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HYDROGEOLOGIC INVESTIGATION STABILIZATION POND

ITASCA STATE PARK MINNESOTA

Minnesota
DEPARTMENT OF NATURAL RESOURCES

NOVEMBER 1980

EUGENE A. HICKOK AND ASSOCIATES

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November 26, 1980

Mr. Keith C. Englesby, P.E.
Engineering Coordinator
Department of Natural Resources
Bureau of Engineering
444 Lafayette Road - 4th Floor
St. Paul, Minnesota 55101

Re: Hydrogeological Investigation
Stabilization Pond
Itasca State Park, Minnesota

Dear Mr. Englesby:

We are pleased to submit herewith an Hydrogeologic Investigation for the Stabilization Pond for the Itasca State Park.

This report is in response to concern by the Minnesota Department of Natural Resources about the use of the Itasca Stabilization Pond as an adequate sewage treatment system. The Department has also indicated a comparative interest in similar pond usage at other state parks.

The study consisted of constructing nine groundwater monitoring wells, providing chemical analysis of surface and subsurface water, conducting a permeability study of the pond, and characterization of the wastewater introduced into the pond.

The objectives of the project: 1) to define the impact of the wastewater seepage on adjacent ground and surface water; 2) to define the percentage of the total wastewater generated that is lost by seepage; and 3) to define the adequacy of the existing treatment system to abate surface and groundwater pollution were met and are discussed in this report.

We will be available to discuss and explain any aspect of this report with you at your convenience.

Sincerely,

EUGENE A. HICKOK AND ASSOCIATES

Norman C. Wenck, P.E.
Vice President

crs

HYDROGEOLOGICAL INVESTIGATION

STABILIZATION POND

ITASCA STATE PARK, MINNESOTA

November, 1980

Eugene A. Hickok and Associates

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Norman C. Wenck, P.E. — 8946 Minn. Reg. No.

Larry L. Johnson, C.P.G.S. — 4644 A.I.P.G. Reg. No.

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I. INTRODUCTION

In accordance with an agreement of May, 1979 between the Minnesota Department of Natural Resources and E.A. Hickok and Associates, an hydrogeologic investigation has been completed at the sewage treatment system located at Itasca State Park in Clearwater County, Minnesota.

The objectives of the project were to: (1) define the impact of the wastewater seepage on adjacent ground and surface water; (2) define the percentage of the total wastewater generated that is lost by seepage; and (3) define the adequacy of the existing treatment system to abate surface and groundwater pollution. The study consisted of constructing nine groundwater monitoring wells, providing chemical analysis of surface and subsurface water, conducting the permeability study of the pond, and characterization of the wastewater introduced into the pond.

II. CONCLUSIONS AND RECOMMENDATIONS

1. The wastewater stabilization pond exerts no significant detrimental impacts on the local groundwater or surface water outside of the immediate pond area.

2. The estimated average pond seepage rate is 2,000 gal/acre/day. This amount represents approximately 200 percent of the annual sewage inflow.

3. It appears that the existing facility is adequate as a treatment system under the present conditions.

4. The groundwater movement in the vicinity of the pond is west to Lake Itasca and east to LaSalle Creek. The average rate of groundwater movement is approximately 100 feet per year.

5. It is recommended that the monitoring wells be left in place in order to continue monitoring for chemical and physical groundwater parameters annually for long-term analysis of the pond operation.

6. It is recommended that a permanent staff gauge be installed in the primary pond in order to accurately evaluate the use and condition of the pond.

III. DISCUSSION

A. Existing Conditions

Itasca State Park is located in the southeastern portion of Clearwater County, approximately 20 miles north of Park Rapids. The existing sewage treatment system was installed in 1965 and consists of a two cell stabilization pond system (Figure 1).

The active primary cell covers approximately 20 acres and the inactive secondary cell is approximately 5 acres in size. Dikes at the east and west ends of the primary pond contain the wastewater in the natural depression, separating the primary pond from the existing wetland. The design plans called for grubbing and brush clearing of the previously existing wetland area and excavation of a portion of the wetland at the west end near the inlet. The present condition of the stabilization pond is that open water is found in the western portion corresponding with the excavated area and a heavy growth of cattails and brush cover the remaining pond area.

Wastewater from the Headwaters area, from Brower Inn, from the Park Headquarters, from the permanent residences, from campgrounds, and from the University of Minesota Forestry School is pumped to the lagoon by a series of lift stations. The raw wastewater is pumped directly to the stabilization pond.

The stabilization pond system was designed to operate as two cells, a primary cell for receiving wastewater with a controlled discharge to a secondary cell. However, the secondary cell has no recorded discharge from the primary cell so the system actually operates as a single pond.

The seepage pond is located within the drainage of the Mississippi River. The pond is located at a surface water divide. Surface water and groundwater flows westerly to Lake Itasca and also to the east-southeast via LaSalle Creek to the Mississippi River. The wastewater escapes from the pond by seepage and evapotranspiration. There is no known overland discharge from the pond.

B. Field Program

1. Monitoring Wells

Nine monitoring wells, ranging in depth from 12 to 40 feet, were drilled around the seepage pond. Six of these wells were installed on June 11-13, 1979. These monitoring wells were positioned so that groundwater data could be gathered to present a representative sampling of the groundwater regime. Three additional monitoring wells were installed on June 25, 1980 as supplemental data gathering points. Figure 2 is a map showing the location of the monitoring wells.

The 1979 monitoring wells designated as Wells 1, 2, 3, 4, 6 and 7 were drilled with a Simco 4-inch flight auger rig. Drilling samples were taken at 2 to 5-foot intervals.

These samples were taken at the surface after a time lapse was allowed for material to be augered to the top. As the auger was withdrawn, the sandy soils caved in to the approximate level of the water table. The holes bored in clay material remained intact.

After the holes were drilled, a 2-inch diameter PVC plastic casing was inserted into the hole with two to five feet of slotted screen on the bottom. The annular space between the plastic casing and the bore hole was then backfilled with filter sand around the screen and native materials to within approximately two feet of the surface. The near-surface portion of the wells were sealed permanently with cement. The top of the wells were finished in such a manner that groundwater at the top of the wells would not enter the monitoring wells.

The 1980 monitoring wells, designated as Wells 5, 8 and 9, were installed in a different manner due to previous drilling difficulties and lack of accessibility. These wells were installed with the use of backhoe. A pit was dug with a backhoe. The monitoring well casing and attached well screen were positioned in the hole and the hole was then backfilled with native material. A special effort was made to backfill with sand throughout the screen length.

Soil borings were conducted within the pond to determine the nature of the pond sediments, the depth of the pond sediments and to understand the chemical characteristics of the soil beneath the pond. The cuttings from the monitoring wells were also chemically analyzed.

2. Water Quality Sampling

After completion, water samples were obtained from the new monitoring wells. Additional water samples were also taken from nearby surface sampling locations as shown on Figure 3. The elevation of each well and the pond were surveyed so that accurate groundwater elevations could be established. The chemical analysis of the water was conducted in the laboratory of E.A. Hickok and Associates. A 24-hour composite of the influent into the pond was also collected and analyzed.

The monitoring wells were sampled two times during 1979 and four times during 1980. These water samples were obtained by the use of a peristaltic pump. The seepage pond and nearby surface water sampling locations were sampled by wading into the ponds or from near-surface water along the shore. Nearby domestic wells were located but were not sampled.

Three 24-hour wastewater influent composite samples were collected. One sample was taken in 1979 and two were taken in 1980. These composites were chemically analyzed in order to characterize the typical summer season influent.

3. Seepage Study

A seepage study was conducted at the pond to determine the annual water budget of the pond, the groundwater impact from the pond and the percentage of influent lost to seepage.

The water balance method is one method used to determine this information. Data collected include influent flow, precipitation, evaporation and change in storage. This is accomplished by the use of on-site instrumentation (Figure 4). Precipitation was determined by an on-site precipitation gauge in 1979 and determined by University of Minnesota Forestry Service records in 1980. An evaporation pan was installed in 1979. In 1980, vegetation was added to the pan to approximate evapotranspiration from the flora-rich pond. Staff gauges in the pond were in-place throughout the study. The detailed water balance equipment was in-place during four summer months of 1979 and during four summer months of 1980. The staff gauges were in-place throughout the entire period of 16 months in order to provide long-term data information.

The field permeability method was also used. Two permeameters were installed in the primary pond; one on the east end and one on the west end. These permeameters were in-place during the 1980 summer study season.

Two soil percolation tests were conducted at the site outside the pond. Both of these permeability tests were conducted approximately 100 feet east of the west dike. One test was on the south side of the pond and the other test was on the north side of the pond.

C. Geology

1. Origin of Materials

The Itasca stabilization pond is located in hummocky terrain, commonly known as knob and kettle topography, which was created as part of the Bemis-Altamont-Gary moranic system. The pond is located in a former bog-filled trough which was probably created as a breach between the significant north-south trending tunnel valleys of the area. Lake Itasca was created as a tunnel valley eroded by water derived from basal melting of the glacier ice.

Nine monitoring wells were completed around the pond. The wells were located in such a manner as to provide pertinent geological and hydrological information about the area. The placement of the wells was planned to include both upgradient and downgradient positions relative to the pond. The logs of the wells are provided as Appendix A.

The logs of the drilling during this investigation reveal the presence of Pleistocene drift. The predominantly gray drift was left by the last invasion of the Keewatin ice lobe, commonly called the Wadena sublobe of Wisconsin age. The drift is a heterogeneous unsorted mixture of materials. In this area, the materials include boulders, cobbles, gravel, sand and clay. Approximately five feet of the upper surface shows various degrees of weathering. The thickness of the drift in these areas is estimated to be 150-200 feet thick. The maximum drilling depth in this material was to

40 feet. The presence of cobbles and boulders in some areas made drilling with an auger rig very difficult.

Below the drift is found Cretaceous sedimentary rocks of unknown thickness. The basement complex is made up of Precambrian igneous and metamorphic rocks. See Figure 5 for a generalized stratigraphic section. The Cretaceous rocks were not encountered in this drilling program.

The permeability of the glacial drift is generally low to moderate except locally in some sandy areas. Two geological cross-sections are provided as Figure 6. Figure 7 shows the location of the cross-sections.

2. Soils

The soils of the area were analyzed chemically and mechanically. Soil samples were taken in the bottom of the pond. Drill cuttings from test borings were also analyzed.

The physical characteristics of selected soils were determined by a mechanical soil analysis. Table 1 presents the results of the mechanical soil analysis. Figures 8-A through 8-E are plots of the soil analysis. The soils analyzed are typical of the soils found during the drilling operations.

The chemical characteristics of the soil were also analyzed. These characteristics include pH, cation exchange capacity and percentage of organic content. The ammonia saturation-displacement method conducted at a pH of 7.0 was used for this study. This data is tabulated as Table 2, Chemical Soil Characteristics.

Samples for this analysis were taken during the drilling operation for the monitoring wells. Core samples were also collected from the primary pond bottom. The pond bottom was found to have six inches of sludge and eight inches of sludge-to-soil transition, with an underlying soil of silty sand. Preconstruction borings at the time the pond was built revealed the presence of peat and sandy clay in the area. The area was cleared and grubbed before filling. Some of the native material in the primary pond was excavated prior to construction of the dike.

D. Hydrogeology

After construction of the monitoring wells, groundwater levels in the wells were allowed to reach equilibrium and then measured to determine groundwater elevations. Figure 9 shows the location of the well screens relative to the water table. Measurements were also taken in the pond by means of a staff gauge. These readings were taken two times per week during the summer study periods. Table 3 provides the water level elevations of the monitoring wells and the pond in an abbreviated form. A graphic presentation of the water level fluctuations is shown as Figure 10.

Figures 11-A and 11-B are water level contour maps showing typical data for 1979 and 1980, respectively. These contour maps illustrate that groundwater flow occurs to the west toward Lake Itasca and also to the east-southeast toward LaSalle Creek. The groundwater direction and velocity to the southeast may be influenced by porous fill placed around a known unused and sealed effluent outfall line which exits the control structure near Well 8, proceeds generally to Well 6, and then continues east-southeast toward LaSalle Creek. These figures also show the groundwater mounding effect of the pond as a result of loading by the wastewater from the lift station.

The horizontal velocity of the groundwater in the study area was estimated by two methods: (1) by observing contaminant migration from the seepage pond and (2) by measuring the recharge rate of the monitoring wells. There is no appropriate quantitative pumping test data from which to make transmissibility comparisons.

A groundwater velocity approximation was made based on contaminant migration. The chloride parameter is used to measure the extent of contaminant migration since chlorides are not easily affected by soil absorption reactions.

Normally, a comparison is made between the upgradient and downgradient chloride concentrations at a pond site. Because of the unusual nature of the groundwater regime at this site and the difficulty in locating upgradient monitoring wells, this comparison must be subjective. Analysis of Table 6-E, Chloride Concentration, reveals that the concentrations at Well 6, for example, are generally higher than the other wells, particularly those along the northeast side of the pond. From this it can be assumed that the chloride ions have traveled at least as far as Well 6. Based on this information, a groundwater velocity approximation can be made as follows:

$$\text{Velocity} = \frac{\text{Chloride Travel Distance}}{\text{Time}}$$

Well 6 is approximately 1500 feet from the seepage pond. The pond was constructed and has been used to receive wastewater effluents since 1965, a period of 15 years. Therefore,

$$\text{Velocity} = \frac{1500 \text{ feet}}{15 \text{ years}} \geq 100 \text{ ft/yr to the southeasterly direction}$$

The second method of analyzing the groundwater velocity is by computations from monitoring well recharge rates. The recharge rate of the monitoring wells was typically slow for the clayey sands in the area. Monitoring wells are typically pumped before sampling to purge the monitoring wells of stagnant water. A water sample is then taken. In this case, the recharge rates were so slow that adequate sample volumes were not available until the next day. For this analysis, the monitoring well was measured before pumping, after pumping and again after a period of time for recharge. The recharge time was typically 18-24 hours at which time a water sample was extracted. Based on these measurements and on the size of the screen in each monitoring well, the horizontal velocity was computed to be approximately 20-200 feet per year. These rates are probably high because of the granular material that was included around the well screen during installation of the monitoring well. The range of values may be due to varying clay content at the monitoring sites.

Based on the ≥100 ft/yr velocity determination of the first method and the 20-200 ft/yr computation of the second method, it is estimated that the horizontal groundwater velocity in the vicinity of the seepage pond is approximately 100 feet per year.

As evidenced by the water level contour maps, the direction of the groundwater movement is from the northerly direction. No upgradient wells were drilled due to (1) access problems created by steep slopes, fencing and vegetation and (2) other drilling problems due to the many large rocks in the drift.

The vertical groundwater velocity was approximated by the following technique: two monitoring wells, Well 1 and Well 2 on the west dike of the primary pond were installed approximately 10 feet apart, with the screen of Well 1 being 10 feet lower than Well 2 screen. From the monitoring well measurements taken, it is evident that a vertical downward gradient is present. This is to be expected due to the mounding created by the artificial ponding of the wastewater on the water table. Apparent anomalies in the monitoring data, particularly in the 1980 data, may be attributed to the formation of a confining layer by the clay organic soils above the screen of Well 1. No definitive value for the downward gradient was determined.

E. Water Balance Study

A seepage study was conducted in order to characterize the seepage rate of the pond. Two methods were used for this study: (1) the water balance method and (2) the flow net analysis method. Two permeameters, precipitation gauge, evaporation pan and staff gauges were utilized for these studies. The location of this equipment is shown on Figure 4. Data collection was primarily by Itasca Park personnel.

The information necessary for a water balance study includes inflow, outflow, precipitation, evaporation and change in pond level. The amount of sewage inflow to the pond was determined by monitoring the pump time clocks of Lift Station No. 3 from which all sewage is pumped to the pond. This data was collected twice per week during the summer investigation periods.

The capacity of the pumps were determined by measuring the change in volume of the pumping chambers during timed manual pump operations. The capacities for the low and high speed pumps were determined to be 190 gpm and 750 gpm, respectively, in 1979. In 1980, a similar test was made resulting in 250 gpm and 1050 gpm rates, respectively. The 1964 specifications sheet for the park lift stations indicates desired capacities of 200 gpm for the low speed pump and 1270 gpm for the high speed pump. Based on these values, the pumpage rates used for this study are assumed to be 200 gpm for the low speed pump and 1000 gpm for the high speed pump.

In the summer of 1979, the amount of precipitation at the pond was measured with an automatic recording precipitation gauge. Year-round precipitation values were taken from Minnesota Pollution Control Agency pond operation reports. Evaporation was measured at the pond by a water level recording device and an evaporation pan. In 1979, the pan contained open water and provided useable results. In 1980, the evaporation pan was filled with typical pond vegetation and water to create a more realistic model of the pond situation. The arrangement provided a more rapid evapotranspiration environment than expected, resulting in less than measurable amounts of water in the pan during certain monitoring periods. Consequently, the data collected in 1980 was of limited use.

Two staff gauges were installed in the primary pond for ascertaining changes in the pond level. One gauge was in the open water of the west end of the pond and one gauge was in the heavily vegetated area of the eastern portion of the pond. These measuring points were left in the pond over the winter of 1979-80. No data was collected during the winter. An additional staff gauge was placed in the secondary pond. No significant amount of water was in the secondary pond during 1979 and it was essentially dry in 1980.

Table 4 reports data that was collected and used as part of the water balance equation. Detailed monitoring was conducted from July through October, 1979 and July through October, 1980.

The following equation is used for the water balance calculation:

$$S = P + I - O - \Delta H - E$$

S = seepage (unknown)
P = precipitation (measured)
I = inflow (measured)
O = outflow (assumed = 0)
ΔH = change in pond elevation (measured)
E = evapotranspiration (computed)

Runoff from the pond watershed is assumed to be 0. Condensation is assumed to be 0.

A pan evaporation coefficient of 0.76 was applied to the calculated pan evaporation to provide a lake evaporation value. Due to the heavily vegetative condition of the pond a factor of 50 percent greater than pan evaporation was used to compute a vegetation correction for evapotranspiration.

The results of the water balance computation are given on Table 5, Seepage Summary, and show a seepage rate range of 1300-5700 gal/A/day. The results of the water balance show some variability. This variability can be attributed to the large size of the pond.

The falling head on-site permeameter method was utilized to study the pond seepage rate during the summer of 1980. The permeameter data is given in Table 5. These permeability values indicate an average permeability of approximately 3×10^{-7} cm/sec.

By comparison, the permeabilities reported in the percolation test in the native soil around the pond are approximately 3×10^{-4} cm/sec. These values are shown on Table 5. The difference in permeability rates may be due to the deposition of organic sludge on the pond bottom which would tend to slow the pond bottom seepage rate.

In order to characterize the seepage rate, two assumptions are made: (1) the average pond depth is four feet and (2) a 10-inch seal has developed on the bottom of the pond during the 15 years of sewage disposal. (The 10-inch seal is computed by adding the six inches of sludge plus one-half of the eight inches of sludge-to-soil transition material.) Based on these assumptions and the reported permeability values of the permeameters, the pond seepage rate by the flow analysis method is calculated to be approximately 1600 gal/acre/day.

Based on seepage rates of 1300-5700 gal/A/day by the water balance method and on a 1600 gal/A/day seepage rate by the flow analysis method, it is assumed that the average seepage rate for the 20 acre primary stabilization pond is estimated to be approximately 2,000 gal/acre/day. This value is nearly 200 percent of the 1100 gal/A/day average annual sewage inflow.

Based on the two year study that was conducted, it appears that the pond is losing more water than it is gaining. This may be attributed to (1) abnormally low rainfall; (2) a decrease in effluent volume due to less tourist activity at the park; (3) accelerated evapotranspiration by the heavy pond vegetation; or (4) the absence of surface runoff to the pond because of the newly installed diversion ditches. If this trend continues, the pond elevation will continue to decrease.

F. Water Quality

1. Data

The water quality in and around the stabilization pond was determined by laboratory analysis. The following parameters were used for quality determination:

Ammonia Nitrogen
Nitrite-Nitrogen
Nitrate-Nitrogen
Organic Nitrogen
Chlorides
Total Phosphorus
Fecal Coliform
Conductivity
Chemical Oxygen Demand
Methylene Blue Active Substances
pH
Iron
Sodium
Magnesium
Calcium

Nitrogen - The compounds of nitrogen are of interest because of the importance of nitrogen in the life cycle of plants and animals. The breakdown of proteins releases the nitrogen compound and the waste products of the body during life. The level of ammonia nitrogen is typically high in wastewater effluent. The relatively recent introduction of nitrogen takes the ammonia form because it is not yet oxidized.

Nitrate-nitrogen in a sewage system results from oxidation of ammonia nitrogen. A high nitrate nitrogen content in water when compared to other nitrogen compounds indicates that recent pollution is probably not the case because of the relatively long time element for oxidation to occur. Nitrite-nitrogen and organic nitrogen are intermediate products of the nitrogen cycle. Tabular displays of these nitrogen compounds are given as Tables 6-A, 6-B, 6-C and 6-D for ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen and organic nitrogen, respectively. Plots of this tabular data for ammonia nitrogen, nitrate-nitrogen and organic nitrogen are given as Figures 12-A, 12-B and 12-C, respectively. The groundwater concentrations are generally at or below the values of Well No. 1, plotted as an example.

Chloride - Sewage effluents commonly have chloride concentrations in a range of 50-500 mg/l. Chlorides in reasonable concentrations are not harmful to humans, however, a salty taste may be objectionable to people and can occur at concentrations above 250 mg/l. The presence of chlorides can be used as an indicator in monitoring groundwater movement because the chloride ion is not adsorbed by the soil nor altered or changed by biological processes. A tabulation of the chloride data is provided as Table 6-E, and a plot of the data is shown as Figure 12-D. Although the chloride levels in the pond are elevated, the groundwater levels are greatly attenuated and are well within reasonable values. Well No. 6 is plotted as an example of the general maximum groundwater concentrations.

Phosphorus - Domestic sewage is relatively high in phosphorus compounds due to human wastes and synthetic detergents. Phosphorus is required by the organisms involved in the biological process for reproduction and synthesis of cell tissue. However, an excess of phosphorus above a critical level will cause nuisance conditions of algal blooms and possibly degeneration of a surface water body. Phosphorus generally poses no health hazard to man and is nontoxic to aquatic life. The phosphorus levels in the analyzed water are shown as Table 6-F while a plot of the data is presented as Figure 12-E.

As expected, the seepage pond water has higher values than the surrounding groundwater monitoring points with the exception of a few anomalous points very close to the pond (as plotted).

Fecal Coliform - Fecal coliforms are fecally associated microbes which have a potential for disease transmission. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are one of the most frequently applied indicators of water quality.

The results of a fecal coliform count are shown as Table 6-G. As might be expected, the colony count is quite high in the discharge area of the west end of the pond. It is interesting to note that the fecal coliform count decreases significantly in the east end of the pond where a great deal of vegetation is present. None of the groundwater monitoring wells showed any sign of coliform contamination and for this reason were not sampled further.

Conductivity - The conductivity of water is a measure of salinity or dissolved solids. Table 6-H shows that the conductivity of the groundwater is basically in the general range as that of the pond water. This situation is illustrated as Figure 12-F.

Chemical Oxygen Demand - The chemical oxygen demand of water indicates relative contamination. High COD values relate to an elevated oxygen requirement to chemically stabilize the water. An excessive chemical oxygen demand would adversely decrease the amount of oxygen available to and needed by living organisms in the water. A record of the COD values is presented as Table 6-I. Figure 12-G is a graph of the data. The groundwater COD values for June 13, 1979 are anomalously high. Data for Wells No. 1 and 3 are plotted as examples.

Methylene Blue Active Substances (MBAS) - Methylene Blue Active Substances were examined because of their tendency to provide undesirable aesthetic effects: to produce dispersion of insoluble or sorbed substances; to foam; and to interfere with the removal of substances by the coagulation, sedimentation and/or filtration processes. Table 6-J provides a record of the MBAS parameters analyzed. Figure 12-H is a plot of these values. The groundwater results were generally less than 0.05 mg/l. The data for Well No. 1 is plotted as a comparison to the primary pond values.

pH - pH is a measure of the hydrogen ion activity in water. The pH of natural waters is a measure of acid-base equilibrium achieved by the various dissolved compounds, salts and gases. pH is an important factor in the chemical and biological systems of natural waters. pH affects the toxicity and solubility of many compounds. Table 6-K provides a record of the pH data collected.

Iron - Iron in water may be present in varying quantities depending upon the geology of the area and other chemical components of the groundwater. Iron is an essential trace element required by both plants and animals. In some waters it may be a limiting factor for the growth of algae and other plants. Iron is an objectionable constituent in water supplies because it can affect the taste of beverages and stain laundry, clothes and fixtures. In some cases, iron precipitates may form as jells or flocks that can be detrimental when suspended in water to fish and other aquatic life. Table 6-L illustrates the iron concentrations in the water during the study period.

Other Metals - Other metals of importance that were analyzed are sodium, magnesium, calcium and lead, as given in Tables 6-M, 6-N, 6-O and 6-P, respectively. These parameters are significant in evaluating the overall condition of the waters.

A 24-hour composite of the wastewater influent was sampled for comparison. Three samples were collected during the study program. Results of composites are given as Table 7. The range of values for the parameters may be a reflection of park visitor usage.

2. Analysis

An analysis of the water quality parameters indicate that pollutants have migrated to the west and also to the east-southeast from the pond in the general direction of the groundwater flow. In general, the contaminant levels in the groundwater are above background levels near the pond. Four samples taken at nearby surface water bodies do not appear to be impacted by the stabilization pond.

Figure 13-A is an ammonia nitrogen isocon map showing a planar view of the movement of the ammonia parameter. The low level contaminant plume extends downgradient from the pond.

Figure 13-B is a total phosphorus isocon map in the vicinity of the pond. This map indicates that the phosphorus contamination of the groundwater is generally limited to the immediate pond area.

Figure 13-C is an isocon map of the chemical oxygen demand. Again, this map shows that the extent of influence of the seepage pond is relatively limited.

The results of the study indicate that there are no significant detrimental impacts on the local groundwater or surface water. This stabilization pond was studied during two summer peak usage time spans and is considered to be representative of the typical use of the pond. The absence of detrimental impacts may be attributed to (1) the low average yearly contaminant loading; (2) nutrient uptake by the heavy vegetation in the pond; and/or (3) by the attenuation capacity of the local soils. It appears that the existing facility is adequate as a treatment system under the present conditions.

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TABLE 1

Mechanical Soil Analysis
Cumulative Percent Passing

Location and Depth	U.S. Sieve Size					
	4	10	40	80	140	200
No. 3 at 20 ft.	100.0	94.7	73.2	48.0	37.9	33.2
No. 3 at 25 ft.	100.0	95.8	75.1	50.3	40.8	36.1
No. 4 at 20 ft.	96.5	91.2	63.3	34.0	24.8	18.1
No. 4 at 25 ft.	100.0	95.5	76.4	50.1	40.0	35.0
No. 5 at 5.5 ft.	51.6	44.9	21.4	10.2	5.8	4.4
No. 6 at 18.5 ft.	57.6	48.3	23.2	8.8	6.4	5.5
No. 7 at 15 ft.	100.0	97.4	79.6	59.3	50.4	42.2
No. 7 at 20 ft.	100.0	95.0	75.0	54.6	45.9	41.2

TABLE 2

Chemical Soil Characteristics

Sample site	Sample Depth	pH	Cation Exchange meq/100 gm soil	Percent Organic Content
Pond Sediments	1 inch	7.3	36	37
Pond Sediment - Soil	7 inches	7.5	17	21
Pond Bottom Soil	16 inches	7.7	22	7
Well No. 1	5 feet	8.0	7	3
Well No. 1	10 feet	7.7	40	27
Well No. 2	20 feet	7.6	7	5
Well No. 3	3.5 feet	7.8	10	5
Well No. 4	25 feet	8.1	5	3
Well No. 6	6 feet	8.2	3	3
Well No. 7	5 feet	8.1	7	1

TABLE 3

Water Level Elevations (NGVD)

Date	Well Number									Pond
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	
*7/2/79	1480.14	1480.26	1479.40	1480.15	--	1479.11	1479.56	--	--	1480.48
7/16	80.18	80.16	79.11	79.90	--	78.90	79.01	--	--	80.38
*8/2	80.03	79.93	78.96	79.70	--	78.88	78.39	--	--	80.22
8/16	80.01	80.01	78.80	79.65	--	78.70	78.35	--	--	80.24
*9/2	80.01	80.01	78.90	79.70	--	78.65	78.51	--	--	80.24
9/17	79.60	79.93	78.67	79.43	--	78.49	77.87	--	--	80.14
*10/1	79.80	79.83	78.52	79.26	--	78.30	77.41	--	--	79.84
10/9	79.76	79.80	78.69	79.32	--	78.30	77.41	--	--	79.90
*10/29/79	1479.80	1479.80	1478.65	1479.43	--	1478.24	1478.24	--	--	1479.94
5/24/80	1479.66	1478.70	--	--	--	--	--	--	--	--
6/14	79.97	79.12	--	--	--	--	--	--	--	--
*7/5	79.60	79.30	1477.94	1478.03	1479.34	1477.53	1477.62	1478.42	1478.87	1479.73
7/15	79.35	78.71	77.44	77.78	78.34	77.32	76.64	77.34	78.70	79.74
*7/26	79.47	79.13	77.61	77.95	78.50	77.45	77.47	77.17	78.95	79.74
8/2	79.35	78.55	77.27	77.78	--	77.28	76.72	76.92	--	79.77
*8/12	79.57	79.18	77.11	77.57	78.29	77.18	77.18	77.02	78.73	79.71
8/23	79.60	79.05	78.02	77.28	78.67	77.32	78.06	77.46	79.20	79.79
*9/4	79.51	78.80	78.44	78.61	78.34	77.36	78.22	78.00	--	79.79
9/18	79.56	78.80	77.82	78.61	78.67	77.36	78.47	77.84	--	79.77
*10/6/80	1479.46	1478.70	1477.90	1478.32	1478.41	1477.23	1478.30	1478.12	--	1479.73

*Data used for construction of Figure 10 - Water Level Fluctuations

TABLE 4

Water Balance Data

Date	Precipitation (in.)	Precipitation (ft.)	Change in Pan Level (ft.)	Inflow (hrs.) at 1000 gpm	Change in Pond Level (ft.) at 20 acres
7/20-8/30/79	2.03	.169	+.006	30.3	-.12
9/13-10/9/79	.62	.052	+.049	11.5	-.30
7/31/79-8/1/80	16.3*	1.36	**	131.7	-.49

*Precipitation for a "normal" year = 25.25 in/yr (HA-278)

**Inferred evapotranspiration = 19.9 in/yr (HA-278)

TABLE 5

Seepage Summary

	Coefficient of Permeability (cm/sec)	Seepage Rate (gal/A/day)
Water Balance		
7/20-8/30/79	--	3500 (3000)*
9/13-10/9/79	--	5700 (5700)*
7/31/79-8/1/80		
ET = 19.9 in/yr	--	1300
ET = 12.9 in/yr	--	1800
Permeameter West	2.56×10^{-7}	1400
Permeameter East	3.30×10^{-7}	1800
Percolation Hole No. 1	5.08×10^{-4}	--
Percolation Hole No. 2	1.27×10^{-4}	--

Therefore, the Assumed Seepage Rate is approximately 2000 gal/a/day

* Vegetation correction applied

TABLE 6-A

Water Quality Data
Ammonia Nitrogen (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	1.1	1.0	8.4	8.5	8.0	0.70
2	0.57	0.25	1.5	1.2	1.6	0.81
3	0.20	0.11	2.5	0.38	0.7	0.62
4	0.29	0.22	4.0	1.3	0.68	0.05
5	--	--	--	.07	0.09	0.72
6	0.07	0.16	0.05	.03	1.10	0.08
7	0.34	0.01	1.66	.04	0.73	0.78
8	--	--	--	<.01	0.28	0.32
9	--	--	--	<.01	0.19	15.90*
Surface Water						
Pond West	23.0	11.5	0.28	0.45	1.56	4.10
Pond East	0.14	0.33	0.41	2.9	--	--
Secondary	0.20	0.38	Dry	Dry	Dry	.09
West of Dike	0.27	--	--	--	--	--
Lake Itasca	0.29	--	--	--	--	--
East Lake	0.16	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-B

Water Quality Data
Nitrite-Nitrogen (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	0.024	0.008	0.017	0.11	0.014	0.019
2	0.015	0.006	0.001	0.006	0.002	0.003
3	0.003	0.005	0.001	0.008	0.005	0.007
4	0.004	0.003	0.001	0.004	0.004	0.028
5	--	--	--	0.006	0.006	0.009
6	0.005	0.011	<0.001	0.002	0.006	0.017
7	0.004	0.033	<0.001	0.004	<0.002	0.012
8	--	--	--	0.003	0.010	0.003
9	--	--	--	0.031	0.009	0.021*
Surface Water						
Primary West	0.490	0.29	<0.001	2.05	0.005	0.350
Primary East	0.003	0.002	<0.001	0.007	--	--
Secondary	0.004	0.001	Dry	Dry	Dry	0.014
West of Dike	0.009	--	--	--	--	--
Lake Itasca	0.001	--	--	--	--	--
East Lake	0.004	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-C

Water Quality Data
Nitrate-Nitrogen (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	0.61	0.07	0.04	0.40	<0.02	0.01
2	0.28	0.02	0.02	0.26	<0.02	0.01
3	0.16	0.01	0.02	0.25	<0.02	0.01
4	0.53	0.01	0.02	0.02	<0.02	<0.01
5	--	--	--	0.04	<0.02	<0.01
6	0.55	0.01	0.03	<0.02	0.08	<0.01
7	0.11	0.04	0.02	<0.02	<0.02	<0.01
8	--	--	--	0.03	0.06	<0.01
9	--	--	--	1.95	0.02	<0.01*
Surface Water						
Primary West	0.40	1.9	0.16	7.65	<0.02	<0.01
Primary East	0.40	0.10	0.22	<0.02	--	--
Secondary	0.30	0.01	Dry	Dry	Dry	<0.01
West of Dike	0.01	--	--	--	--	--
Lake Itasca	0.04	--	--	--	--	--
East Lake	0.01	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-D

Water Quality Data
Organic Nitrogen (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	1.8	1.3	1.16	<0.1	4.1	6.1
2	1.0	1.1	0.87	4.8	0.4	3.39
3	1.4	1.1	0.76	0.3	2.5	0.68
4	1.2	1.0	1.05	2.5	<0.1	2.55
5	--	--	--	0.1	<0.1	<0.1
6	0.88	<0.12	0.64	<0.1	0.2	0.32
7	1.4	0.73	0.84	1.0	0.3	0.62
8	--	--	--	2.5	0.1	0.58
9	--	--	--	0.9	0.4	5.2 *
Surface Water						
Primary West	2.3	40.9	3.44	3.9	<0.1	6.4
Primary East	1.1	3.6	7.28	7.2	--	--
Secondary	1.0	2.2	Dry	Dry	Dry	4.91
West of Dike	1.4	--	--	--	--	--
Lake Itasca	0.44	--	--	--	--	--
East Lake	0.93	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-E

Water Quality Data
Chloride (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	35	4	3	<1	1.0	2
2	30	3	2	<1	1.0	3
3	40	7	2	<1	1.0	2
4	35	2	2	2	1.0	3
5	--	--	--	<1	1.0	4
6	50	5	8	7	2.0	4
7	10	3	2	<1	<1.0	4
8	--	--	--	2	1.0	4
9	--	--	--	3	1.0	1 *
Surface Water						
Primary West	55	80	19	42	44	46
Primary East	40	50	9	8	--	--
Secondary	25	25	Dry	Dry	Dry	4
West of Dike	20	--	--	--	--	--
Lake Itasca	30	--	--	--	--	--
East Lake	45	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-F

Water Quality Data
Total Phosphorus

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	0.02	0.18	0.04	0.08	0.29	0.44
2	0.03	0.03	0.01	0.01	0.07	0.07
3	0.01	0.03	0.01	0.03	0.15	0.12
4	0.03	0.04	0.02	0.01	0.15	0.08
5	--	--	--	17.3	4.6	0.44
6	0.07	0.08	0.01	0.04	0.11	0.09
7	0.05	0.06	0.01	0.13	0.28	0.59
8	--	--	--	3.45	0.68	0.42
9	--	--	--	1.45	0.44	5.59 *
Surface Water						
Primary West	0.50	8.6	0.60	1.75	6.5	1.84
Primary East	0.13	0.66	0.16	0.21	--	--
Secondary	0.05	0.27	Dry	Dry	Dry	0.20
West of Dike	0.04	--	--	--	--	--
Lake Itasca	0.02	--	--	--	--	--
East Lake	0.06	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-G

Water Quality Data
Fecal Coliform
(colonies/100 ml)

Groundwater	9/5/79
Well No. 1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
Surface Water	
Primary West	51000
Primary East	<100
Secondary	<100
West of Dike	--
Lake Itasca	--
East Lake	--

TABLE 6-H

Water Quality Data
Conductivity (micro mhos/cm)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	810	700	500	475	450	520
2	700	700	510	470	390	510
3	700	990	700	680	600	720
4	740	800	570	560	500	610
5	--	--	--	350	300	390
6	650	650	420	440	330	350
7	610	630	490	470	390	420
8	--	--	--	400	620	480
9	--	--	--	600	110	960*
Surface Water						
Primary West	770	890	360	550	500	600
Primary East	280	350	175	210	--	--
Secondary	170	160	Dry	Dry	Dry	92
West of Dike	500	--	--	--	--	--
Lake Itasca	375	--	--	--	--	--
East Lake	140	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-I

Water Quality Data
Chemical Oxygen Demand (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	966	56	84	35	127	109
2	294	48	108	54	72	68
3	2778	40	84	27	32	32
4	966	40	56	31	52	44
5	--	--	--	8	32	56
6	203	68	4	8	8	12
7	143	104	20	15	24	24
8	--	--	--	23	44	36
9	--	--	--	64	202	335*
Surface Water						
Primary West	32	88	75	75	294	124
Primary East	48	72	92	91	--	--
Secondary	56	140	Dry	Dry	Dry	171
West of Dike	116	--	--	--	--	--
Lake Itasca	19	--	--	--	--	--
East Lake	56	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-J

Water Quality Data
Methylene Blue Active Substances (MBAS)
(mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	0.010	0.021	0.030	0.042	<0.05	<0.05
2	0.005	0.028	0.042	0.048	<0.05	<0.05
3	0.014	0.043	0.030	0.036	<0.05	<0.05
4	0.010	0.024	<0.015	0.008	0.10	<0.05
5	--	--	--	<0.005	0.05	<0.05
6	0.005	<0.005	<0.015	<0.005	0.05	0.07
7	0.010	0.032	<0.015	0.008	0.10	<0.05
8	--	--	--	0.008	0.25	0.05
9	--	--	--	0.029	0.05	0.10*
Surface Water						
Primary West	0.030	0.276	0.084	0.795	0.30	<0.05
Primary East	0.010	0.276	<0.015	0.735	--	--
Secondary	0.010	0.192	Dry	Dry	Dry	<0.05
West of Dike	0.005	--	--	--	--	--
Lake Itasca	0.019	--	--	--	--	--
East Lake	0.010	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-K

Water Quality Data
pH

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	8.2	7.8	7.7	7.5	7.2	7.4
2	8.5	7.8	7.0	7.4	6.95	8.1
3	7.9	7.8	7.4	7.2	6.6	7.4
4	7.9	8.0	7.8	7.5	6.9	7.6
5	--	--	--	7.3	6.7	7.4
6	8.1	7.9	7.0	7.4	6.8	7.6
7	7.7	8.0	7.6	7.6	7.0	7.7
8	--	--	--	6.7	6.5	7.2
9	--	--	--	7.1	6.3	6.8*
Surface Water						
Primary West	8.1	7.7	7.3	7.5	6.8	8.3
Primary East	7.9	7.6	6.5	7.2	--	--
Secondary	7.8	7.7	Dry	Dry	Dry	Dry
West of Dike	8.2	--	--	--	--	--
Lake Itasca	8.4	--	--	--	--	--
East Lake	7.6	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-L

Water Quality Data
Iron (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	1.4	1.8	0.66	1.7	3.6	4.0
2	0.24	1.9	0.10	0.05	1.5	1.5
3	0.03	1.4	0.26	4.3	6.8	6.2
4	0.03	0.60	0.32	0.30	1.7	1.6
5	--	--	--	4.2	1.6	2.8
6	0.07	0.19	<0.01	1.0	0.25	0.30
7	0.10	0.33	0.04	4.5	1.2	2.6
8	--	--	--	15	2.2	1.3
9	--	--	--	12	8.5	27 *
Surface Water						
Primary West	0.18	3.1	0.54	1.3	1.2	0.40
Primary East	0.10	0.66	0.07	1.4	--	--
Secondary	0.10	0.10	Dry	Dry	Dry	0.45
West of Dike	7.5	--	--	--	--	--
Lake Itasca	0.03	--	--	--	--	--
East Lake	0.22	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-M

Water Quality Data
Sodium (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	11.6	10	11	11	11	10
2	5.4	5.7	5	5.2	5.0	4.8
3	8.9	7	6	6.2	6.0	5.6
4	14.4	11	11	9.0	9.0	8.0
5	--	--	--	1.8	2.0	2.2
6	7.8	7.2	4	7.4	5.2	4.4
7	13.4	15	16	17	17	16
8	--	--	--	3.6	2.6	2.6
9	--	--	--	4.4	4.2	4.6*
Surface Water						
Primary West	31	43	19	35	42	41
Primary East	8	13	9	16	--	--
Secondary	1.1	0.57	Dry	Dry	Dry	0.4
West of Dike	3.0	--	--	--	--	--
Lake Itasca	6.1	--	--	--	--	--
East Lake	4.1	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-N

Water Quality Data
Magnesium (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	30	29	24	28	26	20
2	24	25	24	27	26	20
3	34	39	30	36	34	36
4	28	28	26	32	35	30
5	--	--	--	25	56	32
6	17	24	20	34	20	18
7	17	20	22	51	25	20
8	--	--	--	27	35	28
9	--	--	--	51	48	72 *
Surface Water						
Primary West	23	37	16	26	26	19
Primary East	4.6	11	6	11	--	--
Secondary	7.3	5.9	Dry	Dry	Dry	4.8
West of Dike	16	--	--	--	--	--
Lake Itasca	16	--	--	--	--	--
East Lake	3.5	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-0

Water Quality Data
Calcium (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	87	100	67	54	86	84
2	60	100	66	35	90	90
3	49	132	69	63	125	170
4	44	108	61	49	115	120
5	--	--	--	55	190	110
6	66	94	61	65	68	71
7	70	85	59	110	74	80
8	--	--	--	81	120	116
9	--	--	--	150	185	275 *

Surface Water	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Primary West	64	100	43	69	72	83
Primary East	19	33	22	30	--	--
Secondary	22	23	Dry	Dry	Dry	18
West of Dike	89	--	--	--	--	--
Lake Itasca	32	--	--	--	--	--
East Lake	10	--	--	--	--	--

*Suspected monitoring well vandalism

TABLE 6-P

Water Quality Data
Lead (mg/l)

Groundwater	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Well No. 1	Not Tested	Not Tested	<0.05	<0.05	<0.05	<0.05
2			<0.05	<0.05	<0.05	<0.05
3			<0.05	<0.05	0.05	<0.05
4			<0.05	<0.05	<0.05	<0.05
5			--	<0.05	<0.05	<0.05
6			<0.05	<0.05	0.10	<0.05
7			<0.05	<0.05	<0.05	<0.05
8			--	<0.05	0.10	<0.05
9			--	<0.05	<0.05	<0.05

Surface Water	6/13/79	9/5/79	5/16/80	6/26/80	8/14/80	10/8/80
Primary West	Not Tested	Not Tested	<0.05	<0.05	<0.05	<0.05
Primary East			<0.05	<0.05	--	--
Secondary			Dry	Dry	Dry	<0.05
West of Dike			--	--	--	--
Lake Itasca			--	--	--	--
East Lake			--	--	--	--

*Suspected monitoring well vandalism

TABLE 7

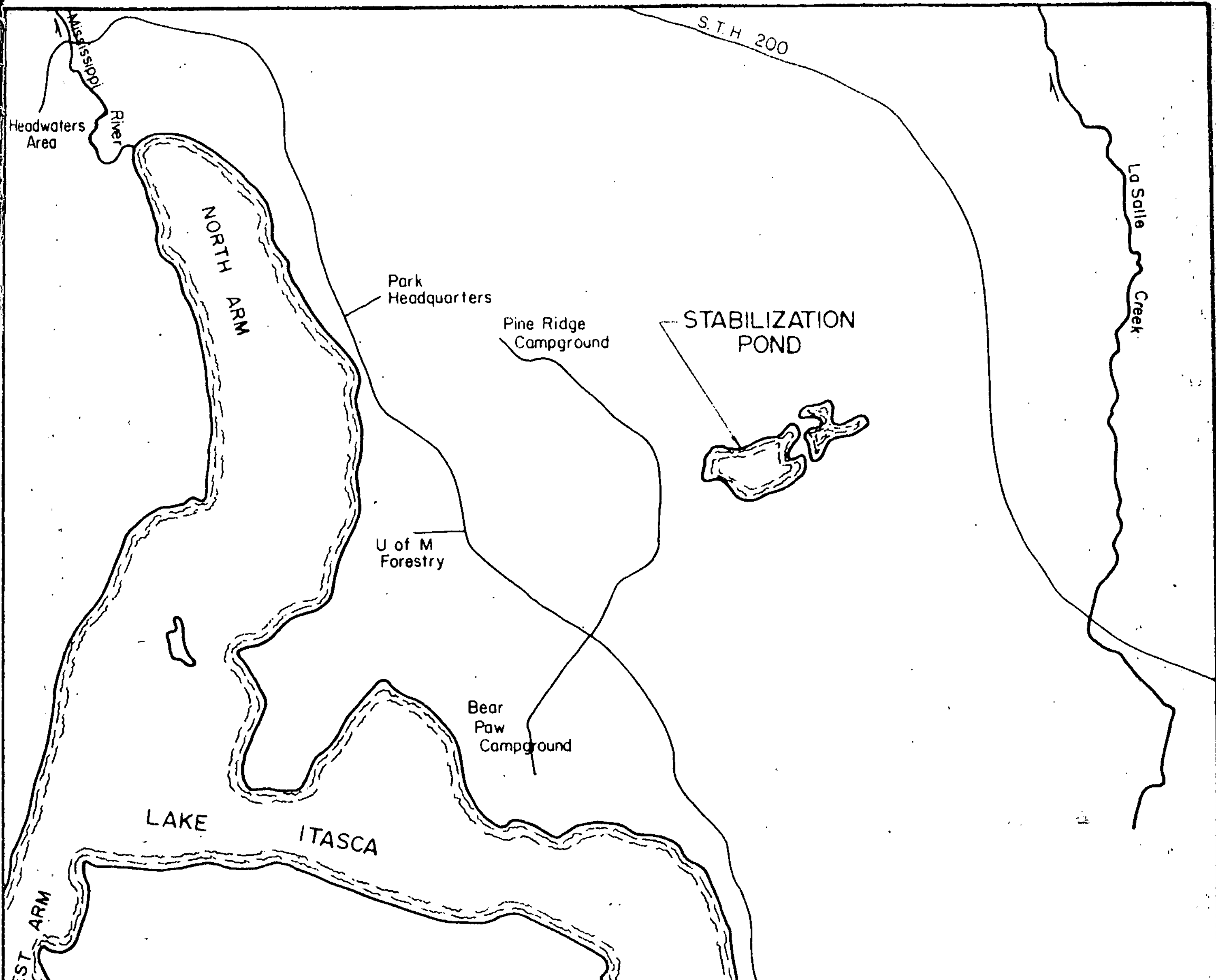
Wastewater Influent
24-Hour Composite Analysis

Parameter	June 27-28, 1979	Aug. 13-14, 1980	Oct. 7-8, 1980
Ammonia-nitrogen (mg/l)	19.5	2.0	0.06
Nitrite-nitrogen (mg/l)	0.028	0.004	0.140
Nitrate-nitrogen (mg/l)	0.30	<0.02	0.40
Organic nitrogen (mg/l)	2.9	0.40	0.64
Chloride (mg/l)	75	23	33
Total Phosphorus (mg/l)	3.0	1.3	0.74
Conductivity (micro mhos/cm)	950	400	520
Chemical Oxygen Demand (mg/l)	106	120	12
Methylene Blue Actuve Substances (mg/l)	0.06	0.10	0.06
pH	7.1	6.9	7.7
Iron (mg/l)	1.8	1.0	0.65
Sodium (mg/l)	39	40	37
Magnesium (mg/l)	24	20	19
Calcium (mg/l)	57	70	84

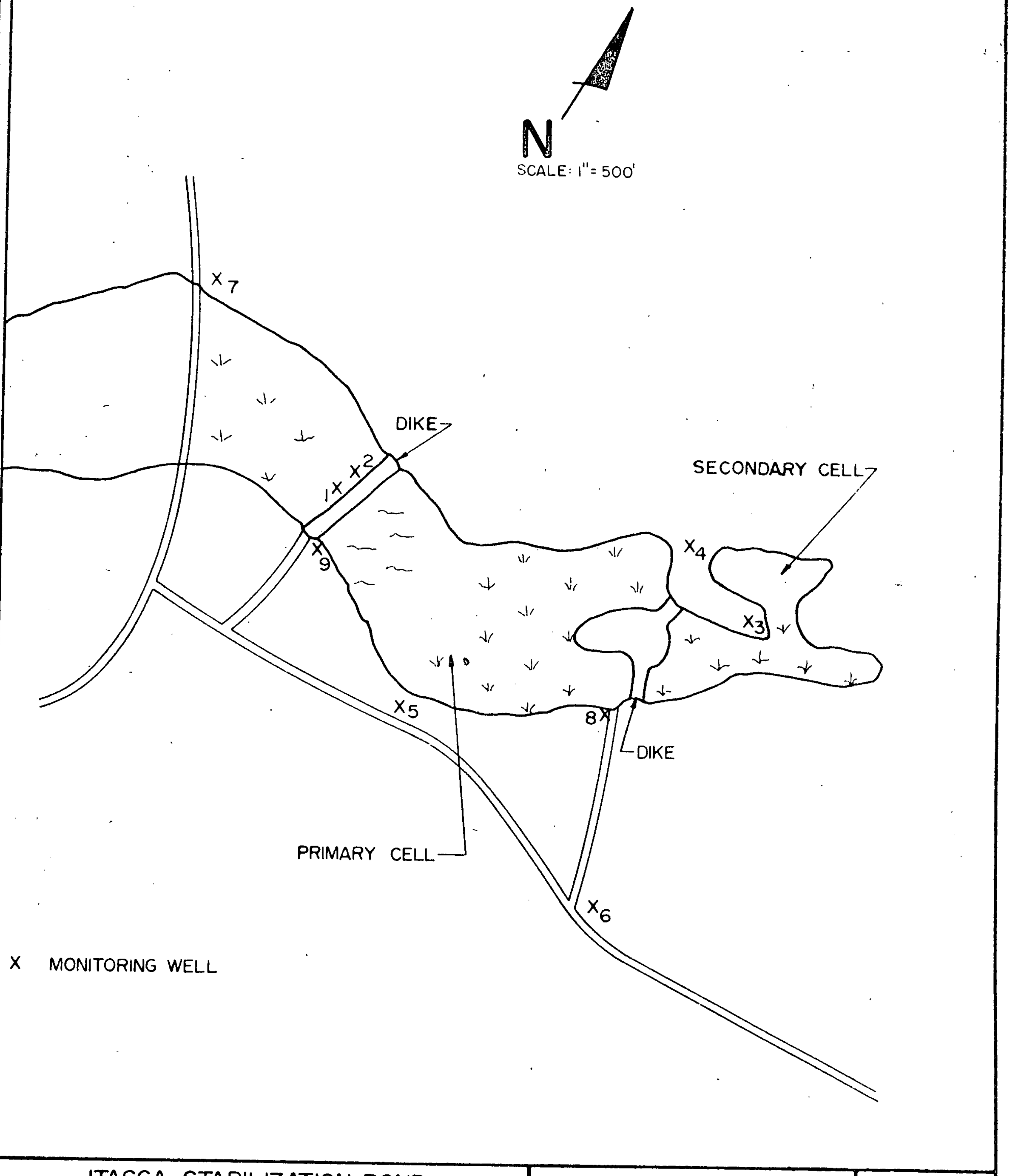
Low

Bod SS

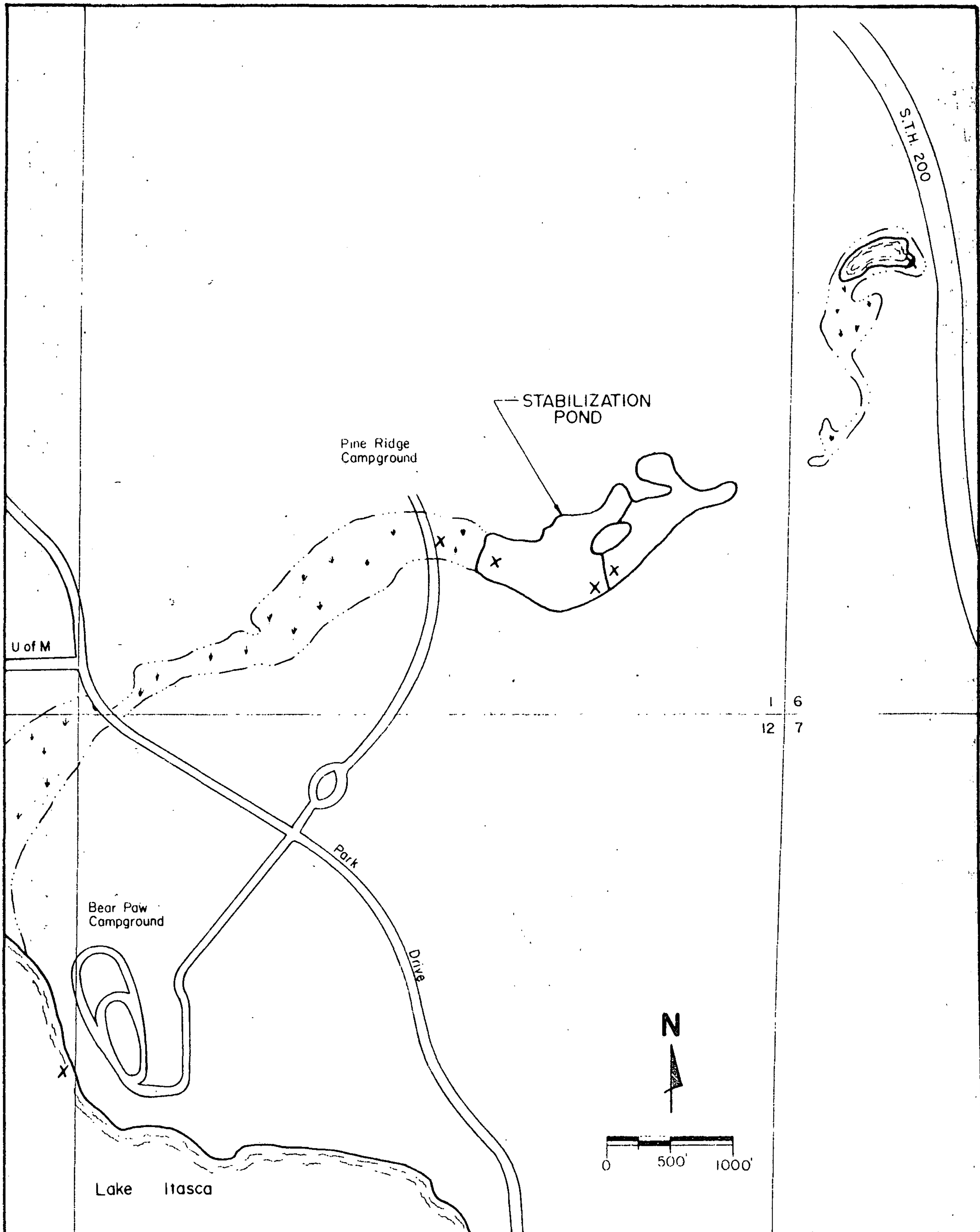
infiltration ?



ITASCA STABILIZATION POND	**E.A. HICKOK & ASSOCIATES**	NOV 1980
AREA LOCATION MAP	**HYDROLOGISTS - ENGINEERS** **MINNEAPOLIS - MINNESOTA**	1



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV. 1980
MONITORING WELLS LOCATION MAP	HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	2



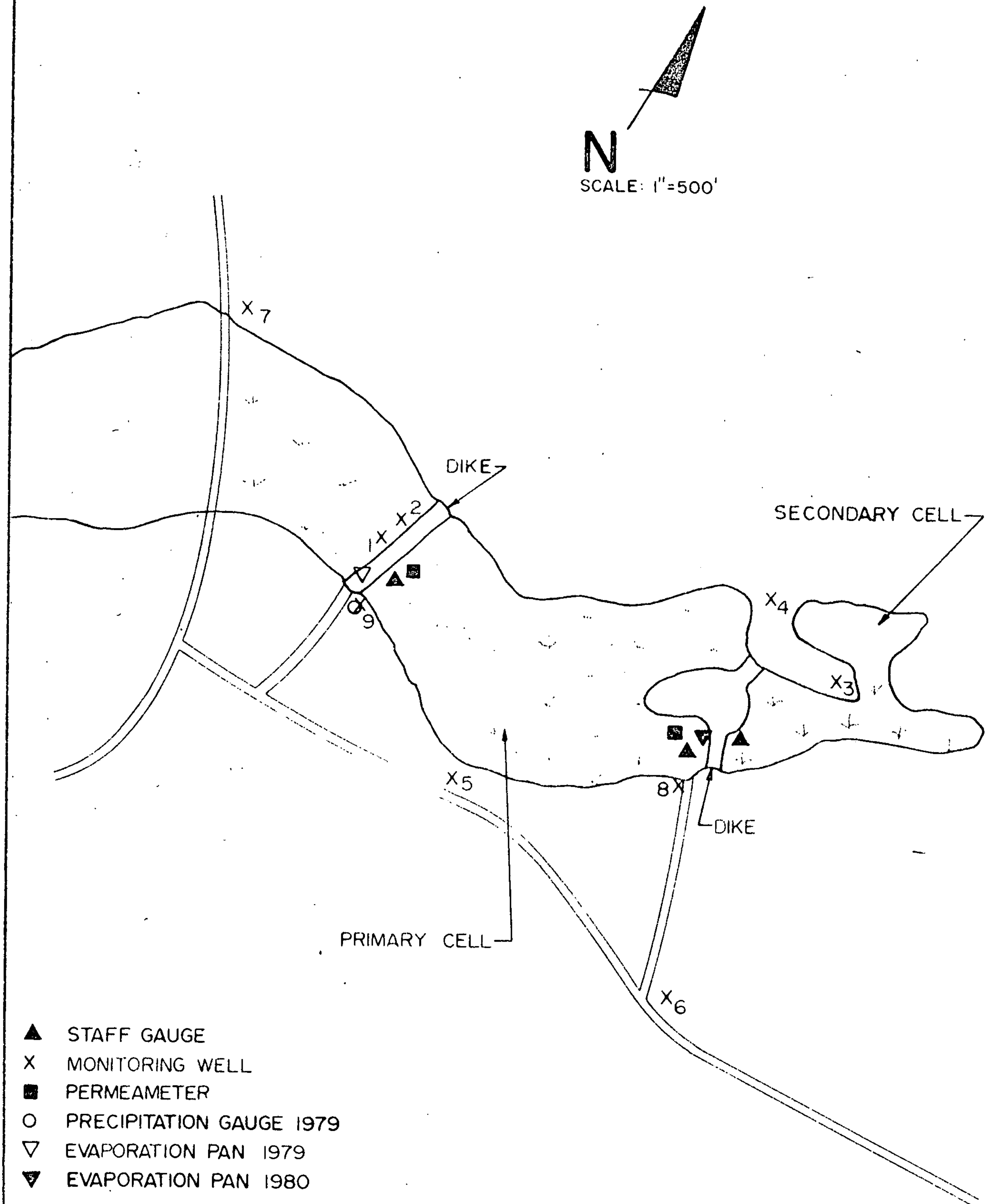
ITASCA STABILIZATION POND

SURFACE SAMPLING LOCATIONS

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS - ENGINEERS
MINNEAPOLIS - MINNESOTA

NOV 1980

3



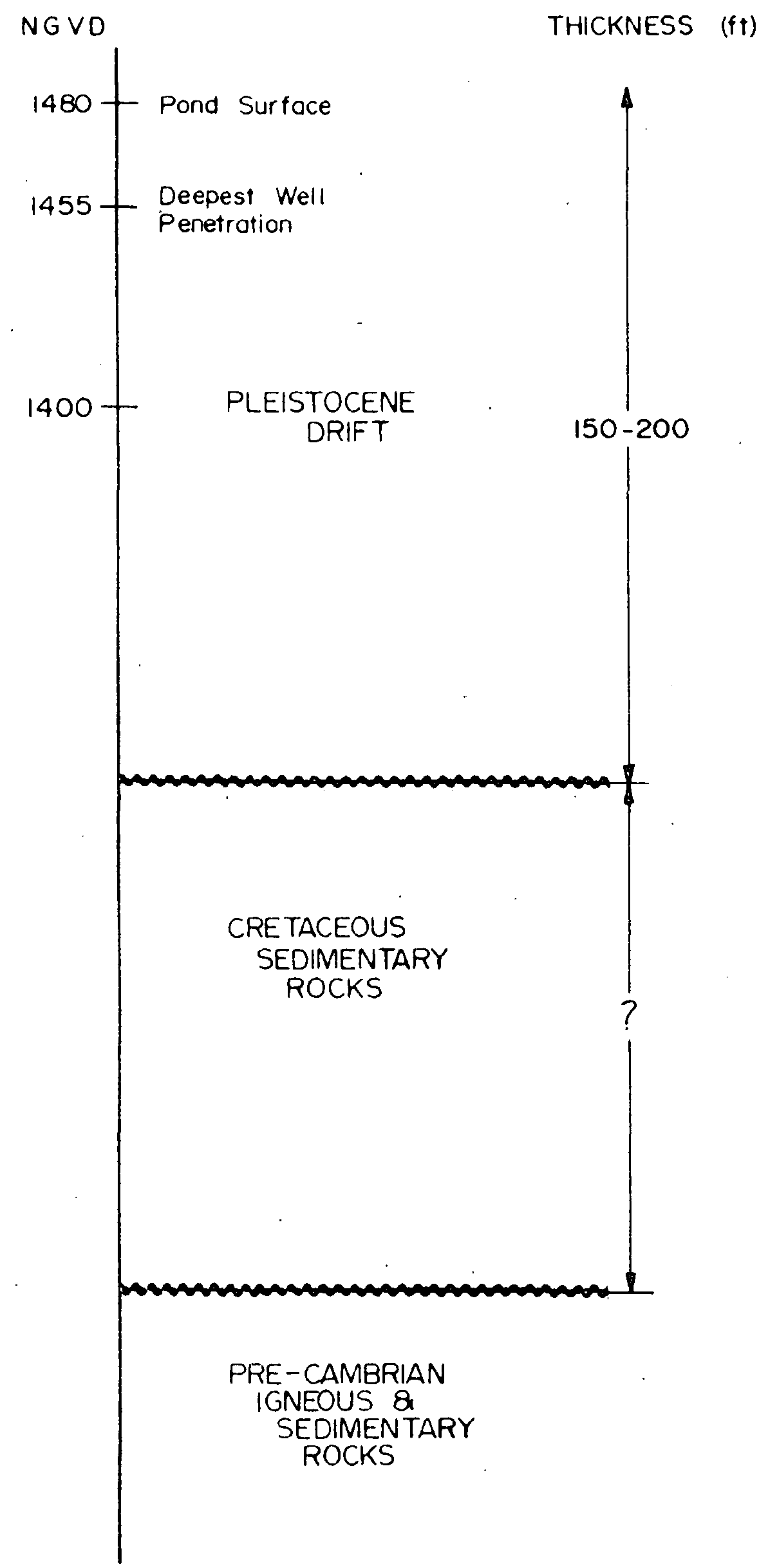
ITASCA STABILIZATION POND

SITE INSTRUMENTATION

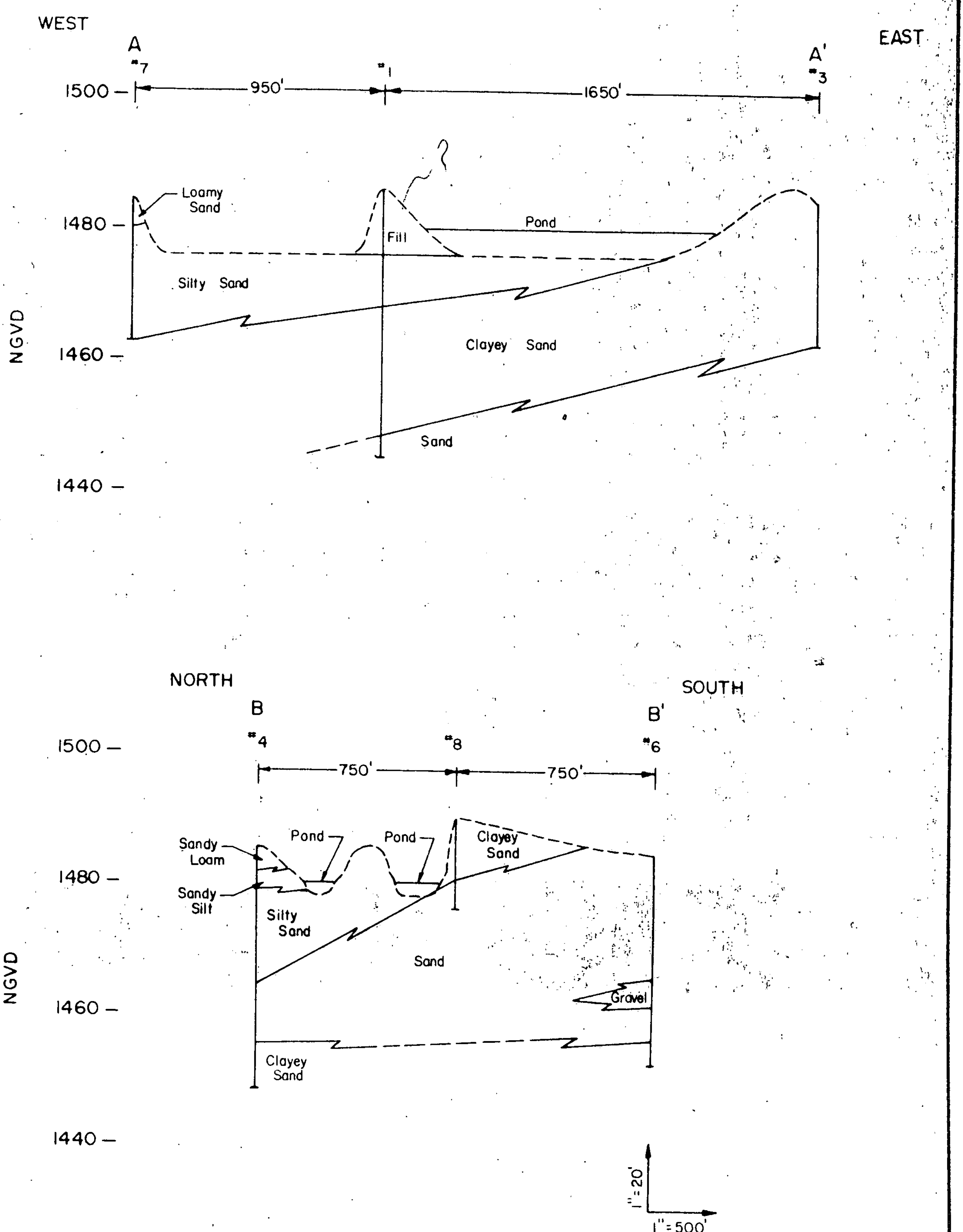
E.A. HICKOK & ASSOCIATES
HYDROLOGISTS - ENGINEERS
MINNEAPOLIS - MINNESOTA

NOV. 1980

4



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
GENERALIZED STRATIGRAPHIC SECTION	HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	5



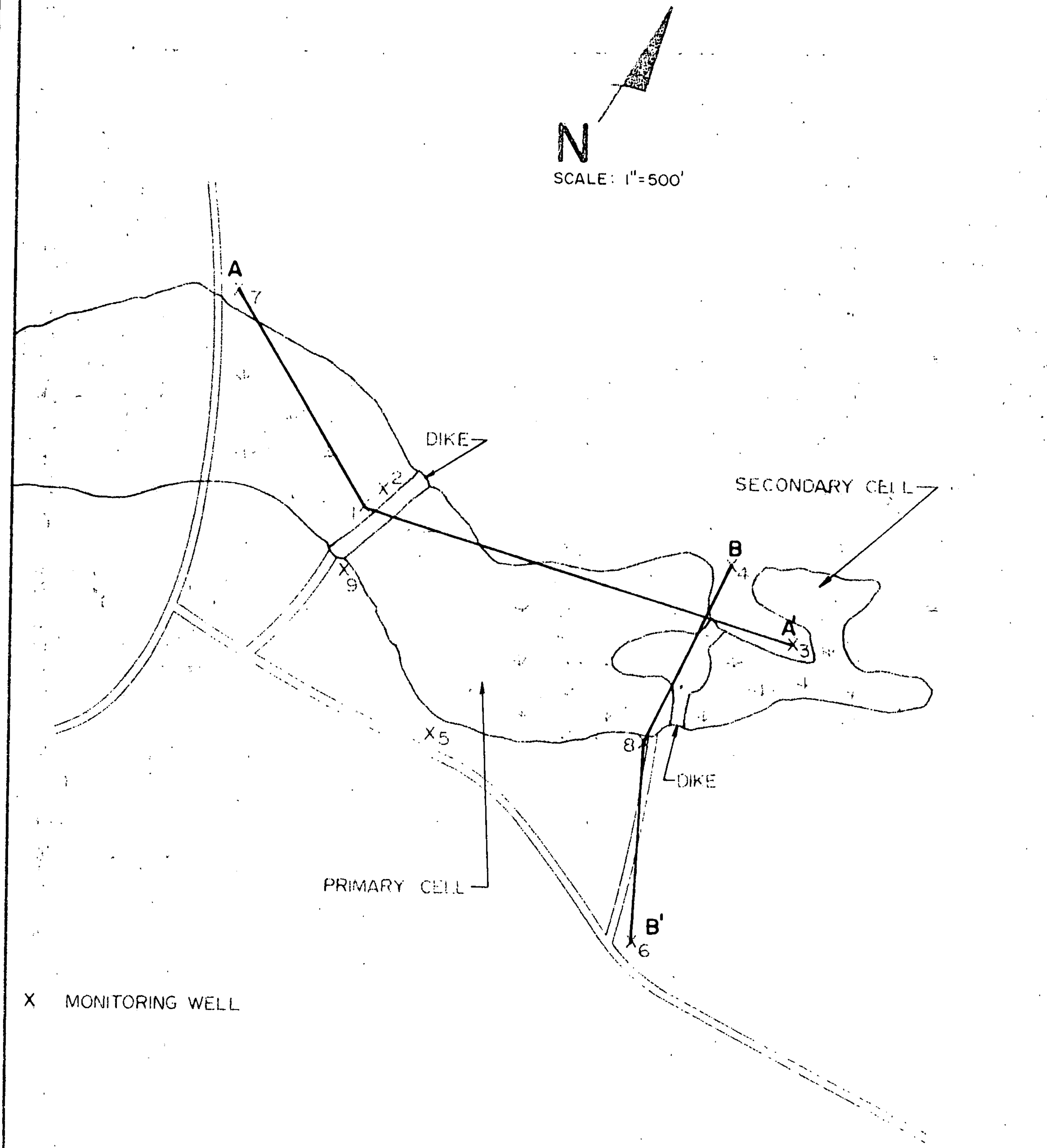
ITASCA STABILIZATION POND

GEOLOGICAL CROSS-SECTIONS

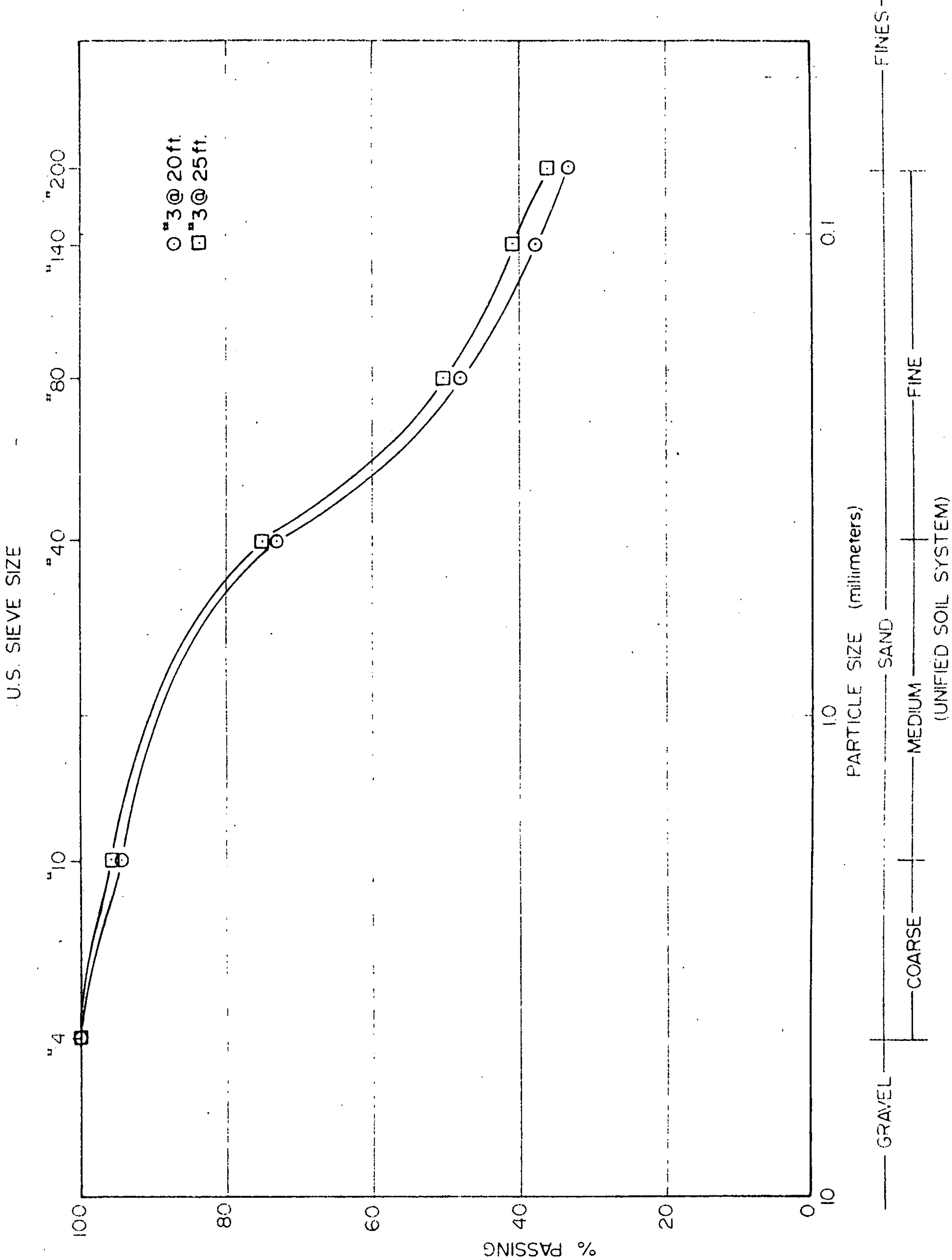
E.A. HICKOK & ASSOCIATES
HYDROLOGISTS - ENGINEERS
MINNEAPOLIS - MINNESOTA

NOV 1980

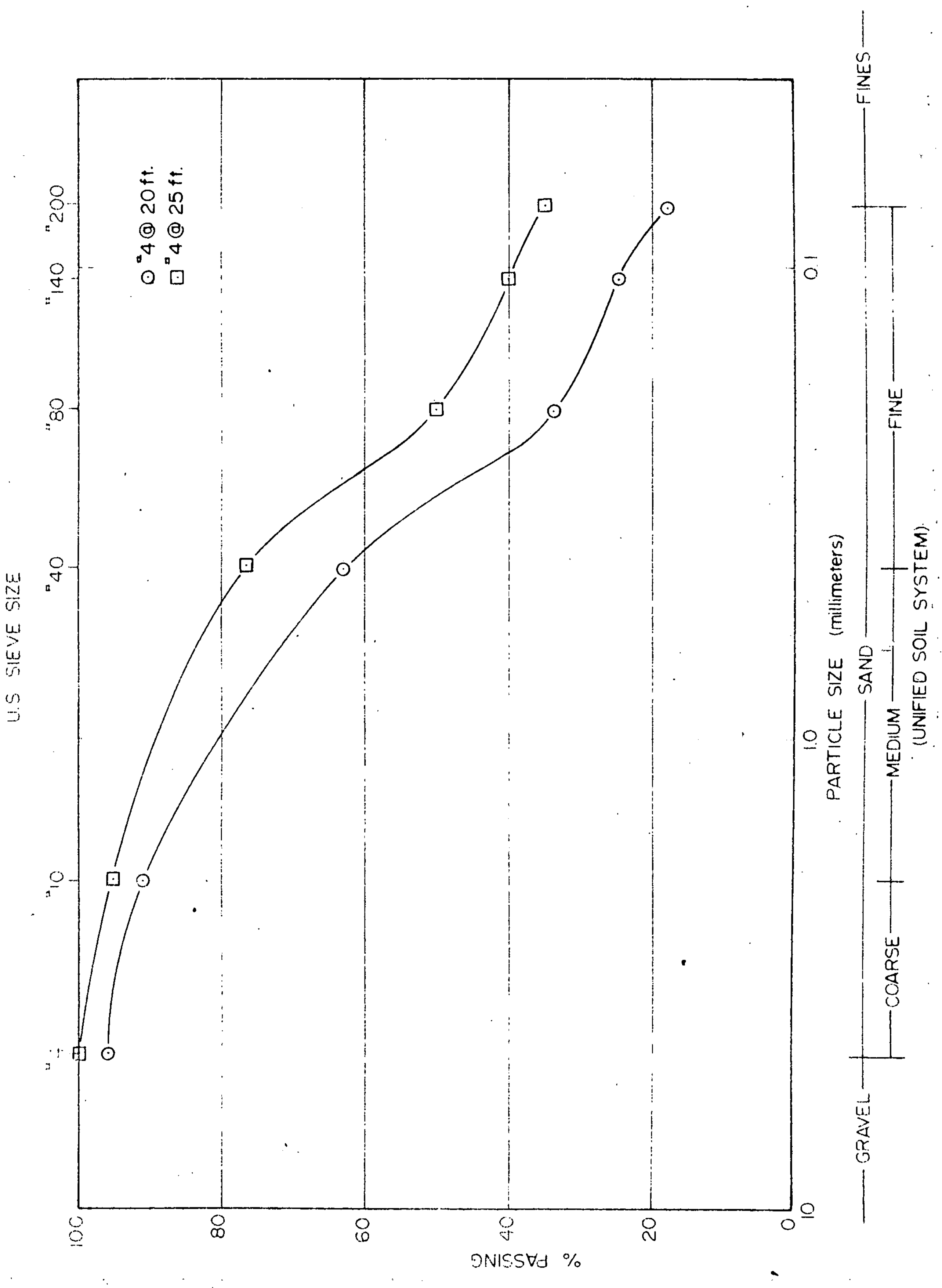
6



ITASCA STABILIZATION POND GEOLOGICAL CROSS-SECTION LOCATION MAP	E.A. HICKOK & ASSOCIATES HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	NOV 1980 7



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
MECHANICAL ANALYSIS WELL #3	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	8-A



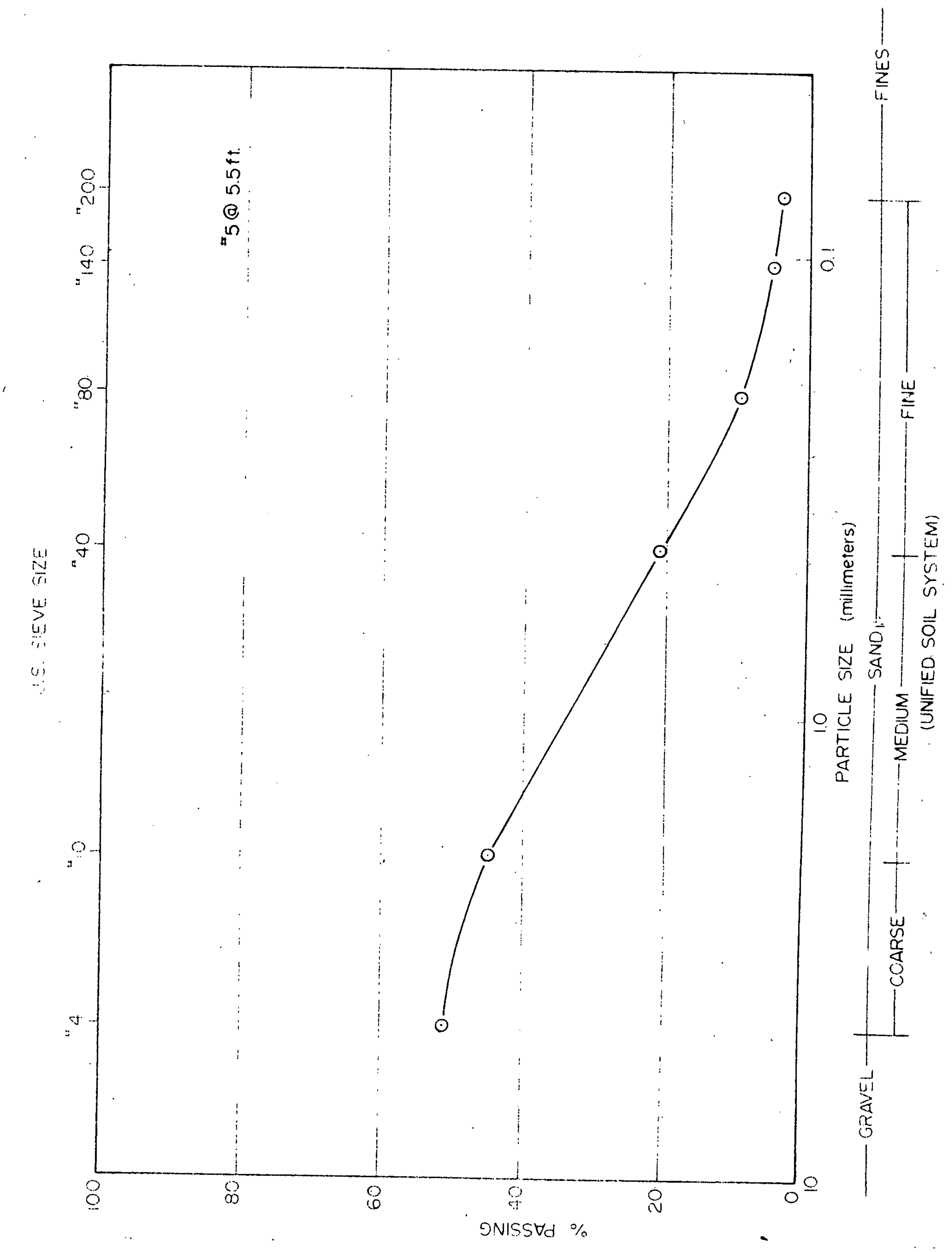
ITASCA STABILIZATION POND

MECHANICAL ANALYSIS
WELL #4

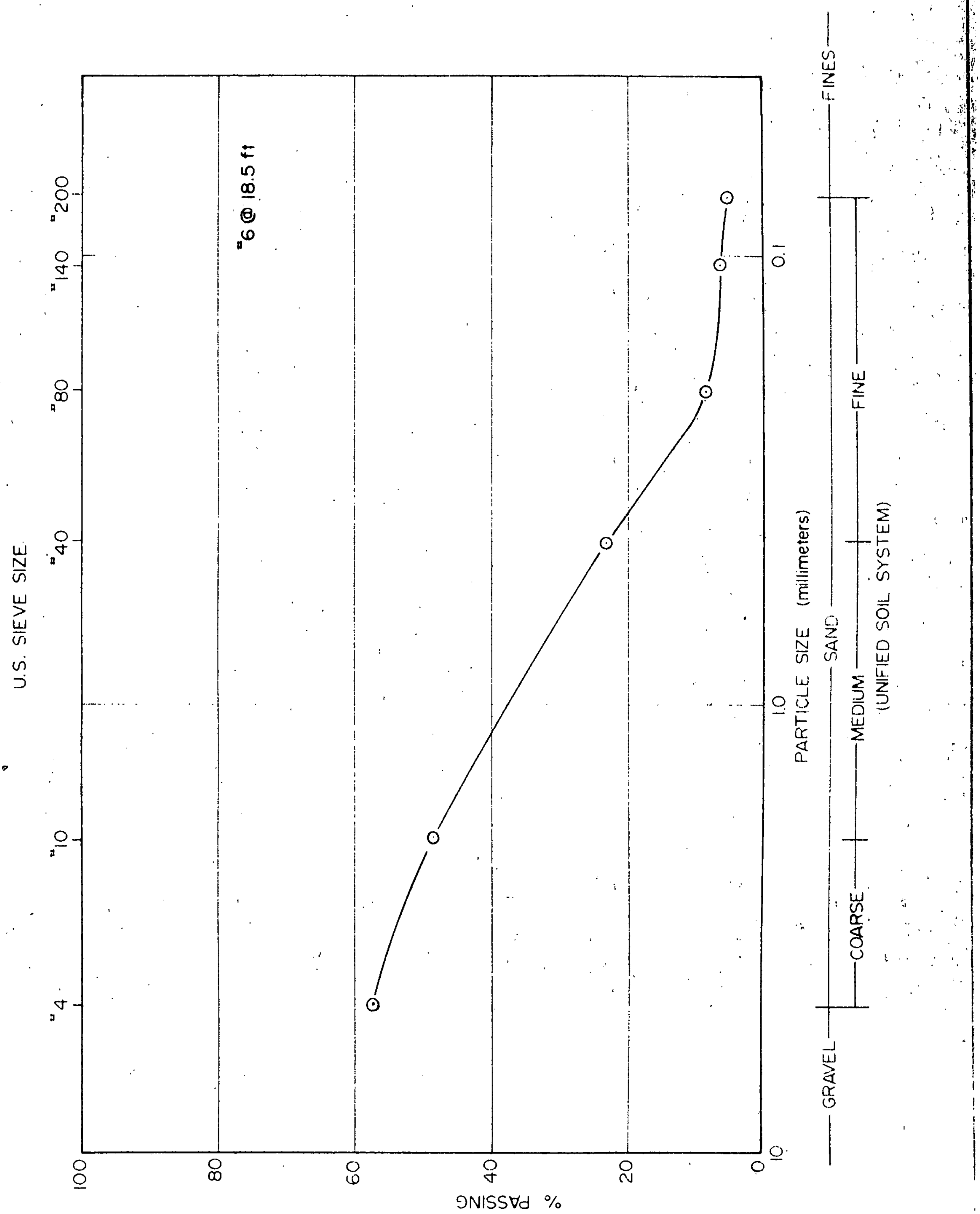
E.A. HICKOK & ASSOCIATES
HYDROLOGISTS - ENGINEERS
MINNEAPOLIS - MINNESOTA

NOV 1980

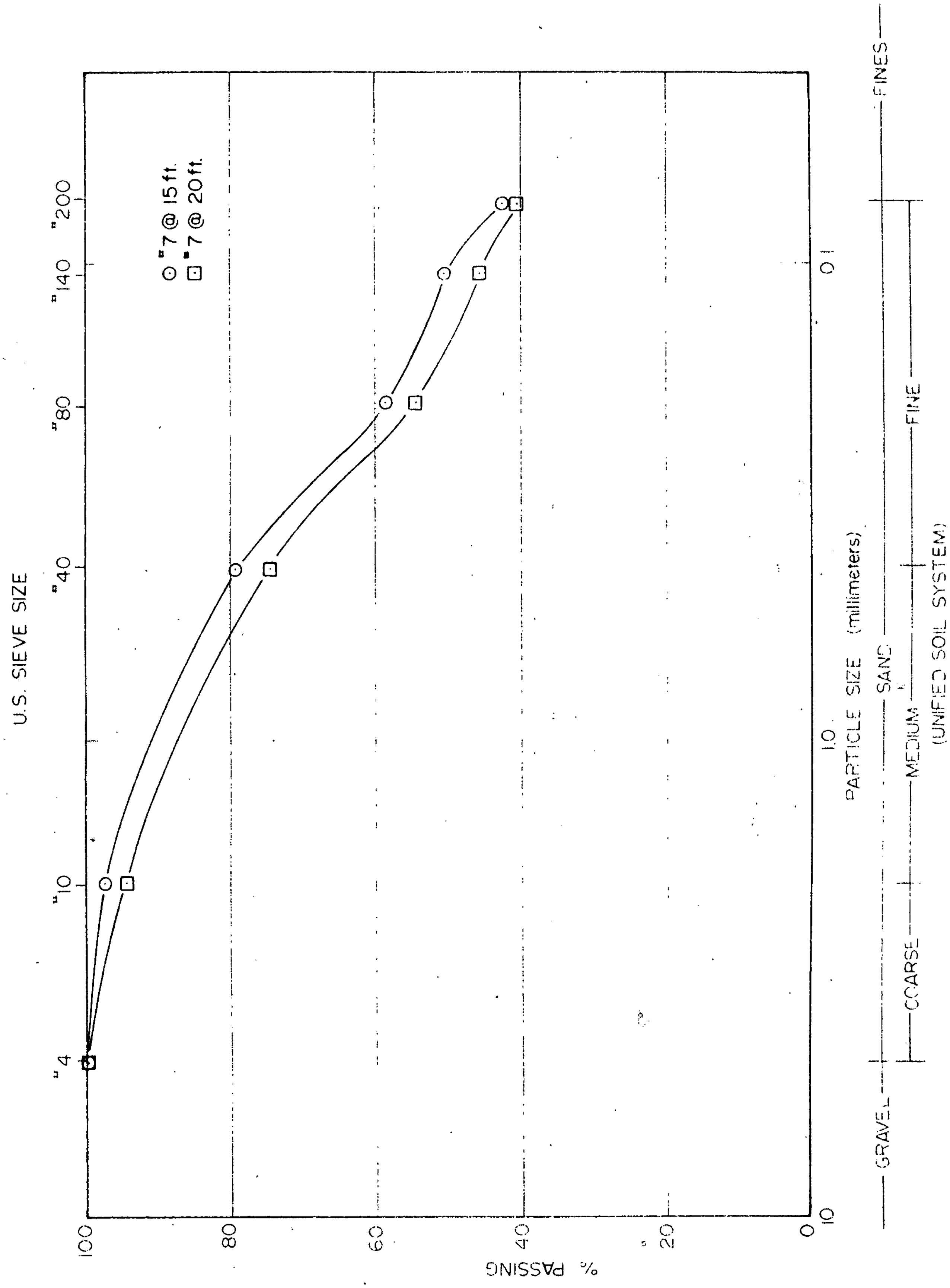
8-B



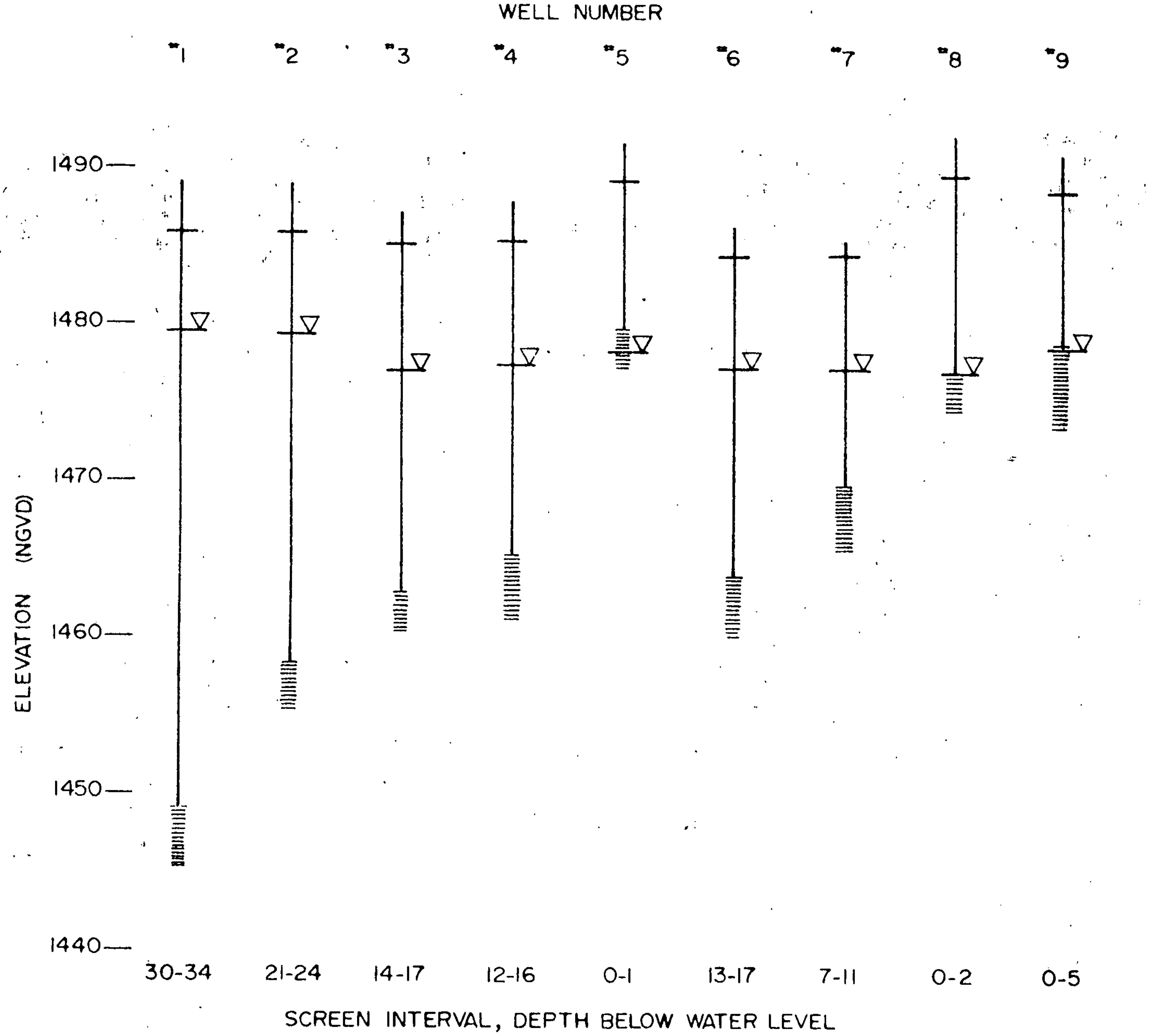
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
MECHANICAL ANALYSIS WELL #5	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	8-C



ITASCA STABILIZATION POND	**E.A. HICKOK & ASSOCIATES**	NOV 1980
MECHANICAL ANALYSIS WELL #6	**HYDROLOGISTS - ENGINEERS** **MINNEAPOLIS - MINNESOTA**	**8-D**

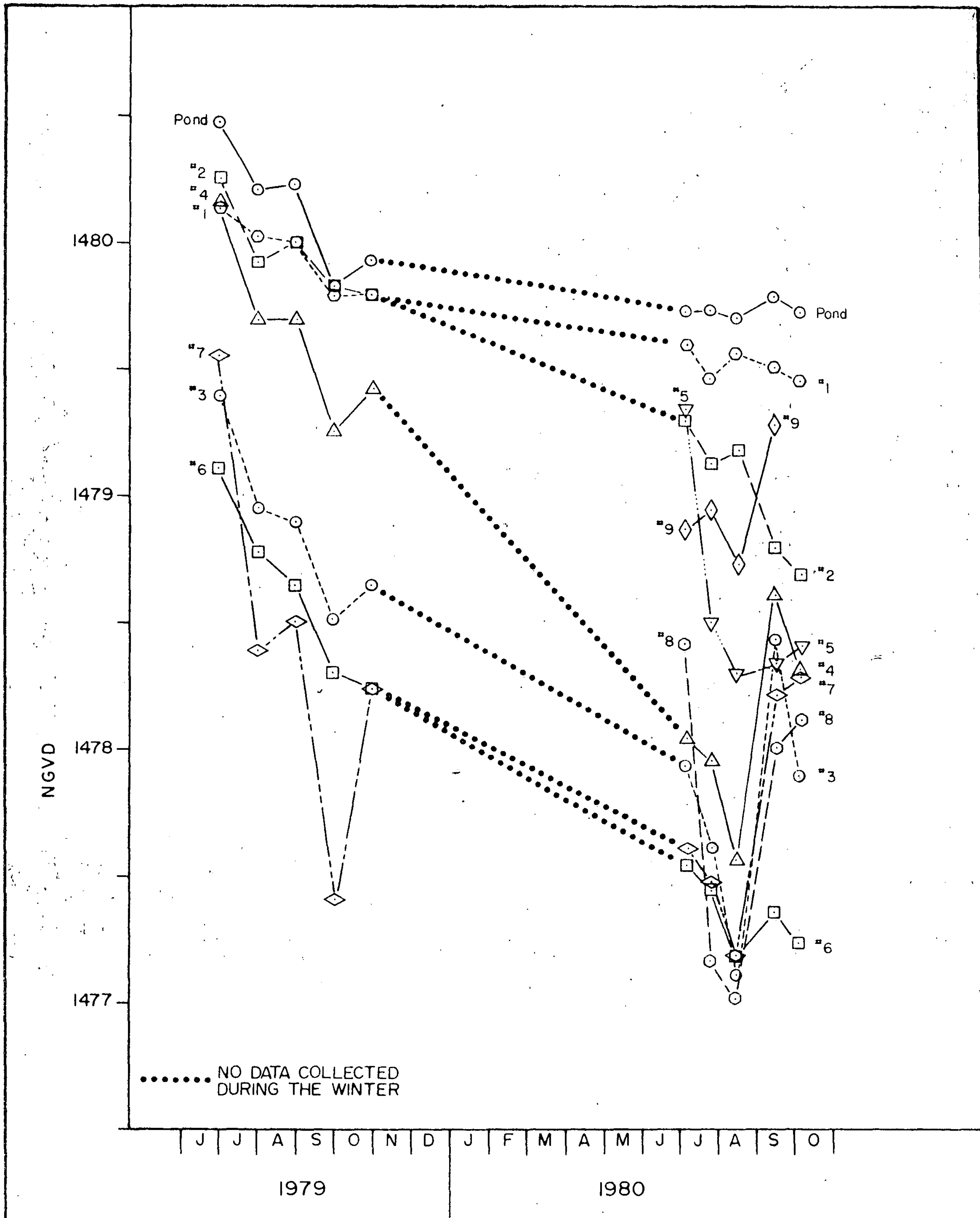


ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
MECHANICAL ANALYSIS WELL #7	HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	8-E

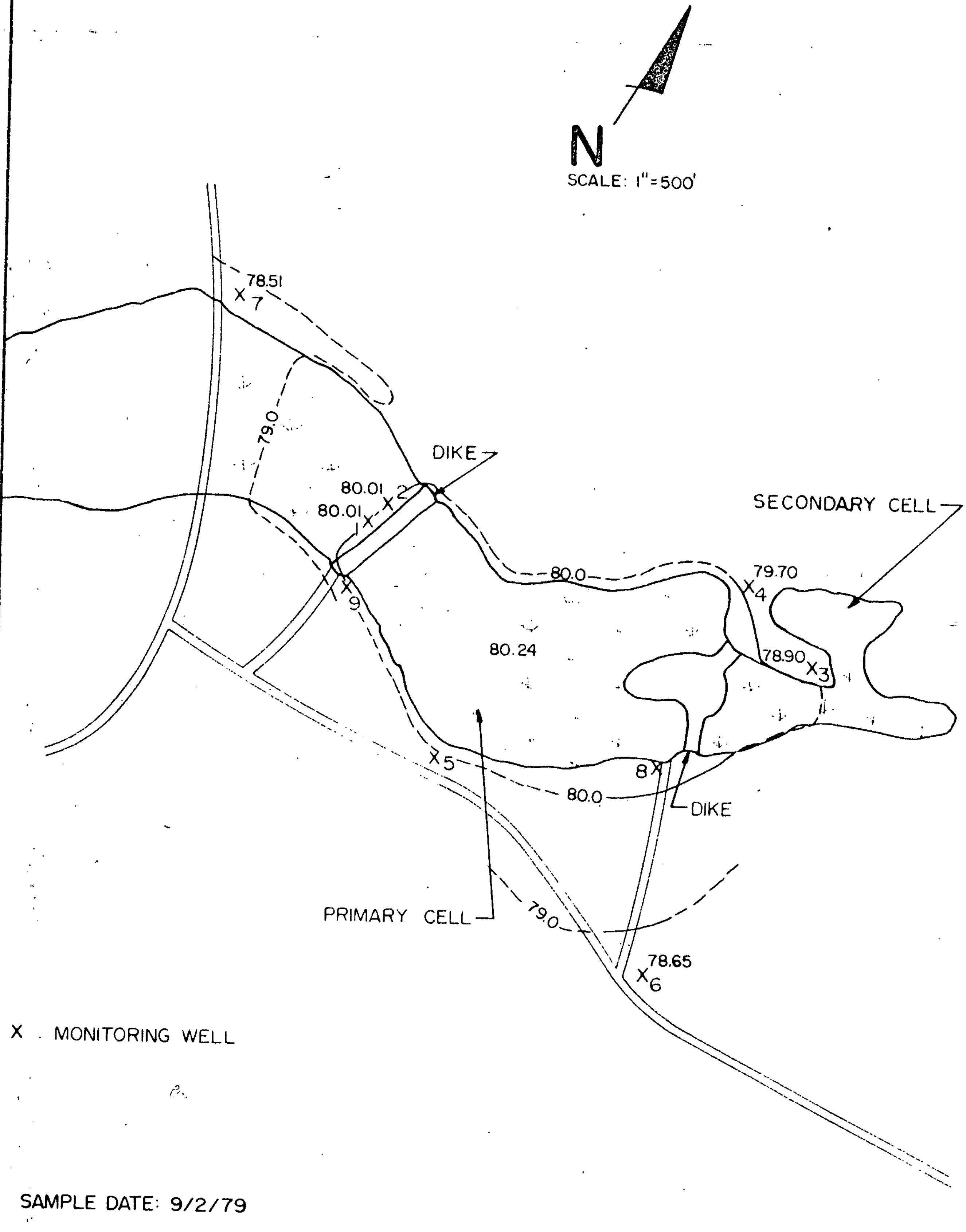


COLLECTION DATE: 8/12/80

ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	NOV 1980
SCREEN POSITIONS		9



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	NOV 1980
WATER LEVEL FLUCTUATIONS		10



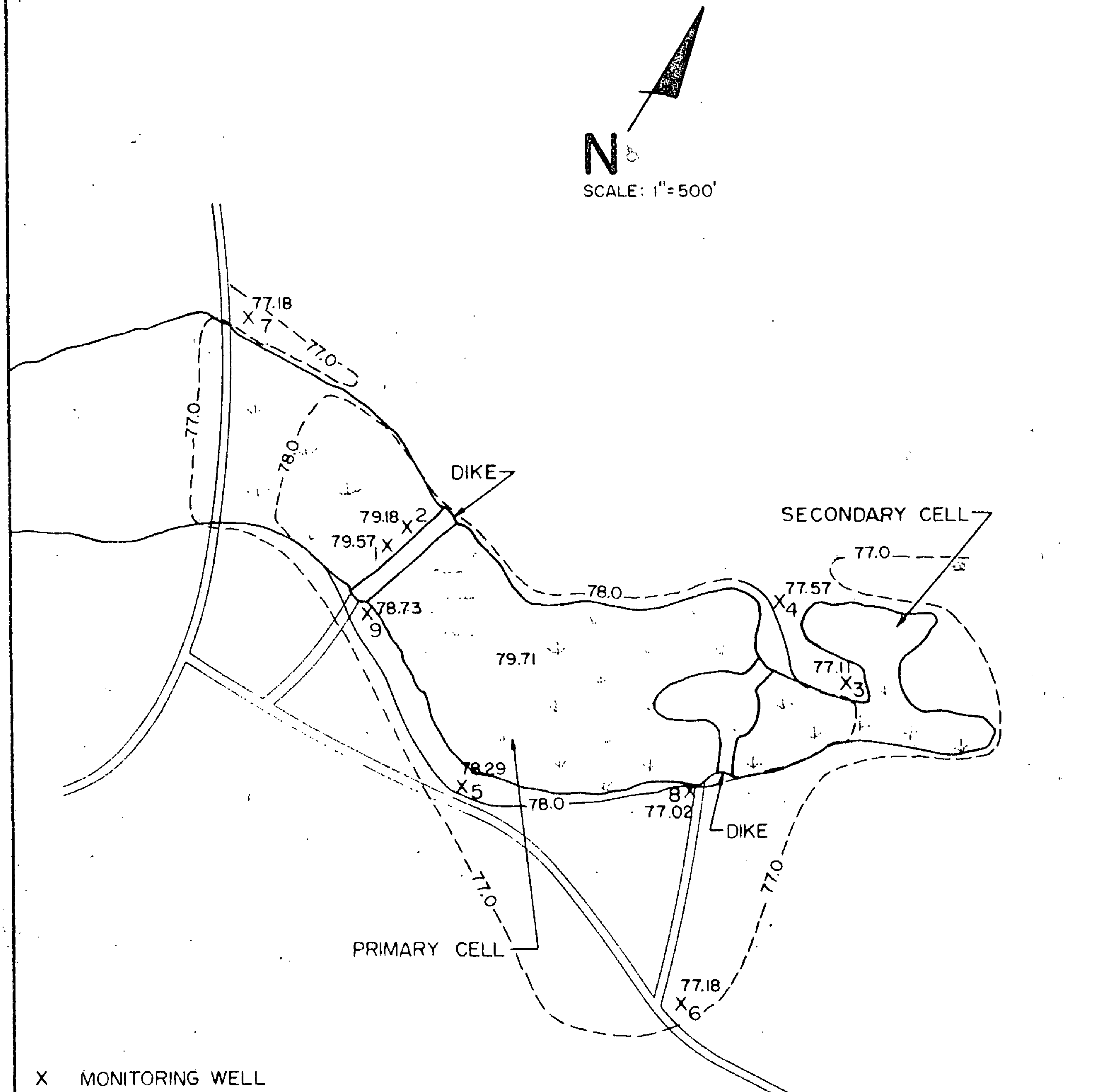
ITASCA STABILIZATION POND

WATER LEVEL CONTOUR MAP
1979

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS - ENGINEERS
MINNEAPOLIS - MINNESOTA

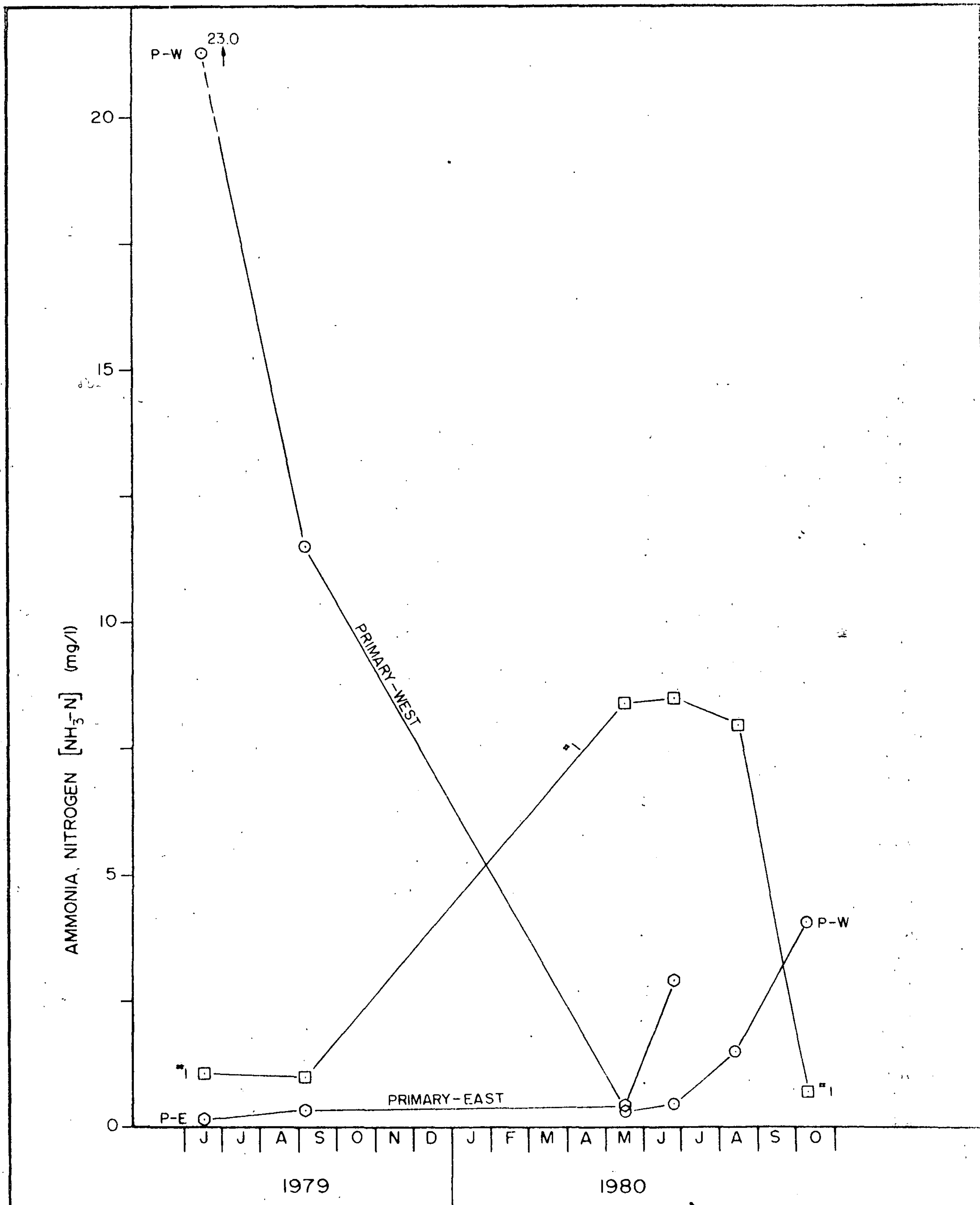
NOV. 1980

II-A

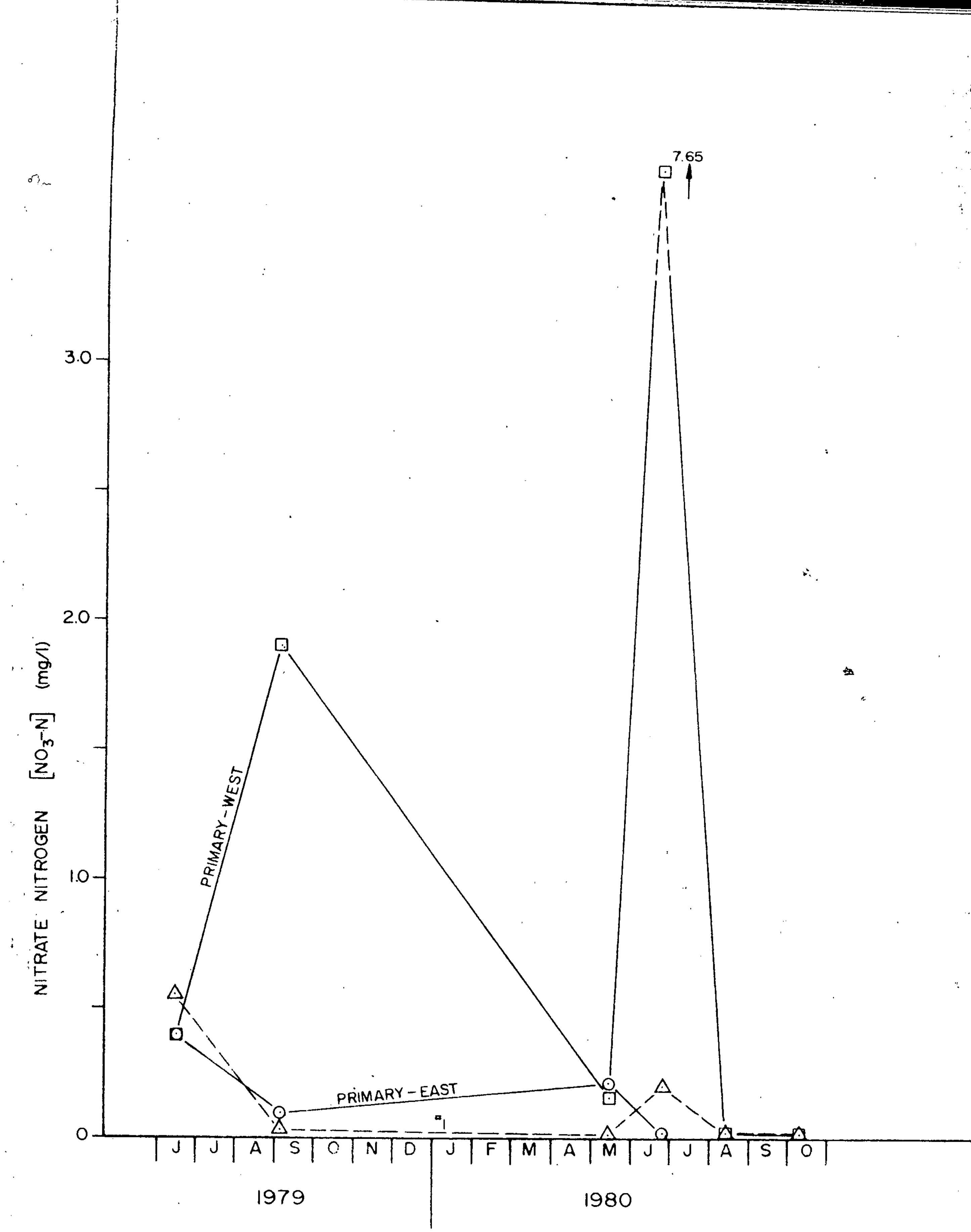


SAMPLE DATE: 8/12/80

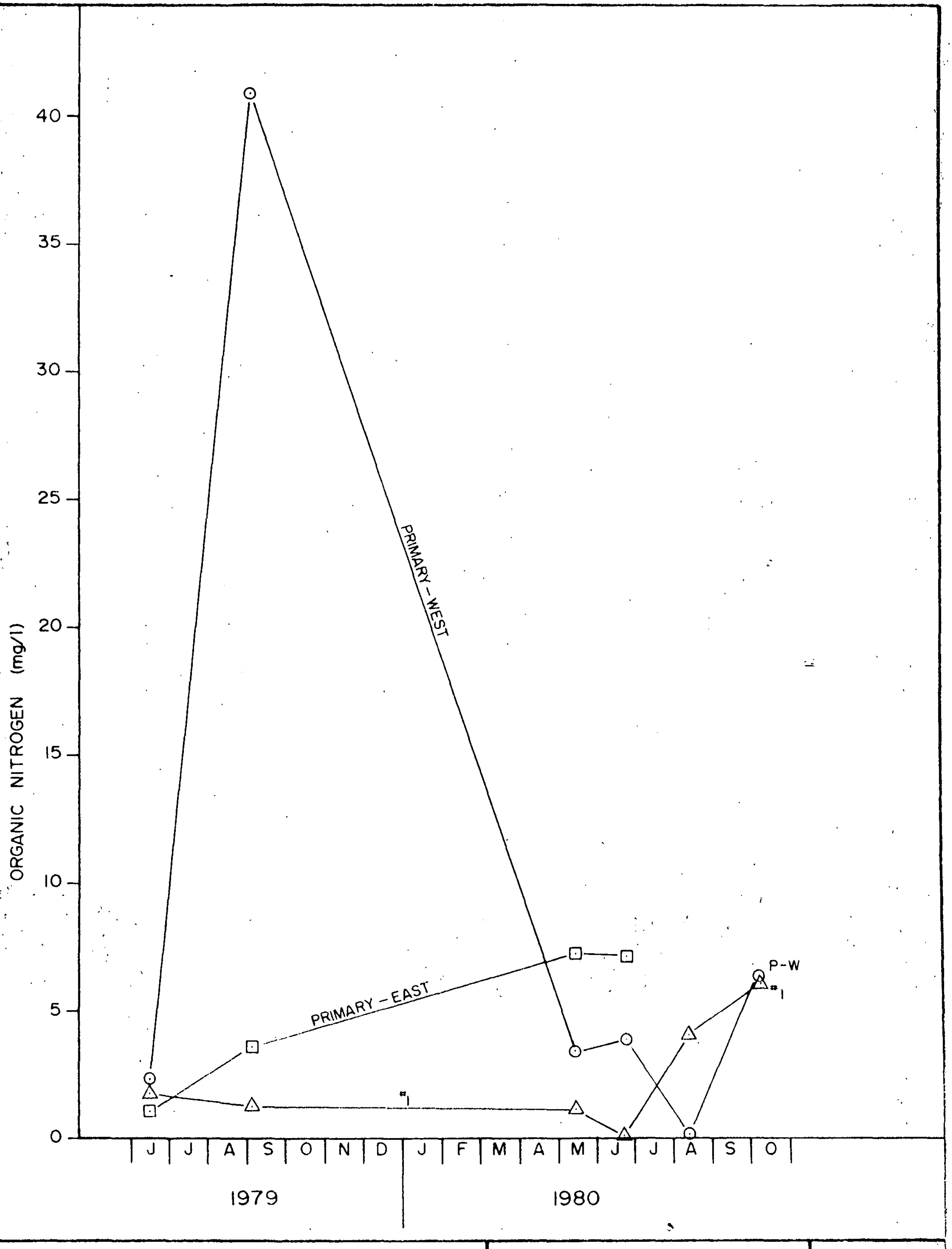
ITASCA STABILIZATION POND	E. A. HICKOK & ASSOCIATES	NOV. 1980
WATER LEVEL CONTOUR MAP 1980	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	11-B



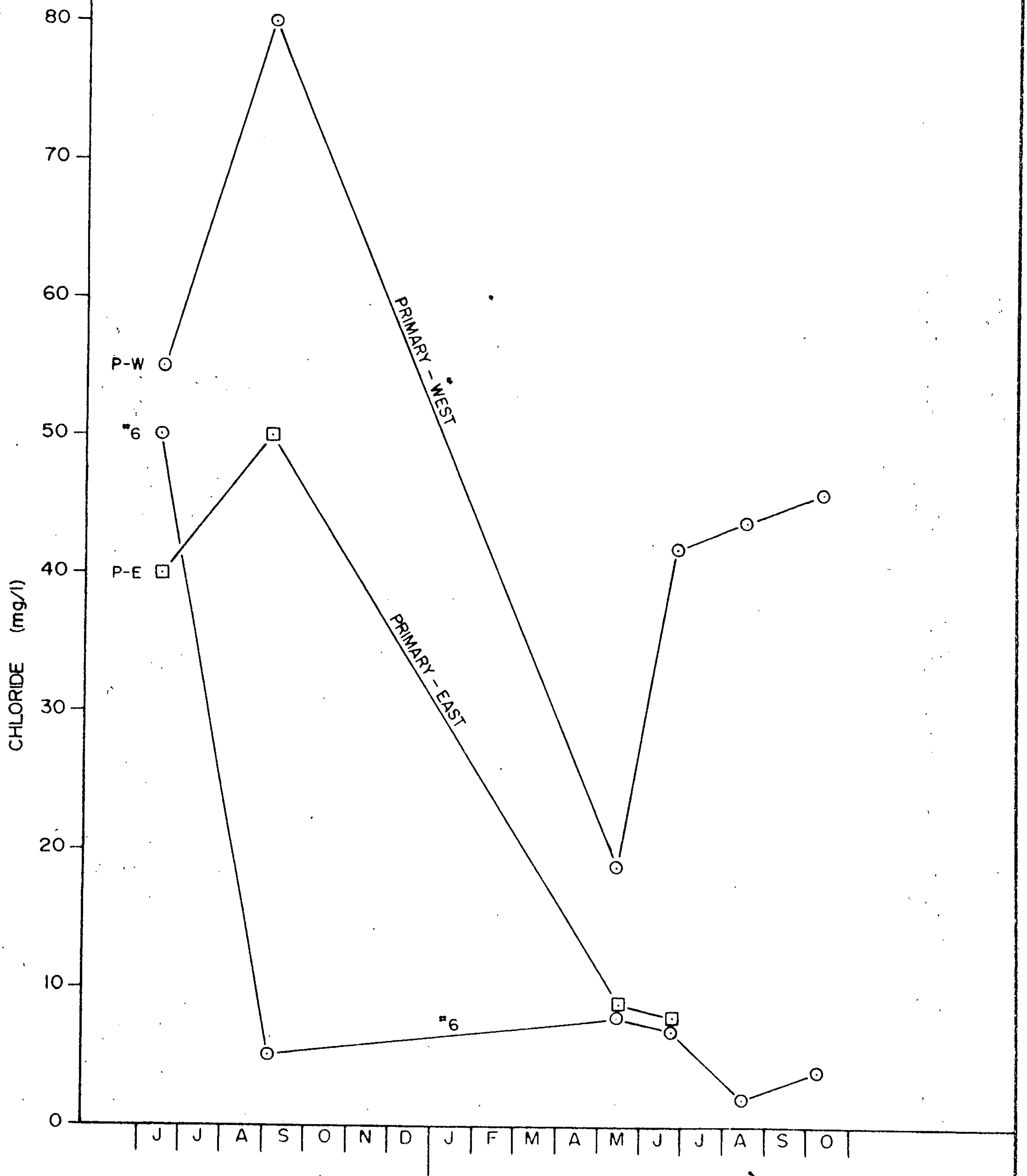
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	NOV 1980
AMMONIA NITROGEN GRAPH		12-A



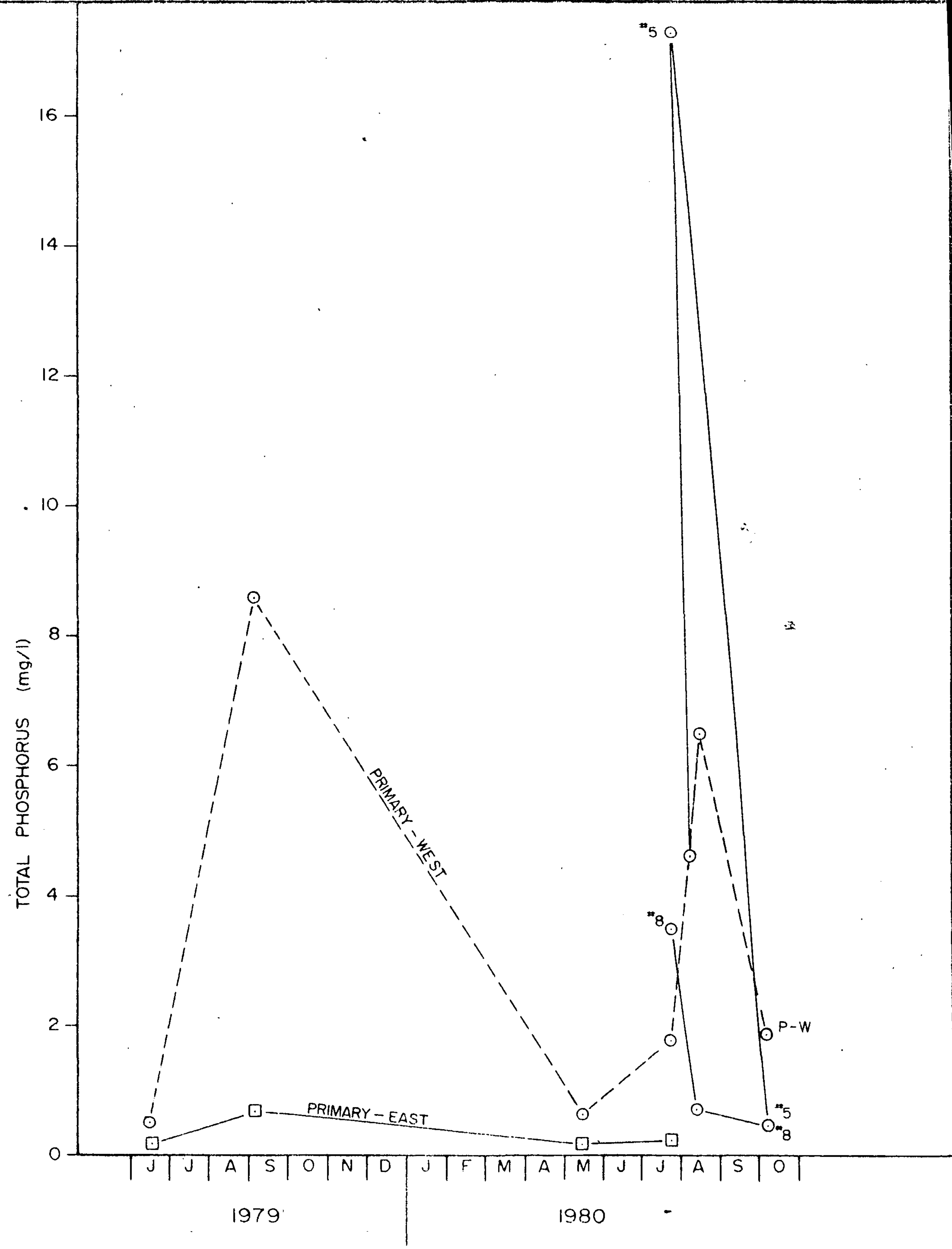
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	NOV 1980
NITRATE NITROGEN GRAPH		12-B



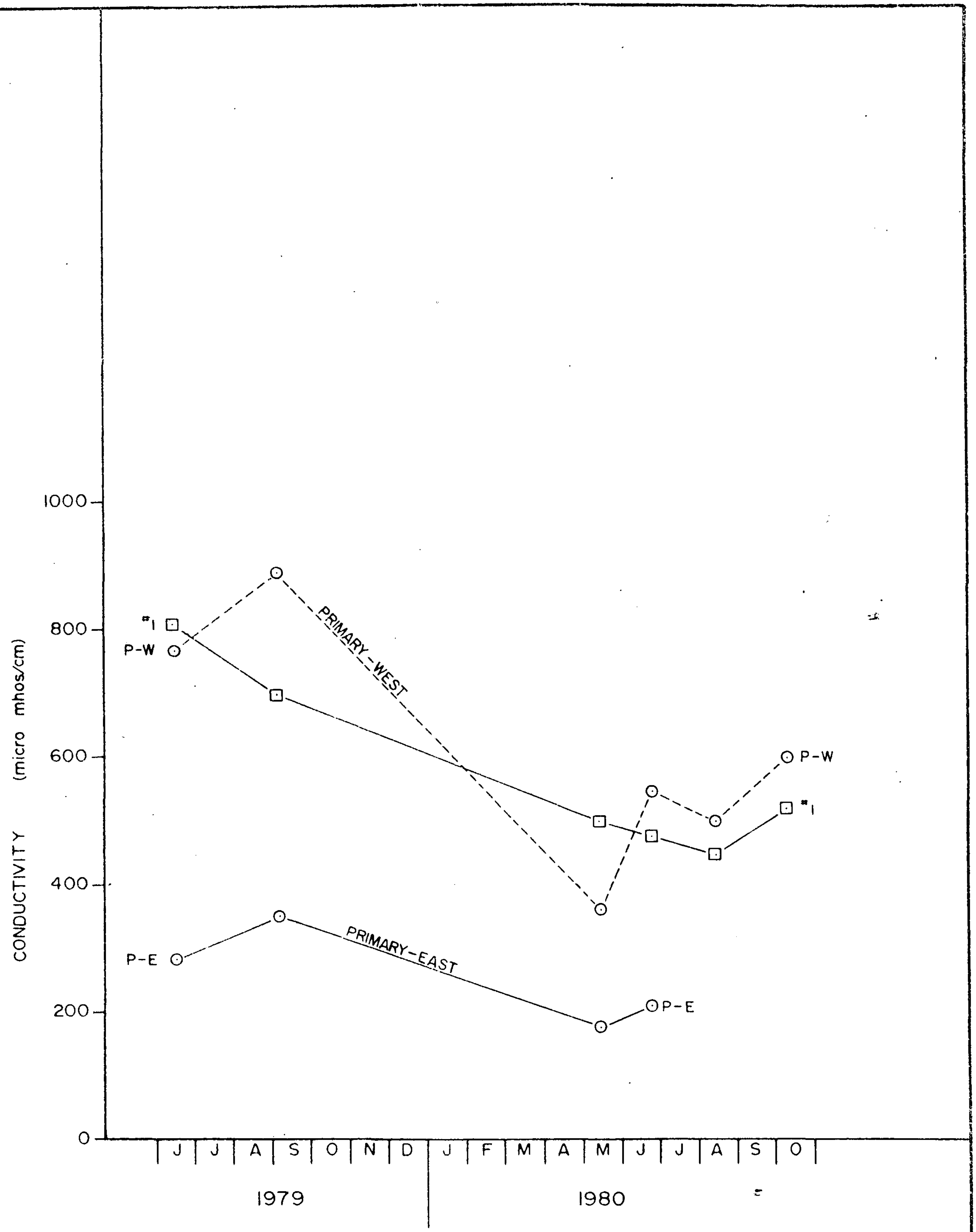
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	NOV 1980
ORGANIC NITROGEN GRAPH		12-C



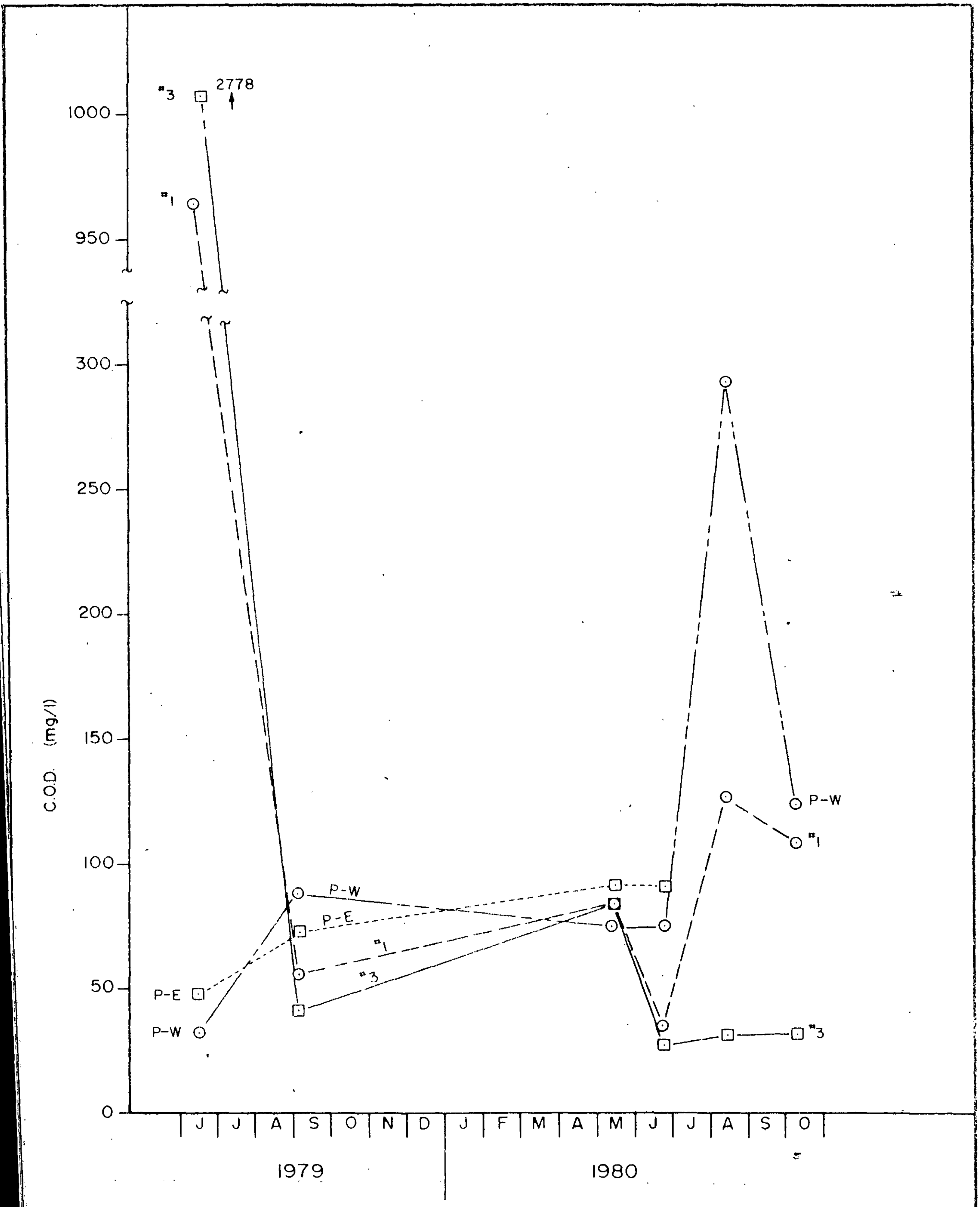
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
CHLORIDE GRAPH	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	12-D



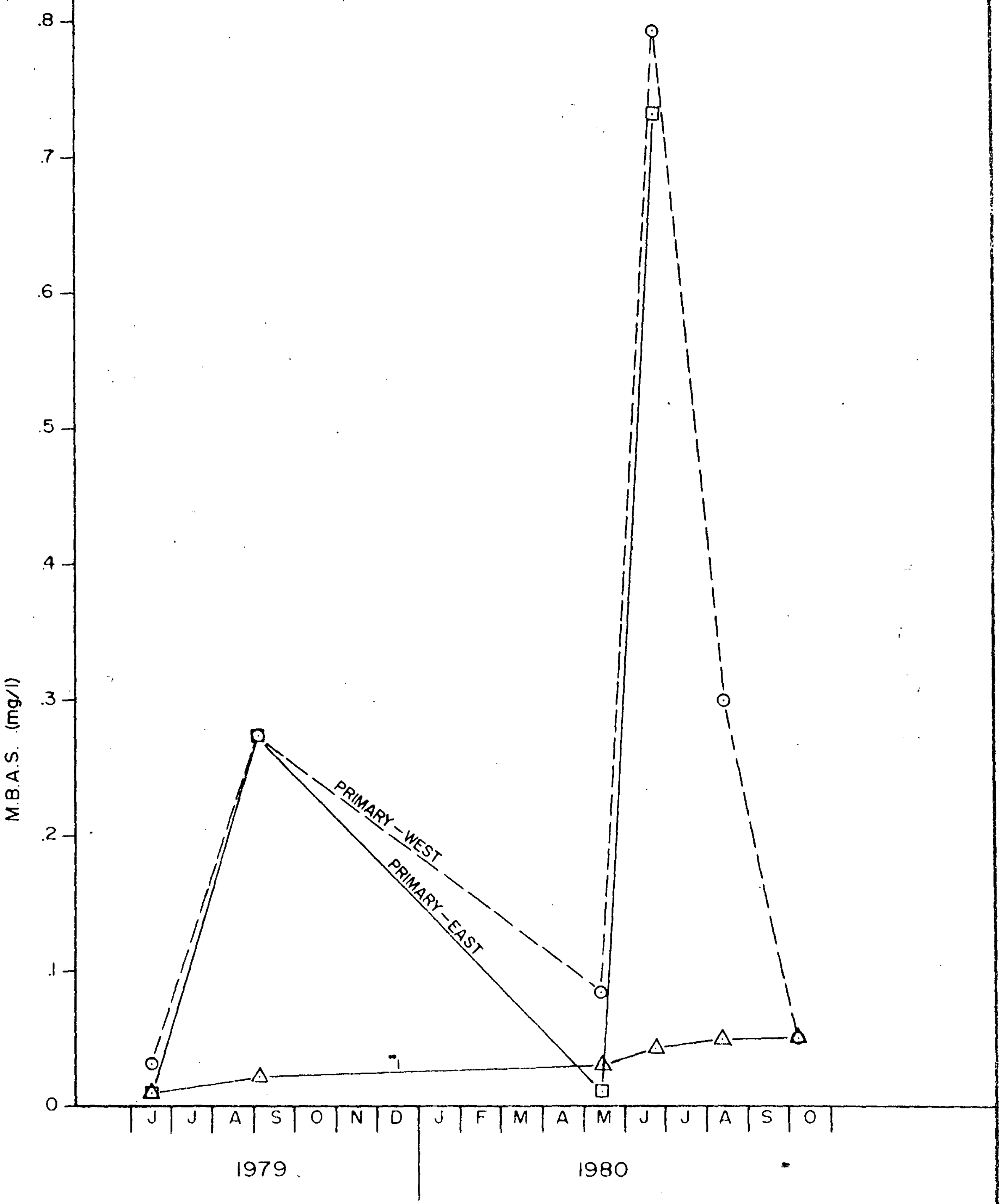
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
TOTAL PHOSPHORUS GRAPH	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	12-E



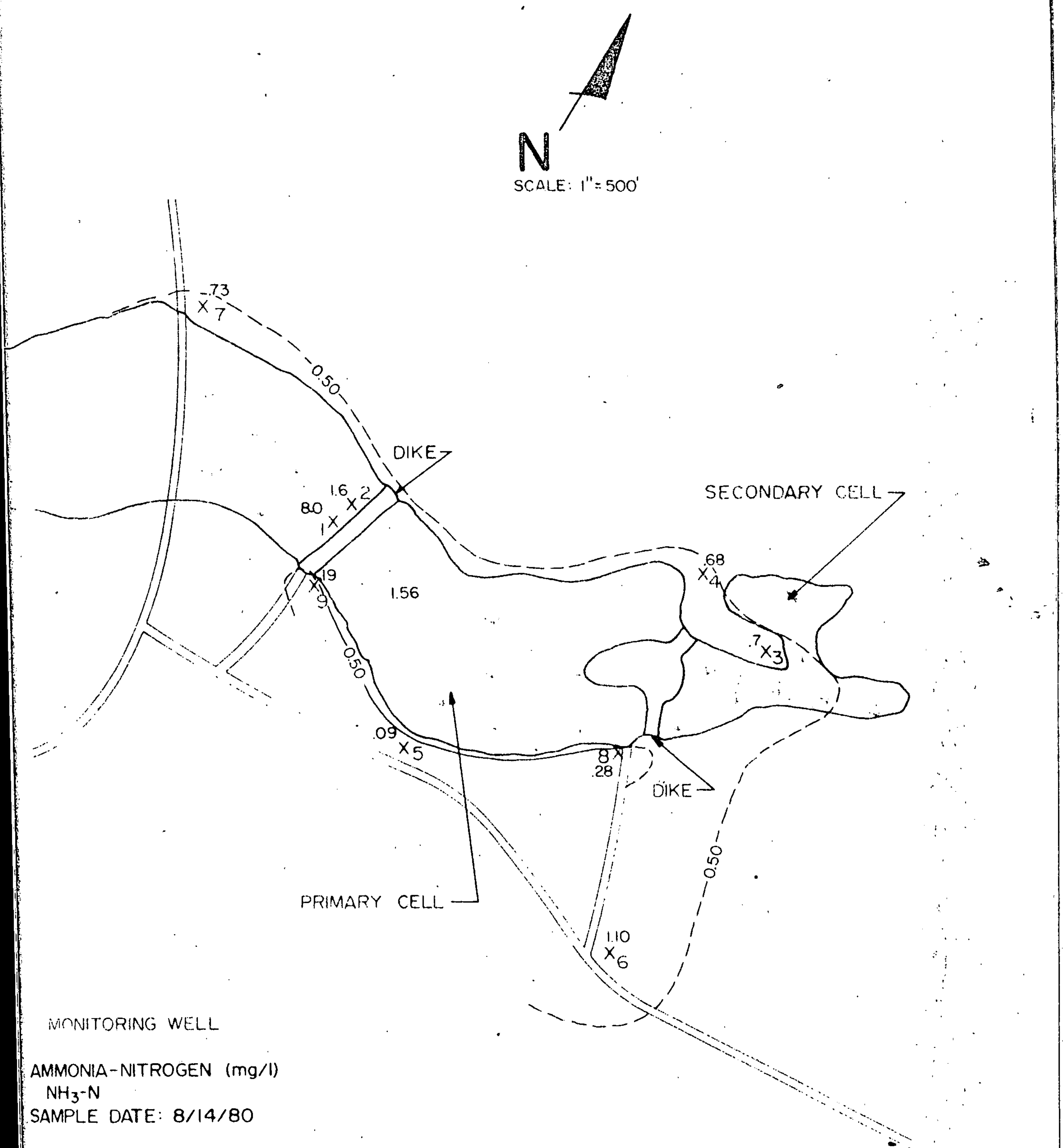
ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
CONDUCTIVITY GRAPH	HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	12-F



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
CHEMICAL OXYGEN DEMAND GRAPH (C.O.D.)	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	12-G



ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
METHYLENE BLUE ACTIVE SUBSTANCES GRAPH (M.B.A.S)	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	12-H



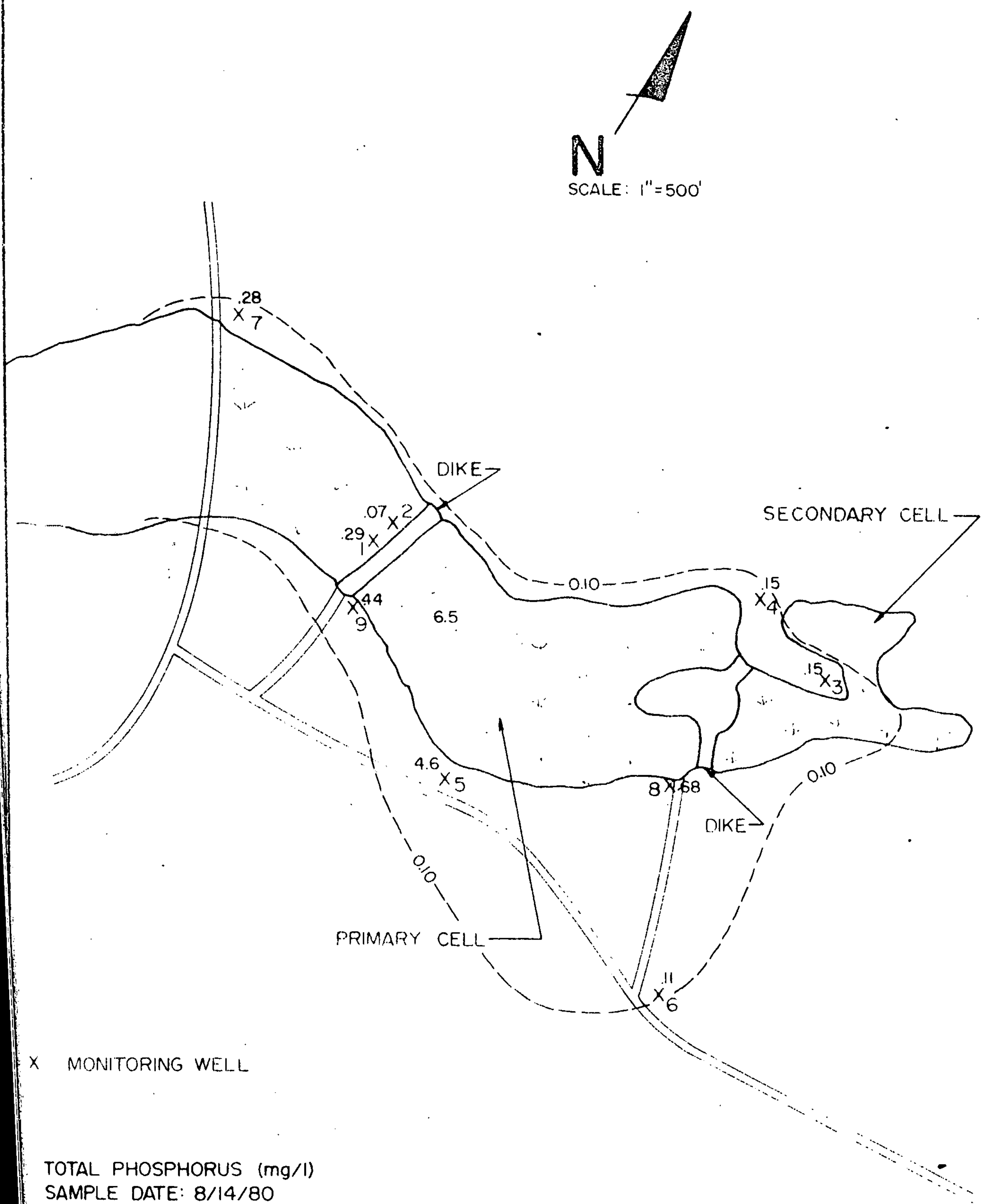
ITASCA STABILIZATION POND

AMMONIA-NITROGEN ISOCON MAP

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

NOV. 1980

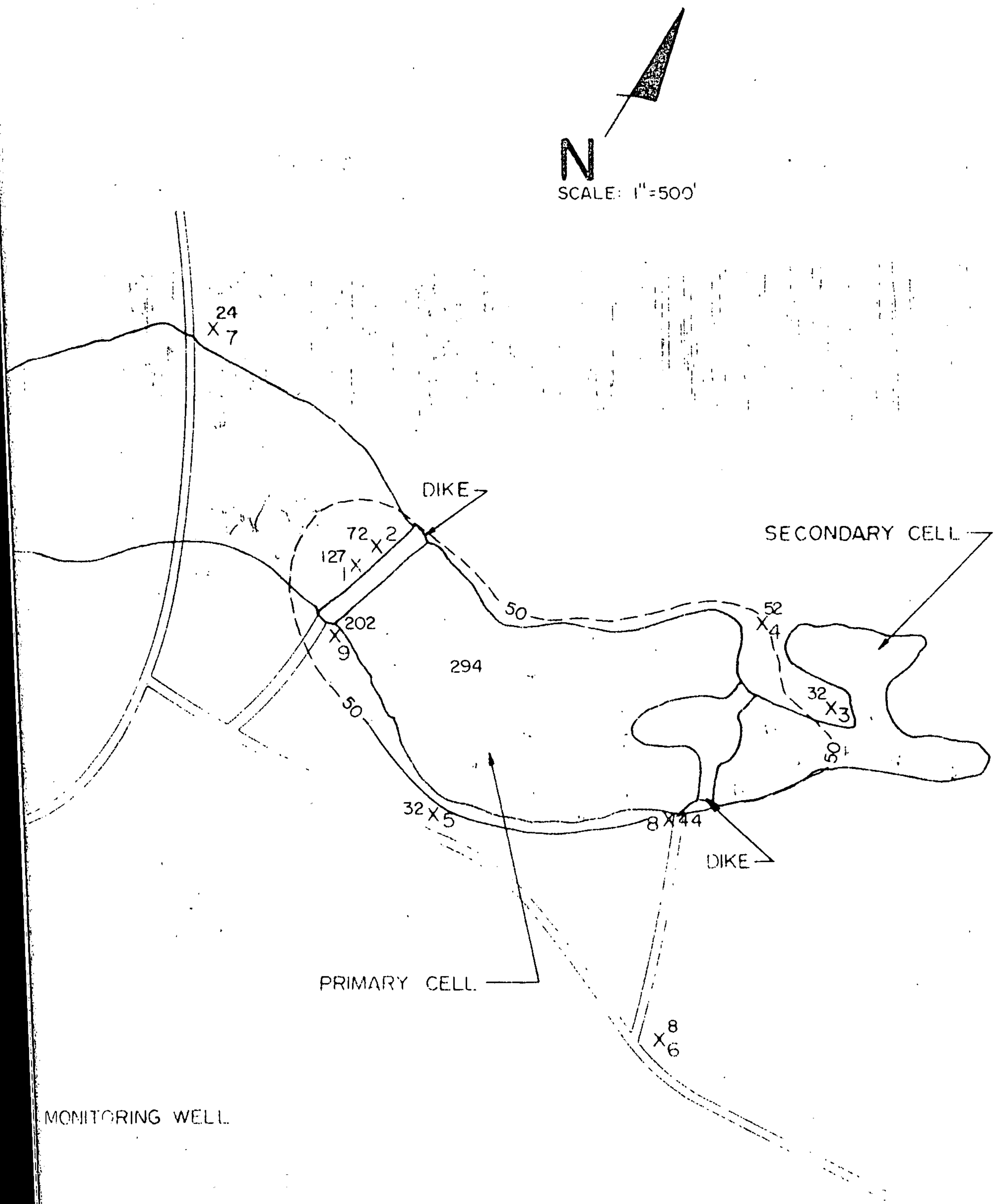
13-A



X MONITORING WELL

TOTAL PHOSPHORUS (mg/l)
SAMPLE DATE: 8/14/80

ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV. 1980
TOTAL PHOSPHORUS ISOCON MAP	HYDROLOGISTS - ENGINEERS MINNEAPOLIS - MINNESOTA	13-B



MONITORING WELL

EMICAL OXYGEN DEMAND (mg/l)
COD
MPLE DATE: 8/14/80

ITASCA STABILIZATION POND	E.A. HICKOK & ASSOCIATES	NOV 1980
CHEMICAL OXYGEN DEMAND ISOCON MAP	HYDROLOGISTS · ENGINEERS MINNEAPOLIS · MINNESOTA	13-C

SOIL LOGS

Well No.	Depth (feet)	Description
#1	0 - 0.2	Fill, loam, sandy, brown, moist.
	0.2 - 3.0	Fill, sand, clayey, light reddish-brown, moist.
	3.0 - 10.0	Fill, sand, clayey, gray-blue, moist.
	10.0 - 18.0	Silt, sandy, with high organic content (peaty), chocolate brown, minor gravel at 12.0.
	18.0 - 30.0	Sand, clayey, gray-blue, saturated.
	30.0 - 37.5	Sand, clayey, brown-gray, saturated, fine-medium grained.
	37.5 - 41.0	Sand, light brown, fine-medium grained, minor fines, well consolidated, colder water than above.
	Auger boring - 1979	
#2	0 - 0.2	Fill, sand, loamy, brown.
	0.2 - 3.0	Fill, sand, clayey, light reddish-brown.
	3.0 - 7.0	Fill, sand, clayey, gray-blue, moist.
	7.0 - 8.0	Fill, sand, clayey, reddish-brown.
	8.0 - 10.5	Fill, sand, clayey, gray-blue.
	10.5 - 19.0	Silt, sandy, peaty, chocolate brown, minor gravel at 12.0.
	19.0 - 22.0	Sand, clayey, gray-blue, wet at 21.0.
	22.0 - 22.5	Sand, clayey, brown.
	22.5 - 31.0	Sand, clayey, gray-blue.
	Auger boring - 1979	
#3	0 - 0.9	Sand, loamy, brown, moist.
	0.9 - 4.0	Sand, clayey, brown, moist.
	4.0 - 7.0	Sand, clayey, brown-gray, moist with minor gravel.
	7.0 - 16.5	Sand, clayey, brown, damp, less clay than above, wet at 13.5.
	16.5 - 22.0	No return, probably clayey sand.
	Auger boring - 1979.	

Well No.	Depth (feet)	Description
#4	0 - 0.2	Sand, loam, light brown, dry
	0.2 - 4.0	Loam, Sandy, brown, moist, cobbles at 2.5-3.7.
	4.0 - 6.5	Silt, sandy, gray-brown, moist, random cobbles.
	6.5 - 21.0	Sand, silty, gray-brown, moist random cobbles, minor sandy silt, wetter at 18.4.
	21.0 - 30.0	Sand, with silt, brown, medium grained, cobbles at 26.5.
	30.0 - 37.0	Sand, clayey, brown.
	Auger boring - 1979	
#5	0 - 14.0	Sand, medium-fine, with pebble layer at 11 feet.
	Backhoe - 1980	
#6	0 - 0.2	Sand, loamy, brown, dry.
	0.2 - 5.0	Sand, with small gravel, moist.
	5.0 - 18.0	Sand, coarse grained, moderate sorting cobbles at 17.9, saturated.
	18.0 - 19.0	Sand, fine-medium, brown, saturated.
	19.0 - 23.0	Gravel, small, uniform size, rounded, saturated.
	23.0 - 28.0	Sand, medium, with 3½" cobbles, little sample return because of wide hole.
	28.0 - 32.0	No sample return, good drilling, no large rocks were encounterd.
	Auger boring - 1979	
#7	0 - 0.1	Loam, sandy, black-brown.
	0.1 - 4.5	Sand, loamy, brown, moist, rock at 4.0.
	4.5 - 22.0	Sand, silty, brown, very damp at 5.0, soupy at 11.0.
	Auger boring - 1979	
#8	0 - 9	Sand, clayey, with boulders.
	9 - 14	Sand, medium-fine.
	Backhoe - 1980	
#9	0 - 10	Sand, clayey, with cobbles
	10 - 14	Sand, fine-medium, with silt
	Backhoe - 1980	