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Sediment Oxygen Demand Studies of Selected Northeastern Illinois Streams

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by Thomas A. Butts and Ralph L. Evans

INTRODUCTION

Special field sampling equipment was designed and employed for gathering data concerning the oxygen consuming potential of bottom sediments and substrates in small streams in a six-county area in the northeastern corner of Illinois. The sampling program was designed so that results from selected sampling locations could be extrapolated for use throughout most natural streams and rivers in the study area, except for the Kankakee River and its tributaries. The data produced is readily usable for input into most dissolved oxygen oriented water quality models. The project was funded by a grant from the Northeastern Illinois Planning Commission (NIPC).

Sediment Oxygen Demand

Sediment oxygen demand (SOD) can be broadly defined as the usage of dissolved oxygen in the overlying water by benthic organisms. In stream waters, it results from the biochemical oxygen demands of micro- and macroorganisms. The principal microdemand is due to bacteria; however, brown algae, protozoa, and aquatic fungi may, at times, contribute also. Macrodemand is caused by both aufwuch communities and burrowing fauna. Worms, insect larvae and nymphs, leaches, snails, and mussels are the principal burrowing types. Periphyton, or organisms which grow on or are attached to underwater substrates, represent an important source of SOD in some streams. Slime bacteria, such as *Sphaerotilua* and *Leptomitus,* form filamentous streamers on the bottoms of many shallow, organically enriched streams and exert significant oxygen demands. Attached filamentous green algae may also represent a demand. Inorganic chemical oxidation reactions can exist in stream bottoms, but the extent and magnitude of their occurrence are minor compared with biological demands.

Oxygen demand due to all the above organisms (except inorganic chemical reactions) has been identified and measured to some degree in the NIPC 208 planning region. In all, 90 successful SOD measurements were made on stream bottoms at 89 locations in the study area. The results of 13 SODs taken in the Fox Chain of Lakes during a separate study[1] are also included in this report.

A number of studies by the State Water Survey (SWS) since 1972 have revealed the need for including SOD in any water quality model involving dissolved oxygen utilization and balance.[1,2,3,4] In the past, SOD generally has not been included irrespective of how sophisticated the model. Models must have often produced erroneous or misleading results, the degree of which must have been dependent upon the general condition of the stream bottoms and the indigenous biota. Oxygen balances often cannot be correctly determined for streams having large, well distributed macroinvertebrate populations by merely determining dissolved biochemical oxygen demands (BOD) and then balancing DO usages and reaeration by the basic Streeter-Phelps equation. As an example, a high benthic oxygen demand exists in a large but localized area of the Keokuk pool in the Mississippi River, This demand is primarily responsible for depressing DO concentrations to values as low as 4 milligrams per liter (mg/1). This is significant in that 45 percent of the benthic demand is due to a very large population of a species of fingernail clam.[4]

In this report, an attempt is made to identify the primary cause of the SOD at each sampling station. Only broad classifications such as bacteria, macroorganisms, algae, etc. are given. Respiration rates for specific organisms are not available for computing percentage compositions except for the one single species of fingernail clam observed to occur in great numbers in the Keokuk pool.

Study Area and Streams Surveyed

The project study area covers the six northeastern Illinois counties of McHenry, Lake, Kane, DuPage, Cook, and Will. Sampling sites were selected on all the major streams in the six-county area excluding the canals and channelized streams subjected to Lake Michigan diversion water and the Kankakee River. The streams and number of locations sampled per stream are as follows: Fox River 24, Nippersink Creek 1, Silver Creek 1, Kishwaukee River 3, Flint Creek 2, Woods Creek 1, Blackberry Creek 1, West Branch DuPage River 6, East Branch DuPage River 6, DuPage River 3, Des Plaines River 15, Salt Creek 6, Skokie Lagoons 3, North Branch Chicago River 1, Little Calumet River 7, Calumet Union Drainage Canal 1, Midlothian Creek 1, Thorn Creek 2, Deer Creek 1, Butterfield Creek 1, and Hickory Creek 3.

The streams having only one or two sampling sites are small streams selected to represent water courses which drain certain land use, geologic, and geographic areas. Specifically, Nippersink Creek was chosen to represent a stream draining mostly rural undeveloped marshy terrain. The Silver Creek station represents conditions expected to exist in the headwater reaches of a small creek subjected to secondary waste treatment effluent, Flint Creek was sampled in two locations--one at an upland site representative of a stream reach draining a large wealthy residential area, and the other at a lowland site after the creek has meandered through a marshy pastoral setting. Woods Creek was sampled a short distance below the Lake-in-the-Hills dam; this site represents an intermittent stream below an impoundment. The North Branch of the Chicago River was sampled below the Skokie Lagoons to determine if the prolific algal growths which seem to perpetually exist in the impoundments affect the outlet stream bottom. The Calumet Union Drainage Canal site represents conditions occurring in a short drainage ditch receiving runoff from modest to low class residential and commercial zones, and light industrial areas. The Deer Creek station is located immediately below a secondary sewage treatment plant and receives drainage from both developed areas and rural agricultural operations oriented principally toward truck farming. Butterfield Creek, above the sampling location, disects mostly golf courses, but a large number of relatively small secondary sewage treatment plants are tributary to the stream. The Skokie Lagoons samples represent bottom conditions which are likely to occur in a relatively large impoundment created on a small stream draining a highly developed residential and commercial area. The Hickory Creek samples represent bottom conditions which are likely to occur in a relatively small impoundment created on a small stream draining a lightly developed, semi-rural area.

Report Format

The methods and procedures developed by the SWS to perform small stream *in-situ* SOD measurements are outlined in detail. The field equipment and methods for collecting biological and sediment samples are presented along with the basic formulas and techniques used in data reduction. The reduced data and results, suitable for use directly in a water quality model, are summarized; this includes SOD, biological, and sediment data and the interrelationships between these parameters. Extensive use was made of tabulations and graphic presentations of raw and supportive data in appendices. Included are appendices pertaining to the field traced SOD curves, benthos identification and enumeration, descriptions and physical features of sediment samples collected with Ekman and ponar dredges, description of sediment samples collected with a coring device, and photographs of core samples.

Acknowledgments

This study was conducted as part of the work of the Water Quality Section (WQS) of the Illinois State Water Survey, Dr, William C. Ackermann, Chief. Jack Williams, Michael Toohill, and Robert Duffner, all of whom spent many long, hard hours in the field, were especially instrumental in making this project successful. Thomas Hill and Patricia Schultz identified and enumerated most of the benthos. David Hullinger performed the laboratory analyses on the sediments.

FIELD SAMPLING EQUIPMENT AND PROCEDURES

Field work consisted of performing *in-situ* sediment oxygen demand measurements, collecting benthos samples with a biological dredge, and taking sediment core samples. A two-man crew was utilized for these operations.

Sediment Oxygen Demand

Personnel of the WQS of the SWS began developing ideas and formulating thoughts in late 1971 on how to best quantify sediment demand. The need for SOD data arose when waste assimilation studies of the upper Illinois waterway showed that first and second stage biochemical oxygen demand did not account for the low dissolved oxygen (DO) concentration frequently observed.[2,5]

A literature review provided only limited information on methods and techniques. Most of the work toward measuring the potential oxygen uptake of sediments has been done in the laboratory with disturbed samples. Bradley and James[6] found differences between theoretical and laboratory measured SODs to be as high as 48 percent. Rolley and Owens[7] reported that sediment-core sample respirators possibly underestimate benthic oxygen usage rates. This speculation was later verified by James.[8] He found that coring techniques reduce sample volumes up to 15 percent, thereby altering the interstitial water content and reducing the concentration gradients of contaminants in the mud which contribute to SOD.

Overall, it appeared that more and better data could be generated if equipment and methodologies could be developed for measuring SODs *in-situ.* Consequently, over the last five years the WQS of the SWS has successfully carried out a research and development program oriented toward measuring SODs in the field and producing results of practical value.

The chamber respirometer, provided with a means of internally circulating water, is the basic concept around which the SWS has developed equipment and procedures for performing *in-situ* measurements. The operation consists essentially of containing a known volume of water over a given bottom area with some type of chamber and measuring the DO drop with a galvanic cell oxygen probe implanted in the chamber.

Two samplers have been designed. One is referred to as the bell sampler and the other as the box sampler. The bell sampler was used during the initial study of sediment oxygen demands in the Illinois waterway; it was designed and fabricated according to the specifications given in figure 1. The basic idea for this design was derived from a plexiglas box type *in-situ* respirometer designed by Lucas and Thomas[9] for use in Lake Erie, The bell sampler is bulky and difficult to handle; it weighs approximately 120 pounds. Consequently, it is not readily suitable for use in small, relatively shallow stream reaches which are accessible only by a small boat or by wading. To fulfill the request for making SOD measurements in small streams and rivers in the NIPC area in conjunction with the 208 study, a much smaller, portable box-type sampler was designed and developed as shown in figure 2. Its areal coverage is only 25 percent of that of the bell sampler, and its height to the seating flange is 1 inch less. The square design was chosen because it provides more interior space for the same height over that of a round top or bell design. This extra space was needed to incorporate flexibility into its operation.

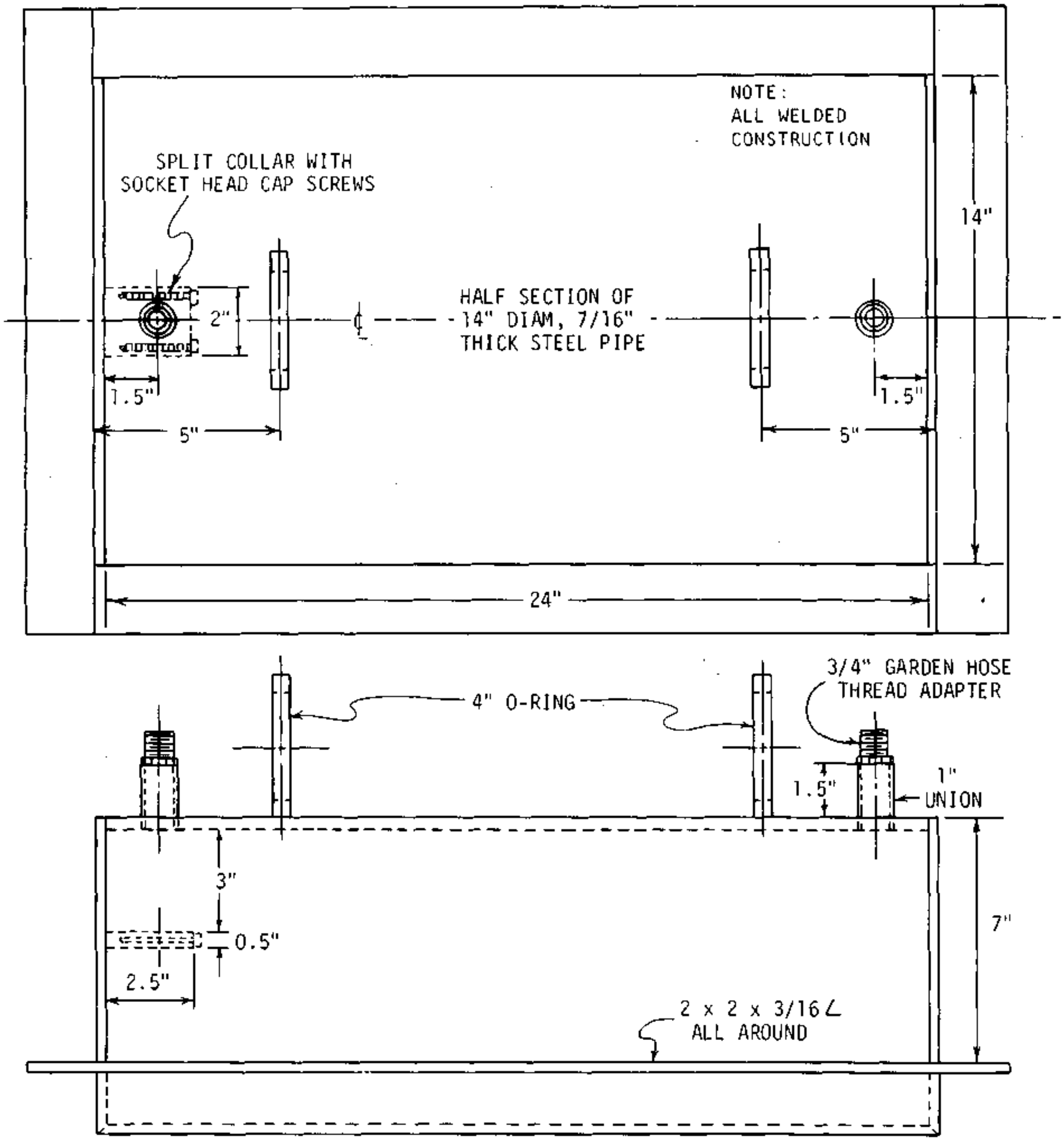


Figure 1. Sediment oxygen demand semipovtable bell sampler

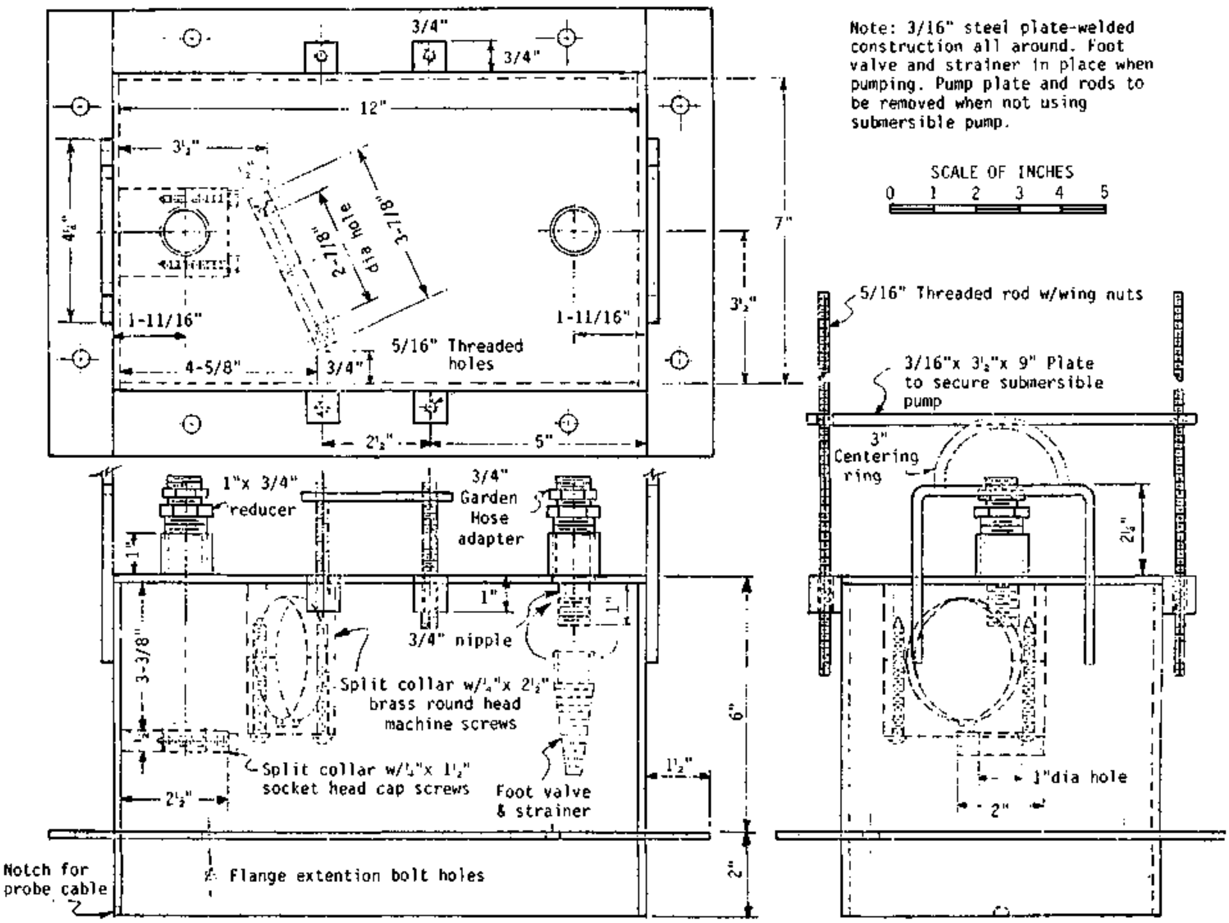


Figure 2. Portable box sediment oxygen demand sampler

The box sampler is 12 inches long, 7 inches wide, and 6 inches deep to the top of the seating flange. It is fabricated of 3/16-inch steel plate welded all around. The seating flanges are 3/16-inch steel plate extending 1 1/2 inches from the outside faces of the box sides; a 2-inch seating depth is provided. Removable water-proofed plywood extension flanges can be bolted to the steel flanges when needed.

The sampler was designed to accommodate three methods of internal water circulation or movement as depicted in figure 3. Included are two different pumping systems and an electrical stirring mechanism. The pumping can be done by either a nonsubmersible or a submersible pump. A split collar is provided near the circulation inlet to secure the DO-temperature probe during the pumping modes of operation. A foot valve and strainer can be attached at the outlet to protect the pumps. The submersible pump is secured to the top of the sampler by the threaded rods and plate shown in figure 2. The stirring mechanism is attached to the large split collar welded to the inside of the top plate (figure 2), The opening in this collar is sized to fit a YSI 5795 submersible stlrrer (circa 1975); consequently, this opening will possibly have to be modified to fit the newer model YSI 5795A stirrer. The DO-temperature probe is housed within the stirrer. Although use of all three circulating methods was anticipated, only the stirring system was utilized since it gives good results, requires less equipment, and is easy to start up and to operate. The stirring system (see figure 3a) eliminates the need for a pump and a bulky and/or heavy power source. The stirrer operates on four, size E rechargeable nickel-cadmium batteries. The power pack and recharging system are integrated directly into the design of the YSI model 57 DO meter, the instrument used by the SWS in its SOD work. The batteries provide approximately five hours of operation before recharging.

On reaches of creeks and streams which could be sampled by wading (wearing chest-waders), the equipment was hand carried to the site and set up. At times this necessitated backpacking the equipment up to a half mile over rugged terrain. Whenever possible, permission was obtained from landowners to drive overland through fields and backwood roads to minimize backpacking operations. A walk-in setup is illustrated in figures 4, 5, and 6.

If the stream could be navigated with a small boat, the setup illustrated in figure 3a was deployed. The boat used was a 14-foot flat bottom john boat having a 70-inch beam and 20-inch deep sides, the minimum size craft recommended for use on small streams. The boat was outfitted with a custom-made winch equipped with a U.S. Geological Survey "A"-reel as shown in figure 3. The winch was pivoted on a platform supported between seats; the pivoting system design is similar to that for the large boat winch used during the original Illinois waterway SOD study.[2] The advantage of this type of winch design is that it can be completely removed to free the boat for other uses.

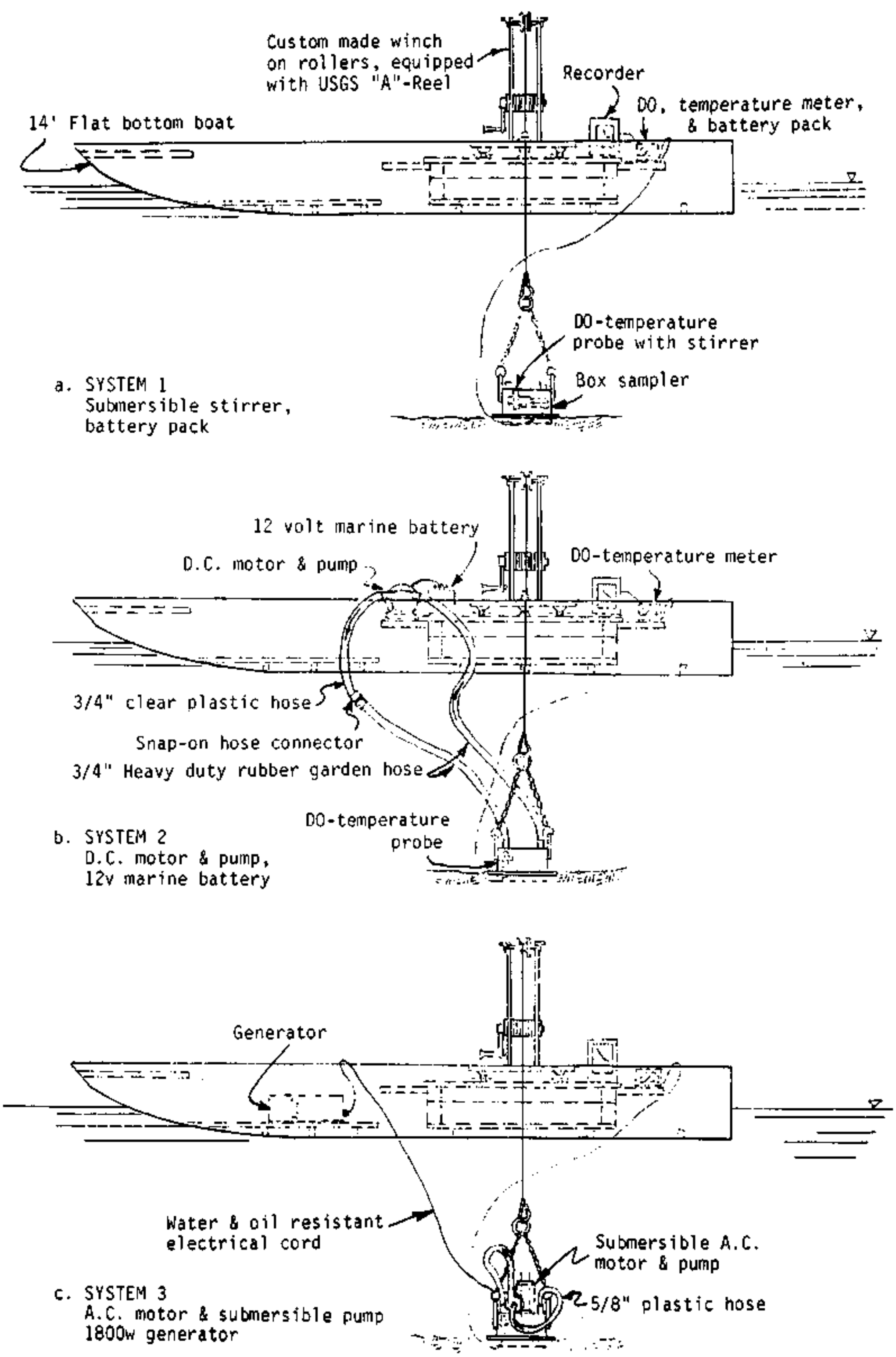


Figure 3. Three systems of operating SOD sampler from a boat

Figure 4. Panoramic; view of small stream SOD setup

Figure 5. SOD sampler periphery equipment and instruments

Figure 6. Box SOD sampler in place in small stream

Before setting up the SOD sampler, either a ponar or Ekman dredge sediment sample was taken for examination. If the bottom sediments were extremely mucky or watery, the extension flanges were installed. If the sediments were sandy, rocky or compacted, a successful run was not possible, or required special operating techniques for success. A portion of the dredge sample was retained for laboratory determinations of water content and volatile solids. A second dredge sample was taken and temporarily stored for washing and sieving after the SOD sampler was set up and running.

The DO probe was air calibrated before each run with the American Society of Civil Engineers DO saturation tables,[10] after which the stirrer-probe was installed in the sampler. The DO meter and recorder were hooked up and turned on, and the sampler was suspended submerged upside down in the water to expel air. The sampler was then lowered to the bottom and firmly seated, and the hose openings were capped if the stream ambient DO concentration was at least 3.0 mg/1. In oxygen deficient streams, aerated water was poured into the sampler at a hose connection through a plastic pipe onto which a large plastic funnel was secured. The pipe was removed and both openings on the sampler were capped. Aerated water was obtained by pouring four to five gallons of stream water from one bucket to another at chest height 10 to 12 times. Almost any stream water can be brought up to saturation by this means.

Sandy, rocky, and solid rock bottoms were set up with the use of sand bags. Five 40-pound sand bags were placed around the bottom of the sampler to seal it. For sandy bottoms, the extension flanges were installed, the sampler was seated to the flanges, and the sand bags were placed on top of them to prevent undermining and scouring. Figure 7 illustrates a sand-bagged installation.

Some streams contained extensive, deep sludge and muck deposits which made wading impossible, as demonstrated by figures 8 and 9. To be able to set up under such conditions, a portable wading ramp was used. It consisted simply of a 3-foot by 40-foot roll of common snow fence which was unrolled into the stream. The muckiest of sediments can be transversed with this device. Figure 10 shows the use of the fence to gain access to the center of a stream having extensive shoreline muck deposits.

Benthic Macroinvertebrates

Aquatic macroinvertebrates are defined as animals which are visible to the unaided eye and are capable of being retained in a U.S. Standard 30-mesh sieve. Benthic macroinvertebrates, often referred to as the benthos, are relatively stationary and therefore tend to reflect minimum water quality conditions at a given stream location. Fish, plankton, and water samples are more transient indicators of stream conditions, whereas the benthos represent a summation of the effects of long-term physical and chemical environmental factors. Consequently, benthic macroinvertebrate sampling provides important supportive information in any stream water quality study, and it is especially imperative that benthos sampling be an integral part

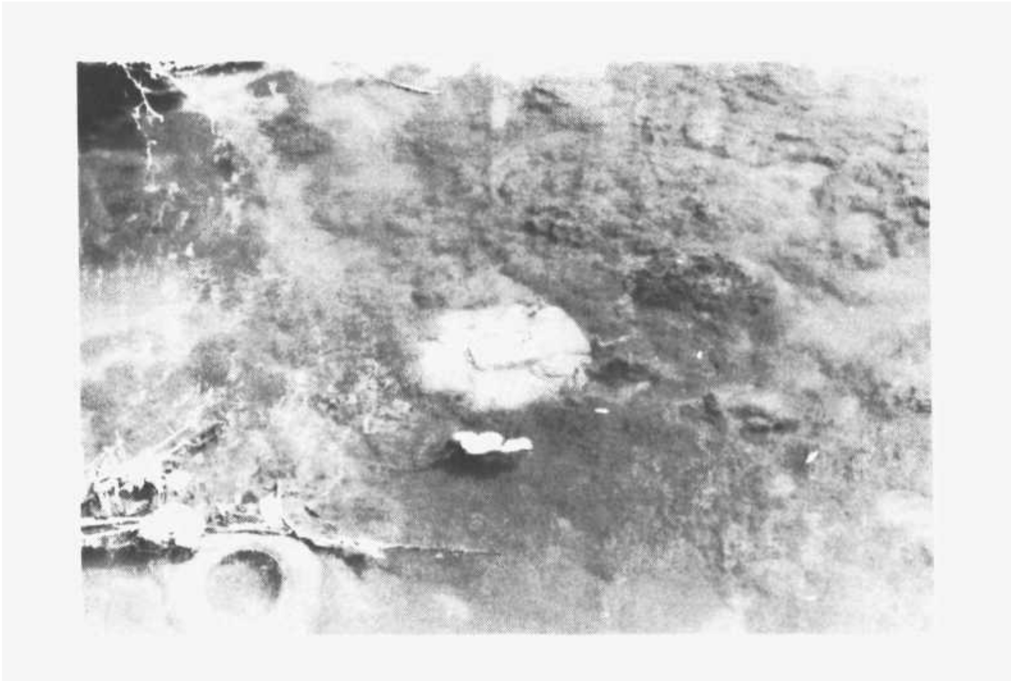


Figure 7. Box SOD sampler sand-bagged in place

Figure 8. Sludge deposition in Little Calumet River

Figure 9. Sediment deposition in Des Plaines River

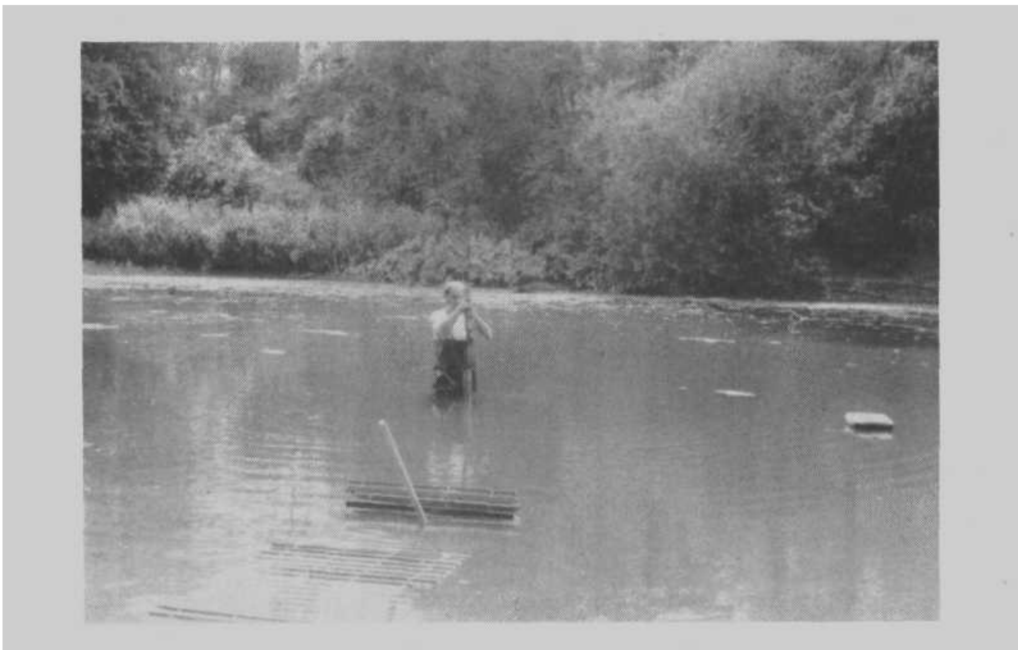


Figure 10. Use of enow fence to traverse mucky bottom

of an SOD study. The identification and enumeration of the benthic organisms can aid in interpreting the SOD data relative to the degree of degradation, and it can also aid in pinpointing the principal source or sources of the oxygen demand.

Benthic macroinvertebrate samples were collected with a 9-inch ponar dredge when SODs were measured from the boat, while a 6-inch Ekman dredge was used for most walk-in operations. At some walk-in stations the bottoms were too rocky to use a biological dredge, so samples were collected by gathering rocks and gravel from a 6-inch area and scraping them with a fine bristle brush. Because of the logistics involved in the overall sampling program, only one benthos sample was taken per SOD sampling site. From a purely scientific standpoint, this is poor sampling technique. However, for SOD work it is acceptable since the data are basically supportive and are used only to indicate orders of magnitude of bottom degradation. The samples were washed in a Wildco model 190 plastic bucket equipped with a No. 30 sieve. Sieved residues were preserved in Mason jars with 10 percent formalin. Organisms were picked in the laboratory by the salt flotation technique. Care had to be taken to insure the organisms floated free when entrapped in samples containing much sand and fine gravel. Picked samples were preserved in 70 percent ethyl alcohol until counts and identification were made.

Sediment and Sediment Cores

Samples were collected from the top two or three inches of benthic sediments for use in determining the two physical parameters, percent dried solids and percent volatile solids. These parameters were anticipated to be of aid in analyzing the condition of the sediments. The volatile solids (loss on ignition) parameter serves as a general indicator of organic content, while the percent dried solids parameter serves as a general indicator of constituency, i.e., the degree of liquidity of the sediments. Either the Ekman or ponar dredge was used to collect these samples except in rocky bottoms. Here gravel and rocks were gathered by hand for the analyses. Approximately 65 to 75 grams of sediment were retained from the top layer of the dredge sediment load. The samples were kept refrigerated after receipt at the laboratory. Volatile solids were run according to procedures outlined in Standard Methods.[11] The percent dried solids was determined by decanting the supernatant from the sediments after the sample was left undisturbed for at least 24 hours, and then oven drying the remaining material at 103°C.

Core samples were obtained with tube coring devices designed and fabricated by personnel of the Hydrology Section of the SWS. Two sizes were utilized—one was a 2 1/2-inch diameter brass tube unit and the other a 2-inch stainless steel tube unit. The smaller stainless steel sampler replaced the brass one after it became severely deformed from repeatedly hitting rocks, but near the end of the study period, the stainless steel tube became almost as severely deformed as the brass unit. The 2-inch sampler is shown in figures 4 and 5 and its use is illustrated in figure 10.

The tube is 5 feet long and contains a plunger which is fitted at the bottom with pump leather. A rammer weight slides on a pipe shaft mounted on top of the tube. As the tube is forced into the sediment with the rammer weight, the plunger moves up forcing the water out of the tube through two ports located at the top. The sample is extracted on the stream bank by pushing the plunger forward.

The core sampler worked very well in sediments having some consistency. However, in thick deposits of very loose watery muck or sand, or in rocky locations, problems were encountered and true core samples could not be taken. Some compression of the cores occurred and true depths of various types of material in the samples could not be ascertained with a high degree of accuracy. Nonetheless, the information gained from this type of coring technique was satisfactory for use in meeting the objectives of this study.

Each core was dissected with a putty knife, and various differential layers of sediments were described, cataloged as to thickness, and photographed. Where the sediments were too loose for coring a ponar or Ekman dredge sample was photographed; representative hand-gathered rocks were photographed at rock and gravel sites.

DATA REDUCTION AND ANALYSES

The data were reduced to useable and manageable form by standard and/or acceptable procedures and techniques whenever possible. In some instances, however, experience and judgment formed the basis for the final answers. This was particularly so in the evaluation of the SOD data.

SOD Data

The SOD curves, as traced out by the recorder (see Appendix A), were utilized as much as possible for analyzing and interpreting the SOD data. Proper interpretation of the curves can be difficult and knowledge of the chemical, physical, and biological conditions which existed during the sampling period can greatly aid in isolating the most representative rate. At times, recorder problems were encountered and hand-recorded data were used. As a check, readings were hand-recorded for all runs and are presented in Appendix A.

The SOD rates as taken from the curves are in units of milligrams per liter per minute (mg/l/min) and must be converted into grams per square meter per day ($g/m^2/day$) for practical use. The general conversion formula is:

$$SOD = (1440SV)/10^3A \qquad (1)$$

where SOD = sediment oxygen demand, $g/m^2/day$
S = slope of some portion of the curve, mg/l/min
V = volume of sampler, liters
A = bottom area of sampler, m^2

The specific formula for the box sampler and stirrer combination varies according to bottom conditions. In mucks and loose sand where the sampler can be sealed up to the seating flanges the rate conversion formula is:

$$SOD = 205.5\ S \tag{2}$$

For rock and hard bottoms where the cutting edges are exposed and sand bags must be placed to seal the unit the rate conversion formula is:

$$SOD = 270.8\ S \tag{3}$$

If a pumping system had been used, an additional formula would have been necessary because of increased volume due to hose and pump storage. The computed volume of the sampler itself up to the seating flanges is 8.261 liters, whereas the directly measured volume with the sampler rigged for field use is only 7.735; consequently, 0.526 liter was taken up by the stirrer and split collars.

Either formula 2 or 3 was applied between all the major deflection points on a curve. The value from a curve recommended in this report for general application in a water quality model is the most stabilized linear portion of a curve, which most often occurs near the end. The beginning of many curves generated for loose sediments exhibit high initial rates that resemble exponential curves. This is due to bottom disturbances. These disturbance rates have been estimated and could be used in a water quality model to simulate conditions during periods of bottom disturbance caused by outboard activity in shallow waters, large boat movements in channels, wind action in shallows, dredging operations, etc.

Besides isolating linear segments of each SOD curve, all the points on the curve were fitted to one single equation by statistical regression techniques. Linear, exponential, and log-log fits were made and compared by the use of correlation coefficients. The reduced data used as an input to the generation of these curves are tabulated in Appendix A.

Stepwise multiple regression techniques were used to compare seven independent variables to the dependent variable, SOD, The independent parameters were: 1) water temperature, 2) dissolved oxygen of overlying water, 3) sediment depth, 4) total number of macroorganisms, 5) number of taxa, 6) percent dry solids, and 7) percent volatile solids. The objective of making this analysis was to determine if relationships exist between some easily measured physical and biological parameters and SOD, and if so, to develop an empirical predictive equation for use in a water quality model. The data used for each of these variable inputs are given in Appendix E.

The *in-situ* SOD measurements taken at ambient water temperatures were corrected to 20 and 25°C for comparative purposes by the equation:

$$SOD_T = SOD_{20}(1.047^{T-20}) \quad (4)$$

where SOD_T = SOD rate at any temperature, T^oC

SOD_{20} = SOD rate at 20^oC

Equation 4 is a form of the Arrhenius model which is widely used in water quality studies involving the stabilization of carbonaceous materials in aqueous environments.[12]

The SODs expressed in terms of the standard areal rate units of $g/m^2/$ day can be converted to mg/1 for a given length of stream by the formula:

$$G' = 3.28Gt/H \quad (5)$$

where G' = oxygen used by the sediments per reach in mg/1
G = SOD in $g/m^2/day$
t = time-of-travel in the reach in days
H = average water depth in the reach in feet

This formula is developed on the assumption that the bottom area of the stream approximates the water surface area. This is a valid assumption for most study area streams. The expression shows that the oxygen depletion in mg/1 per reach is directly related to the areal demand and the time-of-travel through the reach, and inversely related to the average water depth. For most general DO-BOD water quality models the time-of-travel and average water depth parameter values are available or can be estimated.

Benthic Macroinvertebrates

The macroorganism counts per dredge sample were converted to unit values in terms of individuals per square meter. Most organisms were keyed to species and both scientific and common names given.

Bottom conditions, as reflected by benthic macroorganism populations, were evaluated by two methods. One is the Shannon-Weaver diversity index,[13] and the other is the Illinois Environmental Protection Agency (IEPA) pollution tolerance classification.[11]*

A diversity index mathematically relates the total number of organisms to the total number of taxa observed at a given location. The Shannon-Weaver index can be formulated as:

$$D = - \sum_{i-1}^{m} p_i 1.44 \ln p_i \quad (6)$$

where D = Shannon-Weaver diversity index
m = number of genera per sample
ln = natural logarithm
p_i = Ni/Ns

N_i = the i^{th} genera density

N_s = total density

Several authorities[15,16] have suggested using the index for evaluating water quality conditions in a stream. Indexes above 3.0 are generally indicative of clean water, whereas values between 1.0 and 3.0 are indicative of moderately polluted water. Values below 1.0 are indicative of severe pollution. Only species numbers should normally be included in diversity index computations; however, in this study some exceptions were made. Because of the time and expense involved in keying *Chironomidae* and *Tubifiaidae* down to species in the large numbers found at many locations, all species of these organisms were grouped into either *Chironomidae* or *Tubifiaidae* families.

Aquatic biologists, through long-term research and practical field experience, have been able to rate many aquatic organisms as to pollution tolerance. On the basis of ratings, systems for ecologically classifying benthic communities have been formulated such as the one used by the IEPA. The IEPA categorizes organisms into four groups; by definition these are:

Intolerant: Organisms whose life cycle is dependent upon a narrow, stable range of ideal environmental conditions. These organisms usually do not inhabit organically rich areas, and upon degradation or enrichment of the environment, they are replaced by more tolerant organisms.

Moderate: Organisms whose life cycle is not extremely sensitive to environmental stress and changes. Slight to moderate increase in organic enrichment normally results in an increase in abundance, but they do not adapt to severely polluted conditions.

Facultative: Organisms whose life cycle is adaptable to most stream conditions except for gross or severe pollution.

Tolerant: Organisms whose life cycle can tolerate the most severe organic pollution. They inhabit both clean and polluted bottoms; however, they are often found in greatest abundance in areas of organic pollution.

On the basis of the relative numbers of the above organism types, IEPA has developed criteria for aquatic environment classification. This classification is:

	Percentage of organisms present	
Type of environment	*Intolerant*	*Moderate, facultative, tolerant*
Balanced	>50	<50
Unbalanced	<50 but >10	>50
Semi-polluted	<10	>90
Polluted	0	100
Barren areas	0	0

Barren areas can exist because of a natural unhospitable environment or from man-made unhospitable conditions caused, for example, by toxic chemical discharges.

This system of classification was applied to all sampling stations, Bar graphs of the results were developed for each station to provide a quick, visual inspection of the relative overall conditions which were observed.

Sediment and Sediment Cores

The nature of the sediment samples and the cores did not allow for a rigorous analysis of the data. Only the liquidity, volatile solids, and the depths of the cores provided numerical information. The rest is purely descriptive information. The solids factors and sediment depths were used in the step-wise multiple regression analysis as mentioned previously. Sediment samples were taken at locations other than SOD stations to aid in extrapolating the SOD results throughout stream reaches.

Other Methodologies

Milepoint locations of sampling points and stream reaches are all referenced to the U.S. Geological Survey Hydrologic Investigations Atlases. One anomaly occurred in the use of these maps. The milepoint for the Little Calumet River at the match-up of the Blue Island (HA-153) and the Chicago Heights Quads (HA-89) was different on the two maps. The Blue Island value was considered correct and all the sampling point locations in the territory covered by the Chicago Heights Quad were referenced to it. All the SOD sampling sites have been spotted on these maps. Those with the SOD sampling locations spotted on them have been made available to NIPC as a supplement to this report.

Extensive field reconnaissance of benthic sediments throughout the lengths of the major study area streams, examination of available hydraulic and hydrologic maps,[17,18,19] and the taking of supplemental sediment samples for percent solids and percent volatile solids analyses aided in extrapolating SOD values throughout stream reaches.

SUMMARY OF RESULTS

The overall results of the study were very good. The information generated should provide a good base from which to estimate oxygen usage in streams due to a variety of benthic conditions,

SOD Results

Sediment oxygen demand measurements were successfully completed at 89 different stations. At one station two runs were made--one over a spot relatively free of filamentous green algae and the other over a massive filamentous green algae growth. The sampling station number, the stream name, the U.S. Geological Survey floodplain quads (or atlases) on which the stations are located, and the milepoint locations are tabulated in table 1. All milepoints are given to the nearest tenth of a mile except those for the Fox River where accurate estimates to hundredths were made and for those locations considered control points, namely, dams and major stream junctions.

The SOD curves as traced by the recorder in the field and the values recorded by hand as a backup to the recorder are presented in Appendix A. For some curves minor variances occur between the recorder and manually recorded results. For some bottom conditions precise initial calibrations could not be made because of high initial disturbance rates. However, in almost all cases, the overall shape of the recorded curve matches that of the manually plotted one. Major recorder problems were encountered at times, and no curves were generated by the recorder for stations 83 through 86. However, hand traced curves for those four stations were made.

The ambient SOD rates along with those corrected to 20 and 25°C are presented in table 2. These values represent the single best overall estimate. The recorded curves, however, more clearly describe the true oxygen uptake characteristics of the benthic sediments. Gradual rate changes and sudden deflections in DO meter readings are easily detected. References to the curves should be made if rates other than the generalized ones presented in table 2 are of interest.

Extrapolated values suggested for use in water quality modeling for all the major stream reaches in the study area are presented in table 3, Streams for which only one SOD measurement was taken are listed in table 4, The single SOD value given for these streams can be considered representative of the entire stream.

Benthic Macroinvertebrates

Ninety-five stations were sampled for benthic macroinvertebrates from May 2 through October 20, 1976. Sixty-one samples were collected with the Ekman dredge, 33 were collected with the ponar dredge, and 1 was a nonquantitative hand-picked sample. A benthic sample was taken at each of the SOD sampling stations listed in table 1. In addition, benthos samples were collected at points intermediate between stations 1 and 2, 5 and 6, 9 and 10, 17 and 18, and 22 and 23. The exact stream milepoint locations of these intermediate stations are given in table 7. The stations, for identification purposes, have been designated as 1.5, 5.5, 9.5, 17.5, and 22.5. These samples were collected to aid in the extrapolation of SOD results into areas not readily suitable for direct measurement of SOD. The hand-picked sample

Table 1. Sampling Station Locations

Station number	*Stream*	*USGS floodplain atlas name (number)*	*Milepoint location*
1	*Fox River*	McHenry (HA-255)	99.53
2	*Fox River*	Barrington (HA-150)	90.91
3	*Fox River*	Barrington (HA-150)	87.29
4	*Fox River*	Crystal Lake (HA-253)	82.77
5	*Fox River*	Elgin (HA-147)	78.26
6	*Fox River*	Elgin (HA-147)	74.72
7	*Fox River*	Elgin (HA-147)	72.35
8	*Fox River*	Geneva (HA-142)	68.37
9	*Fox River*	Geneva (HA-142)	64.39
10	*Fox River*	Geneva (HA-142)	61.27
11	*Fox River*	Geneva (HA-142)	58.76
12	*Fox River*	Aurora North (HA-170)	57.96
13	*Fox River*	Aurora North (HA-170)	56.62
14	*Fox River*	Aurora North (HA-170)	55.05
15	*Fox River*	Aurora North (HA-170)	54.17
16	*Fox River*	Aurora North (HA-170)	52.84
17	*Fox River*	Aurora North (HA-170)	50.38
18	*Fox River*	Aurora North (HA-170)	49.05
19	*Fox River*	Aurora North (HA-170)	48.48
20	*Fox River*	Aurora North (HA-170)	48.06
21	*Fox River*	Aurora South	46.78
22	*Fox River*	Aurora South	44.89
23	*Fox River*	Aurora South	36.78
24	*Fox River*	Aurora South	36.78RB
25	*Nippersink Creek*	Fox Lake (HA-151)	5.00
26	*Silver Creek*	Woodstock (HA-256)	1.70
27	*Kishwaukee River*	Huntley (HA-361)	50.50
28	*S. Br. Kishwaukee R.*	Huntley (HA-361)	10.50
29	*Kishwaukee River*	Garden Prairie (HA-497)	33.80
30	*Flint Creek*	Barrington (HA-150)	8.60
31	*Flint Creek*	Barrington (HA-150)	2.90
32	*Woods Creek*	Crystal Lake (HA-253)	1.40
33	*Blackberry Creek*	Sugar Grove (HA-227)	14.30
34	*W. Br. DuPage R.*	West Chicago (HA-202)	52.40
35	*W. Br. DuPage R.*	Naperville (HA-154)	42.60
36	*W. Br. DuPage R.*	Naperville (HA-154)	38.90
37	*W. Br. DuPage R.*	Naperville (HA-154)	36.70
38	*W. Br. DuPage R.*	Naperville (HA-154)	32.00
39	*W. Br. DuPage R.*	Normantown (HA-210)	28.40
40	*E. Br. DuPage R.*	Lombard (HA-143)	47.70
41	*E. Br. DuPage R.*	Lombard (HA-143)	46.90
42	*E. Br. DuPage R.*	Wheaton (HA-148)	44.80
43	*E. Br. DuPage R.*	Wheaton (HA-148)	42.20
44	*E. Br. DuPage R.*	Wheaton (HA-148)	38.00
45	*E. Br. DuPage R.*	Romeoville (HA-146)	36.00
46	*DuPage River*	Normantown (HA-210)	25.20
47	*DuPage River*	Plainfield (HA-228)	10.90
48	*DuPage River*	Channahon (HA-362)	1.40RB

Table 1. Concluded

Station number	Stream	USGS floodplain atlas name (number)	Milepoint location
49	*Des Plaines River*	Wadsworth (HA-144)	103.00
50	*Des Plaines River*	Libertyville (HA-88)	92.90
51	*Des Plaines River*	Wheeling (HA-71)	83.40
52	*Des Plaines River*	Wheeling (HA-71)	79.50
53	*Des Plaines River*	Wheeling (HA-71)	73.50
54	*Des Plaines River*	Arlington Heights (HA-67)	69.50
55	*Des Plaines River*	Arlington Heights (HA-67)	65.50LB
56	*Des Plaines River*	Park Ridge (HA-85)	62.40
57	*Des Plaines River*	River Forest (HA-206)	60.60
58	*Des Plaines River*	River Forest (HA-206)	57.50
59	*Des Plaines River*	River Forest (HA-206)	54.30
60	*Des Plaines River*	River Forest (HA-206)	50.10
61	*Des Plaines River*	Berwyn (HA-252)	47.10LB
62	*Des Plaines River*	Berwyn (HA-252)	45.80
63	*Des Plaines River*	Sag Bridge (HA-149)	36.10
64	*Salt Creek*	Palatine (HA-87)	35.50
65	*Salt Creek*	Elmhurst (HA-68)	27.90
66	*Salt Creek*	Elmhurst (HA-68)	23.00
67	*Salt Creek*	Hinsdale (HA-86)	13.60
68	*Salt Creek*	Hinsdale (HA-86)	11.60
69	*Salt Creek*	Berwyn (HA-252)	1.20
70	*Skokie Lagoons*	Park Ridge (HA-85)	24.70
71	*Skokie Lagoons*	Park Ridge (HA-85)	26.10
72	*Skokie Lagoons*	Highland Park (HA-69)	28.30
73	*N. Br. Chicago River*	Park Ridge (HA-85)	17.40
74	*Little Calumet River*	Chicago Heights (HA-89)	26.00*
75	*Little Calumet River*	Chicago Heights (HA-89)	25.40*
76	*Little Calumet River*	Chicago Heights (HA-89)	23.80*RB
77	*Little Calumet River*	Chicago Heights (HA-89)	20.50*RB
78	*Little Calumet River*	Harvey (HA-90)	17.90*
79	*Little Calumet River*	Blue Island (HA-153)	13.80 LB
80	*Little Calumet River*	Blue Island (HA-153)	13.80
81	*Calumet Union Canal*	Harvey (HA-90)	1.00
82	*Midlothian Creek*	Blue Island (HA-153)	0.30
83	*Thorn Creek*	Harvey (HA-90)	18.60
84	*Thorn Creek*	Chicago Heights (HA-89)	10.00RB
85	*Deer Creek*	Chicago Heights (HA-89)	19.50
86	*Butterfield Creek*	Harvey (HA-90)	0.70
87	*Hickory Creek*	Joliet (HA-89)	5.10
88	*Hickory Creek*	Joliet (HA-89)	4.80
89	*Hickory Creek*	Joliet (HA-89)	4.60

* As referenced to mileage on Blue Island Atlas (i.e., station equation: mile 17.58 on Blue Island = 4.0 on Harvey)

RB and LB = Left and Right Bank side of channel centerline looking downstream

Table 2. Measured and Temperature-Corrected SOD Rates

Sta. no.	Avg. temp. (T^oC)	SOD ($g/m^2/day$) at T^oC	20^oC	25^oC	Sta. no.	Avg. temp. (T^oC)	SOD ($g/m^2/day$) at T^oC	20^oC	25^oC
1	23.6	2.57	2.18	2.74	46	17.3	2.20	2.49	3.13
2	23.9	1.55	1.30	1.63	47	16.0	0.97	1.16	1.47
3	24.7	1.30	1.05	1.32	48	16.2	3.30	3.92	4.94
4	25.0	2.26	1.80	2.26	49	9.0	1.84	3.05	3.84
5	24.5	1.85	1.50	1.89	50	14.0	4.70	6.20	7.80
6	25.2	4.22	3.33	4.19	51	12.4	1.01	1.43	1.80
7	23.6	2.47	2.14	2.70	52	10.8	0.71	1.08	1.36
8	22.3	2.14	1.93	2.43	53	13.9	0.82	1.09	1.37
9	22.8	2.64	2.32	2.92	54	19.0	1.93	2.02	2.54
10	26.8	2.35	1.72	2.17	55	21.5	3.93	3.67	4.62
11	23.7	3.43	2.90	3.65	56	21.0	4.11	3.93	4.94
12	21.6	1.92	1.79	2.25	57	18.8	1.91	2.02	2.54
13	21.6	2.06	1.91	2.41	58	17.5	7.42	8.32	10.47
14	25.2	2.90	2.28	2.37	59	21.2	5.61	5.31	6.68
15	25.5	3.38	2.63	3.31	60	25.0	6.17	4.90	6.17
16	22.2	2.24	2.03	2.55	61	23.9	6.17	5.16	6.49
17	26.0	9.79	7.45	9.37	62	20.4	1.96	1.92	2.42
18	24.0	1.52	1.26	1.59	63	19.5	5.53	5.65	7.11
19	27.4	2.73	1.95	2.45	64	17.3	1.76	1.99	2.51
20	28.6	7.16	4.82	6.07	65	18.4	0.86	0.92	1.16
21	25.1	4.17	3.30	4.16	66	24.3	1.23	1.01	1.27
22	30.8	5.99	3.66	4.60	67	18.7	2.20	2.34	2.95
23	20.6	2.36	2.30	2.90	68	21.2	1.93	1.83	2.30
24	27.8	4.90	3.42	4.31	69	24.9	2.87	2.29	2.88
25	5.5	0.63	1.23	1.54	70	17.9	3.63	4.00	5.03
26	6.9	1.93	3.53	4.44	71	16.6	3.64	4.26	5.36
27	9.2	5.14	8.45	10.63	72	19.1	2.62	2.73	3.43
28	7.8	1.03	1.80	2.27	73	13.9	1.64	2.18	2.74
29	7.3	1.41	2.54	3.19	74	19.9	8.87	8.93	11.23
30	12.5	0.27	0.38	0.48	75	24.2	9.49	7.84	9.86
31	14.7	0.93	1.18	1.49	76	20.2	9.32	9.32	11.72
32	29.1	1.94	1.28	1.61	77	22.0	4.26	3.90	4.90
33	19.0	0.86	0.90	1.13	78	24.2	4.20	3.46	4.35
34	21.0	0.98	0.94	1.18	79	14.9	2.06	2.60	3.27
35	21.7	1.62	1.50	1.89	80	15.1	1.33	1.66	2.09
36	23.1	1.38	1.20	1.51	81A	20.0	4.45	4.22	5.32
37	23.0	2.21	1.93	2.43	81B	21.2	7.74	7.34	9.23
38	21.0	1.17	1.12	1.40	82	22.2	4.64	4.20	5.28
39	20.5	2.71	2.65	3.33	83	22.8	2.22	1.95	2.45
40	12.4	2.76	3.93	4.94	84	22.7	2.78	2.45	3.09
41	10.4	1.50	2.34	2.94	85	22.2	2.60	2.35	2.95
42	17.8	6.61	7.31	9.20	86	19.0	1.55	1.62	2.04
43	18.4	1.93	2.08	2.62	87	15.6	0.86	1.05	1.32
44	21.7	2.06	1.90	2.39	88	15.8	1.13	1.37	1.73
45	20.6	0.90	0.88	1.11	89	17.8	0.50	0.55	0.70

Table 3. Estimated SOD Rates for Study Area Stream Reaches

Inclusive milepoints	SOD $g/m^2/day$ at 20^oC	Inclusive milepoints	SOD $g/m^2/day$ at 20^oC
	Fox River		
36.54-38.75	2.8	60.65-62.50	1.7
38.75-43.56	2.5	62.50-64.96	2.3
43.56-46.56	3.7	64.96-67.65	1.0
46.56-47.90	3.3	67.65-68.17	3.5
47.90-48.37	4.8	68.17-71.85	1.9
48.37-48.91	1.9	71.85-73.11	2.1
48.91-52.60	1.5	73.11-74.05	2.6
52.60-54.66	2.0	74.05-76.89	3.3
54.66-54.90	2.6	76.89-78.15	3.5
54.90-56.21	2.3	78.15-81.44	1.5
56.21-56.26	3.5	81.44-82.61	3.5
56.26-56.82	1.9	82.61-86.74	1.8
56.82-58.12	1.8	86.74-89.20	1.1
58.12-58.67	3.5	89.20-98.81	1.3
58.67-59.47	2.9	98.91-98.94	3.5
59.47-60.65	2.5	98.94-106.00	2.2
	Des Plaines River		
17.0-35.60	2.0	60.50-62.30	2.0
35.6-41.00	5.7	62.30-64.75	3.9
41.0-44.45	2.0	64.75-68.4	3.7
44.45-45.10	5.0	68.4-69.30	4.5
45.10-46.70	1.9	69.30-73.10	2.0
46.70-50.80	5.2	73.10-82.35	1.1
50.80-53.83	4.9	82.35-84.14	1.4
53.83-56.50	5.3	84.14-85.67	2.0
56.50-60.40	8.3	85.67-92.83	3.0
60.40-60.50	5.0	92.83-94.20	6.2
		94.20-109.84	3.0
	Salt Creek		
0-11.58	1.1	20.50-25.18	3.0
11.58-13.53	1.4	25.18-35.60	6.2
13.53-14.90	2.0	35.60-42.80	3.0
14.90-20.50	3.0		
	DuPage River		
0-1.05	1.0	19.00-22.00	1.6
1.05-5.10	3.9	22.00-25.10	2.5
5.10-10.60	1.2	25.10-27.69	1.0
10.60-19.00	1.2		

Table 3, Concluded

Inclusive milepoints	*SOD g/m²/day at 20°C*	*Inclusive milepoints*	*SOD g/m²/day at 20°C*
	West Branch DuPage River		
27.69-29.30	2.6	37.40-38.88	1.2
29.30-31.40	2.0	38.88-40.90	1.2
31.40-36.55	1.1	40.90-42.70	1.5
36.55-37.40	1.9	42.70-56.00	0.9
	East Branch DuPage River		
27.69-36.00	0.9	46.70-46.78	2.0
36.00-40.00	1.9	46.78-47.90	2.3
40.00-42.70	2.1	47.90-48.00	3.9
42.70-44.80	5.0	48.00-49.20	2.0
44.80-46.70	7.3	49.20-50.75	1.0
	Little Calumet River		
13.75-14.30	2.1	22.30-24.40	9.3
14.30-19.80	3.5	24.40-25.30	7.8
19.80-22.30	3.9	25.30-26.53	8.9
Thorn Creek		*Hickory Creek*	
22.3-27.3	2.5	0-4.58	0.5
27.3-33.4	2.0	4.58-8.60	1.0
33.4-35.3	1.0	8.60-21.0	0.3
	Kishwaukee River		
30.70-38.10	2.5	45.80-49.50	5.0
38.10-42.30	2.0	49.50-55.50	8.4
42.30-45.80	3.0	55.50-61.30	1.3
South Br. Kishwaukee River		*North Br. Kishwaukee River*	
0-11.15	1.8	0-2.50	3.0
11.15-18.10	0.5	2.50-5.60	3.5
		5.60-8.70	2.5
Silver Creek		*Flint Creek*	
0-1.70	2.0	0-4.80	1.2
1.70-4.70	3.5	4.80-11.10	0.4
Nippersink Creek		*Skokie Lagoons*	
0-17.00	1.2	24.68-26.30	2.7
17.00-22.60	1.5	26.25-27.34	4.3
22.60-34.41	0.5	27.34-29.60	4.0

NOTE; Underlined values indicate control points at dam

Table 4. Suggested SOD Values for Use
Throughout the Listed Streams

Stream	*Sampling location milepoint*	*SOD g/m²/day at 20°C*
N. Br. Chicago River	17.3	2.2
Woods Creek	3.25	1.3
Blackberry Creek	14.2	0.9
Calumet Union	1.0	7.3*
Drainage Canal		4.2**
Midlothian Creek	0.3	4.2
Butterfield Creek	0.8	1.6
Deer Creek	33.1	2.3

* Representative of bottom areas heavily covered with filamentous green algae
** Representative of areas relatively free of filamentous green algae

at station 15 is designated 15a; the results represent brushings from an irregular, jagged, relatively flat rock measuring approximately 12x3x2 inches and two pieces of 2-inch gravel.

The benthic results are summarized in table 5. The summary includes IEPA stream classifications, a computed diversity index, the number of taxa observed per station, the total number of organisms counted per station, and the two principal organism classes and their percentage composition per station.

The number of stations categorized according to IEPA stream classifications for each water body studied is presented in table 6. Only semi-polluted and polluted categories are represented; not one of the 95 samples exhibited either a balanced or unbalanced condition. Details of the benthic results and bar graphs of the percentage composition of each tolerance category are presented in Appendix B.

Sediments and Sediment Cores

A total of 122 sediment samples were taken with either the ponar or Ekman dredge. Descriptions of raw and incinerated samples are given in Appendix C, and include depths of water at the time of sampling and the percent dried solids and the percent volatile solids figures. Milepoints at which sediment samples were collected at locations other than SOD stations are presented in table 7. A very general summary of the benthic sediment conditions observed during the study period are given in table 8.

Core samples were taken at 83 of the 89 SOD stations. At the other six stations, bottom conditions such as rocks and loose watery sand prevented

Table 5. Benthic Macroinvertebrate and Stream Classification Summary

Sta.	IEPA stream classification*	Organisms: Shannon-Weaver diversity index	Organisms: No. of taxa	Organisms: Individuals per square meter	Principal species and % composition: Name	%	Name	%
1	P	1.18	3	1,148	midges	50	aquatic worms	47
1.5	P	0.62	3	669	midges	87	Phantom midges	13
2	P	0.81	2	842	aquatic worms	75	midges	25
3	P	1.22	3	612	midges	66	aquatic worms	25
4	P	1.00	2	2,219	midges	53	aquatic worms	47
5	P	0.99	2	881	midges	57	aquatic worms	43
5.5	P	0.78	2	574	aquatic worms	77	midges	23
6	P	0.99	2	1,588	midges	57	aquatic worms	43
7	SP	0.74	3	1,607	midges	82	aquatic worms	17
8	SP	1.10	3	1,090	aquatic worms	55	midges	44
9	P	0.61	2	517	midges	85	aquatic worms	15
9.5	SP	0.25	2	918	midges	96	caddis-fly	4
10	P	0.99	2	173	aquatic worms	55	midges	45
11	SP	0.99	3	708	midges	59	aquatic worms	38
12	P	0.96	2	1,626	midges	62	aquatic worms	38
13	P	0.92	2	3,636	midges	67	aquatic worms	33
14	P	0.66	2	2,124	midges	83	aquatic worms	17
15	SP	1.65	7	8,396	midges	56	mayfly	26
15a	SP	2.41	12	523	caddis fly	39	mayfly	20
16	P	0.31	2	1,397	aquatic worms	94	midges	6
17	SP	0.83	3	1,952	midges	77	aquatic worms	22
17.5	SP	1.09	3	938	midges	59	aquatic worms	39
18	SP	0.38	3	8,614	aquatic worms	93	midges	7
19	P	0.16	3	6,501	midges	98	aquatic worms	1
20	SP	1.99	13	5,812	caddis fly	61	midges	18
21	P	0.00	1	1,665	aquatic worms	100		
22	SP	0.25	3	1,090	midges	97	mayfly	2
22.5	SP	2.70	16	22,476	caddis fly	32	midges	16
23	P	0.00	1	3,961	midges	100		
24	P	0.46	2	2,736	midges	90	aquatic worms	10
25	SP	1.17	3	2,540	midges	63	aquatic worms	32
26	P	0.97	2	6,762	midges	60	aquatic worms	40
27	SP	1.38	3	906	aquatic worms	57	midges	29
28	SP	0.64	5	6,501	midges	89	aquatic worms	8
29	SP	0.32	3	1,852	midges	95	aquatic worms	4
30	SP	1.61	4	4,391	midges	47	mayfly	30
31	SP	1.11	6	5,126	midges	78	aquatic worms	11
32	P	0.36	3	9,083	midges	94	snails	4
33	P	0.59	2	604	aquatic worms	86	midges	14
34	P	0.00	1	322	aquatic worms	100		
35	P	0.38	2	1,764	aquatic worms	93	midges	7
36	P	0.14	2	6,802	aquatic worms	98	midges	2
37	P	0.00	1	1,980	aquatic worms	100		
38	SP	1.22	3	903	aquatic worms	52	midges	43
39	SP	2.18	8	3,939	mayfly	45	midges	25
40	SP	1.15	7	5,939	midges	78	aquatic worms	13
41	SP	1.75	5	406	aquatic worms	58	midges	10
42	P	0.58	3	45,639	midges	86	aquatic worms	13

* *P = Polluted; SP = Semi-polluted*

Table 5. Concluded

Sta.	IEPA stream classi-fication*	Organisms: Shannon-Weaver diversity index	Organisms: No. of taxa	Organisms: Individuals per square meter	Principal species and % composition: Name	%	Name	%
43	SP	1.01	4	53,605	aquatic worms	55	midges	45
44	P	0.97	2	644	midges	50	aquatic worms	50
45	P	0.81	3	2,282	aquatic worms	83	midges	11
46	SP	2.19	11	3,725	midges	59	aquatic worms	9
47	SP	1.85	7	6,155	mayfly	36	caddis fly	35
48	P	0.60	3	46,072	midges	86	aquatic worms	14
49	SP	1.33	4	1,162	midges	59	aquatic worms	33
50	P	0.42	2	15,888	midges	92	aquatic worms	8
51	P	0.95	2	3,531	midges	63	aquatic worms	37
52	P	0.85	2	2,840	midges	73	aquatic worms	27
53	P	0.33	2	2,840	aquatic worms	94	midges	6
54	SP	1.42	3	774	midges	56	aquatic worms	28
55	P	0.73	2	4,005	aquatic worms	80	midges	20
56	P	0.47	2	6,071	aquatic worms	90	midges	10
57	SP	1.26	5	6,027	aquatic worms	69	midges	21
58	SP	1.55	7	13,861	fingernail clams	68	aquatic worms	12
59	SP	1.85	4	3,918	fingernail clams	41	aquatic worms	27
60	SP	2.48	9	5,853	leaches	40	fingernail clams	17
61	SP	0.56	4	39,861	aquatic worms	90	fingernail clams	7
62	SP	2.07	7	4,736	aquatic worms	36	midges	30
63	P	0.45	2	1,991	aquatic worms	90	midges	10
64	SP	0.94	3	744	aquatic worms	78	midges	21
65	SP	0.90	4	8,223	aquatic worms	81	midges	13
66	P	0.29	2	2,540	aquatic worms	95	midges	5
67	P	0.97	2	32,937	aquatic worms	60	midges	40
68	P	0.99	3	2,368	aquatic worms	69	midges	29
69	SP	0.79	4	4,560	aquatic worms	86	aquatic sow bugs	8
70	P	0.59	3	688	phantom midges	90	midges	8
71	P	1.22	3	516	aquatic worms	63	phantom midges	30
72	P	0.53	2	478	aquatic worms	88	midges	12
73	SP	1.75	4	385	midges	44	aquatic worms	33
74	P	0.00	1	12,061	aquatic worms	100		
75	P	0.88	2	19,809	aquatic worms	64	midges	36
76	P	0.87	2	23,509	midges	99	aquatic worms	1
77	P	0.14	2	294,201	aquatic worms	99	midges	1
78	SP	1.07	7	3,874	aquatic worms	82	snails	8
79	SP	2.29	6	7,115	aquatic worms	39	aquatic sow bugs	22
80	SP	0.20	3	18,735	aquatic worms	97	midges	3
81	SP	0.99	4	6,672	aquatic worms	68	midges	31
82	SP	1.36	4	4,003	aquatic worms	58	midges	32
83	P	0.00	1	387	aquatic worms	100		
84	P	0.99	2	1,465	aquatic worms	56	midges	44
85	SP	1.58	4	3,830	aquatic sow bugs	83	midges	14
86	SP	0.32	3	3,530	aquatic worms	95	midges	4
87	SP	1.19	3	440	aquatic worms	57	midges	39
88	P	0.96	2	306	midges	62	aquatic worms	38
89	SP	1.24	3	497	midges	52	aquatic worms	31

* *P = Polluted; SP = Semi-polluted*

Table 6. IEPA Stream Classification
Summary by Water Body

Body of Water	*Number of Stations* *Semi-Polluted*	*Polluted*
Fox River	12	18
Nippersink Creek	1	1
Kishwaukee River	2	
South Branch, Kishwaukee River	1	
Flint Creek	2	
Lake-in-the-Hills Creek		1
Blackberry Creek		1
West Branch, DuPage River	2	4
East Branch, DuPage River	3	3
DuPage River	2	1
Des Plaines River	8	7
Salt Creek	3	3
Skokie Lagoons		3
North Branch, Chicago River	1	
Little Calumet River	3	4
Union Canal	1	
Midlothian Creek	1	
Thorn Creek		2
Deer Creek	1	
Butterfield Creek	1	
Hickory Creek	2	1

successful coring. Photographs were taken of each core, and where cores were missing, pictures of dredge samples for five of the six stations were substituted; no picture was taken at station 80. Descriptions and photographs of the core samples are presented in Appendix D. The cores represent the maximum penetrable depth which could be achieved without severely damaging the corer or getting it stuck. Consequently, the segmented depths described in Appendix D do not always represent the full spectrum of benthic sediments. However, on a station to station basis they do provide relative depths and sediment consistency.

DISCUSSION

Relationships of Variables

The 90 successful SOD runs represent a wide range of conditions as evidenced by the variability of the raw data presented in Appendices A through D. The 20°C SOD values ranged from a low of 0.38 $g/m^2/day$ at station 30 in Flint Creek to a high of 9.32 $g/m^2/day$ at station 76 on the Little Calumet River. Flint Creek above station 30 drains wealthy subdivisions and developments, and receives effluent from the Lake Zurich Northwest Treatment Plant.

Table 7. Location of Supplemental Benthos and Sediment Samples

Sample number	*Stream*	*USGS Floodplain atlas name (number)*	*Milepoint location*
Benthos			
1.5	Fox River	Barrington (HA-150)	91.67
5.5	Fox River	Elgin (HA-147)	75.09
9.5	Fox River	Geneva (HA-142)	63.79
17.5	Fox River	Aurora North (HA-170)	50.14
22.5	Fox River	Aurora South	44.51
Sediment			
2	Fox River	McHenry (HA-255)	98.30
3	Fox River	McHenry (HA-255)	96.40
4	Fox River	Barrington (HA-150)	93.37
5	Fox River	Barrington (HA-150)	91.67
9	Fox River	Elgin (HA-147)	79.17
10	Fox River	Elgin (HA-147)	78.69
12	Fox River	Elgin (HA-147)	75.09
14	Fox River	Elgin (HA-147)	74.24
15	Fox River	Elgin (HA-147)	73.11
17	Fox River	Elgin (HA-147)	70.27
18	Fox River	Elgin (HA-147)	69.89
19	Fox River	Elgin (HA-147)	69.41
21	Fox River	Geneva (HA-142)	65.34
23	Fox River	Geneva (HA-142)	63.45
24	Fox River	Geneva (HA-142)	62.38
29	Fox River	Aurora North (HA-170)	55.11
31	Fox River	Aurora North (HA-170)	55.05RB
32	Fox River	Aurora North (HA-170)	55.05LB
34	Fox River	Aurora North (HA-170)	53.50
37	Fox River	Aurora North (HA-170)	50.14
38	Fox River	Aurora North (HA-170)	50.00
44	Fox River	Aurora South	44.51
45	Fox River	Aurora South	38.26
46	Fox River	Aurora South	37.35LB
47	Fox River	Aurora South	37.35
48	Fox River	Aurora South	37.35RB
49	Fox River	Aurora South	36.93LB
50	Fox River	Aurora South	36.93
51	Fox River	Aurora South	36.93RB
52	Fox River	Aurora South	36.78RB
79	DuPage River	Channahon (HA-362)	1.40
86	Des Plaines	Arlington Heights (HA-67)	65.50
111	Little Calumet R.	Blue Island (HA-153)	14.30

RB and LB = Left and Right Bank side of channel centerline looking downstream

Table 8. Generalized Sediment Characteristics of Major Streams

Sample numbers	*Water depth range (ft)*	*Solids content range*		*General sediment conditions*
		% Dried	*% Volatile*	
Fox River				
1-54	1.6-7.0	40.0-88.5	0.2-9.2	Above dams gray-black dirty sand; below dams relatively clean sand, gravel, rocks; a few isolated areas of watery unconsolidated mucks
DuPage River				
64-79	0.6-3.7	35.7-91.0	1.0-13.9	W. Br.--thick watery muck behind dams, dirty sand-gravel upper reaches, rocky lower reaches; E. Br.--thick muck throughout; Main Br.--sand, gravel, rocks throughout
Des Plaines River				
80-95	1.0-5.0	42.6-88.6	0.8-8.7	Sediment characteristics variable throughout; lower reaches rocky with pockets of deep muck and sludge; upper reaches sandy muds or muddy sands; middle reach contains thick oily muck along shores and dirty sand in channel; dirty sands generally exist above dams
Salt Creek				
96-101	1.3-3.5	42.0-93.3	0.7-6.9	Relatively clean sand-gravel below Fullersburg Park; deep muck above park dam; dirty sands and scattered pockets of muck in middle reaches; clean sand-gravel in upper reaches
Little Calumet River				
106-113	1.6-7.5	40.8-85.2	2.1-14.0	Very thick septic muck in upper reaches; dirty sand, rock, gravel in middle reaches; extreme lower reach to junction with Cal Sag has thick septic muck along shore, dirty sand in channel

The stream has a clean sand bottom with evidence of some filamentous algae growth in spots, while the Little Calumet above and below station 76 has a bottom lined with sludge type sediments (see figure 8). An examination of the SODs in table 2 shows that the remaining values are well distributed between the two extremes.

Many physical, biological, and biochemical factors enter into this variability. Stepwise regression techniques were used in an attempt to isolate the principal variables and to formulate them into a useable empirical predictive equation. A data base was available for the following seven independent variables: 1) temperature, °C; 2) dissolved oxygen, mg/1; 3) sediment depth, inches; 4) macroinvertebrate density, number/m^2; 5) number of macroinvertebrate taxa; 6) percent volatile solids; and 7) percent solids. These data are tabulated in Appendix E,

For Appendix E, some adjustment was made to the sediment depths presented in Appendix D. At several stations, total sediment depths were modified to exclude deep material considered not to be significant. For instance, at station 5 a sediment core of 17 inches was achieved, but after examining the photograph and the physical description of the sample Csee Appendix D), a judgment was made that the effective depth in relation to oxygen usage was only 4 inches. Where loose sands or rock bottoms existed and cores could not be taken, effective depths were estimated from descriptive field notes taken at the time of SOD sampling. The dependent variable, SOD expressed in g/m^2/day, was used at ambient temperature for the statistical analyses. Also, logarithms to the base 10 were used as an input for the macroinvertebrate numbers because of the extremes in values represented by this independent variable.

Simple correlation coefficients between all the variables generated during the statistical manipulation of the data are presented in table 9 as a matrix. Of particular interest is the last column, the coefficients relating each independent variable to SOD, Sediment depth appears to be the parameter most highly correlated to SOD rates. However, it explains only approximately 31 percent of the variability. Only two of the remaining variables, temperature and log of the number of macroinvertebrates, are significantly correlated to SOD with even a large sample size of 89.

What is surprising are the low correlations between SOD and the volatile solids and the percent solids. Volatile solids are a rough indicator of the organic content of sludges and should be a gage as to the relative amount of food material available for biological activity. The correlation between volatile solids and SOD was significant, but not high, for only 11 silt-clay samples in the original SOD work done on the Illinois waterway.[2] The lack of any correlation for the large 208 study sample size and the relatively low correlation for the small Illinois waterway sample size indicate that organically enriched benthic sediments may not necessarily have high SOD rates.

The percent solids factor shows a low correlation with SOD rates also. This runs counter to intuition somewhat in that liquid, mucky sediments

Table 9. Simple Correlation Coefficient Matrix

	Temp.	*DO*	*Sed. depth*	*Log of no. macro.*	*No. taxa*	*% Vol. solids*	*% Solids*	*SOD*
Temperature	--	.10	-.06	-.03	-.05	.10	-.12	.34
DO		--	.08	-.22	.08	-.13	.07	.04
Sediment depth			--	.12	-.02	.19	-.27	.56
Log. of no. macro.				--	.21	-.02	.09	.35
No. of taxa					--	-.19	.39	.11
% Vol. solids						--	-.73	.08
% Solids							--	-.12
SOD								--

represent poorer bottom conditions and reflect recent sludge or sediment inputs or algal fallout accumulations. However, interestingly, the percent solids-SOD correlation value is in the right direction, i.e., it is negative indicating that as samples become more solid the SOD rates have a tendency to go down.

The fact that the number of taxa is poorly correlated to SOD is not surprising; often a benthic community lacking richness in species diversity has one dominant organism which multiplies to great numbers. Consequently, some benthic communities develop a large biomass around a single species, and this biomass may have the potential of exerting a high SOD rate. A good example of this occurs at station 77 (see tables 2 and 5) where a moderately high SOD rate occurs in a bottom in which 99 percent of the macroinvertebrate biomass of 294,201 organisms/m^2 are aquatic worms.

The lack of a significant dissolved oxygen-SOD correlation can probably be attributed to the fact that, for many of the 89 locations, oxygen usage appeared to result from microbiological respiration from either bacteria or algae or both. McDonnell and Hall[20] have reported that benthic bacterial respiration rates are independent of DO concentration, whereas macroinvertebrate respiration rates decrease with decreasing oxygen levels. Many of the oxygen usage curves (Appendix A) were linear most of the time the readings were taken. This fact was used later to help classify the principal causes of SOD at each station.

Generally, the interrelationships between the independent variables, as characterized by the correlation coefficients in table 9, are what would be expected. Most of the coefficients are not high, but a number are significant and are worth commentary. The water dissolved oxygen levels do appear to have a tendency to be lower for high macroinvertebrate numbers as evidenced by the negative 0.22 correlation coefficient. Also, a relatively high negative coefficient of 0.73 between volatile solids and percent solids indicates that harder, more compact sediments tend to contain less organic matter. Also, the harder, more compact sediments appear to have a slight tendency to harbor more diverse macroinvertebrate populations.

As a result of the step-wise regression analysis only the significant variables were retained in the final formula as follows:

$$SOD = 0.15T + 0.30D + 0.11 \log N - 0.56 \qquad (7)$$

where T = ambient water temperature in C
D = estimated effective sediment depth in inches
N = total number of macroinvertebrates per square meter

The multiple correlation coefficient is 0.729; retaining the remaining four independent variables in the equation increased the correlation to only 0.735. The three independent variables in equation 7 account for 53 percent of the variability and the other four only 1 percent. Consequently, other unknown factors account for the remaining 46 percent. The most significant unknown factors probably are related to bacterial and algal population types and numbers, however, the direct determination of the degree of influence these factors have on the SOD is beyond the scope of this study.

Stochastic formulations can be of aid in predicting general conditions when the input data fall within the limits of that for which the equation was derived. For equation 7 the ranges are: T (5.5 to 30.8°C), D (1 to 17 inches), and N (173 to 294,201/m^2). However, the usefulness of equation 7 is limited in that the standard error of estimate is 1.45 g/m^2/day, a relatively large value. Nevertheless, equation 7 could possibly be used to determine relative reductions with some degree of confidence. For example, station 77 on the Little Calumet River had a predicted SOD of 5.62 g/m^2/day at T = 22°C, D = 8 inches, and N = 294,201/m^2. Let us assume that a water quality program is implemented reducing the persistent input of sludges and sediments, and thereby creating a more balanced benthos. A 50 percent reduction in effective sediment is projected to occur along with a large reduction in the sludge worm population and the evolution of a more balanced benthic macroinvertebrate population of 10,000/m^2. Substituting these values in equation 7 at 22 C results in a predicted SOD of 4.38 g/m^2/day or a 28 percent reduction.

Principal Causes of SOD

To aid in identifying the principal cause or causes of SOD at each station, statistical regression curve-fitting techniques were used to determine if the SOD curves (Appendix A) best fit a linear, log-log, or semi-log model. As previously mentioned, a pure linear usage is indicative of high bacterial demand, whereas a curvilinear usage can be indicative of a mixed demand of bacteria, algae, and macrofauna. If the SOD was almost wholly the result of a macrodemand, a semi-log fit would probably occur since this demand theoretically occurs at a rate in proportion to the remaining oxygen concentration. The results are given in table 10. The mathematical descriptions of the models are:

Table 10. SOD Curve Fitting Results

	Best-fit model						
Sta.	*L*	*SL*	*LL*	*Corr. coef.*	*a*	*b*	*Comments*
1	✓			.9937	-.017	.0129	linear & log-log essentially equal
2	✓			.9971	-.041	.0082	
3	✓			.9914	.111	.0067	linear & log-log essentially equal
4	✓			.9955	.034	.0109	
5	✓			.9963	.017	.0085	
6			✓	.9999	.020	1.0023	log-log & linear essentially equal
7			✓	.9983	.028	.8598	log-log slightly better than linear
8	✓			.9995	-.002	.0103	
9	✓			.9984	.057	.0120	linear & log-log essentially equal
10			✓	.9869	.033	1.0361	
11	✓			.9907	.192	.0142	linear & log-log essentially equal
12	✓			.9988	-.026	.0097	
13	✓			1.0000	.000	.0100	
14	✓			.9989	.044	.0138	
15	✓			.9936	-.068	.0165	
16	✓			.9975	.037	.0118	
17			✓	.9995	.044	.9558	log-log & linear essentially equal
18			✓	.9544	.036	.8984	
19	✓			.9982	-.039	.0140	linear & log-log essentially equal
20	✓			.9960	.172	.0253	linear & log-log essentially equal
21	✓			.9961	.146	.0133	
22	✓			.9881	.173	.0210	
23	✓			.9878	-.167	.0104	
24			✓	.9978	.078	.7275	log-log & linear essentially equal
25		✓		.9857	.034	.0238	
26		✓		.9879	.119	.0190	
27	✓			.9991	.326	.0272	
28			✓	.9930	.045	.4923	log-log & linear essentially equal
29	✓			.9918	-.121	.0069	
30		✓		.9964	.012	.0265	
31	✓			.9951	.015	.0033	linear slightly better than log-log
32	✓			.9977	-.043	.0101	
33	✓			.8814	-.040	.0047	
34	✓			.9966	-.026	.0052	
35			✓	.9963	.042	.6340	
36			✓	.8858	.080	.5158	
37	✓			.9983	-.062	.0110	
38			✓	.9769	.152	.3658	log-log & linear essentially equal
39	✓			.9942	-.172	.0094	
40	✓			.9913	-.001	.0056	
41	✓			.9963	.028	.0133	
42			✓	.9974	.337	.9769	
43	✓			.9984	-.031	.0093	
44	✓			.9992	.089	.0102	
45		✓		.9920	.037	.0251	semi-log & linear essentially equal

Table 10. Concluded

Sta.	L	SL	LL	Corr. coef.	a	b	Comments
	Best-fit model						
46	✓			.9846	-.031	.0064	
47			✓	.9573	-.023	.4257	log-log slightly better than linear
48	✓			.9953	.049	.0160	
49	✓			.9726	.077	.0090	
50	✓			.9901	-.345	.0211	
51			✓	.9955	.015	.7521	log-log & linear essentially equal
52	✓			.9949	.123	.0034	
53	✓			1.0000	-.385	.0050	
54	✓			.9974	-.080	.0087	
55	✓			.9594	-.012	.0188	
56	✓			.9975	-.199	.0213	linear & log-log essentially equal
57	✓			.9961	.103	.0101	
58	✓			.9972	-.098	.0386	linear slightly better than log-log
59	✓			.9985	-.446	.0266	
60	✓			.9944	-.321	.0289	
61			✓	.9883	.160	.7842	
62	✓			.9720	.155	.0100	linear & log-log essentially equal
63	✓			.9985	-.094	.0286	
64	✓			.9851	-.033	.0063	
65	✓			.9937	.020	.0042	linear slightly better than log-log
66	✓			.9782	.205	.0069	
67	✓			.9964	.057	.0114	
68	✓			.9987	.028	.0096	
69	✓			.9960	-.004	.0144	
70	✓			.9950	-.062	.0190	
71	✓			.9980	-.063	.0189	
72	✓			.9983	.005	.0130	
73	✓			.9978	-.005	.0086	
74			✓	.9993	.060	.9436	log-log slightly better than linear
75	✓			.9880	-.079	.0287	
76	✓			.9871	.680	.0522	
77			✓	.9974	.374	.4198	
78	✓			.9971	.024	.0156	linear & log-log essentially equal
79	✓			1.0000	.030	.0100	
80	✓			.9422	.025	.0037	
81A	✓			.9981	.140	.0334	over algal growth
81B	✓			.9991	-.027	.0222	over bare spot
82			✓	.9996	.001	1.9959	log-log slightly better than linear
83	✓			.9920	-.039	.0110	
84		✓		.9855	.052	.0304	semi-log slightly better than linear
85			✓	.9898	.036	.8632	log-log slightly better than linear
86	✓			.9952	-.087	.0075	
87	✓			.9986	-.002	.0042	
88	✓			.9966	.018	.0052	
89			✓	.9941	.012	.6280	log-log slightly better than linear

Linear	DO used = $a + bt$	(8)
Semi-log	DO used = $a \exp(bt)$	(9)
Log-log	DO used = at^b	(10)

where DO used = the dissolved oxygen in mg/1 utilized over a time interval t in minutes, and a and b are regression constants.

For most of the 90 SOD runs completed, little direct evidence existed as to the principal causes of the oxygen usages. However, indirect methods, circumstantial evidence, and engineering judgment were used to formulate broad source classifications, such as bacteria, algae, and macroinvertebrates. Criteria used for developing these categorizations were ambient dissolved oxygen concentration, type and depth of sediment, number of macroorganisms, the SOD curve best-fit model data presented in table 10, and the relative magnitude of the SOD values.

Ambient DO concentrations are indicative of several conditions relevent to benthic oxygen usage. For example, a supersaturated DO level indicates photosynthetic oxygen production from some form of algal activity. If this oxygen production is from benthic algae, either filamentous types or diatoms, these microorganisms will exert SOD when light is shut off as the sampler is placed on the bottom. Consequently, ambient supersaturated DO in water coupled with a significant SOD value would tend to indicate that benthic algal respiration is contributing to benthal oxygen usage. This conclusion can be supported somewhat if a slight initial lag occurs in the DO usage curve.

These exact conditions occurred a number of times, the best example being for station 82 on Midlothian Creek. The water was shallow, very clear, and almost 200 percent saturated with DO; the bottom was lined with brown algae (diatoms). After placement of the sampler, over 16 minutes elapsed before the oxygen usage rate became significant (see the curves and data in Appendix A), and for the total 83 minutes for which the sampler was left in place the final SOD rate was moderately high ($4.64 g/m^2/day$).

Supersaturated dissolved oxygen levels may hinder as well as help interpretation of results if macroinvertebrates exist on the bottom since the influence of their respiration on the shape of the SOD curve may be "masked out" by the high DO concentration. The respiration rates of macroorganisms are probably not proportional to the oxygen available at supersaturated levels; i.e., the respiration rates of fingernail clams probably are no different at the DO concentrations of 20 and 15 mg/1 at 25°C. However, at 25°C the fingernail clam respiration rate at a DO of 8 mg/1 is three times greater than at 5 mg/1 as will be demonstrated in detail later.

Also, respiration rates of suspended algae trapped in the sampler may at times hinder interpretation of the results, particularly for highly productive streams like the Fox River and certain reaches of the DuPage and Des Plaines Rivers. Suspended algae conceivably could enter a respiratory stage in the time frame for which most SODs were run. Unfortunately, sufficient time was not available to develop methods and equipment for isolating this potential source of oxygen usage in the sampler. However, the actual effect on the results, for Fox River stations at least, appears to be minimal since most of the rates were relatively low.

The condition of the bottom sediments can aid in speculating on the source of SOD. A logical assumption is that a clean sand-gravel bottom would be relatively free of bacteria, whereas a sludge bottom would teem with them. However, rocky gravel bottoms covered with slime bacteria such as *Sphaeroti-lue* and *Leptomitus* would certainly exert a significant demand.

The magnitude of macroinvertebrate numbers relative to the SOD value is an important factor to be considered. For example, the bottom at station 77 on the Little Calumet River harbors a sludge worm population of almost 300,000/m^2 partially accounting for a moderately high observed SOD rate of 4.26 g/m^2/day. In contrast, the bottom at station 30 on Flint Creek contained only 4400 macroinvertebrates in a clean sand bottom having an observed SOD of only 0.27 g/m^2/day. However, the macroinvertebrate percentage contribution to SOD appears to be greater in Flint Creek since the unit microinvertebrate contribution in the creek is $6x10^{-5}$ g/m^2/day per organism compared with only $1.4xl0^{-6}$ g/m^2/day per organism in the Little Calumet River,

Estimates of the percentage contribution of broadly classed sources of SOD are given in table 11. These estimates show only the most likely contributors and their relative degree of contribution. At stations 57 through 62, significant numbers of fingernail clams exist for which respiration rates are accurately known.[4] Consequently, the actual oxygen consumption of these organisms was computed and the results showed their contribution ranged from 1 to 7 percent. The highest was at station 58 which had a clam population over 9000/m^2 demonstrating that a very large active biomass is needed to significantly depress the DO, and in most study area streams such large biomasses did not exist.

Examination of table 11 reveals that bacterial demand is ubiquitous and is the primary cause of SOD at all but possibly five stations. At grossly polluted stations like 75 and 76, bacterial populations tend to increase at a faster rate than do unbalanced macroorganism populations. At only 11 stations did the estimated macroinvertebrate SOD percentage composition equal or exceed 50 percent and the dominate contributing organisms were sludge worms and midges.

At a few selected locations specialized biological activity occurred which affected the SOD to various degrees. The fingernail clam activity, mentioned at stations 57 through 62, is an example. Another is respiration of diatoms or brown algae and filamentous green algae. This form of SOD would be significant only on very cloudy days and during the night in selected clear water streams like Flint Creek, Calumet Union Drainage Canal, and Midlothian Creek. The actual SOD measurement may tend to be high at locations where suspended algae blooms were evident at the time of sampling. The check marks in table 11 identify the stations where the results may be influenced to some degree by algal respiration precipitated by the "dark

Table 11. Rough Estimates of Percentage Contribution to SOD

		Macroinvertebrates		*Algae*		
Sta.	*Bacteria*	*Worms-midges*	*Other*	*Attached filamentous*	*Benthic*	*Possible suspended algae effect*
1	90	10				✓
2	95	5				✓
3	90	10				✓
4	90	10				✓
5	90	10				✓
6	90	10				✓
7	85	15				✓
8	90	10				✓
9	95	5				
10	95	5				✓
11	98	2				✓
12	95	5				
13	90	10				
14	95	5				✓
15	80	20				✓
16	85	15				
17	98	2				✓
18	60	40				
19	75	25				
20	90	10				✓
21	95	5				
22	98	2				✓
23	85	15				
24	95	5				✓
25	50	50				
26	60	40				
27	99	1				
28	50	50				
29	85	15				
30	30	25	25		20	✓
31	30	55	15			
32	70	25	5		10	✓
33	90	10				
34	98	2				
35	85	15				
36	60	40				
37	85	10		5	5	
38	85	15				
39	75	5	20			
40	65	30	5			
41	90	7	3			
42	50	50				
43	50	50				
44	90	10				
45	60	40				

Table 11. Concluded

Sta.	Bacteria	*Macroinvertebrates* Worms-midges	Other	*Algae* Attached filamentous	Benthic	Possible suspended algae effect
46	80	15	5			
47	55	15	30			
48	50	50				✓
49	85	15				
50	65	35				
51	65	35				
52	50	50				
53	50	50				
54	90	10				
55	80	20				
56	75	25				
57	60	39	1			
58	90	3	7			✓
59	85	9	6			
60	90	4	6			
61	60	36	4			
62	80	17	3			✓
63	95	5				✓
64	95	5				
65	50	50				
66	75	25				
67	50	50				
68	80	20				
69	70	20		10		✓
70	99	1				✓
71	99	1				✓
72	99	1				✓
73	95	5				
74	90	10				
75	90	10				
76	90	10				
77	40	60				
78	85	10			5	✓
79	70	20	10			
80	55	45				
81A	85	15				✓
81B	40	15		40	5	✓
82	40	10			60	✓
83	99	1				
84	80	5		15		
85	80	3	17			✓
86	90	10				
87	95	5				
88	98	2				
89	95	5				

bottle[11] effect of the sampler. Circumstantial evidence exists, however, which tends to show that algal respiration effects are probably minimal during the relatively short sampling times used. The characteristics of the SOD curve generated for station 82 (Appendix A), a site of obvious benthic diatom activity, showed a very large lag time indicating a balance between oxygen reserves and bacterial and macroinvertebrate respiration. At least 30 minutes elapsed before oxygen usage became discernible from the curve.

In cases where benthic algae significantly influence SOD rates, diurnal adjustments in rates should be made. Basically algal SOD should be neglected during sunny daylight hours and fully utilized during dark periods. The daylight SOD at station 82 for instance, could be assigned a value of 50 percent of 5.28 g/m^2/day. Some values for transitional light conditions could be extrapolated from the SOD curve if a complete model is desired.

Many small streams were not sampled in the study area. If general conditions are known about the bottoms of these streams or if assumptions can be made about benthic conditions on the basis of certain environmental and geographical factors, the generalized SOD values listed in table 12 can be used as a guide for assigning or estimating SOD rates in these streams. Also, the broad classifications presented in table 13 can aid in the assignment of values to various known or assumed bottom conditions where directly measured data are unavailable. The classifications are strictly "best estimates" based upon wide experience and numerous field observations. The percentage occurrence of the various classes in the streams studied were estimated from the probability plot presented as figure 11. The data show a log-normal distribution, but it may be slightly biased since the sampling points were not entirely randomly selected. Roughly three quarters of the stations sampled showed some evidence of pollution; however, only about 20% were heavily polluted.

Anomalous Results

In conclusion, several specific and unique situations which developed during the field sampling operations need to be pointed out and briefly discussed. One occurred at station 45 on the East Branch of the DuPage River where the SOD rate 0.90 g/m^2/day was much lower than expected. The low rate may be the result of a chlorine residual which reportedly occurs persistently in the stream as a result of chlorinated sewage effluent, particularly that from Downers Grove. At the time of the SOD sampling, a Downers Grove technician reported the chlorine residual was 0.2 mg/1 in the stream. This residual level may be high enough to significantly retard bacterial activity, but not high enough to disrupt macroinvertebrate respiration to a large degree.

An anomaly occurred in the measurements made at the originally scheduled location of station 2 on the upper Fox River, The scheduled sampling location was approximately a half mile above where it was finally taken as presented in table 1. An attempt was made at the original location to get

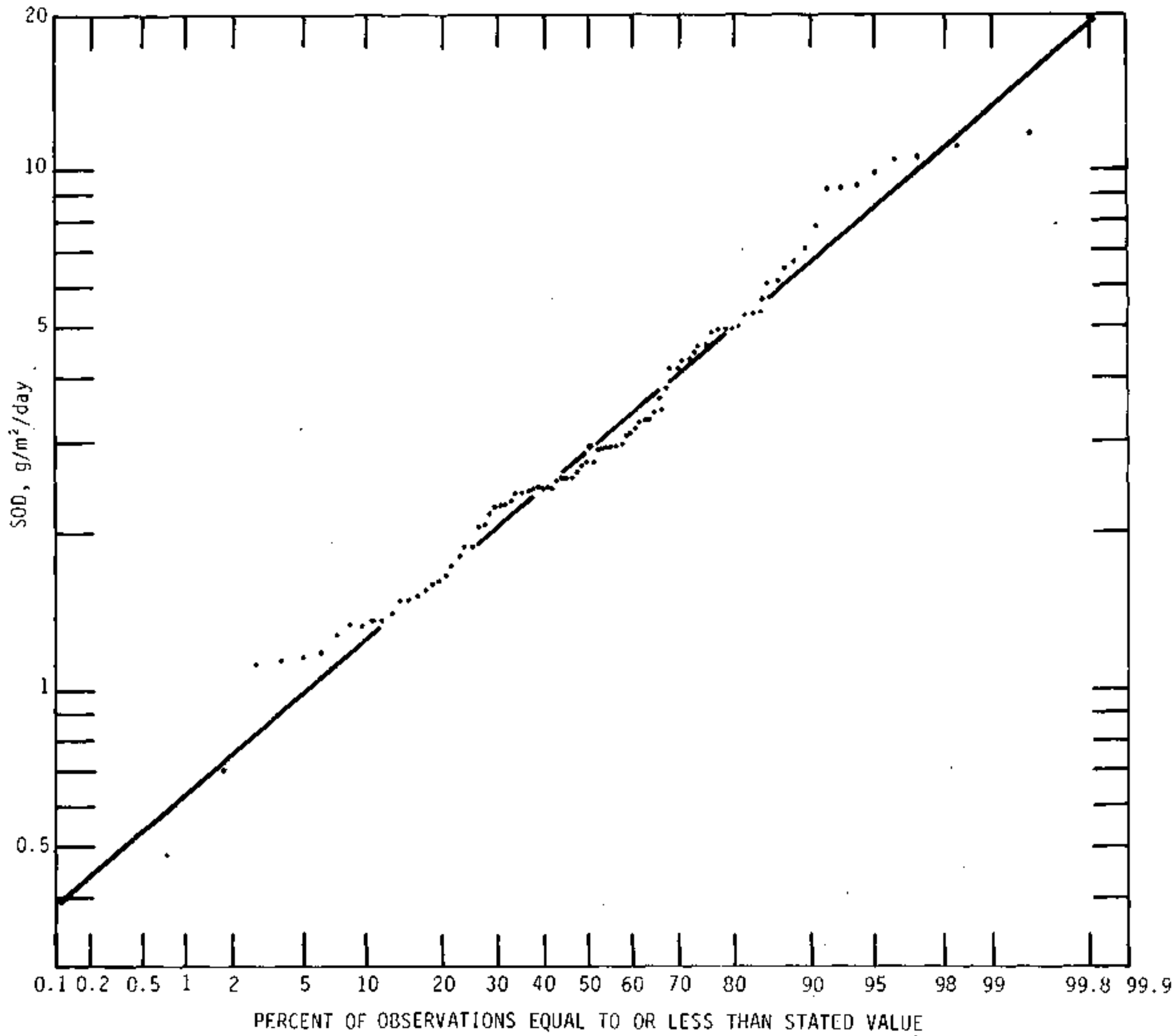


Figure 11. SOD probability distribution—NIPC study area

Table 12. SOD Values for Generalized Stream Conditions

	Generalized stream conditions	*Observed example (Stream - Station)*	*Generalized SOD (g/m^2/day at 25°C)*
1	Watery septic muck from highly developed residential and industrial complex	Little Calumet - 76	11.5
2	Gray-black sand and gravel downstream of treated sewage effluent	Thorn Creek - 83	2.5
3	Relatively stabilized muck behind channel dam on small stream	Salt Creek - 68	2.0
4	Small stream draining rural area with some rural subdivision developments	Blackberry Creek - 33	1.0
5	Small stream draining high class residential and commercial complex	Flint Creek - 30	0.5
6	Small stream draining pasture and marsh lands	Flint Creek - 31	1.5
7	Moderate size stream draining agricultural land and small communities	Kishwaukee River - 29	3.0
8	Very clean sand bottom (clear water)	Flint Creek - 30	0.5
9	Somewhat dirty sand bottom with diatom growth (clear water)	Midlothian Creek - 82	5.0
10	Somewhat dirty sand bottom with diatom and filamentous green algae growth (clear water)	Calumet Union Drainage Canal - 81B	9.0
11	Intermittent stream below residential lake development	Woods Creek - 32	1.5
12	Gravel and rocky riffle areas in an enriched stream	Fox River - 15	3.5
13	Sediments in an impoundment enriched by algal fallout from very productive overlying water	Skokie Lagoons - 70	5.0

Table 13. Generalized Benthic Sediment Conditions Categorized by SOD Rates

SOD range $g/m^2/day$ at 25°C	*Generalized benthic sediment condition*	*% Lower value exceeded in streams studied*
<0.5	Clean	100.0
0.5-1.0	Moderately clean	99.6
1.0-2.0	Slightly degraded	95.0
2.0-3.0	Moderately polluted	72.0
3.0-5.0	Polluted	48.0
5.0-10.0	Heavily polluted	20.0
>10.0	Sewage sludge like	3.0

an SOD measurement but only erratic results were achieved as shown by the first part of the curves listed under station 2 in Appendix A. The bottom appeared to exert large immediate demands and the DO usage was erratic and great. The sampler was taken up and reset a number of times but the results were always the same. The demand in this case appeared to be chemical in nature and could have been the result of bottom disturbances from dredging operations which were reported to have occurred in the vicinity earlier in the summer.

The Skokie Lagoon results are interesting in that the SOD rates for the two stations, 70 and 71, in the deeper areas of the lagoon where eutrophication is rampant, are equal (see table 2), whereas in the upper end at station 72 where very little algal growth is occurring, the SOD rate is significantly lower. The upper reaches are relatively shallow and contain a large visible rough fish population which constantly stirs up the bottom, causing turbidity and retarding algal growth. The difference of 1.0 $g/m^2/day$ between the upper station and the lower two can probably be attributed to algal fallout and the subsequent microbial breakdown of this organic material in the bottom sediments. Algal washout from the lagoons may affect the SOD of the North Branch of the Chicago River far downstream of the Willow Avenue Dam. Station 73 was approximately 10 miles below the dam and its sediments were dirty gray to black, musty smelling sand and gravel (see Appendixes C and D) having a moderately high SOD rate of 2.74 $g/m^2/day$ at 25 C.

Finally one totally unexplainable result occurred. It was the high SOD rate of 5.14 $g/m^2/day$ at 9°C observed for the Kishwaukee River at station 27. Adjusting this rate to 25 C conditions gives a value of 10.63 $g/m^2/day$, an extremely high value indicative of highly polluted sediments. Examination of the sediment data (Appendixes C and D), however, revealed only clean sand-gravel and not the sewage sludge type of sediments normally associated with a demand of this magnitude. The DO meter, DO probe, and sampler were all double checked and found to be operating properly. The only logical explanation would be that a chemical oxygen demand was exerted, though the probability of clean sand and gravel harboring a chemical oxygen demanding substance is unlikely, and in addition, the stream in this area flows entirely through an agricultural environment,

FOX CHAIN OF LAKES DATA

The locations of the SODs taken during the summer of 1975 as part of a comprehensive water quality study of the Fox Chain of Lakes[1] are shown in figure 12. A measurement was made in each lake except for Channel Lake which was considered an extension of Lake Catherine relative to bottom sediments. The SODs are summarized in table 14. Benthic sediment samples were collected in conjunction with SOD measurements but benthos samples were not. Sediment physical characteristics and descriptions are given in tables 15 and 16.

The types of bottoms and the SOD rates varied within the lake system. A low of 3.44 $g/m^2/day$ occurred in the open water area of Fox Lake, while a high of 31.57 $g/m^2/day$ occurred in Pistakee Bay.

Generally, the bottoms of most of the lakes were composed of silts or marls, rich in organic materials. All were in a highly reduced state; all but one of the samples emitted noticeable hydrogen sulfide smells. Many samples showed a relatively high volatile solids content reflecting the organic content of the sediments. On the basis of the SOD results alone, it is concluded that most of the bottoms throughout the lake system are in some state of degradation.

The degree to which these bottoms affect the overlying water is primarily dependent upon water depth. For example, a bottom having a significant SOD in a deep stratified lake will quickly deplete the DO in the lower depths. The rate of oxygen demand cannot be maintained by natural reaeration or by photosynthesis. Oxygen used by high SODs in shallow waters is usually naturally replenished so that the influence of the degraded bottom conditions is not quite so evident as in deeper waters. As an example, Grass Lake which is relatively shallow in most areas (less than 5 feet), had extremely high SOD rates of 14.76 and 12.54 $g/m^2/day$ in the two locations sampled. However, at the time of the SOD measurements the DO was above saturation even near the bottom. In contrast to this, the deep waters of Pistakee Bay and Lake Catherine were devoid of oxygen.

Even the lowest SOD recorded, 3.44 $g/m^2/day$ for Fox Lake, is a highly significant SOD value and would cause rapid DO depletion in deeper lakes. Without oxygen replenishment an SOD rate of 3.73 $g/m^2/day$ would deplete a 5-meter column of water saturated with dissolved oxygen at 20 C in approximately 12 days. For a severely degraded bottom such as that observed for Pistakee Bay, DO depletion would occur in less than 2 days. However, an inherent danger exists in having high SOD rates in shallow water. When the bottom sediments are resuspended physically, such as by boating activity, the SOD rate is momentarily increased several fold causing severe temporary oxygen depletion. As an example, the bottom of Grass Lake at station 14 remained disturbed for 20 minutes after lowering the sampler to the bottom; the disturbed SOD rate was 47.11 $g/m^2/day$ compared with the stabilized rate of 12.54 $g/m^2/day$. During this disturbed period the DO was lowered in the sampler by approximately 2.5 mg/1. In contrast, for a 43-minute period after

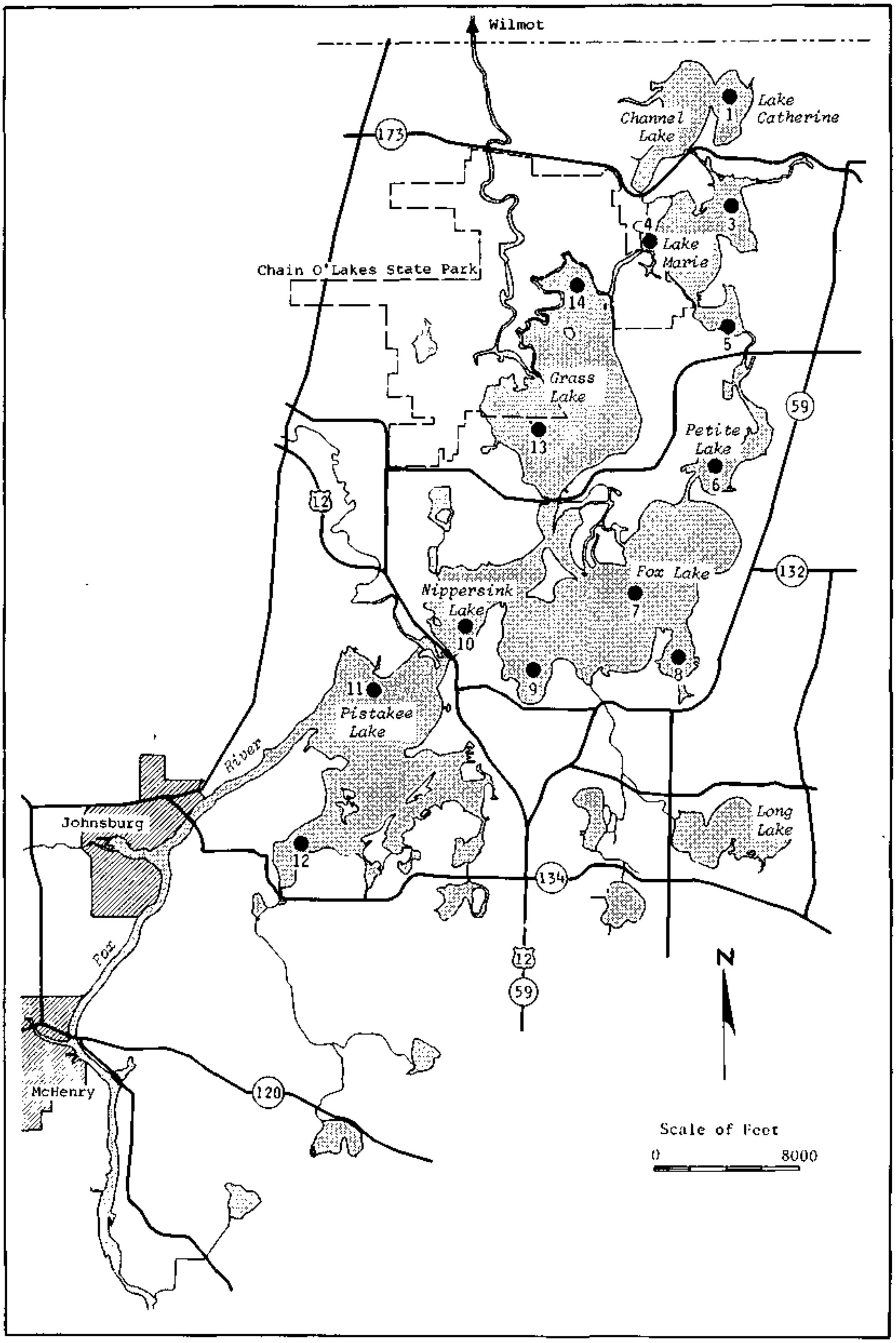


Figure 12. Locations of in-situ SOD measurements in Fox Chain of Lakes

Table 14. Sediment Oxygen Demand Rates for Fox Chain of Lakes

Lake	*Temperature T (°C)*	*Time frame (min)*	*SOD at T°C (g/m²/day)*	*SOD at 25°C (g/m²/day)*
Catherine	13.8	0-2	91.63	153.27
		2-26	9.80	16.42
		24-53	7.76	*12.98**
Marie (east)	20.8	0-4	26.18	32.04
		4-66	5.70	*6.91**
Marie (west)	19.8	0-14	28.05	36.36
		14-49	12.72	*16.04**
Bluff	20.25	0-26	9.82	12.13
		26-60	5.58	*6.98**
Petite	20.3	0-10	13.75	16.98
		10-55	6.25	7.74
		55-103	5.59	*6.95**
Fox	20.4	0-20	4.58	5.70
		20-62	2.81	*3.44**
Stanton Bay (Fox Lake)	21.0	0-13	16.11	19.72
		13-64	5.78	*6.91**
Mineola Bay (Fox Lake)	19.0	0-6	30.54	40.24
		6-60	4.12	*5.43**
Nippersink	19.05	0-8	37.64	49.58
		8-68	6.33	*8.32**
Pistakee	19.0	0-7	14.97	19.57
		7-55	4.36	*5.76**
Pistakee Bay	20.5	0-2	144.00	177.06
		2-26	27.80	34.20
		26-41	42.76	52.58
		41-67	25.68	*31.57**
Grass (south)	18.75	0-21	21.19	28.44
		21-61	11.13	*14.76**
Grass (north)	17.9	0-20	33.38	47.11
		20-63	9.13	*12.54**

* *Italicized values represent stabilized linear portion of SOD curve*

Table 15. Solid-Liquid Composition of Fox Chain of Lakes SOD Samples

(Compositionsinpevcent)

Lake	*Water*	*Fixed solids*	*Volatile solids*
Catherine	75.0	86.7	13.3
Marie (east)	40.0	90.7	9.4
Marie (west)	56.9	95.9	4.1
Bluff	25.5	74.4	25.6
Petite	17.5	85.3	14.7
Fox	62.2	90.8	9.2
Stanton Bay (Fox Lake)	52.3	92.8	7.2
Mineola Bay (Fox Lake)	80.4	74.2	25.8
Nippersink	79.2	79.4	20.6
Pistakee	73.8	83.3	16.7
Pistakee Bay	75.3	84.7	15.3
Grass (south)	55.8	96.7	3.3
Grass (north)	79.7	74.9	25.1
Cedar	23.7	84.2	15.8

restabilization occurred, the DO was lowered only 1.5 mg/1 in the sampler. Table 14 lists the disturbed rates and the subsidence times for all the sampling locations. The consistency of the bottom sediments has a great influence on both the magnitude of the disturbed SOD rate and the time interval over which it is significant. SOD rates are highest in areas of algal silt type bottom sediment.

Table 16. Descriptions of Lake Bottoms at SOD Stations in Fox Chain of Lakes

Lake	*Depth (ft)*	*Before incineration*	*After incineration*
Catherine	39	Sulfide smell, thin watery gritty muck	Hard gray crust of silt and clay, powderable
Marie (east)	10	Slight oily smell, muddy, gritty, slurry with fibrous material	Reddish-gray to brown with some very small shells, easily powdered
Marie (west)	10	Slight sulfide smell, small white snail shells and small-to-moderately large shell fragments, marl like	White snail shells and shell fragments, easily crushed to fine powder.
Bluff	12	Sulfide smell, muddy, gritty, slurry	Clay-silt with some minute shell fragments, powderable
Petite	12	Strong sulfide smell, thin watery muddy grit	Gray hard crust, uniform silt-clay mixture
Fox	8	Slight sulfide smell, thin watery mud and small crushed shells	Very light fluffy mixture of snail and small clam shells, easily powdered
Fox (Stanton Bay)	4	Slight sulfide smell, muddy mixture of shells, fibers, and roots	Crusted mixture of calcium materials and shell fragments, easily powdered
Fox (Mineola Bay)	12	Sulfide smell, thin watery muddy grit	Moderately hard crust, light brown, powderable
Nippersink	6.5	Sulfide smell, thin watery muddy grit	Moderately hard crust light brown, powderable
Pistakee	5	Very strong sulfide smell, muddy, gritty slurry	Moderately hard crust light brown, powderable
Pistakee Bay	32	Sulfide smell, thin watery muddy grit	Moderately hard crust very light brown, powderable
Grass (south)	3.2	Slight sulfide smell, a little mud, mostly small white crushed shells	Dark snail shells and shell fragments, easily powdered
Grass (north)	3.2	Slight sulfide smell, thin watery grit	Soft reddish gray crust, easily powdered
Cedar	45	Sulfide smell, thin watery muddy grit	Fine reddish material with some leaf and wood ash, powderable

REFERENCES

1 Kothandaraman, V., R. L. Evans, N. G. Bhowmik, J. B. Stall, D. L, Gross, J. A. Lineback, and G. B. Dreher. 1977. *Fox Chain of Lake Investigation and Water Quality Management Plan.* Illinois State Water Survey and Illinois State Geological Survey Cooperative Resources Report 5. Urbana, Illinois.

2 Butts, T. A. 1974. *Sediment Oxygen Demand in the Upper Illinois Waterway.* Illinois State Water Survey Report of Investigation 76. Urbana, Illinois.

3 Lee, M. T., J. B. Stall, and T. A. Butts. 1976. *The 1975 Sediment Survey of Lake Meredosia.* Illinois State Water Survey special report. Urbana, Illinois.

4 Butts, T. A., and R. E. Sparks. 1977. *Sediment Oxygen Demand-Fingernail Clam Relationship in the Mississippi River, Keokuk Pool.* Paper presented at the 1977 joint meeting of the Illinois State Academy of Science and Missouri Academy of Science, University of Missouri-St. Louis, St. Louis, Missouri.

5 Butts, T. A., R. L. Evans, and S. Lin. 1975. *Water Quality Features of the Upper Illinois Waterway.* Illinois State Water Survey Report of Investigation 79. Urbana, Illinois.

6 Bradley, R., and A. James. 1968. *A New Method for the Measurement of Oxygen Consumption in Polluted Rivers.* Journal Water Pollution Control 67:462.

7 Rolley, H. L. J., and M. Owens. 1967. *Oxygen Consumption Rates and Some Chemical Properties of River Muds.* Water Research, 1:759.

8 James, A. 1974. *The Measurement of Benthal Respiration.* Water Research, 8:955.

9 Lucas, A. M., and N. A. Thomas. 1972. *Sediment Oxygen Demand in Lake Erie's Central Basin, 1970 (Chapter 5).* In "Project Hypo," by N, M, Burns and C. Ross, Canada Centre for Inland Waters Paper No. 6 and U.S. Environmental Protection Agency Technical Report TS-05-71-208-24.

10 Committee on Sanitary Engineering Research. 1960. *Solubility of Atmospheric Oxygen in Water.* American Society of Civil Engineers, Journal of the Sanitary Engineering Division, 86 (7):41-53,

11 American Public Health Association. 1975. *Standard Methods for the Examination of Water and Wastewater.* 14th Edition.

12 Butts, T. A., V. Kothandaraman, and R. L. Evans. 1973. *Practical Considerations for Assessing the Waste Assimilative Capacity of Illinois Streams.* Illinois State Water Survey Circular 110. Urbana, Illinois,

13 Weber, C. I. 1973. *Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents.* Office of Research and Development, USEPA report EPA-670/4-73-001, Macroinvertebrates p. 16-18, Cincinnati, Ohio.

14 Illinois Environmental Protection Agency. January 1974. *Tolerance Status of Aquatic Macroinvertebrate Organisms Found in Illinois Streams.* IEPA Division of Water Pollution Control, Field Operations Section, Water Quality Monitoring Unit, Springfield, Illinois.

15 Wilhm, J. L., and T. C. Dorris. 1968. *Biological Parameters for Water Quality Criteria.* Bioscience 18: 477-480.

16 Mitchell, D. and J. C. Buzzell, Jr. 1971. *Estimating Eutrophic Potential Pollutants.* American Society of Civil Engineers, Journal Sanitary Engineering Division, 97(SA4):453.

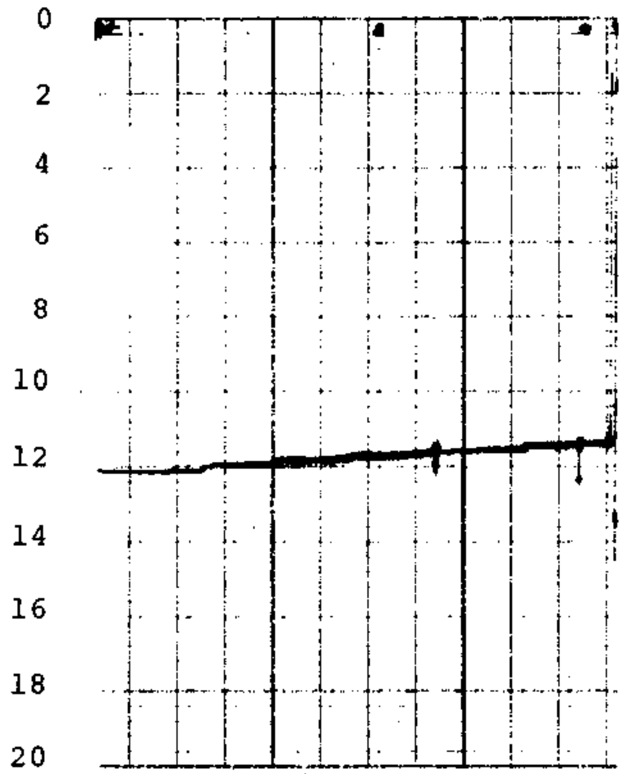
17 State of Illinois. 1962. *Survey Report for Development of Fox River, Ottawa to McHenry Dam, LaSalle, Kane, Kendall, McHenry and Lake Counties - Appendix D, Maps.* Department of Transportation, Division of Waterways, Springfield, Illinois.

18 State of Illinois. 1961. *Plan for Flood Control and Drainage Development. Dee Plaines River, Cook and Lake Counties - Appendix 6, Maps,* Department of Transportation, Division of Waterways, Springfield, Illinois.

19 State of Illinois, 1958. *Plan for Flood Control and Drainage Development, Salt Creek, Cook and DuPage Counties - Appendix E, Maps.* Department of Transportation, Division of Waterways, Springfield, Illinois.

20 McDonnell, A. V., and S. D. Hall. 1969. *Effect of Environmental Factors on Benthal Oxygen Uptake.* Journal Water Pollution Control Federation, Research Supplement, Part 2, v. 41:R353-R363, August.

Appendix A-1. Sediment Oxygen Demand Curves
(X axis = time in minutes, 7.5 min/unit; y axis = DO remaining in mg/1)



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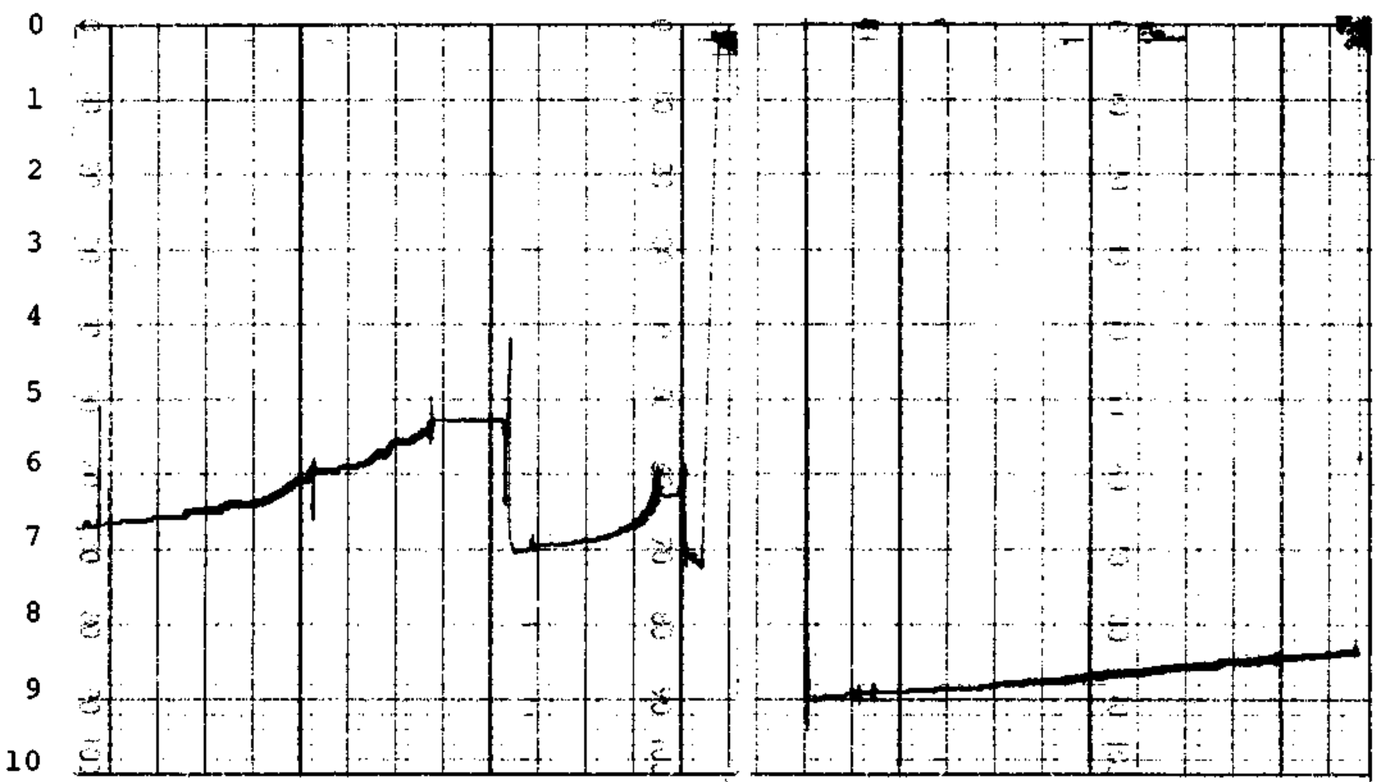

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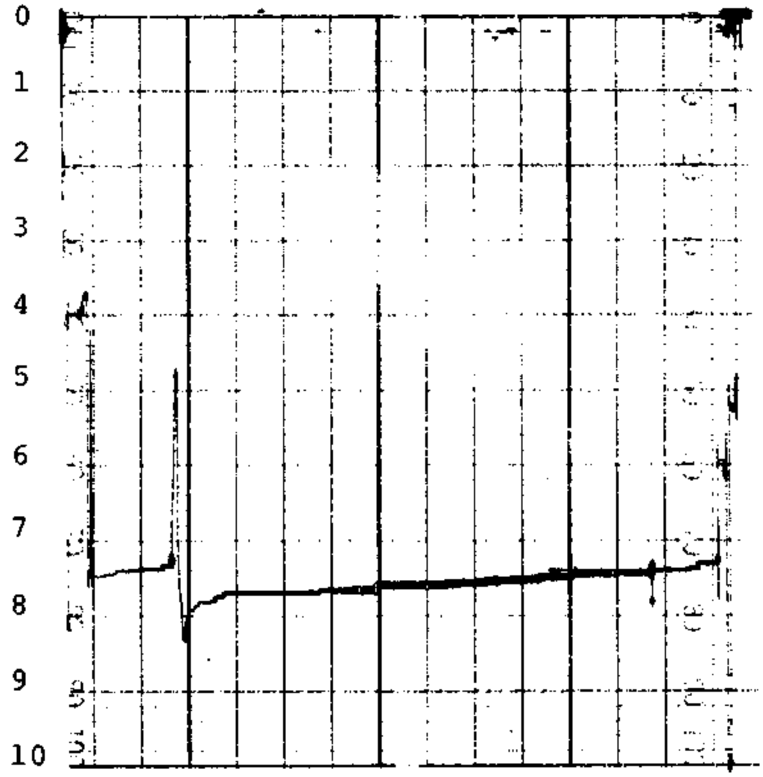

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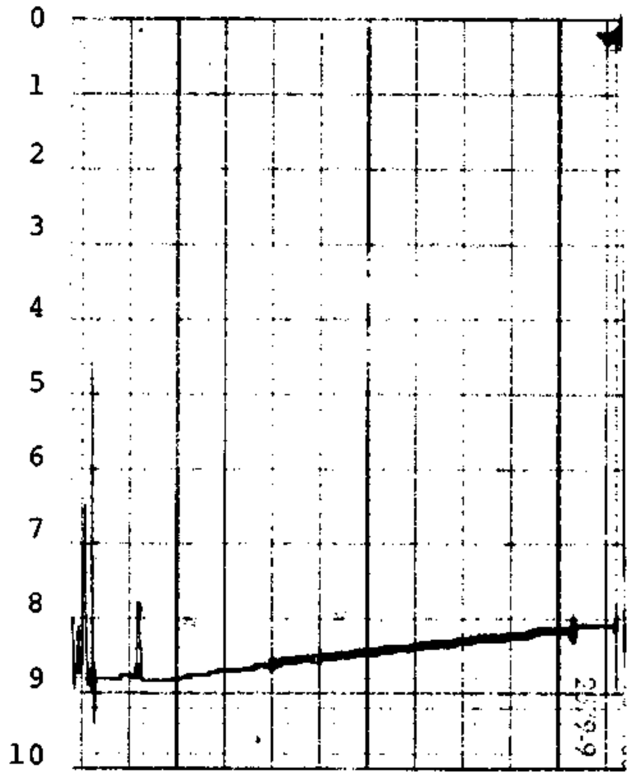

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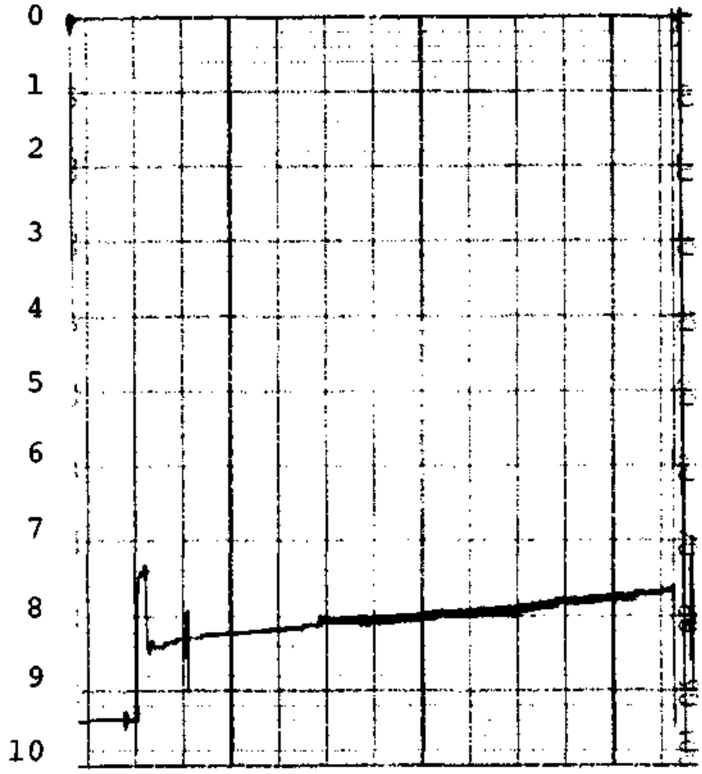

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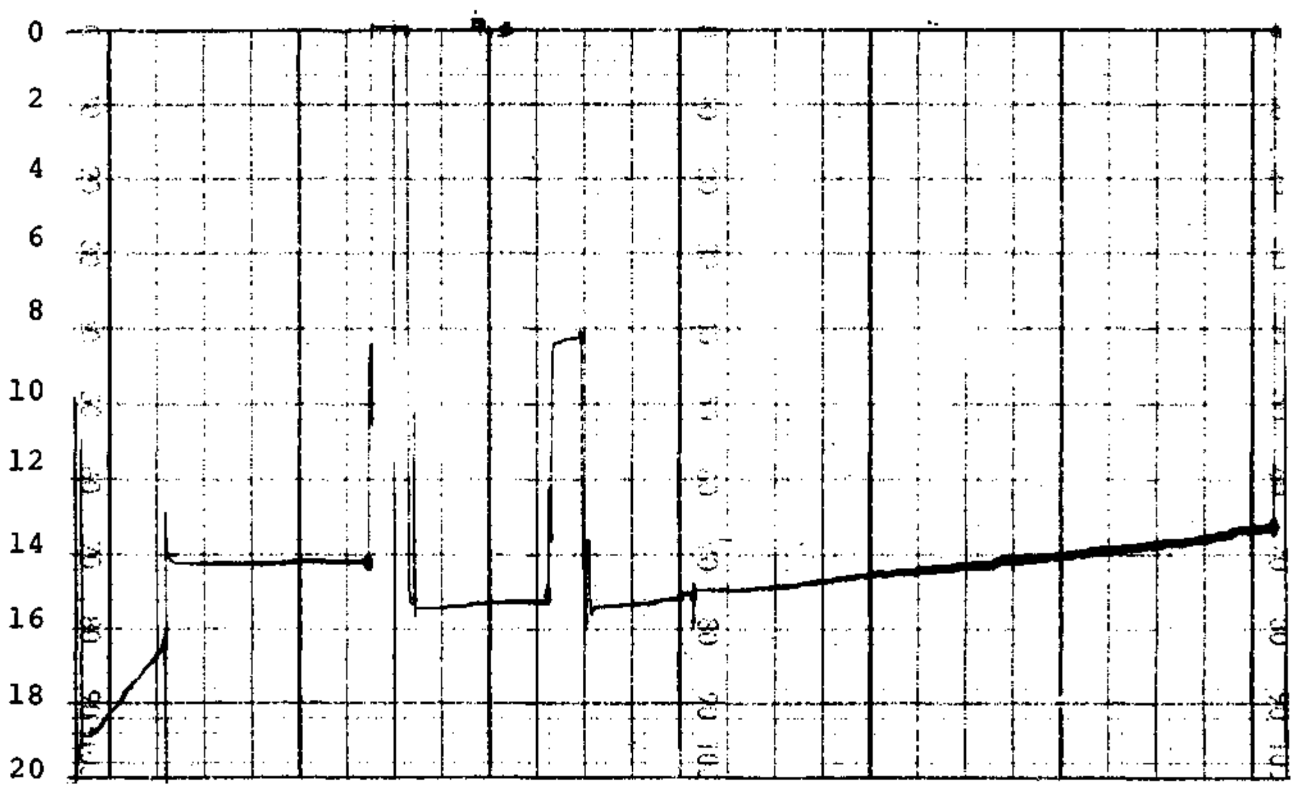

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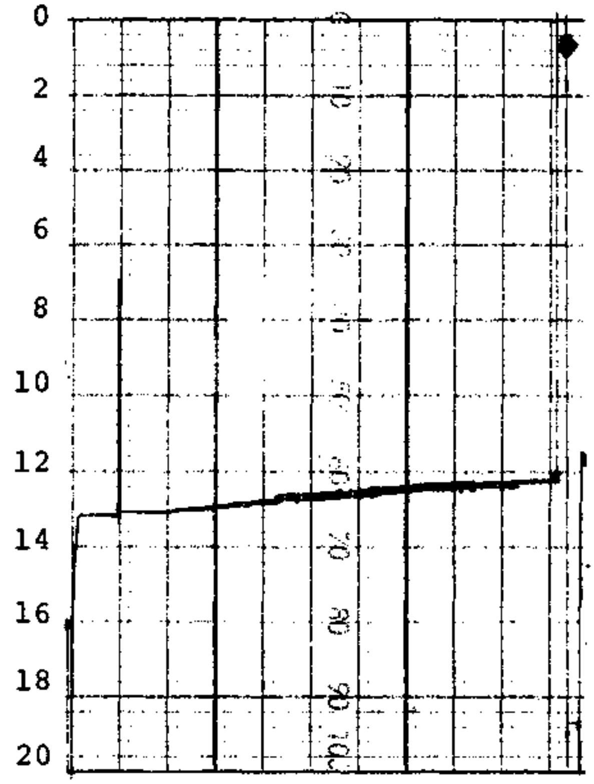

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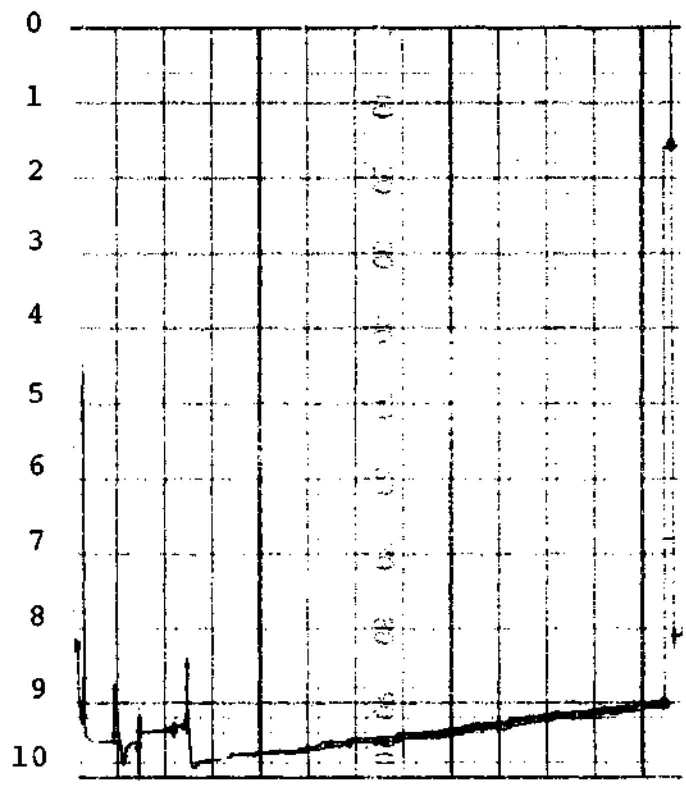

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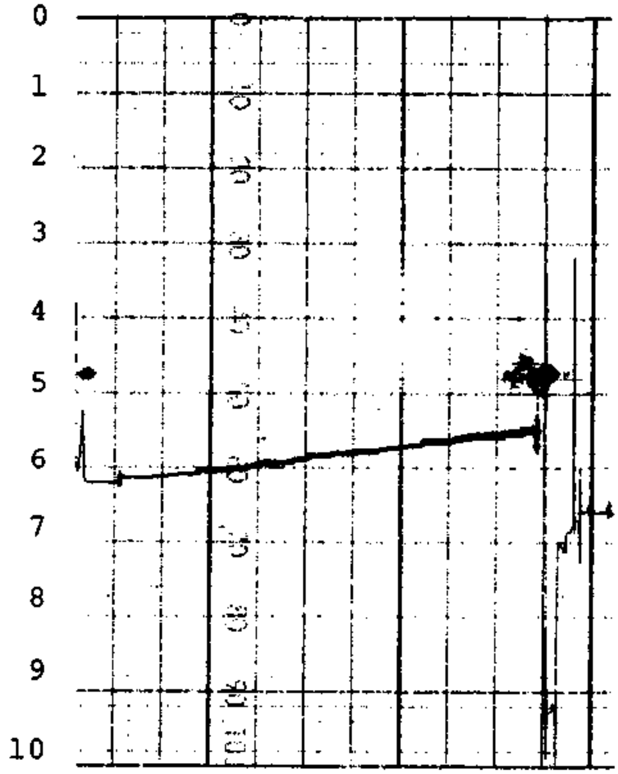

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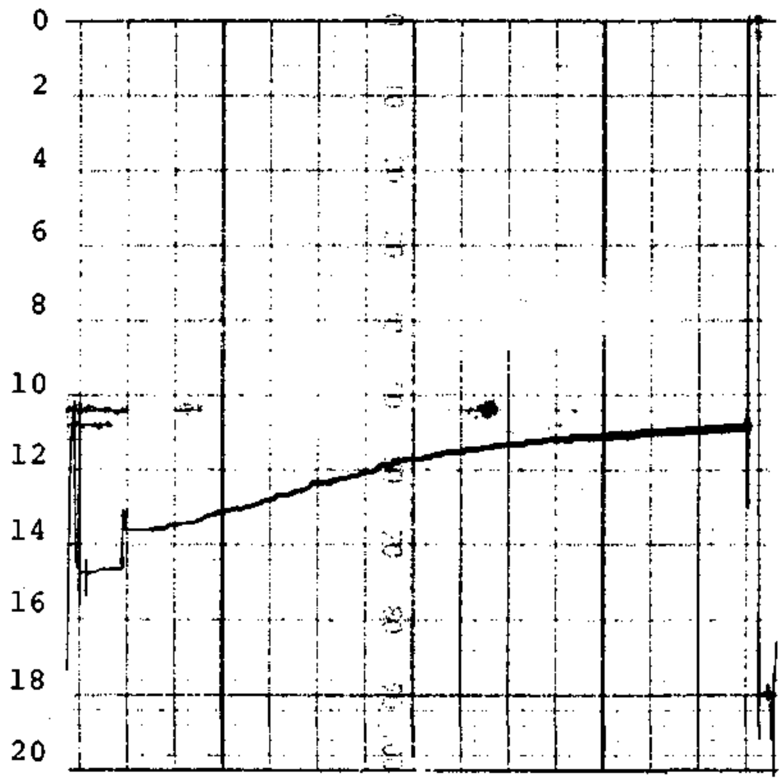

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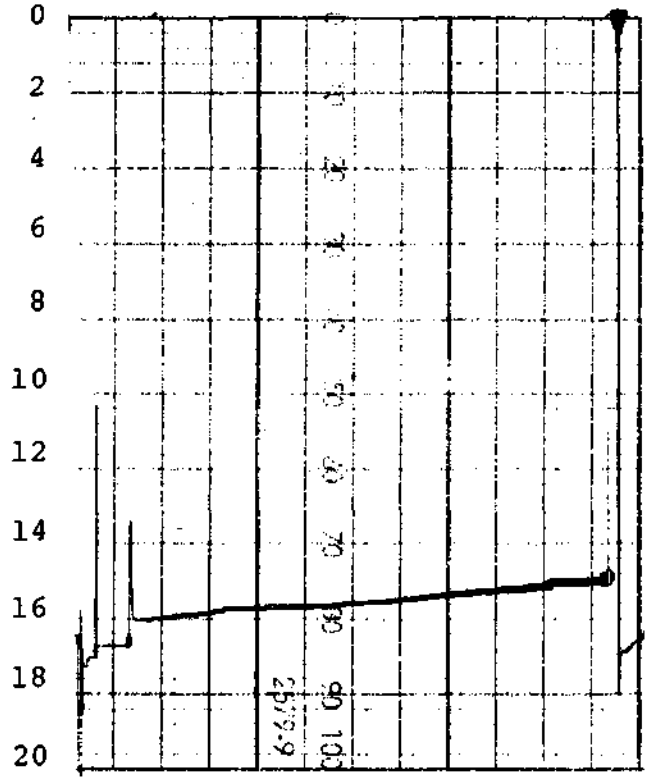

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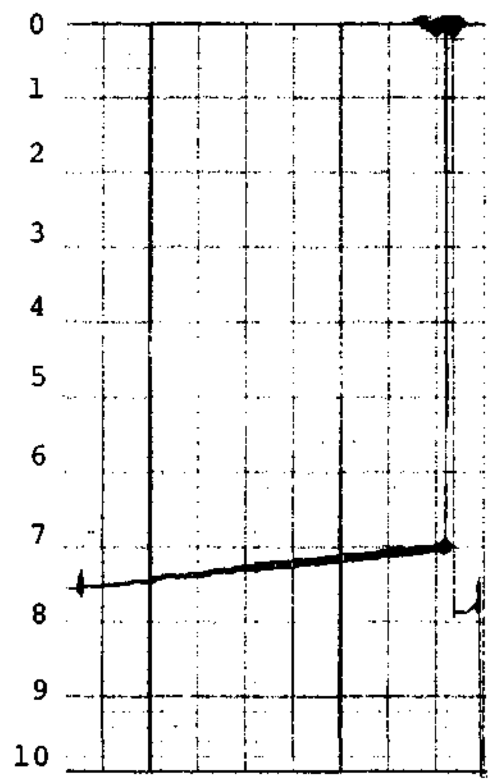

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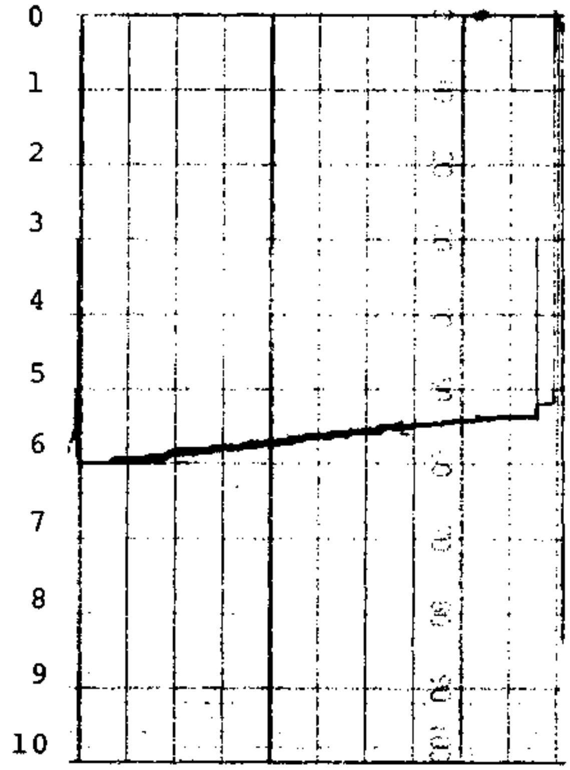

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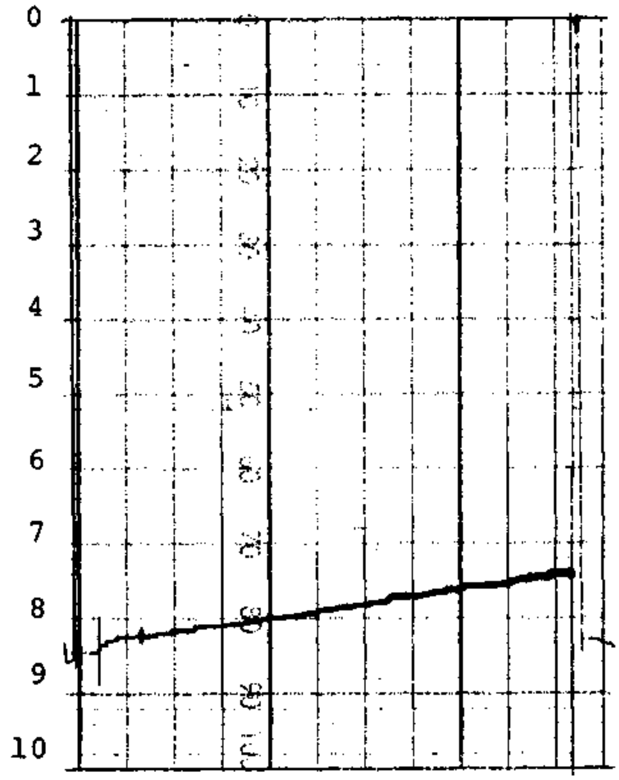

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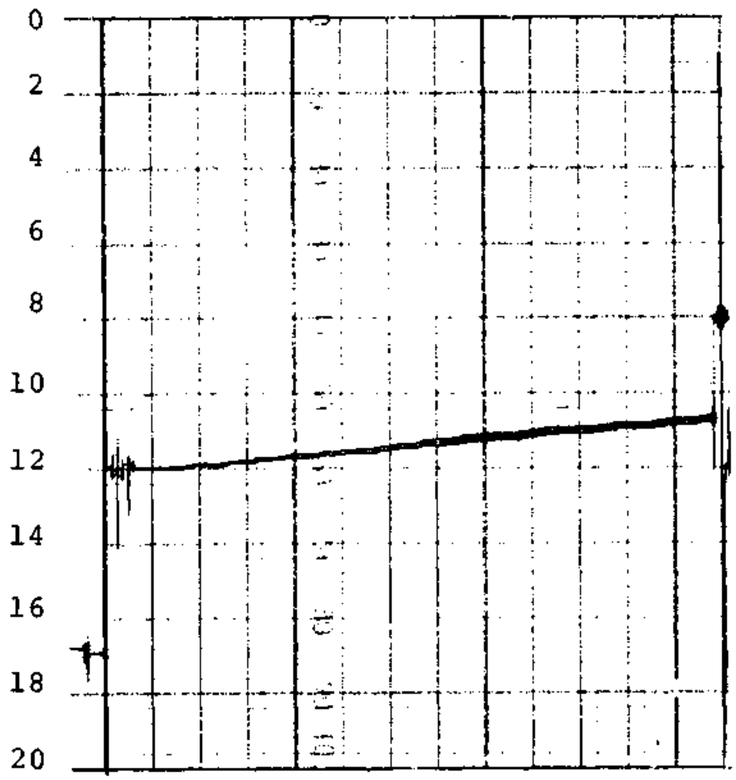

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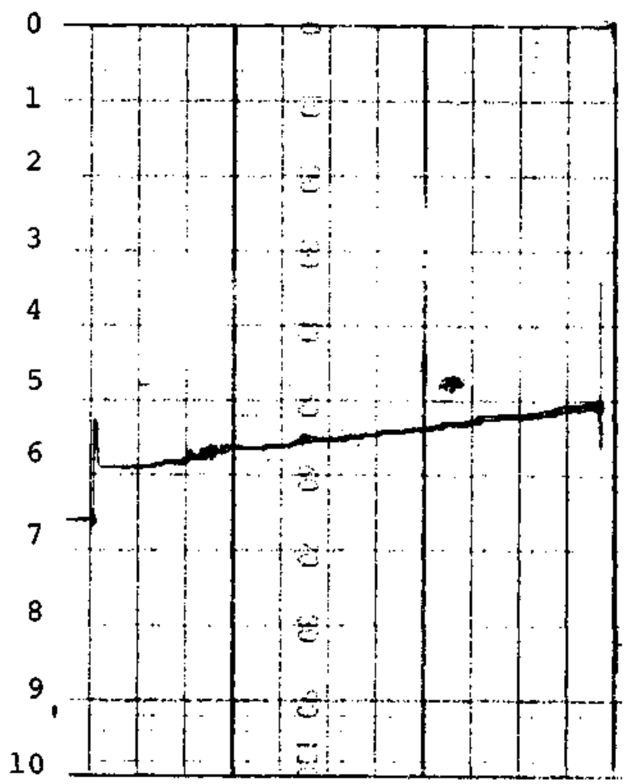

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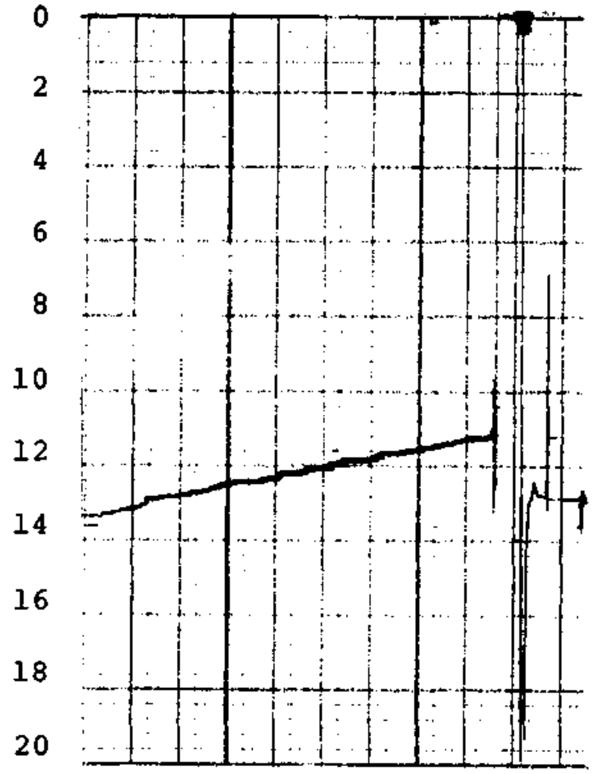

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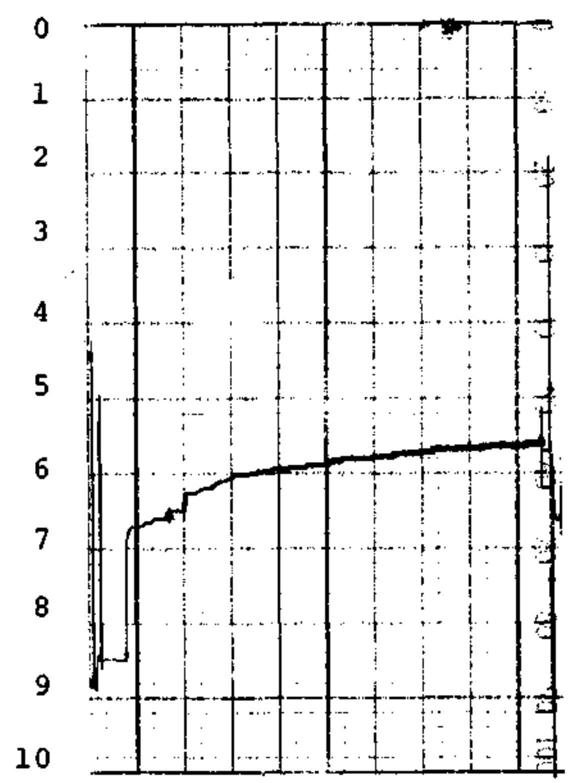

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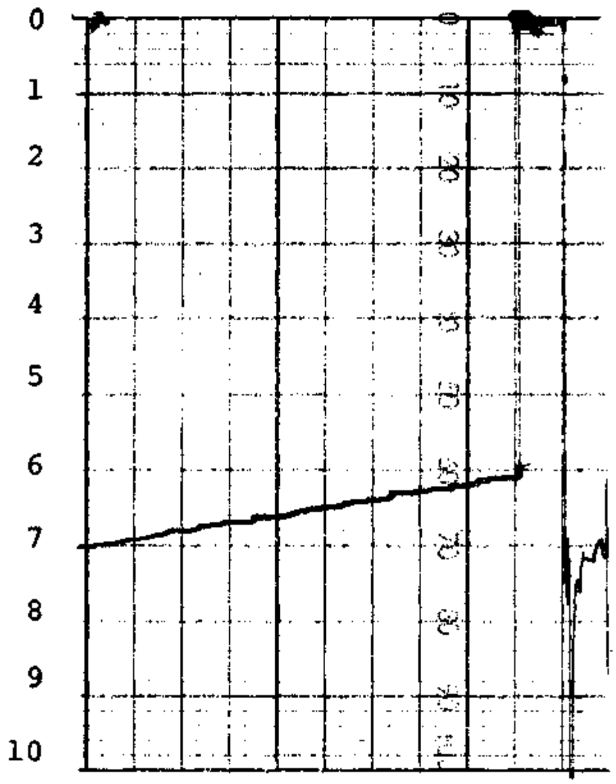

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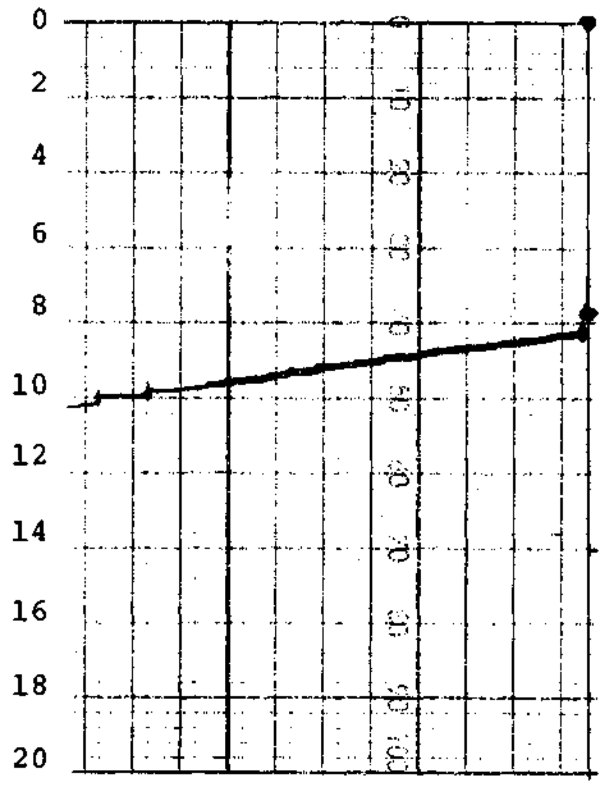

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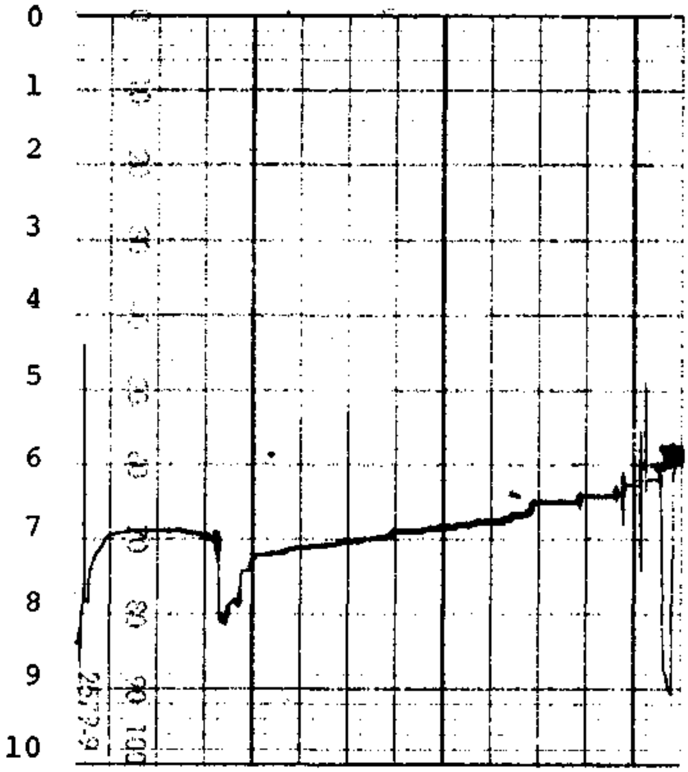

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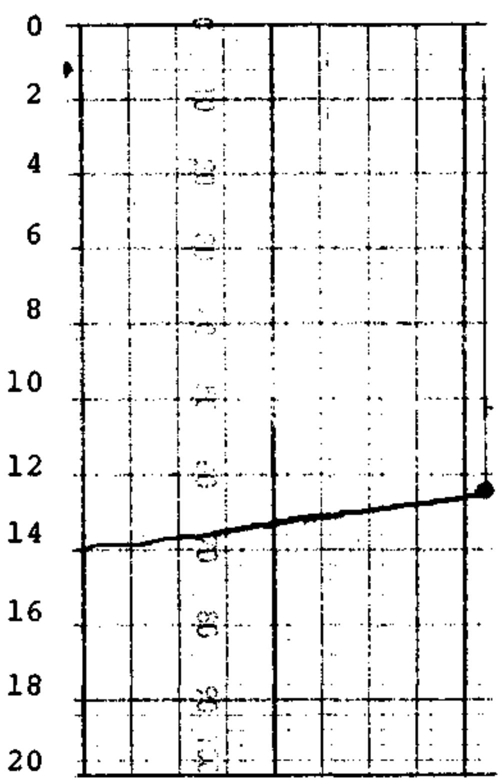

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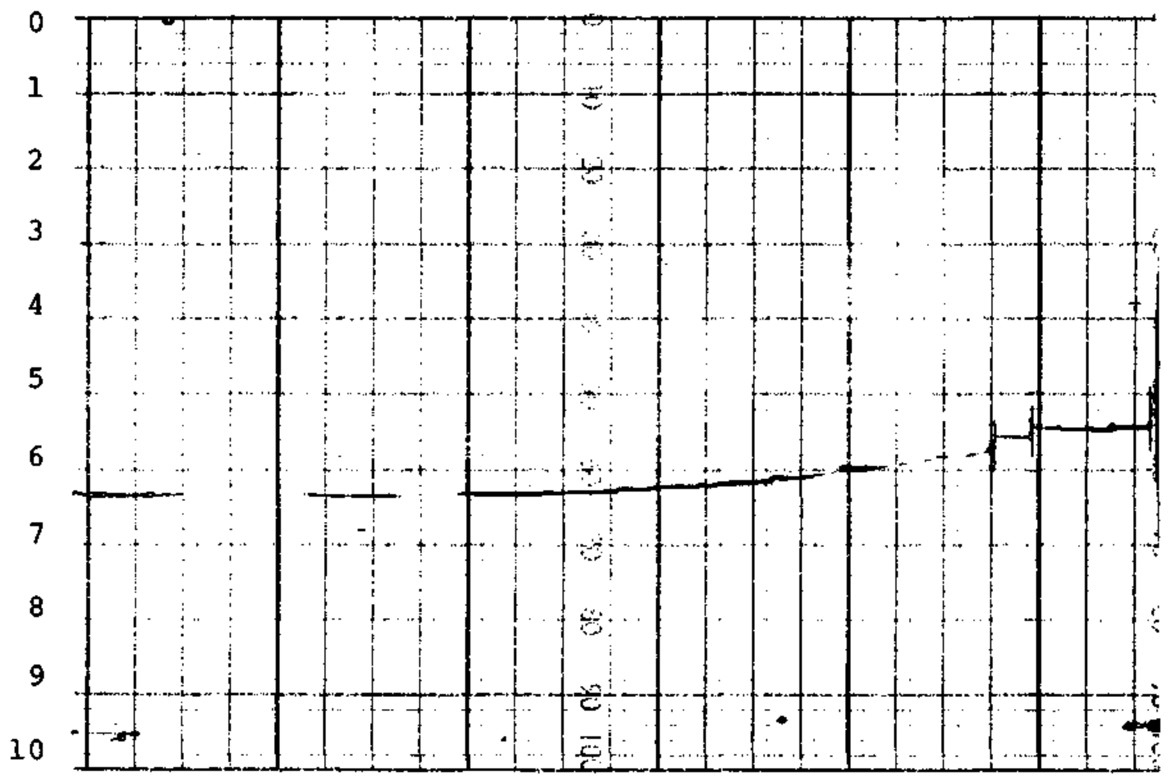

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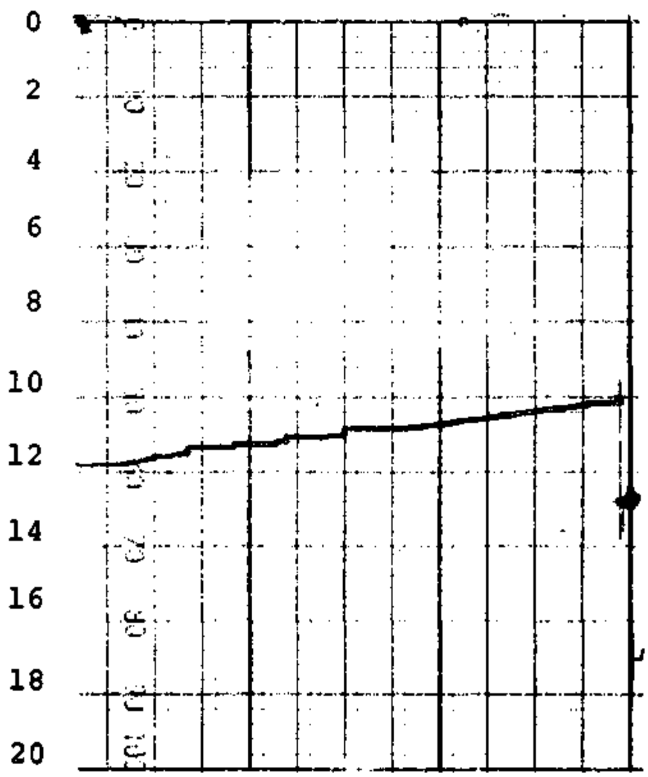

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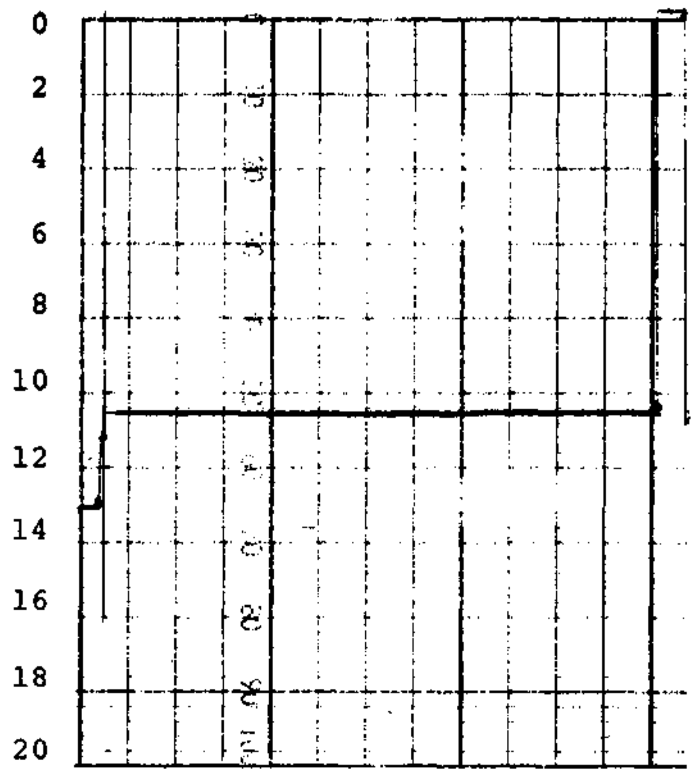

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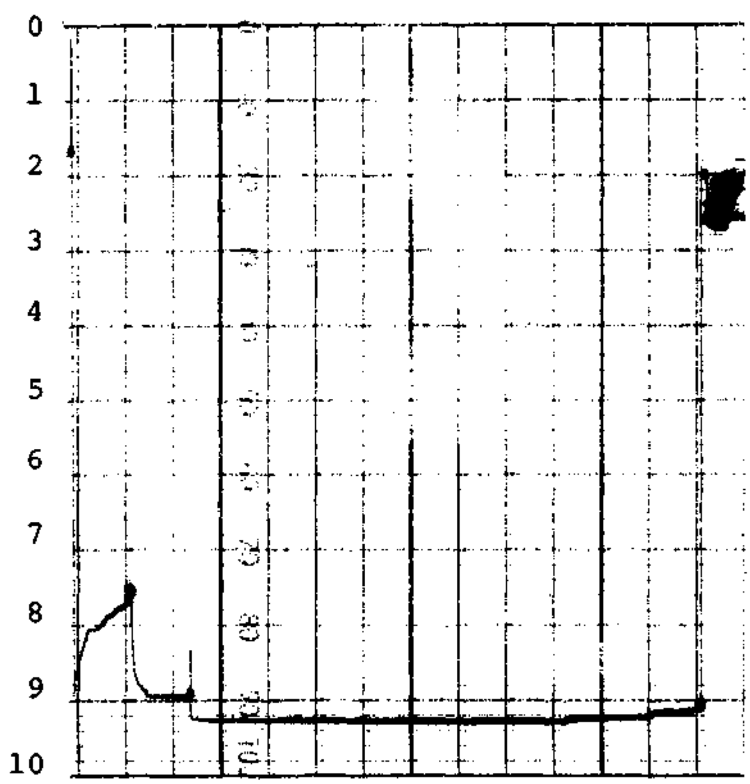

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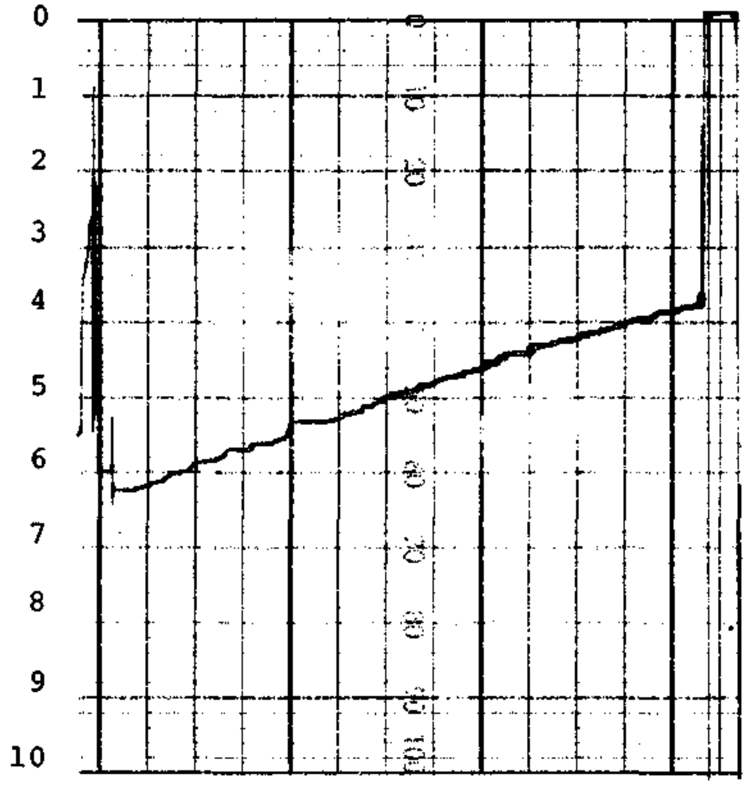

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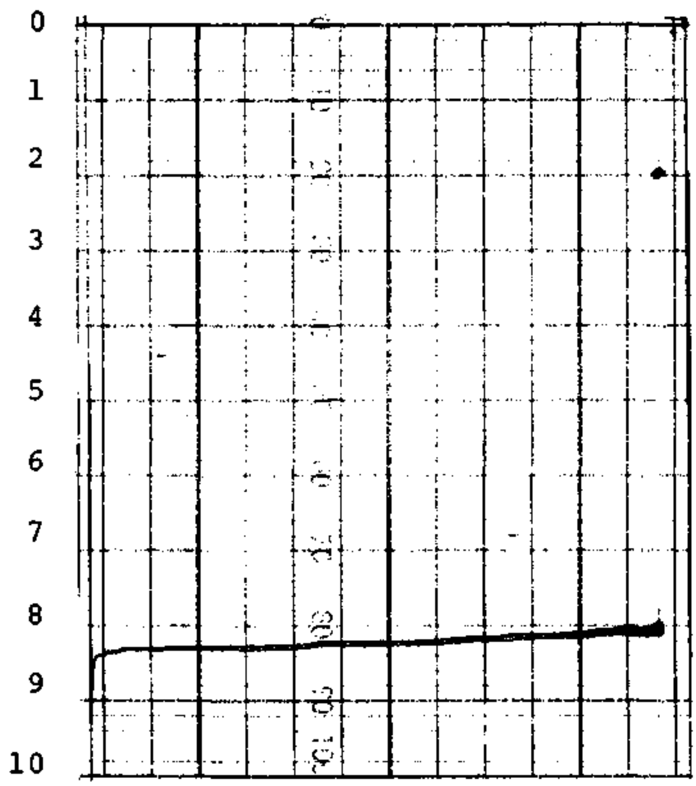

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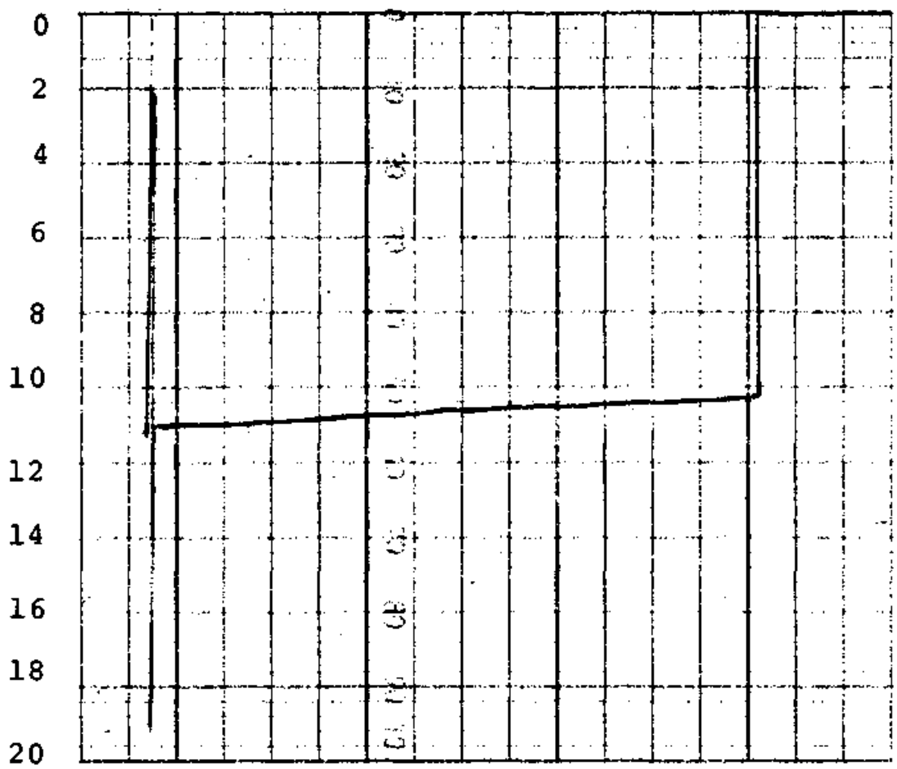

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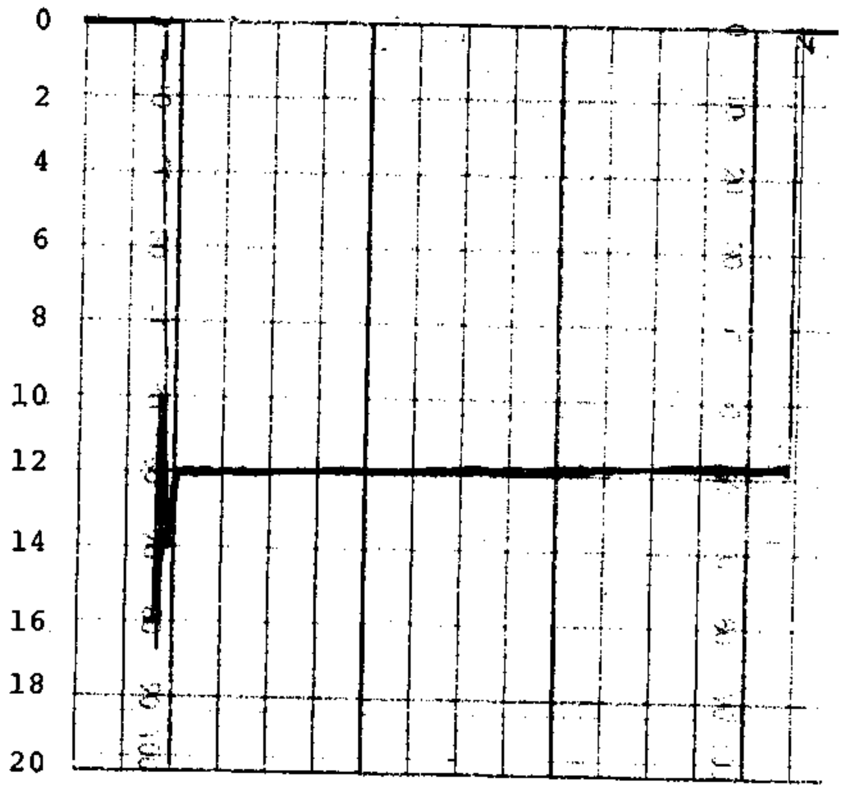

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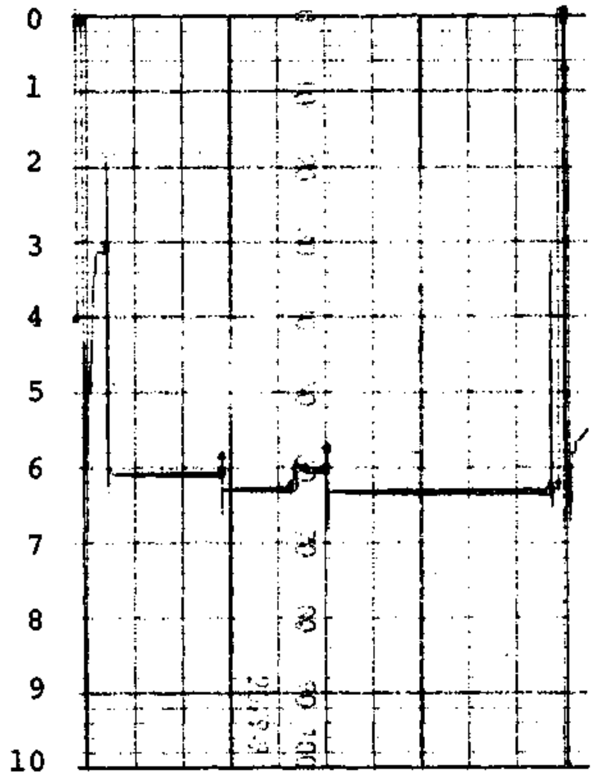

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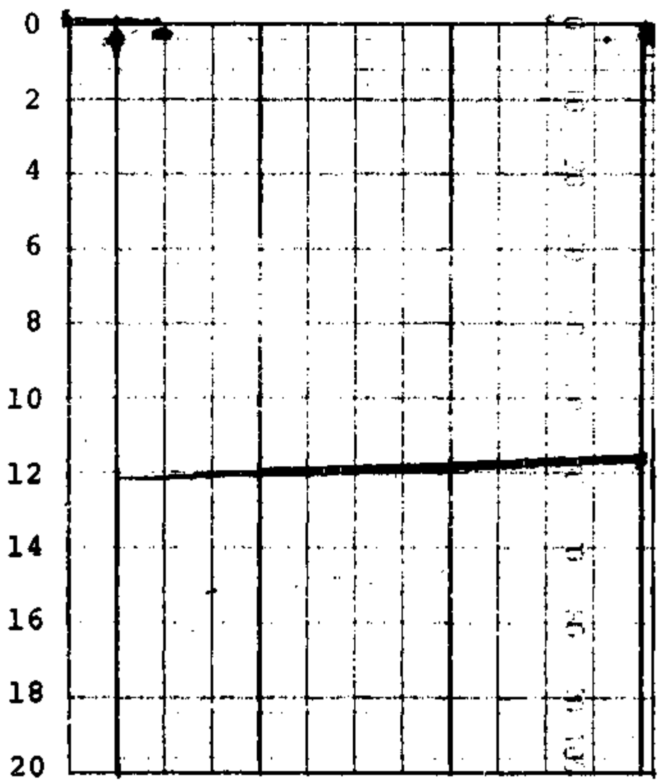

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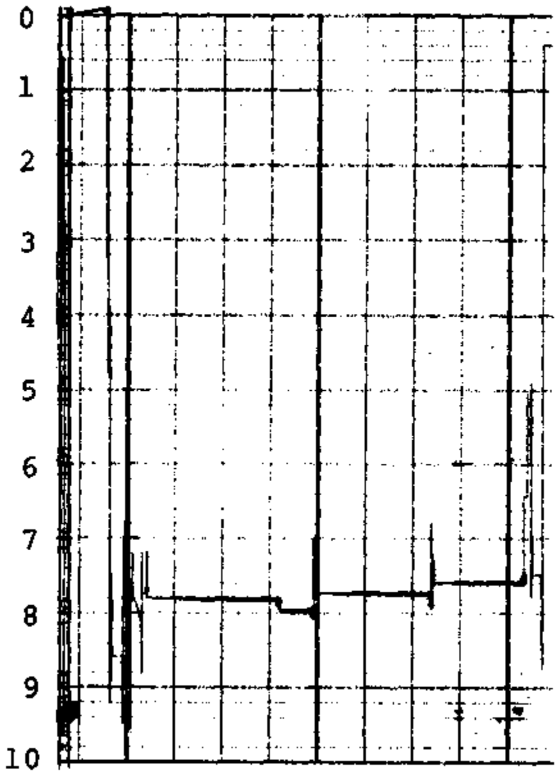

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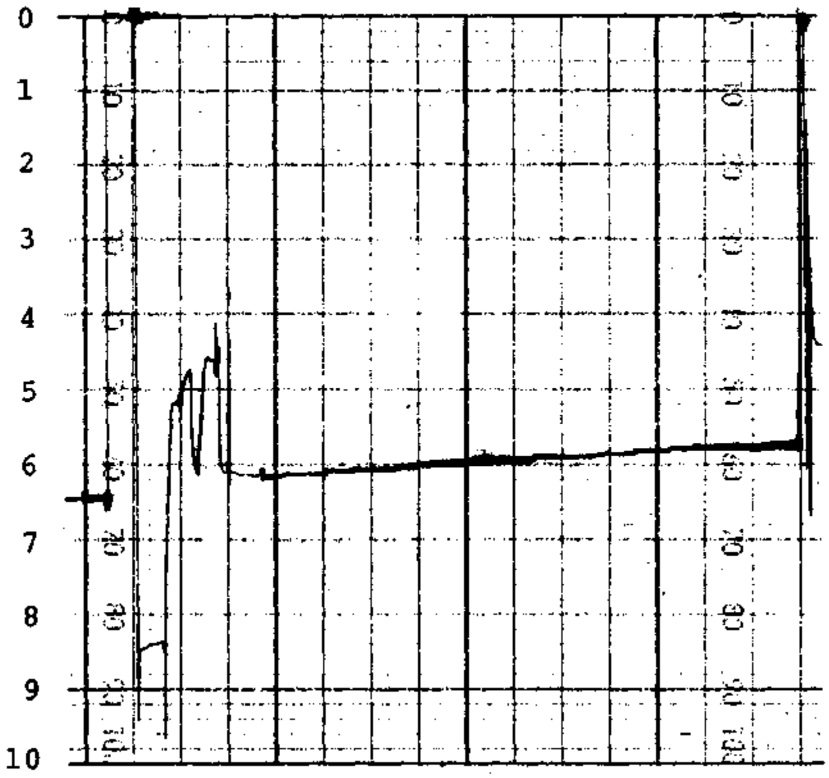

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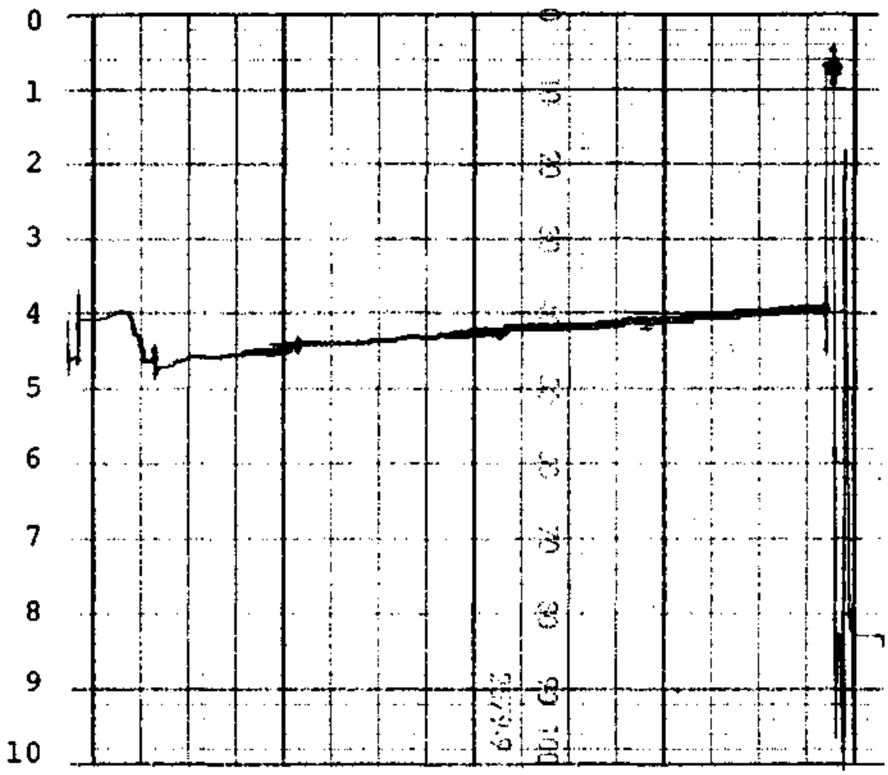

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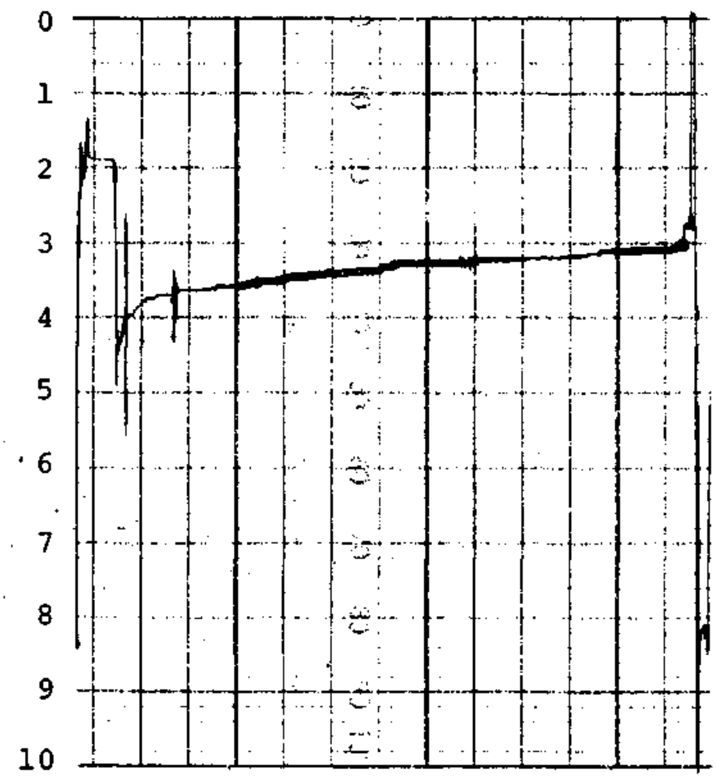

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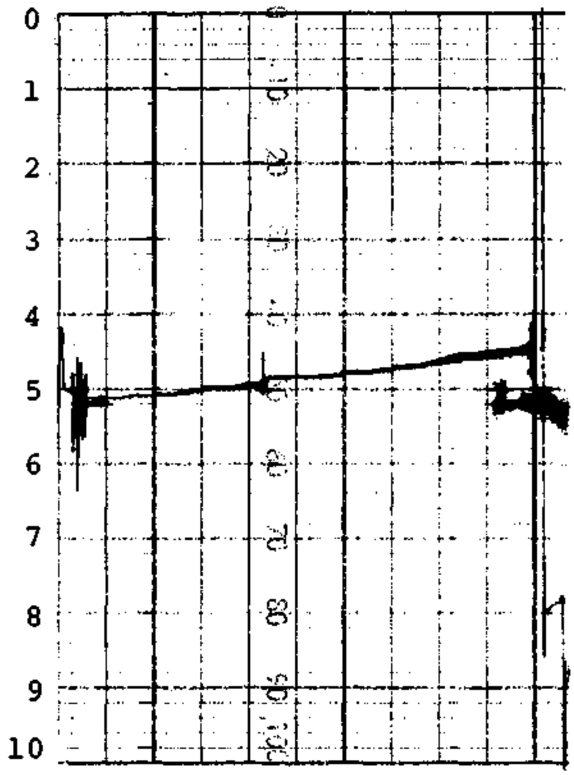

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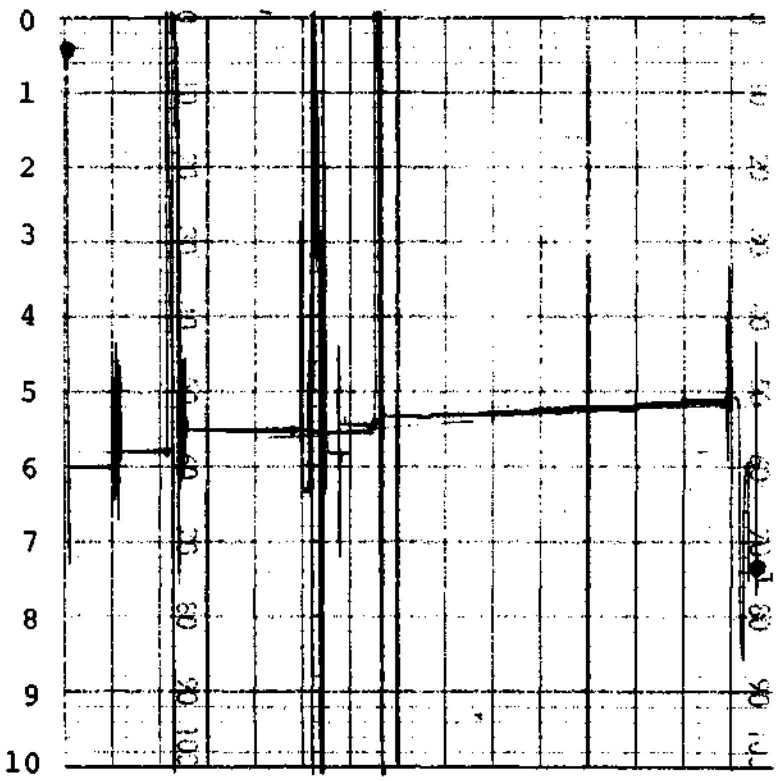

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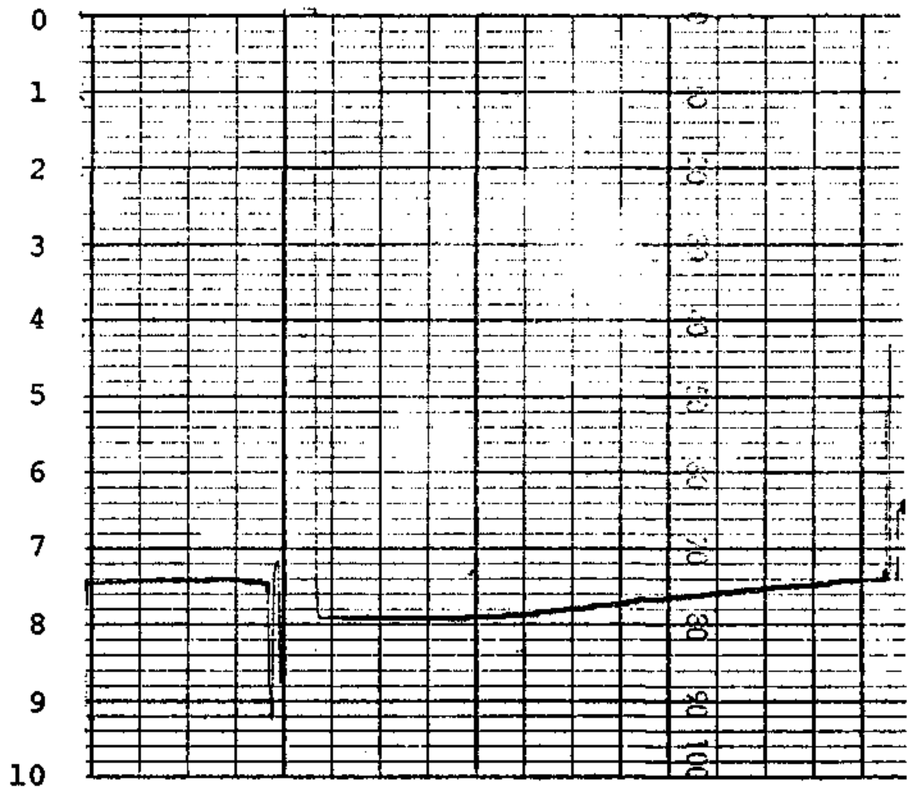

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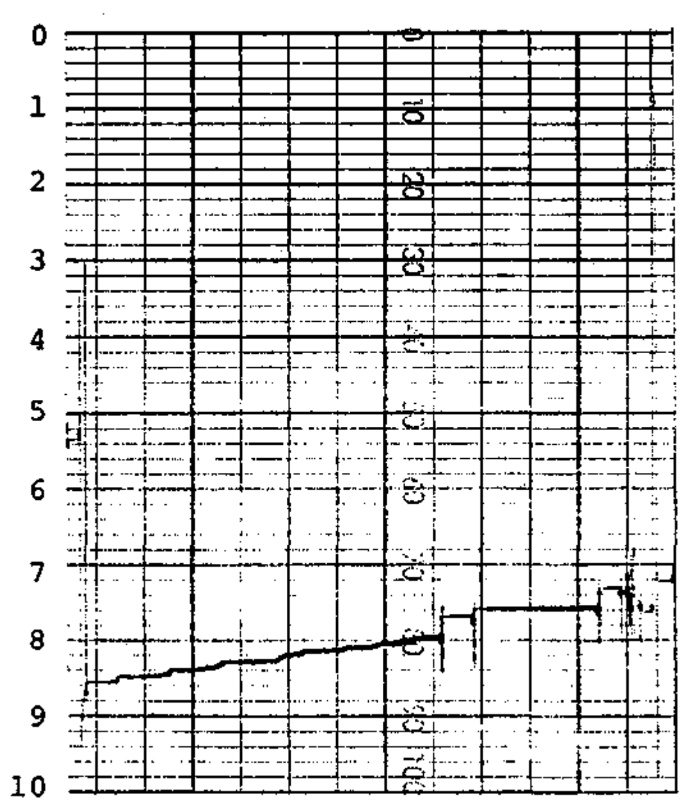

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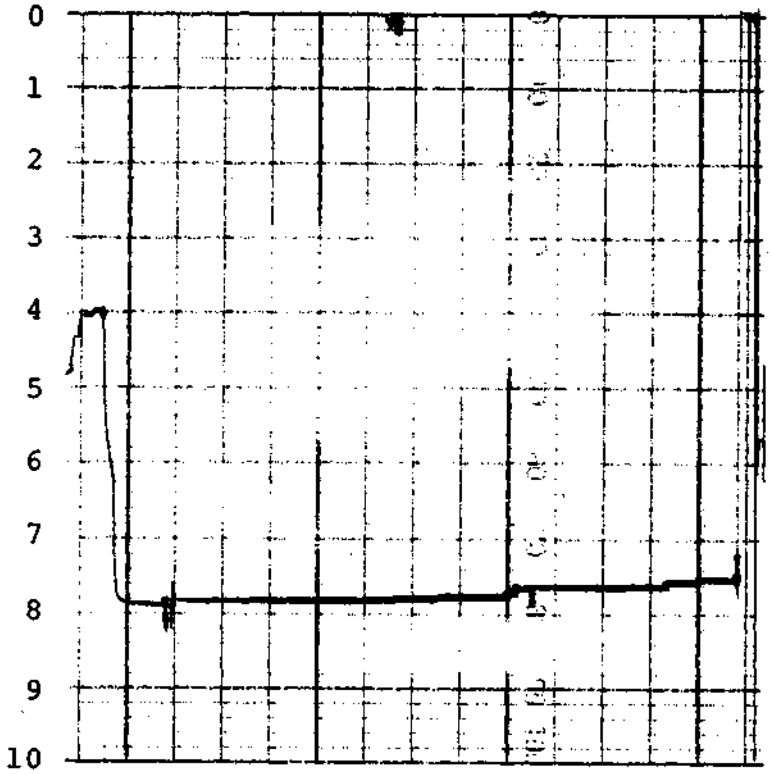

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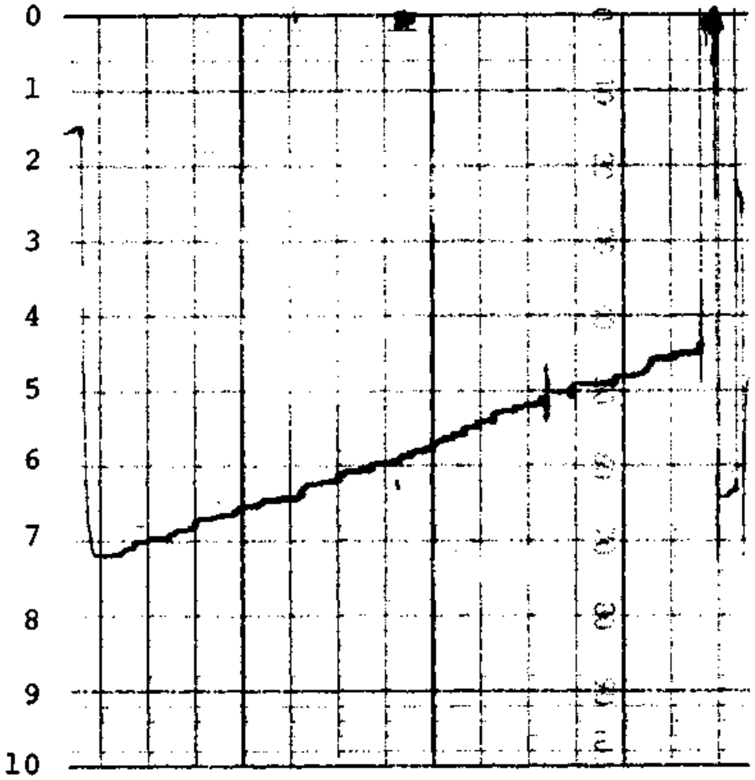
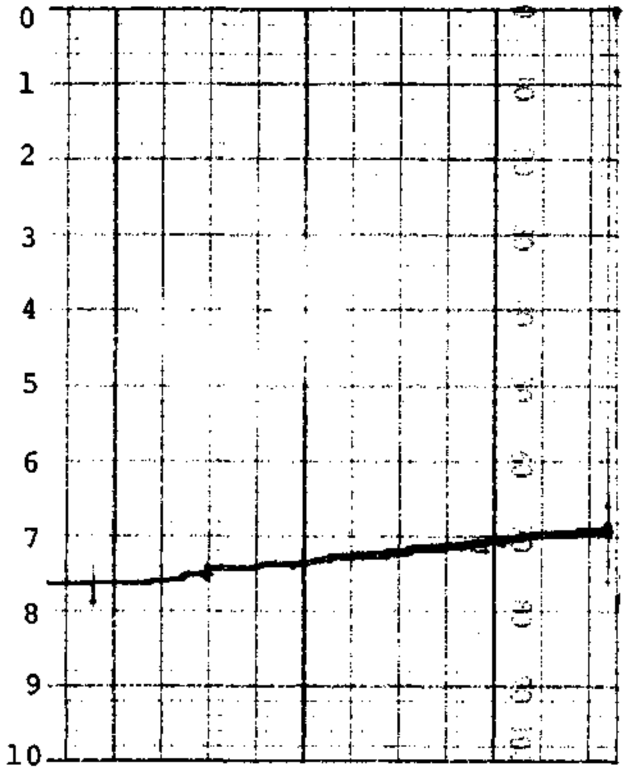


Sta. 42



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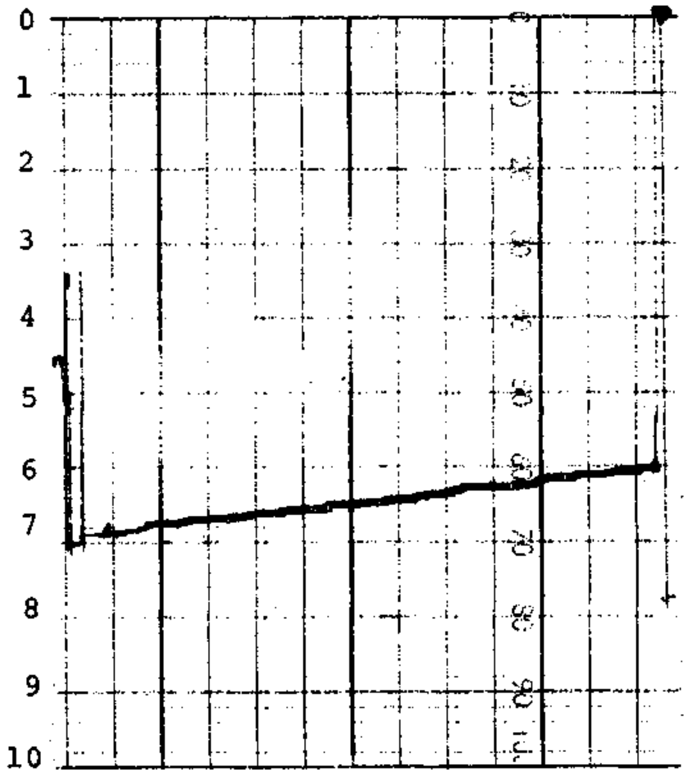

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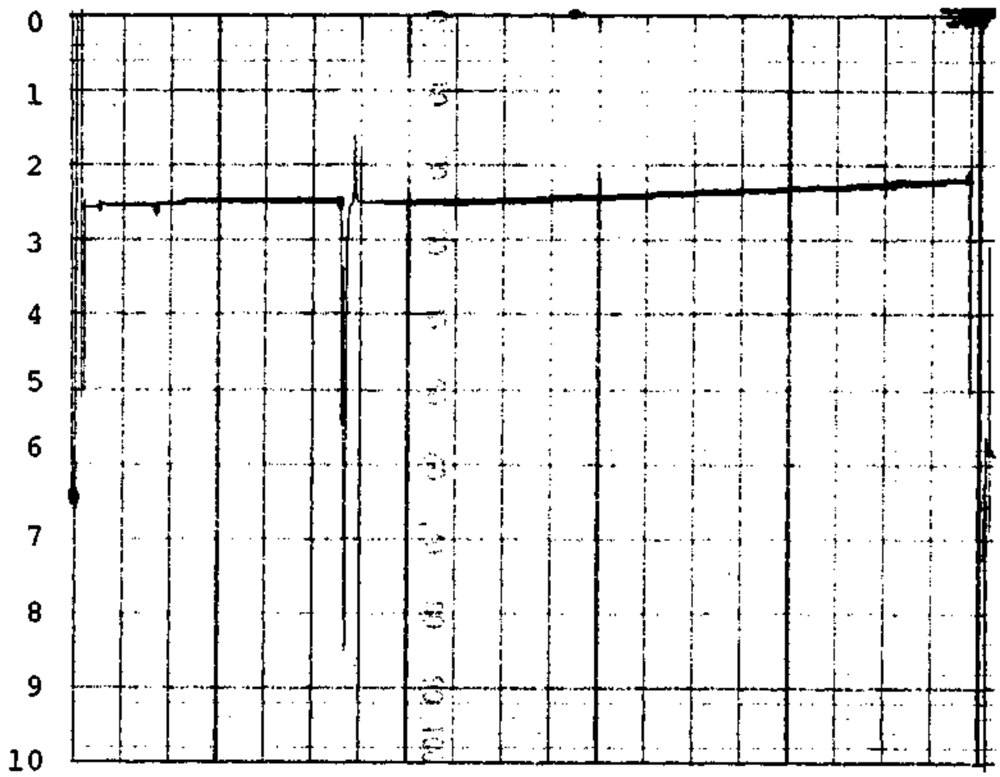

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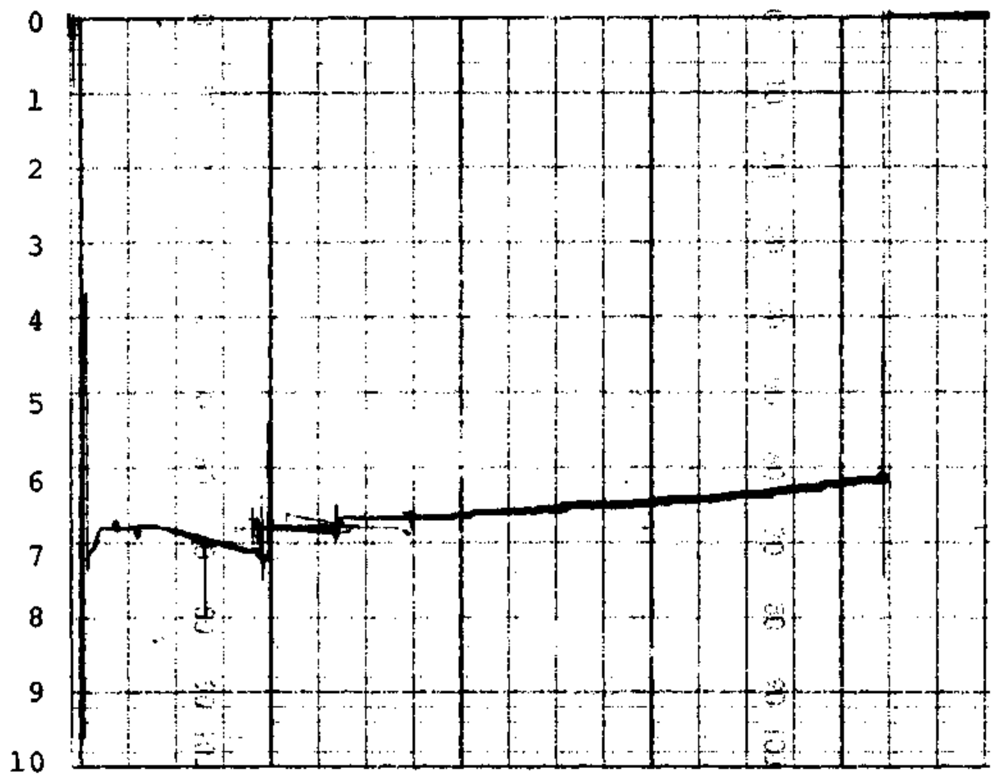

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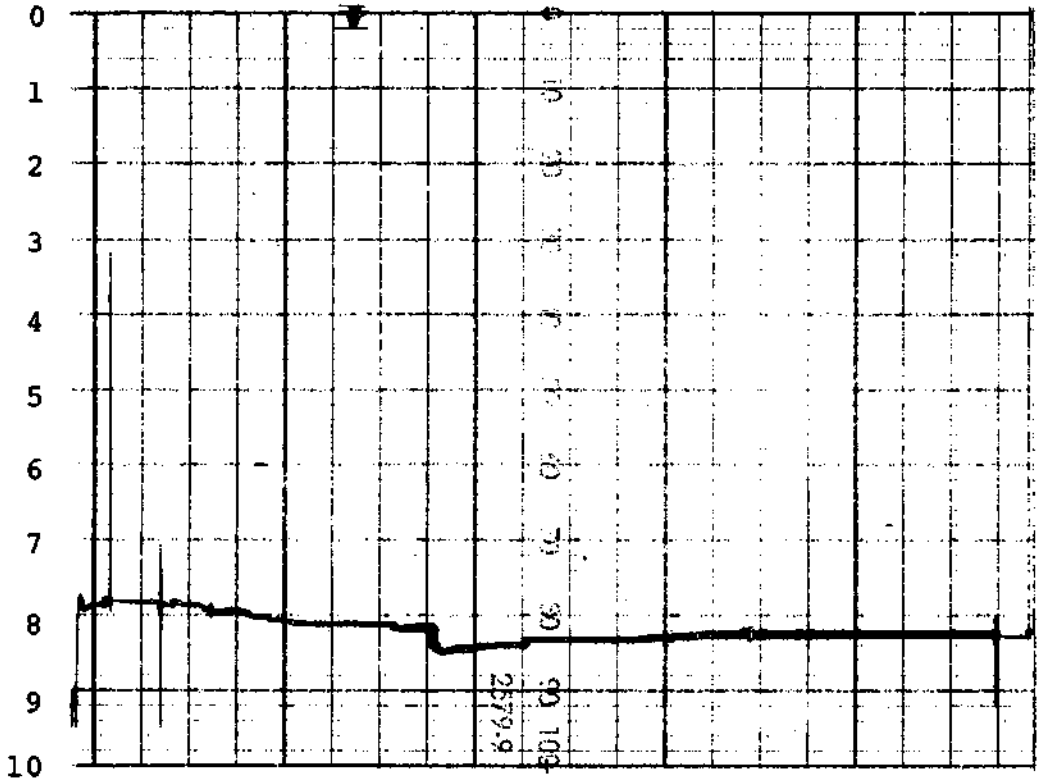

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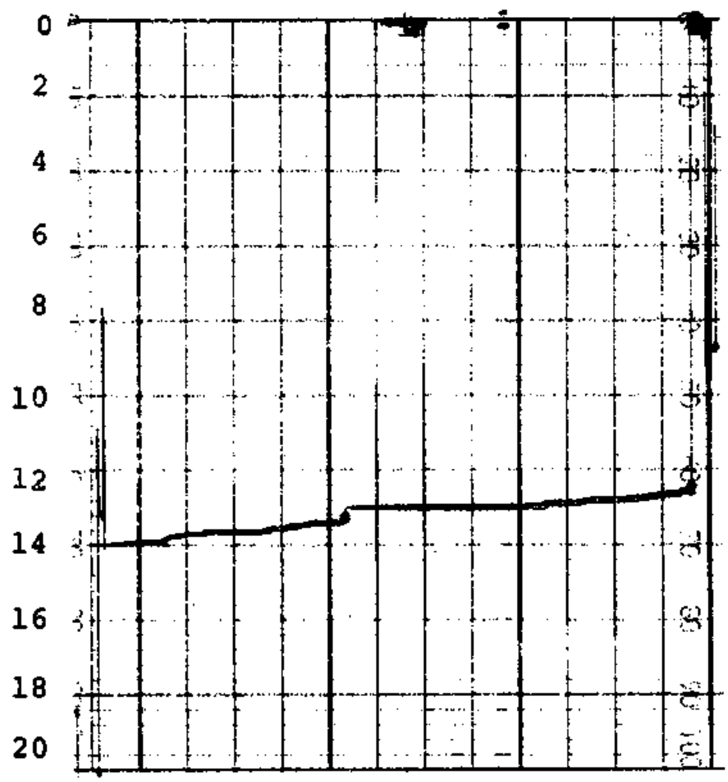

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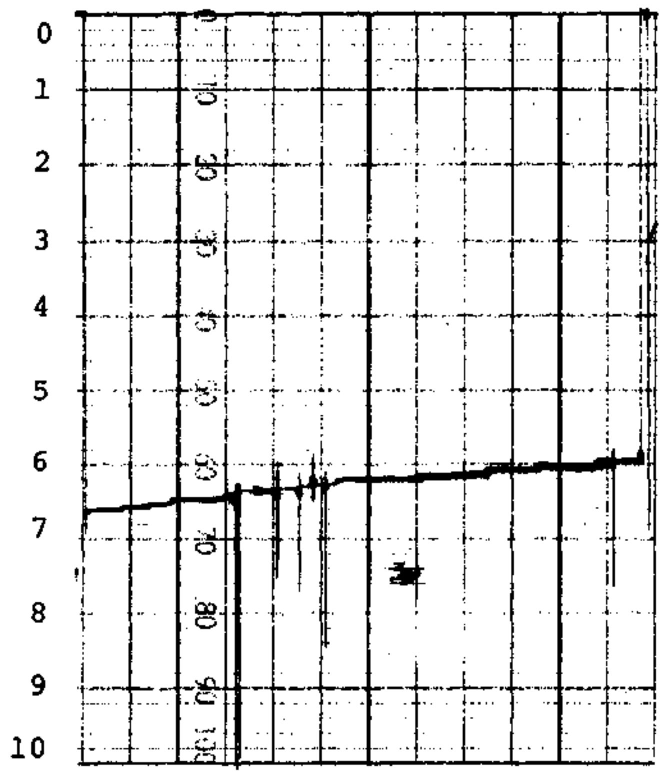

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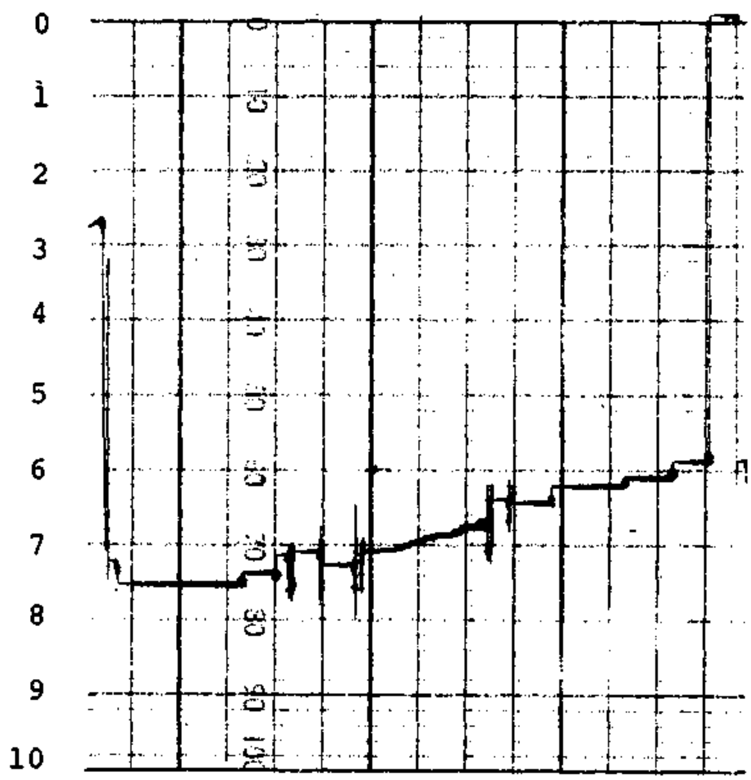

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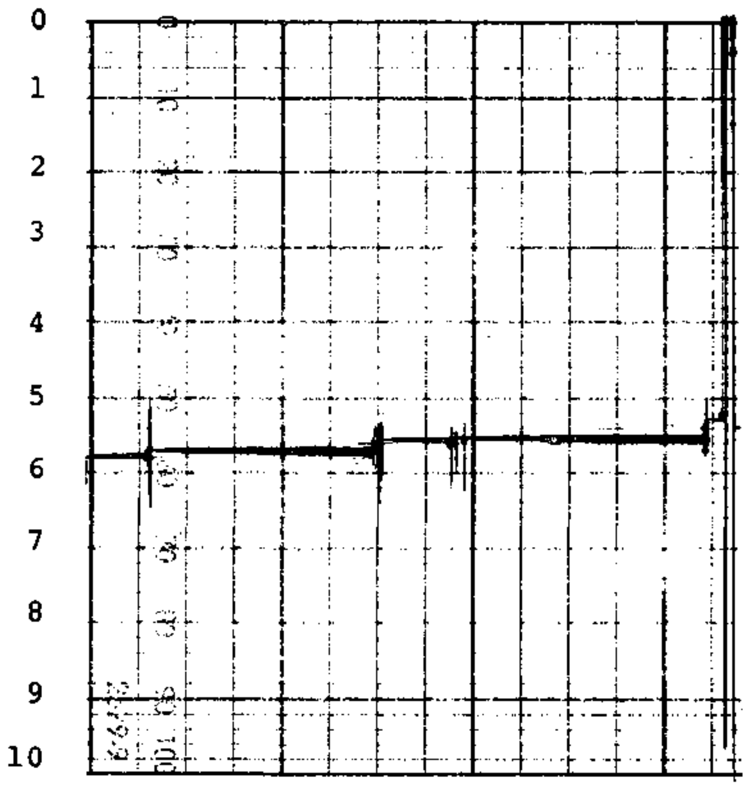

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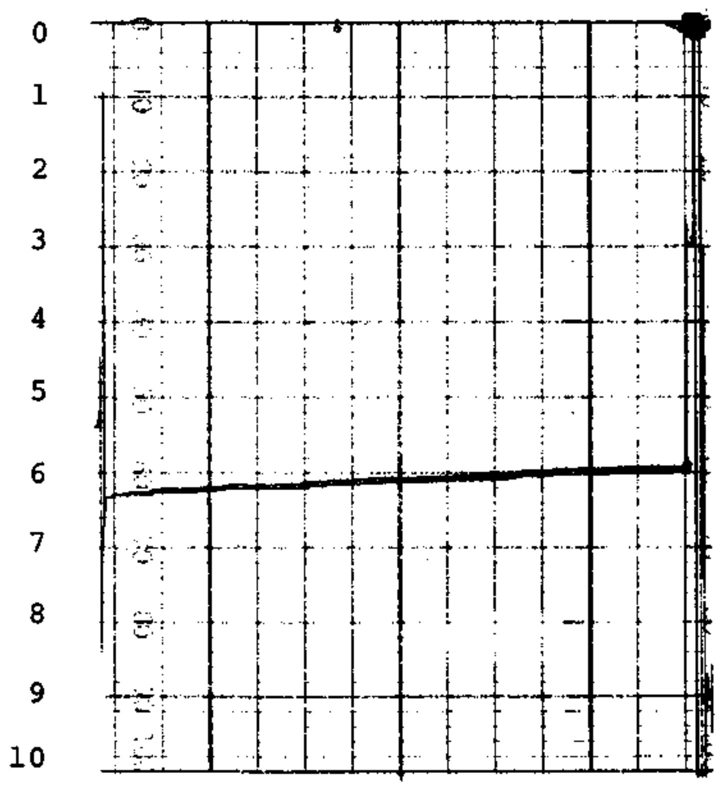

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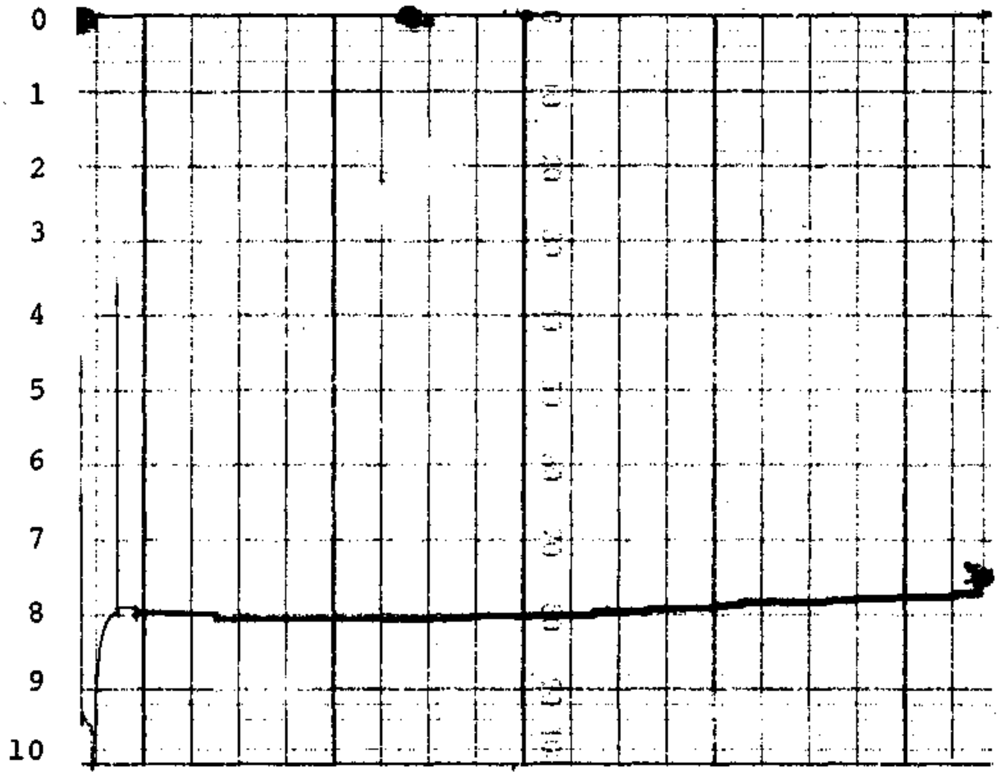

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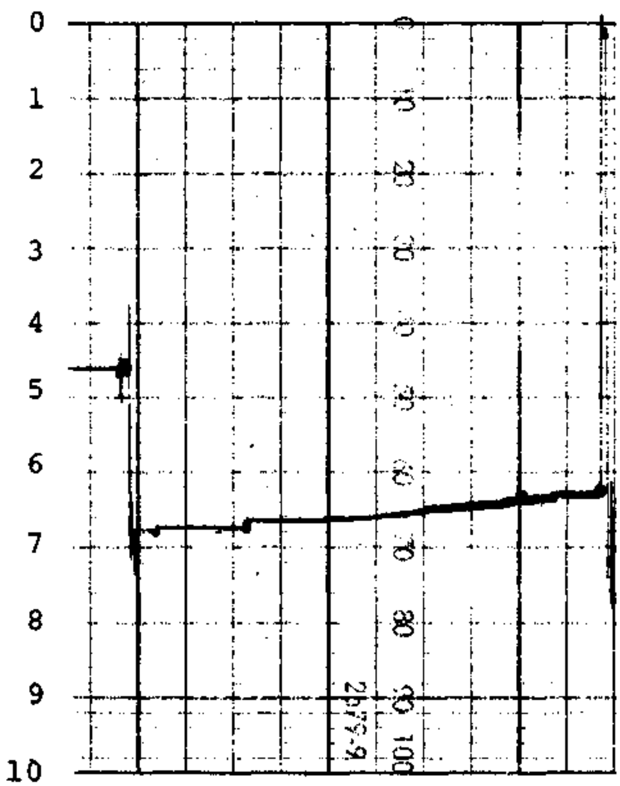

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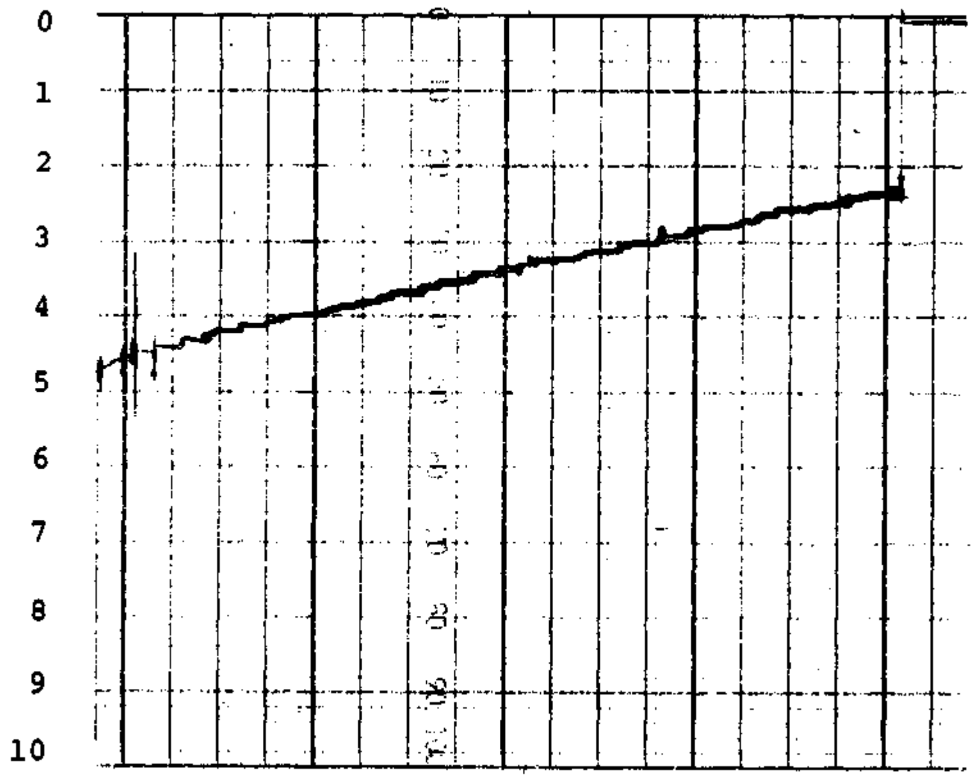

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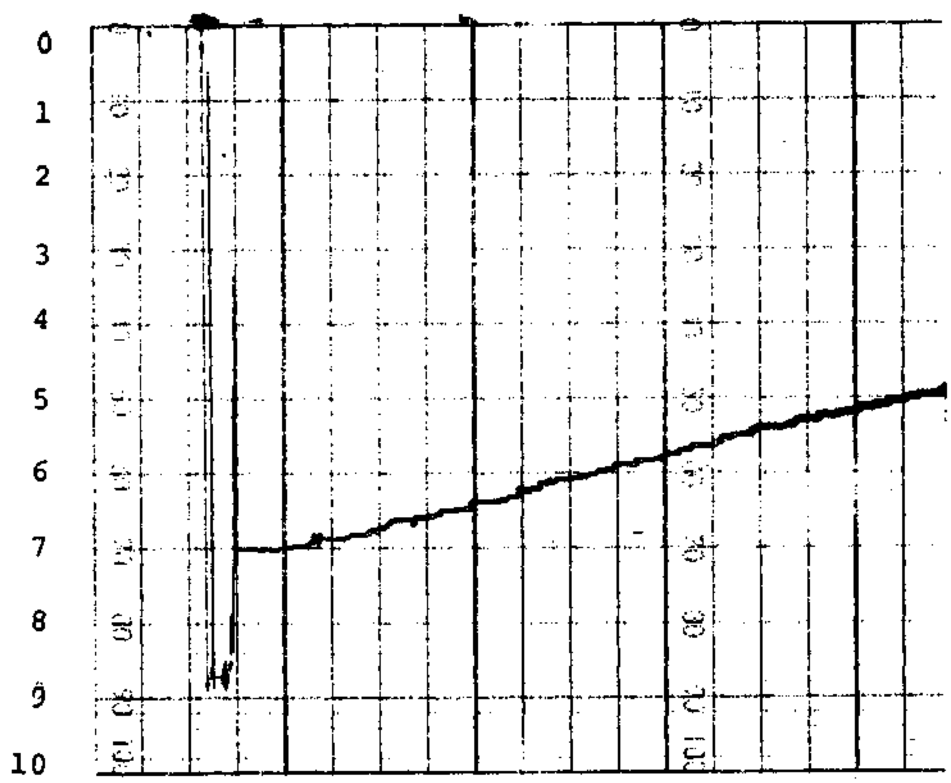

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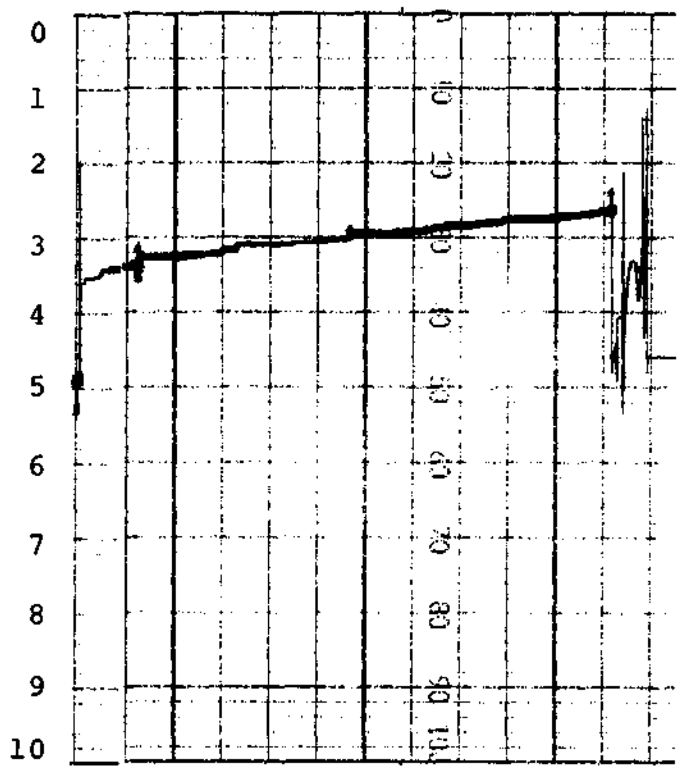

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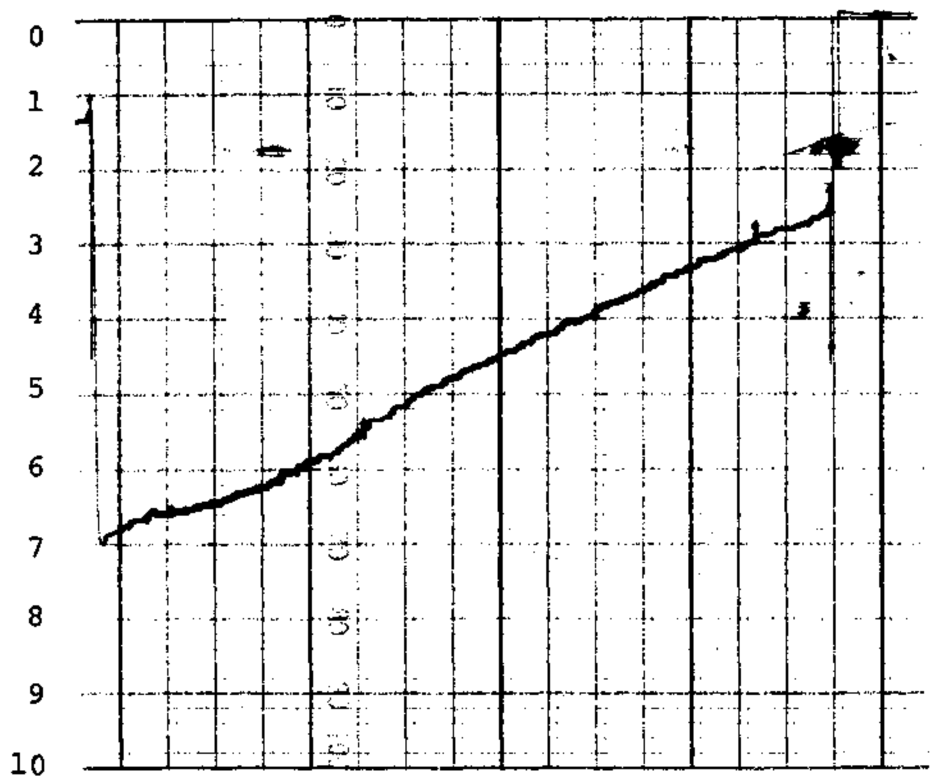

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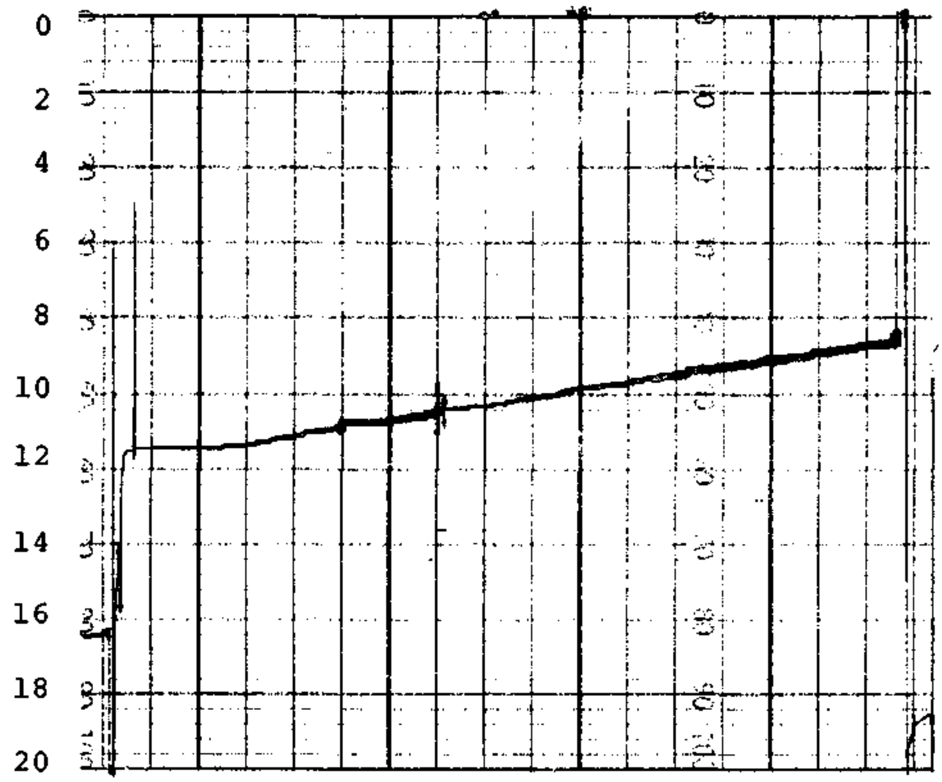
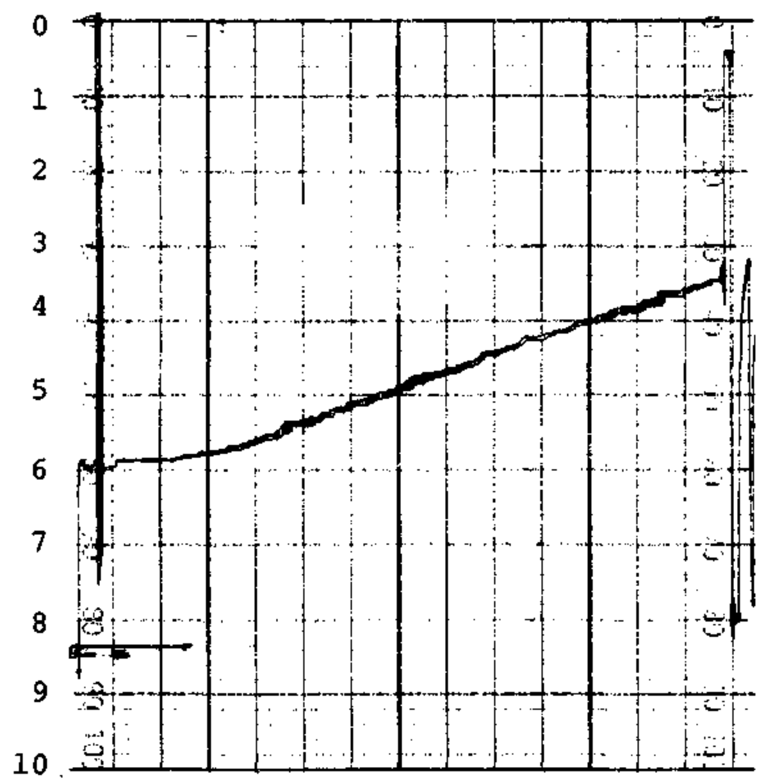


Sta. 59



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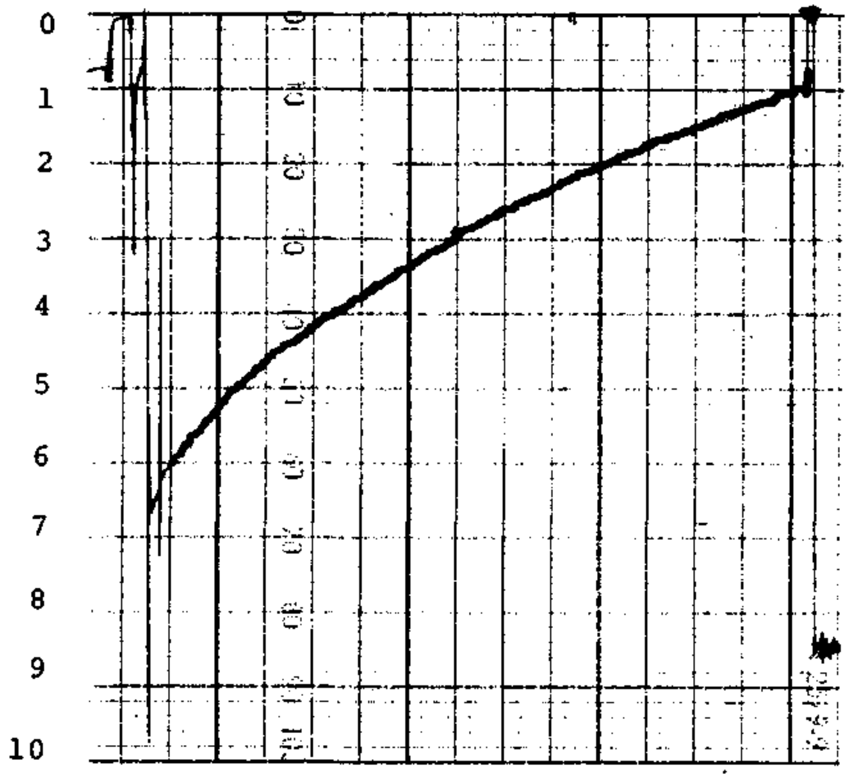

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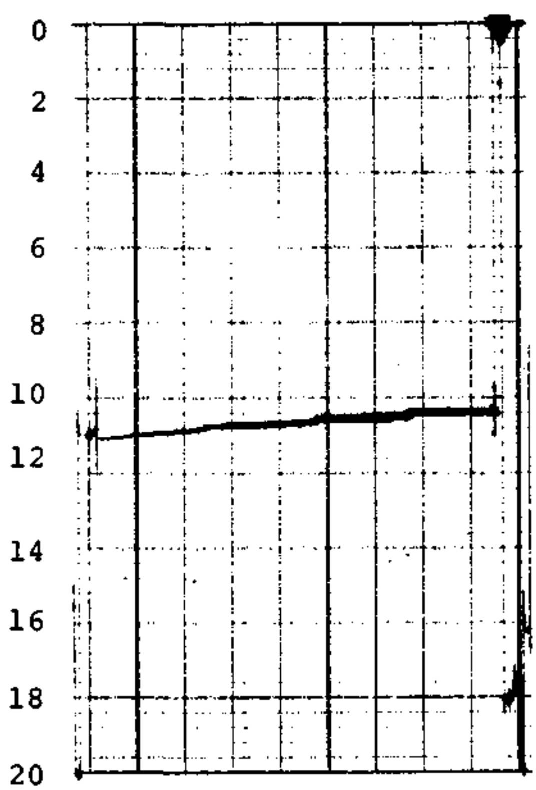
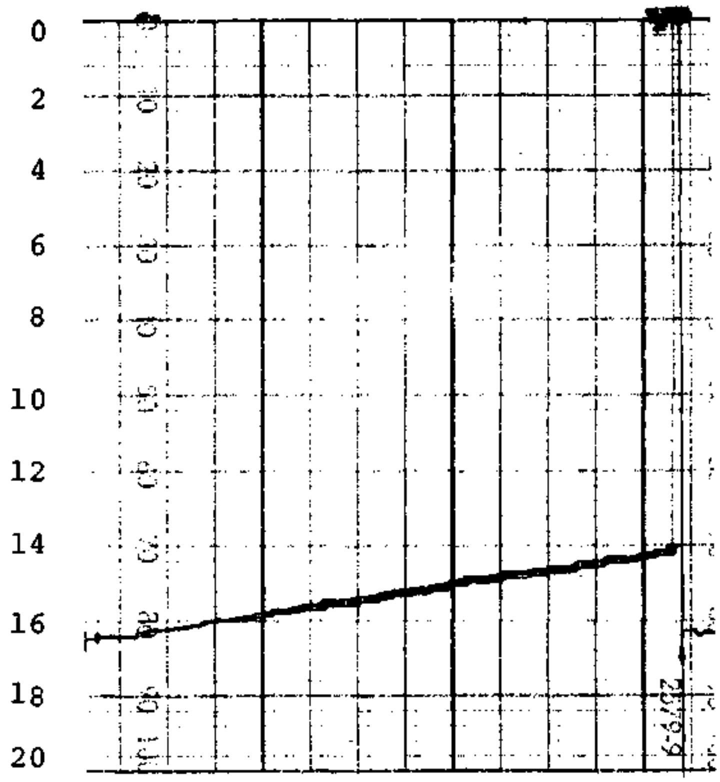
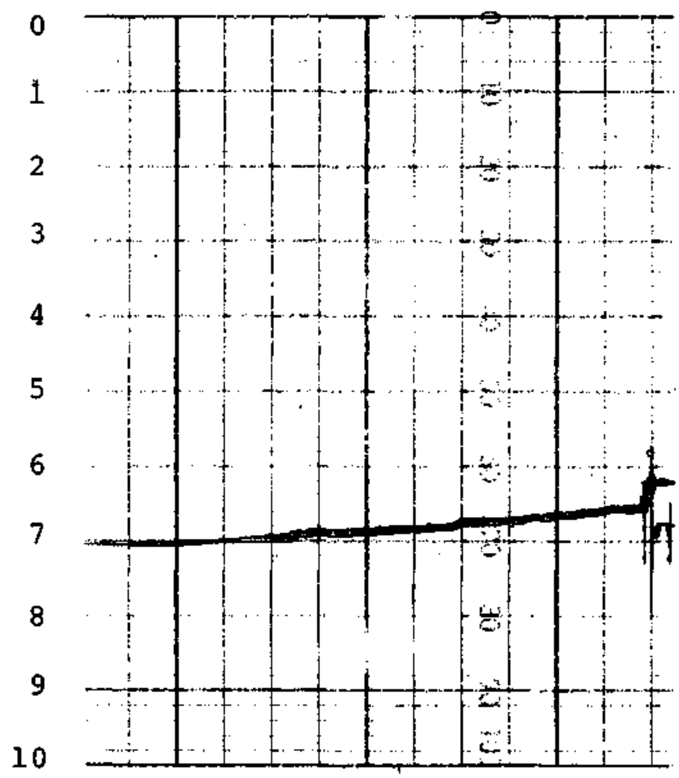


Sta. 62



Sta. 63



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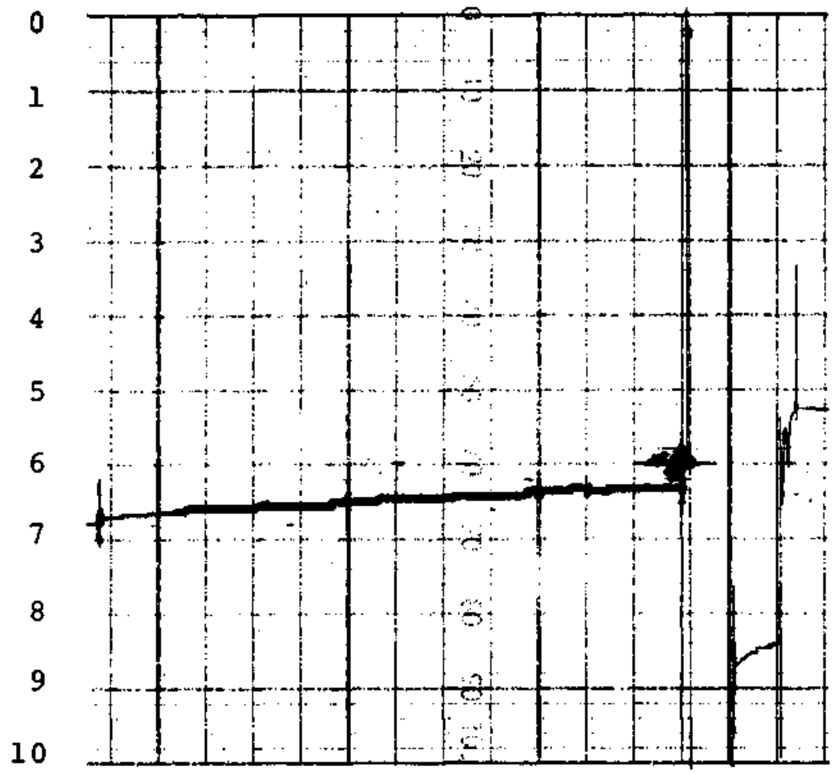

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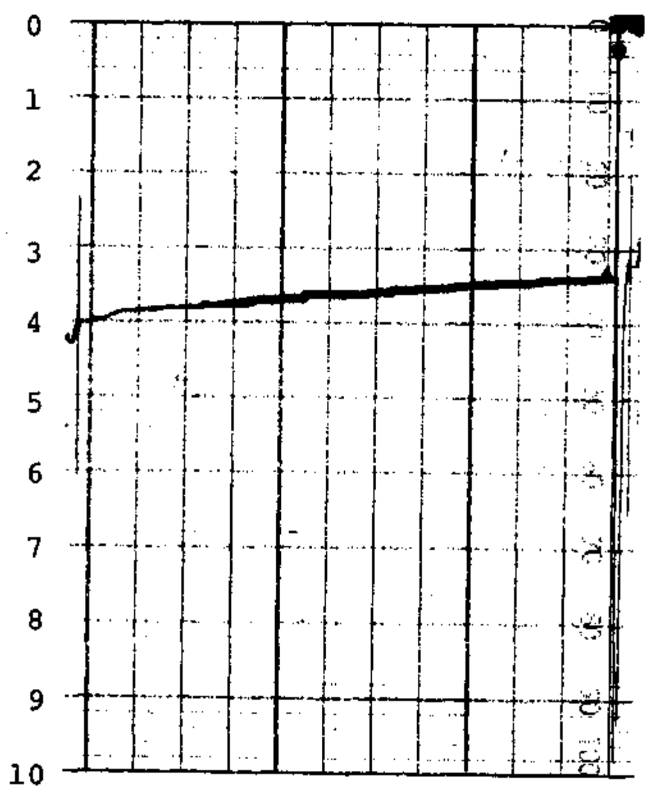

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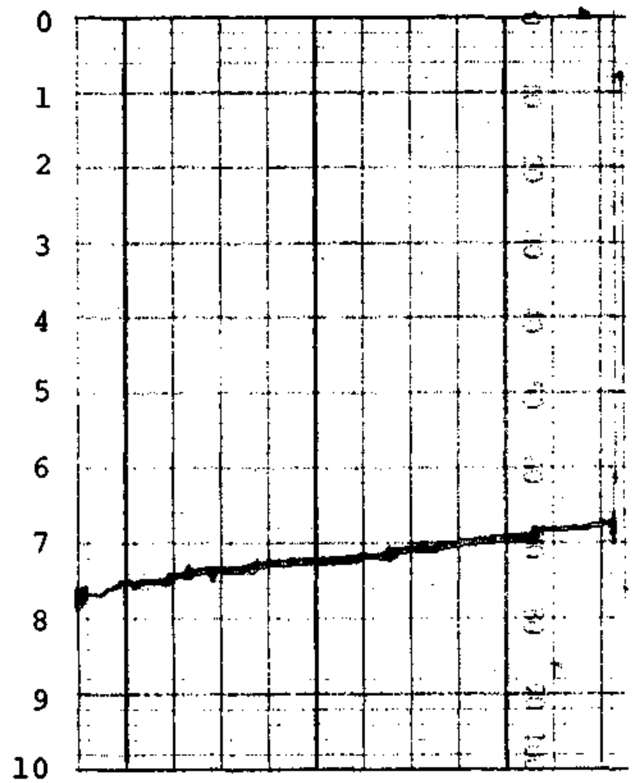
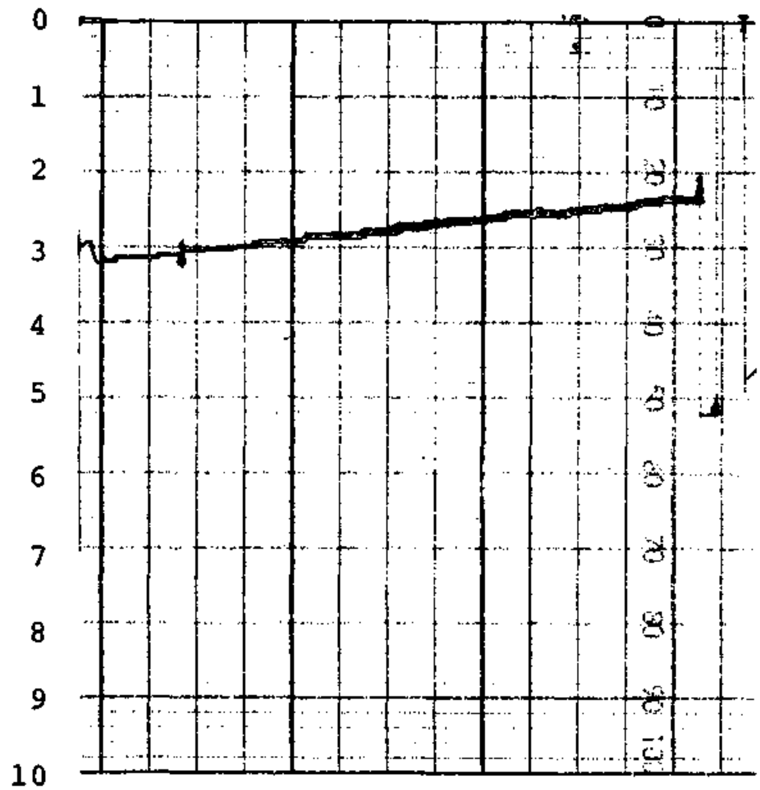


Sta. 67



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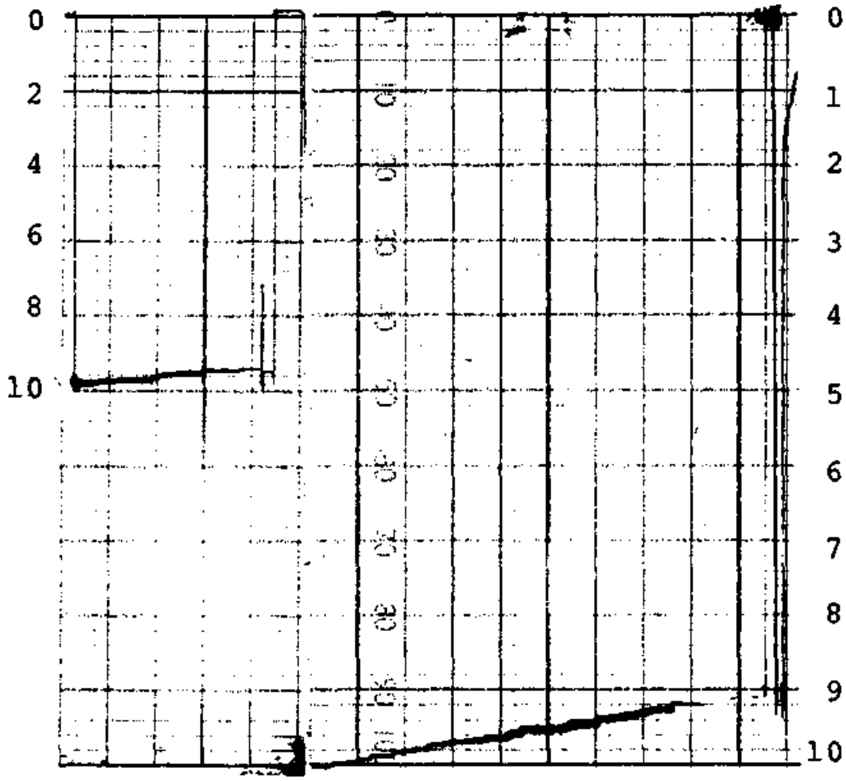
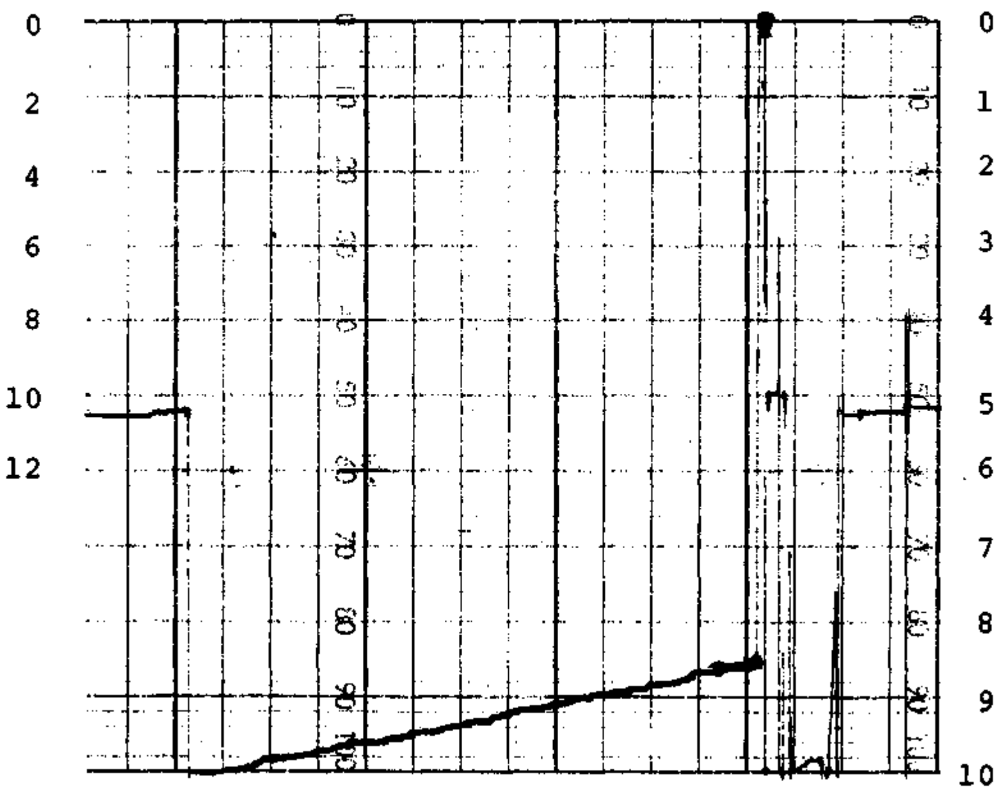


Sta. 69



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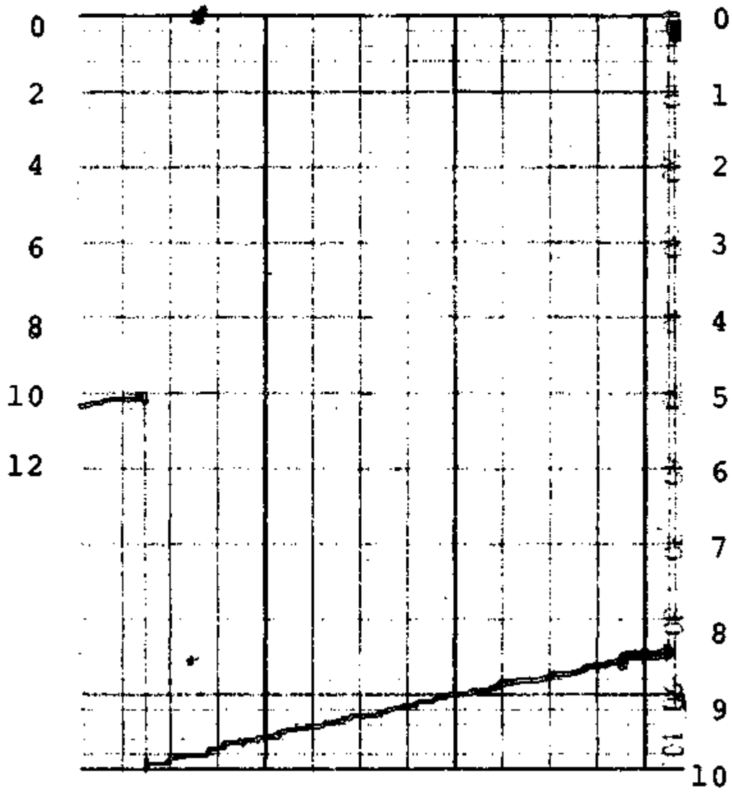
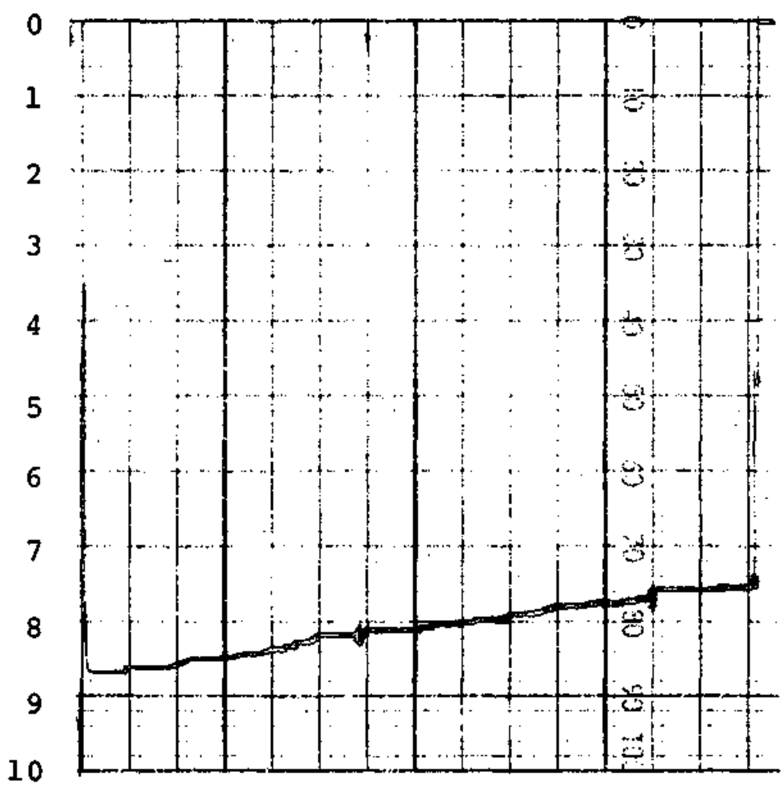


Sta. 71



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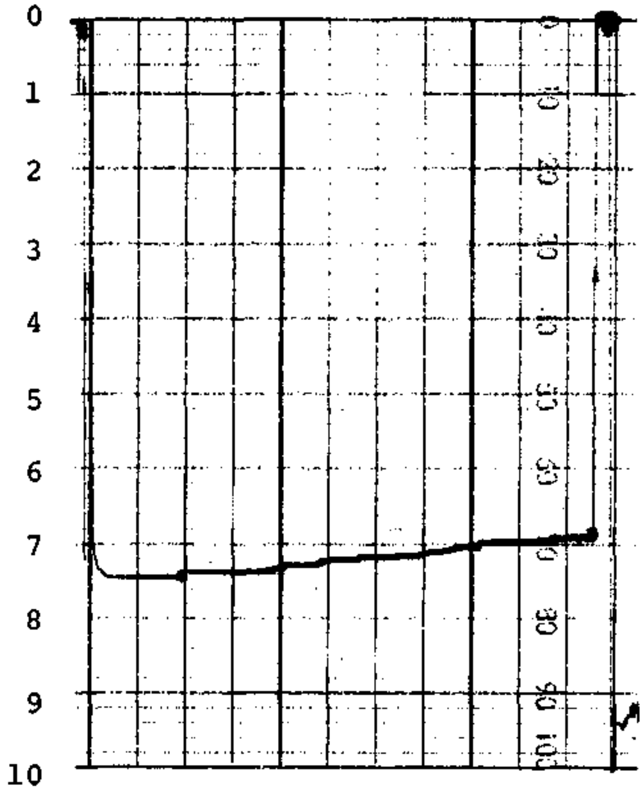

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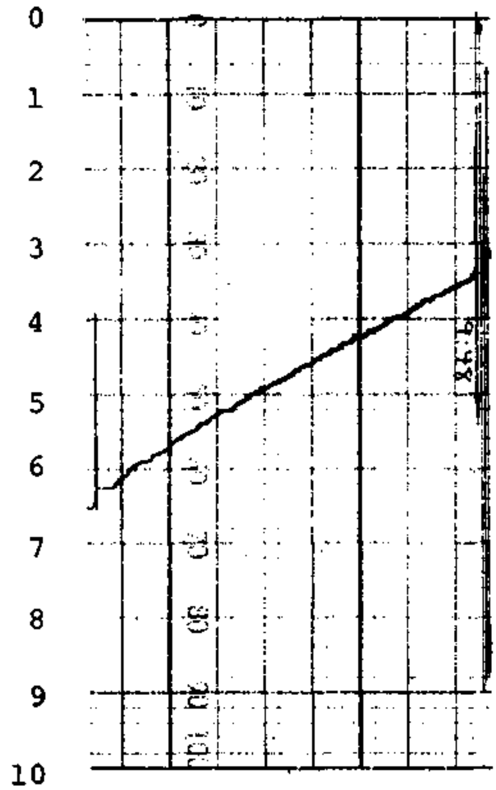

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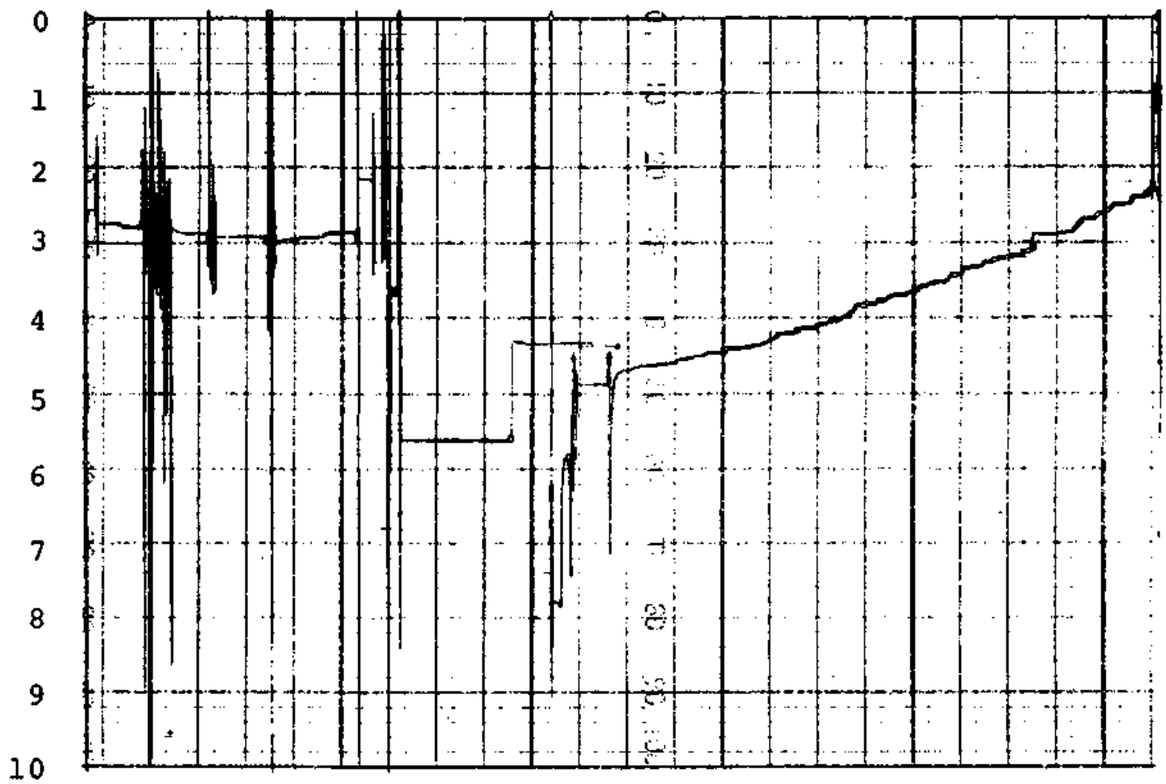

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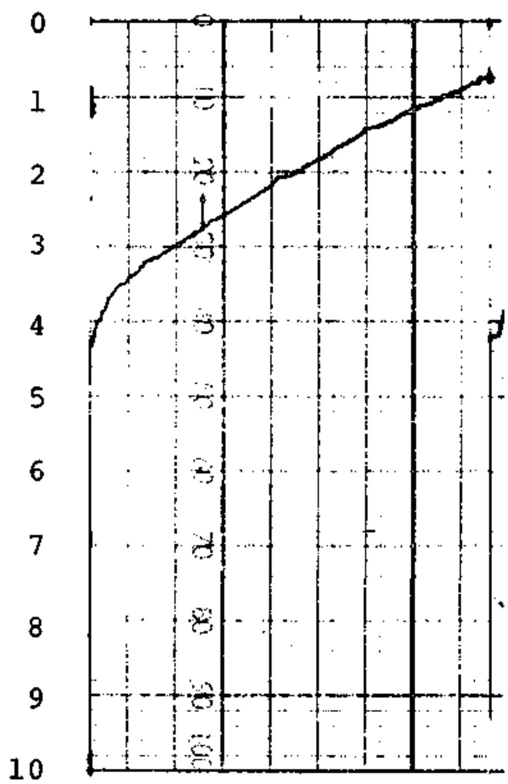

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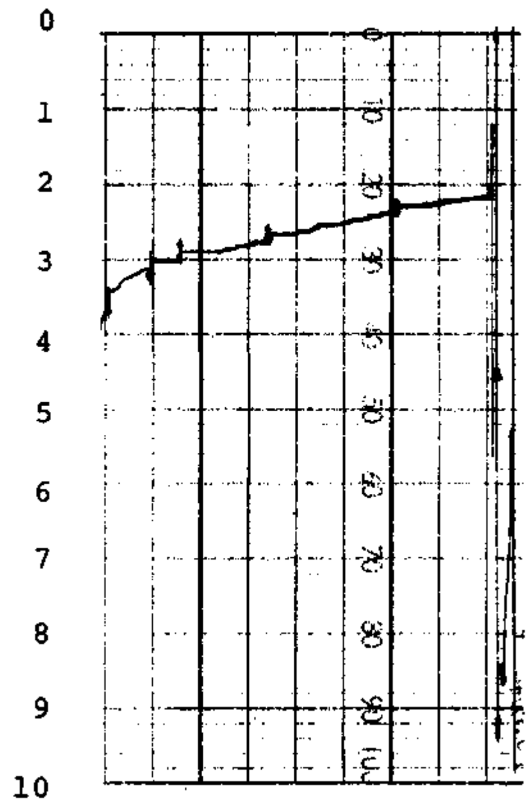

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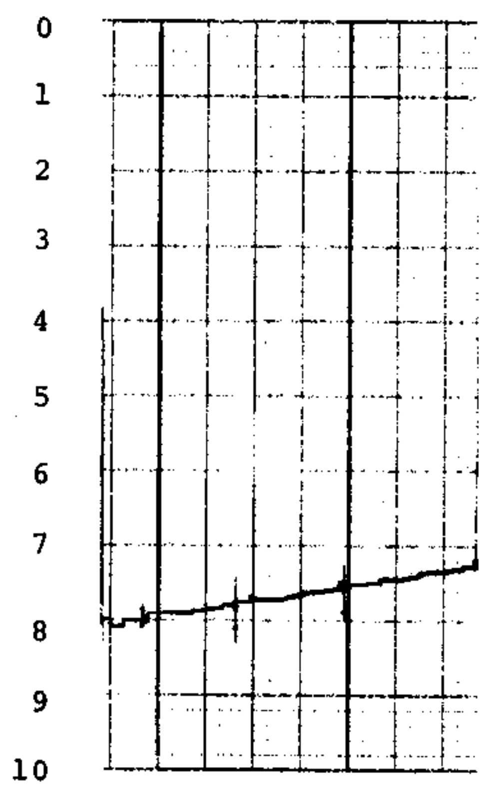

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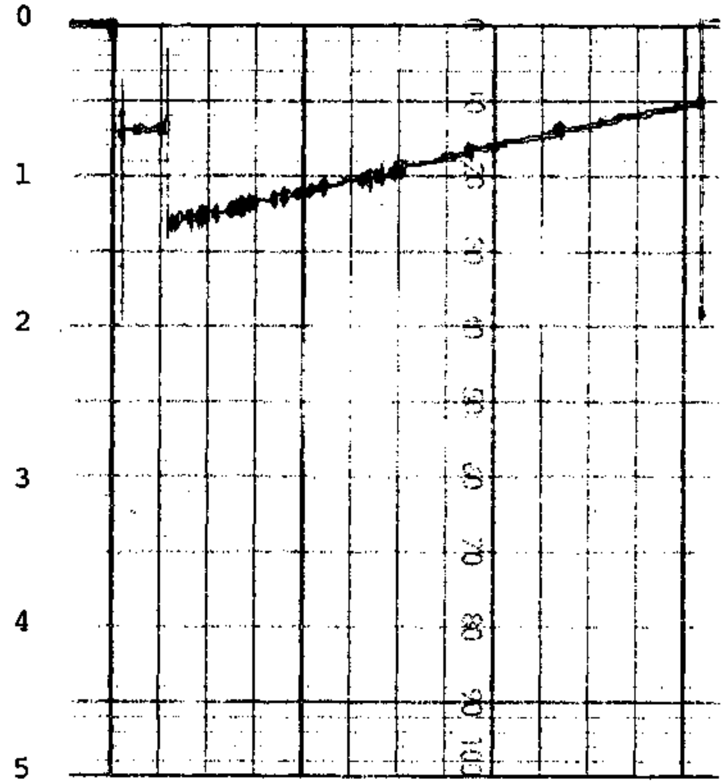

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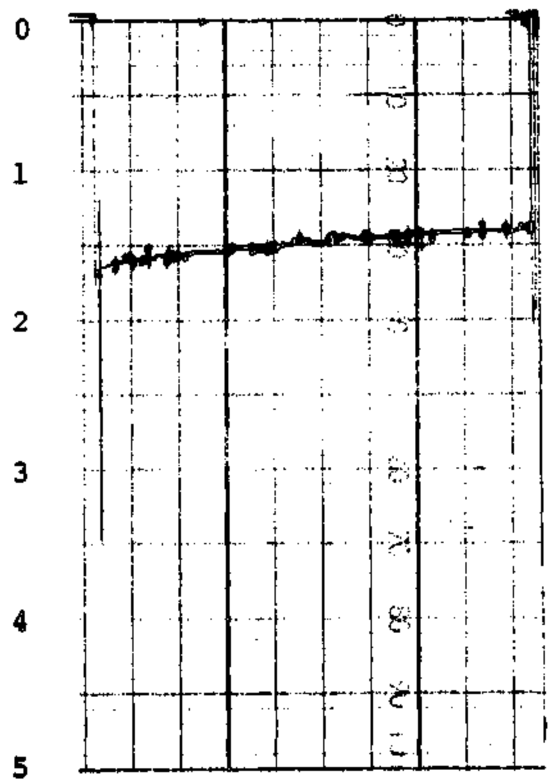

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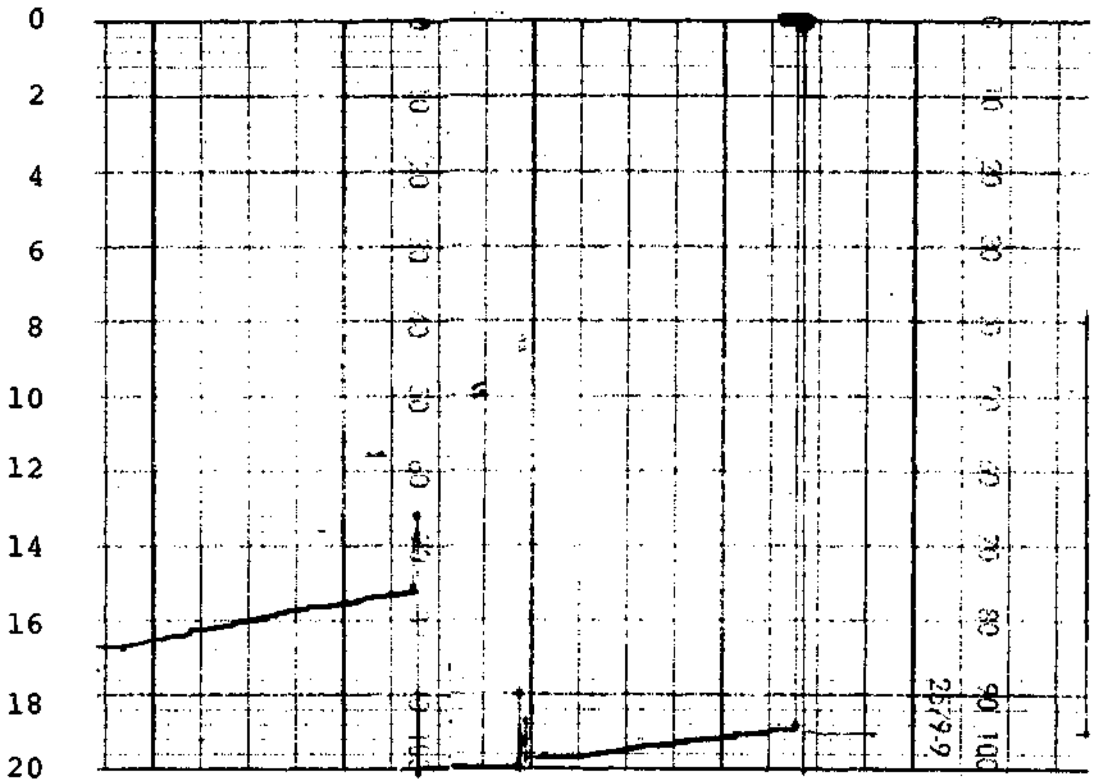

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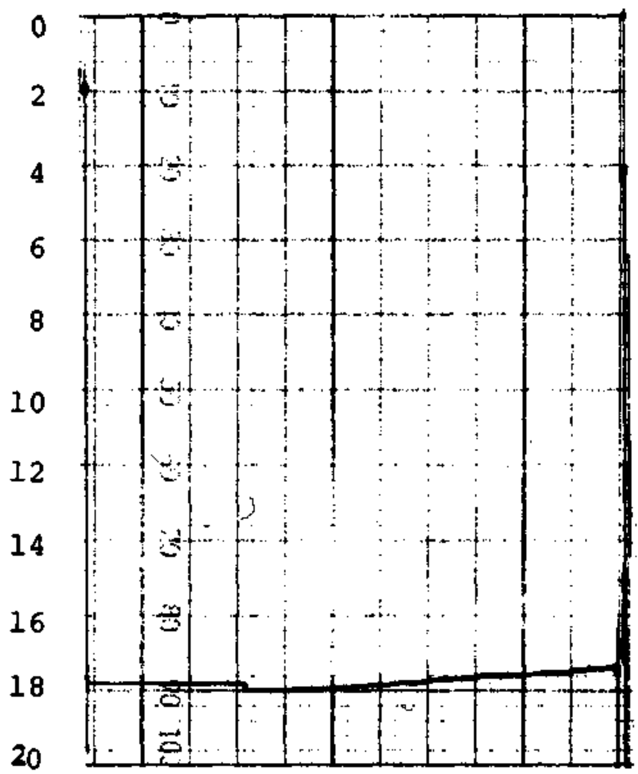

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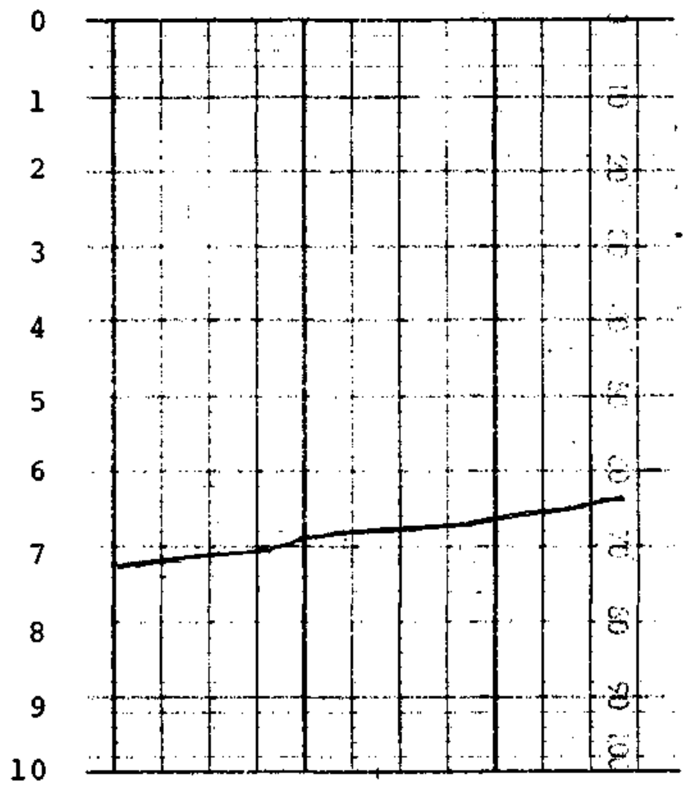

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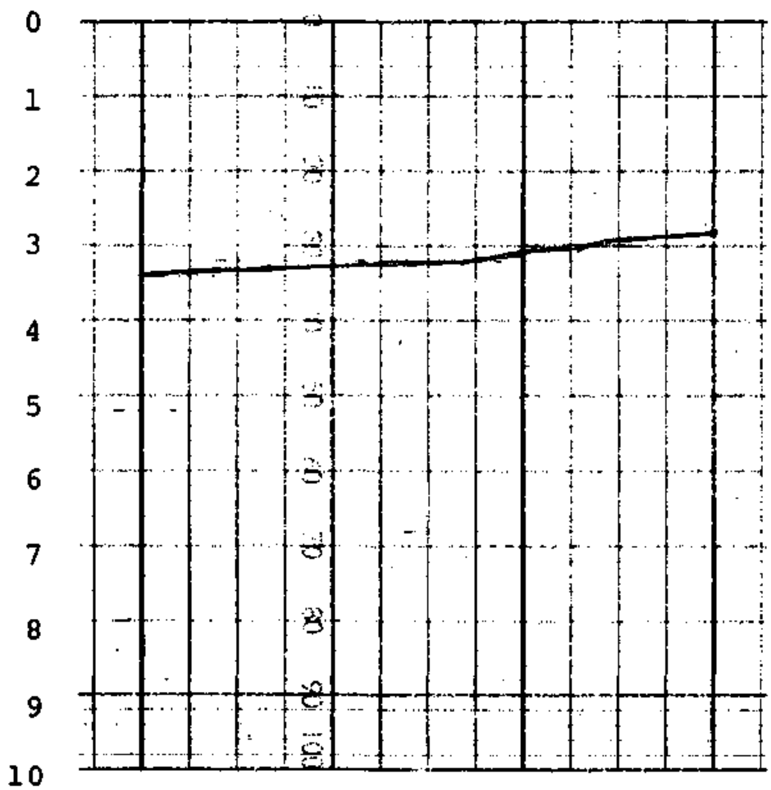

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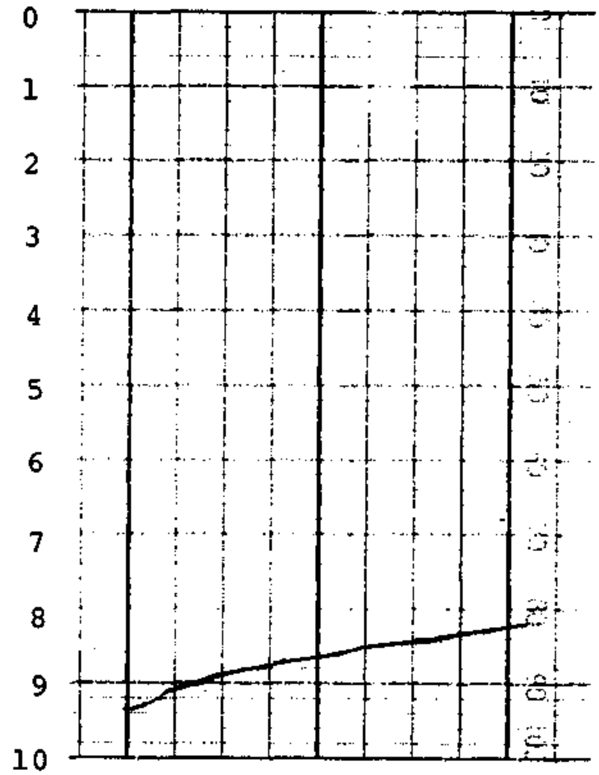

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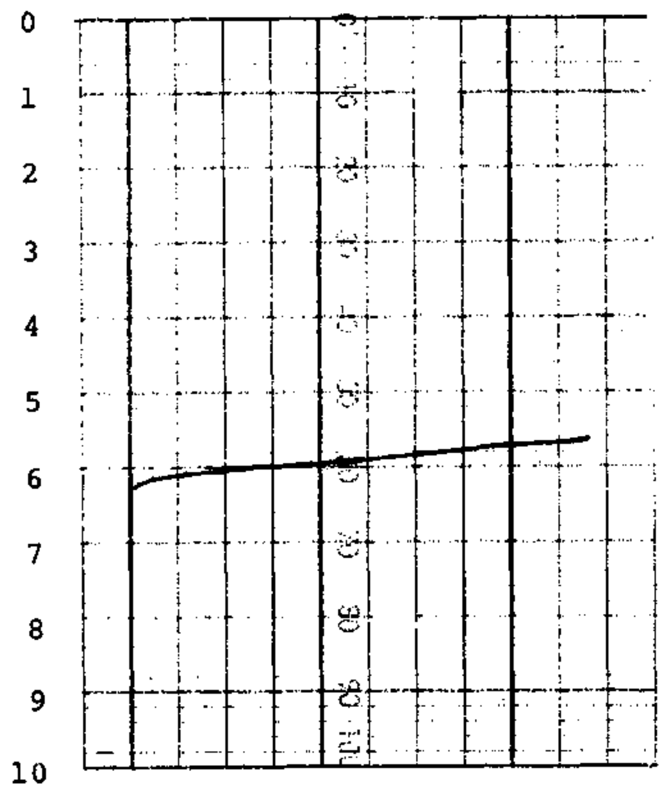
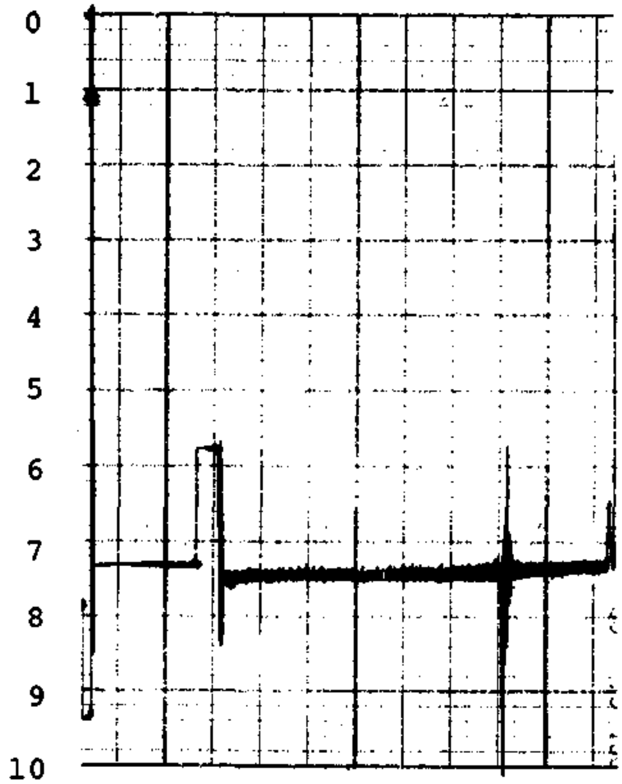


Sta. 86



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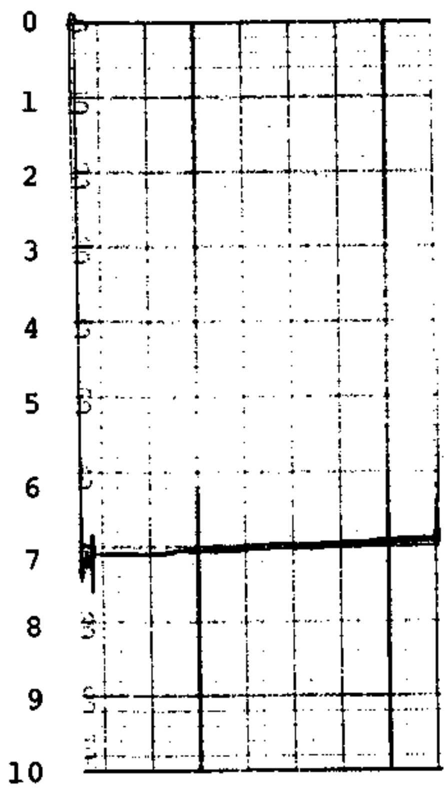
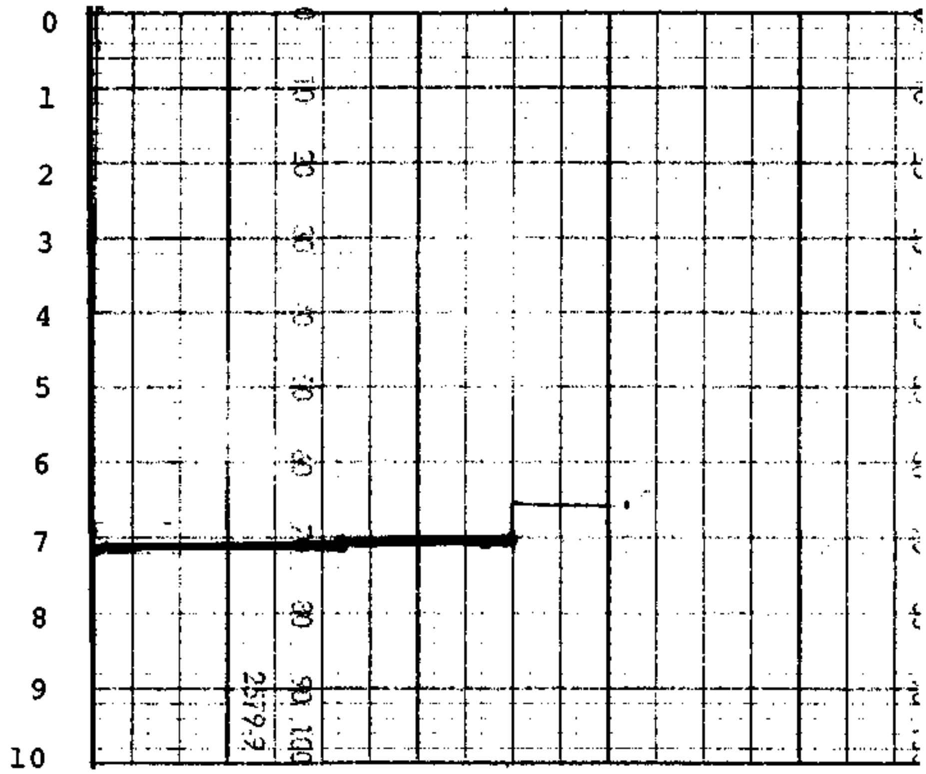


Sta. 88



Sta. 89

Appendix A-2. DO-Used versus Elapsed Time from Recorded Field Notes
(ΣT in minutes; ΣDO in mg/1)

Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	.05	5	.025	1	.05	3	.05	3	.025	5	.10	2	.05	2	.025
9	.10	10	.05	3	.10	5	.10	8	.075	10	.20	5	.10	5	.05
14	.15	15	.075	5	.15	10	.15	13	.15	15	.30	10	.20	7	.075
19	.20	20	.125	8	.20	15	.20	18	.175	20	.40	15	.30	12	.125
24	.35	25	.15	13	.225	20	.25	23	.225	25	.50	20	.40	17	.175
29	.45	30	.175	18	.25	25	.30	28	.275	30	.60	25	.45	22	.225
34	.50	35	.225	23	.275	30	.35	33	.30	35	.70	30	.50	27	.275
39	.55	40	.275	28	.30	35	.425	38	.325	40	.80	35	.60	32	.325
44	.60	45	.325	33	.325	40	.475	43	.375	45	.90	40	.70	37	.374
49	.675	50	.375	38	.375	45	.525	48	.425	50	1.00	45	.75	42	.425
54	.75	55	.425	43	.425	50	.575	53	.45	55	1.10	50	.80	47	.475
59	.80	60	.475	48	.45	55	.625	58	.475	60	1.20	55	.85	52	.525
64	.85	65	.50	53	.475	60	.675	63	.525	65	1.30	60	.90	57	.575
69	.90	70	.55	58	.50	65	.825	68	.60	70	1.40	65	.95	62	.65
74	.95	75	.575	63	.525	70	.775	73	.65	75	1.50	70	1.00	67	.70
79	1.00	80	.60	68	.55	75	.825	78	.70	78	1.60			72	.75
84	1.05	86	.65	73	.575										
				78	.625										
				83	.675										

Station 9		Station 10		Station 11		Station 12		Station 13		Station 14		Station 15		Station 16	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	.05	2	.05	2	.10	5	.025	5	.05	1	.05	5	0	1	.025
5	.10	9	.30	5	.20	7	.05	10	.10	3	.10	10	0	2	.05
10	.20	14	.55	10	.40	12	.075	15	.15	8	.175	15	.17	3	.05
15	.25	19	.75	15	.45	17	.125	20	.20	13	.23	22	.22	8	.125
20	.30	24	1.00	20	.525	22	.20	25	.25	18	.30	35	.50	13	.175
25	.35	29	1.25	25	.60	27	.25	30	.30	23	.35	40	.60	18	.30
30	.42	34	1.50	30	.65	32	.30	35	.35	28	.40	47	.72	23	.35
35	.50	39	1.75	35	.70	37	.325	40	.40	33	.475	50	.80	28	.375
40	.55	44	2.00	40	.775	42	.375	45	.45	38	.55	55	.90	33	.425
45	.60	49	2.20	45	.825	47	.425	50	.50	43	.625	60	.98	38	.50
50	.65	54	2.35	50	.90	52	.475	55	.55	48	.725	65	1.01	43	.55
55	.70	59	2.45	55	.975	57	.525	60	.60	53	.775	73	1.15	48	.60
60	.77	64	2.55	60	1.025	62	.575	65	.65	58	.85	80	1.20	53	.65
65	.82	69	2.60	65	1.10	67	.625	70	.70	63	.925	92	1.40	58	.70
70	.90	74	2.65	70	1.175					68	1.00			63	.75
		79	2.70	75	1.25					73	1.05			68	.85
		84	2.75							78	1.10			73	.90
		89	2.80											78	.95
		94	2.90												
		99	2.95												

Appendix A-2. Continued

Station 17		Station 18		Station 19		Station 20		Station 21		Station 22		Station 23		Station 24	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	.20	2	.05	10	.10	9	.30	5	.20	5	.30	6	0	2	.15
10	.40	5	.10	18	.20	15	.59	10	.30	10	.28	11	.05	4	.20
15	.60	10	.45	29	.37	22	.75	15	.35	16	.48	16	.10	6	.25
20	.80	15	.65	36	.44	28	.90	20	.40	24	.67	21	.10	11	.45
25	1.00	20	.75	43	.56	35	1.05	25	.50	29	.83	31	.125	16	.60
30	1.10	25	.80	51	.69	41	1.20	30	.55	34	.90	36	.175	21	.70
35	1.30	30	.88	60	.80	45	1.30	35	.60	41	1.10	41	.20	26	.80
40	1.50	35	.94	64	.89	49	1.42	40	.65	47	1.23	46	.25	31	.95
45	1.70	40	1.00	73	.98	56	1.60	45	.70	53	1.36	51	.30	36	1.05
50	1.90	45	1.03	76	1.01	60	1.82	50	.85	61	1.38	61	.40	41	1.15
55	2.00	50	1.08			74	2.01	55	.90	66	1.46	66	.45	46	1.25
60	2.20	55	1.10			80	2.20	60	.95			76	.575	51	1.35
65	2.35	60	1.12			84	2.22	65	1.00			86	.70	56	1.45
		65	1.14									91	.80	61	1.55
												96	.875	66	1.65
												101	.90	71	1.75
												106	1.00	76	1.85
												116	1.075	81	1.95
												120	1.10	86	2.05

Station 25		Station 26		Station 27		Station 28		Station 29		Station 30		Station 31		Station 32	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	5	.15	5	.40	5	.10	3	0	10	0	3	-.025	7	.025
10	.05	10	.125	10	.60	10	.15	8	0	20	.025	8	0	12	.05
20	.05	20	.175	15	.75	20	.20	13	0	30	.025	13	.05	17	.125
30	.075	30	.225	25	1.00	30	.225	23	.05	40	.025	18	.075	22	.175
40	.075	40	.25	30	1.15	40	.275	33	.10	50	.05	23	.10	27	.225
50	.10	50	.275	35	1.30	50	.30	43	.20	60	.05	33	.125	32	.275
60	.15	60	.35	40	1.40	60	.325	53	.225	70	.075	43	.15	37	.35
70	.20	70	.45	45	1.55	70	.35	63	.30	80	.1	53	.2	42	.425
80	.25	80	.60	50	1.75	80	.425	73	.35	85	.125	63	.225	47	.45
90	.275	90	.65	55	1.85	90	.45	83	.45			73	.25	52	.475
				60	2.00			93	.55					57	.525
				65	2.10									62	.575
				70	2.20									67	.625
				75	2.40									72	.675
				80	2.50									77	.725
				85	2.60									82	.775
				90	2.75										

Appendix A-2. Continued

Station 33		*Station 34*		*Station 35*		*Station 36*		*Station 37*		*Station 38*		*Station 39*		*Station 40*	
ΣT	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	13	.02	4	.10	4	.28	6	.02	7	.26	5	0	5	0
21	0	22	.1	12	.19	12	.38	15	.11	11	.43	14	.01	10	.05
28	.05	32	.15	21	.30	21	.47	24	.21	16	.46	24	.02	15	.10
33	.15	44	.2	32	.40	31	.58	30	.24	21	.50	31	.10	25	.125
43	.19	52	.25	43	.48	39	.66	41	.37	26	.51	42	.19	35	.175
56	.19	64	.3	52	.50	49	.71	53	.51	31	.52	49	.30	45	.225
60	.25	72	.36	58	.55	57	.78	61	.62	36	.56	62	.41	55	.325
		83	.4	67	.60	68	.85	69	.70	42	.58	75	.52	65	.40
		90	.43	73	.65	75	.90	72	.74	48	.62	81	.61	75	.425
				78	.68	83	.96			54	.61	89	.66	85	.475
				84	.7	88	.99			57	.66			95	.50
				93	.65					60	.66				
				103	.81					64	.70				
										71	.71				
										76	.73				
										81	.75				
										86	.78				
										91	.80				
										97	.81				
										104	.82				
										109	.88				
										113	.90				
										120	.90				

Station 41		*Station 42*		*Station 43*		*Station 44*		*Station 45*		*Station 46*		*Station 47*		*Station 48*	
ΣT	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*	*ΣT*	*ΣDO*
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	.075	3	0	3	0	5	.10	6	.04	5	.05	5	.0	2	0
8	.125	8	.25	8	.05	10	.20	11	.05	10	.05	10	.05	7	.05
18	.30	13	.45	13	.10	15	.25	25	.06	15	.075	25	.10	12	.25
28	.35	23	.75	18	.15	20	.30	34	.10	20	.10	35	.125	17	.35
38	.50	33	.95	23	.20	25	.35	51	.15	25	.125	65	.125	22	.45
48	.675	43	1.30	28	.225	30	.40	61	.19	30	.15	85	.15	27	.475
58	.80	53	1.50	33	.25	35	.45	76	.25	35	.175			37	.65
67	1.00	63	1.85	38	.30	40	.50	86	.29	40	.225			47	.85
78	1.075	73	2.15	43	.35	45	.55	91	.35	45	.25			57	1.00
91	1.20	83	2.65	48	.40	50	.60			50	.275			67	1.15
93	1.25	93	2.95	53	.45	55	.65			55	.25			77	1.25
		98	3.15	58	.50	60	.70			60	.325			87	1.45
				63	.55	65	.75			65	.35			92	1.475
				68	.60	70	.80			70	.40				
				73	.65	75	.85			75	.45				
				78	.70	80	.90			80	.50				
				83	.75	85	.95			85	.55				
				88	.80	90	1.00								

Station 49 ΣT	ΣDO	Station 50 ΣT	ΣDO	Station 51 ΣT	ΣDO	Station 52 ΣT	ΣDO	Station 53 ΣT	ΣDO	Station 54 ΣT	ΣDO	Station 55 ΣT	ΣDO	Station 56 ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	.05	5	0	2	.025	2	.15	2	0	5	0	5	0	5	0
10	.05	10	.05	7	.075	7	.15	7	0	10	.025	10	.10	10	.10
15	.20	15	.075	12	.10	12	.15	12	0	15	.075	15	.30	15	.15
20	.30	20	.075	17	.125	17	.175	17	-.05	20	.10	20	.40	20	.20
25	.35	25	.10	22	.15	22	.20	22	-.05	25	.15	25	.525	25	.30
30	.40	30	.20	27	.175	27	.20	27	-.10	30	.175	30	.70	30	.40
35	.45	35	.25	32	.20	37	.25	32	0.10	35	.20	35	.70	35	.50
45	.55	40	.45	37	.20	47	.275	37	-.10	40	.25	40	.80	40	.60
55	.60	45	.55	42	.225	57	.325	72	0	45	.30	45	.90	45	.75
65	.65	50	.65	47	.250	67	.35	97	.1	50	.35	50	1.00	50	.85
80	.80	55	.90	52	.275	77	.40	117	.2	55	.375	55	1.10	55	.95
95	.85	60	.95	57	.325	87	.425	137	.3	60	.425	60	1.20	60	1.10
		70	1.10	62	.350	92	.425			65	.475	65	1.30	65	1.20
		80	1.35	67	.375					70	.525	70	1.40	70	1.30
		85	1.45	72	.425					75	.575	75	1.45	75	1.45
		90	1.60	82	.425					80	.625	80	1.55	80	1.60
		95	1.70	92	.475					85	.675	85	1.60	85	1.70
				102.	.50					90	.725	90	1.70	90	1.75
												95	1.80	95	1.80
												100	1.90	100	1.90
												105	2.00	105	2.00
												110	2.05	110	2.10
												115	2.10		
												120	2.20		

Station 57 ΣT	ΣDO	Station 58 ΣT	ΣDO	Station 59 ΣT	ΣDO	Station 60 ΣT	ΣDO	Station 61 ΣT	ΣDO	Station 62 ΣT	ΣDO	Station 63 ΣT	ΣDO	Station 64 ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	.10	5	.30	5	-.30	5	.05	1	.10	4	.10	2	-.10	5	.05
10	.20	10	.40	10	-.30	10	.10	2	.35	9	.20	7	0	10	.05
15	.30	15	.50	15	-.10	15	.15	7	.80	14	.30	12	.2	15	.075
20	.325	20	.60	20	0	20	.20	17	1.95	19	.40	17	.4	20	.10
25	.35	25	.70	25	.20	25	.30	22	2.10	24	.45	22	.60	25	.125
30	.40	30	.90	30	.40	30	.40	27	2.35	29	.50	27	.70	30	.15
35	.45	35	1.10	35	.50	35	.60	32	2.60	34	.525	32	.80	35	.175
40	.50	40	1.30	40	.60	40	.70	37	2.90	39	.55	37	.95	40	.20
45	.55	45	1.60	45	.70	45	.90	42	3.10	44	.60	42	1.05	45	.225
50	.60	50	1.85	50	.90	50	1.10	47	3.35	49	.65	47	1.20	50	.25
55	.70	55	2.05	55	1.00	55	1.25	52	3.60	54	.70	52	1.40	55	.275
60	725	60	2.30	60	1.10	60	1.40	57	3.80	59	.725	57	1.55	60	.30
65	.75	65	2.50	65	1.30	65	1.65	62	4.00	64	.725	62	1.70	65	.35
70	.80	70	2.70	70	1.50	70	1.75	67	4.15			67	1.90	70	.40
75	.85	75	2.85	75	1.60	75	1.85	72	4.40			72	2.00	75	.45
80	.90	80	3.05	80	1.70	80	2.00	77	4.60			77	2.10	80	.50
85	.95	85	3.25	85	1.80	85	2.15	82	4.75			82	2.25	85	.56
		90	3.45	90	1.90	90	2.35	87	4.90			87	2.35	90	.575
		95	3.60	95	2.10	95	2.45	92	5.05			92	2.50		
		100	3.75	100	2.20	100	2.55	97	5.20						
		105	3.80	105	2.30			102	5.30						
		110	4.20	110	2.50										
		115	4.30	115	2.70										
		120	4.45	120	2.70										

Appendix A-2. Continued

Station 65		Station 66		Station 67		Station 68		Station 69		Station 70		Station 71		Station 72	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	.025	3	.10	5	.05	5	.1	6	.05	4	- 1	13	.10	5	.05
10	.050	6	.30	10	.15	10	.15	14	.10	11	-.05	15	.20	10	.15
15	.075	13	.325	15	.25	15	.175	19	.25	14	.1	25	.40	15	.20
20	.10	18	.35	20	.30	20	.20	24	.35	16	.1	30	.50	20	.25
25	.125	23	.375	25	.35	25	.25	29	.45	21	.25	35	.60	25	.30
30	.15	28	.425	30	.40	30	.30	34	.50	26	.4	40	.70	30	.35
35	.175	33	.45	35	.45	35	.35	39	.575	31	.5	45	.80	35	.45
40	.20	38	.475	40	.55	40	.40	44	.65	36	.55	50	.90	40	.55
45	.225	43	.50	45	.60	45	.45	49	.75	41	.65	55	1.00	45	.625
50	.25	48	.525	50	.65	50	.50	54	.825	46	.75	60	1.10	50	.70
55	.275	53	.575	55	.70	55	.55	59	.875	51	.85	65	1.20	55	.75
60	.275	58	.625	60	.75	60	.60	64	.925	56	.95	70	1.30	60	.80
65	.30	63	.65	65	.80	65	.65	69	.975	61	1.05	75	1.40	65	.85
70	.325	68	.675	70	.85	70	.70	74	1.10	66	1.15	80	1.50	70	.90
75	.325	73	.70	75	.90	75	.75	79	1.175	71	1.25	85	1.55	75	.95
80	.35	78	.725	80	.95	80	.80	84	1.225	76	1.35	90	1.60	80	1.05
85	.375	83	.75	85	1.00	85	.85	89	1.275	81	1.45	95	1.70	85	1.10
90	.375					90	.90	94	1.35	86	1.55	100	1.80	90	1.20
								102	1.40	91	1.65	105	1.90	95	1.25
								104	1.45	96	1.75	110	1.95	100	1.30
										101	1.80			105	1.35
										106	1.85			110	1.40

Station 73		Station 74		Station 75		Station 76		Station 77		Station 78		Station 79		Station 80	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	13	.66	3	.15	2	.30	3	.55	6	.09	2	.05	1	.025
8	.025	26	1.34	13	.32	3	.70	4	.70	13	.22	7	.10	6	.025
13	.075	39	1.94	25	.59	4	.88	9	.93	18	.31	12	.15	11	.050
18	.10	49	2.35	34	.80	6	1.09	17	1.2	23	.41	17	.20	16	.075
23	.125	56	2.66	43	1.11	8	1.21	21	1.35	33	.56	22	.25	21	.10
28	.175	61	2.85	53	1.42	10	1.38	29	1.49	45	.71	27	.30	26	.125
33	.225			63	1.51	22	2.00	39	1.65	52	.86	32	.35	31	.15
38	.275			73	2.10	29	2.40	49	1.83	60	.93	37	.40	36	.175
43	.325			83	2.47	42	3.00	60	2.00			42	.45	41	.20
48	.375					53	3.49	64	2.07			47	.50	46	.225
53	.425					60	3.10					52	.55	51	.25
58	.45					65	3.88					57	.60	56	.25
63	.50											62	.65	61	.225
68	.55											67	.70	66	.20
73	.575											72	.75		
78	.60											77	.80		
												82	.85		
												87	.90		

Appendix A-2. Concluded

Station 81a		Station 81b		Station 82		Station 83		Station 84		Station 85		Station 86		Station 87	
ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO	ΣT	ΣDO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	.38	8	.18	16	0	11	.07	5	.05	2	.05	3	.10	25	.1
15	.60	16	.30	25	.1	16	.11	10	.08	5	.15	6	.15	35	.15
25	1.00	28	.58	42	.3	23	.21	15	.09	8	.25	9	.16	60	.25
36	1.40	37	.79	61	.6	29	.31	20	.10	15	.45	12	.20		
44	1.60	46	1.00	74	.9	36	.42	25	.10	20	.55	19	.25		
51	1.82	55	1.20	83	1.1	56	.52	30	.12	25	.64	22	.25		
		60	1.30			64	.63	35	.16	32	.75	26	.26		
						71	.72	40	.17	37	.82	29	.30		
						76	.82	50	.18	42	.86	32	.33		
						78	.84	55	.35	47	.94	35	.35		
								58	.39	52	.99	38	.36		
								63	.40	57	1.05	41	.36		
								65	.42	62	1.13	45	.40		
								68	.44			49	.45		
								71	.48			53	.47		
								74	.49			56	.50		
								77	.51			59	.54		
								80	.58			62	.55		
								83	.59			66	.59		
								85	.59			70	.64		
												74	.65		

Station 88		Station 89	
ΣT	ΣDO	ΣT	ΣDO
0	0	0	0
5	.05	10	.05
30	.15	25	.1
40	.25	40	.13
60	.33	55	.15
		70	.17

Appendix B-1. Tabulated Benthos Data

Tolerance category	*Organism*	*Benthic macroinvertebrates (individuals/m²) at station*												
		1	*1.5*	*2*	*3*	*4*	*5*	*5.5*	*6*	*7*	*8*	*9*	*9.5*	*10*
F	Hexagenia limbata (may fly)									19				
M	Sphaerium partemium (fingernail clam)										19			
M	Cheumatopsyche sp. (caddis fly)												38	
T	Chaoborus sp. (phantom midge)	38	38		57									
T	Chironomidae sp. (midge)	574	593	211	402	1167	498	134	889	1320	478	440	880	77
T	Oligochaetae (aquatic worm)	536	38	631	153	1052	383	440	689	268	593	77		96

		11	*12*	*13*	*14*	*15*	*15a*	*16*	*17*	*17.5*	*18*	*19*	*20*
I	Polycentropis cinereus (caddis fly)					128							
I	Baetidae sp. (may fly)						1						
I	Stenonema interpunctatum (may fly)						2						86
I	S. terminatum (may fly)												172
I	Cambarus sp. (cray fish)												43
F	Tricorythodes sp. (may fly)					2196	102						345
F	Pyralidae (aquatic butterfly larvae)						3			19			
F	Stenelmis sp. (riffle beetle)												43
M	Sphaerium partemium (fingernail clam)										19		
M	S. transversum (fingernail clam)	19					1		19				
M	Cheumatopsyche sp. (caddis fly)					1121	205						3574
M	Hydropsyche sp. (caddis fly)					86	62						86
M	H. phalerata (caddis fly)					128	36						86
M	H. bifida (caddis fly)						81						43
M	H. recurvata (caddis fly)					43							43
T	Chironomidae sp. (midge)	421	1014	2430	1760	4694	28	77	1512	555	574	6372	1033
T	Empididae sp. (dance fly)						1						
T	Oligochaetae (aquatic worm)	268	612	1260	364		1	1320	421	364	8021	86	172
T	Branchiura sowerbyi (aquatic worm)											43	86

		21	*22*	*22.5*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*
I	Epheron album (may fly)			259									
I	Stenonema terminatum (may fly)			344									
I	S. interpunctatum (may fly)			43									
I	Gammaridae sp. (scud)									43			
I	Plathemis sp. (dragon fly)												43
I	Neocleon alamance (may fly)			216									
F	Caenis sp. (may fly)											1334	
F	Stenelmis sp. (riffle beetle)			43									
F	Dibiraphia sp. (riffle beetle)										43		
F	Corixidae trichocorixa (water boatman)												173
F	Tricorythodes sp. (may fly)			6114									
F	Hexagenia limbata (may fly)									86			
F	Myzobdella moorei (leech)									43			259
F	Hydrophilidae berosus (water scavenger)											86	
M	Cheumatopsyche sp. (caddis fly)			7146									
M	Hydropsyche sp. (caddis fly)			86									
M	H. orris (caddis fly)			86									
M	H. bifida (caddis fly)			173									
M	H. aerata (caddis fly)			947									
M	H. phalerata (caddis fly)			1593									
M	Potamanthus sp. (may fly)		19	905			128						

Appendix B-l. Continued

Tolerance category	Organism	Benthic macroinvertebrates (individuals/m²) at station 21	22	22.5	23	24	25	26	27	28	29	30	31
M	Planariidae sp. (flat worm)			990									
M	Sphaerium sp. (fingernail clam)								128				
T	Chironomidae sp. (midge)		1052	3488	3961	2468	1593	4048	259	5769	1766	2066	4005
T	Ceratopogonidae (biting midge)												86
T	Oligochaetae sp. (aquatic worm)	1665		43		268	819	2714	518	560	43	905	560
T	Branchiura sowerbyi (aquatic worm)		19										

Tolerance category	Organism	32	33	34	35	36	37	38	39	40	41	42	43
I	Stenonema sp. (may fly)								43				
I	Ishnura verticales (damsel fly)									86			
F	Ectopria sp. (water penny)							43	216				
F	Caenis sp. (may fly)								43		43		
F	Tricorythodes sp. (may fly)								1766				
F	Corixidae trichocorixa (water boatman)									43			
M	Cheumatopsyche sp. (caddis fly)								86				
M	Potamanthus sp. (may fly)								322				
M	Perithemis sp. (dragon fly)										43		
M	Asellus sp. (aquatic sow bug)									86			
M	A. communis (aquatic sow bug)									171			43
T	Chironomidae sp. (midge)	8568	86		128	128		387	990	4561	43	39440	23982
T	Chaoborus sp. (phantom midge)										43	43	43
T	Physa sp. (snail)	387											
T	Oligochaetae (aquatic worm)	128	518	322	1636	6674	1980	473	473	774	234	6156	29537
T	Branchiura sowerbyi (aquatic worm)									128			

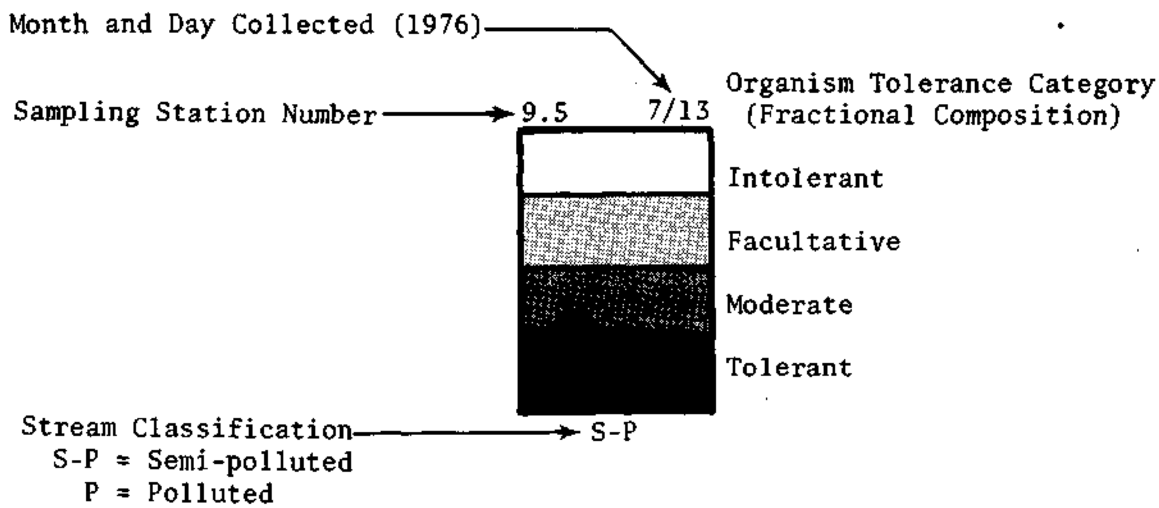
Tolerance category	Organism	44	45	46	47	48	49	50	51	52	53	54	55
I	Stenonema interpunctatum (may fly)			43									
I	S. terminatum (may fly)				43								
I	Planaria (flat worm)			171									
F	Hexagenia limbata (may fly)						43						
F	Pyralidae sp. (aquatic butterfly larvae)				1420								
F	Tricorythodes sp. (may fly)			86	2239								
F	Dubiraphia sp. (riffle beetle)						43						
F	Myzobdella moorei (leech)											128	
F	Caenis sp. (may fly)			43									
M	Cheumatopsyche sp. (caddis fly)			340	2196								
M	Potamanthus sp. (may fly)			86	128								
M	Asellus sp. (aquatic sow bug)			171	43								
M	A. communis (aquatic sow bug)			43									
M	Argria sp. (damsel fly)			216									
T	Chironomidae sp. (midge)	322	259	2196	86	39483	689	14554	2239	2206	171		819
T	Chaoborus sp. (phantom midge)					43							
T	Oligochaetae (aquatic worm)	322	1895	340		6546	387	1334	1292	744	2669	216	3186
T	Physa sp. (snail)		128										

Appendix B-l. Concluded

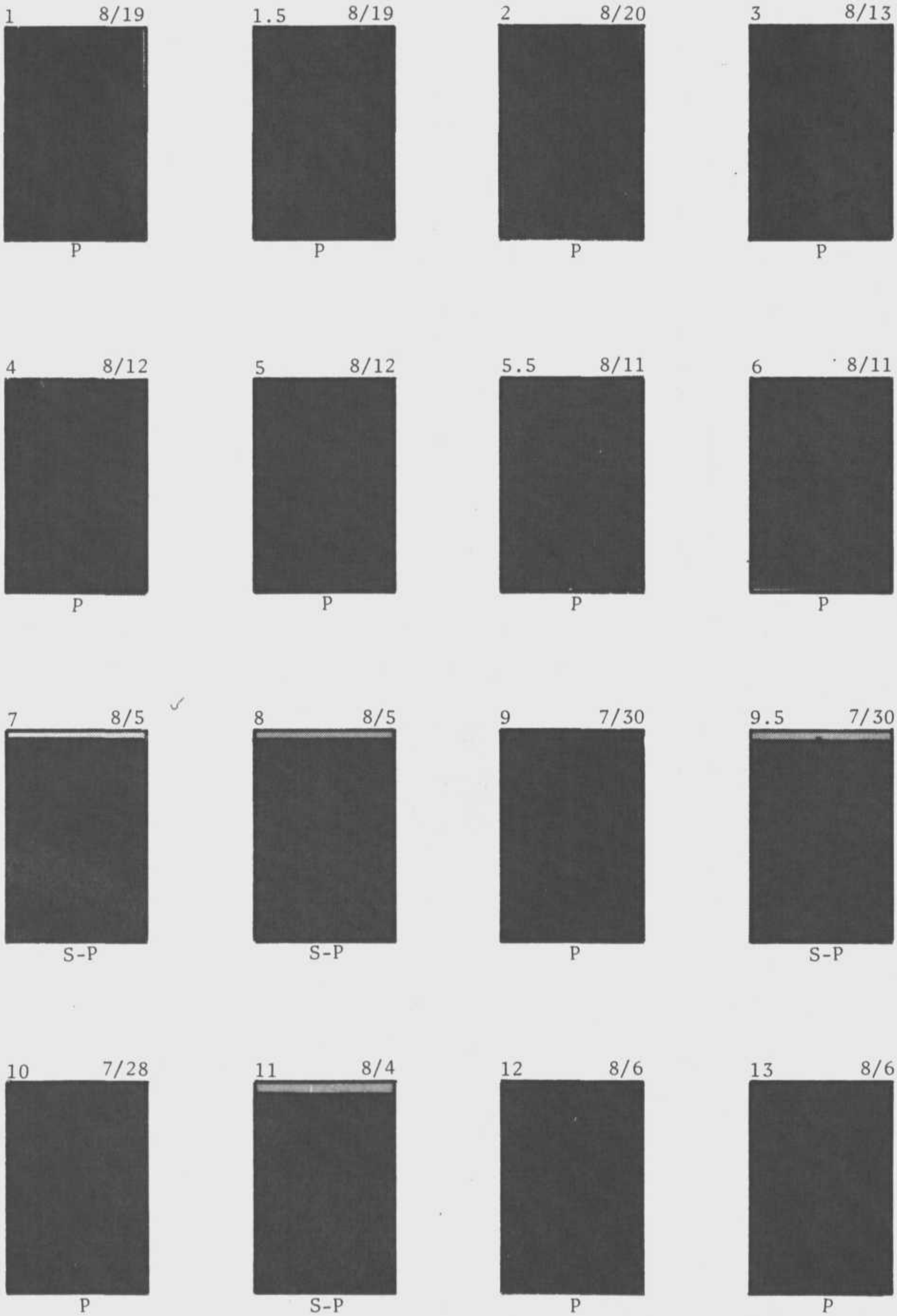
Tolerance category	Organism	Benthic macroinvertebrates (individuals/m²) at station											
		56	57	58	59	60	61	62	63	64	65	66	67
F	Gyraulus parvus (snail)					43							
F	Dina bucera (leech)		43			518	43	19					
F	Myzobdella moorei (leech)		86	1076	387	2367	364				387		
F	Piscicolaria reducta (leech)			344									
M	Sphaerium partemium (fingernail clam)						287						
M	S. transversum (fingernail clam)		473	9473	1990	2990	2714				86		
M	Asellus sp. (aquatic sow bug)			128		603	19			43			
M	A. communis (aquatic sow bug)					387							
T	Chironomidae sp. (midge)	603	4176	1033	862	128	1152	631	192	128	1076	128	13089
T	Oligochaetae (aquatic worm)	5468	1249	1721	1076	774	35952	765	1799	603	6674	2412	19848
T	Physa sp. (snail)			86		43		19					
		68	69	70	71	72	73	74	75	76	77	78	79
F	Caenis sp. (may fly)						43						
F	Myzobdella moorei (leech)		128									86	402
M	Sphaerium partemium (fingernail clam)											86	
M	S. transversum (fingernail clam)												861
M	Asellus sp. (aquatic sow bug)		344									43	1569
M	A. communis (aquatic sow bug)											43	823
T	Chaoborus sp. (phantom midge)	43		619	153		43						
T	Chironomidae sp. (midge)	689	171	57	38	57	171		7061	23250	387	128	670
T	Oligochaetae (aquatic worm)	1636	3917	19	325	421	128	12961	12745	259	293814	3186	2794
T	Physa sp. (snail)											302	
		80	81	82	83	84	85	86	87	88	89		
I	Psychomyiid Genus A (caddis fly)		43										
F	Hexagenia limbata (may fly)								19				
F	Dubiraphia sp. (riffle beetle)										38		
F	Myzobdella moorei (leech)	38											
M	Asellus sp. (aquatic sow bug)						2026	43					
M	A. communis (aquatic sow bug)		43				1163						
M	Sphaerium transversum (fingernail clam)			344									
T	Chironomidae sp. (midge)	498	2066	1292		646	473	128	172	191	306		
T	Oligochaetae (aquatic worm)	18193	4520	2324	387	819	171	3359	249	115	153		
T	Physa sp. (snail)			43									

Appendix B-2. Bar Graphs of IEPA Stream Classifications Using Benthos Data

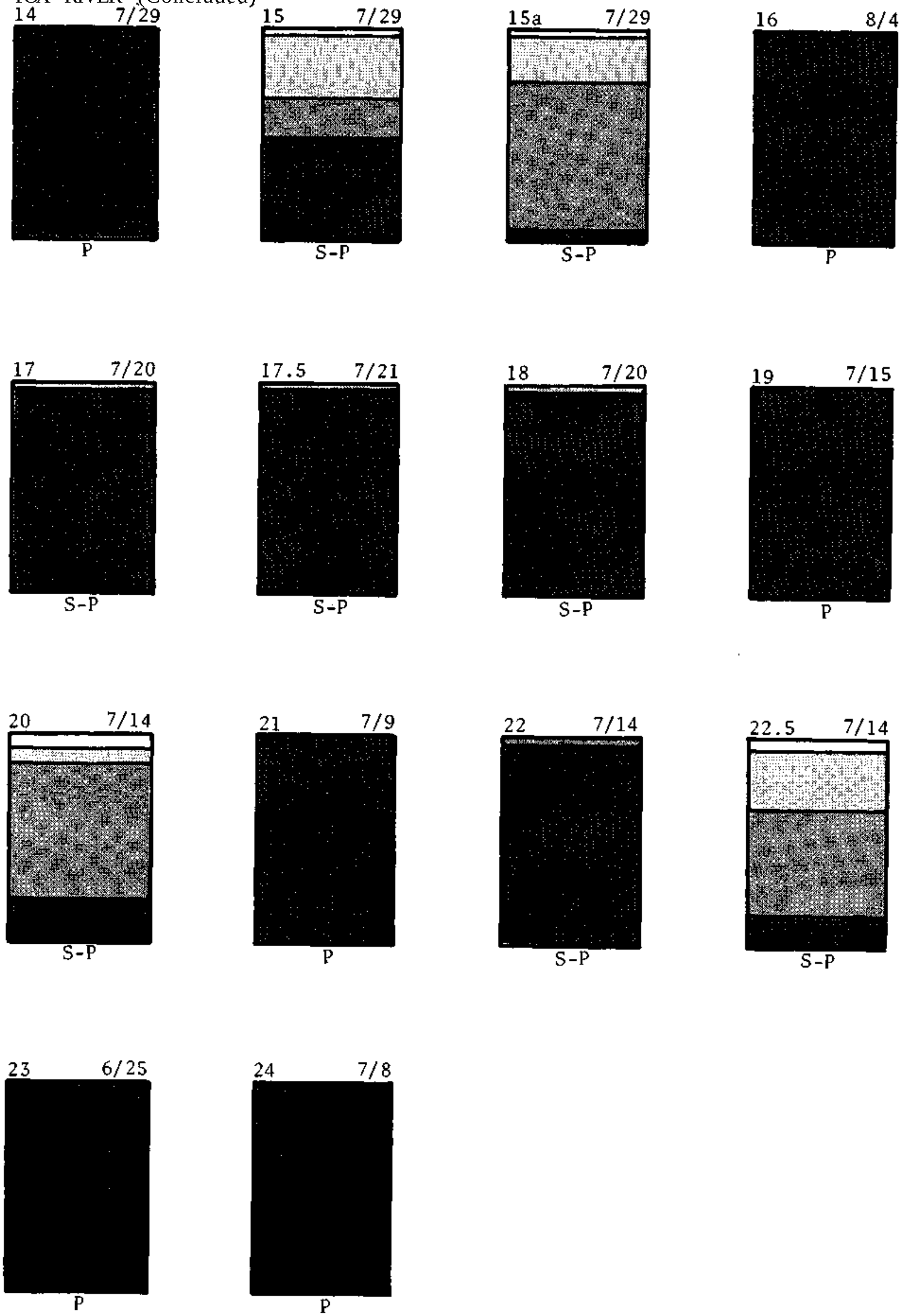
BAR GRAPH KEY



FOX RIVER


1 8/19
P
1.5 8/19
P
2 8/20
P
3 8/13
P
4 8/12
P
5 8/12
P
5.5 8/11
P
6 8/11
P
7 8/5
S-P
8 8/5
S-P
9 7/30
P
9.5 7/30
S-P
10 7/28
P
11 8/4
S-P
12 8/6
P
13 8/6
P

FOX RIVER (Concluded)

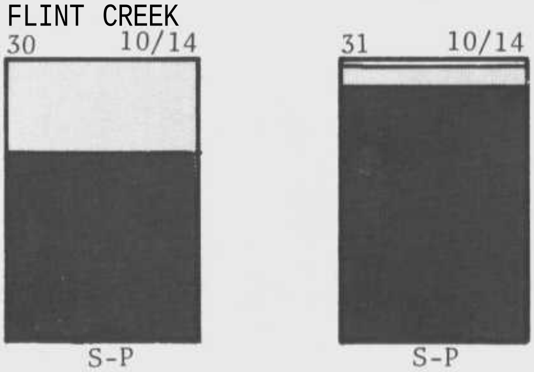


NIPPERSINK CREEK

SILVER CREEK

SOUTH BRANCH KISHWAUKEE RIVER

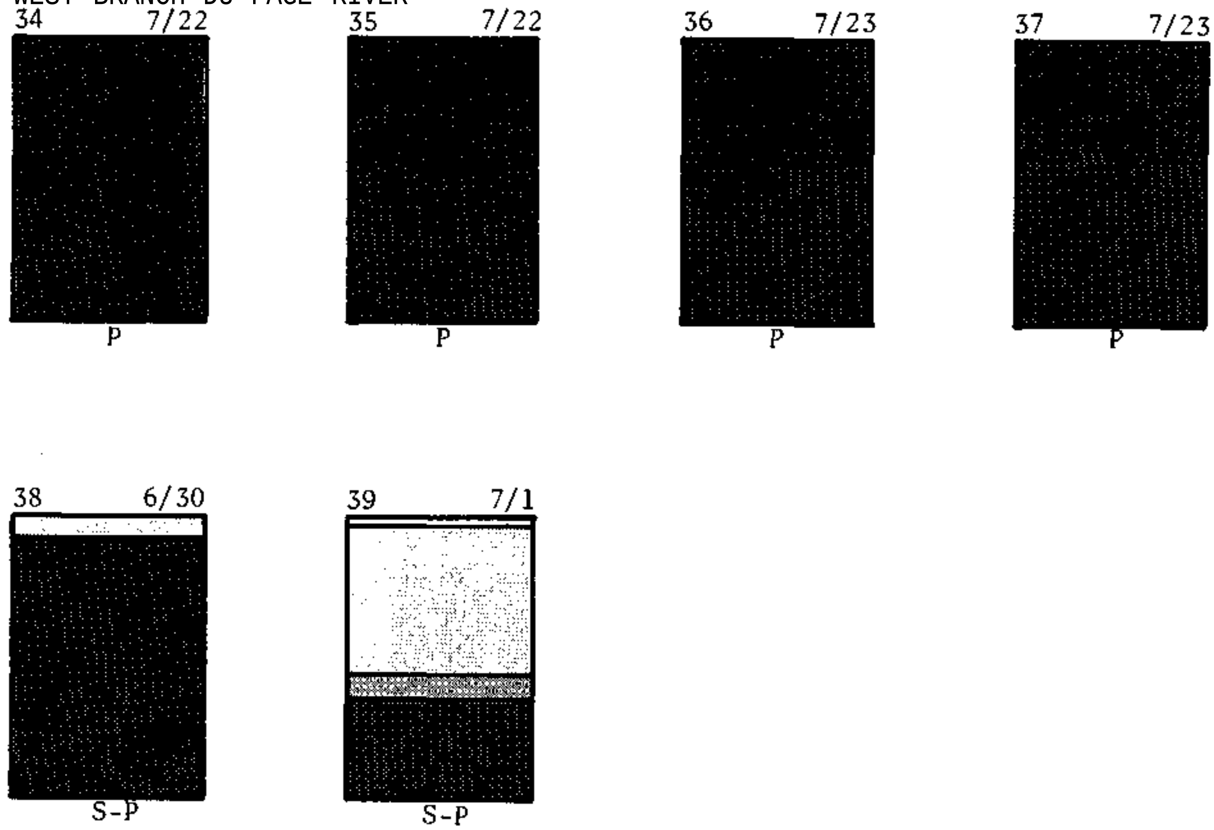
FLINT CREEK



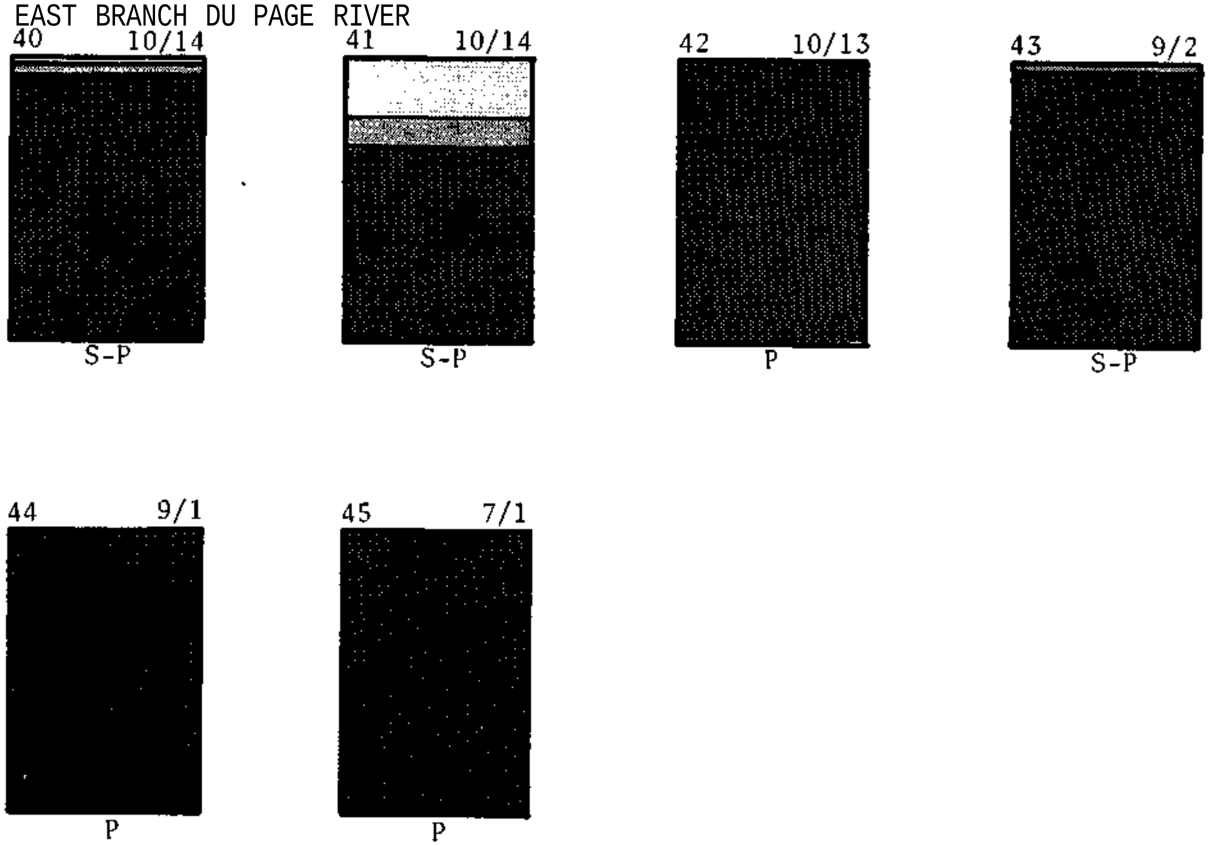
WOODS CREEK

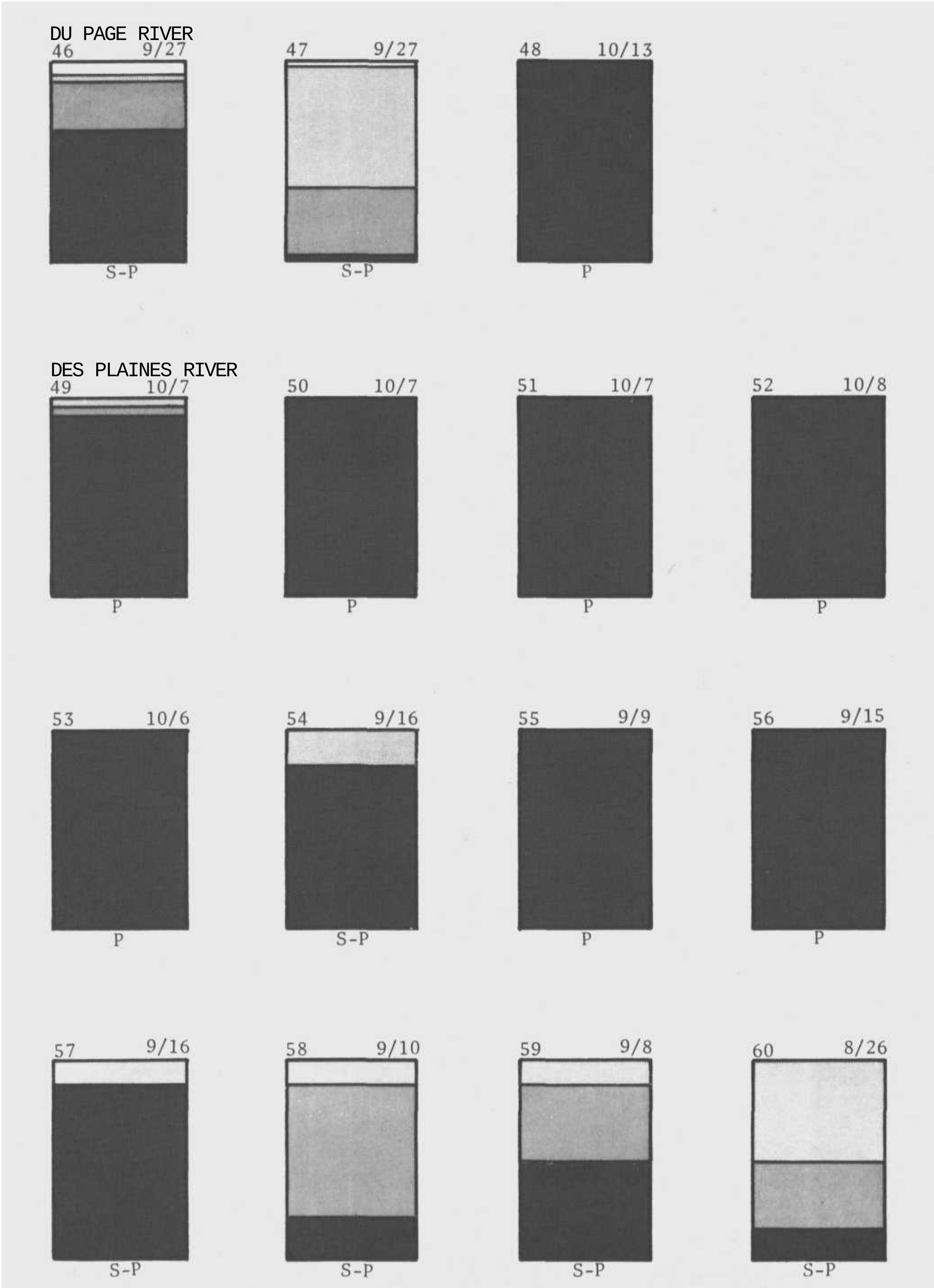
BLACKBERRY CREEK

WEST BRANCH DU PAGE RIVER

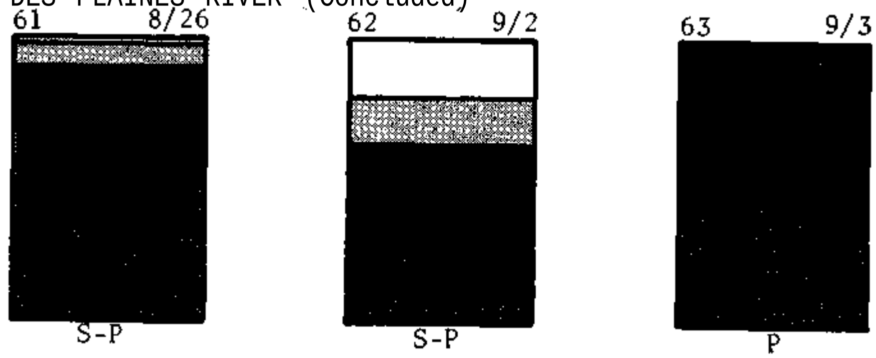


EAST BRANCH DU PAGE RIVER

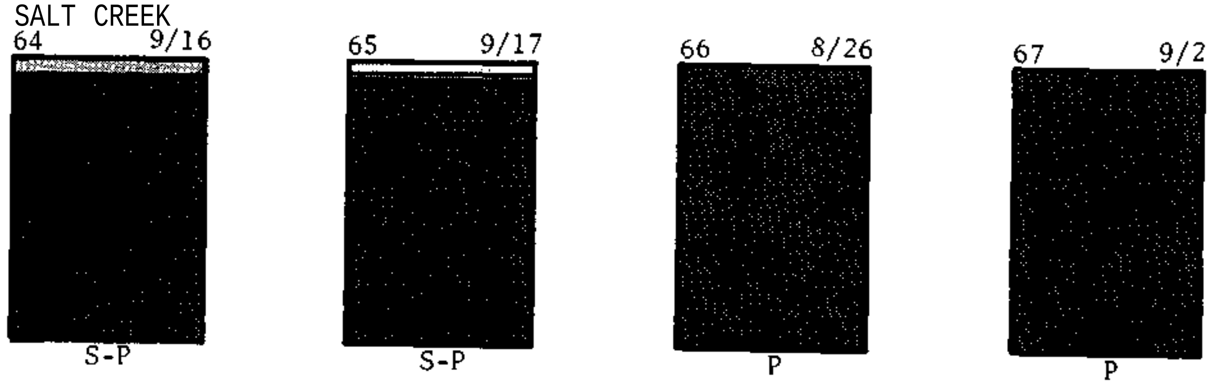


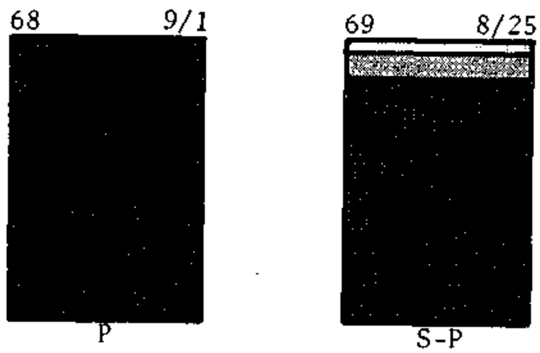

DU PAGE RIVER
46 9/27
S-P
47 9/27
S-P
48 10/13
P
DES PLAINES RIVER
49 10/7
P
50 10/7
P
51 10/7
P
52 10/8
P
53 10/6
P
54 9/16
S-P
55 9/9
P
56 9/15
P
57 9/16
S-P
58 9/10
S-P
59 9/8
S-P
60 8/26
S-P

DES PLAINES RIVER (Concluded)

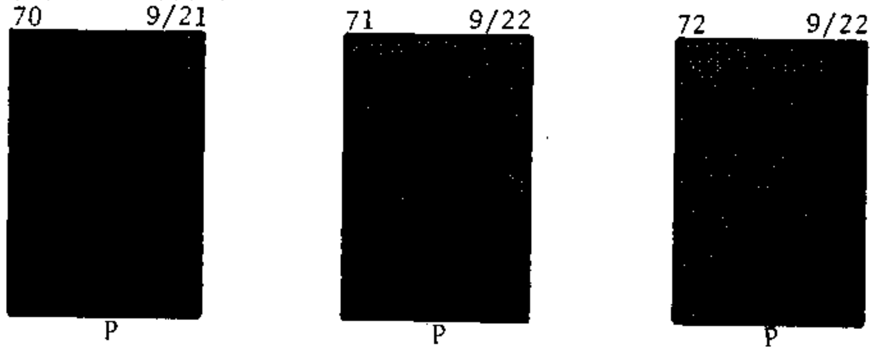


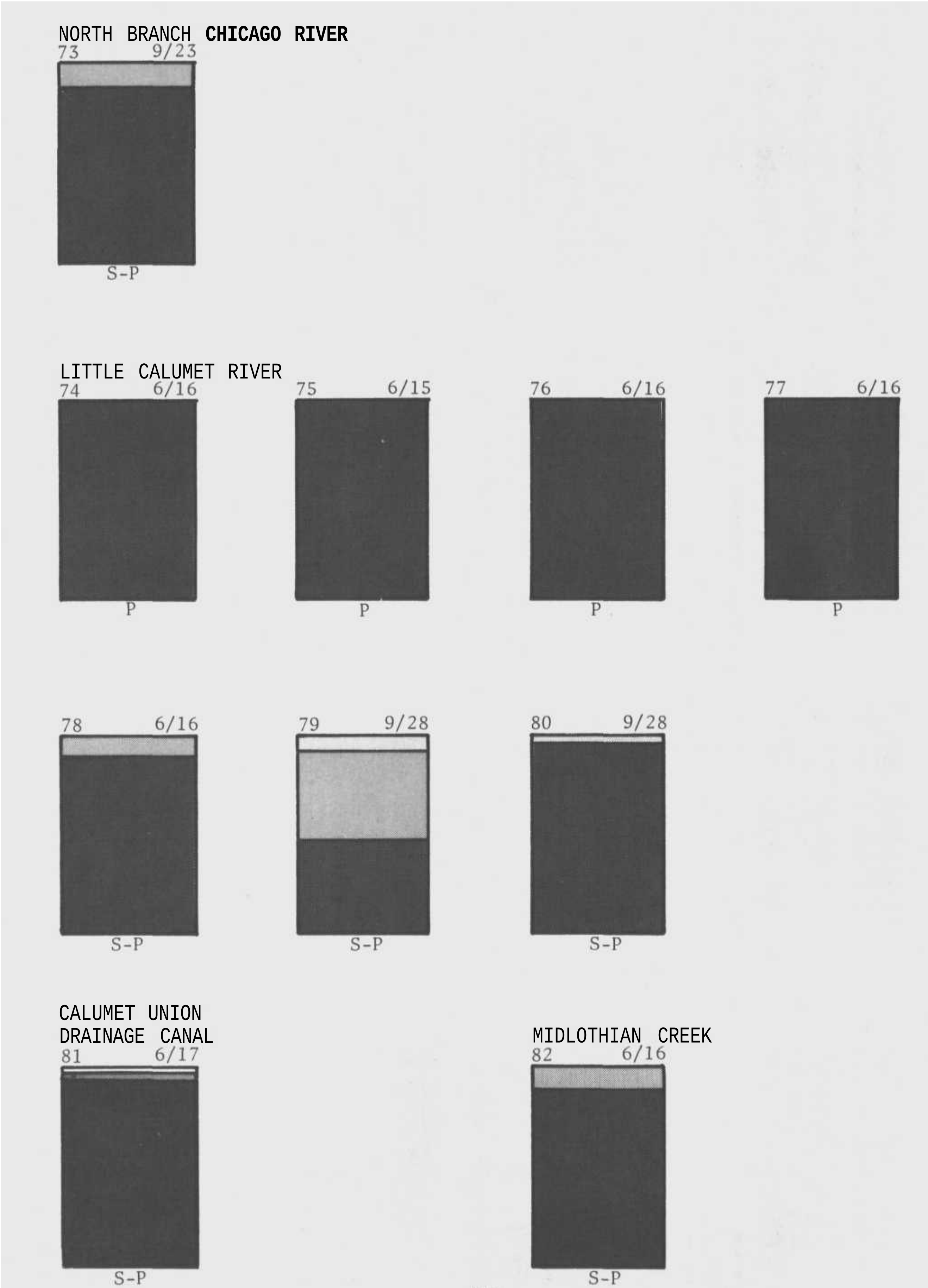
SALT CREEK





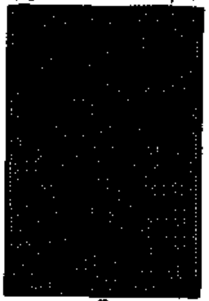
SKOKIE LAGOONS




NORTH BRANCH CHICAGO RIVER
73 9/23
S-P
LITTLE CALUMET RIVER
74 6/16
P
75 6/15
P
76 6/16
P
77 6/16
P
78 6/16
S-P
79 9/28
S-P
80 9/28
S-P
CALUMET UNION DRAINAGE CANAL
81 6/17
S-P
MIDLOTHIAN CREEK
82 6/16
S-P

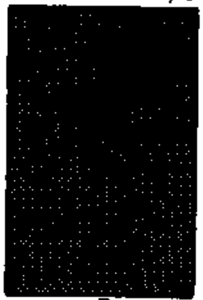
THORN CREEK

83 6/8



P

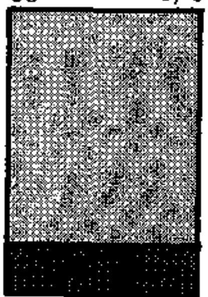
84 6/9



P

DEER CREEK

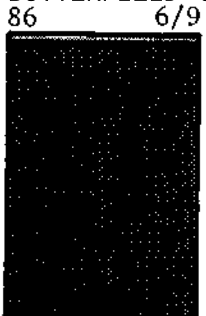
85 6/8



S-P

BUTTERFIELD CREEK

86 6/9



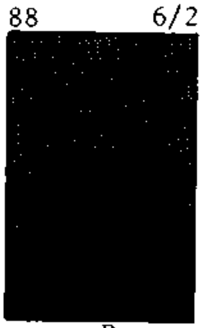
S-P

HICKORY CREEK

87 6/2

S-P

88 6/2



P

89 6/2

S-P

Appendix C. Physical Description of Surface Benthic Sediments

SOD station number	*Sample number*	*Water depth (ft)*	*Raw*	*Incinerated*	*Percent dried solids*	*Percent volatile solids*
1	1	6.0	watery, medium to coarse black sand, snail shells, shell frag., a little organic detritus	light brown silt, fine to coarse sand, shells	60.4	3.4
	2	7.0	watery, coarse gray sand, small rocks, shell frag. (on top of hard gray clay)	light brown fine to coarse sand, small rock	82.8	0.2
	3	6.5	gray black brown uniform fine sand with thin silt layer on top, shell frag.	light brown fine sand, many shell frag.	77.0	1.2
	4	5.0	medium to coarse black sand, snail shells, shell frag., a little organic detritus	light brown medium to coarse sand	83.4	0.9
	5	6.0	very black watery muck on top of small to medium gravel	light brown clay, some small gravel	39.9	6.5
2	6	6.0	black muck with medium to coarse sand, many pulverized shell frag.	brown medium to coarse sand, some silt, shell frag.	67.0	2.6
3	7	5.5	watery, sandy gray-black muck, many shells and shell frag.	fine to medium sand, silt, small gravel, shell frag.	63.9	3.3
4	8	5.6	thick sandy black muck	light brown clay with very fine sand	40.0	8.9
	9	5.7	watery brown silt on top of coarse sand-small gravel, few snail shells	light brown silt, some fine sand, very small gravel	53.9	4.5
	10	3.8	dirty brown coarse sand, small to medium gravel, a few snail shells	coarse sand and pea size gravel	83.3	3.5
5	11	2.8	gray black sandy compact mud	light red clay, fine sand	74.6	1.7
	12		watery gray-black sandy muck with some small gravel	light brown silty fine to medium sand, small gravel	65.6	3.6
6	13	5.0	gray-black to black sandy muck	light brown silty fine sand	73.6	2.1
	14	5.8	watery sandy muck on top of gelatinous black muck	light brown silt, fine sand	61.7	3.7
	15	6.5	watery gray-black slightly sandy muck, some small gravel, shells	light brown silt, coarse sand, small gravel	64.4	3.6
7	16	5.5	watery black sandy muck on top of more compacted black muck	light brown silt, fine sand	57.1	5.4
	17	4.8	watery gray-brown sandy muck mixed with small to large gravel	light brown silt, coarse sand, small gravel, snail shells	63.5	2.7
	18	4.3	watery gray-brown sandy muck mixed with small to large gravel	dark brown silty sand some small to medium gravel	77.8	2.2
	19	7.3	watery sandy gray black muck on top of rocks	light brown sandy silt	50.8	6.6
8	20	4.7	semi-compacted sandy black muck	light brown silt	51.0	8.6
	21	3.0	dirty coarse sand, medium to large gravel, shell frag.	dark brown medium to coarse sand, snail and clam shells	80.5	1.6

Appendix C. Continued

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
9	22	3.5	watery gray-black sandy muck, some organic detritus and small gravel	light brown silt clay, some small gravel and snail shells	61.5	3.6
	23	4.8	gray-black stratified gelatinous muck on top of compacted dirty sand	light brown silt-clay, a few snail shells	54.4	5.7
	24	5.3	thin layer of watery gray-black muck on top of dirty sand	light brown silt clay with some fine sand	55.2	4.6
10	25	7.7	very watery gray-brown muck with black streaks	light brown clay	31.5	8.0
11	26	5.3	thin watery muck on top of sand and shell frag.	dark brown silt-sand, shells	56.0	4.5
12	27	3.0	watery gray-black sandy muck, a little small gravel	light brown silt sand, small gravel, snail shells	59.3	3.9
13	28	4.4	very watery gray-black gritty muck on top of compact fine sand	light brown silt fine sand some very small gravel	57.0	5.4
	29	2.5	slightly muddy loose coarse sand and small gravel	a little silt, sand, small gravel	83.9	1.6
14	30	2.0	gray-black sandy muck	light brown silt, a little small gravel, snail shells	73.7	9.2
	31	3.1	dirty watery coarse sand, small to medium gravel	light brown medium sand, small to medium gravel snail shells	77.4	3.1
	32	2.0	very watery gray-black sandy muck	light brown silt, fine sand, a little gravel	69.0	5.2
15	33	2.5	clean coarse sand, small to medium gravel, shell fragments	dark brown, medium to coarse sand, small to medium gravel, snail shells	86.0	1.2
	34	6.1	thin watery layer of muck on top of medium to large gravel	light brown silt, some small gravel and clam shells	48.6	5.9
16	35	5.8	thin watery layer of gray-black muck on top sandy rocky marl	light brown silt	46.3	5.9
17	36	3.0	fine to medium to coarse dirty relatively dry sand	light brown silt, some fine sand, a few small shells	67.9	4.2
	37		coarse sand and shell fragments, snail shells	medium to coarse sand, snail and clam shells	70.1	6.6
	38	1.6	medium coarse sand, shell fragments and clean marl like material	medium to coarse sand, small clams and snails	77.9	1.7
18	39	5.3	dirty medium to coarse sand, some shell fragments	medium sand, small gravel, small to medium snail shells	77.5	2.8

Appendix C. Continued

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
19	40	4.0	dirty coarse sand, small to medium gravel	small to large sand, small to medium gravel, small shells some charred material	74.7	7.2
20	41	1.3	clean coarse sand, small to medium gravel	clean coarse sand with small to medium gravel	88.5	1.4
21	42	6.5	very watery black silt-clay slimey muck on top of large gravel and rocks	orange-brown clay with some sand and small to medium gravel	65.3	2.9
22	43	4.8	dirty sand, coarse sand, medium to large gravel, some organic detritus	orange brown, medium to coarse sand, small to medium gravel	84.6	1.8
	44	3.3	medium to coarse sand, medium to large gravel, some small shells	light brown medium to coarse sand, medium to large gravel, shells	85.9	1.3
	45	2.5	large rocks	large mud ball consisting of silt incrusted around rocks, very hard porous	65.3	2.9
	46	6.5	very watery black muck with small gravel	porous silt clumps, some sand and pulverized shells	34.5	7.8
	47	4.8	very watery black silt-clay, some fine sand, pulverized shell fragments	silt-clay, shell particles, a few whole snail shells	45.5	4.5
	48	4.8	slightly dirty black medium to coarse sand, small to large gravel	sand to large gravel, some whole snail shells	85.8	1.9
	49	6.3	slightly dirty, black fine to medium sand, small to large gravel	light brown silt to large gravel, whole snail shells	75.6	2.9
	50	5.0	slight dirty, black coarse sand to large gravel, whole snail shells	light brown sand and gravel, whole snail shells	75.8	2.4
	51	3.7	dirty black medium to coarse sand, medium gravel, large shell fragments	light brown silt to gravel, shells and shell fragments	73.0	3.4
	52	1.6	watery black silt clay on top of gelatinous organic muck	light brown porous clay mass	43.3	8.0
23	53	6.0	black watery medium to coarse sand, small gravel, shells and shell fragments	light brown silt to sand, shell fragments	67.5	4.1
24	54	2.5	loose dirty black medium to coarse sand, pulverized shell fragments	light brown silt and sand, many snail shells and fragments	70.0	3.7
25	55	1.1	slightly dirty fine to coarse sand, small gravel, some organic detritus	clean medium to coarse sand, very small gravel	85.6	0.4
26	56	1.2	watery black sandy muck, fibrous organic detritus	light brown silt-fine sand	67.2	3.1

Appendix C. Continued

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
27	57	0.8	clean fine to coarse sand, small to medium gravel	silt to medium gravel	84.4	1.1
28	58	1.5	watery black coarse sand, small to large gravel	light red fine to coarse sand, small to large gravel	81.8	2.1
29	59	1.5	very black sand-silt, small gravel	clean medium to coarse sand and very small gravel	85.6	0.4
30	60	1.3	loose brown coarse sand, small to medium gravel	silt to small gravel	82.7	1.7
31	61	1.2	thin layer of black flocculent silt on top of coarse sand to medium gravel	coarse sand and small gravel	85.3	0.8
32	62	0.2	thin brown flocculent silt on top of rocks and bed rock	reddish brown clay, coarse sand, some medium gravel	79.4	1.0
33	63	1.0	clean coarse sand, small gravel to large rocks, shell fragments	clean sand to medium gravel, shell fragments	90.2	0.8
34	64	2.0	light weight dry silt, some coarse sand, organic detritous, decayed vegetation	light brown silt-clay with some small gravel	49.2	13.9
35	65	2.0	black sticky medium to coarse sand, small to medium gravel, pulverized detritous	fine to coarse sand, small gravel	77.4	1.8
36	66	0.6	watery black sandy muck loaded with organic detritus, a little small gravel	light brown silt-clay	44.8	7.9
37	67	2.1	watery black silt loaded with pulverized organic detritus	light brown silt-clay	41.6	8.1
38	68	1.3	clean gray coarse sand to medium gravel, large rocks, large shell fragments	light brown silt, small gravel with silt coat	86.2	1.0
39	69	0.9	watery gray clay, medium to large gravel, large rocks, small shell fragments	light brown silt to small gravel, very hard	84.6	3.1
40	70	1.7	light brown muddy coarse sand, some woody material, glass fragments	silt, very small to medium gravel	77.5	2.4
41	71	2.0	gray-black gelatinous muck with slight petroleum smell		35.7	15.1
42	72	3.7	odorous, black septic sludge-like sandy muck	silt-sand with some small rocks	58.0	4.2
43	73	1.7	dirty black coarse sand, small mud balls, very small to small gravel	small rocks and gravel, some silt and sand	56.7	13.0
44	74	2.5	very watery black muck	light brown silt-clay, some medium sand	46.4	7.5
45	75	1.7	some black clay-silt, coarse sand, small gravel, small rocks, woody detritus	orange-brown silt and gravel coated with an orange-brown layer	76.2	3.3
46	76	1.8	light brown musty smelling fine sand to large gravel, small rocks, much filamentous algae	light brown sand and very small gravel	85.2	1.0

Appendix C. Continued

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
47	77	2.0	black growth on medium to large rocks, small to large gravel, some medium to coarse sand, filamentous algae	very small gravel to medium rocks	91.0	1.0
48	78	3.7	gray-black sticky muck with a little sand	hard dense clay	46.0	6.2
	79	3.0	gray-black watery uniform coarse sand	fine to coarse sand, some small shells	76.4	1.2
49	80	1.5	black septic sandy mud, clay balls, some small gravel	light brown fine sand and clay	52.0	6.9
50	81	1.0	gray-black dirty sand and gravel some small rocks	medium sand, very small to small gravel	81.4	0.9
51	82	2.2	gray-black dirty sand and gravel, some small rocks	sand, very small to small gravel and rocks	86.3	0.8
52	83	3.3	gray-black septic smelling silty sand, very small to small gravel	fine to medium sand, some clay and small gravel	77.1	1.8
53	84	1.5	gray-black sand, very small to medium gravel	fine to coarse sand, very small to small gravel	86.0	0.8
54	85	4.2	coarse sand, small to medium gravel	some brown clay and sand, small to medium gravel	88.6	0.8
	86		1"-2" of watery black muck on top of sand and gravel	light brown silt, very small gravel	49.6	5.5
55	87	3.0	12"-18" of watery black muck on top of sand and gravel	reddish brown silt-clay, some fine sand	57.3	6.4
56	88	3.0	watery black sandy muck, some large rocks	light brown clay and very coarse sand	60.0	3.4
57	89	3.3	black dirty coarse sand and gravel	brown clay, coarse sand, small to medium gravel	88.6	0.8
58	90	3.5	watery black muck loaded with fingernail clams	light brown clay-silt small gravel, fingernail clams	76.8	1.8
59	91	2.7	dirty black coarse sand, small to medium gravel, fingernail clams	light brown medium to coarse sand, very small gravel, fingernail clams	77.2	2.0

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
60	92	2.0	loose dirty black coarse sand, small to medium gravel, filamentous algae	light brown sand, small gravel	86.7	2.1
61	93	2.0	black watery oily muck loaded with fingernail clams and clam shells	very hard orange clay-silt, fingernail clams	42.6	8.7
62	94	5.0	coarse sand, small gravel, crushed shells, some gray clay chunks	very small to small gravel, fingernail clam shells	83.6	0.9
63	95	4.8	gray-black pasty or gelatinous muck	light brown extremely hard packed silt-clay	40.9	7.3
64	96	1.3	clean coarse sand and small gravel	clean sand and gravel	93.3	0.7
65	97	1.7	dirty coarse sand, small to large gravel	light brown clay, sand, small to large gravel	86.3	1.3
66	98	3.0	watery black sandy muck loaded with organic detritus and woody detritus	orange-brown clay to fine sand, some medium sand	60.5	6.9
67	99	3.5	dirty black coarse sand, small gravel	small gravel, some clay to fine sand	82.2	1.6
68	100	3.0	very black watery muck	light brown hard packed silt-clay	42.0	6.8
69	101	2.0	gray black dirty uniformly medium sand	light brown medium to coarse sand, some fingernail clam shells	78.3	2.6
70	102	6.5	gray clay with stratified layers of black clay, smooth and somewhat watery	light brown hard packed clay-silt	31.5	7.1
71	103	5.0	fresh looking brownish gray, somewhat watery silt-clay on top of black septic silt-clay	light brown-gray hard packed clay	43.3	5.2
72	104	0.7	earthy smelling gray-black-brown watery silt-clay	light brown hard packed clay	42.2	6.3
73	105	2.8	dirty gray slightly musty smelling coarse sand, very small gravel	reddish brown coarse sand to small gravel	83.8	1.4
74	106	2.6	black odorous sludge	orange hard packed clay	48.9	8.3
75	107	1.6	very black odorous fine sand	orange fine sand	76.5	3.6

Appendix C. Concluded

SOD station number	Sample number	Water depth (ft)	Raw	Incinerated	Percent dried solids	Percent volatile solids
76	108	1.6	black odorous sludge	orange hard packed clay	40.8	10.5
77	109	1.6	black odorous sludge	orange hard packed clay	44.9	6.2
78	110	2.4	coarse sand to large black septic looking rocks, some fingernail clams	orange crust over light gray sand, small gravel, shells, charred organics	75.7	9.7
	111	3.0	black septic coarse sand to large rocks	gray sand, medium rocks	85.2	2.1
79	112	5.5	black gelatinous muck and sludge, petroleum odor	light brown hard packed silt	46.8	6.6
80	113	7.5	thin watery muck on top of black coarse sand, some woody detritus and finger-nail clam shells	gray sand very small gravel	83.2	14.0
81	114	0.6	relatively clean coarse sand some small gravel and gray clay	orange sand, small gravel compacted with clay	77.5	3.4
82	115	0.7	medium to coarse clean sand, small gravel, a few shell fragments	sand and small gravel	74.9	4.9
83	116	0.9	fine to coarse gray sand, small gravel on top of hard gray clay	brown fine to coarse sand, small gravel, hard clay	86.9	2.1
84	117	1.7	coarse sand, shells and shell fragments, some silt and small gravel	light brown sand-silt	81.2	3.0
85	118	1.6	black sandy muck with sewage odor	light brown hard brittle clay	73.0	3.1
86	119	0.4	black fine to coarse sand	very fine sand-silt	81.6	1.4
87	120	4.0	compact gray clay-silt mixed with fine to coarse sand	orange silt-sand	43.4	7.6
88	121	5.5	gray-black somewhat watery silt-clay, some sand	orange silt-sand	48.2	8.4
89	122	4.5	dirty gray sand, shells, shell fragments	gray sand, shells, shell fragments, snail shells	75.8	4.9

Appendix D-1. Physical Description of Sediment Core Samples

Station number	*Depth interval (inches)*	*Description*
1	surface	no core possible, ponar dredge sample taken, water, sand
2	surface	no core possible, ponar dredge sample taken, thin layer of loose muck on top of fine sand
3	0-0.5	very watery sandy gray-black muck
	0.5-2.5	semi-compacted gray-black coarse sand with shells and shell fragments
	2.5-3.5	relatively dry coarse sand, considerable calcareous material and shell fragments
	3.5-6.0	very compacted dry to medium to coarse sand with a layer of very white dry compacted calcareous material
4	0-1.5	watery black mud with woody material and organic detritus
	1.5-9.5	gray-black gelatinous silty muck
	9.5-11.0	gritty gray-black muck with snail shells and shell frags.
5	0-2	very compacted gray-black uniform fine sand
	2-4	very compacted gray-black fine sand and some silt
	4-12	compacted gray uniform fine sand
	12-16	compacted gray fine sand with some silt
	16-17	gray-black sandy putty-like silt
6	0-0.5	thin watery sandy black muck
	0.5-1.0	transition from watery to compacted sand
	1.0-2.0	wet semi-compacted gray-black coarse sand
	2.0-5.0	compacted gray-black coarse to fine sand with some organic detritus
	5.0-6.5	relatively dry black fine sand with shell fragments and some small gravel
	6.5-9.5	dry compacted silt with shell fragments and small to medium gravel
	9.5-12.5	dry black silt-sand
	12.5-16.0	gray-black putty-like silt-clay
	16.0-17.0	gray-black putty-like silt-clay with some sand
7	0-0.5	watery silt-clay
	0.5-1.0	transition from watery silt-clay to semi-compacted silt-clay
	1.0-13.5	gray rubbery, putty-like silt-clay
8	0-1	watery black sandy muck
	1-3	very black coarse sand, shells, small gravel
	3-5	gray-black silt
	5-6	gray-black clay with coarse sand, small gravel, shells
9	0-2.5	loose dirty sand, snail shells, shell fragments, snail shells, small gravel
	2.5-6.0	somewhat compacted medium to coarse sand, small gravel, large snail shells, shell fragments
	6.0-10.0	compacted black fine to medium sand, a few shells, large piece of woody detritus

Appendix D-l. Continued

Station number	*Depth interval (inches)*	*Description*
10	surface-1"	no core possible, ponar dredge sample taken of thin watery gray-brown muck with black streaks on top of bed rock and stones
11	0-0.5	watery black sandy muck
	0.5-1.0	less watery gray-black sand and small gravel
	1.0-4.0	relatively dry black coarse sand to medium gravel, shells, shell fragments
	4.0-5.5	same as above with some silt-clay
	5.5+	appears to be solid rock
12	0-1	thin watery gray-black sandy muck
	1-3	gray-black silty muck
	3-4	gray-black sandy, silty muck
13	0-1.0	watery gray-black muck
	1.0-1.5	transition from watery muck to a more compacted sandy sediment containing organic detritus
	1.5-5.0	relatively dry compacted gray silt with shell fragments and organic detritus
	5.0-6.0	very fine gray-black sand with very finely pulverized shell fragments
	6.0-6.5	transition from fine sand to dry gray-brown sand and finely pulverized organic detritus
	6.5-10.0	gray brown heavily laden with finely pulverized organic detritus
	10.0-13.0	relatively dry compacted light gray sand containing shells, shell fragments, small gravel and a little organic detritus
14	0-1.0	sandy muck with thin watery surface layer containing detritous
	1.0-1.5	relatively dry sandy muck and small gravel
	1.5-2.0	transition from sand to compacted clay
	2.0-3.0	silt-clay with some sand and shell fragments
	3.0-4.5	relatively dry silt-clay with a few shell fragments
	4.5-6.5	marl type sediment with some silt clay and coarse shell fragments
	6.5-11.0	dry silt-clay with considerable pulverized organic detritus
15	0-0.5	watery medium to coarse clean sand and fine to medium gravel
	0.5-4.5	gray-black medium to coarse sand, large gravel some shell fragments
16	0-0.5	thin watery gray-black muck
	0.5-2.0	less watery sandy muck
	2.0-3.5	large gravel and rocks with some coarse sand, small gravel, and shell fragments

Appendix D-l. Continued

Station number	Depth interval (inches)	Description
17	0-1	dry fine dirty sand
	1-2	compacted fine dry dirty sand
	2-5	fine dirty sand with some silt and clay
	5-7	compacted black silt-clay
	7-9	dirty fine to medium sand, some shell fragments
	9-11	primarily woody detritus, some snail shell fragments
	11-12.5	dirty medium to coarse sand, shell fragment, some small gravel
18	0-6	dirty medium to coarse sand, some small gravel and snail shells
19	0-3	large rocks
	3-5	small rocks, coarse dirty gravel with some organic detritus
	5-12	black dirty coarse sand to small gravel
20	0-2	large rocks
	2-4	large gravel to small rocks
	4-7	small to large gravel
21	surface	no core possible, very watery black muck over medium to large gravel and rock, rocks stained and coated with a black anaerobic looking film
22	0-0.5	dirty black spetic looking fine sand and some silt
	0.5-3.0	large rocks
	3.0-5.0	large gravel, small rocks
	5.0-9.0	coarse sand, large gravel, small rocks
23	0-1.5	dirty black fine to coarse sand, gravel, some small and organic detritus
	1.5-2.0	silt-clay with gravel and small rocks
	2.0-4.0	dirty silty fine sand, small to medium gravel, shell fragments, some organic detritus
24	0-0.5	very flocculent gray-black silt clay
	0.5-6.5	gelatinous gray-black silt clay
	6.5-9.0	somewhat drier and more compacted gray-black silt-clay
	9.0-10.0	same as above except organic detritus evident
	10.0-14.0	compact gray-black silt-clay
	14.0-14.5	sandy silt-clay with some small gravel and snail shells
25	0-12	loose watery gray-brown fine to coarse sand, small gravel, shell fragments
26	0-5	black fine to medium sand
	5-8	very black compacted fine to medium sand with some silt-clay and shell fragments
	8-9	same as above with some small gravel
	9-14	compacted putty-like gray clay
	14-16	transition from gray clay to black fine sand
	16-17	gray-black uniform fine sand

Appendix D-l. Continued

Station number	Depth interval (inches)	Description
27	0-1	loose gray-brown fine sand to medium gravel, some shell fragments
	1-3	dark gray-brown coarse sand to large gravel woody detritus
	3-5	gray compacted organic detritus in coarse sand
	5-8	loose black coarse sand to medium gravel
28	0-2.0	loose black coarse sand to medium gravel
	2.0-3.0	compacted coarse sand to medium gravel
	3.0-7.5	dry compacted gray clay with some small gravel
29	0-0.5	very black fine to coarse sand
	0.5-7.5	gray-brown fine sand to small gravel
	7.5-9.0	black organic sand
	9.0-11.5	solid wood
30	0-2.0	loose conglomeration of gray-yellow clay, sand, gravel
	2.0-6.5	hard compacted gray clay
	6.5-7.0	yellow clay-sand mixture
31	0-2	small to large gravel and rocks
	2-4	gray-black coarse sand to medium gravel
	4-7	watery gray medium to large gravel
32	-	no core possible, photo is of stream, sandy rocky bottom; fine sand to large gravel and jagged-edged large rocks on top of bed rock
33	0-2	medium to large gravel
	2-4	coarse sand to medium gravel, shell fragments
	4-9	dirty coarse sand to medium gravel
34	0-0.5	dirty coarse sand to very large gravel
	0.5-1.5	very black clay-silt, medium to coarse sand, some organic detritus
	1.5-2.5	transition from black sand-gravel to clean medium sand, organic detritus
	2.5-6.0	gray clean silt-sand to medium gravel
35	0-0.5	very watery black septic silt
	0.5-1.5	dirty black coarse sand, small gravel
	1.5-2.5	compacted black septic coarse sand, with small to medium gravel
	2.5-4.5	very compacted dry black septic sand, small gravel
	4.5-5.5	gray-black medium to coarse sand
	5.5-8.5	gray medium to coarse sand
36	0-1.0	very watery black muck with small gravel
	1.0-1.5	dry black septic muck with considerable organic detritus
	1.5-2.0	transition between sediment and native bottom
	2.0-5.5	dry compacted gray-black clay-silt
	5.5-13.5	very hard compacted gray-black clay-silt
	13.5-15.5	same as above with considerable organic detritus

Appendix D-l. Continued

Station number	Depth interval (inches)	Description
37	0-1.0	very watery earthy smelling black muck
	1.0-3.0	semi-watery very black septic looking muck
	3.0-4.5	semi-compacted very black gray streaked muck
	4.5-5.0	transition between muck and sand-gravel
	5.0-8.5	black sand to small gravel
38	0-3.0	medium to large rocks
	3.0-5.5	dirty gray coarse sand to large gravel shell fragments
	5.5-6.5	same as above but cleaner
39	0-3.0	large rock and stones coated with thin layer of slime bacteria
	3.0-3.5	gray clay, coarse sand to small gravel
	3.5-6.5	very hard compacted relatively dry clay
40	0-2	medium to large gravel and rocks
	2-3	medium sand to medium gravel
	3-5	gray-black silt, coarse sand, small gravel
	5-7	light gray silt, coarse sand, large gravel
	7-11	light gray compacted clay with some small gravel, fibrous organic material
41	0-2	very black muck loaded with detritus
	2-6	very black septic looking muck
	6-9	same as above except drier
	9-10	black septic looking silt-clay, coarse sand, small gravel
	10-11	gray-black sand with some silt-clay, transition to native soil
	11-13	native gray clay-silt and coarse sand
42	0-2	black septic sandy-gravely muck
	2-3	same as above but more compacted
	3-6	gray-black relatively dry coarse sand and small gravel
	6-8	black septic looking clay-silt, coarse sand, organic detritus
	8-9	gray loose coarse sand
	9-11	dry gray clay to coarse sand
	11-19	dry, very compacted gray-black clay
43	0-0.5	very black dirty loose coarse sand, clay balls
	0.5-1.0	dry coarse sand with clay balls
	1.0-3.5	dry compacted black clay to medium gravel
	3.5-8.5	dry compacted black silt-clay
	8.5-9.0	lense of very fine gray-black sand
	9.0-13.5	dry compacted black silt clay
44	0-0.5	watery, gray muck
	0.5-2.0	watery very black muck with some organic detritus
	2.0-3.0	more compacted gray-black muck
	3.0-9.0	semi-compacted gray silt
	9.0-14.5	compacted gelatinous gray silt-clay
	14.5-15.0	dry compacted silt-clay with some rocks

Station number	*Depth interval (inches)*	*Description*
45	0-2.0	dirty coarse sand, some organic detritus
	2.0-3.0	same as above except contained a 2" chunk of clay
	3.0-6.0	dirty black septic-looking coarse sand and small gravel
	6.0-7.0	semi-compacted black clay-silt with organic detritus
	7.0-8.0	very black septic-looking coarse sand with organic detritus
	8.0-9.5	very compacted black organic detritus
	9.5-11.0	large pieces of compacted woody detritus (leaves, woods chips, etc.)
	11.0-14.0	same as above except some clay mixed within
	14.0-15.0	small stones, one large rock some clay-silt and organic septic-looking organic detritus
46	(0-3± under rocks)	rocky, gravel bottom, no good core possible, tan coarse sand under rocks
47	-	rocky, gravel bottom no core possible
48	0-2	thin watery gray-black silt-clay
	2-10	gray-black gelatinous silt-clay
	10-11	same as above but more black and septic
	11-13	dry black silt-clay, shells, shell fragments, organic fibrous material
	13-17	hard compacted gray-black silt-clay
49	0-0.5	loose gray-black dirty fine sand
	0.5-1.5	dry gray-black silty sand
	1.5-6.5	gray-brown silt-clay with some fine sand and organic fibrous material
	6.5-7.0	gray-brown fine sand with woody detritus
	7.0-11.5	clean gray fine sand
	11.5-16.0	clean gray fine sand with woody detritus
50	0-5.5	gray-black coarse sand
	5.5-6.5	lense of black sand with organic and woody detritus
	6.5-9.0	coarse sand to medium gravel, shell fragments
51	0-3.0	loose coarse gray sand and pea gravel
	3.5-8.5	very hard dry gray clay with large gravel fragments
52	0-1	gray-black silty sand with organic detritus and large leaf fragments
	1-3	gray-brown coarse sand, small to medium gravel
	3-4	brown medium gravel to large rocks
53	0-2	loose coarse sand to large gravel, some hard clay
	2-5	gray-black coarse sand to large gravel
54	0-3	clean loose small to medium gravel
	3-5+	loose gravel with some fine black sand
55	0-1.0	watery black muck
	1.0-3.0	watery black muck with coarse sand to large gravel

Appendix D-l. Continued

Station number	*Depth interval (inches)*	*Description*
55	4.0-5.0	very compact gray medium sand to large gravel
	5.0-6.5	complex mix of gray clay,coarse sand, gravel
	6.5-9.0	very compact putty-like gray clay
56	0-1.0	watery sandy black muck
	1.0-11.5	dry gray-black coarse sand
57	0-4	thin layer of muck on top of loose black sand and gravel
	4-10	very compact putty-like gray clay
58	0-1.0	dirty black coarse sand with many fingernail clams
	1.0-4.0	gray-black medium sand to small gravel
	4.0-6.0	gray coarse sand and small gravel
	6.0-10.5	gray coarse sand, small to medium gravel, large rocks
	10.5-13.5	gray fine to coarse sand, very small gravel
	13.5-18.0	dry compact gray-brown fine sand
	18.0-20.5	very loose watery small gravel
59	0-1	very watery black coarse sand
	1-3	less watery gray-black coarse sand, shell fragments
	3-10	same as above but more compact and drier
	10-17	same as above but compact and dry
60	0-9+	dirty black coarse sand to large gravel
61	0-4	watery black oily muck
	4.0-4.5	watery black muck
	4.5-10.5	hard compact dry gray-tan clay
62	0-10	very loose but dry coarse sand small gravel, shells
63	0-1.0	gray-black pasty silt
	1.0-6.0	gelatinous gray-black silt
	6.0-16.0	putty-like gray-black silt
	16.0-16.5	dry gray-black silt with shells and shell fragments
64	0-3	clean coarse sand to large gravel
	3-7.5	very hard compact dry gray clay
65	0-2.0	gray brown coarse sand to large gravel
	2.0-6.5	brown clay with coarse sand to medium gravel
66	0-3	watery slightly sandy black muck loaded with leaves and woody detritus
	3-4	very black layer of organic material
	4-7	light to dark gray putty-like clay
	7-9	light to dark gray putty-like clay with dirty coarse sand
67	0-1.0	gray-black clay mixed with coarse sand and gravel
	1.0-3.5	black medium to coarse sand mixed with medium gravel
	3.5-4.5	same as above but more compact
	4.5-8.0	compact dry coarse sand and gravel with woody detritus
	8.0+	small to medium gravel

Appendix D-l. Continued

Station number	Depth interval (inches)	Description
68	0-1.0	watery gray-black muck
	1.0-2.5	watery black muck with decaying leaves and woody detritus
	2.5-4.5	more compacted black muck
	4.5-6.0	same as above but more compacted
	6.0-8.0	relatively dry compacted muck
	8.0-11.0	relatively dry compacted muck with some sand and gravel
	11.0-13.0	gray-black sandy pasty silt-clay
	13.0-16.0	very dry black medium to coarse sand
69	0-0.5	loose dirty sand medium size rock fragments
	0.5-1.5	dry dirty sand large gravel and rock fragments
	1.5-3.0	dry hard compacted tan clay with small rocks
70	0-2	very watery black clay
	2-5	watery black clay
	5-14	less watery black clay
	14-17	semi-compacted gray black streaked clay
71	0-2	watery gray-black clay
	2-8	less watery black, gray-streaked clay
	8-9	semi-compacted black, gray-streaked clay
	9-11+	compacted gray clay
72	0-2	gray silt-clay with septic black streaks
	2-6	very black gelatinous clay
	6-9	relatively dry gray-black silt-clay
	9-10	transition from silt-clay to dry black sand
	10-17	uniform gray-black sand with lenses of dry gray silt
73	0-0.5	loose gray-black coarse sand to medium gravel
	0.5-2.5	very loose gray coarse sand small gravel
	2.5-3.5	same as above but black and septic looking
	3.5-4.5	sandy gray clay
	4.5-7+	very dry compacted, putty-like gray clay
74	1-2	very watery muck with clay balls
	2-7	watery muck with small clay balls and organic detritus
	7-17	pasty gray clay
	17-20	compacted hard gray clay
75	0-0.5	thin septic-looking flocculent silt
	0.5-1.0	loose black fine sand with organic detritus
	1.0-2.0	fine sand, small gravel loaded with worms
	2.0-5.5	uniform compacted fine black sand
	5.5-6.0	transition from black sand to clean fine sand to small gravel and rocks
	6.0-10.5	uniform fine clean gray sand
76	0-2.0	watery sewage-like sludge loaded with worms
	2.0-8.0	less watery sewage-like very black sludge
	8.0-9.0	transition from contaminated surface sediments to natural gray-black clay-silt
	9.0-12.0	gray sandy clay-silt

Appendix D-1. Continued

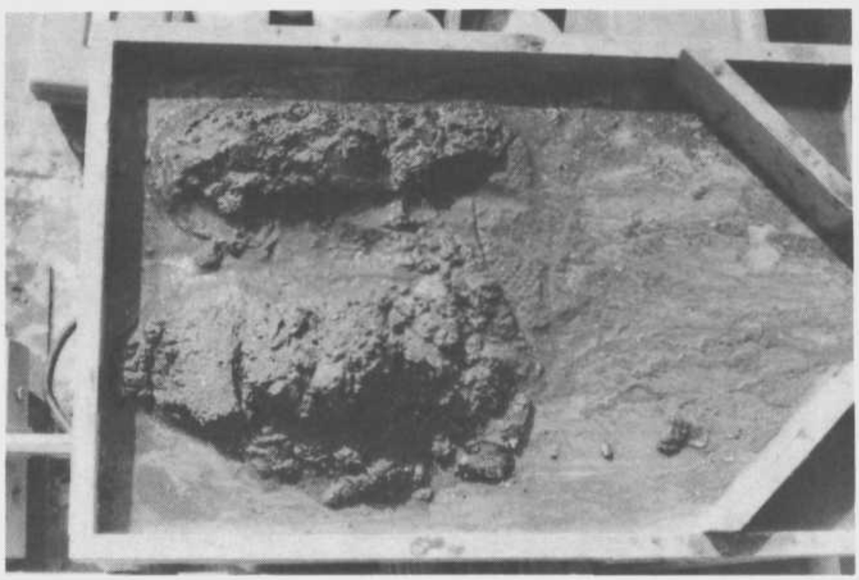
Station number	Depth interval (inches)	Description
76	12.0-13.5	coarse sand with some silt-clay
	13.5-17.0	relatively dry compacted clay-sand with many shell fragments and marl-like material
	17.0-20.5	dry compacted sandy-clay
	20.5-21.5	sand with some shell fragments and clay
	21.5-23.0	dry sandy clay
	23.0-25.0	coarse sand with some shell fragments
77	0-0.5	very watery black muck
	0.5-1.0	watery black muck
	1.0-3.0	semi-compacted gray-black muck
	3.0-6.0	semi-compacted gray muck with organic detritus
	6.0-7.0	watery black muck
	7.0-8.0	semi-compacted gray-black muck
	8.0-12.0	compacted gray-clay
	12.0-24.0	compacted gray clay with black streaks
	24.0-36.0	dry compacted gray clay with some thin lenses of black clay
78	surface	no core sample taken, sandy rocky bottom; coarse sand to large rocks with zoogleal growth
79	0-3.0	watery black silt-clay
	3.0-10.0	semi-compacted gray-black silt-clay
	10.0-15.0	compact gray-black silt-clay
	15.0-20.5	compact gray silt-clay with black streaks
	20.5-23.5	uniform relatively dry fine gray sand
80	-	no core sample taken; stations 79 and 80 are on the same cross section, 79 is near the left bank, 80 on the centerline; ponar taken at 80 showed a thin layer of watery muck on black coarse sand
81	0-1.0	gray-brown coarse sand
	1.0-1.5	thin layer of tan clay
	1.5-4.5	very hard compacted gray clay
82	0-5	clean coarse sand
	5-7	clean coarse sand, small gravel, small rocks
83	0-2	gray-black fine to coarse sand
	2-6	extremely hard compacted gray clay
84	0-1	gray coarse sand to large gravel
	1-4	dirty coarse sand
	4-5	semi-compacted gray clay with medium gravel
	5-13	very hard compacted dry gray clay
85	0-0.5	watery silt-sand with some organic detritus
	0.5-2.5	compacted gray, black streaked clay
	2.5-5.5	relatively clean fine sand to very small gravel
	5.5-9.0	compacted gray-black silt-clay and fine sand
	9.0-11.0	silt-clay, fine sand, some small gravel

Appendix D-l. Concluded

Station number	Depth interval (inches)	Description
	11.0-13.0	small gravel with some silt
	13.0-14.0	small gravel with some silt and fine sand
	14.0-14.5	hard compacted gray clay
86	0-0.5	relatively clean loose fine sand
	0.5-2.5	clean compacted fine sand
	2.5-6.0	clean coarse sand to medium gravel
87	0-2	semi-compacted gray-black silt-clay
	2-10	compacted gray-black silt-clay
	10-12	dirty fine sand to very small gravel
88	0-1	watery gray-black silt-clay
	1-12	semi-compacted silt-clay with some sand
	12-18	compacted silt-clay
	18-22	coarse sand, small gravel, some organic detritus
89	0-2.0	clean coarse sand, shell and shell fragments
	2.0-5.0	semi-compacted silt-clay
	5.0-5.5	dirty fine sand
	5.5-9.0	compacted silt-clay
	9.0-9.5	coarse sand with some silt clay
	9.5-11.5	compacted silt-clay
	11.5-13.5	coarse sand and small gravel
	13.5-15.0	silt-clay, fine sand

Appendix D-2. Photographs of Core Samples

SOD STATION 1



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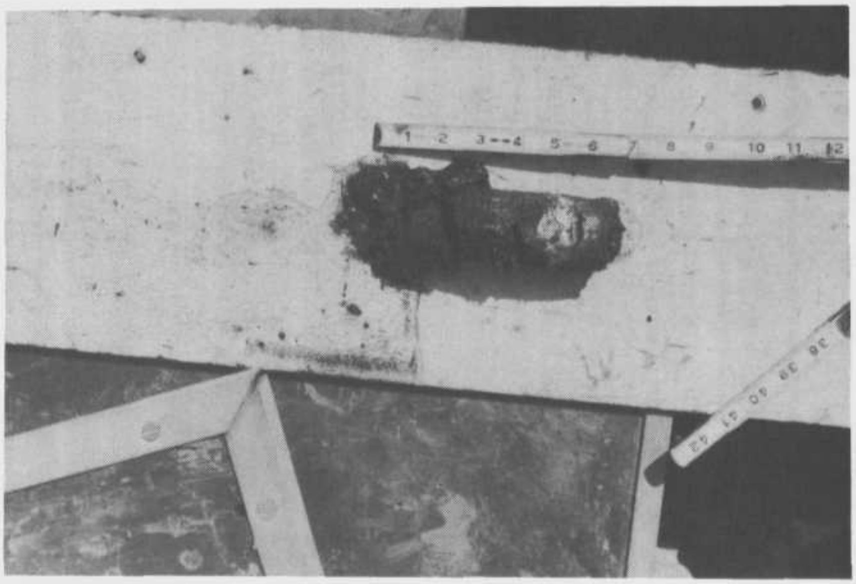
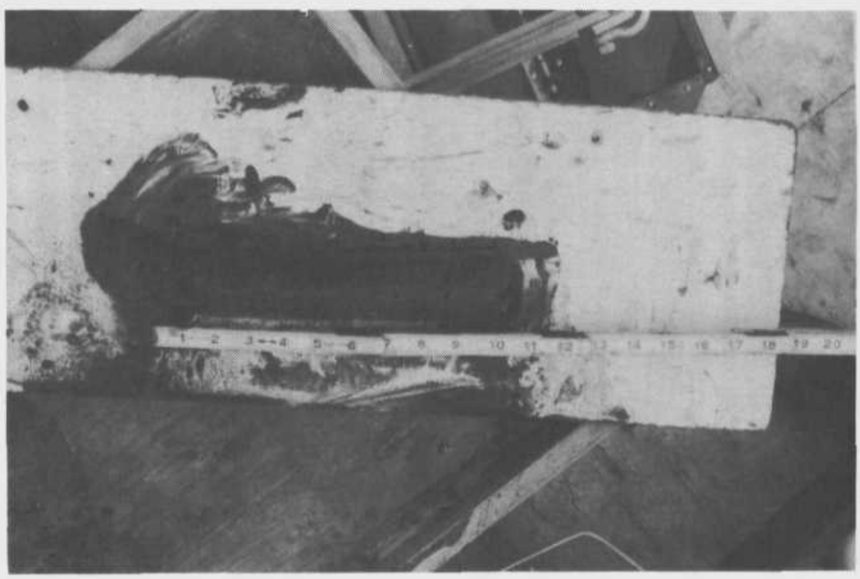
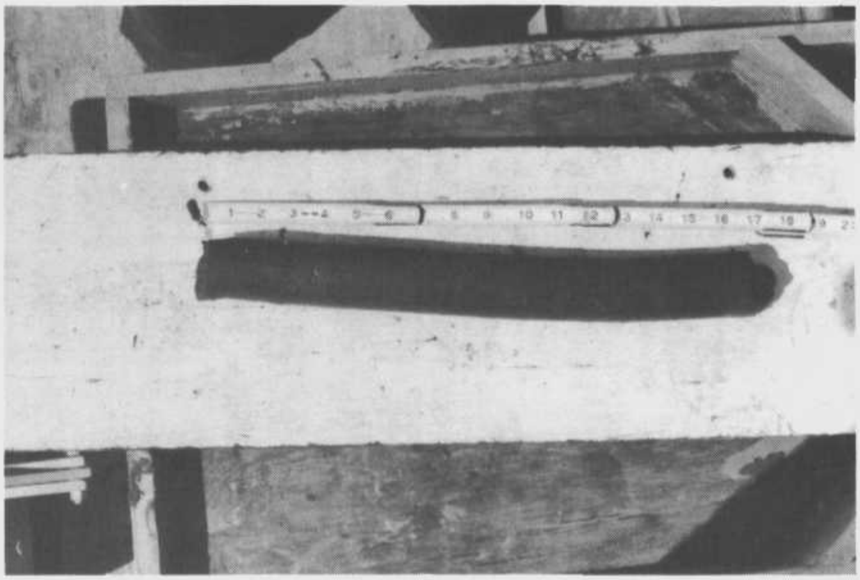


SOD STATION 3



SOD STATION 4



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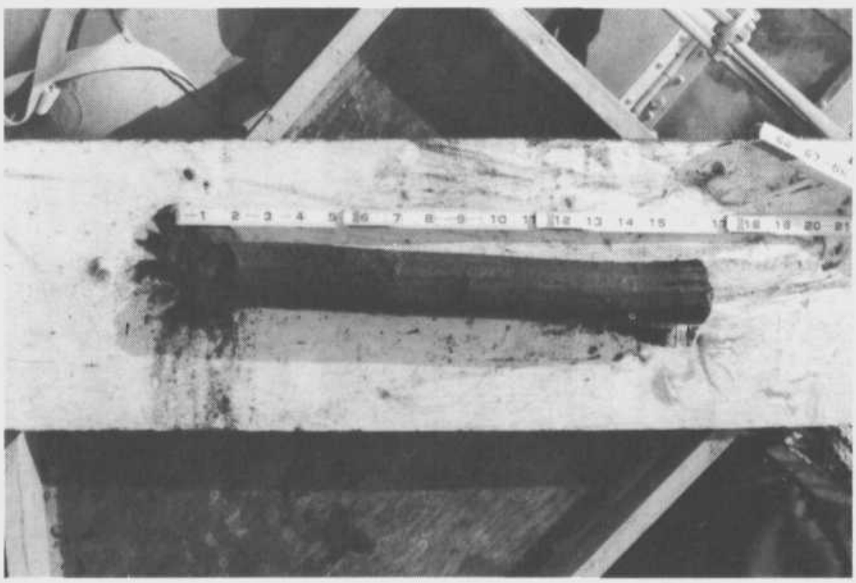

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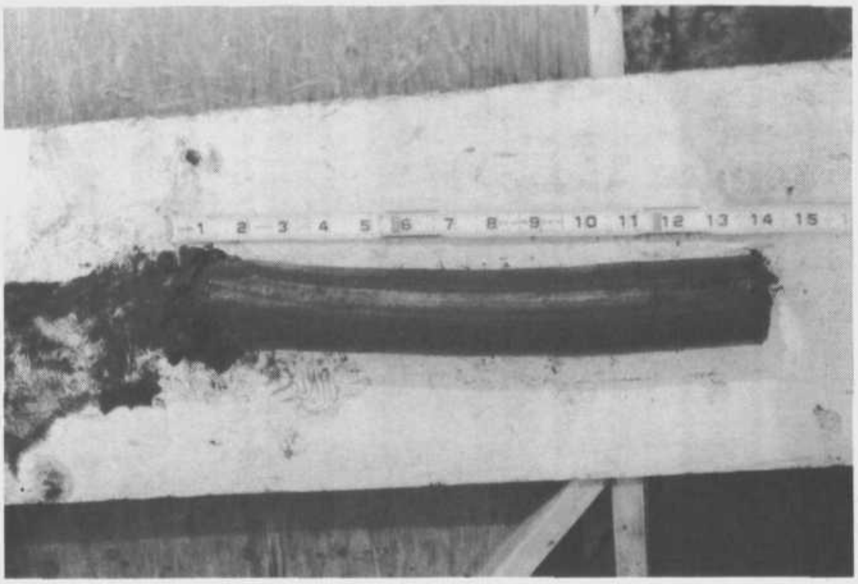

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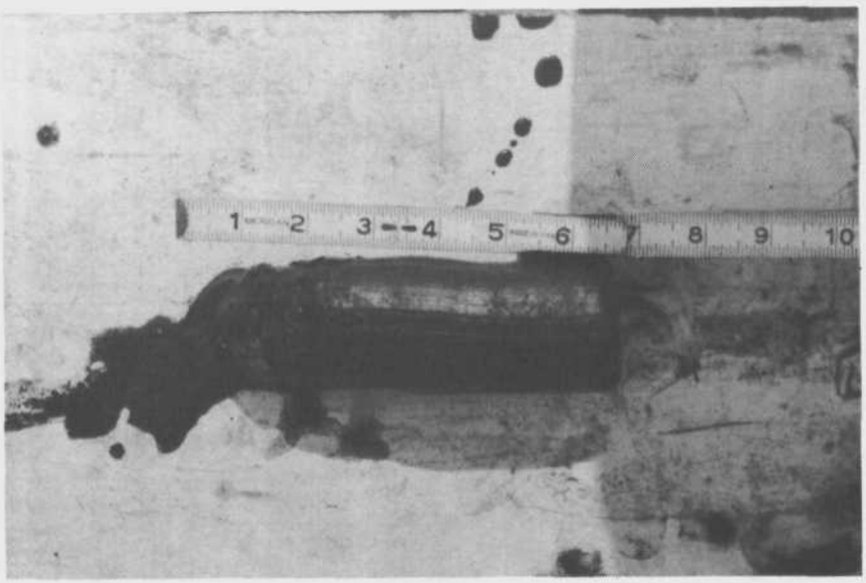

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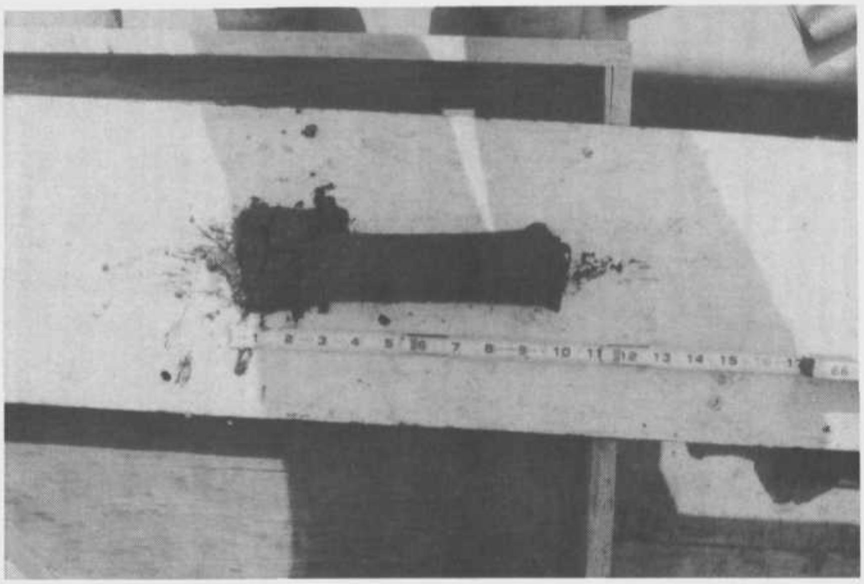

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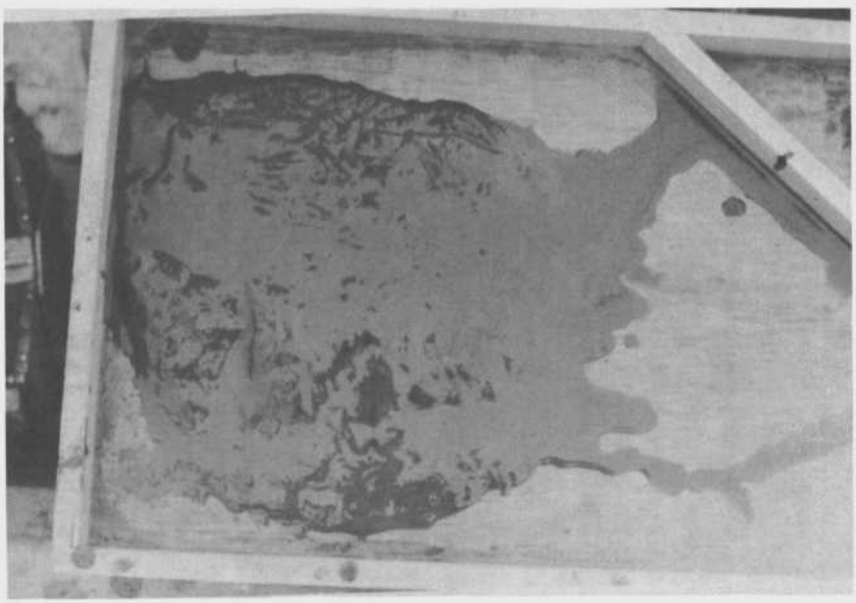

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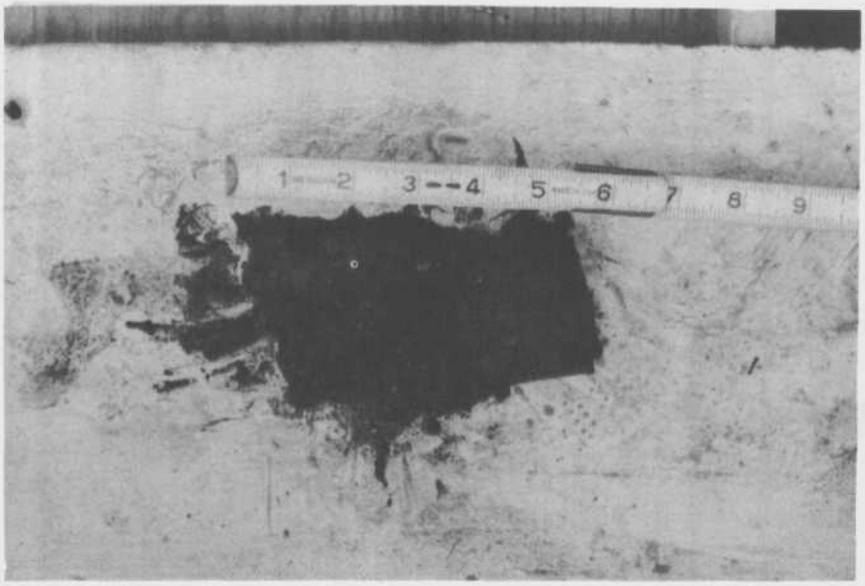

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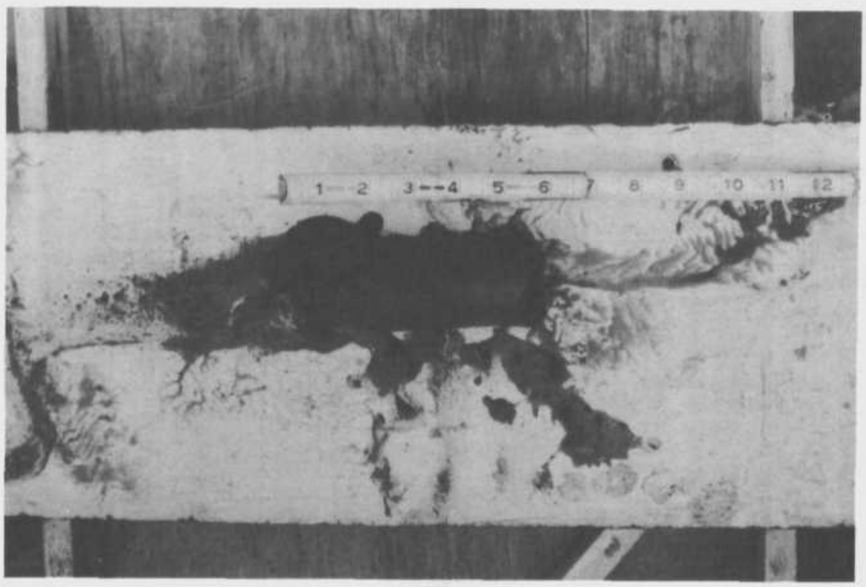

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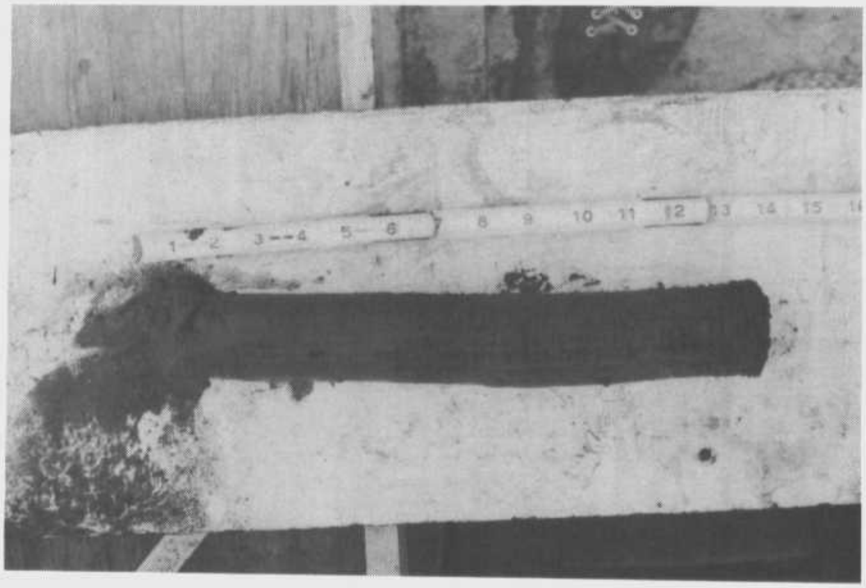

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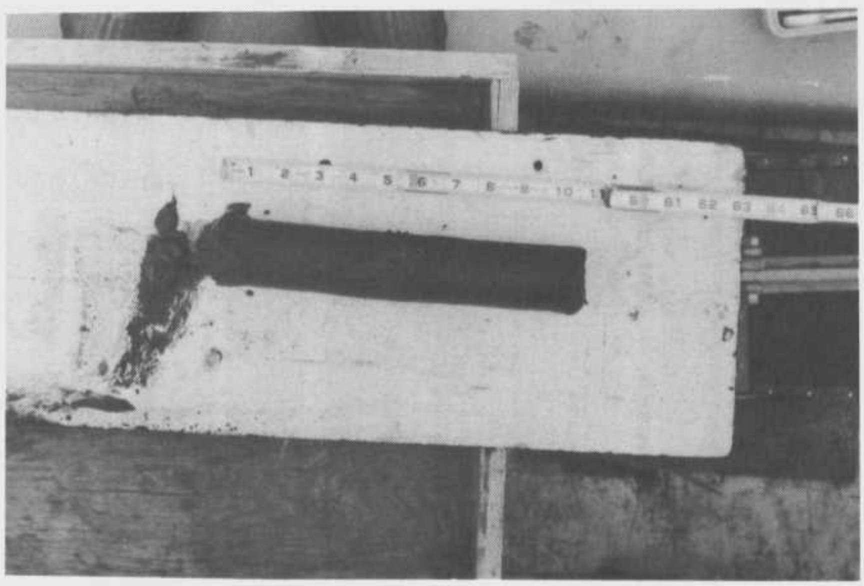

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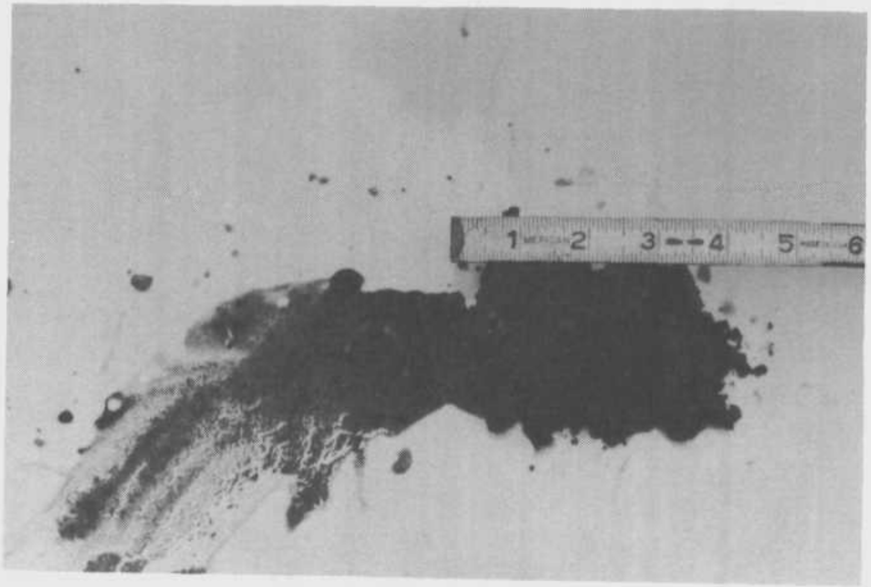

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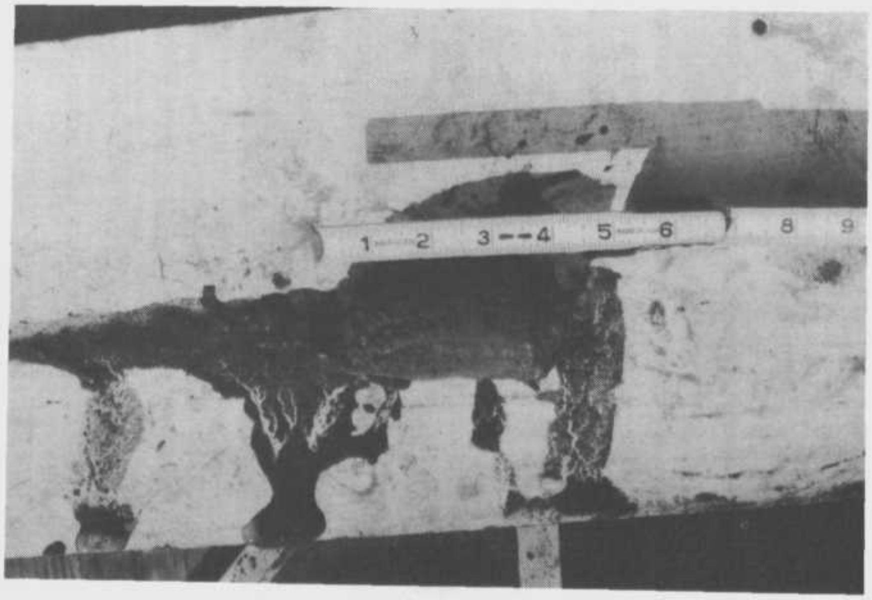

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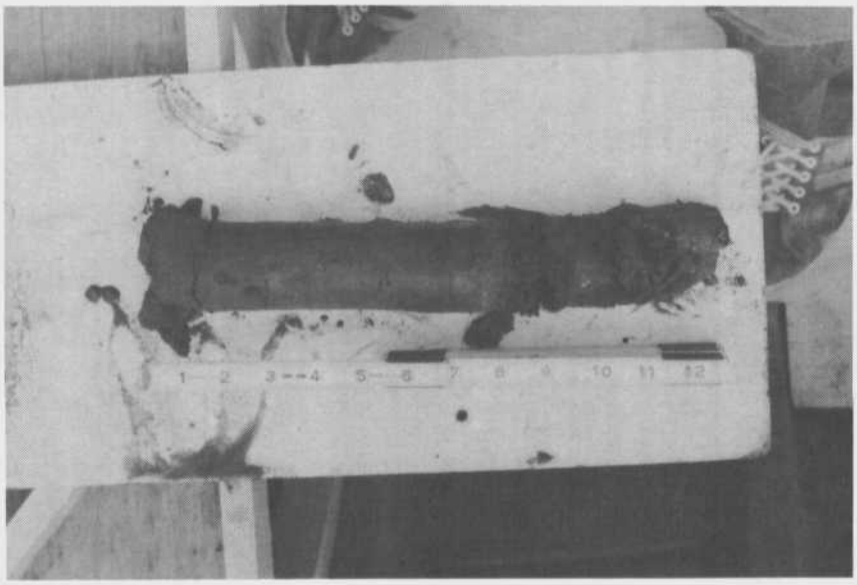

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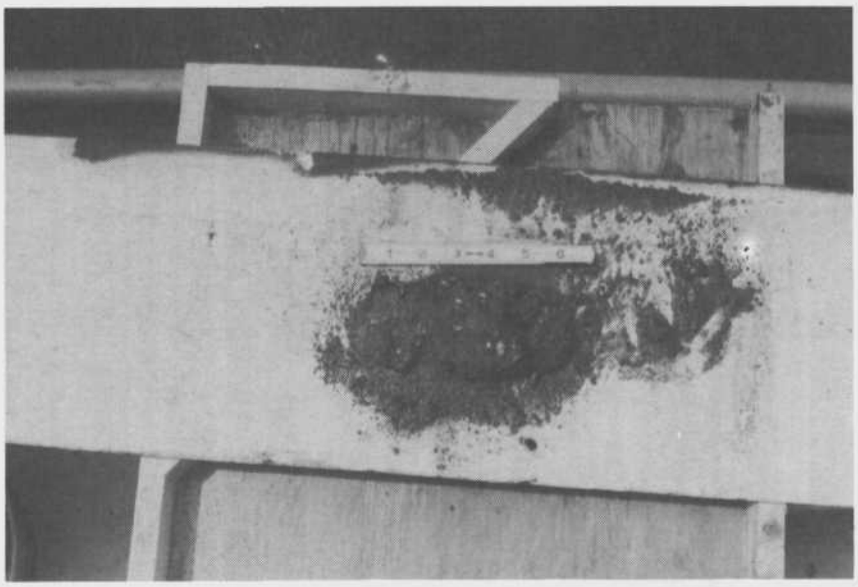

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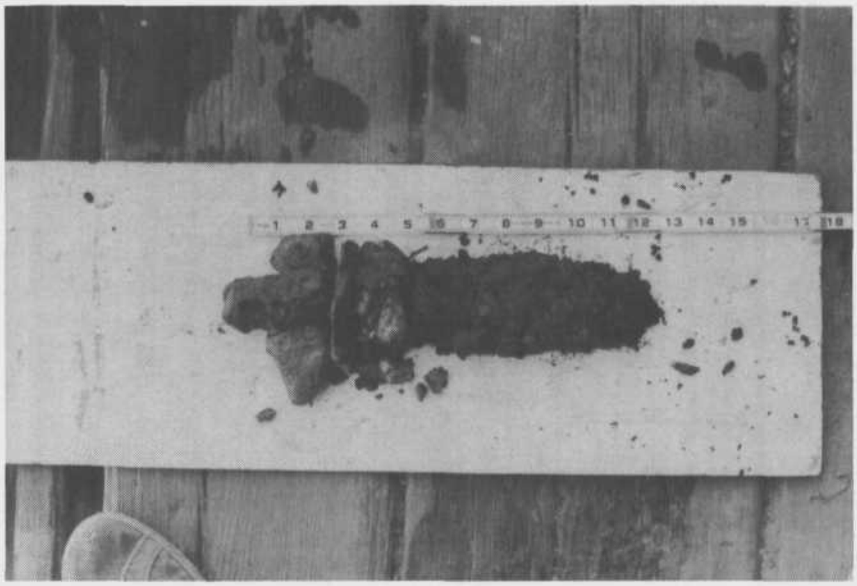

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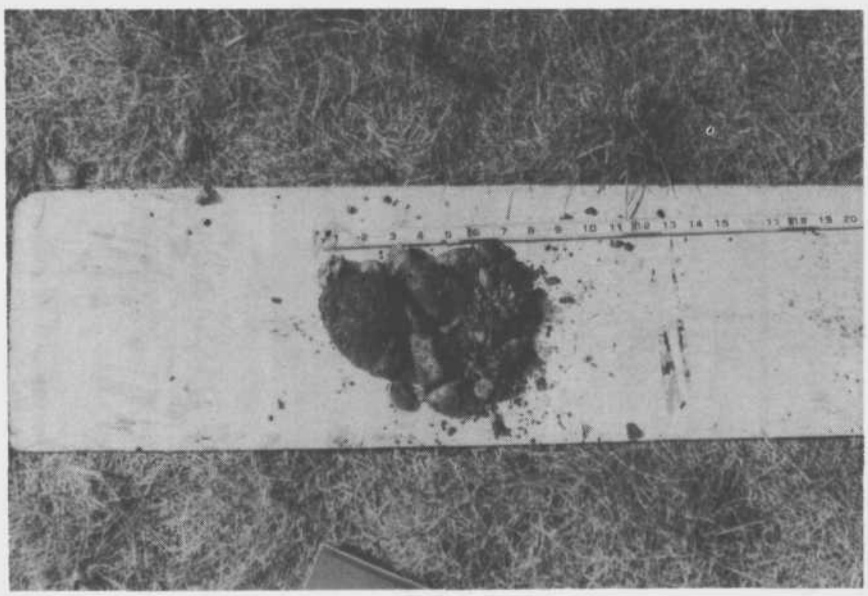

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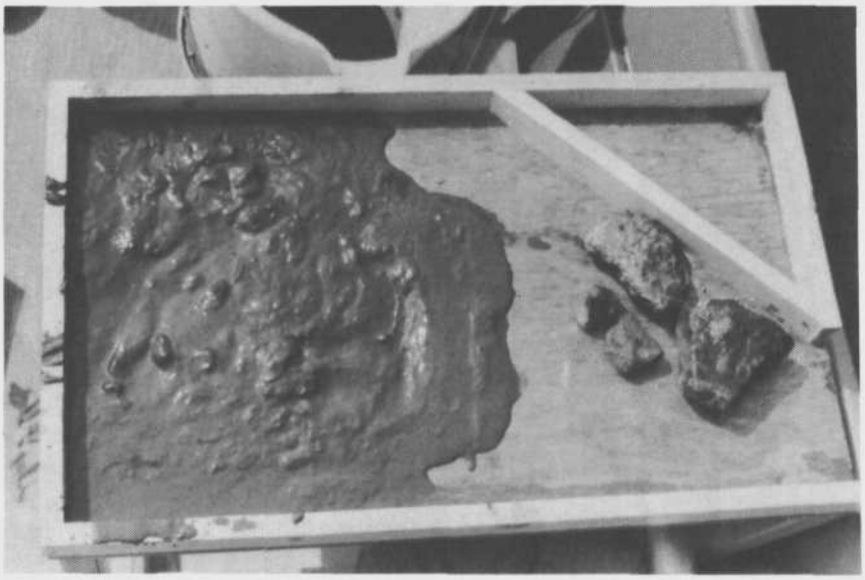
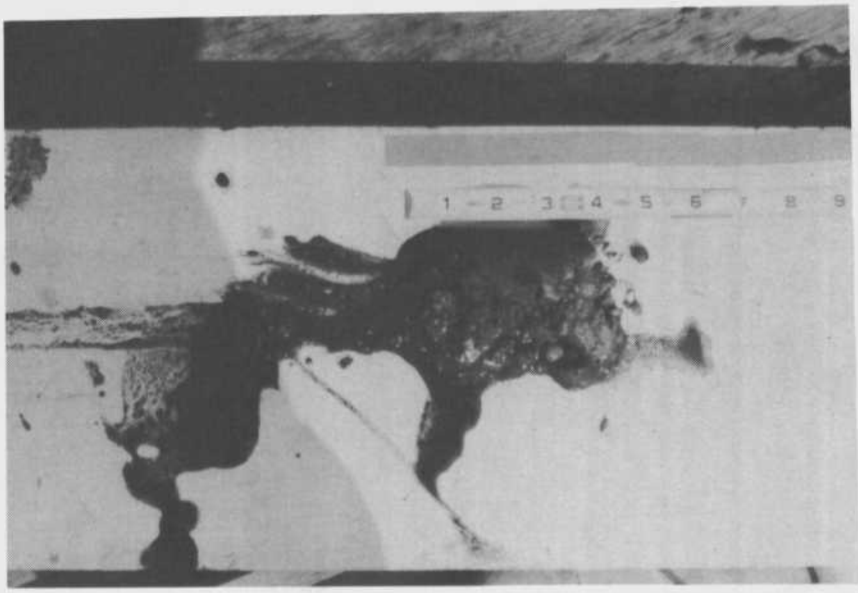


SOD STATION 21

SOD STATION 22



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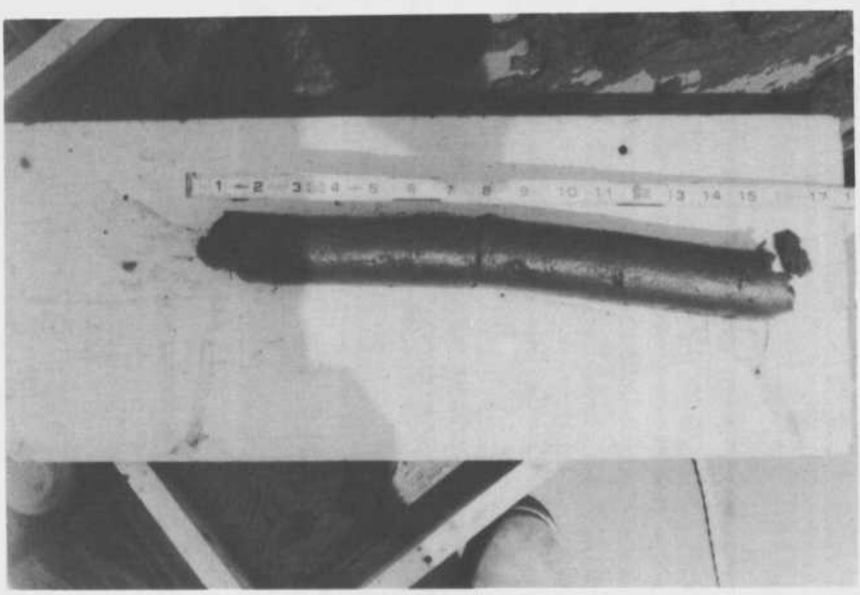

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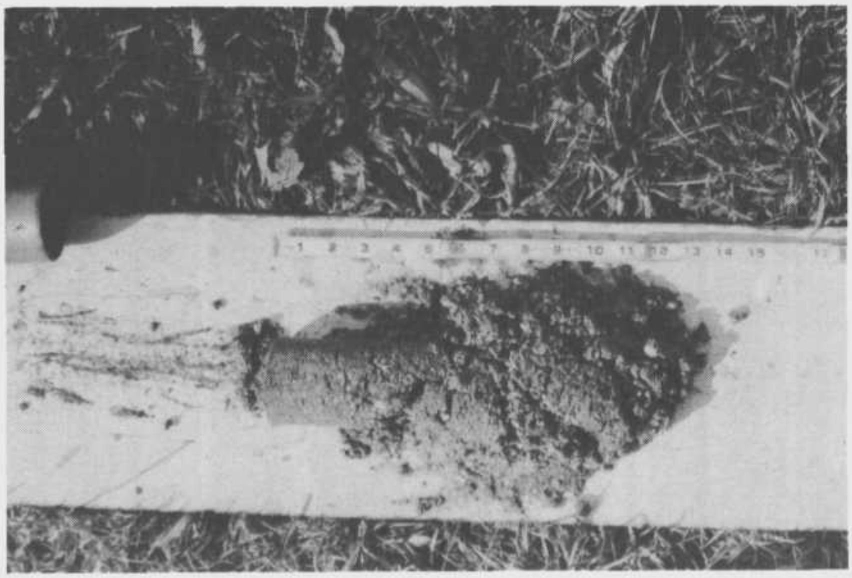

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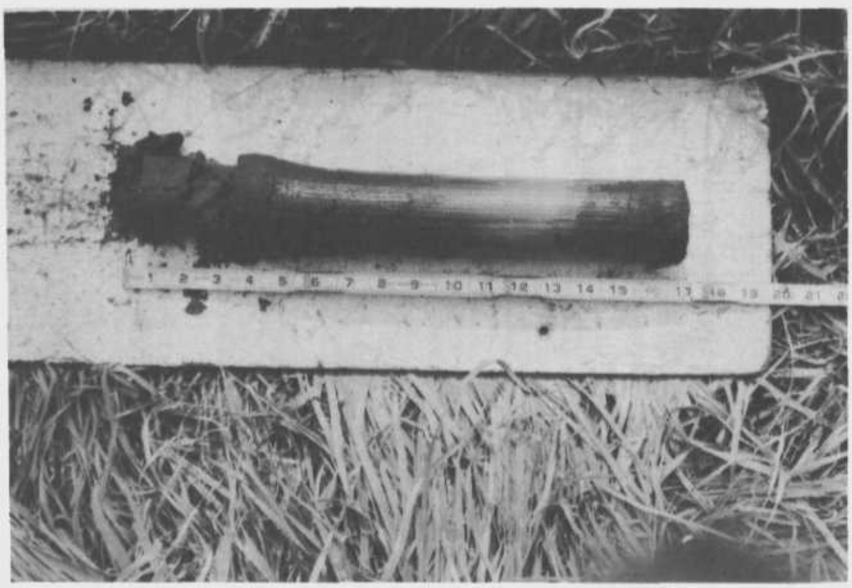

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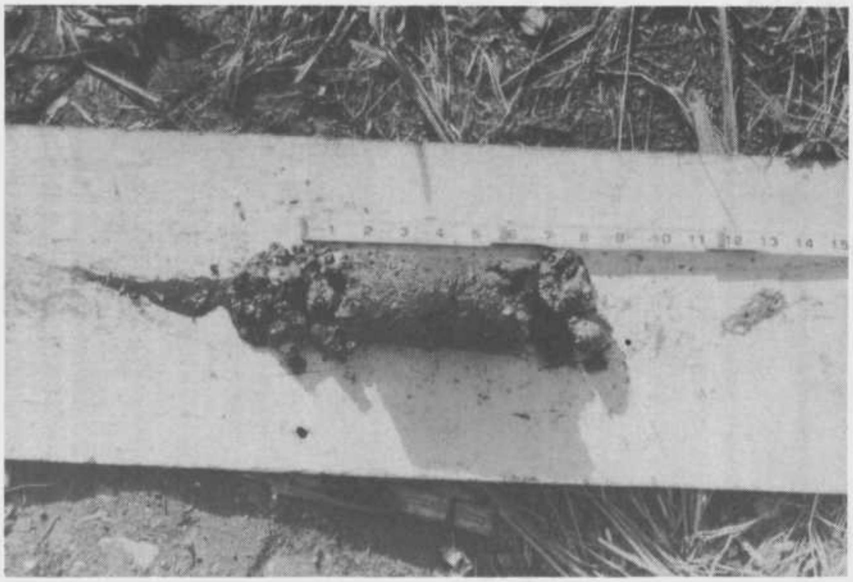

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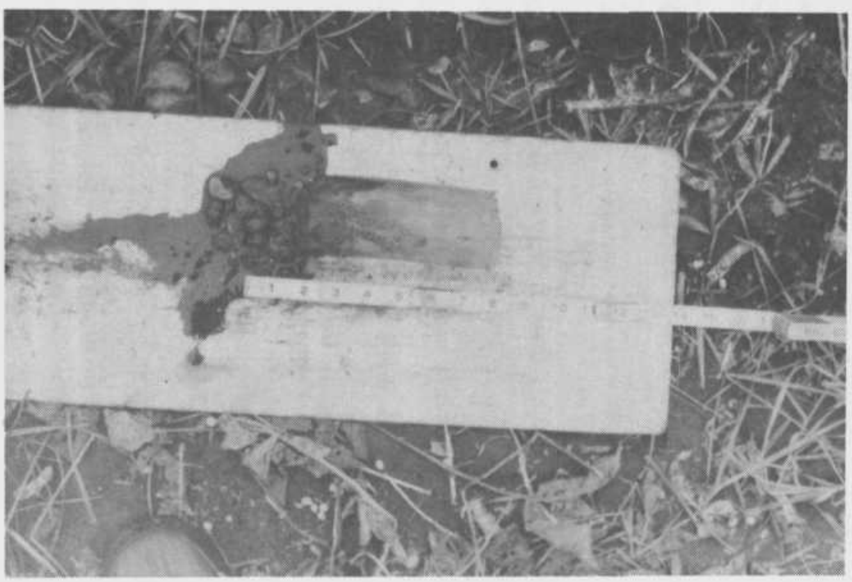

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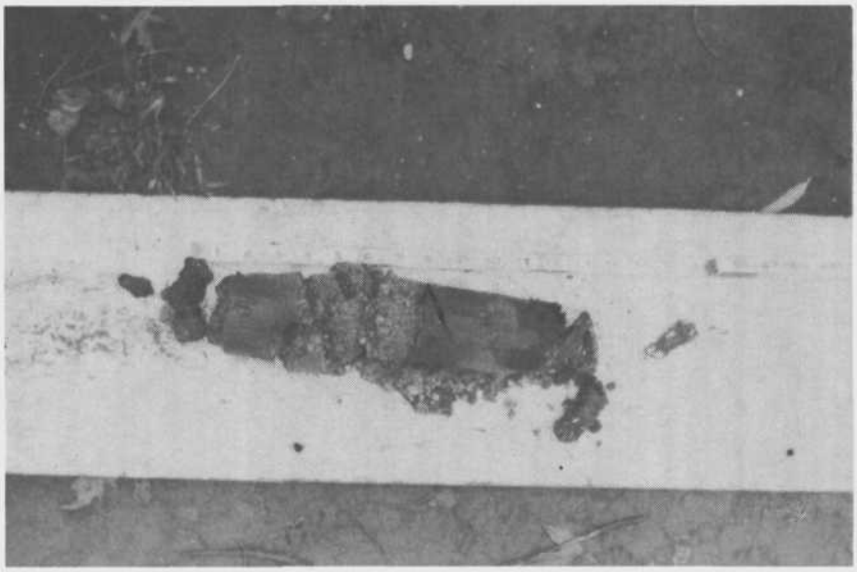

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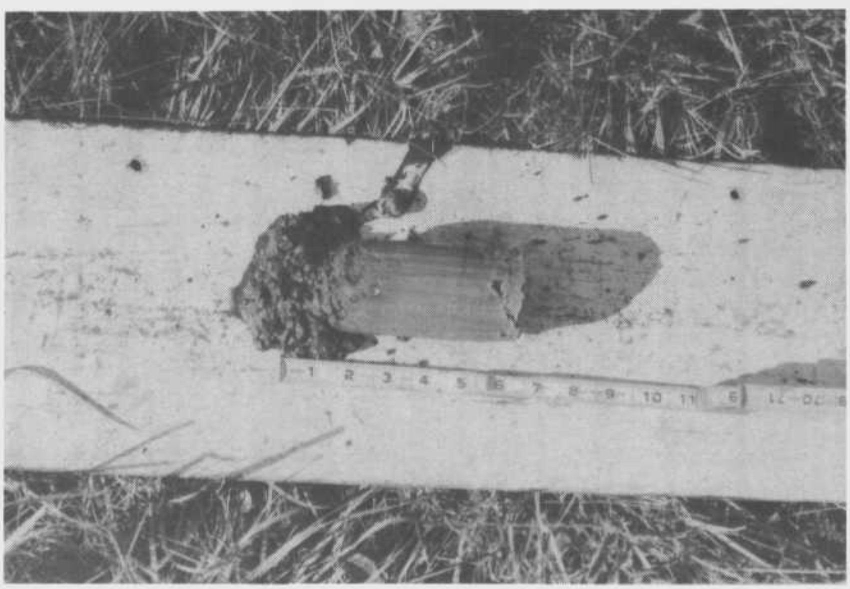

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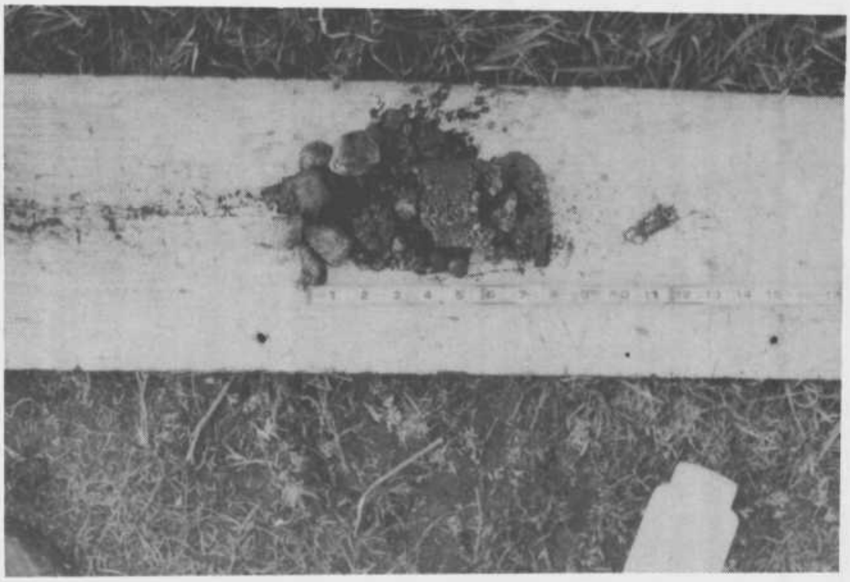

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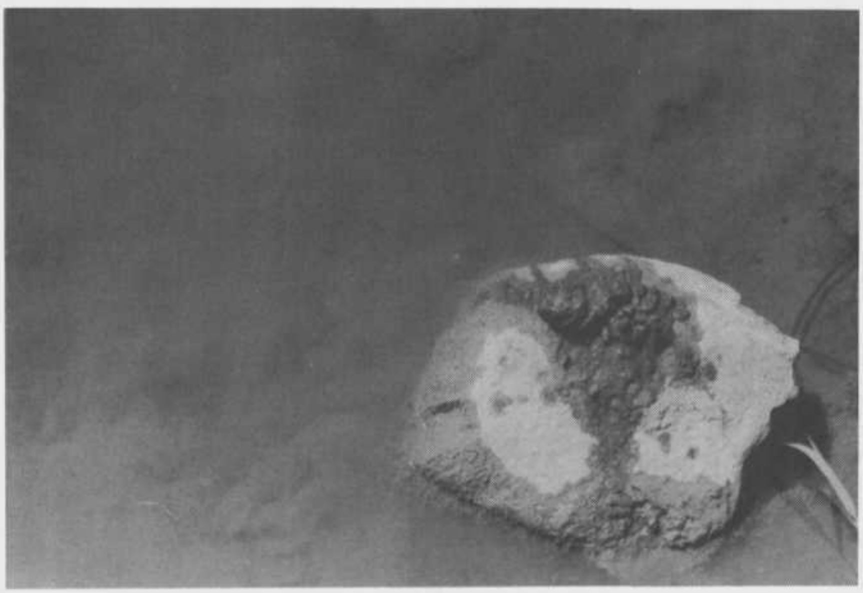

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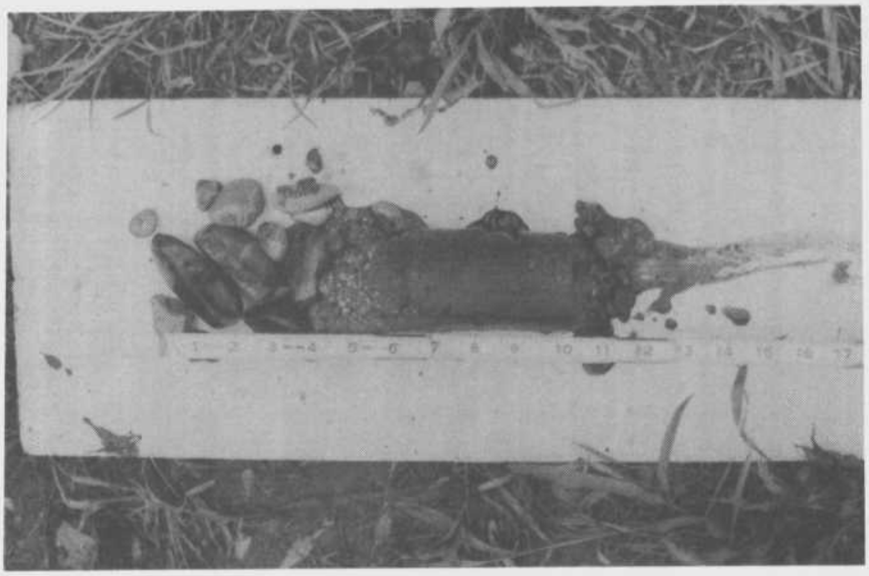

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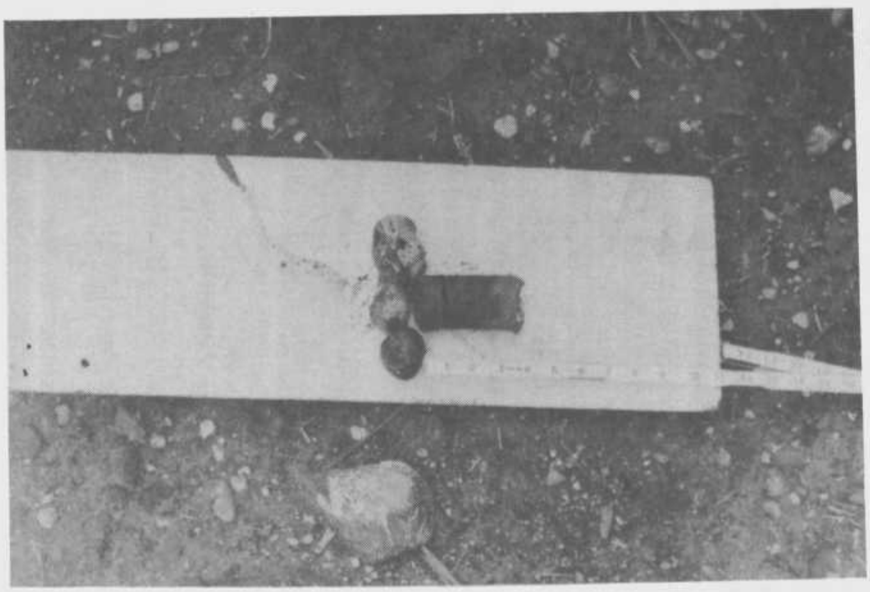

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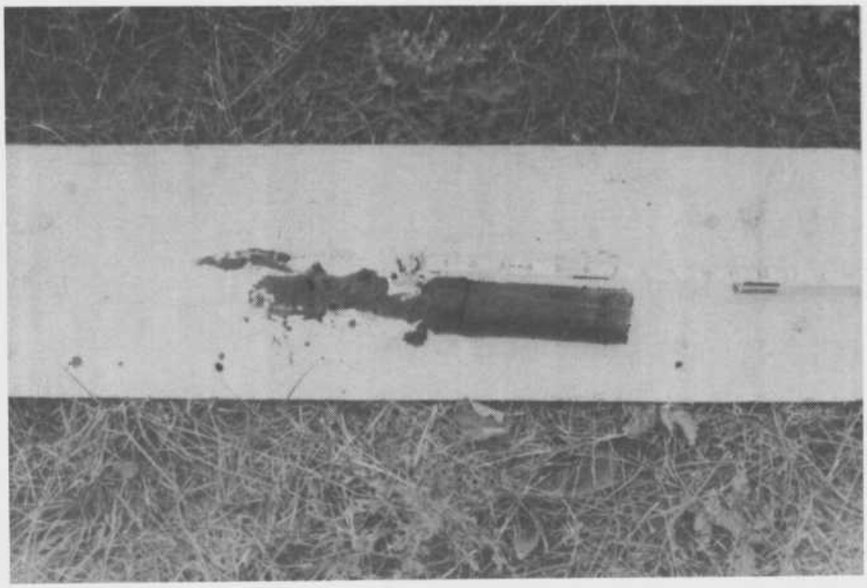

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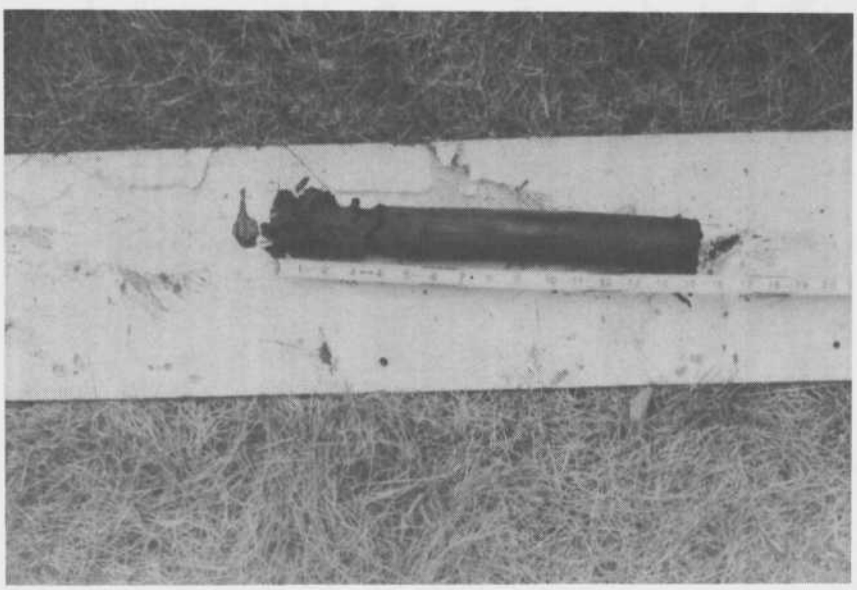

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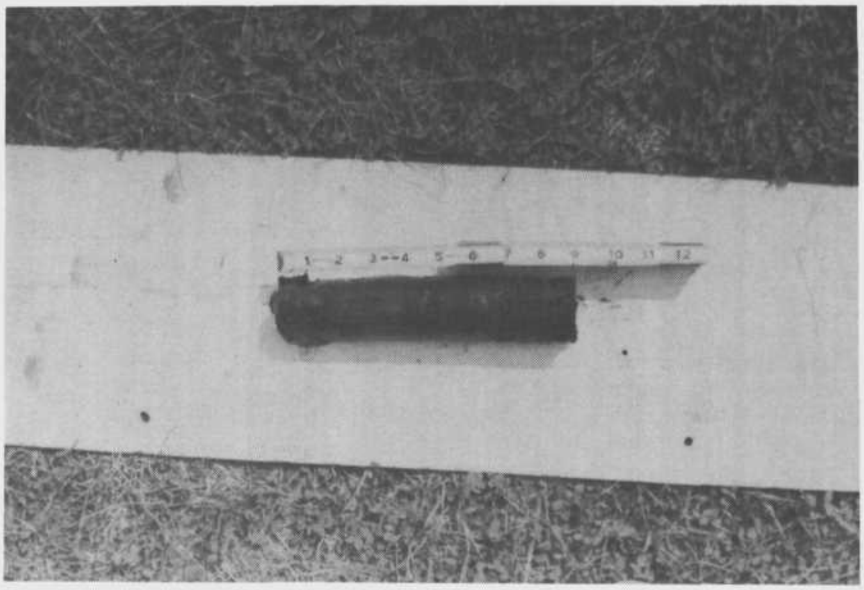

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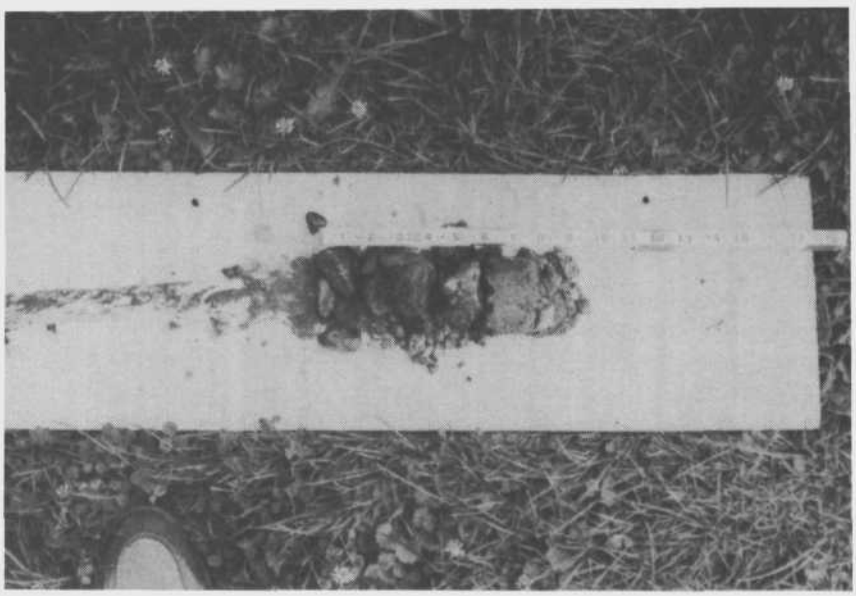

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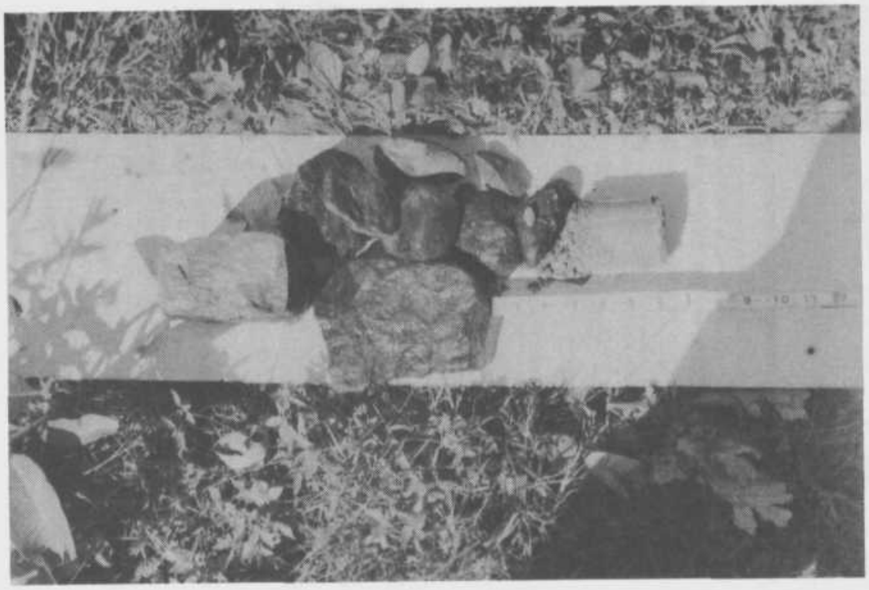

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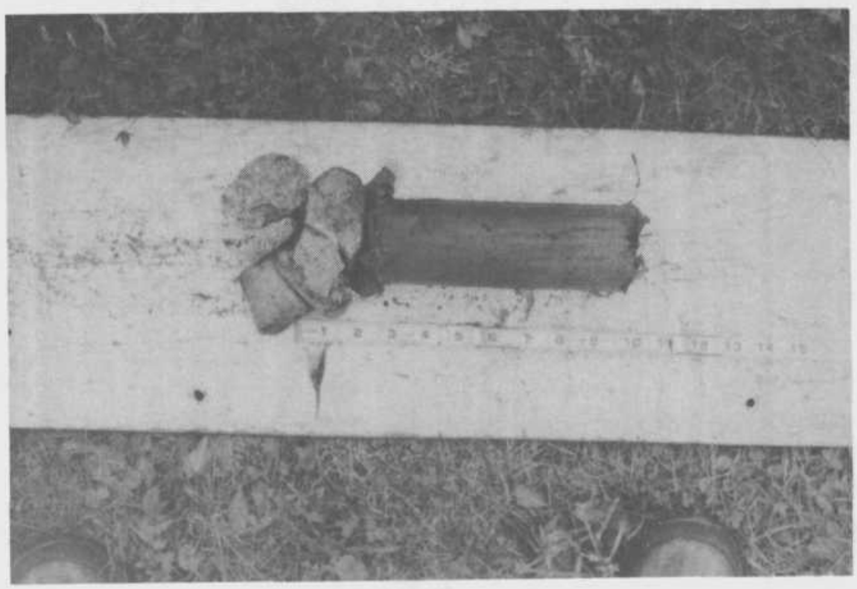

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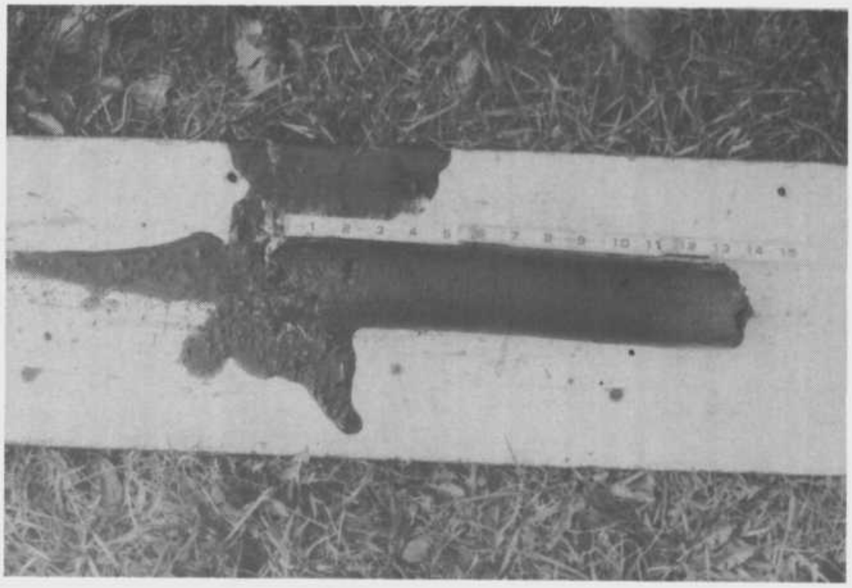

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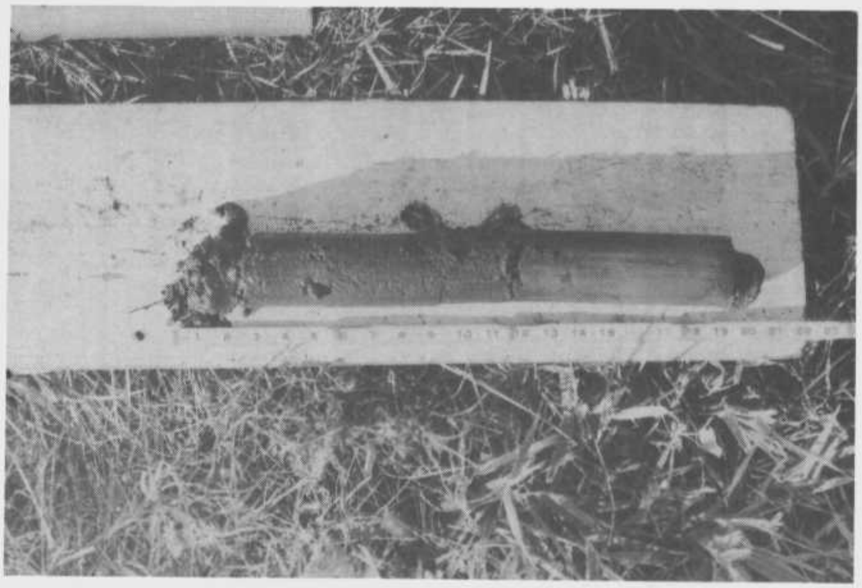

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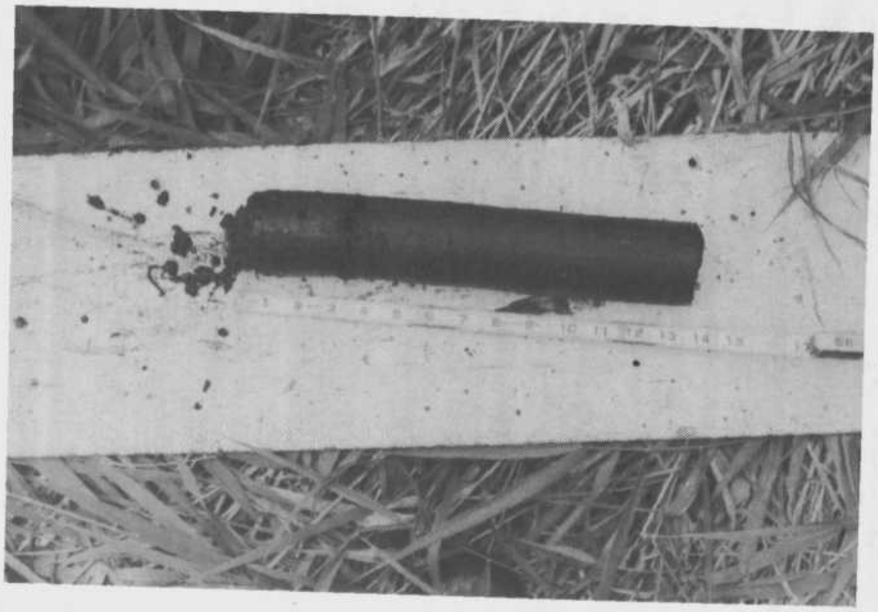

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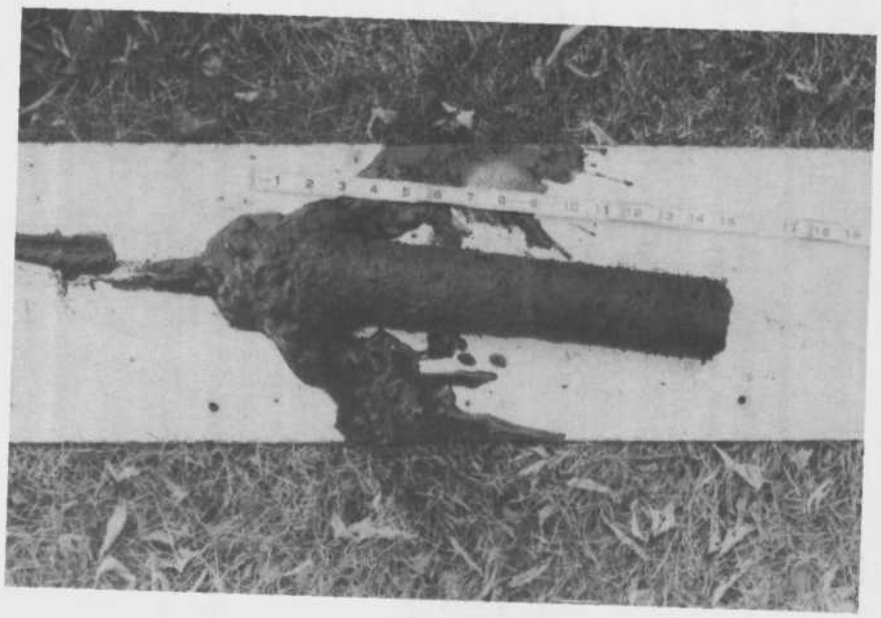

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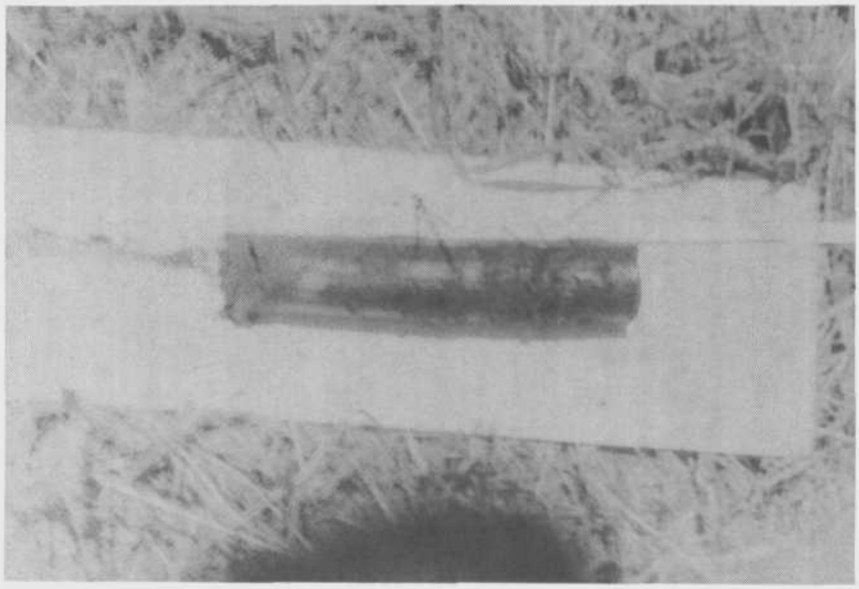

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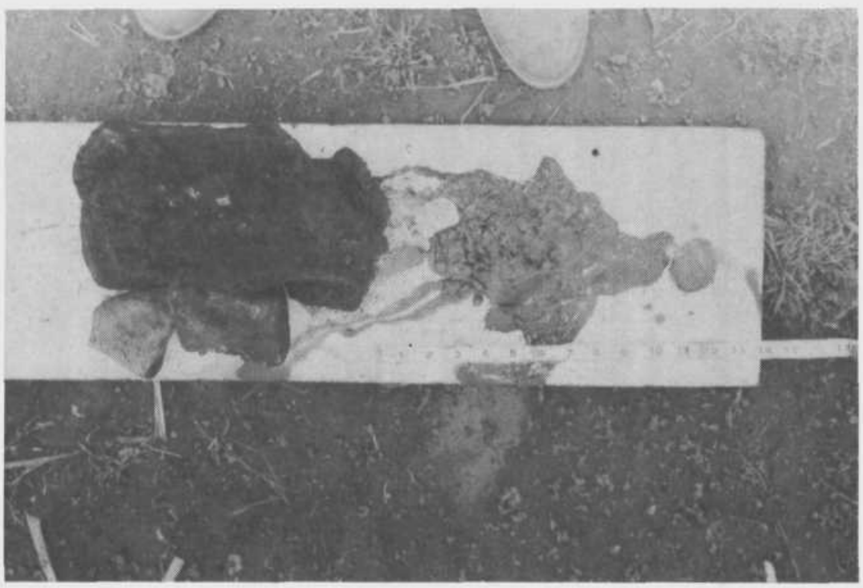

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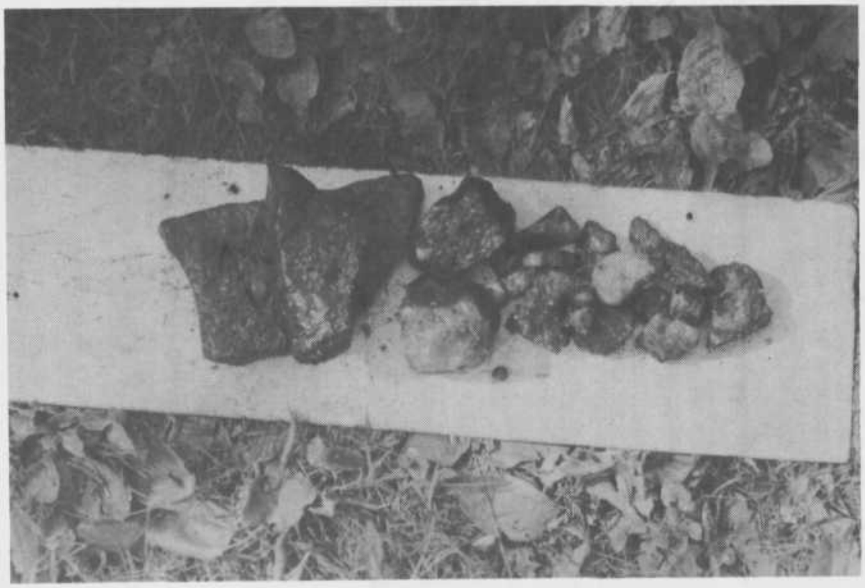

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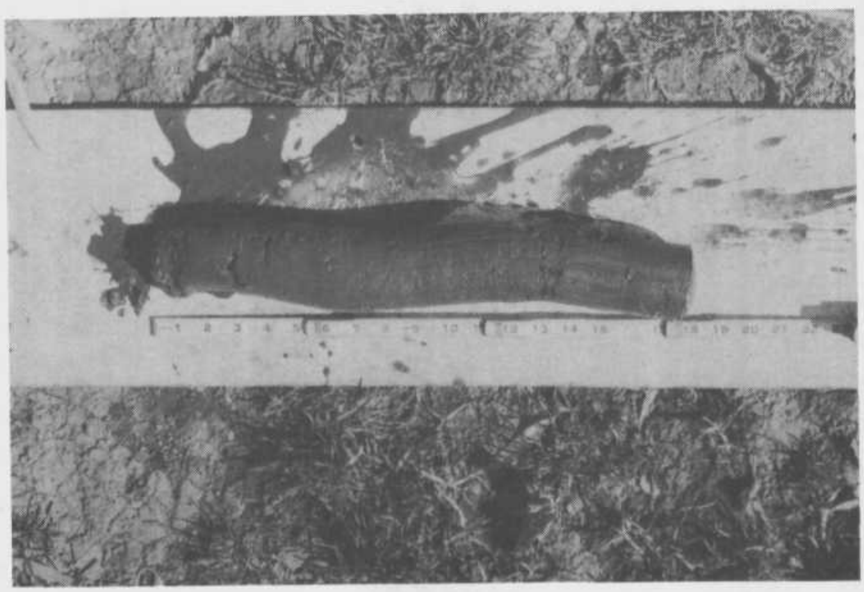
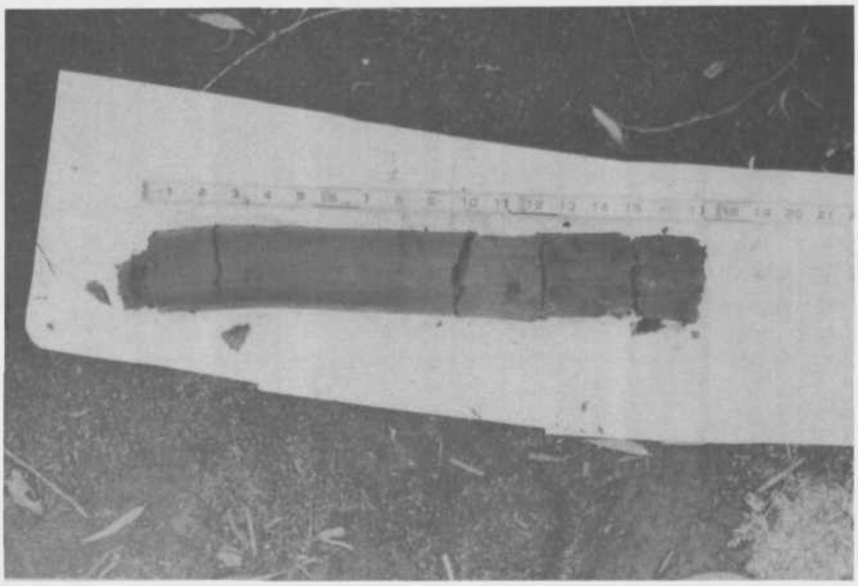
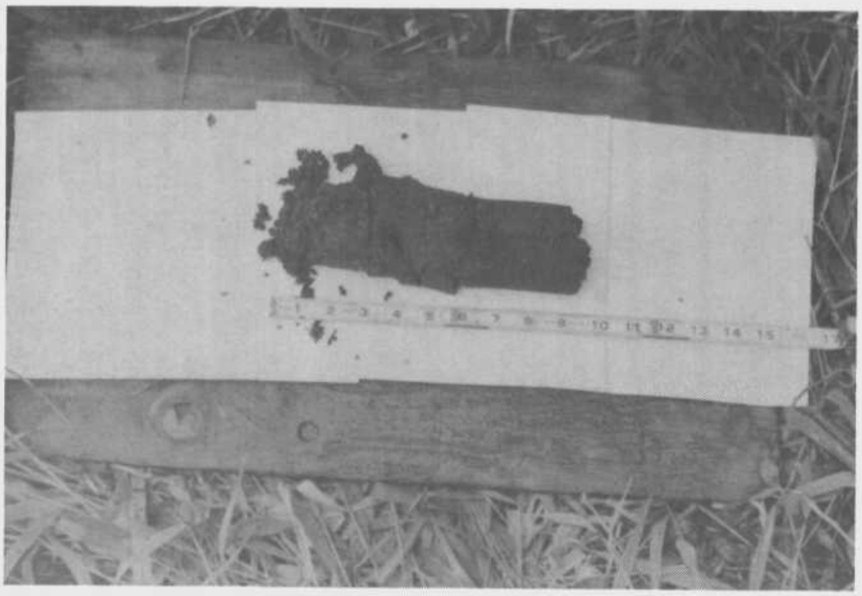


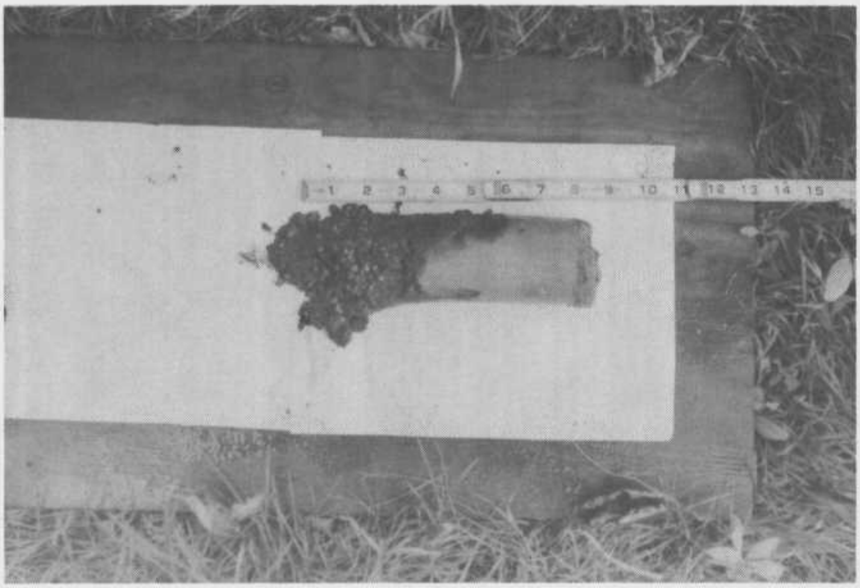
SOD STATION 48



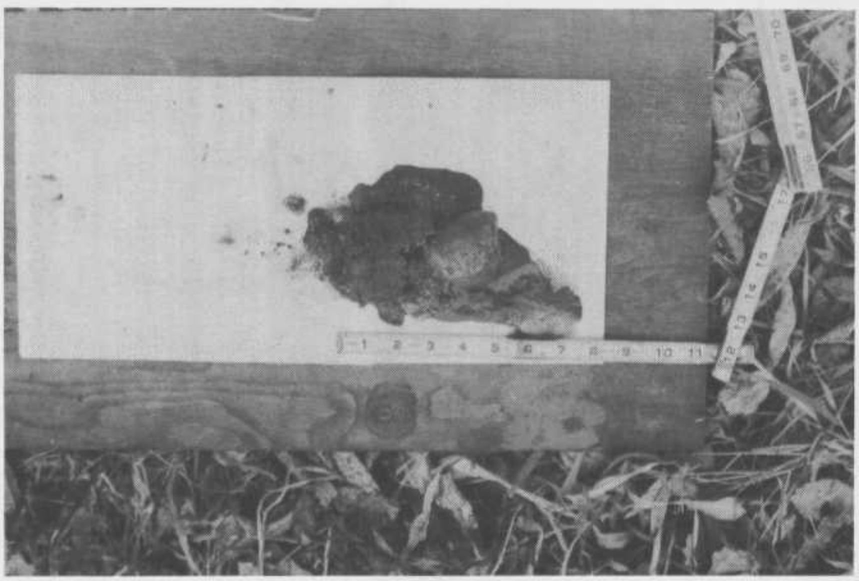
SOD STATION 49



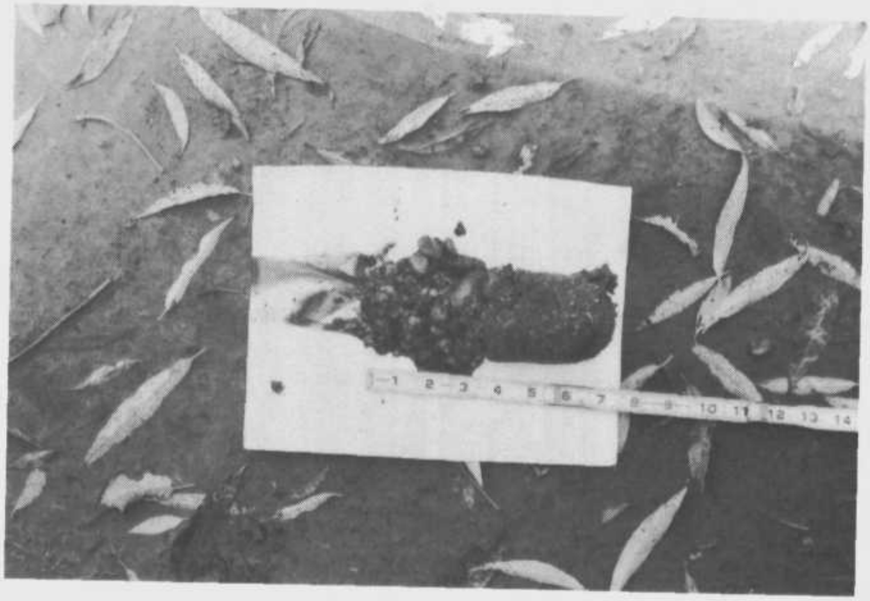
SOD STATION 50



SOD STATION 51



SOD STATION 52



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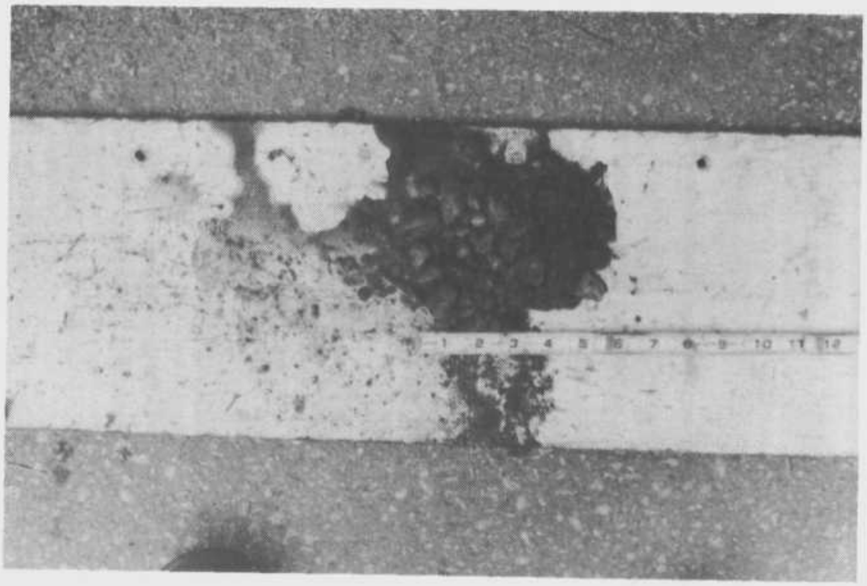
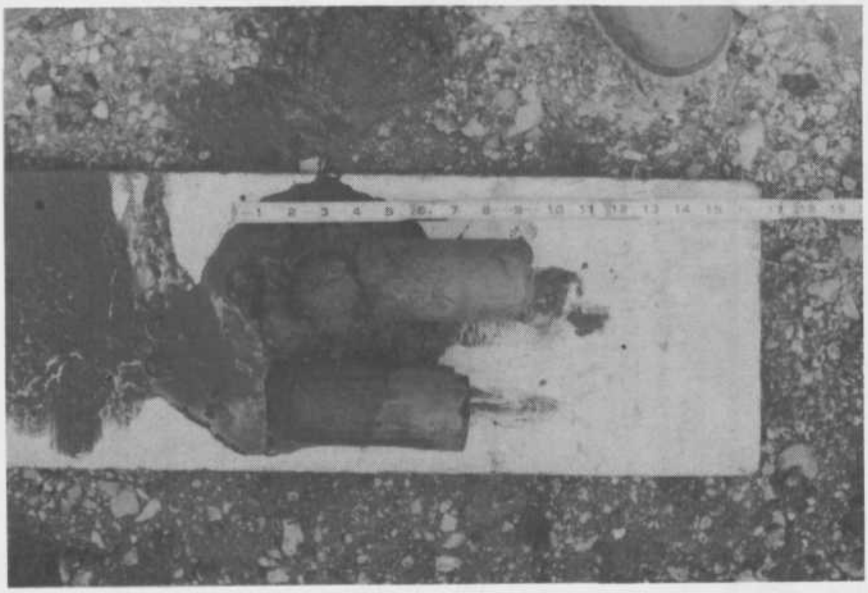
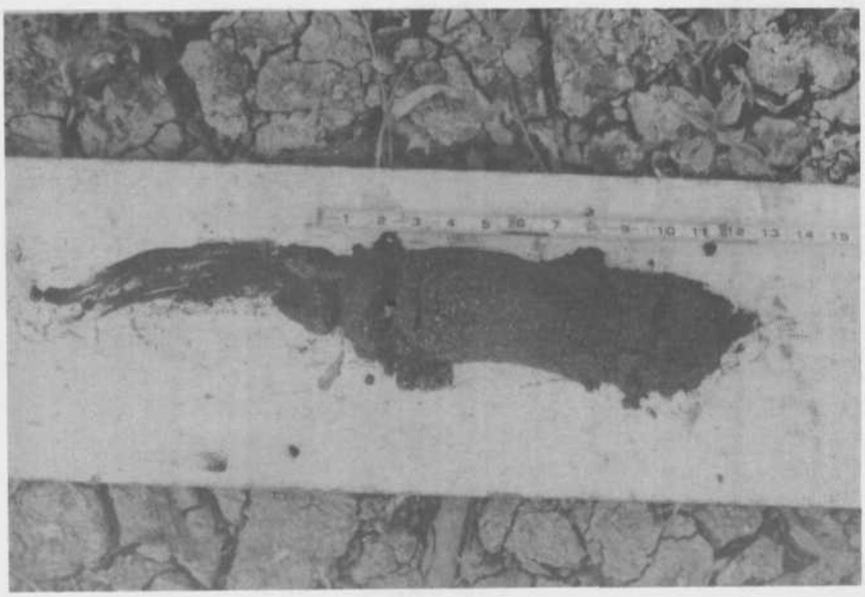


SOD STATION 54



SOD STATION 55



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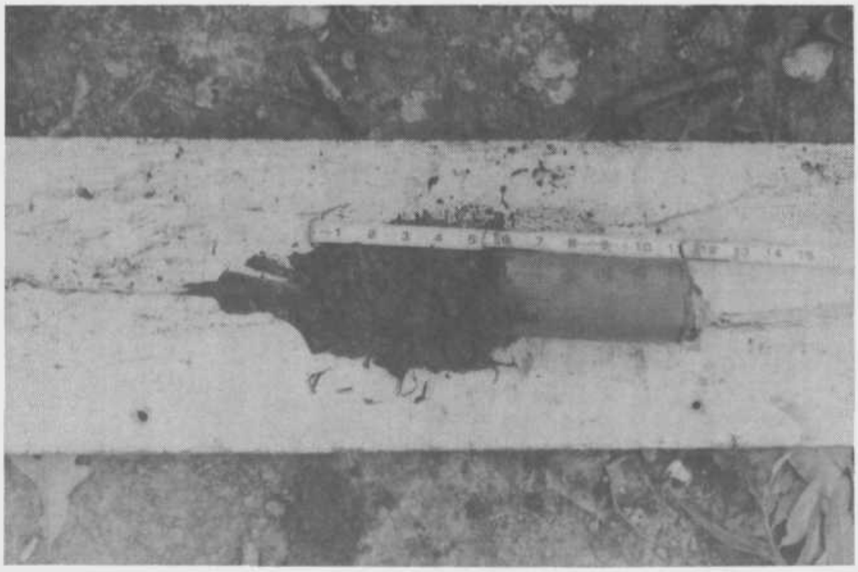

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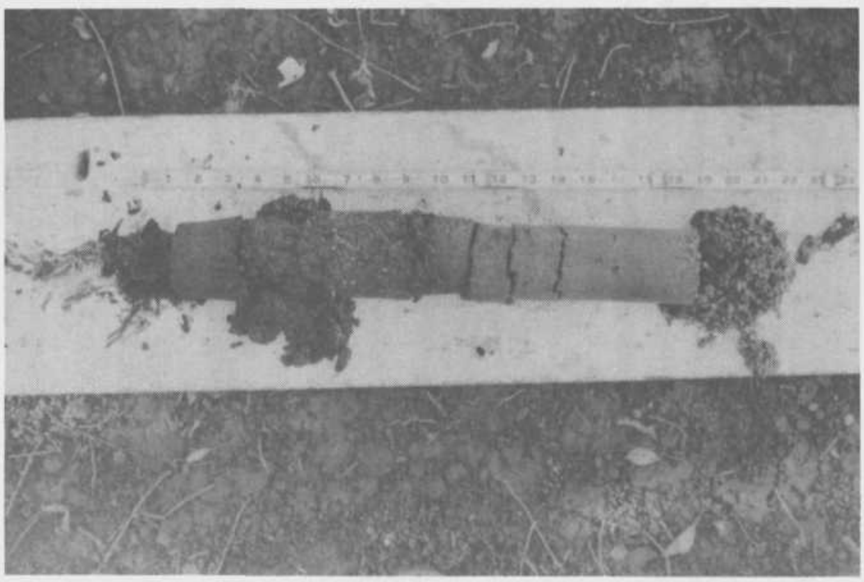
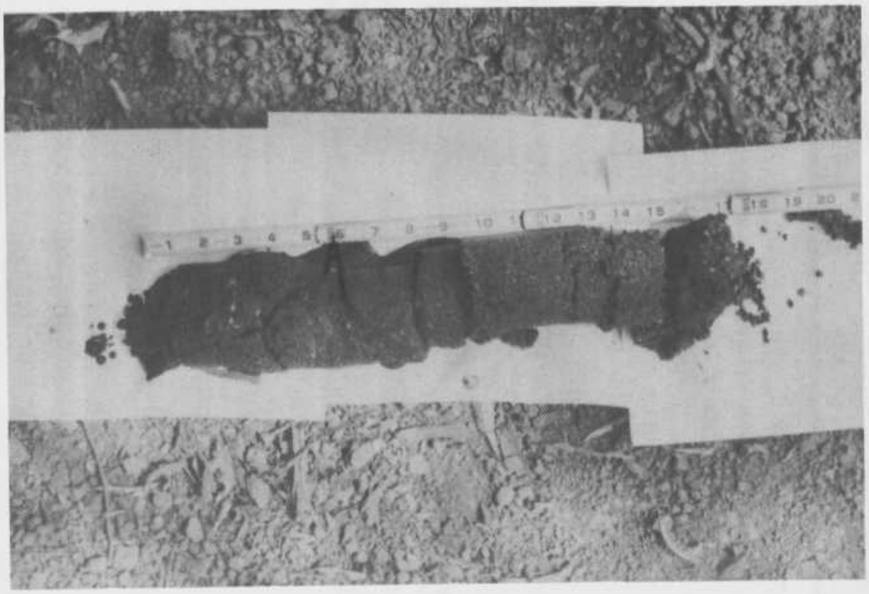
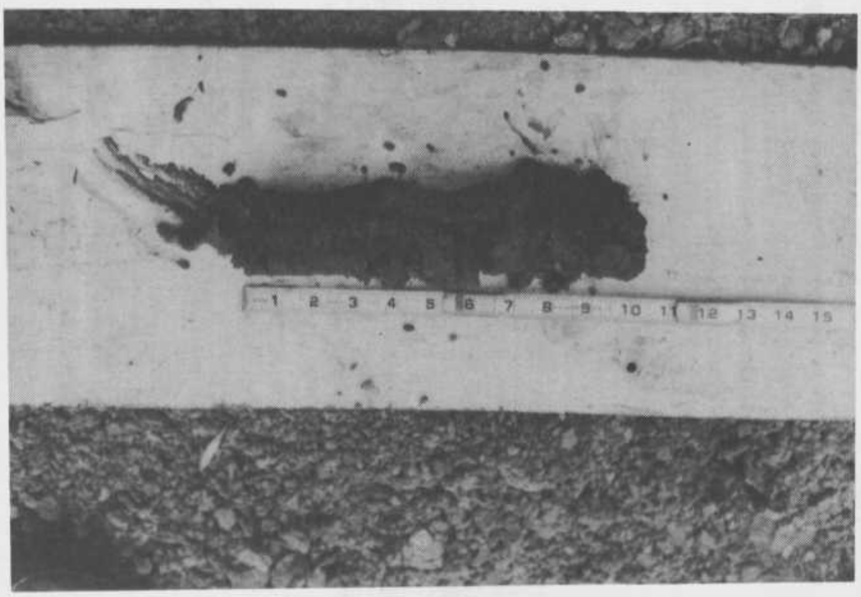


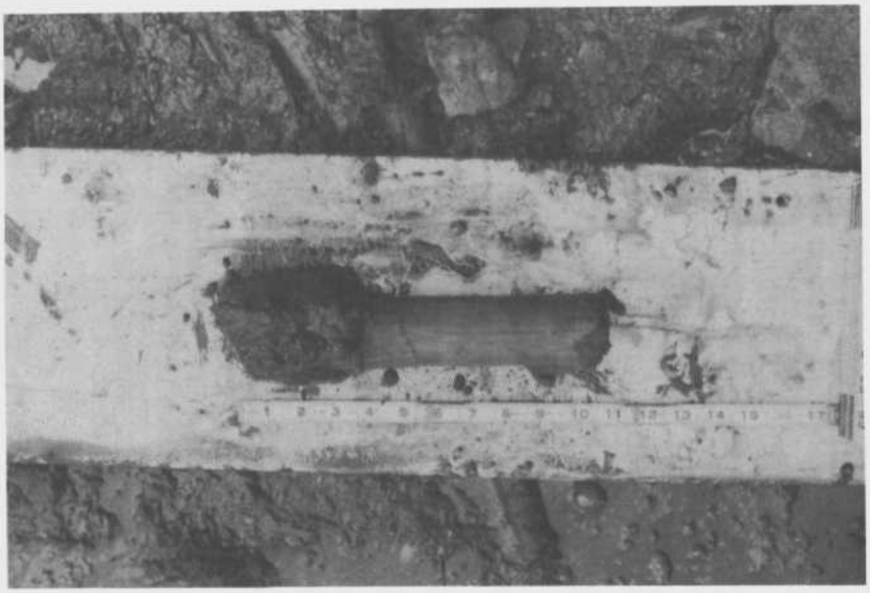
SOD STATION 58



SOD STATION 59



SOD STATION 60



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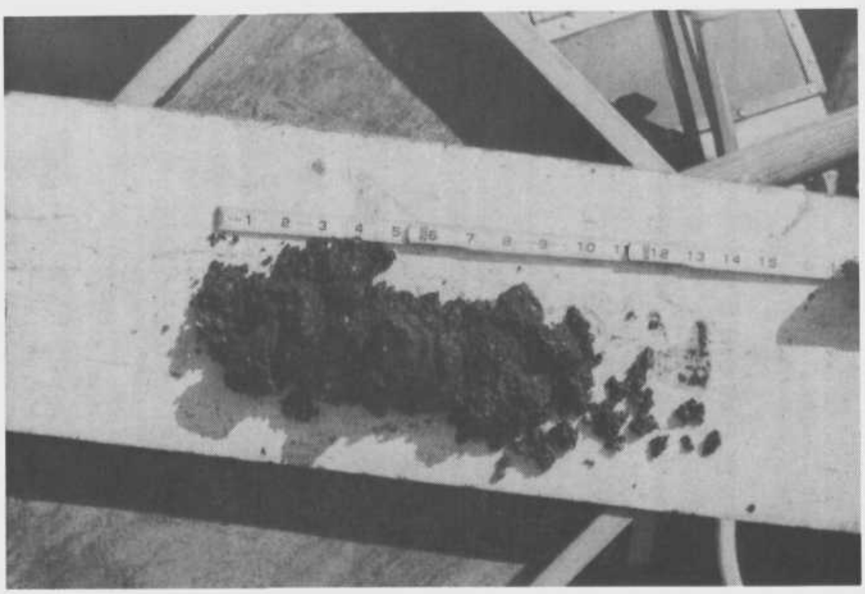

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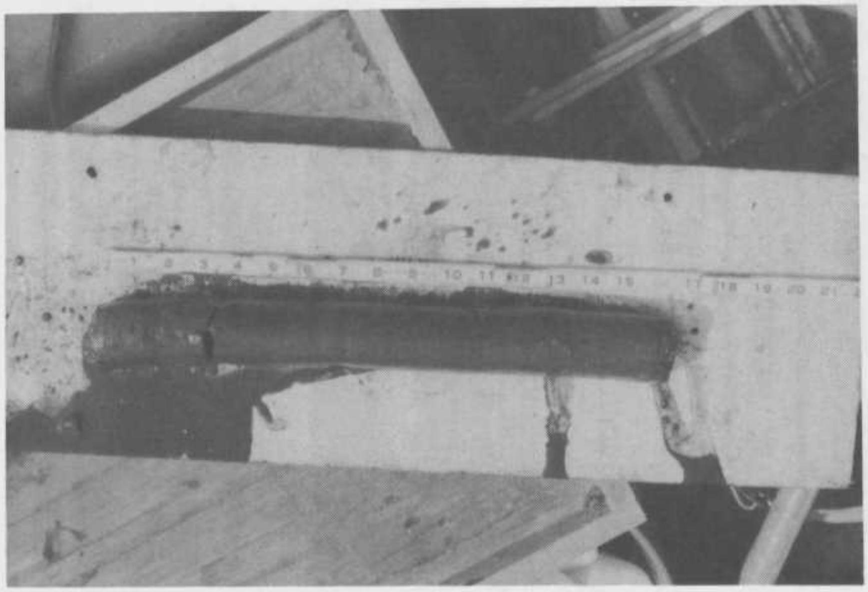

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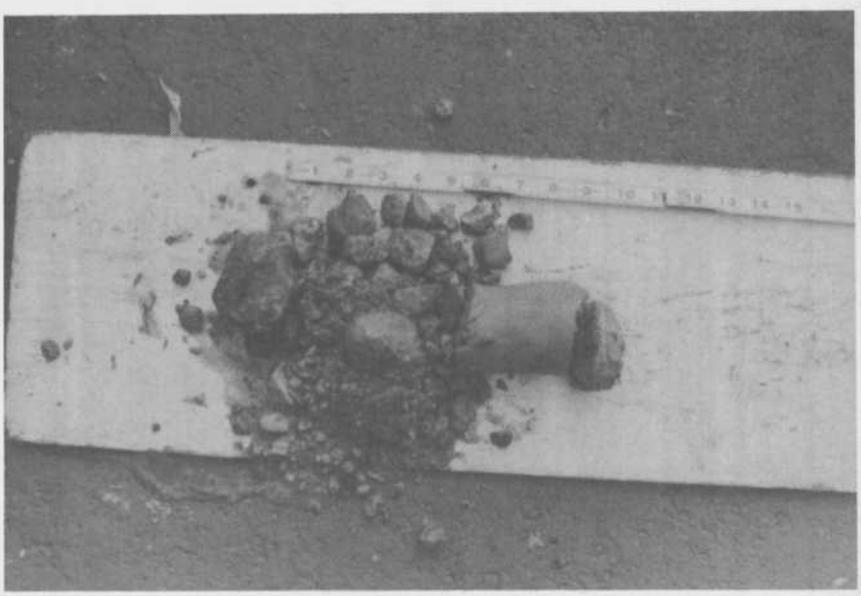

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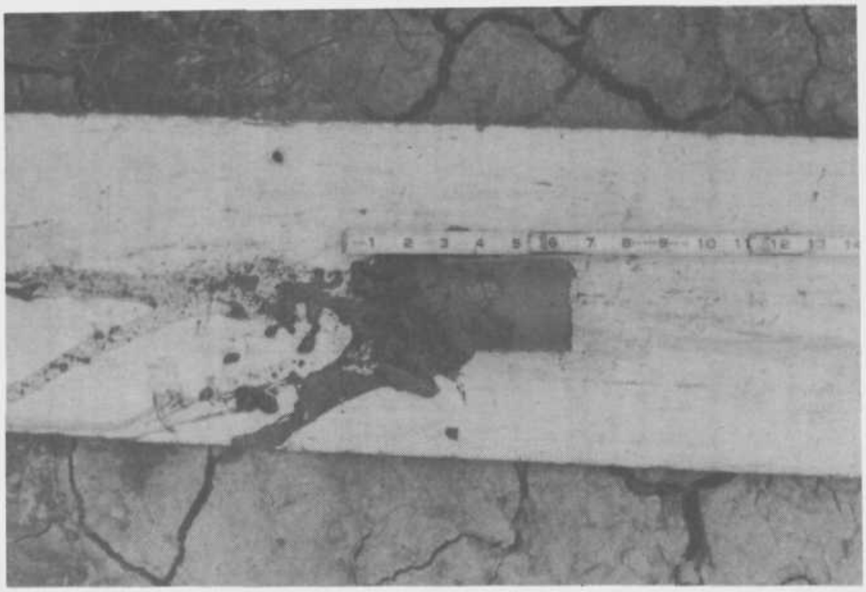

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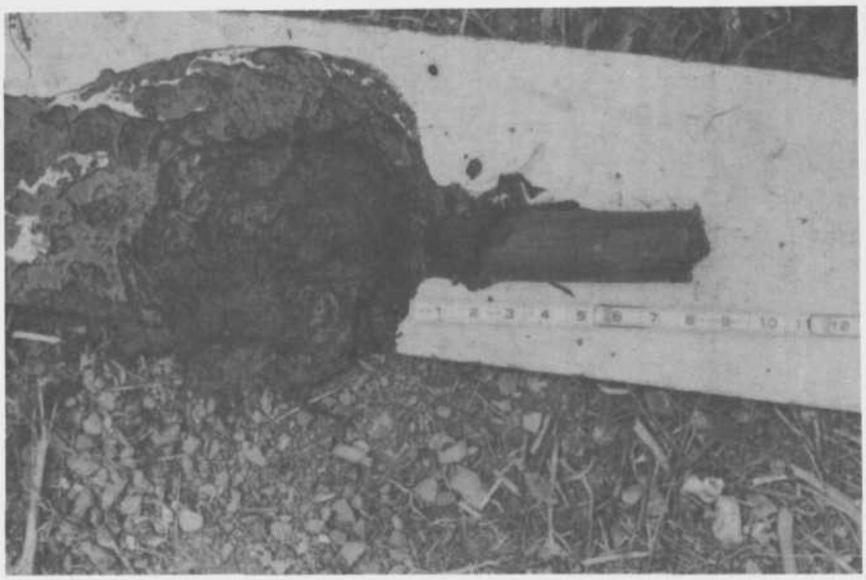

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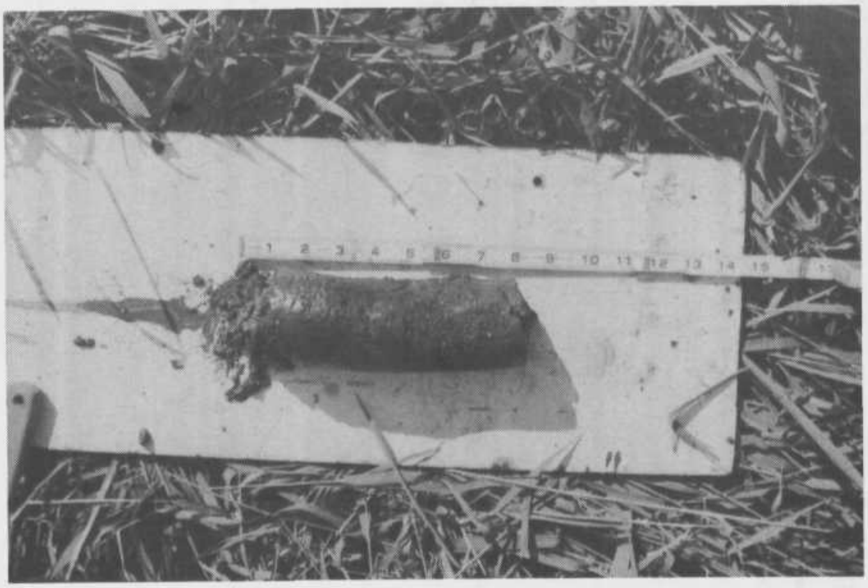
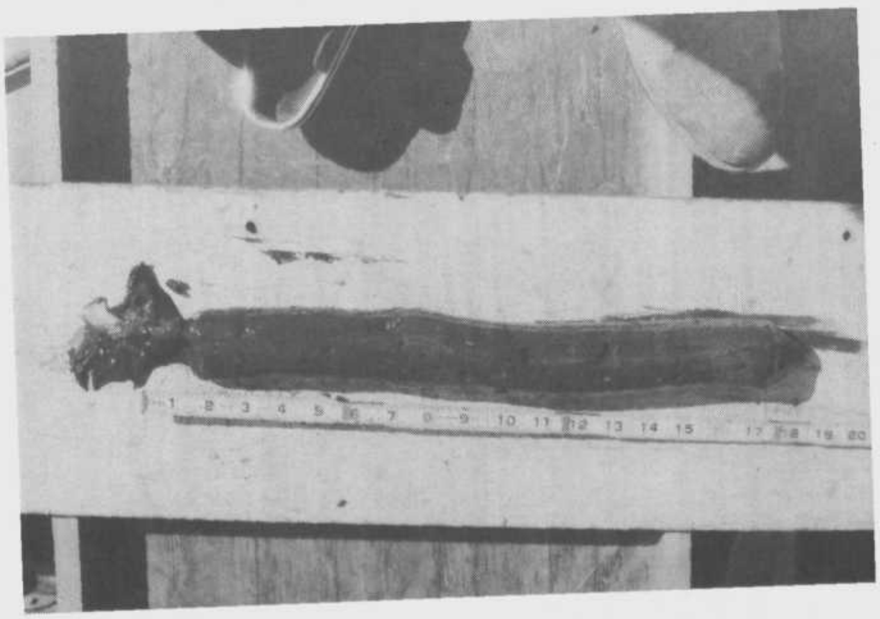


SOD STATION 67

SOD STATION 68

SOD STATION 69



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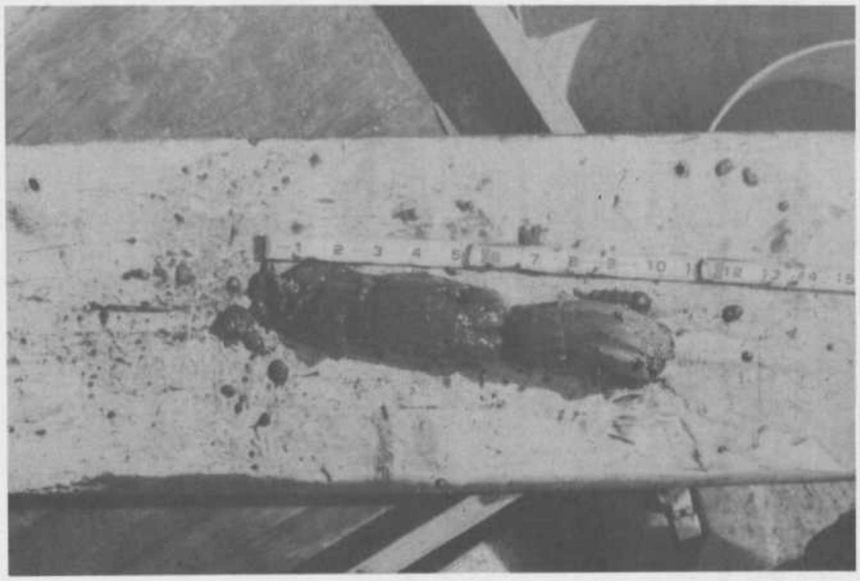

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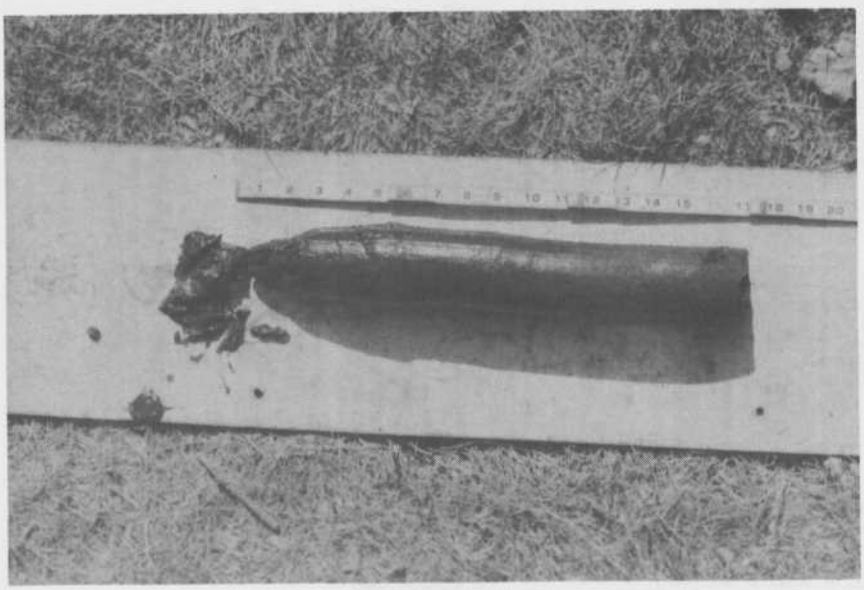

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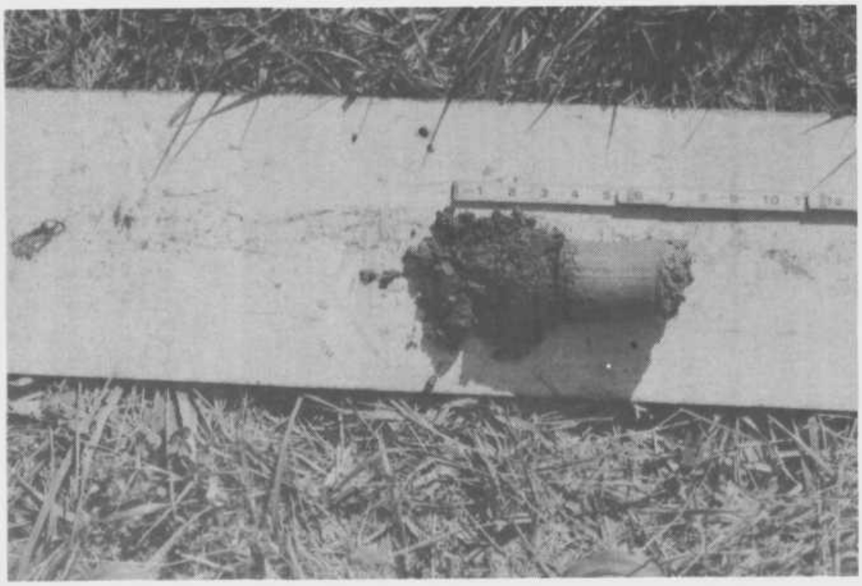

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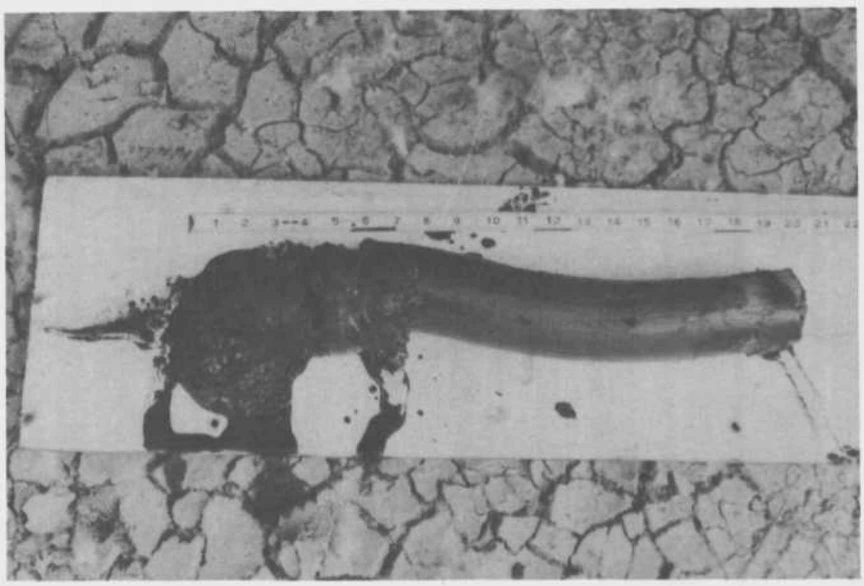

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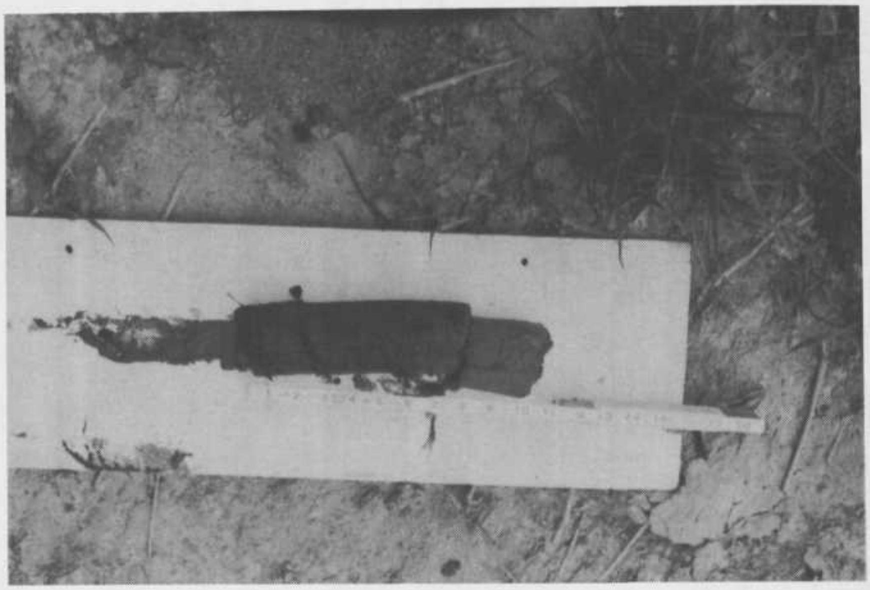

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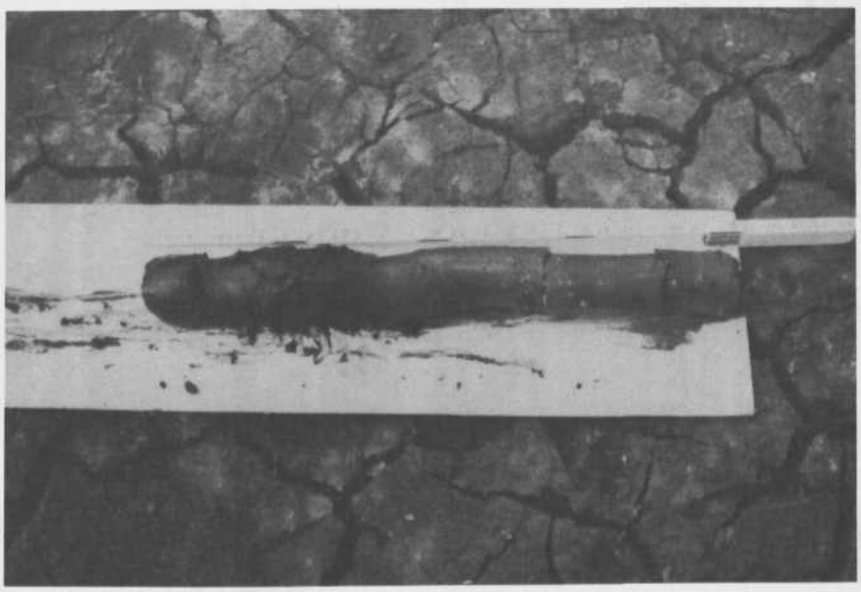

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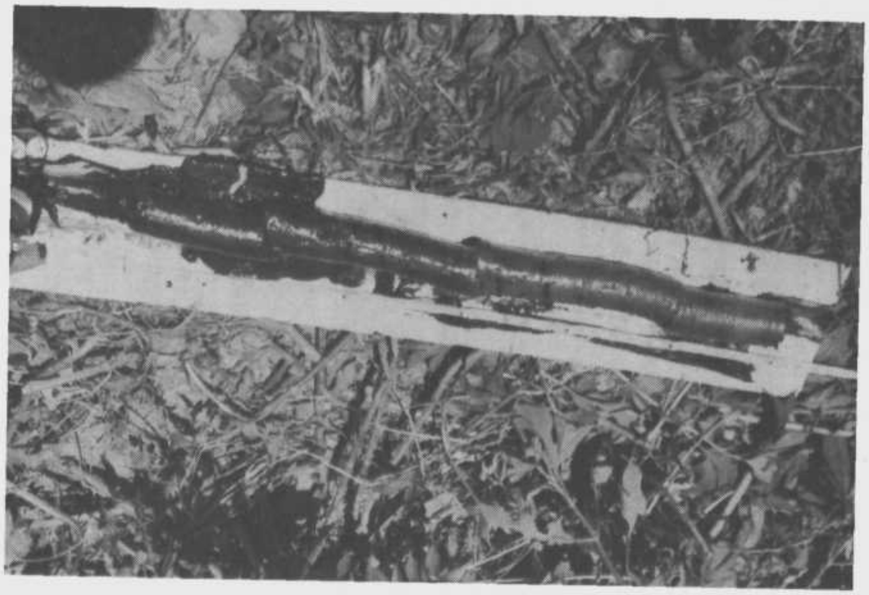

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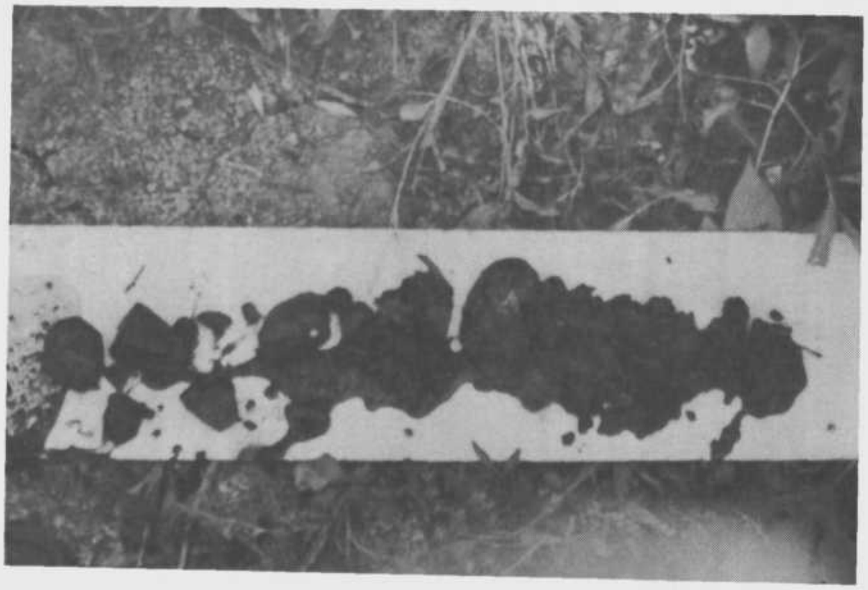

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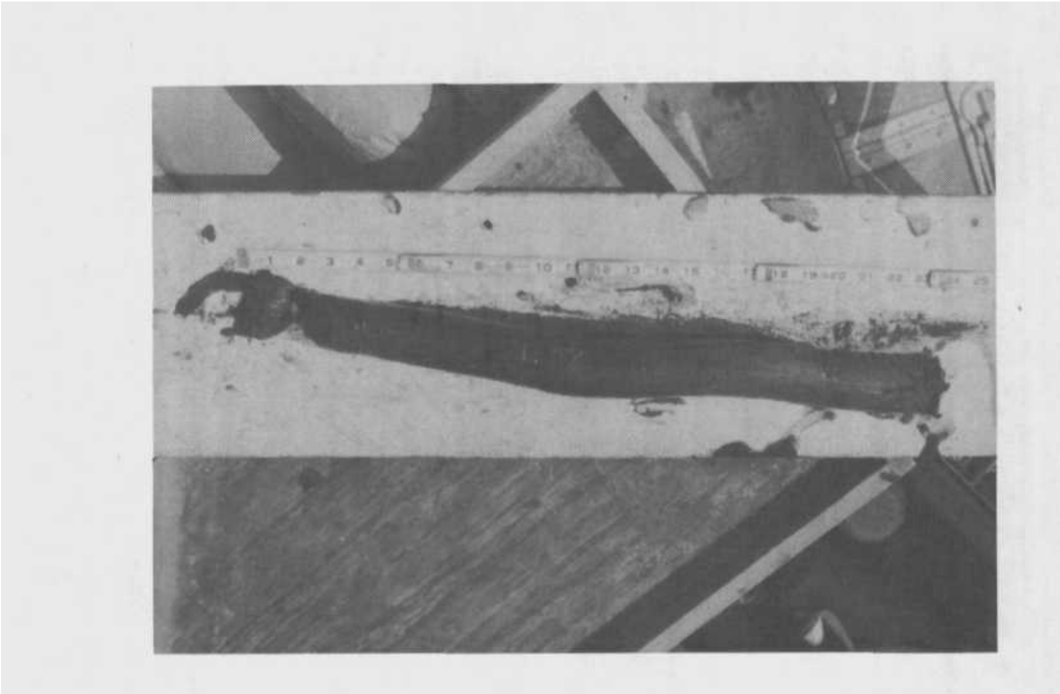
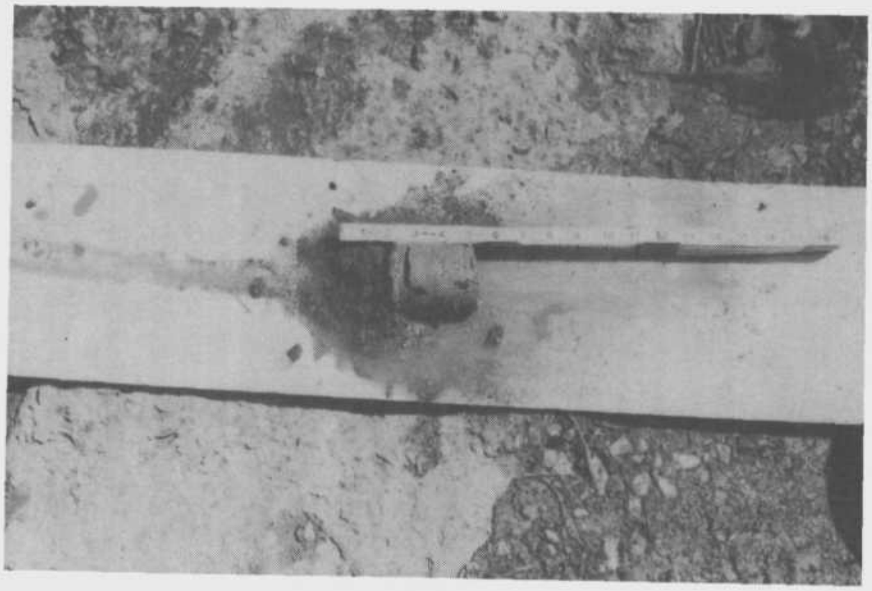
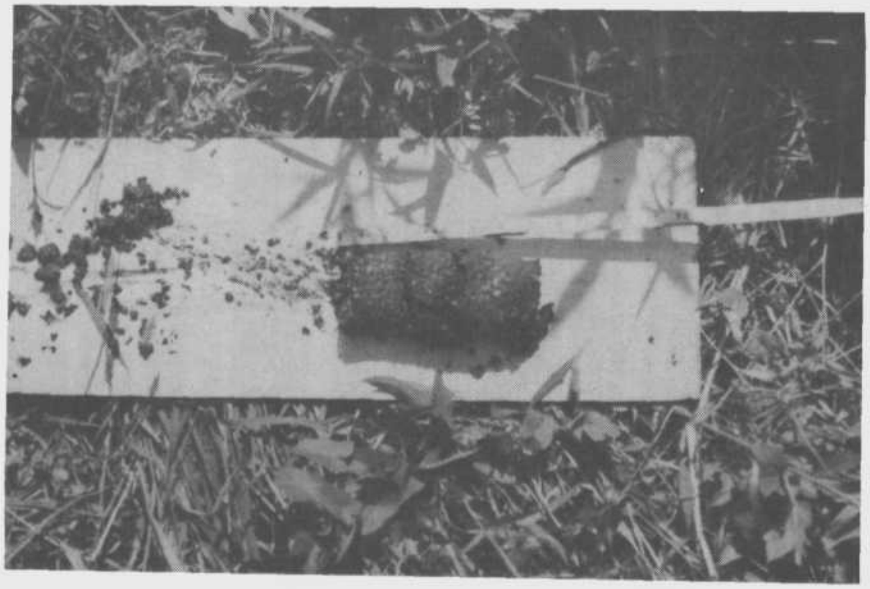


SOD STATION 79

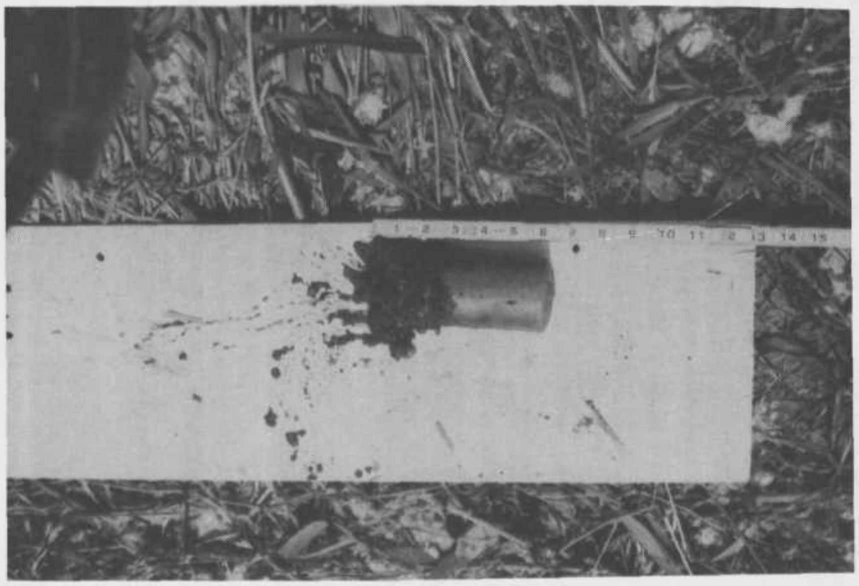
SOD STATION 80
No core sample taken



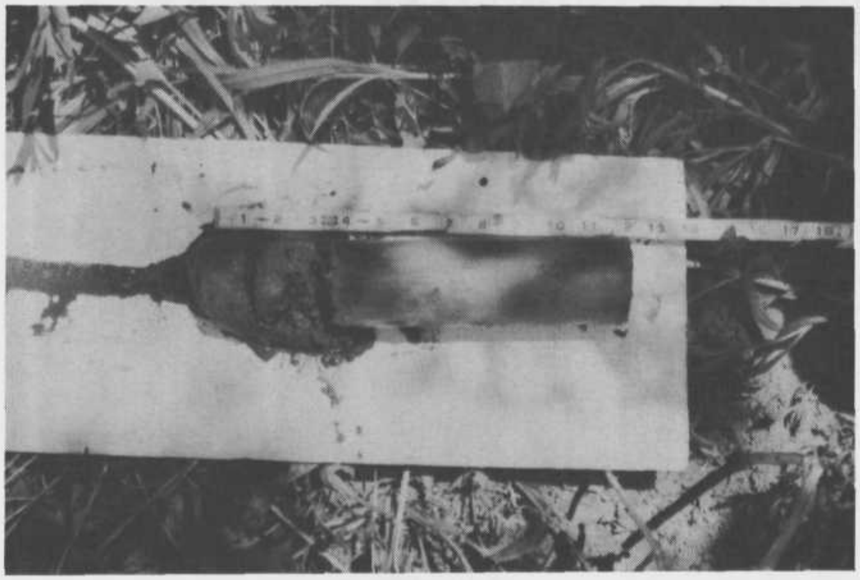
SOD STATION 81



SOD STATION 82

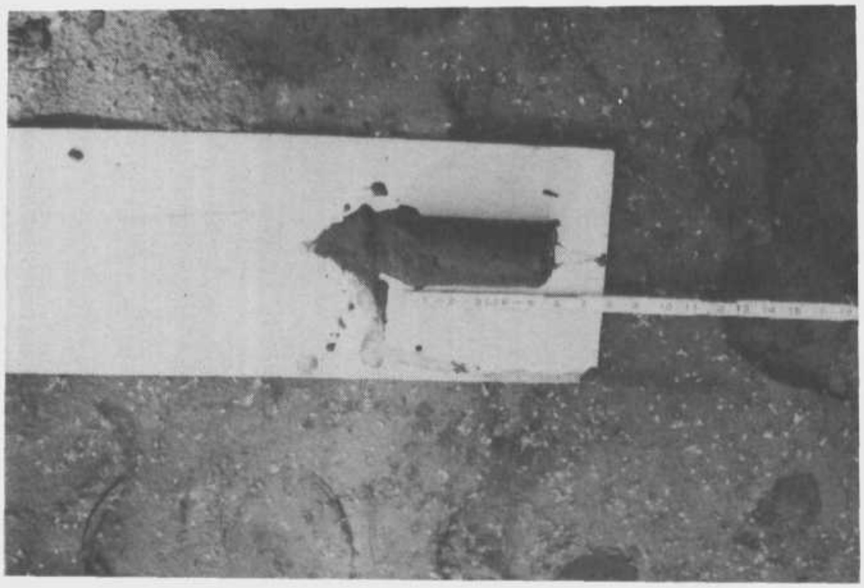


SOD STATION 83

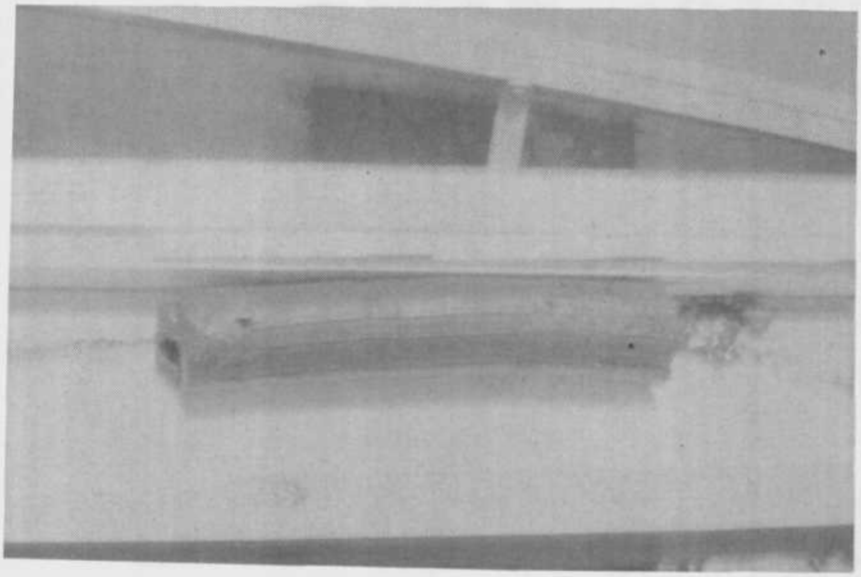


SOD STATION 84

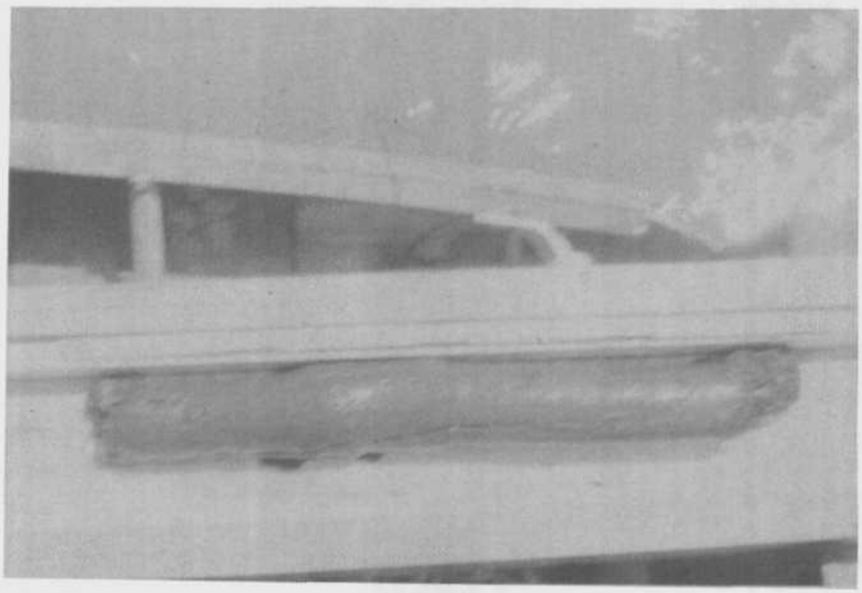
SOD STATION 85



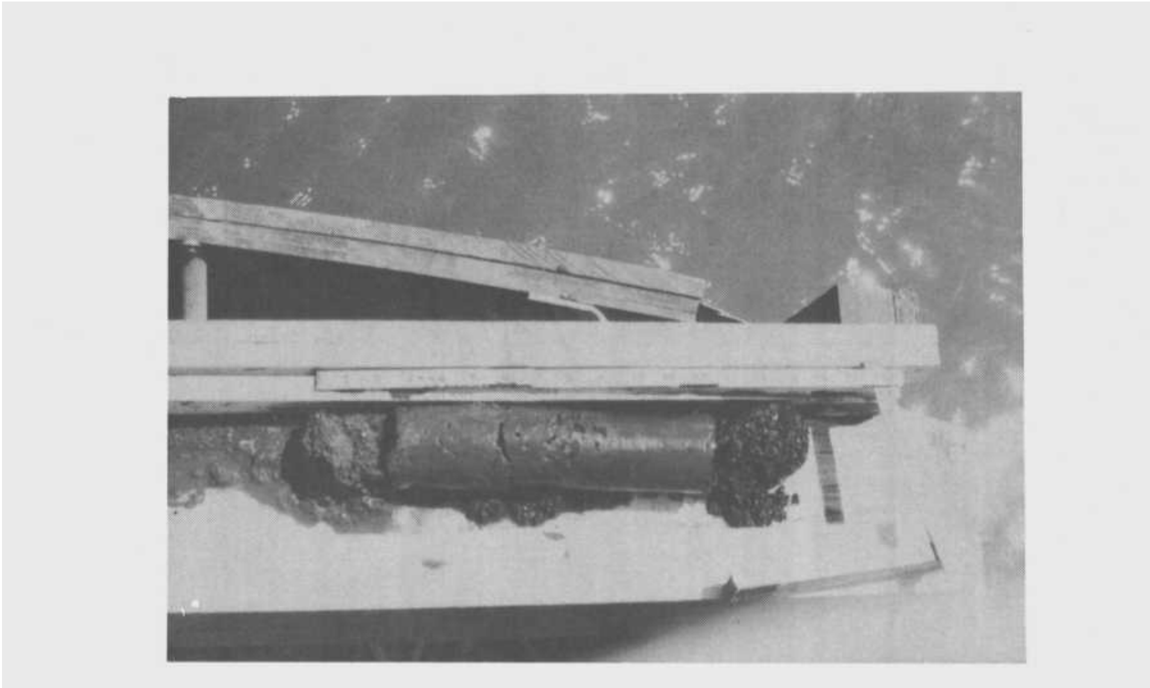
SOD STATION 86



SOD STATION 87



SOD STATION 88



SOD STATION 89

Appendix E. Chemical and Physical Data Observed during SOD Sampling Period

Station number	*Temp. (°C)*	*DO (mg/l)*	*Sed. depth (in)*	*No. per m^2 of macro-organisms*	*No. of taxa*	*Percent volatile solids*	*Percent solids*	*SOD $g/m^2/day$*
1	23.6	11.68	6	1148	3	3.4	60.4	2.57
2	23.9	8.48	5	842	2	2.6	67.0	1.55
3	24.7	7.51	2.5	612	3	3.3	63.9	1.30
4	25.0	8.44	11	2219	2	8.9	40.0	2.26
5	24.5	7.95	4	881	2	1.7	74.6	1.85
6	25.2	14.00	5	1588	2	2.1	73.6	4.22
7	23.6	12.50	13	1607	3	5.4	57.1	2.47
8	22.3	9.40	5	1090	3	8.6	51.0	2.14
9	22.8	5.85	2.5	517	2	3.6	61.5	2.64
10	26.8	10.8	1	173	2	8.0	31.5	2.35
11	23.7	15.38	5.5	708	3	4.5	56.0	3.43
12	21.6	7.29	4	1626	2	3.9	59.3	1.92
13	21.6	5.70	6	3636	2	5.4	57.0	2.06
14	25.2	7.90	3	2124	2	9.2	73.7	2.90
15	25.5	10.85	4.5	8396	7	1.2	86.0	3.38
16	22.2	5.53	3.5	1397	2	5.9	46.3	2.24
17	26.0	12.23	12.5	1952	3	4.2	67.9	9.79
18	24.0	5.63	5	8614	3	2.8	77.5	1.52
19	27.4	6.50	7	6501	3	7.2	74.7	2.73
20	28.6	9.29	7	5812	13	1.4	88.5	7.16
21	25.1	6.80	6	1665	1	2.9	65.3	4.17
22	30.8	13.35	9	1090	3	1.8	84.6	5.99
23	20.6	5.74	4	3961	1	4.1	67.5	2.36
24	27.8	10.83	14	2736	2	3.7	70.0	4.90
25	5.5	10.44	12	2540	3	0.4	85.6	0.63
26	6.9	8.89	8	6762	2	3.1	67.2	1.93
27	9.2	3.83	8	906	3	1.1	84.4	5.14
28	7.8	8.38	3	6501	5	2.1	81.8	1.03
29	7.3	10.68	9	1852	3	0.4	85.6	1.41
30	12.5	11.84	2	4391	4	1.7	82.7	0.27
31	14.7	6.28	4	5126	6	0.8	85.3	0.93
32	29.1	11.69	4	9083	3	1.0	79.4	1.94
33	19.0	7.68	9	604	2	0.8	90.2	0.86
34	21.0	5.89	2.5	322	1	13.9	49.2	0.98
35	21.7	4.30	2.5	1764	2	1.8	77.4	1.62
36	23.1	3.26	2.0	6802	2	7.9	44.8	1.38
37	23.0	4.74	5.0	1980	1	8.1	41.6	2.21
38	21.0	5.35	2.5	903	3	1.0	86.2	1.17
39	20.5	7.53	3.5	3939	8	3.1	84.6	2.71
40	12.4	8.08	7	5939	7	2.4	77.5	2.76
41	10.4	7.55	11	406	5	15.1	35.7	1.50
42	17.8	5.68	9	45,639	3	4.2	58.0	6.61
43	18.4	7.20	3.5	53,605	4	13.0	56.7	1.94
44	21.7	6.40	3	644	2	7.5	46.4	2.06
45	20.6	2.35	8	2282	3	3.3	76.2	0.90
46	17.3	6.31	3	3725	11	1.0	85.2	2.20
47	16.0	8.34	1	6155	7	1.0	91.0	0.97
48	16.2	13.11	11	46,072	3	6.2	46.0	3.30
49	9.0	6.38	6.5	1162	4	6.9	52.0	1.84
50	14.0	6.65	9	15,888	2	0.9	81.4	4.70
51	12.4	5.58	3	3531	2	0.8	86.3	1.01
52	10.8	6.06	4	2840	2	1.8	77.1	0.71
53	13.9	7.90	5	2840	3	0.8	86.0	0.82
54	19.0	6.34	5	774	3	0.8	88.6	1.93
55	21.5	3.40	6.5	4005	2	6.4	57.3	3.93
56	21.0	5.53	11.5	6071	2	3.4	60.0	4.11
57	18.8	2.98	4	6027	5	0.8	88.6	1.91
58	17.5	4.63	13.5	13,861	7	1.8	76.8	7.42

Appendix E. Concluded

Station number	*Temp. (°C)*	*DO (mg/l)*	*Sed. depth (in)*	*No. per m^2 of macro-organisms*	*No. of taxa*	*Percent volatile solids*	*Percent solids*	*SOD $g/m^2/day$*
59	21.2	10.00	10	3918	4	2.0	77.2	5.61
60	25.0	4.45	12	5853	9	2.1	86.7	6.17
61	23.9	1.33	4.5	39,861	4	8.7	42.6	6.17
62	20.4	10.44	10	4736	7	0.9	83.6	1.96
63	19.5	15.25	16.5	1991	2	7.3	40.9	5.53
64	17.3	6.56	3	774	3	0.7	93.3	1.76
65	18.4	6.49	2	8223	4	1.3	86.3	0.86
66	24.3	3.65	4	2540	2	6.9	60.5	1.23
67	18.7	4.13	4.5	32,937	2	1.6	82.2	2.20
68	21.2	2.70	8	2368	3	6.8	42.0	1.93
69	24.9	9.73	1.5	4560	4	2.6	78.3	2.87
70	17.9	9.09	17	688	3	7.1	31.5	3.63
71	16.6	9.43	9	516	3	5.2	43.3	3.64
72	19.1	8.10	10	478	2	6.3	42.2	2.62
73	13.9	7.15	3.5	385	4	1.4	83.8	1.64
74	19.9	4.06	17	12,961	1	8.3	48.9	8.87
75	24.2	2.55	10.5	19,806	2	3.6	76.5	9.49
76	20.2	1.06	13.5	23,509	2	10.5	40.8	9.32
77	22.0	2.60	8	294,201	2	6.2	44.9	4.26
78	24.2	7.55	5	3874	7	9.7	75.7	4.20
79	14.9	0.85	10	7115	6	14.0	83.2	2.06
80	15.1	1.29	3	18,735	3	6.6	46.8	1.33
81	20.0	21.2	2	6672	4	3.4	77.5	4.45
82	22.2	16.35	7	4003	4	4.9	74.9	4.64
83	22.8	6.80	2	387	1	2.1	86.9	2.24
84	22.7	3.01	4	1465	2	3.0	81.2	2.78
85	22.2	9.13	5.5	3830	4	3.1	73.0	2.60
86	19.0	6.18	2.5	3530	3	1.4	81.6	1.55
87	15.6	7.38	2	440	3	7.6	43.4	0.86
88	15.8	6.99	12	306	2	8.4	48.2	1.13
89	17.8	7.07	5.5	497	3	4.9	75.8	0.50

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