A SURVEY OF THE WATER QUALITY PARAMETERS OF STEELE CREEK LAKE, SULLIVAN COUNTY, TENNESSEE

Submitted to Mrs. Nancy Dickerson
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ABSTRACT

As previously thought, the water quality of Steele Creek Lake was highly influenced by certain surrounding factors, which included Steele Creek, its tributaries, and Steele Creek Golf Course. The averages of the water parameter results were taken after water entered the lake. The averages were as followed: dissolved oxygen (d. o.) of 8.23 ppm; pH of 8.82; a water temperature of 15.26 degrees Celsius; an air temperature of 18.65 degrees Celsius; and a Secchi depth reading of 71.86 cm. The correspondence of the tested parameters showed that the lake was highly influenced by point and nonpoint source pollutants. As compared to Joe Jackson's study, transported sediment from the creeks was slowly filling in the lake and adding to high turbidity readings. Also, shoreline erosion caused high turbidity, which increased during rainfall.

Acknowledgments

After nine months, I owe much gratitude to many people who offered what time and service they had, and gave a helping hand in one form or another. This project began taking shape during my ecology courses with Phil Gentry. Ideas became actions soon after meeting with Kevin Hamed at Steele Creek Park Nature Center. Working with Kevin was a great experience and a testament to his devotion of Bristol's state park.

The great balancing act of this entire project came when I signed up for a special-projects biology course that integrated a research project. The course coincided with my last semester at Tennessee High as well as the latter half of my project. I enrolled and used the course (taught by Nancy Dickerson) to study scientific writing and construct this report. Without Mrs. Dickerson's guidance, it would be hard to imagine how this report could solidify the way that it has.

I am appreciative of the services that Phil Gentry, Kevin Hamed, and Nancy Dickerson offered over the course of a year. In addition, I would like to thank Jim Lapis, whose generous offering of a canoe ensured that I would stay dry. Joe Jackson conducted the first survey of water quality parameters of Steele Creek Lake, and it is his report that I first studied in order to help style my project. I also thank Wallace Coffey, Charlie Robinett, and others, whom have given their time.

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INTRODUCTION

The main purpose of this water quality study is to accumulate data on the Steele Creek lake, analyze the collected data to establish the general health of the lake, and compare it to past studies done on the lake. Comparable works of the past include: Limnological Studies on Steele Creek Reservoir conducted by Joseph Jackson in the Summer of 1971; Water Quality of the Steele Creek Watershed with Emphasis on the Swimming Area of Steele Creek Lake by Melody L. Shipley, in 1993; and A Comparison of Three Small Lakes In Sullivan County, Tennessee and Washington County, Virginia as Habitat For Waterbirds During The Winter Of 1997-1998 by Sarah Garrett.

Steele Creek Lake was first proposed in the early 1960s as a recreation area for Bristol, TN. A section of Beaver Creek Knob was the chosen site. Observations indicated that the drainage area of this watershed is mainly porous rocks and soil types such as limestone and red clay (Shipley 1993). Stoffel Creek, Mill Creek, and Steele Creek with all of its tributaries, are the water sources for the lake. These creek beds consist mainly of limestone based rocks. The water surface extends 52 acres. The length of the shoreline is 4,902 meters (3.05 miles) (Garrett 1998). The surface of the lake is found at 1,580 feet above sea-level. Depths fluctuate from 1 foot to 28 feet. It was noted that the reservoir is no deeper than the thermocline of other, deeper lakes, meaning that Steele Creek Lake should be classified as a pond (Jackson 1971). Recreations include fishing, and paddle boats. Because of the high fecal coliform counts, swimming was banned in 1993. From July of 1951 to the Fall of 1974, Bristol's Water Treatment Plant was

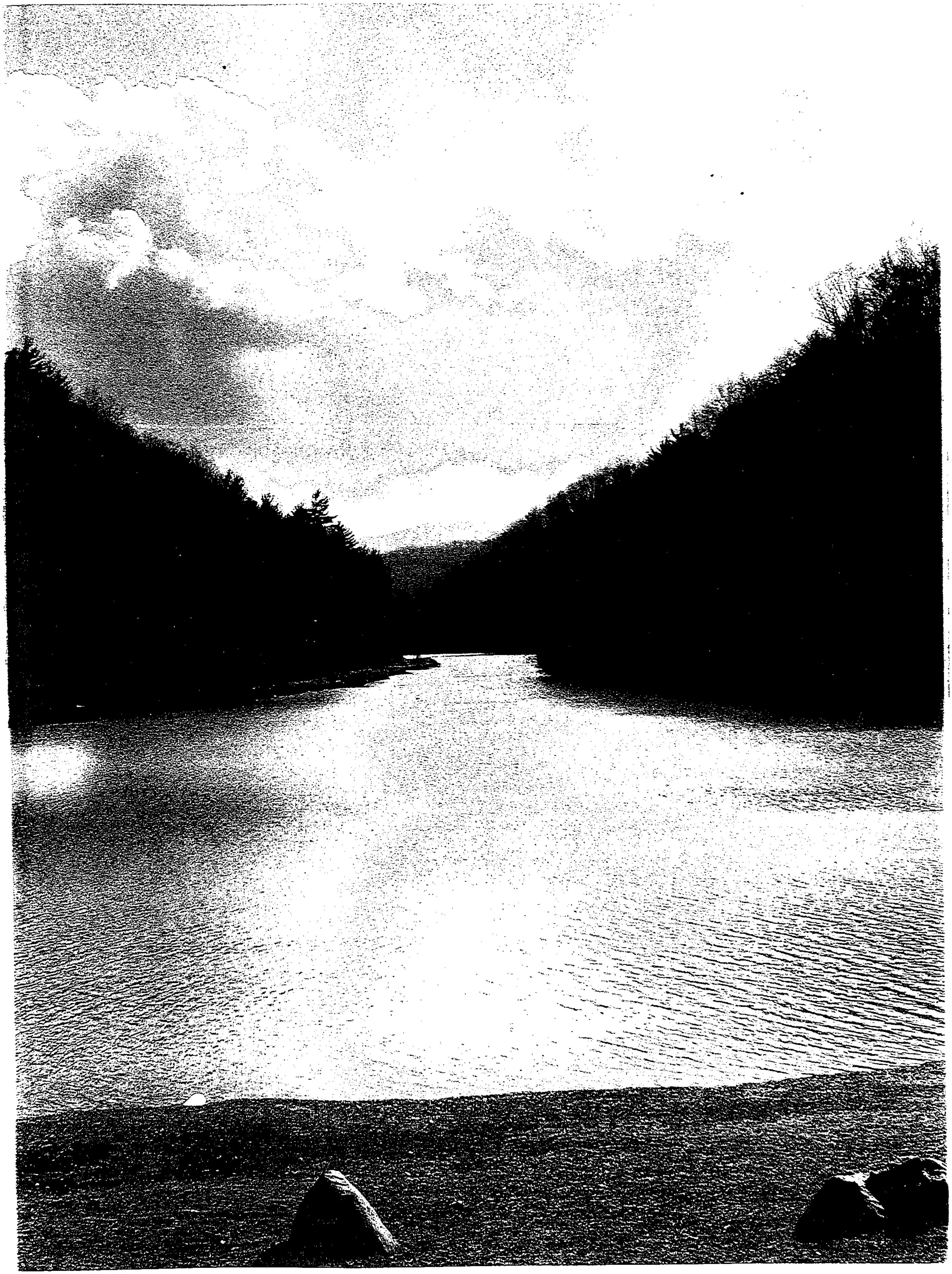


Figure 1: Steele Creek Lake as seen from below the Nature Center.

located across from Rooster Front, downstream from the lake (Robinette 1999). Because Steele Creek was situated in-between the plant and the city, a sewer line was built running under the surface of the lake. Occasionally, the pumping station would malfunction, causing the line to overflow into the lake.

Joseph Jackson conducted the first lake analysis in 1971. Jackson's water quality monitoring was included in his full scale study of Steele Creek Park, which extended over a ten week period from 6/1/71 to 8/12/71. A copy of the study shows sixteen test sites located within the reservoir (Jackson, 1971). Four of the chosen five sites for data collecting coincide with these. When reading through Jackson's report, it is important for one to remember that not only was swimming allowed in the lake, (which included a distribution of seventy five pounds of chlorine gas per-day, during swimming season) but the water treatment plant was located across from the park, which resulted in a few occurrences of a sewage spill. Steele Creek Lake was found to be highly productive because of excessive nutrient loading entering the lake. The water was found to be murky due to the high concentration of phytoplankton, which caused high turbidity and low dissolved oxygen levels (Jackson 1971).

Since August of 1998, the author has been collecting data from five specially selected sites which monitor the lake. The chosen parameters were dissolved oxygen, (d.o.) pH, Secchi disc measurements, water & air temperatures, depth measurements, and rainfall records. The objectives of this survey were to: monitor Steele Creek Lake on a weekly basis; perform various tests at selected sites throughout seasonal changes compile the collected data determine the seasonal fluctuation of the parameters decide whether or not the water is undergoing natural filtration as it passes though the lake; and judge the productivity of the lake based on the past studies.

Dissolved oxygen is an important indicator of the general health and the metabolic productivity of a lake. The concentration of d.o. in the water will determine the types of aerobic organisms which can live in a lake (fish, zooplankton, invertebrates). Both the diffusion of atmospheric oxygen and photosynthesis by algae and aquatic weeds are the main sources of oxygen for a body of water. Diffusion of oxygen from the atmosphere to water is done so by agitating water by means of wind, waves, and running over rocks. This creates a larger surface area for the diffusion. The dissolved oxygen dropped from a slightly higher than normal 10.4 ppm at the surface to less than 1.0 ppm between 10 and 15 feet (Jackson 1971). D.O. levels rise from morning through the afternoon, reaching a peak in late afternoon. Photosynthesis stops at night, but plants and animals continue to respire and consume oxygen. As a result, d.o. levels fall to a low point just before dawn (Mitchell and Stapp 1995). When incoming water is high in organic matter, the bacteria that decompose organic matter can consume the lake's dissolved oxygen supply more quickly than it can be replenished (ITC 1982). Physical influences include climate, temperature, altitude, atmospheric pressure, seasonal fluctuations, and turbidity.

Temperature has a direct effect on the solubility of oxygen in water (ITC 1982). Temperature patterns influence the fundamental processes occurring in a lake such as dissolved oxygen depletion, nutrient release, and algal growth. Cold weather prevents any prolonged algal bloom (Moore and Thornton 1988).

pH is the measurement of free hydrogen ions located in the water (ITC

1982). Very few species can tolerate pH values lower than 5 or greater than 9 (Andrews 1972). When first observed, Steele Creek Reservoir had a pH of 8.0, which was influenced by the amount of chlorine added (Jackson 1971). More recently, the pH average was 9.1 (Garrett 1998). Changes in the pH of a lake are influenced by photosynthesis. The pH of a body of water generally drops as the body of water ages. A body of water is usually basic when young and it becomes more acidic with time. This is caused chiefly by the buildup of organic materials which release carbon dioxide into the water when they decompose. The geologic make-up of a body of water and its surroundings is a major influence on the pH level. Other influences of pH include salts, acids, and bases. The normal pH for high fish production is 8.3 (ITC 1982).

Turbidity (light penetration) is measured by the amount of organic and inorganic suspended solids within the water. A Secchi disc is one of the instruments used to measure the turbidity of the water. Phytoplankton and zooplankton are the major contributors to Steele Creek's lack of visibility. Silt has played a significant role in the turbidity of the lake, and Secchi depth soundings have shown to be from 2 to 5 feet (Jackson 1971). When water has a high turbidity, making waters murky, there is a reduction of the light available for photosynthesis. This will cause a dissolved oxygen depletion. Since fertilizers from the golf course provide nutrients to these colonies of phytoplankton, a number of algal blooms were witnessed in Par Bay and White Oak Cove (Jackson 1971). There are many factors which influence a lakes light penetration. The largest factor of light penetration is sediment.

Sedimentation can be caused within the lake, or can enter the lake by way of its water source. Most sediment comes from areas under development. Another reason is poor management of agricultural land and run-offs of streets and interstates. Sediment ranks number one among non-point source pollution of all lakes in the United States. This statistic will only increase in the years to come because of the growing population and development (Terrell and Perfetti 1988). For the same amount of rainfall, a typical city block has nine times more run-off than a wooded area the same size. This run-off carries all of the contaminants associated with urban land uses: oil from streets and parking lots, lawn care products, and sediment from construction sites.

METHODS & MATERIALS

Observations and tests were performed at five chosen locations which best represented the 52 acre lake. The parameters were: total amount of rainfall per-week, air & water temperatures, Secchi depth readings, depth measurements, pH, and dissolved oxygen (D.O.). All rain records used for this project were collected and kept by Kevin Hamed and the Steele Creek employees. The first site tested from the canoe was the fourth horizontal beam on the bridge before entering Par Bay and White Oak Cove (Figure 3). After dropping anchor, the air temperature was noted. After the air temperature was observed, the water temperature was taken by lowering the thermometer into the water with the bulb at a depth of one to two feet. Next, the metal Secchi disc, which was 20 cm in diameter and divided into quadrangles that were patterned in black and white, was lowered into the water until it disappeared (then a measurement of the length of the cord was measured using a 48 inch-long measuring device).

The dissolved oxygen test was then performed using the Winkler Method. Before the water sample was taken in a 60ml Bottle, the bottle was first rinsed with water to be tested. Grasping the bottom of the bottle, the bottle was placed underwater 5 to 12 inches until the bottle was completely empty of all air bubbles. The first 2 of the 3 chemicals which ensured a "fixed" sample, were 8 drops of both Manganous Sulfate and Alkaline Iodide-Azide Reagent. After a total of 16 drops, the cap was placed back on the bottle and shaken until the 2 chemicals were mixed. The last of the fixing agents was 8 drops of Sulfamic acid. The cap was then placed back on the bottle and inverted several times. After a dark yellow was obtained, if oxygen is present, the sample was relocated to a 20 ml bottle. A titration syringe was then filled to the .10 marker with Sodium Thiosulfate, and one drop at a time was added to the sample until the tint of the yellow lightened to a faint yellow. The cap to the 20 ml bottle was removed and 8 drops of Starch Indicator Solution were added. After mixing, a blackish-purple was obtained. Once replacing the titration syringe, with the same amount of Sodium Thiosulfate in it, the author continued adding drop-by-drop until the sample became clear. The extra amount in the syringe was then calculated out as the amount of dissolved oxygen in a part-per-millionth. If the sample was not entirely clear by the time the syringe was empty, I added however many units were needed to clear the sample.

For the HACH pH test, the 10 ml tube was rinsed with the water to be tested. Carefully, with my hand away from the lid of the tube to prevent contamination of the sample, the tube was placed 5 to 12 inches below the surface of the water, and a 10 ml sample was collected. Five drops of the HACH Wide Range 4 Indicator Solution were added and then shaken. The tube was then placed in the HACH color wheel box. The color of the sample was matched with the closest color.

After the pH was determined, the thermometer was checked for any variation in temperature since first arriving at the test site. At the third site, located parallel to the first manhole at the beginning of the channel, (Figure 3) the exact same process was then performed. After the third site's data was complete, the same procedures were performed at the fourth site out in the middle of the lake, parallel to the deep cove (Figure 3). After the fourth site was completed, the author went to the opposite side of the dam, where the fifth site was located (Figure 3). This included pulling ashore and carrying the equipment.

Depending on the time of day, or the time of year, the second test site was either tested first or last. This was because of the isolation of the second site from

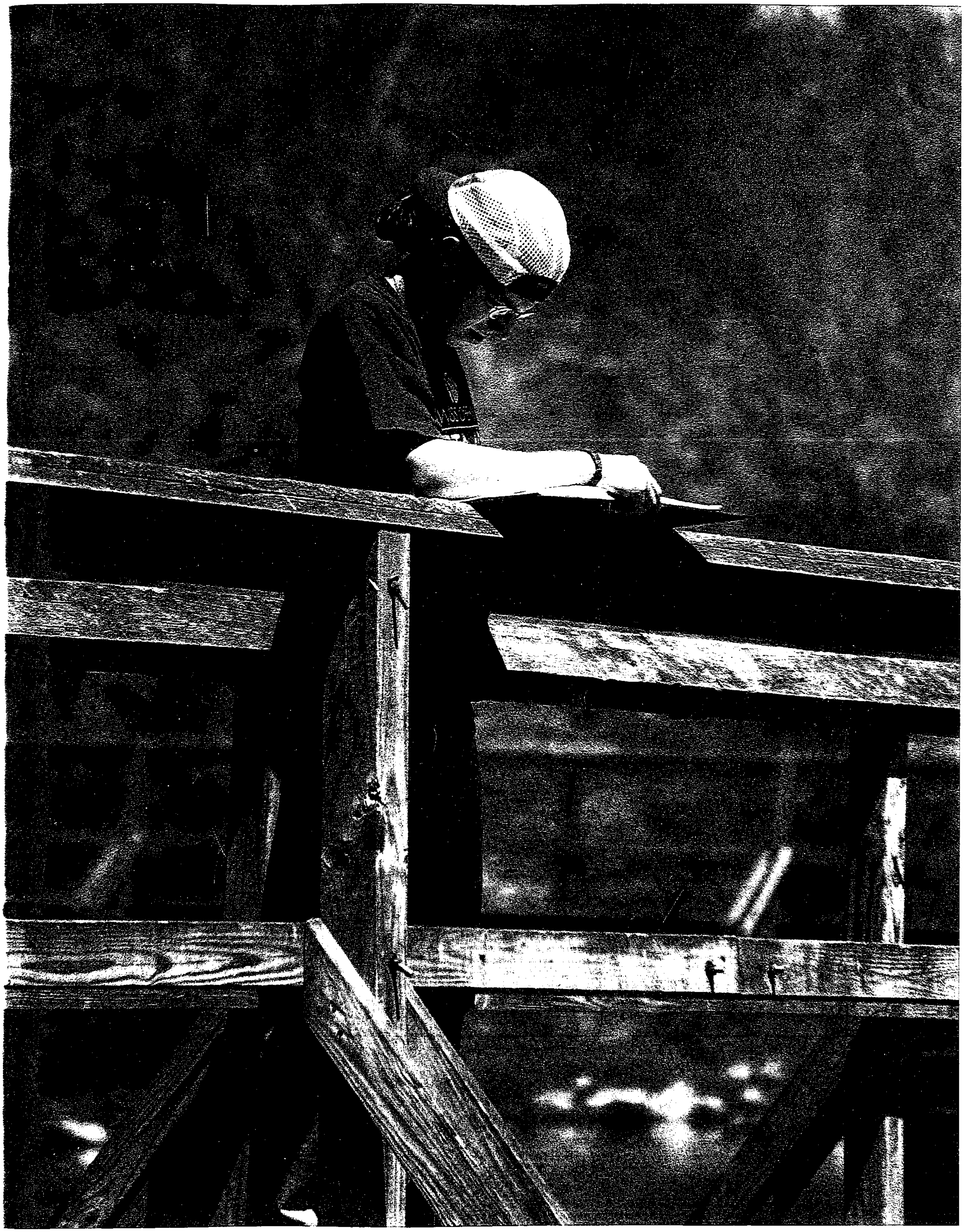
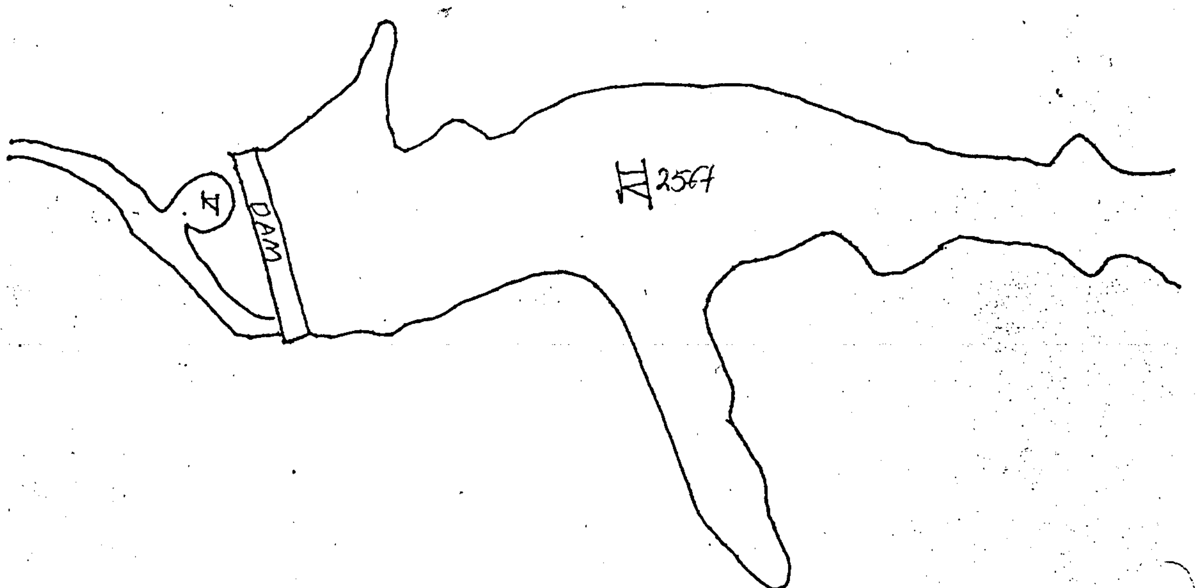


Figure 2: The author recording results of the parameters of site 2.

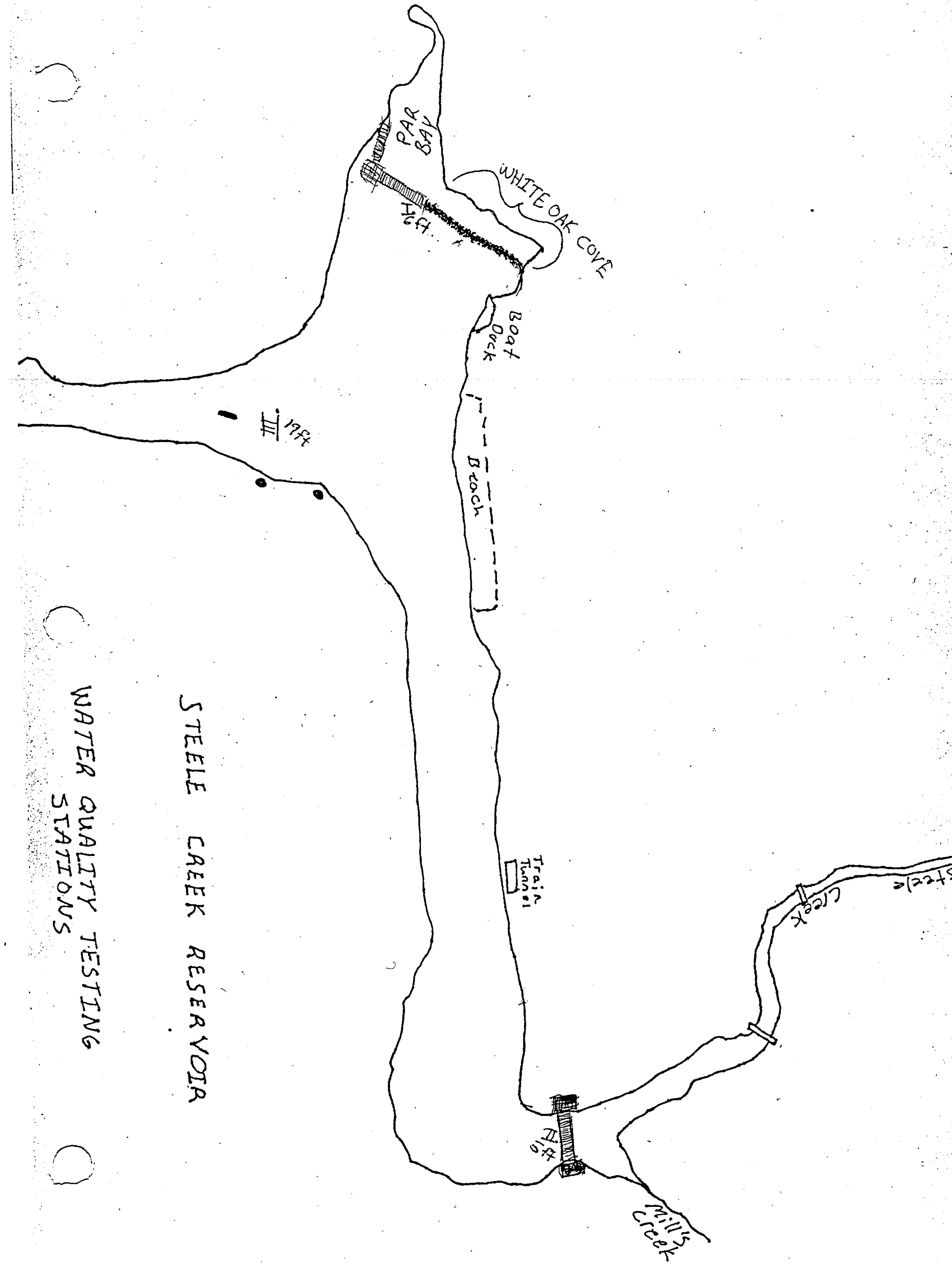
the rest of the sites. This site was located on a bridge (Figure 2), on the opposite side of the lake where Steele Creek and Mill's Creek join together (Figure 3). The author found it much more of a convenience to drive to the second site.

MATERIALS

-1 Star Bright "Blue Hole" canoe
-1 LaMotte dissolved oxygen test kit (code #:5860)
-1 HACH pH test kit (code #: A1-36B)
-15 pound anchor
-2 Carlisle paddles
-1 pair of neoprene gloves
-35 ft. chain (for anchor)
-1 Secchi disc
-1 metal measuring stick (48 inches)
-1 Weksler thermometer (Celsius, -10 - 110) (code #:5263)
-1 Enviro-safe thermometer (Celsius, -20 - 110)
-1 lifejacket
-1 notebook & Pilot pen
-1 Hummingbird fish-finder (sonar)
-1 1987 Chevrolet Celebrity station wagon



(Figure 3)
Map of locations with depths
(sampling sites highlighted)



RESULTS

This survey extended from the late Summer of 1998, into the early Spring of 1999. By taking samples on a weekly basis, the author would monitor seasonal fluctuations, and then determine the general health of the lake.

The water quality monitoring extended from August 15,1998, to April 24, 1999, with 33 days of surveying. It should be noted that from August 15, to November 7, water samples were collected for d.o. and pH from the five sites, and taken back to the lab located inside the Nature Center. There, two water specimens were taken from each of the five bottles and d.o. and pH were calculated. If for some reason(s) the test kit(s) was/were unavailable at the moment, because of other use, the samples were placed inside the refrigerator until the test kit(s) was/were available. As of November 14, d.o. was determined immediately upon being collected. By December 10, pH was calculated on site as well.

The author investigated into the point source pollution which influenced site 1. A list of the chemicals used, and the time of applications, was taken while meeting with the Superintendent of the Greens at Steele Creek Golf Course. Scotts' Turf Fertilizer Plus, and Scotts' Preamerge Weed Control were added once a year. Scotts' Greens & Tees Contect, and Scotts' Contect 15-0-30 High K were applied three times a year: early spring, late spring, and fall (applications vary with the weather). The summer's dry, hot weather was not the ideal time to apply chemicals to the golf course. Three bags of each product (50 lbs.) were used when applied. From the end of September 1998, to the first week of March 1999, no fertilizers or herbicides were added to the park. The Superintendent also stated

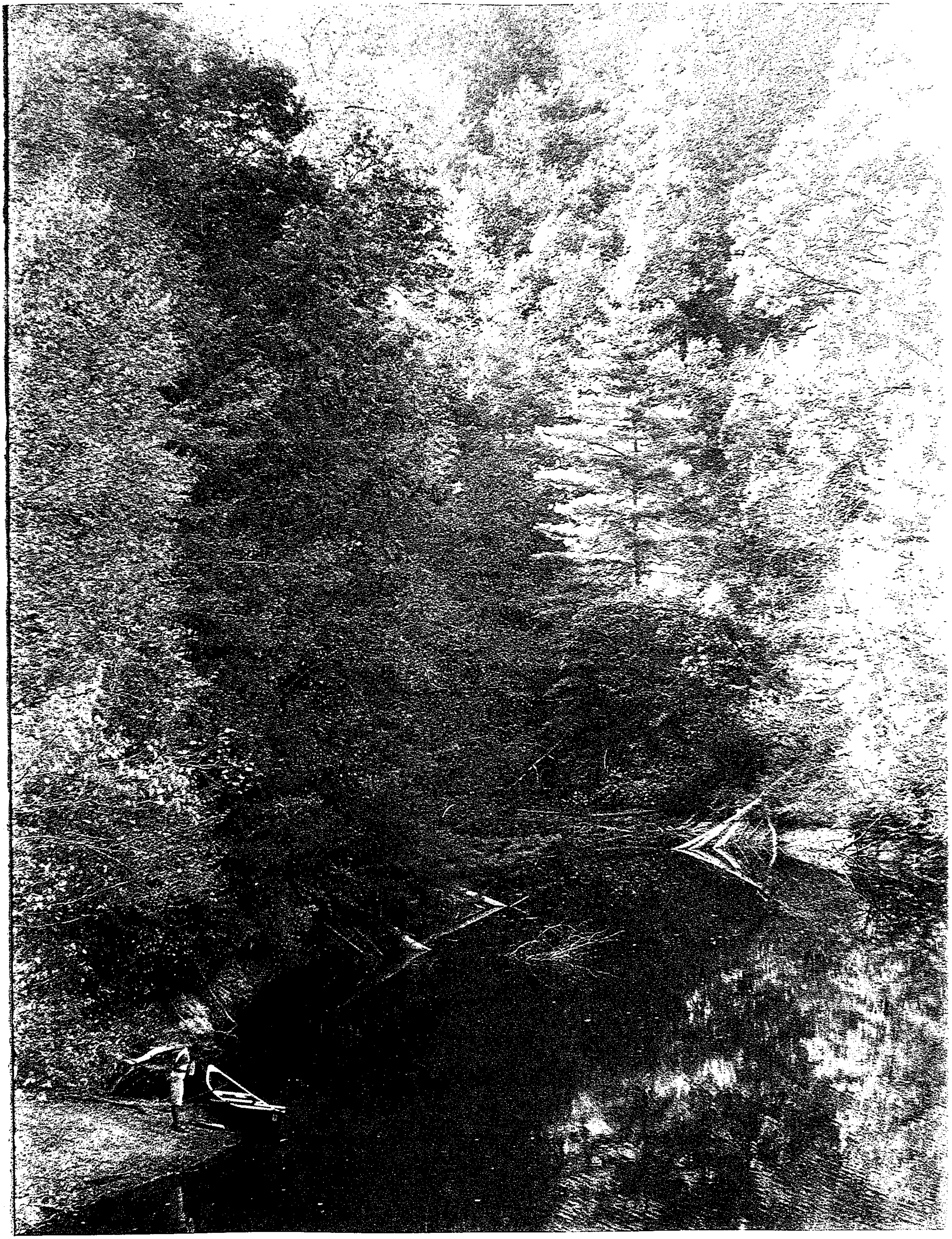


Figure 4: Upon arriving at the landing for site 5, the author begins to gather his equipment.

that chemicals were not applied to the holes next to the lake because of the run-off which would occur.

To correlate information at a faster pace, the 33 monitoring days were divided into four sections: Late Summer (8/15/98 - 10/3/98); Fall (10/10/98 - 11/14/98); Winter (11/23/98 - 2/14/99); and Early Spring (2/27/99 - 4/24/99) (the seasonal names were also referred to as 1st, 2nd, 3rd, & 4th quarters). The cut-off dates were determined by a noticeable decrease (increase) in air temperature. The records which were used to determine these dates were taken by the author on the days of monitoring.

Kevin Hamed and the employees of the Steele Creek Nature Center provided measurements and records of rainfall (Appendix B). Alterations to the dates of the four quarters were made **only** to account for the amount of rain for the week before each monitoring day. The altered dates for each quarter were as followed: first quarter (8/9/98 - 10/3/98); second quarter (10/3/98 - 11/14/98); third quarter (11/16/98 - 2/14/99); fourth quarter (2/20/99). This left two gaps in-between the quarters. The first gap spanned from 11/14/98 to 11/16/98, leaving the fifteenth of November unaccountable for. The second gap spanned from 2/14/99 to 2/20/99. The fifteenth through the nineteenth of February were not included. During the five day period, rainfall occurred on the eighteenth and nineteenth of February (Appendix B).

All dissolved oxygen records were measured in parts-per-millionth (ppm); pH was measured on a scale of one to twelve, with seven being neutral. Below seven is acidic, and above seven is basic (alkaline); Both air and water temperatures were measured in 'degrees Celsius'; All Secchi disc measurements, which were taken in inches and then converted, are to be read as centimeters (cm).

Secchi disc depths were not performed at the fifth site, because of the shallowness of the water (Figure 1). For that reason, 'not observed' is abbreviated by "N.O."

Table 1: FIRST QUARTER AVERAGES (8/15/98 - 10/3/98)

	D.O.	pH	Air Temp.	Water Temp.	Secchi
Site #1:	7.54	8.58	25.89	22.11	60.96
Site #2:	7.02	8.59	25.56	22.11	49.95
Site #3:	7.18	8.66	24.78	21.67	78.88
Site #4:	7.24	7.53	25.11	18.78	100.19
Site #5:	6.26	8.58	25.78	21.89	N.O.

The first quarter spanned 56 days, and 9 surveying days. From the entrance of the lake, (site 2) the average d.o. falls 0.76 ppm to become 6.26 ppm (site 5). The average water temperature was found to decrease from 22.11 degrees (sites 1 & 2) to 18.78 degrees, (site 4) and then increase 3.11 degrees to 21.89 degrees Celsius (site 5). As the water temperature decreased, the depth of light penetration increased. Each site's average air temperature remained higher than its average water temperature. 49.95 cm (site 2) was the shallowest average Secchi reading, except for site 5. 100.19 cm (site 4) was the deepest Secchi reading. The average pH ranged from 7.53 (site 4) to 8.6 (site 3). Rainfall occurred during ten days, leaving a total of 2.84 inches of rain in the first quarter (Appendix B).

Table 2: SECOND QUARTER AVERAGES (10/10/98 - 11/14/98)

	D.O.	pH	Air Temp.	Water Temp.	Secchi
Site #1:	8.57	9.73	21.50	15.67	88.48
Site #2:	8.48	9.83	18.67	16.50	67.31
Site #3:	7.78	9.82	16.67	15.83	113.86
Site #4:	7.97	9.73	16.67	16.00	118.53
Site #5:	8.55	9.92	16.83	16.17	N.O.

The second quarter spanned 42 days and 6 surveying days. The highest d.o. average was 8.57 ppm (site 1). The average concentration then decreased to 7.97 (site 4). After the spillway, the d.o. averaged 8.55 ppm (site 5). The average pH fluctuated very little throughout the five sites, obtaining a high 9.7 - 9.9 concentration. The warmest air temperature was 21.50 degrees (site 1). This average decreased in sites 2, 3, 4, and 5. The average air temperature for each of the five sites remained higher than its average water temperature. 16.50 degrees was the highest average water temperature (site 2). Site 5's average was the second highest water temperature which was 16.17 degrees. The lowest average water temperature was 15.67 degrees (site 1). After the spillway, the average water temperature increased .17 degrees to become 16.17 degrees (site 5). 67.31 cm (site 2) was the shallowest average Secchi reading. The deepest average for Secchi readings was 118.53 cm (site 4). Rainfall occurred on five days, leaving 1.80 inches (Appendix B). October consisted of only one day of rain, accumulating one inch (Appendix B).

Table 3: THIRD QUARTER AVERAGES (11/23/98 - 2/14/99)

	D.O.	pH	Air Temp.	Water Temp.	Secchi
Site #1:	7.88	7.61	7.38	6.70	75.22
Site #2:	8.26	7.61	9.38	7.62	75.42
site #3:	7.95	7.61	7.77	6.85	80.69
Site #4:	8.12	7.64	7.69	6.77	118.80
Site #5:	8.95	7.64	7.46	7.00	N.O.

The third quarter spanned 92 days and 13 surveying days. The highest average d.o. concentration was 8.95 ppm (site 5). 7.88 ppm (site 1) was the lowest of the average d.o. concentrations. Each of the five site's average air temperature was higher than its average water temperature. After the spillway, the average air temperature increased .23 degrees. 6.70 degrees (site 1) was the lowest average water temperature. 7.62 degrees (site 2) was the highest average water temperature. Site 5's water temperature was the second highest average which was 7.00 degrees. 75.22 cm (site 1) was the shallowest average Secchi depth. 118.80 cm (site 4) was the deepest average Secchi reading. 11.89 inches accumulated during 38 days of rainfall (Appendix B).

Table 4: FOURTH QUARTER AVERAGES (2/27/99 - 4/24/99)

	D.O.	pH	Air Temp.	Water Temp.	Secchi
Site #1:	10.04	9.12	20.00	13.60	79.25
Site #2:	9.14	9.24	21.00	14.80	94.74
Site #3:	8.66	9.04	20.00	14.00	104.14
Site #4:	8.94	9.22	19.80	13.40	171.70
Site #5:	9.34	9.06	20.20	13.80	N.O.

The fourth quarter's time spanned 64 days, and 5 surveying days. 10.04 ppm (site 1) was the highest average d.o. concentration. The lowest average d.o. concentration was 8.66 ppm (site 3). Average pH values ranged from 9.04 (site 3) to 9.24 (site 2). For each of the five sites, the average air temperature was higher than the average water temperature. After the spillway, the average water temperature increased 0.40 degrees to become 13.80 degrees (site 5). The shallowest average Secchi depth reading was 79.25 cm (site 1). 171.70 cm (site 4) was the deepest average Secchi depth reading. Rainfall occurred for 29 days of the 64 day quarter, accumulating a total of 6.75 inches (Appendix B).

Table 5: SURVEY AVERAGES (8/15/98 - 4/24/99)

	D.O.	pH	Air Temp.	Water Temp.	Secchi
Site #1:	8.51	8.76	18.69	14.52	75.98
Site #2:	8.23	8.82	18.65	15.26	71.86
Site #3:	7.89	8.78	17.31	14.59	94.39
Site #4:	8.07	8.53	17.32	13.74	127.31
Site #5:	8.28	8.80	17.57	14.72	N.O.

The entire sampling period covered 222 days, and 33 surveying days. 8.51 ppm (site 1) was the highest average d.o. 7.89 ppm (site 3) was the lowest average d.o. 8.82 (site 2) was the highest average pH, and 8.80 (site 5) was the second highest average. 8.53 (site 4) was the lowest average pH. 15.62 degrees (site 2) was the highest average water temperature, followed by 14.72 degrees (site 5). 13.74 degrees (site 4) was the lowest average water temperature. 127.31 cm (site 4) was the highest average Secchi reading, followed by 94.39 cm (site 3). 71.86 cm (site 2) was the lowest average Secchi reading. There were 82 days of rain, accumulating a total of 24.68 inches.

DISCUSSION

The data gave insight into the metabolic and filtration processes of Steele Creek Lake during seasonal changes. Due to the physical contours of the lake and its natural and unnatural surroundings, the results of the parameters were consistent with what was expected. With the occurrence of an event or action, the lake's metabolic productivity was impacted by it, and then began the processes toward equilibrium.

During the course of the survey the water level of the lake was lowered in order to stabilize the banks of the lake (Appendix D). The lake began lowering on the thirteenth of September, 1998, by means of the dam's flood gates. These gates were located near the bottom of the dam, which when used, suctioned water off the bottom of the lake. These gates remained open for ten days. Construction then continued for two and a half weeks. On the nineteenth of September, the author conducted the first parameters since the lake had been lowered. Within the six day period, the lake had decreased three and a half feet, leaving an excess of debris, thick sediment, and a strong odor of organic decay throughout the lake. This resulted in lower than usual d.o. concentrations and Secchi depth readings (Appendix C).

The geologic make-up of the Steele Creek Lake and its surroundings is mainly limestone rock. The creek beds which empty into the lake and the spillway located at the dam also contained limestone (Gentry 1999). Steele Creek Lake's higher than normal pH was due in part to exposure with such rocks. Site 2's average pH of 8.82 was the highest average during sampling (Table 5). The

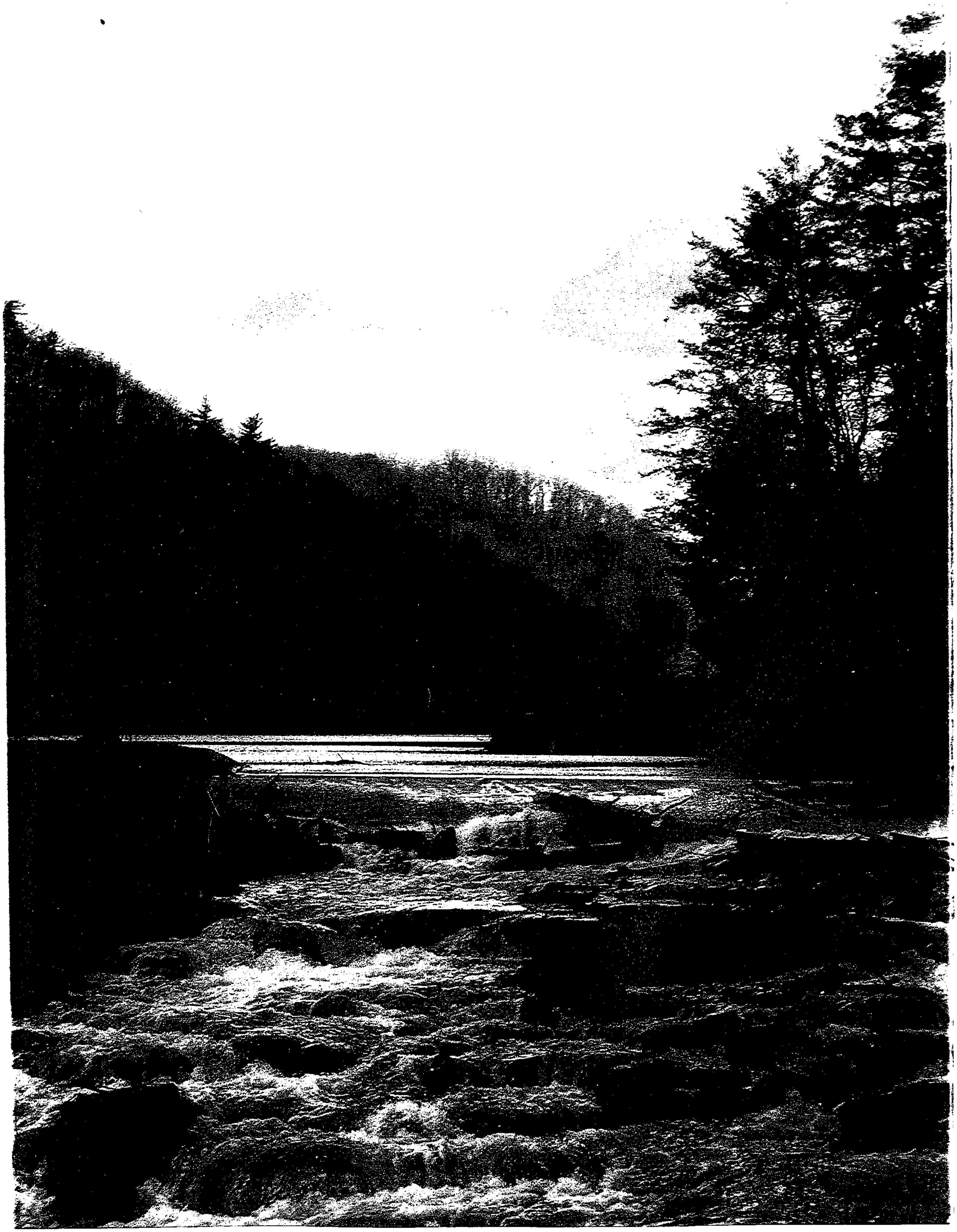


Figure 5: The entrance of the spillway, which remained active throughout the survey.

alkalinity of the limestone was what caused this result. The average pH of site 5 was 8.80 (Table 5). From site 4's average pH of 8.53 the pH increased an average of 0.27 units (Table 5). This showed that the limestone rocks in the bed of the spillway had much of the same effect on pH as did the creeks on site 2. Site 4's overall average of pH (8.53) was the lowest of the five sites. This comparatively low average was influenced by the depth of site 4, which caused the dilution of hydrogen ions. Compared to the third quarterly pH averages, site 1 had a relatively high pH. Its fourth quarter pH average was 9.12 compared to the third's average of 7.61. A factor that may have played a crucial role in this high average was the addition of nutrient-rich fertilizers.

The dissolved oxygen concentrations were strongly affected by light penetration, agitation, rainfall, air and water temperatures, and non-point source pollution. Site 1 obtained an average d.o. concentration of 8.51 ppm (Table 5). During the fourth quarter, site 1's average d.o. was 10.04 ppm (Table 4). This was the highest d.o. average of any quarter during surveying. This average may be due in part to the application of Scott's fertilizers used by Steele Creek Golf Course during the first week of March. These fertilizers led to a greater amount of nitrates, phosphates, and potassium, which contributed to the increase in phytoplankton. From the first of March to the twenty-fourth of April, 5.7 inches of rain had accumulated (Appendix B). This excessive amount of rain led to heavy run-off from the golf course despite that no fertilizer applications were given to the greens next to the lake. The agitation of Steele Creek and Mill Creek also influenced the d.o. concentration. Site 2's d.o. concentration averaged 8.23 ppm. Site 5's average d.o. was 8.28 ppm (Table 5). The increase of 0.21 ppm from site 4 was a result of the agitation of water and air, caused by the spillway. On the nineteenth of September, site 5's d.o. concentration was 5.0 ppm, the lowest d.o. observed during the project (Appendix C). When the flood gates were opened on the previous Sunday, water was taken off the bottom of the lake as opposed to the surface. The dissolved oxygen was in higher demand at the bottom, in order for decomposition to occur. The analyzed data showed the dissolved oxygen content to be inversely proportional to the temperature of the water. Results show that the dissolved oxygen content slowly increased with the passing of seasons (Figure 7). This climax was reached in the middle of January, in which water temperatures were at there lowest point (Figure 9). As water temperatures began to increase, the solubility of the oxygen decreased.

In areas where depths were at a minimum, the water captured more of the sun's energy than deeper water, where the sun's energy was dispersed more evenly down the water column. The longer this occurred, the more likely the water temperatures were to increase. Steele Creek and Mill Creek created such a condition for Site 2, before entering the lake. The average water temperature for site 2 was 15.26 degrees (Table 5), the highest of the five sites. Site 2 also maintained the highest quarterly water temperature averages throughout the sampling period. Across the lake at the dam, the spillway created the same effect for site 5 as did the two creeks for site 2. Site 5's average water temperature was 14.72 degrees, an average 0.98 degrees increase from site 4's average water temperature, which was 13.74 degrees (Table 5).

The result of the water temperatures from the five sites is telling. Although slight trends may have been detected, these trends were not significant enough.

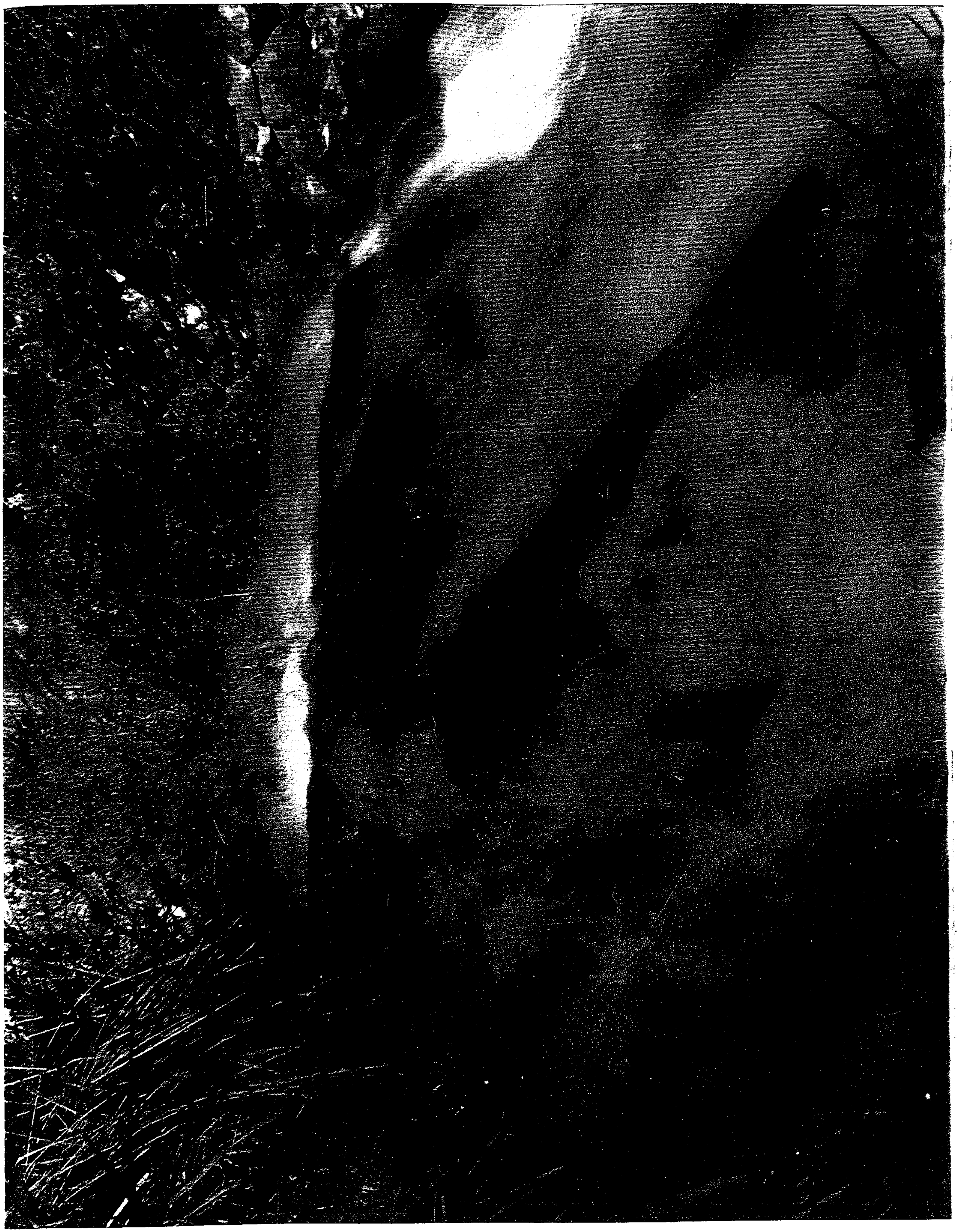


Figure 6: After entering the spillway, the limestone rock provided an increase in pH, while the rushing water increased the oxygen content.

This raises an important point about the water temperature of the lake. Due to the quick circulation of the lake water from site 2 to site 5, there is not enough time for much change to occur to the thermal properties of the lake. Such restriction upon water is due to its high specific heat when compared to other substances.

The air temperature of a certain site was largely influenced by the time testing was performed at that site. Because of that, a direct comparison of the data is difficult, if at all possible. However, Figure 5 shows the instability of the atmosphere when compared to the aquatic environment, the relationship of air and water molecules, and how the two function with one another.

The results of the Secchi readings show site 4 to have the highest clarity of the four sites tested (Figure 11). Site 4 averaged 127.31 cm of light penetration (Table 5). Fourth quarter's average of 171.70 cm was the highest average of any of the sites (Table 4). Site 3's 94.39 cm was the second highest averaged Secchi depth (Table 5). On average, site 2 had the lowest light penetration, which was 71.86 cm (Table 5). This builds substantial evidence that there is a high amount of bank erosion occurring along the creeks feeding into the lake. Whether or not rainfall occurred, it had a reverse effect on light penetration throughout the lake, as seen in Figures 11 and 12, by following the contours of site 4, and the contours of the rainfall. This proved that when rainfall was high, light penetration was low, and when rainfall was low, light penetration was high.

Soundings, conducted on the eighth of May, 1999, (Appendix E) were done for comparison with the soundings done on the ninth of August, 1971, (Appendix F) by Joseph Jackson. Both sets of soundings were done to better understand the contours and depths and to figure the siltation process of the man-made lake. During his study, Joseph Jackson predicted that the man-made Steele Creek Lake, with the characteristics of a large pond, would eventually fill up with sediment. The soundings conducted in May of 1999, almost thirty years after Jackson's, were direct evidence of this foretold buildup. Jackson brought it to the author's attention at the end of the survey that a dredging project took place at only the creek's entrance to the lake. This dredging occurred in the early 1980s, during the repair of the pipe running along the side of the lake. There are no known soundings of the lake entrance after being dredged. Such data would be valuable for assessing the last fifteen years of sediment deposits. The soundings were successful in showing the amount of bank erosion that has occurred over the years and depositing itself on the bottom. Thus, the shoreline becomes steeper and the bottom steeper. This depositing effect can be seen especially in the channel and dam area of the lake. The bank stabilization project that occurred in September of 1998, was a direct result of the erosion (Appendix D). Unfortunately, there are other areas where stabilization is needed. The channel is one such area. It is the author's opinion that most of the sediment came from upstream and not from the lake itself. The amount of siltation that has occurred in the channel and dam area and Par Bay over a thirty-year period is less than that of what has built up in the entrance area of the lake over a fifteen-year period.

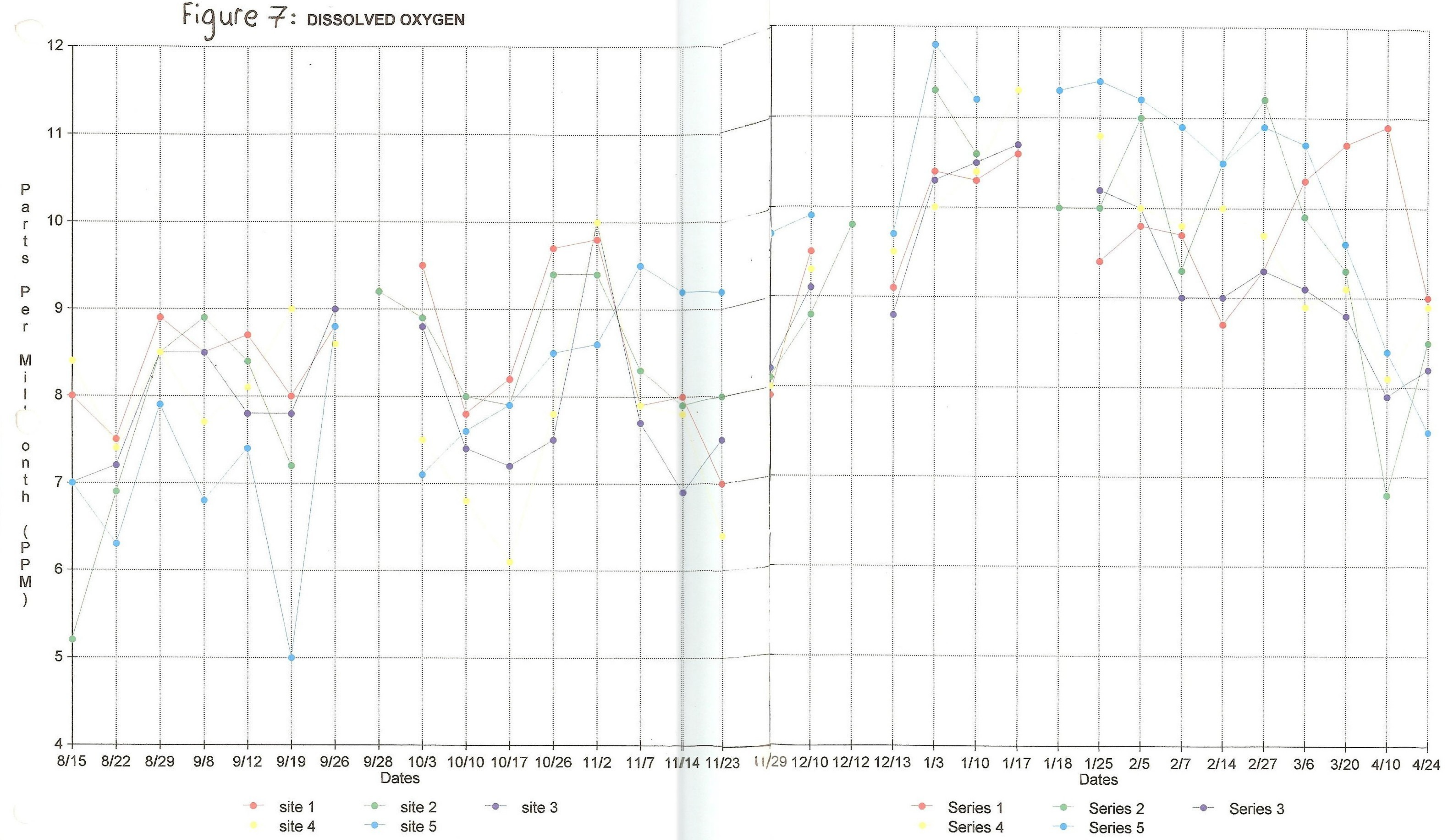
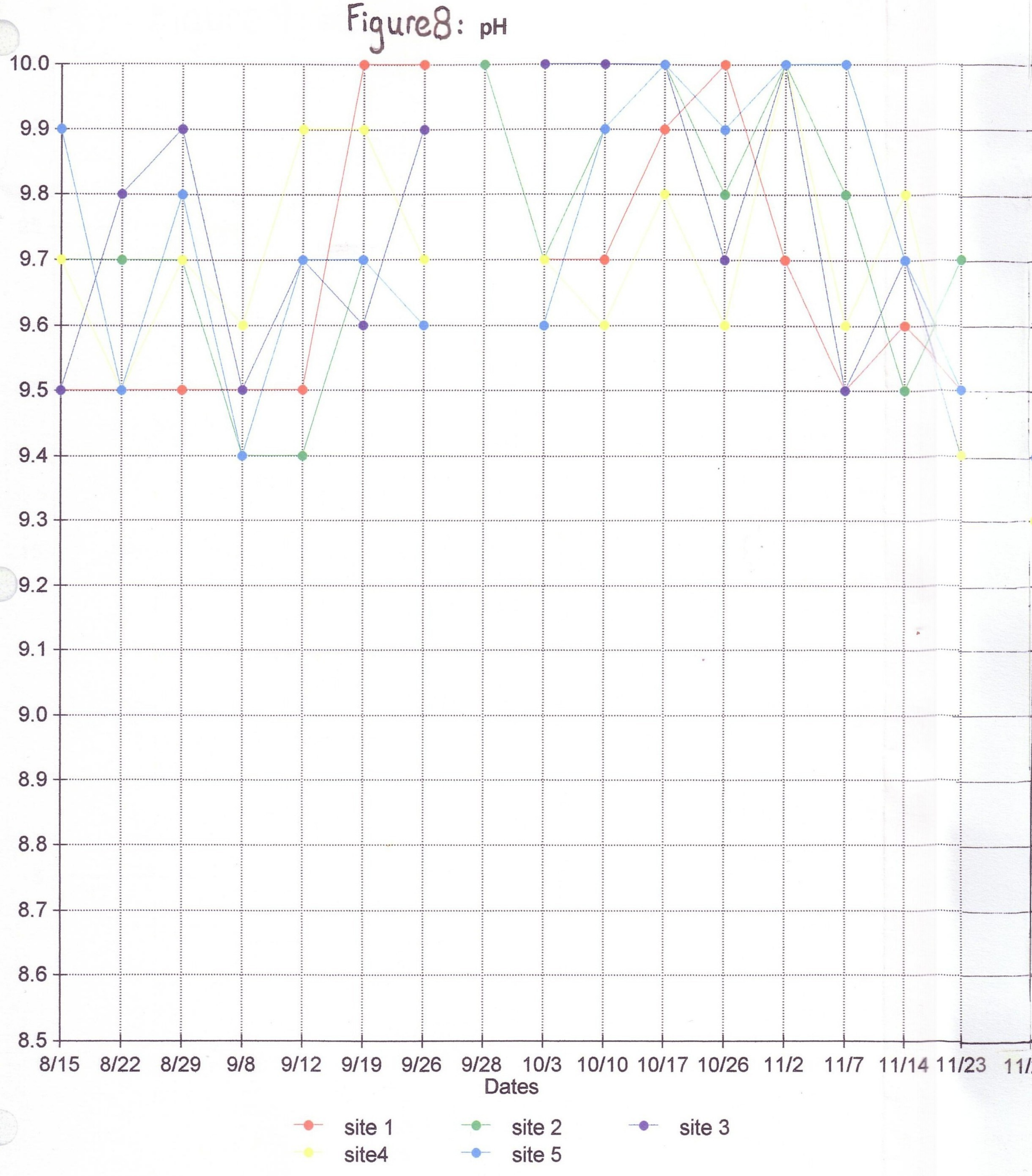
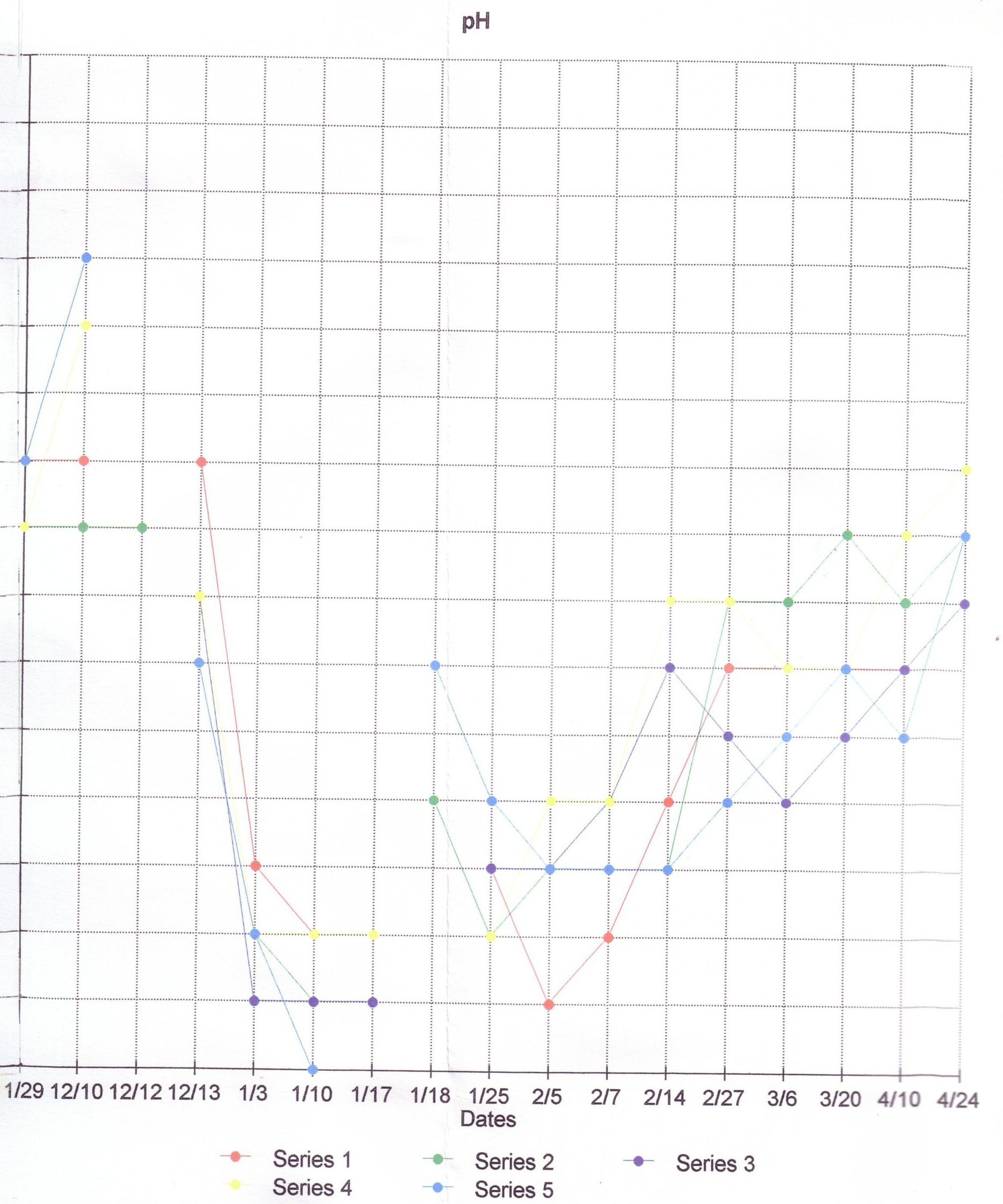


Figure 7: DISSOLVED OXYGEN
Parts Per Million (PPM)
12
11
10
9
8
7
6
5
4
8/15 8/22 8/29 9/8 9/12 9/19 9/26 9/28 10/3 10/10 10/17 10/26 11/2 11/7 11/14 11/23 11/29 12/10 12/12 12/13 1/3 1/10 1/17 1/18 1/25 2/5 2/7 2/14 2/27 3/6 3/20 4/10 4/24
Dates
Dates
site 1
site 2
site 3
site 4
site 5
Series 1
Series 2
Series 3
Series 4
Series 5

Figure8: pH



10.0
9.9
9.8
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9.0
8.9
8.8
8.7
8.6
8.5
8/15 8/22 8/29 9/8 9/12 9/19 9/26 9/28 10/3 10/10 10/17 10/26 11/2 11/7 11/14 11/23
Dates
site 1
site 2
site 3
site4
site 5



pH
11/29 12/10 12/12 12/13 1/3 1/10 1/17 1/18 1/25 2/5 2/7 2/14 2/27 3/6 3/20 4/10 4/24
Dates
Series 1
Series 2
Series 3
Series 4
Series 5

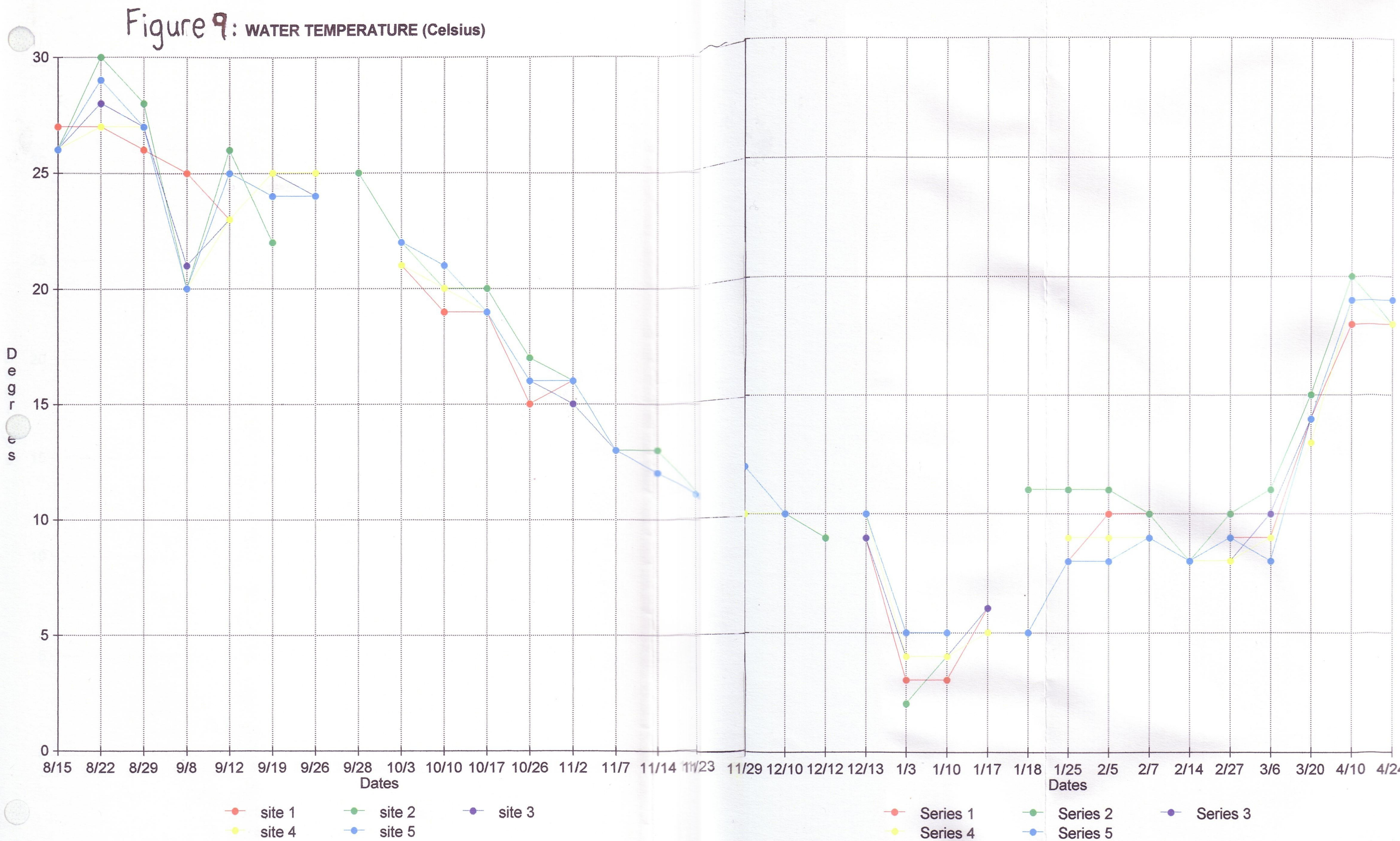


Figure 9: WATER TEMPERATURE (Celsius)
Degrees
30
25
20
15
10
5
0
8/15
8/22
8/29
9/8
9/12
9/19
9/26
9/28
10/3
10/10
10/17
10/26
11/2
11/7
11/14
11/23
Dates
site 1
site 2
site 3
site 4
site 5
11/29
12/10
12/12
12/13
1/3
1/10
1/17
1/18
1/25
2/5
2/7
2/14
2/27
3/6
3/20
4/10
4/24
Dates
Series 1
Series 2
Series 3
Series 4
Series 5

Figure 10: AIR TEMPERATURE (Celsius)

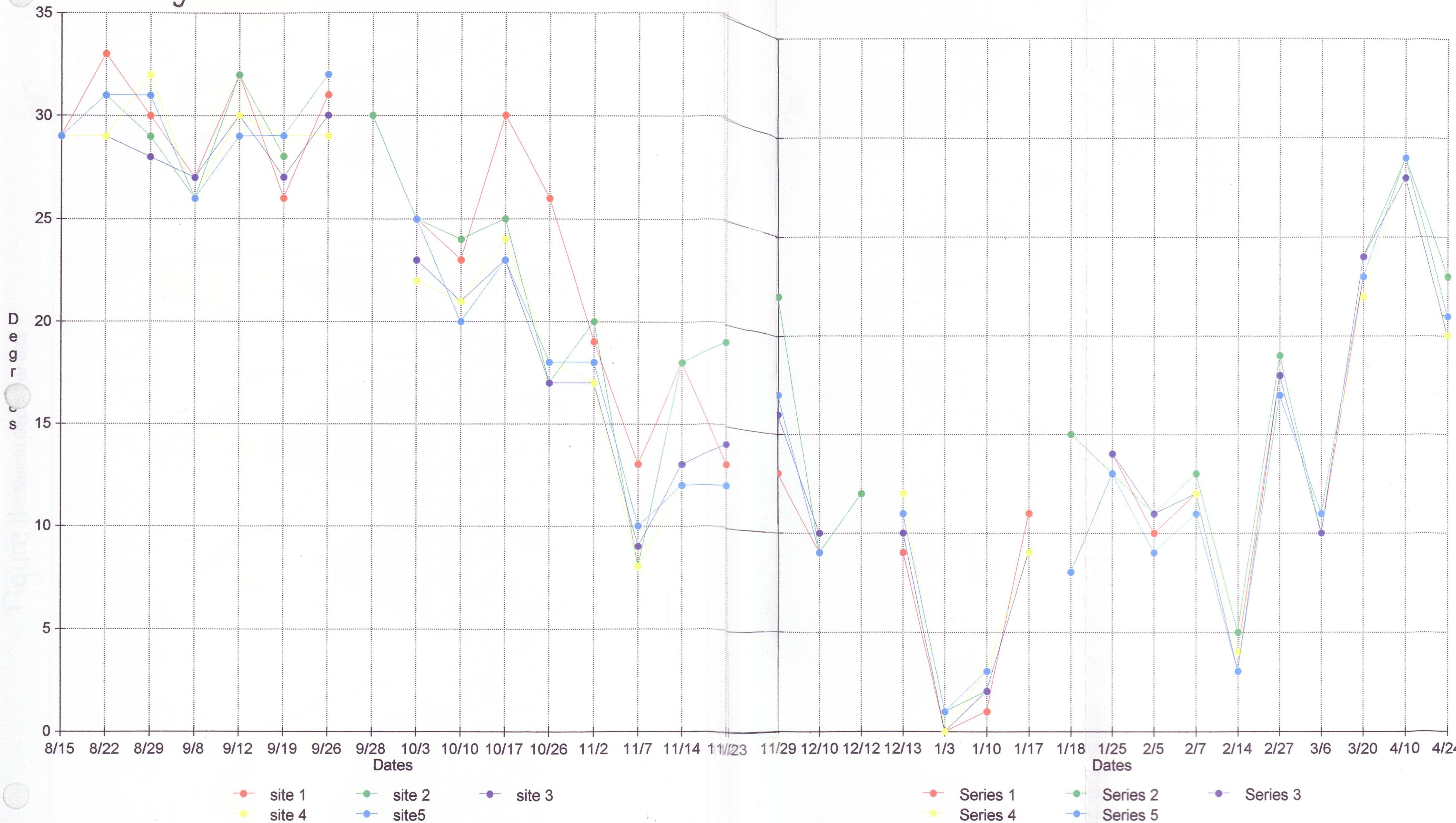


Figure 11: **Secchi Depth Per Site**

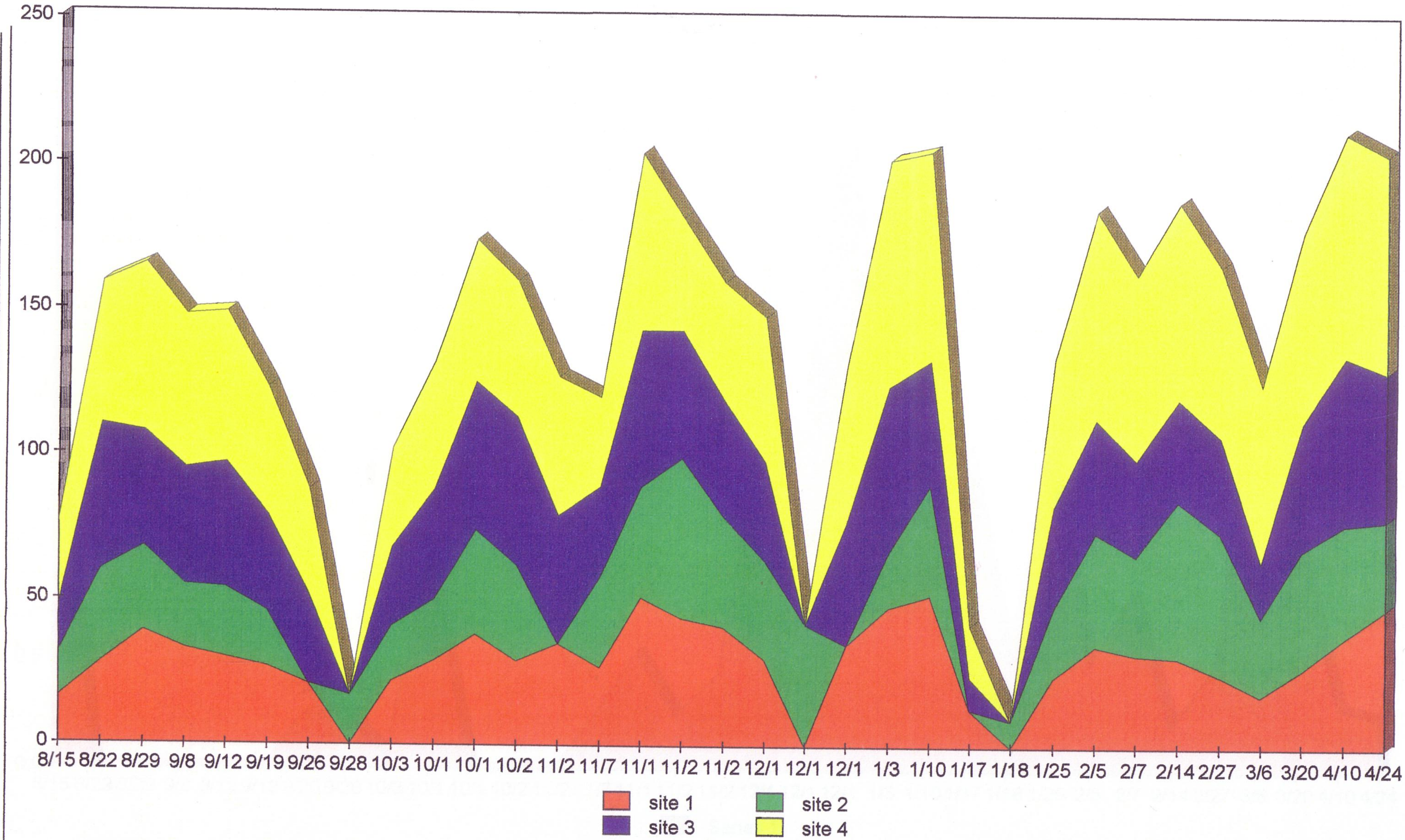
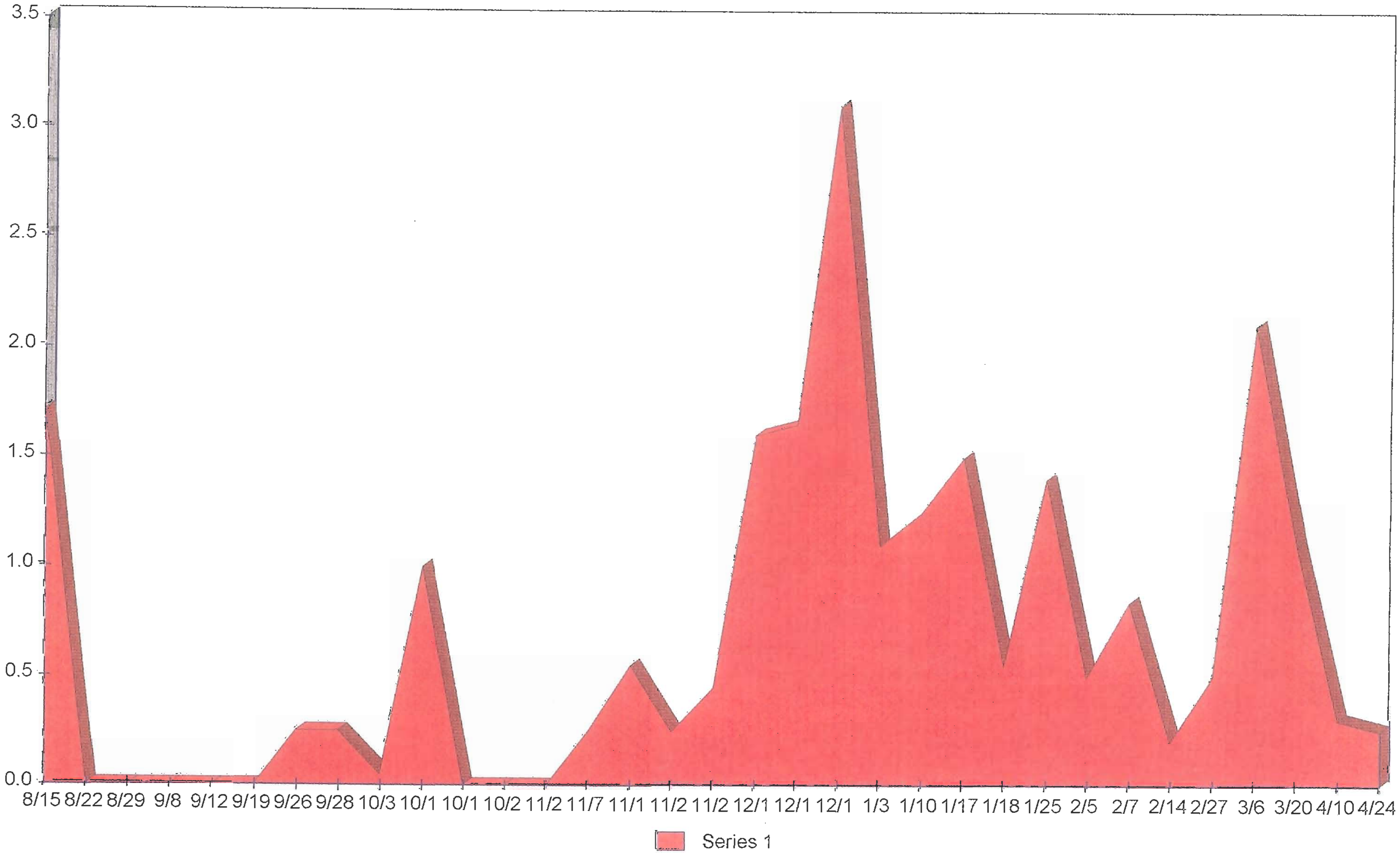


Figure 12: Rainfall



Appendix A

A Sample Field Data Sheet

Steele Creek Park

Total rain for the week: 0.0   11:00-6:30

Site	Date	Time	Weather	Air Temp	H2O Temp	Secchi	pH	Comments	D.O.
1	9/19	2:55 3:06	cloudy, slight breeze	26°c/26°c	25°c	27"	10	sediment was in the outcome for D.O. H_2O level = 4 ft	8.0 ppm
2	9/19	5:00 5:07	same	28°c/28°c	22°c	19"	9.7	tested last; Barrowed sarah's waiders to test #2 & fell in H_2O level = N.O.	7.2 ppm
3	9/19	3:11 3:25	same	27°c/27°c	25°c	33"	9.6	17 ft = H_2O level	7.8 ppm
4	9/19	3:40 3:49	same	29°c/29°c	25°c	44"	9.9	22½ ft	9.0 ppm
5	9/19	4:01 4:09	sunny, breezy	29°c/29°c	24°c	—	9.7	stream has gone down drastically	5 ppm

Total rain for the week: ¼" - 9/21   1:00-7:00

Site	Date	Time	Weather	Air Temp	H2O Temp	Secchi	pH	Comments	D.O.
1	9/26	3:05 3:12	sunny, few clouds & windy	31°c/31°c	25°c	21"	10		8.8 ppm
2	9/26	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.		N.O.
3	9/26	3:20 3:30	same	30°c/30°c	24°c	31"	9.9		9.0 ppm
4	9/26	3:46 3:55	same	29°c/29°c	25°c	36"	9.7		8.6
5	9/26	4:05 4:14	same	32°c/32°c	24°c	—	9.6		8.8

Total rain for the week: ¼" - 9/21   4:05-4:45

Site	Date	Time	Weather	Air Temp	H2O Temp	Secchi	pH	Comments	D.O.
1	9/28	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.	I had to return monday because sarah did	N.O.
2	9/28	4:05 4:45	sunny, few clouds breezy	30°c/30°c	25°c	17"	10	not have her waiders. The water level had risen	9.2 ppm
3	9/28	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.	a little bit, and I slipped on a rock yielding a	N.O.
4	9/28	N.O.	N.O.	N.O.	N.O.	N.O.	N.O.	wet Ayres. This will be the last time I attempt	N.O.
5	9/28	N.O.	N.O.	N.O.	N.O.	—	N.O.	this.	N.O.

Appendix B

Rainfall Records

RAINFALL RECORDS

August total=2.29"
9= .01"
10= .25"
11= .25"
14= .80"
15= .40"
16= .40"
19= .18"

September total=.55"
8= .25"
21= .25"
30= .05"

October total=1.0"
8= 1.0"

November total=1.50"
3= .25"
8= .10"
11= .40"
14= .05"
21= .25"
26= .45"

December total=5.9"
5= .20".
6= .05"
8= .30"
9= 1.05"
12= .05"
13= 1.75"
18= .20"
19= .05"
20= .15"
21= .05"
22= .45"
23= .10"
24= closed
25= closed
26= .95"
29= .20"
30= .10"
31= .25"

January total=4.25"
3= .55"
6= .10"
8= .20"
9= .50"
13= .05"
14= .35"
15= .60"
16= .50"
18= .60"
23= .05"
24= .75"

Feburary total=3.64'
1= .45"
2= .05"
6= .14"
7= .20"
8= .05"
13= .15"
14= .05"
18= .35"
19= 1.15"
20= .25"
23= .10"
24= .05"
25= .05"
27= .05"
28= .55"

March total=3.75
1= .10"
3= .10"
4= .10"
5= 1.25"
6= .20"
9= .30"
11= .05"
12= .10"
13= .10"
14= .20"
15= .80"
21= .30"
23= .05"
24= .05"
28= .05"

April total=1.95'
3= .30"
10= .05"
11= .55"
15= .45"
17= .20"
20= .05"
26= .10"
27= .25"

Appendix C

Data Tables

		D.O.			
dates	site 1	site 2	site 3	site 4	site 5
8/15	8	5.2	7	8.4	7
8/22	7.5	6.9	7.2	7.4	6.3
8/29	8.9	8.5	8.5	8.5	7.9
9/8	8.5	8.9	8.5	7.7	6.8
9/12	8.7	8.4	7.8	8.1	7.4
9/19	8	7.2	7.8	9	5
9/26	8.8		9	8.6	8.8
9/28		9.2			
10/3	9.5	8.9	8.8	7.5	7.1
10/10	7.8	8	7.4	6.8	7.6
10/17	8.2	7.9	7.2	6.1	7.9
10/26	9.7	9.4	7.5	7.8	8.5
11/2	9.8	9.4	10	10	8.6
11/7	7.9	8.3	7.7	7.9	9.5
11/14	8	7.9	6.9	7.8	9.2
11/23	7	8	7.5	6.4	9.2
11/29	7.9	8.1	8.2	8	9.7
12/10	9.5	8.8	9.1	9.3	9.9
12/12		9.8			
12/13	9.1		8.8	9.5	9.7
1/3	10.4	11.3	10.3	10	11.8
1/10	10.3	10.6	10.5	10.4	11.2
1/17	10.6		10.7	11.3	
1/18		10			11.3
1/25	9.4	10	10.2	10.8	11.4
2/5	9.8	11	10	10	11.2
2/7	9.7	9.3	9	9.8	10.9
2/14	8.7	10.5	9	10	10.5
2/27	9.3	11.2	9.3	9.7	10.9
3/6	10.3	9.9	9.1	8.9	10.7
3/20	10.7	9.3	8.8	9.1	9.6
4/10	10.9	6.8	7.9	8.1	8.4
4/24	9	8.5	8.2	8.9	7.5

		pH			
dates	site 1	site 2	site 3	site 4	site 5
8/15	9.5	9.7	9.5	9.7	9.9
8/22	9.5	9.7	9.8	9.5	9.5
8/29	9.5	9.7	9.9	9.7	9.8
9/8	9.5	9.4	9.5	9.6	9.4
9/12	9.5	9.4	9.7	9.9	9.7
9/19	10	9.7	9.6	9.9	9.7
9/26	10		9.9	9.7	9.6
9/28		10			
10/3	9.7	9.7	10	9.7	9.6
10/10	9.7	9.9	10	9.6	9.9
10/17	9.9	10	10	9.8	10
10/26	10	9.8	9.7	9.6	9.9
11/2	9.7	10	10	10	10
11/7	9.5	9.8	9.5	9.6	10
11/14	9.6	9.5	9.7	9.8	9.7
11/23	9.5	9.7	9.4	9.4	9.5
11/29	9.4	9.3	9.3	9.3	9.4
12/10	9.4	9.3	9.6	9.6	9.7
12/12		9.3			
12/13	9.4		9.2	9.2	9.1
1/3	8.8	8.7	8.6	8.7	8.7
1/10	8.7	8.6	8.6	8.7	8.5
1/17	8.7		8.6	8.7	
1/18		8.9			9.1
1/25	8.8	8.7	8.8	8.7	8.9
2/5	8.6	8.8	8.8	8.9	8.8
2/7	8.7	8.8	8.9	8.9	8.8
2/14	8.9	8.8	9.1	9.2	8.8
2/27	9.1	9.2	9	9.2	8.9
3/6	9.1	9.2	8.9	9.1	9
3/20	9.1	9.3	9	9.1	9.1
4/10	9.1	9.2	9.1	9.9	9
4/24	9.2	9.3	9.2	9.4	9.3

Secchi depths

dates	site 1	site 2	site 3	site 4
8/15	16	15	16	29
8/22	28	32	50	49
8/29	39	29	39.5	58
9/8	33	22	40	53
9/12	30	24	43	52
9/19	27	19	33	44
9/26	21		31	36
9/28		17		
10/3	22	19	27	34
10/10	29	21	38	44
10/17	38	36	51	49
10/26	29	33	51	47
11/2	35		44	48
11/7	27	31	31	31
11/14	51	38	54	61
11/23	44	55	44	39
11/29	41	38	40	41
12/10	30	34	34	50
12/12		42		
12/13	35		42	55
1/3	48	19	57	78
1/10	52	38	43	72
1/17	13		11	18
1/18		9		
1/25	24	24	35	51
2/5	35	39	39	72
2/7	32	34	33	64
2/14	31	54	35	68
2/27	25	49	33	59
3/6	18	27	19	61
3/20	27	41	44	66
4/10	38	39	58	77
4/24	48	30.5	51	75

water temperature

dates	site 1	site 2	site 3	site 4	site 5
8/15	27	26	26	26	26
8/22	27	30	28	27	29
8/29	26	28	27	27	27
9/8	25	20	21	20	20
9/12	23	26	23	23	25
9/19	25	22	25	25	24
9/26	25		24	25	24
9/28		25			
10/3	21	22	21	21	22
10/10	19	20	20	20	21
10/17	19	20	19	19	19
10/26	15	17	16	16	16
11/2	16	16	15	16	16
11/7	13	13	13	13	13
11/14	12	13	12	12	12
11/23	11	11	11	11	11
11/29	10	12	10	10	12
12/10	10	10	10	10	10
12/12		9			
12/13	9		9	10	10
1/3	3	2	4	4	5
1/10	3	4	4	4	5
1/17	6		6	5	
1/18		11			5
1/25	8	11	9	9	8
2/5	10	11	9	9	8
2/7	10	10	9	9	9
2/14	8	8	8	8	8
2/27	9	10	8	8	9
3/6	9	11	10	9	8
3/20	14	15	14	13	14
4/10	18	20	19	19	19
4/24	18	18	19	18	19

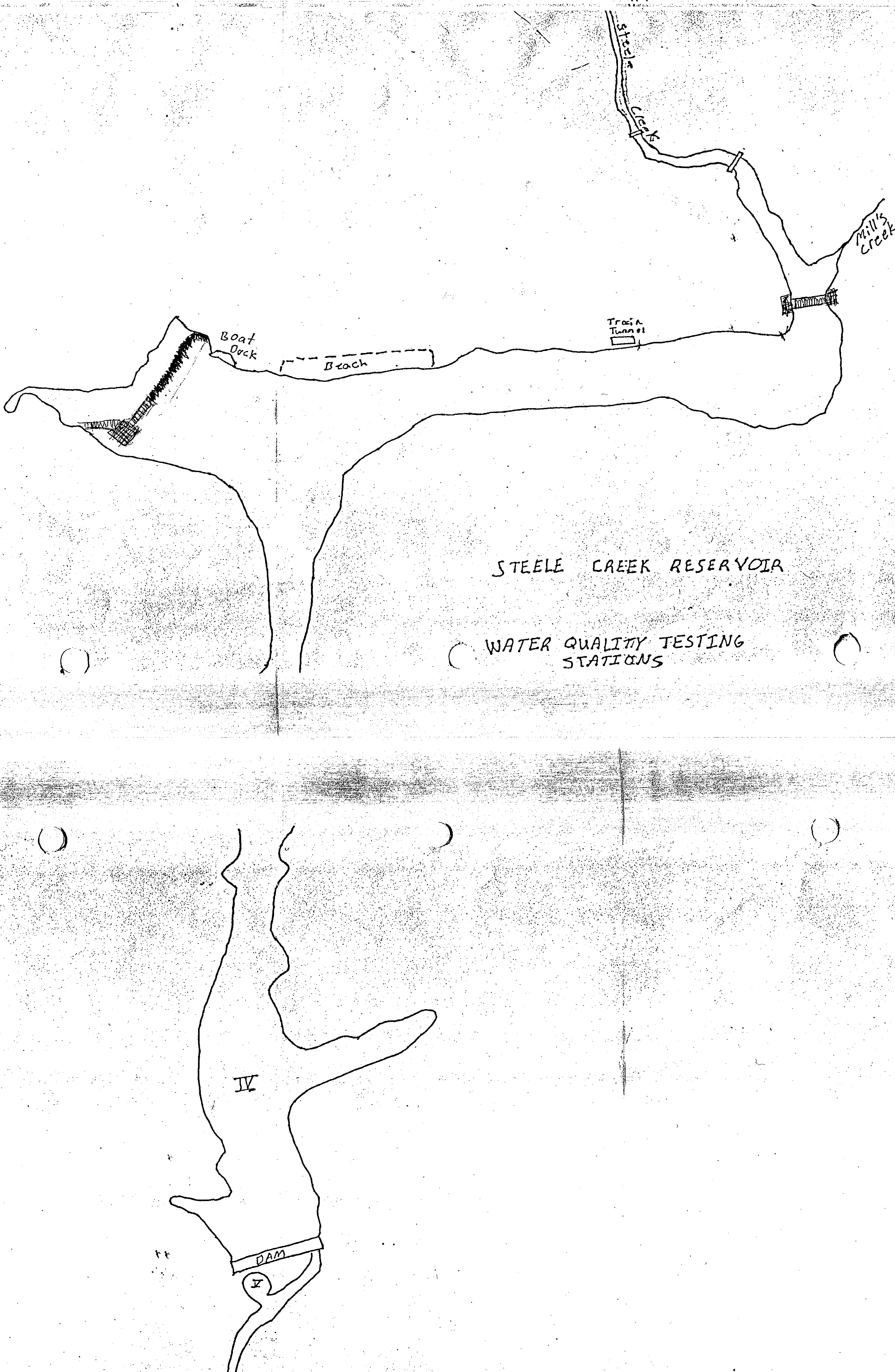
		air temperature			
dates	site 1	site 2	site 3	site 4	site 5
8/15	29	29	29	29	29
8/22	33	31	29	29	31
8/29	30	29	28	32	31
9/8	27	26	27	26	26
9/12	32	32	30	30	29
9/19	26	28	27	29	29
9/26	31		30	29	32
9/28		30			
10/3	25	25	23	22	25
10/10	23	24	21	21	20
10/17	30	25	23	24	23
10/26	26	17	17	18	18
11/2	19	20	17	17	18
11/7	13	8	9	8	10
11/14	18	18	13	12	12
11/23	13	19	14	12	12
11/29	13	22	16	17	17
12/10	9	9	10	9	9
12/12		12			
12/13	9		10	12	11
1/3	0	1	0	0	1
1/10	1	2	2	3	3
1/17	11		9	9	
1/18		15			8
1/25	14	13	14	13	13
2/5	10	11	11	9	9
2/7	12	13	12	12	11
2/14	4	5	3	4	3
2/27	18	19	18	17	17
3/6	10	10	10	11	11
3/20	23	24	24	22	23
4/10	29	29	28	29	29
4/24	20	23	20	20	21

Appendix D

Map of Areas where bank-Stabilization Occurred

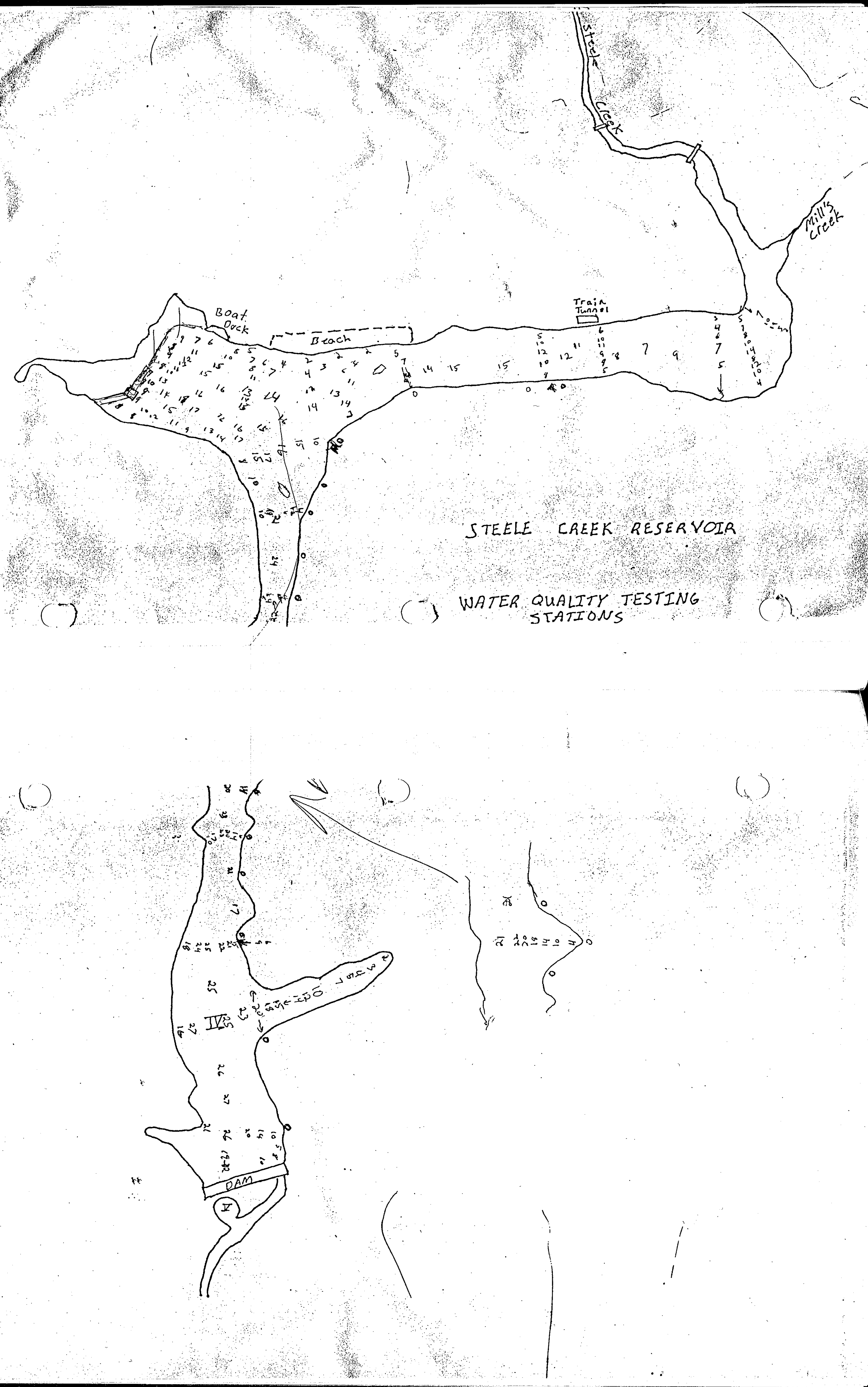
STEELE CREEK RESERVOIR

WATER QUALITY TESTING STATIONS



Appendix E

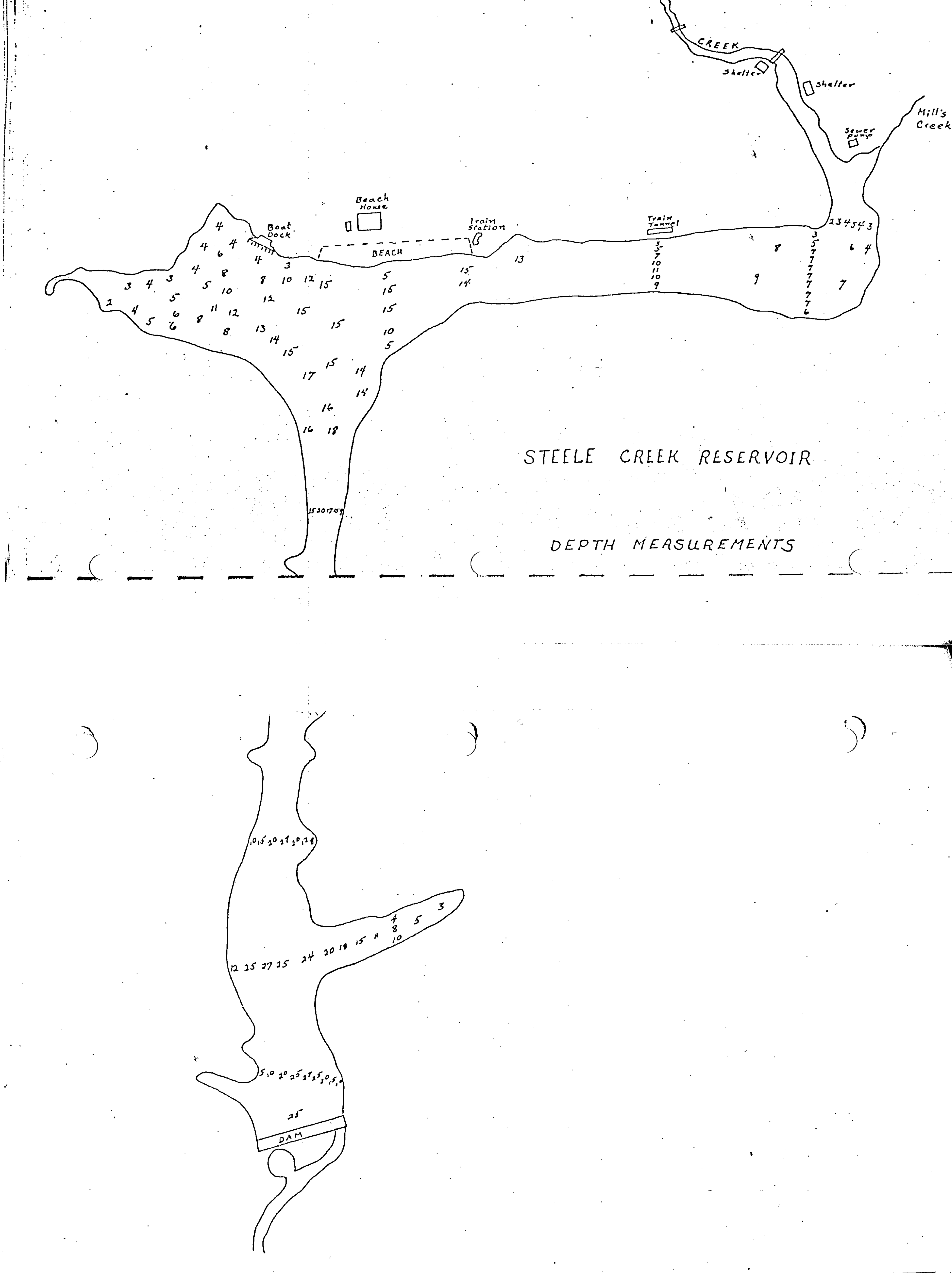
Map of Soundings (Performed 5/8/99)


STEELE CREEK RESERVOIR
WATER QUALITY TESTING STATIONS
Steele Creek
Mill's Creek
Boat Dock
Beach
Train Tunnel
DAM
IV
V

Appendix F

Map of Soundings (performed 8/9/71)

Fig. 22. [illegible] of Steele Creek Reservoir [illegible]



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