Main Channel and Near-shore Warming of the Colorado River Under Low Steady Flows

Bill Vernieu

Grand Canyon Monitoring & Research Center

US Geological Survey

Flagstaff, AZ

Colorado River Ecosystem

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Native Fish Issues

- No Mainstem Spawning
- Poor Recruitment
- Non-native Interaction

- Temperature Control Device
- Low Steady Flows
- Near-shore Environments

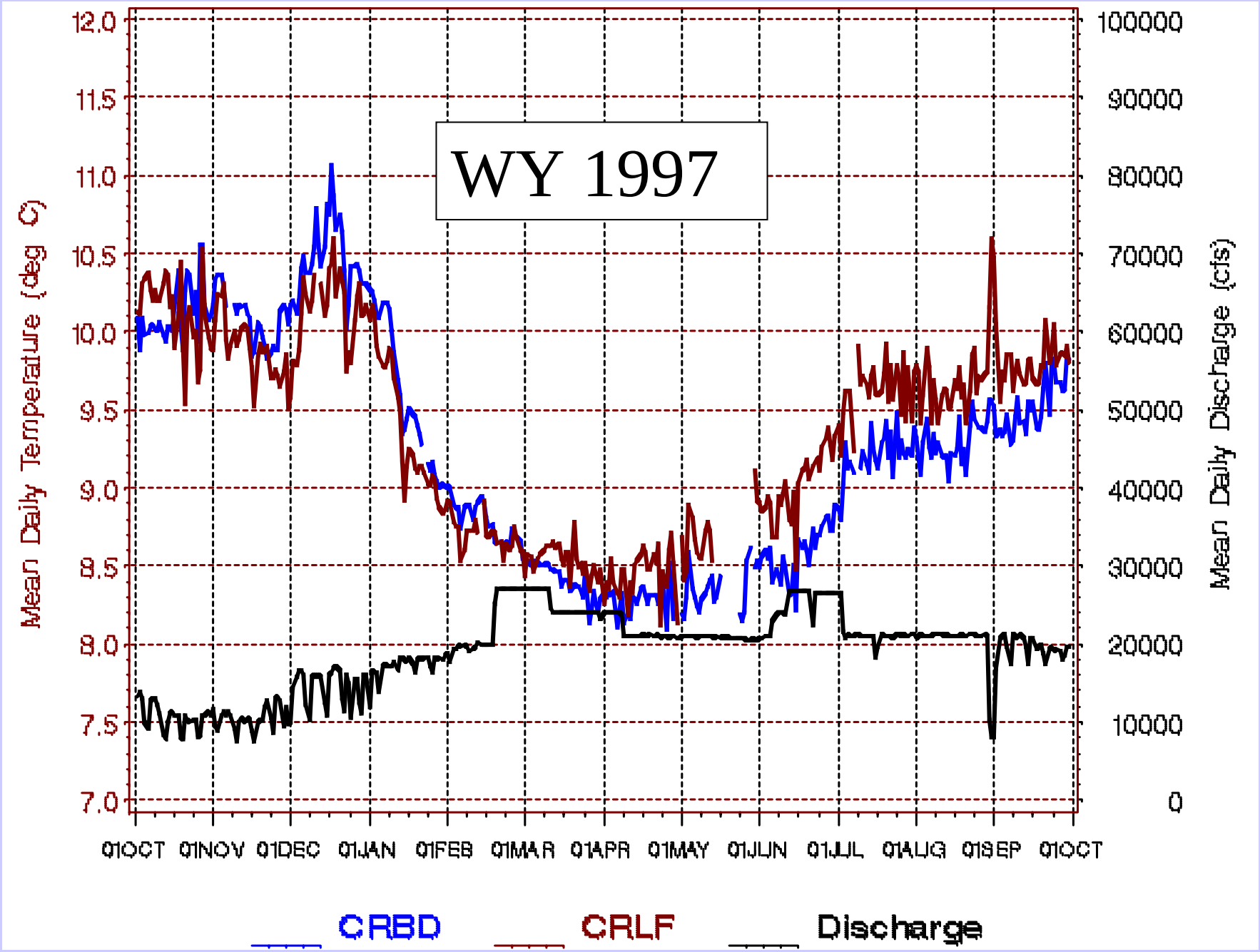
Mainstem Warming

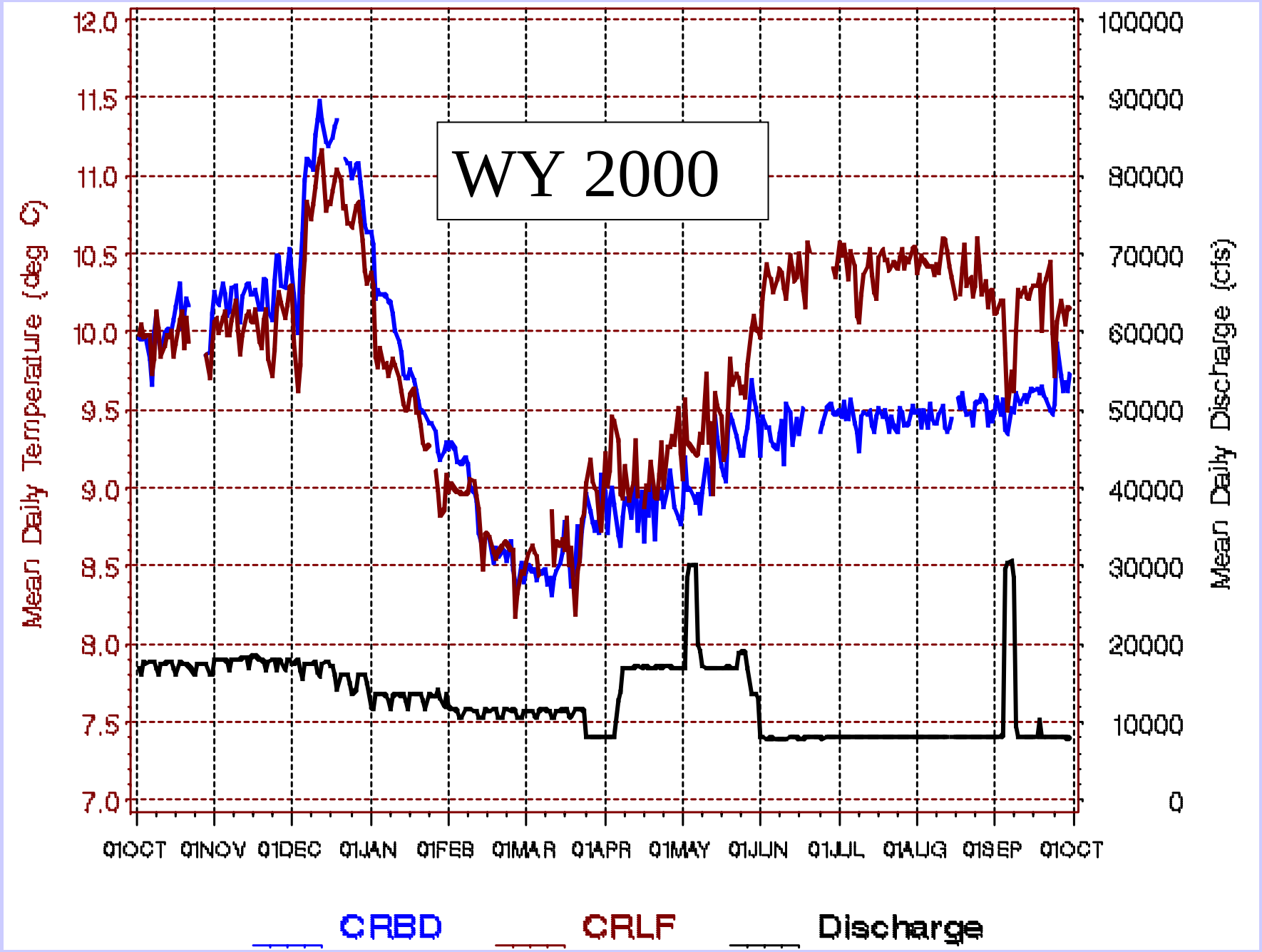
- Ho: Water temperatures in the mainstem will not increase downstream greater than temperatures previously observed under other flow conditions
- Method: 11 sites from Glen Canyon Dam to Diamond Creek monitored as part of long-term GCMRC Integrated Water Quality Program

Near-Shore Warming

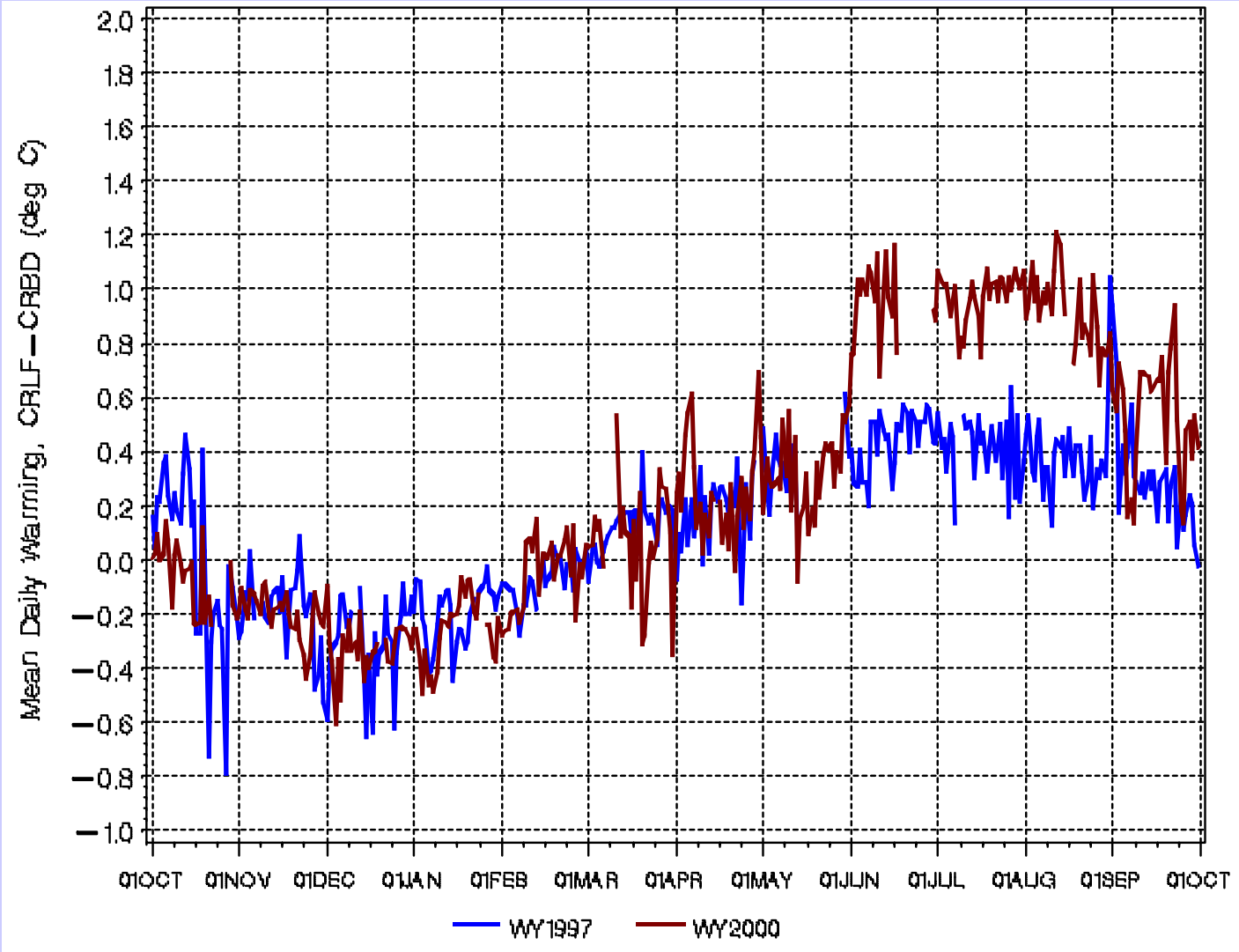
- Ho: Near-shore temperatures in structurally complex habitats will not differ significantly from those observed in the mainstem
- Method: Thermistor strings deployed perpendicularly from shore in various near-shore habitat types during July and August


Mainstem Warming


WY 1997
Mean Daily Temperature (deg C)
Mean Daily Discharge (cfs)
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
01OCT
01NOV
01DEC
01JAN
01FEB
01MAR
01APR
01MAY
01JUN
01JUL
01AUG
01SEP
01OCT
CRBD
CRLF
Discharge

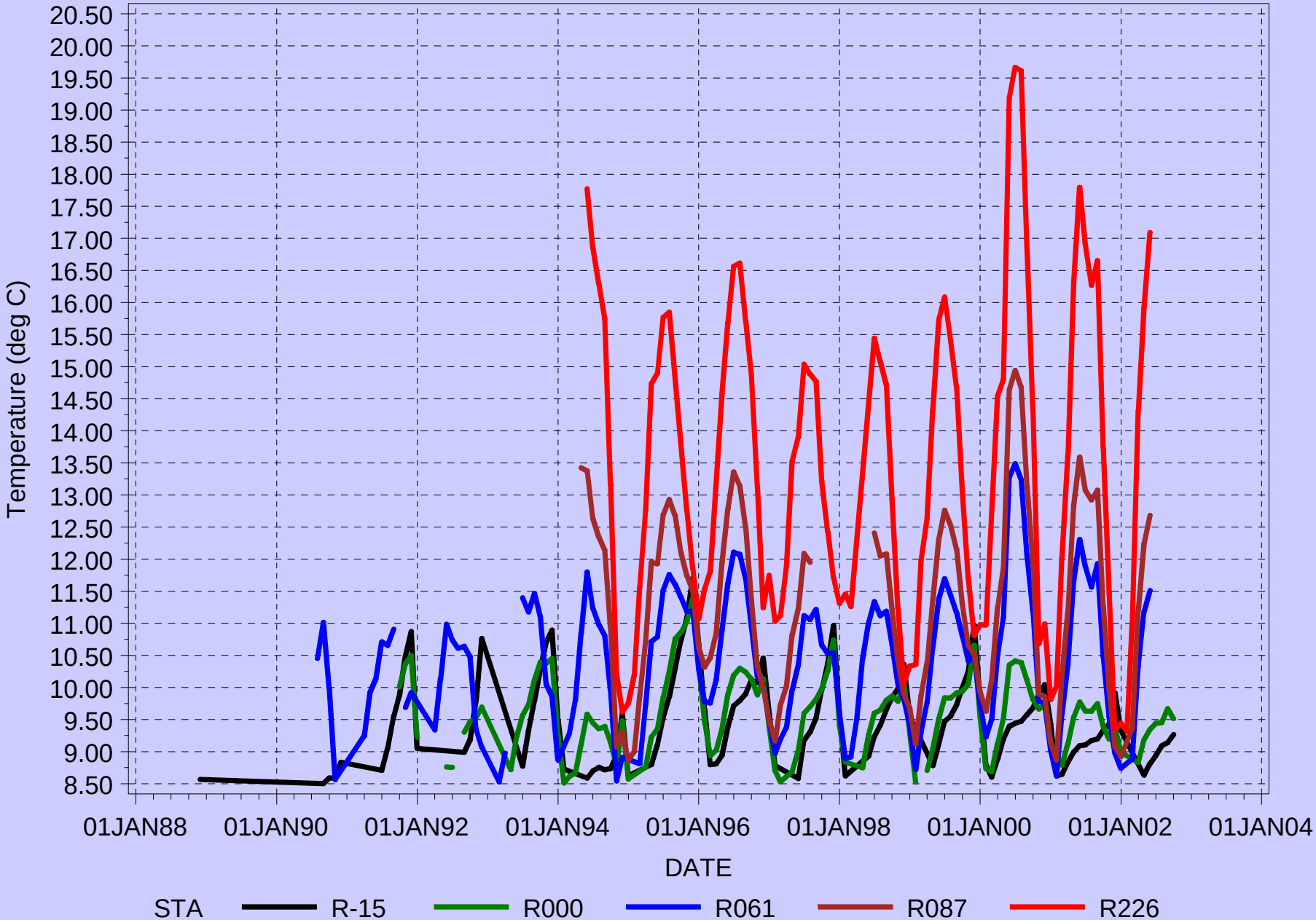

WY 2000
Mean Daily Temperature (deg C)
Mean Daily Discharge (cfs)
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
01OCT
01NOV
01DEC
01JAN
01FEB
01MAR
01APR
01MAY
01JUN
01JUL
01AUG
01SEP
01OCT
CRBD
CRLF
Discharge

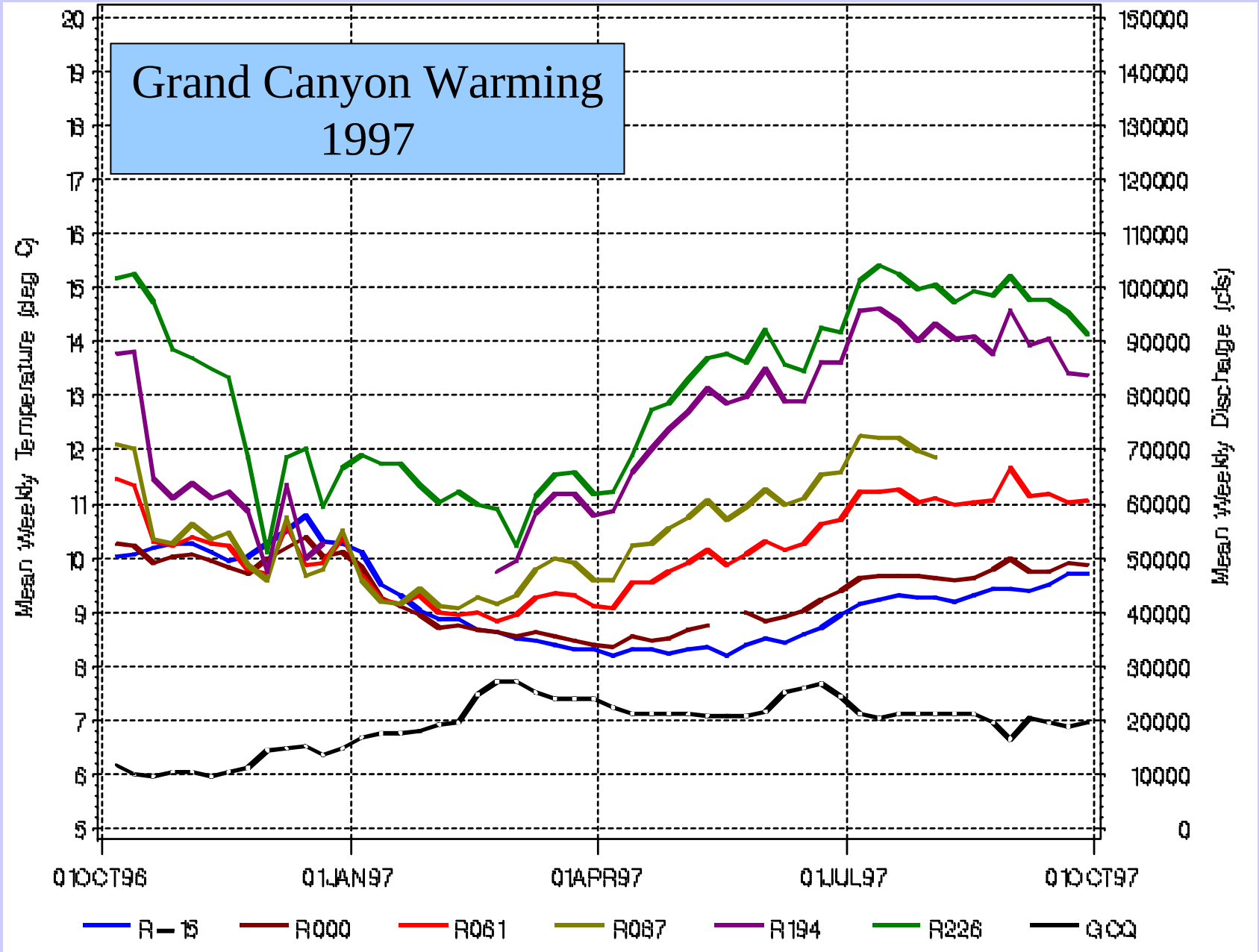
Lees Ferry Warming 1997 vs. 2000

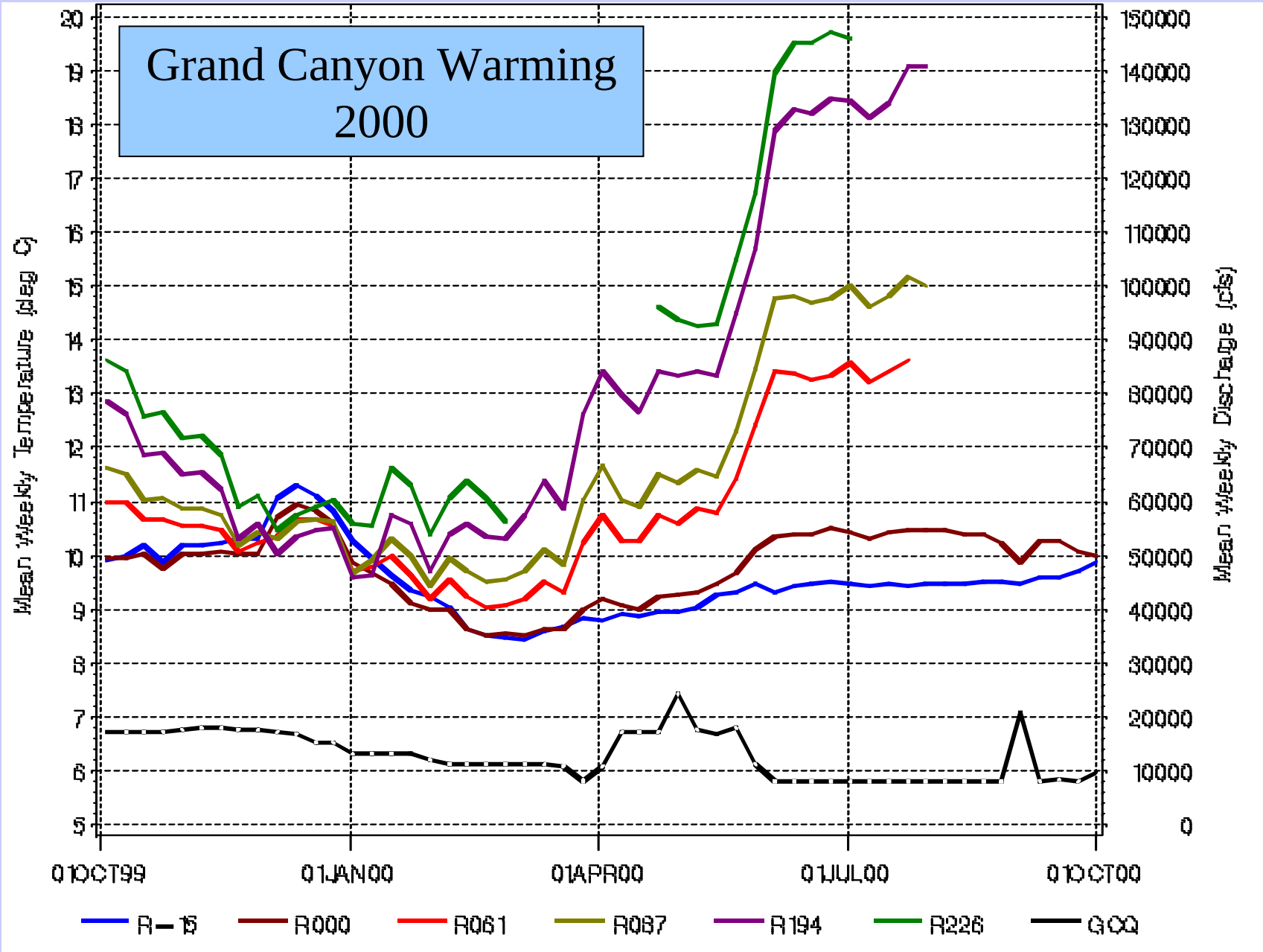


Grand Canyon Warming

(Selected Stations)

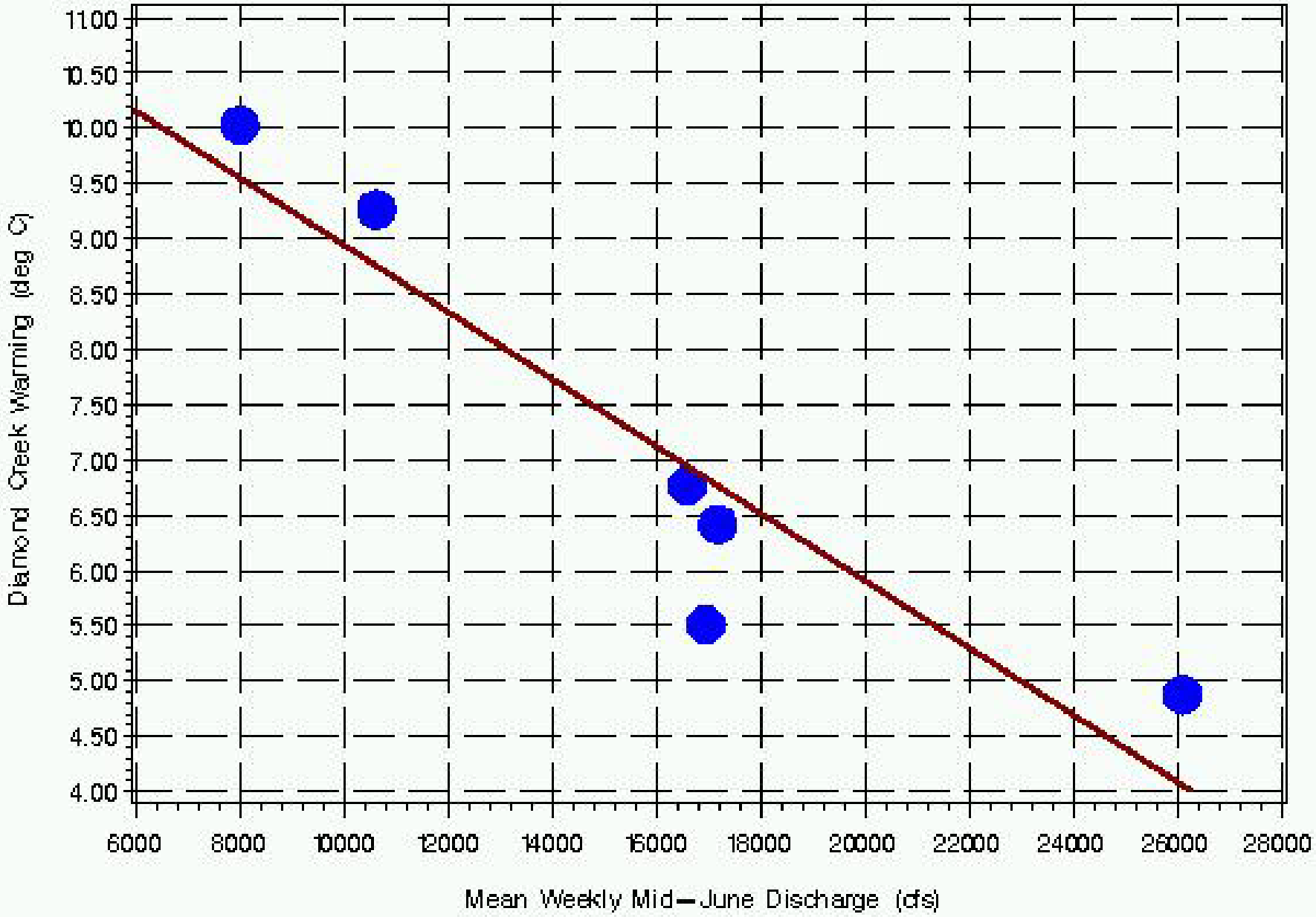



Grand Canyon Warming
1997
Mean Weekly Temperature (deg C)
Mean Weekly Discharge (cfs)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
01OCT96
01JAN97
01APR97
01JUL97
01OCT97
R-15
R000
R061
R087
R194
R226
GCG


Grand Canyon Warming
2000
Mean Weekly Temperature (deg C)
Mean Weekly Discharge (cfs)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
01OCT99
01JAN00
01APR00
01JUL00
01OCT00
R-15
R000
R061
R087
R194
R226
GCG

Week beginning	CRBD	CRLF		R226		Discharge (cfs)
	T	T	ΔT	T	ΔT	
12JUN94	8.5	9.6	1.06	17.8	9.27	10631
18JUN95	9.1	9.3	0.20	14.6	5.51	16956
16JUN96	9.4	9.9	0.52	15.9	6.42	17189
15JUN97	8.6	9.0	0.44	13.5	4.88	26111
14JUN98	9.0	9.4	0.32	.	.	18456
13JUN99	9.2	9.6	0.37	16.0	6.77	16599
18JUN00	9.5	10.4	0.93	19.5	10.03	8008

Effect of Discharge on Mid-June Warming in Grand Canyon

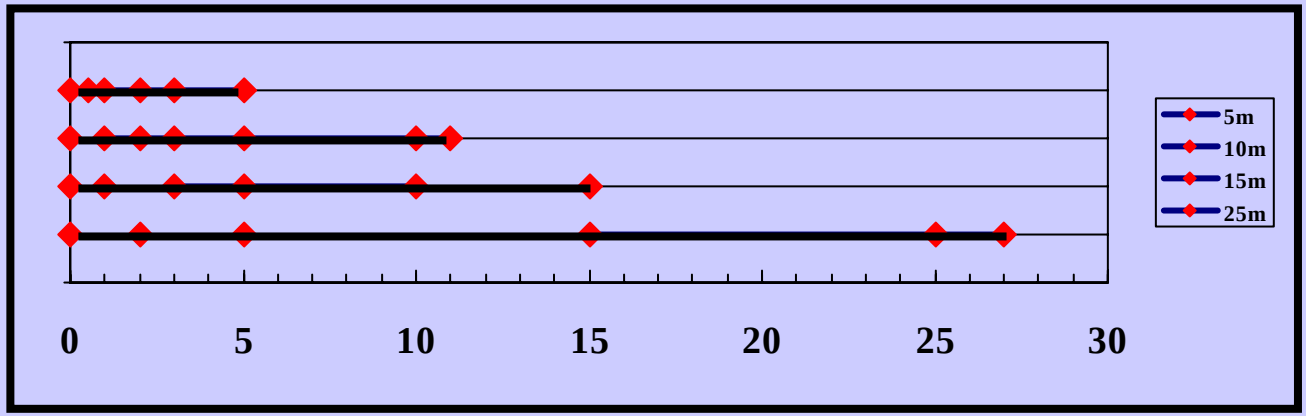


Mainstem Warming Conclusions

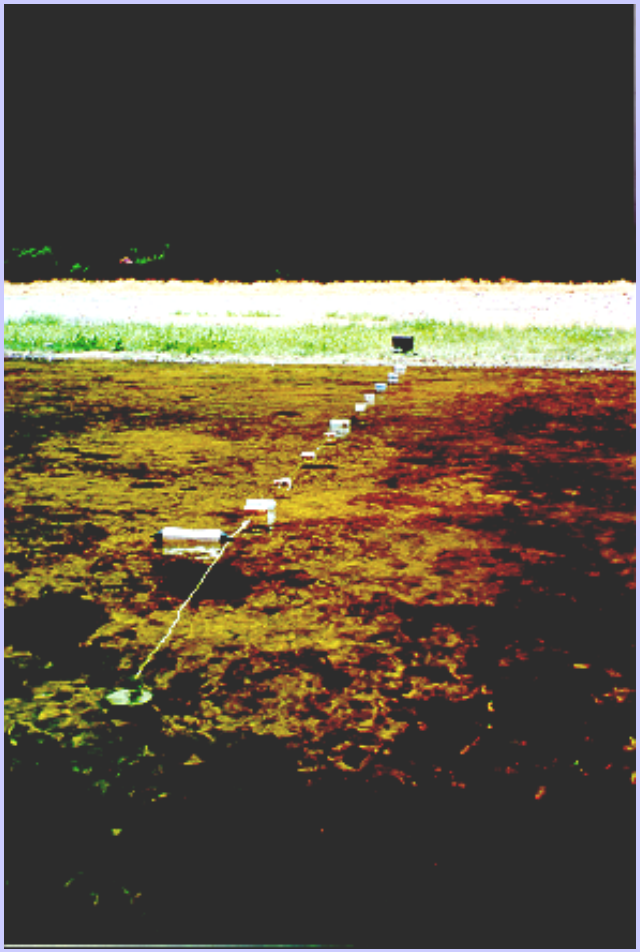
- Instream warming of Glen Canyon dam releases increased significantly during low steady flow period
- Highest temperatures observed in Grand Canyon in last decade and possibly since early 1970s
- Strong inverse correlation of amount of warming with discharge level

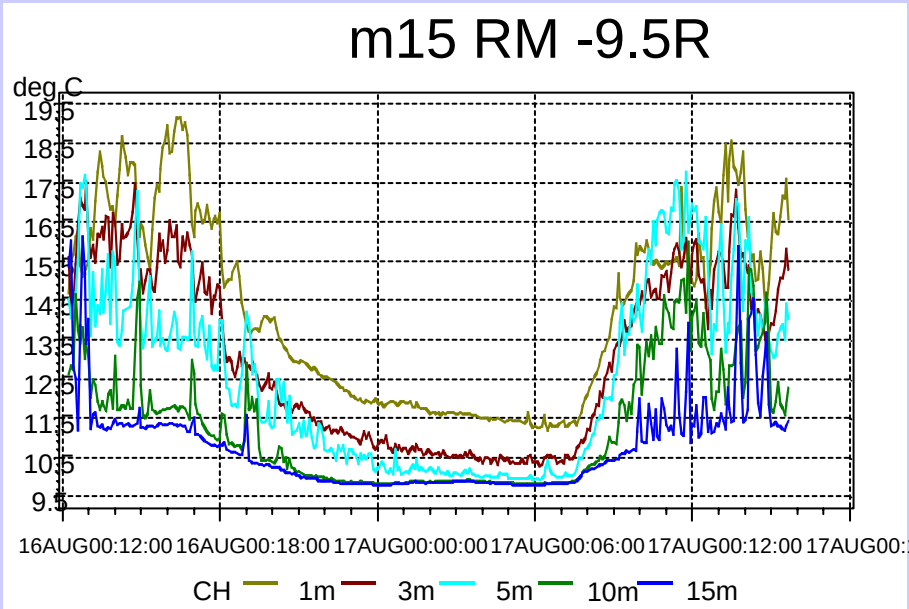

Near-Shore Warming

Near-Shore Thermistor Strings



5 m	10 m	15 m	25 m
• 0.5 m	• 1 m	• 1 m	• 2 m
• 1.0 m	• 2 m	• 3 m	• 5 m
• 2.0 m	• 3 m	• 5 m	• 15 m
• 3.0 m	• 5 m	• 10 m	• 25 m
• 5.0 m	• 10 m	• 15 m	• 27 m
	• 11 m		

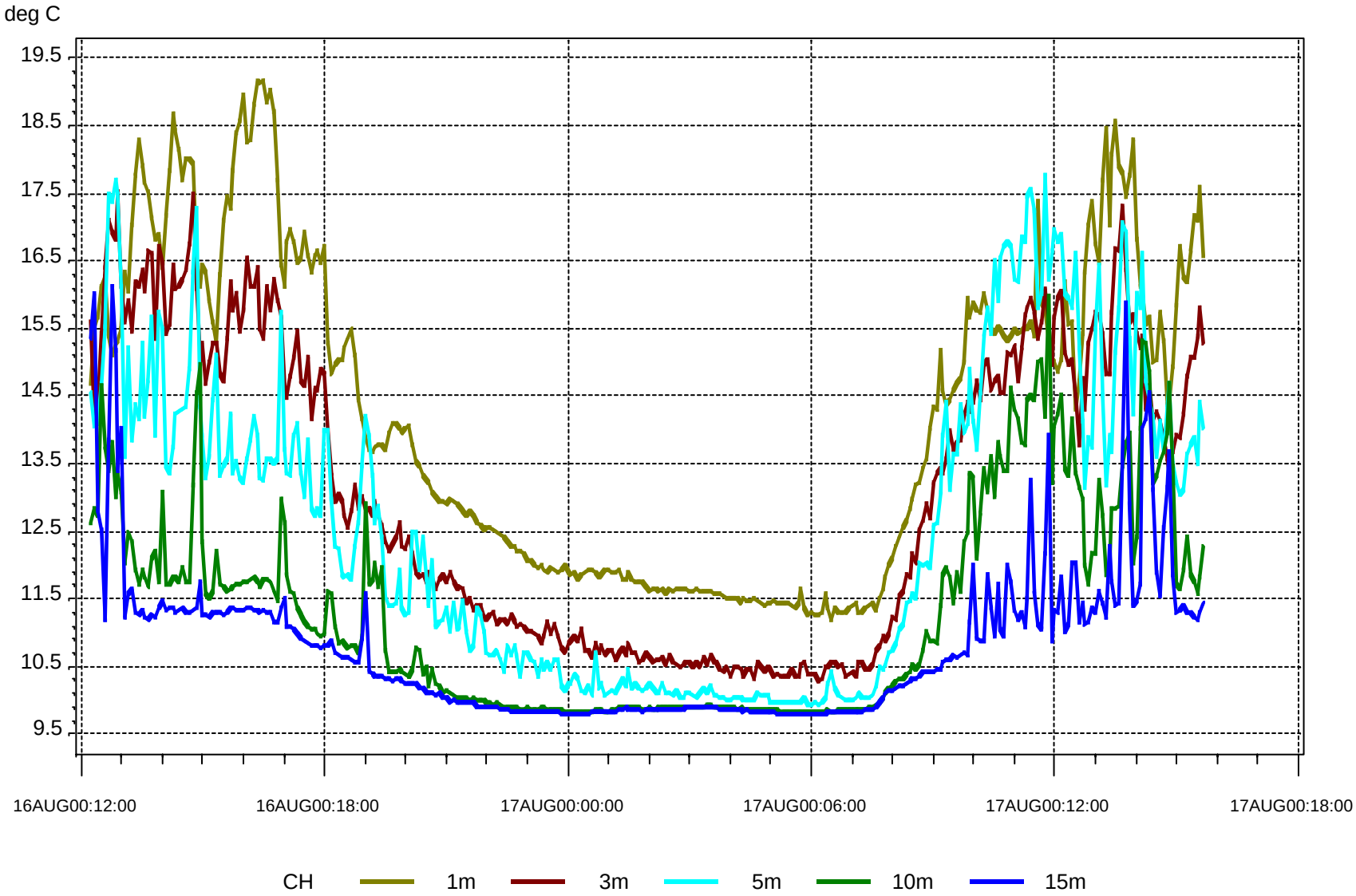


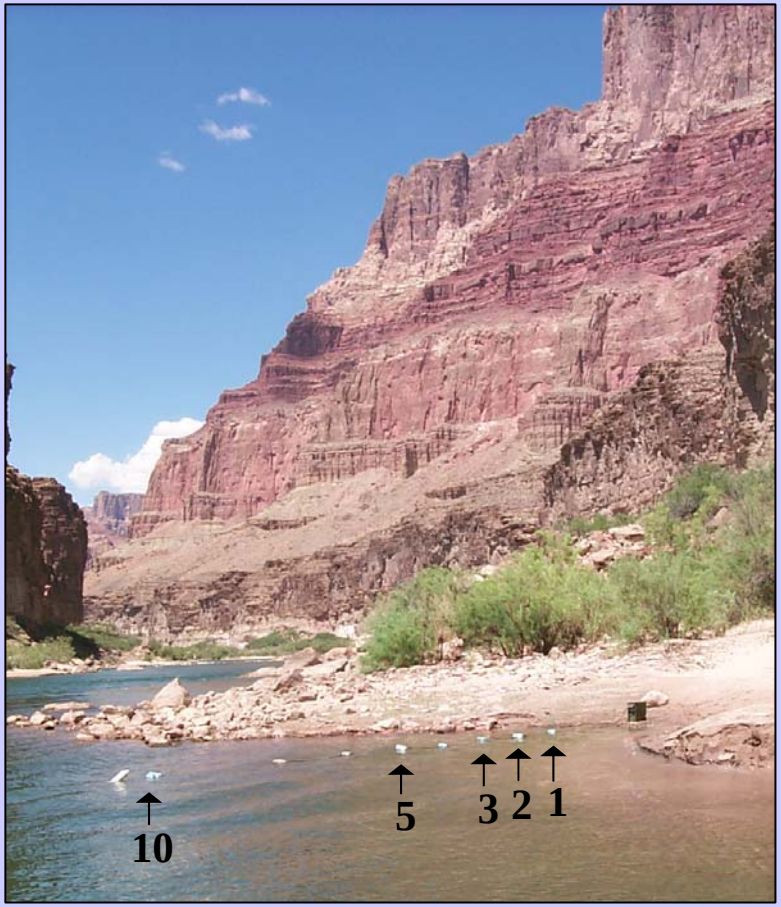


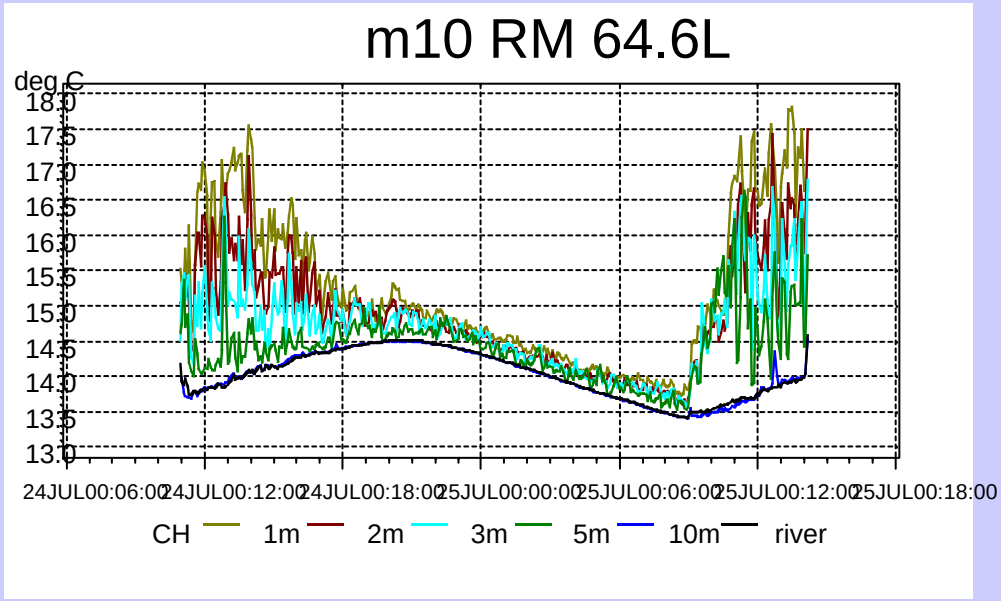
RM –9.5m

15m Thermistor String (Open Channel)

m15 RM -9.5R


deg C
19.5
18.5
17.5
16.5
15.5
14.5
13.5
12.5
11.5
10.5
9.5
16AUG00:12:00
16AUG00:18:00
17AUG00:00:00
17AUG00:06:00
17AUG00:12:00
17AUG00:18:00
CH
1m
3m
5m
10m
15m

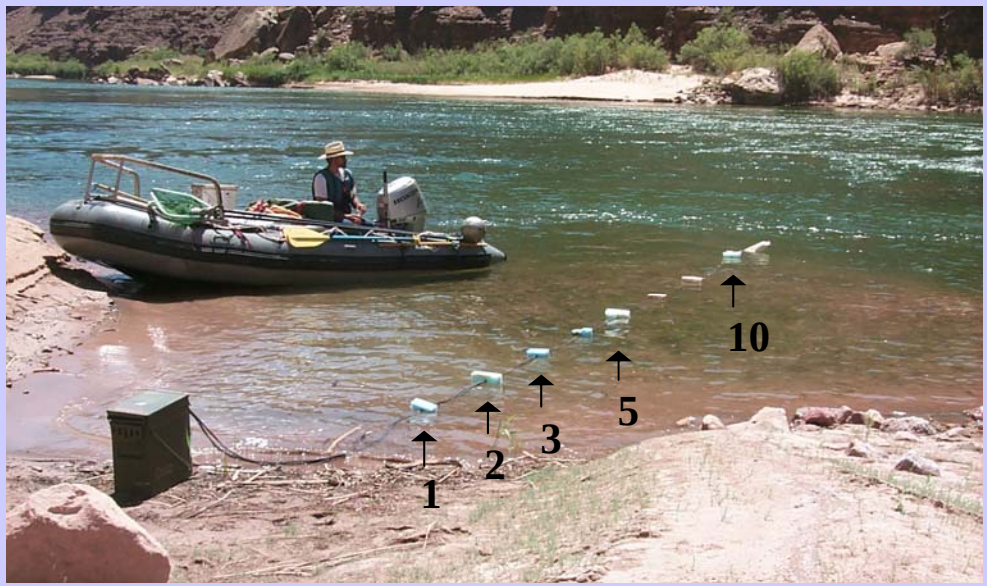




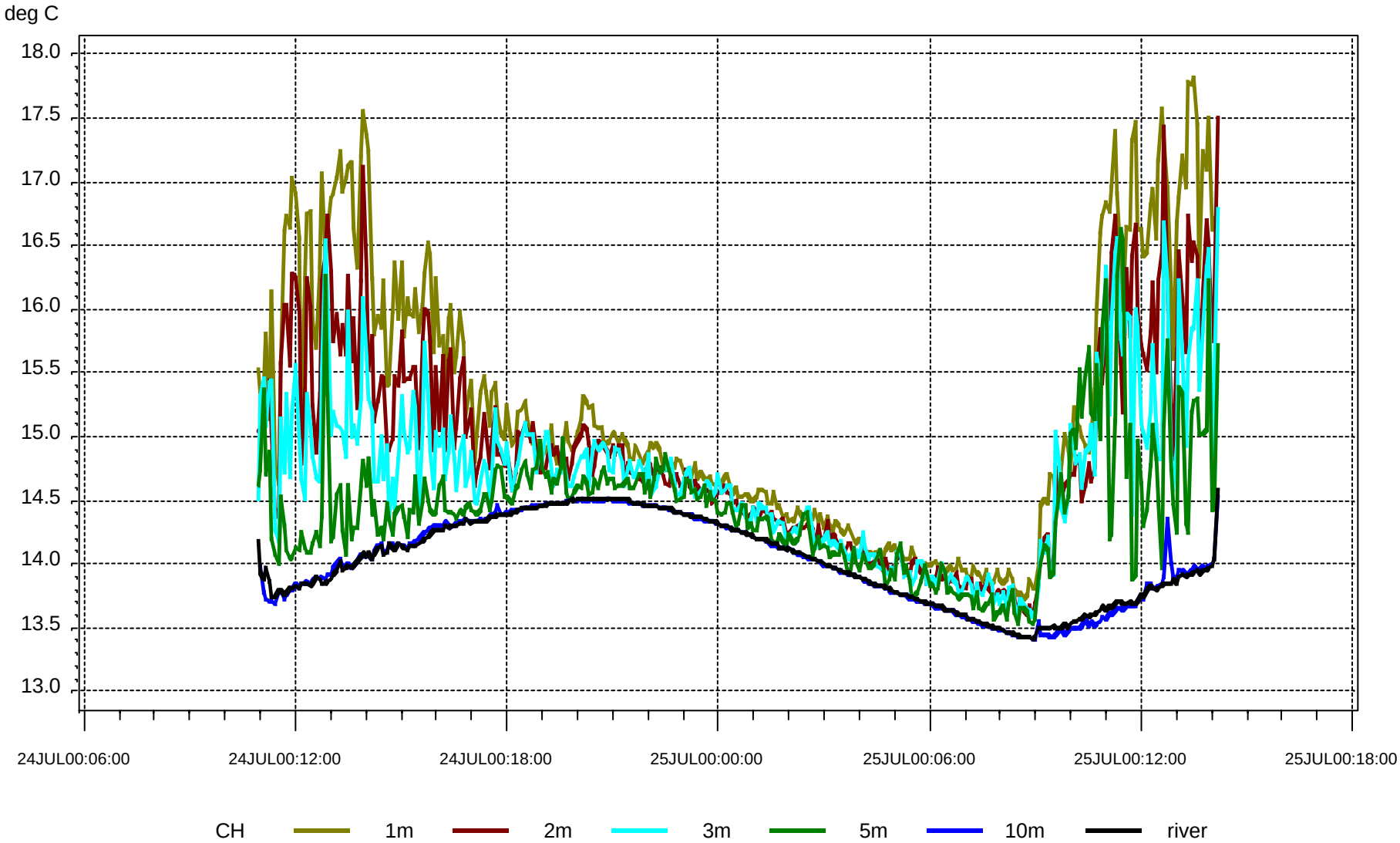
RM 64.6L

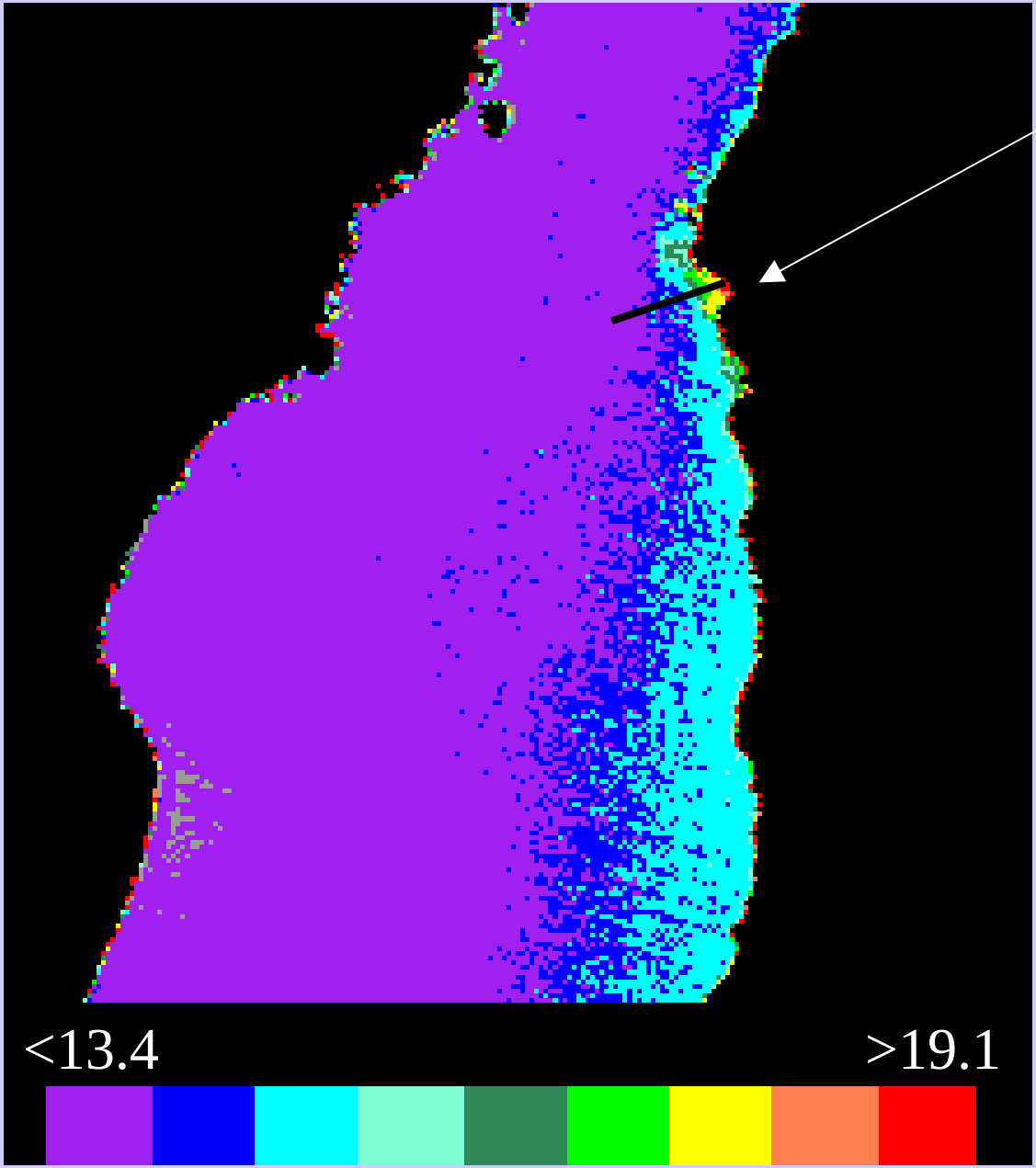
10m Thermistor String

(Open Backwater)



m10 RM 64.6L

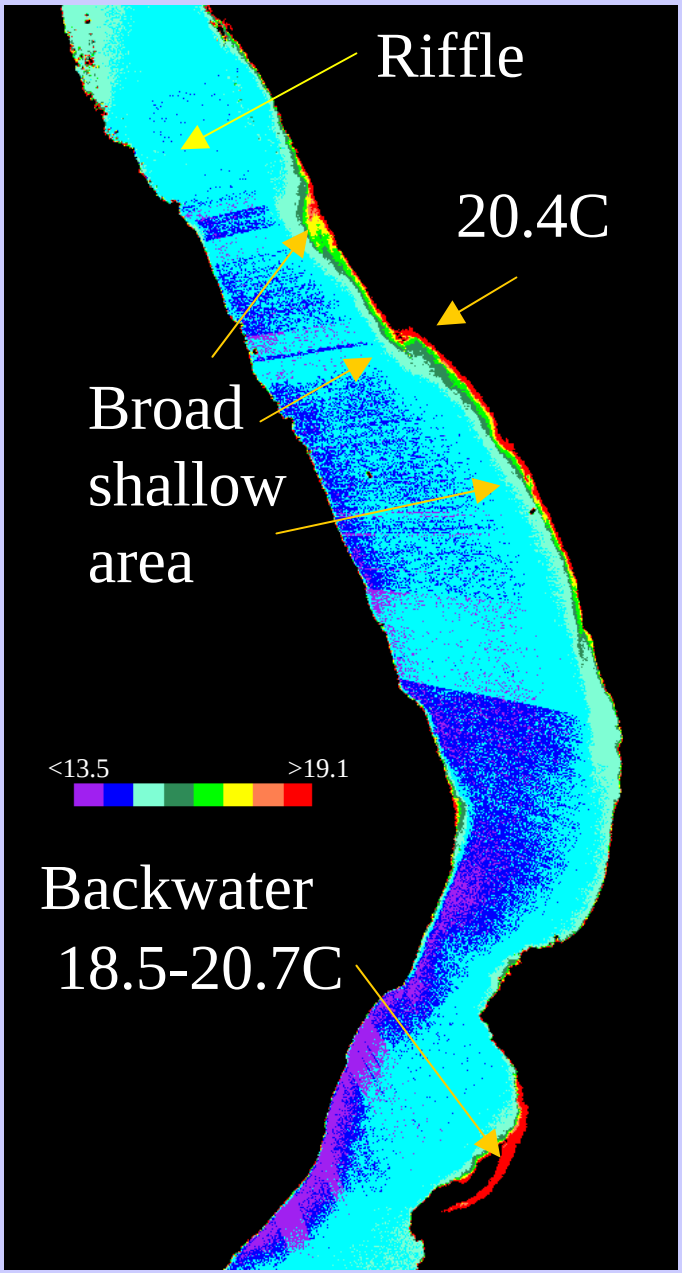

deg C
18.0
17.5
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
24JUL00:06:00
24JUL00:12:00
24JUL00:18:00
25JUL00:00:00
25JUL00:06:00
25JUL00:12:00
25JUL00:18:00
CH
1m
2m
3m
5m
10m
river



RM 64.6L

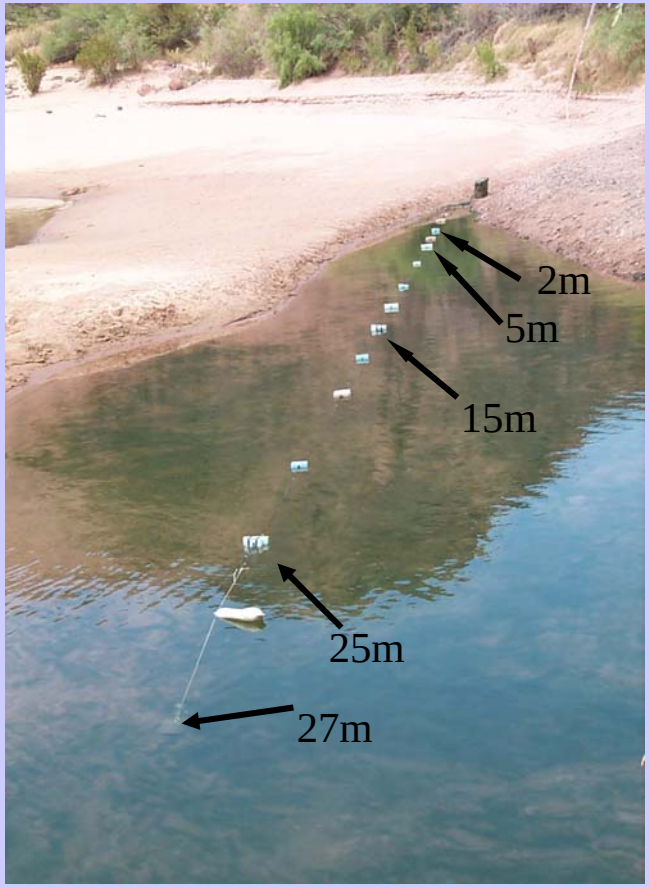
Thermal Infared Imagery
7/25/00

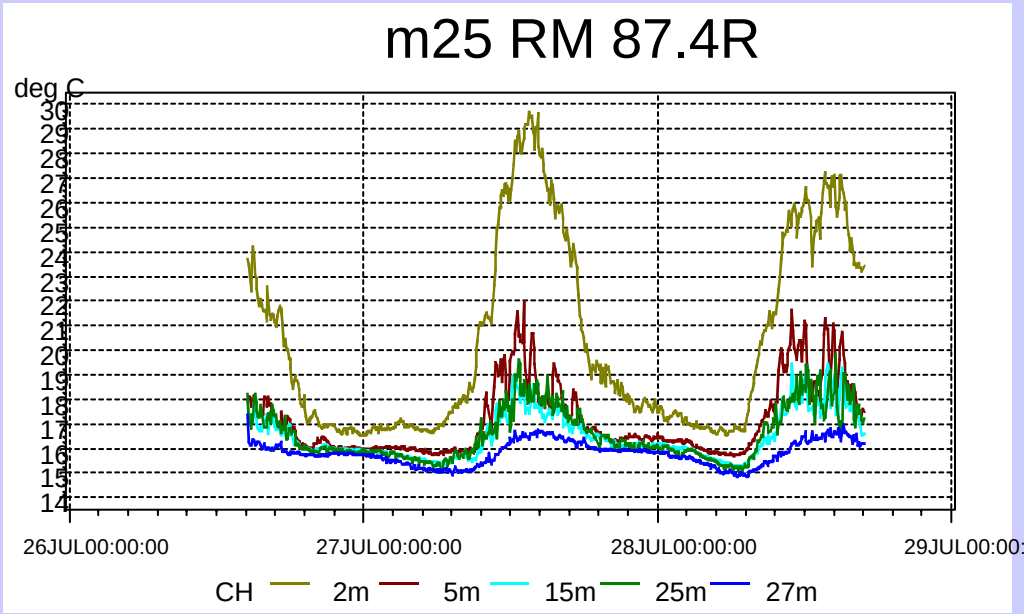
location of 10m thermistor string shown



RM 68 - Above Tanner Canyon

Thermal infared image
7/25/00

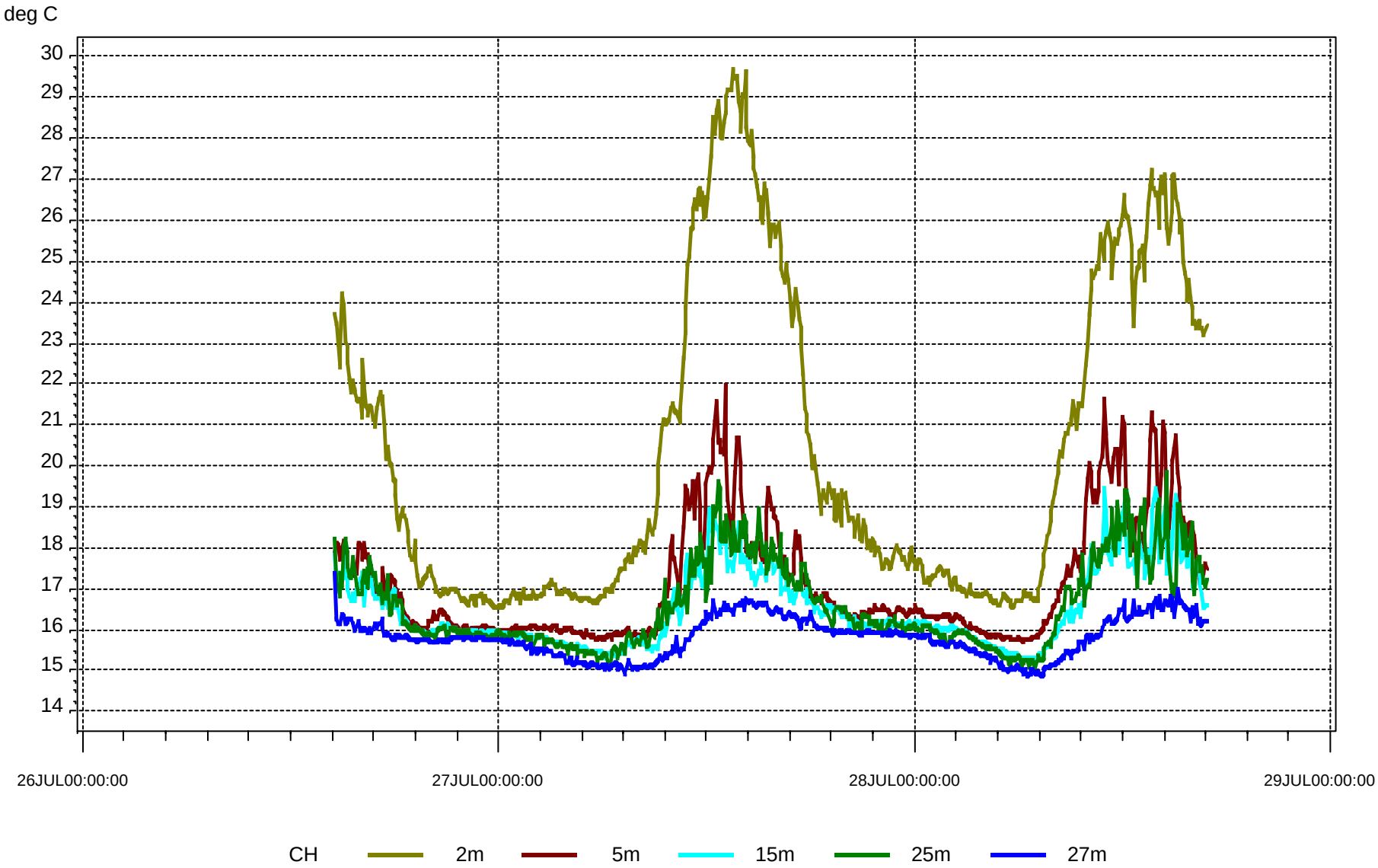




RM 87.4R

25m Thermistor String (Backwater)

m25 RM 87.4R


deg C
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
26JUL00:00:00
27JUL00:00:00
28JUL00:00:00
29JUL00:00:00
CH
2m
5m
15m
25m
27m

Near-shore Warming Conclusions

- Certain near-shore environments exhibited significant warming above mainstem temperatures
- Warming highly dependent on incident solar radiation
- Warming dependent on amount of isolation from main channel current
- Most warming seen in shallow water (<1m) with little or no velocity
- Larval fish or fry present at all locations where warming was observed

Final Conclusions

- Timing and operational constraints of a proposed TCD limit temperature and amount of available warm water for consistent warm water release downstream
- Consideration should be given to instream warming effects of lower flows to achieve desired temperatures at given target location downstream

Final Conclusions (cont'd)

- Mainstem warming probably more a function of discharge level rather fluctuation
- Near-shore warming probably more of a function of stable flows during daylight hours rather than discharge level
- Main channel temperature sets baseline above which near-shore environments can warm

Bill Vernieu

USGS – Grand Canyon Monitoring & Research Center

Flagstaff, AZ

(928) 556-7051

bvernieu@usgs.gov