

UNIVERSITY OF MINNESOTA
ST. ANTHONY FALLS LABORATORY
Engineering, Environmental and Geophysical Fluid Dynamics

Project Report No. 447

Field Data Report - Devils Lake, North Dakota
June - September 1998
June - September 1999

by

Joe D. Manous, Jr.



July 2000
Minneapolis, Minnesota

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Abstract

Devils Lake, a terminal, saline lake in North Dakota has experienced a 24-foot rise in lake elevation resulting in the flooding of over 60,000 acres since 1992. At lower water-surface elevations, Devils Lake functions as a series of connected basins with salinity increasing in an eastward direction due to longer water retention times. The recent increase in water depth provides an opportunity for mixing due to wind and buoyancy forces.

The following data were collected during the summers of 1998 and 1999 to identify the processes causing exchange-flows within the lake. The data were later used to calibrate a numerical model, based on energy and conservation of mass principles, to estimate the redistribution of sulfate within Devils Lake. The magnitude and rate of redistribution is of interest in understanding the lake's ecosystem and as design input for a possible water diversion to stabilize the water-surface elevation.

Information concerning the collection and analyses of these data are presented elsewhere¹.

¹ Manous and Stefan. 2000. Sulfate Distribution within Devils Lake, ND: Movement of Dissolved Solids by Gravity, Buoyancy, and Wind Induced Advection. Ph.D. Thesis. University of Minnesota. Minneapolis.

Table of Contents

Section

1. Field Data Report, Devils Lake, North Dakota: June - September 1998).....I
2. 1999 Field Data
 1. August 1999 Temperature and Specific Conductance ProfilesII
 2. July and August 1999 Thermistor ProfilesIII
 3. July and August 1999 Thermistor Record..... IV
 4. July 1999 Mission Bay-East Bay Exchange Zone Specific
Conductance Record V
 5. 1992-1998 Devils Lake Precipitation, Surface In-Flow and Lake
Stage Correlations VI

Section I

**Field Data Report
Devils Lake, North Dakota:
June - September 1998**

**22 March 1999
(Revised 23 June 2000)**

Field Data Report
Devils Lake, North Dakota
June - September 1998

Prepared by

Joe D. Manous, Jr.
Lieutenant Colonel, U.S. Army Corps of Engineers

Study conducted as part of a
Doctoral Degree program in Environmental (Civil) Engineering
at the University of Minnesota

22 March, 1999

(Revised 26 June, 2000)



Abstract

Devils Lake, North Dakota has experienced a 21-foot rise in lake elevation resulting in the flooding of over 60,000 acres since 1992. In response to the economic loss caused by flooding, Congress authorized the U.S. Army Corps of Engineers ST. Paul District to investigate the feasibility of an emergency outlet to lower the lake level by water removal. The most direct water diversion is to the Sheyenne River, which joins the Red River of the North. In addition to cost, this interbasin transfer has several technical challenges including allowable total dissolved solids (TDS) and sulfate concentrations in both the Sheyenne and Red Rivers. Consequently, the feasibility of a Devils Lake diversion to the Sheyenne River is directly related to controlling TDS and sulfate inputs from Devils Lake.

As a terminal lake in the north central United States, Devils Lake has high TDS and sulfate concentrations. These concentrations increase in the direction of surface inflow, west to east, in response to increased residence time. What is not obvious is the cause of extremely high dissolved solids gradients across the exchange zones between the sub-basins (bays) of the lake. These high gradients may be the result of a century of lake flow in which the four basins of Devils Lake functioned similarly to four connected lakes. However, with the recent rise in lake elevation, the four bays seem to be functioning as a single large basin with mixing resulting from wind induced exchange flows. To ascertain the significance of this mixing, the flow and mixing rates require comparison with the volumes of water in the bays involved.

This data collection effort produced wind, water, and water quality data necessary to develop a cells-in-series model for prediction of dissolved solids redistribution within Devils Lake. The model is similar in concept to previous models prepared by the St. Paul District and U.S. Geological Survey, but the inclusion of wind induced mixing and morphometric constraints addresses important mechanisms neglected or discounted in previous work. Hopefully, these model additions will help account for the unexpected distribution of dissolved solids observed in Devils Lake.

Table of Contents

<u>Section</u>	<u>Page</u>
-- Abstract.....	i
-- Table of Contents.....	ii
1. Purpose.....	1
2. Support and Coordination	1
3. Objective	1
4. Current Situation	3
5. Study Area	4
6. Model Description.....	6
7. Specific Objectives of the Field Investigation	7
8. Data Collection.....	8
9. Results	9
10. Conclusions.....	11
11. References.....	12
 <u>Appendices</u>	
1. Methods	1-1
2. Fixed Sampling Locations	2-1
3. Temporal Sampling Locations.....	3-1
4. West Bay and Main Bay Exchange Zone Measurements	4-1
5. Main Bay and East Bay Exchange Zone Measurements	5-1
6. East Bay and East Devils Lake Exchange Zone Measurements.....	6-1
7. Water-Surface Set-Up Correlation Plots.....	7-1
8. Temporal Conductance, Temperature, DO & pH Profiles	8-1
9. Regional versus Field Study Wind Correlation Plots	9-1
10. Specific Conductance Centerline Profiles	10-1
11. Bridge and Culvert Measurements	11-1

**Field Data Report
Devils Lake, ND
June - September 1998**

1. Purpose.

This report provides field data collection results with preliminary analysis from field studies conducted during Summer 1998 at Devils Lake, North Dakota.

2. Support and Coordination.

Lieutenant Colonel Joe Manous, U.S. Army Corps of Engineers, organized and executed the data collection as part of an Environmental Engineering Ph.D. program at the University of Minnesota. The collection plan was coordinated with the St. Paul District of the U.S. Army Corps of Engineers and under the guidance of Professor Heinz Stefan, University of Minnesota. Additional consultations were conducted with the North Dakota U.S. Geological Survey, North Dakota State Water Commission, and the Ramsey County North Dakota County Commissioner.

The St. Paul District partially funded and supplied equipment for the field investigation. Facilities at the University of Minnesota St. Anthony Fall Hydraulics Laboratory were used for equipment calibration.

3. Objective.

The objective of this project is to develop information for predicting the movement of dissolved solids within Devils Lake that includes inflow; precipitation; evaporation; lake morphometry; wind-induced advection; and density currents. These predictions, produced through a deterministic model, are for use in evaluating dissolved solids redistribution as the result of water level fluctuation, water diversions, or changes in flow patterns by filling or damming.

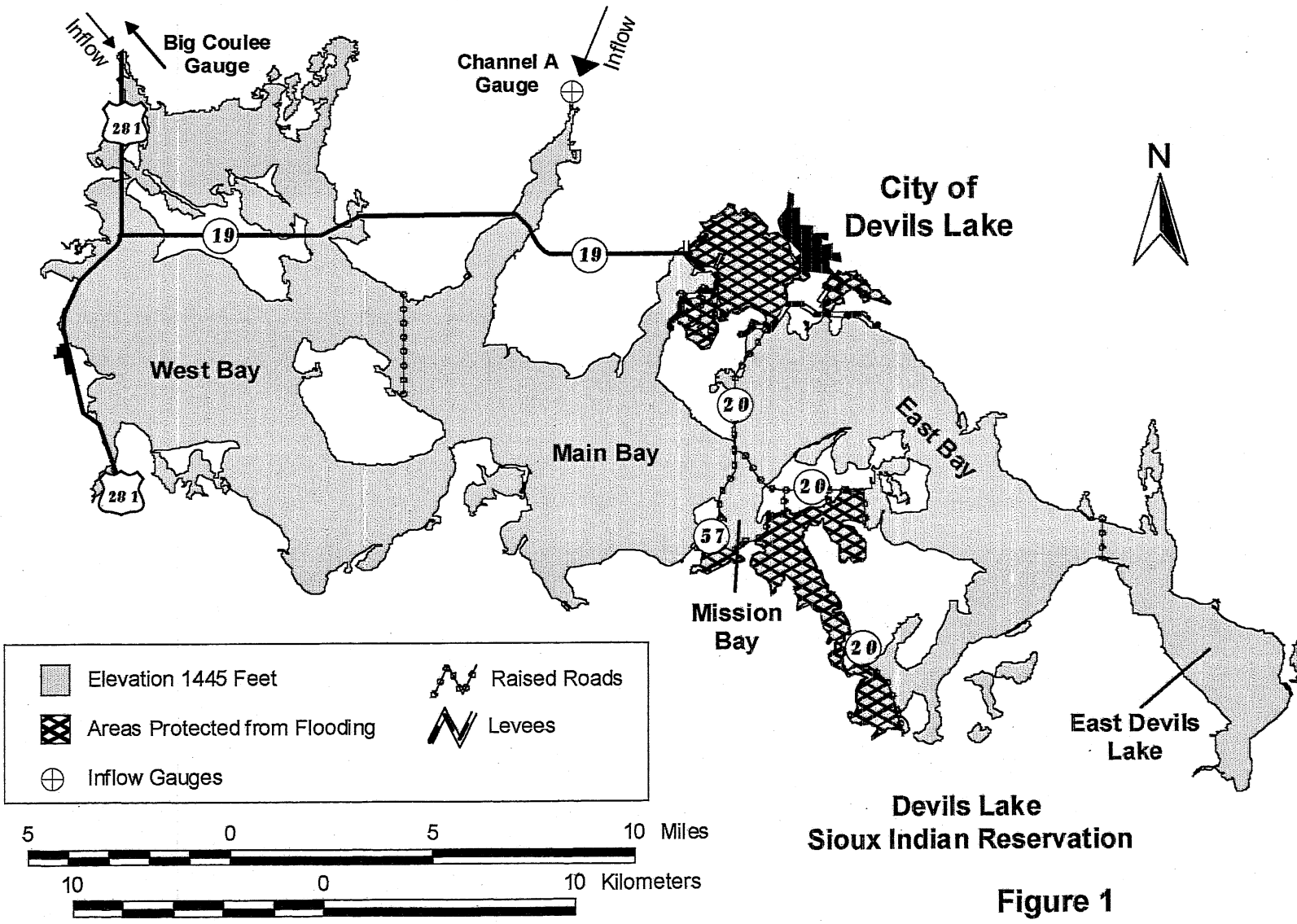


Figure 1

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

4. Current Situation.

Devils Lake, North Dakota (Figure 1) has experienced a 21-foot rise in lake elevation resulting in the flooding of over 60,000 acres since 1992. This rise in lake elevation is not unprecedented as indicated by lake elevation records dating to the late 1880's (Figure 2) and is primarily the result of normal climatic fluctuations (Wiche 1996).

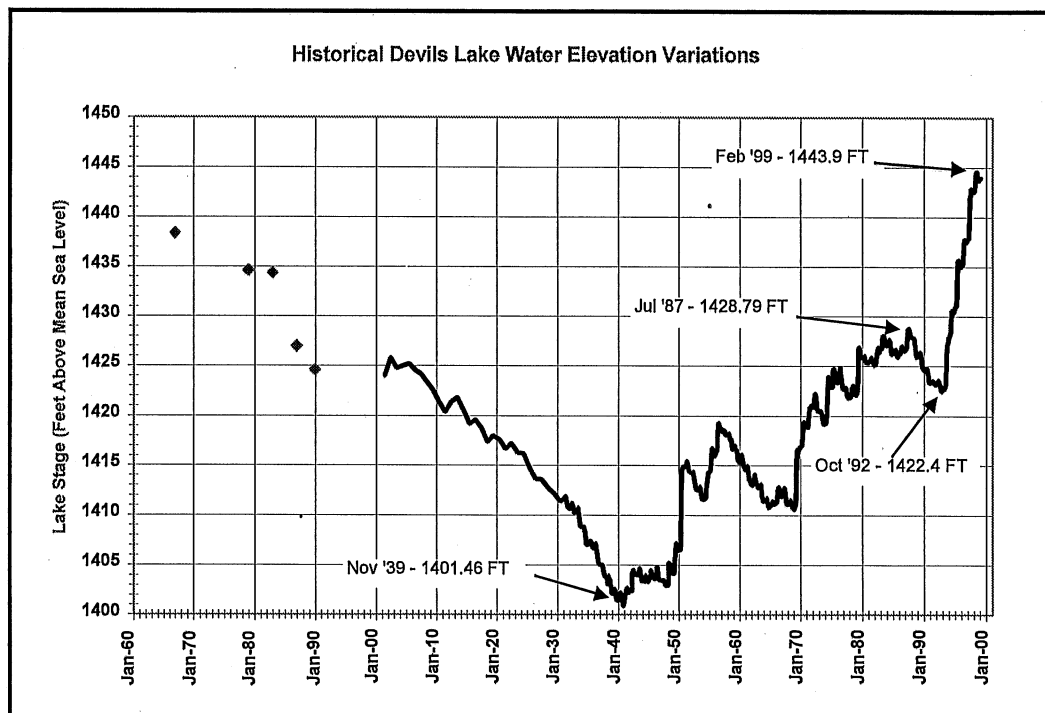


Figure 2 - Devils Lake Water Elevation Record (USGS 1998)

In response to the economic damage caused by flooding, several State of North Dakota and Federal agencies have executed lake containment and facility elevating activities to mitigate economic losses. In addition, Congress authorized the U.S. Army Corps of Engineers St. Paul District to investigate the feasibility of an emergency outlet to lower the lake level by water removal

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

(USACE 1996). The most direct water diversion is southward from Devils Lake approximately 10 miles to the Sheyenne River where the water flows east to the Red River and then northward to Hudson Bay, Canada. In addition to cost, this interbasin transfer has several technical challenges including allowable total dissolved solids (TDS) and sulfate (SO_4^{-2}) concentrations in the Sheyenne and Red Rivers established under State (North Dakota and Minnesota) water quality standards and international objectives by treaty. The allowable sulfate and TDS concentrations for the Red River are 250 and 500 mg/L respectively, while the Sheyenne has a sulfate limitation of 450 mg/L with no specified TDS control. Seasonal flows in both the Sheyenne and Red Rivers approach limiting concentrations (USACE 1996). These concentration constraints will require regulation of Devils Lake discharges to ensure downstream waters do not exceed concentration limitations. Typical 1998 Devils Lake West Bay concentrations of sulfate and TDS were 500 and 1150 mg/L (USGS 1998).

5. Study Area

The Devils Lake Basin consists of 3,810 square miles in northeastern North Dakota. Approximately 490 square miles of watershed are tributary to Stump Lake while the remaining 3,810 square miles feed Devils Lake. A small quantity of direct overland and tributary flow enters Devils Lake, but small lakes to the north collect most of the watershed surface flow before entering Devils Lake. Originally, this water flowed westward through an interconnected chain of lakes before reaching Lake Irvine and flowing southward through Big Coulee to Devils Lake (Figure 3). In 1979, the construction of a levee across the natural outlet of Dry Lake interrupted this flow pattern and diverted Dry Lake outflow directly to Devils Lake's Sixmile Bay. The Ramsey and Cavalier County Water Management Boards constructed Channel A with gated flow regulation specifically for this purpose

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

(Wiche 1996). Both Big Coulee and Channel A continue to provide significant inflows (USGS 1998). A minor groundwater inflow contribution to Devils Lake during periods of high precipitation was determined through a detailed boring, mass balance, and stratigraphic analysis conducted by the North Dakota State Water Commission (NDSWC) (Pusc 1993).

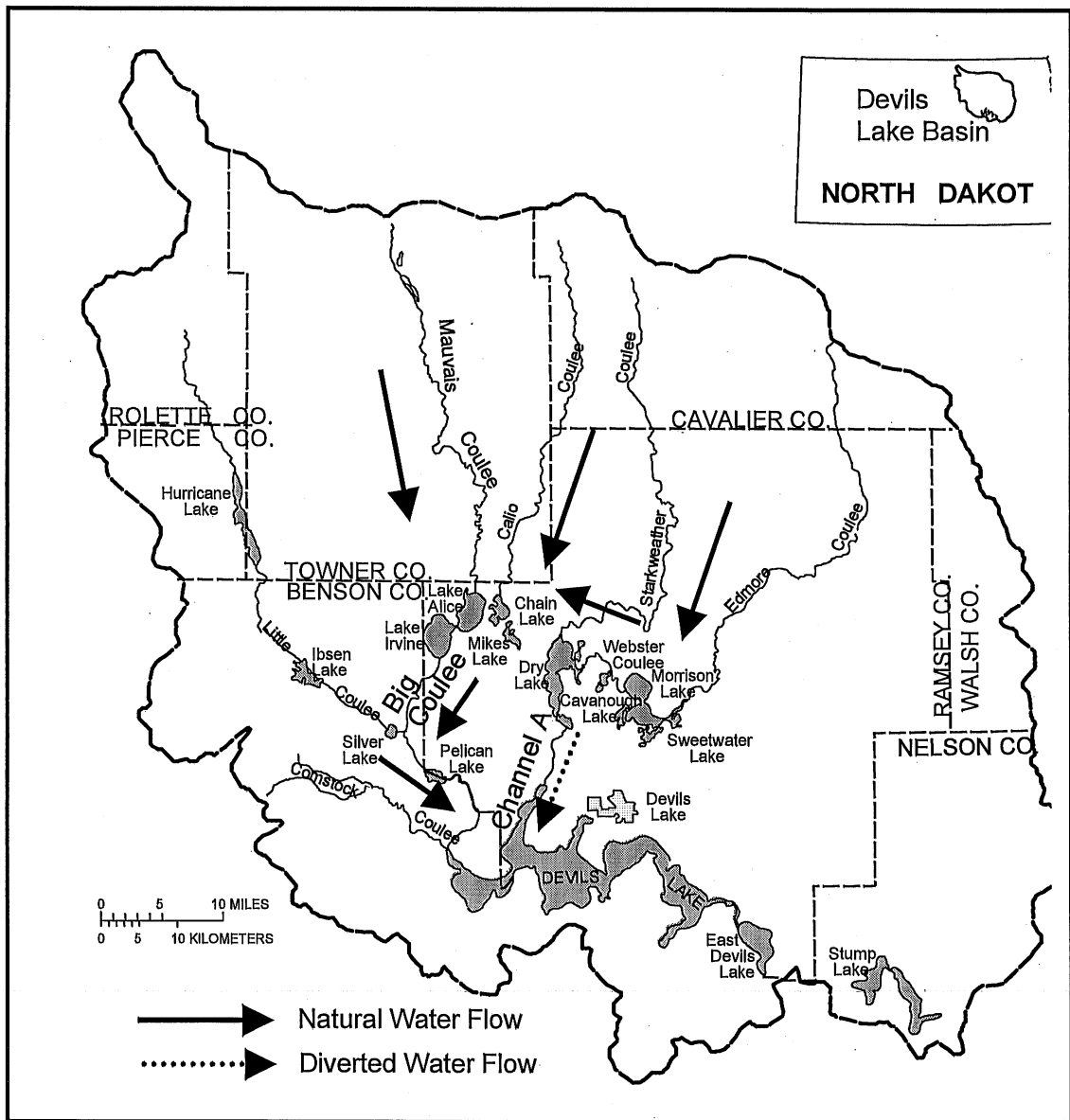


Figure 3 - Devils Lake Basin (USGS 1998)

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

Devils Lake is a terminal lake of glacial origin. The July 1998 water elevation was 1444.6 feet above mean sea level (amsl) with a natural overflow elevation to Stump Lake of 1446.6 feet amsl (Unpublished Data, USACE 1998). At the current water elevation, the lake extends approximately 32 miles from west to east and covers 110,000 acres. The current water depths range from 14 feet in West Bay south of Highway 19 to 43 feet in East Devils Lake. Of particular interest is the eastward decrease in water quality reflected by the increase in dissolved ions and TDS (Swenson 1955; Mitten 1968; Williams-Sether 1996).

6. Model Description

The salinity model under development is based on a cells-in-series concept and uses water mass balance and energy (piezometric head) relationships to solve for flow.

An essential component of this model is the determination of wind induced water flow. Saville (1952), Stefan and Anderson (1977), and Stefan and Demetracopoulos (1979) demonstrated that wind induced water movements between interconnected basins can be significant and predicted. Given Devils Lake's relatively low, advective inflow compared with overall lake volume, it is reasonable to postulate that wind is the primary driver of Devils Lake water currents and not surface inflow.

7. Specific Objectives of the Field Investigation

A) Demonstrate that water movement in Devils Lake responds to wind.

The existence of wind induced exchange currents between the basins of Devils Lake is the underlying premise of this research. To demonstrate that wind induced exchange flows occur, wind velocity and direction, water flow direction and velocity, specific conductance, and lake stage were measured at continuously recording, fixed stations located at primary

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

water exchange points. A comparison of water flow or conductance variations with wind will provide qualitative relationships. In addition, a quantitative comparison is possible using wind and lake set-up following the methodology employed by Saville (1952), Stefan and Anderson (1977), and Stefan and Demetracopoulos (1979).

- B) Obtain a wind record and determine a correlation between lake surface wind measurements and regional wind measurements.

In this field investigation, wind measurements at two fixed stations located 6 feet above the water surface were recorded over a period of several weeks. However, regional wind data, measured at the Devils Lake Airport, are available through the National Weather Service for several years of record. A linear relationship is to be expected between the on-site and regional data, however, sheltering of on-site wind measurement stations and non-averaged regional wind measurements may cause deviations.

- C) Delineate possible new flow patterns through the lake.

The recent lake elevation rise has flooded surrounding areas of Devils Lake and potentially created new flow pathways. These flooded areas require physical inspection to determine the actual size and existence of flow paths.

- D) Determine the degree of vertical, lateral, and longitudinal mixing across the lake.

The spatial and profile distribution of dissolved solids is qualitatively known from previous work (Swenson 1955; Mitten 1968; Williams-Sether 1996). However, the use of a cells-in-series model for dissolved solids movement will require a greater resolution of the dissolved solids distribution. Of particular interest are dissolved solids gradients within the

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

exchange zones between bays. Spatial specific conductivity profiling should delineate dissolved solids gradients. Water chemistry analysis can then correlate ion concentrations with specific conductance. The North Dakota USGS independently conducted a water chemistry, field investigation for the St. Paul District during the same period as this field study (USGS 1998).

E) Detail the lake morphometry, bridge geometry, and culvert sizes.

Considerable bathymetric information on Devils Lake is available from the St. Paul District, the USGS, and the North Dakota State Water Commission. However, increased resolution of the Devils Lake morphometry is necessary for accurate volume estimates for a cells-in-series model. In addition, the presence of physical obstructions and flow restrictions under bridges and through culverts is equally important for modeling. Soundings can identify missing morphometry information and physical measurements can identify bridge and culvert dimensions.

8. Data Collection

Data were gathered continuously from 5 fixed locations during the period 29 June 98 through 7 September 98 and temporally from 184 and 129 sampling locations during 6-12 July and 9-14 August 1998, respectively. The fixed stations were sited to capture information within the exchange zones between different Devils Lake basins. Station 1 was located between West Bay and Main Bay and Station 5 was positioned between East Bay and East Devils Lake. The complexity of the exchange zone between Main Bay and East Bay required three fixed stations, Stations 2-4, to record the flow characteristics within that water exchange area. The fixed sites included various combinations of sensors for wind direction and velocity, water flow direction and velocity, lake surface elevation, specific conductivity, dissolved

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

oxygen, pH, and water temperature measurements. Temporal sampling stations included soundings and water profiles of specific conductivity, dissolved oxygen, pH, and water temperature measurements. Appendix 1 includes a detailed description of sampling methods employed, Appendix 2 provides details on the fixed stations, and Appendix 3 lists the temporal sampling sites.

9. Results

A) Wind and water movement.

Time series of wind direction and velocity; water flow direction and velocity; specific conductance; and wind set-up are plotted for the exchange areas between West Bay and Main Bay (Appendix 4), Main Bay and East Bay (Appendix 5) and East Bay and East Devils Lake (Appendix 6). Wind components in the assumed direction of maximum water flow through a given exchange zone are also plotted. A wind component is defined as $(\text{wind velocity}) \times (\cos \theta)$, where θ represents the angle between the actual wind direction and the wind component direction. Water movement from west to east defines a positive wind component.

A preliminary data analysis indicates a strong correlation between wind and water movement, however considerable data scatter exists. Additional data analysis is required to select the "correct" wind component and water component directions, select appropriate "lag" times for the various comparisons, and filter the wind data for sheltering effects. Appendix 7 presents a few preliminary correlations.

B) Water quality profiles.

Appendix 8 includes the plotted results of the temporal data collection. Specific conductance, water temperature, dissolved oxygen, and pH are profiled based on July and August 1998 samplings. The results indicate

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

that temperature stratification does occur, but the duration of stratification is unclear.

C) Regional and study wind comparisons.

Appendix 9 presents regional, wind-component correlations from the KDVL meteorological station with the on-lake wind measurements. A correlation r^2 value is improved.

D) Analysis of possible lake flow patterns.

Figure 1 shows restrictions to natural flow between basins. The main restrictions include the town of Devils Lake levees, raised roads south of Mission Bay in the Devils Lake Sioux Indian Reservation, and the road from State Highway 19 south to Grahams Island. In addition, near the town of Minnewaukan no water flowed to Devils Lake under State Highway 19 or under U.S. Highway 281.

E) Lake Mixing.

Spatial specific conductance profiles for July 98 and August 98 are presented in Appendix 10. These profiles also include bathymetric information from the field study soundings. The results indicate well-mixed conditions in the major bays of Devils Lake and very strong conductivity gradients at exchange points between Main Bay and East Bay, and East Bay and East Devils Lake. A lesser gradient exists between West Bay and Main Bay. The profiles were generated by plotting spatial profile data along the centerline shown on the map.

F) Bridge and Culvert Dimensions.

Appendix 11 contains measured bridge and culvert dimensions.

Devils Lake, ND Preliminary Field Data Report, Jun - Sep 1998 (Cont.)

10. Conclusions

The data gathering effort was successful and without injury or loss of property. The preliminary results indicate that wind is inducing water currents and water mixing between bays. The specific conductivity gradients between bays are extreme and occur over short horizontal distances. These sharp gradients may be the result of morphometric limitations, but additional analysis and modeling is required to clarify this point.

An important aspect not addressed in this report is the possibility of density flows, particularly during ice cover periods. The bathymetric data gathered during this study are a prerequisite in addressing this issue.

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Methods

1. Sampling Locations

A) Fixed Sites. There were five fixed site locations with sensor configurations shown in Appendix 2. These sites operated continuously from 29 Jun 98 through 7 Sep 98.

B) Temporal Sites.

(1) 6-12 Jul 98. During this period, 58 lake profiles of water temperature, dissolved oxygen, specific conductance, and pH were measured using a Hydrolab Surveyor 3 along with 126 additional soundings using a Lowrance X-60 depth finder with a model HS-WST transducer. Appendix 3 includes a listing of the sample sites.

(2) 9-14 Aug 98. During this period, 42 lake profiles were measured using a Hydrolab Surveyor 3 along with 87 additional using a Lowrance X-60 depth finder with a model HS-WST transducer. Appendix 3 includes a listing of the sample sites.

2. Equipment Used During the Field Investigation

A) Wind Measurements

(1) Wind velocity was recorded using a MET-1, model 013 Wind Speed Sensor at a height of 6 feet above the water surface. Measurements were averaged over 10-minute intervals.

(a) Calibration - The output of each sensor was compared to the output of three similar sensors prior to deployment. The manufacturer's specified accuracy is +/- 0.25 MPH.

(b) Performance - No problems noted. Field results were consistent with similar field measurements.

Methods (Continued)

- (2) Wind direction was recorded using a MET-1, model 023 Wind Direction Sensor at a height of 6 feet above the water surface. Measurements were averaged over 10-minute intervals.
 - (a) Calibration - Calibrated with a magnetic compass. The manufacturer's specified averaged accuracy is +/- 5 degrees.
 - (b) Performance - No problems noted. Results were consistent through out the field study.

B) Water Measurements

- (1) Water velocity was recorded using a locally fabricated (rotational) current meter at depths of 2 and 4 feet below the water surface (Figure 1-1). The meter consisted of a PVC casing which spun freely on a centered needle point on top of a metal mast. Three plastic cups attached at right angles, 6 inches away from the base of the PVC casing caught the flowing water. The number of PVC casing revolutions over a 10-minute period then determined the water

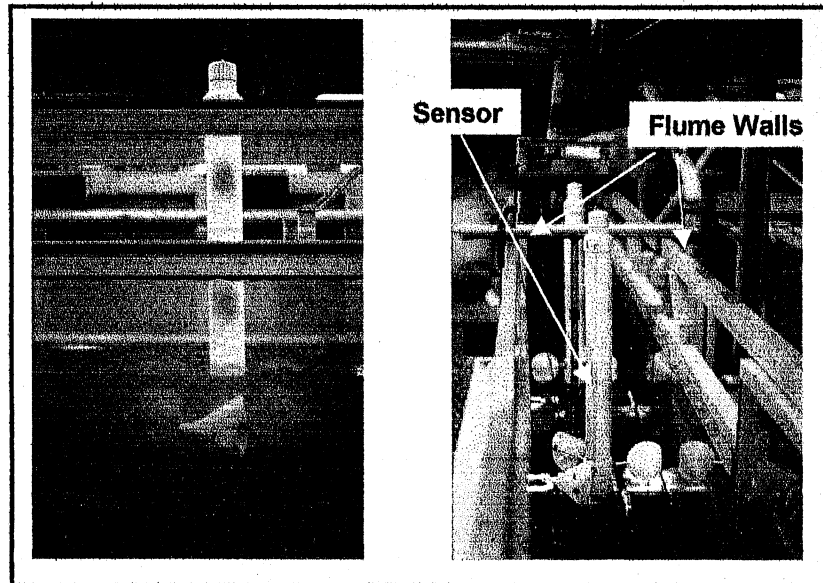


Figure 1-1 - Locally fabricated water velocity sensors being calibrated in a flume at St. Anthony Falls Laboratory.

Methods (Continued)

velocity. A magnetic reed switch attached to the sensor pipe must counted one revolution as a magnet attached to the PVC casing passed over the switch. Measurements were averaged over 10-minute intervals.

(a) Calibration - The sensors were calibrated in a flume before and after deployment. Equations were developed by linear regression to convert revolutions to water speed (Figures 1-2, 1-3, 1-4).

(b) Performance - Sensors performed very well. Comparison of before and after deployment calibrations demonstrated minimal variation.

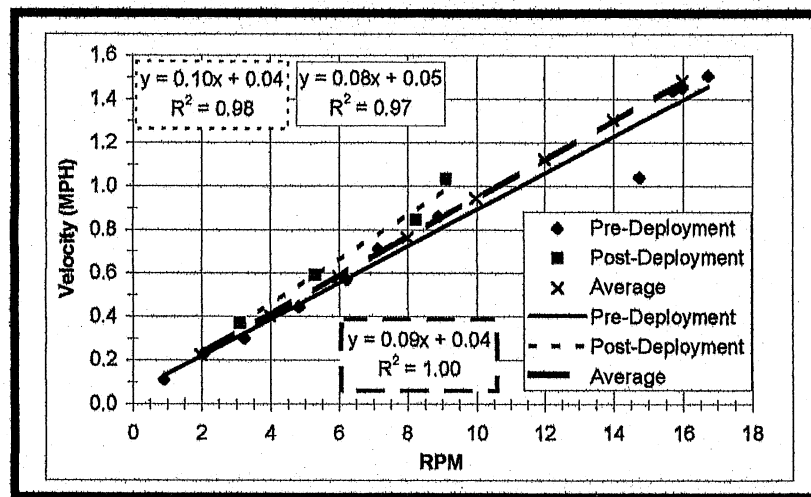


Figure 1-2 - Calibration curves for water velocity sensor located at Site DL1.

Methods (Continued)

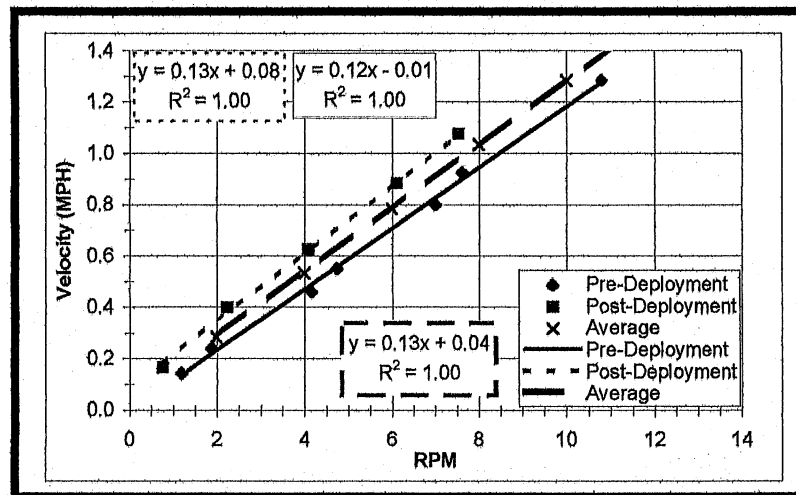


Figure 1-3 - Calibration curves for water velocity sensor located at Site DL4.

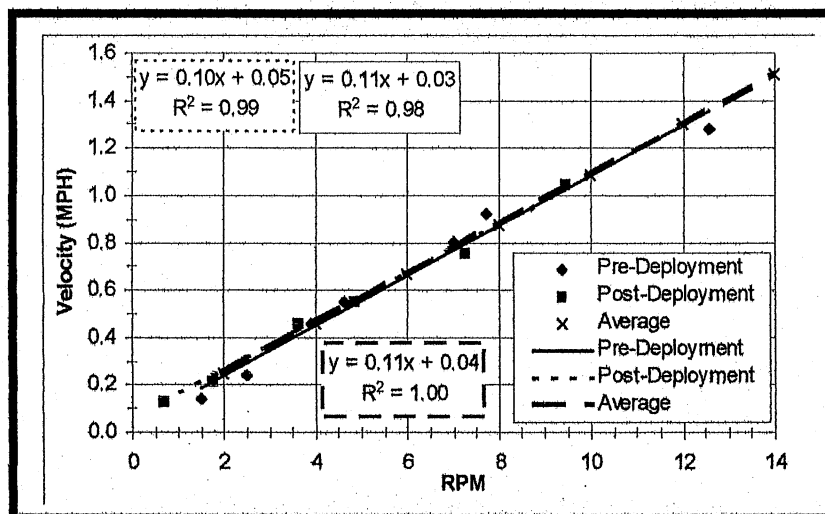


Figure 1-4 - Calibration curves for water velocity sensor located at Site DL5.

- (2) Water direction was recorded by modifying a MET-1, Model 023 Wind Direction Sensor with an extended metal mast and PVC rotating casing. Measurements were made at 10-minute intervals (Figure 1-6).
 - (a) Calibration - Calibrated with a magnetic compass.
 - (b) Performance - Initially good, but after 2 months, the weight of the PVC casing and wave action caused the sensor's top pivot to bind

Methods (Continued)

and yield less accurate results. The actual degree of degradation depended on the sensor. The one sensor modified to function at a depth of 4 feet lasted less than a month under the increased casing weight.

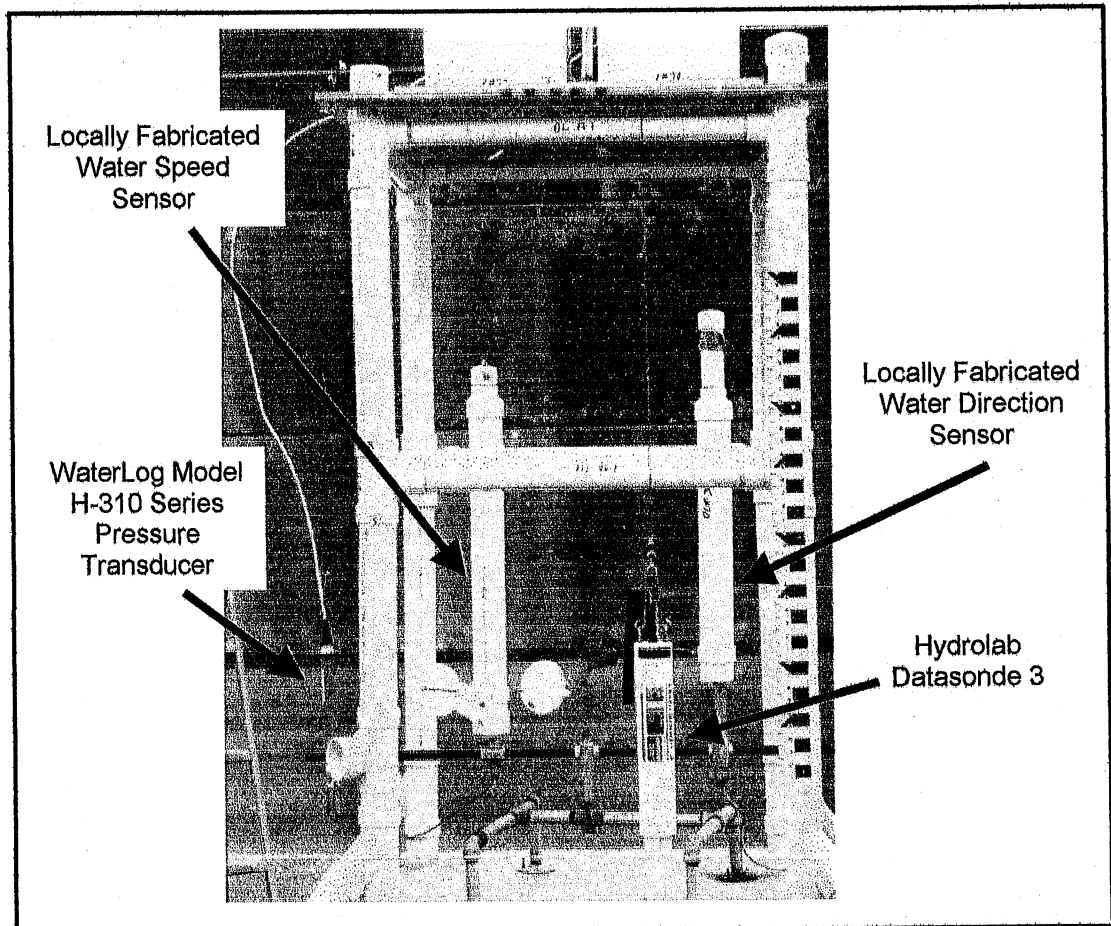


Figure 1-6 - Field sensors before field deployment.

C) Water Quality Measurements

- (1) Fixed stations - Hydrolab Datasonde 3 units measured temperature ($\pm 0.15^{\circ}\text{C}$), specific conductance ($\pm 1\%$ of calibrated range), dissolved

Methods (Continued)

oxygen (± 0.2 mg/L), pH (± 0.2 units), and depth (± 0.45 m) on an hourly basis (Figure 1-6).

(a) Calibration - Followed manufacturer's calibration instructions. Specific conductance and pH were calibrated to index solutions while DO and depth were calibrated to atmospheric pressure.

(b) Performance - No problems noted.

(2) Spatial stations - A Hydrolab Surveyor 3 with H2O Sensor Unit measured temperature ($\pm 0.15^\circ\text{C}$), specific conductance ($\pm 1\%$ of calibrated range), dissolved oxygen (± 0.2 mg/L), and pH (± 0.2 units) over depth (± 0.45 m).

(a) Calibration - Followed manufacturer's calibration instructions. Specific conductance and pH were calibrated to known solutions while DO and depth were calibrated to atmospheric pressure.

(b) Performance - No problems with accuracy noted.

D) Water Surface Elevation Measurements

- Conducted using WaterLog Model H-310 series pressure transducer submerged in water depths ranging from 2.5 to 6 feet (Figure 1-6). The sensors resided in 4-inch diameter stilling wells with readings averaged over 10 minute intervals. The manufacturer's specified accuracy is 1:250,000 or ± 0.002 FT in the depths of measurement.

(a) Calibration - Instruments were calibrated by the manufacturer prior to deployment.

(b) Performance - No problems noted.

Methods (Continued)

E) Data Logging

(1) Hydrolab Units used internal self-logging capability with data download via RS-232, serial connection to a laptop computer.

(a) Calibration - None required.

(b) Performance - No problems noted. A 1-hour sampling interval was selected to conserve battery power.

(2) All other sensors were connected to battery powered Sutron Model 8200 dataloggers with data retrieval via RS-232, serial connection to a laptop computer.

(a) Calibration - None required.

(b) Performance - Determination of battery life was difficult and short periods of sensor malfunction occurred due to premature battery exhaustion. No collected data was lost due to battery failure.

F) Positioning

- Sampling sites were located and marked using a Garmin 12 global positioning system (GPS) receiver. Locations were marked with an approximate accuracy of 50 to 100 feet depending on the number of satellites available at the time of position locating. Position averaging by the GPS receiver partially compensated for Selective Availability (SA) enablement.

(a) Calibration - None required.

(b) Performance - Unit performed well under conditions of SA. Fixed positions, such as platforms and boat launches, were relocated within 100 feet of GPS positioning.

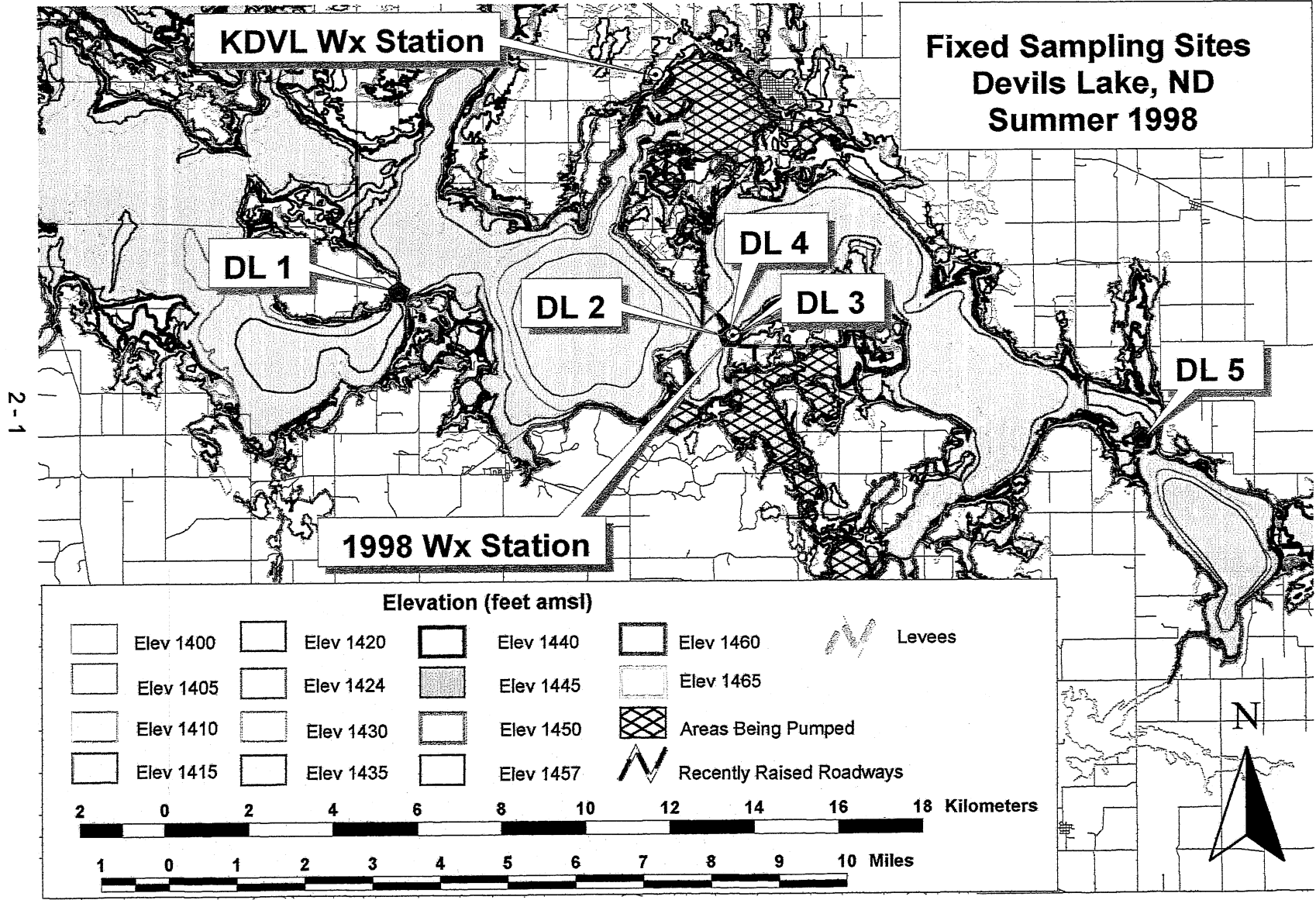
Methods (Continued)

G) Soundings

- Soundings were conducted using a Lowrance X-60 digital-display depth finder with a model HS-WST transducer and manually recording the results.

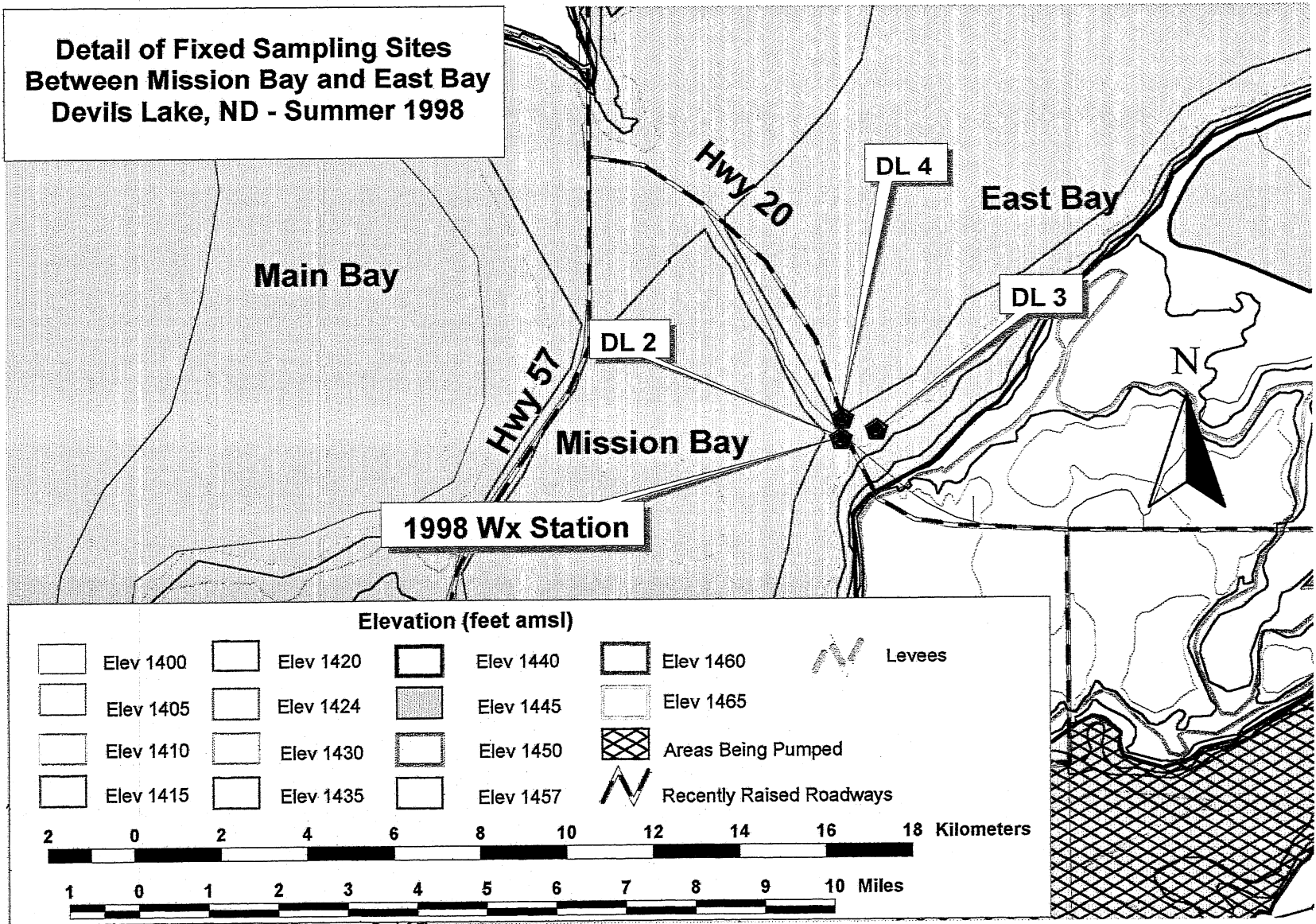
(a) Calibration - None required.

(b) Performance - Unit performed reasonably well. Some error due to wave swell and boat drift was noted while conducting field measurements.



**Detail of Fixed Sampling Sites
Between Mission Bay and East Bay
Devils Lake, ND - Summer 1998**

2-2



Fixed Sampling Sites

Station	Position (Northing) (Easting)	Instrumentation						Site Description
		Wind Velocity (MET-1 013)	Wind Direction (MET-1 023)	Water Velocity	Water Direction	DO, Cond, pH, Temp	Depth (Waterlog H-310)	
DL1	14U 496370 5320712	X	X	X	X	X	X	PVC platform located in narrows S. of Graham's Is.
DL2	14U 509112 5318967	X	X				X	PVC platform located 100 FT SW of Hwy 20 Bridge
DL3	14U 508971 5319006						X	Mounted to tree trunk in +15 FT of water
DL4	14U 501512 5334497			X	X	X*		Mounted to E. side of Hwy 20 Bridge
DL5	14T 524694 5314915			X	X	X		Mounted to tree trunk in 4.5 FT of water

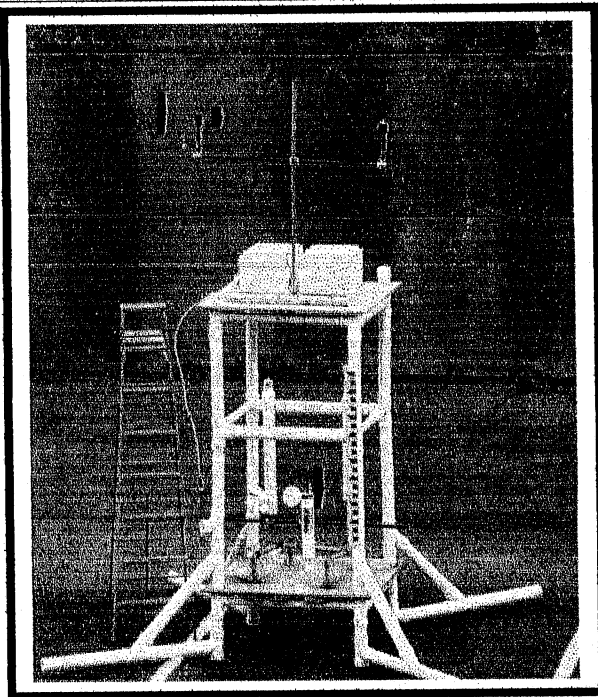


Figure 2-1 - One of the PVC platforms used at Stations DL1 and DL2.

Fixed Sampling Sites (Continued)

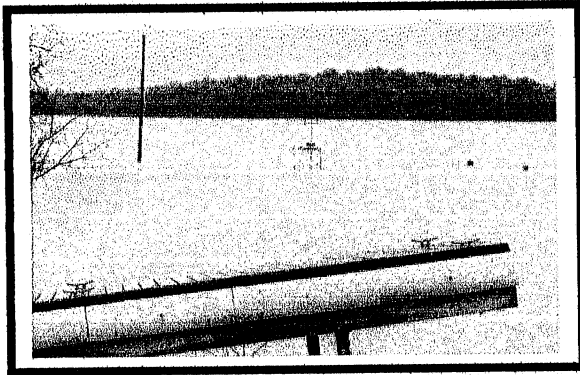


Figure 2-2 - Station DL1 located in narrows south of Graham's Island.



Figure 2-3 - Station DL2 located west and south of the Highway 20 bridge.

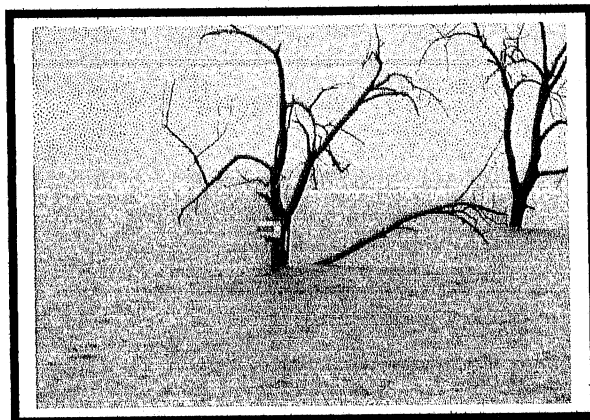


Figure 2-4 - Station DL3 located east and south of the Highway 20 bridge.

Fixed Sampling Sites (Continued)

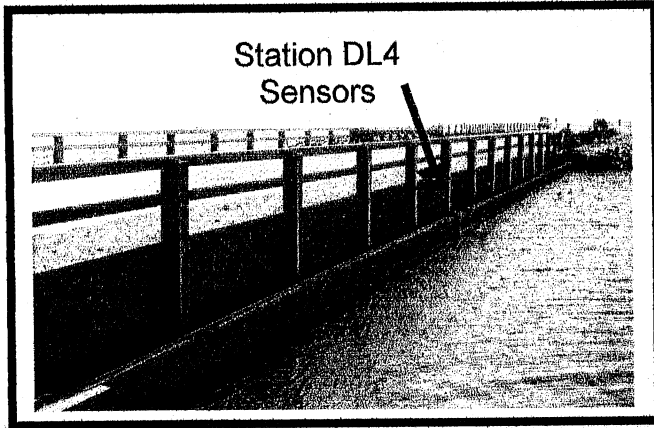


Figure 2-5 - Station DL4 located on east side of Highway 20 bridge.

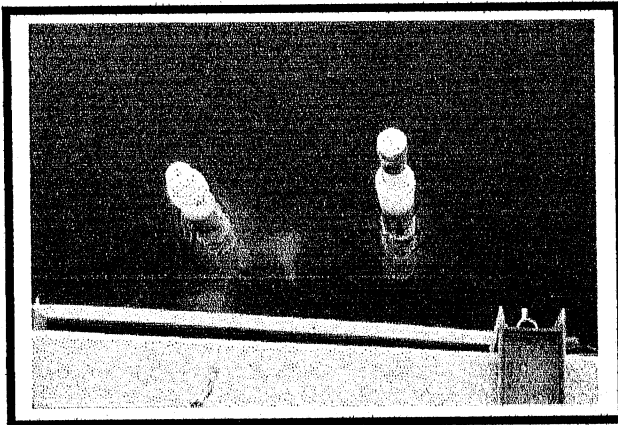


Figure 2-6 - Top view of Station DL4.

Locations of Temporal Sampling Sites 7-12 Jul 98

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
MAUVIS	14	U	486059	5345186			729	12-Jul-98	00:13	
DL_1	14	U	496370	5320712	5	1439.7		9-Jul-98	17:06	
DL_2	14	U	509112	5318967	5	1439.7		11-Jul-98	15:39	
DL_3	14	U	508971	5319006				11-Jul-98	15:45	
DL_5	14	T	524694	5314915	4	1440.7		10-Jul-98	14:03	
RUT_WOD	14	U	522598	5316674	1	1443.7		10-Jul-98	12:14	
1	14	U	509092	5319146	8.0	1436.7	2540	7-Jul-98	18:29	A
2	14	U	510056	5320985	9.9	1434.8	3103	7-Jul-98	18:36	B
3	14	U	511014	5322037	10.8	1433.9	3144	7-Jul-98	18:44	C
4	14	U	512462	5323031	10.8	1433.9	3142	7-Jul-98	18:51	D
5	14	U	514571	5323033	10.9	1433.8	3236	7-Jul-98	19:01	E
6	14	U	515470	5321984	10.0	1434.7	3271	7-Jul-98	19:07	F
7	14	U	516070	5319928	8.0	1436.7	3288	7-Jul-98	19:19	G
8	14	U	516477	5320486	2.9	1441.8	3277	7-Jul-98	19:25	G1
09A	14	T	519000	5316000	8.6	1436.1	3411	7-Jul-98	15:20	I
9	14	U	518613	5317845	11.6	1433.1	3385	7-Jul-98	19:40	I1
10	14	U	521979	5316587	9.0	1435.7	3441	7-Jul-98	19:53	J
11	14	T	522174	5316074	6.0	1438.7	3457	7-Jul-98	20:00	J1
12	14	U	523455	5316200	7.8	1436.9	6478	7-Jul-98	20:16	K
13	14	U	523643	5316197	7.6	1437.1	6759	7-Jul-98	20:24	K1
14	14	T	524952	5315075	6.7	1438.0	6413	7-Jul-98	20:33	L
15	14	T	524545	5314997	1.2	1443.5	6197	7-Jul-98	20:51	L1
16	14	T	525062	5314088	8.9	1435.8	7473	7-Jul-98	20:57	M
17	14	T	526985	5312059	15.0	1429.7	7438	7-Jul-98	21:04	N
18	14	T	528141	5309198	15.0	1429.7	7458	7-Jul-98	21:13	O
19	14	T	525037	5314653	7.2	1437.5	6326	7-Jul-98	21:36	Z
21	14	U	522700	5316637	7.2	1437.5	7.6	7-Jul-98	21:49	RUT-E

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
22	14	U	522550	5316762	7.0	1437.7	3576	7-Jul-98	22:48	RUT-W
23	14	T	521475	5315974	7.2	1437.5	3542	7-Jul-98	22:57	8A
24	14	T	518518	5313808	10.6	1434.1	3565	7-Jul-98	23:14	P
25	14	T	517472	5312953	10.7	1434.0	3573	7-Jul-98	23:17	Q
26	14	T	516007	5311318	10.9	1433.8	3580	7-Jul-98	23:25	R
27	14	U	514412	5321521	9.4	1435.3	3412	7-Jul-98	23:57	3A
28	14	U	508988	5319089	4.0	1440.7	2534	8-Jul-98	00:19	Z1
29	14	U	508737	5320938	4.0	1440.7	3205	8-Jul-98	00:25	Z2
30	14	U	509460	5323888		1444.7	3266	8-Jul-98	00:30	Z3
31	14	U	496560	5320741	8.4	1436.3	1963	8-Jul-98	15:33	A1
32	14	U	496619	5320658	8.5	1436.2	1962	8-Jul-98	15:34	A1-1
33	14	U	496718	5320535	7.9	1436.8		8-Jul-98	15:37	A1-2
34	14	U	498537	5321471	9.0	1435.7	1999	8-Jul-98	15:42	A17
35	14	U	502011	5321527	14.1	1430.6	2041	8-Jul-98	15:51	A35
36	14	U	500941	5318785	13.7	1431.0	2060	8-Jul-98	15:58	A19
37	14	U	502971	5317673	14.2	1430.5	2061	8-Jul-98	16:05	A20
38	14	U	505086	5317534	14.3	1430.4	2062	8-Jul-98	16:11	A21
39	14	U	505548	5318934	14.0	1430.7	2062	8-Jul-98	16:18	A22
40	14	U	507390	5318762	9.4	1435.3	2067	8-Jul-98	16:26	A23
41	14	U	507795	5318648	11.0	1433.7	2296	8-Jul-98	16:31	A24
42	14	U	507975	5316929	9.8	1434.9	2327	8-Jul-98	16:39	A25
43	14	U	508677	5318239	9.1	1435.6		8-Jul-98	16:45	A26A
44	14	U	508867	5318895	7.8	1436.9	2252	8-Jul-98	16:48	A26
45	14	U	508083	5319620	7.9	1436.8	2334	8-Jul-98	16:57	A27
46	14	U	507801	5319742	8.5	1436.2	2069	8-Jul-98	17:08	A28
47	14	U	505545	5321057	13.7	1431.0	2061	8-Jul-98	17:19	A29
48	14	U	504321	5320974	14.0	1430.7		8-Jul-98	17:25	A29A

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
49	14	U	503417	5320966	13.7	1431.0	2056	8-Jul-98	17:28	A30
50	14	U	503984	5323091	13.4	1431.3	2050	8-Jul-98	17:34	A31
51	14	U	504514	5324566	12.0	1432.7	2053	8-Jul-98	17:40	A32
52	14	U	505216	5326138	9.5	1435.2	2066	8-Jul-98	17:46	A33
53	14	U	505952	5326856	9.2	1435.5	2058	8-Jul-98	17:52	A34
54	14	U	499995	5322464	9.1	1435.6	2011	8-Jul-98	18:08	A18
55	14	U	497528	5324003	10.5	1434.2	1974	8-Jul-98	18:16	A13
56	14	U	496893	5325248	9.3	1435.4	1919	8-Jul-98	18:22	A14
57	14	U	497918	5326461	10.0	1434.7	1933	8-Jul-98	18:29	A15
58	14	U	498518	5328476	10.3	1434.4	1916	8-Jul-98	18:36	A16
59	14	U	499283	5329466	8.0	1436.7	1943	8-Jul-98	18:47	A16A
60	14	U	495918	5322915	9.5	1435.2	1975	8-Jul-98	19:09	A12
61	14	U	496464	5320265	8.2	1436.5	1854	8-Jul-98	19:22	A2
62	14	U	494958	5317963	7.9	1436.8	1713	8-Jul-98	19:31	A3
63	14	U	493945	5319099	7.5	1437.2	1724	8-Jul-98	19:37	A4
64	14	U	491431	5316913	7.6	1437.1	1695	8-Jul-98	19:45	A5
65	14	U	490496	5319554	7.7	1437.0	1689	8-Jul-98	19:53	A6
66	14	U	489421	5321513	6.6	1438.1	1640	8-Jul-98	20:01	A7
67	14	U	487486	5322975	6.6	1438.1	1662	8-Jul-98	20:09	A8
68	14	U	485301	5325439	6.1	1438.6	1626	8-Jul-98	20:18	A9
69	14	U	496588	5320739	9.1	1435.6	1963	8-Jul-98	20:58	A2A
70	14	U	482793	5327188	3.8	1440.9	1649	9-Jul-98	15:39	A10
71	14	U	482249	5326948	3.7	1441.0	1657	9-Jul-98	15:39	A10A
72	14	U	490299	5325614	5.0	1439.7	1636	9-Jul-98	15:58	A11
73	14	U	493948	5325477	5.1	1439.6	1528	9-Jul-98	16:13	A37
74	14	U	491300	5328751	3.8	1440.9	1378	9-Jul-98	16:26	A38
75	14	U	491655	5327942	4.1	1440.6	1449	9-Jul-98	16:38	A39

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
76	14	U	483529	5328975	0.0	1444.7	1338	9-Jul-98	18:22	A40
77	14	U	483556	5328997	0.0	1444.7	1102	9-Jul-98	18:24	A41
78	14	U	482098	5327191	0.0	1444.7	1656	9-Jul-98	18:51	A42
79	14	U	482084	5327219	0.0	1444.7	1589	9-Jul-98	18:57	A43
80	14	U	482787	5327954	0.0	1444.7	1418	9-Jul-98	19:04	A44
81	14	U	491236	5328899	5.6	1439.1	1148	9-Jul-98	19:26	A45
82	14	U	499400	5329532	7.9	1436.8	1250	9-Jul-98	20:13	A46
83	14	U	522499	5316603	6.2	1438.5	3834	10-Jul-98	12:04	B1
84	14	U	522682	5316688	7.1	1437.6	6551	10-Jul-98	12:19	B2
85	14	T	524972	5314916	7.0	1437.7	7133	10-Jul-98	12:31	B4
86	14	T	525026	5314712	7.4	1437.3	7022	10-Jul-98	12:50	B3
87	14	T	525019	5314701	6.1	1438.6		10-Jul-98	12:51	
88	14	T	525012	5314654	5.8	1438.9		10-Jul-98	12:52	
89	14	T	525006	5314646	5.2	1439.5		10-Jul-98	12:52	
90	14	T	525001	5314640	4.9	1439.8		10-Jul-98	12:52	
91	14	T	524990	5314637	4.5	1440.2		10-Jul-98	12:53	
92	14	T	524983	5314632	4.0	1440.7		10-Jul-98	12:53	
93	14	T	524986	5314624	3.5	1441.2		10-Jul-98	12:53	
94	14	T	524995	5314607	4.1	1440.6		10-Jul-98	12:54	
95	14	T	525005	5314604	5.2	1439.5		10-Jul-98	12:54	
96	14	T	525011	5314602	5.6	1439.1		10-Jul-98	12:54	
97	14	T	525017	5314601	6.0	1438.7		10-Jul-98	12:54	
98	14	T	525027	5314598	6.4	1438.3		10-Jul-98	12:55	
99	14	T	525033	5314600	6.7	1438.0		10-Jul-98	12:55	
100	14	T	525043	5314597	7.2	1437.5		10-Jul-98	12:55	
101	14	T	525073	5314564	7.0	1437.7		10-Jul-98	12:56	
102	14	T	525085	5314553	6.6	1438.1		10-Jul-98	12:57	

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM			Current Lake Elev (FT) = 1444.7							
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
103	14	T	525119	5314520	5.7	1439.0		10-Jul-98	12:57	
104	14	T	525073	5314471	6.1	1438.6		10-Jul-98	12:58	
105	14	T	525013	5314433	6.2	1438.5		10-Jul-98	12:59	
106	14	T	525004	5314403	4.3	1440.4		10-Jul-98	13:00	
107	14	T	525024	5314384	4.6	1440.1		10-Jul-98	13:00	
108	14	T	525062	5314350	4.6	1440.1		10-Jul-98	13:01	
109	14	T	525108	5314301	5.5	1439.2		10-Jul-98	13:02	
110	14	T	525111	5314294	5.9	1438.8		10-Jul-98	13:02	
111	14	T	525110	5314289	6.3	1438.4		10-Jul-98	13:02	
112	14	T	525119	5314265	7.0	1437.7		10-Jul-98	13:03	
113	14	T	525140	5314247	7.5	1437.2		10-Jul-98	13:03	
114	14	T	525180	5314206	7.8	1436.9		10-Jul-98	13:04	
115	14	T	525233	5314145	8.5	1436.2		10-Jul-98	13:05	
116	14	T	525242	5314140	9.0	1435.7		10-Jul-98	13:06	
117	14	T	525288	5314089	9.6	1435.1		10-Jul-98	13:07	
118	14	T	525294	5314086	9.8	1434.9		10-Jul-98	13:07	
119	14	T	525360	5314028	10.6	1434.1		10-Jul-98	13:08	
120	14	T	525335	5314075	10.6	1434.1	7087	10-Jul-98	13:17	B5
121	14	U	522125	5316665	7.5	1437.2		10-Jul-98	14:17	
122	14	U	522099	5316674	8.0	1436.7		10-Jul-98	14:17	
123	14	U	522051	5316676	8.5	1436.2		10-Jul-98	14:18	
124	14	U	521979	5316683	8.9	1435.8		10-Jul-98	14:18	
125	14	U	521820	5316674	9.5	1435.2		10-Jul-98	14:20	
126	14	U	521798	5316663	10.1	1434.6		10-Jul-98	14:20	
127	14	U	521700	5316654	10.4	1434.3		10-Jul-98	14:21	
128	14	U	521529	5316668	10.6	1434.1		10-Jul-98	14:22	
129	14	U	521304	5316688	10.6	1434.1		10-Jul-98	14:24	

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
130	14	U	521071	5316716	11.1	1433.6		10-Jul-98	14:28	
131	14	U	520493	5316602	11.4	1433.3		10-Jul-98	14:31	
132	14	T	514370	5309913	0.0	1444.7	3614	10-Jul-98	15:34	B6
133	14	T	514334	5309874	0.0	1444.7	3500	10-Jul-98	15:37	B7
135	14	U	501512	5334497			780	10-Jul-98	21:29	BDG
136	14	U	509012	5319061	8.0	1436.7	3122	10-Jul-98	23:36	A3
148	14	U	508979	5319035	6.6	1438.1	3002	11-Jul-98	00:00	A4
149	14	U	514708	5322415	6.0	1438.7		11-Jul-98	14:00	
150	14	U	514657	5322469	8.0	1436.7		11-Jul-98	14:01	
151	14	U	514646	5322527	8.6	1436.1		11-Jul-98	14:02	
152	14	U	514649	5322560	9.1	1435.6		11-Jul-98	14:02	
153	14	U	514652	5322642	10.1	1434.6		11-Jul-98	14:03	
154	14	U	514690	5322927	10.1	1434.6		11-Jul-98	14:05	
155	14	U	514722	5323324	10.7	1434.0		11-Jul-98	14:06	
156	14	U	514737	5323711	10.4	1434.3		11-Jul-98	14:09	
157	14	U	514804	5324061	7.2	1437.5		11-Jul-98	14:11	
158	14	U	514749	5323998	8.3	1436.4		11-Jul-98	14:12	
159	14	U	514661	5323965	10.0	1434.7		11-Jul-98	14:13	
160	14	U	515513	5319615	7.1	1437.6		11-Jul-98	14:24	
161	14	U	515533	5319651	8.3	1436.4		11-Jul-98	14:24	
162	14	U	515540	5319667	9.0	1435.7		11-Jul-98	14:25	
163	14	U	515571	5319687	9.5	1435.2		11-Jul-98	14:26	
164	14	U	515610	5319703	10.0	1434.7		11-Jul-98	14:26	
165	14	U	515774	5319859	10.1	1434.6		11-Jul-98	14:28	
166	14	U	515969	5320067	9.5	1435.2		11-Jul-98	14:29	
167	14	U	516140	5320235	8.0	1436.7		11-Jul-98	14:30	
168	14	U	516336	5320448	6.0	1438.7		11-Jul-98	14:32	

Locations of Temporal Sampling Sites 7-12 Jul 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.7						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Log Time	Name
					(FT)	(FT)	(uS/cm)			
169	14	U	516547	5320623	4.4	1440.3		11-Jul-98	14:33	
170	14	U	516623	5320576	3.9	1440.8		11-Jul-98	14:35	
171	14	U	516674	5320481	5.9	1438.8		11-Jul-98	14:36	
172	14	U	516622	5320386	6.9	1437.8		11-Jul-98	14:37	
173	14	U	516565	5320296	7.7	1437.0		11-Jul-98	14:38	
174	14	U	516558	5320140	8.5	1436.2		11-Jul-98	14:39	
175	14	U	516572	5319853	8.7	1436.0		11-Jul-98	14:41	
176	14	U	516417	5319598	10.2	1434.5		11-Jul-98	14:42	
177	14	U	516834	5319387	10.1	1434.6		11-Jul-98	14:44	
178	14	U	517040	5319665	10.1	1434.6		11-Jul-98	14:46	
179	14	U	517183	5320078	10.0	1434.7		11-Jul-98	14:47	
180	14	U	517093	5320318	9.4	1435.3		11-Jul-98	14:49	
181	14	U	517000	5320487	8.0	1436.7		11-Jul-98	14:50	
182	14	U	516547	5320754	4.8	1439.9		11-Jul-98	14:52	
183	14	U	516231	5320913	8.5	1436.2		11-Jul-98	14:53	
184	14	U	515926	5321081	10.0	1434.7		11-Jul-98	14:54	
185	14	U	515724	5321191	10.3	1434.4		11-Jul-98	14:56	
186	14	U	508684	5318977	9.0	1435.7		11-Jul-98	21:49	
187	14	U	508670	5318995	10.1	1434.6		11-Jul-98	21:49	
188	14	U	508601	5318947	10.8	1433.9		11-Jul-98	21:50	
189	14	U	508530	5318967	10.9	1433.8		11-Jul-98	21:51	
190	14	U	508412	5318951	11.2	1433.5		11-Jul-98	21:53	
191	14	U	508090	5318830	10.7	1434.0		11-Jul-98	21:57	
192	14	U	507868	5318774	10.9	1433.8		11-Jul-98	21:59	
193	14	U	507696	5318717	10.6	1434.1		11-Jul-98	22:01	
194	14	U	507478	5318642	3.0	1441.7		11-Jul-98	22:04	

Locations of Temporal Sampling Sites 9-14 Aug 98

NAD27 CONUS DATUM			Current Lake Elev (FT) = 1444.3						
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Time Logged
					(FT)	(FT)	(uS/cm)		
195	14	U	508946	5322882	31.5	1412.8	3267	9-Aug-98	15:23
197	14	U	508722	5320931	32.5	1411.8	3176	9-Aug-98	15:45
199	14	U	508982	5319111	23.0	1421.3	2804	9-Aug-98	16:00
201	14	U	510048	5320962	32.8	1411.5	3207	9-Aug-98	16:38
203	14	U	509490	5323946	26.9	1417.4	3300	9-Aug-98	16:57
205	14	U	512500	5323040	33.5	1410.8	3329	9-Aug-98	17:13
207	14	U	516478	5320500	9.5	1434.8	3459	9-Aug-98	17:29
210	14	U	516079	5319946	23.3	1421.0	3389	9-Aug-98	17:46
212	14	U	515996	5317962	30.8	1413.5	3474	9-Aug-98	17:54
216	14	T	518532	5313803	32.8	1411.5	3445	9-Aug-98	18:11
220	14	U	521954	5316609	27.2	1417.1	3543	9-Aug-98	18:30
221	14	U	522439	5316716	18.0	1426.3	3545	9-Aug-98	18:41
224	14	U	518605	5317847	34.1	1410.2	3531	9-Aug-98	18:56
229	14	U	496610	5320658	25.9	1418.4	1871	10-Aug-98	18:31
230	14	U	497016	5321017	27.6	1416.7	1914	10-Aug-98	18:40
231	14	U	496989	5321504	28.9	1415.4	1932	10-Aug-98	18:48
233	14	U	496985	5322010	30.2	1414.1	1943	10-Aug-98	18:58
235	14	U	498530	5328499	31.2	1413.1	1920	10-Aug-98	19:15
237	14	U	498998	5322009	30.2	1414.1	1978	10-Aug-98	19:29
238	14	U	499998	5322002	32.8	1411.5	1990	10-Aug-98	19:41
239	14	U	501011	5322005	38.7	1405.6	2042	10-Aug-98	19:56
245	14	U	507384	5318772	29.2	1415.1	2056	10-Aug-98	20:24
246	14	U	507787	5318644	32.1	1412.2	2439	10-Aug-98	20:39
247	14	U	508805	5318919	29.8	1414.5	2361	10-Aug-98	20:47
250	14	U	503417	5320987	43.3	1401.0	2062	10-Aug-98	21:08
254	14	U	496463	5320253	23.9	1420.4	1850	10-Aug-98	21:25
258	14	U	495001	5318995	23.9	1420.4	1820	10-Aug-98	21:40
261	14	U	490471	5319569	22.3	1422.0	1761	10-Aug-98	21:55

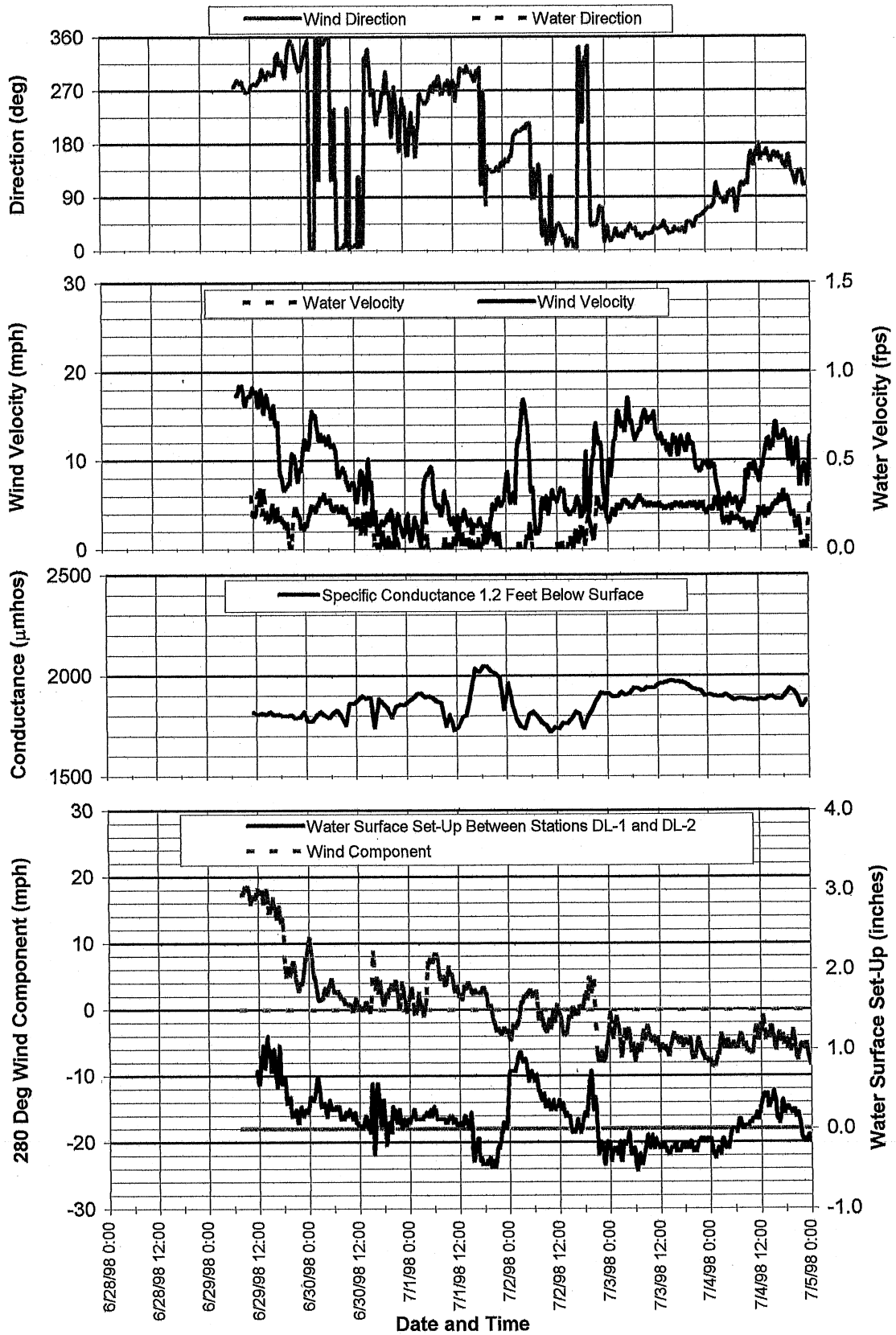
Locations of Temporal Sampling Sites 9-14 Aug 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.3					
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Time Logged
					(FT)	(FT)	(uS/cm)		
262	14	U	487465	5322990	19.4	1424.9	1700	10-Aug-98	22:05
263	14	U	490292	5325636	15.1	1429.2	1649	10-Aug-98	22:14
265	14	U	491801	5325603	15.1	1429.2	1576	10-Aug-98	22:25
266	14	U	490953	5325800	13.8	1430.5	1588	10-Aug-98	22:30
277	14	U	508731	5320933			3183	13-Aug-98	13:55
278	14	U	508985	5319122			2626	13-Aug-98	14:03
279	14	U	510041	5321004			3204	13-Aug-98	14:18
280	14	U	509459	5323880			3246	13-Aug-98	14:26
281	14	U	512448	5323049			3263	13-Aug-98	14:33
282	14	U	516475	5320502			3441	13-Aug-98	14:43
283	14	U	516075	5319938			3432	13-Aug-98	14:46
284	14	T	518521	5313815			3486	13-Aug-98	14:56
285	14	U	521976	5316608			3476	13-Aug-98	15:06
286	14	U	522488	5316841			3489	13-Aug-98	15:12
287	14	U	518623	5317843			3457	13-Aug-98	15:22
288	14	U	515997	5318000			3438	13-Aug-98	15:29
289	14	U	509012	5322982			3172	13-Aug-98	15:43
290	14	U	496636	5320615			1915	13-Aug-98	21:31
291	14	U	496994	5321506			1939	13-Aug-98	21:39
292	14	U	496997	5322002			1966	13-Aug-98	21:45
293	14	U	498523	5328485			1887	13-Aug-98	21:57
294	14	U	500006	5321975			1980	13-Aug-98	22:10
295	14	U	501009	5321999			1985	13-Aug-98	22:17
296	14	U	507395	5318758			2037	13-Aug-98	22:30
297	14	U	507798	5318650			2119	13-Aug-98	22:38
298	14	U	508836	5318913			2394	13-Aug-98	22:44
299	14	U	503428	5320964			2010	13-Aug-98	22:59

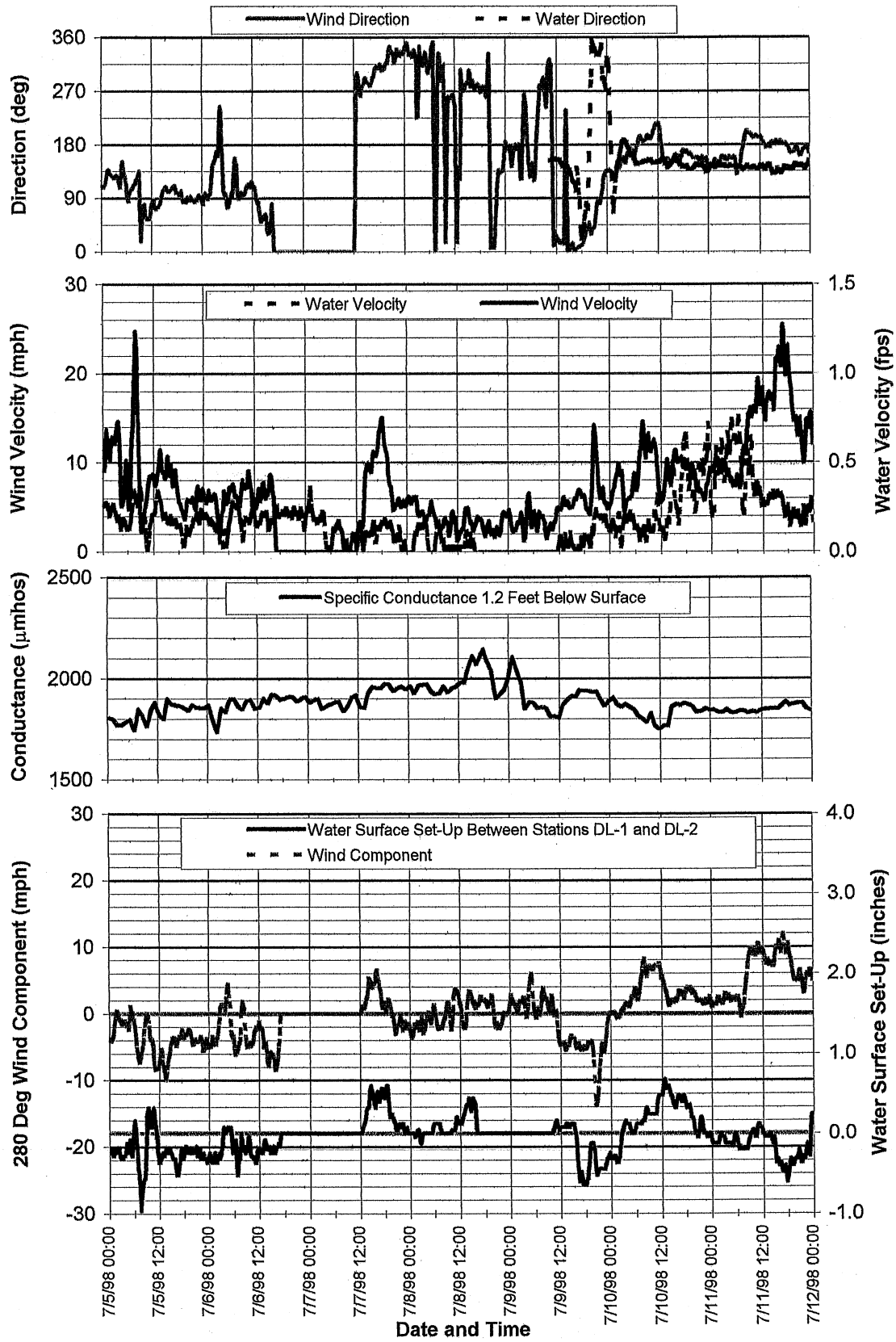
Locations of Temporal Sampling Sites 9-14 Aug 98 (Continued)

NAD27 CONUS DATUM				Current Lake Elev (FT) = 1444.3					
Way Pt			Easting	Northing	Depth	Bottom Elev	Surface Cond	Date Logged	Time Logged
					(FT)	(FT)	(uS/cm)		
300	14	U	496462	5320265			1907	13-Aug-98	23:13
301	14	U	496522	5319787			1792	13-Aug-98	23:19
302	14	U	494997	5318991			1793	13-Aug-98	23:24
303	14	U	490487	5319556			1718	13-Aug-98	23:34
304	14	U	487482	5322970			1666	13-Aug-98	23:45
305	14	U	490309	5325596			1647	13-Aug-98	23:56
306	14	U	490846	5325744	13.8	1430.5	1560	14-Aug-98	00:00
307	14	U	509464	5323886			3185	14-Aug-98	11:11
308	14	U	512469	5323013			3210	14-Aug-98	11:22
309	14	U	510053	5320989			3180	14-Aug-98	11:31
310	14	U	509037	5319141	22.6	1421.7	2897	14-Aug-98	11:41
311	14	T	529009	5311978			7440	14-Aug-98	16:33
312	14	T	526993	5312062			7414	14-Aug-98	16:41
313	14	T	524719	5314003			6936	14-Aug-98	16:51
314	14	T	525058	5314093			7283	14-Aug-98	16:57
315	14	T	525062	5314694	22.3	1422.0	7065	14-Aug-98	17:06
316	14	T	525052	5315598	19.7	1424.6	7143	14-Aug-98	17:12
317	14	U	523654	5316186	23.6	1420.7	7010	14-Aug-98	17:18
318	14	U	522699	5316642			6667	14-Aug-98	17:26

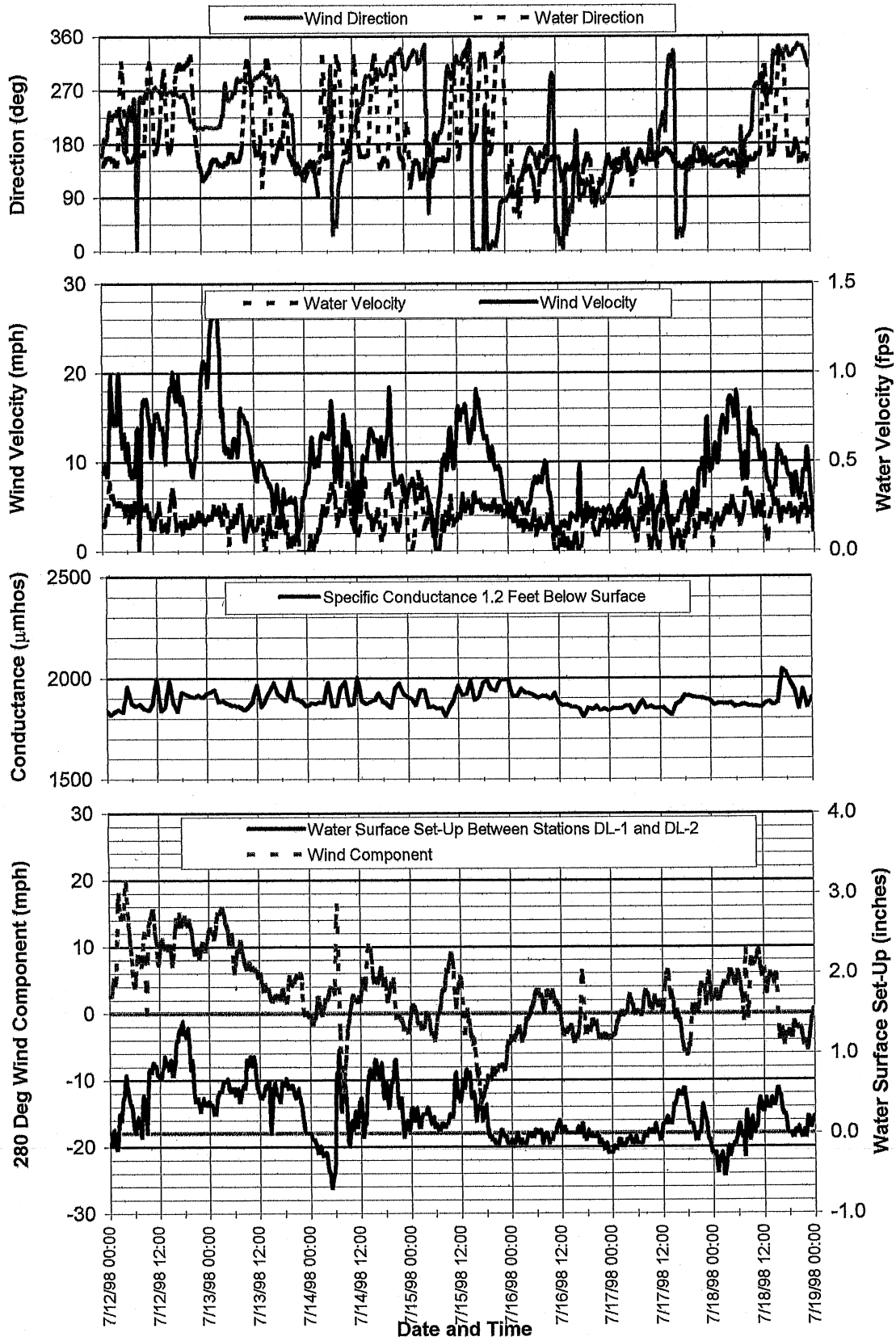
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



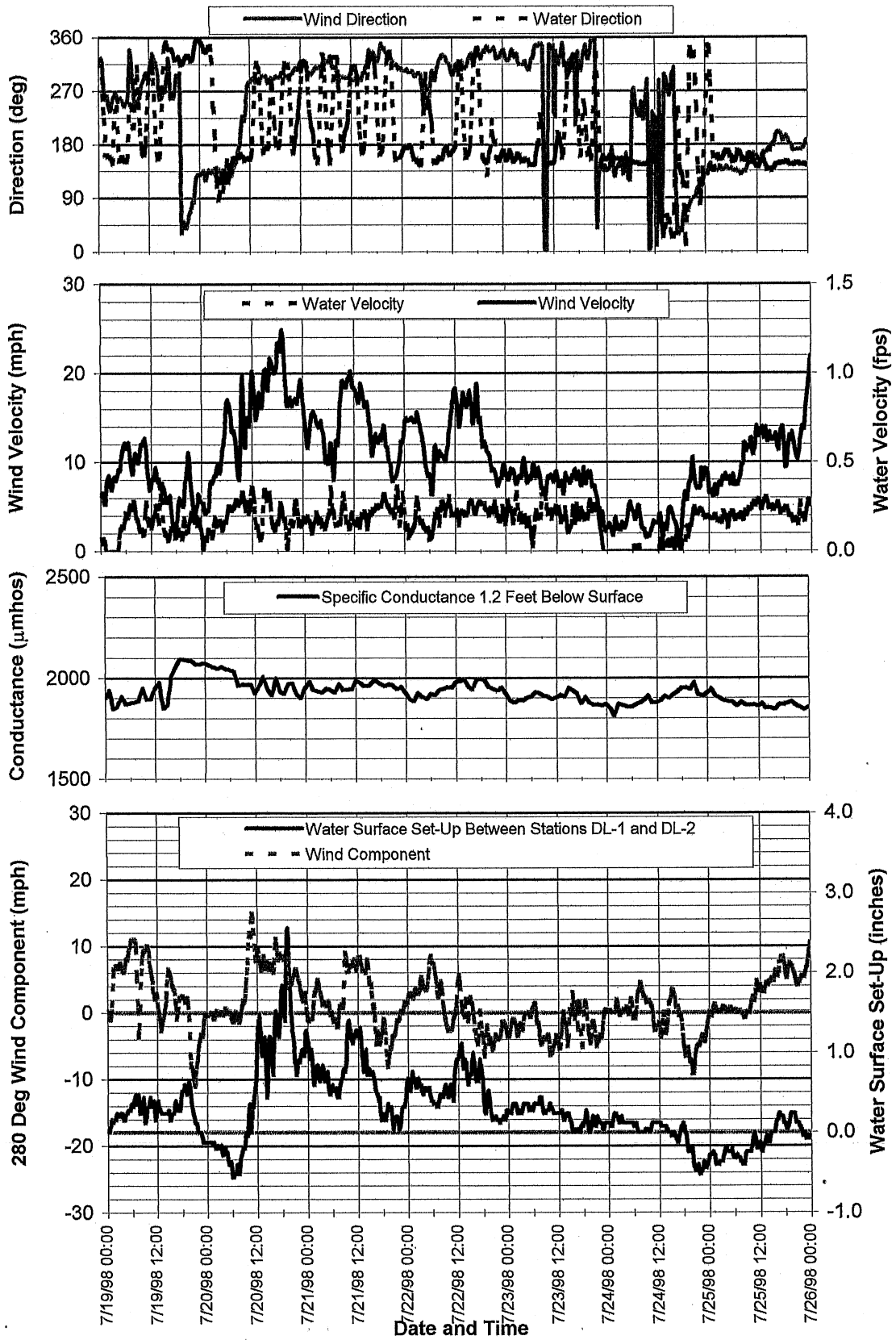
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



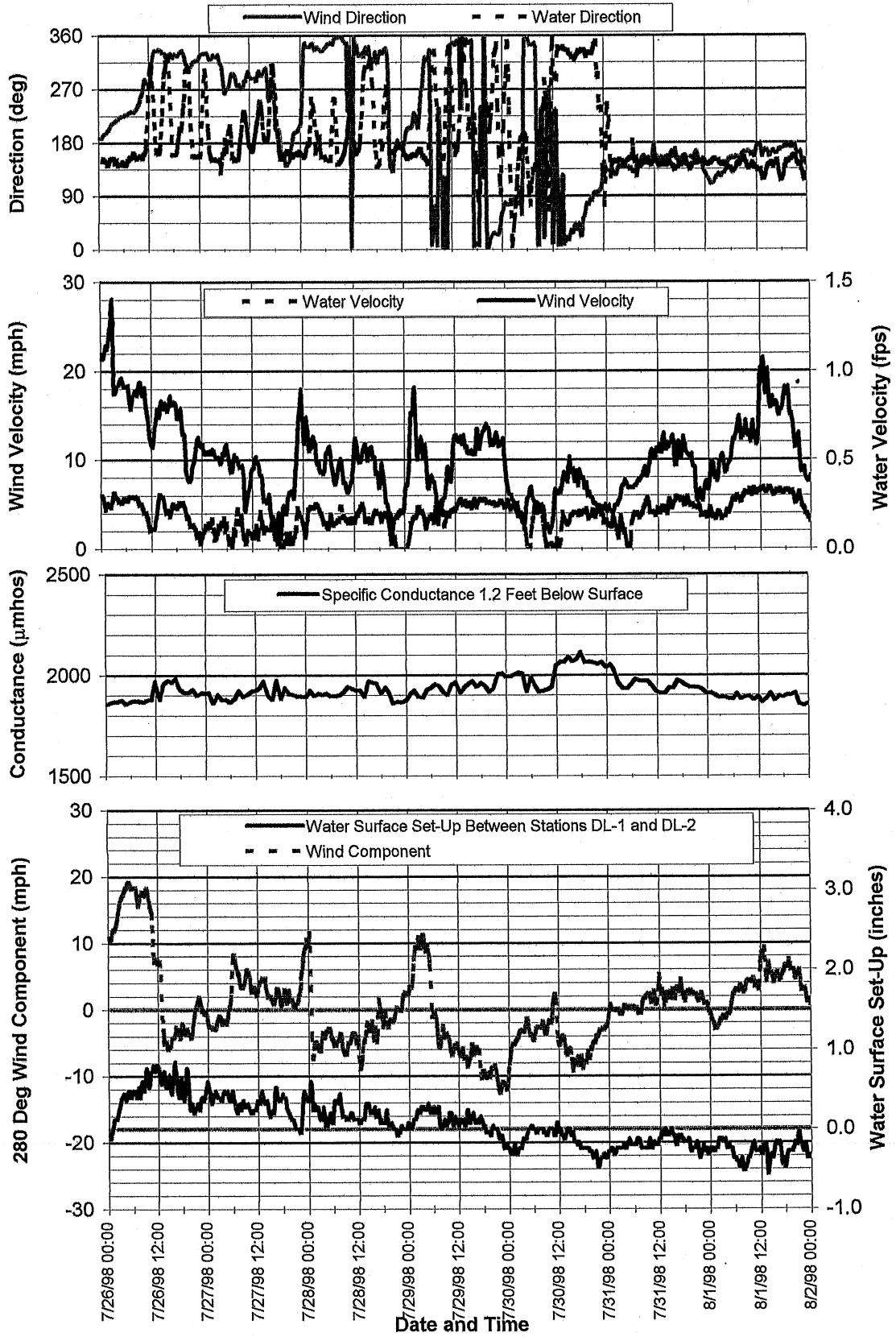
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



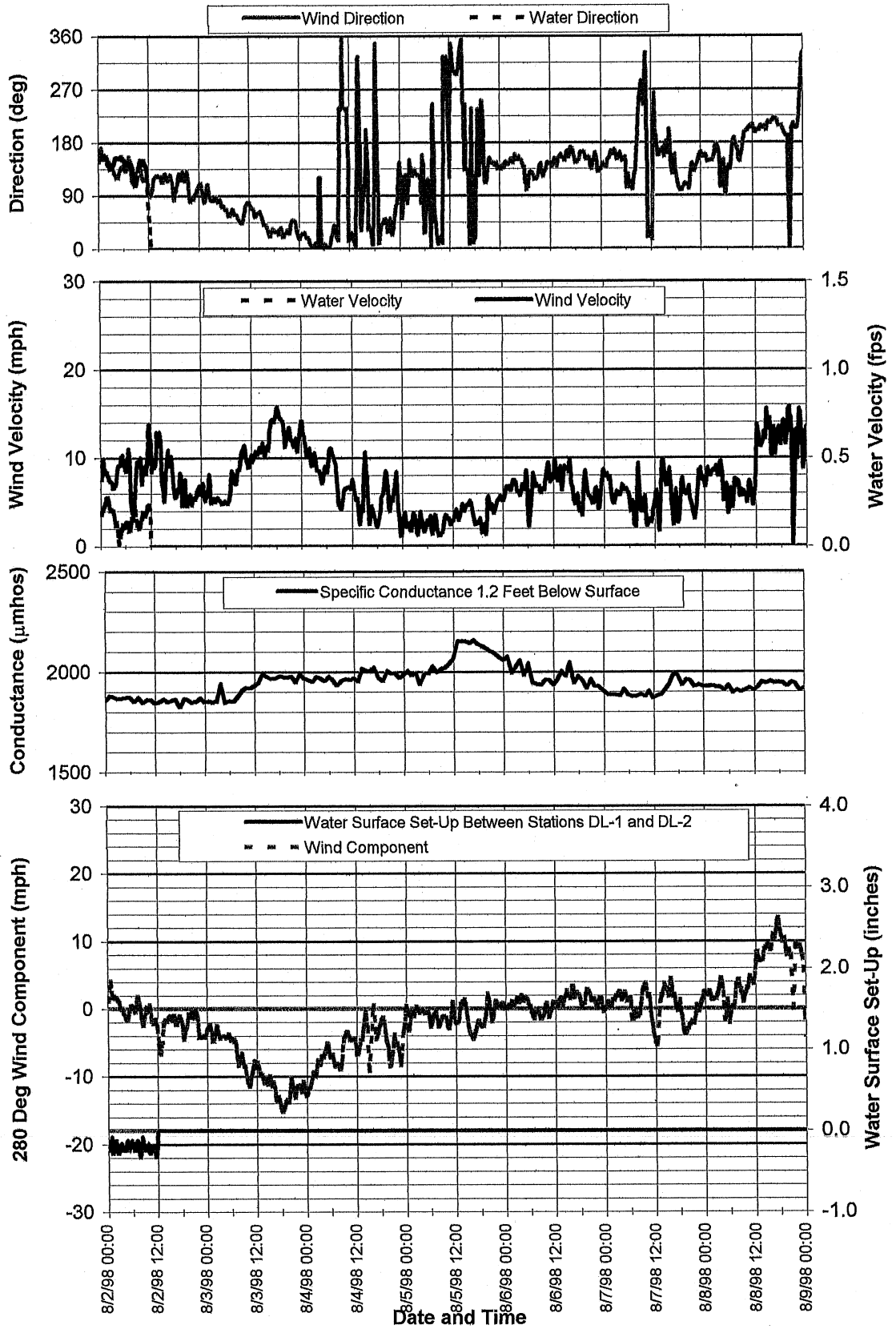
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



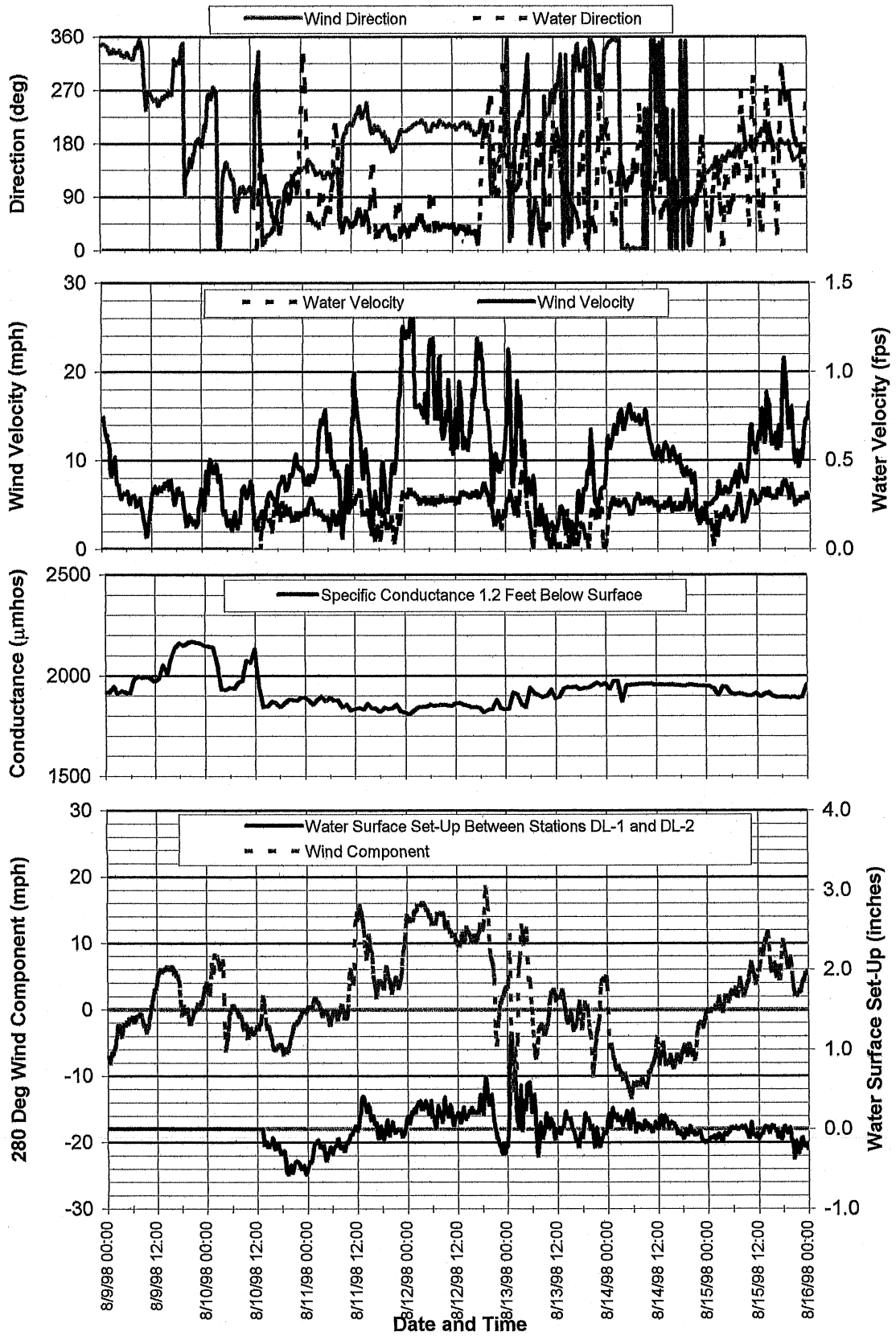
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



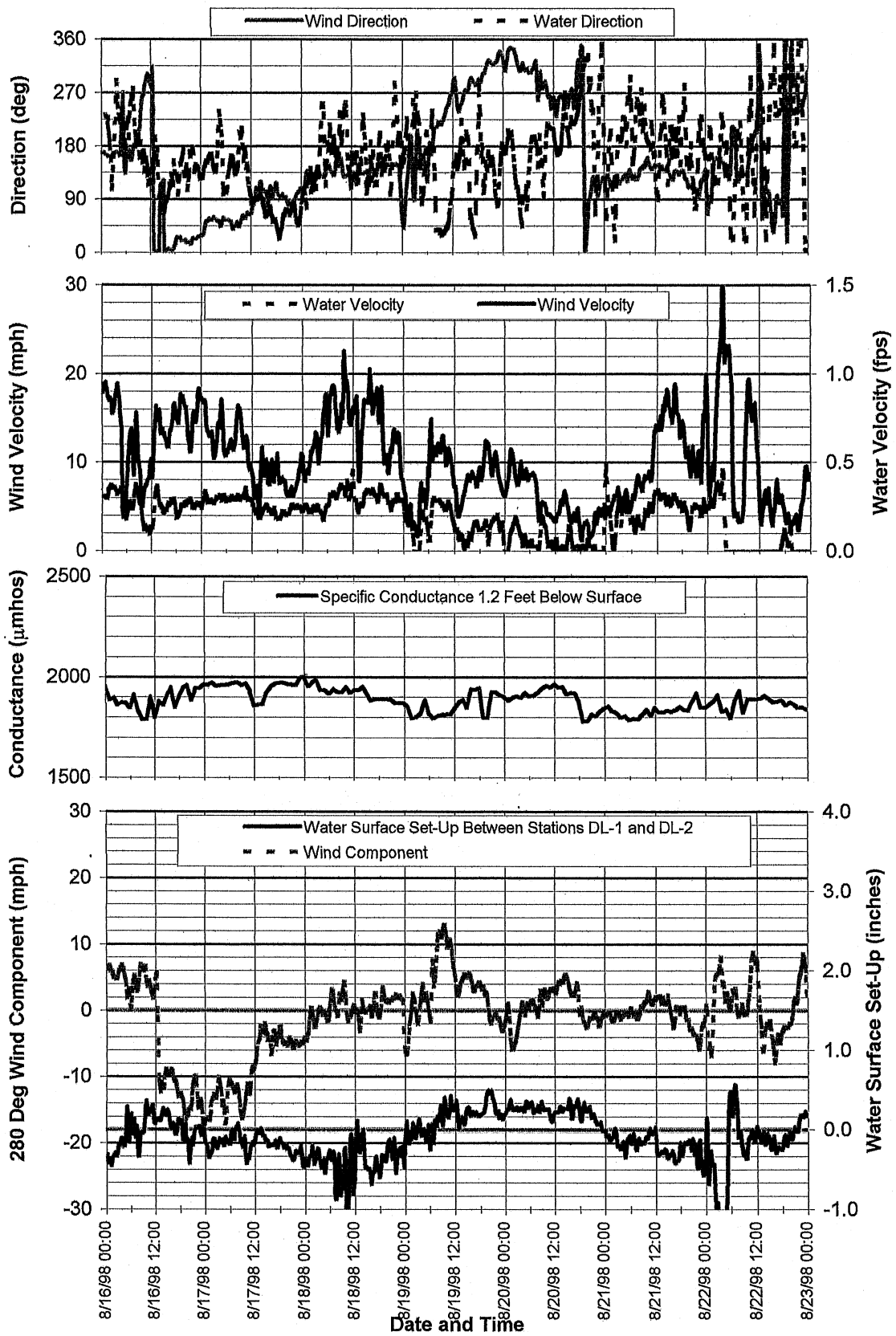
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



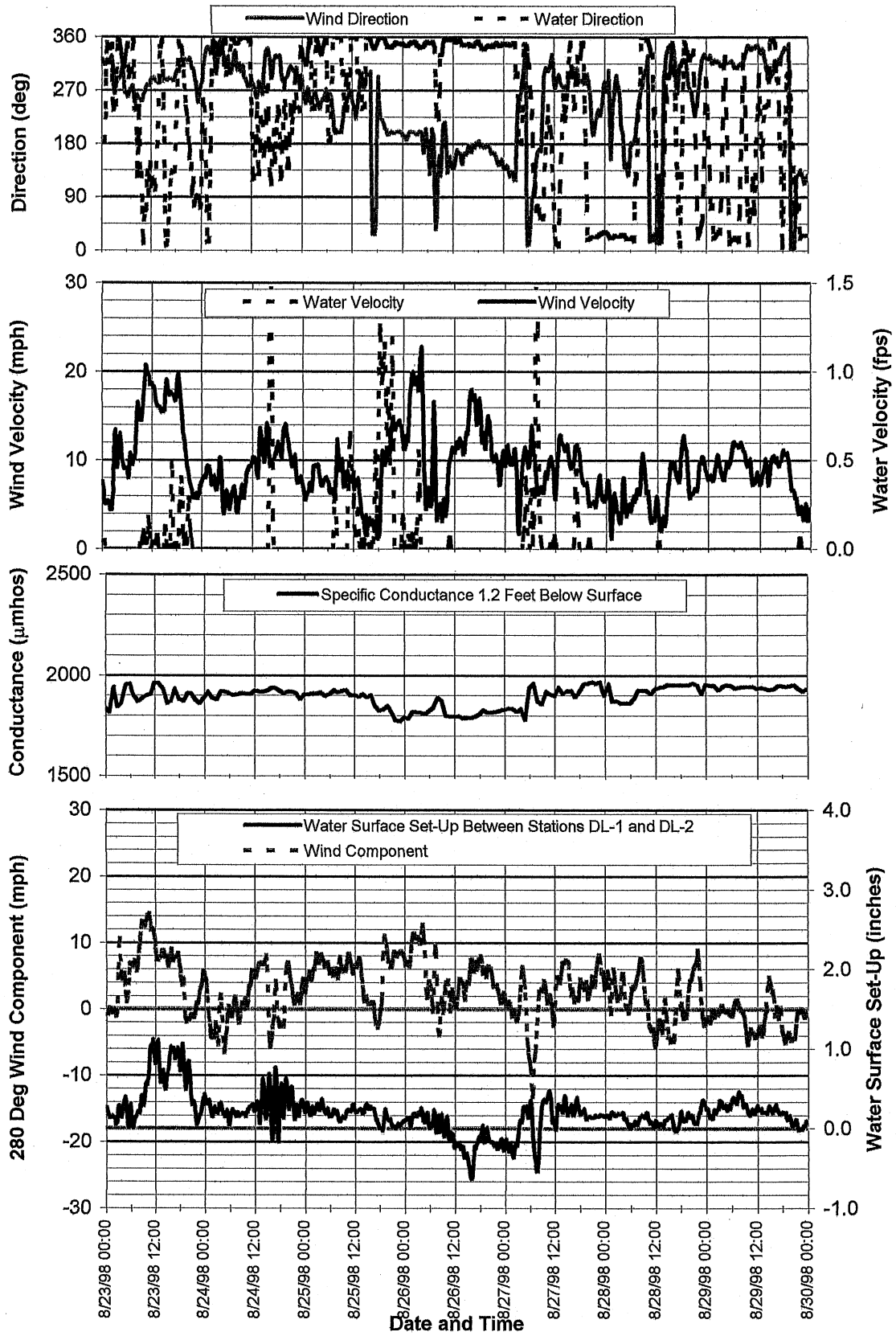
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



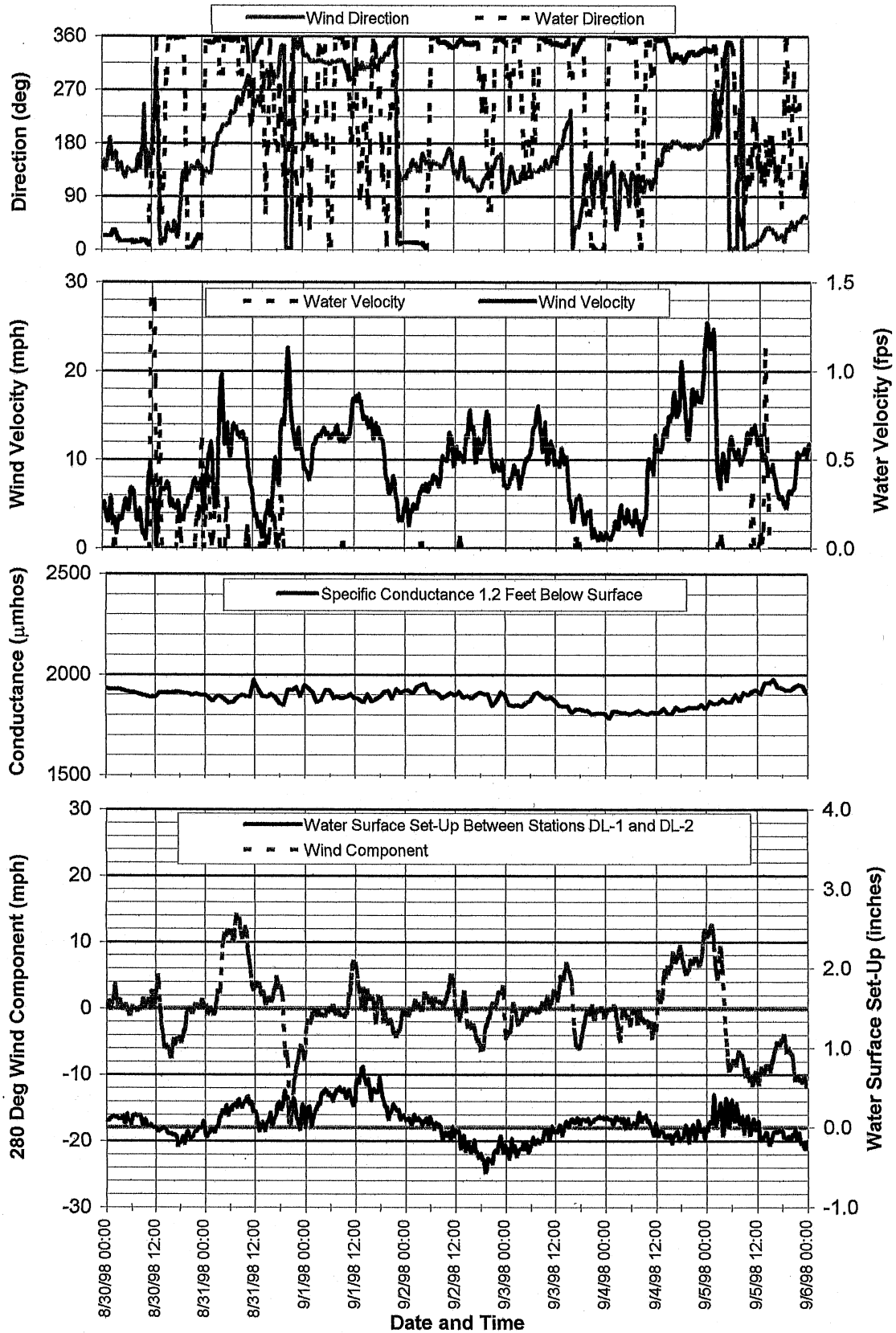
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



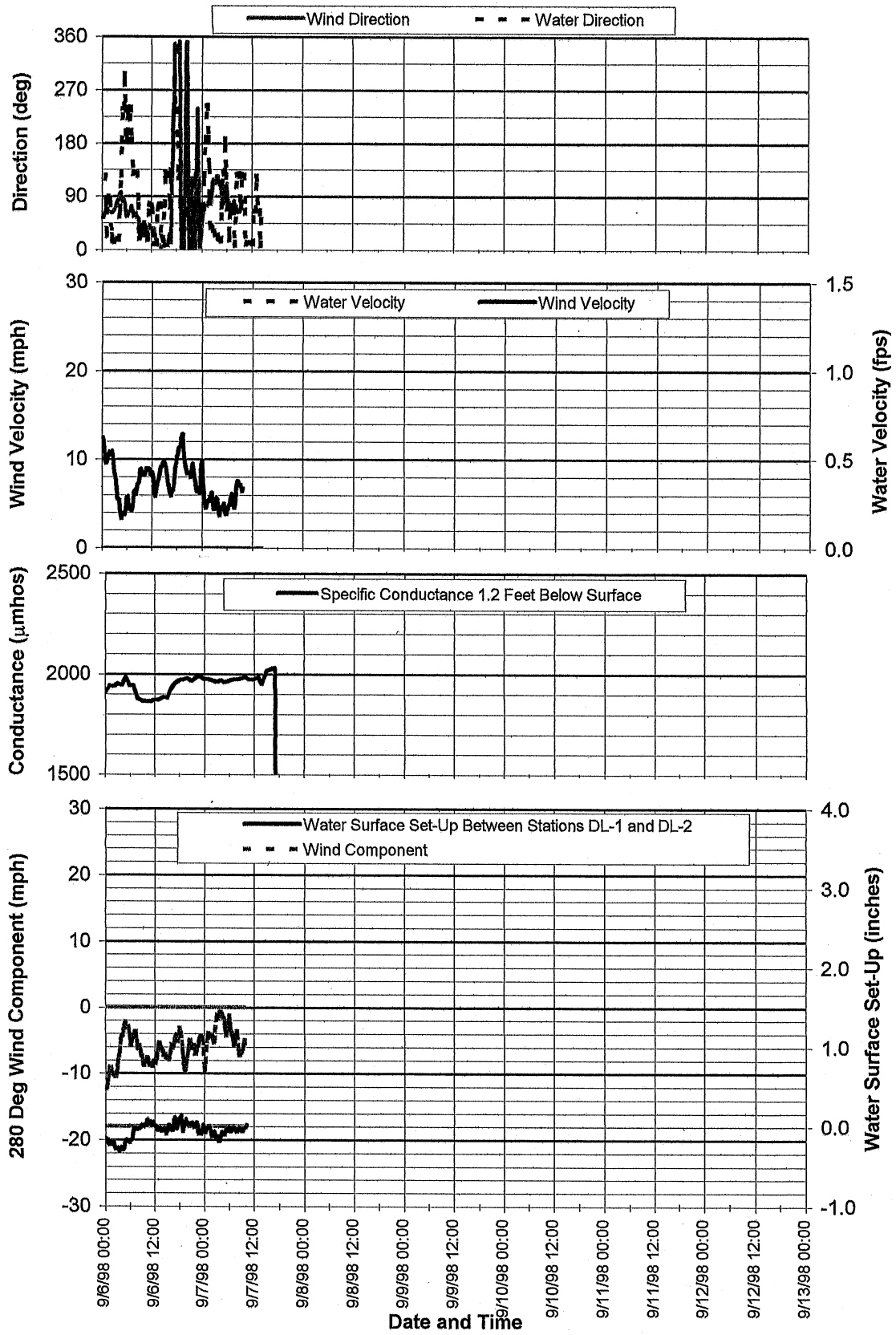
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



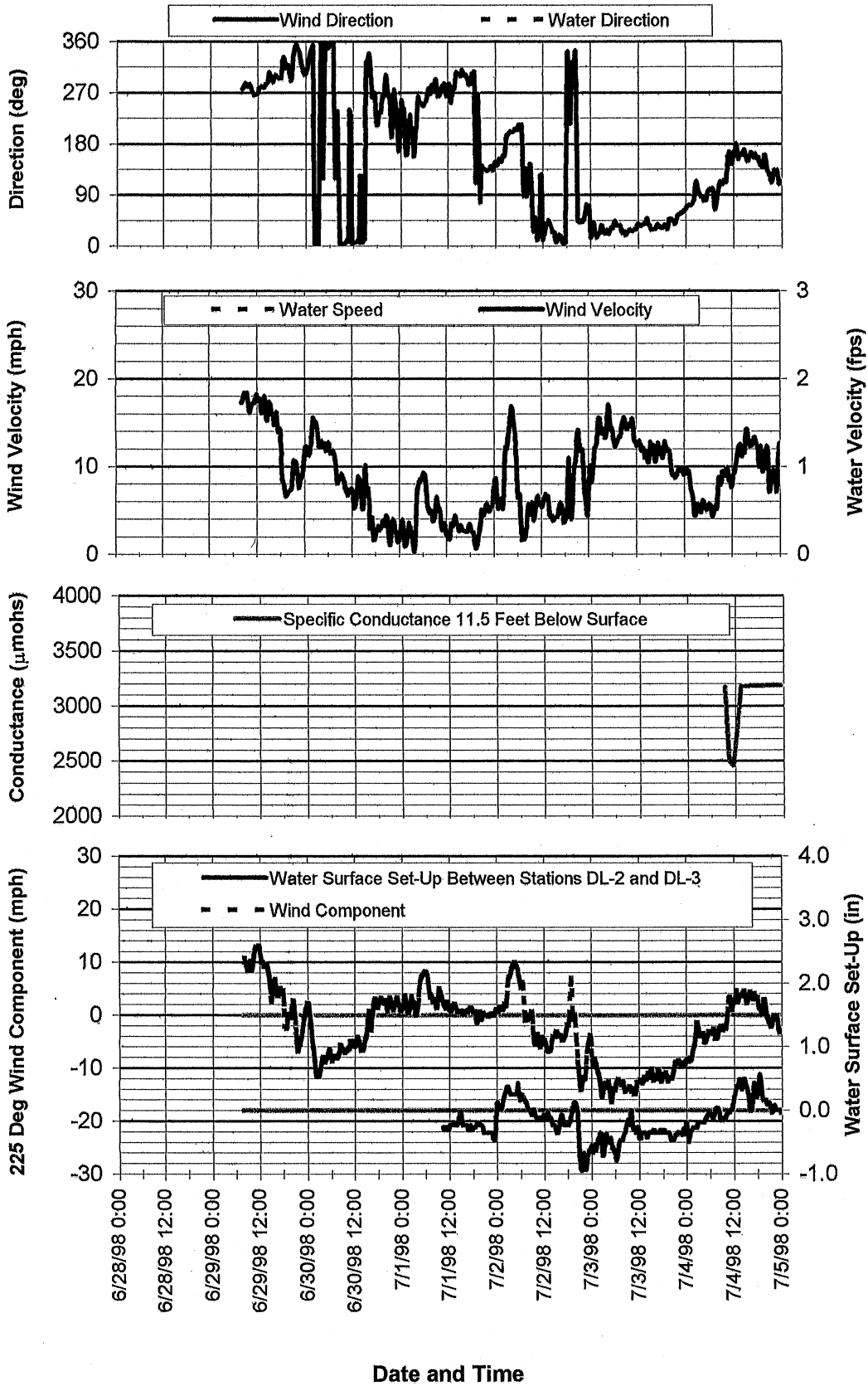
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



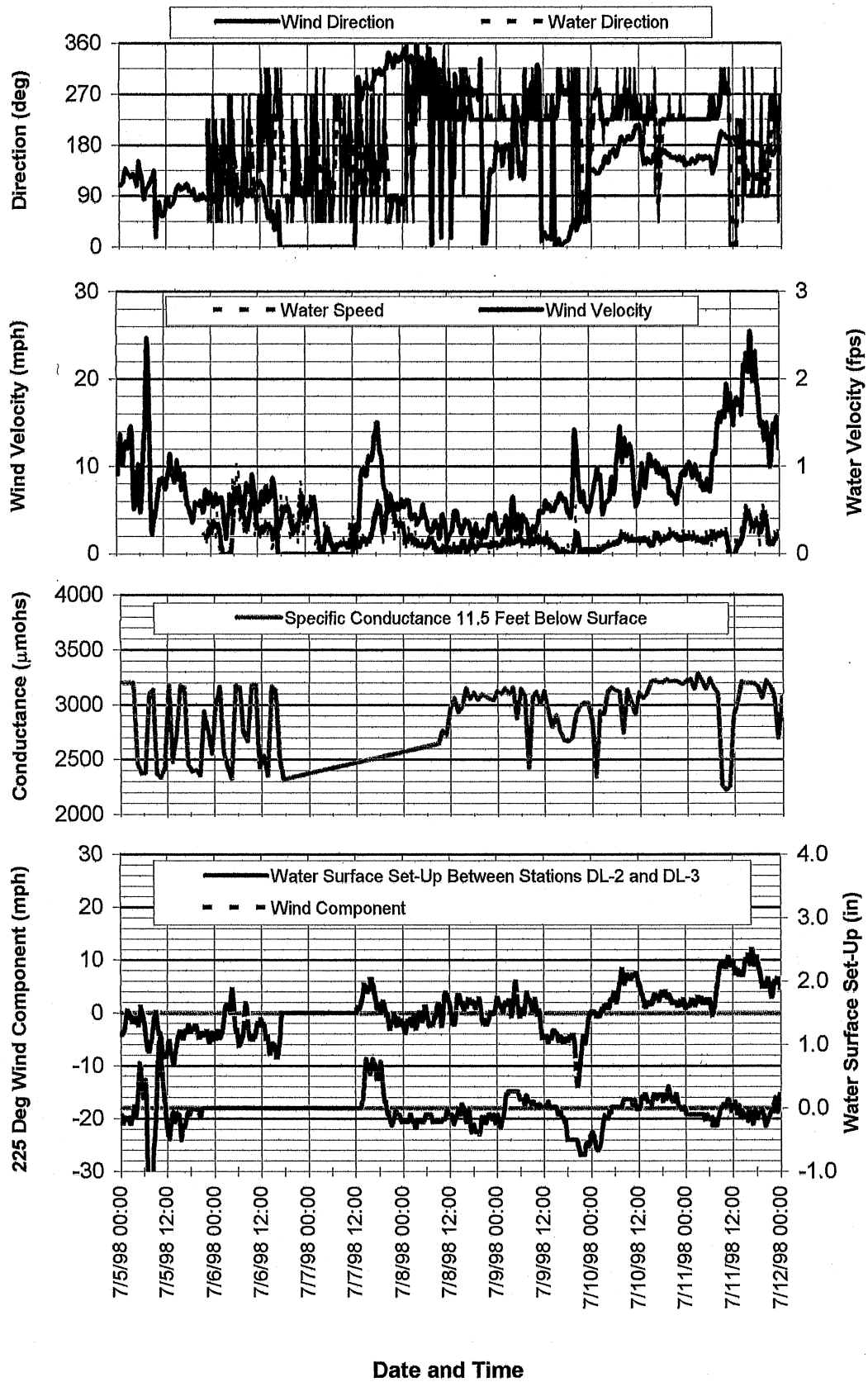
West Bay and Main Bay Exchange Zone Measurements (Sta DL1)



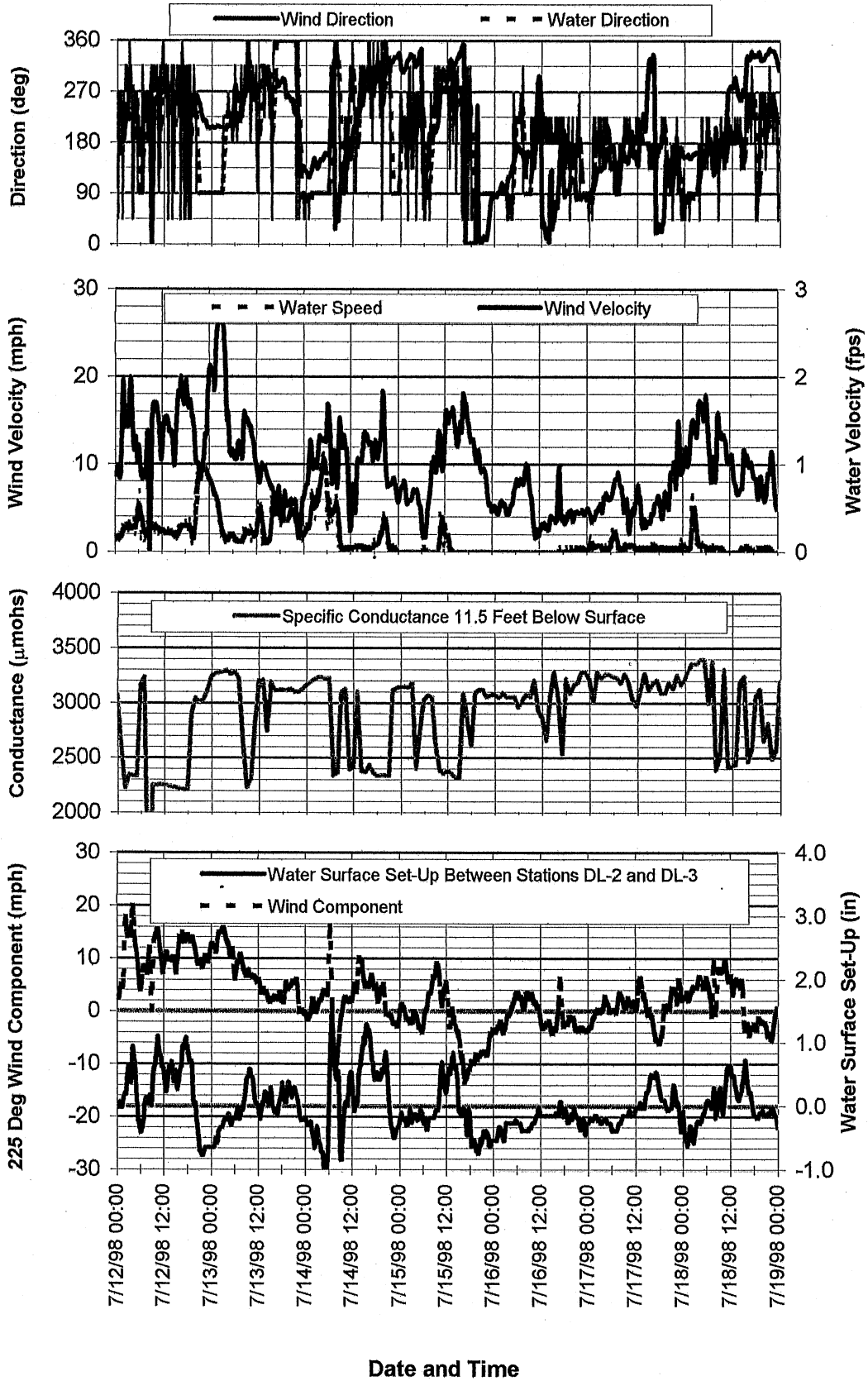
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



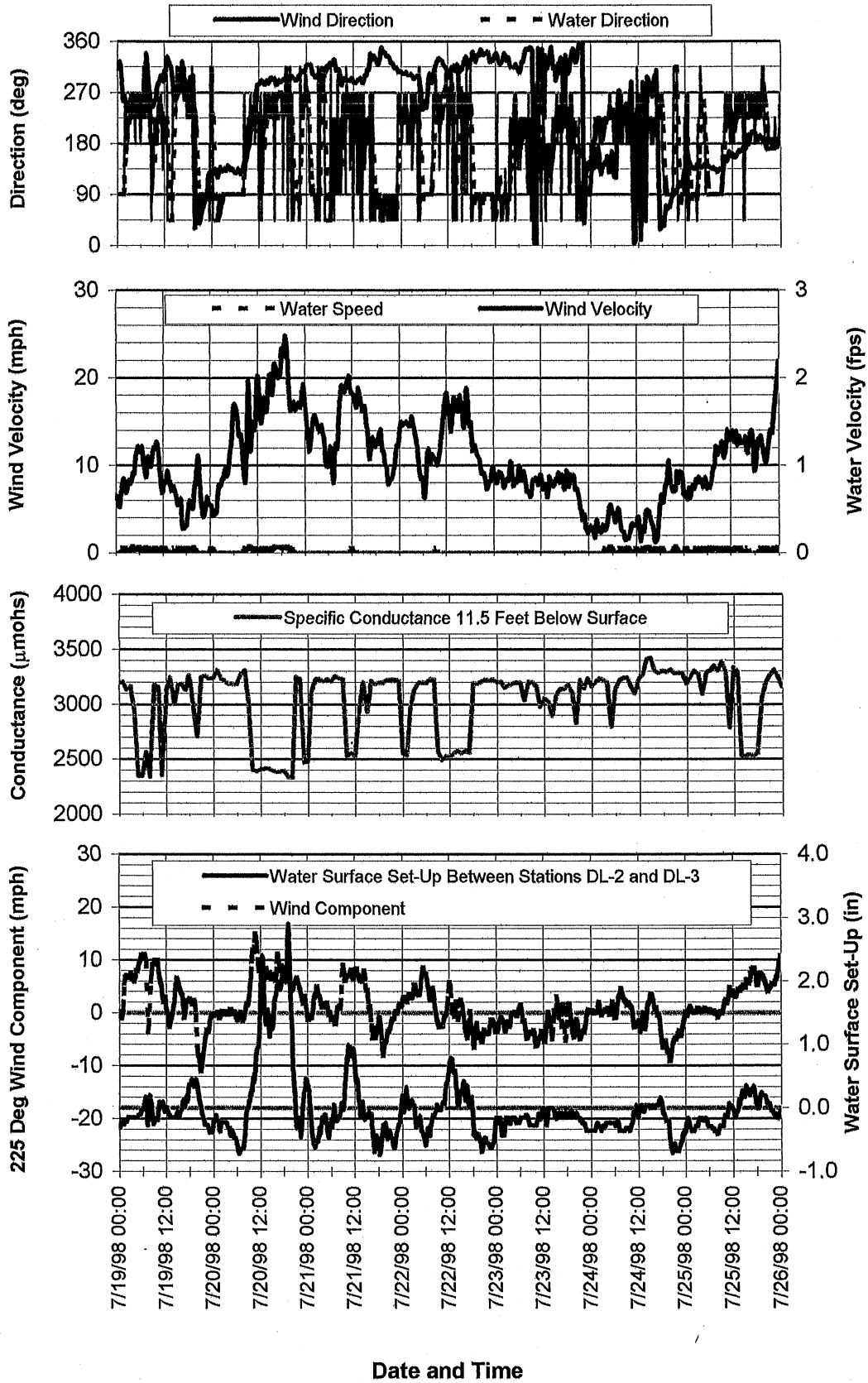
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



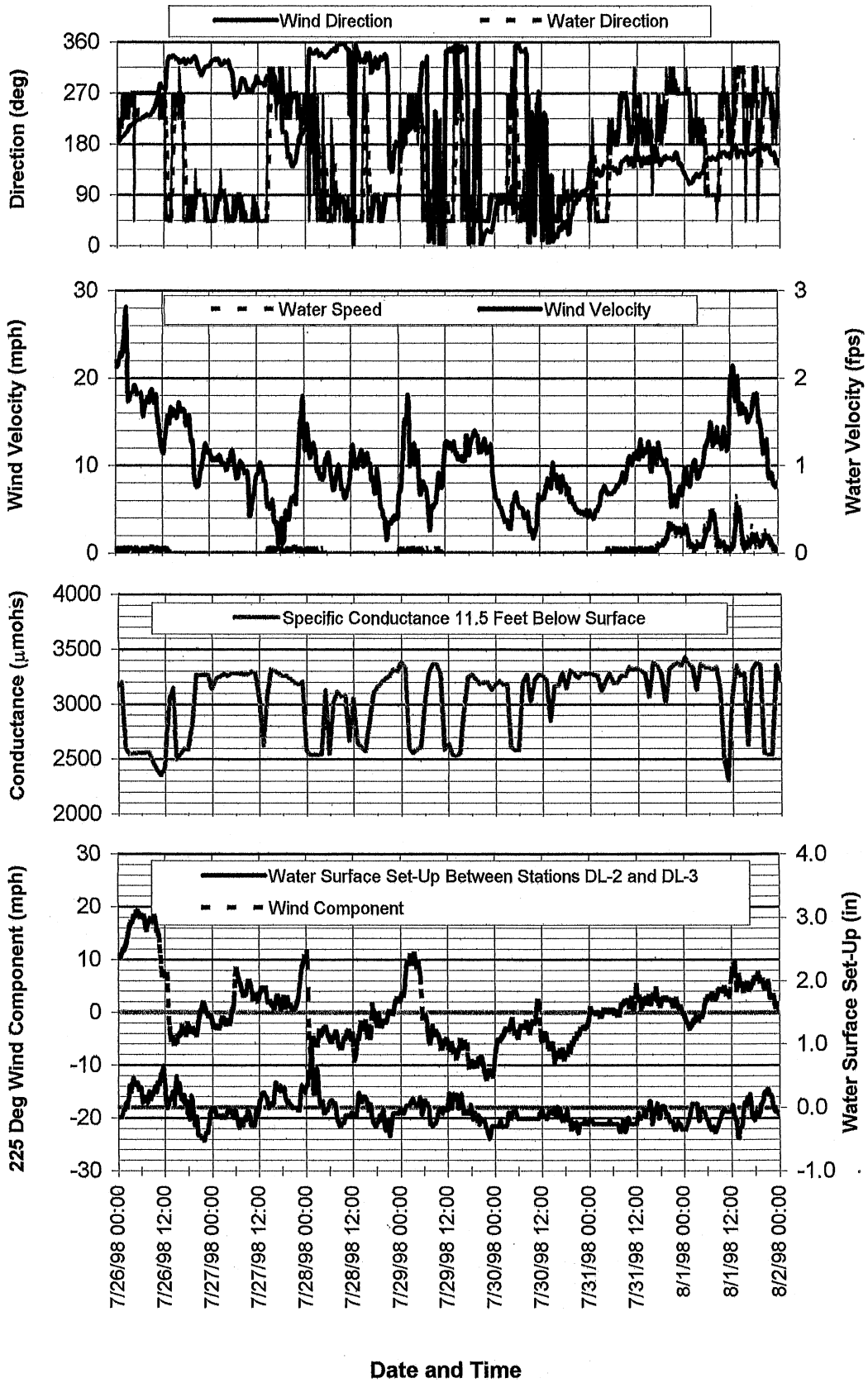
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



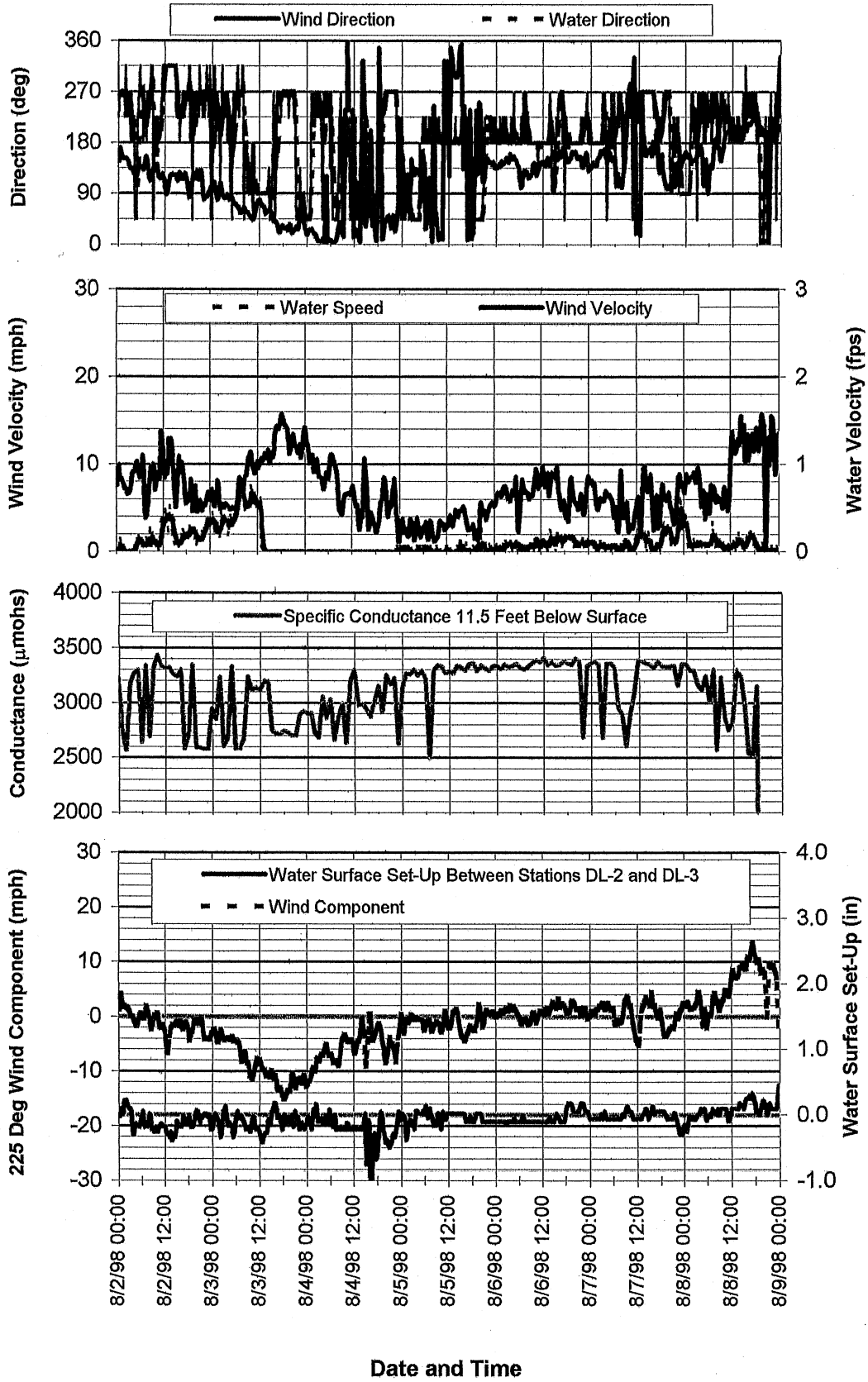
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



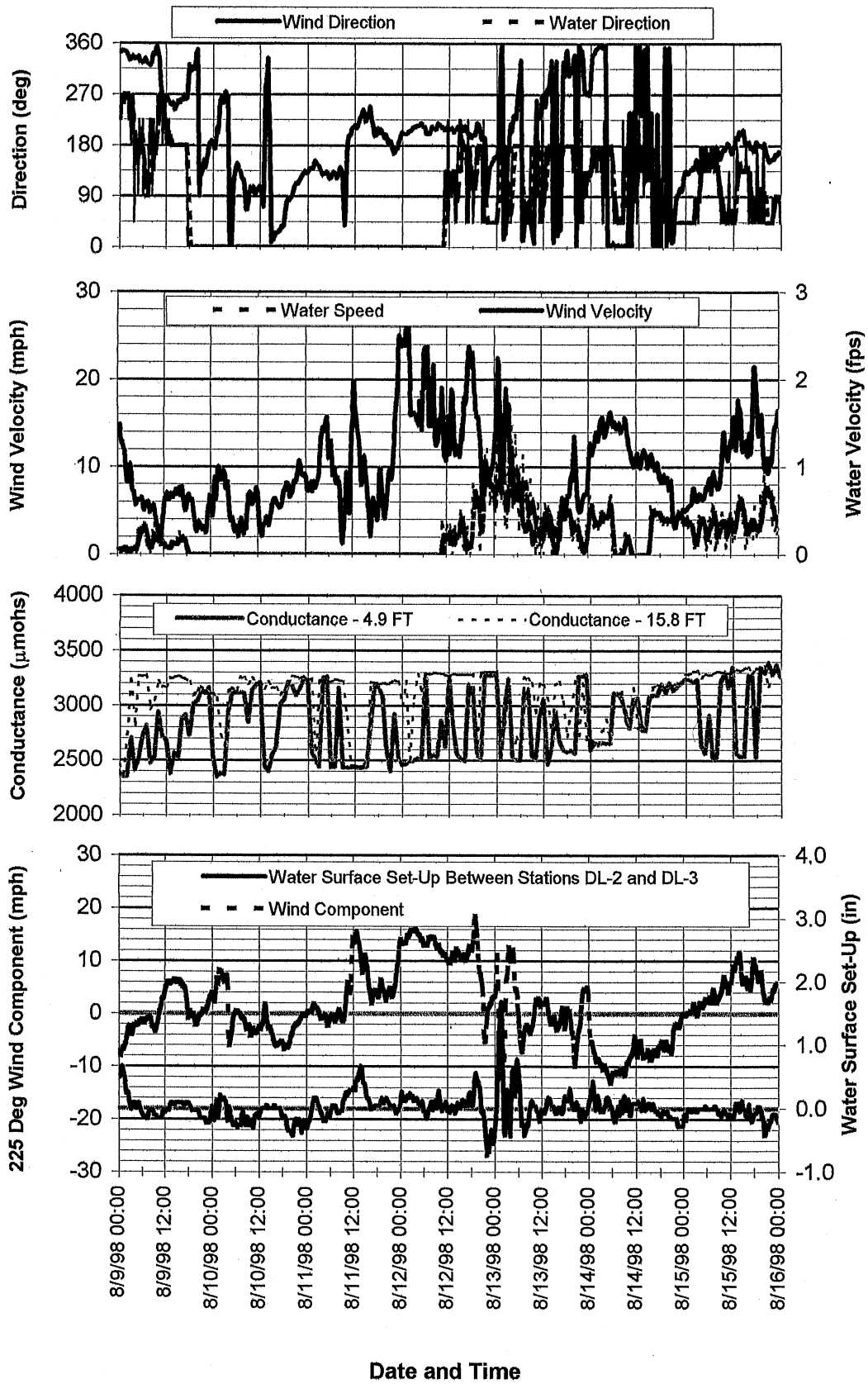
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



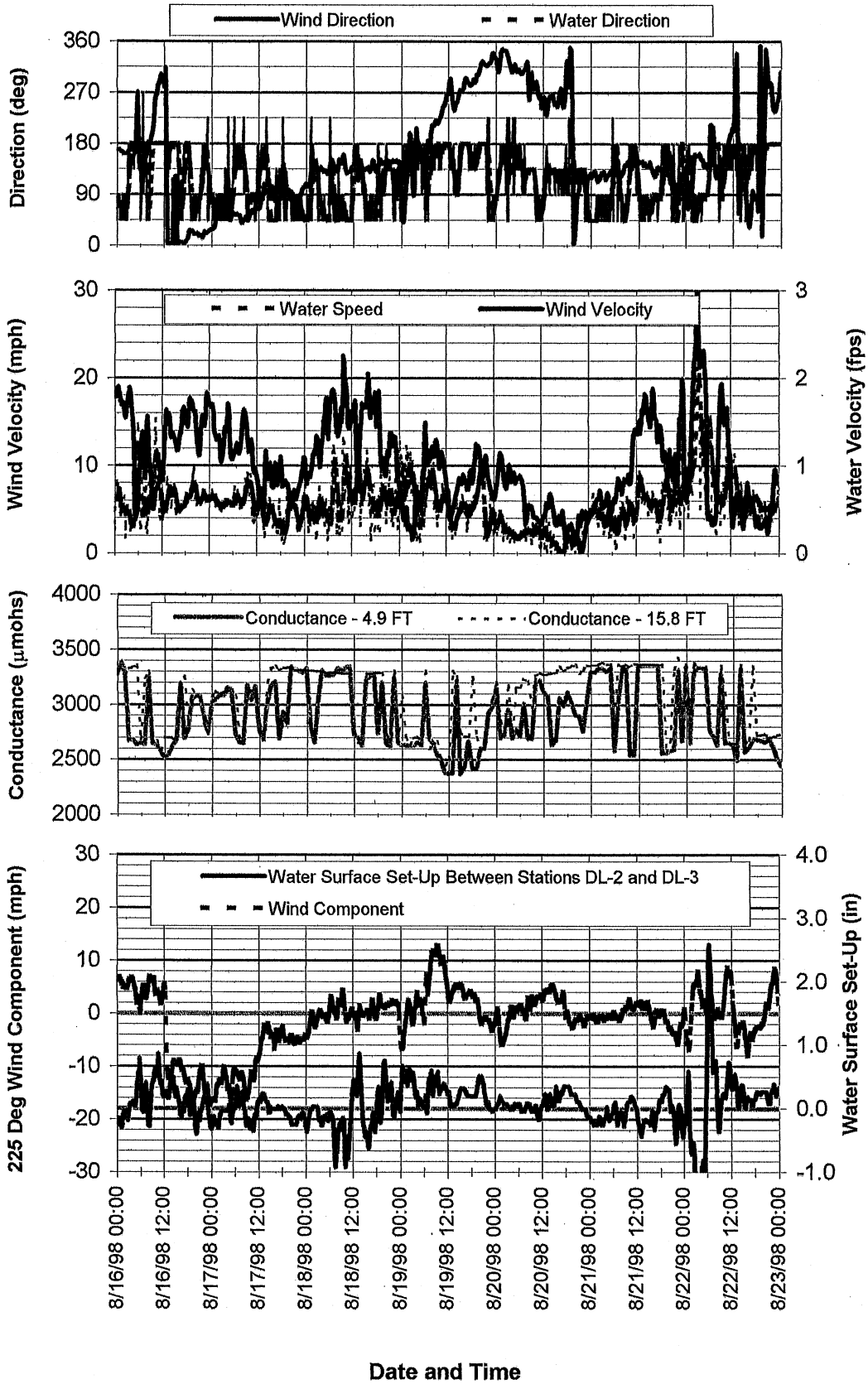
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



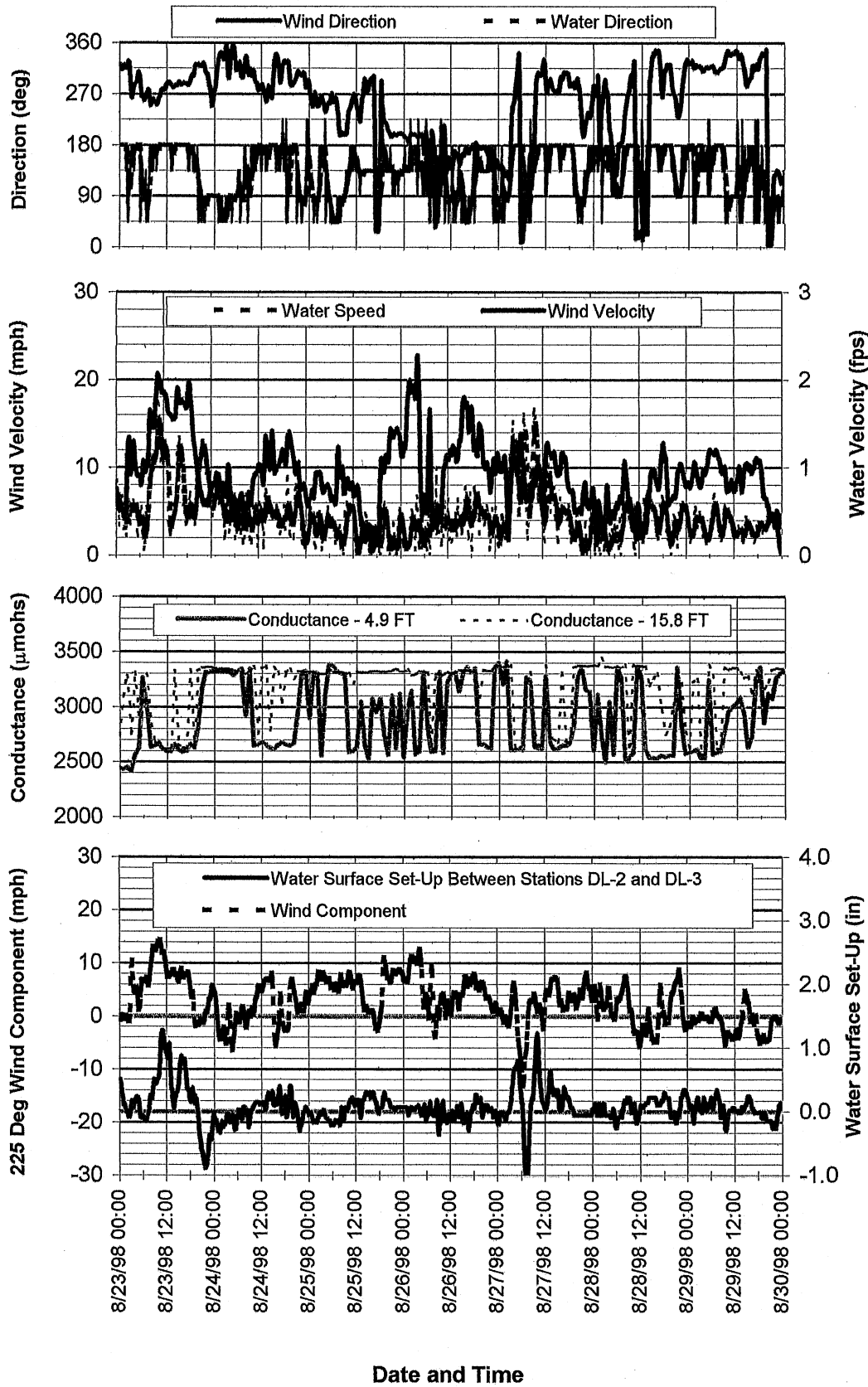
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



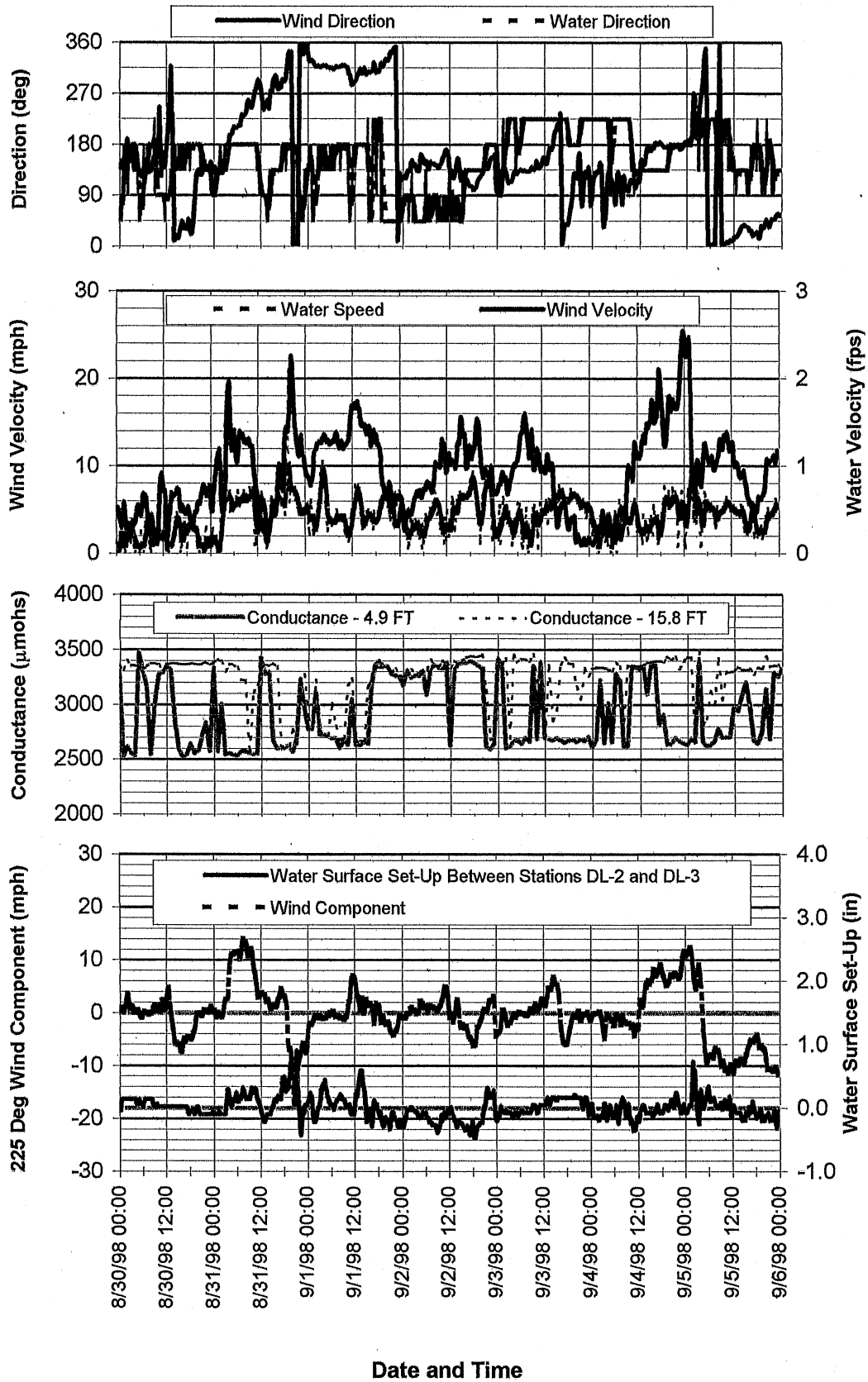
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



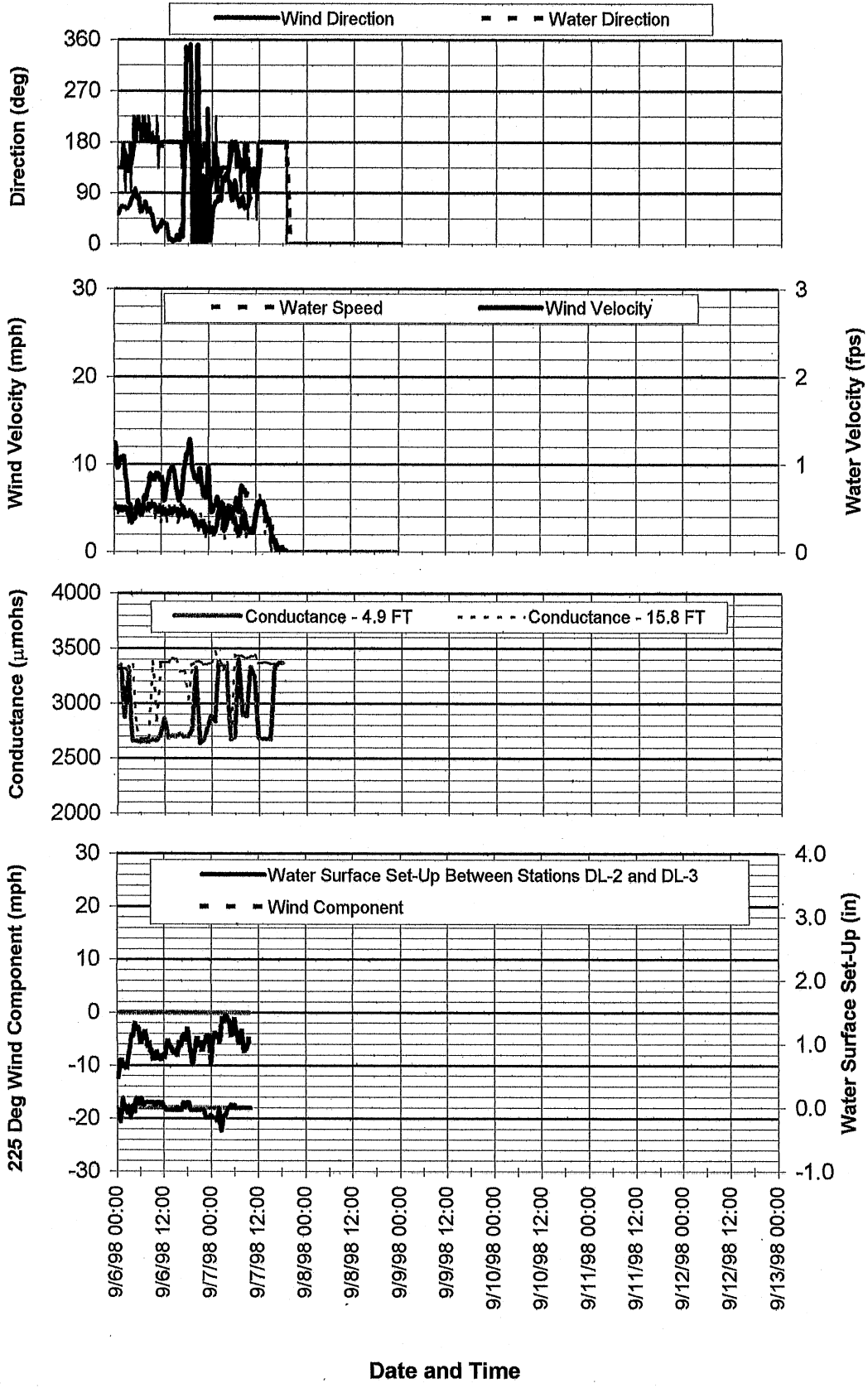
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



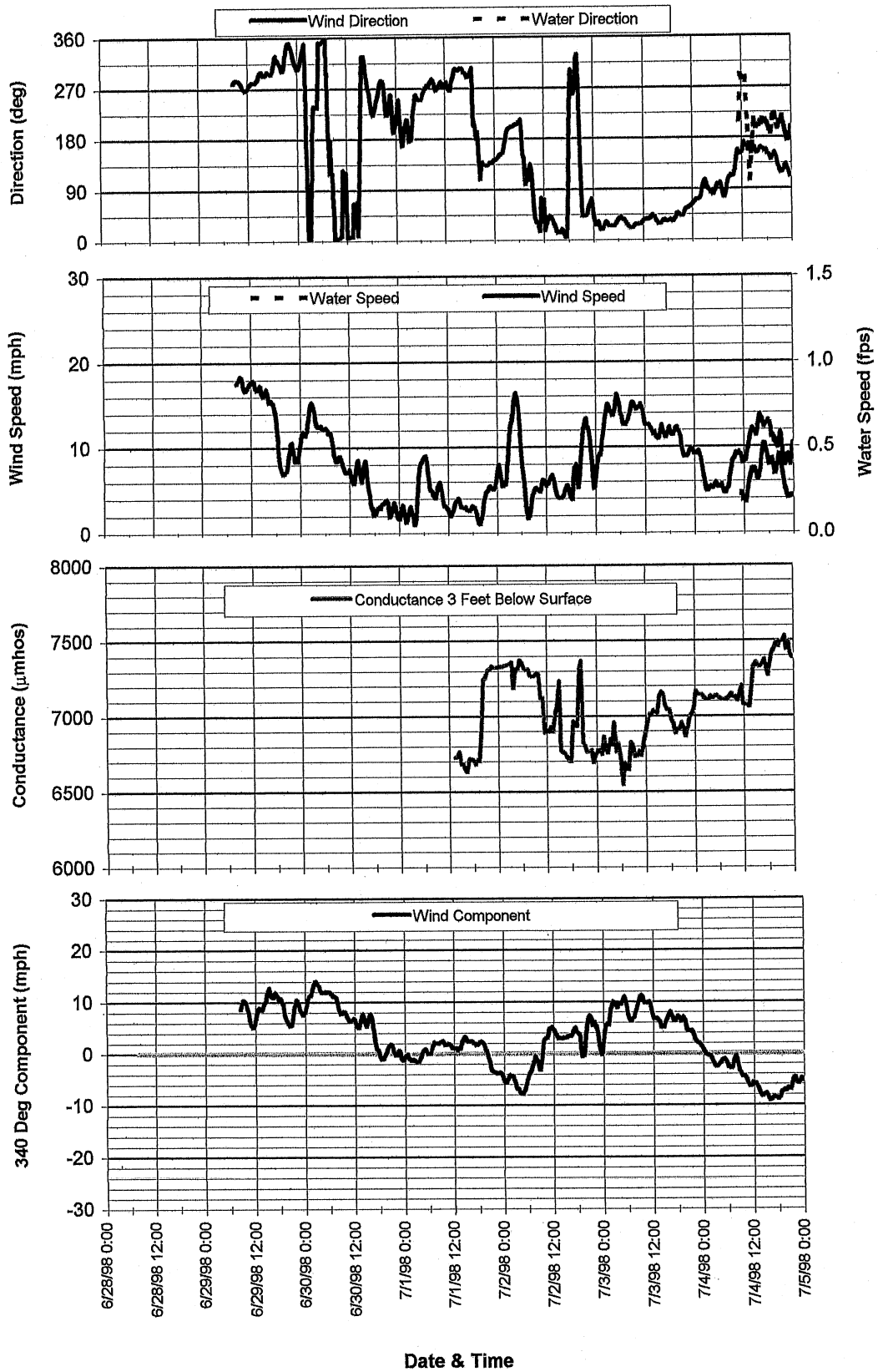
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



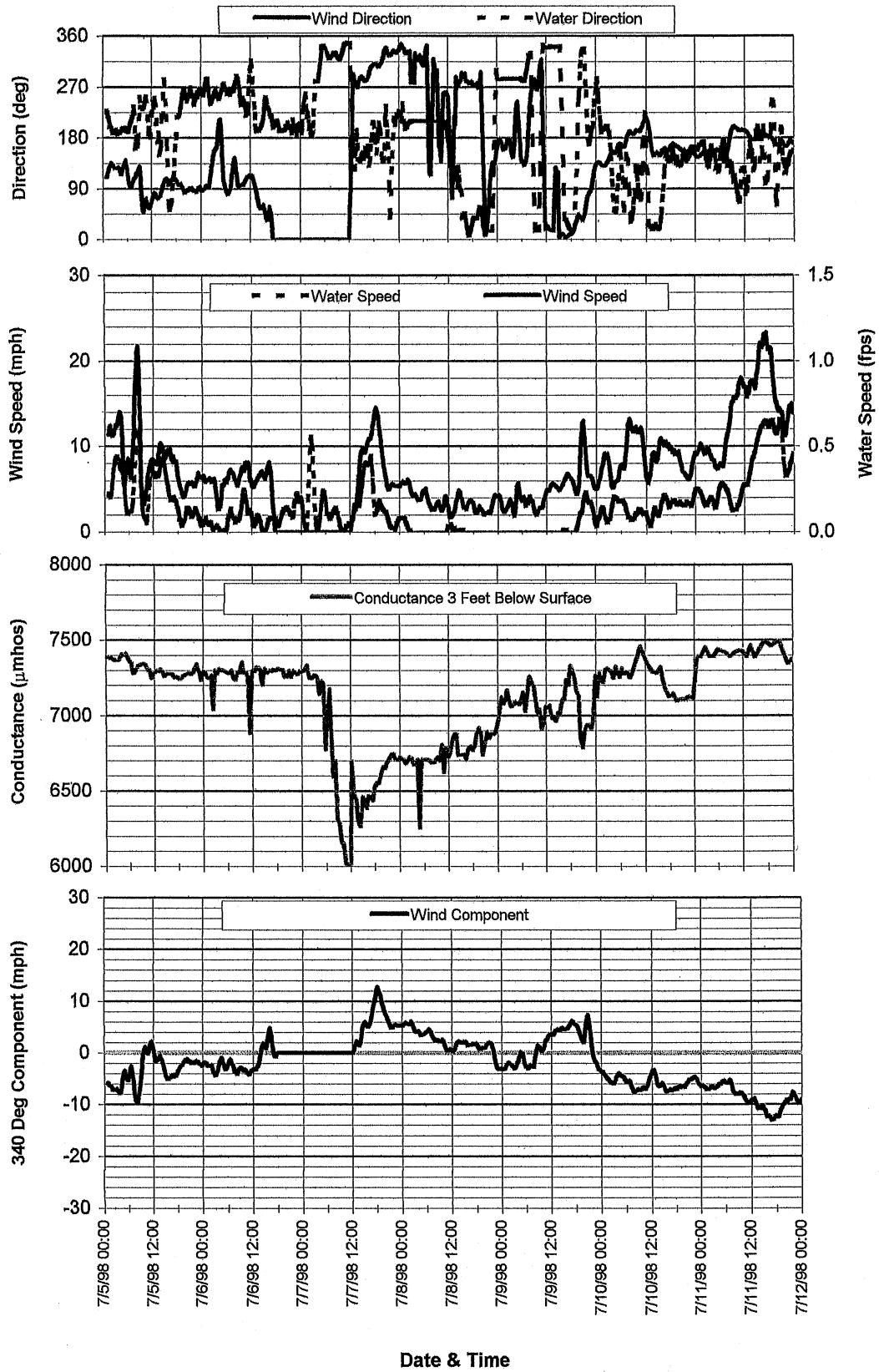
Main Bay and East Bay Exchange Zone Measurements (Sta DL4)



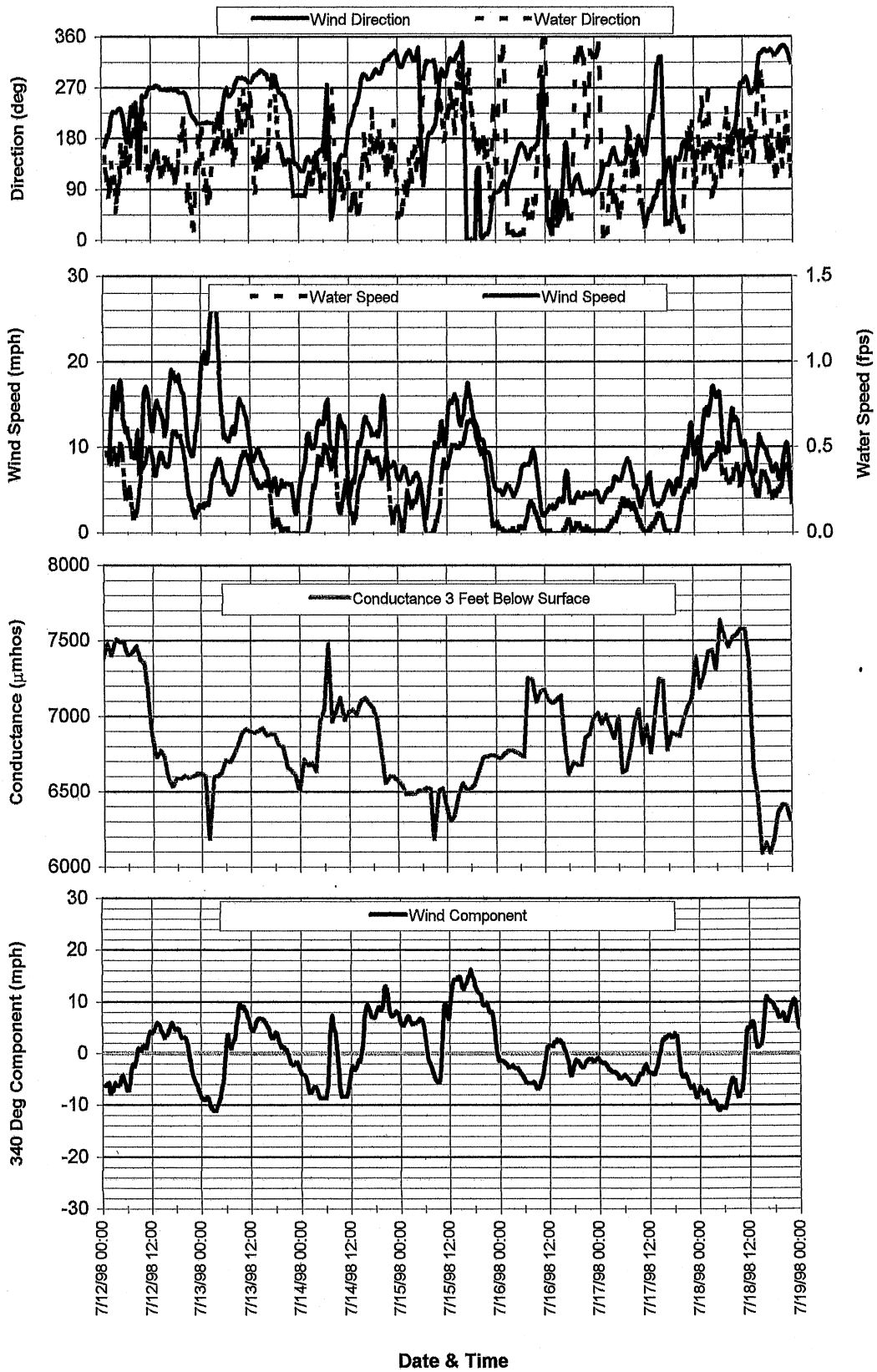
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



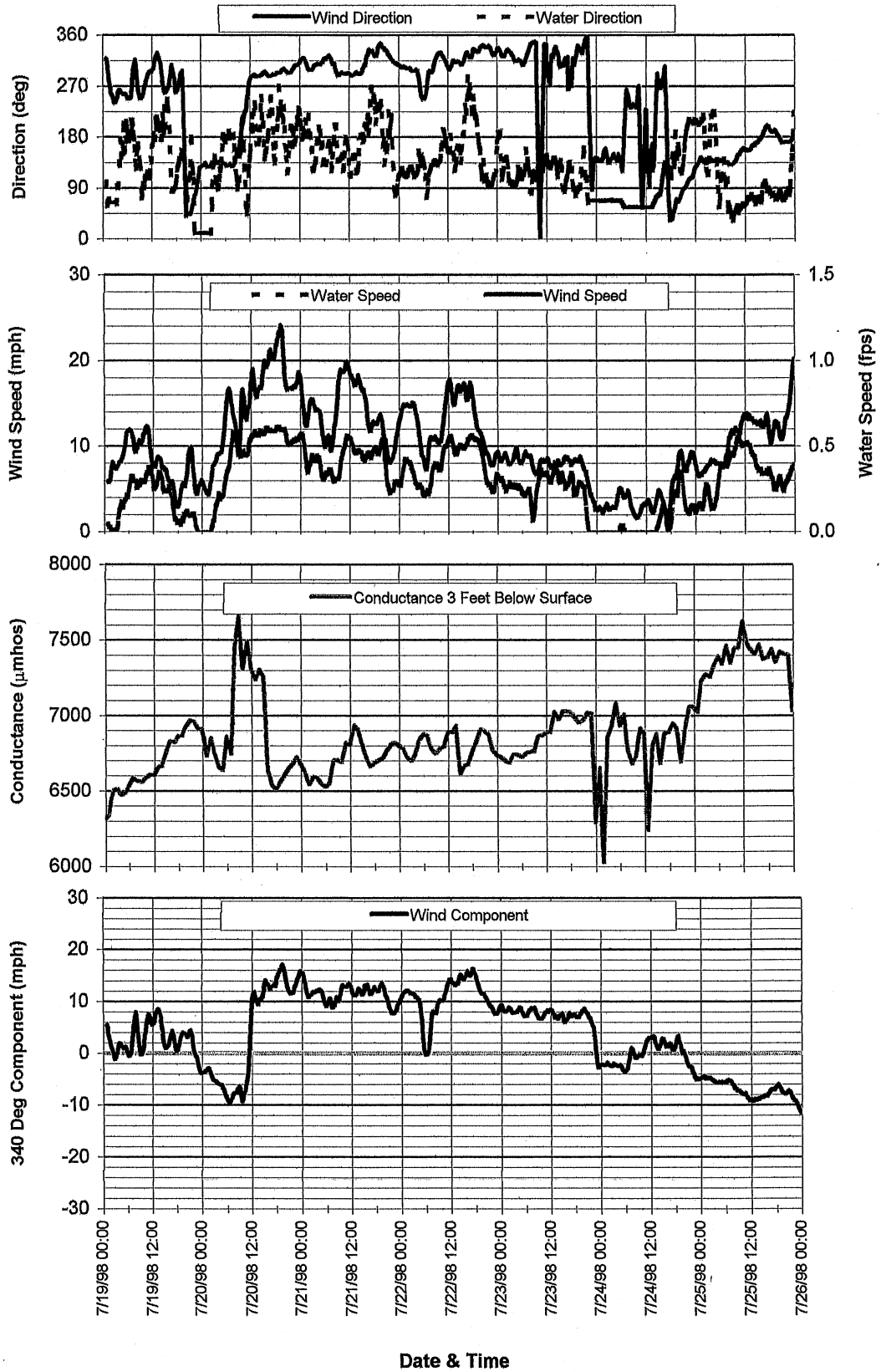
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



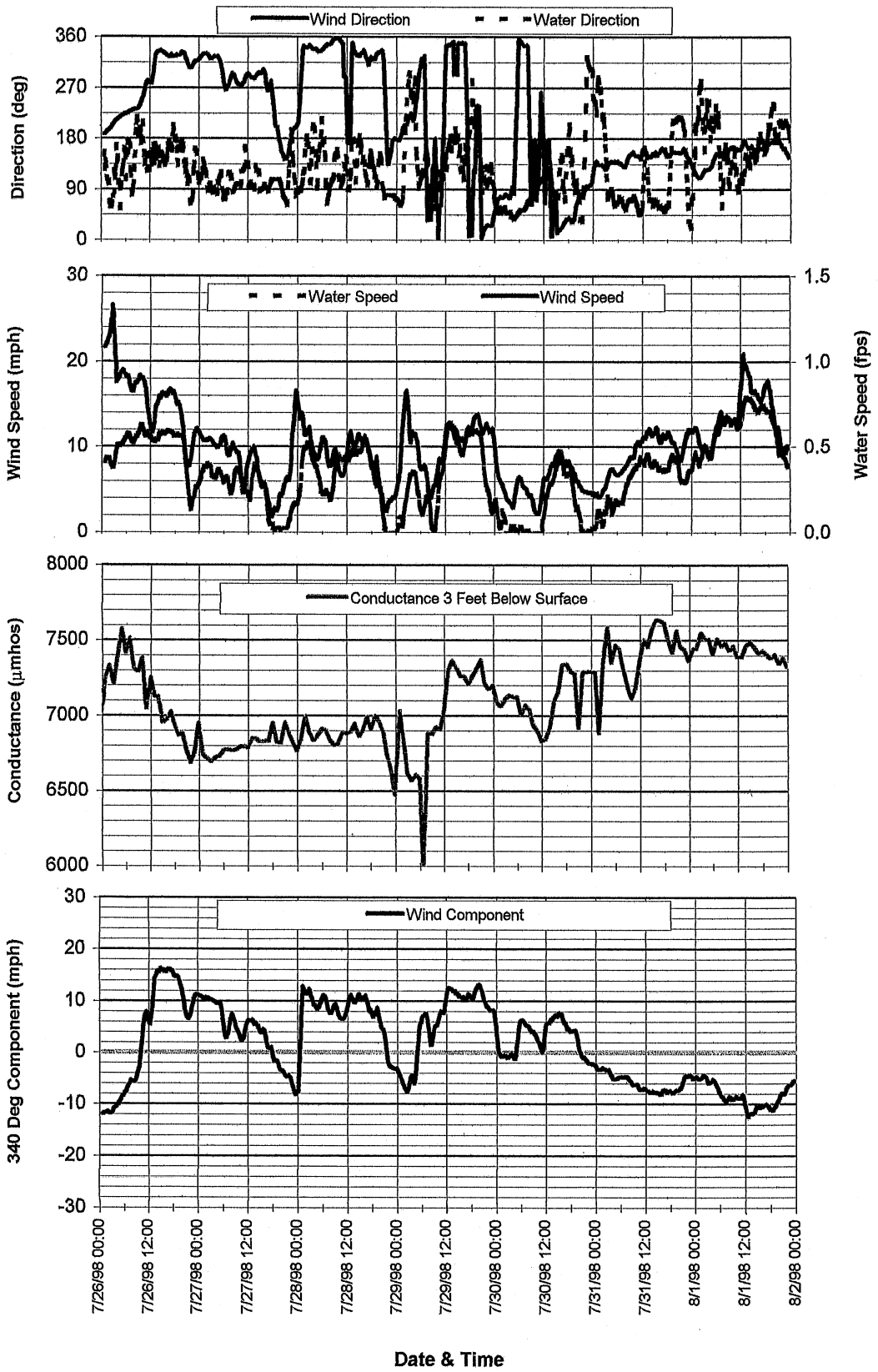
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



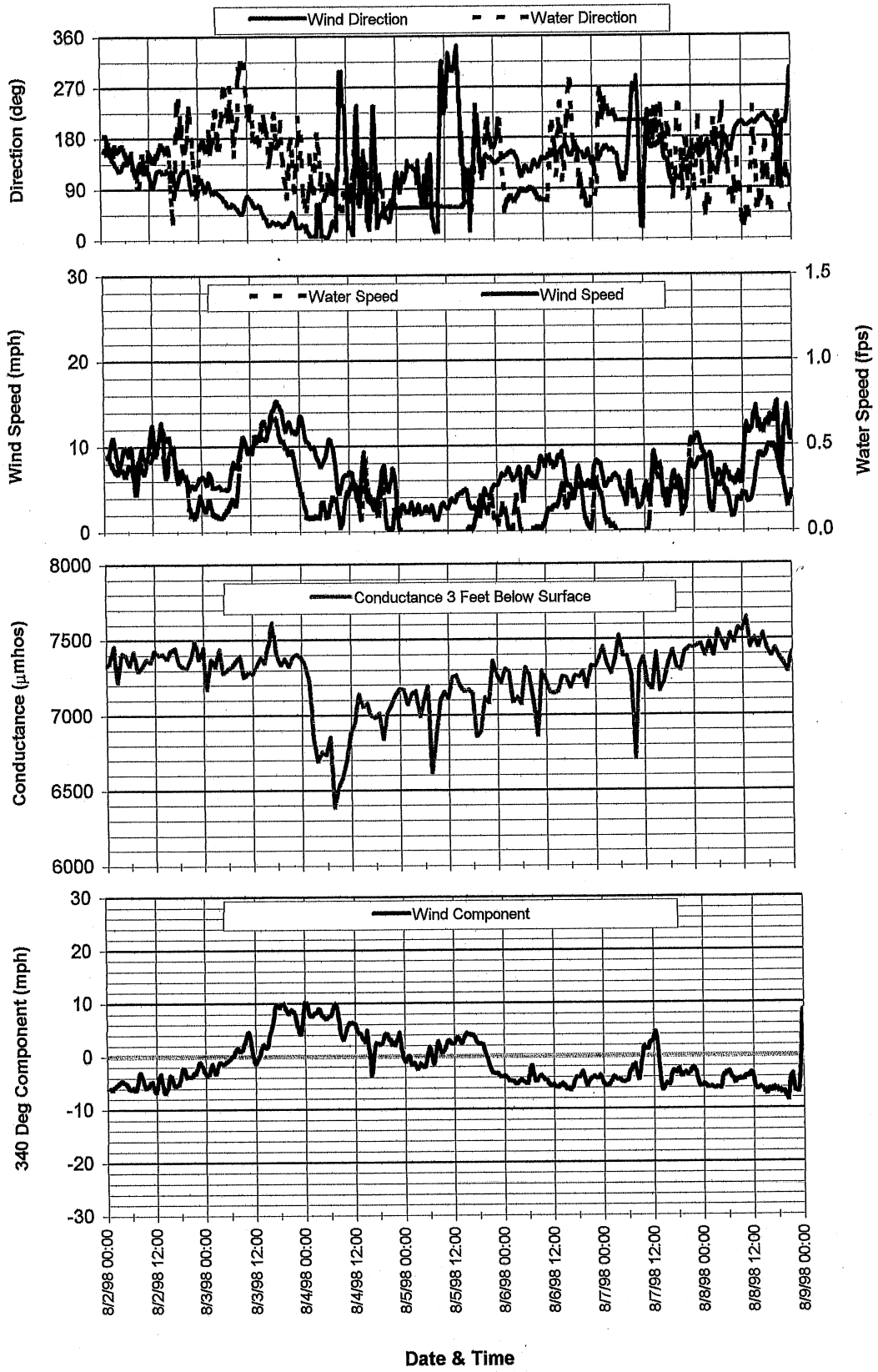
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



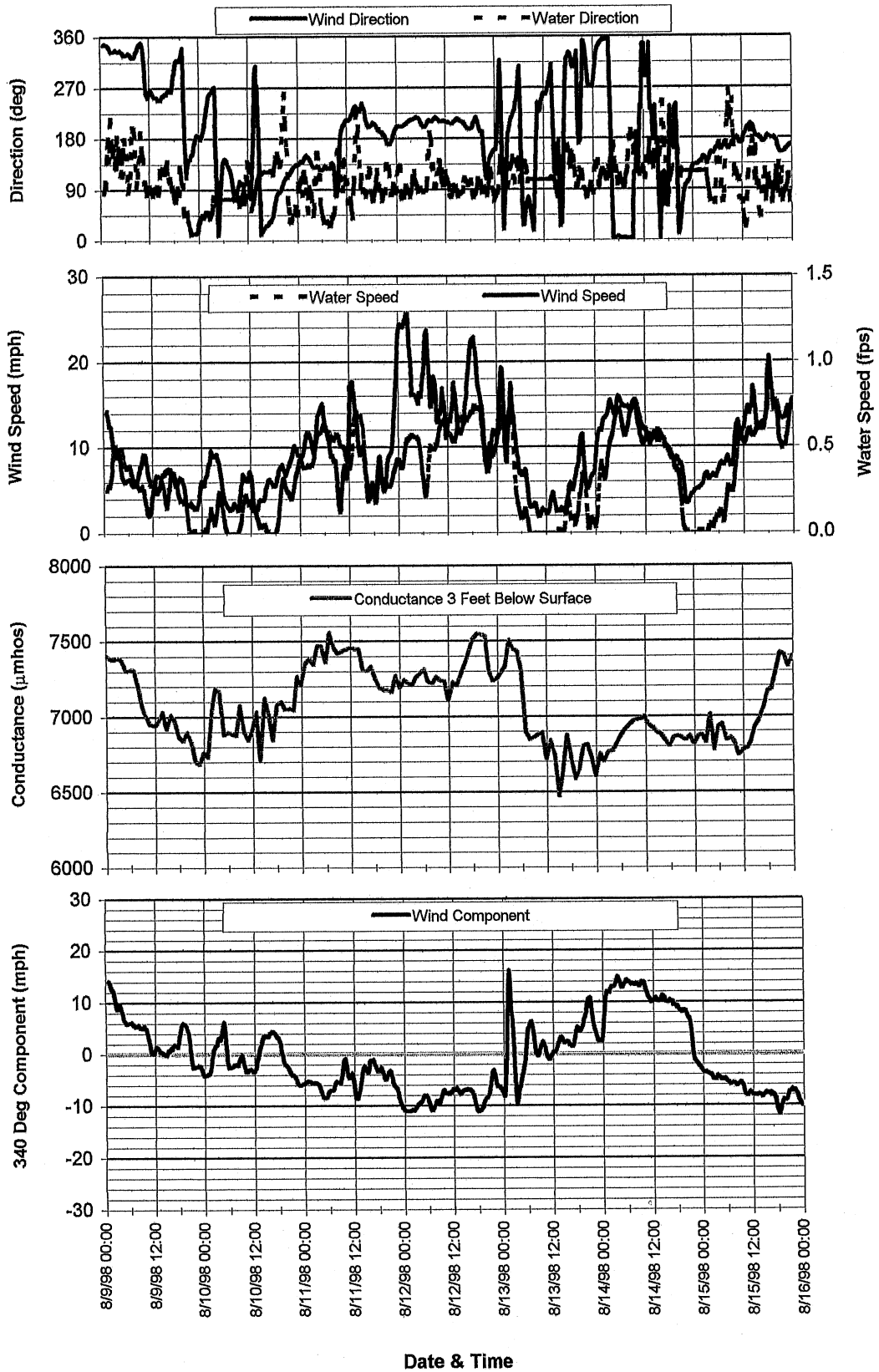
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



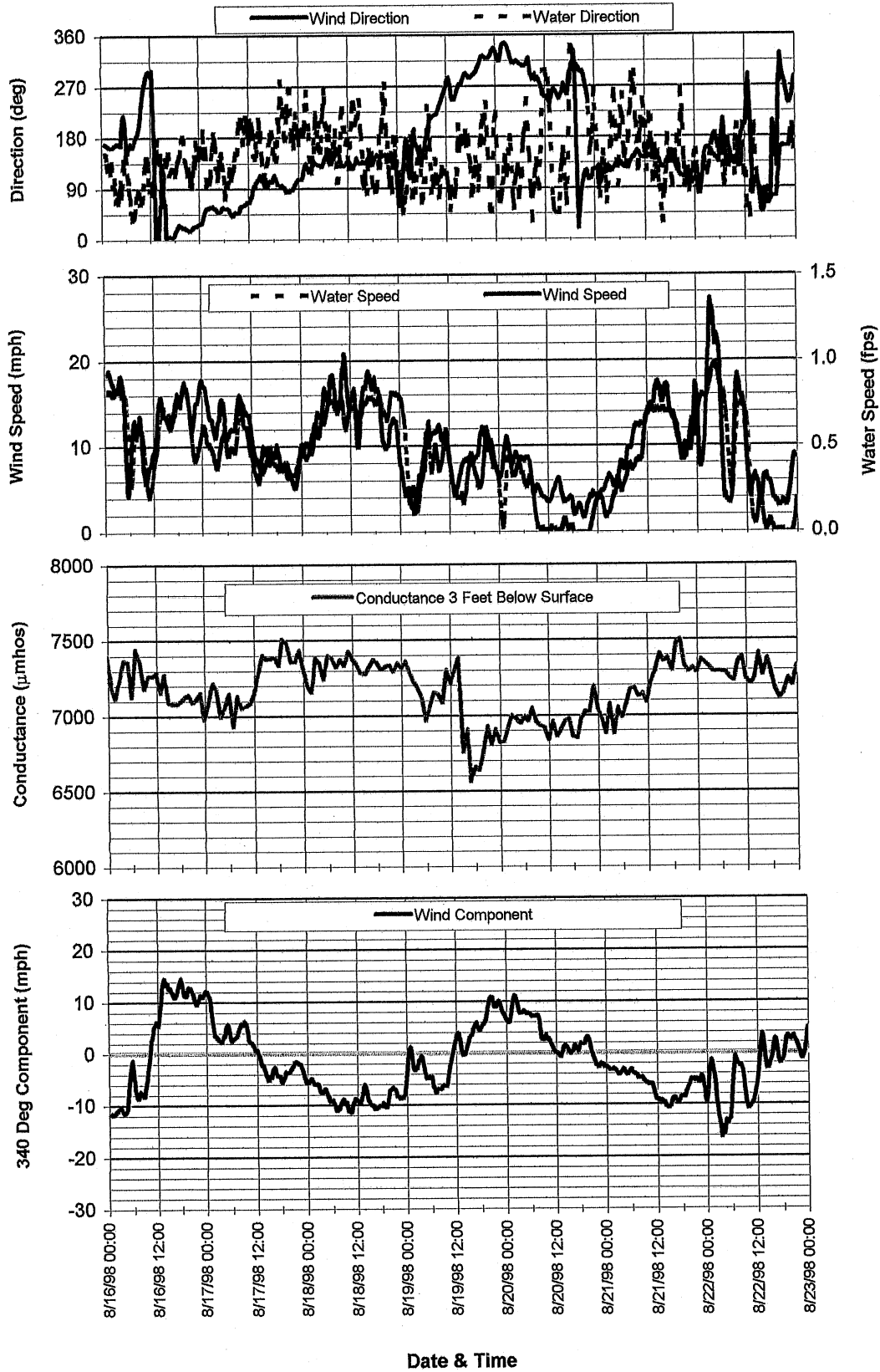
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



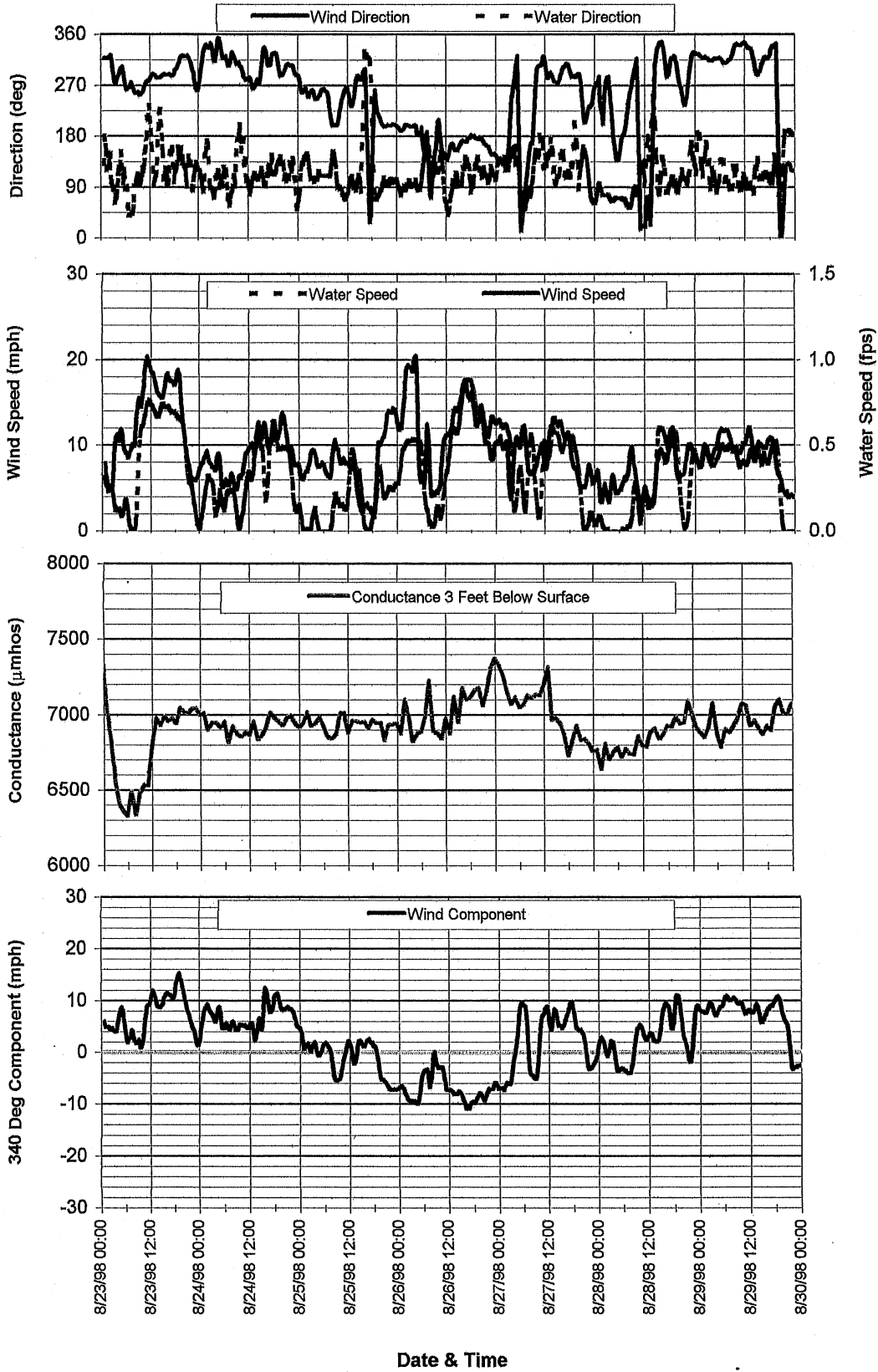
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



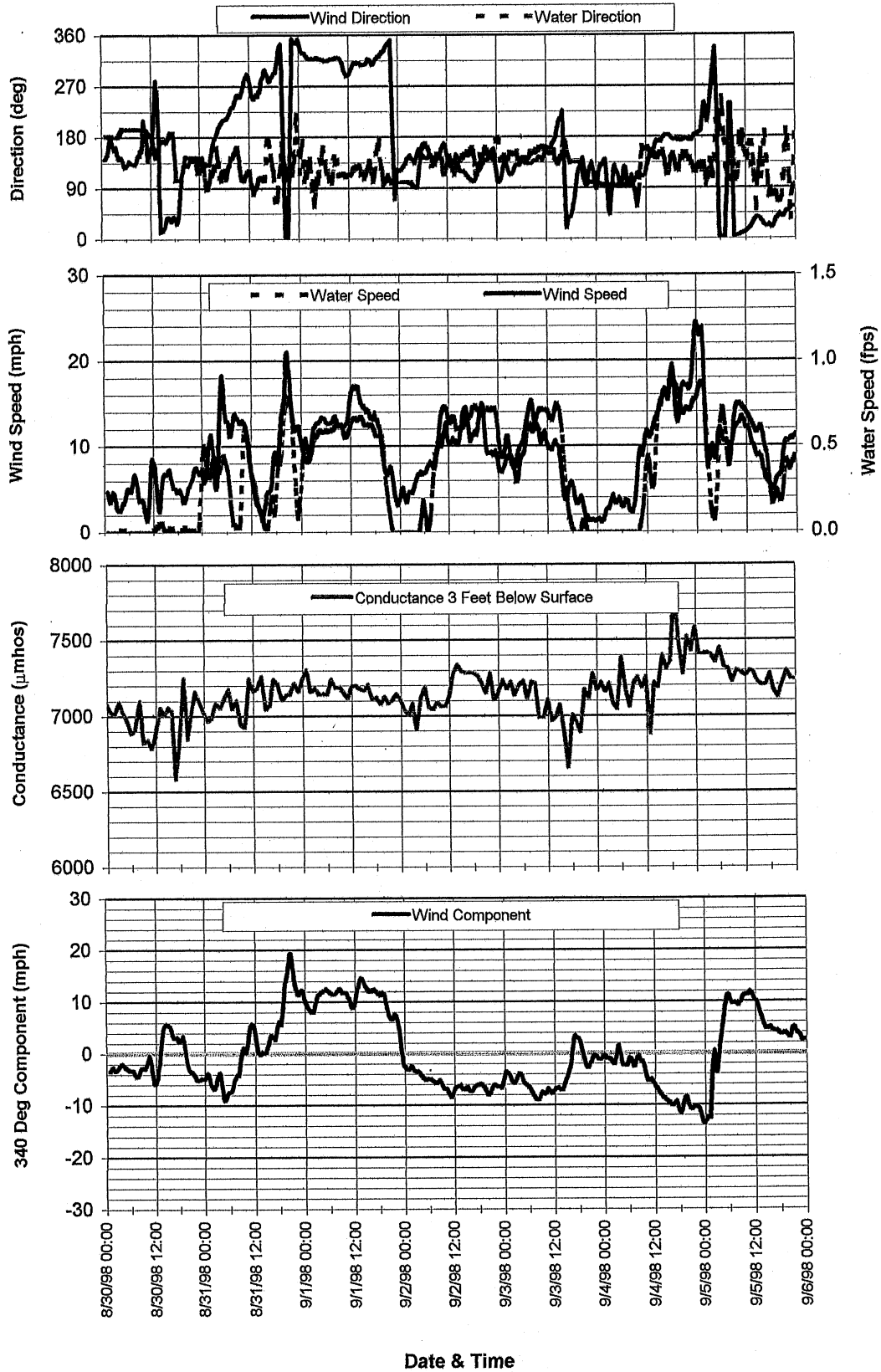
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



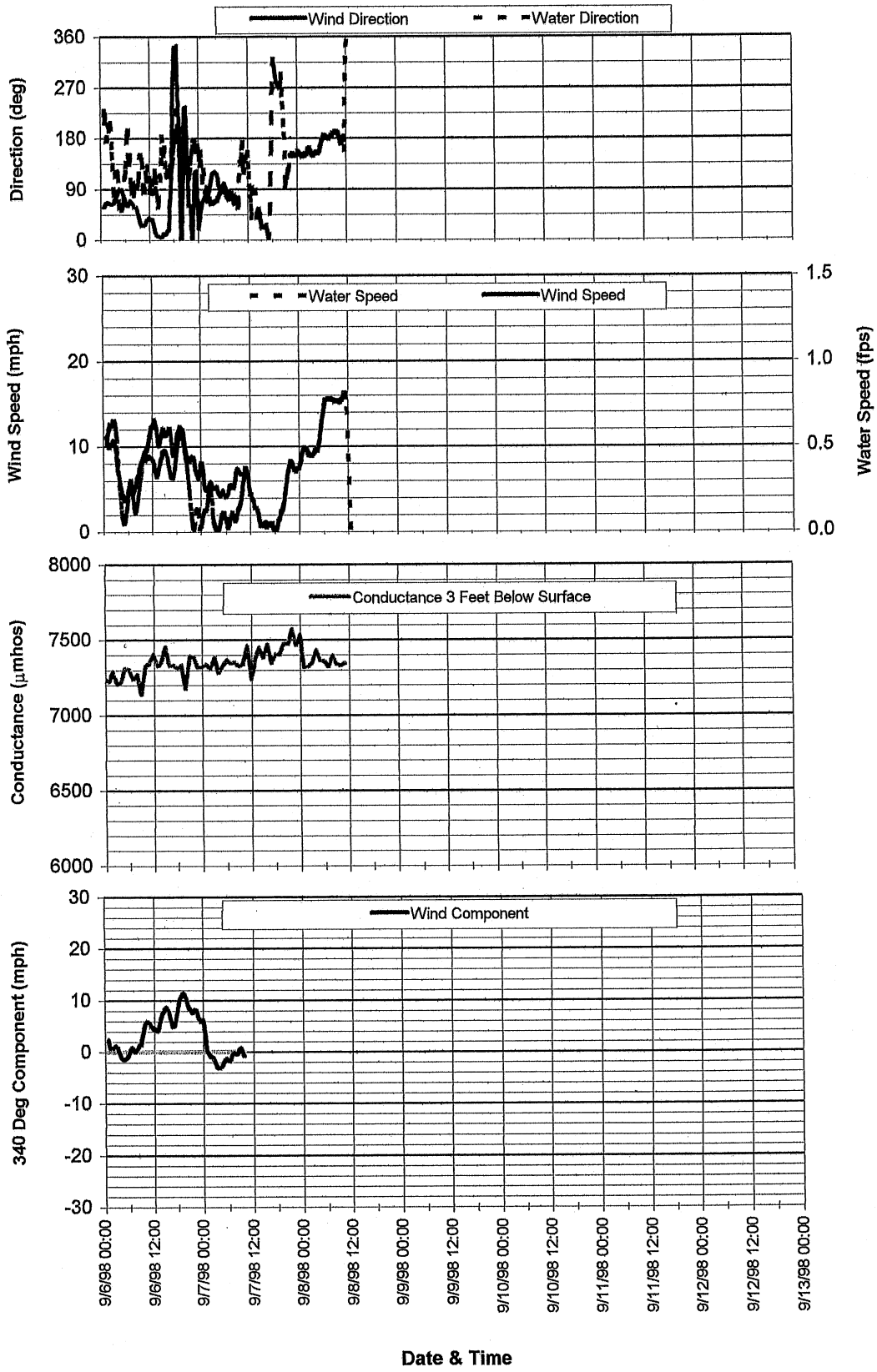
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



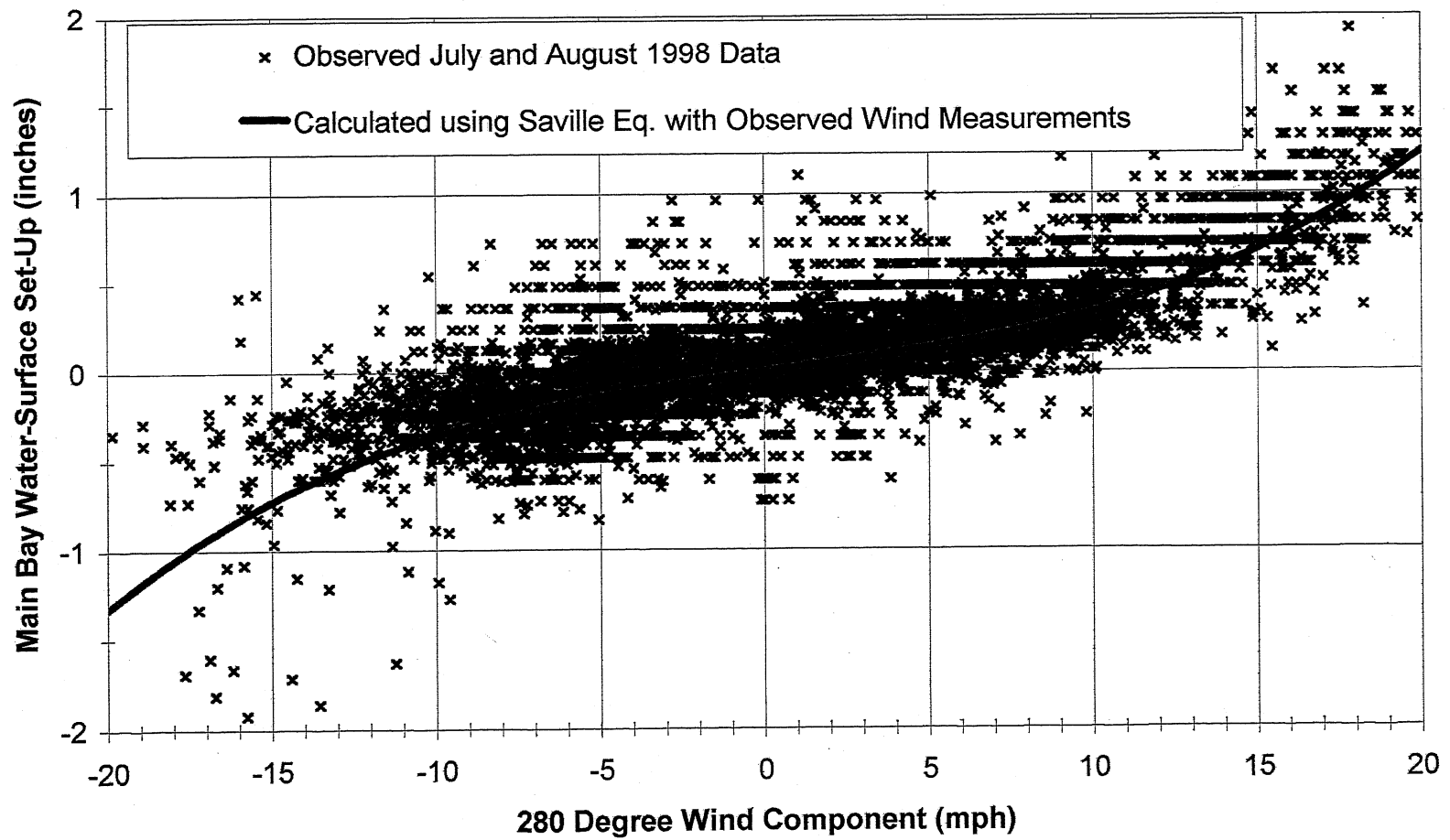
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



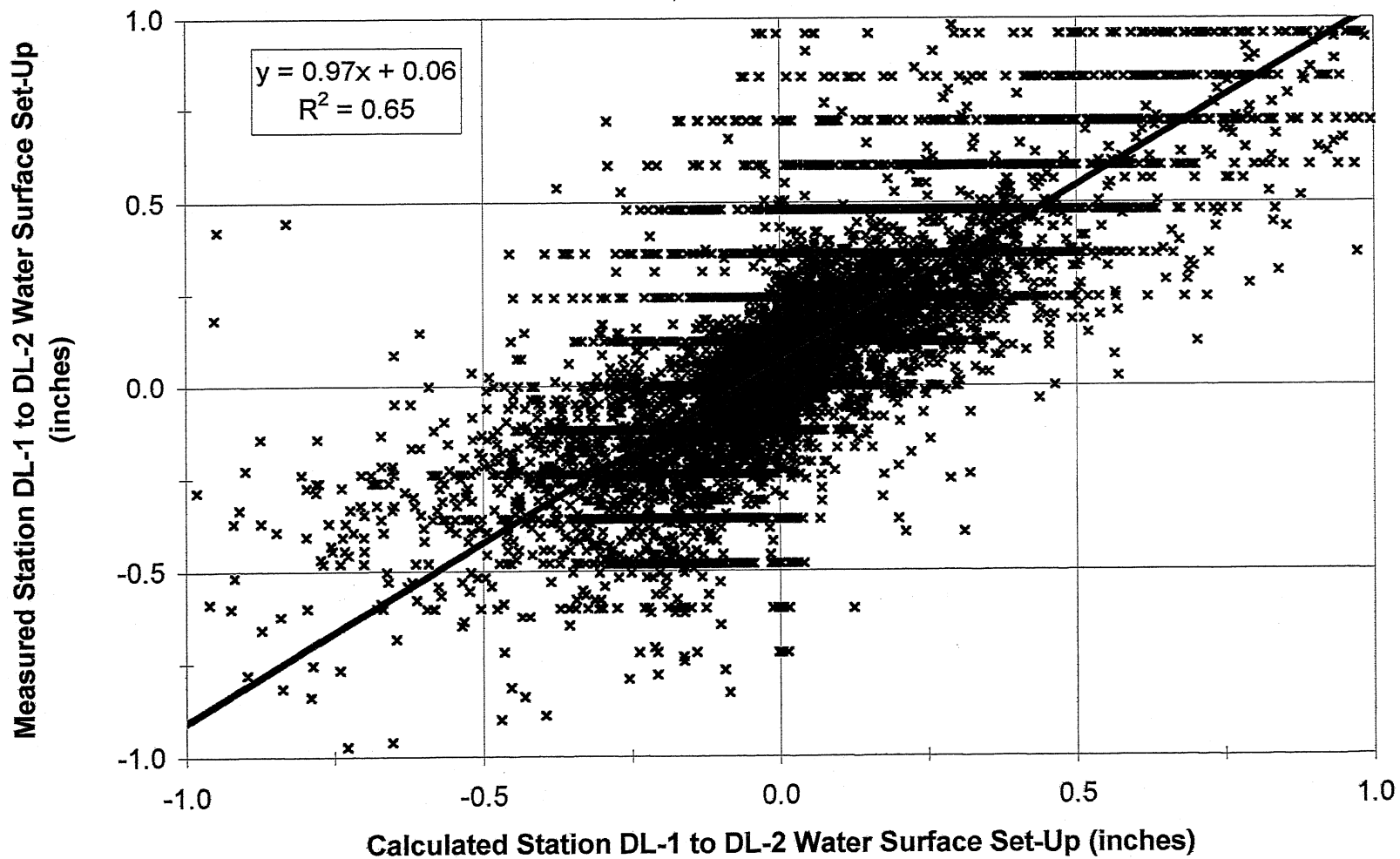
East Bay and East Devils Lake Exchange Zone Measurements (Sta DL5)



Comparison of Measured and Calculated Water-Surface Set-up Across Main Bay
with the Measured Wind Component



Comparison of Measured versus Calculated Water-Surface Set-up Across Main Bay



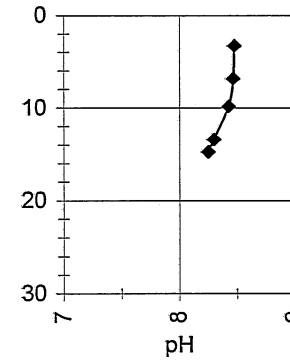
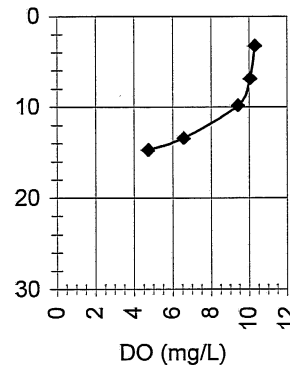
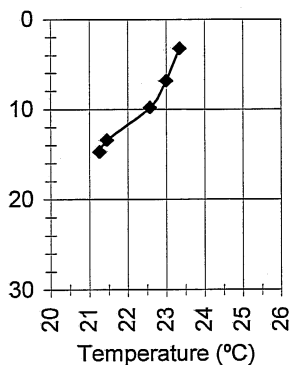
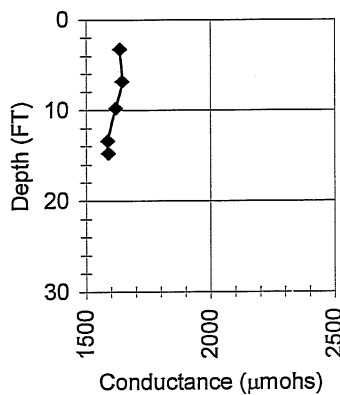
Devils Lake Temporal Profiles - Summer 1998

Location: A11
Bottom Depth (FT): 16.4

Northing: 490299
Easting: 5325614

Station: 04+53
Offset: 250R

Date: 7/9/98
Time: 1058



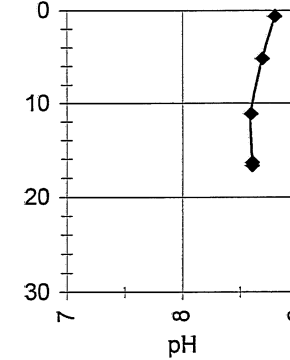
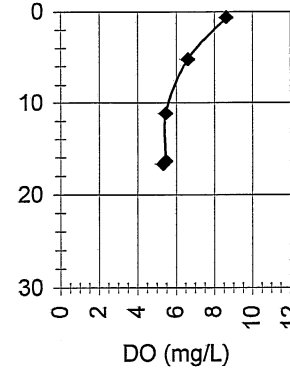
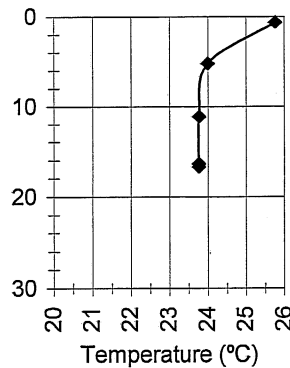
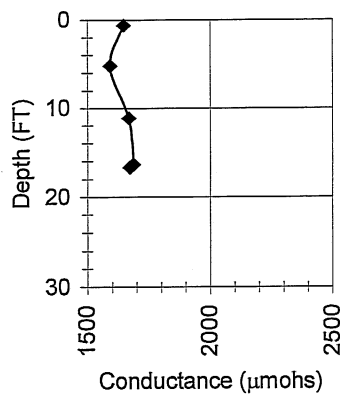
1 - 8

Location: 305
Bottom Depth (FT): 16.4

Northing: 490309
Easting: 5325596

Station: 04+50
Offset: 200L

Date: 8/13/98
Time: 1856



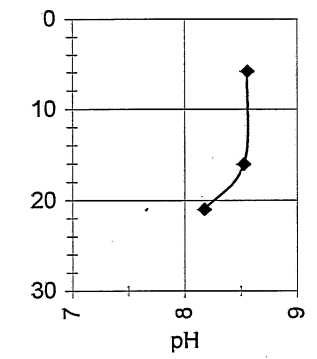
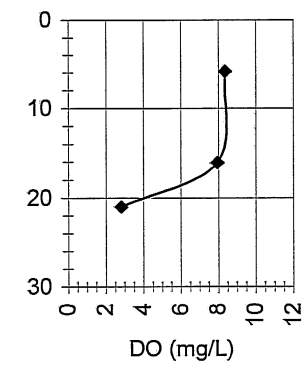
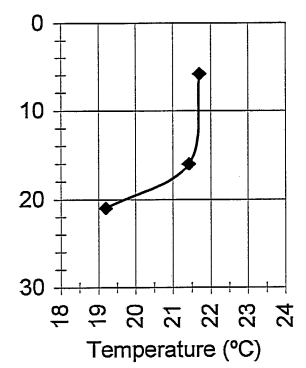
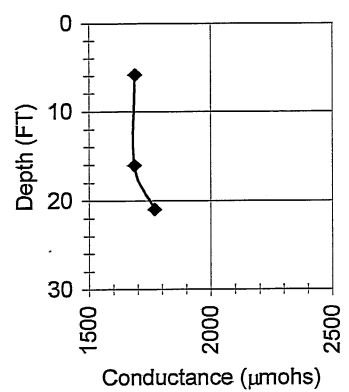
Devils Lake Temporal Profiles - Summer 1998

Location: A6
Bottom Depth (FT): 25.3

Northing: 490496
Easting: 5319554

Station: 12+23
Offset: 60R

Date: 7/8/98
Time: 1453



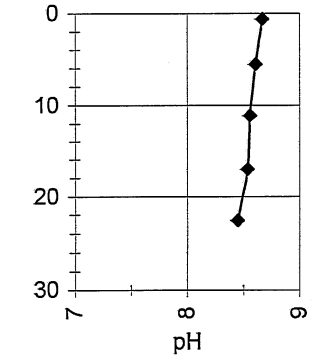
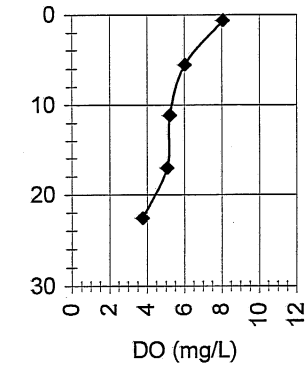
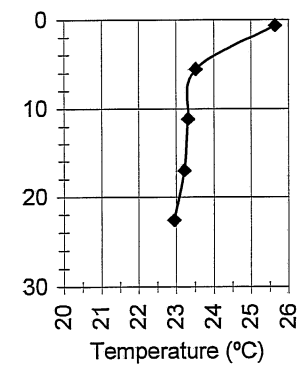
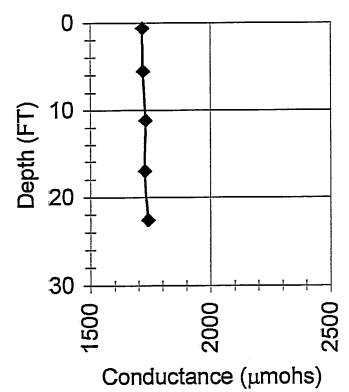
Z-8

Location: 303
Bottom Depth (FT): 25.3

Northing: 490487
Easting: 5319556

Station: 12+23
Offset: 50R

Date: 8/13/98
Time: 1835



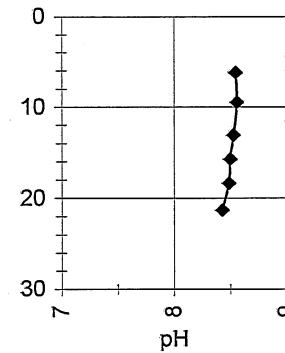
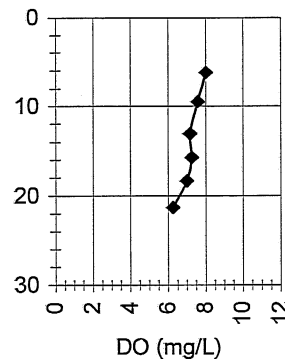
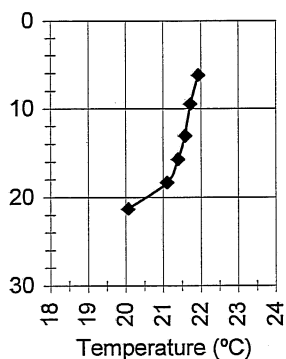
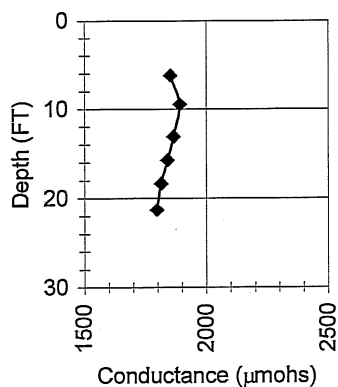
Devils Lake Temporal Profiles - Summer 1998

Location: A2
Bottom Depth (FT): 26.9

Northing: 496464
Easting: 5320265

Station: 18+97
Offset: 150R

Date: 7/8/98
Time: 1421



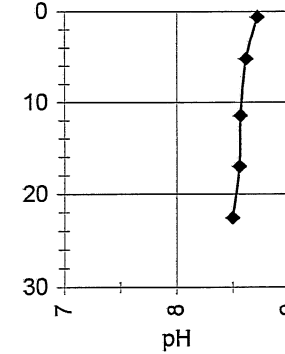
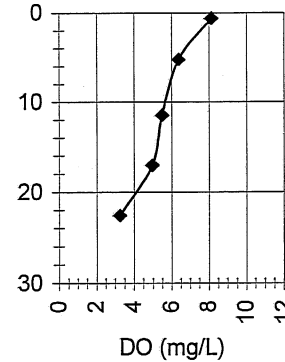
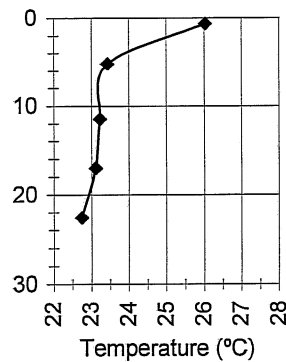
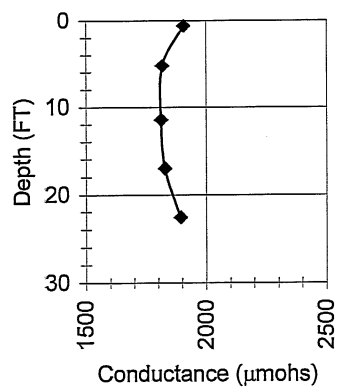
3-8

Location: 300
Bottom Depth (FT): 27

Northing: 496462
Easting: 5320265

Station: 19+00
Offset: 110R

Date: 8/13/98
Time: 1813



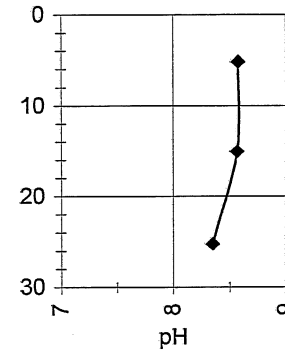
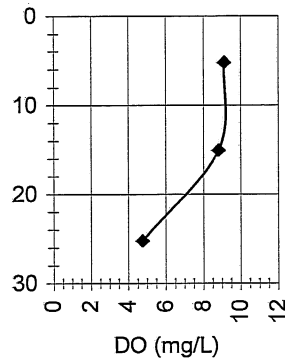
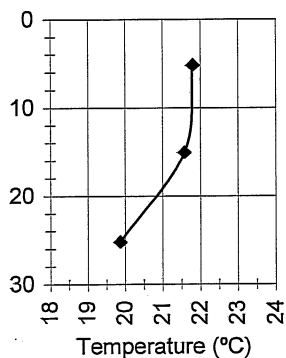
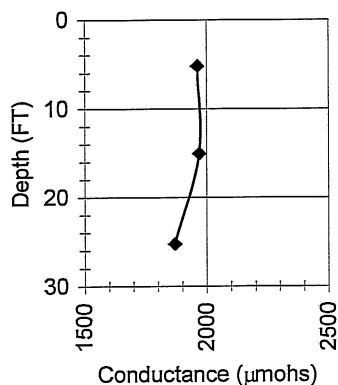
Devils Lake Temporal Profiles - Summer 1998

Location: A1
Bottom Depth (FT): 27.6

Northing: 496560
Easting: 5320741

Station: 19+38
Offset: 130L

Date: 7/8/98
Time: 1029



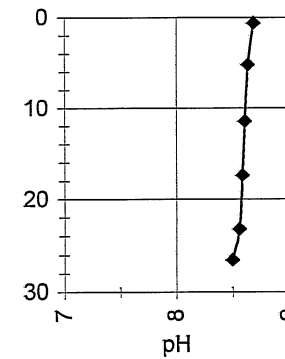
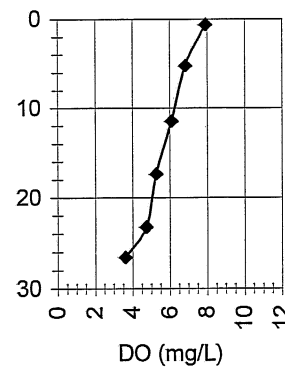
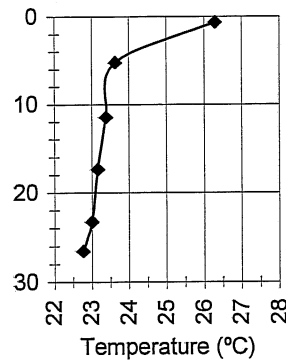
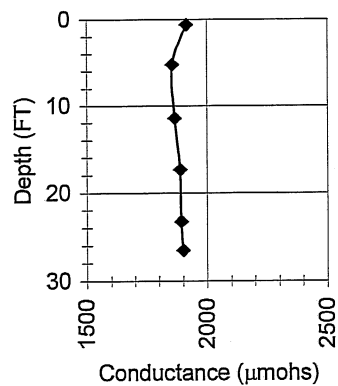
8-4

Location: 290
Bottom Depth (FT): 27

Northing: 496636
Easting: 5320615

Station: 19+35
Offset: 0

Date: 8/13/98
Time: 1631



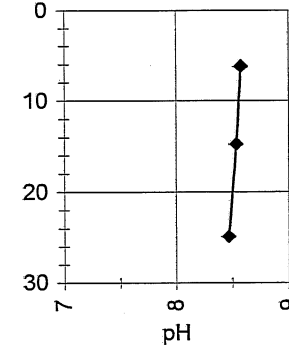
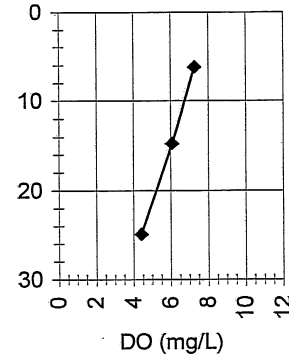
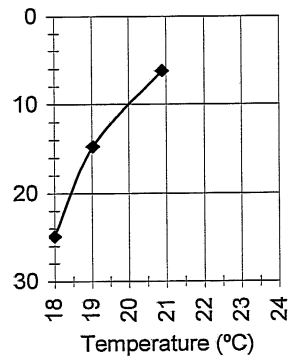
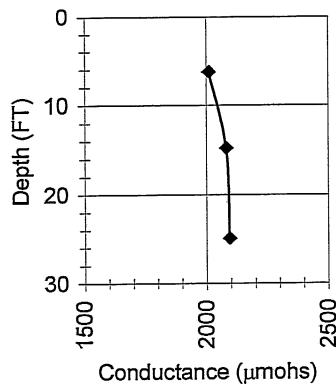
Devils Lake Temporal Profiles - Summer 1998

Location: A18
Bottom Depth (FT): 29.8

Northing: 499995
Easting: 5322464

Station: 22+95
Offset: 1220L

Date: 7/8/98
Time: 1307



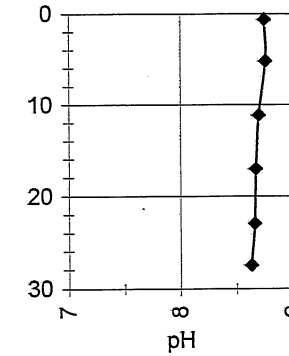
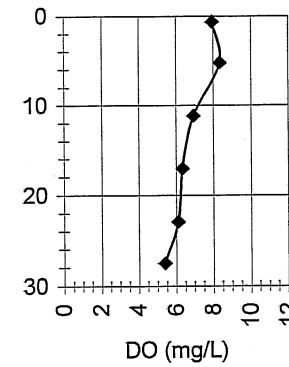
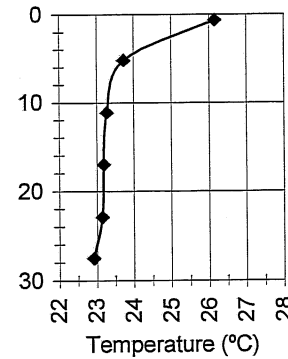
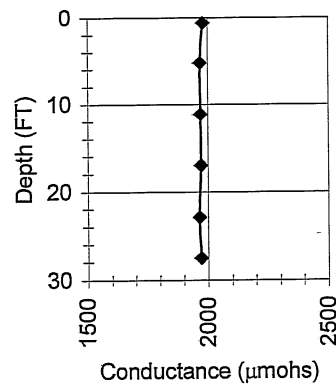
9-8

Location: 294
Bottom Depth (FT): 30

Northing: 500006
Easting: 5321975

Station: 23+08
Offset: 760L

Date: 8/13/98
Time: 1711



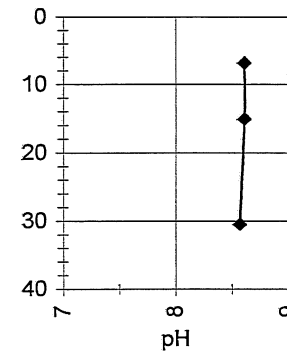
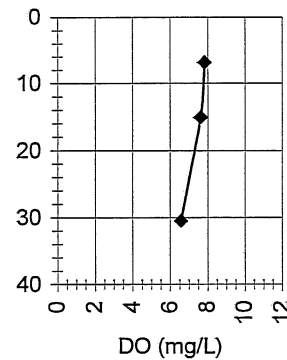
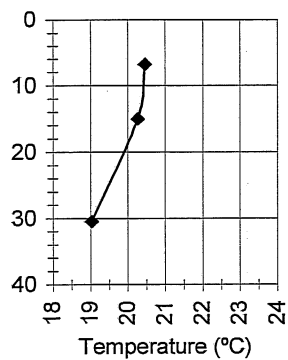
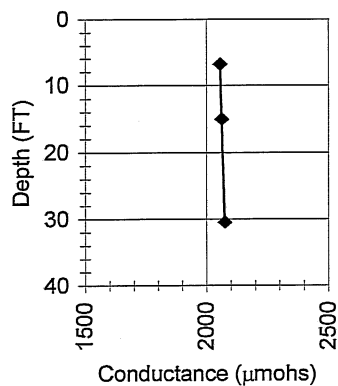
Devils Lake Temporal Profiles - Summer 1998

Location: A30
Bottom Depth (FT): 44.9

Northing: 503417
Easting: 5320966

Station: 26+53
Offset: 800L

Date: 7/8/98
Time: 1227



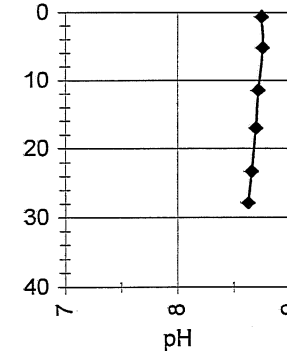
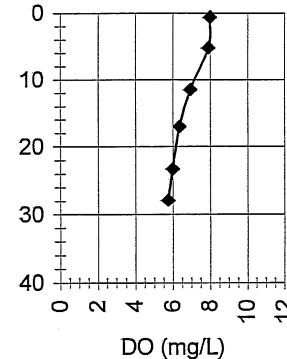
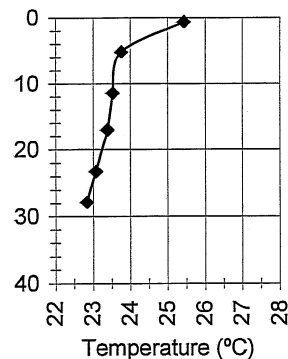
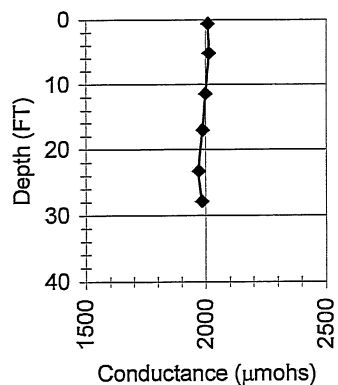
9 - 8

Location: 299
Bottom Depth (FT): 45

Northing: 503428
Easting: 5320964

Station: 26+55
Offset: 800L

Date: 8/13/98
Time: 1759



Devils Lake Temporal Profiles - Summer 1998

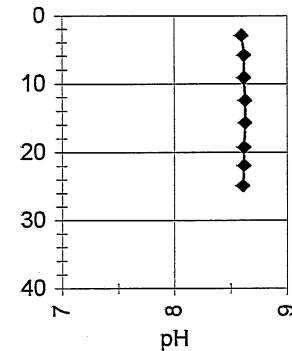
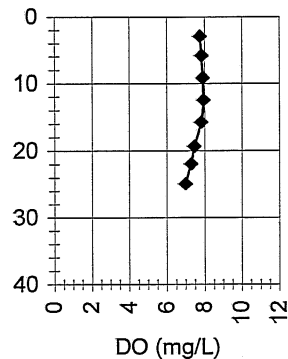
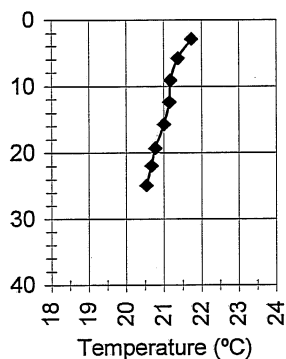
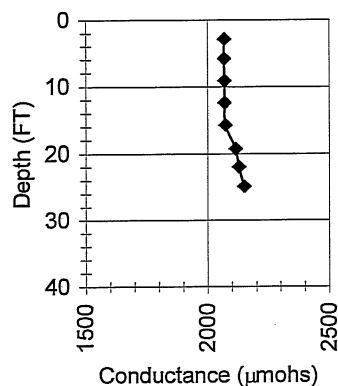
Location: A28
Bottom Depth (FT): 27.9

Northing: 507801
Easting: 5319742

Station: 30+95
Offset: 920L

Date: 7/8/98
Time: 1207

L-8

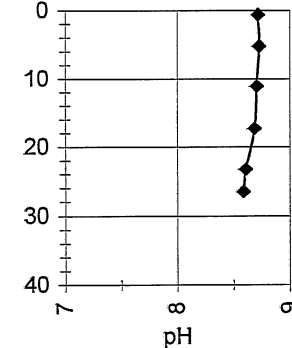
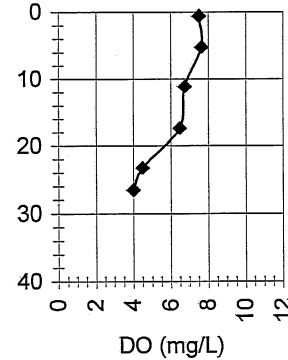
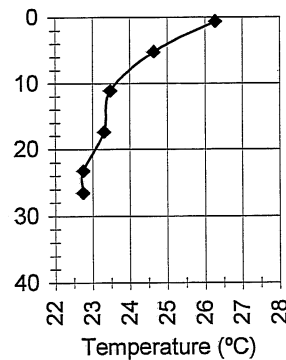
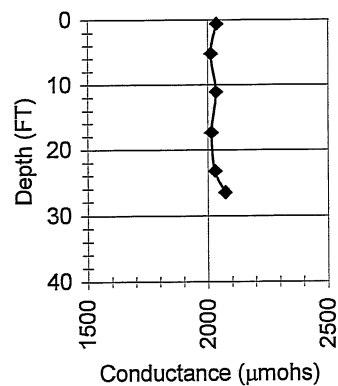


Location: 296
Bottom Depth (FT): 31

Northing: 507395
Easting: 5318758

Station: 30+85
Offset: 130R

Date: 8/13/98
Time: 1730



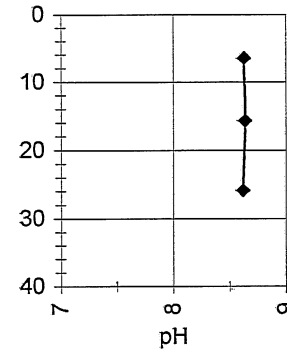
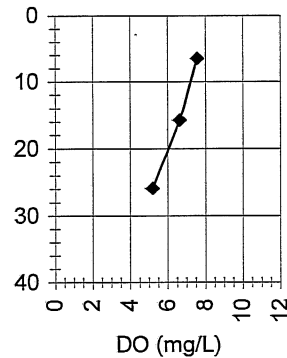
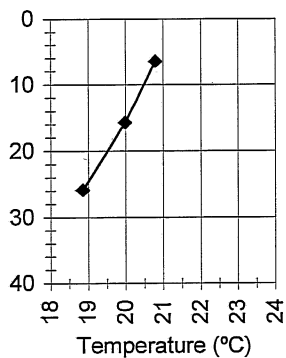
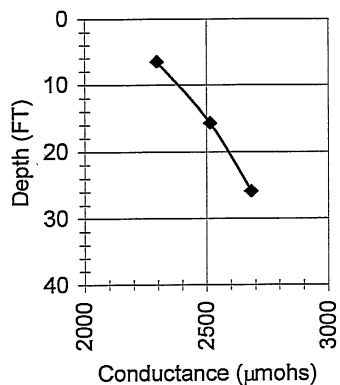
Devils Lake Temporal Profiles - Summer 1998

Location: A24
Bottom Depth (FT): 36.1

Northing: 507795
Easting: 5318648

Station: 31+18
Offset: 220R

Date: 7/8/98
Time: 1131



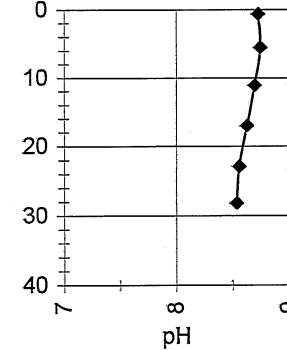
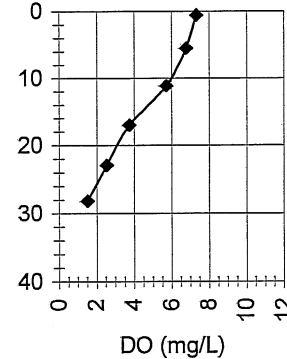
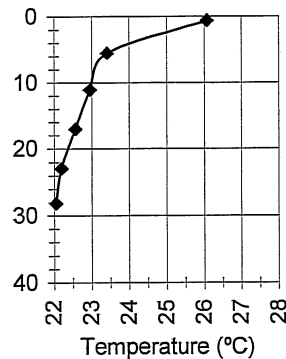
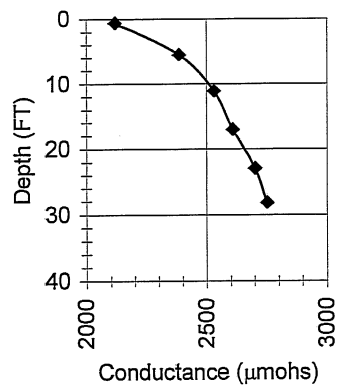
8-8

Location: 297
Bottom Depth (FT): 36

Northing: 507798
Easting: 5318650

Station: 31+18
Offset: 200R

Date: 8/13/98
Time: 1738



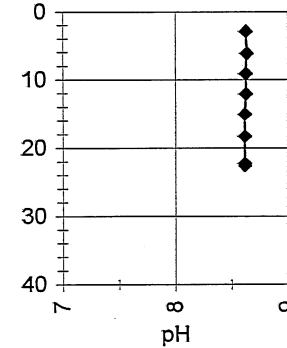
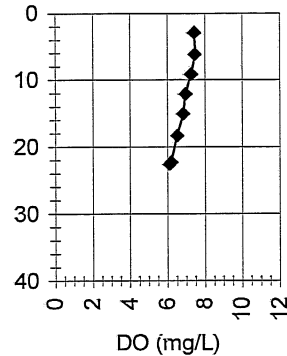
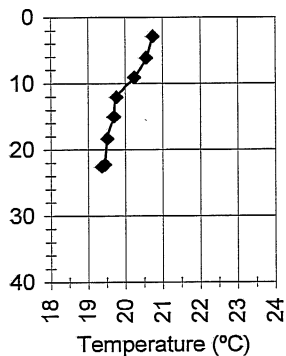
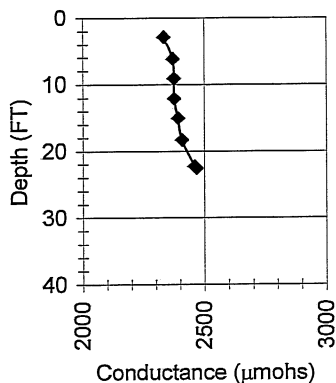
Devils Lake Temporal Profiles - Summer 1998

Location: A27
Bottom Depth (FT): 25.9

Northing: 508083
Easting: 5319620

Station: 31+54
Offset: 730L

Date: 7/8/98
Time: 1157



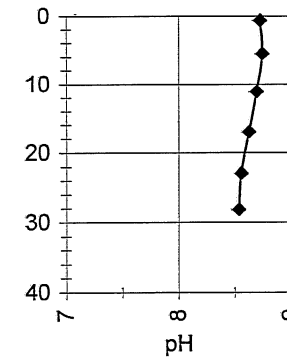
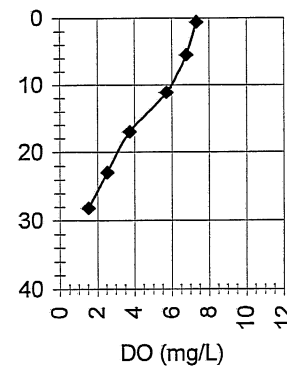
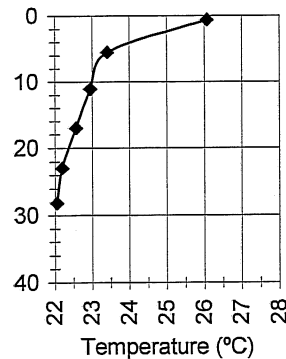
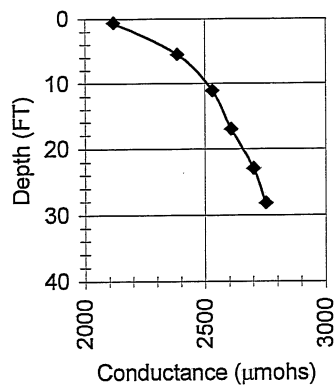
6 - 8

Location: 297
Bottom Depth (FT): 36

Northing: 507798
Easting: 5318650

Station: 31+18
Offset: 200R

Date: 8/13/98
Time: 1738



Devils Lake Temporal Profiles - Summer 1998

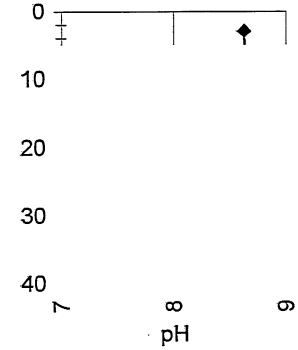
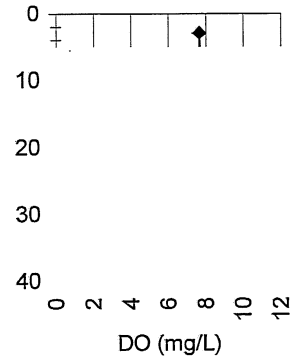
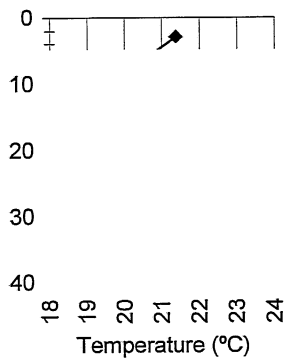
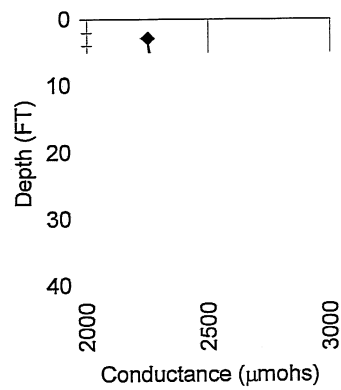
8 - 10

Location: A26
Bottom Depth (FT): 25.6

Northing: 508867
Easting: 5318895

Station: 32+13
Offset: 170R

Date: 7/8/98
Time: 1157

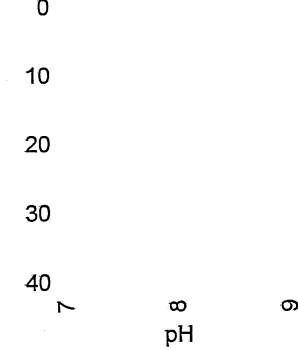
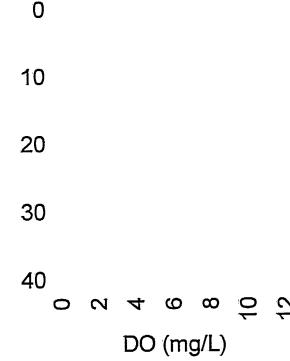
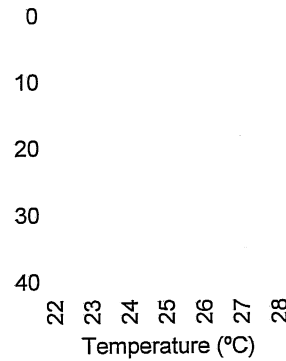
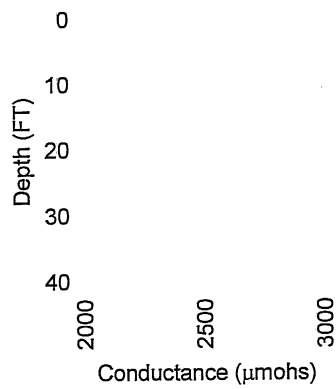


Location: 298
Bottom Depth (FT): 26

Northing: 508836
Easting: 5318913

Station: 32+12
Offset: 180R

Date: 8/13/98
Time: 1744



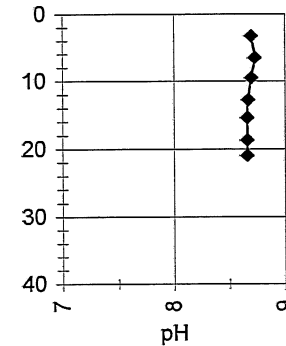
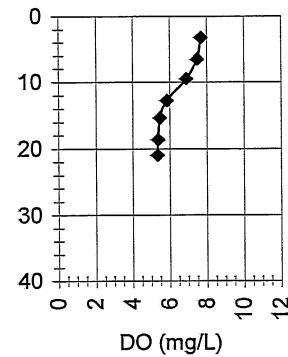
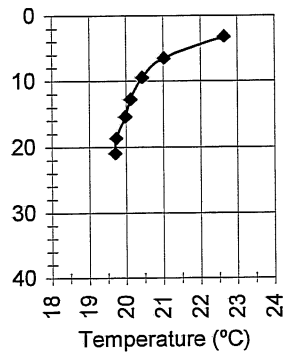
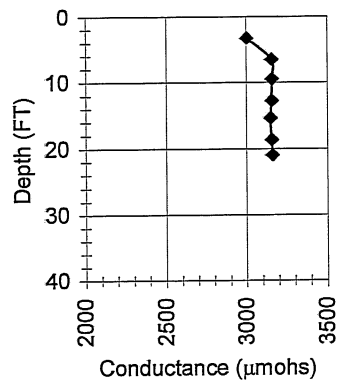
Devils Lake Temporal Profiles - Summer 1998

Location: A4-1
Bottom Depth (FT): 21

Northing: 508979
Easting: 5319035

Station: 32+22
Offset: 220R

Date: 7/10/98
Time: 1900



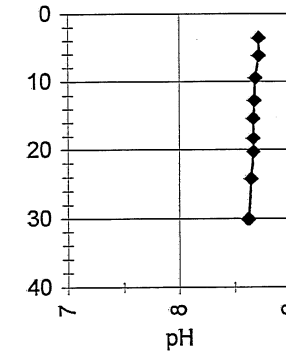
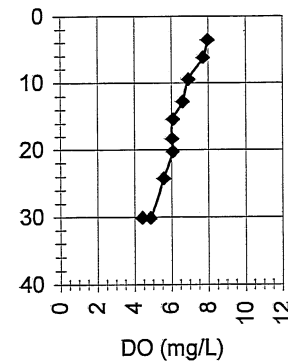
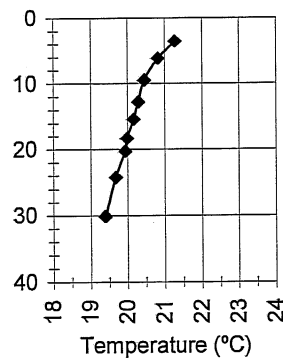
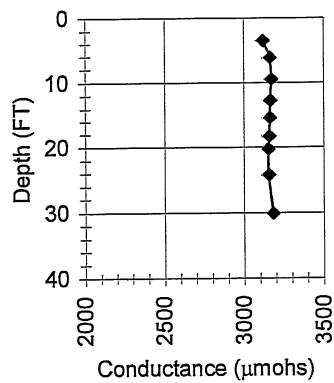
8 - 11

Location: A3-1
Bottom Depth (FT): 30

Northing: 509012
Easting: 5319061

Station: 32+34
Offset: 230R

Date: 7/10/98
Time: 1837



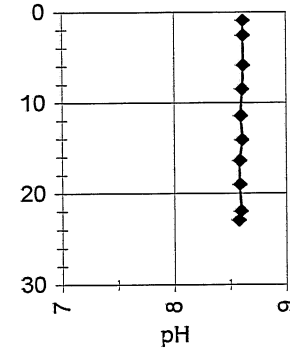
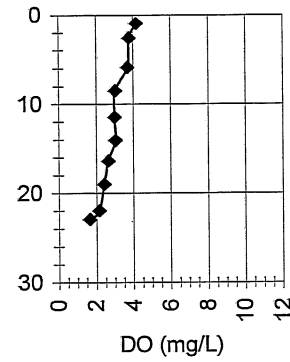
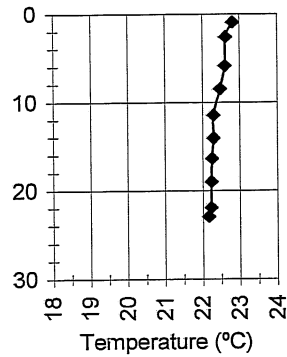
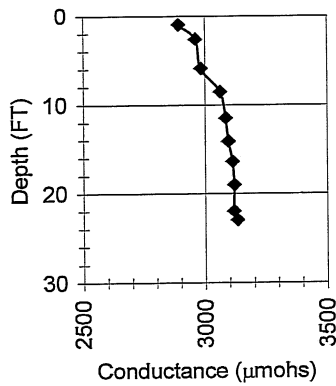
Devils Lake Temporal Profiles - Summer 1998

Location: 20 BDG
Bottom Depth (FT): 21

Northing: 508971
Easting: 5319013

Station: 32+30
Offset: 100R

Date: 8/13/98
Time: 1111



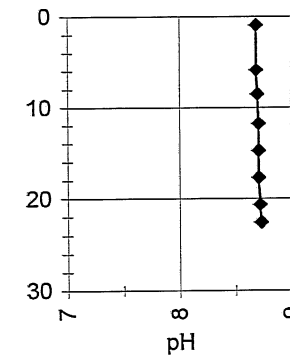
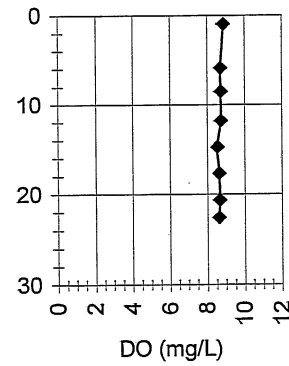
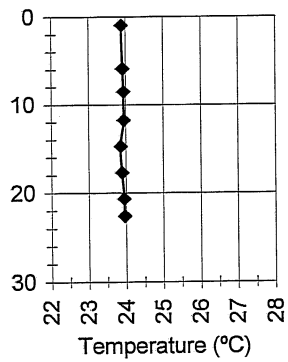
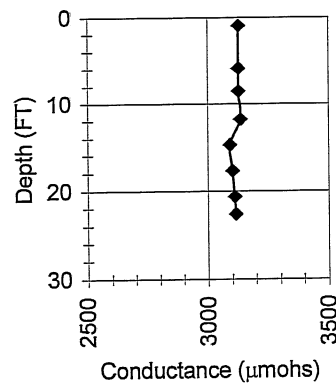
8 - 12

Location: 20 BDG
Bottom Depth (FT): 21

Northing: 508971
Easting: 5319013

Station: 32+30
Offset: 100R

Date: 7/10/98
Time: 1837



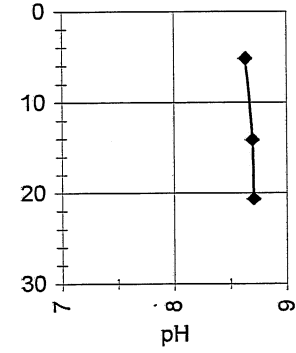
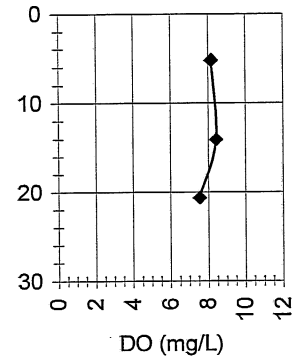
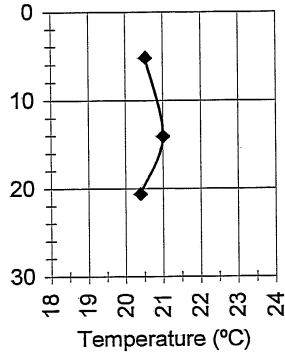
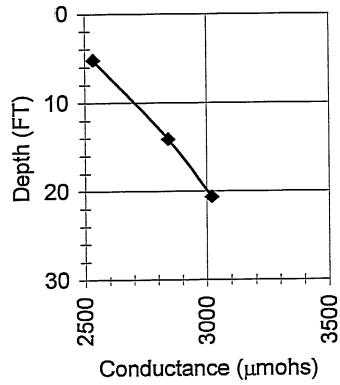
Devils Lake Temporal Profiles - Summer 1998

Location: Z1
Bottom Depth (FT): 13.1

Northing: 508988
Easting: 5319089

Station: 32+36
Offset: 200R

Date: 7/7/98
Time: 1915



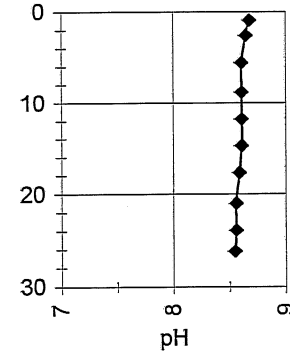
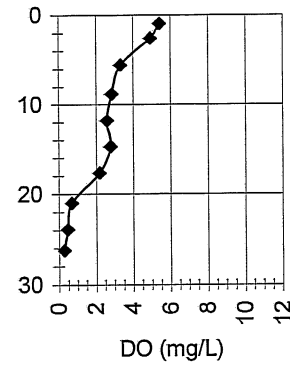
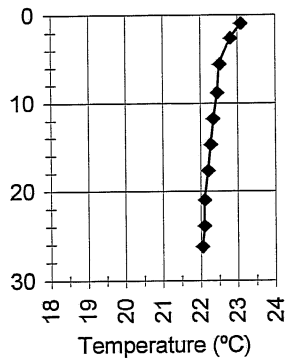
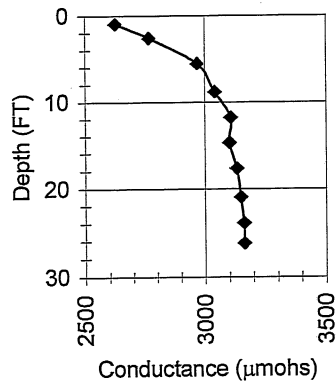
8 - 13

Location: 278
Bottom Depth (FT): 13

Northing: 508985
Easting: 5319122

Station: 32+38
Offset: 160R

Date: 8/13/98
Time: 0904



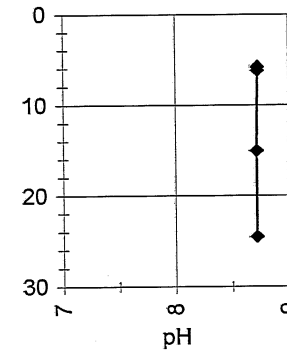
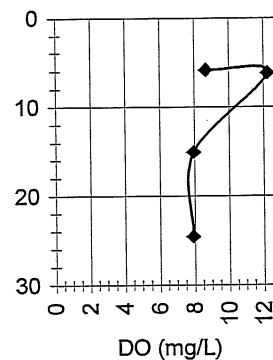
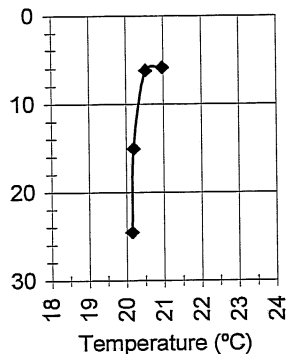
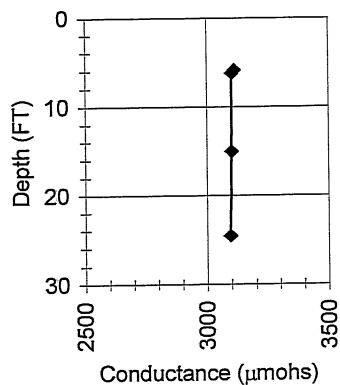
Devils Lake Temporal Profiles - Summer 1998

Location: B
Bottom Depth (FT): 32.5

Northing: 510056
Easting: 5320985

Station: 34+43
Offset: 190L

Date: 7/7/98
Time: 1338



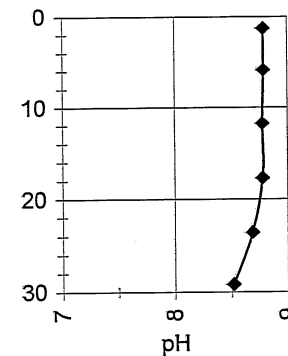
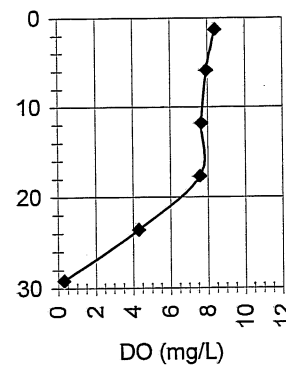
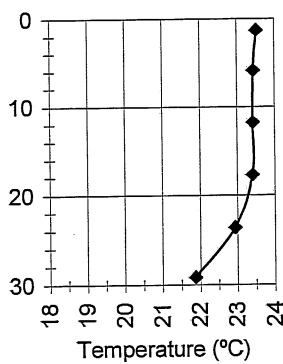
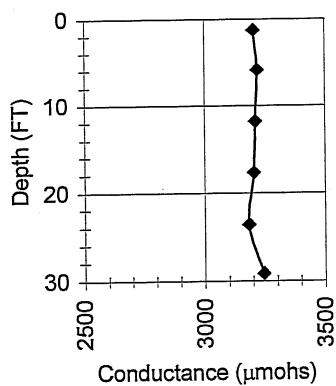
8 - 14

Location: 279
Bottom Depth (FT): 32

Northing: 510041
Easting: 5321004

Station: 34+40
Offset: 210L

Date: 8/13/98
Time: 0918



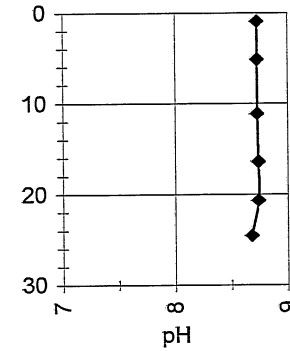
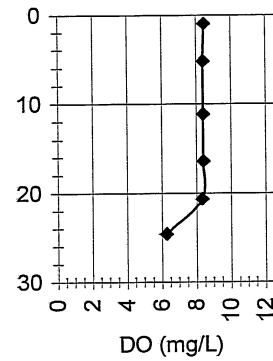
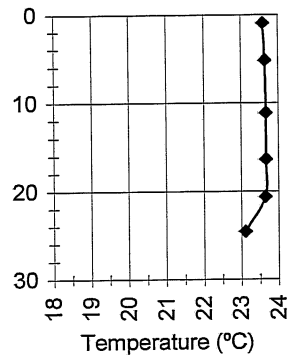
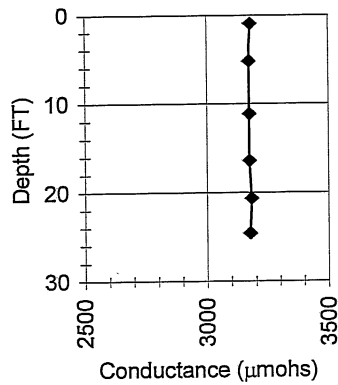
Devils Lake Temporal Profiles - Summer 1998

Location: 309
Bottom Depth (FT): 32

Northing: 510053
Easting: 5320989

Station: 34+43
Offset: 220L

Date: 8/14/98
Time: 0633



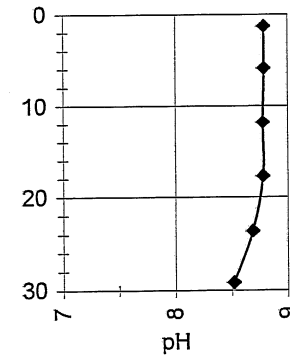
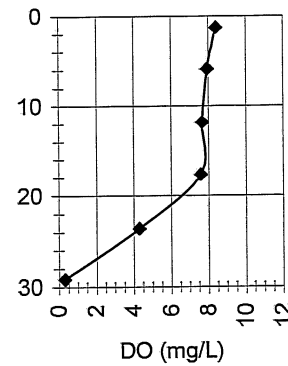
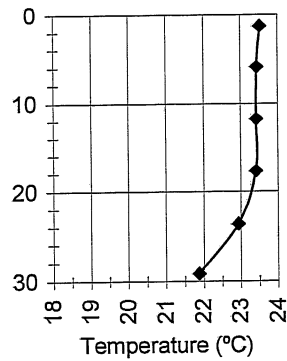
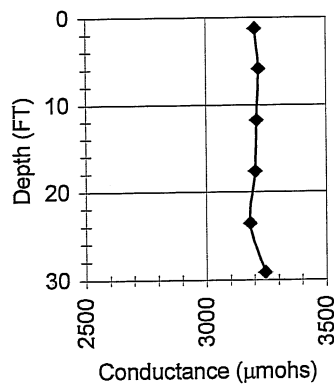
8 - 15

Location: 279
Bottom Depth (FT): 32

Northing: 510041
Easting: 5321004

Station: 34+40
Offset: 210L

Date: 8/13/98
Time: 0918



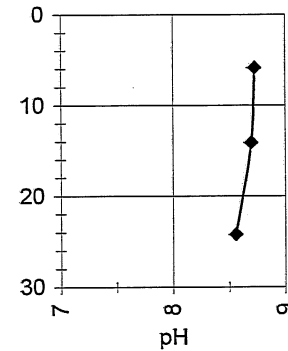
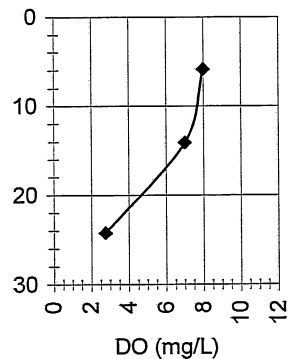
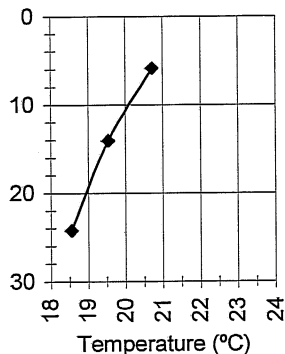
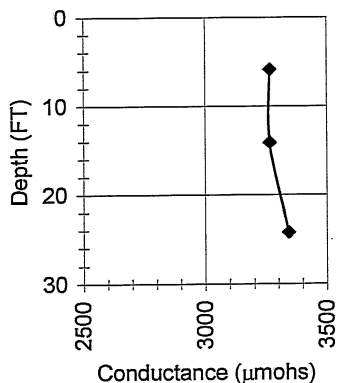
Devils Lake Temporal Profiles - Summer 1998

Location: Z3
Bottom Depth (FT): 35.4

Northing: 509460
Easting: 5323888

Station: 36+22
Offset: 2500L

Date: 7/7/98
Time: 1930



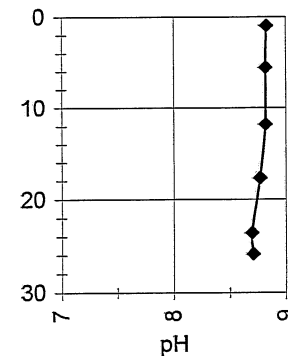
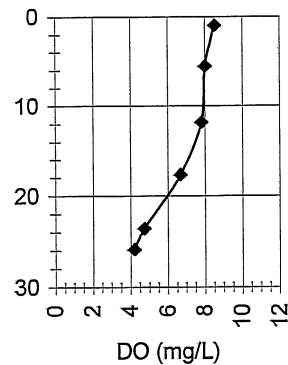
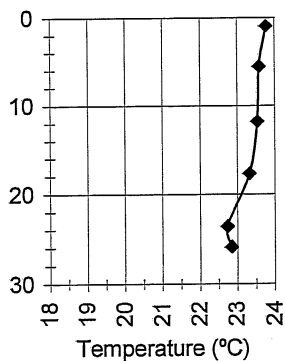
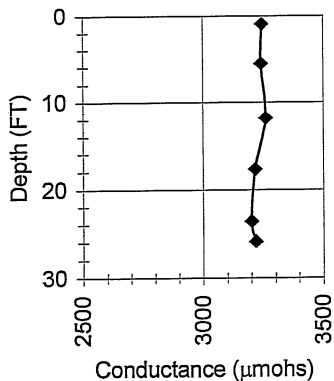
8 - 16

Location: 280
Bottom Depth (FT): 35

Northing: 509459
Easting: 5323880

Station: 36+25
Offset: 2510L

Date: 8/13/98
Time: 0926



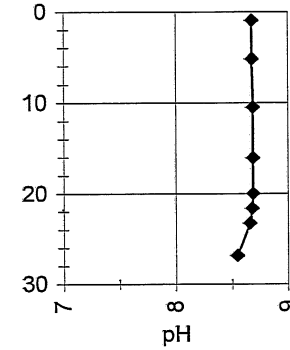
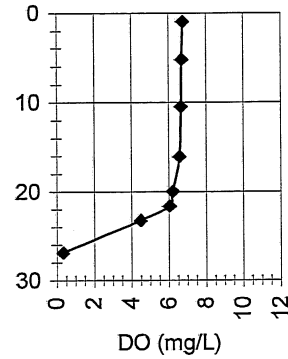
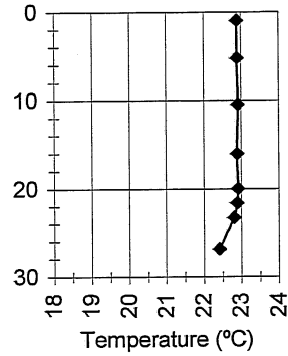
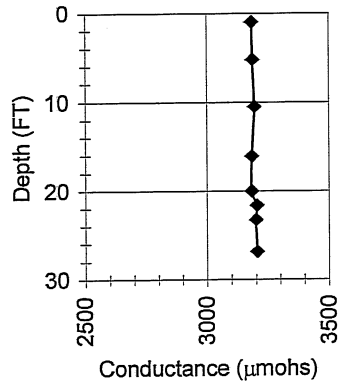
Devils Lake Temporal Profiles - Summer 1998

Location: 307
Bottom Depth (FT): 35

Northing: 509464
Easting: 5323886

Station: 36+23
Offset: 2510L

Date: 8/14/98
Time: 0612



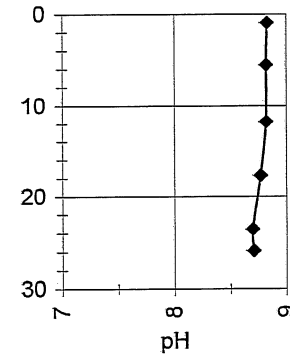
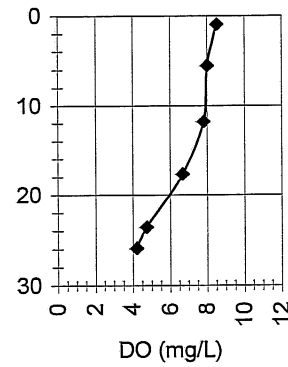
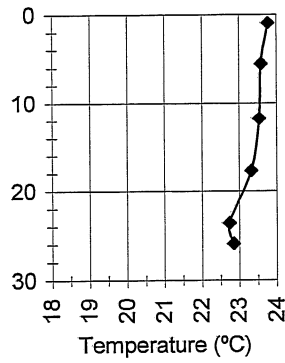
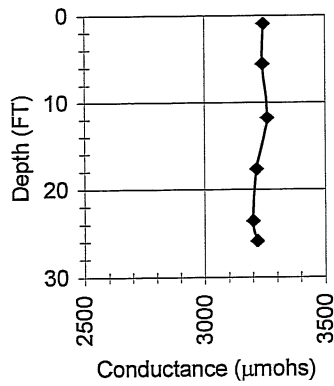
8 - 17

Location: 280
Bottom Depth (FT): 35

Northing: 509459
Easting: 5323880

Station: 36+25
Offset: 2510L

Date: 8/13/98
Time: 0926



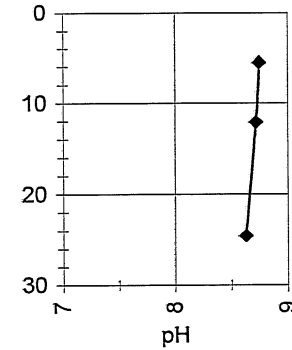
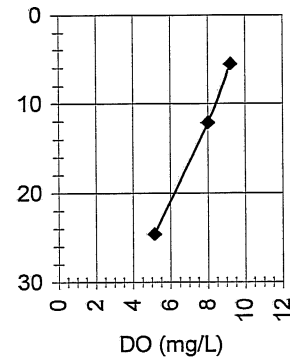
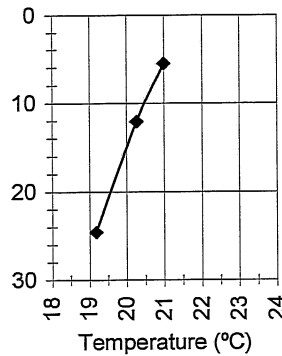
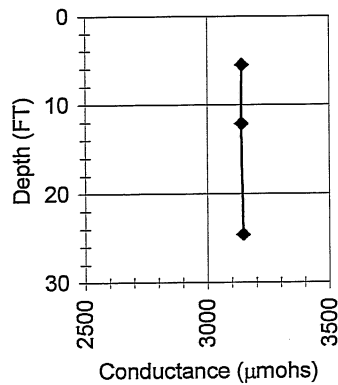
Devils Lake Temporal Profiles - Summer 1998

Location: D
Bottom Depth (FT): 35.4

Northing: 512462
Easting: 5323031

Station: 37+45
Offset: 360R

Date: 7/7/98
Time: 1352



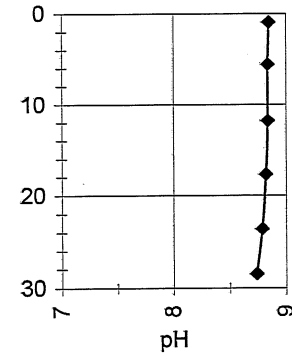
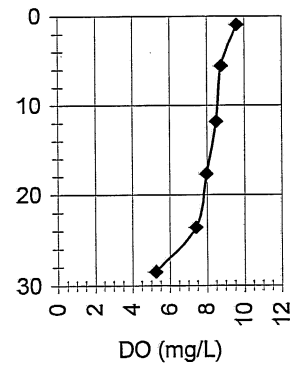
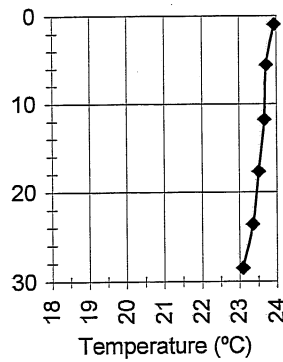
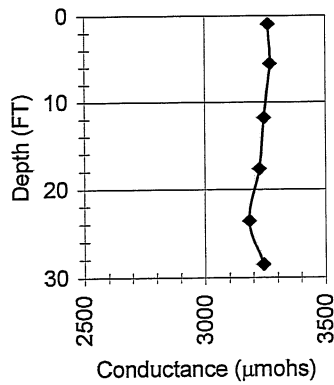
8 - 18

Location: 281
Bottom Depth (FT): 35

Northing: 512448
Easting: 5323049

Station: 37+45
Offset: 380R

Date: 8/13/98
Time: 0933



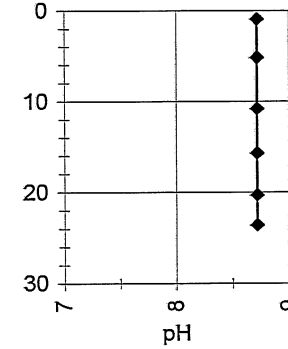
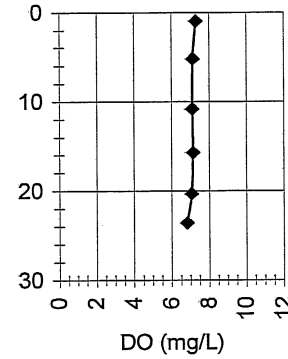
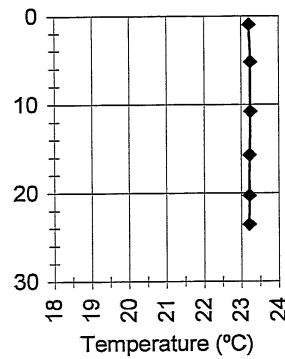
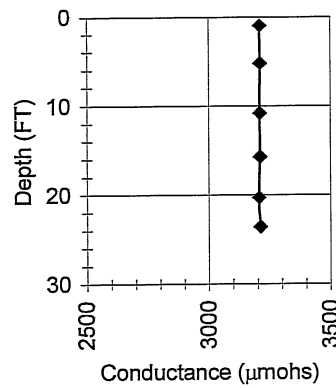
Devils Lake Temporal Profiles - Summer 1998

Location: 308
Bottom Depth (FT): 35

Northing: 512469
Easting: 5323013

Station: 37+45
Offset: 360R

Date: 8/14/98
Time: 0623



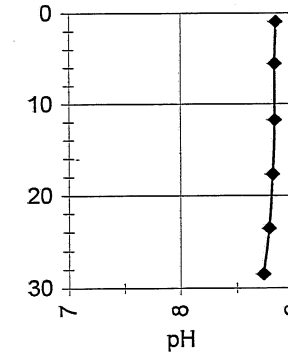
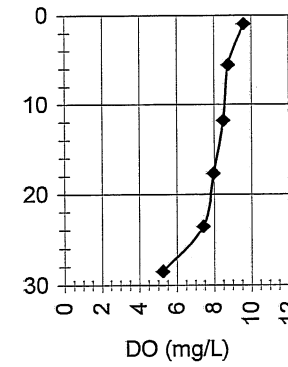
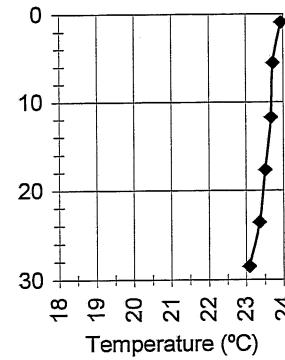
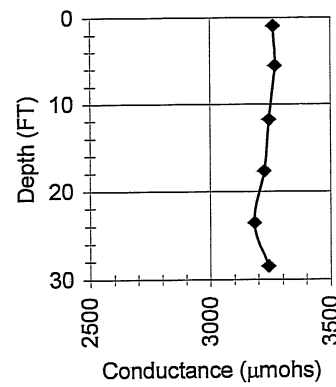
8 - 19

Location: 281
Bottom Depth (FT): 35

Northing: 512448
Easting: 5323049

Station: 37+45
Offset: 380R

Date: 8/13/98
Time: 0933



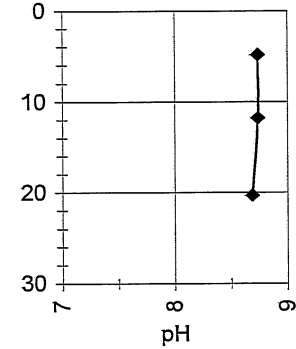
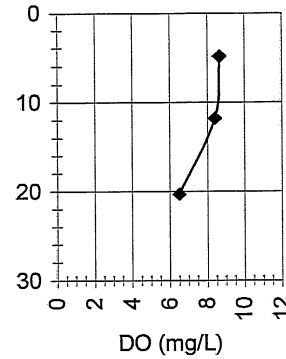
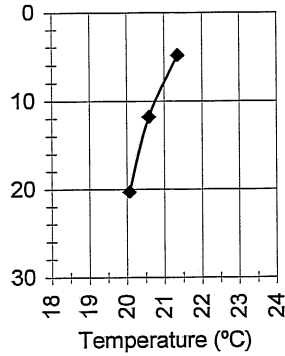
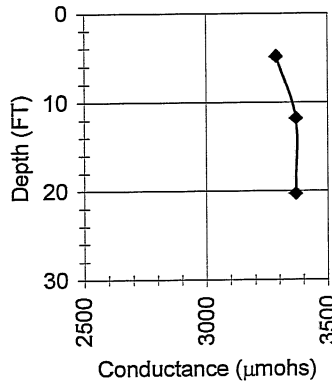
Devils Lake Temporal Profiles - Summer 1998

Location: G
Bottom Depth (FT): 26.2

Northing: 516070
Easting: 5319928

Station: 43+90
Offset: 490L

Date: 7/7/98
Time: 1419



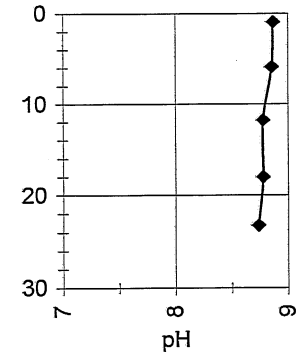
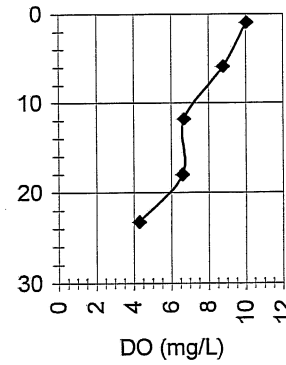
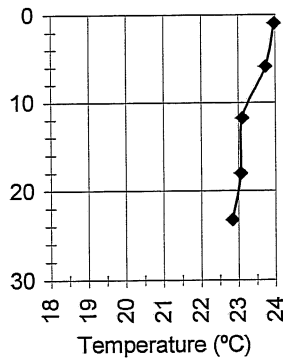
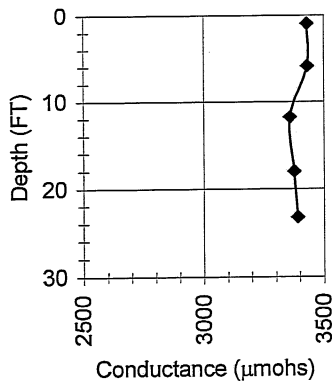
8 - 20

Location: 283
Bottom Depth (FT): 26

Northing: 516075
Easting: 5319938

Station: 44+20
Offset: 460L

Date: 8/13/98
Time: 0947



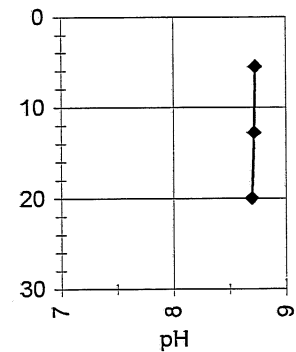
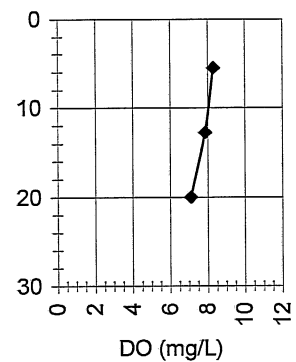
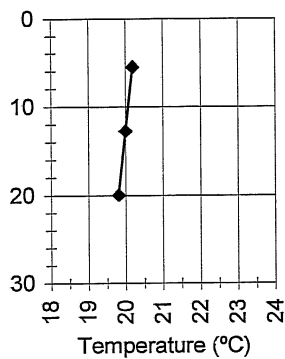
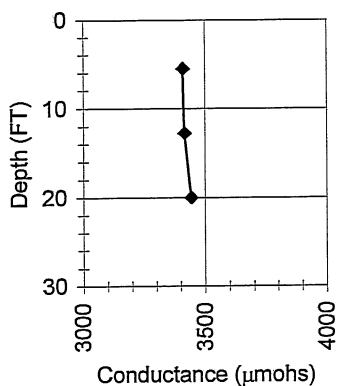
Devils Lake Temporal Profiles - Summer 1998

Location: 1
Bottom Depth (FT): 28.2

Northing: 519000
Easting: 5316000

Station: 48+36
Offset: 1440R

Date: 7/7/98
Time: 1433



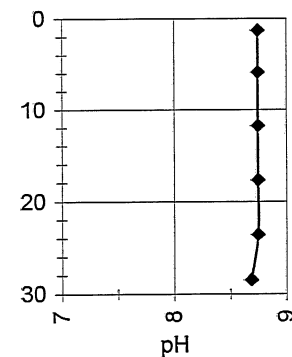
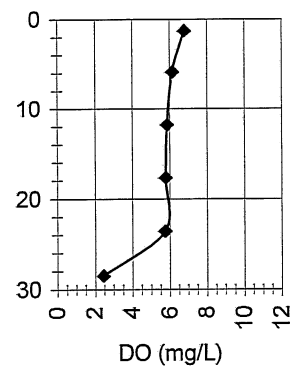
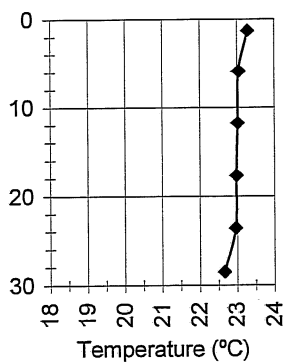
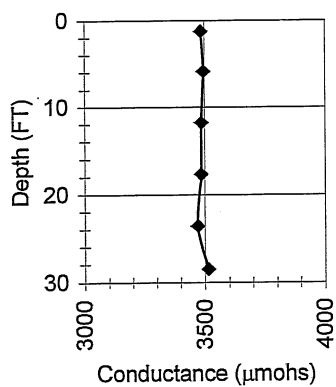
8 - 21

Location: 284
Bottom Depth (FT): 28

Northing: 518521
Easting: 5313815

Station: 48+50
Offset: 3670R

Date: 8/13/98
Time: 0957



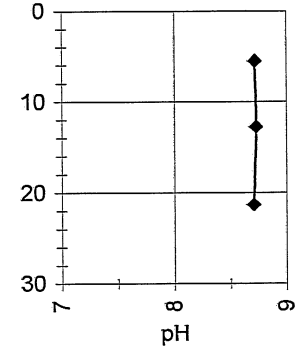
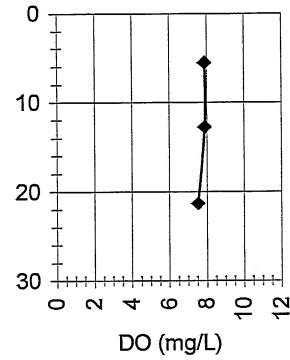
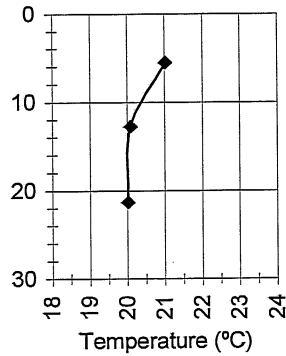
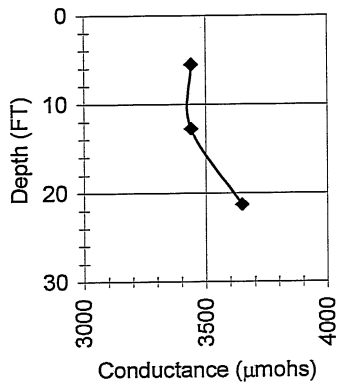
Devils Lake Temporal Profiles - Summer 1998

Location: J
Bottom Depth (FT): 29.5

Northing: 521979
Easting: 5316587

Station: 51+01
Offset: 100R

Date: 7/7/98
Time: 1453



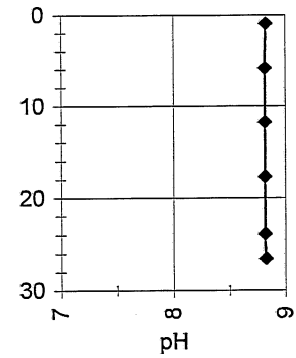
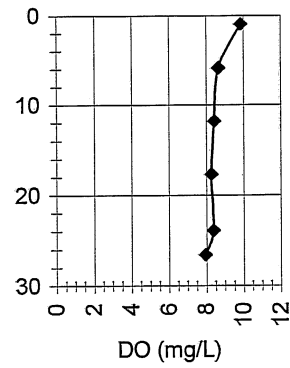
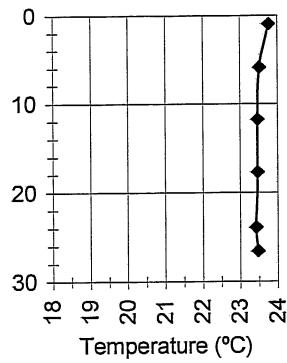
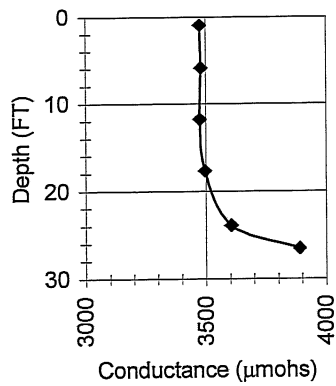
8 - 22

Location: 285
Bottom Depth (FT): 30

Northing: 521976
Easting: 5316608

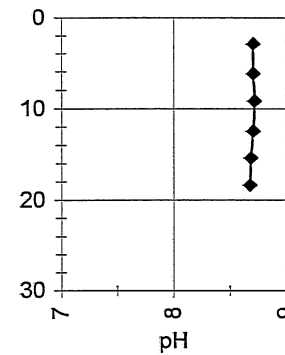
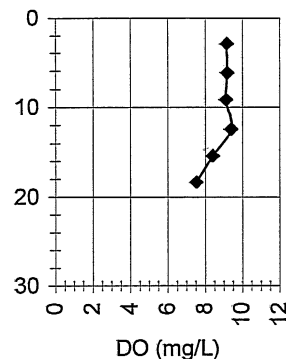
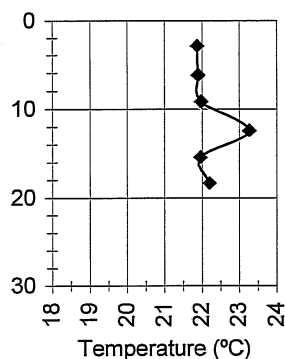
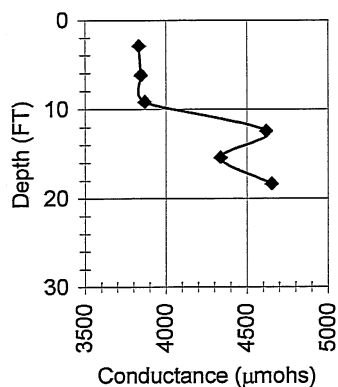
Station: 50+98
Offset: 80R

Date: 8/13/98
Time: 1006



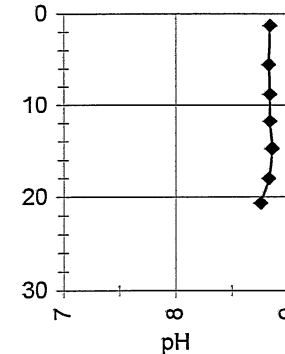
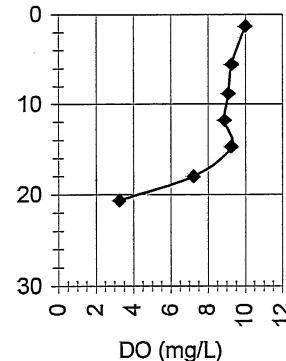
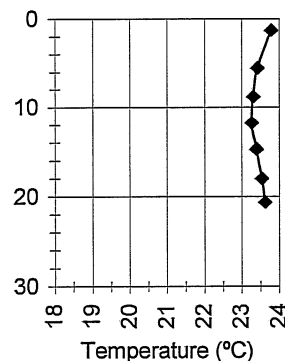
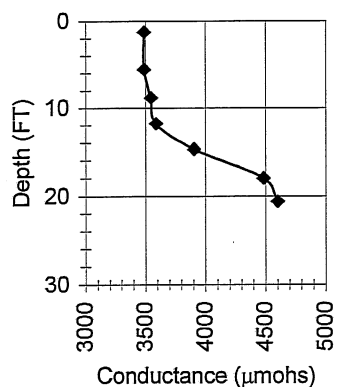
Devils Lake Temporal Profiles - Summer 1998

Location: B1	Northing: 522499	Station: 51+50	Date: 7/10/98
Bottom Depth (FT): 20.3	Easting: 5316603	Offset: 50L	Time: 0705



8 - 23

Location: 286	Northing: 522488	Station: 51+40	Date: 8/13/98
Bottom Depth (FT): 20	Easting: 5316841	Offset: 270L	Time: 1013



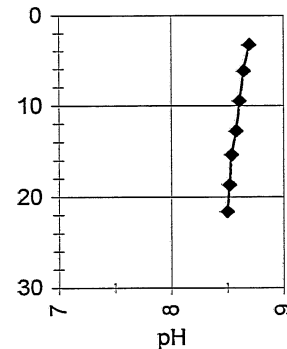
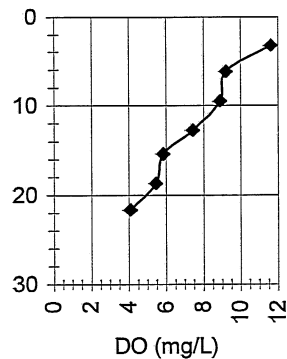
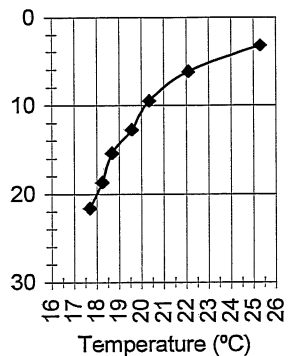
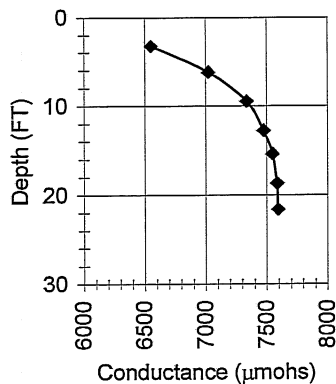
Devils Lake Temporal Profiles - Summer 1998

Location: B2
Bottom Depth (FT): 23.3

Northing: 522682
Easting: 5316688

Station: 51+64
Offset: 190L

Date: 7/10/98
Time: 0717



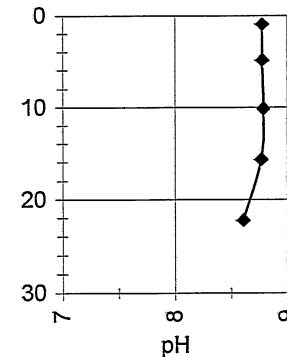
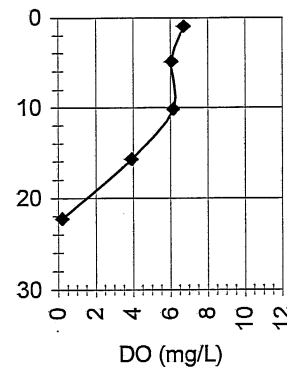
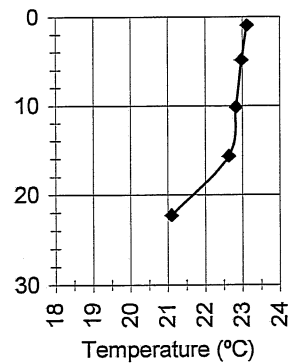
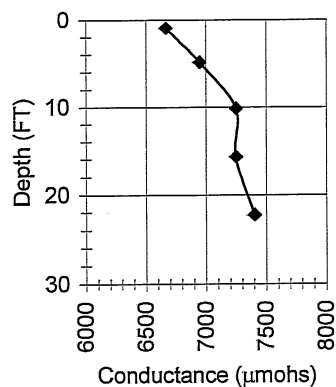
8 - 24

Location: 318
Bottom Depth (FT): 23

Northing: 522699
Easting: 5316642

Station: 51+67
Offset: 150L

Date: 8/14/98
Time: 1226



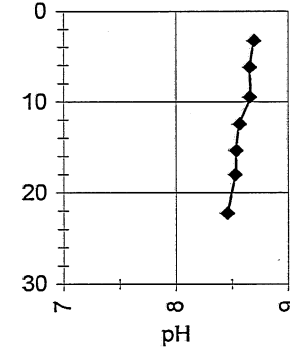
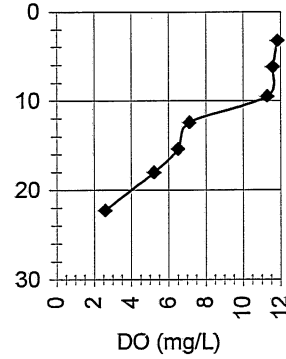
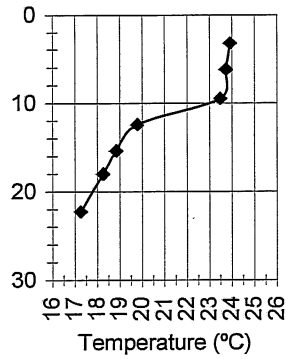
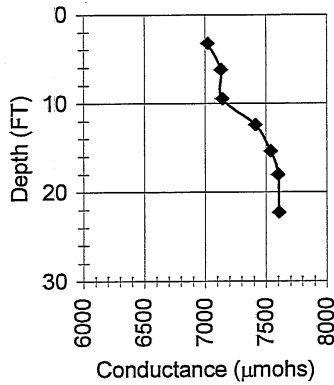
Devils Lake Temporal Profiles - Summer 1998

Location: B3
Bottom Depth (FT): 24.3

Northing: 525026
Easting: 5314712

Station: 55+14
Offset: 10L

Date: 7/10/98
Time: 0738



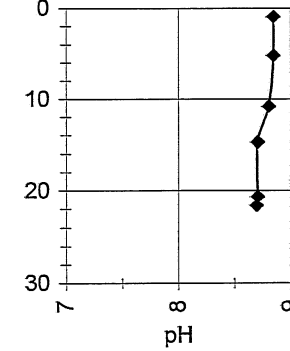
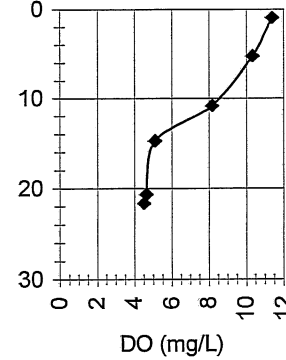
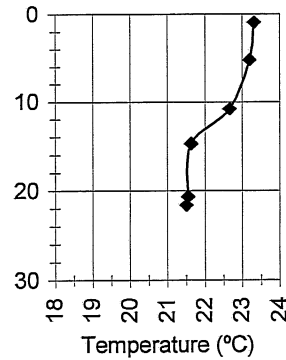
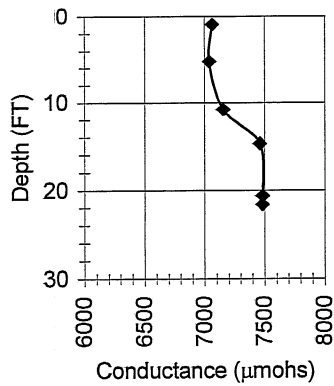
8 - 25

Location: 315
Bottom Depth (FT): 24

Northing: 525062
Easting: 5314694

Station: 55+14
Offset: 40L

Date: 8/14/98
Time: 1206



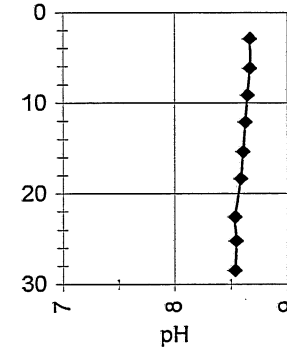
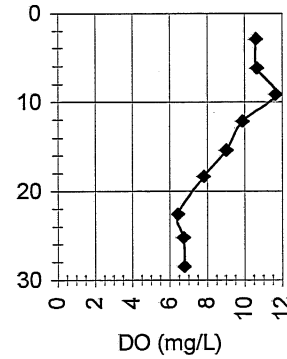
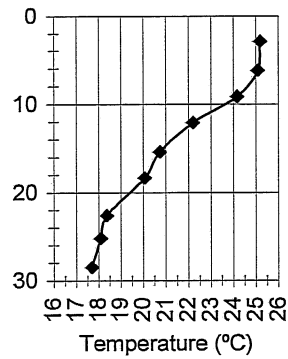
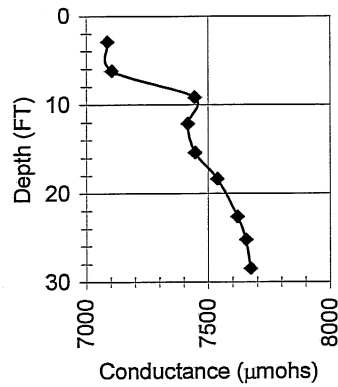
Devils Lake Temporal Profiles - Summer 1998

Location: B5
Bottom Depth (FT): 34.8

Northing: 525335
Easting: 5314075

Station: 56+40
Offset: 590L

Date: 7/10/98
Time: 0809



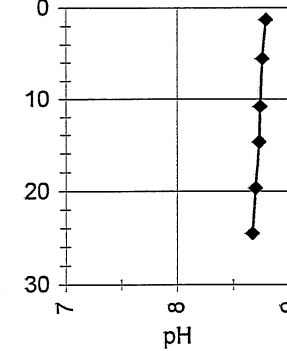
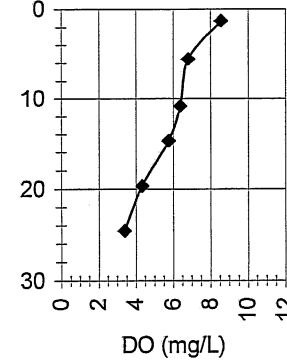
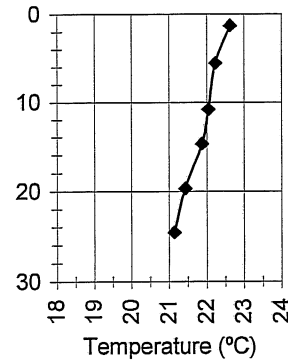
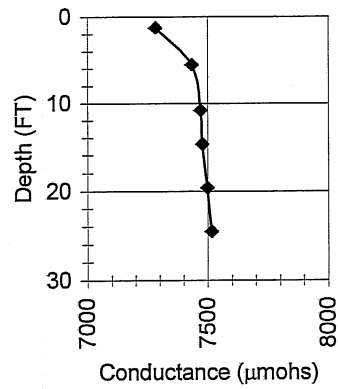
8 - 26

Location: 314
Bottom Depth (FT): 35

Northing: 525058
Easting: 5314093

Station: 56+18
Offset: 410L

Date: 8/14/98
Time: 1158



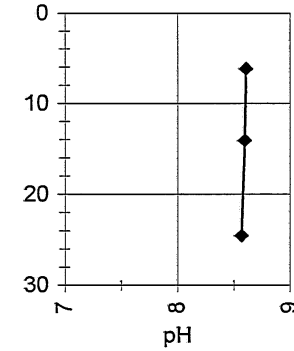
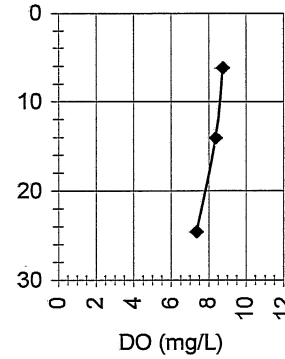
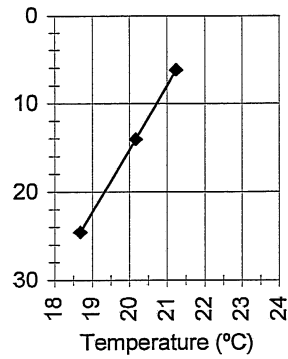
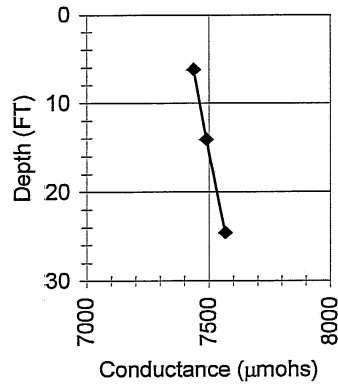
Devils Lake Temporal Profiles - Summer 1998

Location: N
Bottom Depth (FT): 49.2

Northing: 526985
Easting: 5312059

Station: 58+90
Offset: 220L

Date: 7/7/98
Time: 1604



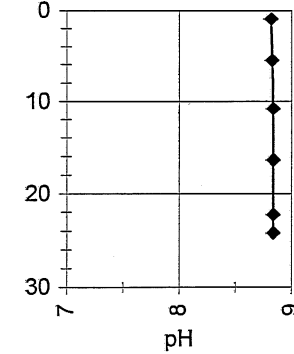
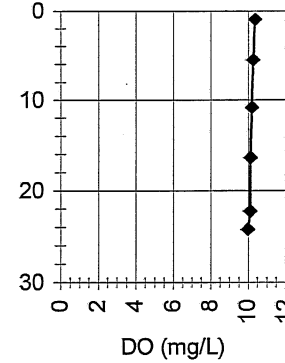
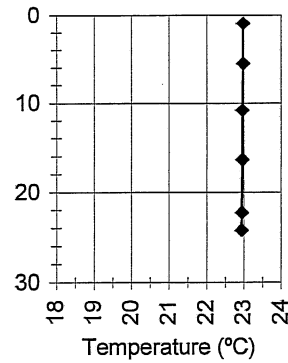
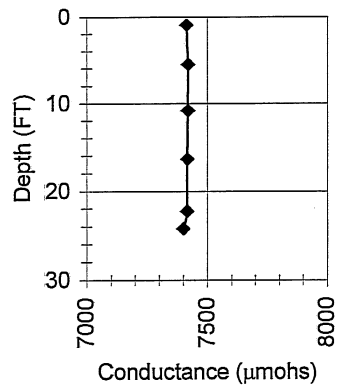
8 - 27

Location: 312
Bottom Depth (FT): 50

Northing: 526993
Easting: 5312062

Station: 58+91
Offset: 220L

Date: 8/14/98
Time: 1141



Devils Lake Temporal Profiles - Summer 1998

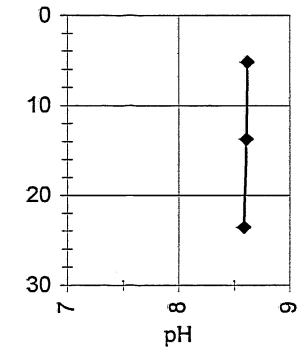
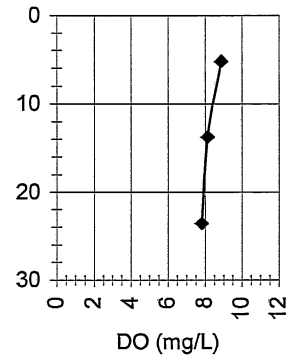
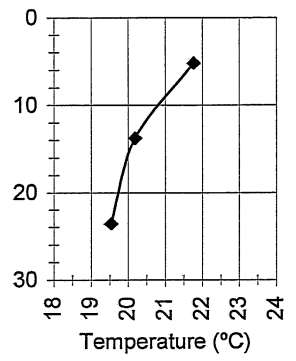
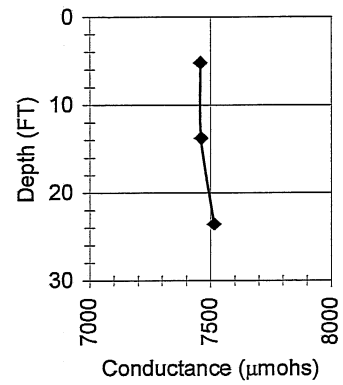
8 - 28

Location: O
Bottom Depth (FT): 49.2

Northing: 528141
Easting: 5309198

Station: 61+62
Offset: 1125R

Date: 7/7/98
Time: 1613

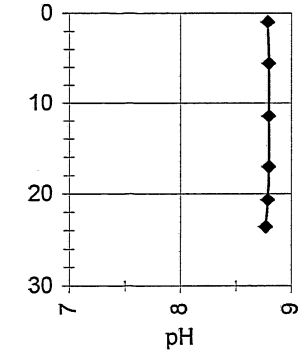
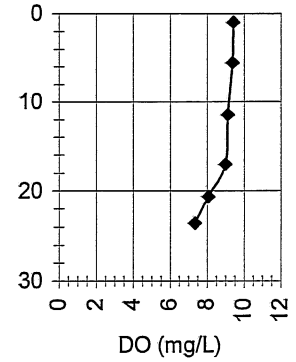
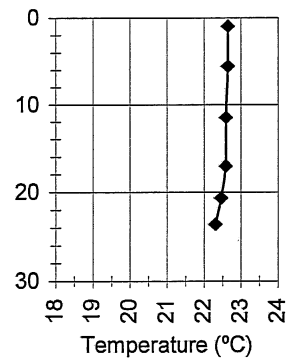
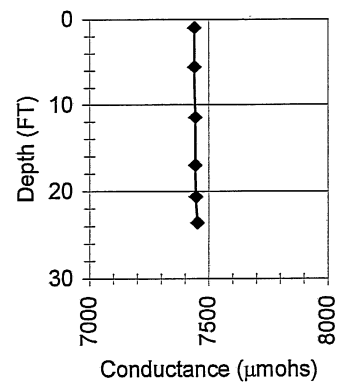


Location: 311
Bottom Depth (FT): 50

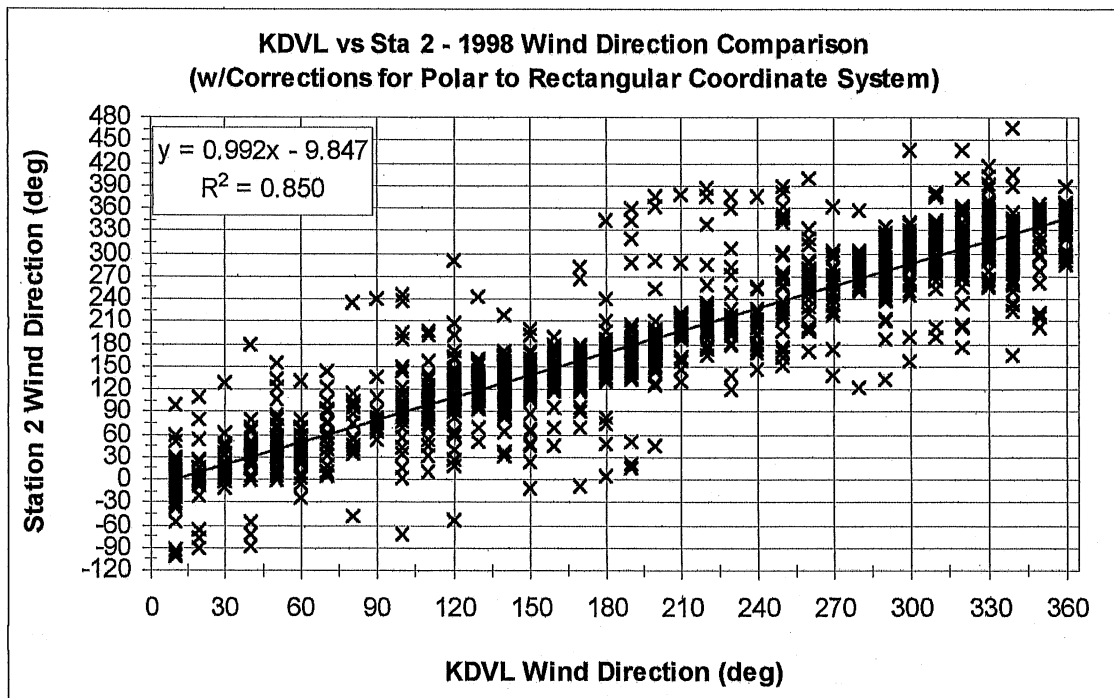
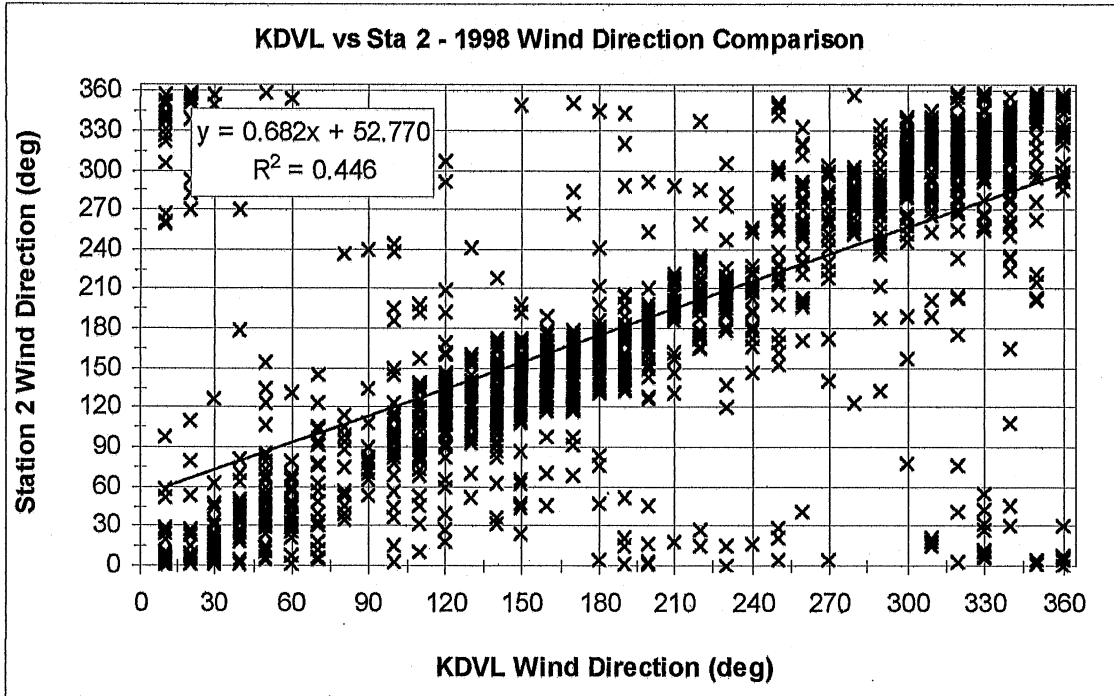
Northing: 529009
Easting: 5311978

Station: 60+44
Offset: 1530L

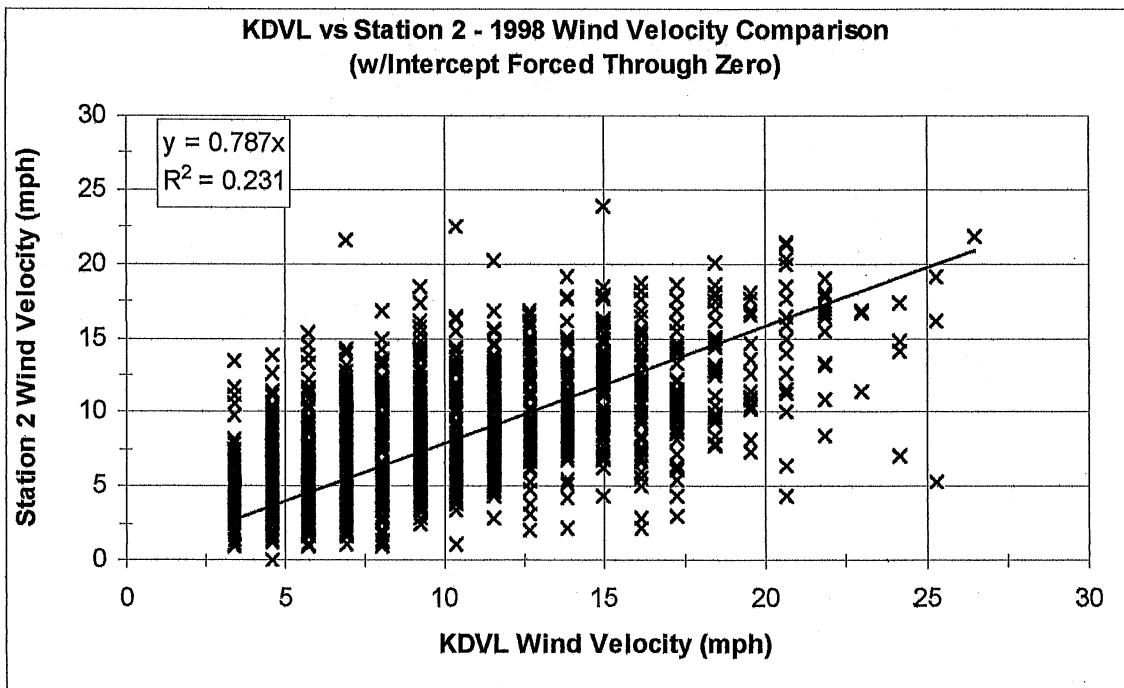
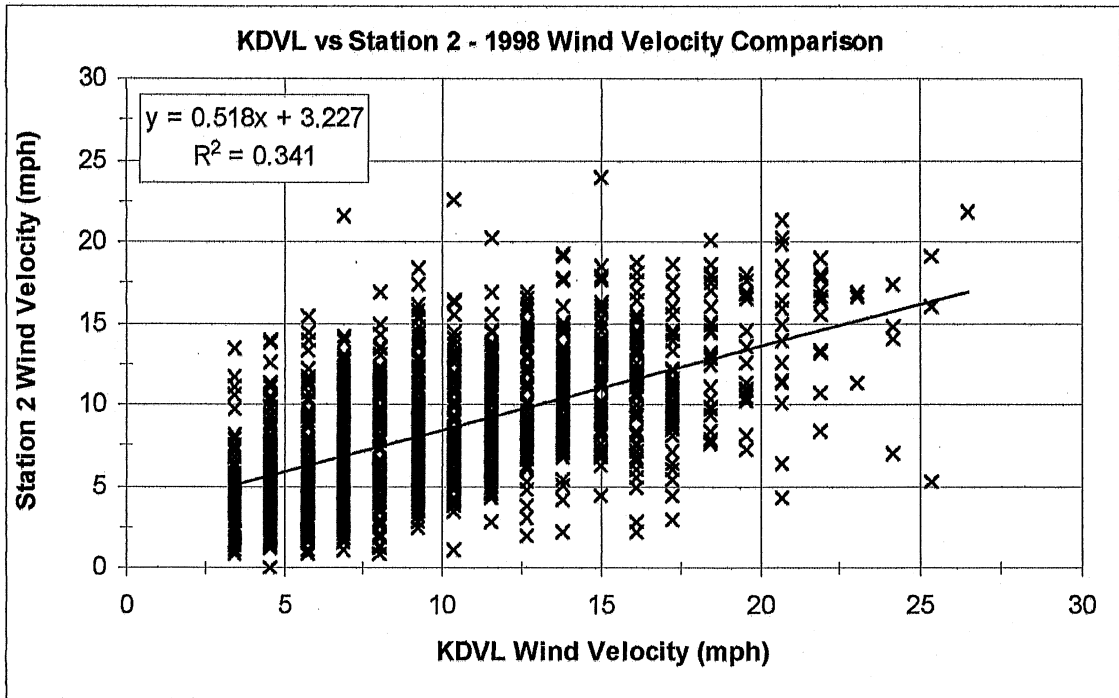
Date: 8/14/98
Time: 1133



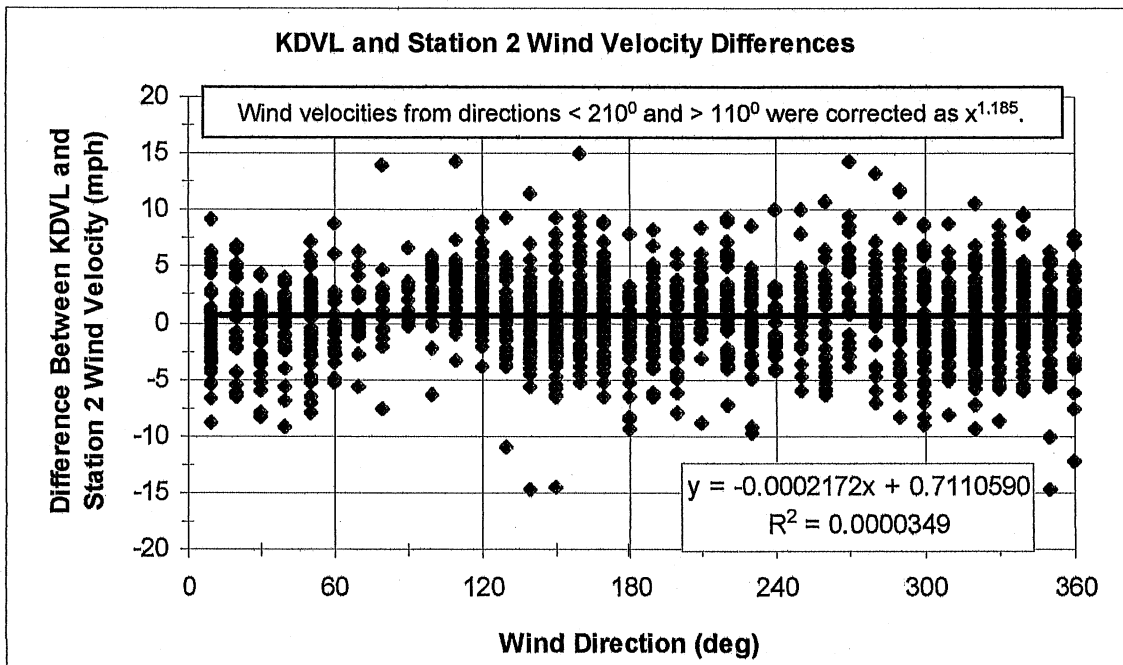
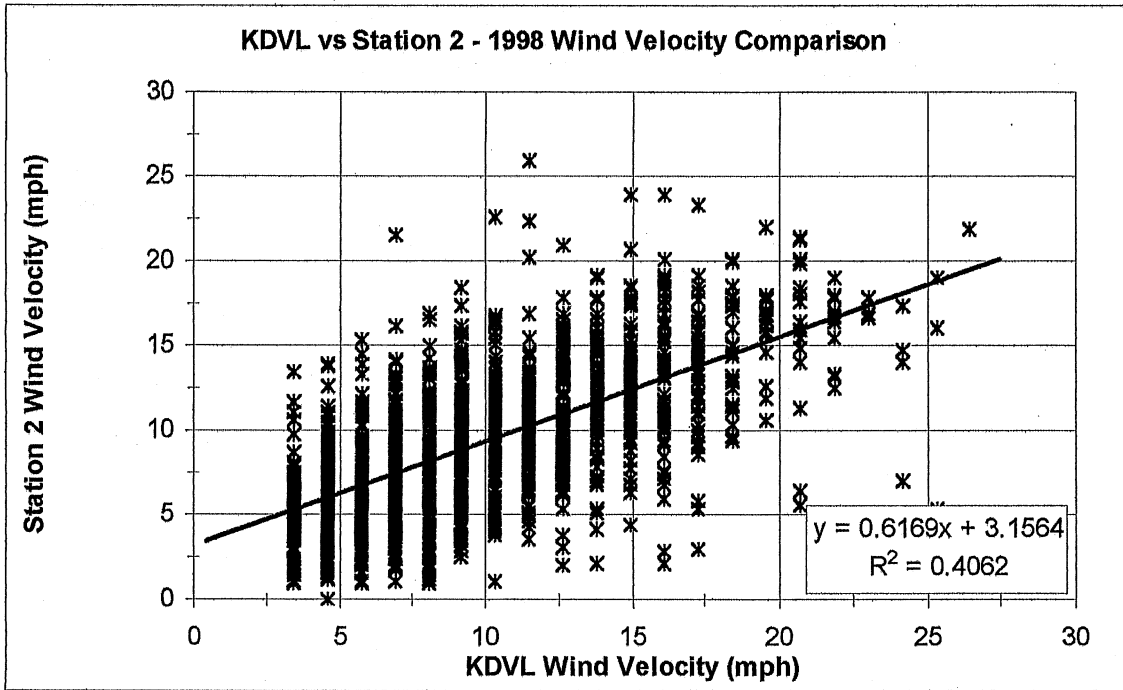
Comparison of Wind Measurements from Station 2 (Operated on Devils Lake) and Station KDVL (National Weather Service)



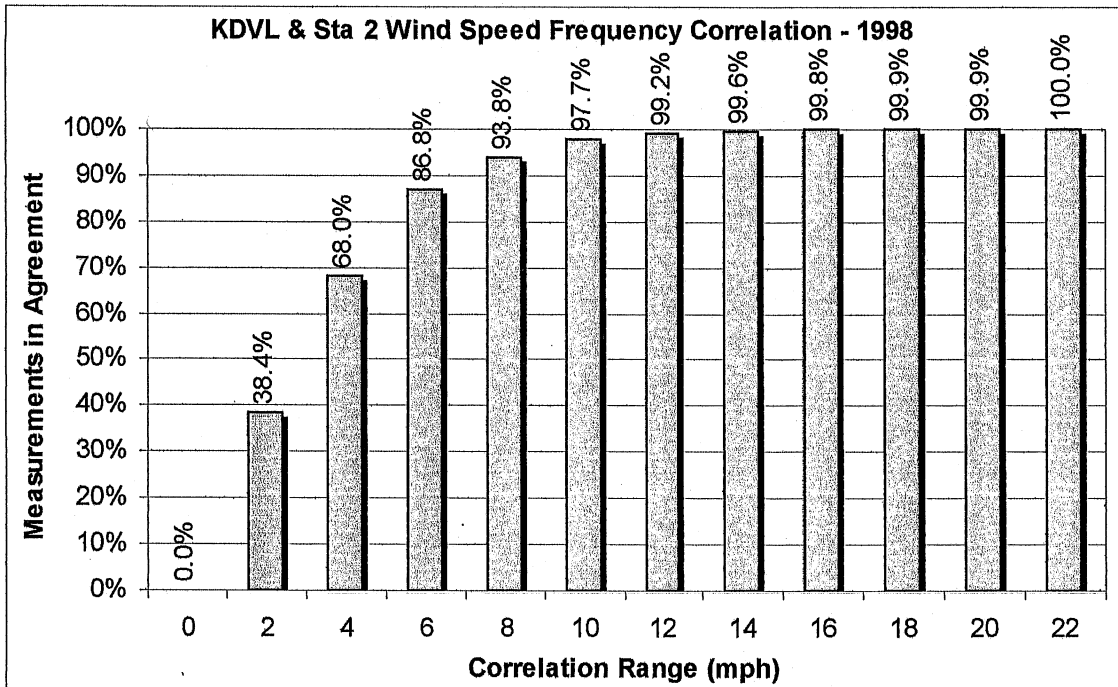
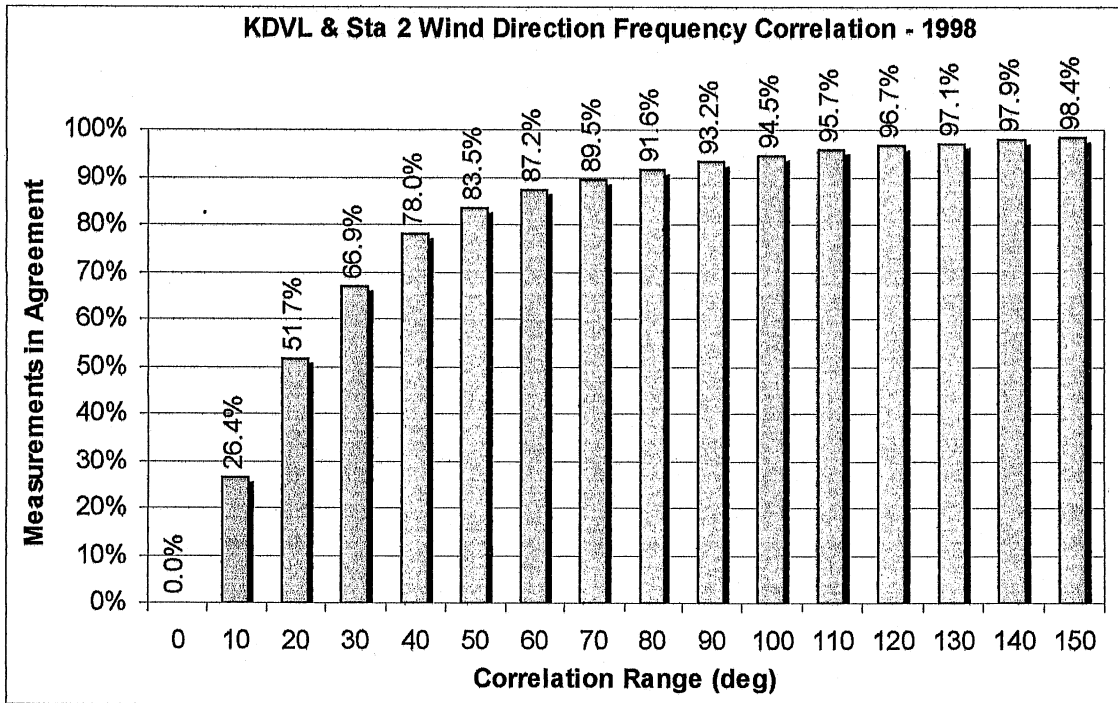
Comparison of Wind Measurements from Station 2 (Operated on Devils Lake) and Station KDVL (National Weather Service)



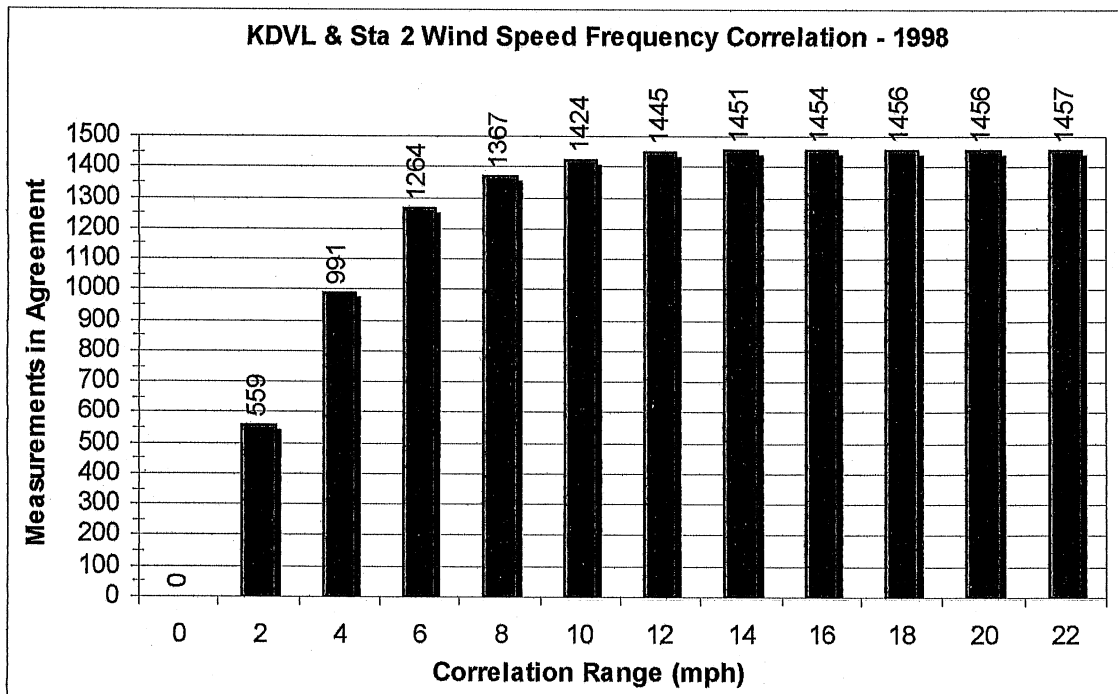
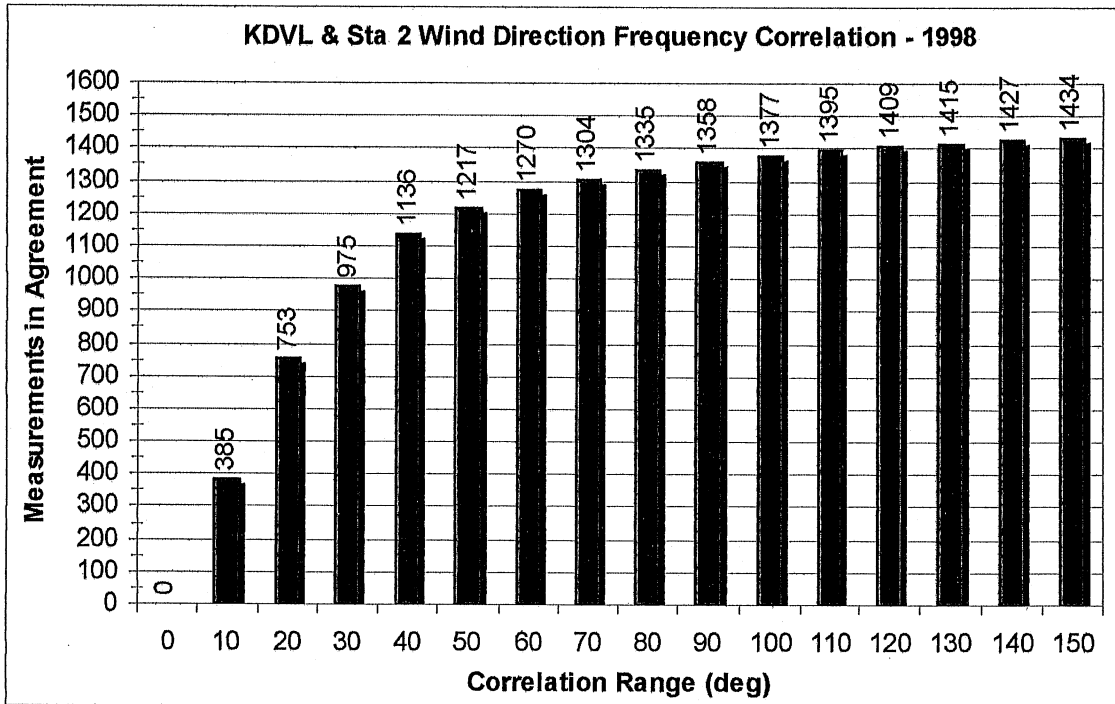
Comparison of Wind Measurements from Station 2 (Operated on Devils Lake) and Station KDVL (National Weather Service)



Comparison of Wind Measurements from Station 2 (Operated on Devils Lake) and Station KDVL (National Weather Service)



Comparison of Wind Measurements from Station 2 (Operated on Devils Lake) and Station KDVL (National Weather Service)



Bridge and Culvert Measurements

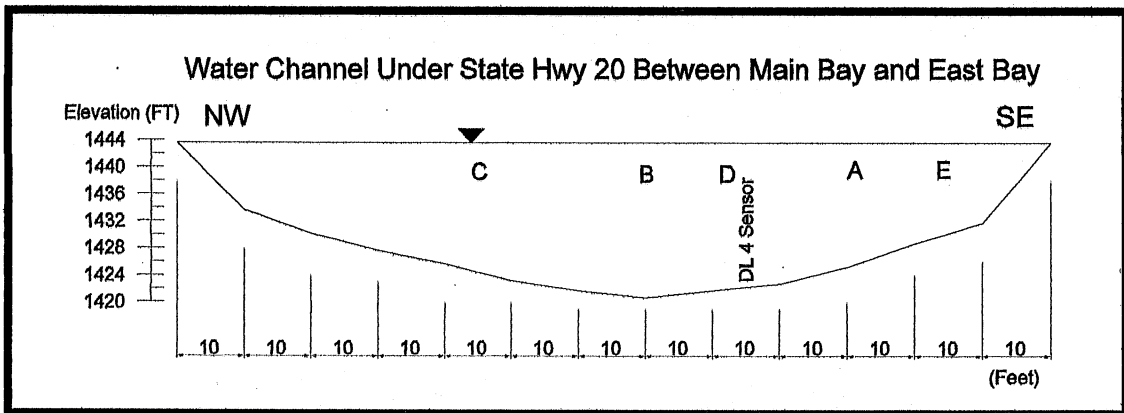


Figure 11-1.

Table 11-1 - Water velocity measurements recorded at State Highway 20 Bridge using a small, vertical axis Price meter.

Site ->	A			B			C			D			E	
Depth (FT)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)
4	13	0.48	0.70	3	0.12	0.18	4	0.16	0.23	3	0.12	0.18	3	0.
6	5	0.19	0.28	9	0.34	0.49	8	0.30	0.44	13	0.48	0.70	7	0.
8				14	0.51	0.75	15	0.55	0.81	14	0.51	0.75	14	0.
12				13	0.48	0.70	11	0.41	0.60	10	0.37	0.55		
Site ->	A			B			C			D			E	
Depth (FT)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)
3	4	0.30	0.44	3	0.23	0.34	2	0.16	0.23					
6	0	0.00	0.00	1	0.09	0.13	0	0.00	0.00					
9	3	0.23	0.34	1	0.09	0.13	3	0.23	0.34					
12	3	0.23	0.34	4	0.30	0.44	3	0.23	0.34					
15	0	0.00	0.00	2	0.16	0.23	4	0.30	0.44					
18				2	0.16	0.23	5	0.37	0.55					
21				5	0.37	0.55	5	0.37	0.55					
Site ->	A			B			C			D			E	
Depth (FT)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)
3	4	0.30	0.44	10	0.73	1.07	5	0.37	0.55					
6	5	0.37	0.55	6	0.44	0.65	4	0.30	0.44					
9	4	0.30	0.44	8	0.59	0.86	4	0.30	0.44					
12	4	0.30	0.44	7	0.51	0.75	5	0.37	0.55					
15	6	0.44	0.65	7	0.51	0.75	5	0.37	0.55					
18	4	0.30	0.44	7	0.51	0.75	3	0.23	0.34					
21	6	0.44	0.65	6	0.44	0.65	3	0.23	0.34					
Site ->	A			B			C			D			E	
Depth (FT)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)	(MPH)	(Rev)	(FPS)
0.5				5	0.37		6	0.44						
3	8	0.59	0.86	5	0.37	0.55	5	0.37	0.55					
6	6	0.44	0.65	7	0.51	0.75	6	0.44	0.65					
9	5	0.37	0.55	7	0.51	0.75	7	0.51	0.75					

Bridge and Culvert Measurements (Continued)

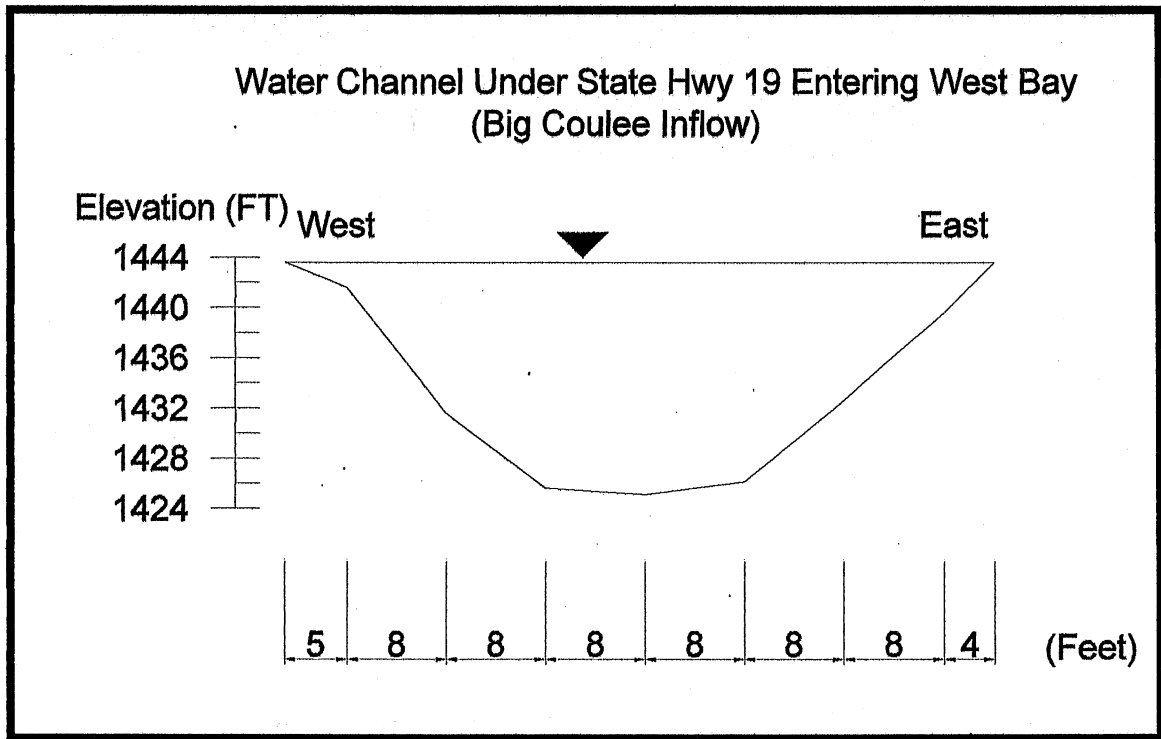


Figure 11-2

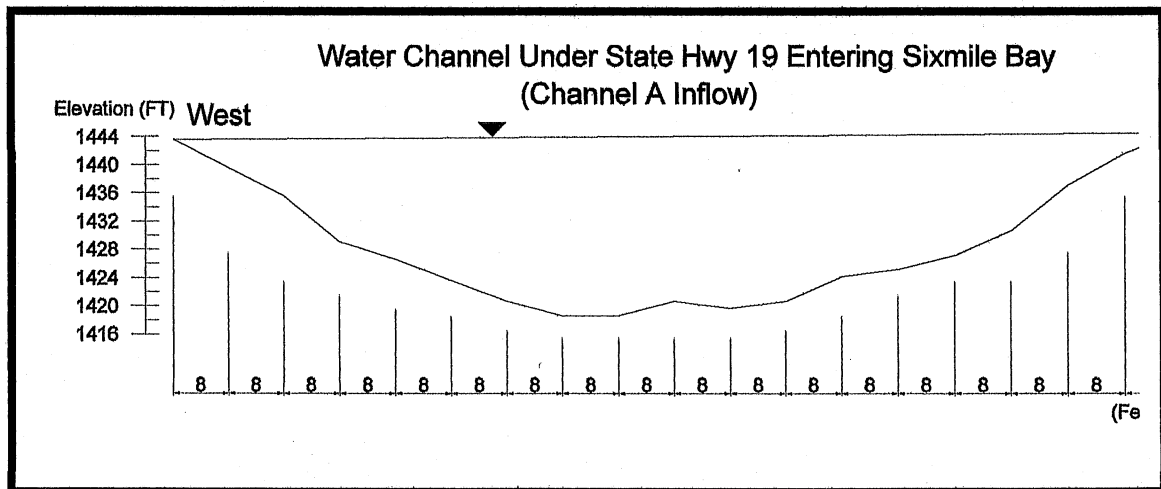


Figure 11-3

Bridge and Culvert Measurements (Continued)

Culvert Data

1. State Highway 281 between State Highway 19 and the town of Minnewauken.

- A) 2 each 84" culverts
- B) 2 each 60" culverts
- C) 2 each, 24" culverts

Flow was observed moving from west to east through the culverts.

2. State Highway 19 north of West Bay.
 - 2 each, 54" culverts

Culverts were submerged and direction of flow was not visible, however the impoundment to the north of Highway 19 was not large and did not appear to be a Devils Lake source.

3. Road leading to Graham's Island from State Highway 19.

No culverts were visible. It does not appear that the culverts were replaced when the road was raised.

4. State Highway 57 at the "narrows".

The road was covered with approximately 3 feet of water and the channel beneath the submerged bridge did not appear blocked.

5. Woods-Rutten Road.

The road was covered with approximately 1 foot of water. Existing culverts were not visible, so their functionality was not checked.

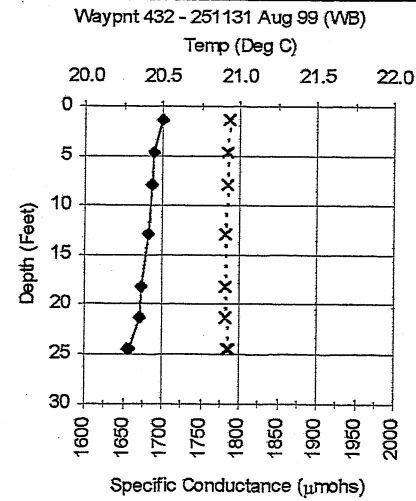
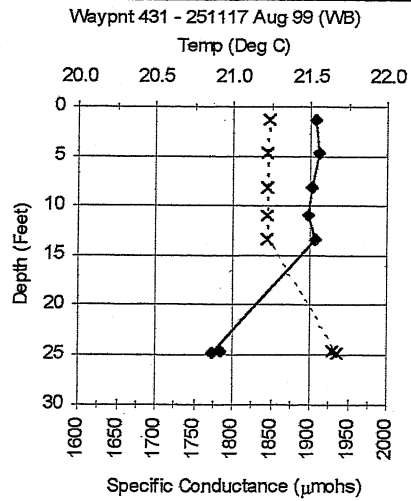
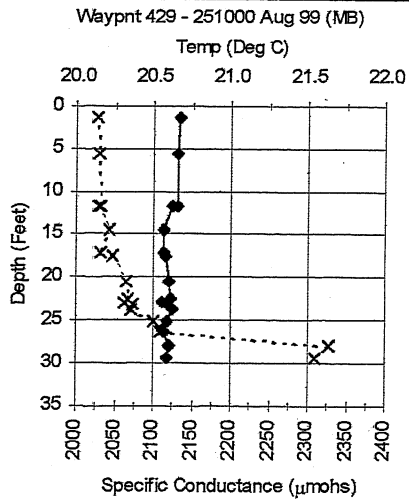
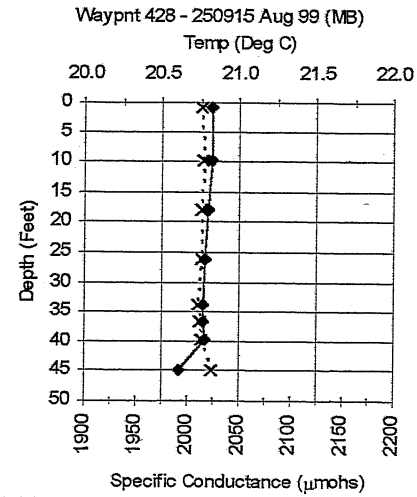
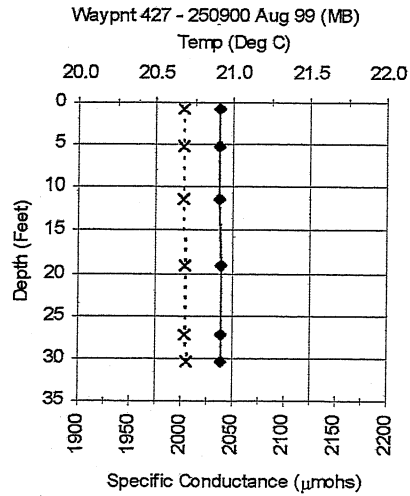
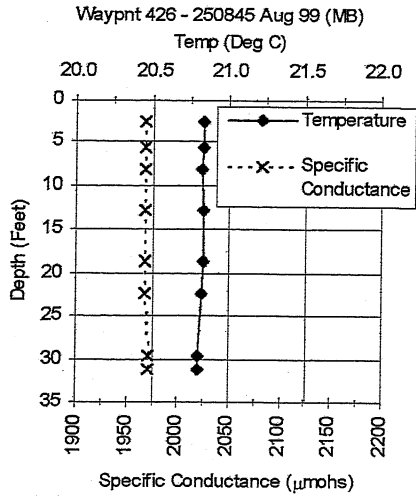
Section II

August 1999

Temperature and Specific Conductance Profiles

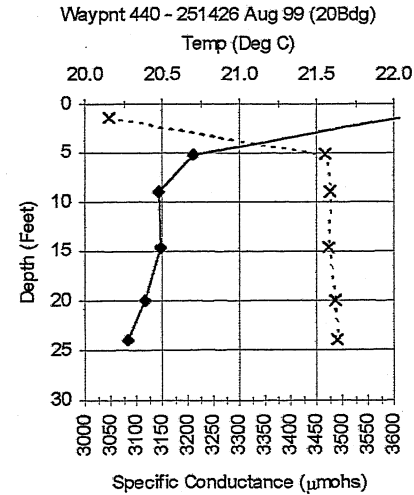
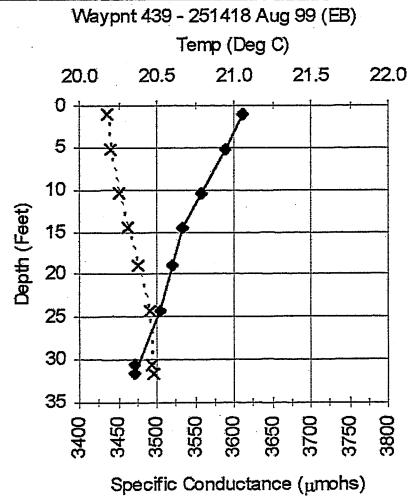
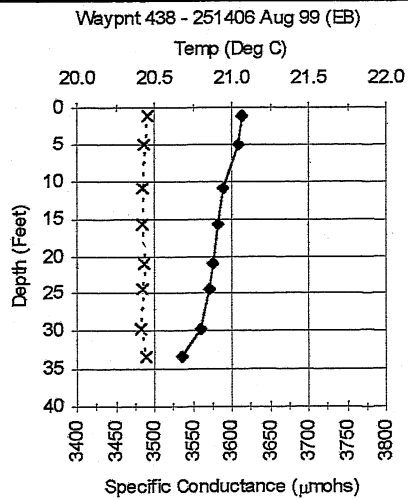
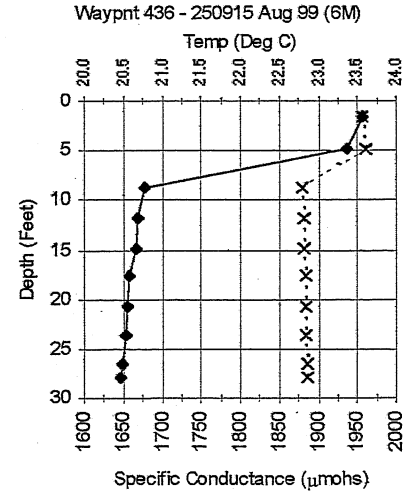
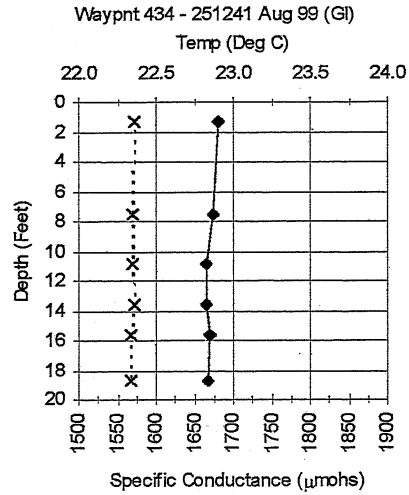
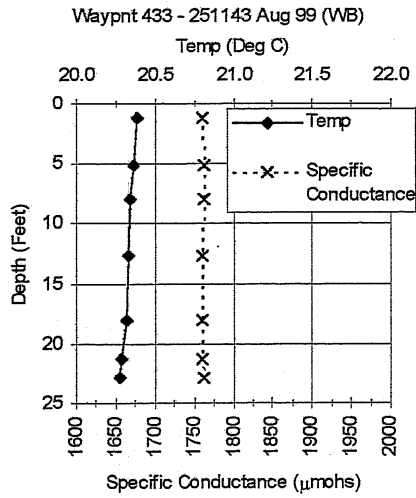
August 1999 Devils Lake Profiles

MB = Main Bay
WB = West Bay



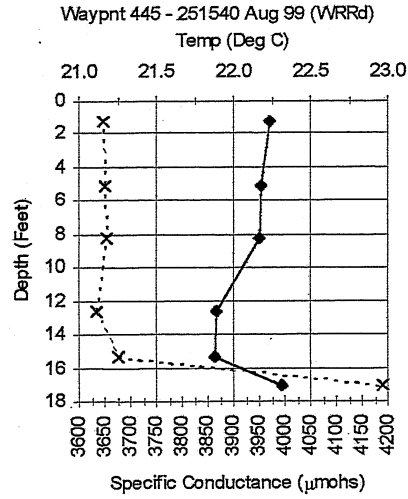
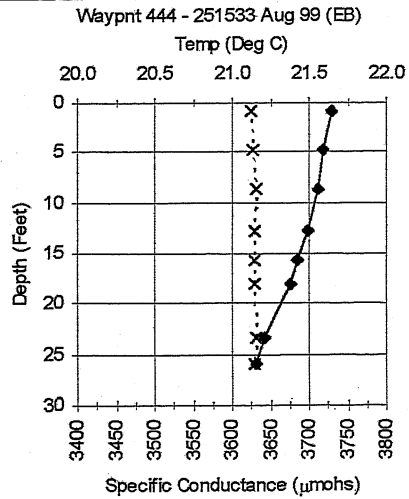
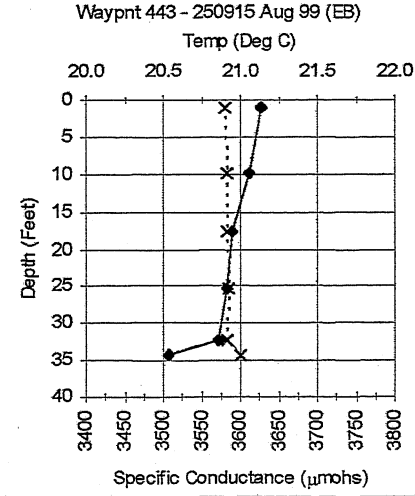
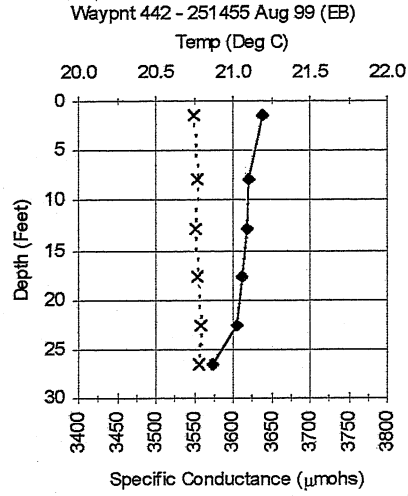
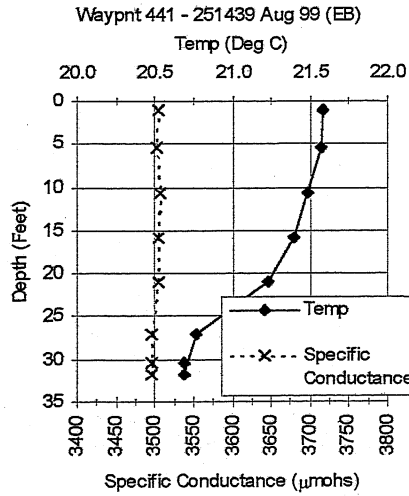
August 1999 Devils Lake Profiles

WB = West Bay
 GI = Graham's Island
 6M = Six Mile Bay
 EB = East Bay



August 1999 Devils Lake Profiles

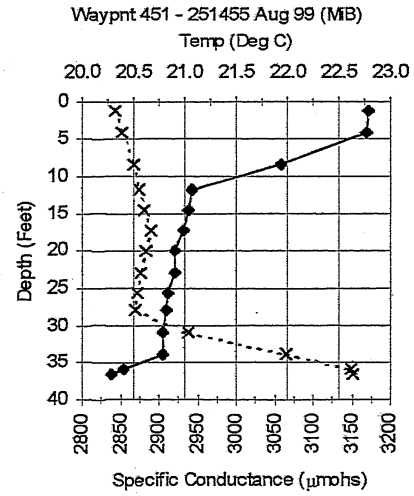
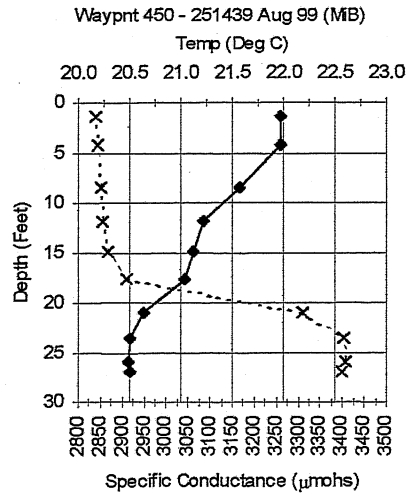
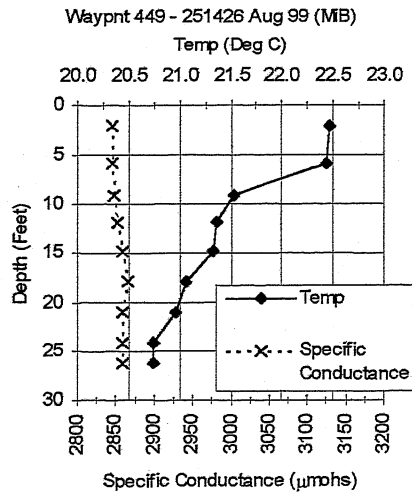
EB = East Bay
WRRd = Woods-Rutten Road



August 1999 Devils Lake Profiles

MiB = Mission Bay

11-4

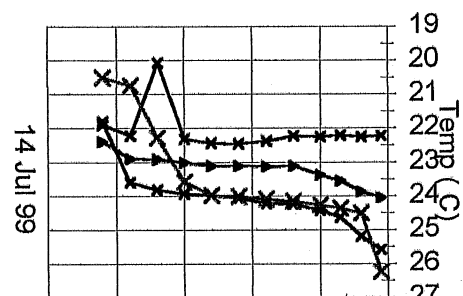
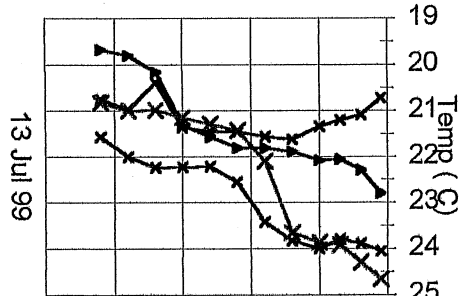
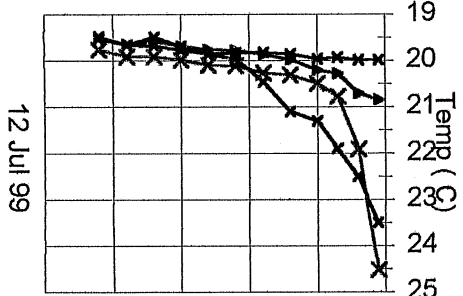
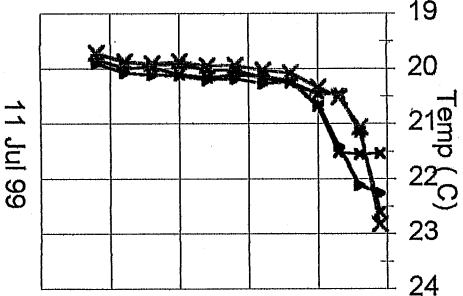
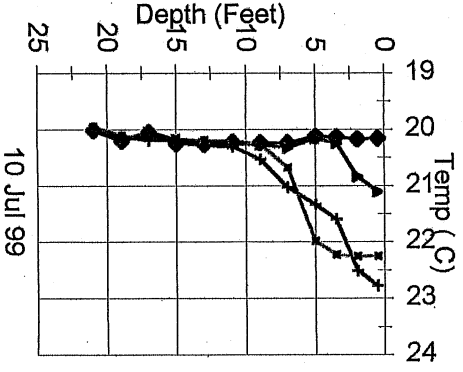
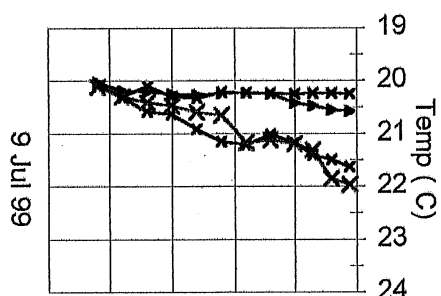
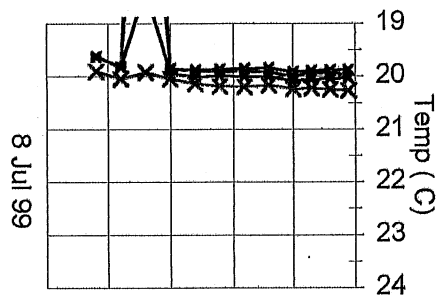
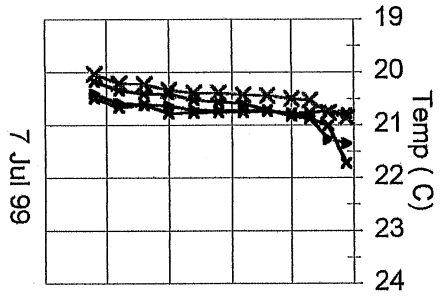
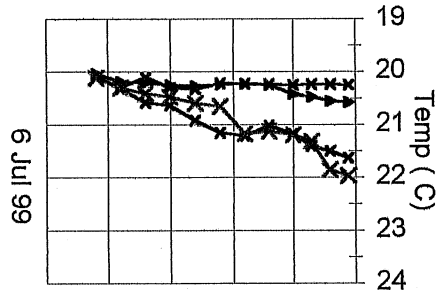
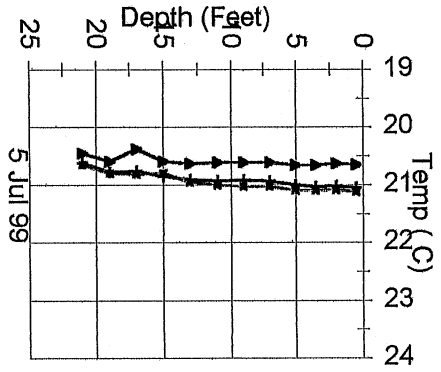


Section III

July and August 1999

Thermistor Profiles

Devils Lake Thermistor Chain Profiles (East Bay)



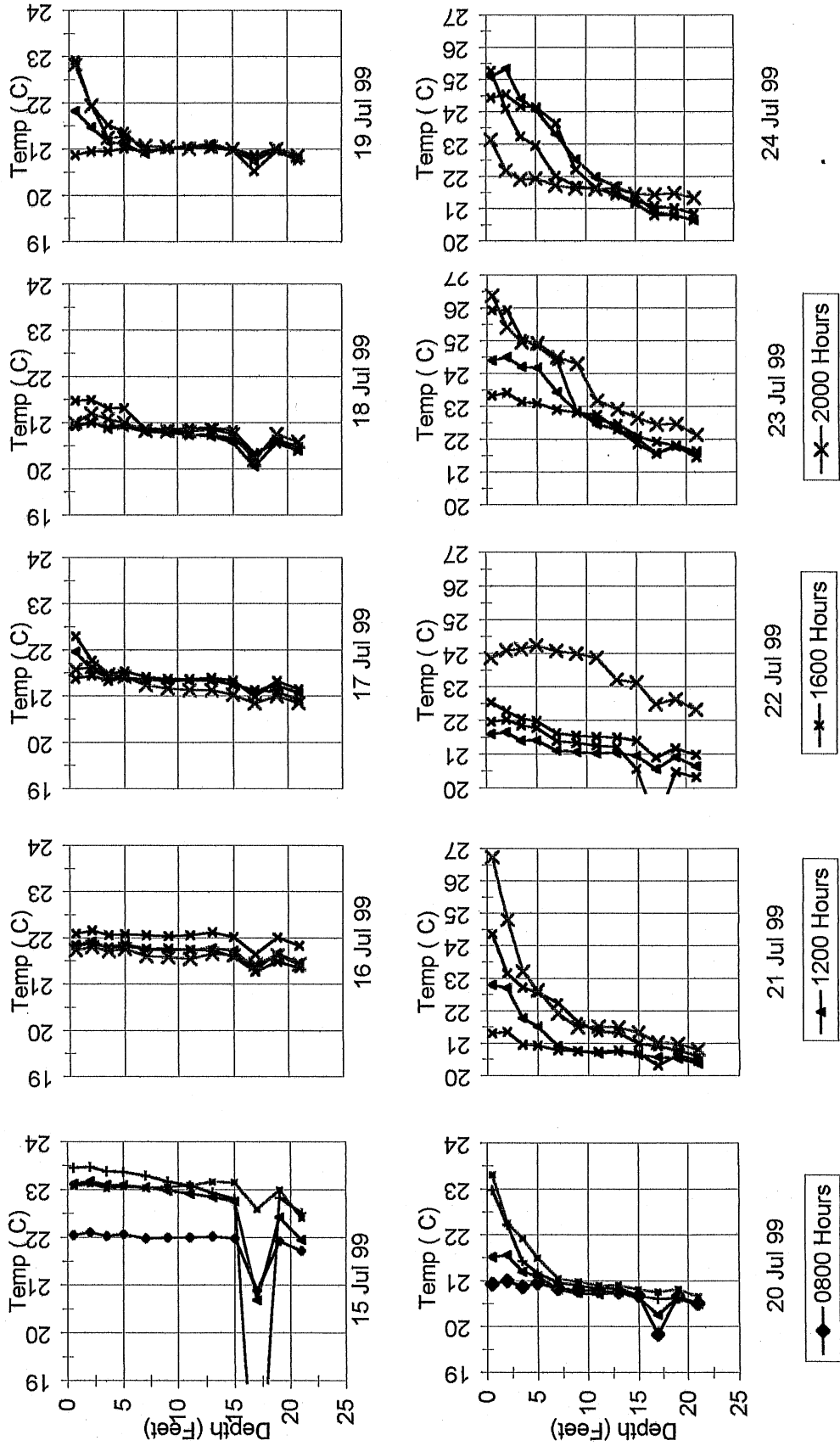
—●— 0800 Hours

—▲— 1200 Hours

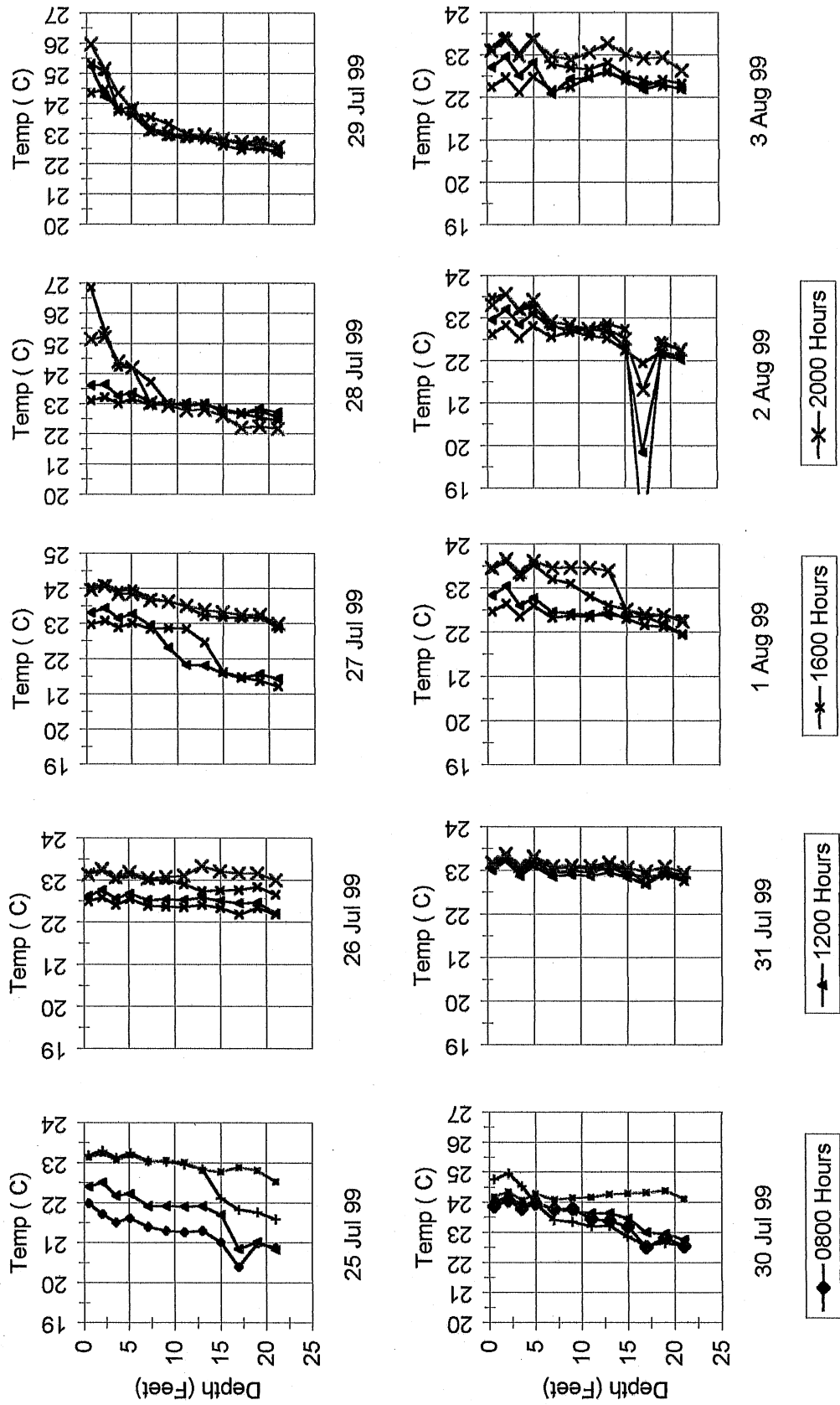
—*— 1600 Hours

—x— 2000 Hours

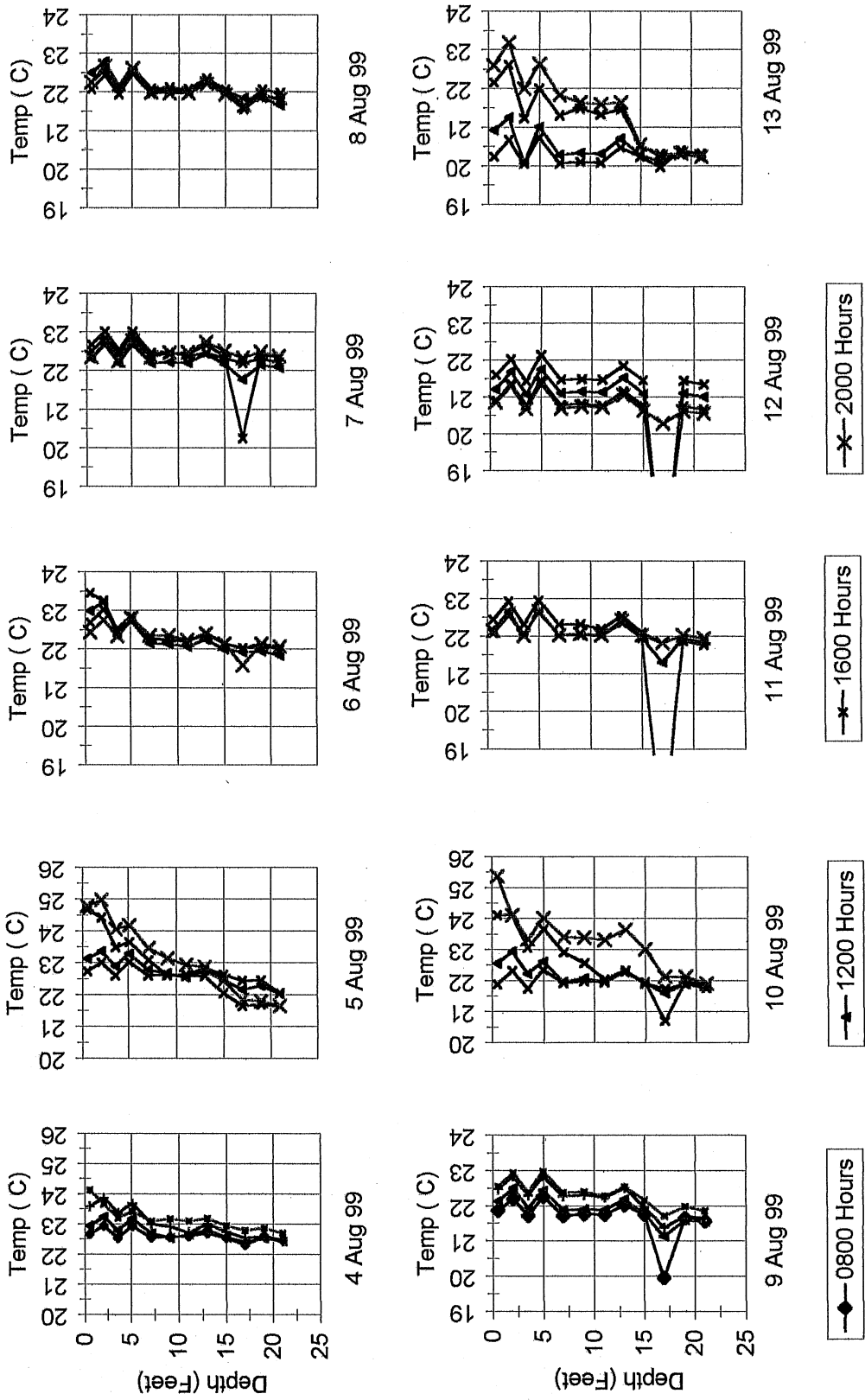
Devils Lake Thermistor Chain Profiles (East Bay)



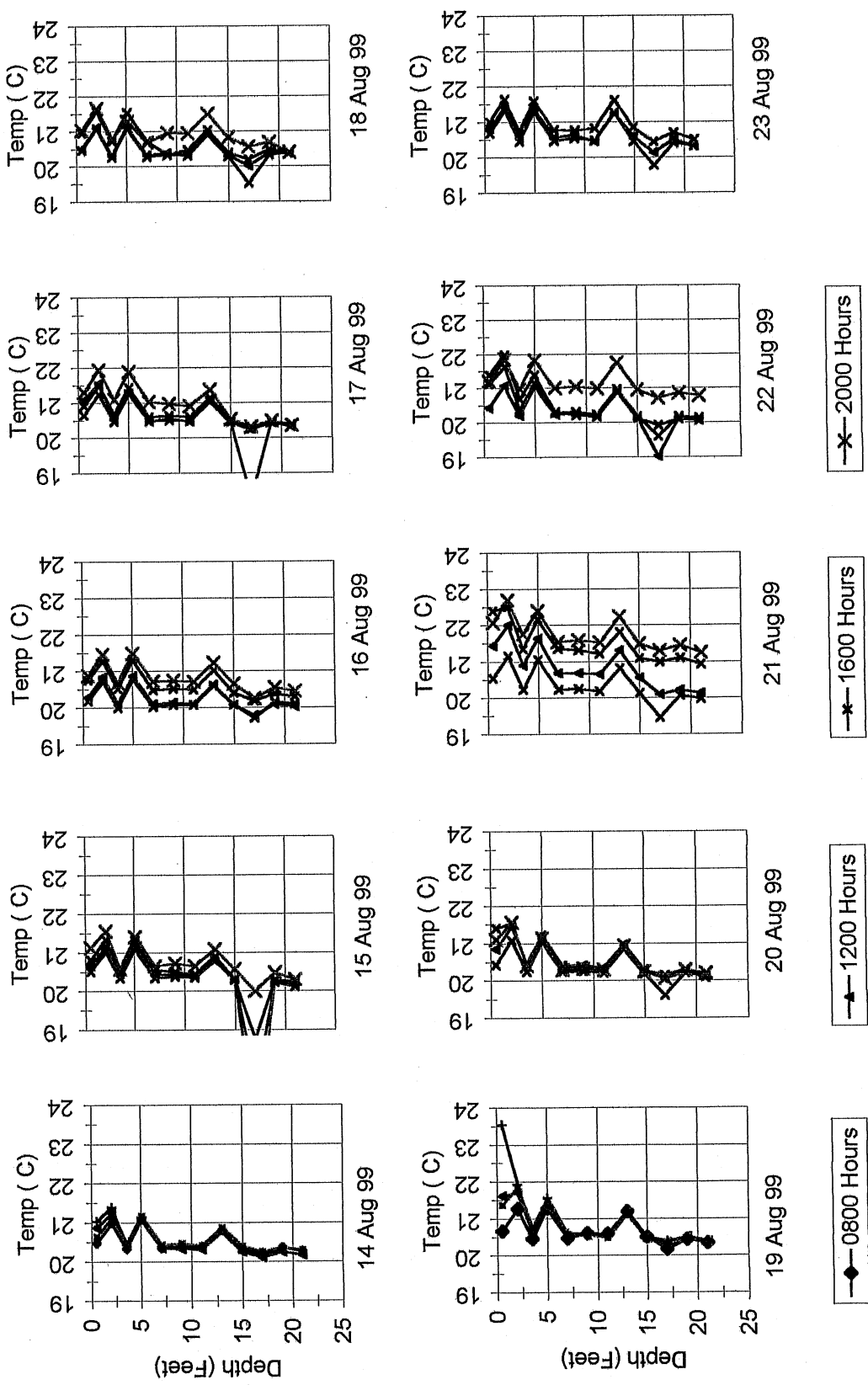
Devils Lake Thermistor Chain Profiles (East Bay)



Devils Lake Thermistor Chain Profiles (East Bay)



Devils Lake Thermistor Chain Profiles (East Bay)

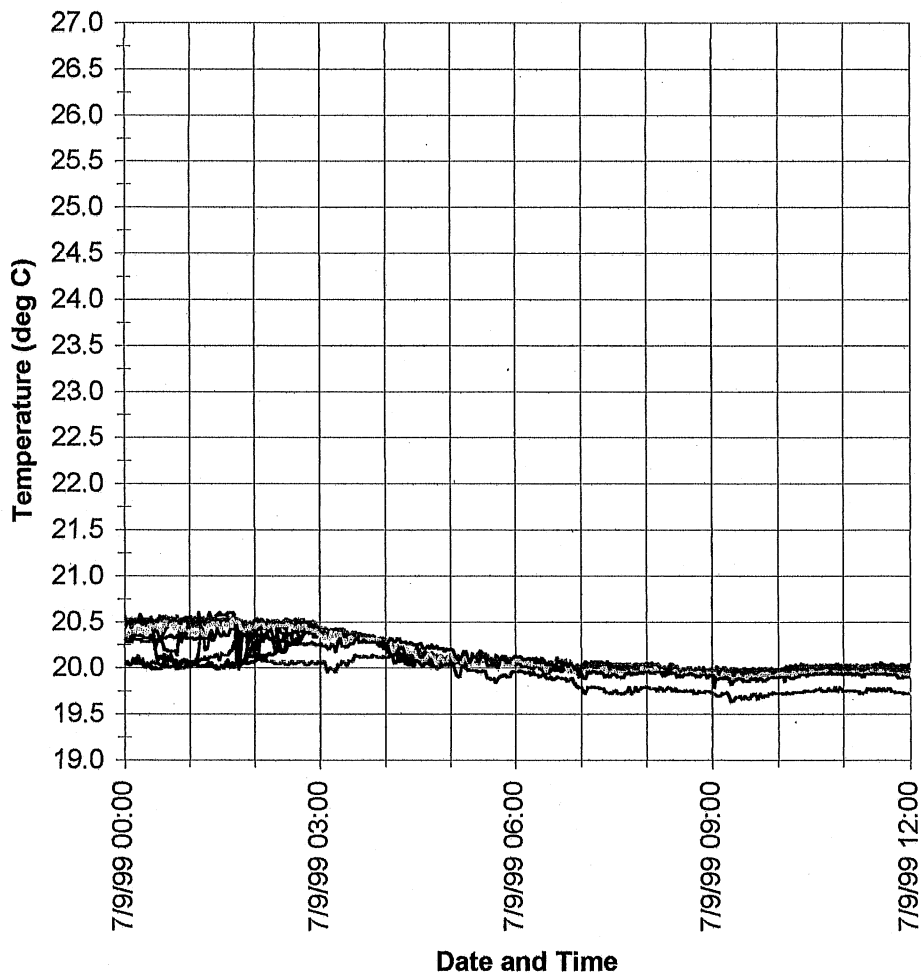
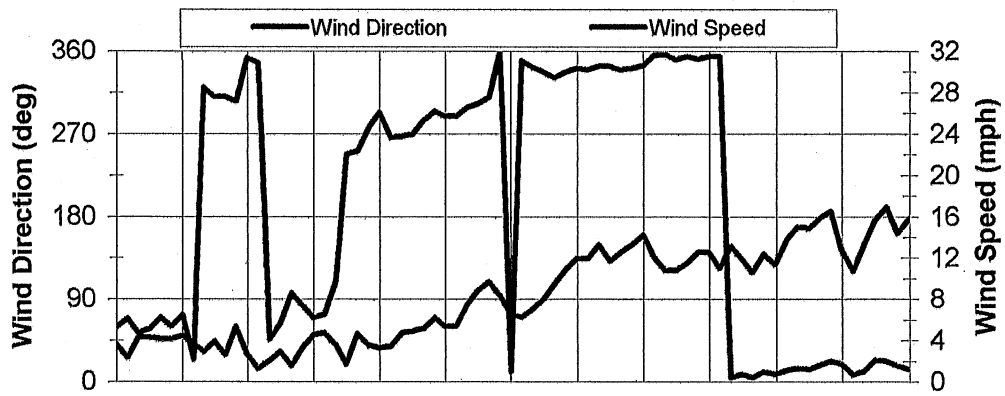


Section IV

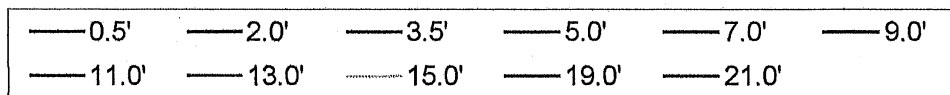
July and August 1999

Thermistor Record

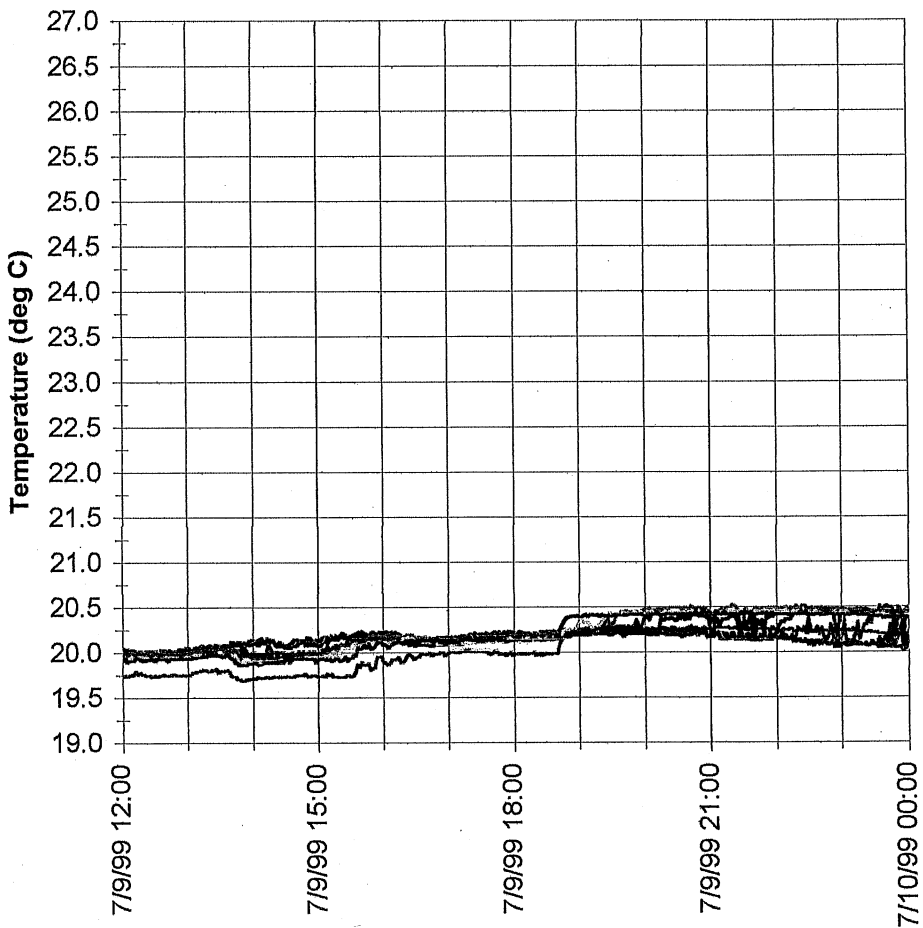
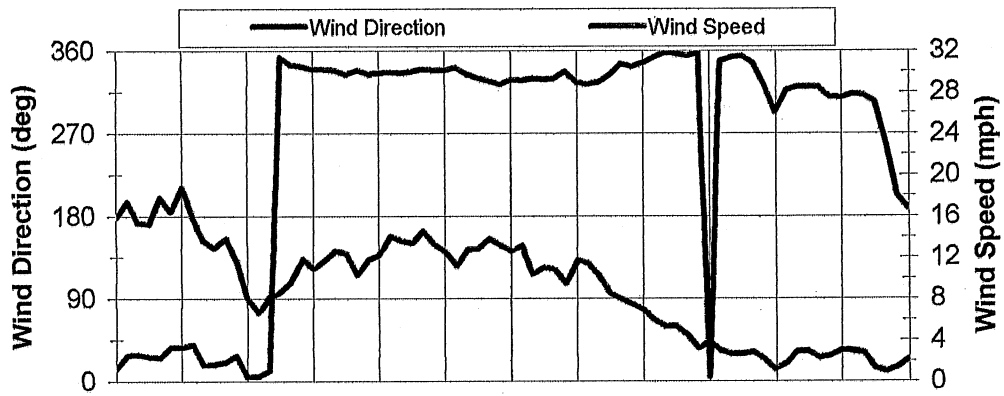
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

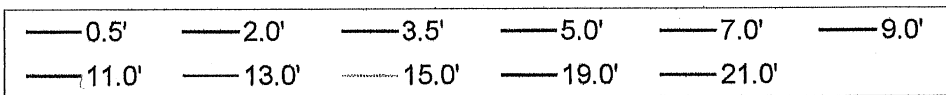


Devils Lake Thermistor Chain Record (East Bay)

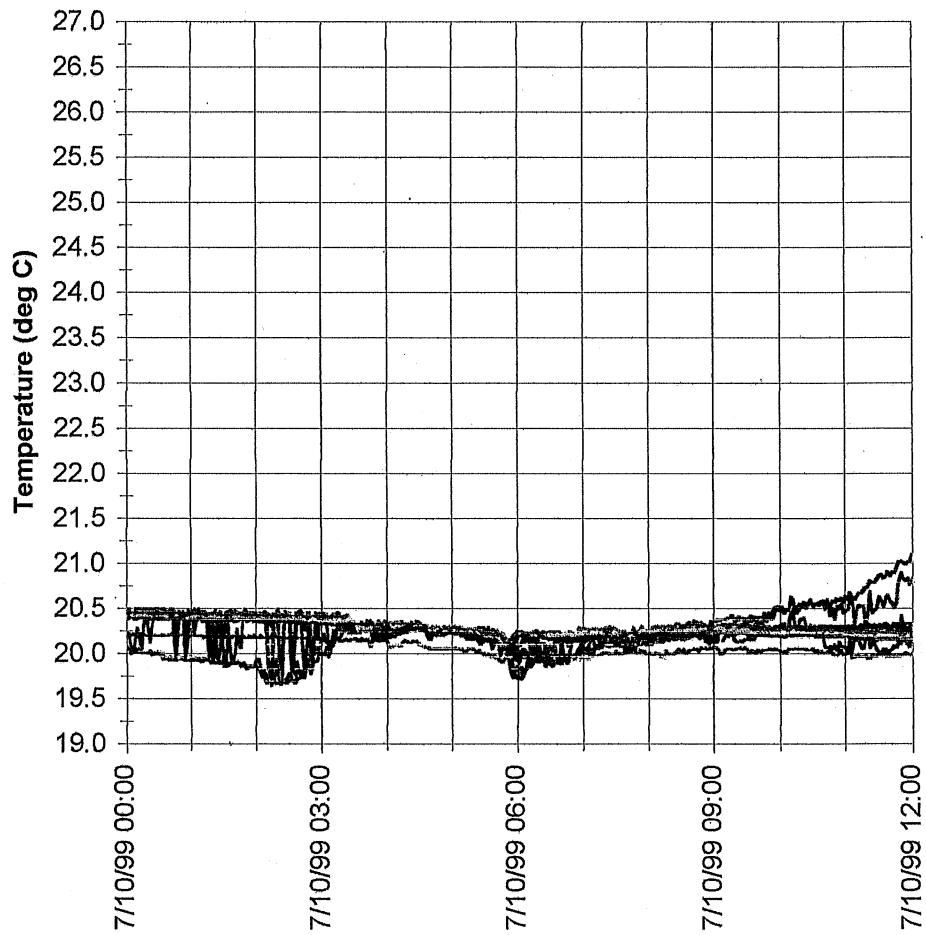
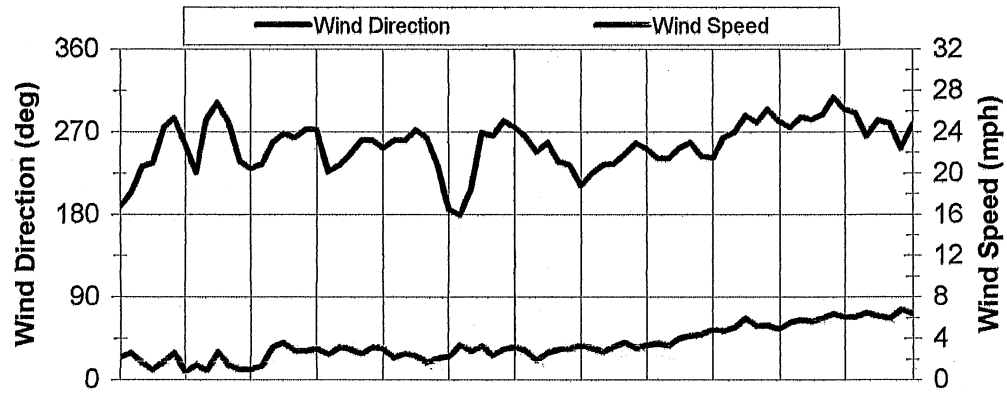


Date and Time

Depth From Surface

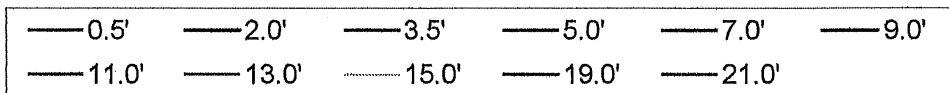


Devils Lake Thermistor Chain Record (East Bay)

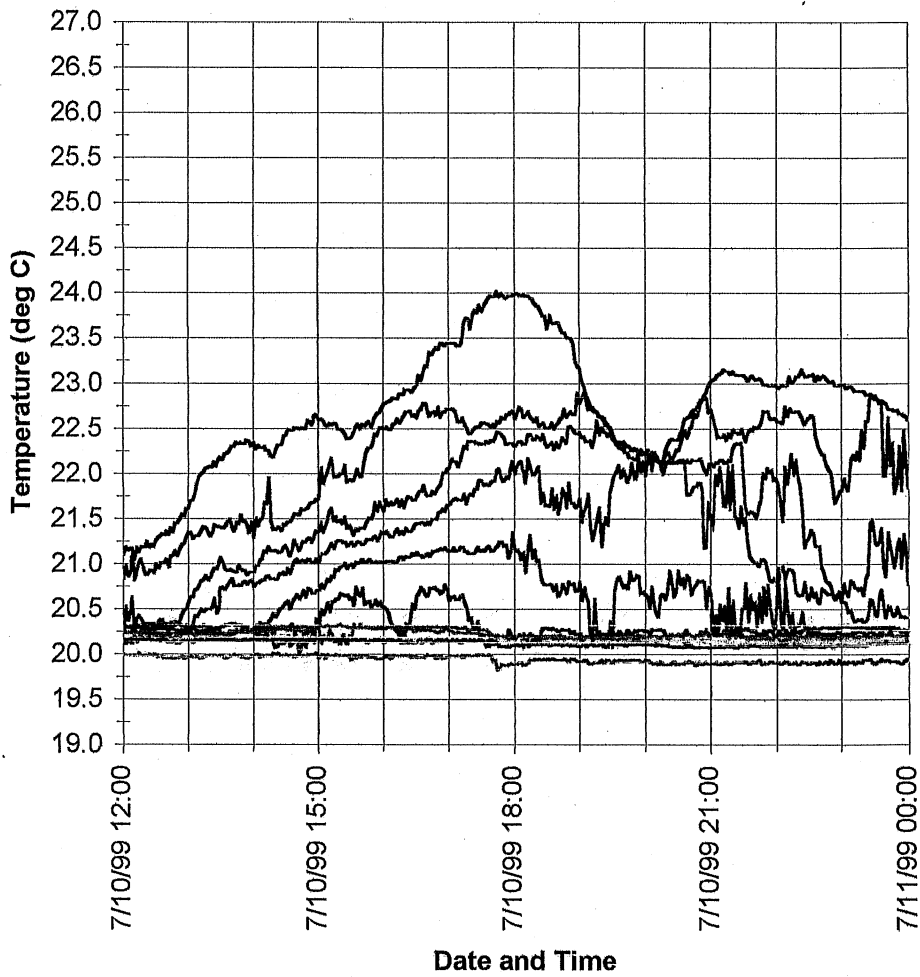
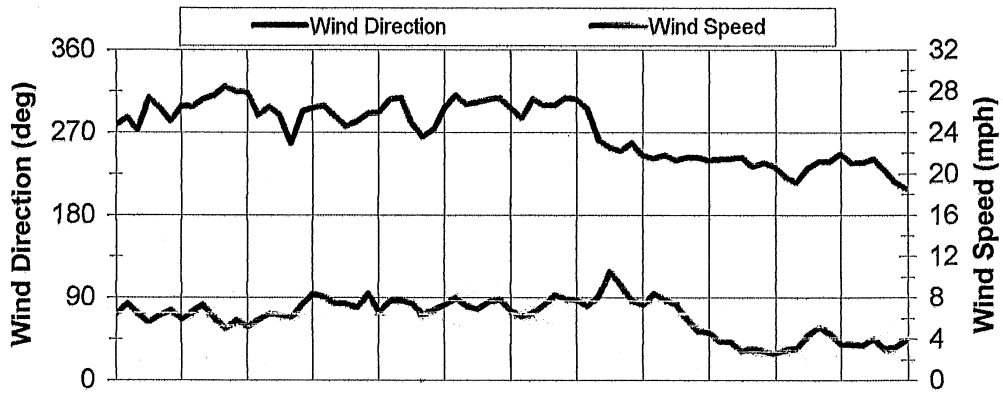


Date and Time

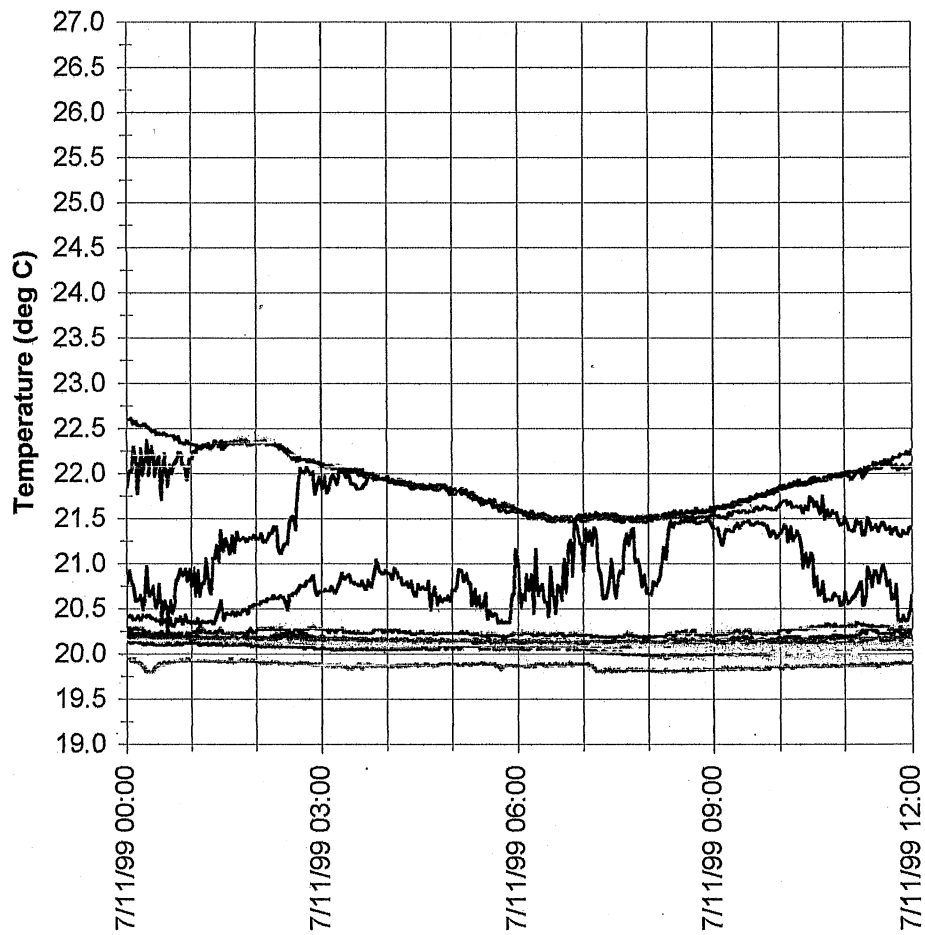
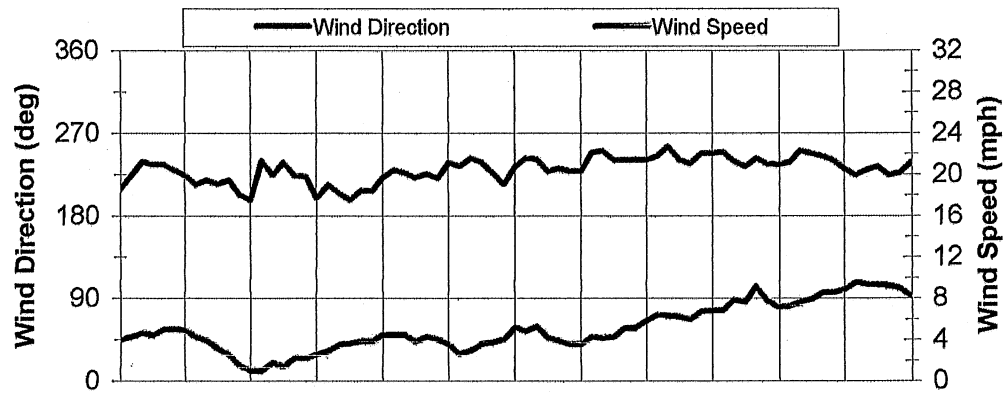
Depth From Surface



Devils Lake Thermistor Chain Record (East Bay)

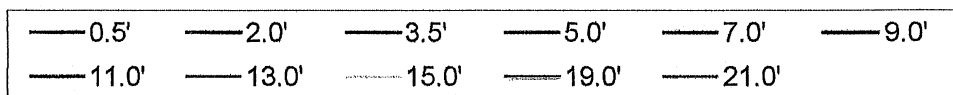


Devils Lake Thermistor Chain Record (East Bay)

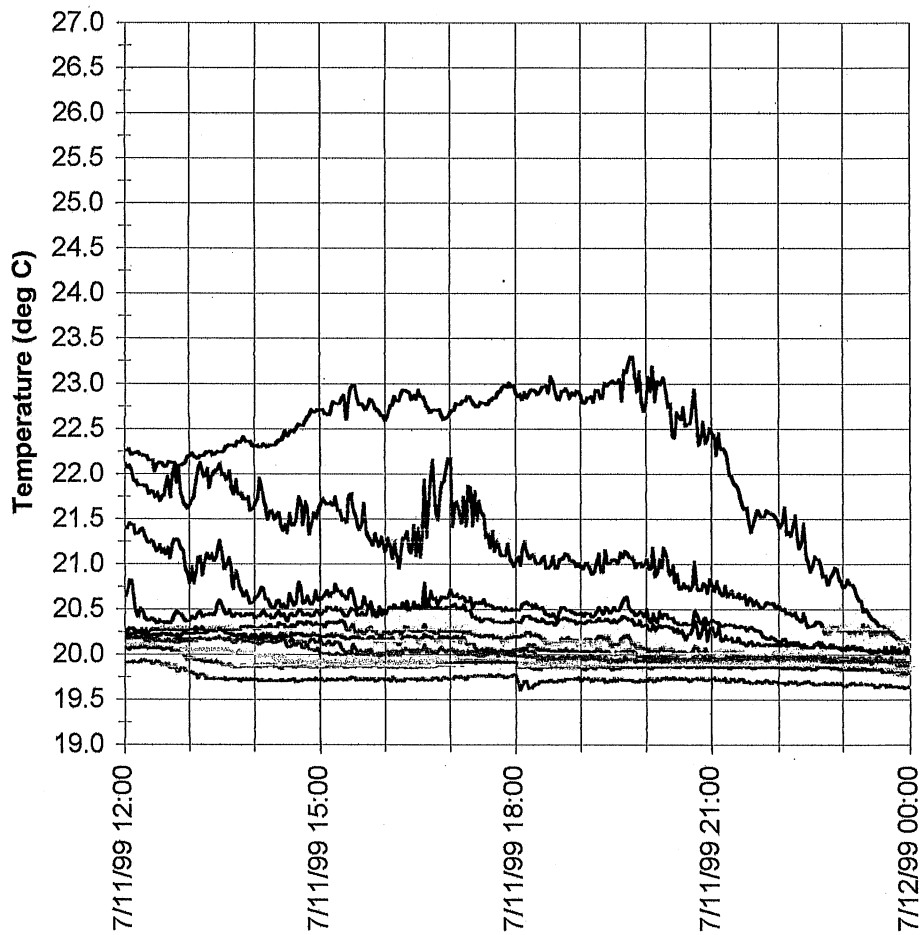
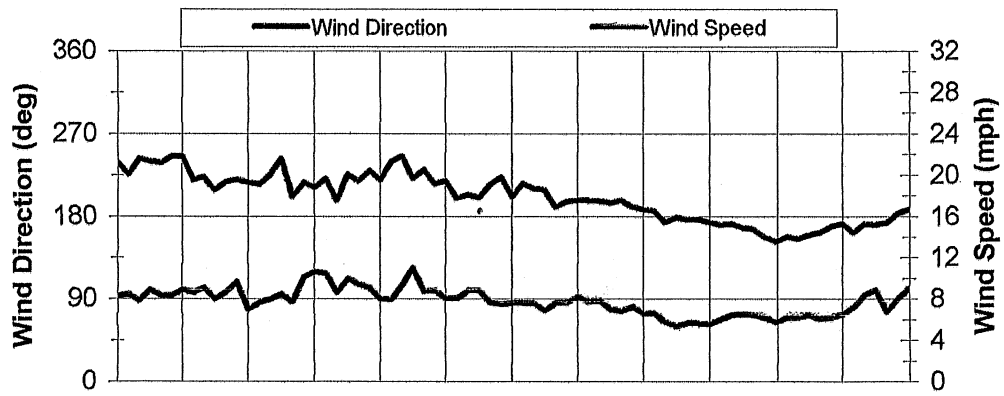


Date and Time

Depth From Surface

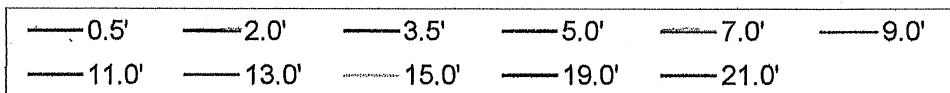


Devils Lake Thermistor Chain Record (East Bay)

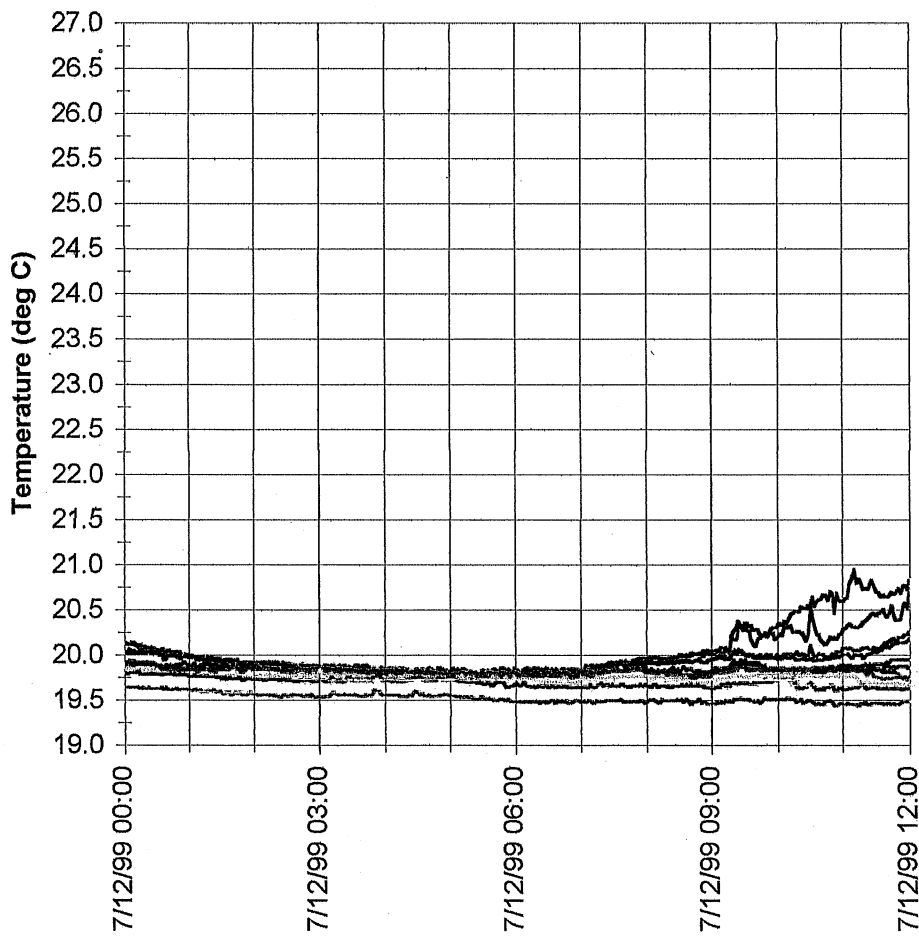
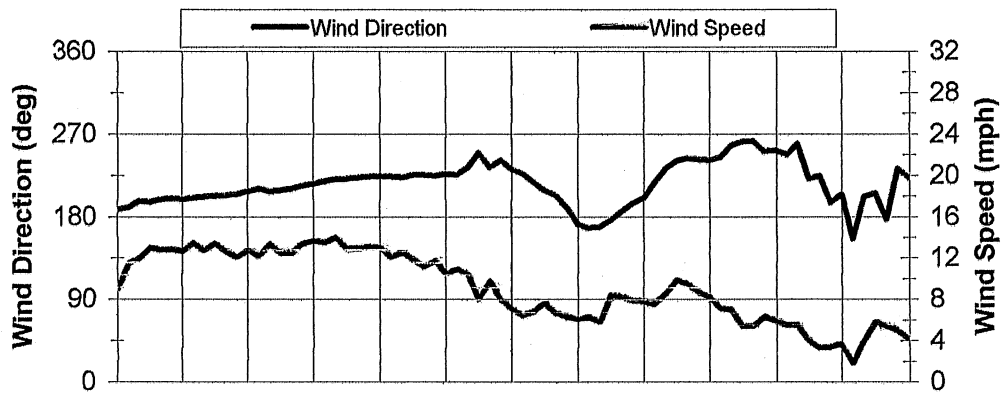


Date and Time

Depth From Surface

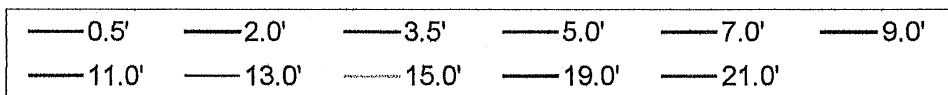


Devils Lake Thermistor Chain Record (East Bay)

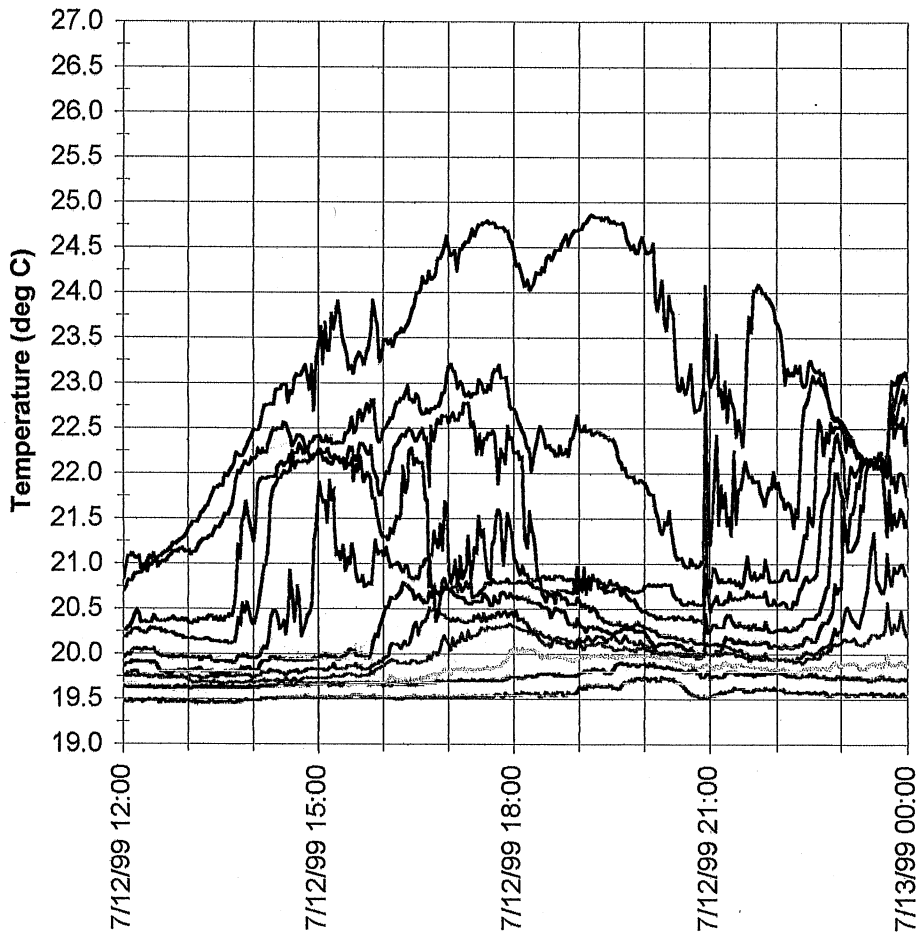
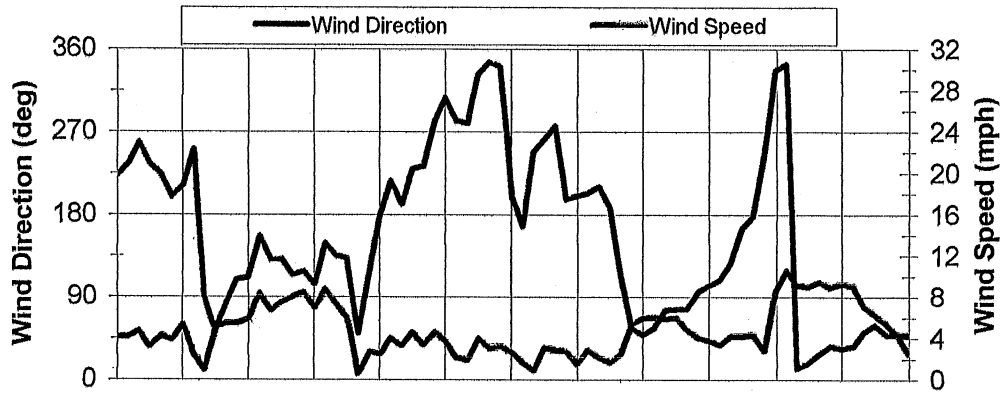


Date and Time

Depth From Surface

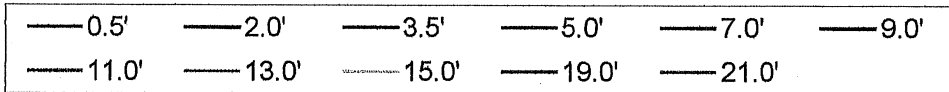


Devils Lake Thermistor Chain Record (East Bay)

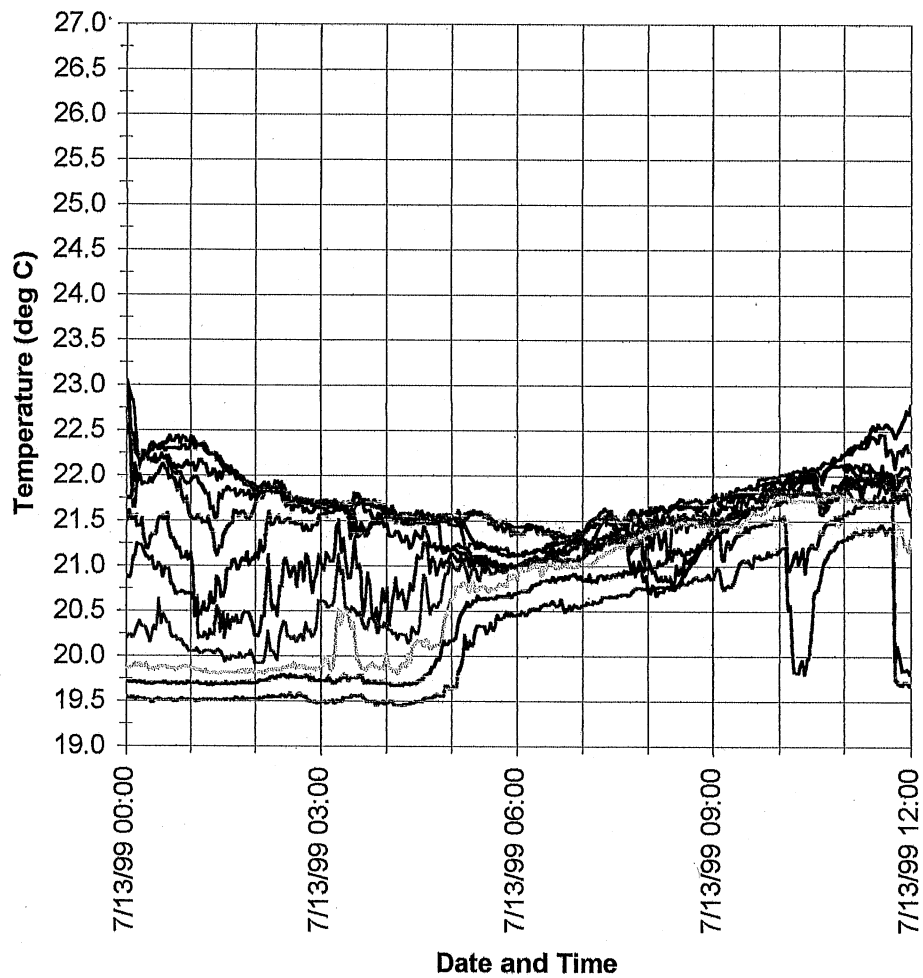
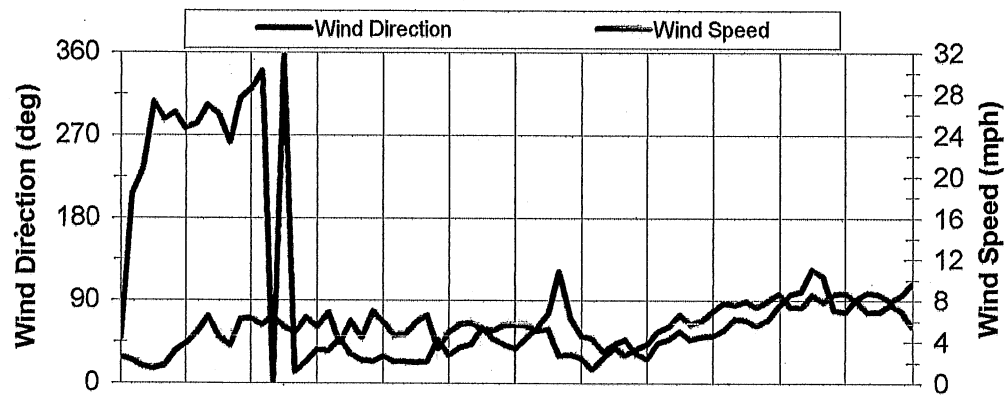


Date and Time

Depth From Surface



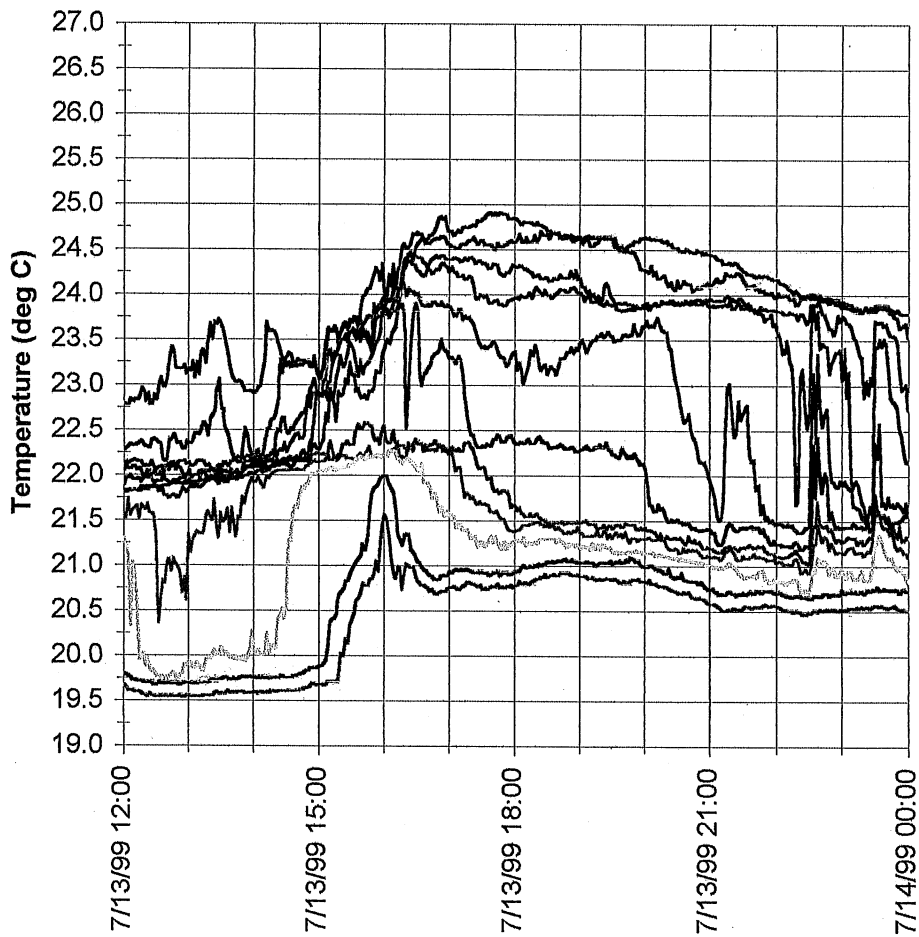
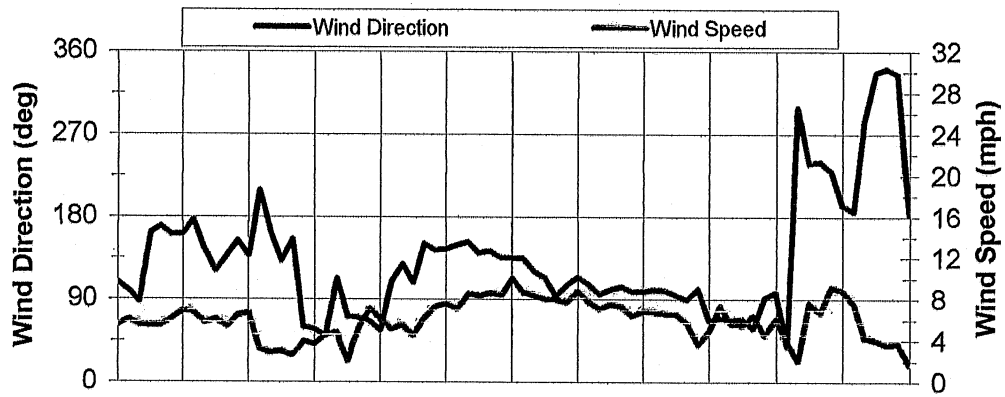
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

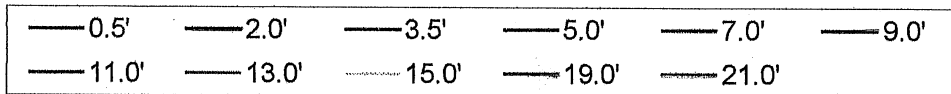
— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

Devils Lake Thermistor Chain Record (East Bay)

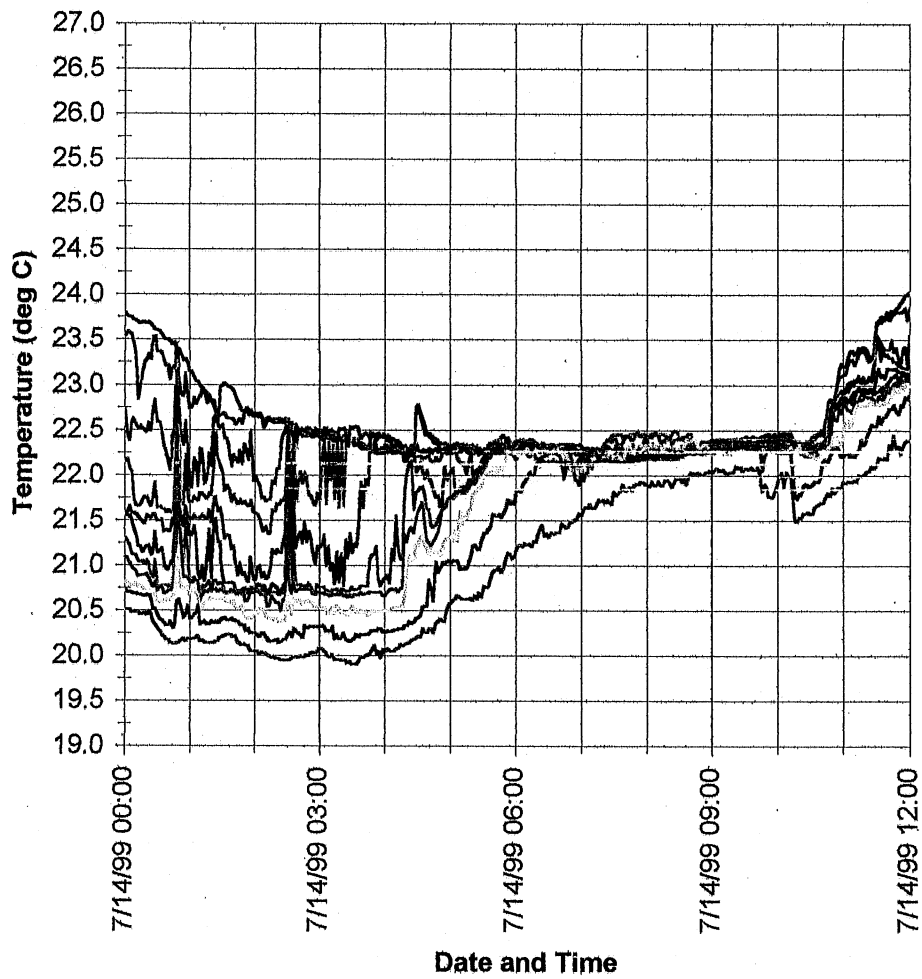
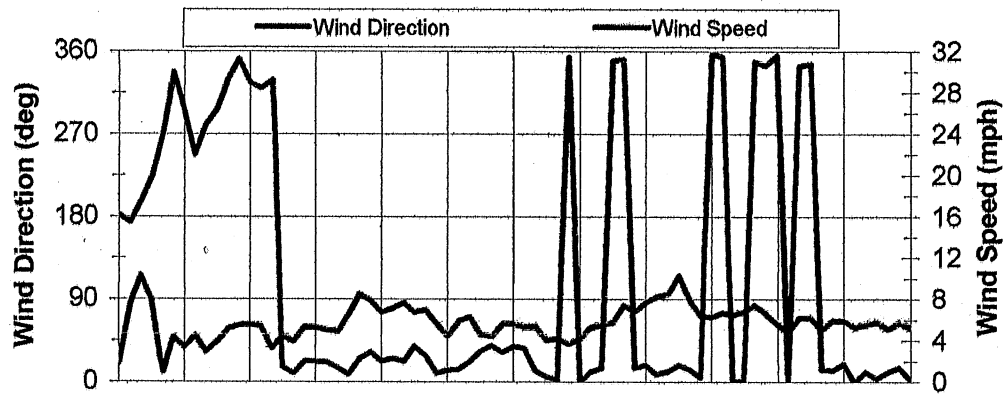


Date and Time

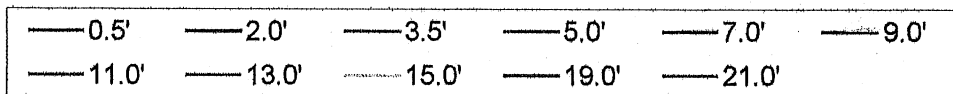
Depth From Surface



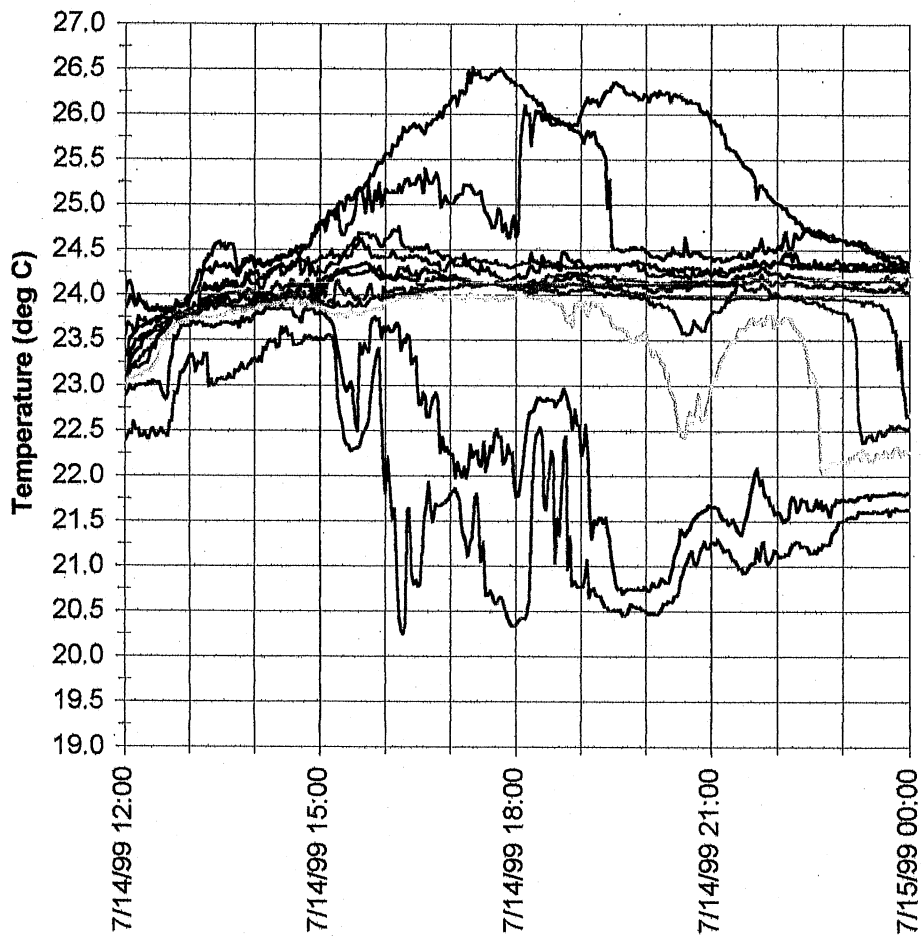
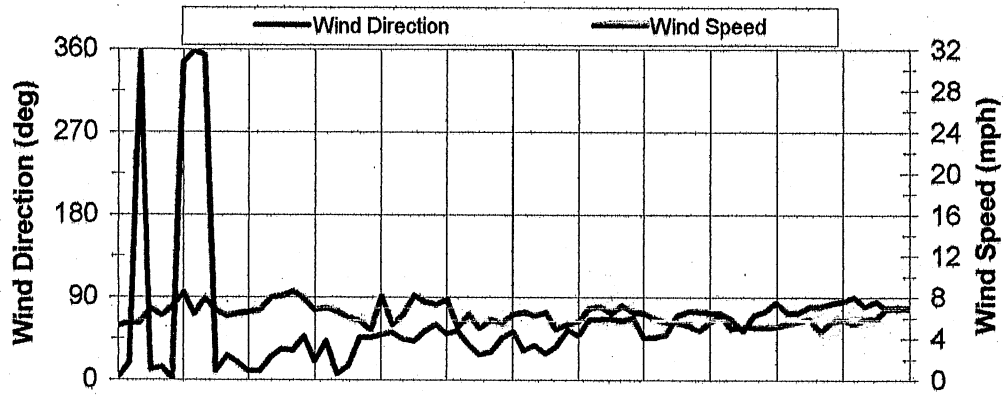
Devils Lake Thermistor Chain Record (East Bay)



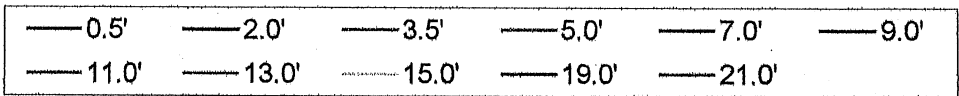
Depth From Surface



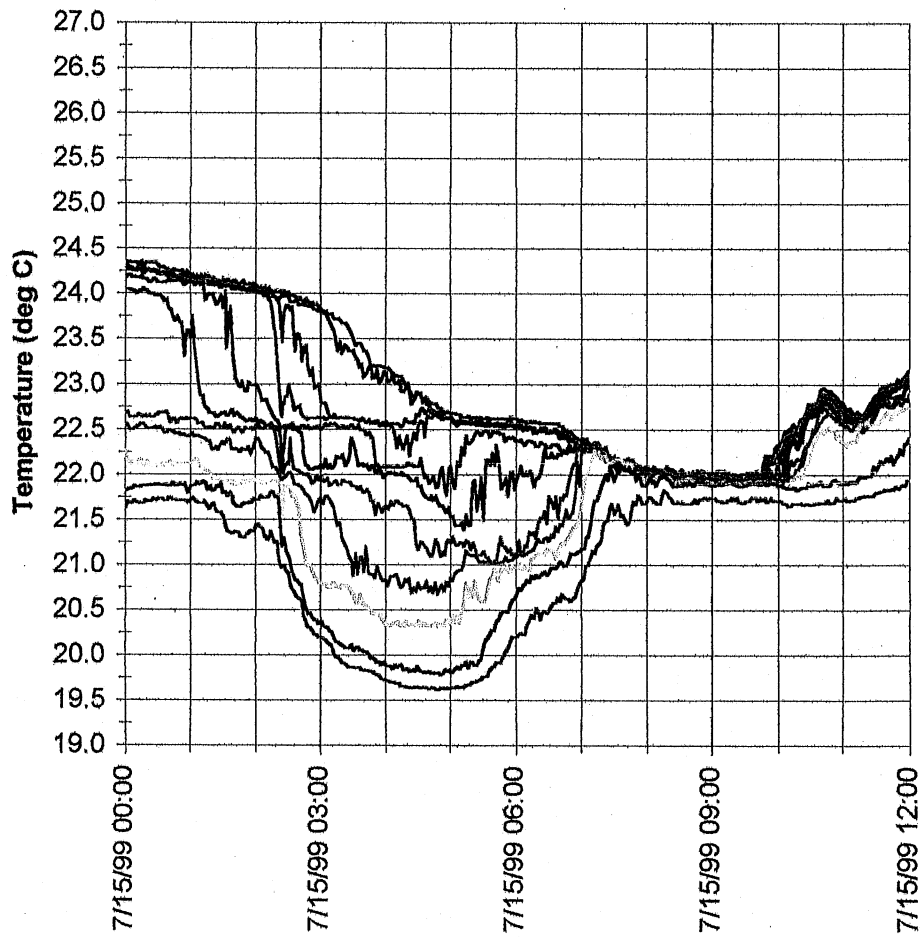
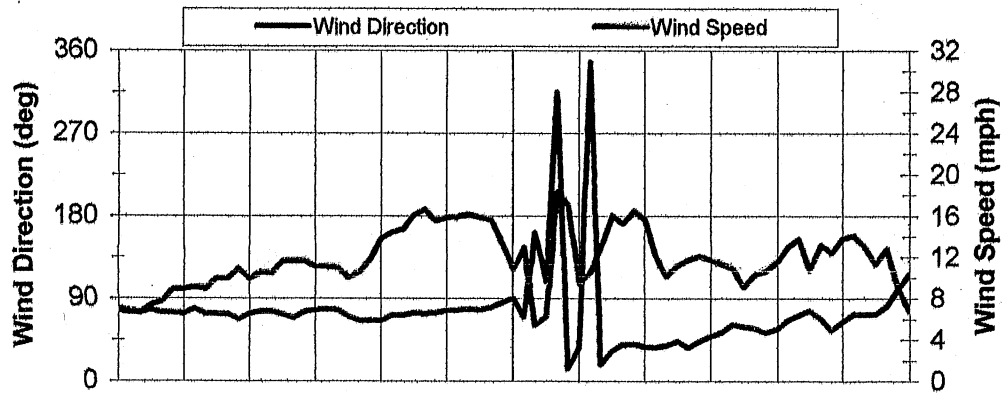
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

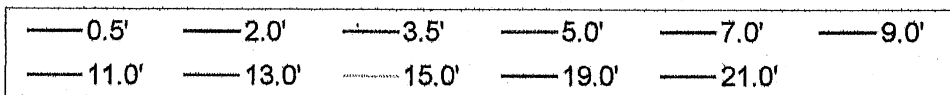


Devils Lake Thermistor Chain Record (East Bay)

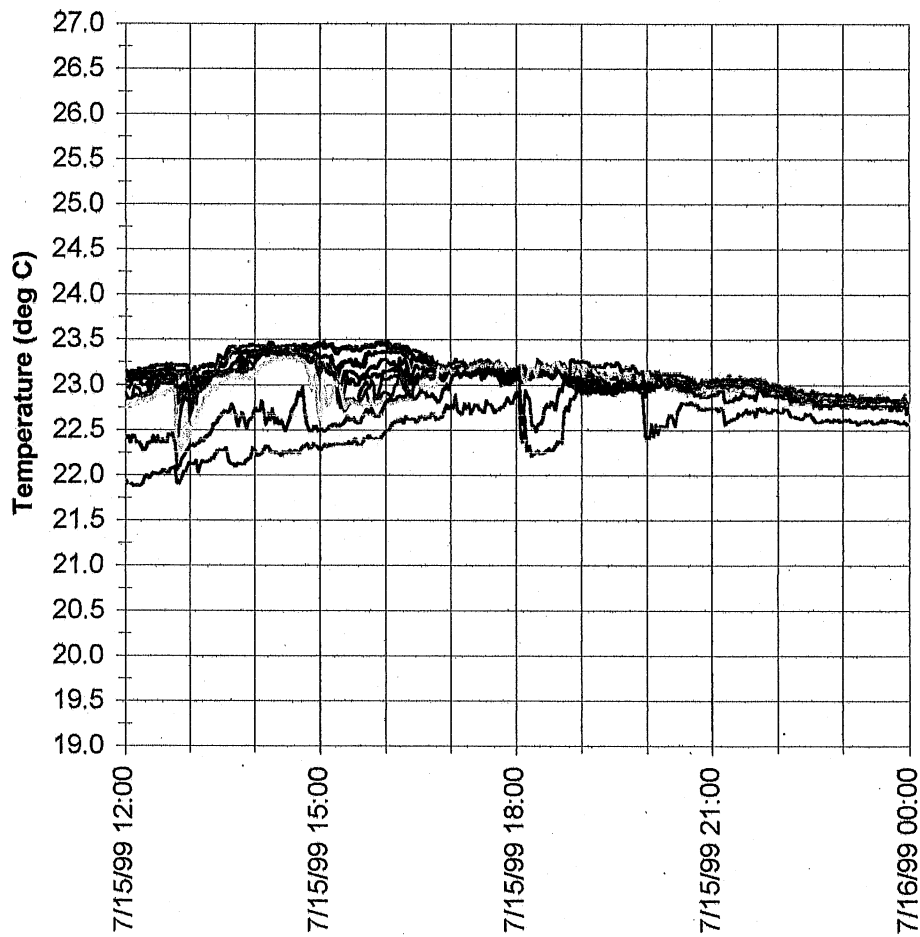
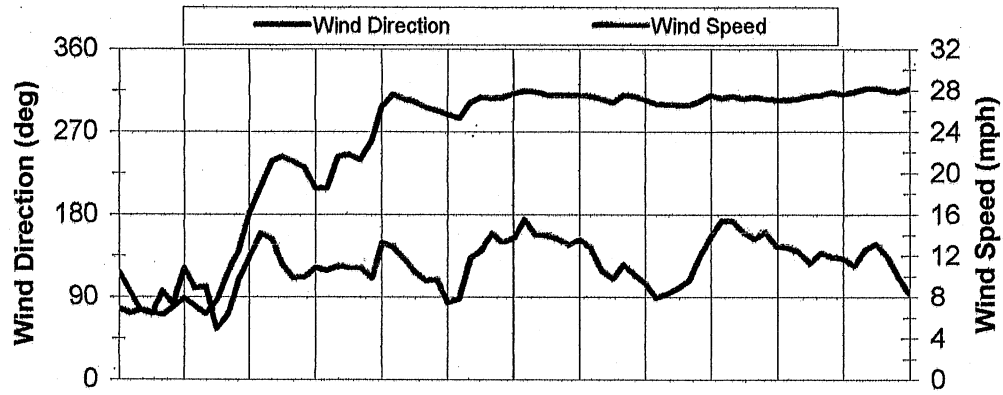


Date and Time

Depth From Surface

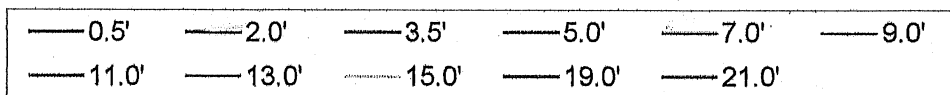


Devils Lake Thermistor Chain Record (East Bay)

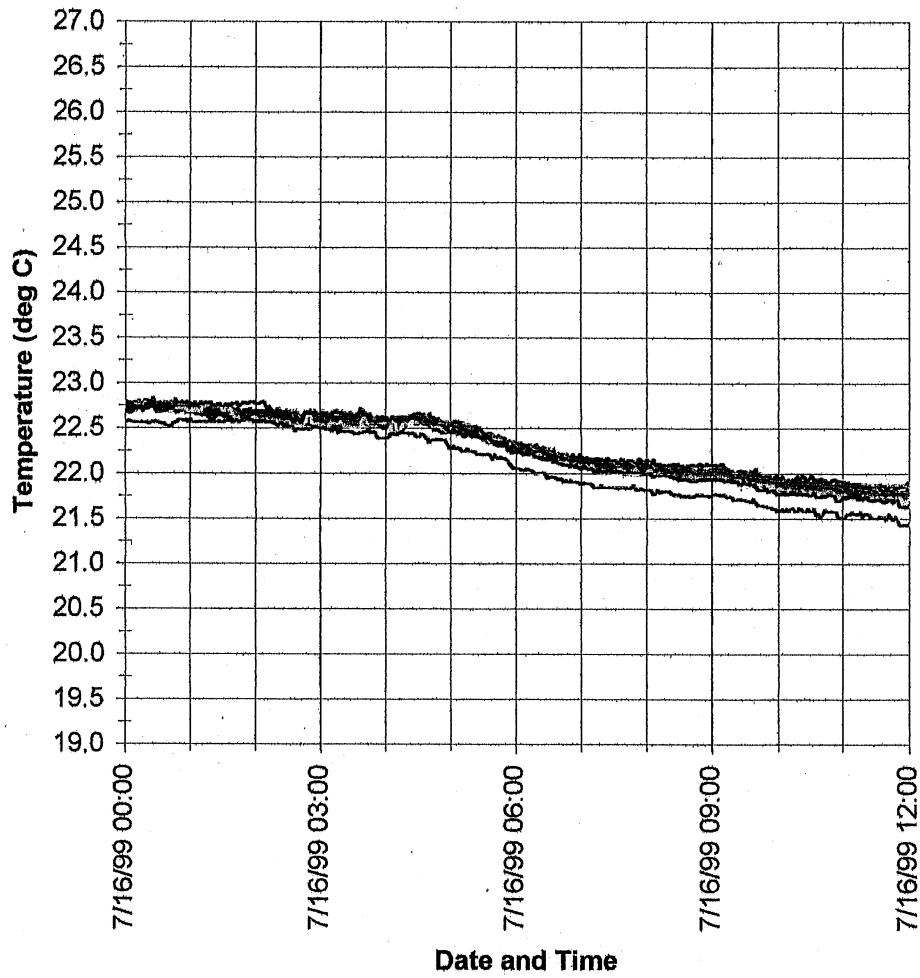
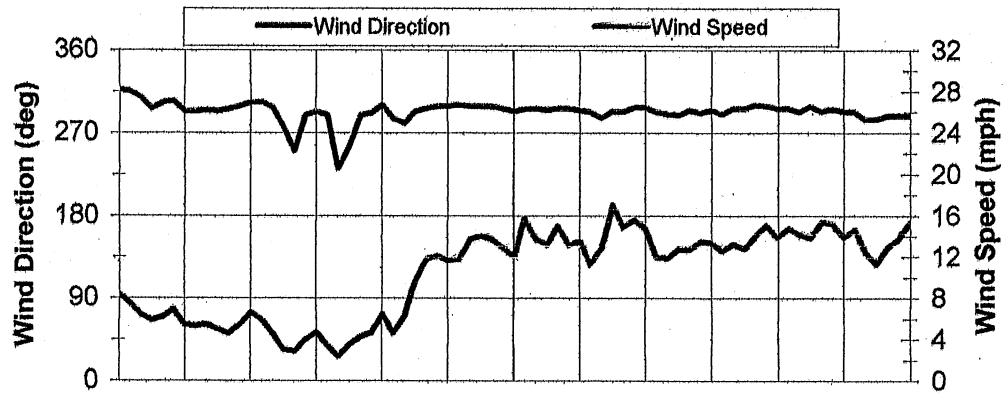


Date and Time

Depth From Surface

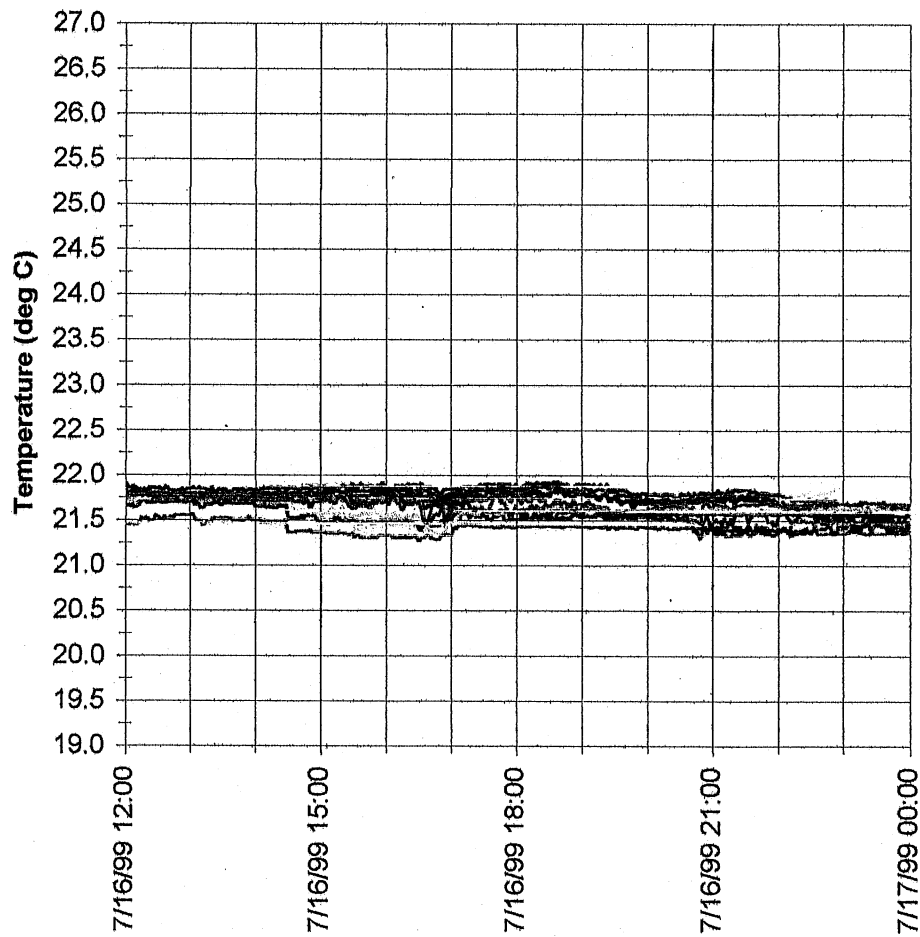
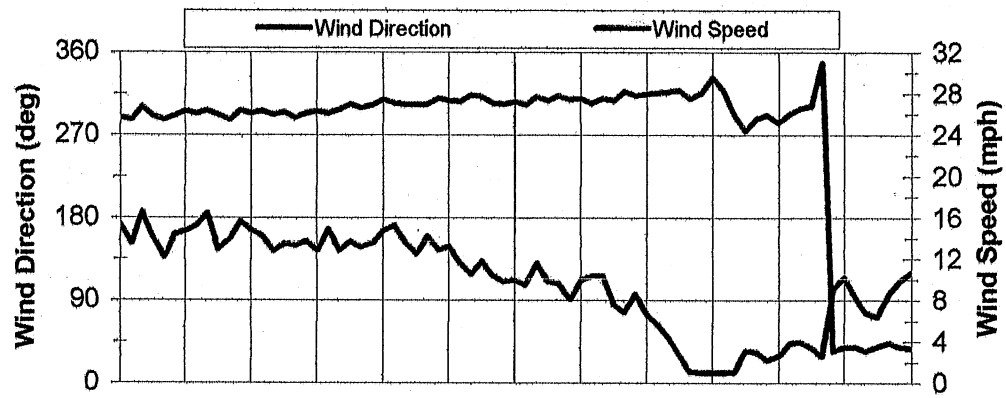


Devils Lake Thermistor Chain Record (East Bay)



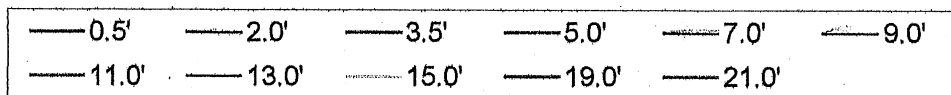
— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

Devils Lake Thermistor Chain Record (East Bay)

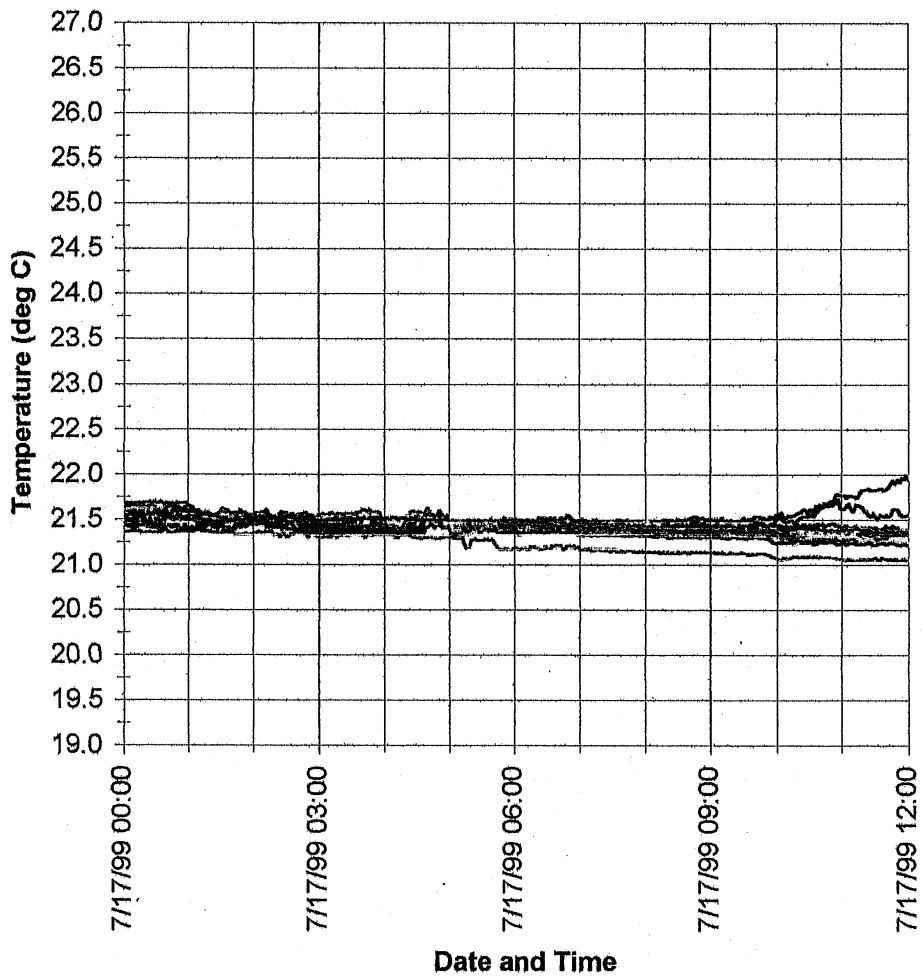
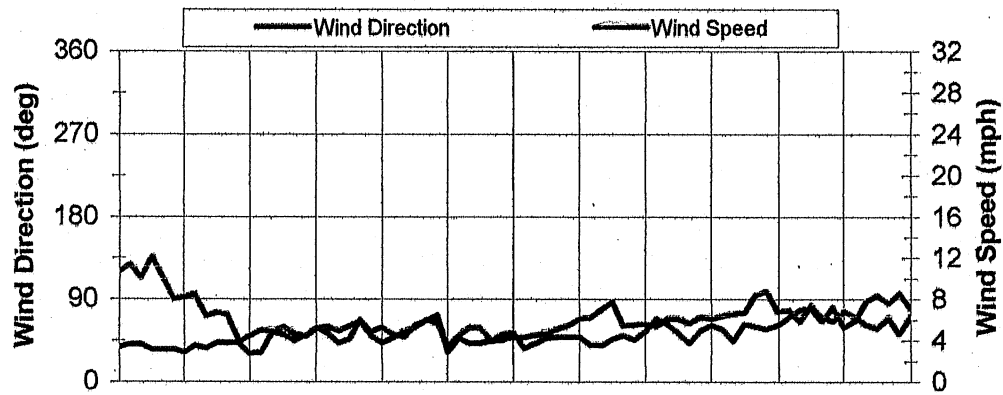


Date and Time

Depth From Surface



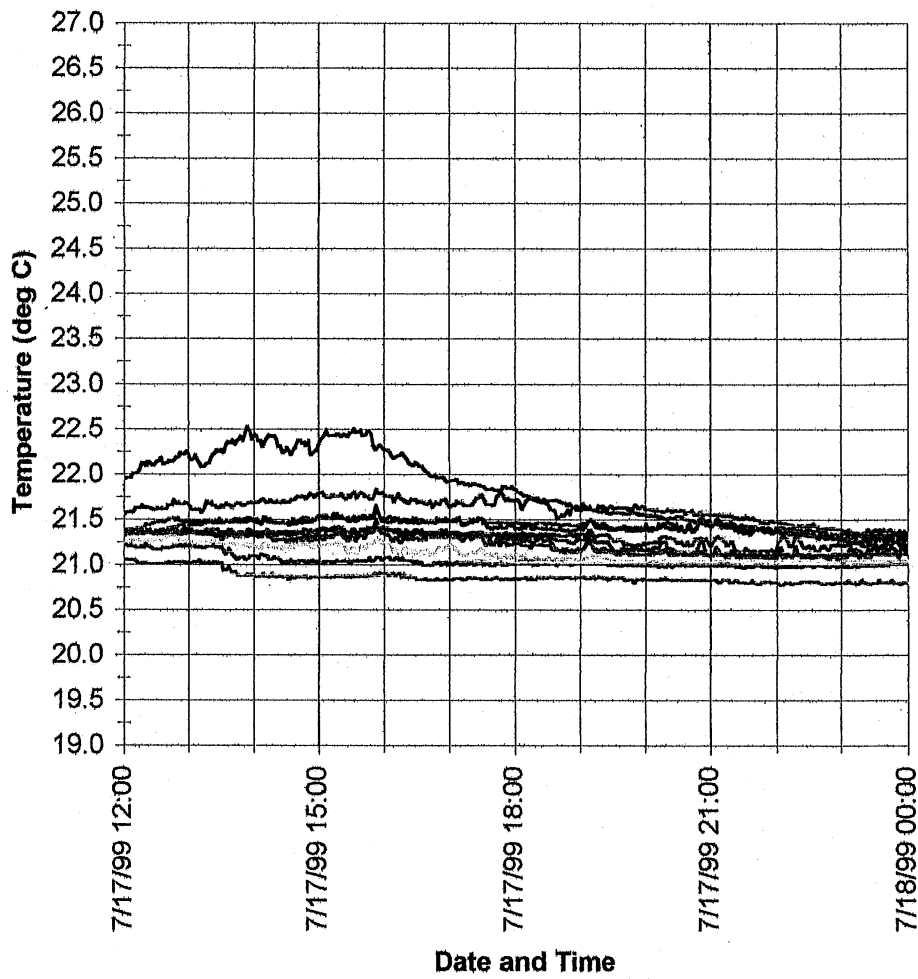
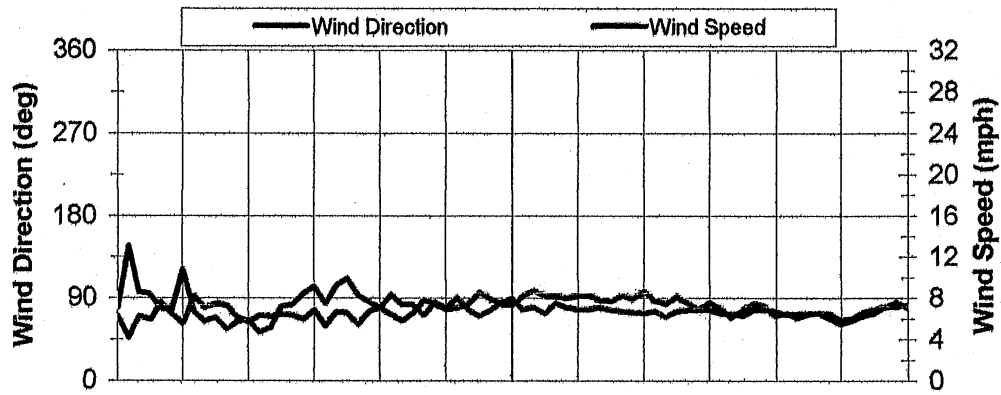
Devils Lake Thermistor Chain Record (East Bay)



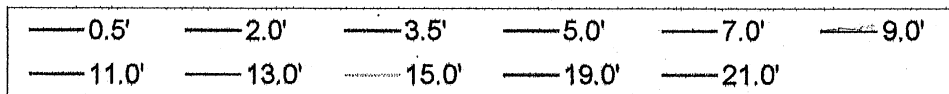
Depth From Surface

— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

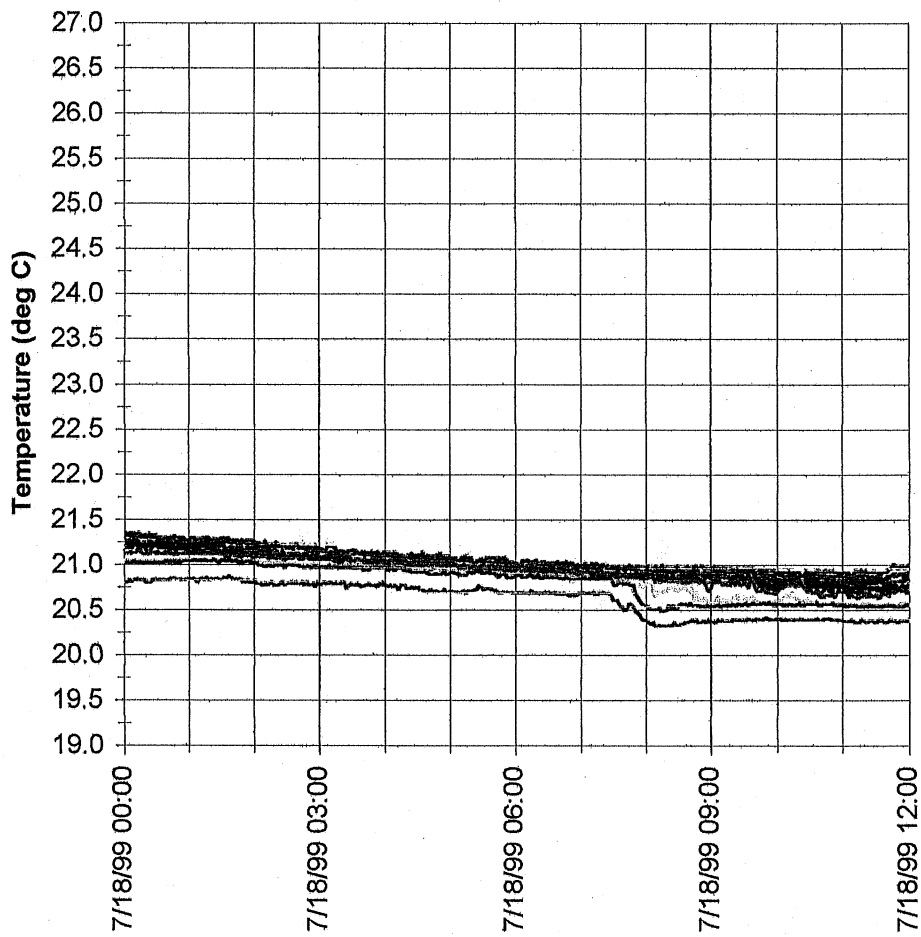
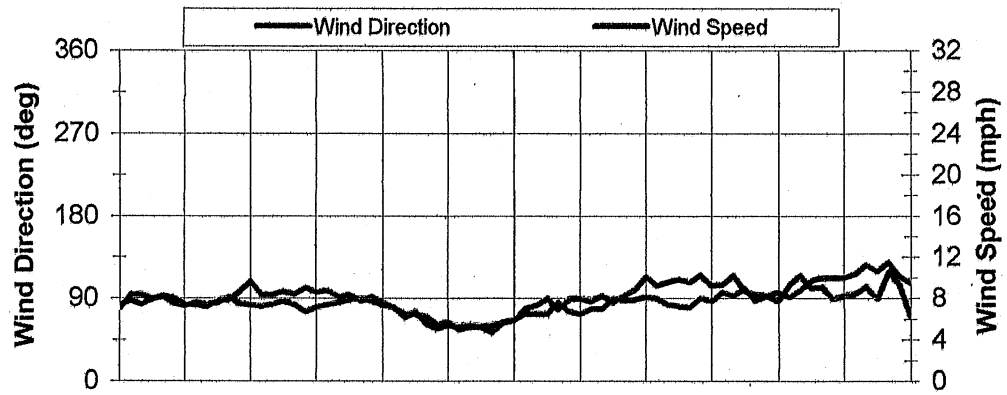
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

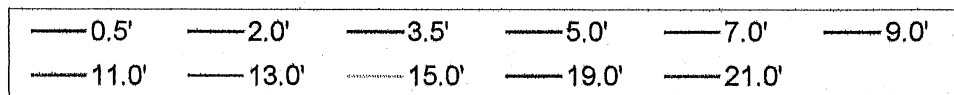


Devils Lake Thermistor Chain Record (East Bay)

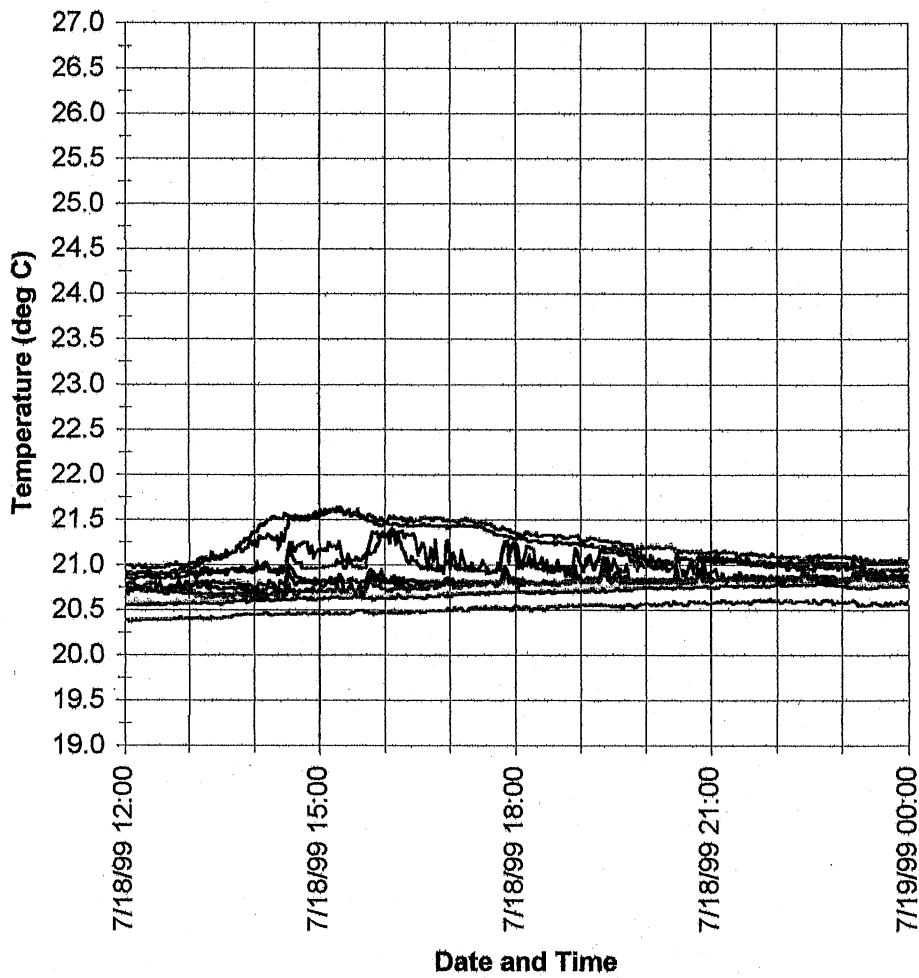
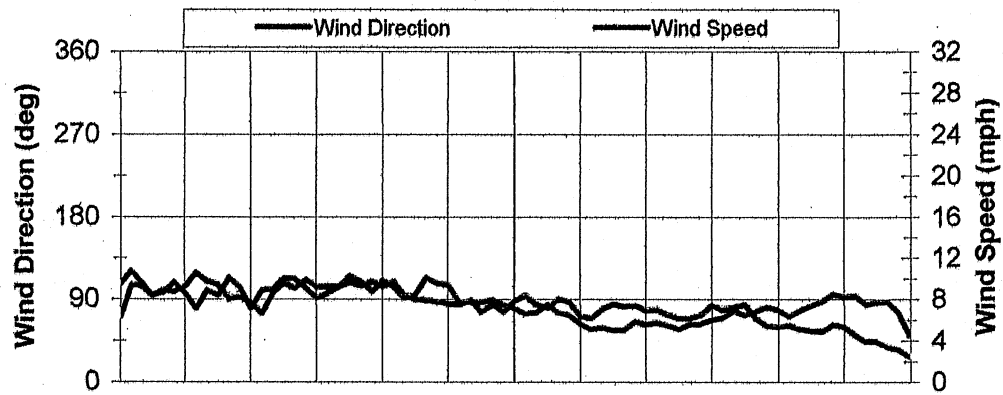


Date and Time

Depth From Surface



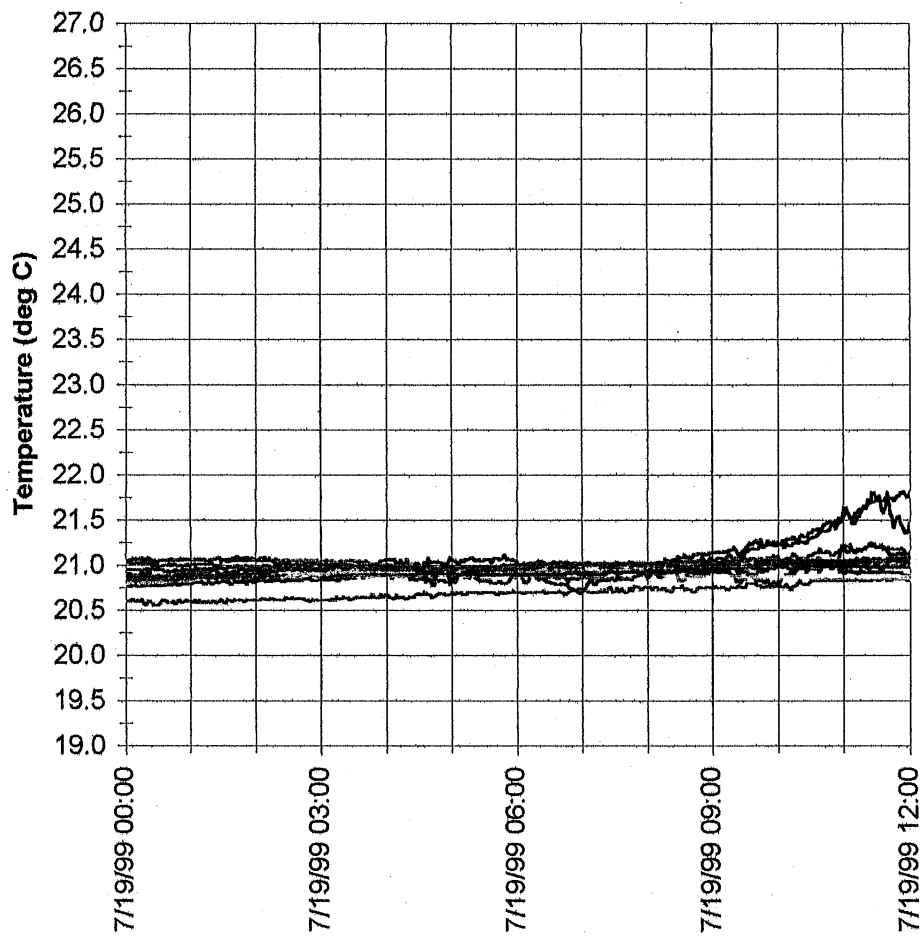
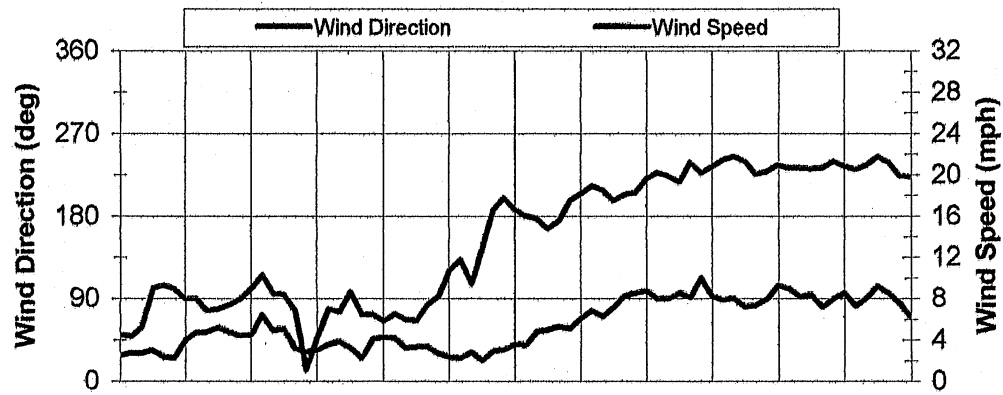
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

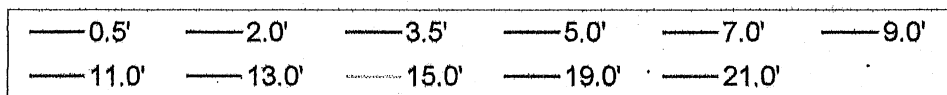
— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

Devils Lake Thermistor Chain Record (East Bay)

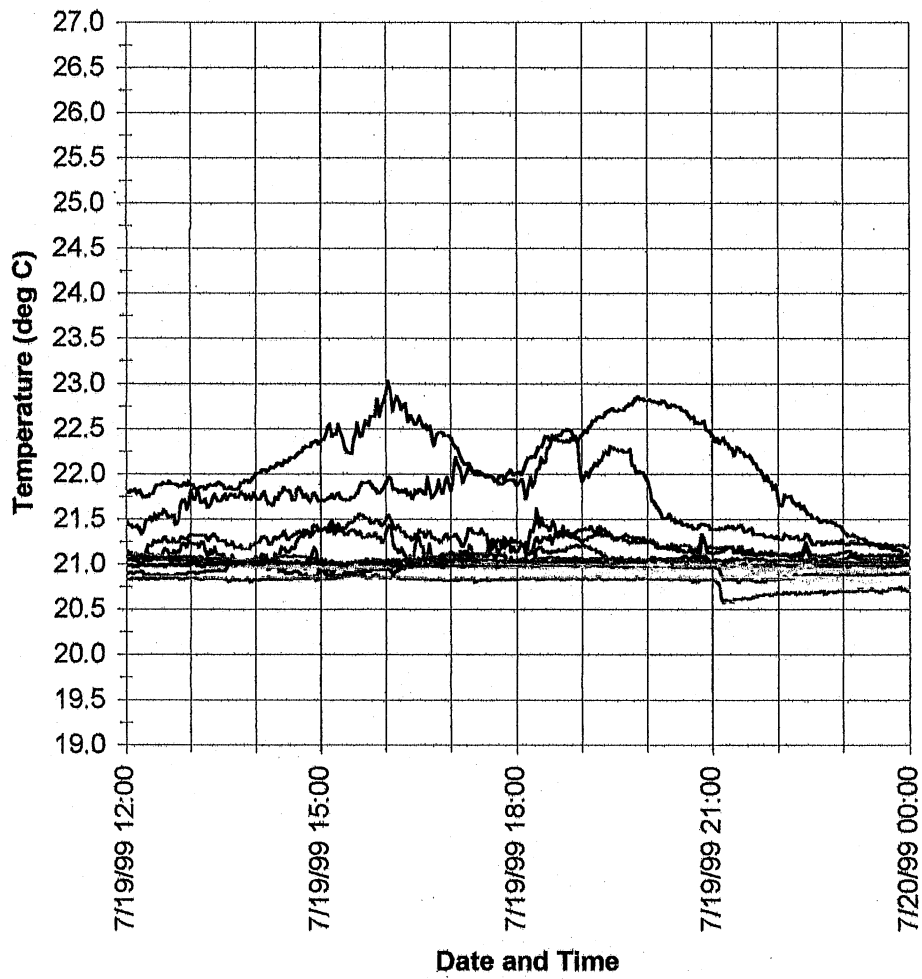
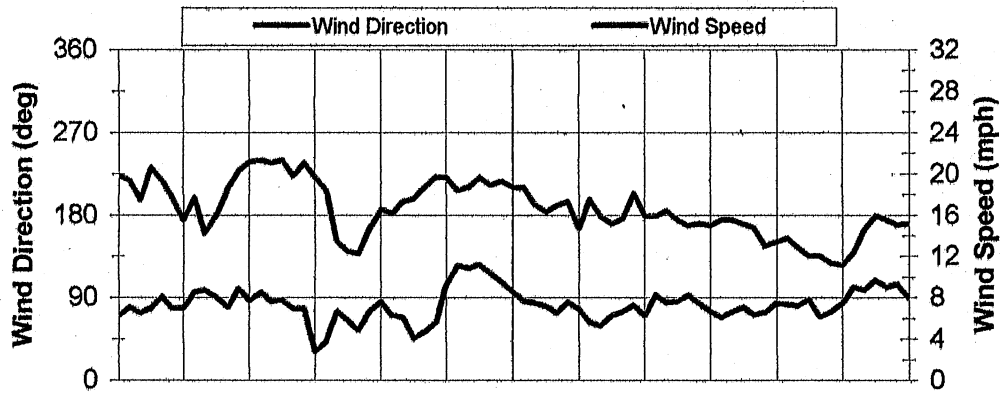


Date and Time

Depth From Surface

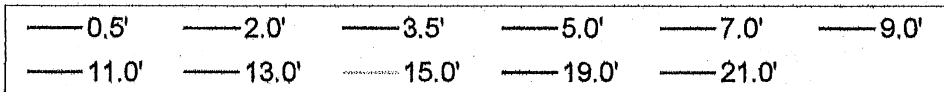


Devils Lake Thermistor Chain Record (East Bay)

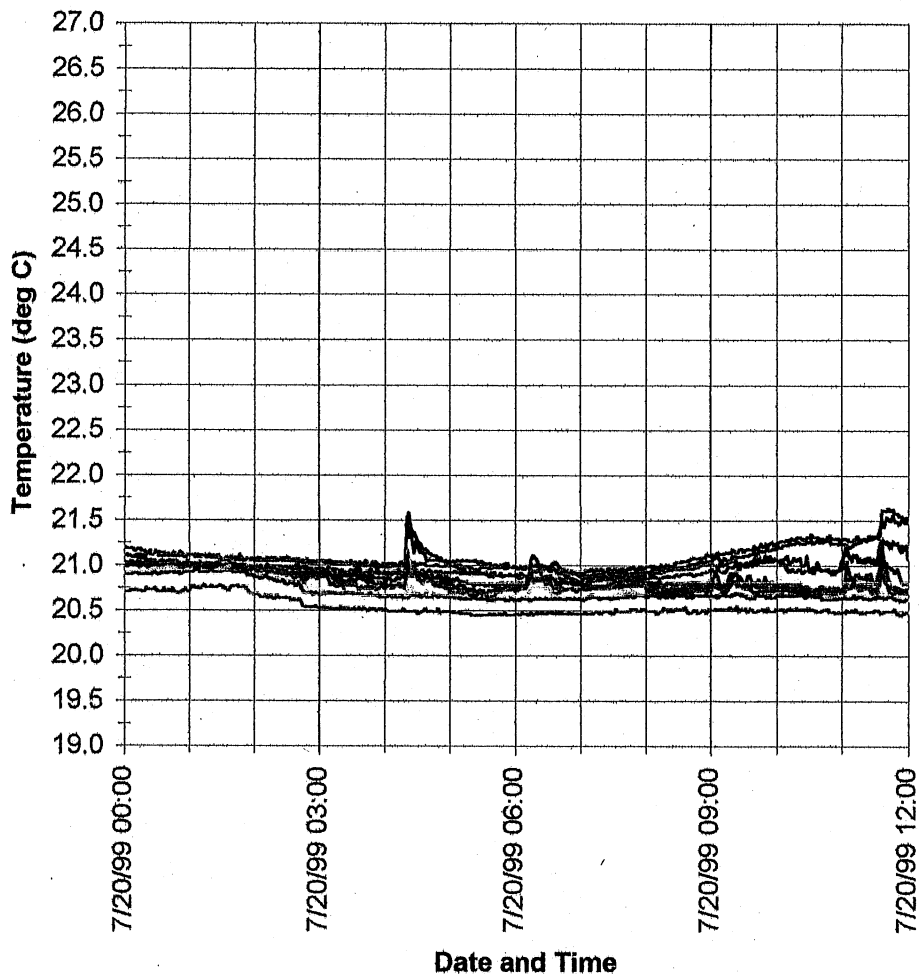
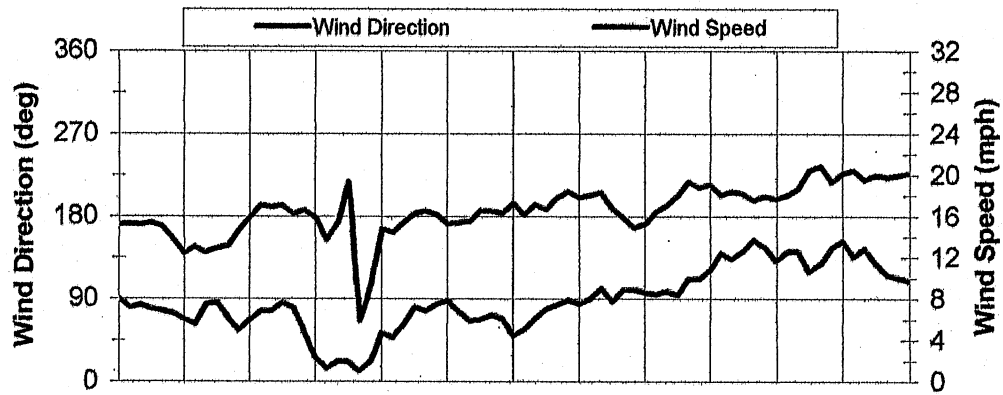


Date and Time

Depth From Surface



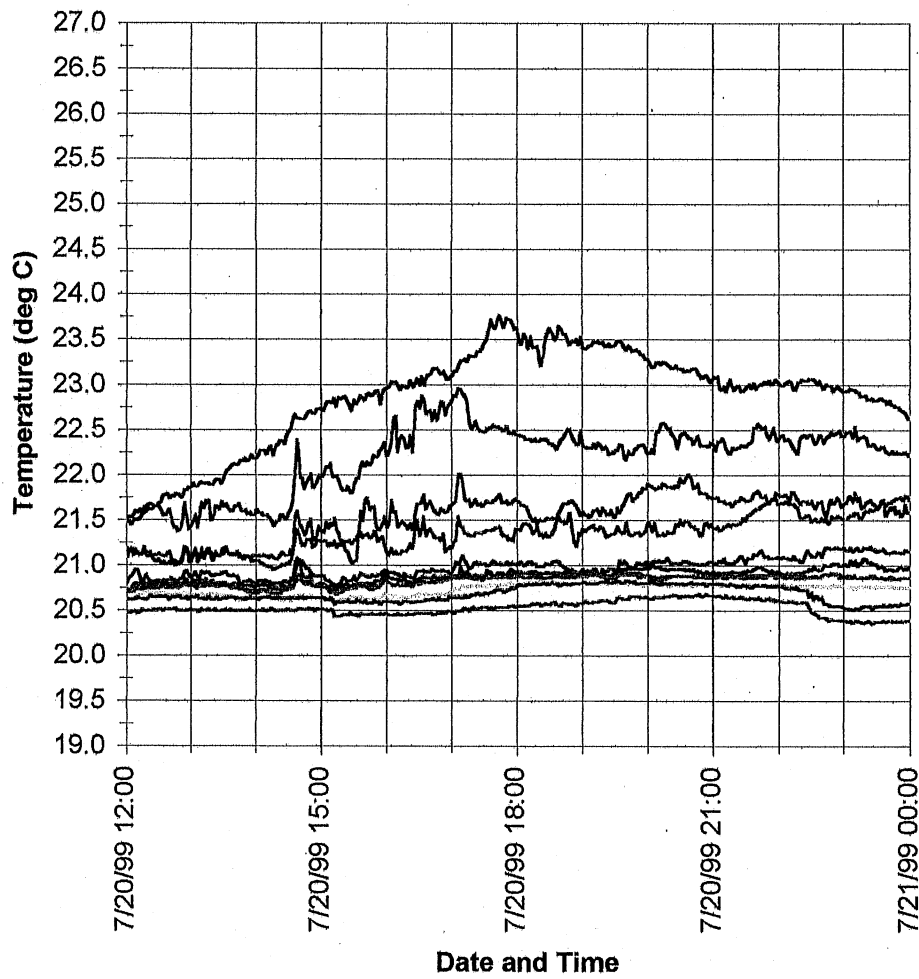
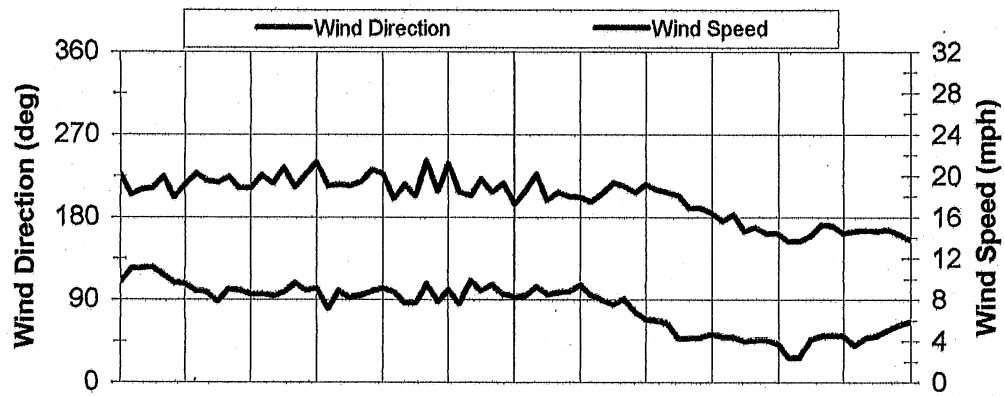
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

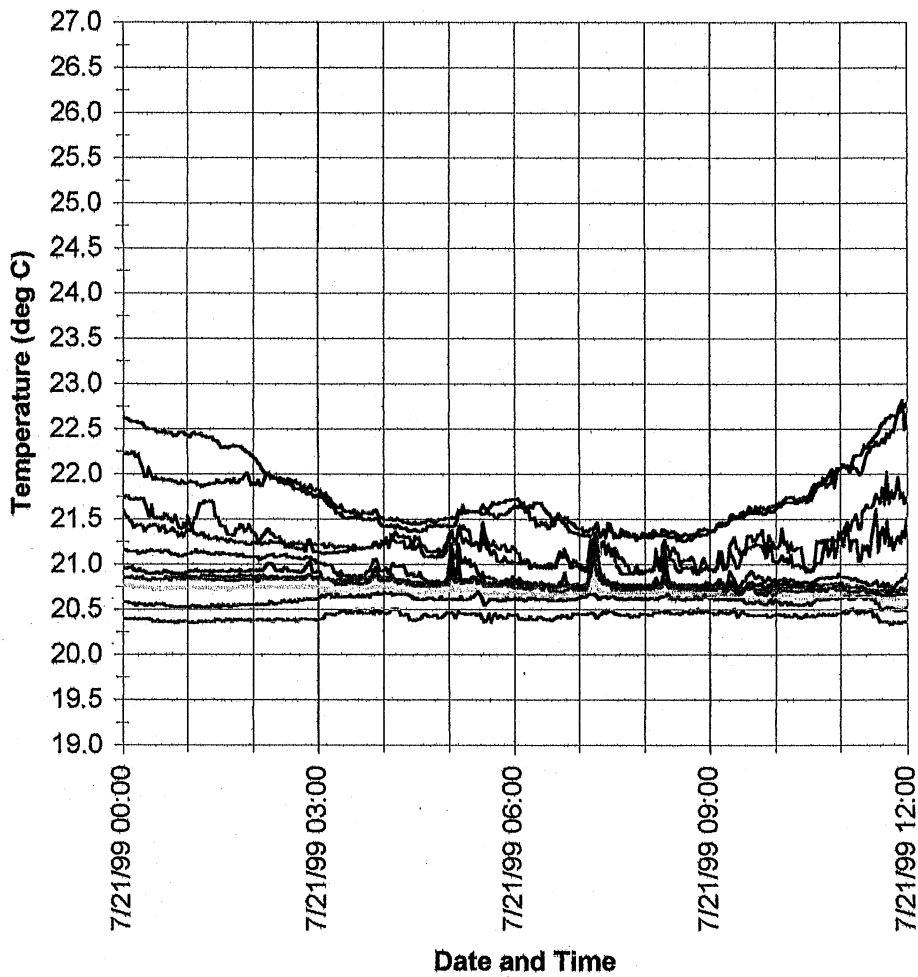
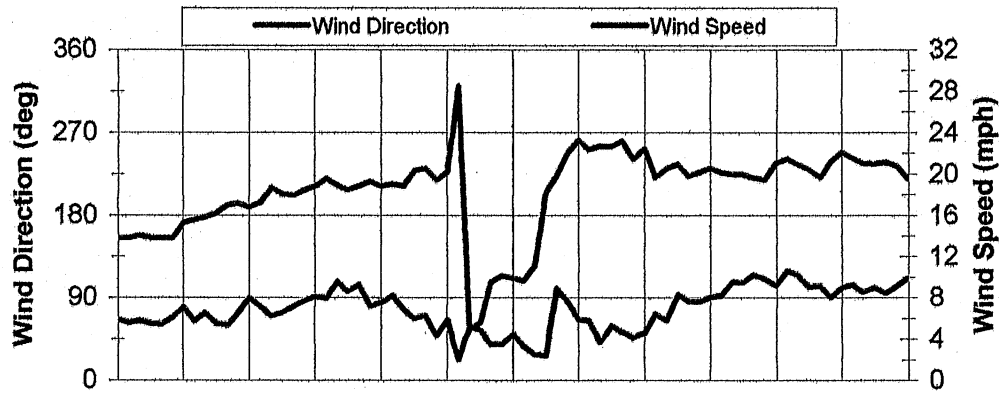
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

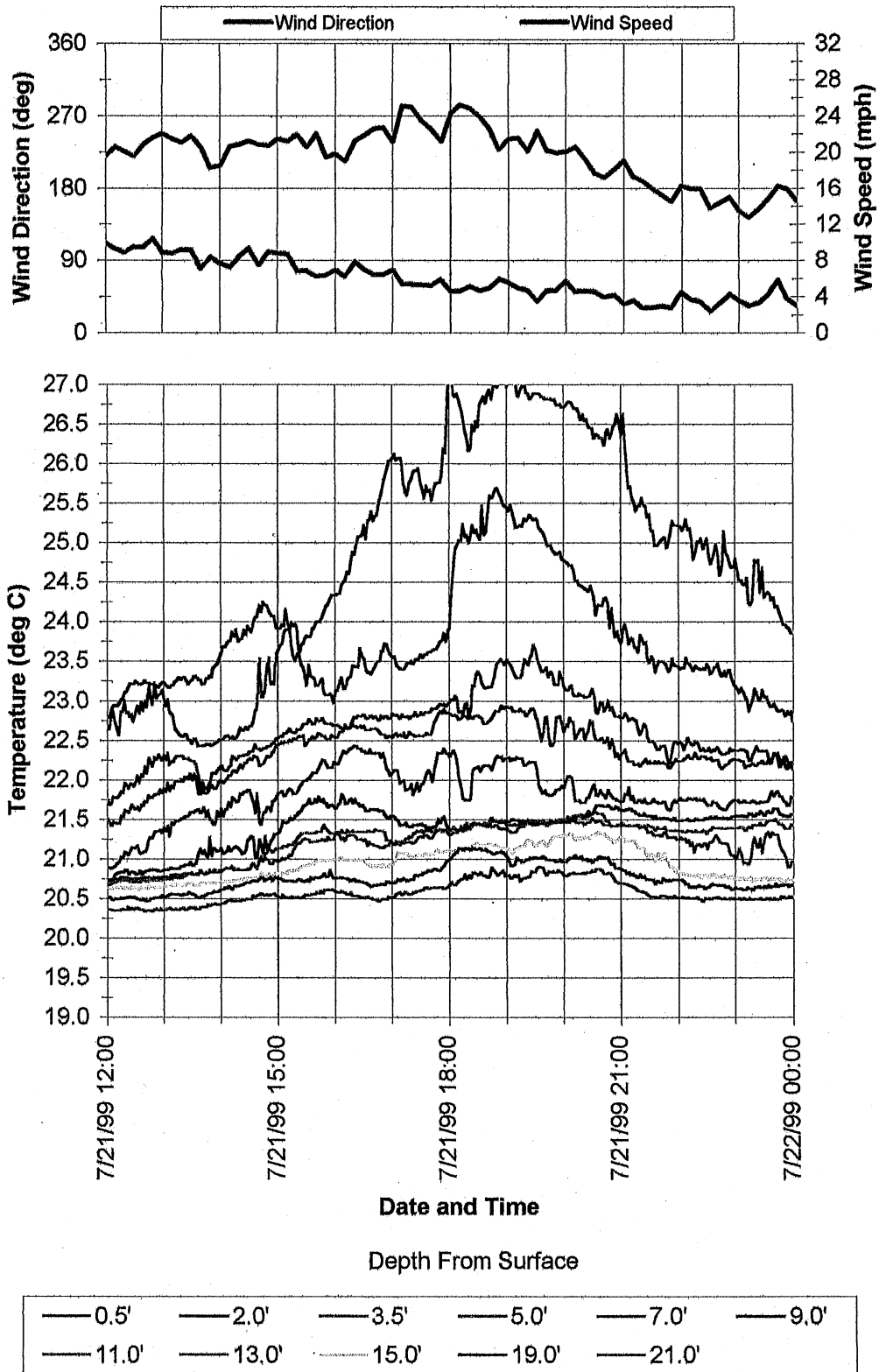
Devils Lake Thermistor Chain Record (East Bay)



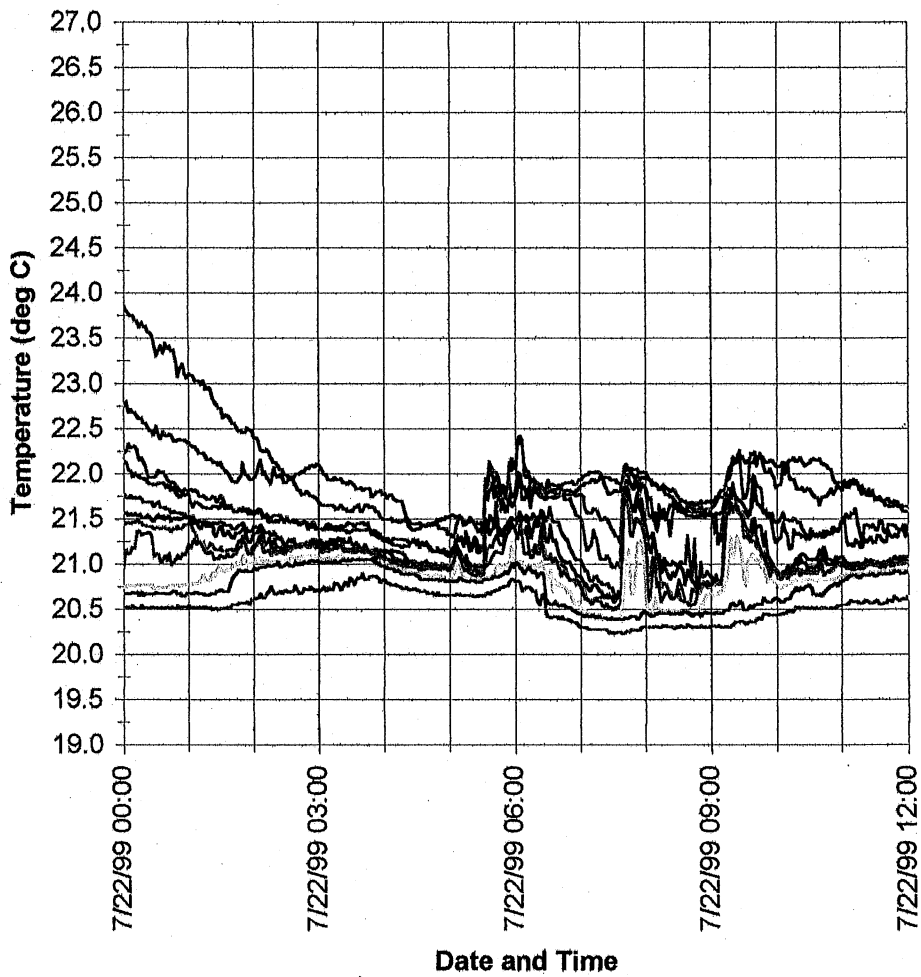
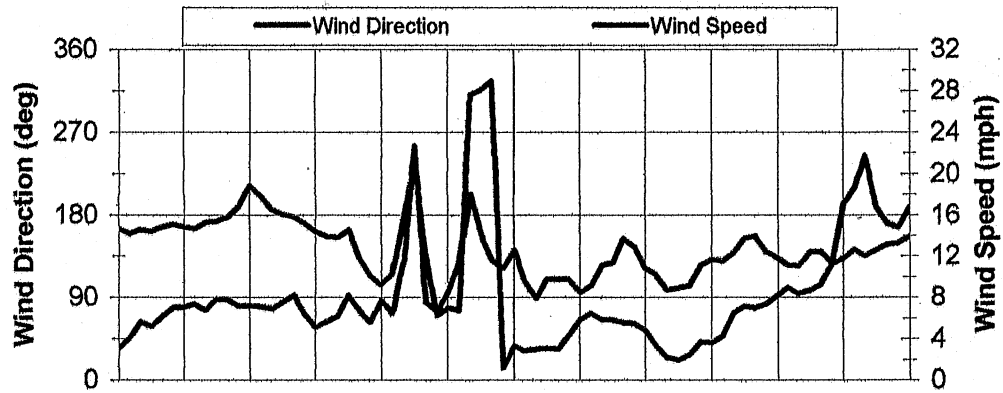
Depth From Surface

— 0.5'	— 2.0'	— 3.5'	— 5.0'	— 7.0'	— 9.0'
— 11.0'	— 13.0'	— 15.0'	— 19.0'	— 21.0'	

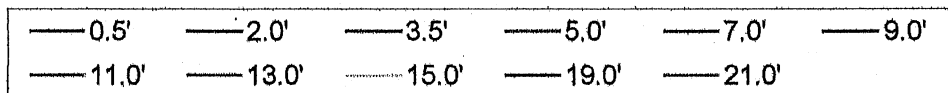
Devils Lake Thermistor Chain Record (East Bay)



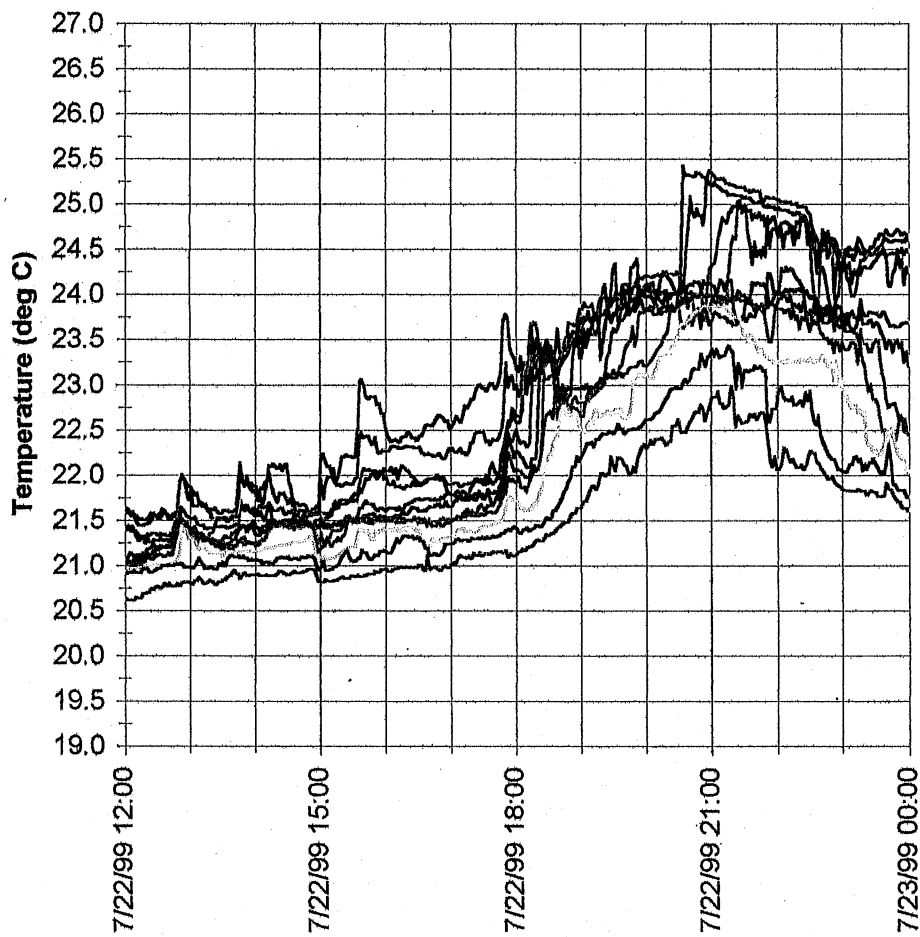
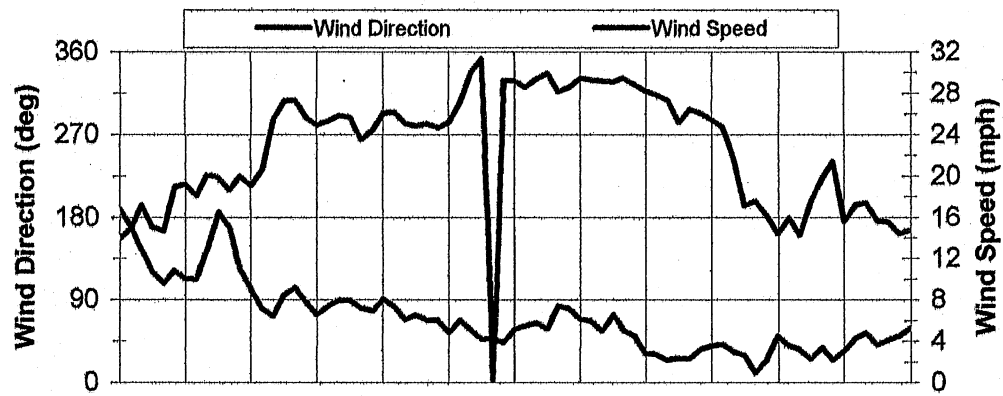
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

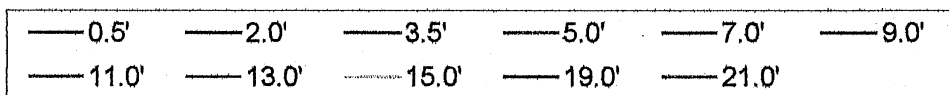


Devils Lake Thermistor Chain Record (East Bay)

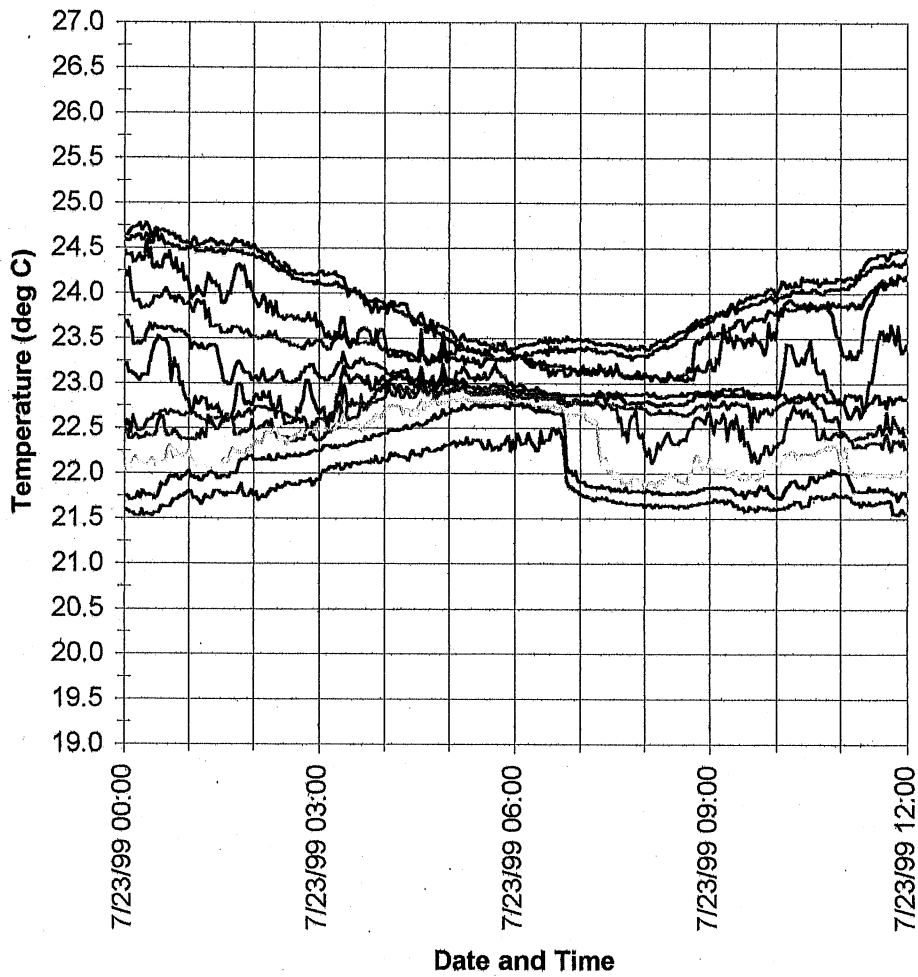
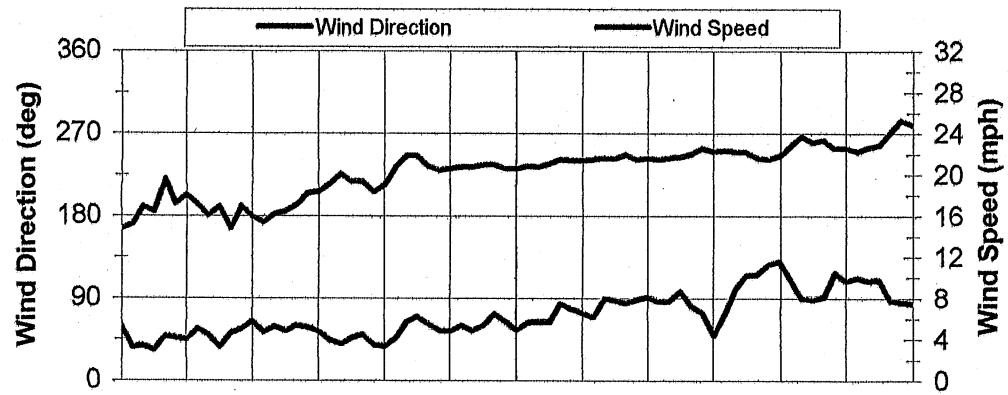


Date and Time

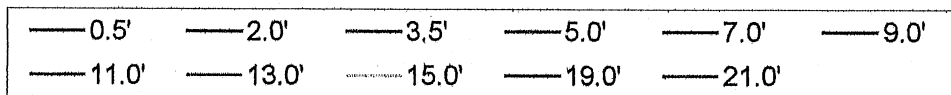
Depth From Surface



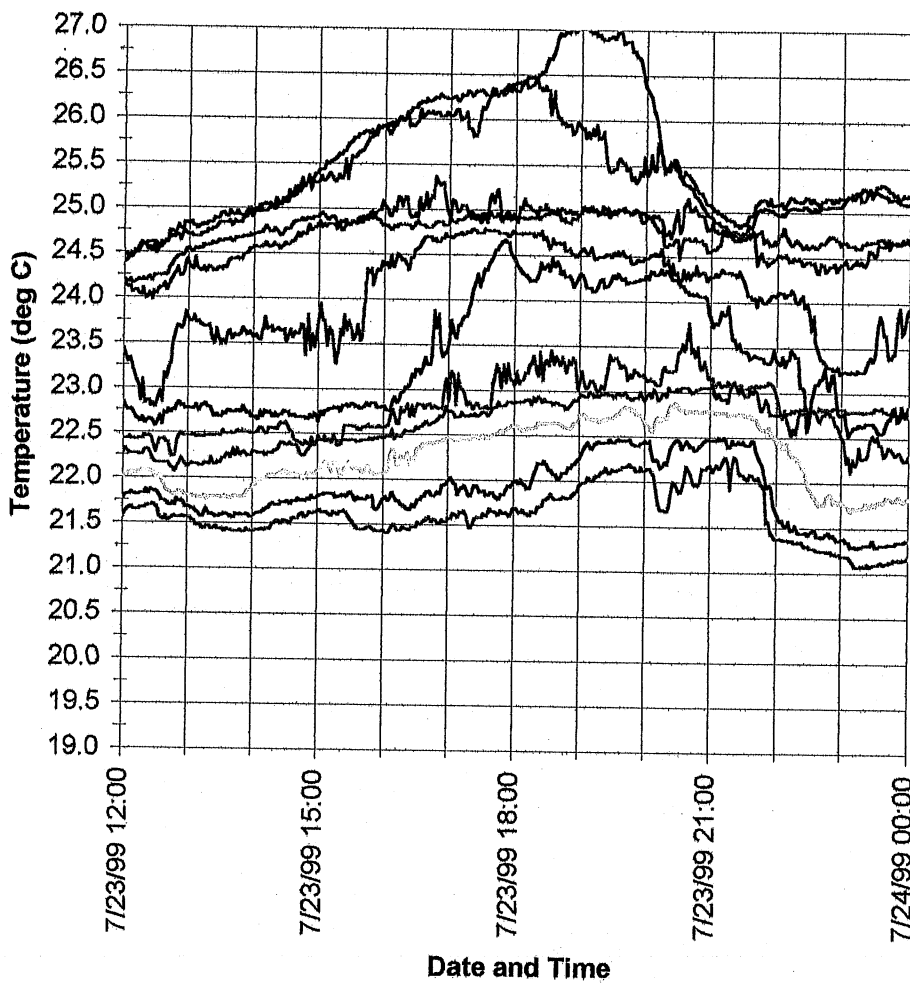
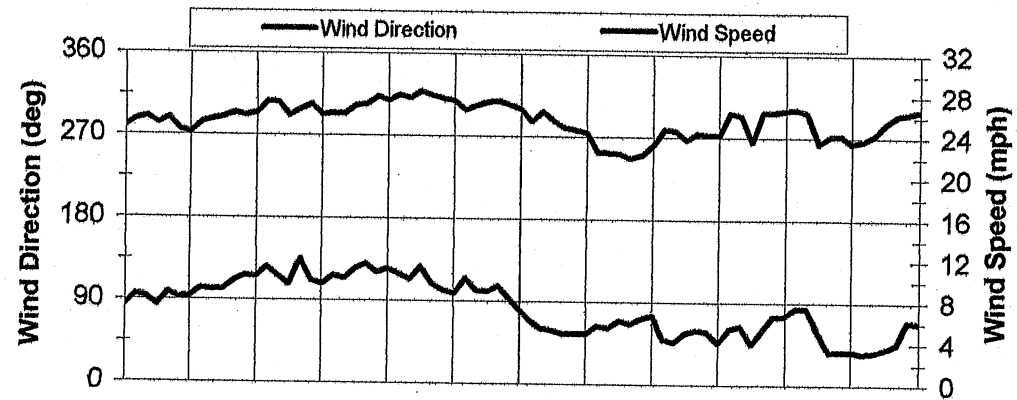
Devils Lake Thermistor Chain Record (East Bay)



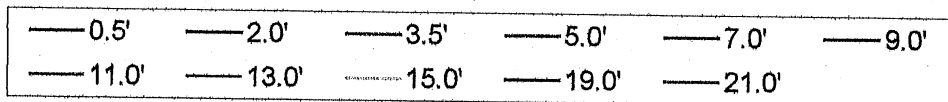
Depth From Surface



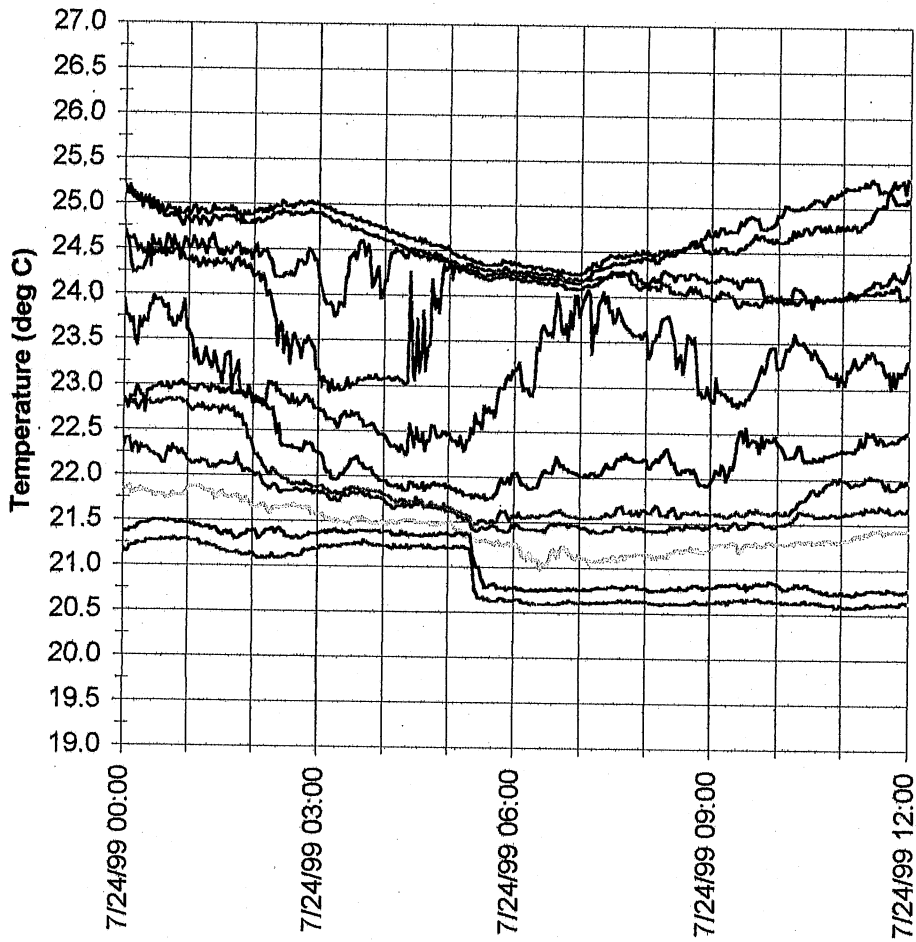
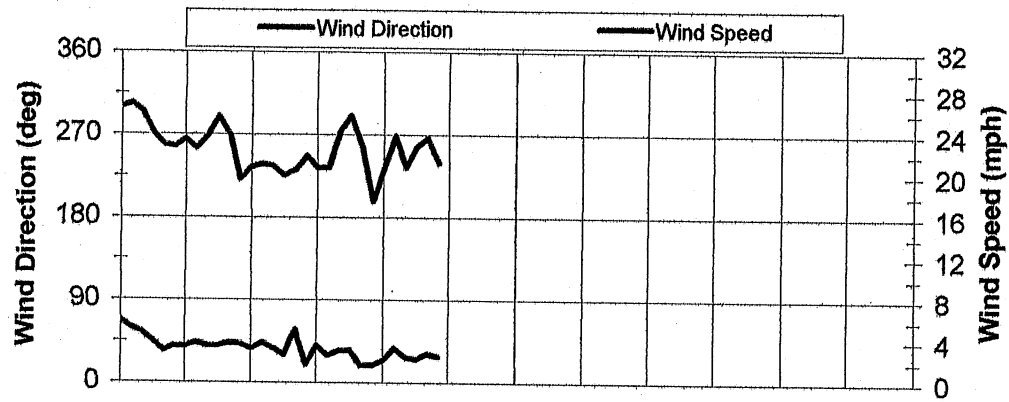
Devils Lake Thermistor Chain Record (East Bay)



Depth From Surface

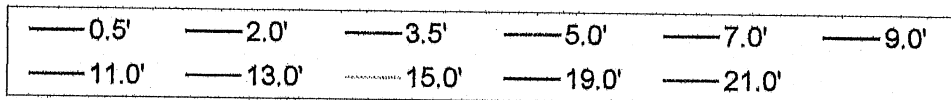


Devils Lake Thermistor Chain Record (East Bay)



Date and Time

Depth From Surface

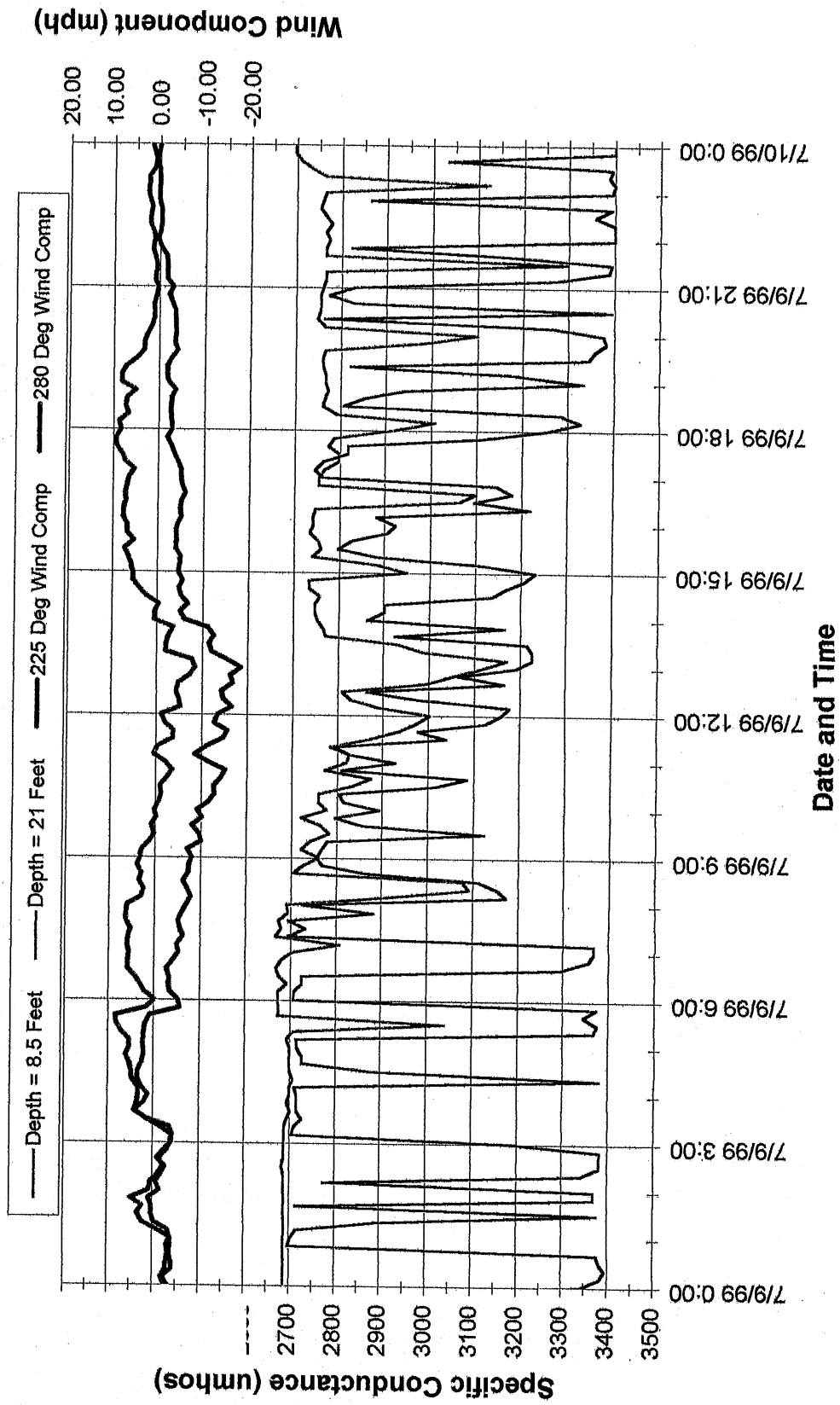


Section V

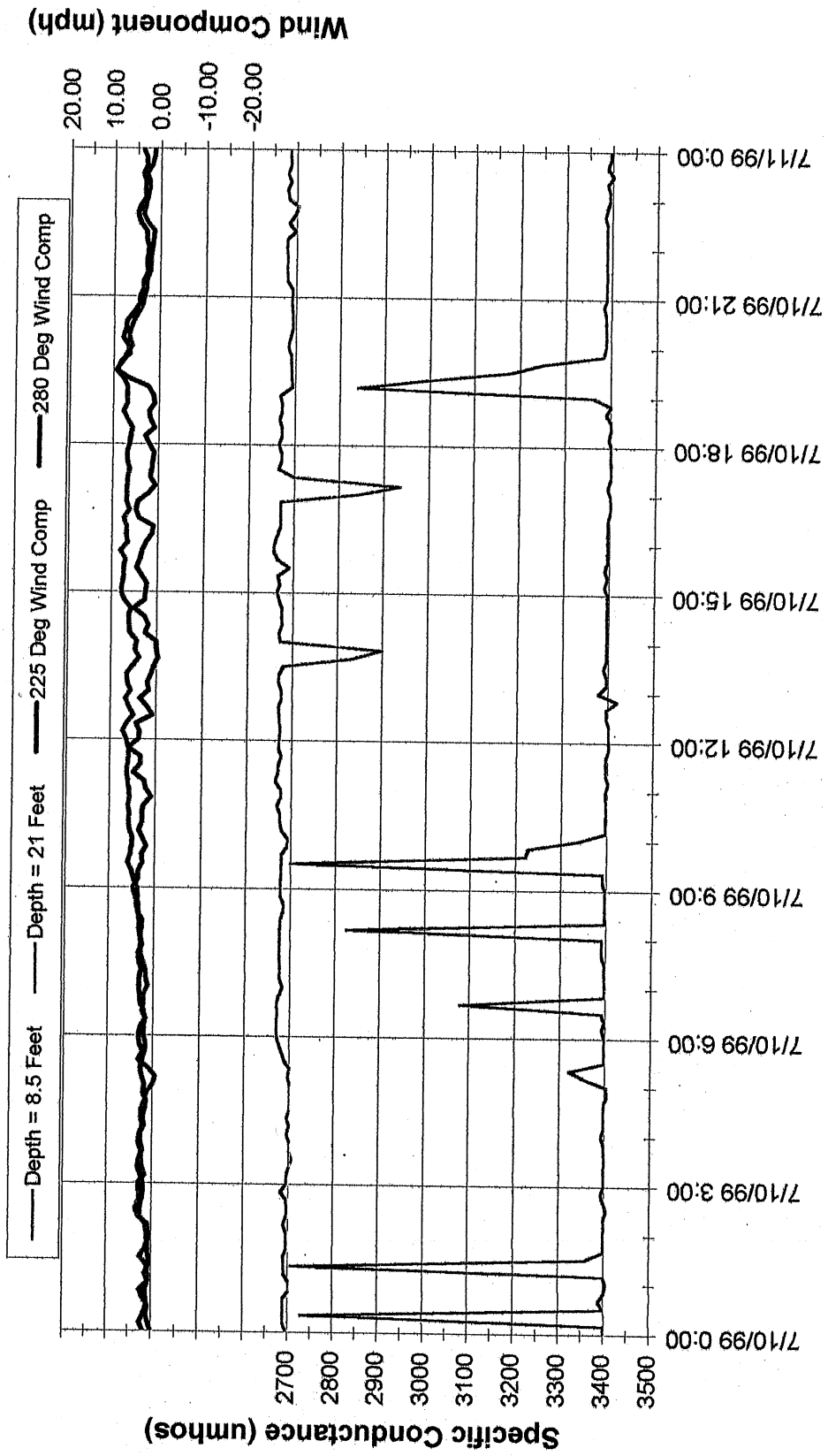
July 1999

**Mission Bay-East Bay Exchange Zone
Specific Conductance Record**

Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone



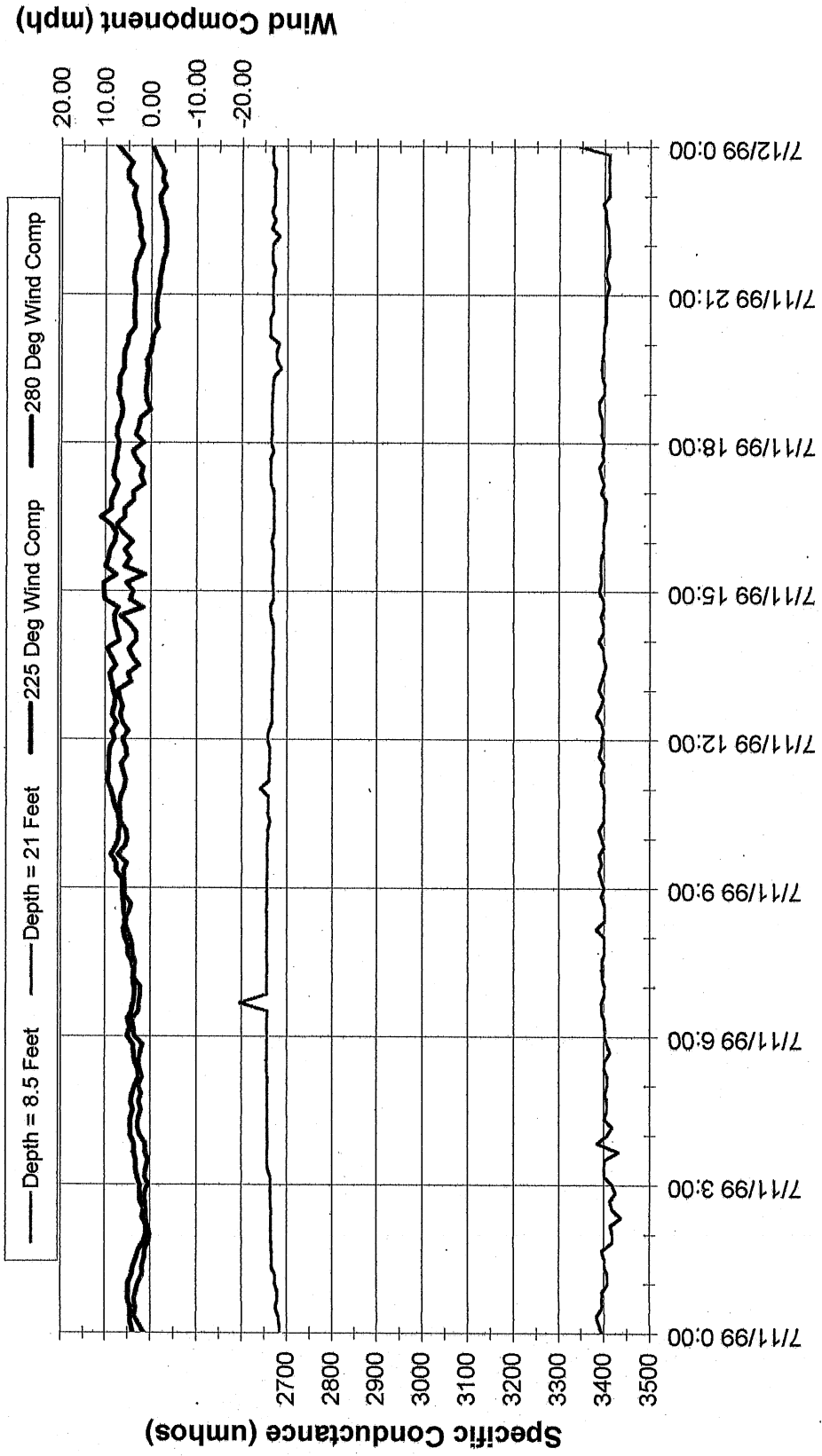
**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**



Date and Time

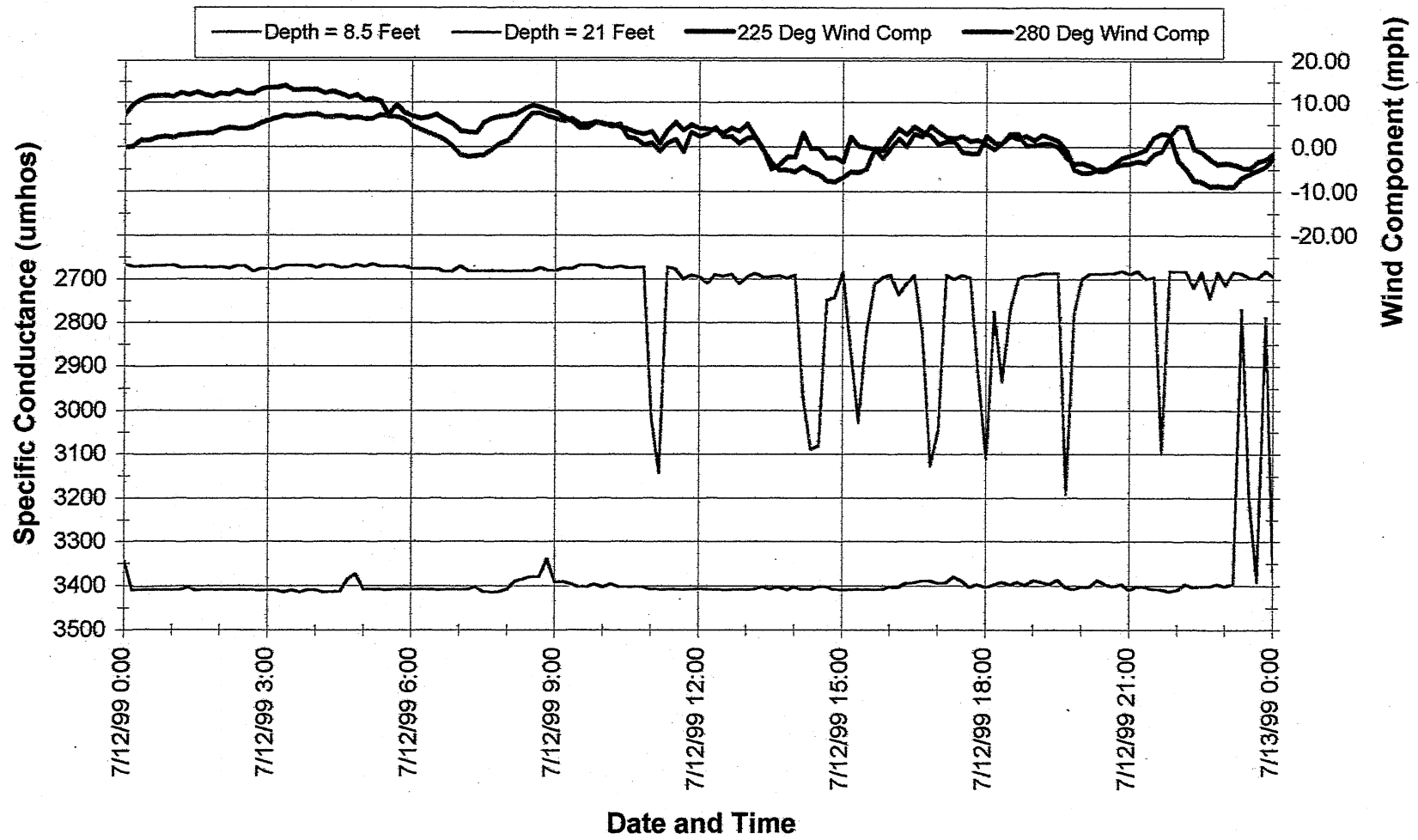
V-2

**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**

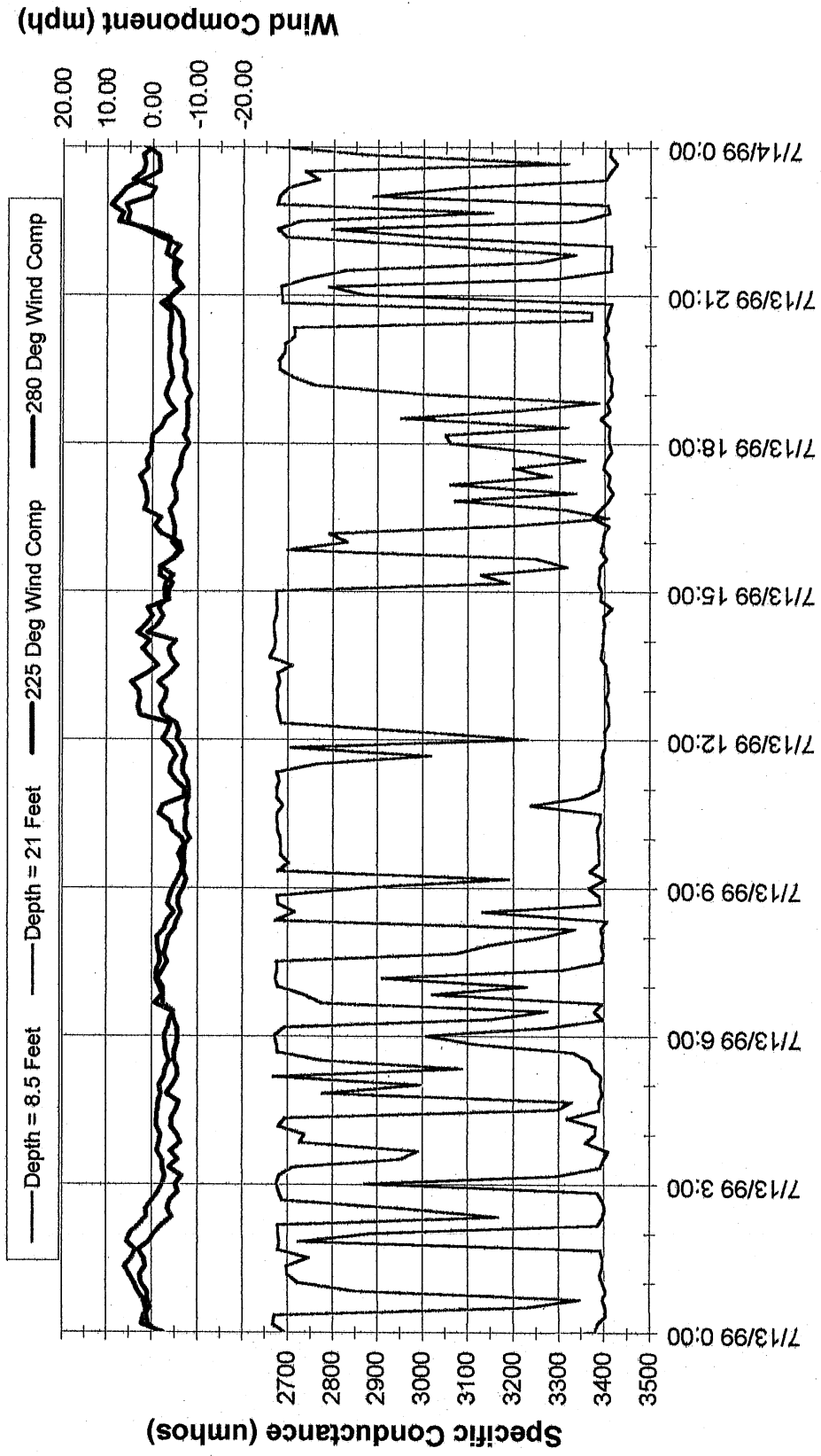


Date and Time

Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone

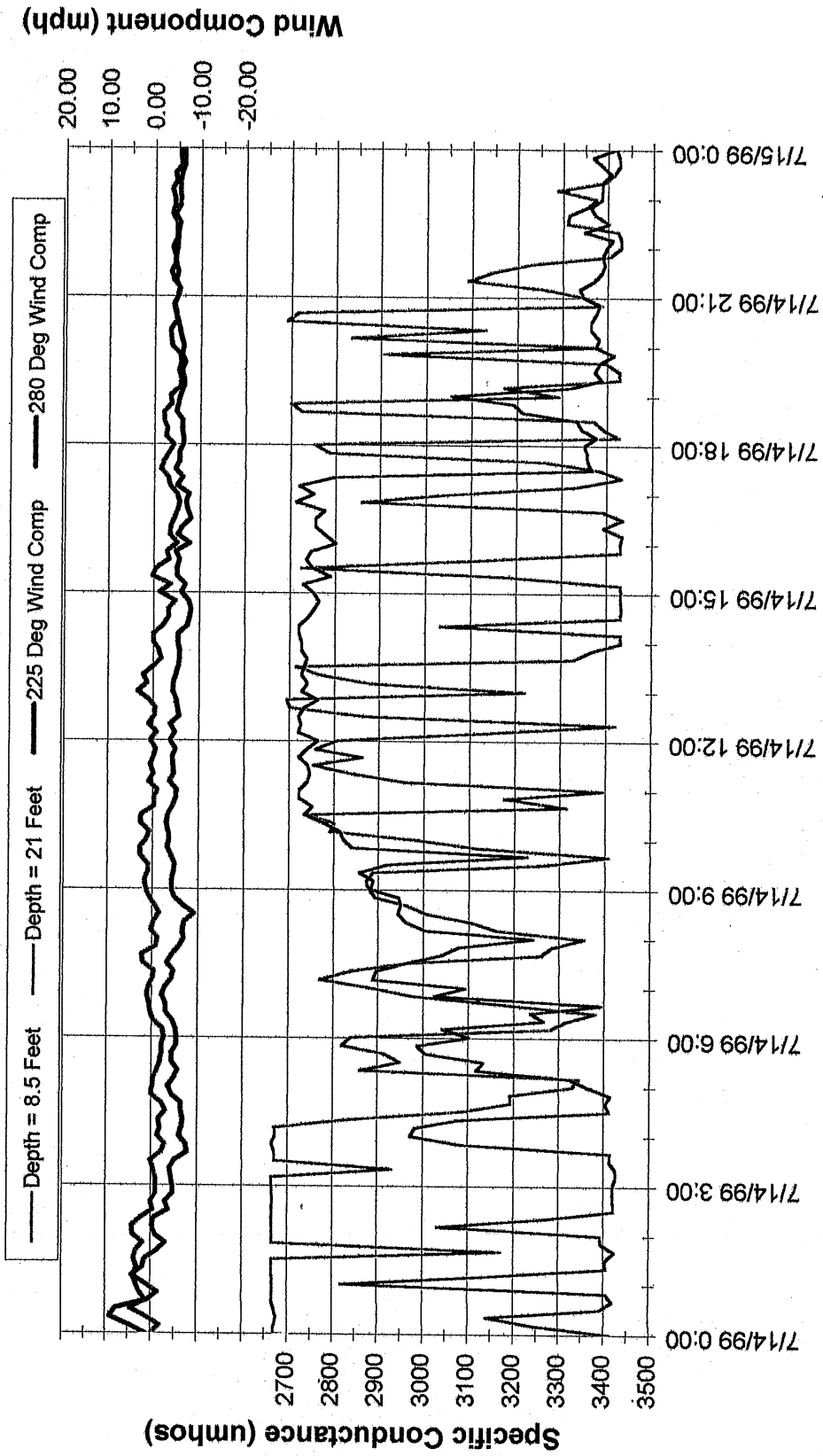


**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**



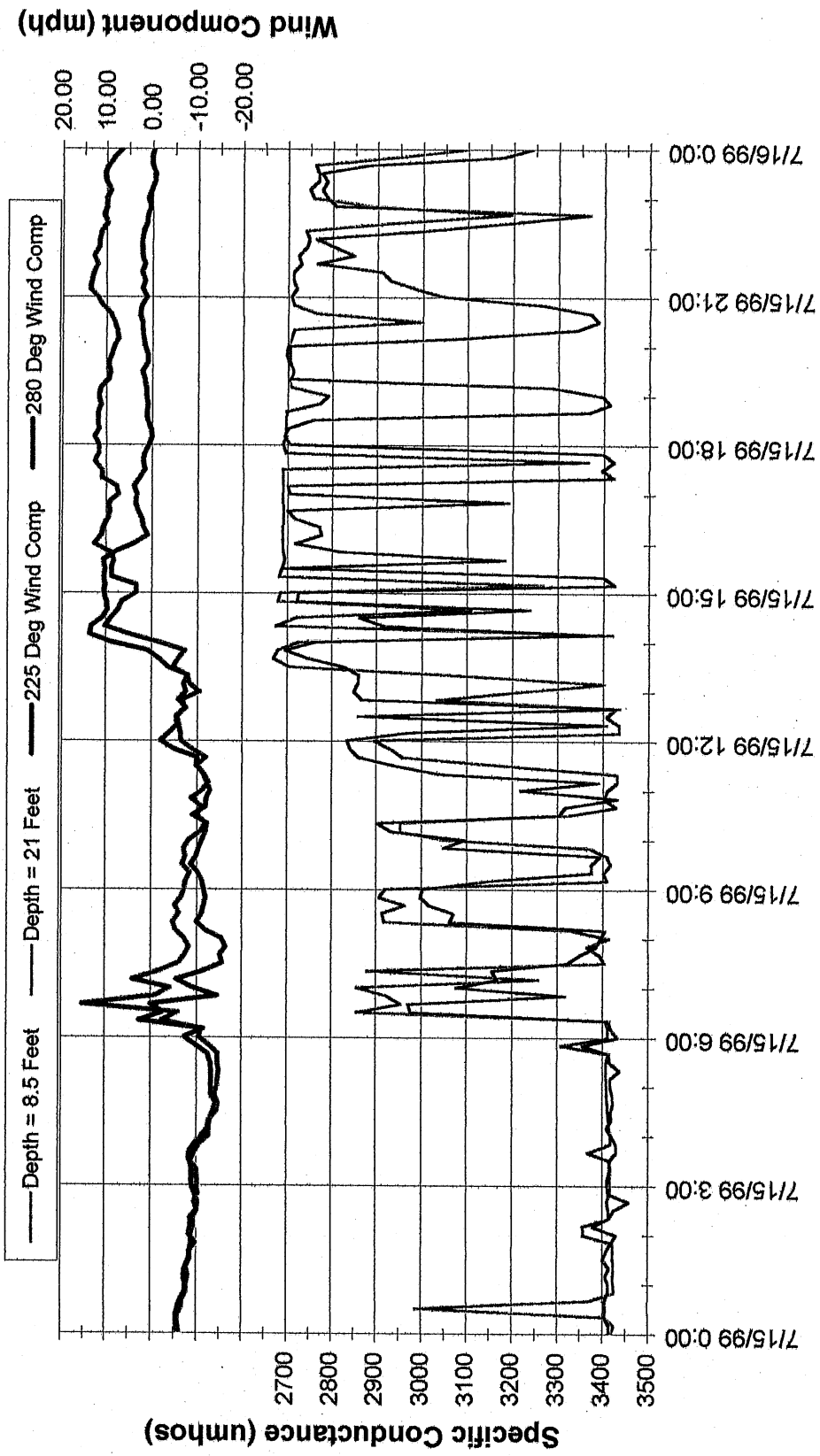
Date and Time

**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**



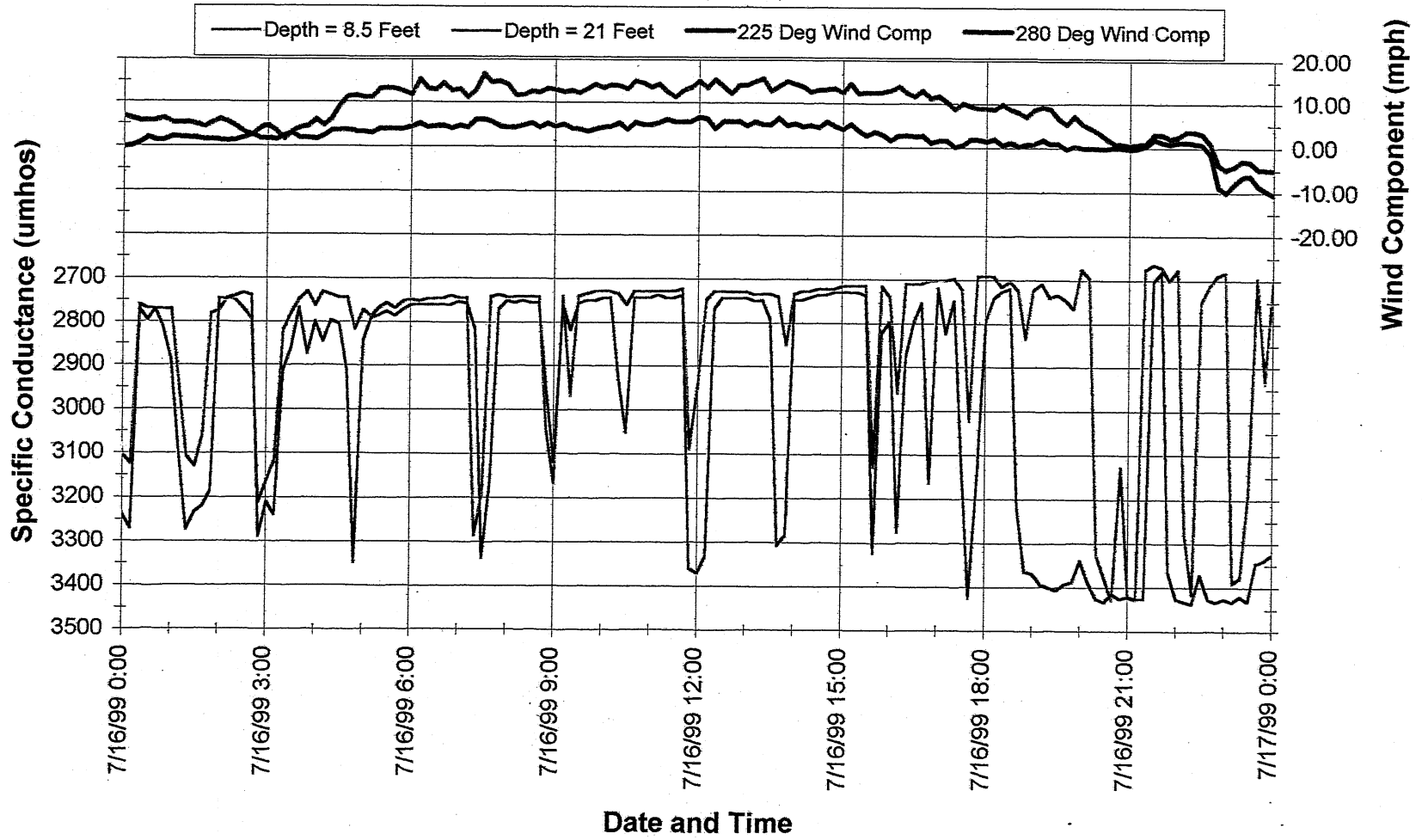
Date and Time

**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**

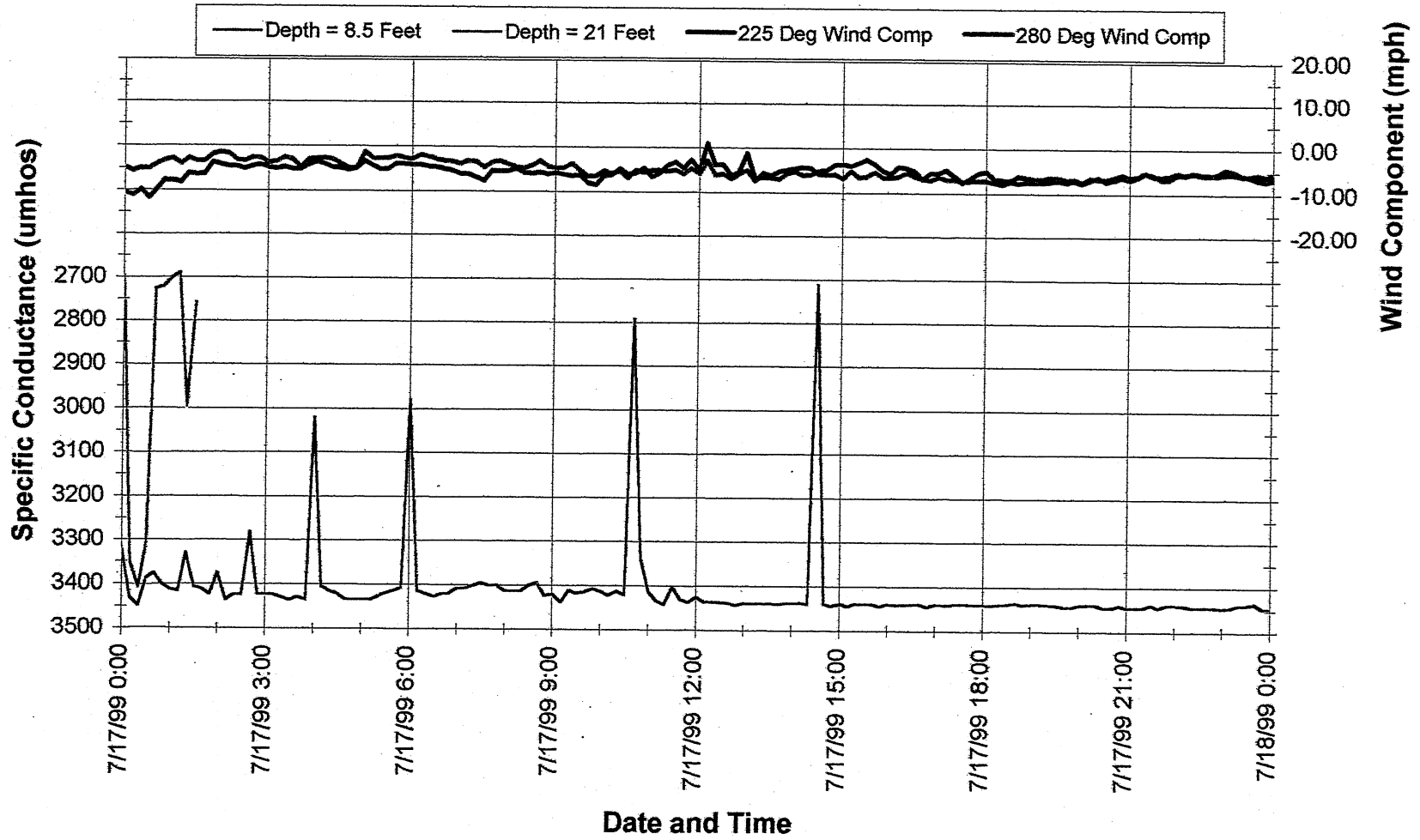


Date and Time

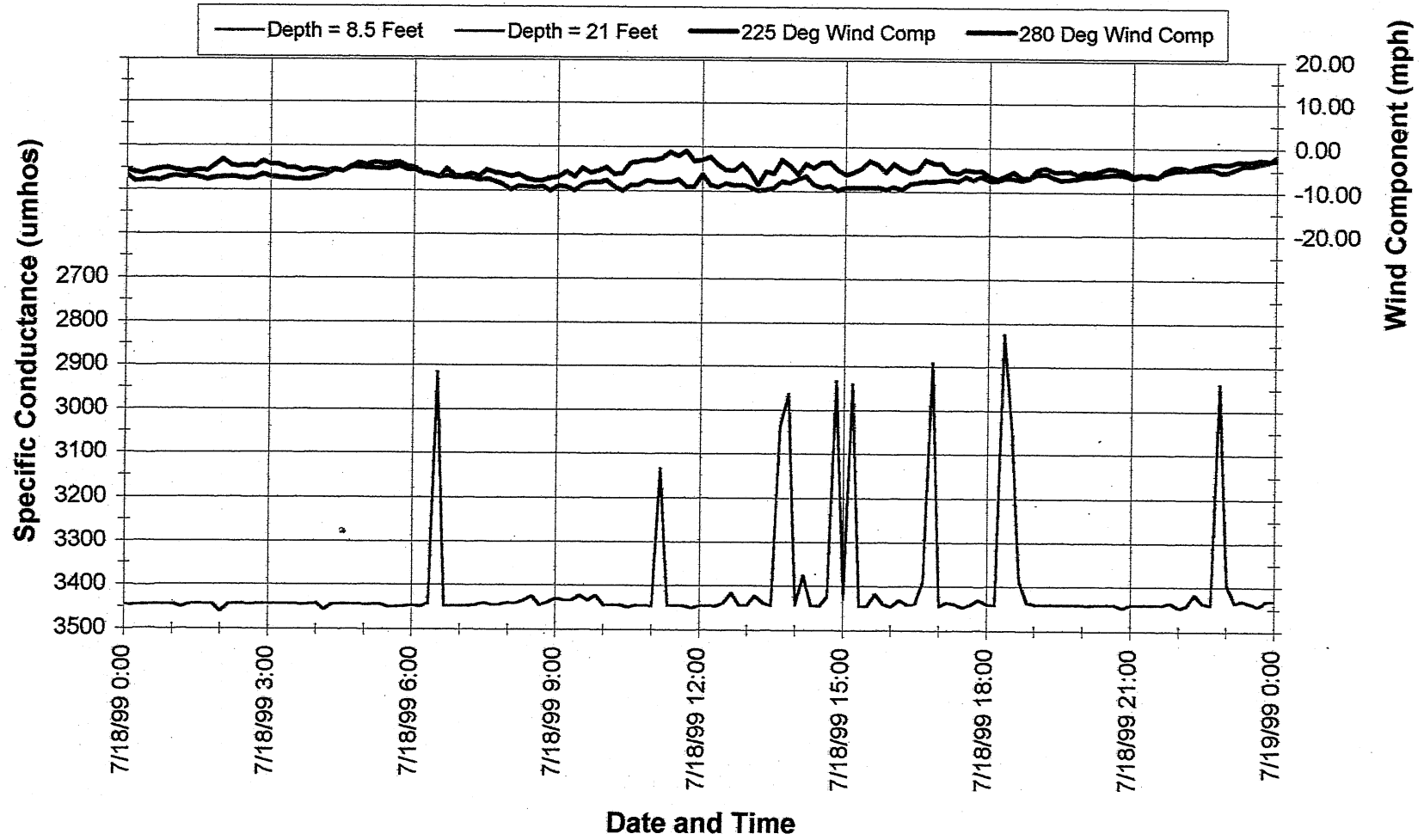
Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone



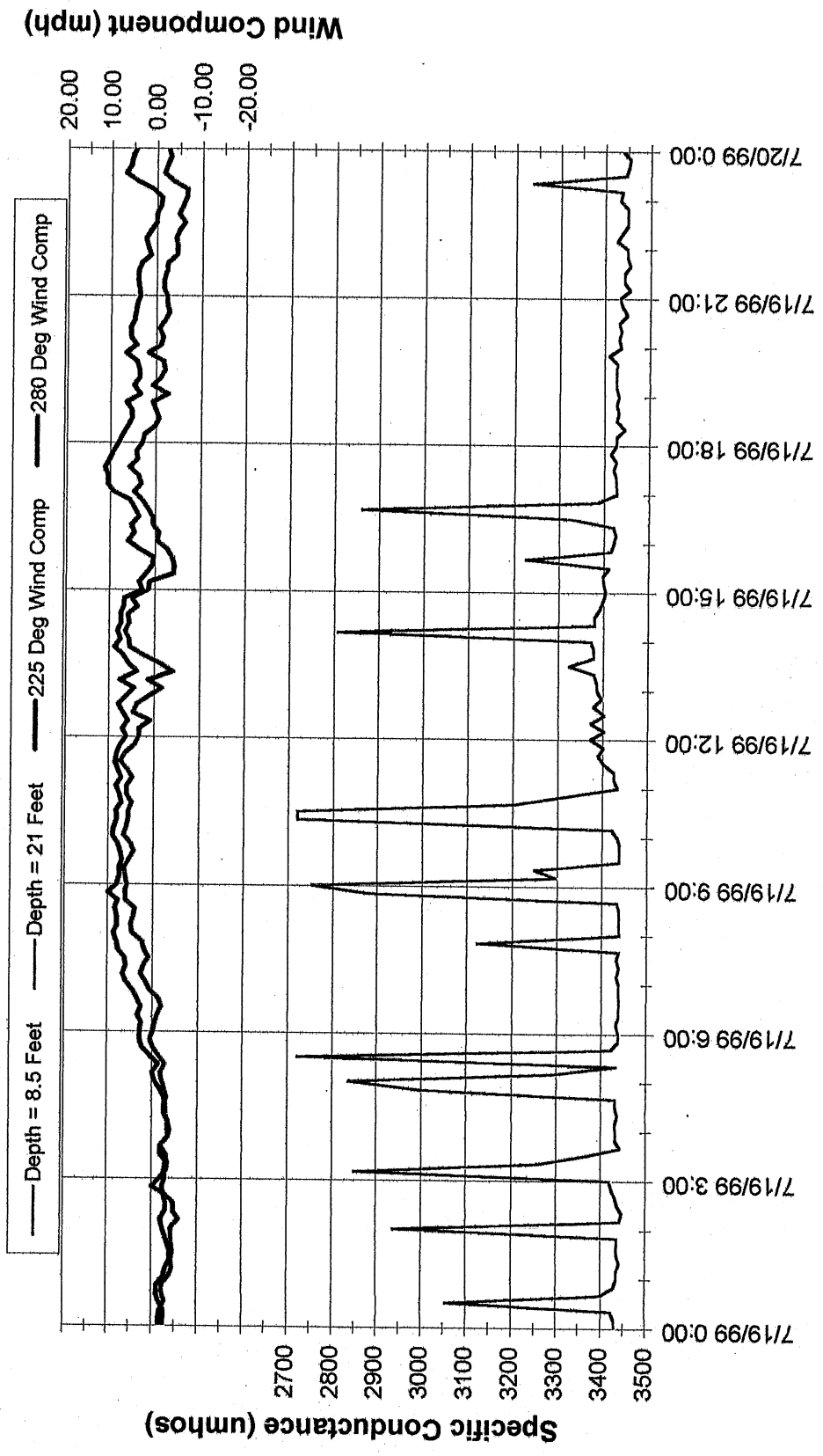
Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone



Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone

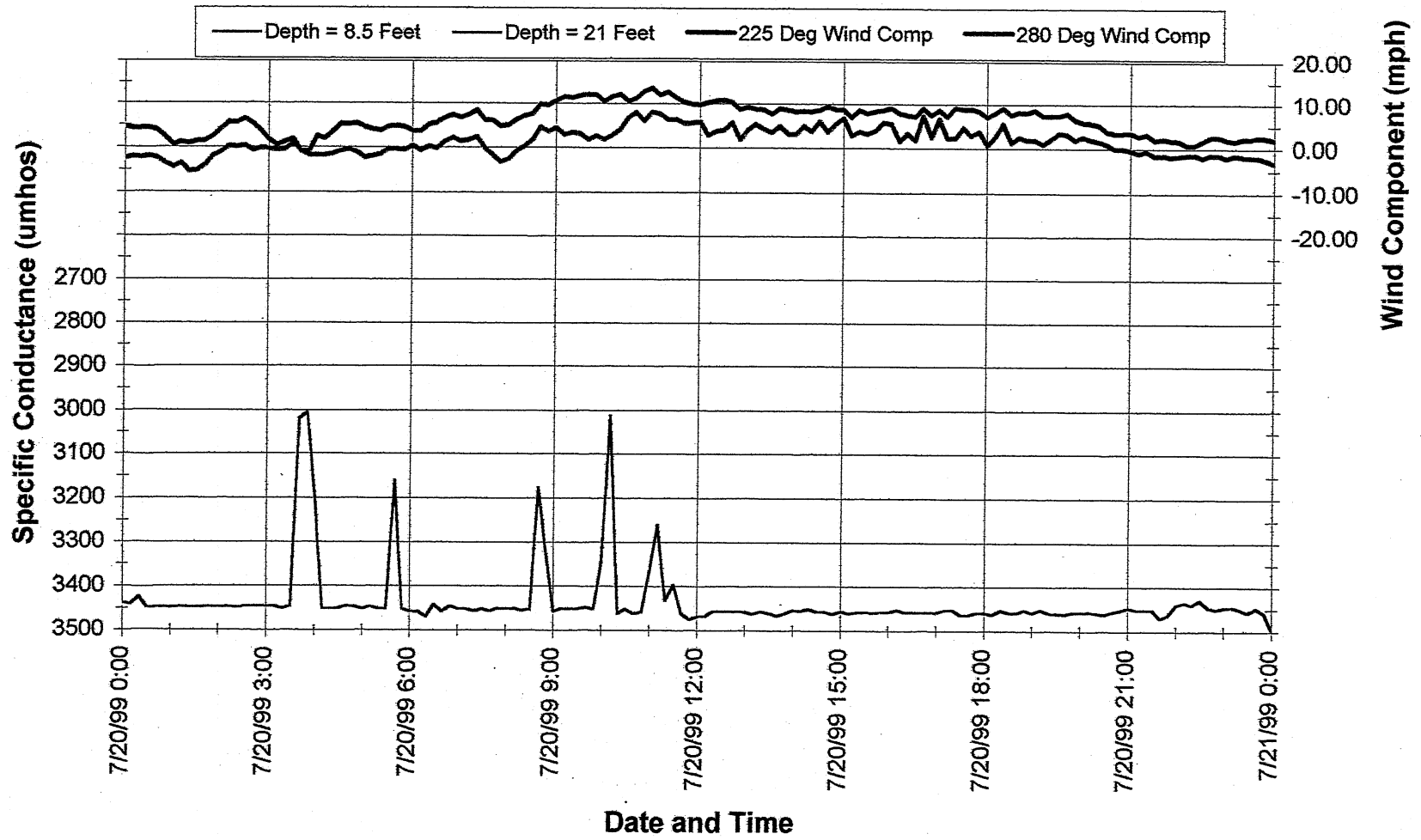


Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone

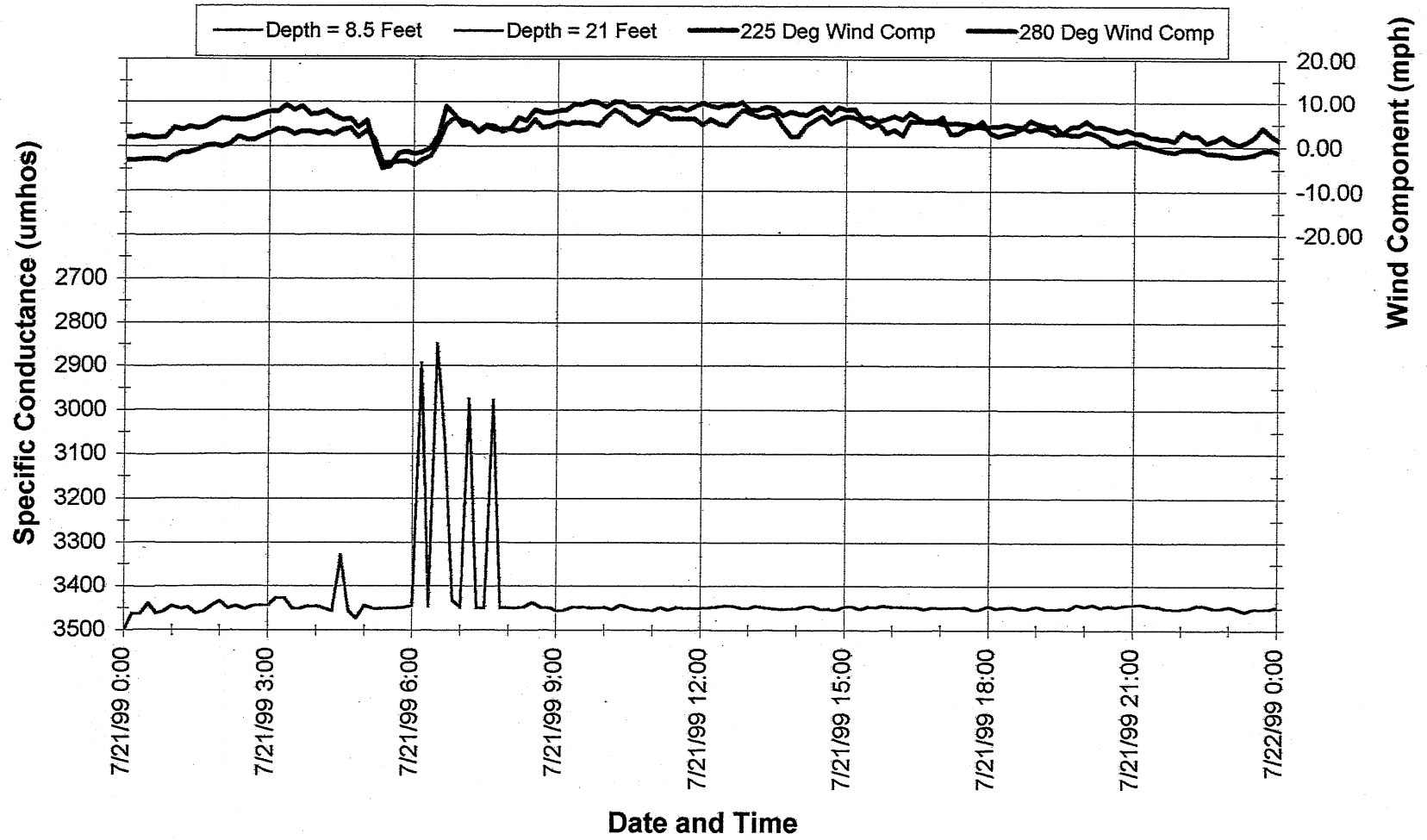


Date and Time

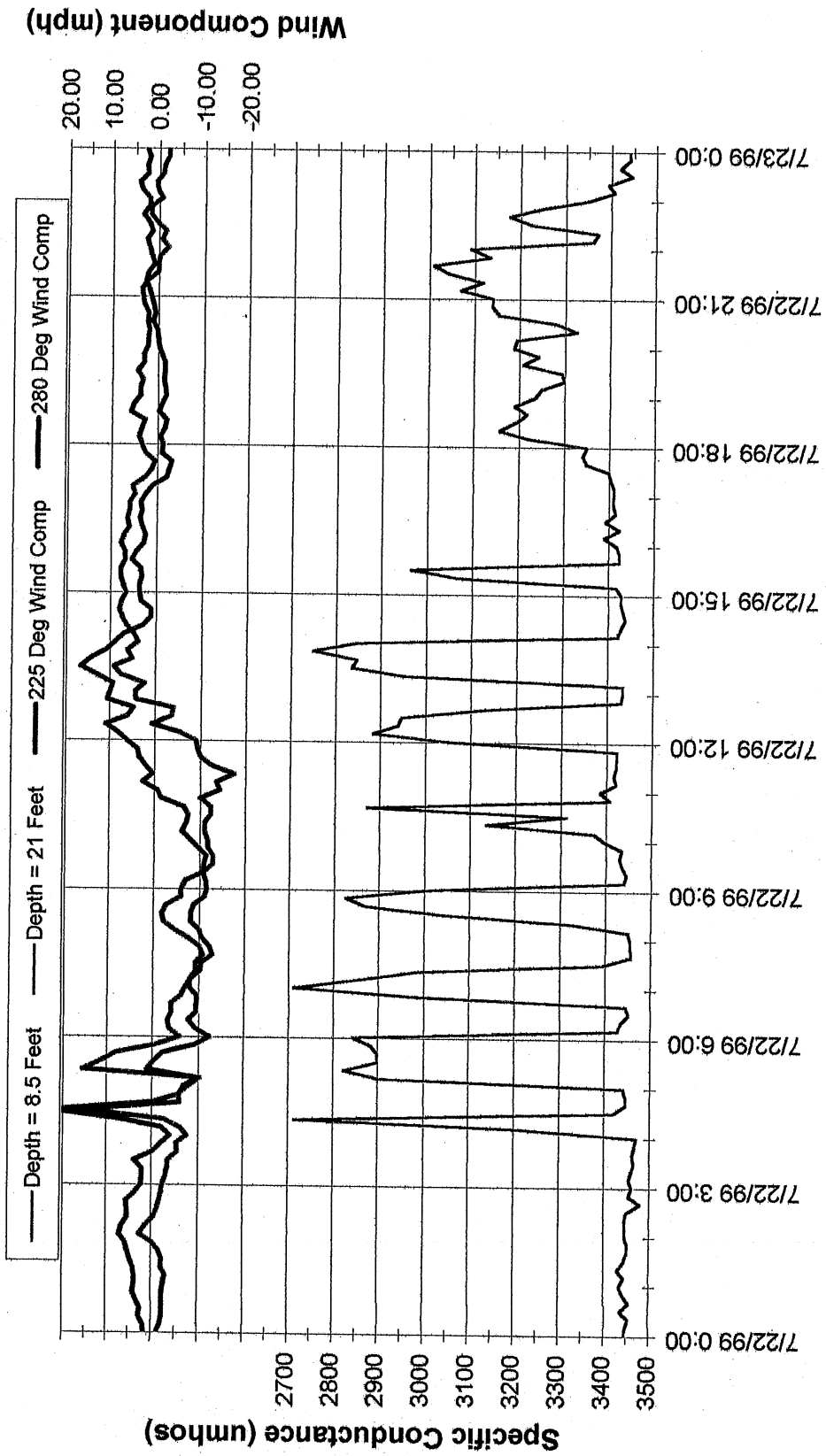
Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone



Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone

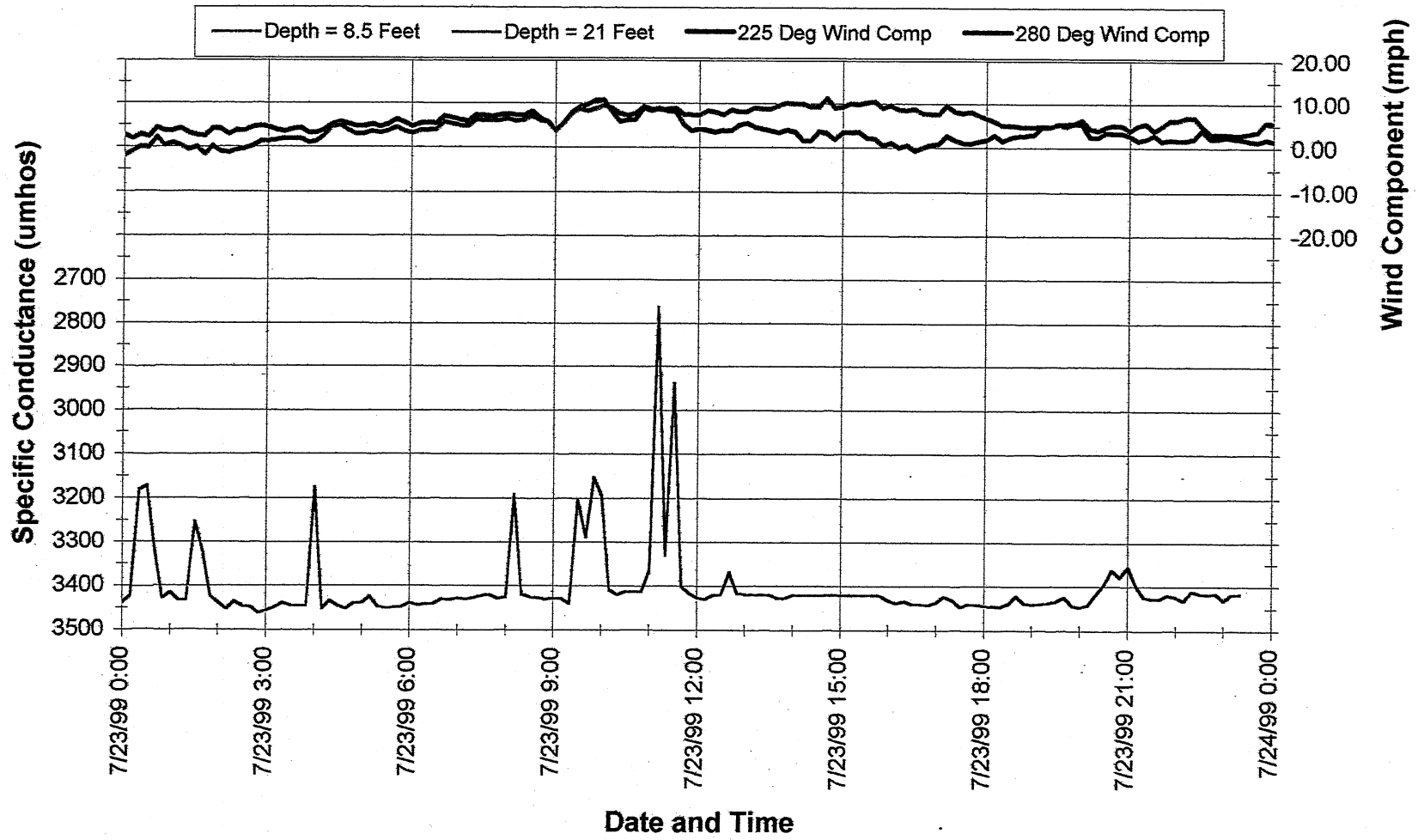


**Wind Component and Specific Conductance
Mission Bay - East Bay Exchange Zone**



Date and Time

Wind Component and Specific Conductance Mission Bay - East Bay Exchange Zone

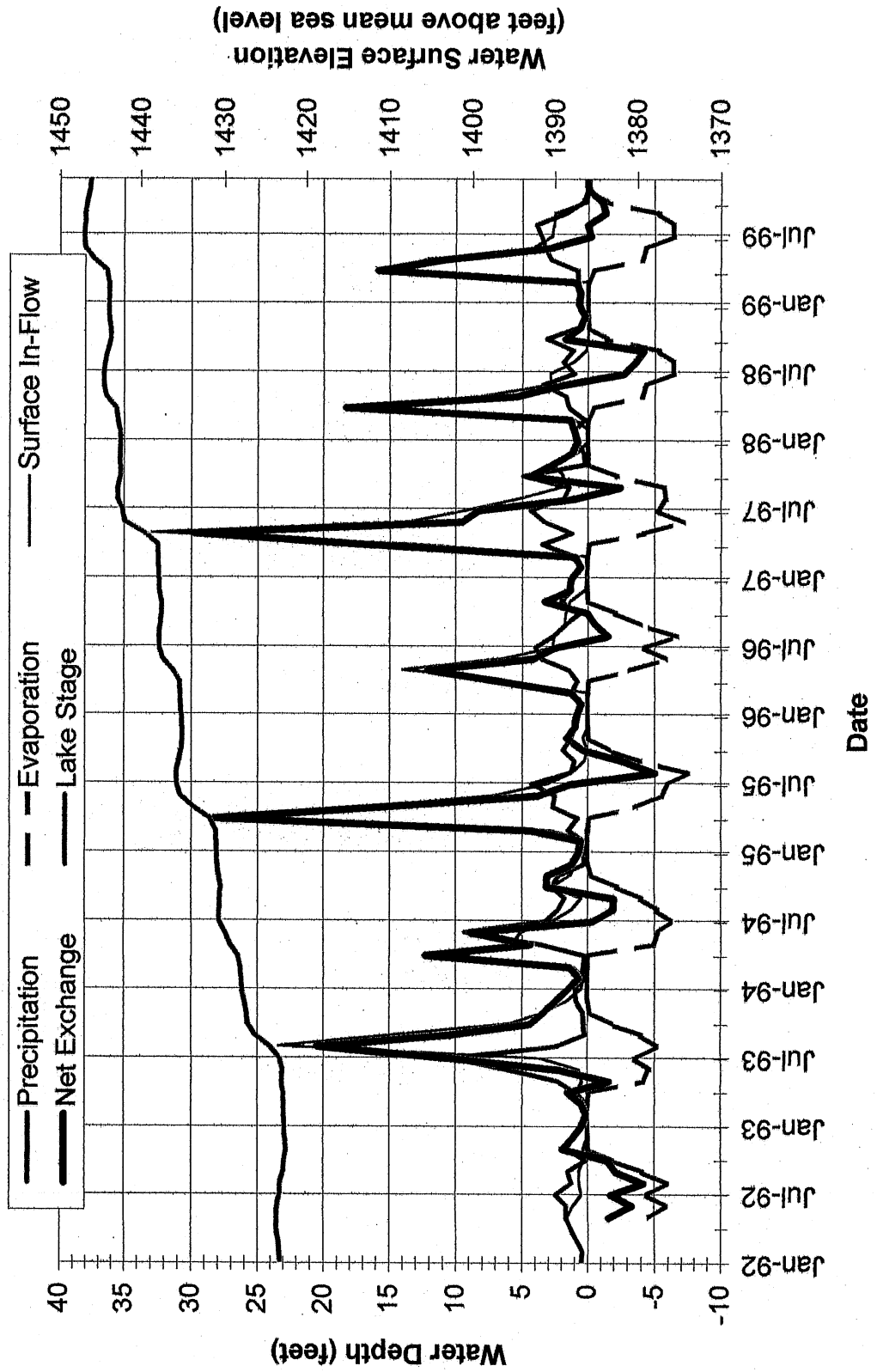


Section VI

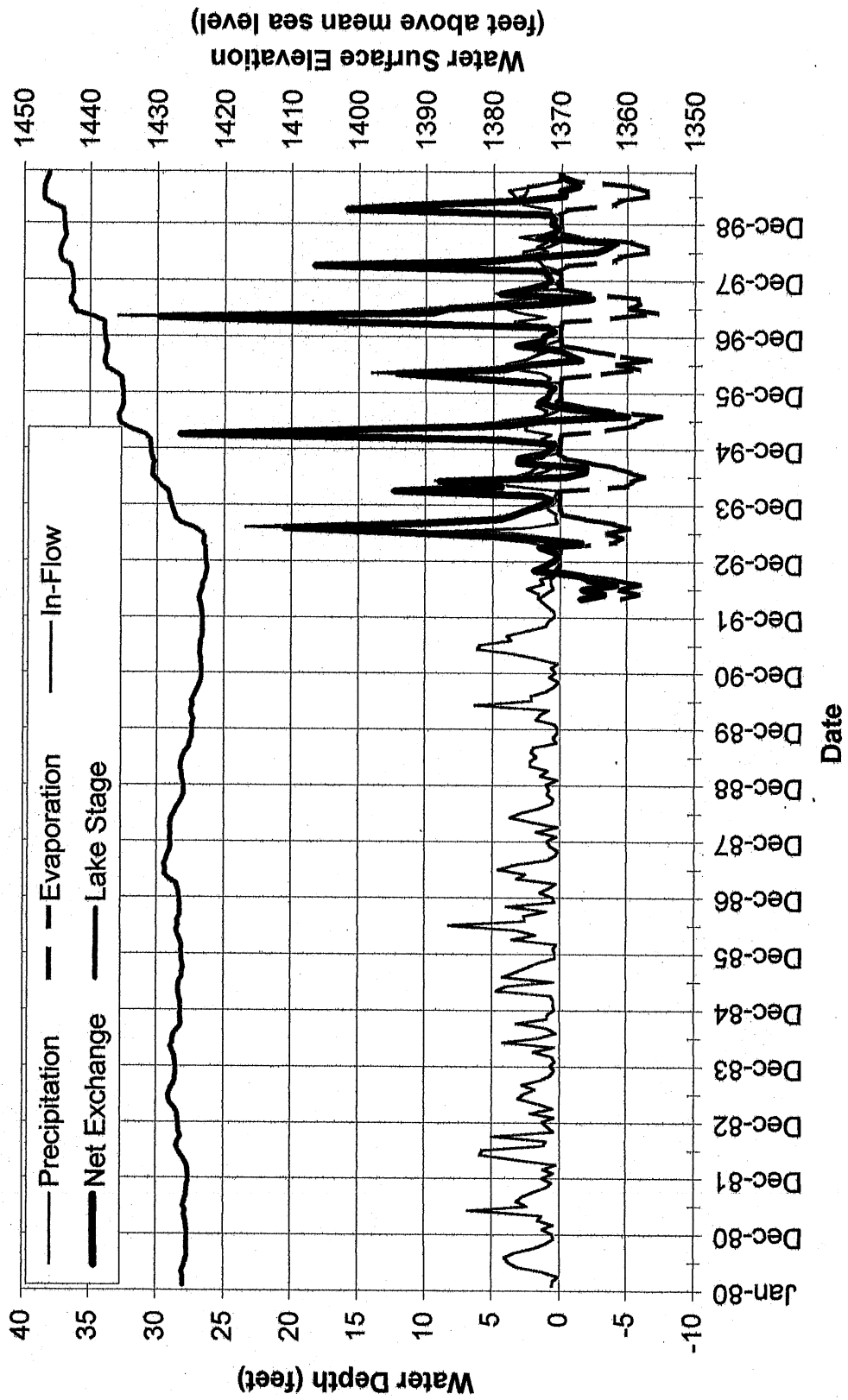
1992-1998

**Devils Lake Precipitation, Surface In-Flow
and Lake Stage Correlations**

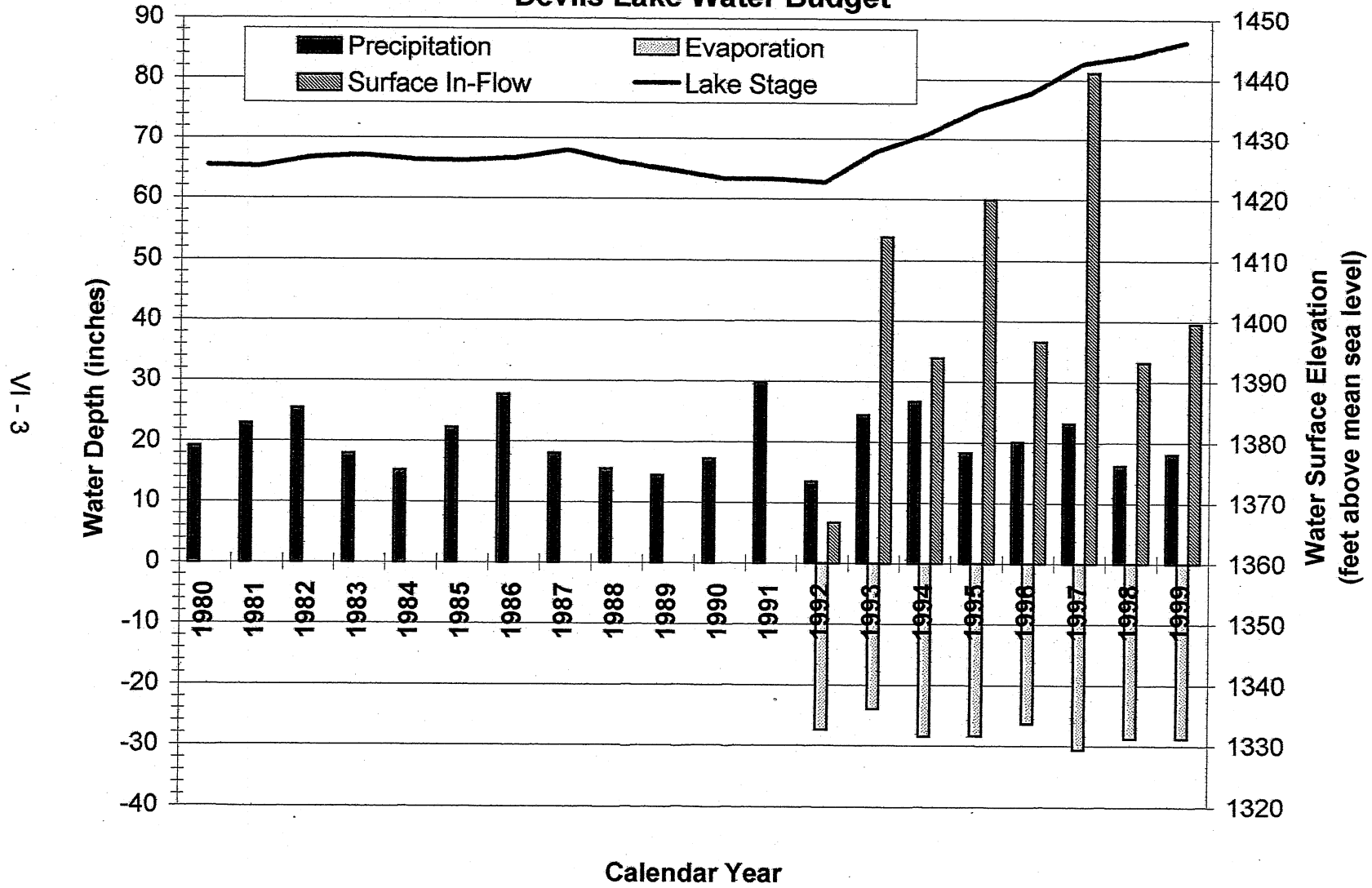
Devils Lake Water Budget, 1980-1999



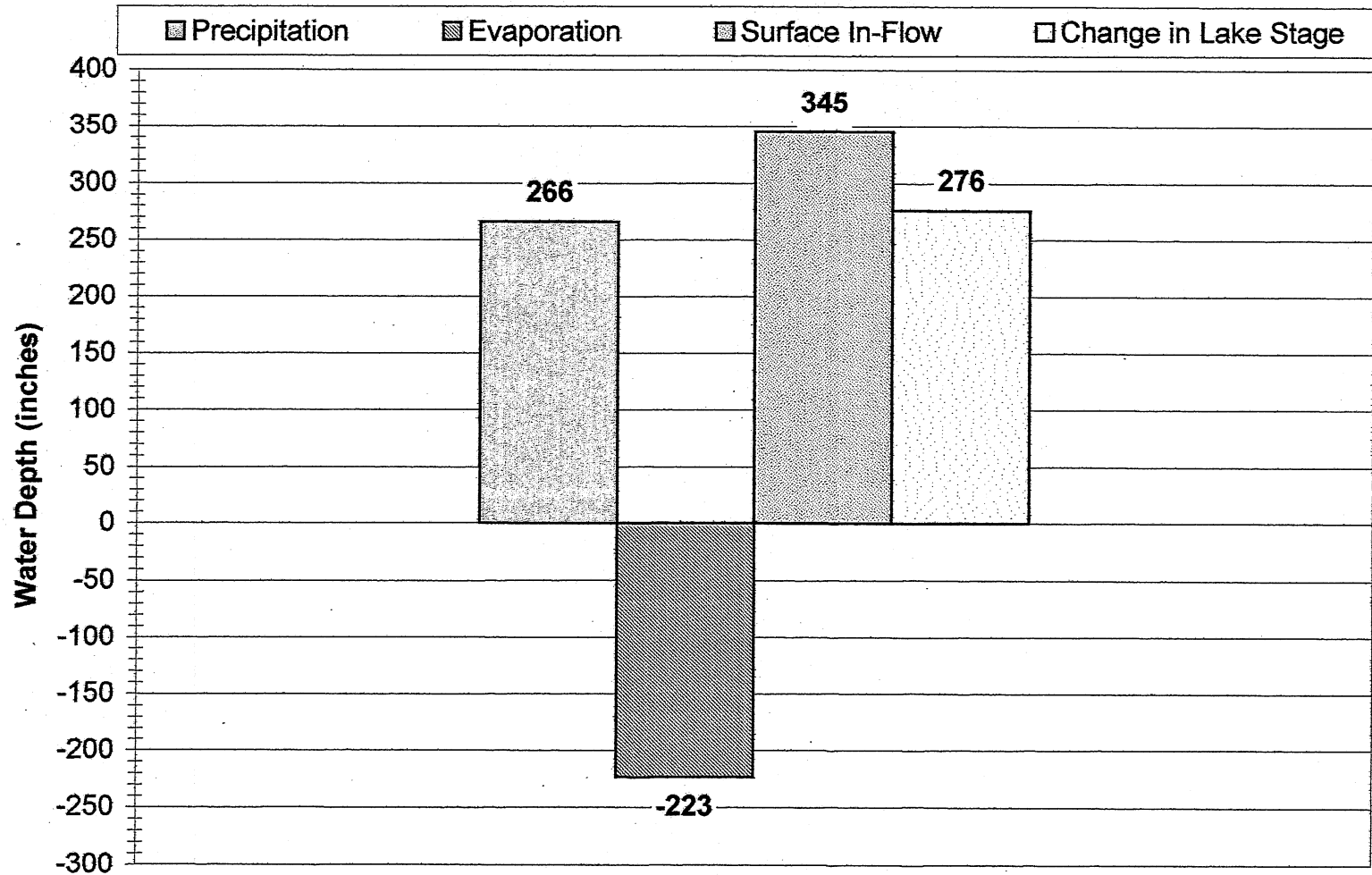
Devils Lake Water Budget, 1980-1999



Devils Lake Water Budget

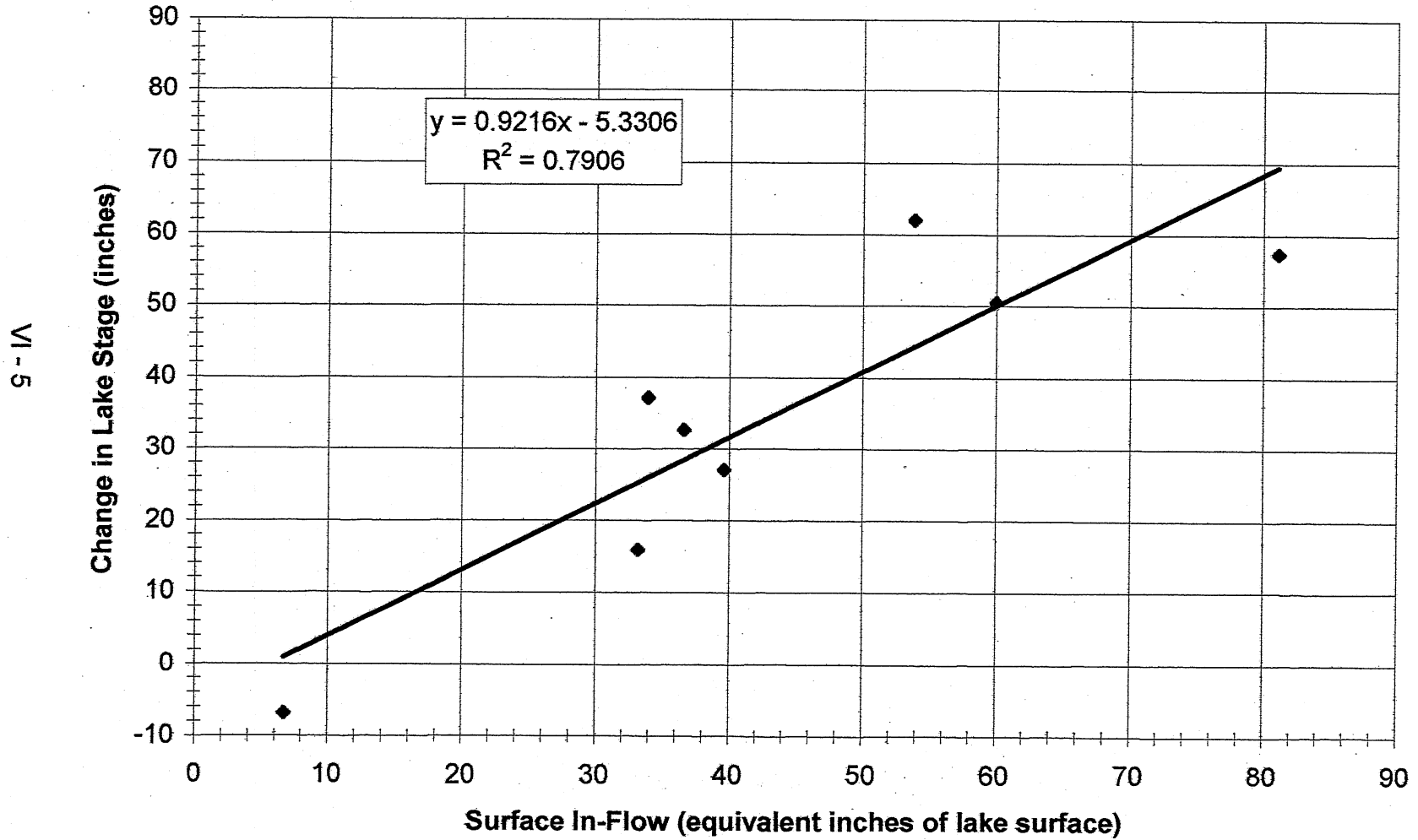


Devils Lake Water Budget

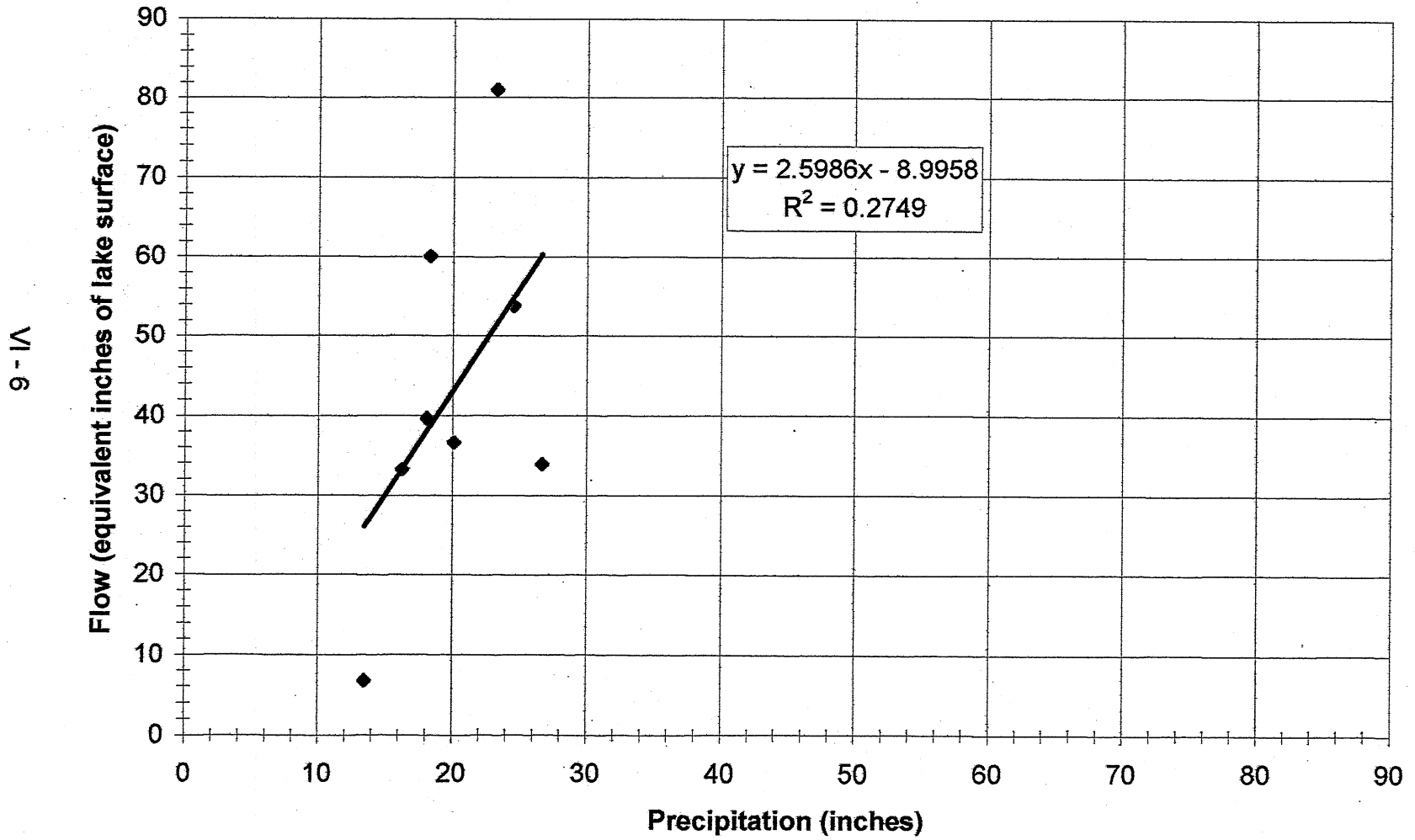


Water Years 1992 - 1999

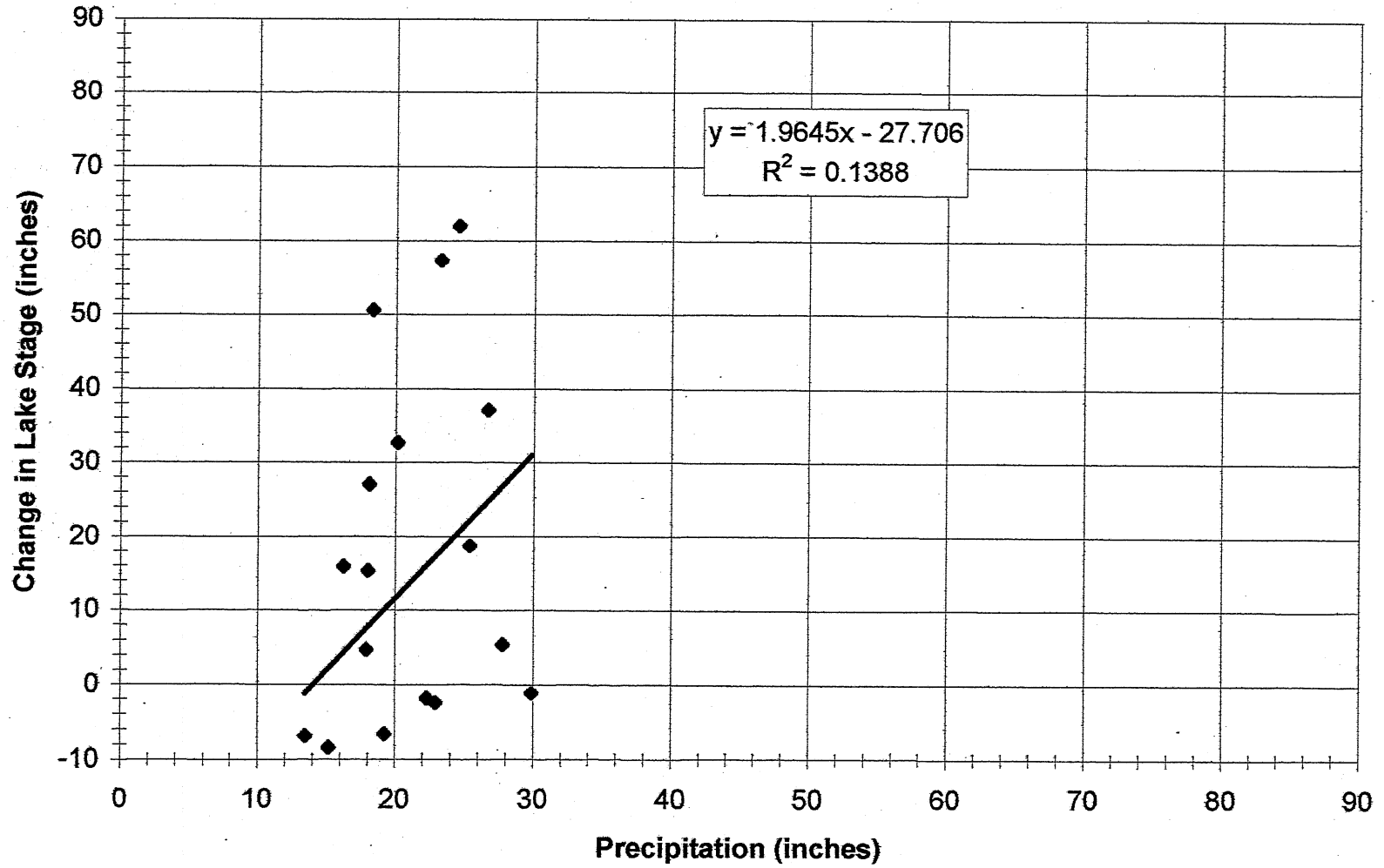
Annual Change in Lake Stage versus Annual Average Surface In-Flow, 1992 - 1999



Annual Average Surface In-Flow versus Annual Precipitation, 1992 - 1999

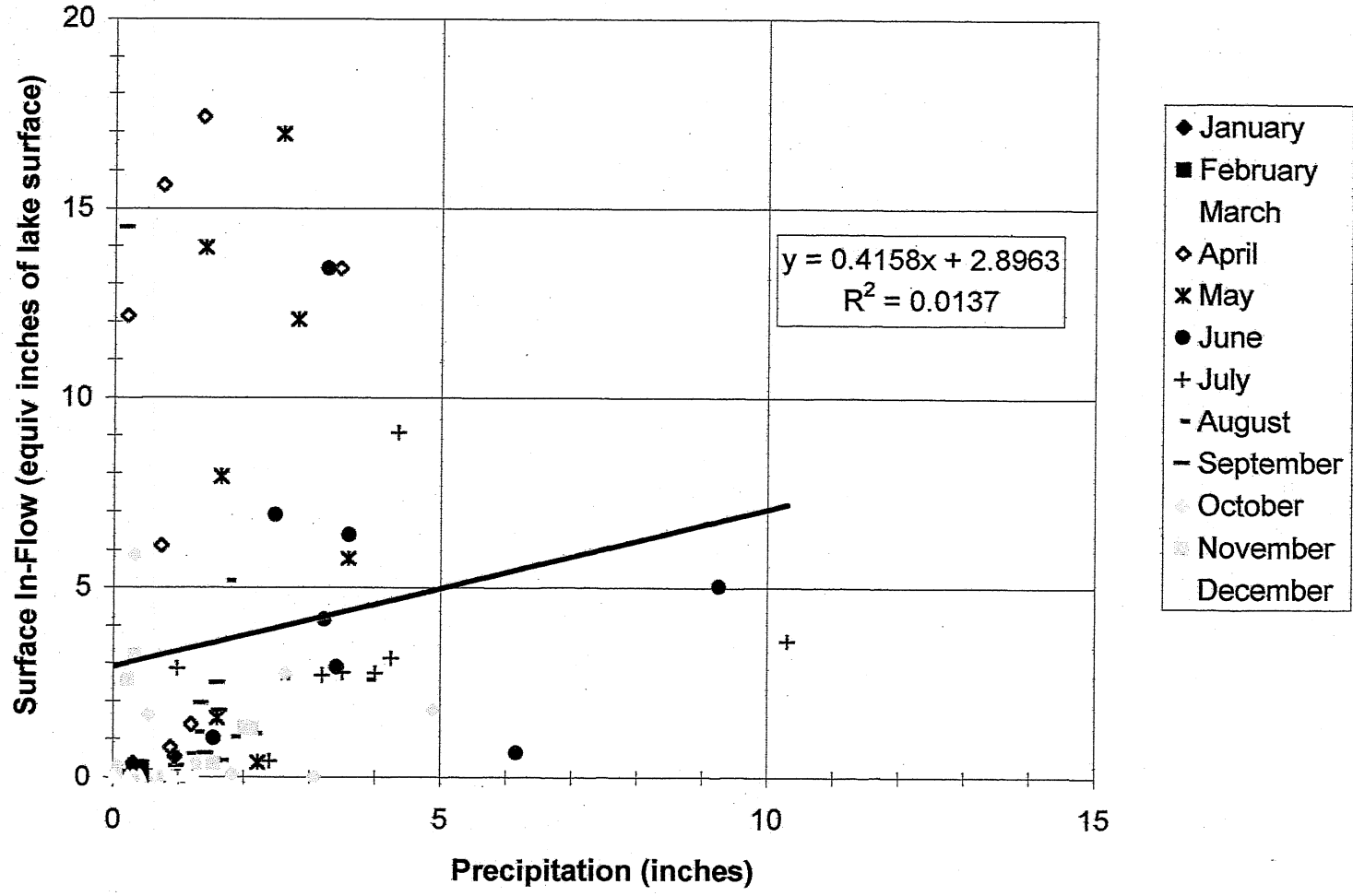


Annual Change in Lake Stage versus Annual Precipitation, 1980 - 1999



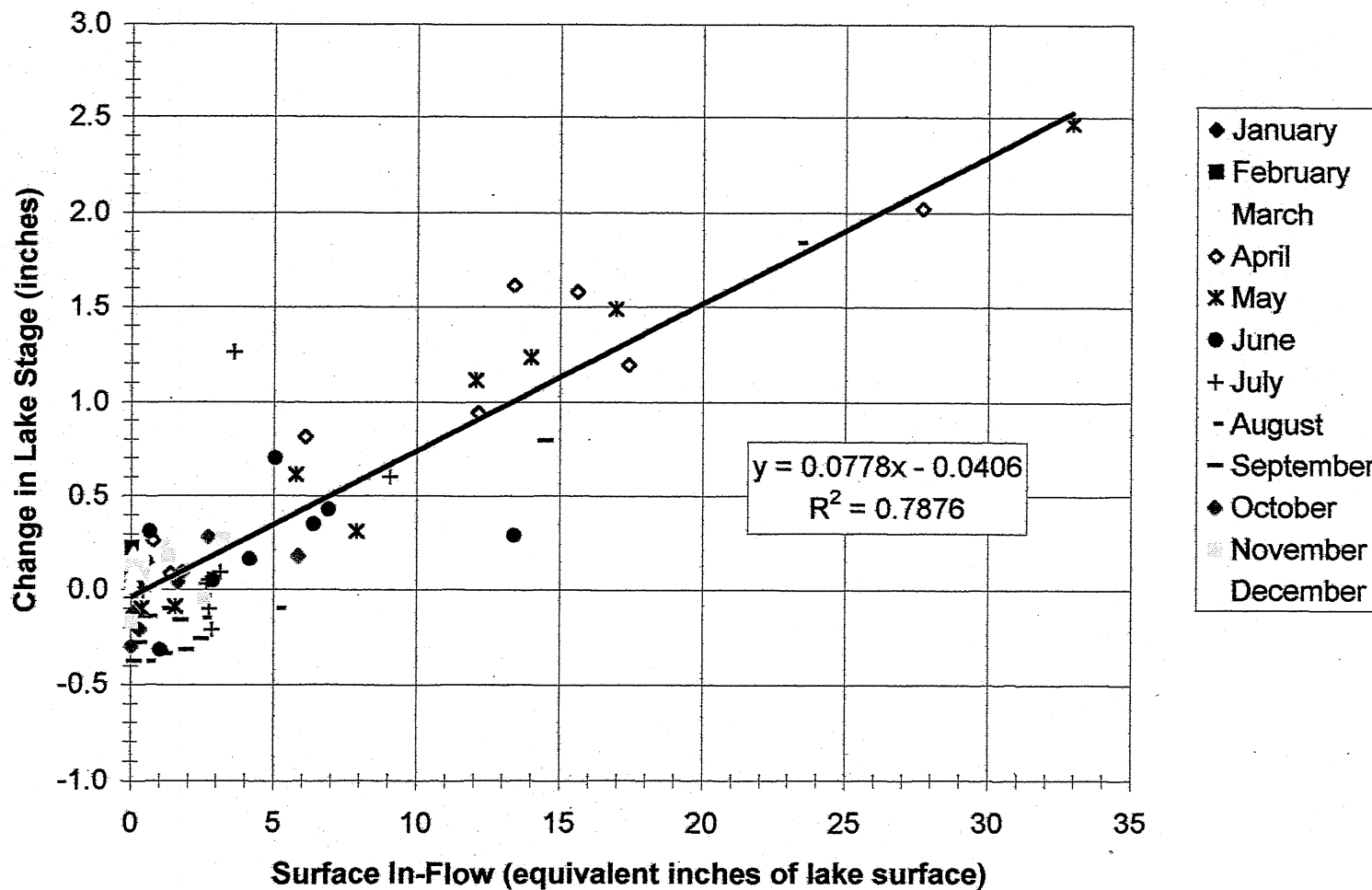
VI - 7

Average Monthly Surface In-Flow versus Monthly Precipitation, 1992 - 1999

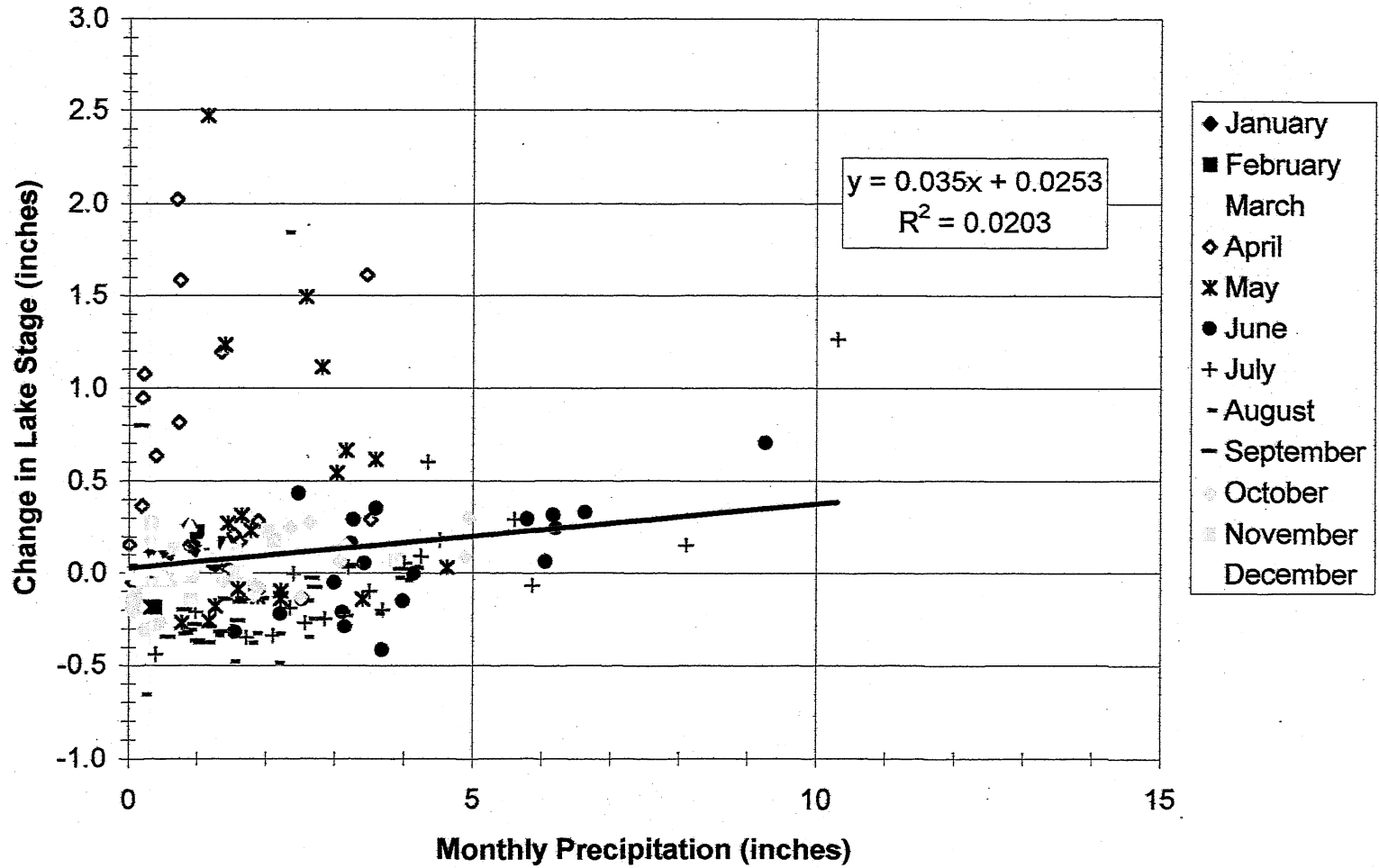


Monthly Change in Lake Stage versus Average Monthly Surface In-Flow, 1992 - 1999

6 - 1A

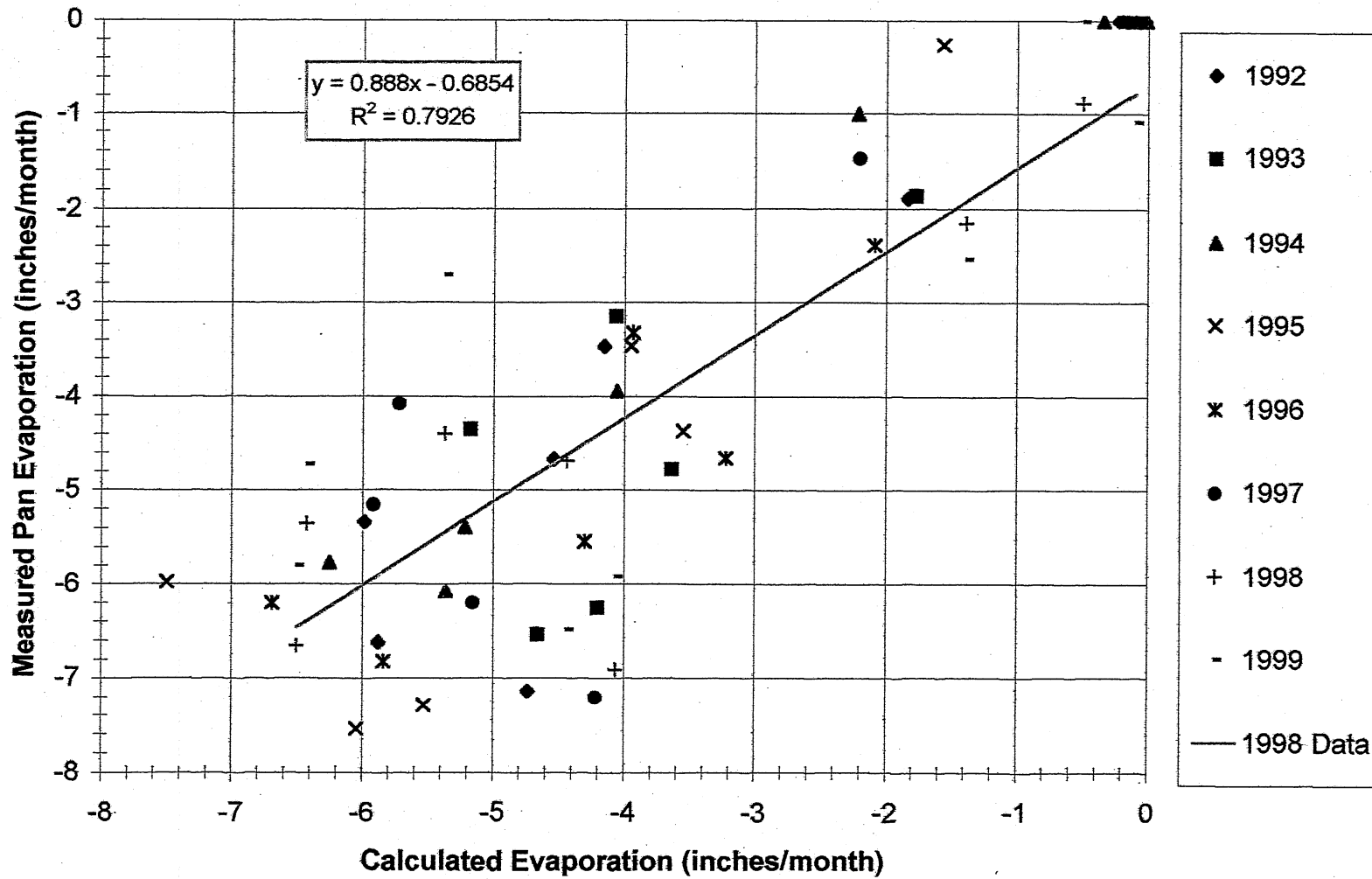


Monthly Change in Lake Stage versus Monthly Precipitation, 1980 - 1999

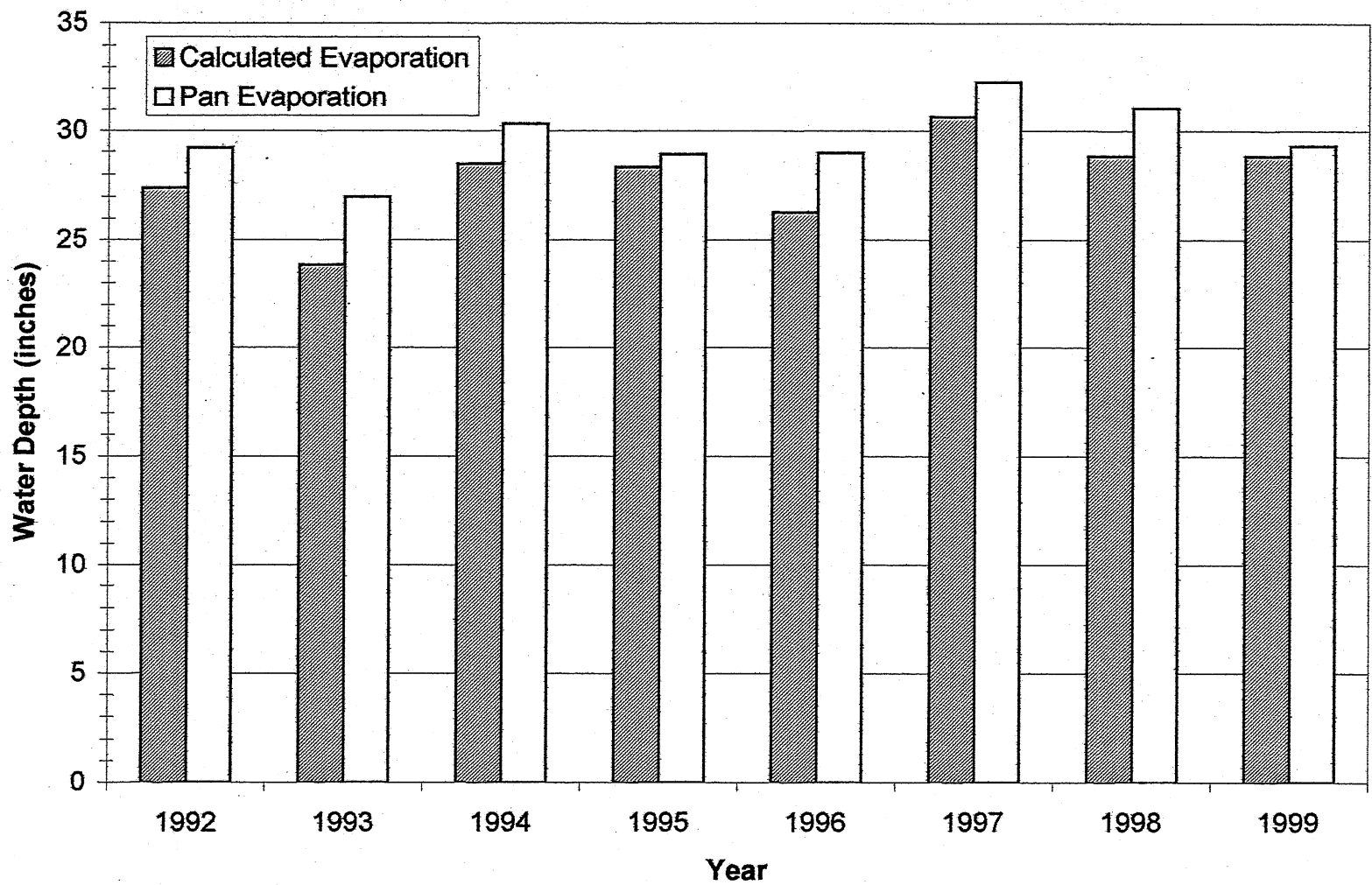


VI - 10

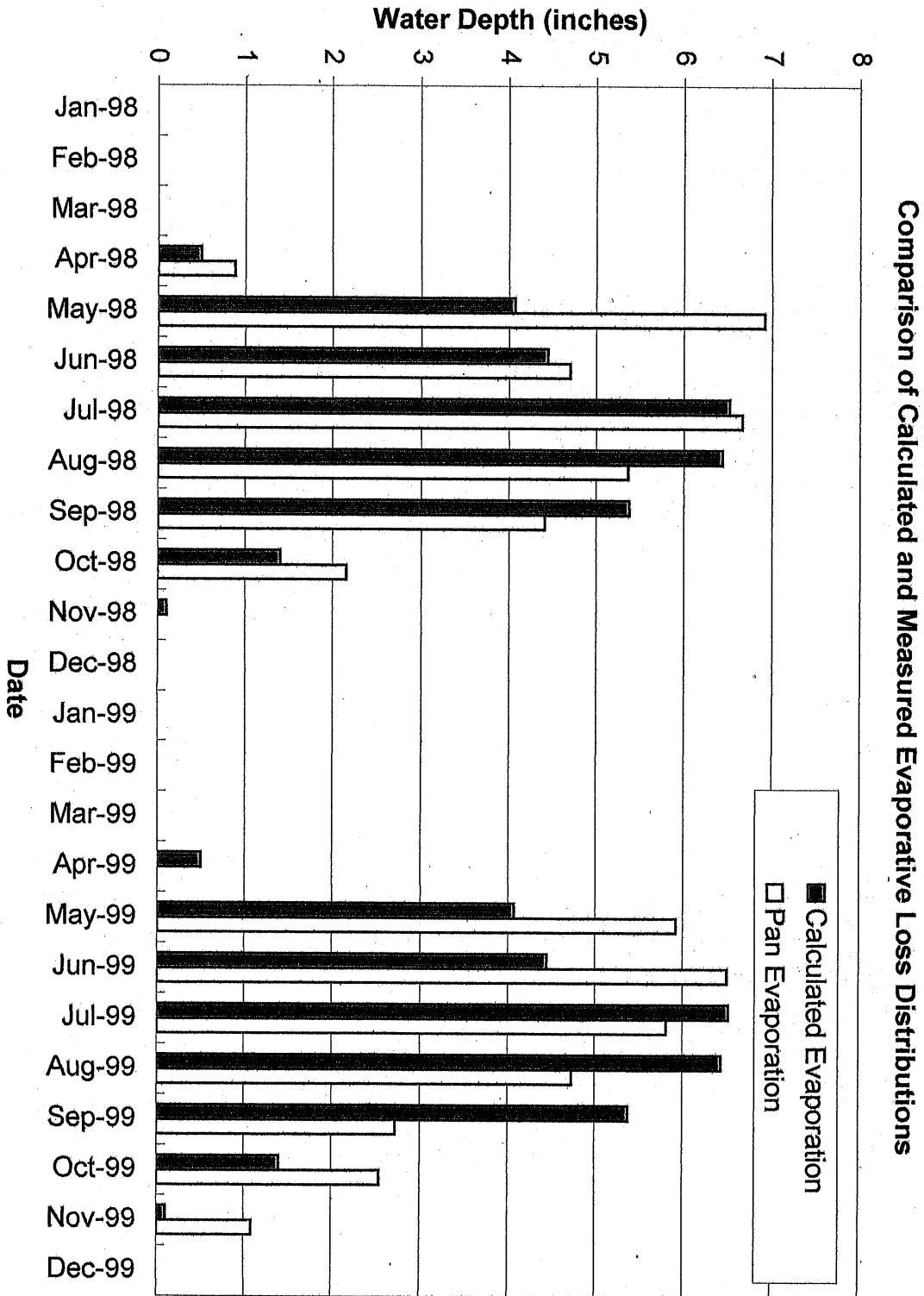
Measured versus Calculated Evaporation Rates



Comparison of Calculated and Measured Annual Water Losses Due to Evaporation



VI - 12



Comparison of Calculated and Measured Evaporative Loss Distributions