix D.

2.3.2. System Components

2.3.2.1. Centralized Wastewater Management

The overall design of a wastewater management system [e.g., a "project alternative"] must take into account methods for reduction of the flow and waste generation rates at residences. Other important considerations include methods for providing collection of wastewater for transport to centralized off-site treatment, methods of treatment, effluent disposal, and sludge treatment and disposal. The design options for the centralized collection and treatment alternatives are presented in Appendix D.

2.3.2.2. Decentralized Wastewater Management

Design of decentralized alternatives must consider methods of providing on-site wastewater treatment, cluster system collection and treatment methods for small outlying areas, and septage disposal methods. These options for development of decentralized wastewater management alternatives are presented in the following discussion.

2.3.2.2.1. On-site Wastewater Treatment

The on-site systems (septic tank/soil absorption systems [ST/SAS] and ST/mound systems) presently being installed in the area are considered adequate both in terms of construction and capacity. Septic tanks should have an exposed manhole or inspection port to monitor the contents of the tank. If, during pumpouts and inspections, certain septic tanks are found to be faulty or seriously undersized, these tanks would then be repaired or replaced.

The drain beds and drainfields currently being installed in the area could have a greater than 20-year design life, if they are installed according to Code and maintained properly. The 400 square feet of drain bed should be adequate for most residences, unless the soil material contains greater than normal quantities of silt and clay. In these soil materials, the drain bed must be larger or the finer-textured soil material must be removed and replaced with sand. Similarly, in coarse-textured soils (coarse sand and gravel), the drain bed should be over-excavated and replaced with 18 inches of fine sand. Without the sand lining, the potential for groundwater pollution is high because of inadequate treatment.

Mound systems (Figure 2-12) are constructed according to detailed design standards to overcome soil permeability or shallow bedrock limitations. The design for raised drain beds is essentially that of the standard drain bed elevated by fill to achieve the appropriate depth to groundwater. Thus, the elevation of the raised bed can be highly variable, from 6 inches to 3 feet. Some mound systems utilize gravity distribution systems while others use pumps and pressure distribution systems. In areas where the soils are peat and marl, the natural ground is first excavated and replaced with sand. Water-using appliances are usually kept to a minimum with these systems in order to keep the volume of sand fill needed to a minimum. It is noted that the use of proper materials and correct construction techniques is essential for these systems to operate satisfactorily.

Based on design criteria, no new soil absorption systems should be permitted on soils that have a water table within 1 foot of the ground surface or that are formed in organic material. This would include the Blackhoof and Newson soils. These soils have high water tables due to natural groundwater levels and could only be drained with extensive measures that lower the groundwater level of the area. The soils that have

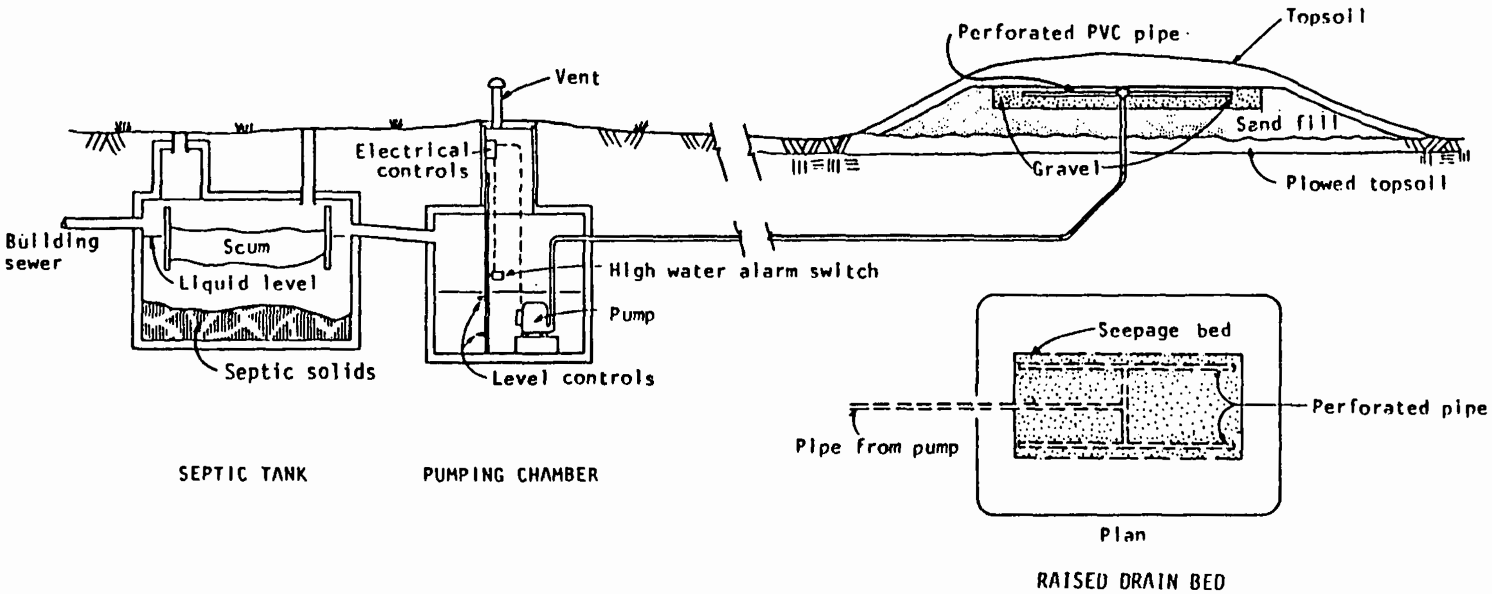


Figure 2-12. Layout of septic tank with raised drainfield bed.

a water table within 1 to 3 feet of the ground surface can have raised drain beds constructed on them. These soils are Dusler and Nemadji. Drain beds and drain fields are appropriate for the other soils where slopes allow construction activities (Section 2.2.1.1.).

Soils that have permeabilities slower than 1 inch/hour require special consideration. Soils mapped in the service area that are in this category include Duluth, Duluth Variant, Dusler, and Blackhoof. The size of the seepage bed or trench drainfields in these soils will have to be designed for a larger surface area for wastewater infiltration compared to drainfields in more permeable soils. Alternatively, mound systems may be employed which partially treat the wastewater in the mound and then disperse the effluent over a large basal area. For lots with size limitations, wastewater separation with blackwater holding tanks may be appropriate.

Blackwater holding tanks do not strictly constitute on-site treatment because the treatment of the toilet wastes must occur away from the site. Components of the system include a low-flow toilet (2.5 gallons per flush or less), the holding tank for toilet wastes only, and the usual septic tank-soil absorption system for the remainder of the wastewater. When the toilet wastes are diverted from the septic tank-soil absorption system, the absorption system has an opportunity to function properly and minimal pollution of groundwater and surface water occur. Significant reductions of organic loads and 20 to 40% reductions in phosphorus loadings to the septic tank and soil absorption system occur when toilet wastes are excluded. The blackwater holding tank would have a 1,000 gallon capacity and be equipped with a high-level alarm. Nearly all residences that would require holding tanks are seasonally occupied, requiring approximately three pumpings annually.

2.3.2.2.2. Cluster System Wastewater Treatment

The cluster system employs collection facilities for a group of residences and a common soil absorption system for wastewater treatment. The common soil absorption system is used because the individual lots are unsuitable for on-site soil absorption systems. An area of soils suitable for the common soil absorption system must be available within a reasonable distance in order to consider this option.

It is assumed that all existing septic tanks, with some replacements, would be adequate in their present condition for inclusion in a cluster system. Septic tank effluent could be conveyed by small-diameter gravity sewers or pressure sewers to the common soil absorption field. A cost-effectiveness analysis would be done to determine which collection system to use for a particular area. A "dosing" system is typically required on cluster drain fields in order to achieve good distribution. Where the collection system uses pressure sewers, a separate accumulator tank and lift station is required. The wet well and lift station on the septic tank effluent gravity sewers can perform that function.

Cluster drain fields are usually designed with three contiguous drain fields. Two of these would be dosed on a daily basis, and the third would be rested for period of one year. Design criteria require that 400 square feet of trench bottom per residence is required for each drain field.

Although the present soils information and topography indicate that cluster drain fields may be feasible in certain areas, further field investigations would be needed before final designs could be made. The depth of permeable material must be determined in order to show that excessive groundwater mounding beneath the drainfield would not occur.

The operation and maintenance requirements of cluster systems are minimal. Periodic inspections of the lift stations and the drain fields are essentially all that would be necessary. The septic tanks and the lift station wet wells would require regular pumping. Maintenance of the collection piping is expected to be minimal (Otis 1979). Once a year the rested drain field would be rotated back into use, and another one would be rested. Blockages of the collection systems should occur only rarely, since clear effluent would be used. Lift stations are entirely dependent on a reliable power supply; thus, power outages will affect operation of the system. Since wastewater generation is also dependent on power for pumping well water, the potential for serious environmental effects is somewhat mitigated.

2.3.2.2.3. Peatland Bog System for Wastewater Treatment

The treatment of wastewater by a peatland system is similar in approach to treatment by a cluster drainfield in that solids are retained in a septic tank and primary effluent is taken off-site and treated by a "soil" absorption system. In this case peat is used rather than soil for treatment. Extensive areas of peatland are present in the project area. Some of these areas are in an unaltered or relatively "natural" state and others have been partially drained in an attempt to move water off surrounding lands.

The bog treatment system proposed for this project is modeled after the ditch treatment systems that have been in use in Finland for more than 30 years. Undecomposed peats, usually found in surface or near-surface horizons, have large pores which permit very rapid water flow. Nutrient removal and sterilization processes which take place in peat materials may be advanced over those of most other soils as a result of the highly reductive chemical environment of peat, although control of the water table and of the oxic condition are required to maintain these processes. In Finland, peatland disposal areas have been drained to lower the water levels and force waste material through the more decomposed peats at lower levels to achieve better treatment (Surakka 1971, Kamppi 1971, and Surakka and Kamppi 1971). Based on a review of published and unpublished literature there is no comparable system operating in the United States.

The proposed ditch system for the Moose Lake area uses a shallow feeder ditch to apply septic tank effluent to a peat bog. The deeper collector ditches, spaced approximately 40 meters apart, draw the effluent applied to the shallow feeder ditches through the peat and into a receiving pond. The peat bog area being considered for this design, shown in Figure 2-13, has previously been channelized for other drainage purposes to a depth of 1 to 2 feet.

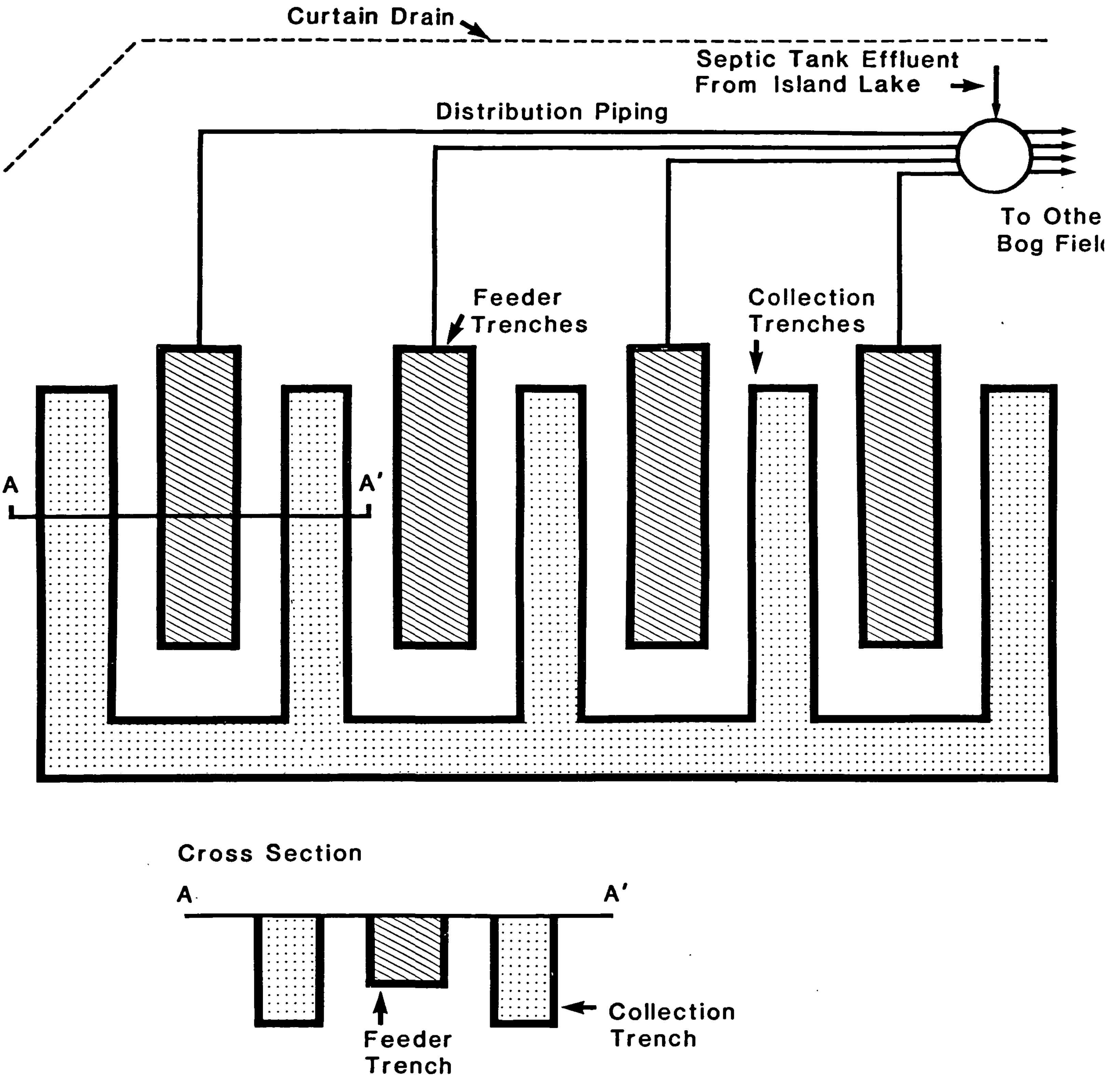


Figure 2-13. Layout of proposed peatland "bog" wastewater treatment system.

2.3.2.2.4. Septage Disposal Methods

The use of a septic system requires periodic maintenance (3 to 5 years) that includes pumping out the accumulated scum and sludge, which is called septage. Approximately 65 to 70 gallons per capita per year of septage could accumulate in a properly functioning septic system used by permanent residents (USEPA 1977). Septage is a highly variable anaerobic slurry that contains large quantities of grit and grease and a highly offensive odor and has: the ability to foam; poor settling and dewatering characteristics; high solids and organic content and; a minor accumulation of heavy metals. The general methods of septage disposal are:

- Biological and physical treatment,
- Land disposal,
- Treatment in a wastewater treatment plant.

Septage in the Moose Lake area is treated by biological and physical methods in anaerobic lagoons. Advantages of anaerobic treatment systems are that the waste undergoes stabilization of organic solids and lagoons have relatively low operation and maintenance costs. A disadvantage of anaerobic treatment is the high BOD_5 of the effluent and the potential for odor nuisance.

A detailed cost-effectiveness analysis for septage and holding tank wastes treatment and disposal was not performed for this study. It is assumed that the septage would continue to be pumped by commercial haulers and would be disposed of in a manner consistent with present disposal practices (Section 2.2.4.). The cost of disposal is included in the operation and maintenance costs of the septic and holding tanks.

2.3.3. Centralized Collection System Component Options

Three centralized collection system component options are considered in this document. They are:

- Alternative A: conventional gravity sewers, pumping stations, and force main collection system

- Alternative B: septic tank effluent and small-diameter gravity sewer system.

- Alternative C: septic tank effluent pumps and pressure sewers, coupled with a gravity sewer system.

Seven project alternatives have been developed for wastewater management in the EIS project area (Section 2.4). No centralized collection systems are included in the first three alternatives (Alternatives 1, 2, and 3), a limited collection system is proposed for Island Lake in two others (Alternatives 4 and 5), and a full collection system is proposed for Island Lake in Alternative 6. A collection system is proposed to surround both Island Lake and Sturgeon Lake in Alternative 7. The location of the proposed treatment facilities varies with the project alternative, and is discussed for each in Section 2.4. The costs associated with the collection systems, as proposed for each alternative, also are presented in Section 2.4.

2.3.4. Centralized Wastewater Treatment Component Options

The following centralized wastewater treatment component options were evaluated in the MLWSD Facilities Plan:

- Upgrading existing waste stabilization lagoons operated by the City of Moose Lake;

- Construction of a new activated sludge wastewater treatment plant, land disposal of sludge, and land application or outfall discharge of effluent;

- Construction of a new oxidation ditch wastewater treatment plant, land disposal of sludge, and land application or outfall discharge of effluent.

The cost analysis presented in the MLWSD Facility Plan concluded that upgrading the existing Moose Lake lagoons was the most cost-effective approach for the regional alternatives considered as well as for the subregional alternatives that did not include the Barnum service area. Based on the Facility Plan conclusion, upgrading the Moose Lake lagoons is the major treatment alternative considered for all of the EIS alternatives which require centralized treatment. For limited service areas around

Island Lake and Sturgeon Lake, the use of cluster drain fields and a bog treatment system are also considered.

The existing City of Moose Lake lagoon system is described in Section 2.1. The permitted capacity of the existing lagoon system is 444,000 gpd. The sufficiency of that capacity must be re-evaluated because the centralized treatment proposed in the EIS alternatives would add significant flows to the system and MPCA has indicated it will be required that the maximum calculated capacity of the lagoon system be reduced to 316,100 gpd to meet updated requirements (By telephone Mr. Zdon, MPCA to WAPORA, Inc. 15 July 1982). The existing and revised design critera and design capacities are compared in Table 2-9a.

The year 2000 loading from the existing WWTP service area to the lagoons has been estimated based on population projections and on corrected infiltration/inflow estimates from the Facilities Plan and on an allowance for septage generation. The estimated year 2000 population equivalent for the existing WWTP service area is presented in Table 2-10. The estimated, corrected infiltration/inflow is presented in Table 2-11.

The estimated excess capacity available in the existing lagoons is presented in Table 2-12. If the existing design criteria are used in the evaluation there is an excess capacity of 89,400 gpd available for base flow and infiltration/inflow from new connections. However, if the revised MPCA design criteria are used in the evaluation, there is a capacity deficiency of 16,000 gpd for the existing system, and no excess capacity to serve new connections.

The adequacy of the interceptor sewers and lift stations in the existing WWTP service area to handle the existing flow (after I/I corrections) and to accommodate additional flows from Island Lake and Sturgeon Lake was evaluated in the MLWSD Facility Plan. The analysis presented in the Facility Plan was re-evaluated for this report based on the revised (updated) year 2000 population assumptions (Section 3.2.1.3.). The conclusion made based on this re-evaluation was that the existing sewer lines and pumping stations through Sand Lake to the main lift station in Moose Lake are adequate to accommodate the total year 2000 EIS population from the Island

Table 2-9a. Existing capacity and revised capacity existing Moose Lake WWTP.

	Existing Design Capacity	MPCA[a] Design Criteria	Revised Design Capacity
Pond Area			
Primary (Ac)	43		43
Secondary (Ac)	15.2		15.2
Total (Ac)	58.2		58.2
Secondary/Total	1/3.8	1/3	1/3.8
Pond Depth			
Bottom Storage (ft)	1	2	2
Active (ft)	4	3-4	3
Total (ft)	5	5-6	5
Total Active Vol (MG)	75.863		56.690
Active Storage (days)	180	180	180
Capacity (Gal/day)	421,500		316,100
Primary Pond Area (Ac)	43		38.8[c]
BOD Loading (lb/day-1000 SF)		0.5	0.5
BOD Capacity (lb/day)	973		845

[a]MPCA, Recommended Design Criteria for Sewage Stabilization Ponds, 1980

[b]Required by MPCA if significant additional connections made to system (Mr. Zdon, MPCA, to WAPORA, Inc. 15 July 1982)

[c]Based on MPCA requirement of Secondary Pond Area/total Pond Area = 1/3

Table 2-10. Estimated population in the Moose Lake WWTP service area Year 2000 (PRC-Consoer Townsend, 1980)

Area	Population Equivilant (PE) Year 2000
Moose Lake	1,876
State Hospital	1,780
Mercy Hospital	210
Coffee Lake	240
Sand Lake	729
Total	3,835

Note: The Facility Plan reported a 1978 base wastewater flow of 210,000. The 1978 population is not known, but the 1980 equivalent popula- for the above area totaled 3,768. Therefore, the approximate ADBF is 210,000/3,768 = 56 gpcd/60 gpcd is used in this EIS.

Table 2-11. Estimated inflow/infiltration in the Moose Lake WWTP service area

	Infiltration	Inflow	Total I/I
Before Rehabilitation			
Av Flow gpd	111,000	72,000	183,000
Peak flow gpd	772,000	610,000	1,382,000
Estimated Correction	25%	75%	45%
After Rehabilitation			
Av Flow gpd	83,000	18,000	101,000
Peak flow gpd[a]	579,000	153,000	732,000

[a] Calculated assuming Average/Peak ratio is the same before and after rehabilitation.

Table 2-12. Estimated excess capacity existing Moose Lake WWTP Year 2000.

Flow Basis	Existing Design Capacity	Revised Design Capacity[a]
Capacity (gpd)	421,500	316,100
Flow from existing service area ADBF-(3835 PE[b] x 60 gpcd) (gpd)	230,100	230,100
Uncorrected infiltration/inflow[c] (gpd)	101,000	101,000
Septage gpd[d]	1,000	1,000
Total	332,100	332,100
Excess capacity available (gpd)	89,400	-16,000
Influent Loading Basis		
Loading (lb/day)	937	854
Loading from existing service area 3835 PE x 0.17 lb/cd (lb/day)	652	652
Septage[e] (lb/day)	42	42
Total	694	694
Excess capacity available (lb/day)	243	160

[a]Revised capacity based on MPCA Design Criteria (See Table 2-9). Total pond area: 58.2 Ac, active storage volume: 3 ft, storage period: 180 days.

[b]Year 2000 population equivalent for existing Moose Lake WWTP service area (Facility Plan) (Table 2-10)

[c]Source: Facility Plan, SSES in progress. (Table 2-11)

[d]Septage volume based on 365 septic tanks pumped per year which is 26.5% of the total year 2000 housing units in Windemere Township (Table 3.16)

[e]Septage BOD = 5,000 mg/l (USEPA 1980 a).

Lake and Sturgeon Lake areas. The only part of the existing collection system that will require additional capacity is the main lift station (pumping to the WWTP) which is presently undersized and cannot handle the existing or corrected I/I flow from the existing system.

Based on the above analysis of the existing Moose Lake WWTP and of the existing collection system, the following criteria were used as the basis for development centralized treatment in the project alternatives:

- The design capacity of the existing lagoons, and lagoon expansions developed for any alternative were based on the MPCA revised design criteria.

- All alternatives that include expansion of the existing lagoons include costs for additional pond area to accommodate the existing 16,000 gpd deficit in lagoon capacity.

- Alternatives that do not include expansion of the existing lagoons do not include costs to eliminate the 16,000 gpd capacity deficit. (The 16,000 gpd deficit can be accommodated by operating the ponds with an active storage depth of 3.5 feet instead of 3.0 feet.)

- Lagoon expansions were designed to increase the secondary pond area because the existing ratio of secondary to total capacity does not meet MPCA revised criteria. However, if the additional pond area required would not be sufficient to meet the criteria, the existing configuration would not be rearranged to do so.

- It was assumed that I/I corrections will be made to the collection system and to the main pumping station. Costs for I/I corrections were not included in any alternatives. (The 16,000 gpd deficit can be accommodated by operating the ponds with an active storage depth of 3.5 feet instead of 3-0 feet.) (These costs are being identified in an on-going SSES.)

- It was assumed that the additional design capacity required for the main lift station to adequately serve additional population will be identified prior to the I/I corrections.

- The construction cost and O&M cost for the additional pumping capacity is an <u>incremental</u> cost.

2.4. Project Alternatives

Feasible and compatible sets of collection and treatment options were developed into project alternatives for the project area. The project alternatives developed represent combinations of on-site options, centralized collection system options, and effluent treatment and disposal options. A total of seven potential project alternatives were developed and evaluated for technical feasibility, cost-effectiveness, and environmental concerns. These alternatives include a no-action alternative (Alternative 1). Project Alternatives 2 through 6 are consecutively less comprehensive in providing major on-site soil absorption system upgrades over the 20-year design period (Figure 2-14). Conversely, Alternatives 2 through 6 provide consecutively more hookups of residences to centralized collection systems (Table 2-13). Costs associated with each of these alternatives are described in the following sections. All cost data are based on March 1982 price levels and are comprehensive of direct, operational, maintenence, and administrative costs.

2.4.1. Alternative 1 - No-Action

The EIS process must evaluate the consequences of not taking action. The "No-Action" Alternative implies that neither USEPA, MPCA, or FHA would provide funds to build, upgrade, or expand existing wastewater treatment systems. If the No-Action Alternative is "implemented", existing on-site systems in the project area would continue to be used in their present conditions and no new facilities would be built. Any changes or improvements in malfunctioning systems would be at the initiative and expense of either property owners or a local government. With the No-Action Alternative, additional numbers of holding tanks would be built on lots with site limitations and documented problems would continue to exist.

2.4.2. Alternative 2 - On-Site System Upgrades for the Entire Service Area

This alternative consists of selectively upgrading the existing on-site systems and future on-site systems. All other residences within the service area would continue to rely on their current on-site system. All

Table 2-13. Year 1980 residences served by proposed alternatives.

Component	Alternative 2	3	4	5	6	7
On-site upgrade[b]						
Island Lake	103	87	37	37	-	-
Sturgeon Lake	141	122	122	122	122	-
Other[a]	42	42	42	42	42	42
Total	286	251	201	201	164	42
Cluster system						
Island Lake	-	30	-	-	-	-
Sturgeon Lake	-	20	20	20	20	-
Total	-	50	20	20	20	-
Centralized system						
Island Lake	-	-	88	88	151	151
Sturgeon Lake	-	-	-	-	-	197
Total	-	-	88	88	151	348
Total residences served	286	301	309	309	335	390
Residences served by existing systems without upgrades						
Island Lake	48	34	26	26	-	-
Sturgeon Lake	56	55	55	55	55	-
Other[a]	25	25	25	25	25	25
Total	129	114	106	106	80	25
Total project area residences	415	415	415	415	415	415

[a]Includes remainder of EIS project area (Rush Lake, Passenger Lake, Hogans Acres, Wild Acres).

[b]Includes major upgrades (to correct obvious and potential problems) plus minor upgrades (addition of observation port to existing septic tanks in good operating condition).

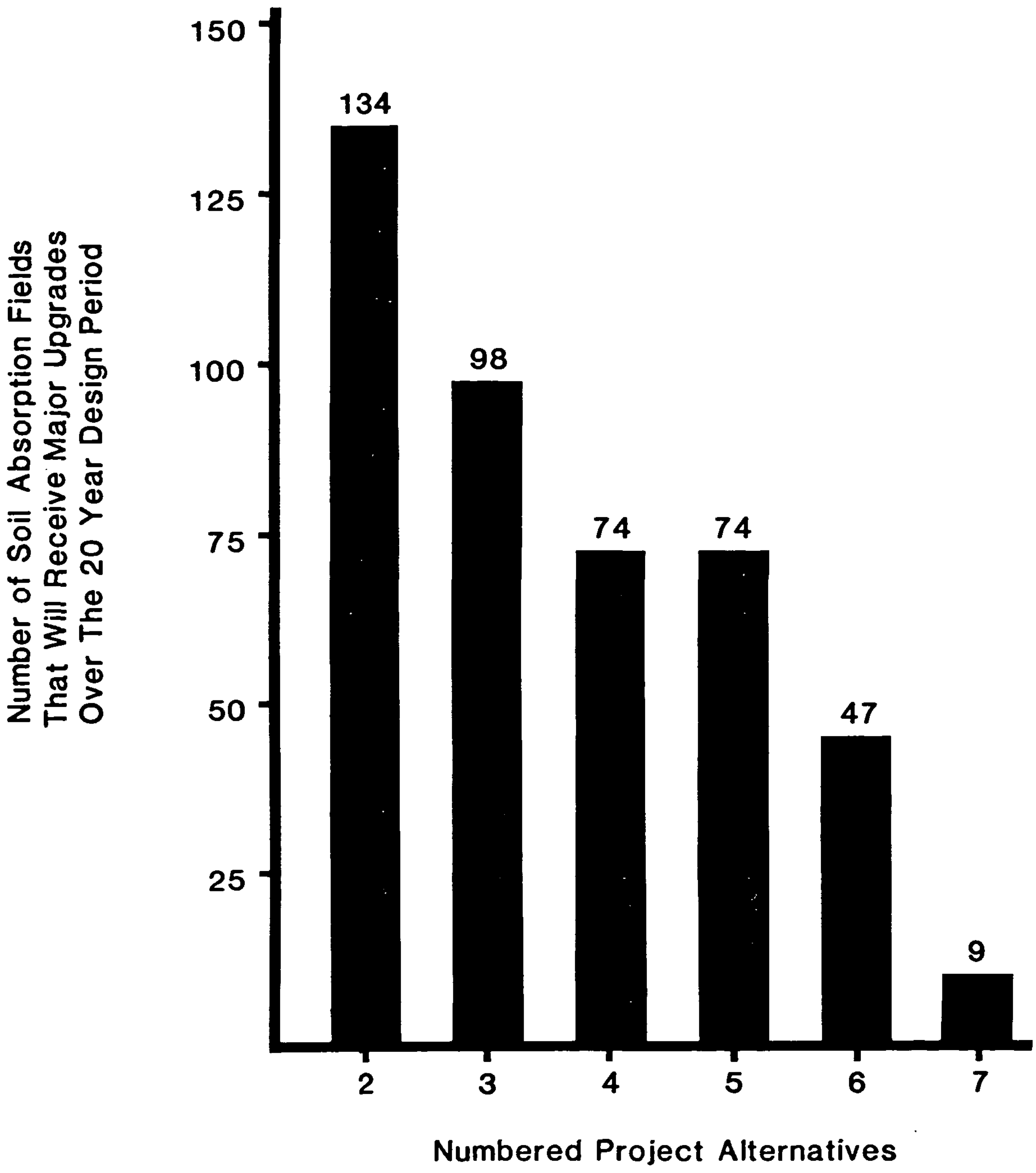


Figure 2-14. Number of soil absorbtion fields that will receive major upgrades over the 20-year design period. Alternative 2 is the full-upgrade or most decentralized alternative. Alternative 7 is the most centralized alternative.

septic tanks in the service area would be fitted with observation ports to facilitate manual inspection. The installation of an observation port is referred to as a minor upgrade. Some major upgrades also may be required under this alternative. The preferred major upgrade, where conditions permit, is the ST/SAS with a serial-parallel trench system (described in Section 2.3.2.6.). Depending on lot limitations, the appropriate alternative on-site system would be selected. Alternative on-site systems include ST-seepage beds, ST-mound systems, and wastewater segregation. The criteria used for determination of the appropriate on-site system at each lot requiring a major upgrade were soil characteristics, depth to groundwater table, landscape slope, and lot size.

For instance, where wastewater segregation was recommended, the graywater would continue to be treated with the existing septic tank and soil absorption system (which may be upgraded). The blackwater components would include a new low-flow toilet and a holding tank. Quantities and types of systems to receive major upgrades are presented in Appendix C. The number and types of upgraded systems are subject to redefinition after final site evaluation is completed. The total present worth cost for this alternative was estimated to be $1,012,890, including administrative costs. The detailed cost estimates made for the various components of this alternative are presented in Appendix E.

2.4.3. Alternative 3 - Cluster Drainfields for Limited Areas and On-site System Upgrades Elsewhere

Alternative 3 consists of centralized collection of septic tank effluent from three areas with pressure and gravity sewers (Figure 2-15). Treatment and disposal are provided in two cluster drainfields in each case. Two of the areas are along the western shoreline of Island Lake, and the third is on the eastern shore of Sturgeon Lake. All other residences in the project area would continue to rely on their current form of on-site system or be upgraded as described in the previous alternative (Alternative 2).

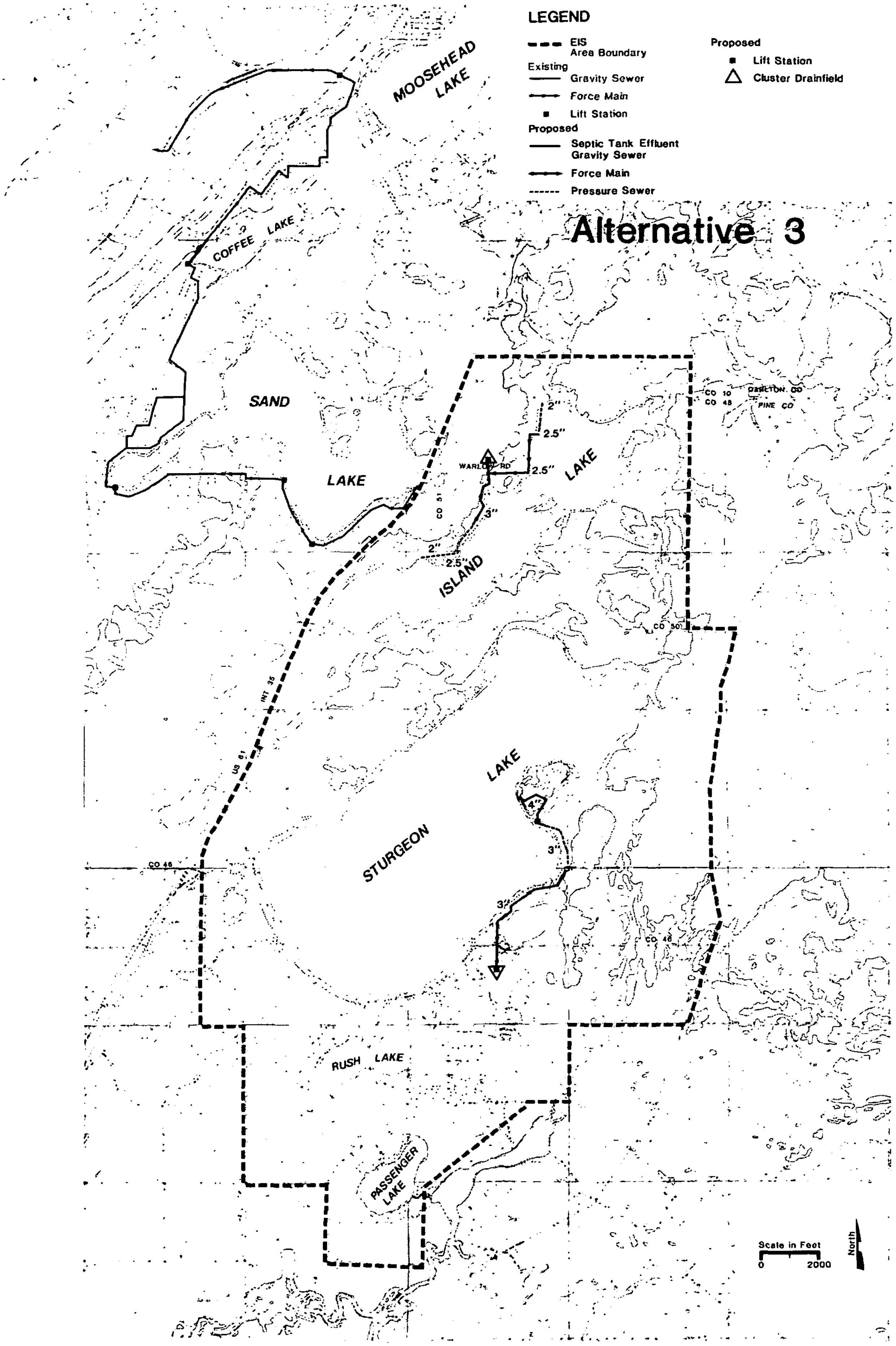


Figure 2-15. Wastewater collection and treatment facilities for Alternative 3

The three areas identified as needing off-site treatment were selected based on soil conditions and on the documented on-site system problems described in Section 2.2.3. The number of residences served by the cluster systems, and the numbers and types of upgraded on-site systems required under Alternative 3, are presented in Appendix E.

Each cluster collection system would employ septic tank effluent pumps and pressure and/or gravity sewers for collection. Each cluster treatment system would consist of a dosing tank or pump station, and three drain fields to allow for phased or "staggered" use at the site. With this management regime, two of the fields would be in use during the year, while the third field was being rested.

Alternative 3 has an estimated present worth cost of $575,020 for the upgrading of existing on-site systems and for future upgrades and an additional $985,220 for the three cluster drainfields (including the collection system). The total present worth for Alternative 3 totals $1,847,010, including administrative costs. Detailed cost estimates for the components of this alternative are presented in Appendix E.

2.4.4. Alternative 4 - Island Lake: Limited Centralized Collection and Treatment at Moose Lake WWTP - Sturgeon Lake: Cluster Drainfield for Limited Area - On-Site System Upgrades Elsewhere.

Alternative 4 considers three component options for centralized collection (4A, conventional gravity; 4B, septic tank effluent gravity; and 4C, septic tank effluent pressure, as described in Section 2.3.3.). Centralized collection would be provided along the north and west shoreline of Island Lake (all of Segment II and part of Segment I) with off-site treatment provided at the Moose Lake WWTP. On the eastern shore of Sturgeon Lake, a centralized collection of septic tank effluent with cluster drainfield treatment is proposed. All other residences in the project area would continue to rely on their current form of on-site system or be upgraded as described in Alternative 2. Criteria for selection of the lakeshore area needing collection for off-site treatment were based on soil conditions, existing septic tank conditions, and the predominance of permanent versus seasonal residences. The number of housing units included in the collection systems for the cluster, and the number and type of upgraded on-site systems are presented in Appendix X.

The layout for Alternative 4A with conventional gravity sewer collection for the limited Island Lake area is presented in Figure 2-16. The layout for Alternative 4B with septic tank effluent gravity sewers is identical to 4A. The lay out for Alternative 4C with pressure sewers also is identical to 4A except that the pressure sewers discharge to a manhole at the top of the hill on Warlow Road near Route 51 and flow by gravity to the existing sewers around Sand Lake.

Comparison of the costs (see Appendix E) associated with the three optional collection system components indicated that the septic tank effluent gravity sewer option (Alternative 4B) would be the most cost-effective, with an estimated total present worth of $815,300 versus $894,080 for conventional gravity sewers (Alternative 4A), and $815,300 for septic tank effluent gravity sewers (Alternative 4C). Based on this cost comparison, Alternatives 4A and 4C were eliminated from further consideration for selection of a project alternative.

Alternative 4B would add an estimated year 2000 population of 310 (seasonal and permanent) to the Moose Lake WWTP, resulting in an additional flow of 21,700 gpd and a additional BOD loading of 20 lb/day. As discussed in Section 2.3.4, the treatment plant would be expanded to accommodate this additional flow, plus the 16,000 gpd deficiency for a total of 37,700 gpd capacity. Based on the new (1980) MPCA design criteria, the additional lagoon area required under Alternative 4B would be 5.20 acres of secondary pond with a volume of 6.79 mg. The total pond area after construction would be 43 acres of primary pond and 20.4 acres of secondary pond for a total of 63.4 acres.

Alternative 4B also would require that the existing main lift station from Moose Lake to the WWTP be upgraded to accommodate the additional flow. As discussed in Section 2.3.4, costs are included for the incremental capacity required to be added during the expected upgrading of the pumping station for infiltration/inflow correction under other contracts.

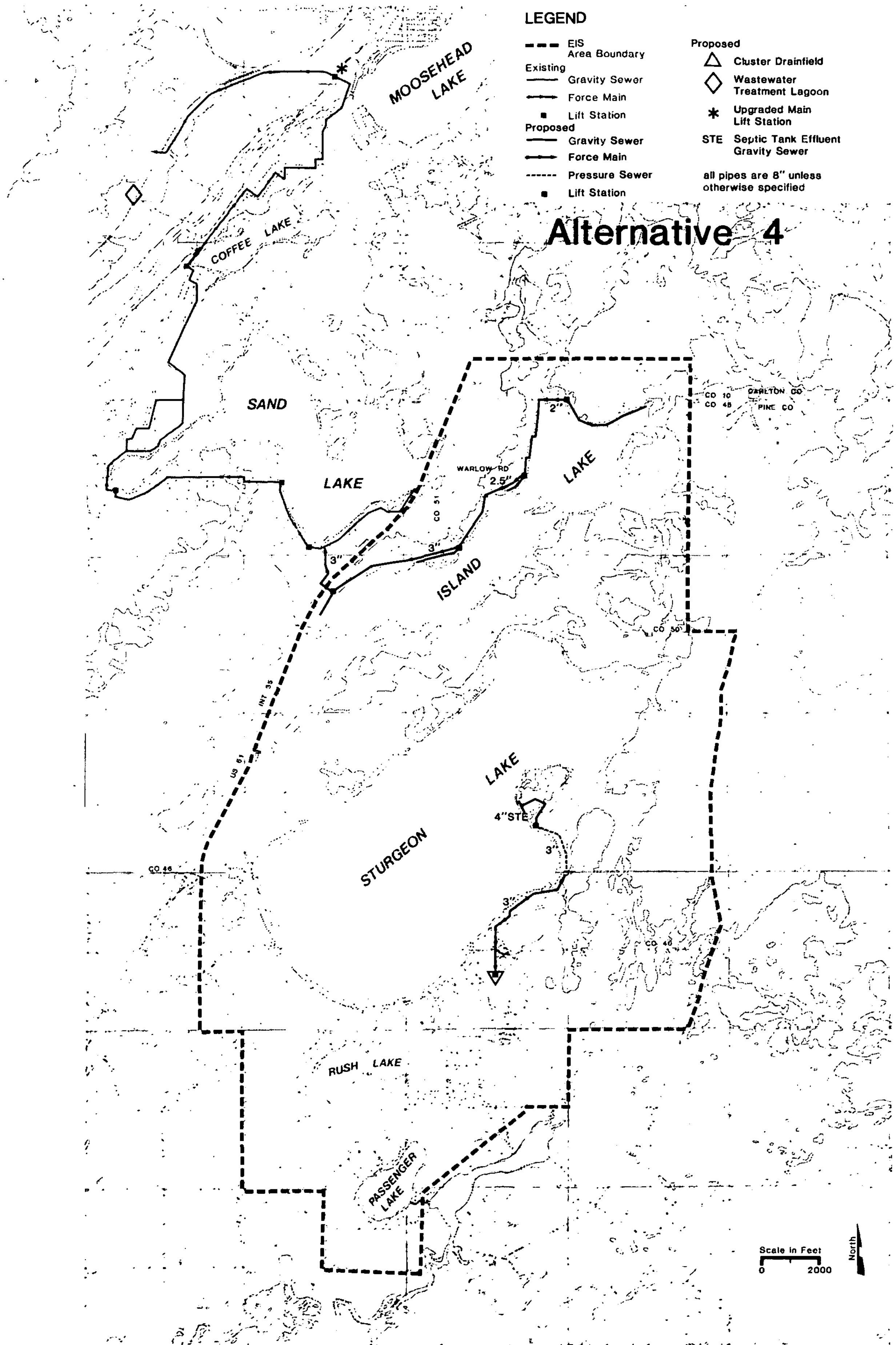


Figure 2-16. Wastewater collection and treatment facilities for Alternative 4
Note: Sewer layout shown is for Project Option 4A (conventional gravity), similar for Project Option 4B (STE gravity) and Project Option 4C (STE pressure).

The cluster drainfield proposed to serve the area on Sturgeon Lake under Alternative 4B consists of septic tank effluent gravity and pressure sewers, and community drainfields with a dosing pump station (as described in Alternative 3).

Alternative 4B has estimated total present worth costs of $815,300 for the centralized collection system, $498,300 for the cluster drainfield (including collection system), $268,340 for the centralized treatment system (including the upgrade of the existing lift station), and $400,880 for the upgrading of on-site treatment systems. The total present worth of Alternative 4C was estimated to be $2,269,680, including administrative costs. Detailed cost estimates for each of the components are presented in Appendix E.

2.4.5. Alternative 5 - Island Lake: Limited Centralized Collection and Bog Treatment
- Sturgeon Lake: Cluster Drainfield for Limited Areas
- On-Site System Upgrades Elsewhere.

Alternative 5 considers two component options for centralized collection of septic tank effluent (5A, gravity sewers; 5B, pressure sewers). Centralized collection would be provided along the north and west shorelines of Island Lake, with treatment provided by a "spaghnum" or peat bog system (described in Section 2.3), located just south of Island Lake. Centralized collection and cluster drainfield treatment also would be provided for the Island on the eastern shore of Sturgeon Lake. All other residences in the EIS service area would continue to rely on their current form of on-site system, or be upgraded as described in Alternative 2.

The developed areas considered for service with centralized collection and off-site treatment in Alternative 5 are the same as those in Alternative 4. However, Alternative 5 utilizes the bog treatment of septic tank effluent, whereas Alternative 4 proposes centralized treatment at the Moose Lake WWTP.

The layout for Alternative 5A, with septic tank effluent gravity sewer collection for the limited Island Lake area is shown in Figure 2-17.

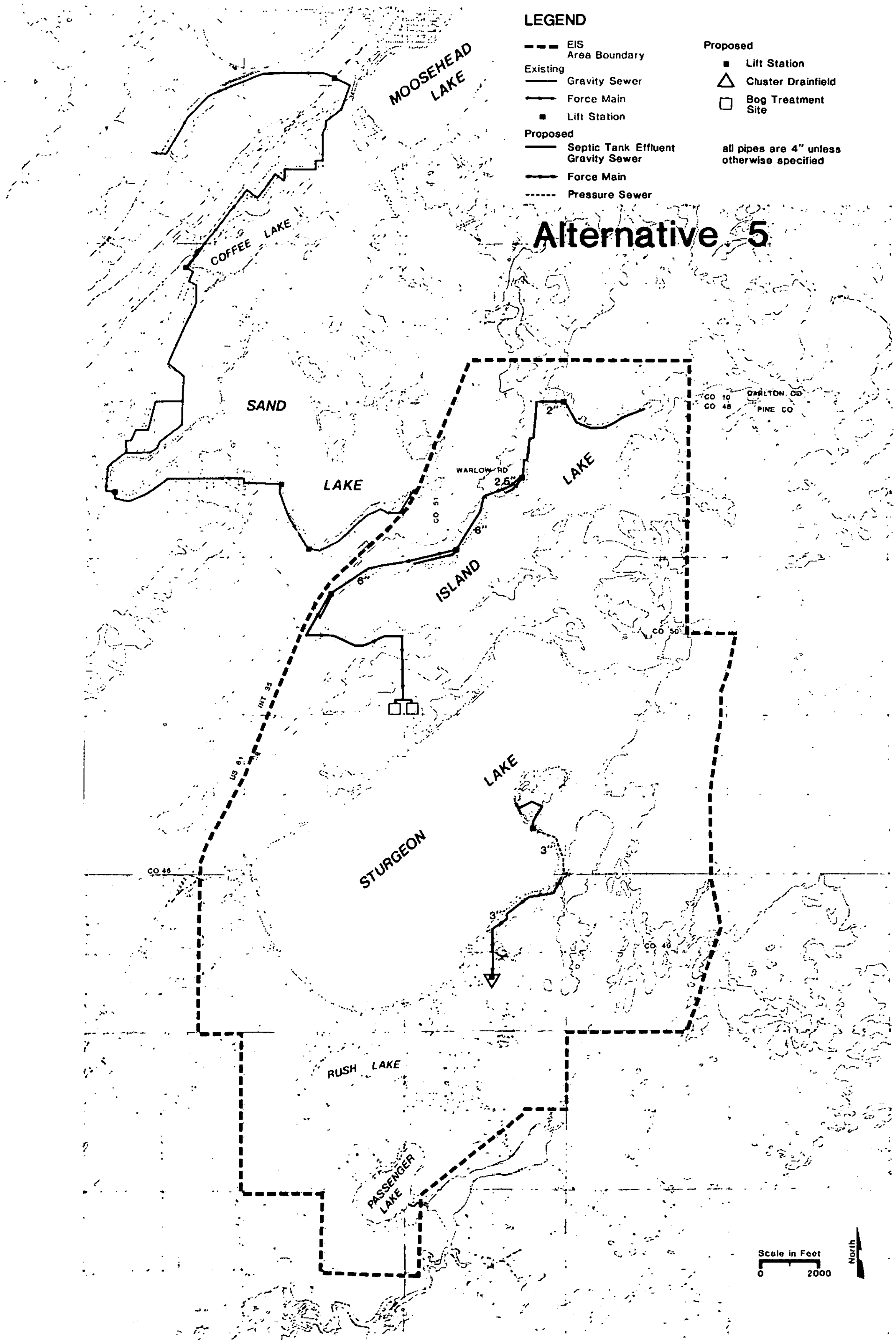


Figure 2-17. Wastewater collection and treatment facilities for Alternative 5
Note: Sewer layout shown is for Project Option 5A (STE gravity), similar for Project Option 5B (STE pressure).

The layout of Alternative 5B, with pressure sewers, is identical to 5A except that there is only one lift station located at a point along the west lakeshore.

Comparison of the costs (see Appendix) associated with the collection systems considered indicated that septic tank effluent pressure sewers (Alternative 5B) are the most cost-effective for the limited Island Lake service area, with an estimated total present worth of $815,940 versus $871,070 for septic tank effluent gravity sewers (Alternative 5A). Based on this cost comparison, Alternative 5A was eliminated from further consideration for selection of a project alternative.

The cluster drainfield consists of septic tank effluent gravity and/or pressure sewers and three drainfields with one dosing pump station, as described in Alternative 3.

Alternative 5B has estimated total present worth costs of $815,940 for the centralized collection system, $498,370 for the cluster drainfield (including collection system), $327,170 for the bog treatment system, and $400,880 in the remainder of the service area for the upgrading of on-site treatment systems. The total present worth was estimated to be $2,329,150, including administrative costs. Detailed cost estimates for each component are presented in Appendix E.

2.4.5. Alternative 6 - Island Lake; Centralized Collection and Treatment at Moose Lake WWTP
- Sturgeon Lake; Cluster Drainfield for limited service area
- On-Site system Upgrades Elsewhere.

Alternative 6 considers three component options for provision of centralized collection (6A, conventional gravity; 6B, STE gravity; 6C, STE pressure as described in Section 2.3.). Centralized collection would be provided for the entire shoreline of Island Lake, with treatment provided at the Moose Lake WWTP. Centralized collection also would be provided for a limited area of the eastern shore of Sturgeon Lake with treatment provided at a cluster drainfield system. All other residences in the EIS project area would continue to rely on their current form of on-site system or be upgraded as described in Alternative 2.

Alternative 6 serves the entire shoreline of Island Lake with a centralized collection system. The service area population for this area is limited to the year 2000 projection (Section 3.2.1.3.). The collection system layout generally follows the June 1980 plans developed to serve Island Lake (Howard A. Kuusisto 1980) except that the pipe and pumping stations have been sized to serve the EIS population projection.

The layout for Alternative 6A with conventional gravity sewer collection for the Island Lake area is shown in Figure 2-18. The layout for Alternative 6B with septic tank effluent gravity sewers would be identical to 6A. The layout for Alternative 6C with pressure sewers also would be identical to 6A, except that the pressure sewers would discharge to an manhole at the top of the hill on Warlow Road near Route 51 and flow by gravity to the existing sewers around Sand Lake.

Comparison of the costs associated with the collection systems considered indicated that septic tank effluent pressure sewers (Alternative 6C) would be the most cost-effective, with an estimated total present worth of $1,475,590 versus $1,205,950 for conventional gravity sewers (Alternative 6A) and $1,589,360 for septic tank effluent gravity sewers (Alternative 6B). Based on the cost comparison, Alternatives 6A and 6B have been eliminated from further consideration for the selection of a project alternative.

Alternative 6C would add an estimated year 2000 population of 579 (seasonal and permanent) to the Moose Lake WWTP, resulting in an additional flow of 40,530 gpd and an additional BOD loading of 34.5 lb/day. As discussed in Section 2.3.4, the Moose Lake treatment plant would be expanded to accommodate the additional flow plus the 16,000 gpd deficiency for a total of 56,530 gpd. Based on the new (1980) MPCA design criteria, the additional lagoon area required would be 7.8 acres of secondary pond with a volume of 10.18 MG. The new total pond area would be 43 acres of primary pond and 23 acres of secondary pond for a total of 66 acres.

Alternative 6C also would require that the existing main lift station from Moose Lake to the treatment plant be upgraded to accommodate the

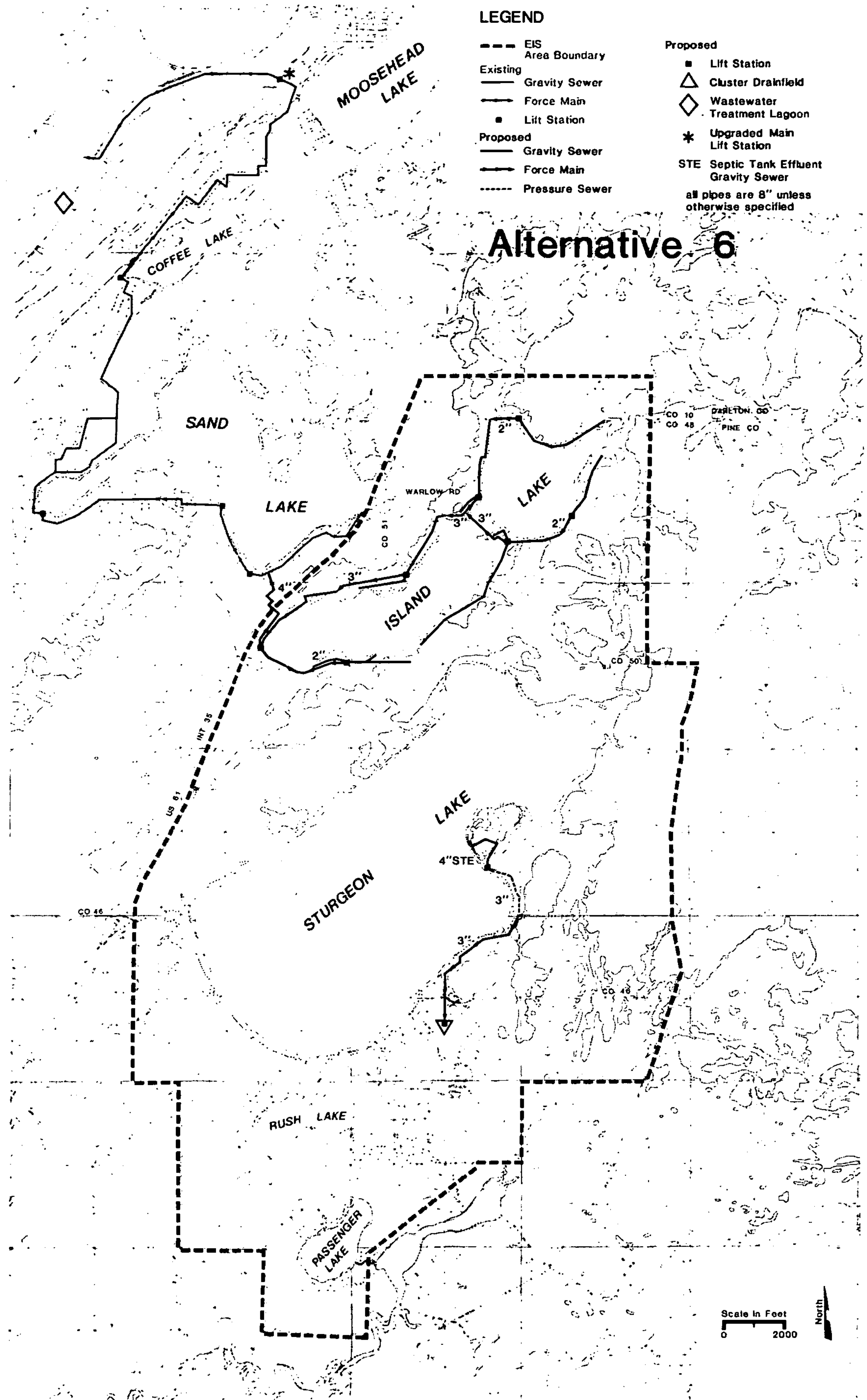


Figure 2-18. Wastewater collection and treatment facilities for Alternative 6
Note: Sewer layout shown is for Project Option 6A (conventional gravity), similar for Project Option 6B (STE gravity) and Project Option 6C (STE pressure).

additional flow. As discussed in Section 2.3.4, costs are included for the incremental capacity required to be added during the expected upgrading of the pumping station for infiltration/inflow correction under other MLWSD contracts.

The cluster drainfield proposed with Alternative 6C to serve the limited area on the east shore of Sturgeon Lake consists of septic tank effluent gravity and pressure sewers, and three drainfields with dosing pump stations, as described in Alternative 3.

Alternative 6C has estimated total present worth costs of $1,475,590 for the centralized collection system, $498,370 for the cluster drainfield (including collection system), $394,100 for the centralized treatment system (including the upgrading of the existing lift station), and $271,010 for the upgrading of on-site treatment systems in the remainder of the service area. The total present worth was estimated to be $2,925,860, including administrative costs. Detailed cost estimates for each component are presented in Appendix E.

2.4.7. Alternative 7 - Complete Centralized Collection for the Shorelines of Island Lake and of Sturgeon Lake - On-site System Upgrades Elsewhere.

Alternative 7 considers three component options for centralized collection (7A, conventional gravity; 7B, septic tank effluent gravity, STE pressure, as described in Section 2.3) along the shorelines of both Island Lake and Sturgeon Lake, with treatment provided at the Moose Lake WWTP. All other residences in the EIS service area would continue to rely on their current form of on-site system with upgrades as described in Alternative 2.

Alternative 7 serves the entire shoreline of Island Lake and most of the shoreline of Sturgeon Lake with a centralized collection system. The total service area population of Alternative 7 is limited to the year 2000 EIS projection (Section 3.2.1.3.). The collection system for Island Lake generally follows the June 1980 plans presented by the MLWSD to serve that area, and the collection system for Sturgeon Lake generally follows the layout proposed in the Facility Plan. However, the pipe sizes and pumping station capacities have been limited to serve the projected year 2000 population only, at maximum flow.

The layout proposed in Alternative 7A, with conventional gravity sewer collection for Island Lake and Sturgeon Lake is shown in Figure 2-19. The layout for Alternative 7B with septic tank effluent gravity sewers would be identical to 7A. The layout for Alternative 7C with pressure sewers also would be identical to 7A, except that a lift station would be required in the area of the YMCA camp to convey a portion of the Sturgeon Lake sewage to the Island Lake collection system, and a main lift station at the southern end of Island Lake would convey all of the sewage from Sturgeon Lake and a major portion of Island Lake to the existing sewers around Sand Lake. The remainder of the sewage collected from Island Lake would discharge from the pressure sewers at a manhole at the top of the hill on Warlow Road near Route 51 and flow by gravity to the existing Sand Lake sewers. In addition, the island on the eastern shore of Sturgeon Lake would be partially served by septic tank effluent gravity sewers and a pump station provided to connect this area to the pressure sewer main.

Comparison of the costs associated with the collection systems considered indicates that septic tank effluent gravity sewers (Alternative 7B) would be the most cost-effective, with an total estimated present worth of \$3,616,080 versus \$3,846,980 for conventional gravity sewers (Alternative 7A) and \$3,641,590 for septic tank effluent pressure sewers (Alternative 7 C). Based on the cost comparison, Alternatives 7A and 7C have been eliminated from further consideration for the selection of a project alternative.

Alternative 7B would add an estimated year 2000 population (seasonal and permanent) to the Moose Lake WWTP as follows: Island Lake 579; Sturgeon Lake 802; YMCA camp 120, for a total of 1,501. This would result in an additional flow of 105,070 gpd and an additional BOD loading of 41.6 lb/day to the plant. As discussed in Section 2.3.4, the treatment plant would be expanded to accommodate the additional flow plus the 16,000 gpd

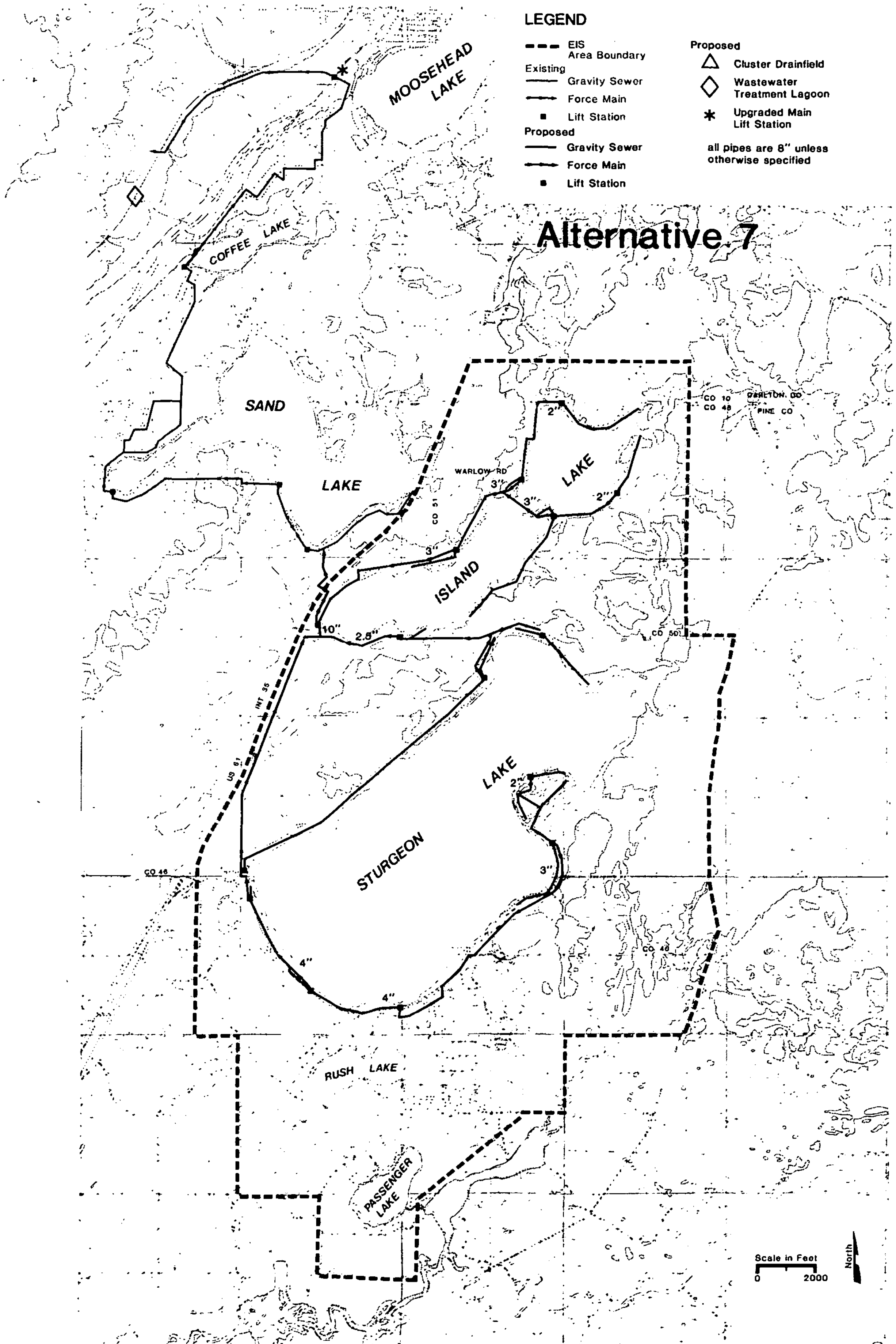


Figure 2-19. Wastewater collection and treatment facilities for Alternative 7
Note: Sewer layout shown for Project Option 7A (conventional gravity), similar for Project Option 7B (STE gravity) and Project Option 7C (STE pressure).

deficiency, for a total of 121,100 gpd. Based on the new (1980) MPCA design criteria, the additional lagoon area required would be 16.7 acres of secondary pond, with a volume of 21.79 mg. The new total pond area would be 43 acres of primary pond and 31.9 acres of secondary pond, for a total of 74.9 acres.

Alternative 7B also would require that the existing main lift station from Moose Lake to the plant be upgraded to accommodate the additional flow. As discussed in Section 2.3.4, costs are included for the incremental capacity required to be added during the expected upgrading of the pumping station for infiltration/inflow correction under other contracts.

Alternative 7B has estimated total present worth costs of $3,616,080 for the centralized collection system, $625,080 for the centralized treatment system (including the upgrading of the existing lift station), and $89,710 for the upgrading of on-site treatment systems. The total present worth of Alternative 7B was estimated to be $4,617,660, including administrative costs. Detailed cost estimates for each component are presented in Appendix E.

2.5. Flexibility and Reliability of the Project Alternatives

2.5.1. Flexibility

Flexibility measures the ability of a system to accommodate future growth and depends on the ease with which an existing system can be upgraded or modified. Six of the seven project alternatives considered in this EIS include such components as: centralized collection sewer systems, upgrades of the existing Moose Lake waste stabilization lagoons, a cluster system, and various levels of upgrades for project area on-site systems. The components are found in a majority of the alternatives, and the following evaluation is generally applicable to most of the alternatives unless otherwise stated in the discussion. The proposed bog treatment system is discussed separately due to considerations of management straints and the lack of demonstrated technical feasibility .

For both gravity and pressure sewer systems, the flexibility to handle future increases in flows greater than the original design flow generally is low. However, interceptor sewers generally are designed for capacity beyond that which is projected as a result of population growth to the end of the planning period. A subsequent increase in capacity of collector sewers would be a somewhat expensive process. Also, the layout of the system depends upon the location of the treatment facility. The expansion of a sewer system is generally easy with the addition of new sewers, but is expensive.

The existing Moose Lake waste stabilization lagoons can be expanded relatively easily. With proper design of the pond expansion the costs and effort required for expansion would be relatively small.

On-site systems are flexible in that they are generally designed for the constraints of each user. As long as spatial and environmental parameters are met, the type of systems can be chosen according to individual requirements. Existing septic systems can be expanded by adding tank and drain field capacity, if suitable land is available. Flow can usually be distributed to an added system with little disturbance of the existing one. In the case of mound systems, future expansion may be difficult or impossible. Cluster systems treat wastewater from more than one house. The flexibility for design and expansion of such a system is somewhat less than for a standard septic system.

No data are available on the variation in bog treatment system performance as a function of wastewater load increases. The performance which would be associated with moderate expansions in wastewater load above that resulting from the year 2000 design population cannot be estimated. Therefore, in the bog treatment systems, the flexibility to handle future increases in flow is highly dependent on the availability of additional bog area, contiguous to the proposed treatment site. With proper original design, the cost of any needed expansion may be relatively small.

Based on the above discussions, it is concluded that the majority of the alternatives considered in this report generally have similar flexibility for future growth and/or planning.

2.5.2. Reliability

Reliability measures the ability of a system or of system components to operate without failure at the designed level of efficiency. It is particularly important to have dependable operation in situations where adverse environmental or economic impacts may result from failure of the system.

The gravity sewer is highly reliable when designed properly. Such systems require little maintenance, consume no energy, and have no moving parts subject to malfunction. Gravity sewer problems can include clogged pipes that result in sewer backups; infiltration/inflow which increases the volume of flow beyond the design level; and broken or misaligned pipes. Major contributors to these problems are improperly jointed pipes and damage to manholes, especially where these are not located in paved roads. Where large sewers are used in order to achieve lower pipe slopes, problems with solids deposition can mean that frequent flushing with large volumes of water will be necessary.

Pump stations and force mains increase operation and maintenance requirements and decrease system reliability. Backup pumps are installed in order to provide service in case the pump fails. A backup power source is usually provided by means of either dual power lines or stationary or portable emergency generators. Force mains are generally reliable; excessive solids deposition and burst pipes occur rarely. Leaking joints occur more frequently and can cause adverse impacts to the environment.

Septic tank effluent pumps and pressure sewers generally are reliable means of conveying effluent to a treatment plant. Because the solids have been removed in the septic tank, problems associated with solids deposition are avoided. The pump units themselves have been shown to be reliable; when failures or power outages do occur, storage of approximately 1.5 day's sewage volume in the pump chamber and septic tank permits replacements to be made before backups occur. The pressure sewers themselves should be even more reliable than force mains because the pumped liquid is clear.

Federal Guidelines for Design, Operation, and Maintenance of Wastewater Treatment Facilities (Federal Water Quality Administration 1970) require that:

> All water pollution control facilities should be planned and designed so as to provide for maximum reliability at all times. The facilities should be capable of operating satisfactorily during power failures, flooding, peak loads, equipment failure, and maintenance shutdowns.

The wastewater control system design for the project area will consider the following types of factors to ensure system reliability:

- Duplicate sources of electric power
- Standby power for essential plant elements
- Multiple units and equipment to provide maximum flexibility in operation
- Readily available replacement parts
- Holding tanks or basins to provide for emergency storage of overflow and adequate pump-back facilities
- Flexibility of piping and pumping facilities to permit rerouting of flows under emergency conditions
- Provision for emergency storage or disposal of sludge
- Dual chlorination units
- Automatic controls to regulate and record chlorine residuals
- Automatic alarm systems to warn of high water, power failure, or equipment malfunction
- No treatment plant bypasses or upstream bypasses
- Design of interceptor sewers to permit emergency storage without causing backups
- Enforcement of pretreatment regulations to avoid industrial waste-induced treatment upsets
- Flood proofing of treatment plant
- Plant Operations and Maintenance Manual to have a section on emergency operation procedures

- Use of qualified plant operators.

The upgraded Moose Lake WWTP would be highly reliable if these measures were incorporated. The reliability of the proposed bog treatment system under local wastewater load characteristics is not known. The collection systems have reduced reliability because so many pump stations are required. If dual power lines from separate substations can be extended to every pump station (an expensive proposition), a reasonable level of reliability can be attained. Supplying permanent auxiliary power units for each pump station is not feasible. A failure of a pump station would likely result in raw sewage or septic tank effluent being discharged into one of the lakes. Because as many as eleven pump stations must operate in series, a failure of one would likely result in spillage into a lake.

The on-site systems are generally a reliable means of treating and disposing of wastewater. Except with certain systems, they operate with no power inputs and little attention. When failures do occur, the impact to the environment is small and diffuse. Total failures very rarely occur in which no treatment at all takes place.

Septic tanks provide reliable treatment when they are properly designed and maintained. The principal maintenance requirement is periodic pumping of the tank, usually every 3 to 5 years. The treatment process can be harmed if large quantities of strong chemicals are flushed into the tank.

Soil absorption systems generally provide excellent treatment if the design and installation are accomplished properly and the soil conditions are suitable. Other key factors in the successful operation of soil absorption systems are: proper functioning of the septic tank or other treatment unit and observance of reasonable water conservation practices consistent with the design flows. Soil absorption systems can malfunction when extended wet weather results in total saturation of the soil, when solids carryover plugs the drain bed, and when compaction of the soil surface results in restricted permeability. Mound systems can be more reliable than drain bed systems where water tables are high because potential groundwater problems are minimized. Mound systems do require an effluent pump, though, and thus rely on a dependable power supply. The septic tank and pump chamber generally can hold approximately 1.5 days of storage, which is probably longer than the average power outage. A malfunctioning pump can be replaced readily if the units are standardized. The cost of a mound system is about three times that of a drain bed system; thus, it would be utilized only where a drain bed system has failed or has little chance of operating properly. The average design life of soil absorption systems is greater than 20 years; some could be expected to fail earlier. Some soil absorption systems could be expected to last indefinitely, as long as the system is not overloaded with water or solids.

Cluster systems serve a group of houses with a set of components that are similar to those used in individual septic tank soil absorption systems. The individual septic tanks would operate at similar levels of reliability. The septic tank effluent sewers are exposed to hazards of breakage and to plugging due to cleanout failure similar to gravity sewers. Sewage solid accumulations in the sewers does not occur when the septic tanks are maintained properly. The soil absorption system should be sited on permeable soils that have a water table always greater than 6-foot depth. The operation of the drain field has the potential to be more reliable than an individual on-site soil absorption system because of pressure distribution by dosing and because of the ability to site the drainfields in an optimum location, but there have been few long-term studies to evaluate the drainfield reliability.

2.6. Comparison of Alternatives and Selection of the Recommended Action

The selection of the most cost-effective, environmentally acceptable, and implementable alternative(s) through the EIS process involved the consideration of technical feasibility, reliability, costs, environmental effects, public desirability, and the ability to comply with the applicable design and effluent discharge standards for the State of Minnesota. Selection of the most cost-effective alternative also required identification of trade-offs between costs and other relevant criteria.

2.6.1. Comparison of Alternatives

2.6.1.1. Project Costs

Project costs were categorized into capital expenses, operation and maintenance (O&M) expenses, administrative expenses, and salvage values for the equipment and structures for each alternative. The costs for the collection, conveyance, and treatment systems for each alternative were separately estimated. A summary of the estimated costs of Alternatives 1-7 are displayed in Table 2-14. Appendix E contains a description of the methodology and assumptions used in the analyses as well as the detailed costs for each alternative.

The capital cost for the selected alternative would be shared by the Federal government through the Federal Construction Grants Program, by state grants administered by MPCA, and by local participants. Until 1984, funding levels for conventional systems would be 75% Federal, and 15% State for a total of 90% of eligible construction costs. Funding for innovative and alternative wastewater collection and treatment systems would be 85% Federal and 9% State for a total of 93%. For construction started after 30 September 1984 the Federal share will be 55% for conventional systems and 75% for innovative and alternative systems (Federal Register, Vol 47, NO92, May 12, 1982; changes in regulations governing construction grants for treatment works). The state share after 30 September 1982 is not known at this time. Eligibility of construction costs for Federal and state grants is discussed in Section 4.1.3. Annual O&M costs would be financed entirely by the local users of the system.

Based on total estimated present worth cost, upgraded on-site systems throughout the project area (Alternative 2) is the lowest cost alternative. Alternatives 3, 4C, and 5B, which include upgraded on-site systems and service of certain critical lakeshore areas with cluster drain fields and/or centralized collection and treatment, are ranked second through fourth, respectively. Alternative 6C, which includes centralized collection and treatment for all of Island Lake, is ranked fifth based on cost. Based on total present worth cost, Alternative 7B, which is similar

Table 2-14. Summary of the estimated costs for Project Alternatives 1 through 7 in March 1982 dollars.

Alternative Number and Name	Total Present Worth[a]							Average Annual Equivalent Costs	Cost Ranking
	On-Site Upgrade	Cluster Drainfield[b]	Centralized Collection	Centralized Treatment[c]	Sub Total	Administrative[f]	Total		
1 No-Action in EIS service area	-	-	-	-	-	-	-	-	NA
2 Upgrade on-site systems within EIS service area	726,100	-	-	-	726,100	286,790	1,012,890	100,300	1
3 Cluster drainfield for limited areas and on-site system upgrading elsewhere in EIS service area	575,000	985,220	-	-	1,560,220	286,790	1,847,010	182,900	2
4B Island Lake-limited area collection by STE gravity sewers and treatment at upgraded Moose Lake WWTP; Sturgeon Lake-cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	400,880	498,370	815,300	268,340	1,982,890	286,790	2,269,680	224,760	3
5B Island Lake-limited area collection by STE pressure sewers and peat bog treatment; Sturgeon Lake - cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	400,880	498,370	815,940	327,170	2,042,360	286,790	2,329,150	230,650	4
6C Island Lake entire shoreline STE pressure collection and treatment at upgraded Moose Lake WWTP; Sturgeon Lake - cluster drainfield for limited area; on-site system upgrading elsewhere in EIS service area	271,010	498,370	1,475,590[d]	394,100	2,639,070	286,790	2,925,860	289,740	5
7B Island Lake and Sturgeon Lake shorelines STE gravity collection and treatment at upgraded Moose Lake WWTP; on-site system upgrading elsewhere in EIS service area.	89,710	-	3,616,080[e]	625,080	4,330,870	286,790	4,617,660	457,270	6

[a] Includes costs for on-site or off-site treatment of wastewater from existing and future residences in the EIS project area to the year 2000. See Appendix E for a description of cost development methodology.

[b] Includes STE pressure and gravity collection system

[c] Includes upgrading of existing lift station to Moose Lake WWTP

[d] For comparison, the estimated present worth cost of conventional gravity collection is $1,705,950 ($2,866,430 subtotal, $3,153,220 total, $312,250 Equiv. Ann.).

[e] For comparison, the estimated present worth cost of conventional gravity collection is $3,846,980 ($4,561,770 subtotal, $4,848,560 total, $480,140 Equiv. Ann.).

[f] Includes annual personnel and overhead costs for administration and billing.

to the recommended alternative of the MLWSD Facility Plan that includes centralized collection and treatment for Island Lake and Sturgeon Lake, is the most expensive alternative, and ranks seventh. The estimated total present worth cost ranges from $985,220 for Alternative 2 to $4.6 million for Alternative 7B.

2.6.1.2 Environmental and Financial Impacts

The No-Action Alternative would entail almost no construction impacts. The significant environmental impacts of the six action alternatives would primarily be short-term impacts on the local environment due to construction (Section 4.1.1.).

The implementation of the onsite systems component of Alternatives 3, 4, 5, 6 and 7 or the full onsite upgrade alternative (Alternative 2), would have direct impacts on those lots where upgraded onsite systems are necessary.

Cluster drainfield and cluster mounds (Alternatives 3, 4, 5, and 6) would involve construction on the drainfield sites of a similar nature to that of the onsite upgrades.

The construction of centralized collection facilities (Alternatives 3, 4, 5, 6 and 7) would have considerable impacts on the right-of-way where the sewers are located. Dewatering for deep sewer excavations and pump stations could affect wells in the vicinity. Construction of additional treatment capacity of the Moose Lake WWTP (Alternatives 4, 6 and 7) would have a significant effect at the site of treatment. The proposed lagoon expansion sites are prime agricultural land that would be irretrievably converted to treatment plant use.

Construction of a bog treatment system (Alternative 5) would have significant adverse impacts on the biota of the site.

The expanded Moose Lake WWTP discharging to the Moose Horn River would be required to meet the effluent requirements established by MPCA. Water quality would be altered, but not seriously degraded. Spills of septic tank effluent or of raw sewage at pump stations could occur if a malfunction or power failure were to occur. The nutrient load from one pump station spill could easily equal the average annual nutrient load from existing on-site systems. Proper maintenance of the pumps, and backup powers sources for all the pump stations, would reduce the potential for such impacts.

The centralized collection, treatment and disposal facilities, and the onsite upgrading would have a positive effect on groundwater quality by eliminating existing failing onsite systems. Onsite upgrades and management of onsite systems would replace failing onsite systems with appropriate new systems or holding tanks.

In general, there is no significant difference in long-term impact on the natural environment between any of the project alternatives.

The financial impact on the system users will depend on the availability of Federal and State grants (Section 4.3.). Estimated annual residential user charges (Table 4-3) range from $104 for Alternative 2 with Federal and State grants to $1,259 for Alternative 7A with no grants. The equivalent annual user charge for Coffee Lake and Sand Lake are $120 and $145 respectively (based on assessed connection charge and user fee, Section 3.2.4.).

Based on USEPA guidelines (Section 4.3.) the average annual user charges for Alternatives 6A and 7A are considered "expensive" for users even with Federal and State Grants (Table 4-4). Without grants, Alternative 2 is the only alternative that is not considered expensive.

The increase in per capita debt within the Sanitary District will exceed standard limits (Section 4.3.) for Project Alternative 7, the most comprehensive sewering proposal, if no grants are available (Table 4-5). None of the project alternatives exceed the excess debt criteria if Federal and State grants are available.

2.6.1.3. Implementability

The Moose Lake-Windemere Sanitary District is the management agency which would be responsible for implementing the wastewater management plan. As described in Section 2.1., the District presently manages collection and transmission sewers only. Transmission to the treatment plant is provided by the City of Moose Lake.

The proposed Project Alternatives all require some level of management of combinations of "centralized" and "decentralized" components. The centralized components of Alternatives 3 through 7 include collection systems and centralized treatment. The decentralized components of Alternatives 3 through 6 include cluster drainfields and on-site systems.

Because most sanitary districts have, in the past, been formed around the concept of centralized collection and treatment of wastewater, there is a great deal of information about the implementation of such systems. Decentralized collection and treatment, however, is relatively uncommon and there is little comparable management experience on which to draw conclusions regarding implementability.

The value of decentralized, small waste flows systems began to be recognized in the 1970s as being important as long-term rather than short-term alternatives to centralized collection and treatment. As a result, communities preparing facilities plans after 30 September 1978 were required to provide an analysis of the use of innovative and alternative wastewater processes and techniques that could solve a community's wastewater needs (PRM 78-9; USEPA 1978a). Included as alternative processes are individual and other on-site treatment systems with subsurface disposal units (drain fields).

The 1977 Clean Water Act amendments recognized the need for continual supervision of the operation and maintenance of decentralized on-site systems. USEPA Construction Grants Regulations (USEPA 1978a and 1979b) which implement the Act require an applicant to meet a number of preconditions before a construction grant for private wastewater systems may be made. The preconditions to be met include:

- Certifying that a public body will be responsible for the proper installation, operation, and maintenance of the funded systems;
- Establishing a comprehensive program for the regulation and inspection of on-site systems that will include periodic testing of existing potable water wells and, where a substantial number of on-site systems exists, more extensive monitoring of aquifers;
- Obtaining assurance of unlimited access to each individual system at all reasonable times for inspection, monitoring, construction, maintenance, rehabilitation, and replacement.

PRM 79-8 extends these requirements to grants for publicly owned systems.

Regardless of whether the selected alternative is primarily centralized or decentralized, four aspects of the implementation program must be addressed:

- There must be legal authority for the managing agency to exist and financial authority for it to operate;
- The agency must manage construction, ownership, and operation of the facilities;
- A choice must be made between the several types of long-term financing that are generally required in paying for capital expenditures associated with the project;
- A system of user charges to retire capital debts, to cover expenditures for operation and maintenance, and to provide a reserve for contingencies must be established.

In the following sections, these requirements are examined first with respect to centralized systems and then with respect to decentralized systems.

Centralized Systems

The Moose Lake-Windemere Sanitary District was formed in accordance with Minnesota Statutes Chapter 116A. This chapter enables a County Board or District Court to create a sewer district for the purposes of constructing, operating, and maintaining wastewater collection and treatment facilities. Additional powers include the power to make contracts, to incur indebtedness, and ro levy user charges, special assessments, and taxation (Otis and Steward 1976).

The District would construct, maintain, and operate the centralized collection and treatment facilities proposed in Alternatives 3 through 7, except those parts of Alternatives 4, 6, and 7 that propose utilizing the WWTP operated and maintained by the City of Moose Lake. These alternatives require revisions of the agreement with the city to facilitate the upgrading of the lift station and lagoons and provision for distribution of operation and maintenance costs.

The managerial capacity of the District can be readily expanded to provide for additional centralized collection systems proposed for Alternatives 3-7. There are several options for septic tank effluent pumps that are connected to pressure sewers:

- The station may be designed to agency specifications, with the responsibility for purchase, maintenance, and ownership residing with the homeowner;
- The station may be specified and purchased by the agency, with the homeowner repurchasing and maintaining it;
- The station may be specified and owned by the agency, but purchased by the homeowner;
- The station may be specified, purchased, and owned by the agency.

Alternative 5 proposes a centralized peat bog treatment system to treat wastewater from homes along a limited segment of the Island Lake shoreline. This would require expansion of the managerial capacity of the District into the operation and maintenance of a treatment facility, which is beyond its present scope, but within its authority and capability. The implementability of Alternative 5 faces serious questions in the context of approvals that would be required from Federal and State of Minnesota granting and permiting agencies. Specifically, the peat bog system design has had no technical feasibility assessment made prior to this level of the planning. As a result, the time that may be required to determine the feasibility of bog treatment for the secondary effluent and the time required to gain granting and reviewing agency approval of this alternative, may eliminate any present cost advantage by postponing construction until the federal funding level for alternative and innovative treatment systems falls from the 85% level to 75% of the total cost.

Capital expenses associated with a centralized project component may be financed by several techniques which are discussed in detail in Section 4.1.3. User charges are set at a level that will provide for repayment of long-term debt and cover operation and maintenance expenses. The user charges for the different alternatives are discussed in Section 4.1.3. In addition, prudent management agencies frequently add an extra charge to provide a contingency fund for extraordinary expenses and for equipment replacement.

Decentralized Systems

The local agency presently responsible for approval and regulation of on-site systems in the project area is the office of the Pine County Zoning Administrator.

In general, regulation of on-site wastewater treatment systems has evolved to the point where most new facilities are designed, permitted, and inspected by local health departments or other agencies. After installation, the local agency has no further responsibility for these systems until malfunctions become evident. In such cases the local agency may inspect and issue permits for repair of the systems. The sole basis for governmental regulation in this field has been its obligation to protect public health. Rarely have governmental obligations been interpreted more broadly to include monitoring and control of other effects of on-site system use or misuse. The general absence of quantitative information concerning septic system impacts on groundwater and surface water quality has been coupled with a lack of knowledge of the operation of on-site systems. The State of Minnesota does not presently have legislation which explicitly authorizes governmental entities to manage wastewater facilities that are not connected to conventional collection system. However, Minnesota Statutes Sec. 444.085, Sec. 444.065, Sec. 444.075 and Chapter 116A have been interpreted as providing cities, villages, counties, and special purpose sewer and water districts, respectively, with sufficient powers to manage decentralized facilities (Otis and Steward 1976).

The purpose of managing a decentralized system through the sanitary district would be to balance the costs of management with the needs of public health and environmental quality. Management by the sanitary district for this new purpose implies formation of a new agency charter and formulation of new policies. A discussion of community obligations for management of private wastewater systems and six community management models can be found in the Draft-Generic Rural Lake Projects EIS (USEPA 1981).

The cluster systems proposed in Project Alternatives 3, 4, 5, and 6 could be managed by one of several agencies. The MLWSD probably is best equipped at this point to assume responsibility for these systems. While the technologies involved may be unsual for the District, no components are involved that are especially difficult to manage. Other possible management agencies include different authorization for the County Zoning Department, a township board, another division of county government, another, special district, or a public utility commission (USEPA 1979). The system itself should be simple to manage. The residential pumping units use electrical power; thus, power interruptions may result in operational or environmental problems. Maintenance and repair activities are more critical for this system than for gravity sewers. Regular cleaning of the septic tanks is essential for the system to operate properly. The operation of the cluster drain field must be carefully monitored so that the treatment aspect of the soil is not abrogated. The billing of the user charge could be similar to the charge system set up for the conventional gravity sewer and treatment plant.

The management of on-site systems (Alternatives 2-7) can be accomplished in many ways (USEPA 1979 and 1979). The management structure will depend primarily on state law and local preference. The USEPA requires a public agency to serve as grantee and to provide assurances that the systems be constructed properly and that maintenance be performed to ensure that environmental laws are not violated. In other locations around the nation many different agencies are presently responsible for on-site systems: health departments, sanitary districts, homeowners' associations, on-site management districts, private companies, and county government. Management responsibilities range from a detailed permit process to complete ownership of all facilities. There are certain advantages with each type of management and ownership option. Complete control by the agency comes closest to guaranteeing that the systems will be operating at optimal levels, but represents the most costly approach. The least costly approach would be to keep the homeowner responsible for all maintenance activities and costs. The homeowner then would be more inclined to utilize water-saving measures and other methods to minimize maintenance costs. However, environmental protection may suffer when the homeowner is responsible for maintenance, but appropriate maintenance is neglected. Other factors also should be considered. Systems for residences constructed after 27 December 1977 are not eligible for Federal grants. Having the homeowner pay for installation constitutes a considerable expense for new residences. This funding requirement would discourage future on-site systems and cause residential growth in the area. Additionally, the USEPA requires the grantee to certify that public ownership is not implementable, a demonstration that may be difficult to make.

The agency in the planning area with the most experience with on-site systems is the Pine County Zoning Department. However, the Zoning Department has no experience in writing and implementing contracts, because their primary role is issuing permits and ispecting construction. The MLWSD has the necessary experience with contracts and management of maintenance activities, although it does not have management experience with on-site systems. Experience with on-site systems is crucial for the personnel responsible for the design, construction, and inspection of these systems. Thus it is anticipated that the most cost-effective managerial arrangement would be for the Zoning Administrator to maintain authority over the installation and management of on-site systems, and for the District to perform the functions of contracting, billing, administration, and maintenance. The local costs for the construction of new systems and rehabilitation of existing systems can be assessed equally to each user by a variety of means, or can be assigned to the respective homeowners. Operation and maintenance costs also can be handled in the same way, based on public or private ownership. The billing system could be similar to that used in the centralized waste water management system.

2.6.2 The Recommended Project Alternative

The recommended action from both an economic and environmental perspective is to implement Alternative 2 - on-site system upgrades for the entire service area. The significant beneficial environmental impact of Alternative 2 includes elimination of any phosphorus load to the lakes that might now or in the future be due to failing on-site systems. Alternative 2 will help prevent further degradation of the project area lakes.

Alternative 2 has an estimated total present worth cost of $1,012,890. The MLWSD Facility Plan recommended alternative was for conventional gravity sewer installation around Island Lake and Sturgeon Lake, with treatment at the Moose Lake WWTP upgraded to meet the additional demand. This is equivalent to Project Option 7A, presented herein, which has an estimated total present worth of $4.8 million. Another alternative under discussion by the MLWSD is provision of a conventional gravity collection system for Island Lake only, with treatment at the Moose Lake WWTP upgraded to meet the demand. This is equivalent to Project Option 6A which has an estimated total present worth of $3.2 million.

Compared with alternatives that include centralized collection and treatment, Alternative 2 is expected to have fewer construction impacts because extensive construction within road right-of-ways is not required. Adverse construction impacts that might result in disturbance and erosion on individual lots can be mitigated with good construction management practices. Alternative 2 is not expected to have impacts on the groundwater that are significantly different than any other action alternative.

Evaluation of the existing data on the natural and man-made environment in the project area indicates that existing water quality impacts due to on-site systems are inconsequential in the context of other manageable and unmanageable nutrient sources, and that the recommended action will not significantly improve the quality of the lakes.

The on-site upgrades for Alternative 2 were designed on a lot-by-lot basis to correct the obvious and potential problems identified in Section 2.2.3. A summary of the total on-site systems to be upgraded and the components included is presented in Table 2-13. The appropriate on-site upgrades were determined based on soil characteristics, depth to groundwater, landscape slope, and lot size. In addition, all septic tanks would be fitted with an observation port to permit inspection.

For the entire project area a total of 58 residences would have one or more major components upgraded to correct obvious and potential problems, and an additional 228 residences spread over 415 existing lakeshore lots would receive some type of upgrade in the future (20 year design period). The number and types of upgrades are projected subject to revision after site inspection during final design.

The future management objectives for residences with on-site systems can be met in a number of ways (Section 2.6.1.3.). It is anticipated that the most cost-effective managerial system would be for the County Zoning Administrator to maintain authority over the installation and management of the on-site systems (as is presently the case) and that the MLWSD would perform the contracting, billing, administration and maintenance functions. If these on-site system management functions were delegated and accepted by the respective local units of government, Alternative 2 - on-site system upgrades for the entire project area would eliminate problems with on-site systems in the most cost effective manner, with a minimum of adverse environmental and financial impacts.

3.0. AFFECTED ENVIRONMENT

Elements of the natural and man-made environments of the planning area are described in this chapter. The contents of this chapter are based upon a compendium of new information gathered during the preparation of this Phase II Report (the EIS) and updated and corrected information from the Existing Conditions chapter of the Phase I Environmental Report (USEPA 1981). Corrections and supplements to portions of the Phase I Report were made by USEPA based on public comments on that document made at the 24 April 1981 public meeting and based on comments received from the MPCA, the MLWSD, and the CAC.

3.1. Natural Environment

3.1.1. Atmosphere

The significant elements of the atmospheric environment are: climate, air quality, and noise. A summary of the characteristics of these elements follows.

3.1.1.1. Climate

Minnesota has a continental climate. Seasonal average temperatures at Moose Lake range from the high 60s (degrees fahrenheit [°F]) in the summer to below freezing in the winter, with an annual average temperature of approximately 40 °F. Precipitation averages 28.16 inches annually and is heaviest from April through September (National Oceanic and Atmospheric Administration [NOAA] 1979a). Recorded wind data from Duluth, Minnesota, located approximately 35 miles northeast of the study area, indicate that winds predominantly blow out of the west-northwest, except in May, June, and August, when they originate from the east (NOAA 1979b).

Field investigations were conducted in the project area in 1981 during the periods of 24-27 August; 7-15 September; 28-30 September; and 1-5 October. During these sampling periods, prevailing wind directions were easterly; westerly changing to southerly and then back to northwesterly; easterly; and widely variable, respectively.

Peak daily air temperatures recorded at the Duluth International Airport over the periods of field sampling are presented in Appendix J. The strong 5-day warming trend indicated by increased peak daily temperatures between 9 September and 13 September preceeded the blue-green algae bloom observed in Island Lake on 14 September 1981 (Section 3.1.3.2.).

3.1.1.2. Air Quality

Moose Lake is located in the Duluth-Superior Interstate Air Quality Control Region (AQCR) #129. Air quality parameters for both Carlton and Pine counties are below the National Ambient Air Quality Standards (NAAQS). Concentrations of total suspended particulates (TSP), sulfur dioxide (SO_2), and ozone (O_3) in Carlton County are better than the NAAQS. Carbon monoxide (CO) levels cannot be classified, but are thought to be below the NAAQS. In Pine County, TSP, SO_2, O_3, and CO concentrations are all better than the NAAQS. The entire State of Minnesota either cannot be classified or is better than the national standard for nitrogen dioxide (By telephone, Mr. Jay Bortzer, USEPA to WAPORA, Inc., 16 January 1981).

There are no significant odor problems in the area. One minor odor problem is associated with the stabilization pond at the Moose Lake wastewater treatment plant (WWTP). The spring thaw and normal break-up of the pond produces a short-term odor problem (By telephone, Mr. Pat Mader, MPCA to WAPORA, Inc., 23 March 1981). Another odor problem is reported by homeowners with property adjacent to Island Lake associated with algal bloom accumulations along the shoreline (Section 3.1.4.1.). This problem, which results from wind blowing floating blue-green algae shoreward, is reported to occur in Island Lake periodically throughout the summer months, but primarily in August and September (Personal communication, Citizens Advisory Committee to WAPORA, Inc. October 1981).

3.1.1.3. Noise

The only major source of noise in the planning area is the heavy trucks utilizing Interstate 35, the major link between Duluth and the Twin Cities. There are no other significant noise sources located in this predominantly rural area (By telephone, Mr. Al Perez, MPCA to WAPORA, Inc., 20 February 1981).

3.1.2. Land

3.1.2.1. Geology

The Phase I Environmental Report (USEPA 1981) provided detailed discussions of topography, surficial glacial geology, and bedrock geology for the project area. An important geological consideration to wastewater management is that depth to bedrock in the project area is usually in excess of 50 feet. This means that septic leachate will not generally have access to fractured bedrock or to solution channels in bedrock and thus, the potential for well contamination is reduced.

3.1.2.2. Soils

The Phase I Environmental Report (USEPA 1981) also provided discussions of general soil associations and soil suitability for wastewater treatment in the project area. However, a detailed soil survey was not available for Pine County and the generalized data presented in the Phase I Report were insufficient for the purposes of evaluating wastewater treatment systems in terms of the soil characteristics of individual lots in Windemere Township. Therefore, a detailed soil survey of the portion of Windemere Township (Pine County) immediately surrounding Island, Sturgeon, Rush, and Passenger Lakes was conducted. The results of this survey are summarized and evaluated in Section 2.2.1.1. of this report. A copy of the original soil survey report and soil unit map is presented in Appendix B.

3.1.3. Water Resources

The Phase I Environmental Report (USEPA 1981) provided a synopsis of baseline information on the water resources of the planning area. The topics covered included hydrology, water uses, water quality and effluent discharge standards, and published water quality data on the surface water of Pine and Carlton Counties. Groundwater quality and uses were also covered.

This EIS focuses on a more limited geographic setting, covering new information gathered on the Windemere Township lakes and streams. Aspects of the new information utilized for assessing the need for improved wastewater treatment are presented in the following sections.

3.1.3.1. Surface Water Resources

The residents of Windemere Township regard the project area lakes as a most valuable recreational resource. The special attractions of Island and Sturgeon Lakes, in particular, are attested to by the concentration of the Township's recent residential growth along their shorelines (Section 3.2.1.).

The Windemere Township lakes encompassed by the proposed project area (Figure 2-4) are:

- Island Lake, 582 acres; mean depth, 11 feet
- Sturgeon Lake, 1,456 acres; mean depth, 22.5 feet
- Rush Lake, 88 acres; mean depth, 5.6 feet
- Passenger Lake, 75 acres; mean depth, 7.1 feet.

Also in the Township, but outside the project area, are Sand Lake, Lake Eleven, Lake Twelve, Dago Lake, and Big Slough Lake. Sand Lake, already sewered by the MLWSD, is 575 acres in size with an average depth of 13.9 feet. The other four outlying lakes are small (less than 100 acres) and less accessible to Interstate Highway 35 than are Sand Lake or the project area lakes. Of the four service area lakes, only Passenger Lake does not have a public access available for boat launching. The launch site on Rush Lake, while not strictly private, is not immediately accessible via County highway, and appears to be used principally by nearby property owners.

Surface Water Movement

Two small, continuously flowing lake outlet streams are found in the project area portion of Windemere Township. One is the outlet of Island Lake, which drains to the Moose River via Sand and Coffee Lakes. The other is the outlet of Passenger Lake which drains to the Moose River via the Willow River. Rush and Sturgeon Lakes are "seepage lakes" with no defined inflow streams and no continuously flowing surface outlets. Island Lake, according to the USGS topographic sheet (1979), has two unnamed, intermittent tributary streams entering on the north shore and two additional unnamed, discontinuous inlets entering its northwest basin via Little Island Lake. Information on surface water discharge from the lakes via groundwater flow is presented in Section 2.2.1.5.

Water Levels

Water level fluctuations in Island Lake have been an important local issue (Personal communication, Mr. Harold Westholm, MLWSD to WAPORA, Inc.). A few developed lots on Island Lake are reported to experience standing water due to excessive lake levels for up to one month each year. These problems are related to seasonal events such as spring runoff or summer storms which can result in 0.5- to 1.0-foot water level increases in a short period of time (MDNR records, unpublished). These flooding problems probably are aggravated by a long-term trend in increasing water levels due to climatic changes affecting all of the lakes in the project area. All of the lakes in the region reached their contemporary low levels during the draught years of the 1930s, prior to any extensive lakeshore residential development. Since that time, lake levels have increased. According to MDNR records (unpublished), the annual maximum water level in Island Lake has increased approximately 2.6 feet since 1941, and the annual maximum level in Sturgeon Lake has increased approximately 0.7 feet since 1945. The difference between these rates of increase may be attributable, in part, to differences in the soils of the watersheds of these lakes and in watershed size. The Island Lake watershed is more than two and a half times greater in size than the Sturgeon Lake watershed and also has less permeable soils, thus contributing to increased runoff under conditions of increased precipitation. In addition, a number of other factors may have combined to accelerate the increases in the annual maximum water levels in Island Lake. Recent siltation of the outlet of Island Lake may have decreased it's stormwater outflow capacity. A general siltation of clayey soil materials in the lake due to recent shoreline development may also have reduced the lake's overall groundwater outflow capacity. Also, the groundwater table level in the area has increased since the 1930's and may be contributing to higher lake levels (Personal communication, David Ford, MDNR hydrologist to WAPORA, Inc., 2 February 1982). Increases in the acreage of impervious surfaces, including roof tops, roads, parking lots, and hard packed soils in the Island Lake watershed, coupled with modern agricultural drainage practices in the area, also may have contributed to increased watershed runoff intensity during wet-weather periods. A permit to place an additional culvert at the Island Lake outlet in order to increase the stream outflow capacity has been applied for (Personal communication, Mr. Harold Westholm, MLWSD to WAPORA, Inc.). It is anticipated that an increase in lake outflow capacity will reduce the duration of flooding problems.

3.1.3.2. Water Quality of the Project Area Lakes

Representatives of the MLWSD have seen the water quality problems of Island Lake as a primary impetus for facility planning in Windemere Township. The plan to provide sewage collection and treatment around Island Lake as a means of improving water quality and providing a convenience for residential users has been discussed frequently at public meetings, reported on in local newspapers, and cited in formal communications (Section 1.1.). Although the MLWSD Facility Plan also proposes the sewering of most of the Sturgeon Lake shoreline, reference is not made to the water quality improvements that could result from sewering Sturgeon Lake. Sturgeon Lake is not cited in the Facility Plan as having severe algal blooms or poor water clarity. Rush and Passenger Lakes, likewise, have not been described as degraded. The proximity of Island Lake to the existing sewage collection network and the local perception that failing on-site systems are largely responsible for it's blue-green algae blooms and poor water clarity reinforce the emphasis on serving Island Lake with sewers.

One objective of this EIS is to provide an up-to-date and quantitative framework in which to portray the water quality of all four service area lakes. Future residential growth has been projected on platted lots around all four lakes (Section 3.2.1.) and thus, protection of the quality of Sturgeon, Rush, and Passenger Lakes is as important to consider as improving the quality of Island Lake.

Water quality parameters measured in the lake waters during 1981 and 1982 field studies included:

- Dissolved oxygen concentrations and temperature with depth to describe lake stratification.
- Chlorophyll a concentration as an indication of overall phytoplankton productivity.
- Secchi disk depth and phytoplankton biovolume as measures of water clarity and blue-green algae abundance.
- Phosphorus concentration as an indication of lake fertility.

Sampling Stations and Schedule

The sampling stations visited and the sampling program and schedule carried out in the late summer and fall of 1981 also are described in Appendix J. Supplemental sampling took place in February 1982 which included the collection of lake water phosphorus samples and surficial lakebed sediment samples. The complete field survey program and schedule is summarized in Appendix J. Little Island Lake, a sub-basin of Island Lake, was included in the February 1982 sampling for comparative purposes because the land use in its watershed does not include shoreline residential development.

Field Conditions During Sampling

The sampling dates included both warm and cold weather conditions. A blue-green algae bloom, which produced floating accumulations of algae over the surface of Island Lake and algal "mats" on its downwind shores, was observed during the mid-September sampling period. Weather antecedant to the mid-September sampling was unseasonably warm and sunny (Appendix J), which resulted in elevated lake temperatures. Weather during subsequent sampling was in transition to cooler fall weather. Significant heat loss from the lakes and complete water column mixing had taken place by the 30 September 1981 sampling.

Results of the Surface Water Sampling

Historic dissolved oxygen and temperature profile data were obtained from the MDNR to supplement the 1981/1982 data. Summary tables and figures for contemporary and historic data are discussed below.

Of the four lakes sampled, Island Lake had the highest average chlorophyll a concentrations on both 9 and 15 September, (Table 3-1.) (Island Lake chlorophyll a was lowest in the samples taken just above the sediment surface and significantly higher at the mid-depth and surface levels [Appendix B].) Average chlorophyll a concentrations in Sturgeon Lake were roughly one-third of the average Island Lake concentration on both September sampling dates. Rush Lake's average chlorophyll a concentration was comparable to Sturgeon Lake's concentration, while chlorophyll a levels in Passenger Lake were higher due to a bloom of non-blue-green phytoplankton.

Phytoplankton biovolume calculations were made based on plankton cell size measuresment and counts for water samples taken from all three depth levels. These data describe the overall productivity and give insight into phytoplankton ecology in late summer. The methodology and results of the phytoplankton analyses were explained in the Report on Algae (Appendix B). In order to quantify trophic status and relate phytoplankton growth to water clarity, graphical presentations of average Secchi disk depth and average phytoplankton biovolume in the surface samples were made (Figures

Table 3-1. Average chlorophyll a concentrations for Island, Sturgeon, Rush and Passenger Lakes. Mathematical averages of analytical results from surface, mid-depth, and off-bottom samples at 6, 4, 1, and 1, stations respectively.

Lake	No of Stations	10 September 1981	15 September 1981
Island	6	27 ug/liter	26 ug/liter
Sturgeon	4	09 ug/liter	09 ug/liter
Rush	1	11 ug/liter	11 ug/liter
Passenger	1	15 ug/liter	23 ug/liter

3-1 and 3-2). In these figures biovolume was plotted inversely, on the y-axis, to more conveniently show the cause-and-effect relationship of plankton abundance (as biovolume) to water clarity (as Secchi disk depth). Comparison of these two parameters indicates a continuing direct relationship over the sampling period between plankton abundance and water clarity for Island, Sturgeon, and Rush Lakes. The anomalously poor water clarity of Passenger Lake, with respect to the relatively low phytoplankton biovolume observed, is attributable to non-living organic matter present in the surface waters, probably originating from the marshlands surrounding the lake.

Although chlorophyll a data were not taken on all 1981 sampling dates, the general levels of chlorophyll and all other parameters interrelate in a logical fashion for one simultaneous sampling of the lakes (excepting the anomalous Passenger Lake). The relationship of water clarity and biovolume of phytoplankton (especially of blue-green algae) with chlorophyll a is illustrated by the data from the sampling period of 14 and 15 September 1981 (Table 3-2). On these dates, a severe blue-green algae bloom was in progress in Island Lake. Blue-green algae also were found to dominate the phtoplankton populations in Sturgeon and Rush Lakes on these dates, but not to "bloom" proportions. Passenger Lake had only a small portion of its phytoplankton population made up of blue-green algae (Table 3-2).

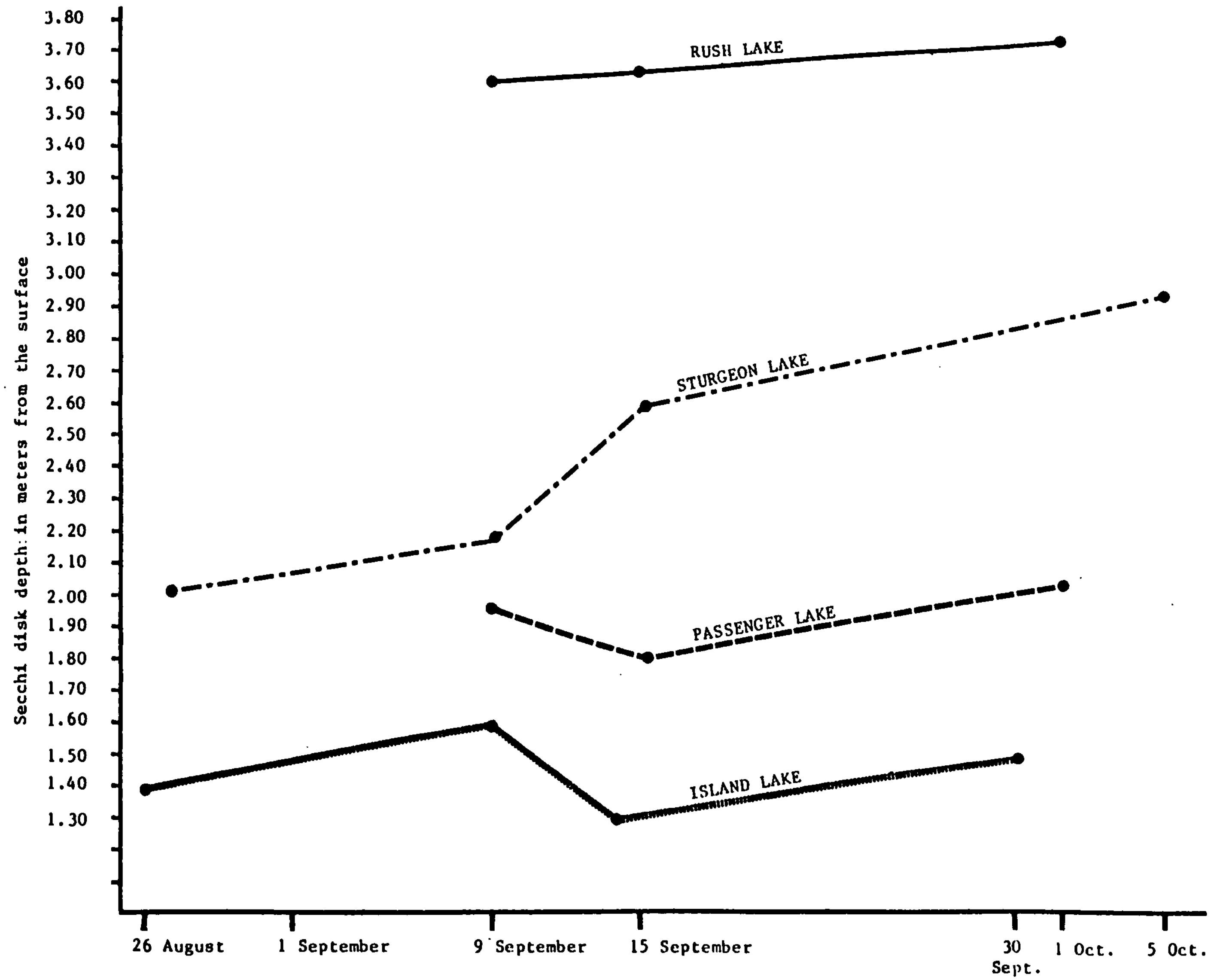


Figure 3-1. Average Secchi disk values with time. Data are from 1981 field surveys of Island, Sturgeon, Rush, and Passenger Lakes, Pine County, MN.

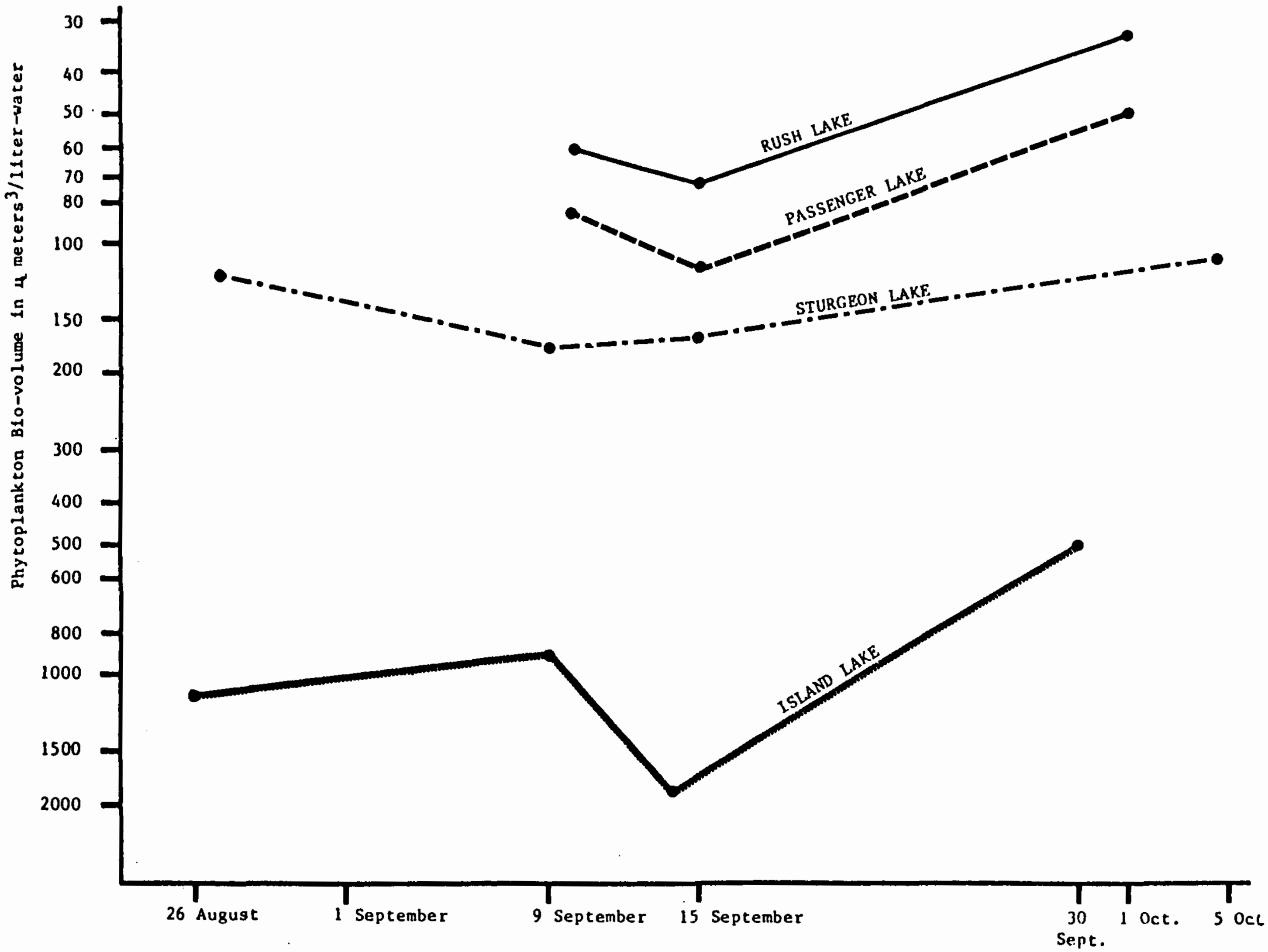


Figure 3-2. Average phytoplankton biovolume values with time. Data are from 1981 field surveys of Island, Sturgeon, Rush, and Passenger Lakes, Pine County, MN. Plotted values are numerical averages of surface samples only and are plotted inversely to correlate with Secchi disk values.

Table 3-2. Average Secchi disk, surface chlorophyll a, and surface biovolume values on Island, Sturgeon, and Rush Lakes 14-15 September 1981.

Parameter	Lake: Island	Sturgeon	Rush
Secchi disk depth in meters	1.29 (lowest)	2.58 (intermediate)	3.63 (highest)
Phytoplankton bio volume at the surface,[a] in um^3/l water	1851 (highest)	163 (intermediate)	71 (lowest)
Chlorophyll a at the surface in ugl/1	25 (highest)	9 (intermediate)	5 (lowest)

[a]All three lakes cited had blue-green algae comprising in excess of 70% of the biovolume estimated in the surface samples; Passenger Lake, not represented in the table, had less than 25% of the phytoplankton counted as blue-green in the surface samples.

Based on the data presented in Table 3-2, it was concluded that blue-green dominance at the lake surface had an effect on water clarity proportional to both total phytoplankton biovolume and chlorophyll a concentration of the surface in Island, Sturgeon, and Rush Lakes. Island Lake had the lowest water clarity and the most severe blue-green algae bloom problems. Sturgeon and Rush Lakes had less blue-green algae at the surface and much better water clarity (Table 3-2). The relatively low clarity found on 15 September in Passenger Lake (1.80 meters, Secchi disk; 112 um^3/liter biovolume at the surface; 5 ug/l chlorophyll a at the surface) was not due to blue-green algae abundance. The dominant species found in Passenger Lake were golden brown and green algae (Appendix H).

Stratification and destratification of the lakes are of interest because the stability of the water column may affect the amount of phosphorus which may be mobilized from lake sediments and low-lying waters to induce blue-green algal bloom problems. Thermal and chemical lake stratifications are quantified, respectively, by gradations in temperature and dissolved oxygen concentration with depth in the lake. A temperature and oxygen concentration plot can be used to locate the depth range over which the gradations are greatest. In instances where the epilimnion (surface layer) of a lake is considerably warmer and more oxygen rich than the underlying hypolimnion, the zone of most rapid gradation is termed "thermocline" for temperature and "chemocline" for oxygen gradation. The depth ranges for these zones of rapid gradation in the project area lakes are well defined in some of the profiles presented in Appendix J.

Just as the productivity and clarity of each of the project area lakes are unique (Table 3-2), the dissolved oxygen/temperature profile characteristics are highly individual (Appendix J). The forces which most strongly shape the summer dissolved oxygen and temperature profiles are lake shape and volume, rate of solar energy influx, and the degree of wind mixing (circulation). Ragotzkie (1978) has developed an empirical formula which expresses the effect of wind mixing on thermocline depth as a function of lake "wind fetch" (the distance over the lake on which the wind blows in an uninterrupted path). This predictive equation states that: in temperate climates, the average depth of the summer thermocline (in meters) is estimated by four times the square root of the wind fetch (in kilometers) for lakes with a fetch between 1 and 20 kilometers. Using this formula for the project area lakes, where applicable, the average summer thermocline depths were estimated. These estimates were compared with the observed thermocline depth ranges (Table 3-3). Observed thermocline depth ranges were estimated based on the profiles in Appendix J. The thermocline depth prediction for Island Lake's greatest fetch is generally in good agreement with the observed thermocline ranges and especially good for the 14 September 1981 sampling date when the gradations of temperature and oxygen were strong. The estimated thermocline depth for Sturgeon Lake (25 feet maximum) does not compare well with the profiles.

The reason that no thermocline has been observed in Sturgeon Lake profiles (Appendix J) may stem from the fact that little protective topographic relief exists on the south and west shores, increasing the potential for wind mixing, and from the strong role of groundwater in the flow

Table 3-3. A comparison of predicted and observed depth of the thermoclines in Island and Sturgeon Lakes, Pine County MN. Predicted depth of thermocline based on the equation of Ragotzkie (1978).

Lake	Greatest Fetch	Predicted Thermocline	Least Fetch	Predicted Thermocline	Observed Thermoclines
Island	1.50 mi.	20 ft.	0.30 mi	NA	(Aug. 1967) 20'-25' (Aug. 1979) 15'-20' (Aug. 1979) 15'-20' (Sept. 1981) 19'-20'
Sturgeon	2.28 mi.	25 ft.	1.00 mi.	17 ft.	No thermocline observed. Complete mixing is assumed.

NA: Calculation not appropriate for fetch less than 1 Km (0.62 miles).

regime of the lake. Sturgeon Lake is principally a "seepage lake" and significant groundwater influx may be occurring in spring and early summer which could prevent the formation of a strong thermocline. The tendency of Sturgeon Lake to remain homeothermal is illustrated by the profiles made from the 4 August 1955 sampling of Sturgeon Lake (MDNR, unpublished) when the warmest surface water temperatures ever recorded did not result in a thermal stratification (Appendix J.).

Based on the information presented above, the potential for phosphorus cycling from the hypolimnions of the project area lakes may be evaluated as follows:

- Island Lake is classed as "polymictic", meaning that it mixes more than twice each year. It has an elongate shape and, depending on prevailing wind direction, the depth of the summer thermocline may be less than that associated with the greatest fetch. Thus, periodic thermal stratification and/or development of an anoxic hypolimnion is followed by partial mixing of the understrata with surface waters. This reasoning is supported by the progressive phases of Island Lake's stratification and destratification observed to be associated with weather changes in September 1981 (Appendix J).

- Sturgeon Lake appears to remain thermally unstratified throughout most of the summer (Appendix J.). Although observations are limited to five warm season profiles, the existing data indicate that Sturgeon Lake is also "polymictic" and that oxygen is generally greater than 1.0 mg/l throughout the water column.

- Rush and Passenger Lakes are probably both "dimictic", meaning that circulation is complete only in spring and fall when water temperatures are low. Oxygen was deficient in the hypolimnions of both lakes during September 1981.

For each lake, important phosphorus cycling inferences may be made from the lake mixing classifications (above) and from chemical stratification profiles. Phosphorus availability to phytoplankton of the project area lakes is influenced by many physiochemical factors, but can be generally represented as follows. This bioavailability of sedimentary phosphorus is advanced by conditions which result from very low levels of dissolved oxygen and retarded under the chemical environment provided by more oxic conditions. A periodic re-circulation of low lying (hypolimnetic) waters that have become anoxic may cycle biologically available phosphorus to the productive upper water layers and thus can aggravate the symptoms of eutrophication.

Based on the analysis made in this EIS, the blue-green algae bloom problems observed in Island Lake each summer appear to be aggravated by phosphorus being periodically cycled to the epilimnion from the sediments and hypolimnetic waters.

Sturgeon Lake's hypolimnion appears to be a phosphorus "sink" throughout most of the summer. Only on one occasion out of five warm season field surveys was low dissolved oxygen found in Sturgeon Lake (4 August 1955) and on that sampling date very low oxygen was found only below 35 feet of depth. It can be concluded that the waters of Sturgeon Lake probably remain generally well oxygenated throughout most summers if it is assumed that, as observed, water circulation usually extends to the 35-foot depth level.

Although the water quality data base for Rush and Passenger Lakes is limited, the existing information suggests that their hypolimnions are generally summer phosphorus sinks which preclude phosphorus cycling to surface (epilimnetic) waters.

Supplemental Total Phosphorus Sampling and Sedimentary Studies

An additional sampling visit was made to Island and Sturgeon Lakes during the period of 3-5 February 1982 to determine the levels of total phosphorus (P_t) in the water column and to measure the chemical characteristics of surficial lake-bed sediments. The objective of gathering the supplemental data was to improve the analysis of needs documentation by determining if there were high levels of phosphorus enrichment attributable to on-site system failures.

Island and Sturgeon Lakes and Little Island Lake were studied. Little Island Lake has a large watershed area relative to its surface area and the surface water outflow from it is via road bed culvert which discharges directly to Island Lake. There is only one dwelling unit in the Little Island Lake watershed and no shoreline development (Figure 3-3). No blue-green algal bloom problems have been documented in Little Island Lake.

It was thought that if, as presented by the MLWSD (Section 2.3.1.2.), a disproportionately large number of septic system surface failures existed on the shoreline lots of Island Lake, a conservative parameter such as phosphorus may reflect this in the water column or in near-shore lake sediments. Little Island Lake was studied for comparative purposes because it should be influenced only by non-wastewater phosphorus inputs from its watershed. The sampling stations visited for water column and sediment grab sampling in these supplemental studies are presented in Figure 3-3. The 15- and 25-foot depth contours are included in Figure 3-3 to illustrate that the majority of the surficial sediment grab samples taken were above or slightly below the 15-foot depth contour.

Over the long term, the processes of sediment delivery, settling, and resuspension are expected to "focus" light organic materials and clay particles into the deeper (profundal) zones of these lakes, resulting in

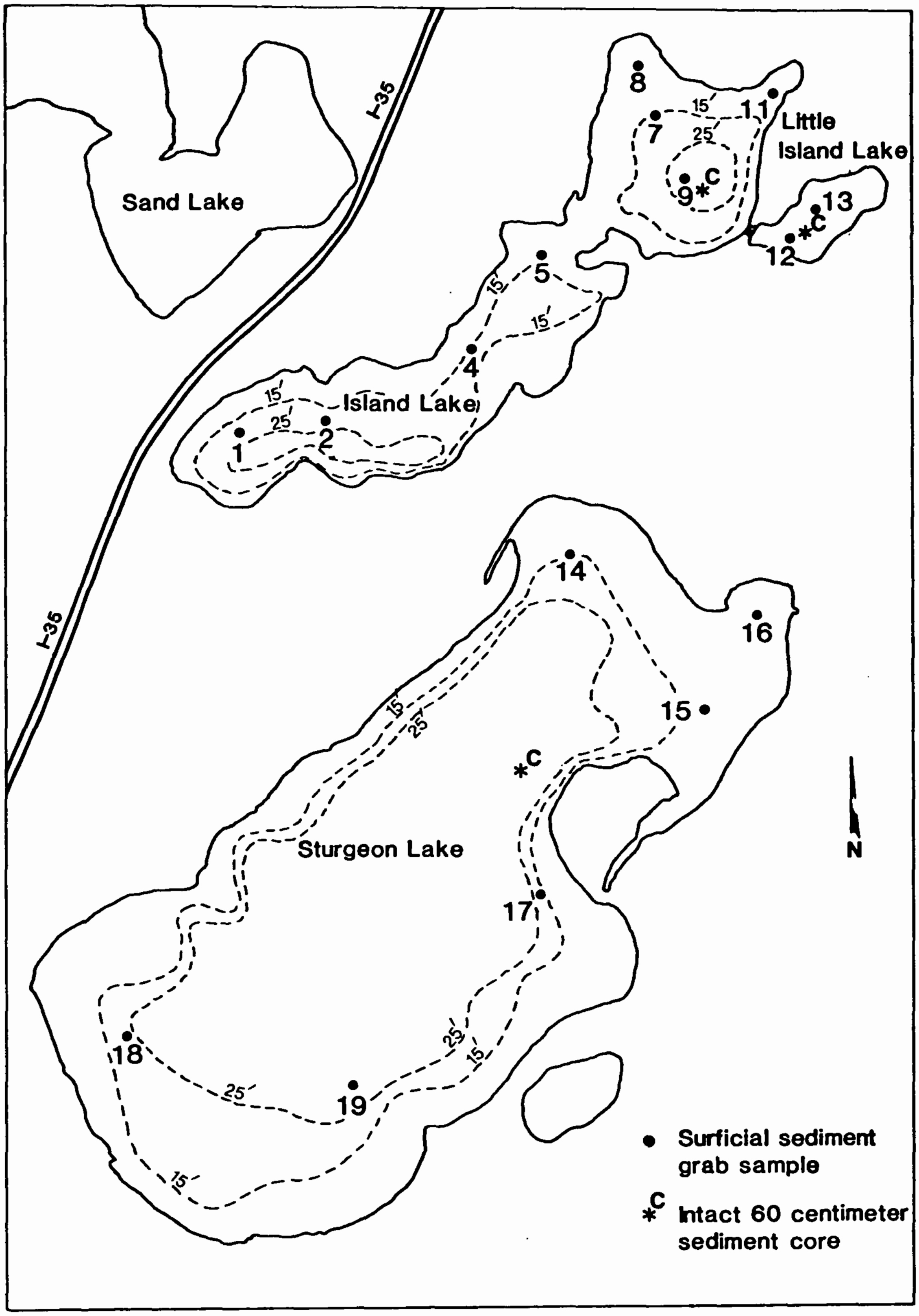


Figure 3-3. Stations established for sampling of water column total phosphorus, surficial sediment characteristics, and intact sediment cores. All samples taken in February and March of 1982.

continued sediment deposition in areas of more than 25-foot depth. These processes scour unvegetated littoral sediments so that surficially deposited silt within the 10- to 20-foot depth contours would be expected to be most strongly reflective of any ongoing pollution from nearby land uses. Little Island Lake is largely a littoral environment where sediment "focusing" into the profundal zone is not as significant. Sturgeon Lake has an extensive profundal zone and Island Lake is intermediate in the proportion of the bottom area defined as profundal. Sediment focusing processes are more significant in Island and Sturgeon Lakes.

The water column samples, also taken on 3 and 5 February 1982, were tested for P_t concentrations only. The P_t water samples were taken at stations 2 and 9 in Island Lake, stations 12 and 13 in Little Island Lake, and stations 14 and 18 in Sturgeon Lake (Figure 3-3). Only a large scale failure rate of on-site wastewater treatment systems around Island Lake or Sturgeon Lake would be reflected in these water column P_t concentrations because dispersion rates of nearshore waters would probably be low under ice cover conditions. At the time of sampling, more than 56 inches of snow cover was reported to be on the ground, ice cover on the lakes exceeded 24 inches, and water clarity in all three lakes appeared to be high. Complete oxygen depletion was not observed in the lakes (Table 3-5). In both Island and Sturgeon Lakes, water was sampled both below the ice and just above the bottom. The resultant water column P_t values are presented in Table 3-4. The laboratory detection limit for the reported P_t values is 0.01 mg/liter.

A special phosphorus form, non-apatitic or inorganic phosphorus, which is "biologically available" was tested in the sediment samples by the method of Williams and others (1976). This phosphorus form was tested because it best reflects the presence of phosphorus which originates from human waste and fertilizer sources. The non-apatitic phosphorus testing method was identical to the method utilized in the intact sediment core analyses as described in Section 2.1.3.4. (a study of the trophic history of Island and Sturgeon Lakes).

Table 3-4. Total phosphorus concentrations in the waters of Island, Little Island, and Sturgeon Lakes, 3-5 February 1982 (USEPA Method 365.3).

Lake	Station Number	P_t (mg/liter)	Water Column Average P_t (mg/liter)
Island	09; surface	0.01	0.04
Island	09; bottom	0.07	
Island	02; surface	0.05[a]	0.04
Island	02; bottom	0.03[a]	
Little Island	12; surface	0.02	0.03
Little Island	13; bottom	0.03	
Sturgeon	14; surface	0.03	0.02
Sturgeon	14; bottom	0.01	
Sturgeon	18; surface	0.03	0.02
Sturgeon	18; bottom	0.01	

[a]Value is an average of two replicates.

Conclusions Based on the Supplemental Studies

No significant differences appear to exist in the average water column P_t values between the three lakes. Little Island Lake, which has no on-site systems located on its shoreline, had an average P_t concentration similar to Island Lake (Table 3-4). Plankton growth under the ice is not likely to have made a large contribution to the reported P_t concentrations owing to the reduced light penetration caused by the heavy snow and ice cover. The positive difference in average water column [P_t] between Island Lake and Sturgeon Lake (0.02 mg/l) probably can be attributed to additional abiotic phosphorus sources of phosphorus and to a slightly higher productivity in Island Lake. Nonetheless, this differential in the amount of phosphorus is small considering that Island Lake has a smaller volume of water and far more permanent residences around its shoreline than does Sturgeon Lake (Section 2.2.1.3).

Results of the analyses of sediment samples are presented in Table 3-5. The number of lake sediment samples tested are insufficient for estimation of lake-wide sediment characteristic averages, primarily because there are two few profundal zone samples. The limited observations made based on the sediment sampling data are:

- Wide textural variations were found in the samples within each lake, but the shallow samples, taken where sediment scouring was probably greatest, were classified into categories similar to soil textural classifications on the adjacent shoreline (Section 2.2.1.1.). Sample #7 from Island Lake was classified as sandy loam - near clay loam, reflecting the adjacent natural sandy soils on the upland area of the northwest shore of Island Lake (Appendix B).

- The concentration of non-apatitic phosphorus measured in The Little Island Lake sediment sample, station #13 (11 feet deep), exceeded that of all other stations. This reflects the potential significance of non-wastewater nutrient sources to Little Island Lake and to Island Lake.

- The second highest concentration of non-apatitic phosphorus was found in Sturgeon Lake, station #15 (10 feet deep) located offshore from a steep, terraced slope previously in use as a pasture for dairy cattle.

3.1.3.3. Nutrient Inputs and Lake Trophic Status

The major water quality concern for the four service area lakes is eutrophication. The luxuriant plant growth associated with advanced eutrophication is generally caused by an excessive input of nutrients to a lake. The importance of phosphorus as the primary nutrient stimulating plant growth in lakes is widely accepted in the scientific community (Smith and Shapiro 1981a, Vollenweider 1979, and Dillon and Rigler 1975). By controlling phosphorus inputs, excessive algal growth can be halted or slowed if the morphometry and flushing rate of a lake are favorable. Although the degree to which algal growth will respond to phosphorus inputs has been controversial (Lorenzen 1981, Rast and Lee 1981, Smith and Shapiro 1981b), work published by Vollenweider (1979), Schindler (1977), and others suggest that the appropriate phosphorus load reductions will definitely result in less eutrophic conditions in certain types of lakes. The pathways and magnitudes of phosphorus inputs into the project area lakes and the po-

Table 3-5. Analyses of surficial lake sediment grab samples. All sampling done 3 through 5 February 1982.

Sample No.	mg/l Dissolved Oxygen at Bottom	Depth	Lake	pH	Mg. NAI-P/kg (dry wt)[1]	Volatile Solids (% Organics)[2]	% Clay	% Silt	% Sand	Textural Classification[3]
1.	5.8 mg/l	24 ft	Island	5.7	44.1	19.0	24.0	51.0	25.0	Silt loam-near clay loam
2.	6.0	24 ft	Island	6.0	54.9	19.2	38.8	60.8	l	Silty clay loam
4.	6.8	20 ft	Island	5.8	18.8	22.2	15.0	45.0	40.0	Loam
5.	4.8	16 ft	Island	5.7	13.6	20.0	22.1	31.0	46.9	Loam
7.	4.0	10 ft	Island	5.8	18.2	34.7	8.0	43.9	48.1	Sandy loam-near loam
[a]8.	10.2	6 ft	Island	5.8	45.4	35.7	28.9	32.3	38.8	Clay loam-near loam
9.	1.8	28 ft	Island	5.8	14.8	23.9	ND	ND	ND	
11.	5.6	7 ft	Island	5.6	21.1	11.8	5.8	55.0	39.2	Silt loam
12.	2.8	3 ft	Little Island	5.7	76.4	38.1	ND	ND	ND	
13.	0.9	11 ft	Little Island	5.8	230.0	32.8	ND	ND	ND	
14.	12.8	14 ft	Sturgeon	5.8	55.1	17.7	14.5	68.7	16.8	Silt loam
[b]15.	-	10 ft	Sturgeon	5.8	103.0	25.4	40.5	48.1	11.4	Silty clay
16.	1.6	5 ft	Sturgeon	5.8	32.5	26.0	18.0	35.5	46.5	Loam
17.	3.0	15 ft	Sturgeon	6.0	22.3	10.0	7.4	20.4	72.7	Sandy loam
18.	9.0	14 ft	Sturgeon	6.1	25.5	11.1	5.8	2.4	91.8	Sand
19.	5.6	28 ft	Sturgeon	5.9	65.4	24.9	23.9	76.1	l	Silt loam

1 Non-apatite phosphorus on a dry weight basis.

2 Volatile solids calculated by subtracting percent ash (dry weight basis) from 100; the result is intended to portray the organic fraction.

3 Classifications based on textural triangle (USDA 1962)

[a] Station just offshore from domestic goose farm.

[b] Station just offshore from dairy farm/ manure pile.

ND - No data due to insufficient sample size for distribution testing.

tential for successful management of the trophic status of these lakes are discussed in the following two sections.

Estimation of Phosphorus Loads

One of the water quality benefits typically associated with improved wastewater treatment systems is the elimination of a source of phosphorus. In assessing the need for new wastewater management systems, USEPA requires that the projected improvements in lake water quality which would be attributable to the proposed systems be documented explicitly. It is therefore important to look at all sources of phosphorus that may be affecting the service area lakes and to estimate the significance of the phosphorus resulting from existing on-site treatment systems in relation to the other phosphorus sources. It is possible that the removal of a single phosphorus source (e.g., septic tank effluent) would not appreciably change the water quality of these lakes and that the control of multiple sources would be needed to reduce eutrophy. Other sources which may be controlled include lawn fertilizers, construction erosion, cropland erosion, and livestock waste. Some phosphorus sources such as dustfall, forest land runoff, and oldfield runoff are unmanageable.

Phosphorus may enter a lake by a number of quantifiable pathways including municipal treatment plant effluent, atmospheric fallout, overland runoff, groundwater, resuspension from the lake sediments, or septic tank leachate. The most precise method for estimating such phosphorus inputs would be to directly measure the contributions of each source in a watershed. A comprehensive data base of direct measurements would be too costly for most lakes and was not developed for the service area lakes. Instead, a phosphorus loading was calculated using a compendium of published literature values for annual contributions from nonpoint runoff sources, from precipitation (USEPA 1980), and from a "worst case" estimate of the phosphorus load from on-site waste system leachate.

Numerous methods have been reported by researchers (Dillon and Rigler 1975, Dillon and Kirchner 1975, Omernik 1977, and USEPA 1980) for estimating the theoretical nutrient export rates from watersheds. For the project area lakes, export coefficients from a recently published literature review (USEPA 1980) were used to calculate annual phosphorus inputs. Representative phosphorus export coefficients were selected from the referenced study based on the regional location, land use, soil type, and rainfall. The phosphorus export coefficients selected for the service area and the land use acreages within the watersheds of the four project area lakes are listed in Table 3-6. The land use classifications were determined by inspecting aerial photographs and ISPA landsat photographs, from personal communications with a soil scientist who surveyed the area, and by field checks by project personnel. The number of hectares associated with each land use was measured by planimeter after the land uses had been plotted on a base map.

The phosphorus loading associated with on-site waste treatment systems was calculated with an occupancy rate of 2.8 persons per dwelling (US Census Bureau 1980), the number of seasonal or permanent residences, and the assumption that the per capita phosphorus contribution was 0.8 kg/yr, with the soil absorption system retaining 25% of the phosphorus (USEPA 1980). Additionally, it was assumed that permanent residents have on-site systems that fail continuously and that seasonal residents have systems that fail throughout the summer. Based on the information presented in Section 2.2.3., this assumption results in a serious over-estimate of the pollutional significance of on-site systems. The resultant phosphorus load estimate attributed to on-site systems is also very high because soil absorption systems usually attenuate much more than 25% of the phosphorus in septic tank effluent (Section 2.2.2.4). The estimated annual phosphorus load of each source was determined for nine separate source categories within the watershed of each lake. The individual source load estimates were then aggregated into three categories according to manageability potential for phosphorus control (Table 3-7).

Based on the estimated nutrient loading regime (Table 3-7), it was concluded that the annual phosphorus load to Island and Sturgeon Lakes is dominated by manageable sources of phosphorus which include combined inputs from agriculture, lawns, livestock, and on-site systems. These two lakes both have relatively small direct drainage areas, but the agricultural

Table 3-6. Phosphorus export coefficients (USEPA 1980) and land use in hectares within the watersheds of the project area lakes.

Land Use	Land Runoff Phosphorus Export Coefficients (kg/ha/yr)	Land Use Within Watershed (ha)			
		Island	Sturgeon	Rush	Passenger
Forest	0.28	32	214	175	84
Wetlands	0.157	24	34	40	5
Indirect Drainage	0.08	1,189	88	0	0
Cultivated Land	14.0	16	77	0	0
Pasture	3.8,[a] 0.64[b]	156	106	0	0
Lawns	2.7	51	36	0	5
TOTAL		1,468	555	222	94

Additional phosphorus coefficients:

Atmosphere	0.31 kg/ha/yr (applied to lake surface area only)
Livestock	0.031 kg/day/1,000 lbs
Poultry	0.28 kg/day/100 lbs
Septic tanks	0.8 kg/cap/yr

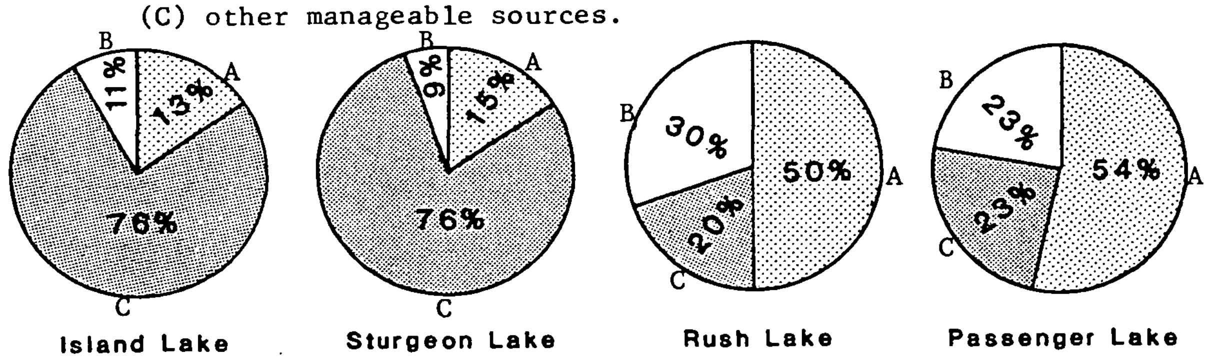
[a] Export coefficient used for Island Lake. Predominantly clay soils results in high overland runoff.

[b] Export coefficient used for Sturgeon Lake. Sandy soils results in relatively low overland runoff.

Table 3-7. Estimated phosphorus loading to the project area lakes, in kilograms per year. Pie diagrams below represent the percent contribution from the three aggregate categories: uncontrollable sources, on-site systems, and other manageable sources

	Phosphorus Source	Estimated Phosphorus Loading (kg/yr) Island Lake	Sturgeon Lake	Rush Lake	Passenger Lake
A	Atmosphere	65	213	10	8
A	Wetlands & forests	13	65	55	25
A	Indirect tributary drainage	95	6	0	0
B	On-site waste treatment systems	141	179	39	14
C	Agricultural runoff	817	1146	27	0
C	Lawn runoff	138	97	0	14
C	Livestock or poultry	46	228	0	0
	Total annual phosphorus load	1315	1934	131	61
	Areal phosphorus loading rate in grams per square meter of lake surface per year	0.62	0.28	0.21	0.09

Figure 3-4. Percentage contribution to the phosphorus load by aggregate category: (A) uncontrollable sources, (B) on-site systems, and (C) other manageable sources.



lands (pasture, grass, and crops) and homes with lawns within the direct drainage areas are located either on high ground just away from the lakes or immediately adjacent to them on clayey soils with generally steep slopes. As a result, manageable phosphorus sources contribute at least 76% of the phosphorus load to both Island Lake and Sturgeon Lake (Figure 3-4). The worst-case estimated on-site system phosphorus load comprises about 11% and 9% respectively of the total annual load to Island Lake and Sturgeon Lakes (Figure 3-4).

Although Sturgeon Lake was estimated to have a greater mass of phosphorus entering it than Island Lake, it has a lower areal phosphorus loading rate (grams per meter^2 per year) than Island Lake because of its greater surface area. Lake size and other parameters of comparative interest for the service area lakes are presented in Table 3-8. Rush and Passenger Lakes receive smaller areal phosphorus loads than do Island or Sturgeon Lakes (Table 3-4). Rush and Passenger Lakes both have relatively small areal loading rates because their watersheds are dominated by wetlands and forest cover with little agricultural or residential land use. Although with 'worst-case' estimates the phosphorus loads to Rush and Passenger Lakes from on-site systems were estimated to contribute a high percentage of the total phosphorus input compared to Island or Sturgeon Lakes, the total estimated phosphorus mass presently entering Rush and Passenger Lakes is actually very small.

Modeling of Trophic Status

A classification of the trophic status of the four project area lakes was made based on the estimated total annual phosphorus loading and on an empirical model developed by Dillon (1975). This model predicts in-lake concentrations of phosphorus and classifies the trophic status of a lake by relating mean depth to a mathematical equation that includes the estimated total annual phosphorus loading, a phosphorus retention coefficient, and the estimated hydraulic flushing rate. The calculated trophic condition or "classification" of the four lakes based on the Dillon model, using the

Table 3-8. Lake parameters of comparative interest.

	Lakes in the Service Area			
Parameter	Island	Sturgeon	Rush	Passenger
Lake surface area (ha)	211.0	686.0	35.6	30.4
Mean depth (meters)	3.4	5.9	1.7	2.2
Lake volume ($m^3 \times 10^4$)	717.0	4,066.0	60.5	66.9
Q_3 Hydraulic budget ($m^3/yr \times 10^5$)[a]	26.0	8.4	4.0	2.0
Hydraulic detention time (yrs)[b]	3.1	49.0	1.5	3.3
Length of shoreline (km)	10.1	12.9	2.4	2.3

[a]Calculation based on rainfall and runoff estimates (USEPA 1980).

[b]Calculation of time required to displace all water in a lake based on the hydraulic budget and on lake volume.

estimated annual phosphorus loads (Table 3-7), is presented in Figure 3-5. The initial calculation classified both Island Lake and Sturgeon Lakes as eutrophic. Rush Lake was classified as being on the borderline between eutrophic and mesotrophic, and Passenger Lake was classified as being mesotrophic. When the model calculations were redone without the "worst case" phosphorus input assumed to be associated with on-site systems in the first calculation, the trophic status classifications of Island and Sturgeon Lakes did not change significantly. However, Rush Lake changed toward improved trophic status, moving into the mesotrophic class. Passenger Lake moved into the oligotrophic class (Figure 3-5).

When trophic status data for the lakes (Section 3.1.3.2.) and the estimated annual phosphorus loads (Table 3-7) were applied to an arbitrary scale (after Uttormark and Wall 1979) that indicates the potential need for phosphorus management (Figure 3-6), Island and Sturgeon Lakes appeared to need other extensive phosphorus load reductions in addition to the control of on-site waste treatment systems in order to curtail eutrophication. On the same scale, Rush and Passenger Lakes did not appear to need extensive phosphorus management measures to protect water quality. It must be noted that the existing water quality of Sturgeon, Rush, and Passenger Lakes appears to be satisfactory based on water quality data collected for this project (Section 2.2.2.4.). Conversely, Island Lake was shown to have serious water quality problems associated with nutrient enrichment. Blue-green algae blooms in Island Lake, were documented as being associated with its existing eutrophic condition and reflected the availability of luxuriant amounts of phosphorus. This documentation is discussed in detail in Section 3.1.3.2.

Conclusions Based on Phosphorus Loading Estimates and on Trophic Status Modeling

On-site waste treatment systems must be considered a relatively minor source of phosphorus to both Island Lake and Sturgeon Lake. The prospective benefits of curtailing on-site system phosphorus loads appear small in light of this. Additionally, a paradoxical situation could result from curtailing just on-site system phosphorus loads to Island and Sturgeon Lakes because on-site waste management systems are estimated to contribute a relatively minor fraction of the combined load from all manageable sources (Figure 3-4). Important sources of phosphorus in the direct drainages of Island and Sturgeon Lakes also include lawn runoff and generalized erosion from cleared land (Table 3-7). The paradox would exist should a waste management alternative such as sewer service be implemented and promote enough new residential growth around the lakes to substantially increase the runoff of nutrients from the land. The resultant load of phosphorus from this runoff could conceivably equal or exceed the phosphorus load originating from failing septic systems prior to the construction of sewers.

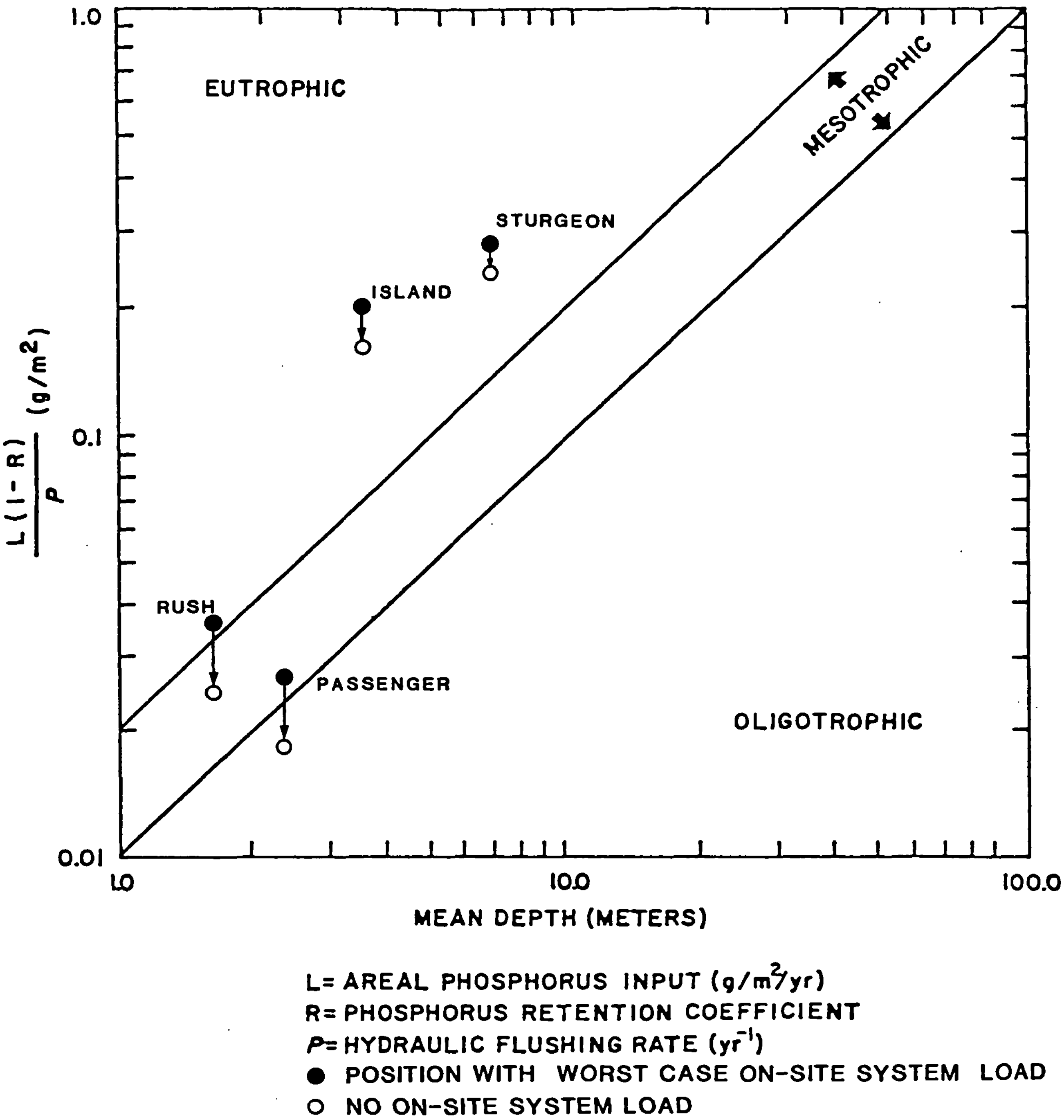


Figure 3-5. Graphical representation of the modeling of trophic status, with and without the "worst case" phosphorus load assumed for on-site waste management systems. Derived from Dillon (1975).

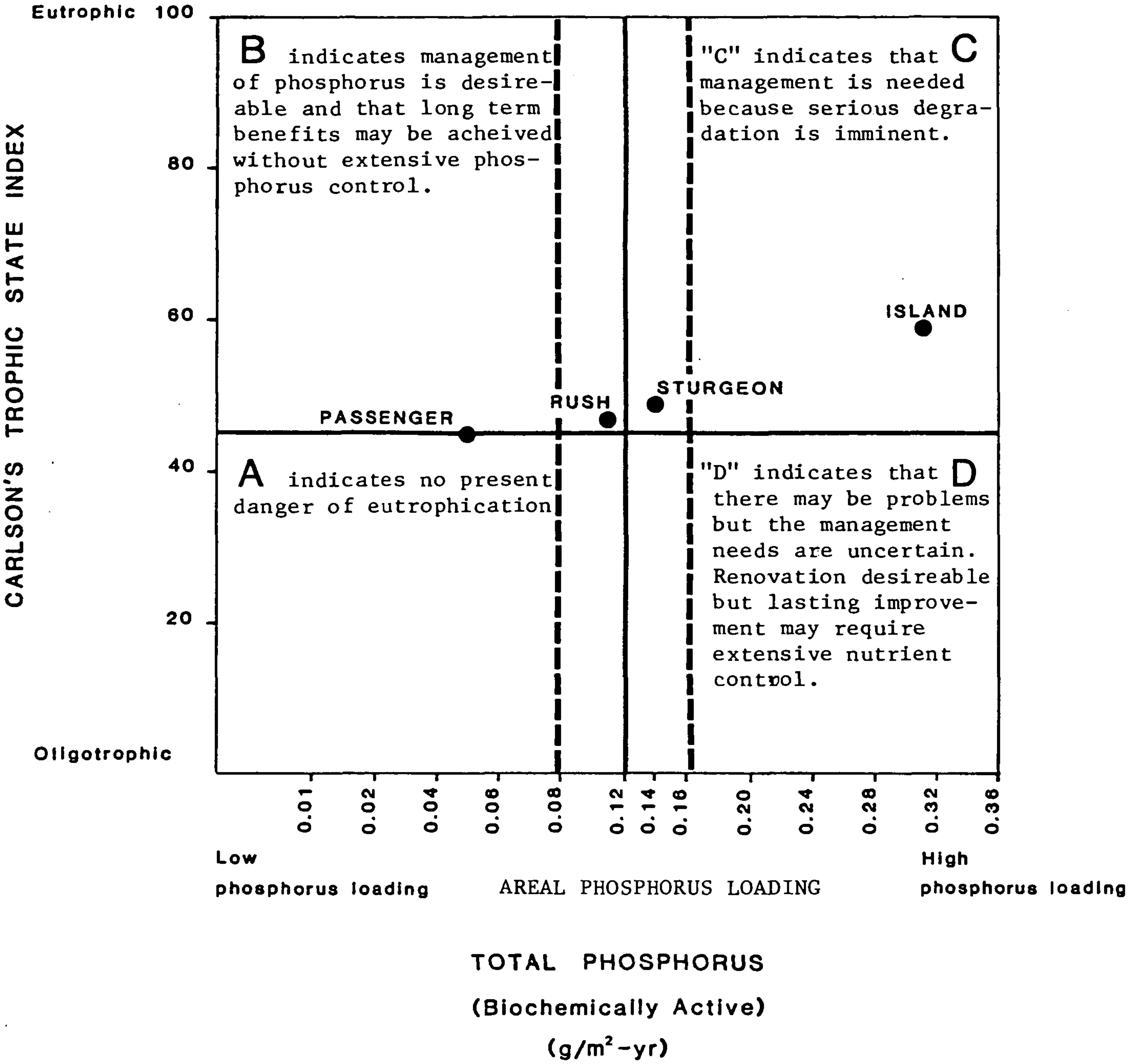


Figure 3-6. Graphical representation of the need to control phosphorus sources affecting lakes. Based on an arbitrary scale of phosphorus loading and on a trophic status index, as presented in Uttormark and Wall (1979).

The modeling of trophic status provided no indication that the abatement of an assumed "worst case" on-site system phosphorus load would improve the trophic status of Island Lake. The modeling results and the apparent natural fertility of Island Lake indicate that success in reversing Island Lake's eutrophication by abating a single phosphorus source is unlikely.

The model calculations presented in this EIS are not capable of providing insight into whether specific waste management alternatives can slow the eutrophication of Sturgeon Lake. The modeling did indicate initially that abatement of "worst case" on-site system loads would moderately improve the trophic status of Rush and Passenger Lakes (Figure 3-5). Because the initially assumed on-site system load was "worst case" and because that assumption is a serious over estimate (Section 2.2.2.4.), the classification of Rush and Passenger Lakes made without any on-site system phosphorus load (Figure 3-5) is probably a more realistic depiction of present quality. Considering the more realistic estimate of on-site system phosphorus loads, the abatement of on-site system loads with any type of improved wastewater management around Rush and Passenger Lakes would be of minimal benefit.

3.1.3.4. Trophic History of Island Lake and Sturgeon Lake

Background

Island Lake and Sturgeon Lake are currently surrounded by shoreline residential development. The lakeshore community represented by this level of development began in the decade of the 1950's, experienced its greatest rate of growth in the 1970's, and now is comprised of approximately 350 households (Section 3.2.1.). A primary concern of many of the residents of this community has been the notion that the blue-green algae blooms currently experienced in Island Lake are a recent problem linked to the existence of a large number of failing on-site wastewater treatment systems. However, one long-time resident of the area has reported that the blue-green algal blooms in Island Lake represent a problem of much longer standing, predating any significant amount of lakeshore development, (Letter of Mr. Walter Johnson to Mr. Gregory Evenson, Appendix K.).

Information contained in the MLWSD Facility Plan (Section 2.2.1.2.) indicates that a large proportion of the lakeshore community's permanent population is concentrated around Island Lake and that the residences around Island Lake experience a greater rate of surface failure with on-site systems than do the Sturgeon Lake residences. In the context of the popular conception which holds that failing septic systems are the cause of Island Lake's problems, a logical concern for the residents of the Sturgeon Lake area is that extensive conversion of dwellings to permanent use status will potentially result in problems comparable to those being experienced with Island Lake.

Empirical observations which associate symptoms of advanced eutrophication only with increasing population levels in the lakeshore community may ignore other important historic events in a lake's watershed. USEPA determined that a scientific investigation of the course of eutrophication in Island and Sturgeon Lakes was needed to provide a more comprehensive understanding of events that have influenced the their quality. The objective of the investigation was to determine the historic trends of the eutrophication of these lakes.

The Investigation of Trophic History

To complete the investigation of trophic history, special supplemental data were gathered in the late winter and early spring of 1982. A chronology of population growth and historical events was first constructed to document the course of events which could have an impact on phosphorus loads to the lakes (Section 3.2.2.2.); and, a supporting paleolimnological investigation was conducted by examining the characteristics of lake sediment with depth. A complete report on the paleolimnological investigation is presented in Appendix L. A summary discussion of the methods and findings of this investigation is presented below.

Intact 60-centimeter long sediment cores were taken from the profundal sediments of Island, Little Island, and Sturgeon Lakes (Figure 3-3).

Little Island Lake, a shallow water body contiguous to Island Lake, was studied for comparative purposes due to its lack of lakeshore development. Each sediment core was sectioned at even intervals as it was removed from the coring device. The sections were subsequently analyzed for the list of parameters discussed below.

In each core section:

- Chlorophyll break-down products were analyzed on a concentration basis for phytoplankton productivity trend analysis.

- Calcium carbonate was analyzed on a concentration basis to allow calculation of the percent by weight of the sediment made up of $CaCO_3$. This parameter can, in particular situations, be a reflection of overall plant productivity, including both phytoplankton and aquatic macrophytes.

- The dry weight composition of the sediments in terms of both organic and clastic matter was analyzed to allow presentation of these parameters on a percentile basis. These data allow analysis of changes in overall watershed sediment transport phenomena and lake productivity.

- The activity of Cesium (Cs) 137 isotope was measured to allow a calculation of annual sedimentation rates. The presence of Cs 137 is associated with the atmospheric testing of atomic weapons and provides a "dateline" for sedimentation studies.

- Three phosphorus forms were measured on a concentration basis to make a trend analyses of lake fertility. The changes in ratio of organic phosphorus to non-apatitic phosphorus were to be examined to determine where strong changes in the phosphorus loading regime to the lakes had taken place (if any).

Plots were made of these parameters to characterize sediment stratigraphy of the lakes. (The core segments were "dated" according to the sedimentation rate estimates.) Example plots of some of the parameters with depth/ date information for Island Lake, Little Island Lake, and Sturgeon Lake are presented in Figures 3-7 through 3-9.

The important conclusions made as a result of the paleolimnologic investigation are that:

- Island Lake has been approximately twice as productive as

Figure 3-7. Dated stratigraphic profiles of Island Lake sediments.

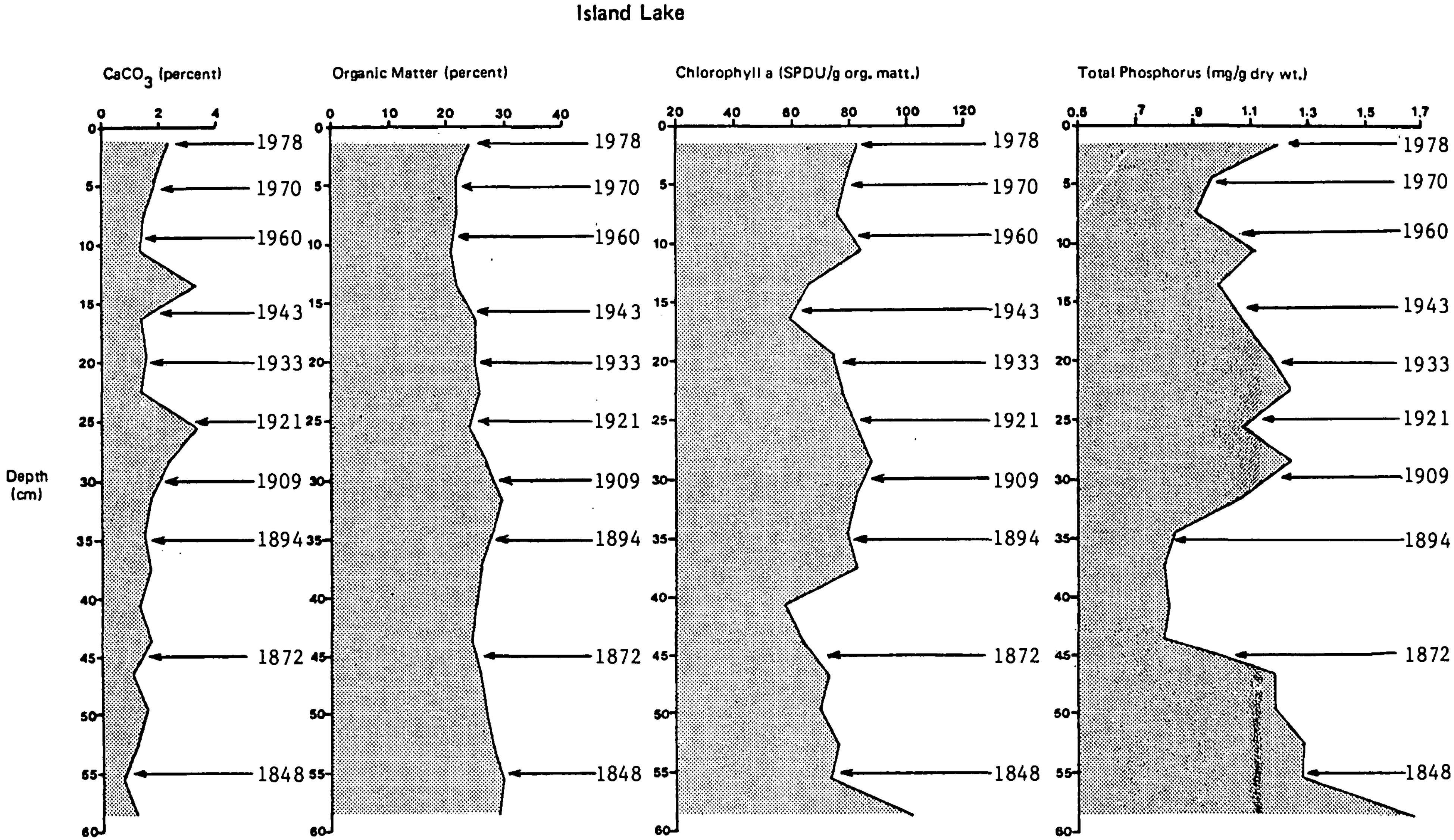


Figure 3-8. Dated stratigraphic profiles of Little Island Lake sediments.

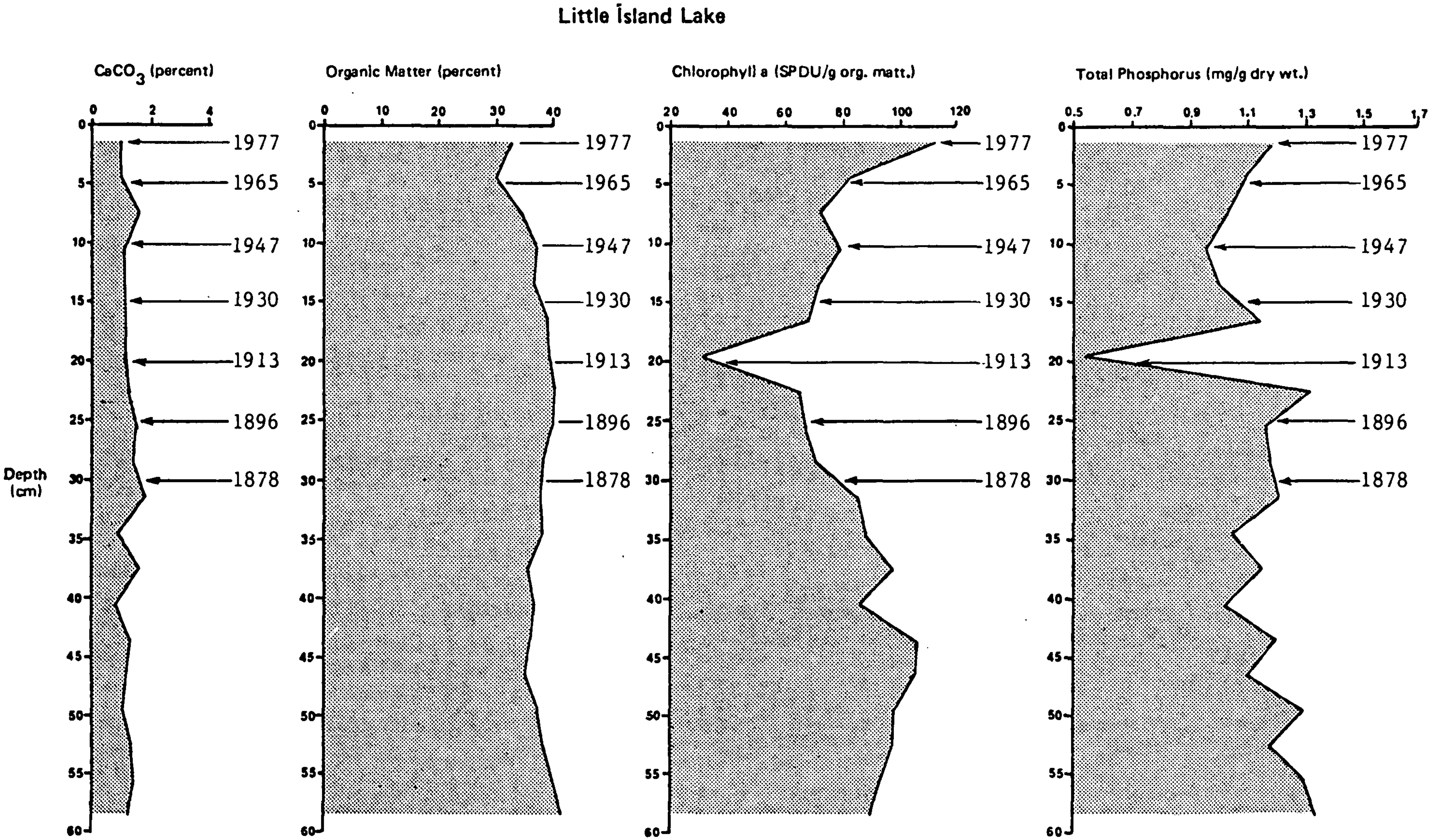
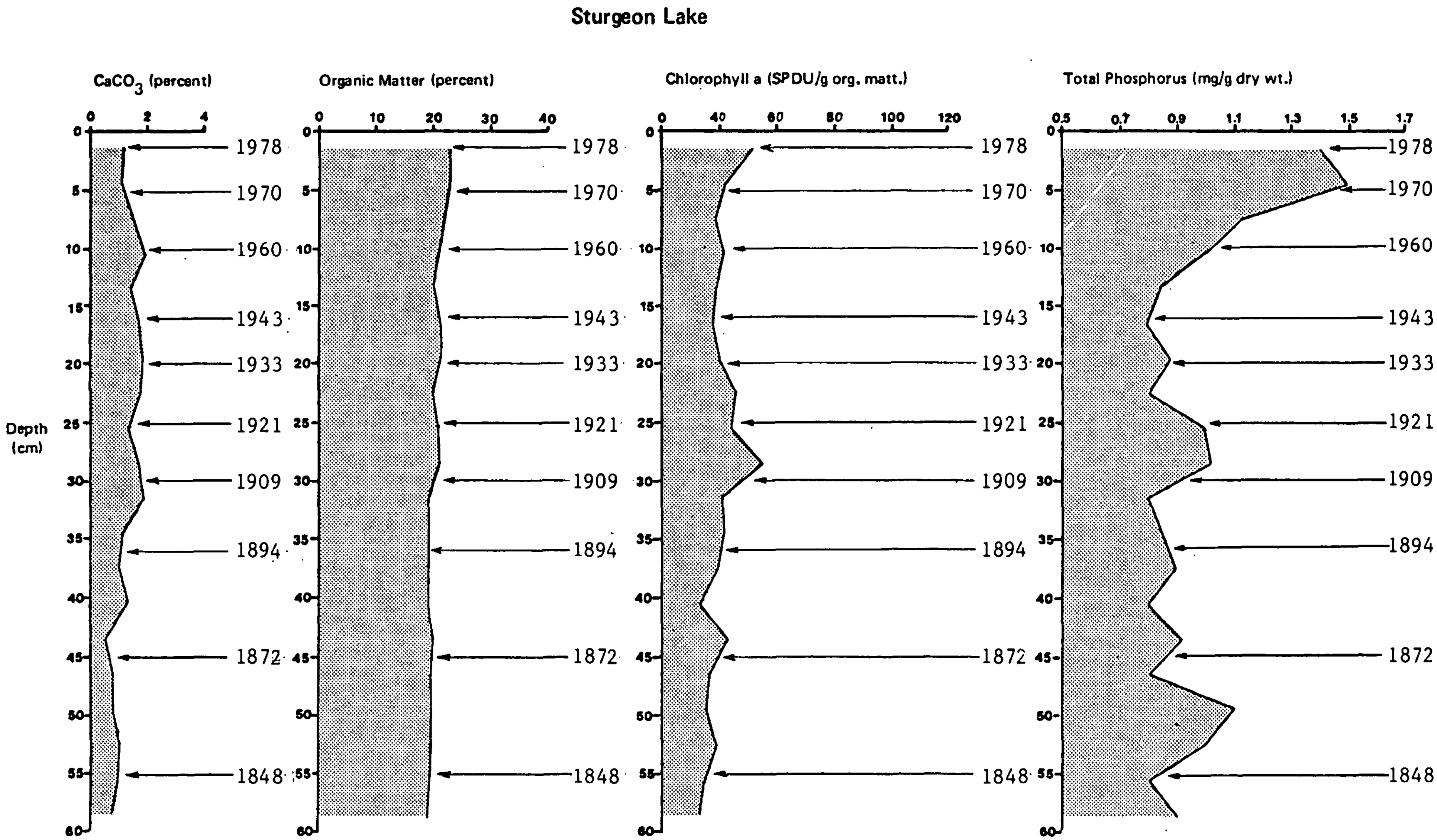


Figure 3-9. Dated stratigraphic profiles of Sturgeon Lake sediments.



Sturgeon Lake for as far back in the sedimentary record as the depth of cores allowed estimation.

- Significant change in the diatom community indicating a change in status from mesotrophic to eutrophic for Island Lake was found to be occurring following approximately 1930, 12 years after the Moose Lake fire and coincident with the onset of the development of a dairy-based agricultural economy. This trend in the diatom community did not appear to further accelerate coincident with the development of a lakeshore residential community after 1950.

- The organic phosphorus levels in the sediments of Little Island Lake were found to be significantly higher than in Island Lake throughout the dated sedimentary record, demonstrating the overall significance of non-wastewater sources of phosphorus to lake productivity.

- Sturgeon Lake was found to have remained almost unchanged in terms of phytoplankton productivity until 1975. Increases found in the concentration of phosphorus deposited after 1945 did not result in concommitant increases in phytoplankton productivity. The origins of the increased amounts of phosphous found near the sediment surface could include wastewater sources. However, agriculture and increased use of lawn fertilizer may also be significant phosphorus sources to Sturgeon Lake. It is emphasized that regardless of increased phosphous in recently deposited sediments, no significant acceleration in the rate of eutrophication of Sturgeon Lake was indicated by the other parameters.

3.1.4. Aquatic Biota

The Phase I Environmental Report (USEPA 1981) contained a broad overview description of the aquatic biota of the planning area's lakes. This section focuses on the aquatic biota of the project area lakes only, with an emphasis on data useful in evaluating the need for improved wastewater treatment. Topics covered include phytoplankton ecology in late summer and early fall, a special report on the presence of toxicity producing blue-green algal species, a description of the location of beds of aquatic macrophytes and a summary of some MDNR fish management survey data for Island and Sturgeon Lakes.

3.1.4.1. Phytoplankton Ecology and the Presence of Toxicity Producing Blue-Green Algae

Concerns have been expressed in public meetings held in the Moose Lake, Minnesota about possible health risks associated with blooms of blue-greem algae in the area's lakes (Section 1.3.). These concerns reflect a widespread perception that blue-green algae blooms pose a health hazard to swimmers and pets and that pollution from lakeshore septic tanks was a major factor in the development of these blooms. Because of these concerns, a Report on Algae was prepared by USEPA to investiage the factors leading to the development of blue-green algae blooms, to examine documented episodes of algal toxicity, and to assess the potential health risks associated with blue-green algae blooms in the lakes within the proposed service area. The Report also describes the information on phytoplankton populations and water quality obtained from sampling Rush, Passenger, Sturgeon, and Island Lakes during August, September, and October 1981. A detailed summary of the Report on Algae is presented in Appendix H. General findings of that report are presented in the following paragraphs.

There are approximately 1,500 known species of blue-green algae in both soil and aquatic habitats. Blue-green algae are often considered to be an aquatic "nuisance species" though, because of their ability to remain in position at the surface and because the larger cell colonies are visible to the naked eye. Their bouyancy can also result in the formation of floating mats of dead and living blue-green algae which accumulate on the downwind side of a water body. As the algae decompose, unpleasant odors and colors are produced. Decomposition of blue-green algae can adversely affect the taste of water.

Under favorable environmental conditions, algae reproduce at extremely rapid rates and form "blooms" in which they are present in very high concentrations. Excessive growth or blooms of phytoplankton may include one or several kinds of algae. The growth-limiting factors affecting algae abundance in lakes are nutrients (primarily phosphorus and nitrogen), temperature, and light. Seasonal variability in these factors are collectively responsible for the occasional rapid growth and resulting dominance of blue-green algae over other algae in freshwater lakes. Often more than one factor is responsible for inducing a severe bloom. In eutrophic lakes (i.e., waterbodies with high nutrient content and the highest algal growth), blue-green algae typically become dominant in late summer because of a general depletion of dissolved nitrogen and silica which excludes the growth of other phytoplankton. Blue-green algae alone are able to fix atmospheric nitrogen into a useful nutrient and are thus able to achieve greater growth than other phytoplankton in late summer.

In addition to the nuisance characteristics commonly associated with blue-green algal blooms, three genera of freshwater blue-green algae occasionally produce substances that can cause a variety of toxic effects, and in some cases, have caused death in wildlife and livestock. The only way for toxic blue-green algae to cause death in animals is from drinking algae-laden water. There are documented episodes of toxic blue-green algae blooms in southern Minnesota which resulted in livestock mortality. There are no documented or reported cases of human mortality associated with toxic strains of fresh-water blue-green algae. However, symptoms associated with ingestion in humans such as itching, nausea, and diarrhea have been commonly reported.

The development of toxic blooms is unpredictable and usually occurs in short-lived pulses. They usually reoccur in the same body of water in 2 or 3 year cycles. The fact that bloom toxicity is so varied and unpredictable make any blue-green algae bloom potentially dangerous and suspect at all times, even though the majority are actually non-toxic.

To investigate the potential for blue-green algal toxicity in the four project area lakes, phytoplankton, water quality and public health surveys were conducted in Pine County from late August to early October 1981. Although the health officers, physicians, and veterinarians contacted reported no health related or toxicological problems with swimming or in drinking from the four lakes, Island Lake was found to have a potential health hazard associated with blooms of blue-green algae. This potential is based on the presence in Island Lake of algae belonging to the three genera shown to be associated with toxicity incidents with domestic animals and with humans in other Minnesota lakes. The potential health problem with Island Lake must not be exaggerated, however, because the dominant blue-green algae in Island Lake was found to be Anabaena macrospora, which was not found to be associated with toxicity in a review of literature. The other three project area lakes were found to support lower concentrations of blue-green algae and did not experience blue-green growth to bloom proportions. Because of this, blue-green algae do not appear to pose a potential threat to public health in Sturgeon, Passenger, or Rush Lakes.

The survey found that Island Lake had the highest algae density of the four lakes and also had the poorest water clarity. In a pattern common for eutrophic lakes, Island Lake was found to be dominated in late August by non-blue-green algae. Subsequently, in early September, the concentrations of non-blue-green algae species declined in Island Lake while two species of blue-green algae increased in number to achieve total dominance. Blue-green algae increased from 16% to 95% of the total phytoplankton community from 26 August to 9 September.

Although phytoplankton were much less abundant in Sturgeon Lake than in Island Lake, blue-green algae remained the dominant phytoplankton group in Sturgeon Lake throughout September. Sturgeon Lake had better water clarity than Island Lake primarily because blue-green algae were much less abundant.

Passenger Lake had relatively low amounts of algae and, in particular, very low volumes of blue-green algae compared to both Island and Sturgeon Lakes. On each of the three sampling dates in September and October, non-blue-green algae were dominant in Passenger Lake. The relatively low clarity of Passenger Lake was attributed to other factors such as dissolved and suspended organic matter. Rush Lake had the lowest abundance of phytoplankton of the four lakes tested and had the greatest water clarity.

3.1.4.2. Aquatic Macrophytes

Emergent and submergent aquatic plants encountered in significant stands during the 1981 field surveys were noted. The objective of locating areas of luxuriant aquatic plant growth was to evaluate their potential association with any failing on-site systems detected through the septic leachate survey (Section 2.2.1.5.). It was anticipated that confined embayments or shallow areas protected from the waves by a point or shoal could be experiencing luxuriant plant growth if adjacent residences were contributing significant amounts of septic leachate. No such conditions were documented by the field crew; e.g., the potential septic leachate plumes that were located were not found to be emerging in isolated macrophyte beds.

In Sturgeon Lake, the observation was made that some shallow, sandy areas along the south and southwest shore appeared to have been cleared of native emergent plants, presumably to provide a more attractive swimming beach for the property owners. Thus, the potential association of aquatic plant growth and residential development was obscured due to "beach clearing" practices.

3.1.4.3. Fish

The fisheries resources of the project area lakes are relatively good, according to MDNR records dating to 1979. Gill net and trap net catches made in Island and Sturgeon Lakes were reported to be above the state average for walleye, northern pike, perch, and sunfish.

Some game fish and panfish are found with neascus (blackspots on the fish's epidermis caused by a cyst of a snail). This condition has been documented in MDNR fishery records since the mid-1950s. The regional fish manager has reported that this condition is typical for many lakes in this part of the state (Personal communication to WAPORA, Inc.).

Recently, a strong increase was reported in the population of yellow perch and sunfish in Island and Sturgeon Lakes (MDNR, unpublished files). A summary of the fishery data indicating recent increases in the panfish populations of Island and Sturgeon Lakes is presented in Figure 3-10. The exact cause of the reported increases in the number of yellow perch and blue-gill sunfish captured in these lakes is not known, although it may be

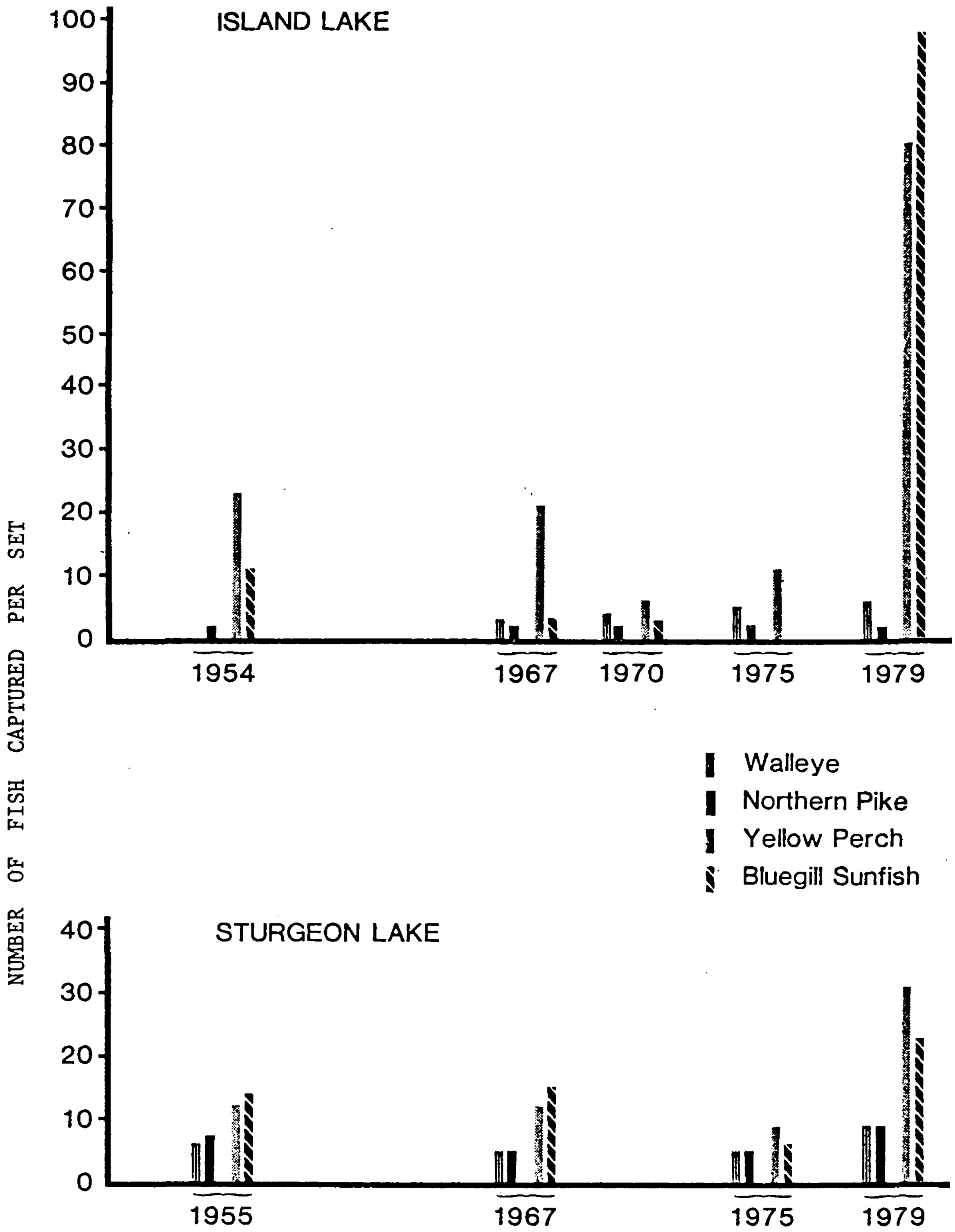


Figure 3-10. Gillnet and trapnet capture rates with time for gamefish and panfish in Island and Sturgeon Lakes, Pine County, MN. Data are from fish management survey records (MDNR, unpublished).

speculated that increased fishing pressure on predator fish, following extensive residential development of the area in early 1970's, may have played a role in shaping the fish community. Removal of a portion of the walleye or northern pike population due to increased fishing pressure could have resulted in concommitant increases in the prey species (such as yellow perch and sunfish). Because perch and sunfish are predators on zooplankton, an increase in these smaller panfish species may have resulted in a significant decrease of the zooplankton population. A decrease in the zooplankton population would lower the grazing pressure on phytoplankton, especially green algae. As a result, the reduced zooplankton grazing can be expected to have stimulated an increase in the phytoplankton population, increasing the biological turbidity in Island and Sturgeon Lakes. In other Minnesota lakes, an increase in phytoplankton has occurred when the zooplankton population decreased (Shapiro 1979). An overall increase in phytoplankton in the context of late summer successional patterns may favor the growth of blue-green algae.

3.1.5. Terrestrial Biota

The Phase I Environmental Report (USEPA 1981) contained an extensive overview discussion of the terrestrial biota of Pine and Carlton counties. Topics covered in that discussion included land cover, significant natural areas, wetlands, floodplains, and wildlife.

Additional information on the extent of wetland soils within the project area may be deduced from the soil survey conducted in a portion of Windemere Township for preparation of this Environmental Impact Statement (Section 2.2.1.1.). Further discussion of forest and agricultural land cover extent in the watershed areas of Island and Sturgeon Lakes is presented in Section 3.2.2.2.

3.2 Man-Made Environment

3.2.1. Demographics

3.2.1.1. Historic and Current Population Trends

Two distinct trends are reflected by the population data for the jurisdictions within and surrounding the project area (Windemere and Moose Lake Townships, the City of Moose Lake, and Pine and Carlton Counties). The first trend, one of erratic growth and decline, is evident in the population data for the 40-year period from 1930 to 1970 (Tables 3-9 and 3-10). During this period Windemere Township and Pine County both experienced population decline. Moose Lake Township, the City of Moose Lake, and Carlton County each experienced population growth during this period, however, the rate of growth varied widely. This population trend reflects both national trends and local aberrations and also reflects, to a great extent, changes in the economy of the area. The historic growth of the local region was based on the development of the forestry industry and agricultural expansion. After 1940, however, increased mechanization in agricultural operations and a general decline in the forestry industry ushered in a period of erratic growth and population decline. The population trend experienced by the jurisdictions within the project area between 1940 and 1970 was indicative of the national rural-to-urban migratory pattern that resulted, at least partially, from a shrinkage in employment opportunities in rural areas with natural resource-based economies.

The second population trend apparent in the project area, and especially in Windemere Township, is the rapid population growth that has occurred since 1970. The construction of seasonal homes around Island and Sturgeon Lakes, a trend that began in the 1950s, appears to have created much of the impetus for the population gains. The number of housing units in Windemere Township increased by 56% from 1950 to 1960 while the year-round population of the Township decreased by 4.6% (US Bureau of the Census 1952, 1963). Although the natural resource segment of the local economy continued to decline between 1960 and 1980, the growth of the seasonal population around the lakes apparently stimulated an increase in the service sector of the economy which resulted in an increase in the permanent population. Between 1960 and 1980, the number of housing units in Windemere Township increased by 200% while the population increased by only 145% (US Bureau of the Census 1963, 1973, 1982). The increases that took place

Table 3-9. Historic population growth in the jurisdictions within and surrounding the project area (US Bureau of the Census 1952, 1963, 1973, 1982).

Jurisdiction	1930	1940	1950	1960	1970	1980
Windemere Township	528	489	392	374	511	915
Moose Lake Township	548	1,063	1,206	1,577	1,170	1,237
City of Moose Lake	742	1,432	1,603	1,514	1,400	1,408
Pine County	20,264	21,478	18,223	17,004	16,821	19,871
Carlton County	21,232	24,212	24,584	27,932	28,072	29,936
Minnesota	2,253,953	2,792,300	2,982,483	3,413,864	3,805,069	4,077,148

Table 3-10. Percent change in the population in the jurisdictions within and surrounding the project area from 1930 to 1980 (US Bureau of Census 1952, 1963, 1973, 1982).

Jurisdiction	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980
Windemere Township	-7.4	-19.8	-4.6	36.6	79.1
Moose Lake Township	94.0	13.5	30.8	-25.8	5.7
City of Moose Lake	93.0	11.9	-5.6	-7.5	0.6
Pine County	6.0	-15.2	-6.7	-1.1	18.1
Carlton County	14.0	1.5	13.6	0.5	6.6
Minnesota	8.9	6.8	14.5	11.5	7.1

State and national trends. Many urban area populations have declined since 1970, whereas rural "amenity" areas similar to Windemere Township have grown.

The recent trend toward increased development and population growth in certain areas of the upper Midwest, as epitomized by the rural lake community of the project area, is well documented. Gustafson (1973) found that rural, non-farm populations experienced an overall increase between 1960 and 1970 and that the rural, non-farm areas that experienced the greatest demand for new housing were in: (1) counties adjacent to Minneapolis-St. Paul; (2) in lake areas of central Minnesota; and (3) in northern and central Wisconsin.

3.2.1.2. Household Size and Resident Age

Household sizes in the project area did not change to any significant extent between 1970 and 1980 (US Bureau of the Census 1973, 1982). The maintenance of household sizes at their 1970 levels is somewhat inconsistent with the nationwide trend toward increased numbers of one- and two-person households and a consequent decrease in average household size. The average number of persons per household in Windemere Township in 1970 was 2.66 (US Bureau of the Census 1973). According to the 1980 census, the average household size in the Island Lake and Sturgeon Lake portions of Windemere Township (ED 504; Figure 3-11) was 2.65 and in the remaining portion of the Township (ED 503; Figure 3-11) the average household size was 2.74. These household sizes are slightly lower than the household size in Pine County (Table 3-11), which is one indication of a greater number of households made up of retired individuals.

Median age is an index of the overall age structure of the population being studied. The 1980 median age in the census enumeration district surrounding Island and Sturgeon Lakes in Windemere Township was 37.9. This is significantly higher than the median age in Pine County and in the State (Table 3-11) and is attributed to the growing number of retired residents who are attracted by the recreational and scenic amenities of the project area.

Table 3-11. Selected population characteristics in the jurisdictions within and surrounding the project area in 1980 (US Bureau of the Census 1952, 1963, 1973, 1982).

Jurisdiction	Permanent Population	Year-round Housing Units	Median Number of Persons per Occupied Housing Unit	Median Age	Percent Under 18 Years	Percent Over 65 Years
Windemere Township[a]						
ED 504	329	138	2.65	37.9	23.7	12.5
ED 503	586	269	2.74	34.0	29.7	15.0
Moose Lake Township[b]	934	353	3.04	29.7	33.0	10.9
City of Moose Lake	1,408	571	2.17	43.1	19.4	27.2
Pine County	19,871	10,299	2.80	31.1	NA	NA
Carlton County	29,936	11,782	2.87	30.5	NA	NA
Minnesota	4,077,148	1,613,343	2.74	29.2	NA	NA

[a] See Figure a for the boundaries of the two EDs within Windemere Township.

[b] Does not include Moose Lake State Hospital.

NA - Not Applicable.

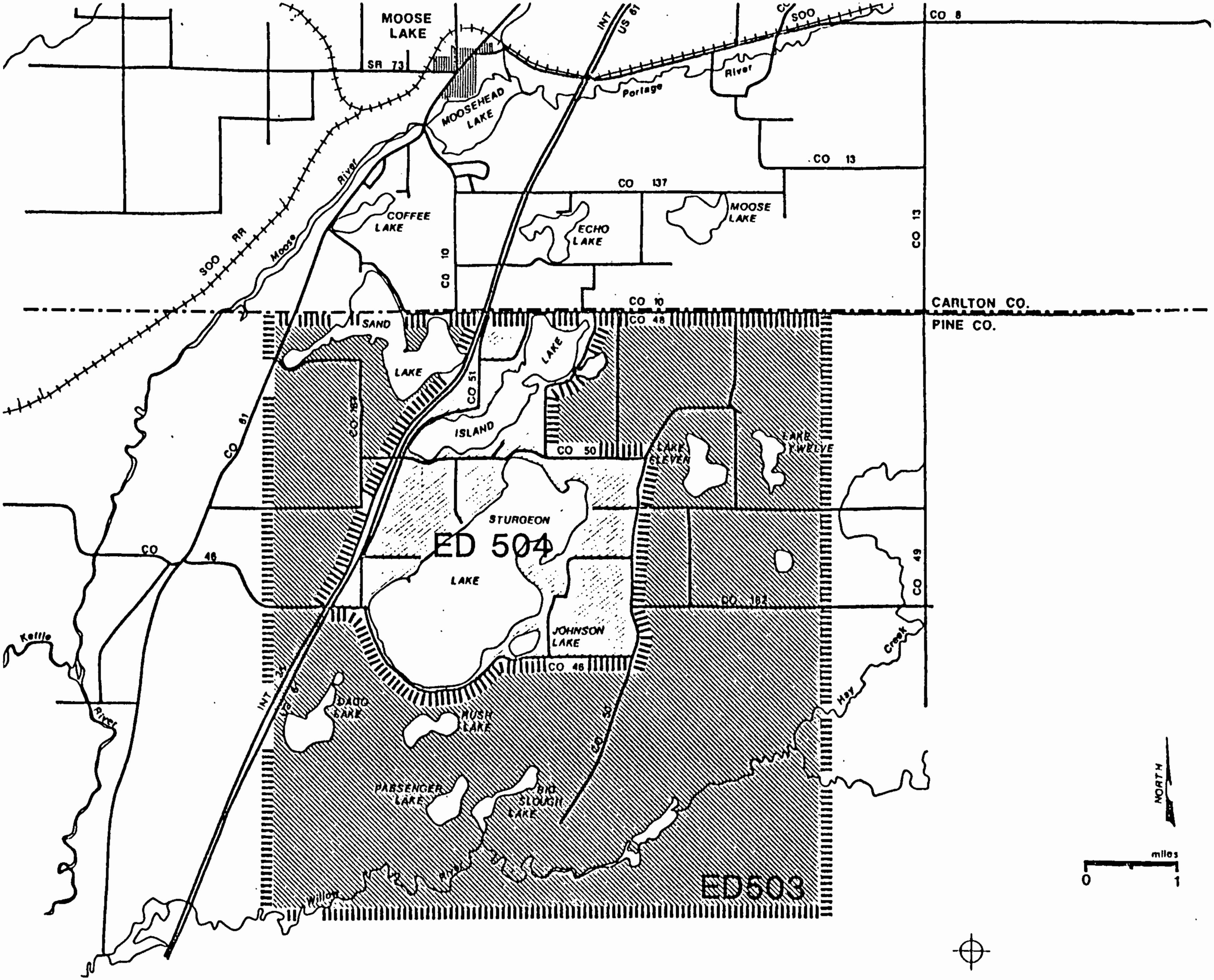


Figure 3-11. Enumeration districts for census.

3.2.1.3. Housing Stock Characteristics

The housing stock in the project area comprises both year-round and seasonal dwellings. According to the 1980 census, there are 919 housing units in Windemere Township; 512 of these are used on a seasonal basis and 407 are occupied year-round or are vacant (Table 3-12). The percentage of seasonal units in Moose Lake Township is significantly less; only 50 of the 403 total housing units are used on a seasonal basis (Table 3-12). Because Moose Lake Township is a predominantly rural area with less riparian development and related amenities than Windemere Township, its lower percentage of seasonal housing does not appear to be unusual.

3.2.1.4. Population Projections

Background

The accuracy of population projections is highly dependent on two factors: the size of the base population and the period of time for which the projections are made. The estimation of population growth generally is less accurate for small populations than for larger populations when made over long periods of time. This is because attitudinal or technological changes can significantly affect small communities, whereas large communities can better absorb such changes.

The effect of these limitations can be minimized if population projections are based on observations derived from a thorough analysis of historical trends. Two observations regarding population trends in the project area must be considered in forecasting future population trends:

- Prior to 1960, population growth in Windemere and Moose Lake Townships was erratic. Since 1960, however, the number of housing units in the two townships increased steadily, often at a greater rate than population growth. For example, between 1960 and 1970 the number of housing units in Windemere Township increased by 89.2% while the population increased by only 36.6% (Table 3-13). The substantial increase in the number of housing units is indicative of the high local demand for recreational homes because of the amenities associated with the Township's lakefront property.

Between 1970 and 1980, the number of housing units in Windemere Township increased by 59.3% while the population increased by 79.1% (Table 3-13). This reversal of the preceeding decade's trend (1960 to 1970) appears to be indicative of the recent national trend of net migration from urban to rural areas. Rural areas were attractive during the 1970s for a variety of reasons that have been widely documented, including lower land values, the amenities of "country life," and an absence of "urban" problems. This current trend of population increase is expected to continue in the project area, at similar or somewhat reduced rates for identical reasons and because of the area's perceived quality among retired people.

- The relationship between population change in the two project area Counties and the population change in the two project area Townships has not been stable over the period from 1950 to 1980 (Table 3-14). The increasing percentage contribution of the Windemere Township population to the Pine County population is indicative of the area's historic growth potential as a result of development around the Township's lakes. The decreasing contribution of the Moose Lake Township population to the Carlton County population is indicative of the lesser development potential of Moose Lake Township (Table 3-14). Because of the variations between these two adjacent Townships it does not appear that for either Pine or Carlton County there is a strong correlation between County and Township growth trends.

Other factors also will have some impact on future population growth. Higher fuel costs, further declines in employment opportunities, and/or a stagnant regional economy might directly and indirectly affect population growth. The growth attitudes of existing residents, local governments, and commercial interests also could affect future population levels.

Methodology

The population projections for the project area are based on 1960, 1970 and 1980 data and were developed from projections of the number of additional housing units that will be built in the project area by the year 2000. A housing unit projection methodology was used because the available data on housing units are of a similar quality as the available data on populations and because fewer extrapolations are required to estimate the future seasonal population (Appendix I).

Table 3-12. Project area housing summary for 1980 (US Bureau of the Census 1982).

Jurisdiction	Year-round Vacant Units	Year-round Occupied Units	Total Year-round Units	Seasonal Units	Total Units
Windemere Township	69	338	407	512	919
ED 504	14	124	138	259	397
ED 503	55	214	269	253	522
Moose Lake Township[a]	46	307	353	50	403
City of Moose Lake	46	525	571	16	587

[a]Does not include Moose Lake State Hospital.

Table 3-13.

Changes in the population and housing stock in Windemere and Moose Lake Townships, 1960 to 1980 (US Bureau of the Census 1963, 1973, 1982).

	1960		1970			1980		
Jurisdiction	Population	Housing Units	Population	Housing Units	Percent Change 1960-1970	Population	Housing Units	Percent Change 1970-1980
Windemere	374		511		36.6	915		79.1
Township		305		577	89.2		919	59.3
Moose Lake	1,577		1,170		-25.8	1,237		5.7
Township		224		287	28.1		403	40.4

Table 3-14. Percentage of Pine and Carlton County population residing in Windemere and Moose Lake Townships in 1950, 1960, 1970 and 1980 (US Bureau of the Census 1952, 1963, 1973, 1982).

Jurisdiction	1950	1960	1970	1980
Windemere Township (Pine County)	2.2	2.2	3.0	4.6
Moose Lake Township (Carlton County)	4.9	5.6	4.2	4.1

Permanent and seasonal population projections for Windemere Township were developed based on the housing unit projections (Tables 3-15 and 3-16). The total population for the year 2000 is estimated to be 3,621 which includes 1,503 (41.5%) permanent residents and 2,118 (58.4%) seasonal residents (Table 3-17). The projected increase in total population over the planning period is 47.7%. The permanent population is projected to increase by 64.3% while the seasonal population is projected to increase by 37.9%. The population around Island Lake is projected to increase by 39.9% and the population around Sturgeon Lake is projected to increase by 41.9%. The greater amount of developable lakefront property around the other Township lakes is indicated by the projected population increase in ED 503 of 53.6%.

Table 3-15. Permanent population projections within Windemere Township, 1980 to 2000.

Location	1980	1990	2000
ED 504[a]	329	429	532
Island Lake	153	200	246
Sturgeon Lake	100	131	172
Outlying Areas	76	98	114
ED 503[b]	586	764	971
Windemere Township	915	1,193	1,503

[a] Population projections for 1990 and 2000 are based on 2.384 persons per household as derived from 1980 census data and include a vacancy factor.

[b] Population projections for 1980 and 2000 are based on 2.178 persons per household as derived from 1980 census data and include a vacancy factor.

Table 3-16. Seasonal population projections within Windemere Township, 1980 to 2000[a].

Location	1980	1990	2000
ED 504	777	1,017	1,023
Island Lake	261	339	333
Sturgeon Lake	465	615	630
Outlying Areas	51	63	60
ED 503	759	993	1,095
Windemere Township	1,536	2,010	2,118

[a]Population projections for 1990 and 2000 are based on 3.0 persons per household.

Table 3-17. Combined seasonal and permanent population projections within Windemere Township, 1980 to 2000[a].

	1980	1990	2000
ED 504	1,106	1,446	1,555
Island Lake	414	539	579
Sturgeon Lake	565	746	802
Outlying Areas	127	161	174
ED 503	1,345	1,757	2,066
Windemere Township	2,451	3,203	3,621

[a]An additional 120 seasonal residents are projected for the YMCA Boys Camp on Sturgeon Lake. This projection will remain constant to the year 2000.

The individual Island Lake and Sturgeon Lake area population projections (Table 3-17) are significantly lower than the population estimates which were presented in the Draft MLWSD Facility Plan (P.R.C.-Consoer Townsend 1980). The "population equivalents" for the year 1955 were estimated in the Facility Plan to be 931.0 for the Island Lake vicinity and 1,382.5 for the Sturgeon Lake vicinity. These numbers are in contrast with the year 2000 population projections made in this report of 579 for the Island Lake area (62% of the MLWSD projection) and 802 for the Sturgeon Lake area (58% of the MLWSD projection). [An additional 120 residents must be added to the Sturgeon Lake projections to cover the YMCA Boys Camp summer population if sewers are being designed.] The sources of the discrepancies between the Facility Plan and these projections are thought to be:

- the year 2000 projections that are being used in this Environmental Report are based on detailed 1980 census data for the local area that was not available at the time the MLWSD Facility Plan was prepared;
- the assumptions used to develop the projections reflect a direct assessment of available lots in the lakeshore areas and interviews with local real estate sales offices (Section 3.2.2.4).

3.2.2. Land Use

The Phase I Report on existing conditions presented a regional overview of land use characteristics. In that report, land use data were presented only on the basis of political units such as by town and county area.

The descriptions presented in this section of historic land use trends in Pine and Carlton counties and of the land use within specific lake drainage areas or "watersheds" are intended to provide a quantitative framework for estimating the origin and significance of eutrophying nutrients exported into the area's lakes. Historic land use indicators such as population figures, cropland production statistics, and logging, forest fire and settlement dates were used to indicate the variations over time in active uses of the land. The existing land use in individual lake watersheds was determined by planimetric measurement to provide a basis for calculation of annual phosphorus loads to each lake. Both historic and contemporary land use information provide a basis for assessing the consequences of specific waste management alternatives.

3.2.2.1. Historic Land Use Trends in Pine and Carlton Counties

The settlement of northeastern Minnesota in the nineteenth century was directly related to the area's rich timber resources. "The story of the lumbering days is the main theme of every community of the county in the pioneer days" (Miller 1949). By 1860, the logging era was well underway, with the timber industry providing the necessary economic foundation for the development of railroads and roads, and towns were founded as the population grew. This basic infrastructure later provided the basis for the development of the region's second historical economy, dairying, by providing a source of capital and transport linkages to the metropolitan areas.

Most of the communities in Pine and Carlton counties originated in the 1860s and 1870s. The first road connecting St. Paul and Duluth-Superior was completed in 1857 and was followed by the Lake Superior-Mississippi railroad in 1870 and the Great Northern railroad in 1887. The timber industry reached its peak in the region between approximately 1870 and 1894 and numerous mills were built throughout the area to process the logs. In 1890, Minnesota ranked first in the country in lumber production.

> "In 1870 a dam was built across the Grindstone River by W. H. Grant, Sr., who had arrived the year before from St. Paul with a portable sawmill. In the fall McKane Bros. built a larger mill and obtained power from the river. This mill was enlarged from time to time until in 1894 it employed 400 men. In 15 years this mill cut 300,000,000 feet of lumber." (Miller 1949).

Although the white pine forests were once regarded as inexhaustable, by 1900 the timber industry in this area of Minnesota was essentially finished. The transition from logging to farming began in much of Pine County virtually overnight as a result of the event of September 1894 when the great Hinckley fire devastated much of the central portion of Pine County. Although the timber industry was already on the decline at the time of the Hinckley fire (and forest slash left from logging operations probably contributed greatly to the spread of the fire), Pine County was never to have a timber industry of the scale that had previously been present. "After this catastrophe, the Paul Bunyan aspect of the county changed, and a great movement was started by the railroads and the government to bring in the real settlers, the farmers" (Miller 1949).

The northern part of Pine County (where the service area is located) and the southern part of Carlton County (including part of the Island Lake watershed) were not burned over in the Hinckley fire and, thus, logging continued there into the early 1900s. As the stands of white pine and hardwoods were depleted, though, settlers began to move into the area to drain and clear the land for farming. Many of the settlers were recruited from neighboring states as well as from Europe, with promises of cheap land and good growing conditions. The conversion of land from forest to farm in this area was greatly increased by the "Moose Lake fire" of 1918. This fire burned throughout much of Windemere Township and definitely burned most of the remaining stand of timber in the watershed of Little Island Lake (US Forest Service Map, unpublished).

By 1920, farming was the predominant land use in these watershed areas. The number of dairy cows being milked in Pine and Carlton counties continued to increase until approximately 1935 (Figures 3-12 and 3-13). From 1935 to 1950, the number of dairy cows in the two counties declined somewhat, but from 1950 to 1955, a recovery in the number of dairy cows was recorded. Since 1955, the number of dairy cows in the two counties has steadily declined, to the point where there are now fewer dairy cows in Pine and Carlton counties than there were in 1920 (US Department of Commerce 1929, 1934, 1939, 1949, 1969, 1978). The amount of land in crop production in the two counties has exhibited a similar trend; peak acreages occurred between 1935 and 1945 followed by steady declines (Figures 3-12 and 3-13). A chronology of some of the more important events and trends in Pine County and Windemere Township during the 20th Century is presented in Figure 3-14.

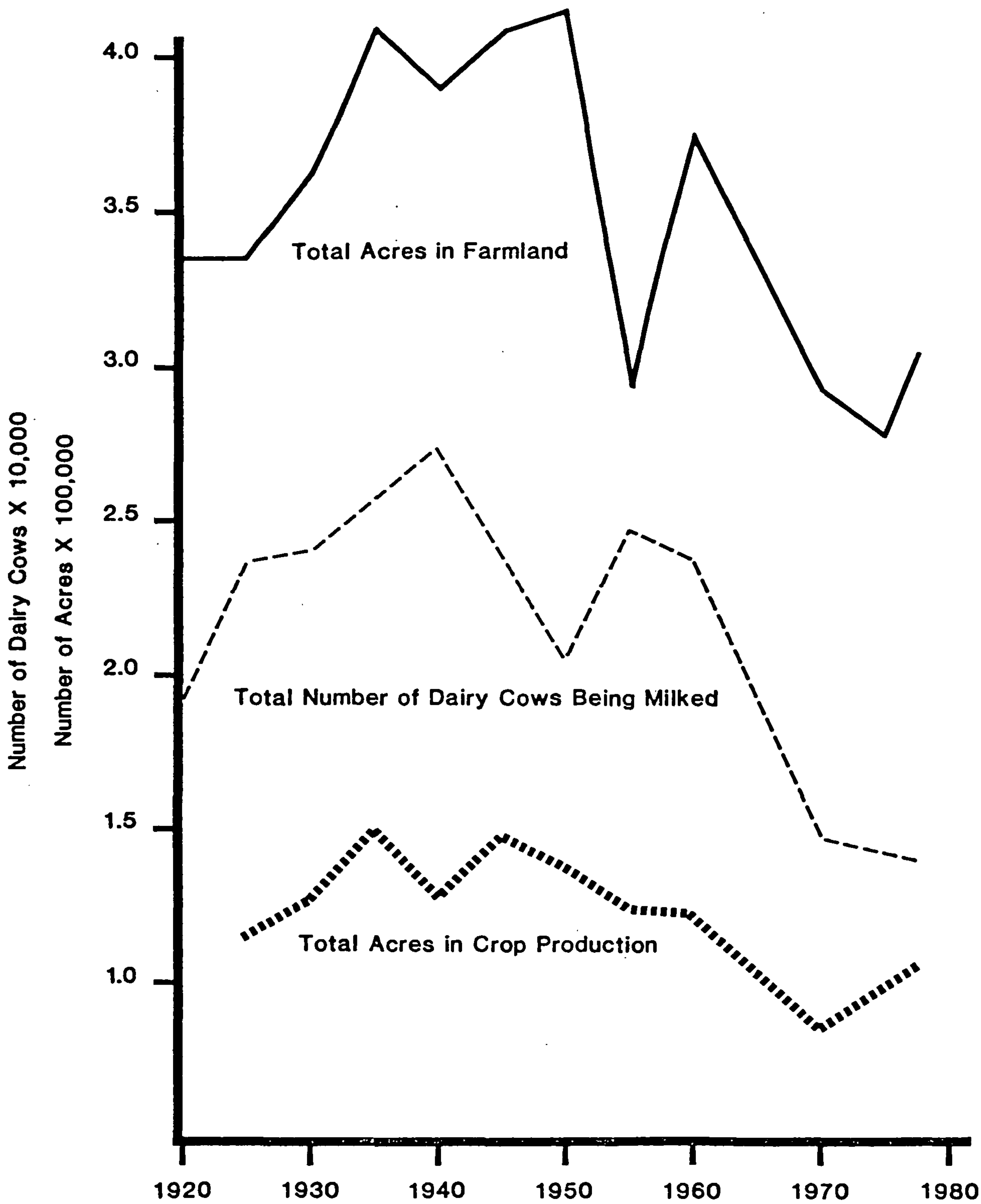


Figure 3-12. Pine County, MN: trends in agriculture from 1920 to 1978. Data are from the U.S. Department of Agriculture, Census of Agriculture.

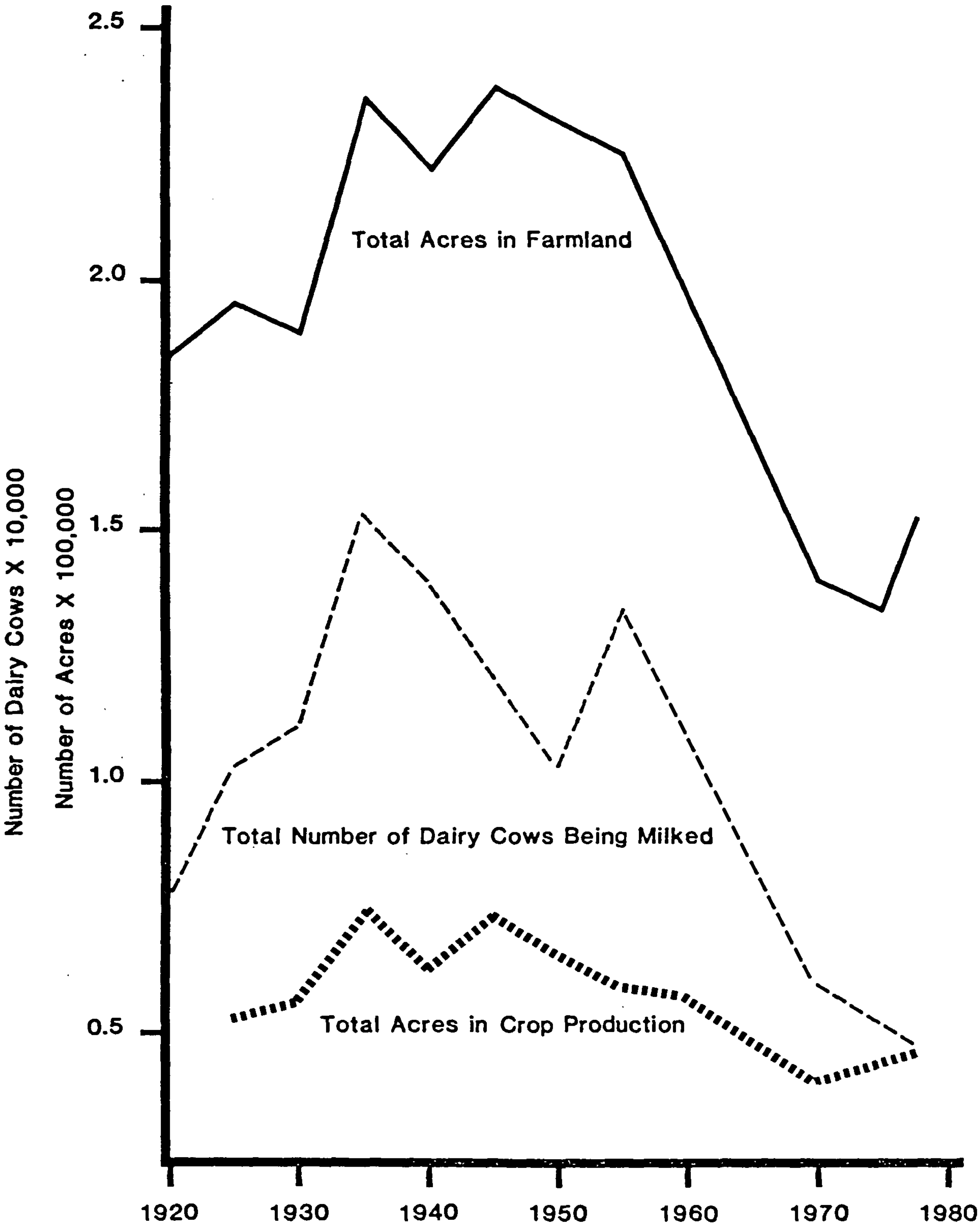
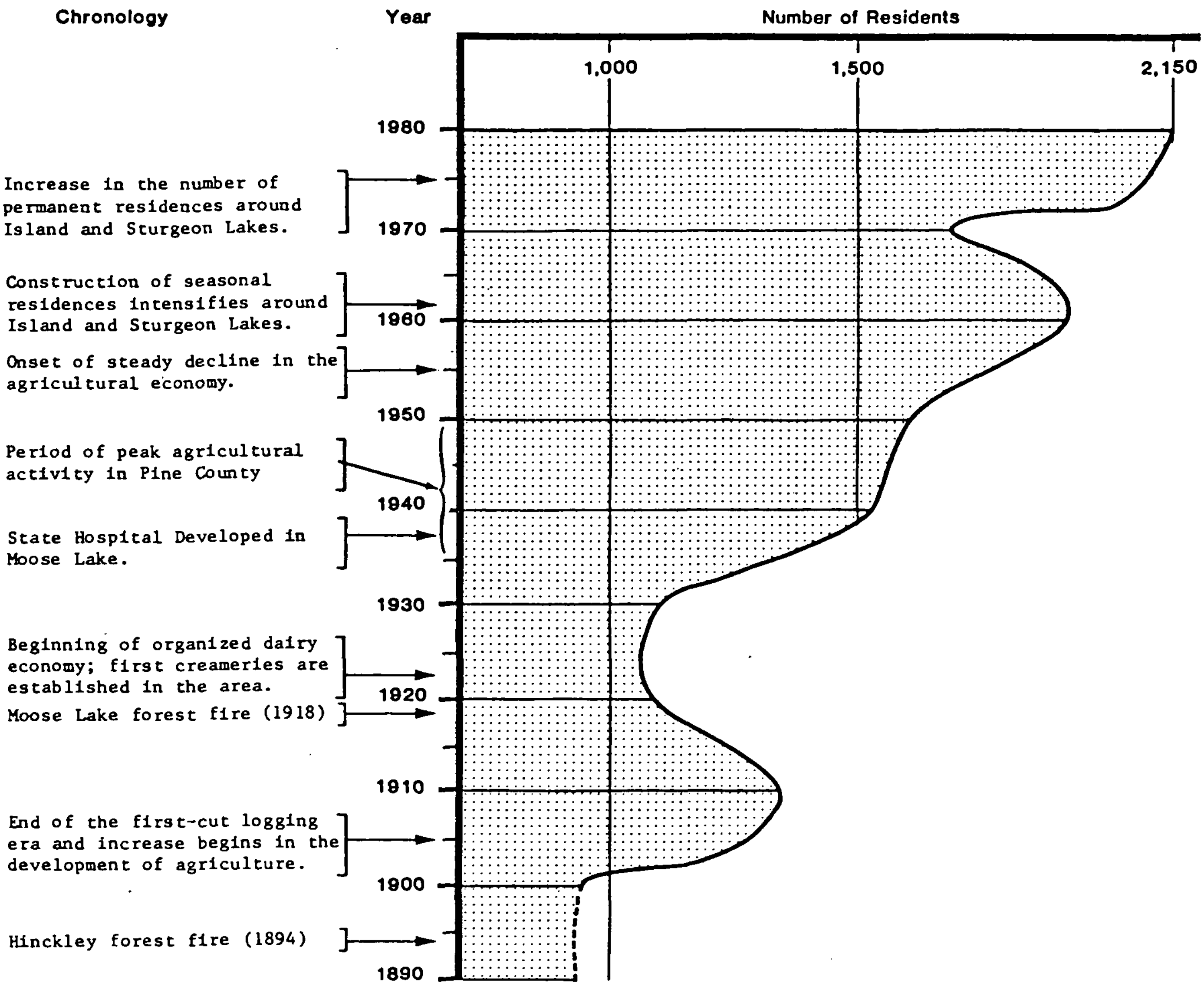


Figure 3-13. Carlton County, MN: trends in agriculture from 1920 to 1978. Data are from the U.S. Department of Agriculture, Census of Agriculture.

Figure 3-14. A chronology of 20th century events and trends in Windemere Township, Pine County, MN.



In a study of the forest cover of Pine and Carlton counties conducted by the US Forest Service in the period of 1974 to 1978 (Spencer and Ostrum 1979 and Vasilevsky and Hackett 1980) it was reported that 61% of Carlton County and 53% of Pine County was forested. Carlton County also was reported to have 87.4 thousand hectares of non-forested land, 51% of which was combined cropland, pastureland, and idle farmland. Pine County's 173.0 thousand hectares of non-forested land had 67% of the acreage in farm related uses. If the combined land use categories of cropland, pastureland, and idle farmland, as reported by the US Forest Service, are taken to define the total agricultural land use, Carlton County had approximately 44.6 thousand hectares of agricultural land and Pine County had 115.9 thousand hectares of agricultural land. Based on these figures, it is estimated that in 1978 a maximum of 19.7% of Carlton County and 31.3% of Pine County was being used for agricultural purposes. These percentages are compared with watershed agricultural land use percentages in the following section.

3.2.2.2. Project Area Land Use Trends

An examination of the trends in land use within the "watersheds" of the project area lakes is useful in assessing the past and present causes of lake eutrophication. The generalized watershed areas of Island, Sturgeon, Rush, and Passenger Lakes are presented in Figure 3-21. The generalized watershed areas were determined by contour interpolation of USGS topographic maps (1979). Field checks were made to confirm the watershed boundaries where alterations to the landscape have been made through highway and other construction activities.

The land uses within each watershed area were determined separately for direct drainage areas and for indirect tributary drainages using the topographic maps and aerial photographs (USGS 1974) along with review of color-infared remote sensing imagery (EMSL 1980) and field checks in the lakeshore vicinities. The aerial extent of each land use in a watershed's sub-area was estimated by planimetry for forest, wetland, cultivated land, pasture, lawn, and open water categories (excluding the surface areas of the lakes themselves). These watershed land use tabulations, summarized in Section 3.1.3.3. are referenced in Table 3-18 for comparison to county agricultural land use percentages.

Although the methodologies were not identical for estimating county and watershed land use, the differences found between the county and watershed percentages are great enough to indicate a significant divergence of the local (watershed) from the regional (county) land use pattern.

Table 3-18. Estimated percent agricultural land use in county versus watershed delineations.

Watershed	County	County Agricultural Land Use Percentage[a]	Watershed Agricultural Land Use Percentage[b]
Island Lake	Carlton/Pine	20%/31%	42%
Sturgeon Lake	Pine	31%	34%
Rush Lake	Pine	31%	3%
Passenger Lake	Pine	31%	0%

[a]Derivation of County percent agricultural land is explained in Section 3.2.2.1. Original data are from the US Forest Service (Spencer and Ostrum 1979 and Vasilevsky and Hackett 1980).

[b]By direct estimation from topographic maps and aerial photograph.

The most striking aspect of the information contained in Table 3-18 is the apparent predominance of agricultural land use in the Island Lake watershed. Island Lake has the largest total watershed area of any of the four lakes, and the percentage of agricultural land in its watershed is also the highest of the four. Additionally, the Island Lake watershed, which is bisected by the boundary between Carlton and Pine counties on the northern tip of the lake (Figure 3-15), has a much greater estimated agricultural land use percentage (42%) than either of the counties (20% Pine County; 31% Carlton County). Conversely, Rush Lake and Passenger Lake watersheds have little or no land in agricultural use.

The modern prevalence of agricultural land use that is apparent in the Island Lake watershed (Table 3-18) may have been preceded by an equal or even greater intensity of agricultural use in that area when dairying was a much more important segment of the local economy (Section 3.2.2.1). For example, there were 116 producing farms in Windemere Township in 1930 which accounted for 13,055 acres of land, 3,395 acres of which were in crop

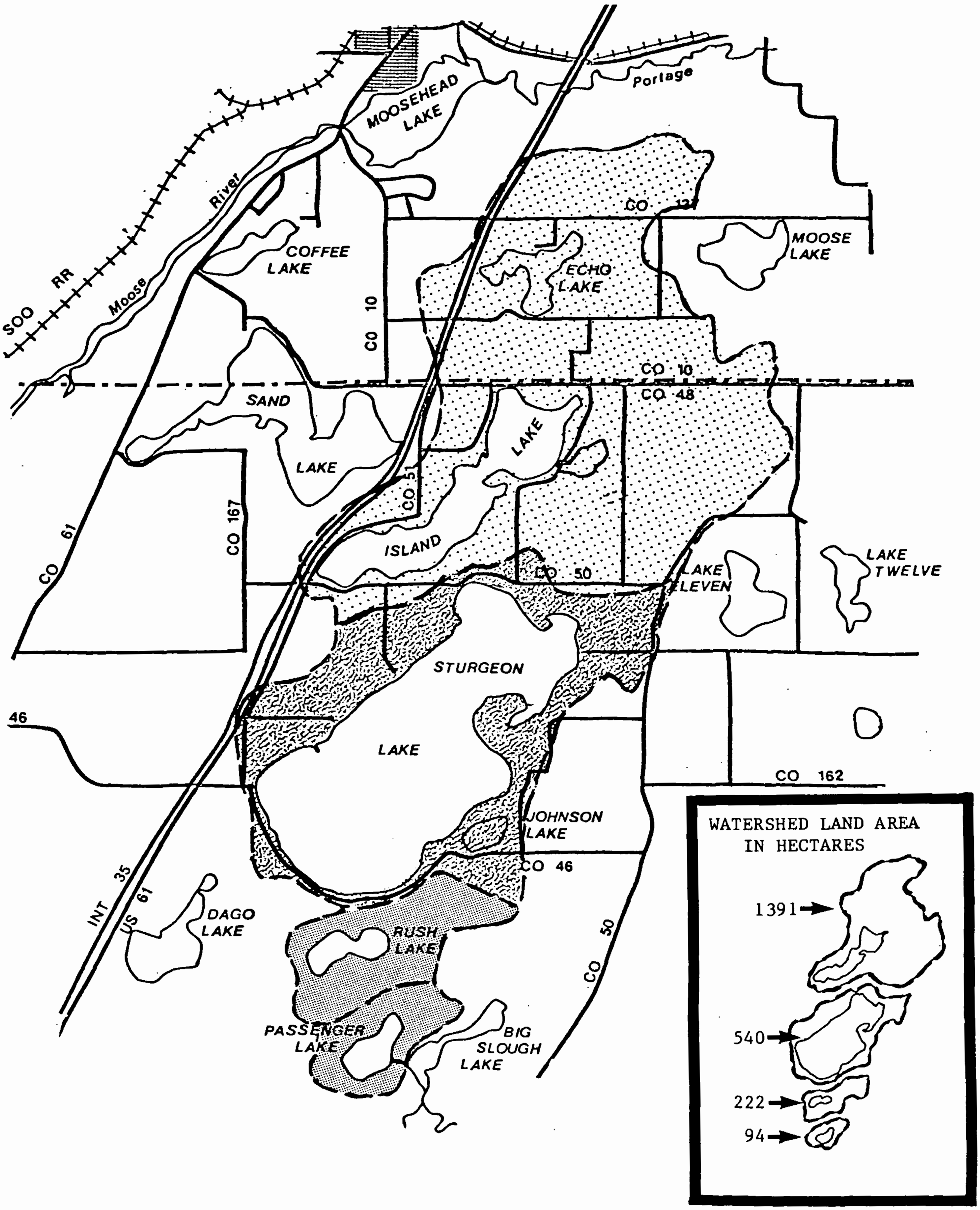


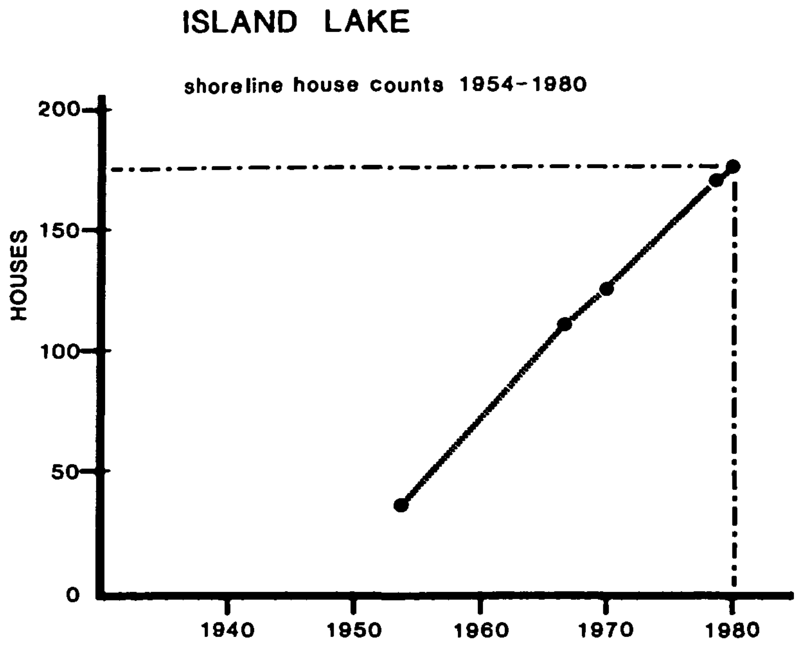
Figure 3-15. Generalized watershed areas for Island, Sturgeon, Rush, and Passenger Lakes. Values shown are exclusive of surface waters.

production (US Department of Commerce 1929). This represents the level of agricultural development in the Township which initiated the period of peak dairying activities in the region as reflected by the number of dairy cows being milked in Pine and Carlton counties between 1935 and 1940 (Figures 3-13 and 3-14). These data suggest that the Island Lake watershed historically supported a much larger dairy animal population than it now does. Much of the agricultural economy of the Windemere and Moose Lake Townships area appears to be concentrated in and around the watershed area of Island Lake and the northern portion of the Sturgeon lake watershed. This may be due to the concentration of prime agricultural land in these respective areas (Section 3.2.2.3). Long-time residents of the area have noted a concentration of productive farms in the direct drainage area of Island Lake and also have described the previous existence of several barnyards which gave domestic stock direct access to its waters (by letter, Mr. Walter C. Johnson to Mr. Gregory Dean Evenson, March 1980) [Appendix K].

Another significant land use trend pertinent to the assessment of the causes of lake eutrophication is the rate of development of lakeshore properties for residential use. In 1954, there were an estimated 35 houses located adjacent to Island Lake but, by 1967, 110 houses were counted around Island Lake (MDNR n.d. Fish and Wildlife Division, lake survey data sheets, unpublished). Sturgeon Lake also has experienced an increased rate of residential development since the 1950s. The rates of shoreline development around Island and Sturgeon Lakes since 1954 are depicted in Figure 3-16.

3.2.2.3. Prime Farmlands

One of the increasing concerns in the nation is the reduction in the finite supply of prime farmland. Prime farmland is that land best suited for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses. According to the most recent Council on Environmental Quality directive (11 August 1980), prime and unique farmland is cropland, pastureland, rangeland, forest land, or other land (excluding built-up urban land) which is capable of being used as prime and unique farmland



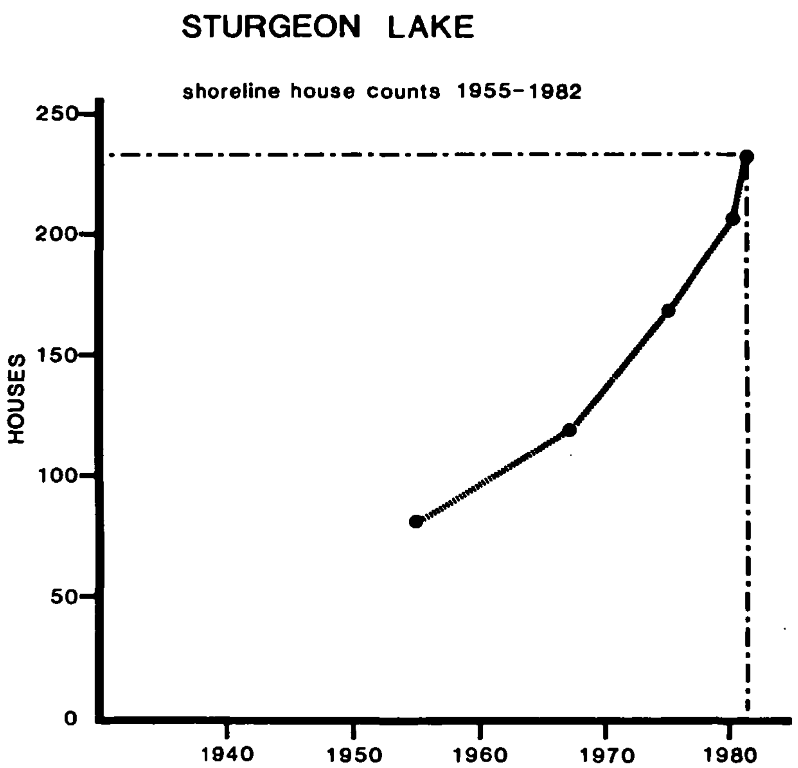


Figure 3-16. Rates of residential development on the shorelines of of Island and Sturgeon Lakes.

as defined by the specific criteria established by the USDA. The primary criterion used to characterize prime farmland is the capability class and subclass assigned to soils and which show, in a general way, the suitability of soil capability classes I and II. Class I soils have few limitations that restrict their use and Class II soils have only moderate limitations that reduce the choice of crops or that require moderate conservation practices. There are no Class I soils in Carlton County or in the Island and Sturgeon Lakes area of Pine County (SCS 1978, Finney 1981).

Capability subclasses are soil groups within one soil class that characterize more specific limitations such as erosion, wetness, shallowness, or climatic limitations (e.g., too dry, too cold, etc.). The only soil in the project area that can be characterized as prime farmland is the Duluth very fine silt loam with 0 to 6% slopes (SCS 1978). This soil has been assigned a capability rating of IIc-1. This classification indicates that the main limitations of the soils are the cool climate and short growing season.

Although a detailed soil survey of Pine County has not been prepared, the soils in the Pine County portion of the service area were mapped by a registered soil scientist in support of the preparation of this Environmental Report (Appendix B). This soils mapping indicated that much of the service area, including Island Lake's direct drainage basin as well as much of the northeastern half of the Sturgeon Lake watershed, contain Duluth very fine silt loam with less than 4% slopes (Figure 3-17). (The Duluth very fine silt loams in Pine County were delineated either as having slopes less than or greater than 4%. Therefore, the area in Pine County depicted in Figure 3-17 slightly understates the amount of prime farmland because it does not indicate those unmappable areas of Duluth very fine silt loams with 4 to 6% slopes which can be characterized as prime farmland.)

3.2.2.4. Development Potential

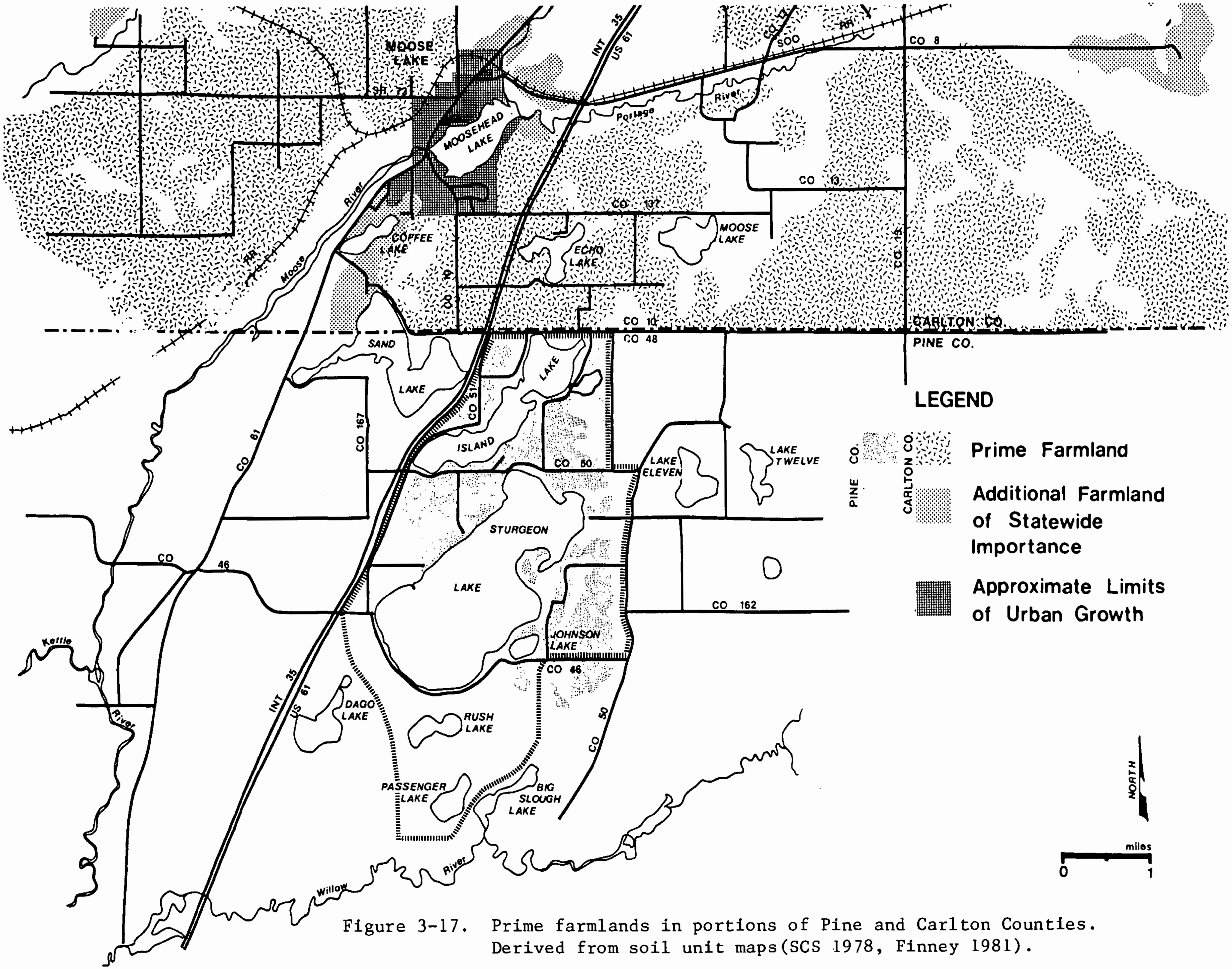


Figure 3-17. Prime farmlands in portions of Pine and Carlton Counties. Derived from soil unit maps(SCS 1978, Finney 1981).

Development Controls

Windemere Township does not have an overall zoning ordinance in effect to control development. However, Pine County has adopted zoning regulations as required by the Minnesota Shoreland Management Act of 1969. The Act affects all land within 1,000 feet of a lake, pond, or flowage and within 300 feet of a river or stream. In rural area, the Act applies to all lakes over 10 hectares (25 acres) in area and to rivers and streams with drainage areas in excess of 518 hectares (1,280 acres).

The purpose of the Act and the accompanying local regulations is to control development alongside lakes, rivers, and streams so that the natural resource values of the water body are maintained to the greatest extent possible. Public waters are classified according to the Act in one of three categories - Natural Environment, Recreational Development, or General Development. The different classifications control the kind of intensity of development by regulating uses, building and sewer setbacks, and minimum lot sizes. Island, Sturgeon, Rush, and Passenger Lakes are all classified as Recreational Development lakes (By telephone, Mr. Steve Preston, MDNR to WAPORA, Inc., 26 February 1981). The minimum development standards for unincorporated, unsewered areas around recreational development lakes are:

Lot area: 40,000 ft^2

Water frontage and lot width: 150 ft

Building setback from ordinary high water mark: 100 ft

Building setback from roads and highways: 30-50 ft

Building elevation above highest known water level: 3 ft

On-site waste treatment system setback from ordinary high water mark: 75 ft

Septic absorption system elevation above groundwater or bedrock: 4 ft

The minimum development standards for sewered areas of municipalities that are within the shoreland zone of recreational development lakes are less stringent. The required minimum lot sizes for such areas are 20,000

ft^2 for riparian lots and 15,000 ft^2 for other lots within the shoreland zone. In addition, the water frontage and lot width requirement is 75 feet and the minimum building setback from the ordinary high water mark also is 75 feet. MDNR has indicated that the less rigorous minimum development standards applied within municipalities may also be applied to sewered, non-municipal (i.e., unincorporated) lakes (By telephone, Mr. Steve Prestin, MDNR to WAPORA, Inc., 26 February 1981).

Future Development Potential

Although water-related recreation and similar amenities continue to attract new residents, the focus of the demand generated by the natural resource values of the project area lakes appears to be shifting. According to the 1980 census, the population growth rate exceeded the growth rate for new housing units during the 1970. This means that some seasonal homes were converted to year-round residences and that more homes were built for permanent use than for seasonal, recreational use. This most recent trend apparently is a result of retired people moving to the area on a permanent basis, and the desire of some people to live in a high amenity, rural area and commute long distances to work. Continued growth of the non-retired permanent population will be significantly influenced by several external factors including the regional economy, the price of gasoline, and long-distance commuting costs.

Much of the lakeshore development activity within the service area over the last 30 years has been concentrated around Island and Sturgeon Lakes. As a result, there now is a limited supply of vacant lakefront lots around these two lakes. Based on a house count and examination of plat maps and tax records, it is estimated that there are approximately 50 vacant lakefront lots around Island Lake and approximately 105 vacant lakefront lots around Sturgeon Lake. This estimate does not reflect development constraints such as wet soils, steep slopes, lack of road access, or other natural features. If current growth rates are maintained, both of these lakes will become "built-out" during the planning period. After this occurs, it is possible that some housing demand will continue in this area and will translate into development around the smaller lakes in the service area (e.g., Rush and Passenger Lakes), in the second-tier or back lots, or around other small, less desirable lakes in outlying areas.

Whether the high growth trends of the 1970's will continue through the next 20 years is uncertain. One local realtor that was contacted felt that the Island-Sturgeon Lake area still has a lot of growth potential and that second-tier lots or homes are in demand, particularly to retirees and young couples, because of their lower cost (By telephone, Ms. Ann Brown, Century 21 Real Estate to WAPORA, Inc., 12 April 1982). One subdivision development that exemplifies the basis of this opinion is the Wild Acres - Hogan Acres projects located to the southeast of Sturgeon Lake and east of Rush Lake. All of the 92 lots platted in the Hogan Acres have been sold and more than 100 of the 136 platted lots in Wild Acres have been sold. Although most of the lots have been sold, many of the buyers apparently do not intend to develop their parcels immediately. There are an estimated 75 structures permanently inplace in the two subdivisions, including standard homes, manufactured homes, and campers. Many of the other lot owners leave campers on the property only during the summer and then spend weekends in the area for recreation. The developer intentionally structured the development in this way and uses this aspect of the project as a marketing device. One of the developer's brochures states: "It is not necessary to build on the lots. The use of mobile homes, travel trailers, campers, motor homes, and tents is allowed."

Other realtors are less optimistic about the development potental of the area. The most common reasons cited are the generally soft local and regional economies and the absence of employment opportunities, particularly for young people (By telephone, Mr. Bud Fuller, Ken Brown Realty to WAPORA, Inc., 12 April 1982). Although all of the realtors contacted indicated that demand for lakefront lots or homes continues to be strong, they also noted that most of the prime lakefront areas are already developed. In spite of the good sales history at Wild Acres - Hogan Acres, other realtors have not had good success in selling homes or lots in the second tier or in outlying areas. For this reason, they are are less optimistic about the development potential of the area (by telephone, Mr. Clarence Schoen, Clarence Schoen Realty to WAPORA, Inc., 12 April 1982).

3.2.3. Economics

3.2.3.1. Income

Current data on median family income are available from the US Department of Housing and Urban Development (HUD) Office of Economic Affairs (Data from the 1980 Census are not yet available). These data are available at the county level only and were derived from statistical adjustments of previous census data. Although the county estimates are reasonably accurate, the use of the data for jurisdictions within a county is tentative and their applicability will depend on the relative wealth or poverty of the area as compared to the county.

The level of income in the project area and Pine and Carlton counties as indicated by per capita and median family income data, is relatively low (Table 3-19 and Table 3-20). In 1981 the estimated median family incomes of $17,000 for Pine County and $21,100 for Carlton County both were below the estimated median family incomes of Non-Standard Metropolitan Statistical Area (SMSA) counties ($22,850), the North Central Census Region ($25,600), and the US ($24,400) (By telephone HUD). The relatively low level of income characteristic of the project area and Pine and Carlton counties reflects the concentration of employment in the relatively low-paying trade, government, and service industries and the high level of unemployment (Section 3.2.3.2. Employment).

The income distribution within the project area varies widely. The estimated median family income ranges from $16,275 in Moose Lake Township to $26,356 for the City of Moose Lake. The estimated median family income for Windemere Township is $21,132. This is 24% greater than the estimates for Non-SMSA counties, the North Central Census Region and the US. The estimated median family income in the City of Moose Lake is greater than the estimates for all of the jurisdictions for which data were analyzed. This probably reflects the economic function of the City of Moose Lake as a primary trade center (Section 3.2.3.2. Employment).

Table 3-19. Per capita income estimates for selected jurisdictions (US Bureau of the Census 1972, 1980).

Jurisdiction	1969 ($)	1977 ($)	Percent Change 1969-1977	Estimated 1981 Income ($)
Pine County	2,183	4,054	86%	5,797
Windemere Township	2,657	5,004	88%	7,206
Carlton County	2,513	4,731	88%	6,813
Moose Lake Township	1,705	3,457	103%	5,255
City of Moose Lake	3,147	5,909	88%	8,510
State of Minnesota	3,038	5,778	90%	8,378

Table 3-20. Estimated 1981 median family income for selected jurisdictions.

Jurisdiction	Median Income Estimates ($)
Pine County	$17,000
Windemere Township	21,100
Carlton County	21,100
Moose Lake Township	16,275
City of Moose Lake	26,356

3.2.3.2. Employment

The economic structure of the project area and surrounding region (Northeastern Minnesota: Aitkin, Carlton, Cook, Itasca, Koochiching, Lake, and St. Louis counties [Region 7] and Pine County) contrasts with the economic structure of Minnesota and the US in some very important ways. First, the dominant industry in northeastern Minnesota is trade (concentrated in the Moose Lake and Duluth-Superior areas), whereas at the State and National level, manufacturing is the dominant industry (Northeastern Minnesota Labor Market Information Center 1980). In 1978, manufacturing employment in northeastern Minnesota accounted for 13.9% of the wage and salary workers as compared to the statewide percentage of 22.1. This is particularily important because overall the trade industry traditionally has been associated wth low wages (especially retail trade) and is very sensitive to cyclical variations in the economy (e.i., when "spending money" becomes tight many of the goods and services available through the trade industry are not consumed, thus levels of employment decrease).

Second, in 1978 the mining industry was the largest industry in northeastern Minnesota in terms of wages paid, but ranked fifth in total employment. This is not characteristic of the State and National employment structures where the manufacturing industry is the largest industry in terms of both employment and total wages paid (Peterson and Gronseth 1980). This also is important because any changes in the level of employment in the mining industry would quickly affect other sectors of the economy, especially port activity (concentrated in the Duluth-Superior area), which also plays an important role in the economy of the region. In 1979, the value of income generated by port activities from wages paid and the purchase of goods and services amounted to $239 million (Northeastern Minnesota Labor Market Review 1980).

In April 1982, Pine County had an estimated labor force of 9,549 and an unemployment rate of 10.3% (By telephone, Patrick Connelly, East Central Region Development Commission, to WAPORA, Inc., 12 July 1982). During the same month, Carlton County had an estimated labor force of 11,900 and an unemployment rate of 11.4%. The unemployment rates for the two counties compares to an unemployment rate 9.8% for Region 7, 13.6% for Region 3, 7.0% for the State and 9.2% for the US. The comparatively high unemployment rate for Region 3 is a result of the weakness of those national industries that are most directly tied to the regional economy. In April 1982, less than one-half of the steel industry's potential capacity was being utilized and this had a direct impact on the need for taconite produced on the Minnesota Iron Range and hence on local employment levels (Minnesota Department of Economic Security 1982).

The local economy in Windemere Township differs somewhat from that of Pine County or the region in that agriculture and forestry are the predominant industries. Not including agriculture, an employment survey counted 54 people employed in Windemere Township (Pine County Area Redevelopment Organization 1979). The greatest potential for economic development in Pine County probably is in the tourism-recreation industry.

Only 3.5% of the County's total gross sales are from the tourist-traveler, and Pine County currently ranks 53rd out of 87 counties in Minnesota in tourist-travel income. The relatively modest contribution of tourism-recreation to the county economy probably is not indicative of the contributions that tourism-recreation make to the more local economy of Windemere Township (Pine County Area Redevelopment Organization 1979).

At present there are approximately 127 business establishments in the Moose Lake area (Moose Lake Planning Commission 1980). Fifty-three of the businesses (42%) are categorized as retail and wholesale sales establishments. This category includes grocery stores, clothing stores, and wholesale distributors. In 1977, there were $10,146,312 in retail sales in Moose Lake, and it is estimated that this could increase to $12,000,000 annually by 1985. Moose Lake is considered the primary retail trade center for a fairly large area. The trade zone of Moose Lake includes the cities of Moose Lake, Barnum, Kettle River, Sturgeon Lake, Denham, and Kerrick, and the Townships of Moose Lake, Barnum, Silver, Split Rock, Birch Creek, Kerrizk, Sturgeon Lake, and Windemere.

3.2.4. Public Finance

A variety of community services are provided for the residents of Moose Lake and Windemere Townships. Among them are health and welfare services, transportation facilities, police and fire protection and, within the city of Moose Lake, wastewater collection and treatment. The ability of the townships to maintain and improve these services is dependent on the continued ability of township residents to finance them. Income and employment levels are one measure of a community's ability to support community services. Additionally, the assessed valuation of property directly affects tax revenues collected by local governments, and consequently their financial capabilities. The amount of outstanding indebtedness and annual debt service borne by a community also affects the communits capability to finance public works projects. The 1980 assessed valuation, property tax, total revenue, outstanding indebtedness, and debt service for the jurisdictions within the project area are presented in Table 3-21.

Table 3-21. Selected financial characteristics of the project area jurisdictions in 1980 (Carlson 1982a, 1982b; by telephone, Minnesota Department of Revenue to Wapora, Inc., 4 June 1982; by letter, Mr. Harold Westholm, Moose Lake-Windemere Sanitary District to WAPORA, Inc., 2 April 1982).

Jurisdiction	Assessed Valuation ($)[a]	Full Market Value ($)[b]	Debt ($)[c]	Debt Service ($)[d]	Property Tax ($)[e]	Total Revenue ($)[f]
Windemere Township	3,310,539	11,377,679	-0-	-0-	32,925	56,362
Moose Lake Township	1,701,968	5,812,784	-0-	-0-	50,037	27,300
Moose Lake-Windemere Sanitary District	4,552,404	17,190,463	1,295,551	82,100	23,982	1,381,989
Pine County	46,876,244	-	120,000	20,000	2,523,087	9,699,480
Carlton County	88,981,157	-	750,000	-	3,714,732	11,332,481
Moose Lake School District	10,529,509	-	245,000	78,807	545,043	-
City of Moose Lake	2,608,374	-	540,000	22,000	52,305	363,138

[a] The value of all taxable general property as determined by the municipal assessor.

[b] The value of all taxable general property as determined by the Minnesota Department of Revenue. This value is determined independently of the assessed value and reflects actual market value.

[c] General obligation bonds, long-term notes, revenue bonds, and installment contracts.

[d] Debt payment = principal + interest.

[e] State, County, local, and school property tax levies.

[f] Total revenues for general operations.

Criteria for prudent fiscal management have been developed by several authors, and an adaptation of these criteria is presented in Table 3-21. These recommended standards can be compared with relationships developed from the previously discussed municipal data (Table 3-22) to assess local financial conditions. Based on these criteria, the financial condition of the MLWSD in 1980 appears to be sound. All of the values for the MLWSD fall below the limits given in Table 3-23. However, the indicators concerning debt to full market value and debt to personal income are close to the standard upper limits. This appears to be the result of the relatively large debts that the MLWSD has incurred for the Sand Lake and Coffee Lake improvement projects. If additional large debts are undertaken in the near future, it is possible that some of the standard upper limits would be exceeded. This would depend, though, on the retirement schedule for outstanding debts and the amount of capital needed for improvement projects.

Table 3-22. Values for Moose Lake-Windemere Sanitary District full-faith and credit debt analyses during 1980.

1980 Population	Debt Per Capita ($)[a]	Debt to Full Value (%)[a]	Debt Service to Revenue (%)	Debt to Income (%)[a]
3,817	394	8.7	5.9	6.0

[a] Debt includes school and county debt apportioned on the basis of the Sanitary District's percentage of the assessed valuations of the school district and counties.

Table 3-23. Criteria for local government full-faith and credit debt analysis (Adapted from Moak and Hillhouse 1975 and Aronson and Schwartz 1975).

Debt Ratio	Standard Upper Limit for Debt
Debt per Capita	
Low Income	$ 500
Middle Income	1,000
High Income	5,000
Debt to Market Value Property	10% of current market value
Debt Service to Revenue	25% of the local government's total budget
Debt to Personal Income	7%

Households in the MLWSD pay a user fee of $4.00 per month. This represents an annual user fee of $48. The monthly fee includes $3.25/month for operation and maintenance, $0.50/month for use of the City of Moose Lake's waste treatment plant, and $0.25/month for District administrative costs. In addition to the user fee, users are assessed a connection charge payable over a 30-year period. Users around Coffee Lake are assessed $2,150 for connecting to the system. The assessment is $2,900 for users around Sand Lake. Assuming that a user presently is paying the annual user fee and the assessment, the typical total annual charge to users around Coffee Lake and Sand Lake is $120 and $145, respectively.

3.2.5. Transportation

The private automobile is the primary mode of transportation in the project area. County Highway CH10 and CH46 are the major, paved thoroughfares in the project area. Interstate 35 (I-35), which is located just west of the proposed service area, is a limited access highway and facilitates accessibility north to Duluth (approximately 45 miles) and south to Minneapolis-St. Paul and beyond. There is a full traffic interchange on I-35 at CH 46. Although most of the other roads in the project area are either sand or gravel surfaced, the annual average daily traffic (adt) is equal to or greater than the adt on other roads for which data were available in most of northwestern Pine County (Minnesota Department of Transportation [MNDOT] 1979); Appendix M. The adt on I-35 within Pine County increases from north to south indicating heavier traffic away from Duluth. On State Highway 61, the main thoroughfare to Moose Lake, the adt increases from south to north indicating heavier traffic toward Moose Lake.

The closest automatic traffic recorder (atr) station to the project area is located 1.5 miles east of County State Aid Highway (CSAH) 21, south of the project area near Sandstone MN. Seasonally adjusted monthly adt indicate that adt peaks in November (MNDOT 1981; Appendix M). Data on the total daily volume indicate that the highest adt occurs on Saturday. These phenomena reflect the autumn season, hunting-generated traffic which is greater than the summer season, recreation-generated traffic.

The other modes of transportation available in or in close proximity to the project area are: Senior citizen bus service, railroad, and airplane. The Pine County Committee on Aging operates an 11-passenger bus five times a month for medical services and provides transportation services to 12 Senior Citizen Centers located throughout Pine County (By telephone, Ms. Pearl Oleson, President, Pine County Committee on Aging to WAPORA, Inc., 12 July 1982). The nearest commercial airport is located at Duluth. Numerous intermediate airports are located in the vicinity of the project area. Burlington Northern, Inc. and Soo Line own and operate rail facilities in the vicinity of the project area.

3.2.6. Energy

There are four types of energy available for space heating and appliance use in the project area: fuel oil, liquid propane gas (lp gas), wood, and electricity. Natural gas is not available in the service area, but is available in the City of Moose Lake. There are no published data available on consumption patterns in the area and local opinion varies. Wood, lp gas, and fuel oil are most commonly used for space heating (By telephone Mr. J. Sanders, Carlton-Aitkin-Pine Cooperative Oil Association; Mr. C. Chmielewski, Chmielewski Oil Company; and Roger Davidson, Carlton County Cooperative Power Association to WAPORA, Inc. 14 June 1982). Electricity is not a popular choice for space heating unless it is used at an off-peak reduced rate as a back-up for wood (Mr. Roger Davidson, Carlton County Cooperative Power Association to WAPORA, Inc., 14 June 1982). The use of wood for space heating has increased in recent years. A back-up system which requires either lp gas, fuel oil, or electricity is necessary. Electricity, followed by lp gas and fuel oil is most commonly used for appliances. There are no major commercial, industrial, or retail energy consumers in either the project area or the City of Moose Lake. The state hospital in Moose Lake is the biggest consumer in the area (By telephone, Mr. L. Johnson Moose Lake Municipal Power Plant to WAPORA, Inc., 11 June 1982).

Pine County is located in State Planning Region 7E and Carlton County is located in State Planning Region 3. In terms of the cost for residential energy these two regions ranked approximately seventh and fourth, respectively, out of the thirteen state planning regions (Table 3-24.). The differences in total cost reflect both differences in unit cost and in degree heating days. The unit cost for the various forms of energy is higher in Region 3 (Carlton County) than in Minnesota as a whole. This also is true in Pine County, except for natural gas which is less expensive than the state-wide average (Appendix N.).

Table 3-24. Average cost for residential energy during the period from April 1980 to March 1981 (Minnesota Energy Agency 1981).[a]

Region	Use	Fuel Type			
		Natural Gas	Electricity	Fuel Oil	LP Gas
3 (Carlton County)	Space heating	$703	$ 978	$1,281	$1,107
	Total energy	988	1,562	1,865	1,640
7E (Pine County)	Space heating	490	994	1,101	1,064
	Total energy	849	1,585	1,692	1,616

[a] Data are not available for wood. A full cord of wood is estimated to cost approximately $50 (By telephone, Mr. C. Chmielewski, Chmielewski Oil Company to WAPORA, Inc. 14 June 1982).

There are no restrictions foreseen on natural gas hook-ups in the Moose Lake area at this time (By telephone, Intercity Gas Limited to WAPORA, Inc., 11 June 1982). Electrical energy in the service area is supplied by the Carlton County Cooperative Power Association. The Moose Lake Municipal Power Plant supplies electricity to the City of Moose Lake. Both of these suppliers purchase electricity from United Power Association (UPA) of Elk River, Minnesota. UPA owns a 2-year old generating station in North Dakota which currently is operating at 50% of its capacity. There are currently no foreseen shortages of either lp gas or fuel oil.

3.2.7. Recreation and Tourism

The tourism-travel industry is not considered a major industry in Pine County (East Central Regional Development Commission [ECRDC] 1981). However, there are indicators that the industry is growing as energy costs inhibit long-distance travel and Twin Cities vacationers seek recreational opportunities closer to home. The 1979 gross sales for the tourism-travel industry in Pine County was $1,880,000 (By telephone, Mr. Igmar Sollin, Minnesota Department of Tourism to WAPORA, Inc., 14 June 1982). The estimated cost breakdown is shown below:

$376,000	lodging
470,000	transportation
507,000	food and beverage
414,000	retail and other services
113,000	amusements and other miscellaneous

The gross sales in the tourism-travel industry accounted for 3.5% of the total gross sales in Pine County during 1979 (By telephone, Mr. Patrick Connelly, ECRDC to WAPORA, Inc. 14 July 1982). This figure can be considered significant to Pine County where trade is the largest employment sector. In comparison to tourism-travel sales statewide, however, Pine County sales are less significant, accounting for only 0.10% of the statewide sales during 1979 (By telephone, Mr. Igmar Sollin, Minnesota Department of Tourism to WAPORA, Inc., 14 June 1982).

The tourism-travel industry in the project area primarily consists of private development. There is a public access area on each of the four lakes. There are two resorts in the project area, both of which are on Sturgeon Lake. The Eidelweiss Campground has six cabins and 60 campsites (By telephone, Ms. Sheldine Ion, Eidelweiss Campground to WAPORA, Inc., 14 July 1982). Ray and Marges Resort has cabins and a bar. Both resorts rent small fishing boats.

Fishing is the major recreational activity on the service area lakes, although pleasure boating is a major recreational activity on Sturgeon Lake and Island Lake. There are private piers and swimming beaches only. There are no public parks or marinas in the project area (By telephone, Mr. Don Clausen, Moose Lake Village Clerk to WAPORA, Inc., 14 July 1982).

3.2.8. Cultural Resources

Both the National Register of Historic Places and the Minnesota State Historic Preservation Officer (SHPO) were consulted concerning the archaeological and historic resources within the MLWSD (Appendix). There are currently no known resources within the project area that are listed in or considered eligible for inclusion to the National Register of Historic Places.

3.2.8.1. Historic Sites

The following sites have been identified by the SHPO as being located within the boundaries of the EIS project area:

- 21 PN 6 - A group of 14 mounds located near Sturgeon Lake. Section 20, T45 R19, Pine County
- 21 PN 18 - Two mounds located near Eidelweiss Resort on Sturgeon Lake. Section 20, T45 R19, Pine County
- 21 PN 19 - Historic archaeological site (Charcoal Kilns) located in Section 20, T45 R19, Pine County
- Unnumbered site located in Sections 16 and 21, T45 R19, Pine County.

The SHPO has stated that Pine Cunty has been surveyed recently for historic, standing structures. While no structures were determined to be eligible for the National Register of Historic Places, one site of local historic interest was identified within the proposed service area. This site is the original YMCA Boys Camp containing the original Camp Miller Log Cabin structure, located in the southern half of Section 17, Township 45N Range 19 W (southwest shore of Sturgeon Lake). This structure was constructed prior to 1920 and is listed as being in good condition according to the records of the SHPO.

3.2.8.2. Archaeological Sites

While few archaeological sites have been recorded within the boundaries of the project area, it is the opinion of the SHPO that this absence is related to a lack of systematic surveys for the area rather than an actual absence of resources. The SHPO has stated that an archaeological survey may be necessary for the service area. Final recommendations on the necessity of a survey will be withheld pending review of the final project alternative.

4.0. ENVIRONMENTAL CONSEQUENCES

The potential environmental consequences of the project alternatives described in Section 2.4. are discussed in the following sections. The impacts resulting from the construction and operation of the alternatives may be beneficial or adverse, and may vary in duration and significance. A summary of the significant impacts of project alternatives is presented in Table 4-1.

Environmental effects are classified as either primary or secondary impacts. Primary impacts result directly from the construction and/or operation of the proposed facilities. Short-term primary impacts generally occur during construction. Long-term primary impacts result from the operation of the proposed project.

Secondary impacts are indirect effects of the project, such as changes in demographic and other socioeconomic characteristics. As these changes occur, other impacts which may result include: air or water pollution, increased noise levels, increased energy consumption, increased development pressure, diminished wildlife habitats, increased employment or business activity, and increased property values. Secondary impacts also may be either short-term or long-term. An example of a short-term secondary impact is the disruption of the environment that occurs during the construction of secondary development. Long-term secondary impacts can result, for example, from urban runoff that occurs for an indefinite period after development of agricultural land or undeveloped areas.

Measures to control or mitigate adverse impacts are also discussed in this chapter. These measures include planning activities and construction techniques that can reduce the severity of both primary and secondary adverse impacts. The use of appropriate mitigative measures should be stipulated as an integral part of all project plans and specifications developed by the Sanitary District.

Table 4-1. A summary of significant environmental impacts of Project Alternatives.

PRIMARY IN NATURE / SECONDARY IN NATURE	ADVERSE IMPACTS	BENEFICIAL IMPACTS
Construction of the Project	Project Alternatives 4 through 7 could cause short-term water quality degradation during construction of centralized collection and treatment facilities. See Section 4.1.1.3.	
Construction of the Project	Project Alternatives 2 through 7 would have short-term impacts on backyard vegetation and on vegetation and wildlife in sewer corridors and at treatment sites. Alternative 5 would have significant short-term impacts on wildlife due to construction of exclusionary fence. See Section 4.1.1.5.	
Operation of the Project	Project Alternative 5 could have long-term impacts on the groundwater and biota at the site of treatment. See Sections 4.1.2.2. and 4.1.2.5.	
Operation of the Project	Project Alternative 5 could have long-term impacts on the peat soils at the treatment site. See Section 4.1.2.2.	
Operation of the Project	Project Alternative 7 is a high cost system that could pose a significant financial burden on users even if State and Federal grants are available. Project Alternative 2 is the only alternative that would not pose a significant financial burden on users if no grants are available. See Section 4.1.3. for details.	
Operation of the Project	Project Alternatives 2 through 7 may have a significant secondary impact on low income families with residences on the shorelines of Island and Sturgeon Lakes. These families may be displaced from the project area if they are unable to afford user charges. See Section 4.2.2. and Table 4-4 of Section 4.1.3.	

4.1. Primary Impacts of the Seven Project Alternatives

4.1.1. Construction Impacts

Each of the alternatives involves some construction initially, including the No-Action Alternative, which incorporates some construction of new systems and upgraded systems in the course of the 20-year design period. Evaluation of the impacts associated with the No-Action Alternative is discussed with operational impacts in Section 4.1.2. Construction impacts for Alternatives 2 through 7 (the "action" alternatives) are addressed in the following subsections for each of the major elements of the natural and man-made environments.

4.1.1.1. Atmosphere

Construction activities for Alternatives 2 through 7 will produce short-term adverse impacts to local air quality. Cleaning, grading, excavating, backfilling, and other related construction activities will generate fugitive dust, noise, and odors. Emissions of fumes and noise from construction equipment will be a temporary nuisance to residents living near the sewer pipe construction corridor and near the treatment facilities.

4.1.1.2. Soils

Soils exposed during construction will be subjected to accelerated erosion until the soil surface is protected by revegetation or other means. Most of the force mains will be laid within road rights-of-way where runoff tends to concentrate in roadside drainageways, but some sewers will be laid through residential yards.

Major storms could cause considerable erosion in some drainageways or on lots on steep slopes. The alternatives that involve the construction of considerable lengths of sewers and force mains can be expected to result in the greatest amount of erosion and subsequent sedimentation. Adverse consequences due to increased sedimentation include additional phosphorus inputs to lakes and streams, clogging of road culverts, localized flooding where drainageways are filled with sediment, and localized filling of the lake bed so that a substrate for aquatic plant growth is provided.

4.1.1.3. Surface Water

Wastewater collection system and treatment plant construction activities (Alternatives 4 through 7) could produce discharges of turbid waters pumped from excavations and trenches, and turbid surface runoff from disturbed areas, resulting in increased turbidity and sedimentation in adjacent wetlands or lakes. This sediment transport could result in water quality degradation, and has the potential to result in adverse impacts to aquatic biota. Upgrading on-site systems (Alternatives 2 through 7) and construction of collection systems for cluster drainfields (Alternatives 3 through 6) also would contribute turbid runoff to lakes or waterways, but to a lesser extent compared to the construction of the centralized collection and treatment alternatives.

4.1.1.4. Groundwater

Groundwater may be impacted by construction activities in localized areas. Construction dewatering may cause some shallow wells to fail, especially where pump stations are to be constructed. A potential change in water quality would likely occur where organic soils are disturbed either directly or by altering the water table. Organics may leach out of these areas and affect the taste of water in nearby wells. Spilled fuel and other construction materials could quickly pass through the sandy soils to contaminate the groundwater.

4.1.1.5. Biota

Construction activities associated with various components of the proposed alternatives would result in impacts to wildlife and vegetation to various degrees. Collection sewers (Alternatives 4 through 7) and upgraded systems (Alternatives 2 through 7) would be placed on residential lots; temporary loss of grassed areas and the removal or death of trees would result from construction of these facilities. Disruption of backyard gardens, shrubs, and lawns, and the presence of construction equipment and noises, would cause temporary displacement of most vertebrate species and mortality of a few (probably small mammal) species, but replacement of vegetation and cessation of construction activities would allow re-establishment of the animals to the areas. More likely the animals commonly associated with human habitation (e.g., cottontail rabbits, house sparrows, European starlings) that would be displaced would move to suitable neighboring habitats but would not induce density-related stress upon those habitats.

A bog treatment system (Alternative 5), cluster drainfields (Alternatives 3 through 6), and an upgraded lagoon (Alternatives 4, 6, and 7,) would adversely affect vegetation and wildlife during construction, depending upon the proposed sites. Establishment of exclusionary fences around the bog treatment site would disrupt feeding and migration habits of whitetail deer and other large mammals. Placement of cluster drainfields would be somewhat removed from residential areas, and little disruption of vegetation or wildlife would be expected by their construction. The impacts on terrestrial biota that would result from upgrading the existing on-site systems would be insignificant because a relatively small total amount of construction on developed land would be required to complete the project.

4.1.1.6. Demographics

Temporary jobs created by the construction of wastewater collection and treatment facilities are not likely to attract any new permanent residents to the project area. These positions would most likely be filled by workers from the immediate and surrounding areas. Some permanent residents may reduce the time spent in their homes while construction of on-site or sewer systems occurs on their property. Because many residents utilize their lakeshore property for vacation purposes, vacation schedules may be disrupted by the construction activities. No significant demographic impacts will occur during reconstruction of wastewater treatment facilities.

4.1.1.7. Land Use

Construction activities associated with the implementation of Alternatives 3 through 7 would require some conversions of land use in the project area. Under Alternatives 3 through 7, residential, agricultural, forest, and wetland areas would be affected to varying degrees. The construction of the lagoon expansion at the existing Moose Lake WWTP, the bog treatment system, and the cluster drainfields will require permanent land conversion, as shown in Table 4-2. Under any of the Project Alternatives, less than 0.1% of the farmland in Pine County would be converted to treatment sites.

Table 4-2. Land use conversions for "action" alternatives.

Project Alternative	Treatment System	Acres Converted	Existing Land Use
#2	On-site	None	Residential
#3	Cluster drainfield	16	Farm
#4	Lagoon upgrade[a]	14	Farm[b]
	Cluster drainfield	5	Farm
#5	Bog treatment	20	Wetland
	Cluster drainfield	5	Farm
#6	Lagoon upgrade[a]	22	Farm[b]
	Cluster drainfield	5	Farm
#7	Lagoon upgrade[a]	48	Farm[b]

[a] Upgrade lagoons at existing Moose Lake WWTP
[b] Prime farmland

The construction of sewers under Alternatives 3 through 7 would occur primarily in residential areas. However, certain environmentally sensitive areas would be affected. Agricultural, wetland, and forest areas will be traversed by connector sewers under these alternatives. Following construction of the sewer systems, a 30- to 40-foot easement may be enforced to ensure access to the sewer system for repairs and maintenance. The magnitude of these impacts is not anticipated to be significant because most of the sewer system would follow existing rights-of-way, such as those along roadways.

Wetlands may be subject to sedimentation during construction of the sewer collection system. As a result, water circulation patterns within these wetlands may be permanently modified. Excavation, clearing, grading, and backfilling may temporarily affect the productivity and aesthetic value of wetlands, agricultural, orchard, and forest lands during construction of conveyance lines.

The construction of on-site systems under Alternatives 2 through 6 would occur primarily on lots which are already developed for residential use. Cluster systems would be built on agricultural land, but an insignificant amount of the total agricultural area would be necessary for their construction. The amount of prime agricultural farmland affected by construction activities is dependent upon the actual location of the wastewater treatment facilities. The prime farmland within the project area is discussed in Section 3.2.2.3.

The Council on Environmental Quality (CEQ) has issued a memorandum (CEQ 1976) to all Federal agencies requesting that efforts be made to insure that prime and unique farmlands (as designated by SCS) are not irreversibly converted to other uses unless other national interests override the importance of or benefits derived from their protection.

The USEPA has a policy of not allowing the construction of a treatment plant or the placement of interceptor sewers funded through the Construction Grants Program in prime agricultural lands unless it is necessary to eliminate existing point discharges and or to accommodate flows that violate the requirements of the Clean Water Act (USEPA 1981b). The policy of USEPA is to protect prime agricultural land from being adversely affected by both primary and secondary impacts. It is considered to be a significant impact if 40 or more acres of prime agricultural land are diverted from production.

Less than 40 acres of prime agricultural land are likely to be directly affected under any of the project alternatives except Alternative 7, which requires 48 acres for upgrading the existing lagoons (Table 4-2). These lands would be taken out of production and used as lagoons, treatment facilities, buffer zones, or access roads. The actual total amount of acres of prime agricultural land which may ultimately be taken out of production for each project alternative is dependent upon the precise location and placement of the treatment sites and interceptor routes, as will be determined in completion of the facility planning for the MLWSD.

4.1.1.8. Economics

The construction of wastewater treatment facilities under any of the project alternatives would create a limited number of short-term construction jobs. Masons, pipefitters, heavy equipment operators, electricians, truck drivers, plumbers, roofers, painters, and carpenters would be among the tradesmen necessary to complete construction of the proposed facilities. Most jobs would be filled by persons living within the project area or within commuting distance of the project area.

The purchase of construction materials from project area merchants would benefit the local economy. However, few firms offering materials required for the construction of wastewater facilities are established within the project area. Purchases made by construction workers within the project area also would benefit the local economy. These purchases would likely be for fuel, food, and clothing. Patronage may be reduced for some businesses along sewer lines when road closings and disruptions occur. No significant economic impacts are anticipated to occur during the construction of wastewater facilities under any of the alternatives.

4.1.1.9. Transportation

Increased truck and grading equipment traffic during the construction of wastewater treatment components would increase road congestion. Vehicular traffic would be inconvenienced by excavating, grading, backfilling, and temporary road closures during construction of conveyance lines along roadways under Alternatives 4 through 7. The inconvenience experienced during these periods is not anticipated to be significant.

4.1.1.10. Energy Resources

Residential, commerical, and industrial energy requirements are not likely to be affected during the construction of wastewater facilities under any of the alternatives. Active competition for specific energy sources would become apparent if there were a recurrence of a national fuel crisis such as the one precipitated by the oil embargo of 1977. Trucks and construction equipment used during the construction of wastewater treatment facilities would increase demand for local supplies of gasoline and diesel fuel. There is ample power generation to meet the electrical needs of any of the construction phase activities.

4.1.1.11. Recreation and Tourism

Many recreational activities in the project area are concentrated on or along the perimeter of lakes. No significant air, water, noise, or traffic impacts are expected to occur near the lakes which would seriously interfere with tourism and recreation activities. Construction activities may curtail some recreation and tourist activities by interupting access to recreational facilities. However, these impacts are not anticipated to be significant.

4.1.1.12. Cultural Resources

Final routings of conveyance lines should be presented to the SHPO for assessment before construction activities begin. If construction excavations uncover significant cultural resources, the SHPO should be notified immediately. To provide adequate consideration of impacts affecting historic sites, a survey of the Miller cabin on the YMCA property should be conducted preceding implementation of any alternative which involves conveyance of wastewater to the City of Moose Lake treatment plant.

4.1.2. Operational Impacts

Each of the alternatives, including the No-Action Alternative, involves operations that will continue through the project period. Included in the definition of operations are construction of new septic tank systems for new structures and upgrading on-site systems that fail. Impacts are addressed for each of the major elements of the natural and man-made environments.

4.1.2.1. Atmosphere

Potential emissions from the operation of the centralized wastewater treatment components include aerosols, hazardous gases, and odors. The emissions could pose a health risk or be a public nuisance.

Organic material that contains sulfur or nitrogen may be partially oxidized anaerobically and result in the emission of byproducts that may be malodorous. Common emissions, such as hydrogen sulfide and ammonia, are often referred to as sewer gases, and have odors reminiscent of rotten eggs and concentrated urine, respectively. Some organic acids, aldehydes, mercaptans, skatoles, indoles, and amines also may be odorous, either individually or in combination with other sewage compounds. Sources of wastewater related odors include:

- Untreated or incompletely treated wastewater.
- Screenings, grit, or skimmings containing septic or putrescible matter.
- Oil, grease, fats, and soaps from food-handling enterprises, homes, and surface runoff.
- Gaseous emissions from treatment processes, manholes, wet wells, pumping stations, leaking containers, turbulent flow areas, and outfall areas.
- Raw or incompletely stabilized sludge or septage.

Wastewater stabilization lagoons typically emit considerable odors when the ice cover melts in the spring. These odors are likely to be noticeable at least one-half mile in the downwind direction. Odors from septic tank effluent sewers may escape from lift stations where turbulent flow occurs unless proper design steps are taken to minimize odors. Sewage may become septic and odorous in the lengthy force mains that are part of some alternatives especially during the low-flow winter season. The occasional failure of an on-site system may release some odors. Septage haulers using inadequate or improperly maintained equipment may create odor nuisances. None of the Project Alternatives are anticipated to cause significant public health or nuisance impacts if proper mitigative measures are employed. For example, restrictive zoning for residential development around the lagoon systems should be implemented.

4.1.2.2. Soils

The operation of the bog treatment system and cluster drainfields for wastewater treatment would alter the soils of these sites over the life of the project. The potential changes depend on the existing soil chemical and hydraulic properties and on the chemical characteristics and application rate of the septic tank effluent. In general the phosphorus and nitrogen content of the soils will be affected. Chemical and physical properties of the soils of the area are discussed in Section 2.2.1.1. Impacts to the peat soil under the bog treatment alternative (Alternative 5) are of some concern due to the treatment requirement that the water table be artificially maintained at a steady and low level. Deleterious impacts to the soils in the cluster systems and onsite upgrades (Alternatives 2 through 7) are expected to be minimal. The general nature of potential impacts of all project alternatives on soil is described in Appendix G.

4.1.2.3. Surface Water

Operational impacts that could affect surface water quality through the 20-year design period concern the following types of wastewater pollutants: coliform bacteria, dissolved organics, suspended solids, and excessive nutrients. Other wastewater pollutants such as trace metals or chlorinated organics are not expected to significantly affect any surface water uses.

Measurements of fecal coliform (bacterial contamination) made in the project area lakes are inconclusive because bacterial sampling efforts usually involved one sample per station for a single date. USEPA regulations require that conclusions as to the violation of standards be based on the geometric mean of a minimum of five samples.

Continued reliance on existing systems (No-Action Alternative) in areas with a high water table increases the potential for bacterial contamination of surface water. For the other alternatives, the wastewater management system proposed should effectively preclude these problems, although bacterial contamination is still a possibility with centralized alternatives in cases of pumping station malfunctions, or with upgraded on-site systems in cases of surface ponding of the effluent.

Treatment of wastewater by soil absorption systems is an effective way of eliminating or immobilizing sewage-borne pathogens. In fine-textured soil, bacteria can be filtered out by 1 to 2 meters of soil. Soils containing clay remove most organisms through adsorption. Sandy soil removes them through filtration (Lance 1978).

On-site systems should effectively remove suspended solids from the septic tank effluent and most dissolved organic substances should be removed by soil adsorption. The septic leachate survey, which is indicative of dissolved organics or dissolved salts as components of suspected leachate plumes, detected a very limited number of such plumes in each of the lakes. Dissolved organics will exert a BOD resulting in the consumption of dissolved oxygen within a lake. Within a properly maintained on-site system, BOD movement to lake waters should be insignificant.

Centralized collection and treatment alternatives that use the Moose Horn River as a receiving stream for discharge of treated wastewater effluents from the treatment lagoons (Alternatives 4, 6, and 7) are operated with the discharge timed for release during the spring runoff period. The waste stabilization lagoons are designed to meet State and Federal discharge standards. Suspended solids and dissolved organics are expected to exert a BOD in the receiving stream that could depress dissolved oxygen levels. Most of the residual BOD and ammonia should be oxidized within the Moose River or Kettle River and not affect the downstream St. Croix River.

The input of excessive nutrients to lakes within the project area is a signficant concern. Previous discussions presented in Chapter 2 (Section 2.2.2.4.) and Chapter 3 (Section 3.1.3) address in detail the potential water quality impacts of proposed wastewater treatment alternatives. These are summarized in the following paragraphs.

If the No-Action Alternative were selected, the phosphorus loading to all lakes is likely to increase in comparison with present conditions. This projected increase is based on future population estimates around the project area lakes, and would stem from the generalized nutrient transport to the lakes associated with residential development. For example, an increased population would use additional on-site systems, possibly resulting in some additional phosphorus loads to the lakes.

Centralized collection systems would eliminate the phosphorus loads associated with failing on-site systems. Upgrading existing on-site systems and placing certain residences in critical areas on a cluster collection system also could result in decreased phosphorus loads to the lakes compared to present conditions. However, the additional residential development that would ultimately be served by the centralized collection systems proposed in any of the project alternatives also would generate new sources of phosphorus to the lakes. These phosphorus loads would stem from the generalized phosphorus movement associated with erosion and lawn fertilization in residential land use. Additional phosphorus loads to the lakes may stem from sewer exfiltration. These impacts are secondary in nature, as discussed in Section 4.2.3., but the result is that gains achieved in abatement of on-site system phosphorus loads through centralized collection and treatment is of reduced long-term significance.

The principal water quality benefit that might be anticipated through provision of improved wastewater management for the lakeshore community is an improvement in lake trophic condition whereby algae blooms would be reduced. This would be a long-term benefit the results of which would not be seen for many years if the hydraulic residence time of a lake was great or if other sources of phosphorus predominated. Based on evaluations of water quality, nutrient loading regimes, trophic histories, and the aquatic biota of the project area lakes it is concluded that no significant beneficial impact on trophic status will result from any of the seven project alternatives. The eutrophic condition of Island Lake would not be changed, and blue-green algae blooms would not be lessened in frequency or severity. The existing good water quality of Sturgeon, Rush, and Passenger Lakes would not be protected to any greater degree as a result of implementing any of the proposed project alternatives.

The fact that none of the proposed project alternatives offers a prospect of beneficial water quality impacts is a consequence of the local environment, rather than of the design of the alternatives. All existing data on the natural and man-made environment of the project area indicate that impacts of domestic wastewater on lakes are inconsequential in the context of other manageable and unmanageable nutrient sources.

An additional concern of implementing an alternative which calls for collection sewers is the effect of such an alternative on lake water levels. Lake water levels may decline slightly with the centralized collection alternatives because water that formerly went to soil adsorption systems would be exported from the basin. The groundwater inflow and outflow of the lakes are an important component in their hydrologic budgets and export of groundwater introduced to sewers through wastewater disposal and through general infiltration could lower the lakes' flushing rates. Assuming no long-term change in average surface water inflows and outflows, a water volume equivalent to between 1 and 2 inches of lake surface would be exported from Island or Sturgeon Lake during the summer through the collection sewers exposed under Alternatives 6 and 7. Potential impacts of lowered lake levels include a decrease in hydraulic residence time for the lakes and concomitant changes in phosphorus levels and algae growth.

4.1.2.4. Groundwater

Operational impacts that could affect groundwater in the 20-year design period concern the following types of pollutants: coliform bacteria, dissolved organics, and excessive nutrients. Movement to groundwater of other wastewater constituents or of soil chemicals would continue to occur under the alternatives employing on-site systems, but are not expected to significantly affect any of the uses of the groundwater within the service area.

Bacteria and dissolved organics are readily removed by filtration and adsorption onto soil particles. Two meters of soil material is generally adequate for bacterial removal (Wilson and others 1982), except in very coarse-grained, highly permeable soil material. Contamination of drinking water wells or surface water with bacteria and dissolved organics in the service area is unlikely under any of the project alternatives.

High phosphorus concentrations in groundwater which discharges to lakes can contribute to excessive eutrophication. Section 4.1.2.2. contains a discussion of phosphorus movement in groundwater, and indicates that phosphorus inputs to the lakes will not be significantly different under any of the Alternatives. Field studies have shown that most soils, even medium sands, typically remove in excess of 95% of phosphates in relatively short distances from effluent sources (Jones and Lee 1977). However, soil absorption systems can be a potential source of phosphorus input to lakes when located very close to the lakeshore and may stimulate algal growth in localized areas where effluent plumes emerge; but their contribution to lake eutrophication is not considered to be a primary factor in the project area. The largest contribution of groundwater phosphorus to the lakes would come from the No-Action Alternative. The lowest groundwater phosphorus contributions to lakes would originate from alternatives that incorporate increased centralized wastewater collection.

The wastewater stabilization lagoons which are components of the centralized alternatives, (Alternatives 4, 6, and 7), may contribute phosphorus to the groundwater if seepage from the lagoons is considerable. A study of Minnesota wastewater stabilization lagoons (E.A. Hickok and Associates 1978) concluded that none of the ponds (all had natural soil liners) were capable of meeting the designed and specified seepage rates. Most of the ponds studied removed phosphorus effectively, although some had seepage rates considerably higher than the maximum allowable.

Nitrates in groundwater are of concern at concentrations greater than 10 mg/l as nitrogen because they may in some circumstances cause methemoglobinemia in infants who ingest liquids prepared with such waters. This limit was set in the National Interim Primary Drinking Water Regulations (40 CFR 141) of the Safe Drinking Water Act (PL 93-523).

The density of soil absorption systems is said to be the most important parameter influencing pollution levels of nitrates in groundwater (Scalf and Dunlop 1977). The potential for high nitrate concentrations in groundwater is greater in areas of multi-tier or grid types of residential developments than in single tier developments. Depending on the groundwater flow direction and pumping rates of wells, nitrate contributions from soil absorption systems may become cumulative in multi-tier developments. Because extensive areas of multi-tier development are not projected in the project area through the 20-year design period (Section 3.2.2.4.), nitrate contamination of wells is considered to have a low risk potential. If wells were found to have high nitrate concentrations they may need to be made deeper so that a hydraulically limiting layer is penetrated (Section 2.2.2.3.).

Cluster drainfields are designed with criteria similar to individual drainfields except that they are applied on a large scale. Nitrate concentrations in the groundwater below a cluster drainfield are anticipated to be no higher than those below an individual soil absorption system. However, insufficient experimentation has been conducted to enable designing for nitrogen removals from cluster drainfields. Therefore, a wise precaution would be to locate the cluster drainfield as far from wells as is feasible. This is one reason why cluster drainfields under Alternatives 3 through 6 have been designed to be sited away from residential areas in this project.

Seepage from the wastewater stabilization lagoons could result in elevated nitrate levels in the groundwater below the lagoons. Clay liners are not impermeable, and plastic liners can be punctured and can deteriorate. Field studies (EA Hickok and Associates 1978) have shown that a seepage rate of no more than 500 gallons per acre per day is very difficult to maintain even on in-place, fine-textured soils. Nitrate contamination of groundwater by seepage from the Moose Lake sewage lagoons is not anticipated to be a problem over the operational period of this project because groundwater use for potable supplies is not common near the lagoon, and because groundwater discharge from the vicinity is probably to the nearby stream course.

4.1.2.5. Biota

No significant adverse long-term effects on the biota of the project area are expected to occur as a result of the operation of Project Alternatives 1, 2, 3, 4, 6, and 7. Alternative 5 may have significant adverse impacts on plants and animals currently using the peat bog area to fill principal habitat requirements.

4.1.2.6. Demographics

The operation and maintenance of wastewater facilities proposed under the project alternatives will not have a significant impact on the demography of the project area. A limited number of long-term jobs created by the operation and maintenance of these facilities are likely to be filled by persons living within the project area or within commuting distance. No new residents are expected to be attracted to the project area to fill these positions.

4.1.2.7. Land Use Impacts

The land use conversion discussed in Section 4.1.1.7. would remain in effect for the operation of the proposed wastewater treatment facilities under the project alternatives. Land use under the easement of sewage conveyance lines would be intermittently affected when maintenance or repairs were performed on sections of the lines. Periodic excavating and filling would disturb vegetation and soil along conveyance lines. The release of low level odors and aerosols from WWTPs may affect land use adjacent to the plants. Improper maintenance of cluster and on-site systems may create malodorous conditions which would adversely affect adjacent land uses.

4.1.2.8. Economics

The operation of centralized wastewater treatment facilities under Alternatives 4 through 7 would create a few long-term jobs. The few positions required could be filled by persons residing in the project area. The existing staff at the MLWSD is expected to assume any additional responsibilities as a result of implementing any of the alternatives.

Existing contractors are expected to satisfy local demand for construction and maintenance service of on-site systems. Contractors and tradesmen involved in the construction and maintenance of on-site systems would suffer a loss of work opportunities within the project area under Alternative 1 and Alternatives 4 through 7. These contractors and tradesmen are likely to compete for work opportunities in neighboring areas. No significant economic impacts will occur during the operation of wastewater treatment facilities under any of the alternatives.

4.1.2.9. Transportation

Impacts arising during the construction of conveyance lines (Section 4.1.1.) would reoccur when maintenance or repairs are made on those lines. Occasionally some roads may be closed temporarily. Truck traffic to and from the Moose Lake treatment plant under Alternatives 1 through 7 will be associated with supply deliveries. Truck traffic associated with repairs and sludge hauling also will occur periodically under Alternatives 1 through 7.

4.1.2.10 Energy

The operation of wastewater treatment facilities and pump stations under Alternatives 3 through 7 require the use of electricity and fossil fuels. Alternative 7 would require the greatest amount of these energy sources, while Alternative 3 would require the least. No significant demands would be placed on local energy supplies under any of the alternatives.

4.1.2.11. Recreation and Tourism

The operation of wastewater facilities under any of the alternatives could affect tourist and recreational activities in the project area if a malfunction of those facilities occurred. A failure in the system components of the WWTPs under alternatives 4, 5, 6, and 7 could cause untreated or partially treated waste to be discharged into project area surface waters. This would result in short-term and long-term water quality degradation and a reduction in the recreational use of that body of water. Odors emanating from malfunctioning on-site systems may locally curtail outdoor recreational activities. With proper operational and maintenance procedures no significant adverse impacts are anticipated for any of the Project Alternatives.

4.1.3. Public Finance

The total project capital costs will be apportioned between the USEPA, the State, and the local residents. The apportionment is made based on what capital costs are eligible to be funded by the USEPA and the state. The estimated initial capital costs and the capital costs eligible for funding for each action alternative are presented in Appendix F. The local construction costs (capital costs not eligible for funding) and the entire cost of systems operation and maintenance will be borne entirely by the system users.

Federal funding through the National Municipal Wastewater Treatment Works Construction Grants Program will provide funds to cover 75% of the eligible planning, design, and construction costs of conventional wastewater treatment facilities. State grants administered by MPCA will provide an additional 15% of the project cost for a total of 90% funding. "Innovative/alternative" components of the proposed treatment systems, such as pressure sewers, septic tank effluent sewers, septic tanks, soil absorption systems, other on-site upgrades, cluster drainfields and bog treatment systems are eligible for 85% Federal funding and 9% State funding for a total of 94%.

The estimated average annual residential user costs for project options are presented in Table 4-3. Detailed average annual residential user costs with and without Federal and State grant monies are presented in Appendix F. Average annual users costs range from $152 per residence served for Alternative 2 with Federal and State Grants to $1,406 for Alternative 7A with no grants. The equivalent annual user charges for nearby Coffee Lake and Sand Lake (already sewered) are $120 and $145, respectively (based on assessed connection charge and user fee, Section 3.2.4).

The average annual user costs presented in Table 4-3 represent the cost of all system components included in the alternative. When user charges are calculated for the constructed system, each connection will have to pay its fair share of the treatment system it uses: on-site upgrade, cluster system, or centralized collection and treatment. For example, typical annual user costs for the on-site systems component of Alternatives 2 through 7 would be on the order of $150 with Federal and State grants and $240 without grants (from Alternative 2). Typical annual user costs for the centralized collection and treatment component of alternatives 4 through 7 would be on the order of $670 for gravity collection with Federal and State grants ($1,400 without grants), and $300 for STE pressure or gravity sewers with Federal and State grants ($1,300 without grants for Alternative 7).

Wastewater treatment facilities can create significant financial impacts for communities and users who will pay the capital, operational, maintenance, and debt costs associated with sewage treatment facilities. The USEPA guideline for determining the magnitude of the financial impacts is based on the ratio of the average annual user cost to median household income (USEPA 1981b). The USEPA considers projects to be expensive and to have adverse impacts on the finances of users when average annual user costs are:

- 1.0% of 1980 median household incomes less than $10,000
- 1.5% of 1980 median household incomes between $10,000 and $17,000

Table 4-3. Estimated average annual residential user costs[a] ($ per year)

[b]Project Options	Project Funding		
	Federal and State Grant	Federal Grant Only	Without Grants
2	151.68	160.32	242.04
3	177.48	213.24	551.28
4A	372.00	422.52	751.68
4B	212.64	266.04	714.36
4C	208.56	261.00	702.49
5A	220.56	270.48	743.04
5B	214.92	262.32	710.28
6A	522.00	586.80	976.92
6B	234.48	306.48	921.36
6C	221.76	288.60	855.00
7A	666.60	789.60	1,405.56
7B	297.96	404.04	1,309.08
7C	296.76	398.16	1,257.72

[a]Operation and maintenance costs plus local share of initial capital costs amortized for 20 years at 8 3/8% (see Appendix F) Existing equivalent annual user charges for Coffee Lake and Sand Lake are $120 and $145, respectively (Section 3.2.4).

[b]Underlined Project Options constitute Project Alternatives that were identified on the basis of net present worth and not on the basis of having the lowest user cost. Other project options are presented for purposes of comparison. (Option 7A is most comparable to the MLWSD Facility Plan, representing conventional gravity sewers around Island and Sturgeon Lakes, with treatment at Moose Lake.)

* 1.75% of 1980 median household incomes greater than $17,000.

Estimated 1980 median household incomes for Pine County, Windemere Township, and Carlton County are $12,252, $15,606, and $16,420, respectively (1980 Census-preliminary tape data, by telephone, K. Hoefer, U.S. Bureau of The Census, Data Users Division, Kansas City, to WAPORA, Inc., 7 December 1982). The majority of the project area is in Windemere Township, with a small portion in Carlton County.

Average annual user costs for project options are expressed as a percentage of 1980 median household income in Table 4-4. The user fee for Project Options 4A, 6A, 7A, 7B, and 7C surpass the suggested upper limit user fee even with Federal and State grants. Without grants, Alternative 2 is the only one that does not surpass the suggested limit. Alternative 2 offers the lowest user cost for system users. With the exception of Project Options 4A, 6A, 7A, 7B, and 7C if Federal and State grants are available, none of the other options surpass the suggested upper limit user costs as a percentage of median household income, indicating that none of them would be a "high cost" system that would pose a significant financial burden on system users.

The impact of the new debt requirements on the total debt per capita in the Moose Lake Windemere Sanitary District is presented in Table 4-5. The 1980 debt per capita of $394 was developed in Section 3.2.4. Alternative 2 offers the lowest additional debt per capita increase and Alternative 7 the greatest increase. None of the project options exceed the standard upper limit for the debt per capita for middle income communities ($1,000 Table 3-28) if Federal and State grants are available. If no grants are available, the total debt per capita will exceed the limit under 6A, 6B, 7A, 7B, and 7C.

It should be noted that the financial stress on low income families and the local share of capital cost for the proposed wastewater system, under any of the action alternatives, will be affected by the interest rate available at the time of financing. The debt service portion of the annual

Table 4-4. Average annual user costs expressed as a percentage of 1980 median household income for Windemere Township[a]

[c]Project Options	Project Funding: Federal and State Grant	Federal Grant Only	Without Grants
2	0.97%	1.03%	1.55
3	1.14	1.37	3.53[b]
4A	2.38[b]	2.71[b]	4.82[b]
4B	1.35	1.70	4.59[b]
4C	1.34	1.67	4.50[b]
5A	1.41	1.73	4.76[b]
5B	1.38	1.68	4.55[b]
6A	3.34[b]	3.76[b]	6.25[b]
6B	1.50	1.96[b]	5.90[b]
6C	1.42	1.85[b]	5.49[b]
7A	4.27[b]	5.06[b]	9.01[b]
7B	1.91[b]	2.59[b]	8.39[b]
7C	1.90[b]	2.55[b]	8.06[b]

[a]Estimated 1980 median household income for Windemere Township is $15,606 (Portion of the project area is in Carlton County, which has an estimated 1980 median household income of $16,420. (1980 median household income from 1980 census preliminary tape data, by telephone, K. Hoefer, U.S. Bureau of the Census, Data Users Division, Kansas City, to WAPORA, Inc., 7 December 1982). The USEPA considers a project expensive when average annual user charges exceed 1.75% of median household income greater than $17,000.

[b]The costs residents would pay under these alternatives would be considered expensive according to USEPA guidelines.

[c]Underlined Project Options constitute Project Alternatives that were identified on the basis of net present worth estimates and not on the basis of the percent of 1980 median household income that would be consumed by user costs.

Table 4-5. Impact of new debt requirements on total debt per capita in the Moose Lake-Windemere Sanitary District.

Project Options[b]	Debt per capita ($)[a] Federal and State Grant New	Federal and State Grant Total	Federal Grant Only New	Federal Grant Only Total	No Grant New	No Grant Total
2	12	406	18	412	76	470
3	22	416	49	443	304	698
4A	166	560	206	599	460	854
4B	42	436	84	478	430	824
4C	42	436	83	477	424	818
5A	30	424	68	462	434	828
5B	28	422	65	459	411	805
6A	302	696	357	751	684	1,078
6B	60	454	121	515	636	1,030
6C	57	451	113	507	588	982
7A	472	866	592	986	1,193	1,587
7B	110	504	213	607	1,096	1,490
7C	106	500	205	599	1,044	1,438

[a]New debt per capita is local share of construction costs divided by total 1980 population of Moose Lake-Windemere Sanitary District (3,817, Table 3-27). Existing 1980 debt per capita = $394 (Table 3-27).

[b]Underlined Project Options constitute Project Alternatives identified on the basis of net present worth estimates and not on the basis of new debt requirements.

user charge has been calculated based on a 8 3/8% interest rate over 20 years (based on the current FmHA intermediate rate discussed below).

The Farmers Home Administration (FmHA) was contacted to determine the eligibility of the project for special financing (By telephone, Mr. John Melbo, FmHA Regional Office, St. Paul MN, to WAPORA, Inc., 25 August 1982). The FmHA will provide loans to fund the local share of the capital costs for USEPA-approved projects if funding is not available from other sources at interest rates determined as "affordable" for the community, based on median family income. The poverty rate is available to communities where the median family income is less than $9,000 and there is a sanitary and health problem (no area in Minnesota qualifies for the poverty rate at this time). The intermediate rate is available to communities with median family income less than 85% of the non-SMSA median family income for the state. For other communities the market rate is available. In August 1982 the poverty rate was 5%, the intermediate rate was approximately 8 3/8%, and the market rate (based on the Bond Buyers Index) was 11 5/8%.

The 1981 non-SMSA median family income for the State of Minnesota is $22,850 (Section 3.21). The estimated median family income is $21,100 for Windemere Township and Carlton County, $17,000 for Pine County, and $16,275 for Moose Lake Township (Section 3.2.1. Table 3-25). The median family income is less than 85% of $22,850 ($19,420) in Pine County and Moose Lake Township, and greater in Windemere Township and Carlton County. Therefore, if affordable funding is not available elsewhere, the District might qualify for an intermediate interest rate from FmHA. If not, the market rate would apply.

4.2. Secondary Impacts

Each of the alternatives, including the No-Action Alternative, will have effects that extend beyond primary or direct impacts. These secondary impacts would occur, for example, in the form of induced growth or unanticipated changes in lake water quality. The categories of the natural and man-made environment that may experience significant secondary impacts are described in the following sections.

4.2.1. Surface Water

Increased housing developed along the lake shore may increase nutrient and sediment loads into the lakes as a result of the following processes:

- o Construction of impervious surfaces such as rooftops, parking areas, paved roads, and hard-packed soils may increase not only the amount of surface runoff, but also its ability to erode soil and to transport pollutants.
- o Lawn and garden fertilization may create relatively high nutrient levels in runoff.
- o The Conventional practice of placing lawn clippings and leaf litter in drainageways may speed the process of nutrient transport to the lakes.

Population growth will neither be hindered or induced significantly under any of the action alternatives (2 through 7). Lakeshore area population growth and housing stock growth will proceed at comparable rates regardless of whether improved on-site systems or centralized collection and treatment are provided. No extraordinarily high levels of erosion-borne nutrient loads are anticipated to be generated under any single project alternative. Population growth will take place and erosion and runoff will increase with the No-Action Alternative just as in the other alternatives. Over the long term, no single alternative offers an advantage of reduced secondary water quality impacts in terms of decreasing the rate of eutrophication.

4.2.2. Demographics

Wastewater management facilities historically have been major factors in determining the capacity of an area to support population growth and development. On-site wastewater treatment facilities, although theoretically available to any potential user, limit development to areas with suitable soil and site characteristics. Sewer systems remove these site constraints and allow development virtually anywhere within hookup distance of the system. Consequently, the construction of sewers usually causes an initial increase in the inventory of developable land and subsequent increases in the density of development. This may allow development on lots that otherwise would be considered undesirable or too small for permanent use.

The inducement of growth through sewer service already provided around nearby Sand Lake is not evident nor is it anticipated to occur with any of the project alternatives. Economic factors apparently outweigh any incentive for growth which wastewater facilities might otherwise provide.

Long-term population growth trends in the project area are not likely to be changed by any of the project alternatives. The sewers encompassing portions of Island Lake proposed under Alternatives 4 through 7 would provide service to a corridor which is already heavily developed and where few other lakeshore lots are available for development. Parallel population increases would occur in the Sturgeon Lake lakeshore corridor with all of the Project Alternatives. However, the cost for users on both lakes under Alternatives 2 through 7 may create a financial burden for families with low incomes. This may result in displacement of these families from the project area because they could not afford user charges.

The selection of any one of Alternatives 4 through 7 would allow for the development of a very limited number of lots which otherwise would not be developed due to existing size constraints for on-site systems. However, no significant housing stock or population increase is anticipated to occur as a result of allowing development of those lots.

Under any of the Project Alternatives, net population growth in the service area would occur to a parallel degree as discussed in Section 3.2.1. The rate of conversion of seasonal dwellings to permanent homes would be unaffected. Population increases will be dependent solely upon the carrying capacity of the land and aesthetic factors influencing development choices (Section 3.2.4.).

4.2.3. Land Use

Economic factors and the availability of aesthetically desirable lakeshore lots (Section 3.2.3.) will have a greater influence than the provision of wastewater facilities (Section 4.2.) in determining land use for the study area during the planning period. The location of wastewater treatment facilities and sewer systems proposed under Alternatives 4 through 7 will not significantly direct patterns of future development. Residential development will be concentrated along lakeshore areas regardless of the wastewater management techniques implemented. Because of this and because additional growth will not be induced in the lakeshore corridor, no significant land use impacts will occur.

Under Alternatives 1 through 3, future development within the project area would be most limited by the carrying capacity of the land and by aesthetic considerations. Increased potential for nuisances attributable to failing on-site systems in lakeshore residential areas could make infill development of vacant lots less desirable. As a result, new development on back-tier lots may be increased at the expense of vacant lake-contiguous lots which may remain undeveloped. This is not expected to be a significant trend, however, because relatively few nuisance causing conditions are projected for the lakeshore community (Section 2.2.3).

Little prime agricultural farmland is likely to be taken out of production to accommodate wastewater treatment facilities (Table 4-2). This will result in a minimal net loss of food and fibre production.

4.2.4. Economics

The additional wastewater treatment capacity required under Alternatives 4 through 7 will not stimulate any increased population, development, or economic growth (Section 3.2.3.). Under Alternatives 1 through 3, economic development also would proceed as discussed in Section 3.2.3. Continuing nuisances created by failing on-site systems under the No-Action Alternative could further detract from the area's economic development potential. However, the existing perception by the public that Island Lake already has poor water quality will detract to an even greater degree from the economic development stimulus of water-based recreation. Under Alternatives 2 through 7, no significant improvement of Island Lakes quality is anticipated. Therefore, no significant secondary impact on economics would occur under any of the Project Alternatives.

4.2.5. Recreation and Tourism

Increased and continuing nuisances created by failing on-site systems under the No-Action Alternative could detract from the project area's reputation as a desirable recreational area. If there were obvious algal blooms in Sturgeon Lake, permanent and seasonal residents of the project area would likely decrease their recreational activities. However, an increased fertility marked by blue-green algae blooms also can mean better fishing becaused of increases in overall lake productivity. Whether the impact is then considered in the balance to be favorable or adverse is a value judgement to be made by recreational users. No evidence exists which suggests that Alternatives 2 through 7 would preclude the development of blue-green algal blooms in Sturgeon, Rush, or Passenger Lakes. Additionally, no evidence exists which suggests Island Lake will be improved by any of the action alternatives. Therefore, no significant secondary impacts on recreation and tourism are anticipated.

4.3. Mitigation of Adverse Impacts

As previously discussed, various adverse impacts would be associated with the proposed alternatives. Many of these adverse impacts could be reduced significantly by the application of mitigative measures. These mitigative measures consist of implementing legal requirements, planning measures, and design practices. The extent to which these measures are applied will determine the ultimate impact of the selected action. Potential measures for alleviating primary (construction & operation) and secondary impacts are presented in the following sections.

4.3.1. Mitigation of Construction Impacts

The construction oriented impacts presented in Section 4.1. primarily are short-term effects resulting from construction activities at WWTP sites or along the route of proposed sewer systems. Proper design should minimize the potential impacts, and project plans and specifications should incorporate mitigative measures consistent with the following discussion.

Fugitive dust from excavation and backfilling operations for the force mains and treatment plants can be minimized by various techniques. Frequent street sweeping of dirt from construction activities can reduce the major source of dust. Prompt repaving of roads disturbed by construction also could reduce dust effectively. Construction sites, spoil piles, and unpaved access roads should be wetted periodically to minimize dust. Soil stockpiles and backfilled trenches should be seeded with a temporary or permanent seeding, or covered with mulch to reduce susceptibility to wind erosion.

Street cleaning operations where trucks and equipment gain access to construction sites, and on roads along which a force main would be constructed, will reduce loose dirt that otherwise would generate dust, create unsafe driving conditions, or be washed into roadside ditches or storm drains. Trucks transporting spoil material to disposal sites should cover their loads to eliminate the escape of dust while in transit.

Exhaust emissions and noise from construction equipment can be minimized by proper equipment maintenance. The resident engineer should have, and should exercise, the authority to ban from the site all poorly maintained equipment. Soil borings along the proposed force main rights-of-way conducted during system design would identify organic soils that have the potential to release odors when excavated. These areas could be bypassed by rerouting the force main if a significant impact might be expected at a particular location.

Spoil disposal sites should be identified during the project design stage to ensure that adequate sites are available and that disposal site impacts are minimized. Landscaping and restoration of vegetation should be conducted immediately after disposal is completed to prevent impacts from dust generation and to avoid unsightly conditions.

Lands disturbed by trenching for force main construction should be regraded and compacted as necessary to prevent future subsidence. However, too much compaction will result in conditions unsuitable for vegetation.

Areas disturbed by trenching and grading at the treatment plant site should be revegetated as soon as possible to prevent erosion and dust generation. Native plants and grasses should be used. This also will facilitate the re-establishment of wildlife habitat.

Construction-related disruption in the community can be minimized through considerate scheduling by the contractor and by appropriate public announcements. The State and County highway departments have regulations concerning roadway disruptions, which should be rigorously applied. Special care should be taken to minimize disruption of access to frequently visited establishments.

Announcements should be published in local newspapers and broadcast on local radio stations to alert drivers of temporary traffic disruptions on primary routes. Street closings should be announced by flyers delivered to each affected household.

Planning of routes for heavy construction equipment and materials should ensure that surface load restrictions are considered. In this way, damage to streets and roadways would be avoided. Trucks hauling excavation spoil to disposal sites or fill material to the WWTP sites should be routed along primary arteries to minimize the threat to public safety and to reduce disturbance to residential environments.

Erosion and sedimentation must be minimized at all construction sites. USEPA Program Requirements Memorandum 78-1 establishes the following requirements for control of erosion and runoff from construction activities. Adherence to these requirements would mitigate potential problems.

- Construction site selection should consider potential occurence of erosion and sediment losses.
- The project plan and layout should be designed to fit the local topography and soil conditions.
- When appropriate, land grading and excavating should be kept to a minimum to reduce the possibility of creating runoff and erosion problems which require extensive control measures.

- Whenever possible, topsoil should be removed and stockpiled before grading begins.

- Land exposure should be minimized in terms of area and time.

- Exposed areas subject to erosion should be covered as quickly as possible by means of mulching or vegetation.

- Natural vegetation should be retained whenever feasible.

- Appropriate structural or agronomic practices to control runoff and sedimentation should be provided during and after construction.

- Early completion of stabilized temporary and permanent drainage systems will substantially reduce erosion potential.

- Access roadways should be paved or otherwise stabilized as soon as feasible.

- Clearing and grading should not be started until a firm construction schedule is known and can be effectively coordinated with the grading and clearing activities.

The Natural Historic Preservation Act of 1966, Executive Order 11593 (1971), the Archaeological and Historic Preservation Act of 1974, and the 1973 Procedures of the Advisory Council on Historic Preservation require that care be taken early in the planning process to identify cultural resources and minimize adverse effects on them. USEPA's final regulations for the preparation of EISs (40 CFR 1500) also specify that compliance with these regulations is required when a Federally funded, licensed, or permitted project is undertaken. The State Historic Preservation Officer must have an opportunity to determine that these requirements have been satisfied.

4.3.2. Mitigation of Operation Impacts

The majority of potentially adverse operational impacts of the WWTP alternatives are related to the discharge of effluent to surface waters. For the bog treatment and cluster treatment designs the most significant potential adverse effects are impacts on groundwater and possible health risks. Adverse impacts associated with the operation of cluster and on-site systems are primarily related to malodorous conditions which may affect outdoor recreational activities. Measures to minimize these and other operation phase impacts of all the alternatives are discussed below.

Adverse impacts related to the operation of the proposed sewer systems and treatment facilities would be minimal if the facilities are designed, operated, and maintained properly. Gaseous emissions and odors from the various treatment processes can be controlled to a large extent. Aboveground pumps should be enclosed and installed to minimize sound impacts. Concentrations of the effluent constituents discharged from the City of Moose Lake treatment plant are regulated by the conditions of the NPDES permits. The effluent quality is specified by the State of Minnesota and must be monitored. Proper and regular maintenance of cluster and on-site systems also would maximize the efficiency of these systems and minimize the amount of odors released.

In the document Federal Guidelines for Design, Operation, and Maintenance of Wastewater Treatment Facilities (Federal Water Quality Administration 1970), it is required that:

> All water pollution control facilities should be planned and designed so as to provide for maximum reliability at all times. The facilities should be capable of operating satisfactorily during power failures, flooding, peak loads, equipment failure, and maintenance shutdowns.

4.3.3. Mitigation of Secondary Impacts

As discussed in Section 4.2., few secondary impacts are expected to occur during the operation of any of the six action alternatives. Adequate zoning, health, and water quality regulation and enforcement would minimize these impacts. Local growth management planning would assist in the regulation of general location, density, and type of growth that might occur.

4.4. Unavoidable Adverse Impacts

Some impacts associated with the implementation of any of the action alternatives cannot be avoided. The centralized collection and treatment components of Alternatives 4 through 7 would have the following adverse impacts:

- Considerable short-term construction dust, noise, and traffic nuisance.

- Alteration of vegetation and wildlife habitat along the sewer and force main corridors and at the WWTP site.

- Considerable erosion and siltation during construction.

- Significant odors during spring turnover of waste stabilization lagoons.

- User costs for wastewater treatment services for the residents within the proposed sewer service areas.

The alternatives that include significant reliance on continued use of existing and upgraded on-site systems and either cluster systems or blackwater holding tanks for critical areas would have the following adverse impacts:

- Some short-term construction dust, noise, and traffic nuisance.

- Limited amounts of erosion and siltation during construction.

- Discharge of percolate with elevated levels of nitrates and chlorides from soil absorption systems to the groundwater.

- Occasional ephemeral odors associated with pumping septic tanks and holding tanks and trucking these wastes to disposal sites.

- User costs for management and operation of wastewater treatment services for the residents within the proposed service areas.

4.5. Irretrievable and Irreversible Resource Commitments

The major types and amounts of resources that would be committed through the implementation of any of the six action alternatives are presented in Section 4.1. and 4.2. Each of the action alternatives would include some or all of the following resource commitments:

- Fossil fuel, electrical energy, and human labor for facilities construction and operation.

- Chemicals, especially chlorine, for the City of Moose Lake WWTP operation.
- Tax dollars for construction and operation.
- Some unsalvageable construction materials.

For each alternative involving a WWTP (Alternatives 4, 5, 6 and 7), there would be significant consumption of these resources with no feasible means of recovery. Thus, more non-recoverable resources would be foregone for the provision of the proposed wastewater control system for these alternatives than for alternatives 2 and 3. However, the total quantities involved for any of the alternatives is small.

Accidents, which could occur from system construction and operation of any alternative, could cause irreversible bodily damage or death, and damage or destroy equipment and other resources. For alternatives 4, 6 and 7, unmitigated WWTP failure and by-passing potentially could kill aquatic life in the mixing zone in the Moose Horn River.

None of the alternatives would have an impact on archaeological sites known at this time. However, the potential accidental destruction of undiscovered archaeological sites through excavation activities for any alternative would not be reversible. This would represent permanent loss of such a site.

5.0 Responses to Comments on the Draft EIS

Comments on the Draft Environmental Impact Statement (DEIS) were received at the public hearing held 10 June 1983 in Moose Lake, Minnesota and also were received by mail. Comments and questions received at the public hearing were documented in a hearing transcript. In some cases, detailed responses to comments were not made at the public hearing and the need for more explanation was evaluated from the hearing transcript. The appropriate responses are presented in Section 5.1. Written comments on the DEIS were received from a total of nine public agencies and seven private citizens (Appendix O). Responses to written comments are presented in Sections 5.2, 5.3, and 5.4. An index to comments is presented in Section 5.5.

5.1 Response to Comments from the Public Hearing

Mr. Gregory Dean Evenson; (hearing transcript, 10 June 1983)

1.) The DEIS did not provide an evaluation of the impact that the possible closure of the Moose Lake State Hospital might have on wastewater treatment capacity at the City of Moose Lake Treatment Plant.

> Comment noted. Closure of the State Hospital would reduce wastewater flows to the treatment plant and also could have significant economic impact in the area: including changes in the fee structure for user-charges. However, until the future of the Hospital is decided by the State of Minnesota, the potential impacts of closure or of partial closure are non-quantifiable.

Mr. Seth Shepard; (hearing transcript, 10 June 1983)

2.) The EIS gave no consideration to the beneficial impacts of sewers on property values. An increase in property value could be anticipated for property owners on Island and Sturgeon Lakes if sewers were constructed.

> Comment noted. Sewers may have significant financial impacts on property owners, including an increase of property values. Such impacts are beneficial to those owners who are able to afford installation, hook-up, and user-fee costs for the duration of the period for which they wish to maintain ownership.

The cost impacts may be adverse for those who cannot afford the loss of disposable income represented by sewer charges of any kind and who do not wish to sell their property for personal reasons or due to market considerations. It was not possible to assess the increased property value related impacts in detail because the willingness to sell is determined by unpredictable market forces.

3.) The EIS made no specific study of the impact of on-site waste management systems on private water wells.

Comment noted. No well sampling and analysis was done as part of the EIS. However, areas with coarse soils, where well contamination potentials are highest, are identified in the EIS. The potential for well contamination in these situations can be reduced by construction of properly designed wells of depth more typical of those serving permanent residences. Implementation of the EIS alternative would further protect wells by bringing on-site systems up to standards of sanitary code. Therefore, the EIS does recognize the potential for well contamination in certain areas (page 2-41).

Mr. Bob Eikum; (hearing transcript, 10 June 1983)

4.) The EIS contained no reference to the potential for well contamination by degreasing or cleaning agents sold for use in improving septic system performance.

Comment noted. During preparation of the Draft EIS no work was done to investigate this issue. Following the public hearing, an additional review of the sanitary service questionnaires (Section 2.2.1.3. in the EIS) was made. Responses to the questionnaire regarding maintenance of septic systems gave no indication that such chemical agents were used. This represents a survey of more than one hundred septic system owners in the Island and Sturgeon Lake area. As noted at the public hearing, the proper method for septic system maintenance is removal of sludge and solids by mechanical pump.

5.2 Correspondence from Federal Agencies

US Department of Agriculture, Soil Conservation Service; (10 June 1983)

5.) Draft EIS needs no further comment.

US Department of the Army, Corps of Engineers; (9 June 1983)

6.) No Department of the Army permit would be required to carry out Alternative #2.

Comment noted.

US Department of Interior, Office of the Secretary; (20 June 1983)

7.) Both the bald eagle and the gray wolf occur in the project area. However, considering the location and types of activities proposed, this project should have no effect on the above listed species. This precludes the need for further action on this project as required by the Endangered Species Act of 1973, as amended.

Comment noted.

8.) The Final EIS should evidence approval by the SHPO of compliance with mandates pertaining to the identification and protection of cultural resources.

Due to the lack of exact knowledge of the future location of all individual on-site waste management systems to be upgraded or built, it is not possible to identify potential impacts on cultural resources. This evaluation of compliance will need to be completed in the development of plans and specifications.

US Department of Transportation, Federal Highway Administration; (2 June 1983)

9.) The EIS recommended project would have no effect on the Federal-aid highway system.

Comment noted.

5.3 Correspondence from State and Local Agencies

East Central Regional Development Commission; (26 May 1983)

10.) The Commission concurs with the Draft EIS recommendation.

Comment noted.

Minnesota Department of Natural Resources; (21 June 1983)

11.) The DEIS did not present costs to control all significant sources of nutrients to the lakes.

Comment noted. It was concluded that the solution to the water quality problem in Island Lake would include implementation of practices which abate all significant non-point sources of pollution. And, certain in-lake management practices would also be required to curtail algae growth. Estimation of the costs for all such practices would have obscured the purpose of the EIS, which was to assess the cost-effectiveness of a number of domestic wastewater management alternatives.

Minnesota Pollution Control Agency; (8 August 1983)

12.) The EIS should state more clearly that available information indicates no threat to public health as a result of blue-green algae blooms.

Comment noted. Editorial revisions to the sections discussing the potential for algal toxicity have been made in the Final EIS.

13.) The statement that winter phosphorus levels in Island and Sturgeon Lakes are similar (page 2-57) does not appear to be justified based on the limited number of samples taken.

Comment noted. The samples taken were limited in number. However, the data are useful for evaluating previous studies as referenced in the Phase II Report (USEPA 1981). (Studies by the Moose Lake Windemere Sanitary District had reported water column phosphorus (1979-1980) which were at levels typically associated with untreated domestic wastewater. The values reported for Island Lake were particularly high and the explanation given was that this reflected the greater number of year-round residents living on Island Lake.) In spite of the high phosphorus detection limit for winter samples and low number of samples taken, the sediment and water column phosphorus data (USEPA 1983) placed the referenced studies (USEPA 1981) in perspective and countered the assertion that on-site waste treatment systems have a significant and obvious impact on phosphorus levels. In summary, the issue being addressed was the gross level of accuracy, and not so much the precision of phosphorus measurements.

14.) The land runoff coefficients used to estimate external phosphorus loading appear to be excessive for some land use categories. (and) Ground water movement of phosphorus is not considered as a vector of nutrient loading.

Comments are noted. Selection of 'appropriate' phosphorus export coefficients is in large part a matter of professional judgment based on observation of cropping practices, slopes, proximity of animal waste storage facilities to water, and other land use characteristics in the direct drainage area.

It was assumed that the most cost-efficient abatement of phosphorus transport to the lake could be achieved by focusing on land management needs in the direct drainage. (The intermittent and continuous streams draining upland areas pass through peat bogs and ponds which are effective sedimentation basins even during spring runoff. Thus, Island lake would be most cost-effectively managed by controlling the critical phosphorus sources (those most proximate to the shoreline)). All such critical phosphorus sources were evaluated on a worst-case basis. It was felt that an objective approach to assessing management needs must consider both animal waste and domestic waste in equal terms.

Groundwater vectors of nutrient movement were considered for the estimate of loading from on-site systems. This was discussed at length in the Draft EIS on page 3-23. The groundwater vector was not considered as important for the export of nutrients to the lake from agricultural land and lawns. Most lawns, croplands, and barnyards in the direct drainage area are on clayey soil, on moderate to steep slopes, where groundwater infiltration is low and where the runoff function was judged to be the most significant. Additionally, groundwater nutrient levels were tested in a number of locations around the shoreline of Island and Sturgeon Lakes and the results, presented in the Appendix of the Draft EIS, were considered to indicate low levels of phosphorus in groundwater.

15.) The Final EIS should make more clear that phosphorus control is always a desireable goal for freshwater lakes. Wording in the Draft EIS created the impression that better control over on-site waste treatment systems is not needed because other sources of phosphorus to the lakes are more significant but not manageable.

Comment noted. The EIS alternative recommends that on-site systems should be designed to function correctly within the limitations of each lot and that failures should be corrected through regular maintenance and by provision of necessary upgrades. However, based on the evidence assembled in the EIS, there is a possiblity that no amount of pollution control in the Island Lake watershed would result in water quality improvements. This does not imply that continuing on-site system failures would not worsen the water quality of Island Lake or increase eutrophication of the other lakes. Therefore, the basic goal of implementing the selected alternative is to preserve and protect the quality of the project area lakes. This is indeed a desireable goal.

16.) The chosen alternative is on-site upgrades for the project area. Based on soil descriptions, there are problem soils in the area which have severe ratings for soil absorption systems. How was it decided who would get mounds and who would get drainfields? There should be a discussion of this documented. It may be that everyone located on the Duluth soils were given mounds and those on Omega soils were given drainfields.

The correlation between soil types and on-site systems with obvious or potential problems is given in Table 2-9 (p. 2-65) and shows a majority of the problems (68%) occurred in Duluth loam soils. In the System Components section (p. 2-74 to 2-77), types of systems appropriate for various soils in the project area are discussed. The criteria used for selection of on-site systems (given in Section 2.4.2., p. 2-9 and Section 2.6.2., p. 2-121) was based on soil characteristics as well as depth to water table, land slope, and lot size. Typically, lots with Duluth loam soils were given a mound system. Lots with Duluth Variant or Omega sandy loam soils were given drainfields.

17.) Duluth (loam) soils have up to 48% clay with estimated permeabilities as low as 0.06 inches/hr. which translates to percolation rates greater than 300 minutes per inch (mpi). According to WPC-40 criteria individual mounds could not be constructed on soils with percolation rates slower than

120 mpi without a variance. This is not to say something could not be designed for these slow rates, but it would require a much larger area and may not be reflected in the costs. Conversely, Omega soils are very course and may have percolation rates that are too fast as stated in WPC-40. Therefore, trench liners would have to be added to costs. If these problems have not been considered, the feasibility and costing may not be truly reflective of actual needs.

The type of onsite system upgrades for lots on Duluth loam soils was based on: the existing obvious or potential problems; the type of system currently in place; and information obtained in a telephone interview with a majority of residents who reported problems. The Duluth Loam soils have some variability and in some cases even conventional drainfields would function properly. However, based on all the collected information, residences with the most severe problems on Duluth Loam soils were given flow reduction devices, a blackwater holding tank for toilet wastes, and a mound system for greywater treatment. When properly installed, the mound system is considered to be adequate for treatment of the reduced wastewater load which would include only greywater flows.

For the areas with Omega sandy loam soils, the percolation rate may in some cases exceed the WPC criteria. In these instances, drainfield liners would be needed to slow down the percolation rate. Only 6 initial upgrades were proposed for systems on Omega sandy loam soils and approximately 90 new drainfields were proposed for the 20 year design period. The cost of the liners would be covered by the contingency component (included as part of the service factor) and represents 15% of the construction cost (Appendices, p. D-2). The contingency component is set aside for unforeseen costs.

18.) The EIS alternatives for cluster systems and bog treatment should not be considered feasible alternatives at this time.

Comment noted. The Draft and Final EIS concurs with this assessment and the selected alternative does not incorporate either treatment technology.

19.) Where will septage from the on-site systems go? On p. 2-72, septages for the Moose Lake area is said to go to the Moose Lake system. What would this include? Is the pond surface area designed for this extra BOD loading? Estimates were given of up to 4500 gpd of septages introduced to the system in spring and fall. On p. 2-81 it states septage in the Moose Lake area is treated in anaerobic lagoons. What is the estimate of septages to be produced for alternative #2?

Septage from onsite systems will continue to be disposed of in a manner consistent with the present disposal practice (p. 2-81) which is introduction to the Moose Lake Treatment system via a manhole (p. 2-73). The septage would include the residential solids generated in septic tanks and raw sewage pumped from holding tanks with a 40 mile radius, as is currently the case (p. 2-73). As seasonal residents return or leave their cabins in spring and autumn, they have their onsite systems pumped out, resulting in short periods when up to 4500 gpd of septage is introduced to the Moose Lake system.

Based on a septage volume for 365 septic tanks pumped per year and septage BOD of 5000 mg/l, there is 160 lb/day excess BOD treatment capacity to the year 2000 using the revised capacity with new MPCA design criteria. Based on the existing lagoon design capacity, there is 243 lb/day excess BOD treatment capacity at the Moose Lake WWTP for the year 2000 (p. 2-86).

20.) How was the conclusion reached that no private water well contamination problems existed in 'critical areas', e.g. areas with highly permeable soils which are developed with homes served by shallow wells.

No final conclusion was reached on this topic in the Draft EIS. The DEIS did state that the Minnesota State Department of Health records indicated no serious problems with private well contamination in the area. Also, the questionnaire responses from homeowners in critical areas indicated no problems with well contamination. Therefore, as stated in the DEIS, it was <u>presumed</u> that no broad degree of need for improved waste treatment exists (currently) as a result of private water well contamination. However, the DEIS provided a lengthy discussion which demonstrates the continuing potential for such contamination to occur in sandy soils where shallow wells are used. The EIS section dealing with well water contamination also pointed out that prevention of contamination problems can be accomplished through construction of new wells or upgrading of existing wells. Without well improvements, the potential for contamination would continue to be high in the critical areas regardless of which type of wastewater management is provided. The EIS also listed a number of potential causes of well contamination in northeastern Minnesota and stated the types of field studies that would be needed to determine conclusively which are most significant in the project area. It was concluded that such studies would contribute little more to the understanding of <u>future</u>

problems than already existed as a result of the identification of high potential areas and the identification of on-site systems (and wells) needing upgrades. (Even if an extensive well monitoring program were undertaken for the purpose of sampling wells in the summer, when the largely seasonal residences of the critical areas are in use, it may not provide an adequate assessment of the future potential for well contamination. Sampling would look at one year's problems, whereas consideration of where the highest contamination potential exists takes into consideration what is likely to happen throughout the 20 year wastewater management planning period.)

21.) Nitrates will not be prevented from entering the groundwater even if on-site waste treatment systems are properly operating.

Comment is noted. Revisions have been made to the Final EIS to correct the statement to this effect on pp. 15 of the DEIS.

22.) Were housing unit projections compared to available lakefront lots in making population projections and which rate of housing stock increase was used to estimate population growth?

Available lots were evaluated directly and through interviews with real estate agents, as explained in Section 3.2.2.5. of the Draft EIS. Explanation of the housing stock increased rate(s) used for estimating population growth was provided in Appendix I of the Draft EIS.

23.) When the final alternative is selected, the State Historical Preservation Officer (SHPO) should be contacted to determine whether field surveys are necessary and whether surveys, if any, must be completed prior to EIS finalization.

Comment noted. The Phase II Report (USEPA 1980) did contain a letter of review from the SHPO which listed all known sites of historical and cultural significance in Windemere Township. However, due to the lack of exact knowledge of the future location of individual on-site waste treatment systems to be upgraded or built, it is not possible to identify potential impacts on these cultural resources. This evaluation of compliance will need to be made in the development of plans and specifications, during Step 2 of the facilities planning.

24.) Have groundwater impacts of the final alternative been evaluated by groundwater dispersion modeling techniques?

The final alternative was not evaluated with a dispersion model to indicate the potential for water table elevation or gradient changes. The state-of-the-art in groundwater modeling techniques presently is such that results may not be easily verified and calibration to field conditions would be a significant expense. While selection of an alternative calling for community drain field or 'cluster system' may have justified the additional modeling work, such an alternative was not selected and therefore modeling was not done.

25.) The planning area map on page 2-9 did not include the City of Barnum nor the corridor between Moose Lake and Barnum. It should be noted in the EIS that these planning areas were included in Phase I of the EIS preparation.

Comment noted. These planning areas were discussed on page two of the DEIS Summary and again on page 1-4.

26.) On Island Lake, it was estimated that 64 residences were used on a permanent basis and on Sturgeon Lake, 42 were used as permanent residences. How were these estimates made?

The fraction of lakeshore residences being used permanently or seasonally was determined by examination of three types of information. First, questionnaire respondents indicated the duration of use and seasons in which that use took place. This data was compared to the proportion of property owners along the lakeshore listing local versus non-local tax form mailing addresses. Finally, both the above types of information were compared to the breakdown in seasonal versus permanent use as reported in the 1980 census data for the individual enumeration districts (Table 3-11 of the EIS). The 138 permanent homes in Enumeration District 504 were then disaggregated to either the Island or Sturgeon Lake vicinity. This was compared to the seasonal/permanent lakeshore home breakdown by lake as presented in the MLWSD Facility Plan. Further, adjustments were made as the EIS design work progressed because various sources provided information on recent property sales, use conversions within the preceeding two years, recent in-migration, etc. (The most obvious bias resulting from the questionnaire survey techniques was that permanent residents tended to respond more frequently than seasonal residents to the mailed survey form. It is felt that this bias was overcome by consideration of all above listed types of information.)

27.) What effort was made to assure that all potential on-site system failures were found in the Sturgeon Lake area?

All eight categories of survey information as presented in Section 2.2.1 of the EIS were co-evaluated to determine present and potential future failure rates. No attempt was made to re-survey Sturgeon Lake with the Septic Leachate Detector under more ideal conditions. As a practical matter, the onset of late fall weather precluded this option.

28.) The Hogan's Acres area south of Sturgeon Lake did not receive detailed survey for problems with on-site systems.

The intensity of survey and amount of attention paid to the available information was equal for all segments of the project area with two qualifications. First, the MLWSD did not develop detailed surveys of the Hogan's Acres area and thus, the Facilities Plan provided little indication of need with which to compare the EIS data. Second, the questionnaire response from Hogan's Acres property owners was low. Consequently, the follow-up survey (DEIS Section-2.2.1.8.) was specifically focused on that area to obtain a better understanding of the types of systems and problems being encountered.

29.) An average size for on-site systems was used in the EIS for cost evaluation purposes. During plan and specification development, individual Septic Absorption Systems would need to be sized according to lot conditions and house size.

Comment noted. This is correct. The typical residence in the area has two bedrooms. Although lot conditions in terms of soil type, slope, and size were evaluated, the estimated SAS size was based on the average two bedroom home. Residences with more bedrooms will need a larger system than what was estimated in the EIS. It was assumed that the total extra cost which would be incurred for constructing or upgrading the larger systems would be picked up in the contingency component of the service factor costs.

30.) The MPCA concurrs with the findings of the Draft EIS.

Comment noted.

5.4 Correspondence from Private Citizens

Mrs. Margaret Bowler; (10 June 1983)

31.) The Bowler family does not support any alternatives which require the construction of sewers.

Comment noted.

Mr. and Mrs. John C. Thomas; (21 June 1983)

32.) Sewering alternatives appear unjustified because of studies in the DEIS which indicate that environmental improvements will not result from sewer installation. Additionally, the high costs of sewers would make it impossible for ownership of the existing property to continue.

Comments noted.

Mr. George Rapp, Jr.; (1 June 1983)

33.) The DEIS recommended alternative (#2) is supported by Mr. Rapp and his brothers.

Comment noted.

Mrs. Ethell Spell; (21 June 1983)

34.) Establishment of sewer is opposed, and upgrading of on-site systems is supported.

Comment noted.

Mrs. Marcia N. Cavanaugh; (13 June 1983)

35.) Sewers are not necessary and are not affordable for the Cavanaugh family.

Comment noted.

Mr. Walter C. and Mrs. Kristi H. Johnson; (21 June 1983)

36.) Construction of a sewer is opposed and alternatives which involve upgrading or replacement of on-site waste management systems are supported.

Comment noted.

37.) USEPA failed to adequately communicate with citizens of the area during the last stages of DEIS preparation and review.

Comment noted. Additional effort will be taken to edit and expand the mailing list for persons wishing to receive the final EIS.

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6.0. LITERATURE CITED

Aronson, R., and E. Schwartz (Editors). 1975. Management policies in local government finance. International City Managers Association, Washington DC.

Carlson, A.H. 1980a. Report of the State Auditor of Minnesota on the revenues, expenditures, and debt of the local governments in Minnesota. St. Paul MN, 127 p.

Carlson, A.H. 1980b. Report of the State Auditor of Minnesota on the revenues, expenditures, and debt of the towns in Minnesota. St. Paul MN, 100 p.

Dillon, P.J. and W.B. Kirchner. 1975. The effects of geology and land use on the export of phosphorus from watersheds. Water Research 9: 135-148.

Dillon, P.J. and F. H. Rigler. 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. Journal of the Fisheries Research Board of Canada. 32:1,519-1,531.

East Central Regional Development Commission. 1981. Overall economic development program annual update. Mora MN, p. 1-7 plus attachments.

Federal Water Quality Administration. 1970. Federal guidelines for design, operation, and maintenance of wastewater treatment facilities. US Department of the Interior, Washington DC, 29 p.

Finney, H.R. 1981. Soil survey of part of Windemere Township, Pine County, Minnesota. Completed under contract to WAPORA, Inc. St. Paul MN, 28 p. plus soil map plates.

Gustatson, N.C. 1973. Recent trends, future prospects, a look at upper midwest population changes. Federal Reserve Bank, Upper Midwest Council, Minneapolis MN.

Goldreich, E.E. 1965. Detection and significance of fecal coliform bacteria in stream pollution studies. Journal Water Pollution Control Federation 37:1722

Howard A. Kuusisto. 1980. Moose Lake-Windemere Sanitary Sewer District, Unit No. 3, "Island Lake". Consulting Engineers, St. Paul MN, Plans 19 sheets, specifications

Jones, R.A., and G. F. Lee. 1977. Septic tank disposal systems as phosphorus sources for surface waters. EPA 600/3-77-129. Robert S. Kerr Environmental Research Laboratory, Ada OK.

Kamppi A. 1971. Studies of water disposal on peatland forest basin infiltration systems which were in effect in Findland in 1970. Report A4 National Board of Water, Helsinki, Finland. (English Summary).

Lorenzen, M.W. 1981. Correspondence. Environmental Science & Technology 15:1508-1509.

Miller, J.P. (ed). 1949. One hundred years in Pine County. Pine County Historical Society, reprint 1979. American Publishing Co., Askov. Minnesota.

Minnesota Department of Economic Security. 1982. Northeastern Minnesota labor market review, June 1982. Regional Labor Market Information Center, Duluth MN 8 p.

Minnesota Department of Energy, Planning, and Development. 1982. Fact Sheet: BTU contents of fuel. St. Paul MN, 1 sheet.

Minnesota Department of Transportation. 1979. 1979 Traffic map. St. Paul MN, 1 sheet.

Minnesota Department of Transportation. 1981. Minnesota automatic traffic recorder data summary. St. Paul MN, 591 p.

Minnesota Energy Agency. 1981. Residential energy prices in Minnesota. Forecasting Division, St. Paul MN, 39 p.

Moak, L.L., and A.M. Hillhouse. 1975. Concepts and practices in local government finance. Municipal Finance Officers Association of the US and Canda, Chicago IL, 454 p.

Moose Lake Planning Commission. 1981. City of Moose Lake, land use downtown development strategies. Moose Lake MN, 62 p.

MPCA. 1980. Recommended design criteria for stabilization ponds (aerated and non-aerated, 34 p.

National Oceanic and Atmospheric Administation. 1979a. Climatological data annual summary, Minnesota. National Climatic Center, Asheville NC, 16 p.

National Oceanic and Atmospheric Administration. 1979b. Local climatological data, annual summary with comparative data, Duluth, Minnesota. National climatic Center, Asheville NC, 4 p.

National Oceanic and Atmospheric Administration. 1981. National weather service surface weather observations. Duluth MN.

Northerneastern Minnesota Labor Market Review. 1980. Labor market data summary for fiscal year 1981, Northeastern Minnesota - Region 3. Minnesota Department of Economic Security, Duluth MN, 43 p.

Omernik, J.M. 1977. Non-point source stream nutrient level relationships: a nationwide survey. EPA 600/3-77-105. National Environmental Research Laboratory, Corvalis OR.

Otis R.J., and D. E. Stewart. 1976. Alternative wastewater facilities for small unsewered communities in rural America. Annual report to the Upper Great Lakes Region Commission.

Otis, R.J. 1979. Alternative wastewater facilities for small communities - a case study. In: Proceedings of a workshop on alternative wastewater treatment systems. UILU-WRC-79-0010. Water Resources Center and Cooperative Extensive Service, University of Illinois - Urbana, Urbana IL, p. 44-40.

Peterson, J.M., and G.O. Gronseth. 1980. Selected economic data for Duluth and Northeastern Minnesota through 1979. University of Minnesota, Duluth, Duluth MN, 68 p.

Pine County Area Redevelopment Organization. 1979. Pine County overall economic development plan. Pine City MN, 61 p.

Pound, C.E., and R.W. Crites. 1973. Wastewater treatment and reuse by land application, Volume I, summary. USEPA Office of Research and Development, Washington DC, 80 p.

PRC Consoer, Townsend and Associates LTD. 1980. Moose Lake-Windereme Sanitary Sewer District facility plan for wastewater collection and treatment. Duluth MN.

Ragotzkie, R.A. 1978. Heat budgets of lakes. Chapter I IN: Lakes; chemistry, geology, and physics. Pub Springer and Verlag, New York, NY 3,062 p.

Rast, W. and G. F. Lee. 1981. Correspondence. Environmental Science and Technology 15:1509-1510

Reneau, R. B. Jr., and D. E. Pettry. 1975. Movement of coliform bacteria from septic tank effluent through selected coastal plain soils of Virginia. Journal of Environmental Quality 4:41-44

Schindler, D.W. 1977. Evaluation of phosphorus limitation in lakes. Science 195:260-262

Seigrist, R. L., T. Woltanski, and C.E. Walforf. Water conservation and wastewater disposal. In: Proceedings of the second national home sewage treatment symposium (ASAE Publication 5-77). American Society of Agricultural Engineers, St. Joseph MI, p. 121-136.

Shapiro, J. 1979. The need for more biology in lake restoration. in Lake Restoration EPA 440/5-79-001 Washington, D.C. pp. 161-167

Simmons, J.D., and J.O. Newman. 1979. On-site liquefaction and variable gradient transport lines for rural sewage disposal. Paper No. SER 79-047. American Society of Agricultural Engineers, St. Joseph MI, 16 p.

Smith, V.H. and J. Shapiro. 1981. Chlorohyll phosphorus relations in individual lakes. Their importance to lake restoration strategies. Environmental science and technology 15:444-451.

Soil Conservation Service. 1978. Soil survey of Carlton County, Minnesota. US Department of Agriculture. In cooperation with the Minnesota Agricultural Experiment Station. 77 p. plus map sheets.

Spencer, J.S., Jr., and A.J. Ostrom. 1979. Timber resources of Minnesota's aspen-birch unit, 1977. Resource Bulletin NC-43, US Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul MN, 52 p.

Surakka, S. 1971. Some observations on the possibilities to infiltrate wastewater in peatlands according to results obtained in Kesalahden Town, Finland (English Summary). Vesitalous 8:26-31.

Surakka, S. and A. Kamppi. 1971. Infiltration of wastewater into peat soil (English Summary). SMO. 22:51:58

Tofflemire, T.J. and M. Chien. 1977. Phosphate removal by sands and soils. Groundwater 15:377.

US Bureau of the Census. 1952. US Census of population: 1950. Volume II, characteristics of the population, part 23, Minnesota. Department of Commerce, US Government Printing Office, Washington, DC, 220 p.

US Bureau of the Census. 1963. US census of population: 1960, Volume I, Chacteristics of the population, part 25, Minnesota. Department of Commerce, US Government Printing Office, Washington DC.

US Bureau of the Census. 1973. General social and economic characteristic, Minnesota. Department of Commerce, US Government Priting Office, Washington DC, 495 p. plus appendixes.

US Bureau of the Census. 1980. 1978 population estimates and 1977 and revised 1976 per capita income estimates for counties, incorporated places, and selected minor civil divisions — Minnesota. Department of Commerce, Washington DC.

US Bureau of the Census. 1982. Advance reports: Minnesota general population characteristics. Department of Commerce, Washington DC.

US Department of Agriculture. 1962. Soil survey manual. Handbook No. 18. Agricultural Research Administration, p. 209.

US Department of Commerce. 1929. State and county data, Minnesota census of agriculture. Washington DC.

US Department of Commerce. 1934. State and county data, Minnesota census of agriculture. Washington DC.

US Department of Commerce. 1939. State and county data, Minnesota census of agriculture. Washington DC.

US Department of Commerce. 1949. State and county data, Minnesota census of agriculture. Washington DC.

US Department of Commerce. 1969. State and county data, Minnesota census of Agriculture. Washington DC.

US Department of Commerce. 1978. State and county data, Minnesota census of Agriculture. Washington DC.

US Environmental Protection Agency. 1976. Quality criteria for water. Office of Water and Hazardous Materials. Washington DC, 255 p.

US Environmental Protection Agency. 1977. Alternatives for small wastewater treatment systems, on-site disposal/septage treatment and disposal. EPA 625/4-77-011. Technology Transfer, Washington DC, 90 p.

US Environmental Protection Agency. 1978. Funding of sewage collection system projects. Program Requirements Memorandum (PRM 78-9). Office of Water and Hazardous Materials, Washington DC.

US Environmental Protection Agency. 1978. Management of small waste flows. USEPA-600/2-78-173. Municipal Environmental Research Laboratory. Cincinnati OH.

US Environmental Protection Agency. 1979. Construction grants program requirements memorandum 79-7. Washington DC, 2 p.

US Environmental Protection Agency 1979. Management of on-site and alternative wastewater systems (Draft). Prepared for USEPA Environmental Research Information Center, by Roy F. Weston, Inc., Cincinnati, OH, 111 p.

US Environmental Protection Agency. 1979. Planning wastewater management facilities for small communities (Draft). Prepared for USEPA Municipal Environmental Research Laboratory, by Urban Systems Research Engineering, Inc., Cincinnati, OH, 141 p.

US Environmental Protection Agency. 1979. Region V, Water Division, Chicago, IL Draft environmental impact statement. Alternative waste treatment systems for rural lake projects. Case study number 1, Crystal Lake area sewage disposal authority, Benzie County, Michigan.

US Environmental Protection Agency. 1979. Region V, Water Division, Chicago, IL Draft environmental impact statement alternative waste treatment systems for rural lake projects. Case study number 2, Green Lake sanitary sewer and waster district, Kandiyohi County, Minnesota.

US Environmental Protection Agency. 1979. Region V, Water Division, Chicago, IL Draft environmental impact statement. Alternative waste treatment systems for rural lake projects.. Case study number 3, Springvale-Bear Creek sewage disposal authority, Emmet County, Michigan.

US Environmental Protection Agency. 1979. Region V, Water Division, Chicago, IL Draft environmental impact statement. Alternative waste treatment systems for rural lake projects. Case study number 4 Steuben Lakes Regional Waste District, Steuben County, Indiana.

US Environmental Protection Agency. 1979. Region V, Water Divisions, Chicago, IL Draft environmental impact statement. Alternative waste treatment systems for rural lake projects. Case study number 5, Ottertail County Board of Commissioners Ottertail County, Minnesota

US Environmental Protection Agency. 1980. Design manual. On-site wastewater treatment and disposal systems. Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH 391 p.

US Environmental Protection Agency. 1980. Modeing phosphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. EPA 440/5-80-011. Clean Lake Section USEPA, Washington, DC.

US Environmental Protection Agency. 1981. Alternative waste treatment system for rural lake projects. Draft generic environmental impact statement. USEPA Region V, Water Division, Chicago IL, 133 plus appendixes.

US Environmental Protection Agency. 1981. Facilities Planning 1981. Municipal wastewater treatment. EPA 430/9-81-002 office of Water Program Operations, Washington DC, 116 p.

US Environmental Protection Agency. 1981. Resource inventory and septic system survey. Moose Lake - Windemere Sewer District, Minnesota. Environmental Monitoring Systems Laboratory, Las Vegas NV.

US Environmental Protection Agency. 1981. Region V, Water Division, Chicago, IL Draft environmental impact statement. Alternative treatment systems for rural lake projects. Case study number 6, Williams County Commissioners, Nettle Lake area, Williams County, Ohio.

US Geological Survey. 1979. Bruno and Moose Lake quadrangles Minnesota. 15 minute series (topographic). Department of Interior, Washington DC, 2 sheets (1:62,500).

Uttormark, P.D., and J.P. Wall. 1975. Lake classification for water quality management. University of Wisconsin Water Resources Center.

Vasilevski, A. and R.L. Hackett. 1980. Timber resource of Minnesota's central hardwood unit, 1977. US Department of Agriculture Forest Service Resource Bulletin NC-46. North Central Forest Experiment Station, St. Paul MN, 65 p.

Viraraghavan, T., and R. G. Warnock., 1976. Groundwater quality adjacent to a septic tank system. Journal of the American Water Works Association 68:611-614.

Vollenweider, R.A. 1975. Input - output models with special reference to the phosphorus loading concept in limnology. Schweiz. Z. Hydrol 37:53-83.

Williams, J.D.H. J-M Jaquet, and R. L. Thomas. 1976. Forms of phosphorus in the surficial sediments of Lake Erie. Journal Fish Res. Board Can - 33:413-429.

Wisconsin Department of Natural Resources Technical Bulletin #81, Influence of organic pollution on the density and production of trout in a Wisconsin stream 1975.

7.0. INDEX

8.0. GLOSSARY OF TECHNICAL TERMS

Activated sludge process. A method of secondary wastewater treatment in which a suspended microbiological culture is maintained inside an aerated treatment basin. The microbial organisms oxidize the complex organic matter in the wastewater to carbon dioxide, water, and energy.

Advanced secondary treatment. Wastewater treatment more stringent than secondary treatment but not to advanced waste treatment levels.

Advanced waste treatment. Wastewater treatment to treatment levels that provide for maximum monthly average BOD_5 and SS concentrations less than 10 mg/l and/or total nitrogen removal of greater than 50% (total nitrogen removal = TKN + nitrite and nitrate).

Aeration. To circulate oxygen through a substance, as in wastewater treatment, where it aids in purification.

Aerobic. Refers to life or processes that occur only in the presence of oxygen.

Aerosol. A suspension of liquid or solid particles in a gas.

Algae. Simple rootless plants that grow in bodies of water in relative proportion to the amounts of nutrients available. Algal blooms, or sudden growth spurts, can affect water quality adversely.

Algal bloom. A proliferation of one species of algae in lakes, streams or ponds to the exclusion of other algal species.

Alluvial. Pertaining to material that has been carried by a stream.

Ambient air. Any unconfined portion of the atmosphere: open air.

Ammonia-nitrogen. Nitrogen in the form of ammonia (NH_3) that is produced in nature when nitrogen-containing organic material is biologically decomposed.

Anaerobic. Refers to life or processes that occur in the absence of oxygen.

Anoxia. Condition where oxygen is deficient or absent.

Apatite. Calcium phosphate with chloride, fluoride or hydroxyl Ca(Cl, F, OH) $Ca_4(PO_4)_3$; forms hexagonal crystals; earlier was often confused with fluorite.

Aquifer. A geologic stratum or unit that contains water and will allow it to pass through. The water may reside in and travel through innumerable spaces between rock grains in a sand or gravel aquifer, small or cavernous openings formed by solution in a limestone aquifer, or fissures, cracks, and rubble in harder rocks such as shale.

Artesian (adj.). Refers to groundwater that is under sufficient pressure to flow to the surface without being pumped.

Artesian well. A well that normally gives a continuous flow because of hydrostatic pressure, created when the outlet of the well is below the level of the water source.

Bar screen. In wastewater treatment, a screen that removes large floating and suspended solids.

Base flow. The rate of movement of water in a stream channel that occurs typically during rainless periods, when stream flow is maintained largely or entirely by discharges of groundwater.

Bed Rock. The solid rock beneath the soil and subsoil.

Biochemical oxygen demand (BOD). A bioassay-type procedure in which the weight of oxygen utilized by microorganisms to oxidize and assimilate the organic matter present per liter of water is determined. It is common to note the number of days during which a test was conducted as a subscript to the abbreviated name. For example, BOD_5 indicates that the results are based on a five-day long (120-hour) test. The BOD value is a relative measure of the amount (load) of living and dead oxidizable organic matter in water. A high demand may deplete the supply of oxygen in the water, temporarily or for a prolonged time, to the degree that many or all kinds of aquatic organisms are killed. Determinations of BOD are useful in the evaluation of the impact of wastewater on receiving waters.

Biota. The plants and animals of an area.

Chemocline. A stratum of stronger concentration gradient of dissolved substances.

Chlorination. The application of chlorine to drinking water, sewage or industrial waste for disinfection or oxidation of undesirable compounds.

Circulation period. The interval of time in which the density stratification of a lake is destroyed by the equalization of temperature, as a result of which the entire water mass becomes mixed.

Clay. The smallest mineral particles in soil, less than .004 mm in diameter; soil that contains at least 40% clay particles, less than 45% sand, and less than 40% silt.

Coliform bacteria. Members of a large group of bacteria that flourish in the feces and/or intestines of warm-blooded animals, including man. Fecal coliform bacteria, particularly *Escherichia coli* (*E. coli*), enter water mostly in fecal matter, such as sewage or feedlot runnoff. Coliforms apparently do not cause serious human diseases, but these organisms are abundant in polluted waters and they are fairly easy to detect. The abundance of coliforms in water, therefore, is used as an index to the probability of the occurrence of such disease-producing organisms (pathogens) as *Salmonella*, *Shigella*, and enteric viruses which are otherwise relatively difficult to detect.

Community. The plants and animals in a particular area that are closely related through food chains and other interactions.

Cultural resources. Fragile and nonrenewable sites, districts, buildings, structures, or objects representative of our heritage. Cultural resources are divided into three categories: historical, architectural, or archaeological. Cultural resources of special significance may be eligible for listing on the National Register of Historic Places.

Decibel (dB). A unit of measurement used to express the relative intensity of sound. For environmental assessment, it is common to use a frequency-rated scale (A scale) on which the units (dBA) are correlated with responses of the human ear. On the A scale, 0 dBA represents the average least perceptible sound (rustling leaves, gentle breathing), and 140 dBA represents the intensity at which the eardrum may rupture (jet engine at open throttle). Intermediate values generally are: 20 dBA, faint (whisper at 5 feet, classroom, private office); 60 dBA, loud (average restaurant or living room, playground); 80 DBA, very loud (impossible to use a telephone, noise made by food blender or portable standing machine; hearing impairment may result from prolonged exposure); 100 dBA, deafening noise (thunder, car horn at 3 feet, loud motorcycle, loud power lawn mower).

Demographic. Pertaining to the science of vital and special statistics, especially with regard to population density and capacity for expansion or decline.

Detention time. Average time required to flow through a basin. Also called retention time.

Digestion. In wastewater treatment a closed tank, sometimes heated to 95°F where sludge is subjected to intensified bacterial action.

Disinfection. Effective killing by chemical or physical processes of all organisms capable of causing infectious disease. Chlorination is the disinfection method commonly employed in sewage treatment processes.

Dissolved oxygen (DO). Oxygen gas (O_2) in water. It is utilized in respiration by fish and other aquatic organisms, and those organisms may be injured or killed when the concentration is low. Because much oxygen diffuses into water from the air, the concentration of DO is greater, other conditions being equal, at sea level than at high elevations, during periods of high atmospheric pressure than during periods of low pressure, and when the water is turbulent (during rainfall, in rapids, and waterfalls) rather than when it is placid. Because cool water can absorb more oxygen than warm water, the concentration tends to be greater at low temperatures than at high temperatures. Dissolved oxygen is depleted by the oxidation of organic matter and of various inorganic chemicals. Should depletion be extreme, the water may become anaerobic and could stagnate and stink.

Drainage Basin. A geographical area or region which is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away by a single drainage system by gravity to a common outlet or outlets; also referred to as a watershed or drainage area.

Drift. Rock material picked up and transported by a glacier and deposited elsewhere.

Effluent. Wastewater or other liquid, partially or completely treated, or in its natural state, flowing out of a reservoir, basin, treatment plant, or industrial treatment plant, or part thereof.

Endangered species. Any species of animal or plant that is in known danger of extinction throughout all or a significant part of its range.

Epilimnion. The turbulent superficial layer of a lake lying above the metalimnion which does not have a permanent thermal stratification.

Eutrophication. The progressive enrichment of surface waters particularly non-flowing bodies of water such as lakes and ponds, with dissolved nutrients, such as phosphorous and nitrogen compounds, which accelerate the growth of algae and higher forms of plant life and result in the utilization of the useable oxygen content of the waters at the expense of other aquatic life forms.

Fauna. The total animal life of a particular geographic area or habitat.

Fecal coliform bacteria. See coliform bacteria.

Floodway. The portion of the floodplain which carries moving water during a flood event.

Flood fringe. The part of the floodplain which serves as a storage area during a flood event.

Flora. The total plant life of a particular geographic area or habitat.

Flowmeter. A guage that indicates the amount of flow of wastewater moving through a treatment plant.

Force main. A pipe designed to carry wastewater under pressure.

Gravity system. A system of conduits (open or closed) in which no liquid pumping is required.

Gravity sewer. A sewer in which wastewater flows naturally down-gradient by the force of gravity.

Groundwater. All subsurface water, especially that part in the zone of saturation.

Holding Tank. Enclosed tank, usually of fiberglass, steel or concrete, for the storage of wastewater prior to removal or disposal at another location.

Hypolimnion. The deep layer of a lake lying below the epilimnion and the metalimnion and removed from surface influences.

Infiltration. The water entering a sewer system and service connections from the ground through such means as, but not limited to, defective pipes, pipe joints, improper connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow. The water discharged into a wastewater collection system and service connections from such sources as, but not limited to, roof leaders, cellars, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross-connections from storm sewers and combined sewers, catch basins, storm waters, surface runoff, street wash waters or drainage. Inflow does not include, and is distinguished from, infiltration.

Influent. Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment facility, or any unit thereof.

Interceptor sewer. A sewer designed and installed to collect sewage from a series of trunk sewers and to convey it to a sewage treatment plant.

Innovative Technology. A technology whose use has not been widely documented by experience and is not a variant of conventional biological or physical/chemical treatment.

Lagoon. In wastewater treatment, a shallow pond, usually man-made, in which sunlight, algal and bacterial action and oxygen interact to restore the wastewater to a reasonable state of purity.

Land Treatment. A method of treatment in which the soil, air, vegetation, bacteria, and fungi are employed to remove pollutants from wastewater. In its most simple form, the method includes three steps: (1) pretreatment to screen out large solids; (2) secondary treatment and chlorination; and (3) spraying over cropland, pasture, or natural vegetation to allow plants and soil microorganisms to remove additional pollutants. Much of the sprayed water evaporates, and the remainder may be allowed to percolate to the water table, discharged through drain tiles, or reclaimed by wells.

Leachate. Solution formed when water percolates through solid wastes, soil or other materials and extracts soluble or suspendable substances from material.

Lift station. A facility in a collector sewer system, consisting of a receiving chamber, pumping equipment, and associated drive and control devices, that collects wastewater from a low-lying district at some convenient point, from which it is lifted to another portion of the collector system.

Littoral. The shoreward region of a body of water.

Loam. The textural class name for soil having a moderate amount of sand, silt, and clay. Loam soils contain 7 to 27% of clay, 28 to 50% of silt, and less than 52% of sand.

Macroinvertebrates. Invertebrates that are visible to the unaided eye (those retained by a standard No. 30 sieve, which has 28 meshes per inch or 0.595 mm openings); generally connotates bottom-dwelling aquatic animals (benthos).

Macrophyte. A large (not microscopic) plant, usually in an aquatic habitat.

Mesotrophic. Waters with a moderate supply of nutrients and no significant production of organic matter.

Metalimnion. The layer of water in a lake between the epilimnion and hypolimnion in which the temperature exhibits the greatest difference in a vertical direction.

Milligram per liter (mg/l). A concentration of 1/1000 gram of a substance in 1 liter of water. Because 1 liter of pure water weighs 1,000 grams, the concentration also can be stated as 1 ppm (part per million, by weight). Used to measure and report the concentrations of most substances that commonly occur in natural and polluted waters.

Moraine. A mound, ridge, or other distinctive accumulation of sediment deposited by a glacier.

National Register of Historic Places. Official listing of the cultural resources of the Nation that are worthy of preservation. Listing on the National Register makes property owners eligible to be considered for Federal grants-in-aid for historic preservation through state programs. Listing also provides protection through comment by the Advisory Council on Historic Preservation on the effect of Federally financed, assisted, or licensed undertakings on historic properties.

Nitrate-nitrogen. Nitrogen in the form of nitrate (NO_3). It is the most oxidized phase in the nitrogen cycle in nature and occurs in high concentrations in the final stages of biological oxidation. It can serve as a nutrient for the growth of algae and other aquatic plants.

Nitrite-nitrogen. Nitrogen in the form of nitrite (NO_2). It is an intermediate stage in the nitrogen cycle in nature. Nitrite normally is found in low concentrations and represents a transient stage in the biological oxidation of organic materials.

Nonpoint source. Any area, in contrast to a pipe or other structure, from which pollutants flow into a body of water. Common pollutants from nonpoint sources are sediments from construction sites and fertilizers and sediments from agricultural soils.

Nutrients. Elements or compounds essential as raw materials for the growth and development of an organism; e.g., carbon, oxygen, nitrogen, and phosphorus.

Outwash. Sand and gravel transported away from a glacier by streams of meltwater and either deposited as a floodplain along a preexisting valley bottom or broadcast over a preexisting plain in a form similar to an alluvial fan.

Oligotrophic. Waters with a small supply of nutrients and hence an insignificant production of organic matter.

Ordinance. A municipal or county regulation.

Outwash. Drift carried by melt water from a glacier and deposited beyond the marginal moraine.

Outwash Plain. A plain formed by material deposited by melt water from a glacier flowing over a more or less flat surface of large area. Deposits of this origin are usually distinguishable from odinary river deposits by the fact that they often grade into moraines and their constituents bear evidence of glacial origin. Also called frontal apron.

Oxidation lagoon (pond). A holding area where organic wastes are broken down by aerobic bacteria.

Percolation. The downward movement of water through pore spaces or larger voids in soil or rock.

pH. A measure of the acidity or alkalinity of a material, liquid or solid. pH is represented on a scale of 0 to 14 with 7 being a neutral state; 0, most acid; and 14, most alkaline.

Piezometric level. An imaginary point that represents the static head of groundwater and is defined by the level to which water will rise.

Plankton. Minute plants (phytoplankton) and animals (zooplankton) that float or swim weakly in rivers, ponds, lakes, estuaries, or seas.

Point source. In regard to water, any pipe, ditch, channel, conduit, tunnel, well, discrete operation, vessel or other floating craft, or other confined and discrete conveyance from which a substance considered to be a pollutant is, or may be, discharged into a body of water.

Pressure sewer system. A wastewater collection system in which household wastes are collected in the building drain and conveyed therein to the pretreatment and/or pressurization facility. The system consists of two major elements, the on-site or pressurization facility, and the primary conductor pressurized sewer main.

Primary treatment. The first stage in wastewater treatment, in which substantially all floating or settleable solids are mechanically removed by screening and sedimentation.

Prime farmland. Agricultural lands, designated Class I or Class II, having little or no limitations to profitable crop production.

Pumping station. A facility within a sewer system that pumps sewage/effluent against the force of gravity.

Runoff. Water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams. It can collect pollutants from air or land and carry them to the receiving waters.

Sanitary sewer. Underground pipes that carry only domestic or commercial wastewater, not stormwater.

Screening. Use of racks of screens to remove coarse floating and suspended solids from sewage.

Secchi Disk. A disk, painted in four quadrants of alternating black and white, which is lowered into a body of water. The measured depth at which the disk is no longer visible from the surface is a measure of relative transparency.

Secondary treatment. The second stage in the treatment of wastewater in which bacteria are utilized to decompose the organic matter in sewage. This step is accomplished by introducing the sewage into a trickling filter or an activated sludge process. Effective secondary treatment processes remove virtually all floating solids and settleable solids, as well as 90% of the BOD and suspended solids. USEPA regulations define secondary treatment as 30 mg/l BOD, 30 mg/l SS, or 85% removal of these substances.

Sedimentation. The process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.

Seepage. Water that flows through the soil.

Seepage cells. Unlined wastewater lagoons designed so that all or part of wastewater percolates into the underlying soil.

Septic snooper. Trademark for the ENDECO (Environmental Devices Corporation) Type 2100 Septic Leachate Detector. This instrument consists of an underwater probe, a water intake system, an analyzer control unit and a graphic recorder. Water drawn through the instrument is continuously analyzed for specific fluorescence and conductivity. When calibrated against typical effluents, the instrument can detect and profile effluent-like substances and thereby locate septic tank leachate or other sources of domestic sewage entering lakes and streams.

Septic tank. An underground tank used for the collection of domestic wastes. Bacteria in the wastes decompose the organic matter, and the sludge settles to the bottom. The effluent flows through drains into the ground. Sludge is pumped out at regular intervals.

Septic tank effluent pump (STEP). Pump designed to transfer settled wastewater from a septic tank to a sewer.

Septic tank soil absorption system (STAS). A system of wastewater disposal in which large solids are retained in a tank; fine solids and liquids are dispersed into the surrounding soil by a system of pipes.

Settling tank. A holding area for wasteater, where heavier particles sink to the bottom and can be siphoned off.

Sewer, Interceptor. See Interceptor Sewer.

Sewer, lateral. A sewer designed and installed to collect sewage from a limited number of individual properties and conduct it to a trunk sewer. Also known as a street sewer or collecting sewer.

Sewer, sanitary. See Sanitary Sewer.

Sewer, storm. A conduit that collects and transports storm-water runoff. In many sewerage systems, storm sewers are separate from those carrying sanitary or industrial wastewater.

Sewer, trunk. A sewer designed and installed to collect sewage from a number of lateral sewers and conduct it to an interceptor sewer or, in some cases, to a sewage treatment plant.

Sinking fund. A fund established by periodic installments to provide for the retirement of the principal of term bonds.

Slope. The incline of the surface of the land. It is usually expressed as a percent (%) of slope that equals the number of feet of fall per 100 feet in horizontal distance.

Sludge. The accumulated solids that have been separated from liquids such as as wastewater.

Soil association. General term used to describe taxonomic units of soils, relative proportions, and pattern of occurrence.

Soil textural class. The classification of soil material according to the proportions of sand, silt, and clay. The principal textural classes in soil, in increasing order of the amount of silt and clay, are as follows: sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. These class names are modified to indicate the size of the sand fraction or the presence of gravel, sandy loam, gravelly loam, stony clay, and cobbly loam, and are used on detailed soil maps. These terms apply only to individual soil horizons or to the surface layer of a soil type.

State equalized valuation (SEV). A measure employed within a State to adjust actual assessed valuation upward to approximate true market value. Thus it is possible to relate debt burden to the full value of taxable property in each community within that State.

Stratification. The condition of a body of water when the water is divided into layers of differing density. Climatic changes over the course of the seasons cause a lake to divide into a bottom layer and surface layer, with a boundary layer (thermocline) between them. Stratification generally occurs during the summer and again during periods of ice cover in the winter. Overturns, or periods of mixing, generally occur once in the spring and once in the autumn. This "dimictic" condition is most common in lakes located in middle latitudes. A lake which stratifies and mixes more than twice per year is defined as "polymictic".

Threatened species. Any species of animal or plant that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

Till. Unsorted and unstratified drift, consisting of a heterogeneous mixture of clay, sand, gravel, and boulders, that is deposited by and underneath a glacier.

Trickling filter process. A method of secondary wastewater treatment in which the biological growth is attached to a fixed medium, over which wastewater is sprayed. The filter organisms biochemically oxidize the complex organic matter in the wastewater to carbon dioxide, water, and energy.

Topography. The configuration of a surface area including its relief, or relative evaluations, and the position of its natural and manmade features.

Unique farmland. Land, which is unsuitable for crop production in its natural state, that has been made productive by drainage, irrigation, or fertilization practices.

Wastewater. Water carrying dissolved or suspended solids from homes, farms, businesses, and industries.

Water quality. The relative condition of a body of water, as judged by a comparison between contemporary values and certain more or less objective standard values for biological, chemical, and/or physical parameters. The standard values usually are based on a specific series of intended uses, and may vary as the intended uses vary.

Watershed. The region drained by or contributing water to a stream, lake, or other body of water.

Water table. The upper level of groundwater that is not confined by an upper impermeable layer and is under atmospheric pressure. The upper surface of the substrate that is wholly saturated with groundwater.

Wetlands. Those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

9.0. LIST OF PREPARERS

The Draft Environmental Statement (DES) was prepared by the Chicago Regional Office of WAPORA, Inc., under contract to USEPA, Region V. USEPA approved the DES and hereby publishes it as a Draft EIS. The USEPA Project Officers and the WAPORA staff involved in the preparation of the DES/DEIS during the past two years include:

USEPA

Charles Quinlan III	Project Officer
James Novak	Project Officer (former)

WAPORA, Inc.

Robert France	Project Administrator
Lawrence Olinger	Project Administrator
J. P. Singh	Project Administrator and Senior Engineer
John Laumer	Project Manager and Principal Author
Steven McComas	Environmental Scientist, Engineeer, and Principal Author
Ross Sweeney	Civil Engineer and Principal Author
Gerald Lenssen	Agricultural Engineer
Andrew Freeman	Demographer
Rhoda Grant	Editor
Peter Woods	Graphic Specialist
Richard Gill	Biologist
Thomas Davis	Chemist
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Richard Kubb	Biologist
Greg Lindsey	Land Use Planner
Ellen Renzas	Socio-Enconomist
Jan Saper	Socio-Economist
Delores Jackson-Hope	Production Specialist

In addition, several subcontractors and others assisted in the preparation of this document. These, along with their areas of expertise, are listed below:

- Aerial Survey
  Office of Research and Development
  USEPA
  Las Vegas, Nevada

- Soil Survey and Mapping
  Mr. Harlan R. Finney
  Professional Soil Scientists
  1828 Draper Drive
  St. Paul, MN 55113

- Paleolimnological and Lake Management Studies
  Lake Management Consultants, Inc.
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  Madison, Wisc. 53704

- Field Survey Arrangements and Data Development
  Moose Lake-Windemere Sanitary District
  Moose Lake, MN 55767

10.0. LIST OF THOSE SENT COPY OF THE DRAFT EIS

Federal

Senator Rudolph E. Boschwitz
Senator David Durenberger
Representative James Oberstar
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Health, and Human Services
Department of Housing and Urban Development
Department of the Interior
US Fish & Wildlife Service
Geological Survey
Heritage Conservation & Recreation Service
National Park Service
Advisory Council on Historic Preservation
Department of Labor
Department of Transportation
US Army Corps of Engineers
US Soil Conservation Service
USEPA Regional Offices

State

Senator Florian Chmielewski
Representative Doug Carlson
Office of the Governor
Office of the Lieutenant Governor
Minnesota Pollution Control Agency
Minnesota Water Resources Board
Minnesota Department of Natural Resources
Minnesota Department of Health
Minnesota State Planning Agency
Minnesota Environmental Quality Board
Minnesota Department of Transportation
Minnesota Energy Agency
Minnesota Department of Agriculture

Local

Mayor, City of Moose Lake
Mayor, City of Barnum
Moose Lake-Windemere Sanitary District Board
Township Clerk for Moose Lake Township
Township Clerk for Windemere Township
Chairman, Pine County Board of Commissioners
Chairman, Carlton County Board of Commissioners

Citizens and Groups

This list is available upon request from USEPA.

LIST OF APPENDICES

Appendix A

A-1. The Notice of Intent (NOI)

APPENDIX A NOTICE OF INTENT

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO ATTENTION OF:
5WEE/EIS

JUL 11 1980

NOTICE OF INTENT

TO ALL INTERESTED GOVERNMENT AGENCIES, PUBLIC GROUPS AND CITIZENS:

In accordance with the procedures for the preparation of Environmental Impact Statements, an Environmental Review has been performed on the proposed action described below.

Name of Applicant: Moose Lake-Windemere Sanitary Sewer District Moose Lake, Minnesota

Planning Area: The Facilities Planning area, as recommended by the Minnesota Pollution Control Agency (MPCA), includes the Moose Lake-Windemere Sanitary Sewer District and the City of Burnum including the Northern Pacific Railroad and the corridor between the Cities of Moose Lake and Burnum, (see attached map). The planning area encompasses approximately 60 square miles. The majority of the District lies in central northern Pine County, but the majority of the District's year round population resides in central southern Carlton County, Minnesota. The City of Moose Lake is the largest incorporated area of the District having a 1970 population of 1452. In addition to the City of Moose Lake, the Moose Lake-Windemere Sanitary Sewer District also serves Windemere Township in Pine County and Moose Lake Township in Carlton County.

Proposed Action: The District has prepared, with grant assistance from this Agency, a facilities plan which was completed in March 1980. The selected alternative of the facilities plan proposes to construct collection sewers around Island and Sturgeon Lakes, construct interceptor sewers and pump stations to bring Island and Sturgeon Lakes in the system, modify existing interceptors, infiltration/inflow correction in the Moose Lake sewer system, rebuild or construct a new pump station, construct a storm water overflow pond and modify the existing wastewater treatment facility located in the City of Moose Lake.

State and Federal agency review of the above proposed project identified the possibility of significant environmental impacts involving the following issues.

A. Impact on Water Quality

There was no documentation supporting the need to sewer around Island and Sturgeon Lakes except that there appears to be public opinion that the increased degradation of these lakes is caused by failing or poorly designed on-site treatment systems.

B. Socioeconomic Impact

The substantial local costs will probably have a significant impact on the service area families, particularly those on fixed or lower incomes in the Island and Sturgeon Lakes area, encouraging or forcing them to sell their property and thus accelerating changes in occupancy patterns. As presented in the March 28, 1980 public hearing, the cost of repairs to the existing sewer system and construction of new interceptors would cost all homes in Sewer District $8.40 a month. Additionally the cost of the collection system around Island and Strugeon Lakes would cost those residents another $22.40 per month assuming a $3,000.00 assessment and a 50% grant from Farmers Home Administration, along with low interest long-term loans.

C. Secondary Impact and Induced Growth

The probable development and land use change induced by the project, and its effect on the demand for future services, must be assessed.

Consequently, this Agency has determined that the preparation of an Environmental Impact Statement (EIS) on the above project is warranted.

If you or your organization need additional information, want to be placed on the mailing list, and/or wish to participate in the preparation of the Draft EIS for the Moose Lake-Windemere Sanitary Sewer District, please contact the EIS Section, (5WEE) at the letterhead address.

Sincerely yours,

John McGuire
Regional Administrator

Attachment

Appendix B

B-1. Soils Survey of a Portion of Windemere Township, Pine County, Minnesota.

B-2. Soil Map Plates.

B-3. Soils Testing Data.

B-4. Summary and interpretation of soils information.

APPENDIX B Soils information.

Appendix B-1.

SOIL SURVEY OF PART OF WINDEMERE TOWNSHIP, PINE COUNTY, MINNESOTA

BY

Harlan R. Finney
Professional Soil Scientist

1828 Draper Drive
St. Paul, Minnesota 55113

November, 1981

<u>Contents</u>

ABSTRACT

A soil survey of about 7,000 acres of land in Windemere Township, Pine County, Minnesota was conducted 14 September to 6 November 1981. The survey area comprises lands surrounding Island, Passenger, Rush, and Sturgeon Lakes. A soil survey consists of the following parts: (1) identification and classification of soils of the area, (2) a map showing the location of the different kinds of soil, and (3) interpretations about the response of the different kinds of soil to use and management.

Ten major kinds of soil were identified and classified on the basis of properties in the upper 60 inches of soil. These comprise 3 that formed in loamy glacial till, 3 that formed in sandy glacial outwash, 1 that formed in a mantle of glacial outwash and underlying glacial till, organic soils, alluvial soils and soils on lake beaches.

The 3 kinds of soil that formed in till and the 3 kinds that formed in outwash are distinguished one from another in the basis of properties associated with degree of wetness. Soils that formed in till are the well and moderately well drained Duluth series, the somewhat poorly and poorly drained Dusler series, and the very poorly drained Blackhoof series. Soils that formed in glacial outwash are the somewhat excessively drained Omega series, the somewhat poorly drained Nemadji series, and the poorly and very poorly drained Newson series. Three phases of both the Duluth and Omega series are recognized on the basis of slope.

The three dominant soils in the survey area are the Duluth and Omega series and organic soils. The Duluth series and its wetter associates are on most all land adjacent to Island Lake and on land adjacent the northern and eastern parts of Sturgeon Lake. The Omega series and its wetter associates are dominant on land adjacent to Passenger and Rush Lakes and on land adjacent to the southern and southwestern parts of Sturgeon Lake. Organic soils are in small to large areas throughout the survey area, but the largest single area of such soils begins not too far from the central part of the west shore of Sturgeon Lake.

The National Cooperative Soil Survey has rated the soils in regards to limitations for conventional septic tank absorption fields among other uses. The ratings are slight, moderate, and severe. The Duluth, Dusler, and Blackhoof series are rated as severe because of low rates of percolation or the presence of a seasonal high water table or both. The Omega, Nemadji, and Newson series likewise are rated as severe because of being a poor filter of sewage effluent or for having a seasonal high water table or both. Organic soils are rated as severe because of a seasonal high water table.

DESCRIPTION OF SOILS

Important features of taxonomic and map units are described here. Taxonomic units are the basic kinds of soil that were identified in the survey area, whereas map units are bodies of soil that are delineated on the maps.

The following items are described.

Taxonomic Units

Landscape setting and some interpretations
Associated soils
Seasonal high water
Description of a representative pedon
Range in characteristics

Map Units

Setting
Inclusions

The permeability class for each taxonomic unit is given in the first paragraph. This class is based on the most restrictive horizon within a depth of 60 inches. Estimates of the permeability of each horizon are in the detailed pedon description. Rates and class names follow:

Inches/hour	Class name
<0.06	very slow
0.06- 0.20	slow
0.20- 0.60	moderately slow
0.60- 2.00	moderate
2.00- 6.00	moderately rapid
6.00-20.00	rapid

The pattern of soils in most of the survey area is very complex. Thus, even at the rather large map scale of this survey, small area of different kinds of soil are included in many of the delineations of each map unit.

Soils in this survey area were identified and mapped on the basis of properties of the upper 60 inches of the soil. Statements here, thus, only refer to the nature of the soil from the surface to a depth of 60 inches.

If the meaning of some terms used in this report is not known, refer to the glossary of a modern soil survey report, for example, Carlton County, Minnesota.

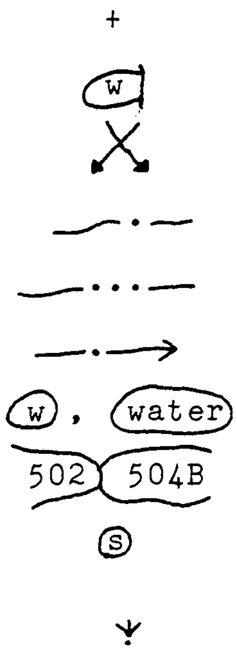
An identification legend with the map units arranged numerically by map symbol is attached to the soil map. An identification legend with the map units arranged alphabetically follows.

Identification Legend

Map Units

Map Symbol	Name
1002	Alluvial soils
1016	Altered soils
614	Blackhoof muck
504B	Duluth loan, 1 to 4 percent slopes
504C	Duluth loam, 4 to 15 percent slopes
504E	Duluth loam, 15 to 60 percent slopes
1350B	Duluth variant loamy fine sand, 1 to 4 percent slopes
1350C	Duluth variant loamy fine sand, 4 to 15 percent slopes
502	Dusler loam
1032	Lake beaches
995	Organic soils
186	Nemadji loamy sand
274	Newson mucky sandy loam
188B	Omega loamy sand, Oto 5 percent slopes
188C	Omega loamy sand, 5 to 20 percent slopes
188E	Omega loamy sand, 20 to 60 percent slopes

Conventional and Special Features



Section corners

Dams and associated reservior

Gravel and sand pits

Perennial drainage way

Intermittent drainage way

End of drainage way

Unnamed lakes and ponds

Soil delineations and map unit symbols

Soil sample site

Small area, 1/8 to 1/2 acre, of poorly drained or wetter soils in delineations of better drained soils

Taxonomic and Mapping Units

Alluvial Soils

Alluvial soils consist of poorly to moderately well drained sandy and loamy soils that formed in alluvium on flood plains. They have moderately slow to rapid permeability. These soils typically are flooded one or more times each year.

Alluvial soils are primarily associated with soils of the Duluth and Omega series, which are on bluffs adjacent to the flood plains. The Duluth series formed in glacial till and Omega soils formed in glacial outwash. Organic soils are associated with Alluvial soils in a few places. No description of a pedon of Alluvial soils is given because of their limited extent, great variability, and insignificance to the purpose of this soil survey.

1002 Alluvial soils, mixed. This map unit has linear slopes with gradient of less than 1 percent on flood plains, delineations of this unit primarily are elongate in shape and are about 2 to 20 acres in size. Areas of these soils are in pasture or forest.

Small areas of organic soils are included in some delineations of this map unit.

Altered Soils

Areas where the soils have been altered by cutting and filling are the basic components of this unit. Most areas are on glacial moraines. Thus, most areas resulting from cutting consist of loamy material as in the B and C horizons of soils such as Duluth. Further, most areas resulting from filling consist of similar material. The internal drainage of these soils mostly ranges from somewhat poor to moderately well drained. Permeability is mostly slow.

1016 Altered soils. Only one map unit of altered soils is used in this survey. Areas of altered soils along roads, highways, and around houses and cabins are not included in this map unit. Instead they are considered as normal inclusions in other appropriate units where delineations of them include such cultural features. This map unit of altered soils consists mostly of discrete, cut and filled areas away from those cultural features except in on place where extensive cutting and filling has occurred along a county highway.

Blackhoof Series

The Blackhoof series consists of nearly level, very poorly drained, slowly and very slowly permeable soils that formed in a thin mantle of organic soil material and in underlying loamy glacial till or old local aluvium or both. These soils have concave and linear slopes and are in depressions and drainage ways on glacial moraines.

The Blackhoof series primarily is associated with the Dusler and Duluth series and organic soils. This series is wetter and has colors of low chroma to greater depth than the Dusler and Duluth series. This series has a thinner mantle of organic soil material than Organic soils.

The seasonal high water table in the Blackhoof series commonly begins within one foot of the surface throughout most of the year. Water is on the surface in most of the spring and autumn months.

A description of a representative pedon (S-81-MN-58-9-samples 1 to 5) of the Blackhoof series in the mapping unit of Blackhoof muck (map symbol 614) which is located in the upper part of a drainage way about 530 feet east and 370 feet south of the northwest corner of the southwest ¼ of section 10, R. 19 W.,T. 45 N. is in the following paragraphs. This pedon was described and sampled 5 November 1981. It is located in a thicket of alder with a ground cover of grasses and sedges. A delineation of Duluth loam, 4 to 15 percent slopes is adjacent to this delineation of Blackhoof muck. The water table was at the surface.

Oa--8 to 0 inches; black (10YR 2/1) broken face and rubbed, sapric material (muck); moderate very fine and fine granular structure; very friable, slightly sticky; many very fine and fine and few medium and coarse roots; pH 5.0; moderate permeability; clear smooth boundary.

A11(A1)* --0 to 5 inches; black (N 2/0) mucky silt loam; moderate very fine and fine granular structure; very friable, slightly sticky; common very fine and fine roots; pH 5.0; moderate permeability; abrupt smooth boundary.

A12(A2)-- 5 to 8 inches; black (10YR 2/1) silt loam; massive; firm, slightly sticky; few very fine roots; pH 5.0; slow permeability; abrupt smooth boundary.

*Recently revised designations for horizons are given in this part of descriptions if they differ from former designations.

B21g(Bgw1)--8 to 25 inches; dark gray (5Y 4/1) silty clay loam; many medium and large olive brown (2.5Y 4/4) mottles throughout and common fine prominent dark brown (7.5YR 4/4) mottles mostly in the lower part; massive; very firm, slightly sticky; pH 7.0; very slow permeability; diffuse smooth boundary.

B22g(Bgw2)-- 25 to 48 inches; gray (5Y 5/1) silt loam near loam; many fine distinct light olive brown (2.5Y 5/4), common medium distinct greenish gray (5G 5/1) and few fine prominent yellowish red (5YR 4/6) mottles; massive; firm, slightly sticky; pH 7.5; slow permeability.

The O horizon ranges from 4 to 16 inches in thickness. The A horizon is 3 to 9 inches thick, and is loam, silt loam, clay loam, or silty clay loam. The B horizon is silt loam, loam, silty clay loam, or clay loam.

614 Blackhoof muck. This map unit is in depressions and drainageways on glacial moraines. It has concave and linear slopes with gradient 0 to 1 percent. Delineations of this soil which encompass drainageways commonly are narrow and enlongated in shape and mostly range from 2 to 10 acres in size. Delineations in depression commonly are circular in shape and mostly range from 2 to 8 acres in size. Most areas of these soils are in pasture or forest.

Soils included in delineations of this map unit have similar interpretations. Common included soils are Organic soils, and soils that are similar to the Blackhoof series except that they lack the layer of organic soil material. Also, a few included soils are sandy in some to all parts of the A horizon and B horizon. Further, small areas of Newson soils are included in a few delineations.

Duluth Series

The Duluth series consists of gently undulating to very steep, moderately well and well drained, moderately slow and slowly permeable soils that formed mostly in loamy calcareous glacial till on glacial moraines. They mostly have convex slopes, but they have linear or concave slopes on the lower parts of some steep and very steep slopes.

The Duluth series is primarily associated with the Blackhoof and Dusler series, and Organic soils. The Duluth series lacks a seasonal high water table within depths of 5 feet, whereas these associated soils have a seasonal high water table beginning at depths of 4 feet or less. Also, the Duluth series lacks mottles in the B horizon, whereas the Blackhoof and Dusler series have mottles in the B horizon. The Duluth series is similar to Duluth variant. The Duluth series formed either entirely in till or in a thin mantle of outwash and in underlying till, whereas the Duluth variant formed in a mantle of sandy outwash that is 20 to 40 inches in thickness and in underlying till.

The Duluth series typically lacks a seasonal high water table within depths of 5 feet. However, some soils of the Duluth series are saturated in some horizons for short periods of time during periods of above normal rainfall.

Since the Duluth series is the dominant soil in the area, descriptions of two pedons are presented. The first (S-81-MN-58-8-samples 1 to 7) is in a delineation of Duluth loam, 1 to 4 percent slopes (map symbol 504B), located about 800 feet east and 1,050 feet south of the northwest corner of the southwest ¼, section 10, R. 19 W., T. 45 N. It has a convex slope of about 2 percent and is about 100 feet from the boundary of a delineation of Duluth loam, 15 to 60 percent slopes (map symbol 504E) on the bluffs adjacent to Sturgeon Lake. It is in an old meadow field. It was described and sampled 5 November 1981. It was very moist in the upper 30 inches and moist below.

Ap--0 to 6 inches; dark brown (7.5YR 3/2) loam; moderate fine and medium granular structure; friable; many very fine and fine roots; about 2 percent coarse fragments; pH 6.5; moderate permeability; abrupt smooth boundary.

A2(E)--6 to 10 inches; brown (7.5YR 5/2) loam; massive in some parts and weak thick platy structure in other parts; firm, fractures abruptly under pressure; common very fine and fine roots; about 2 percent coarse fragments; pH 6.5; slow permeability; abrupt wavy boundary.

B&A(B/E)--10 to 13 inches; B part comprising about 85 percent is reddish brown (2.5YR 4/4) clay loam; A part comprising about 15 percent as tongues and interfingers is brown (7.5YR 5/2) loam; weak fine and medium prismatic structure parting to moderate fine and medium subangular blocky; very firm, slightly sticky; few thin clay films on faces of secondary peds; few very fine and fine roots mostly on faces of peds; about 2 percent coarse fragments; pH 5.0; moderately slow permeability; clear smooth boundary.

B21t(Bt1)--13 to 22 inches; reddish brown (2.5YR 4/4) clay loam; weak fine and medium prismatic structure parting to moderate fine and medium angular blocky; firm, sticky; common thin and medium clay films on faces of peds; common thin coatings of A2 material on faces of prisms; few fine roots; about 2 percent coarse fragments; pH 4.5; moderately slow permeability; diffuse smooth boundary.

B22t(Bt2)--22 to 36 inches; reddish brown (2.5YR 4/4) loam near clay loam; moderate fine angular blocky structure; firm, sticky; common thin clay films on faces of peds; few fine and medium roots; about 2 percent coarse fragment; pH4.5; moderately slow permeability; diffuse smooth boundary.

B3t(BCt)--36 to 64 inches; reddish brown (2.5YR 4/4) loam; moderate fine angular blocky structure; firm, slightly sticky; few thin clay films on faces of peds; few thin black coatings on faces of peds; few very fine roots; about 2 percent coarse fragments; pH 7.5; moderately slow permeability; clear smooth boundary.

C--64 to 76 inches; reddish brown (5YR 4/3) loam; weak thin to thick platy structure; firm, slightly sticky; common very fine and fine masses of $CaCO_3$; about 2 percent coarse fragments; pH 7.8; slow permeability.

The second pedon (S-81-MN-58-10-samples 1 to 6) is in a delineation of Duluth loam, 4 to 15 percent slopes (map symbol 504C) located about 330 feet east and 460 feet south of the northwest corner of section 3, R. 19., T. 45 N. It has a convex slope of about 8 percent. It is about 200 feet from the boundary of a delineation of Duluth loam, 15 to 60 percent slopes (map symbol 504E) on the bluffs adjacent to Island Lake. It is under a plantation of white spruce. It was described and sampled 5 November 1981. It was very moist in the upper 36 inches, and slightly moist below.

Ap--0 to 6 inches; dark brown (7.5YR 3/2) to brown (7.5 YR 4/2) loam; moderate medium granular structure; friable; common very fine and fine and few medium and coarse roots; about 2 percent coarse fragments; pH 6.5; moderate permeability; abrupt smooth boundary.

B&A(B/E)--6 to 9 inches; B part comprising about 85 percent is reddish brown (2.5YR 4/4) clay loam; A part comprising about 15 percent as tongues and interfingers is reddish brown (5YR 5/3) sandy loam; moderate fine and medium prismatic structure parting to moderate fine and medium subangular blocky; firm, slightly sticky; few thin clay films on faces of secondary peds; common fine and medium roots mostly on faces of peds; about 2 percent coarse fragments; pH 6.0; moderately slow permeability; clear wavy boundary.

B21t(Bt1)--9 to 18 inches; reddish brown (2.5YR 4/4) clay loam; moderate medium prismatic structure parting to moderate fine and medium angular blocky; firm, slightly sticky; many thin and medium clay films on faces of peds; few thin coatings of A2 material on faces of peds; few fine and medium roots; about 2 percent coarse fragments; pH 5.5; moderately slow permeability; gradual smooth boundary.

B22t(Bt2)--18 to 38 inches; reddish brown (5YR 4/4) light clay loam; moderate medium and coarse angular blocky structure parting to moderate very fine angular blocky; firm slightly sticky; common thin clay films on faces of peds; about 2 percent coarse fragments; pH 5.5; moderately slow permeability; diffuse smooth boundary.

B3(BC)--38 to 60 inches; reddish brown (2.5YR 4/4) loam; weak very fine angular blocky structure; firm, slightly sticky; few thin clay films on faces of peds; few thin black coatings on faces of peds; few fine roots; about 2 percent coarse fragments; pH 7.5; moderately slow permebility; sampled at depths of 38 to 49 and 49 to 60 inches.

The thickness of solum and depth to free carbonates ranges from 40 to 80 inches. The content of coarse fragments ranges from 1 to 8 percent. The A horizon is fine sandy loam, sandy loam, loam, or silt loam. The B horizon has hue of 2.5YR or 5YR and has 18 to 35 percent clay. It is loam or clay loam. The C horizon is loam or clay loam and has weak platy or angular blocky structure.

504B Duluth loam, 1 to 4 percent slopes. This map unit mostly has convex slopes and is on glacial moraines. Delineations of this map unit are variable in size and shape. They range from as small as one acre to as large as 100 acres in size. In some places they are circular and other places elongated. This map unit commonly is on the higher parts of the landscape. Most areas of these soils are in pasture and forest, but significant areas of them are used as sites for homes or cabins. Duluth soils in this map unit commonly have thicker sola than they do in the other two map units.

Small areas of Blackhoof and Dusler series are included in some delineations of this map unit. Most areas of these kinds of included soils are indicated by the symbol for wet spots and drainage ways. Small areas of the Duluth variant and soils similar to Duluth soils except for having sandy A horizons, also, are included in some delineations of this map unit. Further, soils that are similar to the Duluth series except for having more clay in the B horizon or C horizon or both are included in a few delineations of this map unit. Small areas with slopes steeper than 4 percent are included in a few places.

504C Duluth loam, 4 to 15 percent slopes. This map unit mostly has convex and linear slopes on glacial moraines. Linear slopes primarily are on the lower lying parts of delineations of this map unit. Delineations primarily are rather narrow and elongated, and commonly range from 2 to 20 acres in size. They primarily are on slopes adjacent to lower lying wetter soils. Most areas of these soils are in forest or pasture, but significant areas of them are used as sites for cabins and homes. Duluth soils in this map unit commonly have sola that are intermediate in the range of thickness.

Small areas of Blackhoof and Dusler series are included in a few delineations of this map unit. Most of these inclusions are indicated by the symbol for wet spots and drainage ways. Small areas of Duluth variant and soils similar to Duluth except for having sandy A horizons and upper B horizons or only sandy A horizons are included in a few delineations. Further, soils that are similar to the Duluth series except for having more clay in the B horizon or C horizon or both are included in a few delineations of this map unit. Small areas with slopes of less than 4 percent and more than 15 percent are included in a few places.

504E Duluth loam, 15 to 60 percent slopes. This map unit has convex, linear, and concave slopes. Linear and concave slopes are on the lower lying parts of delineations of this map unit. Delineations primarily are rather narrow and elongated and commonly range from 5 to 50 acres in size. This map unit primarily is on bluffs adjacent to Island and Sturgeon Lakes. Most areas of these soils are in forest, but a few are in pasture. Duluth soils in this map unit commonly have the shallower range in thickness of sola.

A few small areas of wetter soils are included in a few delineations of this unit. Such soils are mostly in drainage ways. Small areas of the Duluth variant and soils similar to the Duluth series except for having sandy A horizons and upper B horizons or sandy A horizons only are included in a few delineations. Further, soils that are similar to the Duluth series except for having more clay in the B horizon or C horizon or both are included in a few delineations. Small areas with slopes of less than 15 percent and more than 60 percent are included in a few places.

Duluth Variant

The Duluth variant soils consist of gently sloping and sloping, moderately well and well drained, moderately slow and slowly permeable soils that formed in a 20 to 40-inch thick mantle of sandy outwash and in underlying loamy calcareous glacial till on glacial moraines. These soils mostly have convex and linear slopes.

Soils here identified as Duluth variant have not yet been recognized as a named soil series by the Cooperative Soil Survey of Minnesota. They have unique properties and are significant enough in extent to recognize as a discrete kind of soil in this survey. They primarily occur in a transition zone between soils such as the Duluth series which formed in till in the eastern part of the survey area and soils such as the Omega series which formed in outwash in the western part of the survey area. Duluth variant soils have sandy horizons extending from the surface to depths of 20 to 40 inches, whereas the Duluth series formed in glacial till and has loamy upper horizons. Duluth variant soils have loamy B horizons beginning within depths of 20 to 40 inches, whereas the Omega series formed in glacial outwash and is sandy throughout.

The Duluth variant soils typically lack a seasonal high water table within depths of 5 feet. However, some of the Duluth variant soils are saturated in the lower part of the sandy mantle or in the upper part of the soil in glacial till for short periods of time during periods of above normal rainfall.

A description of a representative pedon (S-81-MN-58-2-samples 1 to 7) in a large delineation of the mapping unit Duluth variant loamy fine sand, 1 to 4 percent slopes (map symbol 1350B) which is located near the summit of a knoll with a convex slope of 2 percent on a glacial moraine about 2,440 feet west and 2,380 feet south of the northeast corner of section 17, R. 19 W., T. 45 N. is in the following paragraph. The delineation with this pedon primarily is bounded by Omega soils to the west and Duluth and Dusler soils to the east. It is in an old field on the Y.M.C.A. property. This pedon was described and sampled 3 November 1981. It was moist throughout.

Ap--0 to 9 inches; dark brown (7.5YR 3/2) loamy fine sand; weak fine and medium granular structure; very friable, non-sticky; many very fine and fine roots; pH 6.5; rapid permeability; abrupt smooth boundary.

B21(Bw1)--9 to 20 inches; dark reddish brown (5YR 3/4) loamy fine sand; weak fine subangular blocky structure; very friable; common very fine and fine roots; pH 6.0; rapid permeability; clear smooth boundary.

B22(Bw2)--20 to 25 inches; dark reddish brown (5YR 3/4) loamy sand; massive; very friable; common very fine and fine roots; about 5 percent gravel; pH 6.0; rapid permeability; abrupt smooth boundary.

11B&A(2B/E)--25 to 31 inches; B part comprising about 85 percent is yellowish red (5YR 4/6) clay loam; A part comprising about 15 percent as tongues and interfingers is reddish brown (5YR 5/3) sandy loam and loamy sand; weak fine and medium prismatic structure parting to moderate medium subangular blocky; firm; few fine roots on faces of peds; about 2 percent coarse fragments; pH 5.5; moderately slow permeability; gradual smooth boundary.

11B21t(2Bt1)--31 to 41 inches; reddish brown (2.5YR 4/4) clay loam; few fine distinct yellowish red (5YR 5/6) mottles; weak medium prismatic structure parting to moderate fine and medium subangular blocky; firm; common thin clay films and few thin to thick reddish gray (5YR 5/2) coatings of A2 material on faces of peds; few fine dark colored concretions; few fine roots mostly on faces of peds; about 5 percent coarse fragments; pH 5.5; moderately slow permeability; diffuse boundary.

IIB22t(2Bt2)--41 to 52 inches; reddish brown (2.5YR 4/4) clay loam; weak fine and medium angular blocky structure; firm; few thin clay films on faces of peds; irregular mass of sandy loam in lower part; about 5 percent coarse fragments; pH 6.5; moderately slow permeability; diffuse boundary.

IIB3(2BC)--52 to 60 inches; dark reddish brown (2.5YR 3/4) clay loam near loam; weak very fine and fine angular blocky structure; firm; few thin clay films on faces of peds; about 5 percent coarse fragments; pH 7.0; slow permeability.

The thickness of solum ranges from 50 to 80 inches. The mantle of outwash is 20 to 40 inches thick. That mantle lacks or has as much as 20 percent of coarse fragments. These fragments are more common in the lower part of the mantle. Horizons in glacial till have 1 to 10 percent of coarse fragments. Horizons in the mantle of outwash typically have texture of fine sand, sand, loamy fine sand, or loamy sand. However, the A horizon in some pedons is fine sandy loam or sandy loam. The part of the B horizon in the sandy mantle has hue of 7.5YR or 5YR. The B and C horizons in glacial till have hue of 2.5YR or 5YR and are loam or clay loam. Those horizons have 18 to 35 percent clay.

<u>1350B Duluth variant loamy fine sand, 1 to 4 percent slopes.</u> This map unit mostly has convex slopes, but some parts of it has linear or concave slopes. This unit is on glacial moraines. Most delineations of this unit are elongate in shape and typically ar 4 to 100 acres in size. Most areas of these soils are in forest, but few are in pasture and sites for homes and cabins. The Duluth variant soils in this map unit have the full range of properties described for that soil.

Small areas of the Duluth and Omega series are included in some delineations. Also, small areas of soils that are wetter than Duluth variant soils are in some delineations. Most areas of such soils are shown by the symbols for wet spots and drainage ways. Further, a few small areas of soils with sandy loam or fine sandy loam texture in the upper part of the B horizon are included. Small areas with slopes of more than 4 percent are included in a few places.

<u>1350C Duluth variant loamy fine sand, 4 to 15 percent slopes.</u> This map unit mostly has convex slopes. However, some parts of it has linear and concave slopes, and these kinds of slopes are mostly on the lower lying parts of it. This map unit is on glacial moraines. Some delineations are circular in shape and are on knolls typically ranging from 2 to 10 acres in size. Other delineations of it are elongate and typically range from 5 to 20 acres in size. Most areas of these soils are in forest or pasture, but a

few areas are used as sites for cabins and homes. The Duluth variant soils in this map unit have the full range of properties described for that soil.

Small areas of the Duluth and Omega series are included in a few delineations. Also, a few small areas of soils with sandy loam or fine sandy loam texture in the upper part of the B horizon are included. Small areas with slopes of less than 4 percent or more than 15 percent are included in a few places.

Dusler Series

The Dusler series consists of nearly level, somewhat poorly and poorly drained, slowly permeable soils that formed mostly in loamy calcareous glacial till. These soils have slightly convex to slightly concave slopes on glacial moraines.

The Dusler series primarily is associated with the Blackhoof and Duluth series and Organic soils. The Dusler series is wetter than the Duluth series, and it has mottles in the B horizon which are lacking in the Duluth series. The Dusler series is not as wet as the Blackhoof series and Organic soils.

The seasonal high water table in the Dusler series commonly begins within depths of 1 to 4 feet during the period of October to June. It commonly is at greater depths in other times of the year.

A description of a representative pedon (S-81-MN-58-1-samples 1 to 6) of the Dusler series in the map unit of Dusler loam (map symbol 502) located on a linear slope of about 0.5 percent 1,520 feet west and 2,380 feet south of the northeast corner of section 17, R. 19 W., T. 45 N. is in the following paragraphs. This pedon is about 500 feet from the shore of Sturgeon Lake. The delineation in which this pedon occurs primarily is bounded by Duluth, Duluth variant, and Organic soils. This pedon is in a deciduous-coniferous forest on the Y.M.C.A. property. It was described and sampled on 3 November 1981. Free water began at depths of about 5 inches.

A1(A)--0 to 6 inches; very dark gray (10YR 3/1) loam; moderate fine and medium granular structure; slightly sticky; many fine and medium and few large roots; about 2 percent coarse fragments; pH 6.0; moderate permeability; clear smooth boundary.

A2(E)--6 to 12 inches; dark grayish brown (10YR 4/2) loam; few fine prominent yellowish red (5YR 4/6) mottles; moderate medium granular structure; slightly sticky; common fine and few large roots; about 2 percent coarse fragments;

pH 6.0; moderate permeability; clear smooth boundary.

B&A(B/E)--12 to 17 inches; B part comprising about 80 percent is brown (7.5YR 4/4) heavy loam with common fine distinct yellowish red 5YR 4/6) mottles; A part comprising about 20 percent as tongues and interfingers is brown (7.5YR 5/2) loam with few fine distinct gray (5YR 6/1) mottles; weak fine and medium prismatic structure parting to weak medium and coarse subangular blocky; very firm, sticky; few thin clay films on faces of secondary peds; common fine roots mostly on faces of peds; about 2 percent coarse fragments; horizon not yet saturated; pH 5.5; slow permeability; clear wavy boundary.

B21t(Bt1)--17 to 28 inches; reddish brown (5YR 4/4) clay loam; weak fine and medium prismatic structure parting to moderate fine and medium subangular blocky; sticky; many thin and medium reddish gray (5YR 5/2) and dark reddish gray (5YR 4/2) clay films and coatings on faces of peds; few fine roots mostly on faces of peds; about 2 percent coarse fragments; pH 5.0; moderately slow permeability; gradual boundary.

B22t(Bt2)--28 to 42 inches; dark reddish brown (5YR 3/4) clay loam near loam; weak fine and medium angular blocky structure; sticky; few thin clay films on faces of peds; few fine roots mostly on faces of peds; about 2 percent coarse fragments; p H 6.5; moderately slow permeability; diffuse boundary.

B3(BC)--42 to 60 inches; reddish brown (5YR 4/3 heavy loam; weak very fine and fine angular blocky structure; slightly sticky; very few fine roots; about 2 percent coarse fragments; pH 7.5; slow permeability.

The thickness of solum ranges from 50 to 70 inches. The content of coarse fragments typically ranges from 1 to 8 percent, but fragments are lacking in the upper part of some pedons. The A horizon is sandy loam, fine sandy loam, loam, or silt loam. The B horizon primarily has a matrix with hue of 2.5YR or 5YR. Mottles in the upper part of the B horizon range from few to many. The B horizon has 18 to 35 percent clay.

502 Dusler loam. This map unit typically has linear or concave slopes, but it has slightly convex slopes in a few places. Slope gradient ranges from 0 to 2 percent. These soils are on glacial moraines. Delineations of the map unit are variable in size and shape. They range from as small as about one acre to as large as about 40 acres. The range in shape from elongate to circular. Most areas of these soils are pasture or forest. Dusler soils in this map unit have the full range in properties described here for the series.

Small areas of Blackhoof series and Organic soils are included in some delineations. Most of thsee inclusions are indicated by the symbol for wet spots and drainage ways. Small areas of Duluth soils are included in some delineations. These are on small low knolls. Small areas of soils that are similar to Dusler except for having sandy textures in the A horizon or upper part of the B horizon or both, also are included in a few delineations. Small areas of Nemadji soils are included in a few delineations.

Lake Beaches

Lake beaches consist of nearly level, very poorly to moderately well drained, moderately to rapidly permeable soils that formed mostly in recent to rather old sandy beach deposits adjacent to lakes. The deposits in which these soils formed result from the action of wind and ice. The higher lying parts of these soils may be a result of once higher lake levels.

Lake beaches are bounded by soils of Duluth and Omega series on their upslope side. These soils are on bluffs around the lakes among other places. They are bounded by water on their down-slope side. The part of these soils that are adjacent to lakes have free water beginning at or near the surface throughout the year. Where Lake beaches border Duluth and Omega soils, they have a water table beginning within 1 to 3 feet of the surface during the wetter parts of the year.

No soil series have yet been defined by the Minnesota Cooperative Soil Survey to comprise soils here called Lake beaches. Actually two or three soil series would be needed to adequately define the soils in Lake beaches in this survey area. Since no series exist for these soils, the name Lake beaches is used for them in this report.

An example of a pedon (S-81-MN-58-5-samples 1 to 6) in a delineation Lake beaches (map symbol 1032) located near the west shore of Passenger Lake about 990 feet east and 2,510 feet north of the center of section 32, R. 19 W., T. 45 N. is in the following paragraphs. This pedon has a concave slope with gradient of about ½ percent. It is about 50 feet east of the beginning of a delineation of Omega loamy sand, 20 to 60 percent slopes, which is on the bluffs around the lake. It is about 100 feet west of the border of that lake and is about 3 feet above the level of the lake. A deciduous-coniferous forest is at the site. The pedon was described and sampled 4 November 1981. The water table began at about 30 inches. The soil was moist above that depth.

Oa--2 to 0 inches; black (5YR 2/1) sapric material (muck); moderate very fine and fine granular structure; very friable; many very fine and fine and many medium and coarse roots; many particles of sand; pH 4.5; moderate permeability; abrupt smooth boundary.

A1(A)--0 to 3 inches; very dark grayish brown (10YR 3/2) sandy loamy; weak fine and medium granular structure; very friable; many very fine and fine and common medium and coarse roots; pH 4.5; moderate permeability; clear smooth boundary.

B2(Bw)--3 to 21 inches; brown (7.5YR 5/2 to 5/4) sand; few fine and medium distinct yellowish red (5YR 4/8) mottles; single grained; loose; few medium and coarse roots; pH 6.0; rapid permeability; clear smooth boundary.

C1--21 to 29 inches; stratified brown (7YR 5/2) and very dark grayish brown (10YR 3/2) sand and loamy sand; massive; friable in some parts and very friable in other parts; few small masses and strata of black (10YR 2/1) sapric and hemic materials; pH 6.0; moderately rapid permeability; gradual smooth boundary.

C2--29 to 36 inches; dark brown (7.5YR 4/2) sand; few fine and medium distinct gray (N 5/0) mottles; single grained; loose; few pebbles in some parts; pH 4.5; rapid permeability; clear smooth boundary.

C3--36 to 60 inches; dark gray (5YR 4/1) stratified sand, coarse sand, and gravelly and very gravelly sand and coarse sand; few fine and medium distinct gray (N 5/0) mottles; single grained; loose; gravel mostly 0.2 to 1.0 cm; pH 6.0; rapid permeability.

The content of gravel ranges from 0 to 35 percent. The color in these soils below the A horizon has hue from 5Y to 5YR, value of 4 to 6 and chroma of 1 to 4. The depth to horizons with mottles ranges from 0 to 30 inches. The A horizon ranges from sands to sandy loams with or without gravel. Textures below the A horizon are mostly sands or loamy sands with or without gravel. Textures commonly are stratified within the limits of a pedon, but some pedons lack such stratification.

<u>1032 Lake beaches.</u> Delineations of this map unit are narrow and elongated and typically range from 1 to 20 acres in size. These soils primarily are adjacent to Passenger and Sturgeon Lakes, but small areas of them are adjacent to Island and Rush Lakes. Most areas of these soils are forested or have shruby and herbaceous, wetland vegetation. However, significant areas of these soils are used as sites for cabins and homes.

Lake beaches that have glacial till beginning at shallow depths are included in a few places. Such inclusions primarily are along Island Lake and along the eastern and northern shore of Sturgeon Lake.

Organic Soils

Organic soils consist of very poorly drained, nearly level soils with slow to moderately rapid permeability. They formed in organic soil material, namely slightly to highly decomposed remains of a variety of plants. They primarily are in small to large depressions on glacial moraines and outwash plains. Some of these depressions were formerly lakes. These soils are on floodplains in a few places.

Organic soils primarily are associated both with soils formed in glacial till, namely the Duluth, Dusler, and Blackhoof series and soils formed in glacial outwash, namely the Omega, Nemadji, and Newson series. Of the above named associated soils, Organic soils are most similar to the Blackhoof anf Newson series. However, they differ from those series by having a thicker layer of organic soil material.

The water table typically begins within depths of less than one foot throughout the year. Further, water commonly is on the surface during several months of the growing season.

Different kinds of Organic soils were not mapped in this survey because of lack of time to properly identify them and because interpretive differences among the different kinds were not important to the purpose of this soil survey.

A description of a representative pedon (S-81-MN-58-3 samples 1 to 4) of Organic soils in the largest bog in the survey area is in the following paragraphs. This pedon is in the map unit of Organic soils (map symbol 995) and is located about 800 feet north and 150 feet east of the southwest corner of section 9, R. 19 W., T. 45 N. This pedon has a linear slope with gradient of less that ½ percent. It is in a coniferous forest dominated by black spruce and tamarack. Moss-covered hummocks rise as much as 10 inches above the common surface. Mosses are the dominant ground cover. This pedon was described and sampled on 3 November 1981. The water table began about 10 inches below the surface. This bog has been partially drained.

Oa--0 to 4 inches; very dark brown (10YR 2/2) broken face and rubbed sapric material (muck); moderate very fine granular structure; sticky; pH 4.0; moderately permeable; clear smooth boundary.

Oe1--4 to 22 inches; dark brown (7.5YR 3/2) matrix, dark yellowish brown (10YR 4/4) fiber, dark brown (7.5YR 3/2) rubbed, hemic material (mucky peat); about 60 percent fiber, about 40 percent after rubbing; massive; non sticky; mostly herbaceous fiber with a trace of woody fragments; pH 4.0; moderate permeability; gradual boundary.

Oe2--22 to 65 inches; very dark gray (10YR 3/1) matrix, dark yellowish brown (10YR 4/4) fiber, dark brown (7.5YR 3/2) rubbed, hemic material (mucky peat); about 40 percent fiber, about 20 percent after rubbing; massive; slightly sticky; mostly herbaceous fiber, trace of woody fragments; pH 5.5; moderate permeability; clear boundary.

Oe3--65 to 80 inches; very dark grayish brown (10YR 3/2) matrix, brown (10YR 4/3) fiber, dark yellowish brown (10YR 3/4) rubbed, hemic material (mucky peat); about 60 percent fiber, about 40 percent after rubbing; massive; non sticky; herbaceous fiber; pH 6.0; moderate permeability.

Organic soils in this survey area have a wide range in properties and several series could have been identified. The thickness of organic soil material ranges from 16 inches to more than 6 feet in thickness. This material is mostly sapric (muck) and hemic material (mucky peat), but a few have some fibric material (peat). This material is mostly derived from herbaceous plants, but in some it is derived from woody anc mossy plants. The mineral soil material underlying the organic soil material primarily is sandy or loamy.

<u>995 Organic soils.</u> This map unit has nearly level slopes, gradient of less than 1 percent. Individual delineations of this map unit are variable in shape and size. Some are nearly circular in shape and others are narrow and elongated. They range from about one acre to more than 100 acres in size. Most areas of these soils are forested or are dominated by herbaceous plants such as sedges.

This map unit has few inclusions of other kinds of soil. Included soils primarily are the Blackhoof and Newson soils, and these primarily are near the boundary between Organic soils and other kinds of soil.

Nemadji Series

The Nemadji series consists of nearly level, somewhat poorly drained, rapidly permeable soils that formed in sandy glacial outwash. These soils have slightly convex to slightly concave slopes on glacial outwash plains.

The Nemadji series primarily is associated with Newson and Omega series and Organic soils. The Nemadji series has mottles in the B horizon, but the better drained Omega series lacks mottles in that horizon. The Nemadji series has higher chroma in the B horizon than does the wetter Newson series. The Nemadji series lacks or has a thin layer of organic soil material, whereas Organic soils have thicker layers of organic soil material and are wetter.

The seasonal high water table typically begins within depths of 1.5 to 4 feet during the months of March to June. It commonly is at greater depths during other parts of the year except during periods of above normal rainfall.

A description of a representative pedon (S-81-MN-58-6-samples 1 to 7) of the Nemadji series in the map unit Nemadji loamy sand (map symbol 186) located on a linear slope of about 0.5 percent about 2,050 feet west and 1,190 feet north of the southeast corner of section 21, R. 19 W., T. 45 N. is in the following paragraphs. The delineation with this pedon is bounded by delineations of the Omega and Newson series and Organic soils. This pedon is in a coniferous-deciduous forest. It was described and sampled 4 November 1981. Free water began at depths of about 50 inches. The soil was moist above that depth.

O-- 2 to 0 inches; very dark gray (10YR 3/1) highly decomposed leaf litter, weak fine and medium granular structure; very friable; many clean sand grains; many very fine to medium roots; pH 4.5; moderate permeability; abrupt smooth boundary.

A1(A)--0 to 4 inches; dark brown (7.5YR 3/2) loamy sand; weak very fine and fine granular structure; very friable; common clean sand particles; many very fine and fine and common medium and large roots; pH 4.5; moderately rapid permeability; abrupt smooth boundary.

B21(Bw1)--4 to 11 inches; reddish brown (5YR 4/4) sand; few medium faint yellowish red (5YR 4/6) mottles; weak very fine and fine granular structure; very friable; common medium and large roots; pH 5.5; rapid permeability; clear smooth boundary.

B22(Bw2)--11 to 25 inches; yellowish red (5YR 4/8) sand; many fine and medium in upper part and large in lower part distinct (5YR 5/3) mottles; massive; very friable; few fine slightly consolidated masses of dark reddish brown (2.2YR 3/4); few medium and large roots; about 1 percent pebbles; pH 5.5; rapid permeability; gradual smooth boundary.

B23(Bw3)--25 to 42 inches; reddish brown (5YR 5/3) sand; many fine to coarse distinct yellowish red (5YR 4/8) mottles; single grained; loose; about 1 percent pebbles; few medium and large roots; pH 6.0; rapid permeability; gradual smooth boundary.

B3(BC)--42 to 55 inches; dark reddish brown (5YR 3/4) sand; many medium and coarse faint reddish brown (5YR 5/3) mottles; single grained ; loose; about 1 percent pebbles; few very fine roots; pH 6.5; rapid permeability; gradual smooth boundary.

C--55 to 60 inches; dark grayish brown (5YR 4/2) sand; single grained; loose; pH 6.5; rapid permeability.

The sola range from 40 to 60 inches in thickness. The B and C horizons have a matrix with hue of 2.5YR or 5YR. The depth to horizons with mottles ranges from 3 to 30 inches. However, mottles with chroma of 2 or less are lacking within depths of 40 inches. The A and B2 horizons are sand, fine sand, loamy sand or loamy fine sand. The B3 and C horizons are sand or fine sand.

186 Nemadji loamy sand. Delineations of this map unit typically are elongated in shape and range from 2 to about 30 acres in size. Some areas of these soils are in cropland and pasture and others are in forest. The Nemadji series in this map unit have the full range of properties described for the series here in a previous paragraph.

Delineations of Nemadji loamy sand located in sections 4 and 20 have some soils that contain either more coarse sand, gravel or silt and clay than the Nemadji series. However, most interpretations for such soils are similar to those for the Nemadji series.

Newson Series

The Newson series consists of nearly level, poorly and very poorly drained, rapidly permeable soils that formed mostly in sandy glacial outwash. These soils have linear to concave slopes on glacial outwash plains.

The Newson series primarily is associated with the Nemadji and Omega series and with Organic soils. The Newson series is wetter than the Nemadji and Omega series and has colors with lower chroma in the B horizon than those soils. The Newson series lacks or has a thinner layer of organic soil material than Organic soils.

The seasonal high water table typically is within depths of 1 foot during the months of November through June. The water table typically begins at greater depths during other parts of the year except during periods of above normal rainfall.

A description of a representative pedon (S-81-MN-58-7-samples 1 to 6) of the Newson series in the map unit of Newson mucky sand loamy (map symbol 274) located on a slightly concave slope of about 0.5 percent about 1,390 feet west and 1,720 feet north of the southeast corner of section 21, R. 19 W., T. 45 N. is in the following paragraphs. The delineation with this pedon is bounded by delineations of the Nemadji series, Duluth variant, and Organic soils. The pedon is in a thicket of alder with grasses and sedges dominant in the herbaceous layer. It was described and sampled 4 November 1981. Free water began at depths of 8 inches. The soil was very moist above that depth.

Oa--4 to 0 inches; black (10YR 2/1) sapric material (muck); strong fine and medium granular structure; very friable; many very fine, fine and medium roots; pH 4.5; moderate permeability; abrupt smooth boundary.

A1(A)--0 to 4 inches; very dark gray (10YR 3/1) sandy loam; massive; firm; breaks into angular fragments under moderate pressure; few medium and coarse roots; pH 4.5; moderately permeability; abrupt smooth boundary.

B21g(Bgw1)--4 to 12 inches; dark gray (10YR 4/1) loamy sand near sandy loam; few fine distinct dark brown (7.5YR 4/4) mottles; massive; firm; breaks into angular fragments under moderate pressure; few medium and coarse roots; pH 4.5; moderate permeability; clear smooth boundary.

B22g(Bgw2)--12 to 22 inches; grayish brown (10YR 5/2) loamy sand; common medium distinct dark brown (7YR 4/4) and few fine prominent yellowish red (5YR 5/6) mottles; massive; friable; few very fine to medium roots; pH 5.5; moderately rapid permeability; gradual smooth boundary.

C1--22 to 49 inches; reddish brown (5YR 5/4) sand; single grained; loose; pH 6.0; rapid permeability; diffuse smooth boundary.

C2--49 to 60 inches; reddish brown (5YR 5/3) sand; few coarse faint reddish brown (5YR 4/4) mottles; single grained; loose; pH 6.0; rapid permeability.

The sola range from 20 to 40 inches in thickness. The layer of organic soil material is lacking in some pedons and is thick as 6 inches in others. The A horizon is loamy sand or sandy loam. It is 3 to 8 inches thick. The B2 horizon has a matrix with hue of 10YR to 5Y and chroma of 1 or 2. It is sand or loamy sand. The C horizon has a matrix with hue of 5YR to 10YR. It is sand or loamy sand.

274 Newson mucky sandy loam. Delineations of this map unit typically are elongated in shape and range from 3 to 15 acres in size. Most areas of these soils are in shruby forest, but some have been cleared and are in pasture. The Newson soils in this map unit have the full range in properties described for the series here in a previous paragraph.

Delineations of Newson mucky sandy loam in section 4 and 20, have some soils that contain either more coarse sand, gravel, or silt and clay than the Newson series. However, most interpretations for such soils are similar to those for the Newson series.

Omega Series

The Omega series consists of nearly level to very steep, somewhat excessively drained, rapidly permeable soils that formed in sandy glacial outwash. These soils have convex to concave slopes on glacial outwash plains and moraines.

The Omega series primarily is associated with the Nemadji and Newson series and the Duluth variant and Organic soils. The Omega series lacks mottles in the B horizon, whereas the wetter Nemadji and Newson soils have mottles in their B horizon. The Omega soils are sandy throughout, but the Duluth variant soils have horizons in loamy glacial till beginning within depths of 20 to 40 inches. The Omega series is much better drained than Organic soils.

Soils of the Omega series lack a seasonal high water table beginning within depths of 5 feet.

A description of a representative pedon (S-81-MN-58-4-samples 1 to 5) of the Omega series in the map unit Omega loamy sand, 0 to 5 percent slopes (map symbol 188B) located on a 2 percent convex slope about 600 feet east and 330 feet south of the center of section 32, R. 19., T 45 N. is in the following paragraphs. The delineation in which this pedon is located extends for many hundreds of feet to the west and is bounded on the east at a distance of 100 feet by a delineation of Omega loamy sand, 20 to 60 percent slopes, which is on the bluffs around the west edge of Passenger Lake. This pedon is in a deciduous-coniferous forest. It was described and sampled 4 November 1981. It was moist throughout.

A1(A)--0 to 3 inches; very dark gray (10YR 3/1) loamy sand; weak fine and medium granular structure; very friable; common clean sand particles; many very fine and fine and common medium and large roots; pH 4.5; moderately rapid permeability; abrupt smooth boundary.

B21(Bw1)--3 to 9 inches; dark reddish brown (10YR 3/4) sand near loamy sand; weak fine and medium granular structure; very friable; many fine and medium and few large roots; pH 5.5; rapid permeability; gradual smooth boundary.

B22(Bw2)--9 to 22 inches; reddish brown (5YR 4/4) sand; weak medium and coarse subangular blocky structure; very friable; many medium and coarse roots; pH 5.5; rapid permeability; gradual smooth boundary.

B31(BC1)--22 to 38 inches; yellowish red (5YR 4/6) stratified sand and coarse sand; single grained; loose; few medium and coarse roots; about 2 percent gravel; pH 6.0; rapis permeability; gradual smooth boundary.

B32(BC2)--38 to 60 inches; reddish brown (5YR 4/4) coarsesand; single grained; loose; few coarse roots; about 5 gravel; pH 6.5; rapid permeability.

The thickness of solum ranges from 20 to more than 60 inches in thickness. The 10 to 40 inch depth zone lacks or has as much as 10 percent of gravel. The A1 horizon is 1 to 4 inches in thickness. It is sand, fine sand, loamy sand, or loamy fine sand, sandy loam or fine sandy loam. The B horizon has a hue of 2.5YR or 5YR. It is sand, fine sand, loamy sand, loamy fine sand, sandy loam, or fine sandy loam in the upper part and coarse sand, sand or fine sand in the lower part.

<u>188B Omega loamy sand, 0 to 5 percent slopes.</u> This map unit has convex through concave slopes mostly on glacial outwash plains. It is on glacial moraines in a few places. Delineations of this map unit are variable in size and shape. They range from about 5 acres to more than 100 acres in size. They typically are elongate in shape. They mostly are on the higher lying parts of the landscapes. Most areas of these soils are forested, but some areas are use for pasture, cropland, and sites for homes and cabins. Soils of the Omega series in this unit have sola that comprise the thicker range in thickness described in a previous paragraph, but they have the full range described for other properties.

Most delineations of this map unit have few included soils. However, some soils with more gravel, or coarse sand, or silt and clay are included in this map unit primarily in section 4 and 22. Also, a few soils with layers of loamy sand, loamy fine sand or finer textures in the B horizon are included in a few places. Further soils that have mottles in the lower part of the B horizon or in the upper part of the C horizon are included in a few places. Small areas of poorly drained or wetter soils are included in a few places, and most of them are indicated by the symbol for wet spots.

A few small areas with steeper slopes are included in a few places.

188C Omega loamy sand, 5 to 20 percent slopes. This map unit mostly has convex slopes. However, linear and concave slopes commonly are on lower lying parts of this map unit. Most of this unit is on glacial outwash plains, but it is on glacial moraines in a few places. Most delineations of this unit are elongated and rather narrow in shape. They primarily are on slopes adjacent to lakes, peat bogs, and drainage ways. Thy mostly range from 5 to 30 acres in size. Most areas of these soils are forested, but a few areas are in pasture or sites for homes and cabins. Soils of the Omega series in this unit have sola that comprise the intermediate range in thickness described in a previous paragraph, but they have the full range described for other properties.

Most delineations of this map unit have few included soils. However, some soils with more coarse sand and gravel in the solum and C horizon or more silt and clay in the A horizon are included in a few places. Such included soils are mostly in delineations of this map unit in sections 3, 4, and 22. A few small areas with slopes of less than 5 percent or more than 20 percent are included in some delineations.

188E Omega loamy sand, 20 to 60 percent slopes. This map unit mostly has convex slopes, but it has linear and concave slopes on the lower lying parts. Most of this unit is on glacial outwash plains. Delineations of it there are narrow and elongate and typically 10 to 30 acres in size. They mostly are on bluffs along lakes and peat bogs. It is on hills in glacial moraines in a few places. Delineations of it there are elongate to circular in shape and typically are 3 to 20 acres in size. Most areas of this unit are in forest. Soils of the Omega series in this unit have sola in the thin range in thickness, but they have the full range described for other properties.

Most delineations of this map unit have few included soils. However, some soils with more coarse sand and gravel in the solum and C horizon, or more silt and clay in the A horizon and upper part of the B horizon are included in a few places. Also, small areas of the Duluth series and Duluth variant soils are included in a few places. A few small areas with slopes of less than 20 percent or more than 60 percent are included in some delineations.

INVESTIGATION PROCEDURES

I began a review of the literature about the soils and soil forming factors of the area immediately after WAPORA made initial contact with me on 2 September 1981. The more important literature that I reviewed follows.

Clayton, L. and T.F. Freers (Chief Ed.'s). 1967 Glacial geology of the Missouri Coteau and adjacent area. N.D. Geol. Sur. Mis. Series 30. 170 pp.

Cummins, J.F. and D.F. Grigal. 1981. Soils and land surfaces of Minnesota - 1981. Minn. Agr. Exp. Sta. Soils Series No. 110, Misc. Pub. 11. 59 pp. Map.

Lewis, R.R., P.R.C. Nyberg, R.O. Paulson, and J.A. Sharp. 1978. Soil Survey of Carlton County, Minnesota. U.S.D.A. Soil Cons. Serv. Gov. Printing Off. 77 pp. Maps.

Simmons, C.S. and A.E. Shearin. 1941. Soil Survey of Pine County, Minnesota. U.S.D.A. Bur. Plant Ind. 44 pp. Maps.

Soil Survey Staff. 1978. Soil survey laboratory data and descriptions for some soils of Minnesota. U.S.D.A. Soil Cons. Serv. and Minn. Agr. Exp. Sta. Soil Sur. Invest. Rpt. No. 33. 123 pp.

Wright, H.E., Jr. 1972. Quaternary history of Minnesota. Pp. 515-548 in Sims, P.K. and G.B. Morey (Ed.'s) Geology of Minnesota - A centennial volume. Minn. Geol. Sur.

Wright, H.E., Jr. 1973. Tunnel valleys, glacial surges, and subglacial hydrology of the Superior lobe, Minnesota. Geol. Soc. Am. Mem. 136:251-276.

Wright, H.E., Jr. and W.A. Watts. 1969 Glacial and vegetational history of northeastern Minnesota. Minn. Geol. Surv. SP-11. 59 pp.

I did have some knowledge of the soils of the area because I worked in soil survey in Minnesota from 1965-1979. During that period, I was State Soil Correlator, Assistant State Soil Scientist and State Soil Scientist for the Soil Conservation Service. I was involved in field reviews, sampling and correlation for the soil survey of Carlton County.

I received verbal approval of my proposal for this soil survey on 11 September 1981. I began field work on 14 September 1981, and completed it 5 November 1981.

My first task enroute to the field was to stop at the district office of the Soil Conservation Service at Hinckley, Minnesota. I wanted to inform them about my project, and, more importantly, to determine if any mapping had been done in the survey area. I learned that about 500 acres had been mapped. I borrowed aerial photography of 22 April 1957 from them because it was of excellent quality especially for stereoptic viewing and it had all previous soil mapping on it.

Procedures used in this soil survey were within the specifications of both the National and Minnesota Cooperative Soil Surveys as recorded in the following documents.

Soil Survey Staff. 1951. Soil Survey Manual. U.S.D.A. Handb. 18, 503 pp.

Soil Survey Staff. 1974 to present. National Soils Handbook. (An evolving, working document.)

Soil Survey Staff. 1975. Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys. U.S.D.A. Handb. 436, 754 pp.

Soil Survey Staff. Various dates. Soil series descriptions and interpretations.

Soil Survey Staff, Minn. 1979. Soil survey mapping legend, Minnesota. Minn. Coop. Soil Surv. 46 pp.

Soil as used in the report refers to the upper 60 inches of the regolith.

I made a reconniassance of the survey area during my first few days in the field to develop a trial legend for mapping. During this period I studied the landscape, geologic materials, and soils of the area.

I began mapping on 21 September 1981. I mainly used two sets of aerial photography while mapping, namely the 9 April 1977 photography of Mark Hurd Aerial Surveys, Inc. which had been enlarged to a scale of 1:9,750 and the 22 April 1957 photography that I had borrowed form S.C.S. The later was at a scale of 1:15,840 and it was used primarily for stereoptic study of the landscape. The former was used for recording boundaries. Also, the true color photography of 11 October 1980 at a scale of 1:30,000 and the color infrared photography of 20 October 1980 at a scale of 1:7,000 were used to further study the landscape and soil boundaries. These latter two sets of photography are in the report "EPA-Resource inventory and septic system survey, Moose Lake-Windmere Sewer District, Minnesota, October-November 1980".

Tools used in this soil survey include various kinds of sampling tubes, bucket augers, and shovels for examining the soil. A clinometer was used for measuring the inclination of slopes. A "Hellige-Truog soil reaction tester kit" was used for determing soil pH. Munsell color charts were used for measuring soil color. A "pocket" stereoscope was used for studying aerial photographs.

Ten pedons were described and sampled 2-5 November 1981. Most pedons were exposed by digging a small pit to depths of 30 to 40 inches. A large bucket auger was subsequently used to obtain samples from that depth to a depth of 60 inches. One pedon was described and sampled from road-cut. The pedon of an organic soil was exposed with a "Macaulay peat sampler." Samples of about ½ pint in size were collected from all soil horizons in each pedon. Large samples of about 1 quart in size were collected from 2 to 4 major horizons of each pedon. A standard indentifacation symbol was given to each pedon. For example, in the symbol S-81-58-1-2, S signifies sample, 81 is the year 1981, 58 is the number for Pine County, 1 is the pedon number, and 2 is the second horizon sampled from that pedon. In the introduction to pedon descriptions in the section of this report entitled "Description of Soils" the last entry in the identification number, 1 to 6 for example, indicates that 6 horizons were sampled from that pedon.

A.E. Jacobson, an SCS soil scientist stationed at Duluth, Minnesota, and I conducted a review and correlation of this soil survey on 23 October 1981.

Boundaries between soils along the boundary between Carlton and Pine Counties do not join some places. The main reason for these no-joins is that this survey was mapped at a larger scale and at higher intensity than was the survey of Carlton County.

Appendix B-2.

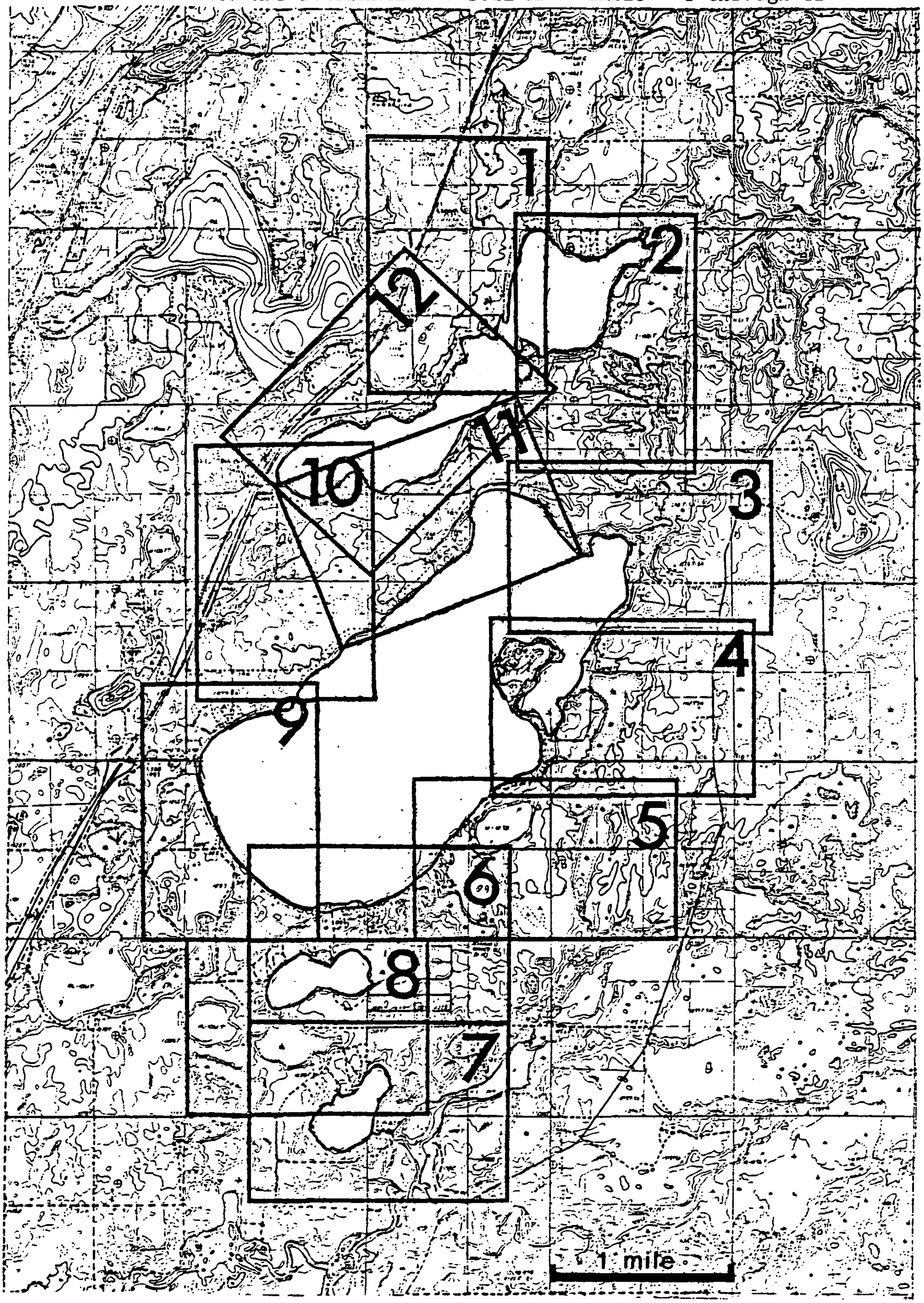
SOIL MAP PLATES

SOIL MAP PLATES OF THE LAND AREA IMMEDIATELY SURROUNDING ISLAND, STURGEON, RUSH, AND PASSENGER LAKES

Pine County MN

Scale: 6 inches/mile

LOCATION AND BOUNDARIES OF SOIL MAP PLATES - 1 through 12



Soil Map Identification Legend

for

[1]THE SOIL SURVEY OF A PORTION OF WINDEMERE TOWNSHIP, PINE COUNTY, MN

- Map Units -

Map symbol	Name of soil
186	Nemadji loamy sand
188B	Omega loamy sand, 0 to 5% slopes
188C	Omega loamy sand, 5 to 20% slopes
188E	Omega loamy sand, 20 to 60% slopes
274	Newson mucky sandy loam
502	Dusler loam
504B	Duluth loam, 1 to 4% slopes
504C	Duluth loam, 4 to 15% slopes
504E	Duluth loam, 15 to 60% slopes
614	Blackhoof muck
995	Organic soils
1002	Alluvial soils
1016	Altered soils
1032	Lake beaches
1350B	Duluth variant loamy fine sand, 1 to 4% slopes
1350C	Duluth variant loamy fine sand, 4 to 15% slopes

- Conventional and Special Features -

+	Section corners
	Dams and associated reservoirs
	Gravel or sand pits
	Perennial drainage way
	Intermittent drainage way
	End of drainage way
	Unnamed lakes and ponds
	Soil delineations and map unit symbols
	Soil sample site
	Small area (1/8 to 1/2 acre) of poorly drained or wetter soils in delineations of better drained soils.

[1]The soil map for which this legend was developed is not rectified and thus may not be used to overlay other rectified maps of the area.


N
HIGHWAY
502
504B
504
C
995
614
1350B
188B
274
504C
186
W
4
188C
188
B
1350
B
504 E
504 C

Plate #1


R. 19 W.
N
504B
995
504C
1350B
614
502
188B
274
186
1032
1016
1350C
504E
188E
504 B
188C

Plate #2


N
NO ACCESS
—unmapped—
504B
504C
504E
995
614
502
1032
188E
1016

Plate #3


NO ACCESS
— unmapped —
504B
504C
504E
502
995
614
1016
1032
15
16
N

Plate #4


STURGEON
N
504B
504C
504E
502
614
995
1032
1350B
188B
188C
186
274
1002
22

Plate #5

Plate #6


188B
188C
188B
188E
995
188C
188C
188B
188E
188C
188E
188C
188E
188C
995
188C
188B
188E
995
188B
188C
188E
995
188B
188C
188E
188C
188E
186
995
188C
188B
995
188E
188C
188E
188B
188B
188E
188B
995

Plate #7

Plate #8


HIGHWAY
188B
188C
1350B
1350 C
995
1032
STURGEON LAKE
995
274
W
995
188C
1032
70
188B
1032
274
188B
N
188B
186
188C
188C
274
1032
188B
995
274
188E
995

Plate #9


N
HIGHWAY
STURGEON
LAKE
504C
1016
995
1350B
1016
504B
614
504C
502
995
504C
1350B
188B
1350C
995
1350B
188C
614
188C
188B
1350B
502
1350C
614
17
188B
1350C
995
504E
504B
1032
502
995

Plate #10

Plate #11


HIGHWAY
N
4
186
188C
188B
188D
504B
504C
502
614
995
1350B
1016
1032
W

Plate #12

APPENDIX B-3

SOILS TESTING DATA

Paricle Size Distributions

For Soil Samples Taken in Windemere TN

Pine County MN

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-21T STS JOB NO.: 22561
SAMPLE NO. : 4 PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 17.00-28.00 in. W/C: — SP.GR.: —
CLASSIFICATION: Dusler Loam LL : — PL : — PI : —

SIEVE ANALYSIS-

SAMPLE WEIGHT: 94.61 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
.375"	0.00	0.00	100.00
#4	1.07	1.13	98.87
#10	0.48	0.51	98.36
#16	0.30	0.32	98.04
#40	1.55	1.64	96.41
#60	4.29	4.53	91.87
#140	7.71	8.15	83.72
#200	2.39	2.53	81.20
#325	2.17	2.29	78.91
[illegible]	[illegible]	[illegible]	[illegible]

HYDROMETER ANALYSIS-

SAMPLE WEIGHT: 52.03 GRAMS
SOIL SPECIFIC GRAVITY:
ZERO HYDROMETER HEIGHT: 10.45
CORRECTION FACTOR: 5.5

ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	50.00	44.50	0.0740	83.24
0.50	22.5	48.50	43.00	0.0531	80.43
1.00	22.5	46.50	41.00	0.0383	76.69
5.00	22.5	45.00	39.50	0.0174	73.89
8.00	22.5	44.00	38.50	0.0139	72.02
15.00	22.5	42.50	37.00	0.0103	69.21
30.00	22.5	40.50	35.00	0.0074	65.47
60.00	22.5	38.00	32.50	0.0053	60.79
134.00	22.5	35.00	29.50	0.0037	55.18
1390.00	22.5	27.00	21.50	0.0012	40.22

SOIL TESTING SERVICES, INC.

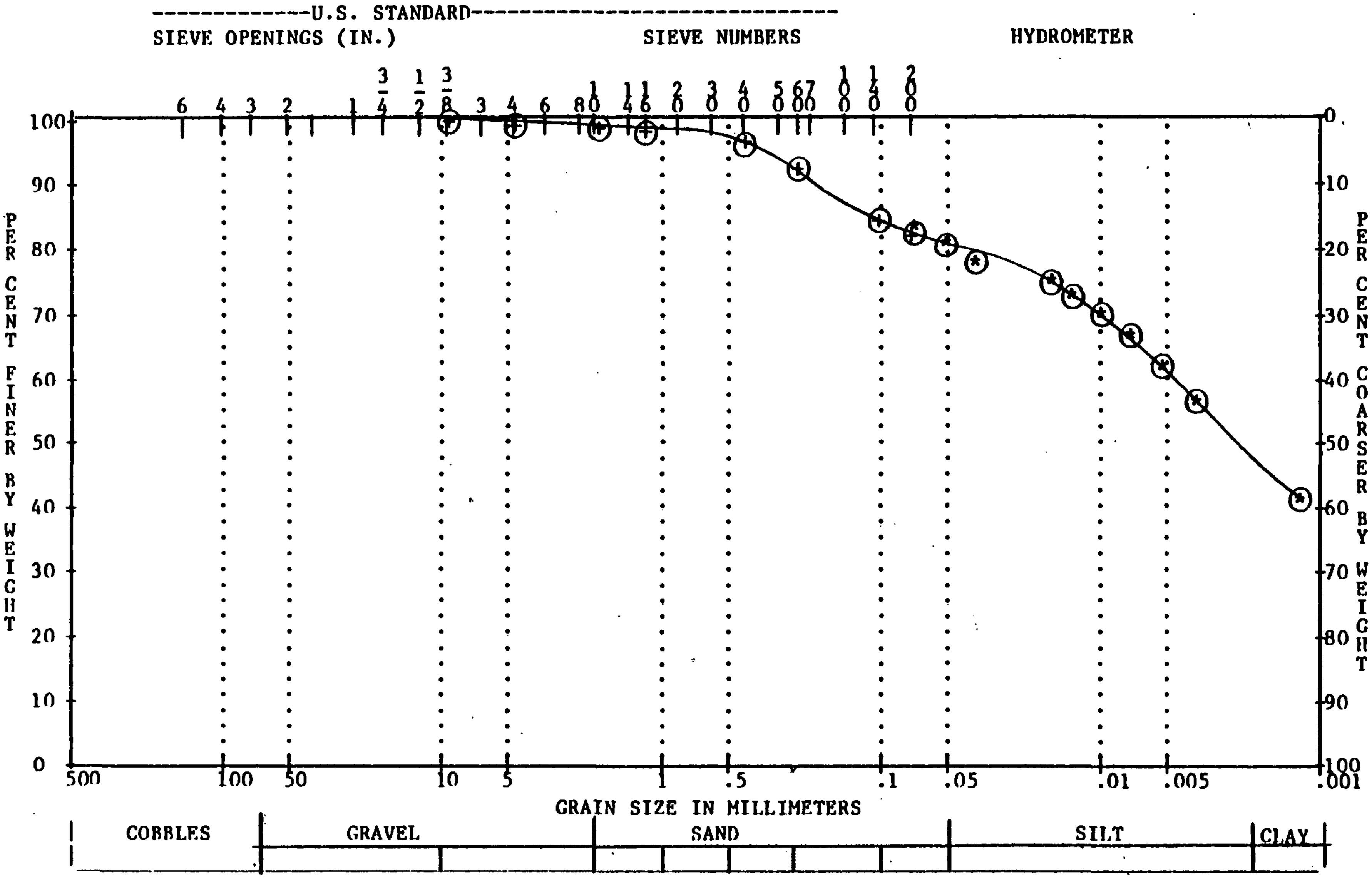
GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-21T STS JOB NO.: 22561

SAMPLE NO. : 4 PROJECT : MOOSE LAKE WINDEMERE

DEPTH : 17.00-28.00 in. W/C: — SP.GR.: —

CLASSIFICATION: Dusler loam LL : — PL : — PI : —



B-3-2

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : II-B3 STS JOB NO.: 22561

SAMPLE NO. : 7 PROJECT : MOOSE LAKE WINDEMERE

DEPTH : 52.00 -60.00 in. W/C: — SP.GR.: —

CLASSIFICATION: Duluth varient loam LL : — PL : — PI : —

fine sand

SIEVE ANALYSIS-

SAMPLE WEIGHT: 72.83 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
.375"	0.00	0.00	100.00
#4	0.48	0.66	99.34
#10	0.36	0.49	98.85
#16	0.20	0.27	98.57
#40	1.10	1.51	97.06
#60	3.36	4.61	92.45
#140	6.13	8.42	84.03
#200	1.84	2.53	81.50
#325	2.17	2.98	78.52

HYDROMETER ANALYSIS-

SAMPLE WEIGHT: 51.61 GRAMS

SOIL SPECIFIC GRAVITY:

ZERO HYDROMETER HEIGHT: 10.45

CORRECTION FACTOR: 5.5

ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	49.00	43.50	0.0737	81.56
0.50	22.5	47.00	41.50	0.0531	77.81
1.00	22.5	45.50	40.00	0.0381	75.00
5.00	22.5	42.00	36.50	0.0176	68.44
8.00	22.5	40.50	35.00	0.0141	65.63
15.00	22.5	39.00	33.50	0.0104	62.81
30.00	22.5	36.00	30.50	0.0076	57.19
60.00	22.5	33.00	27.50	0.0055	51.56
120.00	22.5	30.00	24.50	0.0040	45.94
1425.00	22.5	18.00	12.50	0.0012	23.44

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

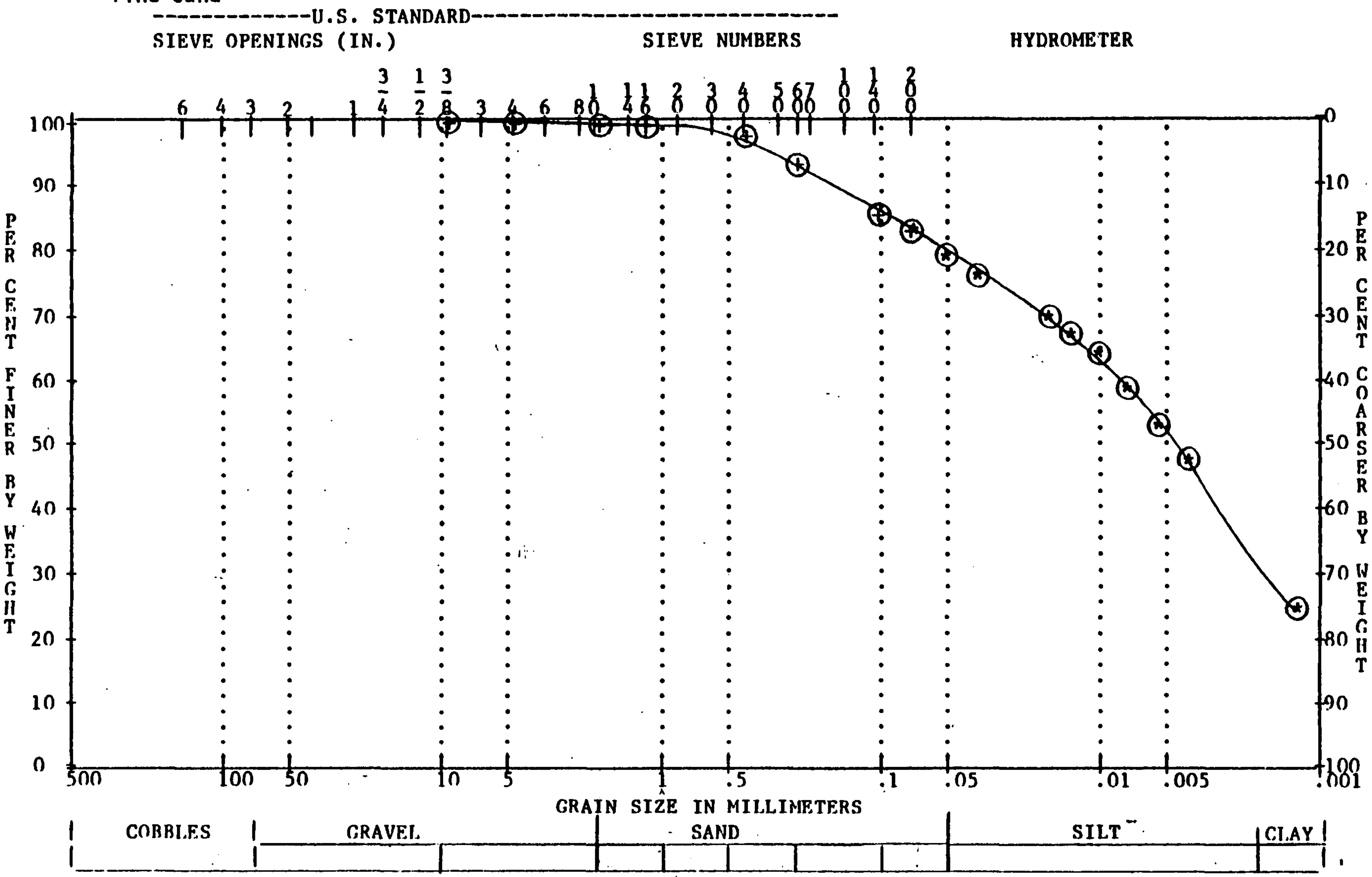
BORING NO. : II-B3 STS JOB NO.: 22561

SAMPLE NO. : 7 PROJECT : MOOSE LAKE WINDEMERE

DEPTH : 52.00 -60.00 in. W/C: — SP.GR.: —

CLASSIFICATION: Duluth varient loam LL : — PL : — PI : —

fine sand



B-3-4

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION — DATE: 1-19-82

BORING NO. : B-31 — STS JOB NO.: 22561
SAMPLE NO. : 4 — PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 22.00-38.00 in. — W/C: — — SP.GR.: —
CLASSIFICATION: Omega loamy sand — LL : — PL : — PI : —

SIEVE ANALYSIS-

SAMPLE WEIGHT: 147.99 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
.75"	0.00	0.00	100.00
.5"	3.24	2.19	97.81
#4	2.87	1.94	95.87
#10	2.89	1.95	93.92
#16	4.39	2.97	90.95
#40	56.83	38.40	52.55
#60	57.70	38.99	13.56
#140	12.81	8.66	4.91
#200	1.26	0.85	4.05
#325	0.20	0.14	3.91

HYDROMETER ANALYSIS-

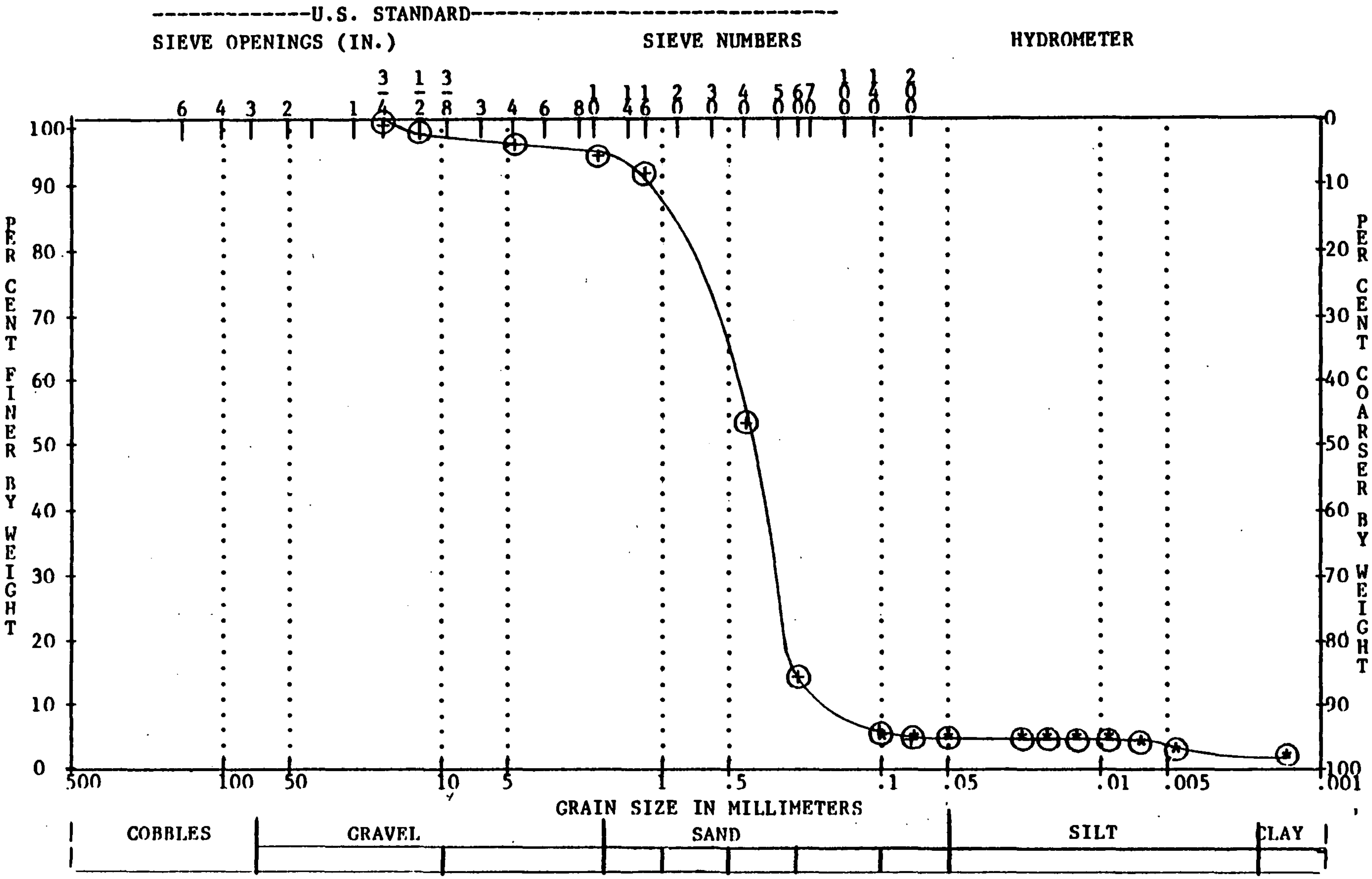
SAMPLE WEIGHT: 54.08 GRAMS
SOIL SPECIFIC GRAVITY:
ZERO HYDROMETER HEIGHT: 10.45
CORRECTION FACTOR: 5.5

ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	8.00	2.50	0.1043	4.40
0.50	22.5	8.00	2.50	0.0737	4.40
1.00	22.5	8.00	2.50	0.0521	4.40
5.00	22.5	8.00	2.50	0.0233	4.40
8.00	22.5	8.00	2.50	0.0184	4.40
15.00	22.5	8.00	2.50	0.0135	4.40
30.00	22.5	8.00	2.50	0.0095	4.40
60.00	22.5	7.50	2.00	0.0068	3.52
127.00	22.5	7.00	1.50	0.0047	2.64
1390.00	22.5	6.50	1.00	0.0014	1.76

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-31 STS JOB NO.: 22561
SAMPLE NO. : 4 PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 22.00-38.00 in. W/C: — SP.GR.: —
CLASSIFICATION: Omega loamy sand LL : — PL : — PI : —



B-3-6

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-22T STS JOB NO.: 22561
SAMPLE NO. : 5 PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 22.00-36.00 in. W/C: — SP.GR.: —
CLASSIFICATION: Duluth Loam #1 LL : — PL : — PI : —

SIEVE ANALYSIS-

SAMPLE WEIGHT: 86.79 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
#4	0.00	0.00	100.00
#10	0.22	0.25	99.75
#16	0.23	0.27	99.48
#40	1.31	1.51	97.97
#60	4.21	4.85	93.12
#140	7.64	8.80	84.32
#200	2.49	2.87	81.45
#325	2.26	2.60	78.85

HYDROMETER ANALYSIS-

SAMPLE WEIGHT: 51.66 GRAMS
SOIL SPECIFIC GRAVITY:
ZERO HYDROMETER HEIGHT: 10.45
CORRECTION FACTOR: 5.5

ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	49.00	43.50	0.0737	82.23
0.50	22.5	47.50	42.00	0.0529	79.39
1.00	22.5	45.50	40.00	0.0381	75.61
5.00	22.5	42.50	37.00	0.0175	69.94
8.00	22.5	41.50	36.00	0.0140	68.05
15.00	22.5	40.00	34.50	0.0103	65.21
30.00	22.5	38.00	32.50	0.0074	61.43
60.00	22.5	35.50	30.00	0.0054	56.71
120.00	22.5	33.00	27.50	0.0039	51.98
1405.00	22.5	25.00	19.50	0.0012	36.86

SOIL TESTING SERVICES, INC.

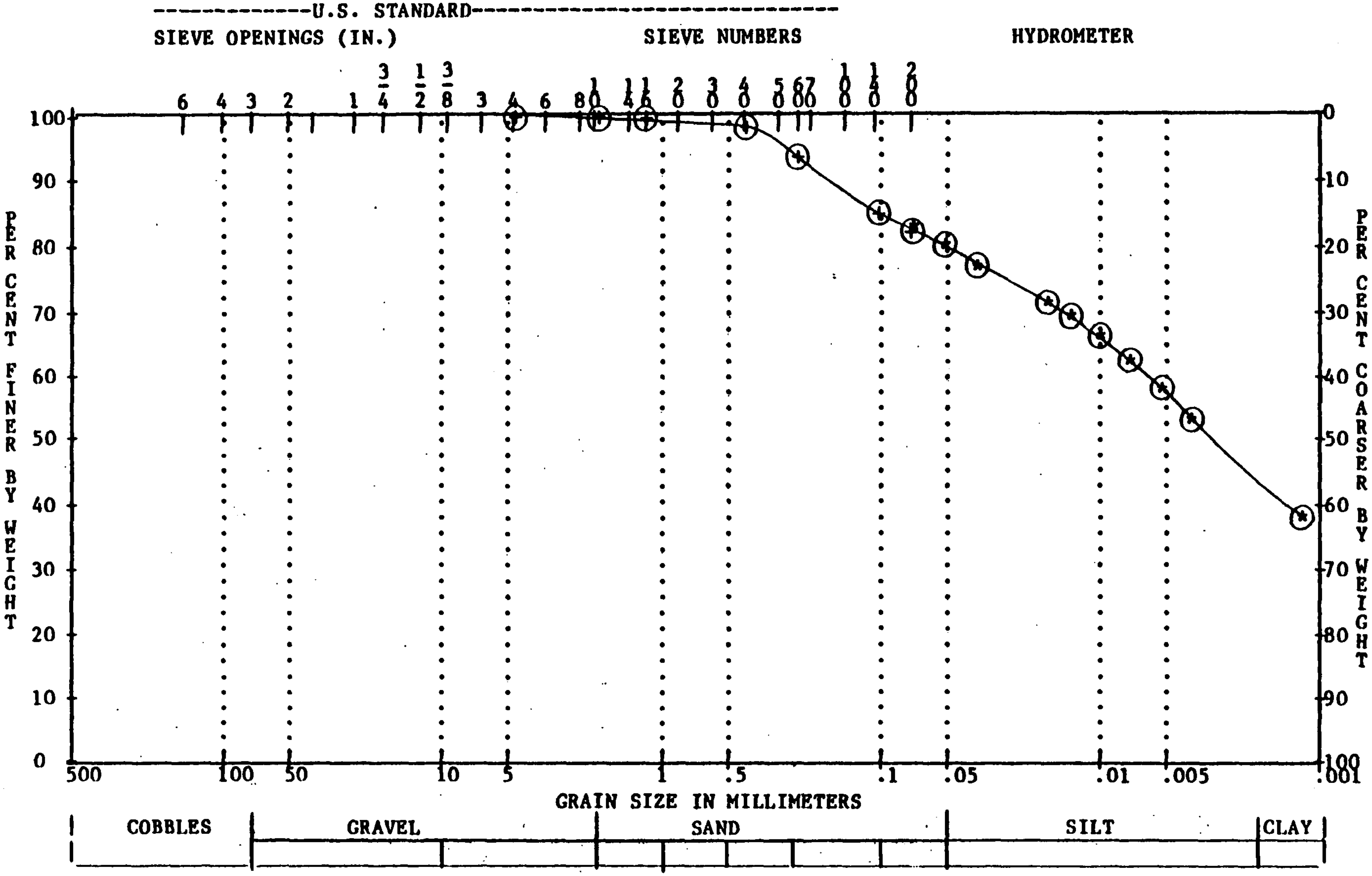
GRAIN SIZE DISTRIBUTION — DATE: 1-19-82

BORING NO. : B-22T — STS JOB NO.: 22561

SAMPLE NO. : 5 — PROJECT : MOOSE LAKE WINDEMERE

DEPTH : 22.00-36.00 in. — W/C: — — SP.GR.: —

CLASSIFICATION: Duluth loam #1 — LL : — PL : — PI : —



B-3-8

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-22T STS JOB NO.: 22561
SAMPLE NO. : 4 PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 18.00 -38.00 in. W/C: — SP.GR.: —
CLASSIFICATION: Duluth Loam #2 LL : — PL : — PI : —

SIEVE ANALYSIS-

SAMPLE WEIGHT: 111.5 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
#4	0.00	0.00	100.00
#10	0.69	0.62	99.38
#16	0.29	0.26	99.12
#4Q	1.27	1.14	97.98
#60	3.64	3.26	94.72
#140	6.43	5.77	88.95
#200	2.05	1.84	87.11
#325	2.21	1.98	85.13

HYDROMETER ANALYSIS-

SAMPLE WEIGHT: 51.67 GRAMS
SOIL SPECIFIC GRAVITY:
ZERO HYDROMETER HEIGHT: 10.45
CORRECTION FACTOR: 5.5

ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	51.50	46.00	0.0724	87.17
0.50	22.5	51.00	45.50	0.0515	86.22
1.00	22.5	50.00	44.50	0.0368	84.32
5.00	22.5	48.00	42.50	0.0168	80.53
8.00	22.5	46.50	41.00	0.0135	77.69
15.00	22.5	45.00	39.50	0.0100	74.85
30.00	22.5	42.50	37.00	0.0072	70.11
63.00	22.5	39.00	33.50	0.0051	63.48
125.00	22.5	35.50	30.00	0.0037	56.85
1386.00	22.5	23.50	18.00	0.0012	34.11

SOIL TESTING SERVICES, INC.

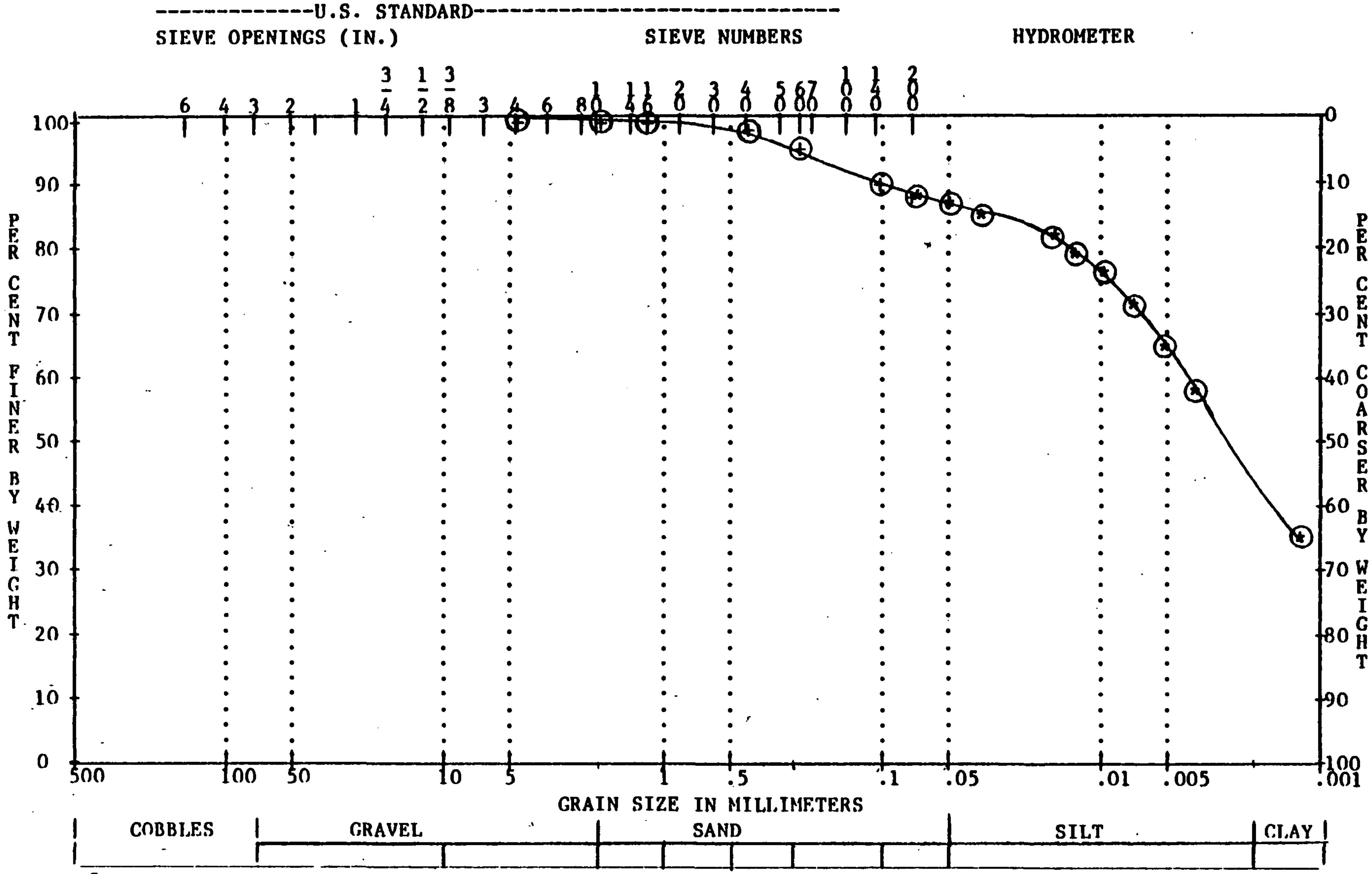
GRAIN SIZE DISTRIBUTION — DATE: 1-19-82

BORING NO. : B-22T — STS JOB NO.: 22561

SAMPLE NO. : 4 — PROJECT : MOOSE LAKE WINDEMERE

DEPTH : 18.00 -38.00 in. — W/C: — — SP.GR.: —

CLASSIFICATION: Duluth Loam #2 — LL : — PL : — PI : —



B-3-10

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION DATE: 1-19-82

BORING NO. : B-3 STS JOB NO.: 22561
SAMPLE NO. : 6 PROJECT : MOOSE LAKE WINDEMERE
DEPTH : 49.00-60.00 in. W/C: — SP.GR.: —
CLASSIFICATION: Duluth loam #2 LL : — PL : — PI : —

SIEVE ANALYSIS-

SAMPLE WEIGHT: 71.43 GRAMS

SIEVE SIZE	WEIGHT RETAINED	PER CENT RETAINED	PER CENT PASSING
#4	0.00	0.00	100.00
#10	0.17	0.24	99.76
#16	0.15	0.21	99.55
#40	0.52	0.73	98.82
#60	1.60	2.24	96.58
#140	3.15	4.41	92.17
#200	1.09	1.53	90.65
#325	1.40	1.96	88.69

HYDROMETER ANALYSIS-

SAMPLE WEIGHT: 51 GRAMS
SOIL SPECIFIC GRAVITY:
ZERO HYDROMETER HEIGHT: 10.45
CORRECTION FACTOR: 5.5

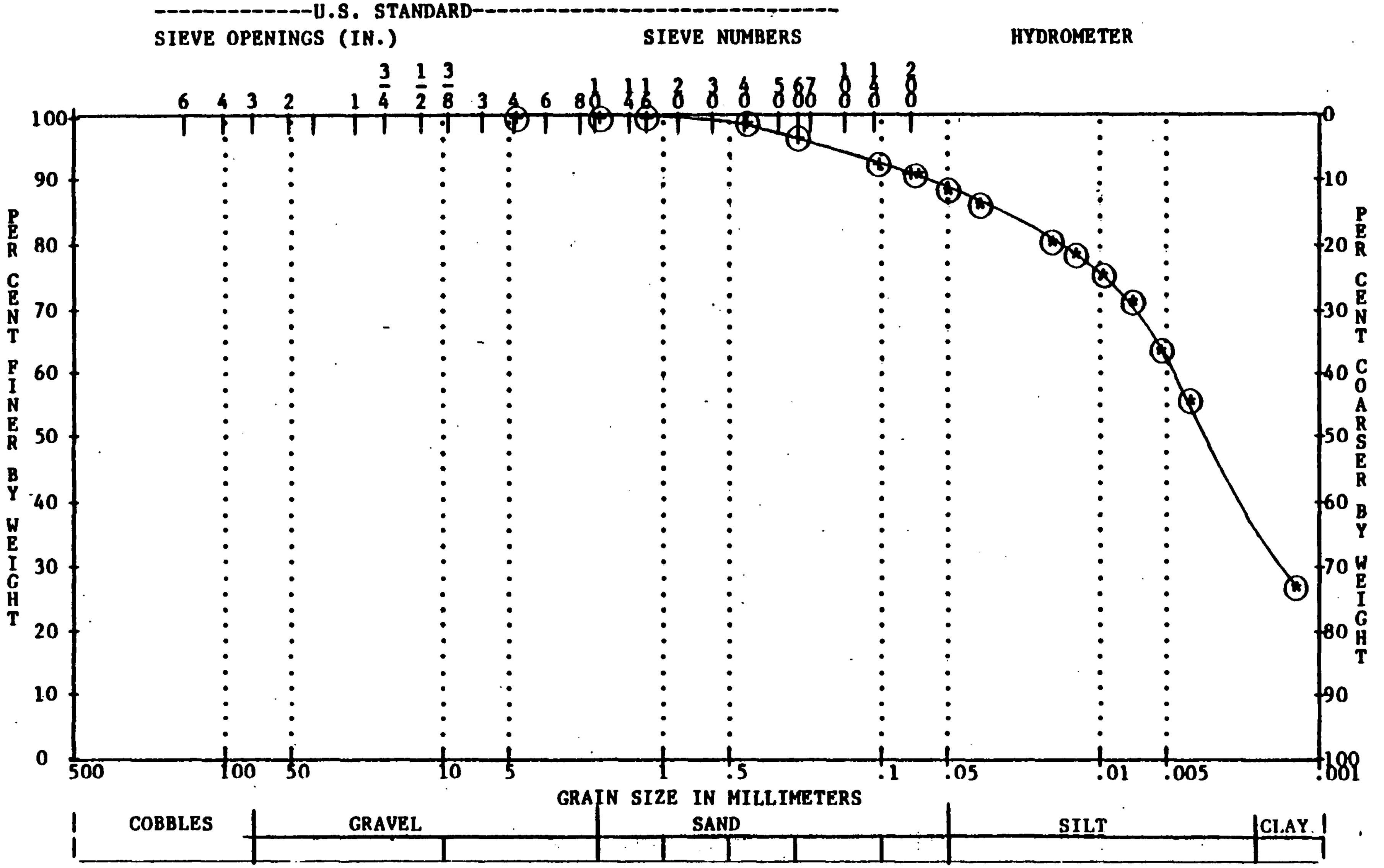
ELAPSED TIME	TEMPERATURE	ACTUAL READING	ADJUST READING	GRAIN SIZE	PER CENT FINER
0.25	22.5	52.50	47.00	0.0710	90.01
0.50	22.5	51.00	45.50	0.0510	87.13
1.00	22.5	50.00	44.50	0.0365	85.22
5.00	22.5	47.00	41.50	0.0168	79.47
8.00	22.5	46.00	40.50	0.0134	77.56
15.00	22.5	44.00	38.50	0.0100	73.73
30.00	22.5	42.00	36.50	0.0072	69.90
60.00	22.5	38.00	32.50	0.0053	62.24
120.00	22.5	34.00	28.50	0.0038	54.58
1410.00	22.5	19.00	13.50	0.0012	25.85

SOIL TESTING SERVICES, INC.

GRAIN SIZE DISTRIBUTION — DATE: 1-19-82

BORING NO. : B-3
SAMPLE NO. : 6
DEPTH : 49.00 -60.00 in.
CLASSIFICATION: Duluth loam #2

STS JOB NO.: 22561
PROJECT : MOOSE LAKE WINDEMERE
W/C: — SP.GR.: —
LL : — PL : — PI : —



B-3-12

Appendix B-4.

SUMMARY AND INTERPRETATION OF SOILS INFORMATION

B-4.1. Soil Types

Each soil association (Section 2.2.1.) contains a number of soil types. A brief description of the eleven identified soil types follows, including a discussion of the topography, drainage properties (Figure B-1), and other characteristics of the area's soils in relation to the suitability for conventional soil absorption systems (Table B-1). No assessment is made of the suitability of the area's soils for "innovative" or unconventional on-site waste treatment systems.

DRAINAGE CLASS

- *Excessively drained.*—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.
- *Somewhat excessively drained.*—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.
- *Well drained.*—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.
- *Moderately well drained.*—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.
- *Somewhat poorly drained.*—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.
- *Poorly drained.*—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.
- *Very poorly drained.*—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

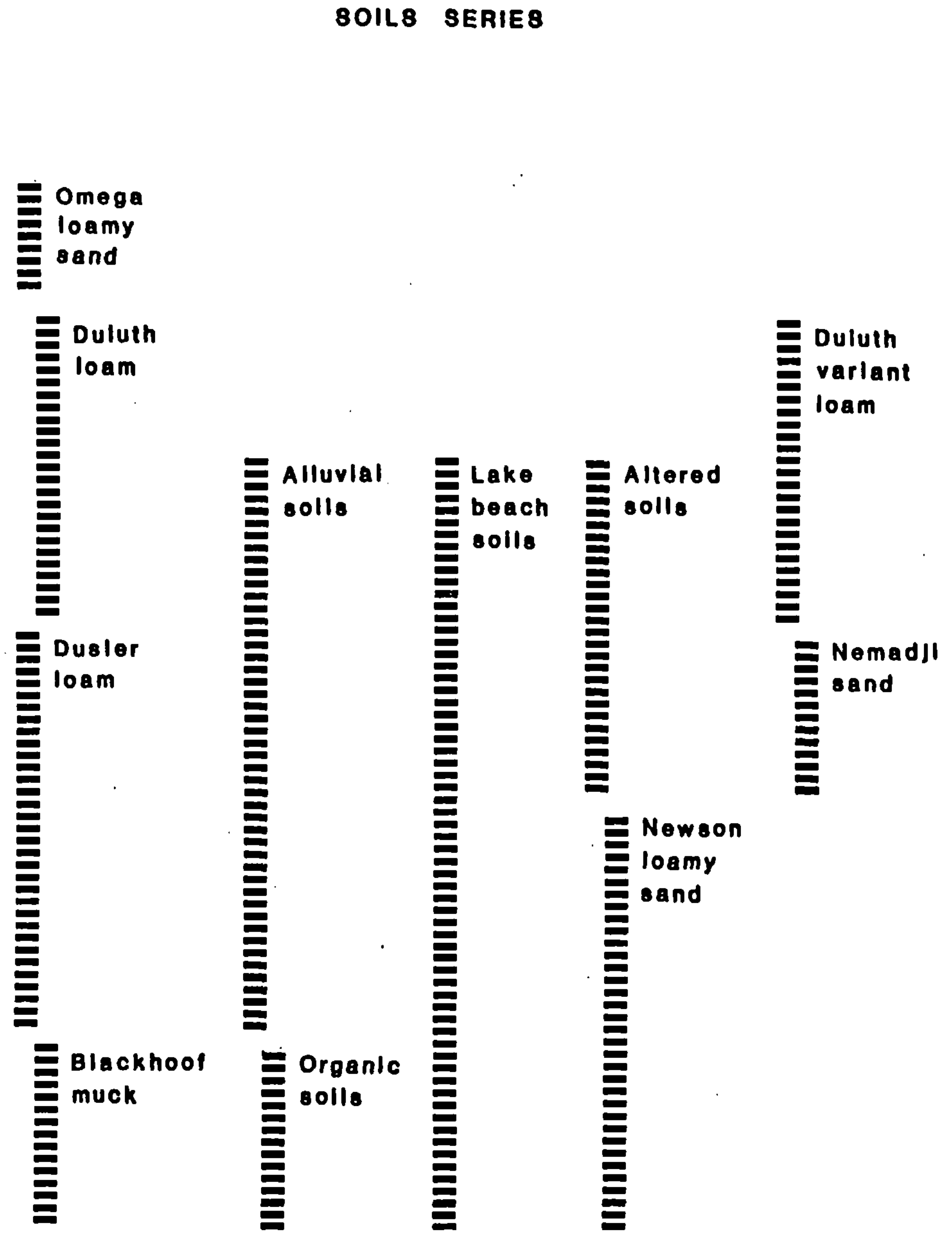


Figure B-1. Drainage class ranges of soils in a portion of Windemere Township. Derived from Finney (1981) and SCS (1978).

Table B-1. Soil series characteristics and soil absorption system ratings for soils in the surveyed portion of Windemere Township (Finney 1981; SCS 1978).

Predominant Substratum	SCS Soil Name and Mapping Symbol		Slope Range (percent)	Surface Texture	Substratum Texture	Depth to Water Table	Permeability Range (inches/hour)	SCS Rating Soil Absorption Systems[a]
Loam								
	Duluth	504B	1-4	loam	loam	72"	0.06-0.20 (13"), 0.20-0.60 (64")	Severe; sp
		504C	4-15	"	"	72"	" "	Severe; sp
		504E	15-60	"	"	72"	" "	Severe; sl, sp
	Duluth Variant[b]	1350B	1-4	loamy sand	clay loam	72"	6.00-20.00 (20"), 0.20-0.60 (52")	-
		1350C		"	"	72"	" "	-
	Dusler	502	0-2	loam	clay loam	12"-48"	0.60-2.00 (12"), 0.20-0.60 (42")	Severe, sp
	Blackhoof	614	0-1	mucky silt loam	silt loam	0-12"	0.06 (5"), 0.06-0.20 (48")	Severe; shwt
Sand or Gravelly Sand								
	Omega	188B	0-5	sand	coarse sand	72"	6.00-20.00 (22"), 6.00-20.00 (60")	Slight[c]
		188C	5-50	"	"	72"	" "	Severe; sl[c]
		188E	20-60	"	"	72"	" "	Severe; sl[c]
	Nemadji	186	0-2	sand	sand	18"-48"	6.00-20.00 (11"), 6.00-20.00 (55")	Severe; shwt
	Newson	274	0-1	loamy sand	"	12"	0.60-0.20 (22"), 6.00-20.00 (65")	Severe; shwt
	Lake Beaches[b]	1032	0-2	sand	coarse sand	12"-36"	6.00-20.00 (21"), 6.00-20.00 (60")	-
Other								
	Organic	995	0-2	mucky peat	mucky peat	12"	0.60-2.00 (22"), 0.60 - 2.00 (65")	-
	Alluvial	1002	0-1	-	-	Occasional flooding	variable	-
	Altered	1016	-	mostly loam	mostly loam	variable	mostly 0.06-0.20	-

[a]Ratings abbreviations for soil absorption systems are: sp - slow permeability, sl - slope, shwt - shallow high water table.

[b]These soils series were identified during the soils survey of the project area, but have not yet been recognized by the Minnesota Co-operative Soils Survey.

[c]Rapid permeability represents potential hazard to groundwater supplies if pollution is present.

Loamy Soils

Soils with loamy substrata predominate in the northern half of the surveyed area. The loamy soils identified in the survey include the Duluth, Duluth Variant, Dusler, and Blackhoff series.

Duluth Loam

The Duluth series consists of gently undulating to very steep, moderately well and well drained, moderately slow and slowly permeable soils that formed mostly in loamy calcareous glacial till on glacial moraines. They mostly have convex slopes, but they may also have linear or concave slopes on the lower parts of some steep and very steep slopes.

The SCS rates Duluth soil as having "severe" limitations to soil absorption systems use because of its relatively slow permeability. Duluth soil can accommodate a soil absorption system under certain conditions if the design is appropriate. However, on sites with steep slopes, or with lot size constraints or with low soil permeabilities, unconventional designs for soil absorption systems may have to be used to obtain satisfactory performances.

It is estimated that approximately 60% of the platted lakeshore lot area around Island Lake is mapped as Duluth soil. Most of the platted areas with Duluth soil are found along the south shore of the Lake. Duluth soil is also common along the north half of Sturgeon Lake, covering approximately 40% of its platted lakeshore lot area. Duluth soil was not mapped in significant amounts around the platted shoreline areas of Rush and Passenger lakes.

Duluth Variant

Duluth Variant soil consists of gently sloping and sloping, moderately well and well drained, moderately slow and slowly permeable soils that were formed in a 20- to 40-inch thick mantle of sandy glacial outwash material and in underlying loamy calcareous glacial till on glacial moraines. These soils may have both convex and linear slopes.

As was discussed in Section 2.2.1., Duluth Variant soils are found in the transition area between the two major soil associations. The upper horizons of the Duluth Variant soil have a rapid permeability. Thus, septic tank effluent absorption systems constructed in adequate depths of this upper horizon should function satisfactorily. Duluth Variant has not been formally recognized as a named soil series by the Cooperative Soil Survey of Minnesota. Therefore, no SCS rating for soil absorption system operation is available.

Duluth Variant soil is primarily found at some distance from the lakeshore away from existing development within the surveyed area. Although common in the surveyed area, Duluth Variant soil was mapped on only approximately 10% of the platted lakeshore lot area around Island Lake, and on approximately 5% of the platted area around Sturgeon Lake. Duluth Variant soil is uncommon in the vicinity of Rush and Passenger lakes.

Dusler Loam and Blackhoof Muck

Dusler soil consists of nearly level, somewhat poorly and poorly drained, slowly permeable soils that were formed mostly in loamy calcareous glacial till. This soil has slightly convex to slightly concave slopes on glacial moraines.

Blackhoof soil consists of a nearly level, very poorly drained, slowly to very slowly permeable soil that was formed in a thin mantle of organic soil and in underlying loamy glacial till or in old aluvium or both. This soil has concave or linear slopes and is found in depressions and drainage ways on glacial moraines.

Dusler and Blackhoof soils both have "severe" soil absorption system ratings according to the SCS. Although Dusler soil has a permeability similar to Duluth soil, septic systems are still more difficult to operate in Dusler soil because Dusler soil is often poorly drained. In addition to having low permeability, Blackhoof soil also has the water table within one foot of the land surface. Therefore, conventional soil absorption systems will not function properly in Blackhoof soil.

Dusler and Blackhoof soils each are mapped on approximately 3% percent of the platted lakeshore lot area around Island Lake, mostly in areas along the northwest shoreline. Dusler and Blackhoof soils are uncommon on platted lakeshore lots around Sturgeon, Rush, or Passenger lakes. However, relatively large areas of these soils are found adjacent to platted lots along the northwest shore of Sturgeon Lake.

Sandy Soils

Soils with sandy substrata predominate in the southern half of the surveyed area. The sandy soils identified in the survey are the Omega, Nemadji, and Newson series. A special classification termed Lake Beach soil was also made in the southern portion of the surveyed area.

Omega Loamy Sand

The Omega series consists of nearly level to very steep, somewhat excessively drained, rapidly permeable soils that were formed from sandy glacial outwash materials. These soils have convex to concave slopes on glacial outwash plains and moraines.

Septic tank absorption systems operate very well in Omega soil. However, the SCS rates Omega soil as having severe limitations for soil absorbtion systems because this soil may occasionally have excessive drainage (high permeability). This rating is due to the potential for wastewater to pass through Omega soils too quickly for proper treatment to occur, thereby causing adjacent wells to become contaminated. The chances of such contamination occuring can be minimized by not locating absorption fields on Omega soils dominated by very coarse sand or by replacing the coarse sand by fine sand or loam.

Omega loamy sand is the predominant soil in the southern half of the survey area. Around Island Lake approximately 8% of the platted lakeshore lot area is mapped as Omega soil, while Omega covers approximately 20% of the platted shore area of Sturgeon Lake. The estimated proportion of Omega soil mapped on the platted lakeshore lot area around Rush and Passenger lakes is much higher; 85% and 50% respectively.

Nemadji Loamy Sand and Newson Mucky Sandy Loam

The Nemadji series consists of nearly level, somewhat poorly drained, rapidly permeable soils that were formed in sandy glacial outwash materials. These soils have slightly convex to slightly concave slopes on glacial outwash plains.

The Newson series consists of nearly level, poorly and very poorly drained, rapidly permeable soils that were formed mostly from sandy glacial outwash materials. These soils have linear to concave slopes located on glacial outwash plains.

Nemadji and Newson soils are rated by SCS as having "severe" limitations for the operation of septic tank absorption systems because of poor drainage and the presence of a high water table. There is little that can be done to engineer conventional absorption systems to work properly in these two soils unless the drainage characteristics of a site can be physically altered.

Nemadji and Newson soils are mapped on a small proportion of the total surveyed area and a small proportion (approximately 1%) of the platted lakeshore lot area around Island Lake. A small proportion of the land area with platted lots around Sturgeon Lake also is mapped as Nemadji soil; Newson soil was not found near Sturgeon Lake. Nemadji and Newson soils were not mapped in significant areas around Rush and Passenger lakes.

Lake Beach

Lake Beach soil consists of a nearly level, very poorly to moderately well drained, moderately to rapidly permeable soil that was formed in recent to rather old sandy deposits adjacent to lakes. The formation of this soil resulted from the action of water and ice and the higher lying parts of this soil are a result of historically higher lake levels.

Lake Beach soil has not been formally recognized by the Minnesota Cooperative Soil Survey, and therefore it has no SCS soil absorption system limitation rating. The characteristics of Lake Beach soil relative to the operation of septic tank absorption systems may vary considerably from site to site. It can be stated however, that on Lake Beach soil with good drainage, an absorption system will probably operate well from the standpoint of percolation. It is estimated that Lake Beach soil is mapped on roughly 20% of the platted lakeshore lot area around Sturgeon Lake, 10% of the platted area around Rush Lake, and 50% around Passenger Lake. Lakes Beach soil is uncommon along the shores of Island Lake.

Other Soils

Three miscellaneous soil types also were identified during the soil survey. Organic soil is the major type in this category. Small areas of Altered and Alluvial soils also were identified.

Organic Soil

Organic soil consists of very poorly drained, nearly level soil with slow to moderately rapid permeability. It is formed from the slightly to highly decomposed remains of a variety of plants. Organic soil was found primarily in depressions on glacial moraines and outwash plains. Some of these depressions were formerly small lakes.

Soil absorption systems will not operate properly in Organic soil due to poor drainage and the presence of a high water table. Because Organic soils also possess significant limitations to construction, very few dwellings are located on this soil inside the surveyed area.

Organic soil is mapped on approximately 20% of the total surveyed area, but is mapped on less that 5% of the platted lakeshore lot area around each of the four lakes. Large areas of Organic soil are found in the wetlands to the northwest of Sturgeon Lake (surrounding a 100 to 120 acre bog), and in a 60 acre wetland immediately adjacent to the northeast shore of Rush Lake.

Altered and Alluvial Soils

Altered soil was identified in the soil survey where natural soils had been altered by cutting and filling. Most altered soils were found adjacent to the lakeshore in or near areas of Duluth soils, in the northern portion of the surveyed area. Altered soils may exhibit a range of absorption system performances depending on the degree of compaction and the nature of the fill materials. Altered soils are mapped on less than 5% of the platted lakeshore lot area around both Island and Sturgeon Lakes. No Altered soils were identified around Rush and Passenger lakes.

Alluvial soil consists of sandy and loamy soils that were formed in alluvium (material deposited by rivers). Such soil is usually flooded one or more times each year, and if this is the case would not provide an acceptable site medium for soil absorption systems. Although limited areas having Alluvial soil were identified in the soil survey, this soil was not found in significant amounts on the platted lakeshore lot areas.

B-4.2. Soil Texture

The SCS Soil Survey of Carlton County, Minnesota (1978) contains particle size distribution (texture) data for many soils of the same series found in the surveyed area. Particle size distributions were measured for six representative soils sampled in the surveyed area in order to ensure that the textural classifications were consistent with the classifications made for Carlton County. Any significant differences in soil texture will be considered in the development of wastewater management alternatives.

Testing Methodology

Soil particles are the discrete units which make up the solid portion of soils. The relative proportions of the different sized particles of a soil are relatively stable and can be used as a basis to determine the agricultural and engineering properties of particular soils. When quantified, the proportions of these particles are termed 'particle size distributions'.

Particle size distributions are commonly represented by the relative mass proportions (percentage by weight) of soil particles less than or equal to a given particle diameter. The proportions are measured by physical fractionation procedures, usually in a two step process. To fractionate the larger diameter soil particles, a soil sample is passed through a series of sieves with decreasing mesh sizes, each sieve successively letting soil particles pass through the mesh openings of known diameter. The fractions of clay and silt are then measured by mixing what has passed through the smallest sieve size with water and measuring the change in the density of the water over time as the suspended particles settle. The rate of change in density is related to the size of the particles by an empirical mathematical relationship.

Comparison of Sample Testing Results with Regional Soil Survey Data

Particle size distributions reported in the SCS Carlton County Soil Survey were compared to the analytical results for six Pine County soil samples (Table B-2). The Pine County soil samples were found to have particle size distributions which indicate a somewhat finer texture of soils than those reported for the same soil types in the Carleton County Soil Survey. In the loamy soils examined, the percent of material passing through a number 200 seive (all the clay, silt and part of the very fine sand) exceeded the upper limit of the estimated range presented in the Carlton County survey. Based on these results, it was concluded that the Duluth and Dusler soils in the project area are more silty and clayey in texture than those in Carlton County, and thus could pose greater constraints to the design of soil absorption systems.

The particle size distribution data can be further analyzed to determine whether the observed fraction of fine particles would actually limit the use of septic tank absorption fields in the surveyed area. The hydrometer tests that were performed on the portion of the soil sample which passed through the smallest mesh size can be used to distinguish the percent clay and the percent silt of the sample (by weight). The remainder is made up of sand of varying size distributions. The individual clay, silt, and sand fractions of each sample can then be interrelated to classify the

Table B-2. Comparison of particle size distribution data from the Carlton County Soil Survey (SCS 1978) with particle size distribution data obtained from testing soil samples taken during the soil survey of a portion of Windemere Township (Finney 1981).

Soil Type	Horizon	Depth of sample	Percent of sample passing #4 sieve (4.7mm)		Percent of sample passing #10 sieve (2.0mm)		Percent of sample passing #40 sieve (0.42mm)		Percent of sample passing #200 sieve (0.074mm)	
			Carlton Cty.	Windemere Tn.	Carlton Cty.	Windemere Tn.	Carlton Cty.	Windemere Tn.	Carlton Cty.	Windemere Tn.
[1]Duluth Loam	B22t	22"-36"	95 - 100	100	85 - 98	100	85 - 95	98	55 - 75	81
[2]Duluth Loam	B22t	18"-38"	95 - 100	100	85 - 98	99	85 - 95	98	55 - 75	87
[3]Duluth Loam	B3	49"-60"	95 - 100	100	85 - 98	100	85 - 95	99	55 - 75	91
[4]Duluth Variant	IIB3	52"-60"	--------	99	-------	99	-------	97	-------	82
[5]Dusler Loam	B21t	17"-28"	95 - 100	99	85 - 98	98	85 - 95	96	55 - 75	81
[6]Omega Loamy Sand	B31	22"-38"	95 - 100	96	90 - 100	94	70 - 90	53	2 - 10	4

[1]Sample taken near north shore of Island Lake.

[2,3]Sample taken near north shore of Sturgeon Lake.

[4]Sample taken near northwest shore of Sturgeon Lake. Not recognized as a soil series in the Carlton County Soil Survey published by the US Soil Conservation Service. Substratum of the Duluth Variant was observed to be similar in texture to Duluth Loam.

[5]Sample taken near northwest shore of Sturgeon Lake.

[6]Sample taken near west shore of Passenger Lake.

soil. These data are of interest because silt is much more hydraulically conductive than clay and the relative fractions of both must be known before it can be concluded that soils are tight enough to pose limitations for the use of septic absorption fields. In general, a high clay fraction indicates poor septic absorption field performance regardless of silt or sand content. Conversely, a high silt content indicates good septic leachate field performance if clay content is moderate to low. Additionally, the silt/clay fractions can be used to determine whether the clay and silt content is too low to provide adequate treatment of septic leachate.

The USDA (1980) definition of silt includes those soil particles within the diameter range of 0.002 millimeters to 0.05 millimeters. Using the particle size distribution graphs (Appendix B-3 to interpolate within these diameters the silt weight fraction can be determined. USDA defines clay as particles of less than 0.002 millimeters in diameter. The weight fraction of the material finer than this diameter also can be determined by interpolating from the graphs in Appendix A. The percent by weight of silt, clay, and sand in six soil samples were estimated and classified based on the above definitions (Table B-3). The soil textural classes presented in the soil survey (Appendix A) characterize only the surface horizon. Samples from deeper horizons must be analyzed and classified for the substratum. The six soil samples tested for this report were from horizons which ranged from 17 to 60 inches in depth. These horizons are being classified because soil characteristics at that depth range are important to the performance of septic absorption fields. The silt, clay, and sand fractions for the six samples were plotted on the Textural Triangle presented in Figure B-2 and the resultant substratum classifications were compared with the descriptions of those horizons which were made in the field (Table B-3).

Comparison of the six substratum classifications with descriptions made in the field indicates that the soils of the Duluth and Dusler series which were mapped in Windemere Township had higher than expected clay content at depth. Additionally, the relatively fine texture of these sampled horizons as compared to similar horizons reported in the Carlton County Soil Survey appears to be a result of the high clay content and not a

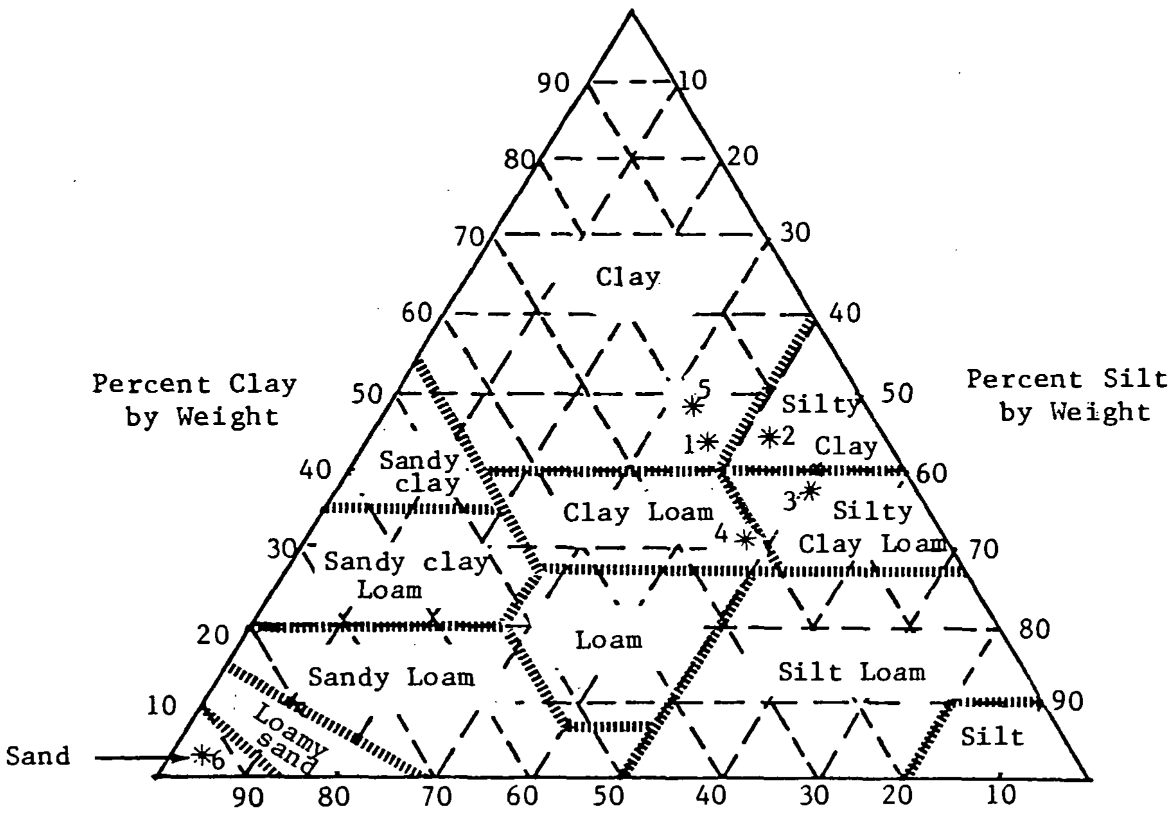
Table B-3 Comparison of textural classifications for soil samples taken during the soil survey of a portion of Windemere Township.

#	Soil Sample	Horizon	Weight Fractions by Percent Silt	Clay	Sand	[1] Description of the Sample Based on Field Observation	[2] Textural Classification of the Sample Based on Weight Fraction by %
1	Duluth loam	B22t 22"-36"	37%	43%	20%	loam, near clay loam	clay
2	Duluth loam	B22t 18"-38"	43%	44%	13%	loam, near clay loam	silty clay
3	Duluth loam	B3 49"-60"	51%	37%	12%	loam	silty clay loam
4	Duluth variant loamy find sand	IIB3 52"-60"	48%	31%	21%	clay loam, near loam	clay loam
5	Dusler loam	B21t 17"-28"	33%	48%	19%	clay loam	clay
6	Omega sandy loam	B31 22"-38"	3%	2%	95%	sand and coarse sand	sand

[1] Samples of the various horizons were examined in the field and the classifications reported on in the soil survey by Finney (1981).

[2] Textural classifications were made based on the weight fractions of silt, clay, and sand as determined from particle size distribution data and based on application of the weight fraction data to the Textural Triangle as developed by USDA (1962).

Figure B-2. Textural triangle of soil particle fractions for the classification of soil samples. Sample locations are indicated by an asterix. Textural triangle is from USDA references (1962).



Sample 1; Duluth loam, 22"-36", B22t
Sample 2; Duluth loam, 18"-38", B22t
Sample 3; Duluth loam, 49"-60", B3
Sample 4; Duluth variant, 52"-60", IIB3
Sample 5; Dusler loam; 17"-28", B21t
Sample 6; Omega loamy sand, 22"-38", B31

→ See Table B-3 for classifications

result of high silt content (except in the Duluth Variant loamy fine sand sample where no comparison is possible).

The degree to which the six substratum samples represent all comparable horizons on the mapped areas of Duluth and Dusler soils has not been established. It appears, however, that substratum textural limitations to the use of septic absorption fields in the surveyed portion of Windermere Township may be more restrictive than would be expected based on typical soils classification definitions.

Appendix C

C-1. Methods and Results of the Septic Leachate Survey.

C-2. Well Testing Data

Appendix C-1.

METHODS AND RESULTS OF THE SEPTIC LEACHATE SURVEY

Methods

The Septic Leachate Detector System's operational functions are outlined in the following description, excerpted from the manufacturer's operations manual:

- The ENDECO Type 2100 Septic Leachate Detector System is a portable field instrument that monitors two parameters; fluorescence (organic channel) and conductivity (inorganic channel). The system is based on a stable relationship between fluorescence and conductivity in typical leachate outfalls. Readings for each channel appear visually on panel meters while the information is recorded on a self-contained strip chart recorder. Recording modes are selectable between individual channel outputs or a combined output. The combined output is the arithmetic result of an analog computer circuit that sums the two channels and compares the resultant signal against the background to which the instrument was calibrated. The resultant output is expressed as a percentage of the background. Also, the combined recorded output is automatically adjusted for slow background changes. The system can be operated from a small boat enabling an operator to continuously scan an expansive shoreline at walking pace and, through real time feedback, effectively limit the need for discrete grab samples to areas showing high probability of effluent leaching. Expensive laboratory time for detailed nutrient analysis is greatly reduced while survey accuracy is increased substantially...

- The Septic Leachate Detector System consists of the subsurface probe, the water intake system, the logic analyzer control unit, panel meters and the strip chart recorder...

- The probe/wand is submerged along the shoreline. Background water plus groundwater seeping through the shore bottom is drawn into the subsurface intake of the probe and is lifted upwards to the analyzer unit by a battery operated, submersible pump...

- Upon entering the analyzer unit the solution first passes through the fluorometer's optical chamber where a continuous measurement is made of the solution's narrow band response to UV excitation. The solution then flows through a conductivity measurement cell. An electrode-type conductivity/ thermistor probe continuously determines the solution's conductivity. The solution exits the conductivity cell directly to the discharge where discrete samples may be collected if indicated by the response of the leachate detector. Both parameters are continuously displayed on separate panel meters. Zero controls are provided for both parameters (organic and inorganic) to enable "dialing out" the background characteristics to provide maximum sensitivity, as well as enhancing the response caused by a suspected abnormality. Span controls are also provided to control the sensitivity for each parameter separately during instrument calibration...

- The signals generated and displayed on the panel meters are also sent to an arithmetic/comparator analog computer circuit designed to detect changes in the ratio of organics and inorganics typical of septic leachate. The output of this circuitry is recorded continuously on a strip chart and is the key indicator of a suspected leachate outfall. However, isolated increases in either parameter may be cause for concern and should be sampled for analysis for other potential forms of nutrient pollution.

The magnitude of the signal outputs and of the synthesized "combined output" when detecting an effluent plume is subject to many non-instrumental factors related to variable dilution of effluents in lake water. Interference with the survey could potentially be caused by overland or sub-surface flow of water bearing large amounts of organic substances such as would be the case with barnyard runoff or with water moving out of a bog or marsh. Additionally, rapidly changing wind conditions may change the ambient water quality of the lake by introducing waters from the deeper zones of the lake which also contain large amounts of organic substances. Therefore, detailed field notes and subsequent map analysis of recorded data are necessary parts of the survey design. Expert interpretive analysis is required to deduce the significance of an increase in instrument signal output under such changing conditions.

The Septic Leachate Survey of Island, Sturgeon, Rush, and Passenger lakes was completed during the period of 2-9 October 1981. The survey covered the developed shorelines of Sturgeon, Island, Rush, and Passenger lakes and was conducted from a 12 foot boat with a 20 horsepower outboard motor. The boat was operated at its lowest speed (approximately 0.5 to 1 mph) as near as possible to the shore. An electrically powered trolling motor was used in waters too shallow for the outboard motor. Dense colonies of emergent aquatic plants occasionally prevented scanning along a course closely parallel with the shoreline. Paths leading through these dense stands to mooring areas near houses were utilized to approach the shore for surveying such areas. Sampling was always performed as close as possible to the shoreline to minimize the effects of dilution and wave/ current disruption of emergent effluent plumes.

During scans the detector's meters were adjusted to maximum sensitivity. Adjusting the meters to maximum sensitivity requires a greater emphasis on operator real-time interpretation of recorded signals, but also increases the likelihood of detection of effluent plumes.

During most scans the instrument was set to record data on the combined signal output mode. This setting provides automatic adjustment for changing background levels of fluorescence or conductivity, but still records the short-term increases indicative of localized sources such as effluent plumes. It also permits the operator to pay greater attention to observing possible sources and to recording observations. Prior to scanning the shoreline, the instrument was calibrated by recording fluorescence along a transect to mid-lake (no signal expected above background) and along a developed shoreline (varying signals expected). These calibration checks enable the instrument to be used throughout the entire lake without futher adjustment, and thus allows relative comparisons to be made between plume readings.

One particularly useful feature of the Septic Leachate Detector for sample collection is the nearly instantaneous flow-through and signal recording of water samples. This feature provides for precise location of a plume's center and recording of the sample's fluorescence or combined signal as it is being collected. After effluent plumes were located, water quality samples were collected from the meter's discharge. In the laboratory these samples were analyzed for:

- Nitrate, nitrite, and ammonia nitrogen
- Total phosphorus, pH, alkalinity, and Methylene Blue Active Substances
- Fecal coliform bacteria concentration.

For most samples, analysis of all parameters except fecal coliform bacteria was begun within 24 hours at the WAPORA, Inc. Cincinnati laboratory. One group of samples arrived 3 days late at the lab, exceeding the recommended holding time. Although the recommended time was exceeded, this delay is not expected to have altered the levels of total nitrogen and total phosphorus measured in the samples. Analyses of fecal coliform samples were begun within 6 hours of collection at ERA Laboratories, Inc., in Duluth, Minnesota.

Selection of suspected wastewater plumes for sampling was a field decision weighed in favor of the most concentrated plumes and intended to identify those shoreline areas most seriously affected by the influx of septic leachate.

Results of the Septic Leachate Survey

Two sources of positive instrument readings were detected during the leachate survey: streams and suspected wastewater plumes. The locations of these sources are shown in Figures 2-6, 2-7, 2-8, and 2-9. A positive instrument reading was recorded when, in the judgement of the operator, there was a significant and simultaneous increase in the flouescence and conductivity readings.

Streams

A single runoff water source was found to be discharging into Rush Lake. No runoff water sources were found discharging into Passenger Lake. The two tributaries of Island Lake produced positive combined signals on the leachate detector. Intermittent localized stormwater runoff sources to Island Lake and Sturgeon Lake also produced positive responses. These positive signals were always generated by rapid increases in fluorescence accompanied by relatively lessor increases in conductivity. The highest such readings recorded were generated by runoff waters entering Sturgeon Lake from a long narrow wetland, the mouth of which is located between groundwater flow stations 24 and 43. These high readings appeared to be caused by the flourescent products of vegetative decay which were being released from the wetland. Runoff or stream sources of dissolved organic matter, because of their considerable volume, are not as readily diluted by lake water as are septic leachate plumes and therefore may cause interference problems in locating nearby septic leachate plumes. High flourescence and conductivity readings resulting from stream sources caused interference difficulties with effluent plume data along the north shore of Island Lake and near the public launch on the north shore of Sturgeon Lake.

Wave action and currents also may cause localized variations in flourescence sometimes resulting in a natural pattern resembling closely spaced septic plumes. Misinterpretation from this interference source was avoided by observing the uniformity of conductivity measurements and spacing of lakeshore development, then disregarding detector readings obviously caused by wave action patterns.

Suspected Wastewater Sources

All non-stream related localized variations in fluorescence and/or conductivity recorded by the leachate detector were initially assumed to be due to wastewater percolating into the lake from nearby on-site wastewater systems. Typically, such signals were highly localized (brief in duration and low in magnitude) compared to stream plumes. Along shorelines exposed to moderate wave action, the magnitude of these signals was generally less because of rapid dispersion by currents. Under calm conditions, the magnitude and duration of the signals tended to be greater because the plumes were less rapidly dispersed.

The number of potential effluent plumes identified by this survey were not evenly distributed around the lakes. Plume emergence appeared to be strongly controlled by factors such as land use, topography, and lakeshore groundwater flow patterns (Figures 2-6 through 2-9).

A total of 39 potential septic plumes were detected, which represents less than 10% of the residences along surveyed shorelines. During identification of the 17 suspected septic leachate plumes around Sturgeon Lake, the strengths of the instrument signals were lessened by the water currents created by the high winds prevailing at the time of the survey. Therefore, some additional weak or more transient plumes may not have been located on Sturgeon Lake due to these high winds.

Not all plumes located at seasonal residences were fully emergent because the survey was conducted during the first week of October when seasonal occupancy was low. On the other hand, a considerable amount of precipitation had preceded the survey and would have generally increased the lakeward flow of groundwater. Thus, while this survey may not have located the septic leachate plumes from all seasonal homes it probably did detect all lakeward moving plumes generated by permanent residences. Permanent residences with on-site systems have the greatest potential pollutional significance due to the fact that they contribute waste flows year round, whereas seasonal residences only do so for parts of the summer season.

Results of the Chemical and Bacterial Analyses

During the onshore portion of the septic leachate survey, background groundwater quality samples were gathered for comparison with groundwater samples taken directly from the centers of onshore effluent plumes. These data are presented in Tables C-1, C-2, and C-3.

One small discharge of runoff water was found entering into the north side of Rush Lake, but was not sampled. Analytical water quality results of influent stream samples collected near the perimeters of Island and Sturgeon Lakes are shown in Table C-1. These data indicate that incoming streams were not contaminated by septic leachate. The relatively high fecal coliform counts made in samples of the runoff and streamwater are probably associated with extensive habitat utilization by resident waterfowl in backwater areas or with runoff from pastures or barnyards. The stream influence points and pastures or barnyards are shown in Figures 2-6 through 2-9.

Nitrate levels in runoff or streams were always found to be below detection limits. Total phosphorus also was low and ammonia concentrations were consistent with those to be expected from wetland areas where decaying vegetation is present.

Table C-1. Analytical results of water quality samples and leachate detector readings for surface water runoff entering Island and Sturgeon Lakes.

Chemical Sampling Station #	Approximate Location	Nitrate (mg-N/l)	Nitrite (mg-N/l)	Ammonia (mg-N/l)	Total Phosphorus (mg-P/l)	pH	Total Alkalinity (mg/l $CaCO_3$)	Fecal Coliforms (#/100ml)	Leachate Detector (Relative Scale) Combined	Floures- cense	Conduc- tivity
	Island Lake										
C62	Near Flow Station 16	0.05	0.05	0.24	0.01	6.5	38.2	560	30	35	100
C73	200 yds. South of Flow Station 22	0.05	0.05	0.15	0.02	6.6	34.2	70	100	100	100
C60	At Flow Station 1	0.05	0.05	0.26	0.01	6.2	50	10	100	100	100
C61	Near NE Corner of Lake	0.05	0.05	0.22	0.01	6.6	42	60	100	100	0
C72	Near Flow Station 21	0.05	0.05	0.16	0.40	6.5	51.4	50	100	80	100
	Sturgeon Lake										
C77	At Wetland, W. of Public Access	0.05	0.05	0.15	0.01	7.1	52.2	10	100	100	100
C85	At Stream Mouth, 300 yds. South of Flow Station 32	0.05	0.05	0.16	0.02	7.0	44.0	70	85	100	100
Background Values	Island Lake (center)								0	30	30
	Sturgeon Lake (center)								0	30	30

Island Lake data gathered 7 October 1981, Sturgeon Lake data gathered 8 October 1981.

Table C-2. Analytical results of water quality samples and leachate detector readings for the Island Lake survey of septic leachate plumes.

Chemical Sampling Station #	Approximate Location/Type	Nitrate (mg-N/l)	Nitrite (mg-N/l)	Ammonia (mg-N/l)	Total Phosphorus (mg-P/l)	pH	Total Alkalinity (mg/l $CaCO_3$)	MBAS (mg-LAS/l)	Fecal Coliforms (#/100ml)	Leachate Detector (Relative Scale) Floures-cense	Leachate Detector (Relative Scale) Conduc-tivity
	Near Flow Sta. 23:										
C74	Background	0.06	0.05	0.17	0.89	6.3	97.0	-	10	248	198
C75	Plume	0.05	0.05	0.22	0.87	6.6	130	0.010	40	313	2000
C76	Detector	0.05	0.05	0.17	0.01	6.4	32.4	-	10	207	206
(collected 7 October 1981)											
	Near Flow Sta. 20:										
C69	Background	0.05	0.05	0.23	1.01	6.4	74.4	-	10	532	463
C70	Plume	2.10	0.05	0.12	0.29	6.2	42.4	0.010	50	802	732
C71	Detector	0.05	0.05	0.25	0.01	6.6	30.2	-	10	-	-
(collected 7 October 1981)											
	Near Flow Sta. 16:										
C63	Background	0.05	0.05	0.26	0.04	6.5	47.4	-	10	230	341
C64	Plume	0.05	0.05	0.24	0.93	6.1	106	0.035	10	1000	868
C65	Detector	0.05	0.05	0.22	0.06	6.5	36.2	-	20	-	-
(collected 7 October 1981)											
	Near Flow Sta. 19:										
C66	Background	0.12	0.05	0.09	0.53	6.3	83.0	-	350	416	558
C67	Plume	0.61	0.05	0.12	0.49	5.9	41.4	0.016	2300	2000	862
C68	Lake Sample	0.05	0.05	0.10	0.03	5.9	22.8	-	10	213	270
(collected 9 October 1981)											

Background -- uncontaminated groundwater collected onshore in vicinity of suspected leachate effluent plume.

Plume -- contaminated groundwater collected onshore from leachate effluent plume.

Detector -- lakewater sample collected directly from detector discharge during period of positive reading.

Lake Sample -- lakewater grab sample collected during period of positive leachate detector reading.

Table C-3. Analytical results of water quality samples and leachate detector readings for the Sturgeon, Rush, and Passenger Lake surveys of septic leachate plumes.

Chemical Sampling Station #	Approximate Location/Type	Nitrate (mg-N/l)	Nitrite (mg-N/l)	Ammonia (mg-N/l)	Total Phosphorus (mg-P/l)	pH	Total Alkalinity (mg/l $CaCO_3$)	MBAS (mg-LAS/l)	Fecal Coliforms (#/100ml)	Leachate Detector (Relative Scale) Floures-cense	Leachate Detector (Relative Scale) Conduc-tivity
	Near Flow Sta. 29										
C78	Background	0.05	0.05	0.16	0.13	7.1	63.0	-	10	292	301
C79	Plume	0.05	0.05	0.11	0.31	6.7	51.6	0.010	10	815	273
C80	Detector	0.05	0.05	0.27	0.01	7.1	46.0	-	10	-	-
(collected 8 October 1981)											
	Near Flow Sta. 33										
C81	Background (high)	2.41	0.05	0.26	0.04	6.8	53.4	-	10	349	418
C82	Background (low)	0.05	0.05	0.19	0.01	6.9	45.6	-	10	152	241
C83	Plume	0.05	0.05	0.10	0.06	6.9	67.6	0.010	10	573	320
C84	Lake sample	0.48	0.05	0.16	0.01	7.0	44.2	-	10	26	279
(collected 8 October 1981)											
	Near Flow Sta. 45										
C86	Background	0.20	0.05	0.26	0.13	6.8	62.0	0.031	10	183	292
C87	Plume	0.05	0.05	0.12	0.26	6.0	76.0	0.030	10	478	336
C88	Detector	0.05	0.05	0.16	0.01	6.8	68.5	-	10	-	-
(collected 8 October 1981)											
	Near Flow Sta. 50										
C89	Background	0.05	0.05	0.19	1.54	6.3	43.6	-	10	135	211
C90	Plume	0.05	0.05	0.12	0.26	6.0	62.4	0.010	10	2000	281
C91	Detector	0.05	0.05	0.16	0.01	6.3	49.7	-	10	74	236
(collected 9 October 1981)											
	Near Flow Sta. 59										
C92	Background	0.37	0.05	0.10	0.14	5.5	28.0	0.010	10	28	262
C93	Plume	0.52	0.05	0.10	1.00	6.1	49.6	-	10	773	420
C94	Lake Sample	0.05	0.05	0.10	0.01	6.7	68.0	-	10	135	230
(collected 9 October 1981)											

<u>Background</u> -- uncontaminated groundwater collected onshore in vicinity of suspected leachate effluent plume.

<u>Plume</u> -- contaminated groundwater collected onshore from suspected leachate effluent plume.

<u>Detector</u> -- lakewater sample collected directly from detector discharge during period of positive reading.

<u>Lake Sample</u> -- lakewater grab sample collected during period of positive detector reading.

Analyses of samples collected at locations of nine septic plumes which were strongly detected are presented in Tables C-2 and C-3. These water quality or "chemical" sampling locations are depicted in Figures 2-6 through 2-9. Three subsamples were obtained from each sampled plume:

- Lake water collected either by grab sample or directly from the detector overflow while the probe was held within an emergent plume. (Indicated as either "lake sample" or "detector" respectively in Tables C-2 and C-3.
- Groundwater sampled on shore directly from the effluent plume center using a portable well point
- Groundwater background sample collected onshore at a distance from the apparent plume; data used for comparison with groundwater plume parameters.

When a strong plume of probably septic origin was encountered, a sample was collected directly from the flow-through outlet of the leachate detector. Groundwater samples were collected at 20-foot intervals in a transect made along the shoreline perpendicular to the plume flow direction and a portion of each sample was then injected into the detector to determine relative levels of fluorescence and conductivity. The device used to collect the samples was a small-diameter well point, slotted along its pointed end, with a hand-operated pump attached. After identifying the approximate groundwater plume location, two samples were collected: one from the approximate plume center and one from the interval characterized by the lowest instrument readings. The latter sample functioned as a measure of groundwater background levels.

All samples of groundwater and surface water showed measurable levels of ammonia nitrogen (mg-N/l) which in no case exceeded a value of 0.30 mg ammonia -N/l. No significant differences were noted in comparisons of ammonia concentrations from stream influx, lake water, or groundwater in plumes. Thus, either the on-site systems which were studied are effectively transforming ammonia to the oxidized nitrogen form, nitrate, or ambient ammonia nitrogen levels in surface waters were seasonally high due to the decomposition of plant material of the fall season. If higher ammonia levels had been detected in groundwater or in plumes emerging into the lake than in runoff or streams, this would have indicated rapid offshore transport of incompletely treated leachate. This was not the case. Largely due to the probable presence of naturally elevated ammonia levels during the fall survey, data are inconclusive with regard to the pollutional significance of ammonia from on-site systems.

Fecal coliforms were detected at all four of the suspected septic plume water quality sampling stations on Island Lake. Measurable coliform counts also were found in the onshore groundwater leachate plumes at sampling stations C67, C70, and C75. The fecal coliform count of 2,300 organisms per milliliter (C67) reported for the groundwater plume at flow station 19 could have indicated the presence of septic leachate. However, the data are insufficient to preclude the possibility of non-human fecal material being the source of the organisms that were found. Dogs or waterfowl can also introduce fecal coliform organisms into the soil surface and water table aquifer through their fecal material. A background groundwater sample collected at a distance from the plume center (C66) also contained measurable fecal coliforms, as did the sample (C65) which was collected from the detector overflow. Fecal coliforms in the latter sample were very low in concentration and therefore not clearly associated with the suspected plume.

Except for the stream sample (C85) described earlier, none of the Sturgeon Lake samples contained measurable fecal coliform counts. No fecal coliforms were found in the groundwater samples collected at Rush and Passenger Lakes. One of the samples collected from Rush Lake via the detector overflow had a measurable, but very small coliform count; thus, the sample was not clearly associated with the suspected plume.

Nitrite concentrations in all samples were below the limit of detection (0.05 mg -N/1). Nitrites in measurable quantities could have been present in the samples collected on 9 October 1981, but the acceptable holding time for this group of samples was exceeded by 3 days. Three days is sufficient time for nitrites to transform to nitrates via oxidation.

Nitrate levels in the samples were consistently low and of an order of magnitude which naturally occurs in groundwater not contaminated by human activities. The highest detected concentration, 2.4 mg -N/1, was found in a groundwater background sample collected near a suspected septic plume in Sturgeon Lake. It was evident that during the time of the survey, elevated concentrations of nitrate were not being introduced to any of the lakes.

In general, phosphorus concentrations measured in samples taken in suspected on-shore effluent plumes were high (Tables C-2 and C-3). Several values measured over 1.0 mg total dissolved P per liter with the highest value measured at 1.5 mg total dissolved -P per liter in the groundwater plume. The observed low levels of this nutrient in samples collected from these plumes at their points of emergence into the lake (called "detector" sample in Tables C-2 and C-3) indicates that a large percentage of the phosphorus of human origin was being removed by the soil, precluding entry to the lake. The total -P data indicate little significant influx of phosphorus from the suspected plumes during the time of the survey.

The pH range of all samples measured in the laboratory was 5.5 to 7.1, with only three values lower than 6.0. The highest and lowest total alkalinity values, 130 and 23 mg/l $CaCO_3$, respectively, were found in Island Lake.

Methylene Blue Active Substances (MBAS) are those organic substances which form a quantitative reaction product with methylene blue which can be measured by a standard analytical method. The MBAS of most significance to water quality is linear alkylate sulfonate (LAS), which is an anionic surfactant used to make detergents and other cleaning products. High MBAS concentrations are indicative of detergent contamination. Ten samples, mostly from suspected wastewater plumes, were analyzed for MBAS. Only four of the samples showed detectable levels, and these levels do not indicate significant detergent contamination.

Appendix C-2.

WELL-WATER QUALITY DATA FOR PINE AND CARLTON COUNTIES, MINNESOTA

Well-water quality data for Pine and Carlton Counties. Information was obtained in 1979, 1980 and 1981 (Minnesota Department of Public Health, unpublished).

1979

Well Number	County	Well Depth(ft)	Static Water Level(ft)	Nitrates (mg/1)	Caliform Bacteria(MPN)	Specific Conductivity (Umhos/cm)	Fluoride mg/1
1	P[a]	94	42	<0.4	<2.2	-	-
2	C[b]	52	26	<0.4	16.0	-	-
3	C	90	42	<0.4	9.2	-	-
4	C	117	6	<0.4	<2.2	-	-
5	C	210	15	<0.4	<2.2	-	-
6	P*	145	32	<0.4	<2.2	-	-
7	P	112	28	5.3	<2.2	-	-
8	P	105	24	<0.4	<2.2	-	-
9	C	62	14	<0.4	<2.2	-	-
10	P	155	21	<0.4	<1.0	-	-
11	C	300	92	<0.4	<2.2	-	-
12	C	175	10	<0.4	>2.0	-	-
					<2.2 resampled	-	-
13	P	80	45	<0.4	<2.2	-	-
14	P	95	33	3.0	<2.2	-	-
15	P	66	8	<0.4	<2.2	-	-
16	P	60	8	<0.4	<2.2	-	-
17	C	64	14	<0.4	<2.2	-	-

Well-water quality data for Pine and Carlton Counties (continued).

1980

Well Number	County	Well Depth(ft)	Static Water Level(ft)	Nitrates	Caliform Bacteria(MPN)	Specific Conductivity (vmhos/cm)	Fluoride mg/l
18	P	155	36	<0.4	<2.2	190	0.10
19	P	50	14	<0.4	<2.2	350	0.15
20	P	95	32	<0.4	<2.2	480	0.14
21	P	90	16	<0.4	<2.2	330	0.12
22	P	91	13	<0.4	<2.2	320	0.10
23	P	80	15	<0.4	<2.2	170	0.12
24	C	185	25	<0.4	<2.2	300	0.24
25	C	170	52	<0.4	<2.2	300	0.20
26	P	95	50	<0.4	<2.2	370	0.14
27	P*	230	33	<0.4	<2.2	230	0.22
28	P	43	10	<0.4	<2.2	270	0.14
29	P	50	11	<0.4	<2.2	320	0.18
30	P	163	56	0.72	<2.2	370	0.20
31	P	275	18	<0.4	<2.2	340	0.13
32	P	50	4	<0.4	2.2	190	0.10
				---	<2.2 resampled	240	0.10
33	P*	300	66	<0.4	<2.2	300	0.62
34	P	125	100	<0.4	<2.2	370	0.26
35	P	110	45	<0.4	<2.2	190	0.13
36	P	155	24	<0.4	<2.2	---	0.50
37	P	144	5	<0.4	<2.2	310	0.13
38	P	126	27	<0.4	<2.2	300	0.24
39	P	102	17	<0.4	2.2	240	0.14
				---	<2.2 resampled	---	----
40	P	96	41	<0.4	<2.2	390	0.18
41	P	90	16	<0.4	<2.2	279	0.12
42	P	45	---	1.4	>2.0	254	0.12

Well-water quality data for Pine and Carlton Counties (concluded).

1981

Well Number	County	Well Depth(ft)	Static Water Level(ft)	Nitrates	Caliform Bacteria(MPN)	Specific Conductivity (vmhos/cm)	Fluoride mg/l
43	P*	138	24	<0.4	<2.2	280	0.18
44	P*	64	26	<0.4	<2.2	280	0.26
45	P	176	50	<0.4	5.1	146	0.12
					<2.2 resampled	---	----
46	P*	105	21	<0.4	<2.2	300	0.18
47	P	66	23	<0.4	>2.0	250	0.1
48	P	50	13	<0.4	>2.0	110	0.1
49	P	113	41	0.92	<2.2	---	----
50	P	105	12	0.4	<2.2	---	----
51	P	181	49	0.4	<2.2	---	----
52	C*	538	77	0.4	<2.2	---	----
53	P	115	21	0.88	<2.2	---	----
54	C*	78	32	<0.4	<2.2	---	----
55	P*	125	28	<0.4	>2.0	---	----
56	P*	160	40	<0.4	<2.2	---	----
57	P*	165	42	<0.4	<2.2	---	----
58	P	171	35	<0.4	<2.2	---	----
59	C	217	70	<0.4	<2.2	---	----
60	C	43	30	1.1	<2.2	---	----

P[a] = Pine County

P[b] = Carlton County

* = indicates well was located in Windemere Township

Appendix D

Design Criteria and Component Options for Centralized Wastewater Management Systems

Wastewater Load Factors

Wastewater flow projections for each project alternative for the Island Lake and Sturgeon Lake areas were developed based on a projected year 2000 design population (Section 3.2.1.3), an average daily base flow (ADBF) of 45 gallons per capita per day (gpcd) for individual systems served by holding tanks and 60 gpcd for all other services, and a design infiltration of 10 gpcd for gravity sewers (based on maximum permissible infiltration rate of 200 (gallons per inch-diameter per mile per day).

The organic loads were projected on the basis of the accepted design values of 0.17 pounds of BOD_5 per capita per day and 0.20 pounds of suspended solids (SS) per capita per day (ten state standards). These values were applied to the projected year 2000 population.

Effluent Requirements

The Minnesota Pollution Control Agency (MPCA) issued effluent limits for the City of Moose Lake wastewater treatment facility, as presented in Section 2.1.

Economic Factors

The economic cost criteria consist of an amortization or planning period from the present to the year 2000, or approximately 20 years; an interest rate of 7.625%, and service lives of 20 years for treatment and pumping equipment, 40 years for structures, and 50 years for conveyance facilities. Salvage values were estimated using straight-line depreciation for items that could be used at the end of the 20-year planning period. An annual appreciation rate of 3% over the planning period was used to calculate the salvage value of the land. Operation and maintenance (O&M) costs include labor, materials, and utilities (power). Costs associated with the treatment works, pumping stations, solids handling and disposal processes, conveyance facilities, and on-site systems are based on prevailing rates.

Costs are based on the USEPA STP Construction Cost Index of 410.9, the USEPA Complete Urban Sewer System (CUSS) Construction Cost Index of 193, and the Engineering News Record (ENR) Construction Cost Index of 3,370 for the first quarter of 1982 (March 1982 for Minneapolis MN). The total capital cost includes the initial construction cost plus a service factor. The service factor includes costs for engineering, contingencies, legal and administrative, and financing. The service factors used for different alternative components are summarized in Table D-1. The economic cost criteria are summarized in Table D-2.

System Components

— Flow and Waste Reduction —

Economy in the construction and operation of sewage collection, treatment, and disposal facilities, is, in many localities, achieveable by controlling waste flows or the amounts of impurities carried in the sewage. This economy is generally recognized in the short-term monetary savings that result from the reduced design capacities of facilities or from the long-term savings realized when facility expansion or replacement is unnecessary. Other savings can be achieved throughout the life of the facilities from reduced operational costs.

Methods of flow and waste reduction considered for use in the study area include water conservation measures and waste segregation.

Table D-1. Service factor[a].

Item	Conventional Collection and Treatment System (%)	Pressure Sewer, Cluster, and On-site Systems (%)
Contingencies	10	15
Engineering	10	13
Legal & Administrative	3	3
Financing	4	4
Total	27	35

[a] A service factor is applied to the construction cost to compute the capital cost. Interest during construction is not included.

Table D-2. Economic cost criteria.

Item	Units	Value
Amortization period	years	20
Interest (discount) rate	%	7-5/8
STP construction cost index - 1st Quarter 1982	-	410.9
Sewer (CUSS) construction cost index - 1st Quarter 1982	-	193
ENR construction cost index - 1st Quarter 1982		3730
Service life		
Equipment	years	20
Structures	years	40
Conveyance facilities	years	50
Land	years	permanent
Salvage value		
Equipment	%	0
Structures	%	50
Conveyance facilities	%	60
Land	%	103

—Water Conservation Measures—

Clean water has for many years often been regarded as one of the nation's bountiful free goods. Concerns over water supply and wastewater disposal and an increasing recognition of the benefits that may accrue through water conservation are serving to greatly stimulate the development and application of water conservation practices. The diverse array of water conservation practices may, in general, be divided into these major categories:

- Elimination of non-functional water use
- Water-saving devices, fixtures, and appliances
- Wastewater recycle/reuse system.

Non-functional water use is typically the result of the following:

- Wasteful, water-use habits such as using a toilet flush to dispose of a cigarette butt, allowing the water to run while brushing teeth or shaving, or operating a clotheswasher or dishwasher with only a partial load

- Excessive water supply pressure - for most dwellings a water supply pressure of 40 pounds per square inch (psi) is adequate and a pressure in excess of this can result in unnecessary water use and wastewater generation, especially with wasteful water-use habits

- Inadequate plumbing and appliance maintenance - unseen or apparently insignificant leaks from household fixtures and appliances can waste large volumes of water. Most notable in this regard are leaking toilets and dripping faucets. For example, even a pinhole leak which may appear as a dripping faucet can waste up to 170 gallons per day at a pressure of 40 psi. More severe leaks can generate larger wastewater quantities.

The quantity of water traditionally used by household fixtures or appliances often is considerably greater than actually needed. Typically, toilet flushing, bathing, and clotheswashing collectively account for over 70% of the household's interior water use and waste flow volume (Siegrist, Woltanski, and Waldorf 1978). Thus, efforts to accomplish major reductions in the wastewater flow volume, as well as its pollutant mass, have been directed toward the toilet flushing, bathing, and clotheswashing areas. Some selected water conservation/waste load reduction devices and systems developed for these household activities include:

- Toilet devices and systems
    - Toilet tank inserts - such as water filled and weighted plastic bottles, flexible panels, and/or dams
    - Dual-flush toilet devices
    - Shallow-trap toilets
    - Very low volume flush toilets
    - Non-water carriage toilets

- Bathing devices and systems
    - Shower flow control devices
    - Reduced-flow shower fixtures

- Clotheswashing devices and systems of a clotheswasher with a suds-saver attachment

  The suds-saver feature is included as an optional cycle setting on several commercially made washers. The selection of suds-saver cycle when washing provides for storage of the washwater from the wash cycle for subsequent use as the wash water for the next wash load. The rinse cycle remains unchanged.

<u>Wastewater Recycle/Reuse Systems</u>

These systems provide for the collection and processing of all household wastewater or the fractions produced by certain activities for subsequent reuse. A system which has received a majority of development efforts includes the recycling of bathing and laundry wastewater for flushing water-carriage toilets and/or outside irrigation.

<u>Other Water Conservation Measures</u>

One possible method for reduction of sewage flow is the adjustment of the price of water to control consumption. This method normally is used to reduce water demand in areas with water shortages. It probably would not be effective in reducing sanitary sewer flows because much of its impact is usually on luxury water usage, such as lawn sprinkling or car washing. None of the luxury uses impose a load on a separated sewerage system and on on-site systems. Therefore, the use of price control probably would not be effective in significantly reducing wastewater flows. More importantly most of homes in the service area have their own wells and therefore are not charged for water use.

Other measures include educational campaigns on water conservation in everyday living and the installation of pressure-reduction valves in areas where the water pressure is excessive (greater than 60 pounds per square inch). Educational campaigns usually take the form of spot television and radio commercials, and the distribution of leaflets with water and sewer bills. Water saving devices must continue to be used and maintained for flow reduction to be effective.

Wastewater flows on the order of 15 to 30 gpcd can be achieved by installation of combinations of the following devices and systems:

- Replace standard toilets with dual cycle or other low volume toilets
- Reduce shower water use by installing thermostatic mixing valves and flow control shower heads. Use of showers should be encouraged rather than baths whenever possible
- Replace older clotheswashing machines with those equipped with water-level controls or with front-loading machines
- Eliminate water-carried toilet wastes by use of in-house composting toilets
- Use recycled bath and laundry wastewaters to sprinkle lawns in summer
- Recycle bath and laundry wastewaters for toilet flushing. Filtration and disinfection of bath and laundry wastes for this purpose has been shown to be feasible and aesthetically acceptable in pilot studies (Cohen and Wallman 1974; McLaughlin 1968). This is an alternative to in-house composting toilets that could achieve the same level of wastewater flow reduction
- Commercially available pressurized toilets and air-assisted shower heads using a common air compressor of small horsepower would reduce sewage volume from these two largest household sources up to 90%.

Methods that reduce the flow or pollutant loads can provide the following benefits to a wastewater management program:

- Reduce the sizes and capital costs of new sewage collection and treatment facilities
- Delay the time when future expansion or replacement facilities will be needed
- Reduce the operational costs of pumping and treatment

- Mitigate the sludge and effluent disposal impacts
- Extend the life of the existing soil absorption system for an existing system functioning satisfactorily
- Reduce the wastewater load sufficiently to remedy a failing soil absorption system in which the effluent is surfacing or causing backups
- Reduce the size of the soil disposal field in the case of new on-site systems. However, the pretreatment process of the on-site systems should be maintained at full-size to provide the necessary capacity to treat and attenuate peak flows.

—Waste Segregation—

Various methods for the treatment and the disposal of domestic wastes involve separation of toilet wastes from other liquid waste. Several toilet systems can be used to provide for segregation and separate handling of human excreta (often referred to as blackwater), and, in some cases, garbage wastes. Removal of human excreta from the wastewater serves to eliminate significant quantities of pollutants, particularly suspended solids, nitrogen, and pathogenic organisms (USEPA 1980a).

Wastewaters generated by fixtures other than toilets are often referred to collectively as graywater. Characterization studies have demonstrated that typical graywater contains appreciable quantities of organic matter, suspended solids, phosphorus, and grease. The organic materials in graywater appear to degrade at a rate not significantly different from those in combined residential water. Microbiological studies have demonstrated that significant concentrations of indicator organisms, such as total and fecal coliforms, are typically found in graywater (USEPA 1980).

Although residential graywater does contain pollutants and must be properly managed, graywater may be simpler to manage than total residential wastewater due to a reduced flow volume. A number of potential strategies for management of segregated human excreta (blackwater) and graywater are presented in Figure D-1 and Figure D-2 , respectively.

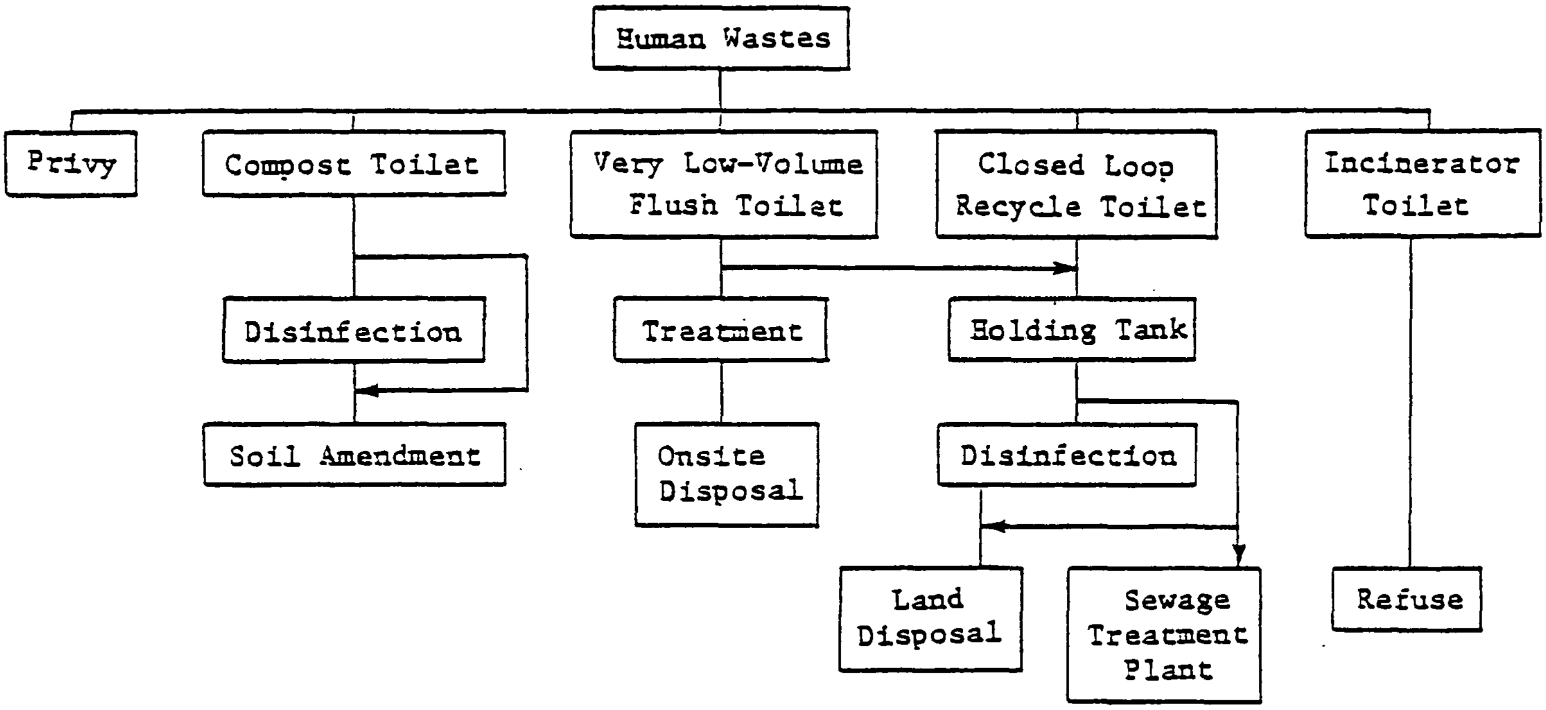


Figure D-1. Example strategies for the management of segregated human wastes.

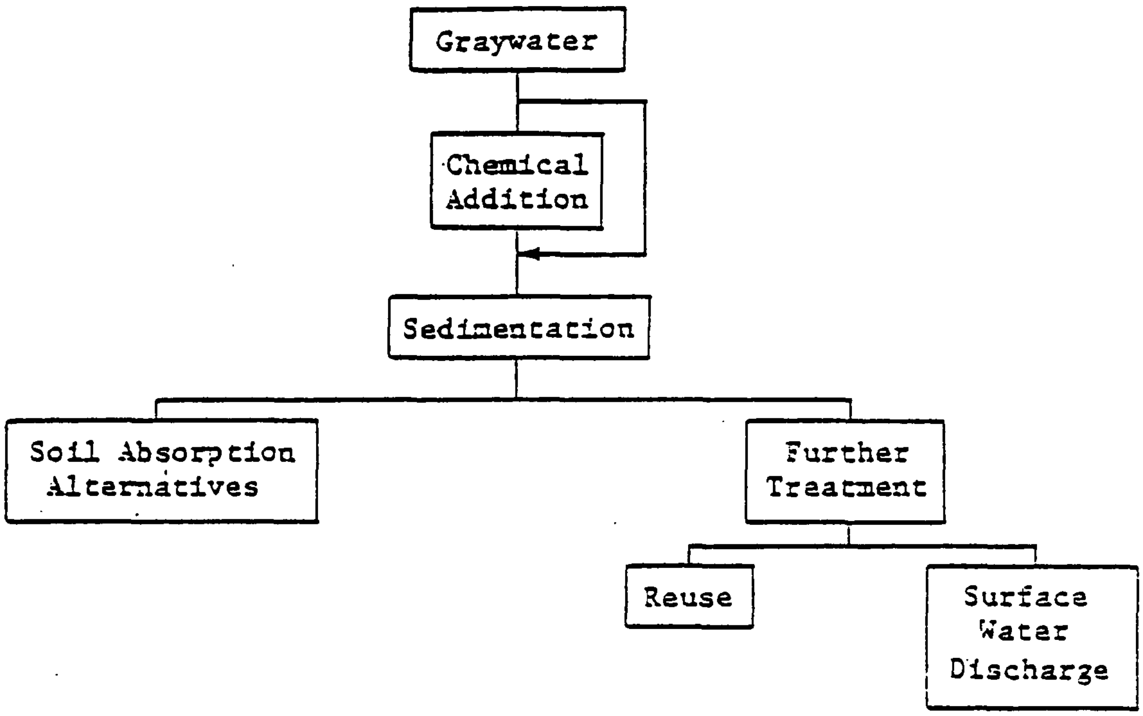


Figure D-2. Example strategies for the management of residential greywater.

—Summary—

To reduce the waste loads (flow volume and/or pollutant contributions) generated by a typical household, an extensive array of techniques, devices, and systems are available. Because the per capita amount of water utilized (approximately 65 gpcd) in the study area for the centralized treatment alternatives is relatively small, water conservation measures would be marginally effective in reducing wastewater flows and, thus, are not necessary. Also, because the efficacy of water conservation is complex and must be determined on a case-by-case basis, a comprehensive water conservation alternative is not proposed in this document. However, on-site system alternatives may include separate treatment strategies for the graywater and blackwater. The proposed treatment for blackwater and graywater is described in Section 2.4.

Collection System

Two types of collection and conveyance sewer systems are proposed: a gravity sewer system and a pressure sewer system. Both types of collection systems are briefly described in the following sections.

— Gravity Sewer System —

The gravity sewer system generally consists of gravity sewers, pumping stations, and force mains. A gravity sanitary sewer carries wastewater by gravity (downslope) only. Apart from pumping facilities sometimes required at sewage treatment plants, the principal conditions and factors necessitating the use of pumping stations in the sewage collection system are as follows:

- The elevation of the area to be serviced is too low to be drained by gravity to existing or proposed trunk sewers
- Service is required for areas outside natural drainage areas, but within the sewage or drainage district
- Omission of pumping, although possible, would require excessive construction costs because of the deep cuts required for the installation of a trunk sewer to drain the area.

The pumping station pumps wastewater under pressure through a pipeline known as a force main. For the sake of economy, the force main profiles generally conform to existing ground elevations.

Gravity sewers that carry raw sewage are called, in this report, conventional gravity sewers. In these sewers, sewage should flow with sufficient velocity to prevent the settlement of solid matter. The usual practice is to design the sewers so that the slope is sufficient to ensure a minimum velocity of 2 feet per second (fps) with flow at one-half full or full depth. Pumping stations within the conventional gravity sewer system must be designed to handle the solids in raw sewage, either by grinding them or by screening larger material and passing smaller material through the pump. Force mains are generally designed with adequate velocity to prevent deposition of solids at minimum flow. Solids will not settle out at a velocity of 2.0 fps, but solids that settle out when no flow occurs (pumps are operating discontinuously) require a velocity of 3.5 fps to resuspend them.

Gravity sewers that carry septic tank effluent are called septic tank effluent gravity sewers in this report (Figure D-3). Other terms commonly applied to them are Australian sewers and small-diameter sewers. Because only clear effluent from septic tanks is carried, a minimum velocity of 1.5 fps can be designed. Also, a minimum pipe size of 4-inch diameter is sufficient. Cleanouts, rather than manholes, are recommended so that less dirt enters the pipes (Otis 1979). Pipes do not need to be laid at a constant slope nor in a straight line (Simmons and Newman 1979). Pumping equipment does not need solids handling equipment and force mains have no minimum velocity requirements. Because septic tank effluent is odorous, special measures must be taken to ensure that odors are properly handled and treated.

— Pressure Sewer System —

Essentially, a pressure sewer system is the reverse of a water distribution system. The latter employs a single inlet pressurization point and a number of user outlets, while the pressure sewer embodies a number of

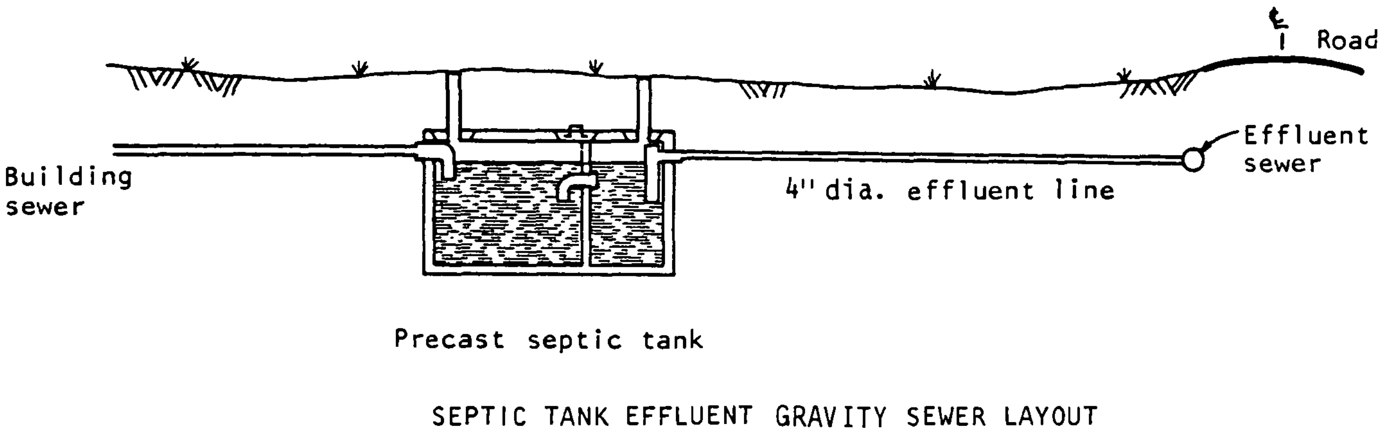


Figure D-3. Septic tank effluent gravity sewer layout.

pressurizing inlet points and a single outlet, as shown in Figure D-4. The pressure main follows a generally direct route to a treatment facility or to a gravity sewer, depending on the application. The primary purpose of this type of design is to minimize sewage retention time in the sewer.

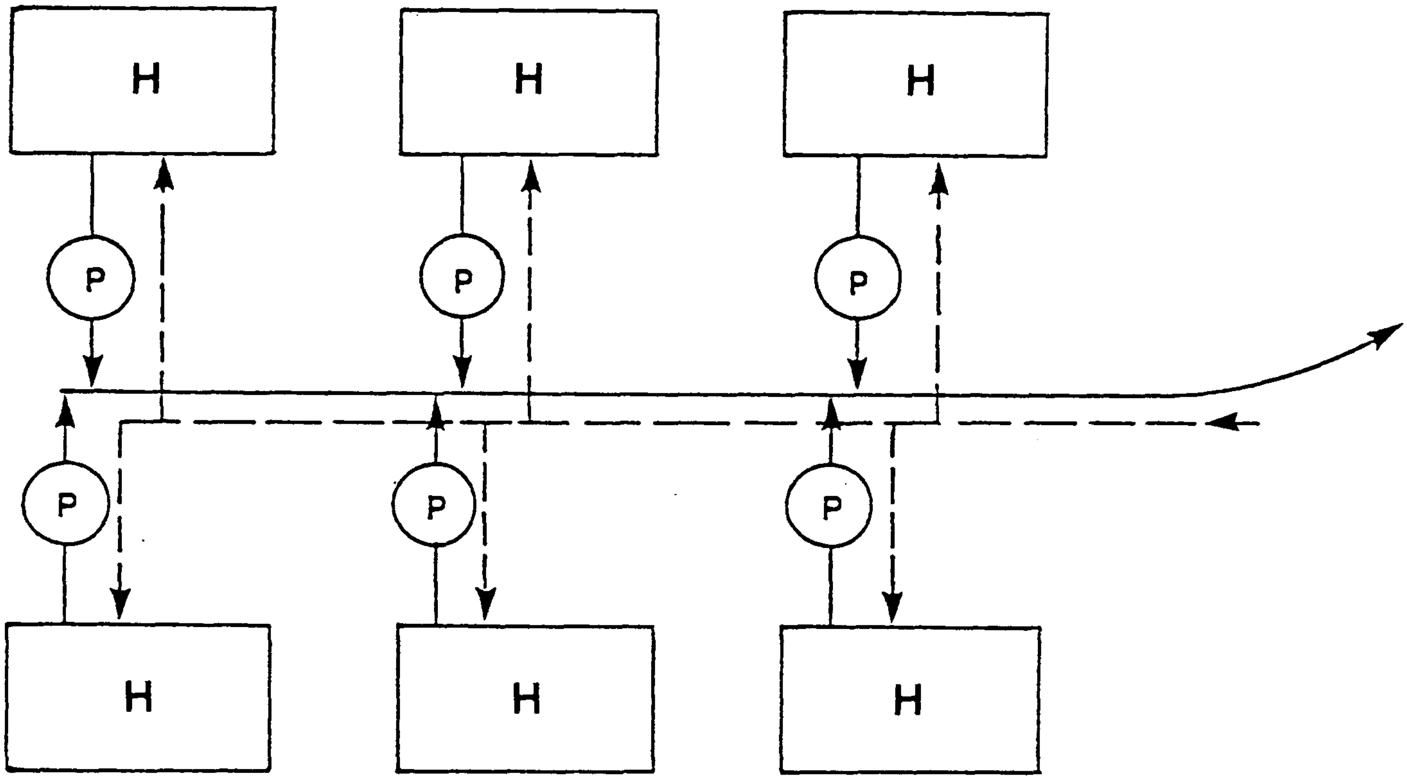
There are two major types of pressure sewer systems: the grinder pump (GP) system and the septic tank effluent pump (STEP) system. As shown in Figure D-5 , the major differences between the alternative systems are in the on-site equipment and layout. There are also some subtle differences in the pressure main design methods and in the treatment systems required to reduce the pollutants in the collected wastewater to an environmentally acceptable level. Neither pressure sewer system alternative requires the modification of household plumbing, although neither precludes it if such modifications are deemed desirable.

The advantages of pressure sewers are primarily related to installation costs and inherent system characteristics. Because these systems use small-diameter plastic pipes buried just below the frost penetration depth, their installation costs can be quite low compared to conventional gravity systems in low-density areas. Other site conditions that enhance this cost differential include hilly terrain, rock outcropping, and high water tables. Because pressure sewers are sealed conduits, there should be no opportunity for infiltration. The sewers can be designed to handle only the domestic sewage generated in the houses serviced, which excludes the infiltration that occurs in most gravity systems. The high operation and maintenance costs for the use of mechanical equipment at each point of entry to the system is the major disadvantage of a pressure sewer system.

Most of the dwellings in the proposed service area have existing septic tanks. Therefore, the septic tank effluent pump (STEP) system was considered for the centralized collection system alternatives.

Wastewater Treatment Processes

A variety of treatment options were considered in the Facilities Plan in development of alternative wastewater management plans including:



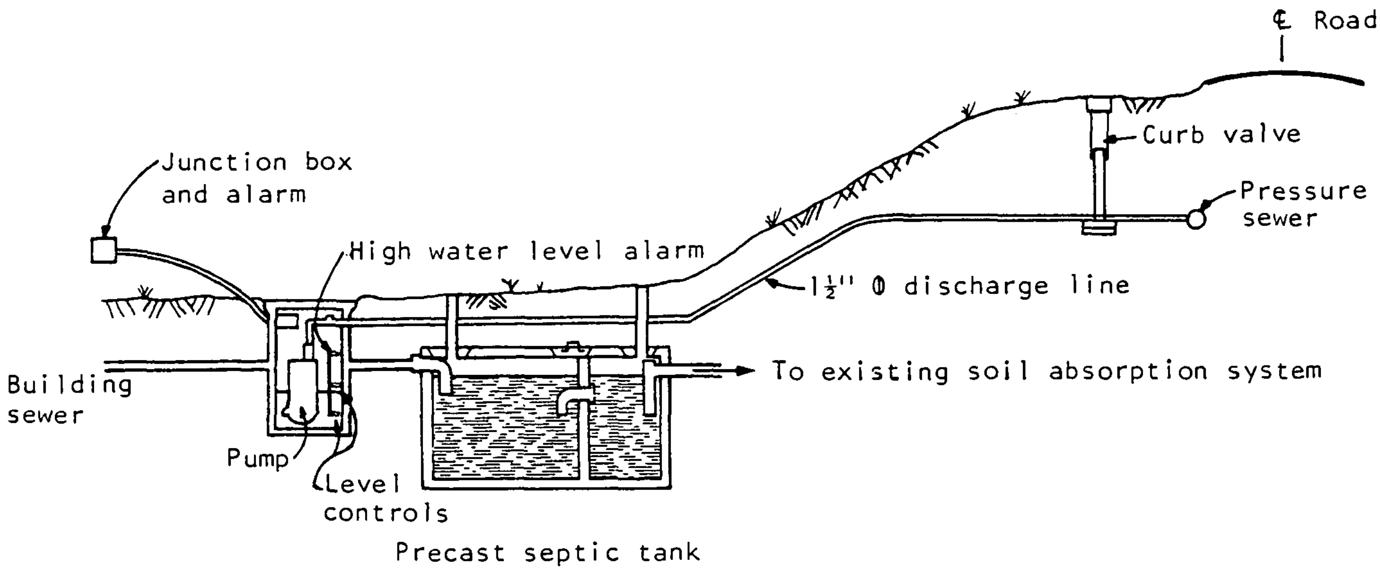
——— Pressure sewer

– —– – Water main (under pressure)

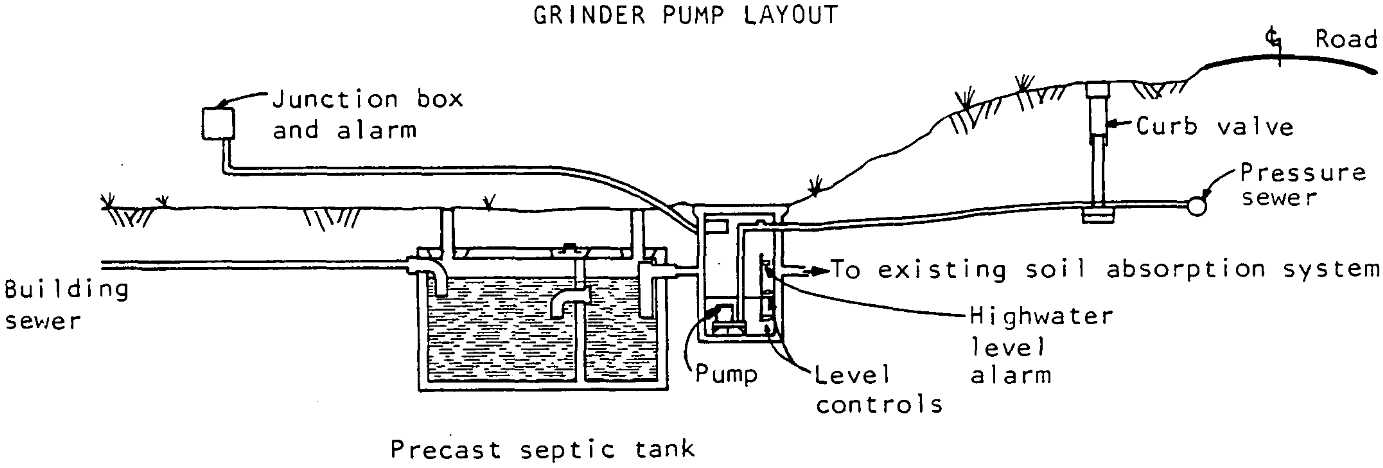
(P) Pressure sewer pump

H Housing unit

Figure D-4. Pressure sewer layout versus potable water supply layout.



GRINDER PUMP LAYOUT



SEPTIC TANK EFFLUENT PUMP LAYOUT

Figure D-5. Types of pressure sewer systems.

- use of existing lagoons
- activated sludge
- oxidation ditch.

The facilities planner recommended modification and expansion of the City of Moose Lake's existing lagoon system.

Effluent Disposal Methods

Three effluent disposal options are available: stream discharge, land application, and reuse.

The Moose Horn River is the receiving stream for discharge of treated wastewater effluent. The discharge is regulated by the NPDES permit issued by MPCA.

Land application or land treatment of wastewater utilizes natural physical, chemical, and biological processes in vegetation, soils, and underlying formations to renovate and dispose of domestic wastewater. Land application methods have been practiced in the United States for more than 100 years and presently are being used by hundreds of communities throughout the nation (Pound and Crites 1973).

In addition to wastewater treatment, the benefits of land application may include nutrient recycling, timely water applications, groundwater recharge, and soil improvement. These benefits accrue to a greater extent in arid and semi-arid areas, but are also applicable to humid areas. Secondary benefits include preservation of open space and summer augmentation of streamflow.

The components of a land application system include a centralized collection and conveyance system, some level of primary treatment, possible secondary treatment, possible storage and disinfection, and the land application site and equipment. In addition, collection of the treated water may be included in the system design along with discharge or reuse of the collected water. These optional components may be necessary to meet state requirements or to make the system operate properly.

Land application of municipal wastewater for treatment encompasses a wide variety of possible processes or methods of application. The three principal processes utilized in land treatment of wastewater are:

- Overland flow
- Slow-rate or crop irrigation
- Rapid infiltration.

Because there is an existing wastewater lagoon system (City of Moose Lake system) the construction of a new land treatment system would forego any economic advantages of utilizing existing facilities (which would require some improvements). Consequently, land treatment processes of overland flow, slow rate-irrigation, and rapid infiltration were screened from consideration as a centralized wastewater treatment process.

Wastewater management techniques included under the category of treated effluent reuse may be identified as:

- Public water supply
- Groundwater recharge
- Industrial process uses or cooling tower makeup
- Energy production
- Recreation and turf irrigation
- Fish and wildlife enhancement.

Reuse of treatment plant effluent as a public water supply or for groundwater recharge could present potential public health concerns. There are no major industries in the area that require cooling water. The availability of good quality surface water and groundwater and the abundant rainfall limit the demand for the use of treated wastewater for recreational and turf irrigation. Organic contamination and heavy metal concentrations also are potential problems. Direct reuse would require very costly advanced wastewater treatment (AWT), and a sufficient economic incentive is not available to justify the expense. Thus, the reuse of treated effluent currently is not a feasible management technique for the study area.

Sludge Treatment and Disposal

Some of the wastewater treatment processes considered will generate sludge. The amount of sludge generated will vary considerably, depending on the process. A typical sludge management program would involve interrelated processes for reducing the volume of the sludge (which is mostly water) and final disposal.

Volume reduction depends on the reduction of both the water and the organic content of the sludge. Organic material can be reduced through the use of digestion, incineration, or wet-oxidation processes. Moisture reduction is attainable through concentration, conditioning, dewatering, and/or drying processes. The mode of final disposal selected determines the processes that are required. In the case of waste stabilization ponds, the sludge would collect in the bottom of the pond and would undergo anaerobic digestion. Inert solids that are not biologically decomposed would remain in the pond and may require cleanout and removal once every 10 to 20 years.

Appendix E

Cost Effectiveness Analysis

Cost Methodology

1. Costs for the conventional gravity sewer collection alternatives were developed from the bids received in August 1981 for the proposed sewers to serve Island Lake, and from published cost data.

2. Costs for the septic tank effluent pressure and gravity sewer collection alternatives were developed from the August 1981 Island Lake bids, costs from other project bids localized and updated, and published cost data.

3. Costs for the on-site system, cluster, and bog treatment alternatives were developed from bid costs from other projects localized and updated locally quoted prices, and published cost data.

4. Costs for upgrading the City of Moose Lake treatment plant were developed from published cost data.

5. Costs for materials, construction, and O&M were updated to June 1981 price levels. Construction costs for treatment units and sewers were based on USEPA indexes for Minneapolis of 410.9 (STP) and 193 (CUSS), respectively. The Engineering News Record Construction Cost Index of 3,730 for March 25, 1982 also was used.

4. Salvage values were determined using straight-line depreciation for a planning period of 20 years. The land value was considered to appreciate by 3 percent per year. The service life of structures, including buildings, concrete process units, etc., was assumed to be 50 years. The service life of process and auxiliary equipment such as clarifier mechanisms, standby generators, pumps, electric motors, etc. was assumed to be 20 years.

7. Capital costs were based on construction costs plus a service factor for engineering, administration, legal and contingencies (See Table 2-16 and Section 2.3.1.3.)

8. Present worth of slavage value, O&M costs, and average annual equivalent costs were determined for 20 years using a discount rate of 7.625%.

9. Present worth of salvage values was determined using a single payment present worth factor of 0.2300 (Salvage value x 0.2300 = present worth of salvage).

10. Present worth of O&M costs were determined using a uniform or equal payment series factor of 10.0983 (average annual O&M cost x 10.0983 = present worth of O&M).

11. Average annual equivalent costs were determined using a capital recovery factor of 0.0990 (total present worth x 0.0990 = average annual equivalent cost).

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Summary Tables

Detail Tables

Component

	Alternative												
	2	3	4A	4B	4C	5A	5B	6A	6B	6C	7A	7B	7C
Collection system													
Island Lake	-	-	E-2	E-3	E-4	E-5	E-6	E-7	E-8	E-9	E-11	E-13	E-15
Sturgeon Lake	-	-	-	-	-	-	-	-	-	-	E-10	E-12	E-14
Cluster system													
Island Lake	-	E-18	-	-	-	-	-	-	-	-	-	-	-
Sturgeon Lake	-	E-17	E-17	E-17	E-17	E-17	E-17	E-17	E-17	E-17	-	-	-
WWTP	-	-	E-19	E-19	E-19	E-20	E-20	E-21	E-21	E-21	E-22	E-22	E-22
On-site upgrade													
Island Lake	E-25	E-28	E-30	E-30	E-30	E-30	E-30	-	-	-	-	-	-
Sturgeon Lake	E-26	E-29	E-31	E-31	E-31	E-31	E-31	E-32	E-32	E-32	-	-	-
Other[a]	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27	E-27
Administrative	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23	E-23

[a]Includes the remainder of the EIS service area (Rush Lake, Passenger Lake, Wild Acres and Hogans Acres)

Table E-1. Summary of collection system costs.

Item	Initial Cost						Future Construction Cost							Total Present Worth
				Present Worth			Annual	Total	Incremental	Present Worth				
	Capital	Salvage	O&M	Salvage	O&M	Total	Construction	Salvage	Ann. O&M	Construction	Salvage	O&M	Total	
Alternative 4 (Island Lake)														
4A Conventional Gravity	892,570	383,500	7,567	88,210	76,410	880,770	1,757	20,230	3	17,740	4,650	220	13,310	894,080
4B STE Gravity	778,700	314,790	7,930	72,400	80,080	786,380	3,747	44,120	17	37,840	10,150	1,230	28,920	815,300
4C STE Pressure	754,180	261,570	6,764	60,160	68,300	762,320	6,220	51,200	101	62,810	11,780	7,280	58,310	820,630
Alternative 5 (Island Lake)														
5A STE Gravity	833,980	334,430	7,976	76,920	80,540	837,600	3,770	44,120	77	38,070	10,150	5,550	33,470	871,070
5B STE Pressure	748,760	259,170	6,781	59,610	68,480	757,630	6,220	51,200	101	62,810	11,780	7,280	58,310	815,940
Alternative 6 (Island Lake)														
6A Conventional Gravity	1,702,890	737,410	14,202	169,600	143,420	1,676,710	3,931	47,260	6	39,700	10,870	430	29,240	1,705,950
6B STE Gravity	1,523,310	614,840	14,692	141,410	148,360	1,530,260	7,627	89,840	38	77,020	20,660	2,740	59,100	1,589,360
6C STE Pressure	1,340,670	469,560	11,630	108,000	117,440	1,350,110	13,215	105,840	227	133,450	24,340	16,370	125,480	1,475,590
Alternative 7														
7A Conventional Gravity - IL	1,670,350	733,020	14,253	168,590	143,930	1,645,590	3,931	47,160	6	39,700	10,850	430	29,280	1,674,970
- SL	2,182,010	942,570	16,629	216,790	167,920	2,133,140	5,239	62,860	6	52,900	14,460	430	38,870	2,172,010
- Total	3,852,360	1,675,590	30,882	385,380	311,850	3,778,830	9,170	110,020	12	92,600	25,310	860	68,150	3,846,980
7B STE Gravity - IL	1,485,420	608,990	14,989	140,070	151,360	1,496,710	7,624	89,840	38	76,990	20,660	2,740	59,070	1,555,780
- SL	1,996,020	805,270	17,388	185,210	175,590	1,986,400	9,532	112,700	49	96,260	25,920	3,530	73,870	2,060,270
- Total	3,481,440	1,414,260	32,377	325,280	326,950	3,483,110	17,156	202,540	87	173,250	46,580	6,270	132,940	3,616,050
7C STE Pressure - IL	1,463,950	517,650	14,037	119,060	141,750	1,486,640	13,215	105,840	227	133,450	24,340	16,370	125,480	1,612,120
- SL	1,818,610	625,050	18,856	143,760	190,410	1,865,260	17,135	134,270	306	173,030	30,880	22,060	164,210	2,029,470
- Total	3,282,560	1,142,700	32,893	262,820	332,160	3,351,900	30,350	240,110	533	306,480	55,220	38,430	289,690	3,641,590

IL = Island Lake
SL = Sturgeon Lake

Table E-2. Quantities and costs for conventional gravity sewers for the north and west shorelines of Island Lake, and transmission to existing Sand Lake sewers. (Alternative 4A).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Sewer Pipe						
8"	LF	13,900	$ 26.50	$368,350	$221,010	$1,043
Force main						
common trench						
2½"	LF	1,060	6.50	6,890	4,130	-
3"	LF	1,540	7.50	11,550	6,930	-
individual trench						
2"	LF	1,200	11.50	13,800	8,280	-
2½"	LF	450	11.80	5,310	3,190	-
3"	LF	2,750	12.70	34,930	20,960	-
3" Highway Crossing	EA	1		36,800	22,080	-
Lift Station						
A 75 gpm, TDH 28 Ft	EA	1		25,400	7,620	1,710
B 60 gpm, TDH 32 ft	EA	1		22,600	6,780	1,700
C 40 gpm, TDH 26 ft	EA	1		22,600	6,780	1,510
D 25 gpm, TDH 19 ft	EA	1		22,600	6,780	1,480
Auxiliary Power Units						
2 Hp	EA	3	6,300	18,900	5,670	-
Wye	EA	88	49	4,310	2,590	-
Service connection	EA	88	140	12,320	7,390	-
House lead						
gravity	EA	86	1,000	86,000	51,600	-
grinder pump	EA	2	2,850	5,700	1,710	124
Abandon septic tank, privy or holding tank	EA	88	54	4,750	-	-
Subtotal initial cost				702,810	383,500	7,567
Service factor (27%)				189,760		
Subtotal initial capital cost				892,570		
Future connection cost						
Wye	EA	28	49	1,370	820	-
Service connection	EA	28	140	3,920	2,350	-
Houselead						
gravity	EA	27	1,000	27,000	16,200	-
grinder pump	EA	1	2,850	2,850	860	62
Subtotal future connection cost				35,140	20,230	62
Annual future connection cost				1,757		3

Table E-3. Quantities and costs for STE gravity sewers for the north and west shorelines of Island Lake, and transmission to existing Sand Lake sewers. (Alternative 4B).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE gravity sewer pipe						
4"	LF	9,530	$ 16.90	$161,060	$96,630	$ 362
6"	LF	4,320	18.40	79,490	47,700	164
Manholes	EA	3	1,160	3,480	2,090	-
Force main						
common trench						
2½"	LF	1,060	6.50	6,890	4,130	-
3"	LF	1,540	7.50	11,550	6,930	-
individual trench						
2"	LF	1,200	11.50	13,800	8,280	-
2½"	LF	450	11.80	5,310	3,190	-
3"	LF	2,750	12.70	34,930	20,960	-
3" Highway Crossing	EA	1		36,800	22,000	-
Lift Station						
A 75 gpm, TDH 28 ft	EA	1		25,400	7,620	1,710
B 60 gpm, TDH 32 ft	EA	1		22,600	6,780	1,700
C 40 gpm, TDH 26 ft	EA	1		22,600	6,780	1,510
D 25 gpm, TDH 19 ft	EA	1		22,600	6,780	1,480
Auxiliary Power Units						
2 Hp	EA	3	6,300	18,900	5,670	-
Service connection						
STE gravity	EA	86	958	82,390	49,430	-
STE pump	EA	2	2,790	5,580	1,680	124
Septic tank						
new + abandon privy	EA	14	854	11,960	7,170	140
upgrade	EA	68	175	11,900	7,140	680
replace	EA	6	854	5,120	3,070	60
Building sewer	EA	14	90	1,260	760	-
Subtotal initial cost				584,220	314,790	7,930
Service factor (35%)				207,480		
Subtotal initial capital cost				778,700		
Future connection cost						
Service connection						
STE gravity	EA	27	958	25,870	15,520	-
STE pump	EA	1	2,790	2,790	840	62
Septic tank						
new	EA	28	800	22,400	13,440	280
replace	EA	25	854	21,350	12,810	-
Building sewer	EA	28	90	2,520	1,510	-
Subtotal future connection cost				74,930	44,120	342
Annual future connection cost				3,747		17

Table E-4. Quantities and costs for STE pressure sewers for the north and west shorelines of Island Lake and transmission to existing Sand Lake sewers. (Alternative 4C).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure sewer pipe						
2"	LF	1,220	$10.10	$ 12,320	$ 7,390	$ 23
2½"	LF	1,830	10.50	19,220	11,530	35
3"	LF	13,550	11.40	154,470	92,680	257
4"	LF	600	15.40	9,240	5,540	11
STE gravity sewer pipe						
6"	LF	2,700	18,40	49,680	29,810	102
6" Highway crossing	EA	1		36,800	22,080	-
Manhole	EA	1	1,160	1,160	700	-
Service connection-STE pump	EA	88	2,790	245,520	73,670	5,456
Septic tank						
new + abandon privy	EA	14	854	11,960	7,170	140
upgrade	EA	68	175	11,900	7,170	680
replace	EA	6	854	5,120	3,070	60
Building sewer	EA	14	90	1,260	760	-
Subtotal initial cost				558,650	261,570	6,764
Service factor (35%)				195,530		
Subtotal initial capital cost				754,180		
Future connection cost						
Service connection						
STE pump	EA	28	2,790	78,120	23,440	1,736
Septic tank						
new	EA	28	800	22,400	13,440	280
replace	EA	25	854	21,350	12,810	-
Building sewer	EA	28	90	2,520	1,510	-
Subtotal future connection cost				124,390	51,200	2,016
Annual future connection cost				6,220		101

Table E-5. Quantities and costs for STE gravity sewers for the north and west shorelines of Island Lake, and transmission to Bog Treatment. (Alternative 5A)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE gravity sewer pipe						
4"	LF	9,530	$ 16.90	$161,060	$96,630	$ 362
6"	LF	5,520	18.40	101,570	60,940	210
Manholes	EA	4	1,160	4,640	2,780	-
Force main, common trench						
2½"	LF	1,060	6.50	6,890	4,130	-
3"	LF	1,540	7.50	11,550	6,930	-
4"	LF	1,000	8.40	8,400	5,040	-
Force main, individual trench						
2"	LF	1,200	11.50	13,800	8,280	-
2½"	LF	450	11.80	5,310	3,190	-
3"	LF	700	12.70	8,890	5,330	-
4"	LF	4,550	13.70	62,340	37,400	-
Lift Station						
A 82 gpm, TDH 88 ft	EA	1		25,400	7,620	1,710
B 60 gpm, TDH 32 ft	EA	1		22,600	6,780	1,700
C 40 gpm, TDH 26 ft	EA	1		22,600	6,780	1,510
D 25 gpm, TDH 19 ft	EA	1		22,600	6,780	1,480
Auxiliary power units						
3 Hp	EA	2	7,800	15,600	4,680	-
2 Hp	EA	1	6,300	6,300	1,890	-
Service connection						
STE gravity	EA	86	958	82,390	49,430	-
STE pump	EA	2	2,790	5,580	1,680	124
Septic tank						
new + abandon privy	EA	14	854	11,960	7,170	140
upgrade	EA	68	175	11,900	7,140	680
replace	EA	6	854	5,120	3,070	60
Building sewer	EA	14	90	1,260	760	-
Subtotal initial cost				617,760	334,430	7,976
Service factor (35%)				216,220		
Subtotal initial capital cost				833,980		
Future connection cost						
Service connection						
STE gravity	EA	27	958	25,870	15,520	-
STE pump	EA	1	2,790	2,790	840	62
Septic tank						
new	EA	28	800	22,400	13,440	280
replace	EA	25	854	21,810	12,810	-
Building sewer	EA	28	90	2,520	1,510	-
Subtotal future connection cost				75,390	44,120	342
Annual future connection cost				3,770		17

Table E-6. Quantities and costs for STE pressure sewers for the north and west shorelines of Island Lake, and transmission to Bog Treatment. (Alternative 5B).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure sewer pipe						
2"	LF	660	$ 10.10	$ 6,670	$ 4,000	$ 13
2½"	LF	890	10.50	9,350	5,610	17
3"	LF	2,740	11.40	31,240	18,740	52
4"	LF	16,670	12.50	208,380	125,030	317
STE gravity sewer pipe						
6"	LF	1,200	18.40	22,080	13,250	46
Manhole	EA	1	1,160	1,160	700	-
Service connection						
STE pump	EA	88	2,790	245,520	73,670	5,456
Septic tank						
new + abandon privy	EA	14	854	11,960	7,170	140
upgrade	EA	68	175	11,900	7,170	680
replace	EA	6	854	5,120	3,070	60
Building sewer	EA	14	90	1,260	760	-
Subtotal initial cost				554,640	259,170	6,781
Service factor (35%)				194,120		
Subtotal initial capital cost				748,760		
Future connection cost						
Service connection						
STE pump	EA	28	2,790	78,120	23,440	1,736
Septic tank						
new	EA	28	800	22,400	13,400	280
replace	EA	25	854	21,350	12,810	-
Building sewer	EA	28	90	2,520	1,510	-
Subtotal future connection cost				124,390	51,200	2,016
Annual future connection cost				6,220		101

Table E-7. Quantities and costs for conventional gravity sewers for the entire shoreline of Island Lake, and transmission to existing Sand Lake sewers. (Alternative 6A).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Sewer Pipe						
8"	LF	28,290	$ 26.50	$ 749,690	$449,810	$2,122
Force main, common trench						
2"	LF	1,710	6.20	10,600	6,360	-
2½"	LF	700	6.50	4,550	2,730	-
3"	LF	2,790	7.50	20,930	12,560	-
4"	LF	1,020	8.40	8,570	5,140	-
Force main individual trench						
2"	LF	2,660	11.50	30,590	18,350	-
3"	LF	1,480	12.70	18,800	11,280	-
4"	LF	2,050	13.80	28,290	16,970	-
3" Lake Crossing				40,000	24,000	-
4" Highway Crossing				36,800	22,080	-
Lift Station						
A 150 gpm, TDH 43 Ft				25,400	7,620	2,189
B 110 gpm, TDH 31 ft				25,400	7,620	2,081
C 40 gpm, TDH 21 ft				22,600	6,780	1,498
D 25 gpm, TDH 19 ft				22,600	6,780	1,481
E 50 gpm, TDH 33 ft				22,600	6,780	1,677
F 25 gpm, TDH 10 ft				22,600	6,780	1,472
G 25 gpm, TDH 34 ft				22,600	6,780	1,496
Auxiliary Power Units						
5 Hp	EA	2	8,050	16,100	4,830	-
2 Hp	EA	3	6,300	18,900	5,670	-
Wye	EA	151	49	7,400	4,440	-
Service connection	EA	151	140	21,140	12,680	-
House lead						
gravity	EA	148	1,000	148,000	88,800	-
grinder pump	EA	3	2,850	8,550	2,570	186
Abandon septic tank, privy or holding tank	EA	151	54	8,150	-	-
Subtotal initial cost				1,340,860	737,410	14,202
Service factor (27%)				362,030		
Subtotal initial capital cost				1,702,890		
Future connection cost						
Wye	EA	63	49	3,090	1,850	-
Service connection	EA	63	140	8,820	5,390	-
Houselead						
gravity	EA	61	1,000	61,000	36,600	-
grinder pump	EA	2	2,850	5,700	3,420	124
Subtotal future connection cost				78,610	47,260	124
Annual future connection cost				3,931		6

Table E-8. Quantities and costs for STE gravity sewers for the entire shoreline of Island Lake and transmission to existing Sand Lake sewers. (Alternative 6B).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE gravity sewers						
4"	LF	23,430	$ 16.90	$395,970	$237,580	$ 890
6"	LF	3,320	18.40	61,090	36,650	126
8"	LF	2,260	24.10	54,470	32,680	86
Manholes	EA	8	1,160	9,280	5,570	-
Force main, common trench						
2"	LF	1,710	6.20	10,600	6,360	1
2½"	LF	700	6.50	4,550	2,730	-
3"	LF	2,790	7.50	20,930	12,560	-
4"	LF	1,020	8.40	8,570	5,140	-
Force main, individual trench						
2"	LF	2,660	11.50	30,590	18,350	-
3"	LF	1,480	12.70	18,800	11,280	-
4"	LF	2,050	13.80	28,290	16,970	-
3" Lake crossing				40,000	24,000	-
4" Highway Crossing				36,800	22,080	-
Lift Stations						
A 150 gpm, TDH 43 ft				25,400	7,620	2,189
B 110 gpm, TDH 31 ft				25,400	7,620	2,081
C 40 gpm, TDH 21 ft				22,600	6,780	1,498
D 25 gpm, TDH 19 ft				22,600	6,780	1,481
E 50 gpm, TDH 33 ft				22,600	6,780	1,677
F 25 gpm, TDH 10 ft				22,660	6,780	1,472
G 25 gpm, TDH 34 ft				22,600	6,780	1,496
Auxiluary power units						
5 Hp	EA	2	8,050	16,100	4,830	-
2 Hp	EA	3	6,300	18,900	5,670	-
Service connection						
STE gravity	EA	148	958	141,780	85,070	-
STE pump	EA	3	2,790	8,370	2,510	186
Septic tank						
new + abandon privy	EA	35	854	29,890	17,930	350
upgrade	EA	107	175	18,730	11,240	1,070
replace	EA	9	854	7,690	4,610	90
Building sewer	EA	35	90	3,150	1,890	-
Subtotal initial cost				1,128,380	614,840	14,692
Service factor (35%)				394,930		
Subtotal initial capital cost				1,523,310		
Future connection cost						
Service connection						
STE gravity	EA	61	958	58,440	35,060	-
STE pump	EA	2	2,790	5,580	1,670	124
Septic tank						
new	EA	63	800	50,400	30,240	630
replace	EA	38	854	32,450	19,470	-
Building sewer	EA	63	90	5,670	3,400	-
Subtotal future connection cost				152,540	89,840	754
Annual future connection cost				7,627		38

Table E-9. Quantities and costs for STE pressure sewers for the entire shoreline of Island Lake, and transmission to existing Sand Lake sewers. (Alternative 6C).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure sewers						
2"	LF	2,020	$10.10	$ 20,400	$ 12,240	$ 38
2½"	LF	2,280	10.50	23,940	14,360	43
3"	LF	12,900	11.40	147,060	88,240	245
4"	LF	17,340	12.50	216,750	130,050	329
STE gravity sewers						
8"	LF	2,700	24.10	65,070	39,040	103
Manholes	EA	2	1,160	2,320	1,390	-
8" Highway crossing	EA	1		36,800	22,080	-
Service connection STE pump	EA	151	2,790	421,290	126,390	9,362
Septic tank						
new + abandon privy	EA	35	854	29,890	17,930	350
upgrade	EA	107	175	18,730	11,340	11,630
replace	EA	9	854	7,690	4,610	90
Building sewer	EA	35	90	3,150	1,890	-
Subtotal initial cost				993,090	469,560	11,630
Service factor (35%)				347,380		
Subtotal initial cost				1,340,670		
Future connection cost						
Service connection						
STE pump	EA	63	2,790	175,770	52,730	3,906
Septic tank						
new	EA	63	800	50,400	30,240	630
replace	EA	38	854	32,450	19,470	-
Building sewer	EA	63	90	5,670	3,400	-
Subtotal future connection cost				264,290	105,840	4,536
Annual future connection cost				13,215		227

Table E-10. Quantities and costs for conventional gravity sewers for the entire shoreline of Sturgeon Lake and transmission to new Island Lake sewers. (Alternative 7A).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Sewer Pipe 8"	LF	34,200	$26.50	$906,300	$543,780	$2,567
Force main, common trench						
2"	LF	1,740	6.20	10,790	6,470	-
4"	LF	960	8.40	8,060	4,840	-
6"	LF	500	11.10	5,550	3,330	-
Force main, individual trench						
2"	LF	1,900	11.50	21,850	13,110	-
2½"	LF	2,610	11.80	30,800	18,480	-
3"	LF	3,640	12.70	46,230	27,740	-
4"	LF	1,880	13.80	25,940	15,570	-
6"	LF	8,900	16.70	148,630	89,180	-
Lift Stations						
A 25 gpm, TDH 8 ft				22,600	6,780	1,478
B 60 gpm, TDH 51 ft				22,600	6,780	1,745
C 90 gpm, TDH 24 ft				25,400	7,620	1,713
D 110 gpm, TDH 21 ft				25,400	7,620	2,058
E 190 gpm, TDH 54 ft				25,400	7,620	2,234
F 35 gpm, TDH 49 ft				22,600	6,780	1,553
G 25 gpm, TDH 69 ft				22,600	6,780	1,508
H 25 gpm, TDH 95 ft				22,600	6,780	1,525
Auxiliary Power Units[a]						
5 HP	EA	2	8,050	16,100	4,830	-
3 HP	EA	4	7,800	31,200	9,360	-
2 HP	EA	4	6,300	25,200	7,560	-
Wye	EA	197	49	9,650	5,790	-
Service connection	EA	197	140	27,580	16,550	-
House lead						
gravity	EA	193	1,000	193,000	115,800	-
grinder-pump	EA	4	2,850	11,400	3,420	248
Abandon septic tank, privy or holding tank	EA	197	54	10,640	-	-
Subtotal initial cost				1,718,120	942,570	16,629
Service factor (27%)				463,890		
Subtotal initial capital cost				2,182,010		
Future connection cost						
Wye	EA	85	49	4,170	2,500	-
Service connection	EA	85	140	11,900	7,140	-
Houselead						
gravity	EA	83	1,000	83,000	49,800	-
grinder pump	EA	2	2,850	5,700	3,420	124
Subtotal future connection cost				104,770	62,860	124
Annual future connection cost				5,239		6

[a] Serving Island Lake and Sturgeon Lake.

Table E-11. Quantities and costs for conventional gravity sewers for the entire shoreline of Island Lake, and transmission of both Island Lake and Sturgeon Lake wastewater to existing Sand Lake sewers. (Alternative 7A).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Sewer Pipe						
8"	LF	27,600	$26.50	$731,400	$438,840	$2,070
10"	LF	700	22.20	19,040	11,420	53
Force main, common trench						
2½"	LF	2,410	6.50	15,670	9,400	-
3"	LF	2,790	7.50	20,930	12,560	-
6"	LF	1,020	11.10	11,320	6,790	-
Force main, individual trench						
2"	LF	1,970	11.50	22,660	13,590	-
2½"	LF	690	11.80	8,140	4,890	-
3"	LF	1,480	12.70	18,800	11,280	-
6"	LF	2,050	16.70	34,240	20,540	-
3" Lake crossing	LS			40,000	24,000	-
6" Highway crossing	LS			36,000	22,080	-
Lift Stations						
A 280 gpm, TDH 23 ft				25,400	7,620	2,467
B 110 gpm, TDH 31 ft				25,400	7,620	2,081
C 40 gpm, TDH 21 ft				22,600	6,780	1,498
D 25 gpm, TDH 19 ft				22,600	6,780	1,481
E 50 gpm, TDH 33 ft				22,600	6,780	1,677
F 25 gpm, TDH 10 ft				22,600	6,780	1,472
G 40 gpm, TDH 36 ft				22,600	6,780	1,538
Wye	EA	151	49	7,400	4,440	-
Service connection	EA	151	140	21,140	12,680	-
House lead						
gravity	EA	148	1,000	148,000	88,800	-
grinder-pump	EA	3	2,850	8,550	2,570	186
Abandon septic tank, privy or holding tank	EA	151	54	8,150	-	-
Subtotal initial cost				1,315,240	733,020	14,523
Service factor (27%)				355,110		
Subtotal initial capital cost				1,670,350		
Future connection cost						
Wye	EA	63	49	3,090	1,850	-
Service connection	EA	63	140	8,820	5,290	-
House lead						
gravity	EA	61	1,000	61,000	36,600	-
grinder pump	EA	2	2,850	5,700	3,420	124
Subtotal future connection cost				78,610	47,160	124
Annual future connection cost				3,931		6

Table E-12. Quantities and costs for STE gravity sewers for the entire shoreline of Sturgeon Lake and transmission to new Island Lake sewers. (Alternative 7B).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE gravity sewer						
4"	LF	25,120	$16.90	$424,530	$254,720	$ 955
6"	LF	4,640	18.40	85,380	51,230	176
8"	LF	5,920	24.10	142,670	85,600	225
Manholes	EA	4	1,160	4,640	2,780	-
Force main, common trench						
2"	LF	1,740	6.20	10,790	6,470	-
4"	LF	960	8.40	8,060	4,840	-
6"	LF	500	11.10	5,550	3,330	-
Force main, individual trench						
2"	LF	1,900	11.50	21,850	13,110	-
2½"	LF	2,610	11.80	30,800	18,480	-
3"	LF	3,640	12.70	46,230	27,740	-
4"	LF	1,880	13.80	25,940	15,570	-
6"	LF	8,900	16.70	148,630	89,180	-
Lift Stations						
A 25 gpm, TDH 8 ft				22,600	6,780	1,478
B 60 gpm, TDH 51 ft				22,600	6,780	1,745
C 90 gpm, TDH 21 ft				25,400	7,620	1,713
D 110 gpm, TDH 21 ft				25,400	7,620	2,058
E 190 gpm, TDH 54 ft				25,400	7,620	2,234
F 35 gpm, TDH 49 ft				22,600	6,780	1,553
G 25 gpm, TDH 69 ft				22,600	6,780	1,508
H 25 gpm, TDH 95 ft				22,600	6,780	1,525
Auxiliary Power Units[a]						
5 HP	EA	2	8,050	16,100	4,830	-
3 HP	EA	4	7,800	31,200	9,360	-
2 HP	EA	4	6,300	25,200	7,560	-
Service connection						
STE gravity	EA	193	958	184,890	110,940	-
STE pump	EA	4	2,790	11,160	3,350	248
Septic tank						
new + abandon privy	EA	30	854	25,630	15,370	300
upgrade	EA	155	175	27,130	16,280	1,550
replace	EA	12	854	10,250	6,150	120
Building sewer	EA	30	90	2,700	1,620	-
Subtotal initial cost				1,478,530	805,270	17,388
Service factor (35%)				517,490		
Subtotal initial capital cost				1,996,020		
Future connection cost						
Service connection	EA					
STE gravity	EA	83	958	79,510	47,710	-
STE pump	EA	2	2,790	5,580	1,670	124
Septic tank						
new	EA	85	800	68,000	40,800	850
replace	EA	35	854	29,890	17,930	-
Building Sewer	EA	85	90	7,650	4,590	-
Subtotal future connection cost				190,630	112,700	974
Annual future connection cost				9,532		49

[a] Serving Island Lake and Sturgeon Lake

Table E-13. Quantities and costs for STE gravity sewers for the entire shoreline of Island Lake and transmission of Island Lake and Sturgeon Lake wastewater to existing Sand Lake sewers. (Alternative 7B).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE gravity sewer						
4"	LF	22,020	$16.90	$372,140	$223,280	$ 837
6"	LF	3,320	18.40	61,090	36,650	126
8"	LF	2,260	24.10	54,470	32,680	86
10"	LF	800	24.80	19,840	11,900	30
Manhole	EA	10	1,160	11,600	6,960	-
Force main, common trench						
2½"	LF	2,410	6.50	15,670	9,400	-
3"	LF	2,790	7.50	20,930	12,560	-
6"	LF	1,020	11.10	11,320	6,790	-
Force main, individual trench						
2"	LF	1,970	11.50	22,660	13,590	-
2½"	LF	690	11.80	8,140	4,890	-
3"	LF	1,480	12.70	18,800	11,280	-
6"	LF	2,050	16.70	34,240	20,540	-
3" Lake Crossing				40,000	24,000	-
6" Highway Crossing				36,000	22,080	-
Lift Stations						
A 280 gpm, TDH 23 ft				25,400	7,620	2,467
B 110 gpm, TDH 31 ft				25,400	7,620	2,081
C 40 gpm, TDH 21 ft				22,600	6,780	1,498
D 25 gpm, TDH 19 ft				22,600	6,780	1,481
E 50 gpm, TDH 33 ft				22,600	6,780	1,677
F 25 gpm, TDH 10 ft				22,600	6,780	1,472
G 40 gpm, TDH 36 ft				22,600	6,780	1,538
Service connection						
STE gravity	EA	148	958	141,780	85,070	-
STE pump	EA	3	2,790	8,370	2,510	186
Septic tank						
new + abandon privy	EA	35	854	29,890	17,930	350
upgrade	EA	107	175	18,730	11,240	1,070
replace	EA	9	854	7,690	4,610	90
Building sewer	EA	35	90	3,150	1,890	-
Subtotal initial cost				1,100,310	608,990	14,989
Service factor (35%)				385,110		
Subtotal initial capital cost				1,485,420		
Future connection cost						
Service connection						
STE gravity	EA	61	958	58,440	35,060	-
STE pump	EA	2	2,790	5,580	1,670	124
Septic tank						
new	EA	63	800	50,400	30,240	630
replace	EA	38	854	32,450	19,470	-
Building sewer	EA	63	90	5,670	3,400	-
Subtotal future connection cost				152,470	89,840	754
Annual future connection cost				7,624		38

Table E-14. Quantities and costs for STE pressure sewers serving the entire shoreline of Sturgeon Lake and transmission to new Island Lake sewers. (Alternative 7C).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure pipe						
2"	LF	1,300	$10.10	$ 13,130	$ 7,880	$ 25
2½"	LF	6,900	10.50	72,450	43,470	131
3"	LF	15,070	11.40	171,800	103,080	286
4"	LF	13,880	12.50	173,500	104,100	264
6"	LF	2,950	15.40	45,430	27,260	56
STE gravity sewer						
4"	LF	1,740	16.90	29,410	17,640	66
Manholes	EA	2	1,160	2,320	1,390	-
Force main, individual trench						
6"	LF	9,650	16.70	161,160	96,690	-
Lift stations[a]						
B 50 gpm, TDH 99 ft				22,600	6,780	1,784
C 130 gpm, TDH 18 ft				25,400	7,620	2,060
Auxiliary Power Units[b]						
5 HP	EA	2	8,050	16,100	4,830	-
Service connection STE pump	EA	197	2,790	549,630	164,890	12,214
Septic tank						
new + abandon privy	EA	30	854	25,620	15,370	300
upgrade	EA	155	175	27,130	16,280	1,290
replace	EA	12	854	10,250	6,150	120
Building sewer	EA	30	90	2,700	1,620	-
Subtotal initial cost				1,347,120	625,050	18,856
Service factor (35%)				471,490		
Subtotal initial capital cost				1,818,610		
Future connection cost						
Service connection						
STE pump	EA	85	2,790	237,150	71,150	5,270
Septic tank						
new	EA	85	800	68,000	40,800	850
replace	EA	35	854	29,890	17,730	-
Building sewer	EA	85	90	7,650	4,590	-
Subtotal future connection cost				342,690	134,270	6,120
Annual future connection cost				17,135		306

[a] Lift station A is included on Table E-15.

[b] Serving Island Lake and Sturegon Lake.

Table E-15. Quantities and costs for STE pressure sewers for the entire shoreline of Island Lake and transmission of Island Lake and Sturgeon Lake wastewater to existing Sand Lake sewers. (Alternative 7C).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure pipe						
2"	LF	1,920	$10.10	$ 19,390	$ 11,640	$ 36
2½"	LF	2,020	10.50	21,210	12,730	38
3"	LF	11,260	11.40	128,360	77,020	214
4"	LF	13,540	12.50	169,250	101,550	257
STE gravity sewer						
6"	LF	2,000	18.40	36,800	22,080	76
8"	LF	3,270	24.10	78,810	47,280	124
Manhole	EA	3	1,200	3,600	2,160	-
8" Highway crossing	EA	1		36,800	22,080	-
Force main, individual trench						
6"	LF	2,350	16.70	39,250	23,550	-
6" Highway crossing	EA	1		36,800	22,080	-
Force main, common trench						
6"	LF	720	11.10	7,990	4,800	-
Lift Stations						
A 200 gpm, TDH 34 ft				25,400	7,620	2,420
Service connection-STE pump	EA	151	2,790	421,290	126,390	9,362
Septic tank						
new + abandon privy	EA	35	854	29,890	17,930	350
upgrade	EA	107	175	18,730	11,240	1,070
replace	EA	9	854	7,690	4,610	90
Building sewer	EA	35	90	3,150	1,890	-
Subtotal initial cost				1,084,410	517,650	14,037
Service factor (35%)				379,440		
Subtotal initial capital cost				1,463,950		
Future connection cost						
Service connection STE pump	EA	63	2,790	175,770	52,730	3,906
Septic tank						
new	EA	63	800	50,400	30,240	630
replace	EA	38	854	32,450	19,470	-
Building sewer	EA	63	90	5,670	3,400	-
Subtotal future connection cost				264,290	105,840	4,536
Annual future connection cost				13,215		227

Table E-16. Summary of cluster systems, WWTP, and administrative costs.

Item	Initial Cost						Future Construction Cost							Total Present Worth
				Present Worth			Annual	Total	Incremental	Present Worth				
	Capital	Salvage	O&M	Salvage	O&M	Total	Construction	Salvage	Ann. O&M	Construction	Salvage	O&M	Total	
Cluster Systems														
Island Lake (Alt. 3)	483,250	187,980	3,373	43,240	34,060	474,070	1,433	13,010	18	14,470	2,990	1,300	12,780	486,850
Sturgeon Lake (Alt. 3,4,5,6)	453,630	153,200	6,491	35,240	65,550	483,940	1,472	10,970	29	14,860	2,520	2,090	14,430	498,370
Total (Alt. 3)	936,880	341,180	9,864	78,480	99,610	958,010	3,205	23,980	47	29,330	5,510	3,390	27,210	985,220
WWTP[a]														
Alt. 4	287,150	180,980	2,260	41,630	22,820	286,340	-	-	-	-	-	-	-	268,340
Alt. 5 (Bog treatment)	244,850	67,490	9,689	15,520	97,840	327,170	-	-	-	-	-	-	-	327,170
Alt. 6	377,190	254,320	3,010	58,490	30,400	349,100	-	-	-	-	-	-	-	349,100
Alt. 7	688,340	491,950	4,940	113,150	49,890	625,080	-	-	-	-	-	-	-	625,080
Administrative (All Alts.)	-	-	28,400	-	286,790	286,790	-	-	-	-	-	-	-	286,790

[a]Upgrade existing Moose Lake WWTP (except for Alt. 5)

Table E-17. Quantities and costs for STE pressure collection for a limited area on the east shore of Sturgeon Lake, transmission, and treatment and disposal in a Cluster Drainfield. (Alternatives 3, 4, 5 and 6)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Collection & transmission						
STE gravity pipe						
4"	LF	2,100	$16.90	$35,490	$21,290	$ 80
STE pressure pipe						
3"	LF	7,850	11.40	89,490	53,690	149
Lift Station						
25 gpm, TDH 66 ft				22,600	6,780	1,502
Auxiliary Power						
3 Hp	EA	1	7,800	7,800	2,340	-
Service connection						
STE pump	EA	20	2,790	55,800	16,740	1,240
Septic tank						
new + abandon privy	EA	1	854	850	510	10
upgrade	EA	18	175	3,150	1,890	180
replace	EA	1	854	850	510	10
Building sewer	EA	1	90	90	50	-
Cluster Drainfield						
Gravel road	LF	800	7.00	5,600	-	320
Land	AC	5	3,000	15,000	27,090	-
Fence	LF	1,900	8.14	15,570	-	95
Fence gate	EA	1	560	560	-	-
Dosing chamber (7000 gal)	EA	1	7,500	7,500	4,500	-
Dosing pumps (Duplex 250 gpm, TDH 20 ft)	EA	1	16,000	16,000	4,800	2,180
6" STE gravity pipe	LF	1,630	13.30	21,680	13,010	62
Monitoring well & testing	EA	2	1,250	2,500	-	240
Trench drainfield	SF	16,900	2.10	35,490	-	423
Subtotal initial cost				336,020	153,200	6,491
Service factor (35%)				117,610		
Subtotal initial capital cost				453,630		
Future connection cost						
Service connection						
STE pump	EA	8	2,790	22,320	6,700	500
Septic tank						
new	EA	8	800	6,400	3,840	80
Building sewer	EA	8	90	720	430	-
Subtotal future connection cost				29,440	10,970	580
Annual future connection cost				1,472		29

Table E-18. Quantities and costs for STE pressure sewers for two areas on the western shoreline of Island Lake, transmission, and treatment and disposaling cluster drainfield. (Alternative 3)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
STE pressure pipe						
2"	LF	700	$10.10	$ 7,070	$ 4,240	$ 13
2½"	LF	5,100	10.50	53,550	32,130	97
3"	LF	3,250	11.40	37,050	22,230	62
Service connection						
STE pump	EA	30	2,790	83,700	25,110	1,860
Septic tank						
new & abandon privy	EA	9	854	7,690	4,610	90
upgrade	EA	13	175	2,280	1,370	130
replace	EA	8	854	6,830	4,100	80
Building sewer	EA	9	90	810	490	-
Cluster Drainfield						
Land	AC	11	3,000	33,000	59,600	-
Fence	LF	2,700	8.14	21,980	-	135
Fence Gate	EA	1	560	560	-	-
Dosing Chamber	EA	1	7,500	7,500	4,500	-
6" STE gravity pipe	LF	3,710	13.30	49,340	29,600	141
Monitoring well & testing	EA	2	1,250	2,500	-	240
Trench drainfield	SF	21,000	2.10	44,100	-	525
Subtotal initial cost				357,960	187,980	3,373
Service factor (35%)				125,890		
Subtotal initial capital cost				483,250		
Future connection cost						
Service connection						
STE pump	EA	5	2,790	13,950	4,190	310
Septic tank						
new	EA	5	800	4,000	2,400	50
replace	EA	12	854	10,250	6,150	-
Building Sewer	EA	5	90	450	270	-
Subtotal future connection cost				28,650	13,010	360
Annual future connection cost				1,433		18

Table E-19. Quantities and costs for upgrading existing Moose Lake WWTP to serve North and West shorelines of Island Lake. (Alternative 4)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Land	AC	14	$3,000	$ 42,000	$ 75,860	-
Lagoon Construction & Site Work	LS			166,300	99,780	$1,000
Bentonite liner	LS			13,200	3,960	-
Main Lift Station Incremental capacity	LS			4,600	1,380	1,260
Subtotal				226,100	180,980	2,260
Service factor (27%)				61,050		
Total initial capital cost				287,150		

Table E-20. Quantities and costs for Bog Treatment WWTP to serve north and west shorelines of Island Lake. (Alternative 5)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Land	AC	20	$2,000	$ 40,000	$53,600	-
Site evaluation	LS			15,200	-	-
Site preparation	LS			1,600	-	-
Trench construction	CY	11,330	4.20	47,590	-	-
Curtain drain trench	LF	1,580	6.50	10,270	2,370	$ 93
Pumps & chambers	EA	2	3,400	6,800	670	1,487
Dewatering piping	LF	800	4.00	3,200	1,920	305
Flow meter assembly	LS			10,000	3,000	-
Distribution Box	LS			2,000	1,200	-
Pipe to trenches (Matl. only)	LF	2,625	3.00	7,880	4,730	-
Monitoring wells	EA	6	100	600	-	-
Laboratory analysis	LS			-	-	7,480
Service Roads	LF	300	7.00	2,100	-	120
Fencing	LF	4,070	8.14	33,130	-	204
Electrical service	LS			1,000	-	-
Subtotal				181,370	67,490	9,689
Service factor (35%)				63,480		
Total initial capital cost				244,850		

Table E-21. Quantities and costs for upgrading existing Moose Lake WWTP to serve the entire shoreline of Island Lake. (Alternative 6).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Land	AC	22	$3,000	$ 66,000	$119,200	-
Lagoon construction & sitework	LS			199,600	119,760	$1,300
Bentonite liner	LS			19,800	11,880	-
Main lift station incremental capacity	LS			11,600	3,480	1,710
Subtotal				297,000	254,320	3,010
Service factor (27%)				80,190		
Total initial capital cost				377,190		

Table E-22. Quantities and costs for upgrading existing Moose Lake WWTP to serve the entire shoreline of Island Lake and Sturgeon Lake. (Alternative 7).

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Land	AC	48	$3,000	$144,000	$260,080	-
Lagoon construction & sitework	LS			332,600	199,560	$2,100
Bentonite Liner	LS			42,300	25,380	-
Main lift station Incremental capacity	LS			23,100	6,930	2,840
Subtotal				542,000	491,950	4,940
Service factor (27%)				146,340		
Total initial capital cost				688,340		

Table E-23. Administrative costs. (All Alternatives)

Item	Unit	Quantity	Unit Cost	Construction	Salvage	O&M
Office/Garage	LS			-	-	$ 1,400
Administrative Personnel Services	LS			-	-	27,000
Subtotal initial cost				-	-	28,400

Table E-24. Summary of on-site upgrade costs.

Item	Initial Cost						Future Construction Cost							Total
				Present Worth			Annual	Total	Incremental	Present Worth				Total
	Capital	Salvage	O&M	Salvage	O&M	Total	Construction	Salvage	Ann. O&M	Construction	Salvage	O&M	Total	Present Worth
Alternative 2														
Island Lake	171,360	17,140	5,334	3,940	53,860	221,280	13,000	53,110	202	131,280	12,220	14,570	133,630	354,910
Sturgeon Lake	105,660	23,940	4,522	5,510	45,670	145,820	13,430	65,980	211	135,620	15,180	15,220	135,660	281,480
Other[1]	14,510	6,450	420	1,480	4,240	17,270	7,590	40,920	72	76,660	9,410	5,190	72,440	89,710
Total	291,530	47,530	10,276	10,930	103,770	384,370	34,020	160,010	485	343,560	36,810	34,980	341,730	726,100
Alternative 3														
Island Lake	156,520	14,410	4,349	3,320	43,920	197,120	10,480	44,290	156	105,830	10,190	11,250	106,890	304,010
Sturgeon Lake	51,650	17,090	1,456	3,930	14,700	62,420	12,240	60,640	128	123,600	13,950	9,230	118,880	181,300
Other[1]	14,510	6,450	420	1,980	4,240	17,270	7,590	40,920	72	76,660	9,410	5,190	72,440	89,710
Total	222,680	37,950	6,225	8,730	62,860	276,810	30,310	145,860	406	306,090	33,550	25,670	298,210	575,020
Alternatives 4 & 5														
Island Lake	56,250	6,600	1,850	1,520	18,680	73,410	5,640	25,350	74	56,950	5,830	5,340	56,460	129,870
Sturgeon Lake	51,650	17,090	1,456	3,930	14,700	62,420	12,240	60,640	128	123,600	13,950	9,230	118,880	181,300
Other[1]	14,510	6,450	420	1,480	4,240	17,270	7,591	40,920	72	76,660	9,410	5,190	72,440	89,710
Total	122,410	30,140	3,726	6,930	37,620	153,100	25,471	126,910	274	257,210	29,190	19,760	247,780	400,880
Alternative 6														
Sturgeon Lake	51,650	17,090	1,456	3,930	14,700	62,420	12,240	60,640	128	123,600	13,950	9,230	118,800	181,300
Other[1]	14,510	6,450	420	1,480	4,240	17,270	7,591	40,920	72	76,660	9,410	5,190	72,440	89,710
Total	66,160	23,540	1,876	5,410	18,940	79,690	19,831	101,560	200	200,260	23,360	14,420	191,320	271,010
Alternative 7														
Other[1]	14,510	6,450	420	1,480	4,240	17,270	7,591	40,920	72	76,660	9,410	5,190	72,440	89,710

[1]Includes the remainder of the EIS service area (Rush Lake, Passenger Lake, Hogans Acres and Wild Acres)

Table E-25. Quantities and costs for upgrading and operation of on-site systems for Island Lake. (Alternative 2).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	89	175	15,575	9,345	890
Upgrade (major)	9	854	7,686	4,612	90
Soil absorption system					
Trench	7	1,129	7,903	-	-
Seepage bed (400 sq ft)	2	904	1,808	-	-
Mound (400 sq ft incld. pump)	32	2,504	80,128	-	2,304
Waste separation					
Blackwater HT - Permanent	5	885	4,425	2,655	1,915
Blackwater HT - Seasonal	1	885	885	531	135
Low flow toilet	6	1,420	8,520	-	-
Initial cost			126,930	17,140	5,334
Service factor (35%)			44,426	-	-
Initial capital costs			171,360	-	-
Future costs					
Building sewer	63	90	5,670	3,402	-
Septic tank, new	63	800	50,400	30,240	630
Septic tank, upgrade	38	854	32,452	19,471	-
Trench SAS	35	1,129	39,515	-	-
Seepage bed SAS	23	904	20,792	-	-
Mound (400 sq ft incld. pump)	43	2,504	107,672	-	3,096
Total future costs			260,001	53,110	4,036
Annual future costs			13,000	-	202

HT - holding tank, SAS - soil absorption system

Table E-26. Quantities and costs for upgrading and operation of on-site systems for Sturgeon Lake. (Alternative 2).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	129	175	22,575	13,545	1,290
Upgrade (major)	12	854	10,248	6,149	120
Soil absorption system					
Trench	2	1,129	2,258	-	-
Mound (400 sq ft incld. pump)	3	2,504	7,512	-	216
Mound (250 sq ft incld. pump)	8	2,154	17,232	-	576
Waste separation					
Blackwater HT - Permanent	5	885	4,425	2,655	1,915
Blackwater HT - Seasonal	3	885	2,655	1,593	405
Low flow toilet	8	1,420	11,360	-	-
Initial cost			78,265	23,940	4,522
Service factor (35%)			27,393	-	-
Initial capital costs			105,660	-	-
Future costs					
Building sewer	85	90	7,650	4,590	-
Septic tank, new	85	800	68,000	40,800	850
Septic tank, upgrade	35	854	29,890	17,934	-
Trench SAS	33	1,129	37,257	-	-
Seepage bed SAS	68	904	61,472	-	-
Mound (400 sq ft incld. pump)	19	2,504	47,576	-	1,368
Mound (250 sq ft incld. pump)	3	2,154	6,462	-	216
Pump chamber	6	700	4,200	-	372
Blackwater HT - Permanent	3	885	2,655	1,593	1,149
Blackwater HT - Seasonal	2	885	1,770	1,062	270
Low flow toliet	5	350	1,750	-	-
Total future costs			268,682	65,980	4,225
Annual future costs			13,430		211

HT - Holding tank, SAS - soil absorption system

Table E-27. Quantities and costs for upgrading and operation of on-site systems for Rush Lake, Passenger Lake, Hogans Acres and Wild Acres. (Alternatives 2, 3, 4, 5, 6, and 7).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	37	175	6,475	3,885	370
Upgrade (major)	5	854	4,270	2,562	50
Initial cost			10,745	6,450	420
Service factor (35%)			3,761	-	-
Initial capital costs			14,506	-	-
Future costs					
Building sewer	68	90	6,120	3,672	-
Septic tank, new	68	800	54,400	32,640	680
Septic tank, upgrade	9	854	7,686	4,612	-
Seepage bed SAS	70	904	63,280	-	-
Mound (400 sq ft incld. pump)	7	2,504	7,528	-	504
Pump chamber	4	700	2,800	-	248
Total future costs			151,814	40,924	1,432
Annual future costs			7,591	-	72

SAS- soil absorption system

Table E-28. Quantities and costs for upgrading and operation of on-site systems for Island Lake. (Alternative 3).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	68	175	11,900	7,140	680
Upgrade (major)	9	854	7,686	4,612	90
Soil absorption system					
Trench	7	1,129	7,903	-	-
Seepage bed (400 sq ft)	2	904	1,808	-	-
Mound (400 sq ft incld. pump)	30	2,504	75,120	-	2,160
Waste separation					
Blackwater HT - Permanent	3	885	2,655	1,593	1,149
Blackwater HT - Seasonal	2	885	1,770	1,062	270
Low flow toilet	5	1,420	7,100	-	-
Initial cost			115,942	14,410	4,349
Service factor (35%)			40,580	-	-
Initial capital costs			156,520	-	-
Future cost					
Building sewer	58	90	5,220	3,132	-
Septic tank, new	58	800	46,400	27,840	580
Septic tank, upgrade	26	854	22,204	13,322	-
Trench SAS	30	1,129	33,870	-	-
Seepage bed SAS	23	904	20,792	-	-
Mound (400 sq ft. incld. pump)	31	2,504	77,624	-	2,232
Pump chamber	5	700	3,500	-	310
Total future costs			209,610	44,290	3,122
Annual future costs			10,480	-	156

HT - holding tank, SAS - soil absorption system.

Table E-29. Quantities and costs for upgrading and operation of on-site systems for Sturgeon Lake. (Alternative 3).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	114	175	19,950	11,970	1,140
Upgrade (major)	10	854	8,540	5,124	100
Soil absorption system					
Trench	2	1,129	2,258	-	-
Mound (400 sq ft incld. pump)	3	2,504	7,512	-	216
Initial cost			38,260	17,094	1,456
Service factor (35%)			13,391	-	-
Initial capital costs			51,651	-	-
Future costs					
Building sewer	76	90	6,840	4,104	-
Septic tank, new	76	800	60,800	36,480	760
Septic tank, upgrade	35	854	29,890	17,934	-
Trench SAS	33	1,129	37,257	-	-
Seepage bed SAS	68	904	61,472	-	-
Mound (400 sq ft)	14	2,504	35,056	-	-
Mound (200 sq ft incld. pump)	2	2,154	4,308	-	144
Pump chamber	6	700	4,200	-	372
Blackwater HT Permanent	3	885	2,655	1,593	1,149
Blackwater HT Seasonal	1	885	885	531	135
Low flow toliet	4	350	1,400	-	-
Total future costs			244,763	60,642	2,560
Annual future costs			12,238	-	129

SAS - soil absorption system, HT - holding tank

Table E-30. Quantities and costs for upgrading and operation of on-site systems for Island Lake. (Alternatives 4 and 5).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	28	175	4,900	2,940	280
Upgrade (major)	3	854	2,562	1,537	30
Soil absorption system					
Trench	5	1,129	5,645	-	-
Seepage bed (400 Sq Ft)	2	904	1,808	-	-
Mound (400 sq ft incld. pump)	7	2,504	17,528	-	504
Waste Separation					
Blackwater HT - Permanent	2	885	1,770	1,062	766
Blackwater HT - Seasonal	2	885	1,770	1,062	270
Low flow toilet	4	1,420	5,680	-	-
Initial cost			41,663	6,600	1,850
Service factor (35%)			14,582	-	-
Initial capitol costs			56,250	-	-
Future costs					
Building sewer	35	90	3,150	1,890	-
Septic tank, new	35	800	28,000	16,800	350
Septic tank, upgrade	13	854	11,102	6,661	-
Trench SAS	15	1,129	16,935	-	-
Seepage bed SAS	19	904	17,176	-	-
Mound (400 sq ft incld. pump)	14	2,504	35,056	-	1,008
Pump chamber	2	700	1,400	-	124
Total future costs			112,820	25,350	1,482
Annual future costs			5,640	-	74

HT- holding tank, SAS- soil absorption system

Table E-31. Quantities and costs for upgrading and operation of on-site systems for Sturgeon Lake. (Alternatives 4 and 5).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	114	175	19,950	11,970	1,140
Upgrade (major)	10	854	8,540	5,124	100
Soil absorption system					
Trench	2	1,129	2,258	-	-
Mound (400 sq ft incld. pump)	3	2,504	7,512	-	216
Initial cost			38,260	17,090	1,456
Service factor (35%)			13,391	-	-
Initial capitol costs			51,650	-	-
Future costs					
Building sewer	76	90	6,840	4,104	-
Septic tank, new	76	800	60,800	36,480	760
Septic tank, upgrade	35	854	29,890	17,934	-
Trench SAS	33	1,129	37,257	-	-
Seepage bed SAS	68	904	61,472	-	-
Mound (400 sq ft)	14	2,504	35,056	-	-
Mound (200 sq ft incld. pump)	2	2,154	4,308	-	144
Pump chamber	6	700	4,200	-	372
Blackwater HT Permanent	3	885	2,655	1,593	1,149
Blackwater HT Seasonal	1	885	885	531	135
Low flow toliet	4	350	1,400	-	-
Total future costs			244,760	60,640	2,560
Annual future costs			12,240	-	128

SAS - soil absorption system, HT - holding tank

Table E-32. Quantities and costs for upgrading and operation of on-site systems for Sturgeon Lake. (Alternative 6).

Item	Quantity	Unit Cost	Construction	Salvage	O&M
Septic tank					
Upgrade (minor)	114	175	19,950	11,970	1,140
Upgrade (major)	10	854	8,540	5,124	100
Soil absorption system					
Trench	2	1,129	2,258	-	-
Mound (400 sq ft incld. pump)	3	2,504	7,512	-	216
Initial cost			38,260	17,090	1,456
Service factor (35%)			13,391	-	-
Initial capitol costs			51,650	-	-
Future costs					
Building sewer	76	90	6,840	4,104	-
Septic tank, new	76	860	60,800	36,480	760
Septic tank, upgrade	35	854	29,890	17,934	-
Trench SAS	29	1,129	37,257	-	-
Seepage bed SAS	68	904	61,472	-	-
Mound (400 sq ft)	14	2,504	35,056	-	-
Mound (200 sq ft incld. pump)	2	2,154	4,308	-	144
Pump chamber	6	700	4,200	-	372
Blackwater HT Permanent	3	885	2,655	1,593	1,149
Blackwater HT Seasonal	1	885	885	531	135
Low flow toliet	4	350	1,400	-	-
Total future costs			244,760	60,640	2,560
Annual future costs			12,240	-	128

SAS - soil absorption system, HT - holding tank

Appendix F

Analysis of Grant Eligibility

GRANT ELIGIBILITY

The eligibility of initial capital costs for State and USEPA grants are based on MPCA policy and USEPA Region V policy which are in turn based on the Code of Federal Regulations, Title 40, Part 35. These regulations are currently being revised. Interim Final regulations were issued in the Federal Register on May 12, 1982, and the Final regulations are expected in the immediate future. Current MPCA policy was used to determine costs eligible for grants (Mr. L. Zdon, MPCA, to WAPORA, Inc., 18 August 1982 and 29 November 1982).

A project that is determined to be innovative and alternative qualifies for a greater percentage of grant funding of eligible initial capital costs than conventional projects. The percentage is shown below:

	Grant Percentage of Eligible Costs[1]		
	USEPA Grant	State Grant	Total Grant
Innovative and Alternative	85%	9%	94%
Conventional	75%	15%	90%

The initial capital costs include the following:

- Eligible costs - Initial capital costs eligible for USEPA and state grants.
- Ineligible costs - Initial capital costs not eligible for USEPA and State grants (not including homeowner ineligible costs).
- Homeowner inelgible costs - Initial capital costs that must be financed by the individual homeowner.

Operation and maintenance costs are not grant eligible.

Grant eligibility in this report was based on the following:

Collection and Conveyance

1. STE gravity and STE pressure sewers - All costs were considered eligible for innovative and alternative funding, except for building sewers which were considered homeowner ineligible.

2. Conventional gravity sewers - Pump stations, force mains, and any gravity sewers used only as inteceptors were considered eligible for conventional funding. Gravity collection sewers were considered ineligible. House leads (piping from the residence to the edge of the sewer easement) were considered ineligible.

Centralized Treatment

1. Upgrading the Moose Lake WWTP - All costs were considered eligible for conventional funding except for land purchase which was considered ineligible

2. Bog Treatment - All costs (including land) were considered eligible for innovative and alternative funding.

Cluster Drainfields

All costs were considered eligible for innovative and alternative funding (including STE gravity and STE pressure collection systems) except building sewers which were considered homeowner ineligible.

Upgrading On-Site Systems

Upgrading on-site systems for lots inhabited prior to December 1977 were considered eligible for innovative and alternative funding. The number of eligible residences was determined from permits and questionnaires. All ineligible residences were assumed to require minor upgrades only. Low-flow toilets were considered homeowner ineligible.

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[1] For construction started after 30 September 1984 the Federal share will be 55% for conventional systems and 75% for innovative and alternative systems (Federal Register, Vol 47, NO 92, May 12, 1982; Changes in regulations governing construction grants for treatment works). The state share after 30 September 1984 is not known at this time.

Table F-1. Governmental grants and local share costs for Alternative 2 (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	262.7	-	223.3 (85%)	39.4 (15%)	223.3 (85%)	23.6 (9%)	15.8 (6%)
ineligible	28.8	10.3	-	28.8 (100%)	-	-	28.8 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	291.5	38.7	223.3	68.2	223.3	23.6	44.6

Table F-2. Governmental grants and local share costs for Alternative 3 (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	207.0	-	176.0 (85%)	31.0 (15%)	176.0 (85%)	18.6 (9%)	12.4 (6%)
ineligible	15.7	6.2	-	15.7 (100%)	-	-	15.7 (100%)
Cluster Systems							
eligible	936.0	-	795.6 (85%)	140.4 (15%)	795.6 (85%)	84.2 (9%)	56.2 (6%)
homeowner ineligible	0.9	9.9	-	0.9 (100%)	-	-	0.9 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,159.6	44.5	971.6	188.0	971.6	102.8	85.2

Table F-3. Governmental grants and local share costs for Alternative 4A (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	109.2	-	92.8 (85%)	16.4 (15%)	92.8 (85%)	9.8 (9%)	6.6 (6%)
ineligible	13.2	3.7	-	13.2 (100%)	-	-	13.2 (100%)
Cluster Systems							
eligible	453.5	-	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	6.5	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	412.3	-	309.2 (75%)	103.1 (25%)	309.2 (75%)	61.9 (15%)	41.2 (10%)
ineligible	388.0	7.6	-	308.0 (100%)	-	-	388.0 (100%)
homeowner ineligible	91.7	-	-	91.7 (100%)	-	-	91.7 (100%)
Centralized Treatment							
eligible	245.2	-	183.9 (75%)	61.3 (25%)	183.9 (75%)	36.8 (75%)	24.5 (10%)
ineligible	42.0	2.3	-	42.0 (100%)	-	-	42.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,755.2	48.5	971.4	783.8	971.4	149.3	634.5

Table F-4. Governmental grants and local share costs for Alternative 4B (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	109.2	-	92.8 (85%)	16.4 (15%)	92.8 (85%)	9.8 (9%)	6.6 (6%)
ineligible	13.2	3.7	-	13.2 (100%)	-	-	13.2 (100%)
Cluster Systems							
eligible	453.5	-	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	6.5	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	777.4	-	660.8 (85%)	116.6 (15%)	660.8 (85%)	70.0 (9%)	46.6 (6%)
ineligible	-	7.9	-	-	-	-	-
homeowner ineligible	1.3	-	-	1.3 (100%)	-	-	1.3 (100%)
Centralized Treatment							
eligible	245.2	-	183.9 (75%)	61.3 (25%)	183.9 (75%)	36.8 (15%)	24.5 (10%)
ineligible	42.0	2.3	-	42.0 (100%)	-	-	42.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,641.9	48.8	1,323.0	318.9	1,323.0	157.4	161.5

Table F-5. Governmental grants and local share costs for Alternative 4C (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	109.2	-	92.8 (85%)	16.4 (15%)	92.8 (85%)	9.8 (9%)	6.6 (6%)
ineligible	13.2	3.7	-	13.2 (100%)	-	-	13.2 (100%)
Cluster Systems							
eligible	453.5	-	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	6.5	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	752.9	-	640.0 (85%)	112.9 (15%)	640.0 (85%)	67.8 (9%)	45.1 (6%)
ineligible	-	6.8	-	-	-	-	-
homeowner ineligible	1.3	-	-	1.3 (100%)	-	-	1.3 (100%)
Centralized Treatment							
eligible	245.5	-	183.9 (75%)	61.3 (25%)	183.9 (75%)	36.8 (15%)	24.5 (10%)
ineligible	42.0	2.3	-	42.0 (100%)	-	-	42.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,617.4	47.7	1,302.2	315.2	1,302.2	155.2	160.0

Table F-6. Governmental grants and local share costs for Alternative 5A (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	109.2	-	92.8 (85%)	16.4 (15%)	92.8 (85%)	9.8 (9%)	6.6 (6%)
ineligible	13.2	3.7	-	13.2 (100%)	-	-	13.2 (100%)
Cluster Systems							
eligible	453.5	6.5	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	-	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	832.7	-	707.8 (85%)	124.9 (15%)	707.8 (85%)	74.9 (9%)	50.0 (6%)
ineligible	-	8.0	-	-	-	-	-
homeowner ineligible	1.3	-	-	1.3 (100%)	-	-	1.3 (100%)
Centralized Treatment							
eligible	244.9	-	208.2 (85%)	36.7 (15%)	208.2 (85%)	22.0 (9%)	14.7 (6%)
ineligible	-	9.7	-	-	-	-	-
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,654.9	56.3	1,394.3	260.6	1,394.3	147.5	113.1

Table F-7. Governmental grants and local share costs for Alternative 5B (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	109.2	-	92.8 (85%)	16.4 (15%)	92.8 (85%)	9.8 (9%)	6.6 (6%)
ineligible	13.2	3.7	-	13.2 (100%)	-	-	13.2 (100%)
Cluster Systems							
eligible	453.5	6.5	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	-	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	747.5	-	635.4 (85%)	112.1 (15%)	635.4 (85%)	67.3 (9%)	44.8 (6%)
ineligible	-	6.8	-	-	-	-	-
homeowner ineligible	1.3	-	-	1.3 (100%)	-	-	1.3 (100%)
Centralized Treatment							
eligible	244.9	-	208.2 (85%)	36.7 (15%)	208.2 (85%)	22.0 (9%)	14.7 (6%)
ineligible	-	9.7	-	-	-	-	-
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	1,569.7	55.1	1,321.9	247.8	1,321.9	139.9	107.9

Table F-8. Governmental grants and local share costs for Alternative 6A (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	66.2	-	56.3 (85%)	9.9 (15%)	56.3 (85%)	6.0 (9%)	3.9 (6%)
ineligible	7.0	1.9	-	7.0 (100%)	-	-	7.0 (100%)
Cluster Systems							
eligible	453.5	6.5	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	-	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	759.9	-	569.9 (75%)	190.0 (25%)	569.9 (75%)	114.0 (15%)	76.0 (10%)
ineligible	786.4	14.2	-	786.4 (100%)	-	-	786.4 (100%)
homeowner ineligible	156.6	-	-	156.6 (100%)	-	-	156.6 (100%)
Centralized Treatment							
eligible	311.2	-	233.4 (75%)	77.8 (25%)	233.4 (75%)	46.7 (15%)	31.1 (10%)
ineligible	66.0	3.0	-	66.0 (100%)	-	-	66.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	2,606.9	54.0	1,245.1	1,361.8	1,245.1	207.5	1,154.3

Table F-9. Governmental grants and local share costs for Alternative 6B (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	66.2	-	56.3 (85%)	9.9 (15%)	56.3 (85%)	6.0 (9%)	3.9 (6%)
ineligible	7.0	1.9	-	7.0 (100%)	-	-	7.0 (100%)
Cluster Systems							
eligible	453.5	6.5	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	-	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	1,520.1	-	1,292.1 (85%)	228.0 (15%)	1,292.1 (85%)	136.8 (9%)	91.2 (6%)
ineligible	-	14.7	-	-	-	-	-
homeowner ineligible	3.2	-	-	3.2 (100%)	-	-	3.2 (100%)
Centralized Treatment							
eligible	311.2	-	233.4 (75%)	77.8 (25%)	233.4 (75%)	46.7 (15%)	31.1 (10%)
ineligible	66.0	3.0	-	66.0 (100%)	-	-	66.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	2,427.3	54.5	1,967.3	460.0	1,967.3	230.3	229.7

Table F-10. Governmental grants and local share costs for Alternative 6C (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-Site Systems							
eligible	66.2	-	56.3 (85%)	9.9 (15%)	56.3 (85%)	6.0 (9%)	3.9 (6%)
ineligible	7.0	1.9	-	7.0 (100%)	-	-	7.0 (100%)
Cluster Systems							
eligible	453.5	6.5	385.5 (85%)	68.0 (15%)	385.5 (85%)	40.8 (9%)	27.2 (6%)
homeowner ineligible	0.1	-	-	0.1 (100%)	-	-	0.1 (100%)
Centralized Collection							
eligible	1,337.5	-	1,136.9 (85%)	200.6 (15%)	1,136.9 (85%)	120.4 (9%)	80.2 (6%)
ineligible	-	11.6	-	-	-	-	-
homeowner ineligible	3.2	-	-	3.2 (100%)	-	-	3.2 (100%)
Centralized Treatment							
eligible	311.2	-	233.4 (75%)	77.8 (25%)	233.4 (75%)	46.7 (15%)	31.1 (10%)
ineligible	66.0	3.0	-	66.0 (100%)	-	-	66.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	2,244.7	51.4	1,812.1	432.6	1,812.1	213.9	218.7

Table F-11. Governmental grants and local share costs for Alternative 7A (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	9.6	-	8.2 (85%)	1.4 (15%)	8.2 (85%)	0.9 (9%)	0.5 (6%)
ineligible	4.9	0.4	-	4.9 (100%)	-	-	4.9 (100%)
Centralized Collection							
eligible	2,503.9	-	1,877.9 (75%)	626.0 (25%)	1,879.9 (75%)	375.6 (15%)	250.4 (10%)
ineligible	1,344.9	30.9	-	1,344.9 (100%)	-	-	1,344.9 (100%)
homeowner ineligible	3.6	-	-	3.6 (100%)	-	-	3.6 (100%)
Centralized Treatment							
eligible	544.4	-	408.2 (75%)	136.1 (25%)	408.2 (75%)	81.6 (15%)	54.5 (10%)
ineligible	144.0	11.5	-	144.0 (100%)	-	-	144.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	4,555.2	71.2	2,294.3	2,260.9	2,294.3	458.1	1,802.8

Table F-12. Governmental grants and local share costs for Alternative 7B (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	9.6	-	8.2 (85%)	1.4 (15%)	8.2 (85%)	0.9 (9%)	0.5 (6%)
ineligible	4.9	0.4	-	4.9 (100%)	-	-	4.9 (100%)
Centralized Collection							
eligible	3,475.5	-	2,954.2 (85%)	521.3 (15%)	2,954.2 (85%)	312.8 (9%)	208.5 (6%)
ineligible	-	32.4	-	-	-	-	-
homeowner ineligible	5.9	-	-	5.9 (100%)	-	-	5.9 (100%)
Centralized Treatment							
eligible	544.3	-	408.2 (75%)	136.1 (25%)	408.2 (75%)	81.6 (15%)	54.5 (10%)
ineligible	144.0	11.5	-	144.0 (100%)	-	-	144.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	4,184.2	72.4	3,370.6	813.6	3,370.6	395.3	418.3

Table F-13. Governmental grants and local share costs for Alternative 7C (costs stated in 1000's of dollars followed in parenthesis by the percentage share of capital costs).

System Component	Total Estimated Capital Cost	Annual O&M (Local Cost)	USEPA Grant		USEPA Grant & State Grant		
			Federal	Local	Federal	State	Local
On-site Systems							
eligible	9.6	-	8.2 (85%)	1.4 (15%)	8.2 (85%)	0.9 (9%)	0.5 (6%)
ineligible	4.9	0.4	-	4.9 (100%)	-	-	4.9 (100%)
Centralized Collection							
eligible	3,276.7	-	2,785.2 (85%)	491.5 (15%)	2,785.2 (85%)	294.9 (9%)	196.6 (6%)
ineligible	-	32.9	-	-	-	-	-
homeowner ineligible	5.9	-	-	5.9 (100%)	-	-	5.9 (100%)
Centralized Treatment							
eligible	544.3	-	408.2 (75%)	136.1 (25%)	408.2 (75%)	81.6 (15%)	54.5 (10%)
ineligible	144.0	11.5	-	144.0 (100%)	-	-	144.0 (100%)
Administrative							
ineligible	-	28.4	-	-	-	-	-
Total	3,985.4	73.2	3,201.5	783.9	3,201.6	377.4	406.4

Table F-14. Average annual residential user costs with Federal and State grants.

Alternative	Cost ($1,000x) Capital costs	Federal Share	State Share	Local Share	Annual Equivalent of Local Share[1]	Annual O & M[2]	Annual Cost to Local Residents	1980 Residences Served[3]	Average Annual Cost per Residence	Average Annual Cost per Residence
2	291.5	223.3	23.6	44.6	4.7	38.7	43.4	286	12.64	151.68
3	1,159.6	971.6	102.8	85.2	8.9	44.5	53.4	301	14.79	177.48
4A	1,755.2	971.4	149.3	634.5	66.4	48.5	114.9	309	31.00	372.00
4B	1,641.9	1,323.0	157.4	161.5	16.9	48.8	65.7	309	17.72	212.64
4C	1,617.4	1,302.2	155.2	160.0	16.8	47.7	64.5	309	17.38	208.56
5A	1,654.9	1,394.3	147.5	113.1	11.8	56.3	68.1	309	18.38	220.56
5B	1,569.7	1,321.9	139.9	107.9	11.3	55.1	66.4	309	17.91	214.92
6A	2,606.9	1,245.1	207.5	1,154.3	120.9	54.0	174.9	335	43.50	522.00
6B	2,427.3	1,967.3	230.3	229.7	24.1	54.5	78.6	335	19.54	234.48
6C	2,244.7	1,812.1	213.9	218.7	22.9	51.4	74.3	335	18.48	221.76
7A	4,555.2	2,294.3	458.1	1,802.8	189.8	71.2	260.0	390	55.55	666.60
7B	4,184.2	3,370.6	395.3	418.3	43.8	72.4	116.2	390	24.83	297.96
7C	3,985.4	3,201.5	377.4	406.4	42.6	73.2	115.8	390	24.73	296.76

[1] Local share is amortized at 8 3/8% interest at 20 years (0.10471)

[2] Includes administrative costs

[3] See Table 2-22

Table F-15. Average annual residential user costs with Federal grant only.

Alternative	Capital costs	Federal Share	Local Share	Annual Equivalent of Local Share[1]	Annual O & M[2]	Annual Cost to Local Residents	1980 Residences Served[3]	Average Annual Cost per Residence	Average Annual Cost per Residence
	Cost ($1,000x)								
2	291.5	223.3	68.2	7.1	38.7	45.8	286	13.36	160.32
3	1,159.6	971.6	188.0	19.7	44.5	64.2	301	17.77	213.24
4A	1,755.2	971.4	783.8	82.1	48.5	130.6	309	35.21	422.52
4B	1,641.9	1,323.0	318.9	33.4	48.8	82.2	309	22.17	266.04
4C	1,617.4	1,302.2	315.2	33.0	47.7	80.7	309	21.75	261.00
5A	1,654.9	1,394.3	260.6	27.3	56.3	83.6	309	22.54	270.48
5B	1,569.7	1,321.9	247.8	26.0	55.1	81.1	309	21.86	262.32
6A	2,609.9	1,245.1	1,361.8	142.6	54.0	196.6	335	48.90	586.80
6B	2,427.3	1,967.3	460.0	48.2	54.5	102.7	335	25.54	306.48
6C	2,244.7	1,812.1	432.6	45.3	51.4	96.7	335	24.05	288.60
7A	4,555.2	2,294.3	2,260.9	236.7	71.2	307.9	390	65.80	789.60
7B	4,184.2	3,370.6	813.6	85.2	72.4	157.6	390	33.67	404.04
7C	3,985.4	3,201.5	783.9	82.1	73.2	155.3	390	33.18	398.16

[1] Local share is amortized at 8 3/8% interest for 20 years (0.10471)

[2] Includes administrative costs

[3] See Table 2-22

Table F-16. Average annual residential user costs without any governmental grants.

Alternative	Cost ($1,000x) Capital Costs	Annual Equivalent of Local Share[1]	Annual O & M[2]	Annual Cost to Local Residents	1980 Residences Served[3]	Average Monthly Cost per Residence	Average Annual Cost per Residence[2]
2	291.5	30.5	38.7	69.2	286	20.17	242.04
3	1,159.6	121.4	44.5	165.9	301	45.94	551.28
4A	1,755.2	183.8	48.5	232.3	309	62.64	751.68
4B	1,641.9	171.9	48.8	220.7	309	59.53	714.36
4C	1,617.4	169.4	47.7	217.1	309	58.54	702.49
5A	1,654.9	173.3	56.3	229.6	309	61.92	743.03
5B	1,569.7	164.4	55.1	219.5	309	59.19	710.28
6A	2,609.9	273.3	54.0	327.3	335	81.41	976.92
6B	2,427.3	254.2	54.5	308.7	335	76.78	921.36
6C	2,244.7	235.0	51.4	286.4	335	71.25	855.00
7A	4,555.2	477.0	71.2	548.2	390	117.13	1,405.56
7B	4,184.2	438.1	72.4	510.5	390	109.09	1,309.08
7C	3,985.4	417.3	73.2	490.5	390	104.81	1,257.72

[1] Local share is amortized at 8 3/8% interest for 20 years (0.10471).

[2] Includes administrative costs

[3] See Table 2-22.

Appendix G

Impacts of On-site Wastewater

Treatment Systems on Soils

IMPACTS ON SOILS

The application of septic tank effluent to soil in the operation of the cluster drainfields (Alternatives 3 through 6) and on-site systems (alternatives 2 through 7) will have an impact on the amount of prosphorus and nitrogen in the soil.

Phosphorus would be present in septic tank effluent in an inorganic form as orthophosphate (primarily HPO_4-2), as polyphosphates (or condensed phosphates), and as organic phosphate compounds. Because the pH is alkaline, the predominant form usually is orthophosphate (USEPA 1976). Polyphosphate is converted quickly to orthophosphate in conventional wastewater treatment, in soil, or in water. Dissolved organic phosphorus is converted more slowly (day to weeks) to orthophosphate.

When septic tank effluent is applied to soils, dissolved inorganic phosphorus (orthophosphate) may be adsorbed by the iron, aluminum, and/or calcium compounds, or may be precipitated through with soluble iron, aluminum, and calcium. Because it is difficult to distinguish between adsorption and precipitation reactions, the term "sorption" is utilized to refer to the removal of phosphorus by both processes (USEPA and others 1977). The degree to which phosphorus is sorbed in soil depends on its concentration, soil pH, temperature, time, total loading, and the concentration of other wastewater constituents that directly react with phosphorus, or that affect soil pH and oxidation-reductions (USEPA and others 1977).

The phosphorus in the absorbed phase in soil exists in equilibrium with the concentration of dissolved soil phosphorus (USEPA and others 1977). As an increasing amount of existing adsorptive capacity is used, such as when wastewater enriched with phosphorus is applied, the dissolved phosphorus concentration of phosphorus in the percolate, and thus in the groundwater or in the recovered underdrainage water.

Eventually, adsorbed phosphorus is transformed into a crystalline-mineral state, re-establishing the adsorptive capacity of the soil. This transformation may occur slowly, requiring from months to years. However, work by various researchers indicate that as much as 100% of the original adsorptive capacity may be recovered in as little as 3 months. In some instances it may take years for the adsorptive capacity to fully recover because the active cations may become increasingly bound in the crystalline form. The possible amount of phosphorus that could precipitate to the crystalline form, based on a 2% to 4$ iron and 5% to 7.5% aluminum soil content, is estimated to be 250,000 pounds of phosphorus per acre-foot of soil (Ellis and Erickson 1969).

Dissolved organic phosphorus can move quickly through permeable soils. Adequate retention of the wastewater in the unsaturated soil zone is necessary to allow enough time for the organic phosphorus to be hydrolized by microorganisms to the orthophosphate form. In the orthophosphate form, it then can be adsorbed.

Nitrogen loadings in the septic tank effluent are of greatest concern because of the potential for well contamination by nitrates. Nitrogen would be present in applied wastewater principally in the form of ammonium (NH_4) and organic nitrogen. When septic tank effluent is applied to soils, the natural supply of soil nitrogen is increased. As in the natural processes, most added organic nitrogen slowly is converted to ionized ammonia by microbial action in the soil. This form of nitrogen, and any ionized ammonia in the effluent, is adsorbed by soil particles.

Plants and soil microbes both utilize ammonium directly. Microbes oxidize ammonium to nitrite (NO_2) that is quickly converted to the nitrate (NO_3) from through nitrification. Nitrate is highly soluble and is utilized by plants, or leached from the soil into the groundwater. Under anaerobic conditions (in the absence of oxygen), soil nitrate can be reduced by soil microbes to gaseous nitrogen forms (denitrification). These gaseous forms move upward through the soil atmosphere and are dissipated into the air. Denitrification depends on organic carbon for an energy source; thus, the interface between natural soil and the gravel fill in a drain bed has both requisite characteristics for denitrification.

Unlike phosphorus, nitrogen is not stored in soil except in organic matter. Organic matter increases within the soil would result from increased microbial action and from decreased oxidation. The increased organic matter improves the soil tilth (workability), water holding capacity, and capability of retaining plant nutrients.

Appendix H

Excerpts from the Report on Algae

Excerpts from the Report on Algae (USEPA 1982).

Excerpts were taken from the Report on Algae to provide summaries and conclusions regarding the major topical areas covered. The full Report on Algae was originally published and distributed by USEPA Region V in January of 1982. This report was prepared as a supporting technical reference document for the Environmental Impact Statement on the Moose Lake-Windemere Sanitary District's proposed wastewater treatment system. Complete copies of the Report on Algae are available from the Project Monitor.

2.3.5. Summary of Blue-Green Algal Toxicity

Three genera of freshwater blue-green algae, *Anacystis*, *Anabaena* and *Aphanizomenon*, are most commonly associated with toxin production and have been reported to produce several different types of toxins. The toxicological and pharmacological properties of the toxins as well as their chemical identities are not well understood. In addition, very little is currently known about the physiological and/or ecological factors and interactions that lead to toxic episodes.

There is well documented evidence, however, that blue-green algae can produce toxic effects in animals and livestock. Livestock and wildlife poisonings occur most frequently in lakes, reservoirs, and ponds in temperate climates. Toxic blooms usually occur between late spring and early autumn. Toxic effects in animals can occur only through ingestion of contaminated water. A variety of toxic effects have been documented in the laboratory and from observations of livestock and wildlife populations and include convulsions, gastrointestinal disorders, respiratory disorders, liver failure, and death. There are, however, no documented or reported cases of human mortality associated with toxic strains of freshwater blue-green algae.

Although more than 12 species belonging to 9 genera of freshwater cyanophytes have been implicated in cases of animal poisoning, toxic strains of the three most common bloom forming species, *Microcystis aeruginosa*, *Anabaena* flos-aque, and Aphanizomenon flos-aque have been responsible for the majority of the documented episodes. (In the literature, Anacystis is used synonymosly with the genus Microcystis.) The poisonings attributable to Anabaena flos-aque have been more dramatic in terms of the number of animals affected, but toxic strains of Microcystis aeruginosa appear to be more widely distributed geographically.

To date, twelve different toxins have been identified from strains and/or blooms of the three most common toxigenic species. The toxins differ in their reaction time and their chemical structure. Several of the toxins are very fast-acting and are suspected of being alkaloids. Some have a pronounced latent period following ingestion and are suspected of being peptides. The available evidence also indicates that a single bloom may contain several different toxins simultaneously.

Investigations into the nature and occurrence of toxic blooms of blue-green algae indicate that such blooms have a highly variable and mosaic nature. The development of toxic blooms is unpredictable and usually occurs in short-lived pulses. They infrequently recur in the same body of water in subsequent years. The fact that bloom toxicity is so varied and unpredictable makes any bloom potentially dangerous and suspect at all times, even though the majority are actually nontoxic.

There have been several documented episodes of toxic blue-green algae blooms in southern Minnesota. Toxic blooms are rare, however, in the northern part of the state.

3.3. Summary of the Causes of Swimmers' Itch

Swimmers' itch can be cercarial related or blue-green algae related. Man is not a host or "carrier" of the schistosome which causes the cercarial dermatitus form of swimmers itch. Therefore human waste (excrement) can not be responsible for the presence of this more severe type of swimmers' itch. However, the blue-green algae blooms which are responsible for the less serious form of dermatitus can in part be caused by an influx of nutrients from human waste.

4.0. PHYTOPLANKTON COMMUNITY STRUCTURE AND EVIDENCE OF PUBLIC HEALTH PROBLEMS: MOOSE LAKE, MINNESOTA

Four lakes in the Moose Lake-Windermere Sanitary District were investigated to gather baseline information on phytoplankton community structure and on existing water quality. The objective of this investigation was to evaluate the relative abundance of blue-green algae in the four lakes and to assess potential problems associated with blooms of blue-green algae. A secondary purpose was to determine if cercarial dermititus (swimmers' itch) is a problem in the Moose Lake area. The Moose Lake-Windermere Sanitary District is located in eastern Minnesota between Minneapolis and Duluth. The four lakes that were studied are Island, Sturgeon, Rush, and Passenger Lakes (Figure 4-1).

The description and evaluation of the phytoplankton community structure was based on lake sampling and water quality data analysis. Information on blue-green toxicity events and swimmers' itch outbreaks was gathered in interviews with local physicians and veterinarians as well as with state health officials.

4.1. Phytoplankton Community Structure

4.1.1. Description of Phytoplankton Community Structure

Phytoplankton community structure is determined primarily through interactions involving physical-chemical factors, zooplankton, and fish. Typically, the dominance of a phytoplankton community by a particular species will shift during the course of a year. That is, a particular phytoplankton species may form the greatest proportion of the algal community biomass (weight of living matter) only at certain times of the year when the interactions taking place within the water body favor that particular phytoplankton. As the aquatic ecosystem changes during the year, numerous interactions occur that may, in sequence, favor other phytoplankton. For example, in eutrophic lakes diatoms may be the dominant phytoplankton in the spring because they are favored by high silicate concentrations, high light peneration, and cool water temperatures present at that time of the year. In early summer as silicate

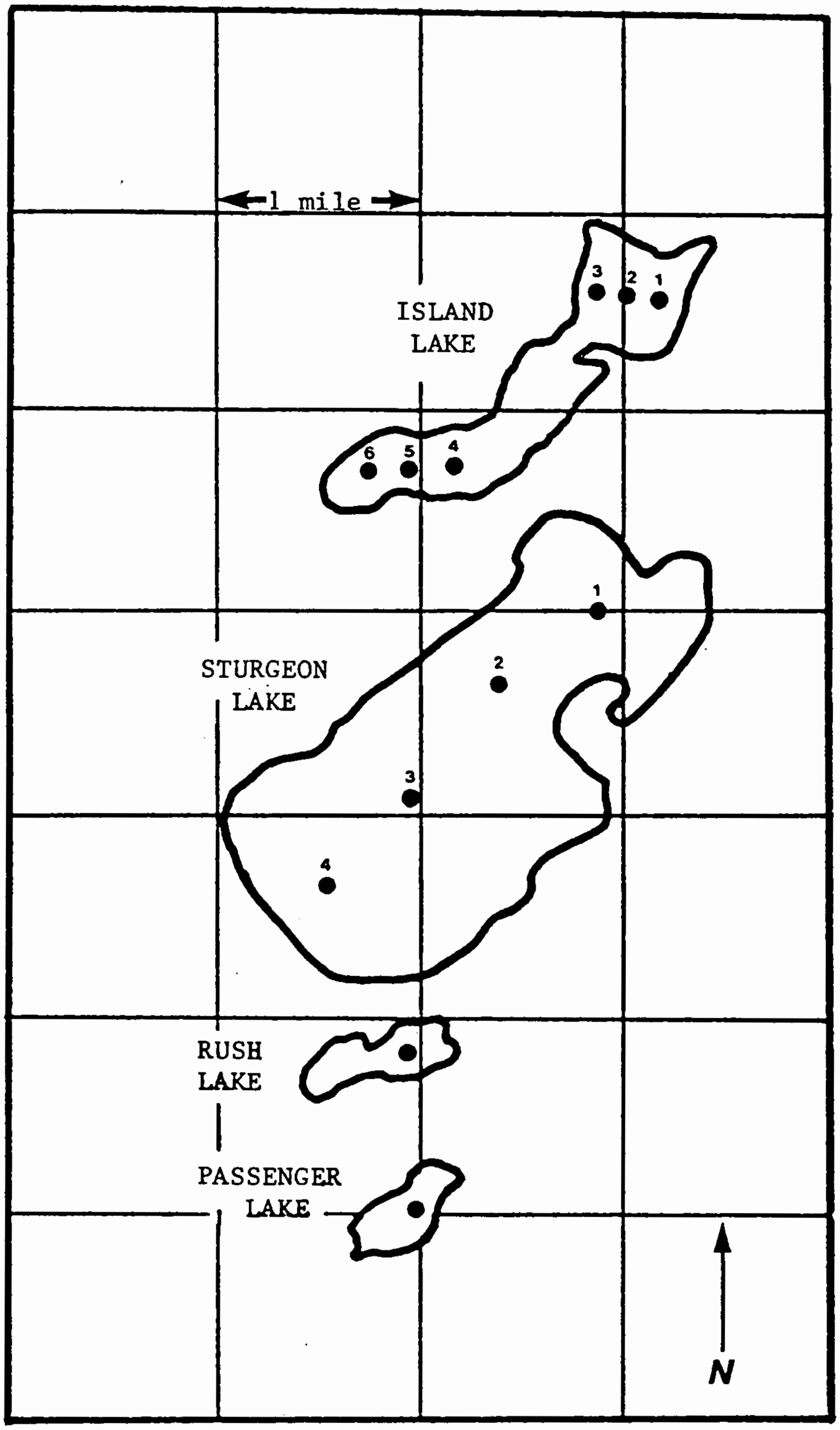

Figure 4-1. Locations of mid-lake sampling stations for phytoplankton, nutrient, temperature, dissolved oxygen and chlorophyll data.

concentrations decrease, green algae may become dominant because of increased water temperatures and increased nutrient availability. As water temperature reaches the late summer peak, and as dissolved nitrate levels decrease following uptake by green algae and by rooted aquatic plants, blue-green algae may become dominant. In late summer blue-green algae hold an advantage over other algal species when levels of phosphorous are high compared to nitrogen because blue-greens alone can fix atmospheric nitrogen into a useful nutrient form. In addition, blue-green algae use their unique gas vacuoles to remain in position at the water surface and take advantage of the diminished sunlight as well as shade out other algae found deeper in the water column.

Algal groups such as blue-greens, diatoms, or greens are characterized as dominant based on biovolume measurements micrometers cubed per milliliter ($\mu m^3/ml$). Biovolume is a parameter which generally reflects biomass. It is expressed in this Report as a volume of plankton per unit volume of water and is therefore indicative of visible accumulations of living matter.

Phytoplankton samples were collected from Island Lake (6 stations) and Sturgeon Lake (4 stations) on four sampling dates during late summer and early autumn. Passenger and Rush Lakes were sampled on three dates during the same period at one station in the middle of each the lakes. Phytoplankton samples were taken in each instance at one meter below the surface, at mid-depth, and at one meter from the bottom. The sampling station locations are shown in Figure 4-1. Algal identification was taken at least to the genus level and to the species level where possible. Phytoplankton dimensional measurements were made of the most numerous phytoplankton species found. Measurements for other less numerous phytoplanktons were taken from unpublished species lists for Minnesota lakes (by letter, Nancy Holm, Limnological Research Center, University of Minnesota) and from Wetzel (1975). The list of phytoplankton volumes used to calculate biovolumes in this investigation is included in Appendix A-3. Chlorophyll a samples were collected concurrent with phytoplankton sampling on two dates at the same sample locations and depths. Secchi disk depth was measured at all sample sites and on all sample dates.

Island Lake

Phytoplankton biovolume (abundance) and the percent composition (dominance) of major phytoplankton groups for Island Lake at the surface, mid-depth, and bottom depths are depicted in Figure 4-2. From 26 August to September 9 there was an overall decrease in algal density and a dramatic shift in algal dominance. The decrease in algal density was due primarily to the decline of the large dinoflagellate, Ceratium hirundinella, which had an estimated volume of 75,000 um^3 per organism. Over this same time period a large blue-green species, Anabaena macrospora (45,000 μm^3 per organism) and another blue-green, Aphanizomenon flos-aquae (2800 μm^3 per organism) grew in number while a smaller blue-green, Phormidium mucicola (10 μm^3 per organism) decreased in number. Thus, although the total blue-green algae cell number per ml remained relatively constant from 26 August to 9 September, because of the shift from small blue-green algae species to large-sized blue-green algae species and declines in other phytoplankton (the dinoflagellates declined from 77% to less than 1% of the phytoplankton biovolume), blue-green algae increased from 16% to 94% of the total phytoplankton biovolume. For the remainder of September, blue-greens were dominant in Island Lake, with the blue-green abundance reaching a peak around the September 14 sampling date (Table 4-1).

Throughout the sampling period (26 August to October 5) Island Lake consistently had the highest phytoplankton density of the four lakes investigated. High blue-green algal and other phytoplankton densities in Island Lake also contributed to poor water clarity. Island Lake had the lowest Secchi disk readings of the four lakes. The changes in the average Island Lake Secchi disk readings were followed closely by the changes in phytoplankton abundance (Figure 4-3a and b).

Sturgeon Lake

Changes in phytoplankton abundance and dominance in the water column for the four Sturgeon Lake sampling dates are shown in Figure 4-4. The total phytoplankton biovolume in Sturgeon Lake was lower than in Island Lake but blue-green algae were still the dominant phytoplankton group throughout the month of September. The dominant blue-green species was Anacystis spp. Diatoms were an important component of the phytoplankton community in Sturgeon Lake on all four sampling dates and were found at all depths but never accounted for more than 24% of the phytoplankton biovolume. Based on Secchi disk readings, water clarity was observed to be much greater in Sturgeon Lake than in Island Lake (Figure 4-3a).

ISLAND LAKE

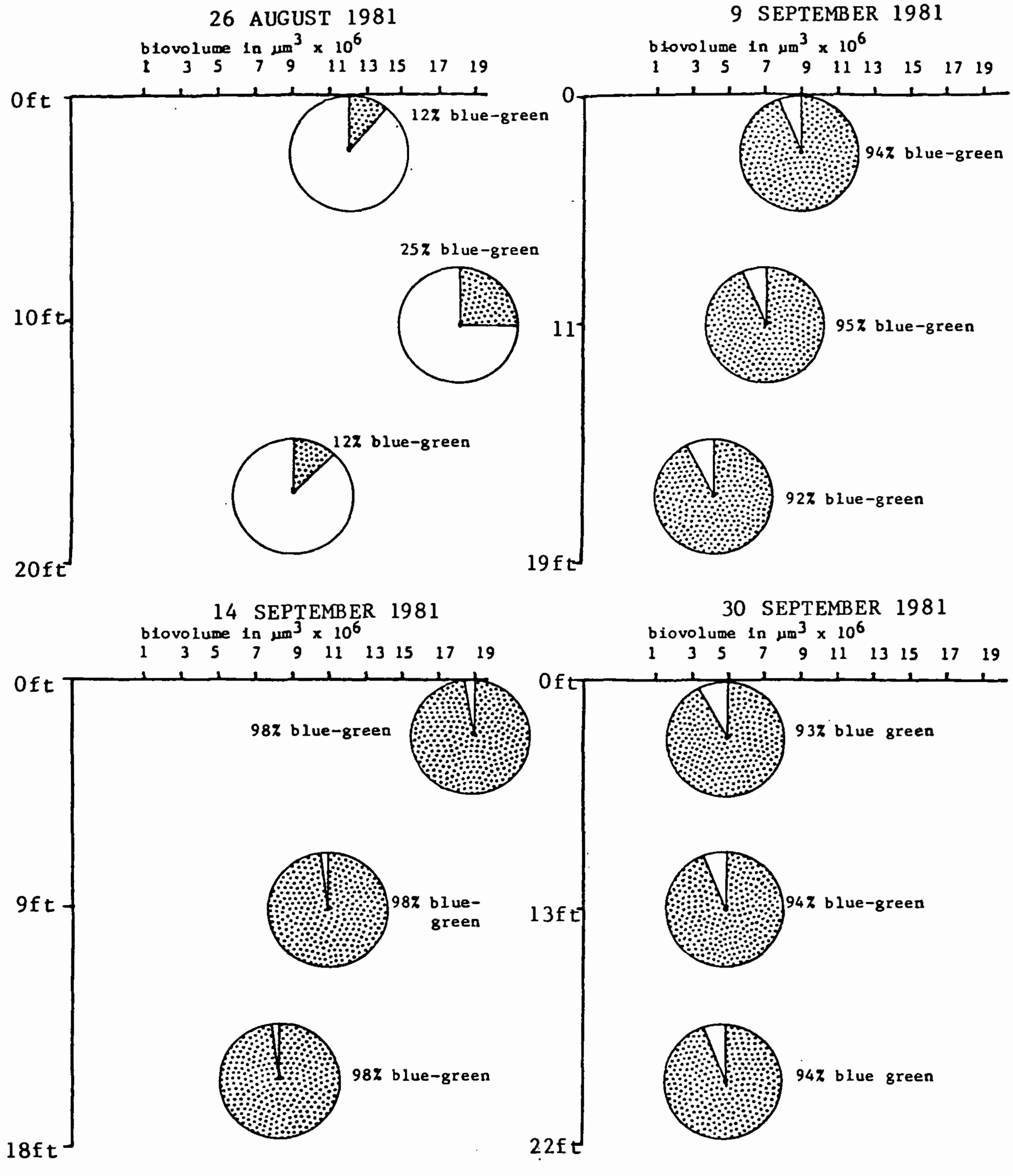

Figure 4-2. Abundance and dominance of major phytoplankton forms based on biovolume data. Derived from plankton counts made on samples taken from Island Lake on four sampling dates. Depths of samples are approximately as shown.

Table 4-1. Blue-green algal biovolumes ($\mu m^3 \times 10^4$/ml) of four lakes in the Moose Lake area and four lakes from southern Minnesota (the Minneapolis-St. Paul area). Blue-green algae genera listed are those most commonly associated with incidences of blue-green algae toxicity in North America.

Location/ Date	*Anabaena* spp.	*Anacystis* spp.	*Aphanizomenon flos-aquae*	Sampling Depth
Island Lake				
26 August 1981	61	17	67	Surface
9 September 1981	671	7	169	
14 September 1981	1336	11	466	
30 September 1981	92	8	358	
Sturgeon Lake				
27 August 1981	30	58	0	Surface
9 September 1981	41	102	1	
15 September 1981	74	66	0	
5 October 1981	30	48	1	
Passenger Lake				
10 September 1981	0	18	0	Surface
15 September 1981	14	14	0	
1 October 1981	5	2	0	
Rush Lake				
10 September 1981	30	0	0	Surface
15 September 1981	27	24	0	
1 October 1981	0	4	0	
Cedar Lake, MN				
9 September 1974	14	2	169	2 meters
Lake Harriet, MN				
22 July 1974	41	2	297	2 meters
Lake of the Isles, MN				
22 July 1974	476	2	460	Surface
Lake Calhoun, MN				
26 August 1974	232	0	544	Surface

WATER CLARITY
(SECCHI DISK MEASUREMENTS)

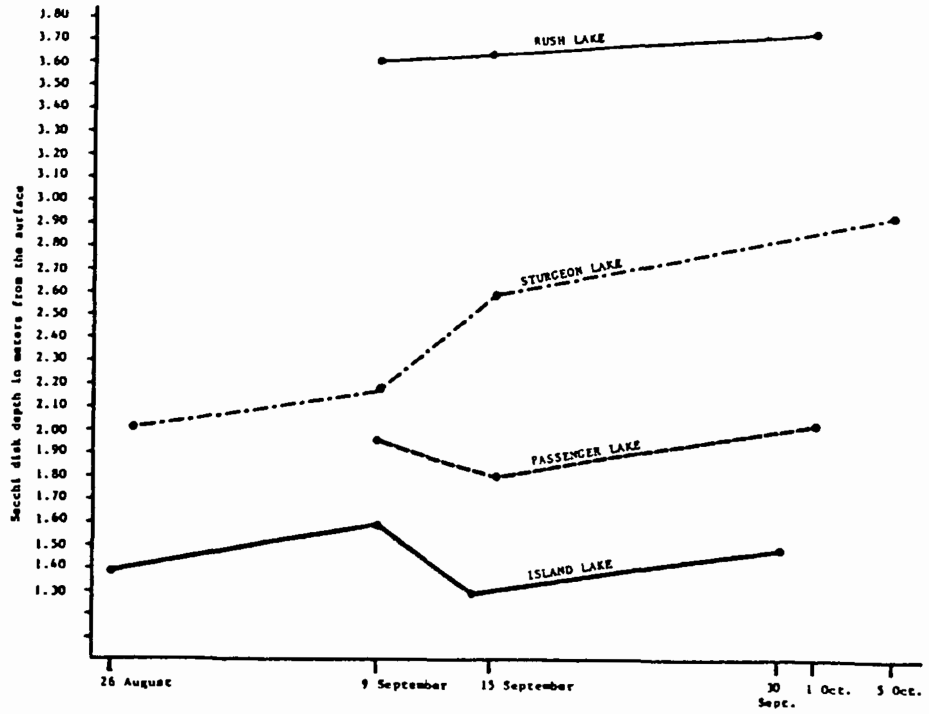

Figure 4-3a. Average Secchi disk values for the project area lakes versus time. Data are from 1981 field surveys.

PHYTOPLANKTON ABUNDANCE
(BIO-VOLUME ESTIMATES FROM CELL COUNTS)

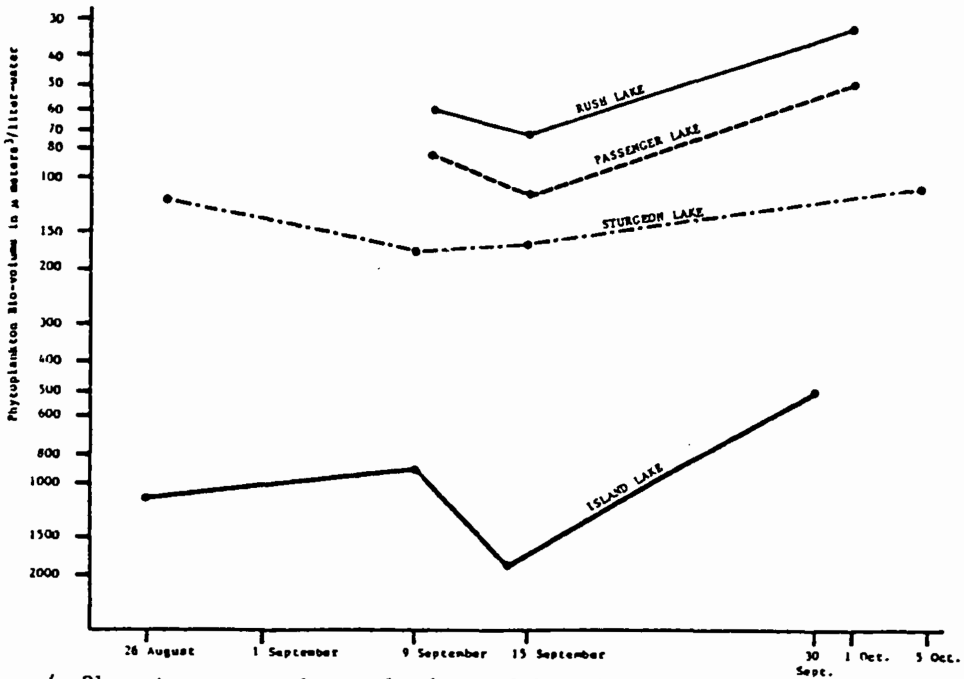

Figure 4-3b. Average phytoplankton biovolumes for the project area lakes versus time. Plotted data are representative of the photic zones of the lakes, as only samples from just below the surface of the water were taken into the averages.

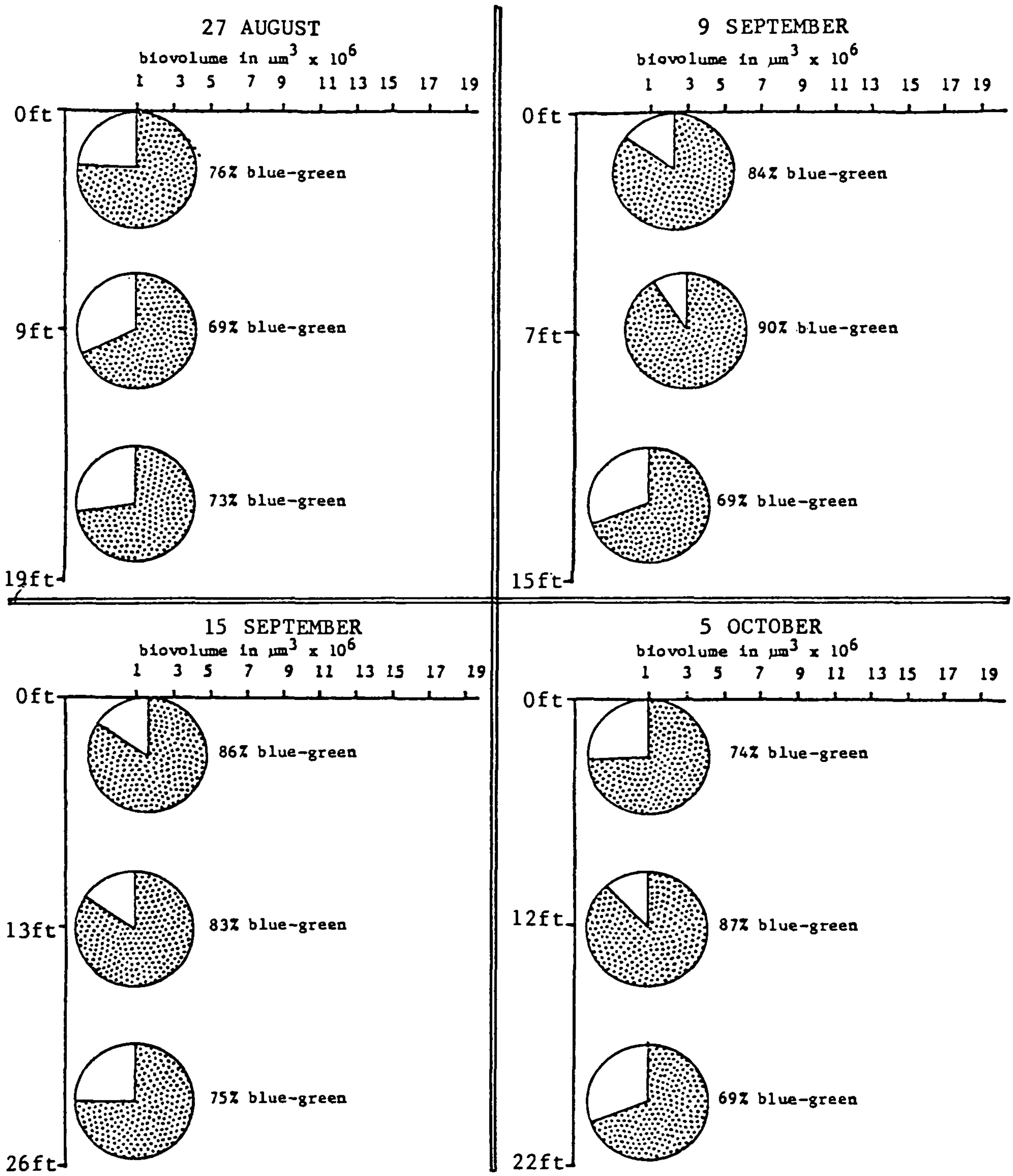

Figure 4-4. Abundance and dominance of major phytoplankton forms based on biovolume data. Derived from plankton counts made on samples taken from Sturgeon Lake on four sampling dates. Depths of samples are approximately as shown.

Passenger Lake

Passenger Lake had low phytoplankton biovolumes (Figures 4-3b and 4-5) and low blue-green algae biovolumes (Table 4-1) compared to Island and Sturgeon Lakes. Although Passenger Lake had the highest cell count per milliliter of all four lakes (Appendix A) the phytoplankton that accounted for these high numbers (Ochromonas spp; 4500 cells/ml) was a small golden-brown algae (40 μm^3 per organism). For the three sampling dates, two phytoplankton groups were dominant, the golden-brown algae and the cryptomonads. Based on the the findings of lower biovolumes in Passenger Lake than in Sturgeon Lake, deeper Secchi disk readings in Passenger Lake would be expected. This was not observed (Figure 4-3a). The lower (shallow) Secchi disk readings in Passenger Lake may have been due to increased light scattering caused by the high number of phytoplankton cells, by color due to dissolved organics, by suspended solids brought into the photic zone (surface layer) from bottom sediment resuspension, or by sediments carried into the Lake from the surrounding watershed.

Rush Lake

Rush Lake had the lowest phytoplankton abundance (Appendix A-2), and had blue-green biovolumes similar to Passenger Lake. Consequently, a relatively small blue-green biovolume could dominate the overall phytoplankton community (Figure 4-6). Other groups that were important in terms of the the biovolume percentages of Rush Lake included cryptonomads and dinoflagellates. Cell sizes in the phytoplankton samples were small (less than 1000 μm^3 per organism) except for the dinoflagellate, Ceratium hirundinella. Large phytoplankton can have a significant impact on biomass concentrations even at low densities. For example, in the 10 September mid-depth sample the total cell density was 748 cells/ml, and although Ceratium was found at only 5 cells/ml, it represented 38% of the total phytoplankton biomass (Appendix A-1 and Figure 4-5). The low phytoplankton biovolumes in Rush Lake are associated with the highest (deepest) Secchi disk readings of the four lakes investigated. Based on the survey data of September 1981 it appears Rush Lake had the greatest water clarity of the four studied lakes (Figure 4-3a).

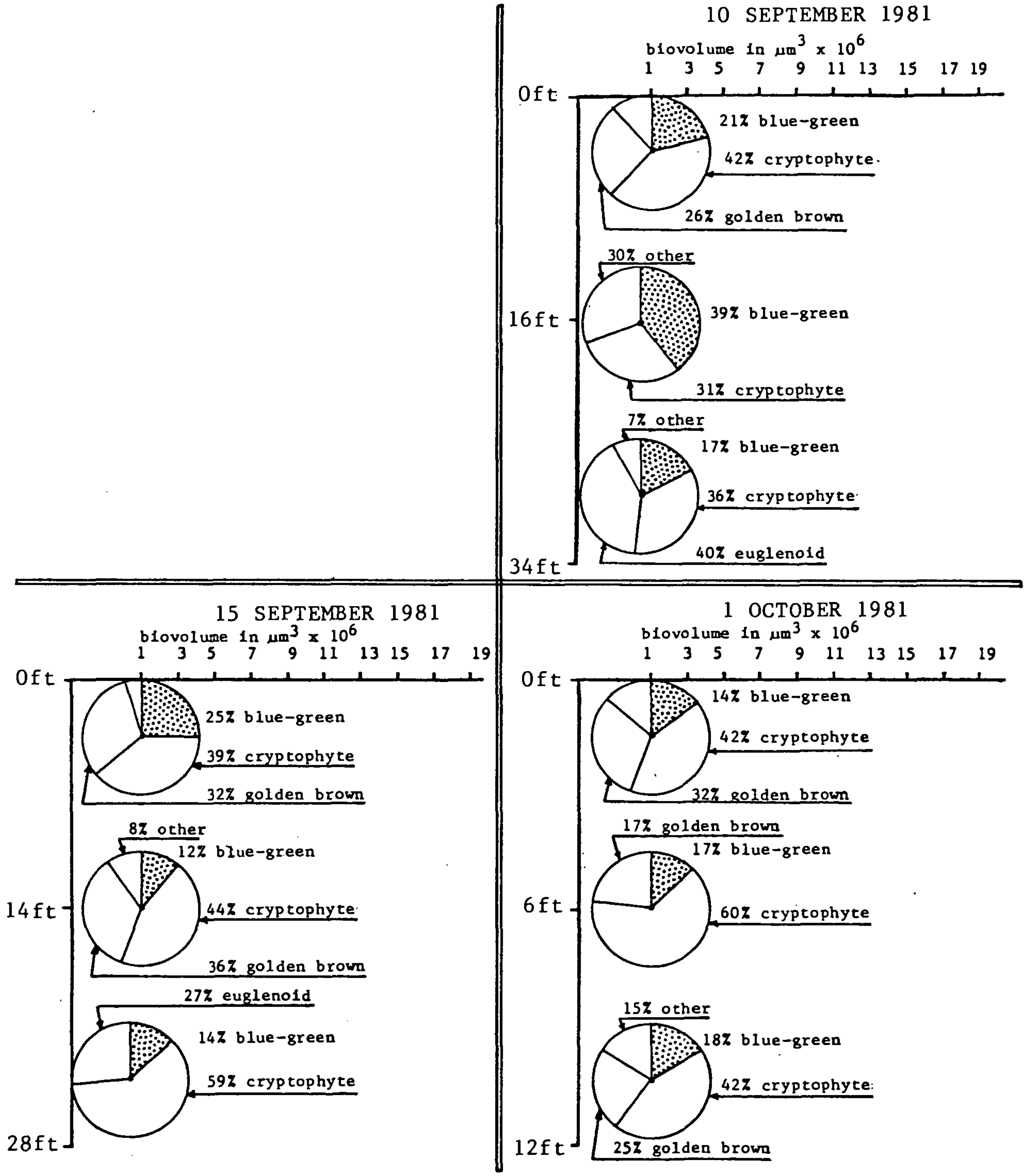

Figure 4-5. Abundance and dominance of major phytoplankton forms based on biovolume data. Derived from plankton counts made on samples taken from Passenger Lake on three sampling dates. Depths of samples are approximately as shown.

RUSH LAKE

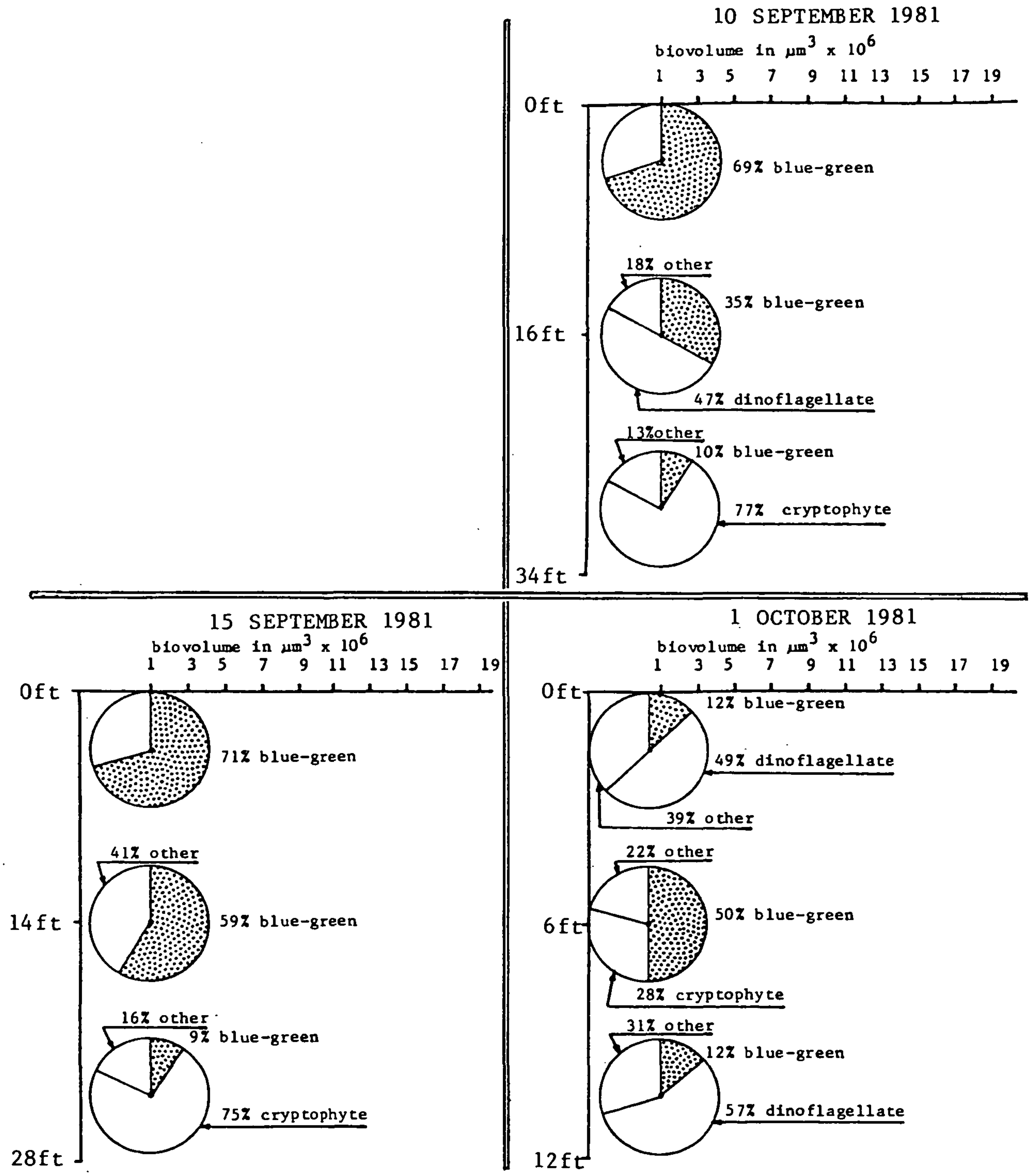

Figure 4-6. Abundance and dominance of major phytoplankton forms based on biovolume data. Derived from phytoplankton counts made on samples taken from Rush Lake on three sampling dates. Depths of samples are approximately as shown.

Chlorophyll a was another parameter measured in the four lakes. Chlorophyll a is a general indicator of the total phytoplankton biomass but does not differentiate between specific groups and does not always correlate well to water clarity. Table 4-2 lists chlorophyll a concentrations for the 8 September and 15 September sampling dates. In general, chlorophyll a concentrations in Island Lake samples were higher than in Sturgeon, Rush, or Passenger Lake samples. Higher chlorophyll a concentrations may also have resulted in the observed green appearance of Island Lake's water compared to the other three lakes. This characteristic has been reported by a number of lakeside residents and may be enhanced by the presence in Island Lake of suspended clay matter which scatters (back-reflects) light. The presence of clayey soils in the watershed of Island Lake is discussed in Section 4.1.2. below.

Table 4-2. Chlorophyll a concentrations (μg/l) for Island, Sturgeon, Passenger, and Rush Lakes.

	SEPTEMBER 8			SEPTEMBER 15		
	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Island						
Is-1	37	34	28	19	45	26
Is-2	28	26	19	30	--	12
Is-3	28	33	24	39	33	28
Is-4	32	24	8	9	32	22
Is-5	32	28	14	26	40	6
Is-6	36	29	21	29	20	16
Sturgeon						
St-1	10	11	10	8	8	9
St-2	3	9	11	10	7	13
St-3	9	8	9	8	8	8
St-4	8	8	7	9	14	8
Passenger	11	6	28	10	7	53
Rush	20	10	4	5	16	13

4.2. Physician and Veterinarian Interview Report

A survey of medical practitioners was conducted to determine whether any human, pet or livestock health problems had been diagnosed in the drainage areas of Island, Sturgeon, Passenger or Rush Lakes since 1979. Personal and telephone interviews were conducted with local medical and veterinary clinics; state, county, and local health and water agencies; and experts. All respondents were asked to consult their records and to poll their staffs on medical problems that might be attributed to water pollution in the study area. They were requested to document cases involving toxic effects attributable to blue-green algae, bacterial and viral infections, and outbreaks of cercarial dermatitus (swimmers' itch). An explanation of symptoms exhibited by humans, pets and livestock after exposure to toxic strains of blue-green algae, and of swimmers' itch was provided to all survey participants. A phone number was left with each respondant and they were encouraged to contact USEPA if they wished to provide additional information.

None of the agencies, clinics, or experts polled had records of or were aware of any medical problems associated with water contaminated by blue-green algae, or due to the presence of bacteria or virus originating from human waste in the study area (Table 4-4).

The Minnesota Department of Natural Resources' (MDNR) Water Monitoring and Control Unit (WMCU) is responsible for issuing permits for applying copper sulfate to provide emergency control of cercarial dermatitus (swimmers' itch), rooted aquatic plants and phytoplankton growth. No permits have been issued for copper sulfate applications on Island, Sturgeon, Passenger or Rush Lakes during the past twenty years (By telephone, Howard Krosch, Supervisor WMCU, MDNR 10 November 1981).

Instances of animal illness or death attributed to blue-green algae are rare in the northern portion of the state of Minnesota. Occasional toxic blue green algae blooms have been recorded in southern and western Minnesota, typically reappearing in two to three year intervals (By telephone, Howard Krosch, WMCU, MDNR 18 November 1981). There have been no documented domestic animal deaths attributable to blue-green algae in northern Minnesota near the Moose Lake area (Personal communication, Dr. Clarence Stowe, Large Animal Clinic - University of Minnesota, 9 November 1981).

Conversely, cercarial dermatitus (swimmers' itch) is reported to be common in lakes throughout Minnesota (By telephone, Gene Jordan, Minnesota State Department of Health, 5 November 1981). However, none of the state or

Table 4-4. Responses to public health survey questions. (Based on telephone interviews November, 1981)

Respondents	Since 1979, have you recorded or are you aware of any health problems (human, pet or livestock) associated with ground or surface water contamination in the drainage areas of Island, Passenger, Rush or Sturgeon lakes?	If health problems were documented, check the appropriate cause:				Are you aware of any health problems associated with water quality in the study area which are not covered in this survey?
		Blue-Green Algae	Bacteria	Virus	Cercarial Dermatitus	
Minnesota Department of Natural Resources - Water Monitoring and Control Unit St. Paul						
Howard Knosch - Supervisor	No	—	—	—	—	No
David Zapitillo - Aquatic Biologist	No	—	—	—	—	No
Minnesota Department of Health: Epidemiology Department Minneapolis						
Dr. Michael Olsterholm	No	—	—	—	—	No
Public Water Supply Department Minneapolis						
Richard Clark, Supervisor	No	—	—	—	—	No
Charles Schneider, Engineer	No	—	—	—	—	No
Minnesota Department of Health, Duluth						
Gene Jordan, Supervisor	No	—	—	—	—	No
Minnesota Pollution Control Agency Water Quality Division St. Paul						
Larry Livsay, Biologist-Limonologist	No	—	—	—	—	No

Table 4-4. Responses to public health survey questions, concluded.

Minnesota Board of Animal Health St. Paul						
Dr. Keller Dr. Flint	No	—	—	—	—	No
University of Minnesota Large Animal Clinical Services St. Paul						
Dr. Clarence M. Stowe	No	—	—	—	—	No
Moose Lake Veterinary Clinic Moose Lake						
Dr. Frank J. Skalko	No	—	—	—	—	No
Moose Lake Windemere Sanitary District Moose Lake						
Harold Westholm, Director	Yes	—	—	—	[redacted]	No
Pine County Department of Human Services Pine City						
Janet Schumaker	No	—	—	—	—	No
Carlton County Board of Health Cloquet						
Rachel Puite, Nurse	No	—	—	—	—	No
Carlton County Zoning Office Cloquet						
Bruce Benson	No	—	—	—	—	No
Pine City Area Clinic Pine City						
Dr. Mock	No	—	—	—	—	No
Hinckley Area Clinic Hinckley						
Mary Marks Clinic Coordinator	No	—	—	—	—	No
Dr. Charles Bloom	No	—	—	—	—	No
Mora Medical Clinic Mora						
Lorraine Carlson, Insurance Director	No	—	—	—	—	No
Gateway Family Health Clinic Moose Lake						
Dr. Raymond Christensen	No	—	—	—	—	No
Dr. Kenneth Etterman	No	—	—	—	—	No

county agencies surveyed had records of any outbreaks of swimmers' itch in Island, Sturgeon, Rush or Passenger Lakes (Table 4-4). Most patients treated for swimmers' itch in the Moose Lake area probably contracted it while swimming in Moose Head lake (By telephone, Doctors Raymond Christensen and Kenneth Etterman, 12 November 1981). Local citizens have not reported occurences of swimmers' itch on Sturgeon, Rush or Passenger Lakes. One instance of swimmers' itch occurring on 4 July 1981 was reported by a home owner on the south shore of Island Lake (Personal communication, Harold Westholm, November 1981). No reoccurences have been reported.

Table A-2. Phytoplankton bio-volume data and Secchi disk data for four lakes in Pine County MN.[1]

	[a]26, [b]27 AUGUST 1981			[c]9, [d]10 SEPTEMBER 1981			[e]14, [f]15 SEPTEMBER 1981			[g]30 SEPTEMBER and [h]1, [i]5 OCTOBER		
	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
[a,c,e,g] ISLAND LAKE												
% blue-green algae, bio-volume	12	25	12	94	95	92	98	98	98	93	94	94
% dinoflagellate, bio-volume	82	71	81	0	0	0	0	0	0	0	0	0
% other phytoplankton, bio-volume	6	4	7	6	5	8	2	2	2	7	6	6
μm^3 (total biovolume) x 10^4/ml.	1211	1808	921	899	746	379	1851	1113	835	491	532	484
Secchi disk depth (meters)	1.39	—	—	1.59	—	—	1.29	—	—	1.48	—	—
[b,c,f,i] STURGEON LAKE												
% blue-green algae, bio-volume	76	69	73	84	90	69	86	83	75	74	87	69
% cryptomond, bio-volume	14	13	13	0	0	0	0	0	0	0	0	0
% diatom, bio-volume	0	13	0	11	0	24	0	0	16	11	0	10
% other phytoplankton, bio-volume	10	5	14	5	10	7	14	17	9	15	13	21
μm^3 (total biovolume) x 10^4/ml.	116	107	94	173	338	102	163	128	86	106	138	107
Secchi disk depth (meters)	2.02	—	—	2.16	—	—	2.58	—	—	2.93	—	—
[c,f,h] RUSH LAKE												
% blue-green algae, bio-volume	—	—	—	69	35	10	71	59	9	12	50	12
% cryptomonad, bio-volume	—	—	—	15	0	77	18	10	75	11	28	22
% dinoflagellate, bio-volume	—	—	—	0	47	0	0	24	0	49	0	57
% euglenoid, bio-volume	—	—	—	0	0	0	0	0	15	0	0	0
% other phytoplankton, bio-volume	—	—	—	16	18	13	11	7	1	28	22	9
μm^3 (total biovolume) x 10^4/ml.	—	—	—	60	80	103	71	102	20	32	22	40
Secchi disk depth (meters)	—	—	—	3.60	—	—	3.63	—	—	3.72	—	—
[d,f,h] PASSENGER LAKE												
% blue-green algae, bio-volume	—	—	—	21	39	17	25	12	14	14	17	18
% cryptomonad, bio-volume	—	—	—	42	31	36	39	44	59	42	60	42
% golden brown algae, bio-volume	—	—	—	26	20	0	32	36	0	32	23	25
% euglenoid, bio-volume	—	—	—	0	0	40	0	0	27	0	0	0
% other phytoplankton, bio-volume	—	—	—	11	10	7	4	8	0	12	0	15
μm^3 (total biovolume) x 10^4/ml.	—	—	—	84	28	25	112	79	12	49	52	57
Secchi disk depth (meters)	—	—	—	1.95	—	—	1.80	—	—	2.02	—	—
[h] SAND LAKE												
% blue-green algae, bio-volume	—	—	—	—	—	—	—	—	—	55	53	56
% diatom, bio-volume	—	—	—	—	—	—	—	—	—	15	19	11
% golden brown algae, bio-volume	—	—	—	—	—	—	—	—	—	12	10	16
% cryptomonad, bio-volume	—	—	—	—	—	—	—	—	—	0	17	15
% other phytoplankton, bio-volume	—	—	—	—	—	—	—	—	—	18	1	2
μm^3 (total biovolume) x 10^4/ml.	—	—	—	—	—	—	—	—	—	75	72	79
Secchi disk depth (meters)	—	—	—	—	—	—	—	—	—	2.05	—	—

[1] Recorded bio-volume values are based on mathematical averages of cell counts reported from a number of sampling stations on Island and Sturgeon Lakes (6 and 4 stations, respectively). Rush and Passenger Lake values are singular as those lakes had one sampling station each. Total depths at sampling stations ranged from 18 to 20 feet at Island Lake, from 15 to 26 feet at Sturgeon Lake, 26 feet at Rush Lake, and to 26 feet at Passenger Lake.

Table A-3. Phytoplankton Measurements

	μm^3
CYANOPHYTA	
Anabaena macrospora	45,000
Anabaena spiroides	9,000[a]
Anacystus spp	1,000
Aphanizomenon flos-aquae	2,800
Oscillatoria sp	300[a]
Phormiduim mucicola	10[a]
CRYPTOPHYTA	
Chroomonas acuta	70
Cryptomonas erosa	1000[b]
CRYSOPHYTA	
Chrysococcus sp	1100[a]
Dinobryon sp	500
Mallomonas pseudocoronata	500[a]
Mallomonas tonsurata	550[a]
Ochromonas spp	40
Uroglena sp	450
PYRRHOPHTA	
Ceratium hirundinella	75,000[a]
EUGLENOPHYTA	
Trachelmonas sp	1400[a]
BACILLARIOPHYTA	
Asterionella formosa	3200[a]
Fragilaria crotonensis	1800
Melosira granulata	3000[a]
Melosira islandica	2000[a]
Navicula spp	690[a]
Stephanodiscus astraea	2000[b]
Tabellaria fenestrata	840[a]
CHLOROPHYTA	
Ankistrodesmus falcatus	250[b]
Chlamydomonas sp	300[a]
Oocystis	620[a]
Scenedesmus bijuga	150[a]
Scenedesmus quadricauda	650[a]
Sphaerocystis schroeteri	500[a]

[a]University of Minnesota measurements/unpublished

[b]Wetzel, p 319, 1975

Appendix I

Methodology for Population Projections

Methodology for Population Projections

The available census data on population within the Townships is for year-round residents only. Thus, estimates of the peak population (seasonal plus year-round) are derived by assigning an average household size for seasonal dwellings to the number of seasonal dwellings and combining the result with the projected number of year-round residents. Because of the large proportion of seasonal dwellings in Windemere Township and the documented historic variability in the growth of the year-round population versus the growth in the total number of housing units, a population based projection would have to incorporate subjective assumptions concerning the change in the ratio of seasonal to permanent residents over time.

Accurate population projections are essential for designing cost effective wastewater treatment facilities. Thus, the peak population is of greatest importance because the wastewater treatment facilities must be designed to accommodate the maximum anticipated wastewater flow for the life of the facilities. A housing unit based projection that is developed from historic data yields a total housing unit projection that can be used to estimate the total population, i.e., year-round as well as seasonal residents.

To determine the population of an area when the number of housing units is known requires two assumptions: the average household size and the ratio of seasonal to permanent residents at the end of the projection period. In this report, a slight decrease in the household size of year-round residents was forecasted because of the documented trend toward smaller households and the high median age in the project area which underscores the attraction of the local region as a retirement area. Site specific information on the average household size of seasonal dwelling is not readily available. In one study conducted by the University of Wisconsin Recreation Resources Center, an average household size of 3.0 was found for seasonal dwellings in a similar rural lake area (University of Wisconsin Recreation Resources Center 1979). Accordingly, the seasonal population projections assume a household size of 3.0 during the planning period. A slight decrease in the proportion of seasonal dwellings to year-round dwellings also is assumed based on the trend apparent during the 1970s when the growth rate for permanent dwellings exceeded the growth rate for seasonal dwellings. In spite of these household size assumptions, and their potential for error, the total projected population, as derived from the housing unit projections, should not result in significant error if the total housing unit growth rates occur as projected. For example, if in the year 2000 the actual number of housing units equals the total number projected, but there are fewer permanent residents than expected, the population on an annual basis should not vary significantly because the summer season population will be larger than estimated while the average winter season population is less.

Projections for Windemere Township

The housing unit projections were made by the "growth rate" method, based on an extrapolation of past growth rates. This method was used because it more closely models actual changes than any of the other methods. The "share" method was not used because it is not suitable for jurisdictions in counties where there is a fluctuation in subcounty population growth rates, i.e., if some places are growing while others are losing. The "ratio-trend" method was not used because of the historical variability in the ratio between Windemere Township's population and Pine County's population. Additionally, the use of the "growth rate" method provides for several different projections based on different assumptions concerning future growth. The different projections can then be comapred with other factors such as the amount of buildable land, land values, public services availability, etc. in determing the most reasonable projection for the facility planning or "service area".

The growth rate method is the only method by which the increase in the number of housing units can be projected directly. One problem with the growth rate method, though, is that the projection results from exponentially applying the average annual growth rate to the previous year's population. If the study area experienced unusually rapid growth in the last decade, the exponential application of the average annual growth rate can lead to an unrealistically high projection. Housing unit projections were initially developed for Windemere Township based on four different assumptions concerning future growth (Table I-1 ; Figure I-1).

Table I-1. Housing Unit Projections, Windemere Township, 1980 to 2000.

Assumptions	1980	1990	2000
1. Straight average: growth rate for the projection period remains constant at the 1960 to 1980 average	919	1,565	2,673
2. Trend rate: growth rate for the projection period changes at the same rate as the 1960 to 1980 change	919	1,349	1,883
3. Rate slowdown: growth rate from 1980 to 1990 equals the 1970 to 1980 growth rate and rate from 1990 to 2000 is onehalf 1970 to 1980 growth rate	919	1,286	1,614
4. Rate change slowdown: growth rate from 1980 to 1990 equals one-half the 1960 to 1980 growth rate and rate from 1990 to 2000 equals one-half the 1960 to 1980 growth rate.	919	1,201	1,375

The exponential aspect of the growth rate method is apparent when the projections are depicted on a graph (Figure I-1). Assumptions 1 and 2 for Windemere Township result in growth taking place at a rate exceeding that experienced in the Township in the last decase. Assumption 3, although termed a "rate slowdown," essentially is a straight-line projection. Assumption 4 for Windemere Township was the projection that was determined to be most realistic. This projection assumes that growth will continue in the Township from 1980 to 1990 at a rate similar to the growth experienced from 1960 to 1980. After 1990, the projection assumes that the growth rate will decrease as the area approaches "saturation."

Rural recreational areas such as the Island Lake and Sturgeon Lake portions of Windemere Township are attractive to development because of the amenities associated with lakefront property. As the first tier of lake contiguous lots becomes fully developed, it is not unusual for growth rates to decrease because property in the second tier (backlots) or on outlying lots is in less demand. There are a total of 151 homes on the platted land areas adjacent to Island Lake at present, and the first tier of these lakeshore lots can accommodate an estimated 185 to 200 homes. Given this situation, is expected that most of the available lakefront lots around Island Lake will be developed in the next 10 years while in the second half of the planning period (1990 to 2000) total growth around the Lake will level off because developable lots will only be available in the second tier (backlots). Assumption 4 appears to represent the possibility that growth will continue, but not at the extremely high rates that were experienced in the 1960s and 1970s.

The housing unit projection for Windemere Township was dissaggregated so that the number of housing units within the subareas could be projected (Table I-2). The housing unit projection for the subareas within Windemere Township assumes that after 1990, more of the Township growth will take place in ED 503 as the supply of lakefront lots around Island and Sturgeon Lakes becomes depleted. The housing unit projections indicate a year 2000 total of 214 and 282 housing units around Island and Sturgeon Lakes, respectively, and 1,375 housing units within Windemere Township. The housing unit projections were further disaggregated according to seasonal and permanent units based on survey information obtained from the

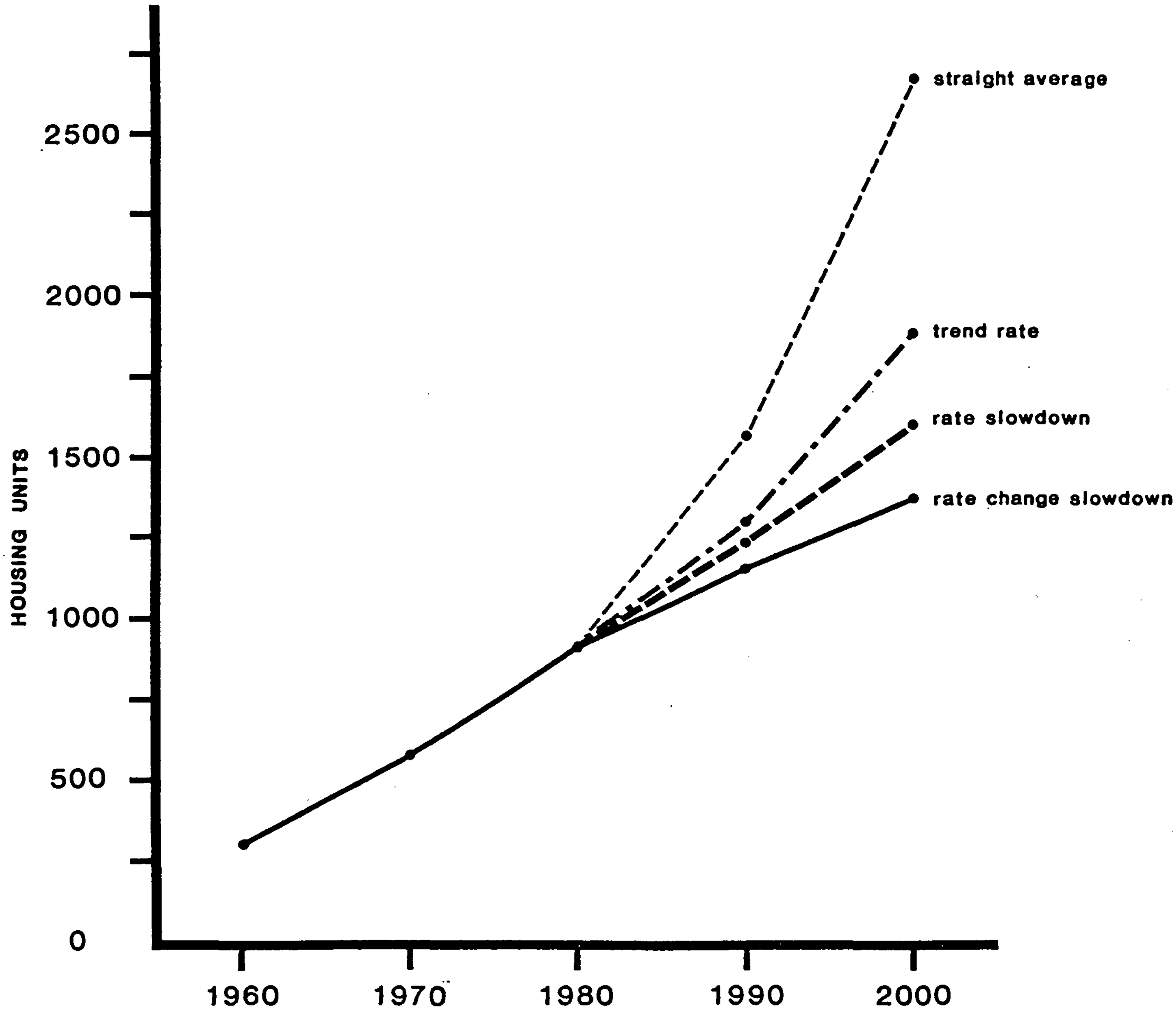

Figure I-1. Windemere Township housing units actual growth 1960 to 1980 and projected growth 1980 to 2000

MLWSD and the 1980 census (Table I-3). The seasonal to permanent projections also assume that permanent residences will form a greater proportion of the total after 1990 as a result of increased numbers of retired residents living in the area on a year-round basis. Information from the 1970 and 1980 census' support this assumption. Between 1970 and 1980, the number of year-round residents in Windemere Township increased by 79.1% while the number of housing units increased by 56.6% (US Bureau of the Census 1981). This is an indication that some housing units that were previously used on a seasonal basis are now being occupied on a year-round basis.

Table I-2. Housing unit projections within Windemere Township, 1980 to 2000 (US Bureau of the Census 1982).

Location	1980	1990	2000
ED 504	397	519	564
Island Lake	151	197	214
Sturgeon Lake	197	260	282
Outlying Areas	49	62	68
ED 503	522	682	811
Windemere Township	919	1,201	1,375

Note: The disaggregated projections assume that growth from 1980 to 1990 is spread evenly between the subareas. Because the amount of developable land in ED 504 is limited, the year 2000 projection assumes that the percentage of the population is ED 504 decreases from 43% to 41% by the year 2000.

Table I-3. Seasonal and permanent housing unit projection within Windemere Township, 1980 to 2000.

Location	1980		1990		2000	
	Permanent	Seasonal	Permanent	Seasonal	Permanent	Seasonal
ED 504	138	259	180	339	223	341
Island Lake	64	87	84	113	103	111
Sturgeon Lake	42	155	55	205	72	210
Outlying Areas	32	17	41	21	48	20
ED 503	269	253	351	331	446	365
Windemere Township	407	512	531	670	670	705

Note: The split between seasonal and permanent housing units was determined from MLWSD records and 1980 census data. The 1990 projections assume the same proportion of seasonal to permanent residents as in 1980. The year 2000 projection assume an increasing proportion of permanent residents as a result of increased demand by retired people for year-round residences and a lower demand for seasonal residences.

Appendix J

Water Quality Tables and Figures

Table J-1. Sampling program and schedule for surface water sampling in Island, Little Island, Sturgeon, Rush, and Passenger Lakes, Pine County MN.

Lake	Sampling Dates	Parameters[a]	Number of Stations Sampled
Island	26 August 1981	d/t; Sd; b	6
	09 September 1981	d/t; Sd; b; chl	6
	14 September 1981	d/t; Sd; b; chl	6
	30 September 1981	d/t; Sd; b	6
	03 February 1982	d/t; P_t	2
Little Island	03 February 1982	d/t; P_t	2
Sturgeon	27 August 1981	d/t; Sd; b	4
	09 September 1981	d/t; Sd; b; chl	4
	15 September 1981	d/t; Sd; b; chl	4
	05 October 1981	d/t; Sd; b	4
	04 February 1982	d/t; P_t	2
Rush	10 September 1981	d/t; Sd; b, chl	1
	15 September 1981	d/t; Sd; b; chl	1
	01 October 1981	d/t; Sd; b	1
Passenger	10 September 1981	d/t; Sd; b; chl	1
	15 September 1981	d/t; Sd; b; chl	1
	01 October 1981	d/t; Sd; b	1

[a] Parameter Key:

d/t = Dissolved oxygen and temperature at 2-foot depth intervals from the surface

Sd = Secchi disk depth at each station

b = biovolume of phytoplankton at surface, mid-depth, and above the lake bottom

chl = chlorophyll a (corrected for breakdown products) at surface, mid-depth, and above the lake bottom

P_t = Total phosphorus at surface (under the ice) and above the lake bottom

Field investigations were conducted in the project area in 1981 during the periods of 24-27 August; 7-15 September; 28-30 September; and 1-5 October. During these sampling periods, prevailing wind directions were easterly; westerly changing to southerly and then back to northwesterly; easterly; and widely variable, respectively.

Table J-2. Peak daily air temperature and prevailing sky cover as recorded at the Duluth International Airport during the four sampling visits made to the Moose Lake Area (NOAA 1981).

Date	Peak Daytime Temperature, °F	Prevailing Daytime Sky Cover
24 August	65	Overcast
25 August	63	Overcast
26 August	68	Overcast
27 August	59	Overcast
07 September	65	Overcast
08 September	67	Clear
09 September	81	Clear
10 September	77	Overcast
11 September	77	Clear
12 September	77	Clear
13 September	78	Clear
14 September	65	Scattered Clouds
15 September	55	Overcast
28 September	46	Overcast
29 September	44	Overcast
30 September	42	Overcast
01 October	40	Overcast
02 October	48	Clear
03 October	50	Overcast
04 October	47	Overcast
05 October	48	Overcast

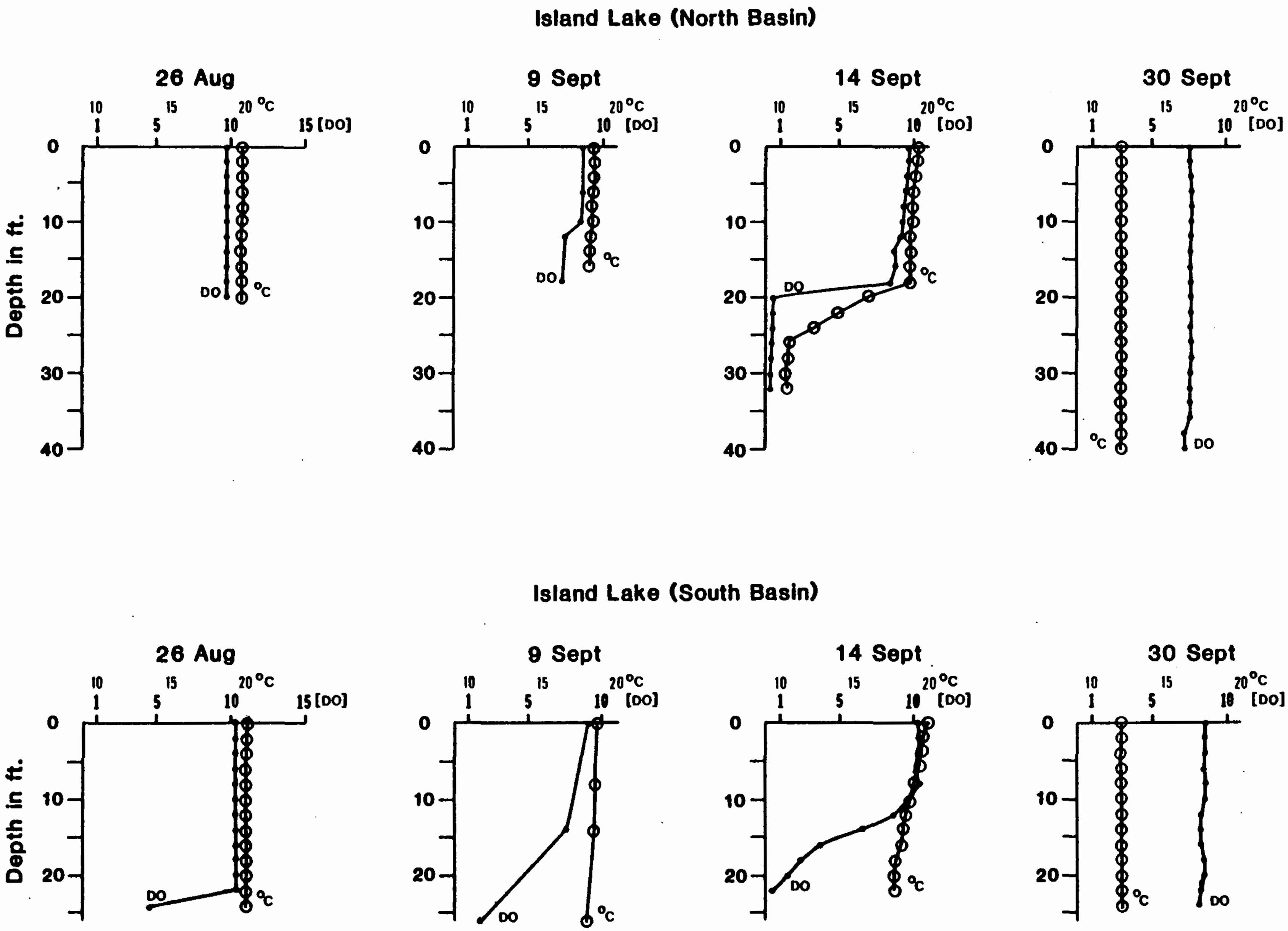

Figure J-1. Dissolved oxygen and temperature profiles for the north and south basins of Island Lake, Pine County, MN. Data are from 1981 field surveys.

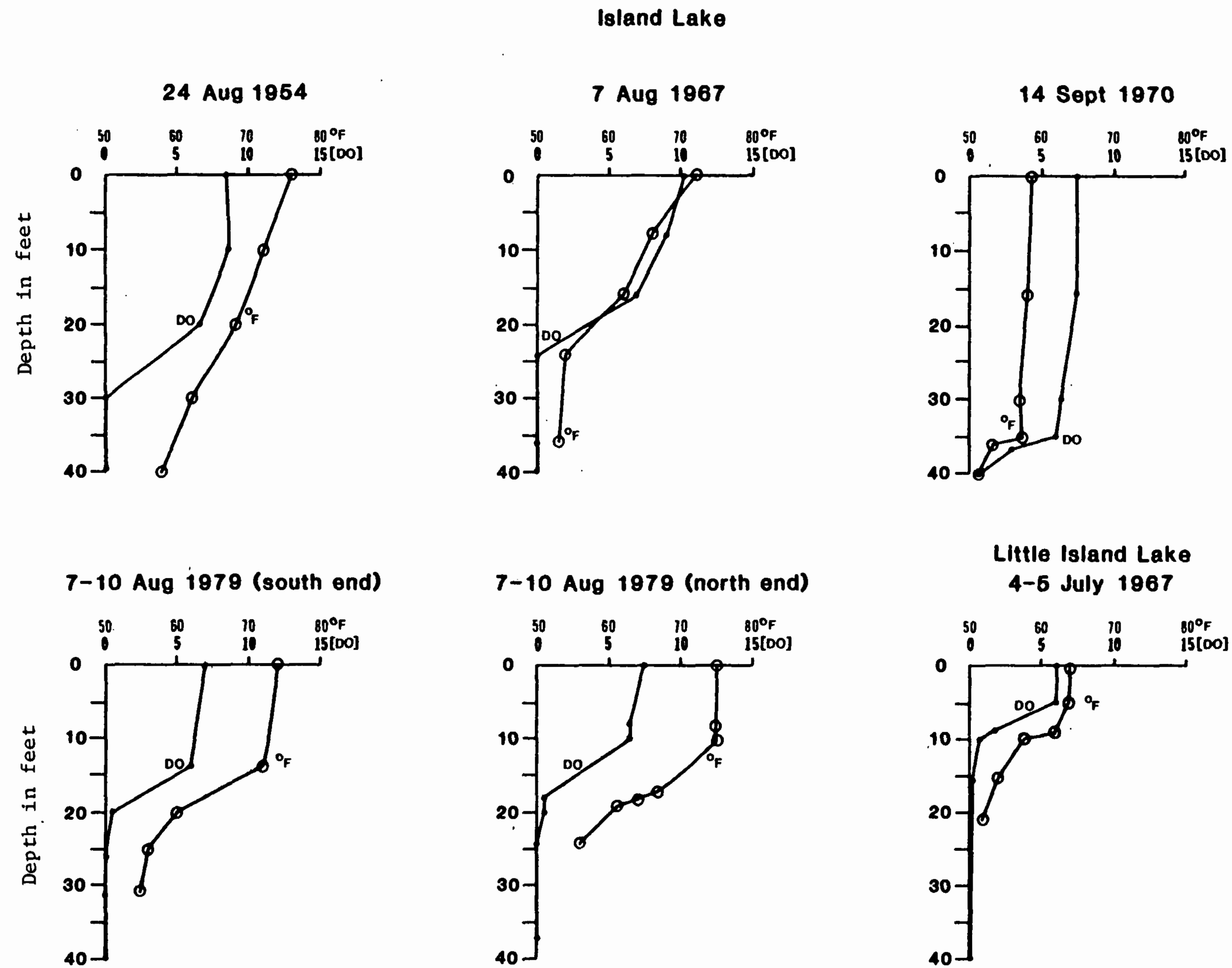

Figure J-2. Dissolved oxygen and temperature profiles for Island Lake and for Little Island Lake, Pine County, MN. Data are from unpublished files of the Minnesota Department of Natural Resources.

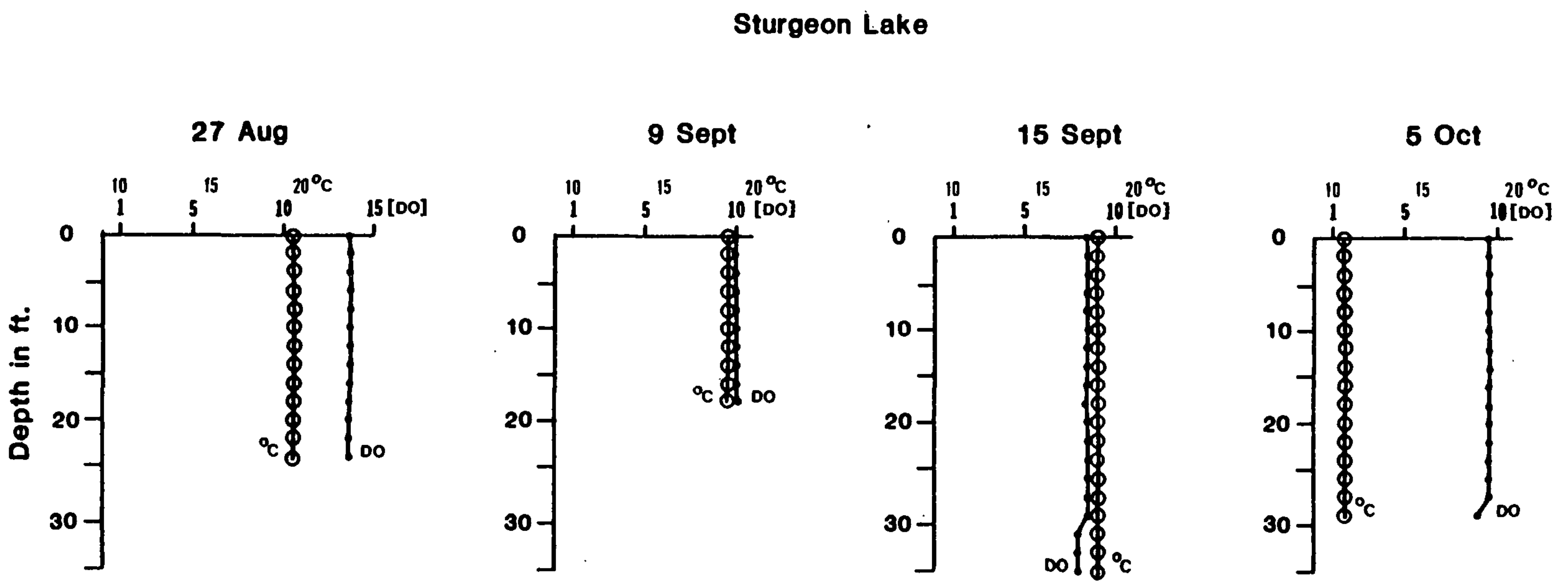

Figure J-3. Dissolved oxygen and temperature profiles for Sturgeon Lake, Pine County, MN. Data are from 1981 field surveys.

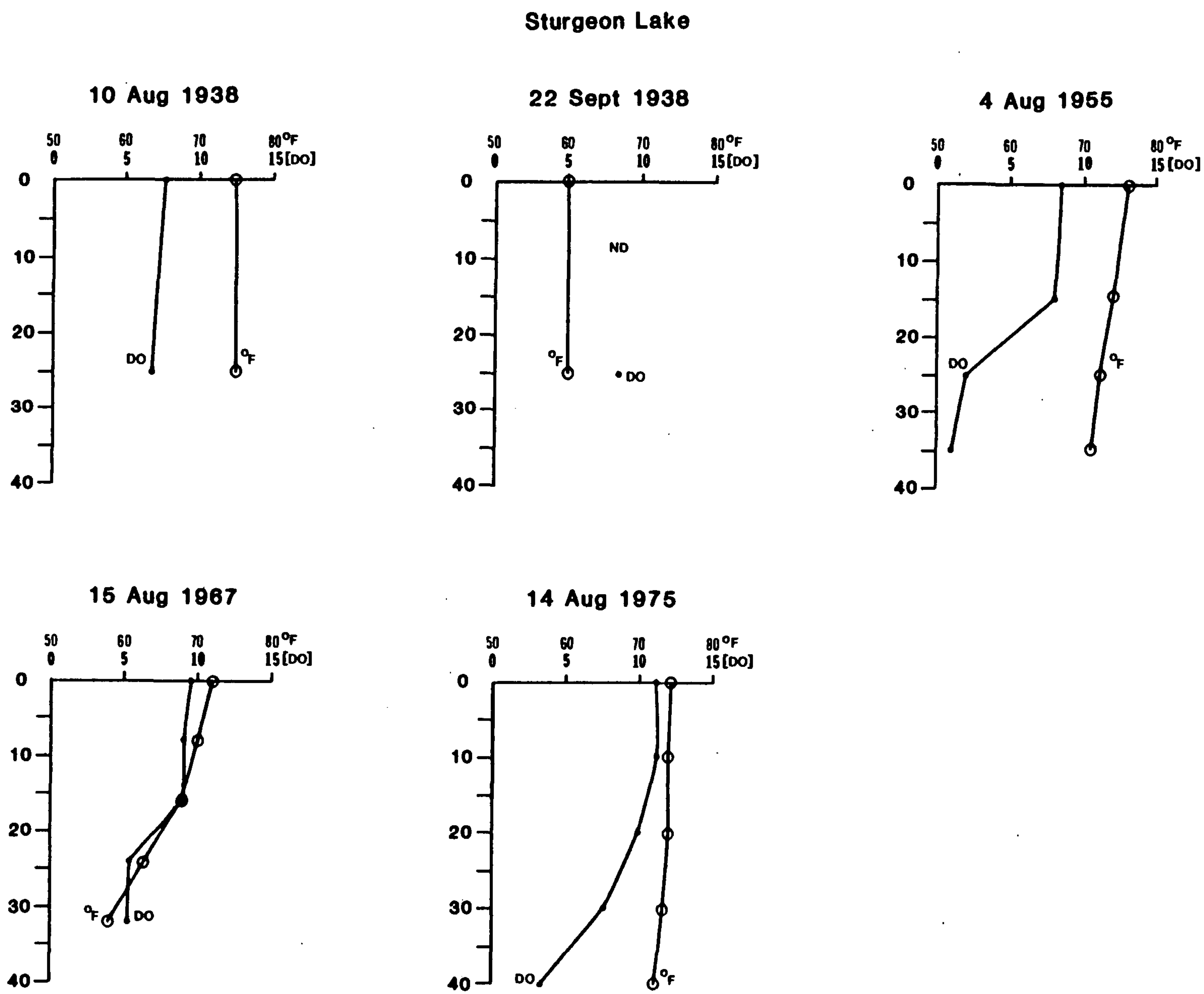

Figure J-4. Dissolved oxygen and temperature profiles for Sturgeon Lake, Pine County, MN. Data are from unpublished files of the Minnesota Department of Natural Resources.

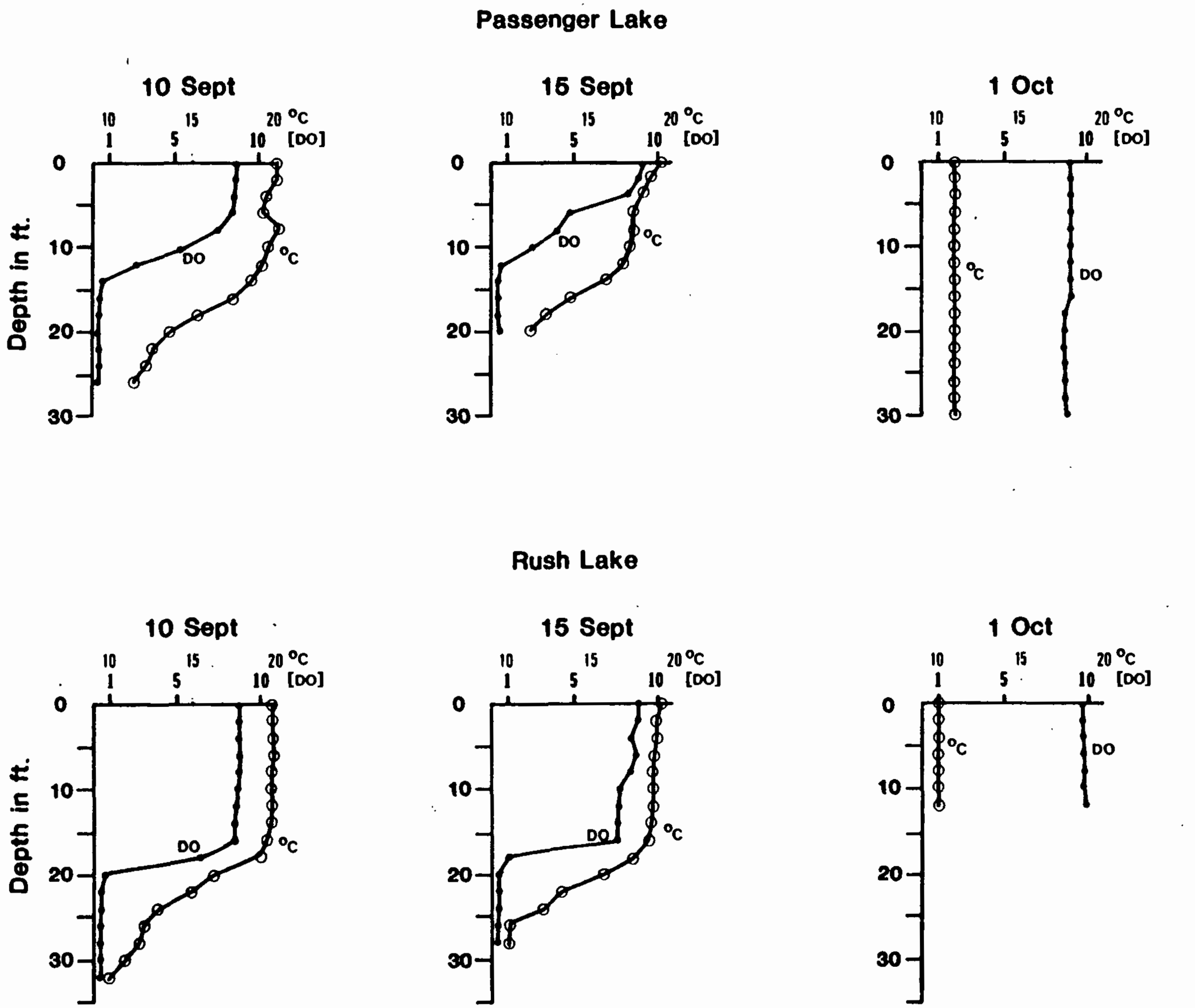

Figure J-5. Dissolved oxygen and temperature profiles for Passenger Lake and for Rush Lake, Pine County, MN. Data are from 1981 field surveys.

Appendix K

Letter to Citizen's Advisory Committee

Rte. 2, Box 140-B
Island Lake
Sturgeon Lake, Mn. 55783
372-3169

RECEIVED FEB 02 1982

Jan. 25, 1982

Mr. Gregory Dean Evenson
Chairman
Citizens Advisory Committee
Moose Lake, Minn. 55767

Dear Mr. Evenson:

You requested ideas from the Citizens Advisory Committee on Jan. 7, 1982 at the meeting which concerned the Draft Report on Algae. Here are my ideas.

First of all and most importantly I am open minded to what this study is investigating concerning the 4 lakes of Windemere Township. It appears that this study must be enacted to satisfy federal and state regulations. From what I have gathered by talking to PCA and WAPORA people, from public meetings, and personally observing Finney doing field work I feel that WAPORA is doing a professional job. However, this work needs to be monitored by Windemere Citizens.

The jewels of Windemere Township our lakes must have truly been that as observed by the native American Indians, early explorers and the early hardy Scandanavian pioneers.

The logging, fires, and land clearing was especially hard on Island Lake due to the heavy clay soil comprising the bulk of the watershed. The pioneers knew that the land around Island Lake would be many times more productive than the relatively sterile jack pine outwash plain around Rush Lake.

The heavy farmland clearing around Island Lake must have contributed greatly to it's eutrophication. As a casual observer around Island Lake since the late 1940's I have noticed contributing factors to eutrophication.

In the NE¼ Section 8, T. 45 R. 18 was located a barnyard directly on the lakeshore with pig pens going right out into the lake. At least two other farms in that Quarter Section had barnyards that drained into the lake. In Section 4 at the end of the present Twilight Lane Holsteins contently grazed along the lake following a fence that went out into the lake to take a drink. There were other barnyards in Sec. 3 and 4 that contributed runoff, as in Sections 9 and 10.

Island Lake has walleyes that grow at 2 times the State average. As being a young fishing partner of Ted Anderson who learned techniques and spots from him, and in turn showed him spots, I can attest to having caught almost numerous quantities of these tasty fish from 6 to 11 pounds. It is my unscientific opinion that the land clearing and barnyard nutrient enrichment has been a factor in good fish growth.

However, land use around Island Lake is changing or has changed to chiefly residential-recreational use.

I had occassion to observe when the bulk of the initial cabin and homesite development took place along the lakeshore. In Sections 3,4 & 9 some filling took place on swampy shoreline. In Sections 3 and 9 some steep clay banks were graded with heavy equipment in the Fall. The following Spring heavy rainfall washed large amounts of clay into the lake. For a time the water along that shore was of a reddish-brown opague color due to clay particles suspended in the water. Each additional developed lot contributes some erosion therefore affecting nutrient balance in the lake.

Of course, inadequate septic tank drainfield systems have added their share of pollutants.

I recall Island Lake as always having "dog days" or algae bloom in August or Sept. in the late 1940's and the 1950's when kids such as myself were told not to go swimming. However, it seems that the blooms are more severe now and I don't let my kids go swimming in "dog days".

A weed came into the lake in the 1950's which we called hair weed, which I believe is milfoil. A truly noxious type of weed as it choked out less noxious valuable shoreline and submerged weed beds. In late Summer large matts of floating "hair weed" would make rowing a boat difficult in shallow areas. The weed is still here but seems to get chopped up by the large number of power boats on the lake today.

In summary I think that this Draft Report On Algae is helping to bring scientific biological investigation to the factors and core problems affecting the eutrophication of these 4 lakes in Pine County, Let us hope that the remainder of the studies will allow us to become better informed citizens to study the alternatives available for the protection of our "jewels" for our children.

Sincerely,

cc Ken Dobbs

Walter C. Johnson

Appendix L

Paleolimnological Investigation

APPENDIX L - Paleolimnological Investigation

ONSITE WASTE TREATMENT AND LAKE EUTROPHICATION: ANALYSIS WITH DATED LAKE SEDIMENTS

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Running Head: Onsite waste treatment and lake enrichment

ABSTRACT:

Three seepage lakes in north eastern Minnesota were studied to evaluate the relative impacts of onsite waste treatment systems and other nutrient sources on lake trophic status. Island and Sturgeon Lakes have had extensive shoreline development in the last 30 years and are served exclusively with onsite waste treatment systems. A third lake (Little Island Lake) located adjacent to Island Lake has had no shoreline residential development. Interpretation of biological remains and geochemical data in lake sediment cores indicated all three lakes had chlorophyll degradation products, diatom communities, and phosphorus concentrations highly influenced by forestry and agricultural land use in their watersheds. Eutrophication caused by onsite waste treatment systems was not clearly established for the two lakes with residential development. The present trophic condition for Island Lake was probably initiated after the turn of the century by conversion of forest lands to agricultural use in the watershed and prior to development of a significant lakeshore community. Sturgeon Lake has a relatively small watershed and inorganic and organic phosphorus concentrations in the sediment core appear to have been influenced in the last 40 years by a single farmstead located on the lakeshore. Little Island Lake (the lake without residential development) is the shallowest of the three lakes and also has the greatest watershed area to lake surface area ratio. Little Island Lake also had the highest chlorophyll and phosphorus sediment concentrations of the three lakes. The effects of a forest fire in its watershed in 1918 had a dramatic impact on chlorophyll and phosphorus concentrations but not on the composition of the diatom community. Relatively minor changes in all three lakes' trophic status have occurred since the 1950s, the period when lakeshore development began to increase rapidly around Island and Sturgeon Lakes.

Key Words: Diatoms, Eutrophication, Lake Sediments, Onsite Systems, Paleolimnology, Phosphorus, Septic Tanks

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INTRODUCTION

The effects of wastewater discharge from municipal sewage treatment plants resulting in lake eutrophication have been well documented (Bradbury, 1978; Bradbury & Waddington, 1973; Neel et al., 1973; Edmondson, 1974; Shapiro et al., 1971). In the United States and Canada there are hundreds of lakeside communities that employ onsite waste treatment systems on individual lots for wastewater treatment (USEPA, 1983a; Dillon & Rigler, 1975). The effects of nutrient inputs from onsite waste treatment systems on lake eutrophication have not been easily evaluated.

The use of nutrient export coefficients and lake modeling has been one approach to evaluate nutrient inputs from onsite systems. Although in rural watersheds, agricultural land use or forested acreage might be expected to dominate phosphorus budgets (Dillon & Kirchner, 1975) lake modeling indicates the phosphorus input from onsite systems could affect trophic conditions in some rural lake settings (USEPA, 1982). Another study offers evidence (USEPA, 1975 cited in USEPA, 1980) that phosphorus inputs from onsite systems may contribute a substantial fraction of the total phosphorus budget.

The phosphorus contribution from onsite systems is typically a calculation based on the concentration of phosphorus in septic tank effluent (ranging from 10 to 30 mg tot. P l^{-1}; Hansel & Machmeier, 1980) the volume of wastewater generated (50 to 150 gal. per capita per day; Laak, 1980), and a soil retention coefficient. Soil retention coefficients may vary widely due to differing soil conditions. Underdrained soil filter beds consisting of a range of particle sizes from sands to clayey silts have been found to remove from 1 to 88% of dissolved phosphorus from septic tank effluent (Brandes et al., 1975).

Nutrient budget calculations for a number of lake watersheds in the midwestern United States (28 lakes in 5 states) estimated septic tank/soil absorption systems contribute generally less than 15% of the lakes' phosphorus budget with an average percentage of 10% and a range of 0 to 45% (USEPA 1979a; 1979b; 1979c; 1979d; 1979e; 1981; 1982). However these calculations also have to consider a flucuating population as well as what proportion of the groundwater is flowing toward the lake and what proportion is flowing away from the lake. Nutrient input predictions are somewhat subjective and USEPA (1980) recommends a range of estimates be considered in some cases.

Another method for evaluating nutrient inputs from onsite systems has been to sample nutrient levels in groundwater influenced by onsite systems. Some studies indicate a high potential for septic tank effluent to elevate groundwater phosphorus concentrations (Viraraghaven & Warnock, 1976), other studies indicate nearly all the phosphorus in septic tank effluent can be attenuated by soil processes (Jones & Lee, 1977) with only a small fraction of the dissolved phosphorus originating from septic tank effluent actually entering lakes (Kerfoot & Skinner, 1980). But are soils a permanent phosphorus sink once dissolved phosphorus is removed from septic tank effluent? Most groundwater studies use batch sampling to monitor groundwater quality. If a couple of events a year result in special conditions (i.e. water logged soils and anaerobicity) labile phosphate could reenter the groundwater flow field. Nutrient pulses could result that might be missed by batch sampling. Several studies have discussed phosphorus desorption and movement under saturated and anaerobic soil conditions (Hill & Sawhney, 1981; Louden & Fay, 1982; Oloya & Logan 1980). For field studies, only continuous monitoring or fortuitous batch sampling would detect these nutrient pulses and these studies are rare.

Another method for evaluating the nutrient input from onsite systems might be through the use of dated lake sediments. Other studies have successfully used lake sediment cores to detect the impact of municipal wastewater discharges on lake water quality (Bradbury, 1978; Shapiro et al., 1971). Chemical and biological parameters in lake sediment cores should reflect the nutrient input from onsite systems if onsite systems have been significant nutrient sources. An advantage of using dated lake sediments is they represent a continuous record of nutrient contributions originating from all onsite systems within the geochemical watershed. Some disadvantages of using lake sediment cores are fine-scale resolution is lost and intrepretation of sediment dates, geochemical data, and biological data have to be analyzed with caution (Engstrom & Wright, in press).

In Northeastern Minnesota, an appropriate setting was found to use lake sediment cores to evaluate the effects of onsite systems on lake water quality. Out of three closely grouped lakes (Fig. 1), two have reached almost total residential buildout, with a majority of first tier lakeshore lots occupied by either seasonally- or permanently-occupied cabins. The increase in housing development around these 2 lakes has been recorded since the 1950s. A third lake has no residential development and has had only one dwelling (a farm) in its watershed in the last 100 years. No municipal wastewater treatment plant discharges enter these lakes. Because all three lakes are seepage lakes (where the water influx is dominated by groundwater rather than streams) the impacts of nutrients from onsite systems on lake water quality should by greater than on drainage lakes, because drainage lakes have significant stream inputs that usually introduce a high proportion of the nutrient budget (Lee, 1976).

The two lakes with residential development (Island and Sturgeon Lakes) are documented to have blue-green algae as the dominant autumn phytoplankter (USEPA, 1983b). The dominant phytoplankters in Island Lake in the autumn of 1981 (Sept. 14) were Anabaena spp. and Aphanizomenon flos-aquae accounting for 98% of the phytoplankton biovolume of 1266 x 10^4 mm^3 ml^{-1} (6 stations, 3 depths). The dominant phytoplankters in Sturgeon Lake for the same time period were Anabaena spp. and Anacystis spp. accounting for 81% of the phytoplankton biovolume of 126 x 10^4 mm^3 ml^{-1} (4 stations, 3 depths). Some lakeshore homeowners are concerned that onsite systems have been and continue to be the primary factor in lake algal blooms (Citizens Activity Council Meeting, 1981).

Little Island Lake is connected to Island Lake by a 1 meter diameter culvert. The water exchange, if any, is in the direction from Little Island to Island Lake (based on lake water levels in the area; USGS, 1979; and MDNR observations for Little Island Lake; MNDR, 1967). About 30% of the water surface of Little Island Lake is covered by standing emergent vegetation with Burreed (Sparganium spp.) most abundant (MDNR, 1967). Submerged aquatic plants are also abundant with waterlilies (Nuphar spp. and Nymphea tuberosa) and bladderwort (Utricularia spp.) most abundant (MDNR, 1967). We did not observe any surface algal blooms in Little Island Lake, although they were evident in Island Lake. Phytoplankton samples were not collected for Little Island Lake. Additional lake and watershed parameters for all three lakes are presented in Table 1.

For the three lakes in this study we analyzed recent dated lake sediment core parameters (organic matter, chlorophyll degradation products, diatoms, and phosphorus fractions) to evaluate changes in lake trophic status covering a time period from settlement of the watersheds by non-indigenous settlers to the present. It was hypothesized that if onsite systems played a significant role in the eutrophication of Island and Sturgeon Lakes, an increase in sediment core parameters associated with nutrient enrichment should be correlated with an increase in the number of onsite systems around both these lakes (circa 1950). Little Island Lake would be expected to have relatively unchanged indicators through this time period because it has no onsite systems in its direct drainage basin. Alternatively, if nutrient inputs from onsite systems played a minor role in the nutrient enrichment of the two developed lakes, the trends of the sediment core indicators for all three lakes should be interpretable based on factors unrelated to onsite systems.

METHODS

In March 1982, two cores of 60 cm length were taken from each of Island, Sturgeon and Little Island Lakes using a plexiglass piston corer with a 11.25 cm inside diameter. One core was extruded in the field in 2 cm sections for determination of sedimentation rates using Cesium-137 dating (Eberline Laboratories, Inc., West Chicago, IL). The other core was sectioned into 3 cm sections for determination of organic matter, chlorophyll degradation products, diatom composition and phosphorus fractions. The samples were stored in sealed plastic bags and frozen until analyzed.

Percent moisture was determined by measuring weight loss of sediment after at least 24 hours of dessication at 105° C. Organic matter was determined after weight loss on ignition at 550° C for one hour. Pigment analysis for algal degradation products was performed on wet sediment using the procedure of Vallentyne (1955). Pigments were extracted with 90% acetone containing 0.5% dimethylanaline as suggested by Manny et al. (1978) and reported as sedimentary pigment degradation unit (SPDU)/gram dry weight. The sediment phosphorus fractions of apatite phosphorus, nonapatite phosphorus, and organic phosphorus were determined following the methods outlined by Williams et al. (1976a). All concentrations have been reported on a dry sediment basis. The diatom preparation, identification, and enumeration was conducted following the methods of Bradbury & Waddington (1973).

RESULTS AND DISCUSSION

Sedimentation Rates

Counting the activity of radioactive Cesium (Cesium-137) in lake sediments can be used to determine recent lake sedimentation rates. Cesium-137 is found in lake sediments as a result of nuclear weapons testing and subsequent atmospheric contamination by the isotope. Testing first began on a small scale in 1946 but increased in 1957 with the peak activity occurring in 1963-1964. Because a 6 to 12 month delay typically occurs between deposition of Cesium-137 in the watershed and delivery to the lake, the maximum peak recorded in lake sediments is assumed to be 1965 (Ritchie *et al.*, 1973).

The recent sedimentation rate in both Sturgeon Lake and Island Lake is estimated to be approximately 0.41 cm year $^{-1}$ (Fig. 2). A 1 cm segment would represent about 2.5 years. The sedimentation rate is not as easily defined in Little Island Lake, but because of the nature of the increase of Cesium-137 activity at 5 cm (Fig. 2), the sedimentation rate is estimated to be 0.29 cm per year (Dr. J. B. McHenry, personal comm.). A 1 cm segment would represent about 3.45 years. Extrapolating sedimentation rates to the bottom of the core represents a time period of around 1832 for Island and Sturgeon Lakes, and around 1775 for Little Island Lake.

Although the sedimentation rate varies within a lake basin, Davis and Ford (1982) found sediment arriving in the deep basin of a lake is well mixed due to resuspension and redeposition and qualitatively representative of much of the basin. The sediment cores collected in this study were from the deepest part of the lake basins. The Island and Little Island Lake watersheds are located in clayey glacial till. The northern half of Sturgeon Lake's watershed is in the same clayey glacial till association as Island and Little Island Lakes' watersheds, while the southern half is in glacial outwash sand. The cores from Sturgeon Lake were taken in the clayey glacial till to stay consistent with the sedimentary characteristics of the sediment cores taken from the other two lakes. The location of the lake sediment cores and the boundary of the glacial outwash sands and clayey glacial till is shown in Fig. 1.

Organic Matter and Chlorophyll Degradation Products

In the Sturgeon Lake core, organic matter (Fig. 3) and sedimentary chlorophyll degradation product (Fig. 4) profiles showed little change with time. Organic matter ranged from 19 to 23 percent while chlorophyll ranged from 6 to 12 SPDU/gram dry weight. Organic matter was relatively unchanged in the lower part of the core although there was a slight increase from the 12-15 cm (1948) segment up to the 3-6 cm segment (1971). Chlorophyll degradation products increased slightly above the 6-9 cm segment (1963).

In the Island Lake core, the % organic matter ranged from 20 to 30 percent and tends to decline slightly from the bottom to the top of the core (Fig. 3). Since the 1950s (above 12 cm) the % organic matter in the cores from Island and Sturgeon Lakes is similar, although in the surficial segment (0-3 cm), % organic matter in Island Lake slightly increased.

Sedimentary chlorophyll degradation products in the Island Lake core ranged from 14 to 30 SPDU/gram dry wt and are greater than levels found in the Sturgeon Lake core. The highest value was at the bottom of the core. From 30 cm to 12 cm (1910-1948) chlorophyll degradation products decreased. Since about 1948 (12-15 cm segment) chlorophyll degradation products have increased (especially in the top surficial segment) but have not exceeded levels observed in the middle of the core.

In the Little Island Lake core, organic matter (Fig. 3) and sedimentary chlorophyll degradation product (Fig. 4) values are generally greater than either Sturgeon or Island Lakes values. The organic matter profile shows a declining trend from the bottom to the top of the core and values range from 30 to 41 percent. The chlorophyll degradation products were unusually low in the 18-21 cm segment (1910-1920). In 1918, the Moose Lake Forest Fire burned much of the lake's watershed and may have had an impact on the chlorophyll values. Prior to 1918, chlorophyll values were declining. The next core segment after 1918 (15-18 cm) shows chlorophyll values returning to pre-1918 levels. Chlorophyll in the surficial core segment increased dramatically compared to the underlying 3-6 cm segment, but is comparable to values at the bottom of the core.

Although chlorophyll degradation product concentrations increase for both Sturgeon and Island Lakes in the surficial sediments, the increase is also found in Little Island Lake. Because the increase has occurred in all three lakes, it can not be attributed entirely to onsite systems. Little Island Lake has no onsite systems on its shoreline. The increase in chlorophyll degradation product concentrations in the surficial segment may represent, in addition to degradation products, relatively undegraded chlorophyll from the previous summer season.

Diatoms

Changes in the diatom community throughout the length of the sediment core have been interpreted on a qualitative basis with indicator species assigned to one of three categories; eutrophic, mesotrophic, or "other". The "other" category includes species associated with benthic habitats or species that have no specific trophic affiliation. Assignments to any of the categories were made with the assumptions and limitations that have been expressed by other authors (Bradbury, 1975; 1978; Kalff & Knoechel, 1978; Harris & Vollenweider, 1982).

In Sturgeon Lake, the highest percentage of eutrophic indicator diatoms is found between 1862-1892 (Fig. 5). Two increases in eutrophic diatoms have occurred since 1915. The second increase, starting after 1960 is still less than what was found in segments representing the late 1800s (Fig. 5). A total of 97 diatom taxa were identified in the Sturgeon Lake core. *Melosira ambigua*, a planktonic diatom and a mesotrophic indicator (Davis & Larson, 1976), and *Fragilaria construens* v. *venter* , a diatom which commonly resides in or near the littoral zone of small lakes or in slightly deeper waters of larger lakes; Bradbury, 1975), were dominant species. From 60 cm up to 37 cm (1832 - 1890), *F. construens* v. *venter* represented 20 to 40 percent of the diatom community. At 37 cm (1890), coinciding with a decline in the logging industry and an increase in farming in the region (Pine County, 1949), *F. construens* v. *venter* strongly declined and *M. ambigua* increased. This change could indicate a rise in water level or decrease in water clarity thus reducing the size of the littoral zone.

Between 17 cm and 7 cm (1940 - 1965) the percentage of littoral species increased (especially Achnanthes spp., Eunotia pectinalis, and E. incisa) while M. ambigua declined. While diatoms indicative of eutrophic conditions (e.g. F. Crotonensis, M. granulata, and Cocconeis placentula) have shown slight increases starting in the 1960s, the continued presence of Cyclotella bodanica (a mesotrophic indicator) and the high level of Melosira ambigua indicate the lake's trophic status has not changed drastically during the time period covered by the sediment core.

In Island Lake the mesotrophic indicator species comprise a majority of the diatom community percentage (Fig. 5). Of a total of 118 diatom taxa identified, the dominant species (Melosira ambigua, M. italica, and Tabelaria fenestrata) are representative of mesotrophic-type conditions (Davis & Larson 1976). Island Lake has shown an increase in eutrophic indicators starting in the late 1930s - early 1940s (15-18 cm segment). At about this time M. italica dramatically decreases in percent composition, while three eutrophic-type taxa either first appear or increase in abundance. The three species were Cocconeis placentula, Melosira granulata, and Fragilaria crotonensis. However, the influence of onsite systems effecting the diatom composition is expected to be minor because onsite systems probably were not contributing a significant nutrient load in the early 1940s. Electricity was just becoming available in the area and it was not until the mid-1940s that most cabins installed indoor plumbing (Don Classen, City clerk, Moose Lake, MN, pers. comm.). Until the 1940s, nearly all lakeshore residences were seasonal and used privies for waste treatment. Because of the minimal water use in residences that have privies and because the privy pit is usually in unsaturated soils, there was probably little nutrient input from the seasonally used privies. Coinciding with the increase in eutrophic indicators for Island Lake in the late 1930s was a peak in agricultural land use intensity (U.S. Depart. Commerce Census records) and a severe drought lasting several years which lowered both groundwater levels and lake levels (Mr. D. Ford, MDNR, pers. comm.) The effects of the drought would enhance eutrophic conditions in the lake whether onsite systems or agricultural land use were the impetus for an increase in eutrophic diatom indicators. But, based on literature values for phosphorus export rates (USEPA, 1980) and on land use characteristics in the watersheds, the agricultural component would contribute a much higher phosphorus load than onsite systems.

Little Island Lake has the most diverse diatom community of the three lakes (based on average Shannon-Weiner values for the length of the sediment core). Although Little Island Lake had the highest percentage of eutrophic indicators, it also had the highest percentage of littoral or benthic species which are included in the "other" category (Fig. 5). Although no single species dominates the community like Melosira ambigua does in Island and Sturgeon Lakes, Fragilaria construens v. venter and Melosira binderana were common. A total of 107 diatom taxa were identified with diatom stratigraphy showing few changes throughout the core. Starting at about 20 cm (1913) there was a gradual but definite increase in the abundance of Achnanthes lancelata, Cocconeis placentula, Fragilaria capucina, and Navicula cryptocephala. All four species have been found in eutrophic lakes or ponds (Jorgensen, 1948; Stormer & Yang, 1970). The consistency of the eutrophic indicator species as well as the benthic and littoral species in the core indicates Little Island Lake has been shallow and productive for the last 200 years, probably predating the earliest sediment core date of 1775.

Phosphorus

Phosphorus in the sediment cores was fractioned into three categories; apatite phosphorus (A-P), nonapatite inorganic phosphorus (NAI-P), and organic phosphorus (Org-P). Apatite phosphorus represents phosphate present in the crystal lattices of apatite grains and generally is of detrital origin (Williams et al., 1976a). Nonapatitic inorganic phosphorus consists of phosphorus not associated with A-P or Org-P, and originates naturally, (i.e. by chemical weathering in the watershed) or from anthropogenic sources (i.e. fertilizers, septic tank drainfields, etc). Organic phosphorus includes all phosphorus associated with organic molecules or more specifically with carbon atoms by C-O-P or C-P bonds and may be an indicator of lake productivity.

In Sturgeon Lake, apatite-P levels are relatively constant throughout the length of the core except for slight increases above 45 cm (1870) and above 30 cm (1907) (Fig. 6). NAI-P increases above 15 cm (1945) but decreases at 5 cm (1970). Org-P is also fairly constant throughout the length of the core with a slight increase in the surficial segment. Of the 3 lakes, Sturgeon Lake has the highest total phosphorus concentration in surficial sediments. An increase in sedimentary phosphorus concentrations in Sturgeon Lake beginning in the 1950s coincides with increased housing development and the number of onsite systems. However, if these phosphorus trends were related to onsite system use, a phosphorus decline in the top surficial segment of the sediment core would not be expected. An alternative explanation for the sedimentary phosphorus dynamics may be related to a farmsite located on the northeast shoreline which includes a 25 ha pasture (estimated) sloping to the lake. The current owner of the property purchased the farm acreage in 1947 and immediately expanded dairy and crop operations. The owner has stated that prior to 1947 there was not much farming activity on this acreage. The owner retired in 1970 and since that time there has been little active farming or dairying. The phosphorus increase and decrease in the sediment core correlates with the changes in this farming operation. In a small watershed, without other significant nutrient inputs, this phosphorus source could be important. In addition, the location of our sediment core site is in an area of the lake basin that would probably accumulate sediments carried in by overland runoff from this farmsite. Most of the phosphorus increase in the 15 cm to 3 cm segment is in the NAI-P fraction. Since org-P and chlorophyll degradation products in this segment (15-3 cm) did not show comparable increases the NAI-P may be agriculturally derived. This phosphorus input apparently only increased phytoplankton productivity slightly, as reflected in the % organic matter and chlorophyll degradation product increases. The percent of eutrophic diatom indicators also increased slightly.

In Island Lake, total phosphorus was highest at the bottom of the core and declined until about the 42-45 cm segment (1875) (Fig. 6). It was somewhat steady from 42 cm to 33 cm and then increased to a peak of about 1.25 mg/g near the middle of the core, the 27 to 30 cm segment, (circa 1910). NAI-P makes up the largest percentage of the three phosphorus fractions and starts the last increase above the 6-9 cm segment (1963). The rapid conversion of forested land to agricultural use in the Island

Lake watershed may have been responsible for the phosphorus increases starting an the 1890s. The Hinckley Forest Fire of 1894 which burned much of the region apparently did not burn Island Lake's watershed, but did hasten the conversion of the lumbering economy to an agricultural economy in the area. Farmlands continued to extend to the lake until at least the early 1920s, when the land was subdivided for development. Initial development started out slowly but increased rapidly in the 1950s and 1960s (Table 2).

A phosphorus peak found in the 9-12 cm segment (circa 1956) of Island Lake may represent the beginning of the housing boom. A portion of the 9-12 cm peak is due to an increase in the A-P fraction. A-P is sometimes associated with sediments arriving in the lake basin from the watershed (Engstrom & Wright, in press). This A-P increase may be associated with the start of serious home and road construction around the lake periphery possibly resulting in an erosional sediment influx to the lake basin. At the start of rapid residential growth only 35 lakeside buildings were recorded (MDNR, 1955) but by the next survey date (1967) 110 buildings were recorded (Table 2). Assuming lake and sediment redox conditions have not seriously affected sediment phosphorus concentrations, the NAI-P and Org-P fractions might have been expected to increase because of an increasing number of onsite systems. But in the next segment (6-9 cm; 1967-1974) phosphorus concentrations were lower. This would not be expected if onsite systems were contributing a significant phosphorus input. Although NAI-P increases in the top two segments, the concentrations are not higher than what was found in some of the earlier dated segments.

A phosphorus increase in the NAI-P and Org-P fractions was recorded in the surficial segment (0-3 cm) in the Island Lake core. Three different explanations for the increase may be; phosphorus migration upward in the sediments, phosphorus influx from onsite systems, or an increase in planktivorous fish. Williams et al. (1976b) discussed the possibility of orthophosphate migrating up the core from a reduced zone to an oxidized microzone layer found at the sediment-water interface resulting in artificially high phosphorus concentrations. Although NAI-P slightly increases in the surficial segment of Little Island Lake, a decrease in NAI-P is found in Sturgeon Lake (Fig. 6). Still it is possible upward migration and the resulting phosphorus increase occurred in Island and Little Island Lakes, and was not as obvious in Sturgeon Lake. If the NAI-P increase in Island Lake was due to onsite systems we might expect an increase in the other developed lake, Sturgeon Lake, but the phosphorus concentration decreases. Alternatively, we would not expect a phosphorus increase in the undeveloped lake, Little Island Lake, but there is a slight increase. An abrupt increase in planktivorous fish could have an indirect impact on increasing Org-P by reducing the zooplankton population, allowing an increase in the phytoplankton population, and resulting in an increase in Org-P deposition to the sediments. In the 1970s, fishing contests were held in both Island and Sturgeon Lakes resulting in heavy fishing pressure on the larger game fish (Mr. E. Dahlen, pers. comm.). A decrease in game fish could result in an increase in their prey, which is often planktivorous fish. MDNR fishery records show an increase in planktivorous fish in Island Lake and a smaller increase in Sturgeon Lake in the late 1970s (Table 3). Information is not available for Little Island Lake but because Island and Little Island Lakes are connected, planktivorous fish probably pass between both lakes and Little Island Lake may have high planktivore populations as well. Hypothetically, the end result would be Org-P increases in Island and Little Island Lakes with only a slight increase in Sturgeon Lake. These changes are found in the surficial segments. But reasons for the NAI-P increase in the surficial segment of Island Lake is not clear.

Little Island Lake has had historically high total phosphorus values in the sediments except for the period of 1910-1920 (18-21 cm segment) (Fig. 6). Otherwise the three phosphorus fractions are relatively constant, increasing only slightly since the 1940s. The organic phosphorus levels are higher than the other two lakes indicating Little Island may be more productive. The sharp phosphorus decline in the 18-21 cm segment is followed by a recovery in the very next segment, 15-18 cm. A similar change in chlorophyll degradation products was also observed in this segment. Extrapolating from the Cesium-137 derived sedimentation rate, this segment of lowest phosphorus and chlorophyll concentration was dated 1910-1920, and corresponds to the time of the Moose Lake Fire (1918). A 1918 U.S. Forest Service map (cited in Moose Lake Gazette, Moose Lake, Minnesota, 7 Oct. 1982) indicated that most of Little Island Lake's watershed burned, while a small portion of Island Lake's watershed burned, and none of Sturgeon Lake's watershed burned in this fire. The high total phosphorus and high Org-P fractions indicate Little Island Lake has always been productive. The primary vestibule of productivity probably has been macrophytes. The bottom sediments through out the core are of a peaty composition with a high organic matter content.

Addressing the Hypothesis

Because the changes in parameters used as trophic indicators in the sediment core in Sturgeon and Island Lakes are not readily correlated with an increasing number of onsite systems (beginning in the mid-1950s), onsite systems do not appear to be the predominate cause of nutrient enrichment in Island or Sturgeon Lakes. The results from the sediment core analysis somewhat support the alternative hypothesis that trends in the sediment core profiles from all three lakes may be explained by factors other than onsite waste treatment systems. All three lakes are limnologically and morphologically distinct; however, trends in all three lakes reflect the impact of land use in the watershed. If onsite systems had an impact on the lakes through nutrient enrichment, the effects were masked by contributions from other sources.

Analysis of the sediment core from Shagawa Lake, Minnesota shows that distinct changes in trophic status after onset of iron ore mining and increased residential development could be attributable to wastewater discharges from a centralized wastewater treatment operation in Ely, Minnesota (Bradbury, 1975; 1978). Our study found changes associated with forest fires and the onset of farming and construction; but we did not find strong evidence for changes correlated with wastewater flows from an increasing number of onsite systems. In addition, unpublished MDNR fishery records, (1938; 1955; 1967; 1970; 1975; 1979) covering the period when development was rapidly increasing around Sturgeon and Island Lakes, indicate Secchi disk depth readings have flucuated only slightly over the years, and an increasing or decreasing trend is not obvious for either lake (Table 4).

In this specific case, because onsite systems do not appear to be the causal factor for lake eutrophication, the effectiveness of implementing an alternative wastewater treatment system to abate the nutrient inputs from onsite systems should be carefully evaluated. For example, if a centralized sewer collection system was installed to remove the nutrient input associated with onsite systems, the eutrophication process for these two developed lakes would not necessarily be reversed. Additional extensive nutrient abatement measures would probably have to be implemented to realize an improvement in lake water quality.

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REFERENCES

Brandes, M., Chowdhry, N.A., & Cheng, W.W. (1975) Experimental study on removal of pollutants from domestic sewage by underdrained soil filters. National Home Sewage Disposal Symp. American Society of Agricultural Engineers, St. Joseph, Michigan, pp. 29-36.

Bradbury J.P. (1975) Diatom stratigraphy and human settlement in Minnesota. U.S. Geol. Surv., Special Paper 171.

Bradbury J.P. (1978) A paleolimnological comparison of Burntside and Shagawa Lakes, northeastern Minnesota. EPA Ecol. Res. Series, EPA-600/3-78-004.

Bradbury J.P. & Waddington J.C.B. (1973) The impact of European settlement on Shagawa Lake, northeastern Minnesota. In, Quaternary plant ecology (Edited by Bisks H.J.B. & West R.G.), pp.289-307. Blackwells, Oxford.

Davis G.E. & Larsen G.L. (1976) Sediment characteristics and the trophic status of four Oregon lakes. Wat. Resour. Res. Instit. Oregon State Univ. WRRI-46.

Davis M.B. & Ford M.S. (1982) Sediment focusing in Mirror Lake, New Hampshire. Limnol. Oceanogr. 27:137-150.

Dillon P.J. & Kirchner W.B. (1975) The effects of geology and land use on the export of phosphorus from watersheds. Water Res. 9, 135-148.

Dillon P.J. & Rigler F.H. (1975) A simple method for predicting the capacity of a lake for development based on lake trophic status. J. Fish. Res. Bd. Can. 32, 1519-1531.

Edmondson W.T. (1974) The sedimentary record of the eutrophication of Lake Washington. Proc. Natl. Acad. Sci. 71, 5093-5095.

Engstrom D.R. & Wright H.E. Jr. (In press) Chemical stratigraphy of lake sediments as a record of environmental change. In Studies in Palaeolimnology and Palaeoecology, Essays in Honour of Winifred Pennington (Edited by Birks, H.J.B. & Haworth E.Y.) University of Leicester.

Hansel M.J. & Machmeier R.E. (1980) On-site wastewater treatment on problem soils. J. Wat. Poll. Cont. Fed. 52, 548-558.

Harris G.P. & Vollenweider R.A. (1982) Paleolimnological evidence of early eutrophication in Lake Erie. Can. J. Fish. Aquat. Sci. 39:618-626.

Hill D.E. & Sawhney B.L. (1981) Removal of phosphorus from waste water by soil under aerobic and anaerobic conditions. J. Environ. Qual. 10, 401-405.

Jones R.A. & Lee G.F. (1977) Septic tank disposal systems as phosphorus sources for surface waters. EPA 600/3-77-129. Robert S. Kerr Environ. Res. Lab., Ada, Oklahoma.

Jorgensen E.G. (1948) Diatm communities in some Danish lakes and ponds. Kangelige Dansk Videnska bernes Selskab, Biologiske Skrifter, Bind V, Nr. 2.

Kalff J. & Knoechel R. (1978) Phytoplankton and their dynamics in oligotrophic and eutrophic lakes. Ann. Rev. Ecol. Syst. 9, 475-495.

Kerfoot W.B. & Skinner Jr, S.M. (1981) Septic leachate surveys for lakeside sewer needs evaluation. J. Water Poll. Cont. Fed. 53, 1717-1725.

Laak R. (1980) Wastewater engineering design for unsewered areas. Ann Arbor Science, Ann Arbor, Michigan.

Lee D.R. (1976) The role of groundwater in eutrophication of a lake in glacial outwash terrain. Intern. J. Speleol. 8, 117-126.

Lee D.R. (1977) A device for measuring seepage flux in lakes and estuaries. Limnol. Oceanogr. 22, 140-147.

Louden T.L. & Fay L. (1982) Water quality from drains around septic systems American Society of Agricultural Engineers, 1982 Winter Meeting. Paper No. 82-2558. Amer. Soc. Agric. Engin., St. Joseph, Michigan.

Manny B.A., Wetzel R.G., & Bailey R.E. (1978) Paleolimnological sedimentation of organic carbon, nitrogen, phosphorus, fossil pigments, pollen, and diatoms in a hypereutrophic, hardwater lake: a case history of eutrophication. Pol. Arch. Hydrobiol. 25, 243-267.

Minnesota Depart. Nat. Resources (1938; 1955; 1967; 1975; 1979) Fisheries lake surveys of Sturgeon Lake, Pine County, MN, unpublished.

Minnesota Depart. Nat. Resources (1954; 1967; 1970; 1979) Fisheries lake surveys of Island Lake, Pine County, MN, unpublished.

Minnesota Depart. Nat. Resources (1967) Fisheries lake survey of unnamed lake, 58-61, Pine County, MN, unpublished.

Neel J.K., Peterson S.A., and Smith W.L. (1973) Weed harvest and lake nutrient dynamics. USEPA Ecol. Res. Ser., EPA 660/3-73-001.

Oloya T.O. & Logan T.J. (1980) Phosphate desorption from soils and sediments with varying levels of extractable phosphate. J. Environ. Qual. 9, 526-531.

Pine County Historical Society (1949) One hundred years in Pine County. Reissued 1977. (Edited by Mill, J.P) Pine County Historical Society, Sandston, Minnesota.

Ritchie J.C., McHenry J.R., & Gill A.C. (1973) Dating recent reservoir sediments. Limnol. Oceanogr. 18, 254-263.

Shapiro J., Edmondson W.T. & Allison D.E. (1971) Changes in the chemical composition of sediments of Lake Washington, 1958-1970. Limnol. Oceanogr. 16, 437-452.

Stormer E.F. & Yang J.J. (1970) Distribution and relative abundance of plankton diatoms in Lake Michigan. Great Lakes Res. Div. Pub. 16, Univ. Mich., Ann Arbor, Michigan.

U.S. Depart. Commerce (1929; 1934; 1939; 1949; 1969; 1978) State and county data, Minnesota census of agriculture. Washington, D.C.

U.S. EPA (1975) National eutrophication survey working paper on Higgins Lake. USEPA Environ. Res. Lab., Corvallis, Oregon.

U.S. EPA (1979a) Alternative waste treatment systems for rural lake projects. Case study number 1, Crystal Lake area sewage disposal authority, Benzie County, Michigan. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1979b) Alternative waste treatment systems for rural lake projects. Case study number 2, Green Lake sanitary sewer and water district, Kandiyohi County, Minnesota. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1979c) Alternative waste treatment systems for rural lake projects. Case study number 3, Springvale-Bear Creek sewage disposal authority, Emmet County, Michigan. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1979d) Alternative waste treatment systems for rural lake projects. Case study number 4, Steuben Lakes regional waste district, Steuben County, Indiana. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1979e) Alternative waste treatment systems for rural lake projects. Case study number 5, Ottertail County Board of Commissioners, Ottertail County, Minnesota. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1980) Modeling phosphorus loading and lake response under uncertainty: a manual and compilation of export coefficients. EPA 440/5-80-011. Office of water Reg. and Stand., Washington, D.C.

U.S. EPA (1981) Alternative waste treatment systems for rural lake projects. Case study number 6, Williams County Commissioners, Nettle Lake area, Williams County, Ohio. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. EPA (1982) Indian Lake/Sisters Lakes wastewater treatment facilities; Berrien, Cass, and VanBuren Counties, Michigan. Draft Environ. Impact Statement. Chicago, Illinois.

U.S. EPA (1983a) Wastewater management in rural lake areas. Final Generic Environ. Impact Statement. Chicago, Illinois.

U.S. EPA (1983b) Moose Lake-Windemere sanitary district wastewater treatment facilities; Pine and Carlton Counties, Minnesota. Draft Environ. Impact Statement, Chicago, Illinois.

U.S. Geological Survey (1979) Bruno and Moose Lake, Minnesota quadrangles. 15 minute series (topographical) Depart. of Interior, Washington, D.C.

Vallentyne J.R. (1955) Sedimentary chlorophyll determination as a paleobotanical method. Can. J. Bot. 33, 304-313.

Viraraghavan T. & Warnock R.G. (1976) Groundwater quality adjacent to a septic tank system. J. Am. Water Works Assn. 68, 611-614.

Williams J.D.H., Jaquet J.-M., & Thomas R.L. (1976a) Forms of phosphorus in the surficial sediments of Lake Erie. J. Fish. Res. Board Can. 33, 413-429.

Williams J.D.H., Murphy T.P. & Mayer T. (1976b) Rates of accumulation of phosphorus forms in Lake Erie sediments. J. Fish. Res. Board Can. 33, 430-439.

Table Headings

Table 1. Lake and watershed parameters for Sturgeon, Island and Little Island Lakes. Information was obtained from recent lake surveys conducted by USEPA (1983b) and MDNR (unpublished).

Table 2. House counts made by MDNR (unpublished).

Table 3. Average number of planktivorous fish caught per set by gillnets and trapnets. Planktivorous fish include yellow perch, black and white crappie, and bluegill and pumpkinseed sunfish.

Table 4. Summary of Secchi disk measurements made by MDNR and USEPA (1982 only)

TABLE 1.

	Sturgeon	Island	Little Island
Number of onsite systems	197	151	0
Length of shoreline (km)	12.9	10.1	1.7
Ratio onsite systems/ km of lake shoreline	15	15	0
Watershed area (ha)	560	1151	294
Lake surface area (ha)	686	211	17
Ratio watershed/lake surface	0.8	5.5	17.3
Mean depth (m)	6.9	3.4	1.6
Mean Secchi disk (m)	2.4 (n=16)	1.4 (n=24)	0.9
Chlorophyll *a* (ug g^{-1})	8 (n=24)	29 (n=35)	NA
Total phosphorus, winter values (mg l^{-1})	0.02(n=4)	0.04(n=4)	0.03(n=2)
Estimated phosphorus budget (kg yr^{-1})	1934	1090	226
Estimated phos. contribution from onsite systems (kg yr^{-1})	179	141	0
Estimated phos. contribution from onsite systems (%)	9	13	0
Current lake trophic status	meso-eutrop.	eutrophic	eutrophic

TABLE 2

	House Counts	
Date	Sturgeon	Island
1979-80	208	169
1975	170	--
1970	--	128
1967	120	110
1954-55	81	35

TABLE 3

	Planktivorous Fish	
Date	Sturgeon	Island
1979-80	57	189
1975	18	--
1970	--	20
1967	47	57
1954-55	30	37

TABLE 4

Date	Secchi Disc Measurement (m)	
	Sturgeon	Island
1982	2.4	1.4
1979-80	2.3	1.3
1975	2.4	2.0
1970	--	1.4
1967	2.9	1.7
1955	--	1.1
1938	2.4	--

Figure Legends

Figure 1. Sampling site locations. Topographical watershed boundries are outlined by the black line. Hatched area represents glacial outwash sand. The remainder of the soils in the lake's watersheds are clayey glacial till.

Figure 2. Stratigraphic profiles of Cesium-137 radioactivity in lake sediment cores.

Figure 3. Organic matter stratigraphic profiles.

Figure 4. Chlorophyll degradation product stratigraphic profiles.

Figure 5. Diatom stratigraphic profiles. Diatom species have been put into one of three categories; eutrophic, mesotrophic, or other based on their trophic affiliation.

Figure 6. Stratigraphic profiles for three phosphorus fractions.

FIGURE 1.

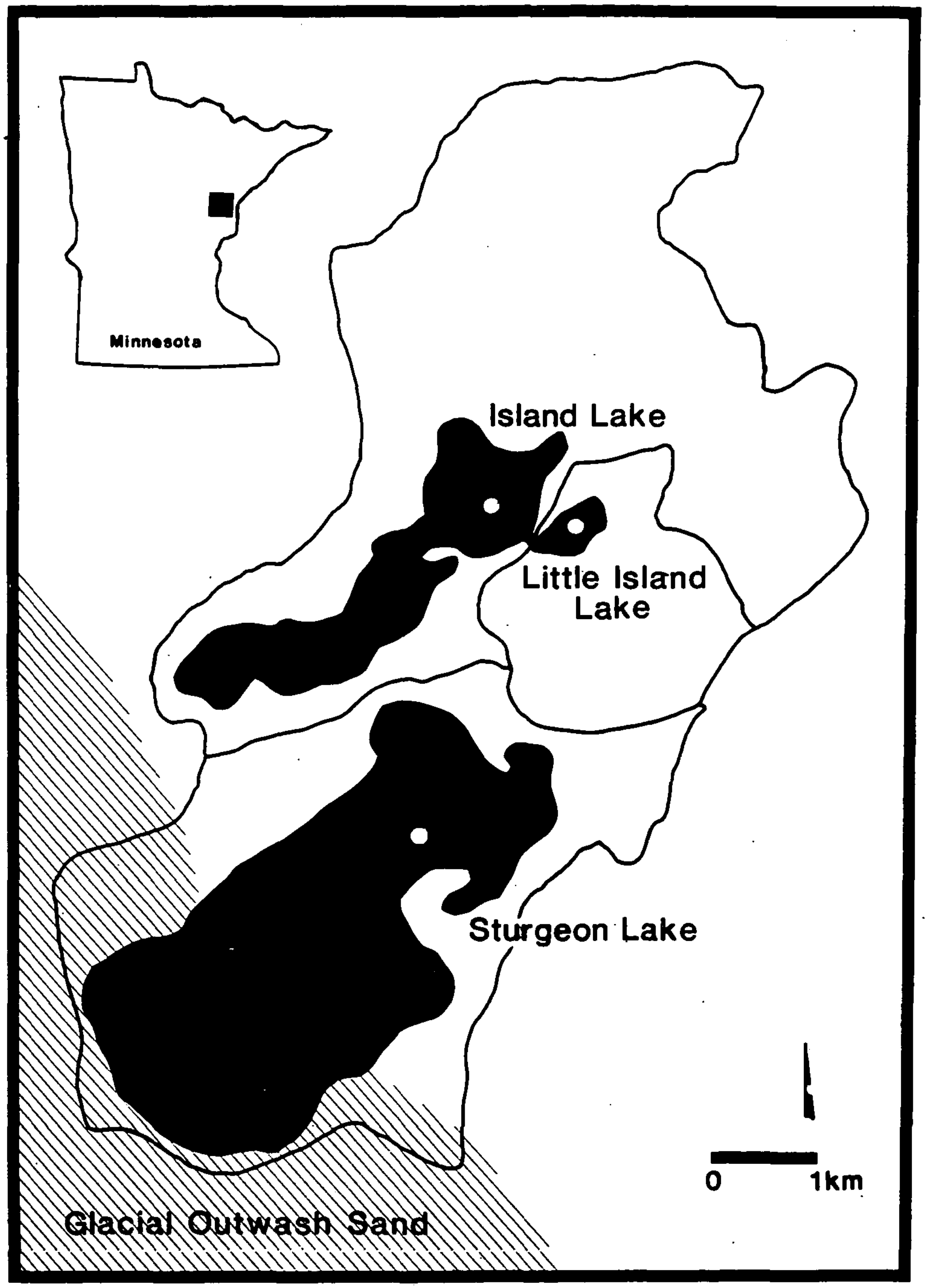

Minnesota
Island Lake
Little Island Lake
Sturgeon Lake
0
1km
Glacial Outwash Sand

FIGURE 2.

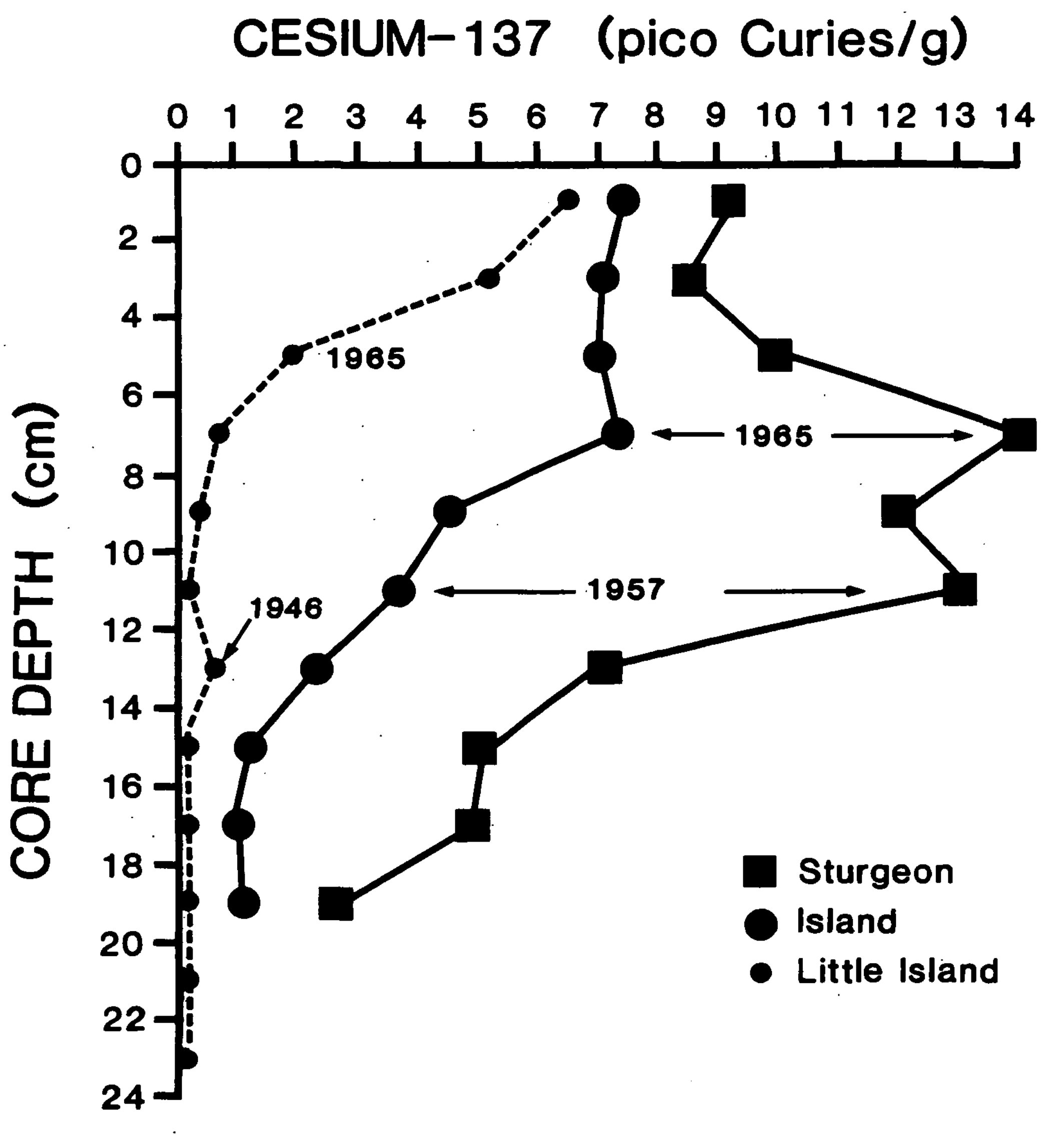

CESIUM-137 (pico Curies/g)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
CORE DEPTH (cm)
0 2 4 6 8 10 12 14 16 18 20 22 24
1965
1965
1957
1946
Sturgeon
Island
Little Island

FIGURE 3

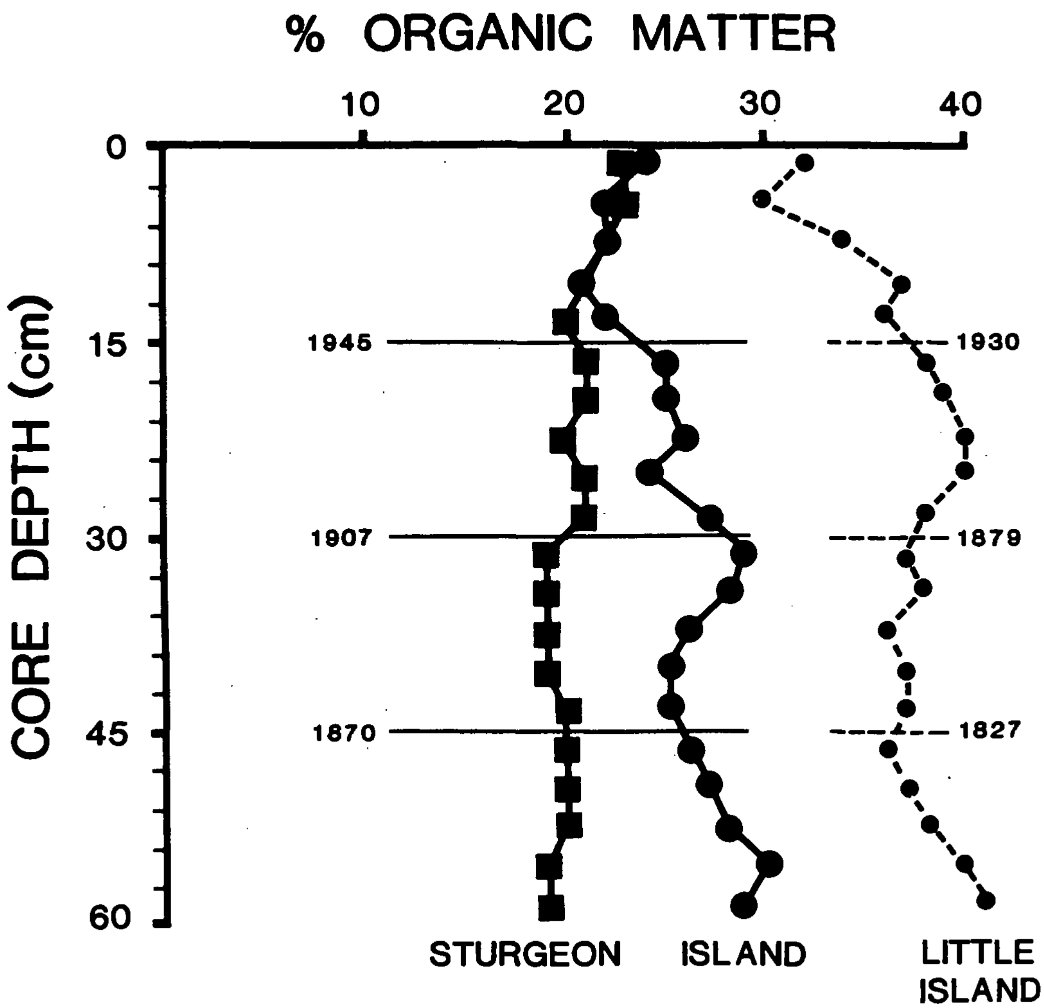

% ORGANIC MATTER
10
20
30
40
0
15
30
45
60
CORE DEPTH (cm)
1945
1907
1870
1930
1879
1827
STURGEON
ISLAND
LITTLE ISLAND

FIGURE 4

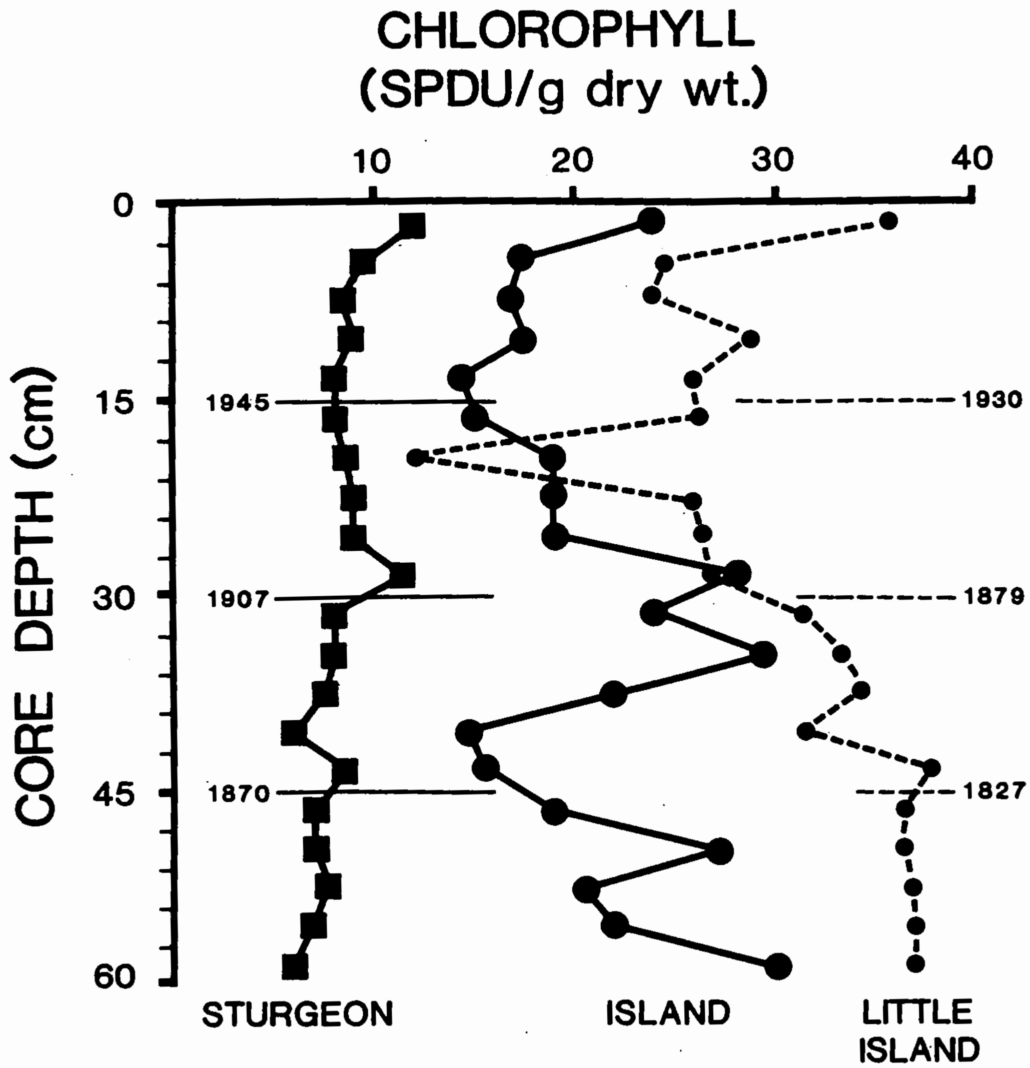

CHLOROPHYLL
(SPDU/g dry wt.)
10
20
30
40
0
15
30
45
60
CORE DEPTH (cm)
1945
1907
1870
1930
1879
1827
STURGEON
ISLAND
LITTLE ISLAND

FIGURE 5

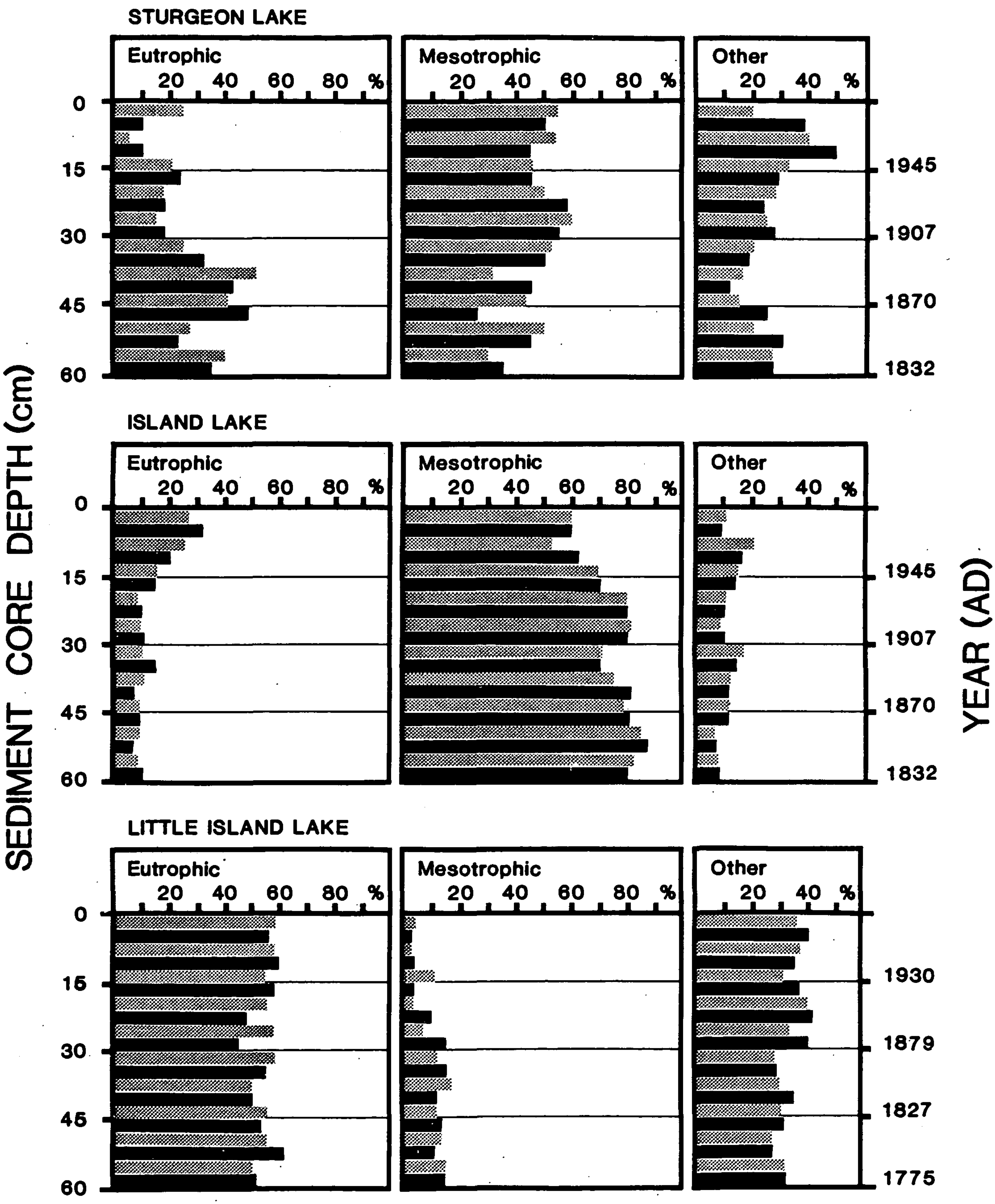
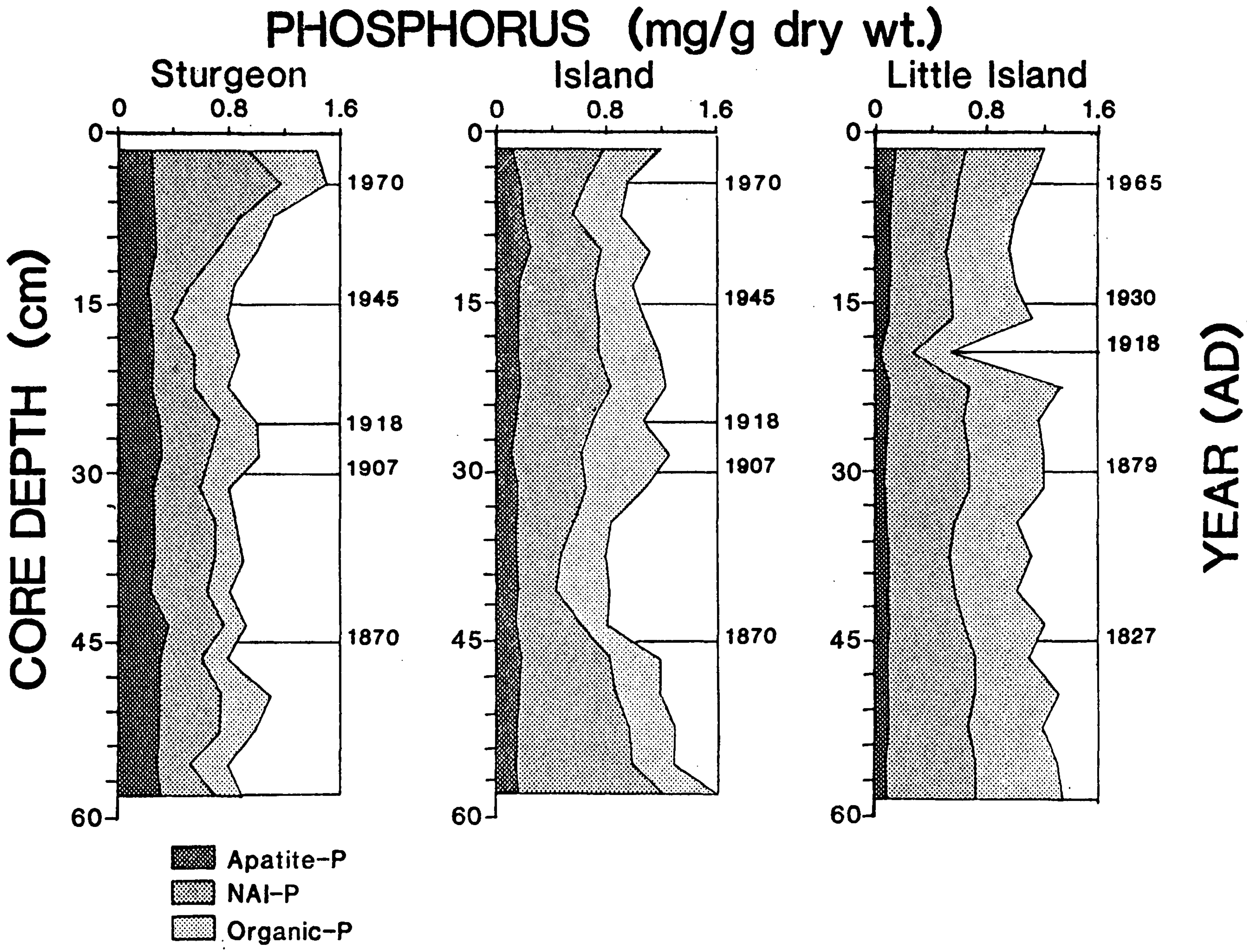

STURGEON LAKE
Eutrophic
Mesotrophic
Other
20 40 60 80 %
0
15
30
45
60
1945
1907
1870
1832
ISLAND LAKE
1945
1907
1870
1832
LITTLE ISLAND LAKE
1930
1879
1827
1775
SEDIMENT CORE DEPTH (cm)
YEAR (AD)

FIGURE 6



PHOSPHORUS (mg/g dry wt.)
Sturgeon
Island
Little Island
0
0.8
1.6
CORE DEPTH (cm)
0
15
30
45
60
YEAR (AD)
1970
1945
1918
1907
1870
1965
1930
1879
1827
Apatite-P
NAI-P
Organic-P

-Supplemental Information-

[a]Range and means of sediment parameters from sediment cores.

	Island Lake	Sturgeon Lake	Little Island Lake
CaCO	0.7-3.3	0.7-1.9	0.8-1.8
(%)	1.7	1.3	1.2
Organic Matter	20.8-29.4	19.0-22.9	29.8-41.1
%	25.6	20.4	36.8
Chlorophyll	57.4-102.0	32.6-54.8	31.0-112.3
(SPDU/g. org. matt.)	79.4	40.7	83.3
Total Phosphorus	0.80-1.72	0.80-1.50	0.54-1.32
(mg/g dry wt.)	1.07	0.95	1.12
Organic Phosphorus	0.21-0.52	0.15-0.40	0.26-0.64
(mg/g dry wt.)	0.34	0.27	0.51
Inorganic Phosphorus	0.44-1.20	0.39-1.18	0.28-0.72
(mg/g dry wt.)	0.73	0.68	0.61
Apatite Phosphorus	0.08-0.24	0.22-0.37	0.04-0.14
(mg/g dry wt.)	0.15	0.27	0.09
Nonapatite Inorganic P.	0.29-1.05	0.15-0.92	0.24-0.63
(mg/g dry wt.)	0.58	0.41	0.52

[a]Note that chlorophyll breakdown products are presented herein on a gram of dry organic matter basis.

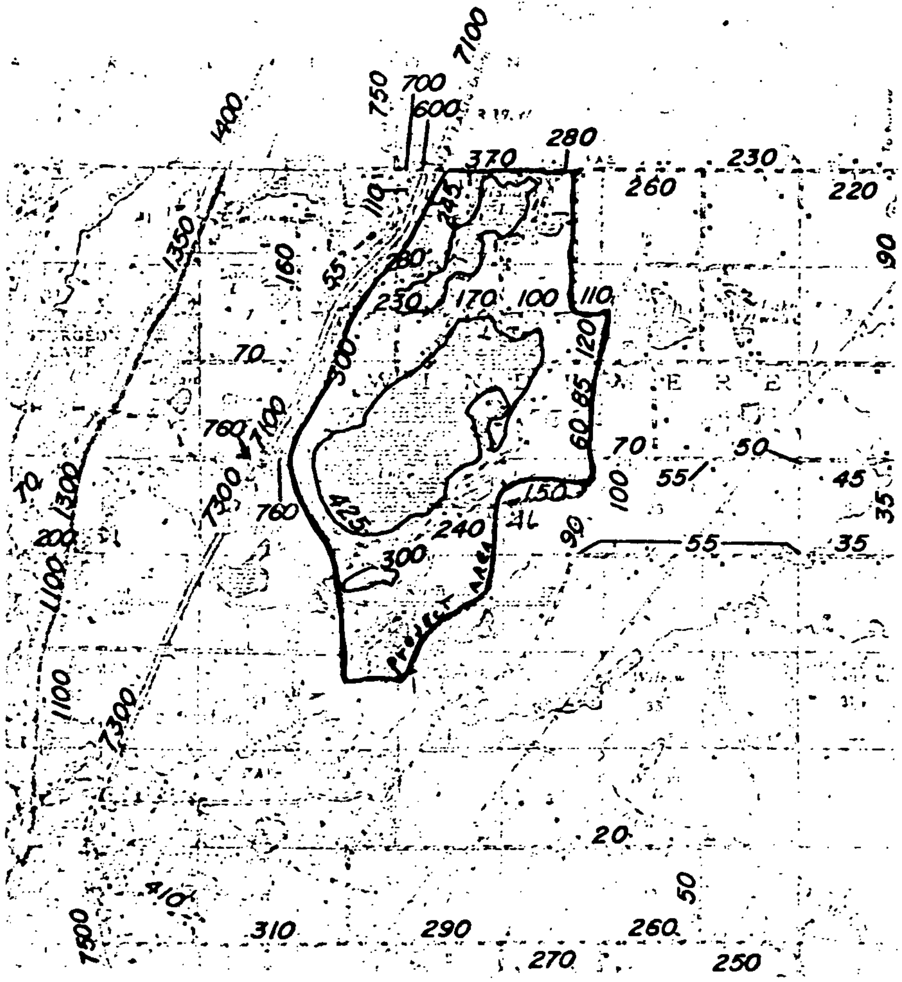


Figure M-1. 1979 average annual daily traffic in northwestern Pine County (MDOT). Traffic volume on the state highway is for 1978.

Figure M-1.

Figure N-1. Unit price for residental energy during the period from April 1980 to March 1981 (Minnesota Energy Agency 1981).

Location	Use	Fuel Type: Natural Gas (per 1,000 cubic feet)	Electricity (per Kelo watt hour)	Fuel Oil (per gallon)	LP Gas (per gallon)
Region 3	Space heating	$3.70	4.72¢	$1.22	71.1¢
	Non-space heating	4.42	5.46		
Region 7E	Space heating	3.33	4.70	1.17	74.7
	Non-space heating	3.85	5.53		
Minnesota	Space heating	3.51	3.64	1.16	69.8
	Non-space heating	4.10	5.21		

[a]The basis for heating values of the fuels are:

Natural gas: 1,000 BTU per cubic feet
Electricity: 3,412 BTU per KW hour
Distillate
Composite (fuel oil): 138,690 BTU per gallon
Propane: 91,500 BTU per gallon

Appendix O

Letters of Comment

United States Department of Agriculture

Soil Conservation Service

200 Federal Building
316 North Robert St.
St. Paul, MN 55101

June 10, 1983

Mr. Harlan D. Hirt, Chief
Environmental Impact Section
Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, IL 60604

Dear Mr. Hirt:

We have reviewed the draft appendicies to the Environmental Impact Statement for the Moose Lake - Windemere Sanitary District Waste Water Treatment System, Pine and Carlton Counties, Minnesota.

The material in the report is satisfactorily presented and needs no further comment. We appreciated the opportunity to review this report.

Sincerely,

Donald G. Ferren
State Conservationist

cc: Peter C. Myers, Chief, SCS, Washington, D.C.

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1135 U. S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

June 9, 1983

Construction-Operations
Regulatory Functions (C30077)

Mr. Harlan D. Hirt, Chief
Environmental Impact Section
U.S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Hirt:

Thank you for giving us the opportunity to review the draft Environmental Impact Statement (EIS) for the Moose Lake Windemere Sanitary Wastewater Treatment System (your reference number 5WFI-12). After examining the various alternatives discussed, we have made the following determinations:

1. No alternative will affect any existing or planned St. Paul District project.

2. No Department of the Army permit would be required to carry out alternative 2, which has been recommended as the selected project alternative.

3. If any one of alternatives 3 through 7 were chosen, authorization from the Corps might be required under Section 404 of the Clean Water Act. More detailed construction information would be required to make a definite jurisdictional determination.

If you have questions, please write or call Mr. Henrik Strandskov of this office at (612)725-7775.

Sincerely,

Dennis E. Cin
Chief, Regulatory Functions Branch
Construction-Operations Division

United States Department of the Interior

OFFICE OF THE SECRETARY
NORTH CENTRAL REGION
175 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

June 20, 1983

ER-83/613

Mr. Valdas V. Adamkus
Regional Administrator
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Adamkus:

The Department of Interior has reviewed the draft Environmental Impact Statement (EIS) for the wastewater treatment system for Moose Lake-Windemere Sanitary District in Pine and Carlton Counties, Minnesota. The following comments are provided for your consideration.

The alternative selected by the U.S. Environmental Protection Agency recommends on-site system upgrading for the entire service area and would only affect residential yards during construction of proposed improvements. In addition, this alternative eliminates any phosphorus/nitrate contribution to adjacent lakes originating from failing on-site systems and will have little or no impact on fish and wildlife resources.

Although threatened and endangered species were not identified in the EIS, both the bald eagle and gray wolf occur in the aforementioned counties. However, considering the location and types of activities proposed, this project should have no effect on the above listed species. This precludes the need for further action on this project as required by the Endangered Species Act of 1973, as amended. Should new information become available that indicates listed or proposed species may be affected, consultation with the Regional Director, U.S. Fish and Wildlife Service, Federal Building, Fort Snelling, Twin Cities, Minnesota 55111, should be reinitiated.

It is indicated on pages 3-82 and 3-83 of the draft that preliminary coordination with the Minnesota State Historic Preservation Officer (SHPO) to identify cultural resources in the proposed project area has been accomplished. The final statement should evidence approval by the SHPO of completed compliance with mandates pertaining to the identification and protection of cultural resources.

Sincerely yours,

Sheila Minor Huff

Sheila Minor Huff
Regional Environmental Officer

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION 5
18209 DIXIE HIGHWAY
HOMEWOOD, ILLINOIS 60430

June 2, 1983

IN REPLY REFER TO: HEP-05

Mr. Harlan D. Hirt, Chief
Environmental Impact Section
U.S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Hirt:

The draft environmental impact statement for the Moose Lake-Windmere Sanitary District Wastewater Treatment System, Pine and Carlton Counties, Minnesota has been reviewed. The recommended project alternative of on-site system upgrades would have no effect on the Federal-aid highway system. The discussion of the other alternatives also recognizes impacts to the highway system in the area. Therefore, we have no comments to offer on the draft EIS.

Sincerely yours,

Lionel H. Wood

Lionel H. Wood, Director
Office of Environmental Programs

cc: HEV-11
Sec. Rep.
P-37
EPA W/O (5 copies)
Minnesota D/O

East Central Regional Development Commission

Serving Local Governments in Chisago, Isanti, Kanabec, Mille Lacs and Pine Counties

May 26, 1983

Environmental Protection Agency
Region V
230 So. Dearborn St.
Chicago, Illinois 60604

Dear Sir/Madam:

The East Central Regional Development Commission reviewed the Moose Lake - Windemere Sanitary Sewer District Wastewater Treatment System Environmental Impact Statement at its regular meeting of May 23, 1983. Upon reviewing the EIS, the EC RDC concurs with the EIS recommendation that the on-site treatment alternative (Alternative #1) is the most cost-effective and is the most feasible treatment alternative for this area.

In previous reviews of the Step I grant application and Step I plan, the EC RDC has expressed concerns regarding the potential serious secondary growth impacts to this relatively undeveloped area. The EC RDC hopes that this recommendation and comment are taken into consideration when EPA takes action on this EIS.

Sincerely,

Michael Sobota
Executive Director

MS:da

119 South Lake Street, Mora, Minnesota 55051-1596 (612) 679-4065

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

BOX , CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

DNR INFORMATION
(612) 296-6157

June 21, 1983

FILE NO.

Mr. Harlan D. Hirt, Chief
Environmental Impact Section
U.S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

RE: Draft EIS for Moose Lake-Windemere Sanitary District Wastewater Treatment System, Minnesota

Dear Mr. Hirt:

The Department of Natural Resources (DNR) has reviewed the above-referenced document and offers the following comments for your consideration.

We foresee no major problems resulting from the project if the recommended alternative is selected.

However, based on the conclusions in the document which state that "evaluation of the existing data on the natural and man-made environment in the project area indicates that water quality impacts due to onsite systems are inconsequential in the context of other manageable and unmanageable nutrient sources, and that none of the action alternatives will significantly improve the quality of the lakes or the groundwater," it seems difficult to justify the expenditure of over $1 million to upgrade onsite systems. From the alternatives presented, it would appear prudent only to select the no-action alternative. However, the data presented in the document seem to indicate that the nutrient loads entering the subject lakes are from non-wastewater sources (agricultural, lawn fertilization, etc.) and any effective solution would have to address these problems, which were not covered in the DEIS.

Thank you for the opportunity to comment.

Sincerely,

Thomas W. Balcom

Thomas W. Balcom
Environmental Review Coordinator

TWB:pje
3618E

cc: Dick Carlson
Earl Huber
Ron Harnack

Minnesota Pollution Control Agency

AUG 0 8 1983

Mr. Charles Quinlan
Environmental Impact Section
U. S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Quinlan:

Re: Moose Lake - Windemere Sanitary District, Minnesota
Draft Environmental Impact Statement
EPA Project No. C271301-01

In follow-up to our phone conversation, the following comments are submitted on behalf of the Minnesota Pollution Control Agency (MPCA) review of the Draft Moose Lake-Windemere Environmental Impact Statement.

1. The discussion of algal toxicity as related to Island Lake is confusing (p. 2-58). The distinction between those species associated with toxic conditions and other non-toxic species of the same general is blurred. The statement that "there is a potential public health problem associated with blue-green algae in Island Lake," appears to be an exaggeration which could unintentionally mislead the public on an at times emotional issue. In our opinion, it should be stated clearly that available information indicates that the algal communities observed in Island Lake do not pose a threat to public health.

2. The opinion (p. 2-57) that average phosphorus levels of .02 mg/l and .04 mg/l in Sturgen and Island Lakes, respectively, are similar is not shared by our technical staff. Further, the advisability of using the March, 1982 sampling results for Island and Sturgen lakes to detect

Phone:______________
1935 West County Road B2, Roseville, Minnesota 55113-2785
Regional Offices • Duluth/Brainerd/Detroit Lakes/Marshall/Rochester
Equal Opportunity Employer

AUG 08 1983

system failure must be questioned based on the limited number of samples, the lack of analytical sensitivity and absence of an adequate scientific rationale for a study of this type.

3. The land runoff phosphorus export coefficients used to estimate external phosphorus supplies to the study appear to be excessive (cf. Table 3-6, page 3-24). In general, the export values which were used appears to be from individual test plots, some as small as .009 mg/l (roughly, 30 ft. x 30 ft.), whose applicability to the study area watersheds has not been demonstrated. We are especially concerned with the high values used to estimate phosphorus export from cultivated land, pasture and lawns. Ground water impacts of nutrients and water have been largely ignored.

4. We are also concerned about what might seem to some readers to be a tendency to diminish the overall importance of phosphorus control in the "Documentation of Need for Improved Wastewater Management" section on pp. 2-60 and 2-61. One should not lose site of the fact that phosphorus control is a desirable goal and the principal means of improving or protecting the water quality of inland fresh water lakes. In this context, all phosphorus sources are important and should be considered candidates for control. While expensive phosphorus control options (e.g., collection system or treatment works) may be difficult to justify, one should guard against creating the impression that better control over on-site waste disposal should not be vigorously pursued though other means, particularly in light of the possibility that our non-point sources of phosphorus may be much more difficult to control.

5. The chosen alternative is on-site upgrade for all the areas involved. From Dr. Finney's description of the soils, there are problem soils in the area all with severe ratings for soil absorption systems. Therefore, how did they decide who would get mounds and who would get drainfield? There should be a discussion of this documented. It may be that everyone located on the Duluth soils were given mounds and those on Omega were given the drainfields.

6. Was there any further investigation to show that conventional and mound systems could be built according to WPC-40? The Duluth soils have up to 48% clay in them with estimated permeabilities as low as .06"/hr. which translate to >300 mip as a perc rate. According to WPC-40,

AUG 08 1983

individual mounds could not be constructed on soils with a perc rate slower than 120 mpi without a variance. This is not to say something couldn't be designed on the slow rates, but, it would require a much larger area and may not be reflected in the costs.

On the other end of the spectrum are the Omega soils - very coarse. These soils may perc too fast for conventional trench systems, therefore trench liners would have to be added to costs. If these problems have not been considered, the feasibility and costing may not be truly reflective of actual needs.

7. Even though they were not chosen, the alternatives for cluster systems and the bog system should not be considered feasible alternatives at this time. To say the least, extensive soil and hydrological work would have to be done for the clusters and peat analysis would have to be done to show the bog system would work.

8. What will happen with the septage from the on-site system? On pg. 2-72, septage for the Moose Lake area is said to go to the Moose Lake System. What would this include? Is the pond surface area designed for this extra BOD loading? Estimates were given up to 4500 gpd of septage introduced to the system in the spring and fall. On pg. 2-81, it states septage in the Moose Lake Area is treated in anaerobic lagoons. What is the estimate of septage to be produced for Alt. #2?

9. There was considerable discussion on ground water contamination to wells and the conclusion was (pg. 2-50) that no problems were documented for any in areas having a high potential for water well contamination. Since none of the wells were samples in the critical areas (p. 2-43) how was this conclusion arrived at?

10. Nitrates will not be eliminated from being introduced to the ground water system even if the system is functioning properly. This was alluded to on pg. 15.

11. Population - Were the housing unit projections compared to available lakefront lots (developable ones)? It is not clear what rate of increase was applied to present housing stock figures to obtain the projected year - 2000 housing stock. In general, this portion of the EIS might appropriately be routed thru State Demographers Office for their comment.

AUG 08 1983

12. Historical sites - unless archaeological survey work is completed during the EIS, there is high probability it will not be completed during Step 1. When the selected alternative is arrived at by WAPORA, EPA, the State Historical Preservation Officer (SHPO) be contacted to determine location of needed surveys, and that these surveys be performed prior to finalization of EIS. Alternatively, the SHPO could be contacted to indicate which sites need surveys among all the alternatives.

13. Ground Water Impacts - Have ground water impacts of the final alternative been evaluated by ground water dispersion modeling techniques. This recommendation would not necessarily apply to individual upgrades, but would certainly in the case of group or community drainfields.

14. The planning map on page 2-9 did not include the City of Barnum nor the coridor between. We realize these two areas were dismissed as part of the final evaluation area in the Phase 1 EIS report; however, it should be noted they were part of the original planning area.

15. On Island Lake it was estimated that 64 residents were permanent and on Sturgen that 42% were permanent. How were these estimates made.

16. The windy weather during the Sturgen Lake Septic Leachate Survey may have caused some minor plumes to be missed. What effort went into that area to assure all failures were found?

17. The Hogan Area did not have a lot of detail survey information on the Septic System.

18. Average size of on-site systems were used for cost evaluation purpose. We would like to emphasize that, during a plan and specification development, individual SAS would be sized according to lot conditions and house size.

In summary we concur with the findings of the report and that the most cost-effective alternative has been proposed in the EIS.

AUG 0 8 1983

If you have any questions regarding these comments, please contact Lawrence S. Zdon at (612)296-7733.

Sincerely,

Gordon E. Wegwart

Gordon E. Wegwart, P.E.
Chief, Technical Review Section
Division of Water Quality

GEW/LSZ:cmc

cc: Mr. John Laumer, WAPORA, Chicago, Illinois

Moose Lake - Windemere Sewer District

604 West Road Moose Lake, Minnesota 55767 Phone 218/485-8276

June 21, 1983

Mr. Charles Quinlan
U. S. Environmental Protection Agency
Region V
230 South Dearborn St.
Chicago, Illinois 60604

Dear Sir:

As per our phone conversation we will expect to receive a transcript from you when ready.

We have some new members on our board of directors and as there is obvious disagreement between the District and the study by Wapora and E.P.A. we will withhold comments and judgement on the Draft until after we have received the transcript.

Sincerely,

Harold Westholm

Executive Director

HW/js

1410 Brainerd Avenue
Duluth MN 55811
1 June 83

Harlan D. Hirt, Chief
Environmental Impact Section
USEPA Region V
230 South Dearborn Street
Chicago IL 60604

Dear Sir:

This letter is written as a public comment on the *Draft Environmental Impact Statement for the Moose Lake-Windemere Sanitary Wastewater Treatment System for Pine and Carlton Counties, Minnesota.* It is written on behalf of my three brothers (Edward, Dale, Burleigh) and myself, owners of approximately 200 acres on Passenger and Big Slough lakes in Windemere township.

The draft Environment Impact Statement appears to be well done and accurate in its assessment. It is our position that of the action alternatives, alternative #2, upgrade on-site systems, is the one that is the most fair, most economically justifiable, and is fully able to protect the aquatic environment without unnecessary expenditures.

We are unable to attend the 10 June 83 hearings in Moose Lake and we desire to be informed if any alternatives other than numbers 1 or 2 are being seriously considered.

Sincerely,

George Rapp Jr

George Rapp, Jr.

cc: Chairman, Windemere
Township Council

Rte. 2, Box 139-A
Sturgeon Lake, Minnesota
55783

June 21, 1983

Mr. Harlan D. Hirt
Chief Environmental Impact Section
U.S. Environmental Protection Agency
Region V
230 South Dearborn St.
Chicago, Illinois 60604

Dear Mr. Hirt:

I am writing concerning the E.I.S. report on sewage disposal around Island Lake, Windemere Township, Pine County, Minnesota.

I have been a property owner on Island Lake since 1946. The proposed sewer pipeline would impose a financial hardship on me as I am retired and live on a small fixed income. I do not want the disruption caused by the digging of a pipeline through my property.

I oppose the establishment of a sewer pipeline and support the upgrading of on site disposal systems.

Sincerely,

Ethel M. Spell

Ethel Spell

Rte. 2, Box 140-B
Sturgeon Lake, Minnesota
55783

June 21, 1983

Mr. Harlan D. Hirt
Chief Environmental Impact Section
U.S. Environmental Protection Agency
Region V
230 South Dearborn St.
Chicago, Illinois 60604

Dear Mr. Hirt:

We are responding to the E.I.S. on sewage disposal around Island Lake, Windemere Township, Pine County, Minnesota. We are property owners on Island Lake.

After reviewing the available studies we have come to the conclusion that we oppose the construction of a sewer pipe line around Island Lake. We favor federal assistance in upgrading or establishing on site sewage disposal systems.

We favor putting the issue to an official closed ballot held in the Windemere Town Hall under proper legal voting procedures.

Minnesota and Pine County Shoreline Ordinances if enforced would have negated the need for these studies and saved the taxpayers money.

As a member of the Citizens Advisory Committee I was not mailed copies of the E.I.S., informed of the public hearing, or see any real intercourse between the Committee and the E.P.A..

We would like to see the Soil Conservation Service and Agricultural Stabilization Conservation Service come up with a project to reduce barnyard nutrients and soil erosion from entering Island Lake. This would be similiar to the Red Clay Project in Carlton County, with increased rates of cost-sharing to landowners.

Windemere Township lakes are a precious resource to be passed on to future generations.

Sincerely,

Walter C. Johnson
Kirsti H. Johnson

8126 Grafton Ave
Cottage Grove,MN 55016

June 13, 1983

U. S. E. PA., Region V
230 South Dearborn Street
Chicago, Illinois 60604

To Whom it May Concern:

I am against the proposed construction of sewers around Island and Sturgeon Lakes.

I own a small piece of property on Island Lake, which has a small cabin on it. Running the sewer line across the property would force me to sell out. With the spiraling cost of living these days and having 2 places to maintain, being a single parent with 4 dependent children, this increased expense would wipe out our being able to retreat to this small unpretentious cabin and the only pleasures the kids and I have.

I cannot understand why it is needed when there is no threat to the lakes. I did not attend the local hearing so I can only go by what I have heard other residents conveyed to me, which is hearsay....I did read a bit about the proposal, and have come to the conclusion, that it is not necessary to put the sewer in this area.

Sincerely,

Marica N. Cavanaugh

Marica N. Cavanaugh

RECEIVED
PROGRAM MANAGEMENT SECTION
JUN 20 1983
USEPA

June 10, 1983

Mr. Harlan D. Hirt
Mr Valdas V. Adamkus
Regional Administator
230 So Dearborn St
Chicago Ill

Re 5WF1-12

Dear Sir

Regarding environmental Impact Statement Sturgeon Lake, Minn.

We have had our cabin on the lake for over 50 years and wish to state we do not want a sewer system

If one happens to get a sewer system how will the costs be determined for example:

# of structure
Platted lots
Running feet facing sewer system

Also seasonal users should get lower annual operating bills

2

When the sewer comes in front of the structure does it have to be connected immediately or a grace period given.

We use the cabin mostly weekends for June, July, Aug & Sept. and do not feel a sewer is necessary for the short periods we are occupying the place.

Yours truly

Mrs. Margaret Bowler
4404 So Aldrich
Minneapolis Minn
55409

C: WATER
CC: RF
Hinkle

6/21/83

Dear Sirs;

I am writting this letter in protest to the proposed sewer around Island + Sturgeon Lakes. We have had a cabin on Island Lake for the past 18 years + has provided that many years of enjoyment for us + our five children.

Our cabin, on a 50 ft lot, would require 188 ft of sewer hook-up to the main line, a pump to bring waste material up to the main line, a minimum of $8.00 sewer usage year round for something we probably use 20-24 days a year. We would probably have to drill a new well as our present one would not be adequate, not to mention the $24,800.00 + 10% interest & the good possibility that [illegible] would not be adequate if the Moose Lake-Windemere Sewer would not be able to handle all the waste + have to be upgraded or worse. Also, what would

(2)

happen if the Moose Lake State Hospital should close?

In light of your EPA findings, I feel that the sewer is unjustified if no enviromental change would occur. It would be put around the lake for the permanent residents at the expense of the cabin owners & those on fixed incomes.

I question the fairness in the way the voting for or against the sewer was done. In the group of 5 cabins we are in, there were 2 that didn't receive any letter. How many more did not have a chance to vote? I object to an unanswered reply meant a yes vote. I also have been told by someone that attends the sewer board meetings that it was said that the cabin owners didn't count. We are asked to pay for something that we use for less than

③

a month out of a year & we don't count!

For us, who are week-end users & retired people, it would be out of the question to keep our place if the sewer goes through. We endorse upgrading our present system to your specifications, if it necessary, & not to pay nearly $9,000.00 plus 10% interest & the increased taxes that will result in the increased property value.

Yours sincerely
Mr & Mrs John G Thomas
301 E [illegible] St.
Duluth, Minn. 55811

$4,800.00 + 10% Interest
2256.00 188 ft. 12.00 per ft
900.00 new well
800.00 pump for refuse to main line
$8756.00

P.S. - could we have a copy of the EPA findings on our lake if any are available.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983—754—238