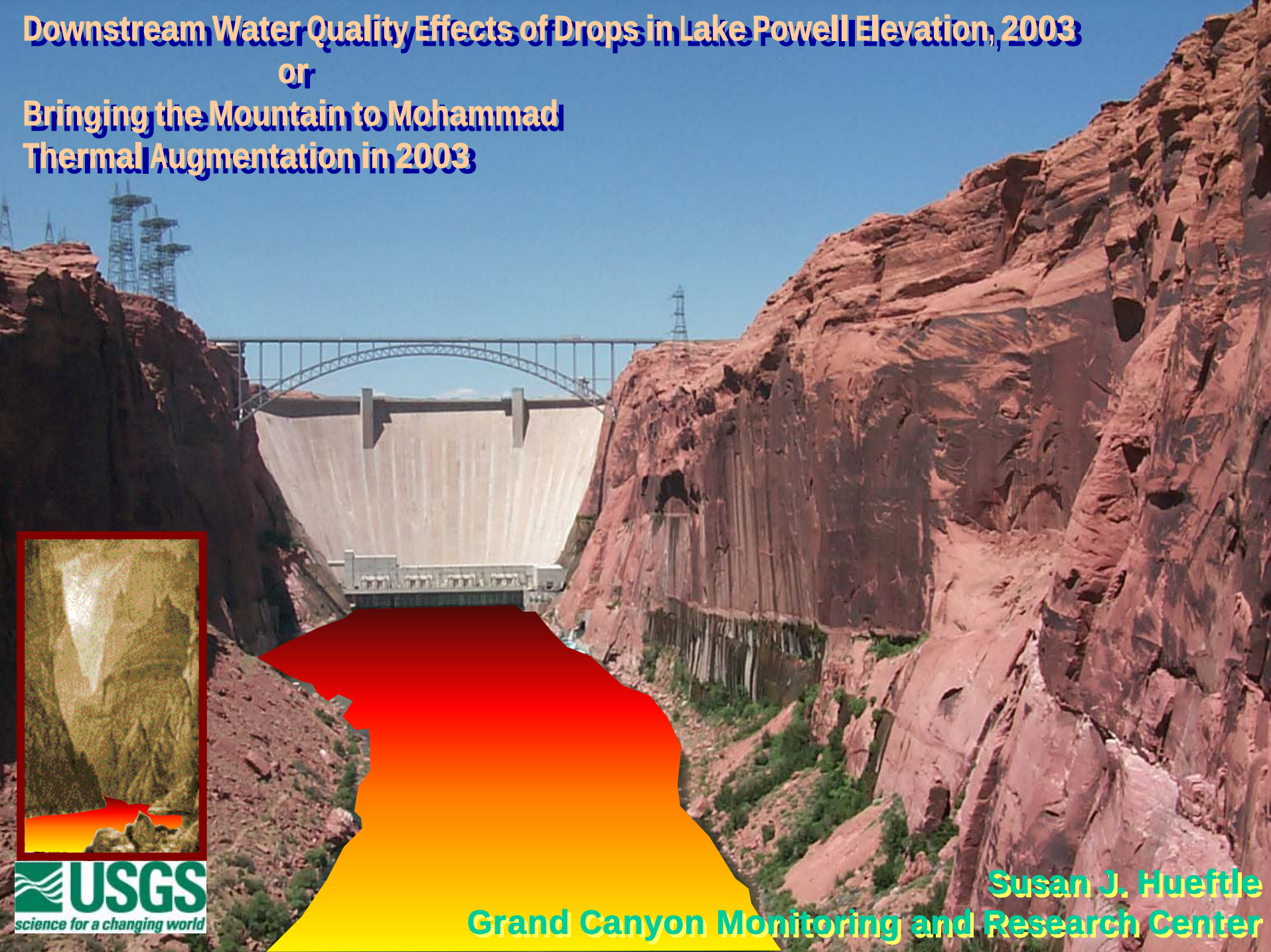
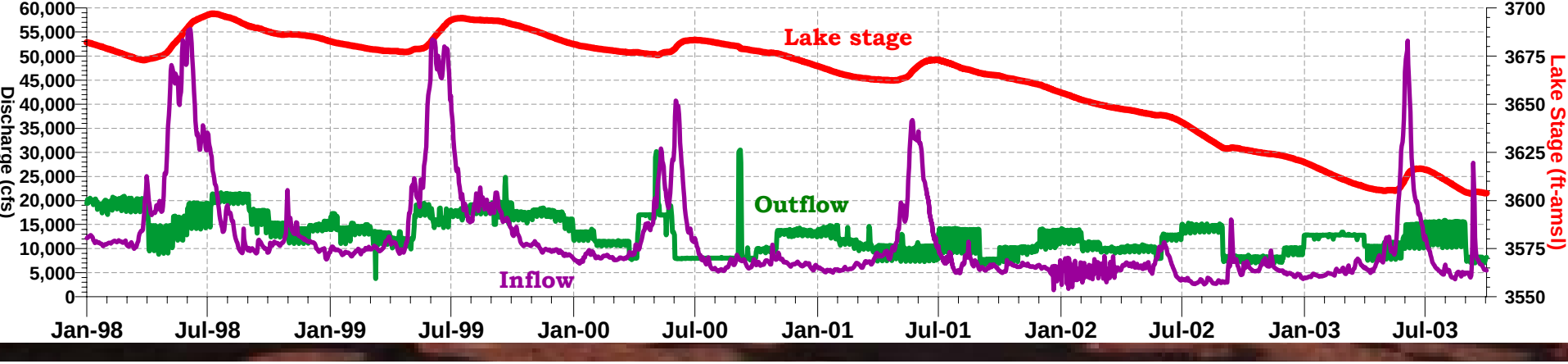
Downstream Water Quality Effects of Drops in Lake Powell Elevation, 2003
or
Bringing the Mountain to Mohammad
Thermal Augmentation in 2003

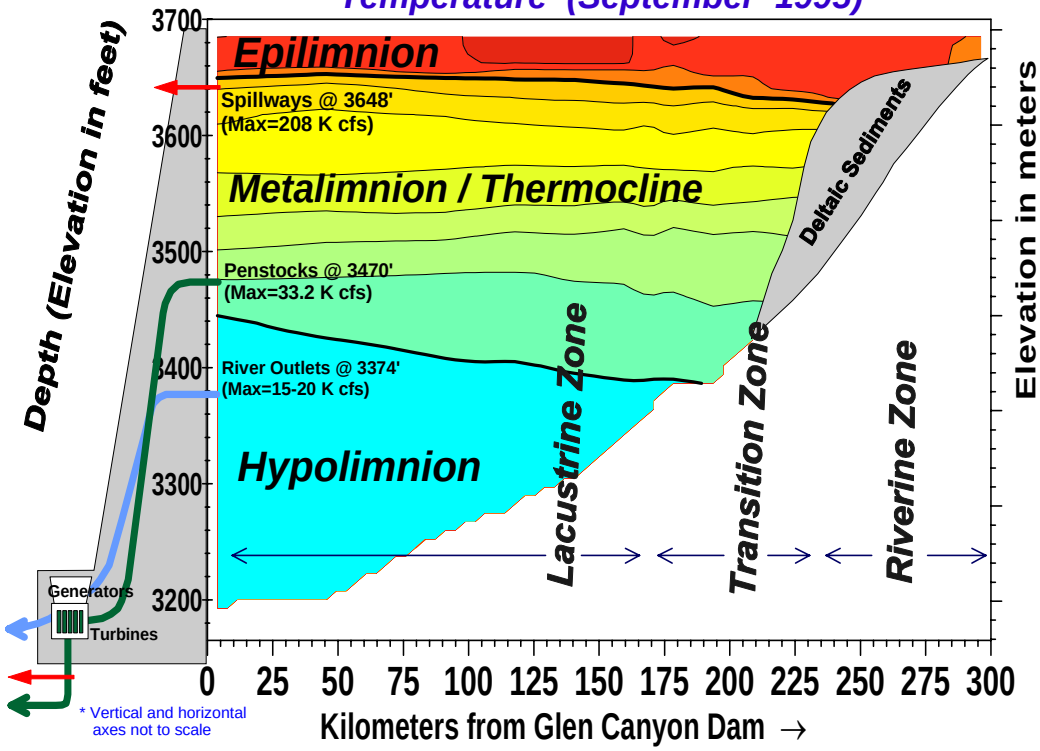


Susan J. Hueftle
Grand Canyon Monitoring and Research Center



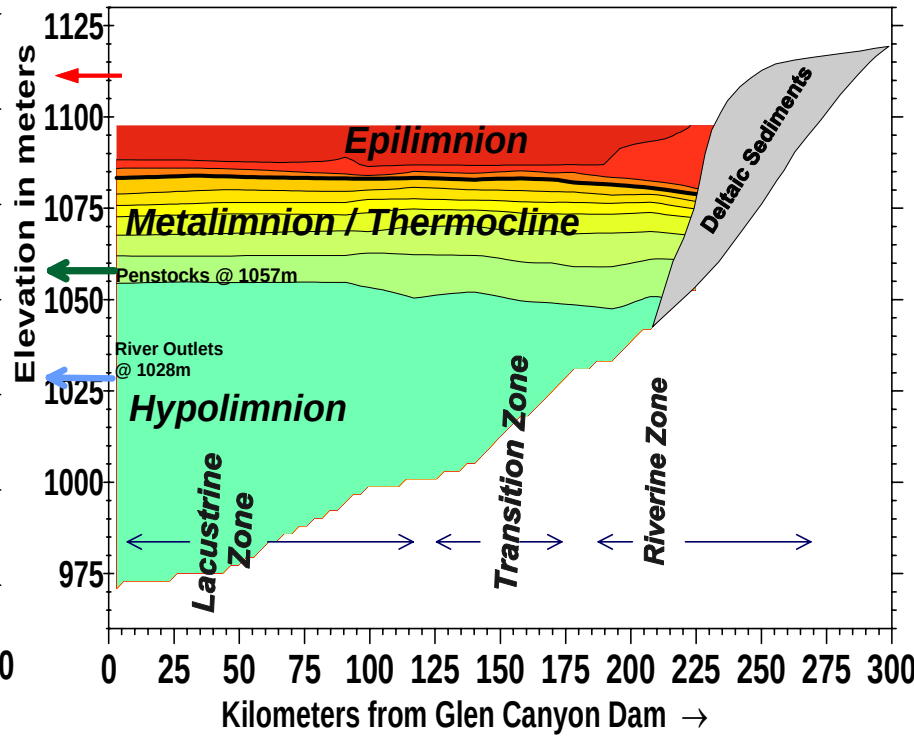
Cross Section through Lake Powell *

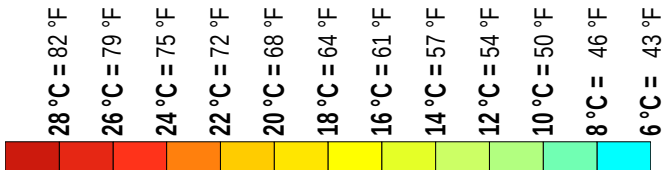
Temperature (September 1995)



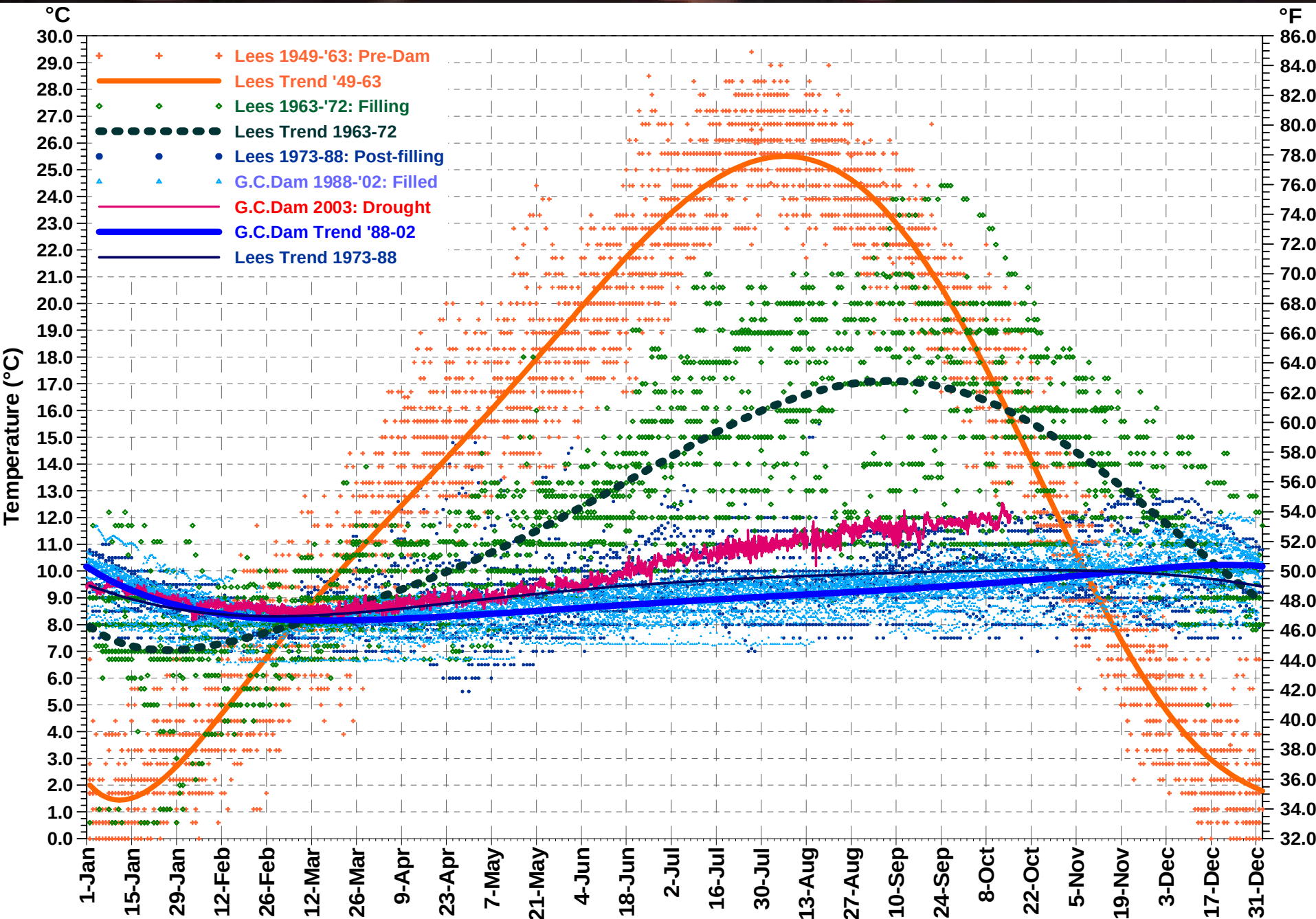
* Vertical and horizontal axes not to scale

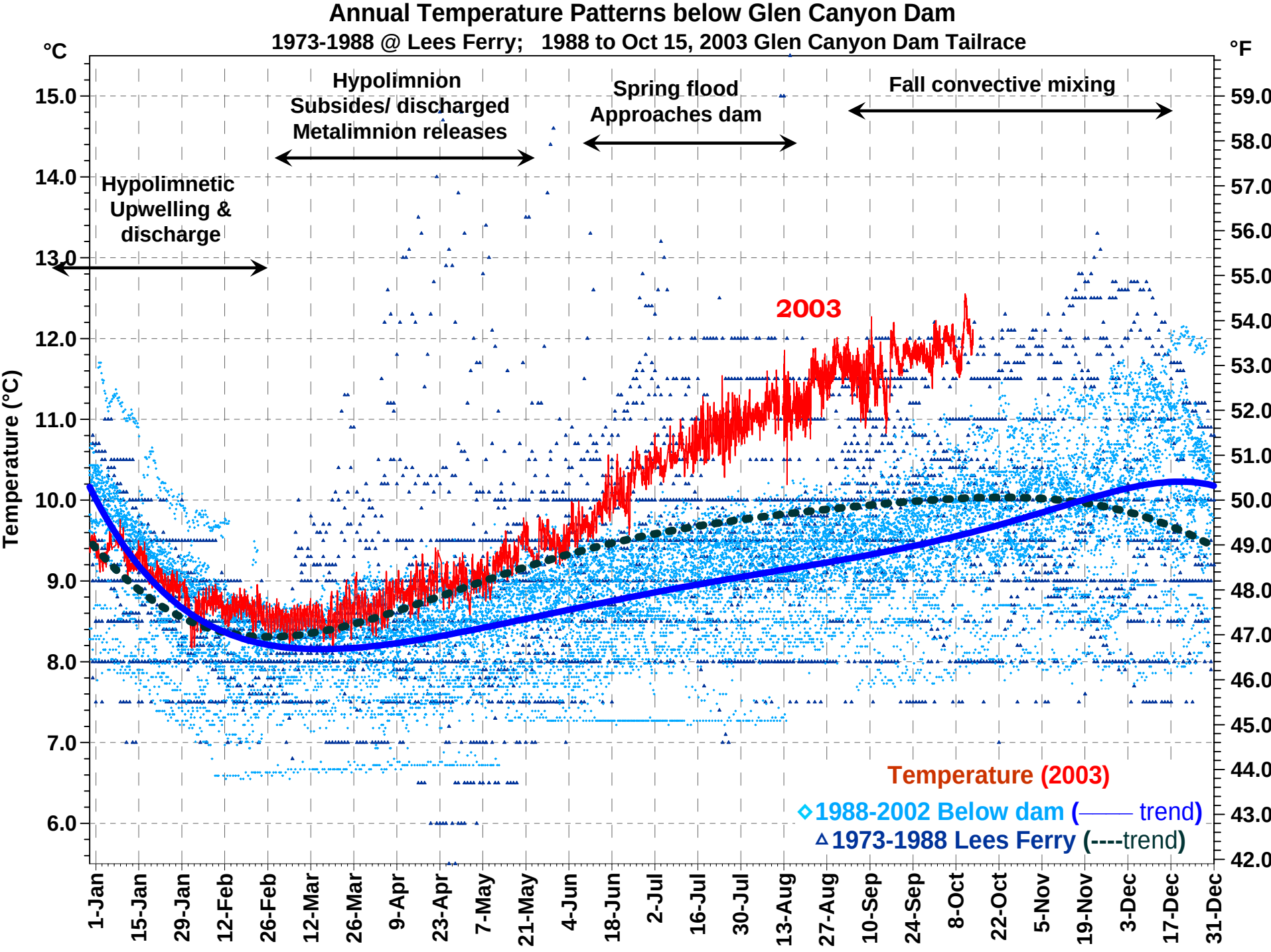
Temperature (September 2003)





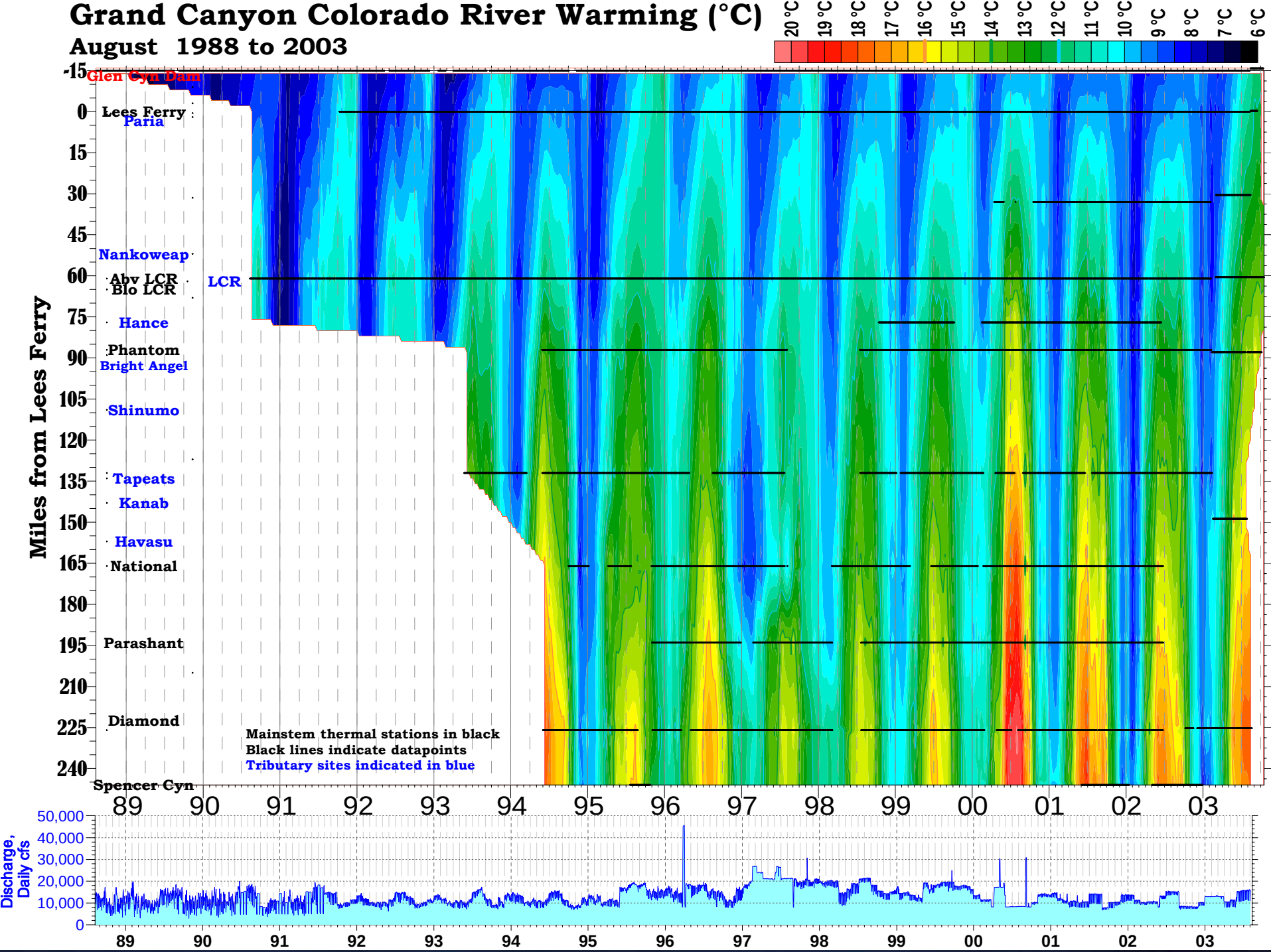
Annual Temperature Patterns below Glen Canyon Dam, 1949-2003

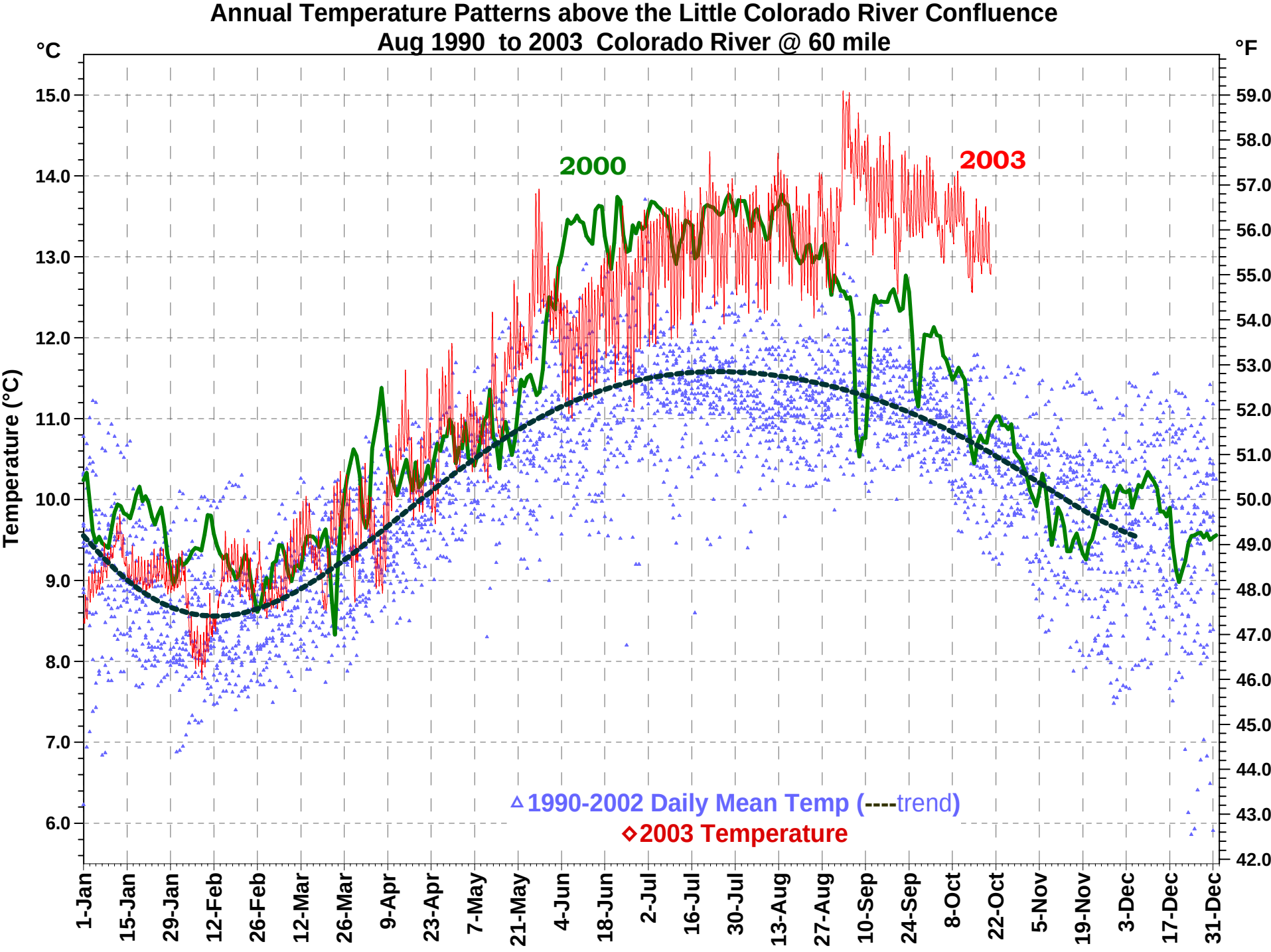


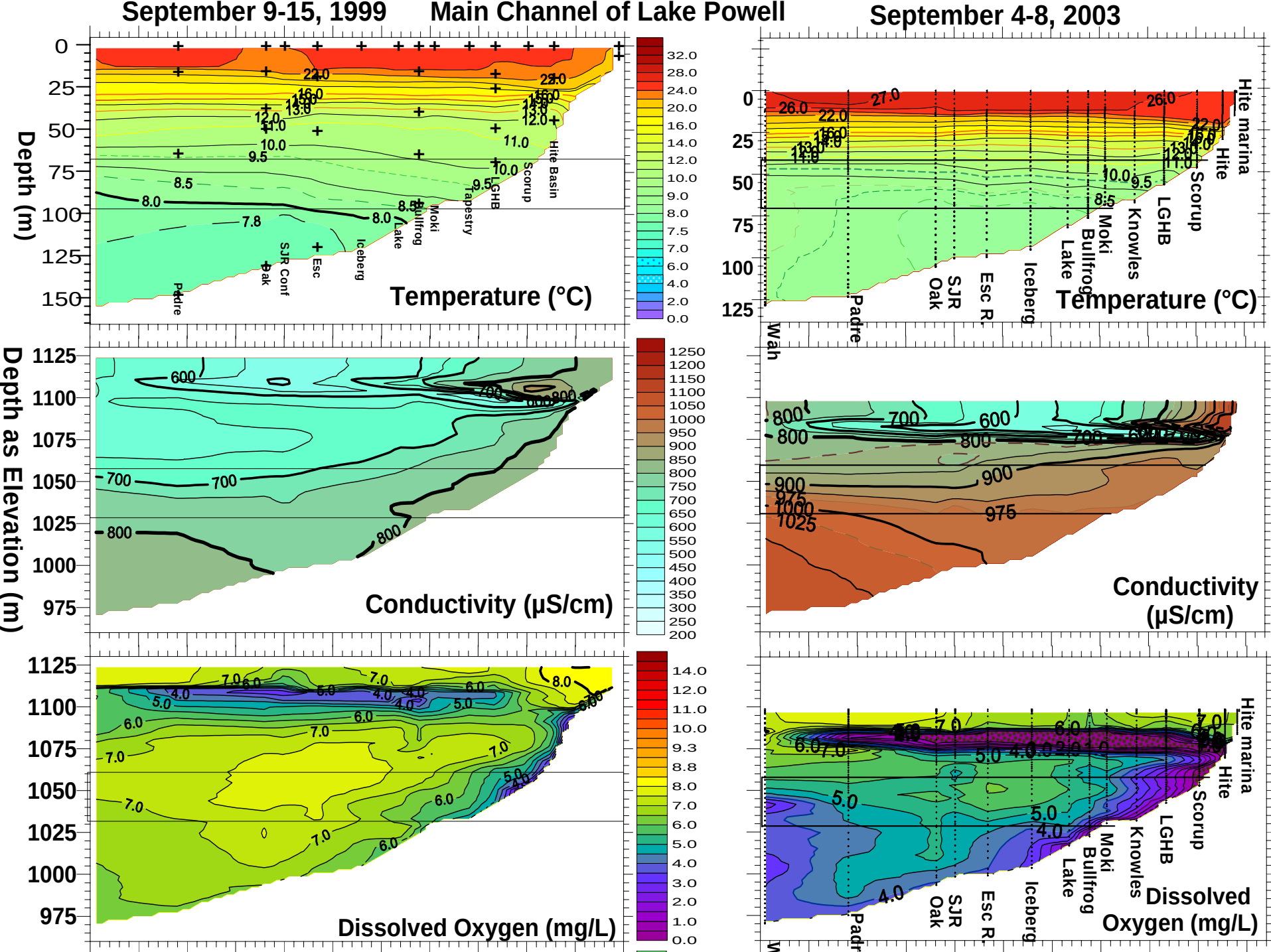

Annual Temperature Patterns below Glen Canyon Dam
1973-1988 @ Lees Ferry; 1988 to Oct 15, 2003 Glen Canyon Dam Tailrace
°C
°F
Temperature (°C)
Hypolimnetic Upwelling & discharge
Hypolimnion Subsides/ discharged Metalimnion releases
Spring flood Approaches dam
Fall convective mixing
2003
Temperature (2003)
1988-2002 Below dam (—— trend)
1973-1988 Lees Ferry (----trend)
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
59.0
58.0
57.0
56.0
55.0
54.0
53.0
52.0
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
1-Jan
15-Jan
29-Jan
12-Feb
26-Feb
12-Mar
26-Mar
9-Apr
23-Apr
7-May
21-May
4-Jun
18-Jun
2-Jul
16-Jul
30-Jul
13-Aug
27-Aug
10-Sep
24-Sep
8-Oct
22-Oct
5-Nov
19-Nov
3-Dec
17-Dec
31-Dec

Grand Canyon Colorado River Warming (°C)

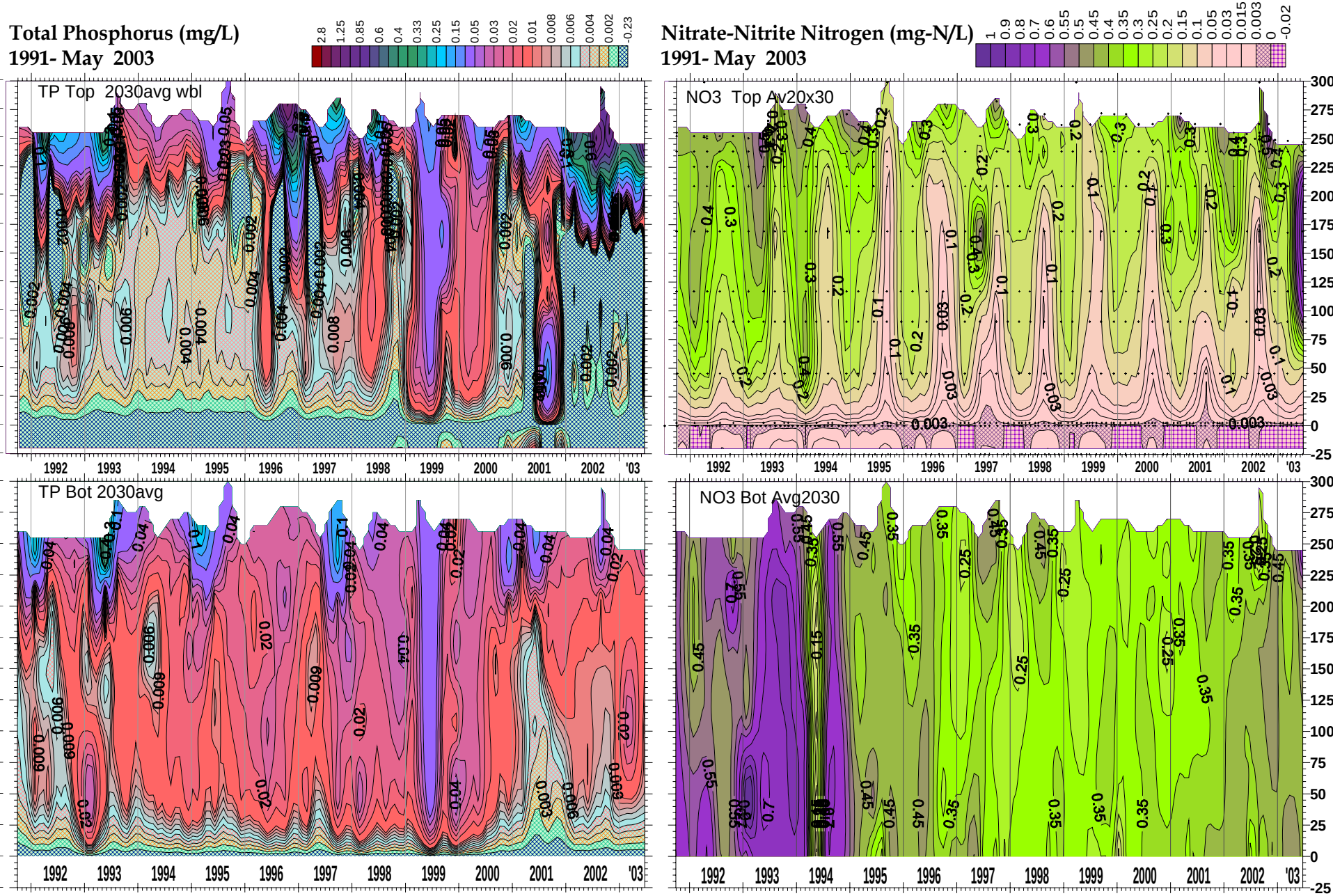
August 1988 to 2003



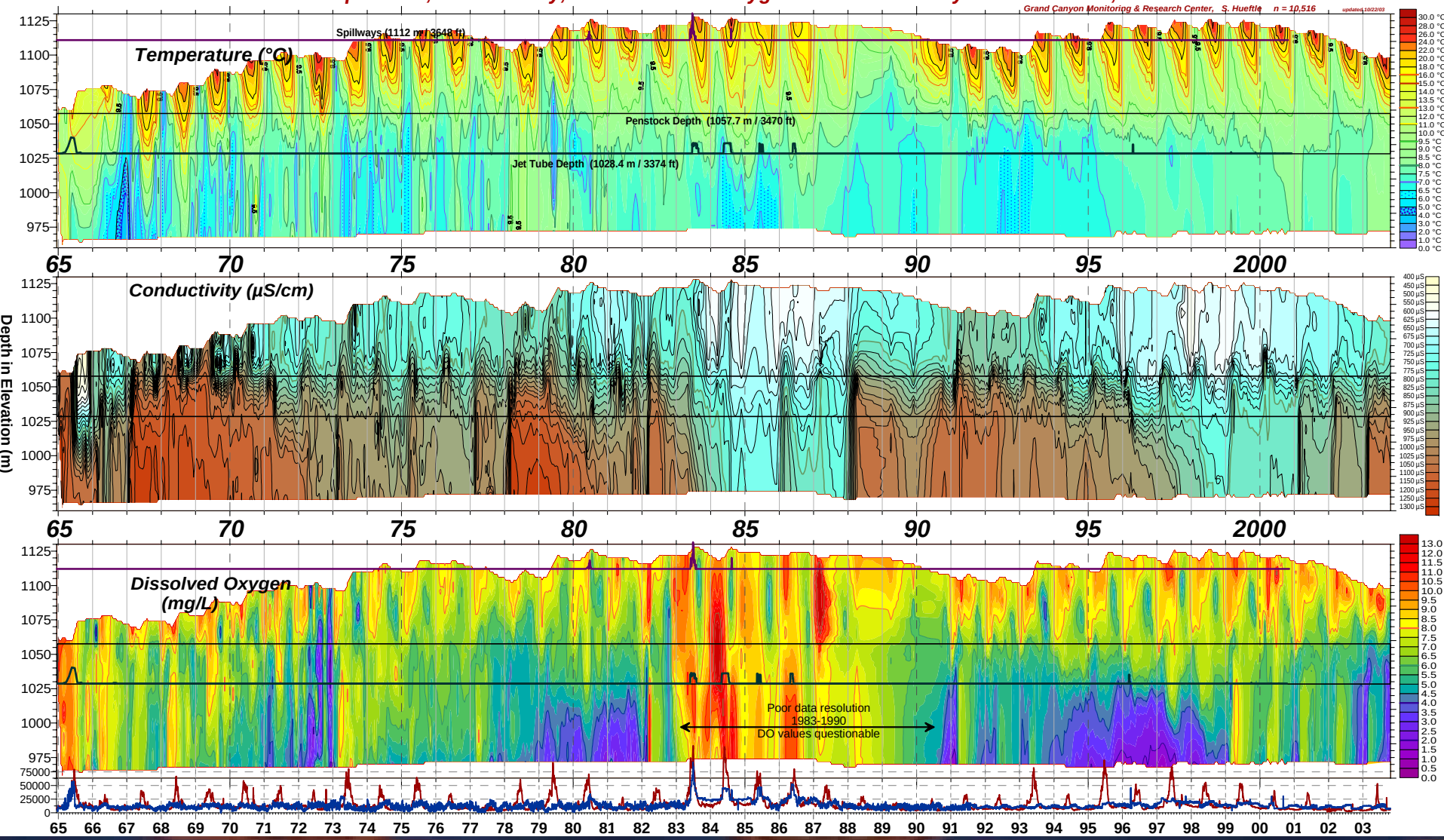

Annual Temperature Patterns above the Little Colorado River Confluence
Aug 1990 to 2003 Colorado River @ 60 mile
°C
°F
Temperature (°C)
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
59.0
58.0
57.0
56.0
55.0
54.0
53.0
52.0
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
2000
2003
1990-2002 Daily Mean Temp (----trend)
2003 Temperature
1-Jan
15-Jan
29-Jan
12-Feb
26-Feb
12-Mar
26-Mar
9-Apr
23-Apr
7-May
21-May
4-Jun
18-Jun
2-Jul
16-Jul
30-Jul
13-Aug
27-Aug
10-Sep
24-Sep
8-Oct
22-Oct
5-Nov
19-Nov
3-Dec
17-Dec
31-Dec


September 9-15, 1999
Main Channel of Lake Powell
September 4-8, 2003
Depth (m)
Depth as Elevation (m)
Temperature (°C)
Conductivity (µS/cm)
Dissolved Oxygen (mg/L)
Padre
SJR Conf
Oak
Esc
Iceberg
Lake
Bullfrog
Moki
Tapestry
LGHB
Scorup
Hite Basin
Knowles
Hite
Hite marina

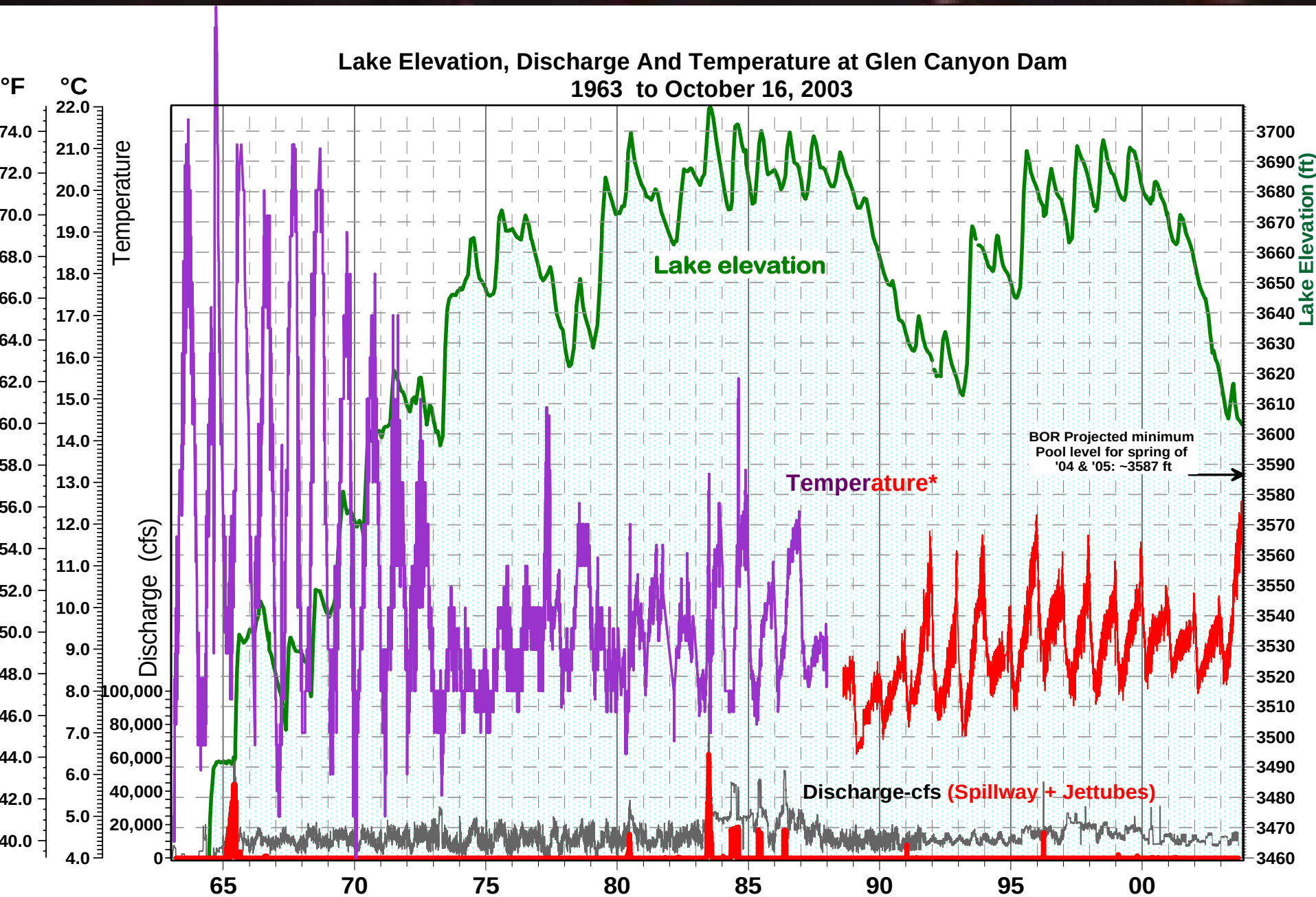
Nutrients in Lake Powell from inflow to Lees Ferry, surface and bottom depths



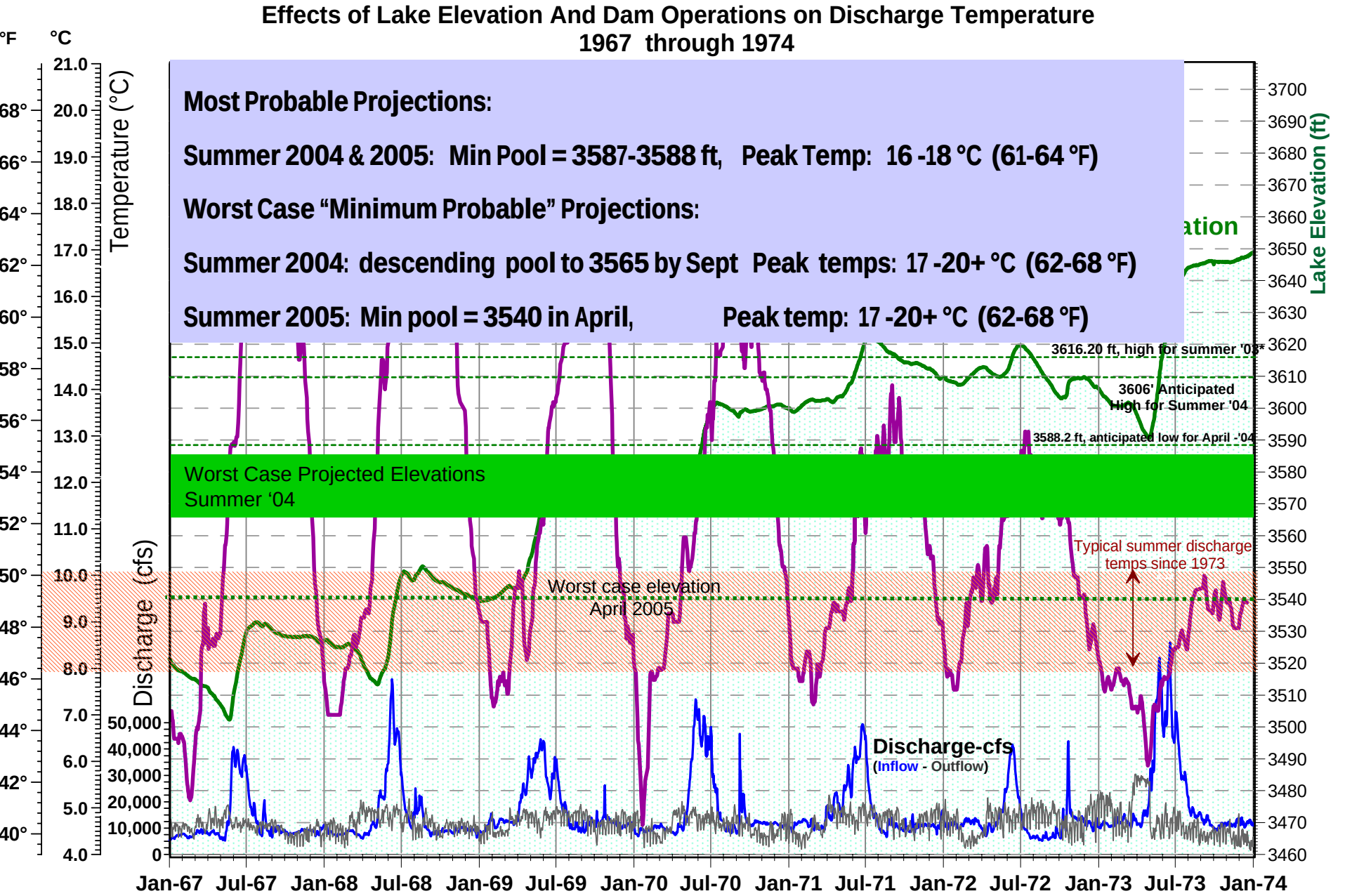
Historical Trends in Temperature, Conductivity, and Dissolved Oxygen near the Forebay of Lake Powell; Dec 1964 to Oct 2003



PROJECTIONS: Lake Elevation, Discharge And Temperature at Glen Canyon Dam



Effects of Lake Elevation And Dam Operations on Discharge Temperature
1967 to 1974



Downstream ecological implications of warm, epilimnetic releases during drought conditions

- Warmer water may enhance native fish recruitment
- Warmer water increases metabolic rates
- Epilimnetic nutrients are generally depleted in the reservoir
- Phosphorus levels tend to decrease in the reservoir during droughts; nitrate levels tend to increase
- ..So primary productivity may be enhanced by temperature but deprived of limiting nutrients -- phosphorus
- The buffering capacity of the reservoir is reduced at low volume, “rapid” shifts in water quality are possible
- Salinity levels will increase; native community evolved in a dynamic salinity regime but not the phytobenthos.

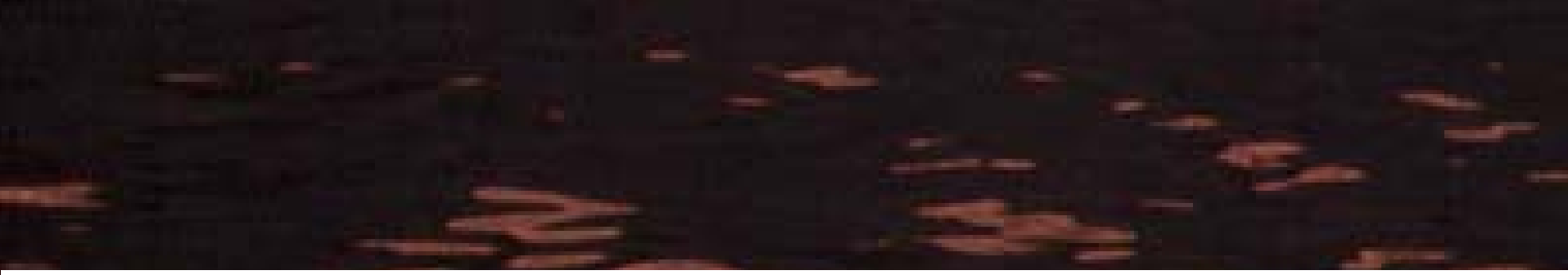
GCMRC S.Hueftle

Short-term Lake Projections
---given continued drought and lower lake elevations:

- Consistent elevations below ~3615 ft produce epilimnetic release, *depending on lake stratification*
- Temperatures will continue to increase to end of year
- Salinity will increase until the next decent flood; surface releases will exacerbate concentration of salts in the reservoir.
- D.O. will probably degrade until convective mixing overcomes it: ~ November-December; winter underflows may offset deep-water hypoxia.
- Nutrients: variable response
- With shorter residence time, reservoir could change quickly

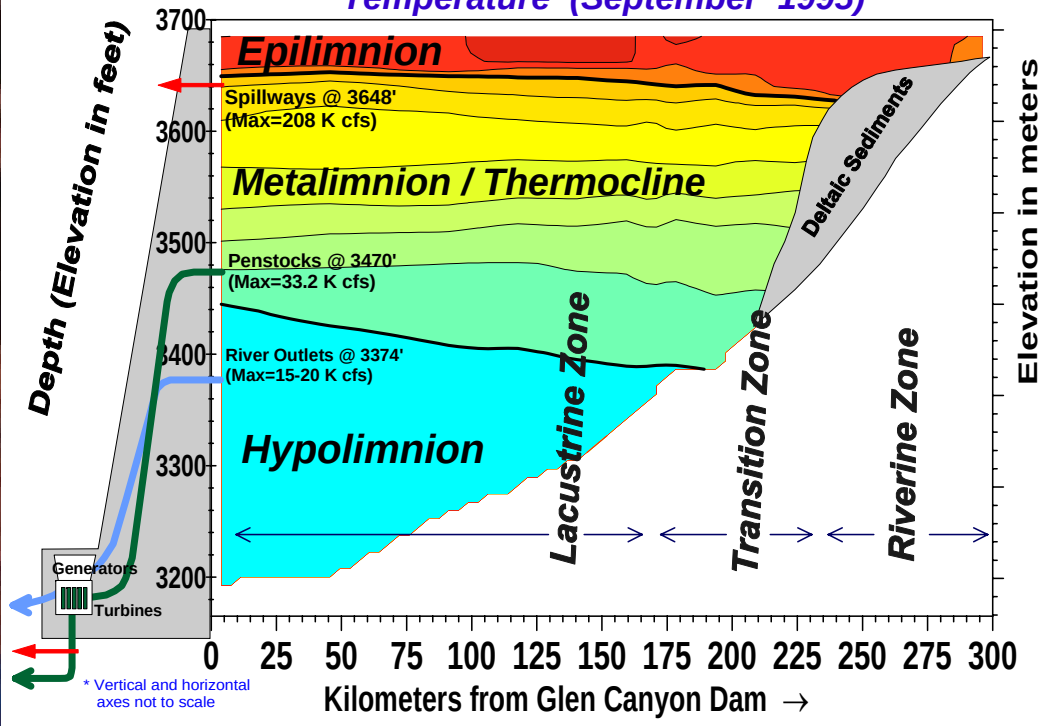
Long-term Lake Projections
---given continued drought and lower lake elevations:

- Consistent elevations below ~3615 ft produce epilimnetic release, *depending on lake stratification*
- Temperatures will continue to increase to end of year
- Salinity will increase; surface releases will exacerbate concentration of salts in the reservoir.
- D.O. will probably degrade until convective mixing overcomes it: ~ November-December; winter underflows may offset deep-water hypoxia.
- Nutrients: variable response
- With shorter residence time, reservoir could change quickly
- Next big flood will probably bring warmer releases



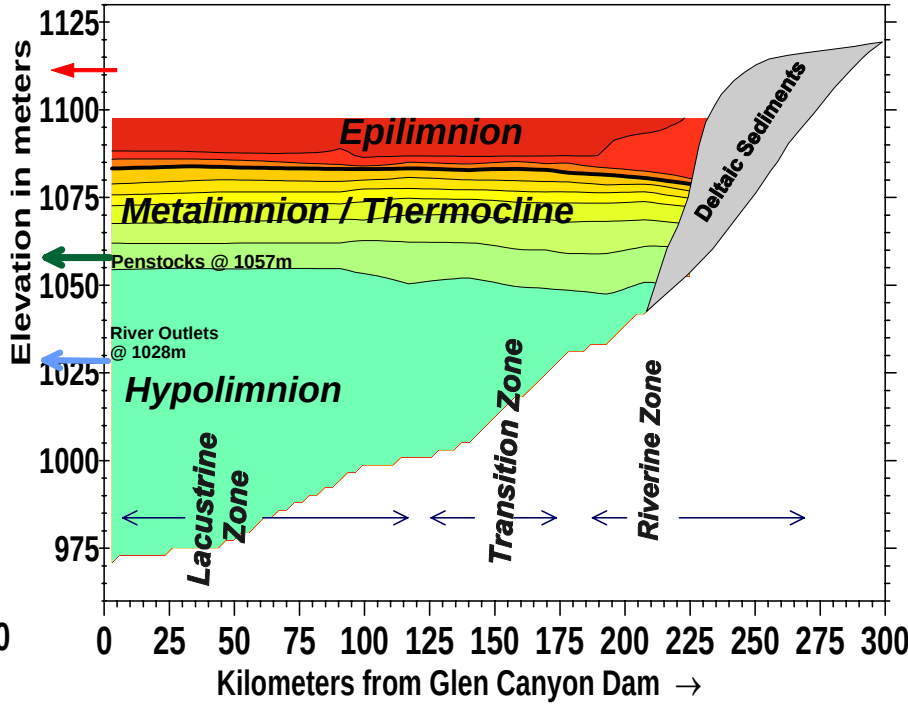
Cross Section through Lake Powell *

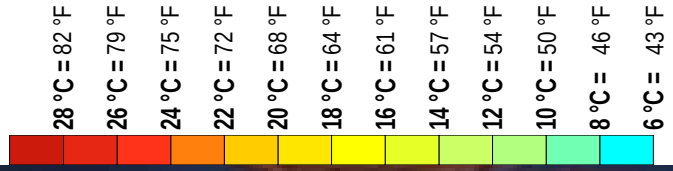
Temperature (September 1995)

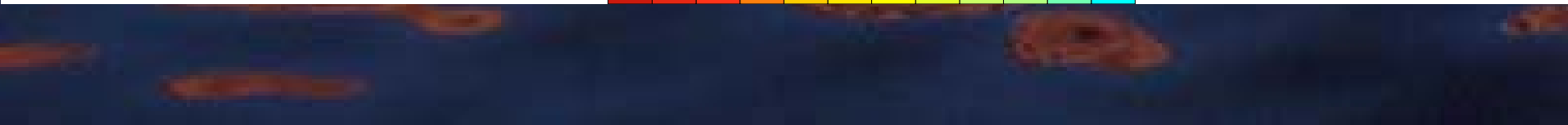


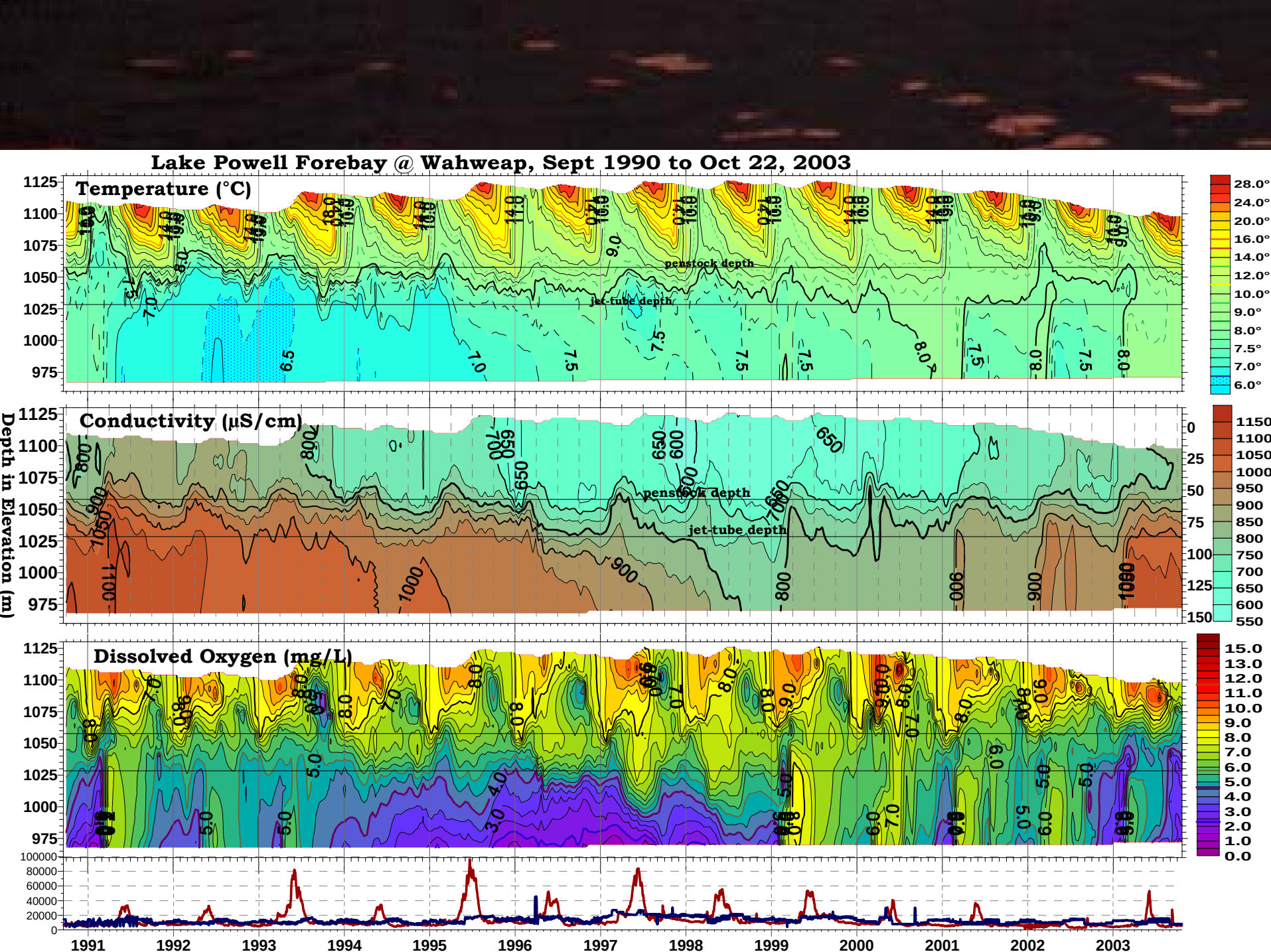
* Vertical and horizontal axes not to scale

Temperature (September 2003)








Lake Powell Forebay @ Wahweap, Sept 1990 to Oct 22, 2003
Temperature (°C)
penstock depth
jet-tube depth
Conductivity (µS/cm)
Dissolved Oxygen (mg/L)
Depth in Elevation (m)
1125
1100
1075
1050
1025
1000
975
28.0°
24.0°
20.0°
16.0°
14.0°
12.0°
10.0°
9.0°
8.0°
7.5°
7.0°
6.0°
1150
1050
950
900
850
800
750
700
650
600
550
0
25
50
75
100
125
150
15.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
100000
80000
60000
40000
20000
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003