United States Department of the Interior

BUREAU OF RECLAMATION

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IN REPLY REFER TO:

D-8290
RES-3.20

JUL 19 1995

MEMORANDUM

To: All on Attached List

From: David L. Wegner, Acting Manager
Technical Service Center, Environmental Resources Service
Glen Canyon Environmental Studies Group

Subject: **Results of June 1995 Quarterly Water Quality Monitoring Survey - Lake Powell**

Enclosed are the results of the June 1995 quarterly water quality monitoring survey of Lake Powell conducted by the Bureau of Reclamation Glen Canyon Environmental Studies. The report summarizes late spring limnological conditions observed during the survey which was conducted from June 7 to June 13, 1995.

This quarterly survey is part of Reclamation's long term water quality monitoring program on Lake Powell and its tailwaters. Other features of this program include monthly water quality profiles and biological sampling of the Glen Canyon Dam forebay and continuous water quality monitoring of the tailwater below Glen Canyon Dam and at Lees Ferry.

Profiles were collected for the physical parameters of temperature, specific conductance, dissolved oxygen, pH, oxidation/reduction potential and turbidity at 26 stations on Lake Powell (refer to Table I). Secchi transparency, weather conditions, and other observations are recorded at each station. At selected locations, water samples are collected for the laboratory determination of major ionic constituents, nutrients, and, in some cases, selected trace elements. Biological samples for chlorophyll, phytoplankton, and zooplankton were also collected. Shipboard alkalinity measurements were also taken at selected sites to gather baseline data for carbonate precipitation dynamics.

Data from this program is processed by the GCES office and stored in a database for subsequent retrieval and analysis. This database contains 30 years of information from various phases of Reclamation's long-term monitoring effort on Lake Powell.

This report was developed to distribute the information collected by Reclamation's Lake Powell program to those interested in conditions in the lake. Please direct any questions or requests for further information to **Susan Hueftle** (email: shueftle@slcm03.uc.usbr.gov) or Bill Vernieu (bvernieu@slcm03.uc.usbr.gov), phone: (520) 556-7363. Your comments, suggestions, and feedback are encouraged. To eliminate needless mailings, please indicate your desire to remain on this list of recipients for future reports.

David L. Weg

Attachments: mailing list
map
7 figures

CURRENT STATUS OF LAKE POWELL

The late spring conditions were evident on Lake Powell during the June monitoring trip. Cooler temperatures and high winds posed a challenge to sampling efforts, but warmer temperatures arrived, raising surface lake temperatures 4 °C during the 7 day course of the trip. The late and heavy spring snowpack in the Rocky Mountains was 600 to 700 percent above the norm, but cool temperatures delayed the advent of the inevitably high runoff. Fortunately, winter lake levels at Powell were approximately 50 feet below full pool, allowing a buffer of over 7 million acre feet (MAF) or 30 percent of the lake's volume. Reclamation's latest projections predict pool levels to peak at 3696 feet in late July; 4 feet below full pool. The experimental spike flood releases from Glen Canyon Dam that were considered for this summer as the water rose, will in fact remain scheduled for the spring of 1996 and are included in the 1996 Annual Operating Plan for the dam. The hydrograph in figure 4 illustrates the combined flows of the Colorado, Green and San Juan Rivers entering Lake Powell. This provides a comparison of the flows of the last 2 years with the flood years of the mid-1980's, as well as an average of the flows since 1982. It indicates this year's peak inflow on June 21 at a level of 94,540 cubic feet per second.

As the high lake levels inundate heavily used beach and camping areas, localized fecal coliform levels have soared. Currently, five beaches around Wahweap and Bullfrog Bays have been closed pending lower bacteria counts.

TABLE 1: STATIONS SAMPLED ON THE JUNE 1995 LAKE POWELL WATER QUALITY MONITORING SURVEY

Main Channel Stations (kilometers from dam)		San Juan Arm (kilometers from main channel)	
Wahweap	2.4	Cha Canyon	19.3
Crossing of the Fathers	45.3	Lower Piute Bay	32.9
Oak Canyon	90.5	Upper Piute Bay	43.1
San Juan Confluence	100.2	Lower Zahn Bay	62.5
Escalante	116.9		
Iceberg Canyon	140.0	**Escalante Arm (kilometers from main channel)**	
Lake Canyon	158.9	Davis Gulch	11.9
Bullfrog Bay	169.2	Willow Creek	20.0
Moki Canyon	177.5	Beaches Site	30.7
Knowles Canyon	193.2	Escalante inflow	34.5
Lower Good Hope Bay	208.5		
Scorup Canyon	225.5	**Miscellaneous Stations (off main channel)**	
Hite Basin	238.7	Mid Navajo Canyon	12.4
Hite Marina	248.0	Face Canyon	3.9
Colorado River inflow, Above Rock Canyon	257.0	Labyrinth Canyon	

NEW DEVELOPMENTS

The map recently developed by the GCES office using a geographic information system was used for locating sampling stations. GPS (global positioning system) handheld units were used to refine station locations for some of the newer sites. Geographical coordinates and river channel distances from selected reference points can now be determined for each locale.

RESULTS AND DISCUSSION:

BIOLOGICAL SAMPLING:

Analysis of phytoplankton and zooplankton samples is not yet available. Observations made during sampling revealed the greatest numbers of zooplankton (primarily cladocerans followed by copepods) in the surface waters at a depth of 0 to 10 meters. Phytoplankton (primarily diatoms) occurred at 10 to 30 meters of depth. Diatoms were the dominant algae form below Bullfrog Bay, while the water above Bullfrog contained many blue-green *Aphanizomenon* colonies-- in increasing numbers from Bullfrog to the inflow. The *Aphanizomenon* appeared to populate the plume of riverine water flowing near the surface of the lake. The dominance of algal populations below the surface accounts for the higher oxygen levels found there, as demonstrated in the isopleths of the lake in figures 2, 6, and 7. The dissolved oxygen maxima can be seen centered at a depth between 8 and 17 meters in the main channel and extends from the dam to above Crossing of the Fathers station 45 kilometers uplake, as well as in the Escalante and San Juan arms.

Results from chemical analysis are not yet available.

PHYSICAL DATA:

Isopleths of the basic water-quality parameters for each arm of Lake Powell are included in figures 2, 3, 5, 6, and 7. These plots represent two-dimensional cross-sections of Powell's three main river channels (Colorado, San Juan and Escalante) from the deepest areas to the inflows. Each line or isopleth on the plot represents the same value of a given parameter throughout the lake. This is similar to isopleths of temperature patterns commonly seen on weather maps. This type of representation of water quality is valuable in showing patterns that exist throughout the lake such as inflow density currents, thermal stratification patterns, or areas of oxygen minima or maxima.

Also included in this report are individual profiles of six selected stations on Lake Powell. These profiles represent changes in five basic water quality parameters (temperature, specific conductance, dissolved oxygen, pH, ORP, and turbidity) with depth, and are useful for indicating how the various physical parameters can influence each other.

PHYSICAL ANALYSIS:

The spring's high inflows have produced pronounced changes since the February trip. Surface temperatures warmed from 11.5 °C to 22 °C. The inflow from the Colorado River above Hite Marina warmed to 15.1 °C and is introducing a large plug of relatively fresh water with a conductance just over 400 µS/cm--nearly 800 µS/cm lower than in February. We observed this muddy plume of river water skim below the lake's surface near Hite Marina and the subsurface plume of low conductance could be traced 125 kilometers downlake at a depth of 10 to 35 meters (see isopleths in figures 5, 6, and 7). At Oak Canyon, depressed oxygen levels and the corresponding drop in pH indicates the leading edge of the plume of nutrient-enriched river water and its corresponding biological oxygen demand-- tracing the river water even further (170 km) downlake from the source. The subsurface plume of river water can be seen in the isopleths to angle toward the surface as it is tracked downstream. The most likely explanation for this intriguing phenomenon is the differential warming of the river and lake water since the spring inflows have commenced. It could also be a function of the hydrograph--as the discharge of the Colorado River increases, so would its bedload and hence its density. This effect could be further enhanced by warmer temperatures which might solubilize more minerals in transit.

The conductivity isopleths at the confluence of the Escalante arm with the main channel (figures 5 and 7) demonstrate a peculiar interfingering of water of varying salinity, which is echoed to a lesser extent by the other physical parameters (see line profile of the Escalante). This could be the result of a phenomenon similar to that discussed in the previous paragraph but on a smaller scale. Spring spates separated by time, temperature, discharge, bedload and salinity may have been injected at different levels of the Escalante arm. At the time of sampling the inflow was 17 °C and 400 µS/cm. Turbidity readings on the Escalante imply that silt-bearing waters rich in organic material resulted in oxygen depletion at the bottom near the inflow. The second pulse of anoxia around Davis Gulch may represent a similar scenario. This organically rich water may find itself effectively "dammed" by the cold, saline water backing up from the main channel. We saw one of the more extreme oxygen maxima and minima of the Lake in the Escalante arm. This may be due both to the low volume of the Escalante inflow and an inhibition to surface wind mixing because of the deep, narrow aspect of the canyon.

Neither such low nor high levels of oxygen were encountered in the San Juan arm. Logistical difficulties prevented sampling of the inflow of the San Juan, but its relatively fresh water (conductivity ~400 µS/cm) was clearly flowing below the surface, injecting at a depth of 10 to 20 meters and extending downstream perhaps as far as the confluence with the main channel. Trends with other parameters in the San Juan arm mimic the upper 150 kilometers of the main channel. The addition of a station at the San Juan confluence revealed a localized lowering of oxygen levels in the main stem's hypolimnion.

SUMMARY

The high inflows will clearly have a marked affect on the reservoir, as has been indicated in past high water years. The hypolimnion of the reservoir is still showing long-term trends initiated after the flood of 1993. The high influx of organic materials from the turbid but relatively fresh flood waters eventually brings about lower oxygen and conductivity levels in the hypolimnion with each successive year's mixing.. This year's flood offers a unique opportunity to study the effects off high water and advective stratification, and GCES will continue its monitoring of Lake Powell.

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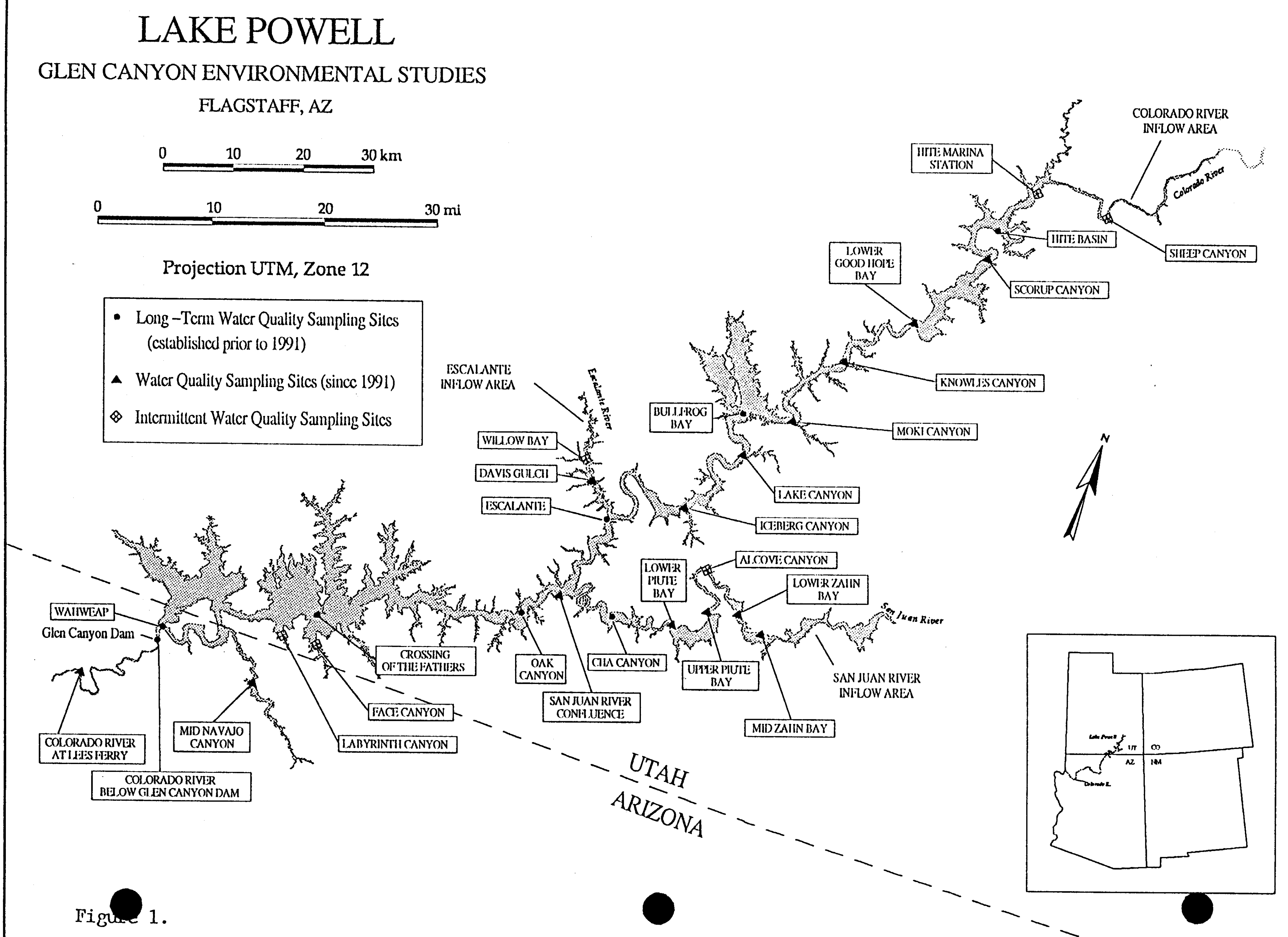
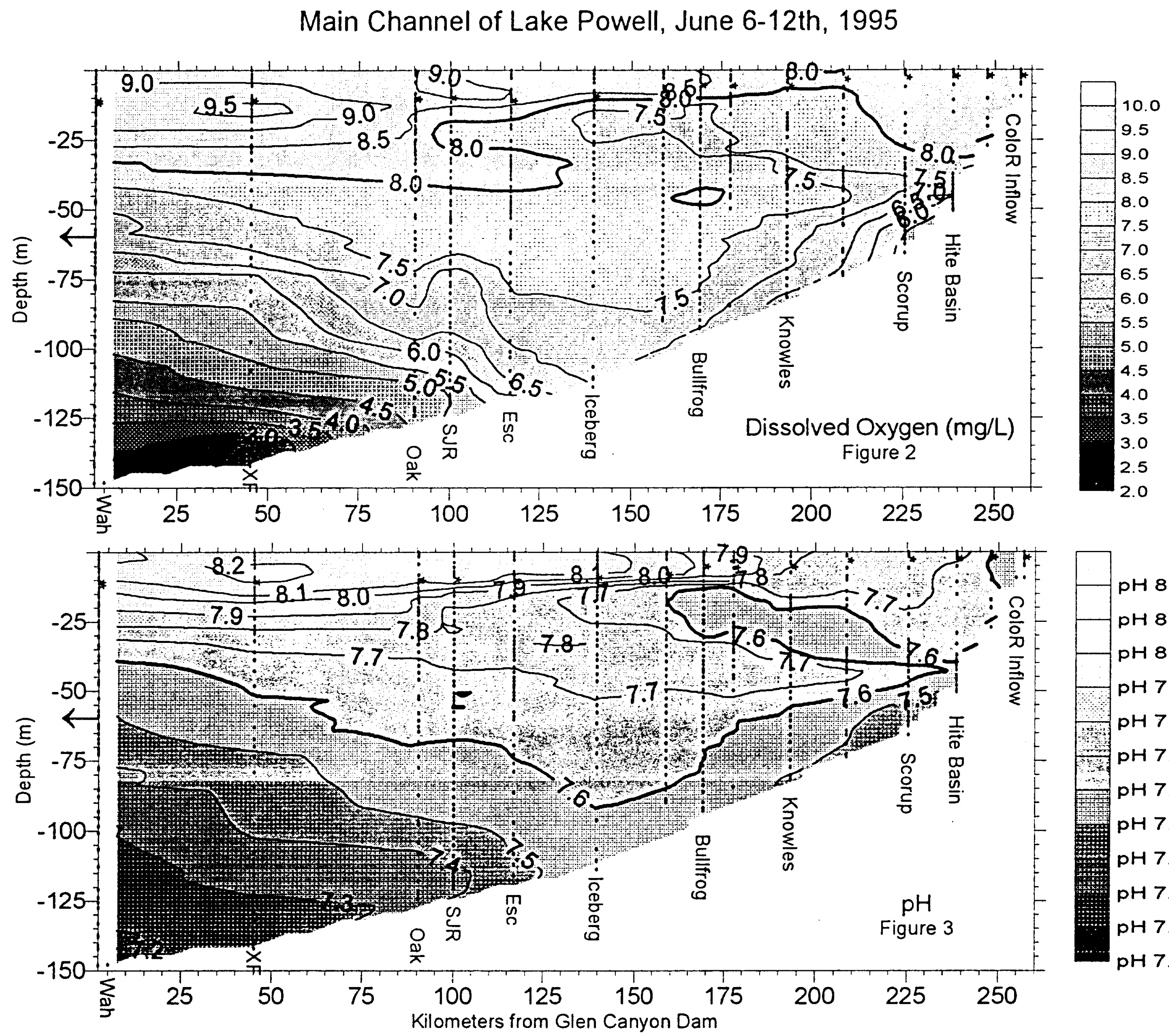

LAKE POWELL
GLEN CANYON ENVIRONMENTAL STUDIES
FLAGSTAFF, AZ
0 10 20 30 km
0 10 20 30 mi
Projection UTM, Zone 12
Long-Term Water Quality Sampling Sites (established prior to 1991)
Water Quality Sampling Sites (since 1991)
Intermittent Water Quality Sampling Sites
COLORADO RIVER INFLOW AREA
Colorado River
HITE MARINA STATION
HITE BASIN
SHEEP CANYON
SCORUP CANYON
LOWER GOOD HOPE BAY
KNOWLES CANYON
MOKI CANYON
BULLFROG BAY
LAKE CANYON
ICEBERG CANYON
ESCALANTE INFLOW AREA
Escalante River
WILLOW BAY
DAVIS GULCH
ESCALANTE
ALCOVE CANYON
LOWER PIUTE BAY
LOWER ZAHN BAY
San Juan River
UPPER PIUTE BAY
CHA CANYON
OAK CANYON
SAN JUAN RIVER CONFLUENCE
SAN JUAN RIVER INFLOW AREA
MID ZAHN BAY
WAHWEAP
Glen Canyon Dam
CROSSING OF THE FATHERS
FACE CANYON
LABYRINTH CANYON
MID NAVAJO CANYON
COLORADO RIVER AT LEES FERRY
COLORADO RIVER BELOW GLEN CANYON DAM
UTAH
ARIZONA
N
UT
CO
AZ
NM

Figure 1.



Figures 2 & 3: Dissolved oxygen (mg/L) and pH in the main channel of Lake Powell. Secchi disk depths indicated by a dash. Penstock depth is -59 m at the dam. Dots on map represent sampling sites. Dashed isopleth lines are out of the normal sequence on the scale, but are added for better resolution to aid interpretation.

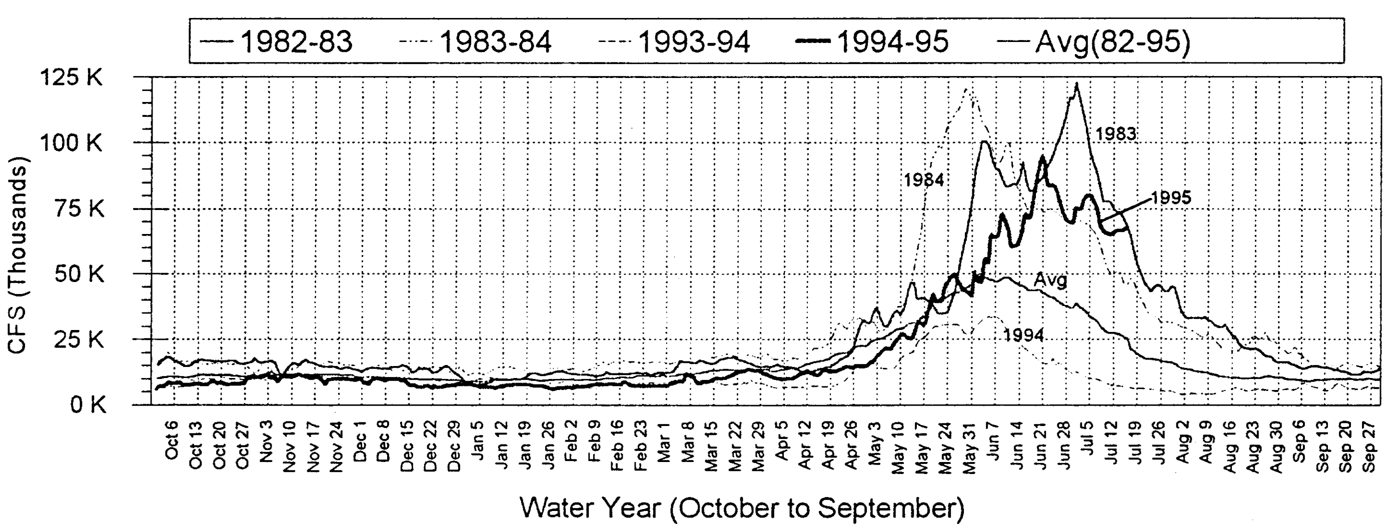


Figure 4: A hydrograph of the combined inflows of the Colorado and San Juan River's entering Lake Powell comparing the current year with last year and past flood years.

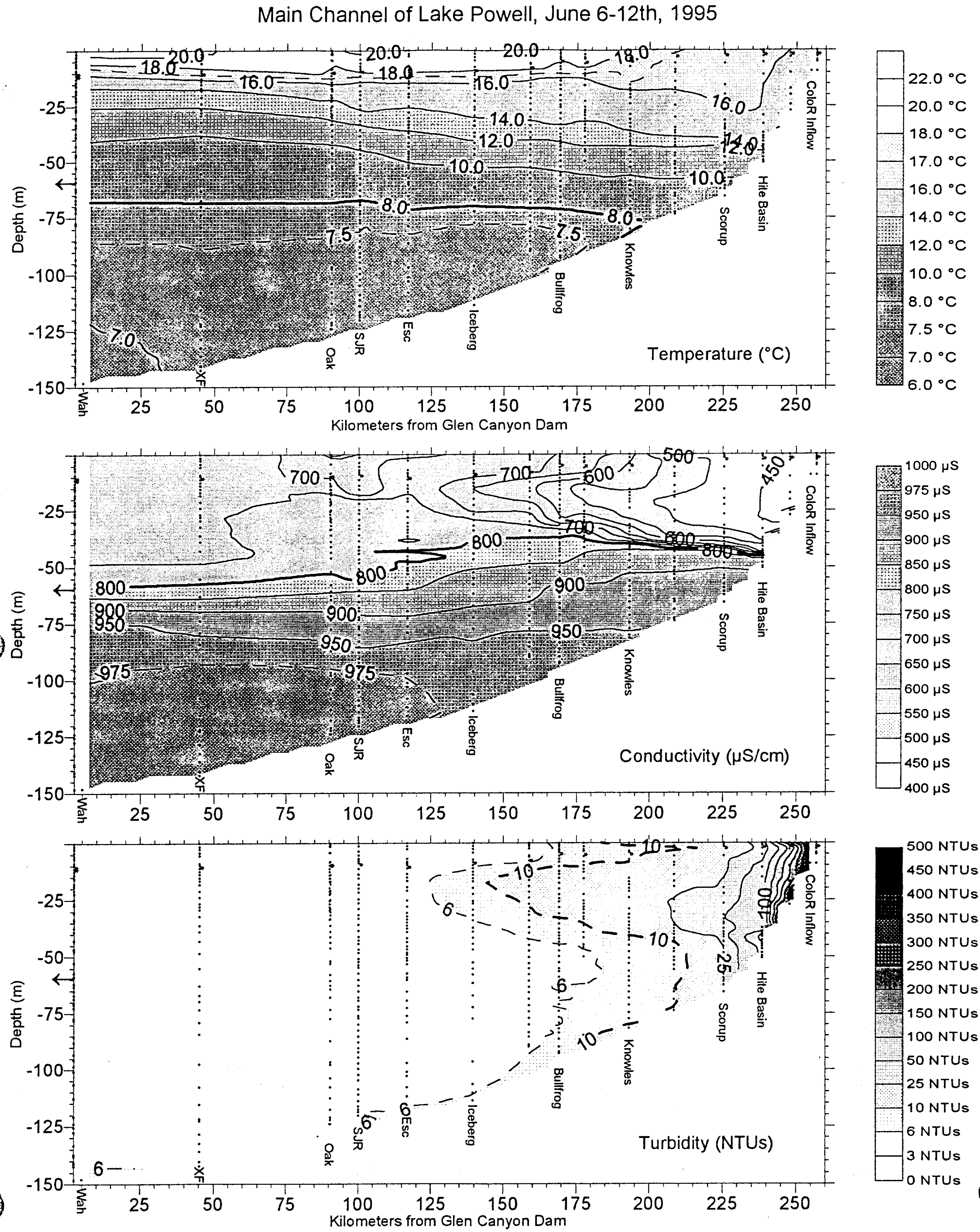


Figure 5: Temperature (°C), Conductivity (µS/cm) and Turbidity (NTUs) in the main channel of Lake Powell, June 6 to 12, 1995. Secchi disk depths indicated by (*). Penstock depth at -59 meters. Dots on map represent sampling sites. Dashed isopleth lines are out of the normal sequence on the scale, but are added for better resolution to aid interpretation.

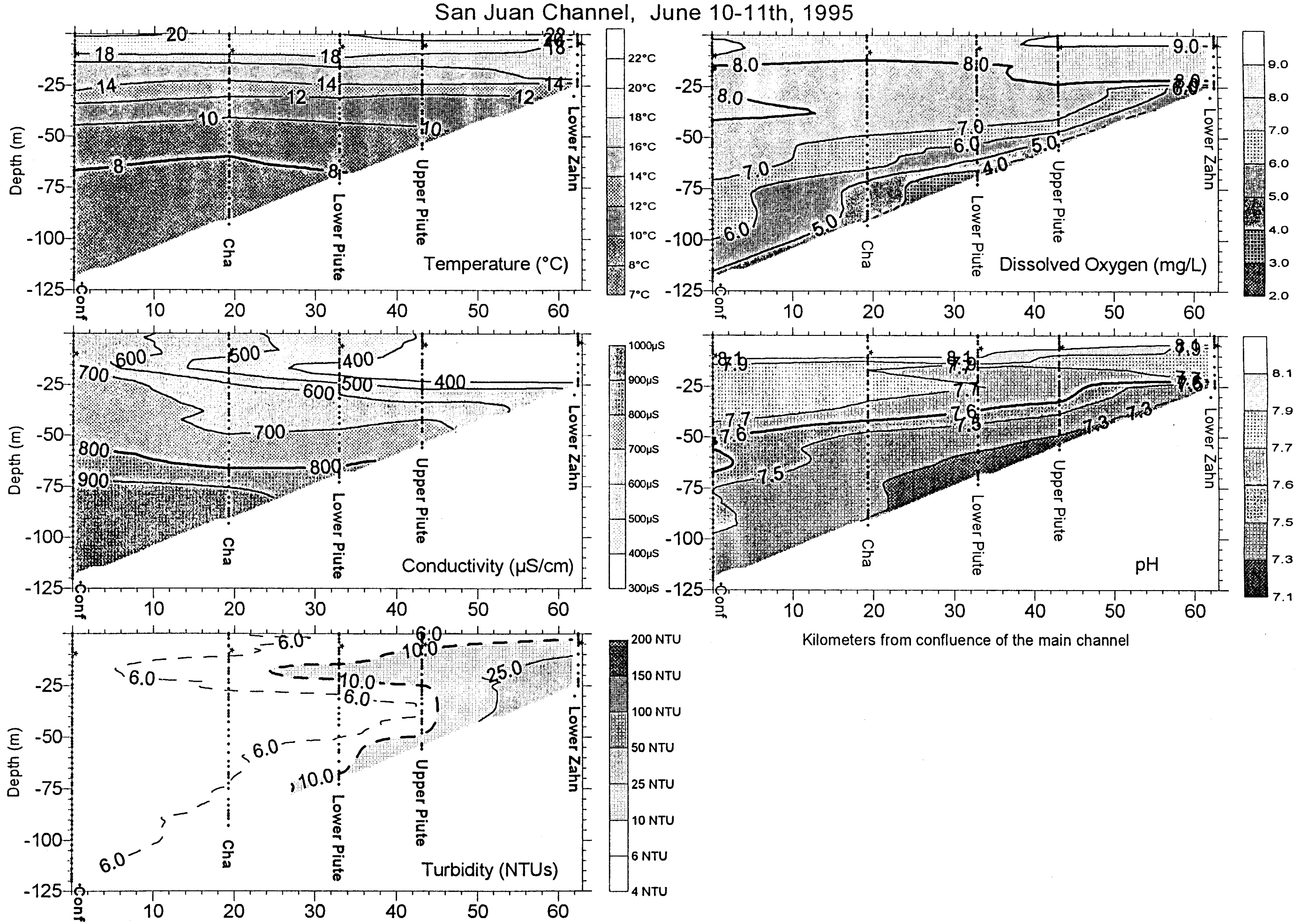


Figure 6: Temperature (°C), conductivity (µS/cm), turbidity (NTUs), dissolved oxygen (mg/L) and pH in the San Juan channel of Lake Powell, June 10-11th, 1995. Secchi disk d[illegible]s indicated by (*). Dots on map represent sampling sites. Dashed isopleth [illegible]es are out of the normal sequence on the scale, but are added for better [illegible]tion to aid interpretation.

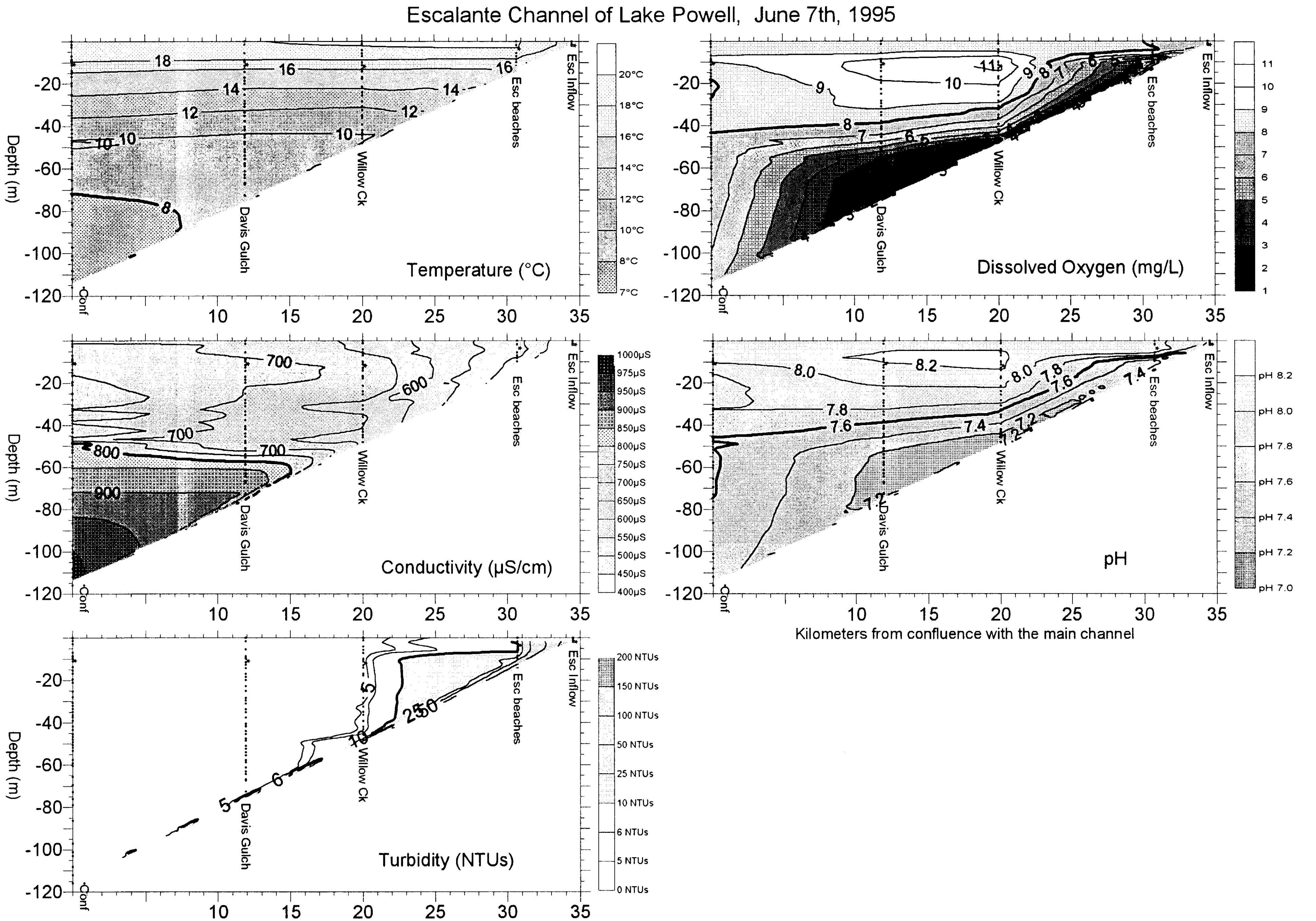
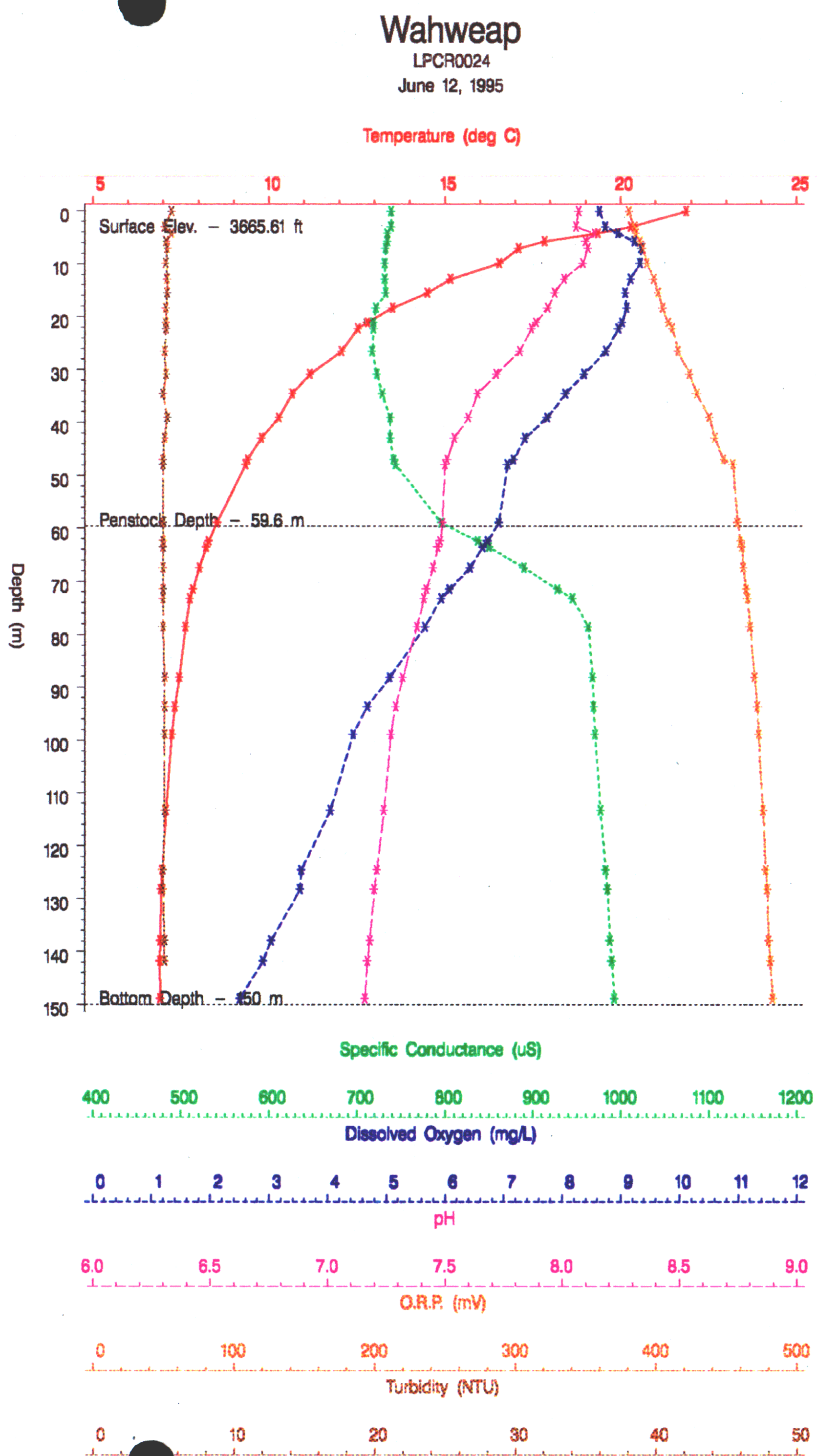
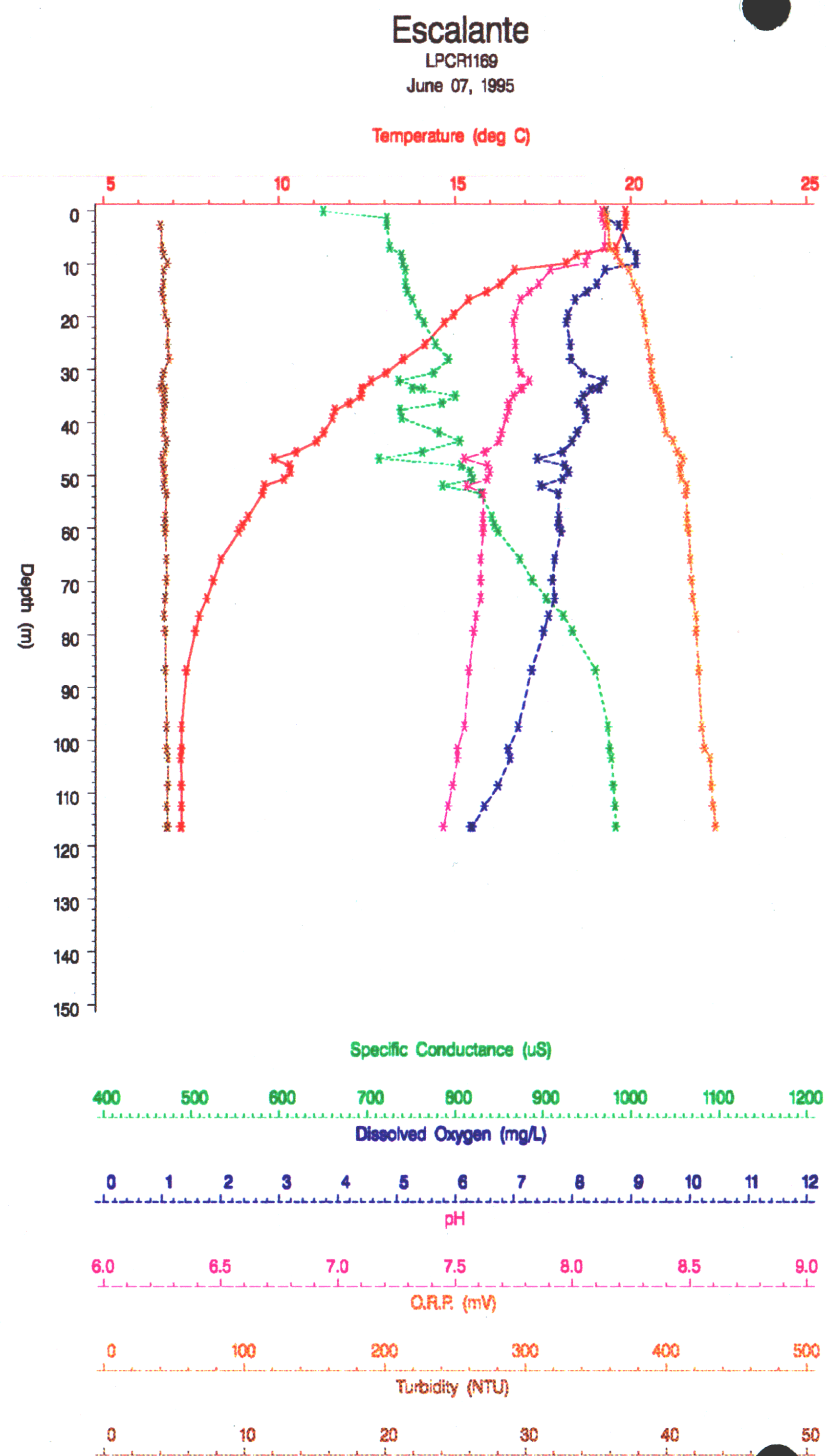


Figure 7: Temperature (°C), conductivity (µS/cm), turbidity (NTUs), dissolved oxygen (mg/L), and pH in the Escalante channel of Lake Powell, June 7th, 1995. Dots on map represent sampling sites and secchi depths by (*). Dashed isopleth lines are out of the normal sequence on the scale, but are added for better resolution to aid interpretation.

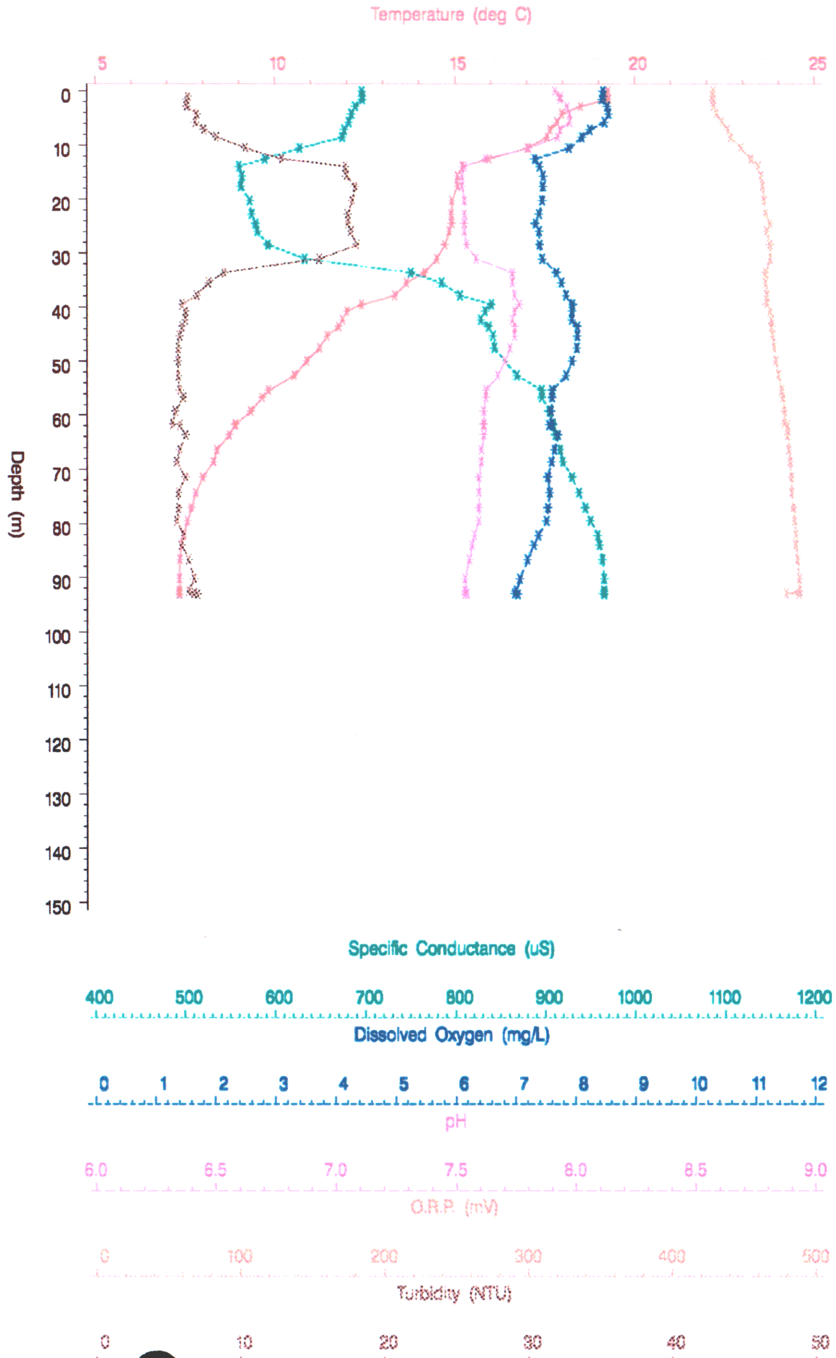

Wahweap
LPCR0024
June 12, 1995
Temperature (deg C)
5 10 15 20 25
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Depth (m)
Surface Elev. – 3665.61 ft
Penstock Depth – 59.6 m
Bottom Depth – 150 m
Specific Conductance (uS)
400 500 600 700 800 900 1000 1100 1200
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
pH
6.0 6.5 7.0 7.5 8.0 8.5 9.0
O.R.P. (mV)
0 100 200 300 400 500
Turbidity (NTU)
0 10 20 30 40 50


Escalante
LPCR1169
June 07, 1995
Temperature (deg C)
5 10 15 20 25
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Depth (m)
Specific Conductance (uS)
400 500 600 700 800 900 1000 1100 1200
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
pH
6.0 6.5 7.0 7.5 8.0 8.5 9.0
O.R.P. (mV)
0 100 200 300 400 500
Turbidity (NTU)
0 10 20 30 40 50

Bullfrog

LPCR1692

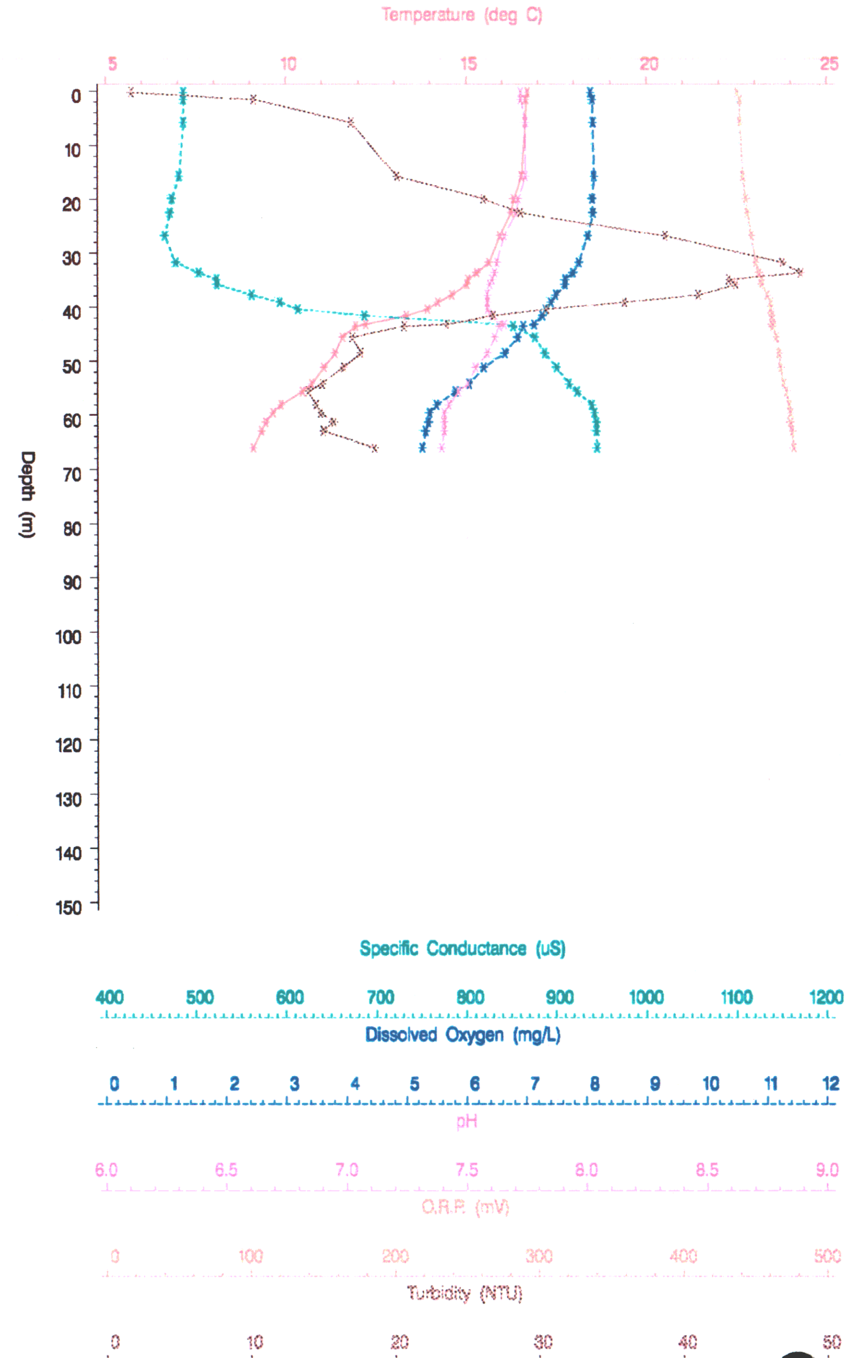
June 09, 1995

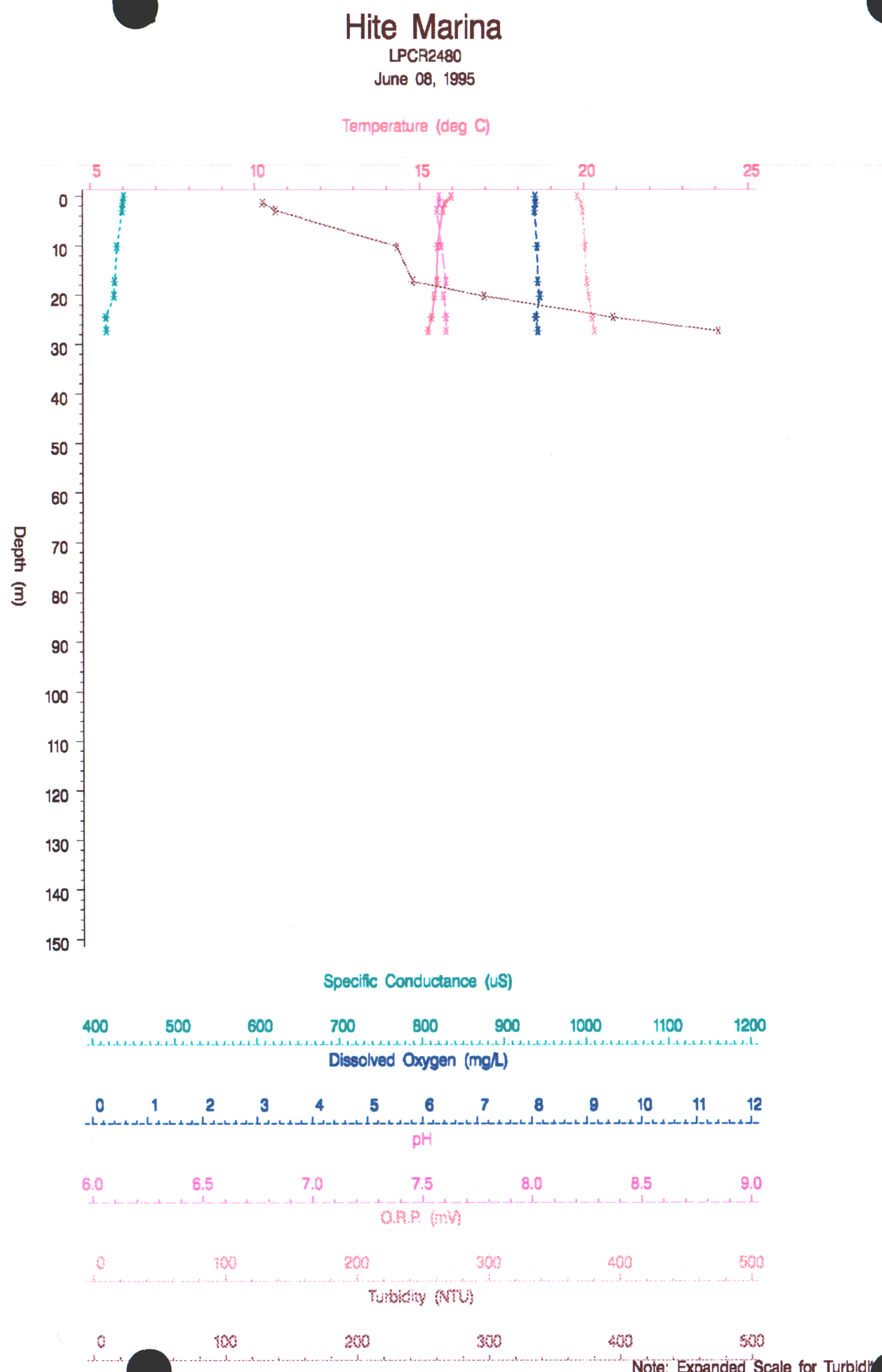


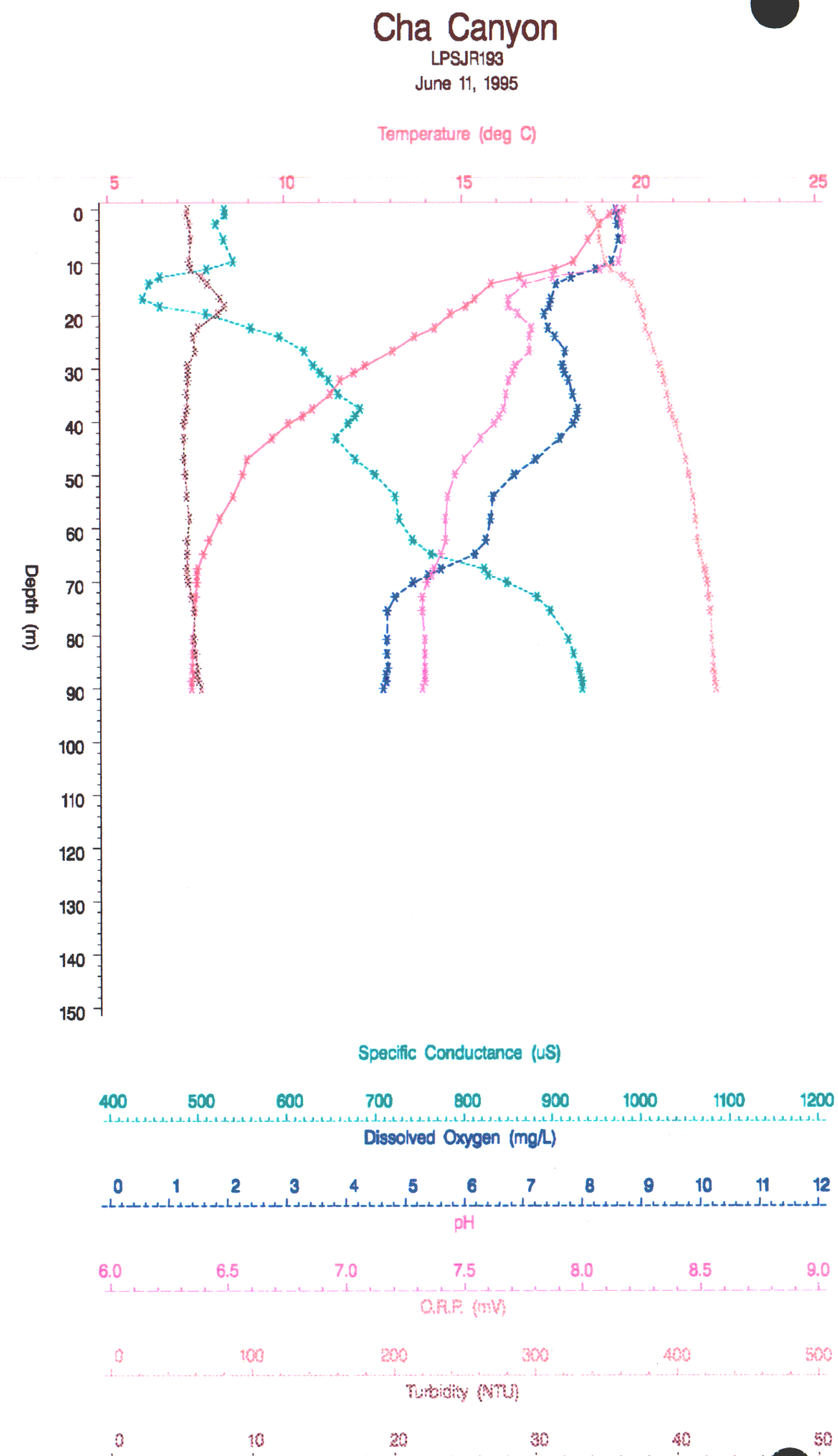
Scorup Canyon

LPCR2255

June 09, 1995




Hite Marina
LPCR2480
June 08, 1995
Temperature (deg C)
5 10 15 20 25
Depth (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Specific Conductance (uS)
400 500 600 700 800 900 1000 1100 1200
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
pH
6.0 6.5 7.0 7.5 8.0 8.5 9.0
O.R.P. (mV)
0 100 200 300 400 500
Turbidity (NTU)
0 100 200 300 400 500
Note: Expanded Scale for Turbidi


Cha Canyon
LPSJR193
June 11, 1995
Temperature (deg C)
5 10 15 20 25
Depth (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Specific Conductance (uS)
400 500 600 700 800 900 1000 1100 1200
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
pH
6.0 6.5 7.0 7.5 8.0 8.5 9.0
O.R.P. (mV)
0 100 200 300 400 500
Turbidity (NTU)
0 10 20 30 40 50