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Region V
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June 1979
Water Division

Environmental Impact Statement

Draft

Alternative Waste WATER Treatment Systems for Rural Lake Projects

Case Study Number 1 Crystal Lake Area Sewage Disposal Authority Benzie County, Michigan

Appendices

VOLUME II APPENDICES

DRAFT ENVIRONMENTAL IMPACT STATEMENT

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS FOR RURAL LAKE PROJECTS

CASE STUDY No. 1: CRYSTAL LAKE AREA SEWAGE DISPOSAL AUTHORITY

BENZIE COUNTY, MICHIGAN

Prepared by the

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION V, CHICAGO, ILLINOIS

AND

WAPORA, INCORPORATED
WASHINGTON, D.C.

Approved by:

John McGuire
Regional Administrator
U. S. Environmental Protection Agency
June, 1979

VOLUME II

A P P E N D I X E S

APPENDIX
A

SOILS

AVAILABLE SOILS DATA

The Soil Conservation Service has cautioned that available soils data should be used for general planning purposes only (by letter, Steve Utic, SCS 1978). The following discussion of how soils data was gathered is useful in assessing its limitations.

Scattered soils conservation mapping was done for private farm land in the county from data gathered by several soil scientists over a period of 20 years. SCS undertook the task of preparing the Land Resources Inventory maps using the available soils data plus aerial photographs. Soils boundaries were extended across unmapped areas by using a stereoscope along with the aerial photographs. The stereoscope permitted the SCS to combine the images of two pictures taken from points of view a little way apart and thus to get the effect of solidity and continuity. The completed maps were checked in the field for accuracy. The maps were also checked by area conservationists. Each area may contain smaller areas with conditions or ratings different from those on individual maps.

The most accurate soils data available is the limited surveying carried out in 1978 for this EIS. However, inasmuch as this surveying mapped only scattered locations it cannot be applied to the entire Study Area.

SOIL FACTORS THAT AFFECT ON-SITE WASTEWATER DISPOSAL

Evaluation of soil for on-site wastewater disposal requires an understanding of the various components of wastewater and their interaction with soil. Wastewater treatment involves: removing suspended solids; reducing bacteria and viruses to an acceptable level; reducing or removing undesirable chemicals; and disposal of the treated water. For soils to be able to treat wastewater properly they must have certain characteristics. How well a septic system works depends largely on the rate at which effluent moves into and through the soil, that is, on soil permeability. But several other soil characteristics may also affect performance. Groundwater level, depth of the soil, underlying material, slope and proximity to streams or lakes are among the other characteristics that need to be considered when determining the location and size of an on-site wastewater disposal system.

Soil permeability - Soil permeability is that quality of the soil that enables water and air to move through it. It is influenced by the amount of gravel, sand, silt and clay in the soil, the kind of clay, and other factors. Water moves faster through sandy and gravelly soils than through clayey soils.

Some clays expand very little when wet; other kinds are very plastic and expand so much when wet that the pores of the soil swell shut. This slows water movement and reduces the capacity of the soil to absorb septic tank effluent.

Groundwater level - In some soils the groundwater level is but a few feet, perhaps only one foot, below the surface the year around. In other soils the groundwater level is high only in winter and early in spring. In still others the water level is high during periods of prolonged rainfall. A sewage absorption field will not function properly under any of these conditions.

If the groundwater level rises to the subsurface tile or pipe, the saturated soil cannot absorb effluent. The effluent remains near the surface or rises to the surface, and the absorption field becomes a foul-smelling, unhealthful bog.

Depth to rock, sand or gravel - At least 4 feet of soil material between the bottom of the trenches or seepage bed and any rock formations is necessary for absorption, filtration, and purification of septic tank effluent. In areas where the water supply comes from wells and the underlying rock is limestone, more than 4 feet of soil may be needed to prevent unfiltered effluent from seeping through the cracks and crevices that are common in limestone.

Different kinds of soil - In some places the soil changes within a distance of a few feet. The presence of different kinds of soil in an absorption field is not significant if the different soils have about the same absorption capacity, but it may be significant if the soils differ greatly. Where this is so, serial distribution of effluent is recommended so that each kind of soil can absorb and filter effluent according to its capability.

Slope - Slopes of less than 15% do not usually create serious problems in either construction or maintenance of an absorption field provided the soils are otherwise satisfactory.

On sloping soils the trenches must be dug on the contour so that the effluent flows slowly through the tile or pipe and disperses properly over the absorption field. Serial distribution is advised for a trench system on sloping ground.

On steeper slopes, trench absorption fields are more difficult to lay out and construct, and seepage beds are not practical. Furthermore, controlling the downhill flow of the effluent may be a serious problem. Improperly filtered effluent may reach the surface at the base of the slope, and wet, contaminated seepage spots may result.

If there is a layer of dense clay, rock or other impervious material near the surface of a steep slope and especially if the soil above the clay or rock is sandy, the effluent will flow above the impervious layer to the surface and run unfiltered down the slope.

<u>Proximity to streams or other water bodies</u> - Local regulations generally do not allow absorption fields within at least 50 feet of a stream, open ditch, lake, or other watercourse into which unfiltered effluent could escape.

The floodplain of a stream should not be used for an absorption field. Occasional flooding will impair the efficiency of the absorption field; frequent flooding will destroy its effectiveness.

Soil maps show the location of streams, open ditches, lakes and ponds, and of alluvial soils that are subject to flooding. Soil surveys usually give the probability of flooding for alluvial soils.

Soil conditions required for proper on-site wastewater disposal are summarized in the Appendix A-3.

Source: Bender, William H. 1971. Soils and Septic Tanks. Agriculture Information Bulletin 349, SCS, USDA.

Guide Sheet 3.--Soil limitation ratings for septic tank absorption fields

Item affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Permeability class[1/]	Rapid[2/], moderately rapid, and upper end of moderate	Lower end of moderate	Moderately slow[3/] and slow
Hydraulic conductivity rate (Uhland core method)	More than 1 in.hr[2/]	1-0.6 in./hr	Less than 0.6 in./hr
Perculation rate (Auger hole method)	Faster than 45 min/in.[2/]	45-60 min/in.	Slower than 60 min/in.
Depth to water table	More than 72 in.	48-72 in.	Less than 48 in.
Flooding	None	Rare	Occasional or frequent
Slope	0-8 pct	8-15 pct	More than 15 pct
Depth to hard rock,[4/] bedrock, or other impervious materials	More than 72 in.	48-72 in.	Less than 48 in.
Stoniness class	0 and 1	2	3, 4, and 5
Rockiness class	0	1	2, 3, 4, and 5

1/ Class limits are the same as those suggested by the Work-Planning Conference of the National Cooperative Soil Survey. The limitation ratings should be related to the permeability of soil layers at and below depth of the tile line.

2/ Indicate by footnote where pollution is a hazard to water supplies.

3/ In arid or semiarid areas, soils with moderately slow permeability may have a limitation rating of moderate.

4/ Based on the assumption that tile is at a depth of 2 feet.

SCS. 1971. Guide for Interpreting Engineering Uses of Soils. USDA.

COMPARISON OF SITE CHARACTERISTICS FOR LAND TREATMENT PROCESSES

	Principal processes			Other processes	
Characteristics	Slow rate	Rapid infiltration	Overland flow	Wetlands	Subsurface
Slope	Less than 20% on cultivated land; less than 40% on noncultivated land	Not critical; excessive slopes require much earthwork	Finish slopes 2 to 8%	Usually less than 5%	Not critical
Soil permeability	Moderately slow to moderately rapid	Rapid (sands, loamy sands)	Slow (clays, silts, and soils with impermeable barriers)	Slow to moderate	Slow to rapid
Depth to groundwater	2 to 3 ft (minimum)	10 ft (lesser depths are acceptable where underdrainage is provided)	Not critical	Not critical	Not critical
Climatic restrictions	Storage often needed for cold weather and precipitation	None (possibly modify operation in cold weather)	Storage often needed for cold weather	Storage may be needed for cold weather	None

1 ft = 0.305 m

Technology Transfer Program. 1977. Process Design Manual for Land Treatment of Municipal Wasteworks. EPA.

APPENDIX
B

NATIONAL AMBIENT AIR QUALITY STANDARDS

NATIONAL AMBIENT AIR QUALITY STANDARDS

	Primary	Secondary
Suspended Particulates		
(micrograms/cu. meter)		
annual geometric mean	75	---
max. 24-hr. conc.*	260	150
Sulfur Oxides		
(micrograms/cu. meter)		
annual arith. average	80 (.03 ppm)	---
max. 24-hr. conc.*	365 (.14 ppm)	---
max. 3-hr. conc.*	---	1300 (.5ppm)
Carbon Monoxide		
(milligrams/cu. meter)		
max. 8-hr. conc.*	10 (9 ppm)	10
max. 1-hr. conc.*	40 (35 ppm)	40
Photochemical Oxidants		
(micrograms/cu. meter)		
max. 1-hr. conc.*	160 (.08 ppm)	160
Nitrogen Oxides		
(micrograms/cu. meter)		
annual arith. average	100 (0.05ppm)	100
Hydrocarbons		
(micrograms/cu. meter)		
max. 3-hr. conc.* (6-9 a.m.)	160 (.24 ppm)	160

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*Not to be exceeded more than once a year per site.

NOTE: Values in parts per million (ppm) are only approximate.

APPENDIX
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INVESTIGATION OF SEPTIC LEACHATE DISCHARGES INTO CRYSTAL LAKE, MICHIGAN

APPENDIX
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INVESTIGATION OF SEPTIC LEACHATE DISCHARGES INTO CRYSTAL LAKE, MICHIGAN

Interpretive Report
December, 1978

Prepared for

WAPORA, Inc.
Washington, D.C.

Prepared by

K-V Associates, Inc.
Falmouth, Massachusetts

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INTRODUCTION

Septic Leachate Plumes - Types and Characteristics

In porous soils, groundwater inflows frequently convey wastewaters from nearshore septic units through bottom sediments and into lake waters, causing attached algae growth and algal blooms. The lake shoreline is a particularly sensitive area since: 1) the groundwater depth is shallow, encouraging soil water saturation and anaerobic conditions; 2) septic units and leaching fields are frequently located close to the water's edge, allowing only a short distance for bacterial degradation and soil adsorption of potential contaminants; and 3) the recreational attractiveness of the lakeshore often induces temporary overcrowding of homes leading to hydraulically overloaded septic units. Rather than a passive release from lakeshore bottoms, groundwater plumes from nearby on-site treatment units actively emerge along shorelines, raising sediment nutrient levels and creating local elevated concentrations of nutrients (Kerfoot and Brainard, 1978). The contribution of nutrients from subsurface discharges of shoreline septic units has been estimated at 30 to 60 percent of the total nutrient load in certain New Hampshire lakes (LRPC, 1977).

Wastewater effluent contains a mixture of near UV fluorescent organics derived from whiteners, surfactants and natural degradation products which are persistent under the combined

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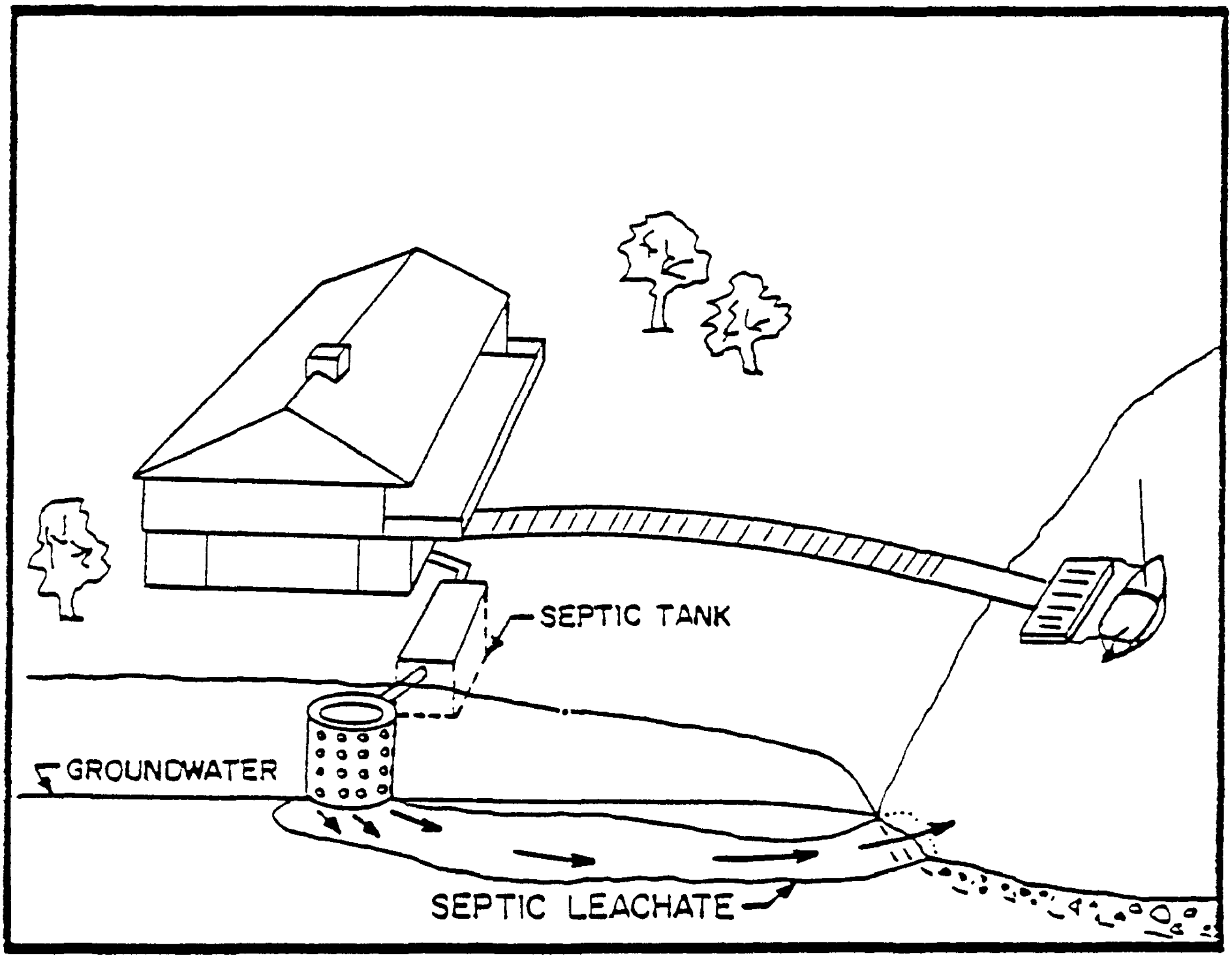

FIGURE 1. Excessive Loading of Septic Systems on Porous Soils Causes the Development of Plumes of Poorly-treated Effluent Which Move Laterally with Groundwater Flow and May Discharge Near the Shoreline of Nearby Lakes.

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conditions of low oxygen and limited microbial activity. Figure 2 shows two samples of sand-filtered effluent from the Otis Air Force Base sewage treatment plant. One was analyzed immediately and the other after having sat in a darkened bottle for six months at 20°C. Note that little change in fluorescence was apparent, although during the aging process some narrowing of the fluorescent region did occur. The aged effluent percolating through sandy loam soil under anaerobic conditions reaches a stable ratio between the organic content and chlorides which are highly mobile anions. The stable ratio (cojoint signal) between fluorescence and conductivity allows ready detection of leachate plumes by their conservative tracers as an early warning of potential nutrient breakthroughs or public health problems.

The Septic Leachate Detector (ENDECO Type 2100 "Septic Snooper") consists of the subsurface probe, the water intake system, the analyzer control unit, and the graphic recorder (Figure 3). Initially the unit is calibrated against stepwise increases of wastewater effluent, of the type to be detected, added to the background lake water. The probe of the unit is then placed in the lake water along the shoreline. Groundwater seeping through the shoreline bottom is drawn into the subsurface intake of the probe and travels upwards to the analyzer unit. As it passes through the analyzer, separate conductivity and specific fluorescence signals are generated and sent to a signal processor which registers the separate signals on a

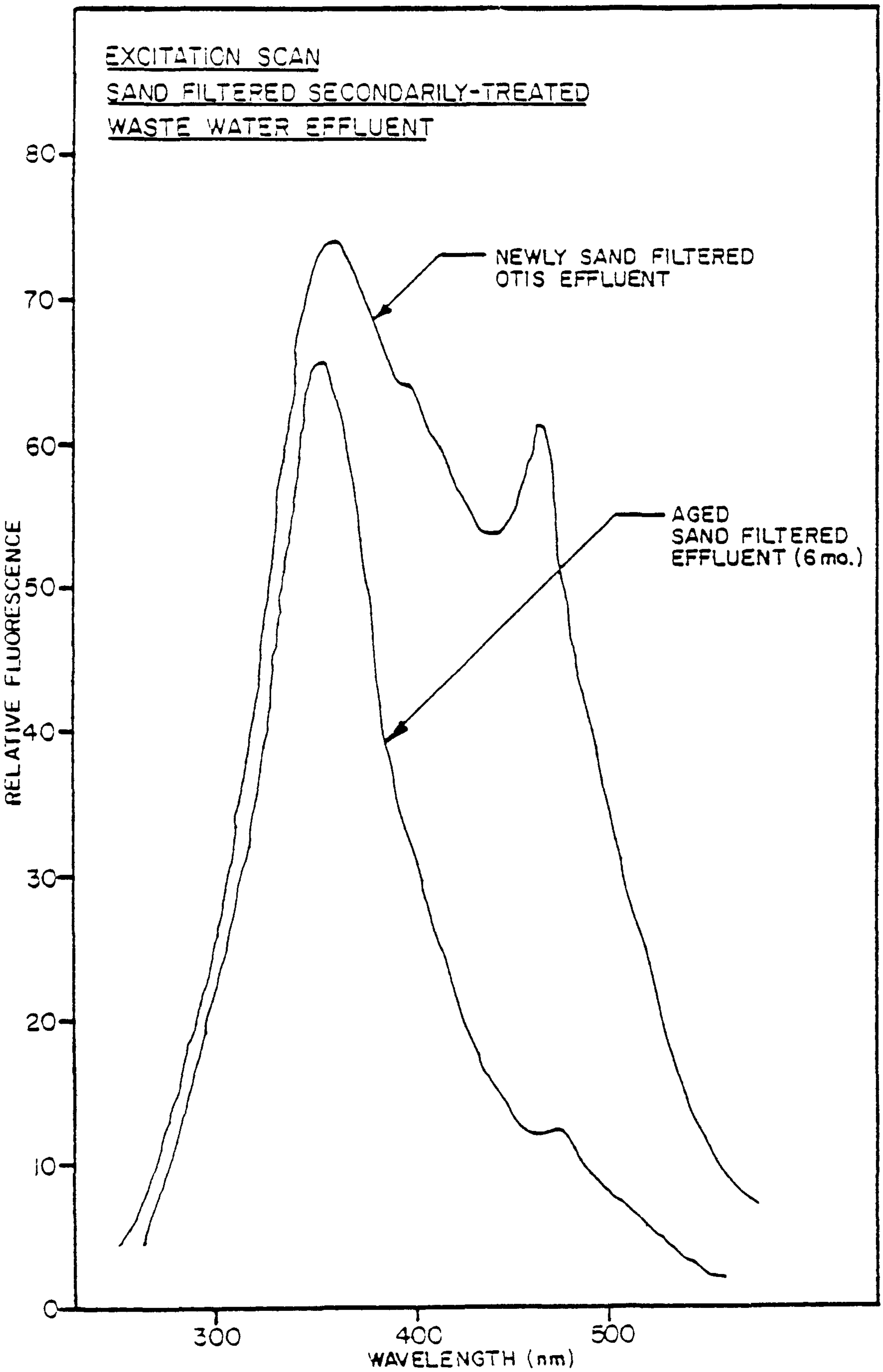

FIGURE 2. Sand-filtered Effluent Produces a Stable Fluorescent Signature, Here Shown Before and After Aging.

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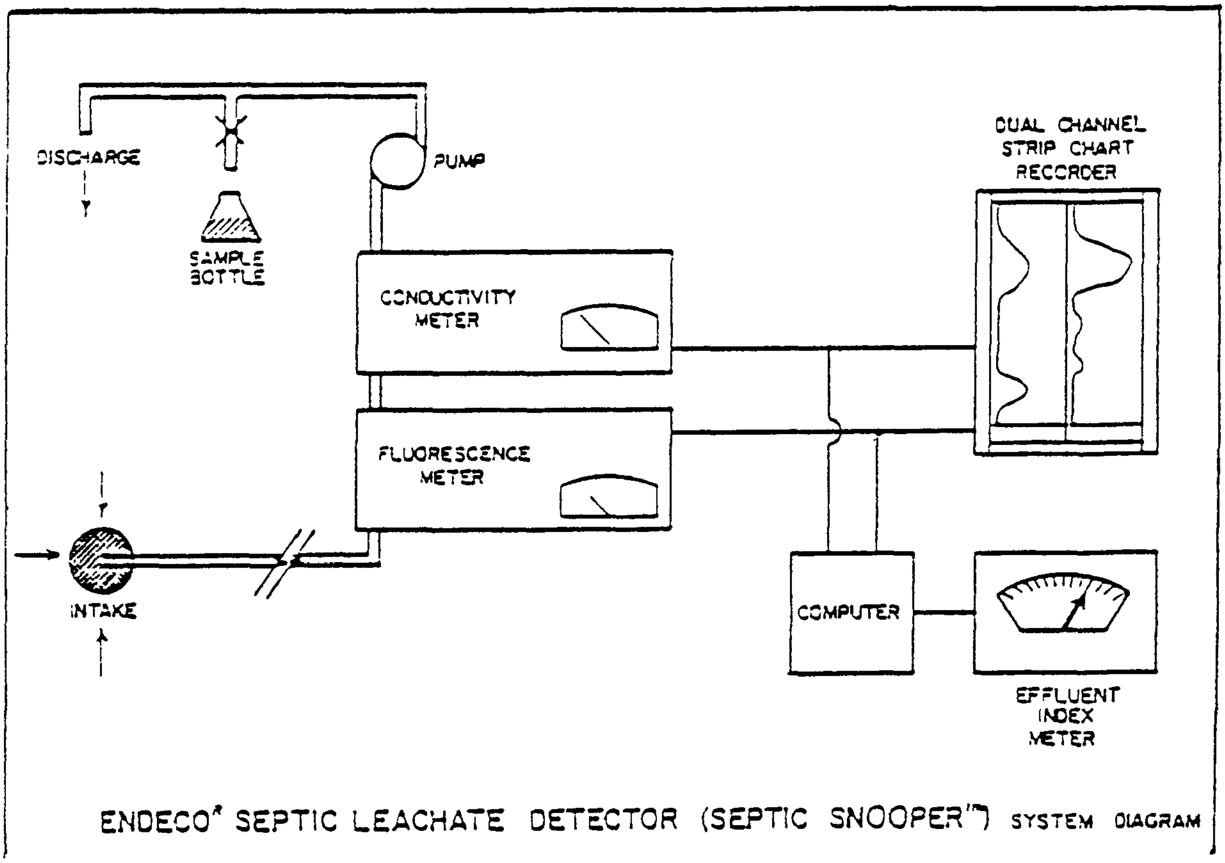

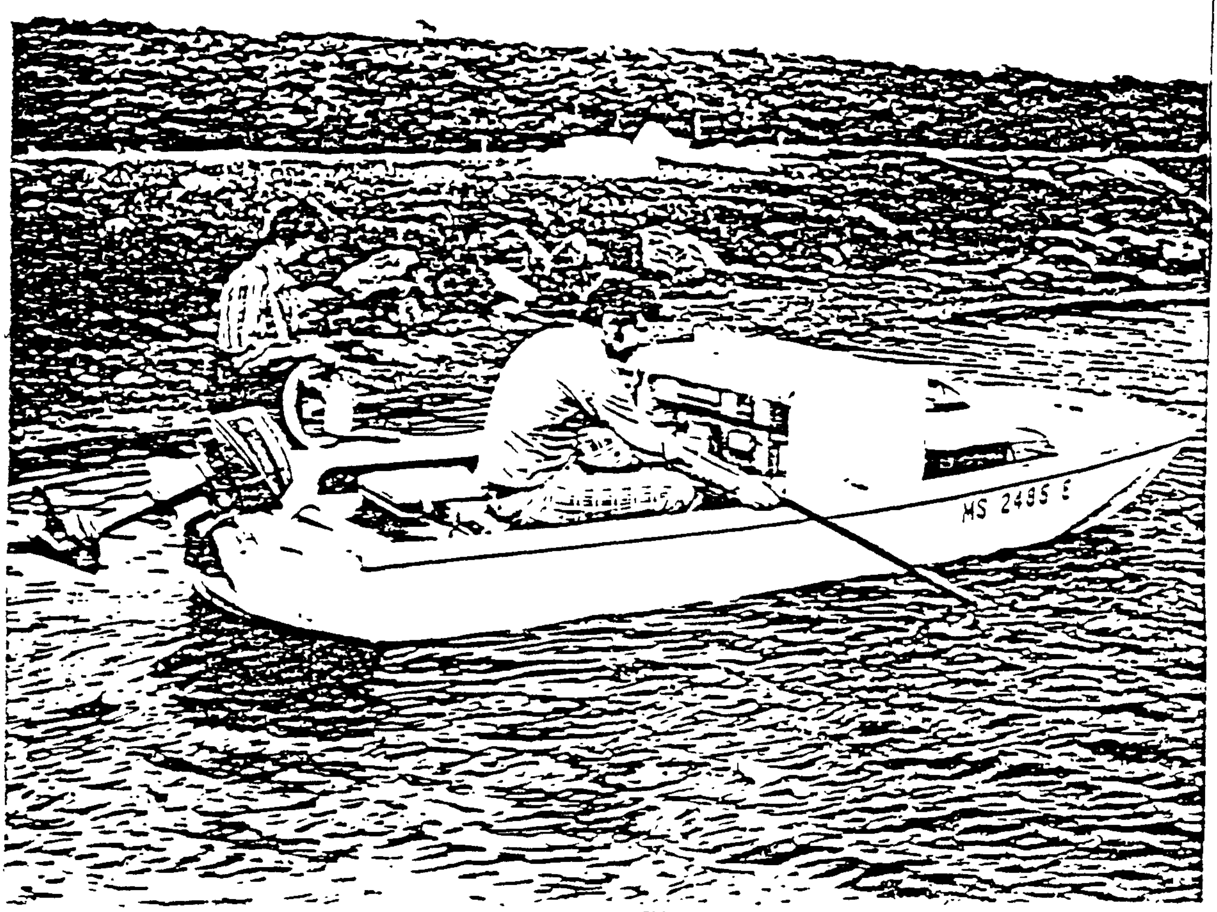

FIGURE 3. The Type 2100 "SEPTIC SNOOPER™" Consists of Combined Fluorometer/ Conductivity Units Whose Signal is Adjusted to Fingerprint Effluent. The Unit is Mounted in a Boat and Piloted Along the Shoreline. Here the Probe is Shown in the Water with a Sample Being Taken at

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strip chart recorder as the boat moves forward. The analyzed water is continuously discharged from the unit back into the receiving water.

Types of Plumes

The capillary-like structure of sandy porous soils and horizontal groundwater movement induces a fairly narrow plume from malfunctioning septic units. The point of discharge along the shoreline is often through a small area of lake bottom, commonly forming an oval-shaped area several meters wide when the septic unit is close to the shoreline. In denser subdivisions containing several overloaded units the discharges may overlap, forming a broader increase.

Three different types of groundwater-related wastewater plumes are commonly encountered during a septic leachate survey: A) erupting plumes, B) passive plumes, and C) stream source plumes. As the soil becomes saturated with dissolved solids and organics during the aging process of a leaching on-lot septic system, a breakthrough of organics occurs first, followed by inorganic penetration (principally chlorides, sodium, and other salts). The active emerging of the combined organic and inorganic residues into the shoreline lake water describes an erupting plume. In seasonal dwellings where wastewater loads vary in time, a plume may be apparent during late summer when shoreline cottages sustain heavy use, but retreat during winter during low flow conditions. Residual organics from the wastewater often still remain attached to soil particles in the

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vicinity of the previous erupting plume, slowly releasing into the shoreline waters. This dormant plume indicates a previous breakthrough, but sufficient treatment of the plume exists under current conditions so that no inorganic discharge is apparent. Stream source plumes refer to either groundwater leachings of nearstream septic leaching fields or direct pipe discharges into streams which then empty into the lake.

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2.0 METHODOLOGY - SAMPLING AND ANALYSIS

Water sampling for nutrient concentrations along the shoreline are coordinated with the septic leachate profiling to clearly identify the source of effluent. The shoreline of Crystal Lake consists predominantly of sand and cobblestones, with a natural beach of shallow slope extending outwards along a natural shelf for considerable distances before dropping steeply. A profile of the shoreline for emergent plumes was obtained by manually towing the septic leachate detector along the lee side of the shoreline in a 5 meter aluminum rowboat. As water was drawn through the probe and through the detector, it was scanned for specific organics and inorganics common to septage leachate.

Whenever elevated concentrations of leachate were indicated on the continual chart recorder, a search was made of the area to pinpoint the location of maximum concentration. At that time 1) a surface water sample was taken from the discharge of the detector for later nutrient analysis, 2) an interstitial groundwater sample was taken with a hand-driven well-point sampler to a depth of .3 meter and 3) finally a surface water sample for bacterial content (total and fecal coliform) was also taken. The combination of the triple sampling served to identify the source of effluent. If the encountered plume originated from groundwater seepage, the concentration of

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nutrients would be considerably elevated in the well-point sample. If the source were surface effluent runoff, a low nutrient groundwater content would exist with an elevated bacterial content. If a stream source occurred, an isolated single plume would not be found during search, but instead a broadening plume traced back to a surface water inlet. Ground water samples taken in the vicinity of the surface outflow would also not show as high a nutrient content as the surface water samples.

Water samples taken in the vicinity of the peak of plumes were analyzed by EPA Standard Methods for the following chemical constituents:

Conductivity (cond.)
Ammonia-nitrogen (NH_4-N)
Nitrate-nitrogen (NO_3-N)
Total phosphorus (TP)
Orthophosphate phosphorus (PO_4-P)

A total of 45 water samples were obtained at locations of selected plumes for analysis. The samples were placed in polyethylene containers, chilled, and frozen for transport and storage. Conductivity was determined by a Beckman (Model RC - 19) conductivity bridge, ammonium-nitrogen by phenolate method, nitrate-nitrogen by the brucine sulfate procedure, and orthophosphate-phosphorus and total phosphorus by the single reagent procedures following standard methods (EPA, 1975).

Water samples for bacterial analysis were placed in sterilized 150 ml glass containers obtained from the Benzonia Health Department and mailed to the Michigan Department of Public Health, Bureau of Laboratories at Lansing for analysis.

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Analyses were performed for total coliform bacteria and fecal coliform by the membrane filter method.

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3.0 PLUME LOCATIONS

Crystal Lake is roughly rectangular in shape, with a maximum length of 8.1 miles northwest to southeast and a distance along shoreline of about 25 miles. Well-drained sand and loamy sand upland soils on outwash plains and till plains predominate the shoreline region. Health Department records confirm that high groundwater conditions occur along the northeast shore of Crystal Lake. More favorable soil conditions for installation of septic systems exist along the northwest and southern shore of the lake. The loamy to sandy, well-drained to excessively-drained soils along the shoreline regions are generally suited for surface disposal at high and moderate rates (EIS, 1973).

Over 90 plumes of wastewater origin were logged along the shoreline of the lake in different stages of development (Figure 4). Solid circles indicate erupting plumes, open circles are dormant plumes, and solid squares represent stream source plumes. A line is drawn from each symbol to the location along the shoreline where the plume was encountered. The highest densities of erupting plumes were observed on either side of the presently-sewered regions of the town of Beulah. The 2.5 mile stretch of the northeast shore contained 23 erupting plumes, 2 dormant plumes, and 5 stream source plumes. Almost all streams discharging into the northeast region contained some effluent seepage.

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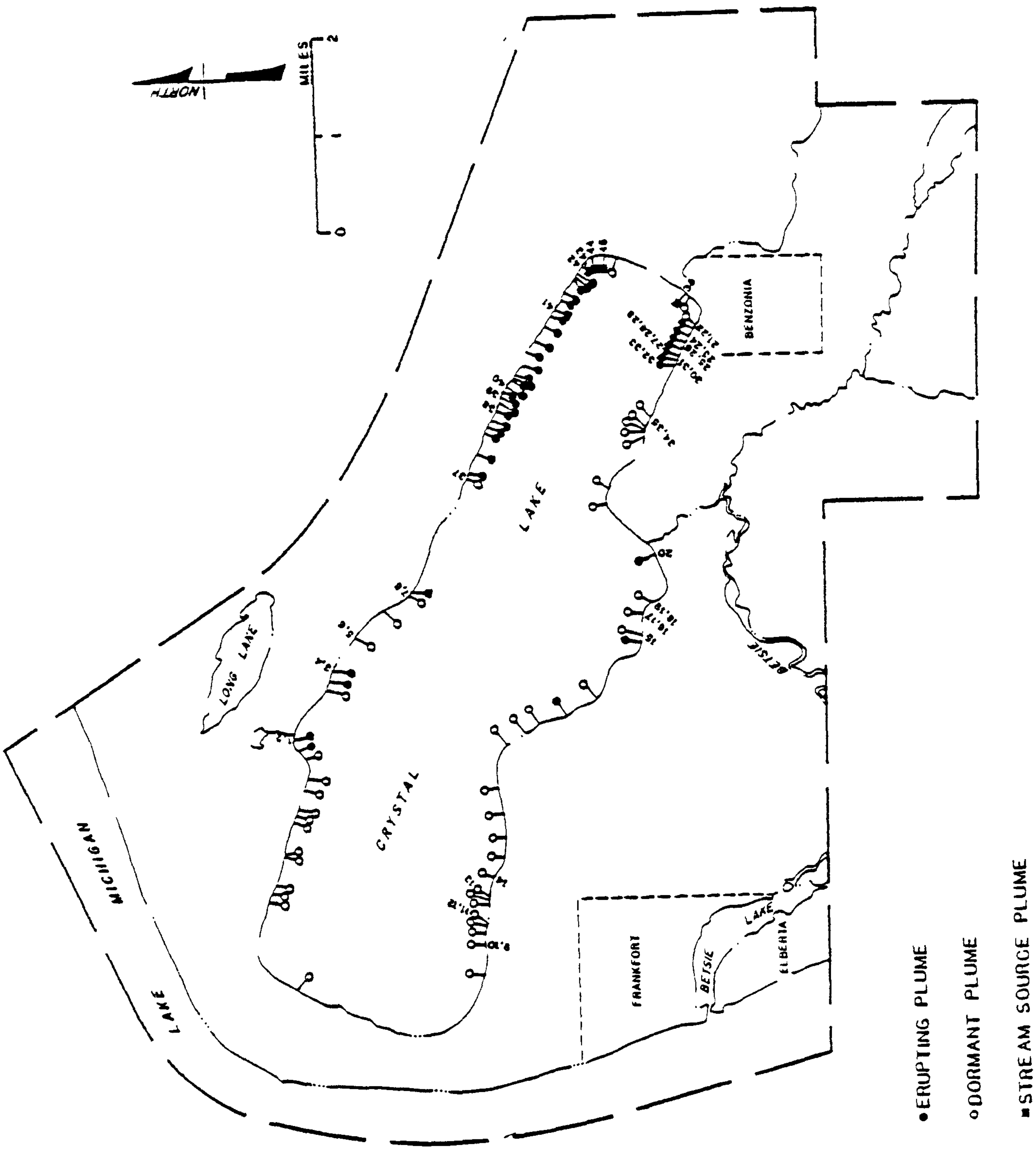

Figure 4. Plume locations on Crystal Lake.

An abrupt cessation of plumes occurred when the sewered area of Beulah was encountered on the east shore. Variation in the background organic signal may indicate low level leakage from collection pipes. However, the only plume source encountered was at the outflow of Cold Creek, a shallow stream which drains the center of town and areas east of Benzonia.

As on the northeast, a densely-packed region of erupting plumes occurred on the southeast shore for about .7 miles just beyond the presently sewered area.

Scattered incidents of dormant plumes with an occassional active discharge of effluent were observed on the south shore. One region containing a strip of cottages and residential houses on high-ground water north of Frankfort exhibited a high frequency of dormant plumes penetrating through medium sand soils and beaches.

The west end of the lake, on the other hand, was virtually devoid of effluent plumes. Many housing units in this region are located back from the shorefront and have favorable ground-water flow conditions. The northwest side of the lakeshore showed scattered dormant plumes. Not all of the plumes were encountered along the shallow sandy beaches. In two cases the discharge of effluent was found penetrating either concrete or cinder block walls, often coated with green algae.

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4.0 NUTRIENT ANALYSES

Completed analyses of the chemical content of the 45 water samples taken along the Crystal Lake shoreline are presented in Table 1. The sample numbers refer to the locations given in Figure 4. The letter "S" refers to surface water sample and the letter "G" to groundwater sample. The conductivity of the water samples as conductance (μmhos/cm) is given in the second column. The nutrient analyses for orthophosphorus (PO_4-P), total phosphorus (TP), ammonium-nitrogen (NH_4-N), and nitrate-nitrogen (NO_3-N) are presented in the next four columns in parts-per-million (ppm - mg/l).

Table 1. Nutrient analyses of surface (S) and groundwater (G) samples taken in the vicinity of wastewater leachate plumes observed on the Crystal Lake shoreline.

Sample Number		Cond.	Concentration (ppm - mg/l) PO_4-P	TP	NH_4-N	NO_3-N	ΔC	Ratio ΔP	ΔN	Breakthrough P	N
1	S	300	.0008	.003	.004	.043					
2	G	525	.004	.009	.263	.003	125	.005	.23	.5%	4%
3	S	250	.0005	.002	.003	.011					
4	G	490	.017	.020	.034	.277	90	.016	.28	.8%	6%
5	S	270	.021	.022	.094	.062					
6	G	460	-	.029	.195	.890	60	.025	1.06	2%	35%
7	S	410	.002	.003	.005	.297					
8	G	280	.0005	.001	.0003	.847					
9	S	315	.008	.004	.001	.060					
10	G	383	.0005	.008	.009	.224					
11	S	410	.002	.003	.004	.048					
12	G	403	.006	.022	.026	.269					
13	S	365	.0009	.002	.006	.128					
14	S	390	.001	.003	.004	.084					
15	bkgs	385	.001	.004	.003	.060					
16	S	380	.002	.003	.004	.045					
17	G	600	.009	.020	.004	1.808	200	.016	1.78	.4%	18%
18	S	382	.004	.004	.004	.048					
19	G	438	.006	.006	.002	.220	38	.002	.19	.3%	10%
20	S	412	.001	.003	.0003	.029					
21	S	384	.003	.004	.008	.024					
22	G	555	.011	.024	3.773	.016	155	.020	3.76	.7%	49%
23	S	416	.002	.004	.024	.026					
24	G	368	.003	.012	.056	.083					
25	S	430	.002	.004	.013	.239					
26	G	636	.010	.020	.025	3.144	236	.02	3.11	.4%	21%
27	S	390	.001	.005	.005	.134					

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Table 1 (continued)

Sample Number		Cond.	Concentration (ppm - mg/l) PO_4-P	TP	NH_4-N	NO_3-N	ΔC	Ratio ΔP	ΔN	Breakthrough P	N
28	S	430	.002	.005	.008	.194					
29	G	610	.043	.057	.020	.950	210	.053	.97	1.4%	9.7%
30	S	420	.002	.003	.010	.171					
31	G	610	.007	.010	.012	1.523	210	.006	1.52	.2%	14.5%
32	S	420	.002	.003	.013	.111					
33	G	490	.009	.012	.125	.029	90	.008	.122	.4%	3%
34	S	400	.002	.004	.078	.048					
35	G	430	.004	.011	.069	.011	30	.006	.05	1%	3%
36	S	360	.004	.011	.032	1.385					
37	S	378	.003	.004	.014	.056					
38	S	403	.002	.004	.009	.391					
39	S	420	.002	.004	.005	.436					
40	S	400	.003	.004	.006	.564					
41	lost in transit										
42	S	410	-	.607	.287	-					
43	S	368	-	.012	.484	-					
44	S	420	-	.024	.167	-					
45	S	270	-	.025	.246	-					
Background concentration		400		.004	.003	.030					
Local effluent							+400	+8	+20		

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5.0 NUTRIENT RELATIONSHIPS

By the use of a few calculations, the characteristics of the wastewater plumes can be described. Firstly, a general background concentration for conductance and nutrients is determined. The concentration of nutrients found in the plume is then compared to the background and to wastewater effluent from the lake region to determine the percent breakthrough of phosphorus and nitrogen to the lake water. Because the well-point sampler does not always intercept the center of the plume, the nutrient content of the plume is always partially diluted by surrounding ambient background groundwater concentrations or downward seepage of lake water. To correct for the uncertainty of location of withdrawal of the groundwater plume sample, the nutrient concentrations above background values found with the groundwater plume are corrected to the assumed undiluted concentration anticipated in standard sand-filtered effluent and then divided by the nutrient content of raw effluent. Computational formulae can be expressed:

for the difference between background (C_o) and observed (C_i) values:

$C_i - C_o = \Delta C_i$	conductance
$TP_i - TP_o = \Delta TP_i$	total phosphorus
$TN_i - TN_o = \Delta TN_i$	total nitrogen (here sum of NO_3-N and NH_4-N)

for attenuation during soil passage:

$$100 \times \left(\frac{\Delta C_{ef}}{\Delta C_i}\right) \Delta TP = \%\text{ breakthrough of phosphorus}$$

$$100 \times \left(\frac{\Delta C_{ef}}{\Delta C_i}\right) \Delta TN = \%\text{ breakthrough of nitrogen}$$

where: C_o = conductance of background groundwater (µmhos/cm)

C_i = conductance of observed plume groundwater (µmhos/cm)

ΔC_{ef} = conductance of sand-filtered effluent minus the background conductance of municipal source water (µmhos/cm)

TP_o = total phosphorus in background groundwater (ppm - mg/l)

TP_i = total phosphorus of observed plume groundwater (ppm - mg/l)

TN_o = total nitrogen content of background groundwater, here calculated as NO_3-N + NH_4-N (ppm - mg/l)

TN_i = total nitrogen content of observed plume groundwater, here calculated as NO_3-N + NH_4-N (ppm - mg/l)

5.1 Assumed Wastewater Characteristics

Local samples of effluent obtained at the Benzonia County and Emmet County sewage treatment plants exhibited a conductance : total phosphorus : total nitrogen ratio of 700:8:20; subtracting the background lake water concentration of 300 µmhos/cm gives a ΔC:ΔTP:ΔTN ratio of 400:8:20 representing the change in concentration to source water by household use in the Crystal Lake region. Of note, the addition of total dissolved solids (as indicated by ΔC) tends to be higher than soft water regions which often show a $\Delta C:\Delta TP:\Delta TN$ ratio of 200:8:20 (Kerfoot and Brainard, 1978; Kerfoot, et. al., 1976). The common use of water softeners in the hard water areas may be a partial contributing factor.

5.2 Assumed Background Levels

Little information exists on background groundwater concentrations in the Crystal Lake area. Generally, the interstitial lake bottom groundwater tended to be slightly higher in dissolved solids and therefore conductance, than the raw lake water. Sample #15 which was taken away from plume regions exhibited a conductance of 385 µmhos/cm compared to 300 µmhos/cm for normal lake water. The total phosphorus content of sample #15 was quite low at .004 mg/l, common for sandy outwash soils which often contain iron concentrations capable of binding phosphorus under aerobic conditions. This corresponds favorably with the mean value of .0037 total PO_4-P reported by Tanis (1978) for the Crystal Lake outlet. Similarly, ammonium-nitrogen contents were quite low, consistent with aerated, permeable soils. Nitrate-nitrogen values were quite variable and the average background for surface lake water found to be about .030 ppm.

Table 2. Background groundwater levels for chemical constituents in interstitial water of Crystal Lake sediments.

Constituent	Cond. (µmhos/cm)	Nutrient Conc. (mg/l) TP	NH_4-N	NO_3-N
Value	400	.004	.003	.030

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5.3 Attenuation of Nitrogen Compounds

On the basis of observed ratios of total nitrogen found in groundwater plumes, breakthrough of nutrient content ranged from a high of 49% to a low of 3% of that expected from the typical effluent (Table 1). A mean of 16% penetration was observed based upon eleven samples with sufficiently high conductance for meaningful analysis. The dominant nitrogen species (eight of eleven) was NO_3-N, consistent with permeable, aerated soils.

5.4 Attenuation of Phosphorus Compounds

Similarly, analysis of the observed ratios of total phosphorus found in groundwater plumes indicated a high of 2% and a low of .2% breakthrough of phosphorus content. A mean penetration of only .7% was calculated from the observed samples. Although the fraction of anticipated phosphorus load of the effluent being received by the lake waters is small, the phosphorus content of the groundwater plume is sufficiently elevated above the observed background groundwater concentration to be able to support the localized growth of attached algae or rooted plants on the sandy nearshore lake bottom.

6.0 COLIFORM LEVELS IN SURFACE WATERS

A series of water samples were analysed for total and fecal coliform content (Table 3) to determine the contribution of septic leachate plumes to bacterial content. Crystal Lake is considered a recreational lake with surface waters classified for total body contact recreation. The Michigan Water Resources Commission has stated that fecal coliforms shall not exceed 200 organisms per 100 ml in five or more consecutive samples.

Table 3. Bacterial content of plumes.

Location	Type of Plume	Coliform Content (#/100 ml) Total	Fecal
#16	Groundwater	900	30
#18	Groundwater	1100	80
#21	Groundwater	600	20
#30	Groundwater	400	<10
#36	Stream source	9300	120
#38	Groundwater	<100	<10
#41	Stream source	2400	10
#43	Stream source	<100	<10
#44	Stream source	4300	<10

No samples were found in excess of the State standards for recreational water use. Previous water testing has consistently shown no apparent penetration of bacteria from plumes passing through medium sandy soil (Kerfoot and Brainard, 1978). The low fecal coliform contents indicate that the effluent fractions which were observed in the small stream outlets of locations 41 through 44 probably result from inland plume leakage

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through stream bank walls rather than any exposed effluent runoff.

6.1 Cold Creek

Previous studies have concluded that Cold Creek delivers significant contributions of nutrients and coliform organisms to Crystal Lake (EIS, 1978). Total coliforms ranged from 170 MPN/100 ml to 7400 MPN/100 ml and fecal coliforms ranged from 9 MPN/100 ml to 310 MPN/100 ml. Sample #36 (Cold Creek) exhibited a total coliform count of 9300 MPN/100 ml and a fecal content of 120 MPN/100 ml. The content of effluent in Cold Creek appeared to be no more than 1.8% during two passages across the outflow on November 15. A dilution of 1.6% local effluent would yield a $\Delta C:\Delta P:\Delta N$ of 6:.13:.320. Using this to compute the probable values of concentration of TP and TN in the surface water based upon the mean .7% TP and 16% TN breakthrough, yields .009 mg/l phosphorus and .051 mg/l nitrogen compared to the observed .011 mg/l P and 1.42 mg/l N. While the November phosphorus load falls within the range expected from effluent seepage, the nitrate-nitrogen values are far in excess and must be related to other non-point sources. Both stormwater runoff and agricultural drainage may serve as potential sources.

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7.0 PLUME CHARACTERISTICS AND GROUNDWATER HYDROLOGY

Distribution of the frequency and types of plumes around the shoreline of Crystal Lake provides some insight into the groundwater hydrology of the lake. Kettle lakes with porous sandy bottom soils induce groundwater flow patterns when their long axes lie parrallel to the direction of groundwater flow. Crystal Lakes acts as a large withdrawal well which encourages the discharge into the lake of overloaded nearshore septic units. While water within the lake basin seeks its own level by gravity, the groundwaters at the eastern end are higher in elevation and the groundwater at the western end near Lake Michigan is lower than lake level. This natural difference in water elevation encourages an inflow of groundwater into the eastern periphery of the lake and a general outflow of lake water into groundwater at the western end (Figure 5).

As a result of the groundwater pattern, the eastern shoreline behaves like a recharge well, with frequent water inflows as springs and creeks, physically encouraging erupting plumes with more rapid groundwater transport inward towards the lake. As mentioned earlier in Section 3.0, the lack of erupting plumes in the Beulah region is due to the wastewater collection system. However on the westernside, the recharge of water from individual homes must be sufficient to offset the gradient of lake flow to produce an erupting plume on the northwestern and southwestern

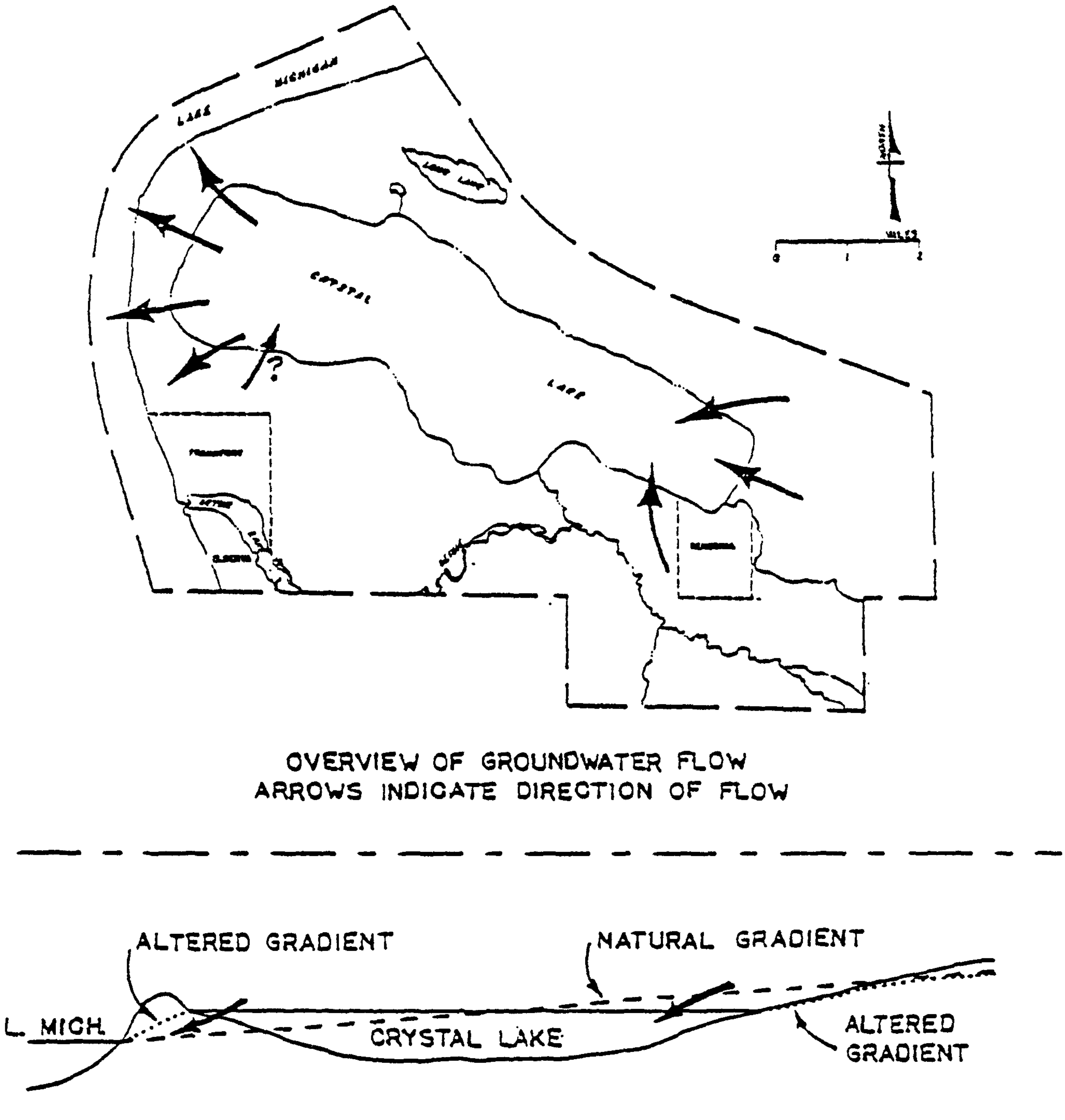

Figure 5. Groundwater flow patterns for Crystal Lake. Heavy arrows indicate direction of flow.

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shorelines in the direction of the lake. Plumes would then most likely intrude during summer and retreat (i.e., be dormant) during other times of the year. On the far western shore, the lack of plumes probably is due to sufficiently steep gradient outflow that wastewater from near-shore systems may flow towards Lake Michigan rather than towards Crystal Lake at all times of the year. The level of Crystal Lake is maintained at an elevation of 600 feet mean sea level (MSL), while the Lake Michigan level is 580 feet above MSL. With less than one mile lateral distance and if a medium sand composition were maintained throughout, the rate of outward flow towards Lake Michigan could be in excess of .9 meters per day.

Twelve Lee-type seepage meters were installed around the shoreline of Crystal Lake during the week of the study. Only one of these remained intact following a severe storm with gale-force winds. The seepage meter was installed at the southwest region in segment 12 at house #99 and showed a volume of 52 ml over 74 hours. The diameter of the cylinder of the seepage meter was 45.7 cm (18 in.). The calculated flow rate would be 4.4 ml per meter^2 per hour, a hardly detectable flow rate. Since seasonal springs occur in this region, there may be some recharge in segment 12 even though the region lies close to the outward flowing western portion of the lake.

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8.0 RELATIONSHIP OF ATTACHED PLANT GROWTH TO PLUMES

Extensive studies of the water quality have demonstrated that on the basis of standard criteria of high transparency, high dissolved oxygen in lake bottom regions, low nutrient content, and low biological productivity, that Crystal Lake's overall water quality ranks among the highest in Michigan. However, the phenomenon of nutrient-dependent growths of algae and aquatic plants along the shoreline of a nutrient-poor lake (oligotrophic) is an important issue with Crystal Lake for a two-fold reason: 1) the attached algae interferes with recreational use and esthetic value and 2) it is symptomatic of degradation of the groundwater which provides a significant fraction of long-term inflow to the lake basin.

Growths of attached algae and aquatic vegetation have been reported as most abundant along the northeastern shore and at the mouth of Cold Creek near Beulah in aerial and ground surveys of Crystal Lake in the summer of 1976 (EIS, 1978). The thickest patches of algae (principally Cladophora) were found concentrated along segments of the shoreline supporting year-round cottages. It was concluded that the presence of shoreline algae, especially as a dense patch, is highly correlated to the location of cottage sites, with septic tank-soil absorption systems being the likely source of nutrients (Tanis, 1978).

Special attention was paid to the location of plume areas in relationship to patches of Cladophora during the survey. In general, substantial Cladophora patches or attached vegetation were found correlated with most emergent or dormant plumes. Samples of the interstitial groundwater revealed a mean phosphorus content of .017 ppm total phosphorus, sufficient to serve as a nutrient source for attached algae, particularly in regions where a significant rate of inflow was maintained as in the northeast region of the lake. The plumes channel nutrient-rich water to the vegetation, in effect acting as hydroponic cultures.

Statistical analysis of the nutrient content of the overlying lake waters of the emerging plumes compared with the interstitial groundwaters failed to show a significant correlation. The findings substantiate that while the nutrients penetrating through the subsurface are sufficient to support attached algae and plants, they are not sufficient to influence surrounding lake water as yet. Stream source inflows such as Cold Creek and other streams penetrating the northeast shoreline are of sufficient volume inflow to influence local surface water nutrient concentrations. These higher volume inflows do contain noticeable nutrient loads from wastewater seepage, presumably along their streambeds.

Rather than compare the total phosphorus load per surface area of the lake following Vollenweider's model to evaluate the impact of nutrients on aquatic algae growth, attached algae and

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plant growth in shoreline regions are sensitive to groundwater nutrient content and should be correlated to the phosphorus loading in groundwater per shoreline length.

Table 4 compares the frequency of plumes to the density of houses in different segments of the shoreline shown in Figure 6. The nutrient loading per segment is computed using the frequency breakthrough of N and P observed for the average plume times a per dwelling loading of 9.1 kg/yr N and 3.6 kg/yr P. The loadings of phosphorus per shoreline mile correspond to the northeastern segments (6, 7/8), the unsewered region of segment 17 (Beulah), and segment 12 in the southwest, coinciding with the areas reporting shoreline algae and plant growth problems.

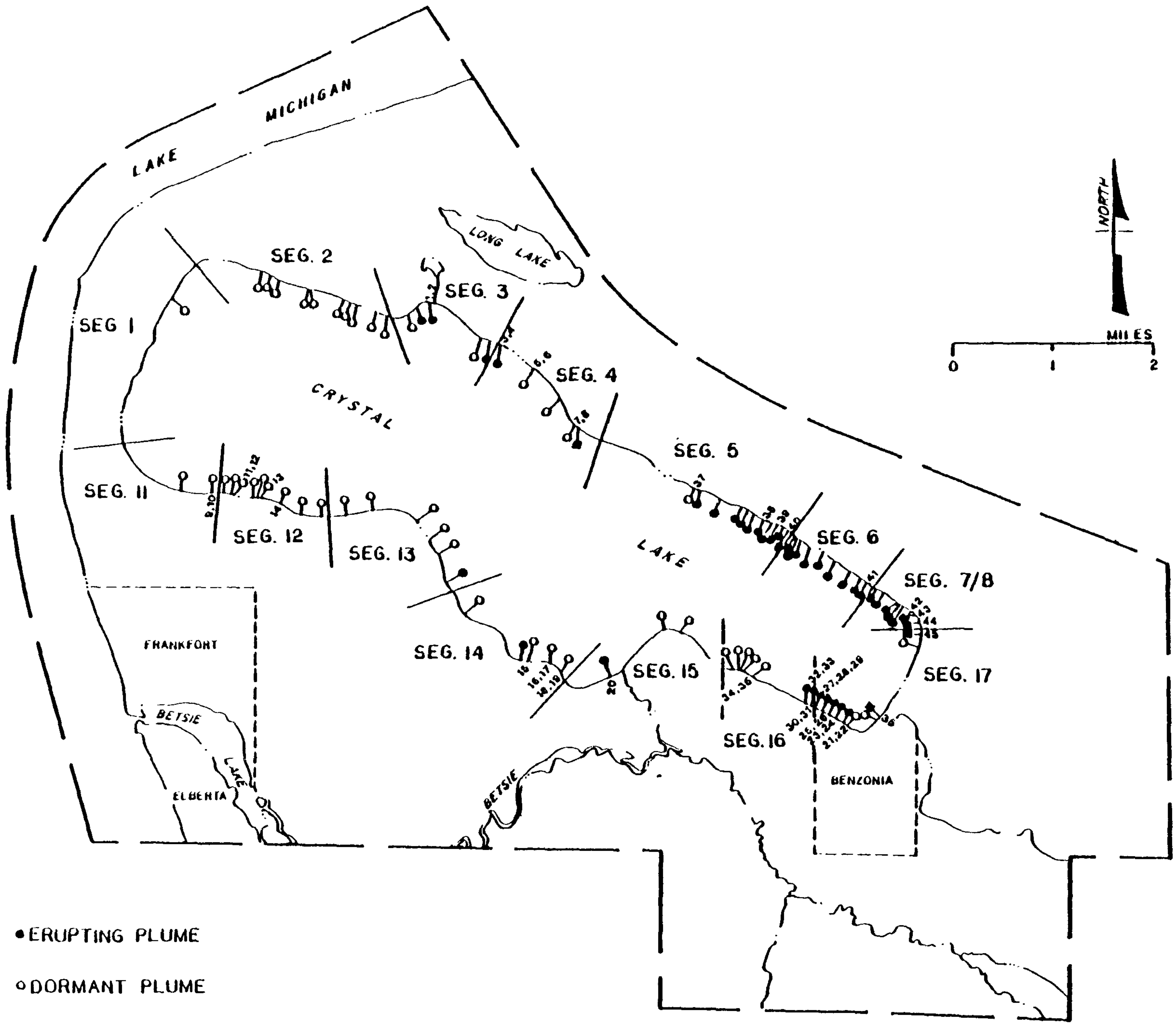

Figure 6. Segmentation of Crystal Lake shoreline for nutrient loading.

Table 4. Calculated phosphorus loading per shoreline length based upon observed frequency of plumes and % breakthrough of nutrients.

Segment	Existing Houses (R)	# of Major Plumes (P)	Frequency (%)	Nutrient Loading (kg/yr) P	Nutrient Loading (kg/yr) N	Approx. Shoreline Length (mi)	Loading per Shore Length (kg P/mile)
1	45	1	2	.025	2.9	1.9	.013
2	53	10	19	.25	14	2.0	.13
3	18	5	28	.13	7.3	1.2	.11
4	56	5	9	.13	7.3	1.2	.11
5	82	11	13	.28	16	2.1	.13
6	39	9	23	.23	13	.9	.26
7/8	17	8	47	.20	12	.7	.29
11	12	2	16	.05	2.9	1.2	.04
12	60	9	15	.23	13	1.1	.21
13	63	6	10	.15	8.7	1.6	.09
14	38	5	13	.13	7.3	1.7	.08
15	18	3	17	.08	4.4	1.8	.04
16	10	7	70	.18	10	.9	.05
17	und.	10	-	.25	15	.6*	.42

*unsewered distance

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9.0 CONCLUSIONS

A septic leachate survey was conducted along the Crystal Lake shoreline during November, 1978. The following observations were obtained from the shoreline profiles, analyses of groundwater and surface water samples, evaluation of groundwater flow patterns, and comparison of attached algae growth with plume location:

1. Over 90 groundwater plumes of wastewater origin were observed to be entering the shoreline of Crystal Lake.

2. The greatest frequency of erupting plumes was found in the northeast and unsewered eastern shoreline. A segment in the southwestern section north of Frankfort also contained a high density of dormant plumes.

3. A high correlation existed between the location of emergence of plumes and attached plant growth, particularly Cladophora. Groundwaters obtained near the peak concentrations of the outflow of the observed plumes contained sufficient nutrients to support attached algae and aquatic week growth.

4. In general, considerable attenuation of nutrients in the wastewater plume is accomplished by the well-drained, porous soils, with an observed breakthrough of .7% phosphorus and 16% mean nitrogen. At the present time, there appears to be no significant change in surface water nutrient contents as the result of plume emergence.

5. The location and characteristics of emergent plumes suggest that groundwater flow is entering the lake in the eastern sections and discharging in the western sections towards Lake Michigan. The low occurrence of plumes along the western shore is undoubtedly related to the predominant outward flow of the region.

6. A high correlation exists between the calculated shoreline phosphorus loadings from observed plumes and the regions of reported nuisance attached algal growth.

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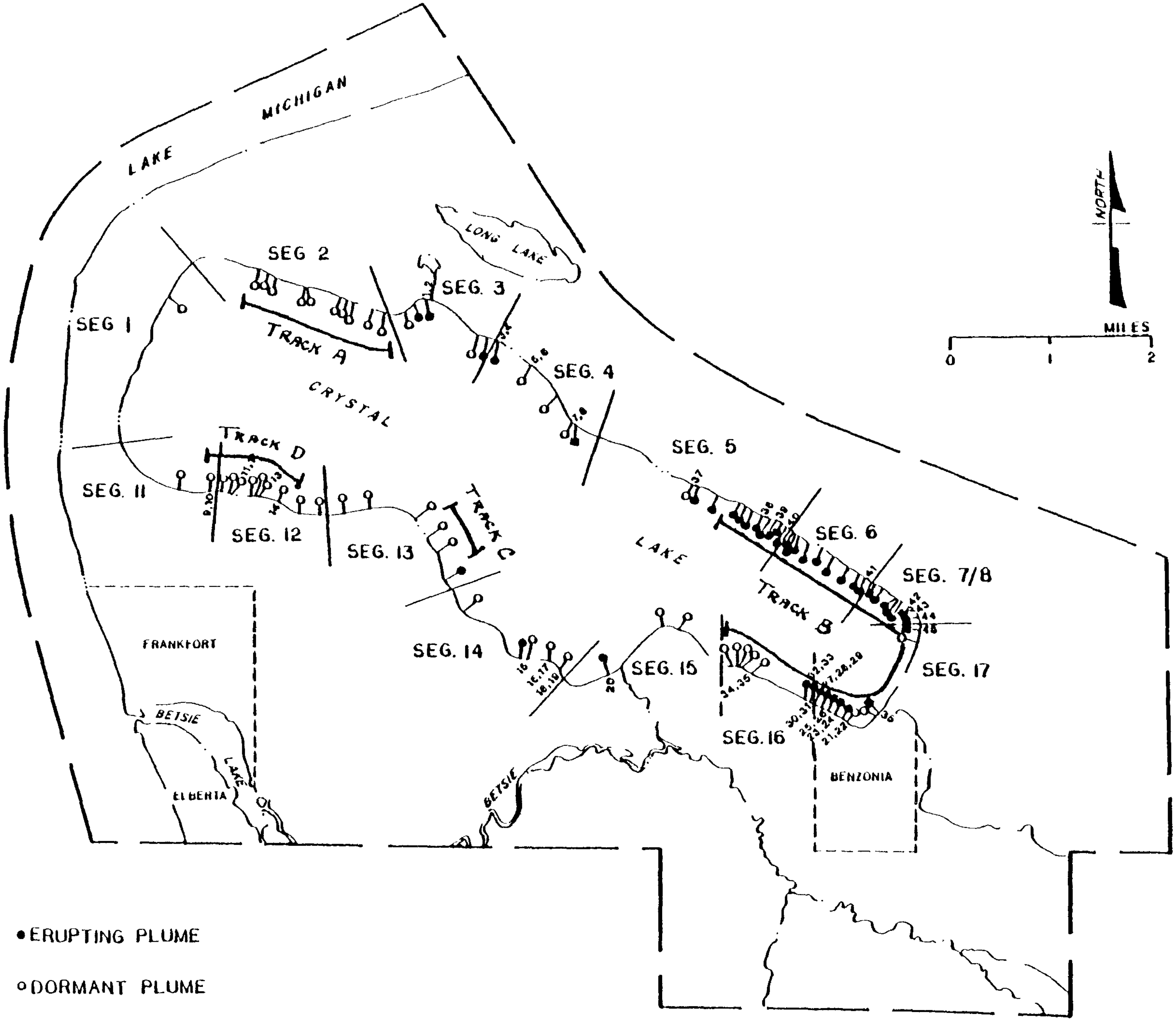
APPENDIX



•ERUPTING PLUME

○DORMANT PLUME

▪STREAM SOURCE PLUME

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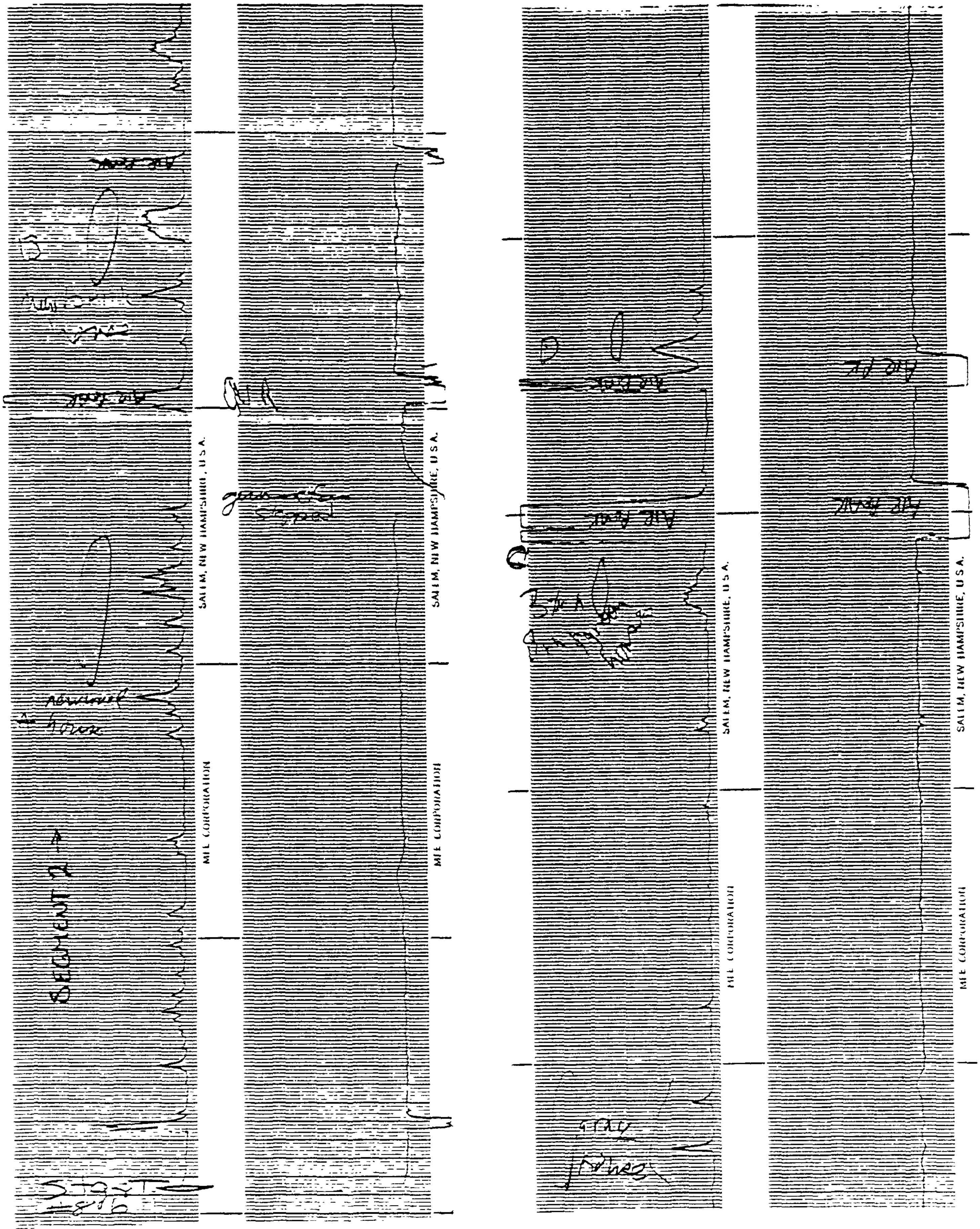
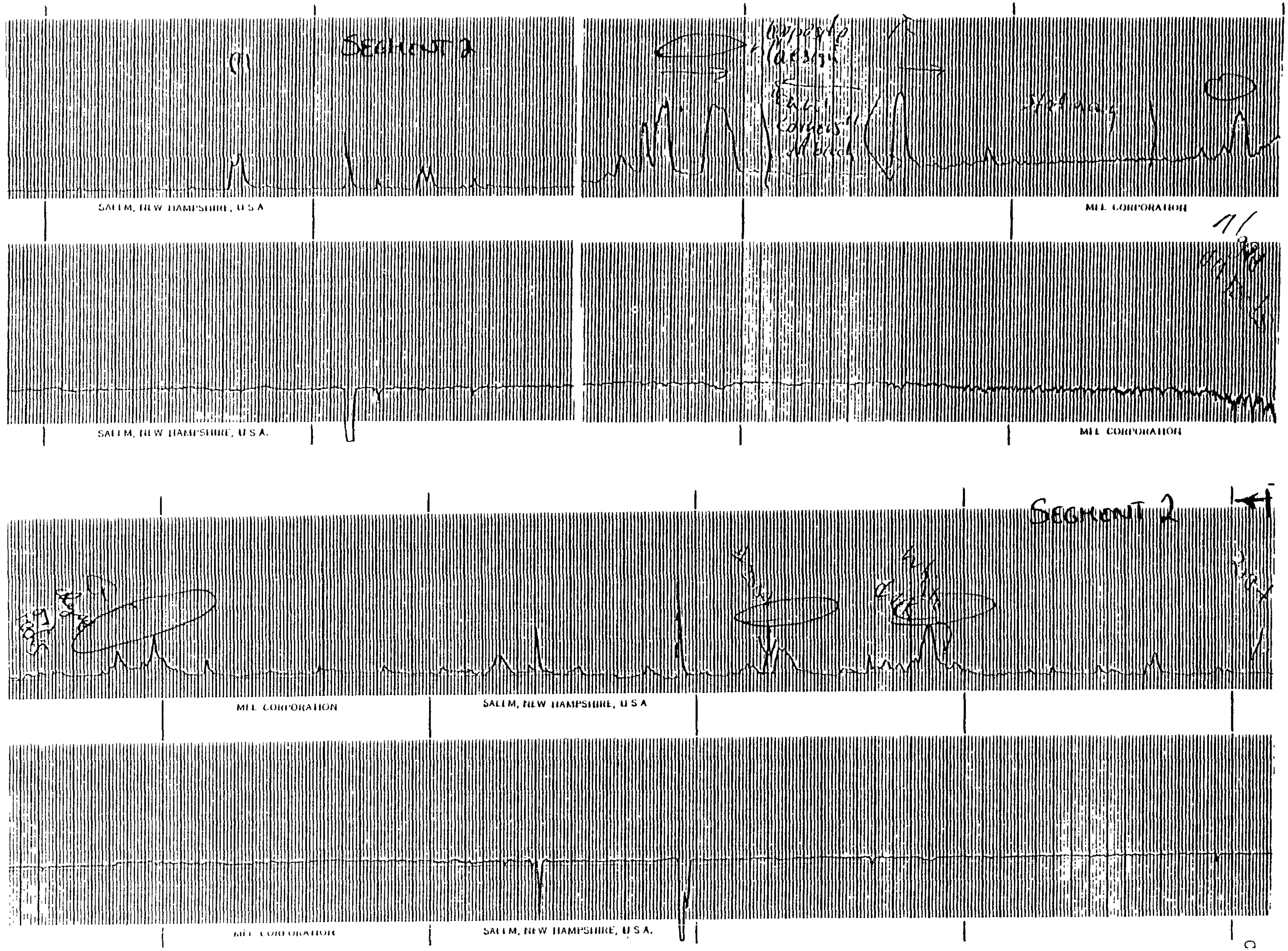
TRACK A

SECTION 2

C

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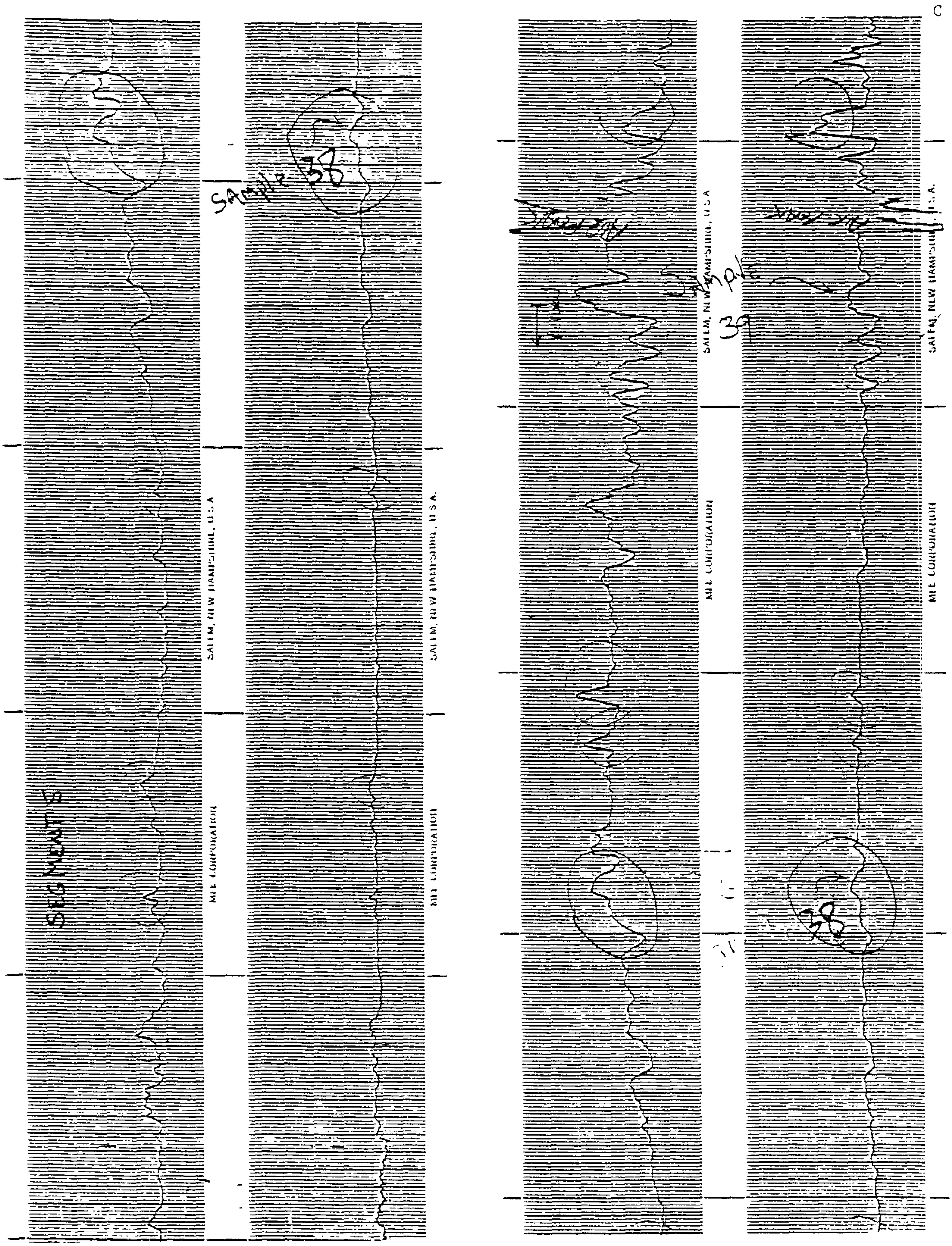
MFL CORPORATION
SEGMENT 2

TRACK B

SECTIONS 5 through 16


C
SEGMENT 5
Sample 38
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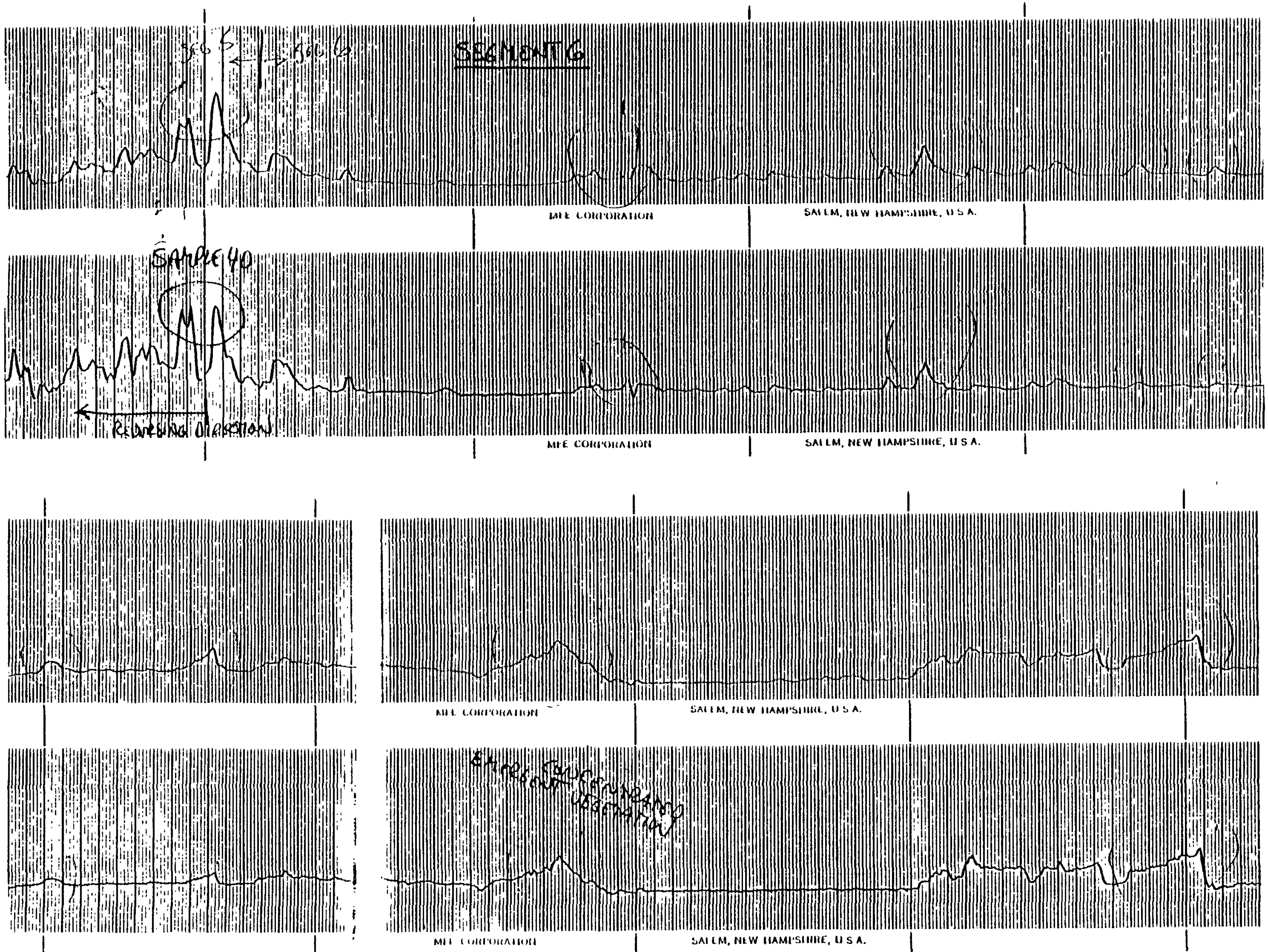
SALEM, NEW HAMPSHIRE, U.S.A.
Sample 39
38



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566
566
SAMPLE 40
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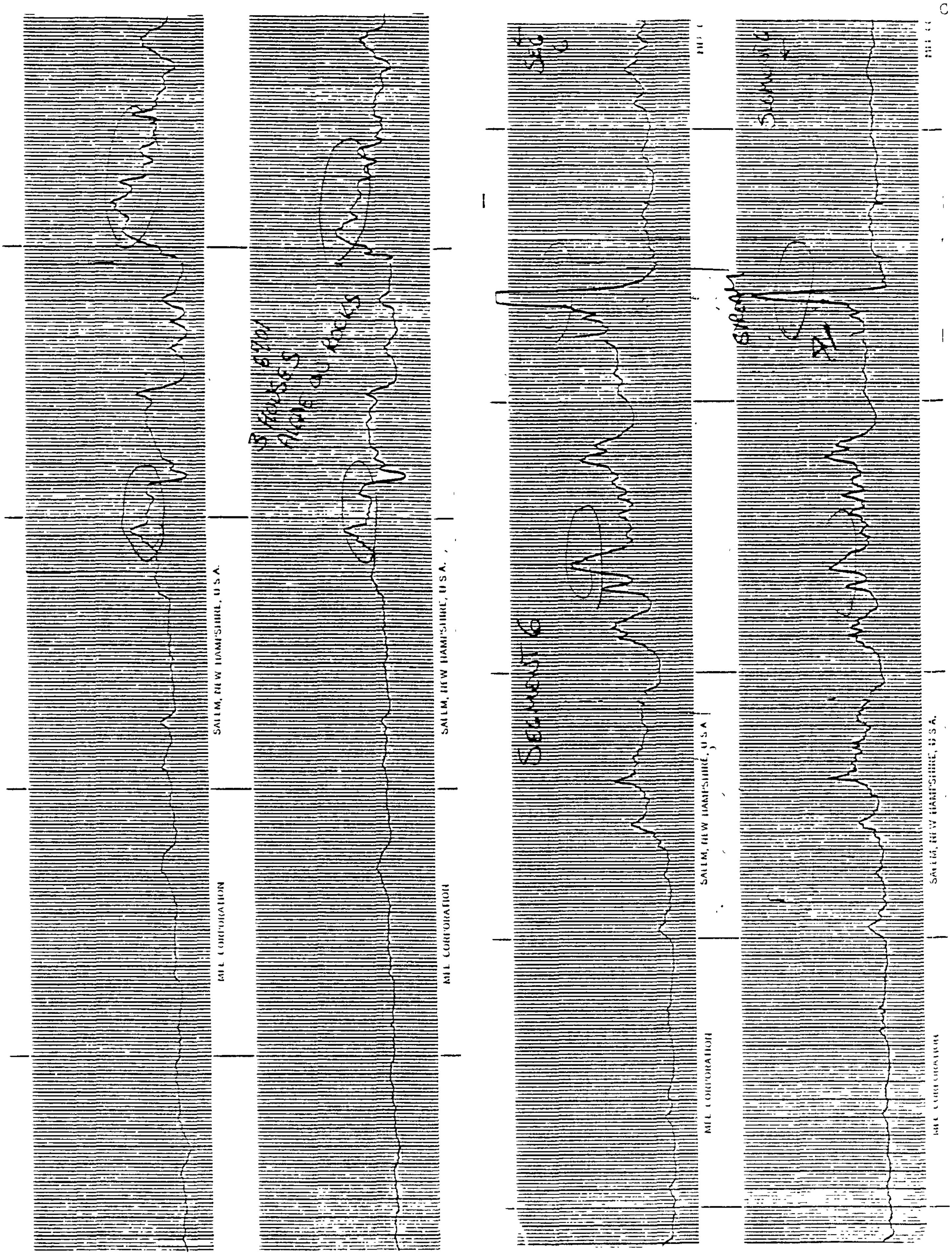
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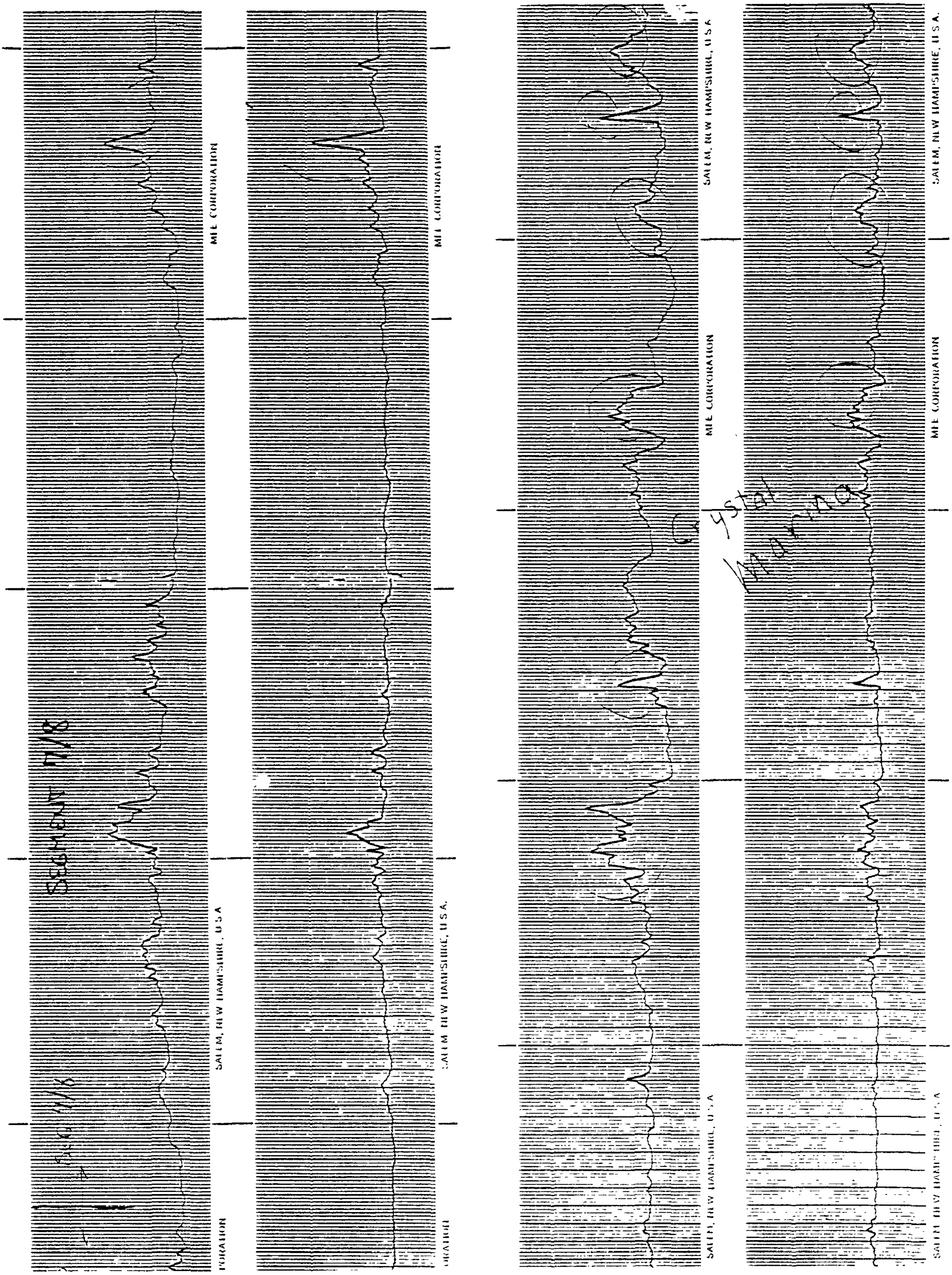
MFE CORPORATION
Segment 6

C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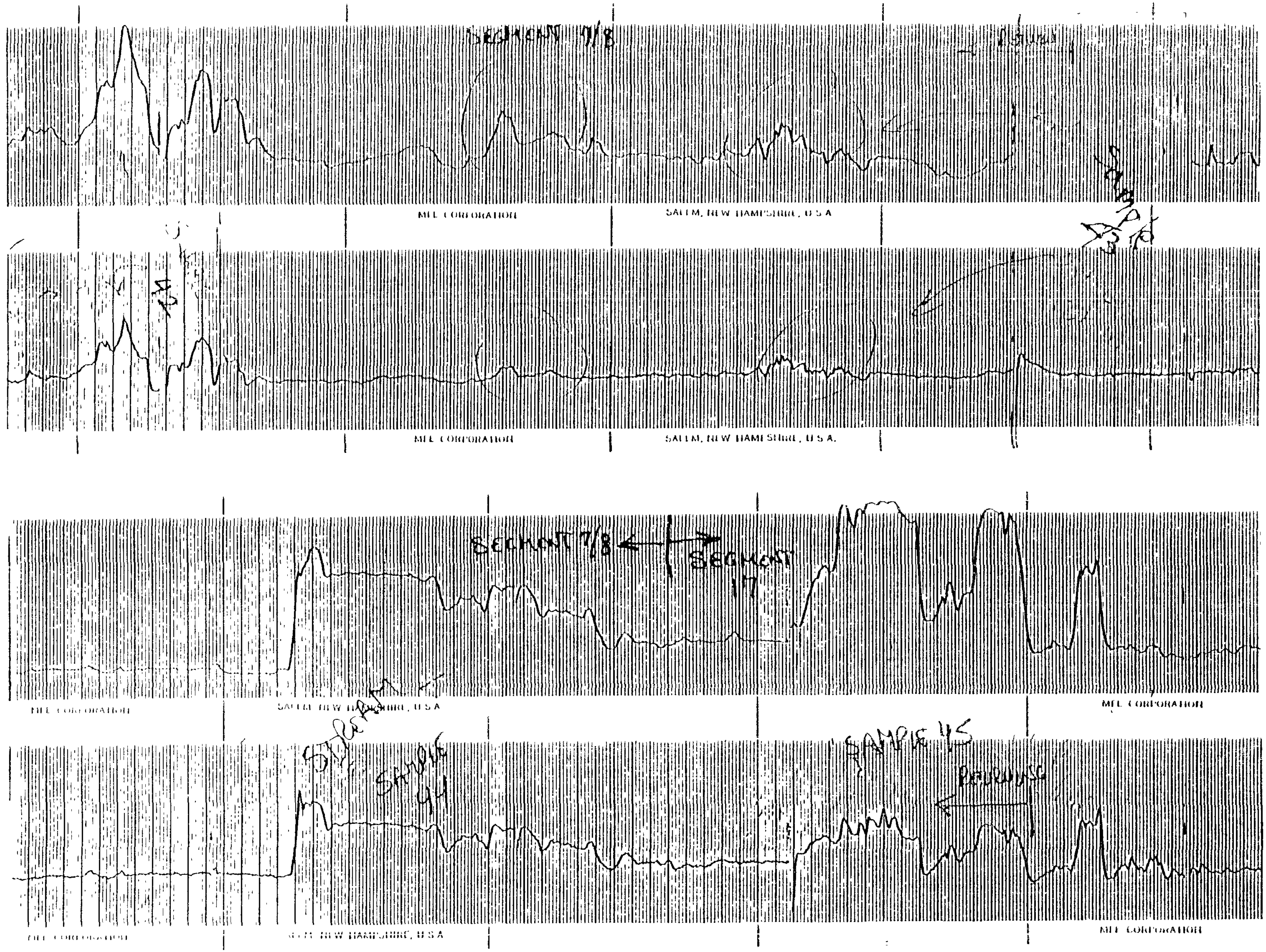
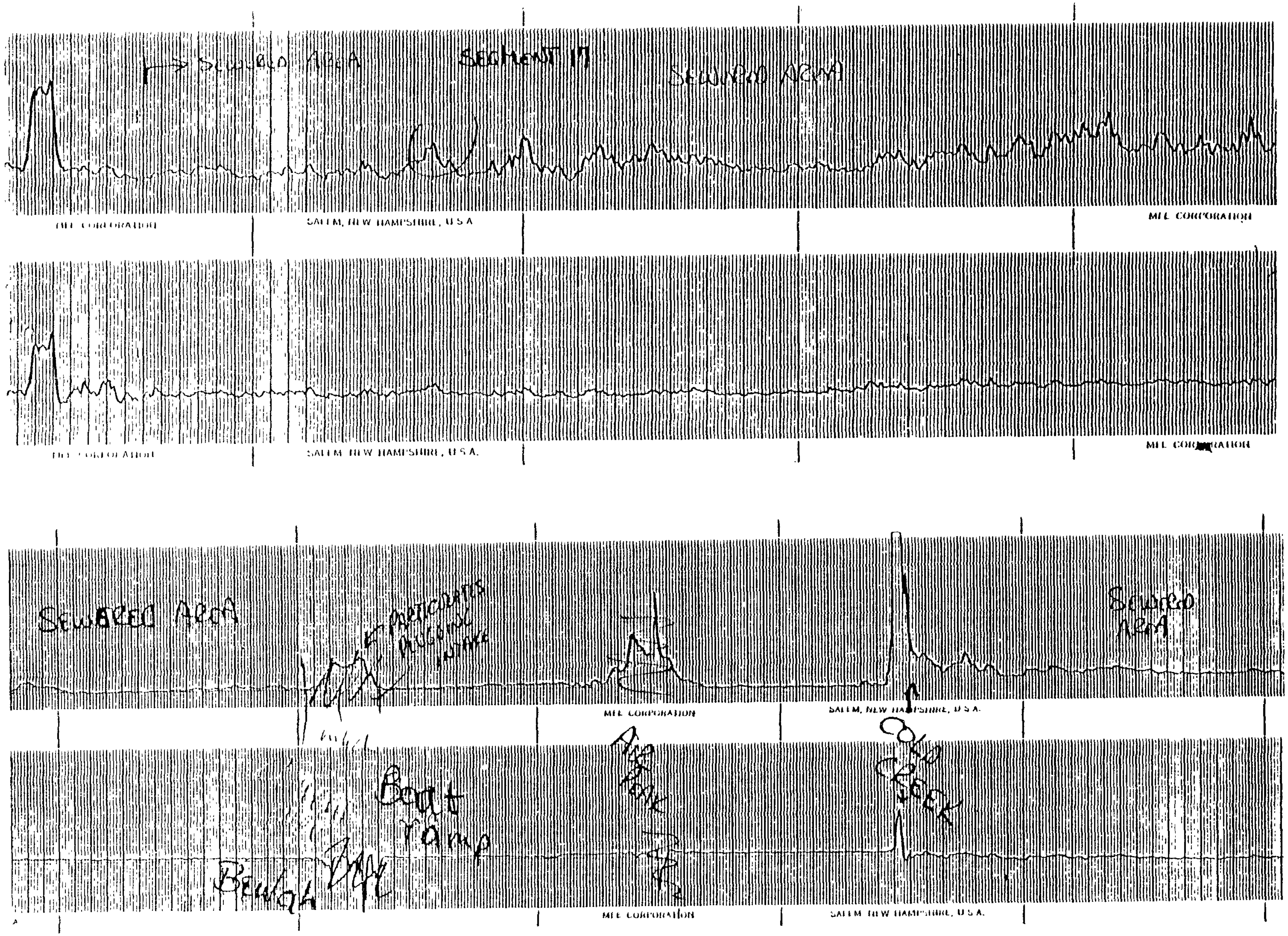
Crystal Marina


SEGMENT 7/8
MEL CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
SAMPLE 43
42
SEGMENT 7/8
SEGMENT 17
SAMPLE 44
SAMPLE 45
MEL CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.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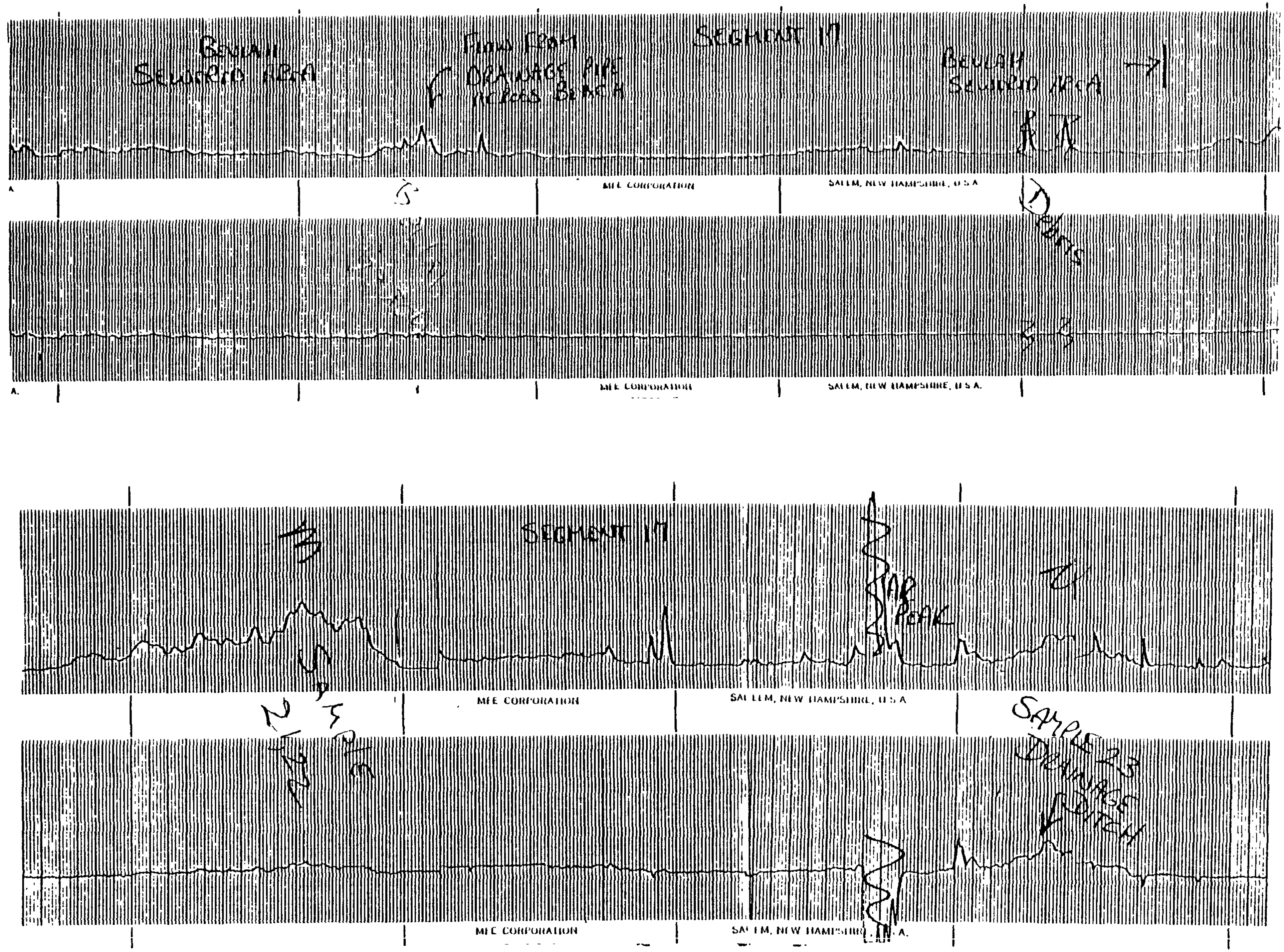
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
SEWARD AREA
Seward Area
Boat ramp
Cold Creek


Benoit Seabird Area
Flow from drainage pipe across beach
Segment 17
Benoit Seabird Area
Debris
MFE CORPORATION
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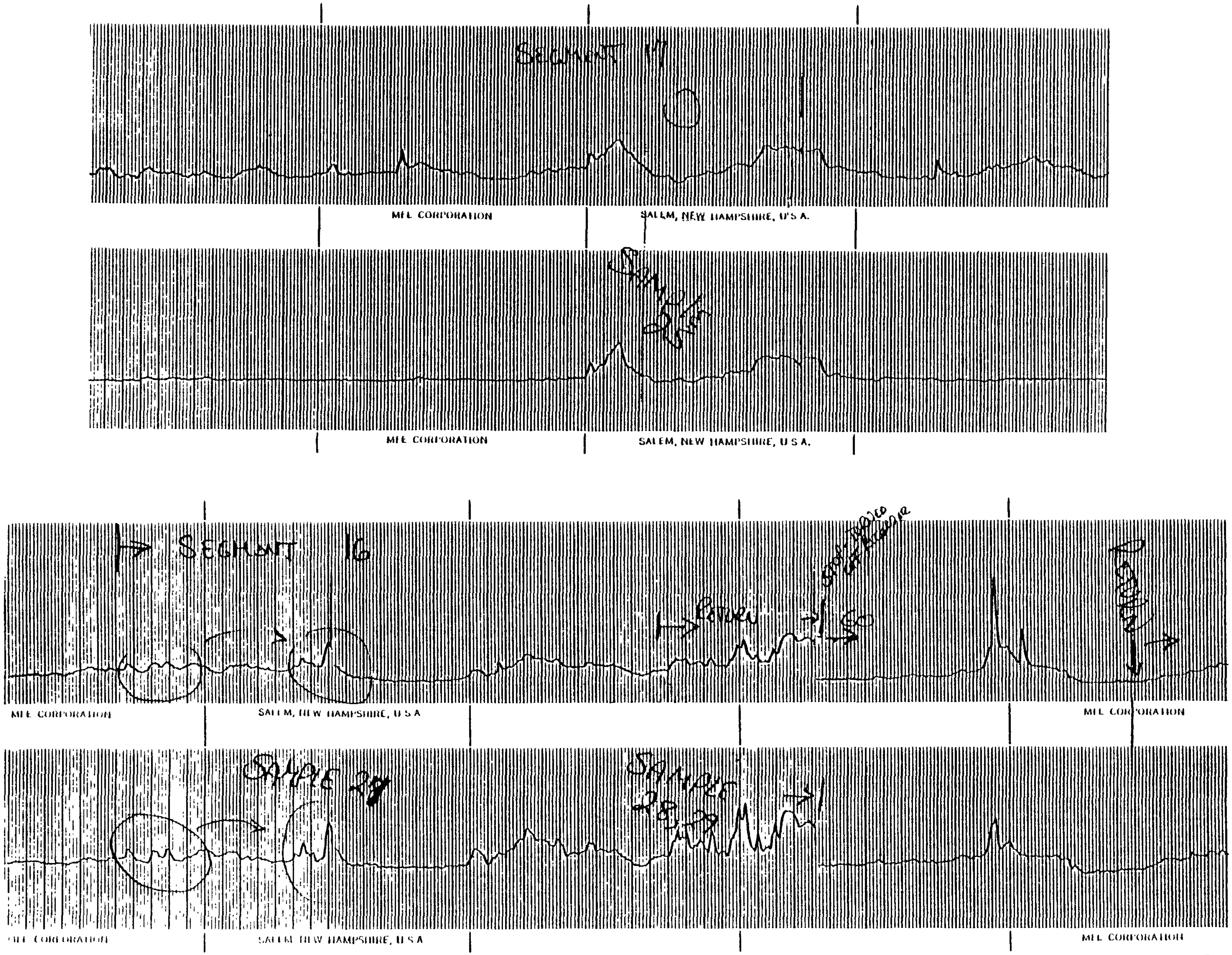
Segment 17
Bar Peak
Sample 21, 22
Sample 23 Drainage Ditch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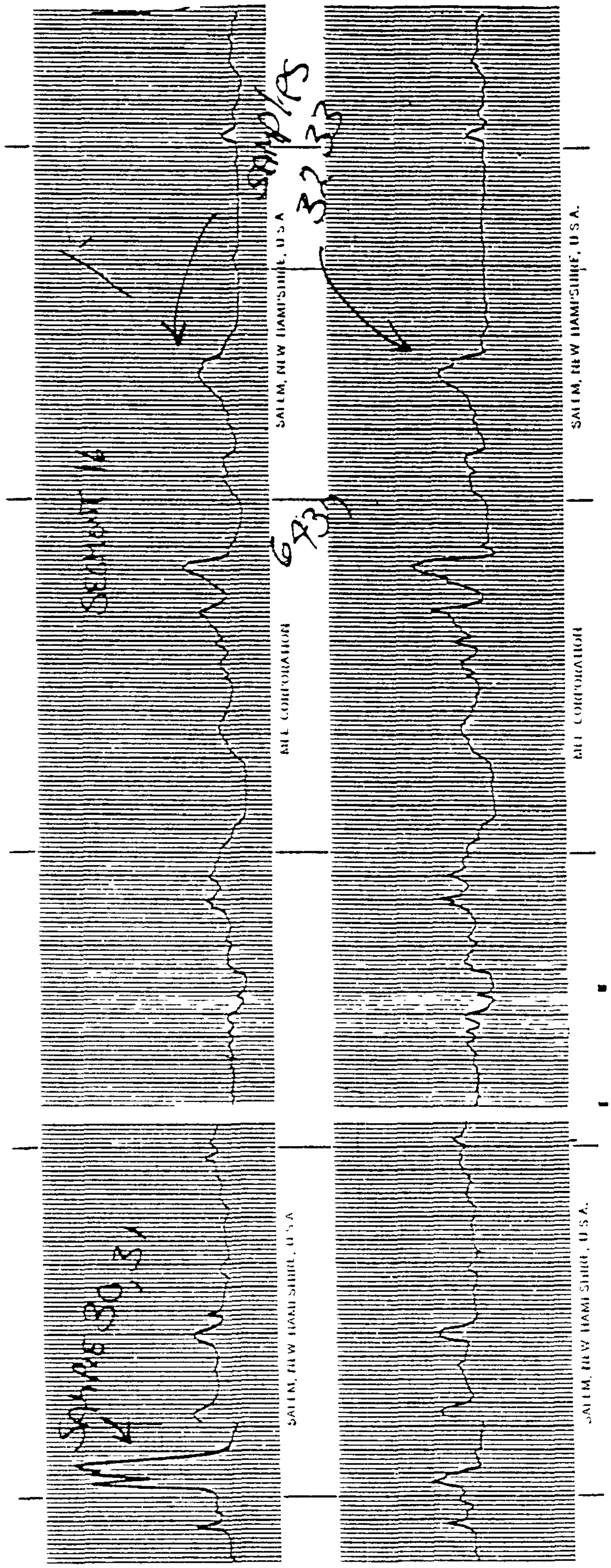
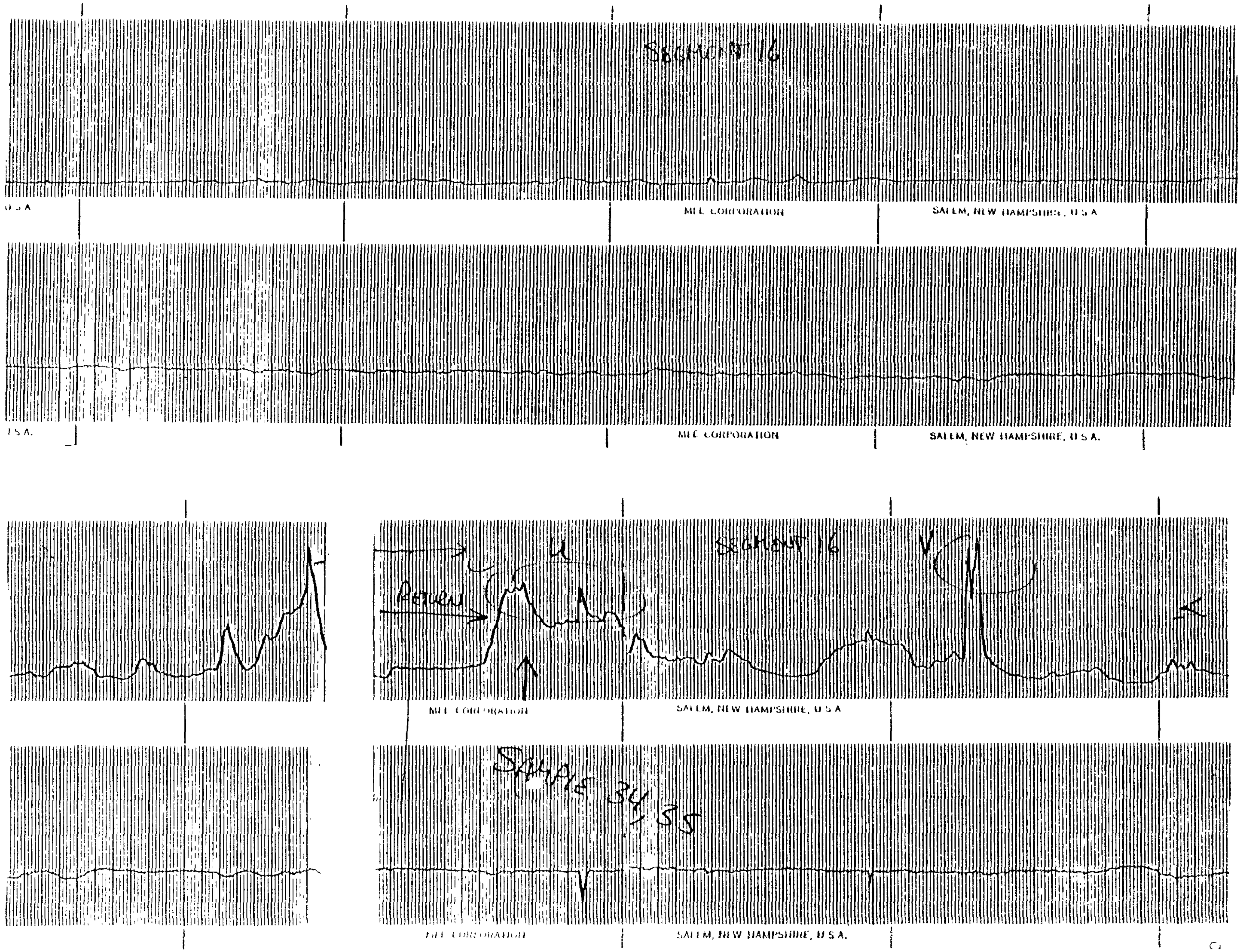
SEGMENT 16
RETURN
SAMPLE 28

C

C





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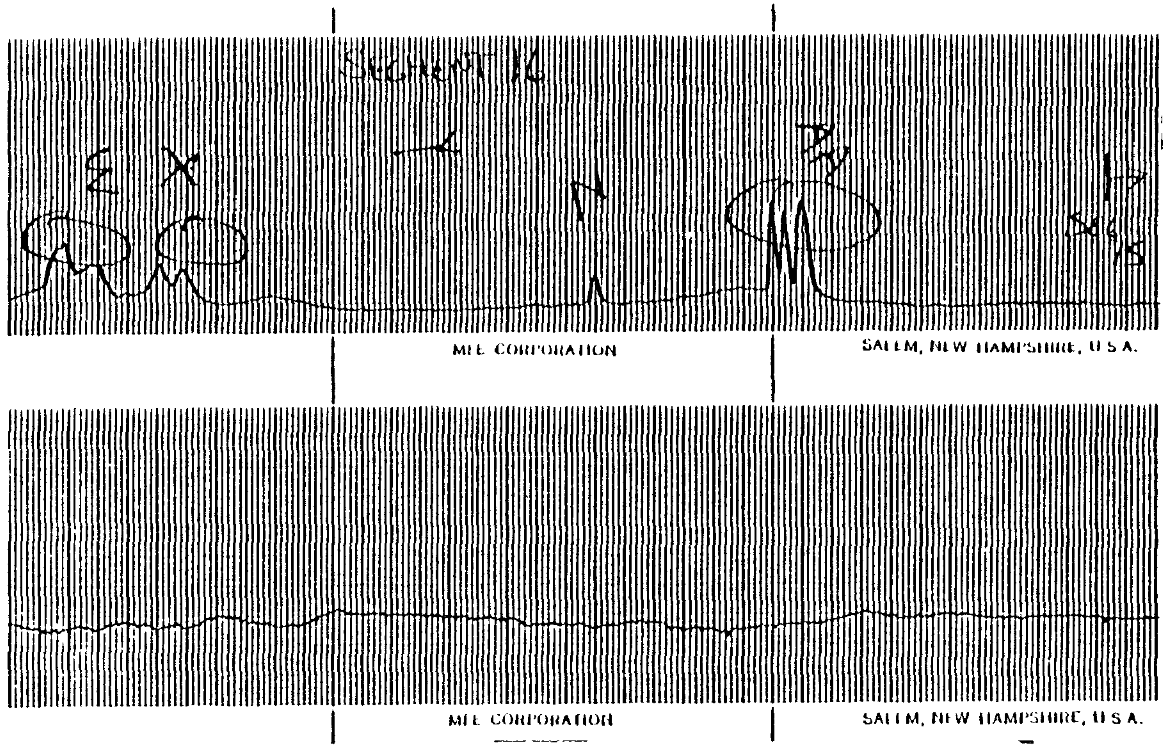
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TRACK C

SECTION 13

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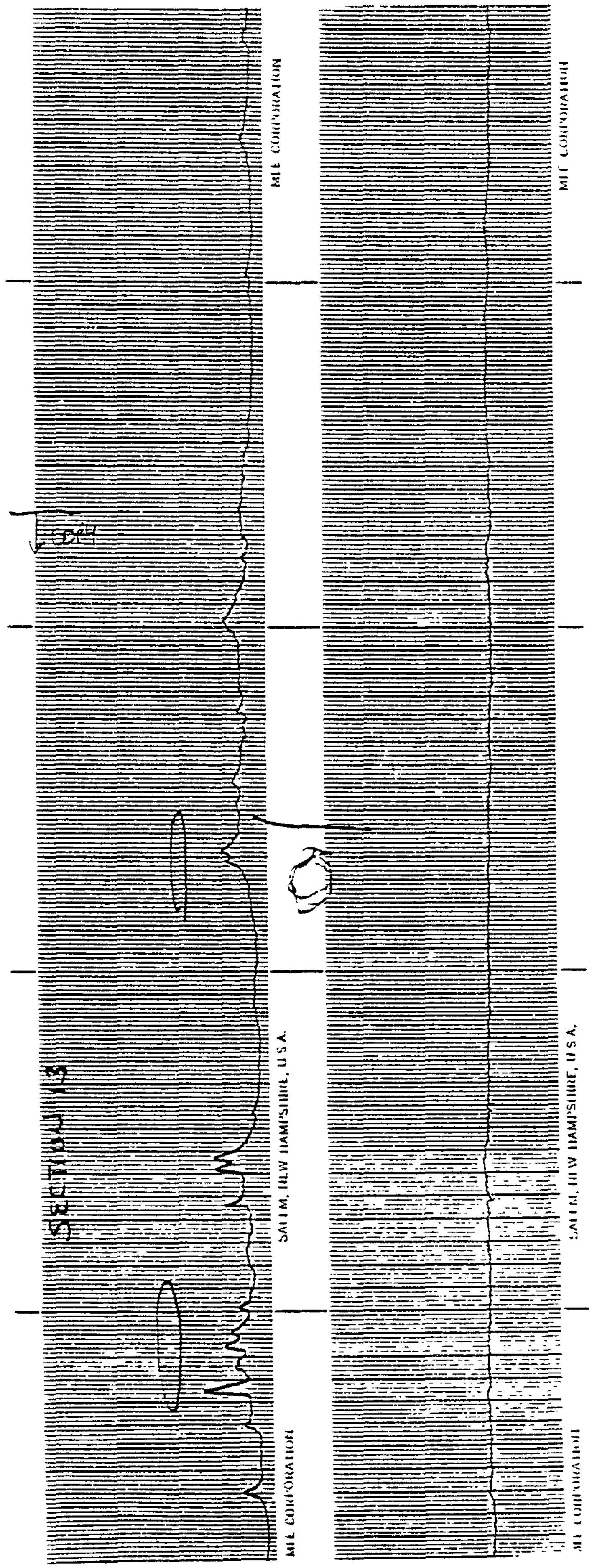
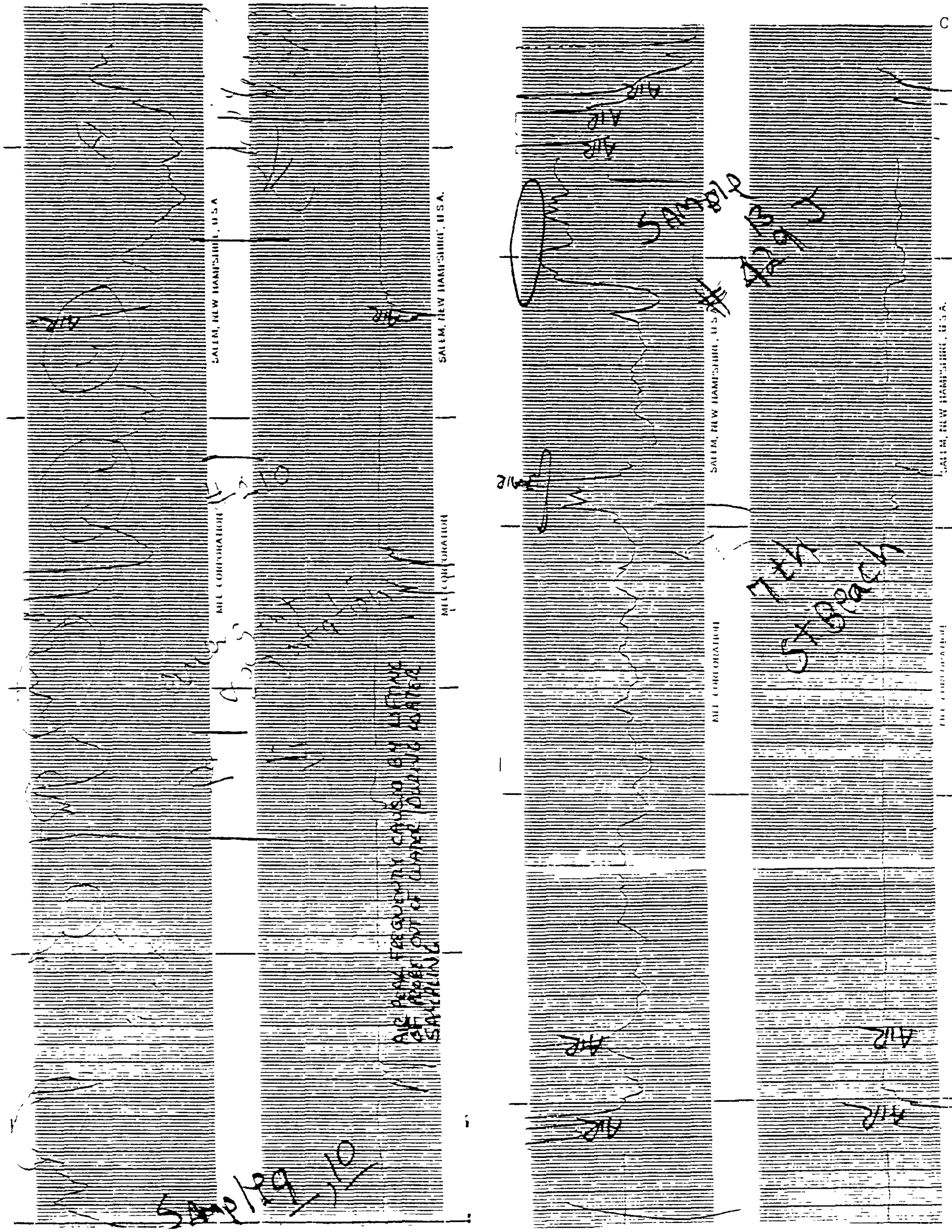
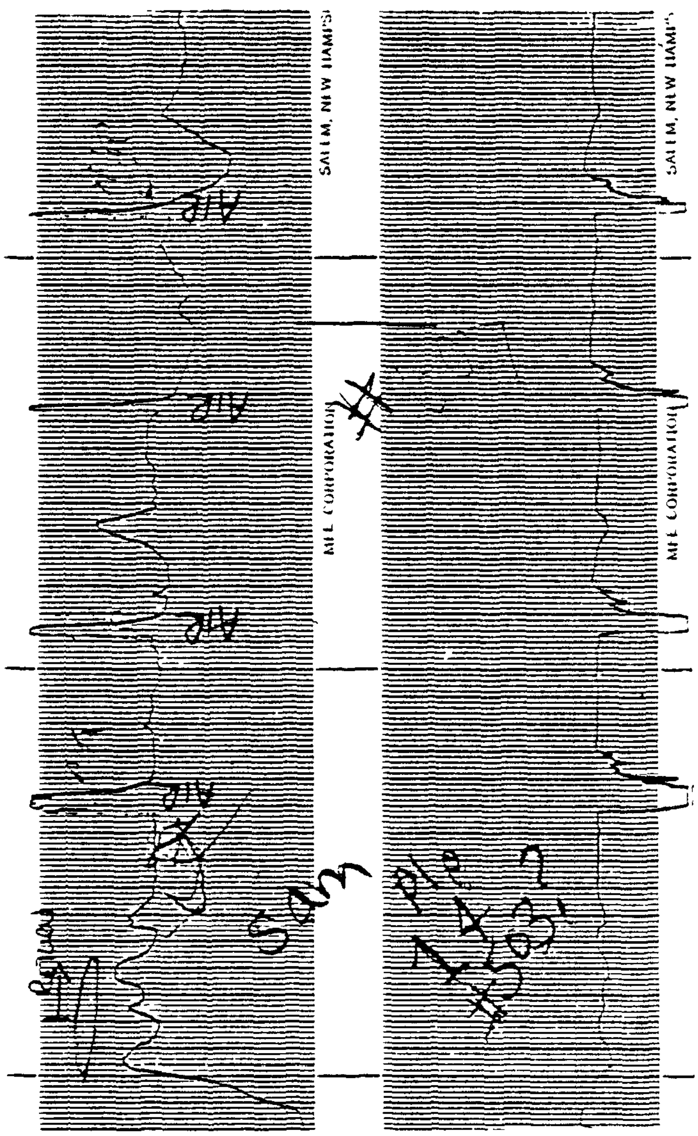


TRACK D

SECTION 12


SALEM, NEW HAMPSHIRE, U.S.A.
MET CORPORATION
AIR
AIR PEAK FREQUENTLY CAUSED BY LIFTING AIR PROBE OUT OF WATER DURING SAMPLING
Sample #10
Sample #42B
7th St Beach

C



APPENDIX
D

CLASSIFICATIONS AND STANDARDS FOR SURFACE WATERS

D-1 Michigan Surface Water Classifications

D-2 Michigan State Water Quality Standards

D-3 Betsie River Natural River Zoning

D-4 Effluent Limits -- Frankfort, Elberta, Beulah

MICHIGAN SURFACE WATER CLASSIFICATIONS

Michigan has established State water quality standards to protect public health and to preserve quality of the several bodies of water for their designated uses. Pertinent Michigan classifications for surface waters follow.

Classification	Use
A-I	Public and Municipal Water Supply
A-II	Industrial Water Supply
B-I	Total Body Contact Recreation
B-II	Partial Body Contact Recreation
C-I	Coldwater Fish (trout, salmon, etc.)
C-II	Warmwater Fish (bass, pike, etc.)
D	Agriculture
E	Navigation

MICHIGAN STATE WATER QUALITY STANDARDS

Surface Water Classifications	A-I	A-II	B-I	B-II	C-I	C-II	D	E
Suspended solids	No unnatural turbidity, color, oil films, floating solids or deposits in quantities which are or may become injurious to any designated use							
Dissolved solids	Shall not exceed concentrations which are or may become injurious to any designated use.							
chlorides	≤ 125 mg/1							
pH	6.5 - 8.8							
Plant nutrients	Nutrients shall be limited to the extent necessary to prevent stimulations of growth of aquatic plants, fungi or bacteria which are or may become injurious to the designated use. Phosphorus from point sources shall be controlled by utilizing best practicable waste treatment technology. Goal is 1 mg/1 of P							
Fecal coliform	≤ 1000/100 ml		200/100 ml	≤ 1000/100 ml				
DO	5 mg/1 but not less than 4 mg/1		6 mg/1		5 mg/1 but not less than 4 mg/1			
Temperature	Temperature standards are dependent on location and type of surface water and also the designated use of the surface water.							

State of Michigan Water Quality Requirements,
Part 4, undated.

These rules became
effective 6/11/77

Appendix
D-3

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF LAND RESOURCE PROGRAMS

BETSIE RIVER NATURAL RIVER ZONING

Filed with Secretary of State
These rules take effect 15 days after filing with the Secretary of State

(By authority conferred on the commission of natural resources by section 13 of Act No. 231 of the Public Acts of 1970, being §281.773 of the Michigan Compiled Laws)

R 281.31. Definitions.
Rule 1. (1) "Applicant" means a person who requests on proper forms and via proper procedures, a zoning permit, special exception permit, or variance.
(2) "Appurtenance" means a structure incidental to a dwelling, including, but not limited to, garages, private access roads, pump houses, wells, sanitary facilities, and electrical service lines.
(3) "Building permit" means a permit issued by the appropriate governmental subdivision as presently required under provisions of the state construction code act of 1972, Act 230 of the Public Acts of 1972, being §125.1501 et seq. of the Michigan Compiled Laws.
(4) "Building inspector" means the agency or individual appointed by the appropriate governmental subdivision to administer provisions of Act No. 230 of the Public Acts of 1972, including issuance of building permits.
(5) "Commission" means the natural resources commission.
(6) "Director" means the director of the department of natural resources.
(7) "Dwelling, single family" means a detached building, or portion thereof, which is used exclusively for residential purposes, and which is designed for or occupied exclusively by 1 family and containing housekeeping facilities.
(8) "Filtered view of the river" means maintenance or establishment of woody vegetation of sufficient density to screen developments from the river, provide for streambank stabilization and erosion control, serve as an aid to infiltration of surface runoff and provide cover to shade the water. It need not be so dense as to completely block the river view. It means no clear cutting.
(9) "Front" means that side of a lot abutting the water's edge of the mainstream or tributary.
(10) "Lot" means a parcel of land occupied or intended to be occupied by 1 single family dwelling and appurtenances incidental to it, including such open spaces as are arranged and designed to be used in connection with such buildings.
(11) "Natural river district" means the Betsie river natural river district as described in subrule (1) of rule 3.

April 28, 1976

(12) "Parcel" means a continuous area or acreage of land which can be described for purposes of transfer, sale, lease, rent, or other conveyance.
(13) "Reforestation" means renewal of vegetative cover by seeding, planting, or transplanting.
(14) "Setback" means the horizontal distance between any portion of a structure and the water's edge, measured at its closest point.
(15) "Soil erosion and sedimentation control enforcement agency" means the local agency appointed by the appropriate governmental subdivision to enforce the provisions of Act No. 347 of the Public Acts of 1972, being §282.101 et seq. of the Michigan Compiled Laws.
(16) "Structure" means anything constructed, erected, or to be moved to or from any premise which is permanently located above, on or below the ground, including signs and billboards.
(17) "Zoning administrator" means the administrator of these zoning rules appointed by the natural resources commission.
(18) "Zoning permit" means a standard form issued by the zoning administrator upon application and declaration by the owner or his duly authorized agent approving proposed construction and use of land and buildings and structures thereon.
(19) "Zoning review board" means a group of 3 or more persons appointed by the commission to act upon requests for special exceptions.

R 281.32. Purpose.
Rule 2. It is the purpose of these rules:
(a) To promote the public health, safety, and general welfare, to prevent economic and ecological damages due to unwise development patterns within the natural river district, and to preserve the values of the natural river district for the benefit of present and future generations.
(b) To protect the free flowing conditions, fish and wildlife resources, water quality, scenic and aesthetic qualities and historical and recreational values of the Betsie river and adjoining land.
(c) To prevent flood damages due to interference with natural flood plain characteristics by excluding developments which are vulnerable to flood damages, and which may reduce the capacity of the floodway of the river to withstand flooding conditions.
(d) To provide for residential and other permitted uses that complement the natural characteristics of the natural river system.
(e) To protect individuals from buying or developing lands which are unsuited for building purposes.

R 281.33. Boundaries; display and filing of zoning map; effect of zoning rules.
Rule 3. (1) The Betsie river natural river district is that area comprising:
(a) The Betsie river from Grass Lake dam in section 2, T25N, R13W in Benzie county to its mouth at Betsie lake in section 35, T26N, R16W, including Thompsonville pond.
(b) The Little Betsie river from its headwaters in section 24, T25N, R13W in Benzie county to its confluence with the Betsie river in section 25, T25N, R14W.

(c) Dair creek from its headwaters in section 15, T25N, R14W, to its confluence with the Betsie river in section 19, T25N, R14W.

(d) The lands lying within 400 feet of the edge of the waters enumerated in subdivisions (a), (b), and (c).

(2) Certified copies of the Betsie river natural river zoning map shall be filed with the local tax assessing officers and with the state tax commission, and additional display copies will be provided to local offices in the Betsie river area, including: county register of deeds, zoning administrator of these rules, local planning and zoning officials, township and county clerks, local building inspector, local soil erosion and sedimentation control enforcement agencies, and soil conservation service.

(3) These zoning rules do not repeal, abrogate or impair any existing easements, covenants, or deed restrictions applicable to lands within the natural river district, except that where these rules impose greater restrictions than found on such easements, covenants or deeds, the provisions of these rules shall prevail.

(4) These zoning rules do not permit actions prohibited by other statutes or ordinances, including zoning ordinances, applicable to the natural river district, therefore:

(a) All earth changing activities, other than normal landscaping or maintenance, undertaken within 500 feet of a lake or stream, must be conducted in accordance with an appointed soil erosion and sedimentation control plan and permit issued by the local soil erosion and sedimentation control enforcement agency.

(b) All development and land uses in the Betsie river natural river district are subject to provisions of appropriate local health codes and building codes, including requirements for permits and approvals.

R 281.34. Permitted uses.

Rule 4. The following uses shall be permitted by the owner upon the owner's property within the natural river district, subject to limitations and requirements outlined in these zoning rules, local ordinances, and other applicable statutes:

(a) One single family dwelling and appurtenances on a lot at least 200 front feet wide, subject to the following limitations:

(i) On the Betsie river mainstream, set back shall be at least 200 feet from the water's edge, except that for every foot of vertical river bank elevation greater than 5 feet above the normal water level, the building setback may be moved 5 feet closer to the edge of the river ridge or escarpment until a minimum of 150 feet is reached.

(ii) On the Little Betsie river and Dair creek, set back shall be at least 100 feet from the water's edge.

(b) Plats, if the minimum setback and lot width requirements specified in subdivision (a) are met.

(c) Camping and other recreational activities outside of the natural vegetation strip, if structures are set back at least 200 feet from the water's edge on the Betsie river mainstream, and at least 100 feet from the water's edge on the Little Betsie river and Dair creek.

(d) Operation of watercraft subject to limitations of local ordinances established under the authority of Act No. 303 of the Public Acts of 1967, being §281.1001 et seq. of the Michigan Compiled Laws.
(e) Fishing and hunting in compliance with current laws and regulations.
(f) Reforestation.
(g) Normal agricultural activities, if those activities meet the requirements of these rules, and if the bureau of environmental protection of the department of natural resources determines that the activities do not contribute to stream degradation.
(h) Operation of licensed motor vehicles on dedicated public roads or access roads to private single family dwellings.
(i) Private foot paths constructed by the landowner of natural materials to facilitate permitted uses.
(j) Private boat docks not to exceed 4 feet in width nor more than 20 feet in length, with no more than 4 feet of the dock extending over the water, if constructed of natural materials and camouflaged into the natural surroundings.
(k) Mining and extractive industries more than 300 feet from the water's edge, if constructed and operated pursuant to applicable laws and rules of the state.
(l) Underground gas and utility lines to private single family dwellings originating from the landward side of the dwelling.
(m) Surface gas and utility lines on lands or interests in real property continuously owned by a utility from and after January 1, 1971, subject to review and approval by the commission.
(n) Disposal fields and septic tanks in conformance with local county health codes and the provisions of these rules.
(o) Cutting and filling of the land surface, unless the high ground water table is within 6 feet of the land surface, if the cutting and filling meets all the requirements of Act No. 347 of the Public Acts of 1972, being §282.101 et seq. of the Michigan Compiled Laws, and approval is granted by the local soil erosion and sedimentation control enforcement agency.
(p) Other uses for which an applicant is granted a permit by the zoning administrator pursuant to rules 6 and 9.

R 281.35. Natural vegetation strip.
Rule 5. A strip 50 feet wide on each side of, and parallel to, the Betsie river mainstream, the Little Betsie river, and Dair creek shall be maintained in trees and shrubs or in its natural state, except that dead, diseased, unsafe, or fallen trees, as well as noxious plants may be removed, and trees and shrubs, upon approval of the area forester, may be selectively pruned or removed for landscaping purposes or to provide a filtered view of the river.

R 281.36. Special exception permits.
Rule 6. (1) Special exception permits may be granted to allow a use in the natural river district that is not specifically permitted by rule 4, where implementation of that use does not contravene the purposes of these rules as specified in rule 2.

(2) Application for a special exception permit shall be made on a form provided by the zoning administrator.

(3) Upon reviewing an application for a special exception permit, the zoning review board, at any time prior to rendering a decision thereon, shall require the applicant to furnish any of the following information as is deemed necessary by the zoning review board for determining the suitability of the particular site for the proposed use:

(a) A detailed description of the proposed activity or use.

(b) A plan (surface view) showing elevations or contours of the ground, including existing earth fills; generalized vegetative cover; size, location, and spatial arrangement of all proposed and existing structures on the site; location and elevations of streets, access roads, water supply and sanitary facilities.

(c) Photographs showing existing land uses and vegetation upstream and downstream from the proposed use.

(d) Valley cross sections showing the natural stream channel, streambanks and high water marks, if any, with indications of locations of proposed developments.

(e) Any other information deemed relevant by the zoning administrator, and necessary to carry out the intent and provisions of these rules.

(4) Before considering applications, the zoning review board shall give notice by certified mail to all property owners within 500 feet of the proposed use as shown on the current tax assessment rolls, and to local officials and department of natural resources personnel, including: township supervisor, township building inspector, county health officer, local soil erosion and sedimentation control enforcement agency, county and township planning and zoning officials, soil conservation service, and regional office and natural rivers section of the department of natural resources.

(5) In review of an application, the zoning review board shall consider all relevant factors specified in these rules in the light of the spirit and intent of the purposes specified in rule 2.

(6) The zoning review board may require public hearings to be held regarding the application. The zoning review board shall decide on an application within 15 days from receiving the application, except that where public hearings are held or additional information is required pursuant to subrule (3) it shall render a decision within 15 days following the hearings or receipt of the last requested information.

(7) The zoning review board shall attach such conditions to the granting of a special exception as are necessary to further the purposes of these rules.

(8) A special exception use shall adhere strictly to the terms of the special exception permit or such permit may be revoked by the zoning administrator.

R 281.37. Nonconforming uses.

Rule 7. (1) The lawful use of any land or structure existing at the effective date of these rules may be continued, although the use does not conform with these rules.

(2) Routine or normal repairs and maintenance work required to keep a nonconforming structure or other use, such as a roadway, in sound condition are permitted. Remodeling of nonconforming structures within the confines of the existing foundation and elevations is permitted.

(3) The granting of a special exception permit is required for the restoration of a nonconforming building or structure damaged or destroyed by more than 50% of its value due to flood, fire or other means. In determining whether 50% of the value has been destroyed, the zoning review board shall use appraised replacement costs as determined by a qualified individual appointed by the zoning review board, and shall compare the value of the part destroyed to the value of the total operating unit where there are several buildings or structures which are used together by the landowner as a single operating unit. A request for restoration of a nonconforming building or structure damaged or destroyed by more than 50% of its value shall be approved if all of the following conditions exist:

(a) The land upon which it is situated is not subject to flooding.

(b) Continued use of a nonconforming building or structure would not lead to accelerated bank erosion or other material degradation of the river resource, and approval is granted by the local soil erosion and sedimentation control enforcement agency.

(c) The continued use conforms with local county health codes and approval is granted by the local county health department.

(d) The continued use conforms with local building codes and approval is granted by the local building inspector.

(e) Restoration of a damaged building or structure approved by the zoning review board shall be started within one year from the time of damage.

(4) A nonconforming use may be changed to a use of a like or similar character, provided the new use conforms more closely to the rules of the natural river district.

(5) A nonconforming use of any land or structure may not hereinafter be enlarged or extended without the granting of a special exception permit upon consideration of the factors outlined below in subdivisions (a), (b), (c), (d), and (e). An enlargement or extension of a nonconforming use of up to 50% of the land area or the floor area of a residential structure or public accommodation providing overnight facilities not exceeding 12 units may be approved by the zoning review board when the owner submits to the zoning review board a detailed description of the proposed enlargement or extension together with a site plan showing the location of all new structures or uses, and upon a determination that all of the following conditions exist:

(a) The land upon which it is situated is not subject to flooding.

(b) The enlargement or extension of the nonconforming use does not lead to accelerated bank erosion or other material degradation of the river resource, and approval is granted by the appropriate local soil erosion and sedimentation control enforcement agency.

(c) The enlarged or extended use conforms with local county health codes and approval is granted by local county health department.

(d) The enlarged or extended use conforms with local building codes and approval is granted by local building administrator.

(e) The enlarged or extended use does not contravene the purposes of these rules as specified in rule 2.

(6) Substitution of nonconforming structures with new structures may be made, but the granting of a special exception permit upon consideration of the factors outlined in subrule (5) is required to ensure that the changed uses conform as closely as possible to the purposes of these rules as specified in rule 2.

(7) If a nonconforming use is discontinued for 12 consecutive months, any future use at that site shall conform to these rules.

(8) A property owner may request the zoning review board to certify the existence of a prior nonconforming use on the owner's property which certification shall be granted where a use meets the criteria of this rule and the common law criteria of nonconforming uses of the state.

R 281.38. Hearing; variances.

Rule 8. (1) An applicant who is denied a zoning permit or a special exception permit shall have a hearing pursuant to sections 71 to 87 of Act No. 306 of the Public Acts of 1969, being §§24.271 to 24.287 of the Michigan Compiled Laws upon petition thereof filed with the director within 30 days of the denial.

(2) Upon receipt of a petition for a hearing, the director shall set a date for a hearing on the facts and proposed action, and shall appoint a hearing officer to preside at the hearing. The proposed hearing shall be scheduled not more than 8 weeks after receipt of the petition. The hearing officer shall hear the evidence and prepare a record of the proceedings and a proposal for a decision, including findings of fact and conclusions of law.

(3) The hearing officer shall give notice of the hearing by certified mail to the persons named in subrule (4) of rule 6 at least 30 days prior to the hearing.

(4) The record of the proceedings and proposal for decision shall be transmitted to the commission and shall be served by certified mail on all other parties to the proceedings not more than 30 days after completion of the testimony.

(5) A final decision or order of the commission in a contested case shall be made not more than 60 days after the date of the hearing and a copy of the decision or order shall be delivered or mailed forthwith to each party and to that party's attorney.

(6) The commission shall prepare an official record of hearing pursuant to section 86 of Act No. 306 of the Public Acts of 1969, being §24.286 of the Michigan Compiled Laws.

(7) The final decision or order of the commission after a hearing is conclusive unless reviewed in accordance with section 87 or sections 101 to 106 of Act No. 306 of the Public Acts of 1969, being §§24.287 and 24.301 to 24.306 of the Michigan Compiled Laws.

(8) In determining a final decision in a contested case, the commission shall consider:

(a) The economic effect of the subject property weighed in light of the applicant's entire contiguous holdings and not merely the portion within the natural river district. If the subject portion is the remainder of a larger holding this fact and a description of the title history shall be included in the hearing evidence.

(b) Increase in flood levels and flood damages that may be occasioned by the proposed use at the site and upstream and downstream from the site, water quality consequences and other factors relevant within the terms of these rules.

(c) Cumulative effect upon the natural river district from potential development of holdings in a legal position similar to the applicant's, if variances are requested and granted for these properties.

(d) Reasonable alternatives available to the applicant.

(e) All other factors relevant to the purposes and provisions of these rules.

(9) In weighing the application for a variance, considerations of public health, safety, and welfare shall prevail, unless private injury is proved by substantial preponderance of the evidence to be so great as to override the public interest.

(10) A variance shall not be granted where the commission determines that the requested use poses substantial hazard to life or property rights either public or private.

(11) Where, by reason of the narrowness, shallowness, or shape of a lot or property at the effective date of these rules, the lot or property cannot accommodate a building because of the required building setback, variances shall be allowed only upon a consideration of the factors prescribed in subrule (8) of rule 8. Such variance shall provide that the structures shall be so placed as to best meet the spirit and objectives of the natural rivers act, Act No. 231 of the Public Acts of 1970, being §281.761 et seq. of the Michigan Compiled Laws.

R 281.39. Zoning administrator and zoning review board; appointment and duties.

Rule 9. (1) The commission shall appoint a zoning administrator and a zoning review board to act as its agent to enforce these rules, including the receiving and processing of applications for zoning permits, special exception permits, petitions for variances, requests for changes, amendments or supplements, as outlined in these rules, or other matters the commission is required to decide.

(2) A person shall not commence excavation, erection, alteration, or repair for a building or structure, or commence a land use, until an application for a zoning permit has been secured from the zoning administrator. Alterations and ordinary maintenance made on dwellings which do not change the character of the structure or land use, and where the total cost does not exceed 5% of the market value of the structure in any 12 month period, are exempt from obtaining a zoning permit, but may be required to obtain a local building permit from the appropriate local building inspector.

(3) Application for a zoning permit shall be filed in writing with the zoning administrator. There shall be submitted with all applications for zoning permits:

(a) Two copies of a site plan giving accurate dimensions on either a scale drawing or a rough sketch and containing the following information:

(i) Location upon the lot of all existing and proposed structures.

(ii) Existing or intended use of the structure.

(iii) Generalized vegetative cover.

(iv) Lines and dimensions of the lot to be used.

(b) Evidence of ownership of all property affected by the coverage of the permit.

(c) Evidence that all required federal, state, county, and township licenses or permits have been acquired or that applications have been file for the licenses or permits.

(d) Other information as may be required by the zoning administrator, and necessary to carry out the intent and provisions of these rules.

(4) One copy of both plans and specifications shall be filed and retained by the zoning administrator, and the other shall be delivered to the applicant when the zoning administrator has approved the application, completed the site inspection and issued the zoning permit. To insure that new land uses in the natural river district are in conformance with these rules, the applicant shall display a permit required by these rules face out within 24 hours of its issuance by placing it in a conspicuous place facing the nearest street or roadway and displaying it continuously until the purpose for which the permit was issued is completed. Failure to obtain and display a permit is a violation of these rules and shall subject a person for whose benefit the permit is required to court action.

R 281.40. Violations.

Rule 10. (1) Buildings erected, razed, altered, moved, or converted, or a use of land or premises, in violation of these rules are declared to be a nuisance.

(2) An alleged violation shall be inspected by the zoning administrator who shall order the applicant, in writing, to correct all conditions found to be in violation of these rules.

(3) Violations of these rules shall be resolved by the appropriate circuit court in accordance with section 13 of Act No. 231 of the Public Acts of 1970, being §281.773 of the Michigan Compiled Laws.

R 281.41. Changes, amendments, and supplements to boundaries and permitted uses.

Rule 11. (1) Changes, amendments, and supplements to boundaries and to permitted uses requested by a local unit of government or by a landowner may be granted where implementation of the change does not contravene the purposes of these rules as specified in rule 2.

(2) A local unit of government or a landowner who requests a change, amendment, or supplement to the boundaries or to permitted uses shall have a hearing held in accordance with, and subject to, sections 71 to 87 of Act No. 306 of the Public Acts of 1969, as prescribed in subrules (2) to (10) of rule 8.

Effluent Limits

Permit No. MI 0021415

Elberta

Quality parameters	30 day average (interim - final)	7 day average (interim - final)
BOD (5 day)	100 mg/l - 10 mg/l	150 mg/l - 15 mg/l
Suspended solids	75 mg/l - 10 mg/l	125 mg/l - 30 mg/l
Fecal coliform bacteria	200/100 ml	400/100 ml
Total phosphorus	1 mg/l or 80% removal - whichever is greater	
pH	6.5 - 9.0	6.5 - 9.0

Effluent limits

Permit No. MI 0020630

Frankfort City

Quality parameters	30 day average (interim - final)	7 day average (interim - final)
BOD (5 day)	250 mg/l - 10 mg/l	300 mg/l - 15 mg/l
Suspended solids	75 mg/l - 15 mg/l	100 mg/l - 25 mg/l
Fecal coliform bacteria	200/100 ml	400/100 ml
Total phosphorus	1 mg/l or 80% removal - whichever is greater	
pH	6.5 - 9.0	6.5 - 9.0

Effluent limits

Permit No. M 00351

Beulah

The original permit (No. MI 0022373) was issued under the NPDES permitting system. Expiration date of this permit was June 30, 1977. Michigan DNR issued a new permit (No. M 00351) to Beulah on July 1, 1977 however, NPDES regulations no longer apply because the treatment system is groundwater discharge. There are no effluent limits associated with this type of discharge; however, the State of Michigan requires extensive monitoring during the term of the permit (June 30, 1982).

APPENDIX
E

WATER QUALITY

SEASONAL AND LONG-TERM CHANGES IN LAKE WATER QUALITY

Seasonal changes of temperature and density in lakes are best described using as an example a lake in the temperate zone which freezes over in winter. When ice coats the surface of a lake, cold water at $0^{o}C$ lies in contact with ice above warmer and denser water between 0^{o} and $4^{o}C$.

With the coming of spring, ice melts and the waters are mixed by wind. Shortly, the lake is in full circulation, and temperatures are approximately uniform throughout (close to $4^{o}C$). With further heating from the sun and mixing by the wind, the typical pattern of summer stratification develops. That is, three characteristic layers are present: (1) a surface layer of warm water in which temperature is more or less uniform throughout; (2) an intermediate layer in which temperature declines rapidly with depth; and (3) a bottom layer of cold water throughout which temperature is again more or less uniform. These three layers are termed epilimnion, metalimnion (or thermocline), and hypolimnion, respectively. The thermocline usually serves as a barrier that eliminates or reduces mixing between the surface water and the bottom water.

In late summer and early fall, as the lake cools in sympathy with its surroundings, convection currents of cold water formed at night sink to find their appropriate temperature level, mixing with warmer water on their way down. With further cooling, and turbulence created by wind, the thermocline moves deeper and deeper. The temperature of the epilimnion gradually approaches that of the hypolimnion. Finally, the density gradient associated with the thermocline becomes so weak that it ceases to be an effective barrier to downward-moving currents. The lake then becomes uniform in temperature indicating it is again well mixed. With still further cooling, ice forms at the surface to complete the annual cycle.

The physical phenomenon described above has significant bearing on biological and chemical activities in lakes on a seasonal basis. In general, growth of algae, which are plants, in the epilimnion produces dissolved oxygen and takes up nutrients such as nitrogen and phosphorus during the summer months. Algal growth in the hypolimnion is limited mainly because sunlight is insufficient. As dead algae settle gradually from the epilimnion into the hypolimnion, decomposition of dead algae depletes a significant amount of dissolved oxygen in the bottom water. At the same time, stratification limits oxygen supply from the surface water to the bottom water. As a result, the hypolimnion shows a lower level of dissolved oxygen while accumulating a large amount of nutrients by the end of summer. Then comes the fall overturn to provide a new supply of dissolved oxygen and to redistribute the nutrients via complete mixing.

Over each annual cycle, sedimentation builds up progressively at the bottom of the lake. As a result, this slow process of deposition of sediments reduces lake depth. Because major nutrients enter the lake along with the sediments, nutrient concentrations in the lake increase over a long period of time. This aging process is a natural phenomenon and is measured in hundreds or thousands of years, depending on specific lake and watershed characteristics.

Human activities, however, have accelerated this schedule considerably. By populating the shoreline, disturbing soils in the watershed, and altering hydrologic flow patterns, man has increased the rate of nutrient and sediment loading to lakes. As a result, many of our lakes are now characterized by a state of eutrophication that would not have occurred under natural conditions for many generations. This cultural eutrophication can in some instances be beneficial, for example by increasing both the rate of growth of individual fish and overall fishery production. In most cases, however, the effects of this accelerated process are detrimental to the desired uses of the lake.

The eutrophication process of lakes is classified according to a relative scale based on parameters such as productivity, nutrient levels, dissolved oxygen, and turbidity in the lake water. Lakes with low nutrient inputs and low productivity are termed oligotrophic. Dissolved oxygen levels in the hypolimmion of these lakes remain relatively high throughout the year. Lakes with greater productivity are termed mesotrophic and generally have larger nutrient inputs than oligotrophic lakes. Lakes with very high productivity are termed eutrophic and usually have high nutrient inputs. Aquatic plants and algae grow excessively in the latter lakes, and algal blooms are common. Dissolved oxygen may be depleted in the hypolimnion of eutrophic lakes during the summer months.

NON-POINT SOURCE MODELING - OMERNIK'S MODEL

Because so little data was available on non-point source runoff in the Study Area, which is largely rural, empirical models or statistical methods have been used to derive nutrient loadings from non-point sources. A review of the literature led to the selection of the model proposed by Omernik (1977). Omernik's regression model provides a quick method of determining nitrogen and phosphorus concentrations and loading based on use of the land. The relationship between land use and nutrient load was developed from data collected during the National Eutrophication Survey on a set of 928 non-point source watersheds.

Omernik's data indicated that the extent of agricultural and residential/urban land vs. forested land was the most significant parameter affecting the influx of nutrient from non-point sources. In the US, little or no correlation was found between nutrient levels and the percentage of land in wetlands, or range or cleared unproductive land. This is probably due to the masking effects of agricultural and forested land.

Use of a model which relates urban/residential and agricultural land use to nutrient levels seems appropriate where agricultural and/or forest make up the main land-use types.

The regression models for the eastern region of the US are as follows:

$$\text{Log } P = 1.8364 + 0.00971A + \sigma_p \text{ Log } 1.85 \qquad (1)$$

$$\text{Log } N = 0.08557 + 0.00716A - 0.00227B + \sigma_N \text{ Lot } 1.51 \qquad (2)$$

where:

P = Total phosphorus concentration - mg/1 as P

N = Total nitrogen concentration - mg/1 as N

A = Percent of watershed with agricultural plus urban land use

B = Percent of watershed with forest land use

σ_p = Total phosphorus residuals expressed in standard deviation units from the log mean residuals of Equation (1). Determined from Omernik (1977), Figure 25.

σ_N = Total nitrogen residuals expressed in standard deviation units from the log mean residuals of Equation (2). Determined from Omernik (1977), Figure 27.

1.85 = f, multiplicative standard error for Equation 1.

1.51 = f, multiplicative standard error for Equation (2).

The 67% confidence interval around the estimated phosphorus or nitrogen consideration can be calculated as shown below:

$$\text{Log } P_L = \text{Log } P \pm \text{Log } 1.85 \qquad (3)$$

$$\text{Log } N_L = \text{Log } N \pm \text{Log } 1.51 \qquad (4)$$

where:

P_L = Upper and lower values of the 67% phosphorus confidence limit - mg/l as P

The 67% confidence limit around the estimated phosphorus or nitrogen concentrations indicates that the model should be used for purposes of gross estimations only. The model does not account for any macro-watershed* features peculiar to the Study Area.

EARLIER WATER QUALITY STUDIES, CRYSTAL LAKE FACILITY PLANNING AREA

Lake	Source	Survey dates	Parameters
Betsie	USEPA. 1975. Report on Betsie Lake, Benzie County, MI. Working Paper #185, Natl. Eutrophication Survey.	Lake: 6/17/72; 9/15/72; 11/12/72. Tributaries: Monthly 10/72 to 9/73.	Temperature, DO, transparency, conductivity, pH, alkalinity, nutrients. Nutrients, streamflow.
Crystal	University of Michigan, School of Public Health. 1970. Crystal lake water quality investigation 5/1/69-2/28/70.	June, July, and August, 1969; July 24, 1968; Sept. 14, 1967; June, August, 1940.	Temperature, pH, DO, nutrients, BOD_5, total and fecal coliforms, transparency.
Crystal	STORET	1967-1977	Temperature, turbidity, transparency, color, conductivity, DO, pH, total alkalinity, solids, nutrients, hardness, chlorophyll a.
Crystal	Tanis, Fred J. 1978. Final summary report on Crystal Lake water quality study for the Crystal Lake Property Owners Assn. (Revised). Ann Arbor MI.	Lake: 8/4/76; 5/4-9/19/76; 7/5/77, 9/5/76; 2/13/77, 4/30/77. Tributaries: Monthly 7/76 to 7/77.	Primary productivity, chlorophyll and transparency, dissolved oxygen, phosphorus. Phosphorus, streamflow.

Earlier Water Quality Studies, Crystal Lake

Lake	Source	Survey dates	Parameters
Betsie River	STORET	1968-1977	Temperature, DO, transparency, conductivity, color, COD, pH, alkalinity, nutrients, hardness, total and fecal coliforms.
	Michigan Department of Natural Resources, 1968. Water Quality of Selected Lakes and Streams in the Grand Traverse Bay Region	7/68	Temperature, DO, total and fecal coliforms, pH, hardness, nutrients, total solids, dissolved solids, suspended solids, chlorides, alkalinity.
Cold Creek	University of Michigan, School of Public Health 1970. Crystal Lake Water Quality Investigation. 5/1/69-2/28/70	6/28/69, 7/16/69, 7/31/69, 8/4/69	Temperature, DO, pH, nutrients, total and fecal coliforms.
	Tanis, Fred J., 1978. Final Summary report on Crystal Lake water quality study for the Crystal Lake Property Owners Assn. (Revised). Ann Arbor, MI.	7/5/76-8/7/77	Ortho PO_4, Total PO_4.

SIMPLIFIED ANALYSIS OF LAKE EUTROPHICATION

Introduction

Two basic approaches to the analysis of lake eutrophication have evolved:

1) A complex lake/reservoir model which simulates the interactions occurring within ecological systems; and

2) the more simplistic nutrient loading model which relates the loading or concentration of phosphorus in a body of water to its physical properties.

From a scientific standpoint, the better approach is the complex model; with adequate data such models can be used to accurately represent complex interactions of aquatic organisms and water quality constituents. Practically speaking, however, the ability to represent these complex interactions is limited because some interactions have not been identified and some that are known cannot be readily measured. EPAECO is an example of a complex reservoir model currently in use. A detailed description of this model has been given by Water Resources Engineers (1975).

In contrast to the complex reservoir models, the empirical nutrient budget models for phosphorus can be simply derived and can be used with a minimum of field measurement. Nutrient budget models, first derived by Vollenweider (1968) and later expanded upon by him (1975), by Dillon (1975a and 1975b) and by Larsen - Mercier (1975 and 1976), are based upon the total phosphorus mass balance. There has been a proliferation of simplistic models in eutrophication literature in recent years (Bachmann and Jones, 1974; Reckhow, 1978). The Dillon model has been demonstrated to work reasonably well for a broad range of lakes with easily obtainable data. The validity of the model has been demonstrated by comparing results with data from the National Eutrophication Survey (1975). The models developed by Dillon and by Larsen and Mercier fit the data developed by the NES for 23 lakes located in the northeastern and northcentral United States (Gakstatter et al 1975) and for 66 bodies of water in the southeastern US (Gakstatter and Allum 1975). The Dillon model (1975b) has been selected for estimation of eutrophication potential for Crystal Lake and Betsie Lake in this study.

Historical Development

Vollenweider (1968) made one of the earliest efforts to relate external nutrient loads to eutrophication. He plotted annual total phosphorus loadings ($g/m^2/yr$) against lake mean depth and empirically determined the transition between oligotrophic, mesotrophic and eutrophic loadings. Vollenweider later modified his simple loading mean depth relationship to include the mean residence time of the water so that unusually high or low flushing rates could be taken into account.

Dillon (1975) further modified the model to relate mean depth to a factor that incorporates the effect of hydraulic retention time on nutrient retention.

The resulting equation, used to develop the model for trophic status, relates hydraulic flushing time, the phosphorus loading, the phosphorus retention ratio, the mean depth and the phosphorus concentration of the water body as follows:

$$L \frac{(1-R)}{\rho} = zP$$

where: L = phosphorus loading ($gm/m^2/yr.$)
R = fraction of phosphorus retained
ρ = hydraulic flushing rate (per yr.)
z = mean depth (m)
P = phosphorus concentration (mg/l)

The graphical solution, shown in Figure E-4-a, is presented as a log-log plot of $L \frac{(1-R)}{P}$ versus z.

The Larsen-Mercier relationship incorporates the same variables as the Dillon relationship.

In relating phosphorus loadings to the lake trophic condition, Vollenweider (1968), Dillon and Rigler (1975) and Larsen and Mercier (1975, 1976) examined many lakes in the United States, Canada and Europe. They established tolerance limits of 20/ug/l phosphorus above which a lake is considered eutrophic and 10 mg/l phosphorus above which a lake is considered mesotrophic.

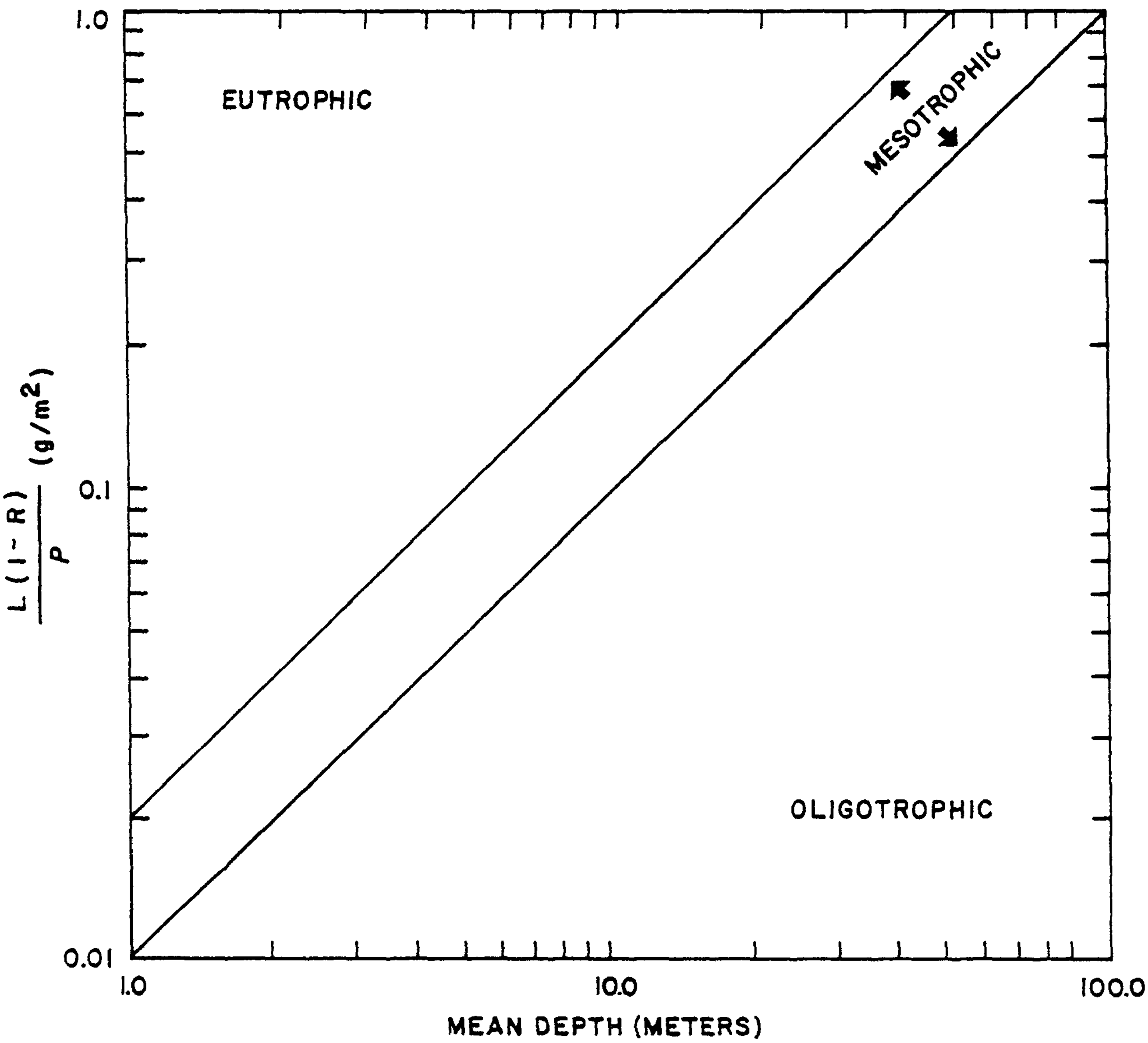
Assumptions and Limitations

The Vollenweider-Dillon model assumes a steady state, completely mixed system, implying that the rate of supply of phosphorus and the flushing rate are constant with respect to time. These assumptions are not totally true for all lakes. Some lakes are stratified in the summer so that the water column is not mixed during that time. Complete steady state conditions are rarely realized in lakes. Nutrient inputs are likely to be quite different during periods when stream flow is minimal or when non-point source runoff is minimal. In addition, incomplete mixing of the water may result in localized eutrophication problems in the vicinity of a discharge.

Another problem in the Vollenweider-Dillon model is the inherent uncertainty when extrapolating a knowledge of present retention coefficients to the study of future loading effects. That is to say, due to chemical and biological interactions, the retention coefficient may itself be dependent on the nutrient loading.

The Vollenweider/Dillon model or simplified plots of loading rate versus lake geometry and flushing rates can be very useful in describing the general trends of eutrophication in lakes during the preliminary

FIGURE E-4-a



L= AREAL PHOSPHORUS INPUT ($g/m^2/yr$)

R= PHOSPHORUS RETENTION COEFFICIENT (DIMENSIONLESS)

P= HYDRAULIC FLUSHING RATE (yr^{-1})

planning process. However, if a significant expenditure of monies for nutrient control is at stake, a detailed analysis to calculate the expected phytoplankton biomass must be performed to provide a firmer basis for decision making.

APPENDIX
F

ON-SITE SYSTEMS

F-1 "Sanitary Systems of Crystal Lake, Benzie County, Michigan: An On-Site Survey"

F-2 Selections from Sanitary Code of Minimum Standards Regulating Sewage Disposal - Water Supplies and Sanitation of Habitable Buildings in Grand Traverse and Benzie Counties, Michigan - 1964

F-3 Sanitary Code of Minimum Standards - 1972

APPENDIX
F-1

SANITARY SYSTEMS OF CRYSTAL LAKE
BENZIE COUNTY MICHIGAN: AN ON-SITE SURVEY

Technical Report to the United
States Environmental Protection Agency
Water Division, Region V

From
The University of Michigan
Biological Station
Pellston, Michigan

December 1978

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ABSTRACT

A detailed survey of 2450 dwellings on the shore of Crystal Lake and their wast water systems was carried out by members of The University of Michigan Biological Station Project CLEAR during the Steptember 20-October 30, 1978 period. This total of 249 homes represents 23% of the total of 1085 homes on the lake shore. From information derived by the survey, it was determined that approximately 76% of the homes on Crystal Lake are used seasonally. The winter population of about 550 easily climbs to 4000 on most summer weekends.

The shoreline was divided for purposes of doing the survey into five sections. These were each evaluated individually (NE, NW, W, SW, SE). The important variables calculated for each section were: percentage of septic systems with problems, percentage of septic systems more than ten years old, percentage of septic systems within 50 feet of the lake, percentage of shore line lots with Cladophora (a microscopic algae), and percentage of septic systems meeting current public health regulations.

Most of the lake is surrounded by sandy, well-drained soils except for the NE and parts of the SE sections. These two sections also had the largest summer populations and the highest concentrations of Cladophora. Central sewering and land application should be considered for these areas. The NW, W, and SW sections are on better soils, have fewer septic system problems, and less Cladophora. On-site improvements would be necessary however, because more than 60% of the homes do not meet current public health regulations.

I. INTRODUCTION

The naturally high water quality of Crystal Lake makes it an attractive resort area. However, the principal factor responsible for making the lake attractive to people is now being diminished by their presence on the shores.

It is highly probable that one major source of nutrients to Crystal Lake, and its consequential enrichment and eutrophic tendency are waste water systems of the individual dwellings on the lake shore line. Since this nutrient influx is not natural, and represents a reasonably controllable source, it is important to determine detailed information concerning individual systems on the lake. Consequently, this survey of septic systems, used in conjunction with soil maps, provides the information necessary to evaluate the existing adequacy of septic systems on the Crystal Lake shore, to determine their contribution of nutrients to the lake and to give planners information upon which to judge the need for alternative waste water systems.

This survey of 249 homes took place during the period of September 20 to October 30, 1978 on Crystal Lake. Three members of Project CLEAR from the University of Michigan Biological Station carried out the actual survey and the organization of information. These project members were Mark Hummel, Sharon Mills and Joan Schumaker. The project was directed by Mark W. Paddock.

II. DESCRIPTION OF STUDY SITE

Located in Benzie County, Michigan, Crystal Lake spans three townships (Crystal Lake, Benzonia, and Lake) and includes the small town of Beulah on its eastern shore. The homes surveyed are in the area colored dark red in William and Works Facility Plan map.

Development around Crystal includes a summer camp with 115 children, a number of cottage resort complexes, and many individual homes.

The topographic configuration of the Crystal Lake shore line area is rather unique. The lake shore rises very slowly from the water for about 100 to 350 feet then rises quickly at a slope of 12-70° to form a bluff of about 100 feet in elevation. Undoubtedly the fact that the lake level was artificially lowered 20 feet a century ago is the reason for this lake terrace type shore line.

III. MATERIALS AND METHODS

SECTIONS OF THE LAKE SHORE

The character of the lake shore dwellings varies considerably with sections of the lake. Density of homes, vegetation, age of homes, distance from the houses to the lake, were easily noted differences. These observed differences between lake shore communities also reflect differences in soil conditions, age of the septic systems, distance from the septic system to the lake, as well as effect on the lake.

The lake shore survey area was divided into five sections. The boundaries for each section were chosen after the survey had been completed. Boundaries reflect equal lengths of shore line, major differences in the character of shore line housing, and convenient road intersections. Buelah was not included in the survey because it has its own waste treatment facility separate from the Frankfort plant.

THE SURVEY

By house to house interviews and the means of visual site evaluations and inspections, as well as through information obtained from local offices and agencies, the survey was intended to:

1. Identify possible sources of ground water and public health problems;
2. Evaluate the reasons for inadequate functioning of existing waste water systems;
3. Develop a quantitative overview of the age, design and present and anticipated use of existing on-site systems
4. Collect site-specific information on individual systems that indicate a need for upgrading and replacement.

THE INTERVIEWS

Two of the survey staff had worked on a similar project on Crooked-Pickerel Lake in Emmet County only one month before the Crystal Lake Survey. The third had no such experience and accompanied a partner twice to listen to wording, approach, and explanations. When we began assembly data into tables, we realized that each of our ideas of which information was most important, and our interviewing styles, were different.

We have two suggestions for surveys administered by more than one person:

1. Observe and be observed in action by partners at the beginning of the survey.
2. Review surveys together every few days, looking for differences that can be remedied before any more surveys are taken.

LOGISTICS OF THE SURVEY

The lake was split into sections similar to those listed under DIVISION OF SECTIONS. We all worked in the Northeast section until it was finished, making it easier to keep track of which homes had already been surveyed. A list of houses was made, noting which had had been surveyed and which had not, and were candidates for return visits.

We then began the next sections, no longer working together in the same sections, but taking care to note which houses had been surveyed and which had not. We were halfway around the lake and averaging twenty surveys per day per person when we began taking turns going back to once-covered areas for return visits. We covered the entire lake shore once and some portions twice. We often surveyed during weekends when people were more likely to be home

MISSING INFORMATION

There are many gaps in the information received from residents, often the person who knew the answers was not home for the interview, or the homeowner had bought the house recently and had not asked the seller about the septic system and well.

We often called homes back in our attempt to talk to someone who knew more about the system than the original interviewee. If this failed, we then consulted the Benzie County Sanitarian's permit file on installations placed since 1972. If permits were not located, we assumed the systems met regulations and estimated their sizes based upon the number of bedrooms and garbage disposal systems. Any gaps in the data still persisting were labelled "DK" for don't know.

IV. RESULTS AND DISCUSSION

POPULATIONS AND NUMBER OF HOMES

There are 1090 dwellings around Crystal Lake in the proposed sewer area. Twenty-three percent of those were surveyed in the three weeks survey effort.

Although the survey took place in October, seventy-six percent of the homes surveyed were seasonal, i.e. used less than ten months of the year (See figure 1). The projection from the survey for number of seasonal homes is therefore probably low because many of the seasonal residents had already gone home for the year.

The population of the homes surveyed was 798, eighty-three percent of which were seasonal residents. The estimated winter population of the Crystal Lake area is 550 The summer population includes year-round, seasonal, and summer guests, and can be as high as 4000 on any given summer weekend (See figure 1).

FIGURE I. PROJECTED PEAK SUMMER AND LOW WINTER POPULATIONS IN EACH SECTION ON CRYSTAL LAKE

			NE	NW	W	SW	SE	TOTAL
1.	HOMES SURVEYED	TOTAL NO. HOMES	270	146	256	230	188	1090
2.		NO. HOMES SURVEYED	69	61	24	56	39	249
3.		% SURVEYED	26	42	9	24	21	23
4.		NO. YEAR-ROUND	25	9	2	7	16	57
5.		NO. SEASONAL	44	52	22	49	23	190
6.		% SEASONAL	64	85	92	88	59	76
7.	PROJECTED NO. OF HOMES ON LAKE	TOTAL NO. OF HOMES	270	146	256	230	188	1090
8.		% SURVEYED	26	42	9	24	21	23
9.		PROJECTED SEASONAL	172	124	235	201	111	827
10.		PROJECTED NO.YR-RD.	98	22	21	29	77	263
11.	POPULATION SURVEYED	(SUMMER) SEASONAL POPULATION	138	230	54	153	91	666
12.		%SEASONAL POPULATION	71	92	92	89	73	83
13		(WINTER) YR-RD. POP. SURVEYED	56	20	5	18	33	132
14.		SUB TOTAL	194	250	59	171	124	798
15.	TOTAL SEASONAL POPULATION	SEASONAL POPULATION SURVEYED	138	230	54	153	91	666
16.		SUMMER GUEST INCREASE	82	21	11	22	30	166
17.		TOTAL SEASONAL POP.	220	251	65	175	121	832
18.		% HOMES SURVEYED	26	42	9	24	21	23
19.	PEAK & LOW	PROJECTED WINTER POPULATION	215	48	56	75	157	551
20.		PROJ. SEAS. POP.	846	598	722	729	576	3471

SEPTIC SYSTEM PROBLEMS

"Septic System problems" refers to backups in the house, ponding over the drainfield/drywell, or odors. Problems were examined in relationship to seasonal vs. year-round usage, age of system, frequency of pumping, and type of system.

SEASONAL VS. YEAR-ROUND

We expected that year-round residents to have more septic system problems than seasonal residents because their systems must bear more use. However, we found instead that seasonal residents had sixty-five percent of the problems. This value is probably conservative, since a disproportionately large number of year-residents were interviewed.

AGE OF THE SYSTEMS

There were no problems discovered within the first five years of any system's life, only fifteen percent in the next 5-10 years, and eighty-five percent with systems greater than ten years old (See figure 2A).

Twenty percent of the systems surveyed had problems. Eighty-six percent of the problems were associated with systems more than ten years old, although only sixty-eight percent of the systems were more than ten years old.

PUMPING FREQUENCY

Contrary to our expectations, systems which were never pumped accounted for only two percent of the problems. Systems pumped every 1-5 years had forty percent of the problems and systems pumped "only once", fifty-eight percent (See figure 2B). As a number of "non-pumpers" explained, "You don't mess with something that's working." That is, they do not pump because they do not have problems. Similarly, "only once" pumpers pump "only when it

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FIGURE 2. SEPTIC SYSTEM PROBLEMS

2A. PROBLEMS ASSOCIATED WITH AGE GROUPS OF SYSTEMS

AGE OF SYSTEM	NUMBER SYSTEMS	% OF ALL SYSTEMS	PROBLEMS (ponding, backups, odors) NUMBER	% OF ALL PROBLEMS	% PROBLEMS IN AGE GP.
0-5	42	17	0	0	0
6-10	37	15	7-1/2*	15	20
11-15	49	20	8	16	16
16-20	43-1/2*	17	10-1/2*	21	24
21+	77-1/2*	31	25	49	32
TOTAL	249	100	51	101	20

2B. PROBLEMS ASSOCIATED WITH PUMPING FREQUENCY

PUMPING FREQUENCY	NO. SYSTEMS	% SYSTEMS	PROBLEMS	% OF OTHER PROBLEMS	PROBLEMS % WITHIN AGE GROUP
EVERY 1-5 YRS.	69	29	21	40	30
NEVER	102	44	1	2	1
ONLY ONCE-	63	27	30	58	48
TOTAL	234	100	52	100	22

- "Only once"-means whenever the tank needs pumping; always less frequent than every five years, usually less frequent than every ten years.

* 1/2 numbers were obtained by counting 1/2 system system if it was a different age than the rest of the system.

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FIGURE 3. NO. OF PROBLEMS ASSOCIATED WITH DIFFERENT SEPTIC SYSTEMS

SS TYPE	NO.S SYSTEMS NO.	%	SYSTEMS WITH PROBLEMS NO.	%	% OF EACH TYPE WITH PROBLEMS
ST & DF	134	57	23	45	17
ST & DW	95	40	27	53	28
ST ONLY	2	1	1	2	50
HT	5	2	0	0	0
TOTAL	236	100	51	100	22

needs it", and should not necessarily be expected to have more problems simply because they pump less often. Regular pumping does not mean there will be a lower incidence of problems. Pumping may be a response to problems rather than a preventative measure.

TYPE OF SYSTEM

The type of sanitary system may be related to septic system problems. There were problems with twenty-eight percent of all drywell systems, as compared to seventeen percent of all drain-field systems (See figure 3). This figure may be deceiving because ninety-two percent of the drywells are older than ten years, while only forty-five percent of the drainfields are older than ten years. Therefore, it may not be the drywell which implies problems, but the age of the system.

SEPTIC SYSTEM SIZE

Size is important information for evaluating a system according to current Health Department regulations. Sixty-seven percent of the respondents were ignorant of their system's size, making it impossible to evaluate their full compliance with regulations. Then, permits were referred to at the Benzie County Health Department Office. But many of the permits were not located for a number of reasons: they had not been legally inspected, the permits were filed incorrectly, or systems were filed under previous owners' names.

In addition to systems forty-one percent sized too small to meet regulation, fourteen percent of the systems had wells too close to their system (less than fifty feet), and another eleven percent had septic systems too close to the lake (less than fifty feet).

It is likely that some respondents, accidentally or otherwise gave false information on the survey. However, considering the large number of problems and small sizes given, the percentage of misinformers was probably small.

ANALYSIS OF EACH SECTION

NORTHEAST

The northeast (NE) section had the largest summer population, 1061, and contains twenty-six percent of the total summer population, making it a key area for analysis.

The NE has high seasonal groundwater and is designated as wetlands on the soil association map. Thirty-one percent of the septic systems are within seventy-five feet of the lake and sixty-two percent of the systems do not meet Health Department regulations (See figure 4). Twenty-two percent of the systems have problems and seventy-eight percent are more than ten years old, making them more likely to have problems. Even more significant, is the fact that sixty-nine percent of the homes surveyed had Cladophora growth along their shores.

NORTHWEST

The northwest (NW) area is on sandy, well-drained soils. Slopes vary from 0-67%, with the majority less than 12%. Thirty-one percent of the homes are within seventy-five feet of the lake, yet only twenty-four percent supported growths of Cladophora (See Table 5 Appendix A). The low concentrations of Cladophora may be correlated with the low number of systems with problems (eight percent) and the fewer number of septic systems are more than ten years old (fifty percent). Fifty-four percent of the systems do not meet regulations (See figure 4).

WEST

The west (W) is located on sandy, well-drained soils, with

0-12% slopes. Twenty-five percent of the systems are within seventy-five feet of the lake. Although sixty-eight percent of the septic systems are more than ten years old, and forty-six percent of the systems do not meet regulations, only five percent of the area had Cladophora.

SOUTHWEST

The southwest (SW) area is on sandy, well-drained soils, with slopes 0-12%. Only six percent of the homes are within seventy-five feet of the lake. The SW corner has the fewest number of systems which do not meet regulations (forty-three percent); however, concentrations of Cladophora were high (thirty-four percent) which may be correlated with the fact that twenty-seven percent of the homes have problems and seventy-five percent of the systems are more than ten years old.

SOUTHEAST

Many of the lakeside homes on the SE side were situated on a well-drained, sandy ridge. Only four percent of the homes were within seventy-five feet of the lake because much of the area has a privately owned greenbelt protecting the lake. Fifty-nine percent of the septic systems do not meet regulations and twenty-four percent of the systems have problems, similar to values calculated for the NE section. Is the SE corner affecting the lake as much as the NE section, despite the greenbelt and sandy soils? Cladophora studies show that it is not. Forty-five percent of the sites in SE section had Cladophora offshore, compared to sixty-nine percent in the NE (See Table 5, Appendix A).

Homes in the SE section, located south of Mollineaux Road, away from the lake, are in soils with high ground water. Two homes built in this area required holding tanks to comply with

FIGURE 4 SEPTIC SYSTEM PROBLEMS BY LAKE SECTION

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NE SECTION

	MEET REGULATIONS NO.	%	DON'T MEET REGULATIONS NO.	%	DON'T KNOW NO.	%	TOTAL
PROBLEMS	0	0	14	93	1	7	15
NO. SYSTEMS	9	13	43	62	17	25	69
% WITH PROBLEMS	0		33		6		22

NW SECTION

	MEET REGULATIONS NO.	%	DONT MEET REGULATIONS NO.	%	DON'T KNOW NO.	%	TOTAL
PROBLEMS	0	0	3	60	2	40	5
NO. SYSTEMS	15	25	33	54	13	21	61
% WITH PROBLEMS	0		9		15		8

W SECTION

	MEET REGULATIONS NO.	%	DON'T MEET REGULATIONS NO.	%	DON'T KNOW NO.	%	TOTAL
PROBLEMS	0	0	0	0	2	100	2
NO. SYSTEMS	2	8	11	46	11	46	24
% WITH PROBLEMS	0		0		2		8

SW SECTION

	MEET REGULATIONS NO.	%	DON'T MEET REGULATIONS NO.	%	DON'T KNOW NO.	%	TOTAL
PROBLEMS	1	8	3	27	7	64	11
NO. SYSTEMS	6	11	24	43	26	46	56
% WITH PROBLEMS	17		13			27	20

SE SECTION

	MEET REGULATIONS NO.	%	DON'T MEET REGULATIONS NO.	%	DON'T KNOW NO.	%	TOTAL
PROBLEMS	0	0	4	50	4	50	8
NO. SYSTEMS	6	15	23	59	10	26	39
% WITH PROBLEMS	8		17		50		21

Public Health Department codes. Additional construction on the south side of Mollineaux will similarly be controlled unless an alternative sewage treatment system is constructed or the regulation restricting the use of fill material is changed.

V. SUMMARY

The NE seems to be a problem area with a large summer population, wet soils, twenty-two percent of the systems have problems, and Cladophora is apparent at sixty-nine percent of the homes (more than twice the number of homes in any other section).

The SE and SW sections are on better drained soils, homes are set the farthest back from the lake, and sixty-two percent and seventy-five percent of the systems respectively, are more than ten years old. Cladophora concentrations are still high, but about fifty percent less on the SW shore and thirty-five percent less on the SE shore than those on the NE shore.

The NW and W shore seem to contribute the fewest nutrients. Both are on well-drained sandy soils, although homes are closer to the lake than for the SE and SW. Together, they have the fewest old systems (more than 10 years old), only seventeen percent of the problems, and by far the smallest concentrations of Cladophora, twenty-four percent and five percent, respectively.

VI. RECOMMENDATIONS

We have had firsthand experience with each of the sections around Crystal Lake. Our perspective is a result of our experience. We walked the entire shore line, observed the state of the lake, talked with residents, township supervisors, Lake Association officers, and the District Sanitarian, and obtained information of a good sub-sample of the septic systems (twenty-three percent) in the study area. With this experience and perspective, we offer some recommendations.

As stated in the Results and Discussion section, the NE section is the problem area with the second largest population, the highest percentage of Cladophora, and the largest majority of systems not meeting regulations. Individual septic system improvements would not adequately solve the problem because seasonal ground water comes too close to the surface to meet regulations. It is also illegal to use fill material to meet the requirement. The only other decentralized alternative is the cluster system, which would not be possible in the immediate area, due to high seasonal ground water, but would require pumping to suitable soils away from the lake.

Sewering and land application, therefore, appear to be the most effective, lowest cost, alternative. Land application would remove the wastes from the immediate area, but not remove them from their natural cycle. A land application site has already been designated in the southern part of Section 31, near Benzonia. To transport the wastes to Frankfort for treatment would be energy intensive, costly, and force construction of a sewer line around three-quarters of the lake. Those areas crossed by the sewer would undoubtedly place pressure on their local officials to permit hook-ups, either immediately, or in the near future.

Most of the remaining lake shore, except for parts of the SW section, is on sandy, well-drained soils. This factor makes on-site improvements both effective, feasible and economical.

The NW section is not in immediate trouble. It has the smallest population, the second smallest concentration of *Cladophora*, and only eight percent of the systems have problems. Individual improvements are necessary, though, since fifty-four percent of the homes surveyed did not meet regulations. If lake-side lots are too small (and several of them are), then lots accross the road will have to be purchased and wastes pumped to them.

There are a number of cottage resorts located in this section. Several of the owners expressed a willingness to combine their individual septic systems into a cluster system on their own premises. Their willingness should be supported.

The western shore is in good shape. No problems were reported and only five percent of the homes surveyed had *Cladophora*. The majority of homes (those in Pilgrim and Crystalia) are located in a rolling, heavily wooded area between Crystal Lake and Lake Michigan. While drainage is towards Crystal, the homes in these settlements are not less than two hundred feet from Crystal's shore line. Their immediate impact is extremely low. Once again, individual improvements are in order because forty-six percent of the systems do not meet regulation.

Most of the homes and septic systems in the SW section are located away from the lake and on large lots. There is plenty of room for individual on-site improvements, which would be the most effective and economical alternative. Fifty-Five percent of the systems require upgrading to meet regulation.

The SE section has the largest summer population and second highest concentration of *Cladophora*. It includes a number of disjunct parts: clusters of small lakeside lots, a long row of homes on a sandy ridge between Mollineaux Road and the lake, a low wet area between Mollineaux Road and M-115 (where present development is restricted by Public Health Code), and a small dense pocket of resort cottages west of Beulah. Because forty-three percent of the homes do not meet current regulations, some type of improvement is necessary. Two alternatives seem reasonable--on-site improvements or a sewer with land application. On-site improvements are attractive as the homes occur in isolated patches throughout the area. It would eliminate sewer conduits crossing large expanses of undeveloped land, raising property values and bringing pressure for development. A sewer with land application is attractive because of the southeast's large population and its close proximity to the proposed land application area near Benzonia. A third alternative would be to link up with the sewage facility in Beulah, if it were upgraded.

APPENDIX A

PRESENCE OF <u>CLADOPHORA</u> AS AN INDICATOR OF NUTRIENT CONCENTRATION

CLADOPHORA STUDY

RESULTS AND DISCUSSION

Previous studies have suggested the presence of algae (especially *Cladophora*) along a lake shoreline can be correlated with nutrient influx from human activity. *Cladophora* is a microscopic filamentous algae which commonly grows attached to solid substrates such as rocks and logs.

Since *Cladophora* requires high concentrations of nutrients for colonization, the normal oligotrophic state of Crystal Lake suggests that the presence of *Cladophora* along the shore is a result of a localized concentration of nutrients from human sources.

Where suitable substrate was available, an attempt was made to link the presence of *Cladophora* with septic system seepage.

A number of variables associated with septic system performance influence the quantity of *Cladophora* present. Given suitable substrate, these include: length of occupancy and number of residents, their water use habits, septic system age, maintenance and problem history and distance from the lake.

The congregation of waterfowl (and subsequent accumulation of their droppings) along the shoreline together with lawn fertilization and lawn watering frequency adds to the nutrient enrichment of an adjacent shoreline. An attempt was also made to correlate these three variables with *Cladophora* presence.

On Crystal Lake eighty-six percent of the waterfront home lots surveyed had suitable substrates available for *Cladophora* growth, but only thirty-five percent of these lots had *Cladophora* present. Of the sites with *Cladophora* thirty-three percent had slight growth, thirty-seven percent had moderate growth, and thirty percent had heavy growth.

In comparing length of occupancy (i.e., year-round vs. seasonal) with the occurance of Cladophora, it was found that thirty percent of the homes with Cladophora were year-round while only sixteen percent of the homes without Cladophora were year-round. It appears a longer length of occupancy may increase Cladophora growth.

Of the homes surveyed, twenty percent of those with Cladophora had more than three living at the residence, while forty-one percent of those without Cladophora had more than three residents. The number of residents does not play as large a role as length of residence in influencing Cladophora growth.

Of the homes with and without Cladophora, fifty six percent each were classified as heavy water users, thus the amount of water use is insignificant correlation. We found ninety-one percent of the homes with Cladophora present had septic systems more than eight years old compared with seventy-seven percent where Cladophora was not present. We learned that fifty-four percent of the systems without Cladophora were not maintained, whereas only thirty-eight percent of the systems were not maintained where Cladophora was present. In our data there does not appear to be a good correlation between unmaintained systems and the presence of Cladophora. It was found that twenty-six percent and twenty-four percent in sites respectively, with and without Cladophora had septic system problems. With these close percentage results, no correlation with Cladophora presence can be made.

There appears to be a correlation between the proximity of septic systems to lake shore and Cladophora growth. We learned that forty-five percent of the lots with Cladophora had septic systems less than seventy-five feet from the shoreline. One sites with no Cladophora, only five percent were closer than fifty feet to the

Our study did not reveal a correlation between feeding waterfowl, lawn fertilization, and lawn watering.

In summary, most variables did not show strong correlations with shoreline Cladophora colonization where adequate substrate was available. The strongest correlation occurred between septic system age, their proximity to the lake and length of occupancy.

TABLE 1. CLADOPHORA STUDY

HOMES WITH CLADOPHORA PRESENT

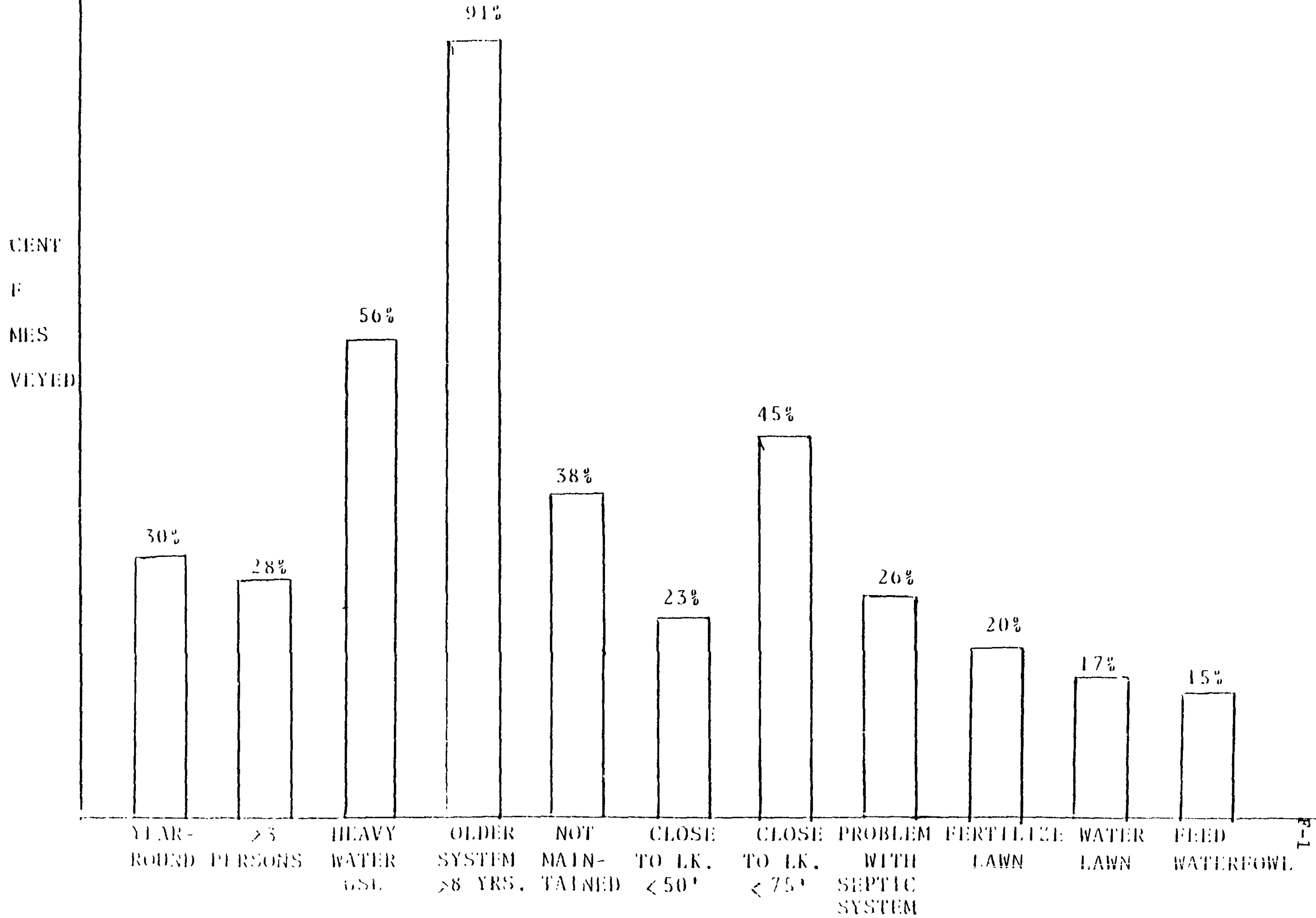

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TABLE 2. CLADOPHORA STUDY

HOMES WITH NO CLADOPHORA PRESENT

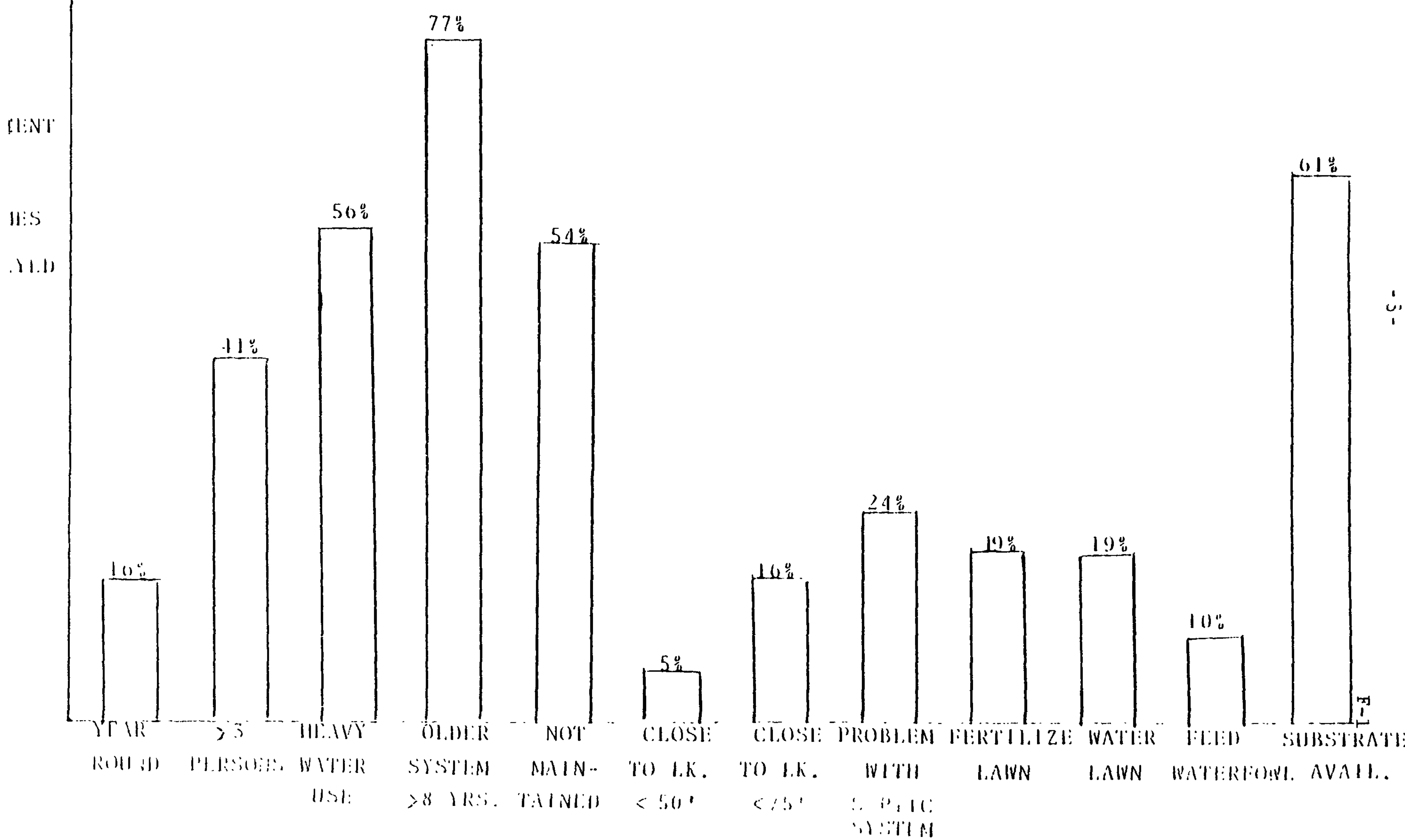


TABLE 3. CLADOPHORA STUDY

CHARACTERISTICS OF HOMES AND SITES WITH CLADOPHORA NOT PRESENT

ECTION OF LAKE	YEAR-ROUND	> 3 PERSONS	HEAVY WATER USE	SEPTIC SYSTEM OLD	SEPTIC SYSTEM NOT MAINT.	CLOSE TO LAKE <50'	CLOSE TO LAKE <75'	PROB. WITH SEPTIC SYSTEM	FER-TILIZE LAWN	WATER LAWN	SUBSTRATE AVAILABLE	FEED WATER FOWL
NO.	5	13	10	13	5	2	4	4	8	6	4	6
%	28	17	56	76	17	11	22	22	44	33	22	33
Y NO.	4	23	30	[illegible]7-1/2	31	4	7	6	10	10	25	5
Y %	8	46	60	75	62	15	8	12	20	20	50	10
NO.	2	4	10	[illegible]2-1/2	9	1	5	8	4	3	13	
%	10	20	50	69	45	25	5	40	20	15	65	0
Y NO.	3	11	19	[illegible]-1/2	16	0	4	10	4	7	24	2
Y %	10	48	66	25	57	0	14	34	14	24	83	7
. NO.	7	11	6	13	13	0	1	4	-	-	16	1
%	41	65	35	31	76	0	6	24	0	0	94	14
TAL NO.	21	55	75	28	72	7	2	32	26	26	82	14
TAL %	16	41	56	77	54	5	16	24	19	19	61	10

TABLE 1. CLADOPHORA STUDY

CHARACTERISTICS OF HOMES AND SITES WITH CLADOPHORA PRESENT

OPHORA URANCE	YEAR-ROUND	> 3 PERSONS	HEAVY WATER USE	SEPTIC SYSTEM OLD	SEPTIC SYSTEM NOT MAINTAINED	CLOSE TO LAKE < 50'	CLOSE TO LAKE ≤ 75'	PROB. WITH SEPTIC SYSTEM	FER-TILIZE LAWN	WATER LAWN	SUBSTRATE AVAIL.	FEED WATER FOWL	TOTAL %
IGH	7	9	13	22	11	6	12	7	4	4	27	6	33
DIUM	5	8	11	28	12	7	13	5	4	3	30	1	37
W	13	6	19	21	8	5	11	9	8	7	25	5	30
TAL NO.	25	23	46	71	51	18	36	21	16	14	82	12	100
OF TOTAL	30	28	56	91	58	23	45	26	20	17	100	15	

TABLE 5. CLADOPHORA STUDY

PERCENT OF HOMES SURVEYED

SECT. of LAKE	YEAR-ROUND	> 3 PERSONS	HEAVY WATER USE	SEPTIC SYSTEM OLD	SEPTIC SYSTEM NOT MAINT.	CLOSE TO LAKE < 50'	CLOSE TO LAKE < 75'	PROB. WITH SEPTIC SYSTEM	FER-TILIZE LAWN	WATER LAWN	FEED WATER FOWL	SUBSTRATE AVAILABLE	CLADOPHORA PRESENT
NE	36	29	54	83	59	16	56	22	13	22	21	78	69
NW	15	47	61	77	82	14	31	18	7	16	23	80	24
W	8	13	50	73	27	8	25	33	21	13	0	74	5
SW	12	27	50	[illegible]	54	5	15	27	14	16	16	97	34
SE	4	51	45	74	49	3	11	24	8	10	11	100	45
TOT. AVE	15	33	52	73	54	9	28	25	13	15	14	86	35

TABLE 6. CLADOPHORA STUDY

NE Shore

CLADOPHORA	S	M	H	No.
NUMBER	9	19	15	19
PERCENTAGE	14	31	24	31

TOTAL 62
31% with no CLADOPHORA
69% with CLADOPHORA

NW Shore

CLADOPHORA	S	M	H	No.
NUMBER	7	1	3	34
PERCENTAGE	15	2	7	76

TOTAL 45
76% with no CLADOPHORA
24% with CLADOPHORA

W Shore

CLADOPHORA	S	M	H	No.
NUMBER	0	1	0	18
PERCENTAGE	0	5	0	95

TOTAL 19
95% with no CLADOPHORA
5% with CLADOPHORA

SW Shore

CLADOPHORA	S	M	H	No.
NUMBER	4	3	6	25
PERCENTAGE	11	8	16	66

TOTAL 38
66% with no CLADOPHORA
34% with CLADOPHORA

SE Shore

CLADOPHORA	S	M	H	No.
NUMBER	7	3	3	16
PERCENTAGE	24	10	10	55

TOTAL 29
55% with no CLADOPHORA
45% with CLADOPHORA

LEGEND FOR CHARTS

1. Year-Round - $\geq$10 months/year

2. >3 people - more than 3 people living at residence

3. Heavy Water Use - consists of homes using any one of the followin, water using fixtures-dishwasher, washing machine and/or garbage disposal in addition to the basi fixtures

4. Septic System Old - $\geq$8 years old

5. Septic System Not Maintained - when no maintenance (pumping, repair, etc.) has been done on the system in $\geq$5 years

6. Close to Lake < 50'
   Close to Lake < 75' - septic systems that were less than 50' and 75' from the lake

7. Problems with Septic System - if there has been any problems with the present system

8. Fertilize Lawn - if resident fertilizes > once a year

9. Water Lawn - if resident waters lawn >once a week

10. Feed Water Fowl - if water fowl are fed at shore

APPENDIX D

SURVEY FORM USED ON CRYSTAL LAKE

SEPTIC SYSTEM SURVEY

Resident # ____

Unanswered
Questions

OCCUPANTS' NAME ______________________________

PROPERTY OWNER'S NAME ______________________________

ADDRESS OF PROPERTY ______________________ PHONE NO. ________

PERMANENT ADDRESS OF PROPERTY OWNER ______________________

PHONE NO. ____________

Surveyor ______________________________ Date ________

Township ______________________________ Lake ____________

Lot Location ____________________

Lake Frontage: yes/no ________ #ft.

Lot size: ________ x ________ ft. (1 acre=200 x 200 ft.)

Was additional soil used to fill your site when your home was constructed? yes/no

I. OCCUPANCY

1. Are you the owner of this property? yes/no

A. (If occupant is not owner)

Can you give the name of the owner and how that person can be located? (write in on cover page)

B. (If occupant is owner)

Are you a year-round or seasonal resident?

Year-round (10 mo. or more) __________
Seasonal (less than 10 mo.) __________

IF year-round

1. How many residents live here year-round? ________
2. Does this number increase during the year? yes/no
3. To how many? ________
4. For how long? 5-9 mo./3-4 mo./4-8 wk./1-4 wk./weekends

IF seasonal

1. During what seasons do people reside here? spring/summer/fall/winter
2. For how long? 5-9 mo./3-4 mo./4-8 wk./1-4 wk./weekends
3. What is the average number of people who live here on a seasonal basis? ________
4. Do you have plans to move here permanently? yes/no

II. DWELLING AND SEPTIC SYSTEM DESCRIPTION

1. How many bedrooms does this house have? ________
2. Do you expect to add on bedrooms or bathrooms? yes/no

3. Is this hous winterized? yes/no
   Do you plan to winterize? yes/no

4. What is the age of the house? 0-5 years/6-10 years/+ 10 years/D.

5. How long have you owned this house? ________

6. What is the age of the present septic system?
   0-5 years/6-10 years/+10 years/D.K.

7. What type of system does does this house have?
   (circle all applicable)

   Septic Tank
   Drainfield
   Trench
   Dry Well
   Other
   D.K.

8. What type of feeding mechanism does the drainfield have?
   (circle all applicable)

   Gravity
   Pumped
   Dosing Box
   Distribution Box/Alternate Drainfield

9.

ST sz.	DW sz.	DF sz.	Distance of DF to Lake	Distance of Well to DF or ST

IV. <u>WATER USE</u>

1. List number of water using fixtures. (note W.C. if designed to conserve)

   _____showers
   _____bathtubs
   _____sinks
   _____toilets
   _____clothes washing machine
   _____dishwasher
   _____garbage disposal
   _____water softener

2. Do you fertilize your lawn? yes/no

   A. How many times a year?

3. Do you water your lawn? yes/no More than once a week?
   Less than once a week?

4. Drainage Facilities: Discharge Location:

   Basement Sump: yes/no

   Roof Drains: yes/no
   Driveway Runoff: yes/no
   Artesian Well Overflow: yes/no

5. Water supply source: community or shared well ________
on-lot well ________
other ________

6. Well depth: ________

CLADOPHORA SURVEY

year-round/seasonal

fertilize? yes/no

feed ducks? yes/no

water lawn? yes/no

artesian discharge into lake? yes/no

substrate available? yes/no Describe

Cladophora present? yes/no

Describe abundance and location

V. ADDITIONAL SITE AND SOIL CHARACTERISTICS

1. Depth to seasonal high ground water: __________

2. Phosphorous retention: __________

3. Permeability: __________

4. Slope: __________

5. Property Sketch

Include: ponding water
signs of selective fertility
prominent vegetation and type

Legend

selective fertility-xxx
ponding water-
well- W
trees- T
dry well/septic tank- DW/ST
drainfield-

VI. SEPTIC SYSTEM HISTORY

1. Have you ever had problems with your septic system such as:

	How often?	Describe
a. Backups		
b. Ponding		
c. Odors		

2. Has your septic system ever been inspected for pumping or maintainance? yes/no
   a. Was it pumped? yes/no
   b. When? ____________________
   c. How often is the septic tank pumped? ____________________

3. Has your septic system ever been repaired or enlarged? yes/no
   a. When? ____________________
   b. Describe

VII. RESIDENT ATTITUDE

1. Do you you feel that how well a septic system works affects the quality of a lake? yes/no

2. How much do feel septic systems are polluting this lake?

   none   some   significantly   DK.

3. Are you aware of the proposed alternatives to the present form of wastewater treatment on this lake?
   a. leave as is
   b. sewer and transport to Frankfort
   c. cluster treatment
   d. central sewer collection and land application

SELECTIONS FROM

(ORIGINAL) SANITARY CODE OF MINIMUM STANDARDS (1964)

REGULATING

SEWAGE DISPOSAL - WATER SUPPLIES

AND

SANITATION OF HABITABLE BUILDINGS

IN

GRAND TRAVERSE AND BENZIE COUNTIES, MICHIGAN

Article IV DISPOSAL OF WATER CARRIED SEWAGE ON PREMISES WHERE A PUBLICLY OPERATED SEWERAGE SYSTEM IS NOT AVAILABLE:

4.1 GENERAL REQUIREMENTS

All flush toilets, lavatories, bathtubs, showers, laundry drains, sinks, and any other similar fixtures or devices hereafter constructed to be used to conduct or receive water carried sewage shall be connected to a septic tank or some other device in compliance with these minimum standards and the Michigan Department of Health regulations, and finally disposed of in a manner in compliance with these minimum standards and the Michigan Department of Health regulations and any other applicable law, ordinance, or regulations.

Provided that such facilities existing at the time these standards are adopted which may become a nuisance or menace to the public health in the opinion of the health officer shall be connected to a septic tank or other approved device and finally disposed of in a manner in compliance with these standards and the Michigan Department of Health requirements. Footing drains, roof water, and any other similar waste water not defined as sewage shall not be connected to or discharged into the sewage disposal system.

4.2 SEWAGE DISCHARGED INTO A BODY OF WATER

No sewage or sewage disposal system shall discharge into any body of water or into or onto the ground surface closer than twenty-five feet (25) feet from a body of water, or its highest known level, or into a public drain.

4.21 TYPE AND LOCATION

No unexposed sewers or pipe used to conduct untreated sewage from a dwelling or habitable building shall be located closer than 10 feet from the nearest unprotected water suction line, well casing, spring structure or other potable water source. When such unexposed pipe or sewer is closer than 50 feet from any unprotected water suction line, well casing, spring structure, or other potable water source, such sewer line shall be constructed of extra heavy cast iron pipe with leaded and caulked joints, tested for water tightness or cast iron pipe with water-tight joints, or other pipe of equal quality approved by the health officer. Where any such pipe or sewer is located inside or beneath a habitable building or dwelling or within 5 feet outside the inner face of such building foundation wall such sewer pipe shall be constructed of such material as described above.

4.22 SIZE

Such pipes or sewers shall be four inches in diameter or larger.

4.23 GRADE

Sewers shall be laid at such a grade as to maintain a sewage flow velocity of not less than two feet per second when flowing full. Sewers four to six inches in diameter shall have a grade of not less than 12 inches per 100 feet or one inch per eight feet of sewer pipe.

4.3 SEPTIC TANKS

4.3.1 LOCATION

Septic tanks shall be located at least 50 feet from any potable water supply, well, spring, or unprotected water suction line, except in the case of schools, resorts, trailer parks, restaurants, taverns or other dwellings or habitable buildings which serve the public such distance shall be 75 feet, except where the Michigan Department of Health regulations require a greater distance, or upon the written approval of the health officer an exception is granted. No septic tank shall be located closer than 5 feet to any footing or foundation wall. No septic tank shall be placed within 10 feet of any lot lines, or within 25 feet of the highest known water mark of any lake, creek, river, pond or other body of water. No septic tank shall be located where it is inaccessible for cleaning or inspection, nor shall any structure be placed over any septic tank rendering it inaccessible for cleaning or inspection.

4.32 MATERIALS AND CONSTRUCTION

Septic tanks shall be of watertight construction and of a material not subject to decay or corrision when installed. Concrete blocks or bricks at least eight inches in thickness may be used in septic tank construction. Septic tanks shall be provided with one or more suitable openings with watertight covers to permit cleaning and inspection. The outlet from such tank shall be constructed so as to permit flow of liquid from the tank and to prevent the escape of floating or settled solids. The inlet shall be designed to permit gasses collected above the liquid level to pass through the inlet and out the vent pipe serving the sewers leading into the septic tank. Cinder blocks shall not be approved for septic tank construction.

4.33 CAPACITY

Every septic tank hereafter installed shall have a liquid capacity of at least the average volume of sewage flowing into it during any 24-hour period. However, in no case shall the liquid capacity of any septic tank be less than 500 gallons. If a compartment tank is installed, the first compartment shall have not less than one-half nor more than two-thirds the total capacity.

The following capacity for septic tanks shall be required except in the opinion of the health officer where increased capacities may be required.

Two-bedroom dwelling 500 gallons (with garbage grinder 750)
Three-bedroom 750 gallons (with garbage grinder 1000 gallon)
Four bedroom dwelling 1000 gallons (with garbage grinder 1250 gallon)

4.4 DOSING TANK

The health officer may require that dosing tanks be provided with automatic siphons or pumps of a type approved by the Michigan Department of Health be used on installations where the liquid capacity of the septic tank is 2,000 gallons or more.

4.51 LOCATION

Sub-surface disposal systems shall be located at least 50 feet from any potable water supply, well casing, spring structure, or unprotected water suction lines, except where the Michigan Department of Health requires a greater distance. Such drain fields shall be located at least 10 feet from a lot line, and 25 feet from any lake, pond, creek, or other surface water flooding, or its highest known level and at least 10 feet from any habitable building or dwelling.

4.52 SEPTIC TANK EFFLUENT

Under no condition may the overflow from any septic tank or any other sewage wastes from any existing or hereinafter constructed premise be discharged upon the surface of the ground within two hundred (200) yards of any habitable building other than the building from which it originates. No sewage shall be discharged into any roadside ditch.

4.53 SIZE AND QUALITY OF DRAIN LINES

4.53 SIZE

Sub-surface disposal system lines shall have a diameter of not less than four inches.

4.53.2 QUALITY

Sub-surface disposal system lines shall be constructed from extra quality drain tile, or such other materials as approved by the Michigan Department of Health and the health officer.

4.54 DEPTH AND POSITION OF TILE OR OTHER APPROVED DEVICE FOR DISTRIBUTION LINES

4.541 DEPTH, SLOPE, AND LENGTH OF LINES

The top of the sub-surface distribution lines shall be not less than 12 inches nor more than 30 inches below the finished grade.

Slope of the distribution lines shall be not more than 4 inches per 100 feet.

Length of any one lateral line shall not exceed 100 feet.

4.542 HEADERS

Watertight headers, or a distribution box or other method or device approved by the health officer shall be set true and level so as to afford an even distribution of all septic tank effluent throughout the sub-surface disposal area.

4.55 FILTER MATERIAL

Sub-surface disposal system lines for distributing septic tank effluent for direct soil absorption shall be laid over at least six inches of washed stone from one-half to one inch in size, or an equivalent aggregate approved by the health officer.

4.56 TRENCH CONSTRUCTION

Trenches shall be not less than 18 inches wide at the bottom. The same washed stone or such other aggregate as may be necessary to prevent the filtering of backfill material around the lateral distribution lines shall be spread over the distribution line to a depth of at least two inches.

4.57 FIELD AREA

Sub-surface disposal field area shall comply with the following minimum trench or stone bed areas, depending upon the average daily volume of septic tank effluent and the type soil in the drain area.

SOIL	Perc. test time for one inch drop	Minimum absorption area per single family residence 3 bedrooms or less
Coarse sand or gravel	Less than 5 min.	300 sq. feet
Sand	5 - 10 min.	450 sq. feet
Loam	11 - 20 min.	600 sq. feet
Sandy clay or clay loam	21 - 30 min.	750 sq. feet
Clay	31 - 45 min.	900 sq. feet
Heavy Clay	over 45 min.	not suitable
	Minimum filter bed (Area: 400 sq.ft.)	

In heavy soils (clay) where the drop in water level is over 45 minutes per inch by standard percolation test or where ground water or an impervious hard pan is found less than 4 feet from the ground surface, an alternate drainage device may be approved at the discretion of the health officer or the permit denied. Drainage fo. systems to serve other than single family residences of 3 bedrooms or less shall be prescribed by the health officer.

Sub-surface disposal systems shall contain at least one (1) lineal foot of tile for every three (3) feet of trench width. Trench excavations exceeding 36 inches in width at the bottom shall be considered tile beds and shall require 50% more trench bottom absorption area than required for single line trench.

Article V. PERMIT

On and after January 1, 1964, no person shall begin construction of any sewage disposal facility as defined in these minimum standards until such person or his duly authorized representative has made written application to the health officer and has received a duly signed construction permit from the health officer, provided, however, no such application or construction permit shall be required in those cases where a permit from the State Department of Health is a statutory prerequisite and has been obtained. Such construction permit shall be issued only when plans and specifications for the proposed installation of the average system are not less than the requirements set forth in these minimum standards.

Said permit shall be in duplicate and shall contain a sketch showing all pertinent plans and specifications of the proposed sewerage disposal installation. Said permit shall be signed by the applicant and the health officer. One copy of the permit shall be given to the applicant to be posted at the construction site. One copy of the application permit shall be retained by the health officer and remain on file in the health department.

The health officer shall make such inspection at the construction site as he deems necessary. Failure to construct according to the approved plans and specifications shall be deemed a violation of these minimum standards for which the person installing the system shall be held liable.

Article III. PRIVATE WATER SUPPLIES

3.1 Private water supplies hereafter installed shall comply with the following:

3.11 LOCATION

All well casing, spring structures, water suction lines, or other drinking water or potable water structure shall be located 50 feet or more from all sources of possible contamination such as seepage pits, cesspools, privies, barnyards, septic tanks, sub-surface disposal systems, surface water drains, waste water or other sources of possible contamination. Buried or unexposed sewers or pipes through which sewage may back up shall not be located closer than ten (10) feet from any potable water well casing or suction pipe. When such sewers or pipes are located within the ten to fifty (10 to 50 foot area),the sewer pipes shall be constructed of extra heavy cast iron with leaded and caulked joints tested for water tightness. All wells shall be located so that possibilities of flooding are reduced to a minimum. The area immediately adjacent to the well shall be such that the surface water is diverted away from the well casing.

3.13 MINIMUM DEPTH

No wells less than 25' in depth shall hereafter be installed or constructed without written approval of the health officer.

(Revised, 1972)

SANITARY CODE OF

MINIMUM STANDARDS

Regulating

Sewage Disposal - Water Supplies

and

Sanitation of Habitable Buildings

GRAND TRAVERSE - LEELANAU - BENZIE
DISTRICT HEALTH DEPARTMENT

10767 TRAVERSE HIGHWAY TRAVERSE CITY, MICHIGAN
BENZIE MEDICAL CARE FACILITY FRANKFORT, MICHIGAN

GRADE

...ers shall be laid at such a grade as to maintain a sewage flow ...city of not less than two feet per second when flowing full. Sewers ...inches in diameter shall have a grade of not less than 12 inches ...feet or one inch per eight feet of sewer pipe

SEPTIC TANKS

LOCATION

...ic tanks shall be located at least:

50 feet from any potable water supply, well, spring, or unprotected suction line (75 feet from public or semi-public supply).

A minimum isolation distance of 50 feet shall be maintained from any lake, pond, creek, or other surface water flooding or its highest flood plain elevation.

No septic tank shall be located closer than 5 feet to any footing or foundation wall.

No septic tank shall be located closer than 10 feet to any lot line.

No septic tank shall be placed where it is inaccessible for cleaning or inspection, nor shall any structure be placed over any septic tank rendering it inaccessible for cleaning or inspection.

Local zoning ordinances may be more restrictive in set-back requirements—check local zoning restrictions.

MATERIALS AND CONSTRUCTION

...tic tanks shall be of watertight construction and of a material not ...ject to decay or corrosion. Concrete block or bricks at least eight ...hes in thickness may be used in septic tank construction. Cinder ...cks shall not be approved for septic tank construction. Septic tanks ...ll be provided with one or more suitable openings with watertight ...er to permit cleaning and inspection. The outlet from such tank ...ll be constructed so as to permit flow of liquid from the tank and ...ll be equipped with a sanitary tee to prevent the escape of floating ...ettled solids. The inlet shall be designed to permit gasses collected ...ove the liquid level to pass through the inlet and out the vent pipe ...ving the sewers leading into the septic tank. The center of the inlet ...ll be held a minimum of 2 inches above the center of the outlet.

CAPACITY

...tic tanks hereafter installed shall have a liquid capacity of at least ...average volume of sewage flowing into it during any 24-hour period. ...wever, in no case shall the liquid capacity of any septic tank be less ...n 800 gallons. If a compartment tank is installed, the first compart...nt shall have not less than one-half nor more than two-thirds the ...d capacity. The following capacity for septic tanks shall be required ...ept in the opinion of the health officer where increased capacities ...y be required.

Two bedroom dwelling or less—800 gallons
(with garbage grinder, 1,000 gallons)

B. Three bedroom dwelling—1,000 gallons
(with garbage grinder, 1,200 gallons)

C. Four bedroom dwelling—1,200 gallons
(with garbage grinder, 1,500 gallons)

D. Four bedroom or greater will require special computation by the Health Officer to determine the size of tank to be installed.

E. A commercial establishment, industry, or semi-public establishment will also require special computation by the Health Officer to determine the size of tank to be installed.

4.4 DOSING TANK

The health officer may require that dosing tanks be provided with automatic siphons or pumps of a type approved by the Michigan Department of Health be used on installations where the liquid capacity of the septic tank is 2,000 gallons or more.

4.51 SUB-SURFACE DISPOSAL SYSTEM

A. Location—same as for Septic Tanks (Sec. 4.31).

B. The trench bottom of a tile field shall not be over 42 inches below the finished grade and not less than 4 feet above the maximum high water table.

Local zoning ordinances may be more restrictive in set-back requirements—check local zoning restrictions.

4.53 SIZE AND QUALITY OF DRAIN LINES

4.53 SIZE

Sub-surface disposal system lines shall have a diameter of not less than four inches.

4.53.2 QUALITY

Sub-surface disposal system lines shall be constructed from vitrified clay tile, cement tile, perforated plastic tile (minimum crush strength of 600 pounds) or such other materials as approved by the Michigan Department of Health and/or the Health Officer.

4.54 DEPTH AND POSITION OF TILE OR OTHER APPROVED DEVICE FOR DISTRIBUTION LINES

4.54.1 DEPTH, SLOPE, AND LENGTH OF LINES

The top of the sub-surface distribution lines shall be not less than 12 inches nor more than 30 inches below the finished grade. Slope of the distribution lines shall be not more than 1 inch per 50 feet. Length of any one lateral line shall not exceed 75 feet.

4.54.2 HEADERS

The watertight header shall be constructed from vitrified clay tile (bell and spigot) solid plastic tile (minimum crush strength of 1,000 pounds), or such other material as approved by the Michigan Department of

Public Health and or the Health Officer. Headers shall be set true and level so as to afford and even distribution of all septic tank effluent throughout the sub surface disposal area.

4.55 FILTER MATERIAL

Sub surface disposal system lines for distributing septic tank effluent for direct soil absorption shall be laid over at least six (6) inches of clean and/or washed stone from one-half to one and one-half inches in size.

4.56 TRENCH CONSTRUCTION

Trenches shall be not less than 24 inches nor greater than 48 inches wide at the bottom. The use of trenches as a means of sewage disposal shall be at the discretion of the Health Officer.

4.57 FIELD AREA

Sub surface disposal field area shall comply with the following minimum disposal filter bed areas, depending upon the average daily volume of septic tank effluent and the type soil in the drain area.

Soil	Perc. Test time for 1" drop	Minimum absorption area per single family residence		
		2 bdrm/less	3 bdrm/less	4 bdrm/less
Coarse sand or gravel	0 5 min.	450 sq. ft.	600 sq. ft.	750 sq. ft
Sand	5 10 min.	600 sq. ft	750 sq. ft.	900 sq. ft.
Loam	11 20 min.	750 sq. ft.	900 sq. ft.	1,050 sq. ft.
Sandy clay or clay loam	21 30 min.	900 sq. ft.	1,050 sq. ft.	1,200 sq. ft
Clay	31 – 45 min.	1,050 sq. ft.	1,200 sq. ft.	1,350 sq. ft.
Heavy clay	45 min. +	not suitable	not suitable	not suitable

4.58 PERMIT DENIAL

A permit to install an on-site sewage disposal system may be denied for any of the following reasons:

1. In heavy soils where the drop in water level is over 45 min. per inch by standard percolation test.
2. Where silts, mucks, or other unstable soils are encountered.
3. Where an impervious layer or hard pan is encountered at less than four feet from ground surface.
4. Where the known high ground water table is encountered within four feet of the ground surface.
5. Where lot size does not provide adequate area to maintain requirements as set forth in Sec. 4.1 through 4.57.

Article V. PERMIT

On and after **January 1, 1964** no person shall begin construction of any sewage disposal facility as defined in these minimum standards until such person or his duly authorized representative has made written application to the health officer and has received a duly signed construction permit from the health officer, provided, however, no such application or construction permit shall be required in those cases where a permit from the State Department of Health is a statutory prerequisite and has been obtained. Such construction permit shall be issued only when plans and specification for the proposed installation of the average system are not less than the requirements set forth in these minimum standards.

Said permit shall be in duplicate and shall contain a sketch showing all pertinent plans and specifications of the proposed sewerage disposal installation. Said permit shall be signed by the applicant and the health officer. One copy of the permit shall be given to the applicant to be posted at the construction site. One copy of the application permit shall be retained by the health officer and remain on file in the health department. "(Said permit effective in Leelanau County June 11, 1966)"

The health officer shall make such inspection at the construction site as he deems necessary. Failure to construct accordingly to the approved plans and specifications shall be deemed a violation of these minimum standards for which the person installing the system shall be held liable.

Article VI. FEE

A fee of $10.00 shall be charged for each permit issued for the installation of a sewerage disposal system of less than 2,000 gallons capacity and/or a water supply system as defined herein. This fee shall be made payable by the applicant to the Grand Traverse, Leelanau, Benzie District Health Department to the account of said Health Department. A fee of $25.00 shall be charged for each permit issued for the installation of a sewerage disposal sytem of 2,000 gallons capacity or more as defined herein.

FEE (Wells)

A fee of $10.00 shall be charged for each permit issued for the installation of a water supply system and/or a sewerage disposal sytem as defined herein. This fee shall be made payable by the applicant to the Grand Traverse, Leelanau, Benzie District Health Department to the account of said Health Department.

Article VII REGISTRATION REQUIREMENT

All persons engaged in any way in the manufacture, installation, construction, maintenance, cleaning or servicing of sewerage systems in the counties of Grand Traverse, Leelanau and Benzie County, Michigan, shall register with the Health Department within 30 days after these minimum standards become effective. No fee shall be required for such registration.

Article VIII DISPOSAL OF SEPTIC TANK, PRIVY VAULT AND OTHER SEWAGE DISPOSAL FACILITIES CONTENTS:

The contents of any septic tank, privy vault, cesspool, dry well, or other waste device or any part thereof shall be disposed of by one of the following:

1. Dumping into a municipal sewage treatment plant when suitable arrangements have been made with the municipality.

2. By spreading on the ground surface in a location that is not less than 200 yards from any habitable building, dwelling, premise, place where food, milk or drink is manufactured, prepared, stored or offered for sale, or of any highway or public thoroughfare. Following which the wastes shall be plowed under the surface of the ground, except that this method will not be approved for lands which may be used for the growing of truck garden crops within one year following the disposal of said sewage wastes thereon.

Article IX SEPTIC TANK MANUFACTURERS RESPONSIBILITY

It shall be the responsibility of any septic tank manufacturer delivering septic tanks within the counties of Grand Traverse, Leelanau and Benzie, Michigan to file each thirty (30) days with the health officer such information concerning place, name, address, size, type and date septic tanks were delivered to any person within the counties of Grand Traverse, Leelanau and Benzie, Michigan. Such information shall be considered confidential by the health officer.

Chapter III WATER SUPPLIES

Commencing one year from the date these minimum standards are effective, no person, firm, society, or corporation shall offer for rent, lease, or occupancy, with or without compensation in whole or in part, any habitable building or dwelling unless the same is equipped with a safe and adequate water supply complying with or constructed in accordance with the provisions as set forth in Chapter III of these minimum standards.

ARTICLE I DEFINITIONS

1.2 AUXILIARY INTAKE

An "auxiliary intake" is any piping connection or other device whereby water may be secured from a source or location other than that normally used

1.3 CROSS CONNECTION

A "cross conection" is any physical connection or plumbing arrangement whereby an approved water supply whether public or private either inside or outside any building is physically connected with any unapproved water supply.

1.4 INTERCONNECTION

An "interconnection" is any system of piping or other arrangement whereby a public or private water supply system is connected directly with a sewer, drain, conduit, swimming pool, storage reservoir, stock watering tank, or other similar device which contains or may contain

sewage or other waste liquid capable of importing to an approved water supply any contamination.

1.5 PRIVATE WATER SUPPLY

A "private water supply" is any water supply not defined in the "Regulations for CERTAIN WATER SUPPLIES IN MICHIGAN", as the terms are used in these regulations.

1.6 PUBLIC, SEMI-PUBLIC AND/OR CERTAIN WATER SUPPLIES

A "public, semi-public and/or certain water supplies" is any water supply which is referred to in the "Regulations For Certain Water Supplies In Michigan"

Article II PUBLIC AND SEMI-PUBLIC AND/OR CERTAIN WATER SUPPLIES

All public and semi-public and/or certain water supplies shall be located, constructed, and maintained in accordance with the regulations of the Michigan Department of Health by authority of Act No. 146, Public Acts of 1919, as amended (CL 1948 S 325.1 et seq) entitled "REGULATIONS PROVIDING MINIMUM STANDARDS FOR THE LOCATION AND CONSTRUCTION OF CERTAIN WATER SUPPLIES IN THE STATE OF MICHIGAN."

Article III PRIVATE WATER SUPPLIES

3.1 Private water supplies hereafter installed shall comply with the following:

3.11 LOCATION

All well casing, spring structures, water suction lines, or other drinking water or potable water structure shall be located 50 feet or more from all sources of possible contamination such as seepage pits, cesspools, privies, barnyards, septic tanks, sub-surface disposal systems, surface water drains, waste water or other sources of possible contamination. Buried or unexposed sewers or pipes through which sewage may back up shall not be located closer than ten (10) feet from any potable water well casing or suction pipe. When such sewers or pipes are located within the ten to fifty (10 to 50 foot area, the sewer pipe; shall be constructed of extra heavy cast iron with leaded and caulked joints tested for water tightness. All wells shall be located so that possibilities of flooding are reduced to a minimum. The area immediately adjacent to the well shall be such that the surface water is diverted away from the well casing.

3.13 MINIMUM DEPTH

No wells less than 25' in depth shall hereafter be installed or constructed without written approval of the health officer.

3.13 CONSTRUCTION

3.13.1 PLATFORM AND COVER

In hand pump installations the well top or platform shall be constructed of a water-tight concrete reinforced slab of a minimum thickness of four inches extending at least two feet from the well casing in all directions. The slab shall rest on compact earth. The concrete slab shall be sloped from the well casing to the edge of the slab. The surface of the slap at the outer edges shall be four inches above the surrounding ground surface.

BIOTA

ANIMAL AND PLANT SPECIES OF THE STUDY AREA

Fish

Game Fish		Betsie River	Crystal Lake	Long Lake
Brown trout	*Salmo trutta*	x	x	
Rainbow trout	*Salmo gairdneri*	x	x	
Brook trout	*Salvelinus fontinalis*	x		
Smallmouth bass	*Micropterus dolomieui*	x	x	x
Rock bass	*Ambloplites cupestris*	x	x	
Pumpkinseed	*Lepomis gibbosus*	x		x
Bluegill	*Lepomis microchirus*	x	x	x
Yellow perch	*Perca flavescens*	x	x	x
Northern pike	*Esox lucius*	x	x	x
Whitefish	*Coregonus clupeaformis*		x	
Cisco	*Coregonus artedii*		x	
Smelt	*Hypomesus olidus*		x	
Lake trout	*Salvelinus namaycush*		x	
Largemouth bass	*Micropterus salmoides*		x	x
Walleye pike	*Stizostedion vitreum*		x	
				x

Forage Fish		Betsie River	Crystal Lake	Long Lake
Common shiner	*Notropis cornutus*	x		
Common blacksider darter	*Percina macvlata*	x		
Emerald shiner	*Notropis atherinoides*	x	x	
Johnny darter	*Etheostoma nigrum*	x	x	
Logperch	*Percina caproldes*	x	x	x
Central mudminnow	*Umbra limi*	x		
Creek chub	*Semotilus atromaculatus*	x		
Blacknose dace	*Rhinichthys atratulus*	x		
Mottled sculpin	*Cottus bairdi*	x		
Bluntnose minnow	*Pimephales notatus*	x	x	
Longnose dace	*Rhinicthys cataractae*	x		
Hornyhead chub	*Noicomis biguttatus*	x		
Trout-perch	*Percopsis omiscomaycus*	x		
Stoneroller	*Campostoma anomalus*	x		
American brook lamprey	*Lampetra lamottei*	x		
Golden shiner	*Notemigonus crysolevcas*	x		
Northern redfin shiner	*Notropis umbratilis*	x		
Iowa darter	*Etheostoma exile*		x	
Spot-tail shiner	*Notropis spilopterus*		x	
			x	
				x

Coarse Fish		Betsie River	Crystal Lake	Long Lake
White sucker	*Catastomus commersoni*	x	x	x
Yellow bullhead	*Ictalurus natalis*	x		
Balck bullhead	*Ictalurus melas*	x		
Brown bullhead	*Ictalurus nebulosus*	x		x
Redhorse	*Moxostoma sp.*	x		

	Other Fish	Betsie River	Crystal Lake	Long Lake
Burbot	*Lota lota*	x	x	
Chestnut lamprey	*Icthyomyzon castaneus*	x		
Silver lamprey	*Icthyomyzon unicuspis*	x		
Bowfin	*Amia calva*	x		

Aquatic Vegetation

Common Name	Scientific Name	Betsie River	Crystal Lake	Long Lake
Pondweed	*Potamogeton sp.*	x	x	x
Duckweed	*Lemna sp.*	x		
Bladderwort	*Utricularia sp.*	x		
Spike rush	*Eleocharis sp.*	x		
Bur reed	*Sparganium sp.*	x		
Waterweed	*Anacharis sp.*	x		
Watercress	*Nasturtium sp.*	x		
Stonewort	*Chara sp.*		x	
Muskgrass	*Chara sp.*		x	
Bulrush	*Scirpus sp.*		x	x
Rush	*Juncus sp.*		x	
Algae		x		x

Mammals

	Common Name	Scientific Name
1.	Northern water shrew	Sorex palustris*
2.	Pygmy shrew	Microsorex hoyi*
3.	Opossum	Didelphis marsupialis*
4.	Masked shrew	Sorex cinereus
5.	Shorttail shrew	Blarina brevicauda
6.	Starnose mole	Condylura cristata
7.	Eastern mole	Scalopus aquaticus
8.	Keen myotis	Myotis keeni
9.	Little brown myotis	Myotis lucifugus
10.	Silver-haried bat	Lasionycteris noctivagans
11.	Red bat	Lasirurus borealis
12.	Big brown bat	Eptesicus fuscus
13.	Hoary bat	Lasiurus cinereus
14.	Black bear	Ursus americanus
15.	Raccoon	Procyon lotor
16.	Least weasel	Mustela rixosa
17.	Shorttail weasel	Mustela erminea
18.	Longtail weasel	Mustela frenata
19.	Mink	Mustela vison
20.	River otter	Lutra canadensis
21.	Badger	Taxidea taxus
22.	Striped skunk	Mephitis mephitis
23.	Coytoe	Canis latrans
24.	Red fox	Vulpes fulva
25.	Gray fox	Urocyon cinereoargenteus
26.	Bobcat	Lynx rufus
27.	Woodchuck	Marmota monax
28.	Thirteen-lined ground squirrel	Citellus tridecemlineatus
29.	Eastern chipmunk	Tamias striatus
30.	Eastern gray squirrel	Sciurus carolinensis
31.	Eastern fox squirrel	Sciurus niger
32.	Red squirrel	Tamiasciurus hudsonicus
33.	Southern flying squirrel	Glavcomys volans
34.	Northern flying squirrel	Glaucomys sabrinus*
35.	Beaver	Castor canadensis
36.	White-footed mouse	Peromyscus leucopus
37.	Deer mouse	Peromyscus maniculatus
38.	Southern bog lemming	Synaptomys cooperi
39.	Borsal redback vole	Clethrionomys gapperi
40.	Meadow vole	Microtus pennsylvanicus
41.	Pine vole	Pitymys pinetorum
42.	Muskrat	Ondatra zibethica
43.	Meadow jumping mouse	Zapus hudsonius
44.	Woodland jumping mouse	Napaeozapus insignis*
45.	Porcupine	Erethizon dorsatum*
46.	Snowshoe hare	Lepus americanus
47.	Eastern cottontail	Sylvilagus floridanus

Reptiles

	Common Name	Scientific Name
1.	Common snapping turtle	Chelydra serpentina
2.	Wood turtle	Clemmys insculpta
3.	Five-lined snake	Eumeces fasciatus
4.	Northern red-bellied snake	Storeria occipitomaculata occipitomaculata
5.	Northern brown snake	Storeria dekay dekay
6.	Midland brown snake	Storeria dekay wrightorum
7.	Northern water snake	Natrix sipedon sipedon
8.	Eastern garter snake	Thamnophis sirtalis sirtalis
9.	Eastern ribbon snake	Thamnophis sauritus sauritus
10.	Eastern hognose snake	Heterodon platyrhinos
11.	Northern ringneck snake	Diadophis punctatus edwardsi
12.	Eastern smooth green snake	Opheodrys vernalis vernalis
13.	Eastern milk snake	Lampropeltig doliata triangulum
14.	Eastern massasaugas	Sistrurus catenatus catenatus

Amphibians

	Common Name	Scientific Name
15.	Mudpuppy	Necturus maculosus
16.	Central Newt	Diemictylus viridescens louisianensis
17.	Blue-spotted salamander	Ambystoma laterale
18.	Jefferson salamander	Ambystoma jeffersonianum
19.	Spotted salamander	Ambystoma maculatum
20.	Red-backed salamander	Plethodon cinereus cinereus
21.	Four-toed salamander	Hemidachylium scutatum
22.	Northern spring peeper	Hyla crucifer crucifer
23.	Eastern gray treefrog	Hyla versicolor versicolor
24.	Blanchard's cricket frog	Acris crepitaws blanchardi
25.	Green frog	Rana clamitans melanota
26.	Wood frog	Rana sylvatica
27.	Bullfrog	Rana catesbeiana

CHECKLIST OF RESIDENT BIRDS OF BENZIE COUNTY, MICHIGAN (NORTHWESTERN LOWER PENINSULA MICHIGAN) DURING HEIGHT OF BREEDING SEASON (MID JUNE TO END OF FIRST WEEK OF JULY) WITH SUMMER NESTING RECORDS AND SPECIES ABUNDANCE

by William and Edith Overlease , Biology Department,
West Chester State College, West Chester, Pa.
19380 , revised July 1976

Breeding records : nest **, young traveling with adults *

Abundance records : A - abundant , F - frequent, C - common though often present in small numbers, O - occasional, R - rare

** Common Loon O
** Pied-billed Grebe R
Great Blue Heron O
** Green Heron C
** Least Bittern O
American Bittern O
** Mute Swan C
** Canada Goose O
** Mallard F
** Black Duck O
* Blue-winged Teal O
** Wood Duck C
Hooded Merganser R
** Common Merganser O
Turkey Vulture C
** Goshawk O
** Sharp-shinned Hawk O
Cooper's Hawk O
* Red-tailed Hawk O
** Red-shouldered Hawk O
** Broad-winged Hawk C
** Bald Eagle O
Marsh Hawk O
** Osprey R
American Kestrel R
** Ruffed Grouse F
King Rail R
** Virginia Rail O
** Sora O
* Common Gallinule O
American Coot O
** Piping Plover R
** Killdeer F
** American Woodcock C
Common Snipe R
** Upland Plover O
** Spotted Sandpiper C
Short-billed Dowitcher R
Herring Gull F
Ring-billed Gull A
Caspian Tern O
** Black Tern O
** Mourning Dove C
Yellow-billed Cuckoo O
** Black-billed Cuckoo O
Screech Owl R
Great-horned Owl O
* Barred Owl O
Whip-poor-will O
** Common Nighthawk C
Chimney Swift C
** Ruby-throated Hummingbird C
** Belted Kingfisher F
** Common Flicker F
** Pileated Woodpecker C
** Red-headed Woodpecker O
** Yellow-bellied Sapsucker C
** Hairy Woodpecker F
** Downy Woodpecker F
** Eastern Kingbird F
Western Kingbird R
** Great Crested Flycatcher F
** Eastern Phoebe C
Yellow-bellied Flycatcher R
Traill's Flycatcher C
** Least Flycatcher F
** Eastern Wood Pewee F
** Olive-sided Flycatcher O
** Horned Lark C
** Tree Swallow F
** Bank Swallow A
** Rough-winged Swallow C
** Barn Swallow F
** Cliff Swallow C
** Purple Martin F

**Blue Jay F
**Common Crow F
**Black-capped Chickadee F
*Tufted Titmouse R
*White-breasted Nuthatch C
*Red-breasted Nuthatch C
*Brown Creeper O
**House Wren C
*Winter Wren C
**Long-billed Marsh Wren O
Short-billed Marsh Wren O
**Mockingbird O
**Catbird F
**Brown Thrasher F
**American Robin A
**Wood Thrush F
**Hermit Thrush C
**Swainson's Thrush R
**Veery F
**Eastern Bluebird C
*Golden-crowned Kinglet O
Loggerhead Shrike R
**Starling F
*Yellow-throated Vireo O
Solitary Vireo R
**Red-eyed Vireo A
Philadelphia Vireo R
Warbling Vireo F
**Black and White Warbler F
* Golden-winged Warbler O
** Nashville Warbler C
Northern Parula R
** Yellow Warbler F
Magnolia Warbler O
Black-throated Blue Warbler C
Yellow-rumped Warbler O
** Black-throated Green Warbler F
* Blackburnian Warbler C
Chestnut-sided Warbler F
* Pine Warbler F
** Prairie Warbler C
** Ovenbird A
Northern Waterthrush C
Louisiana Waterthrush R
**Mourning Warbler C
**Yellowthroat F
**Canada Warbler C
**American Redstart A

**House Sparrow F
*Bobolink C
**Eastern Meadowlark F
Western Meadowlark O
**Red-winged Blackbird A
**Baltimore Oriole (Northern Oriole) F
**Brewer's Blackbird R
**Common Grackle A
**Brown-headed Cowbird F
*Scarlet Tanager F
**Cardinal C
**Rose-breasted Grosbeak F
**Indigo Bunting F
Dickcissel O
*Purple Finch C
Pine Siskin R
**American Goldfinch F
**Red Crossbill R
*Rufous-sided Towhee C
Savannah Sparrow C
Grasshopper Sparrow C
Henslow's Sparrow O
**Vesper Sparrow F
Dark-eyed Junco R
**Chipping Sparrow A
* Field Sparrow C
**White-throated Sparrow F
Swamp Sparrow F
**Song Sparrow A
**Clay-colored Sparrow O

The authors are grateful to the following contributers of nesting records for the county: Carl Freeman, Harold Gall, James Laubach, Alan Marble, Donald McBeath, Lyle Pratt, Sergej Postupalsky, Arvid Tesaker, Keith Westphal

Totals - 153 species,

Breeding records for 111 species

ENDANGERED, THREATENED OR RARE ANIMAL AND PLANT SPECIES OF THE STUDY AREA

Common Name	Scientific Name	Status
Mammals		
Southern Bog Lemming	Synaptomys cooperi	Threate ed
Pine Vole	Microtus pinetorum	Threatened
Water shrew	Sorex palustris	Rare
Thompson's pigmy shrew	Microsorex thompsoni	Rare
Hoary bat	Lasiurus cinereus	Rare
Badger	Taiedea taxus	Rare
Gray Fow	Urocyon cinereo-argencus	Peripheral
Birds		
Peregrine falcon	Falco peregrinus tundrius	Endangered*
Red-shouldered hawk	Buteu lineatus	Threatened
Bald eagle	Heliacetus leucophalus	Threatened*
Marsh hawk	Circus cyaneus	Threatened
Osprey	Panion haliaetus	Threatened
Piping plover	Gharadrius melidus	Threatened
Loggerhead shrike	Lanius ludovicianus	Threatened
American Bittern	Botaurus lentiginosus	Rare
Barred owl	Strix varia	Rare
Fish - None		
Reptiles - None		
Amphibians - None		
Plants		
Calypso or Fair Slipper	Calypso bulbosa	Threatened
Ram's Head lady slipper	Cypripeduum arietinum	Rare/threatened*
Northern wheat-grass	Agropyron dasystacnyum	Threatened
Pitcher's thistle	Cirsium potcheri	Treatened*
Broom rape	Orobanchi facicubata	Threatened

*Species is also on the Federal list

Sources: Letter from Marvin E. Cooley, Michigan DNR, Wildlife Division, Jan. 25, 1979.
Letter from Robert Huff, DNR, July 5, 1978.
By telephone Sylvia Taylor, DNR, June 10, 1978.
By telephone, Mr. Bernard R. Ylkanen, DNR, Fisheries Biologist, Cadillac District, July 1978.

APPENDIX
H

POPULATION PROJECTION METHODOLOGY

POPULATION PROJECTION METHODOLOGY

WAPORA, Inc., produced independent estimates of population in the Proposed Service Area for the year 1975 and independent projections of population for the Proposed Service Area for the year 2000. Estimated 1975 total summer population was 8,518, of whom 4,420 were permanent residents and 4,098 were seasonal residents. Projected year 2000 total summer population in the Proposed Service Area is 12,490 of whom 5,748 would be permanent and 6,742 would be seasonal. This appendix describes data sources and methodologies used by WAPORA in making its estimates and projections and compares WAPORA's year 2000 population projections with those contained in the Facility Plan.

Principal sources of population estimation and projection data used by WAPORA varied considerably in terms of the type of population included (permanent, seasonal and/or total in-summer) and the level for which the estimate was made for (county, minor civil division, service area). The type and level of estimates are summarized by Table H-1. The 1970 Census of Population provides a baseline number for the permanent residential population by minor civil division and for the occupancy rate (number of persons per dwelling). Census populations cannot, however, be directly disaggregated below the minor civil division level so as to provide information specific to the Proposed Service Area. Estimates of 1972 seasonal population for minor civil divisions in the Socioeconomic Area can be made from a count of seasonal dwellings made by the Wilbur Smith and Associates field survey. It is assumed in this case and others where the seasonal population is estimated from the number of seasonal dwellings that the occupancy rate is 4.0 persons per seasonal dwelling. An estimate of population by minor civil division in 1975 is contained in the US Census Bureau's Current Population Estimates. These estimates are based on records of vital statistics (births and deaths) and other indicators such as school enrollment and utility hookups. These estimates are for permanent population only and cannot be directly disaggregated below the minor civil division level. Also, the methods of estimation employed by these estimates allows considerable error in population for areas as small as the minor civil divisions included in the Socioeconomic Study Area. The Grand Traverse Area Data Center has estimated permanent, seasonal and total population for Benzie County. Permanent population estimates are based on a methodology similar to that employed by the Census, while seasonal population estimates are based on sample surveys of seasonal residents and visitors. The Grand Traverse Area Data Center estimated that seasonal population in the area increased by 33% from 1972 to 1975. The Williams & Works field survey in 1976 provided another estimate of the number of dwellings in the Proposed Service Area and an estimate of the proportion of the population of each minor civil division included in the Proposed Service Area. This proportional estimate of the percentage of minor civil division population in the Proposed Service Area provides a calibration factor that can be used to estimate service area population based on estimates and enumerations for minor civil divisions. The Northwest Michigan Regional Planning Commission prepared estimates of permanent population by minor civil division for 5-year intervals from 1975 to 2000.

WAPORA utilized US Census Current Population Reports estimates of 1975 permanent population and the Northwest Michigan Regional Planning Commission's projections of year 2000 population as a basis for projection of population increase in the Proposed Service Area. The Commission's year 2000 estimates contain both "high" and "low" projections based on differing assumptions. The mean of these high and low estimates was chosen as the best estimate of permanent year 2000 populations in the EIS. In minor civil divisions that are only partially in the proposed Service Area, the proportion of the 1975 population in the Service Area was assumed to be the same as the proportion of dwelling units that were found to be in the Service Area in the 1972 Williams & Works field survey. The proportion of minor civil division population in the Proposed Service Area was also assumed to remain constant between 1975 and 2000.

Estimation of 1975 seasonal population was based on the 1972 Wilbur Smith field study as updated by information from the Grand Traverse Area Data Center. No data is available from the US Census as to the number of seasonal residents, and even the Census data on seasonal dwellings is highly suspect as most seasonal residents are not present at the time of enumeration (15 April). As a result, estimation of seasonal population is based on a less complete data base than for permanent population and has a correspondingly greater possible margin of error. The 1972 Wilbur Smith Field survey did provide an enumeration of seasonal dwellings. The number of units found in this enumeration was increased by a factor of one third, based on estimates of a one-third increase in seasonal population for Benzie County as a whole from 1972 to 1975, as made by the Grand Traverse Area Data Center (1977). The occupancy rate for seasonal dwellings was assumed to be 4.0 persons per unit, based on data from a variety of local sources. Thus, seasonal population was estimated to be four times as great as the number of seasonal dwellings. The proportion of seasonal population in each minor civil division that was within the Proposed Service Area in 1975 was assumed to be the same as the proportion of dwelling units in the Proposed Service Area found in the 1972 Wilbur Smith field survey. This proportion was also assumed to remain constant from 1975 to the year 2000. In the absence of any clear cut evidence differentiating seasonal and permanent population growth rates, the rate of seasonal population growth within each minor civil division for the 1975 to 2000 period was considered to be equivalent to the rate of permanent population growth.

It must be recognized that the estimates of current seasonal population and forecasts of future seasonal population growth presented here are highly tentative. This is partly the result of assumptions which must be made concerning seasonal population, such as to occupancy rate. Also, however, seasonal population change is likely to respond much more to a variety of social factors influencing the number of second homes that Americans own. Most important among these volatile factors are changes in disposable personal income, which influence the ability to afford second residences, and changes in gasoline prices, which influence the ability of persons to travel long distances to second homes.

The in-summer population projections for the year 2000 presented here are approximately 4% below those presented in the Facility Plan. Permanent population is projected to be 6% lower than in the Facility Plan, while seasonal population is projected to be 3% lower. Estimates presented in the EIS are significantly (more than 100 persons) lower than those in the Facility Plan for Benzonia Township and Crystal Lake Township permanent population, for Benzonia Village seasonal population, and for both seasonal and permanent population in Lake Township. Predicted populations in the EIS are at least 100 higher than in the Facility Plan for permanent population of Beulah Village and for seasonal population in Crystal Lake Township. The population projections presented here, unlike those in the Facility Plan, do not foresee the appearance of a large seasonal population in Benzonia, where no seasonal population was found by the 1972 Wilbur Smith field survey. Nor do the projections in this EIS foresee the disappearance of seasonal populations found in the 1972 Wilbur Smith field survey in Frankfort and Elberta. Despite relatively large differences in the internal allocation of seasonal and permanent populations, the overall Proposed Service Area populations forecast here for the year 2000 are not significantly different from those forecast in the Facility Plan.

Table H-1
SOURCES OF POPULATION ESTIMATES AND FORECASTS

Source	Level of Aggregation			Type of Population		
	County	Minor Civil Division	Service Area	Permanent	Seasonal	Total In-Summer
US Census of Population	•	•		•		
US Census Current Population Estimates	•	•		•		
Wilbur Smith & Associates Field Survey		•			•	
Grand Traverse Area Data Center	•			•	•	•
Michigan Department of Management and Budget	•			•		
Williams & Works Field Survey		•	•			•
Northwest Michigan Regional Planning Commission	•	•		•		

Table II-2
SERVICE AREA POPULATION, 1975 and 2000

Local Unit	% of Population in Service Area	1975 Service Area Permanent Population	1975 Service Area Seasonal Population(2)	1975 Total In-Summer Population	2000 Service Area Permanent Population(3)	2000 Service Area Seasonal Population	2000 Total Service Area Population
Benzonia Township	35	551	791	1,342	784	1,289	2,073
Benzonia Village	100	484	0	484	545	0	545
Buelah Village	100	542	543	1,085	597	597	1,194
Crystal Lake Township	79	424	1,967	2,391	778	3,600	4,378
Frankfort City	100	1,822	21	1,843	2,190	25	2,215
Elberta Village	100	498	11	507	696	15	711
Lake Township	22	99	765	864	158	1,216	1,374
Study Area	75	4,420	4,098	8,518	5,748	6,742	12,490

Sources: (1) 1975 Population Estimates from U.S. Census Current Population Reports (Series P-25), May, 1977.
(2) Wilbur Smith and Associates, 1973, and Grand Traverse Area Data Center, 1977.
(3) Median of Northwest Michigan Regional Planning Commission high and low estimates.

Table H-3
SERVICE AREA POPULATION COMPARISON

Political Unit		Facility Plan[1]	EIS	EIS-Facility Plan Difference Quantity	EIS-Facility Plan Difference %
Benzonia Township (Excluding Villages)	Permanent	1,083	784	-299	- 28
	Seasonal	1,322	1,289	- 33	- 2
	Total	2,403	2,073	-332	- 25
Benzonia Village	Permanent	481	545	64	13
	Seasonal	206	0	-206	-100
	Total	687	545	-142	- 21
Beulah Village	Permanent	482	597	115	24
	Seasonal	588	597	9	2
	Total	1,070	1,194	124	12
Crystal Lake Township	Permanent	1,002	778	-224	- 22
	Seasonal	3,006	3,600	594	20
	Total	4,008	4,378	370	9
Frankfort City	Permanent	2,156	2,190	34	2
	Seasonal	0	25	25	100
	Total	2,156	2,215	59	3
Elberta	Permanent	606	696	90	15
	Seasonal	0	15	15	100
	Total	606	711	105	17
Lake Township	Permanent	317	158	-159	- 50
	Seasonal	1,798	1,216	-582	- 32
	Total	2,115	1,374	-741	- 35
Service Area Total	Permanent	6,127	5,748	-379	- 6
	Seasonal	6,920	6,792	-178	- 3
	Total	13,047	12,490	-557	- 4

[1] Williams and Works, Crystal Lake Area Facility Plan, 1976.

FLOW REDUCTION DEVICES

Estimated Savings with Flow Reduction Devices

	First Year Savings (or Cost)	Annual Savings After First Year
Shower flow control insert device	$46.46	$48.46
Dual cycle toilet[a]	24.28	44.28
Toilet damming device	18.89	22.14
Shallow trap toilet[a]	17.14	22.14
Dual flush adapter for toilets	14.45	18.45
Improved ballcock assembly for toilets	11.76	14.76
Spray tap faucet	(63.43)	13.77
Faucet flow control device	6.45	9.45
Faucet aerator	1.44	3.94

[a] First year expenditure assumed to be difference in capital cost between flow-saving toilet and a standard toilet costing $75.

Incremental Capital Costs of Flow Reduction in the Crystal Lake Study Area

Dual-cycle toilets:

$20/toilet x 2 toilets/permanent dwelling x 2054 permanent dwellings in year 2000 = $82,160

$20/toilet x 1 toilet/seasonal dwelling x 1620 seasonal dwellings in year 2000 = 32,400

Shower flow control insert device:

$2/shower x 2 shower/permanent dwelling x 2054 permanent dwellings in year 2000 = 8,216

$2/shower x 1 shower/seasonal dwelling x 1620 seasonal dwellings in 2000 = 3,240

Faucet flow control insert device:

$3/faucet x 3 faucets/permanent dwelling x 2054 permanent dwellings in year 2000 = 18,486

$2/faucet x 2 faucets/seasonal dwelling x 1620 seasonal dwellings in 2000 = 6,480

Total $150,982

Note: The $20 cost for dual-cycle toilets is the difference between its full purchase price of $95 and the price of a standard toilet, $75.

Flow Reduction and Cost Data for Water Saving Devices

Device	Daily Conservation (gpd)	Daily Conservation (hot water) (gpd)	Capital Cost	Installation Cost	Useful Life (yrs.)	Average Annual O&M
Toilet modifications						
Water displacement device--plastic bottles, bricks, etc.	10	0	0	H-0[a]	15	0
Water damming device	30	0	3.25	H-0	20	0
Dual flush adaptor	25	0-	4.00	H-0	10	0
Improved bailock assembly	20	0-	3.00	H-0	10	0
Alternative toilets						
Shallow trap toilet	30	0-	80.00	55.20	20	0
Dual cycle toilet	60	0-	95.00	55.20		0
Vacuum toilet	90	0-				
Incinerator toilet	100	0				
Organic waste treatment system	100	0				
Recycle toilet	100	0				
Faucet modifications						
Aerator	1	1	1.50	H-0	15	0
Flow control device	4.8	2.4	3.00	H-0	15	0
Alternative faucets						
Foow control faucet	4.8	2.3	40.00	20.70		0
Spray tap faucet	7	3.5	56.50	20.70	15	0
Shower modification						
Shower flow control insert device	19	14	2.00	H-0	15	0
Alternative shower equipment						
Flow control shower head	19	14	15.00	H-0 or 13.30	15	0
Shower cutoff valve			2.00	H-0		0
Thermostatic mixing valve			62.00	13.30		0

[a]H-0 = Homeowner-installed; cost assumed to be zero.

COSTS AND FINANCING

DESIGN AND COSTING ASSUMPTIONS

Treatment

(1) Rotating Biological Contactor (RBC) System

- All RBC treatment systems contain same components as treatment facility proposed in Crystal Lake Area Facility Plan (Williams & Works 1976) including advanced treatment for nutrient removal.

- The location of the RBC plant was assumed to be on land in Frankfort purchased for this purpose (see Figure III-4).

(2) Land Application

- Facilities for treatment and storage of waste waters prior to land application are same as in Facility Plan.

- Three possible land application sites were identified (see Figure III-3). Alternative costs were developed based on utilizing the site in Sections 25 and 30 of Benzonia Township.

- Design assumptions -

  storage period - 20 weeks per year
  application rate - 2 inches per week
  application technique - spray irrigation, woodlands

- Facilities for recovery and recycling of tailwater provided.

(3) Cluster Systems

- The design and costs for wastewater treatment utilizing cluster systems were developed based on a "typical" system serving 23 residences along the south shore of Crystal Lake.

- Design assumptions -

  flow - 60 gpcd - peak flow 45 gpm
  3.5 persons/home - 3-bedroom home
  50% of existing septic tanks need to be replaced with new 1000-gallon tanks

- Collection of wastewaters is by a low-pressure system with two homes connected to one simplex pumping unit.

- Cluster system includes the following requirements of the State of Michigan.

  monitoring wells
  hydrogeological survey be performed for the potential area

- 200-foot transmission (2- to 3-inch force main) to absorption field assumed.

- Pump Station (50 gpm) required for transmission, 60-foot static head assumed from pump station to distribution box.

Collection

- All sewer lines are to be placed at or below 6 feet of depth to allow for frost penetration in the Crystal Lake area. Gravity lines are assumed to be placed at an average depth of 12 feet.

- Ten % shoring of all gravity collection lines is required, due to prevalent high groundwater as well as unsuitable soils.

- A minimum velocity of 2 fps will be maintained in all pressure sewer lines and force mains to provide for scouring.

- Peaking factor used for design flows was 4.0.

- All pressure sewer lines and force mains 8 inches in diameter or less will be PVC SDR26, with a pressure rating of 160 psi. Those force mains larger than 8 inches in diameter will be constructed of ductile iron with mechanical joints.

- When possible, force mains and pressure sewer collectors will be placed in a common trench.

- Cleanouts in the pressure sewer system will be placed at the beginning of each line, with one every 500 feet of pipe in line. Cleanout valve boxes will contain shut-off valves to provide for isolation of various sections of line for maintenance and/or repairs.

- Individual pumping units for the pressure sewer system include a 2- by 8-foot basin with discharge at 6 feet, control panel, visual alarm, mercury float level controls, valves, rail system for removal of pump, antiflotation device, and the pump itself. (See Figure III-2).

- Effluent pumps are 1-1/2 and 2 HP pumps which reach a total dynamic head of 80 and 120 feet respectively.

Analysis of Cost Effectiveness

- Quoted costs are in 1978 dollars

- EPA Sewage Treatment Plant (STP) Index of 135 (4th Quarter 1977) and Engineering News Record Index of 2693 (1 March 1978) used for updating costs.

- i, interest rate = 6-5/8%
- Planning period = 20 years
- Life of facilities, structures - 50 years
  Mechanical components - 20 years
- Straight line depreciation
- Land for land application site valued at $1000/acre
  (Century 21 Realty, Traverse City, Michigan 4/78)
- Land surrounding Crystal Lake for locating cluster systems
  valued at $10,000/acre

ITEMIZED AND TOTAL COSTS FOR EACH ALTERNATIVE

FACILITY PLAN PROPOSED ACTION

LIMITED ACTION ALTERNATIVE

EIS ALTERNATIVES 1-6

Note: Costs are shown to nearest $100. This should not be interpreted as meaning that estimates are accurate to that level. Most cost estimates are accurate within ± 10%.

PROJECT COSTS

FACILITY PLAN

PROPOSED ACTION

TREATMENT

Q = 0.89 MGD

ROTATING BIOLOGICAL DISCS

Costs in 1978 Dollars X $1,000

PROCESS	CAPITAL COST	O&M	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$191.0		
Preliminary Treatment	89.0		
Primary Sedimentation	102.0		
Secondary Sedimentation	102.0		
Chlorine Contact	51.0		
Anaerobic Digester	583.0		
Digester Building & Gallery	127.0		
Sludge Beds	121.0		
Lab. Equipment	38.0		
Service Buildings	190.0		
Chlorine Equipment	38.0		
Garage	25.0		
Bio Disc and Building	760.0		
Ferric Chloride Storage	25.0		
Chemical Room	38.0		
Microstrainer	144.0		
Plumbing	164.0		
Heating	127.0		
Electrical and Instr.	253.0		
Yardwork	177.0		
Sub-total	3,345.0		
Engineering and Contingencies 25%	836.0		
Total	$4,181.0	$123.0 1st yr. 148.0 20th yr. 1.25/yr. (Gradient)	$1,296.0

PROJECT COSTS

FACILITY PLAN

PROPOSED ACTION

COLLECTION

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
Sub-Total*	10,481.4	58.4	4,724.3
A. 25% Engr. & Contingencies	2,620.3	-0-	944.9
**B. Land Easements	20.0	- --	36.1
1980 TOTAL	13,121.7	58.4	5,705.3
1990-- Additional Service due to Future Growth			
A. North Shore (gravity)	185.4	0.4	144.4
B. Pilgrim Area (gravity)	267.3	0.5	147.44
C. Benzonia Village (gravity)	194.5	0.4	128.4
D. South Shore (gravity)	465.9	1.1	365.3
E. Frankfort (gravity)	575.4	1.3	302.5
F. Elberta (gravity)	285.4	0.8	228.3
Subtotal*	1,973.9	4.5	1,316.3
G. 25% Engr. & Contingencies	493.5	-0-	263.3
1990 TOTAL INCREASE	2,467.4	4.5	1,579.6

* INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

** FIGURES OBTAINED FROM EXISTING FACILITY PLAN

PROJECT COSTS

LIMITED ACTION ALTERNATIVE

TREATMENT

Q = 0.33 MGD

ROTATING BIOLOGICAL DISCS

Costs in 1978 Dollars X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$ 99.2		
Preliminary Treatment	46.4		
Primary Sedimentation	52.8		
Secondary Sedimentation	52.8		
Chlorine Contact	26.4		
Anaerobic Digester	304.0		
Digester Building & Gallery	66.4		
Sludge Beds	63.2		
Lab. Equipment	20.0		
Service Buildings	99.2		
Chlorine Equipment	20.0		
Garage	13.6		
Bio Disk and Building	396.0		
Ferric Chloride Storage	13.6		
Chemical Room	20.0		
Microstrainer	75.2		
Plumbing	85.6		
Heating	66.4		
Electrical & Instr.	132.0		
Yardwork	92.0		
Sub-total	$1744.8		
Engineering & Contingencies 25%	436.2		
Total	2181.0	$64.0 1st yr. 77.6 20th yr. 0.68/yr. (Gradient)	$676.0

PROJECT COSTS

LIMITED ACTION ALTERNATIVE

COLLECTION

AND

ON-LOT TREATMENT

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. Elberta to RBD, Frankfort	104.4	1.4	57.8
*B. Reconstruction, Elberta to Frankfort	263.9	-	-
*C. Frankfort Storm-sewer separation	204.6	-	-
D. On-lot Systems	1,285.2	54.8	147.9
Sub-Total**	1,858.1	56.2	205.7
E. 25% Engr. & Contingencies	464.5		
Cluster land	60.0	-	41.1
1980 TOTAL	2,382.6	56.2	246.8
On-Lot Gradient	93.8		
1990-- Additional Service due to Future Growth			
A. Frankfort (gravity)	575.4	1.3	302.5
B. Elberta (gravity)	285.4	0.8	228.3
C. On-lot systems	-	48.7	128.8
Sub-Total**	860.8	50.8	659.6
D. 25% Engr. & Contingencies	215.2	-	131.9
1990 TOTAL INCREASE	1,076.0	50.8***	791.5

* FIGURES OBTAINED FROM THE EXISTING FACILITY PLAN

** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

*** INCLUDES COST OF MONITORING AND INSPECTION OF ON-LOT SYSTEMS ESTIMATED AT $30 PER SYSTEM PER YEAR

PROJECT COSTS

EIS ALTERNATIVE 1

TREATMENT

ROTATING BIOLOGICAL DISCS

Q = 0.89 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$191.0		
Preliminary Treatment	89.0		
Primary Sedimentation	102.0		
Secondary Sedimentation	102.0		
Chlorine Contact	51.0		
Anaerobic Digester	583.0		
Digester Building & Gallery	127.0		
Sludge Beds	121.0		
Lab. Equipment	38.0		
Service Buildings	190.0		
Chlorine Equipment	38.0		
Garage	25.0		
Bio Disk and Building	760.0		
Ferric Chloride Storage	25.0		
Chemical Room	38.0		
Microstrainer	144.0		
Plumbing	164.0		
Heating	127.0		
Electrical and Instr.	253.0		
Yardwork	177.0		
Sub-total	3,345.0		
Engineering and Contingencies 25%	836.0		
Total	$4,181.0	$123.0 1st yr. 148.0 20th yr. 1.25/yr. (Gradient)	$1,296.0

PROJECT COSTS

EIS ALTERNATIVE 1

COLLECTION

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. North Shore	2,408.7	36.5	713.8
B. Pilgrim Area	1,069.4	17.3	257.4
C. Benzonia Village	1,789.0	9.8	892.8
D. South Shore	3,767.9	61.9	688.4
E. Collection To RBD Frankfort	661.6	3.0	366.7
F. Elberta to RBD, Frankfort	104.4	1.4	57.8
*G. Reconstruction Elberta & Frankfort	263.9	---	----
*H. Frank. Storm Sewer Separation	204.6	---	----
Sub-Total**	10,269.5	129.9	2,976.9
I. 25% Engr. Contingencies	2,567.3	-0-	595.4
J. Land Easements	20.0		36.1
1980 TOTAL	12,856.8	129.9	3608.4
1990-- Additional Service due to Future Growth			
A. North Shore (gravity)	185.4	.4	144.4
B. Pilgrim Area (pressure)	210.0	1.9	124.3
C. Benzonia Village (gravity)	194.5	.4	128.4
D. South Shore (gravity)	723.0	4.6	365.3
E. Frankfort (gravity)	575.4	1.3	302.5
F. Elberta (gravity)	285.4	.8	228.3
Sub-Total**	2,173.7	9.4	1293.2
G. 25% Engr. & Con-Tingencies	543.4	-0-	258.6
1990 TOTAL INCREASE	2,717.1	9.4	1551.8

* FIGURES OBTAINED FROM EXISTING FACILITY PLAN
** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

PROJECT COSTS

EIS ALTERNATIVE 2

LAND TREATMENT SYSTEM

Q = 0.89 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Preliminary Treatment - Aerated Lagoon	$ 113.0	$ 13.0	$ 47.5
Chlorination	55.0	4.1	21.4
Transmission On-Site - Gravity Lines	149.0	0.4	89.4
Storage	475.0	3.2	285.0
Application - Spray Irrigation Solid Set, Woodlands	1,215.0	43.4	182.3
Land 300 Acres	300.0		541.8
Hydro-Geological Survey	60.0		
Tailwater Return	43.9	0.6	15.8
TOTALS	$2,410.9	$64.7	$1183.2

PROJECT COSTS

EIS ALTERNATIVE 2

COLLECTION

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. Pilgrim	1,069.4	17.3	257.4
B. North Shore	2,690.3	36.8	818.5
C. North Shore to Benzonia	271.6	3.7	102.5
D. South Shore	3,995.6	72.5	728.2
E. Benzonia	1,965.	12.	945.6
F. Elberta to Frankfort	104.4	1.4	57.8
*G. Reconstruction Elberta to Frankfort	263.9	---	----
*H. Frankfort Storm Sewer Separation	204.6	---	----
Sub-Total**	10,564.8	143.7	2,910.0
I. 25% Engr. & Contingencies	2,641.2	-0-	582.0
*J. Land Easements	20.0		36.1
1980 TOTAL	13,226.0	143.7	3,528.1
1990-- Additional Service due to Future Growth			
A. Pilgrim(pressure)	210.0	1.9	124.3
B. North Shore (grav.)	185.4	.4	144.4
C. Benzonia Village (gravity)	194.5	.4	128.4
D. South Shore (gravity)	723.0	4.6	365.3
E. Frankfort(gravity)	575.4	1.3	302.5
F. Elberta(gravity)	285.4	.8	228.3
Sub-Total**	2,173.70	9.4	1293.2
G. 25% Engr. & Contingencies	543.4	-0-	258.6
1990 TOTAL INCREASE	2,717.13	9.4	1551.8

* FIGURES OBTAINED FROM EXISTING FACILITY PLAN
** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

PROJECT COSTS

EIS ALTERNATIVE 3

LAND TREATMENT SYSTEM

Q = 0.18 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Preliminary Treatment - Aerated Lagoon	$ 65.8	$ 5.2	$ 27.6
Chlorination	30.4	1.8	11.9
Transmission On-Site - Gravity Lines	118.8	0.4	71.3
Storage	148.5	1.3	89.1
Application - Spray Irrigation Solid Set, Woodlands	445.5	14.4	66.8
Land 75 Acres	75.0		135.5
Hydro-Geological Survey	25.0		
Tailwater Return	30.4	0.2	10.9
TOTALS	$939.4	$23.3	$413.1

PROJECT COSTS

EIS ALTERNATIVE 3

TREATMENT

ROTATING BIOLOGICAL DISCS

Q = 0.45 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COSTS	O&M COSTS	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$ 124.0		
Preliminary Treatment	58.0		
Primary Sedimentation	66.0		
Secondary Sedimentation	66.0		
Chlorine Contact	33.0		
Anaerobic Digester	380.0		
Digester Building & Gallery	83.0		
Sludge Beds	79.0		
Lab. Equipment	25.0		
Service Buildings	124.0		
Chlorine Equipment	25.0		
Garage	17.0		
Bio. Disk and Building	495.0		
Ferric Chloride Storage	17.0		
Chemical Room	25.0		
Microstrainer	94.0		
Plumbing	107.0		
Heating	83.0		
Electrical & Instr.	165.0		
Yardwork	115.0		
Sub-total	$2,181.0		
Engineering & Contingencies 25%	545.0		
Total	$2,726.0	$80.0 1st yr. 97.0 20th yr. 0.85/yr. (Gradient)	$845.0

PROJECT COSTS

EIS ALTERNATIVE 3

COLLECTION

AND

DECENTRALIZED TREATMENT

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. Pilgrim to RBC, Frankfort	371.9	2.2	211.1
B. Elberta to RBC, Frankfort	104.4	1.4	57.8
C. N.E. Corner	937.6	7.0	415.5
D. Pilgrim	915.5	3.8	369.2
E. N.E.Corner to Benzonia	102.0	2.7	9.6
F. Benzonia	1,813.0	9.8	900.0
*G. Reconstruction Elberta to Frankfort	263.9	---	-----
*H. Frankfort Storm sewer Separation	204.6	---	-----
I. On-lot & Cluster Systems	1,297.4	21.6	120.9
Subtotal	6,010.3	48.5	2,084.1
J. 25% Engr. & Contingencies	1,502.6	-0-	416.8
*K. Land Easements & Land Cluster Systems	180.0	-	325.1
1980 TOTAL	7,692.9	48.5	2,826.0
On-Lot Gradient	47.1/yr.		
1990-- Additional Service due to Future Growth			
A. N.E. Corner(gravity)	185.4	.4	144.4
B. Pilgrim(gravity)	267.3	0.5	147.4
C. Benzonia(gravity)	194.5	.4	128.4
D. Frankfort(gravity)	575.4	1.3	302.5
E. Elberta(gravity)	285.4	.8	288.3
F. On-Lot	--	20.6	86.9
Sub-Total**	1,508.0	24.0***	1,037.9
G. 25% Engr. & Contingencies	377.0	-0-	207.6
1990 TOTAL INCREASE	1,885.0	24.0	1,245.5

* FIGURES OBTAINED FROM THE EXISTING FACILITY PLAN

** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

*** INCLUDES COST OF MONITORING AND INSPECTION OF ON-LOT SYSTEMS ESTIMATED AT $30 PER SYSTEM PER YEAR

PROJECT COSTS

EIS ALTERNATIVE 4

LAND TREATMENT SYSTEM

Q = 0.65 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Preliminary Treatment - Aerated Lagoon	$ 97.0	$10.5	$ 41.0
Chlorination	47.0	3.5	18.0
Transmission On-Site - Gravity Lines	134.0	0.4	80.0
Storage	446.0	2.6	268.0
Application - Spray Irrigation Solid Set, Woodlands	972.0	36.0	146.0
Land 225 Acres	225.0		406.4
Hydro-Geological Survey	55.0		
Tailwater Return	38.9	0.5	14.0
TOTALS	$2,014.9	$53.5	$973.4

PROJECT COSTS

EIS ALTERNATIVE 4

COLLECTION

AND

DECENTRALIZED TREATMENT

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. Pilgrim Area	915.5	3.8	369.2
B. Pilgrim to Frankfort	371.9	2.2	211.1
C. Elberta to Frankfort	104.4	1.4	57.8
D. Collection of West to C.L.C.	1,038.4	4.8	311.5
E. Benzonia	1,813.0	9.8	900.0
F. N.E. Corner	937.6	7.0	415.5
G. N.E. to Benzonia	102.0	2.7	9.6
*H. Reconstruction, Elberta to Frankfort	263.9	---	-----
*I. Frankfort Storm Sewer Separation	204.6	---	-----
J. On-Lot & Cluster Systems	1,297.4	21.6	120.9
Sub-Total**	7,048.7	53.3***	2,395.6
K. 25% Engr. & Contingencies	1,762.2	-0-	479.1
*L. Land Easements & Land Cluster Systems	180.0		325.1
1980 TOTAL	8,990.9	53.3	3,199.8
On-Lot Gradient	47.1/yr.		
1990-- Additional Service due to Future Growth			
A. Pilgrim Area (gravity)	267.3	0.5	147.4
B. Frankfort(gravity)	575.4	1.3	302.5
C. Elberta(gravity)	285.4	.8	228.3
D. N.E. Corner(gravity)	185.4	.4	144.4
E. Benzonia(gravity)	194.5	.4	128.4
F. On-Lot		20.6	86.9
Sub-Total**	1,508.0	24.0	1,037.9
G. 25% Engr. & Contingencies	377.0	-0-	207.6
1990 TOTAL INCREASE	1,885.0	24.0	1,245.5

* FIGURES OBTAINED FROM EXISTING FACILITY PLAN

** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

*** INCLUDES COST OF MONITORING AND INSPECTION OF ON-LOT SYSTEMS ESTIMATED AT $30 PER SYSTEM PER YEAR.

PROJECT COSTS

EIS ALTERNATIVE 5

TREATMENT

ROTATING BIOLOGICAL DISCS

Q = 0.65 MGD

Costs in 1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$ 162.0		
Preliminary Treatment	76.0		
Primary Sedimentation	86.0		
Secondary Sedimentation	86.0		
Chlorine Contact	43.0		
Anaerobic Digester	495.0		
Digester Building & Gallery	108.0		
Sludge Beds	103.0		
Lab. Equipment	32.0		
Service Building	161.0		
Chlorine Equipment	32.0		
Garage	22.0		
Bio Disk & Building	645.0		
Ferric Chloride Storage	22.0		
Chemical Room	32.0		
Microstrainer	122.0		
Plumbing	140.0		
Heating	108.0		
Electrical and Inst.	215.0		
Yardwork	150.0		
Sub-total	$2,840.0		
Engineering & Contingencies 25%	710.0		
Total	$3,550.0	$104.0 1st yr. 126.0 20th yr. 1.10/yr. (Gradient)	$1,101.0

PROJECT COSTS

EIS ALTERNATIVE 5
COLLECTION
AND
DECENTRALIZED TREATMENT

Costs in 1978 Dollars
X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980-- Service to Immediate Service Area			
A. Pilgrim Area	915.5	3.8	369.2
B. Pilgrim to Frankfort, RBD	371.9	2.2	211.1
C. Elberta to Frankfort, RBD	104.4	1.4	57.8
D. Collection of East to RBD	670.4	3.9	201.1
E. Benzonia	1,813.0	9.8	900.0
F. N.E. Corner	937.6	7.0	415.5
G. N.E. to Benzonia	102.0	2.7	9.6
*H. Reconstruction, Elberta to Frankfort	263.9	---	-----
*I. Frankfort Storm Sewer Separation	204.6	---	-----
J. On-Lot & Cluster System	1,297.4	21.6	120.9
Sub-Total**	6,680.7	52.4	2,285.2
K. 25% Engr. & Contingencies	1,670.2	--	457.0
*L. Land Easements & Land for Cluster Systems	180.0	--	325.1
1980 TOTAL	8,530.9	52.4	3,067.3
On-Lot Gradient	47.1/yr.		
1990-- Additional Service due to Future Growth			
A. Pilgrim Area(gravity)	267.3	.5	147.4
B. Frankfort(gravity)	575.4	1.3	302.5
C. Elberta(gravity)	285.4	.8	228.3
D. N.E. Corner(gravity)	185.4	.4	144.4
E. Benzonia(gravity)	194.5	.4	128.4
F. On-Lot	--	20.6	86.9
Sub-Total**	1,508.0	24.0	1,037.9
G. 25% Engr. & Contingencies	377.0	-0-	207.6
1990 TOTAL INCREASE	1,885.0	24.0	1,245.5

* FIGURES OBTAINED FROM EXISTING FACILITY PLAN

** INCLUDES COSTS FOR PRIVATE SEWER SERVICE LINE CONNECTIONS

*** INCLUDES COST OF MONITORING AND INSPECTION OF ON-LOT SYSTEMS ESTIMATED AT $30 PER SYSTEM PER YEAR

PROJECT COSTS
EIS ALTERNATIVE 6

Q = 0.33 MGD

TREATMENT
ROTATING BIOLOGICAL
DISCS

Costs in
1978 Dollars
X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Raw Sewerage Pumping Sta.	$ 99.2		
Preliminary Treatment	46.4		
Primary Sedimentation	52.8		
Secondary Sedimentation	52.8		
Chlorine Contact	26.4		
Anaerobic Digester	304.0		
Digester Building & Gallery	66.4		
Sludge Beds	63.2		
Lab. Equipment	20.0		
Service Buildings	99.2		
Chlorine Equipment	20.0		
Garage	13.6		
Bio Disk and Building	396.0		
Ferric Chloride Storage	13.6		
Chemical Room	20.0		
Microstrainer	75.2		
Plumbing	85.6		
Heating	66.4		
Electrical & Instr.	132.0		
Yardwork	92.0		
Subtotal	$1744.8		
Engineering & Contingencies 25%	436.2		
TOTAL	$2181.0	$64.0 1st yr. 77.6 20th yr. 0.68/yr. (Gradient)	$676.0

PROJECT COSTS
EIS ALTERNATIVE 6

Q = 0.18 MGD — LAND TREATMENT SYSTEM — Costs in 1978 Dollars X $1,000

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Preliminary Treatment - Aerated Lagoon	$ 65.8	$ 5.2	$ 27.6
Chlorination	30.4	1.8	11.9
Transmission On-Site - Gravity Lines	118.8	0.4	71.3
Storage	148.5	1.3	89.1
Application - Spray Irrigation Solid Set, Woodlands	445.5	14.4	66.8
Land 75 Acres	75.0		135.5
Hydro-Geological Survey	25.0		
Tailwater Return	30.4	0.2	10.9
TOTAL	$939.4	$23.3	$413.1

PROJECT COSTS
NEW ALTERNATIVE 6

COLLECTION AND DECENTRALIZED TREATMENT

Costs in 1978 Dollars X $1,000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980--Service to Immediate Service Area			
A. Elberta to RBD, Frankfort	$ 104.4	$ 1.4	$ 57.8
*B. Reconstruction, Elberta to Frankfort	263.9	-	-
*C. Frankfort Storm-sewer separation	204.6	-	-
D. N.E. Corner	937.6	7.0	415.5
E. N.E. Corner to Benzonia	102.0	2.7	9.6
F. Benzonia	1813.0	9.8	900.0
G. Cluster Systems+ on S.E. Shore	103.7	1.1	9.1
H. On-lot Systems for remainder of Lake	564.1	34.6	75.4
I. SUBTOTAL	4093.3	56.6***	1462.0
J. 25% Engr. & Contig.	1023.3	0	292.4
K. Land Easements & Land Cluster Systems	30.0	-	54.2
1980 TOTAL	$5146.6	$56.6	$1808.6
On-Lot Gradient	71.1/yr.		
1990--Additional Service due to Future Growth			
A. Frankfort (gravity)	575.4	1.3	302.5
B. Elberta (gravity)	285.4	0.8	228.3
C. N.E. Corner (gravity)	185.4	0.4	144.4
D. Benzonia (gravity)	194.5	0.4	128.4
E. On-Lot Systems	-	35.1	97.5
SUBTOTAL**	1240.7	38.0***	901.1
F. 25% Engr. & Contig.	310.2	0	180.2
1990 TOTAL INCREASE	$1550.9	$38.0	$1081.3

* Figures obtained from the existing Facility Plan
** Includes costs for private sewer service line connections
*** Includes cost of monitoring and inspection of on-lot systems estimated at $30 per system per year
\+ Includes cost of hydrogeological survey

COST SHARING

The Federal Water Pollution Control Act of 1972 (Public Law 92-500, Section 202), authorized EPA to award grants for 75% of the construction costs of wastewater management systems. Passage of the Clean Water Act (P. L. 95-217) authorized increased Federal participation in the costs of wastewater management systems. The Construction Grants Regulations (40 CFR Part 35) have been modified in accordance with the later Act. Final Rules and Regulations for implementing this Act were published in the Federal Register on September 27, 1978.

There follows a brief discussion of the eligibility of major components of wastewater management systems for Federal funds.

Federal Contribution

In general, EPA will share in the costs of constructing treatment systems and in the cost of land used as part of the treatment process. For land application systems the Federal government will also help to defray costs of storage and ultimate disposal of effluent. The Federal share is 75% of the cost of conventional treatment systems and 85% of the cost of systems using innovative or alternative technologies. Federal funds can also be used to construct collection systems when the requirements discussed below are met.

The increase in the Federal share to 85% when innovative or alternative technologies are used is intended to encourage reclamation and reuse of water, recycling of wastewater constituents, elimination of pollutant discharges, and/or recovering of energy. Alternative technologies are those which have been proven and used in actual practice. These include land treatment, aquifer recharge, and direct reuse for industrial purposes. On-site, other small waste systems, and septage treatment facilities are also classified as alternative technologies. Innovative technologies are those which have not been fully proven in full scale operation.

To further encourage the adoption and use of alternative and innovative technologies, the Cost Effectiveness Analysis Guidelines in the new regulations give these technologies a 15% preference (in terms of present worth) over conventional technologies. This cost preference does not apply to privately owned, on-site or other privately owned small waste flow systems.

States that contribute to the 25% non-Federal share of conventional projects must contribute the same relative level of funding to the 15% non-Federal share of innovative or alternative projects.

Individual Systems (Privately or Publicly Owned)

P.L. 95-217 authorized EPA to participate in grants for constructing privately owned treatment works serving small commercial establishments or one or more principal residences inhabited on or before December 27, 1977 (Final Regulations, 40 CFR 35.918, September 27, 1978). A public body must apply for the grant, certify that the system will be properly operated and maintained, and collect user charges for operation and maintenance of the system. All commercial users must pay industrial cost recovery on the Federal share of the system. A principal residence is defined as a voting residence or household of the family during 51% of the year. Note: The "principal residence" requirement does not apply to publicly owned systems.

Individual systems, including sewers, that use alternative technologies may be eligible for 85% Federal participation, but privately owned individual systems are not eligible for the 115% cost preference in the cost-effective analysis. Acquisition of land on which a privately owned individual system would be located is not eligible for a grant.

Publicly owned on-site and cluster systems, although subject to the same regulations as centralized treatment plants, are also considered alternative technologies and therefore eligible for an 85% Federal share.

EPA policy on eligibility criteria for small waste flow systems is still being developed. It is clear that repair, renovation or replacement of on-site systems is eligible if they are causing documentable public health, groundwater quality or surface water quality problems. Both privately owned systems servicing year-round residences (individual systems) and publicly owned year-round or seasonally used systems are eligible where there are existing problems. Seasonally used, privately owned systems are not eligible.

Several questions on eligibility criteria remain to be answered and are currently being addressed by EPA:

- o For systems which do not have existing problems, would preventive measures be eligible which would delay or avoid future problems?

- o Could problems with systems other than public health, groundwater quality or surface water quality be the basis for eligibility of repair, renovation or replacement? Examples of "other problems", are odors, limited hydraulic capacity, and periodic backups.

- o Is non-conformance with modern sanitary codes suitable justification for eligibility of repair, renovation or replacement? Can non-conformance be used as a measure of the need for preventive measures?

- o If a system is causing public health, groundwater quality or surface water quality problems but site limitations would prevent a new on-site system from satisfying sanitary codes, would a non-conforming on-site replacement be eligible if it would solve the existing problems?

In this EIS estimates were made of the percent repair, renovation or replacement of on-site systems that may be found necessary during detailed site analyses. Those estimates are felt to be conservatively high and would probably be appropriate for generous resolutions of the above questions.

Collection Systems

Construction Grants Program Requirements Memorandum (PRM) 78-9, March 3, 1978, amends EPA policy on the funding of sewage collection systems in accordance with P.L. 95-271. Collection sewers are those installed primarily to receive wastewaters from household service lines. Collection sewers may be grant-eligible if they are the replacement or major rehabilitation of an existing system. For new sewers in an existing community to be eligible for grant funds, the following requirements must be met:

- Substantial Human Habitation -- The bulk (generally 67%) of the flow design capacity through the proposed sewer system must be for wastewaters originating from homes in existence on October 18, 1972. Substantial human habitation should be evaluated block by block, or where blocks do not exist, by areas of five acres or less.

- Cost-Effectiveness -- New collector sewers will only be considered cost-effective when the systems in use (e.g. septic tanks) for disposal of wastes from existing population are creating a public health problem, violating point source discharge requirements of PL 92-500, or contaminating groundwater. Documentation of the malfunctioning disposal systems and the extent of the problem is required.

  Where population density within the area to be served by the collection system is less than 1.7 persons per acre (one household per two acres), a severe pollution or public health problem must be specifically documented and the collection sewers must be less costly than on-site alternatives. Where population density is less than 10 persons per acre, it must be shown that new gravity collector sewer construction and centralized treatment is more cost-effective than on-site alternatives. The collection system may not have excess capacity which could induce development in environmentally sensitive areas such as wetlands, floodplains or prime agricultural lands. The proposed system must conform with approved Section 208 plans, air quality plans, and Executive Orders and EPA policy on environmentally sensitive areas.

- Public Disclosure of Costs -- Estimated monthly service charges to a typical residential customer for the system must be disclosed to the public in order for the collection system to be funded. A total monthly service charge must be presented, and the portion of the charge due to operation and maintenance, debt service, and connection to the system must also be disclosed.

Elements of the substantial human habitation and cost-effectiveness eligibility requirements for new collector sewers are portrayed in Figure J-3 in a decision flow diagram. These requirements would apply for any pressure, vacuum or gravity collector sewers except those serving on-site or small waste flow systems.

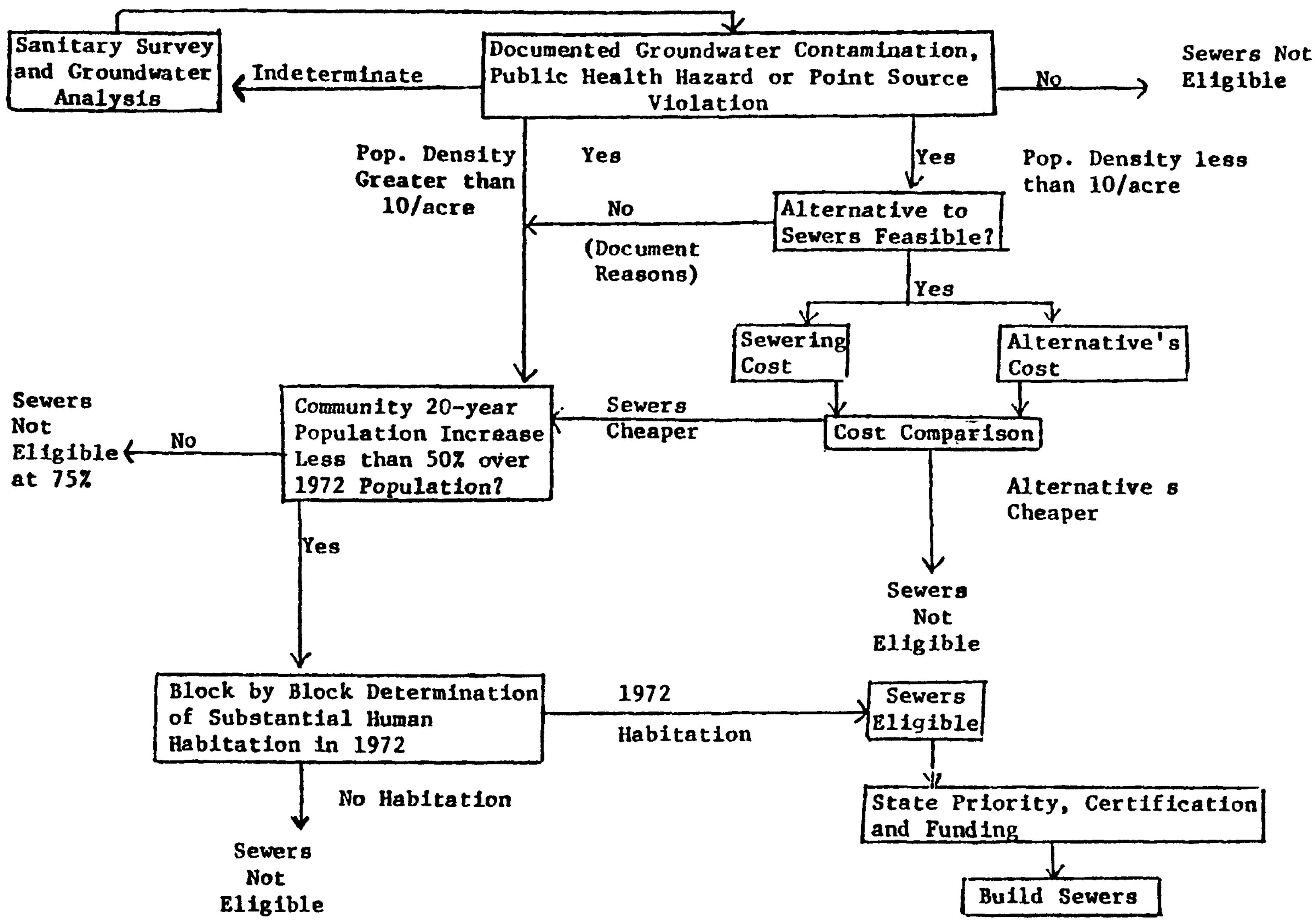
Household Service Lines

Traditionally, gravity sewer lines built on private property connecting a house or other building with a public sewer have been built at the expense of the owner without local, State or Federal assistance. Therefore, in addition to other costs for hooking up to a new sewer system, owners installing gravity household service lines will have to pay about $1,000, more or less depending on site and soil conditions, distance and other factors.

Pressure sewer systems, including the individual pumping units, the pressure line and appurtenances on private property, however, are considered as part of the community collection system. They are, therefore, eligible for Federal and State grants which substantially reduce the homeowner's private costs for installation of household service lines.

FIGURE J-3-a

Collector Sewer Eligibility - Decision Flow Diagram
Based on PRM 78-9



ALTERNATIVES FOR FINANCING THE LOCAL SHARE OF WASTEWATER TREATMENT FACILITIES IN BENZIE COUNTY, MICHIGAN

The financing of wastewater facilities requires a viable strategy. In exercising the authority delegated to them by the state to finance local activities, local governments need not only expertise in budgeting and debt administration but also a general knowledge of the costs and benefits of various complex financial tools and alternative investment strategies.

This section reviews several possible ways to fund the Proposed Action or alternative wastewater management systems in Benzie County, Michigan. It will:

- o Describe options available for financing both the capital and the operating costs of the wastewater facilities; and
- o Discuss institutional arrangements for financing and examine the probable effects of various organizational arrangements on the marketability of the bond.

FINANCING CAPITAL COSTS: OPTIONS

The several methods of financing capital improvements include: (1) pay-as-you-go methods; (2) special benefit assessments; 3) reserve funds; and (4) debt financing.

The pay-as-you-go method requires that payments for capital facilities be made from current revenues. This approach is more suitable for recurring expenses such as street paving than for one-time long-term investments. As the demand for public services grows, it becomes increasingly difficult for local governments to finance capital improvements on a pay-as-you-go basis.

In situations where the benefits to individual properties from capital improvements can be assessed, special benefit assessments in the form of direct fees or taxes may be used to apportion costs.

Sometimes reserve funds are established to finance capital improvements. A part of current revenues is placed in a special fund each year and invested in order to accumulate adequate funds to finance needed capital improvements. Although this method avoids the expense of borrowing, it requires foresight on the part of the local government.

Debt financing of capital facilities may take several forms. Local governments may issue short-term notes or float one of several types of bonds. Bonds are generally classified by both their guarantee of security and method of redemption.

GUARANTEE OF SECURITY

General Obligation (G.O. Bonds)

Debt obligations secured by the full faith and credit of the municipality are classified as general obligation bonds. The borrower is pledging the financial and economic resources of the community to support the debt. Because of the advantages of this approach to debt financing, general obligation bonds have funded over 95% of the water and sewer projects in the State of Michigan. Following are some of the advantages:

- Interest rates on the debt are usually lower than on revenue or special assessment bonds. With lower annual debt service charges, the cash flow position of the jurisdiction is improved.
- G.O. bonds for sewerage offer financial flexibility to the municipality since funds to retire them can be obtained through property taxes, user charges or combinations of both.
- When G.O. bonds are financed by ad valorem property taxes, households have the advantage of a deduction from their Federal income taxes.
- G.O. bonds offer a highly marketable financial investment since they provide a tax-free and relatively low-risk investment venture for the lender.
- In the State of Michigan, a municipality may issue G.O. bonds without the consent of the electorate. However, there is a bill in the legislature that would require all bonds to be subjected to a referendum.

A disadvantage to a general obligation approach is the State constitutional restriction on the total amount of debt outstanding. Michigan law requires that a municipality's total indebtedness not exceed 10% of its assessed valuation. This restriction may lead small rural areas like Crystal Lake to seek alternative regional institutional arrangements for financing the capital costs of wastewater/treatment systems.

Revenue Bonds

Revenue bonds differ from G.O. bonds in that they are not backed by a pledge of full faith and credit from the municipality and therefore require a higher interest rate. The interest is usually paid, and the bonds eventually retired, by earnings from the enterprise.

A major advantage of revenue bonds over general obligation bonds is that municipalities can circumvent constitutional restrictions on borrowing. Although revenue bonds have become a popular financial alternative to G.O. bonds in financing wastewater facilities, they have traditionally been avoided as a financing mechanism in Michigan for several reasons.

- High Interest Rates. Since the bonds are payable only from the earnings of the enterprise and are not supported by the full faith and credit of the jurisdictions, the risk of default is greater than on a general obligation issue.

- Margin of Risk*. The bond market requires earnings to be some multiple of total debt service charges in order to protect investors from possible default. According to E. F. Stratton, bond attorney for Benzie County, Michigan, the current risk margin for Michigan revenue bonds is 50%. For the Study Area this high margin requirement may provide two scenarios. First, since over 60% of the households in the Study Area have incomes under $10,000, investors might consider the returns on the investment to be less than the risks of possible default; should this be the case, the bonds would be unmarketable. Alternatively, if the bond be marketable, then the additional margin requirements* would be charged to households, thereby increasing the cost burden imposed by debt service obligations.

- Record of Earnings. Another difficulty in marketing revenue bonds for new facilities in the Study Area is the lack of previous revenue reports. Although Frankfort and Elberta have earning reports for their own jurisdictions, there is no revenue history for a regional system that would include the Townships of Lake, Crystal Lake and Benzonia.

- Administrative Costs. Issuance of a revenue bond obligates the municipality to provide separate funding and accounting procedures to distinguish the sewer charges from general revenue accounts.

Special Assessment Bond

A special assessment bond is payable only from the collection of special assessments, not from general property taxes. This type of obligation is useful when direct benefits are easily identified. Assessments are often based on front footage or area of the benefited property. This type of assessment may be very costly to individual property owners, especially in rural areas. Agricultural lands may require long sewer extensions and thus impose a very high assessment on one user. Furthermore, not only is the individual cost high, but the presence of sewer lines places development pressures on the rural land and often portends the transition of land from agriculture to residential/commercial use. Because the degree of security is lower than with G.O. bonds, special assessment bonds represent a greater investment risk and therefore carry a higher interest rate.

METHODS OF REDEMPTION

Two types of bonds are classified according to their method of retirement -- (1) serial bonds and (2) term bonds. Serial bonds mature in annual installments while term bonds mature at a fixed point in time.

Serial Bonds

Serial bonds provide a number of advantages for financing sewerage facilities. First, they provide a straightforward retirement method by maturing in annual installments. Secondly, since some bonds are retired each year, this method avoids the use of sinking funds.* Third, serial bonds are attractive to the investor and offer wide flexibility in marketing and arranging the debt structure of the community. Serial bonds fall into two categories (1) straight serials and (2) serial annuities.

Straight Serial Bonds provide equal annual payments of principal for the duration of the bond issue. Consequently, interest charges are higher in the early years and decline over the life of the bond. This has the advantage of 'freeing up' surplus revenues for future investment. The municipality has the option of charging these excess revenues to a sinking or reserve fund or of lowering the sewer rates imposed on households.

Serial Annuities provide equal annual installment payments of principal and interest. Total debt service charges in the early years of the bond issue are thus equal to the charges in later years. The advantage to this method of debt retirement is that the total costs of the projects are averaged across the entire life of the bond. Thus, peak installment payments in the early years are avoided, and costs are more equitably distributed than with straight serial bonds.

Although straight and annuity serials are the most common types of debt retirement bonds, methods of repayment may vary. Such "irregular" serial bonds may result in:

- Gradually increasing annual debt service charges over the life of the issue;
- Fluctuating annual installments producing combinations of rising then declining debt service; or
- Large installments due on the last years of the issue. These are called "ballooning" maturity bonds.

Statutory limitations restrict the use of irregular serial bonds in the State of Michigan. According to the Revenue Bond Act, "all bonds shall not mature at one time, they shall mature in annual series beginning not more than two years from such probable date of beginning of operation and ending as provided herein above for the maturity of bonds maturing at one time, and the sum of the principal and interest to fall due in each year shall be as nearly equal as is practicable."

Term Bonds

Term bonds differ from serial issues in that term bonds mature at a fixed point in time. The issuing entity makes periodic payments (including interest earned on investments) to a sinking fund which will be used to retire the debt at maturity. The major disadvantage to this approach to financing is management of the sinking fund -- a complex operation requiring expertise in national and regional monetary markets to insure maximum return on investment. Mismanagement of the fund could lead to default on the bond.

Until recently, term bonds requiring a sinking fund were illegal in the State of Michigan. In 1977, the Michigan legislature passed a resolution allowing the use of term bonds by requiring annual payments to a sinking fund for use in purchasing or redeeming bonds to retire the debt. There is an advantage to this method of debt retirement, particularly for revenue-producing wastewater treatment facilities. If revenues or user charges from the facilities are estimated to vary widely from year to year, then the community has the option of retiring a greater or lesser portion of the debt in any given year.

OPERATING COSTS

In most cases, operating costs are financed through service charges. Service charges are generally constructed to reflect the physical use of the system. For example, charges may be based on one or a combination of the following factors:

- Volume of wastewater
- Pollutional load of wastewater
- Number or size of connections
- Type of property serviced (residential, commercial, industrial).

Volume and pollutional load are two of the primary methods for determining service charges. Basing service charges on volume of wastewater requires some method for measuring or estimating volume. Because metering of wastewater flows is expensive and impractical, many communities utilize existing water supply meters and, often, fix wastewater volume at a percentage of water flows. When metering is not used, a flat rate system may be employed, charging a fixed rate for each connection based on user type.

INSTITUTIONAL ARRANGEMENTS

The townships and municipalities within the Study Area have available a number of organizational arrangements in financing wastewater facilities. This section discusses these arrangements and reviews the financial effects of various institutional structures on the marketability of the bond.

Organization Structure

Michigan Public Act (P.A.) 129 of 1943, (Michigan Compiled Laws 1970, Section 123.231-236 and subsequent amendments) provides for the following institutional arrangements to administer and finance wastewater facilities.

1. Municipal Ownership. Ownership, operation and administration are conducted by a single community as a service to its residents.

2. Joint Ownership. Two or more communities jointly construct, operate and own the facilities. Each government entity retains title to the facilities in proportion to its share of capital expenditures. The political subdivisions may borrow money and issue joint revenue or general obligation bonds in the name of the participating jurisdictions.

3. Contracting for Service. One entity provides sewer services to an area outside its boundaries on the basis of a contractual agreement. P.A. 129 of 1943, Section 2 states that "any such contracts shall be authorized by the legislative body of each contracting political subdivision and shall be effective for such term as shall be prescribed therein not exceeding 50 years."

4. Special Purpose District (Sanitary Districts). A number of local governments cooperate. This arrangement differs from joint ownership in that a separate governing body is established and embodied with the power to administer the financing and operation of the project. Debt is issued in the name of the district authority, but repayment obligations are the responsibility of all communities in the district.

5. Multi-Purpose Districts. These are similar to the special purpose district, but, in contrast, multi-purpose districts have more than one function. For example, a multi-purpose district may provide water services, sewer services, irrigation and flood control for a specified area. In Michigan, P.A. 40 of 1956, states that a county may, upon petition, establish a drainage board, whose composition it specifies, which is then authorized to create a drainage district for draingage, water and sewer facilities.

FINANCIAL EFFECTS OF INSTITUTIONAL ARRANGEMENTS FOR THE CRYSTAL LAKE STUDY AREA

Water quality problems and proposed solutions in the Crystal Lake area extend beyond municipal boundaries. Of the five arrangements listed above, joint contracts, special purpose districts, and contractual agreements would be the most suitable for the Study Area. The organization arrangement that is selected to administer, finance and implement the project will affect (1) the marketability of the bond, and (2) the administrative costs of the project. These alternative institutional arrangements are discussed below.

Joint Ownership and Special Purpose Districts

Both the joint ownership and special district arrangements provide a means for each participating village and township to share in the costs and benefits provided by the wastewater management system but would be acceptable only if the combined entities can devise a financial structure that will insure the marketability of the bond at a desirable interest rate. For the Crystal Lake Study Area, there are some disadvantages in the use of these institutional arrangements.

First, because Crystal Lake Township, Lake Township and Benzonia Township have no record of earnings for municipal sewerage facilities, it might be difficult to market either general obligation or revenue bonds. Second, previous bond issues for Frankfort, Benzonia Village and Elberta have been for small improvements in water systems, streets, and highways--too small for Moody's Bond Record and Standard and Poor's to rate. Therefore, an investor's ability to evaluate the community's resources to meet periodic principal and interest payments is impaired. Third, in the Socioeconomic Study Area a large proportion of the population with incomes below the poverty level are elderly or retired with limited or fixed incomes. In 1970, the date of the latest available statistics, approximately 20 % of all persons in the Study Area were 65 years or older. These characteristics will tend to reduce the ability of the community to meet debt service charges under adverse economic conditions.

Contracting for Service

A municipality or political subdivision may contract with other political subdivisions to acquire sewage disposal services (P.A. 129 of 1943). A variation of this statute, P.A. 42 of 1964 (Section 257.310a of Michigan Compiled Laws 1970) as amended, allows a county to acquire the facilities, issue bonds and charge participating jurisdictions for sewer services. There are financial advantages to this type of contractual arrangement for the Crystal Lake Study Area.

> County Bond Rate. Benzie County has a high-quality bond rating (AA). Since it has an established financial record, the market interest rate may be lower than sanitary district or joint ownership arrangements.

> Assessed Valuation. The County's total assessed property valuation is greater than the combined valuation of each political subdivision in the Study Area (see Table J-4-a). This would be reflected in the rate of interest for general obligation bonds supported by the full faith and credit of the county.

CONCLUSIONS

Alternatives for financing a wastewater management system in the Study Area and a range of investment strategies for policymakers to employ at the local level were outlined above. This section summarizes these options and recommends a strategy for financing the Crystal Lake system.

Institutional Arrangement

Municipal ownership, joint ownership, and special purpose districts should be avoided as an organizational approach to financing the proposed facilities in the Study Area. The best solution would enable the county to issue the bond, operate the system and charge the participating political subdivision for wastewater services. The major advantage of this approach is that the county can issue debt pledging the *full faith and credit of its economic resources to support the issue.* Such an arrangement would both make possible a lower interest rate and would most improve the marketability of the bond.

Table J-4-a
FINANCIAL CHARACTERISTICS OF THE LOCAL GOVERNMENTS
IN THE CRYSTAL LAKE STUDY AREA

	Benzie County	Benzonia Township	Crystal Lake Township	Lake Township	City of Frankfort	Benzonia Village	Beulah Village	Elberta Village
State Equalized Valuations	$83,663,635	$23,232,181	$15,549,174	$17,594,721	$10,419,600	$2,215,700	$4,647,934	$2,614,194
Total Revenues	2,130,441	95,752	469,799	29,835	791,468	136,280	179,380	131,579
Total Expenditures	1,874,846	94,731	464,889	30,315	780,399	111,868	144,185	164,333
Current Expense	1,726,429	88,748	N/A	30,183	755,143	N/A	N/A	N/A
Capital Outlay	148,417	5,983	N/A	132	25,256	N/A	N/A	N/A
Long Term Debt	140,000	N/A	N/A	N/A	178,000	109,000	85,000	4,000

Source: State of Michigan, Department of Treasury, Michigan County Government Financial Report, for the year ended December 31, 1974. Benzie County Equalization Division. Telephone interview, April 10, 1978.

Merskin and Merskin, Certified Public Accountants, Audited Statements - Benzonia Township, March 13, 1977.
Audit Report - Lake Township, March 31, 1976.
Audit Report - City of Frankfort, June 30, 1977.
Audit Report - Village of Benzonia, December 31, 1976.
Audit Report - Village of Beulah, December 31, 1976.

James J. Day, Certified Public Accountant, Audited Financial Statements - Crystal Lake Township, March 31, 1977.
Financial Statements - Village of Elberta, February 28, 1977.

Capital Costs

The alternative sewerage systems considered in this EIS are expensive and per capita costs are high. Pay-as-you-go financing strategies would clearly be inappropriate to finance the start-up costs for the facilities. (However, pay-as-you-go techniques might be used in the future to finance capital improvements. The future state of the economy, the cash flow position of the County and the nature of anticipated expenditures will be critical variables in determining whether capital improvements can be financed from current revenues.)

Reserve funds are usually intended to finance capital improvements at some future date. Still, a combination of capital reserve and pay-as-you-go approaches could finance construction of new low-cost facilities. However, unless Benzie County has a reserve fund earmarked for sewer and water expenditures, this method of financing current capital costs is presently not feasible for the Study Area.

Special benefit assessments would provide a viable way to finance improvements to those households that would benefit most directly from sewerage facilities. Or, the County could finance the collection component of these facilities with a special assessment tax and fund the remaining capital costs through a series of user charges.

The County should use general obligation bonds to finance the local share of system capital costs. This method will provide the lowest interest rate among alternative forms of debt financing. In addition, a serial bond should be tied to the general obligation bond to gain greater flexibility in marketing and arranging the County's debt structure.

FINANCIAL IMPACT OF ALTERNATIVE WASTEWATER SYSTEMS ON HOUSEHOLDS, COMMERCIAL ESTABLISHMENTS AND INDUSTRY

The traditional method of providing community sewerage facilities is to design and construct sewer lines that collect, transmit and deposit waste at a central treatment plant. For a rural area like Crystal Lake, however, where population density and per capita income are low, an expensive central treatment system can impose heavy financial burdens on the community and force lower-income residents to move.

A more cost-effective means of achieving areawide water quality objectives may lie in alternative subregional or decentralized systems. Decentralized and land disposal methods offer cost advantages because they do not entail secondary and advanced treatment facilities and because their operation and maintenance costs are low.

This appendix describes three ways the costs associated with a centralized sewer system and with the several alternative systems developed by WAPORA might be apportioned among the political jurisdictions in the Crystal Lake Study Area and summarizes the probable financial impacts of each alternative under three different apportionings on residential, commercial and industrial classes of users.

For the analysis, the costs of the collection and treatment components of each system were separated into capital and operating costs. Under one of the methods each of the cost sets was then apportioned among the jurisdictions. Next, the charges to residential, commercial and industrial classes of users within the several jurisdictions were calculated. In the third method, the costs were apportioned between seasonal and permanent residents to reflect the benefits accrued to each class of user. Finally, the charges for a given alternative become the price to its users.

COST OF COMPONENTS

Costs are divided into categories, or sets, that are described below. Costs for all items included in the collection and treatment components of each alternative wastewater management system are detailed in Appendix J-2. It is assumed that the capital portion of those costs will be covered by issuance of a bond.

- Capital Costs

  Interest and principal payments incurred by a General Obligation (G.O.) serial annuity bond for 30 years at an interest rate of 6 7/8% (see Appendix J-4 for a discussion of G.O. serial annuity bonds).

  (The interest rate on the general obligation bond was decided following a survey of counties in Michigan and consultation with the Benzie County bond attorney about trends. Interest rates on general obligation bonds for counties with a Moody's bond rating of AA have recently ranged between 5.5 and 6.3%, but they are expected to rise.)

- Operating Costs

    1) Personnel: salaries and wages

    2) Fringe benefits, including pension accruals

    3) Contractual services

    4) Materials and supplies

    5) Replacement of equipment

    6) Miscellaneous expenses.

- Private Costs

    Excavation, plumbing, and other one-time-only expenditures required to connect an individual household to the sewer collection line (see Appendix J-6).

- Future Costs

    Future capital and operating costs based on the population increases projected for each jurisdiction in the Study Area have been estimated by Arthur Beard and Associates. An average annual cost was calculated and used to estimate future cost patterns to the year 2000. These costs are discussed in Appendix J-7 but were omitted from this analysis of financial impacts because they will be borne by a different (future) population.

ANALYTIC FRAMEWORK

In order to establish the financial impact of the price of each alternative wastewater management system on residential, industrial and commercial classes of users and to arrive at an efficient, equitable rate structure for each class of user set of prices), three different basic approaches were employed to allocate capital and operating costs among jurisdictions and users.

- Proportionate Share Basis (PSB) -- Each jurisdiction in the Study Area shares in the total costs of the project in proportion to the specific benefits it receives from the facilities as measured by the volume of wastewater flow from each.

- Average Cost Basis (ACB) -- The total costs of the project are averaged across all jurisdictions in the Study Area. Charges to each household and commercial establishment are a share of the resulting average price.

- Seasonal/Residential Allocation (SPB) -- Total benefits are apportioned between seasonal and permanent households by a method based on wastewater flow.

PROPORTIONATE SHARE BASIS

The major concern with the ACB approach, which is based on benefits received, is the possibly uneven relationship between usage and costs. The cost factors for each of the alternatives must relate closely to benefits received. The following discussion illustrates the process in which a series of component cost and price sets (see below) is apportioned among Proposed Service Area jurisdictions and an efficient and equitable rate structure determined for various classes of users.

Apportionment of Costs

The division of operating and capital costs in the Study Area among political subdivisions and individual classes of users allocated was based on a combination of two factors: (1) volume of flow and (2) population.

- Volume of flow was used in this method (PSB): to apportion capital and operating costs for each alternative system and, within each system, to separate the costs attributable to the seasonal and the permanent populations. For this latter purpose the allocation scheme referred to below, attributing a weighted average of flow to each group, was employed.

- Population projections were used to determine the proportion of total costs allowable to those areas around Crystal Lake which would employ a decentralized sewerage management system under EIS Alternatives 3, 4, 5 or 6.

COMPONENT PRICE SETS

The allocation of costs by the flow and population variables determines the prices charges to each category of user. This allocation process is demonstrated in Tables J-5-a and b.

Table J-5-a lists the total annual capital and operating costs for the alternative systems.

For Alternative 1 the total annual capital costs of $982,400 (that is, annual principal and interest payments on the bond) was apportioned to the collection and treatment components by determining each component's proportion to total cost. The next step was to allocate the capital cost of each component to the political subdivisions in the Study Area. The criterion for allocation in Alternative 1 under this method was the volume of flow contributed by the population in each jurisdiction. Once the component capital costs were allocated by jurisdiction, a price was charged to the various classes of users by dividing the total capital costs of each component by the number of households and commercial establishments in each political subdivision. This same procedure was employed to allocate operating costs. Table J-5-b demonstrates the results of this analysis.

Table J-5-a

TOTAL ANNUAL CAPITAL (LOCAL SHARE) AND OPERATING COSTS
FOR PROPOSED AND ALTERNATIVE WASTEWATER FACILITIES

	Annual Debt Service	O&M	20% Crystal Reserve	Total
Facility Plan Proposed Action	828,000	181,400	165,612	1,175,000
Limited Action	59,400	120,200	11,900	191,500
EIS Alternative 1	671,400	252,900	134,286	1,058,600
EIS Alternative 2	602,100	208,400	120,426	931,000
EIS Alternative 3	249,200	151,800	49,800	450,800
EIS Alternative 4	235,300	106,800	47,100	389,200
EIS Alternative 5	245,500	156,400	49,100	451,000
EIS Alternative 6	207,500	143,900	41,500	392,900

Table J-5-b

TOTAL ANNUAL CHARGES BY CLASS OF USER FOR EACH
POLITICAL SUBDIVISION IN THE CRYSTAL LAKE STUDY AREA

	Unsewered Area		Frankfort and Elberta		
	Residential	Commercial	Residential	Commercial	Industrial
Facility Plan Proposed Action	720	1,300	110	260	25,500
Limited Action	50	90	100	230	22,940
EIS Alternative 1	650	1,170	90	210	20,600
EIS Alternative 2	590	1,080	60	160	15,750
EIS Alternative 3	220	400	100	230	22,950
EIS Alternative 4	180	330	100	235	23,350
EIS Alternative 5	240	440	90	210	20,560
EIS Alternative 6	190	350	100	230	22,940

Examination of total charges allocated to each class of user based on benefits received demonstrates the cost differentials associated with use of the system. Variations among household charges are sizable, with Alternative 2 exhibiting the largest variations between jurisdictions. As Frankfort and Elberta would be using their own collection and transmission sewers to transport the wastewater to the central treatment plant their annual charges would be relatively low.

The commercial category in Table J-5-b represents the average charge to commercial establishments in Benzonia Village and Frankfort. The allocations were based on the gallons per capita per day used by the 16 commercial outlets in Benzonia and the 47 establishments in Frankfort.

The industrial charge is based on the estimated flow of industrial wastewater from Frankfort. One firm accounts for all of the industrial waste in the Study Area. The total annual charge for the industry ranges from $15,750 (EIS Alternative 2) to $25,500 (Proposed Action).

AVERAGE COST BASIS

The average cost approach differs from the proportionate share method in that there is no relationship between usage and cost. Total costs are equally divided among jurisdictions and various classes of users. The advantage to this approach is that it is simple and straight forward and requires minimum administration. A major disadvantage is that one jurisdiction may subsidize the costs of another jurisdiction.

Under the average cost approach the capital and operating cost of the collection and treatment components are totaled, then divided by the number of households and commercial establishments in the seven jurisdictions to create a total average price for each class of user in the Study Area .

The average cost approach differs from the proportionate share basis in that in the former the differential costs associated with each political subdivision would be averaged across the entire Study Area. This averaging process, however, tends to distort the actual costs associated with provision of sewerage facilities. For example, the average annual household charge for the Proposed Action is $510. A comparison of this price with the prices charged households under the proportionate share approach (Table J-5-b) shows that the average cost basis would force Elberta and Frankfort to subsidize the sewer costs of the other political subdivisions in the Crystal Lake Study Area.

SEASONAL AND PERMANENT RESIDENTIAL COST ALLOCATIONS

Many of the residences in Benzonia Township, Lake Township and Crystal Lake Township are vacation homes, and a large proportion of the total population in these jurisdictions is estimated to be seasonal -- 52%, 89%, and 82% respectively.

Inasmuch as permanent residents benefit from wastewater facilities the year around while seasonal residents benefit only during the vacation months, a method was devised to account for the relative wastewater service benefits received by each group. The scheme employed 90-day flows for the seasonal resident and full-year flows for the permanent resident. The contributing flows from each group were assigned as weights in distributing operating costs for each alternative system.

The difference between the proportionate share technique and the seasonal/residential allocation is the split in charges between seasonal and permanent residents. Capital charges remain the same because capital costs were based on the number of dwelling units. However, operating costs were determined by the volume of wastewater flow contributed by permanent and seasonal residents. This is reflected in the total annual charge to both groups.

SUMMARY

The above analyses offer the policymaker three approaches to allocating costs associated with alternative wastewater management systems. The issues involved with each approach follow.

1. Average Cost Method

The average cost approach is probably not an appropriate method for allocating costs in this situation. Although the approach is simple and direct, it is equitable only when benefits approximate the average cost charged to each household. For the Crystal Lake Study Area, this is clearly not the case. As Table J-5-b indicates, there are built-in inequities, and the range of actual costs associated with benefits received varies considerably between jurisdictions and among alternatives.

However, if differences in costs among political subdivisions are relatively small, the average cost method of separating costs may be an acceptable approach to allocation. The policymaker must weigh the advantages of lower administrative cost against the loss of an equitable rate structure.

2. Proportionate Share Basis

The basis of this approach is that the costs of the facilities are shared by jurisdictions in proportion to benefits received from the system, measured, in the present analysis, by volume of flow from each of the political subdivisions. Although the PSB method provides a method of allocating costs more equitably than the ACB, there are some problems in relying exclusively on a flow factor to measure benefits. First, flow ignores the relative locations of the political subdivisions and the treatment plant. Transmission costs should reflect the distance that a community's waste is transported to the treatment facility. Second, flow disregards topography and the possibility that gravity sewers may need pump stations to push the wastewater flow to the treatment plant. Sewers that serve areas with irregular terrain will therefore tend to incur higher capital and operating costs. Third, the strength of the wastewater is an important cost factor, especially in industrial areas. High concentrations of corrosive acid or BOD may impose heavy burdens on secondary treatment facilities, accelerating the depreciation of equipment.

3. Seasonal/Permanent Basis

This method aims at an equitable allocation of system costs by charging seasonal and permanent residents rates equivalent to the benefits each group receives from the wastewater facilities. However, the SPB approach incorporates many of the same problems of inequity as the ACB method. Weighted costs for seasonal and permanent residents are averaged across the entire Study Area, but differential costs attributable to permanent and seasonal residents living within different jurisdictions are ignored.

PRIVATE COSTS

Private costs are estimated expenditures for connecting individual households to a sewer collection line. Private costs would be paid by only those households that need service lines to join the sewers, and the cost of each hookup would be the exclusive obligation of the household served. Households served by cluster and on-site systems (EIS Alternatives 3, 4, 5, and 6) would not incur this hook-up cost.

Table 1 presents the average private costs associated with each alternative system and the total first year average capital and operating expenditures for all households in the Crystal Lake Study Area. Private costs vary widely among the alternatives, ranging from a low of $50 for the Limited Action Alternative to a high of $1,720 for the Facility Plan Proposed Action Alternative. Considering the low per capita income levels among the jurisdictions around Crystal Lake, the high residential charges could cause the displacement of lower-income households.

Table J-6-1

AVERAGE PRIVATE AND TOTAL FIRST YEAR COSTS PER HOUSEHOLD

	Total Private Costs	Households	Private Costs Per Household	Annual User Charges	Total Cost
Facility Plan Proposed Action	1,384,000	1,334	1,000	720	1,720
Limited Action	0	0	0	50	50
EIS Alternative 1	0	0	0	650	650
EIS Alternative 2	0	0	0	590	590
EIS Alternative 3	803,000	803	1,000	220	1,220
EIS Alternative 4	803,000	803	1,000	180	1,180
EIS Alternative 5	803,000	803	1,000	240	1,240
EIS Alternative 6	497,000	497	1,000	190	1,190

NOTE: Private hook-up costs apply only to the currently unsewered portion of the Proposed Service Area.

FUTURE COSTS

Population growth would induce capital expenditures for new facilities. Arthur Beard and Associates has estimated future capital and operating costs to the year 2000 for each wastewater management alternative. Future costs associated with projected population growth are summarized below.

Capital costs in Table 7 represent the total cumulative costs in 1978 dollars for the construction and design of future collection sewers. Operating costs were derived on an annual basis by determining a linear gradient that increases at a constant rate each year. For the Proposed Action, operating costs would be zero in the year one and increase by $237 each year until the year 2000, when the costs would reach $4500 in 1978 dollars.

A number of options for financing future capital costs for the collection facilities are available to the county.

1. Finance through Current Revenues. As new facilities come on line, fund the capital and operating costs from surplus revenues.

2. Increase the Rate Structure. There are two alternatives with this approach. As population grows, increase the rates throughout the Study Area, or charge only those users who benefit from the new facilities. The funding mechanism could be either a tax on property or a direct user charge.

3. Create a Reserve Fund. Provide a cushion in the present rate structure to allow excess revenues to be deposited in a reserve fund and invested in order to accumulate sufficient funds to finance future capital improvements.

4. Provide Debt Financing. If the capital costs are relatively high, issue a bond and spread the costs across the entire Study Area or charge those users who benefit from the facilities.

Table J-7-a

FUTURE CAPITAL AND OPERATING COSTS FOR
EACH WASTEWATER ALTERNATIVE
(in 000's dollars)

	Capital Costs	Operating Costs	Gradient
Proposed Action	2467.4	0 - 4.5	.2368
Limited Action	1076.0	0 - 2.5	.1316
Alternative 1	2717.1	0 - 9.5	.4989
Alternative 2	2717.1	0 - 9.5	.5000
Alternative 3	1885.0	0 - 4.8	.2526
Alternative 4	1885.0	0 - 4.8	.2526
Alternative 5	1885.0	0 - 4.8	.2526
Alternative 6	1550.9	0 - 4.8	.2526

APPENDIX
K

MANAGEMENT OF SMALL WASTEWATER SYSTEMS OR DISTRICTS

SOME MANAGEMENT AGENCIES FOR DECENTRALIZED FACILITIES

Central management entities that administer non-central systems with various degrees of authority have been established in several States. Although many of these entities are quasi-public, few of them both own and operate each component of the facility. The list of small waste flow management agencies that follows is not comprehensive. Rather, it presents a sampling of what is currently being accomplished. Many of these entities are located in California, which has been in the vanguard of the movement away from conventional centralized systems to centrally managed decentralized systems to serve rural areas (State of California, Office of Appropriate Technology, 1977).

Westboro (Wisconsin Town Sanitary District)

Sanitary District No. 1 of the Town of Westboro represents the public ownership and management of septic tanks located on private property. In 1974 the unincorporated community of Westboro was selected as a demonstration site by the Small Scale Waste Management Project (SSWMP) at the University of Wisconsin to determine whether a cost-effective alternative to central sewage for small communities could be developed utilizing on-site disposal techniques. Westboro was thought to be typical of hundreds of small rural communities in the Midwest which are in need of improved wastewater treatment and disposal facilities but are unable to afford conventional sewerage.

From background environmental data such as soils and engineering studies and groundwater sampling, it was determined that the most economical alternative would be small diameter gravity sewers that would collect effluents from individual septic tanks and transport them to a common soil absorption field. The District assumed responsibility for all operation and maintenance of the entire facility commencing at the inlet of the septic tank. Easements were obtained to allow permanent legal access to properties for purposes of installation, operation, and maintenance. Groundwater was sampled and analyzed during both the construction and operation phases. Monthly charges were collected from homeowners. The system, now in operation, will continue to be observed by the SSWMP to assess the success of its mechanical performance and management capabilities.

Washington State

Management systems have been mandated in certain situations in the State of Washington to assist in implementing the small waste flow management concept. In 1974 the State's Department of Social and Health Services established a requirement for the management of on-site systems: an approved management system would be responsible for the maintenance of sewage disposal systems when subdivisions have gross densities greater than 3.5 housing units or 12 people per acre (American Society of Agricultural Engineers 1977). It is anticipated that this concept will soon be applied to all on-site systems.

Georgetown Divide (California) Public Utility District (GDPUD)

The GDPUD employs a full-time geologist and registered sanitarian who manage all the individual wastewater sytems in the District. Although it does not own individual systems this district has nearly complete central management responsibility for centralized systems. The Board of Directors of the GDPUD passed an ordinance forming a special sewer improvement district within the District to allow the new 1800-lot Auburn Lake Trails subdivision to receive central management services from the GDPUD. The GDPUD performs feasibility studies on lots within the subdivision to evaluate the potential for the use of individual on-site systems, designs appropriate on-site systems, monitors their construction and installation, inspects and maintains them, and monitors water quality to determine their effects upon water leaving the subdivision. If a septic tank needs pumping, GDPUD issues a repair order to the homeowner. Service charges are collected annually.

Santa Cruz County (California) Septic Tank Maintenance District

This district was established in 1973 when the Board of Supervisors adopted ordinance No. 1927, "Ordinance Amending the Santa Cruz County Code, Chapter 8.03 Septic Tank System Maintenance District." Its primary function is the inspection and pumping of all septic tanks within the District. To date 104 residences in two subdivisions are in the district, which collects a one-time set-up fee plus monthly charges. Tanks are pumped every three years and inspected annually. The County Board of Supervisors is required to contract for these services. In that the District does not have the authority to own systems, does not perform soil studies on individual sites, or offer individual designs, its powers are limited.

Bolinas Community (California) Public Utility District (BCPUD)

Bolinas, California is an older community that faced an expensive public sewer proposal. Local residents organized to study the feasibility of retaining many of their on-site systems, and in 1974 the BCPUD Sewage Disposal and Drainage Ordinance was passed. The BCPUD serves 400 on-site systems and operates conventional sewerage facilities for 160 homes. The District employs a wastewater treatment plant operator who performs inspections and monitors water quality. The County health administration is authorized to design and build new septic systems.

Kern County (California) Public Works

In 1973 the Board of Supervisors of Kern County, California, passed an ordinance amending the County Code to provide special regulations for water quality control. County Service Area No. 40, including 800 developed lots of a 2,900-lot subdivision, was the first Kern County Service Area (CSA) to arrange for management of on-site disposal systems. Inspections of installations are made by the County Building Department. Ongoing CSA responsibilities are handled by the Public Works Department. System design is provided in an Operation and Maintenance Manual.

Marin County (California)

In 1971 the Marin County Board of Supervisors adopted a regulation, "Individual Sewage Disposal Systems," creating an inspection program for all new installations (Marin County Code Chapter 18.06). The Department of Environmental Health is responsible for the inspection program. The Department collects a charge from the homeowner and inspects septic tanks twice a year. The homeowner is responsible for pumping. The Department also inspects new installations and reviews engineered systems.

LEGISLATION BY STATES AUTHORIZING MANAGEMENT OF SMALL WASTE FLOW DISTRICTS

In a recent act, the California legislature noted that then-existing California law authorized local governments to construct and maintain sanitary sewerage systems but did not authorize them to manage small waste flow systems. The new act, California Statutes Chapter 1125 of 1977, empowers certain public agencies to form on-site wastewater disposal zones to collect, treat, and dispose of wastewater without building sanitary sewers or sewage systems. Administrators of such on-site wastewater disposal zones are to be responsible for the achievement of water quality objectives set by regional water quality control boards, protection of existing and future beneficial uses, protection of public health, and abatement of nuisances.

The California act authorizes an assessment by the public agency upon real property in the zone in addition to other charges, assessments, or taxes levied on property in the zone. The Act assigns the following functions to an on-site wastewater disposal zone authority:

- To collect, treat, reclaim, or dispose of wastewater without the use of sanitary sewers or community sewage systems;
- To acquire, design, own, construct, install, operate, monitor, inspect, and maintain on-site wastewater disposal systems in a manner which will promote water quality, prevent the pollution, waste, and contamination of water, and abate nuisances;
- To conduct investigations, make analyses, and monitor conditions with regard to water quality within the zone; and
- To adopt and enforce reasonable rules and regulations necessary to implement the purposes of the zone.

To monitor compliance with Federal, State and local requirements an authorized representative of the zone must have the right of entry to any premises on which a source of water pollution, waste, or contamination including but not limited to septic tanks, is located. He may inspect the source and take samples of discharges.

The State of Illinois recently passed a similar act. Public Act 80-1371 approved in 1978 also provides for the creation of municipal on-site wastewater disposal zones. The authorities of any municipality (city, village, or incorporated town) are given the power to form on-site wastewater disposal zones to "protect the public health, to prevent and abate nuisances, and to protect existing and further beneficial water use." Bonds may be issued to finance the disposal system and be retired by taxation of property in the zone.

A representative of the zone is to be authorized to enter at all reasonable times any premise in which a source of water pollution, waste, or contamination (e.g., septic tank) is located, for the purposes of inspection, rehabilitation and maintenance, and to take samples from discharges. The municipality is to be responsible for routinely inspecting the entire system at least once every 3 years. The municipality must also remove and dispose of sludge, its designated representatives may enter private property and, if necessary, respond to emergencies that present a hazard to health.

MANAGEMENT CONCEPTS FOR SMALL WASTE FLOW DISTRICTS

Several authors have discussed management concepts applicable to decentralized technologies. Lenning and Hermason suggested that management of on-site systems should provide the necessary controls throughout the entire lifecycle of a system from site evaluations through system usage. They stressed that all segments of the cycle should be included to ensure proper system performance (American Society of Agricultural Engineers 1977).

Stewart stated that for on-site systems a three-phase regulatory program would be necessary (1976). Such a program would include: 1) a mechanism to ensure proper siting and design installation and to ensure that the location of the system is known by establishing a filing and retrieval system; 2) controls to ensure that each system will be periodically inspected and maintained; and 3) a mechanism to guarantee that failures will be detected and necessary repair actions taken.

Winneberger and Burgel suggested a total management concept, similar to a sewer utility, in which a centralized management entity is responsible for design, installation, maintenance, and operation of decentralized systems (American Society of Agricultural Engineers 1977). This responsibility includes keeping necessary records, monitoring ground and surface water supplies and maintaining the financial solvency of the entity.

Otis and Stewart (1976) have identified various powers and authorities necessary to perform the functions of a management entity:

- To acquire by purchase, gift, grant, lease, or rent both real and personal property;
- To enter into contracts, undertake debt obligations either by borrowing and/or by issuing bonds, sue and be sued. These powers enable a district to acquire the property, equipment, supplies and services necessary to construct and operate small flow systems;
- To declare and abate nuisances;
- To require correction or private systems;
- To recommend correction procedures;
- To enter onto property, correct malfunctions, and bill the owner if he fails to repair the system;
- To raise revenue by fixing and collecting user charges and levying special assessments and taxes;
- To plan and control how and when wastewater facilities will be extended to those within its jurisdiction;
- To meet the eligibility requirements for loans and grants from the State and Federal government.

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