UNIVERSITY OF MINNESOTA
ST. ANTHONY FALLS HYDRAULIC LABORATORY

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IMPACT ASSESSMENT OF HYDROPOWER DEVELOPMENT ON DISSOLVED OXYGEN AT THE BYLLESBY DAM

by

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and

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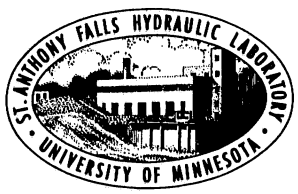

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I. INTRODUCTION

Lake Byllesby Dam is located along the boundary between Dakota and Goodhue Counties, on the Cannon River, approximately 2 miles west of the City of Cannon Falls, Minnesota.

The dam is owned by the two counties. A hydropower plant operated on the site from 1919 until 1966, when it was taken out of commission. Recently it has been rehabilitated by North American Hydro (NAH). The powerplant includes three horizontal scroll case Francis turbines with a total capacity of 2500 kW at approximately 800 cfs utilizing 57 ft of head. The plant has been extensively modified and automated by the developer into a modern hydrostation, with the exception of the original turbine equipment.

Monitoring of dissolved oxygen (D.O.) concentrations and temperature in the Lake and in the river downstream was required by Minnesota Pollution Control Agency (MPCA) for the redevelopment of the site and was also part of the Minnesota Department of Natural Resources (MDNR) operations permit for 1988.

North American Hydro contracted with St. Anthony Falls Hydraulic Laboratory (SAFHL) to do the necessary monitoring and analysis.

The results and analysis of the field surveys undertaken by SAFHL during the summers of 1987 and 1988 are detailed in this report. Mitigation measures are also described in Chapter VII.

II. PHYSICAL DESCRIPTION

Byllesby Dam is an Ambursen–type structure built on limestone foundation. The structure consists of the north dam, south dam, powerhouse and earth embankment, as shown in Fig. 1. The north dam is a non–overflow section which is six feet higher than the spillway crest. The south dam functions as the spillway with optional flashboards and a short non–overflow section on each end at the same elevation as the north dam. The powerhouse is located between the north and south dams. Two 57.5 ft wide hydraulic crest gates were recently installed at the north end of the overflow dam, next to the powerhouse. Flashboards were in place on the remaining overflow section during both summer of 1987 and 1988. The spillway crest is at an elevation of 854.2 ft (260.4m) and the top of the flashboards at 857.2 ft (261.3m).

Lake Byllesby is approximately 1.5 mi wide and 5 mi long and 15m deep in the old river channel. Reservoir storage is 8000 acre–ft at 854 ft elevation and 17,400 acre–ft at 860 ft elevation. Normal operation elevation is set at 856.7 ft (12,400 acre–ft storage) and the turbines use approximately 500 cfs at full design capacity.

The variation of residence time in the reservoir with outflow is given in Table 1, assuming that the elevation is kept at 856.7 ft.

Table 1. Byllesby Lake Residence Time.

Discharge (cfs)	Residence time (days)
50	125
100	62
200	31
300	21
500	13
800	8

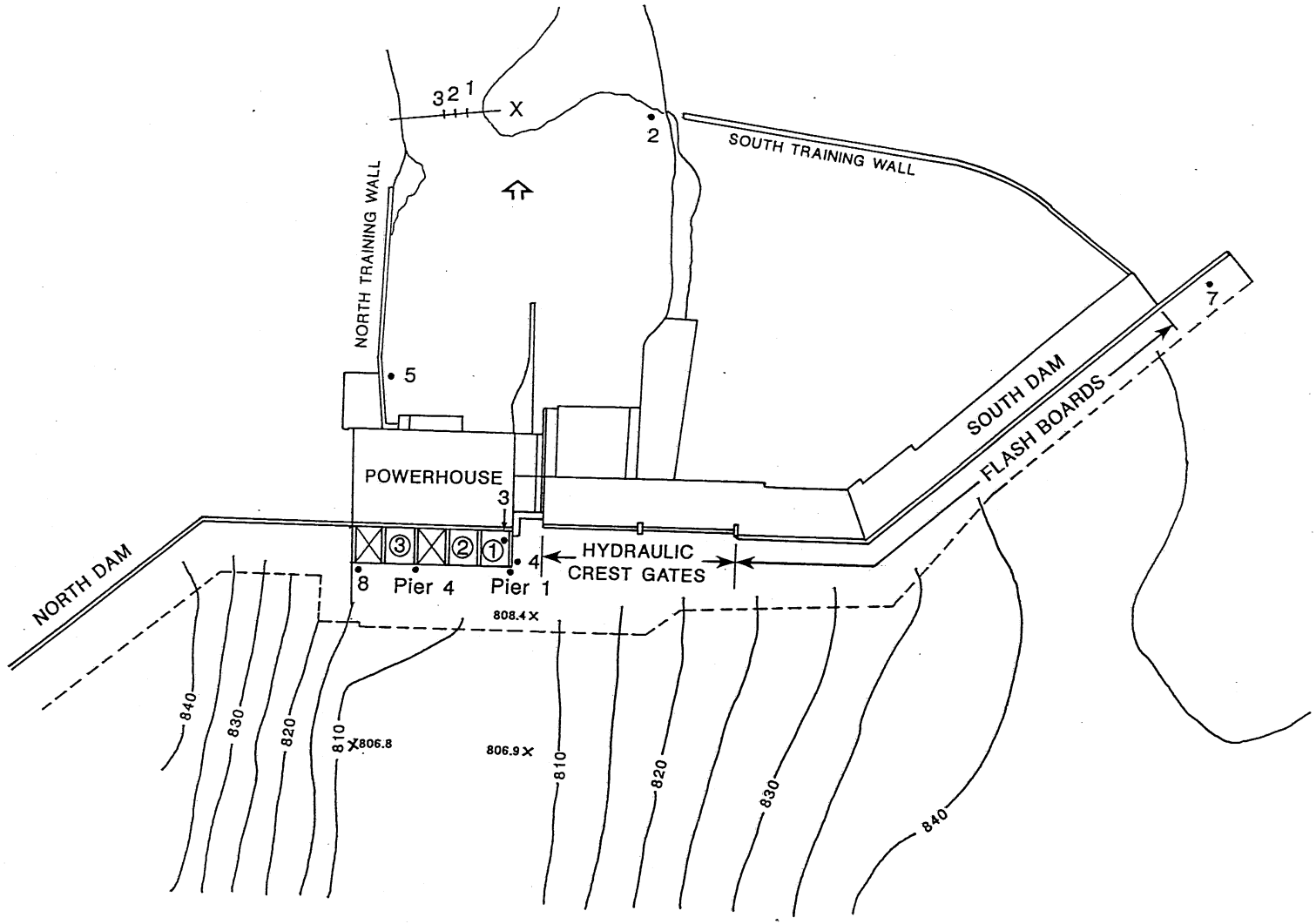


Fig. 1. Dam layout and sampling locations from the structure and banks downstream and in the river channel close to the powerhouse. Numbers indicate sample location.

III. DISSOLVED OXYGEN STANDARDS

In 1987, when the dissolved oxygen investigation for the Byllesby Hydroelectric Redevelopment Project started, MPCA in a letter to North American Hydro (March 24, 1987) stated that "The standard downstream of the dam is 5 mg/ℓ for DO." However, the 1988 operation permit for Lake Byllesby provided by the Minnesota Department of Natural Resources (MDNR), Division of waters states:

> "The Cannon River is a designated Outstanding Resource Value Water (ORVW). The parameter of most concern at this hydroelectric facility is dissolved oxygen. To simplify compliance with the dissolved oxygen criteria, a single dissolved oxygen value will be applied below the Dam. Synoptic surveys are necessary to determine (1) the magnitude of diel variation and (2) the impact of the facility compared to background. Until these surveys are completed, the MPCA will apply a daily minimum dissolved oxygen standard of 6 milligrams per liter applicable between March 1 and July 31 each year. A daily minimum dissolved oxygen standard of 5 milligrams per liter will apply at other times of the year. The application of these standards may be modified depending on the results of the synoptic surveys."

It should be noted that the aforementioned standards set by MPCA and MDNR are more strict than the recommendations of the U.S. EPA [1986], which are based on the most extensive studies available regarding the effect of low D.O. on fish population and growth.

The U.S. EPA recommendations are:

1) For early life stages a daily minimum of 5 mg/ℓ and a 7–day mean of 6 mg/ℓ.

2) For other life stages a minimum of 3 mg/ℓ, a 7–day mean minimum of 4 mg/ℓ and a 30–day mean of 5.5 mg/ℓ.

Increasing the daily minimum for early life stages (March 1 to July 31) to 6 mg/ℓ has not been found [U.S. EPA, 1986] to improve fish growth and survival significantly. An unnecessarily strict standard may therefore limit powerplant operation beyond what is required to protect the fish population, and restrict a beneficial use of the resources.

IV. FIELD MEASUREMENTS

Four types of field measurements (surveys) of D.O. and temperature were undertaken. Reservoir surveys were conducted from the structure and from a boat. Surveys in the reach downstream of the powerplant were conducted by walking through the river. Finally a continuous monitor was also installed towards the end of summer 1988.

A. SURVEYS FROM THE STRUCTURE

In this type of survey as much data as possible was taken from the bridge upstream (Point 6, Fig. 2), the banks of the reservoir, the structure and the banks of the stream downstream of the structure. Sampling points for this type of survey are shown in Fig 1.

B. SURVEYS FROM A BOAT

In this type of survey a boat was used for collection of D.O. and temperature profiles at several locations in the reservoir. The sampling locations were selected to maximize the quality of information gathered, rather than ease of access. This type of survey proved to be best for the Byllesby Reservoir, providing much more information than surveys from the structure.

During the summer of 1987 nine boat surveys were taken to measure stratification characteristics and spatial D.O. variation in the reservoir. All sampling stations are shown in Fig. 2. The cross–sections closer to the dam are given in Fig. 3. In summer 1988 the powerplant was operating; and the number of sampling points in the reservoir was reduced so that more sampling could be done in the downstream section, but point H, 30m upstream from the intakes, was added.

C. SURVEYS IN THE DOWNSTREAM REACH

During the summer of 1988 interest was focused on the downstream reach. The first half kilometer downstream of the powerhouse was approached on foot and measurements were taken at several cross–sections. Additional samples were taken from bridges located 1.6, 2.6 and 3.3 km further downstream, named H52 (Highway 52), GB (Goodhue County Bridge) and RP (Riverside Park), respectively. All downstream sampling locations are shown in Fig. 4.

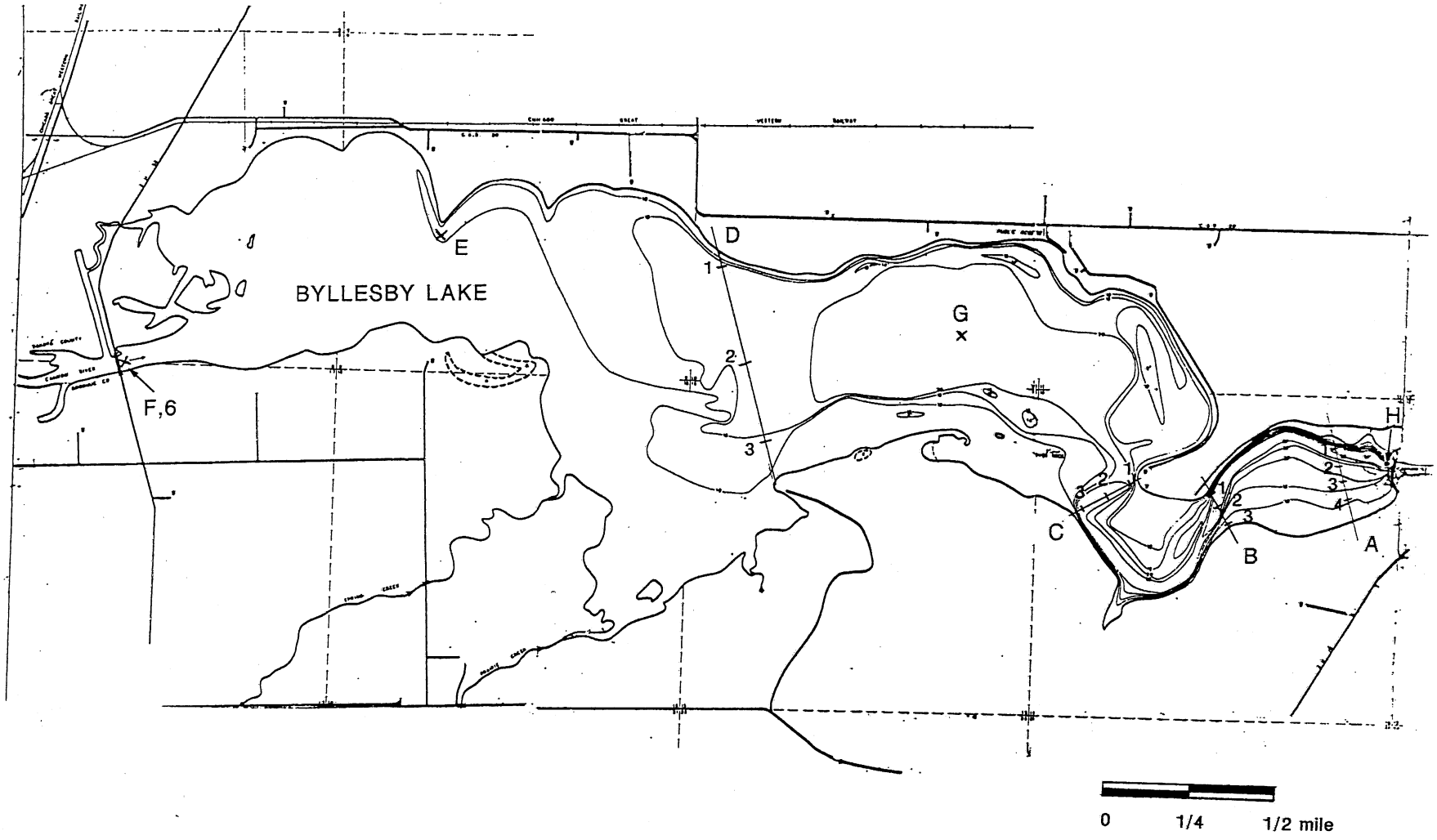


Fig. 2. Sampling locations in the Lake.

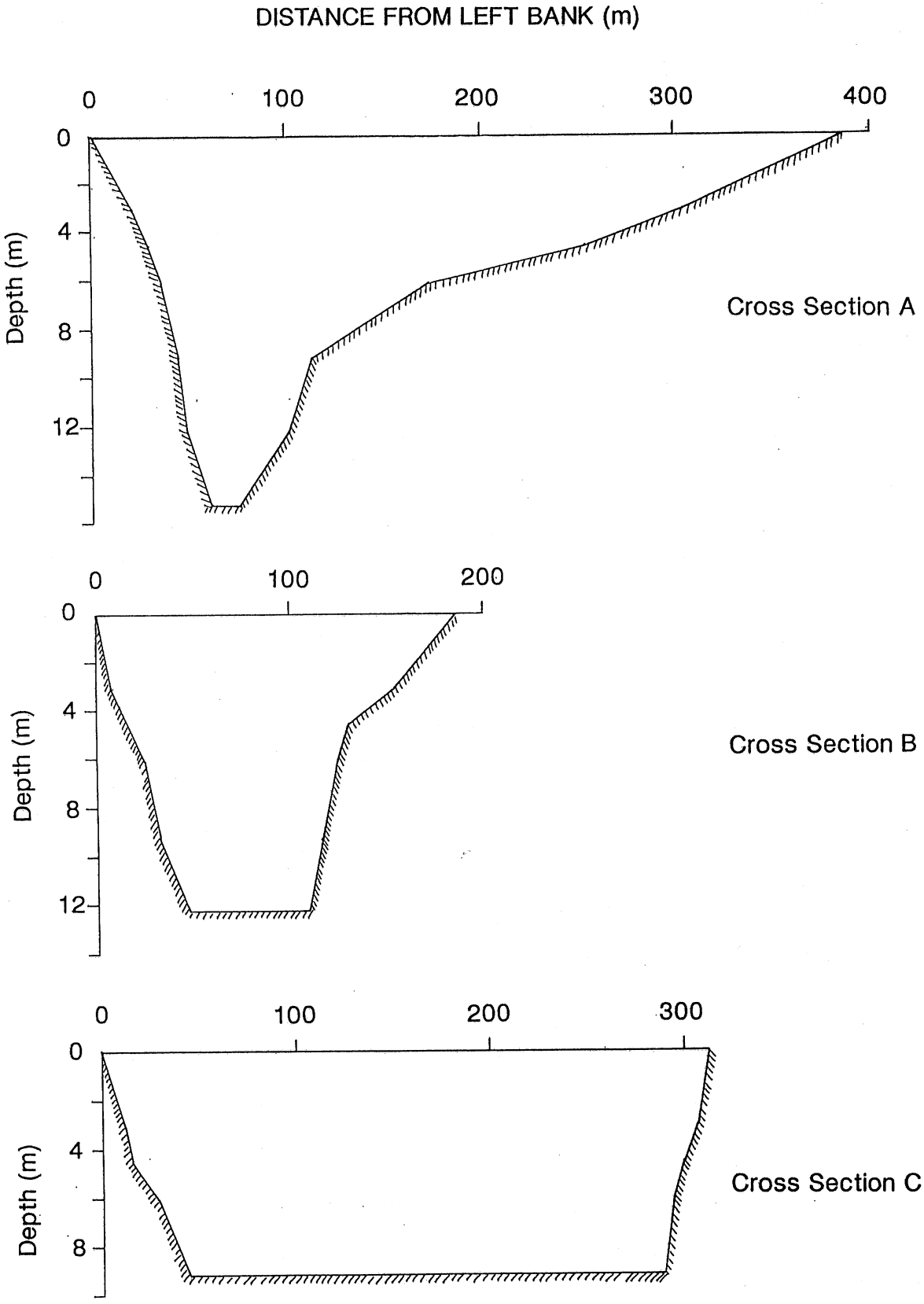


Fig. 3. Cross sections at sampling locations in Lake Byllesby.

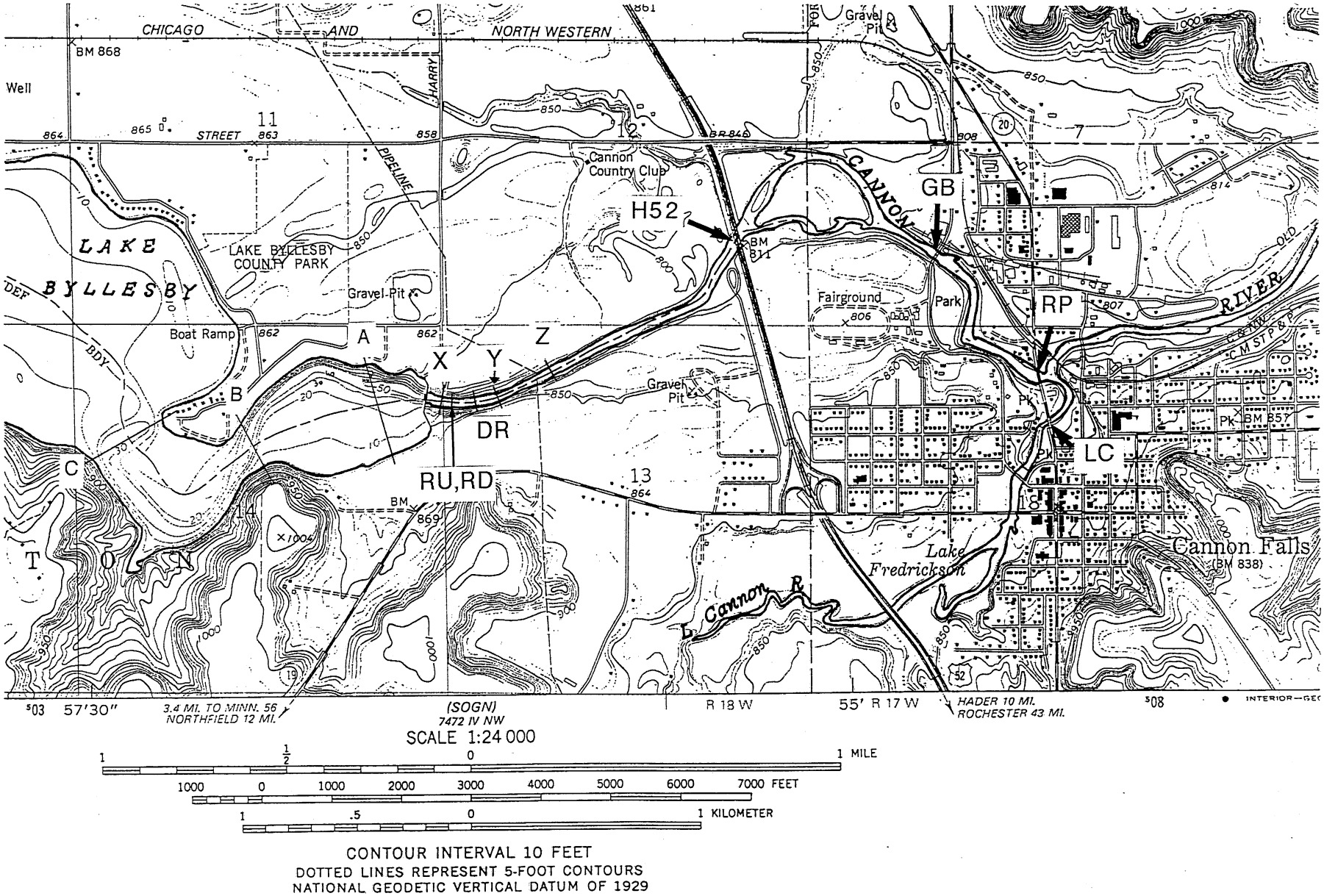


Fig. 4. Sampling locations downstream from the powerhouse.

D. CONTINUOUS MONITORING

Installation of a continuous D.O. monitor in the tailrace of unit 2 was also part of the 1988 field surveys. Unfortunately, delays in ordering and shipping of the monitor, combined with very low flows towards the end of the summer and some problems with the operational schedule of the turbines resulted in a very limited data set.

V. SPILLWAY AERATION

Spillway aeration can be represented by the transfer efficiency, defined as

$$E = \frac{C_d - C_u}{C_s - C_u} \tag{1}$$

where $C_{u,d}$ = upstream and downstream D.O. concentrations, respectively,
and C_s = the saturation concentration.

A value of $E = 0$ indicates $C_u = C_d$ and that no net transfer occurs. $E = 1$ indicates $C_d = C_s$, which means "complete transfer," or that the downstream concentration reaches the saturation concentration.

Field measurements of oxygen transfer on the spillway were performed on February 23, 1985 [Rindels and Gulliver, 1989]. Downstream D.O. concentration was uniform, indicating complete mixing. The transfer efficiency, E, was computed to be 0.92 with a 0.11 uncertainty at 1°C.

It should be noted that transfer efficiency is temperature dependent and the following equation can be used to determine the temperature effect [Gulliver et al., 1989]:

$$E = 1 - (1 - E_T)^f \tag{2}$$

where $$f = \left(\frac{T}{T_T}\right)^{1/2} \left(\frac{\mu_T}{\mu}\right)^{3/4} \left(\frac{\sigma_T}{\sigma}\right)^{3/5} \left(\frac{\rho}{\rho_T}\right)^{17/20}$$

T = absolute temperature (K)
μ = dynamic viscosity,
σ = surface tension, and
ρ = density of the water

and the subscript T indicates value of the parameter at the reference temperature T and the parameters without subscripts are for the temperature of concern. For practical purposes the expression for f can be written as a function of temperature

$$f = 0.6123 + 0.01773\ t + 0.00008261\ t^2 \qquad (3)$$

where t is the temperature in degrees Celsius (°C) [Gulliver et al., 1989]. In the development of the above relation, a reference temperature t = 20°C has been used. In Table 2, the measured transfer efficiency is converted to some representative summer temperatures.

TABLE 2. Spillway Transfer Efficiency

Temperature (°C)	E
1	0.92 (measured)
15	0.973
20	0.982
25	0.988
30	0.993

Measurements from summer 1987 surveys give transfer efficiency values in the the same range (i.e. Aug. 28, 1987 E_{20} = 0.90). Winter measurements, however, are more accurate because the D.O. deficit is higher and the upstream D.O. concentration is more uniform with depth.

The high transfer efficiency values in Table 2 indicate that the spillway at Byllesby is a very effective aerator and for high temperatures any water released over the spillway essentially reaches saturation concentration. Of course it should be kept in mind that saturation concentration decreases with temperature. For example for

$t = 25°\ C,\ p = 740\ mm\ Hg \qquad C_s = 8.02\ mg/\ell$
$t = 30°\ C,\ p = 740\ mm\ Hg \qquad C_s = 7.34\ mg/\ell$

where C_s is saturation concentration adjusted for atmospheric pressure. The mean pressure at the elevation of the Byllesby Dam is approximately 740 mm Hg.

VI. DATA AND ANALYSIS

A. OVERVIEW

In 1987 sluicing of the reservoir took place and the Lake was drawn down from April 27, 1987, through mid–August. During this time, much of the old flood plain was exposed, supporting a highly dense terrestrial vegetation which thrived on both the nutrients in the sediments and the proximity of water. Upon refilling the reservoir, the terrestrial vegetation began to die and decay. This decaying process created an unusually high oxygen demand, causing the D.O. concentrations in the reservoir to drop to low levels. All discharge after mid–August 1987 was passed over the spillway, which is an extremely effective aerator (as shown in the previous section), resulting in high downstream D.O. concentrations.

During Summer 1988 standing vegetation in shallow areas was significantly reduced, although decaying matter still could still be found on the bottom of the reservoir. Near surface concentrations were higher but in the deeper parts of the reservoir very low D.O. concentrations were still measured. With the turbines withdrawing water at 6m depth and no water passing over the spillway, downstream D.O. concentrations also dropped. During July and August high algae populations were observed in the reservoir and in the river downstream. With the very low flows during Summer 1988 the tailwater level also dropped. The river was shallow and photosynthesis affected its whole depth (light penetrated to the bottom). High D.O. concentrations in the afternoon hours resulted in large diel swings of approximately 4 mg/ℓ in the river.

B. SUMMER 1987 DATA

In Summer 1987 data were collected from August 6 through September 4. Four surveys from the structure and nine boat surveys were conducted. The seasonal variation in D.O. concentration for various depths at sections A, B, C in the reservoir are shown in Figs 5, 6, and 7, as measured from the boat surveys. Detailed profiles of D.O. and water temperature are given in the Appendix.

The summer of 1987 was unusual in that there was low flow in the river, and the reservoir had been drained and refilled. Because the reservoir was filled during the summer, the water temperature was nearly uniform from top to bottom with only a weak thermal stratification possible near the surface. After the filling was complete, (and reservoir sluicing was halted before Aug. 19) D.O. near the bottom was depleted rapidly.

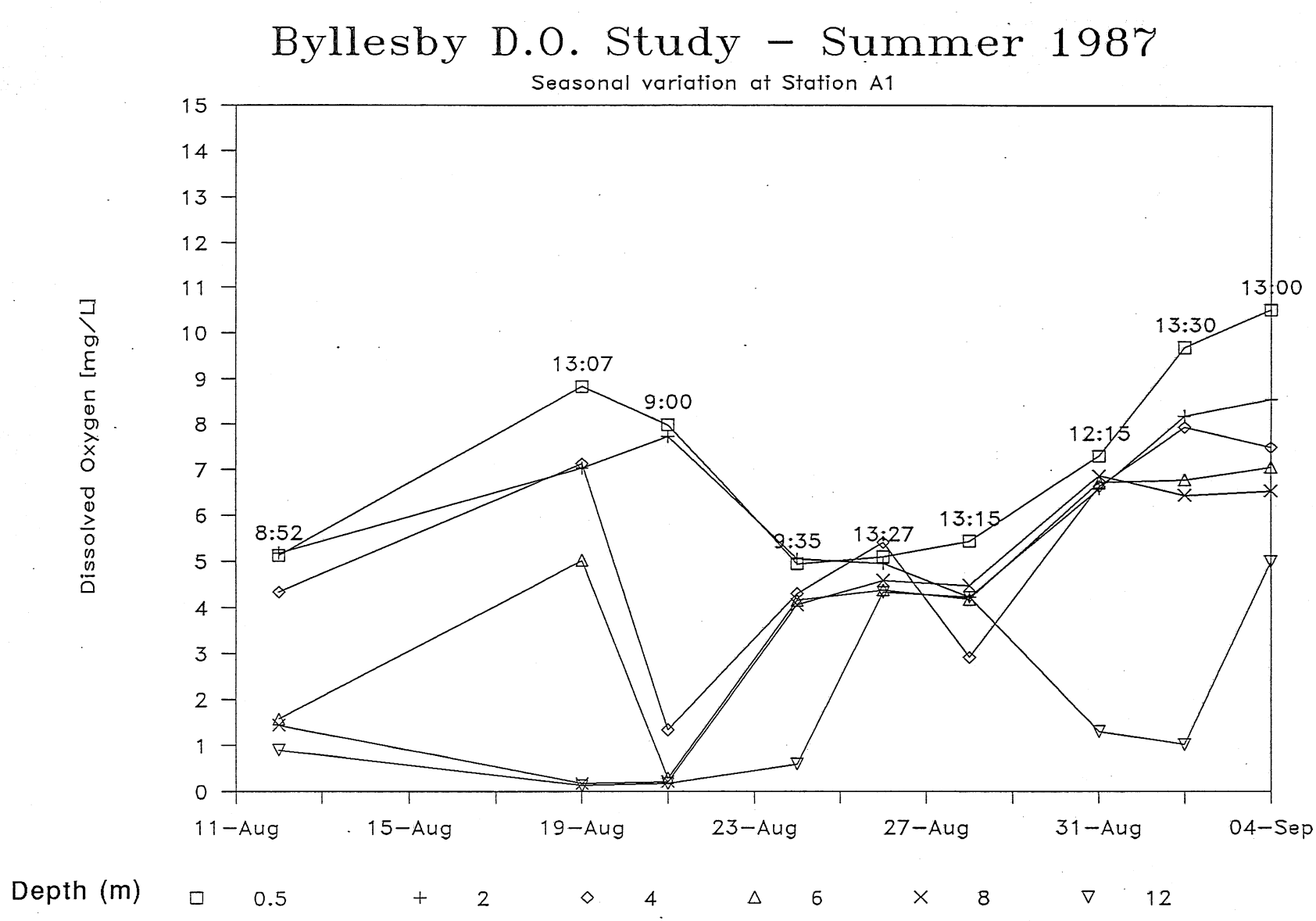


Fig. 5. D.O. concentration variation at cross–section A during summer 1987.

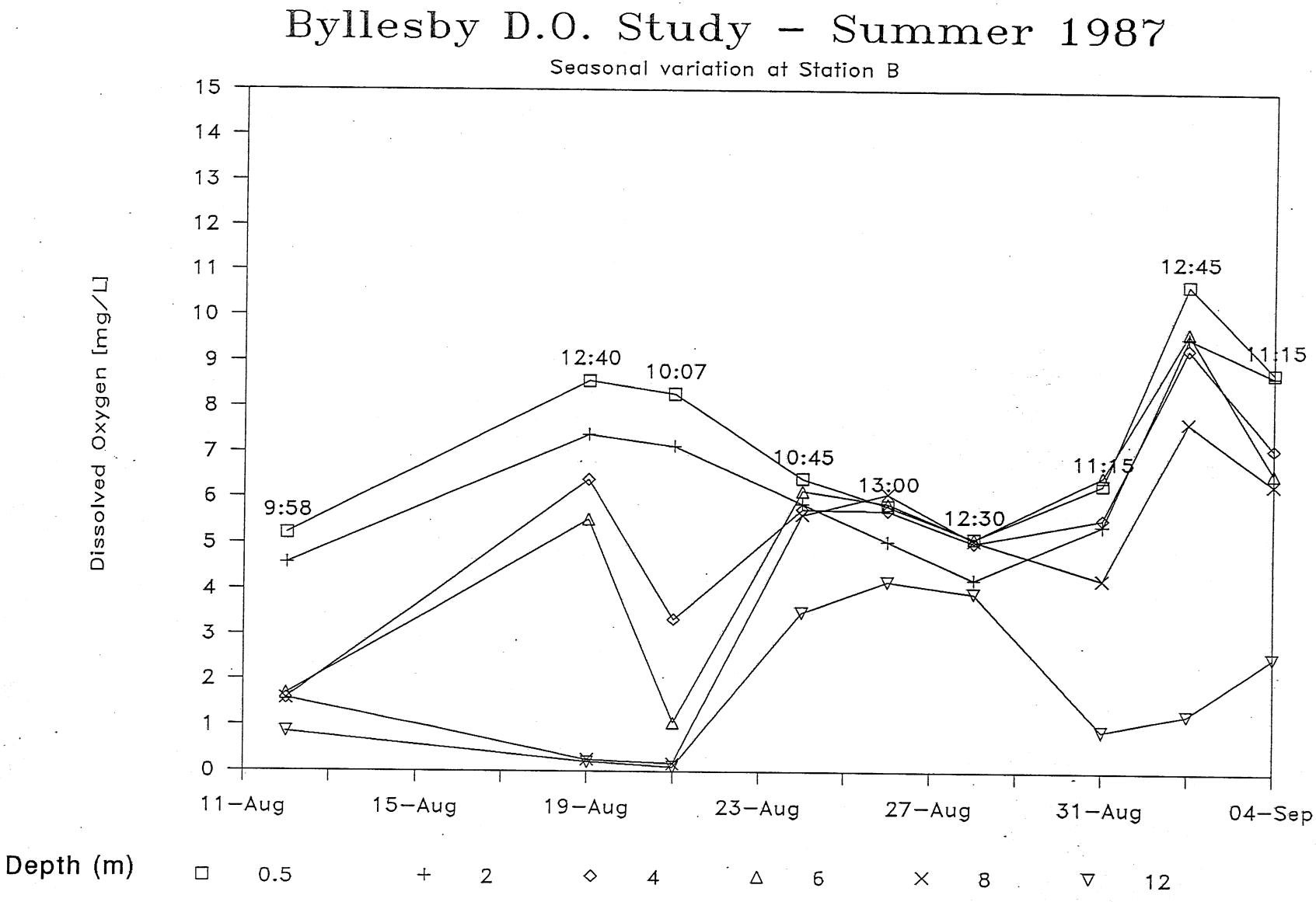


Fig. 6. D.O. concentration variation at cross–section B during summer 1987.

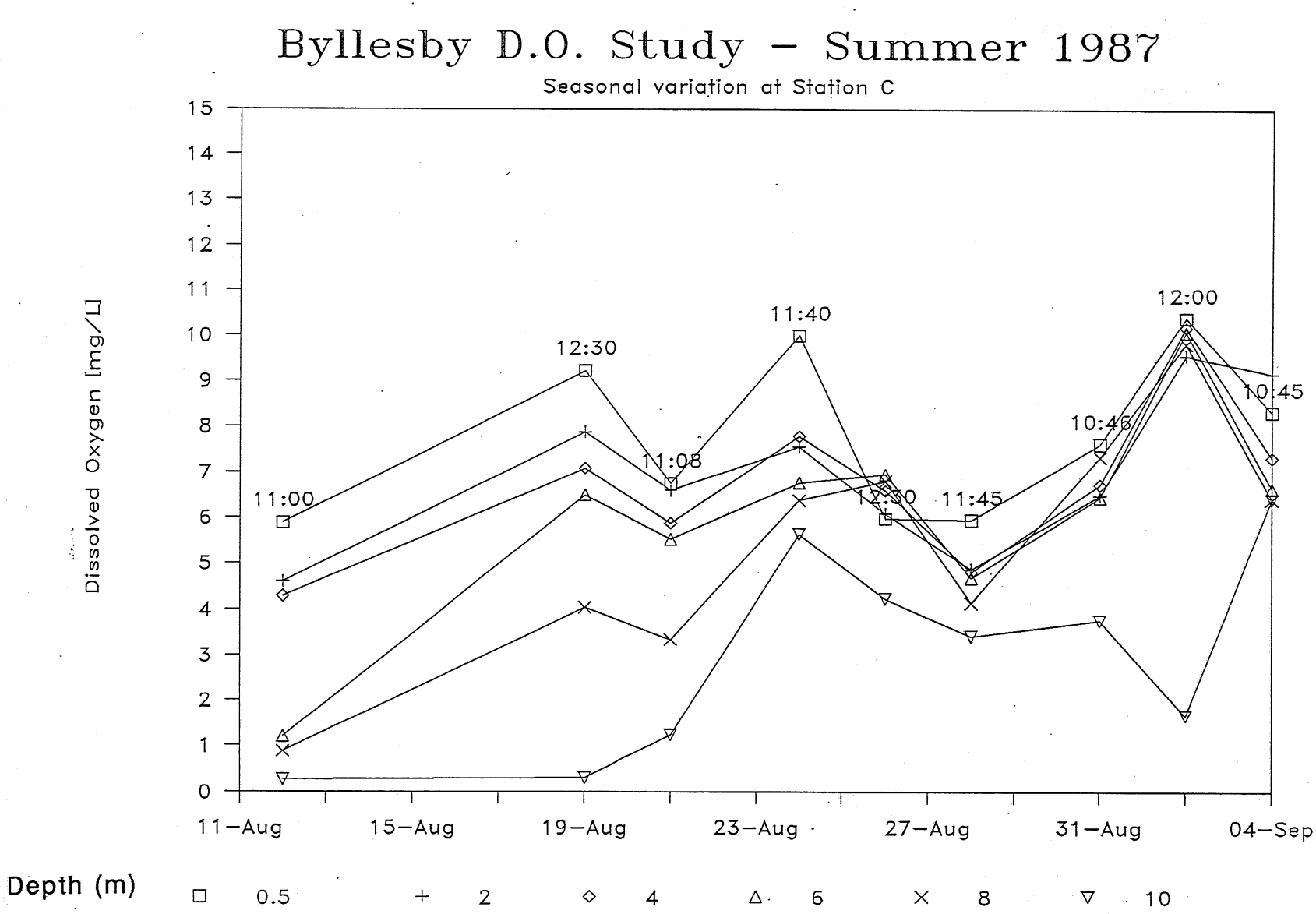


Fig. 7. D.O. concentration variation at cross-section C during summer 1987.

During the one–month sampling period presented in Figs. 5, 6, and 7, a large variability in D.O. in the reservoir was observed. The pattern of variation is quite similar at sections A, B and C.

Because of the weak stratification present, the reservoir was able to "turn over" or mix top to bottom around Aug. 24, which is earlier than under normal conditions. This occurred because the surface water was cooled, due to lower air temperatures, and thus became heavier than the underlying water, sank and was mixed. This process of mixing usually occurs in early fall. The mixing of Aug. 24, coincided with low surface values, indicating a high oxygen demand. Surveys (Aug. 6 and Aug. 14) taken from the dam itself showed even lower values near the surface, as low as 2.3 – 2.7 mg/ℓ at 0.5 m depth. After the initial overturn, the bottom D.O. decreased again, but not to the extreme levels (0–2 mg/ℓ) observed before overturn except near the sediments.

Surface aeration and photosynthesis by algae in the water act to increase surface values of D.O., and both of these processes are affected by weather. Sunlight penetrates only the upper one or two meters of Lake Byllesby; therefore, most of the oxygen produced by photosynthesis is produced near the surface. Wind increases surface aeration and also mixes oxygen from both sources to larger depths, deepening the "mixed layer" where temperature and D.O. tend to be uniform with depth. On calm days D.O. and temperature will remain high near the surface and will not be mixed. Most of the solar heating also occurs near the surface such that a temporary, less stable, stratification developed on calm days without much wind mixing. This allows for isolation of portions of the water column which are depleted of oxygen due to the high demand and lack of sources. All these processes combine to produce the D.O. (and temperature) profiles given in Figs. 5, 6, and 7.

Samples taken downstream of the spillway at Station 2 showed high D.O. concentrations (around 7–8 mg/ℓ) at all times. This is a result of the spillway (and sluiceway) aeration and the fact that the spillway withdraws water from the surface layers of the reservoir that have higher D.O. concentrations.

C. SUMMER 1988 DATA

During summer 1988 10 boat surveys were performed. In Figs 8, 9 and 10 the seasonal variation in D.O. at sections A, B, C is shown for summer 1988. These can be compared to the corresponding figures for 1987 (Figs. 5, 6 and 7), but it should be noted that the time scale is different. Almost one month is shown for 1987, whereas three months are shown for 1988. Furthermore, the sampling frequency in 1987 was two or three times per week, whereas in 1988 it was only once per week, resulting in a different resolution in the data.

Surface D.O. values (with the exception of one date in July) are high and often above saturation due to algae growth and photosynthesis. However, summer D.O. values fall off rapidly at depths from four to six meters. This is important because the intakes for the turbines are about five meters deep with an effective depth of about four meters (for selective withdrawal

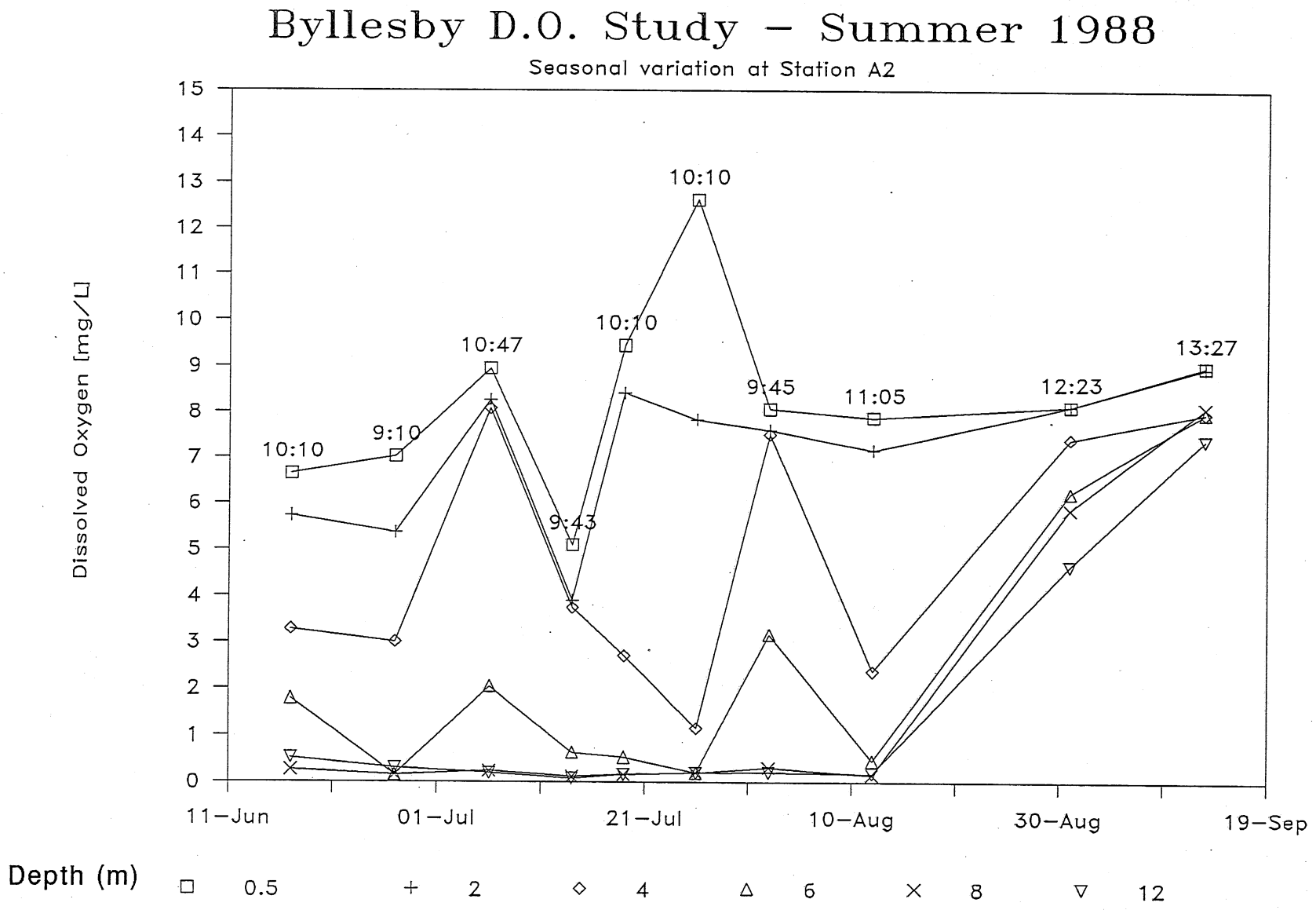


Fig. 8. D.O. concentration variation at cross–section A during summer.

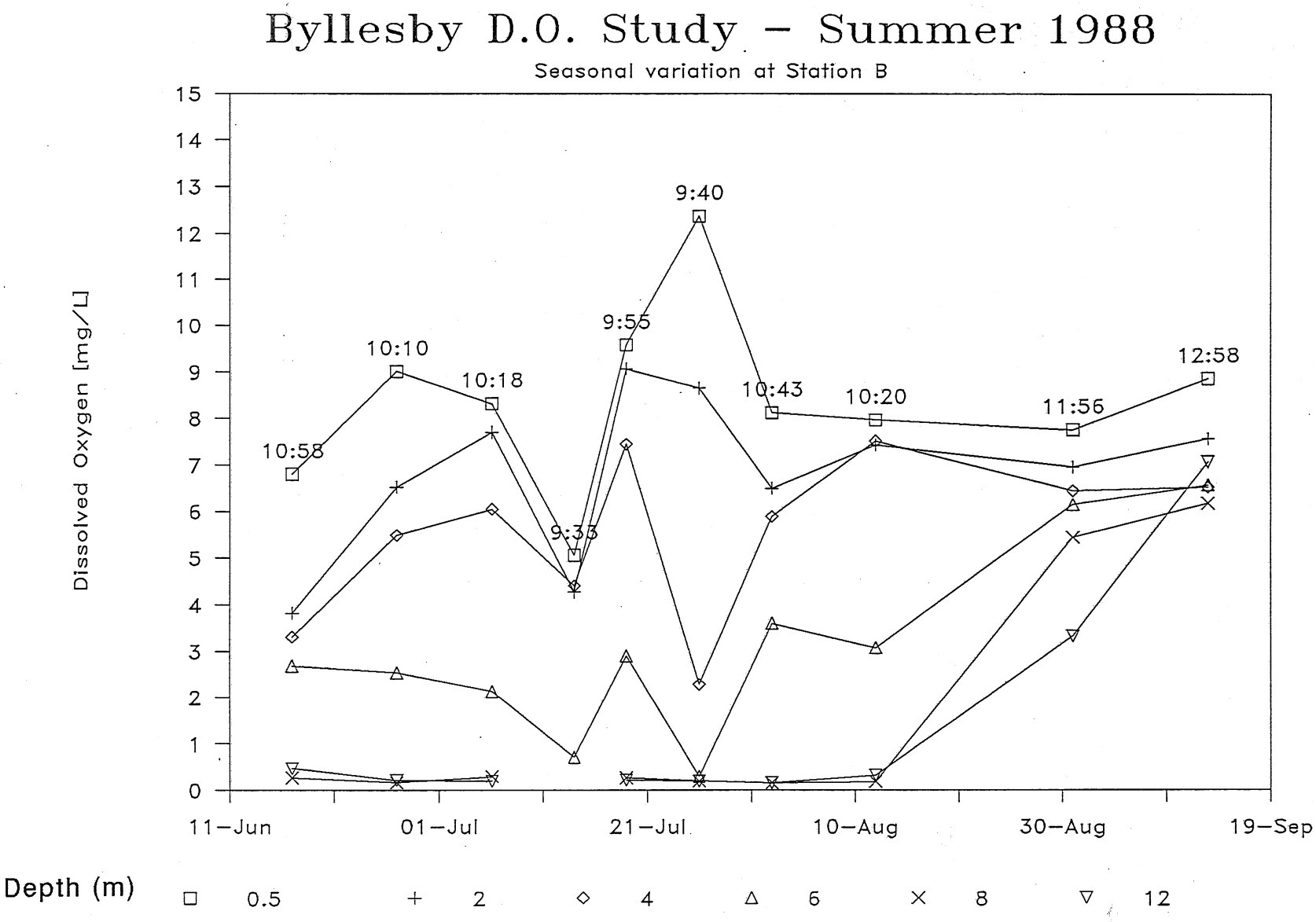


Fig. 9. D.O. concentration variation at cross-section B during summer.

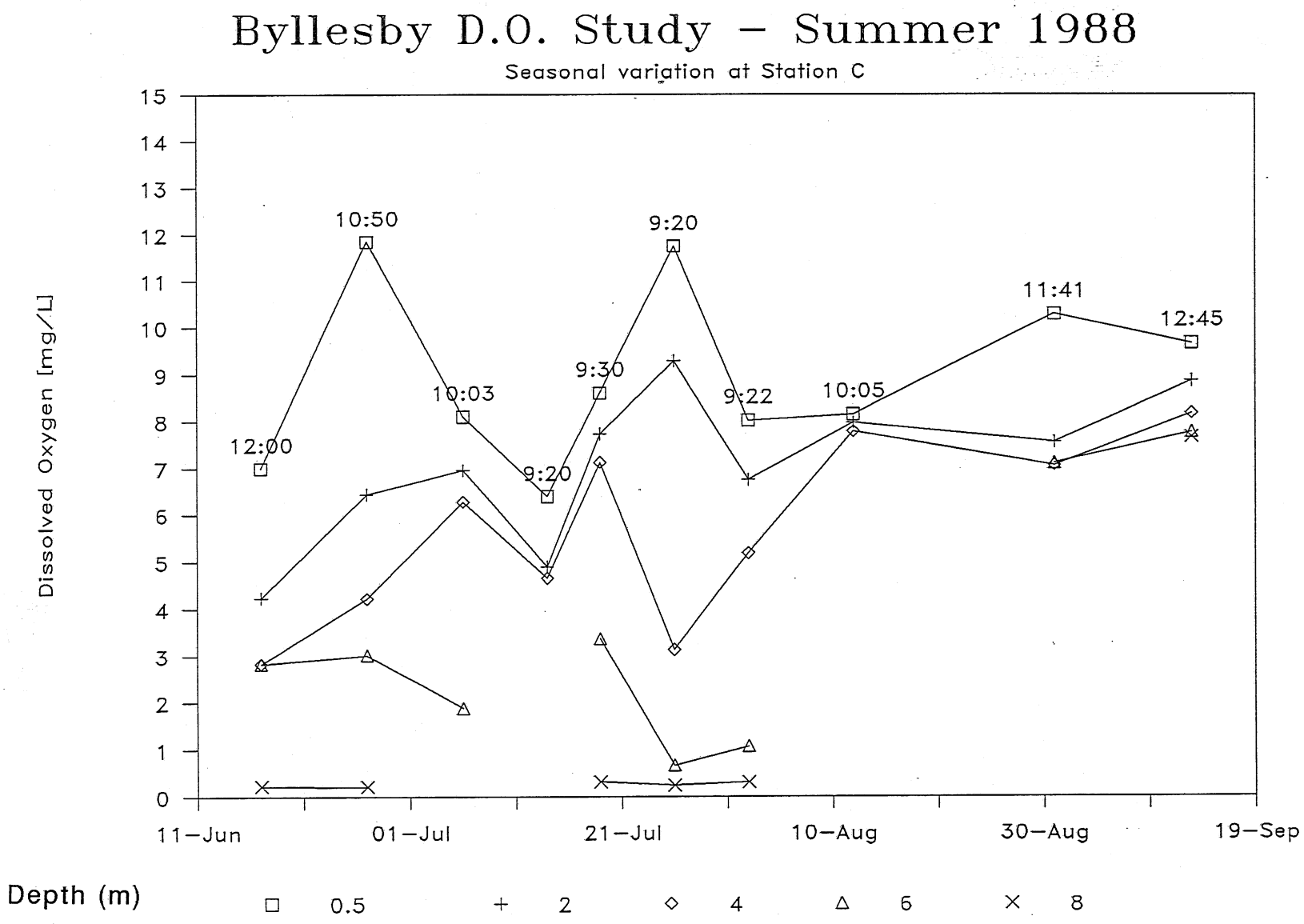


Fig. 10. D.O. concentration variation at cross–section C during summer 1988.

computations, Sect. VII). Dissolved Oxygen close to the bottom (depths of at least 8m) was generally less than 1.0 mg/ℓ, although such low values were also found at depths as small as 5 m. In the deepest parts of Lake Byllesby water temperatures of only 14 to 16° C were observed. This results in a more permanent stratification at depths of 8 m or greater (at station A2) which is normal in lakes during summer, but was not evident in 1987 due to the draining and filling of Lake Byllesby. This stratification will typically last all summer and shut off the water below from oxygen supplies. Thus, it is not unusual to find the water below 8 meters depth without significant dissolved oxygen (or "anoxic").

Because of the location of the intakes, the depth and D.O. of the surface mixed layer are critical in determining the D.O. of the hydro discharge. The depth of the mixed layer and its D.O. content depend on wind mixing and reaeration, night time air temperatures (surface cooling), and solar radiation (surface heating and photosynthesis). These processes cause the variation in the depth of the surface mixed layer, or depth of high D.O. values seen in Figs 8, 9 and 10. The D.O of water reaching the hydro intakes is absolutely dependent on wind mixing to transport D.O. to their depth. Although on some days D.O. was transported to sufficient depth, it was found that D.O. is apparently consumed at a high rate. Thus, if calm conditions prevail, the D.O. at the level of the intakes will soon be low.

Since the powerhouse was operating during summer 1988 the downstream D.O. concentrations were of most interest. Surveys in the first half kilometer downstream from the powerhouse were conducted on eight days. Samples from the bridges further downstream were collected during all the visits to the site.

Sampling a short distance downstream from the hydro plant revealed low D.O. in the discharge. The lowest levels corresponded to relatively calm days while the highest came on windy days. While the D.O. standards might be met on some windy days, these measurements indicated low D.O. will occur unless some mitigation measures are adopted. The "cause" of these low D.O. values in the hydro discharge (although they are actually produced by the biological, meteorological, and physical conditions in the lakes) appears to be that the intakes are not high enough to capture the high D.O. water near the surface. Because of this, one mitigation measure to be explored (in Sec. VII) will be to improve the withdrawal characteristics of the intakes.

In Figs. 11 and 12, morning and afternoon D.O. concentrations measured at bridges 1 mi. and 2 mi. downstream of the powerplant are shown. The difference between morning and afternoon values is high, indicating a diel variation of up to 7 mg/ℓ (average is approximately 4 mg/ℓ). The actual values may be higher since maximums in D.O. generally come in the evening, but the morning measurements are probably close to the daily minimums. Many afternoon D.O. values were above saturation concentration, indicating that the change in D.O. is primarily due to photosynthesis in the stream. Thus, even though some values are below the standards, this large diel swing indicates that the average D.O. may be (well) above standards just 1 to 2 miles downstream. The depth of the river was very small so that the D.O. did not vary with depth. Some lateral variations were observed and could be attributed to small springs discharging groundwater from the steep

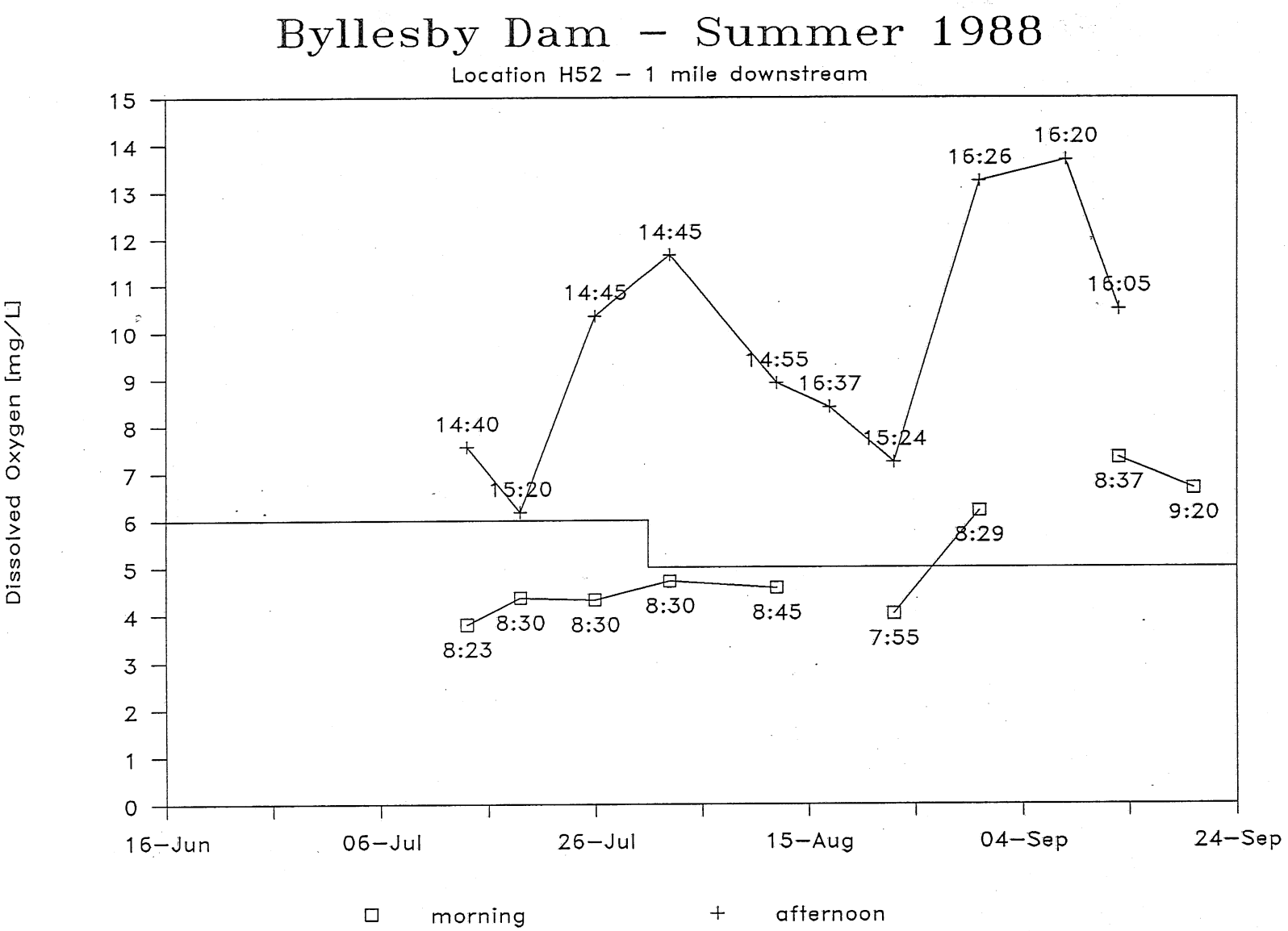


Fig. 11. D.O. concentrations 1 mile downstream from the powerhouse (location H52) – Summer 1988.

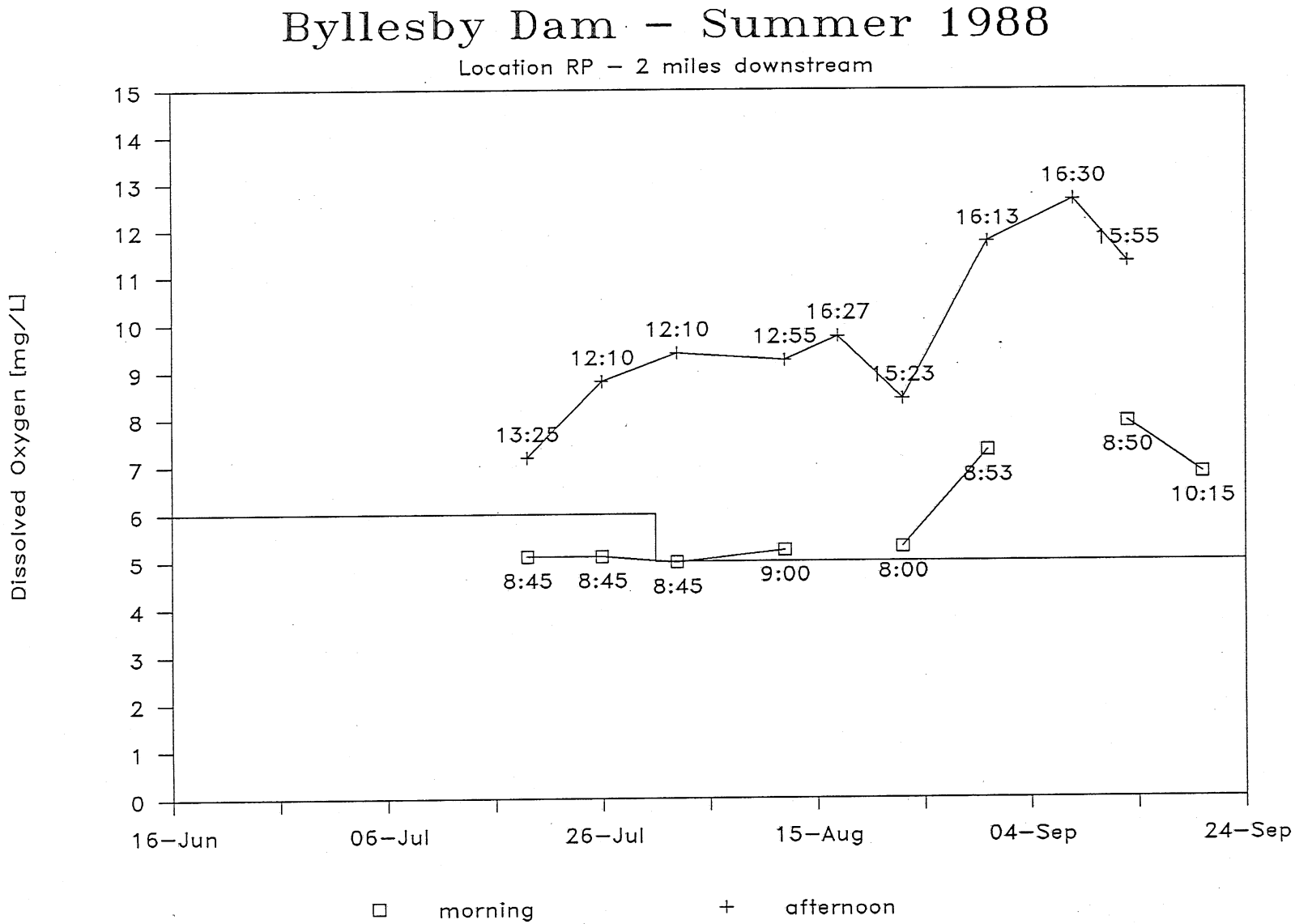


Fig. 12. D.O. concentrations 2 miles downstream from the powerhouse (location R. P.) – Summer 1988.

channel banks. This water was colder than the river water and had high D.O.

Although at 1 mi downstream from the powerplant, morning values (expected to be close to the daily minimum) were below 5 mg/ℓ through the end of August, two miles downstream they were above 5 mg/ℓ indicating that river aeration (in the absence of photosynthesis) can easily bring the concentration up by $\sim$ 1 mg/ℓ in just one mile thus reducing the negative impact to a very short reach.

D. CONTINUOUS MONITOR DATA

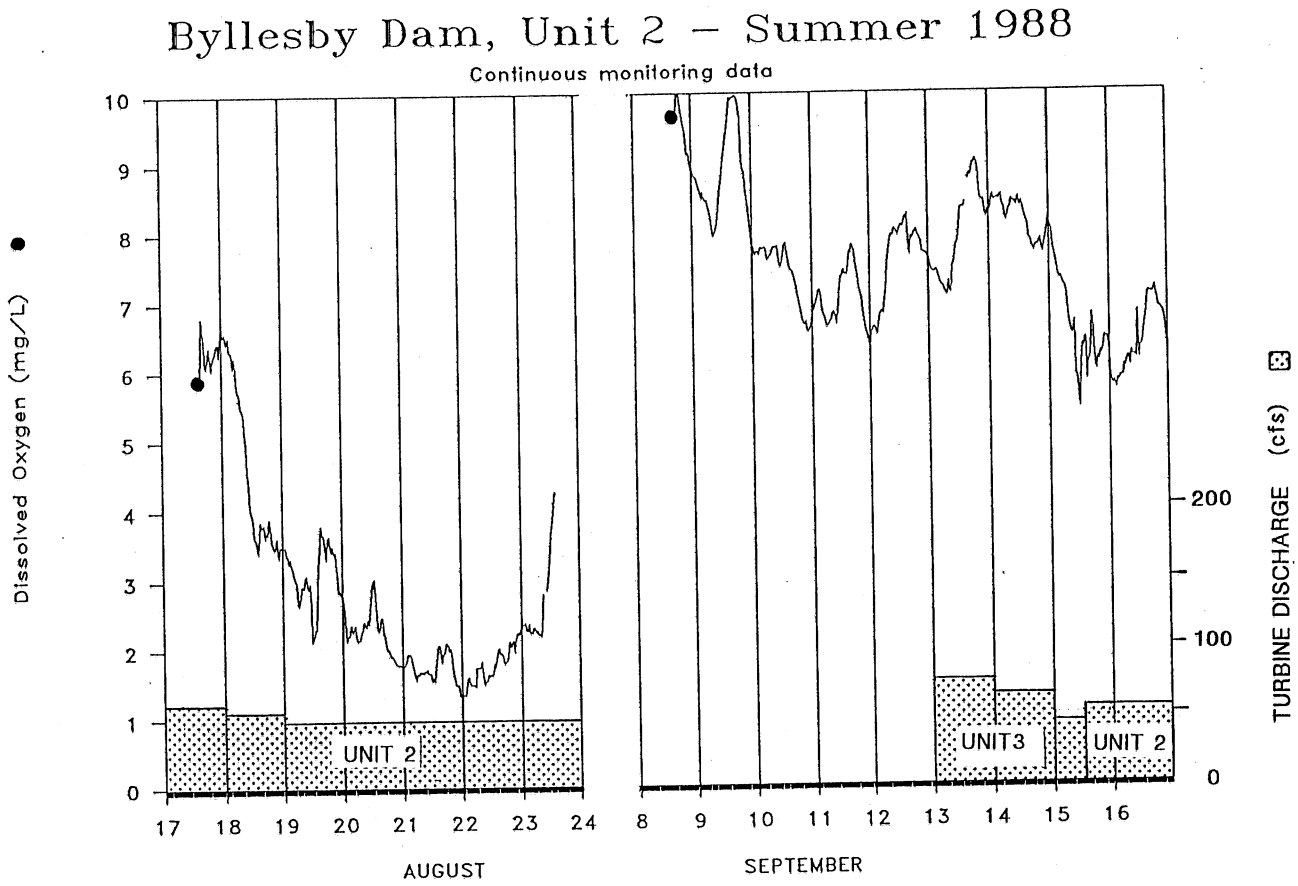
A Datasonde continuous D.O. and temperature monitor was installed in the hydroplant tailrace near the draft tube of Unit 2 on Aug. 17, 1988, and plant operation was switched from Unit 1 and Unit 2. The data are summarized in Fig. 13. Recording through Aug. 23, 1988 indicated extremely low D.O. concentrations. These are probably due to the very low flows (50–120 cfs) resulting in a very long residence time of the water in the reservoir. Problems with the batteries in the probe prevented any recording during the second deployment period. Monitoring during Sept. 8 – Sept. 16 did not present such problems, but the plant was not operating most of the time, rendering the data useless. Moreover, as shown by the field surveys during September, the summer stratification was destroyed, and D.O. was more uniform and well above the 5 mg/ℓ standard.

E. TRAVEL TIME MEASUREMENTS

Some travel time measurements were taken on August 23, 1988, in the reach ($\sim$500m) immediately downstream from the powerhouse. Results are summarized in Table 3. The corresponding discharge is 48 cfs (Sec. VI. F). These measurements were made, since only visual (or pacing) estimates of the distance from the dam to the downstream sampling locations were available. The measurements were made by measuring the travel time of surface floats between cross–sections and should be more informative than distances alone.

TABLE 3. TRAVEL TIME MEASUREMENTS August 23, 1988

Reach	Time
RD – DR	190 sec
	175 sec
DR – Y	155 sec
	165 sec
	170 sec
	165 sec



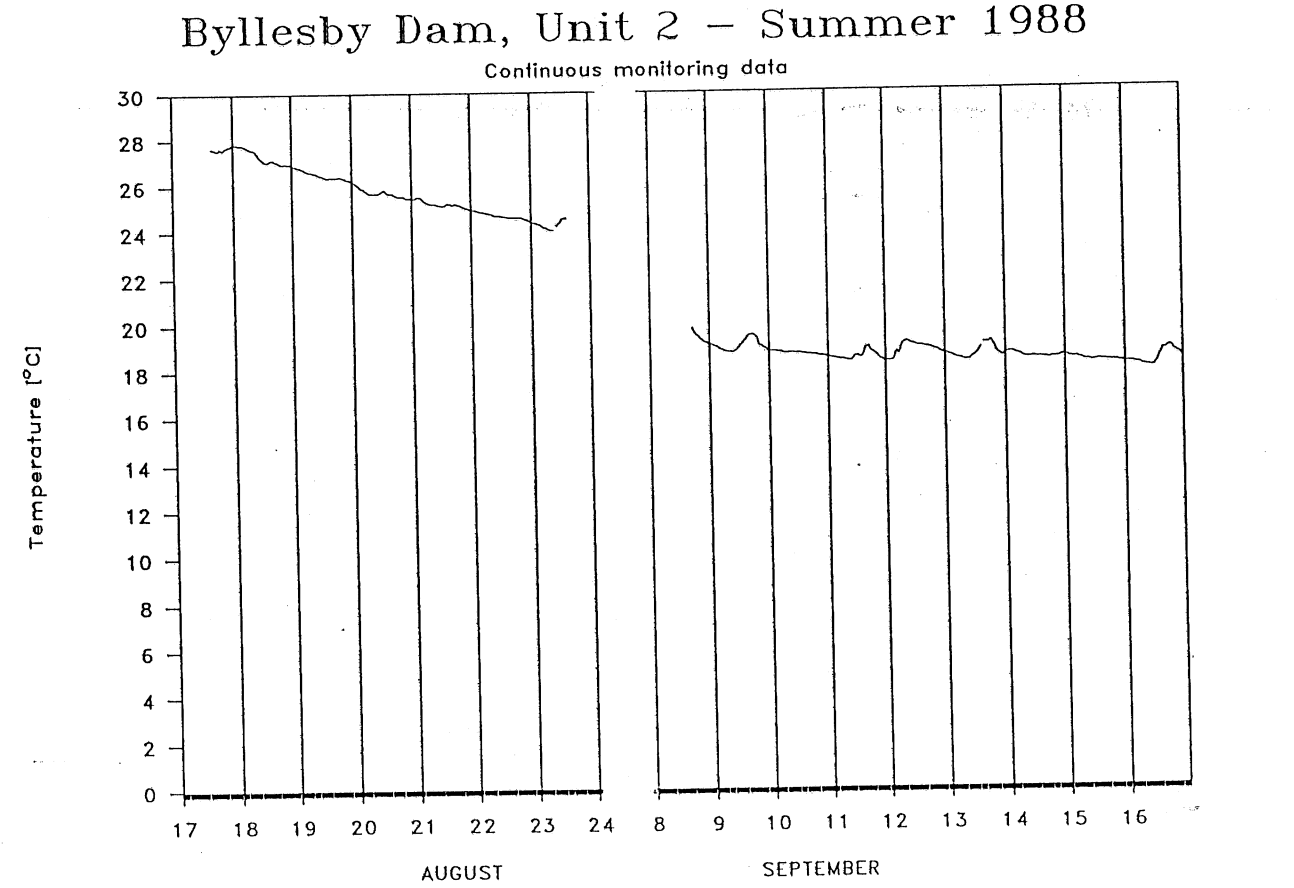


Fig. 13. Continuous monitoring D.O. and temperature data – Summer 1988.

F. TURBINE DISCHARGE RECORDS

Power output and reservoir water elevation records were provided by NAH. Power output is recorded twice a day for each turbine, usually once in the morning and once late in the afternoon. Manufacturer's performance curves were also provided by NAH. These curves were from the 1910's when the turbines were first installed and had to be slightly adjusted to correspond to present conditions. One curve representing all three turbines was developed. The curve, given as power output vs. discharge is presented in Fig. 14. Discharge, power output and headwater elevation for June – September 1988 are given in Table 4. One average value is reported for each day. From June 1 – August 17 only unit 1 was operating. On August 17 operation was switched to Unit 2 because of the installation of the continuous monitor near the draft tube of that unit. Near the end of August (8/30 – 9/3) operational problems with units 1 & 2 caused the powerplant to shut down and some flow was passed through the spillway gate. During September 4 to 15, Unit 3 was operated during September 15 to 20, Units 1 & 2 were operated with varying discharge, and then the operation was returned to Unit 2 through the end of September. Turbine discharge vs time throughout the summer of 1988 is plotted in Fig. 15.

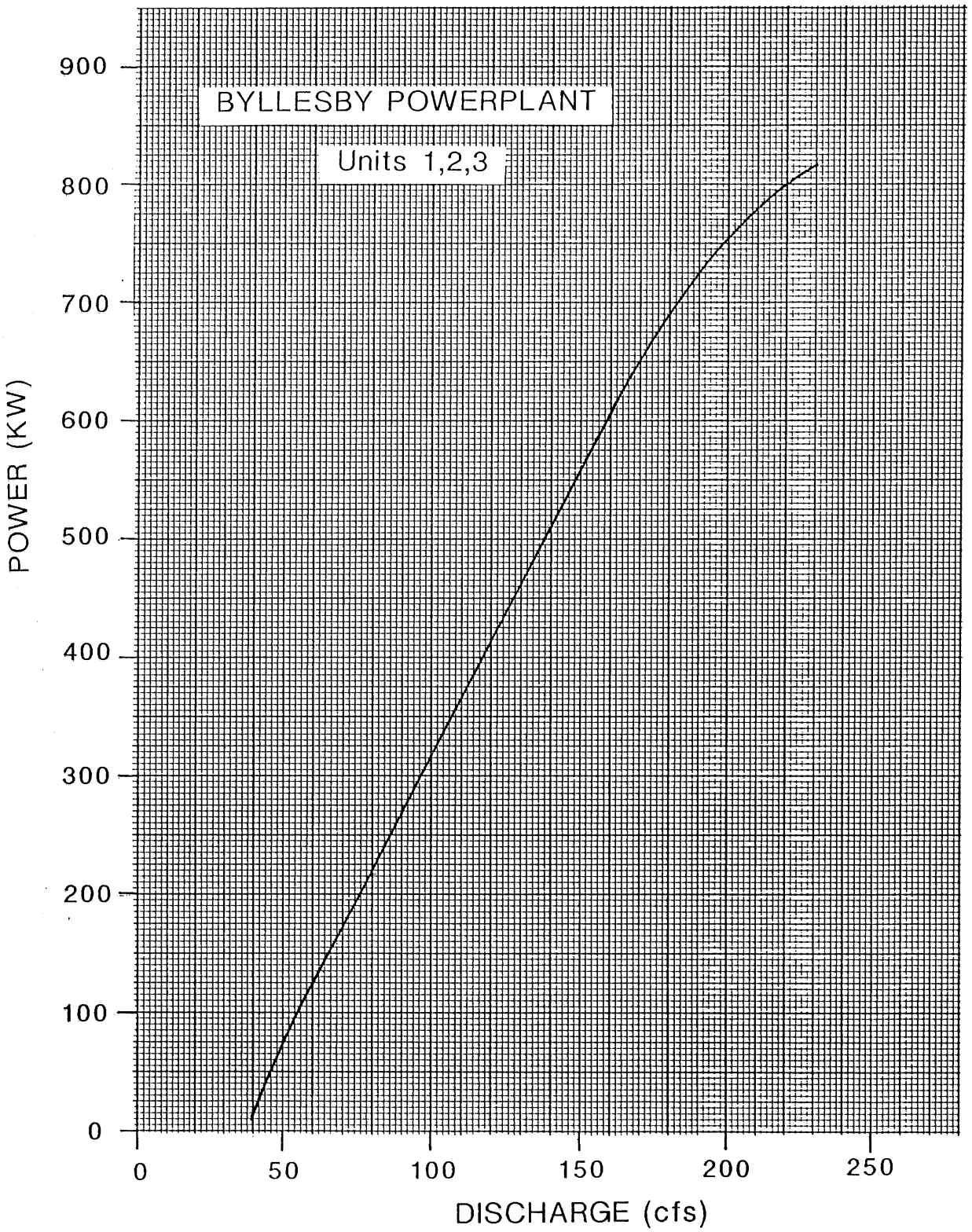


Fig. 14. Power output vs. discharge curve.

TABLE 4. Discharge, Power Output and Headwater Elevation for Byllesby Dam - Summer 1988.

Date	HWE(ft)	P(kW)	Q(cfs)	Date	HWE(ft)	P(kW)	Q(cfs)
JUNE				AUGUST			
1	855.97	600	158	1	856.03	100	55
2	856.00	600	158	2	856.01	100	55
3	856.02	600	158	3	856.03	100	55
4	856.06	600	158	4	856.15	300	97
5	856.09	600	158	5	856.12	300	97
6	856.09	600	158	6	856.10	267	90
7	856.07	540	146	7	856.07	205	78
8	856.06	520	142	8	856.09	350	107
9				9	856.05	210	78
10				10	856.03	120	59
11	856.05	450	128	11	856.05	120	59
12	856.05	450	128	12	856.07	120	59
13	856.05	450	128	13	856.07	120	59
14	856.04	420	132	14	856.06	120	59
15	856.00	420	132	15	856.05	120	59
16	856.01	350	107	16	856.09	120	59
17	856.01	300	97	17	856.05	120	59
18	856.02	300	97	18	856.01	100	55
19	856.06	350	107	19	856.00	60	47
20	856.07	350	107	20	856.00	50	46
21	856.09	325	102	21	856.00	50	46
22	856.09	300	97	22	856.97	50	46
23	856.05	200	76	23	856.00	67	48
24	856.09	200	76	24	855.95	60	47
25	856.14	200	76	25	856.00	0	0
26	856.12	200	76	26	856.00	0	0
27	856.13	200	76	27	856.10	300	97
28	856.13	200	76	28	856.01	112	58
29	856.12	200	76	29	856.00	0	0
30	856.12	260	90	30	856.09	0	0
				31	856.10	0	0
JULY				SEPTEMBER			
1	856.12	250	87	1	856.18	0	0
2				2	856.25	0	0
3				3		0	0
4				4	856.33	570	152
5	856.05	167	69	5	856.18	540	146
6	856.02	140	64	6	856.18	550	148
7	856.01	140	64	7	856.18	400	128
8	856.03	160	68	8	856.07	0	0
9	856.08	200	76	9	856.08	0	0
10	856.11	260	90	10			
11	856.12	300	97	11			
12	856.10	200	76	12	856.20	0	0
13	856.17	280	93	13	856.20	200	76
14	856.17	280	93	14	856.13	150	66
15	856.14	280	93	15	856.03	75	50
16	856.00	225	82	16	856.00	100	55
17	856.06	160	68	17	856.00		
18	856.03	130	61	18	856.04	250	121
19	856.02	120	59	19	856.05	275	126
20	856.12	300	97	20	856.03	950	266
21	856.15	300	97	21	856.09	75	50
22	856.13	250	87	22			
23	856.12	200	76	23	856.00	145	64
24	856.11	160	68	24	856.02	140	64
25	856.10	142	64	25	856.04	140	64
26	856.09	100	55	26	856.06	120	59
27	856.10	100	55	27	856.07	160	68
28	856.09	100	55	28	856.03	130	61
29	856.08	100	55	29	856.06	140	64
30	856.06	100	55	30	856.07	140	64
31	856.04	100	55				

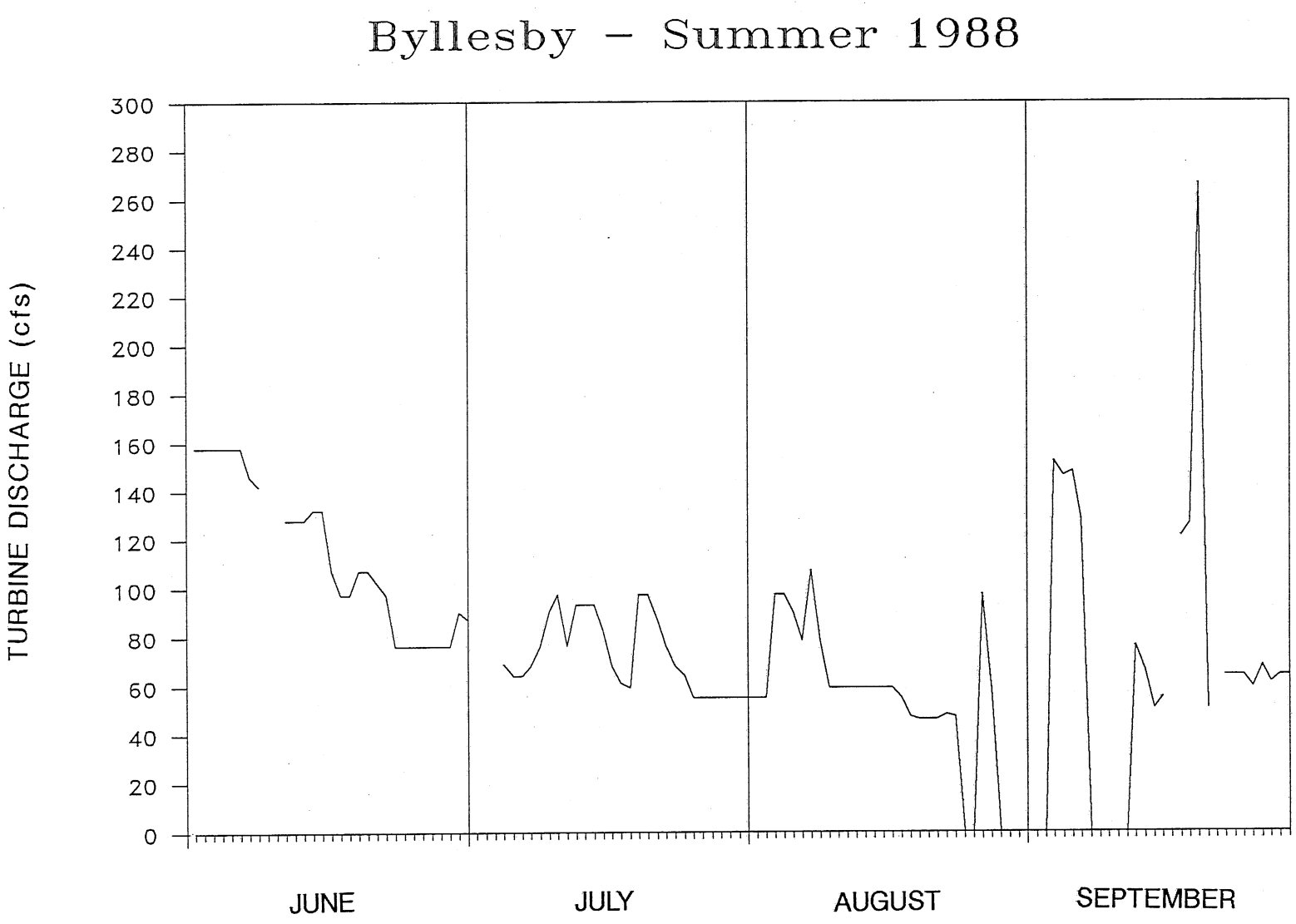


Fig. 15. Turbine discharge vs. time for Summer 1988.

VII. MITIGATION

In view of the low D.O. concentrations measured downstream of the powerplant, mitigation is necessary for compliance with the D.O. standards. The following solutions are considered:

a. Installation of a submerged weir in front of the intake so that the water going through the turbines will be withdrawn from a higher layer and the low D.O. near the bottom of the reservoir will not pass downstream.

b. Installation of a continuous monitor in the tailrace that will be integrated in the automation procedure. The spillway gates will be opened to a prescribed value when D.O. concentration drops below the acceptable levels. This can be used with or without the submerged weir.

c. Reducing turbine discharge by constant percentage during periods when low D.O. concentration is possible in the turbine outlet and passing sufficient flow over the spillway to meet downstream D.O. standards. This option would be in place of option (b), but could be undertaken simultaneously with option (a).

A. OUTFLOW D.O. UNDER 1988 CONDITIONS

The selective withdrawal program SELECT (Davis et al., 1987) was first used for determining the outflow temperature and dissolved oxygen corresponding to the measured profiles during 1988 and then also for the prediction of the change in D.O. and temperature if a submerged weir were installed in front of the intakes.

The intake configuration is shown in Fig 16. Because the geometry shown is different from the assumptions made in the program, a centerline intake elevation of 257.2 m (843.8 ft) had to be assumed to properly represent the outflow. This elevation was determined from a comparison of measured downstream D.O. concentration and that computed using SELECT to determine the withdrawal of water from various levels in the reservoir.

The aeration taking place at the draft tube discharge was computed by the model of Wilhelms et al. (1987) and incorporated in the results as follows

$$C_T = C_S - (C_S - C) \exp \left[\frac{- c_{20} \, (1.024)^{t-20} \, Q^2}{2g \, A^2} \right] \qquad (4)$$

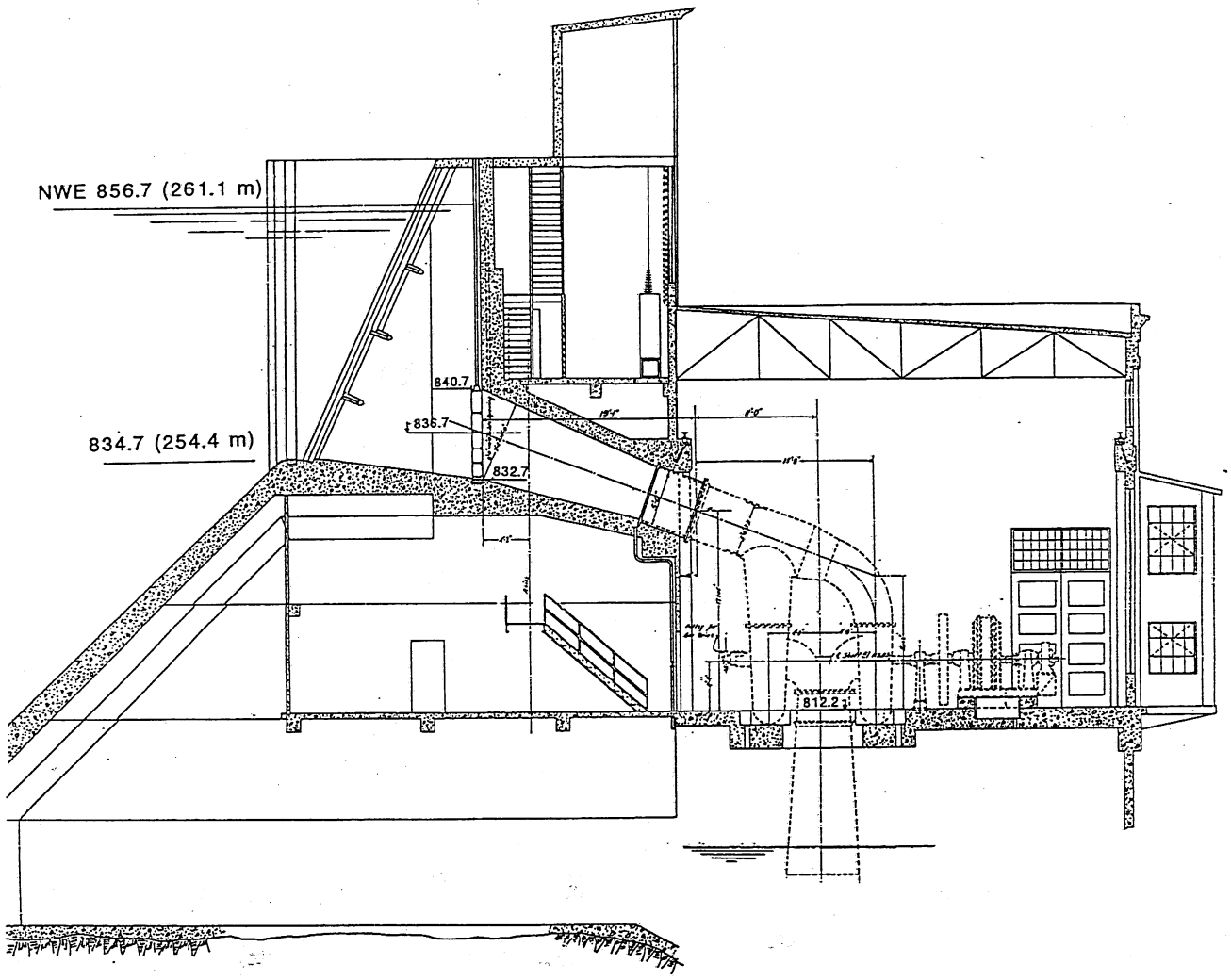


Fig. 16. Byllesby Powerplant Intake configuration.

where C_T = final outflow D.O. concentration from the turbine

C = D.O. concentration as computed from the SELECT program

C_S = saturation concentration

Q = discharge through the turbines

A = cross section of the draft tube (Draft tube diameter is 6.4 ft for this case)

g = acceleration of gravity

c_{20} = energy dissipation coefficient for water @ 20° C, determined to be 0.15 ft^{-1} (Wilhelms et al., 1987)

Eleven measured profiles were chosen for this study and the computed values of outflow D.O. and temperature are given in Table 5. Dissolved oxygen and temperature measurements made later in the day, approximately 60 m downstream from the powerhouse (station X), are given for comparison. Measured values are higher, as expected, since they were usually measured early in the afternoon, whereas the upstream profiles in most cases were measured in the morning. The comparison is shown in Fig. 17. Labels in the graph indicate the time of measurement.

B. SUBMERGED WEIR WITHOUT SPILLWAY GATE OPERATION

One means of increasing outflow D.O. is the installation of a submerged weir in front of the intakes. Stoplogs would be placed in the stoplog slots up to a specified elevation. The height of the weir should be selected such that it effectively seals off low D.O. concentrations and that it does not create a significant headloss.

SELECT was used again with the eleven profiles used in the previous section as input and different elevations of the weir crest were tested. The resulting downstream D.O. for weir crest elevations of 257, 259 and 260 m, respectively, are compared to the results without the weir in Table 6 and Fig. 18. At 257 m no significant improvement is achieved. At 259 m five out of the eight cases that need mitigation reach 5 mg/ℓ and of those five, four reach the 6 mg/ℓ standard. At 260 m the outflow D.O. increases, five of the cases reached the 6 mg/ℓ, and six are above the 5 mg/ℓ limit. The remaining two cases continued to have D.O. concentrations below 5 mg/ℓ because the upstream D.O. was very low right up to the surface (6.72 and 5.09 mg/ℓ at 0.5m).

Setting the weir crest elevation at 260 m gives better results, but it is not recommended for use because the resulting depth of flow over the weir would be only 1.1 m. Therefore the 259 m (849.7 ft) elevation weir is recommended; it results in only slightly lower D.O. concentrations and better hydraulic approach conditions.

TABLE 5. Downstream D.O. and temperature values: Computed at the powerhouse outflow and measured 60 m downstream

Date	Input Station	Profile Time	Discharge (m3/s)	Discharge (cfs)	Outflow Intake @ 257.2 Temp. (°C)	Outflow Intake @ 257.2 D.O. (mg/L)	Downstream measurements Location	Time	Temp. (°C)	D.O. (mg/L)
17-Jun-88	A2	10:10	2.75	97	22.71	3.48	TR	14:50		5.45
17-Jun-88	A2	14:12	2.75	97	23.04	4.15	TR	14:50		5.45
27-Jun-88	A2	9:35	2.15	76	24.69	2.53	X	14:40	25.0	4.09
27-Jun-88	H	13:25	2.15	76	24.98	3.80	X	14:40	25.0	4.09
06-Jul-88	A2	10:47	1.81	64	24.49	6.55	X	13:30	25.2	6.60
14-Jul-88	A1	9:59	2.63	93	25.99	3.23	X	14:10	26.1	3.62
19-Jul-88	H	11:10	1.67	59	26.39	4.42	X	14:50	26.0	6.09
26-Jul-88	H	10:50	1.56	55	24.86	2.83	X	14:15	24.6	3.67
02-Aug-88	H	10:00	1.56	55	26.81	7.35	X	12:45	27.3	7.56
12-Aug-88	H	11:35	1.67	59	25.74	2.60	X	13:18	26.8	5.57
13-Sep-88	H	13:40	2.15	76	18.79	8.83	X	11:55	18.4	8.55

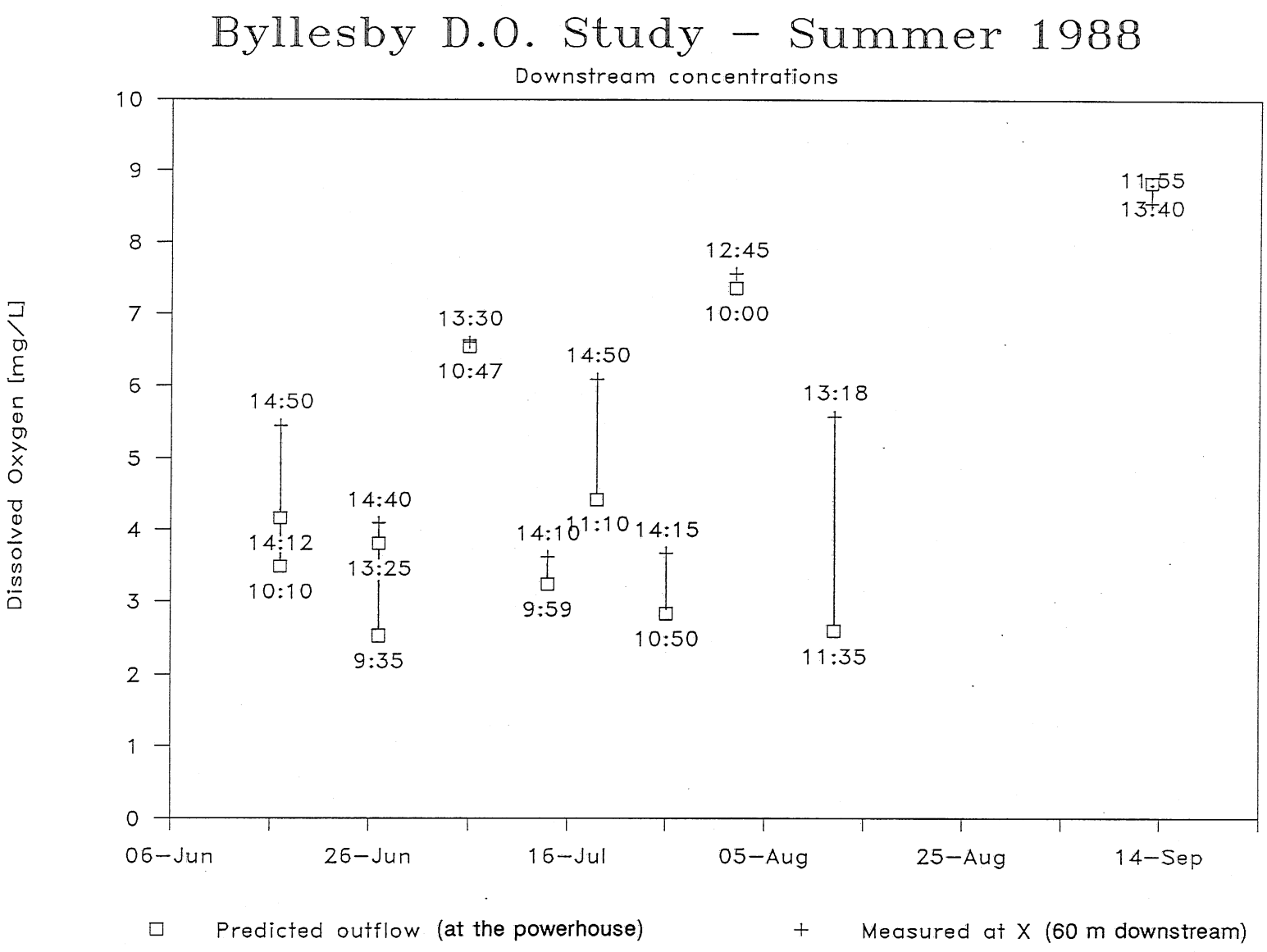


Fig. 17. Comparison of predicted outflow and measured at X (60 m downstream) D.O. values – summer 1988.

TABLE 6. Effect of weir crest elevation on outflow dissolved oxygen and temperature

Date	Input Station	Profile Time	Submerged Weir Crest elevation 257 m	259 m	260 m	Submerged Weir Crest elevation 257 m	259 m	260 m
			Temperature (°C)			D. O. (mg/L)		
17-Jun-88	A2	10:10	22.92	23.09	23.09	3.91	5.07	5.10
17-Jun-88	A2	14:12	23.19	23.58	23.60	4.53	6.58	6.67
27-Jun-88	A2	9:35	24.68	24.92	24.94	2.95	3.50	3.97
27-Jun-88	H	13:25	25.25	26.03	26.52	4.73	7.91	10.19
06-Jul-88	A2	10:47	24.73	24.83	24.83	7.80	8.23	8.23
14-Jul-88	A1	9:59	26.10	26.28	26.46	3.50	3.92	4.23
19-Jul-88	H	11:10	26.49	26.78	26.84	5.01	7.61	8.17
26-Jul-88	H	10:50	25.09	25.74	25.81	4.03	8.79	9.59
02-Aug-88	H	10:00	26.89	26.90	26.90	7.83	7.86	7.86
12-Aug-88	H	11:35	24.79	25.98	26.06	2.78	4.68	6.02
13-Sep-88	H	13:40	18.85	18.87	18.87	8.86	8.94	8.94

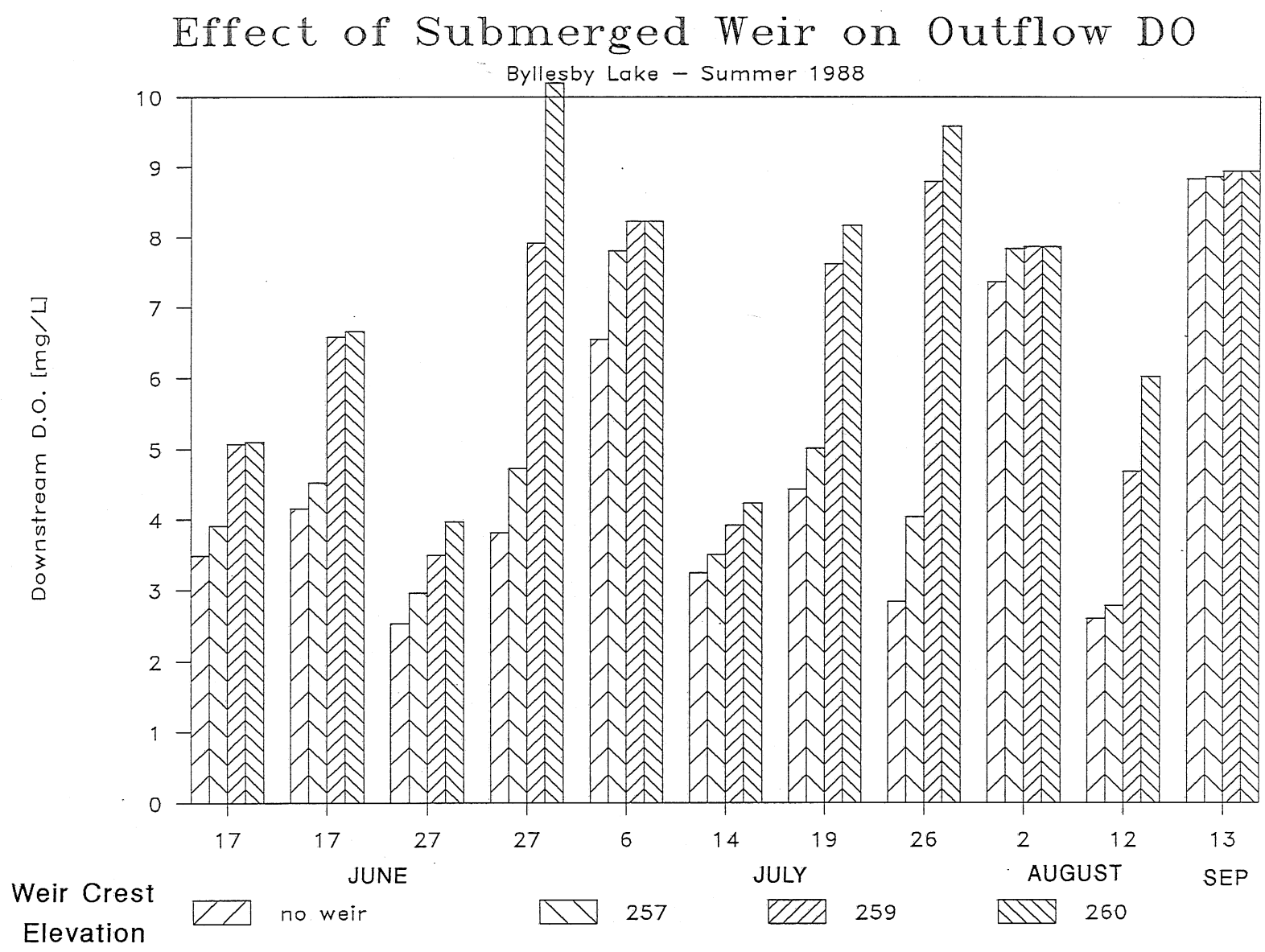


Fig. 18. Effect of weir crest elevation (m) on outfow D.O. (mg/ℓ).

Although weir installation significantly improves outflow D.O. as shown in Table 6 and Figure 18, not all cases could be mitigated. Therefore, the submerged weir cannot be used as a stand alone measure. Using the weir along with continuous monitoring or with a constant percentage of flow diverted through the spillway is discussed in the following sections (VII.C.2 and VII.D.2).

The headloss associated with the weir can be computed as:

$$h_L = K \frac{V^2}{2g} \tag{5}$$

where h_L = headloss
K = headloss coefficient = 0.5 for this case
V = velocity over the weir
g = acceleration of gravity

$$V = \frac{Q}{A} = \frac{Q}{W \times (E_s - E_c)} \tag{6}$$

where Q = discharge
W = width of the intake bay
E_s = water surface elevation
E_c = weir crest elevation

The width of the intake bays is 16.25 ft so W = 16.25 ft if one unit is operating and 48.75 ft if all three units are operating. The headloss is computed in Table 7 for the permanent water surface elevation of 856.7 ft, for two weir crest elevations: 259 m (849.7 ft) and 260m (853 ft) for a number of different discharges.

TABLE 7. Computed Weir Head Losses (ft)

Weir Crest Elevation Water Elevation		849.7 ft 856.7 ft	853.0 ft 856.7 ft
Q (cfs)	# of units operating	Headloss (ft)	Headloss (ft)
100	1	0.006	0.022
200	1	0.024	0.086
400	3	0.011	0.038
500	3	0.017	0.060
600	3	0.024	0.086
800	3	0.043	0.153

The head losses are less than 0.15 ft and 0.04 for a weir crest elevation of 853 ft and 849.7 ft, respectively. This, compared to the 57 ft of total head and the significant improvement in downstream D.O. concentrations when the weir is installed, should be of no concern.

C. SPILLWAY GATE OPERATION WITH CONTINUOUS MONITORING

Since the spillway is a very good aerator (Section V) an option for compliance with the standards is to divert part of the flow through the gated spillway. To determine the percentage of flow to be diverted, the following procedure, based on mass conservation principles, should be implemented.

$$Q = Q_{sp} + Q_T \tag{7}$$

$$\bar{C} = \frac{Q_{sp}}{Q} C_{sp} + \frac{Q_T}{Q} C_T \tag{8}$$

$$C_{sp} = C_T + E(C_s - C_T) \tag{9}$$

where Q = total discharge

Q_T = discharge through the turbines

Q_{sp} = discharge over the spillway

$\bar{C}$ = average downstream D.O.

C_T = outflow D.O. from the turbines

C_{sp} = outflow D.O. from the spillway

C_s = saturation concentration

E = transfer efficiency of the spillway

Solving the above equations we get the fraction of total flow going through the turbines

$$\frac{Q_T}{Q} = 1 - \frac{\bar{C} - C_T}{E(C_s - C_T)} \tag{10}$$

In Eq. 10, both C_s and E are temperature dependent:

$$C_s = 0.9737\left[14.652 - 0.41022\ t + 7.991 \times 10^{-3} t^2 - 7.77774 \times 10^{-5}\ t^3\right] \tag{11}$$

The term 0.9737 accounts for the atmospheric pressure at the elevation of the site and t is the outflow temperature in °C. The temperature dependence of the transfer efficiency is given by Eq. (2) in Section V.

This procedure can be used either with or without the installation of the submerged weir.

1. Without a submerged weir

The results of the above procedure applied to the eleven selected cases are given in Table 8 and Fig. 19. It can be seen that for the cases with violations to meet a standard of $\bar{C} = 5$ mg/ℓ an average of 35% of the flow should be diverted and to meet a standard of $\bar{C} = 6$ mg/ℓ an average of 55% of the flow should be diverted. These lead to significant power loss, especially for the very low flows encountered in the summer of 1988.

TABLE 8. Spillway flow necessary to meet dowmstream D.O. standards ($\bar{C}$)

Without a Submerged Weir

Date	Input Station	Profile Time	Temp. (°C)	Outflow D.O. (mg/L)	Cs (mg/L)	E	Percentage of Flow through turbines $\bar{C}$=5	turbines $\bar{C}$=6	spillway $\bar{C}$=5	spillway $\bar{C}$=6
17-Jun-88	A2	10:10	22.71	3.48	8.32	0.986	68	47	32	53
17-Jun-88	A2	14:12	23.04	4.15	8.27	0.986	79	55	21	45
27-Jun-88	A2	9:35	24.69	2.53	8.01	0.988	54	36	46	64
27-Jun-88	H	13:25	24.98	3.80	7.96	0.988	71	47	29	53
06-Jul-88	A2	10:47	24.49	6.55	8.04	0.988	100	100	0	0
14-Jul-88	A1	9:59	25.99	3.23	7.81	0.989	61	39	39	61
19-Jul-88	H	11:10	26.39	4.42	7.75	0.990	82	52	18	48
26-Jul-88	H	10:50	24.86	2.83	7.98	0.988	57	38	43	62
02-Aug-88	H	10:00	26.81	7.35	7.69	0.990	100		0	
12-Aug-88	H	11:35	25.74	2.60	7.85	0.989	54		46	
13-Sep-88	H	13:40	18.79	8.83	9.01	0.980	100		0	

With a Submerged Weir, Crest at 259 m (849.7 ft)

Date	Input Station	Profile Time	Temp. (°C)	Outflow D.O. (mg/L)	Cs (mg/L)	E	Percentage of Flow through turbines $\bar{C}$=5	turbines $\bar{C}$=6	spillway $\bar{C}$=5	spillway $\bar{C}$=6
17-Jun-88	A2	10:10	23.09	5.07	8.26	0.986	100	71	0	30
17-Jun-88	A2	14:12	23.58	6.58	8.18	0.987	100	100	0	0
27-Jun-88	A2	9:35	24.92	3.50	7.97	0.988	66	43	34	57
27-Jun-88	H	13:25	26.03	7.91	7.81	0.989	100	100	0	0
06-Jul-88	A2	10:47	24.83	8.23	7.99	0.988	100	100	0	0
14-Jul-88	A1	9:59	26.28	3.92	7.77	0.990	72	45	28	55
19-Jul-88	H	11:10	26.78	7.61	7.70	0.990	100	100	0	0
26-Jul-88	H	10:50	25.74	8.79	7.85	0.989	100	100	0	0
02-Aug-88	H	10:00	26.90	7.86	7.68	0.990	100		0	
12-Aug-88	H	11:35	25.98	4.68	7.81	0.989	90		10	
13-Sep-88	H	13:40	18.87	8.94	8.99	0.980	100		0	

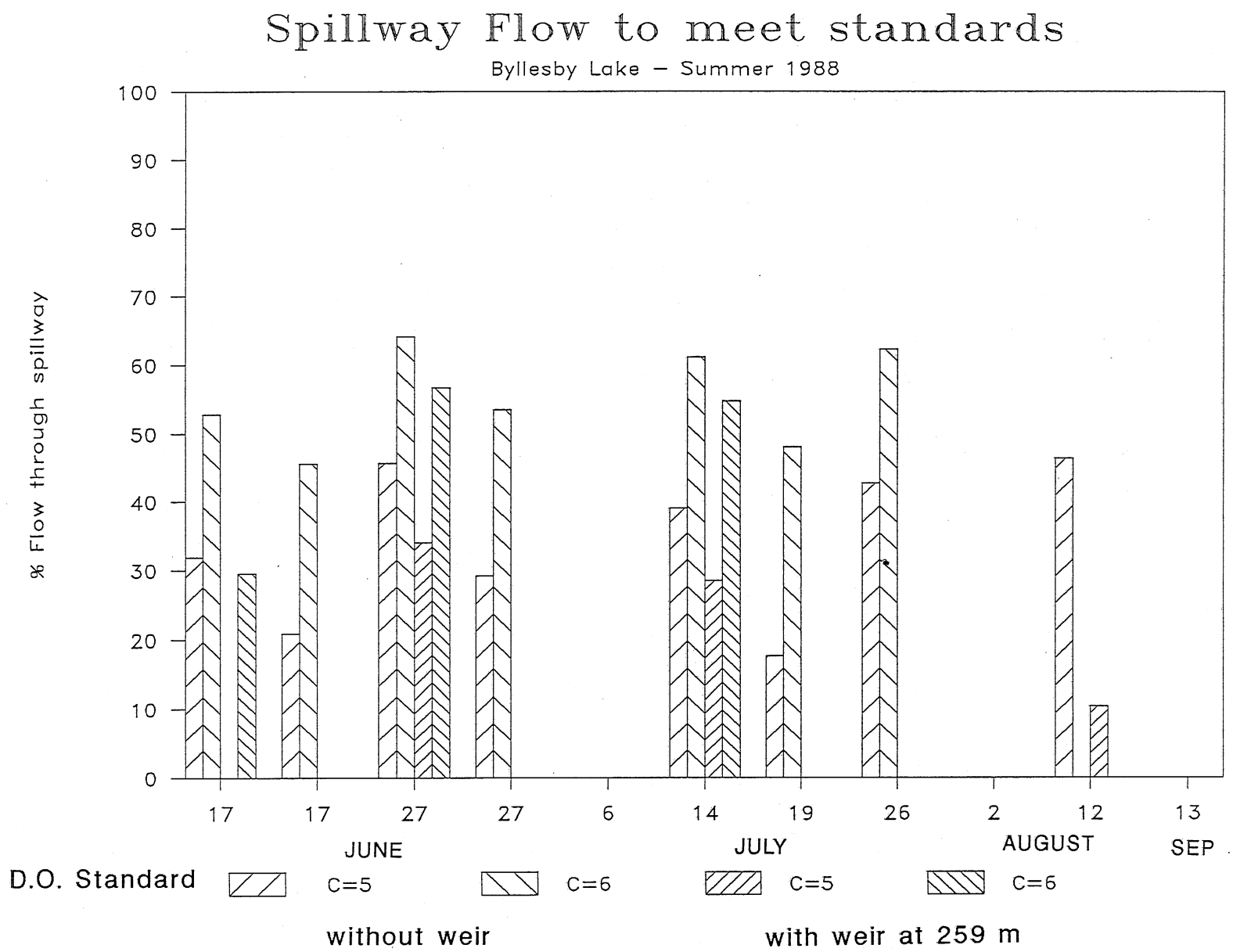


Fig. 19. Percentage of flow to be diverted through the spillway to meet D.O.. standards.

2. With a submerged weir

The same computation as above is repeated for the case when a submerged weir is in place with a crest elevation at 259 m. Violations occur on half as many days as without a weir and for those days the corresponding percentages to be diverted are 24 percent and 46 percent on the average. These results are also given in Table 8. Taking into account that these percentages should be diverted less than half of the time as compared to the results prior to the weir installation, and the fact that they are lower, it can be seen that the weir drastically reduces the power loss associated with passing discharge over the spillway. Moreover, even without the diversion, average outflow D.O. for the eleven cases considered increases from 4.5 mg/ℓ to 6.6 mg/ℓ with the installation of the weir.

D. CONSTANT PERCENTAGE SPILLWAY DISCHARGE WITHOUT CONTINUOUS MONITORING

An alternative to continuous monitoring is to divert a constant percentage of the flow through the spillway gate. In that case the maximum percentage computed in the previous section should be used so that all encountered conditions during 1988 will be covered.

1. Without a submerged weir

For the case that a submerged weir is not installed 46 percent should be diverted through the spillway gate to meet the 5 mg/ℓ daily minimum standard. Using this percentage and Eqs. (7) and (9) the resulting average downstream D.O. is computed and given in Table 9.

2. With a submerged weir

If a submerged weir is installed with a weir crest elevation at 259 m (849.7 ft), the maximum percentage to be diverted to meet the 5 mg/ℓ standard is 34 percent. Using the 34 percent diversion and the results for outflow D.O. for the submerged weir, the resulting average downstream D.O. is again computed from Eqs. (7) through (9) and given in Table 9. For the eleven cases considered, this mitigation leads to an average downstream D.O. of 7.1 mg/ℓ, well above the standard. This compared to the 4.5 mg/ℓ average before mitigation, represents a significant improvement.

Table 9. Average Downstream D.O. for constant percentage Spillway Discharge

Date	Input Profile Station	Time	Average Downstream D.O. Without Weir 46%	With Weir 34%
17-Jun-88	A2	10:10	5.68	6.14
17-Jun-88	A2	14:12	6.02	7.12
27-Jun-88	A2	9:35	5.02	5.00
27-Jun-88	H	13:25	5.69	7.87
06-Jul-88	A2	10:47	7.22	8.15
14-Jul-88	A1	9:59	5.32	5.21
19-Jul-88	H	11:10	5.94	7.64
26-Jul-88	H	10:50	5.17	8.48
02-Aug-88	H	10:00	7.51	7.80
12-Aug-88	H	11:35	4.99	5.73
13-Sep-88	H	13:40	8.91	8.96
		average	6.13	7.10 mg/L

VIII. CONCLUSIONS

1. Extensive monitoring was carried out both in the Byllesby reservoir and downstream from the powerplant during summers of 1987 and 1988.

2. In the summer of 1987 the lake was drawn down and then refilled, thus exposing the old flood plain and allowing dense terrestrial vegetation to grow. Upon refilling of the reservoir the vegetation began to die and decay creating an extremely high D.O. demand in the lower layers and causing very low D.O. concentrations, sometimes extending up to the water surface. Outflow from the reservoir was passed over the spillway, though, resulting in high downstream D.O. concentrations, close to saturation.

3. During the summer of 1988 vegetation in the shallow areas was reduced, although decaying matter could still be found at the bottom. Near surface concentrations were usually high, sometimes above saturation in the afternoon extended through most of the summer in the Cannon River. The resulting long residence time would cause decreased D.O. concentrations in the reservoir, below those normally encountered. In the deeper parts of the reservoir, low concentrations were measured, approaching zero near the bottom.

4. Since the powerplant was operated during summer 1988 outflow was passed through the turbines, withdrawing water at approximately 4–6 m depth. No water was passed over the spillway. As a result downstream concentrations were low, especially in the morning. D.O. values 1 or 2 miles downstream of the powerhouse were higher, indicating a high natural reaeration and photosynthetic capacity of the river. All morning D.O. values (expected to be very close to the daily minimum) measured 2 miles downstream of the powerhouse were above 5 mg/ℓ.

5. Diel swings on the order of 4 mg/ℓ and as high as 7 mg/ℓ were observed downstream of the powerhouse, indicating the strong effect of photosynthetic activity in the river.

6. Mitigation of the observed low D.O. concentrations is necessary. Installation of a submerged weir in front of the intakes was considered. This would cause the turbines to withdraw water from a layer with higher D.O. and thus improve downstream D.O. Although mitigation up to the standards was not possible for all input profiles tested, outflow D.O. would increase in all cases. Average D.O. for the eleven cases considered would increase from 4.5 mg/ℓ to 6.6 mg/ℓ just with the installation of the weir at 849.7 ft. There is a small headloss of a maximum of 0.04 ft for a weir crest elevation of 849.7 ft associated with the weir installation, but this should be considered insignificant compared to the total head of 57 ft and the environmental benefits obtained.

7. Installation of a continuous monitor in the tailrace was considered. This would be used to determine the necessary flow through the spillway gate whenever the D.O. drops below the required standard. The monitor can be integrated with the automation procedure. The percentages computed for 1988 are given in Table 8, for the existing condition and for the case with a submerged weir installed (weir crest at 849.7 ft). For the existing conditions 8 of 11 days are below 5 mg/ℓ and these would require a diversion of 35 percent of the flow on the average. If the weir was in place, there would be just 3 of 11 days below 5 mg/ℓ and this would require 24 percent diversion on the average (for days on which diversion over gates would be required).

8. An alternative without continuous monitoring is the diversion of a constant percentage of the flow through the spillway gates. To insure that all eleven cases considered meet the 5 mg/ℓ standard, the percentage to be diverted will be taken as the maximum computed for all cases (Table 8). If the weir is not installed, a diversion of 46 percent is required, and if the weir is installed, a diversion of 34 percent is required. If the above percentages are diverted, the average D.O. for the eleven cases considered would be 6.1 and 7.1 mg/ℓ, respectively (Table 9). As can be seen, the installation of the weir reduces the percentage of diversion required, thus improving the power production possible under the D.O. restrictions, and also increases the average downstream D.O.

IX. REFERENCES

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APPENDICES

- Data from 1987 summer field surveys
- Data from 1988 summer field surveys
- Dissolved oxygen and temperature profiles in the Reservoir – Summer 1987
- Dissolved oxygen and temperature profiles in the Reservoir and downstream D.O. variation – Summer 1988

DATA FROM 1987 SUMMER FIELD SURVEYS

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 6, 1987

WEATHER: 27^C,OVERCAST/P.C., LIGHT BREEZE

Location:Station 1
Notes: South of banks

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:08	0.5	26.00	2.73
	2.0	26.00	1.97
	3.0	26.00	1.88
	4.0	26.00	1.92
	5.0	26.00	1.79
	5.5	26.00	1.88

Location:Station 2
Notes: South banks - Downstream 100ft

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:10	0.5	24.50	7.15
	1.4	25.00	7.11

Location:Station 3
Notes: The further south intake

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:00	0.4	26.8	4.13
	1.7	26.8	3.86
	2.6	26.8	3.95
	3.5	26.8	3.95
	4.3	26.8	3.86
	5.2	26.7	3.69
	5.6	26.6	3.15
	6.1	26.7	1.21
	6.9	26.5	3.24

Location:Station 4 A
Notes: Northeast end of the spillway

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:20	0.5	26.8	3.82
	2.0	26.8	3.64

BYLLESBY D.O. STUDY

Location:Station 5
Notes: Tailrace

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:30	0.5	24.2	6.02

Location:Station 6
Notes: Cannon River bridge (HWY 55)

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
15:00	0.5	24.3	7.82

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Ave	DO Probe reading
11:20	1	2.70		
		2.94		
			2.82	3.30
12:15	2	7.10		
		7.20		
			7.15	8.10
14:20	4	3.80		
		3.75		
			3.78	4.20

August 6, 1987

BYLLESBY D.O. STUDY

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 10, 1987
WEATHER: 24.8^C, sunny

Location:Station 1
Notes: Depths corrected for angle

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:45	0.5	26.0	7.17
	0.9	26.0	6.07
	1.7	26.0	5.43
	2.6	25.5	2.85
	3.5	25.0	1.56
	4.2	25.0	1.29

Location:Station 2
Notes: Depths corrected for angle

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:40	0.5	29.0	6.67
	0.9	28.5	6.99
	1.3	28.5	6.94

Location:Station 3
Notes: In the shade - Depths corrected

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:08	0.5	26.0	7.49
	0.9	25.7	6.60
	1.7	25.5	6.46
	2.6	25.0	1.87
	3.5	24.7	1.50
	4.3	24.3	1.17
	5.2	24.0	0.80
	6.1	24.0	0.61
	6.9	24.0	0.84
	7.8	24.0	0.94
	8.7	24.0	0.94
	9.3	24.0	0.94

BYLLESBY D.O. STUDY

Location:Station 4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:33	0.5	26.0	8.15
	1.0	25.7	6.65
	2.0	25.0	4.78
	3.0	25.0	1.55
	4.0	24.5	0.75
	5.0	24.0	0.42
	6.0	24.0	0.47
	6.3	24.0	0.66

Location:Station 5
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:53	0.5	23.0	7.21

Location:Station 6
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:16	0.5	23.0	7.30

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
11:00	1	7.85		
		7.60		
			7.72	8.40
11:45	2	7.05		
		7.10	7.07	7.95
13:50	4	8.15		
		8.33		
			8.24	8.80

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 12, 1987
WEATHER: Overcast, Variable winds from the north 0-15 MPH
NOTES: Air Temp. 22.2 C

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
8:52	0.5	24.2	5.12
	1.0	24.2	4.61
	2.0	24.2	5.17
	3.0	24.2	4.99
	4.0	24.2	4.33
	5.0	23.7	1.68
	6.0	23.3	1.58
	7.0	23.2	1.54
	8.0	23.2	1.44
	10.0	23.1	1.40
	12.0	22.8	0.89
	14.0	22.8	0.56
Bottom	14.60		

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:15	0.5	24.2	5.40
	1.0	24.2	5.08
	2.0	24.2	4.89
	3.0	24.2	5.03
	4.0	23.8	1.40
	5.0	23.5	1.44
	6.0	23.3	1.49
	8.0	23.0	1.40
	9.5	23.0	1.26

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:34	0.5	24.1	4.75
	1.0	24.1	4.89
	2.0	24.1	4.47
	3.0	24.0	2.80
	4.0	23.8	1.58
	5.0	23.5	1.40
	5.5	23.3	1.30

BYLLESBY D.O. STUDY

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:45	0.5	24.1	5.40
	1.0	24.1	5.12
	1.5	24.0	1.86
	2.0	23.9	1.30
	3.0	23.8	0.98
	3.4	23.8	0.70

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:58	0.5	24.4	5.22
	1.0	24.4	5.03
	2.0	24.4	4.57
	3.0	24.2	2.05
	4.0	23.9	1.58
	5.0	23.5	1.58
	6.0	23.5	1.68
	8.0	23.2	1.58
	10.0	23.0	1.49
	12.0	22.8	0.84
	14.0	22.6	0.28
Bottom	14.6		

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:20	0.5	24.3	4.99
	1.0	24.3	4.82
	2.0	24.3	3.79
	3.0	24.0	1.96
	3.5	24.0	0.80
	4.0	23.8	0.36
	4.5	23.6	0.13

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:33	0.5	24.8	4.46
	1.0	24.5	2.23
	2.0	24.0	0.18
	3.0	24.0	0.13

August 12, 1987

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:44	0.5	24.2	5.62
	1.0	24.2	5.26
	2.0	24.2	5.08
	3.0	24.2	4.19
	4.0	24.2	3.57
	5.0	24.0	1.78
	6.0	23.3	1.29
	8.0	23.0	1.07
	8.5	23.0	0.94

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:00	0.5	24.1	5.89
	1.0	24.1	5.44
	2.0	24.1	4.59
	3.0	24.1	4.46
	4.0	24.1	4.28
	5.0	23.5	1.56
	6.0	23.3	1.20
	8.0	23.0	0.87
	10.0	22.5	0.27
	11.0	22.5	0.18

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	24.3	4.90
	1.0	24.3	4.82
	2.0	24.3	4.73
	3.0	24.3	4.99
	4.0	24.0	4.10
	5.0	23.5	1.69
	6.0	23.3	1.25
	8.0	23.0	1.03
	10.0	22.5	0.36
	10.4	22.5	0.27

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:36	0.5	24.8	7.09
	1.0	24.8	6.91
	2.0	24.8	6.51
	3.0	24.8	6.87
	4.0	24.8	6.29
	5.0	24.0	4.28
	5.2	24.0	4.19

BYLLESBY D.O. STUDY

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:58	0.5	24.8	7.49
	1.0	24.8	7.13
	2.0	24.8	6.78
	3.0	24.8	6.33
	4.0	24.8	6.33
	5.0	23.8	1.07

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:08	0.5	25.0	7.41
	1.0	25.0	7.19
	2.0	25.0	6.97
	3.0	25.0	5.73
	4.0	24.3	3.13
	4.5	23.5	0.53

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:55	0.5	23.0	5.12
	1.0	23.0	4.98
	2.0	23.0	4.85
	3.0	23.0	5.34
	4.0	23.0	5.29
	4.3	22.8	4.98

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:07	0.5	22.9	6.35
	1.0	22.9	6.04
	1.3	22.9	5.95

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:35	0.5	25.0	9.24
	1.0	25.0	8.93
	2.0	25.0	8.14
	3.0	25.0	7.77
	4.0	24.7	7.09
	5.0	24.5	5.72
	6.0	24.0	2.47
	8.0	24.0	1.58
	10.0	24.0	1.21
	12.0	24.0	1.10
	14.0	24.0	1.02

August 12, 1987

BYLLESBY D.O. STUDY

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:50	0.5	24.3	7.51
	1.0	24.3	6.98
	2.0	24.3	6.62
	3.0	24.3	6.51
	4.0	24.0	3.89
	5.0	23.8	2.00
	6.0	23.6	1.58
	8.0	23.3	1.26
	8.1	23.0	1.26

Location:Station 2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:30	0.50		7.51

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
8:52	A1	5.15		
		5.10		
			5.12	5.50
10:05	B1	5.18		
		5.20		
			5.19	
11:36	D1 *	7.57		
		6.61		
			7.09	7.95
12:55	E	5.05		
		5.18		
			5.12	5.80
14:30	2	7.50		
		7.52		
			7.51	

* Algee in bottles

August 12, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 14, 1987
WEATHER: Overcast, drizzle, air Temp. 20 C
NOTES: Probe connections must be dried before use

Location:Station 7
Notes: By the ladder

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:42	0.5	24.0	3.23
	1.0	24.2	3.18
	1.5	24.2	3.13
	2.1	24.2	2.77
	2.8	24.2	2.72

Location:Station 2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:50	0.5	23.5	7.39

Location:Station 4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:09	0.5	24.8	2.69
	1.0	24.8	2.35
	2.0	24.8	2.88
	3.0	24.8	0.77
	4.0	24.8	0.62
	5.0	24.8	0.48
	6.0	24.5	0.48
	7.2	24.5	0.58

Location:Station 8
Notes: furthest north intake pier

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:22	0.5	24.5	2.40
	1.0	24.8	2.28
	2.0	24.8	2.26 *
	3.0	24.8	2.28 *
	4.0	24.8	0.29
Bottom	4.5	24.8	0.24

*unstable readings

BYLLESBY D.O. STUDY

Location:Station 8
Notes: Check profile again

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:35	0.5		2.26
	1.0		2.21
	1.5		2.45
	2.0		1.78
	2.5		0.40
	3.0		0.20
	4.0		0.18
12:42	4.5		0.13

Location:Station 5
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:56	0.5	22.9	7.20

Location:Station 6
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:15	0.5	21.1	7.01
	1.0	21.1	6.82
	1.3	21.1	6.77

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
10:50	7	3.08		
		3.18		
			3.13	3.05
12:22	8	2.40		
		2.40		
			2.40	2.50

August 14, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 17, 1987

WEATHER: Sunny, west wind 15 mph
Air Temperature 17 C

NOTES: Sluice way closed
All flow over wooden flashboards

Location:Station 7

Notes: Depths corrected for angle

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
8:39	0.5	24.0	6.08
	1.0	24.0	6.23
	1.4	24.0	6.18
	2.1	24.0	6.13
	2.8	24.0	6.18

Location:Station 2

Notes: Winkler samples 7.75, 7.77

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:00	0.50		7.76

Location:Station 4

Notes: Sluice gate is not opening

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:25	0.5	24.0	6.82
	1.0	24.0	6.34
	2.0	24.0	6.02
	3.0	24.0	5.86
	4.0	24.0	5.71
	5.0	24.0	5.34
	6.0	24.0	4.28
Bottom	7.2	23.0	0.48

Location:Station 8

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:42	0.5	23.8	6.92
	1.0	24.0	6.97
	2.0	24.0	6.87
	3.0	24.0	6.81
	4.0	24.0	6.33
Bottom	5.0	24.0	6.27

BYLLESBY D.O. STUDY

Location:Station 5

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:55	0.5	23.1	7.67

Location:Station 6

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:18	0.5	21.8	7.19
	1.0	21.8	7.10
	1.4	21.8	6.97

Winkler Samples - Calibration

Time	Station	Winkler	Average DO	Probe reading
8:45	7	6.44		
		6.45		
			6.45	6.10
9:35	8	6.88		
		6.96		
			6.92	6.40

August 17, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 19, 1987
WEATHER: Sunny until 10:00, partly cloudy later, at noon air temp. 21 C
NOTES: Sluice way closed
variable downstream wind

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:10	0.5	23.9	7.31
	1.0	23.9	7.22
	2.0	23.9	7.22
	3.0	24.0	7.17
	4.0	24.0	7.17
	5.0	24.0	7.12
	6.0	24.0	6.63
	7.8	23.0	0.34
	7.0	23.0	0.24
	6.5	23.5	0.49

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:43	0.5	20.3	7.12
	1.0	20.3	7.02
	1.2	20.3	6.92

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:50	0.5	22.0	4.63
	1.0	22.0	5.12
	2.0	21.8	5.66
	3.0	21.3	5.95
	3.5	21.3	5.85

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	23.0	7.02
	1.0	23.0	6.68
	2.0	23.0	5.80
	3.0	23.0	5.61
	4.0	23.0	5.27
	5.0	23.0	4.49

BYLLESBY D.O. STUDY

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:20	0.5	23.5	7.95
	1.0	23.3	6.93
	2.0	23.1	6.44
	3.0	23.1	6.34
	4.0	23.1	6.34
	4.5	23.1	5.85

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	23.5	8.20
	1.0	23.5	7.80
	2.0	23.3	7.12
	3.0	23.3	7.12
	4.0	23.3	7.12
	4.6	23.3	6.63

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:45	0.5	23.8	8.47
	1.0	24.0	8.37
	2.0	24.0	8.22
	3.0	24.0	7.73
	4.0	23.5	7.73
	5.0	23.5	7.49
	6.0	23.5	6.99
	7.0	23.2	4.92
	7.8	22.8	0.39

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	24.0	9.21
	1.0	24.0	9.26
	2.0	24.0	8.86
	3.0	24.0	8.57
	4.0	23.8	7.68
	5.0	23.5	7.19
	6.0	23.5	6.99
	7.8	23.0	4.92

August 19, 1987

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:15	0.5	24.0	9.46
	1.0	24.0	9.36
	2.0	24.0	9.11
	3.0	23.8	7.68
	4.0	23.8	7.19
	5.0	23.8	7.19
	6.0	23.5	7.04
Bottom	7.9	23.3	5.07

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:30	0.5	24.0	9.21
	1.0	24.0	9.06
	2.0	24.0	7.88
	3.0	23.8	7.34
	4.0	23.8	7.09
	5.0	23.5	6.60
	6.0	23.5	6.50
	8.0	23.0	4.04
Bottom	9.5	23.0	0.30
	9.0	23.0	0.44
	8.5	23.0	1.77

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:40	0.5	24.0	8.57
	1.0	24.0	7.93
	2.0	24.0	7.39
	3.0	24.0	7.09
	4.0	24.0	6.40
	5.0	23.8	6.40
	6.0	23.5	5.52
	7.0	23.0	0.25
	10.0	23.0	0.20
	12.0	22.8	0.20
	12.6	22.8	0.20
	7.0	23.0	0.15

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:50	0.5	24.5	9.51
	1.0	24.3	9.36
	2.0	24.0	7.86
	3.0	24.0	6.71
	4.0	23.5	5.81
	4.4	23.3	5.21

BYLLESBY D.O. STUDY

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:57	0.5	24.8	10.01
	1.0	24.5	9.86
	2.0	24.0	8.36
	3.0	23.5	6.81
	3.7	23.3	5.66

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:07	0.5	24.2	8.82
	1.0	24.2	7.66
	2.0	23.9	7.03
	3.0	23.9	7.14
	4.0	23.9	7.12
	5.0	23.8	7.01
	6.0	23.8	5.01
	7.0	23.1	0.21
	8.0	23.0	0.17
	10.0	22.8	0.15
	12.0	22.8	0.13
	13.5	22.6	0.15

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:20	0.5	24.2	8.58
	1.0	24.2	8.55
	2.0	24.0	7.71
	3.0	23.9	7.16
	4.0	23.8	7.22
	5.0	23.8	6.52
	6.0	23.7	2.30
	8.0	23.0	0.15
	9.4	22.9	0.13

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:30	0.5	24.3	9.01
	1.0	24.3	9.01
	2.0	24.1	8.21
	3.0	24.0	7.23
	4.0	23.9	7.16
	5.0	23.8	7.11
	5.7	23.4	2.70

August 19, 1987

BYLLESBY D.O. STUDY

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:45	0.5	24.7	9.01
	1.0	24.7	9.01
	2.0	24.4	8.41
	3.0	23.8	7.73
	3.7	23.4	6.66

Location:Station 2
Notes: Winklers 7.82, 7.83

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
	0.5		7.82

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
9:30	A2	7.15		
		7.38		
			7.27	7.45
10:40	D3	8.15		
		8.24		
			8.20	8.40
11:45	G		8.47	8.60
13:50	A4	9.13		
		9.09		
			9.11	9.10

August 19, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 21, 1987
WEATHER: Overcast, strong wind from the south
NOTES: Pressure at the lab at 3:45 pm
735.2 mmHg

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:00	0.5	23.8	7.98
	1.0	23.8	7.87
	2.0	23.8	7.72
	3.0	23.6	6.46
	4.0	23.3	1.34
	5.0	23.1	2.60
	6.0	23.1	0.29
	8.0	22.8	0.21
	10.0	22.8	0.20
	12.0	22.6	0.17
	13.5	22.5	0.17

Location:Station A2
Notes: Boat drifting during measurements

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:30	0.5	23.8	7.85
	1.0	23.8	7.85
	2.0	23.8	7.85
	3.0	23.6	6.40
	4.0	23.3	1.00
	5.0	23.0	1.13
	6.0	23.0	0.89
	8.0	22.8	0.20
	9.8	22.8	0.13

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:50	0.5	23.7	7.14
	1.0	23.7	7.19
	2.0	23.5	7.03
	3.0	23.4	4.15
	4.0	23.2	2.47
	4.8	23.0	1.47

BYLLESBY D.O. STUDY

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:57	0.5	23.5	6.09
	1.0	23.5	5.99
	2.0	23.4	4.93
	3.0	23.2	3.14
	3.5	23.2	2.62

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:07	0.5	24.1	8.29
	1.0	24.1	7.98
	2.0	23.9	7.14
	3.0	23.5	4.09
	4.0	23.2	3.34
	5.0	23.2	2.12
	6.0	23.1	1.05
	8.0	23.0	0.17
	10.0	22.8	0.10
	12.0	22.5	0.10
	12.5	22.2	0.19

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:20	0.5	24.1	7.87
	1.0	24.1	7.61
	2.0	23.8	6.19
	3.0	23.4	4.30
	4.0	23.2	3.31
	5.0	23.1	2.93
	5.3	23.1	2.52

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	24.0	7.42
	1.0	24.0	7.09
	2.0	23.8	4.72
	3.0	23.6	2.12
	3.5	23.3	1.47

August 21, 1987

BYLLESBY D.O. STUDY

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:40	0.5	23.5	7.32
	1.0	23.5	7.22
	2.0	23.5	7.02
	3.0	23.2	6.24
	4.0	23.1	6.06
	5.0	23.1	5.60
	6.0	23.0	5.28
	8.0	22.9	3.11
	9.3	22.8	3.02

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:55	0.5	23.5	7.08
	1.0	23.5	7.14
	2.0	23.4	6.90
	3.0	23.4	6.90
	4.0	23.4	6.96
	5.0	23.1	5.94
	6.0	23.1	5.96
	8.0	23.0	4.56
	9.5	22.2	1.02

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:08	0.5	23.2	6.75
	1.0	23.4	6.71
	2.0	23.4	6.60
	3.0	23.3	6.62
	4.0	23.1	5.87
	5.0	23.1	5.54
	6.0	23.1	5.52
	8.0	22.8	3.34
	10.0	22.3	1.22
	10.3	22.2	0.54

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:30	0.5	23.9	8.27
	1.0	23.9	8.40
	2.0	23.9	8.22
	3.0	23.6	7.68
	4.0	23.3	6.74
	5.0	23.1	6.33
	6.0	23.0	5.75
	6.8	22.5	4.20

August 21, 1987

BYLLESBY D.O. STUDY

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:48	0.5	23.9	6.30
	1.0	23.8	6.54
	2.0	23.7	6.42
	3.0	23.5	6.36
	4.0	23.5	6.18
	5.1	23.5	2.94

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	23.8	6.00
	1.0	23.8	6.06
	2.0	23.8	6.12
	3.0	23.8	6.12
	4.0	23.7	6.18
	5.0	23.5	5.94
	5.2	23.1	5.64

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:10	0.5	24.0	6.00
	1.0	24.0	6.06
	2.0	23.9	6.06
	3.0	23.6	6.00
	4.0	23.4	5.88
	5.0	22.8	2.40

Location:Station E
Notes: Bubble in probe first noticed
Previous values corrected assuming bubble not present

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:25	0.5	23.0	10.48
	1.0	23.0	11.03
	2.0	22.6	9.64
	3.0	22.2	8.99
	4.0	22.0	3.89

Location:Station F
Notes: errors may be involved due to bubble
Values uncertain

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:47	0.5	21.9	11.51
	1.0	21.9	12.08
	1.1	21.9	11.63

August 21, 1987

BYLLESBY D.O. STUDY

Location:Station A2
Notes: errors may be involved due to bubble values uncertain

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	24.1	8.40
	1.0	24.0	8.61
	2.0	24.0	8.80
	3.0	23.8	8.40
	4.0	23.4	5.21
	5.0	23.1	3.78
	6.0	23.0	1.66
	8.0	22.8	0.32
	9.5	22.7	0.23

Location:Station 5
Notes: Winkler samples 7.72, 7.78

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:40	0.5		7.76

Location:Station 2
Notes: Winkler samples 7.68,7.68

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:10	0.5		7.68

WINKLER SAMPLES -Calibration

Time	Station	Winkler	Average	DO Probe reading
9:00	A1	7.80 8.05	7.93	7.60
11:15	C3	6.92 6.95	6.94	5.63
12:25	E *		10.48	5.65
13:00	A2	8.47 8.33	8.40	4.00

* bubble in probe - calibration changes

August 21, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 24, 1987

WEATHER: Air Temp. 19 C @ 10:30am, sunny

NOTES: wind blowing downstream
Air Calibration at 8.4 mg/l
in 0-20 scale

Location:Station A1

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:35	0.5	23.0	4.94
	1.0	23.0	5.04
	2.0	23.0	5.04
	3.0	23.0	4.74
	4.0	23.0	4.30
	5.0	23.0	4.20
	6.0	22.5	4.15
	8.0	22.5	4.05
	10.0	22.3	3.76
Bottom	11.5	22.3	0.59

Location:Station A2

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:05	0.5	22.5	5.14
	1.0	22.5	5.09
	2.0	22.5	5.24
	3.0	22.5	5.53
	4.0	22.5	5.29
	5.0	22.5	4.84
	6.0	22.5	4.65
	8.0	22.5	4.35
	9.5	22.3	4.35

Location:Station A3

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:15	0.5	22.3	6.66
	1.0	22.3	6.43
	2.0	22.3	6.37
	3.0	22.3	6.15
	4.0	22.3	5.92
	5.0	22.3	5.70
	5.9	22.0	5.41

BYLLESBY D.O. STUDY

Location:Station A4

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	22.3	7.33
	1.0	22.3	6.95
	2.0	22.3	7.50
	3.0	22.0	7.33
	3.2	21.8	7.33

Location:Station B1

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:45	0.5	22.5	6.43
	1.0	22.5	6.04
	2.0	22.3	5.87
	3.0	22.3	5.75
	4.0	22.3	5.75
	5.0	22.3	5.87
	6.0	22.3	6.15
	8.0	22.3	5.64
	10.0	22.3	5.02
	12.0	22.3	3.50
~ bottom	14.0	22.3	0.96

Location:Station B2

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:00	0.5	22.5	7.17
	1.0	22.5	6.72
	2.0	22.5	6.26
	3.0	22.5	6.15
	4.0	22.5	6.15
	5.0	22.5	5.76
	5.4	22.5	4.91

Location:Station B3

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	22.5	8.30
	1.0	22.5	7.84
	2.0	22.3	6.88
	3.0	22.0	6.32
	3.5	22.0	5.87

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Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:30	0.5	22.5	9.14
	1.0	22.5	8.75
	2.0	22.3	8.35
	3.0	22.3	7.96
	4.0	22.0	7.96
	5.0	22.0	8.07
	6.0	22.0	7.28
	8.0	22.0	6.77
	9.7	22.0	4.51

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:40	0.5	22.8	9.99
	1.0	22.8	8.58
	2.0	22.3	7.56
	3.0	22.3	7.56
	4.0	22.3	7.79
	5.0	22.3	7.79
	6.0	22.0	6.77
	8.0	22.0	6.38
	10.0	22.0	5.64

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:45	0.5	22.5	9.37
	1.0	22.5	8.46
	2.0	22.3	7.79
	3.0	22.3	7.73
	4.0	22.0	7.67
	5.0	22.0	7.51
	6.0	22.0	7.17
	8.0	22.0	6.77
	10.0	22.0	6.21
	10.4	22.0	5.64

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	22.3	8.98
	1.0	22.3	8.98
	2.0	22.3	7.62
	3.0	22.0	7.56
	4.0	22.0	7.56
	5.0	22.0	7.50
	6.0	22.0	7.21
	7.5	22.0	6.67

BYLLESBY D.O. STUDY

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:20	0.5	22.0	8.51
	1.0	22.0	8.15
	2.0	22.0	7.86
	3.0	22.0	8.03
	4.0	22.0	8.03
	5.0	21.0	5.73

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:30	0.5	22.0	8.68
	1.0	22.0	8.39
	2.0	22.0	7.26
	3.0	22.0	7.09
	4.0	22.0	7.44
	5.0	21.3	5.37

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:45	0.5	22.0	10.40
	1.0	22.0	10.04
	2.0	22.0	9.45
	3.0	21.8	7.86
	4.0	21.8	8.21
	4.9	21.0	10.40
	3.5	21.8	7.61

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	20.0	9.86
	1.0	20.0	9.86
	2.0	18.5	8.51
	2.2	18.0	8.21

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:15	0.5	18.0	11.81
	1.0	18.0	11.58
	2.0	18.0	11.58

August 24, 1987

BYLLESBY D.O. STUDY

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:30	0.5	23.0	7.38
	1.0	23.0	7.21
	2.0	23.0	6.38
	3.0	22.8	6.26
	4.0	22.8	6.20
	5.0	22.5	5.79
	6.0	22.5	5.79
	8.0	22.3	6.02
	9.2	22.0	6.38

Location:Station 2
Notes: downstream right bank
Winklers 8.34, 8.39

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:30	0.5		8.37

Location:Station 5
Notes: Station 5 skipped as not
representative of the spillway

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
9:45	A1	5.18	5.09	5.15
		5.00		
10:40	A4	7.21	7.22	6.40
		7.23		
11:25	B3 *	8.30	8.27	7.20-7.35
		8.24		
12:55	D3	10.39	10.40	8.80
		10.40		

* not used - outlier

August 24, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 26, 1988

WEATHER: Air temp 16.5^C, light wind blowing upstream, overcast, high humidity

Notes: Air calibration at 9.4 mg/l in the 0-20 scale
readings taken in 0-10 scale

Location:Station A2

Notes: 1.5 - 2" WAVES

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
9:15	0.5	21.0	3.87	
	1.0	21.3	4.16	
	2.0	21.5	4.88	
	3.0	21.5	5.26	
	4.0	21.5	5.54	
	5.0	21.5	5.59	
	6.0	21.3	4.44	
bottom	6.9	21.3	4.16	
	0.5	21.3	5.64	(CALIB)
	0.75	21.3	4.78	
	0.25	21.3	6.02	

Location:Station F

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:53	0.5	16.5	7.29
	1.0	16.5	7.67
	1.2	16.5	7.84

Location:Station E

Notes: 2.25 m S.D. SECCHI DEPTH

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:05	0.5	18.0	3.72
	1.0	18.0	4.51
	1.5	18.0	6.37
	2.0	17.5	8.35
	2.5	17.5	8.74

BYLLESBY D.O. STUDY

Location:Station D1

Notes: 1.3m S.D. SECCHI DEPTH

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	20.8	7.94
	1.0	20.8	8.20
	2.0	20.8	8.52
	3.0	20.8	8.42
	4.0	20.5	9.11
	5.0	20.3	9.11

Location:Station D2

Notes: 1.2m S.D. SECCHI DEPTH
5" waves, barely breaking

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:45	0.5	20.8	8.20
	1.0	20.8	8.04
	2.0	20.8	8.47
	3.0	21.0	8.74
	4.0	21.0	9.01
	4.8	21.0	9.01

Location:Station D3

Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:00	0.5	20.8	8.26
	1.0	20.8	8.26
	2.0	20.8	8.42
	3.0	20.8	8.58
	4.0	20.5	9.81
	4.4	20.3	9.81

Location:Station G

Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	21.0	8.04
	1.0	21.0	7.40
	2.0	21.0	8.04
	3.0	21.0	8.42
	4.0	21.0	8.58
	5.0	21.0	8.74
	6.0	21.0	8.58
	7.0	21.0	8.36

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Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:30	0.5	21.0	6.91
	1.0	21.3	6.40
	2.0	21.3	6.60
	3.0	21.3	7.33
	4.0	21.3	7.22
	5.0	21.3	7.33
	6.0	21.3	7.07
	8.0	21.0	7.22
	9.3	20.3	4.80

Location:Station C2
Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12.30	0.5	21.3	5.98
	1.0	21.5	5.57
	2.0	21.5	6.09
	3.0	21.5	6.34
	4.0	21.5	6.60
	5.0	21.3	6.76
	6.0	21.3	6.96
	8.0	21.0	6.81
	10.1	20.3	4.23

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:45	0.5	21.3	6.45
	1.0	21.3	5.57
	2.0	21.3	5.67
	3.0	21.3	6.19
	4.0	21.3	6.40
	5.0	21.3	6.40
	6.0	21.3	6.60
	8.0	21.0	6.19
	10.2	20.3	4.44

Location:Station B1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	21.0	5.83
	1.0	21.0	5.16
	2.0	21.0	5.06
	3.0	21.0	5.57
	4.0	21.3	5.73
	5.0	21.3	5.78
	6.0	21.3	5.88
	8.0	21.3	6.09
	10.0	21.0	6.09
	12.7	20.5	4.18

BYLLESBY D.O. STUDY

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:09	0.5	21.1	5.07
	1.0	21.1	4.70
	2.0	21.2	4.83
	3.0	21.2	5.22
	4.0	21.2	5.36
	5.0	21.2	5.44
	6.2	21.2	5.42

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:23	0.5	21.0	5.68
	1.0	21.0	5.28
	2.0	21.0	5.24
	3.0	21.0	5.20
	3.6	21.0	4.92

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:37	0.5	21.0	5.09
	1.0	21.1	4.86
	2.0	21.2	4.95
	3.0	21.2	5.28
	4.0	21.2	5.40
	5.0	21.2	5.23
	6.0	21.2	4.37
	8.0	21.1	4.58
	10.0	21.0	4.49
	12.0	20.8	4.32
not bott.	14.0	20.6	3.72

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:48	0.5	21.1	5.34
	1.0	21.2	5.01
	2.0	21.2	4.90
	3.0	21.2	5.04
	4.0	21.2	5.23
	5.0	21.2	5.35
	6.0	21.2	4.06
	7.0	21.2	3.72

August 26, 1987

BYLLESBY D.O. STUDY

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:59	0.5	21.2	5.49
	1.0	21.2	5.07
	2.0	21.2	4.94
	3.0	21.2	5.07
	4.0	21.2	5.30
	5.0	21.2	5.33
	5.5	21.2	5.06

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:07	0.5	21.2	5.08
	1.0	21.2	4.77
	2.0	21.2	4.73
	3.0	21.0	4.34

Location:Station 2
Notes: Winklers 7.96, 7.96

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
~14:40	0.50		7.96

WINKLRE SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reding
9:25	A2	5.60 5.68	5.64	5.90
10:00	F	7.27 7.28	7.27	6.45
11:05	D3	8.30 8.32	8.31	7.75
12:40	C2	6.33 6.36	6.34	6.15
13:30	B3	5.49 5.63	5.56	5.20
14:15	A4	4.97 4.95	4.96	4.40

August 26, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O. STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 28, 1987
WEATHER: 18.0^C,
NOTES:

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
10:00	0.5	16.8	7.50
	1.0	16.5	8.53
	1.2	16.5	8.58

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
10:30	0.5	18.0	3.89
	1.0	17.8	7.31
	2.0	17.5	9.28
	2.5	17.5	9.00

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
10:45	0.5	20.3	7.77
	1.0	20.3	8.36
	2.0	20.3	9.16
	3.0	20.3	9.56
	4.0	20.3	9.96
	5.2	18.0	6.82

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
10:50	0.5	20.5	8.61
	1.0	20.5	7.17
	2.0	20.3	8.11
	3.0	20.3	8.76
	4.0	20.0	9.06
	5.0	19.3	4.18
	5.1	19.0	3.29

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
11:00	0.5	20.5	9.96
	1.0	20.5	8.16
	2.0	20.3	8.46
	3.0	20.3	8.96
	4.0	20.0	7.02
	4.7	19.5	2.39

Location:Station G
Notes: Secchi depth 1.3 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
11:15	0.5	20.5	8.07
	1.0	20.5	7.12
	2.0	20.3	7.87
	3.0	20.3	8.07
	4.0	20.0	7.32
	5.0	20.0	7.32
	6.0	19.5	5.63
	7.2	18.5	4.83

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
11:30	0.5	21.0	5.76
	1.0	21.0	4.72
	2.0	20.8	4.87
	3.0	20.8	5.49
	4.0	20.0	4.87
	5.0	19.8	4.72
	6.0	19.5	4.18
	8.0	19.0	3.84
bottom	10.0	18.5	3.22

Location:Station C2
Notes: Secchi depth 1.3 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
11:45	0.5	21.0	5.95
	1.0	21.0	5.37
	2.0	20.8	4.87
	3.0	20.5	4.57
	4.0	20.5	4.80
	5.0	20.0	4.80
	6.0	19.8	4.68
	8.0	19.5	4.14
	10.0	19.0	3.42
	10.4	18.5	2.76

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
12:00	0.5	21.0	5.79
	1.0	21.0	4.91
	2.0	21.0	4.22
	3.0	20.5	4.49
	4.0	20.3	4.84
	5.0	20.3	5.03
	6.0	20.0	4.91
	8.0	19.8	4.45
	8.9	19.8	3.30

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
12:30	0.5	21.0	5.12
	1.0	20.8	4.57
	2.0	20.5	4.23
	3.0	20.5	4.53
	4.0	20.3	5.03
	5.0	20.3	5.16
	6.0	20.0	5.12
	8.0	20.0	5.08
	10.0	19.8	4.44
	12.0	19.5	3.93
not bott.	13.5	19.5	3.60

Location:Station B2
Notes: * 0.3 measurement taken after the rest of the profile

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
*	0.3	21.3	5.37
12:45	0.5	21.3	5.80
	1.0	20.8	4.95
	2.0	20.5	4.06
	3.0	20.5	3.85
	4.0	20.5	3.76
	4.3	20.3	3.64

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
13:00	0.5	21.5	6.05
	1.0	21.0	5.25
	2.0	20.8	4.53
	3.0	20.5	4.57
	3.6	20.5	4.10

BYLLESBY D.O. STUDY

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
13:15	0.5	21.0	5.43
	1.0	20.8	4.60
	2.0	20.5	4.21
	3.0	20.5	4.17
	4.0	20.3	2.91
	5.0	20.3	3.26
	6.0	20.0	4.17
	8.0	20.0	4.47
	10.0	20.0	4.47
	11.4	20.0	4.21

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
13:20	0.5	21.0	5.47
	1.0	21.0	4.60
	2.0	20.8	4.17
	3.0	20.5	4.04
	4.0	20.5	2.95
	5.0	20.3	4.17
	6.0	20.0	4.34
	8.1	20.0	4.04

Location:Station A3
Notes: * 0.3 measurement taken after the rest of the profile

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
*	0.3	22.0	5.21
13:25	0.5	21.3	5.51
	1.0	21.0	5.34
	2.0	20.8	3.95
	3.0	20.5	2.39
	4.0	20.3	3.04
	5.0	20.0	4.30
	5.8	20.0	5.30

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
13:40	0.5	22.0	5.56
	1.0	21.0	5.56
	2.0	20.8	4.13
	3.0	20.8	2.17
	3.8	20.5	2.17

August 28, 1987

BYLLESBY D.O. STUDY

Location:Station 2
Notes: Winklers 8.17, 8.18

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/l]
~14:00	0.5		8.18

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
10:05	F	7.30 7.14	7.22	7.70
11:10	D2	8.03 8.10	8.07	8.10
12:00	C3	5.79 5.80	5.79	7.55
12:45	B2	5.82 5.77	5.80	6.85
13:25	A3	5.50 5.53	5.51	6.35

August 28, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 31, 1987
WEATHER: 15.5^C, WINDY 15MPH
NOTES: Air Calibration 9.6 mg/l

Location:Station F
Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:10	0.5	16.5	7.20
	1.1	16.5	7.25

Location:Station E

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:25	0.5	18.3	7.52
	1.0	18.5	7.20
	2.0	18.0	6.29
	2.6	18.0	5.66

Location:Station D1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:40	0.5	19.8	6.82
	1.0	19.8	7.30
	2.0	19.8	8.16
	3.0	19.8	8.59
	4.0	19.8	6.49
	5.0	19.5	4.96
	5.2	19.5	4.15

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:45	0.5	19.8	7.68
	1.0	19.8	6.87
	2.0	19.8	7.68
	3.0	19.8	8.21
	4.0	19.8	8.35
	5.2	19.8	7.63

Location:Station D3
Notes: Secchi depth 1.05 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:55	0.5	20.0	9.06
	1.0	20.0	8.02
	2.0	20.0	8.97
	2.6	19.0	9.35

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	19.8	7.82
	1.0	20.0	7.40
	2.0	20.0	8.11
	3.0	20.0	8.73
	4.0	20.0	9.26
	5.0	20.0	9.35
	6.0	20.0	9.49
	8.2	20.0	7.35

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	19.8	8.11
	1.0	20.0	7.40
	2.0	20.0	7.92
	3.0	20.0	8.49
	4.0	20.0	8.92
	5.0	20.0	9.26
	6.0	19.8	5.92
	7.3	19.8	5.77

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:35	0.5	20.0	8.66
	1.0	20.0	7.81
	2.0	20.0	7.63
	3.0	20.0	7.63
	4.0	20.0	7.11

Location:Station C3
Notes: Secchi depth 1.25 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:46	0.5	20.0	7.63
	1.0	20.0	6.87
	2.0	20.0	6.50
	3.0	20.0	6.64
	4.0	20.0	6.73
	5.0	19.8	4.99
	6.0	19.8	6.45
	8.0	19.5	7.34
	10.0	19.0	3.77
	10.7	19.0	0.94

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	20.0	6.31
	1.0	20.0	5.51
	2.0	20.0	5.41
	3.0	20.0	5.65
	4.0	20.0	5.55
	5.0	20.0	5.55
	6.0	20.0	6.50
	8.0	19.8	4.24
	9.0	19.3	2.17
	11.0	19.0	1.27
	12.8	18.8	0.89

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:30	0.5	20.3	6.87
	1.0	20.0	6.17
	2.0	20.0	5.74
	3.0	20.0	5.74
	4.2	20.0	5.65

Location:Station B3
Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:50	0.5	20.5	7.88
	1.0	20.5	7.64
	2.0	20.0	7.40

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:15	0.5	20.0	7.30
	1.0	20.3	6.57
	2.0	20.0	6.57
	3.0	20.0	6.52
	4.0	20.0	6.62
	5.0	20.0	6.76
	6.0	20.0	6.72
	8.0	19.8	6.86
	10.0	19.0	1.85
	12.0	18.8	1.31
	14.0	18.8	0.88

BYLLESBY D.O. STUDY

Location:Station A2
Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:30	0.5	20.0	7.35
	1.0	20.0	6.72
	2.0	20.0	6.62
	3.0	20.0	6.81
	4.0	20.0	6.72
	5.0	20.0	6.76
	6.0	20.0	6.72
	7.8	19.8	6.81

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:50	0.5	20.0	7.50
	1.0	20.0	7.06
	2.0	20.0	6.87
	3.0	20.0	7.06
	4.0	20.0	7.16
	5.0	20.0	7.21
	5.2	19.8	7.21

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	20.0	8.57
	1.0	20.3	8.28
	2.0	20.0	8.96
	2.2	19.8	8.28

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
9:10	F	7.20	7.20	7.95
		7.20		
9:55	D3	9.08	9.06	9.50
		9.05		
10:45	C3	7.60	7.63	8.10
		7.65		
12:45	A2	7.25	7.25	7.45
		7.25		
13:00	A4	8.60	8.57	8.80
		8.55		

August 31, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: September 2, 1987
WEATHER: 19.0^C, SUNNY, NO WIND

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:30	0.5	17.0	7.10
	1.0	16.8	8.24
	1.1	16.8	8.19

Location:Station E

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:46	0.5	18.8	9.50
	1.0	18.5	8.67
	2.0	18.3	7.73
	2.5	18.0	2.17

Location:Station D1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:00	0.5	19.5	7.73
	1.0	19.8	7.88
	2.0	19.8	8.47
	3.0	19.8	8.72
	4.0	19.5	8.17
	5.0	18.6	5.61
	6.0	18.6	5.32

Location:Station D2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:20	0.5	19.8	7.88
	1.0	19.8	7.14
	2.0	19.8	7.83
	3.0	19.8	8.42
	4.0	19.8	8.91
	5.0	19.5	7.24
	5.1	19.5	7.24

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	19.6	9.95
	1.0	19.5	8.37
	2.0	19.3	8.37
Bottom	3.0	19.0	11.82

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:46	0.5	19.8	9.20
	1.0	20.0	8.19
	2.0	20.0	8.44
	3.0	19.8	9.05
	4.0	19.8	9.75
	5.0	19.8	9.70
	6.0	19.8	9.25
	6.6	19.8	8.79

Location:Station C1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:00	0.5	20.0	9.80
	1.0	20.0	8.69
	2.0	20.0	8.39
	3.0	20.0	8.74
	4.0	20.0	8.94
	5.0	20.0	8.89
	6.0	20.0	8.39
	8.0	19.8	7.38
	10.2	19.0	2.02

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:45	0.5	20.5	9.20
	1.0	20.3	8.78
	1.6	20.0	8.89

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	20.3	10.39
	1.0	20.0	9.82
	2.0	20.0	9.56
	3.0	20.0	9.98
	4.0	20.0	10.18
	5.0	20.0	10.39
	6.0	19.8	10.08
	8.0	19.8	9.82
	10.5	19.0	1.66

BYLLESBY D.O. STUDY

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:45	0.5	20.3	10.70
	1.0	20.3	9.87
	2.0	20.0	9.56
	3.0	20.0	9.09
	4.0	20.0	9.30
	5.0	20.0	9.51
	6.0	20.0	9.66
	8.0	19.8	7.69
	10.0	19.3	4.31
	12.0	18.8	1.25
	12.7	18.8	1.14

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	20.5	10.47
	1.0	20.3	8.98
	2.0	20.0	8.71
	3.0	20.0	8.49
	4.0	20.0	8.28
	4.8	20.0	6.20

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:15	0.5	21.0	11.75
	1.0	20.3	10.26
	2.0	20.0	8.65
	3.0	19.9	8.12

September 2, 1987

BYLLESBY D.O. STUDY

Location:Station A1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:30	0.5	21.3	9.67
	1.0	20.3	9.19
	2.0	20.0	8.17
	3.0	20.0	7.93
	4.0	20.0	7.93
	5.0	20.0	7.93
	6.0	20.0	6.77
	8.0	19.0	6.43
	10.0	19.0	1.74
	12.0	18.8	1.02
	14.0	18.8	1.02

Location:Station A2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:45	0.5	21.0	10.25
	1.0	20.3	8.80
	2.0	20.0	7.69
	3.0	20.0	7.54
	4.0	20.0	7.69
	5.0	20.0	7.50
	6.0	20.0	5.85
	8.0	19.8	5.85
	8.6	19.8	4.84

Location:Station A3

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:00	0.5	22.0	11.12
	1.0	20.8	9.48
	2.0	20.0	7.74
	3.0	20.0	7.59
	4.0	20.0	7.59
	5.0	20.0	7.74
	5.8	20.0	5.56

WINKLER SAMPLES - Calibration

Time	Station	Winkler Average	DO Probe reading
9:35	F	6.91	7.30
10:00	D1	7.73	7.85
10:55	G	9.45	9.35
12:10	C3	10.60	10.20
13:10	B2	10.52	9.85
14:10	A3	11.02	11.40

September 2, 1987

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: 09/04/87
WEATHER: 17.5^C, VERY WINDY
NOTES: D.O. meter unstable
readings varying 7-11 mg/l
10"-15" waves in the middle
of the lake

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:00	0.5	17.3	6.70
	1.0	17.1	7.44
	1.1	17.1	7.44

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:15	0.5	18.7	8.93
	1.0	18.7	9.67
	2.0	18.8	8.48
	2.9	18.0	5.80

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:40	0.5	19.2	9.21
bottom	1.0	19.2	9.21

NOTE: VERY STRONG WINDS AT LOCATIONS
D2 AND D3 - NOT ABLE TO TAKE
MEASUREMENTS

Location:Station G
Notes: 5-10" waves, not as windy

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:00	0.5	19.3	8.68
	1.0	19.5	8.68
	2.0	19.5	8.68
	3.0	19.5	7.95
	4.0	19.5	7.37
	5.0	19.5	6.94
	6.0	19.5	6.72
	6.6	19.5	6.58

BYLLESBY D.O. STUDY

Location:Station C1
Notes: drifting, 45^ angle-depths corrected

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:15	0.4	19.3	8.33
	0.7	19.3	9.57
	1.4	19.3	9.57
	2.1	19.3	9.57
	2.8	19.3	7.91
	3.5	19.1	7.33

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	19.3	9.16
	1.0	19.3	9.16
	2.0	19.5	9.16
	3.0	19.3	8.33
	4.0	19.3	7.58
	5.0	19.3	7.28
	6.0	19.3	6.91

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:45	0.5	19.3	8.33
	1.0	19.3	9.16
	2.0	19.3	9.16
	3.0	19.3	7.99
	4.0	19.3	7.33
	5.0	19.3	6.91
	6.0	19.3	6.66
	8.0	19.0	6.41
	10.4	19.0	6.41

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	19.9	8.80
	1.0	19.9	9.39
	2.0	19.5	8.72
	3.0	19.5	7.59
	4.0	19.3	7.13
	5.0	19.3	6.88
	6.0	19.3	6.58
	8.0	19.3	6.33
	10.0	19.3	6.08
	12.0	19.0	2.52
	12.8	18.9	0.75

September 4, 1987

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:20	0.5	19.8	8.39
	1.0	19.7	8.80
	2.0	19.5	8.39
	3.0	19.5	7.04
	4.0	19.5	6.37
	4.8	19.5	5.95

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	20.0	9.64
	1.0	19.8	9.64
	2.0	19.8	8.39
	3.0	19.5	6.96

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	20.0	10.51
	1.0	19.8	10.08
	2.0	19.8	8.54
	3.0	19.5	7.80
	4.0	19.5	7.49
	5.0	19.5	7.27
	6.0	19.5	7.05
	8.0	19.3	6.53
	10.0	19.0	6.31
	12.0	19.0	4.99
	13.3	18.9	1.14

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:10	0.5	19.8	8.32
	1.0	19.8	8.85
	2.0	19.8	7.53
	3.0	19.8	6.92
	4.0	19.7	6.70
	5.0	19.7	6.31
	6.0	19.7	6.13
	8.0	19.3	5.83
	10.0	19.1	5.56

BYLLESBY D.O. STUDY

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:20	0.5	19.8	7.97
	1.0	19.5	7.53
	2.0	19.5	6.70
	3.0	19.5	6.22
	4.0	19.3	5.87
	5.0	19.1	5.69
	5.8	19.1	5.61

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:30	0.5	19.8	8.68
	1.0	19.8	7.81
	2.0	19.5	6.58
	3.0	19.3	6.21
	3.5	19.0	5.75

WINKLER SAMPLES - Calibration

Time	Station	Winkler	Average	DO Probe reading
9:05	F	6.62	6.66	8.95
		6.70		
9:40	D1	9.20	9.21	12.50
		9.22		
10:00	G	8.65	8.68	12.00
		8.70		
10:45	C3	8.30	8.33	10.00
		8.35		
11:30	B2	8.30	8.30	9.90
		8.30		
13:25	A3	7.90	7.88	9.00
		7.87		
13:30	A4	8.65	8.68	9.50
		8.70		

pressure at the Lab
16:30 737.1 mm Hg

September 4, 1987

DATA FROM 1988 SUMMER FIELD SURVEYS

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: June 17, 1988
WEATHER: windy from south
(from left bank looking upstream)
T=21^C @ 9:30, OVERCAST
NOTES: DISCHARGE ~100cfs
SPILLWAY- 5-10%

Location:Station A1
Notes: Air calibration 8.6 ppm at 21 C
~50 ft from shore

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:40	0.5	23.3	6.58
	1.0	23.4	6.45
	2.0	23.4	6.30
	3.0	23.3	5.99
	4.0	23.0	2.34
	5.0	22.8	1.52
	6.0	22.6	0.76
	8.0	20.6	0.20
	10.0	16.6	0.61
	11.8	15.0	0.41

Location:Station A2
Notes: first buoy-gravel end of structure

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	23.2	6.64
	1.0	23.2	6.23
	2.0	23.2	5.73
	3.0	23.2	5.44
	4.0	22.9	3.27
	5.0	22.8	2.61
	6.0	22.6	1.79
	8.0	20.6	0.26
	10.0	16.6	0.29
	12.0	14.9	0.51
	13.5	14.8	0.43

Location:Station A3
Notes: round white buoy
middle hydraulic cylinder

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	23.1	5.23
	1.0	23.1	5.13
	2.0	23.1	4.72
	3.0	23.1	3.28
	4.0	22.9	2.87
	5.0	22.8	2.65
	6.0	22.6	1.80
	6.0	22.6	1.74

Byllesby D.O. Study

Location:Station A4
Notes: 1st cylindrical buoy from right-park
pavilion or 2nd buoy-mfg plant

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:40	0.5	23.0	3.84
	1.0	23.0	3.65
	2.0	23.0	3.34
	3.0	22.9	2.26
	3.6	22.8	2.01

Location:Station B1
Notes: from dock to car ~50 ft from shore

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:58	0.5	23.3	6.81
	1.0	23.2	6.71
	2.0	23.0	3.82
	3.0	23.0	3.24
	4.0	22.9	3.30
	5.0	22.8	3.15
	6.0	22.7	2.68
	7.0	22.8	1.55
	8.0	20.1	0.26
	10.0	16.1	0.31
	12.0	14.9	0.46
	12.5	14.2	0.46

Location:Station B2
Notes: ~middle

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	23.1	7.56
	1.0	23.2	7.14
	2.0	23.2	6.68
	3.0	22.9	1.74
	3.5	22.9	1.55

*shallow-next time farther out

Location:Station B3
Notes: 75 ft from car

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:22	0.5	23.3	8.35
	1.0	23.3	7.88
	2.1	23.0	2.05

Location:Station C1
Notes: ~100 ft from point

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:45	0.5	23.2	7.40
	1.0	23.2	6.98
	2.0	23.2	6.62
	3.0	22.8	3.02
	4.0	22.8	2.50
	5.0	22.6	1.98
	6.0	22.3	1.67
	8.0	21.0	0.21
bottom	10.0	16.2	0.22

June 17, 1988

Location:Station C2
Notes: middle

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	23.2	7.00
	1.0	23.2	6.58
	2.0	22.9	4.23
	3.0	22.8	2.84
	4.0	22.8	2.82
	5.0	22.7	2.87
	6.0	22.7	2.82
	8.0	19.8	0.22
	9.5	18.2	0.20

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:15	0.5	23.1	6.71
	1.0	23.1	6.29
	2.0	23.0	5.54
	3.0	22.9	3.90
	4.0	22.6	2.62
	5.0	22.6	2.52
	6.0	22.5	2.31
	8.0	20.0	0.21
	10.0	16.8	0.26
	10.1	16.2	0.26

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:37	0.5	23.2	8.36
	1.0	23.2	8.21
	2.0	23.2	7.42
	3.0	23.0	6.68
	4.0	23.0	6.47
	5.0	23.0	5.76
	6.0	22.8	3.16
	6.5	22.6	0.95

Location:Station D1
Notes: getting rougher

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:55	0.5	23.2	9.50
	1.0	23.2	9.50
	2.0	23.2	9.40
	3.0	23.2	9.50
	4.0	23.2	9.45
	5.0	23.2	9.40
	5.5	23.0	5.49

Byllesby D.O. Study

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:08	0.5	23.2	9.10
	1.0	23.2	9.05
	2.0	23.2	8.94
	3.0	23.2	8.89
	4.0	23.2	7.51
	5.0	23.0	7.19

Location:Station D3
Notes: ~150 ft from shore

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:18	0.5	23.2	9.76
	1.0	23.2	9.66
	2.0	23.2	8.70
	3.0	23.0	8.01
	4.0	23.0	6.53
	4.5	22.8	4.67

Location:Station E

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:40	0.5	23.8	11.40
	1.0	23.6	11.08
	2.0	22.8	12.14

Location:Station F

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:50	0.5	21.6	7.68
	1.0	21.2	7.68
	1.1	21.2	7.68

Location:Station A2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:12	0.5	23.8	7.79
	1.0	23.8	7.70
	2.0	23.8	7.49
	3.0	23.5	6.86
	4.0	23.1	3.91
	5.0	22.8	1.64
	6.0	22.6	1.18
	8.0	20.9	0.21
	10.0	16.1	0.21
	12.0	14.8	0.24
	13.5	13.8	0.25

Location:Station TR
Notes: Tailrace - edge of gravel bar downstream of units 1 & 2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
14:45	~0.5		5.98	6.05
			6.12	
14:50	~0.5		5.45	5.48
			5.50	

June 17, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: June 27, 1988

WEATHER: T=25.6^C @ 9:05, 29.4^C @ 3:00, calm
methane(?) bubbles rising to surface

NOTES: flow from powerhouse ~ 90%
small splillway discharge
elevation 0.1 ft below top of flashb

Location:Station A1
Notes: 50 ft from shore
Air calibration 8ppm at 25 C

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
	0.05		8.06
	0.15		8.06
	0.25		7.70
9:10	0.5	25.1	7.03
	1.0	25.1	6.20
	2.0	25.0	5.37
	3.0	25.0	5.19
	4.0	24.9	3.00
	5.0	24.8	0.56
	6.0	24.2	0.15
	8.0	22.6	0.15
	10.0	17.0	0.18
	12.0	15.0	0.30
	12.8	14.6	0.36

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:35	0.5	25.1	6.72
	1.0	25.0	5.79
	2.0	25.0	4.55
	3.0	24.9	3.54
	4.0	24.9	1.81
	5.0	24.8	0.93
	6.0	24.6	1.07
	8.0	22.4	0.14
	9.5	19.2	0.14

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:50	0.5	25.0	6.79
	1.0	25.0	5.59
	2.0	25.0	4.66
	3.0	24.9	3.41
	4.0	24.9	3.00
	5.0	24.8	2.59
	5.8	24.5	1.74

Byllesby D.O. Study

Location:Station A4
Notes: light downstream breeze coming up

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:03	0.5	25.1	7.36
	1.0	25.0	5.82
	2.0	24.9	4.04
	3.0	24.9	4.87
	3.3	24.9	4.56

Location:Station B1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	25.0	9.01
	1.0	25.0	8.18
	2.0	25.0	6.53
	3.0	25.0	5.80
	4.0	24.5	5.49
	5.0	24.5	4.14
	6.0	24.5	2.54
	8.0	22.0	0.16
	10.0	17.5	0.16
	12.0	15.0	0.21
	12.5	14.5	0.21

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:25	0.5	25.0	9.13
	1.0	25.0	7.36
	2.0	25.0	5.60
	3.0	25.0	5.70
	3.5	24.8	5.34

Location:Station B3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:35	0.1	26.0	9.08
	0.2	26.0	9.13
	0.5	26.0	9.13
	1.0	25.3	7.94
	2.0	25.0	5.92
	2.5	25.0	5.71

Location:Station C1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:50	0.5	26.0	11.84
	1.0	25.0	9.87
	2.0	25.0	6.44
	3.0	24.5	6.23
	4.0	24.8	4.21
	5.0	24.8	3.17
	6.0	24.5	3.01
	8.0	22.0	0.21
	10.0	18.0	0.10
	11.1	16.5	0.10

June 27, 1988

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:05	0.5	26.0	12.69
	1.0	25.0	10.50
	2.0	25.0	7.80

Location:Station C3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:10	0.5	26.0	12.38
	1.0	25.0	10.71
	2.0	25.0	5.88
	3.0	25.0	4.58
	4.0	25.0	4.63
	5.0	25.0	4.89
	6.0	24.5	3.17
	8.0	22.0	0.21
	9.3	20.0	0.10

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:25	0.5	25.5	14.16
	1.0	25.0	9.26
	2.0	25.0	6.51
	3.0	24.8	6.45
	4.0	24.8	6.14
	5.0	24.8	6.30
	6.0	24.3	2.39
	8.0	22.0	0.21
	8.3	21.0	0.16

Location:Station D1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:00	0.5	27.0	18.77
	1.0	25.5	13.77
	2.0	25.0	8.34
	3.0	25.0	6.99
	4.0	25.0	5.63
	5.0	24.5	1.98

Location:Station D2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:15	0.5	26.8	17.64
	1.0	25.5	10.96
	2.0	25.0	10.75
	3.0	25.0	11.54
	4.0	25.0	5.64
	4.6	24.5	1.25

Byllesby D.O. Study

Location:Station D3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:35	0.5	27.0	18.60
	1.0	25.0	11.91
	2.0	25.0	10.66
	3.0	25.0	10.24
	4.0	25.0	9.14

Location:Station E
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:50	0.5	27.0	>20
	0.8	27.0	17.15
	1.3	25.0	15.27
	2.0	24.5	7.11

Location:Station F
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:00	0.5	22.5	7.96
	1.0	22.5	7.64
	1.2	22.0	7.54

Location:Station H
Notes: 30 m in front of intake

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:25	0.5	27.0	12.69
	1.0	27.0	12.69
	2.0	26.0	7.34
	3.0	25.0	3.67
	4.0	25.0	3.36
	5.0	24.5	1.78
	6.0	24.0	0.89
	8.0	22.5	0.21
	10.0	17.3	0.21
	12.0	15.0	0.16
	14.0	13.5	0.16

* DOWNSTREAM MEASUREMENTS *

Location	TIME [H:MIN]	TEMP [C]	D.O. [mg/L]	Distance from right bank (m)
RP	14:15		7.87	
X1*	~14:40	26.0	5.25	1
X2		25.0	4.41	3
X3		25.0	4.09	5
RU			4.34	

* Air temperature 23 C
downstream samples taken near the bottom

June 27, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: July 6, 1988
WEATHER: CLEAR,HUMID,WIND FROM SOUTH
WAVY,HIGH 99^F,WIND 30 MPH
NOTES: Same weather day before

Location:Station F
Notes: Secchi depth 0.65 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:03	0.05	25.2	4.64
	1.0	25.2	4.54
	1.1	25.0	4.45

Location:Station E
Notes: Secchi depth 0.35 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:28	0.5	25.2	7.92
	1.0	25.3	7.78
	2.0	25.2	7.54
	3.0	25.2	7.25
	3.3	25.1	7.01

Location:Station D2
Notes: angle to vertical 15 degrees
high waves - rough surface
largest wave ~20 cm - Secchi ~ 0.6 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:40	0.5	24.9	7.60
	1.0	24.9	7.41
	2.0	24.9	7.31
	3.0	24.8	7.22
	4.0	24.8	7.22
	5.0	24.8	7.12
	6.0	24.8	7.12
	7.5 B		

Location:Station G
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:52	0.5	25.1	8.77
	1.0	25.1	8.48
	2.0	25.0	7.90
	3.0	24.9	7.62
	4.0	24.8	6.65
	5.0	24.2	5.01
	6.0	23.8	1.98
	7.0	22.8	0.29
	8.1	21.3	0.24

Location:Station C2
Notes: 10-15 cm waves - Secchi 0.5 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:03	0.5	24.9	8.11
	1.0	24.9	7.63
	2.0	24.8	6.96
	3.0	24.8	6.57
	4.0	24.3	6.28
	5.0	23.9	3.48
	5.5	23.8	1.88

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:18	0.5	24.9	8.32
	1.0	24.8	7.94
	2.0	24.8	7.70
	3.0	24.6	7.65
	4.0	24.5	6.05
	5.0	24.0	3.68
	6.0	23.7	2.13
	7.0	23.0	0.29
	8.0	22.8	0.29
	10.0	19.0	0.19
	12.1	15.0	0.19

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:30	0.5	24.8	8.92	
	1.0	24.9	8.44	
	2.0	24.8	8.25	
	3.0	24.9	7.95	
	4.0	24.8	7.95	
	5.0	24.2	7.57	(+/-.3)
	6.0	23.8	2.62	(+/-.4)
	8.0	23.7	0.19	
	10.0	19.9	0.19	
	12.0	15.6	0.19	
	13.7	14.5	0.19	

Location:Station A2
Notes: windy and wavy
10-15 cm waves with a lot of ripples

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:47	0.5	24.9	8.95
	1.0	24.9	8.51
	2.0	24.9	8.27
	3.0	24.8	7.98
	4.0	24.8	8.08
	5.0	24.5	7.78
	6.0	23.6	2.04
	8.0	23.8	0.24
	10.0	20.4	0.19
	12.0	16.0	0.19
	13.5	14.2	0.19

Byllesby D.O. Study

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
11:02	0.5	24.9	8.30	
	1.0	24.9	8.30	
	2.0	24.9	8.00	
	3.0	24.9	7.81	
	4.0	24.8	7.61	
(+/-.3)	5.0	24.1	4.10	(+/-.3)
	6.0	24.0	1.95	
	7.5	23.0	0.49	

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:13	0.5	24.9	8.60
	1.0	24.9	8.40
	2.0	24.9	7.91
	3.0	24.8	7.52
	4.0	24.4	6.16
	5.5	24.1	5.18

DOWNSTREAM

Distance from powerhouse (m)	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]	
2630	GB	12:45	28.0	8.45	
3320	RP	13:00	27.9	9.01	(+/-0.1)
	LC	13:05	26.3	8.58	(+/-.025)
60	X1	13:30	25.5	6.80	
60	X2		25.0	6.52	
60	X3		25.0	6.47	
110	RU1	13:45	25.2	7.08	
110	RU2		25.1	6.70	
110	RD1		25.2	6.70	
110	RD2		25.1	6.70	
190	DR1	14:00	25.2	6.98	
190	DR2		25.2	6.94	
190	DR3		25.1	6.80	
1585	H52	14:25	28.7	9.59	(+/-.035)

July 6, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: July 14, 1988
WEATHER: CALM,27^C
NOTES: Velocity measurements taken during this survey

Location:Station D2
Notes: Air calibration 7.7 mg/L @ 27 C
Secchi depth 1.05 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:00	0.50	26.2	4.96
	1.00	26.1	4.75
	2.00	26.0	4.66
	3.00	26.0	4.58
	4.00	26.0	4.33
	5.00	25.6	2.00
	5.20	25.5	1.50

Location:Station C2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:20	0.50	26.5	6.40
	1.00	26.5	5.98
	2.00	26.2	4.90
	3.00	26.1	4.99
	4.00	26.0	4.65
	4.60	25.9	4.57

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:33	0.50	26.7	5.06
	1.00	26.8	4.73
	2.00	26.5	4.27
	3.00	26.2	4.56
	4.00	26.2	4.40
	5.00	25.2	1.04
	5.60	25.1	0.71

Location:Station A2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:43	0.50	26.5	5.22
	1.00	26.7	4.48
	2.00	26.5	4.15
	3.00	26.4	3.90
	4.00	26.1	3.48
	5.00	25.9	3.23
	6.00	25.1	0.41
	7.00	24.9	0.17
	8.00	24.3	0.08
	10.00	20.5	0.08
	10.20	19.9	0.08

Byllesby D.O. Study

Location:Station A1
Notes: Secchi depth 1.3 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:59	0.50	27.0	5.09
	1.00	26.7	4.55
	2.00	26.2	3.89
	3.00	26.2	3.89
	4.00	26.1	3.73
	5.00	25.9	2.61
	6.00	25.1	0.62
	8.00	24.4	0.12
	10.00	19.8	0.08
	12.00	16.0	0.08
	12.70	15.0	0.08

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:17	0.50	26.6	5.09
	1.00	26.5	4.30
	2.00	26.5	4.05
	3.00	26.3	4.01
	4.00	26.1	3.47
	5.00	25.5	1.41
	6.00	25.2	0.66

Location:Station A4
Notes: Secchi depth 1.3 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.50	27.0	5.70
	1.00	26.8	5.04
	2.00	26.8	4.42
	3.00	26.5	4.54
	3.10	26.5	4.46

July 14, 1988

Byllesby D.O. Study

DOWNSTREAM

Distance from PH	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	8:23	25.9	3.79 (+/-.035)
2630	GB	11:35	27.9	6.95 (+/-.05)
3320	RP	11:45	27.5	7.60
	LC	12:40	24.9	8.50
110	RU1	13:10	26.8	3.58
110	RU2		26.2	3.58
110	RD1		26.3	3.82
110	RD2		26.2	3.66
110	RD2'		26.1	3.82
190	DR1	13:30	26.1	4.06
190	DR2		26.2	3.77
190	DR3		26.1	3.65
290	Y1	13:40	26.1	4.21
290	Y2		26.2	4.05
290	Y3		26.1	4.01
530	Z1	13:50	25.9	4.69
530	Z2		26.8	4.69
530	Z3		26.5	4.57
60	X1	14:10	26.3	4.04
60	X2		26.0	3.47
60	X3		26.0	3.35
1585	H52	14:40		7.56

July 14, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: July 19, 1988
WEATHER: cloudy, cool, no wind
NOTES: water very calm(in river & lake)
in lake algae arranged in rows
in NE direction (at section C)
Air temp. 21°C @ 8:30

Location:Station C2
Notes: Air calibration 8.2 ppm @ 23.3 C
Secchi depth 0.8 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
9:30	0.5	26.4	8.60	
	1.0	26.4	7.84	
	2.0	26.3	7.74	
	3.0	26.3	7.53	
	4.0	26.2	7.13	
	5.0	26.2	5.40	(+/-.1)
	6.0	26.0	3.36	
	8.0	25.0	0.31	
	10.0	18.1	0.20	
	10.2	17.4	0.20	

Location:Station B2
Notes: Secchi depth 1.2 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:55	0.5	26.5	9.57
	1.0	26.7	8.28
	2.0	26.6	9.06
	3.0	26.5	8.07
	4.0	26.5	7.45
	5.0	26.2	6.42
	6.0	26.1	2.90
	8.0	24.5	0.26
	10.0	21.0	0.21
	12.0	16.0	0.21
	12.2	15.3	0.21

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	26.7	9.45
	1.0	26.7	8.36
	2.0	26.8	8.42
	3.0	26.8	8.10
	4.0	26.3	2.70
	5.0	26.2	1.56
	6.0	26.0	0.52
	8.0	24.9	0.16
	10.0	20.5	0.16
	12.0	16.0	0.16
	13.0	15.0	0.16

Location:Station A2
Notes: Secchi depth ~1 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:30	0.5	26.8	9.93
	1.0	26.8	8.88
	2.0	26.8	7.94
	3.0	26.7	5.64
	4.0	26.5	2.40
	5.0	26.1	1.78
	6.0	25.9	1.05
	7.9	24.9	0.16

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:40	0.5	26.9	9.90	
	1.0	26.8	9.22	
	2.0	26.8	7.65	
	3.0	26.6	4.72	
	4.0	26.5	5.76	4.4-5.0
	5.0	26.1	1.21	
	5.6	26.0	1.05	

Location:Station A4
Notes: Secchi depth 0.8 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:00	0.5	26.9	9.63
	1.0	26.9	8.63
	2.0	26.8	7.63
	3.0	26.7	8.48

Location:Station H
Notes: calibration check 8.17 @22.9 C

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:10	0.5	27.0	9.61
	1.0	26.9	8.98
	2.0	26.8	7.66
	3.0	26.8	8.45
	4.0	26.3	2.22
	5.0	26.1	1.69
	6.0	26.0	1.11
	8.0	24.3	0.16
	10.0	21.0	0.11
	12.0	16.2	0.11
	14.0	14.0	0.11

* light rain as we visited the powerhouse
to check for possible location
to install the continuous DO probe

Byllesby D.O. Study

DOWNSTREAM
low wind, light rain during
downstream sampling

distance from PH	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	8:30	25.1	4.35 (+/-.15)
3320	RP	8:45	23.9	5.11 (+/-.01)
2630	GB	13:10	26.0	6.98 (+/-.01)
3320	RP	13:25	25.3	7.19 (+/-.02)
110	RU1	13:50	26.0	5.44
110	RU2		26.0	5.59
110	RD1		26.0	5.49
110	RD2		26.1	5.44
190	DR1	14:05	26.0	5.89
190	DR2		26.1	5.59
190	DR3		26.2	5.59
290	Y1	14:15	26.0	5.84
290	Y2		26.1	5.79
290	Y3		26.1	5.79
530	Z1	14:30	23.9	6.19
530	Z2		25.9	6.09
530	Z3		25.8	6.04
60	X1	14:50	25.6	6.19
60	X2		26.1	6.19
60	X3		26.1	6.24
60	X4		26.0	5.74
1585	H52	15:20	24.9	6.18 (+/-.01)

* air temperature ~23.5 C
air calibration check 8.0 mg/L @ 21 C (low)

July 19, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: July 26, 1988
WEATHER: CLOUDY,COOL,CALM @9:15
NOTES: WIND FROM SOUTH @ 10:20
Weather on previous day nice
Lake calm, algae floating on surface
Pressure at SAFHL 730 mm Hg @ 5:30pm

Location:Station C2
Notes: very calm, algae and bubbles on surface - Secchi 0.6 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:20	0.50	26.0	11.74
	1.00	25.8	10.42
	2.00	25.5	9.28
	3.00	25.3	6.77
	4.00	24.9	3.13
	5.00	24.8	2.18
	6.00	24.1	0.66
	8.00	23.0	0.24
	9.80	22.0	0.24

Location:Station B2
Notes: Secchi depth 0.5 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:40	0.50	26.1	12.36
	1.00	26.0	11.41
	2.00	26.0	8.65
	3.00	25.6	6.18
	4.00	24.9	2.28
	5.00	24.1	0.76
	6.00	23.5	0.29
	8.00	22.9	0.19
	10.00	22.1	0.19
	12.30	16.6	0.19

Location:Station A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:55	0.50	26.0	13.34
	1.00	26.0	12.20
	2.00	26.0	9.15
	3.00	25.2	2.48
	4.00	24.9	1.33
	5.00	24.2	0.48
	6.00	23.9	0.19
	8.00	23.0	0.19
	10.00	21.8	0.19
	11.10	19.5	0.19

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.50	26.0	12.62
	1.00	26.0	10.90
	2.00	25.9	7.84
	3.00	25.1	3.25
	4.00	24.8	1.15
	5.00	24.5	0.57
	6.00	23.9	0.19
	8.00	22.9	0.19
	10.00	22.0	0.19
	12.00	16.0	0.19
	13.50	14.9	0.19

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:20	0.50	26.0	13.49	
	1.00	26.0	12.44	
	2.00	25.7	9.19	8.4-9.9
	3.00	25.0	3.54	3.1-4.0
	4.00	24.8	1.05	
	5.00	24.4	0.48	
	6.00	23.9	0.19	

Location:Station A4
Notes: Secchi depth 0.5 m
calibration check 7.85 @ 22.8 C

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:30	0.50	26.0	14.00	
	1.00	26.0	12.85	
	2.00	25.9	9.40	(+/-.2)
	3.00	25.1	3.69	
	4.00	24.9	0.72	

Location:Station H
Notes: most of the clouds have cleared out

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:50	0.50	26.1	13.39
	1.00	26.0	11.65
	2.00	25.9	10.02
	3.00	25.1	2.41
	4.00	24.8	0.96
	5.00	24.4	0.48
	6.00	23.9	0.14
	8.00	22.8	0.14
	10.00	21.9	0.14
	12.00	15.5	0.19
	13.70	14.8	0.19

Byllesby D. O. Study

DOWNSTREAM

distance from PH	LOCATION	TIME [H.MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	8:30	22.8	4.31 (+/-.02)
3320	RP	8:45	21.4	5.11 (+/-.05)
2630	GB	11:55	25.0	9.23 (+/-.02)
3320	RP	12:10	24.6	8.80 (+/-.05)
110	RD1	12:45	25.2	4.82
110	RD2		25.0	4.62
190	DR1	12:55	24.9	4.82
190	DR2		25.0	4.62
190	DR3		24.9	4.42
290	Y1	13:10	24.9	5.02
290	Y2		25.0	4.92
290	Y3		25.1	4.92
290	Y1'		25.2	6.02
290	Y2'		25.0	4.92
290	Y3'		25.0	4.72
530	Z1'	13:30	26.0	9.04
530	Z2'		25.9	6.33
530	Z3'		25.5	5.42
530	Z4'		25.5	6.02
530	Z1	13:45	23.5	6.12
530	Z2		24.8	6.02
530	Z3		25.5	6.02
60	X1	14:15	24.8	3.82
60	X2		24.8	3.41
60	X3		24.6	3.51
60	X4		24.5	3.77
60	X5		24.4	3.82
1585	H52	14:45	26.0	10.35

* Water level lower than last time
Width cross section narrower (RU)

Reading at Z1' is not an error
probably due to a small stream a little bit upstream

July 26, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 2, 1988

WEATHER: 30.6^C, SW wind, partly cloudy
NOTES: river water surface wavy
lake water very green, rough surface
Pressure at SAFHL 738.9mm Hg @ 4:10p
Unit #1 - 100-105 kW

Location:Station C2
Notes: air calibration 7.3 mg/L @ 30.5 C

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
9:22	0.5	27.0	8.02	
	1.0	27.0	7.31	
	2.0	26.8	6.75	
	3.0	26.8	6.39	
	4.0	26.4	5.18	
	5.0	26.2	3.40	3.04-3.7
	6.0	25.9	1.07	
	8.0	24.9	0.30	
	8.5	24.8	0.25	

Location:Station A1
Notes: waves ~10cm - storm approaching
dark clouds north of A1, C2

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:37	0.5	27.0	7.92
	1.0	27.0	7.87
	2.0	27.0	7.82
	3.0	27.0	7.82
	4.0	27.0	7.71
	5.0	27.0	7.71

Location:Station A2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
9:45	0.5	27.0	8.07
	1.0	27.0	8.02
	2.0	26.9	7.61
	3.0	26.9	7.51
	4.0	26.9	7.51
	5.0	26.9	7.21
	6.0	26.1	3.15
	8.0	24.8	0.30
	10.0	22.8	0.20
	12.0	18.0	0.20
	13.5	15.1	0.20

Byllesby Dam D.O. Study

Location:Station H
Notes: cloud front moves downstream
clearing around B & C

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:00	0.5	26.9	8.02
	1.0	26.9	8.07
	2.0	26.9	8.02
	3.0	26.9	7.82
	4.0	26.9	7.92
	5.0	26.9	7.82
	6.0	26.9	7.71
	7.0	26.0	2.13
	8.0	25.2	0.30
	10.0	22.9	0.20
	12.0	18.2	0.20
	14.0	14.8	0.20

Location:Station A3
Notes: waves diminishing

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:10	0.5	27.0	8.32
	1.0	26.9	8.32
	2.0	26.9	7.97
	3.0	26.9	7.71
	4.0	26.9	7.51
	5.0	26.5	5.28
	5.6	26.3	3.96

Location:Station A4
Notes: wind not so strong
clearing up from the south

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:19	0.5	26.9	8.17
	1.0	26.9	7.92
	2.0	26.9	7.87
	3.0	26.9	7.05
	3.6	26.8	6.39

Location:Station B2
Notes: almost clear

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:35	0.5	26.9	7.10
	1.0	26.9	7.00
	2.0	26.8	6.70
	3.0	26.8	6.70
	4.0	26.8	6.60
	5.0	26.7	6.14

August 2,1988

Byllesby Dam D.O. Study

Location:Station B1
Notes: windy from west

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:43	0.5	26.9	8.12	
	1.0	26.9	7.51	
	2.0	26.7	6.50	
	3.0	26.7	6.09	
	4.0	26.7	5.89	
	5.0	26.6	5.07	
	6.0	26.2	3.60	3.25-3.9
	8.0	24.8	0.20	
	10.0	21.2	0.15	
	12.5	16.0	0.15	

Notes: Secchi depth 0.5 near the shore in the shade, 0.6 m off the structure - wavy surface @ 14:30

August 2,1988

Byllesby Dam D.O. Study

DOWNSTREAM

Distance from PH	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	8:30	26.8	4.70 (+/-.07)
3320	RP	8:45	25.3	4.98 (+/-.02)
2630	GB	12:00	28.3	9.55 (+/-.025)
3320	RP	12:10	27.8	9.39 (+/-.03)
60	X1	12:45	27.5	7.71
60	X2		27.2	7.61
60	X3		27.2	7.51
60	X4		27.2	7.41
110	RD1		27.4	8.53
110	RD2		27.4	8.32
110	DR1	13:17	27.3	8.63
110	DR2		27.5	8.83
110	DR3		27.4	8.63
290	Y1	13:25	27.1	9.14
290	Y2		27.6	9.34
290	Y3		27.8	9.85
530	Z1	13:40	25.9	9.54
530	Z2		26.0	9.74
530	Z3		26.9	10.00
530	Z4		28.0	11.01
530	Z1'		28.2	12.23
530	Z2'		28.0	11.37
530	Z3'		27.9	11.17
530	Z4'		28.0	11.57
60	X1	14:05	27.4	10.96
60	X2		27.4	10.56
60	X3		27.2	10.35
60	X4		27.2	10.15
1585	H52	14:45		11.65 (+/-.03)

* air temp @ 12:10 29.5 C in the shade

Water downstream of the powerhouse is also very green - may be from algae suspended in the water

Water level downstream lower than on previous days a few cm

At 2:45 pm water surface still wavy
strong wind blowing in the downstream direction

August 2,1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 12, 1988

WEATHER: Sunny with scattered clouds
NOTES: No rain this morning at Byllesby only partly overcast

8:45 water surface calm - reservoir water seems "clear" with algae floating in "polka dots"

Some calibration problems encountered

Location:Station C2
Notes: Cloudy - light SE wind

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:05	0.5	26.0	8.15
	1.0	26.0	8.06
	2.0	26.0	7.97
	3.0	26.0	7.93
	4.0	26.0	7.79

Location:Station B2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
10:20	0.5	26.1	7.97
	1.0	26.1	7.70
	2.0	26.1	7.43
	3.0	26.0	7.25
	4.0	26.0	7.52
	5.0	26.0	7.52
	6.0	25.9	3.08
	8.0	25.3	0.18
	10.0	24.5	0.09
	12.0	17.3	0.32
	12.5	16.1	0.32

Location:Station A1
Notes: Secchi depth 0.87 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	
10:40	0.5	26.0	7.20	
	1.0	26.1	7.16	
	2.0	26.1	6.98	
	3.0	26.1	6.70	
	4.0	26.0	4.58	3.8-5.35
	5.0	25.7	1.09	
	6.0	25.5	0.27	
	8.0	25.1	0.09	
	10.0	23.9	0.09	
	12.0	18.6	0.09	
	14.0	16.0	0.18	

Location:Station A2
Notes: Secchi depth 0.72

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:05	0.5	26.2	7.88
	1.0	26.1	7.47
	2.0	26.1	7.16
	3.0	26.1	6.98
	4.0	26.0	2.36
	5.0	25.6	0.82
	6.0	25.4	0.45
	8.0	25.2	0.14
	10.0	23.9	0.11
	12.0	18.2	0.18
	13.5	15.4	0.23

Location:Station A3
Notes: Cloudy - light SE wind

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:15	0.5	26.1	8.02
	1.0	26.1	7.52
	2.0	26.1	6.80
	3.0	26.0	5.80
	4.0	25.8	2.27
	5.0	25.7	1.09
	6.0	25.5	0.82
	6.2	25.4	0.54

Location:Station A4
Notes: Secchi 0.8 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:25	0.5	26.4	8.24
	1.0	26.2	7.52
	2.0	26.1	6.07
	3.0	25.9	3.04
	3.5	25.8	2.04

Location:Station H
Notes: Secchi 0.87 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:35	0.5	26.2	9.24
	1.0	26.2	8.52
	2.0	26.0	3.81
	3.0	25.9	3.08
	4.0	25.7	1.72
	5.0	25.6	0.91
	6.0	25.4	0.50
	8.0	25.1	0.09
	10.0	24.4	0.05
	12.0	18.6	0.09
	14.0	15.1	0.18

* Around noon small waves developed and a long solitary wave ~15cm between A & B propagated north to south

Byllesby D.O. Study

DOWNSTREAM

Distance from PH	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	8:45	23.9	4.56
3320	RP	9:00	23.9	5.23
2630	GB	12:40	26.5	8.86
3320	RP	12:55	26.9	9.24
60	X1	13:18	27.0	5.75
60	X2		26.8	5.53
60	X3		26.7	5.44
110	RD1	13:35	26.8	5.75
110	RD2		26.7	5.84
190	DR1	13:40	26.7	5.98
190	DR2		26.8	6.07
190	DR3		26.7	5.89
290	Y1	13:50	26.7	6.36
290	Y2		26.8	6.34
290	Y3		26.9	6.25
530	Z1	14:00	25.0	6.80
530	Z2		25.1	6.89
530	Z3		26.1	6.89
530	Z4		27.0	7.16
60	X1	14:20	26.9	6.30
60	X2		26.8	5.89
60	X3		26.8	5.98
1585	H52	14:55	28.8	8.91

Pressure at SAFHL 737.4 mm Hg @ 5:35 pm

August 12, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 17, 1988
WEATHER: Sunny day, light variable winds
NOTES: Calm water surface
Pressure at SAFHL 737.4 mm Hg

Distance from PH	STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	WINKLER #1	WINKLER #2
1585	H52	11:05	0.50	27.7	8.45	8.43	8.47
3320	RP	11:15	0.25	26.9	8.65	8.57	8.72
0	PH	15:45	0.50		6.06	6.01	6.11
0	PH	15:50	0.50		6.00	6.00	6.00
2630	GB	16:20	0.50	30.3	9.30	9.30	9.30
3320	RP	16:27	0.25	30.2	9.73	9.70	9.75
1585	H52	16:37	0.50	29.6	8.05	8.05	*

* precipitate and some brown floats (possibly algae).
Titration overrun. 203.3 ml give 8.45mg/l
35 ml give 7.76 mg/l. Average 8.11 mg/l.
Use only bottle #1

PH = powerhouse

Byllesby D.O. Study

A continuous monitoring D.O. probe (DATASONDE) was installed a little bit upstream of the diffuser of unit 2. Operation was also switched from unit 1 to unit 2 around 14:30.

Air-calibration of YSI Probe 27.8^C, set at 7.6 mg/l

Note: Profile #1 was taken to the left of the pump

STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
P #1	15:10	0.1	27.8	6.09
		0.5	27.8	5.98
		1.0	27.8	5.88
		1.5	27.8	5.98
	Bottom	1.6	27.8	5.98
Pail			27.8	5.98

Note: Thermometer in the pail reads also 27.8

Note: Profile #2 was taken to the right of the pump

STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
P #2	15:20	0.1	27.8	6.09
		0.5	27.8	5.95
		1.0	27.8	5.93
	Bottom	1.5	27.8	5.88

Calibration	Winkler#1	5.92	
	Winkler#2	5.94	
	AVE	5.93	
			CF=1.088
	YSI Probe	5.45	

The above correction factor has already been incorporated in the D.O. values given herein

Note: Profile #3 was taken ~4m upstream of the pump

STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
P #3	15:50	0.1	27.7	5.88
		0.5	27.7	5.77
	Bottom	1.0	27.7	5.77

August 17, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 23, 1988
WEATHER: Some fog,clear skies,west wind
6:00am-60^F, 8:00am-63^F, 3:25pm-78^F
NOTES: Strong winds around noon did not allow boat survey
Pressure 736.6 mm Hg @ 7pm (SAFHL)

STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	WINKLER #1	WINKLER #2	River Meter (m) (from PH)
H52	7:55	0.50	22.1	4.01	3.96	4.05	1585
RP	8:00	0.25	20.6	5.29	5.30	5.27	3320
X1	11:30		24.2	4.36			60
X2			24.2	4.01			60
X3			24.2	3.88			60
X4			24.2	3.81			60
X			24.2	4.11	4.11	4.11	
RD1	11:43		24.2	4.47			110
RD2			24.2	4.34			110
DR1	11:50		24.1	4.42			190
DR2			24.4	4.42			190
DR3			24.3	4.32			190
Y0	12:00		19.8	6.55			290
Y1			24.0	4.63			290
Y2			24.1	4.73			290
Y3			24.4	4.73			290
X1	12:18		24.1	5.11			60
X2			24.3	4.45			60
X3			24.3	4.40			60
X4			24.4	4.35			60
X5			24.5	4.35			60
X			24.7	4.65	4.63	4.67	
RP	12:45	0.25	24.2	8.22	8.22	8.21	3320
GB	15:11	0.50	25.3	8.37	8.36	8.37	2630
RP	15:23	0.25	25.2	8.46	8.42	8.50	3320
H52	15:24	0.50	25.1	7.23	7.20	7.25	1585

* Strong wind causes waves to splash over spillway
Bar near powerhouse was dregded out

Byllesby D.O. Study

Measurements in Unit 2

STATION	TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]	WINKLER #1	WINKLER #2
P #1	8:55	0.5	23.8	2.74	2.72	2.75
Air calibration of YSI Probe 23.9^C-set to 8.4 mg/l						
Pail	10:30		24.2	2.77 Stirrer off		
			24.2	2.84 Stirrer on		
			24.2	2.87 Stirrer off		
P #1	10:35	0.5	24.2	2.85	2.92	2.77
Pail	14:12		24.4	4.61 Stirrer on		
P #1	14:16	0.1	24.6	4.61		
		0.5	24.5	4.40		
		1.0	24.5	4.42		
		1.3	24.5	4.35		
Calib.		0.5	24.5	4.32	4.37	4.27
Pail	14:37			4.22	4.21	4.22

SURVEY FROM THE STRUCTURE

Pier1 - right pier of intake 1
Pier4 - fourth pier from right, next to third bay which is closed

STATION	TIME [H.MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
PIER1	13:40	0.5	24.8	4.90
		1.0	24.8	4.69
		2.0	24.8	4.59
		3.0	24.8	4.69
		4.0	24.8	4.59
		5.0	24.5	4.49
		6.0	24.5	4.49
		6.5	24.5	4.49
PIER4	13:52	0.5	24.2	4.59
		1.0	24.2	4.49
		2.0	24.3	4.36
		3.0	24.3	4.34
		4.0	24.3	4.21
		5.0	24.3	4.10
		6.0	24.4	4.29
		6.8	24.5	4.29

August 23, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: August 31, 1988
WEATHER: Clear skies, sunny, cool

NOTES: At H52 8:30am water surface lightly rippled

Probe air calibration 8.7 mg/L @ 20.6 C

STATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]	WINKLER #1	WINKLER #2	River Meter (m)
H52	8:29	18.5	6.20	6.18	6.21	1585
GB	8:45	17.8	7.43	7.42	7.44	2630
RP	8:53	17.6	7.32	7.31	7.32	3320
X1	9:22	20.2	7.88			60
X2		20.2	7.70			60
X3		20.2	7.70			60
X4		20.2	7.50			60
X5		20.2	7.39			60
X	9:35	20.2	7.86	7.85	7.86	
RD2	9:43	20.2	7.99			110
RD3		20.2	7.89			110
DR1	9:51	19.9	7.82			190
DR2		20.2	7.97			190
DR3		20.2	7.97			190
DR4		20.2	7.87			
Y1	10:03	18.8	8.25			290
Y2		20.0	8.10			290
Y3		20.2	7.97			290
Y4		20.5	8.25			290
Z1	10:16	18.0	8.50			530
Z2		20.2	8.64			530
Z3		20.8	8.94			530
X1	10:42	20.8	8.16			60
X2		20.8	7.96			60
X3		20.7	7.86			60
X4		20.8	7.56			60
						60
X	10:48	20.8	7.96	7.97	7.97	
GB	15:58	24.4	11.72	11.72	11.73	2630
RP	16:13	23.8	11.73	11.70	11.76	3320
H52	16:26	24.3	13.22	13.20	13.23	1585
PH(P#1)	14:15	21.10	6.58	6.61	6.55	0

August 31, 1988

Location:Station C2
Notes: Secchi depth 0.55 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:41	0.5	20.9	10.28
	1.0	20.9	10.13
	2.0	20.1	7.56
	3.0	20.1	7.26
	4.0	20.1	7.06
	5.0	20.1	7.03
	6.0	20.1	7.11
	6.6	20.1	6.65

Location:Station B1
Notes: Secchi depth 0.55 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
11:56	0.5	20.6	7.76
	1.0	20.3	7.46
	2.0	20.2	6.96
	3.0	20.1	6.50
	4.0	20.1	6.45
	5.0	20.1	6.30
	6.0	20.1	6.15
	8.0	20.1	5.44
	10.0	20.0	4.33
	12.0	19.9	3.33
	12.3	19.9	2.87

Location:Station A1

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:13	0.5	20.9	8.78
	1.0	20.9	8.37
	2.0	20.9	8.27
	3.0	20.9	7.76
	4.0	20.7	7.56
	5.0	20.2	6.15
	6.0	20.2	5.87
	8.0	20.1	5.56
	10.0	20.1	5.07
	11.9	20.0	4.54

Location:Station A2
Notes: Secchi depth 0.65 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:23	0.5	20.9	8.12
	1.0	20.9	8.12
	2.0	20.9	8.02
	3.0	20.8	7.81
	4.0	20.8	7.40
	5.0	20.4	6.84
	6.0	20.2	6.22
	8.0	20.1	5.86
	10.0	20.1	5.55
	12.0	20.0	4.63
	13.5	19.9	1.03

Byllesby D.O. Study

Location:Station A3
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:35	0.5	20.9	7.97
	1.0	20.9	7.87
	2.0	20.8	7.76
	3.0	20.8	7.81
	4.0	20.5	7.24
	5.0	20.2	6.62
	6.0	20.2	6.62
bottom	7.0	20.1	5.28

Location:Station A4
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:40	0.5	20.9	7.79
	1.0	20.9	7.68
	2.0	20.8	7.47
	3.0	20.7	7.42
	4.0	20.3	6.85
	5.0	20.2	6.38
	5.3	20.2	5.61

Location:Station H
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:55	0.5	21.1	9.16
	1.0	21.0	8.85
	2.0	20.9	8.21
	3.0	20.9	8.21
	4.0	20.9	8.00
	5.0	20.7	7.69
	6.0	20.2	5.69
	8.0	20.0	5.48
	10.0	20.0	5.27
	12.0	20.0	2.74
	13.8	20.0	1.58

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
14:15		21.1	6.58 +/- 0.03
14:30			6.41 +/- 0.05

no data could be recovered from the continuous monitor battery failure probably (Date set to not existing value 080088)

August 31, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

Datasonde calibration at 12:30
Pressure 733.6 mm Hg

** Setup Datasonde D.O. probe for sampling
through Sep 14, 88 18:00:00
at half hour intervals

DATE: September 8, 1988
WEATHER: Hazy, "smoky", strange sky
NOTES: River calm - algae on the surface
water seems almost stagnant
water level lower than other days

Pressure @ 20:30 @ SAFHL 736.4 mm Hg

Location:Unit 2
Notes: Air calibration 18.5 C - 9 mg/L

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
17:40	0.5	19.9	9.76
	1.0	19.9	9.74
	1.6	19.9	9.71

Location:Pier 3 (from structure)
Notes: small waves, light wind
sky cleared

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
17:57	0.5	19.9	12.15
	1.0	19.9	11.94
	2.0	19.9	11.07
	3.0	19.8	11.07
	4.0	19.8	11.02
	5.0	19.8	10.92
	6.0	19.8	10.56
	6.9	19.7	10.45

Location:Unit 2
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
18:03	0.5	19.7	9.76
	1.0	19.7	9.74
	1.5	19.7	9.76

Byllesby D.O. Study

DOWNSTREAM

Distance from powerhouse (m)	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
1585	H52	16:20	21.0	13.68
3320	RP	16:30	19.8	12.64
0	Pail	17:30		9.69

Winkler samples

	LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]
	Unit 2 Pail	17:30		9.69
*	Unit 2 Calibr.	17:45		9.78
	Unit 2 Pail	18:03		9.82
	Station F	18:30	18.1	17.59

September 8, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: September 13, 1988

WEATHER: Overnight low 42 F
Air temp 50 F
Water calm - "floating stuff"
Pressure @ 7:10 am @ SAFHL 741 mm Hg
Weather on previous day overcast-cool

Location: C2
Notes: rock(?) around 4.5 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:45	0.5	18.8	9.66
	1.0	18.7	9.36
	2.0	18.3	8.86
	3.0	18.2	8.57
	4.0	18.2	8.17
	4.5	18.1	7.77
	6.0	18.0	7.77
	8.0	18.0	7.67
	10.6	17.9	7.47

Location: B1/2
Notes: Secchi depth 0.55 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
12:58	0.5	18.6	8.86
	1.0	18.2	8.44
	2.0	18.2	7.57
	3.0	18.2	6.97
	4.0	18.2	6.52
	5.0	18.1	5.78
	6.0	18.1	6.57
	8.0	18.1	6.18
	10.0	18.0	7.67
	12.5	18.0	7.07

Location: A1
Notes:

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
	0.5	18.8	8.86
	1.0	18.8	8.76
	2.0	18.5	8.67
	3.0	18.2	8.64
	4.0	18.2	8.42
	5.0	18.2	8.29
	6.0	18.2	7.99
	8.0	18.1	7.87
	10.0	18.1	7.67
	12.1	18.1	7.27

Location: A2
Notes: Secchi depth 0.55 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:27	0.5	18.8	8.98
	1.0	18.8	9.01
	2.0	18.8	8.96
	3.0	18.5	8.27
	4.0	18.3	7.97
	5.0	18.2	7.97
	6.0	18.2	7.97
	8.0	18.2	8.09
	10.0	18.2	7.67
	12.0	18.1	7.37
	13.5	18.0	7.37

Location: H
Notes: Secchi depth 0.65 m

TIME [H:MIN]	DEPTH [M]	TEMP [^C]	D.O. [mg/L]
13:40	0.5	18.9	9.21
	1.0	18.9	9.18
	2.0	18.9	9.16
	3.0	18.9	9.06
	4.0	18.9	8.76
	5.0	18.8	8.86
	6.0	18.8	8.76
	8.0	18.3	8.57
	10.0	18.2	7.87
	12.0	18.1	7.77
	13.6	18.1	7.32

Winkler samples - Calibrations

LOCATION	TIME [H:MIN]	TEMP [^C]	D.O. [mg/L]	DO meter [mg/L]
X	10:28		8.42	8.50
X	12:00		8.55	8.67
H	13:47		9.55	9.45

CF = 0.996

Byllesby D.O. Study

DOWNSTREAM

Distance from powerhouse (m)	TIME [H:MIN]	Location	TEMP [^C]	D.O. [mg/L]
60	10:23	X1	18.1	8.69
60		X2	18.2	8.32
60		X3	18.2	8.42
60		X4	18.4	8.47
60		X	18.1	8.47
110	10:38	RD1	18.2	8.54
110		RD2	18.2	8.54
110		RD3	18.2	8.52
190	10:53	DR1	17.9	8.47
190		DR2	18.1	8.47
190		DR3	18.2	8.57
190		DR4	18.3	8.49
290	11:00	Y1	17.0	8.57
290		Y2	17.9	8.47
290		Y3	18.1	8.67
290		Y4	18.3	8.76
290		Y5	18.5	8.72
290		Y6	18.8	8.76
290		Y7	18.7	8.81
290		Y8	18.8	8.86
290		Y9	18.9	9.41
290		Y10	18.9	10.16
530	11:28	Z1'	18.8	11.60
530		Z2'	18.9	10.06
530		Z3'	18.9	9.66
530		Z4	18.9	9.66
530		Z3	18.0	9.26
530		surface	18.5	9.41
530		bottom	18.2	9.31
530		Z2	17.0	9.06
60	11:55	X1	18.3	8.57
60		X2	18.4	8.55
60		X3	18.4	8.47
60		X	18.5	8.64
3320	12:20	RP	17.8	12.00
2630	15:50	GB	20.2	10.31
3320	15:55	RP	20.2	11.29
1585	16:05	H52	20.2	10.49
0	14:30	Pail		8.40

* Air temperature 24.5 C @ 16:05

September 13, 1988

ST. ANTHONY FALLS HYDRAULIC LABORATORY

BYLLESBY DAM AND RESERVOIR D.O.STUDY
FOR NORTH AMERICAN HYDRO

DATE: September 20, 1988
WEATHER: Cloudy, cold, air temp 49 F
water calm

September 19, 88 rainy day

Notes: Terminate Datasonde deployment
Turnover has occured
no more useful data can be taken

Only winkler samples taken

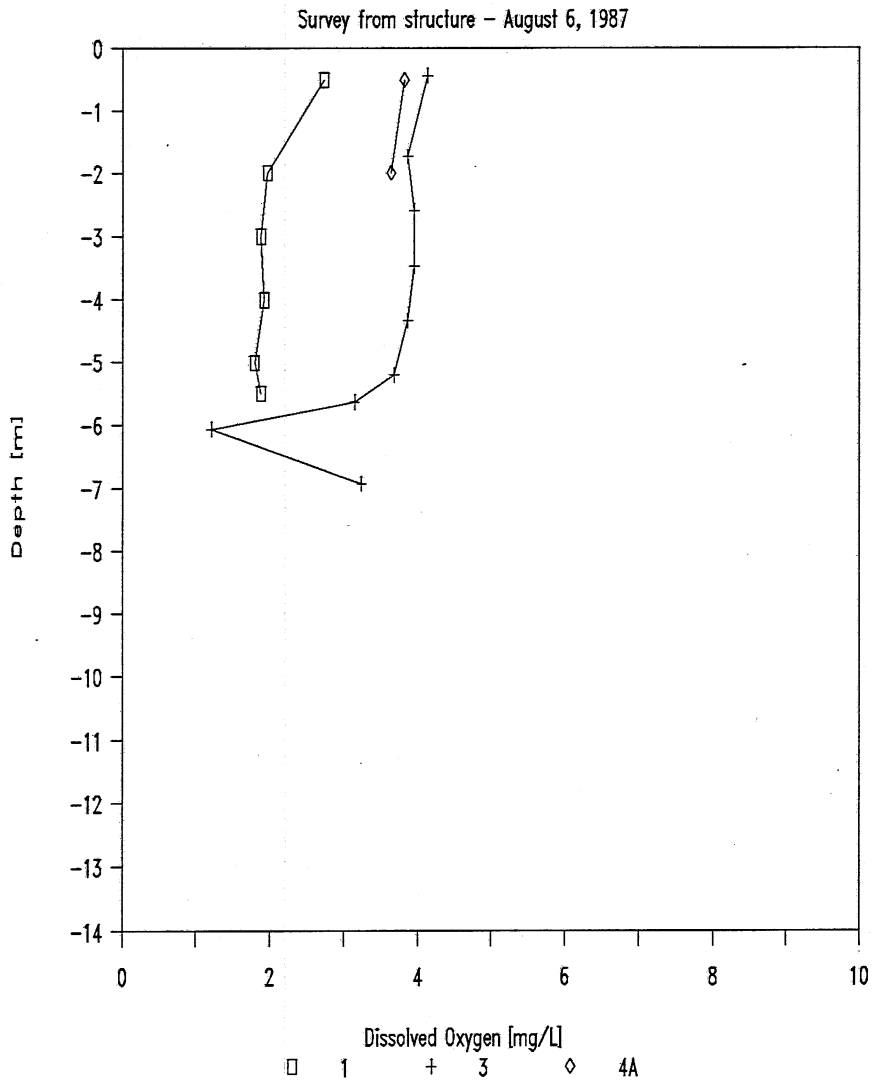
DOWNSTREAM

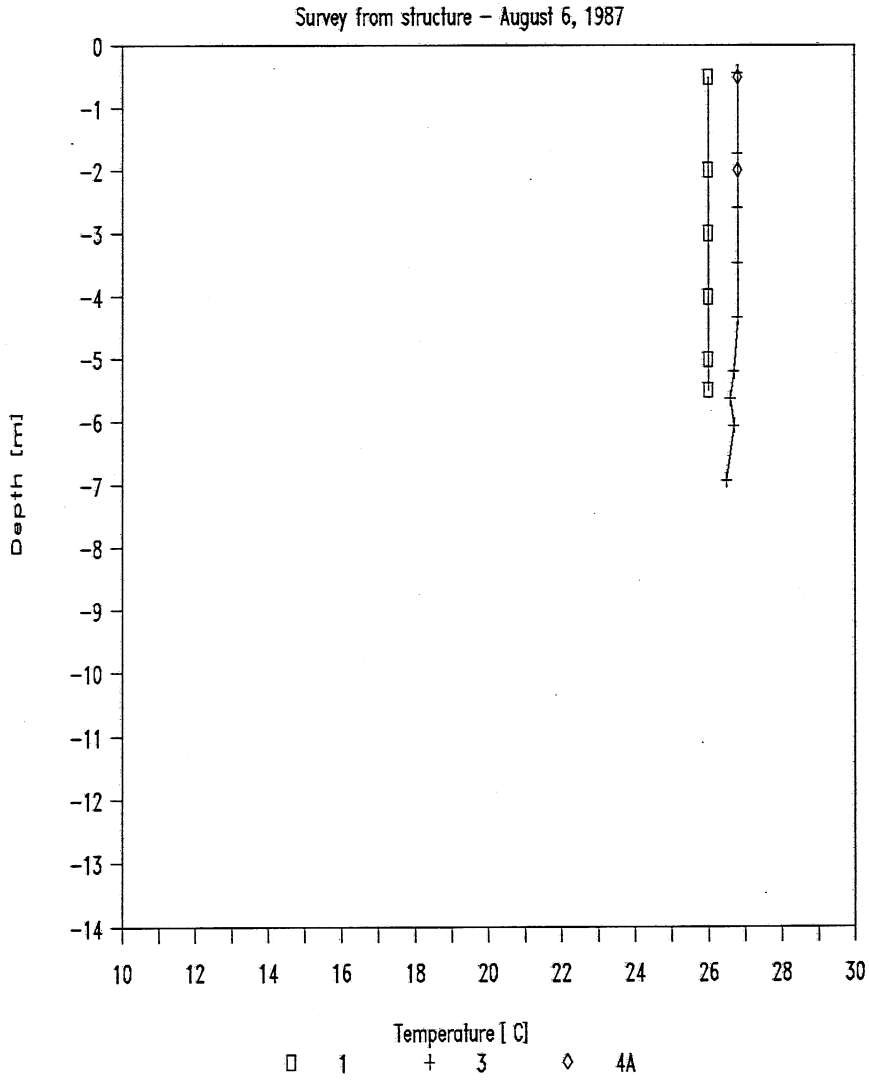
Distance from powerhouse (m)	TIME [H:MIN]	Location	TEMP [^C]	D.O. [mg/L]
1585	9:20	H52	17.0	6.67
3320	10:15	RP	16.7	6.85
0	10:30	Unit2 Pail		6.19

DISSOLVED OXYGEN AND TEMPERATURE PROFILES

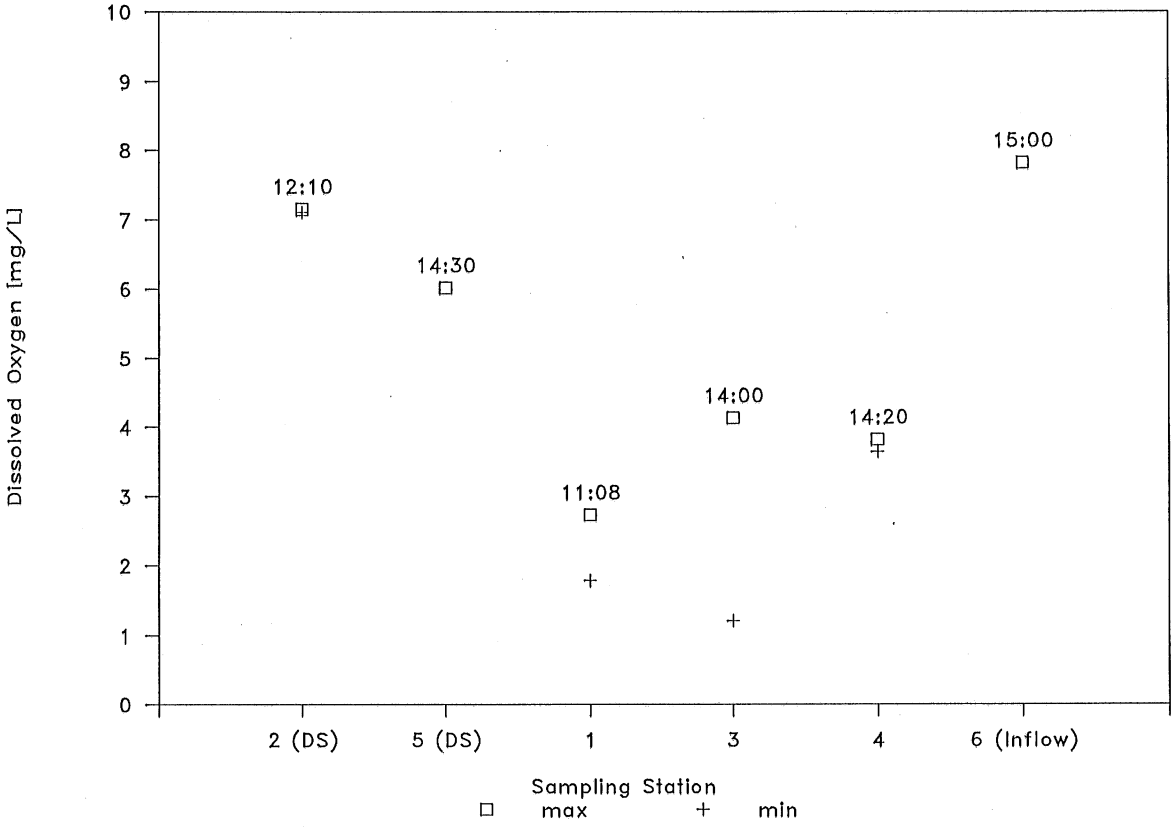
IN THE RESERVOIR – SUMMER 1987

Byllesby Lake – Summer 1987

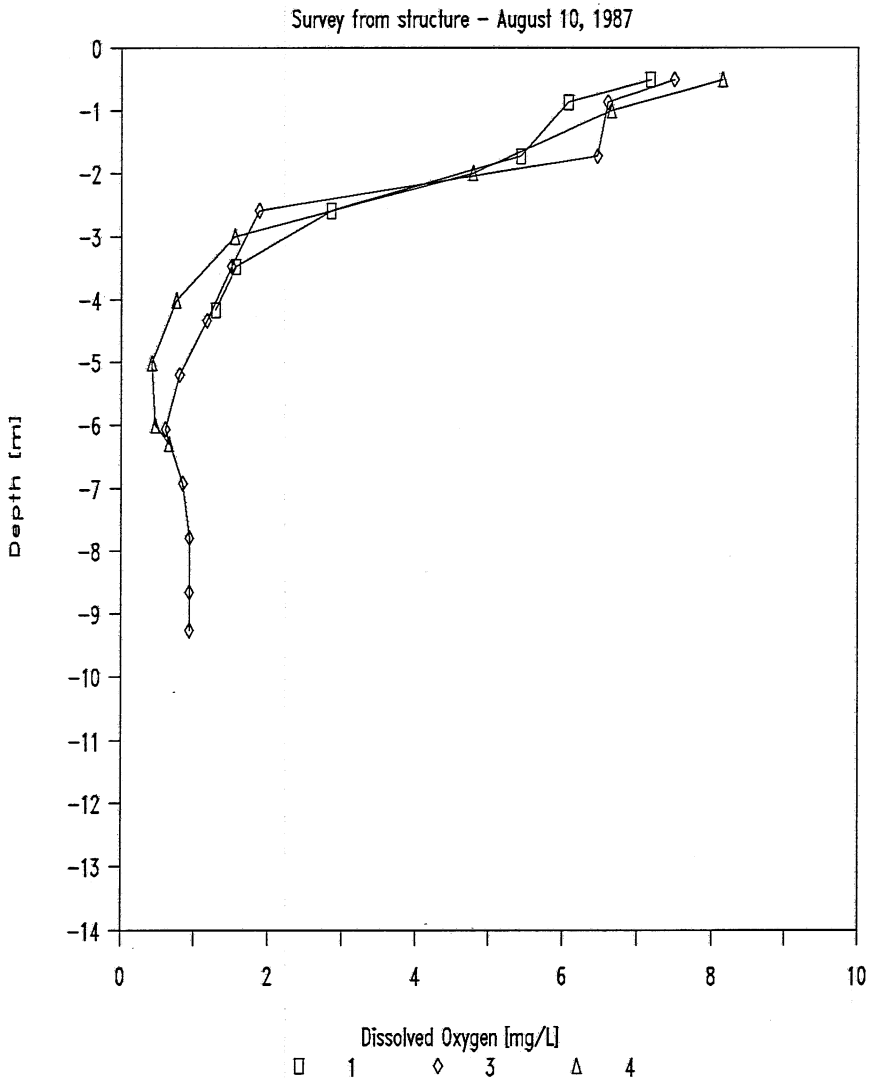


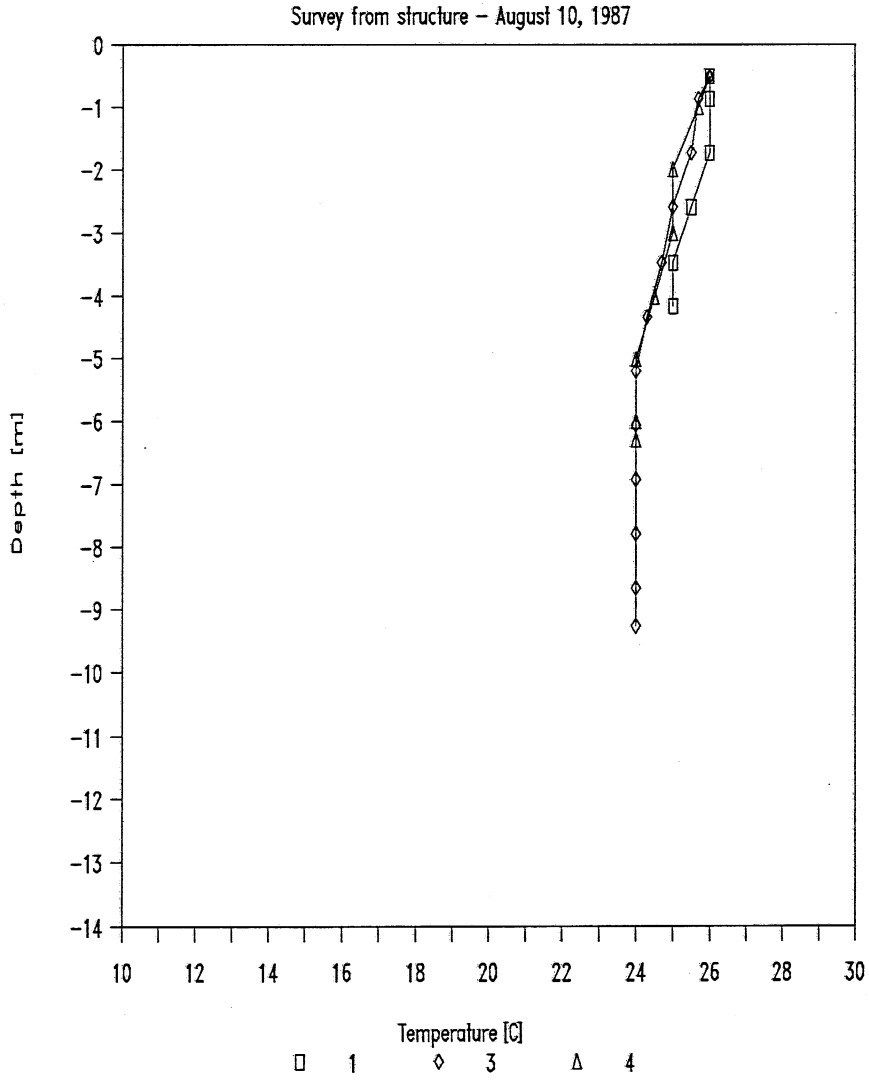


Byllesby Lake – August 6, 1987

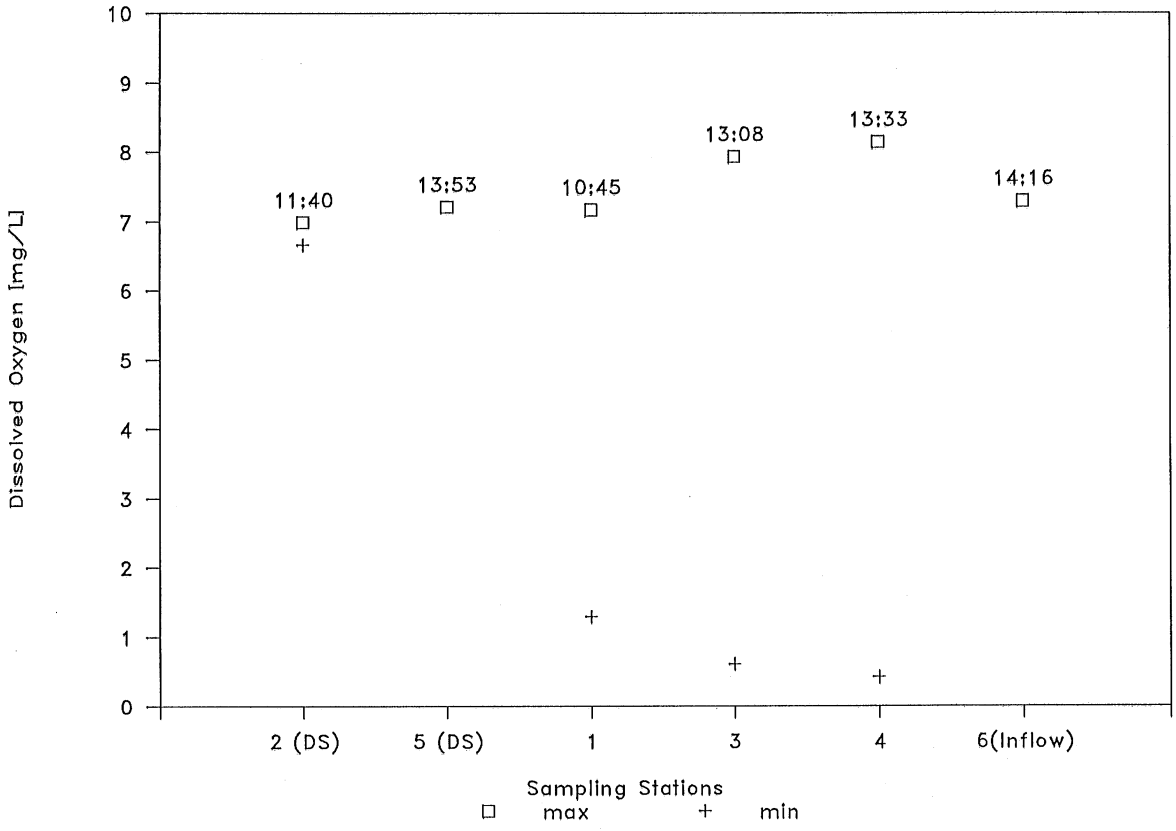


Byllesby Lake – Summer 1987

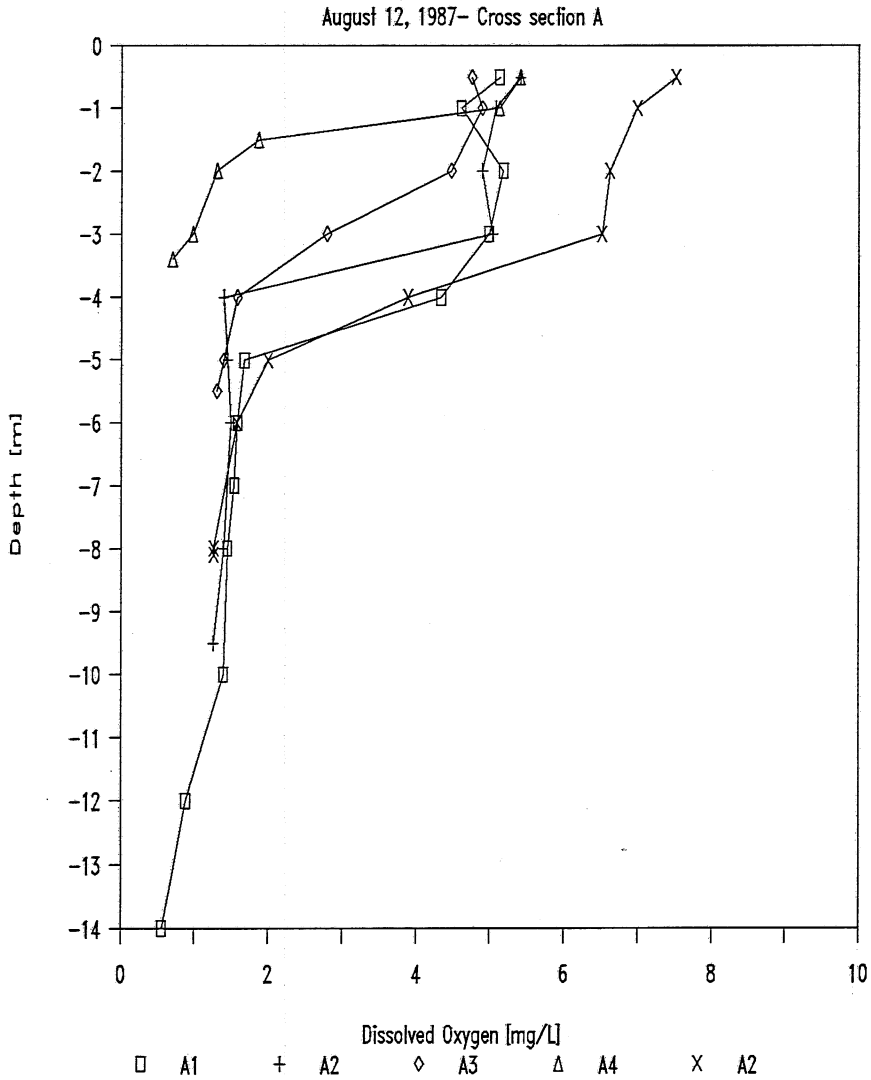


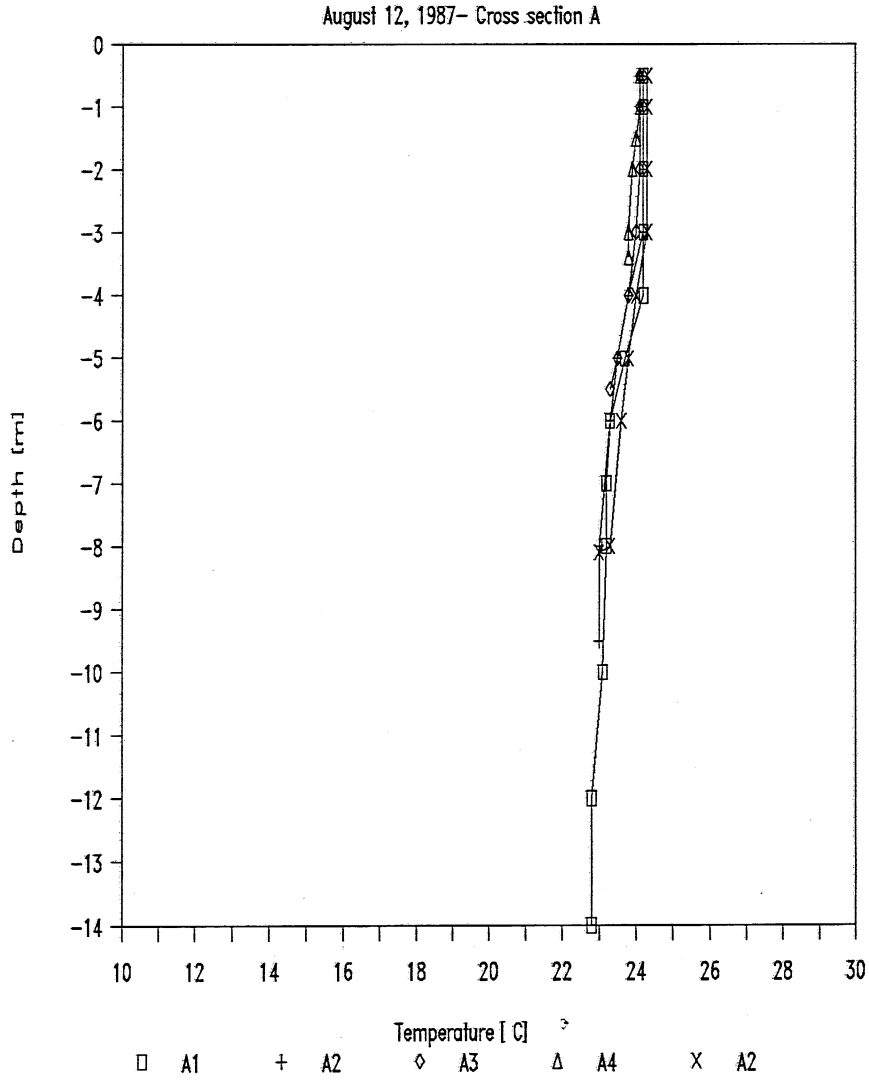


Byllesby Lake – August 10, 1987

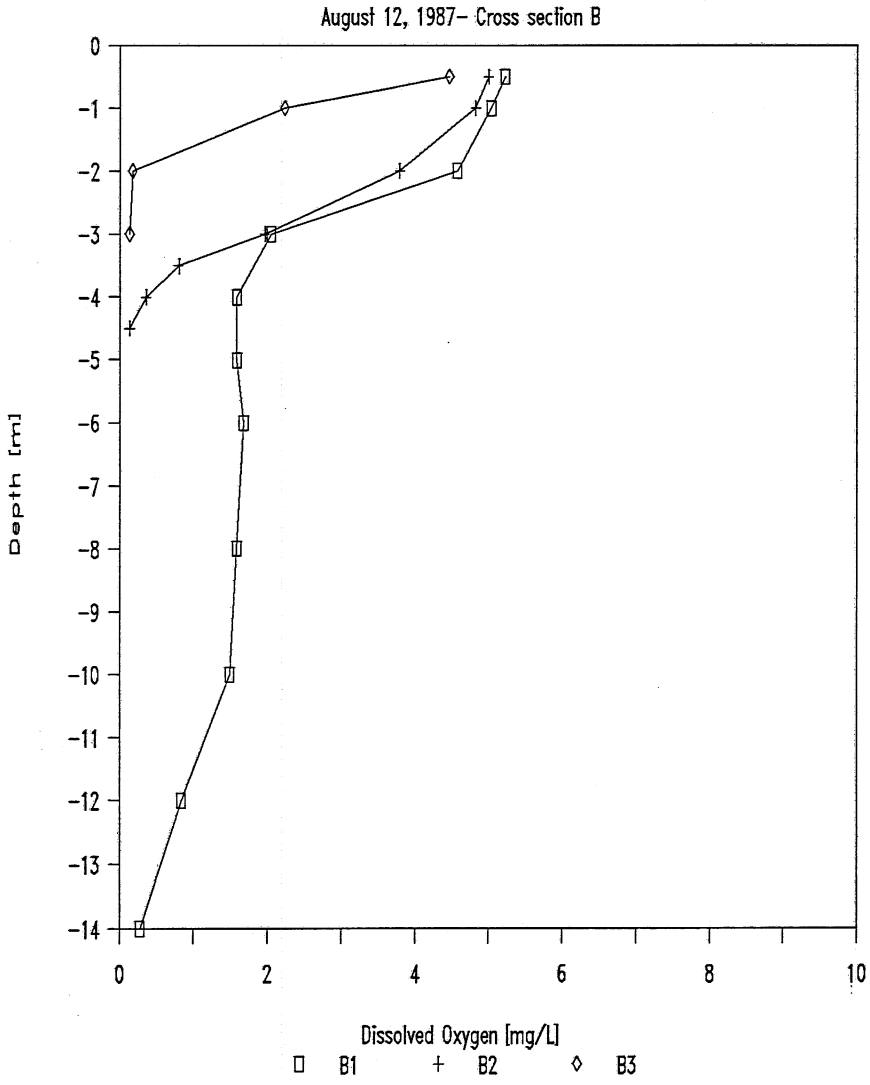


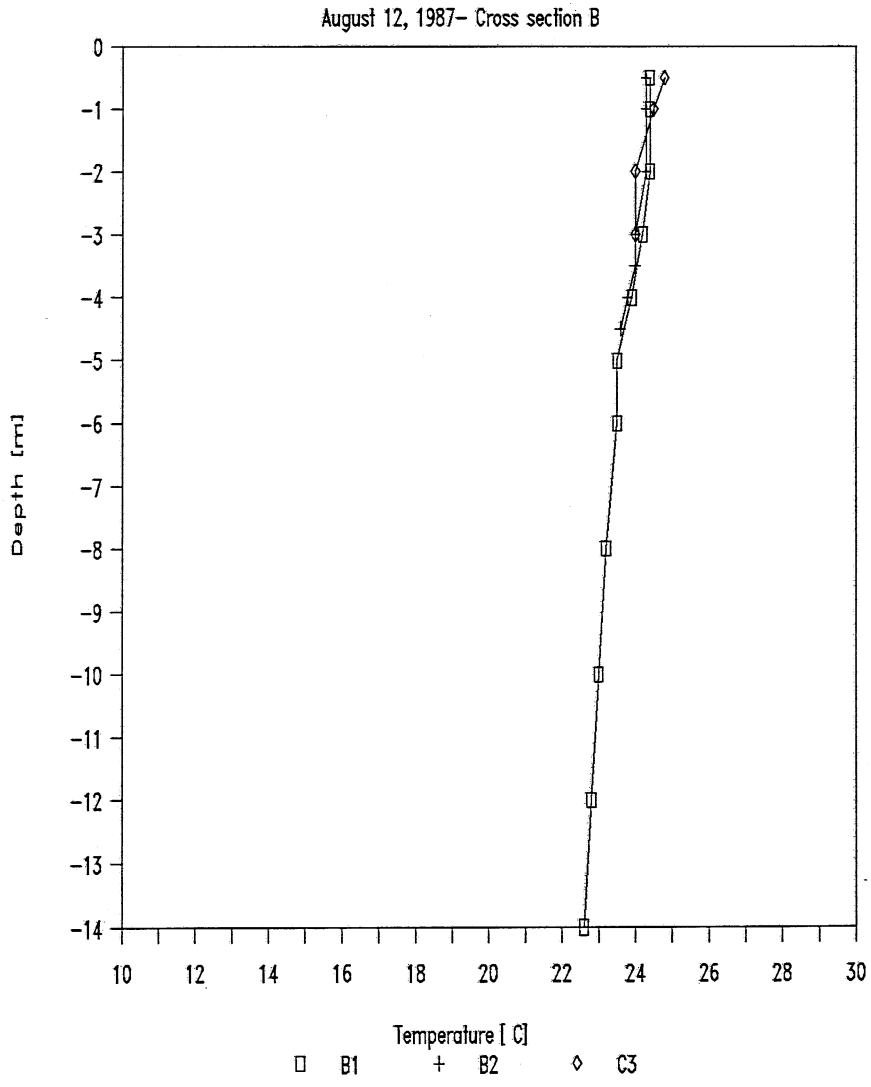
Byllesby Lake - Summer 1987



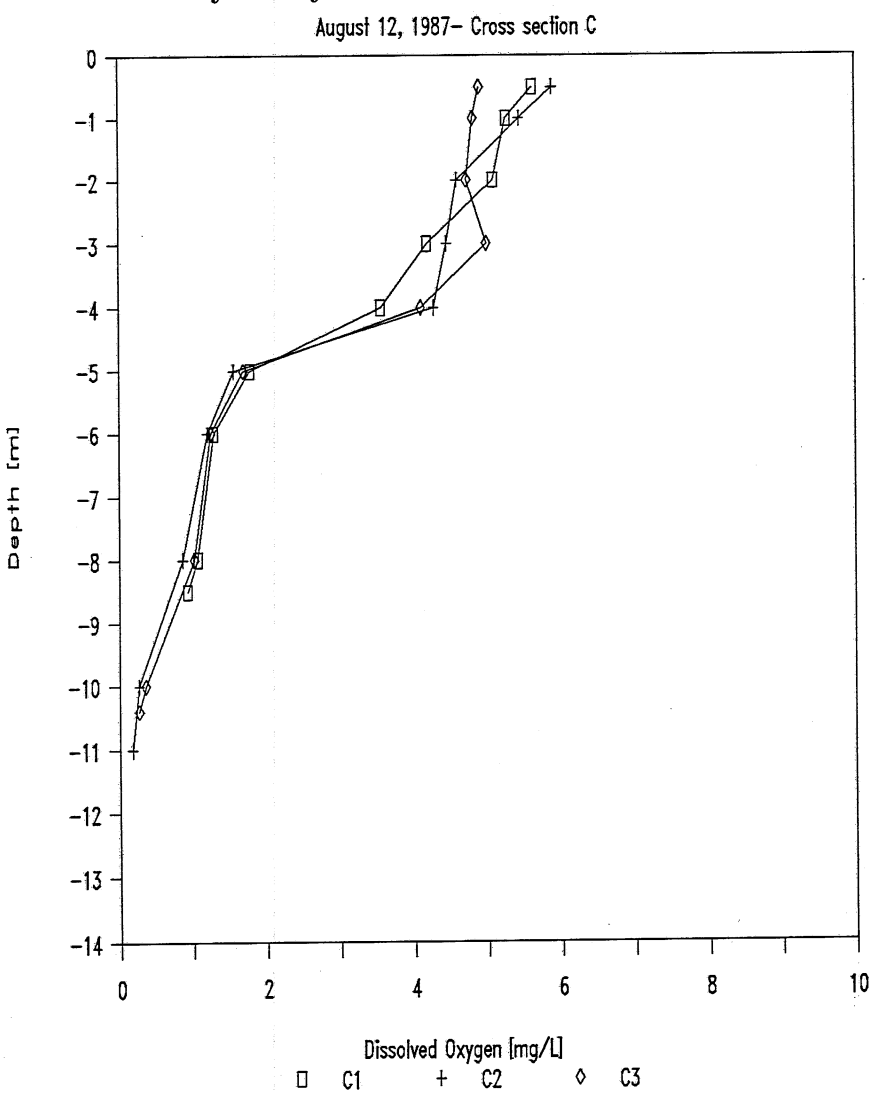


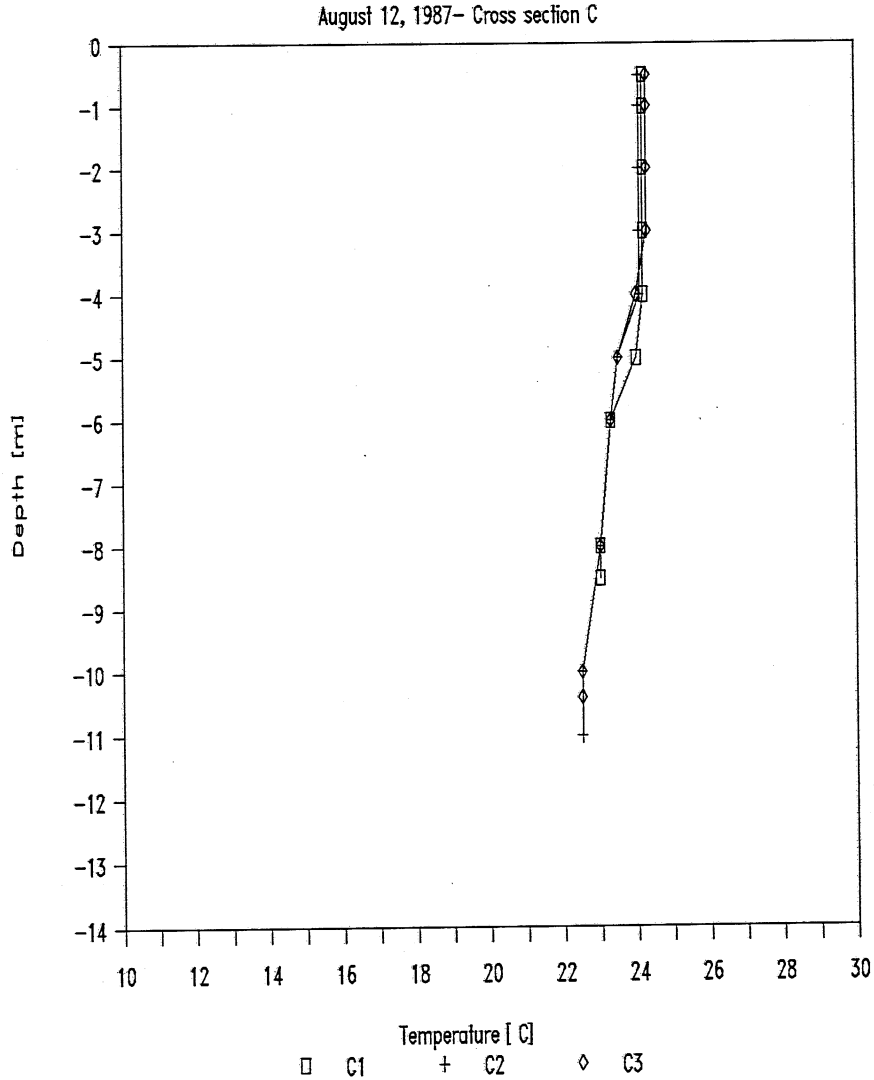
Byllesby Lake - Summer 1987



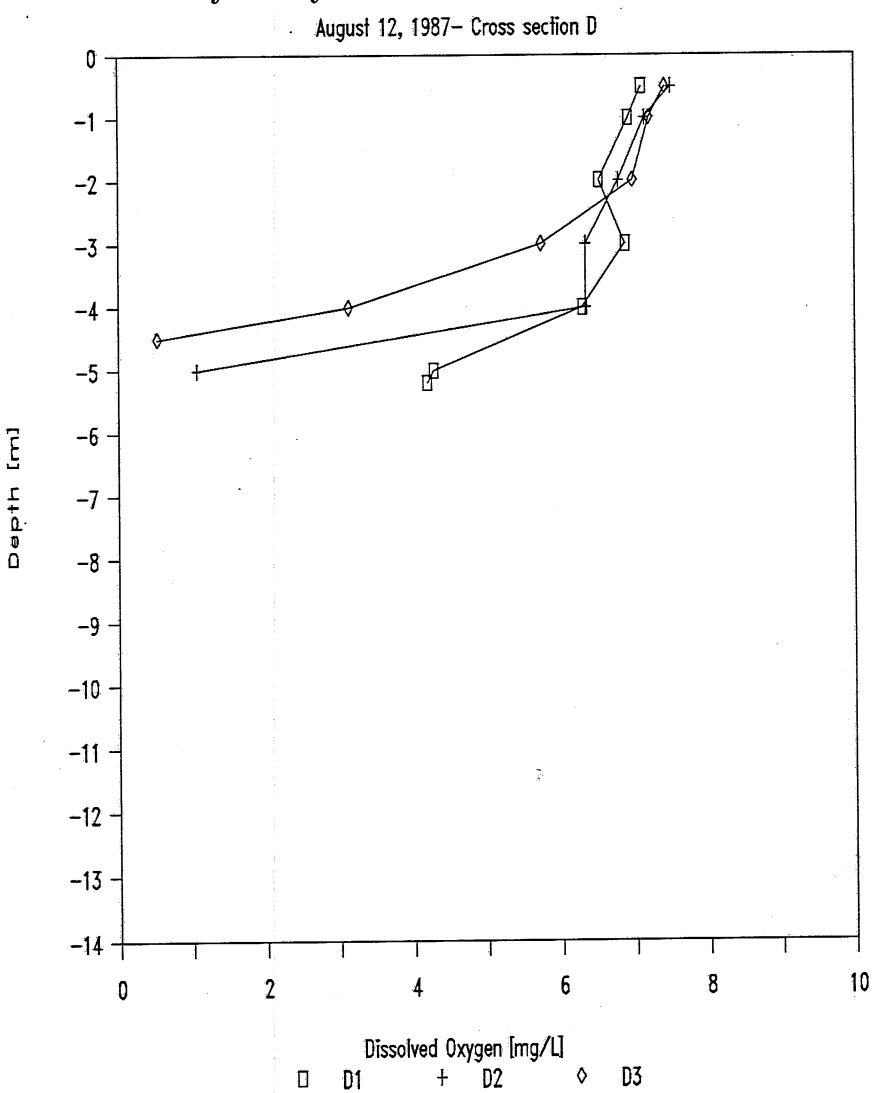


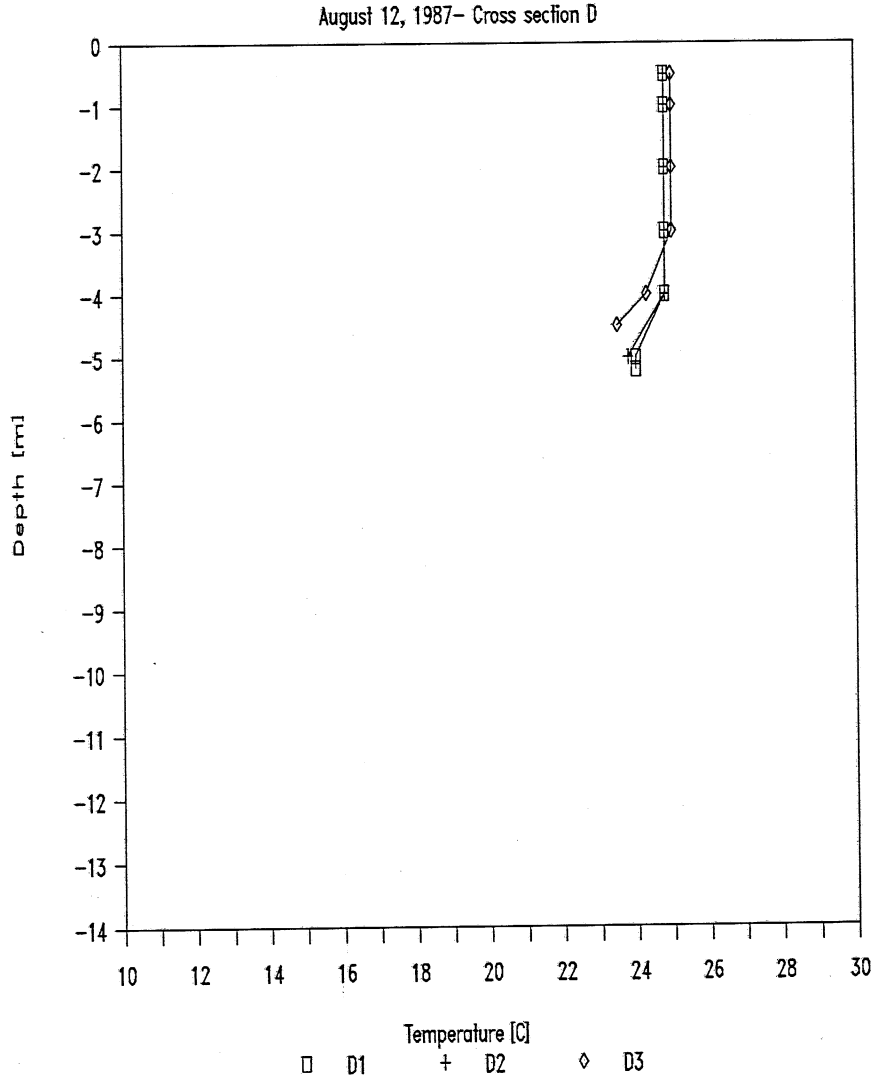
Byllesby Lake – Summer 1987



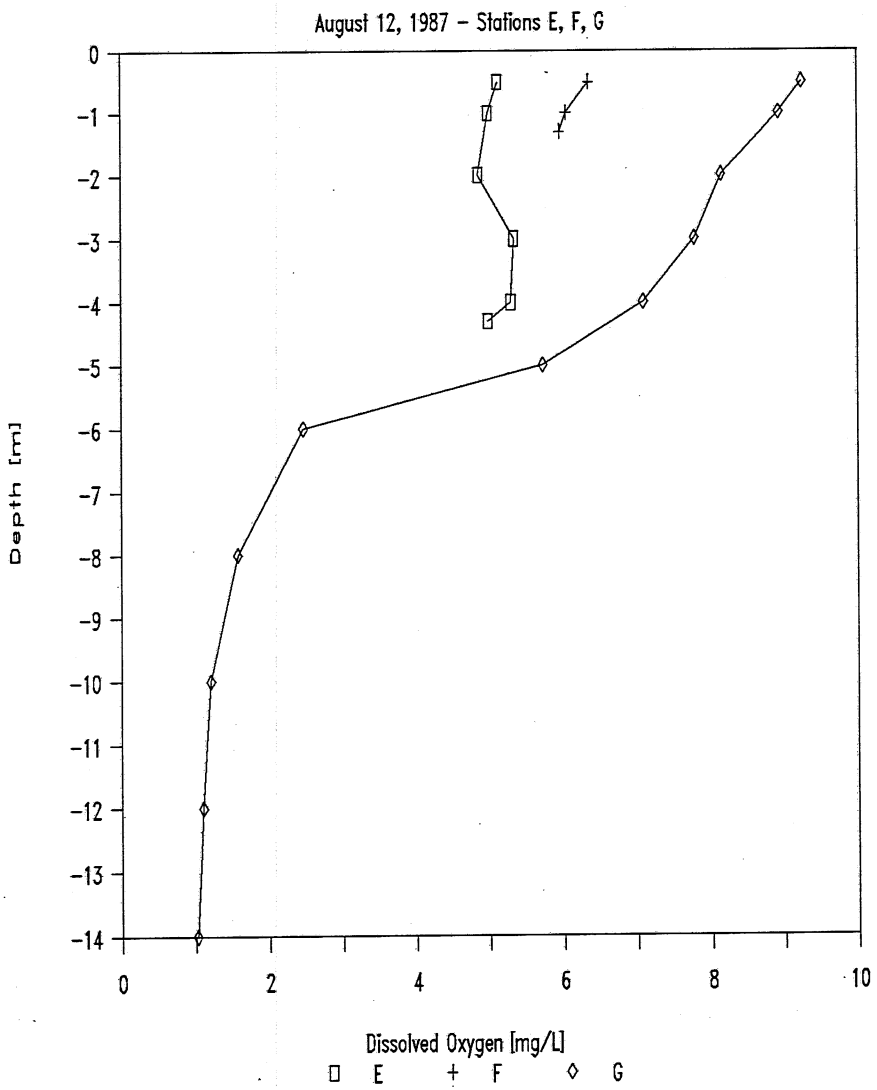


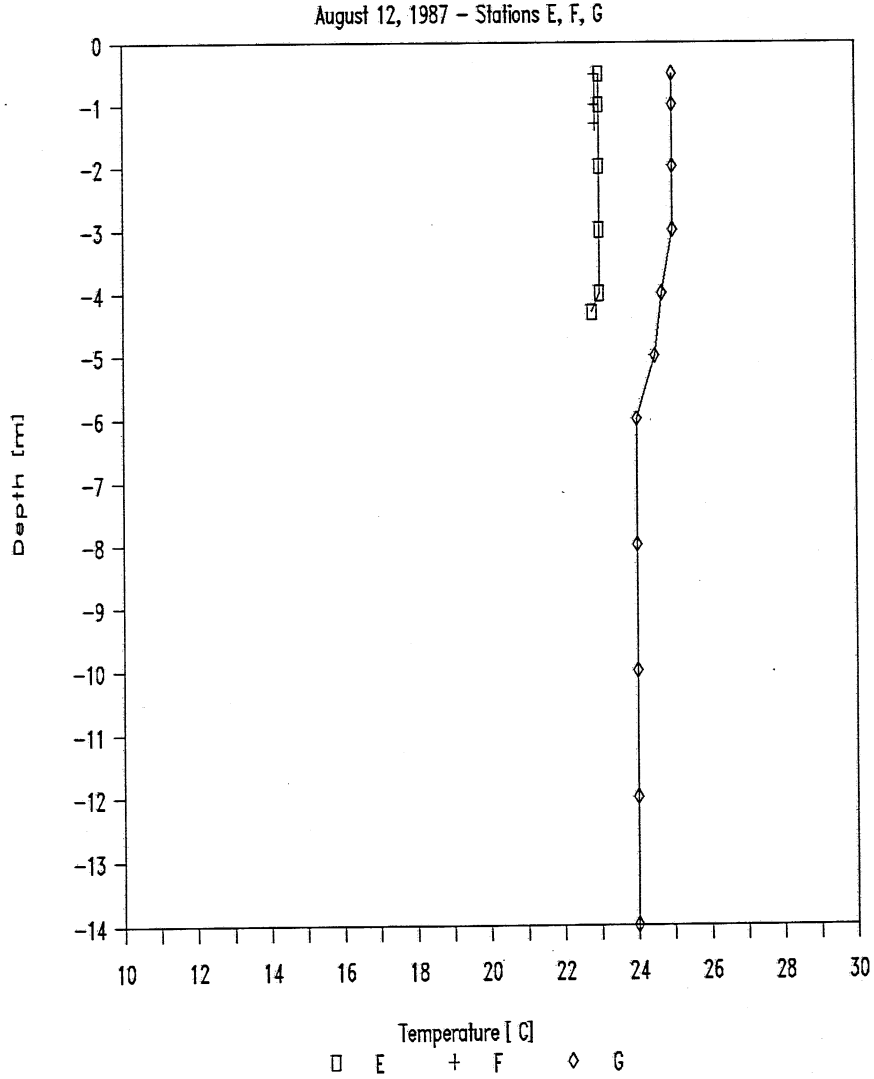
Byllesby Lake - Summer 1987



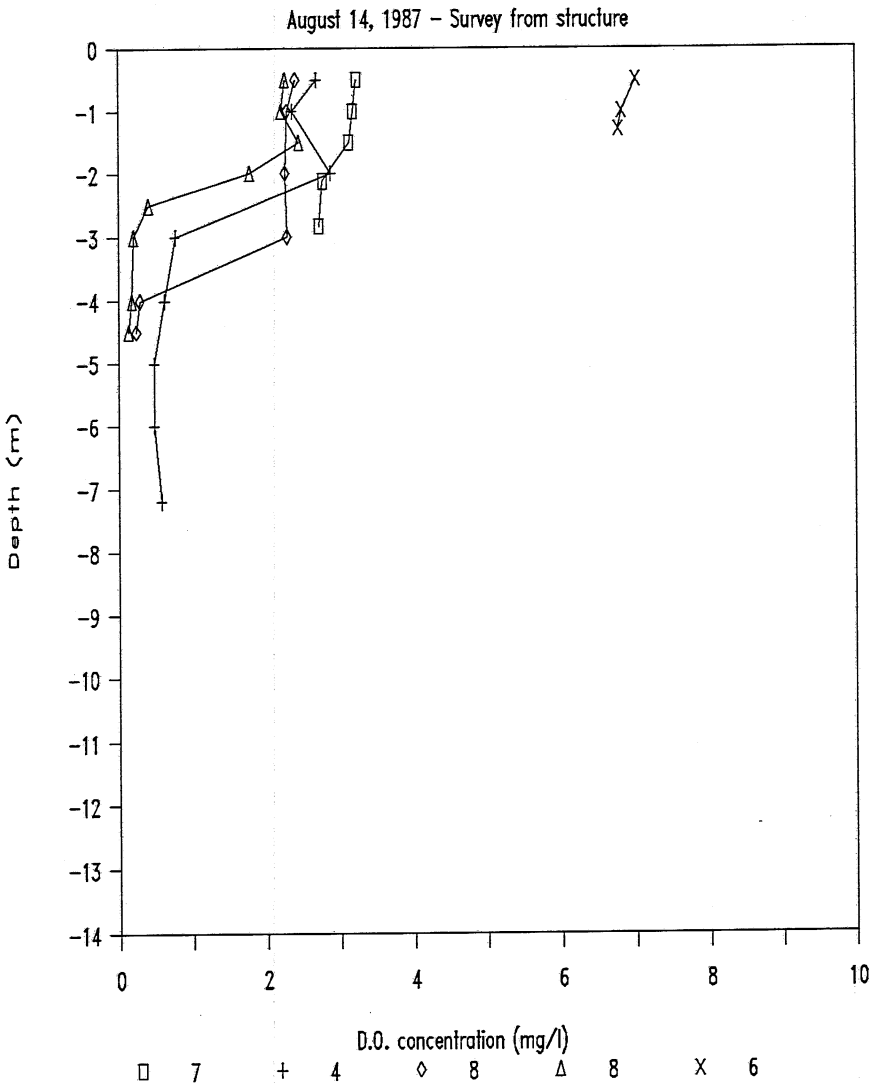


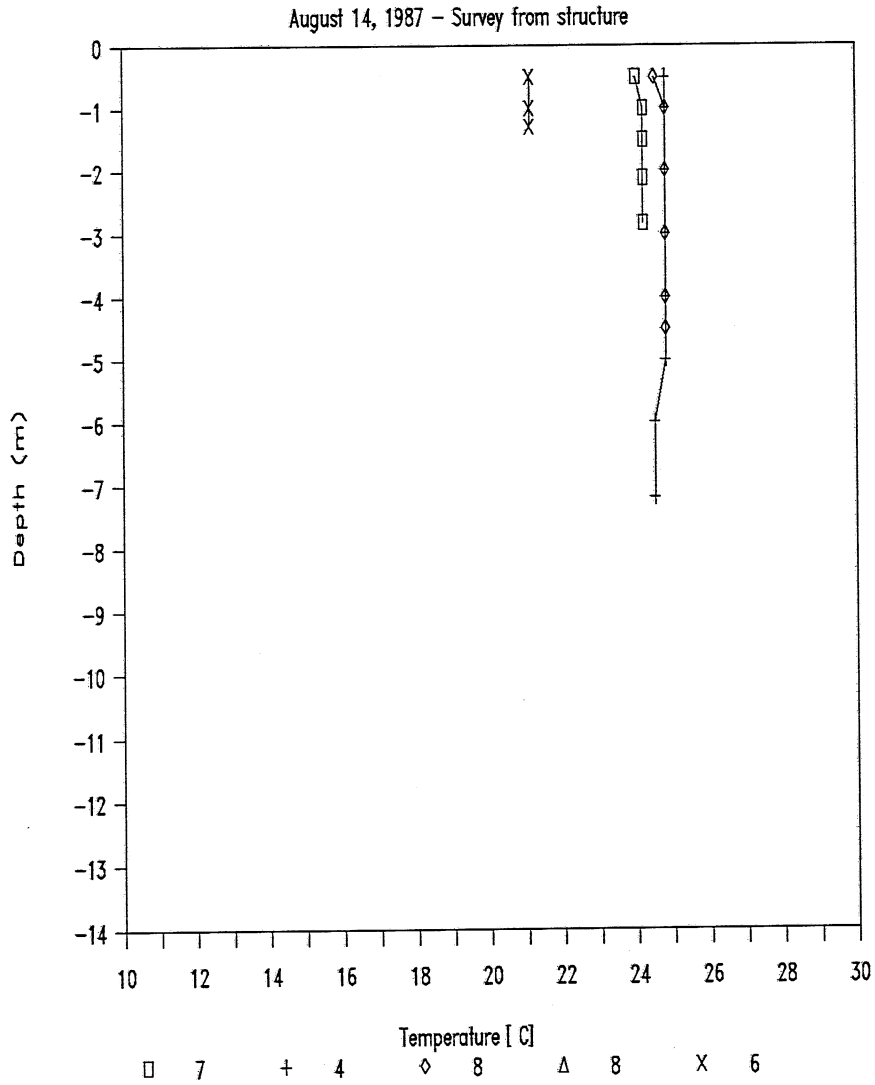
Byllesby Lake – Summer 1987



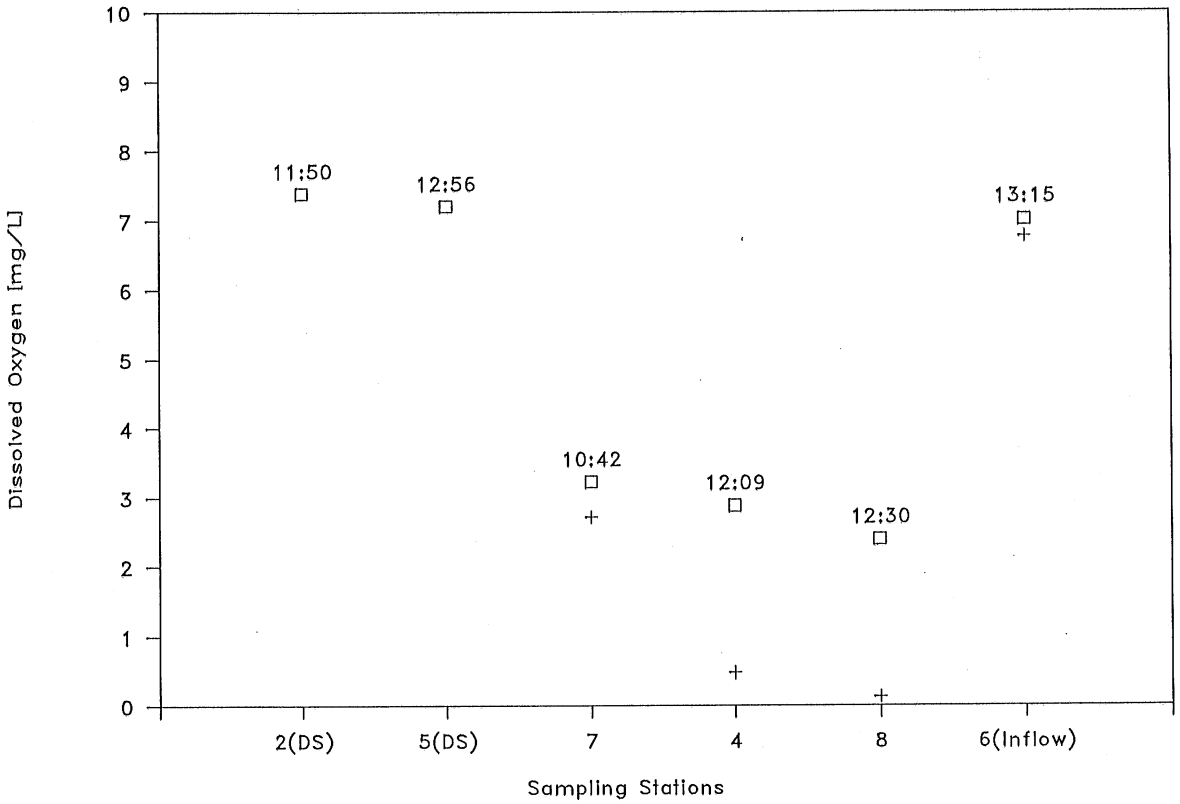


Byllesby lake - Summer 1987

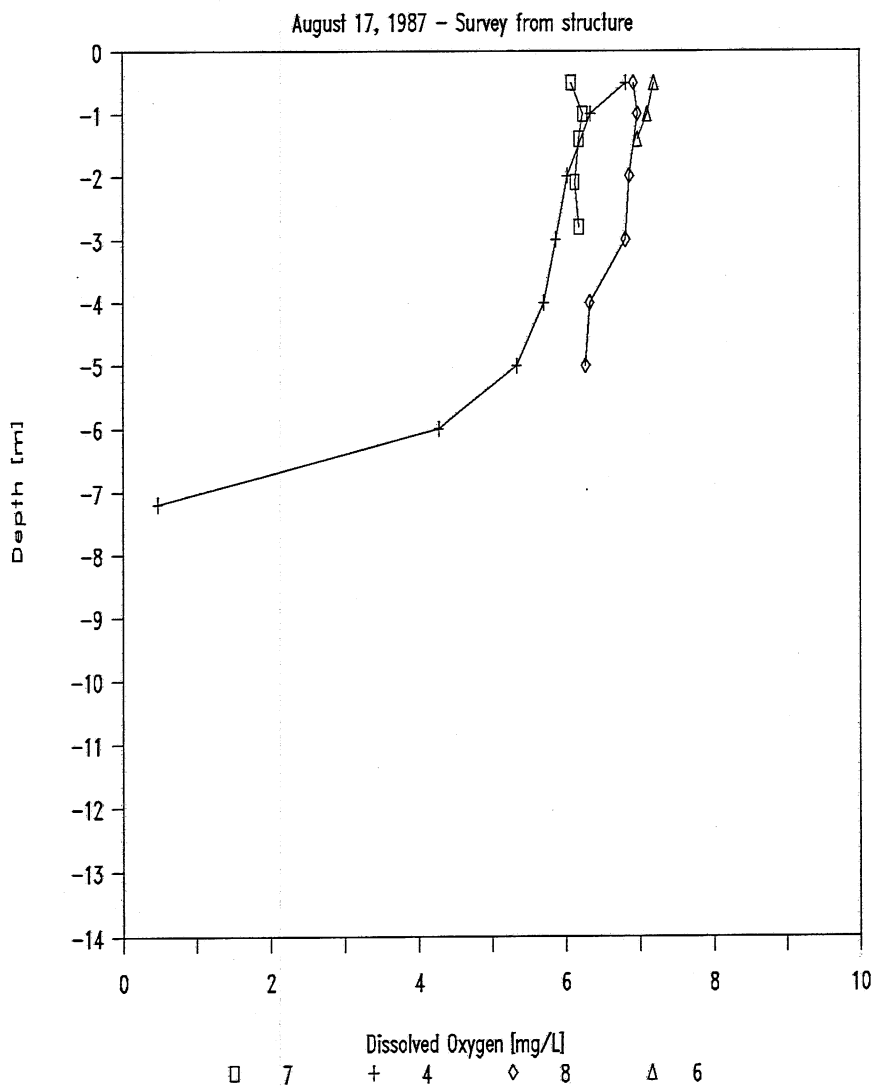


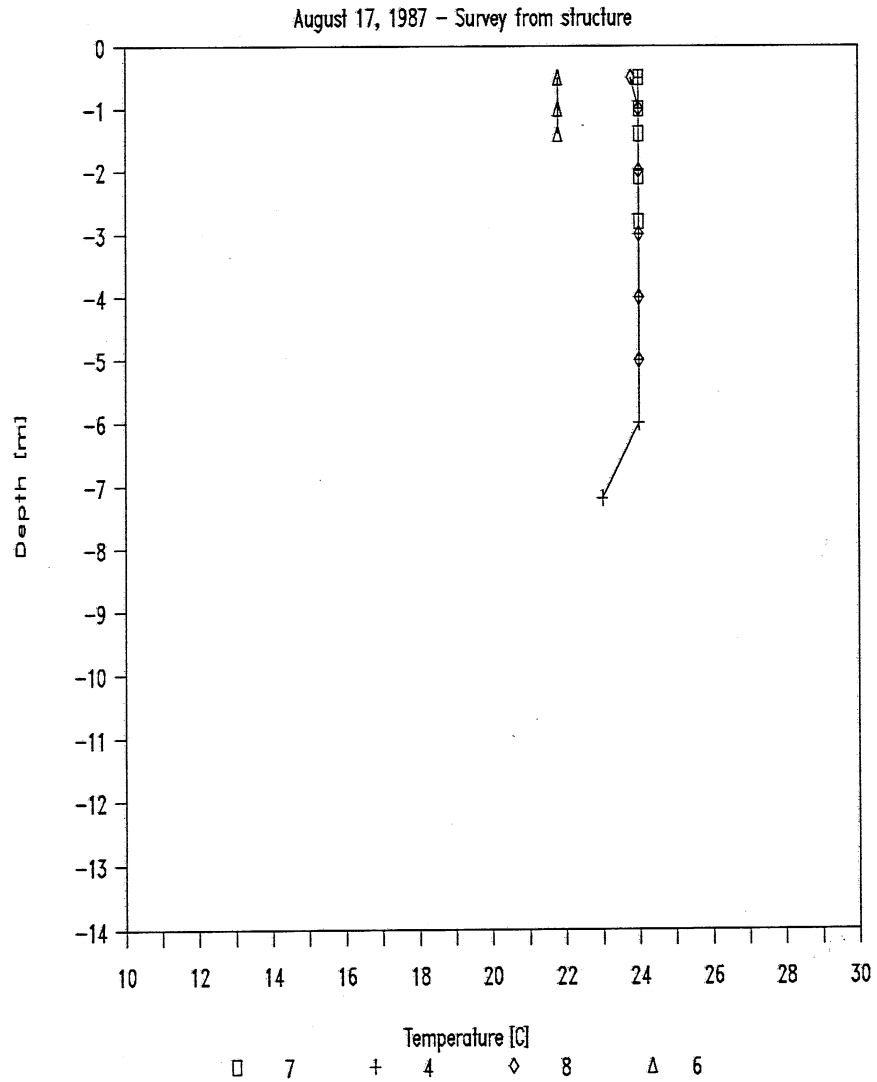


Byllesby Lake – August 14, 1987

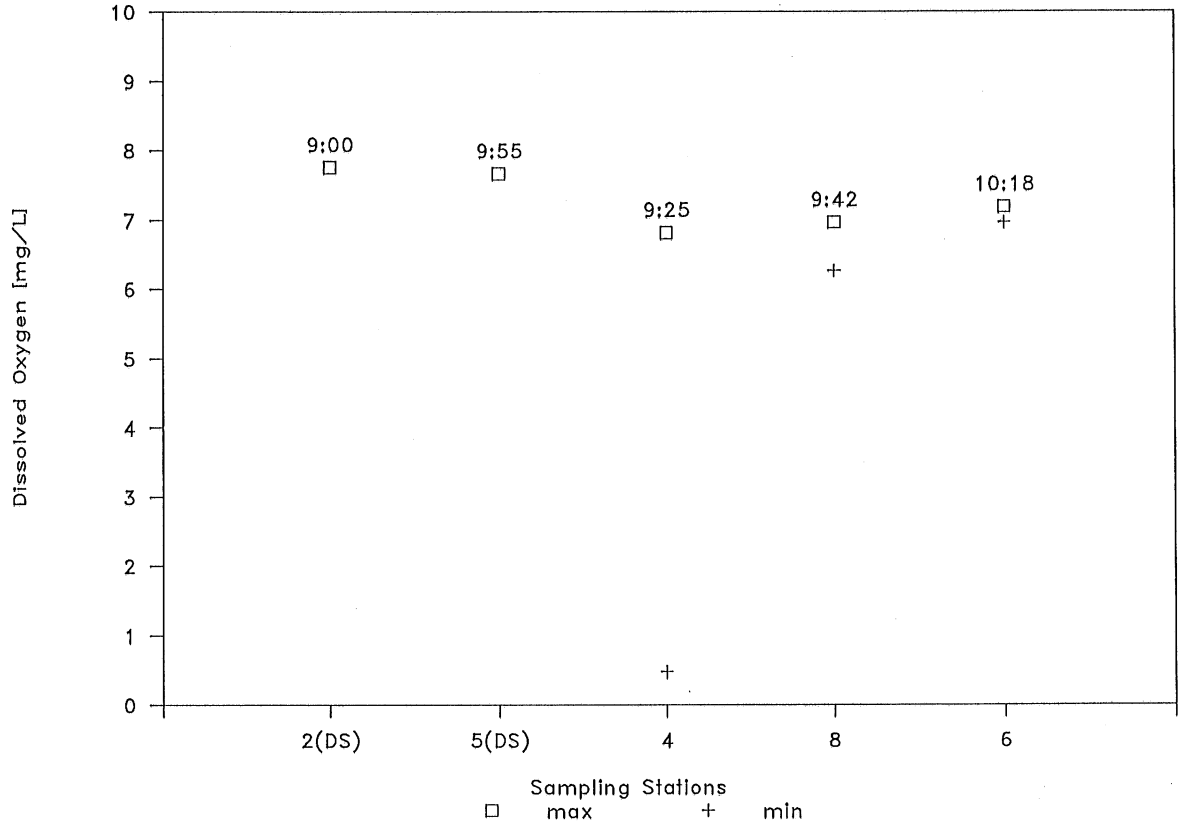


Byllesby Lake - Summer 1988

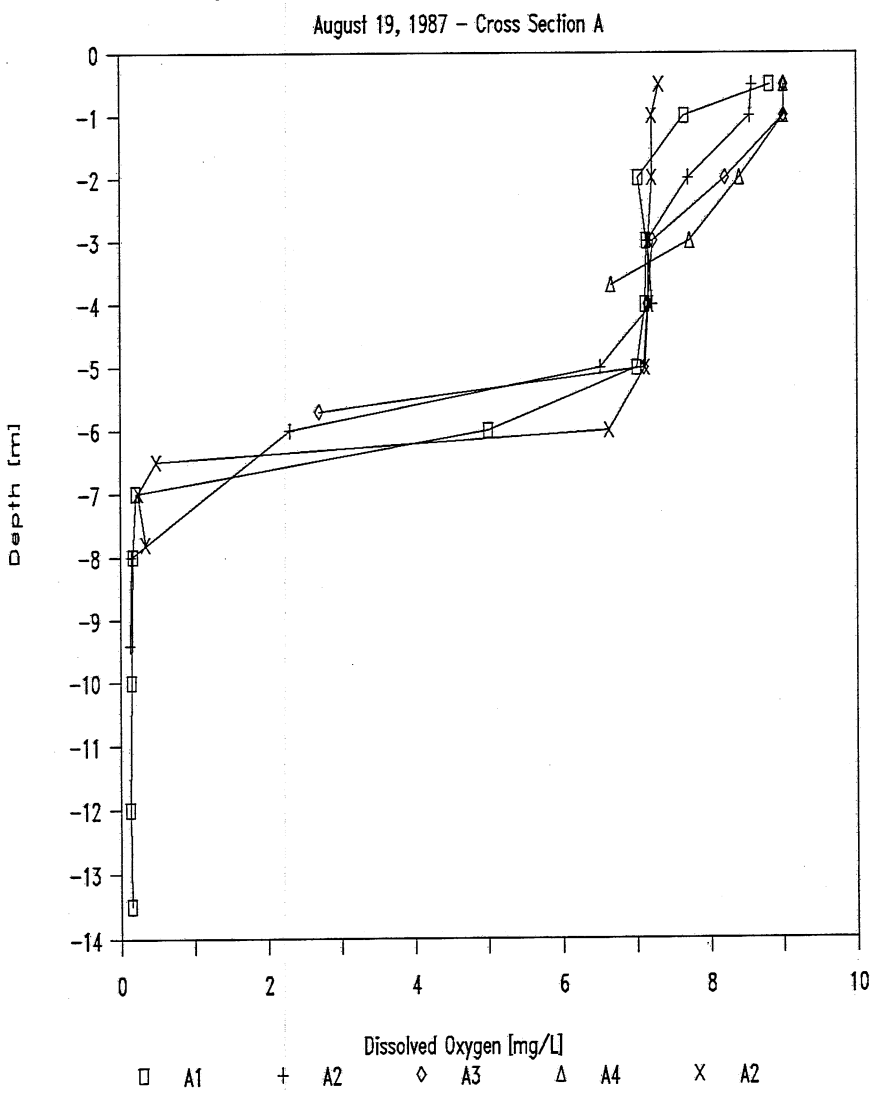


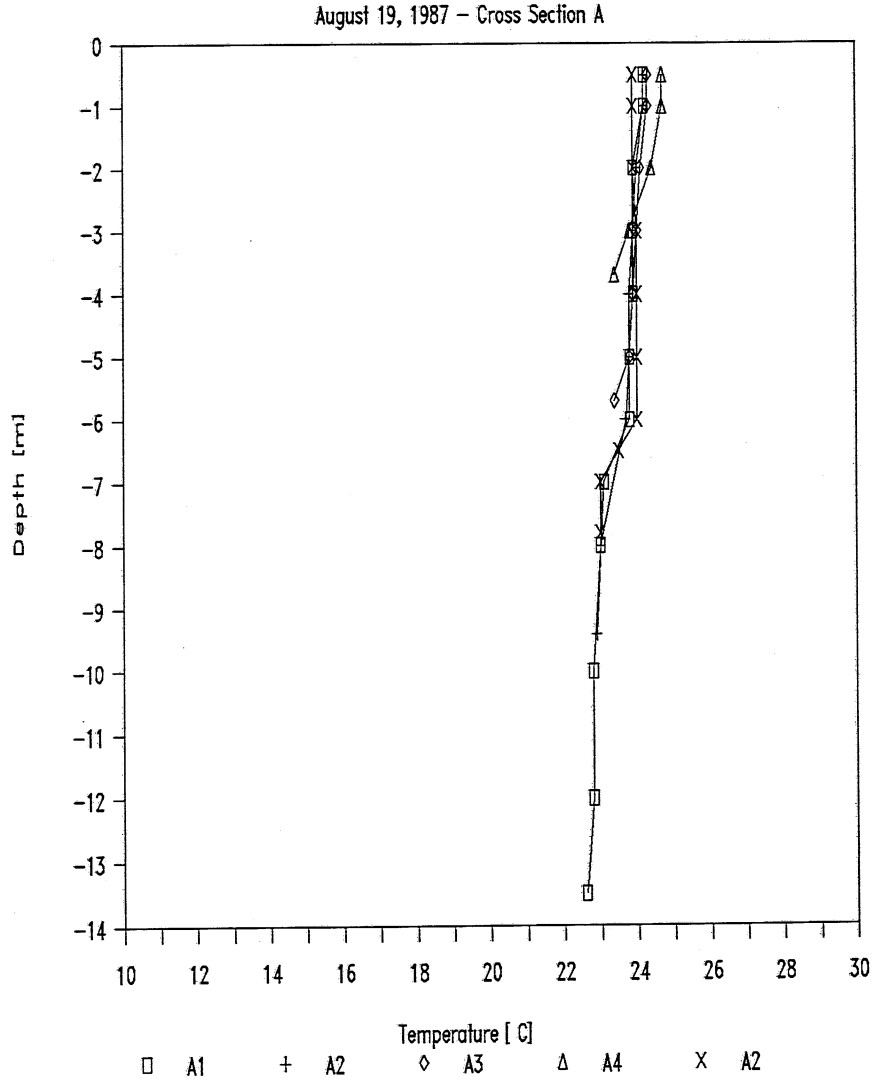


Byllesby Lake – August 17, 1987

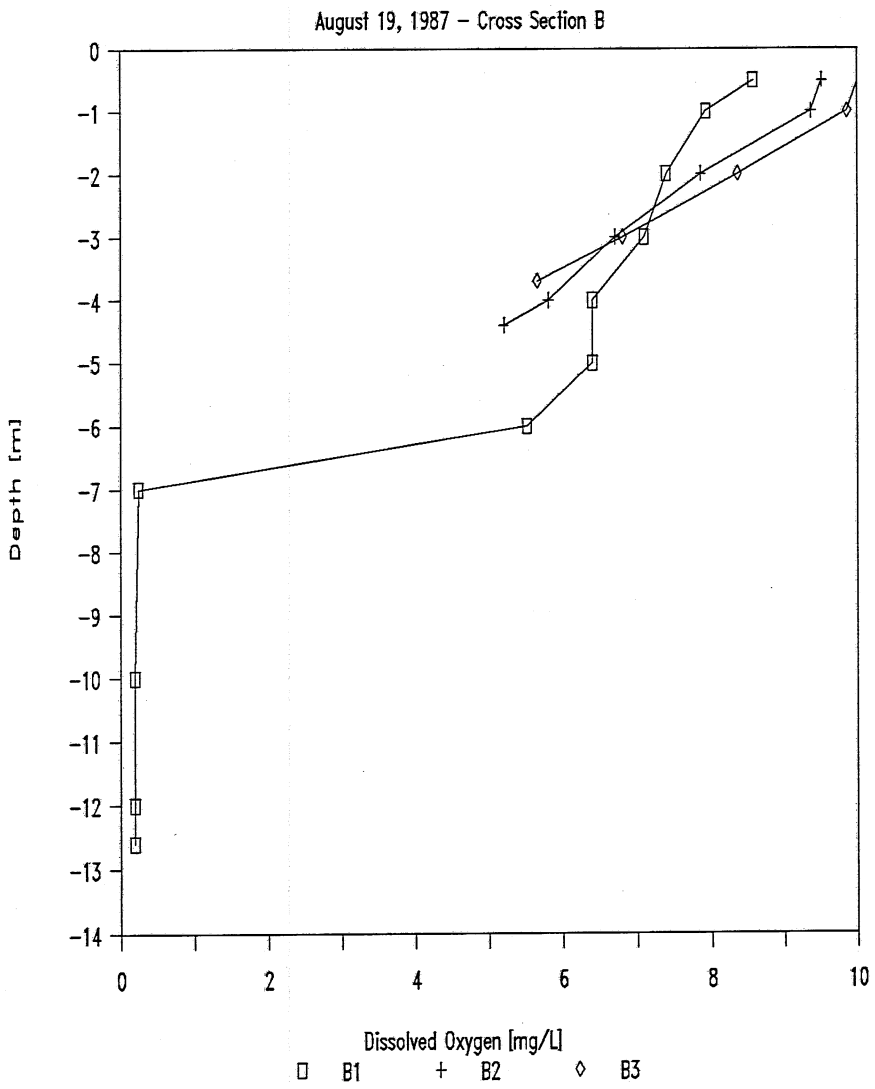


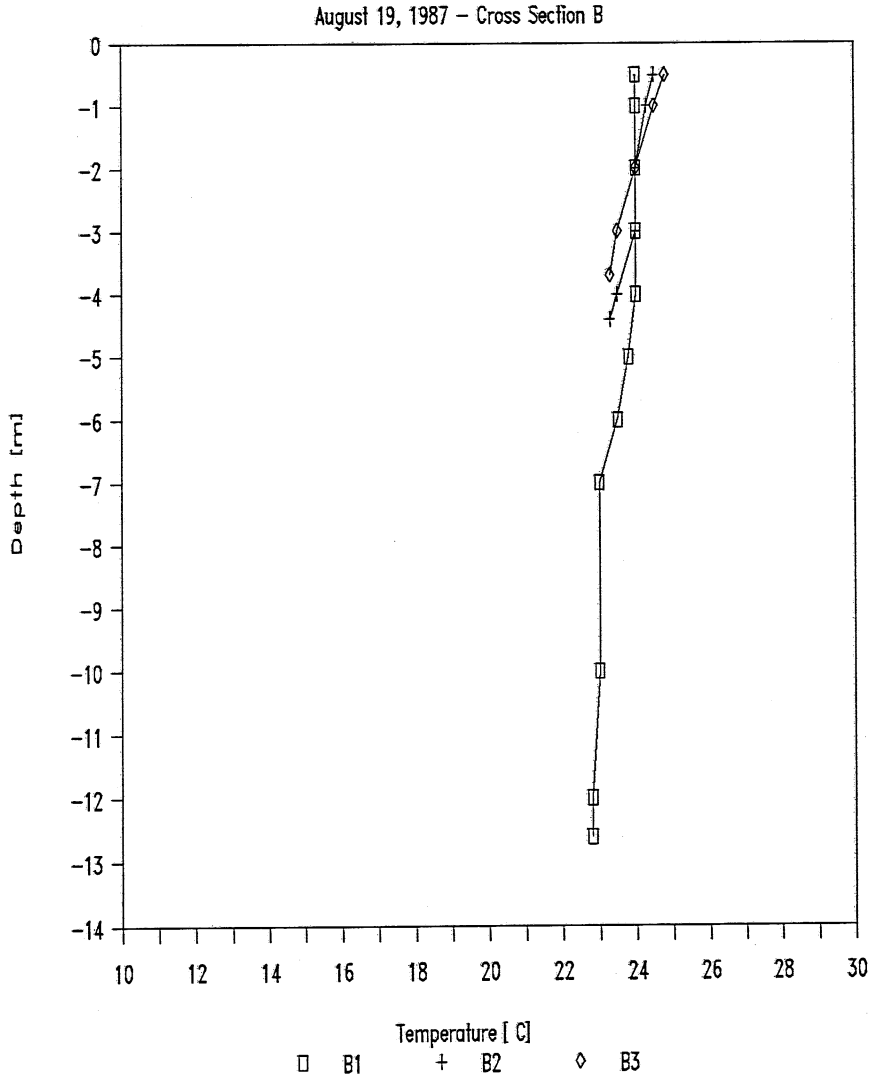
Byllesby Lake - Summer 1987



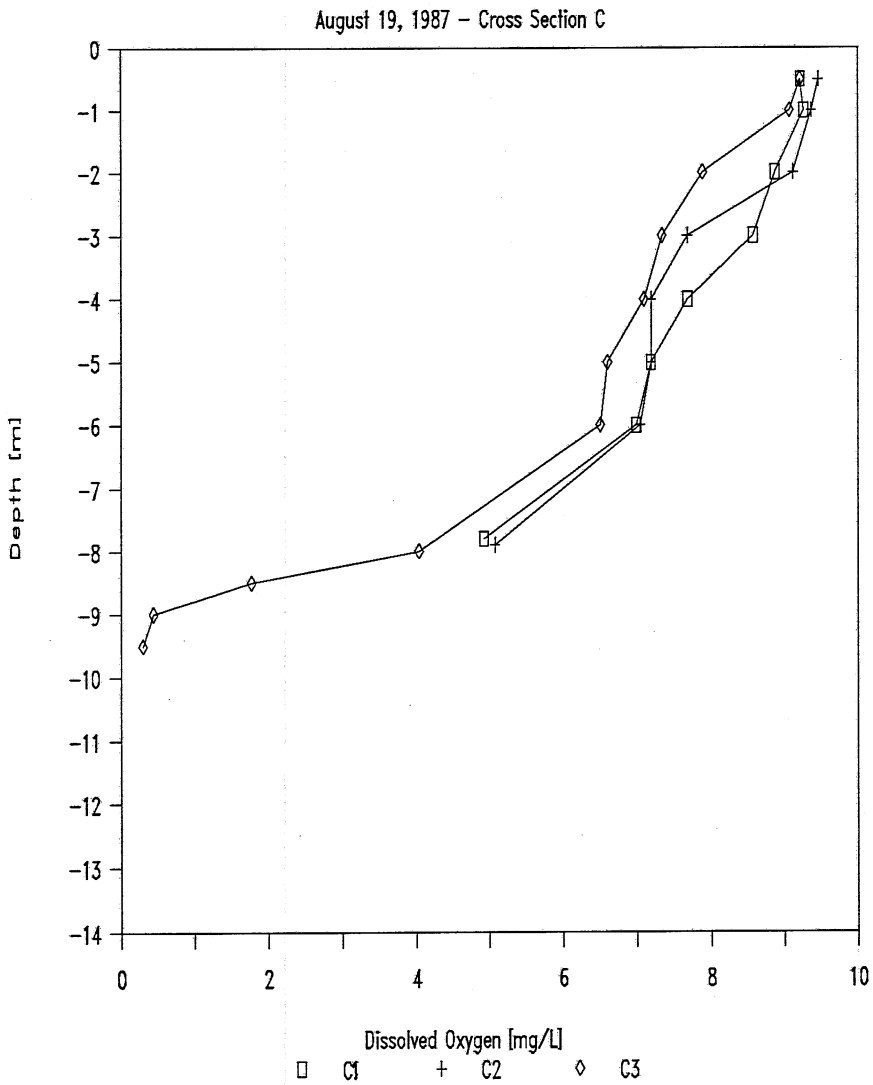


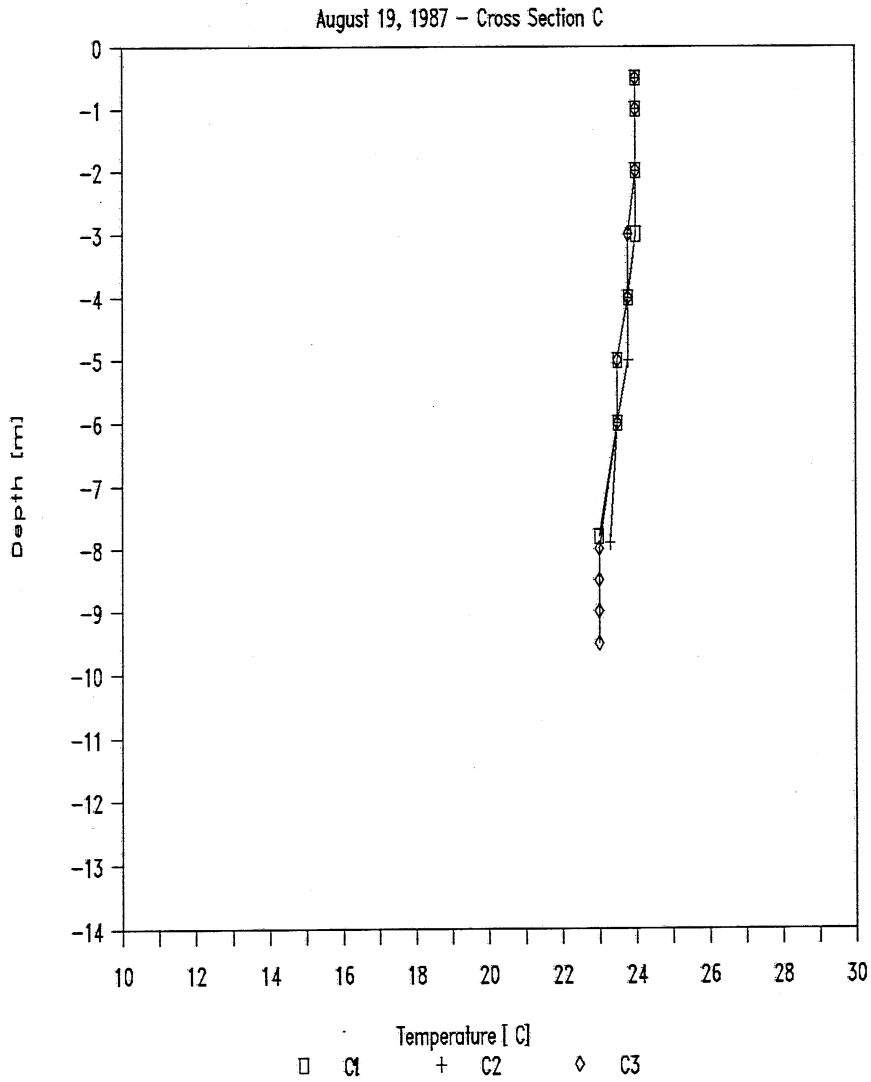
Byllesby Lake - Summer 1987



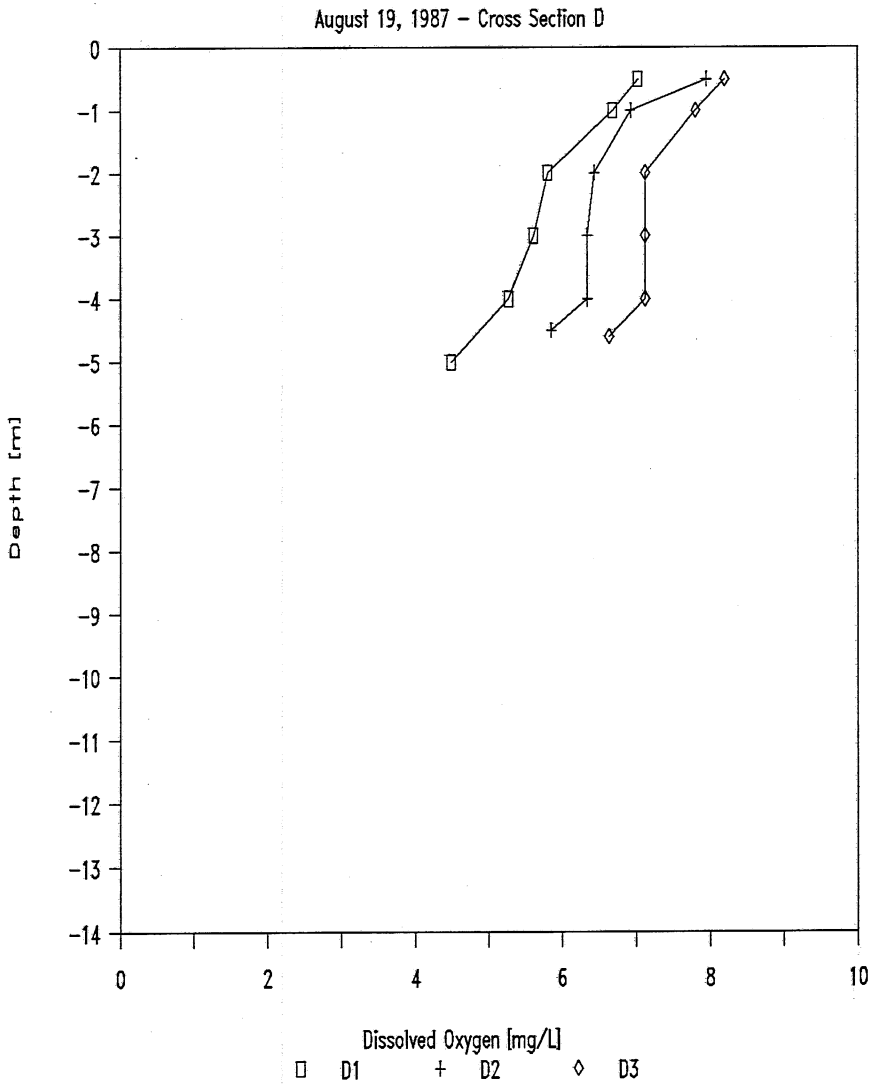


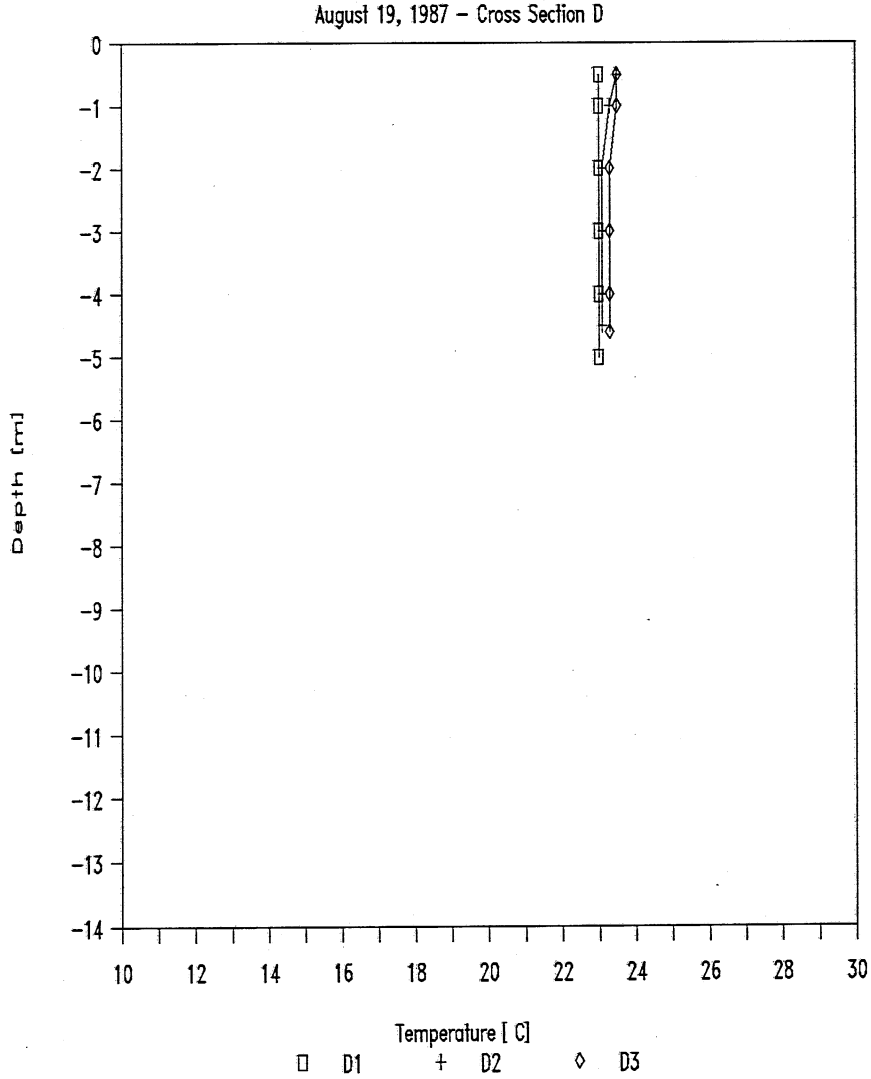
Byllesby Lake – Summer 1987



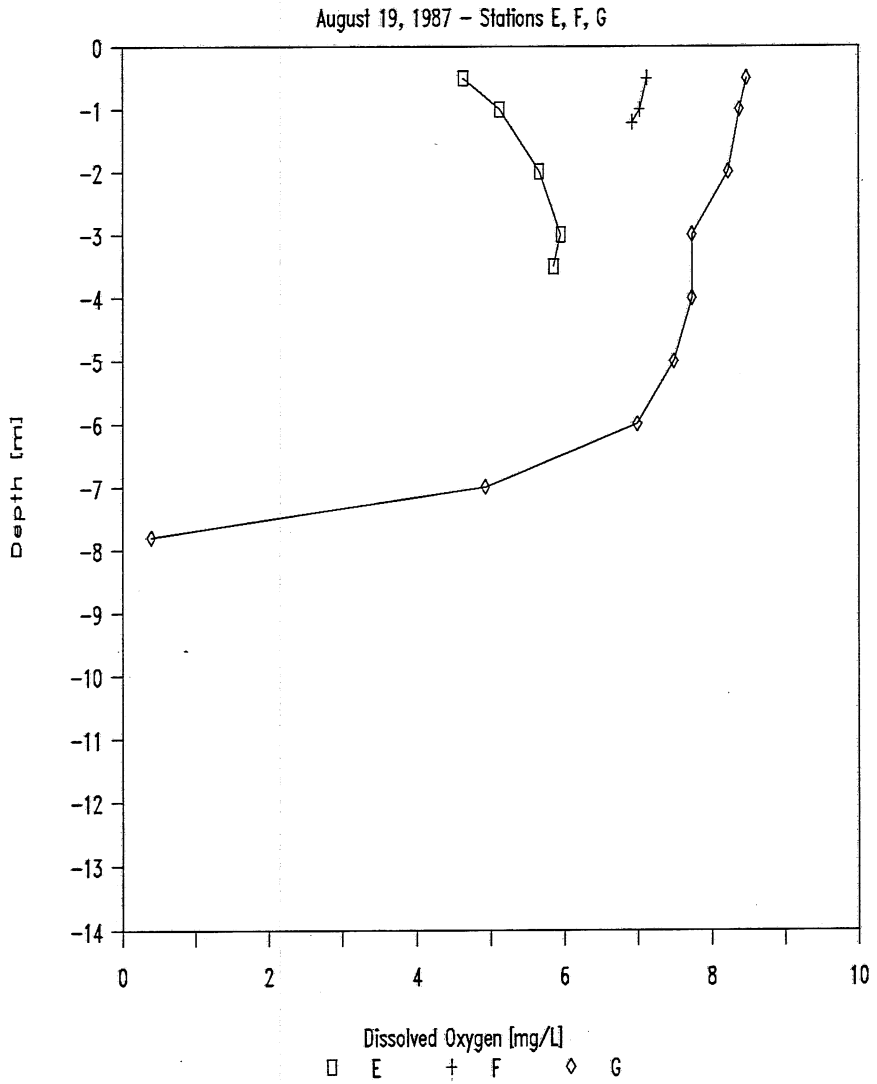


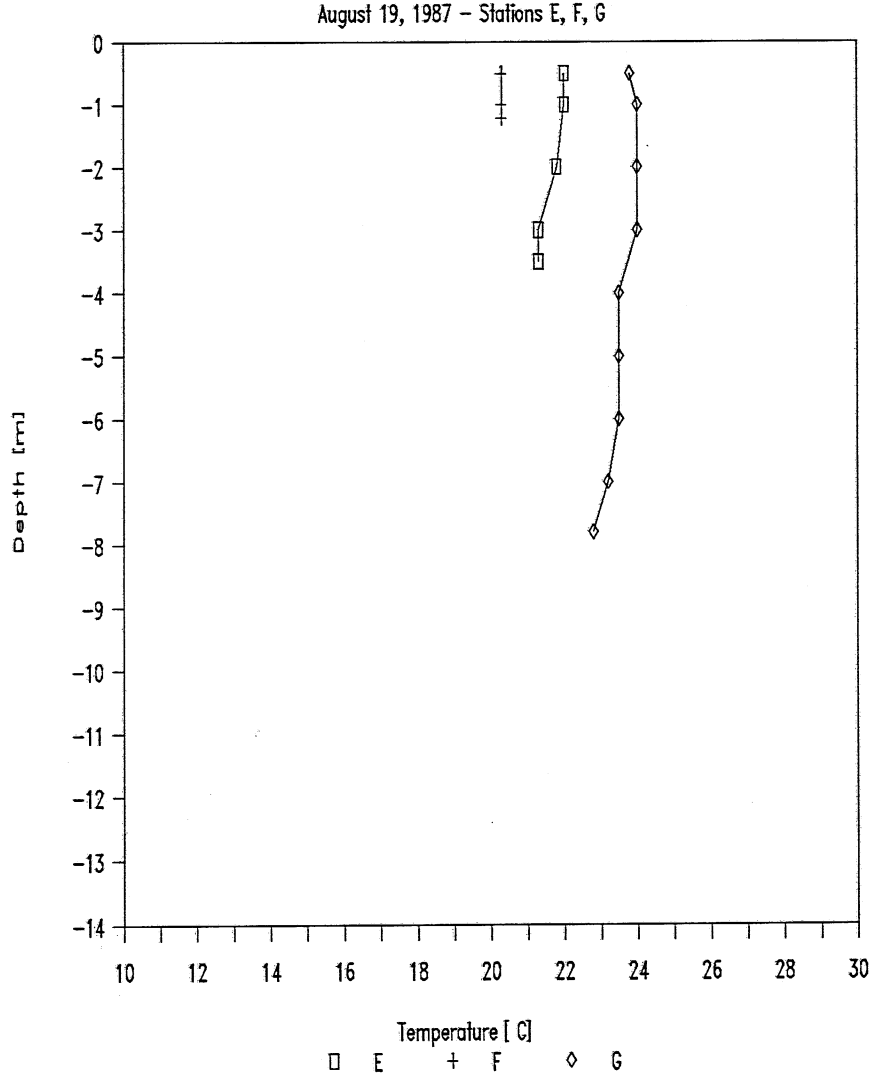
Byllesby Lake – Summer 1987



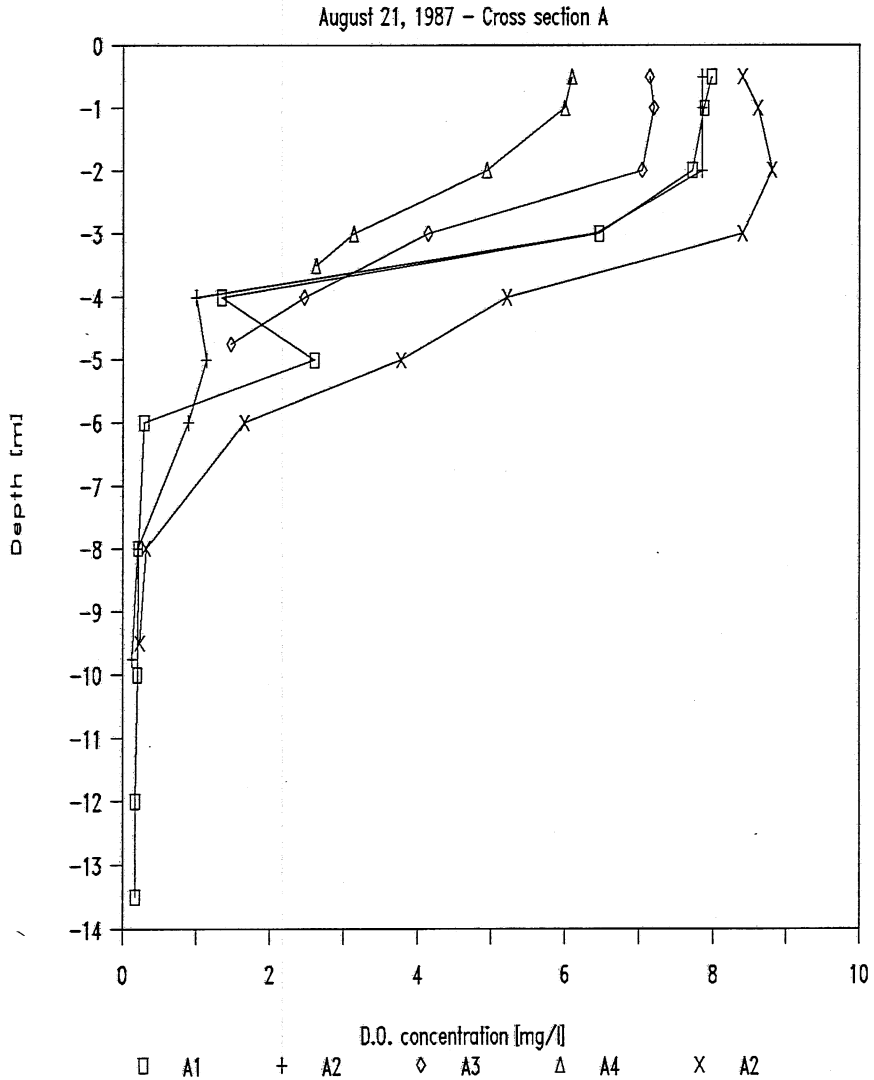


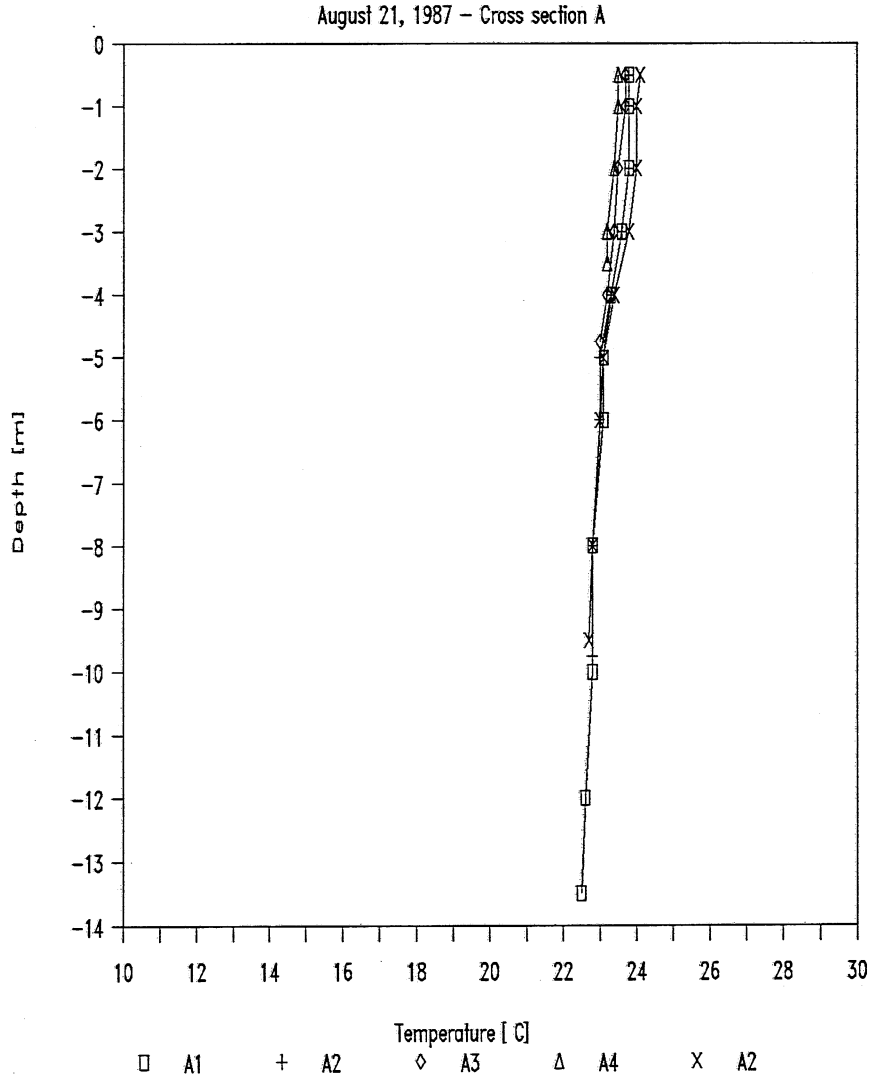
Byllesby Lake – Summer 1987



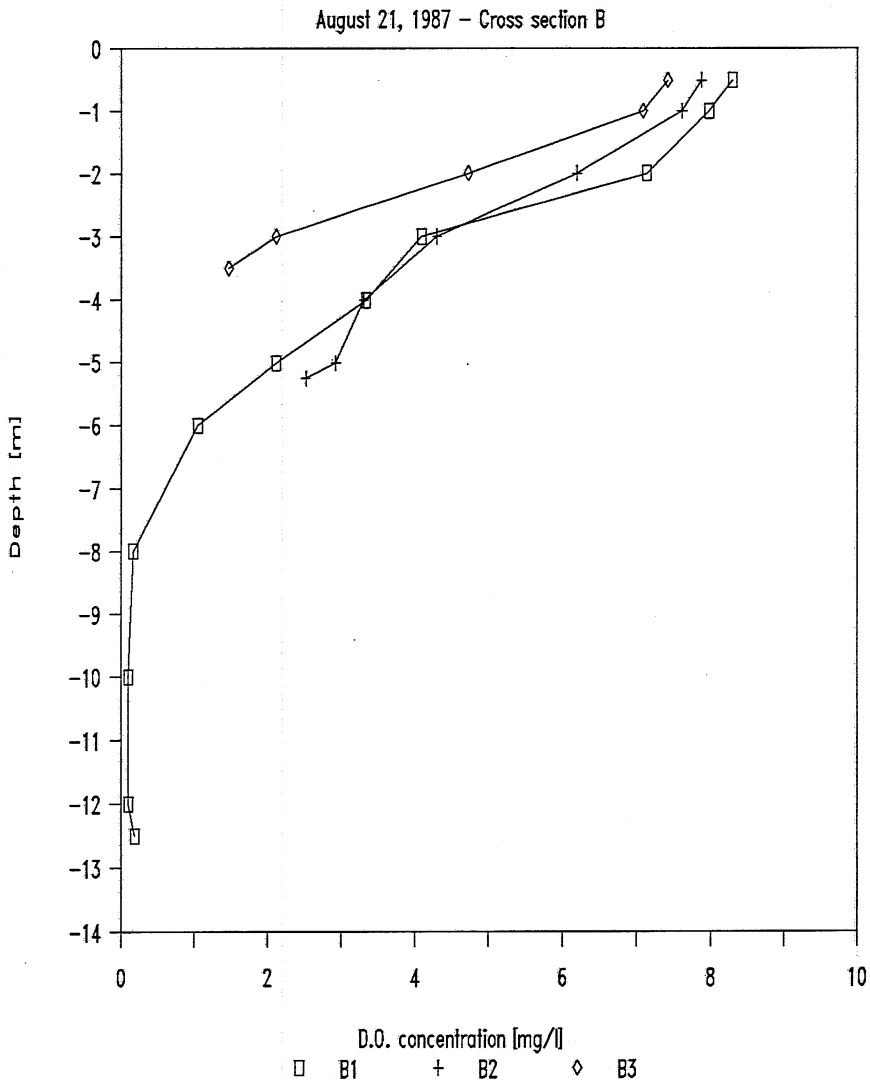


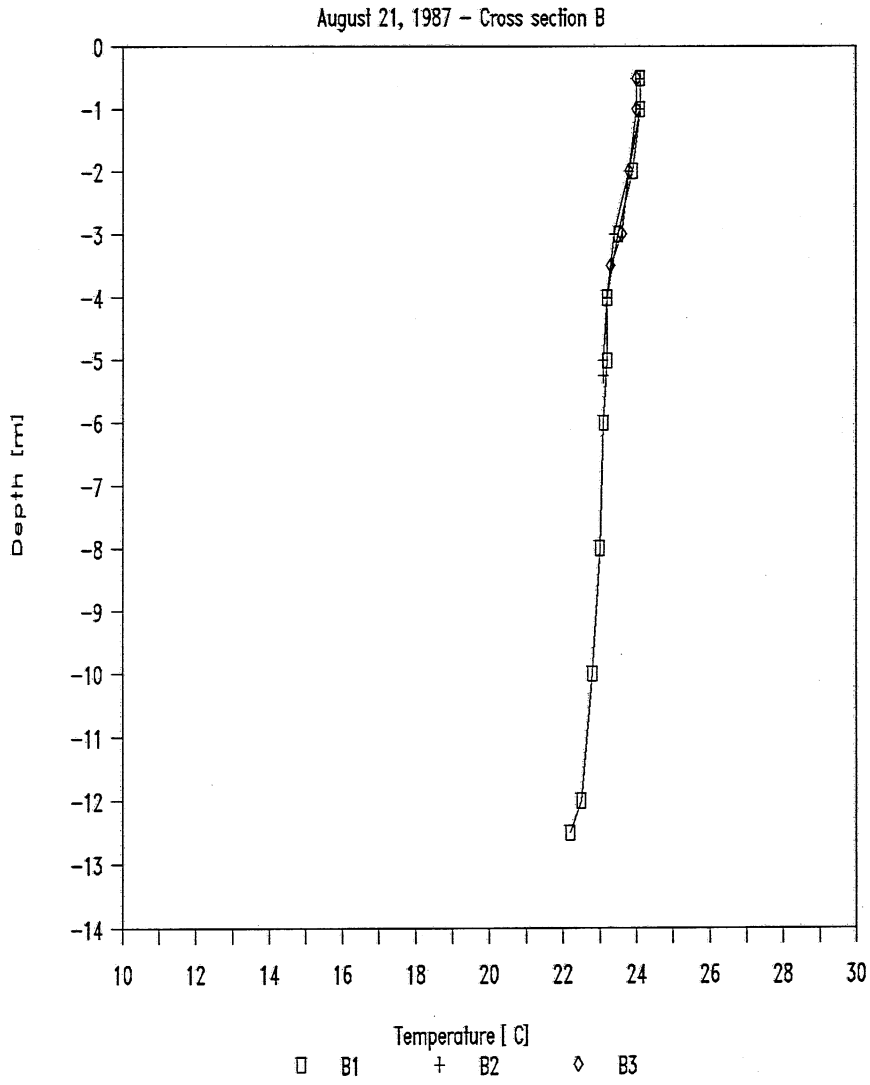
Byllesby D.O. study - Summer 1987





Byllesby D.O. study - Summer 1987





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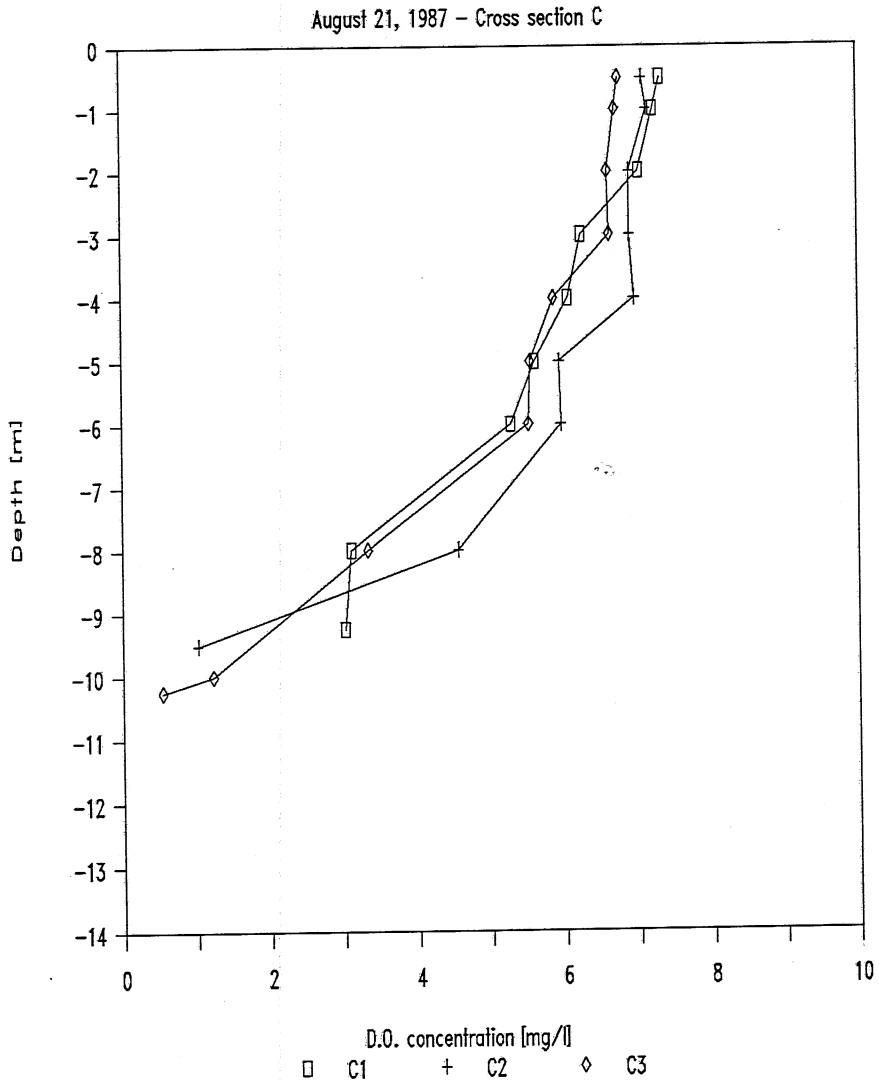

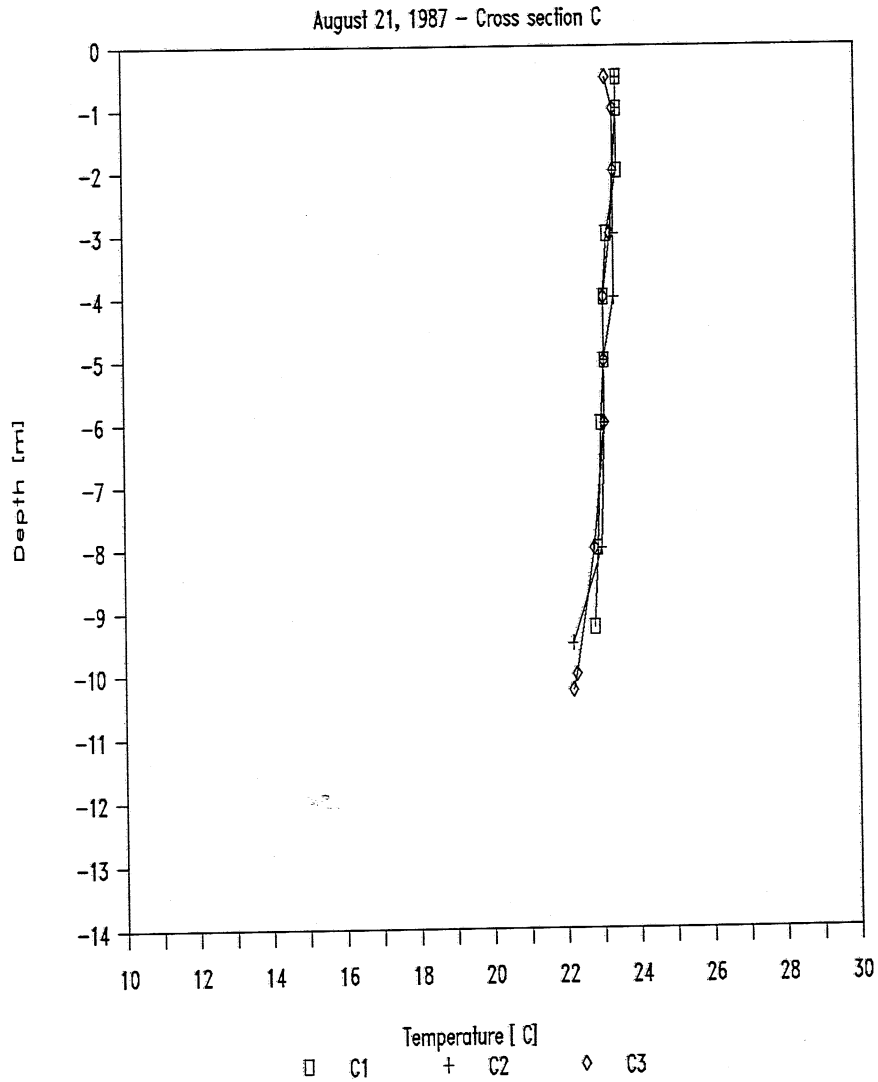

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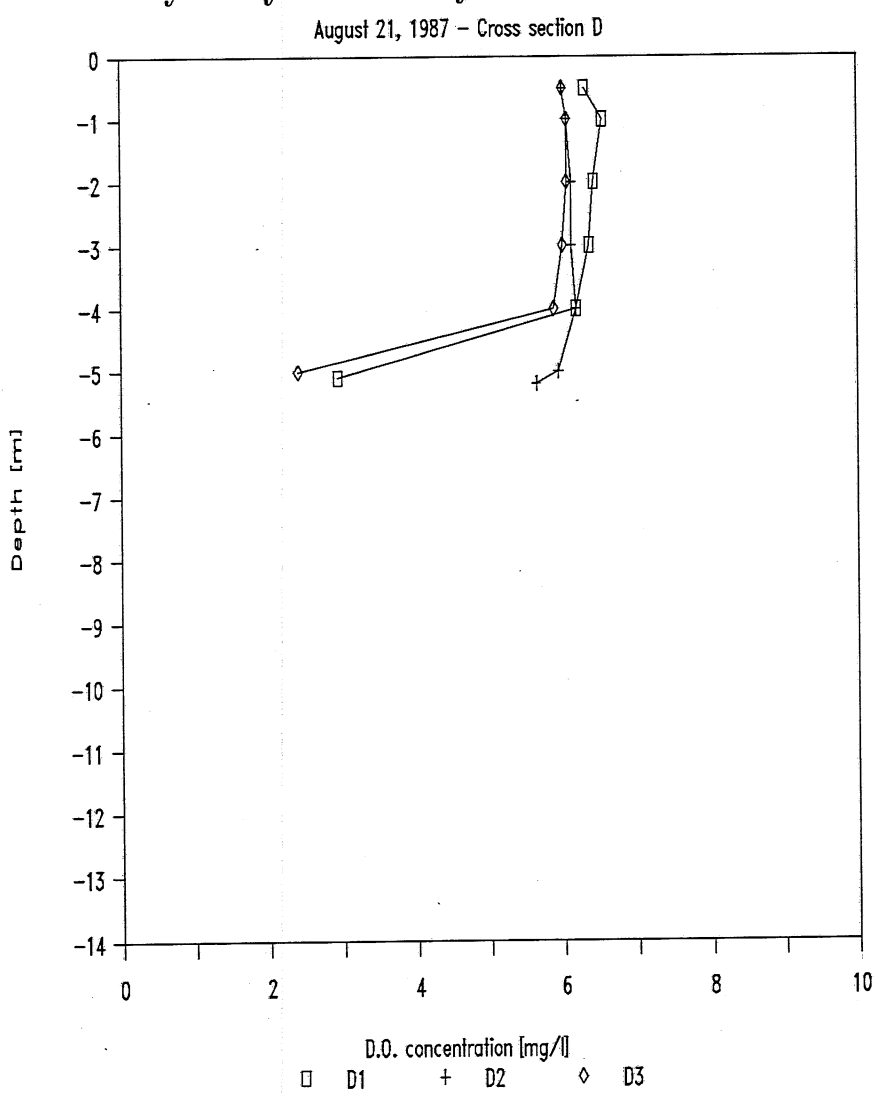

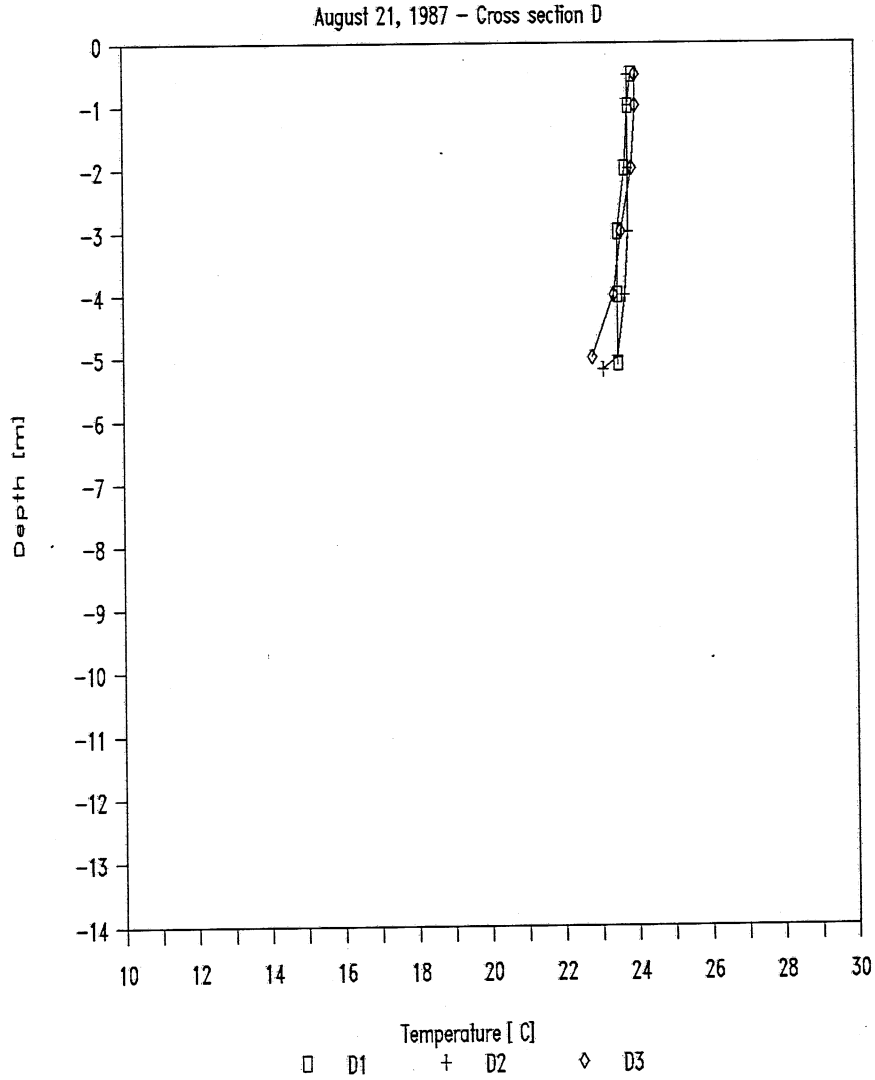

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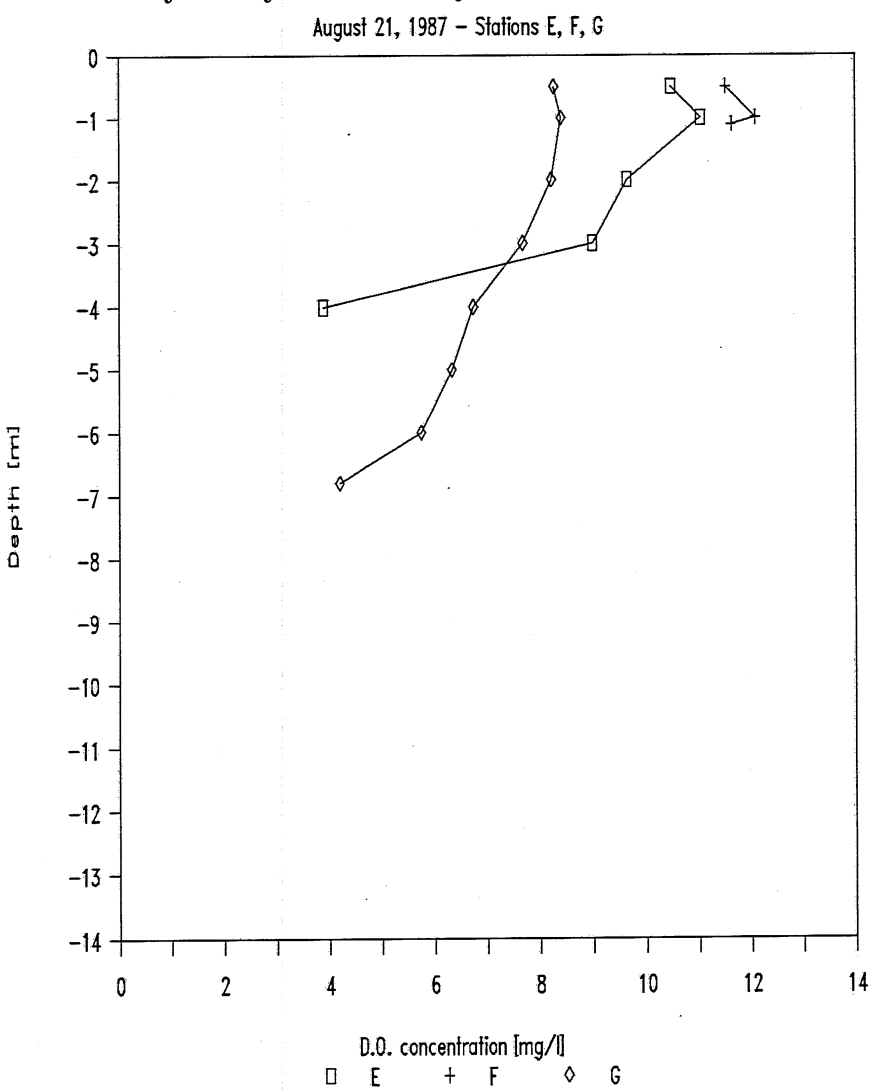

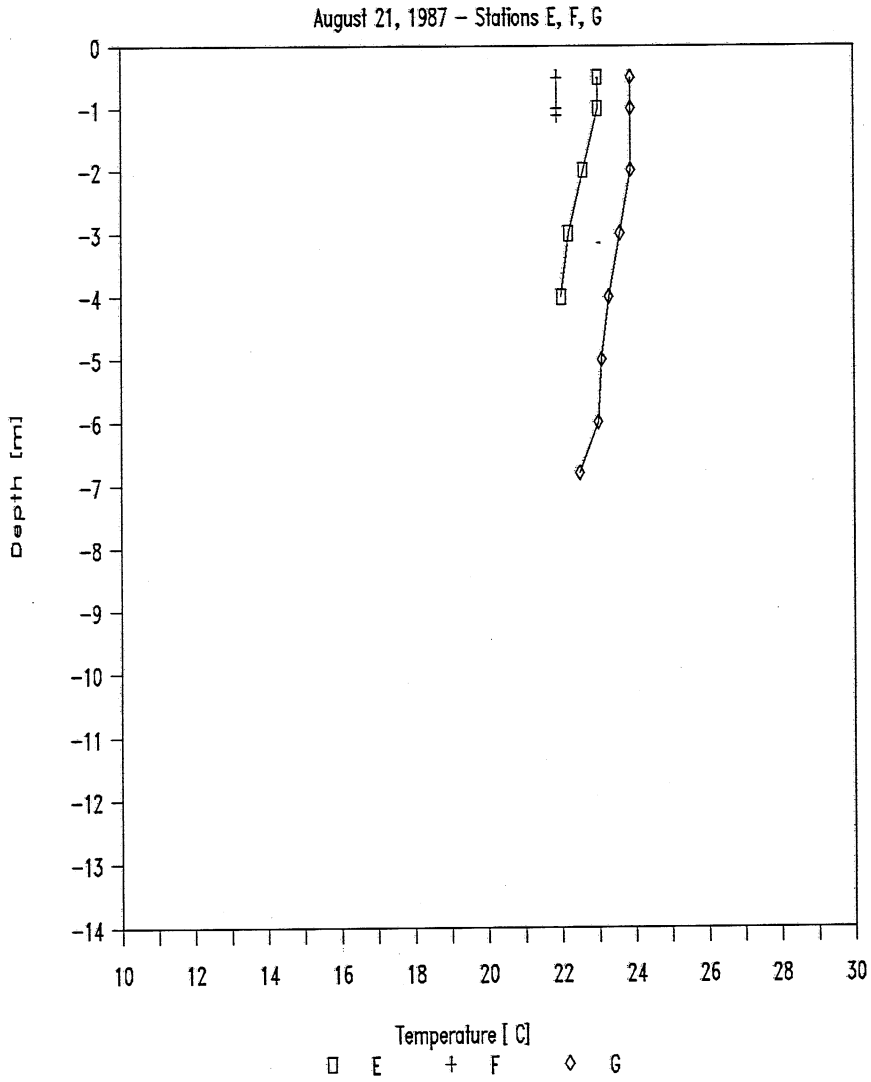

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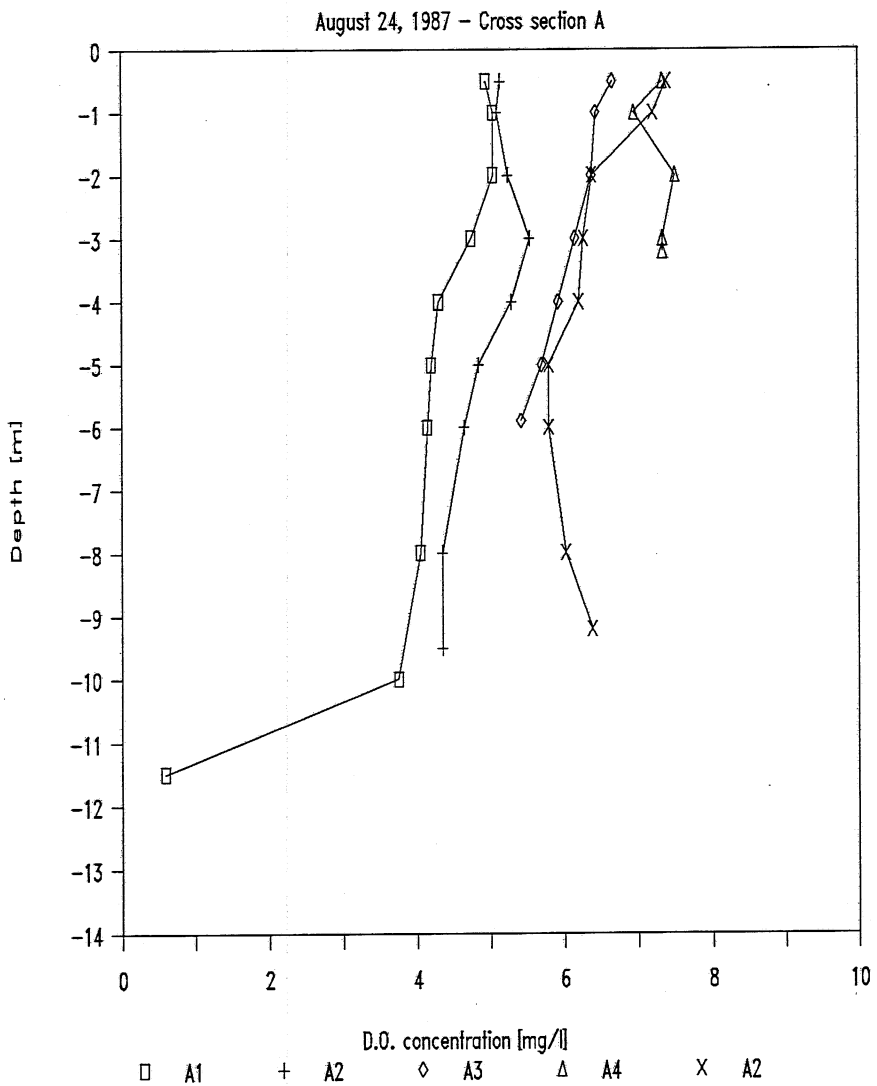

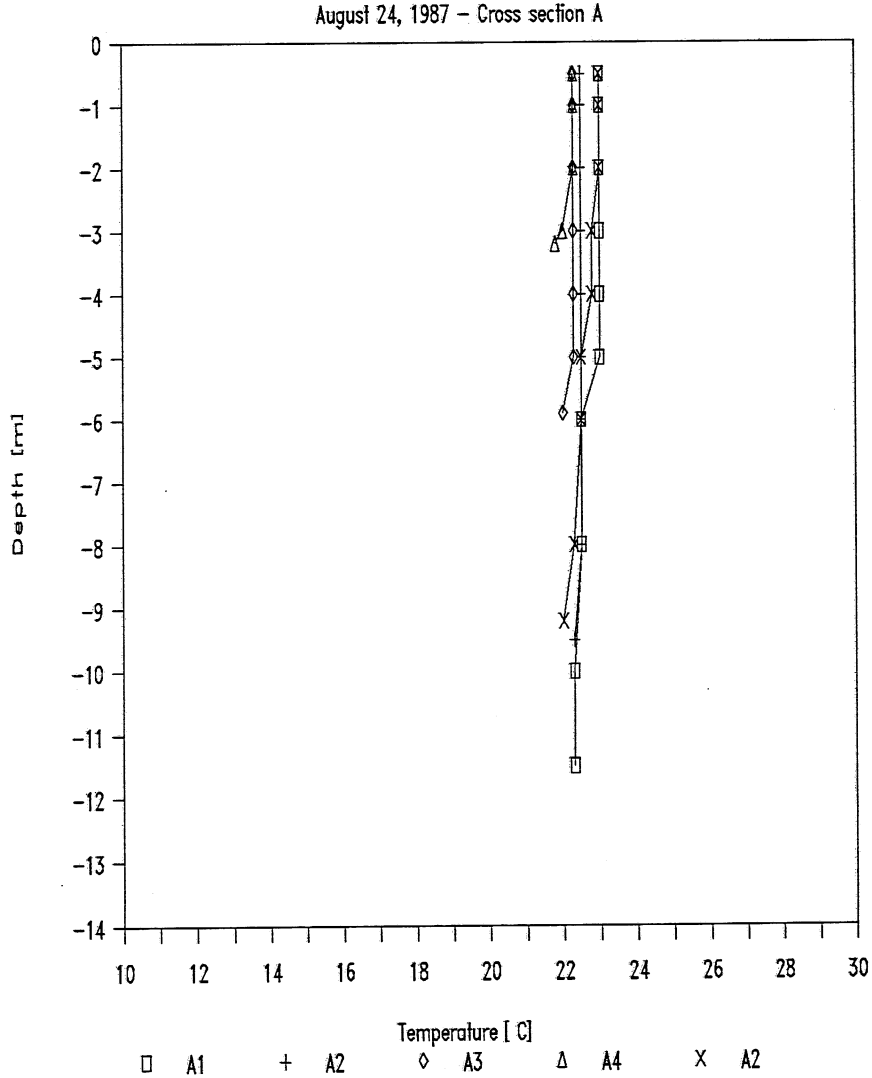

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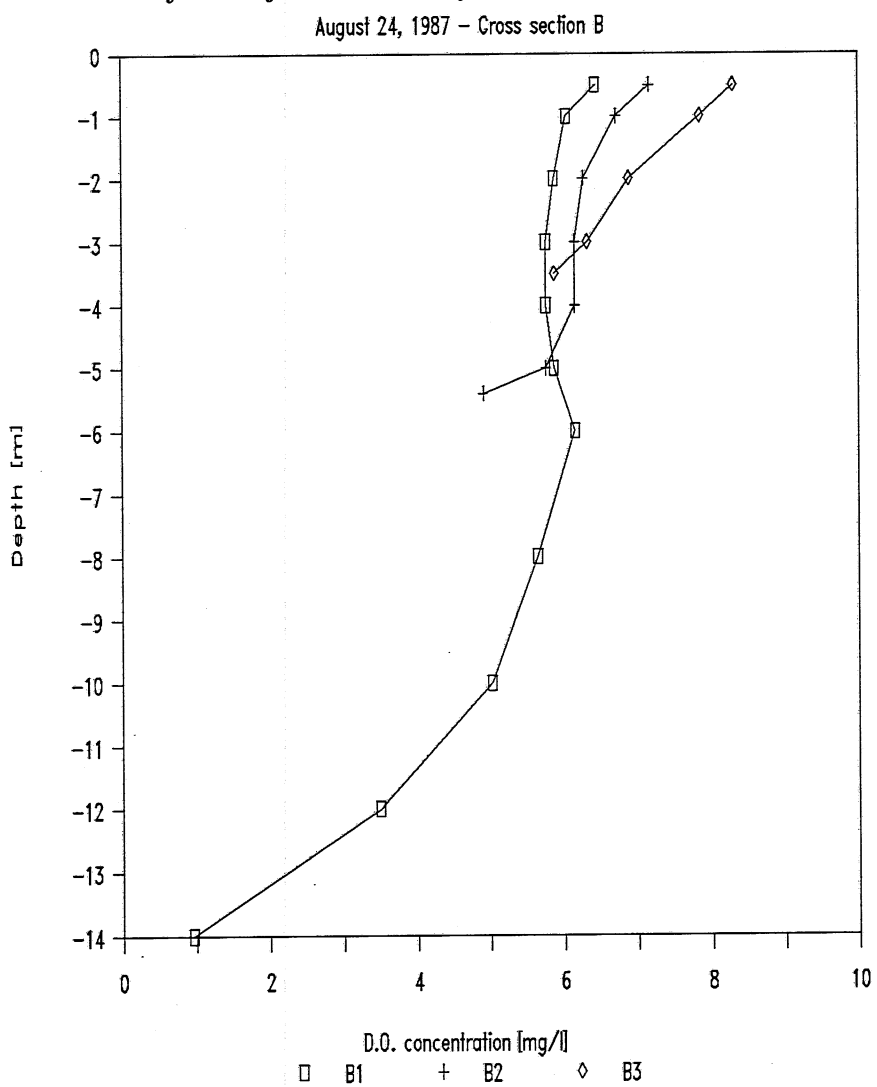

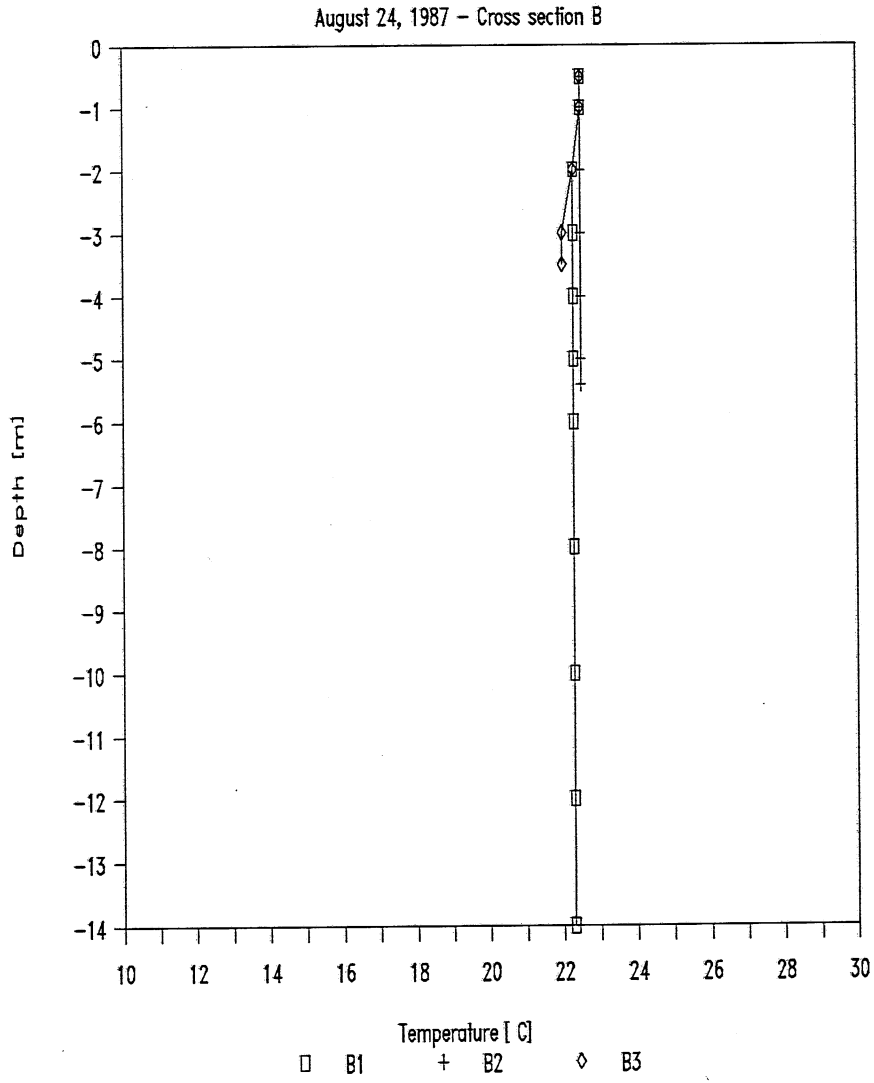

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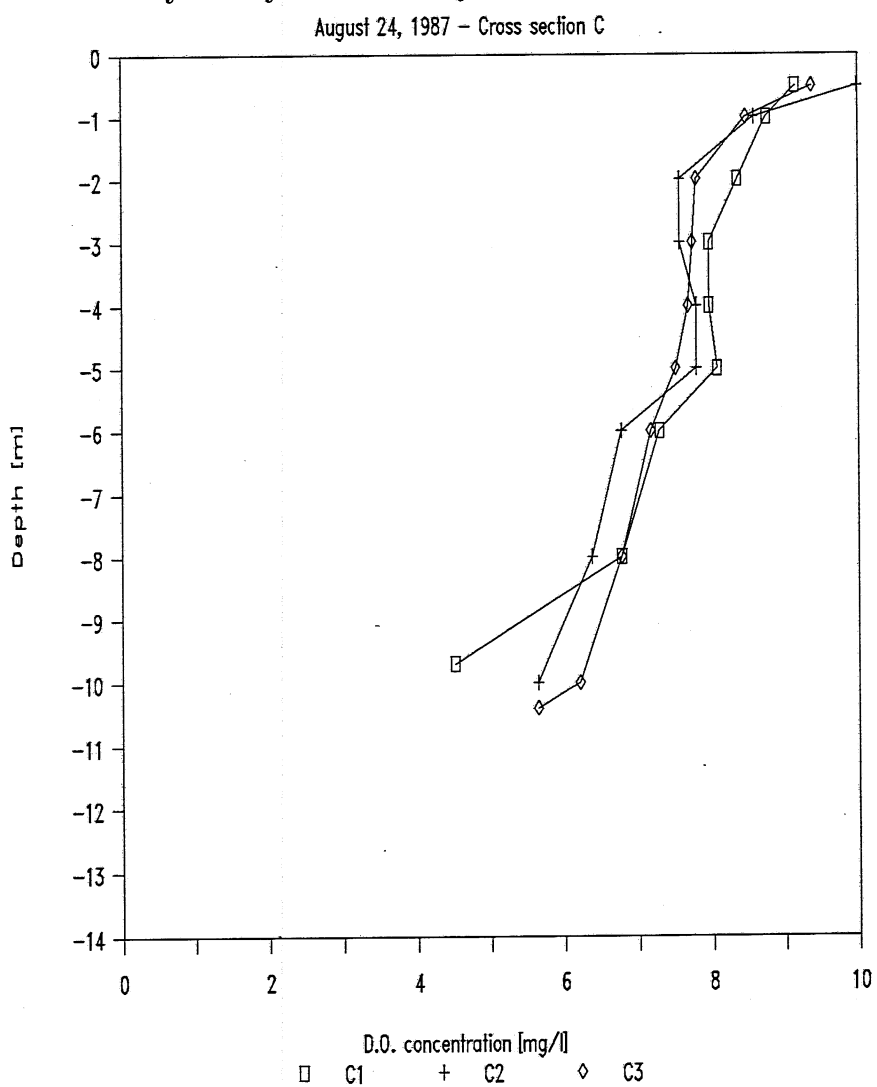

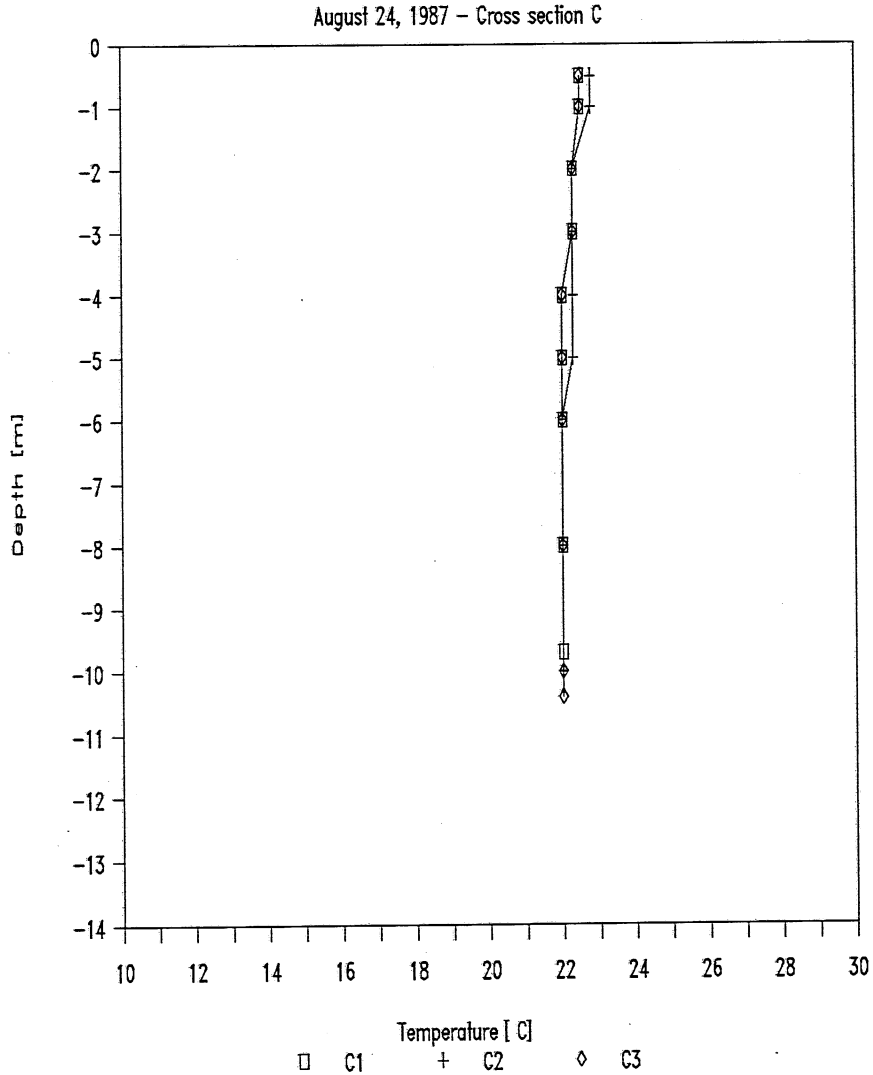

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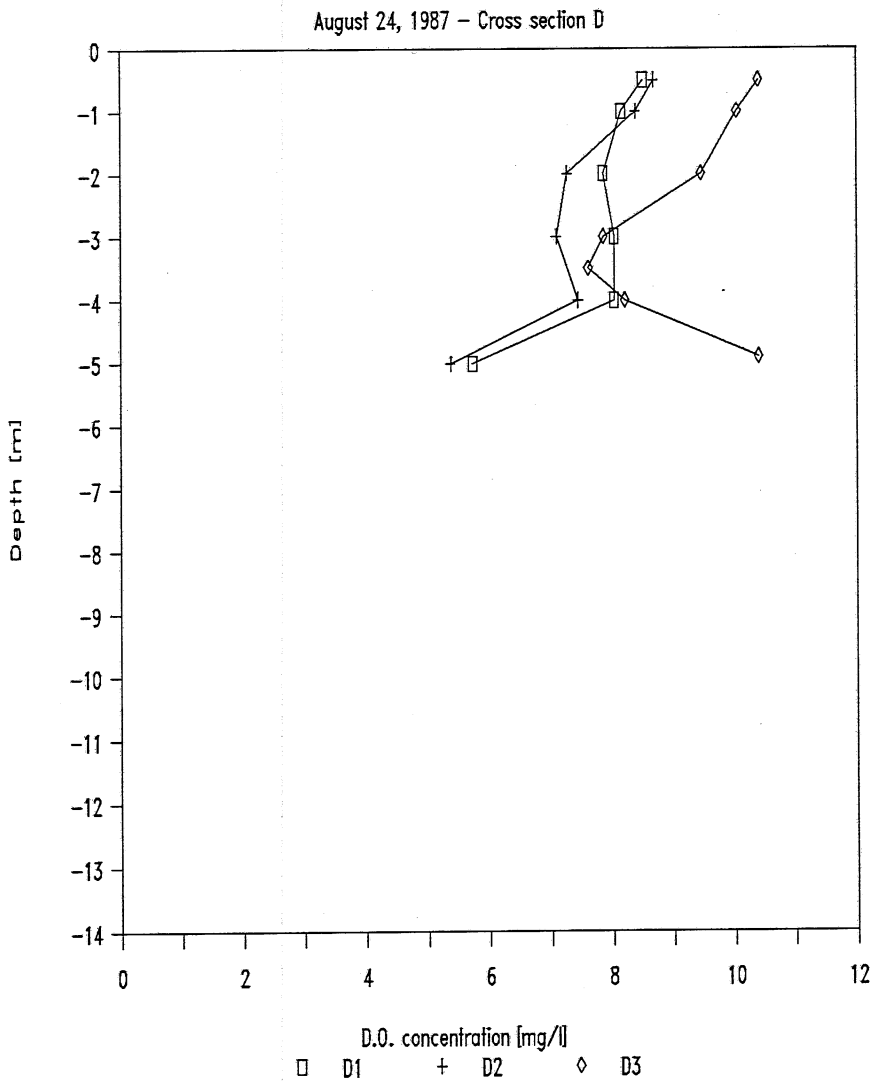

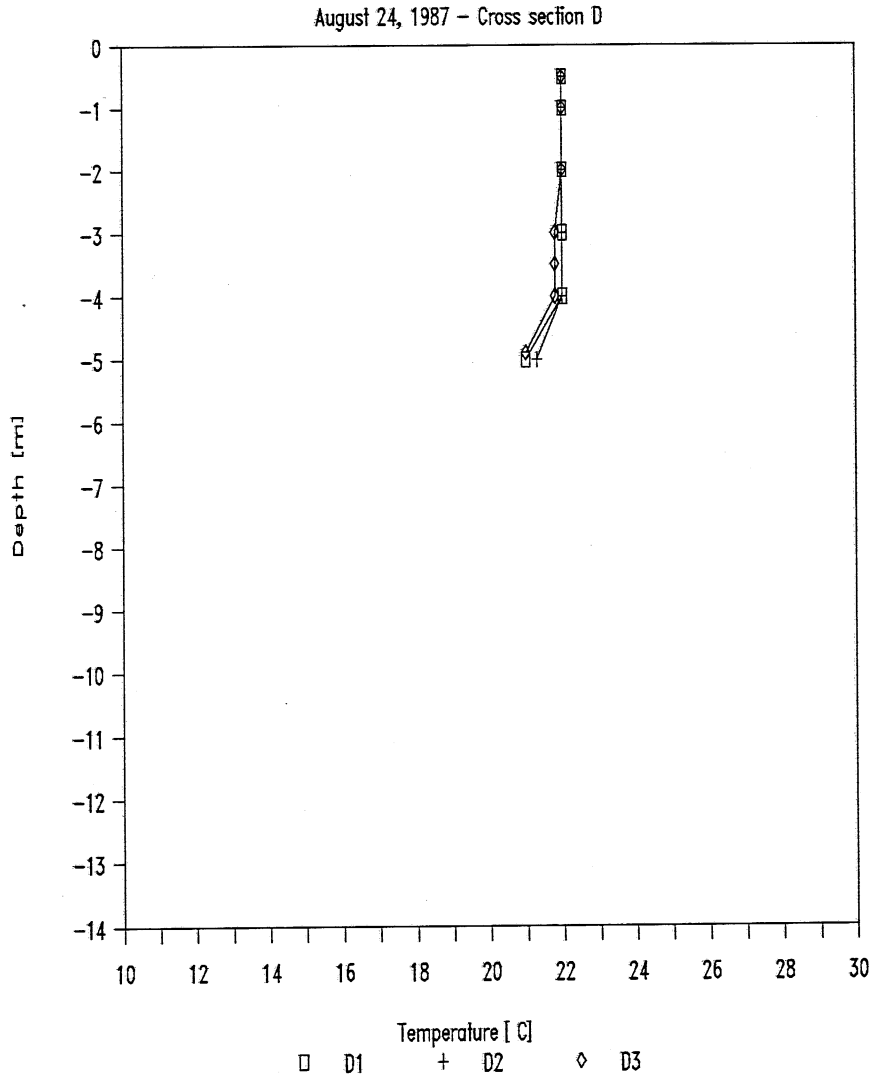

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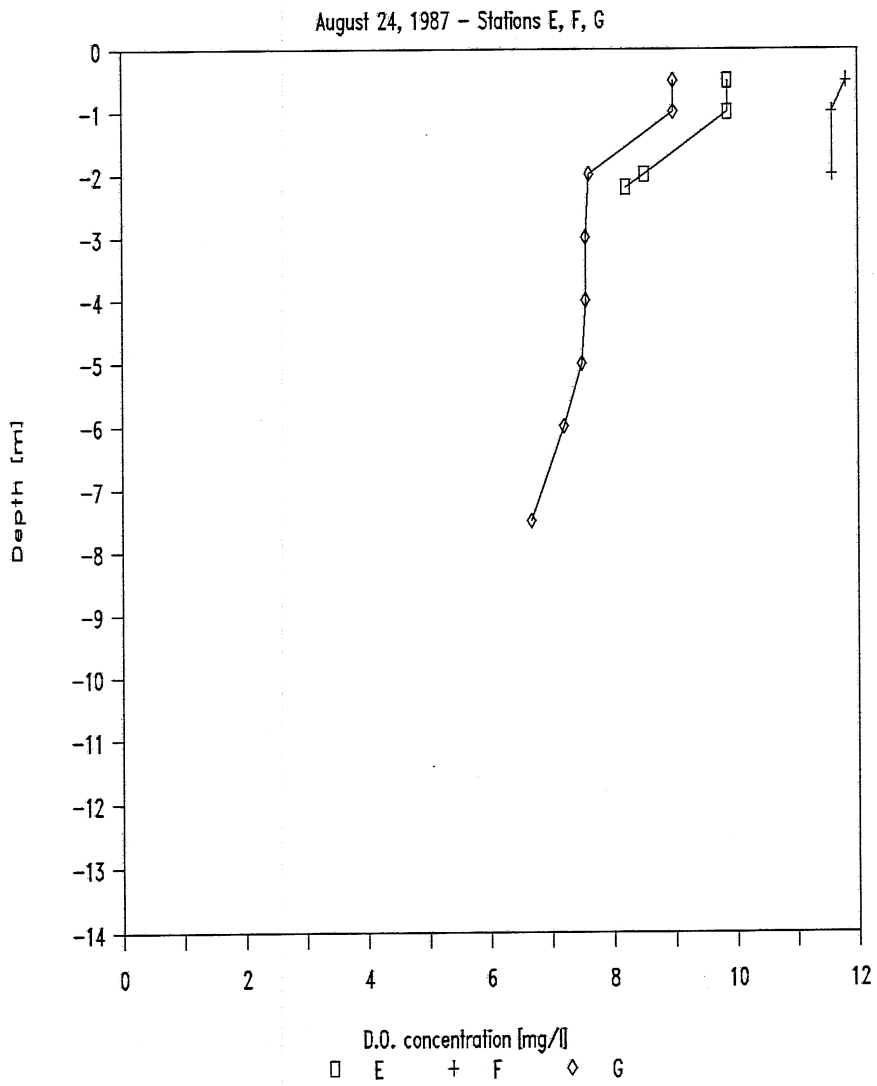

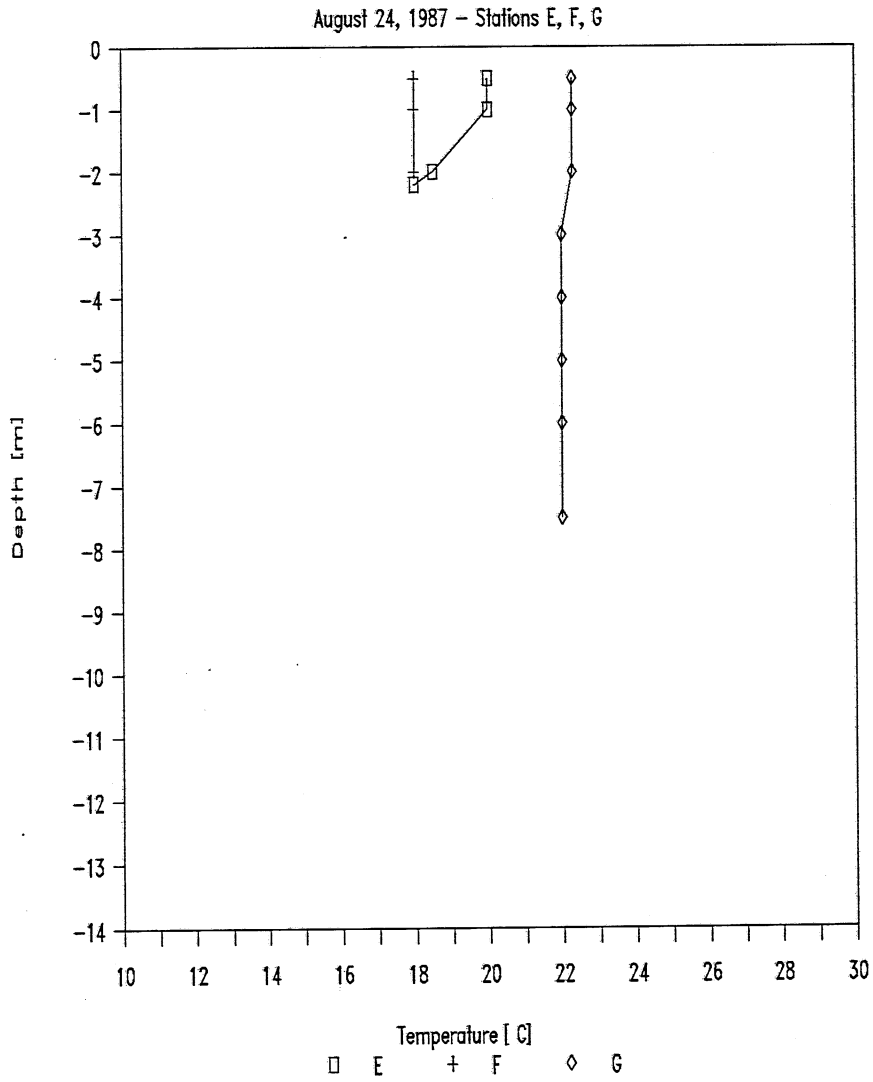

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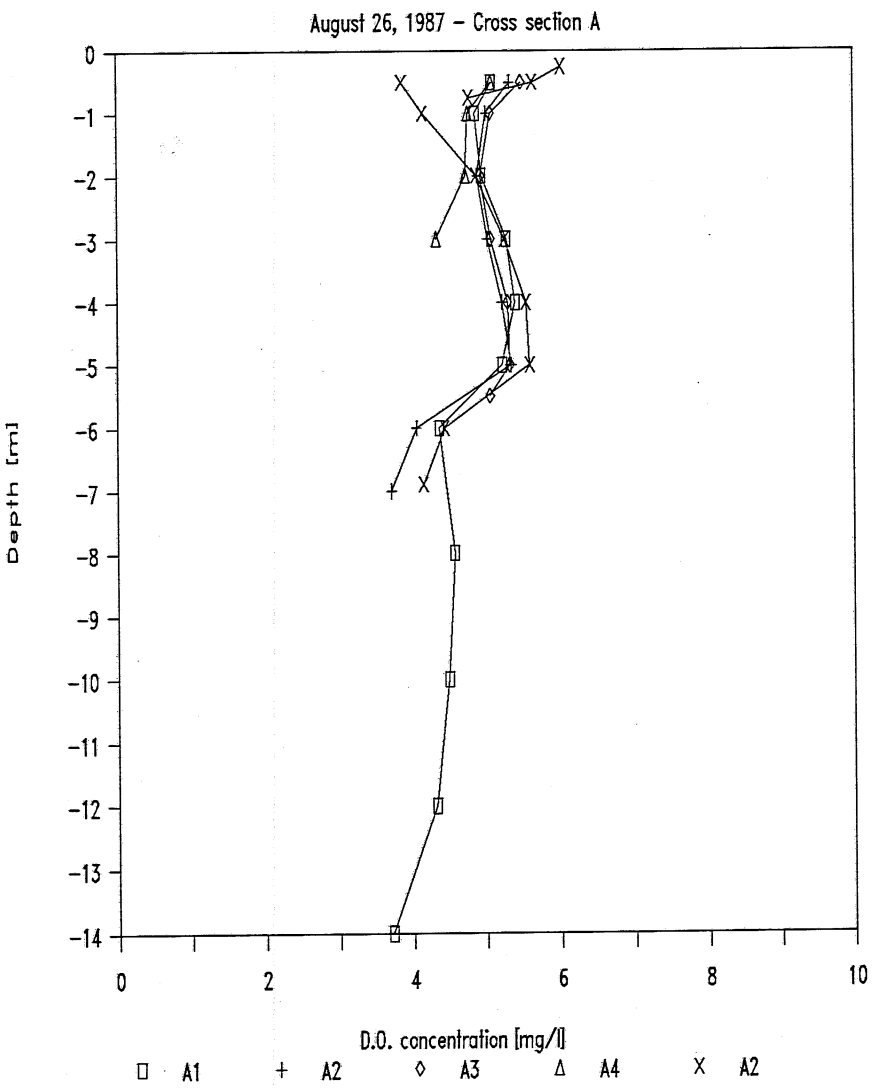

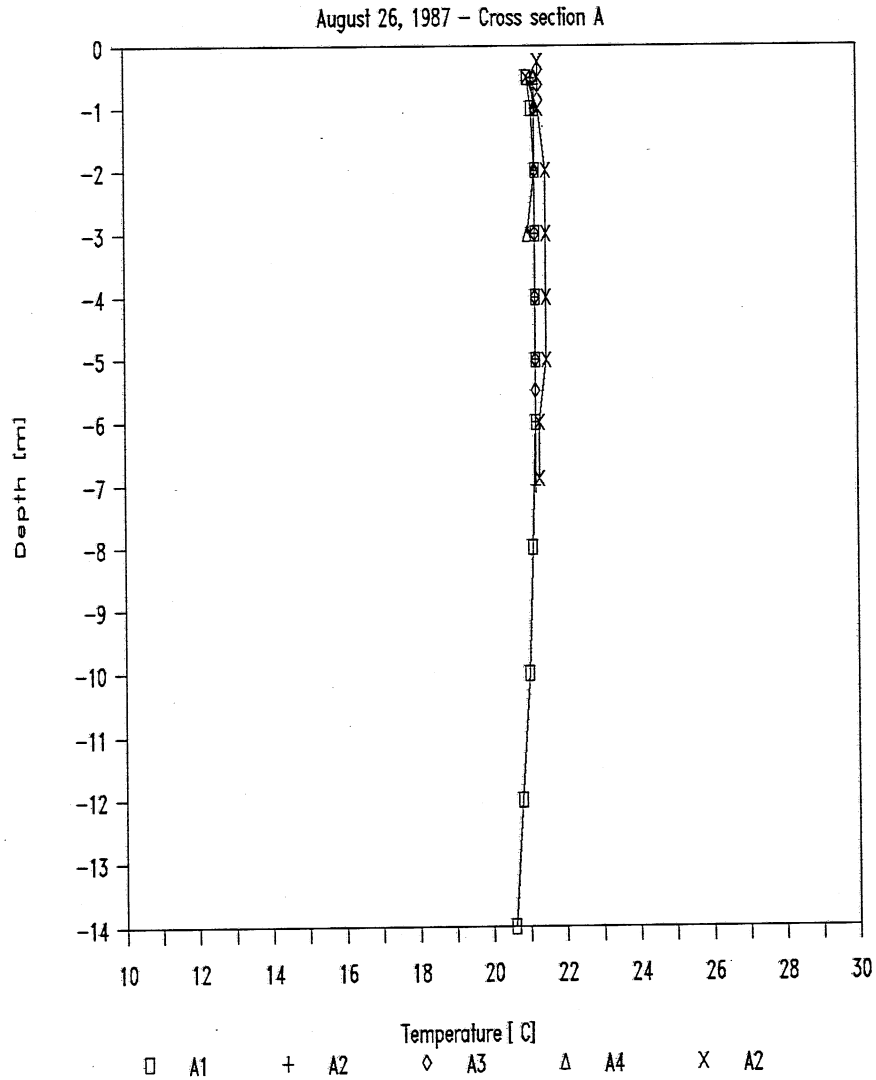

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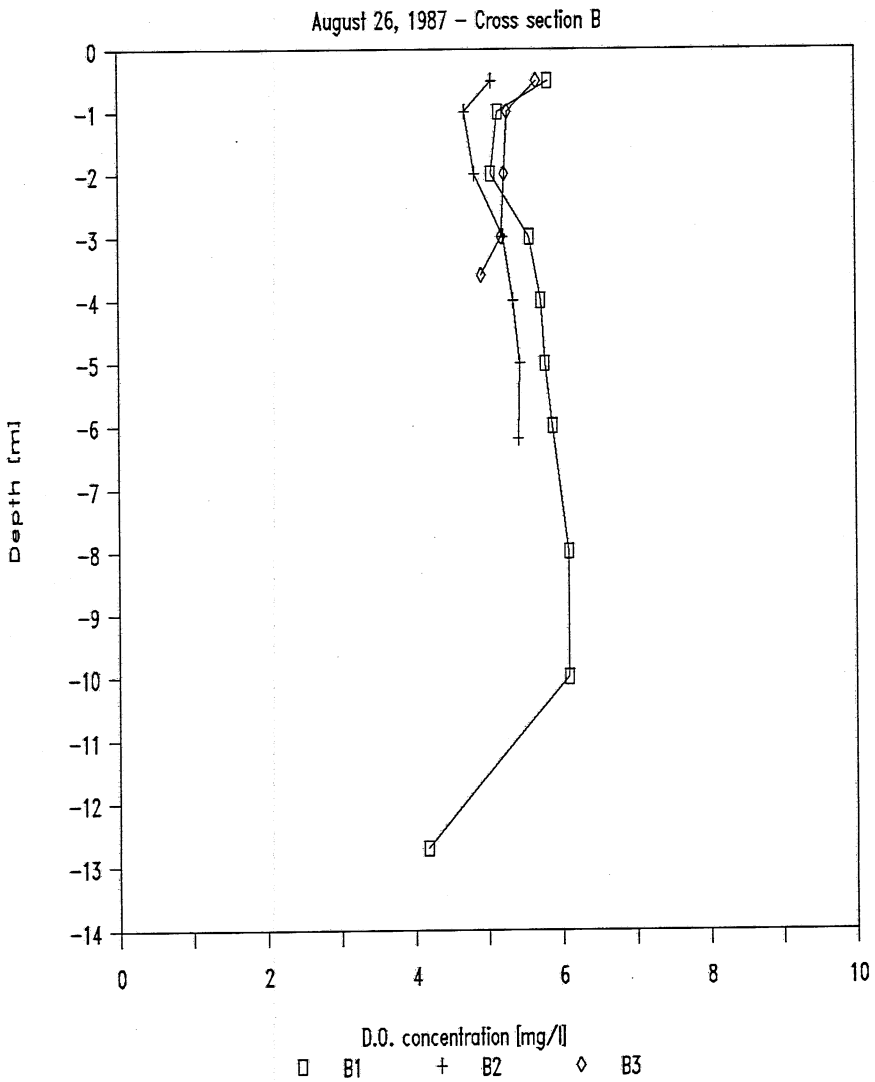

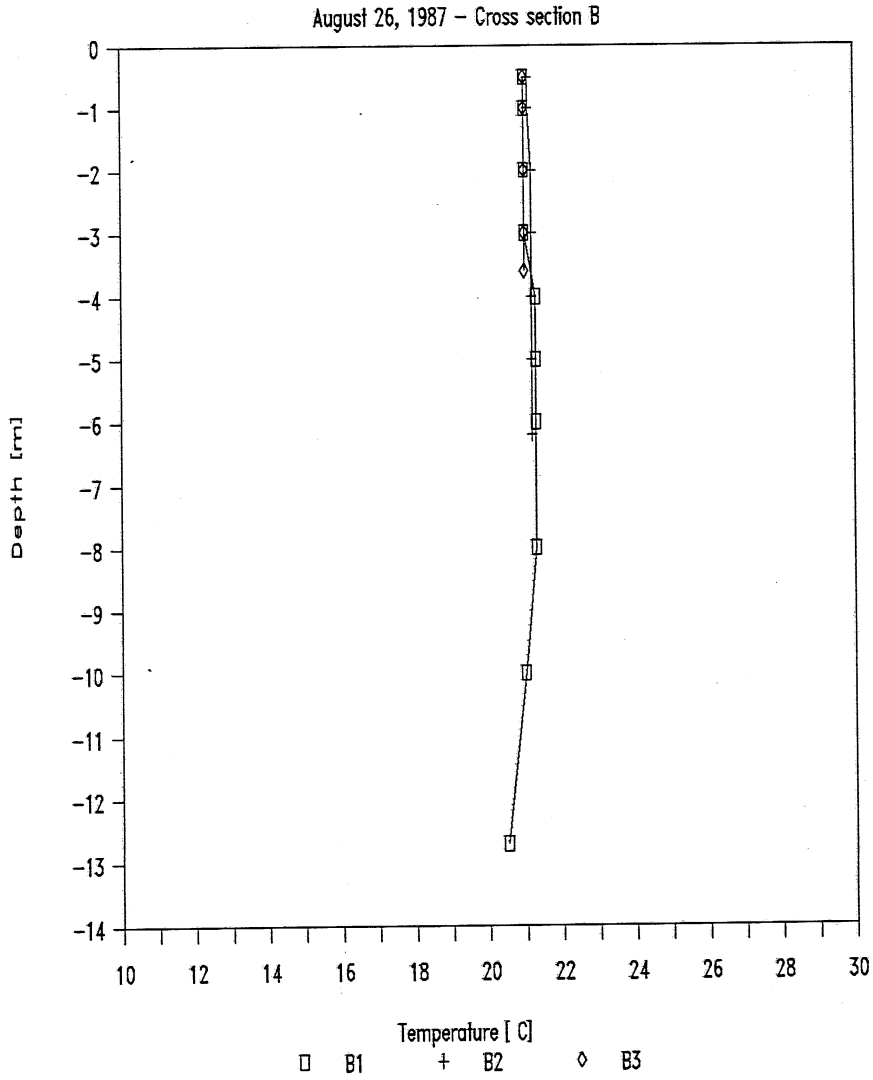

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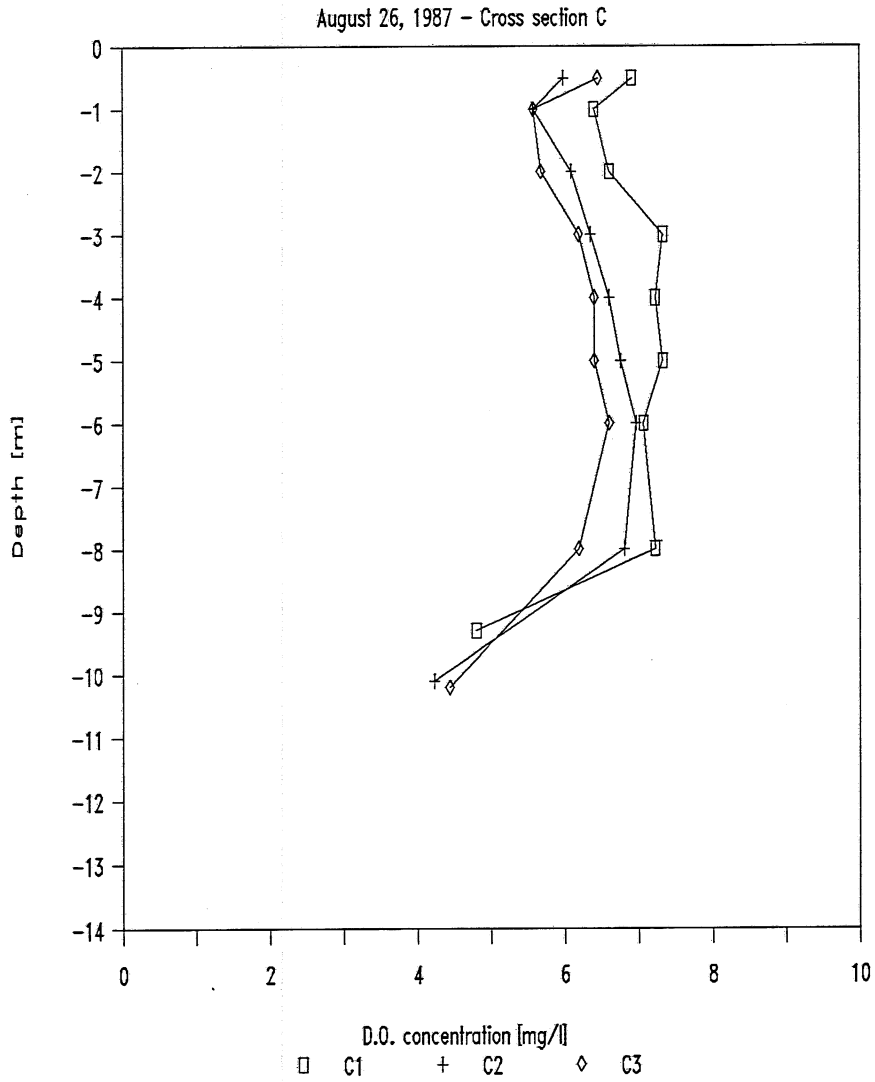

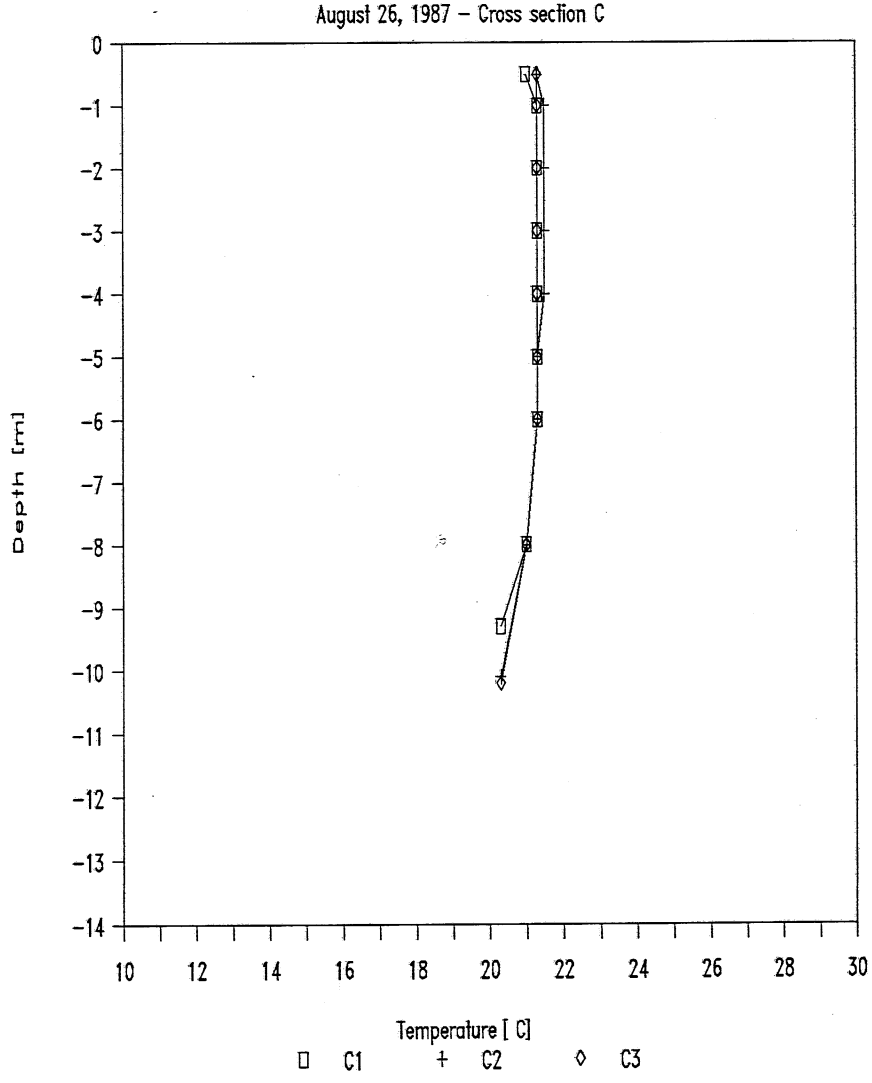

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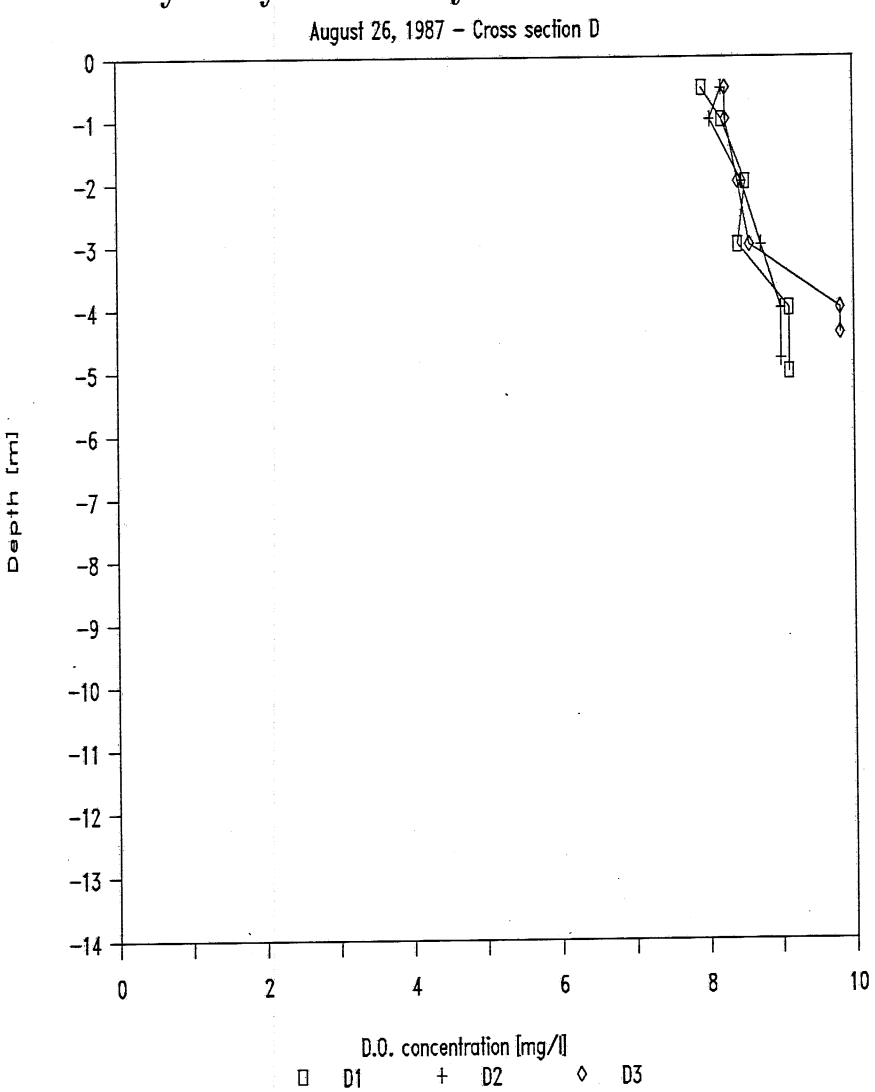

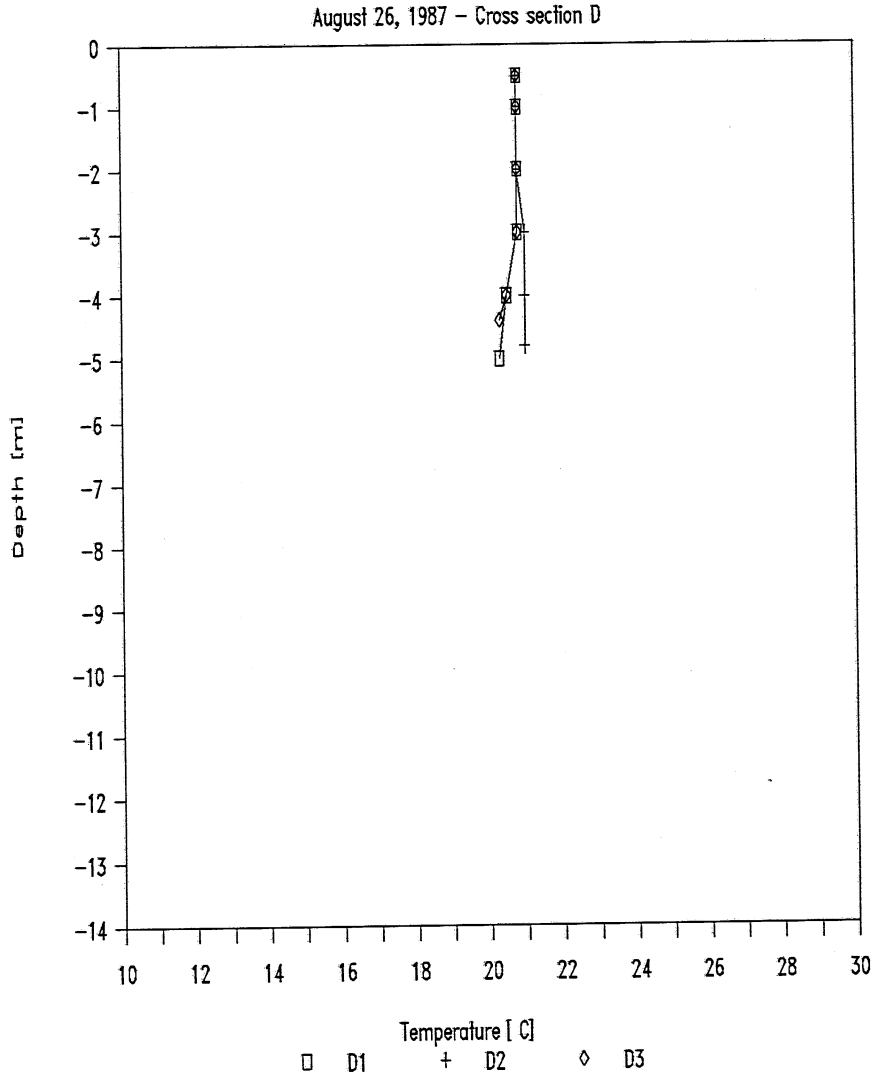

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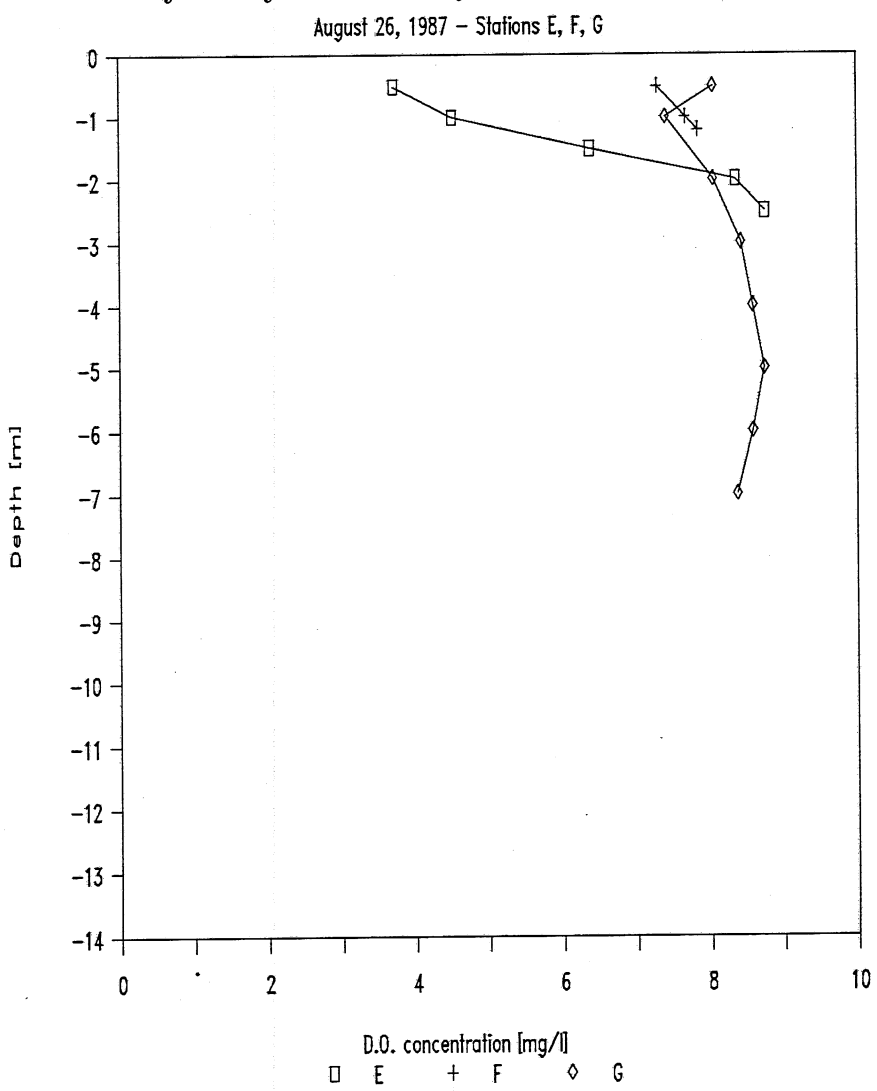

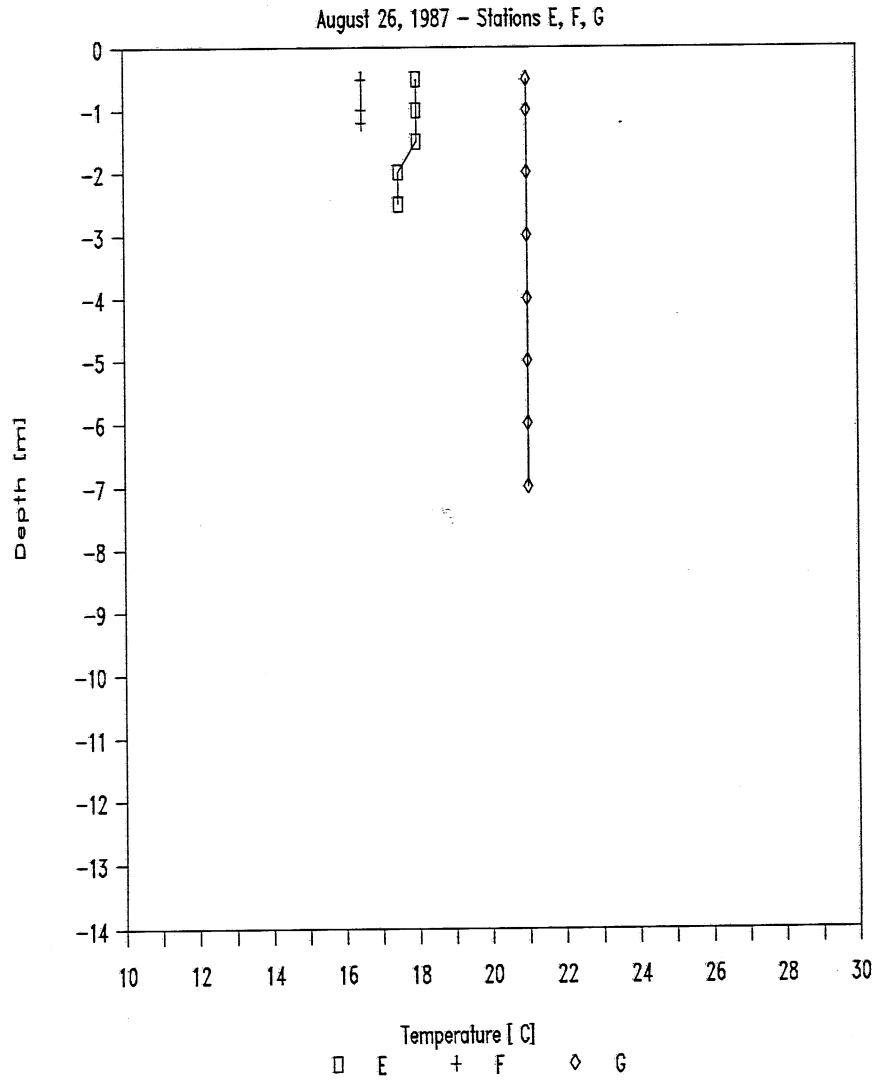

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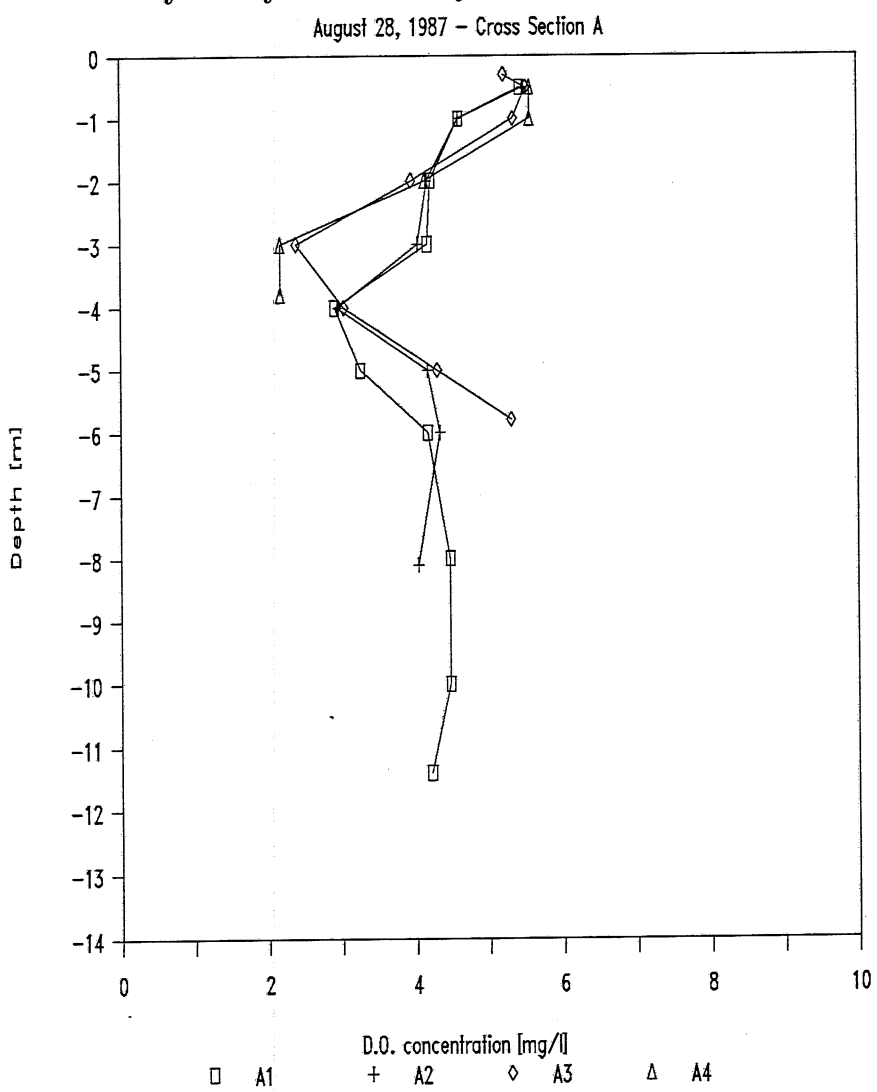

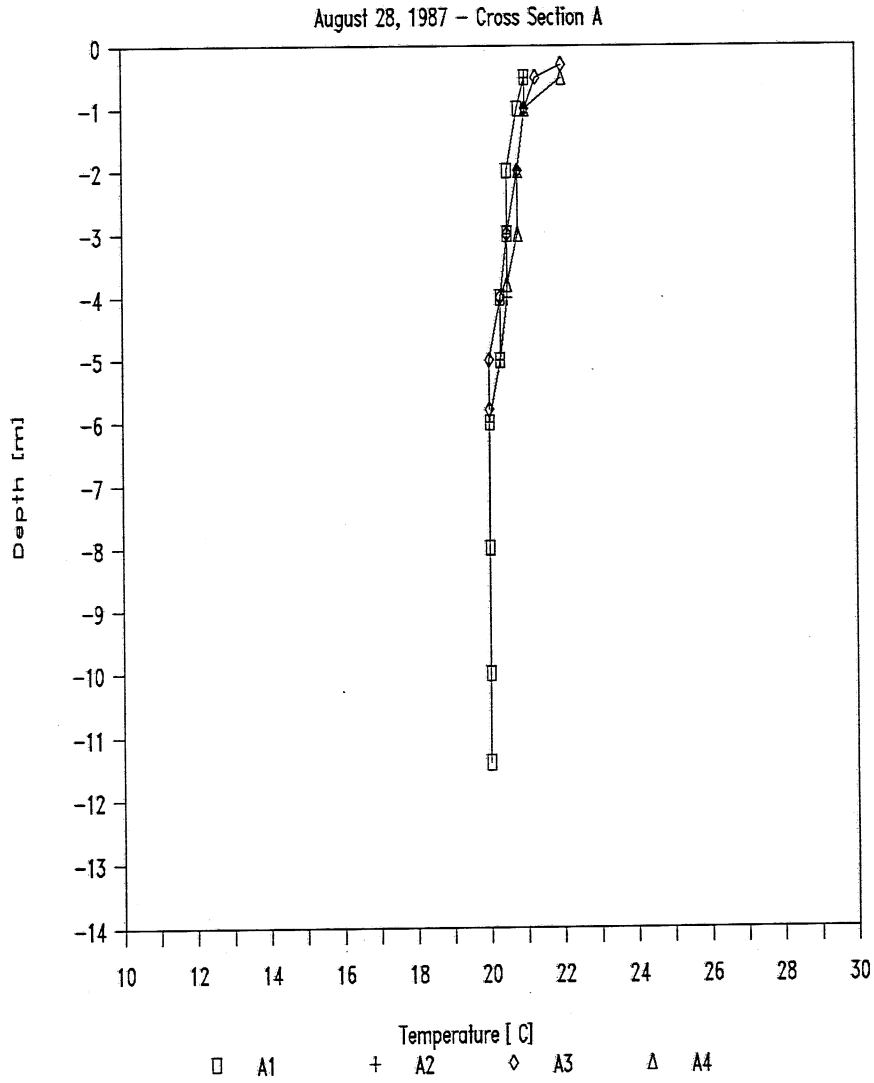

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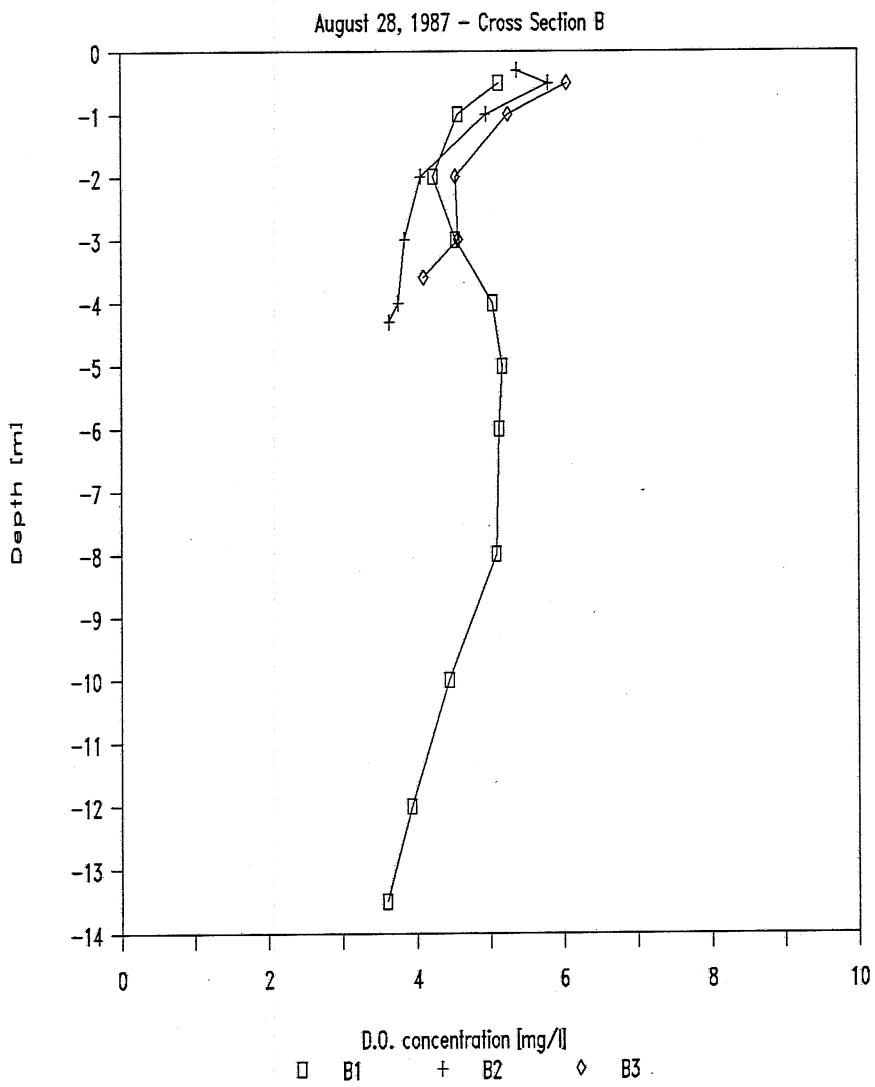

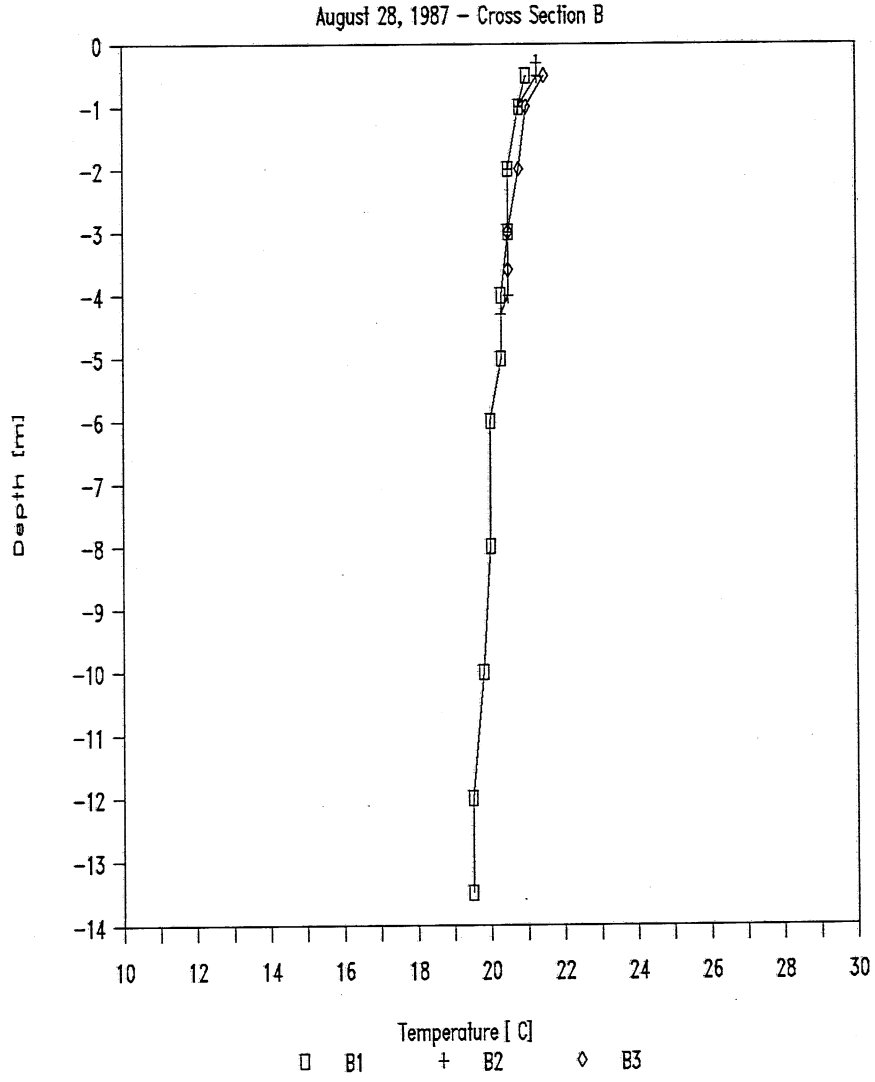

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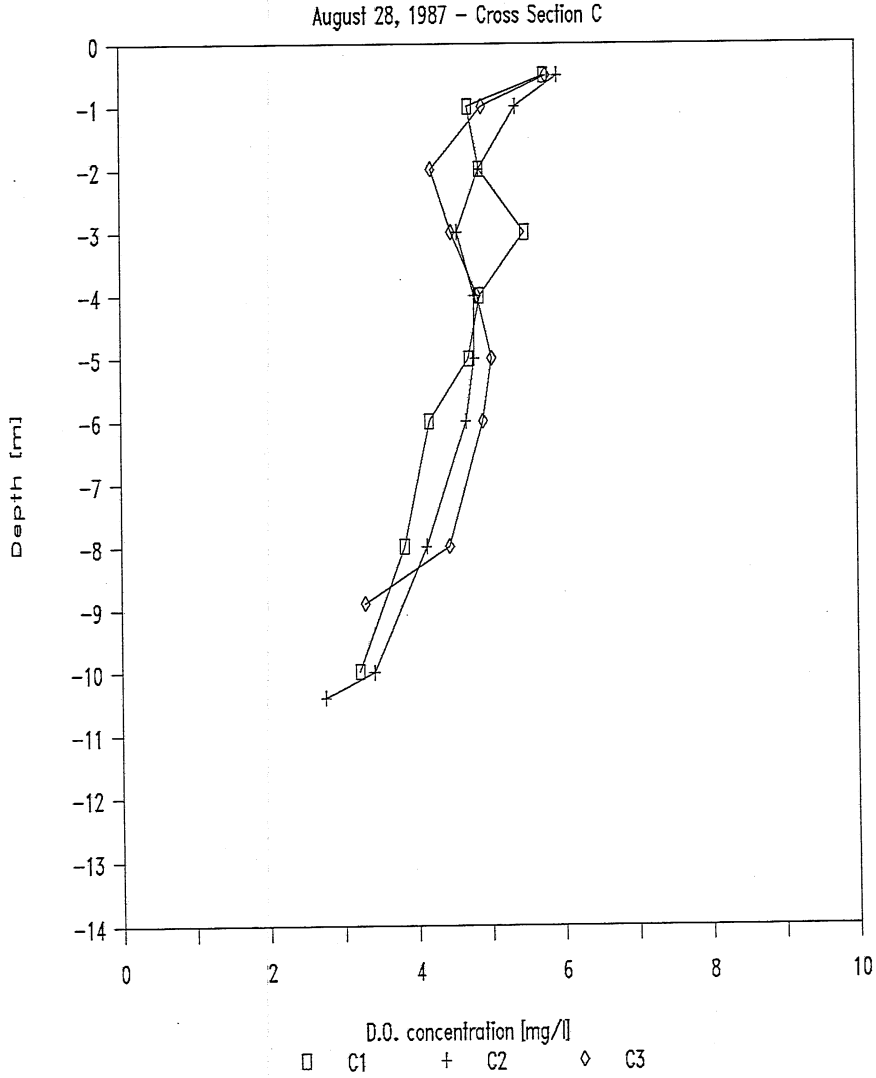

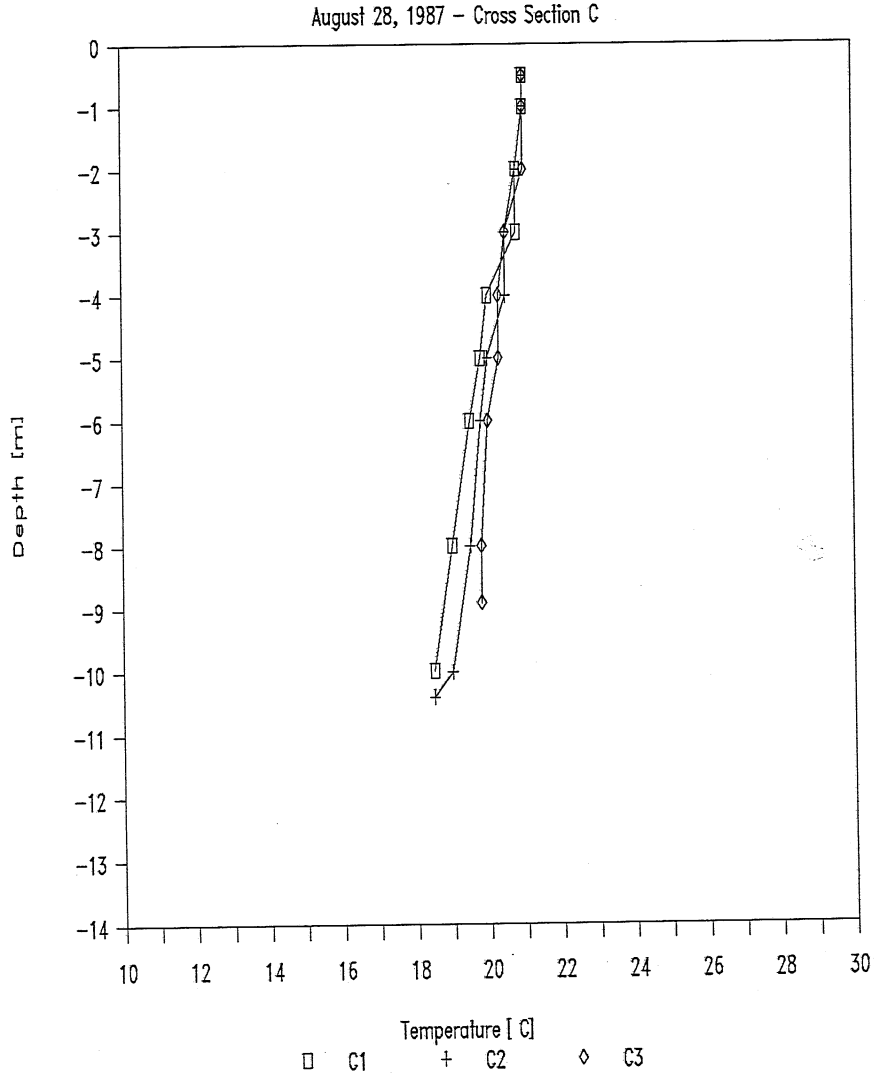

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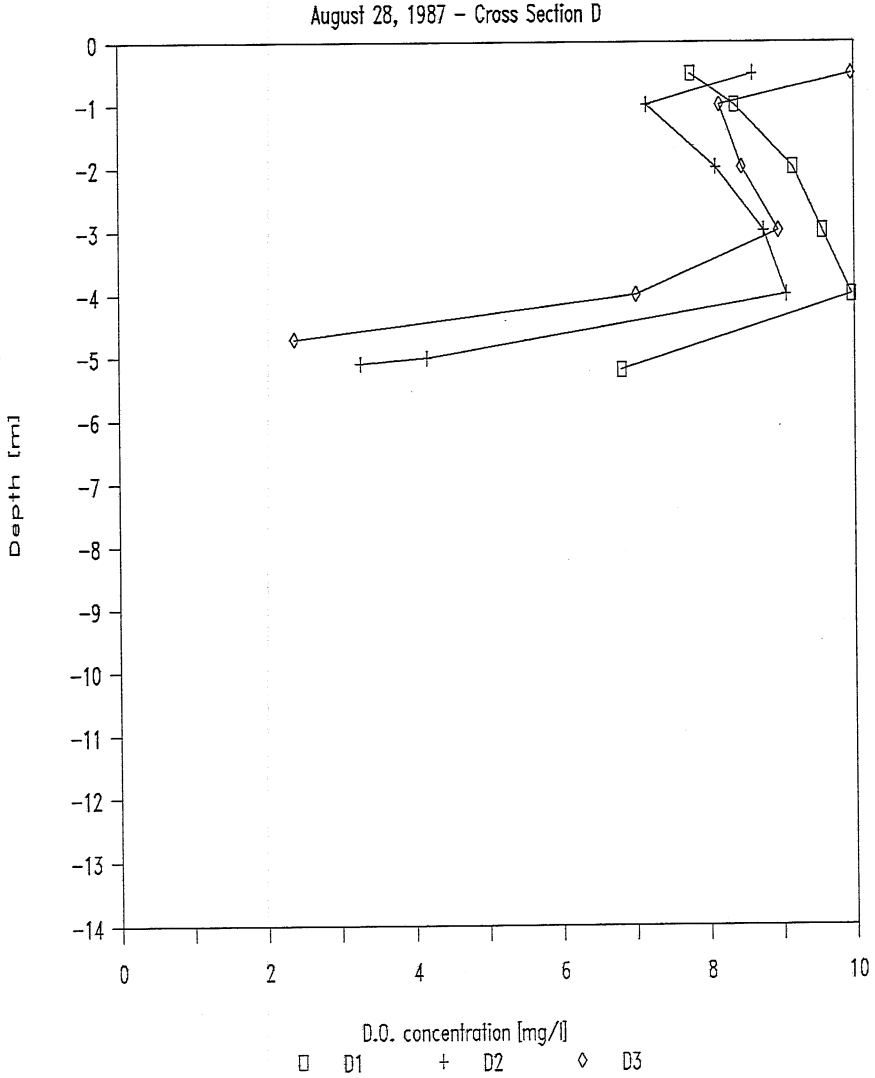

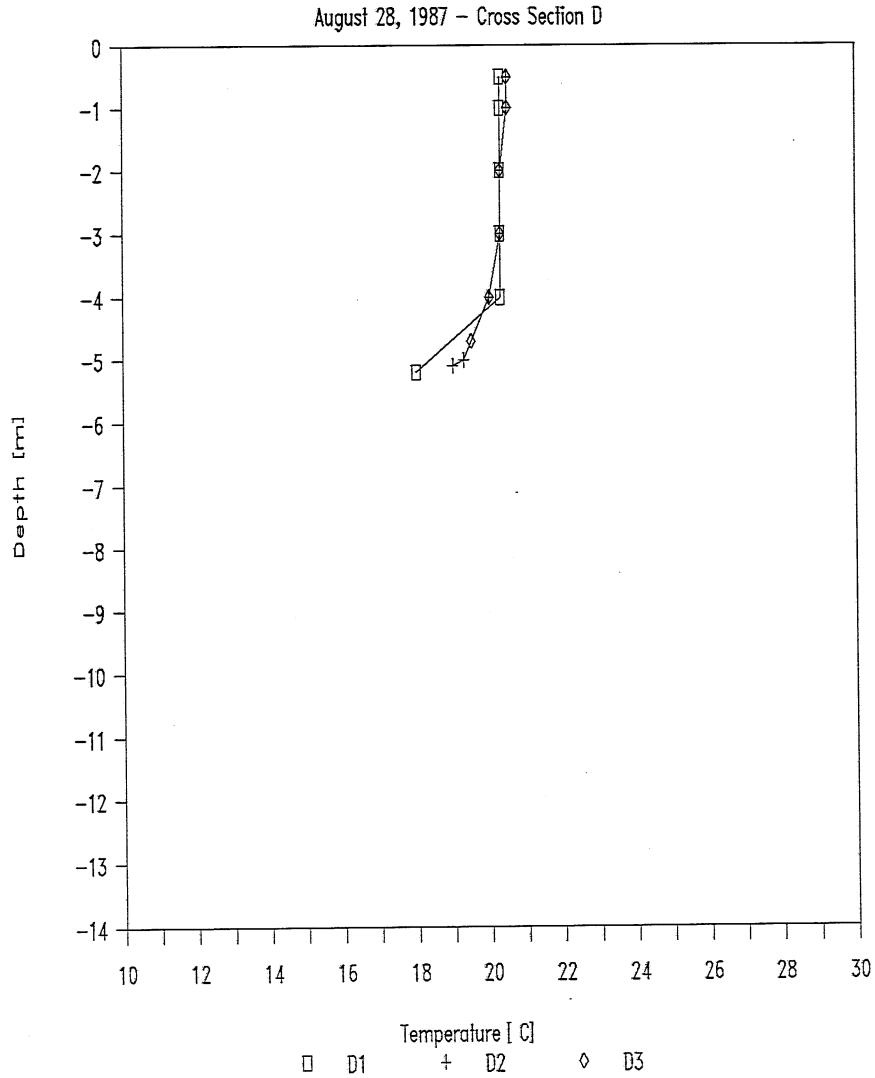

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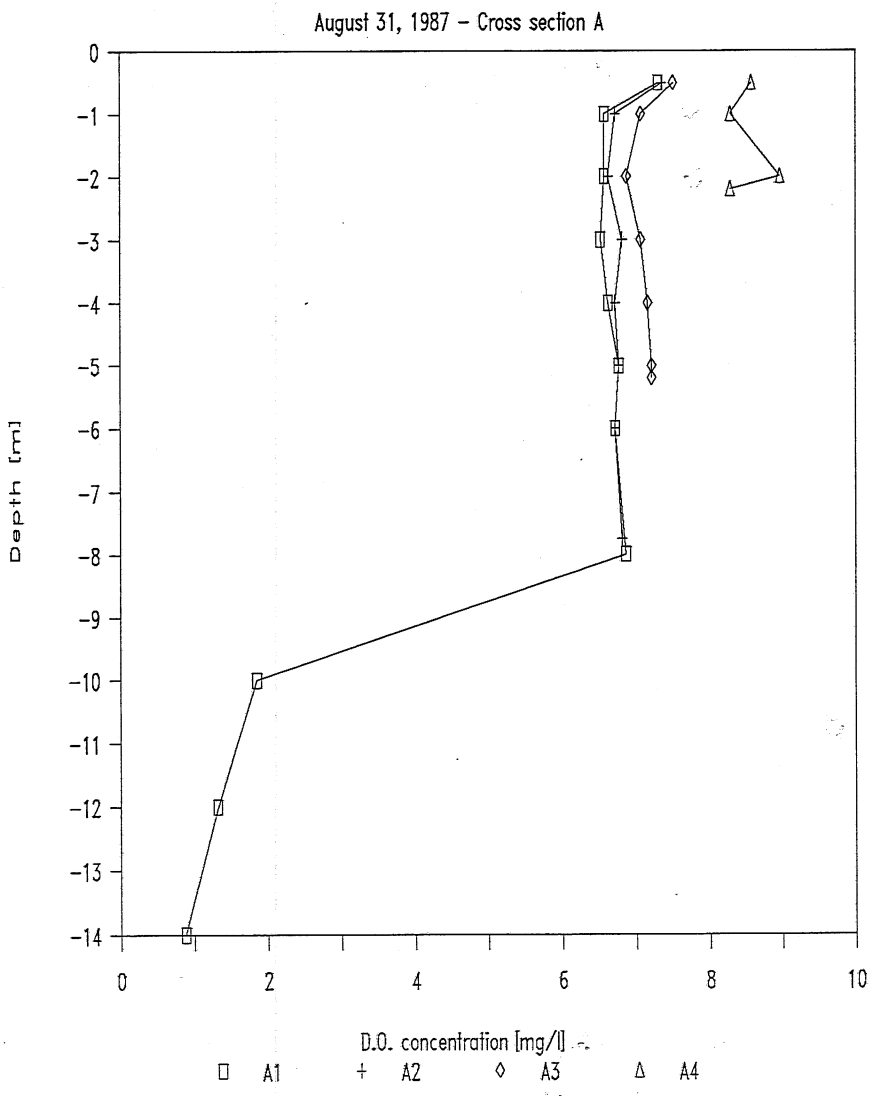

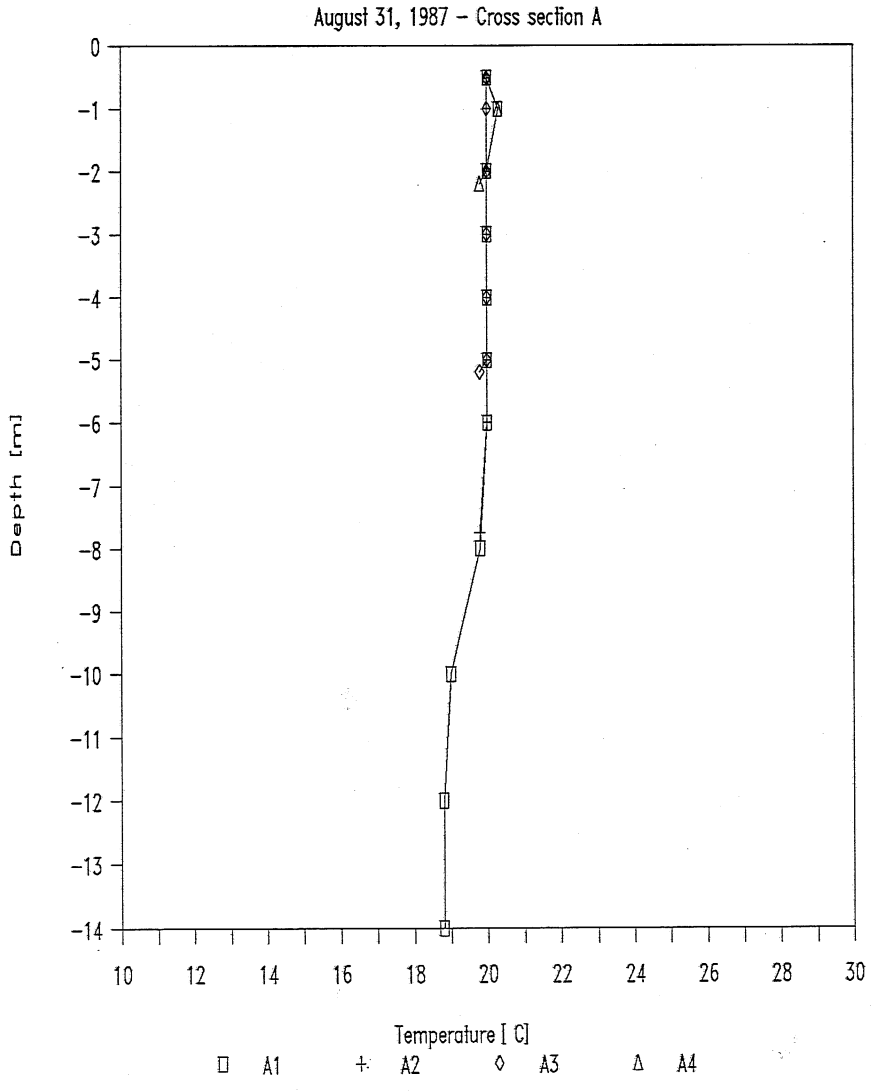

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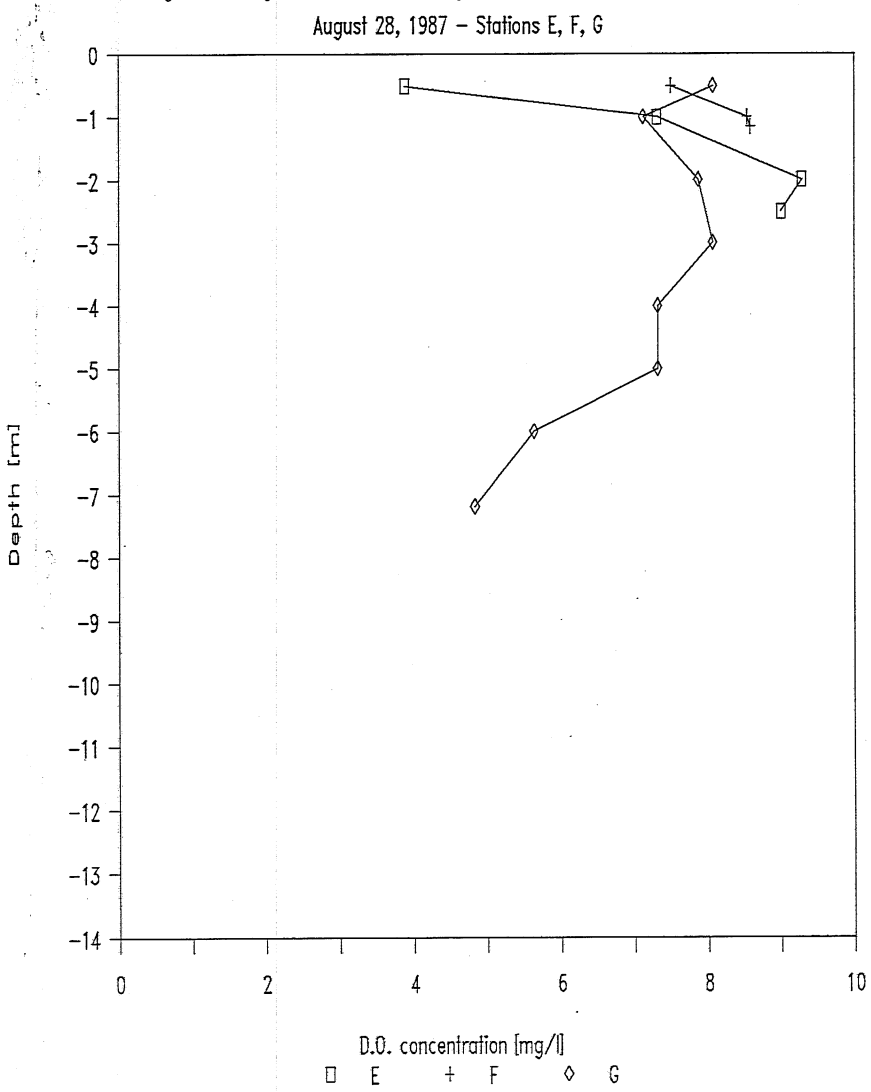

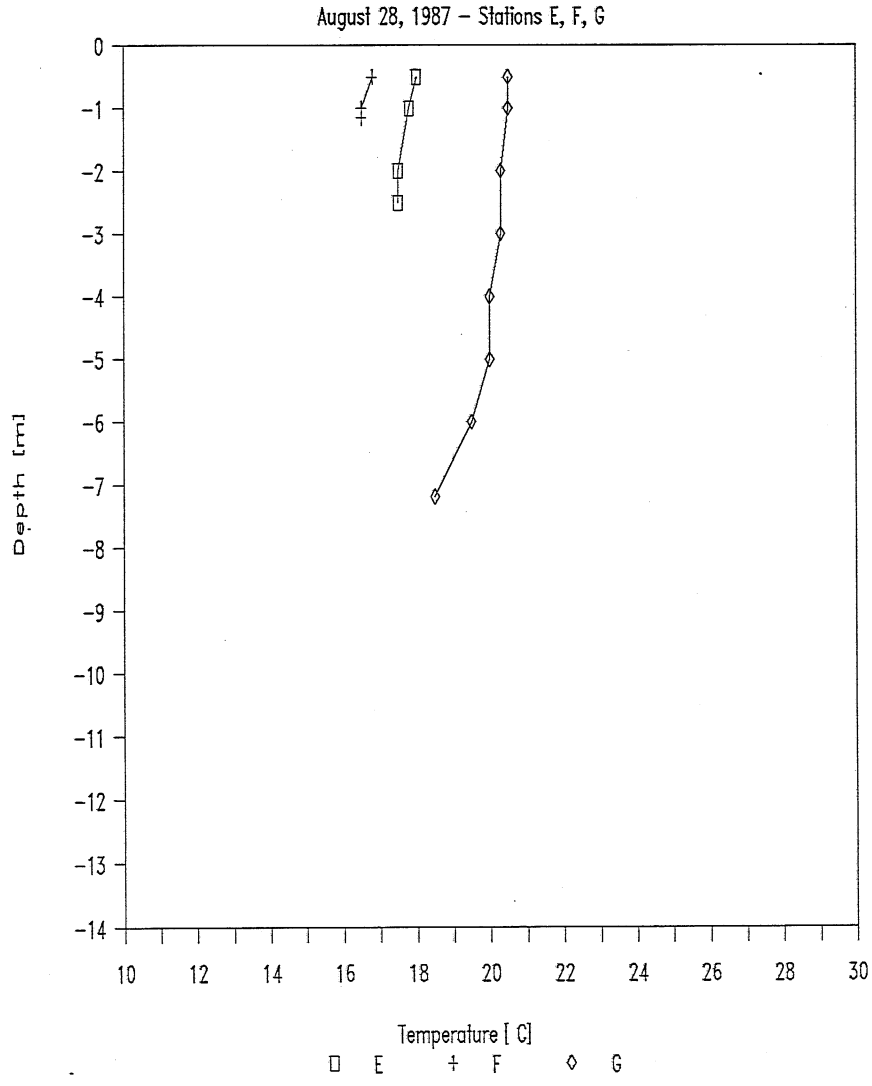

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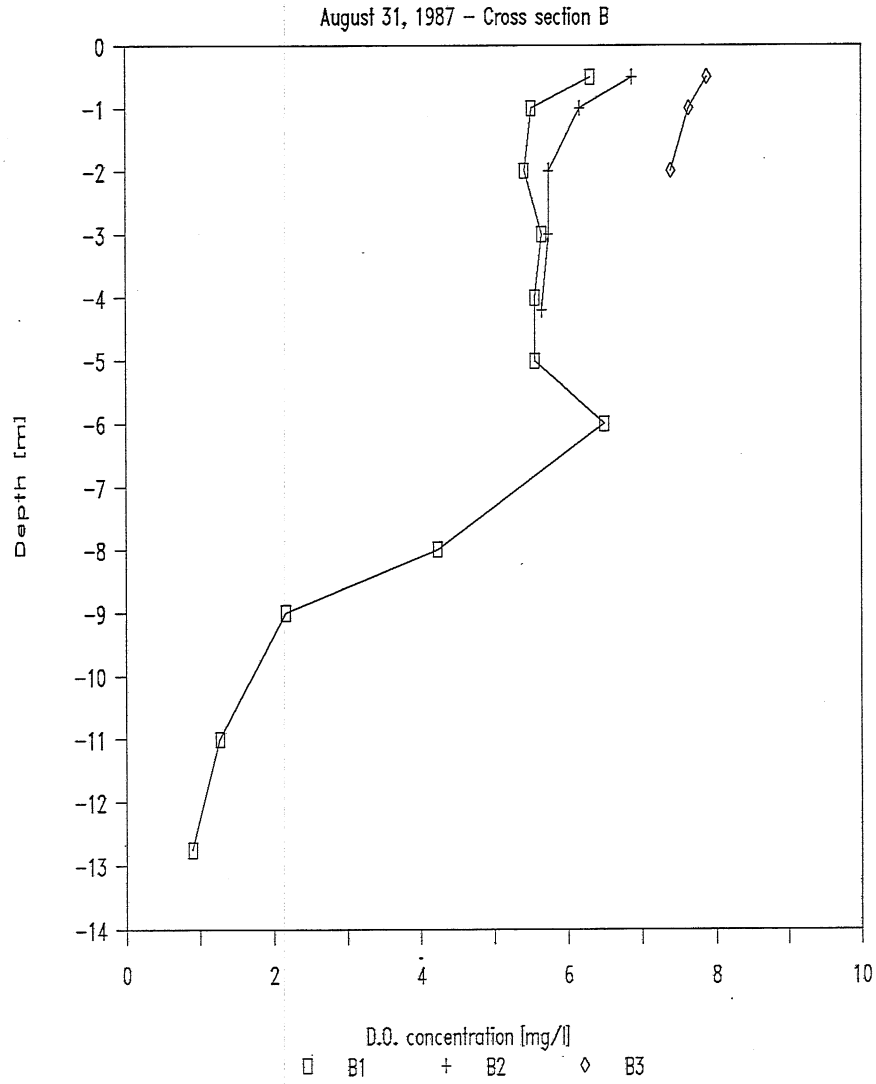

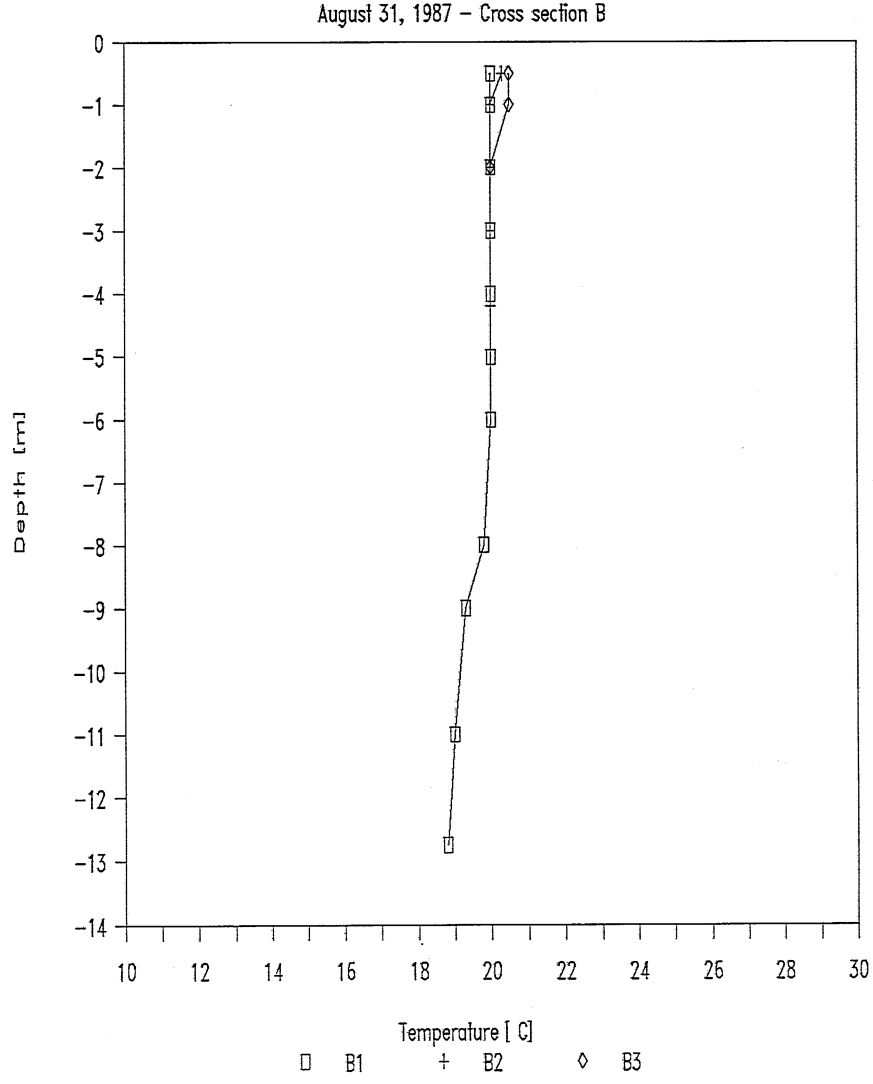

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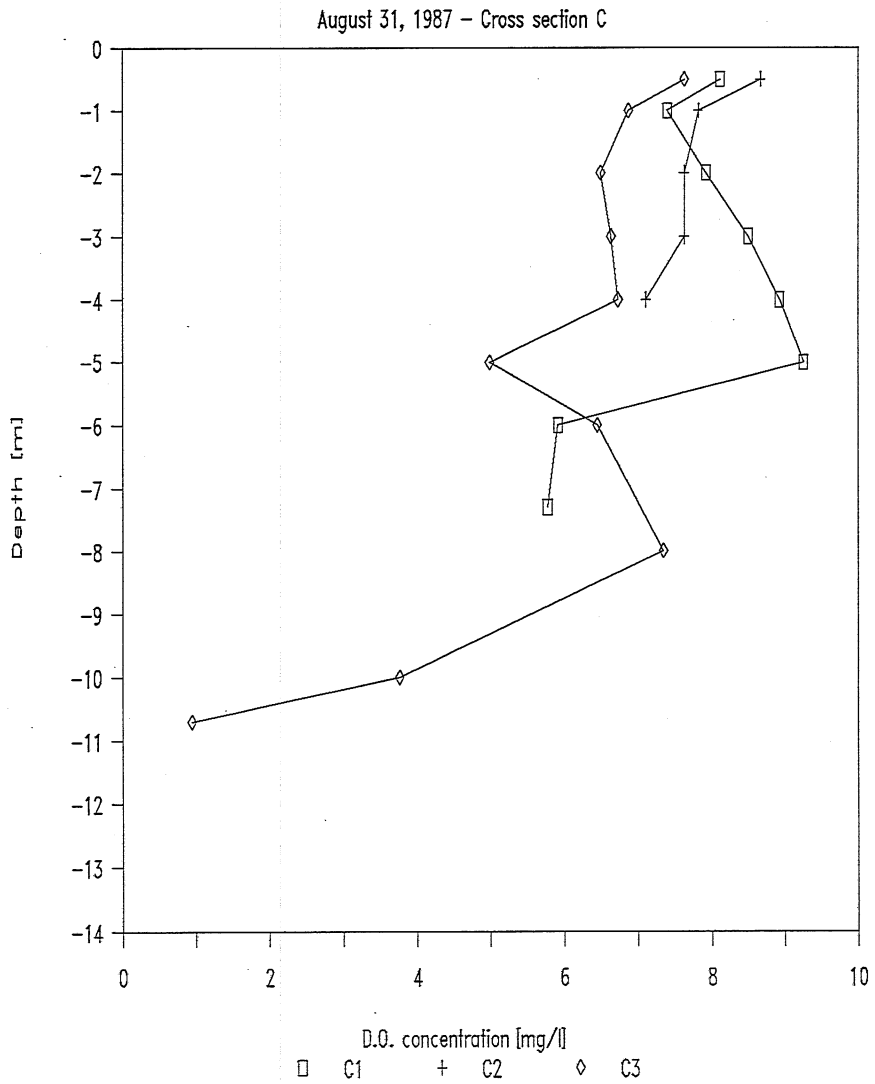

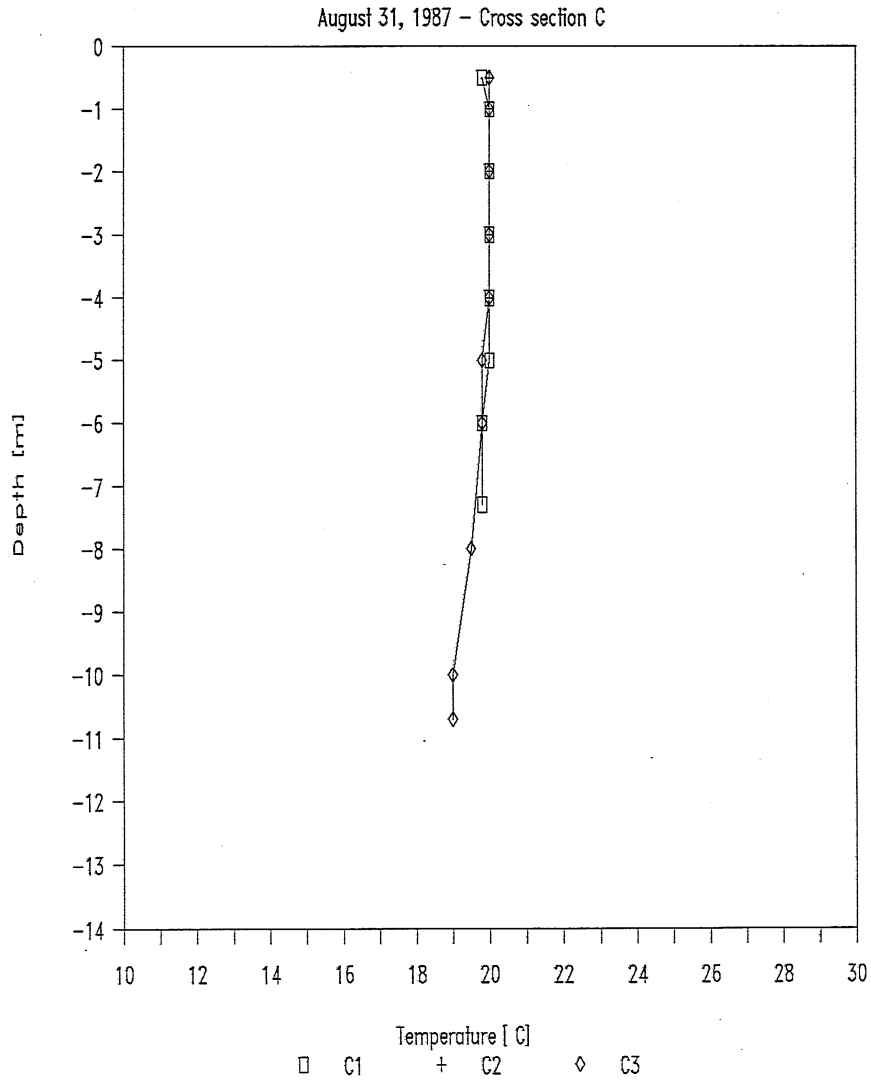

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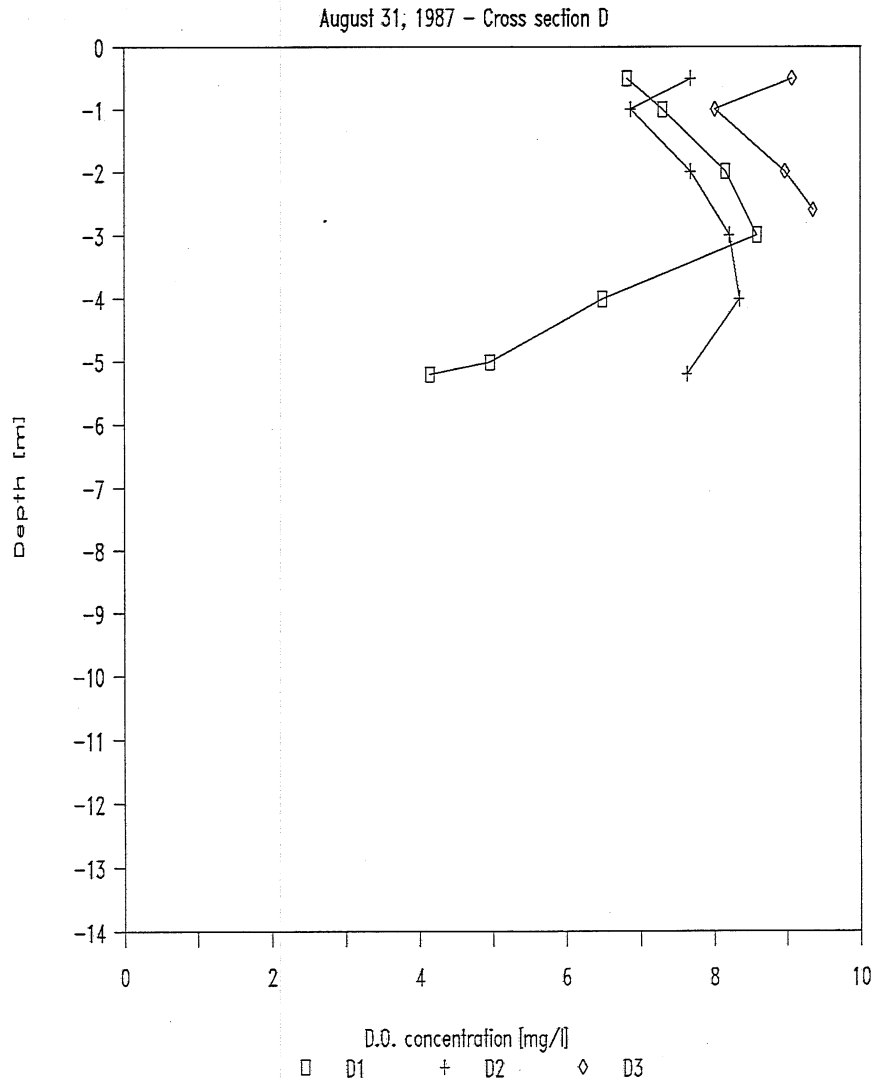

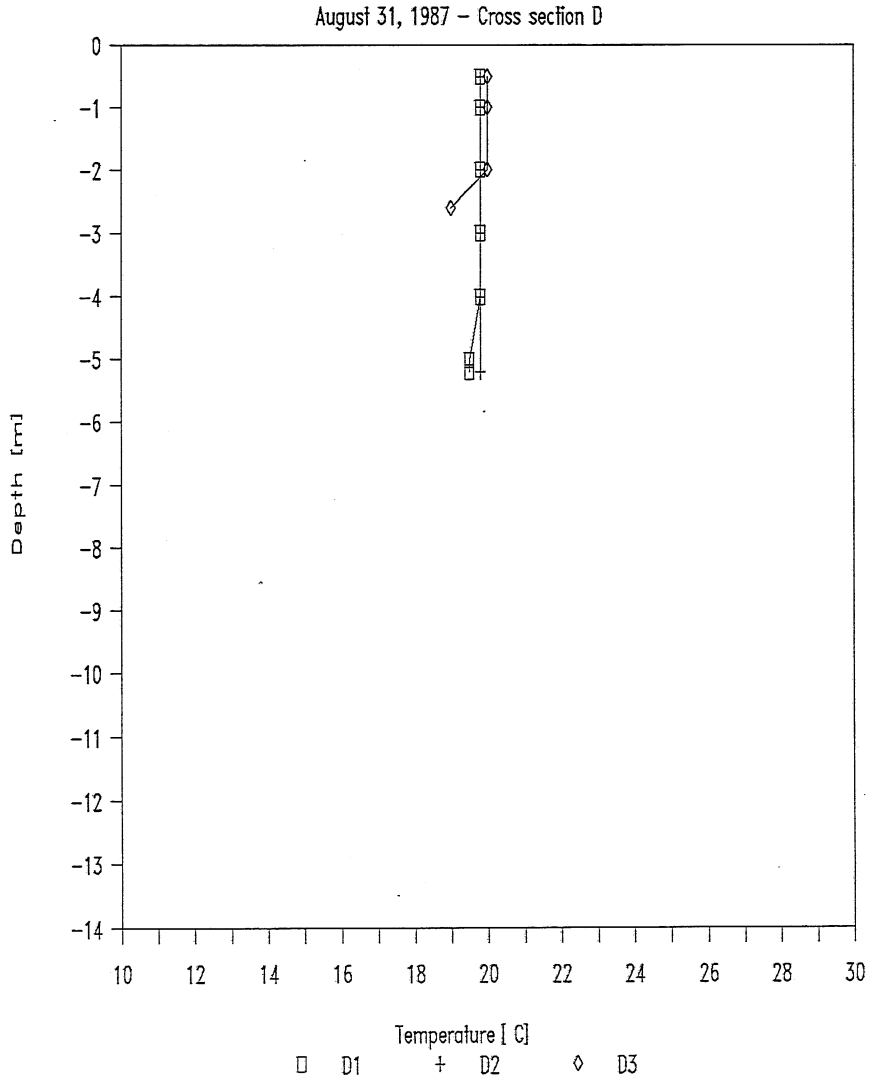

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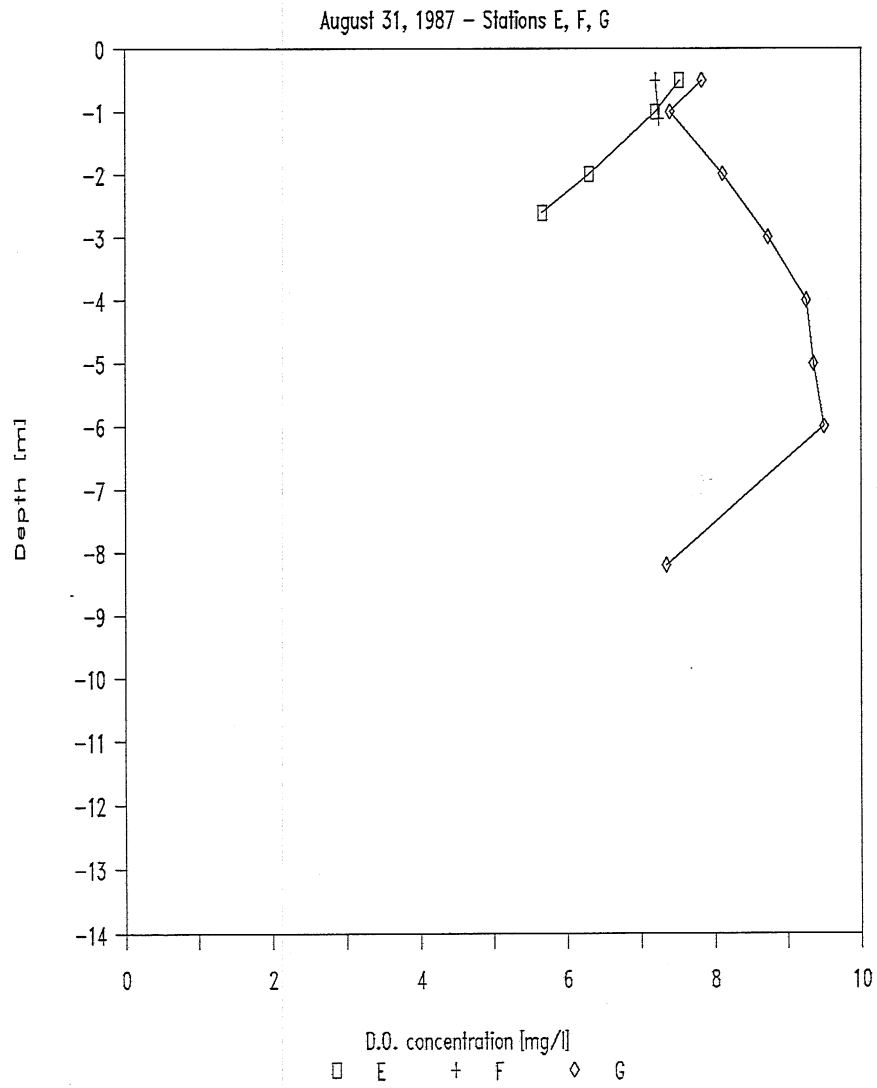

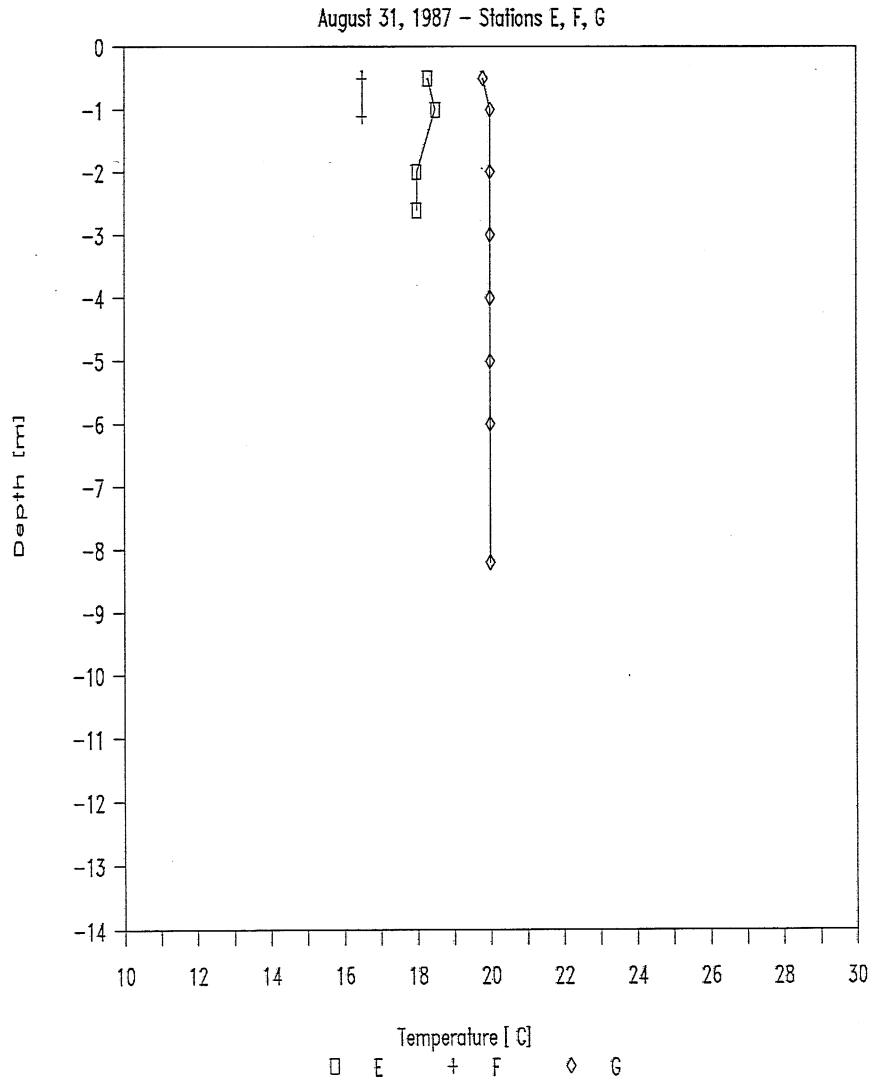

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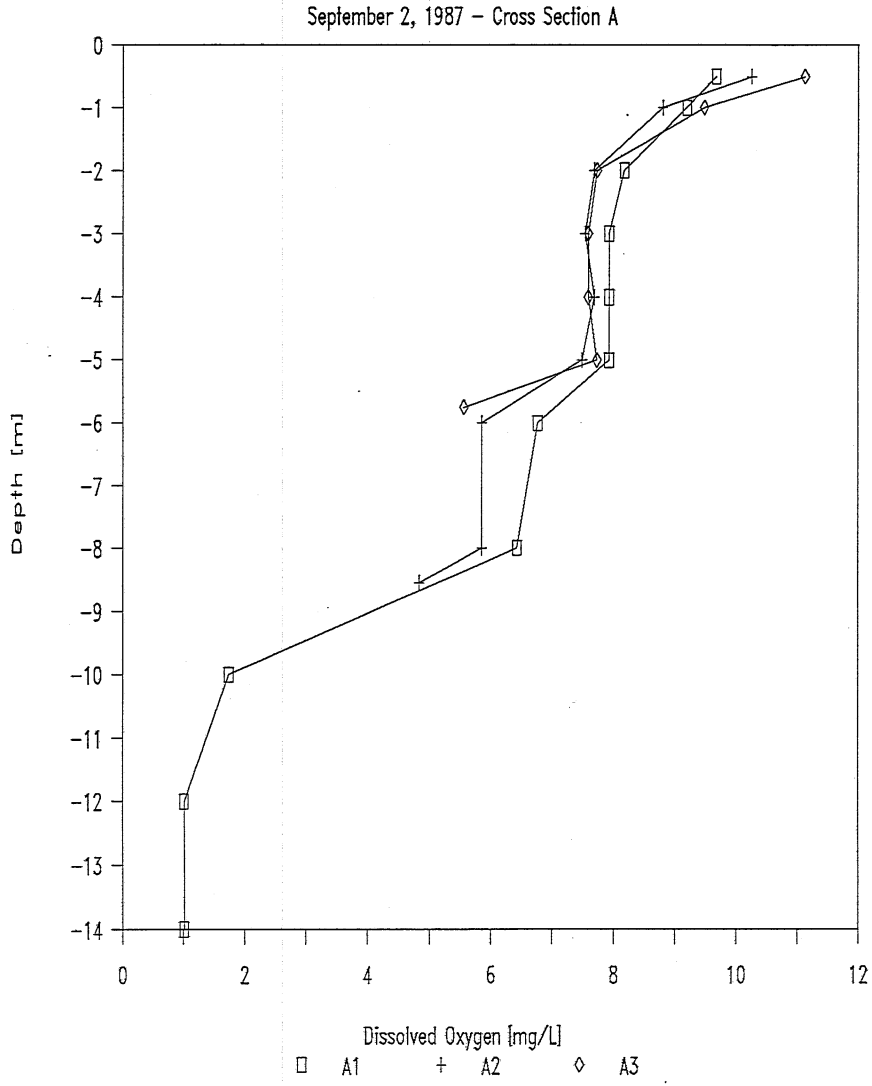

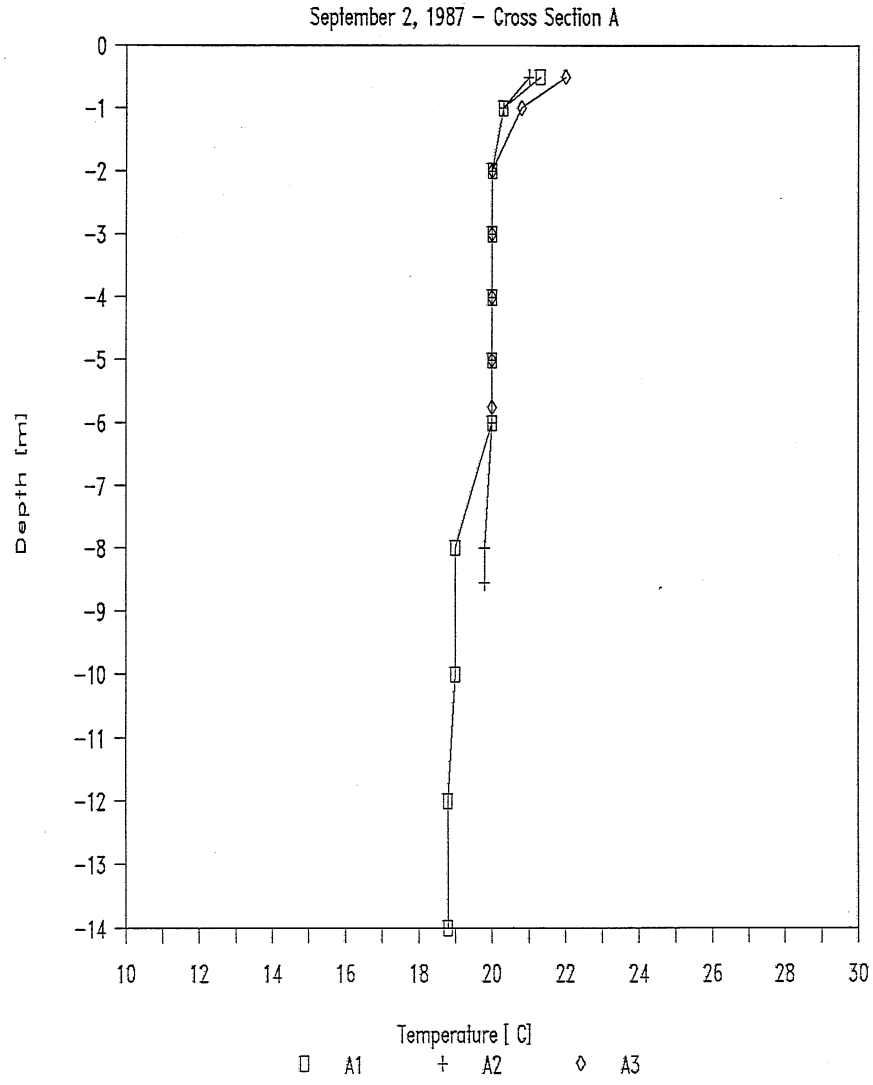

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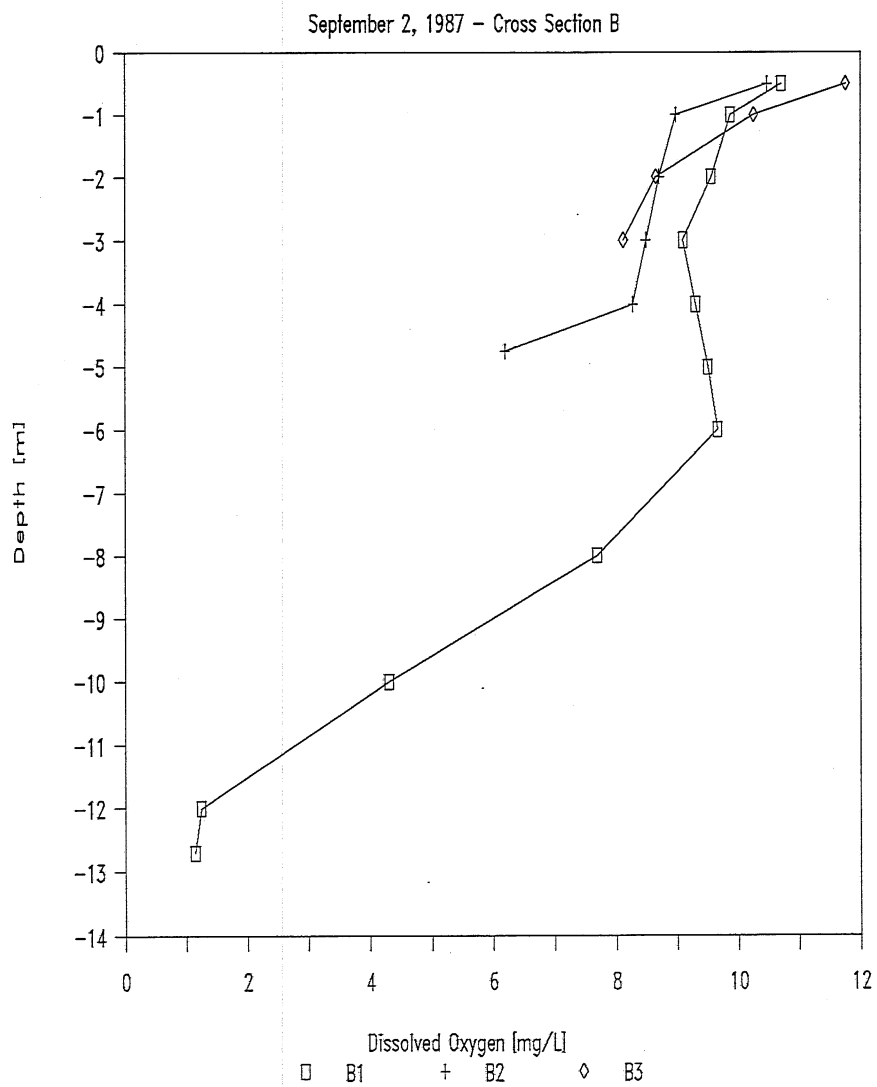

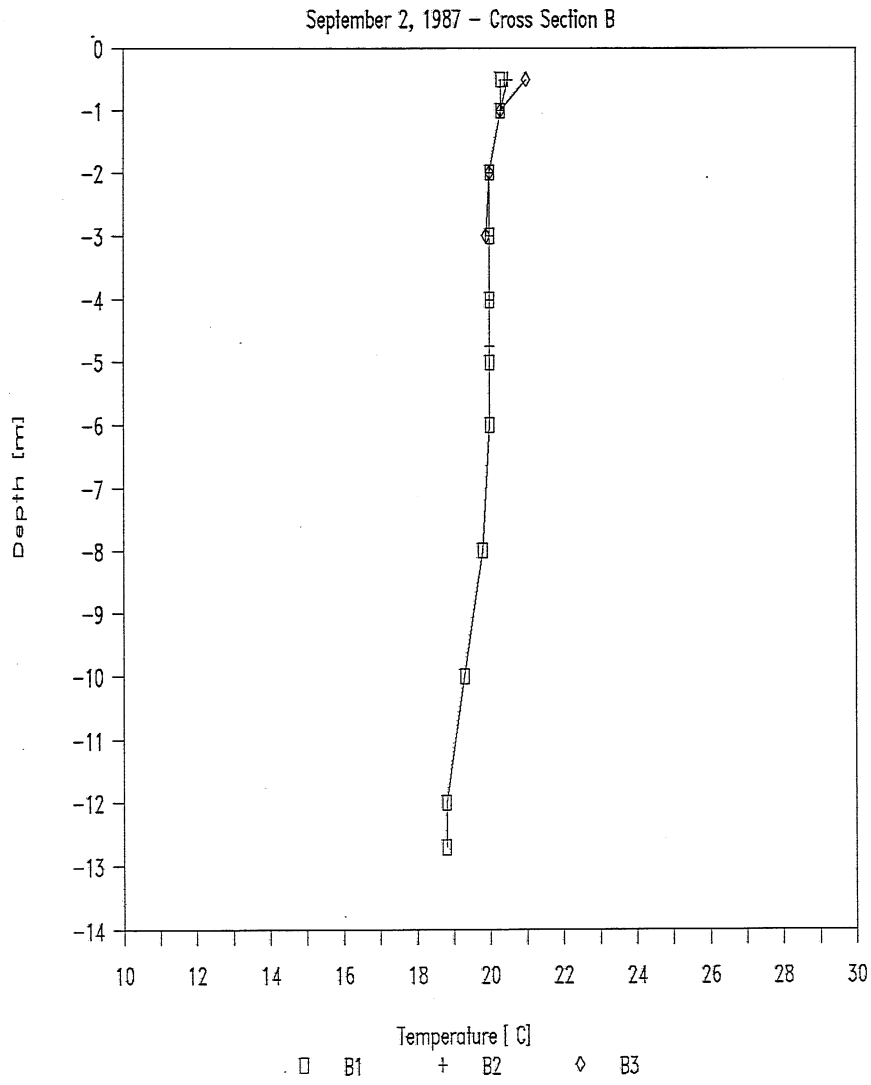

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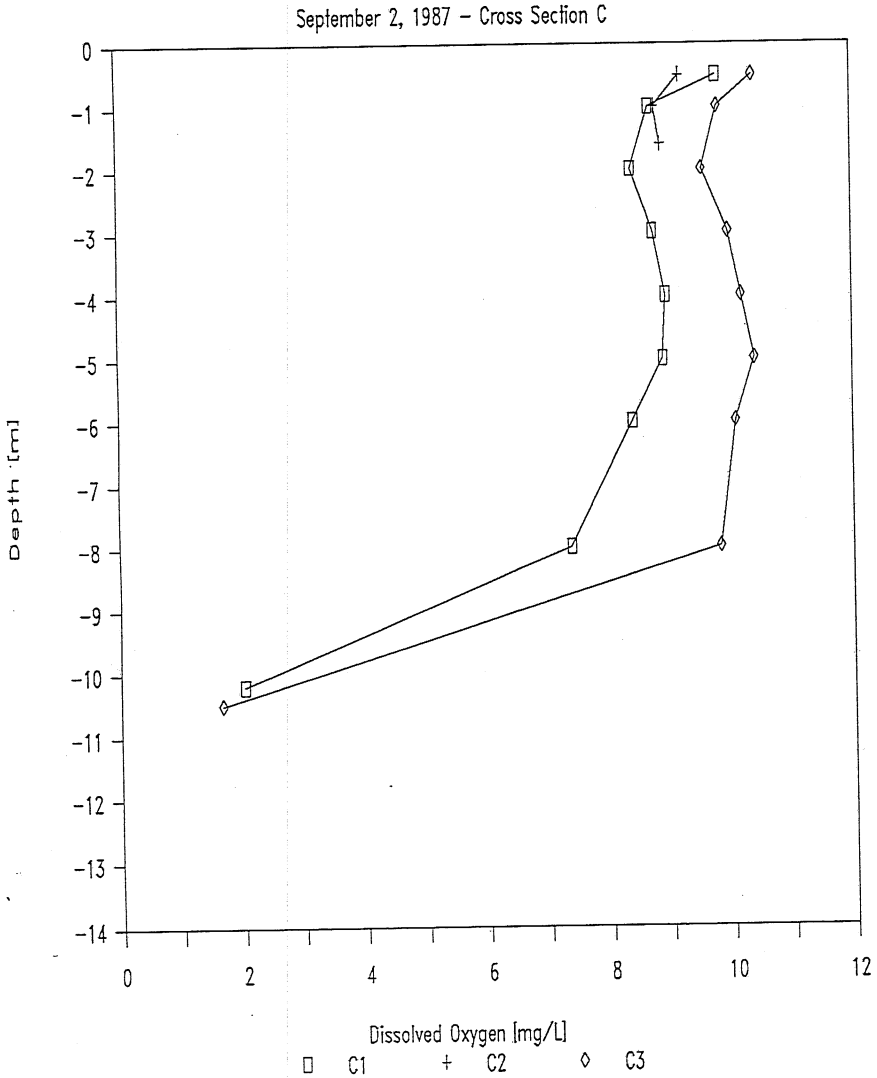

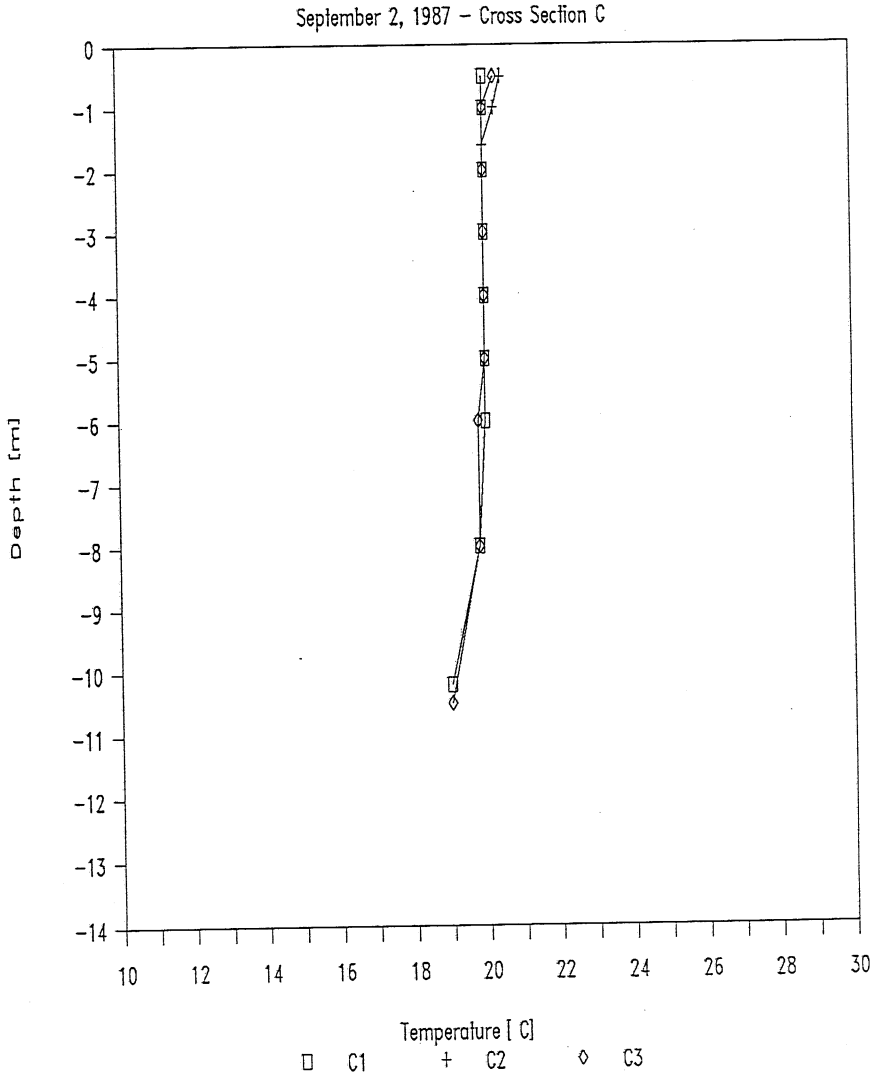

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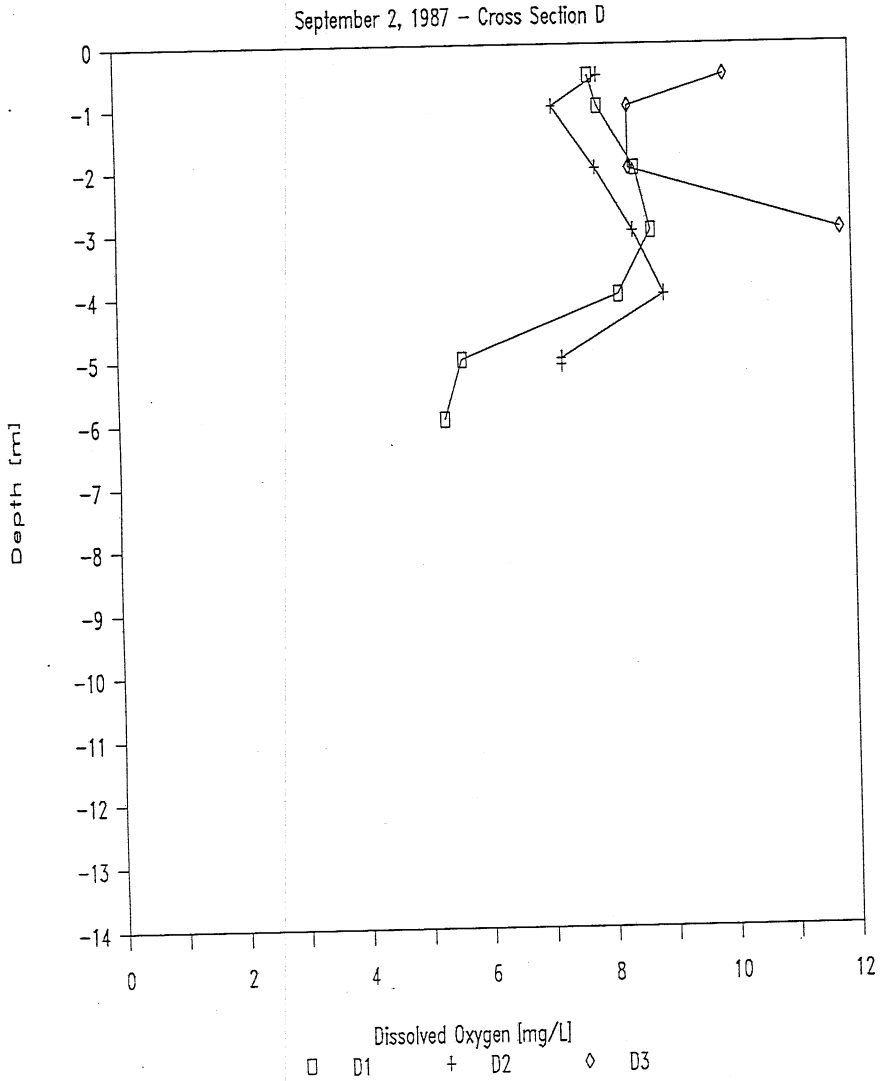

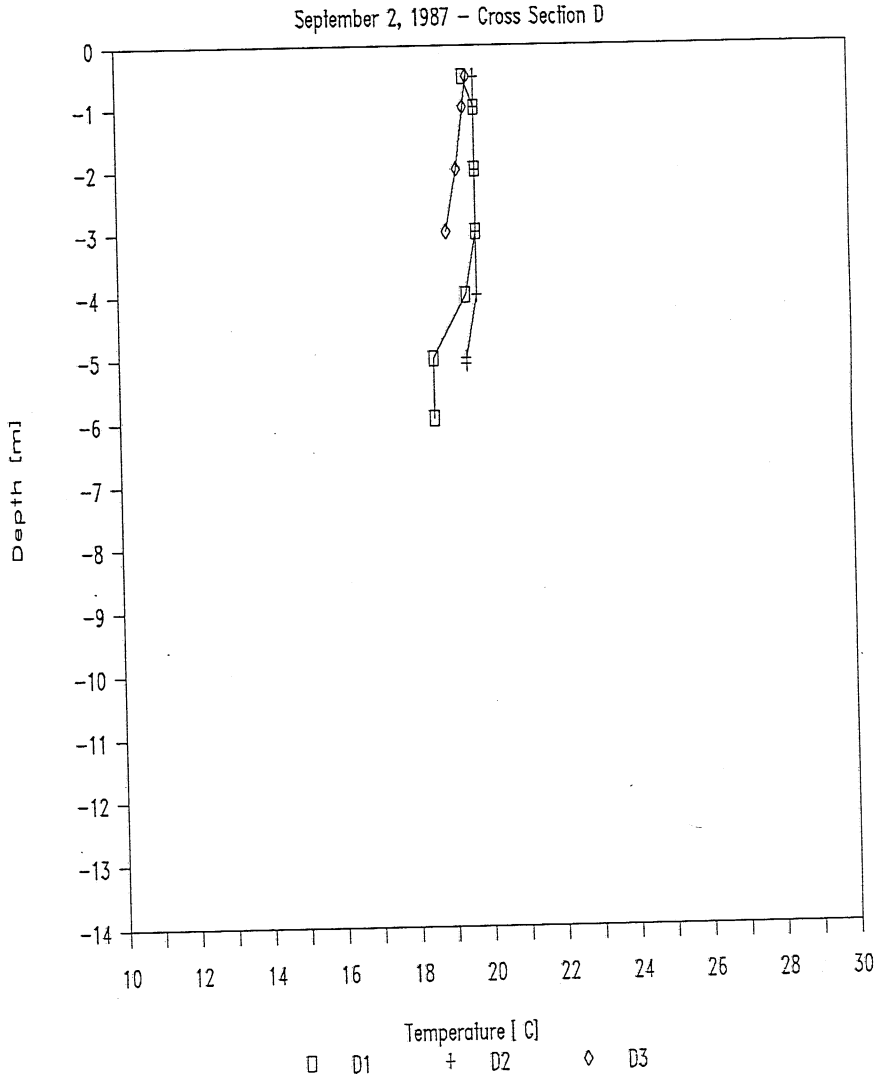

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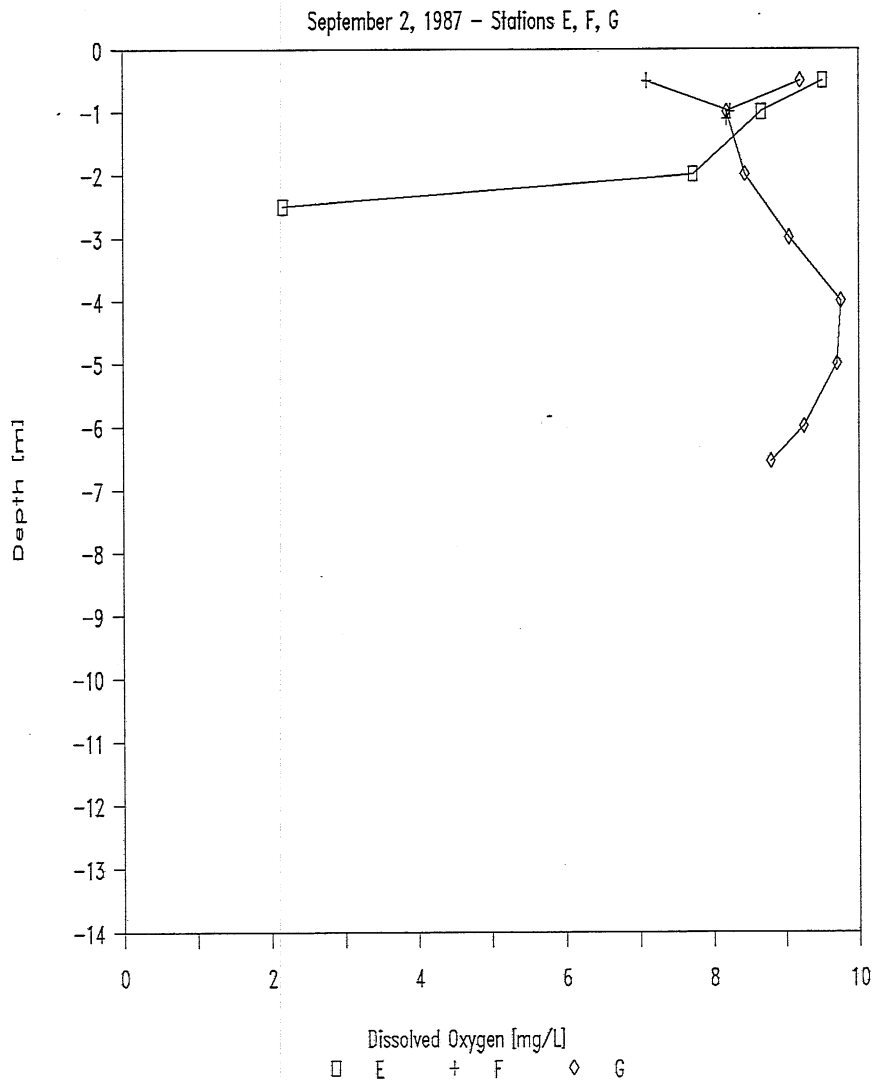

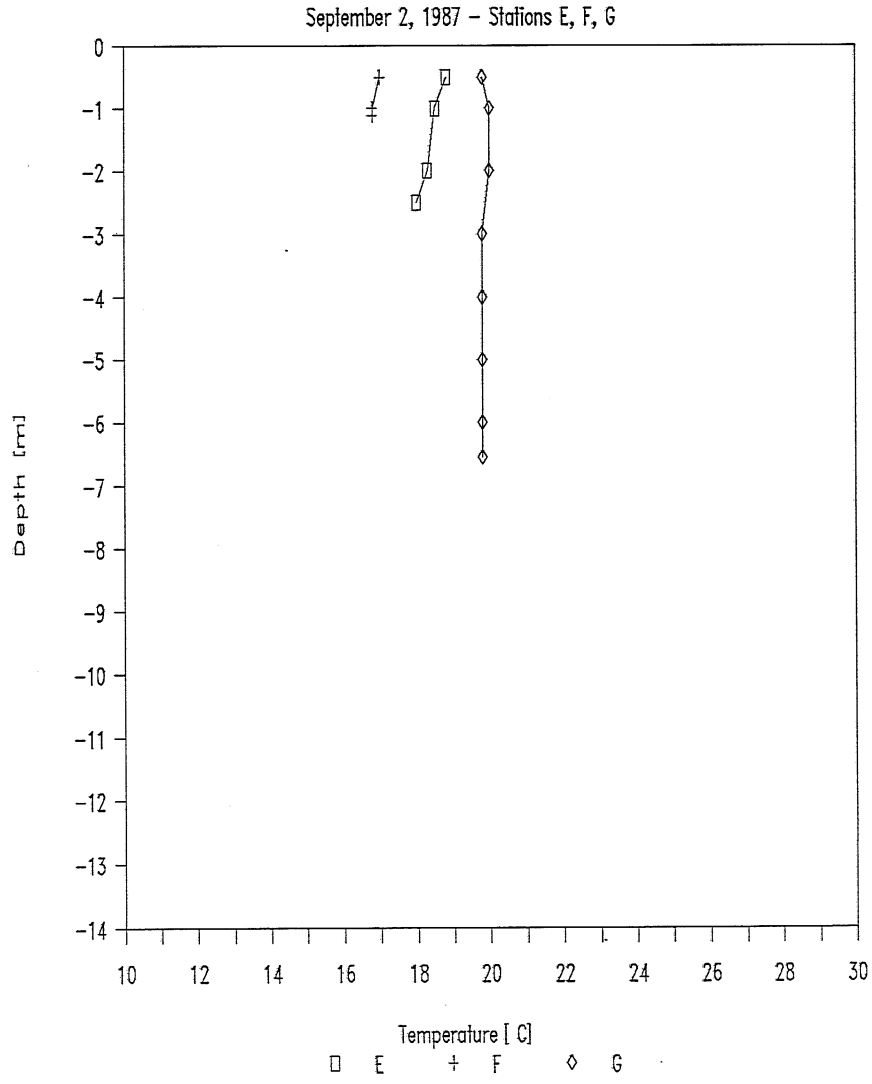

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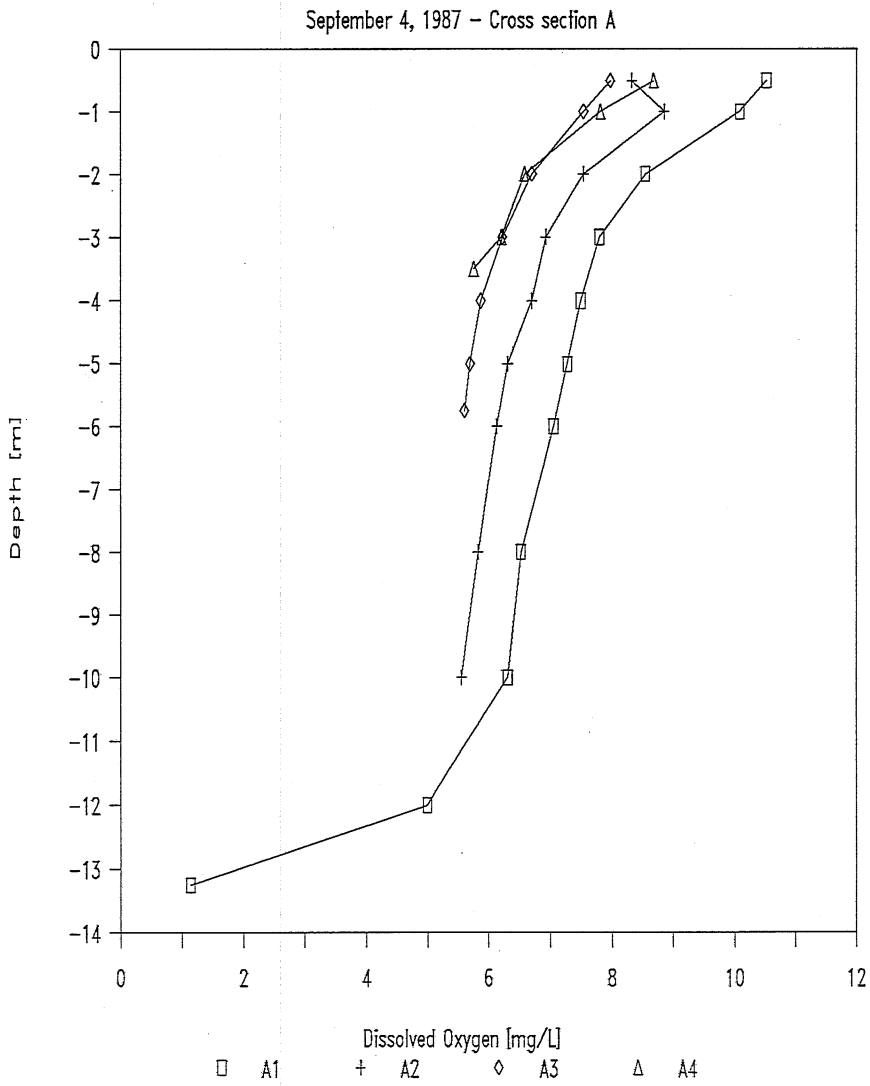

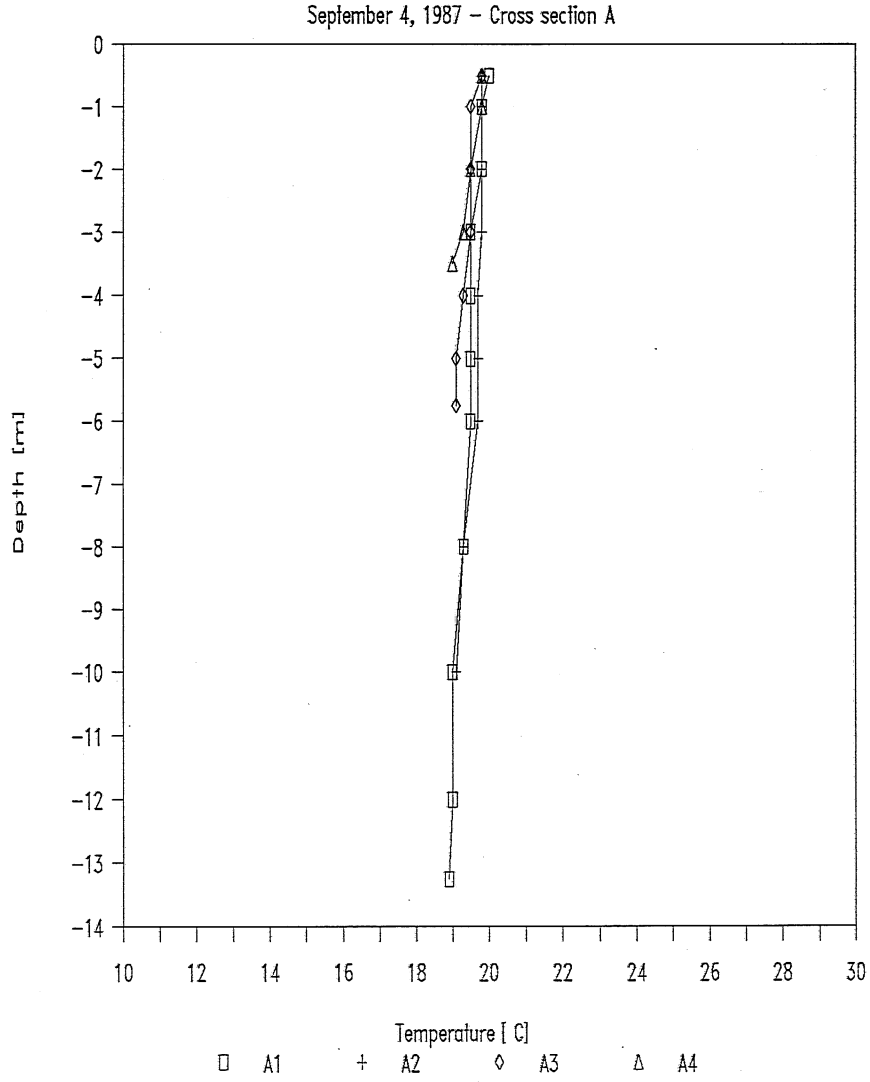

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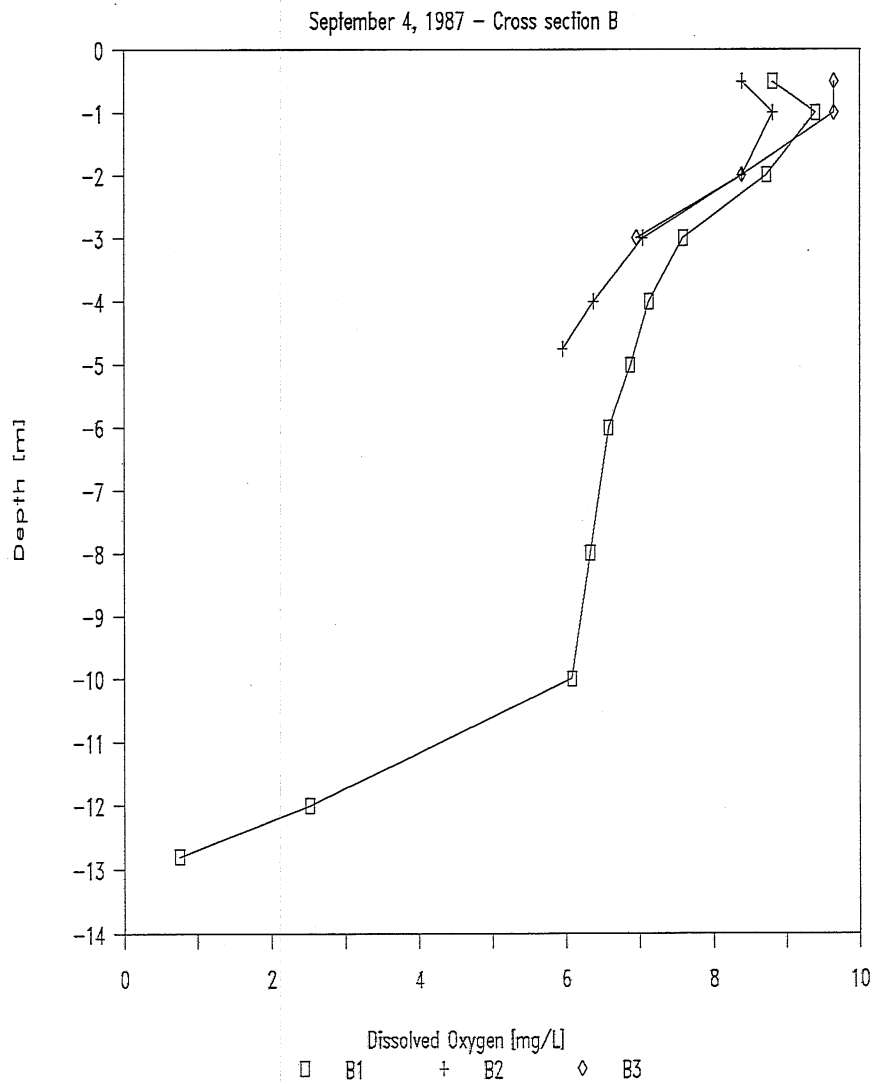
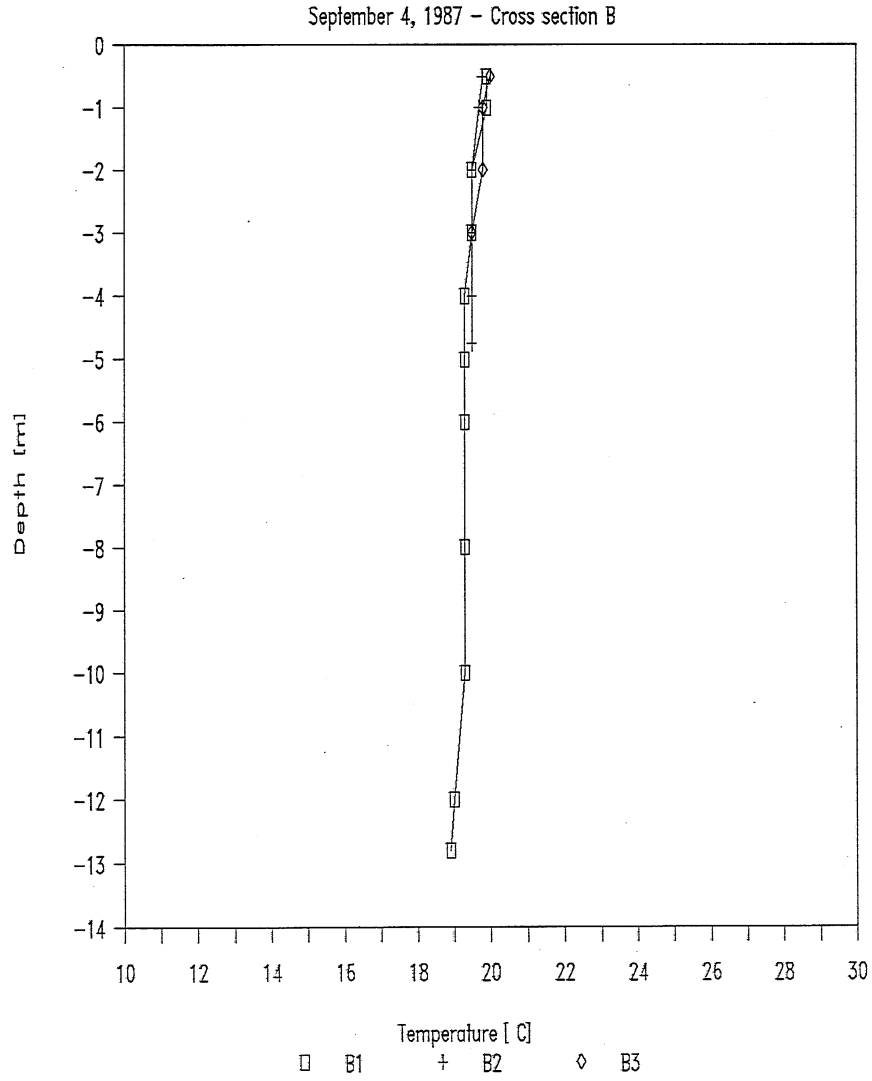
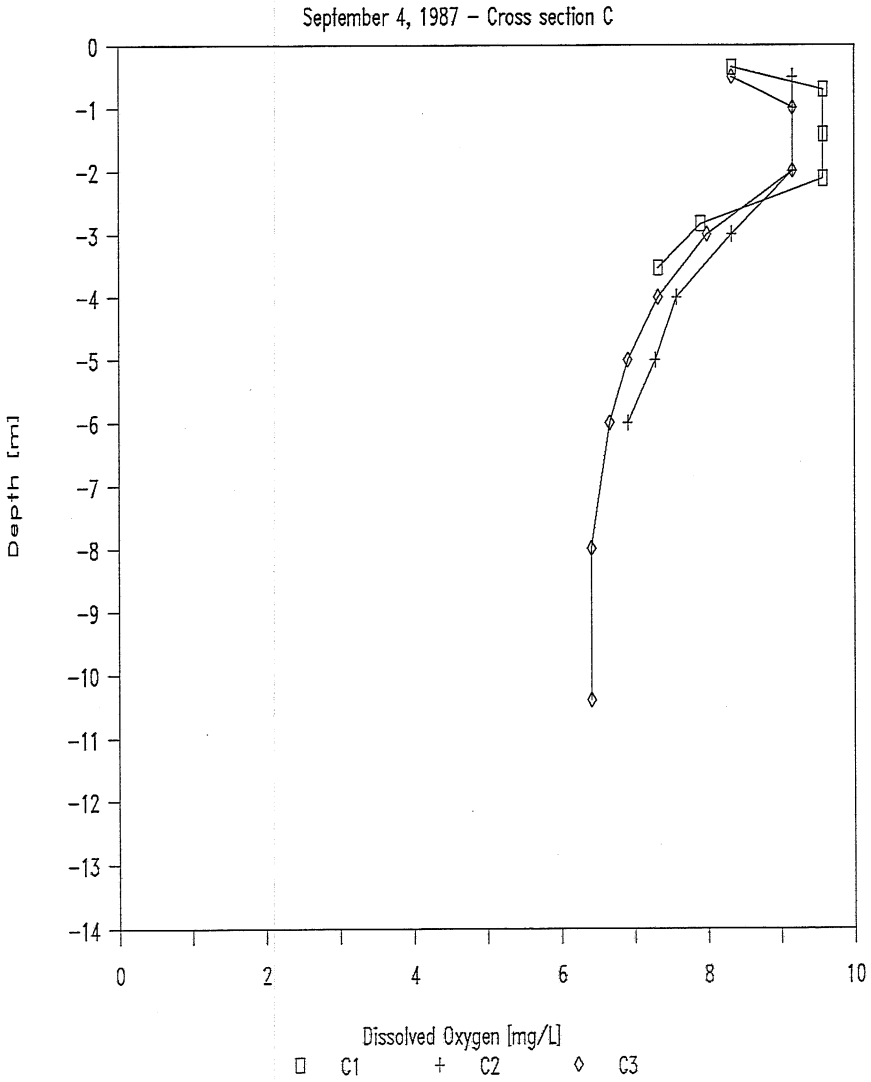
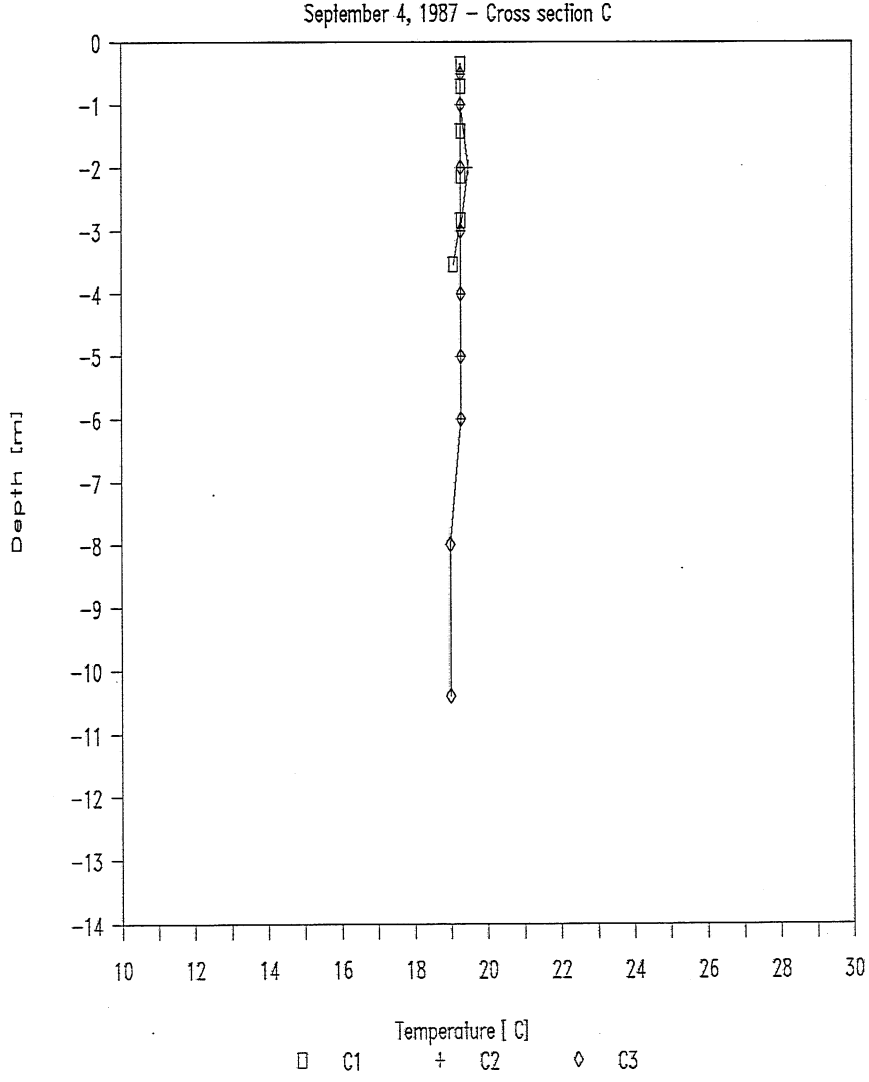


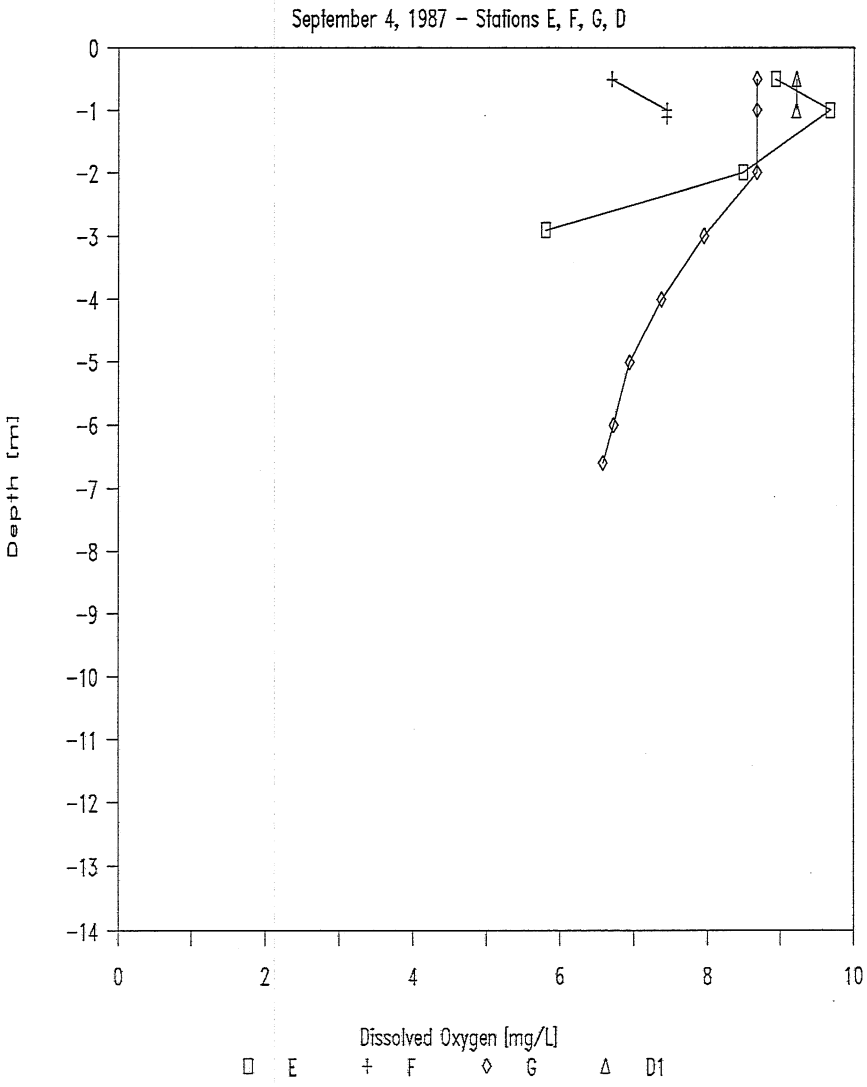


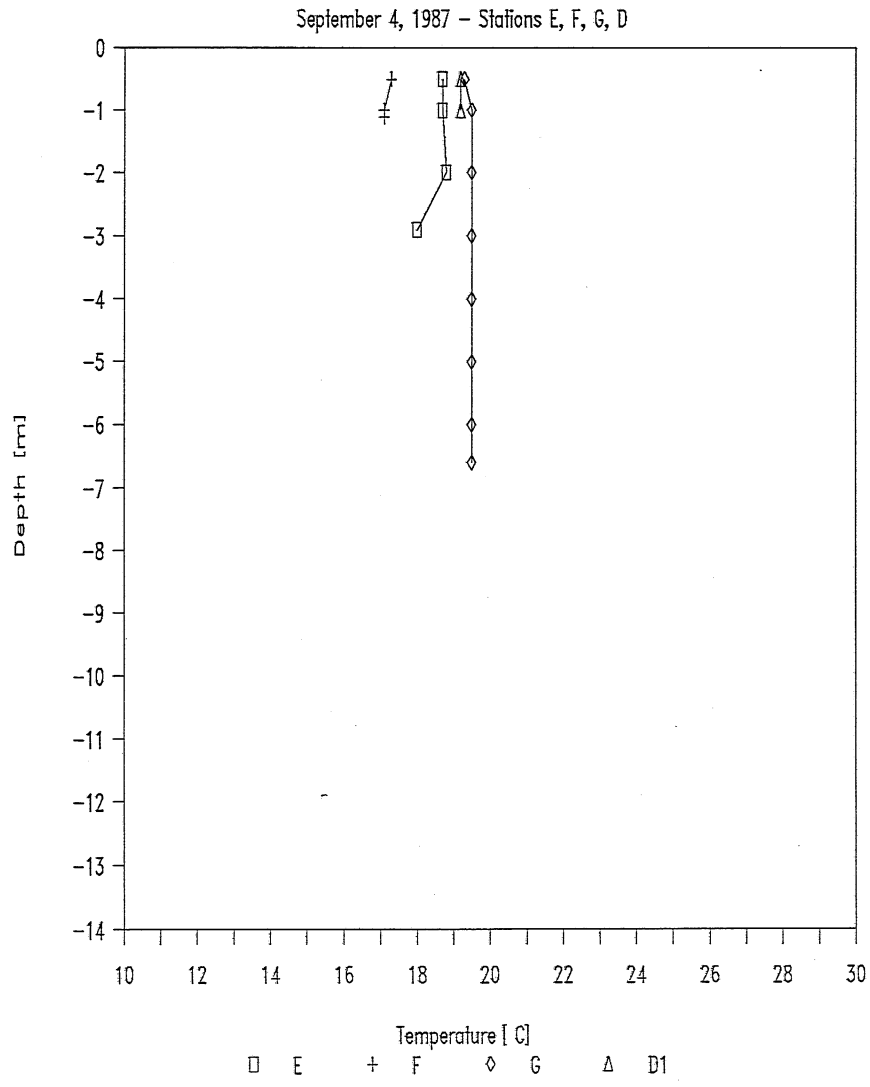
Byllesby D.O. study - Summer 1987





Byllesby D.O. study - Summer 1987



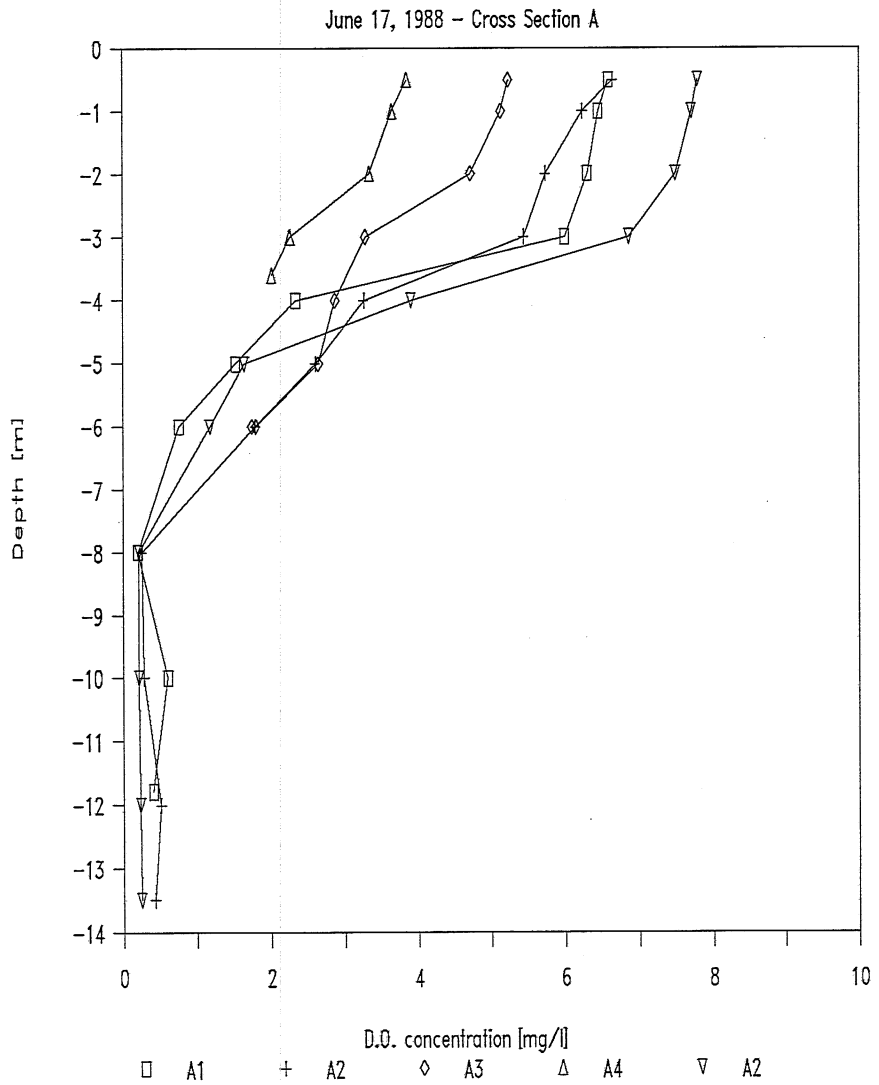


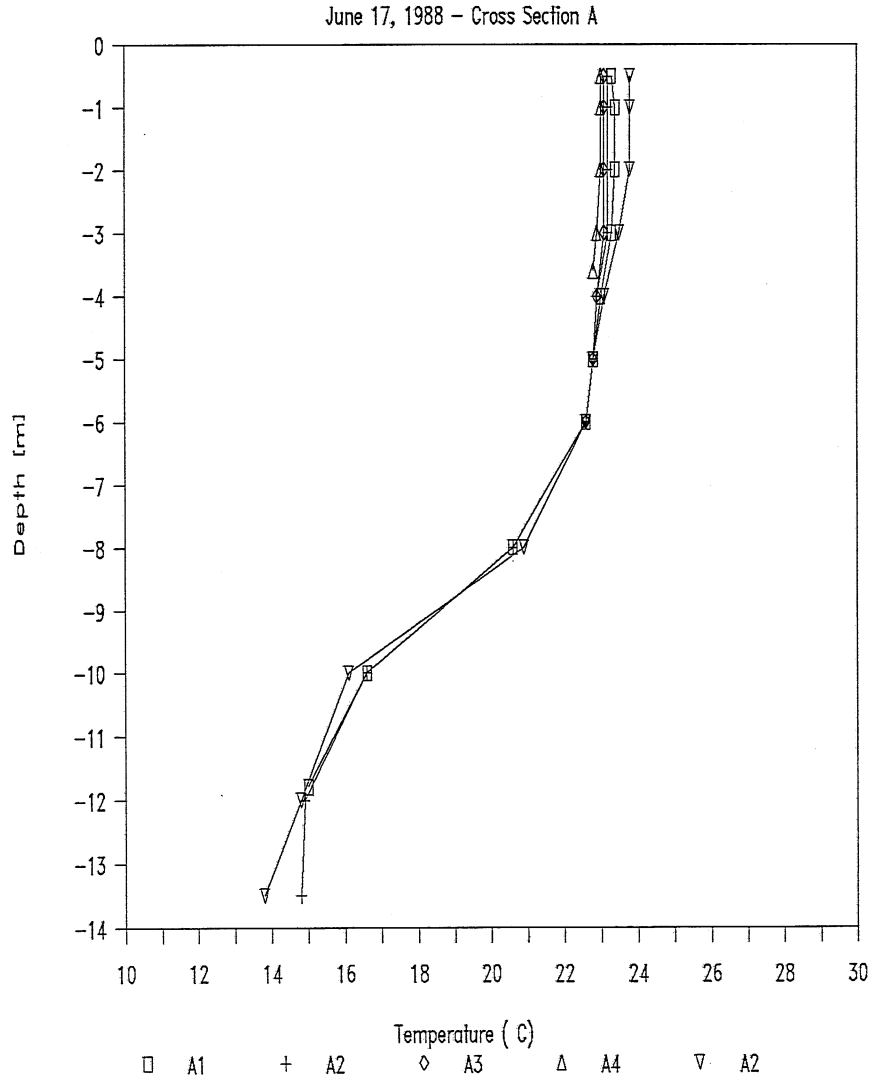
DISSOLVED OXYGEN AND TEMPERATURE PROFILES

IN THE RESERVOIR AND DOWNSTREAM

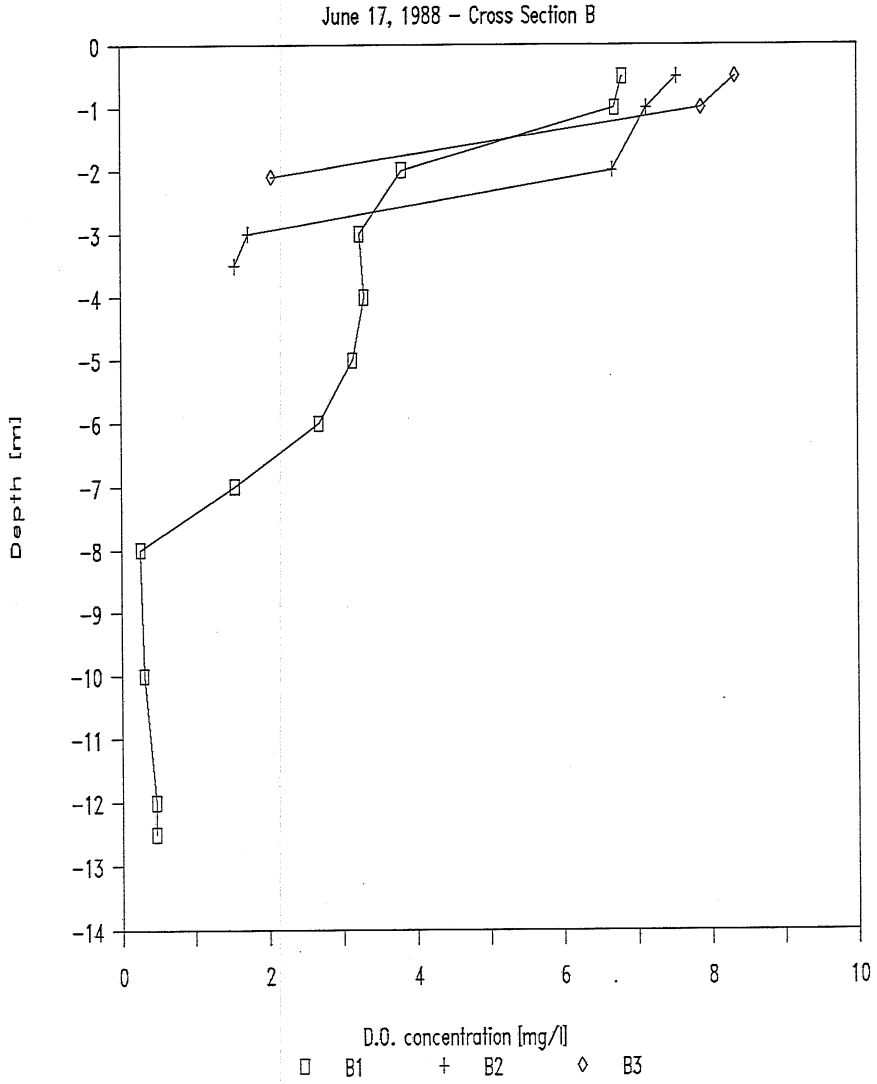
D.O. VARIATION – SUMMER 1988

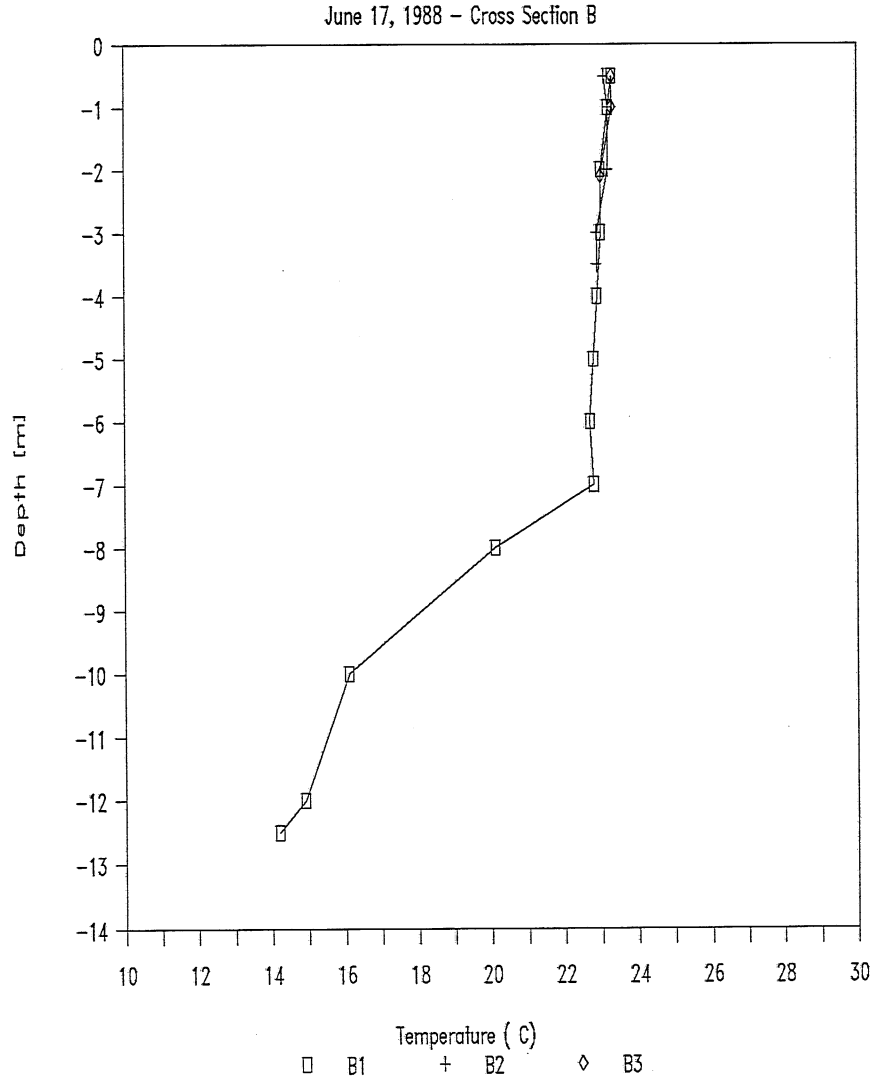
Byllesby Lake D.O. study - Summer 1988



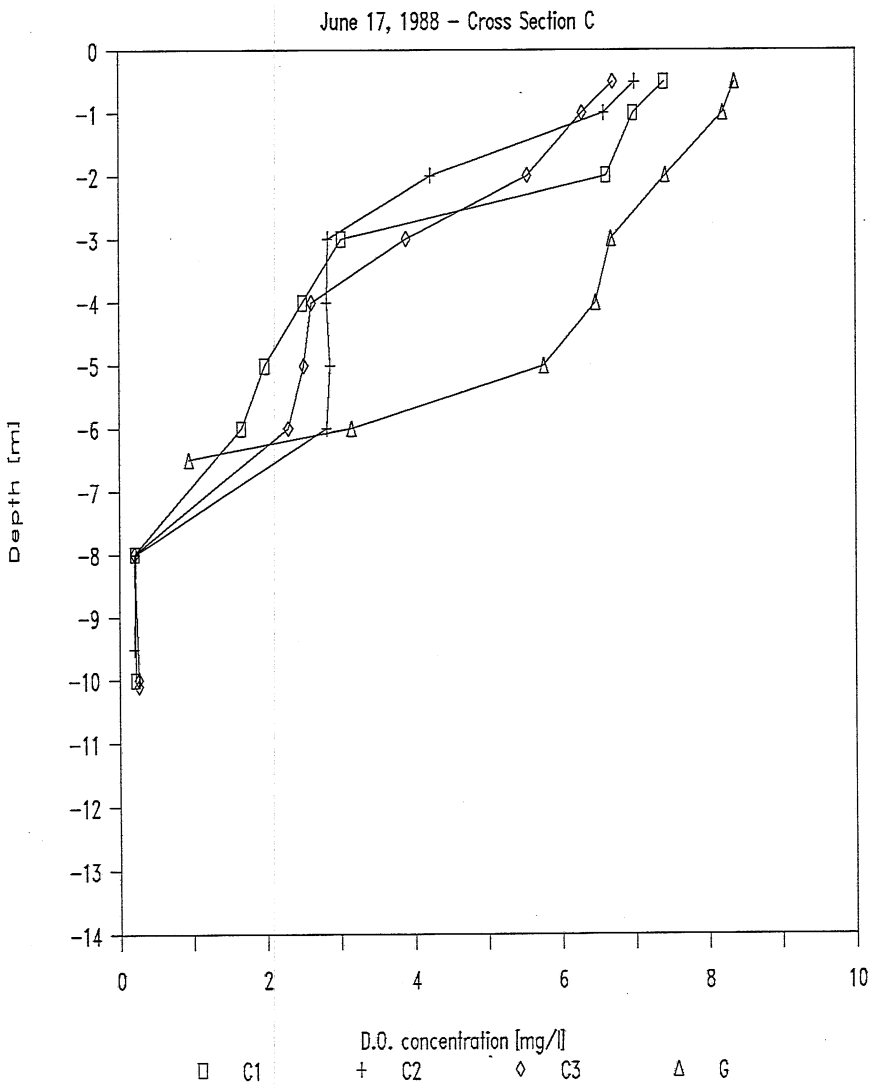


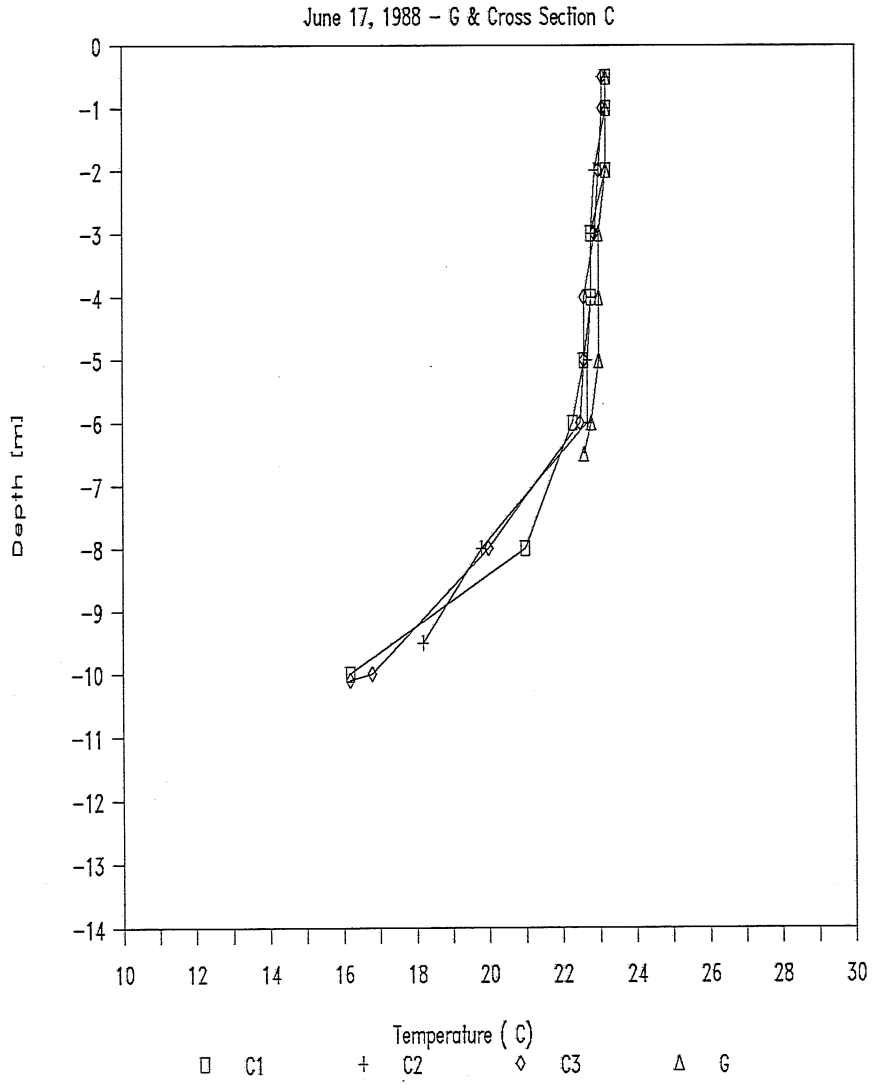
Byllesby Lake D.O. study - Summer 1988



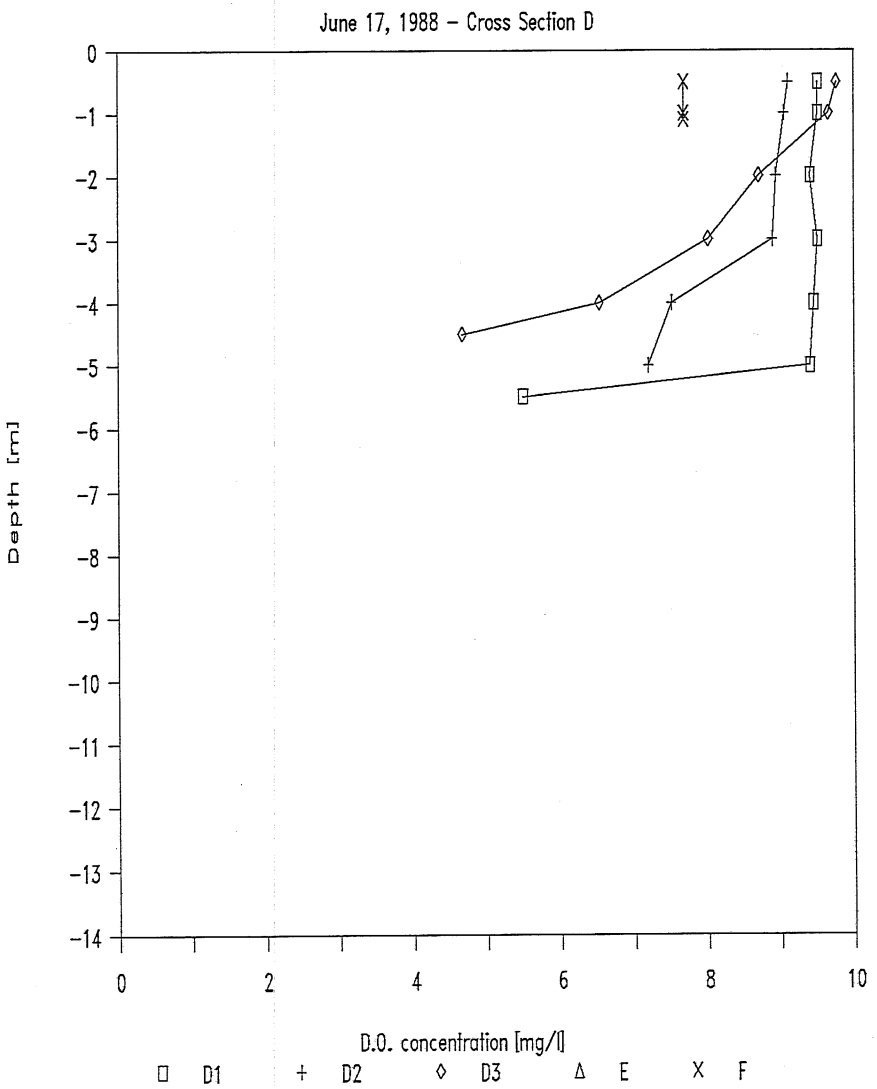


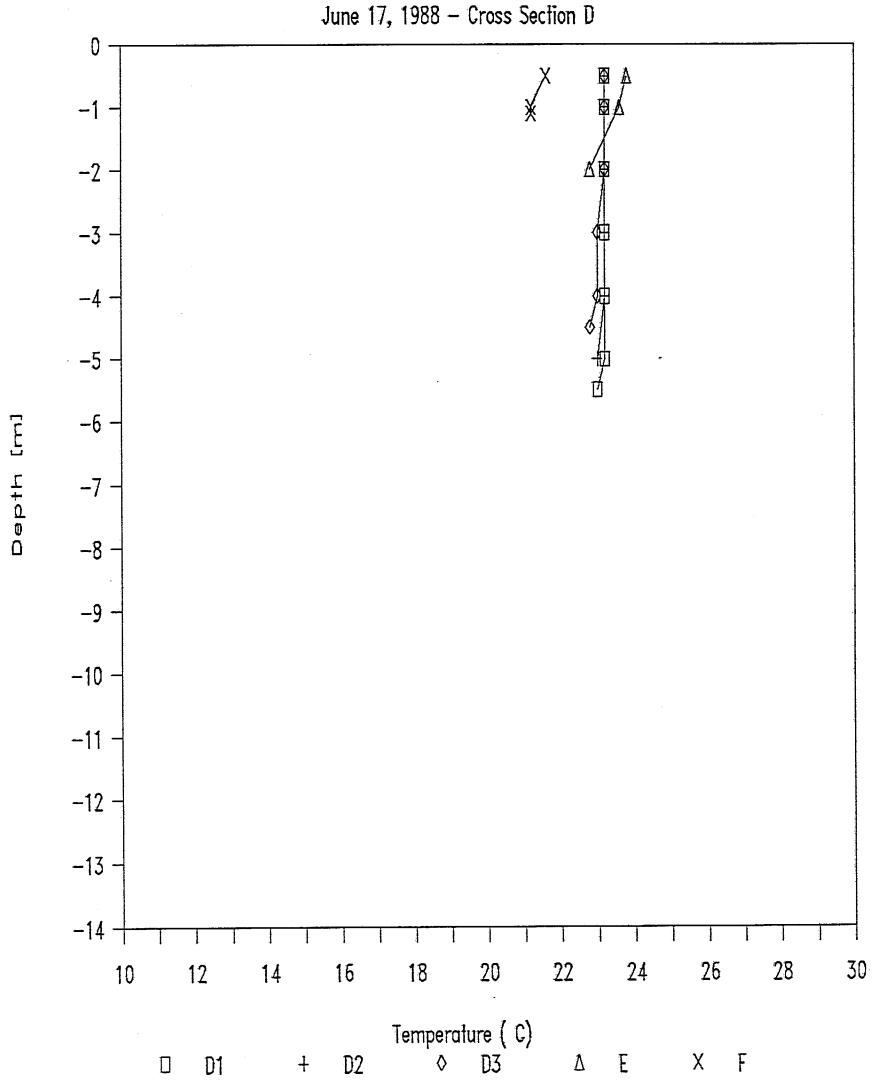
Byllesby Lake D.O. study - Summer 1988



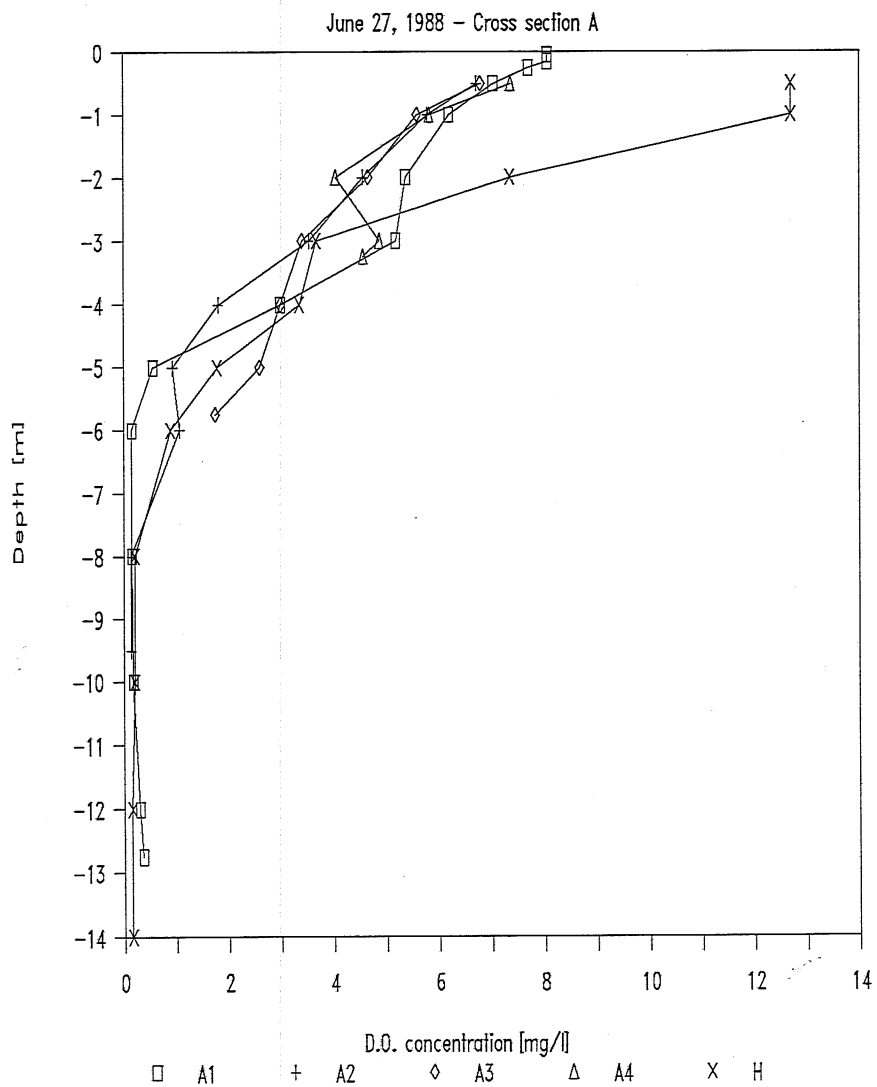


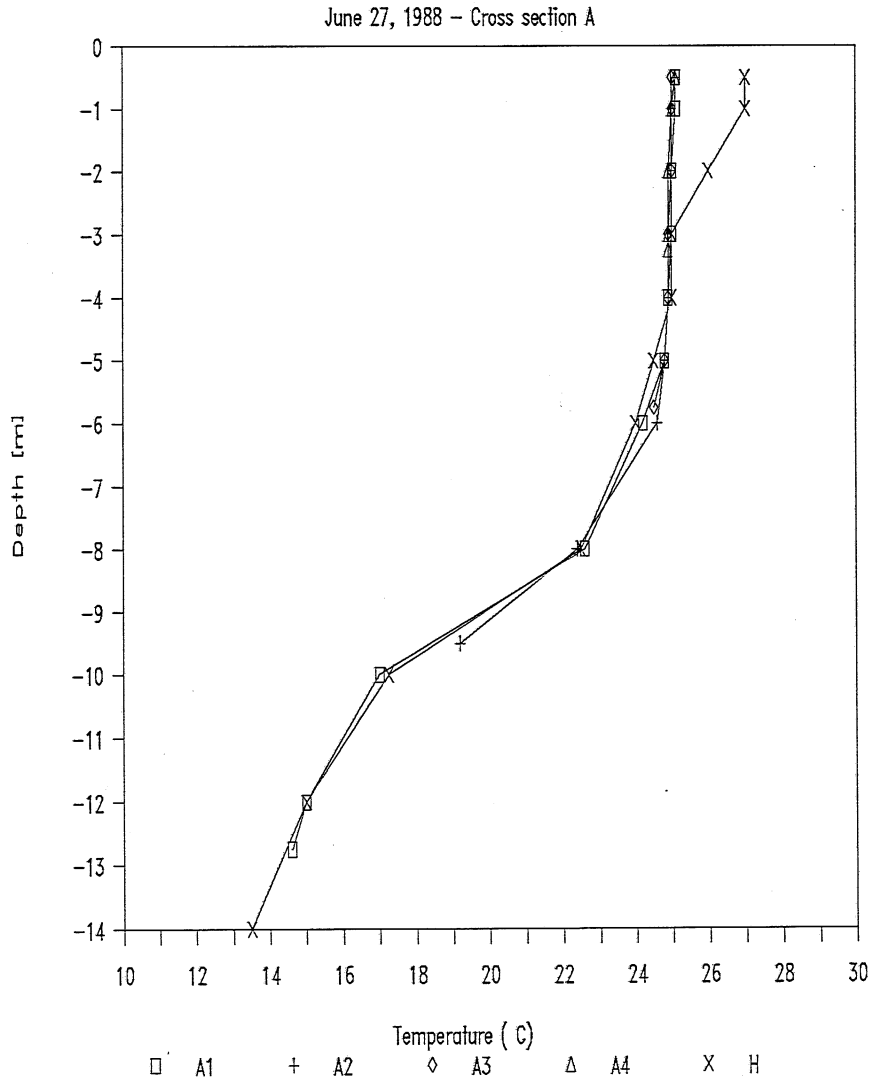
Byllesby Lake D.O. study - Summer 1988



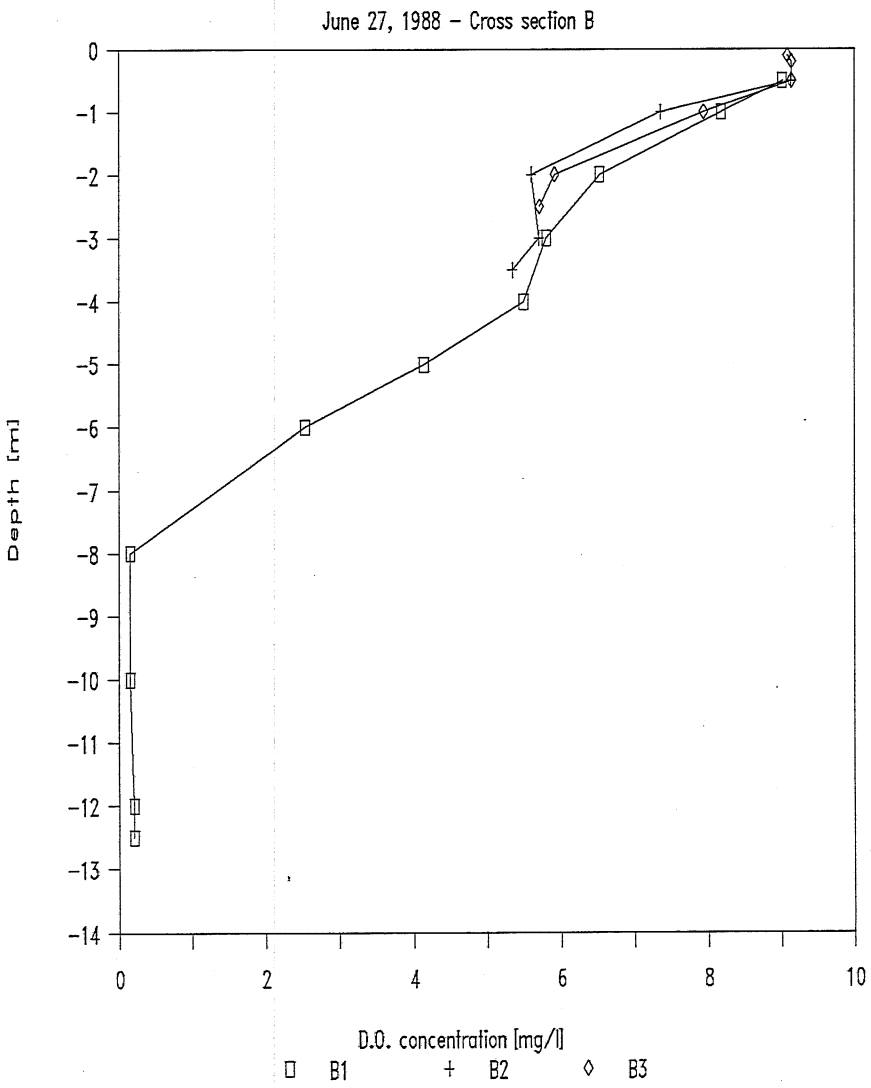


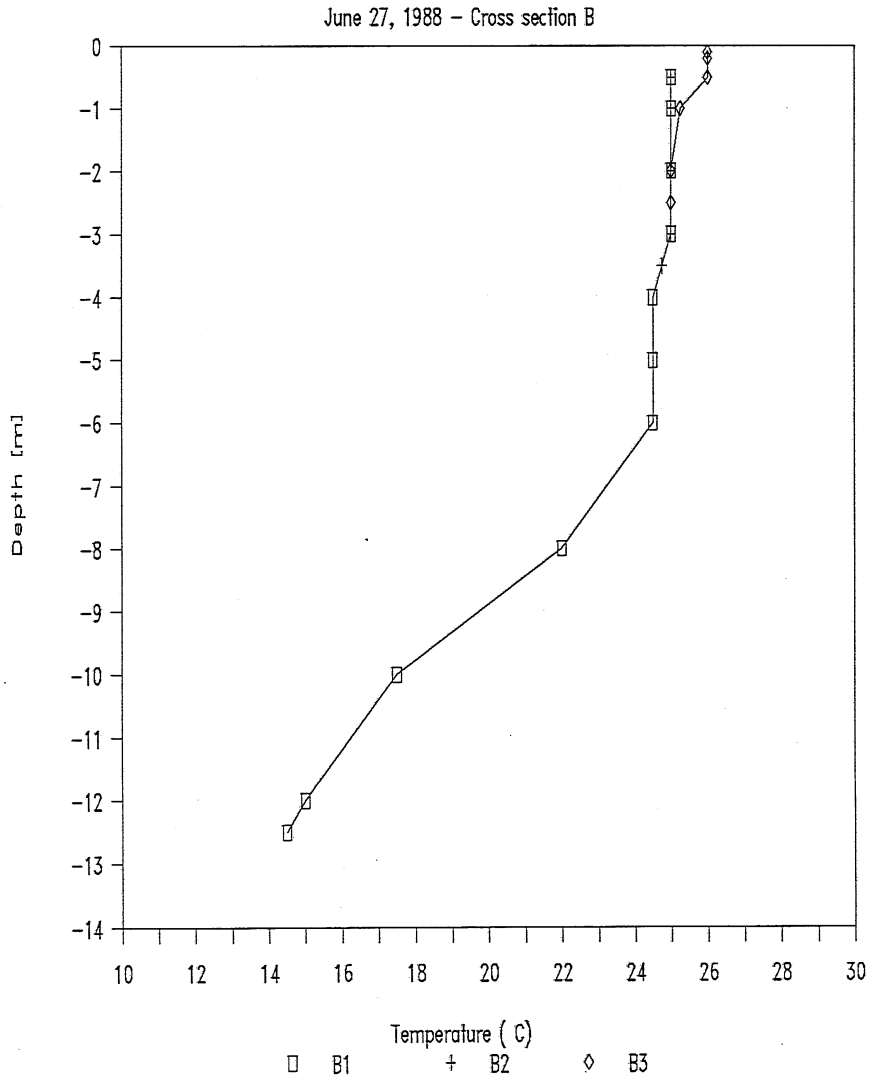
Byllesby Lake D.O. study - Summer 1988



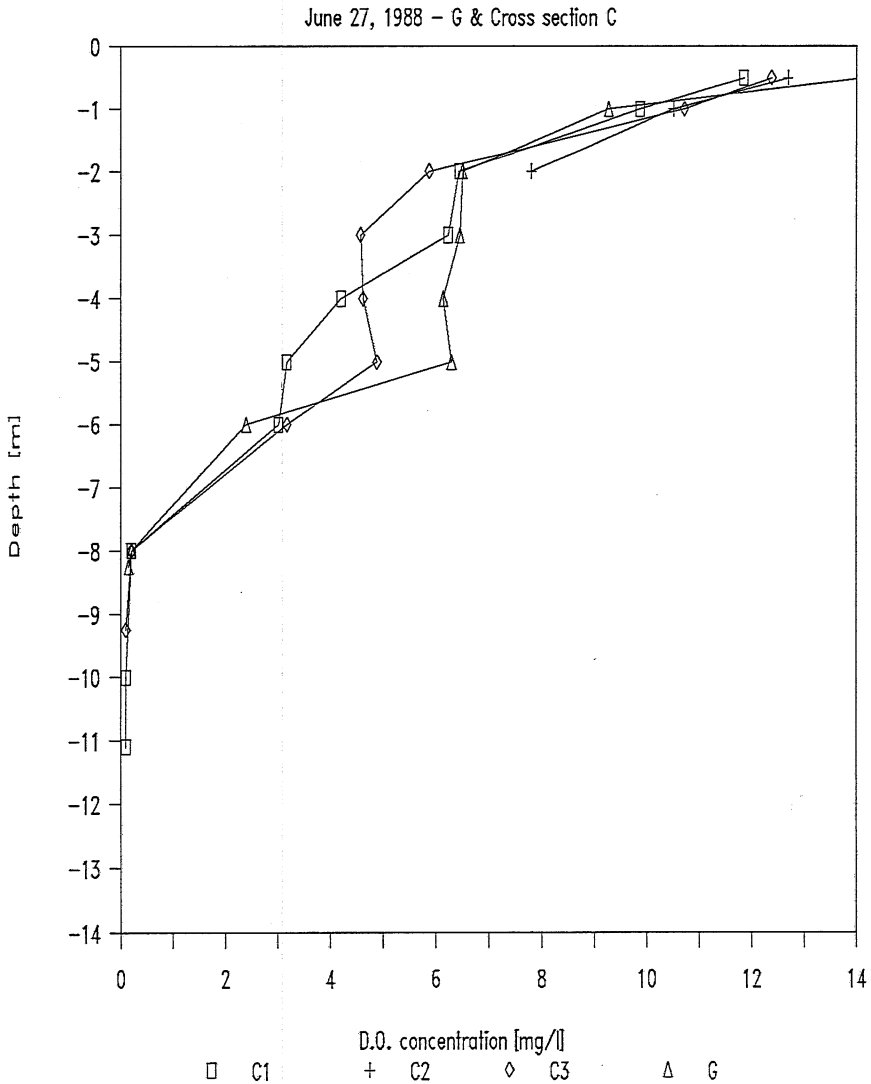


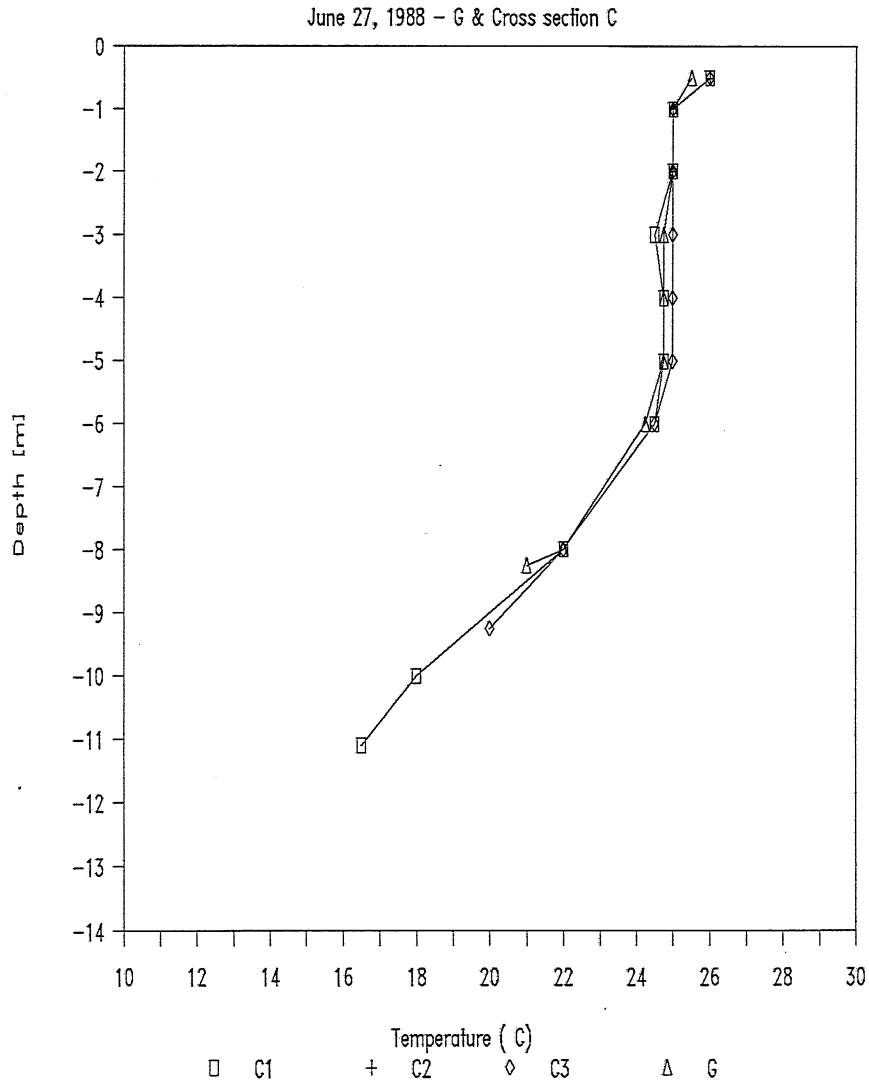
Byllesby Lake D.O. study - Summer 1988



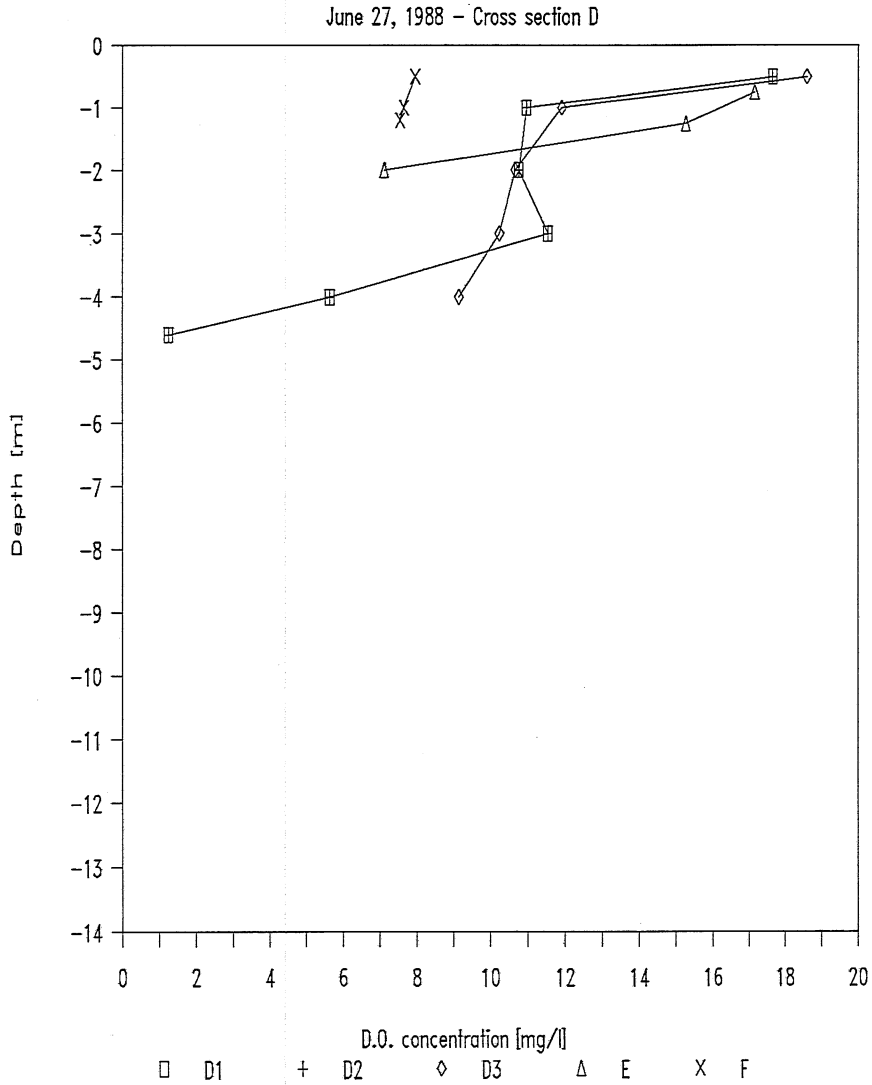


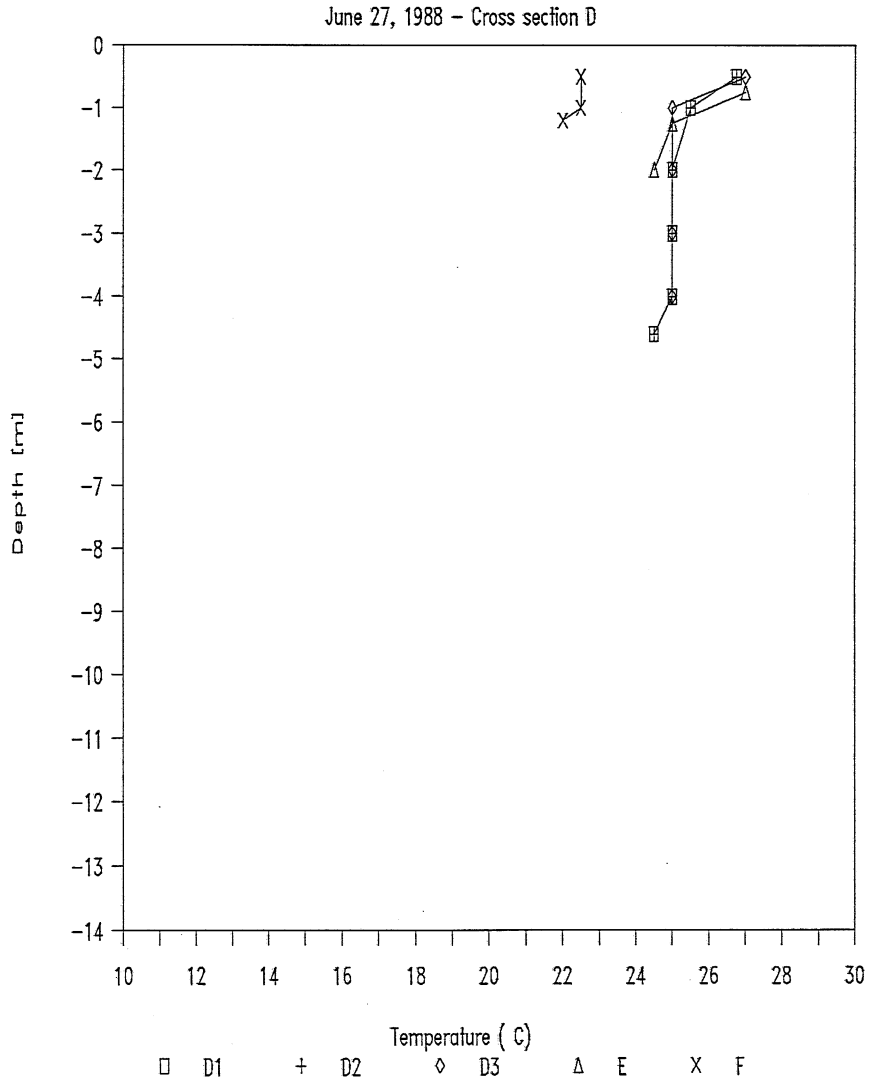
Byllesby Lake D.O. study - Summer 1988



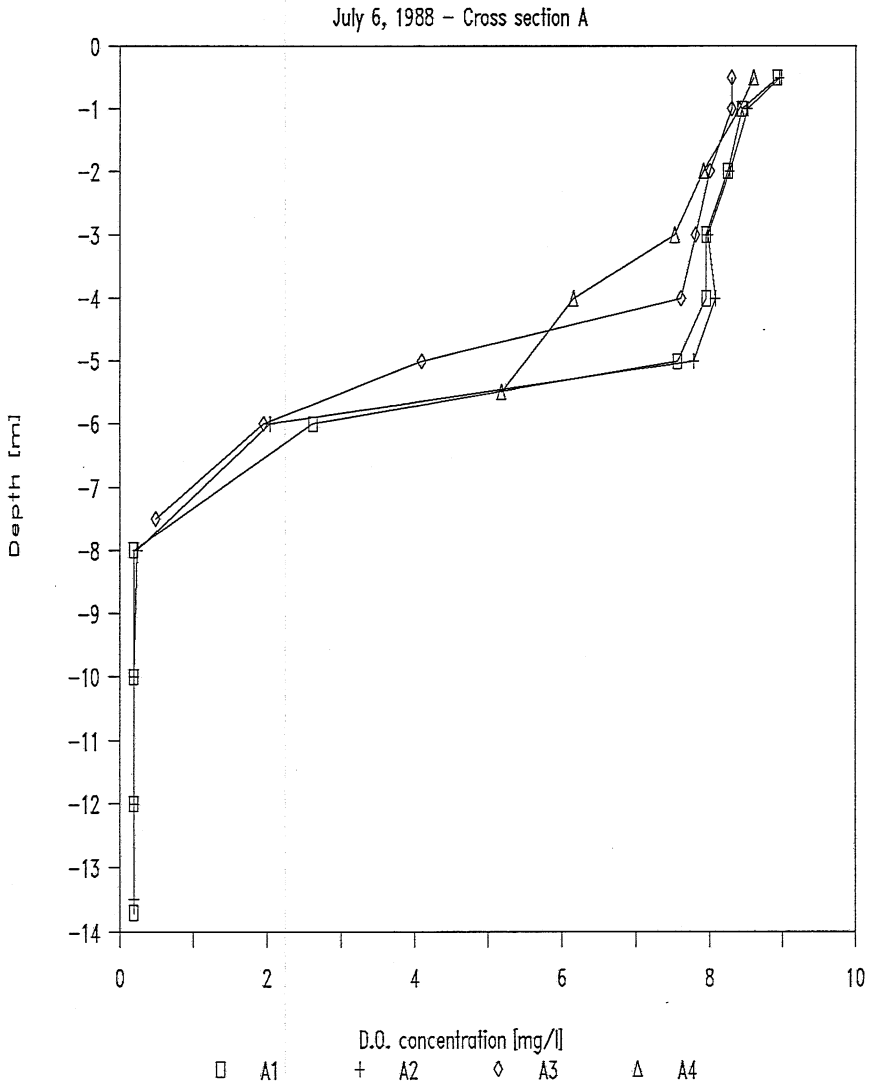


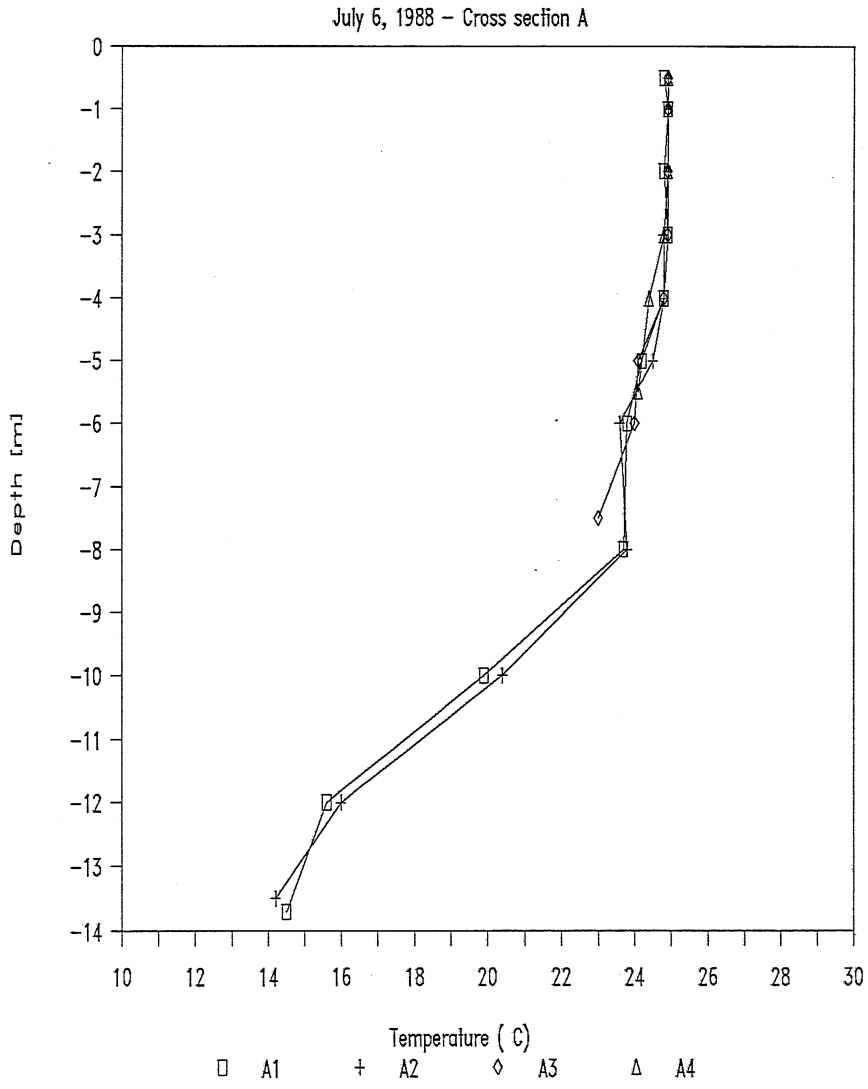
Byllesby Lake D.O. study - Summer 1988



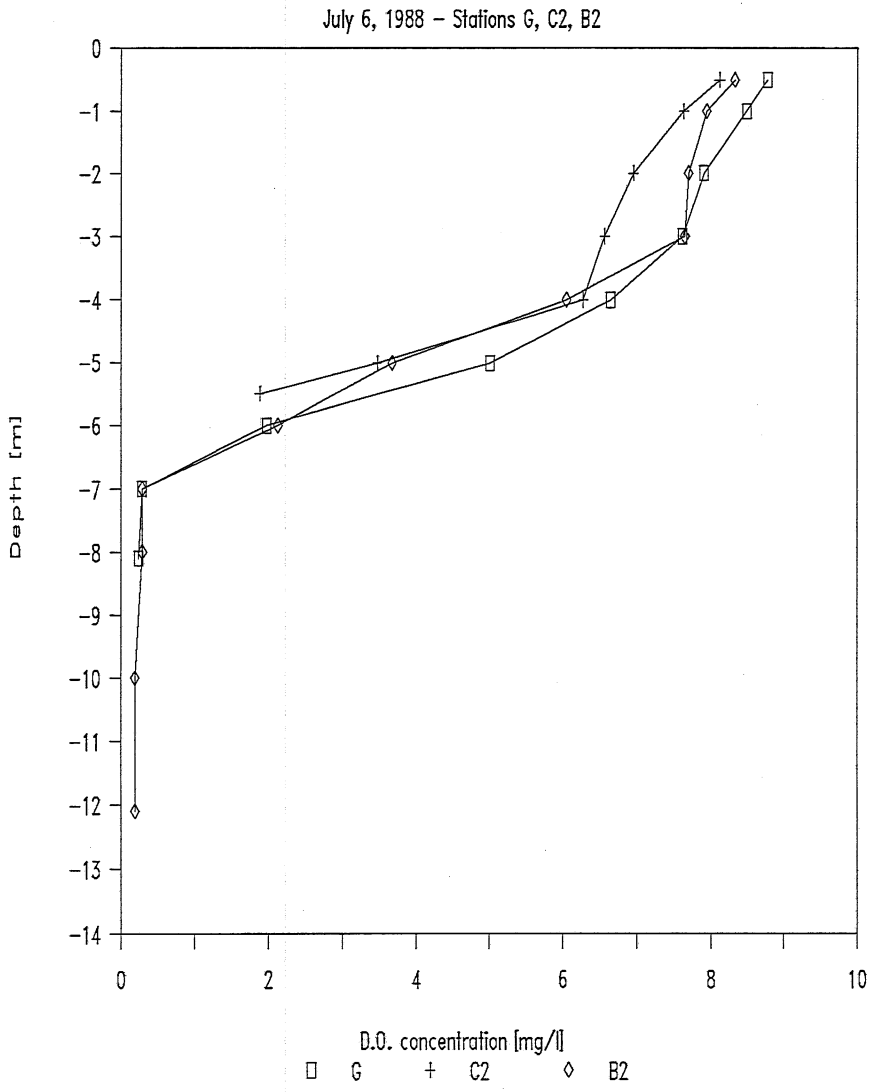


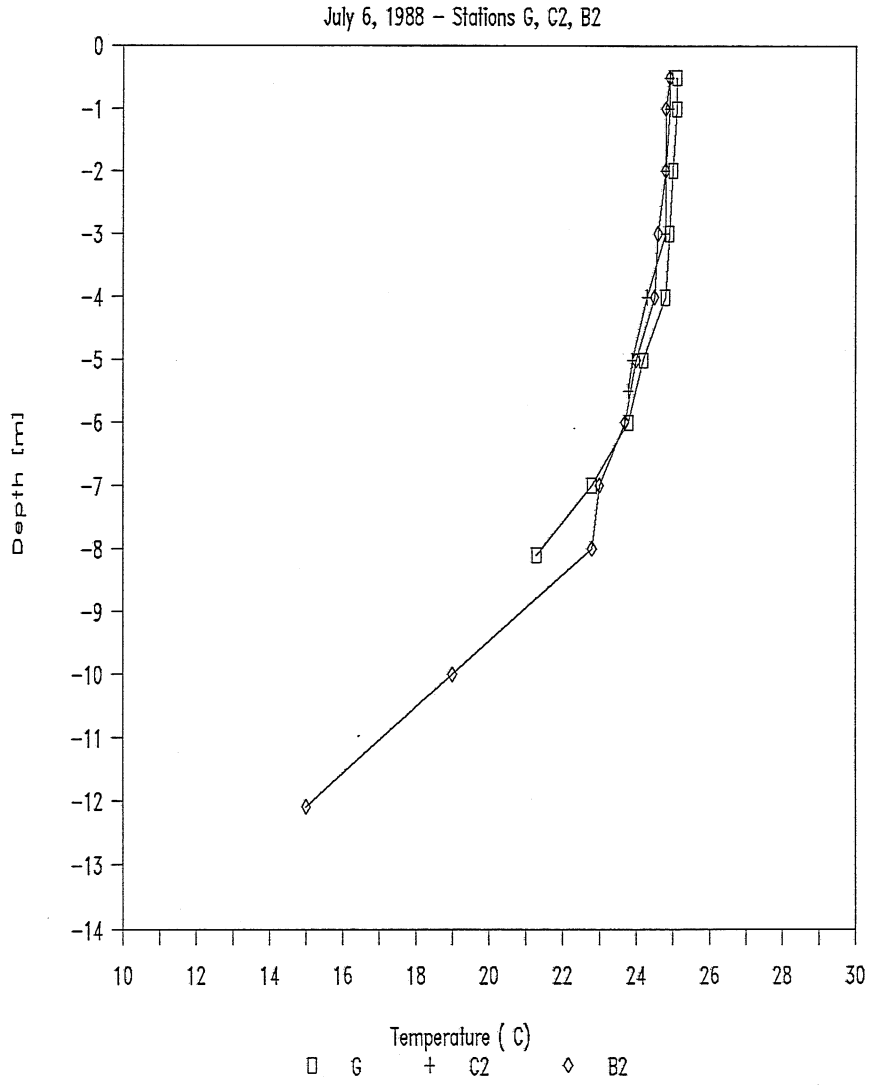
Byllesby Lake D.O. study - Summer 1988



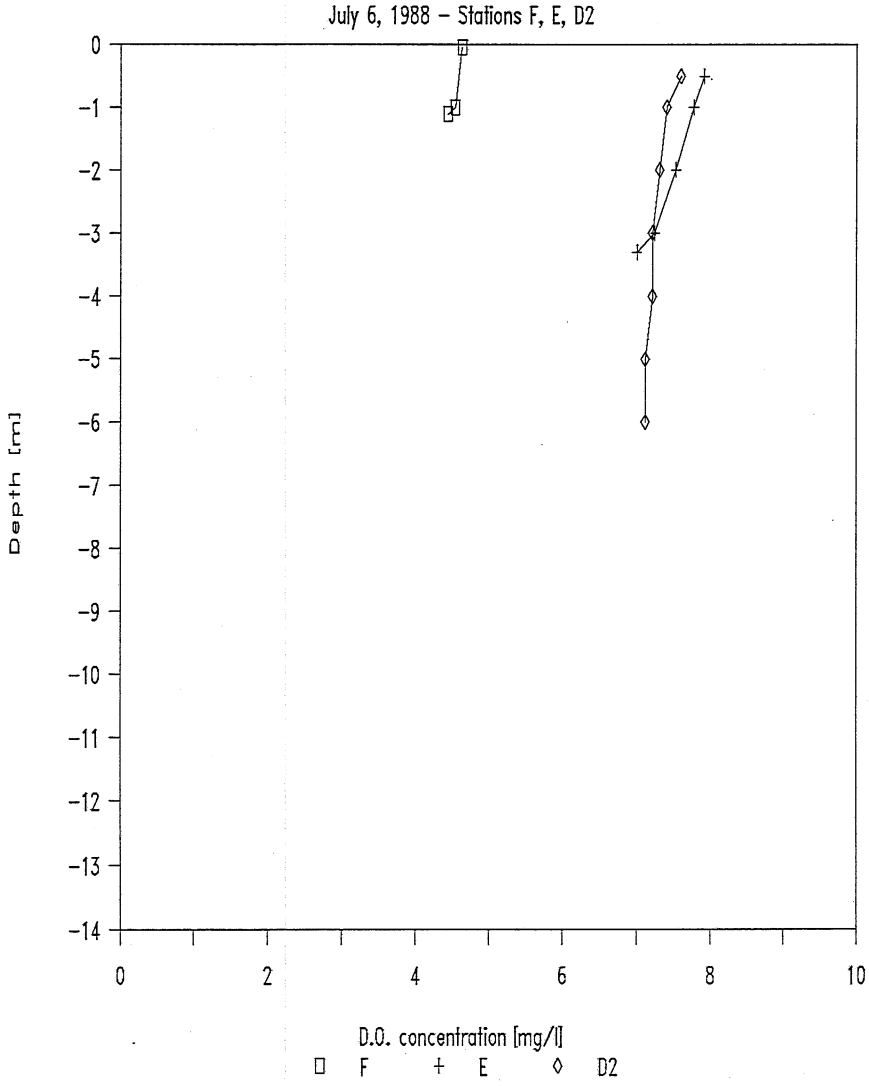


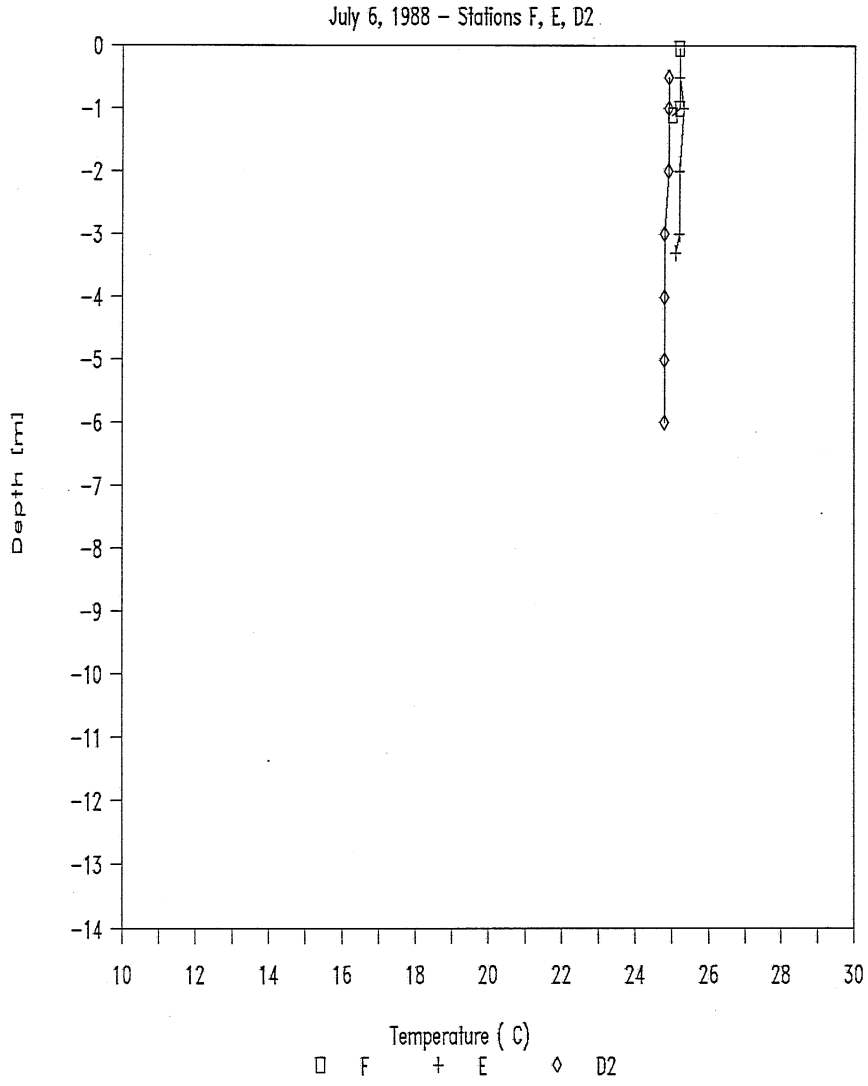
Byllesby Lake D.O. study - Summer 1988





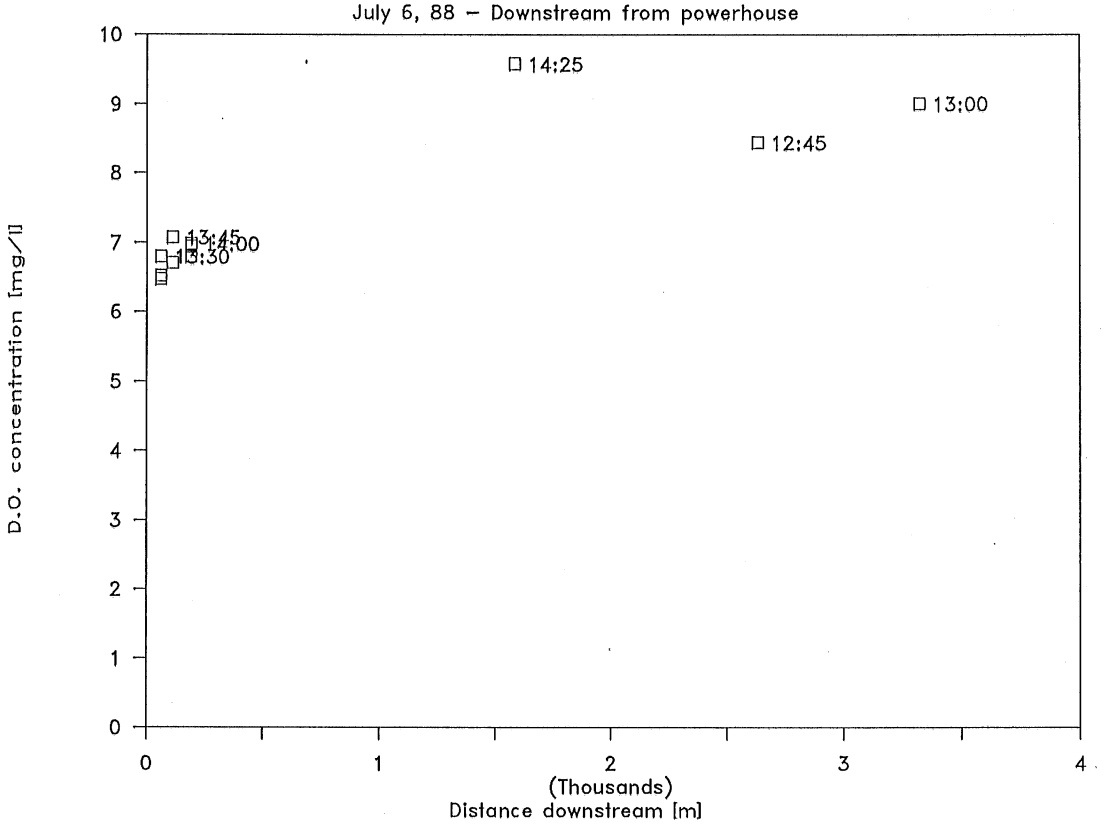
Byllesby Lake D.O. study - Summer 1988





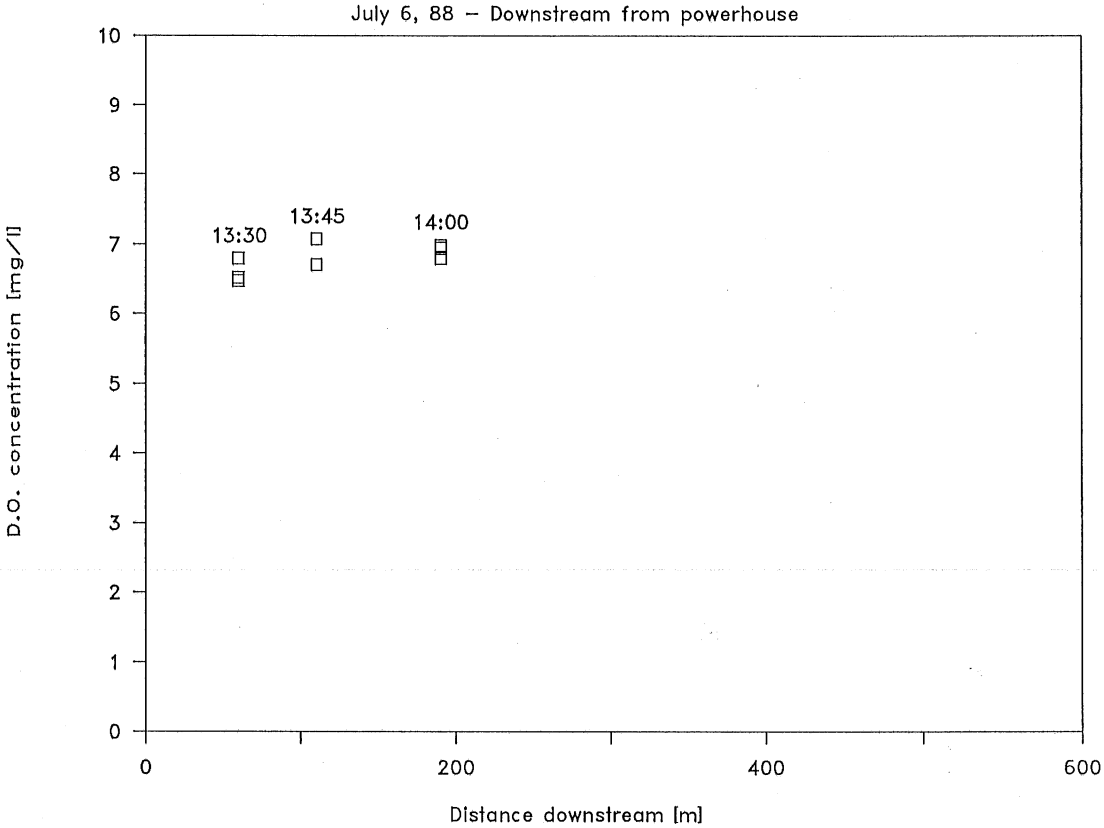
Byllesby Dam – Summer 1988

July 6, 88 – Downstream from powerhouse

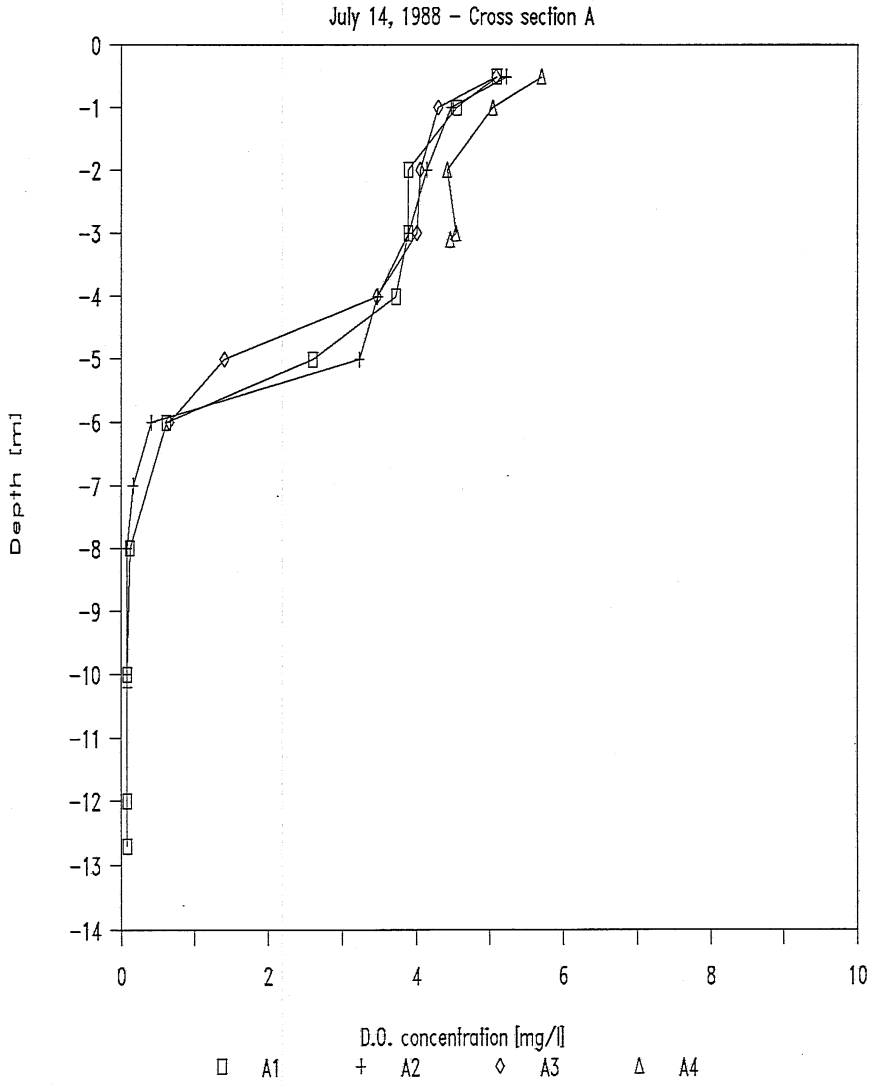


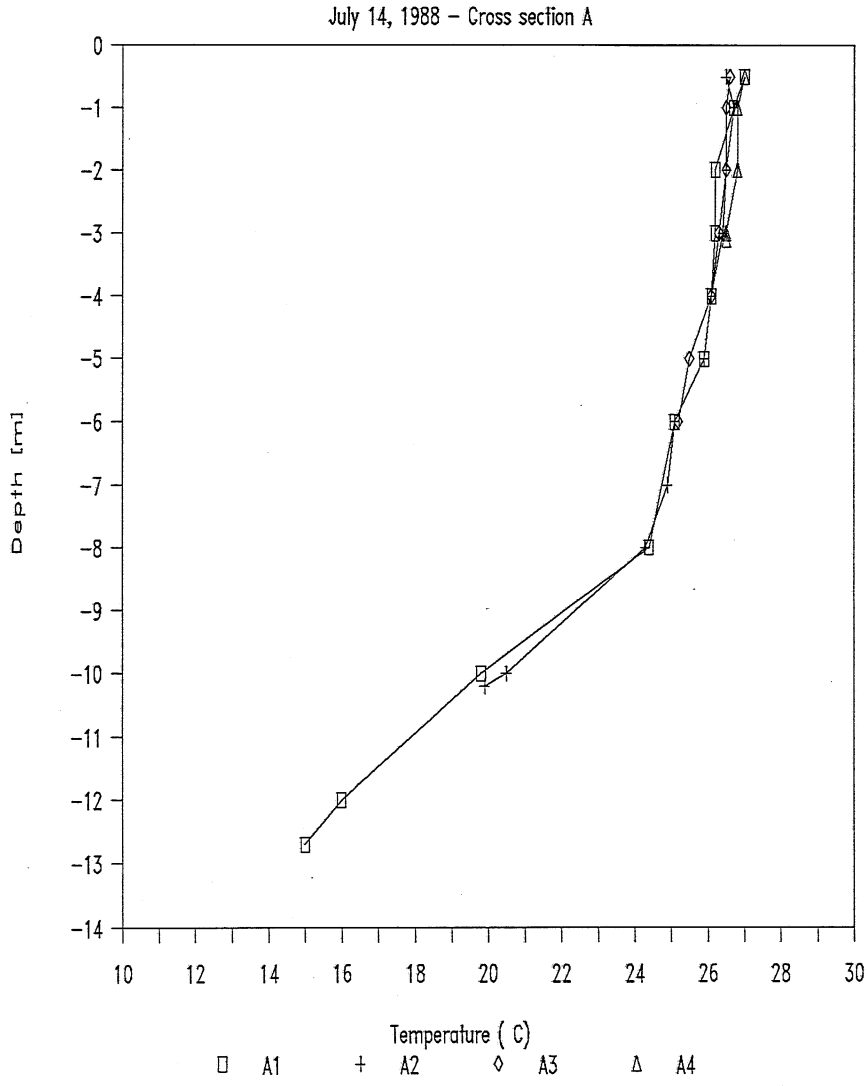
Byllesby Dam – Summer 1988

July 6, 88 – Downstream from powerhouse

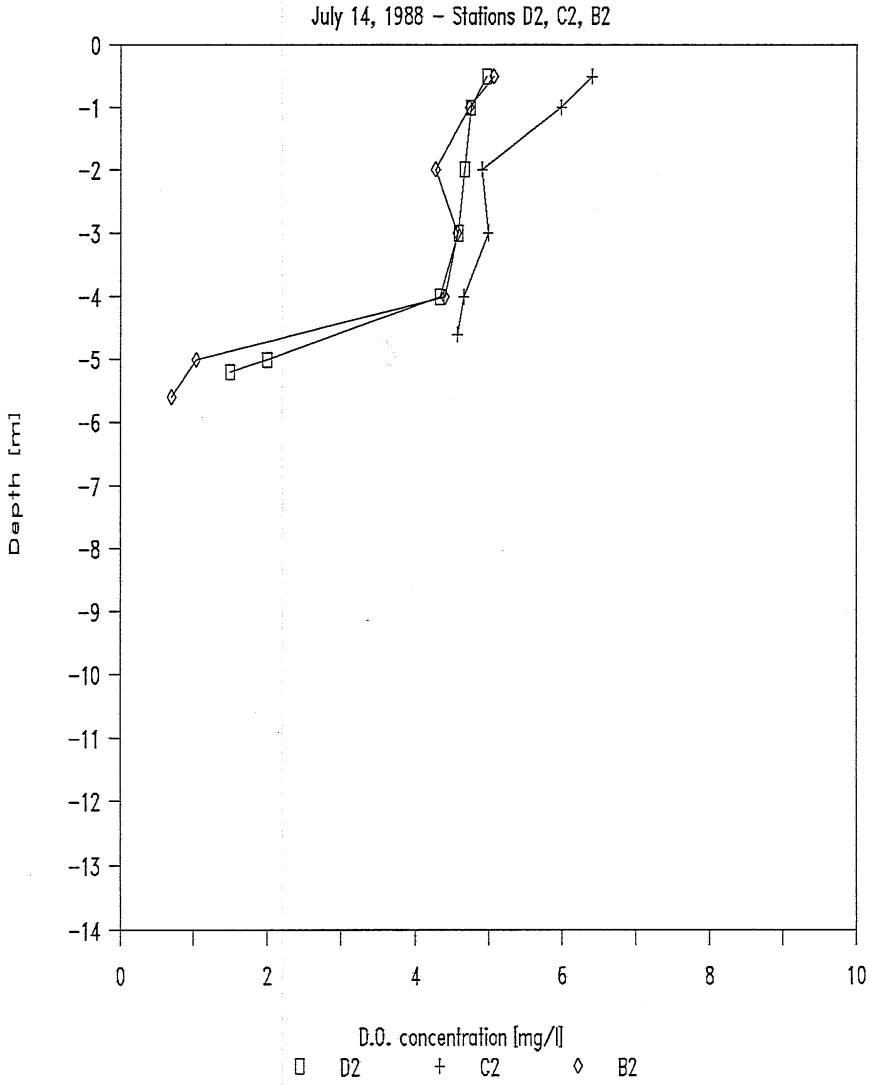


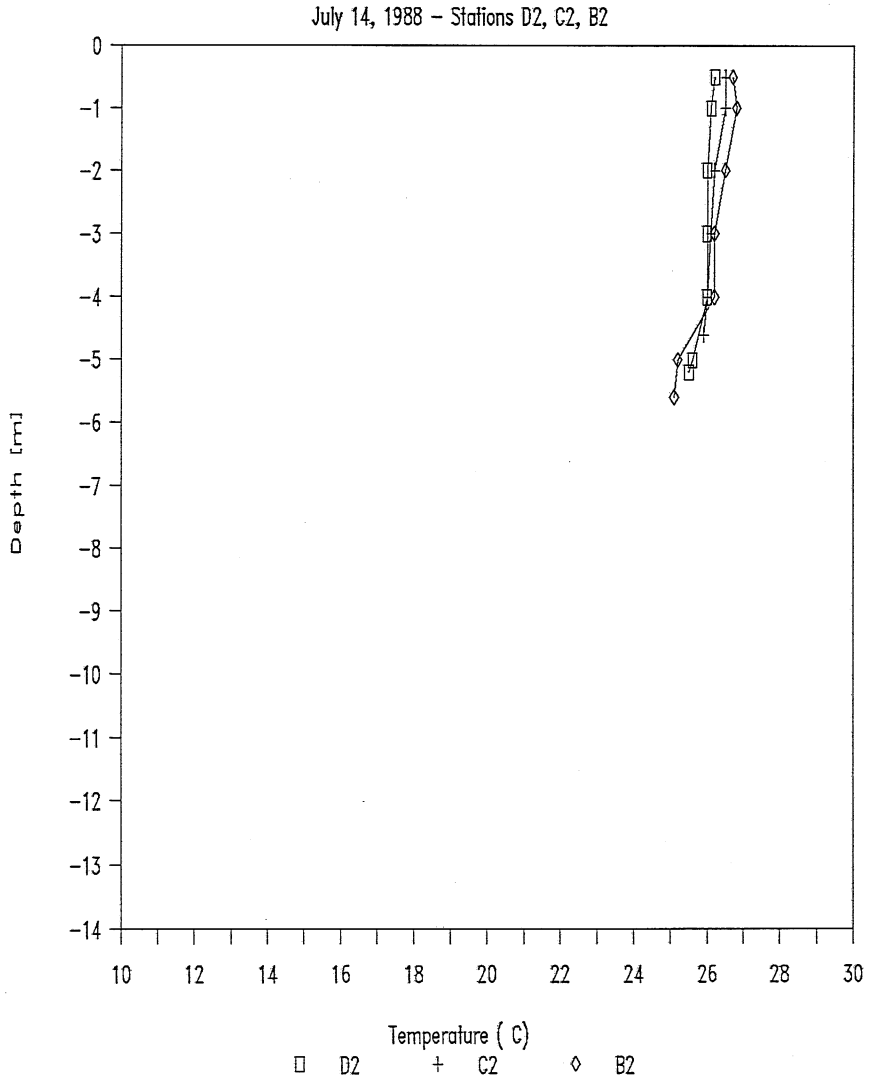
Byllesby Lake D.O. study - Summer 1988





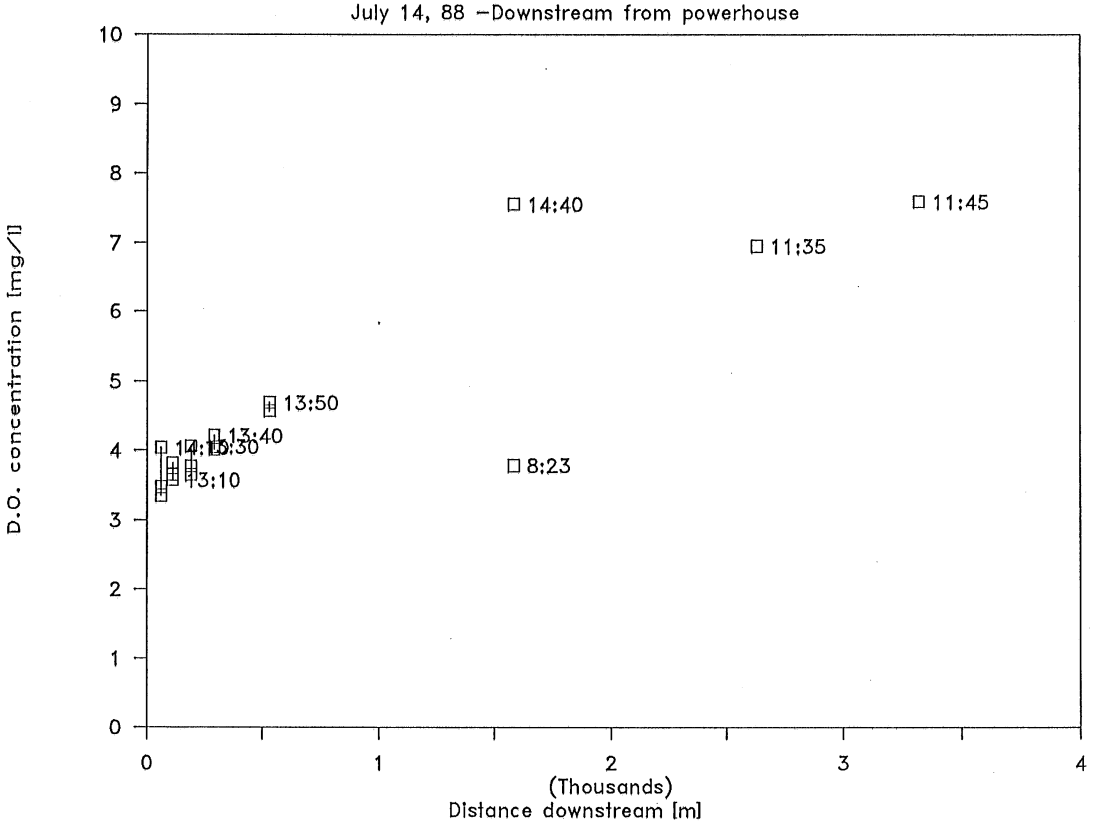
Byllesby Lake D.O. study - Summer 1988





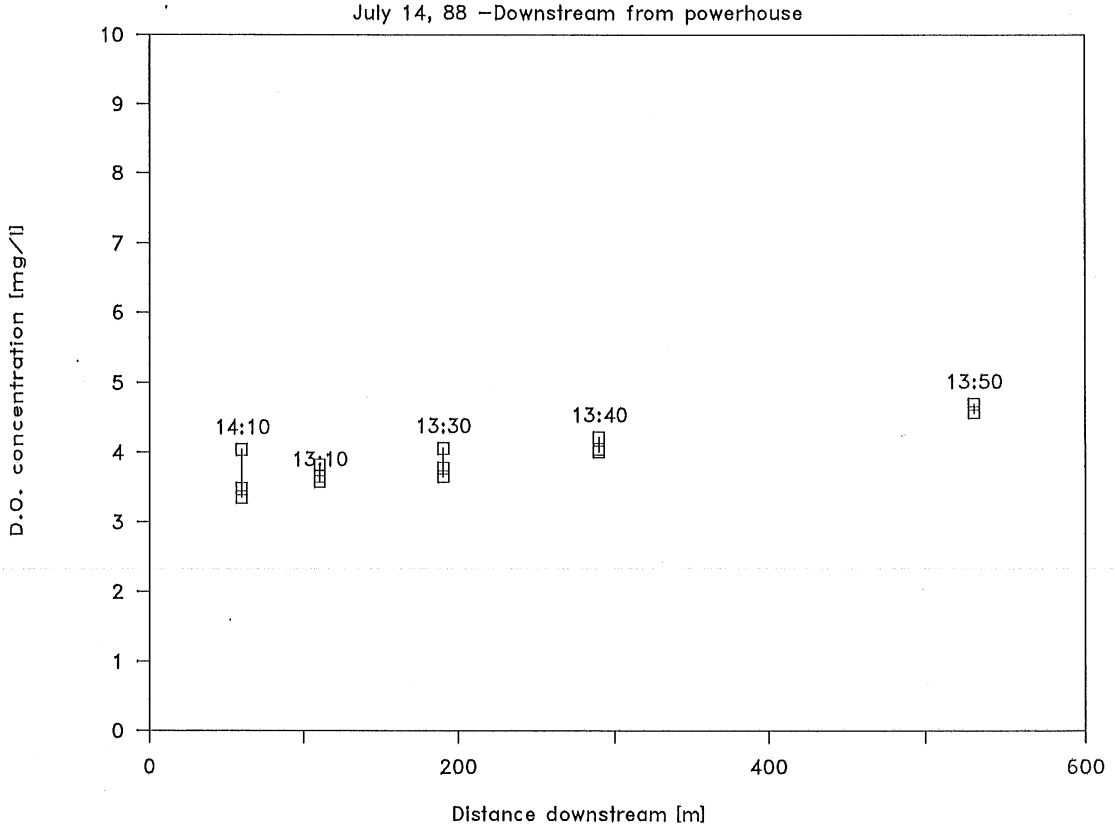
Byllesby Dam – Summer 1988

July 14, 88 –Downstream from powerhouse

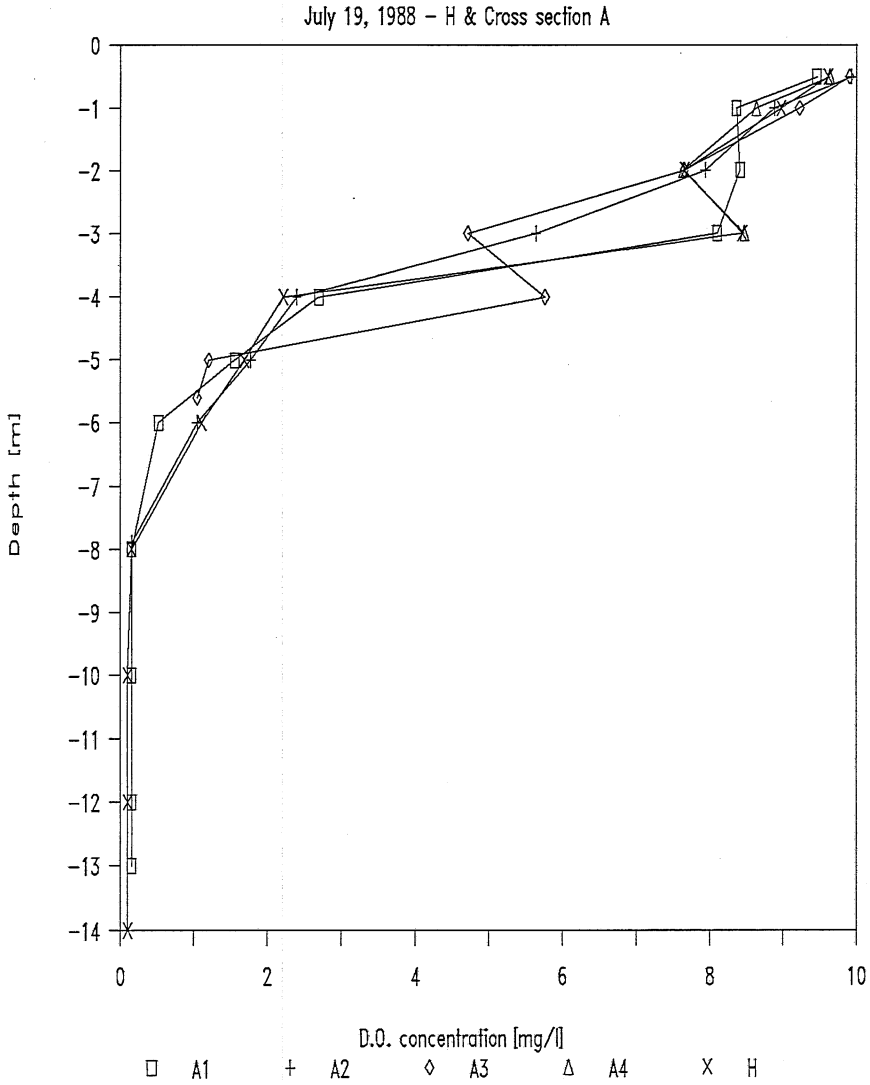


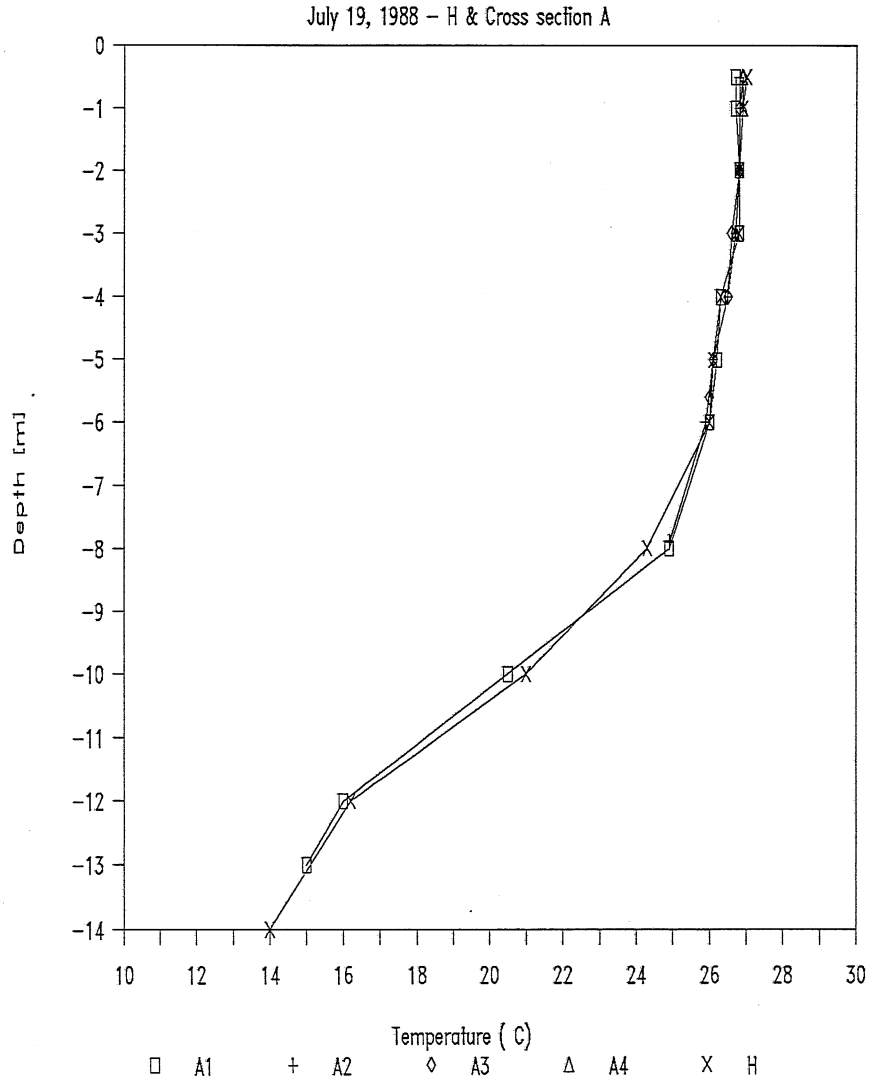
Byllesby Dam – Summer 1988

July 14, 88 –Downstream from powerhouse

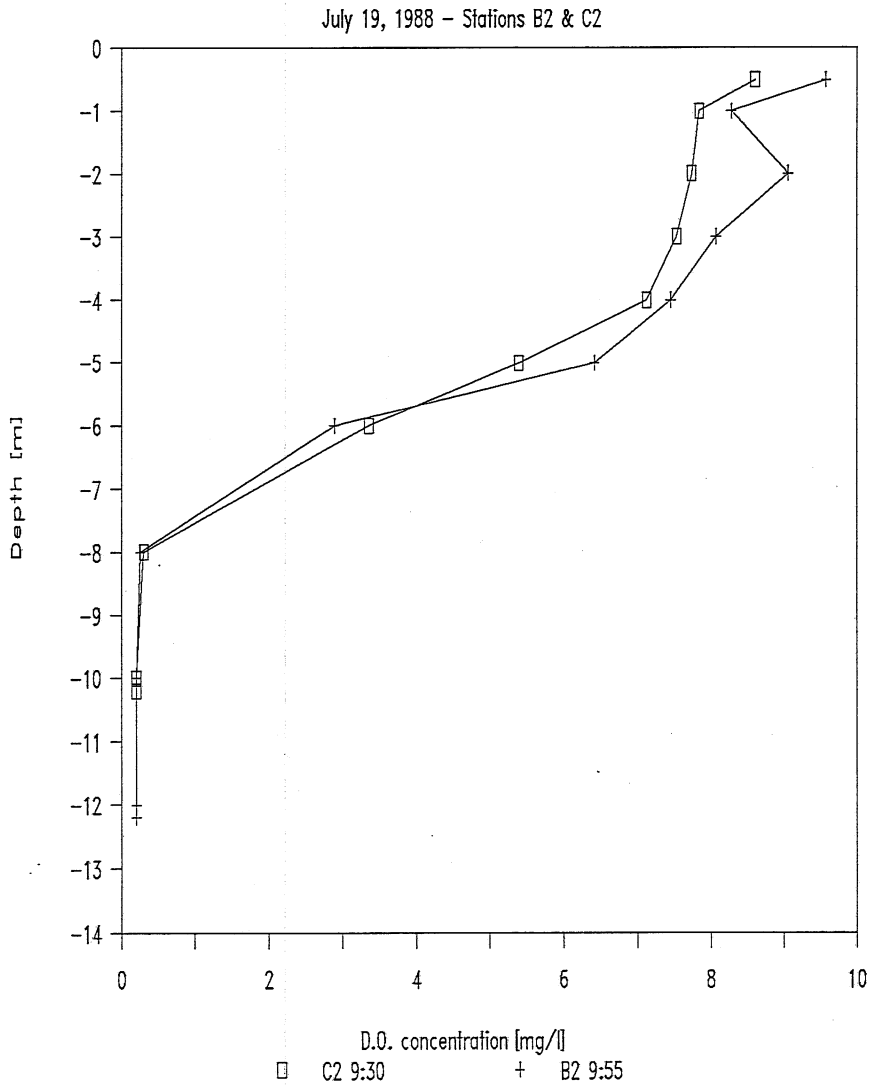


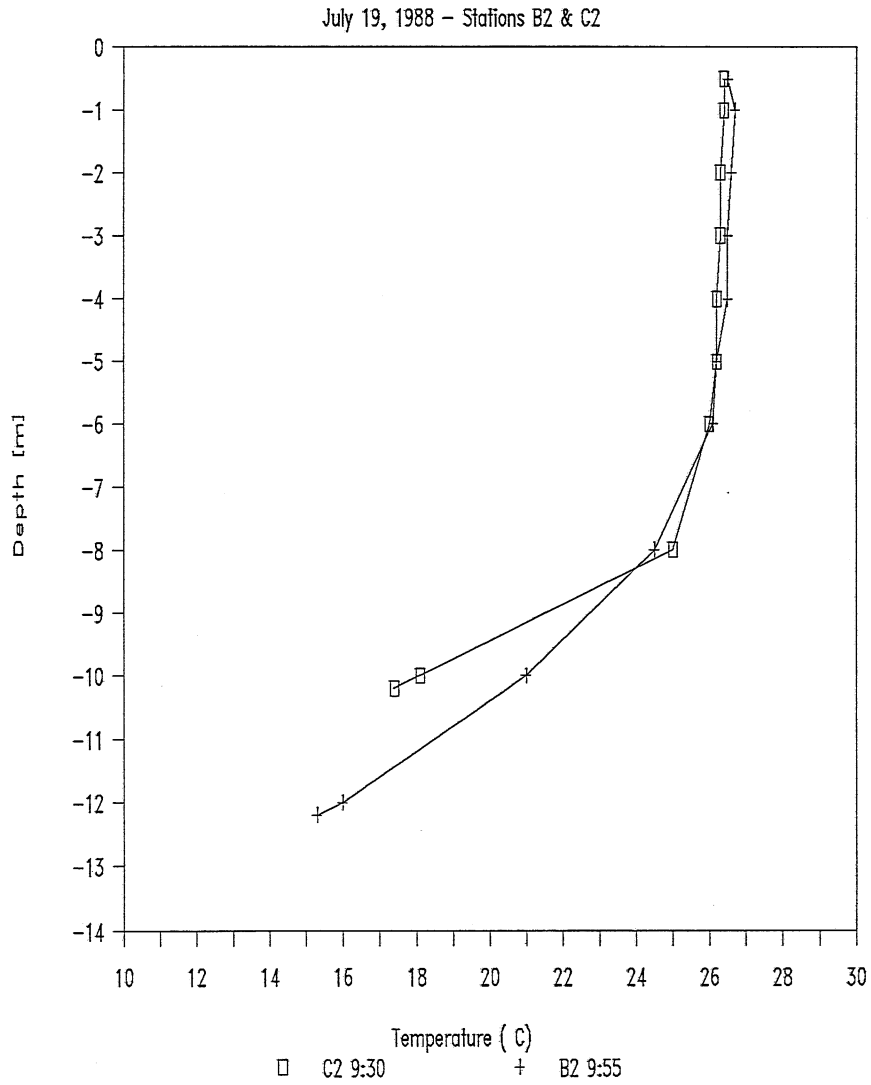
Byllesby Lake D.O. study - Summer 1988





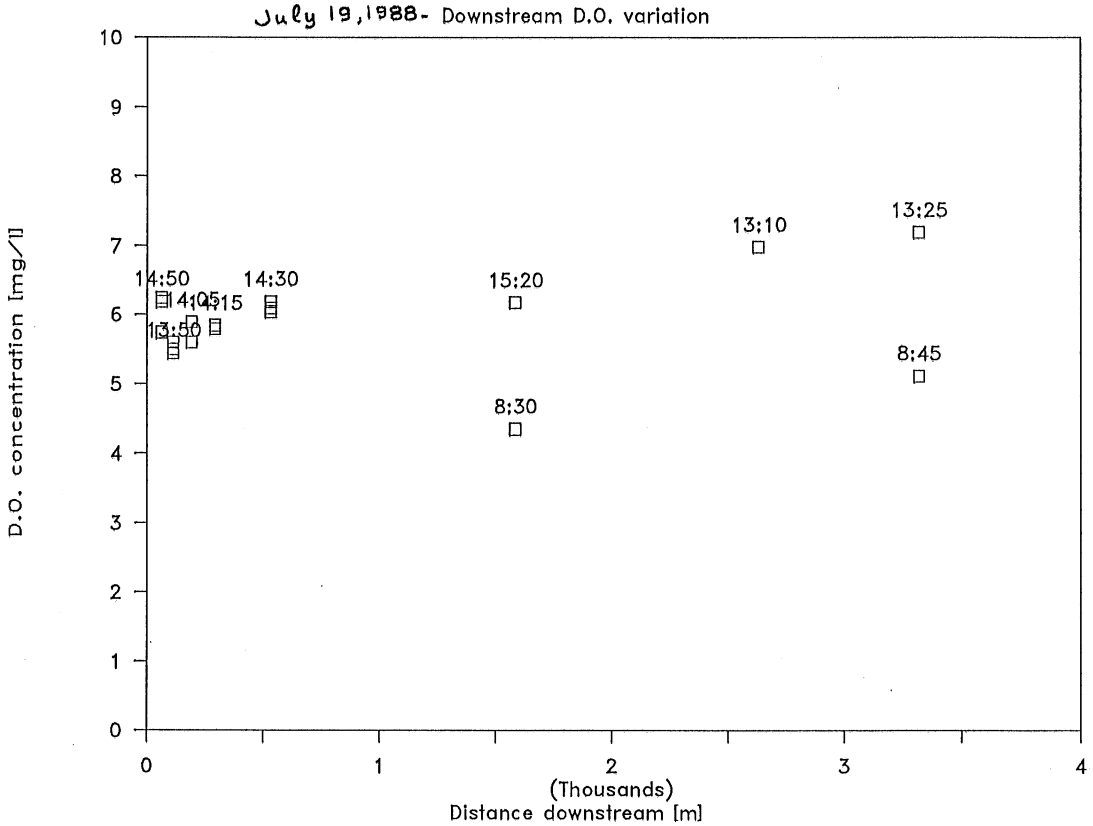
Byllesby Lake D.O. study - Summer 1988





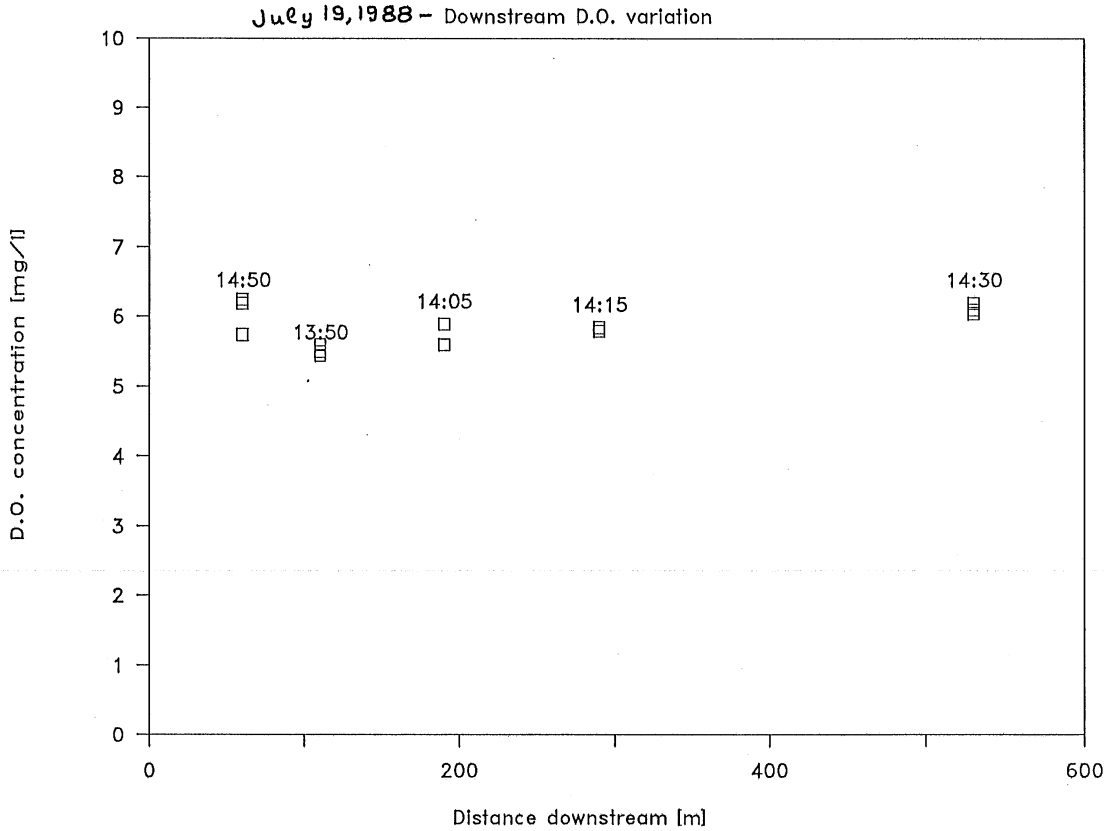
Byllesby Dam – Summer 1988

July 19, 1988 - Downstream D.O. variation

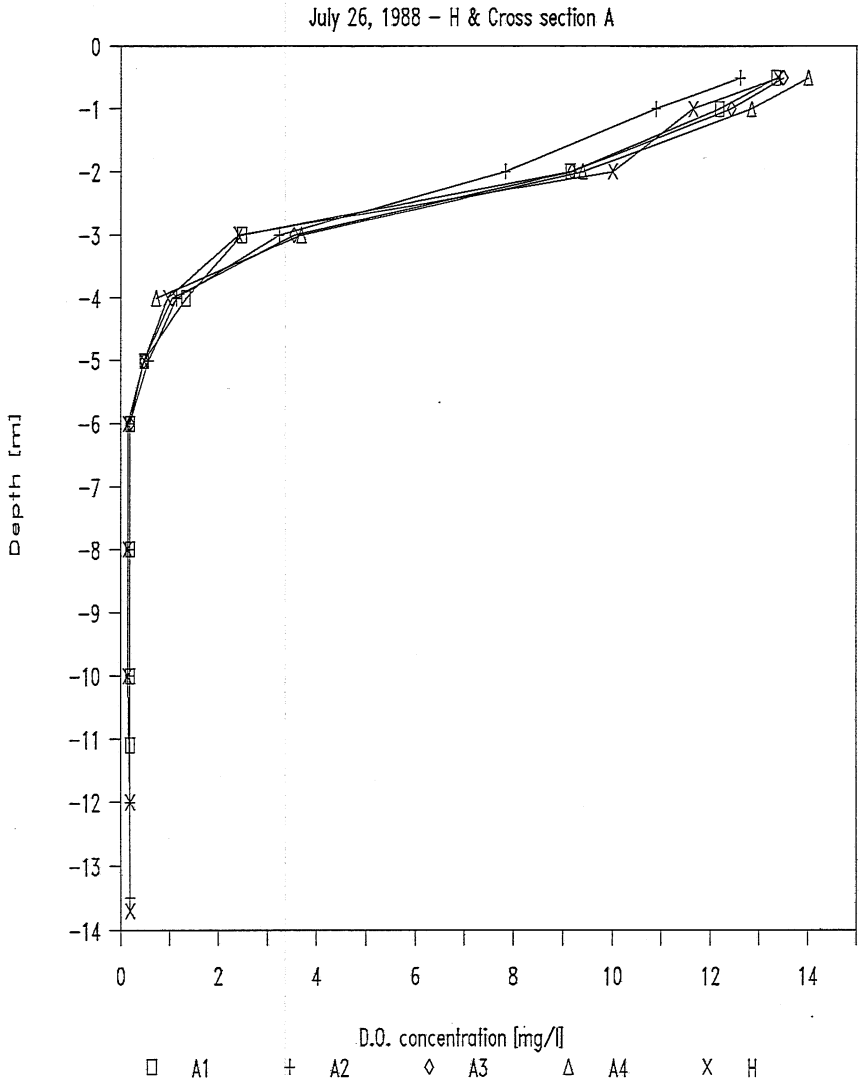


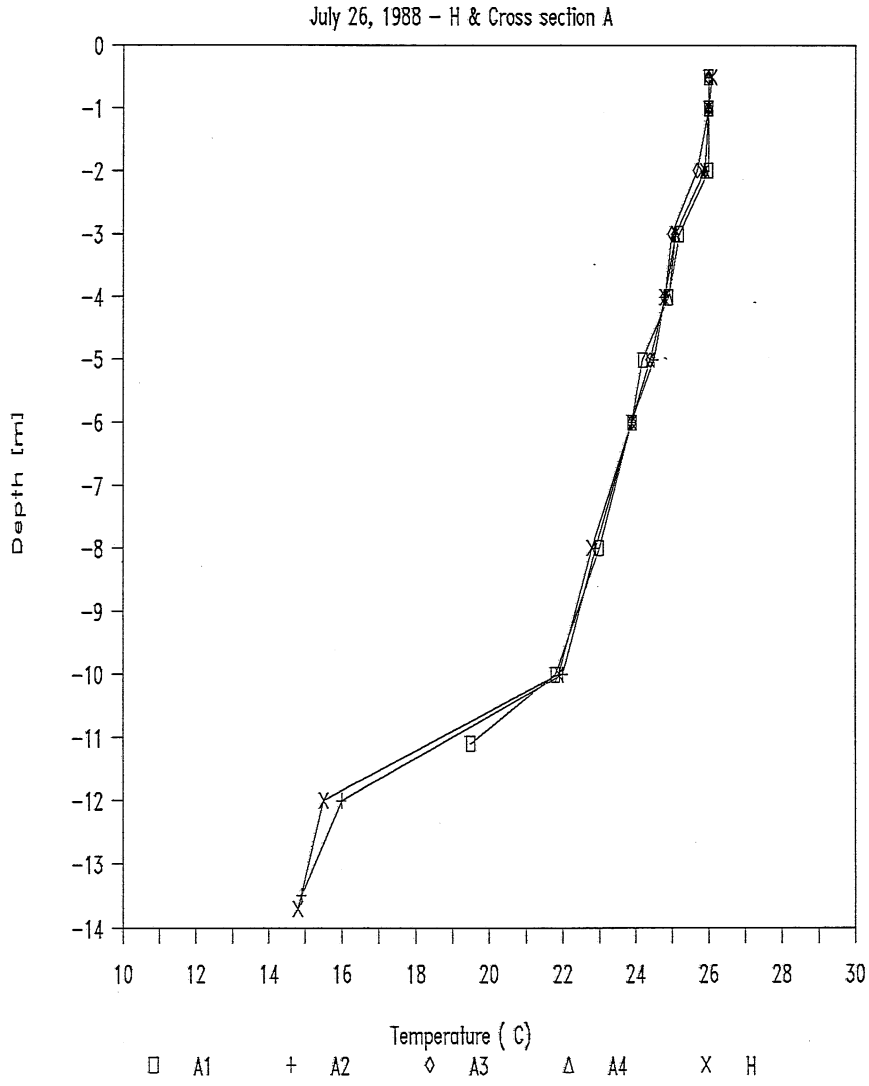
Byllesby Dam – Summer 1988

July 19, 1988 – Downstream D.O. variation

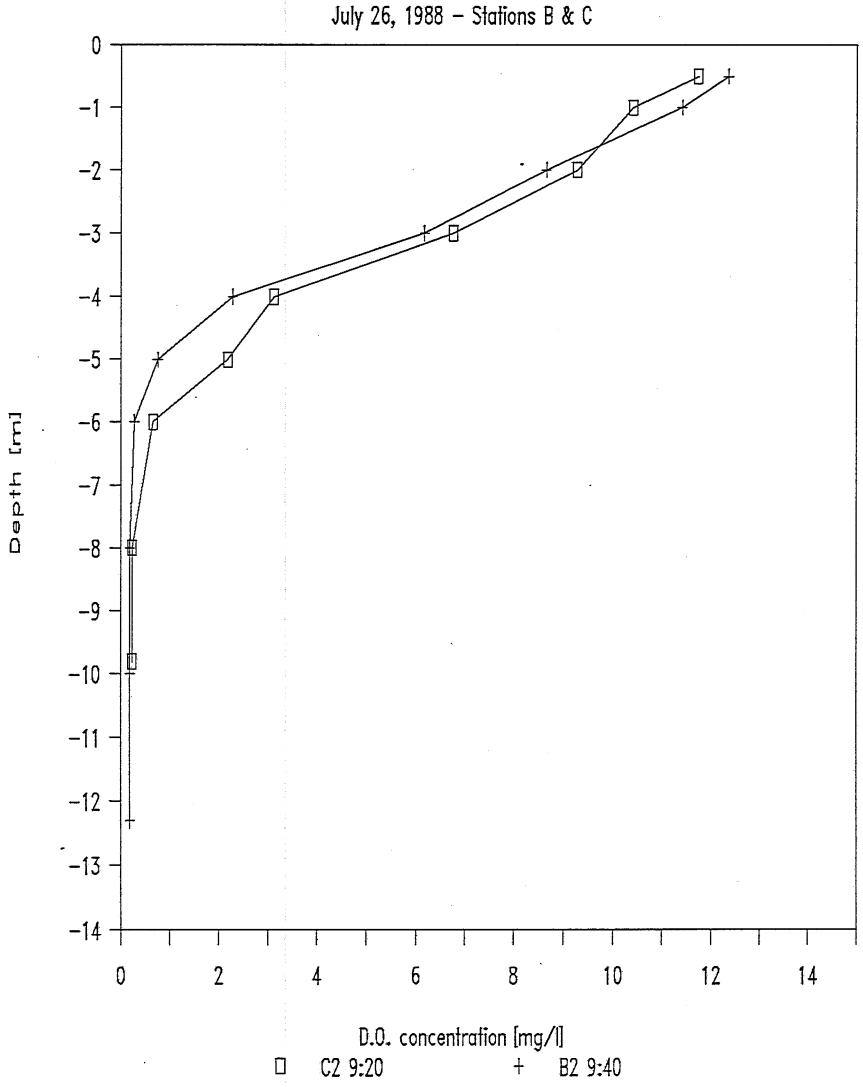


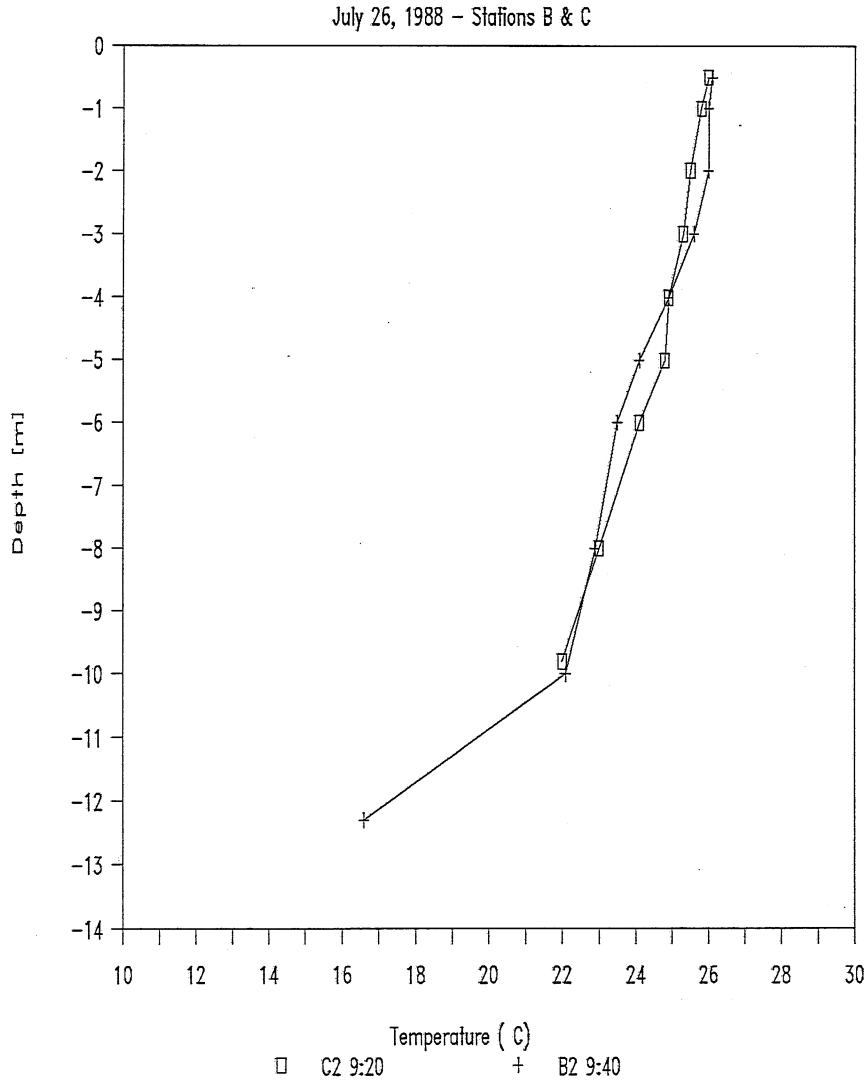
Byllesby Lake D.O. study - Summer 1988





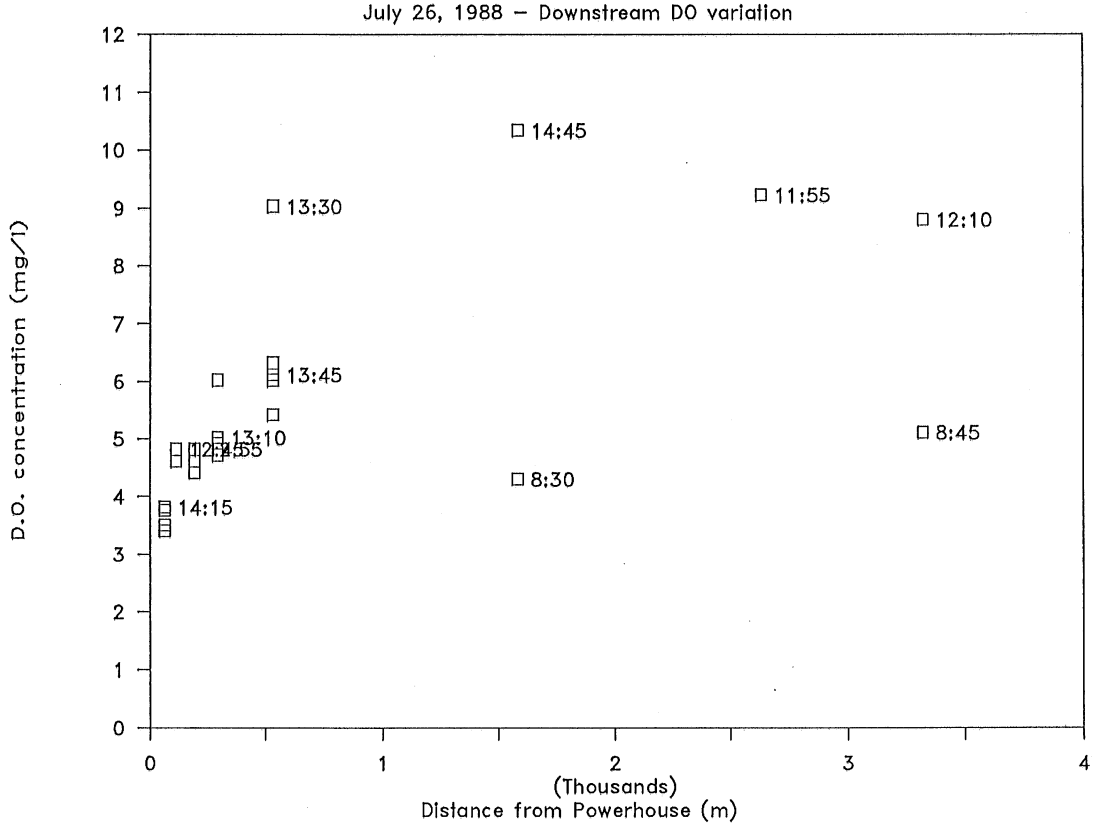
Byllesby Lake D.O. study - Summer 1988





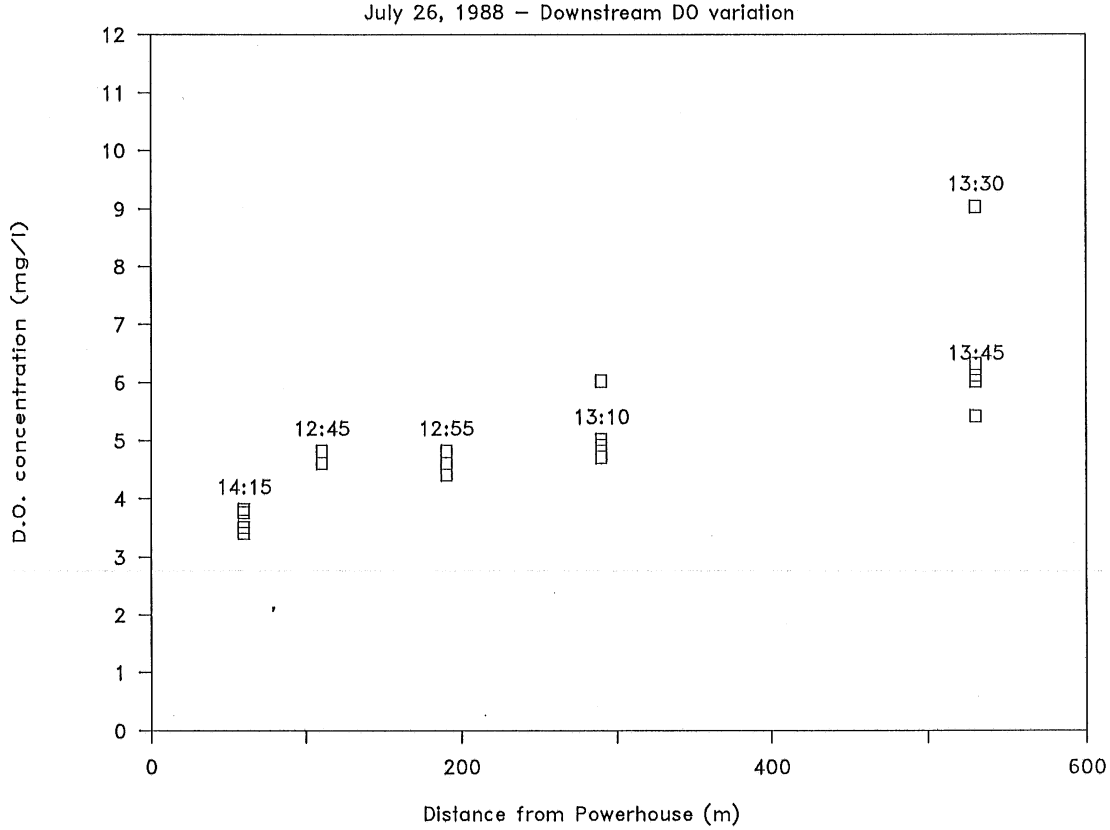
Byllesby Dam – Summer 1988

July 26, 1988 – Downstream DO variation

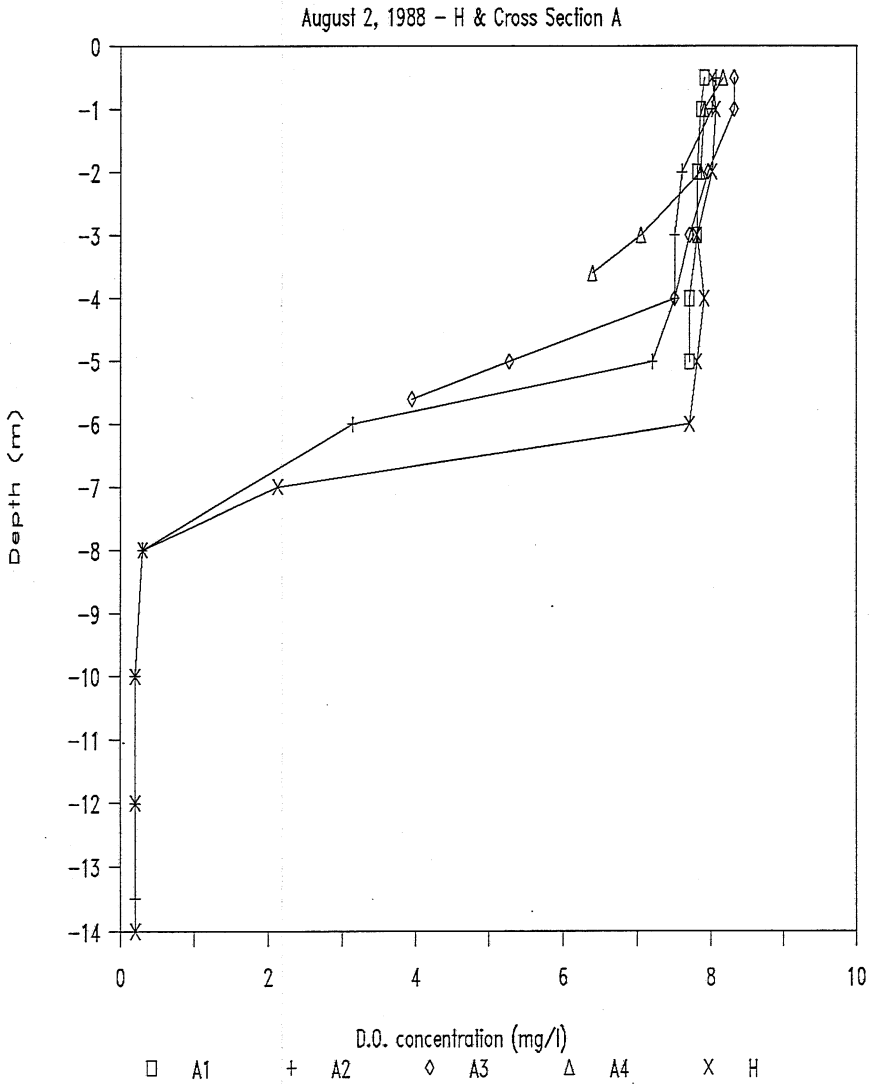


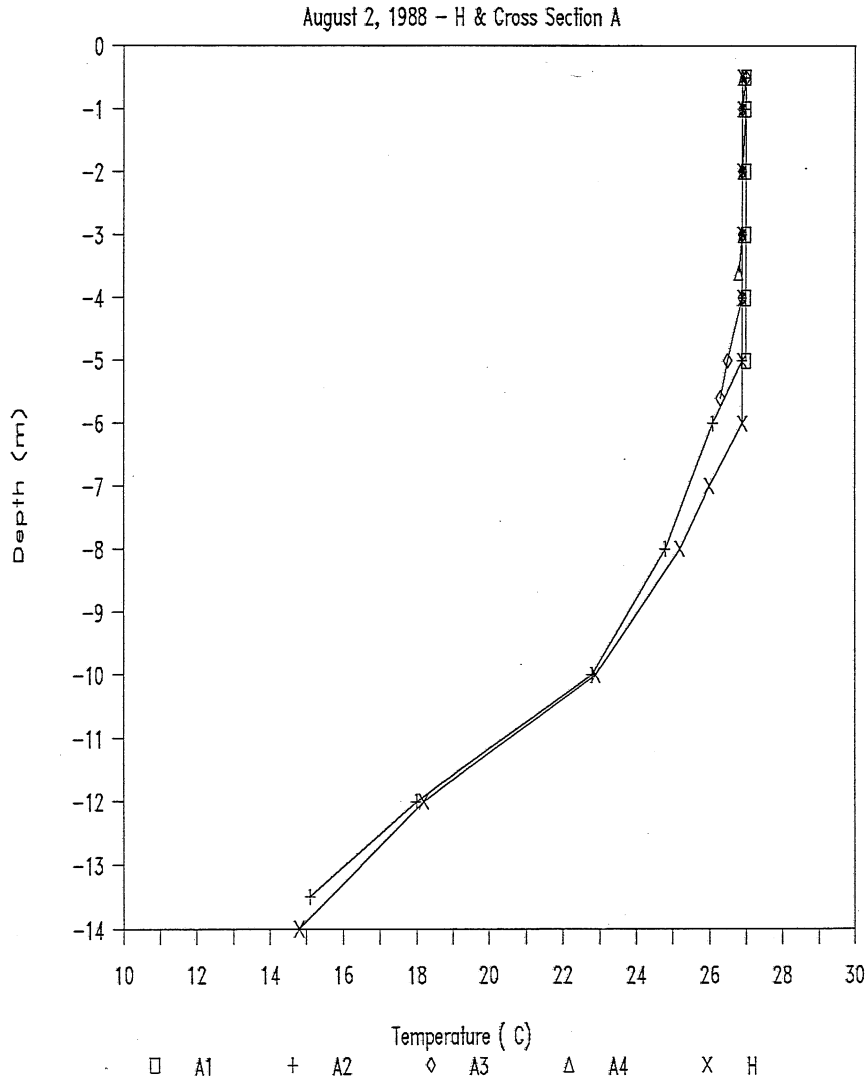
Byllesby Dam – Summer 1988

July 26, 1988 – Downstream DO variation

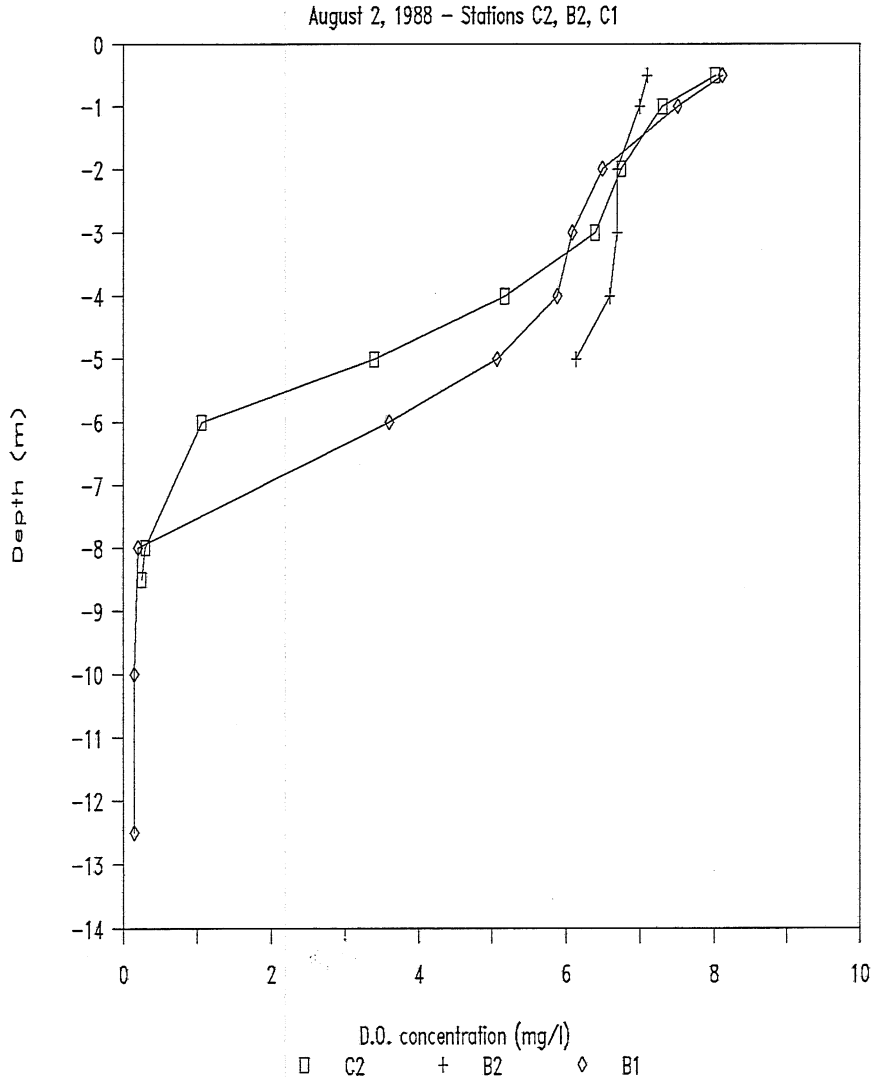


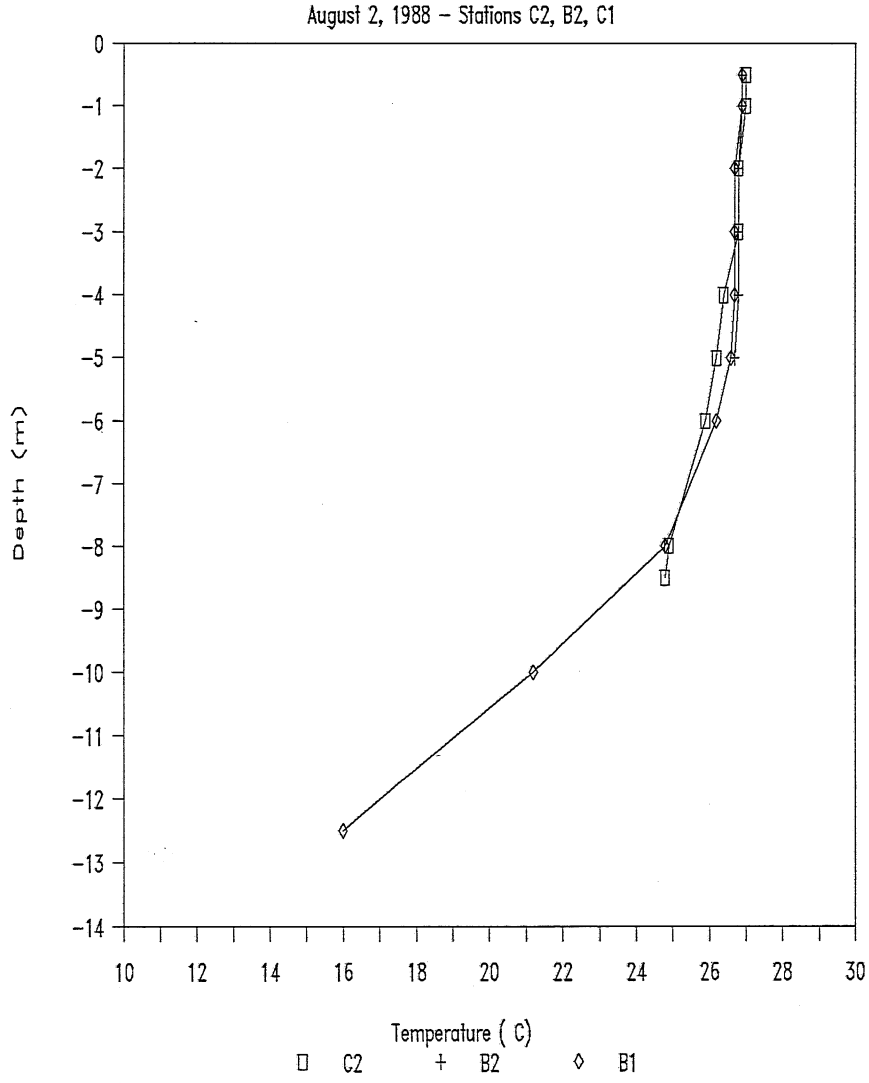
Byllesby Lake D.O. study - Summer 1988





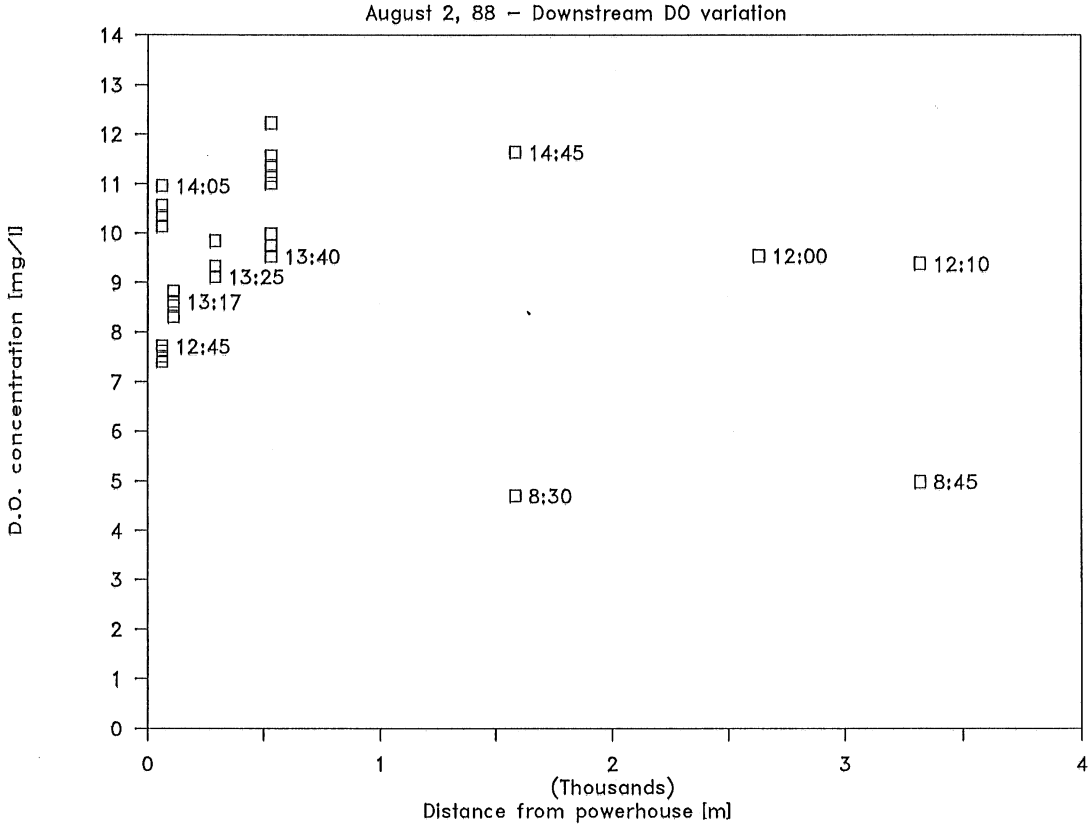
Byllesby Lake D.O. study - Summer 1988





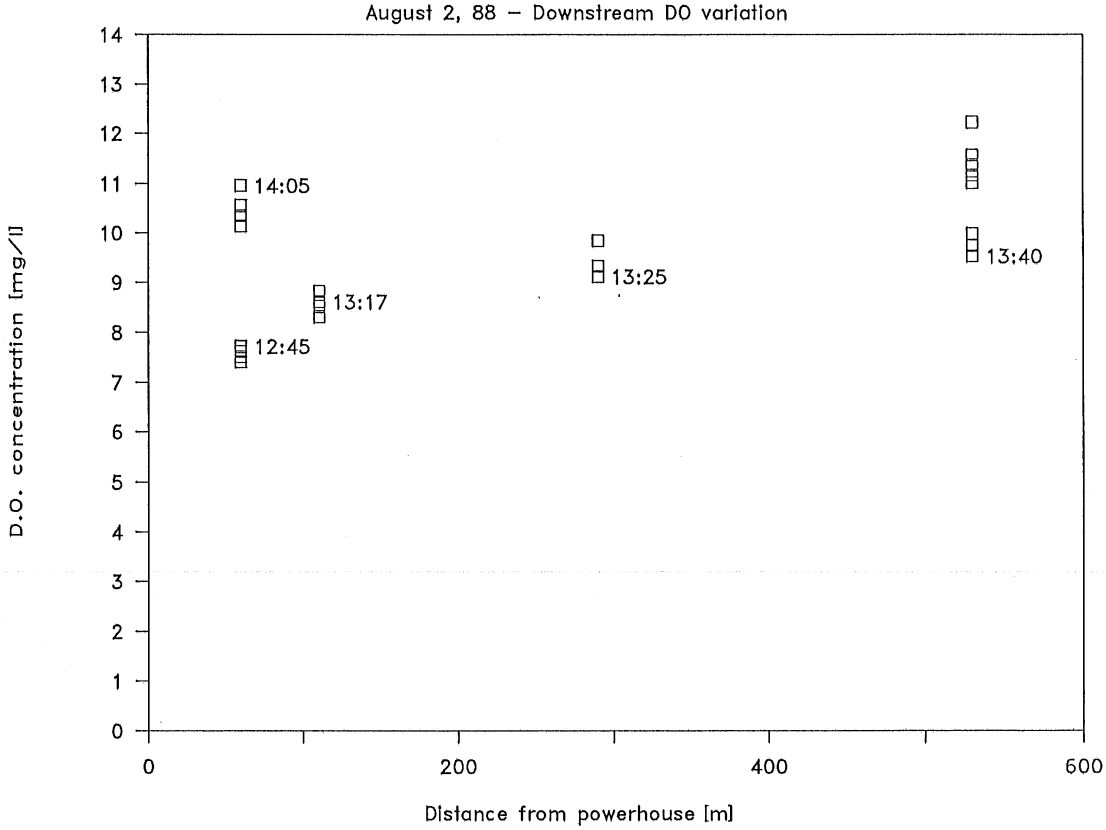
Byllesby Dam – Summer 1988

August 2, 88 – Downstream DO variation

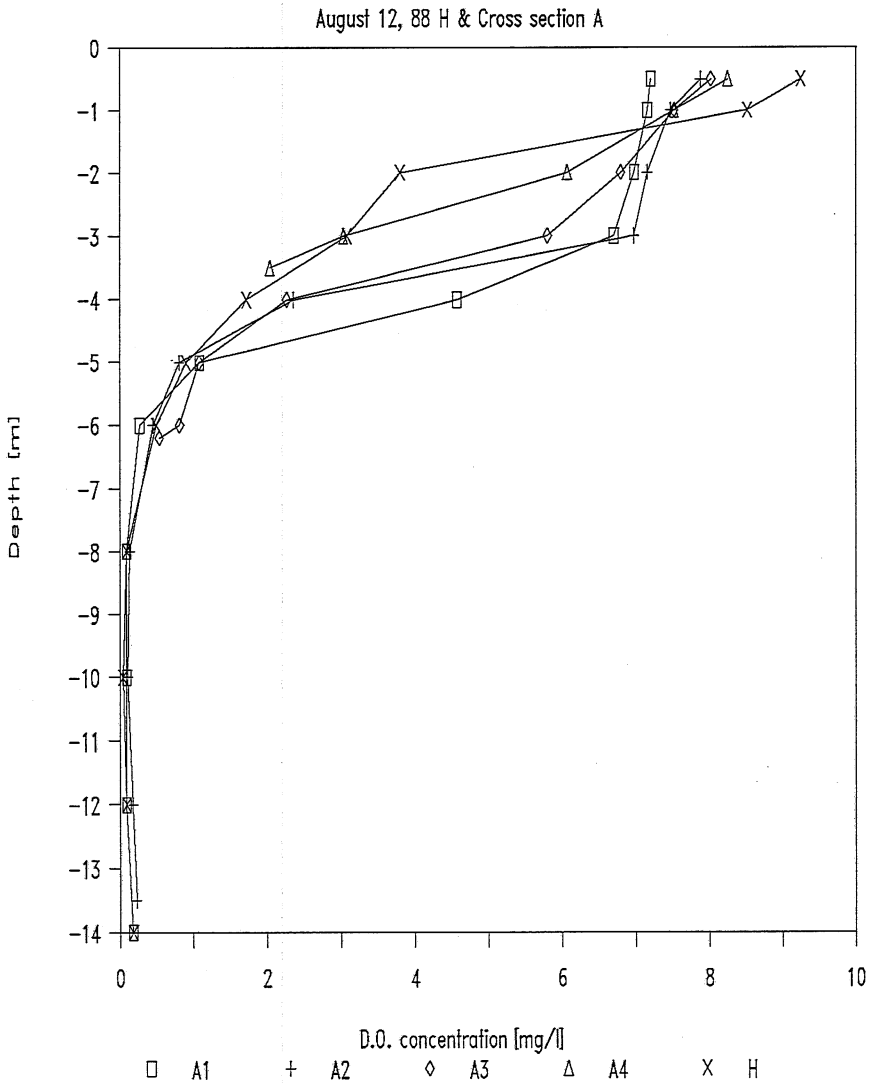


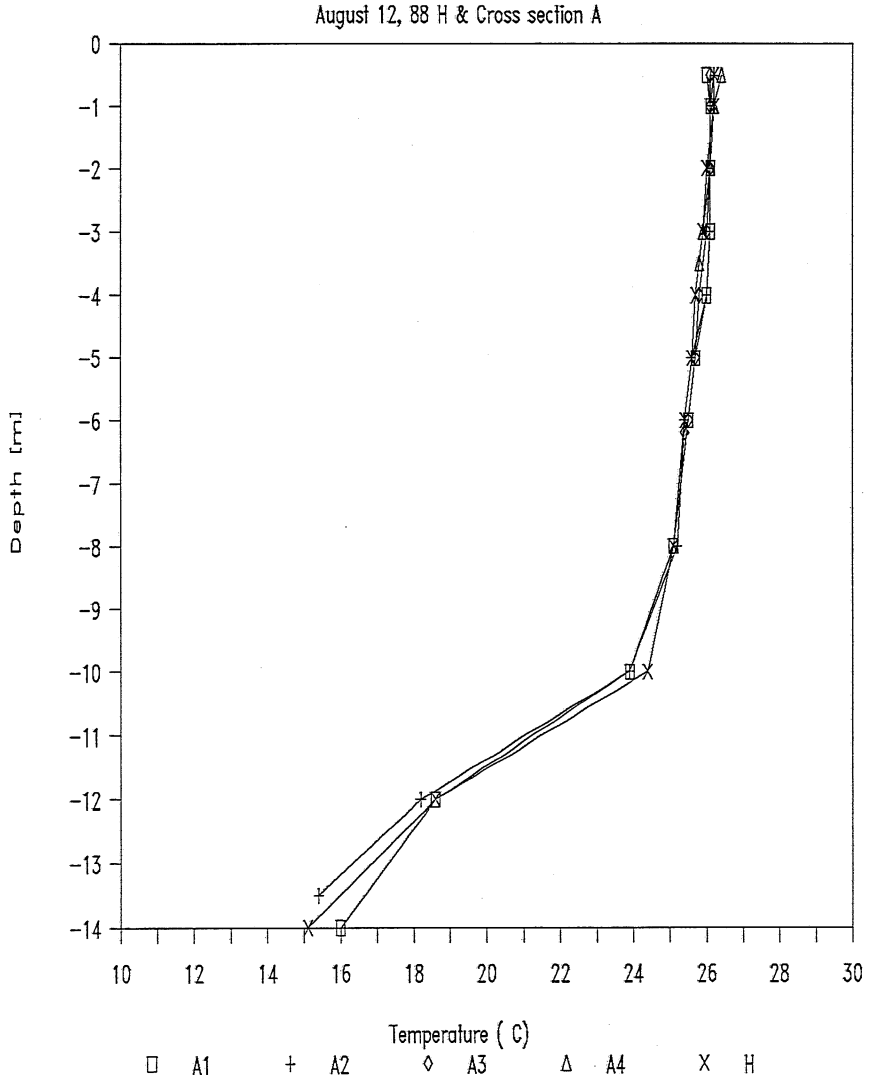
Byllesby Dam – Summer 1988

August 2, 88 – Downstream DO variation

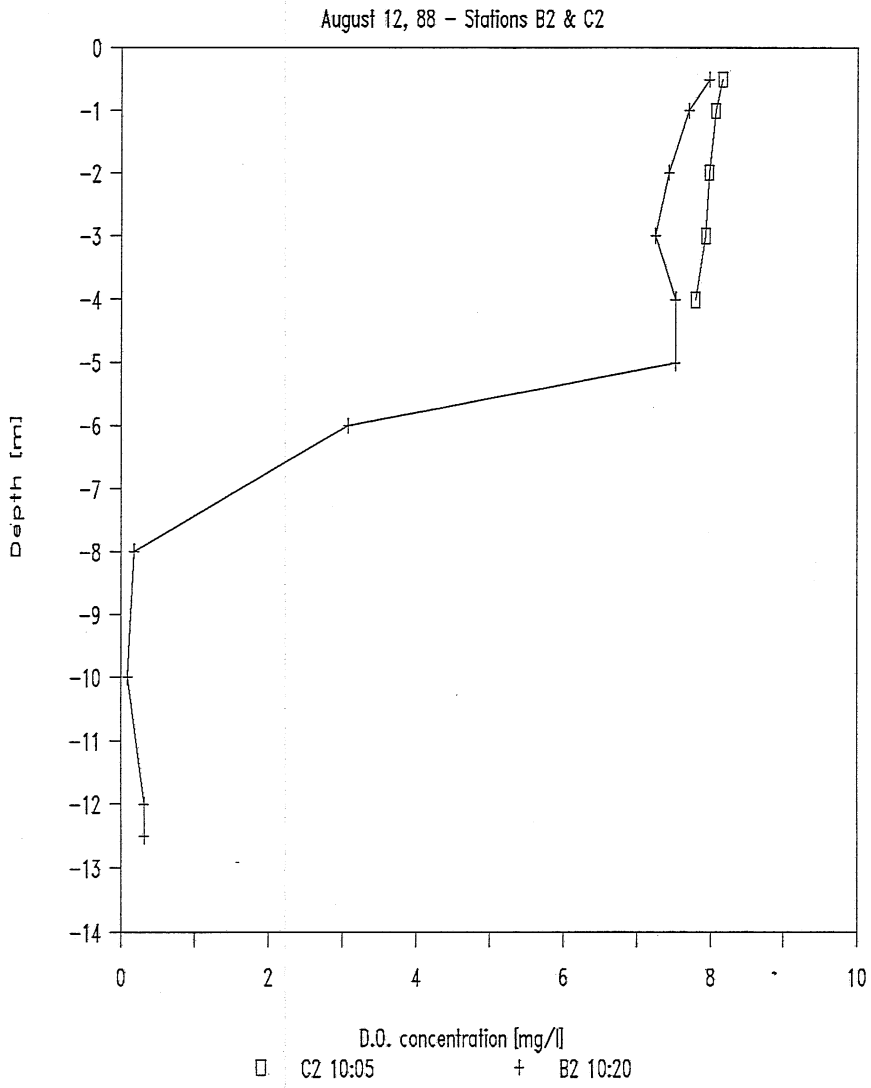


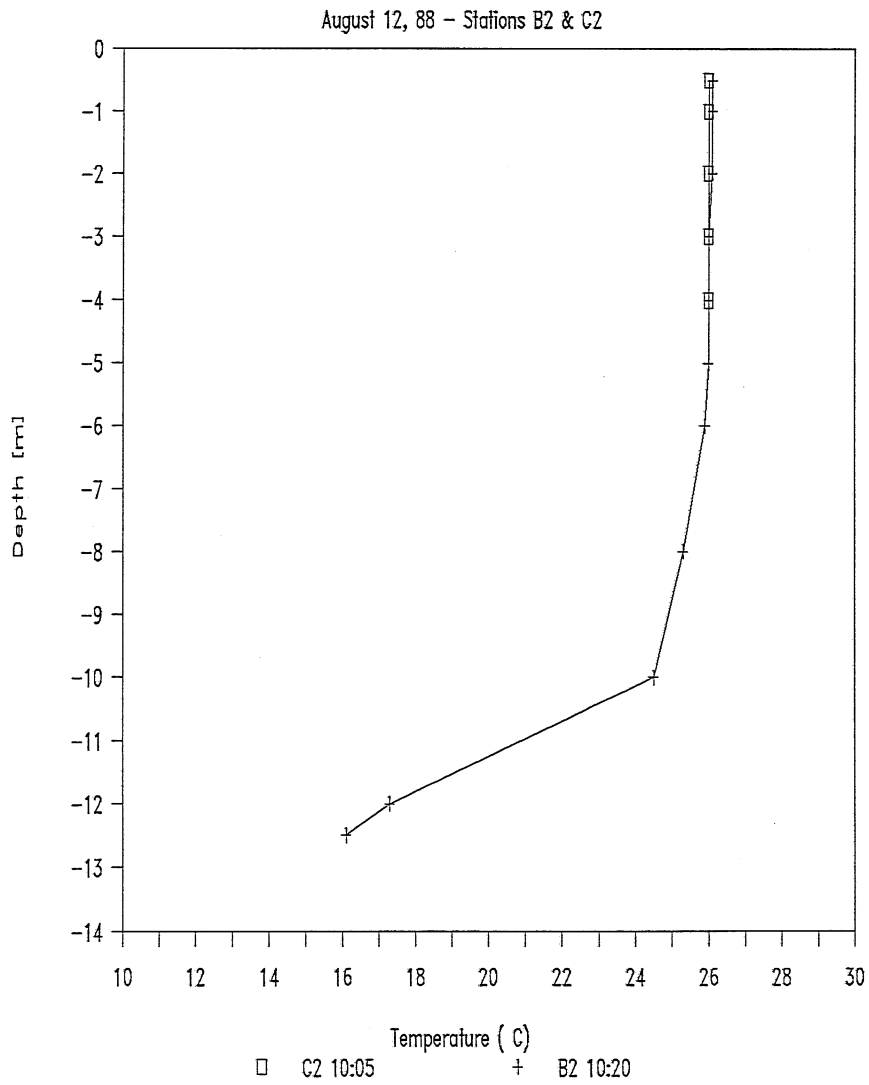
Byllesby Lake D.O. study - Summer 1988





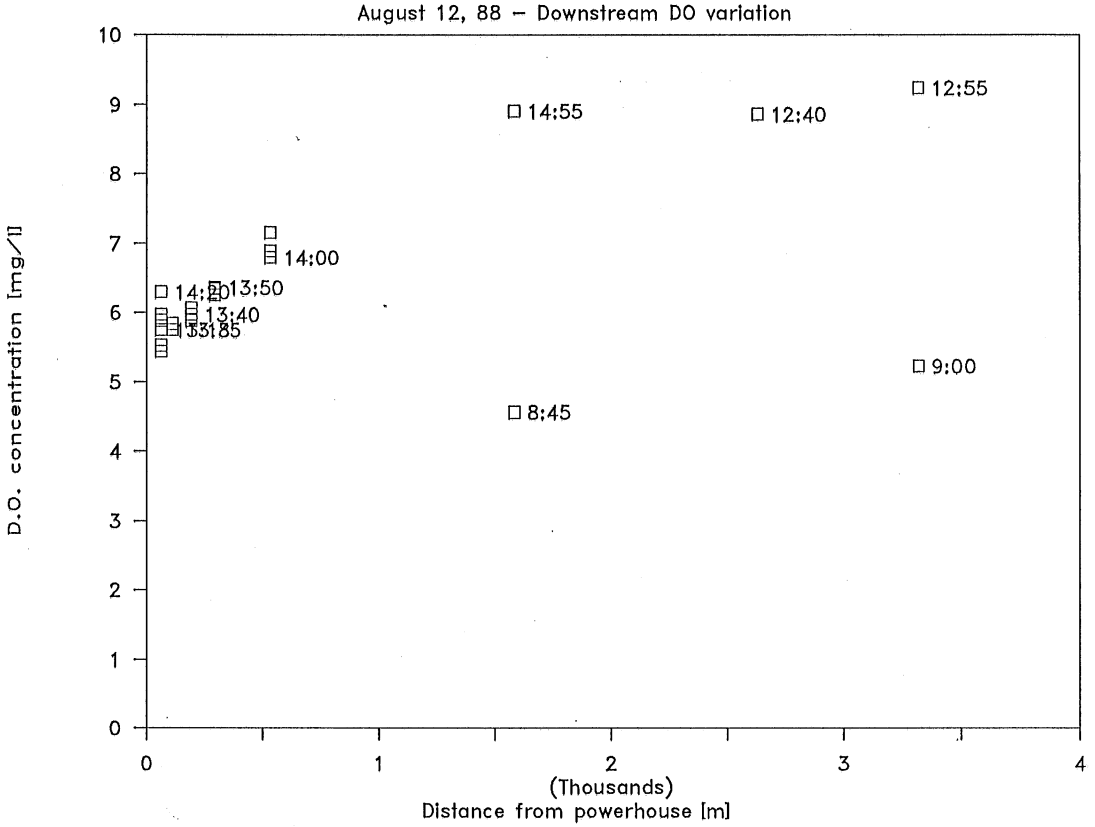
Byllesby Lake D.O. study - Summer 1988





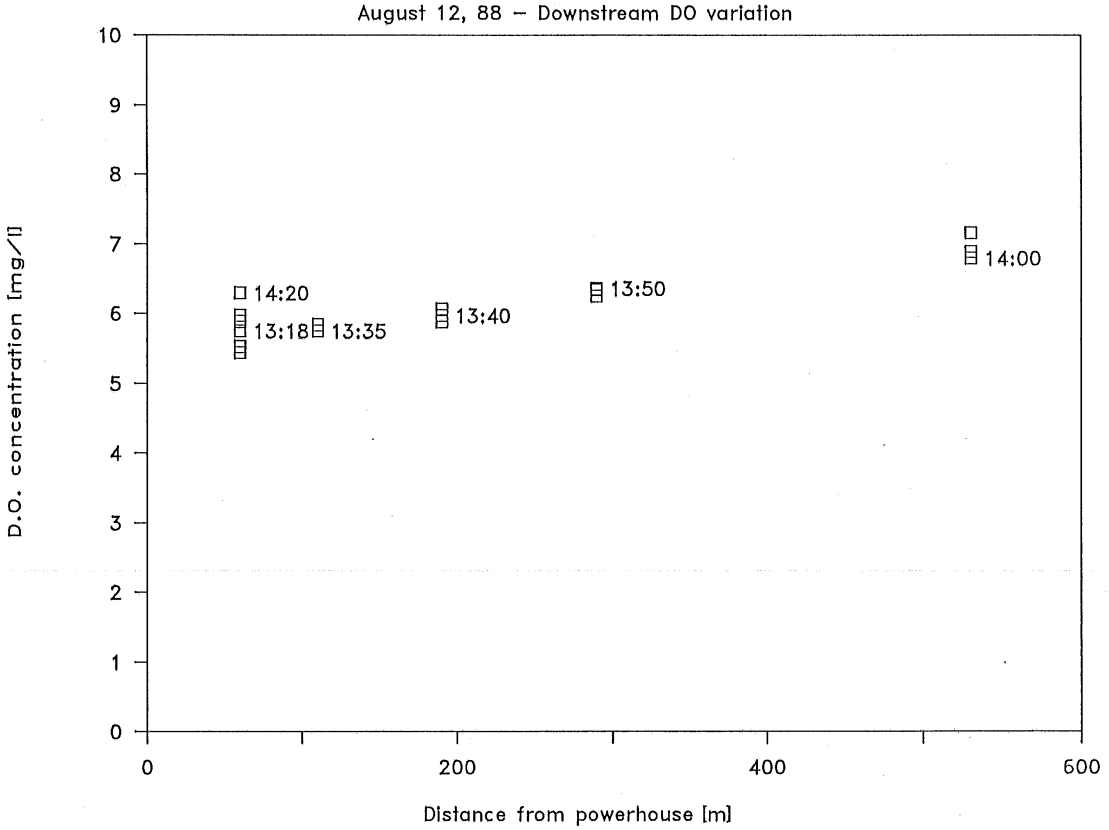
Byllesby Dam – Summer 1988

August 12, 88 – Downstream DO variation

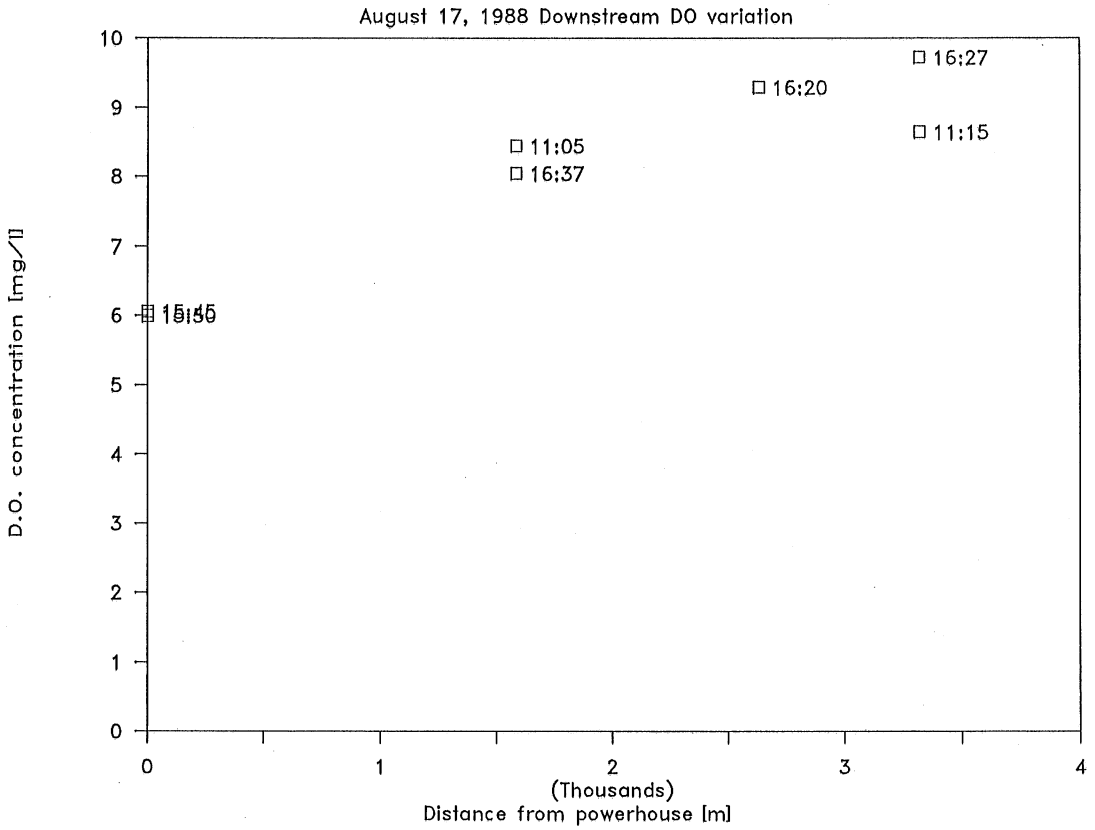


Byllesby Dam – Summer 1988

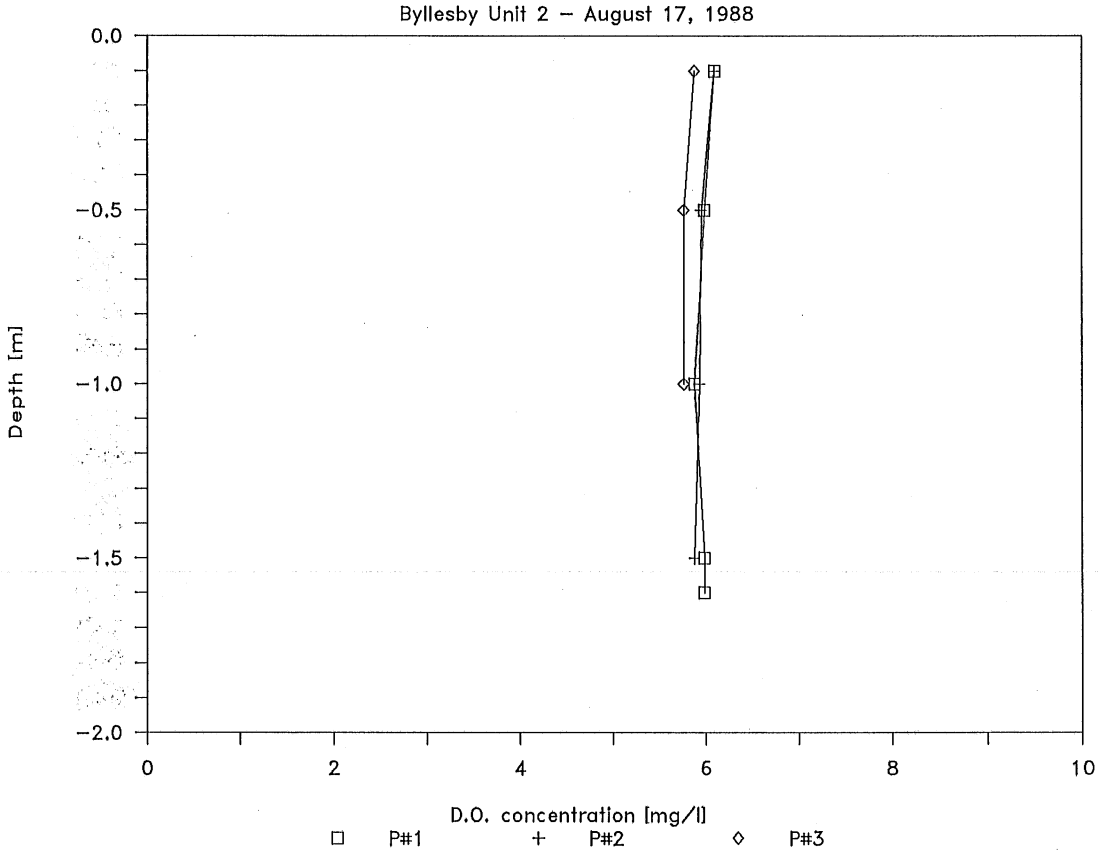
August 12, 88 – Downstream DO variation



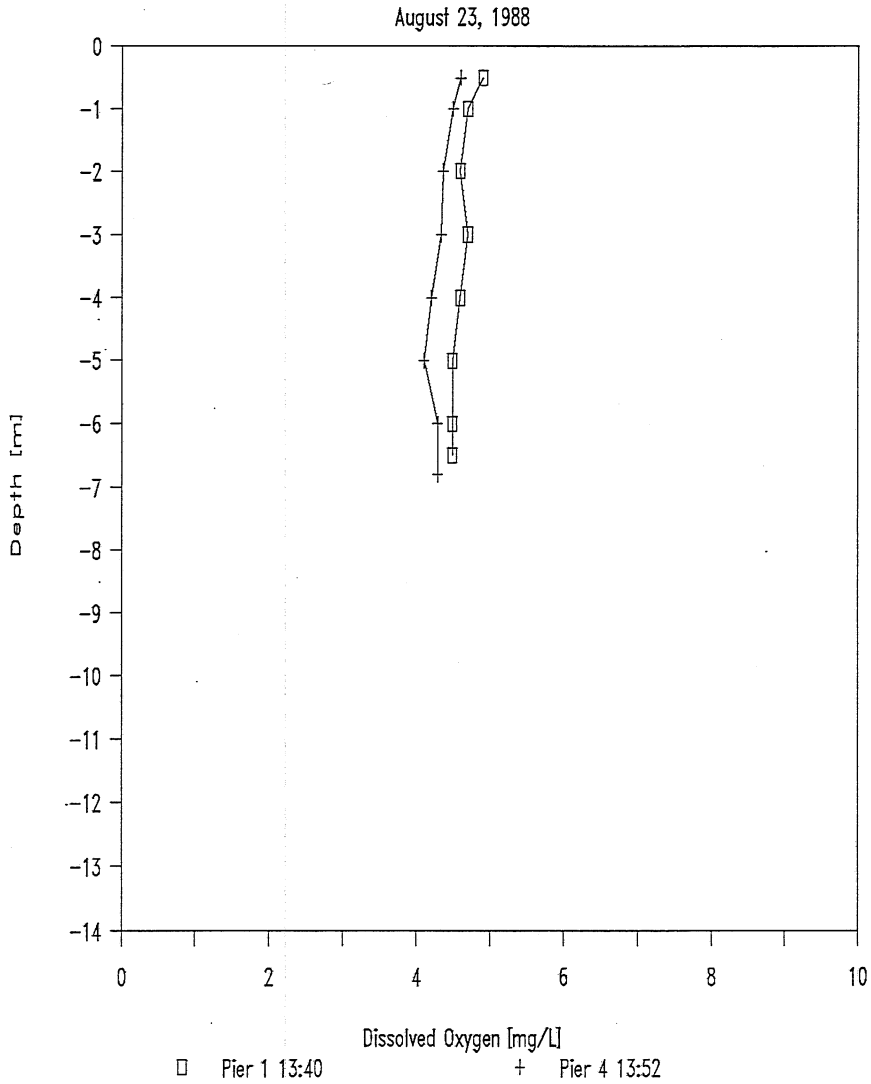
Byllesby Dam – Summer 1988

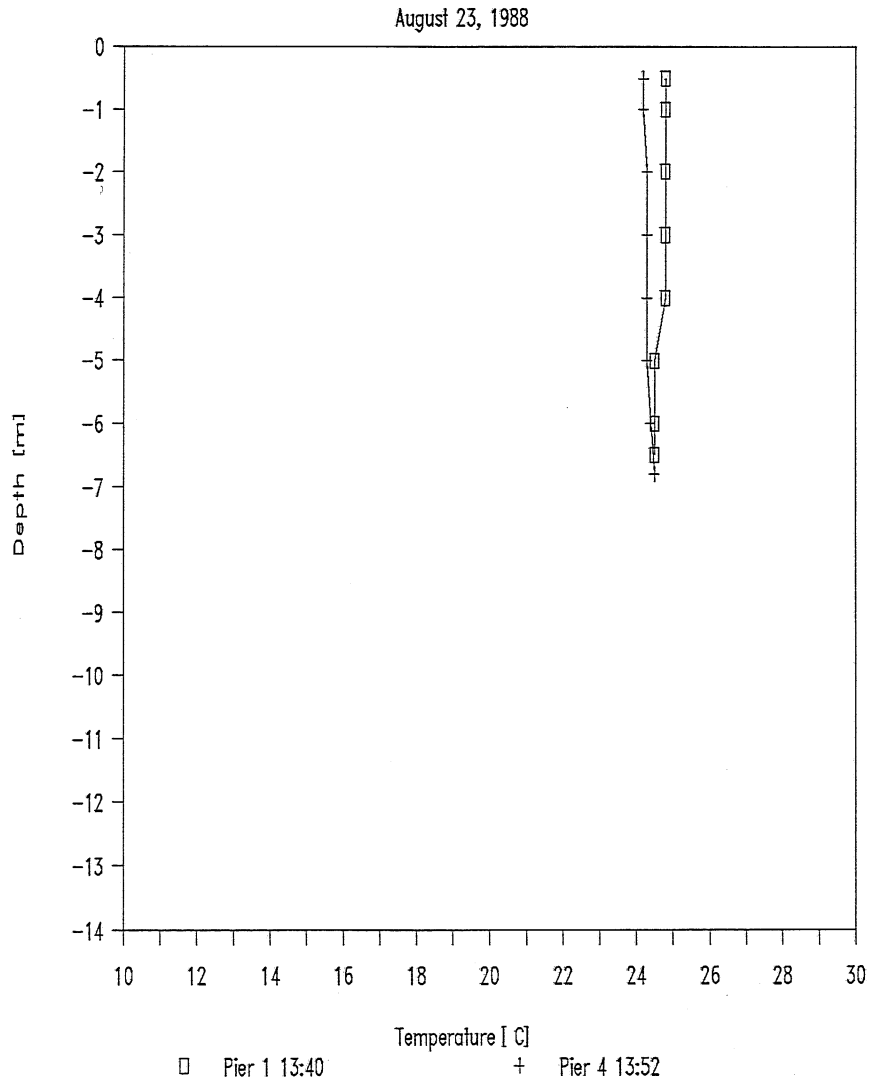


Uniformity Test for Probe Installation



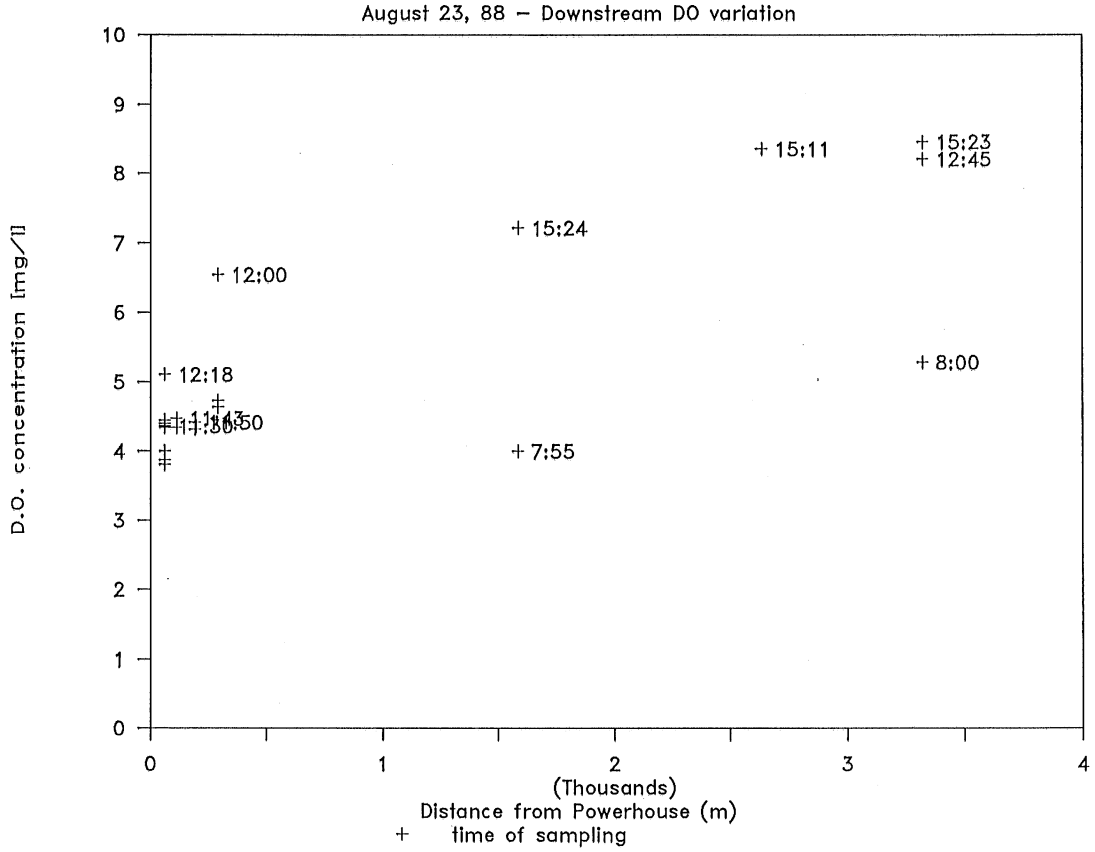
Byllesby Lake D.O. study - Summer 1988





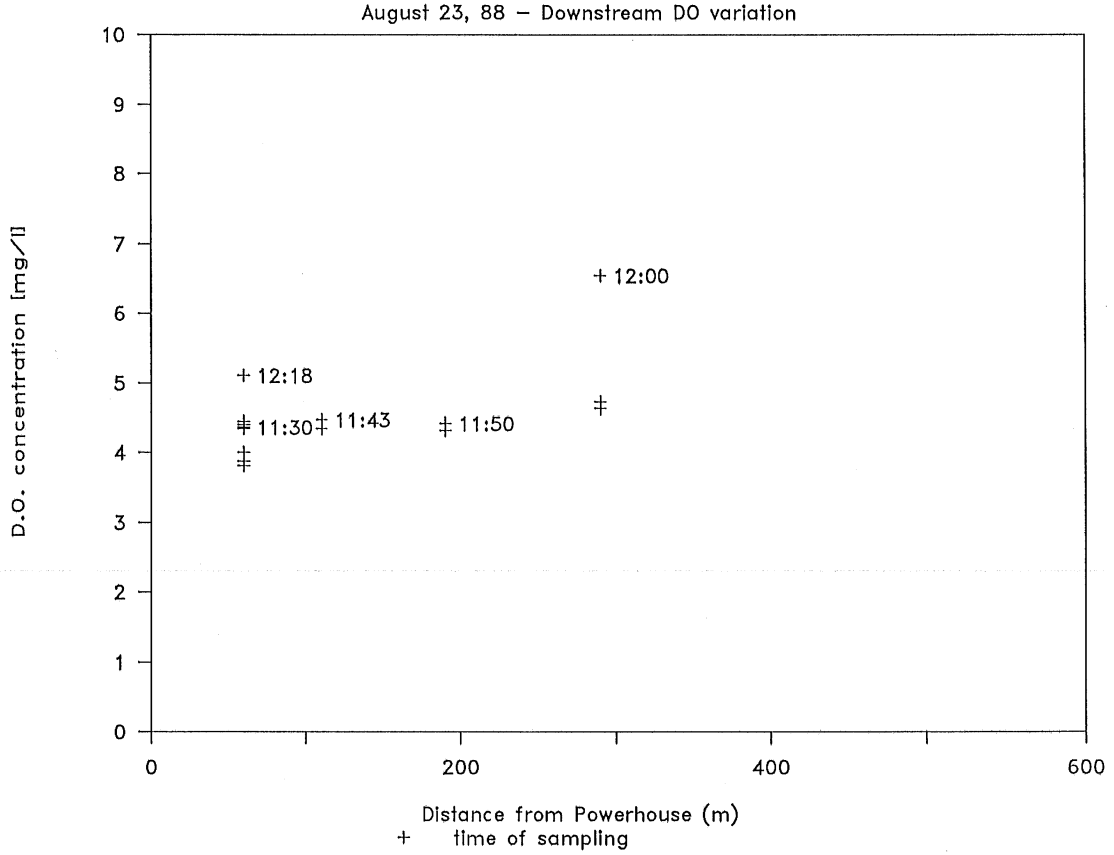
Byllesby Dam – Summer 1988

August 23, 88 – Downstream DO variation

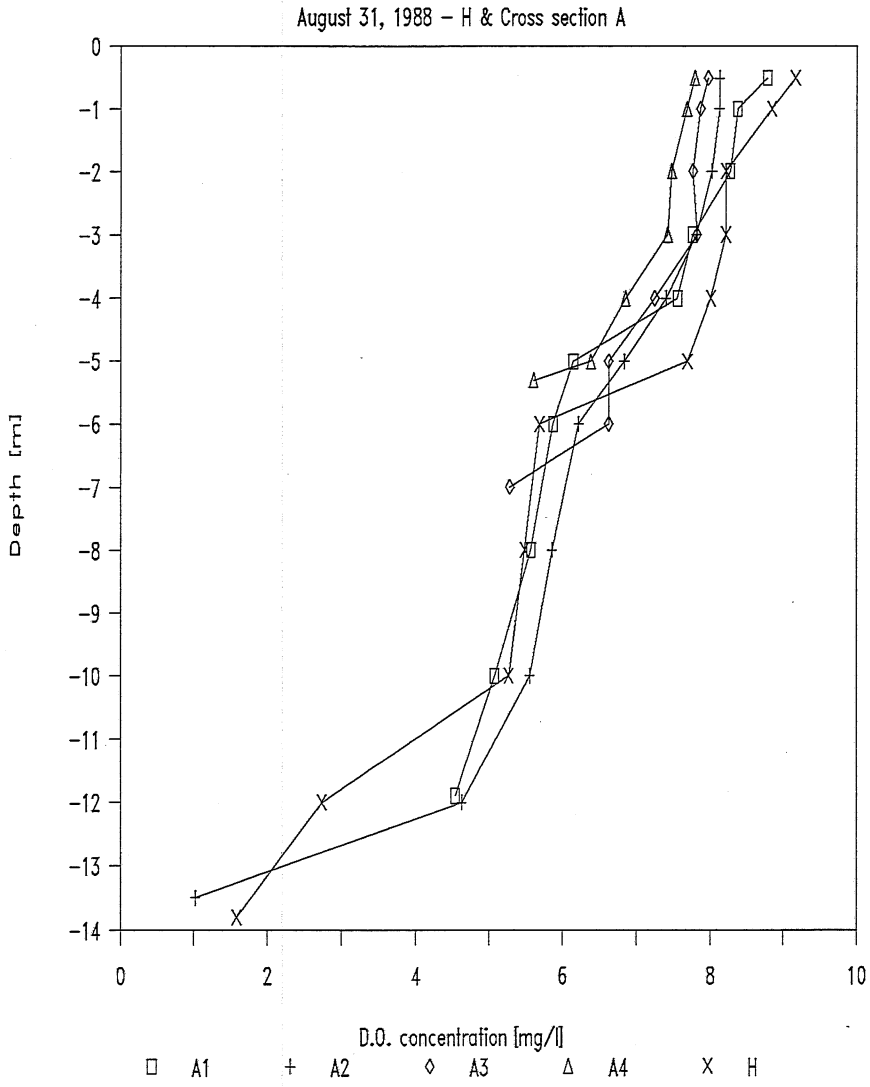


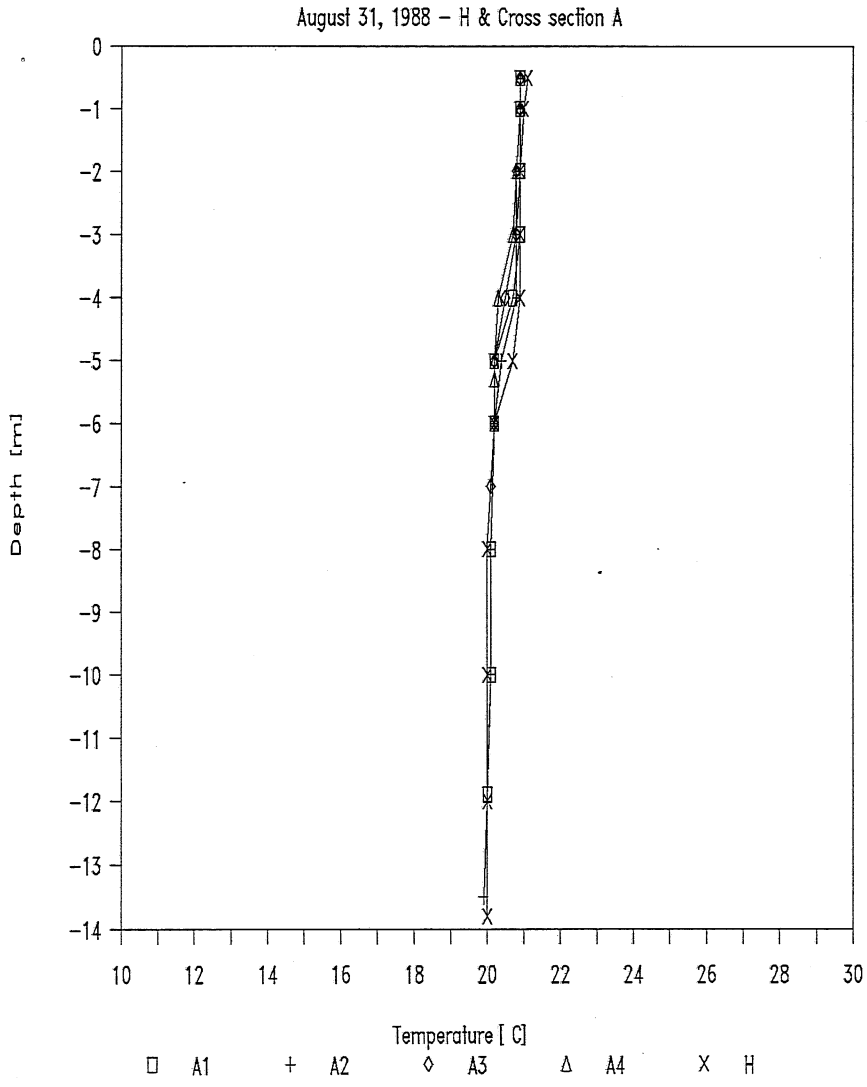
Byllesby Dam – Summer 1988

August 23, 88 – Downstream DO variation

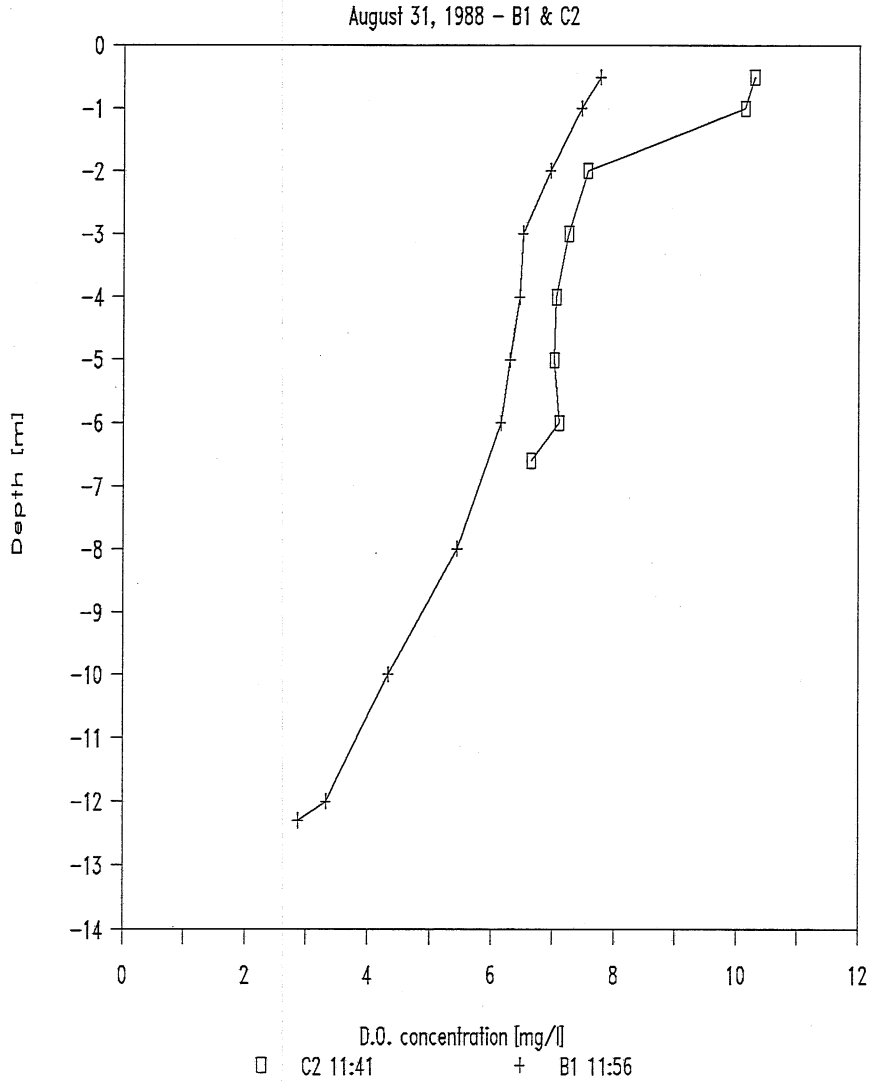


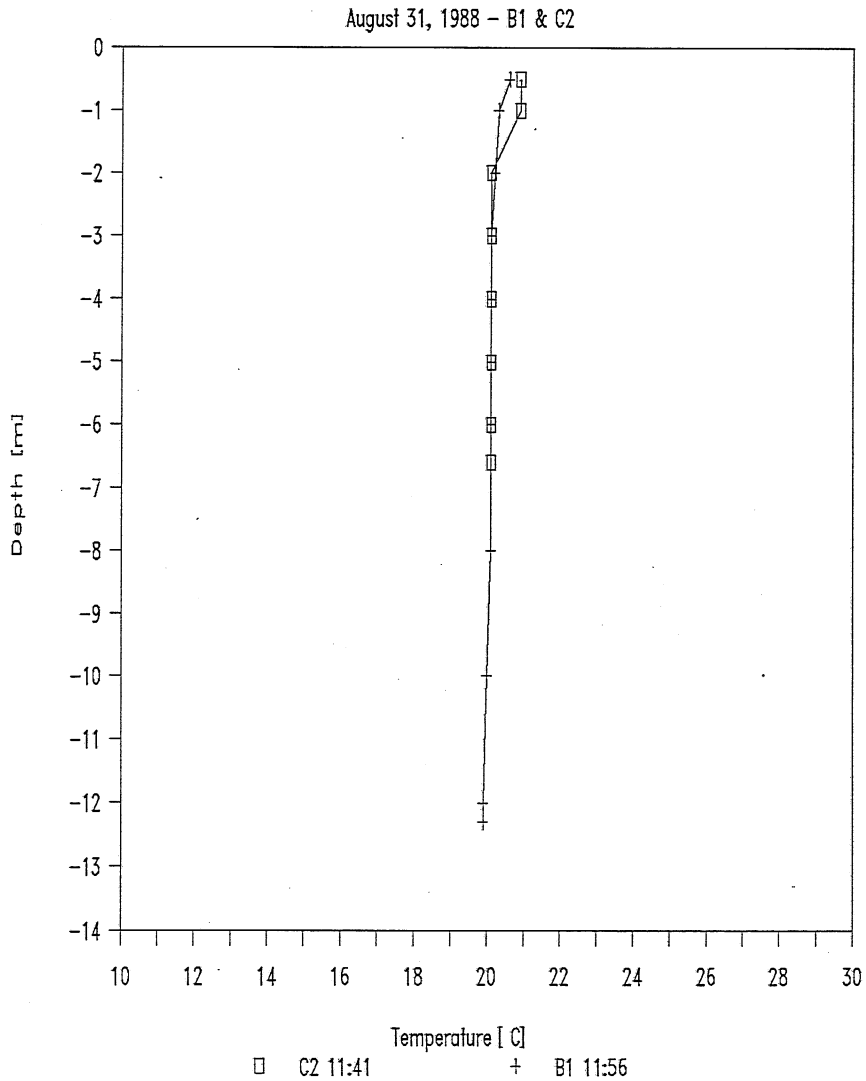
Byllesby D.O. study - Summer 1988



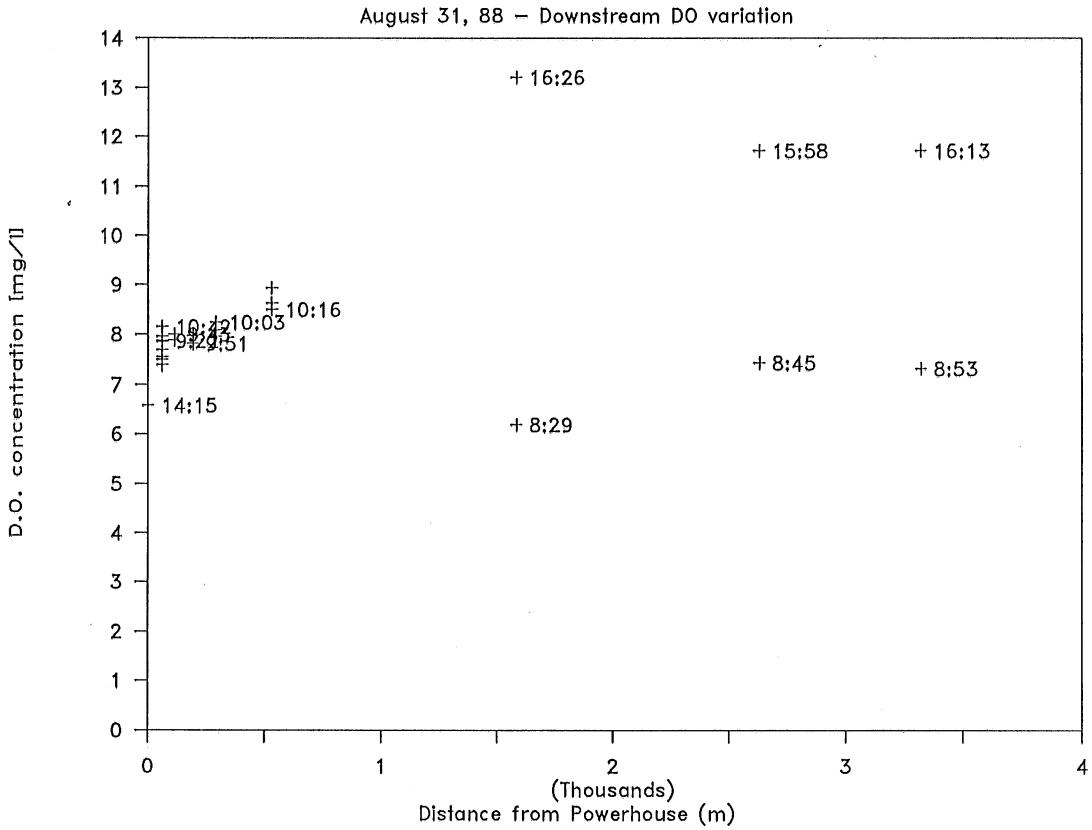


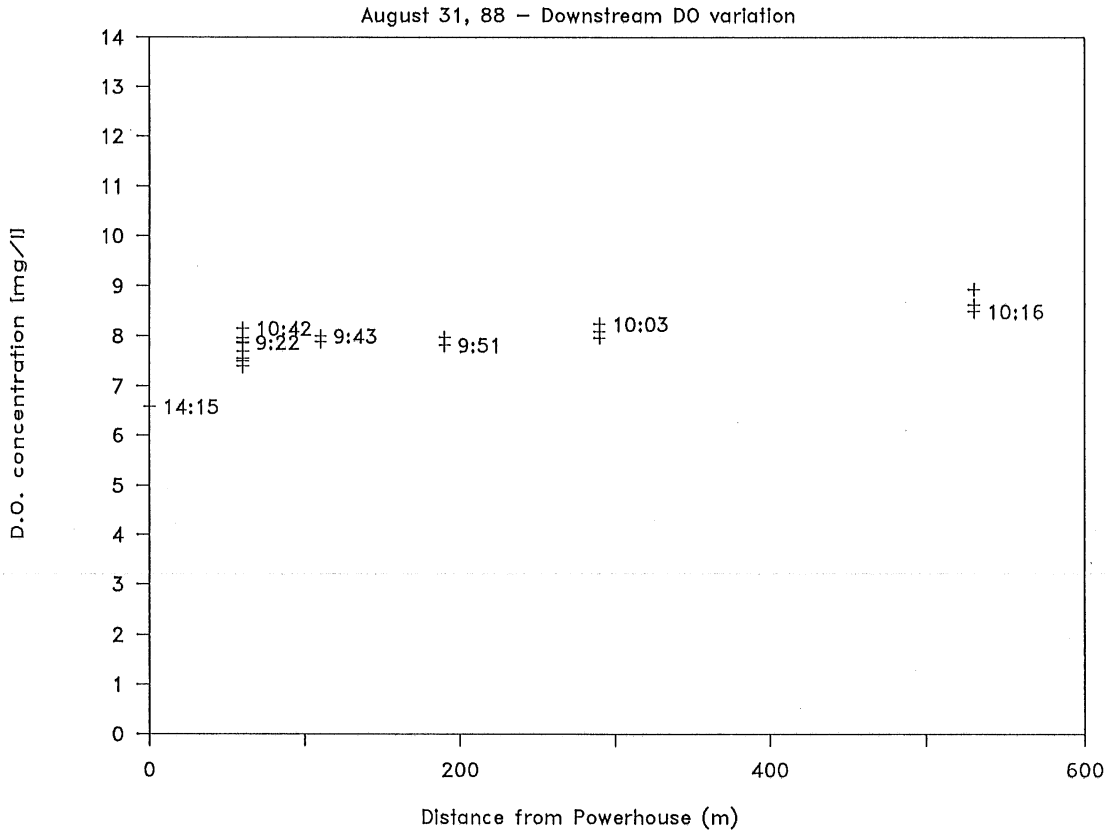
Byllesby D.O. study - Summer 1988



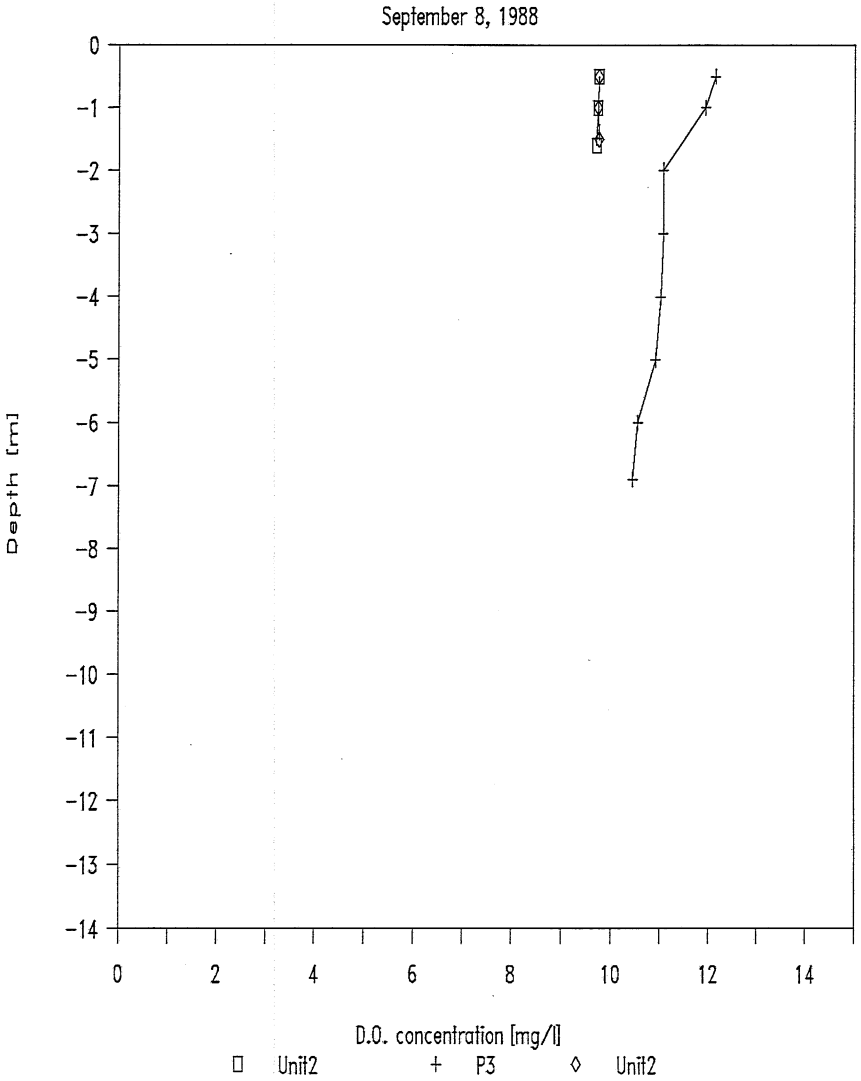


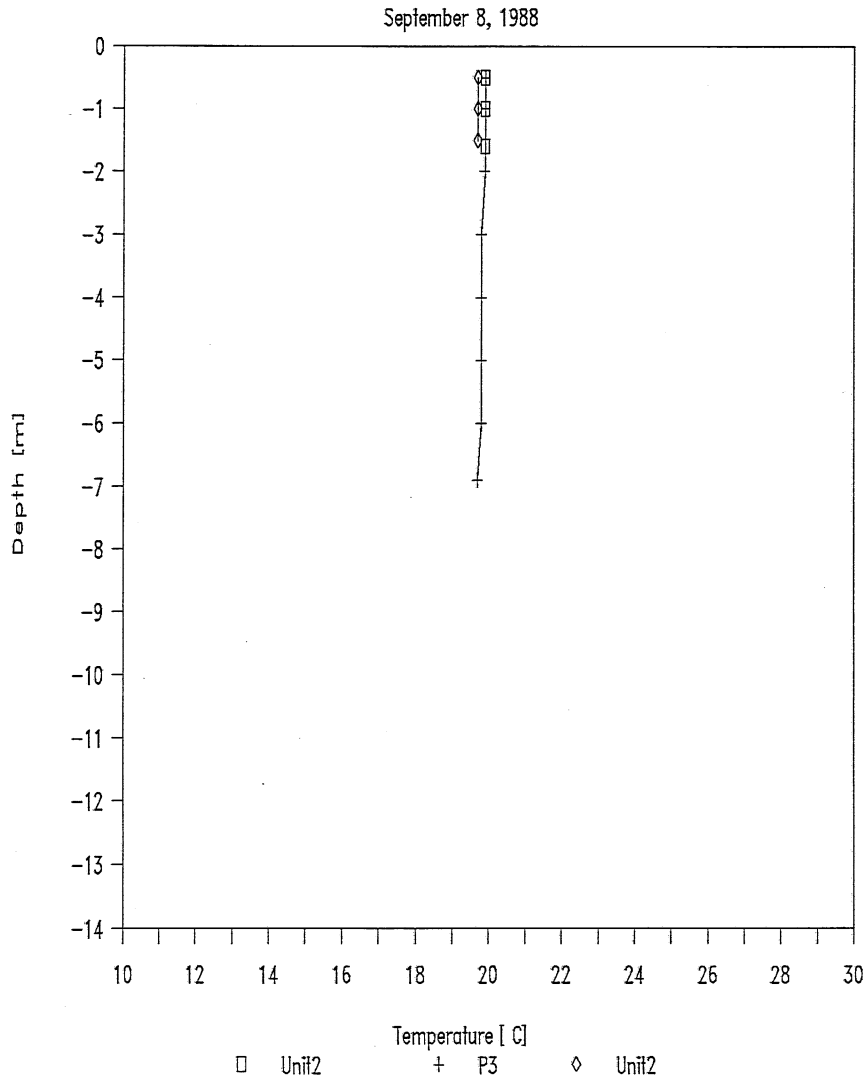
Byllesby Dam – Summer 1988



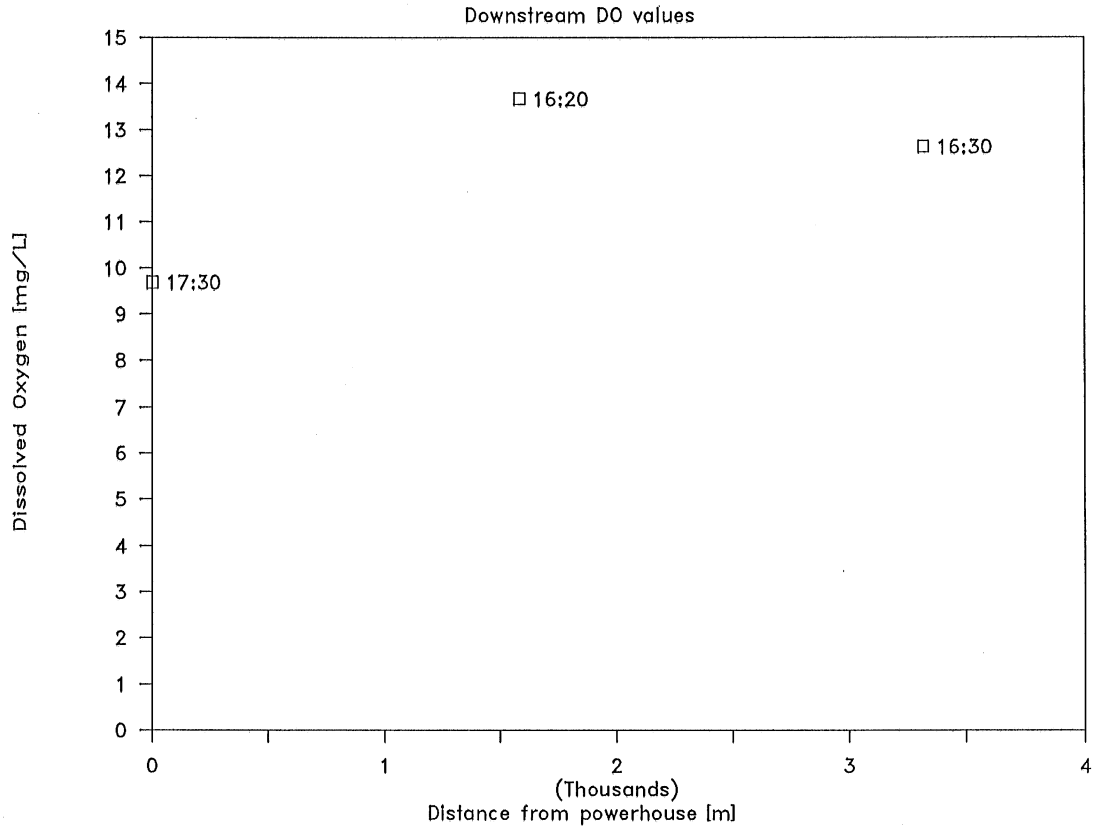


Byllesby Lake D.O. study - Summer 1988

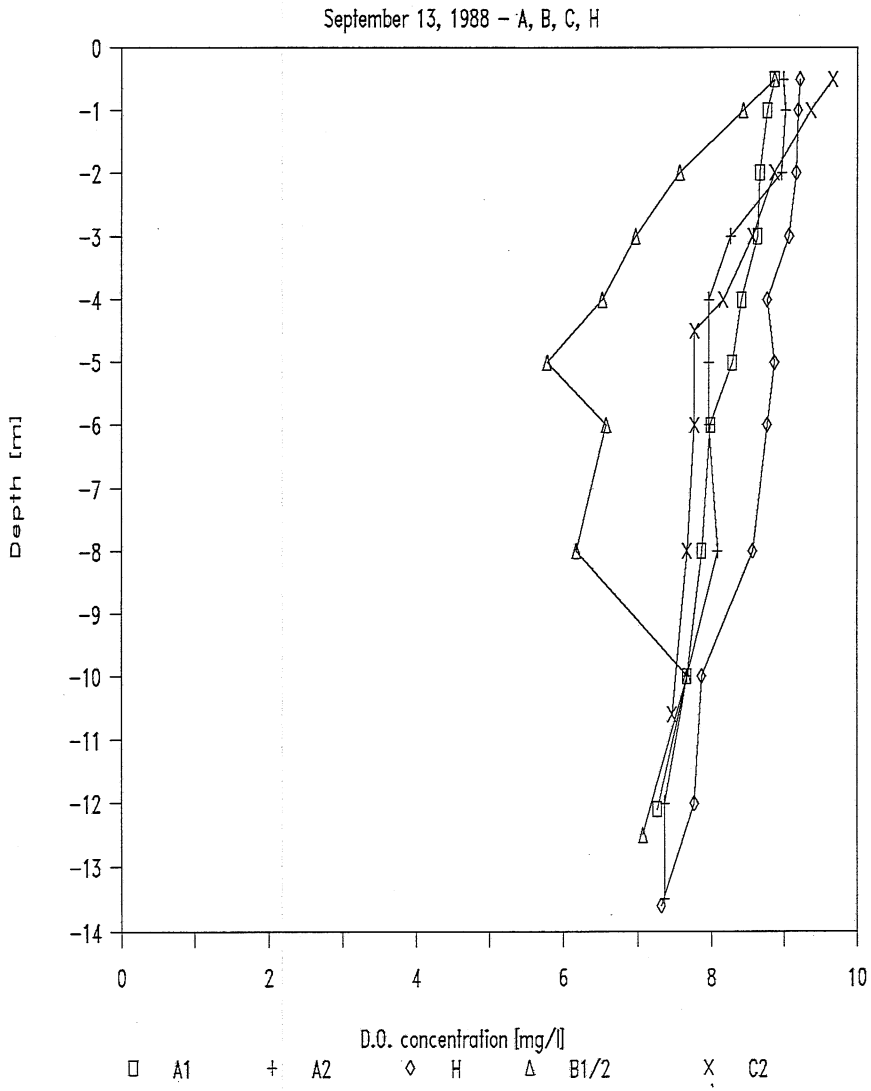


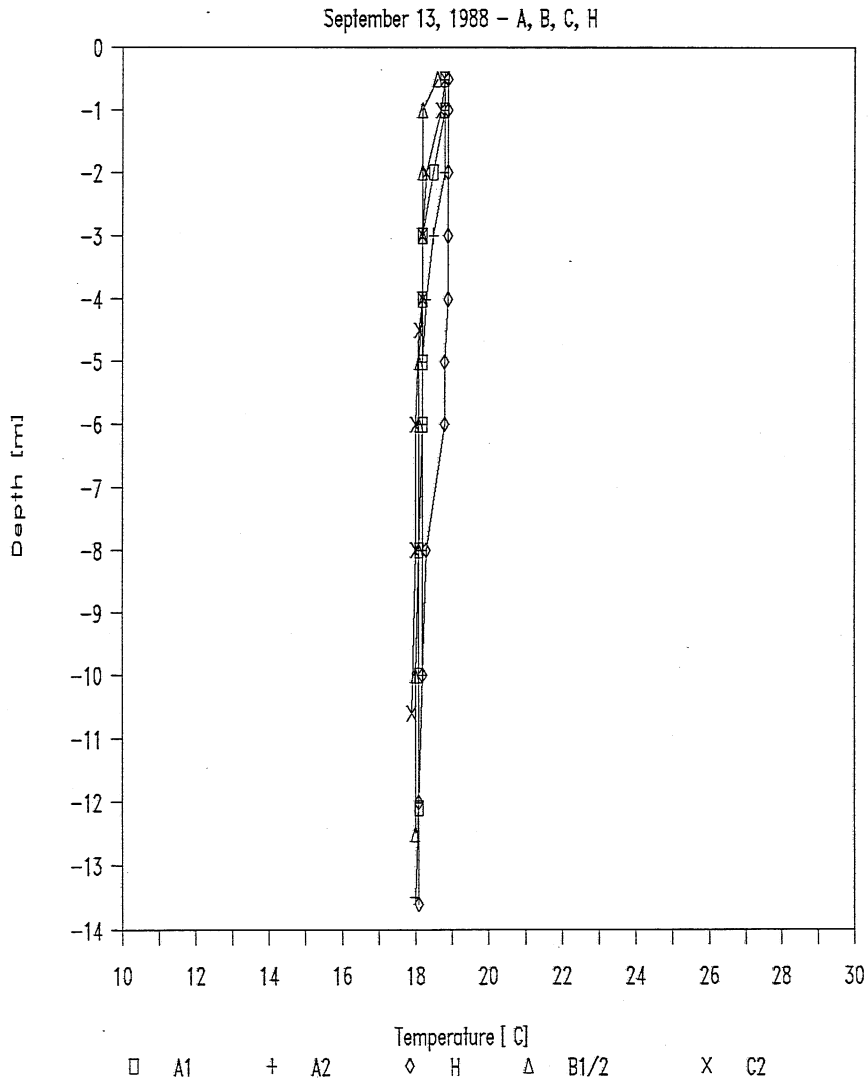


Byllesby dam – September 8, 88

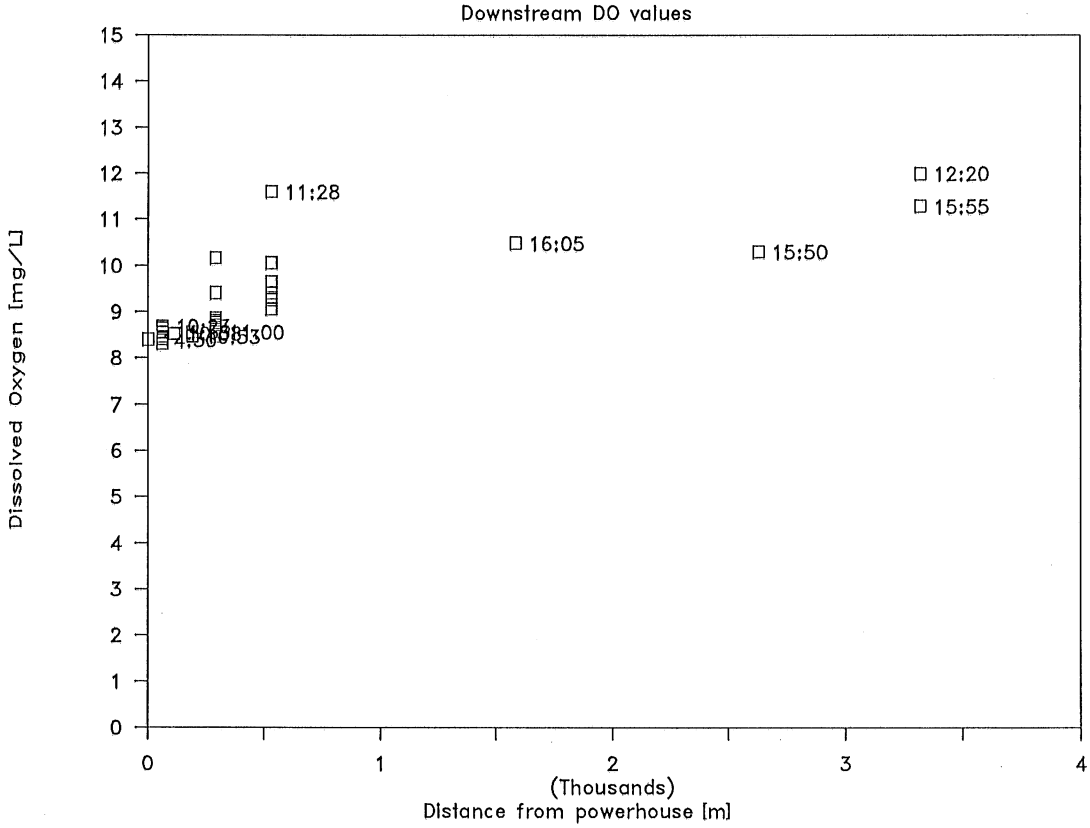


Byllesby Lake D.O. study - Summer 1988

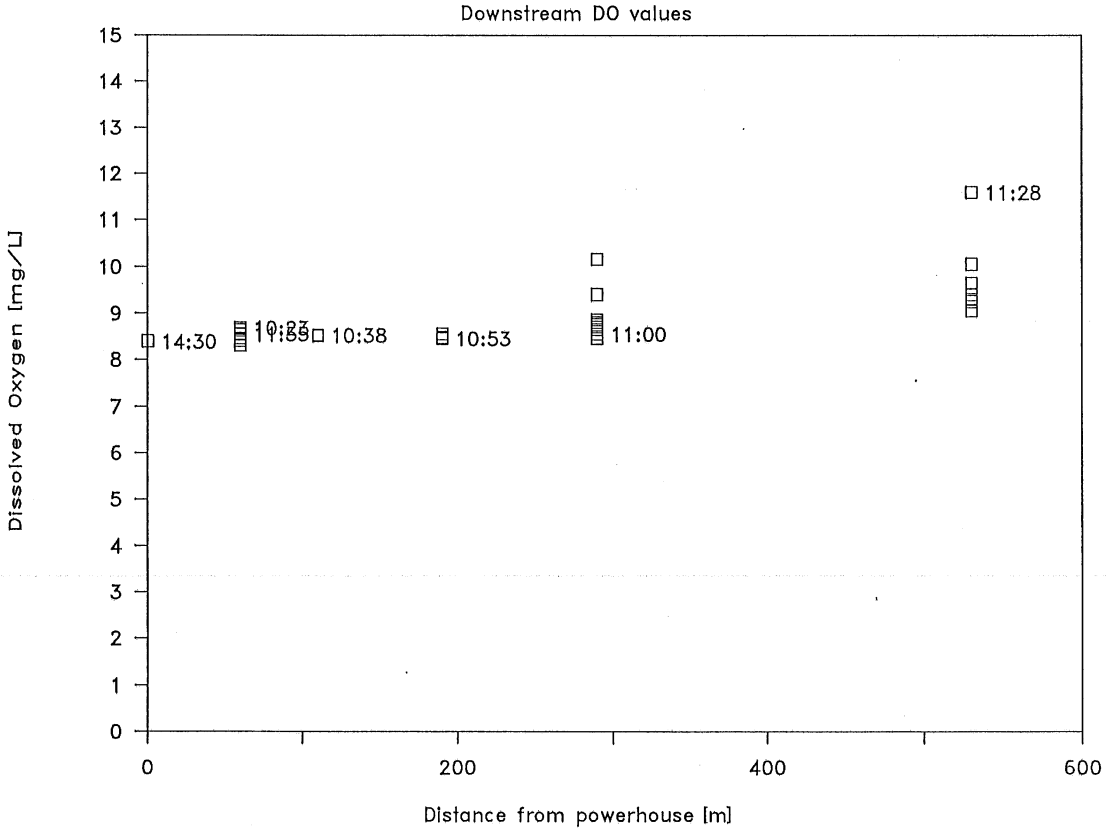




Byllesby dam – September 13, 1988



Byllesby dam – September 13, 1988



Byllesby dam – September 20, 1988