SEPTIC LEACHATE SURVEY

DETROIT LAKES, MINNESOTA

September, 1980

Prepared for

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1.0 INTRODUCTION

During September, 1980, K-V Associates performed a septic leachate survey on Detroit Lake, Sallie Lake and Melissa Lake in Lakeview Township, Minnesota. The survey area comprised the entire unsewered shorelines of Sallie and Melissa Lakes, and only the eastern unsewered shoreline of Detroit Lakes. The survey provided documentation of wastewater impacts necessary for the facilities plan development of Rieke, Carroll, Muller, Inc., engineering design firm of Hopkins, Minnesota.

The field investigation determined the position and frequency of plume discharges into lakeshore waters as well as the relative quality of selected drinking water wells of shorefront property owners. Groundwater direction and flow rates were obtained at fifty-three sand beach measurement sites around the three lakes. Plots of the resultant vectors agreed well with the expected flow lines (northeast to southwest) and give a better definition of shallow groundwater infiltration and exfiltration patterns around the various shore sections. Sixty-nine representative well samples from around the lakes showed noticeable variability in drinking water quality.

2.0 METHODOLOGY

The field team of two scientists performed the continuous shoreline leachate scans in a counter-clockwise direction around the Detroit Lakes. The basic equipment platform was a 14-foot aluminum skiff with small outboard. Portable equipment included the battery-powered leachate detector instrument, hand-driven well points with plastic water sampler filtration apparatus, and field chemical test kits.

As a routine, the team first surveyed each lake with the leachate detector gear, taking appropriate center and background discrete water samples from areas showing no obvious indications of pollution. At those points along the shore where the instrument recorded a significant event above background, the crew secured surface and groundwater samples while charting location and logging any supporting visual observations of the local surroundings. The team walked or motored the boat around the lake within 5 feet of shore in shallow water. Specific conductance of each sample was measured on the boat as each sample was prefiltered and bottled. Each groundwater plume location was profiled vertically by conductivity with at least two groundwater sampling depths taken for each plume in search of local maximum conductivity level characteristic of core centers. Relative fluorescence and conductivity signals were continuously plotted on a dual strip recorder while a separate circuit and recorder highlighted significant co-varying excursions of these two parameters. Positional cross-references were made to detail maps of the lake areas provided by Lake View Township.

After completing the leachate survey of a lake, the team returned for bacterial sampling of selected plumes and surface flows, and took groundwater flow data in the beach sand at distributed points around the lakes.

2.1 Sample Handling

Both ground and surface water samples were collected in the field at plume locations during the septic leachate survey. Water samples of 250 ml for nutrient analysis were filtered to .45 μm and acidified with .5 ml concentrated H_2SO_4. The samples were kept chilled pending nutrient analyses at Falmouth, Massachusetts. Screening tests performed on locations included qualitative determinations for presence of orthophosphate and methylene blue active substances (MBAS).

Bacterial water samples were collected in sterilized plastic bottles at selected plume locations and stream inflows or outflows. These samples were shipped the day of collection to Feed-Rite Controls, Inc. (laboratory) in Minneapolis, Minnesota to be analyzed for fecal coliform bacteria content.

2.2 Leachate Detector Calibration

The shoreline scanning work day began with calibration of the septic leachate instrument. Two solutions were required: the first, a blank sample drawn from an unaffected central portion of the lake; and the second, a sample of Detroit Lakes Sewage Treatment Lagoon effluent. Calibration was by method of additions, a 2% addition of effluent to center water being scaled to cover an arbitrary (up to 50) percent of full meter span for each channel. Sixty ml of effluent was added to 3 liters of background water and recirculated for a dynamic calibration.

2.3 Groundwater Flow Measurements

The survey team utilized the K-V Associates, Inc. Model 10 Dowser groundwater flow meter. To obtain flow measurements, two to three shallow holes were dug to groundwater at each site along sandy shores at spaced intervals around the lakes. The sensor unit of the probe head was inserted about three inches into loose saturated sand substrate. The battery-powered unit required about three minutes to give digital information of flow velocity from which direction was resolved. The unit was calibrated in a simple flow chamber using local beach sand.

2.4 Well Water Sampling

Occupied homes surrounding the lakes were petitioned for samples of untreated well water, particularly those homes in low-lying areas or regions along southern shores where lake water was expected to exfiltrate, and thus shore plumes were not expected. These drinking water samples were screened on the septic leachate detector which was calibrated to a scale where 0% = Detroit Lakes municipal water supply and 100% = a Detroit Lakes municipal treatment lagoon sample. Well samples exceeding 10% scale were worthy of further analysis by field testing for orthophosphate and MBAS, and quantitative laboratory analysis for nitrate and ammonium as nitrogen, and iron.

3.0 PLUME LOCATIONS

3.1 Data Evaluation

With "plume" broadly defined as any emergent pocket of water (from stream or bottom) different from the surrounding background lakewater, the septic leachate survey is directed to distinguishing domestic wastewater plumes from other numerous sources, point and non-point.

The septic leachate detector is the first level of detection, being most sensitive to parameters of fluorescence and conductivity as characteristics of sewage effluent, with bog fluorescence as a common interference. The second level of separation is discrete water sampling for chemical nutrient analysis at locations highlighted by the leachate detector. High levels of nitrates and especially phosphorous point up an emerging nutrient source capable of stimulating productive plant growth. A third level of isolation of the effluent plume is spectrum scanning of the water sample on a laboratory fluorometer which more definitively emphasizes optical differences in chemical properties between effluent and bog which is a common interference and natural source. Additional tests for high mineral salts loading (conductivity) and positive signs of presence of methylene blue active substances (eg. surface active agents common to synthetic detergents) also point up plumes of unnatural origin.

3.2 Map Presentation

The results of the septic leachate and ground water surveys are graphically presented on four large scale maps, Figures 1 through 4. Plume location maps show not only whether plume waters discovered by the leachate detector were broadly dispersed and not actually sampled or discretely

emerging (and sampled) from a shoreline, but also reflect a further evaluation of the nature of the sampled plume: a darkened symbol indicating a significant fluorescent spectrum fingerprint of effluent, as opposed to an unshaded symbol which indicates either a bog or non-effluent pattern. Bacterial sampling locations likewise relate the strength of the fecal coliform colonies found.

3.3 Tabular Data Presentation

Numerical and coded data from the septic leachate, well water and groundwater surveys are listed in a separate appendix by lot owner for each lake. Lakeview Township prepared the master listing of owners, each owned lot group being assigned a number in clockwise sequence around a lake. The Overall Plume Assessment is a summary rating assigning a + for positive effluent potential in each of five evaluation groups: septic leachate detector scan, lab fluorescence spectrum, nutrient level, conductivity, and MBAS/PO_4 field test results. The (+) represents an unconfirmed effluent plume.

3.4 Discussion

3.4.1 Detroit Lake

Big Detroit Lake was surprisingly free of plumes, especially the southern and eastern shores. Only along Burritt Beach to the southeast was a broadly dispersed plume detected very close to the shoreline. In the areas sampled, both phosphorous and nitrate levels were very low, less than .019 and .015 ppm respectively. Unoxidized nitrogen as ammonia in groundwaters was more variable, up to 9.5 ppm even in nominal background areas with no surface indication of a plume. The survey did confirm groundwater infiltration along the length of the broad plume area of Burritt Beach, which is flanked

by two samll streams bearing traces of effluent and higher phosphorous (.019 - .042 ppm TP.)

3.4.2 Lake Sallie

Total phosphorous and orthophosphate levels in Lake Sallie surface water are, overall, significantly higher (average .075 ppm) than either Detroit Lake (.012 ppm) or Lake Melissa (.014 ppm). The eutrophic condition of this weed choked lake has long been known. However, only a discrete handful of groundwater plumes could be confirmed. At least seven of these did show signs of effluent content by lab analysis.

While the lake bottom sediments appear to be leaching nutrients as a result of the past years of receiving effluent-charged Pelican River inflows (likely traceable to St. Clair Lake) the actual frequency of shoreline currently emergent effluent plumes is quite low. The Pelican River issuing from Muskrat Lake had a higher intensity of effluent and bog components (by fluorescent scan) than any other Lake Sallie surface water sample, however, its total phosphorous concentration at .029 ppm was one-third the lake body of .075 ppm.

At one particular plume location (lot 76) the shore was clogged with weeds and the air rife with the odor of hydrogen sulfide. Effluent indications were very strong in the groundwater sample. A seasonal cottage on the site was set back less than 50 feet from the shore on low ground. Elsewhere, isolated patches of algae were noted at plume site lot 15; total phosphorous levels here were high (.126 ppm surface, .373 ppm groundwater). No secondary stream inflows or outflows were found around Lake Sallie.

We found no plumes along Blom Beach or Chautauqua Beach. This is consistent with measured lakewater exfiltration through the Shoreham district to the south. Notably, at least seven wells in Shoreham bore some abnormal level of the effluent fluorescent imprint.

Numerous plume locations appeared around the perimeter of Lake Melissa, including two small stream inflows and the Pelican River. The most extensive regions of emergent plumes occurred along the western and northern shores of the lake. An emergent plume sampled at Shotwell Point showed excessively elevated phosphorous levels. Just north and upgradient of the groundwater flow, numerous well sites were found to contain traces of wastewater effluent. Samples from broad plume bands along Fern Beach and in the vicinity of Hilmers' Resort/Macs' Landing did have strong effluent fluorescent profiles, often in the presence of considerable bog leachate. Strong groundwater infiltration rates coincide with these areas. The broad plume along Charmony Beach is conceivably related by groundwater migration to the distant cluster field situated on top of a hill across highway 17, although future inland sampling should be conducted to substantiate the source.

The emergent wastewater plumes in the vicinity of Shotwell Point and the condition of the inflow stream on the north side of Lake Melissa are related to the high rate of wastewater loading and soil conditions in the land region between Lake Sallie and Lake Melissa. Private well samples for the region showed about 50% presence of effluent. Similar circumstances appeared associated with the numerous discharges found in the Laguna Bay vicinity. Here also, private well waters were impacted.

3.4.4 Lakewater Bacteria and Well Water Results

No lakeshore samples for bacterial contamination exhibited a fecal coliform count in excess of 100 colonies per 100 ml of water.

No well water samples contained nitrate-nitrogen concentrations in excess of 1 ppm, far below the safe drinking water limit of 10 ppm NO_3-N. Shoreham well samples did have an iron (Fe) content on the order of 3.5 ppm and in at least one case, higher than normal total phosphorous (.5 ppm) and ammonia-nitrogen (3.6 ppm). Well water sampling analyses appear in the tabular appendix.

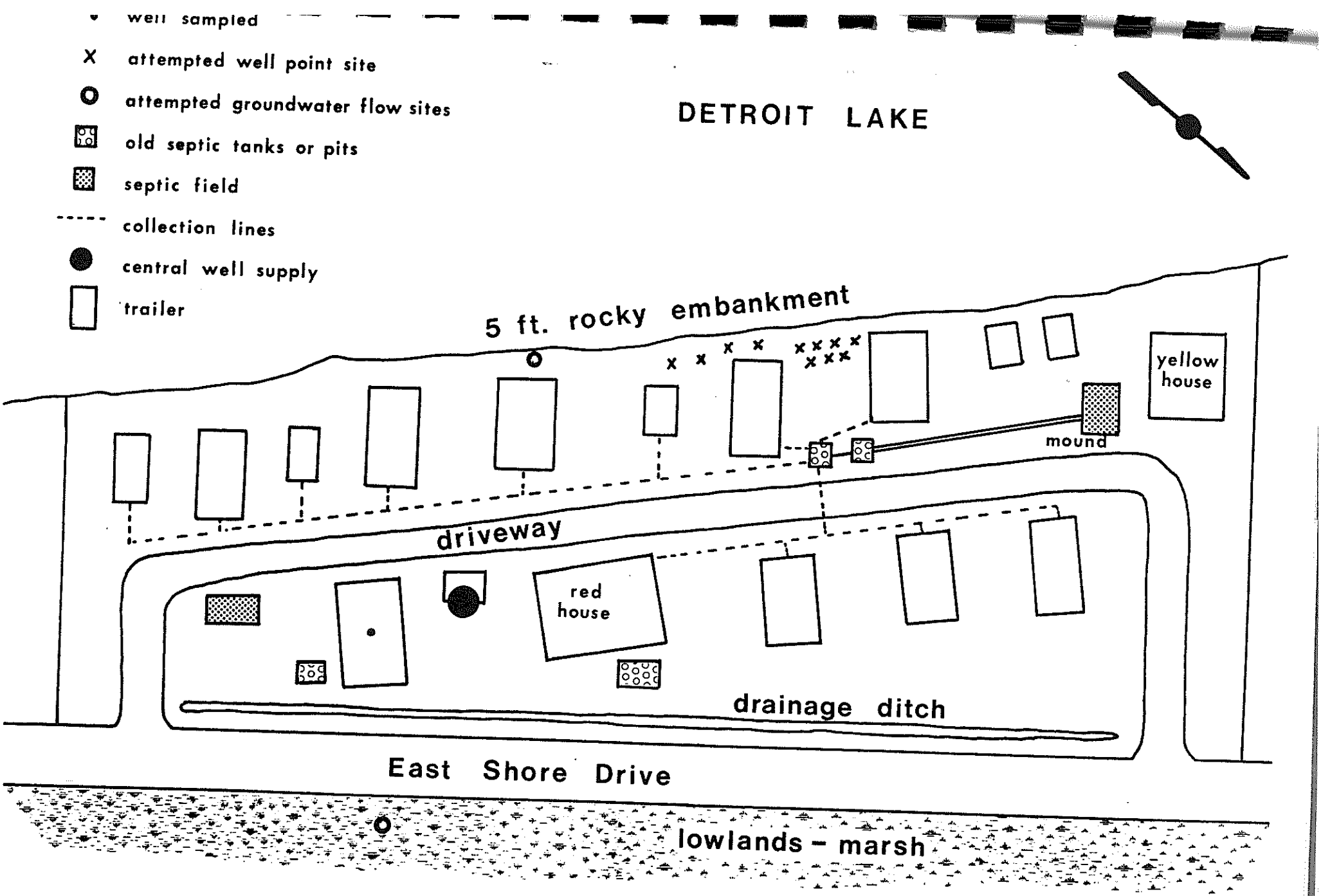


Fig. 5 Specific examination of Sayre's Trailer Park, a high density, low lying residential area along the eastern shore of Detroit Lakes. Rocky fill precluded successful groundwater and well point testing.

3.4.5. Special Study: Sunset Trailer Park, Detroit Lake

Septic leaching to lakewaters could not be definitely confirmed at this popular east shore Detroit Lake trailer park, despite followup on-site study. Sunset Trailer Park is a cluster of residential trailer dwellings along highway 24. As an area of concentrated domiciles, most within 50 feet of the shore and perched some six feet above the water table, this trailer park warranted further investigation for signs that its domestic waste water might be reaching either the lake shore or drinking supply wells. The continuous shoreline leachate detection scan had not turned up any positive indications; thus, the followon approach was to test for plume evidence in the water wells and via well-point samples of groundwater surrounding known septic tank installations.

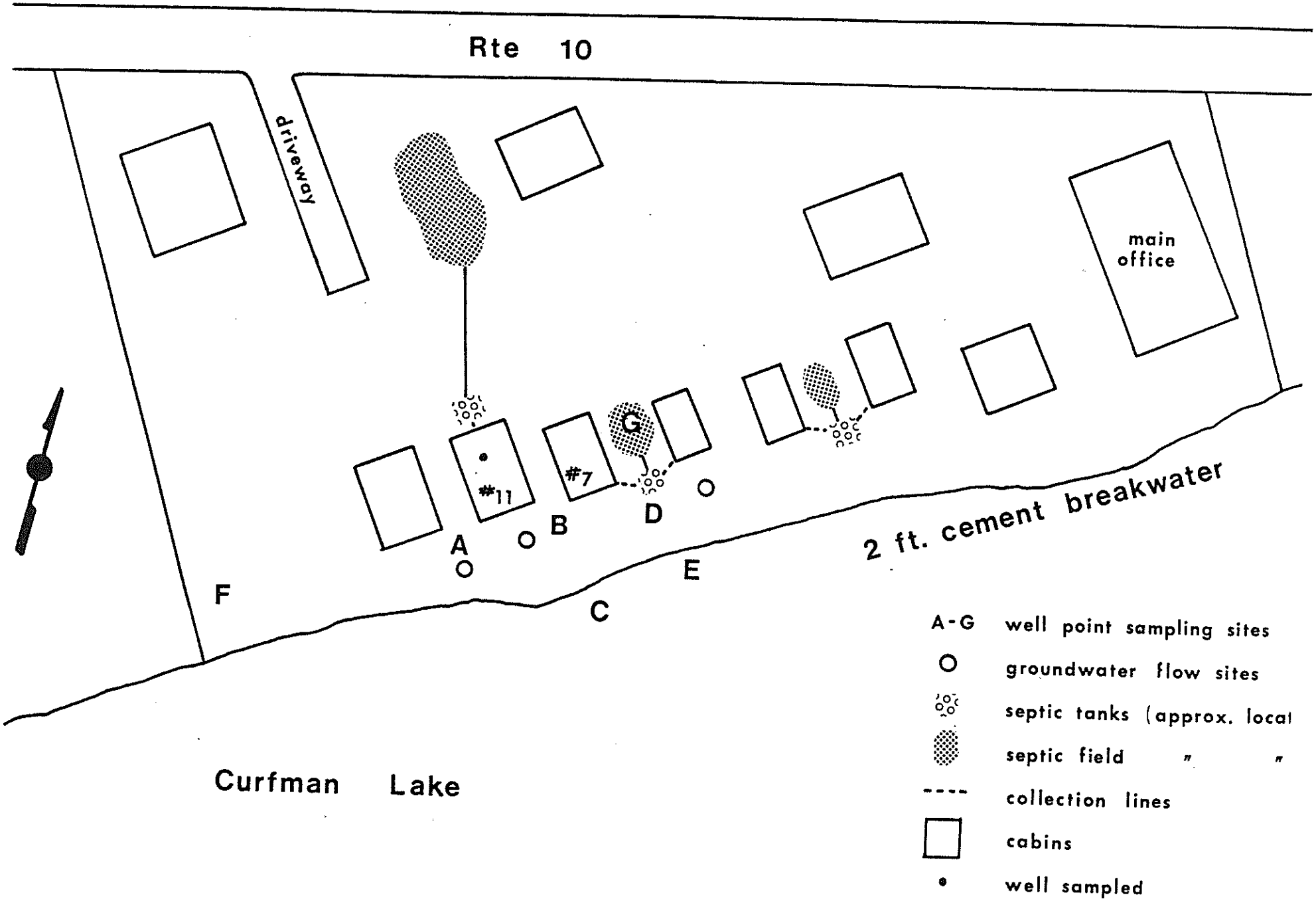
Mr. Sayre, the current owner, related a brief history of the septic field installations. The rough layout of known systems is portrayed in Figure 5. This low lying area had been built up to its present elevation with a rocky fill. The shore embankment is strewn with cobblestones. Our attempts to perform ground water flow measurements and penetrate with the well point sampler were completely frustrated by the compact stoney substrate. One measurement taken outside the park area in a peat marsh across the road showed no detectable flow.

According to Mr. Sayre, most of the old primitive septic leaching pits located beside individual trailers have been abandoned, supplented by collection lines and septic tank system in questionable repair and the overflow pumped to a relatively new mound system as illustrated in Figure 5. Suspected leakage from the old tank could not be directly confirmed.

Samples of the central well supply for the trailer park registered

Sandy loam soil was amenable to groundwater and well point testing.

H (background location) open field



baseline when tested in the septic leachate detector against a scale of municipal tap water (base) to 100% municipal effluent.

3.4.6 Special Study: Baywood Resort, Detroit Lake

Baywood Resort is a cluster of seasonal cottages situated along the northern shore of Curfman Lake (see Figure 6). Characterized by a shallow depth to groundwater (approximately 3 feet on the lake side of the cottages), the Baywood site is part of a broad point of lowlands between the two lobes of Detroit Lake. Groundwater flow measurements gave no indication of significant water table migration through the Baywood area. Despite the high seasonal occupancy rate of Baywood Resort's several cabins with their associated grey water and black water waste leaching fields, the septic leachate detector did not pick up a verifiable plume immediately off shore. Weed growth is prevalent in Curfman Lake and soils are organic mixed with sand. Well point samples drawn from the shoreside terrace in front of the cottages showed the following:

a) Uniform conductivity (600 μmho/cm) at all sites except G, a known septic field.

b) Positive levels of orthophosphate at all sites except A.

c) Sample G (septic field) showed a very distinct effluent spectral profile, all others showing substantial effluent components in the presence of strong bog profiles. Background sample #14 had a low bog level.

Fluorescence analysis revealed that the well water source at Baywood Resort is impacted by effluent. This water ranked near the top in phosphorous content (.4 ppm TP and PO_4-P) of all wells tested.

Thus, although, we could find no trace of a waste water plume actually entering lakewater, it is likely the groundwater around Baywood cabins is saturated with effluent.

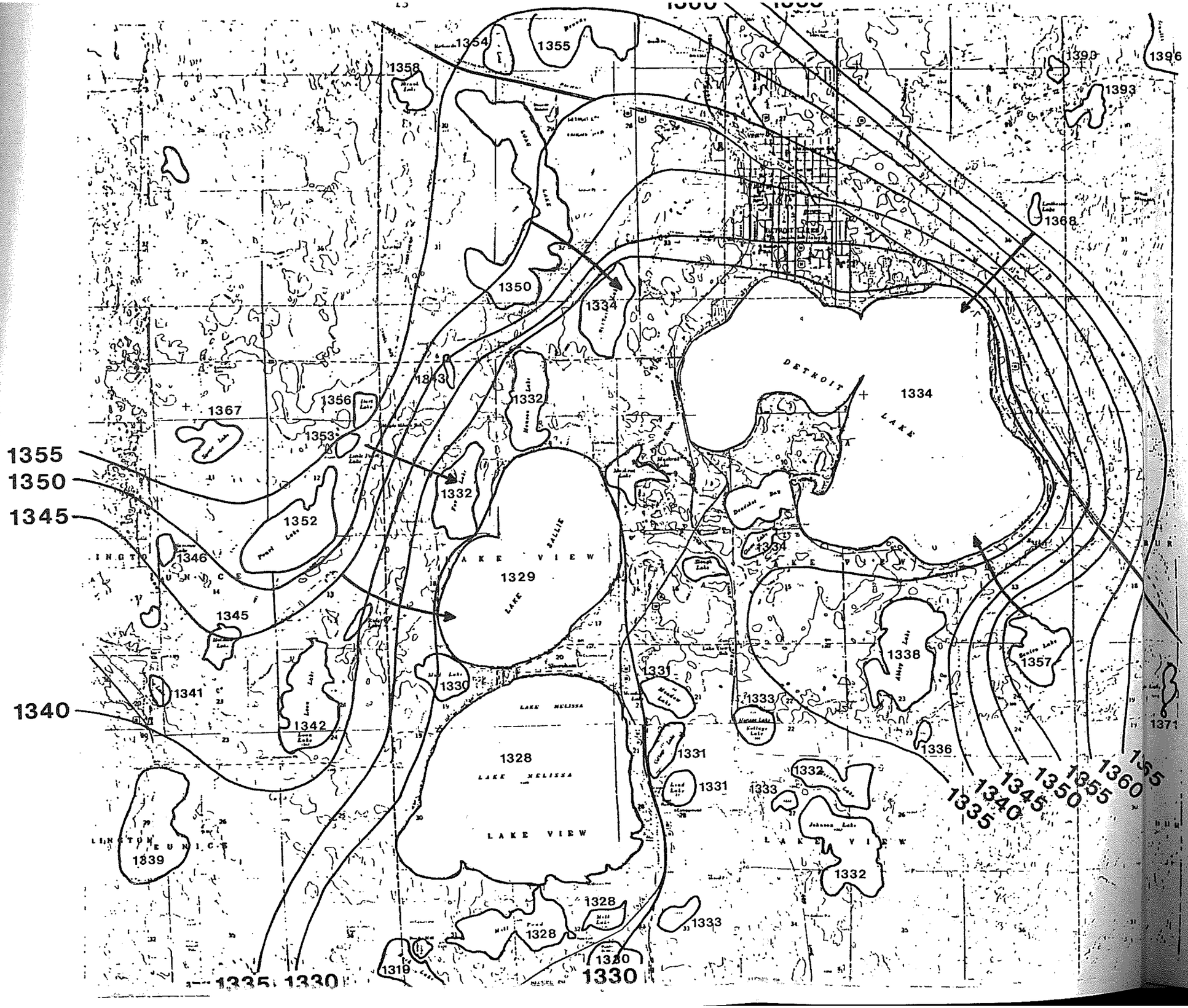


Figure 7:

Projected groundwater flow gradients around the Detroit Lakes, Becker County, Minnesota. Based upon USGS map, (1975).

4.0 GROUNDWATER FLOW DETERMINATIONS

Detroit, Sallie and Melissa Lakes are surrounded by smaller lakes and wetland marshes and are connected by the south-flowing Pelican River. The importance of groundwater flow detection relates to gauging the liklihood of slow-moving subterranean currents for entraining septic leachate waters toward or away from lakeshores and drinking water wells.

A preliminary overview of expected flow patterns was produced using the 1975 USGS map of the lake areas within Detroit and Lakeview Townships. An elementary flow net analysis based upon the USGS elevations of regional open water bodies projected these three main lakes as large recharge wells with overall drainage in the northeast to southwest direction. Figure 7 clearly presents the equipotential lines of the general water table and anticipated lines of flow.

This groundwater field survey was a direct measuring effort for immediate lakeshores for the water table conditions of September, 1980, the lake levels being lower than normal due to drought during the past winter and summer. Surface water flows to and from the three large lakes are relatively low volume. Historically, these lakes were more directly linked with open navigable rivers. The low-lying (Shoreham) area between Sallie and Melissa has long since been filled in and developed.

4.1 Detroit Lake

Flow meter measurements revealed groundwater inflows to the lake as measured at three sites along the southeast shore, Phillips and Burritt Beaches. Southerly outflows from the lake were detected in at least two locations, the southmost ends of Holcomb and Phillips Beaches. A total of thirteen sites on east and west shores failed to yield a discernable flow

direction. Figure 2 displays the vector results. Rock and gravel-laden soils forming beachless shorefront embankments prevented groundwater flow measuring over long stretches of the eastern lake shore. Soils encountered along the western shore of Big Detroit were characterized by cut-and-fill material over old organic marsh soils to the north, and sand-gravel slopes to the south. The region backing the shore development along Rt 114 is a low wetland area.

Substrate soils underlying the Phillips and Burritt Beach developments are highly uniform, permeable coarse sand. Vectors drawn at these sites were quite reproducible.

4.2 Sallie Lake

Thirteen sites were visited for groundwater flow measurement around Lake Sallie: two sites each showed flow into Lake Sallie opposite Munson Lake and opposite Fox Lake; two southernmost sites straddling the outflowing Pelican River indicated exfiltration in the direction of Lake Melissa; and, five sites generated no-flow indications (see figure 4). Shoreside soil conditions ranged from coarse sand to sand/gravel, generally quite permeable. Flows were not detected opposite Mud Lake which appeared to be at equal elevation to Lake Sallie at this time of the year. No secondary streams or pipes were evident around the shoreline of Lake Sallie.

4.3 Lake Melissa

Once again, infiltration patterns were the norm on all but the southern shores of Lake Melissa, with a total of 20 sites measured. Figure 4 shows the changing flow directions around the lake. Ten sites divulged groundwater flowing towards the lake, at points including Elm Grove, Linden Park,

Fern Beach and Galusha Bay. Two areas, Lakeview Beach and the Harold Olson property were confirmed as cases where lake water exits through the shore bottom towards a southerly drainage. At 8 of the 20 sites a predominant vector could not be obtained (no-flow). Overall, the conditions of uniform coarse sand around Lake Melissa were conducive to reliable flow determinations.

Other than the Pelican River, only two small streams (in Galusha Bay and at Lakeview Beach) were found to enter Lake Melissa.

5.0 CONCLUSIONS

A septic leachate survey and groundwater flow study was conducted along the shorelines of Detroit Lake, Lake Sallie and Lake Melissa, Becker County, Minnesota during September, 1980. The following observations were obtained from the shoreline leachate profiles, analyses of groundwater and surface water samples, and evaluation of groundwater flow patterns:

1. On Detroit Lake, the highest frequency of plume occurrence is along the southeast shore, Burritt Beach, 1st and 2nd Additions. Sunset Trailer Park and Baywood Resort could not be confirmed as effluent contributors to lakewaters.

2. Lake Sallie suffers from widespread phosphorous enrichment traceable to effluent in its bottom sediments, but currently emerging plumes are few.

3. Lake Melissa has several stretches of continuous plume activity along its shoreline. The most notable area for effluent potential was found to be Fern Beach and, secondarily, Shotwell Beach and Galusha Bay.

4. Fecal coliforms concentrations in lakewater were very low. In only two of twenty-three sampling locations, did the count reach 100 colonies/100 ml water.

5. Nitrate levels in drinking water of shoreside residents fell far below the 10 ppm NO_3-N safe drinking water maximum standard. However, fluorescent signatures of effluent were found in 25 of 61 wells actually sampled.

6. Lake Sallie was confirmed as the vegetatively more productive lake of the three, its total phosphorous load in surface water more than 5 times

that of the other lakes. Pelican River Inlet water was lower in phosphorous, with high levels found in almost all lake bottom sediments. This suggests a steady leaching of nutrients most related to a past bulk overloading of (sewage) than attributable to current shoreside dwelling with on-site waste disposal systems.