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Rock Creek – Cresta Project

FERC Project No. 1962

R5

Water Temperature Monitoring of 2002

~~**Data Report**~~

FERC License Condition No. 4C

~~Draft~~ Final May 21 ~~April 27~~, 2003

Prepared By:

Pacific Gas and Electric Company™

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1 INTRODUCTION

1.1 BACKGROUND

NFFR water temperatures in the Rock Creek and Cresta reaches reflect a combination of conditions derived from several sources including; the upper North Feather River (Federal Energy Regulatory Commission [FERC] Project 2105), flows from the unregulated East Branch of NFFR, small tributary contributions, releases from Bucks Creek Project (FERC Project 619), and flow within Project bypass reaches. The temperature of water from Project 2105 is primarily determined by conditions at the non-selective Prattville Intake in Lake Almanor. Pursuant to the Rock Creek – Cresta Relicensing Settlement Agreement (Settlement Agreement), the Ecological Resource Committee (ERC) and Forest Service (FS) have agreed to a post-license monitoring and modeling study to determine if structural modification of the Prattville Intake is feasible, and if these modifications can sustain water deliveries such that daily average temperatures in the Rock Creek and Cresta reaches would be maintained below 20°C. Pursuant to FERC Condition 4C of the Project License (issued October 24, 2001), temperature monitoring is required during the summer months to determine if and to what extent the 20°C temperature level can be met with reasonable control measures.

The Rock Creek-Cresta Hydroelectric Project License No.1962 required the Licensee to file a water temperature monitoring plan with FERC, which described the implementation (including a schedule for implementation) of the water temperature monitoring program described in Condition No. 4C of the new Project License. The Rock Creek-Cresta water temperature monitoring plan was prepared in consultation with the Rock Creek - Cresta ERC and the FS and was implemented in June 2002.

The objective of the water temperature monitoring program is to:

1. Document summer water temperatures and flows in the Rock Creek and Cresta reaches as well as in upstream areas tributary to the Project.
2. Install and monitor continuous temperatures at two telemetry stations installed at two flow gaging stations in the Rock Creek and Cresta reaches.
3. Determine if mean daily water temperatures of 20°C or less can be met in the Rock Creek and Cresta reaches to the extent that Licensee can reasonably control such temperatures, particularly if a modified Prattville Intake is implemented.
4. Develop and verify a temperature model that predicts, with reasonable accuracy, the temperature profile of the river based on data from two telemetered temperature stations.

This report documents the results and subsequent analysis of the 2002 monitoring program.

1.2 PROJECT SETTING

The Licensee's North Fork Feather River Projects (FERC 2105 and FERC 1962) are located on the North Fork Feather River (NFFR) watershed in northeastern California (see Figure 1-1). The Project is located in Plumas County, approximately 90 miles northeast of Oroville, California, and encompasses approximately 30 river-miles of the upper NFFR.

The NFFR is part of the greater Sacramento River watershed and drains a large portion of the eastern Sierra-Cascade geomorphic area in California. The NFFR watershed extends from its headwater area originating on the southeastern slope of Mount Lassen to Lake Oroville, traversing lands in Lassen, Plumas, and Butte counties. The main stem of the Feather River is formed downstream of Lake Oroville; the North, Middle, and South forks of the Feather River are impounded behind Oroville Dam which was completed in 1967.

The monitoring program involved collecting data from facilities associated with the Licensee's Upper North Fork Feather River Project (FERC 2105) and Rock Creek-Cresta Project (FERC 1962). Both projects are part of a major hydroelectric generation network that utilizes the water resources of the NFFR and its tributaries for hydroelectric power generation. Downstream of these Projects is the Poe Project (FERC 2107) operated by the Licensee, and the Oroville Project (FERC 2100) owned by the State of California Department of Water Resources (DWR). Delivering water to the NFFR upstream of Licensee's Rock Creek Powerhouse is the Licensee's Bucks Creek Project (FERC 619).

Figure 1-1. Regional location of study area.

2 STUDY DESIGN

2.1 MONITORING PROGRAM

2.1.1 Monitoring Network

A first year of compliance water resource monitoring was initiated in May 2002, and continued through September 2002. The monitoring program consisted of monitoring continuous water temperature and continuous stream flow data from selected locations. All monitoring activities were conducted by staff or contract personnel from the Licensee's Technical and Ecological Services, Land and Water Quality Unit.

A map of the system (Figure 2-1) depicts monitoring stations in relation to the major Project features such as powerhouses, reservoirs and bypass reaches. Station identification, location, monitoring activity and the rationale for selection is shown in Table 2-1. Results of the 2002 water resource monitoring effort are discussed in Section 3.

Table 2-1

Upper NFFR Water Quality Sampling Locations

Station ID	Alternate Station Identification	Station Location	Monitoring Activity [1]
NF1	----	NFFR above Chester, CA.	F, TR
HB1	----	Hamilton Branch of NFFR at HWY bridge	TR,
NF-83	----	Hamilton Branch Powerhouse	F
HB2	----	Hamilton Branch Powerhouse – canal head-works	TR
LA1-S	----	Lake Almanor near Canyon Dam - Epilimnion	TR - buoy
LA1-B	----	Lake Almanor near Canyon Dam - Hypolimnion	TR - buoy
LA – P1	----	Lake Almanor near Canyon Dam – near intake	IS-P
LA – P2	----	Lake Almanor - Offshore of Prattville Intake (LA2)	IS-P
LA – P3	----	Lake Almanor – middle of Eastern lobe (LA8)	IS-P
LA – P4	----	Lake Almanor – middle of Western lobe (LA6)	IS-P
LA-MET	----	Meteorological station on Prattville Intake	M
NF-1	11-399000	Lake Almanor near Prattville	Lake storage
NF2	----	NFFR below Canyon Dam	TR,
NF-2	11-399500	NFFR below Canyon Dam	F
NF3	----	NFFR at Seneca	TR
NF4	NF-47 (PG&E)	NFFR above Caribou No.1 Powerhouse	TR F
BV1		Butt Valley Powerhouse Tailrace	TR,
NF-71	11-400600	Butt Valley Powerhouse	F
BV2-S	----	BVR near Caribou No.1 Intake - Epilimnion	TR - buoy
BV2-B	----	BVR near Caribou No.1 Intake - Hypolimnion	TR - buoy
BV-P1	----	BVR at Caribou No. 1 Intake	IS-P
BV-P2	----	BVR near Cool Springs Campground	IS-P
BV-P3	----	BVR near boat ramp	IS-P
BV-P4A	----	BVR near Caribou No.2 intake channel	IS-P (special)
BV-P4B	----	BVR at mouth of Caribou No.2 intake channel	IS-P (special)
NF-8	11-401050	Butt Valley Reservoir near Caribou (at dam)	Lake storage
CARB1	----	Caribou No. 1 Powerhouse tailrace	TR
NF-63	11-401110	Caribou No. 1 Powerhouse	F
CARB2	----	Caribou No. 2 Powerhouse tailrace	TR
CARB2B	----	Caribou No. 2 Intake channel bottom at structure	TR
NF-263	11-401109	Caribou No. 2 Powerhouse	F
BC1	----	Butt Creek upstream of Butt Valley Reservoir	TR
NF-4	11-400500	Butt Creek below ABC tunnel, near BVR	F
BC2	----	Butt Creek downstream of Butt Valley Reservoir	TR
BC3	----	Butt Creek near confluence with NFFR	TR, F
BD1	----	Belden Reservoir at powerhouse intake	TR
NF-67	11-403050	Belden Reservoir	Lake storage
NF-103	----	Oak Flat Powerhouse	F
NF5	---	NFFR below Belden Dam	TR
NF-70	11-401112	NFFR below Belden Dam	F
MC1	----	Mosquito Creek near mouth	TR, F
NF6	----	NFFR near Queen Lily Campground	TR

Table 2-1 Continued

Station ID	Alternate Station Identification	Station Location	Monitoring Activity [1]
NF7	----	NFFR near Gansner Bar	TR
EB1	----	East Branch of NFFR above confluence	TR
NF-51	11403000	East Branch of NFFR above confluence	F
NF8	----	NFFR at Belden Town Bridge	TR
BD2	----	Belden Powerhouse tailrace	TR
NF-74	11-403050	Belden Powerhouse	F
YC1	----	Yellow Creek near mouth	TR, F
RCK-MET	----	Meteorological station on Rock Creek Dam	M
CHIP	----	Chips Creek near mouth	TR, S
NF9	----	NFFR below Rock Creek Dam	TR
NF10	----	NFFR below Rock Creek Dam at NF-57	TR
NF-57	11-403200	NFFR downstream of Rock Creek Dam	F
MR1	----	Milk Ranch Creek near mouth	TR, F
CHAM	----	Chambers Creek near mouth	TR, S
NF11	----	NFFR below Granite Creek	TR
JC1	----	Jackass Creek near mouth	TR
NF12	----	NFFR above confluence with Bucks Creek	TR
BUCK1	11-403700	Bucks Creek near mouth	TR, F
NF-20	----	Bucks Creek Powerhouse	F
BUCK2	----	Bucks Creek Powerhouse tailrace	TR
NF13	----	NFFR above Rock Creek Powerhouse	TR
RC1	11-403800	Rock Creek Powerhouse (internal)	TR
NF-64	----	Rock Creek Powerhouse	F
RC2	----	Rock Creek near mouth	TR, S
NF14	----	NFFR below Cresta Dam	TR
GR1	----	Grizzly Creek near mouth	TR, F
NF15	----	NFFR downstream of Grizzly Creek	TR
NF-56	11-404330	NFFR downstream of Grizzly Creek	F
NF16	----	NFFR upstream of Cresta Powerhouse	TR
CR1	----	Cresta Powerhouse(internal)	TR
NF-62	11-404360	Cresta Powerhouse	F
MB1	----	Middle Fork Feather River at Milsap Bar	TR

~~1.2~~2.2 METHODOLOGY

2.2.1 Flow Monitoring

Stream flow was monitored throughout the Project area in 2002 at a seven stations (NF1, NF4, BC3, YC1, MR1, BUCK1, and GR1). Flow data were also obtained from permanent stream flow gages and from powerhouses associated with the Project through Pacific Gas and Electric Company's Hydroelectric Department. Flow monitoring station locations are shown on Figure 2-1 and are described in Table 2-1.

Each of the temporary flow monitoring stations consisted of a Campbell CR510 digital recorder, associated Druck 5 psi pressure transducer and a stage pin. The stage pins and pressure transducer were placed in-stream, while the digital recorders were located on the stream bank in locked enclosures. The digital recorders were set to record instantaneous readings every 15 minutes, and stored this data as hourly average transducer values. All data were stored in non-volatile memory. During routine site visits, stream stage was recorded, and stored hourly average transducer data were downloaded to computer.

A simple linear regression was used to define the relationship between transducer readings and the associated stream stage measurements at each station. Average hourly transducer readings were then converted into average hourly stream stage readings using the resultant regression equation. The conversion to a stage value based on a fixed reference (stage pin) facilitated year to year comparison of flow measurements and allowed for correction for error associated with transducer drift.

Stream flow measurements were made at each station during routine site visits at transects located near each gaging station. Measurements were made using U. S. Geological Survey (USGS) approved stream flow measurement techniques (Buchanan 1980). All measurements were made using a Price AA-type flow meter, and 5-foot top-setting wading rod. The errors associated with measurements made in the river were estimated at 10 to 15% due to the large substrate and abundant amount of vegetation in the channel. Measurements made in the tributary creeks had an estimated error of 8 to 10%. The primary objective of the routine flow measurements was to cover the range of observed flows in order to develop a stage-flow rating equation.

The relationship of stream stage to stream flow (stage-flow rating) was developed using flow measurements and the associated stage pin readings collected during routine site visits. The resultant stage-flow rating was used to convert average hourly stage readings into average hourly flow. The rating is only applicable to flow within the defined range of stage, and is also subject to changes in the hydraulic control. All instrumentation-installed *in situ* was removed during months when seasonal high flows could damage the equipment.

Daily flow at four tributary streams (Mosquito, Chambers, Chips, and Rock creeks) was estimated based on periodic flow measurements. A linear decay between measurements was assumed to generate a daily flow estimate. A staff gage (stage pins) was installed at each of these stations to periodically measure stream stage. A total of at least four measurements were made at each station between June and September.

~~1.1.2~~2.2.2 Meteorological Monitoring

Local meteorology was monitored to provide input to the stream temperature model. Two temporary stations were placed in the Project area. One station was located on the Prattville Intake at Lake Almanor; another was located on Rock Creek Dam (Figure 2-1). These stations effectively represent conditions in the upper and middle portion of the Project. Parameters that were measured included; average wind speed and direction, air temperature, relative humidity, and solar radiation. These parameters were monitored continuously using a Campbell Scientific Model CR10 data logger. Data were collected at 1-second intervals and reduced to hourly average readings.

~~1.1.3~~2.2.3 Temperature Monitoring

The temperature-monitoring program used recorders from three different manufactures to monitor temperature during the 2002 effort. The bulk of the data loggers deployed in the system were Vemco Minilog 12T recorders. These units recorded continuous temperature data as instantaneous readings taken at 20-minute intervals, these data are then converted into hourly average temperatures. Campbell Scientific Model CR510 recorders were used at seven stations to monitor temperature. These recorders were also used to record continuous stream stage (flow) at the same locations (Table 2-1). The CR510 loggers recorded continuous temperature data as hourly averages based on readings taken at 15-minute intervals. A final type of recorder deployed during the monitoring program was the Omnidata Model DP112. These units were placed at six locations; these recorders were used exclusively on Project powerhouses (Caribou No. 1, No. 2, Belden, Rock Creek, and Cresta). The tailrace characteristics of these facilities dictated that the temperature sensors be installed internally in the powerhouse. The DP112 loggers recorded continuous temperature data as hourly averages based on readings taken at 5-minute intervals.

Stream temperature sensors were typically deployed in well-mixed areas with elevated velocity and turbulent flow to ensure representative measurements. In general, continuous monitoring of temperature was conducted from June through September 2002.

During the period June through September 2002, vertical profiles were collected from 4 locations on Lake Almanor and from three locations on Butt Valley Reservoir to determine the magnitude and seasonal development of thermal gradients. Profiles were defined using 1-meter vertical spacing from the surface to the bottom.

In addition to the synoptic profiles collected at the three Project reservoirs, vertical temperatures in Lake Almanor and Butt Valley were continuously monitored from June through September 2002. Temperatures were monitored at a single station near the dam in each reservoir (Figure 2-1). A thermistor array consisting of Vemco Model Minilog 12T recorders positioned at two depths, near the surface (1.0 meters below surface) and near the bottom (2 meters above bottom to resting on bottom depending on lake elevation), was placed at each location. The thermistor array was suspended from a buoy so that each recorder was maintained at a fixed depth below the surface.

To verify the operation and accuracy of the temperature recorders, the units were calibrated using an American Society for Testing and Materials (ASTM) reference thermometer, both prior to and following removal from the *in situ* deployment. Typical instrument error is between 0.1 and 0.2°C.

Temperature records from instruments placed internally or in the tailrace of the various Project powerhouses were corrected to reflect periods of powerhouse operation. This process was done on an hourly basis by comparing powerhouse load records with temperature recorder data. This processed helped eliminate periods when there was little or no flow through the powerhouse and temperatures reflected stagnate conditions.

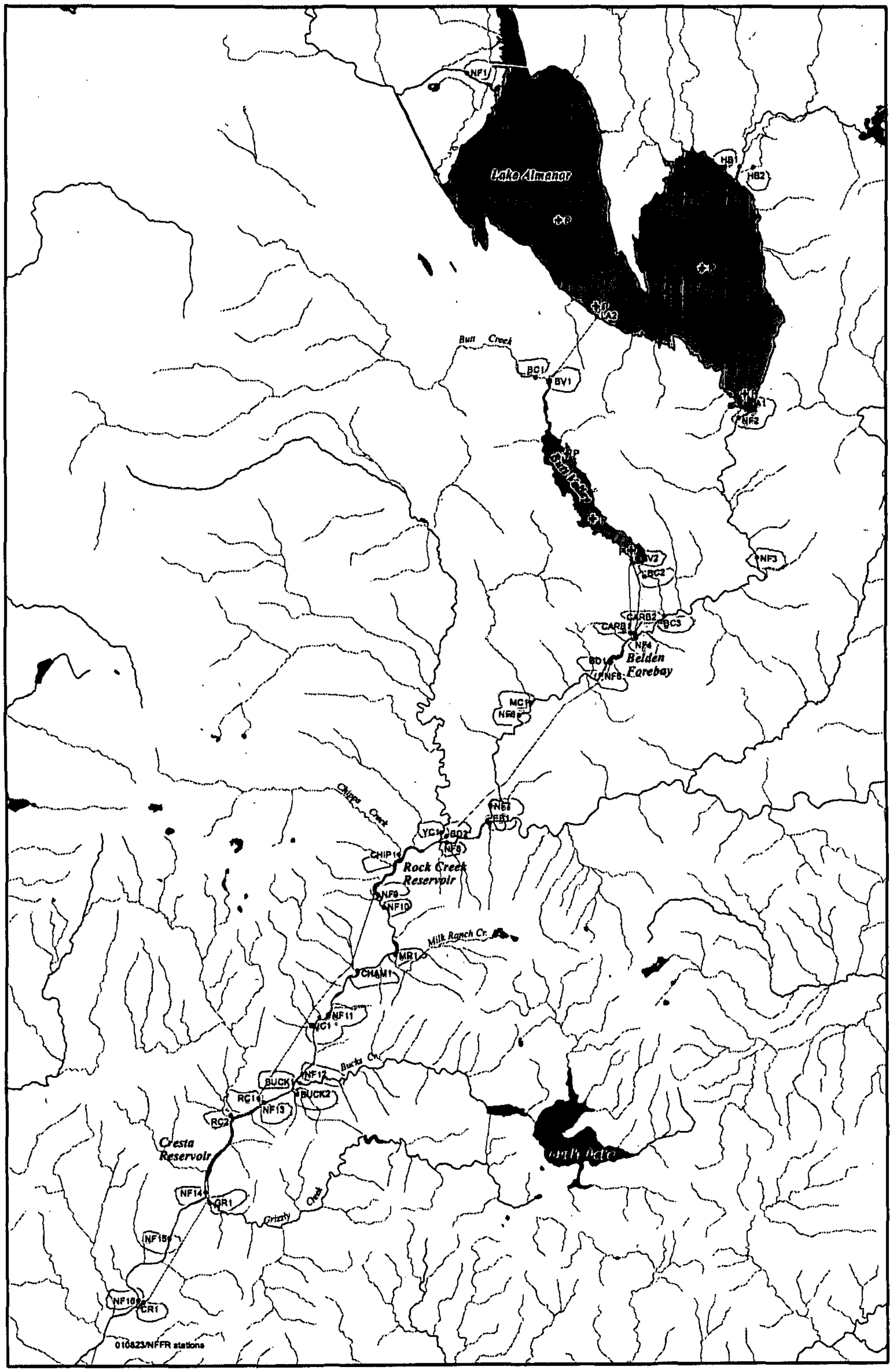

Figure 2-1. Map of station locations used during the 2002 monitoring program.

3 MONITORING RESULTS - 2002

3.1 HYDROLOGY AND METEROLOGY

3.1.1 Streamflow and Reservoir Operation

The Licensee's Upper NFFR Project encompasses the water resources and aquatic habitats of the upper NFFR drainage basin (from Lake Almanor to the NFFR confluence with Yellow Creek [headwaters of Rock Creek Reservoir]). The majority of flow entering the Project originates from water first stored in Lake Almanor. Water is then passed downstream through a series of powerhouses and associated forebays. The Licensee's Rock Creek- Cresta Project encompasses the water resources of the middle portion of the NFFR basin, extending from the confluence of Yellow Creek to the headwaters of Poe Reservoir.

In addition to the permanent flow monitoring stations, the Licensee installed a series of temporary flow monitoring gages. These gages provided supplemental information in support of the temperature modeling effort. Table 3-1 summarizes streamflow data from these temporary flow-monitoring stations.

Table 3-1

Summary of 2002 stream flow monitoring at permanent and temporary stations.

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
NFFR near	2002	June	397	214	298	---	30
Chester (NF1)	2002	July	212	139	175	---	31
[Estimated]	2002	Aug	136	112	120	---	31
	2002	Sept	111	97	104	---	30
Hamilton Branch	2002	June	85.5	69.7	76.8	---	30
at A13 Bridge	2002	July	95.0	67.7	76.8	---	31
(HB1)	2002	Aug	78.0	75.8	76.5	---	31
[Estimated]	2002	Sept	76.2	61.0	71.7	---	30
Hamilton Branch	2002	June	38	32	34	100%	30
Powerhouse	2002	July	35	0	23	69%	21
(NF-83)	2002	Aug	92	11	79	97%	30
[Corrected]	2002	Sept	79	35	72	100%	30
NFFR below	2002	June	36.5	36.5	36.5	---	30
Canyon Dam	2002	July	36.9	36.1	36.5	---	31
(NF-2)	2002	Aug	36.1	35.2	35.8	---	31
[Permanent]	2002	Sept	35.2	34.7	34.9	---	30
NFFR above	2002	June	83.2	77.6	80.1	---	30
Caribou PH	2002	July	77.3	74.9	75.9	---	31
(NF4)	2002	Aug	75.4	73.3	74.2	---	31
[Temporary]	2002	Sept	73.5	71.2	72.7	---	30
Butt Valley	2002	June	1084	0	115	6.5%	4
Powerhouse	2002	July	1283	0	746	49%	29
[Corrected]	2002	Aug	1439	159	984	63%	31
(NF-71)	2002	Sept	1615	504	1436	90%	30
Butt Creek at ABC	2002	June	71.8	48.3	56.2	---	30
Tunnel (NF-4)	2002	July	47.6	43.6	45.6	---	31
[Permanent]	2002	Aug	43.8	42.1	42.9	---	31
	2002	Sept	42.4	40.9	41.6	---	30
Butt Creek at	2002	June	14.2	14.0	14.1	---	30
Mouth	2002	July	14.2	13.7	13.9	---	31
(BC3)	2002	Aug	14.3	14.1	14.2	---	31
[Temporary]	2002	Sept	14.6	14.1	14.3	---	30
Caribou No. 1	2002	June	325	0	21	4%	5
Powerhouse	2002	July	564	0	285	47%	29
(NF-63)	2002	Aug	744	129	516	67%	31
[Corrected]	2002	Sept	716	247	503	72%	30

Table 3-1 (Continued)

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
Caribou No. 2	2002	June	722	108	245	98%	30
Powerhouse	2002	July	735	0	332	90%	28
(NF-263)	2002	Aug	719	33	484	100%	31
	2002	Sept	1070	245	912	100%	30
Oak Flat	2002	June	0	116	105	---	29
Powerhouse	2002	July	0	116	64.5	---	19
(NF-103)	2002	Aug	111	116	114	---	31
	2002	Sept	0	114	49.2	---	26
NFFR below	2002	June	145	143	144	---	30
Belden Dam	2002	July	144	142	143	---	31
(NF-70)	2002	Aug	144	142	143	---	31
[Permanent]	2002	Sept	143	62	69	---	30
Mosquito Creek	2002	June	7.5	5.1	6.2	---	30
At mouth	2002	July	5.1	4.2	4.6	---	31
(MC1)	2002	Aug	4.1	4.0	4.1	---	31
[Estimate]	2002	Sept	4.2	4.1	4.1	---	30
East Branch	2002	June	334	117	187	---	30
NFFR near NFFR	2002	July	118	51.4	79.9	---	31
(NF-51)	2002	Aug	60.9	45.0	52.5	---	31
[Permanent]	2002	Sept	62.0	48.8	55.9	---	30
Belden	2002	June	830	0	121	12%	7
Powerhouse	2002	July	1216	0	518	48%	29
(NF-74)	2002	Aug	1504	241	1001	73%	31
	2002	Sept	1513	677	1108	91%	30
Yellow Creek	2002	June	117	64.5	81.5	---	30
Near mouth	2002	July	63.6	52.4	56.9	---	31
(YC1)	2002	Aug	53.7	50.8	52.2	---	31
[Temporary]	2002	Sept	54.0	48.8	51.3	---	30
Chips Creek	2002	June	107	33.8	64.3	---	30
Near mouth	2002	July	33.3	18.2	25.7	---	31
(CHIP)	2002	Aug	17.7	14.4	15.5	---	31
[Estimate]	2002	Sept	14.3	12.4	13.3	---	30
NFFR below	2002	June	1133	170	267	---	30
Rock Creek Dam	2002	July	774	150	216	---	31
(NF-57)	2002	Aug	553	191	209	---	31
[Permanent]	2002	Sept	650	196	229	---	30

Table 3-1 (Continued)

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
Milk Ranch Creek	2002	June	9.8	6.4	8.2	---	30
Near mouth	2002	July	6.2	4.1	5.0	---	31
(MR1)	2002	Aug	4.2	3.4	3.7	---	31
[Temporary]	2002	Sept	3.5	3.2	3.3	---	30
Chambers Creek	2002	June	46.9	9.9	25.2	---	30
Near mouth	2002	July	9.7	4.6	4.1	---	31
(CHAM)	2002	Aug	4.4	3.0	3.5	---	31
[Estimate]	2002	Sept	3.0	2.5	2.7	---	30
Bucks Creek	2002	June	24.1	19.0	21.7	---	30
Near Mouth	2002	July	18.8	13.8	16.1	---	31
(BUCK1)	2002	Aug	13.7	10.7	12.1	---	31
[Temporary]	2002	Sept	13.5	10.2	12.2	---	30
Bucks Creek	2002	June	51	5	19	29%	27
Powerhouse	2002	July	194	1	83	36%	26
(NF-20)	2002	Aug	228	0	113	44%	21
	2002	Sept	237	109	171	92%	30
Rock Creek	2002	June	1342	204	479	98%	90
Powerhouse	2002	July	1358	97	756	100%	31
(NF-64)	2002	Aug	1596	184	1095	100%	31
	2002	Sept	1744	422	1466	100%	30
Rock Creek	2002	June	44.5	8.9	21.6	---	30
Near mouth	2002	July	8.7	3.0	5.8	---	31
(RC2)	2002	Aug	2.8	2.1	2.3	---	31
[Estimate]	2002	Sept	2.1	1.7	1.9	---	30
Grizzly Creek	2002	June	38.8	28.9	33.6	---	30
Near mouth	2002	July	28.4	20.0	24.1	---	31
(GR1)	2002	Aug	20.2	15.1	17.5	---	31
[Temporary]	2002	Sept	16.9	12.9	14.6	---	30
NFFR below	2002	June	1109	271	321	---	30
Grizzly Creek	2002	July	805	235	265	---	31
(NF-56)	2002	Aug	568	236	260	---	31
[Permanent]	2002	Sept	667	240	262	---	30
Cresta	2002	June	1576	243	600	66%	30
Powerhouse	2002	July	1457	12	820	55%	30
(NF-62)	2002	Aug	1698	216	1135	63%	31
	2002	Sept	1898	544	1658	82%	30

1. Daily values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average flows.

2. Percent powerhouse operation is based on hourly generation data.

~~1.1.1.1~~3.1.1.1 Lake Almanor and tributaries

The major tributaries feeding into Lake Almanor are the NFFR at Chester with an historic average annual flow of approximately 335 cfs, the Hamilton Branch with an historic average flow of 190 cfs, and a number of minor tributaries including Benner, Last Chance, and Bailey creeks.

Flow in the NFFR upstream of Lake Almanor (which provides an estimated 50 percent of the annual inflow to Lake Almanor) is derived from headwaters that originate on the slopes of Mount Lassen. During the 2002 monitoring program, flow in the NFFR upstream of Lake Almanor was measured at a temporary stream gage (NF1) located upstream of the city of Chester, CA. Mean daily flow at this station for the period June-September 2002 ranged from 97 to 397 cfs, averaging 174 cfs. Figure 3.1 compares daily average flow from the NFFR with other stations tributary to Lake Almanor.

Flow in the Hamilton Branch (which provides 20 to 25 percent of the annual inflow to Lake Almanor), originates from the Licensee's Mountain Meadows Project (to be amended to the Application for New License, FERC License 2105). During the 2002 monitoring program, flow in the Hamilton Branch was measured upstream of Lake Almanor at a temporary stream gage (HB1). This station is located near the confluence with Lake Almanor, and is downstream of a series of small diversion facilities that diverts flow into a canal that supplies the Licensee's Hamilton Branch Powerhouse. During the June-September 2002 monitoring period, estimated mean daily flows in the Hamilton Branch upstream of Lake Almanor ranged from 61 to 95 cfs, with an average flow of 75 cfs. Figure 3.1 compares daily average flow from the Hamilton Branch with other stations tributary to Lake Almanor.

The second location monitoring flow in the Hamilton Branch system as inflow to Lake Almanor is the Licensee's Hamilton Branch Powerhouse (NF-83). This facility is located near the mouth of the Hamilton Branch River and discharges directly into Lake Almanor (Figure 2-1). During the June-September 2002 monitoring period, mean daily flows at the Hamilton Branch Powerhouse averaged 52 cfs and ranged from 0 to 92 cfs. Figure 3.1 compares daily average flow from Hamilton Branch Powerhouse with other stations tributary to Lake Almanor.

Lake Almanor is the primary storage reservoir for the Upper NFFR Project; it is located about 90 miles upstream of the city of Oroville. Lake Almanor was created by the construction of a hydraulic fill dam now referred to as Canyon Dam. Canyon Dam was completed in various phases between 1913 and 1927. Lake Almanor has a normal maximum water surface elevation of 4,504 ft (USGS datum) and a storage capacity of 1,142,00 acre-ft. The average residence time in Lake Almanor is approximately 291 days. Major lake outlets include the Canyon Dam Intake, which releases water to the NFFR downstream of Lake Almanor (Seneca Reach), and the Prattville Intake that diverts water to Butt Valley Reservoir through Butt Valley Powerhouse. Figure 3-2 presents daily average reservoir storage for Lake Almanor for the June through September 2002 monitoring period.

Releases from the Prattville Intake to Butt Valley Reservoir represent the greatest portion of water released from Lake Almanor. The maximum flow through the intake is 2,200 cfs. The Prattville Intake is a high-Froude number structure; as a result, water is drawn from the entire water column regardless of thermal stratification conditions. The tunnel invert is situated at the bottom of a narrow steep-sided trough that connects the relatively shallow intake channel with the deeper areas of the reservoir. The invert of the Prattville Intake is located at 4,420 ft. (USGS datum). However, access to the deeper areas of Lake Almanor is restricted by the shallow approach channel that has a base elevation of 4,432 ft (USGS datum). As a result, the water withdrawn by the Prattville Intake is primarily from the warmer layers in the lake.

~~1.1.1.2~~3.1.1.2 Butt Valley Reservoir and tributaries

The main source of inflow to Butt Valley Reservoir is the discharge from Butt Valley Powerhouse (NF-71), which draws water from Lake Almanor through the Prattville Intake. During the June-September 2002 monitoring period, mean daily flows in Butt Valley Powerhouse averaged 820 cfs and ranged from 0 to 1,615 cfs. Figure 3-3 compares daily average flow through Butt Valley Powerhouse with those from the other powerhouses associated with the Upper NFFR Project.

Butt Creek is the only significant natural tributary entering Butt Valley Reservoir. During the June-September 2002 monitoring period, mean daily flows in Butt Creek (NF-4) ranged from 40.9 to 71.8 cfs, with an average flow of 46.6 cfs.

On an annual basis, the Butt Valley Reservoir water surface elevations fluctuate by about 10 to 15 feet from the maximum water surface elevation of 4,142 ft. (USGS datum). Under normal operating conditions, daily changes in elevation are typically less than 1 foot. The retention time for water traveling through the reservoir is 14 to 32 days depending on operating conditions. Figure 3-4 presents average daily storage for Butt Valley Reservoir for the June through September 20002 monitoring period.

The primary outflow from the Butt Valley Reservoir is through the intakes for Caribou No. 1 and No. 2 powerhouses. The Caribou No. 1 Intake has a capacity of about 1,100 cfs and is located in the deepest area of Butt Valley Reservoir near the dam. The Caribou No. 1 Intake tunnel invert elevation is at 4,077 ft. (USGS datum). The actual Caribou No. 1 Intake structure is located in a small depression zone. Recent bathymetric surveys (April 1996), indicated that the main approach channel has an elevation of 4,095 ft. (USGS datum). Caribou No. 2 Intake has a larger capacity (1,460 cfs), and is located in a shallow channel with an entrance elevation (channel invert) of 4,110 ft. (USGS datum). Because of the higher invert elevation, the Caribou No. 2 Intake withdraws warmer surface water from the reservoir.

No controlled minimum release is made from Butt Valley Dam to the Butt Creek channel downstream of the reservoir. The reservoir rarely spills due to the large combined outflow capability of Caribou No. 1 and No. 2 powerhouses (2,560 cfs). The Licensee has monitored leakage flows in Butt Creek below Butt Valley Dam since 1997 to ensure that leakage flows were not reduced after seismic restoration work on the dam was completed in 1997. The average annual leakage flow is about 0.07 cfs (32 gallons per minute [GPM]). Flow conditions in Butt Creek below Butt Valley Dam will be discussed in the following Section.

~~1.1.1.3~~3.1.1.3 Seneca Reach of the NFFR and tributaries

The Seneca bypass reach (Seneca Reach) consists of a 10.8-mile section of the NFFR extending from Canyon Dam to Caribou No.1 Powerhouse. A seasonally constant minimum of 35 cfs is released from Canyon Dam to the NFFR in accordance with Article 26 of FERC License 2105. Flows are measured by the Licensee in cooperation with the USGS at a permanent gaging station (NF-2) located approximately 0.5 mile downstream of the release structure. During the June-September 2002 monitoring period, mean daily flows in NFFR below Canyon Dam (NF-2) ranged from 34.7 to 36.9 cfs, and averaged 35.9 cfs.

Butt Creek enters the NFFR approximately 1.25 miles upstream of Belden Forebay. Butt Creek is the largest of the NFFR tributaries in the Seneca Reach. There are no minimum flow requirements for Butt Creek below Butt Valley Reservoir. Flows in Butt Creek downstream of Butt Valley Dam consist primarily of spring flow accretion, supplemented with leakage from the Butt Valley Dam, and tributary inflow from Benner Creek. During the June-September 2002 monitoring period, mean daily flows in Butt Creek near its confluence with the NFFR (BC3) ranged from 13.7 to 14.6 cfs, with an average flow of 14.1 cfs.

The monitoring station located on the NFFR above Caribou Powerhouse (NF4) is also the site of a discontinued permanent gage (NF-47). This station captures the total flow entering Belden Forebay from the Seneca Reach. During the June-September 2002 monitoring period, mean daily flows in NFFR above Caribou Powerhouse from 71.2 to 83.2 cfs, and averaged 75.7 cfs.

The total mean daily tributary and lateral accretion flows were calculated for the entire Seneca Reach. For the June through September 2002 period tributary flows ranged from 36.0 to 46.7 cfs, and averaged 39.8 cfs. The measured range of accretion (36.0 to 46.7 cfs) constitutes a 103 to 133 percent dilution effect under the existing 35 cfs in-stream release from Canyon Dam.

~~1.1.1.4~~3.1.1.4 Belden Forebay and Caribou Powerhouse complex

Belden Reservoir is located on the NFFR approximately 10.8 miles downstream of Canyon Dam. Belden Forebay forms the afterbay for the Caribou Powerhouses, and is the forebay for Belden Powerhouse. The forebay was created by a rock-filled dam in 1958 and has a maximum water surface elevation of 2,985 ft. (USGS datum) and a usable storage capacity of 2,477 acre-ft. Under normal operation, the water surface elevation fluctuates between 2,960 ft. and 2,973 ft. depending on power operations. Lake Almanor and Butt Valley Reservoir control the majority of upstream run-off; as a result, spill events at Belden Dam are rare. Belden Forebay has no storage capability and therefore the operation of the Caribou Powerhouses is closely coordinated with the operation of

Belden Powerhouse as well as Licensee's other downstream powerhouses. The average residence time in Belden Reservoir is estimated at approximately 0.5 to 1.0 days.

The majority of flow entering Belden Forebay originates from Butt Valley Reservoir and is discharged through the Caribou No. 1 and No. 2 powerhouses. These powerhouses have average annual flow rates of 615 and 674 cfs, respectively (Pacific Gas and Electric Company 1999). Additional inflow is received from the Seneca Reach of the NFFR; the average annual inflow from this source is approximately 120 cfs. Caribou No. 1 was completed in 1921 and Caribou No. 2 was completed in 1958. Depending on water availability and power requirements, one or both powerhouses may be used. The generating units at Caribou No. 2 are more efficient than those at Caribou No. 1, and their operation is favored.

During the June-September 2002 monitoring period, mean daily flows at Caribou No.1 Powerhouse (NF-63) ranged from 0 to 744 cfs, and averaged 331 cfs. Flow through the Caribou No. 2 Powerhouse (NF-263) during 2002 ranged from 0 to 1,070 cfs, and averaged 493 cfs. Figure 3-3 compares daily average flow through the Caribou No.1 and No.2 powerhouses with those from the other powerhouses associated with the Upper NFFR Project.

The primary outflow from Belden Forebay is through an intake structure located on the left bank (looking downstream) near Belden Dam. This intake provides flows of up to

2,610 cfs to Belden Powerhouse, which is located on Yellow Creek immediately upstream of the confluence of Yellow Creek with the NFFR. Water released from Belden Powerhouse enters the NFFR at its confluence with Yellow Creek; this flow enters the Licensee's Rock Creek Reservoir immediately downstream. During the June-September 2002 monitoring period, mean daily flow at Belden Powerhouse (NF-74) ranged from 0 to 1,513 cfs, and averaged 687 cfs. Figure 3-3 compares daily average flow through Belden Powerhouse with those from the other powerhouses associated with the Upper NFFR Project.

~~1.1.1.5~~3.1.1.5 Belden Reach of the NFFR and tributaries

The Belden bypass reach (Belden Reach) is a 9.3-mile section of the NFFR extending from Belden Dam to the confluence of the NFFR and Yellow Creek. Prior to July 1985, releases from Belden Forebay to the NFFR immediately downstream of the Belden Dam were made from a low-level release in the dam or its upper spillway gates. Oak Flat Powerhouse was completed in 1985 and operates on the instream flow release made at the base of Belden Forebay Dam. To accommodate the two flow rates the turbine has a high flow and a low flow runner. These runners are changed in the spring and fall. This change-out takes a few days and during this time the instream flow is met by releasing water through the pressure release valve at the end of the outlet pipe so that a continuous release is maintained. During the June-September 2002 monitoring period, mean daily flows through Oak Flat Powerhouse (NF-103) ranged from 0 to 116 cfs, and averaged 83 cfs.

Under the terms of FERC License 2105 and the California Department of Fish and Game (CDFG) agreement, the Licensee releases a minimum of 140 cfs from the last Saturday in April to Labor Day and 60 cfs during the rest of the year to the NFFR downstream of Belden Dam for the maintenance of fish life in the Belden Reach of the NFFR. The instream flow releases from Belden Dam are measured at a compliance stream gage located approximately 0.5 mile downstream of the Belden Dam-Oak Flat Powerhouse complex. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Belden Dam (NF-70) ranged from 62.1 to 145 cfs, and averaged 125 cfs.

Mosquito Creek is the largest tributary to the NFFR between Belden Forebay and the NFFR confluence with the East Branch NFFR (EBNFFR). Flows in Mosquito Creek typically range from 2 to 10 cfs during the period June through September (Pacific Gas and Electric Company 1987). Flows in Mosquito Creek were estimated based on periodic flow measurements and regression comparison to monitored flows in Yellow Creek. Based on this estimation, mean daily flows during the June-September 2002 monitoring period ranged from 4.0 to 7.5 cfs, and averaged 4.8 cfs.

The EBNFFR is a large unregulated tributary of the NFFR with an average annual flow of 1,031 cfs (Pacific Gas and Electric Company 1999). The EBNFFR and the NFFR merge approximately 1.75 miles upstream of the confluence with Yellow Creek. Winter and spring flows in the EBNFFR are sufficient under most conditions to allow the Licensee to operate the Upper NFFR Project such that water is stored in Lake Almanor until required by the downstream production facilities. During the June-September 2002 monitoring period, mean daily flows in EBNFFR ranged from 45.0 to 334 cfs, with an average of 93.7 cfs.

Yellow Creek is one of the larger tributary streams contributing to the NFFR downstream of the confluence with the EBNFFR. Typical flows in Yellow Creek range from 40 to 170 cfs during the June through September period (Pacific Gas and Electric Company 1986a, 1987). Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Flow during June through September 2002 ranged from 48.8 to 117 cfs, averaging 60.5 cfs.

~~1.1.1.6~~3.1.1.6 Rock Creek Reach of the NFFR and tributaries

Rock Creek Reservoir is located on the NFFR approximately 3.0 miles downstream of Belden Powerhouse. Rock Creek Reservoir forms the afterbay for Belden Powerhouse, and is the forebay for Rock Creek Powerhouse. The forebay was created by a concrete dam in 1950 and has a maximum water surface elevation of 2,216.2 ft. (USGS datum). Rock Creek Reservoir's original operating capacity of 4,400 acre-feet at 2,216.2 ft. has been significantly reduced (greater than 50%) by sediment accumulation.

Chips Creek is a major tributary of the NFFR, discharging directly into Rock Creek Reservoir. Flows in Chips Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 12.4 to 107 cfs, and averaged 29.7 cfs.

The Rock Creek bypass reach (Rock Creek Reach) is an 8.4-mile section of the NFFR extending from Rock Creek Dam to the tailrace of Rock Creek Powerhouse. Under the terms of the FERC License (Dated October 24, 2001), the Licensee released a minimum of 220 cfs in June, and 180 cfs from July through November in 2002. A more detailed discussion of the minimum release requirements is contained in Appendix A of the FERC License.

The instream flow releases from Rock Creek Dam to the Rock Creek Reach of the NFFR are measured at a permanent stream gage located approximately 1.5 miles downstream of the dam. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Rock Creek Dam (NF-57) ranged from 150 to 1,133 cfs, and averaged 230 cfs.

Milk Ranch Creek is one of several tributaries to the Rock Creek Reach of the NFFR. Flows in Milk Ranch Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 3.2 to 9.8 cfs, and averaged 5.0 cfs.

Chambers Creek is another of the streams tributary to the Rock Creek Reach of the NFFR. Flows in Chambers Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 2.5 to 46.9 cfs, and averaged 9.6 cfs.

Flows in Bucks Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flow in Bucks Creek originates from Lower Bucks Reservoir. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 10.2 to 24.1 cfs, and averaged 15.5 cfs.

The source of flow to Bucks Powerhouse is Grizzly Forebay, which receives diversion flow from Bucks Lake and Lower Bucks Lake. Bucks Powerhouse has a maximum capacity of 340 cfs; flows are released to the NFFR immediately upstream of Rock Creek Powerhouse. During the June-September 2002 monitoring period, mean daily flow at Bucks Powerhouse ranged from 0 to 237 cfs, and averaged 97 cfs (Figure 3-5).

The primary outflow from Rock Creek Reservoir is through an intake structure located on the right bank (looking downstream) near Rock Creek Dam. This intake provides flows of up to 3,560 cfs to Rock Creek Powerhouse, which is located on the NFFR upstream Cresta Reservoir. During the June-September 2002 monitoring period, mean daily flow at Rock Creek Powerhouse ranged from 97 to 1,744 cfs, and averaged 949 cfs. Figure 3-5 compares daily average flow through Rock Creek Powerhouse with those from the other powerhouses associated with the Rock Creek-Cresta Project.

Rock Creek is the last major tributary stream to the Rock Creek section of the NFFR; flows enter the NFFR at the upper end of Cresta Reservoir. Flows in Rock Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 1.7 to 44.5 cfs, and averaged 7.9 cfs.

~~1.1.1.7~~3.1.1.7 Cresta Reach of the NFFR and tributaries

Cresta Reservoir is located on the NFFR immediately downstream of Rock Creek Powerhouse, and acts as the afterbay for this facility. Cresta Reservoir forms the afterbay for Rock Creek Powerhouse, and is the forebay for Cresta Powerhouse. The forebay was created by a concrete dam in 1949 and has a maximum water surface elevation of 1,681.20 ft (USGS datum). The original capacity of 4,410 acre-feet has been significantly reduced by accumulated sediments.

Rock Creek flows enter the NFFR at the upper end of Cresta Reservoir. Flows in Rock Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 1.7 to 44.5 cfs, and averaged 7.9 cfs.

The Cresta bypass reach (Cresta Reach) is a 4.9-mile section of the NFFR extending from Cresta Dam to the tailrace of Cresta Powerhouse. Under the terms of the FERC License (Dated October 24, 2001), the Licensee released a minimum of 240 cfs in June, and 220 cfs from July through November 2002. A more detailed discussion of the minimum release requirements is contained in Appendix A of the FERC License.

Flows in Grizzly Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 12.9 to 38.8 cfs, and averaged 22.4 cfs.

The instream flow releases from Cresta Dam to the Cresta Reach of the NFFR are measured at a permanent stream gage located approximately 2.8 miles downstream of the dam, and 2.4 miles downstream of Grizzly Creek. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Rock Creek Dam (NF-56) ranged from 235 to 1,109 cfs, and averaged 277 cfs.

The primary outflow from Cresta Reservoir is through an intake structure located on the left bank (looking downstream) near Cresta Dam. This intake provides flows of up to 3,700 cfs to Cresta Powerhouse, which is located on the NFFR upstream Poe Reservoir. During the June-September 2002 monitoring period, mean daily flow at Cresta

Powerhouse ranged from 12 to 1,898 cfs, and averaged 1,053 cfs. Figure 3-5 compares daily average flow through Cresta Powerhouse with those from the other powerhouses associated with the Rock Creek-Cresta Project.

~~1.1.2~~3.1.2 Meteorology

3.1.2.1 2002 Regional Precipitation

Mean annual precipitation in the upper NFFR watersheds ranges from a low of 20 inches (in eastern portions of the EBNFFR watershed), to a high of 90 inches in the northwestern part of the watershed near Mount Lassen (California Data Exchange Center [CDEC] 2001). Most of the precipitation in the basin occurs from October through May, with maximum storm intensities occurring December through March. Winter precipitation at higher elevations usually occurs as snow, although warm winter storms can produce rain up to the 10,000-ft level. The typical April 1 snow accumulations range from 2 inches of water at an elevation of 5,800 ft, to 32 inches of water at 6,700 ft. (CDEC 2001). Larger snow accumulations occur on Mount Lassen, with an average April 1 snow-water-equivalent of 78 inches. The mean annual precipitation within the Project area ranges from about 30 to 40 inches (CDEC 2002). Table 3-2 summarizes precipitation data from the available stations in the Project vicinity.

Table 3-2

Summary of Precipitation Data from Meteorological Stations in the Upper NFFR Project Vicinity.

		Water Year* (inches)												Annual
Station	**YEAR**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Total**
Chester	2002	1.94	4.43	2.45	1.4	2.17	3.15	2.02	1.67	0	0	0	0	19.23
4,525 ft.	% of Normal	97%	119%	47%	23%	41%	78%	93%	114%	0%	0%	0%	0%	60%
	Average	2.01	3.73	5.24	6.00	5.24	4.02	2.18	1.46	0.93	0.23	0.28	0.60	31.92
Canyon Dam	2002	1.1	5.19	8.2	3.84	2.6	3.54	1.25	1.14	0.02	0	0	0	26.88
4,560 ft.	% of Normal	48%	117%	126%	51%	41%	69%	45%	69%	3%	0%	0%	0%	70%
	Average	2.28	4.44	6.49	7.58	6.30	5.11	2.76	1.65	0.78	0.18	0.29	0.58	38.44
Greenville	2002	1.41	8.28	10.87	3.92	2.39	4.44	1.52	0.98	0	0	0	0	33.81
RS	% of Normal	55%	155%	174%	54%	38%	83%	57%	63%	0%	0%	0%	0%	86%
3,570 ft.	Average	2.55	5.35	6.26	7.22	6.26	5.35	2.68	1.55	0.78	0.26	0.36	0.78	39.40
Caribou PH	2002	1.18	6.53	7.39	5.23	2.51	3.88	1.84	0.95	0.12	0.1	0	0	29.73
2,986 ft.	% of Normal	50%	141%	107%	65%	36%	71%	60%	56%	15%	91%	0%	0%	73%
	Average	2.34	4.62	6.92	7.99	6.88	5.50	3.06	1.71	0.79	0.11	0.20	0.55	40.67

* Water year is period October 1 through September 31

Table 3-2 Continued.

Snow Survey Data from the Greater NFFR Watershed Area

Station	Elevation (ft. USGS)	2002 April 1 Water Equivalents (inches)	Average April 1 Water Equivalents (inches)
Lower Lassen Peak	8,250	79.1	79.8
Mount Dyer 1	7,100	26.6	25.3
Mount Dyer 2	6,050	17.8	16.1
Harkness Flat	6,200	29.8	28.5
Mount Stover	5,600	12.7	16.0
Feather River Meadows	5,400	24.9	22.6
Warner Creek	5,100	17.9	14.9
Humbug Summit 2	4,850	13.4	16.1
Chester Flat	4,600	3.6	6.5

The data from the four stations presented in Table 3-2 broadly define conditions in the upstream watersheds and immediate Project area. Total precipitation during the 2002 water year (October 2001 to September 2002) averaged 72 % of normal (4 stations).

~~1.1.1.2~~3.1.2.2 2002 Monitoring at Prattville Intake and Rock Creek Dam

Two temporary meteorological stations were installed in the Project vicinity during the 2002 monitoring period. One station was located at the Prattville Intake on Lake Almanor; another station was located on Rock Creek Dam. Data from these stations were used as input to the SNTEMP model for calibration and validation. The data collected at these meteorological stations in 2002 are summarized in Table 3-3.

Table 3-3

Summary of 2002 Meteorological Data from Project Area

Prattville Intake Station

				Daily Average [1]			Data
Station	**Units**	**Year**	**Month**	**Max**	**Min**	**Mean**	**Days**
Air Temperature	(°C)	2002	June	20.0	9.5	16.6	30
		2002	July	25.0	18.1	20.6	31
		2002	Aug	23.4	13.3	18.6	31
		2002	Sept	20.1	9.3	15.3	30
Relative Humidity	(%)	2002	June	66	37	49	30
		2002	July	70	29	45	31
		2002	Aug	53	27	41	31
		2002	Sept	73	31	43	30
Solar Radiation	(watts/S)	2002	June	337	211	305	30
		2002	July	326	163	286	31
		2002	Aug	287	181	244	31
		2002	Sept	220	122	184	30
Wind Speed	(mph)	2002	June	4.83	0.94	1.44	30
		2002	July	1.21	0.93	1.10	31
		2002	Aug	2.88	0.99	1.20	31
		2002	Sept	3.46	0.83	1.21	30

Rock Creek Dam Station

				Daily Average [1]			Data
Station	**Units**	**Year**	**Month**	**Max**	**Min**	**Mean**	**Days**
Air Temperature	(°C)	2002	June	25.0	16.5	22.0	30
		2002	July	30.1	23.6	26.0	31
		2002	Aug	29.0	18.7	23.8	31
		2002	Sept	25.9	14.5	20.8	30
Relative Humidity	(%)	2002	June	55	21	38	30
		2002	July	47	23	34	31
		2002	Aug	42	20	31	31
		2002	Sept	62	22	32	30
Solar Radiation	(watts/S)	2002	June	312	238	290	30
		2002	July	302	209	279	31
		2002	Aug	276	223	248	31
		2002	Sept	228	62	193	30
Wind Speed	(mph)	2002	June	3.99	2.34	3.26	30
		2002	July	3.84	2.17	3.01	31
		2002	Aug	3.52	2.40	3.11	31
		2002	Sept	4.31	2.57	3.15	30

1: Base on hourly average data.

~~1.2~~3.2 WATER TEMPERATURE

3.2.1 2002 Monitoring

As discussed in Section 2.2.3, water temperatures were continuously monitored during the summer of 2002. Due to the voluminous nature of this data, the information presented in the following section will summarize the data collected during the monitoring effort. Appendix A presents a summary of hourly average data.

For consistency with the temperature level specified for the Licensee's Rock Creek Cresta Project (FERC 1962) (Pacific Gas and Electric Company 2000b), daily average data are used throughout this document unless otherwise specified. Table 3-4 summarizes the daily average water temperature data collected during the 2002 program.

Table 3-4
Summary of Daily Average Water Temperatures from UNFFR – 2002

			Daily Temperatures [1]			Daily Range [2]			Data
Station	Year	Month	max	min	mean	max	min	mean	Days
NFFR at	2002	June	15.4	9.6	12.7	7.5	3.6	6.6	30
Chester	2002	July	16.8	14.7	15.7	7.6	3.9	6.4	31
(NF1)	2002	Aug	16.1	12.8	14.2	6.7	4.2	5.7	31
	2002	Sept	14.0	9.8	11.5	5.4	2.8	4.4	30
Hamilton	2002	June	12.4	10.1	11.8	5.6	3.6	5.1	30
Branch at	2002	July	12.6	11.5	12.0	5.4	3.7	4.9	31
Road bridge	2002	Aug	12.7	11.0	11.8	7.1	3.9	4.5	31
(HB1)	2002	Sept	11.7	9.3	10.4	4.1	2.0	3.6	30
Hamilton	2002	June	13.4	10.9	12.6	7.9	5.0	7.3	30
Branch	2002	July	14.0	12.4	13.3	8.0	5.3	7.3	21
Powerhouse	2002	Aug	19.1	16.1	17.5	5.2	3.4	4.4	30
(HB2)	2002	Sept	17.0	9.5	14.4	5.1	2.2	3.8	30
Lake Almanor	2002	June	22.5	16.9	19.7	4.1	0.7	1.6	30
at Canyon Dam	2002	July	25.3	21.7	23.6	2.3	0.7	1.3	31
near surface	2002	Aug	25.4	21.8	23.1	1.6	0.5	1.0	31
(LA1-S)	2002	Sept	22.5	18.1	20.0	1.6	0.3	1.0	30
Lake Almanor	2002	June	9.3	8.2	8.9	0.6	0.1	0.2	30
at Canyon Dam	2002	July	10.4	9.3	9.9	0.6	0.2	0.3	31
near bottom	2002	Aug	11.2	10.5	10.8	0.7	0.3	0.4	31
(LA1-B)	2002	Sept	11.4	11.1	11.3	0.4	0.1	0.3	30
NFFR below	2002	June	11.9	10.6	11.3	2.5	0.5	1.0	30
Canyon Dam	2002	July	13.0	11.8	12.5	1.6	0.5	0.8	31
(NF2)	2002	Aug	13.4	12.9	13.3	1.0	0.3	0.6	31
	2002	Sept	14.1	13.3	13.7	1.7	0.5	1.0	30
NFFR at	2002	June	14.7	11.8	13.5	4.6	3.2	4.2	30
Seneca Bridge	2002	July	15.7	14.2	15.0	4.7	3.0	3.9	31
(NF3)	2002	Aug	15.6	13.5	14.5	4.0	2.9	3.3	31
	2002	Sept	14.6	12.2	13.4	3.0	1.4	2.5	30
NFFR above	2002	June	15.6	12.3	14.3	4.3	2.0	3.7	30
Caribou PH	2002	July	16.8	15.0	15.9	4.1	2.0	3.3	31
(NF4)	2002	Aug	16.3	13.9	15.0	3.7	2.3	3.0	31
	2002	Sept	15.0	12.1	13.4	3.0	1.1	2.3	30
Butt Valley	2002	June	16.1	14.8	15.5	8.4	1.4	3.4	4
Powerhouse	2002	July	21.7	17.8	20.2	5.3	1.2	3.1	29
[Corrected]	2002	Aug	21.9	20.4	21.2	3.1	0.3	0.8	31
(BV1)	2002	Sept	21.3	17.9	19.3	1.3	0.3	0.6	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Daily Range [2] max	min	mean	Data Days
Butt Valley Res.	2002	June	22.1	18.3	20.1	2.9	.5	1.2	30
at Caribou Intake	2002	July	24.4	22.1	23.3	2.0	0.6	1.1	31
Near surface	2002	Aug	24.0	21.7	22.7	1.9	0.5	0.9	31
(BV2-S)	2002	Sept	22.2	18.4	20.1	1.6	0.3	0.8	30
Butt Valley Res.	2002	June	11.9	9.4	10.4	0.8	0.2	0.5	30
at Caribou Intake	2002	July	18.5	11.9	15.0	1.6	0.4	0.8	31
Near bottom	2002	Aug	20.8	18.7	20.0	0.7	0.1	0.5	31
(BV2-B)	2002	Sept	20.6	18.2	19.3	0.5	0.1	0.2	30
Butt Creek above	2002	June	15.1	11.6	13.9	7.5	5.1	6.5	30
Butt Valley	2002	July	16.0	13.7	14.7	7.1	4.7	6.0	31
Reservoir	2002	Aug	14.8	11.9	13.1	6.2	4.2	5.4	31
(BC1)	2002	Sept	13.1	9.5	11.1	5.0	2.5	4.1	30
Butt Creek below	2002	June	10.7	10.4	10.6	0.7	0.4	0.6	30
Butt Valley	2002	July	10.8	10.6	10.7	0.6	0.4	0.5	31
Reservoir	2002	Aug	10.8	10.5	10.7	0.7	0.5	0.6	31
(BC2)	2002	Sept	10.7	10.4	10.5	0.6	0.3	0.5	30
Butt Creek at	2002	June	12.1	10.6	11.5	2.6	1.5	2.2	30
Mouth	2002	July	12.8	11.9	12.4	2.3	1.4	2.0	31
(BC3)	2002	Aug	12.9	11.7	12.4	2.4	1.7	1.9	31
	2002	Sept	12.6	11.3	12.0	2.0	0.9	1.6	30
Caribou No. 1	2002	June	13.3	12.3	12.7	1.9	0.1	1.0	5
Powerhouse	2002	July	21.0	16.3	19.3	4.3	0.6	1.3	29
[corrected]	2002	Aug	21.9	21.2	21.4	2.6	0.2	0.9	31
(CARB1)	2002	Sept	21.3	18.2	19.7	0.9	0.3	0.2	30
Caribou No. 2	2002	June	21.5	17.4	19.3	4.1	0.6	1.5	30
Powerhouse	2002	July	24.0	21.9	23.2	2.7	0.6	1.1	28
[corrected]	2002	Aug	23.7	21.5	22.5	1.2	0.3	0.7	31
(CARB2A)	2002	Sept	22.1	18.3	19.9	1.1	0.3	0.6	30
Belden Reservoir	2002	June	21.5	18.1	19.5	1.5	0.3	0.6	30
At Intake	2002	July	22.8	19.3	21.5	1.9	0.2	0.7	31
(BD1)	2002	Aug	22.6	21.4	21.9	0.9	0.3	0.5	31
	2002	Sept	21.7	18.4	19.8	0.6	0.2	0.3	30
NFFR below	2002	June	18.9	15.9	17.4	1.4	0.3	0.6	30
Belden Dam	2002	July	21.1	17.8	19.4	1.3	0.3	0.8	31
(NF5)	2002	Aug	21.2	20.2	20.7	0.7	0.2	0.5	31
	2002	Sept	20.9	16.8	18.8	2.8	0.4	0.5	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	Daily Temperatures [1] min	Daily Temperatures [1] mean	Daily Range [2] max	Daily Range [2] min	Daily Range [2] mean	Data Days
Mosquito Creek	2002	June	14.4	11.4	13.0	2.3	1.4	2.0	30
At mouth	2002	July	15.6	13.8	14.7	2.4	1.4	2.0	31
(MC1)	2002	Aug	15.3	12.9	13.9	2.2	1.5	1.8	31
	2002	Sept	13.7	11.3	12.2	1.7	1.0	1.5	30
NFFR near	2002	June	19.0	15.7	17.1	3.9	2.5	3.4	30
Queen Lily	2002	July	21.1	18.1	19.5	4.2	2.6	3.3	31
Campground	2002	Aug	21.1	19.6	20.3	3.5	2.2	2.8	31
(NF6)	2002	Sept	20.9	19.3	18.0	4.7	2.4	3.5	30
NFFR near	2002	June	19.3	16.2	17.5	5.6	3.6	5.0	30
Gansner Bar	2002	July	21.3	18.5	19.7	6.0	3.5	4.9	31
(NF7)	2002	Aug	21.1	19.1	20.1	5.4	3.4	4.3	31
	2002	Sept	20.5	16.1	17.6	5.5	2.6	4.2	30
East Branch	2002	June	22.3	17.8	20.8	4.6	2.5	3.9	30
NFFR at mouth	2002	July	25.5	22.4	23.8	4.0	1.8	2.9	31
(EB1)	2002	Aug	24.3	19.9	21.8	3.4	1.9	2.5	31
	2002	Sept	21.6	15.9	18.2	2.8	1.1	2.0	30
NFFR at Belden	2002	June	21.2	17.1	19.4	5.2	4.2	4.7	30
Town Bridge	2002	July	22.9	20.4	21.4	5.3	3.5	4.6	31
(NF8)	2002	Aug	22.3	19.5	20.7	5.2	3.9	4.5	31
	2002	Sept	21.0	16.1	18.0	4.4	2.2	3.4	30
Belden	2002	June	18.7	17.7	18.0	1.0	0.4	0.7	7
Powerhouse	2002	July	22.5	19.0	21.2	1.9	0.1	0.6	29
(BD2)	2002	Aug	22.6	21.4	21.8	1.0	0.1	0.4	31
	2002	Sept	21.7	18.3	19.8	0.6	0.2	0.3	30
Yellow Creek	2002	June	17.0	12.3	15.0	3.8	1.9	3.2	30
Near mouth	2002	July	18.6	16.0	17.1	3.5	2.0	2.9	31
(YC1)	2002	Aug	17.7	14.0	15.6	3.1	2.0	2.9	31
	2002	Sept	15.4	11.8	13.1	2.2	0.8	1.7	30
Chips Creek	2002	June	16.2	10.6	13.6	5.4	3.2	4.6	30
Near mouth	2002	July	17.9	15.4	16.8	5.8	3.7	4.9	31
(CHIP)	2002	Aug	17.7	14.5	15.9	5.6	4.0	4.7	31
	2002	Sept	15.9	12.1	13.7	4.8	1.8	4.0	30
NFFR below Rock	---	---	---	---	---	---	---	---	---
Creek Dam	---	---	---	---	---	---	---	---	---
(NF9)	---	---	---	---	---	---	---	---	---
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NFFR at NF-57	2002	June	20.7	20.1	20.3	3.7	1.4	3.0	5
Insitu Recorder	2002	July	22.5	20.0	21.3	2.5	0.6	1.7	31
(NF10)	2002	Aug	22.1	20.5	21.2	2.0	1.1	1.4	31
	2002	Sept	21.2	17.6	19.1	1.4	0.3	1.0	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Daily Range [2] max	min	mean	Data Days
Milk Ranch Creek	2002	June	16.0	10.6	14.0	5.3	3.0	4.7	30
Near mouth	2002	July	17.9	14.8	16.4	5.5	3.2	4.5	31
(MR1)	2002	Aug	17.2	13.3	15.0	4.8	3.1	3.9	31
	2002	Sept	18.1	11.1	12.7	3.5	1.5	2.7	30
Chambers Creek	2002	June	16.5	9.0	13.7	6.3	3.1	5.0	30
Near mouth	2002	July	18.8	14.9	16.9	5.9	3.4	4.9	31
(CHAM)	2002	Aug	18.1	13.9	15.7	5.7	3.5	4.7	31
	2002	Sept	16.3	11.6	13.8	5.1	1.8	4.1	30
NFFR near Tobin	2002	June	20.9	16.0	18.6	5.1	3.0	3.9	30
Blw Granite Crk	2002	July	22.8	20.2	21.5	4.3	2.6	3.5	31
(NF11)	2002	Aug	22.5	19.8	21.0	4.1	2.7	3.2	31
	2002	Sept	21.0	17.3	18.8	3.5	1.5	2.7	30
Jackass Creek	2002	June	16.5	9.6	14.1	6.4	4.2	5.4	30
Near mouth	2002	July	18.9	15.0	17.0	6.1	3.2	4.6	31
(JKC1)	2002	Aug	18.3	13.7	15.9	4.5	2.9	3.7	31
	2002	Sept	16.5	12.2	14.2	3.9	1.4	3.1	30
NFFR abv Bucks	2002	June	21.0	15.9	18.6	5.2	2.7	3.6	30
Creek	2002	July	22.9	20.2	21.6	3.8	2.2	2.9	31
(NF12)	2002	Aug	22.6	19.7	21.0	3.6	2.4	2.8	31
	2002	Sept	21.1	17.2	18.8	3.7	1.3	2.5	30
Bucks Creek	2002	June	18.1	12.4	16.0	7.0	4.1	6.0	30
Near Mouth	2002	July	20.4	16.8	18.6	7.2	3.9	5.7	31
(BUCK1)	2002	Aug	19.3	14.8	16.9	6.2	3.5	4.8	31
	2002	Sept	17.1	12.0	14.0	4.6	1.6	3.5	30
Bucks Creek	2002	June	18.6	13.2	15.6	2.9	0.0	1.4	27
Powerhouse	2002	July	18.9	15.6	16.7	3.6	0.3	1.1	26
(BUCK2)	2002	Aug	15.5	13.5	14.3	4.5	0.3	1.5	21
	2002	Sept.	13.7	12.6	13.0	2.3	0.2	0.6	30
NFFR abv Rock	2002	June	21.0	15.8	18.6	4.6	2.0	3.1	30
Creek Powerhouse	2002	July	22.8	19.4	20.7	4.6	1.9	3.3	31
(NF13)	2002	Aug	21.8	17.6	19.3	5.3	1.9	3.7	31
	2002	Sept	18.1	15.0	16.3	4.5	1.7	2.9	30
Rock Creek	2002	June	20.1	16.1	18.1	1.8	0.2	0.9	30
Powerhouse	2002	July	22.6	19.6	21.3	1.4	0.2	0.8	31
(RC1)	2002	Aug	22.6	21.0	21.7	1.5	0.3	0.9	31
	2002	Sept	21.7	18.4	19.8	1.4	0.4	0.8	31

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Daily Range [2] max	min	mean	Data Days
Rock Creek	2002	June	17.6	11.4	14.8	3.6	1.4	2.3	30
Near mouth	2002	July	19.7	16.5	18.1	2.7	1.47	2.1	31
(RC2)	2002	Aug	19.3	15.6	17.1	2.3	1.3	1.8	31
	2002	Sept	17.1	13.7	14.8	1.9	0.4	1.3	30
NFFR abv Grizzly	2002	June	20.8	16.7	18.4	1.5	0.7	1.1	30
Creek	2002	July	22.2	20.3	21.2	1.6	0.5	1.0	31
(NF14)	2002	Aug	21.9	19.6	20.7	1.6	0.5	1.1	31
	2002	Sept	20.5	17.1	18.5	1.3	0.3	0.8	30
Grizzly Creek	2002	June	18.3	12.7	15.9	4.0	2.7	3.6	30
Near mouth	2002	July	20.8	17.8	19.3	4.4	2.7	3.6	31
(GR1)	2002	Aug	20.5	16.4	18.0	3.8	2.6	3.1	31
	2002	Sept	17.8	13.5	15.0	2.9	0.8	2.1	30
NFFR at NF-56	2002	June	20.9	16.2	18.4	3.2	1.0	2.6	30
blw Grizzly Crk	2002	July	22.1	20.4	21.3	3.2	1.8	2.5	31
(NF15)	2002	Aug	22.0	19.5	20.6	3.1	1.0	2.3	30
	2002	Sept	20.5	16.9	18.4	2.6	0.9	3.1	30
NFFR abv Cresta	2002	June	21.2	16.4	18.7	3.5	2.1	3.1	30
Powerhouse	2002	July	22.6	20.9	21.7	3.7	2.1	2.8	31
(NF16)	2002	Aug	22.4	19.6	20.9	3.1	1.6	2.4	31
	2002	Sept	20.7	17.1	18.5	3.0	1.0	2.1	30
Cresta	2002	June	20.8	16.3	18.5	1.7	0.1	0.7	30
Powerhouse	2002	July	22.5	20.4	21.4	1.3	0.1	0.8	30
(CR1)	2002	Aug	22.5	20.1	21.0	1.8	0.4	1.1	31
	2002	Sept	20.7	17.3	18.7	1.6	0.3	0.6	30
Middle Fork	2002	June	21.1	15.2	18.2	3.3	1.4	2.5	30
Feather River	2002	July	23.3	20.5	21.9	3.7	2.0	3.0	31
At Milsap Bar	2002	Aug	22.9	18.6	20.3	3.0	2.1	2.6	31
(MB1)	2002	Sept	19.9	16.2	17.3	2.6	1.6	2.2	26

1. Daily values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average temperatures. For example, the maximum June temperature represents the maximum daily average measured in June. See Appendix A for a summary of hourly data.

2. Daily range is calculated based on the daily maximum temperature minus the daily minimum temperature. Monthly statistics are based on these daily range values.

~~1.1.1.1~~3.2.1.1 Lake Almanor and Tributaries

Summer water temperatures in the NFFR upstream of Lake Almanor (near Chester) (NF1) were monitored in 2002 by the Licensee. This station was located in the NFFR upstream of the town of Chester and about 1 mile downstream of the Army Corp. of Engineers flood diversion dam. During the 2002 program, daily average temperatures at station NF1a ranged from 9.6 to 16.8°C, and averaged 13.5°C. The diel fluctuation in temperature ranged from 2.8 to 7.6°C, and averaged 5.8°C in 2002.

Under the Rock Creek-Cresta Relicensing Settlement Agreement (Pacific Gas and Electric Company 2000b), a daily average water temperature of 20°C or less is specified as the desired water temperature level. As part of the license, to the extent that can reasonably be controlled the Licensee shall try to maintain conditions at or below this temperature level. For this reason, a comparison to this level was made at applicable locations. At station NF1, daily average temperatures did not exceed 20°C during the 2002 June through September period. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.1°C on July 11, 2002 (Appendix A). Table 3-5 compares daily average temperatures from each station with the 20°C level. Figure 3-6 compares the daily average temperature from the NFFR with other stations tributary to Lake Almanor.

Table 3-5

Summary of daily average temperature comparison with the 20°C level.

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
NFFR at	2002	June	0	30	0%
Chester	2002	July	0	31	0%
(NF1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Hamilton	2002	June	0	30	0%
Branch at	2002	July	0	31	0%
Road bridge	2002	Aug	0	31	0%
(HB1)	2002	Sept	0	30	0%
Hamilton	2002	June	0	30	0%
Branch	2002	July	0	31	0%
Powerhouse	2002	Aug	0	31	0%
(HB2)	2002	Sept	0	30	0%
Lake Almanor	2002	June	13	30	43%
at Canyon Dam	2002	July	31	31	100%
near surface	2002	Aug	31	31	100%
(LA1-S)	2002	Sept	12	30	40%
Lake Almanor	2002	June	0	30	0%
at Canyon Dam	2002	July	0	31	0%
near bottom	2002	Aug	0	31	0%
(LA1-B)	2002	Sept	0	30	0%
NFFR below	2002	June	0	30	0%
Canyon Dam	2002	July	0	31	0%
(NF2)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR at	2002	June	0	30	0%
Seneca Bridge	2002	July	0	31	0%
(NF3)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR above	2002	June	0	30	0%
Caribou PH	2002	July	0	31	0%
(NF4)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Butt Valley	2002	June	0	4	0%
Powerhouse	2002	July	20	29	69%
[Corrected]	2002	Aug	31	31	100%
(BV1)	2002	Sept	5	30	17%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Butt Valley Res.	2002	June	16		53%
at Caribou Intake	2002	July	31		100%
Near surface	2002	Aug	31		100%
(BV2-S)	2002	Sept	14		47%
Butt Valley Res.	2002	June	0		0%
at Caribou Intake	2002	July	0		0%
Near bottom	2002	Aug	15		48%
(BV2-B)	2002	Sept	8		27%
Butt Creek above	2002	June	0	30	0%
Butt Valley	2002	July	0	31	0%
Reservoir	2002	Aug	0	31	0%
(BC1)	2002	Sept	0	30	0%
Butt Creek below	2002	June	0	30	0%
Butt Valley	2002	July	0	31	0%
Reservoir	2002	Aug	0	31	0%
(BC2)	2002	Sept	0	30	0%
Butt Creek at	2002	June	0	30	0%
Mouth	2002	July	0	31	0%
(BC3)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Caribou No. 1	2002	June	0	5	0%
Powerhouse	2002	July	10	29	34%
[corrected]	2002	Aug	31	31	100%
(CARB1)	2002	Sept	8	31	27%
Caribou No. 2	2002	June	8	30	27%
Powerhouse	2002	July	28	28	100%
[corrected]	2002	Aug	31	31	100%
(CARB2A)	2002	Sept	13	30	43%
Belden Reservoir	2002	June	89	30	30%
At Intake	2002	July	28	31	90%
(BD1)	2002	Aug	31	31	100%
	2002	Sept	12	30	40%
NFFR below	2002	June	0	30	0%
Belden Dam	2002	July	7	31	23%
(NF5)	2002	Aug	31	31	100%
	2002	Sept	6	30	20%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Mosquito Creek	2002	June	0	30	0%
At mouth	2002	July	0	31	0%
(MC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR near	2002	June	0	30	0%
Queen Lily	2002	July	7	31	23%
Campground	2002	Aug	23	31	74%
(NF6)	2002	Sept	2	30	7%
NFFR near	2002	June	0	30	0%
Gansner Bar	2002	July	13	31	42%
(NF7)	2002	Aug	18	31	58%
	2002	Sept	2	30	7%
East Branch	2002	June	21	30	70%
NFFR at mouth	2002	July	31	31	100%
(EB1)	2002	Aug	29	31	94%
	2002	Sept	4	30	13%
NFFR at Belden	2002	June	8	30	27%
Town Bridge	2002	July	31	31	100%
(NF8)	2002	Aug	23	31	74%
	2002	Sept	3	30	10%
Belden	2002	June	0	7	0%
Powerhouse	2002	July	25	29	86%
(BD2)	2002	Aug	31	31	100%
	2002	Sept			
Yellow Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(YC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Chips Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(Chip1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR at NF-57	2002	June	5	5	100%
Below Rock Crk	2002	July	29	31	94%
Dam (NF10)	2002	Aug	31	31	100%
	2002	Sept	5	30	17%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Milk Ranch Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(MR1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Chambers Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(Cham1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR near Tobin	2002	June	6	30	20%
Blw Granite Crk	2002	July	31	31	100%
(NF11)	2002	Aug	29	31	94%
	2002	Sept	4	30	13%
Jackass Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(JC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR abv Bucks	2002	June	6	30	20%
Creek	2002	July	31	31	100%
(NF12)	2002	Aug	28	31	90%
	2002	Sept	4	30	13%
Bucks Creek	2002	June	0	30	0%
Near Mouth	2002	July	2	31	6%
(BC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Bucks Creek	2002	June	0	27	0%
Powerhouse	2002	July	0	26	0%
(BC2)	2002	Aug	0	21	0%
	2002	Sept	0	30	0%
NFFR abv Rock	2002	June	6	30	20%
Creek Powerhouse	2002	July	26	31	84%
(NF13)	2002	Aug	10	31	32%
	2002	Sept	0	30	0%
Rock Creek	2002	June	1	30	3%
Powerhouse	2002	July	29	31	94%
(RC1)	2002	Aug	31	31	100%
	2002	Sept	11	30	37%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Rock Creek Near mouth (RC2)	2002	June	0	30	0%
	2002	July	0	31	0%
	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR abv Grizzly Creek (NF14)	2002	June	4	30	13%
	2002	July	31	31	100%
	2002	Aug	27	31	87%
	2002	Sept	4	30	13%
Grizzly Creek Near mouth (GC1)	2002	June	0	30	0%
	2002	July	8	31	26%
	2002	Aug	3	31	10%
	2002	Sept	0	30	0%
NFFR at NF-56 blw Grizzly Crk (NF15)	2002	June	5	30	17%
	2002	July	31	31	100%
	2002	Aug	26	30	84%
	2002	Sept	4	30	13%
NFFR abv Cresta Powerhouse (NF16)	2002	June	6	30	20%
	2002	July	31	31	100%
	2002	Aug	28	31	90%
	2002	Sept	4	30	13%
Cresta Powerhouse (Cresta1)	2002	June	5	30	17%
	2002	July	30	30	100%
	2002	Aug	31	31	100%
	2002	Sept	5	30	17%
Middle Fork Feather River At Milsap Bar (MB1)	2002	June	6	30	20%
	2002	July	31	31	100%
	2002	Aug	16	31	52%
	2002	Sept	0	26	0%

Water temperatures in the Hamilton Branch of the NFFR (Hamilton Branch) are primarily a function of conditions in Mountain Meadows Reservoir and the significant accretion that occurs along its entire length. Temperatures in the Hamilton Branch tend to be less variable and slightly cooler than those measured in the NFFR upstream of Lake Almanor (NF1). The Hamilton Branch station (HB1) was located in the river below the Peninsula Road Bridge; this station was positioned to be upstream of any backwater effect associated with Lake Almanor. During the 2002 program, daily average temperatures at station HB1 ranged from 9.3 to 12.7°C, and averaged 11.5°C. The diel fluctuation in temperature ranged from 2.0 to 7.1°C, and averaged 4.5°C in 2002. Figure 3-6 compares the daily average temperature from HB1 with other stations tributary to Lake Almanor. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 17.1°C on August 1, 2002 (Appendix A). At station HB1, daily average temperatures did not exceed 20°C during the June-September 2002 period (Table 3-5).

Water temperatures associated with flow through Hamilton Branch Powerhouse are a function of conditions in Mountain Meadows Reservoir. The Hamilton Branch Powerhouse station (HB2) was located in the diversion canal immediately upstream of the head-works control structure. The powerhouse discharges directly into Lake Almanor from an elevated tailrace. During the 2002 program, daily average temperatures at station HB2 ranged from 9.5 to 19.1°C, and averaged 14.5°C. The diel fluctuation in temperature ranged from 2.2 to 8.0°C, and averaged 5.7°C in 2002. Figure 3-6 compares the daily average temperature from HB2 with other stations tributary to Lake Almanor.

The higher temperature values observed in the late part of the summer (August-September) were associated with higher instream releases from Mountain Meadows Reservoir. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.6°C on August 2, 2002 (Appendix A). Daily average temperatures did not exceed 20°C during the June-September 2002 period.

As discussed earlier, Lake Almanor is the primary storage reservoir on the NFFR. Lake Almanor has a very large surface area with relatively moderate depths. Resource monitoring indicates that near the Canyon Dam and Prattville intakes, Lake Almanor undergoes thermal stratification (CDFG 1988; DWR 1999; Pacific Gas and Electric Company 1982, 1984, 1986a, 1987, 2002). Thermal gradients typically begin to develop relatively early in Lake Almanor (April-May). During June, the development of temperature stratification is well underway. By July, a fully developed thermal structure is present, including a well-developed epilimnion, thermocline, and hypolimnion. The stratification is persistent throughout the summer, with the epilimnion growing downward throughout the period and with turnover usually occurring in during the period between late September and October.

The general pattern of temperature stratification near the Canyon Dam Intake was continuously measured by a submerged array of digital recorders deployed in 2002. The temperature recorders were set up on a cable attached to a buoy. As a result, the top sensor remained approximately 0.5 meters below the surface, while the bottom sensor was typically 0 to 2 meters off of the bottom depending on lake elevation. Data from 2002 indicated that mean daily temperatures at the lake surface (epilimnion) ranged from 16.9 to 25.4°C during the June through September period. Mean daily temperatures near the bottom (hypolimnion) ranged from 8.2 to 11.4°C during the same period. Figure 3-7 compares mean daily temperatures from the epilimnion and hypolimnion for 2002.

Summer temperature profiles in Lake Almanor show that a warm upper layer (epilimnion) extends to a depth of about 9 meters and that a colder bottom layer (hypolimnion) typically exists below a depth of 12 meters. The seasonal characteristics of the Lake Almanor thermocline were defined using monthly vertical profiles. Figure 3-8 compares monthly profiles from Lake Almanor near the Canyon Dam Intake (LA-P1) for the period June through September 2002.

Vertical temperature profiles were measured at four locations, covering the main body and two longitudinal axes of Lake Almanor. Figure 3-9 compares monthly profiles from each of the four profile stations. This figure illustrates the longitudinal thermal structure present in Lake Almanor in 2002. As illustrated by these figures, temperature profiles indicate that colder water is present only in stations located in the deeper portions of the lake, particularly near Canyon Dam (Pacific Gas and Electric Company 2002).

~~1.1.1.2~~3.2.1.2 Butt Valley Reservoir and tributaries

Butt Valley Reservoir is a long, narrow water body of moderate depth. The deepest areas of the reservoir occur near the dam. Water temperature in Butt Valley Reservoir is essentially driven by conditions in Lake Almanor and the physical configuration of the Prattville Intake. The operations of Butt Valley Powerhouse and the Caribou No. 1 and No. 2 powerhouses are the primary controlling influences on the water resources leaving Butt Valley Reservoir. Under typical conditions, only a limited volume of cold water is available in Butt Valley Reservoir during the summer. Contributions from Butt Creek are seasonally variable, but typically remain a relatively small portion of the total inflow to the reservoir. The thermal structure of Butt Valley Reservoir is driven largely by the physical configuration of the reservoir and the location and operation of the two Caribou intakes.

Although perennial flow is present in Butt Creek upstream of Butt Valley Reservoir, the primary source of flow into the reservoir is through Butt Valley Powerhouse. Temperatures in the tailrace are representative of temperatures withdrawn from the Prattville Intake in Lake Almanor (Pacific Gas and Electric Company 1986a). The Butt Valley Powerhouse station (BV1) was located in the tailrace estuary downstream of the powerhouse. The tailrace discharges directly into the original Butt Creek channel, however, depending on lake elevation this area can exhibit flow characteristics ranging from riverine to lakersturne. During the 2002 program, daily average temperatures at station BV1 ranged from 14.8 to 21.9°C, and averaged 19.1°C. The diel fluctuation in temperature ranged from 0.3 to 8.4°C, and averaged 2.2°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.6°C on August 1, 2002 (Appendix A). The daily average temperatures at station BV1 exceeded 20°C on 56 of 94 operational days (60%) during the 2002 June through September period. Figure 3-10 compares daily average temperatures from BV1 with other station tributary to Butt Valley Reservoir.

Temperatures in Butt Creek (BC1) were monitored upstream of the backwater effect from Butt Valley Reservoir during the 2002 period. During the 2002 program, daily average temperatures at station BC1 ranged from 9.5 to 16.0°C, and averaged 13.2°C. The diel fluctuation in temperature ranged from 2.5 to 7.5°C, and averaged 5.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 18.9°C on July 11, 2002 (Appendix A). The daily average temperatures at station BC1 did not exceed 20°C during the 2002 June through September period (Table 3-5).

A moderately pronounced thermal gradient does develop in Butt Valley Reservoir in the late spring and early summer. However, as a result of the relatively short retention time, and depending on the frequency of usage of the Caribou No. 1 Intake (located in the deeper portion of the lake), the limited cold water volume can be consumed in a few weeks. In general, an identifiable thermocline was present in June and persisted through July. By early August, a well-defined epilimnion was no longer present (Pacific Gas and Electric Company 2002).

The seasonal characteristics of the Butt Valley Reservoir thermocline in 2002 were defined using monthly vertical profiles. Figure 3-11 compares monthly profiles from the Butt Valley Reservoir near Caribou No. 1 Intake (BV-P1) for the period June through September 2002. As indicated by this data Butt Valley Reservoir was essentially isothermal by August 2002.

Vertical temperature profiles were measured at three locations (BV-P1, BV-P2, BV-P3), covering the longitudinal axis of Butt Valley Reservoir. Profiles measured from June through September 2002 indicated little difference in thermal structure along the longitude of the reservoir. Figure 3-12 illustrates the longitudinal thermal structure present in Butt Valley Reservoir in 2002 by comparing monthly temperature profiles from the three profile stations located in the reservoir. As illustrated by these figures the general thermal structure is well established in the upper portion of the reservoir. The data also indicate that the only area with cool water is located near the dam.

The development of temperature stratification near the Caribou No. 1 Intake was measured continuously by a submerged array of digital recorders deployed in 2002. The temperature recorders were set up on a cable attached to a buoy. As a result, the top sensor remained approximately 0.5 meters below the surface, while the bottom sensor was typically 0.5 to 5 meters off of the bottom. Mean daily temperatures recorded in the epilimnion (BV2-S) of Butt Valley Reservoir near the Caribou No. 1 Intake averaged 21.5°C, and ranged from 18.3 to 24.4°C for the period June through September in 2002. Mean daily temperatures from the hypolimnion (BV2-B) ranged from 9.4 to 20.8°C, with an average of 16.2°C during the same period (Table 3-4). Figure 3-13 compares mean daily temperatures from the epilimnion and hypolimnion of Butt Valley Reservoir for 2002. As indicated by the data in this figure, the reservoir became isothermal (less than 2°C difference between top and bottom recorders) by late August.

To further evaluate the withdrawal characteristics of the Caribou No. 2 Intake channel, a series of special profiles were made at two locations near the mouth of the channel. These profiles were taken in July, August, and October. The results of this investigation are presented in Section 3.2.2.2.

~~1.1.1.3~~3.2.1.3 Seneca Reach of NFFR

Water temperature in the NFFR below Canyon Dam is largely determined by the level at which water is released from the lake through the Canyon Dam Intake tower. At present, the Licensee preferentially utilizes the lower gates as the source of fishwater releases. The lower gates in combination with the upper gates the upper gates are used during periods that require high flow releases. During the 2002 monitoring program, the lower gates were used throughout the study period.

Water temperatures in the NFFR downstream of Canyon Dam (NF2) were monitored approximately 0.25 miles downstream of the release structure during the 2002 monitoring effort. This station represents the initial conditions in the Seneca Reach and corresponded with the location of the permanent flow monitoring station (NF-2). During the 2002 program, daily average temperatures at station NF2 ranged from 10.6 to 14.1°C, and averaged 12.7°C. The diel fluctuation in temperature ranged from 0.3 to 2.5 °C, and averaged 0.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 14.8°C on September 29, 2002 (Appendix A). The daily average temperatures at station NF2 did not exceed 20°C during the June through September 2002 (Table 3-5).

Water temperatures in the NFFR at Seneca (NF3) were monitored approximately 60 meters downstream of the Seneca Road Bridge during the 2002 monitoring effort. This station represents conditions present in the middle of the Seneca Reach. During the 2002 program, daily average temperatures at station NF3 ranged from 11.8 to 15.7°C, and averaged 14.1°C. The diel fluctuation in temperature ranged from 1.4 to 4.7°C, and averaged 3.4°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 17.4°C on July 11, 2002 (Appendix A). The daily average temperatures at station NF3 did not exceed 20°C during the June through September 2002 period (Table 3-5).

Water temperatures were monitored in the NFFR approximately 0.5 miles upstream of Caribou Powerhouse (NF4) during the 2002 monitoring effort. This station represents conditions present at the end of the Seneca Reach. During the 2002 program, daily average temperatures at station NF4 ranged from 12.1 to 16.8 °C, and averaged 14.6°C. The diel fluctuation in temperature ranged from 1.1 to 4.3°C, and averaged 3.1°C in

2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 18.4°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF4 did not exceed 20°C during the 2002 June through September period (Table 3-5).

The magnitude of temperature changes occurring in the Seneca Reach depends on several factors including which release gates are used, the magnitude of the release flow, the magnitude of tributary inflows, physical characteristics of the stream channel, and meteorological conditions. To compare the relative change in temperature occurring through the entire bypass reach, the daily average from NF2 was compared with NF4. The daily average temperatures at NF4 (upstream of Caribou Powerhouse) averaged 1.9°C warmer in 2002, than at NF2 (below Canyon Dam) for the June through September period. These values represent the average heating occurring through the entire Seneca Reach and calculate to a 0.2°C per mile increase in temperature for 2002. Figure 3-14 compares the daily average temperatures at the three stations located in the Seneca Reach in 2002.

~~1.1.1.4~~3.2.1.4 Lower Butt Creek

As discussed previously, there is no release from Butt Valley Reservoir to the lower Butt Creek channel. As a result, flows in lower Butt Creek are derived from various sources of tributary and accretion inflows. Water temperature was measured at two locations in Butt Creek downstream of Butt Valley Dam.

The first station in lower Butt Creek was located approximately 0.3 mile below the dam (BC2). This station captured inflow from Benner Creek, leakage flows from Butt Valley Dam, and the spring inflow that arises in the Butt Creek channel downstream of the Benner Creek confluence. During the 2002 program, daily average temperatures at station BC2 ranged from 10.4 to 10.8°C, and averaged 10.6°C. The diel temperature fluctuation ranged from 0.3 to 0.7°C, and averaged 0.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 11.2°C on August 1, 2002 (Appendix A). The daily average temperatures at station BC2 did not exceed 20°C during the June through September period 2002 (Table 3-5).

The second station in lower Butt Creek was located near the mouth (BC3). This station was about 100 meters above the confluence with the NFFR. This station defines the quality of inflow to the NFFR from the largest tributary in the Seneca Reach. During the 2002 program, daily average temperatures at station BC3 ranged from 10.6 to 12.9°C, and averaged 12.1°C. The diel fluctuation in temperature ranged from 0.9 to 2.6°C, and averaged 1.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 14.0°C August 14, 2002 (Appendix A). The daily average temperatures at station BC3 did not exceed 20°C during the June through September period in either 2002 (Table 3-5). Figure 3-15 compares the daily average temperatures from the two stations in lower Butt Creek in 2002.

~~1.1.1.5~~3.2.1.5 Belden Forebay and Caribou Powerhouse complex

Water temperature in Belden Forebay is primarily the result of the combined flows from Caribou No. 1 and No. 2 Powerhouses. Other inflows to Belden Forebay originate from the Seneca Reach of the NFFR. All three-inflow sources enter through the same channel in the upper portion of Belden Forebay.

Water temperatures at Caribou No.1 Powerhouse (CARB1) were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CARB1 ranged from 12.3 to 21.9°C, and averaged 18.3°C. The diel fluctuation in temperature ranged from 0.1 to 4.3°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.2°C on August 17, 2002 (Appendix A). The daily average temperatures at station CARB1 exceeded 20°C on 49 of 95 operational days (52%) during the 2002 June through September period (Table 3-5).

Water temperatures at Caribou No. 2 Powerhouse (CARB2) were monitored direct from the penstock at the main valve house. This location was chosen due to the configuration of the tailrace at this facility, which is submerged by Belden Forebay. Water temperature data were processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CARB2 ranged from 17.4 to 24.0°C, and averaged 21.2°C. The diel fluctuation in temperature ranged from 0.3 to 4.1°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.7°C on July 29, 2002 (Appendix A). The daily average temperatures at station CARB2 exceeded 20°C on 80 of 119 operating days (67%) during the 2002.

Water temperature was monitored in Belden Forebay near the Belden Powerhouse Intake at a fixed depth. During the 2002 program, daily average temperatures at station BD1 ranged from 18.1 to 22.8°C, and averaged 20.7°C. The diel fluctuation in temperature ranged from 0.2 to 1.9°C, and averaged 0.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.0°C on July 29, 2002 (Appendix A). The daily average temperatures at station BD1 exceeded 20°C on 80 of 122 days (66%) during the 2002.

Evaluation of water temperatures measured at BD1 and NF5 from 2000, 2001, 2002 indicate that a thermal gradient exists in Belden Forebay. Due to the short retention time in the forebay, this thermal gradient is likely the result of operational conditions within the system (inflow from both Caribou powerhouses, Belden Powerhouse outflow, and forebay water level fluctuations), and not ambient meteorological conditions. The 2002 data indicates that the difference between BD1 and NF5 temperatures during the June through September period ranged from 0.6 to 3.0°C, and averaged 1.6°C. In all cases, BD1 was warmer than NF5. This data indicates that to some degree cool water and warm water are segregating as flows come into the forebay. This segregation is contined downstream as the cooler water from the forebay is released to the Belden Reach through Oak-flat Powerhouse, and the warmer water is transported to Rock Creek Reservoir via Belden Powerhouse.

As discussed, temperatures at Belden Powerhouse (BD2) are essentially the same as those measured in Belden Forebay at BD1 and primarily reflect the temperature of Butt Valley Reservoir water as released by the Caribou powerhouses, with some minor modification due to mixing and heat exchange in Belden Forebay. Water temperatures at Belden Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station BD2 ranged from 17.7 to 22.6 °C, and averaged 20.2°C. The diel fluctuation in temperature ranged from 0.2 to 1.9°C, and averaged 0.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 29, 2002 (Appendix A). The daily average temperatures at station BD2 exceeded 20°C on 68 of 97 operational days (70%) during the 2002 June through September period. Figure 3-16 compares the daily average temperatures at the four stations associated with the Caribou Powerhouse-Belden Forebay complex in 2002.

~~1.1.1.6~~3.2.1.6 Belden Reach of the NFFR and tributaries

Water temperatures were recorded in the NFFR downstream of Belden Dam (NF5) throughout the 2002 sampling seasons. This station represents initial conditions in the Belden Reach and corresponds with the location of the permanent flow monitoring station (NF-70). During the 2002 program, daily average temperatures at station NF5 ranged from 15.9 to 21.2°C, and averaged 19.1°C. The diel fluctuation in temperature ranged from 0.2 to 2.8°C, and averaged 0.7°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.5°C August 1, 2002 (Appendix A). The daily average temperatures at station NF5 exceeded 20°C on 44 of 122 days (36%) during the 2002 June through September period.

Water temperatures were recorded in Mosquito Creek near its confluence with the NFFR (MC1). Temperatures were comparatively cool with a relatively stable flow regime suggesting a strong groundwater supply during non-runoff periods. Mosquito Creek provides a cooling influence in the Belden Reach. During the 2002 program, daily average temperatures at station MC1 ranged from 11.3 to 15.6°C, and averaged 13.5°C. The diel fluctuation in temperature ranged from 1.0 to 2.4°C, and averaged 1.8°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 16.7°C July 21, 2002 (Appendix A). The daily average temperatures at station MC1 did not exceed 20°C during the 2002 June through September period (Table 3-5).

The station located near the Queen Lily Campground (NF6) represents conditions in the middle section of the Belden Reach and defines conditions downstream of the largest tributary in the reach. During the 2002 program, daily average temperatures at station NF6 ranged from 15.7 to 21.1°C, and averaged 18.7°C. The diel fluctuation in temperature ranged from 2.2 to 4.7°C, and averaged 3.2°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.9°C on August 1, 2002 (Appendix A). The daily average temperatures at station NF6 exceeded 20°C on 32 of 122 days (26%) during the 2002 June through September period.

Station NF7 represents conditions in the NFFR at the end of the upper Belden Reach. This station is also upstream of the confluence with the EBNFFR. During the 2002 program, daily average temperatures at station NF7 ranged from 16.1 to 21.3°C, and averaged 18.8°C. The diel fluctuation in temperature ranged from 2.6 to 6.0°C, and averaged 4.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.0°C July 14, 2002 (Appendix A). The daily average temperatures at station NF7 exceeded 20°C on 33 of 122 days (27%) during the 2002 June through September period.

The total change in daily average temperature in the upper Belden Reach was measured as the difference between the NFFR at the confluence with the EBNFFR (NF7) and below Belden Dam (NF5). The change in temperature between stations NF5 and NF7 was evaluated for the period June-September. The total daily average temperature at NF7 averaged 0.3°C cooler in 2002 than at NF5. These values calculate to a 0.05°C per mile decrease in temperature in the upper Belden Reach. Figure 3-17 compares the daily average temperatures at the four stations located in the upper Belden Reach in 2002.

The temperature station in the NFFR immediately upstream of Yellow Creek (NF8), was located immediately upstream of the Belden Town bridge. This station is approximately 1.75 miles downstream of the confluence of the EBNFFR with the NFFR. Temperatures at this location were warmer than those measured in the NFFR upstream of the EBNFFR (NF7), but cooler than in the EBNFFR. This station represents conditions in the NFFR at the end of the Belden bypass reach. During the 2002 program, daily average temperatures at station NF8 ranged from 16.1 to 22.9°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 2.2 to 5.3°C, and averaged 4.3°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 25.2°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF8 exceeded 20°C on 65 of 122 days (53%) during the 2002 June through September period.

The daily average change in temperature in the NFFR between the NFFR at the confluence with the EBNFFR (NF7) and Belden Town Bridge (NF8) was evaluated for the period June-September. The daily average temperatures at NF8 in 2002 averaged 1.1°C warmer than at NF7. These values calculate to a 0.6 per mile increase in temperature in this section of the NFFR. This increase is attributable to conditions that exist in the EBNFFR.

Temperatures were recorded in the EBNFFR upstream of the confluence with the NFFR (EB1) during the 2002 sampling season. During the 2002 program, daily average temperatures at station EB1 ranged from 15.9 to 25.5°C, and averaged 21.1°C. The diel fluctuation in temperature ranged from 1.1 to 4.6°C, and averaged 2.8°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 26.5°C on July 14, 2002 (Appendix A). This was the highest daily average temperature recorder during the 2002 monitoring program. The daily average temperatures at station EB1 exceeded 20°C on 85 of 122 days (70 %) during the 2002 June through September period.

Temperatures were monitored in Yellow Creek (YC1) 0.5 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions at the mouth of Yellow Creek upstream of the confluence with the NFFR. During the 2002 program, daily average temperatures at station YC1 ranged from 11.8 to 18.6°C, and averaged 15.2°C. The diel fluctuation in temperature ranged from 0.8 to 3.8°C, and averaged 2.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.1°C on July 14, 2002 (Appendix A). The daily average temperatures at station YC1 did not exceed 20°C during the June through September period in 2002 (Table 3-5). Figure 3-18 compares the daily average temperatures from several stations in the lower Belden Reach.

Temperatures were monitored in Chips Creek (CHIP) 0.2 mile upstream of its confluence with the NFFR (Rock Creek Reservoir) during the 2002 sampling season. Chips Creek discharges directly into Rock Creek Reservoir. During the 2002 program, daily average temperatures at station CHIP ranged from 10.6 to 17.9°C, and averaged 15.0°C (Figure 3-20). The diel fluctuation in temperature ranged from 1.8 to 5.8°C, and averaged 4.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.0°C on July 14, 2002 (Appendix A). The daily average temperatures at station CHIP did not exceed 20°C during the June through September period in 2002 (Table 3-5).

~~1.1.1.7~~3.2.1.7 Rock Creek Reach of the NFFR and tributaries

The first temperature station in the NFFR downstream of Rock Creek Dam (NF9) is located immediately below the dam. This station was not installed in 2002; the station located downstream at the NF-57 gage is representative of conditions at this site.

The temperature station in the NFFR downstream of Rock Creek Dam (NF10) was located near the NF-57 gaging station. This station is approximately 1.5 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF10 ranged from 17.6 to 22.5°C, and averaged 20.5°C. The diel fluctuation in temperature ranged from 0.3 to 3.7°C, and averaged 1.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.4°C on July 31, 2002 (Appendix A). The daily average temperatures at station NF10 exceeded 20°C on 70 of 97 days (72%) during the 2002 June through September period. Figure 3-19 compares the 2002 daily average temperatures from NF10 with four other river stations located in the Rock Creek Reach.

A telemetry system was installed at the NF-57 gage station to enable real-time monitoring of temperatures in the Rock Creek Reach. The performance of this station was compared with the *in situ* recorder is presented in Section 3.2.2.4.

Temperatures were monitored in Milk Ranch Creek (MR1) 0.25 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions at the mouth upstream of the influence from the NFFR. During the 2002 program, daily average temperatures at station MR1 ranged from 10.6 to 17.9 °C, and averaged 14.5°C. The diel fluctuation in temperature ranged from 1.5 to 5.5°C, and averaged 4.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.4°C on July 21, 2002 (Appendix A). The daily average temperatures at station MR1 did not exceed 20°C during the June through September period in 2002 (Table 3-5). Figure 3-20 compares 2002 daily average temperatures from MR1 with other stations tributary to the NFFR in the Rock Creek Reach.

Temperatures were monitored in Chambers Creek (CHAM) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions near the mouth upstream of any influence from the NFFR. During the 2002 program, daily average temperatures at station CHAM ranged from 9.0 to 18.8°C, and averaged 15.0°C. The diel fluctuation in temperature ranged from 1.8 to 6.3°C, and averaged 4.7°C in 2002. Figure 3-20 compares 2002 daily average temperatures from CHAM with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.4°C on July 21, 2002 (Appendix A). The daily average temperatures at station CHAM did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The station located on the NFFR below Granite Creek (NF11) represents conditions in the middle section of the Rock Creek Reach and defines conditions downstream of several tributaries. During the 2002 program, daily average temperatures at station NF11 ranged from 16.0 to 22.8°C, and averaged 20.0°C. The diel fluctuation in temperature ranged from 1.5 to 5.1°C, and averaged 3.3°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from NF11 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.3°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF11 exceeded 20°C on 70 of 122 days (57%) during the 2002 June through September period.

Temperatures were monitored in Jackass Creek (JKC1) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions near the mouth upstream of any influence from the NFFR. During the 2002 program, daily average temperatures at station JKC1 ranged from 9.6 to 18.9°C, and averaged 15.3°C. The diel fluctuation in temperature ranged from 1.4 to 6.4°C, and averaged 4.2°C in 2002. Figure 3-20 compares 2002 daily average temperatures from JKC1 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.2°C on July 21, 2002 (Appendix A). The daily average temperatures at station JKC1 did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The NFFR station located upstream of the Bucks Creek confluence (NF12) represents conditions at the end of the Rock Creek Reach and defines conditions prior to inflow from Bucks Creek and Bucks Creek Powerhouse. During the 2002 program, daily average temperatures at station NF12 ranged from 15.9 to 22.9°C, and averaged 20.0°C. Figure 3-19 compares the 2002 daily average temperatures from NF12 with four other river stations located in the Rock Creek Reach. The diel fluctuation in temperature ranged from 1.3 to 5.2°C, and averaged 3.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.0°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF12 exceeded 20°C on 69 of 122 days (57%) during the 2002 June through September period.

Temperatures were monitored in Bucks Creek (BUCK1) 0.10 miles upstream of its confluence with the NFFR during the 2002 sampling season. During the 2002 program, daily average temperatures at station BUCK1 ranged from 12.0 to 20.4°C, and averaged 16.4°C. The diel fluctuation in temperature ranged from 1.6 to 7.2°C, and averaged 5.0°C in 2002. Figure 3-20 compares 2002 daily average temperatures from BUCK1 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.5°C on July 11, 2002 (Appendix A). The daily average temperatures at station BUCK1 exceeded 20°C on 2 days (2%) during the 122 day June through September period in 2002 (Table 3-5).

Temperatures at Bucks Powerhouse (BUCK2) are essentially the same as those present in Lower Bucks Creek Reservoir. Water temperatures at Bucks Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station BUCK2 ranged from 12.6 to 18.9°C, and averaged 14.9°C. The diel fluctuation in temperature ranged from 0.0 to 4.5°C, and averaged 1.2°C in 2002. Figure 3-20 compares 2002 daily average temperatures from BUCK2 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.0°C on July 1, 2002 (Appendix A). The daily average temperatures at station BUCK2 did not exceed 20°C during the 2002 June through September period.

The NFFR station located upstream of Rock Creek Powerhouse (NF13) represents conditions at the end of the Rock Creek Reach and defines conditions prior in receiving diversion flow from Rock Creek Powerhouse. During the 2002 program, daily average temperatures at station NF13 ranged from 15.0 to 22.8°C, and averaged 18.7°C. The diel fluctuation in temperature ranged from 1.7 to 5.3°C, and averaged 3.2°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from NF13 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.1°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF13 exceeded 20°C on 42 of 122 days (34%) during the 2002 June through September period.

The daily average change in temperature in the Rock Creek Reach (NFFR between Rock Creek Dam [NF10] and above Rock Creek Powerhouse [NF13]) was evaluated for the period June 26 through September. The daily average temperature at NF13 averaged 1.7°C cooler in 2002 than NF10. This value calculates to a cooling trend of approximately 0.2°C per mile in this section of the Rock Creek Reach. This change is largely due to the contribution from Bucks Creek and Bucks Creek Powerhouse.

Temperatures at Rock Creek Powerhouse (RC1) are essentially the same as those present in Rock Creek Reservoir. Water temperatures at Rock Creek Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station RC1 ranged from 16.1 to 22.6°C, and averaged 20.2°C. The diel fluctuation in temperature ranged from 0.2 to 1.8°C, and averaged 0.9°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from RC2 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 31, 2002 (Appendix A). The daily average temperatures at station RC1 exceeded 20°C on 72 of 122 operational days (59%) during the 2002 June through September period.

~~1.1.1.8~~3.2.1.8 Cresta Reach of the NFFR and tributaries

Temperatures were monitored in Rock Creek (RC2) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. Rock Creek discharges directly into Cresta Reservoir approximately 0.75 miles downstream of Rock Creek Powerhouse. During the 2002 program, daily average temperatures at station RC2 ranged from 11.4 to

19.7°C, and averaged 16.2°C (Figure 3-22). The diel fluctuation in temperature ranged from 0.4 to 3.6°C, and averaged 1.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.7°C on July 31, 2002 (Appendix A). The daily average temperatures at station RC2 did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The first temperature station in the NFFR downstream of Cresta Dam (NF14) was located upstream of the confluence with Grizzly Creek. This station is approximately 0.4 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF14 ranged from 16.2 to 22.2°C, and averaged 19.7°C. The diel fluctuation in temperature ranged from 0.3 to 1.6°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 15, 2002 (Appendix A). The daily average temperatures at station NF14 exceeded 20°C on 66 of 122 days (54%) during the 2002 June through September period. Figure 3-21 compares the 2002 daily average temperatures at NF14 with three other river stations located in the Cresta Reach.

Temperatures were monitored in Grizzly Creek (GR1) 0.5 mile upstream of its confluence with the NFFR during the 2002 sampling season. During the 2002 program, daily average temperatures at station GR1 ranged from 12.7 to 20.8°C, and averaged 17.1°C. The diel fluctuation in temperature ranged from 0.8 to 4.4°C, and averaged 3.1°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.7°C on July 14, 2002 (Appendix A). The daily average temperatures at station GR1 exceeded 20°C on 11 of 122 days (9%) during the June through September period in 2002 (Table 3-5). Figure 3-22 compares daily average temperatures from GR1 with another station tributary to the NFFR in the Cresta Reach in 2002.

The temperature station in the NFFR downstream of Grizzly Creek (NF15) was located near the NF-56 gaging station. This station is approximately 2.5 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF15 ranged from 16.2 to 22.1°C, and averaged 19.7°C. The diel fluctuation in temperature ranged from 0.9 to 3.2°C, and averaged 2.4°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at NF15 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.5°C on July 15, 2002 (Appendix A). The daily average temperatures at station NF15 exceeded 20°C on 66 of 122 days (54%) during the 2002 June through September period.

A telemetry system was installed at the NF-56 gage station to enable real-time monitoring of temperatures in the Cresta Reach. The performance of this station was compared with the in-situ recorder is presented in Section 3.2.2.4.

The NFFR station located upstream of Cresta Powerhouse (NF16) represents conditions at the end of the Cresta Reach and defines conditions prior in receiving diversion flow from Cresta Powerhouse. During the 2002 program, daily average temperatures at station NF16 ranged from 16.4 to 22.6°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 1.0 to 3.7°C, and averaged 2.6°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at NF16 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.9°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF16 exceeded 20°C on 69 of 122 days (57%) during the 2002 June through September period.

The daily average change in temperature in the Cresta Reach (NFFR between Cresta Dam [NF14] and above Cresta Powerhouse [NF16]) was evaluated for the period June-September. The daily average temperature at NF16 averaged 0.2°C warmer in 2002 than NF14. This value calculates to a warming trend of less than 0.05°C per mile in this section of the Cresta Reach.

Temperatures at Cresta Powerhouse (CR1) are essentially the same as those present in Cresta Reservoir. Water temperatures at Cresta Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CR1 ranged from 16.3 to 22.5°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 0.1 to 1.8°C, and averaged 0.8°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at CR1 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 15, 2002 (Appendix A). The daily average temperatures at station CR1 exceeded 20°C on 71 of 121 operational days (59%) during the 2002 June through September period.

~~1.1.1.9~~3.2.1.9 Middle Fork Feather River

The Licensee collected temperature data in 2002 from a station in the Middle Fork of the Feather River (at Milsap Bar). This data were collected in order to compare temperature conditions in the NFFR with those in the lower portion of the unregulated MFFR. During the 2002 program, daily average temperatures from the Middle Fork of the Feather River at Milsap Bar (MB1) ranged from 15.2 to 23.3°C, and averaged 19.4°C. The diel fluctuation in temperature ranged from 1.4 to 3.7°C, and averaged 2.6°C in 2002. Figure 3-23 compares the 2002 daily average temperatures at MB1 with river stations located in the Rock Creek and Cresta reaches of the NFFR. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 25.3°C on July 14, 2002 (Appendix A). The daily average temperatures at station MB1 exceeded 20°C on 53 of 118 days (45%) during the 2002 June through September period.

As indicated in Figure 3-23, temperatures in the NFFR were similar in value and trend to measured temperatures in the Middle Fork at Milsap Bar through late August. From late August through September NFFR temperatures were similar in value and trend to those observed in the East Branch NFFR. Temperatures in the East Branch NFFR (unregulated) were warmer than those in the Middle Fork during the entire monitoring period. All stations exceeded the 20°C level from late June through early September 2002.

~~1.1.2~~3.2.2 Special Investigations

This section presents the results of various special field tests and data analyses conducted on the 2002 data. These tests and evaluations were conducted in response to specific requests by the ERC or implemented by the Licensee to improve monitoring methods.

~~1.1.1.1~~3.2.2.1 Evaluation of Sensor Placement in Caribou No. 2 Intake

In order to verify the accuracy of temperatures recorded by the sensor installed in the Caribou No.2 Penstock (CARB2A), a backup recorder was placed at the bottom of the Caribou No.2 Intake channel (CARB2B). Data from both stations were compared for the period June through September. In order to facilitate data comparison, both were processed to correct for powerhouse operation. Both data sets were compared with data from the near surface recorder located in Butt Valley Reservoir (BV2-S). Figure 3-24 compares daily average temperatures from these three stations associated with Caribou No. 2 Intake.

The recorder on the bottom of the intake channel (CARB2B) had a daily mean temperature that ranged from 0.4°C warmer to 1.1°C cooler than the penstock recorder. In general, the channel recorder temperatures were consistently lower than both the penstock recorder (CARB2A) and the near surface recorder placed in Butt Valley Reservoir (BV2-S). In addition, the channel recorder did not follow the temporal pattern of temperature as defined by the reservoir surface recorder.

This variability was probably related to the physical characteristics of the channel and the ultimate placement of the recorder. The recorder was placed at a fixed depth (on or near bottom) on the north side of the intake structure. Depending on lake elevation, and powerhouse flow this area can be exposed to backwater conditions of various magnitude. However, the data indicate that the two recorders agree relatively well and during periods of consistent powerhouse operation there was little temperature differential. For the June through September period, the average difference between the penstock recorder and the channel recorder was ±0.4°C. This is within the realm of combined recorder error.

Based on this information and data presented in Section 3.2.2.2, data from the penstock recorder are considered superior to the channel recorder as long as the flow-through-system that connects the sensor to the penstock remains functional. There were no problems with this system in 2002.

~~1.1.1.2~~3.2.2.2 Butt Valley Reservoir Thermal Structure near Caribou No.2 Intake Channel

In an attempt to further define the withdrawal dynamics associated with the Caribou No.2 Intake, the Licensee collected data from two special profile stations located near the mouth of the intake channel. The first location (BV-P4A) was located in Butt Valley Reservoir approximately 50 meters from the mouth of the intake channel. Profiles were collected from this location in June, July, August, and October. The second profile station (BV-P4B) was located in Butt Valley Reservoir at the mouth of the intake channel. Profiles were collected only in August and October from this location. Since October conditions were strongly isothermal, only profiles from June through August were used as part of this evaluation. Figure 3-25 compares monthly temperature data from the special profile stations with those from BV-P1. As indicated by the data presented in Figure 3-25, the thermal structure associated with the Caribou No. 2 Intake channel is essentially identical to that observed at BV-P1.

All profiles were collected between 0900 and 1030. As a result, the elevated near surface temperatures associated with warm afternoon conditions were not captured. Conditions in the Caribou No. 2 penstock and to a lesser degree the intake channel are also influenced by the magnitude and consistency of flow through Caribou No. 2 Powerhouse. At the time the June profile was collected, the Caribou No. 2 Powerhouse was not operating. Caribou No. 2 Powerhouse had been operational for approximately one hour at the time of the July profile, and for four hours at the time of the August profiling effort. Table 3-6 compares data from special profile stations with temperature data from the

Table 3-6

Summary of profile data from select stations in Butt Valley Reservoir.

Profile Date	Profile Time	Profile Temperatures						Caribou No.2 Release Hourly Average (hour)		Powerhouse Operation
		BV-P1		BV-P4A		BV-P4B		Penstock	Channel	
		Average[1]	Average[2]	Average[1]	Average[2]	Average[1]	Average[2]	CARB2A	CARB2B	
6/26/2002	9:30	20.9	21.6	20.9	21.6	---	---	21.6 (0700)	21.6 (0700)	Caribou No.2 not operating at time of profile.
7/9/2002	10:02	22.3	22.8	22.5	22.8	---	---	22.8 (1100)	22.4 (1100)	Caribou No.2 running for ~one hour before profile.
8/21/2002	10:18	22.0	22.0	22.0	22.0	22.0	22.0	22.0 (1100)	21.7 (1100)	Caribou No.2 running for ~four hours before profile.

1. Profile temperatures averaged from surface to 4,110 ft elevation (USG datum).
2. Profile temperatures averaged from surface to 4,115 ft elevation (USG datum).

4,110 ft. is the bottom elevation of the intake channel entrance.

CARB2 and CARB2B data recorders. As indicated by this data, the agreement between the synoptic profiles and data from CARB2 located in the penstock is very good during periods of powerhouse operation. The data also indicates that the effective withdrawal depth associated with the Caribou No. 2 Intake is from the surface to 4,115 ft (USGS datum).

~~1.1.1.3~~3.2.2.3 Performance of telemetry stations

Real-time temperature (telemetry) systems were installed in the gaging stations located at NF-56 and NF-57. Temperatures were measured at 30-minute intervals and stored locally on a data logger as well as being transmitted through SCADA to the Rock Creek and Caribou Powerhouse Switching Centers. The temperature data were processed for the daily average value, mid-night to mid-night, and if temperature levels exceeded 20°C on two consecutive days, a signal alerted operators and the temperature condition was reported to ERC and FS personal. An appropriate course of action was then developed in order to try and maintain daily average temperatures below 20°C at NF-56 and/or NF-57.

In order to evaluate the performance of the two telemetry station sensors, data from the in-situ recorders installed at the telemetry location were used to document performance. Figure 3-28A compares daily average temperatures from station NF-56. The evaluation of telemetry data from the NF-56 station indicated that the average difference was 0.10°C, with a maximum absolute difference of 0.21°C. This level of discrepancy is well within the margin of combined instrument error. Figure 3-28B compares daily average temperatures from station NF-57. The evaluation of data from the NF-57 station indicated that the average difference was 0.12°C, with a maximum absolute difference of 0.69°C. This drift at NF 57 was observed during one of the periodic performance tests. Periodic performance tests were conducted at each station using known temperature bath data on April 15, May 16 and October 28 of 2002. Test results indicated all telemetered remote temperature unit were within the specified accuracy (less than 0.1°C) at all times, except NF 57, which showed a drift of 0.72°C in the October 28 test.

Another stipulation of the FERC 4C Condition was that, "Temperatures at NF57 and at NF56 are to be monitored and telemetered, from June 1 through October 31, for the term of the Project License". If temperatures from the telemetered stations demonstrate that mean daily water temperatures regularly exceed 20°C in October, the entire monitoring program will be expanded to include October". This stipulation was incorporated into the monitoring program presented in the Water Temperature Monitoring Plan.

The telemetered stations were continuously operated through October 2002. Daily average temperatures at NF-56 ranged from 11.3–16.0°C, and from 11.4–16.4°C at NF-57 during October 2002.

~~1.1.3~~3.2.3 Evaluation of Controllable and Non-controllable Conditions

This section will discuss tests conducted to determine the effect of various controllable mitigation options that may have the potential to reduce water temperatures below the 20°C level. As part of the 4C requirements, the Licensee was to determine the effect controllable factors (flow releases, intake configuration, release locations) would have on temperature control in the project area, as well as the effect of non-controllable factors (e.g. solar radiation, lack of shading, tributary inflow, powerhouse return flow).

~~1.1.1.1~~3.2.3.1 Temperature mitigation testing at Caribou complex powerhouses

Butt Valley Reservoir is a long, narrow water body of moderate depth. The reservoir receives inflows from Butt Creek and Butt Valley Powerhouse. Butt Valley Powerhouse has an annual average flow of 1,600 cfs and represents more than 95% of the total inflow to the reservoir. Butt Creek is the largest of the natural inflow sources, with summer flows ranging from 40-56 cfs (Table 3-1). Exclusive of spill events, outflow from Butt Valley Reservoir is through the Caribou No. 1 and Caribou No. 2 powerhouses. Caribou No.1 has a capacity of 1,100 cfs and is older and less efficient unit than Caribou No. 2, which has a flow capacity of 1,400 cfs. Because of this difference in efficiency and operational reliability, Caribou No. 2 is the Licensee's preferred operational unit.

Caribou No. 2 Intake is located in a shallow cove; as a result water withdrawals are restricted to the upper layers of Butt Valley Reservoir by the cove's entrance elevation of 4,110 ft. (USGS datum). Caribou No.1 is located in the deepest portion of the reservoir and can access water from the surface to 4,095 ft. (USGS datum). Several years of data (1985-1986, 2000-2002) have shown that cooler water is present in the deeper portion of the reservoir (Section 3.2.1.2 for 2002 data). The expectation that this cold water could be used to mitigate temperatures in the Rock Creek and Cresta reaches has been suggested in the past and was revisited by the ERC as a possible method of achieving the 20°C temperature level in the NFFR downstream.

The thermal characteristics of Butt Valley Reservoir must be identified before determining the mitigating effect of alternate operational regimes at the Caribou Powerhouse complex. Figure 3-26 displays mean daily temperatures from the three stations associated with conditions in Butt Valley Reservoir for the period June 1 through September 30, 2002. Average daily flow at Caribou No.1 and Caribou No. 2 are included to illustrate the effect of operation on temperature. As indicated by this figure, cooler water was present in the hypolimnion of the reservoir and persisted through June 2002. As part of the normal operational regime, Caribou No.1 had not been significantly utilized prior to July. As soon as use of Caribou No.1 was begun (July 3, 2002) there was a noticeable upward shift in the temperature of the hypolimnion. The upward trend continued as Caribou No.1 was operated for the remainder of the summer. By late August, the reservoir was essentially isothermal. These same thermal characteristics are observed in the monthly synoptic profiles previously presented in Figure 3-11.

The thermal regime present in Butt Valley Reservoir develops in a relatively simple manner. In general, the areas in Butt Valley Reservoir with depths greater than 30 feet are isolated from the effects of short wave solar radiation and surface turbulence. As warmer ambient conditions develop, the cold water present in the deeper portions of the reservoir is preserved. The warmer upper layers of the reservoir are actively maintained as inflows from Butt Valley Powerhouse are matched to outflows from Caribou No.2.

Under the current operational regime, Caribou No. 1 is typically not used until late June or early July. As a result the pool of cool water is left untapped until this period. As soon as Caribou No.1 begins operating, this volume of cool water is rapidly depleted (Figure 3-26). The influence of any cold water inflows from Butt Creek are negated through mixing with inflows from Butt Valley Powerhouse or with the warmer surface layers in the shallow upper reaches of Butt Valley Reservoir. As the volume of stored cool water is released through Caribou No.1, temperatures in the hypolimnion rapidly warm to temperatures that are similar to those observed entering the reservoir through Butt Valley Powerhouse (BV1) (Figure 3-26). This pattern has been observed during previous monitoring efforts in 2000-2001 (Pacific Gas and Electric Company, 2002).

As discussed, the operation of Caribou No. 1 can provide some mitigating effect on downstream temperatures for as long as the pool of cool water is present. By examining the access of each intake structure to Butt Valley Reservoir, the volume of water available exclusively to the Caribou No.1 Intake can be determined. The Caribou No. 2 Intake is located in a shallow cove with an entrance elevation of 4,110 feet (USGS datum). The Caribou No. 1 Intake is in the deeper portion of the reservoir, data from a 1996 bathymetric survey indicates that the intake has access to water from the surface to 4,095 feet (USGS datum). The storage-capacity rating for Butt Valley Reservoir indicates a total volume of 7,837 ac-feet at an elevation of 4,110 feet (USGS) and 598 ac-feet at 4,095 ft (USGS). The difference between these two values (7,239 acre-ft) is the volume of water available to Caribou No.1 that is not available to Caribou No.2. Depending on thermal conditions in the reservoir, some or all of this 7,000 acre-feet comprises the pool of cool water accessed by Caribou No. 1. At a maximum withdrawal rate of 1,100 cfs through Caribou No.1, this volume would last about 80 hours, or 3.3 days. A subsequent reduction in withdrawal rate would extend the period of time the cool water was available, but would also reduce the effective change in downstream temperatures. It can therefore be concluded that preferential operation of Caribou No.1 can only provide a short period of temperature mitigation. When the pool of cool water is depleted there is no temperature benefits associated with operating Caribou No.1 over Caribou No. 2.

To define and quantify the effect that preferential use of Caribou No. 1 has on temperatures in the lower NFFR, the Licensee conducted a special short duration operational test in July 2002. This test was conducted from July 3 through July 7, 2002. During this period Caribou No. 1 was operated preferentially over Caribou No. 2. On three days during this period Caribou No.2 was not operated at all. Because the pool of cool water in Butt Valley Reservoir had not been utilized up to this point, this test represents a best-case scenario with regard to the mitigating effect of using Caribou No. 1 preferentially over Caribou No. 2. Figure 3-27 compares daily average temperatures from the Caribou powerhouse complex, with NFFR stations in the Rock Creek-Cresta reach during this test. Table 3-7 summarizes the data presented in Figure 3-27.

Table 3-7

Summary of temperature data from Caribou complex operational test.

Date	Caribou No. 2 Temperature (°C)	Caribou No. 2 Flow (cfs)	Caribou No.1 Temperature (°C)	Caribou No.1 Flow (cfs)	Resultant Caribou Complex * (°C)	Upper Belden Forebay [BD1] (°C)	NFFR below Rock Creek Dam [NF10] (°C)	NFFR below Forebay [NF13] (°C)	Remarks
6/30/2002	21.4	150	---	---	21.4	21.5	20.9	20.8	Pre-test, no Caribou No.1 flow
7/1/2002	22.2	230	---	---	22.2	21.8	20.7	20.9	Pre-test, no Caribou No.1 flow
7/2/2002	22.0	251	---	3	21.7	22.2	20.8	20.9	Pre-test, no Caribou No.1 flow
7/3/2002	----	---	16.3	203	16.3	21.8	20.7	20.8	Test period
7/4/2002	---	---	16.3	138	16.3	21.0	20.5	20.8	Test period
7/5/2002	---	---	16.4	117	16.4	20.1	20.6	20.8	Test period
7/6/2002	21.8	228	17.3	460	18.8	19.5	20.7	20.7	Test period
7/7/2002	22.2	198	17.3	436	18.8	19.3	20.6	20.7	Test period
7/8/2002	22.5	443	18.1	284	20.8	19.9	20.2	20.8	Post-test, normal operation
7/9/2002	23.2	625	18.4	425	21.3	21.1	20.4	20.3	Post-test, normal operation
7/10/2002	23.0	1,091	18.7	672	21.3	21.5	21.3	20.5	Post-test, normal operation

- Based on mass balance calculations.

Table 3-7
(Continued)

Date	Belden Powerhouse		Belden Reach (Nf5)		Belden Reach				Remarks
	Temperature (°C)	Flow (cfs)	Temperature (°C)	Flow (cfs)	[NF6] (°C)	[NF7] (°C)	[NF8] (°C)	[EB1] (°C)	
6/30/2002	---	0	18.9	144	19.0	19.3	21.2	23.3	Pre-test, no Caribou No.1 flow
7/1/2002	19.8	87	19.1	144	19.0	19.1	21.2	23.3	Pre-test, no Caribou No.1 flow
7/2/2002	20.7	187	19.3	144	19.2	19.3	21.2	23.3	Pre-test, no Caribou No.1 flow
7/3/2002	21.1	58	19.2	143	19.0	19.1	20.8	22.8	Test period
7/4/2002	---	0	18.7	144	18.7	18.8	20.5	22.4	Test period
7/5/2002	---	0	18.3	144	18.5	18.8	20.7	22.7	Test period
7/6/2002	19.0	558	17.9	143	18.2	18.7	20.7	22.9	Test period
7/7/2002	19.0	500	17.8	144	18.1	18.5	20.6	23.2	Test period
7/8/2002	19.6	641	17.9	144	18.1	18.5	20.6	23.1	Post-test, normal operation
7/9/2002	20.9	783	18.1	144	18.3	18.7	20.8	23.5	Post-test, normal operation
7/10/2002	21.2	1216	18.9	144	19.1	19.5	21.5	24.1	Post-test, normal operation

As indicated, in Table 3-7, release temperatures from the Caribou powerhouse complex were approximately 22.0°C before the test began. Once Caribou No. 1 came into full utilization and Caribou No. 2 flows were decreased, release temperatures dropped to approximately 16.3°C. This drop of 5.7°C represents the maximum change in temperature measured at the Caribou complex release, temperatures increased in a progressive manner as contributions from Caribou No. 2 increased following the shut down period.

The observed rate of change in release temperatures at Caribou No. 1 supports the previous discussion. At the beginning of the test, Caribou No. 1 release temperatures measured 16.3°C. At the end of the five day test period, Caribou No.1 release temperatures had risen to 17.3°C, and were 18.7°C by July 10 (eight days after use of Caribou No. 1 began). Caribou No. 1 release temperatures exceeded 20°C, on July 19, 2002; 16 days after the start of Caribou No. 1 utilization, at an average daily flow of 295 cfs.

As discussed in Section 3.2.1.5, a thermal gradient exist in Belden Forebay that is probably the result of operational influences on the system. This gradient, results in cooler water being released to the Belden Reach through Oak-flat Powerhouse and warmer water diverted through Belden Powerhouse. The BD1 monitoring station represents temperatures in the upper layers of the forebay that are passed through Belden Powerhouse. The NF5 station represents temperatures in the lower layers of the forebay, as well as initial temperatures in the Belden Reach. To evaluate the effect of operational changes on temperature each transport pathway will be discussed separately.

During the test, temperatures in the upper portion of Belden Forebay (BD1) showed a gradual reduction through the test period. The maximum decrease in temperature was 2.9°C, which was recorded on the last day of the test period (July 7, 2002). This slow rate of change in the forebay temperature was related to the relatively low rate of inflow (117-203 cfs) and outflow in Belden Forebay. During full load conditions, the retention time in Belden Forebay is less than 12 hours. However, at the flows present during the test, the estimated forebay retention time was about one week (at an average flow of 160 cfs). The longer retention time combined and the presence of pre-test warm water in the Belden Forebay contributed to the slow rate of temperature change as measured at BD1 compared to the Caribou complex release temperatures.

During the test, temperatures in the lower portion of Belden Forebay (NF5) also showed a gradual reduction through the test period. However, because of the thermal gradient in the forebay, the maximum change was much less than that seen in the upper layers. The maximum decrease in temperature was 1.4°C, and was also recorded on the last day of the test period (July 7, 2002). For most of the test period, outflow from the Forebay was comprised entirely of instream releases to the Belden Reach through Oak-flat Powerhouse. The monitoring station at the end of the upper Belden Reach (NF7), is located upstream of the confluence with the East Branch of the NFFR. The maximum decrease in temperature at this station was 0.8°C, and was also recorded on the last day of the test period (July 7, 2002). The last station in the Belden Reach (NF8) is located upstream of the confluence with Yellow Creek. Temperatures at this station reflect the influence of the warmer EBNFFR inflows. As a result of the EBNFFR inflows the temperature reduction in the Belden Reach was further moderated to 0.6°C.

The stations below Rock Creek Dam and Cresta Dam (NF10 and NF14, respectively), were used to detect any effect from the Caribou test. It was assumed that these stations would be the least affected by tributary inflow and ambient conditions. Temperatures at the beginning of the Rock Creek Reach (NF10) showed a maximum decrease of 0.6°C the day after the test ended (July 8, 2002). On the following day (July 9, 2002), the station located below Cresta Dam (NF14) measured a similar maximum decrease of 0.6°C. Temperatures at NF10 and NF14 exceeded 20°C during the entire test period. The results of this test were influenced by the high flow released for whitewater test on July 7, 2002.

It is acknowledged that the 2002 preferential use test was conducted under less than ideal circumstances. Flow through Caribou No.1 was much less than would be expected through Caribou No.2 under normal operations. There was little or no flow through Belden Powerhouse during the test; as a result residence time in the forebay was increased. Finally, a high flow whitewater test was begun in the Rock Creek/Cresta reach on the last day of the preferential use test. This coincidental timing significantly altered the rate of travel through the system and undoubtedly affected the test results in the Rock Creek and Cresta reaches.

In summary, the 2020 preferential use of Caribou No. 1 over Caribou No. 2 produced the following results:

- Routing flows only through Caribou No. 1 produced a 5.7°C decrease in release temperature at the Caribou Powerhouse complex. Caribou No.1 temperatures rapidly increased following the start of withdrawals from the pool of cool water.
- The test produced a 3°C decrease in temperature in the upper layers of Belden Forebay (BD1), and yielded a decrease of 1.4°C in the lower layers of the Forebay (NF5).
- The test yielded a 0.8°C decrease in temperatures at the end of the upper Belden bypass reach (NF7), decrease was further moderated to 0.6°C at NF8 after mixing with the East Branch NFFR.
- The test yielded a 0.6°C decrease in temperatures in the Rock Creek and Cresta bypass reaches at NF10 and NF14 stations
- The reserve of cool water is limited in Butt Valley Reservoir, and operation of Caribou No. 1 in preference over Caribou No. 2 can at best provide only temporary periods (several days) of mitigation.

~~1.1.1.2~~3.2.3.2 Effect of Outlet Use at Cresta Dam on NFFR Water Temperature

The minimum instream flows to the NFFR are released from two sources at Cresta Dam. The primary release is made from the in-stream flow release valves, which are positioned approximately 30 ft. below normal water surface. These valves release a minimum of 150 cfs and self adjusts for changes in reservoir level. The radial gates are the second source of release flow; these gates withdraw water from the top 20 ft. of the reservoir. The radial gates are not self-adjusting and are therefore typically used in conjunction with the instream release valves.

A daily log is kept documenting the total release flow, as well as the flow originating from each outlet. During the June through September 2002 monitoring period, the instream release valve provided 26 to 61 percent of the total release flow. Flow from the radial gate provided 39 to 74 percent of the total flow.

Due to a short retention time, Cresta Reservoir does not undergo thermal stratification. Consequently, no difference in temperature was expected with respect to outlet used. To test this assumption, temperature data from monitoring stations at NF14 and RC1 were used to evaluate the temperature effect associated with differential use of the two Cresta Dam release outlets. A long term evaluation was not possible since both gates were used equally throughout the period to generate the total flow. However, an eight day period (June 28 through July 5) was evaluated during which preferential use of the outlets was alternated. For the period June 28 through July 1 the instream valve averaged 35% of the total release. For the period July 2 through July 5 the instream valve averaged 59% of the total release.

Based on this evaluation, there was no measurable change in the difference between downstream (NF14) and upstream (RC1) temperatures during periods when either gate provided the majority of release flow. For the two day period June 30-July 1, the radial gate provided 66% of the total flow and the mean daily average temperature at NF14 was 20.9°C. For the two day period July 2-3, the instream release valves provided 60% of the total flow and the mean daily average temperature at NF14 was 20.8°C. As a result of this evaluation there appears to be no benefit derived from preferential use of either release outlet.

~~1.1.1.3~~3.2.3.3 Effect of inflow from Bucks Lake system on water temperatures in the NFFR

The Bucks Lake system delivers relatively cool water to the end on the Rock Creek Reach. Two temperature evaluations were performed on data from stations located upstream and downstream of inflows from the Bucks system. The first evaluation focused on inflow from Bucks Creek and Bucks Powerhouse. The second evaluation focused on inflow from Grizzly Creek. Data used for these evaluations is summarized in Table 3-8.

The Bucks Lake system is comprised of Bucks Lake, Lower Bucks Lake, Grizzly Powerhouse, Grizzly Forebay, and Bucks Powerhouse. Bucks Lake is the main storage reservoir and delivers relatively cool water to Lower Bucks Lake through a low level outlet. Water is then diverted from Lower Bucks Lake to Grizzly Forebay through Grizzly powerhouse. A minimum release of 3 cfs (in summer time) is made to Bucks Creek downstream of Lower Bucks Dam; this flow subsequently discharges into the NFFR approximately 1.3 miles upstream of Rock Creek Powerhouse. Flow from Grizzly Powerhouse immediately enters Grizzly Forebay, which provides generation storage for Bucks Powerhouse. Bucks Powerhouse discharges directly to the NFFR approximately 1.0 mile upstream of Rock Creek Powerhouse and 0.3 mile downstream of the mouth of Bucks Creek. A minimum release of 4 cfs (in summer time) is made to Grizzly Creek downstream of Grizzly Forebay Dam; this flow subsequently discharges into the NFFR approximately 0.75 mile downstream of Cresta Dam.

Table 3-8

Temperature data associated with inflows from Bucks Lake system.

A. Daily average temperature and flow data near Bucks Powerhouse.

Date	NF12 (°C)	BUCK1 (°C)	BUCK1 (cfs)	BUCK2 (°C)	BUCK2 (cfs)	NF13 (°C)	ROCK1 (°C)	ROCK1 (cfs)	ROCK2 (°C)	NF14 (°C)
8/14/2002	22.3	19.3	16.1	14.3	188.6	19.4	21.9	1045	18.6	21.5
8/15/2002	22.4	19.3	16.0	14.2	216.2	19.0	22.2	1043	18.8	21.2
8/16/2002	22.4	19.2	15.9	13.9	214.8	19.0	22.4	1021	19.0	21.2
8/17/2002	21.8	18.0	15.8	14.0	135.4	19.5	22.4	1022	18.5	21.2
8/18/2002	21.3	17.5	15.8	13.5	227.7	17.6	22.0	1021	18.0	20.7
8/19/2002	21.2	17.0	15.7	----	0.0	20.7	21.9	1059	17.7	20.5
8/20/2002	20.7	16.0	15.4	----	0.6	20.6	21.5	1009	17.1	21.0
8/21/2002	20.2	15.4	15.2	----	0.0	20.0	21.3	1217	16.5	20.8
8/22/2002	20.1	15.2	15.2	----	0.5	19.9	21.4	1290	16.2	20.5
8/23/2002	20.0	14.8	15.0	----	1.7	19.7	21.2	1205	15.8	20.4

Table 3-8 (Continue)

B. Daily average temperature and flow data near Grizzly Creek.

Date	Daily Average Temperatures			
	NF14	GC1	NF15	Delta-T
8/6/2002	19.8	16.8	19.7	-0.1
8/7/2002	19.6	16.5	19.5	-0.2
8/8/2002	19.7	16.6	19.6	-0.2
8/9/2002	20.1	17.2	20.0	-0.1
8/10/2002	20.3	17.8	20.3	0.0
8/11/2002	20.5	18.3	20.6	0.0
8/12/2002	20.6	18.8	20.7	0.1
8/13/2002	20.8	19.5	21.0	0.2
8/14/2002	21.5	19.9	21.5	0.1
8/15/2002	21.2	20.1	21.4	0.2
8/16/2002	21.2	20.2	21.4	0.2

The Bucks Creek-Bucks Powerhouse (Bucks system) evaluation used temperatures from NF12, NF13, RC1, and NF14 to determine the effect of inflows from Bucks Creek (BUCK1) and Bucks Powerhouse (BUCK2). Bucks Powerhouse was operated on a peaking-type regime during the June through September period. This is done largely to maintain lake levels in Bucks Lake through the summer period in support of recreational concerns and property owner issues.

In order to compare periods with relatively similar ambient meteorological influences, a ten-day test period was selected which included five days of consistent Bucks powerhouse operation and five days of no powerhouse operation.

The test period illustrating the effect of powerhouse operations was from August 14 -18, 2002. During this five day period the average temperature at station NF-12 (upstream of Bucks system inflows) was 22.1°C. The average five day temperature at Bucks Creek was 18.7°C, and the average Bucks Powerhouse temperature was 14.0°C. The resultant temperature in the NFFR downstream of the Bucks system inflows (NF13) was 18.9°C. This represents an average decrease in temperature of 3.1°C; temperatures were also reduced below the 20°C level. Inflow temperatures from Rock Creek Powerhouse averaged 22.2°C during this same five day period. The absolute effect of Bucks system inflows on the NFFR was measured at station NF14. This station is below Cresta Dam and represents resulting temperatures following the mixing of Rock Creek (RC2), Rock Creek Powerhouse (RC1), and the NFFR end of the Rock Creek Reach (NF13) in Cresta

Reservoir. Temperatures at NF14 during the five day period averaged 21.1°C, or 1.0°C cooler than the Rock Creek powerhouse inflow.

The test period illustrating the effect of no powerhouse operations was from August 19 - 23. During this five day period the average temperature at station NF-12 (upstream of Buck Creek and Bucks Powerhouse) was 20.4°C. The average five day temperature at Bucks Creek was 15.7°C. The resultant temperature in the NFFR downstream of the Bucks Creek inflow (NF13) was 20.2°C. This represents an average decrease in temperature of 0.2°C. Inflow temperatures from Rock Creek Powerhouse averaged 21.5°C during the same five day period. Temperatures at NF14 during this five day period averaged 20.7°C, or 0.8°C cooler than the Rock Creek powerhouse inflow.

Results of this evaluation indicate that operation of Bucks Powerhouse can significantly reduce temperatures in the NFFR immediately upstream of Rock Creek Powerhouse. However, due to the large volume of inflow from Rock Creek Powerhouse at temperatures similar to those measured in the NFFR upstream of inflows from the Bucks system, there appears to be no measurable effect downstream of Rock Creek Powerhouse. This is true as long as Rock Creek Powerhouse is operating.

The Grizzly Creek evaluation used temperatures from NF14, and NF15 to determine the effect of inflows from Grizzly Creek (GR1). In order to compare periods with relatively similar ambient meteorological influences, an eleven-day test period was selected which included a wide range of Grizzly Creek inflow temperatures. The test period chosen was August 6-16, 2002. During this period, Grizzly Creek temperatures ranged from 16.2 to 20.5°C. Flows in Grizzly Creek ranged from 16.1 to 20.2 cfs.

Temperatures in the NFFR upstream of the Grizzly Creek confluence (NF14) for this period ranged from 19.6 to 21.5°C. Temperatures in the NFFR downstream of the Grizzly Creek confluence (NF15) for this period ranged from 19.5 to 21.5°C. In general, there was no difference in average temperatures between NF15 and NF14. The absolute difference ranged from 0.2°C cooler to 0.2°C warmer. As indicated by this data, during the summer period when creek flows are low, inflows from Grizzly Creek do not mitigate temperatures in the NFFR.

~~1.1.1.4~~3.2.3.4 Water Temperature Model Evaluation

3.2.3.4.1 Existing Model Evaluation

In 1986 Woodward-Clyde Consultants (WCC) developed temperature models of the Rock Creek Reach and Cresta Reach of the NFFR using the SNTEMP (Stream Network Temperature Model). Both models were developed using data from 1985. As part of the most recent Rock Creek-Cresta Hydroelectric Project relicensing effort (FERC 1962), the 1986 SNTMP temperature models were revised and updated. As part of the updating process, data collected in 2002 was incorporated into the exiting models to strengthen model calibration. The results of this modeling analysis are presented in: Revised Water Temperature Modeling for the Rock Creek-Cresta Hydroelectric Project - FERC Project No. 1962 (TRPA, 2003). This document is included as Appendix B.

Both of the revised models were then used to evaluate a matrix (gaming) of alternative flow scenarios. The calibration and validation of both models was based on two years (1985 and 2002) of hydrologic and meteorologic data, while the 2002 weather conditions was used in scenario gaming.

The original Rock Creek Reach water temperature model was fine-tuned by the addition of tributaries influences not incorporated in the structure of the original model. The 2002 data was merged into the 1985 dataset and the calibration recalibrated. This was followed by scenario gaming of varied flow releases using the 2002 June-September meteorologic data. The original Cresta Reach temperature model structure and calibration was validated using the 2002 data and retained unchanged. Flow release gaming of the Cresta model also used 2002 ambient conditions. Table 3-9 summarizes the quality control statistics for each model.

~~1.1.1.1.2~~3.2.3.4.2 Scenario Simulation

Based upon precipitation within the North Fork Feather River watershed, the year 2002 was classified as a normal hydrologic year. Both reach models were used to predict river temperatures resulting from the gaming of multiple release scenarios under the 2002 hydrologic year conditions. Results of the scenario gaming were then compared to the existing release conditions to evaluate the influence of controllable factors (such as higher instream flow release) relative to uncontrollable factors (meteorological condition s and initial water temperatures).

Table 3-9

Summary of Model Quality Control Statistics

A. Rock Creek Reach (Re-calibration)

North Fork Feather River downstream of Granite Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9932	0.07	0.13	0.64	0.01	122

North Fork Feather River upstream of Bucks Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9901	0.01	0.17	0.71	0.01	122

North Fork Feather River upstream of Rock Creek Powerhouse

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9834	-0.22	0.24	0.95	0.02	122

B. Cresta Reach (Validation 2002 data)

North Fork Feather River downstream of Grizzly Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9988	-0.12	0.05	-0.26	0.00	122

North Fork Feather River upstream of Cresta Powerhouse

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9889	0.08	0.17	-0.67	0.02	122

TRP, 2003

License conditions issued in ~~October,~~October 2001, specified that release flows in each reach be increased to a new level for evaluation at intervals of every five qualified years (a total of three ~~3~~ five-year periods are specified in the license). Release flows were tied to water year type (normal/wet, dry, critical dry) and changed seasonally. Temperature conditions resulting from the increased release flows would then be monitored during each five-year time period. Using the 2002 hydrologic and meteorologic data, flow releases for the "normal/wet" condition from the first, second, and third 5-year periods were modeled. Table 3-10 defines the monthly flow release scenarios used in this modeling effort.

Results of gaming the three alternative flow release scenarios varied for the two river reaches during the four summer months simulated. Table 3-11 presents the results of model simulation under normal/wet conditions. Table 3-11 compares mean monthly water temperature at selected nodes within each reach for each month and release flow. Under the normal/wet condition, model predictions for the Rock Creek Reach suggest that higher instream flow releases produce incrementally higher average water temperature at the end of the reach. This is largely the result of higher release flows over-riding the cooling benefit from colder tributaries and inflows from Bucks Powerhouse. Some reduction in temperature is seen with higher flows closer to the dam. Under the normal/wet condition, model predictions for the Cresta Reach suggest that higher instream flow releases produce incrementally lower water temperature with distance from the dam. Higher releases flows benefit the Cresta Reach largely because of the lack of cooling tributary inflows. Overall, the net temperature change (higher or

Table 3-10

Summary of Release Flows used during Scenario Gaming

A: Rock Creek Reach - Normal/Wet Water Year

Monitoring Year	Flow Release from Rock Creek Dam			
	June	July	August	September
Years 1-5	220	180	180	180
Years 6-10	260	260	260	260
Years 11-15	3940	390	390	390

B: Cresta Reach - Normal/Wet Water Year

Monitoring Year	Flow Release from Cresta Dam			
	June	July	August	September
Years 1-5	240	220	220	220
Years 6-10	325	325	325	325
Years 11-15	440	440	440	440

Table 3-11

Predicted Monthly Average Stream Temperature at Selected Release Flows.

A. Rock Creek Reach

Location on NFFR	Miles below Rock Cr Dam	June			July		
		220 cfs	260 cfs	390 cfs	180 cfs	260 cfs	390 cfs
Rock Creek Dam	**0.00**	18.4	18.4	18.4	21.3	21.3	21.3
Above Milk Ranch Creek	**2.06**	18.8	18.8	18.7	21.7	21.6	21.5
Below Milk Ranch Creek	**2.11**	18.7	18.6	18.6	21.5	21.5	21.5
Above ~~Cummings~~ Chambers Creek	**2.98**	18.8	18.8	18.7	21.7	21.6	21.6
Below ~~Cummings~~ Chambers Creek	**3.04**	18.3	18.4	18.4	21.5	21.5	21.5
Below Granite Creek	**4.10**	18.5	18.5	18.5	21.6	21.6	21.6
Above Bucks Creek	**6.71**	18.4	18.5	18.6	21.7	21.7	21.6
Below Bucks Creek	**6.77**	18.3	18.3	18.4	21.4	21.5	21.5
Above Bucks Cr Powerhouse	**6.96**	18.3	18.3	18.5	21.4	21.5	21.5
Below Bucks Cr Powerhouse	**7.02**	18.1	18.1	18.3	20.2	20.2	20.8
Above Rock Cr Powerhouse	**7.95**	18.2	18.3	18.4	20.3	20.6	20.9

Location on NFFR	Miles below Rock Cr Dam	August			September		
		180 cfs	260 cfs	390 cfs	180 cfs	260 cfs	390 cfs
Rock Creek Dam	**0.00**	21.2	21.2	21.2	19.1	19.1	19.1
Above Milk Ranch Creek	**2.06**	21.3	21.3	21.3	19.1	19.1	19.1
Below Milk Ranch Creek	**2.11**	21.2	21.2	21.2	18.9	19.0	19.1
Above ~~Cummings~~ Chambers Creek	**2.98**	21.2	21.3	21.3	18.9	19.0	19.1
Below ~~Cummings~~ Chambers Creek	**3.04**	21.1	21.2	21.2	18.9	19.0	19.1
Below Granite Creek	**4.10**	21.2	21.2	21.3	18.8	19.0	19.1
Above Bucks Creek	**6.71**	21.1	21.2	21.3	18.7	18.9	19.1
Below Bucks Creek	**6.77**	20.8	21.0	21.2	18.4	18.7	18.9
Above Bucks Cr Powerhouse	**6.96**	20.8	21.0	21.2	18.4	18.7	18.9
Below Bucks Cr Powerhouse	**7.02**	18.8	18.8	19.8	15.9	15.9	17.2
Above Rock Cr Powerhouse	**7.95**	18.9	19.4	19.9	16.0	16.6	17.2

Table 3-11

(Continued)

B. Cresta Reach

Location on NFFR	Miles below Cresta Dam	June			July		
		240 cfs	**325 cfs**	**440 cfs**	**220 cfs**	**325 cfs**	**440 cfs**
Cresta Dam	**0**	18.4	18.4	18.4	21.2	21.2	21.2
Above Grizzly Cr	**0.37**	18.5	18.5	18.5	21.3	21.2	21.2
Below Grizzly Cr	**0.38**	18.2	18.2	18.3	21.1	21.1	21.1
Middle Cresta reach	**2.24**	18.6	18.5	18.5	21.4	21.4	21.4
Above Cresta Powerhouse	**4.72**	19.0	18.9	18.9	21.9	21.7	21.7
Location on NFFR	Miles below Cresta Dam	**August**			**September**		
		220 cfs	**325 cfs**	**440 cfs**	**220 cfs**	**325 cfs**	**440 cfs**
Cresta Dam	**0**	20.7	20.7	20.7	18.5	18.5	18.5
Above Grizzly Cr	**0.37**	20.7	20.7	20.7	18.5	18.5	18.5
Below Grizzly Cr	**0.38**	20.5	20.6	20.6	18.3	18.4	18.4
Middle Cresta reach	**2.24**	20.7	20.7	20.7	18.4	18.4	18.5
Above Cresta Powerhouse	**4.72**	20.9	20.9	20.9	18.4	18.5	18.5

lower) for the various in-stream flow releases was small. A complete presentation of the water temperature model simulation is presented in Appendix B.

Based upon model predictions, controllable factors (flow releases) are over-ridden by non-controllable physical factors (e.g. solar radiation, lack of shading, tributary inflow, starting water temperatures released from the dam). Water temperatures in the NFFR in Rock Creek and Cresta study reaches were frequently above temperature thresholds (18-20°C) for salmonids and other cold water aquatic organisms, primarily due to initial (starting) water temperatures at the release point.

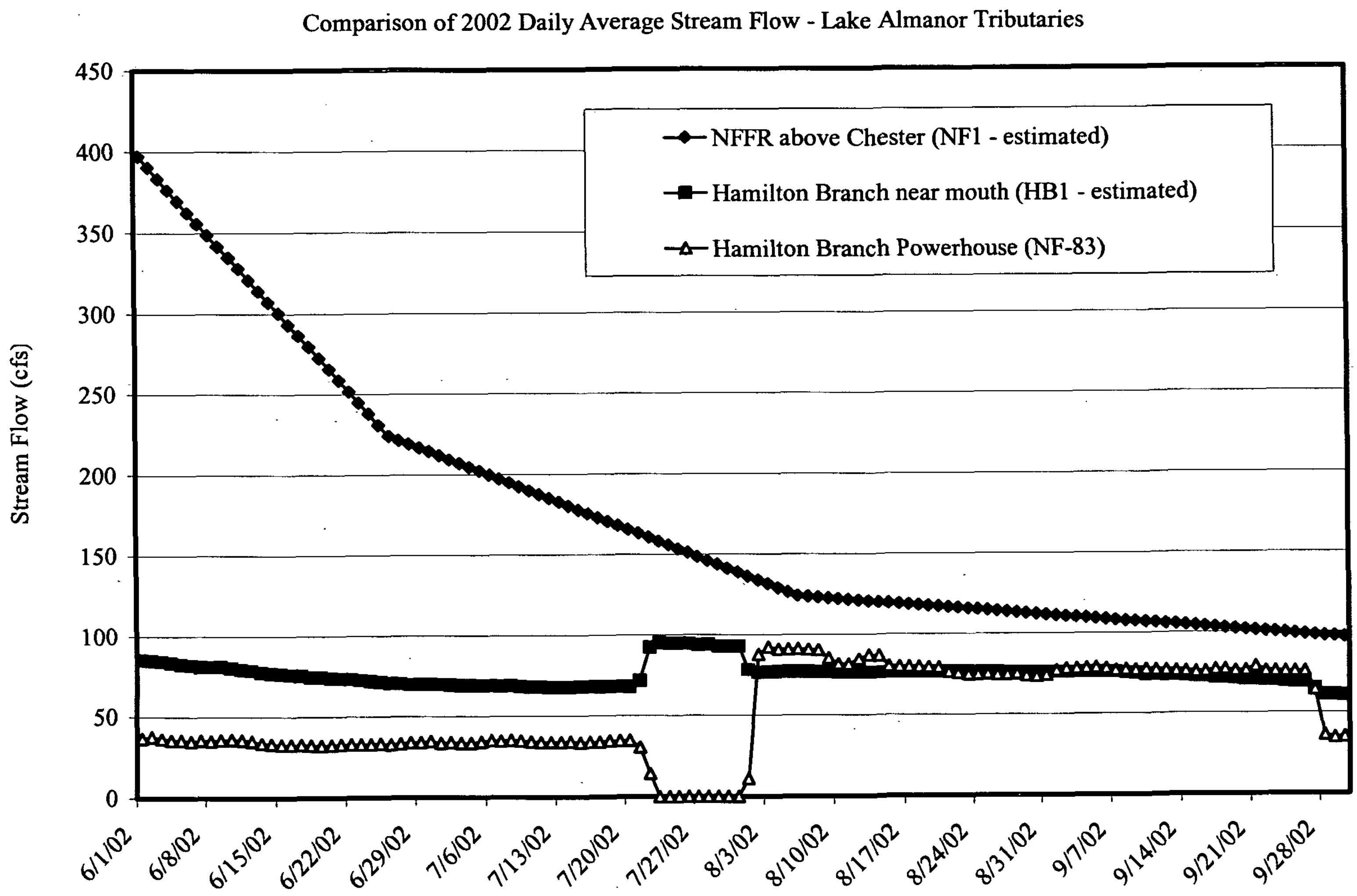


Figure 3-1. Comparison of daily average flow at stations tributary to Lake Almanor – 2002

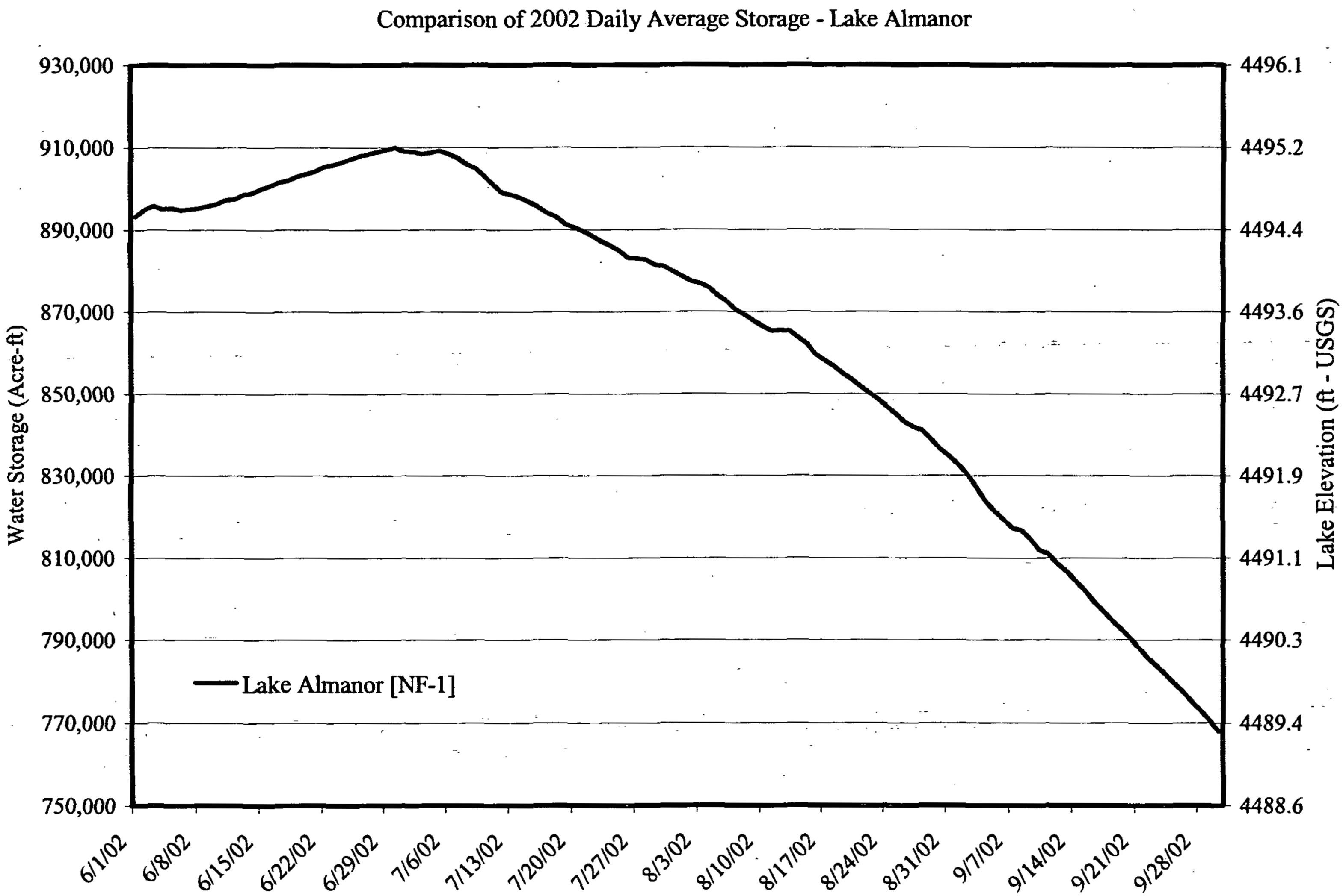
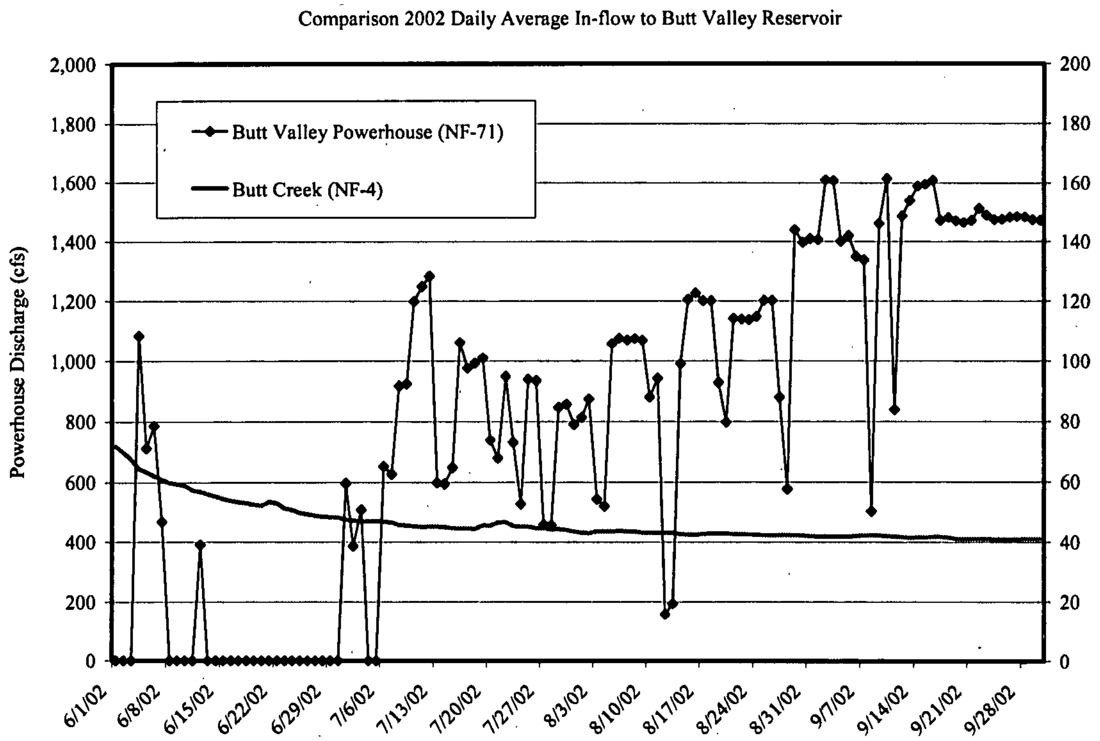
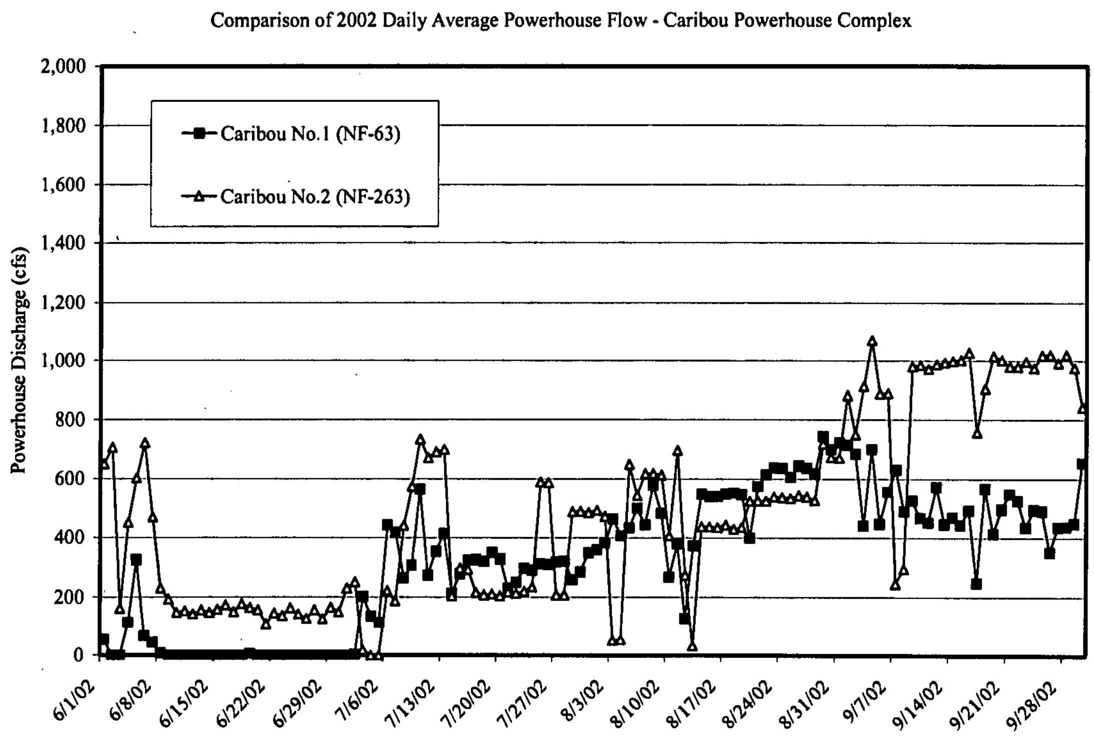


Figure 3-2. Lake Almanor average daily storage and elevation – 2002

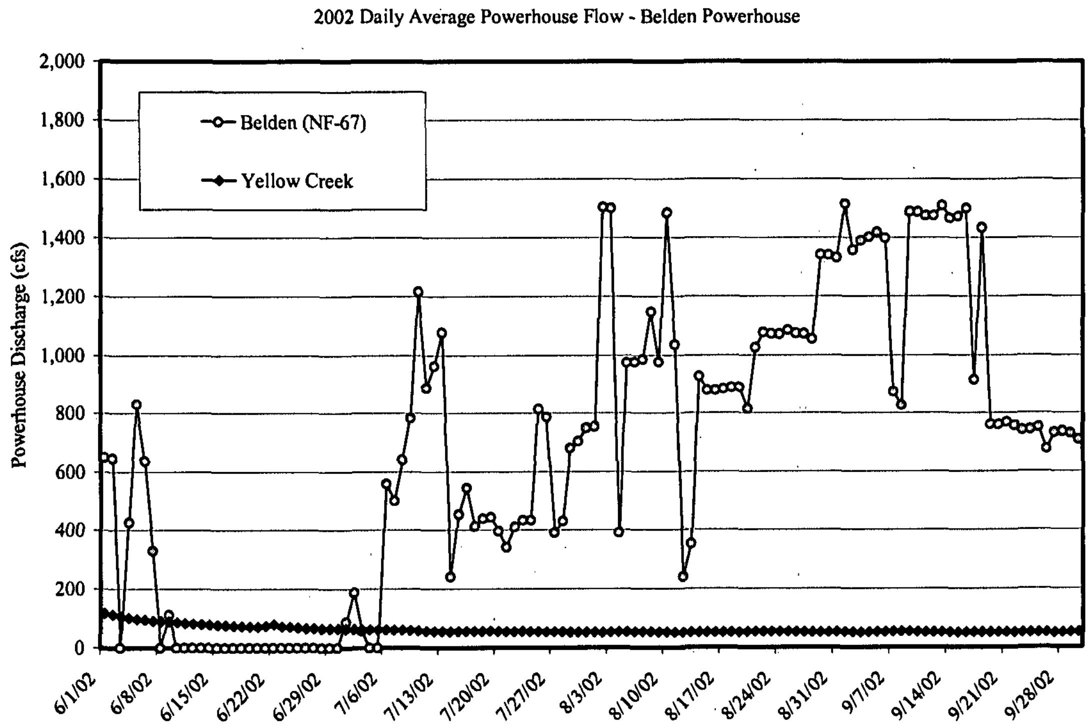


A. Butt Valley Powerhouse and Butt Creek



B. Caribou No.1 and Caribou No.2 powerhouses

Figure 3-3. Comparison of daily average flow from select stations in the upper NFFR Project – 2002



C. Belden Powerhouse and Yellow Creek

Figure 3-3 (continued).

Comparison of daily average flow from select stations in the upper NFFR Project – 2002

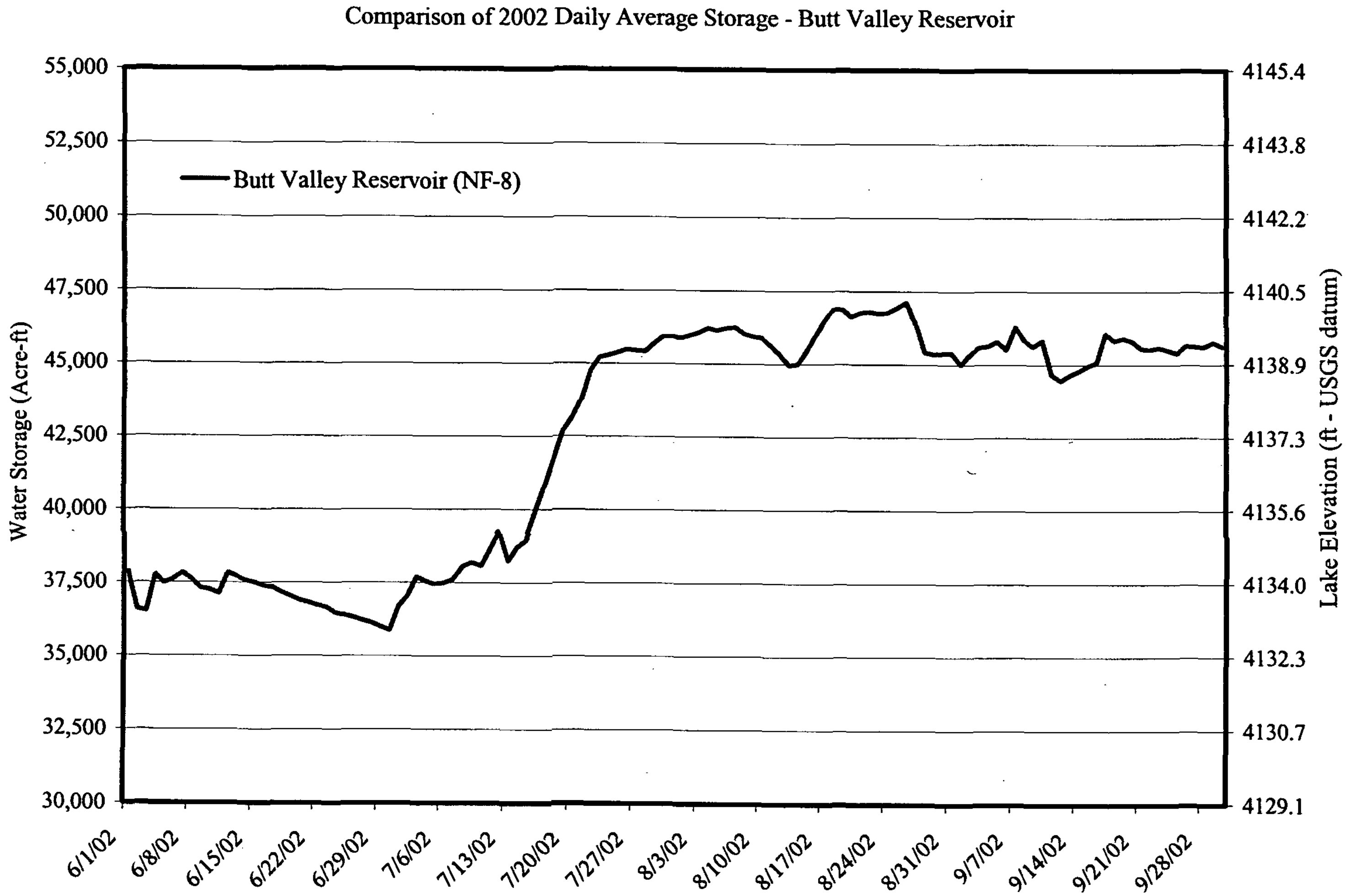


Figure 3-4. Daily Average Storage in Butt Valley Reservoir – 2002

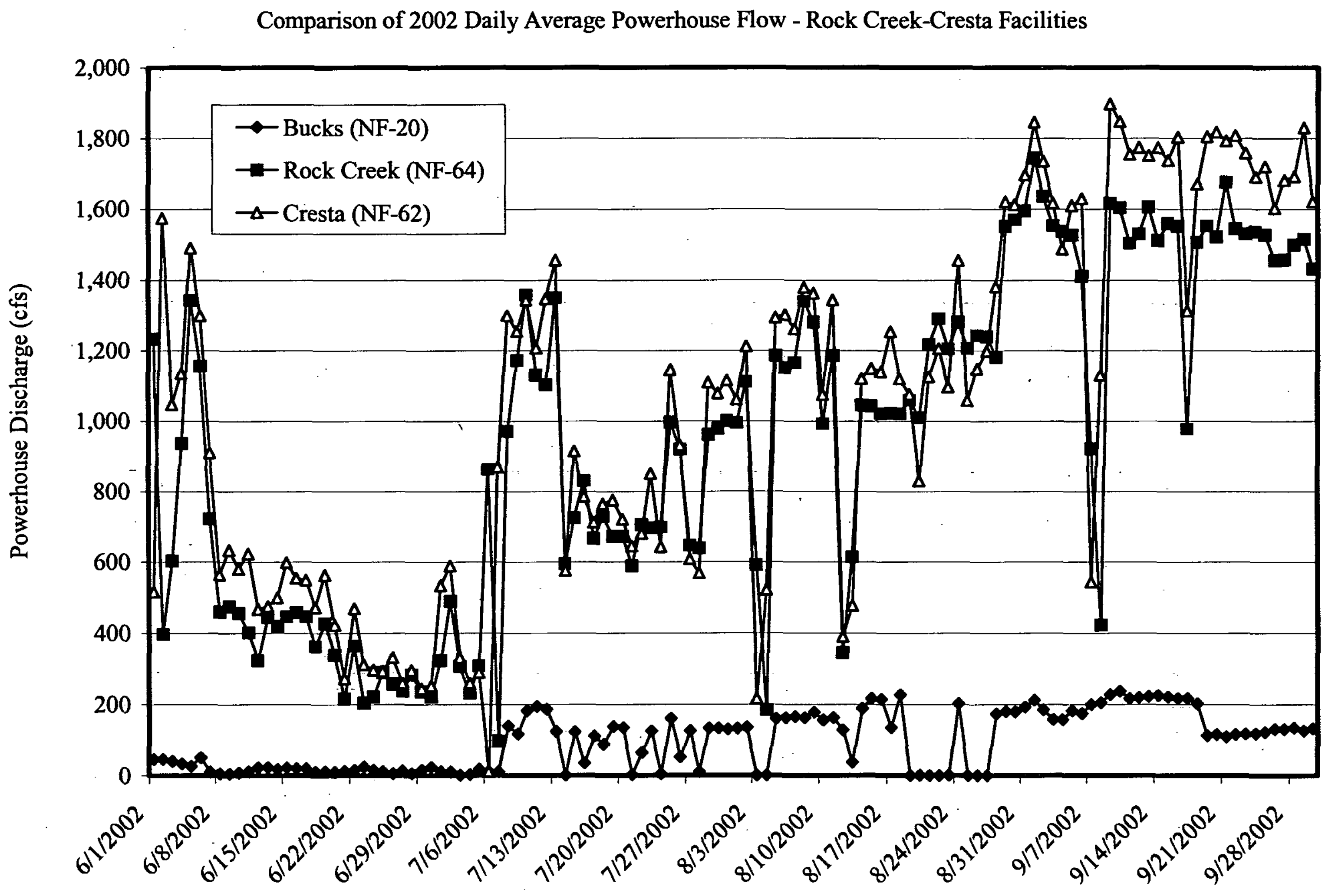


Figure 3-5. Comparison of daily average flow at Rock Creek-Cresta Project powerhouses – 2002

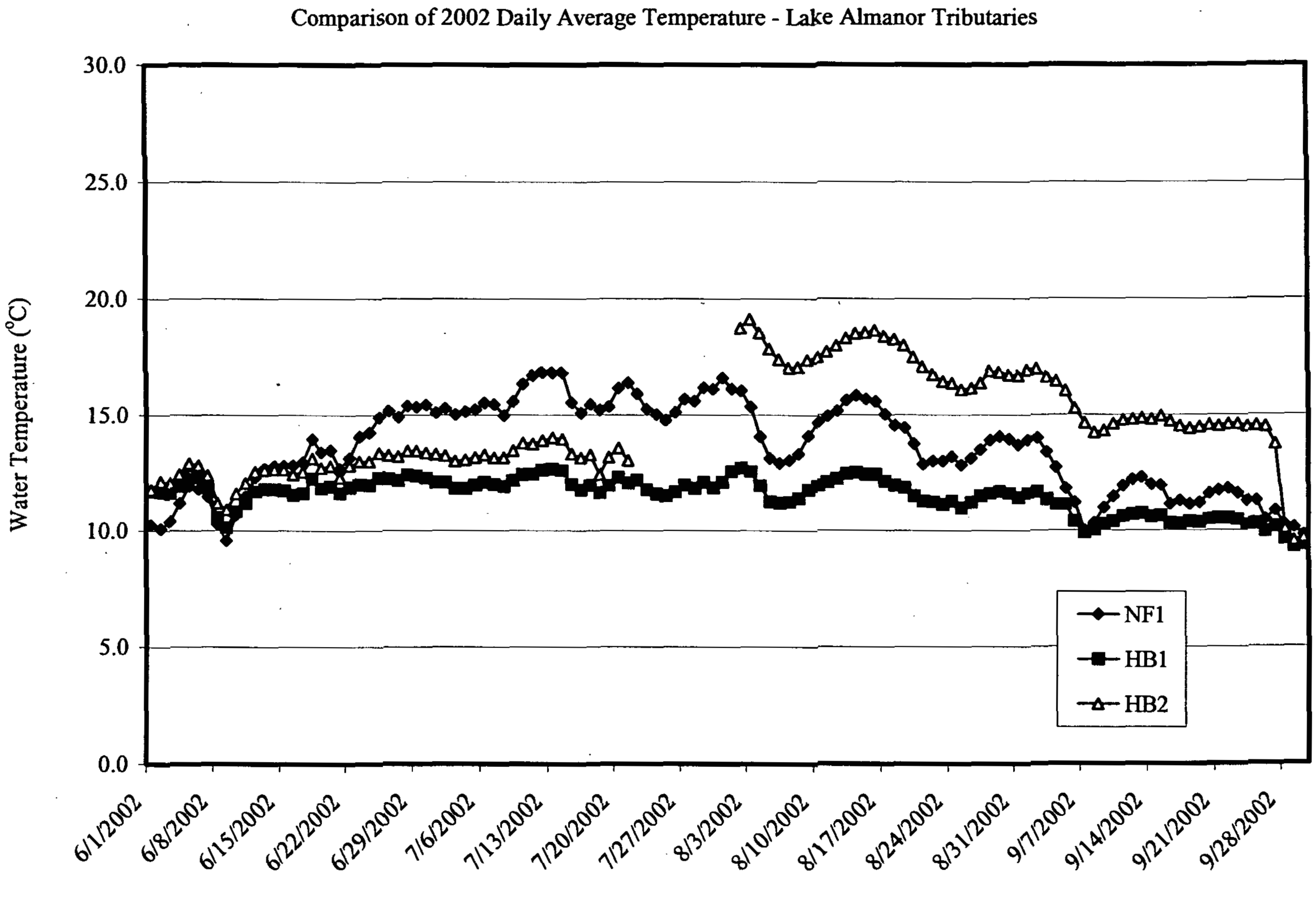


Figure 3-6. Comparison of daily average temperature at stations tributary to Lake Almanor – 2002

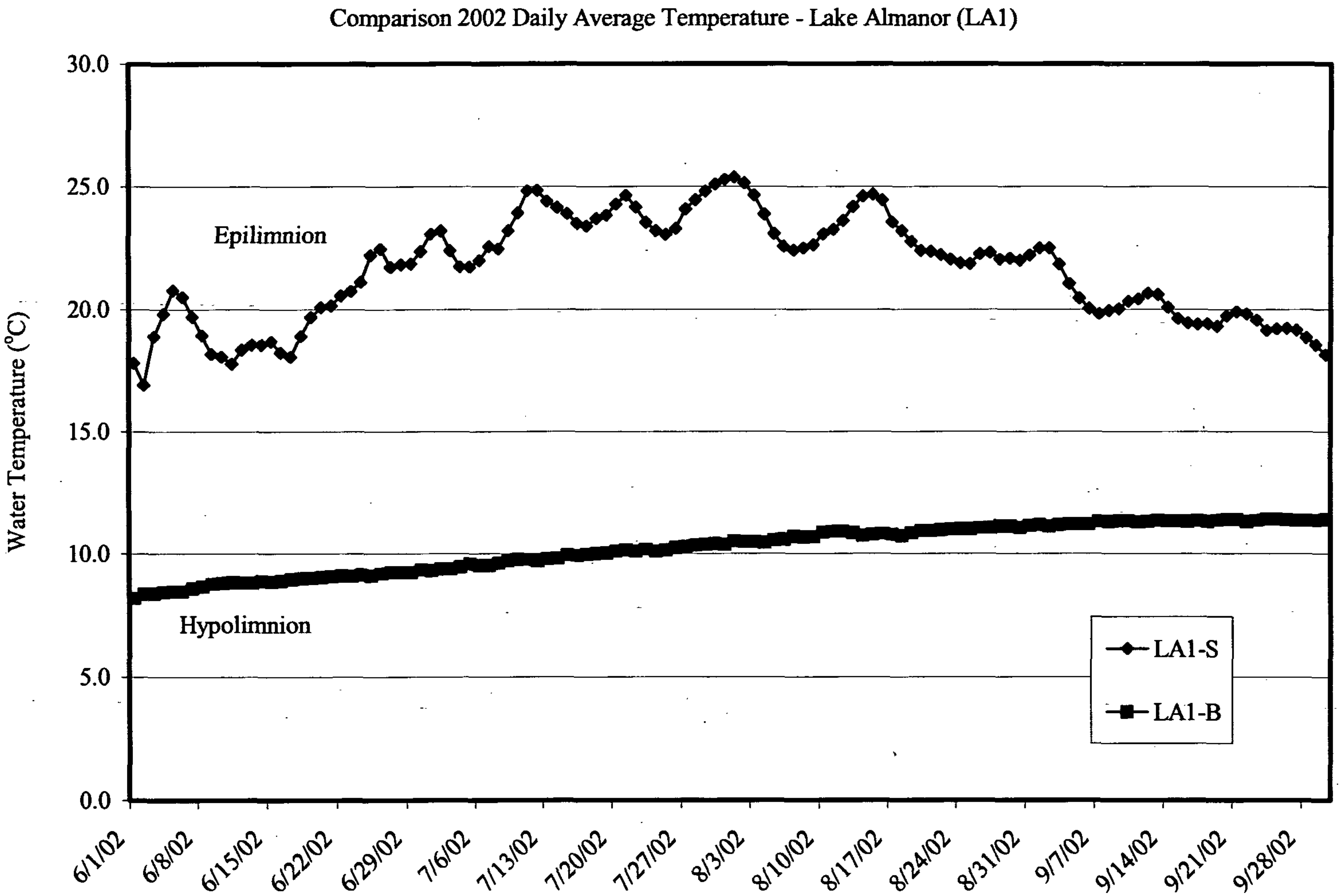


Figure 3-7. Comparison of mean daily temperatures from two depths in Lake Almanor near the Canyon Dam Intake – 2002

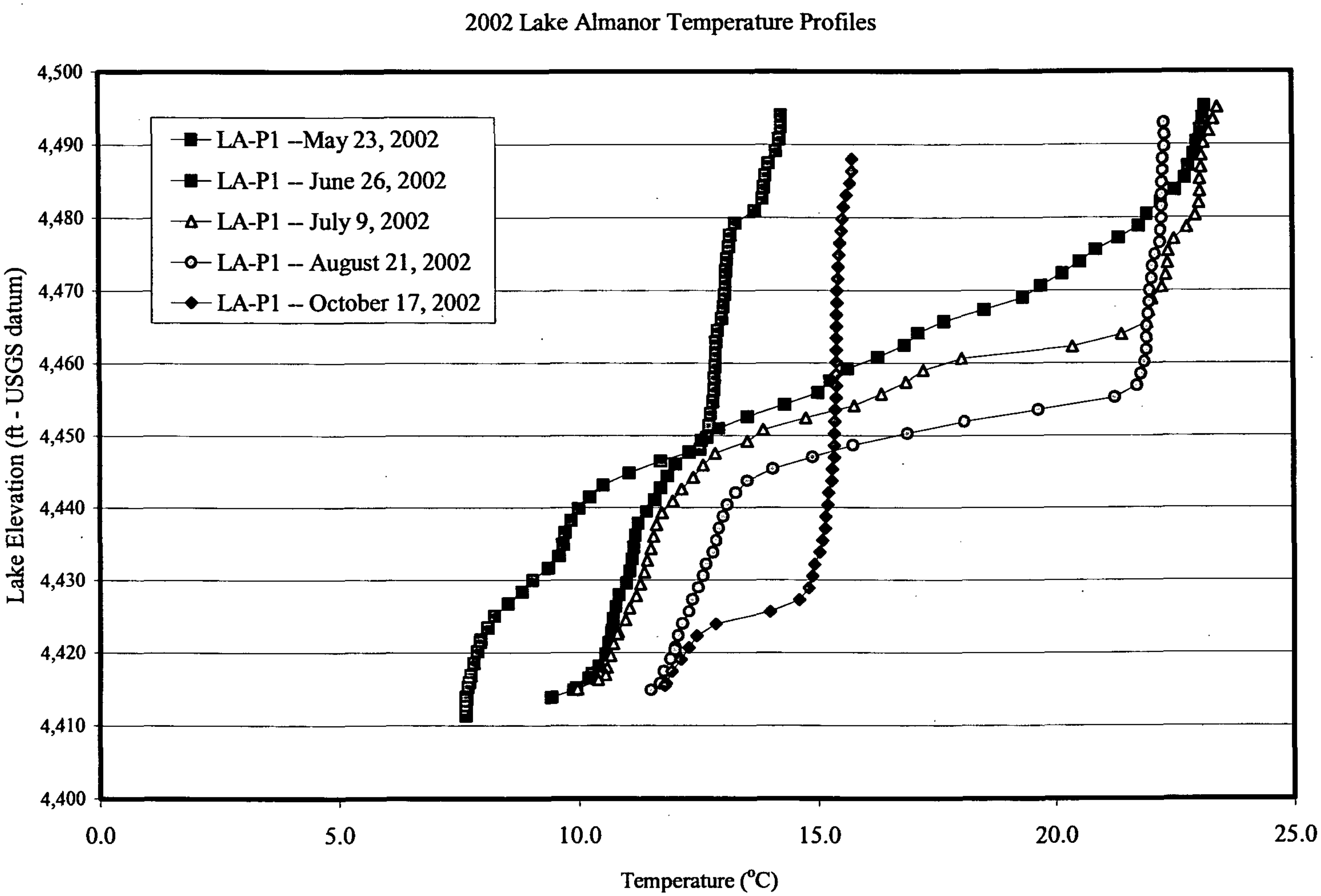
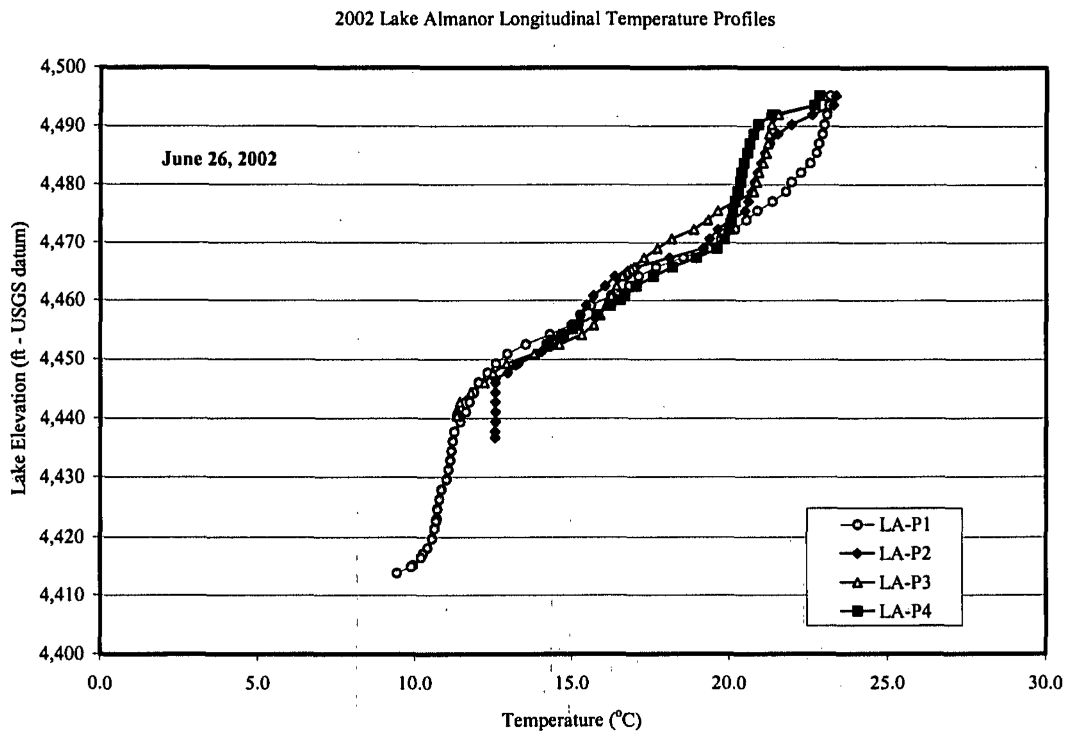
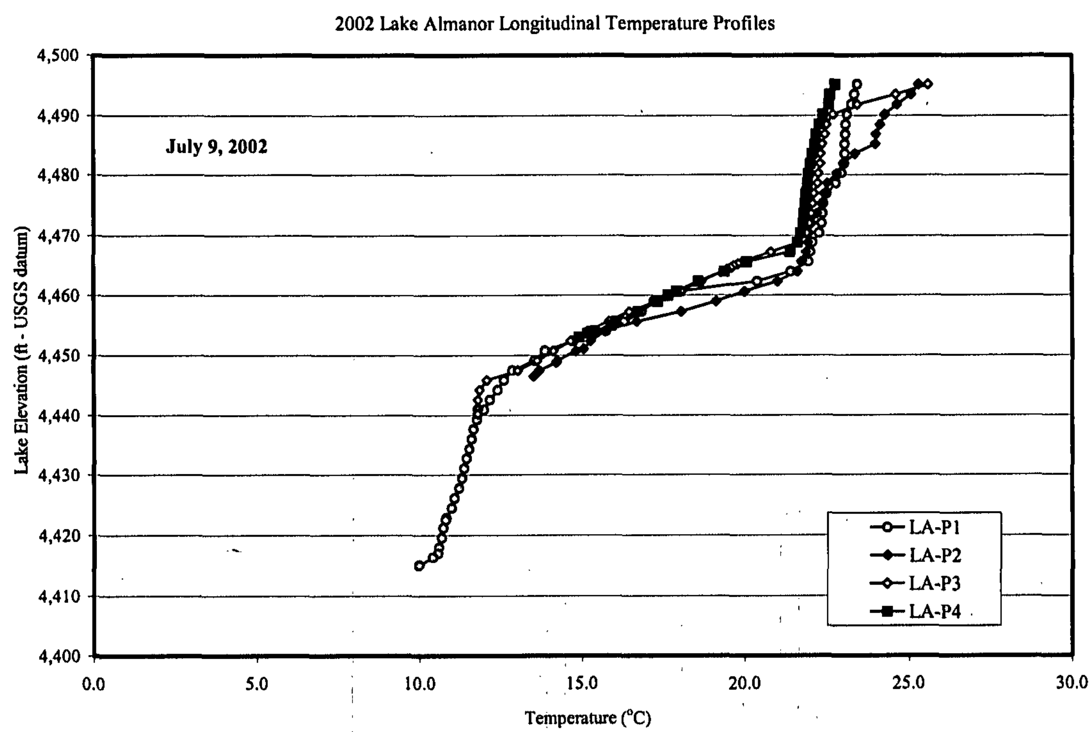


Figure 3-8. Comparison of monthly profiles from Lake Almanor (LA1) for the period June through September 2002

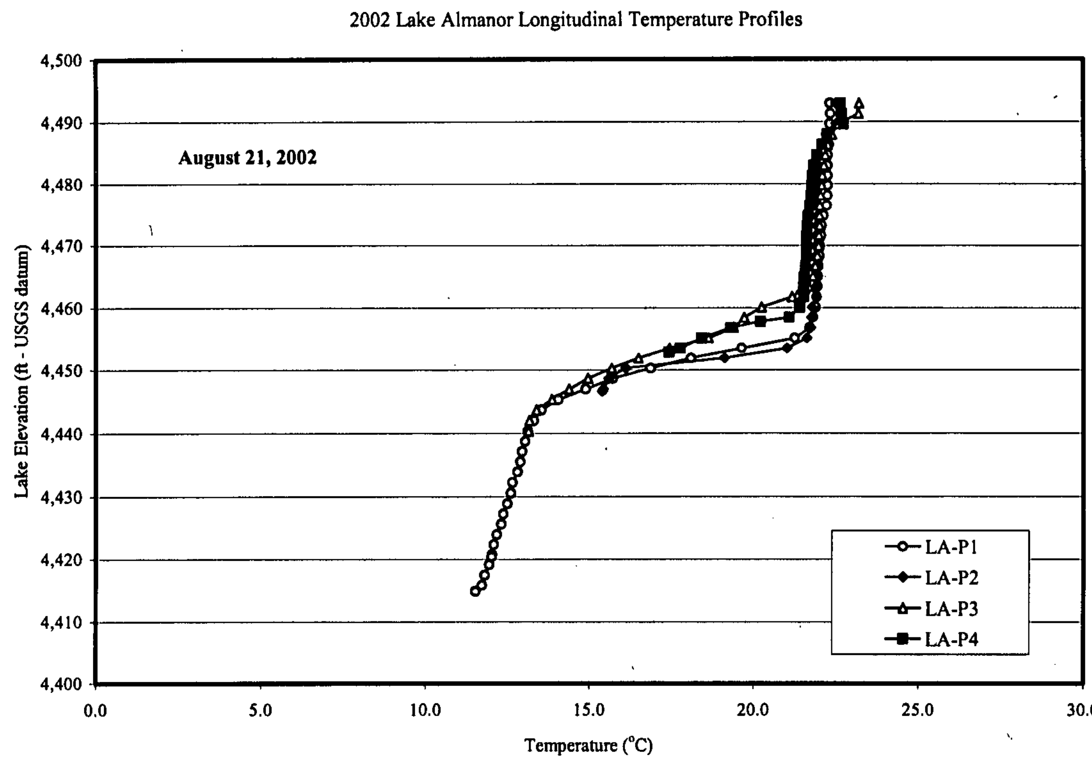


A. June 26, 2002 – Lake Almanor Profiles

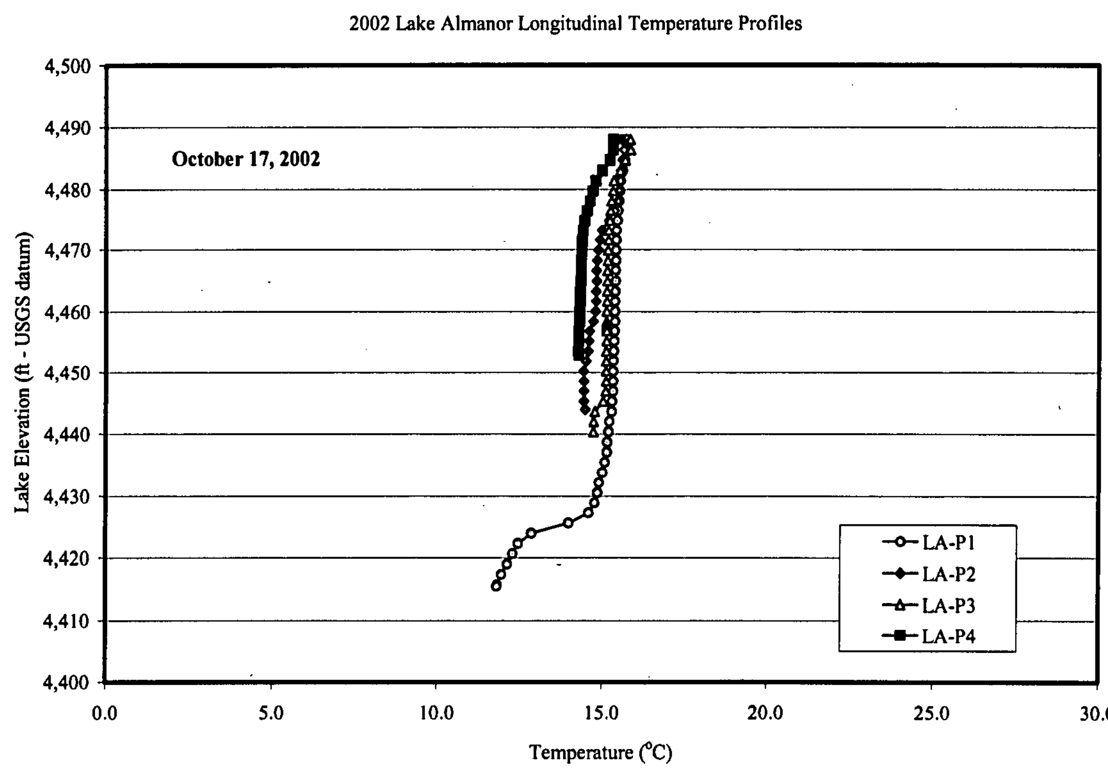


B. July 9, 2002 – Lake Almanor Profiles

Figure 3-9. Longitudinal thermal structure at four profile stations in Lake Almanor – 2002



C. August 21, 2002 – Lake Almanor Profiles



D. October 17, 2002 – Lake Almanor Profiles

Figure 3-9 (continued).

Longitudinal thermal structure at four profile stations in Lake Almanor – 2002

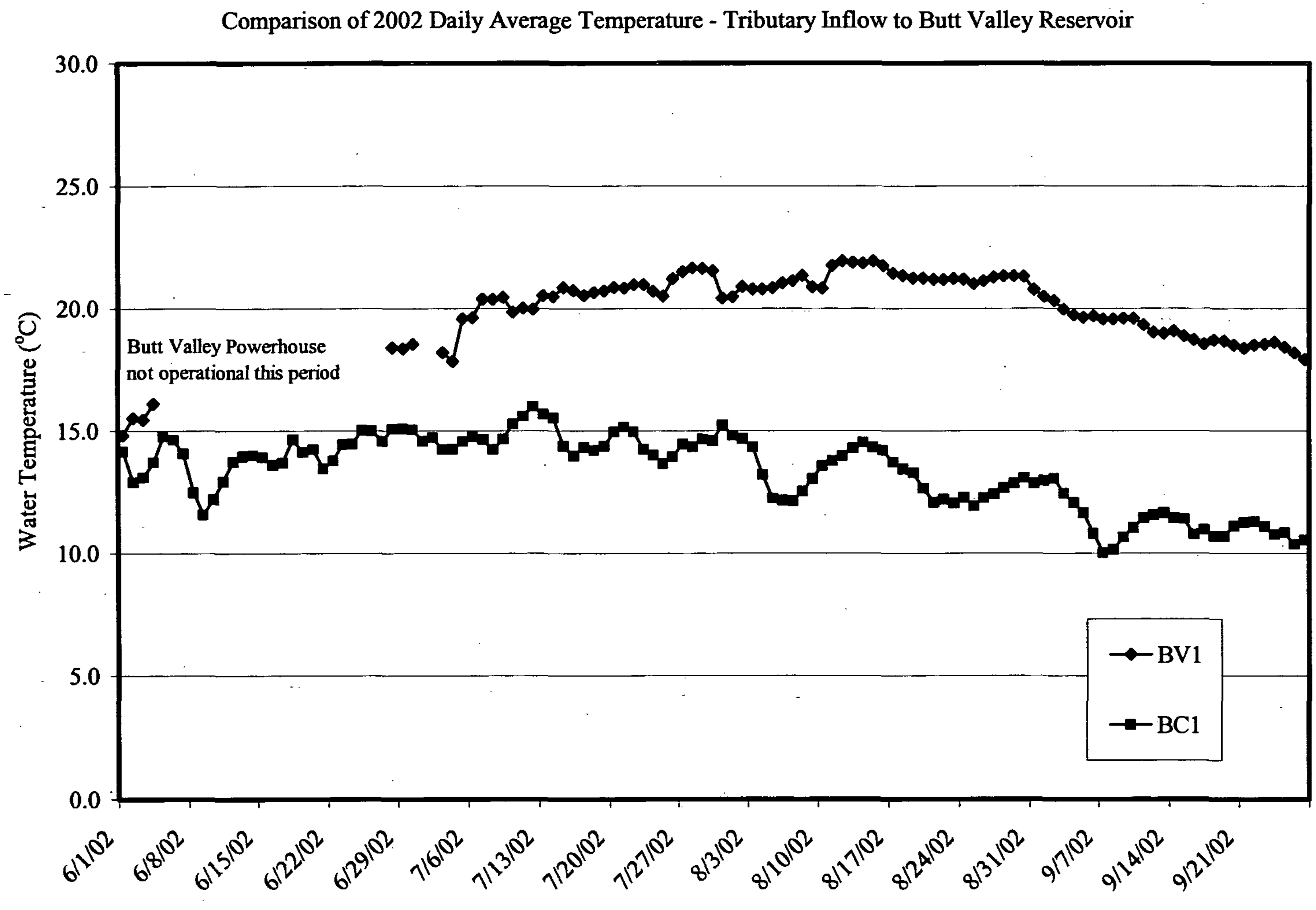


Figure 3-10. Comparison of daily average temperature at stations tributary to Butt Valley Reservoir – 2002

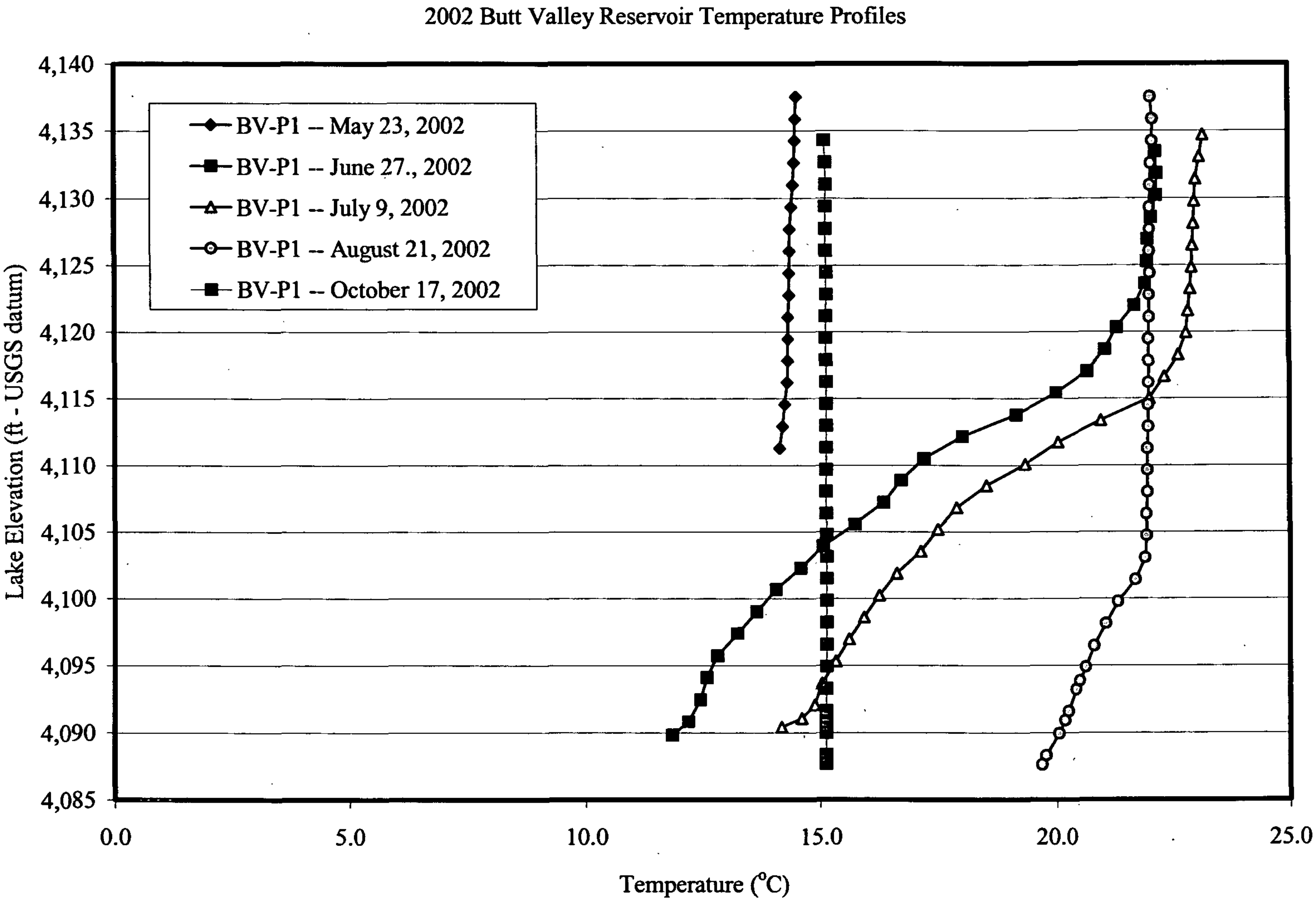
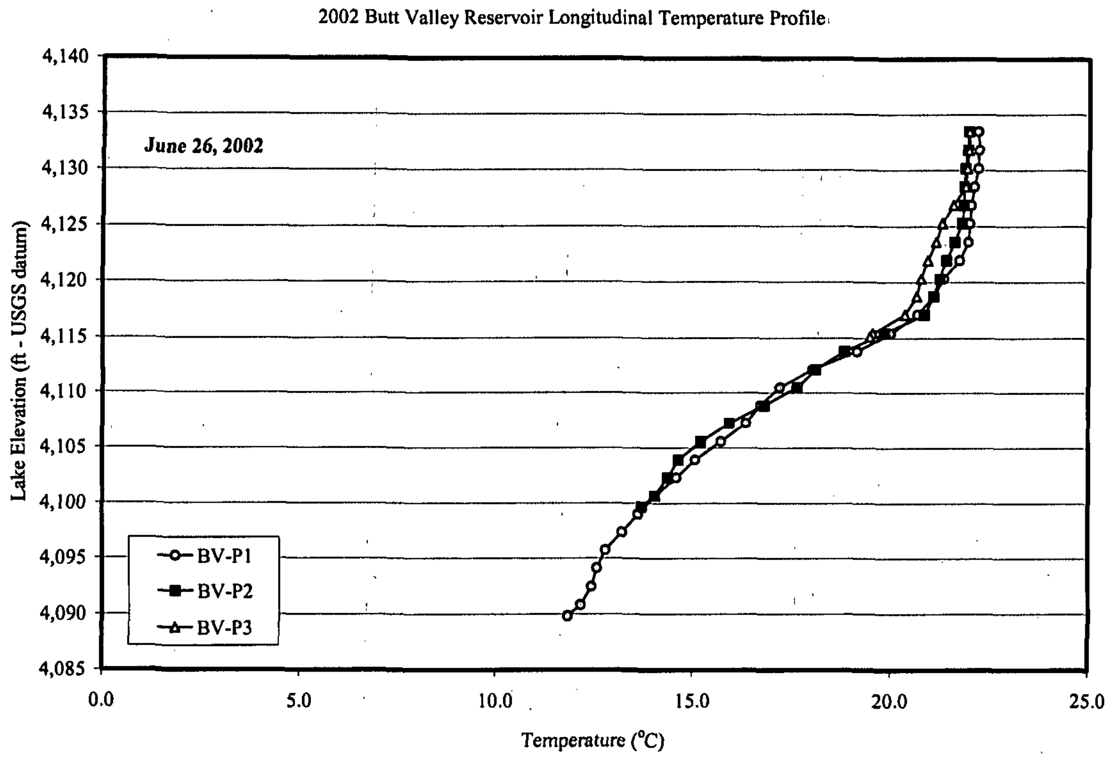
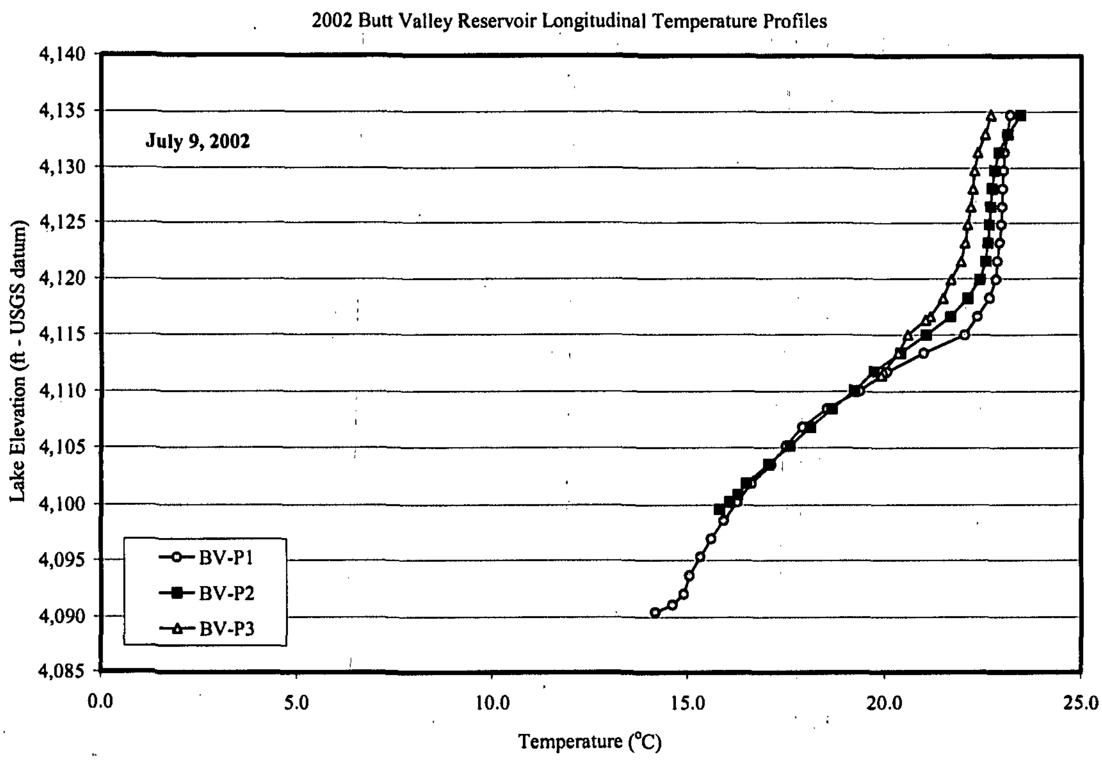


Figure 3-11. Comparison of monthly profiles from Butt Valley Reservoir (BV2-A) for the period June through September 2002

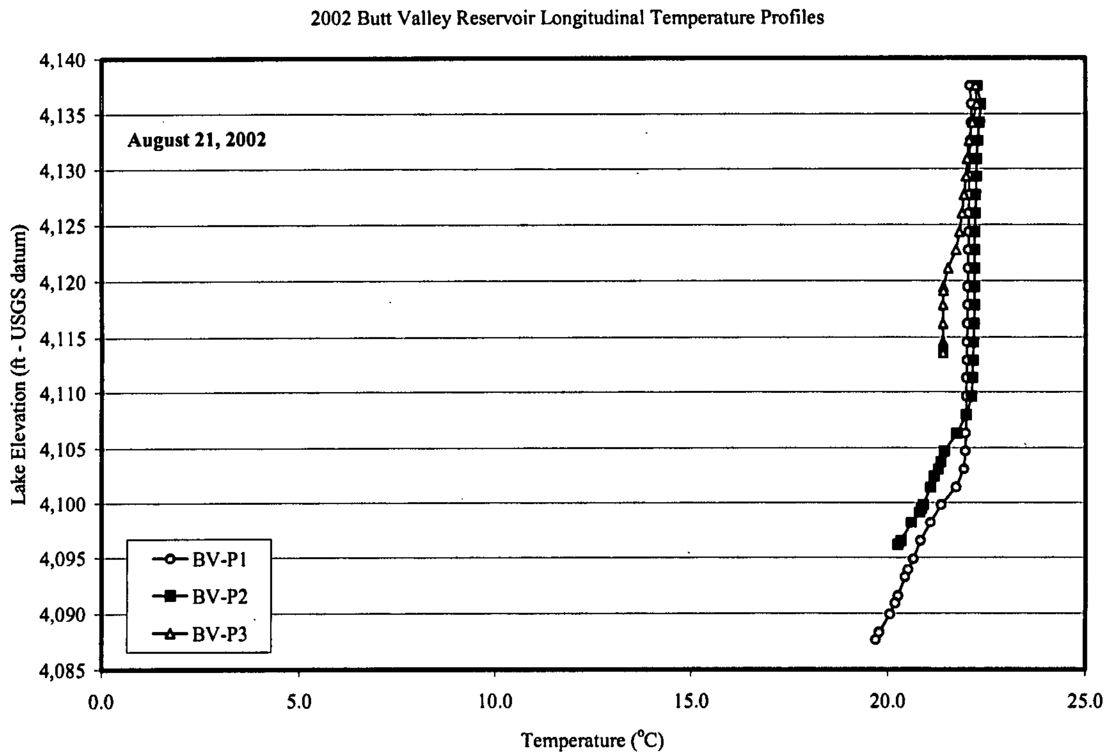


A. June 26, 2002 – Butt Valley Reservoir Profiles

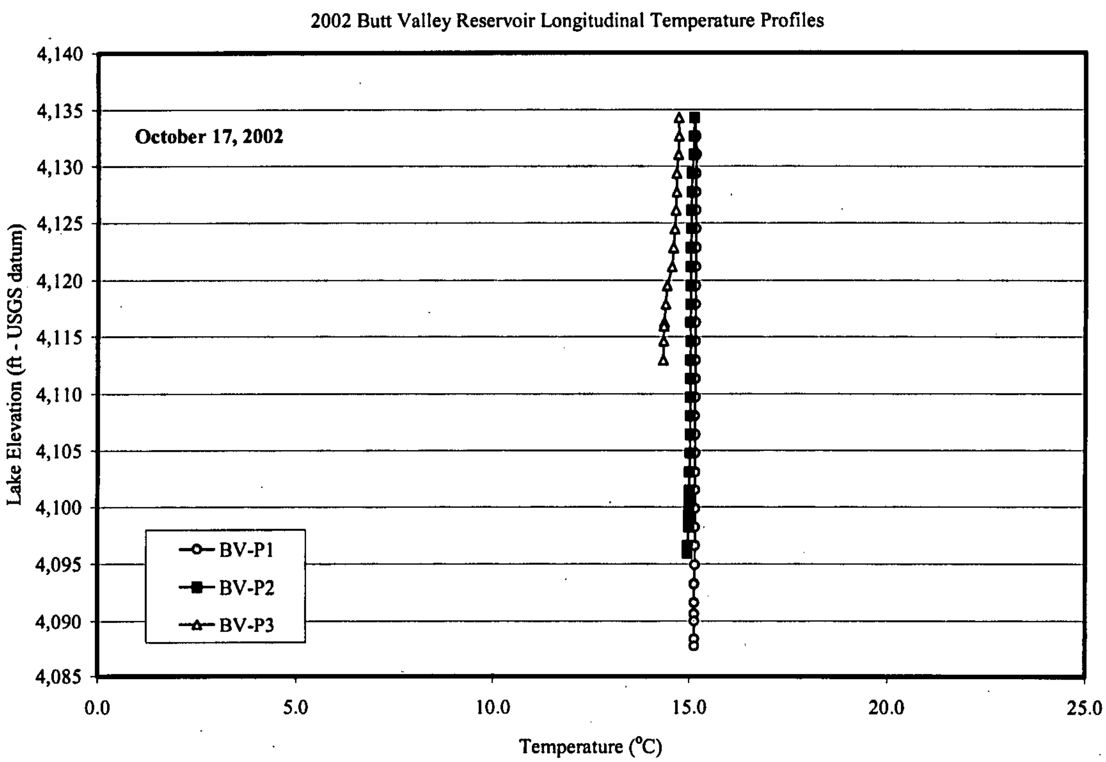


B. July 9, 2002 – Butt Valley Reservoir Profiles

Figure 3-12. Longitudinal thermal structure at three stations in Butt Valley Reservoir – 2002



C. August 21, 2002 – Butt Valley Reservoir Profiles



D. October 17, 2002 – Butt Valley Reservoir Profiles

Figure 3-12 (continued).

Longitudinal thermal structure at three stations in Butt Valley Reservoir – 2002

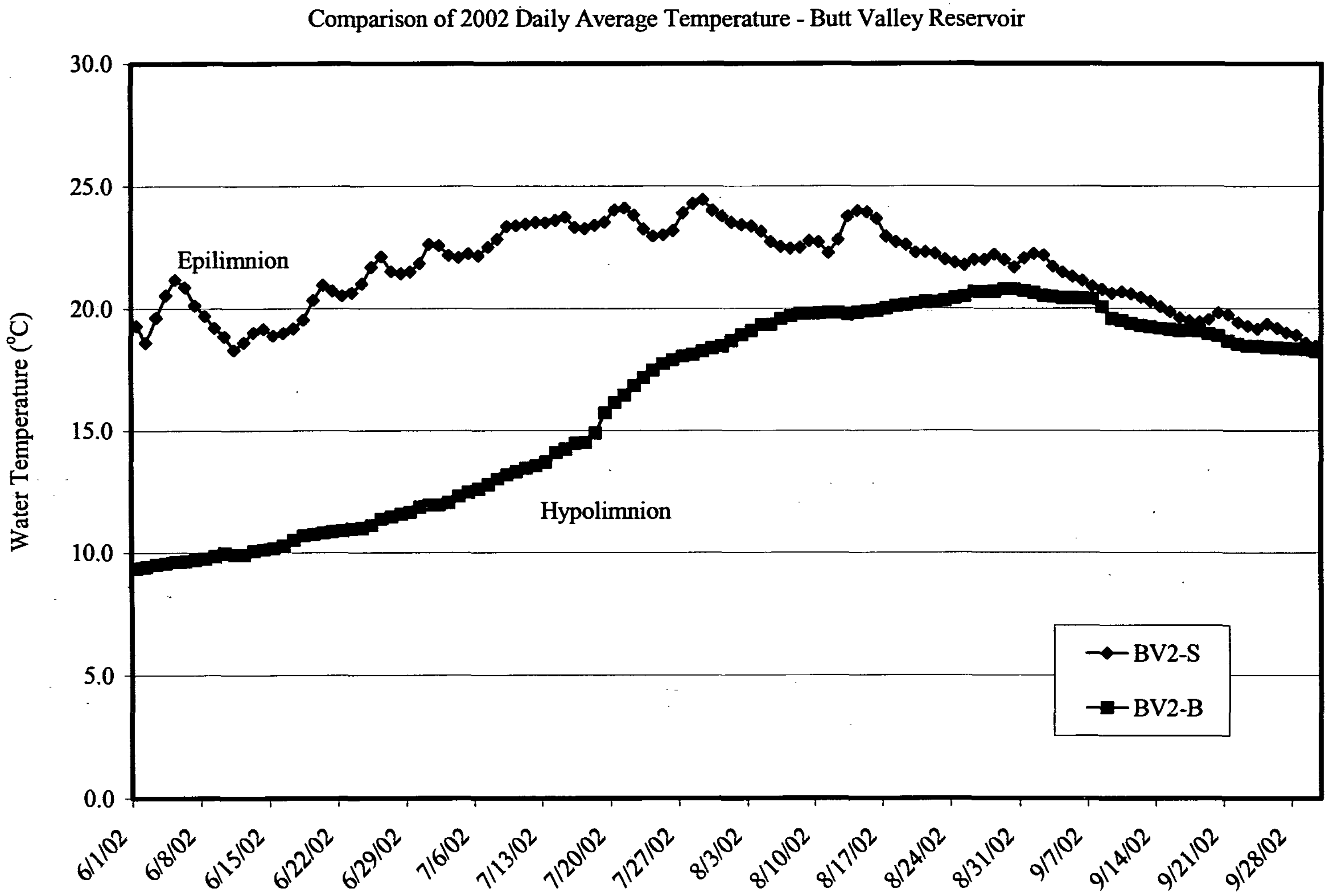


Figure 3-13. Comparison of mean daily temperatures from two depths in Butt Valley Reservoir near Caribou No. 1 Intake – 2002

Comparison of 2002 Daily Average Temperature - Seneca Reach of the NFFR

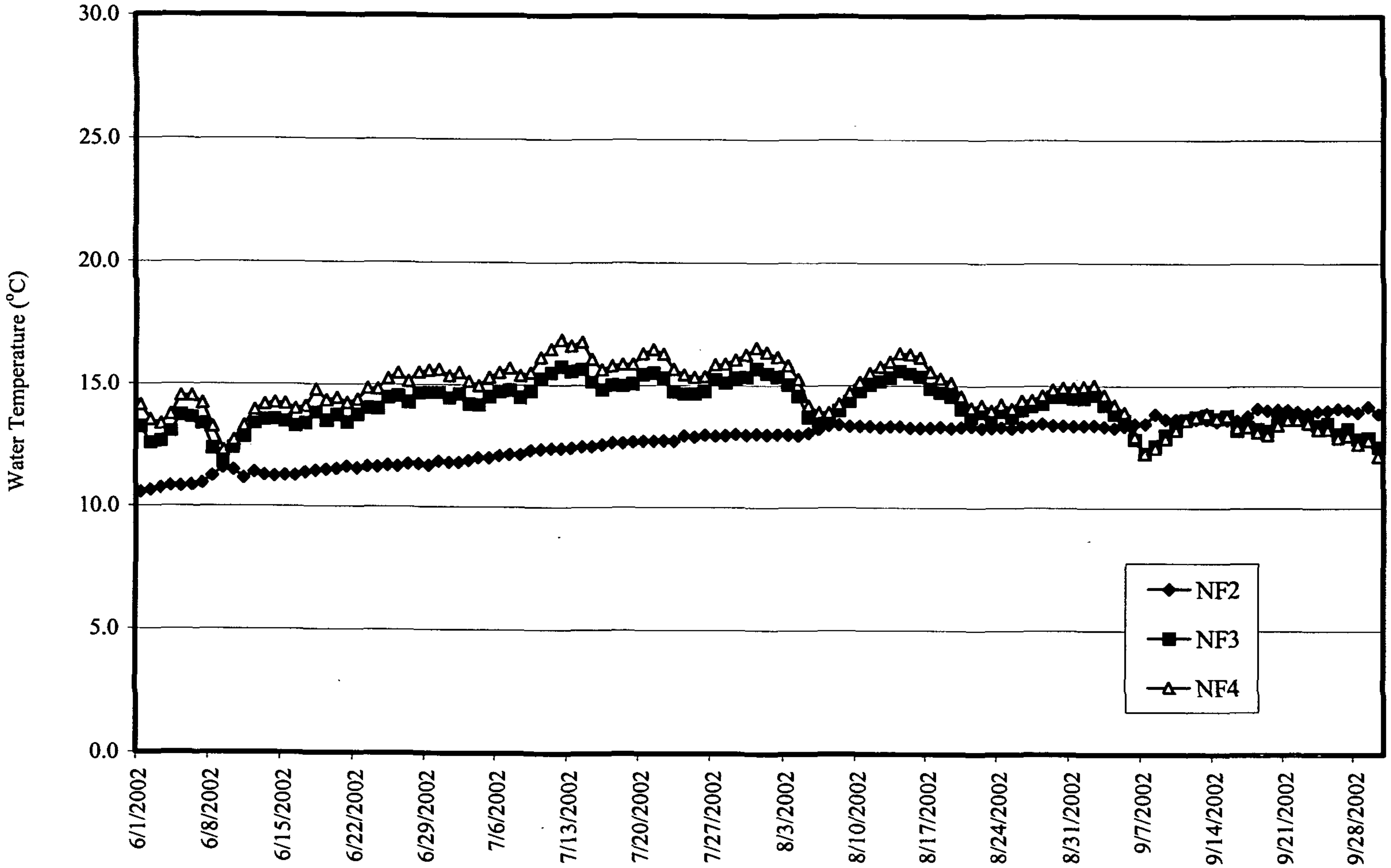


Figure 3-14. Comparison of daily average temperatures in the Seneca Reach – 2002

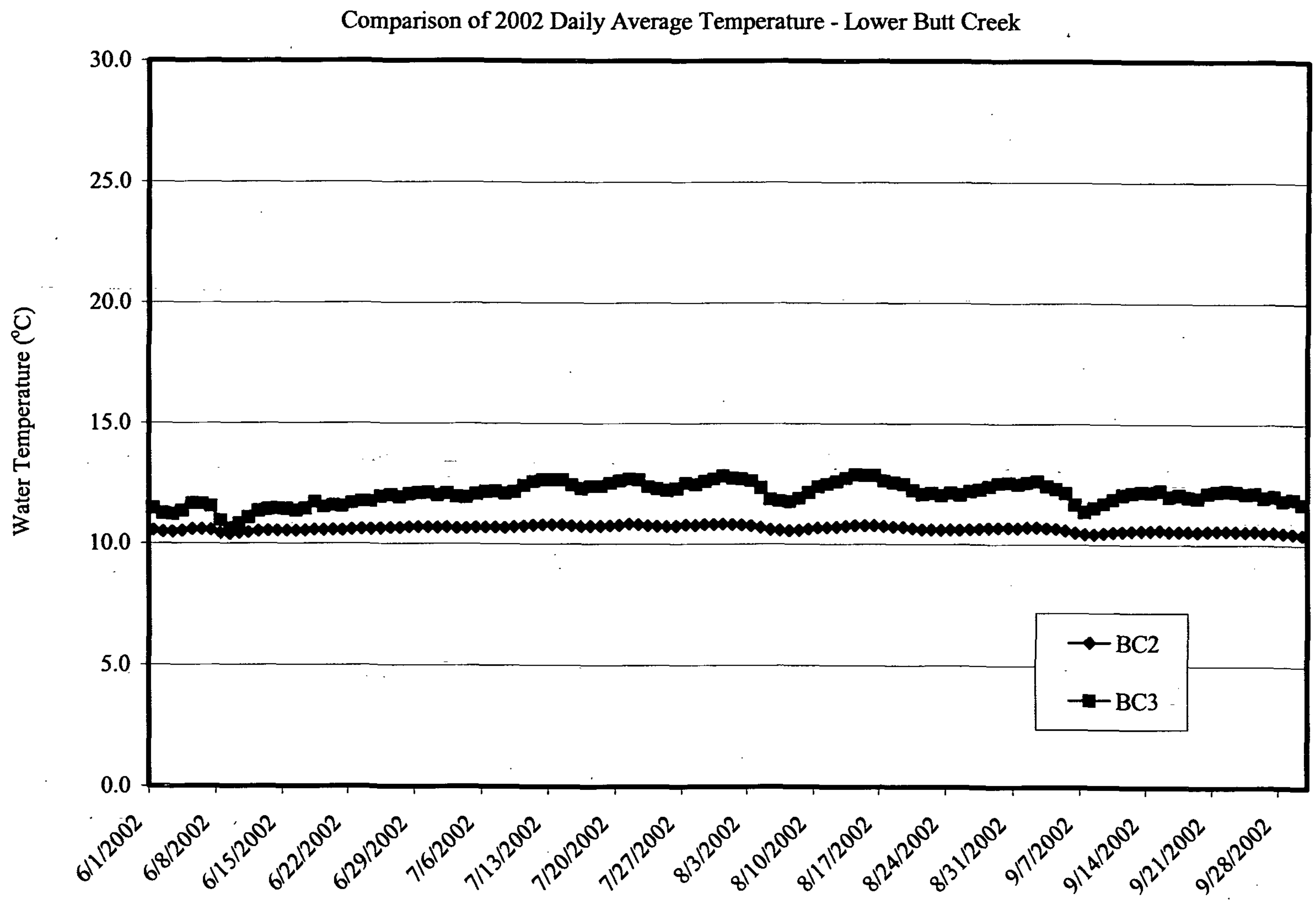


Figure 3-15. Comparison of daily average temperatures in lower Butt Creek – 2002

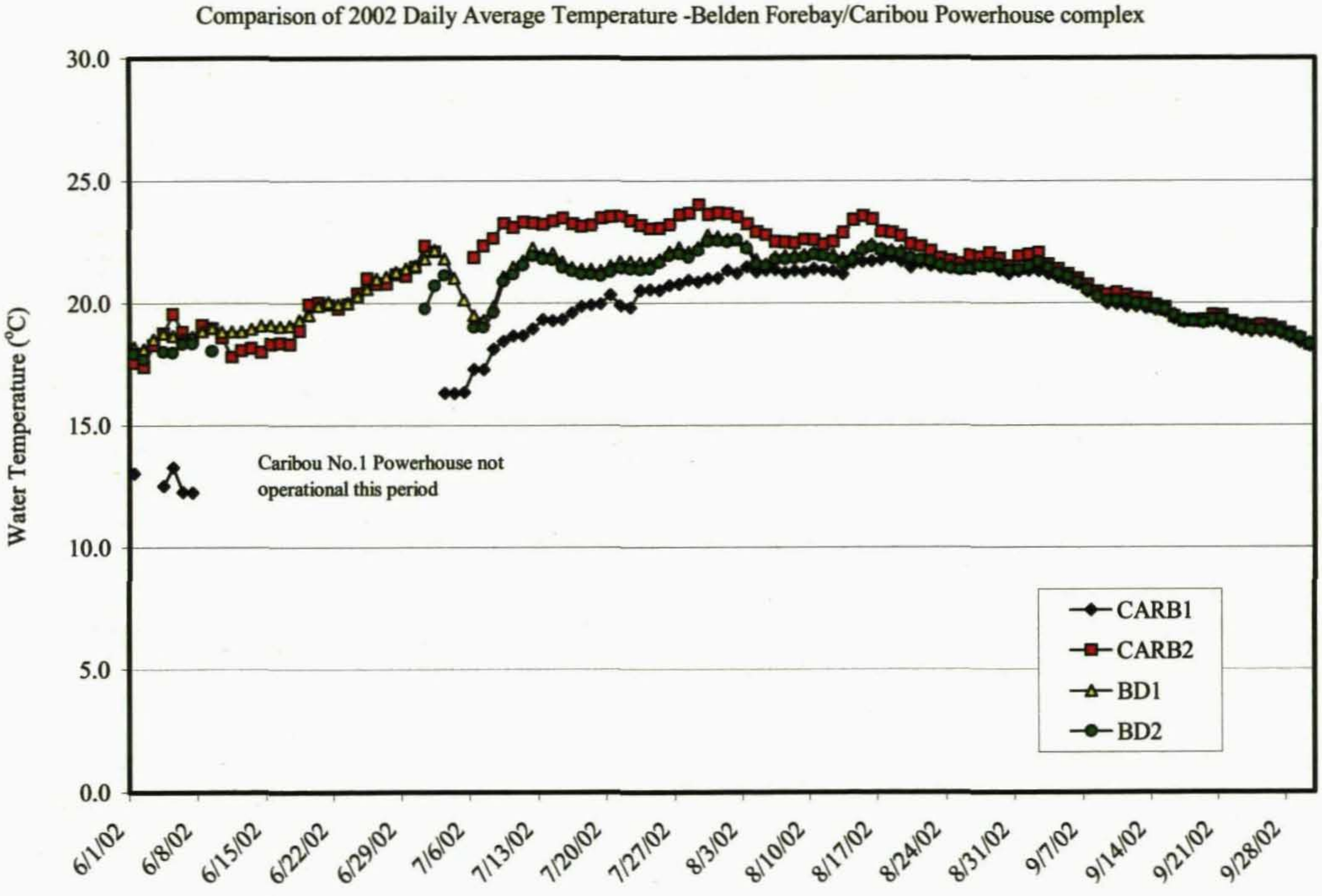


Figure 3-16. Comparison of daily average temperatures from the Caribou Powerhouse/Belden Forebay complex – 2002

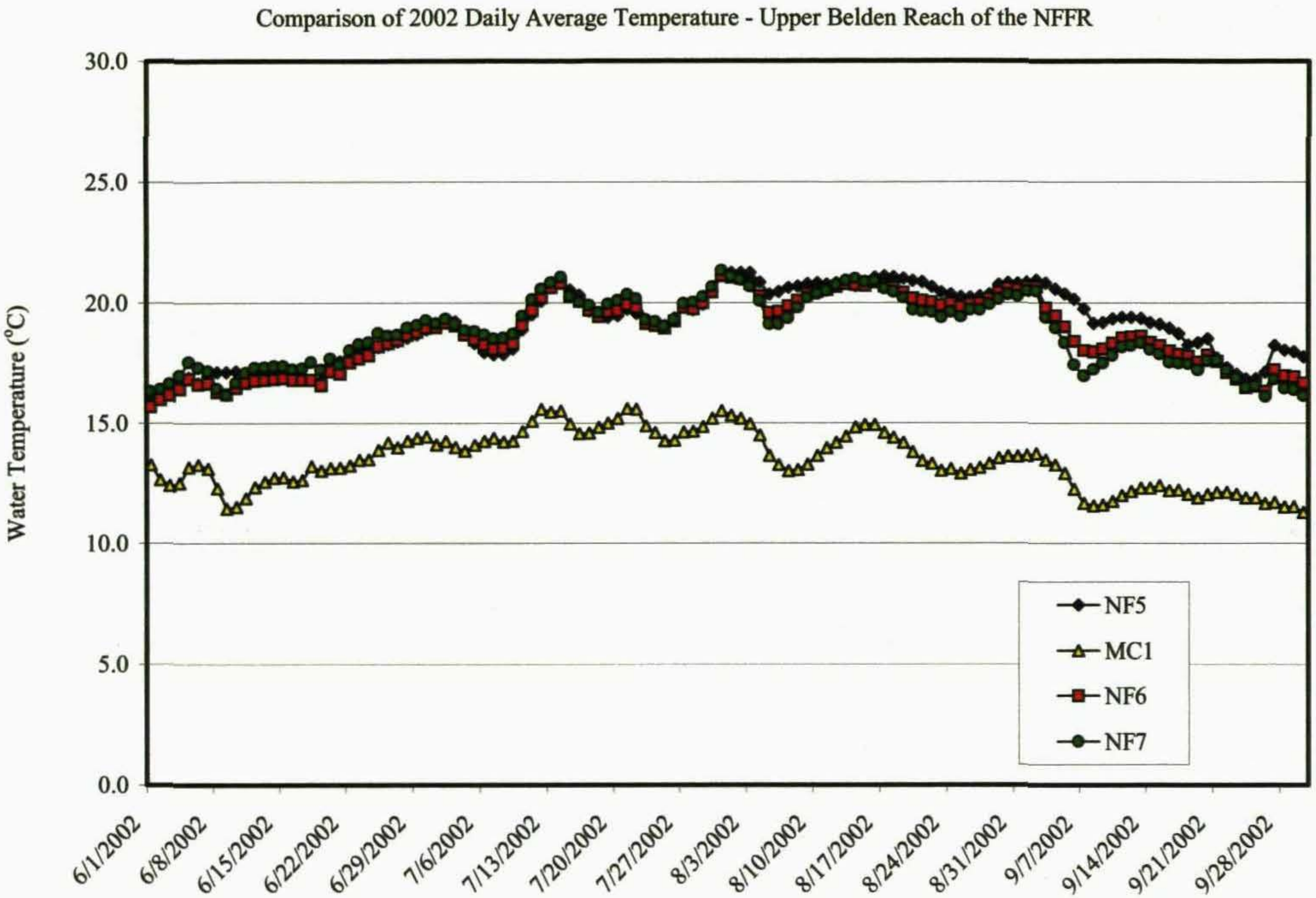


Figure 3-17. Comparison of daily average temperatures in the upper Belden Reach – 2002

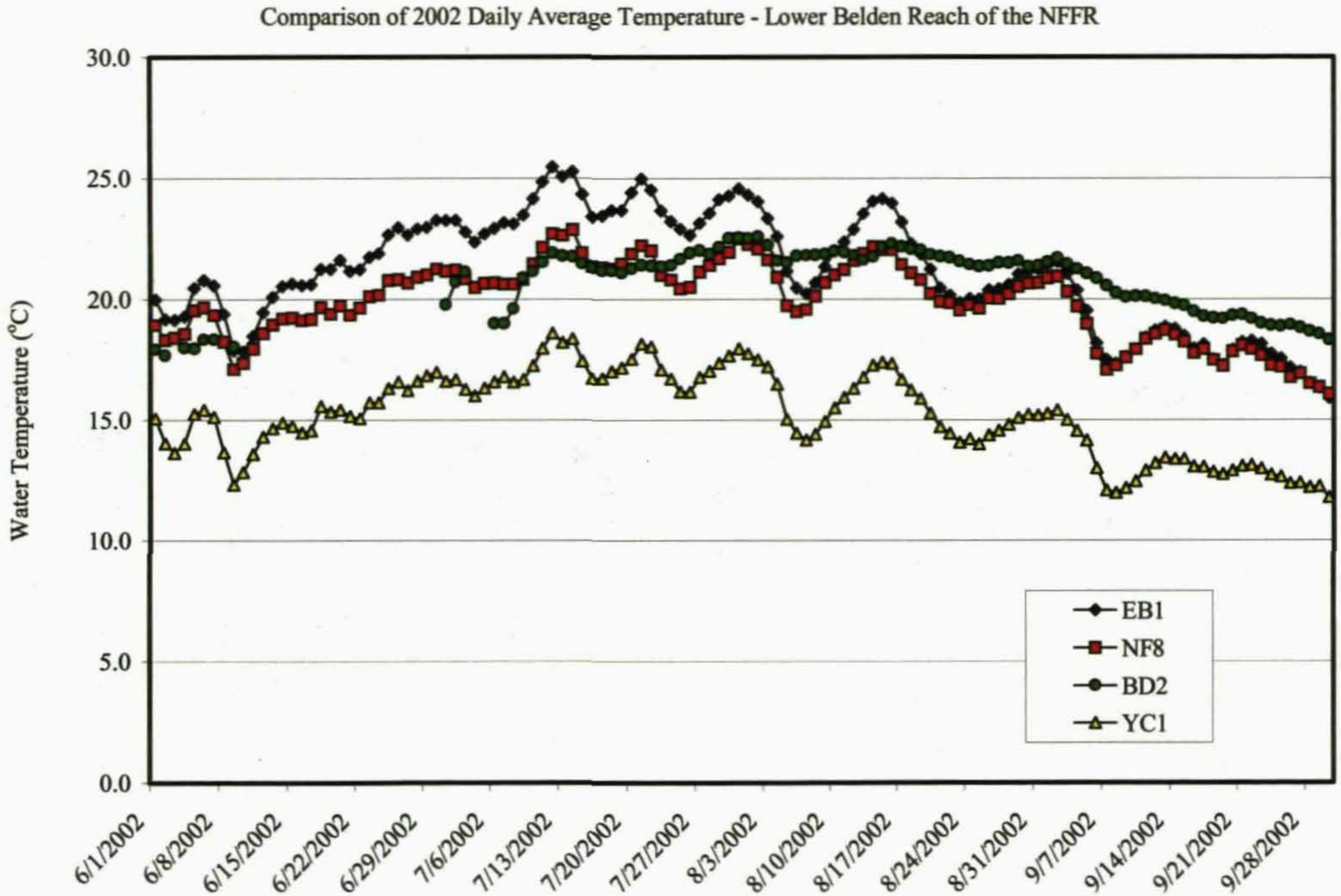


Figure 3-18. Comparison of daily average temperatures in the lower Belden Reach – 2002

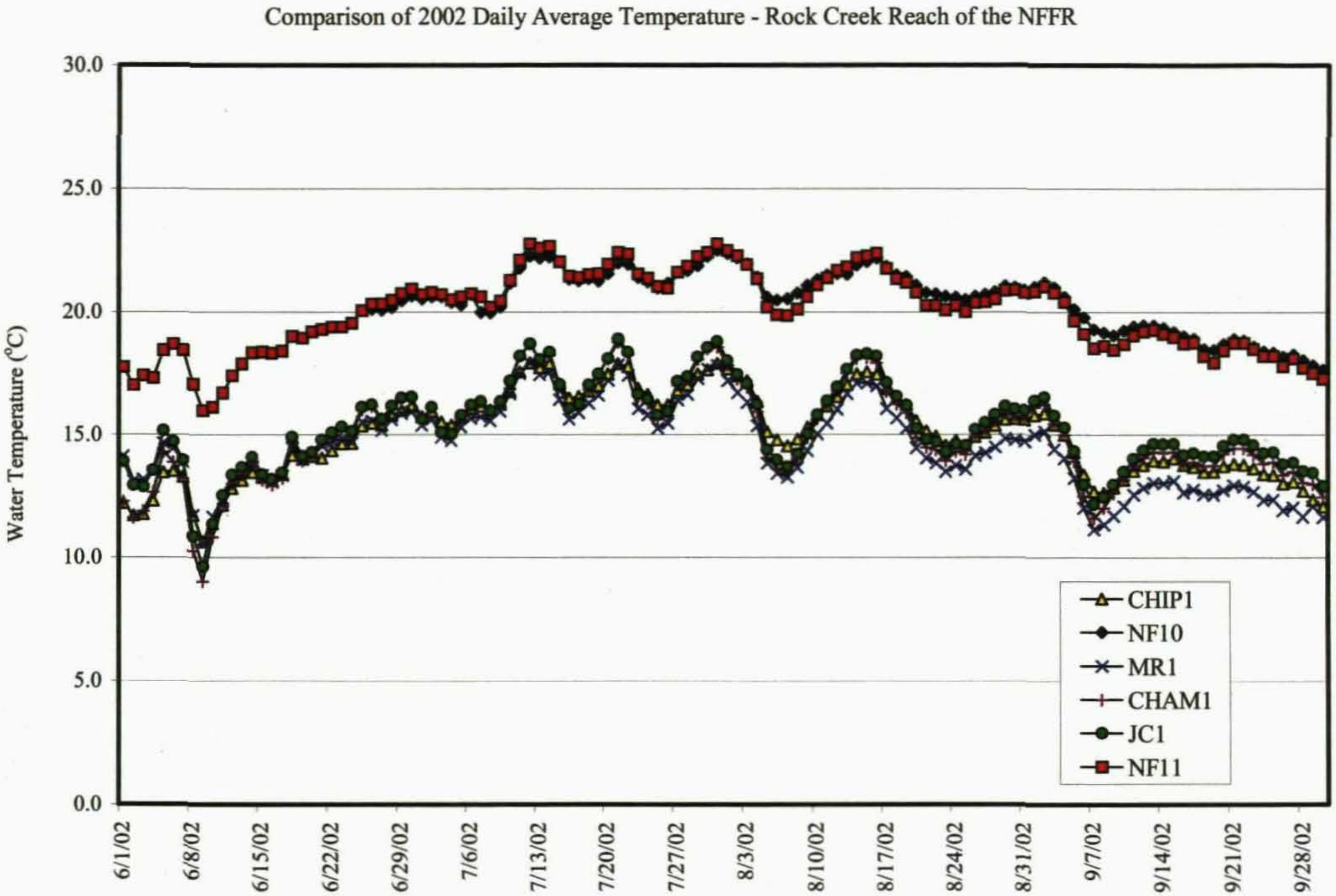


Figure 3-19. Comparison of daily average temperatures from stations in the upper Rock Creek Reach – 2002

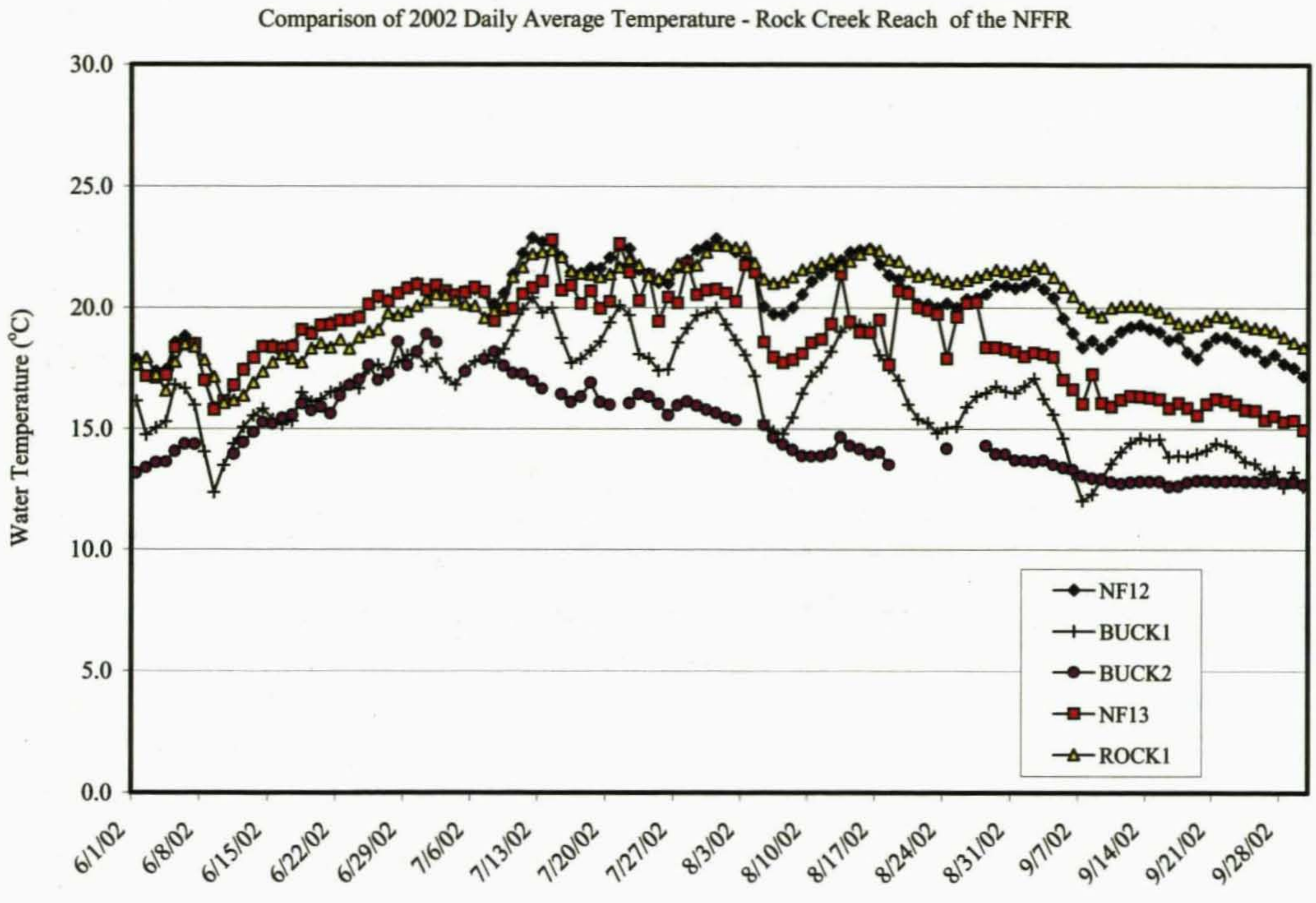


Figure 3-20. Comparison of daily average temperatures from stations in the lower Rock Creek Reach – 2002

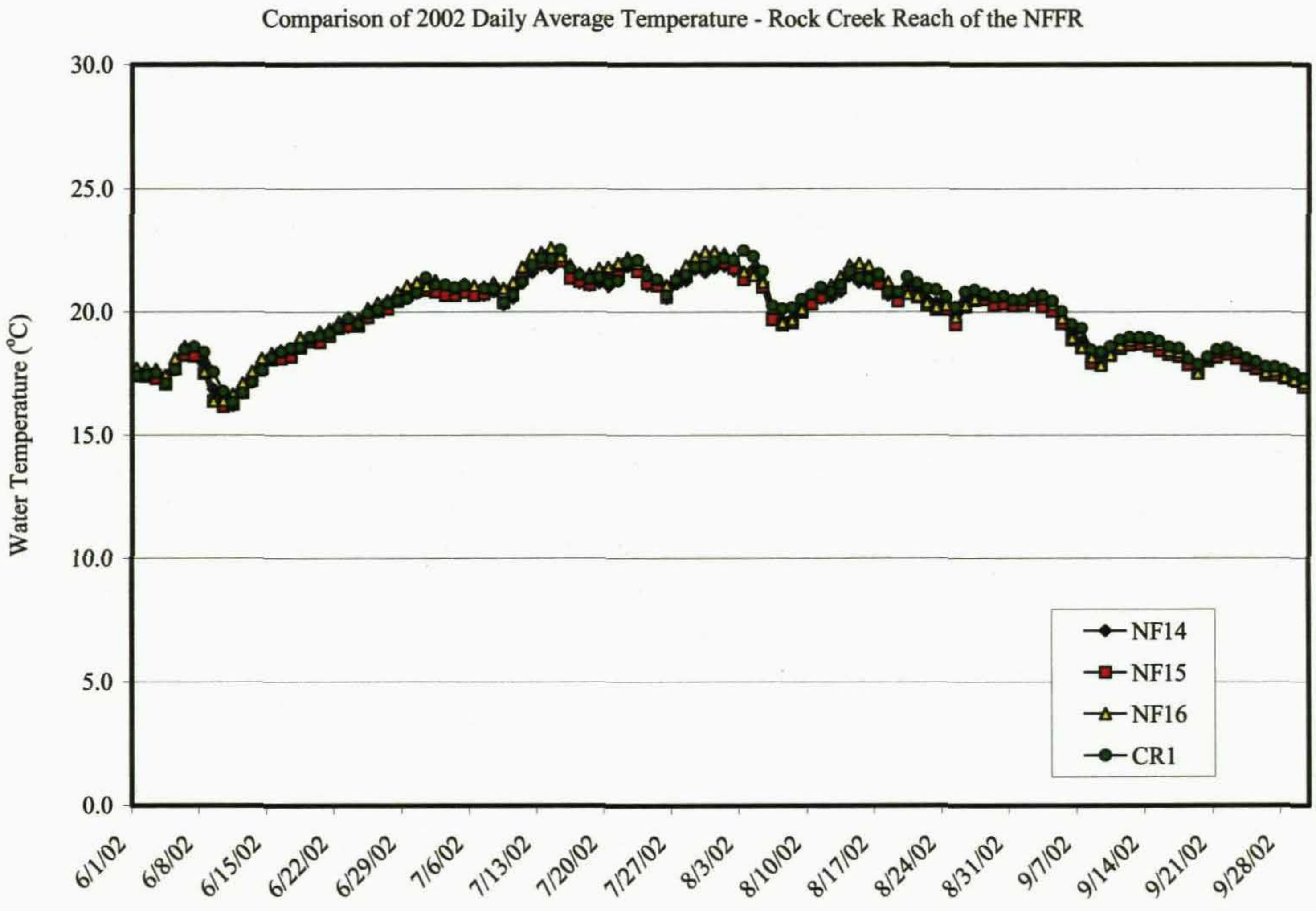


Figure 3-21. Comparison of daily average temperatures from river stations in the Cresta Reach – 2002

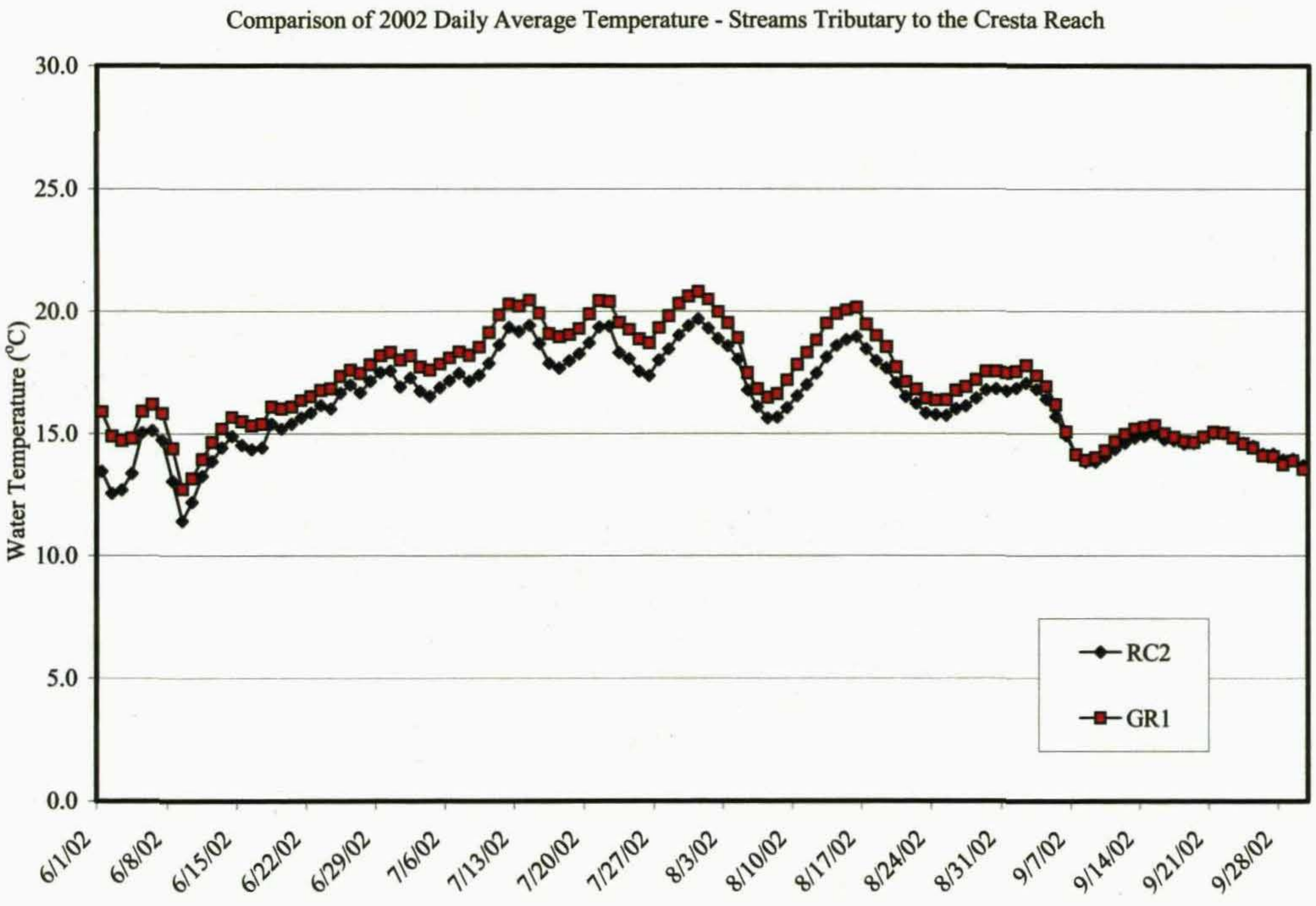


Figure 3-22. Comparison of daily average temperatures in streams tributary to the Cresta Reach – 2002

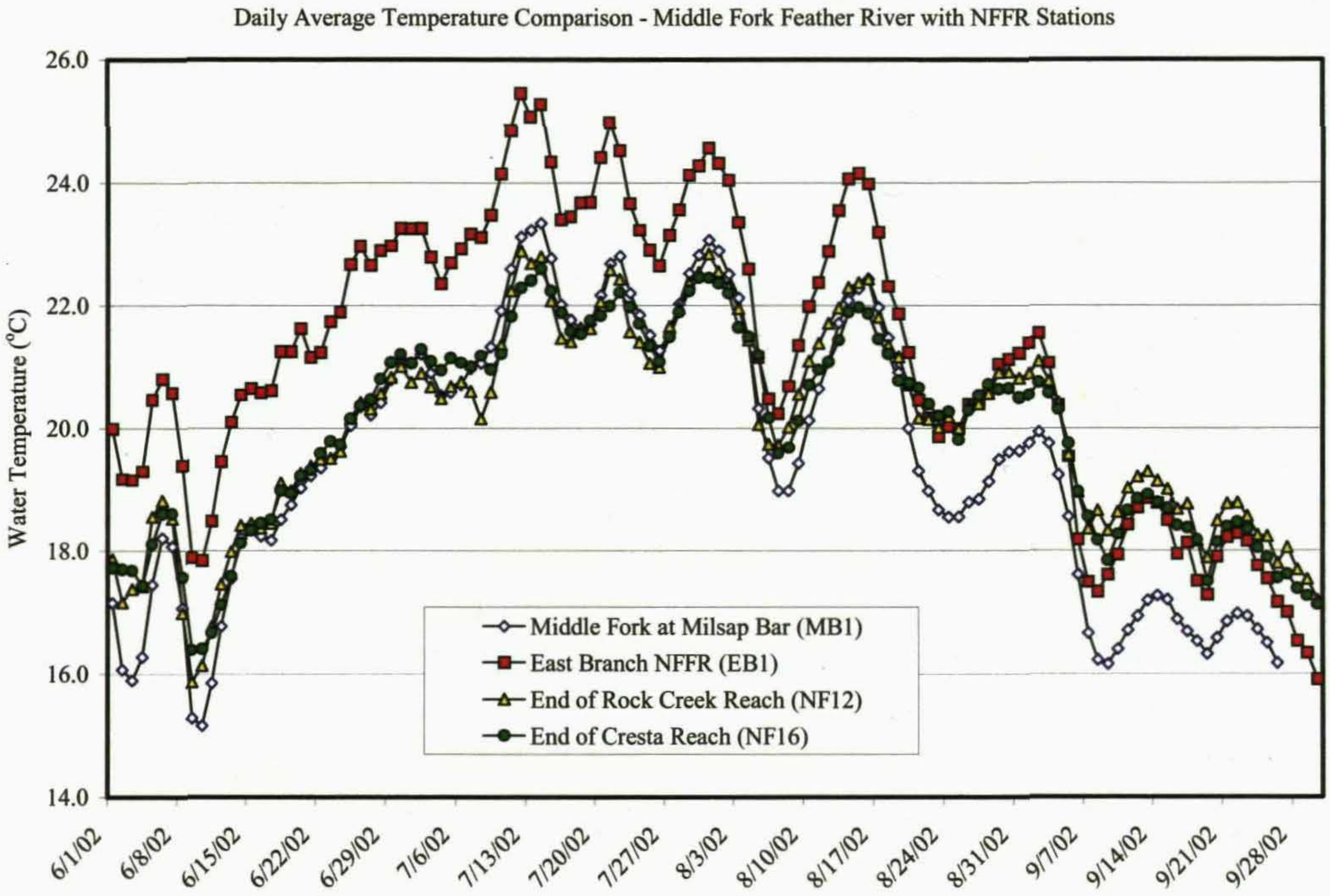


Figure 3-23. Comparison of daily average temperatures from MFFR at Milsap Bar with selected NFFR stations - 2002

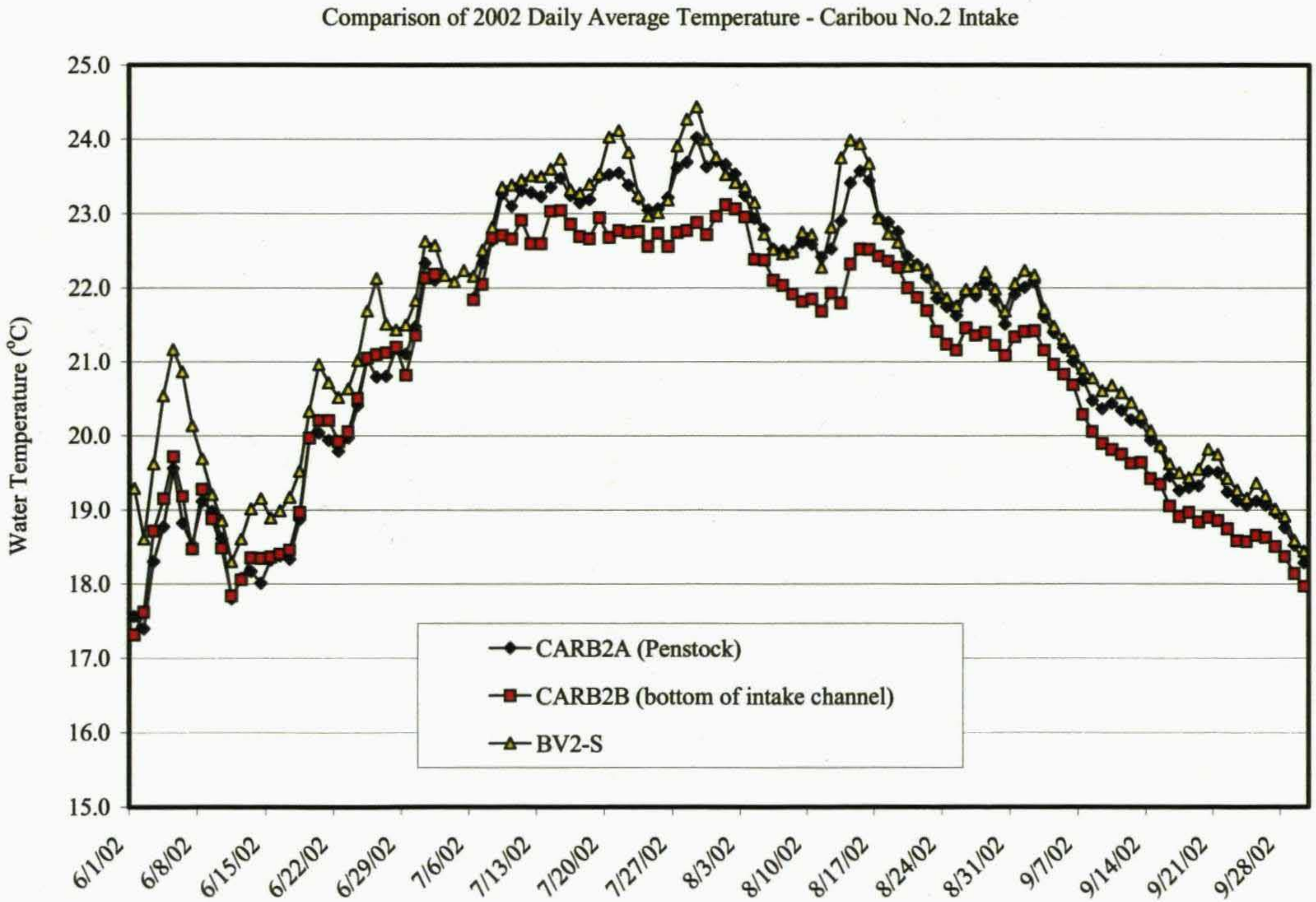
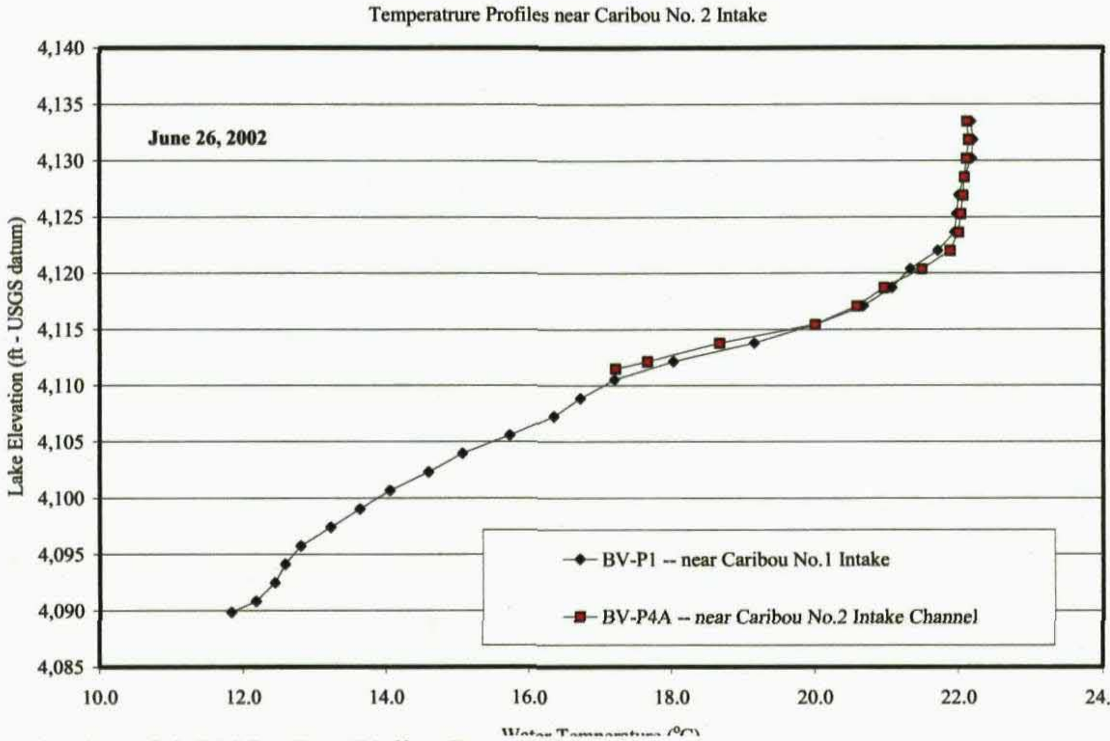
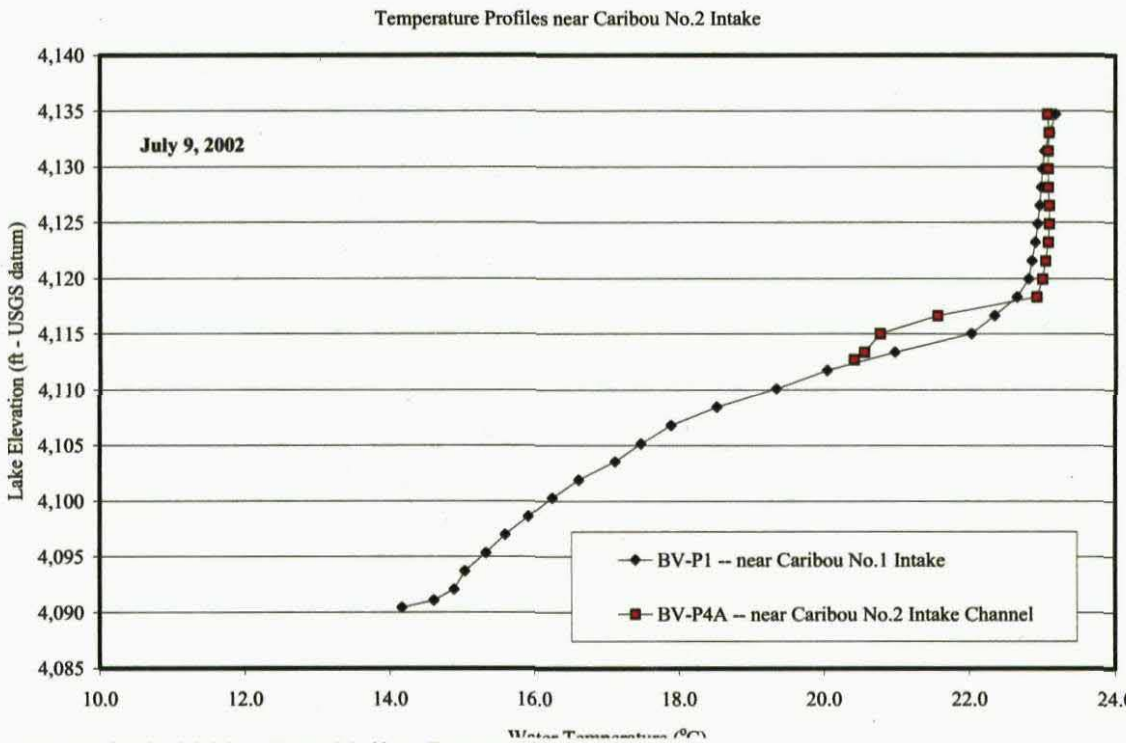


Figure 3-24. Comparison of daily average temperatures from three stations associated with the Caribou No.2 intake – 2002

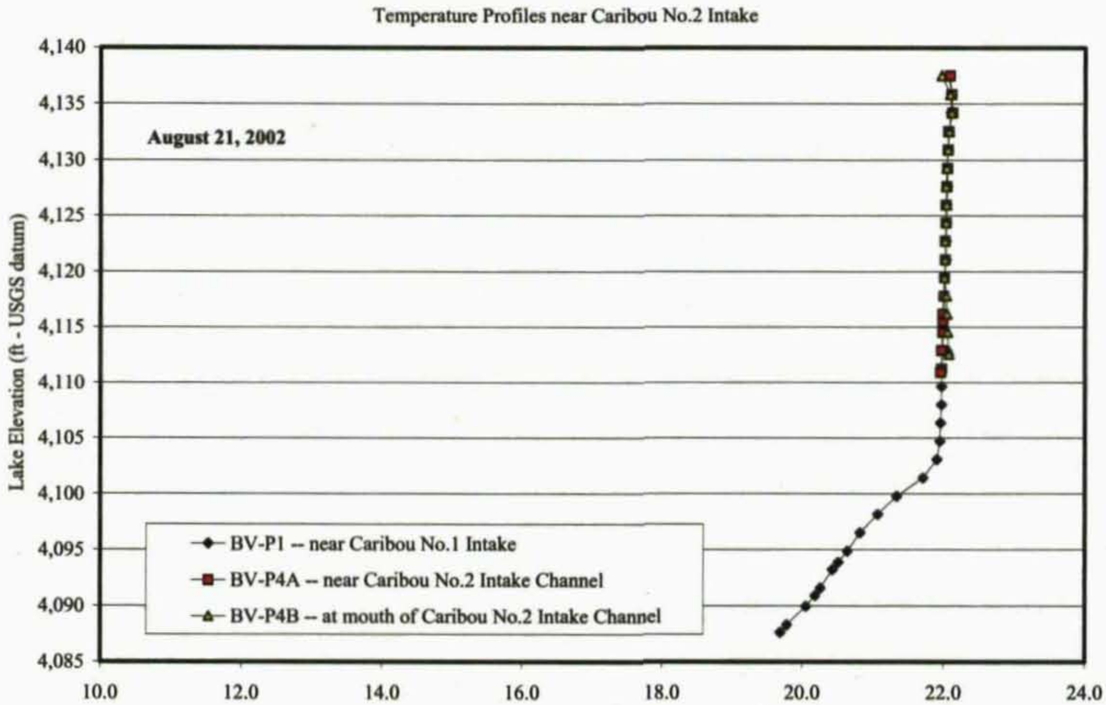


A. June 26, 2002 – Butt Valley Reservoir

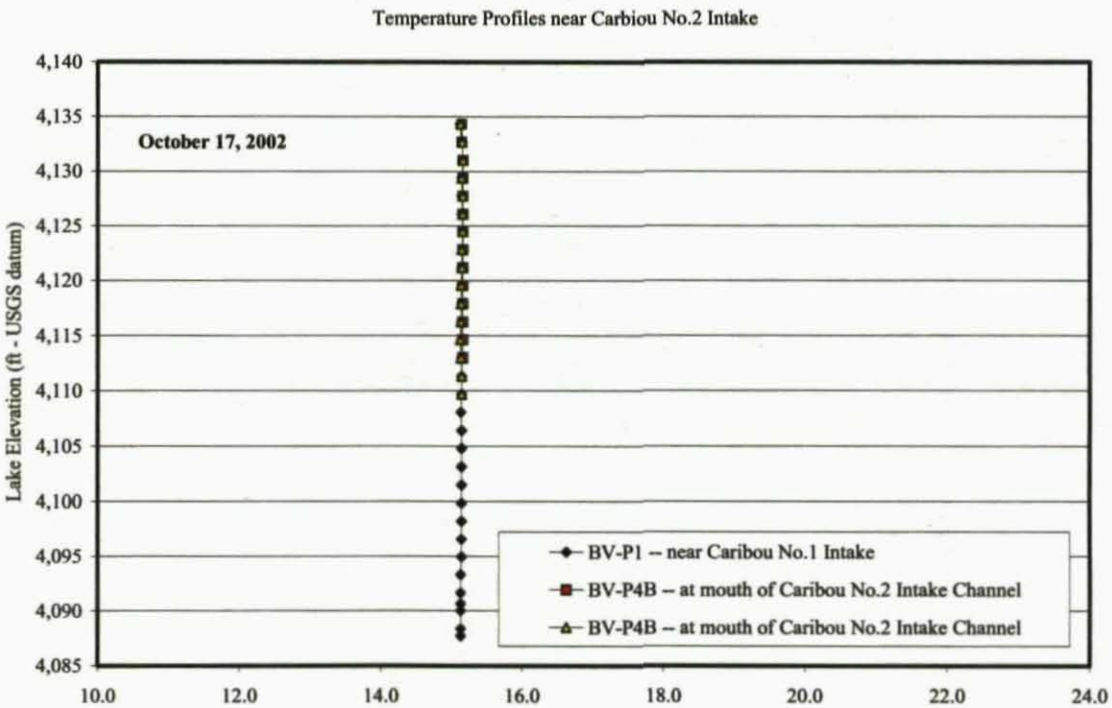


B. July 9, 2002 – Butt Valley Reservoir

Figure 3-25. Profile data from three stations near Caribou No.2 intake – 2002



C. August 21, 2002 – Butt Valley Reservoir Profiles



D. October 17, 2002 – Butt Valley Reservoir Profiles

Figure 3-25 (continued). Profile data from three stations near Caribou No. 2 Intake – 2002

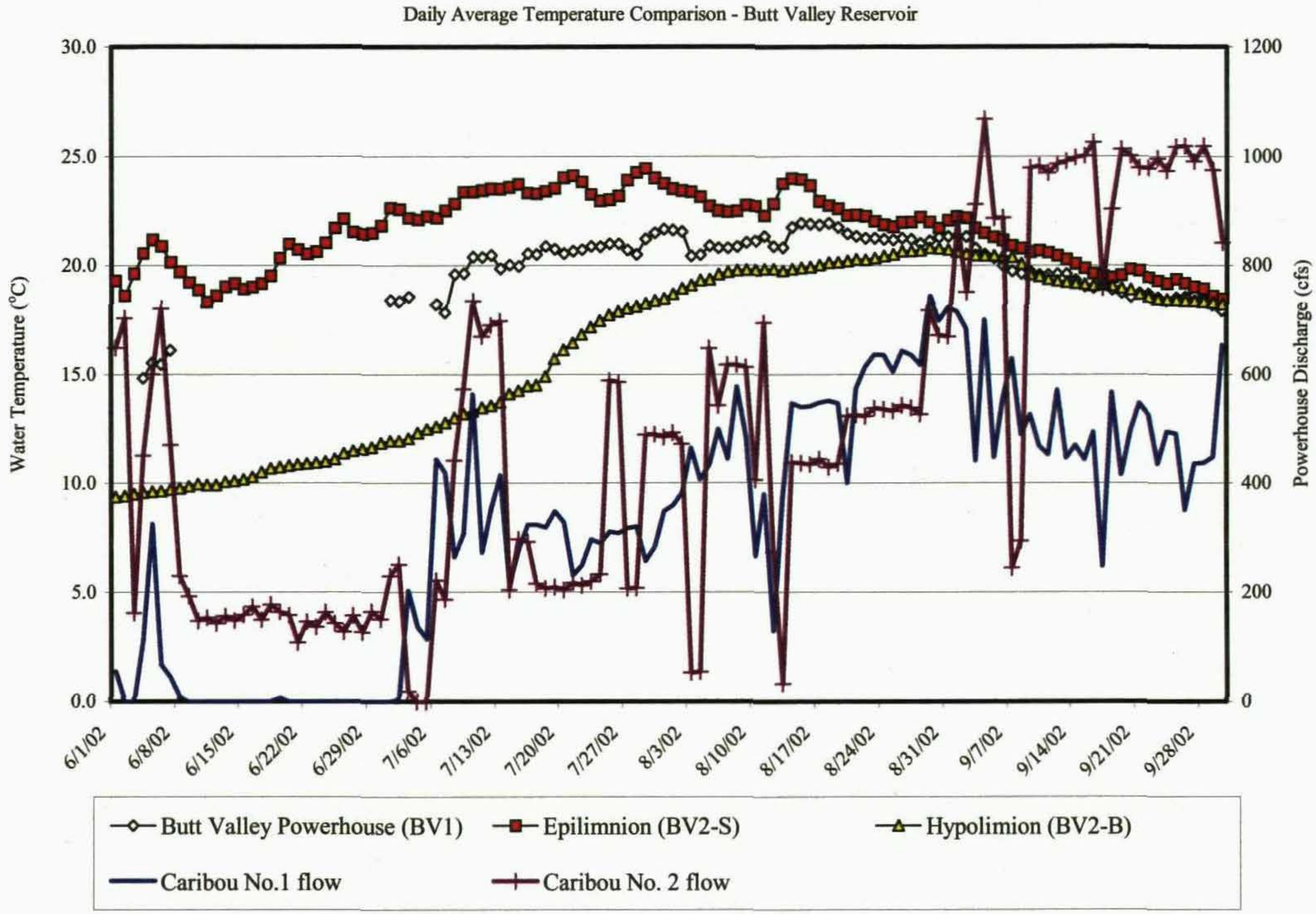


Figure 3-26. Comparison of daily average temperatures from three stations in Butt Valley Reservoir – 2002.

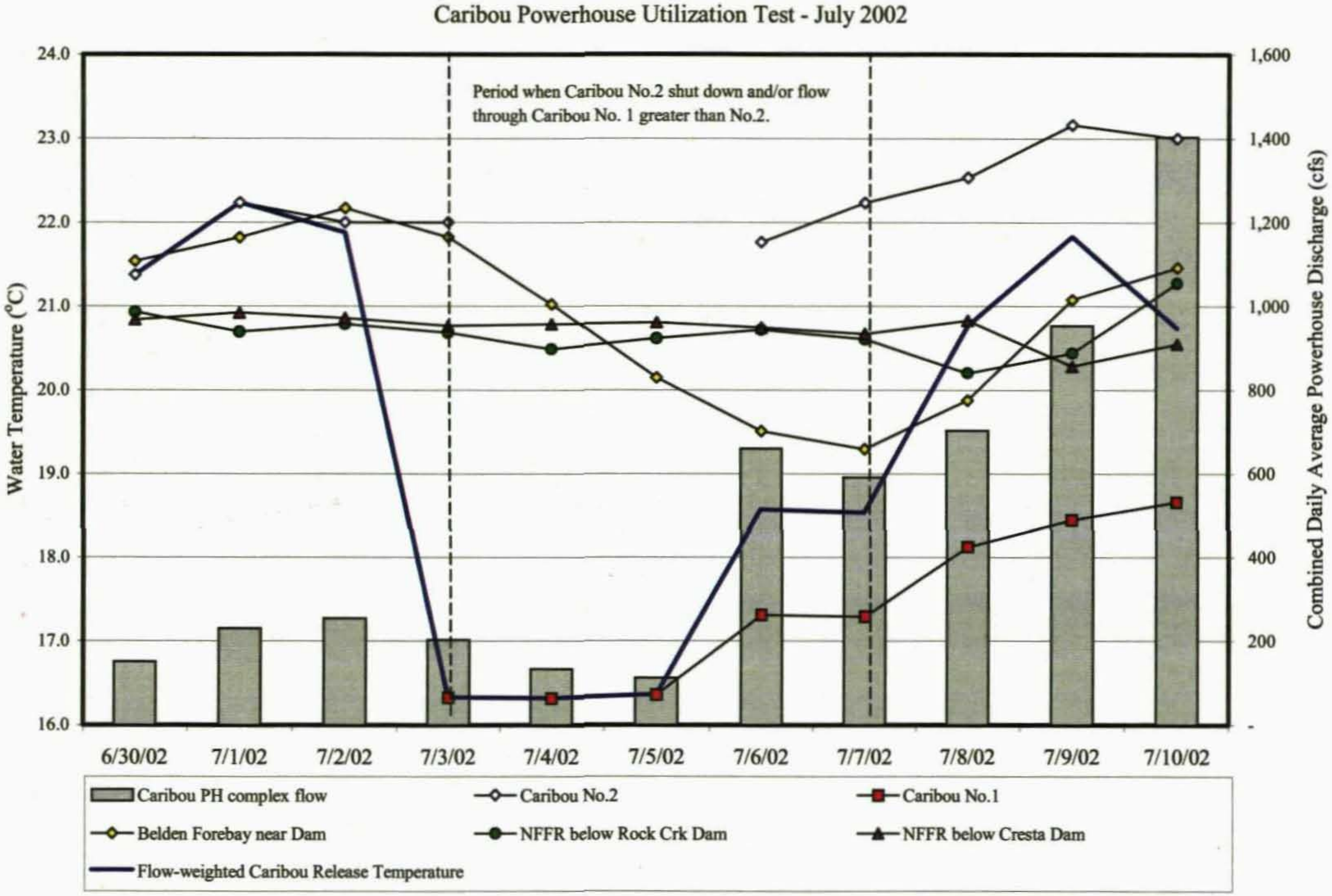
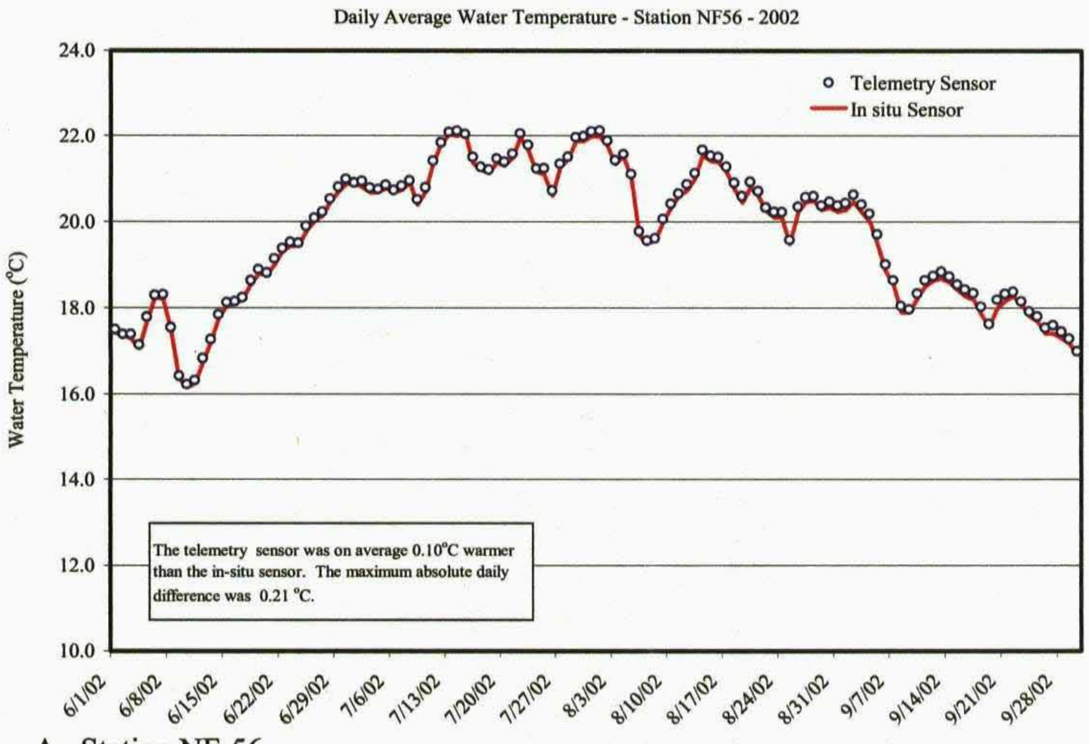
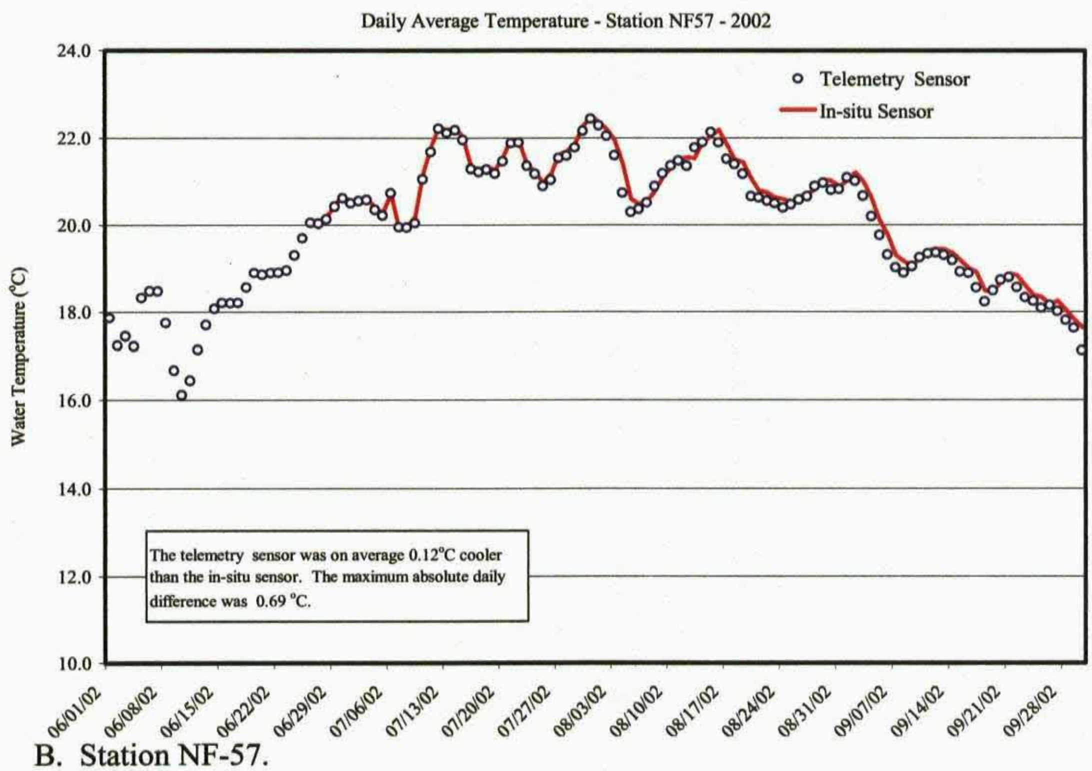


Figure 3-27. Comparison of daily average temperatures from select stations during Caribou complex flow test – 2002.



A. Station NF-56.



B. Station NF-57.

Figure 3-28. Comparison of daily average temperatures from telemetry sensors with insitu recorders – 2002.

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Buchanan, T.J., and W.P. Somers. 1980. *Discharge Measurements at Gaging Stations.* Tech. Water Resources Investigations. Book 3, Chapter A8.

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APPENDIX A

SUMMARY OF DAILY MAXIMUM, MINIMUM, AND MEAN WATER TEMPERATRURE

Appendix A

Summary of Hourly Average Water Temperatures Data - UNFFR 2002

Station	Year	Month	Hourly Temperatures[1] max	min	mean	Data Days
NFFR at	2002	June	19.0	6.4	12.7	30
Chester	2002	July	20.1	11.3	15.7	31
(NF1)	2002	Aug	19.1	9.8	14.2	31
	2002	Sept	16.5	7.5	11.5	30
Hamilton	2002	June	15.3	8.1	11.8	30
Branch at	2002	July	15.4	9.0	12.0	31
Road bridge	2002	Aug	17.1	8.8	11.8	31
(HB1)	2002	Sept	13.8	8.1	10.4	30
Hamilton	2002	June	17.8	7.9	12.6	30
Branch	2002	July	18.3	9.7	13.3	21
Powerhouse	2002	Aug	21.6	14.3	17.5	30
(HB2)	2002	Sept	19.6	8.2	14.4	30
Lake Almanor	2002	June	23.5	14.6	19.7	30
at Canyon Dam	2002	July	25.9	21.1	23.6	31
near surface	2002	Aug	26.0	21.4	23.1	31
(LA1-S)	2002	Sept	23.2	18.0	20.0	30
Lake Almanor	2002	June	9.5	8.1	8.9	30
at Canyon Dam	2002	July	10.7	9.2	9.9	31
near bottom	2002	Aug	11.4	10.2	10.8	31
(LA1-B)	2002	Sept	11.6	10.9	11.3	30
NFFR below	2002	June	13.0	9.8	11.3	30
Canyon Dam	2002	July	13.9	11.3	12.5	31
(NF2)	2002	Aug	14.0	12.5	13.3	31
	2002	Sept	14.8	12.6	13.7	30
NFFR at	2002	June	16.6	9.6	13.5	30
Seneca Bridge	2002	July	17.4	11.9	15.0	31
(NF3)	2002	Aug	17.0	11.5	14.5	31
	2002	Sept	15.7	10.6	13.4	30
NFFR above	2002	June	17.6	10.4	14.3	30
Caribou PH	2002	July	18.4	13.1	15.9	31
(NF4)	2002	Aug	17.9	12.1	15.0	31
	2002	Sept	16.3	10.8	13.4	30
Butt Valley	2002	June	16.9	7.9	15.5	4
Powerhouse	2002	July	22.4	14.3	20.2	29
[Corrected]	2002	Aug	22.6	18.4	21.2	31
(BV1)	2002	Sept	21.6	18.1	19.3	30

north Fork

43 stations

43
x 4
172 total measurements

26 exceed

27 stations exceed

Appendix A (Continued)

[redacted]

Station	Year	Month	Daily Temperatures [1] max	min	mean	Data Days
Butt Valley Res.	2002	June	22.7	17.3	20.1	30
at Caribou Intake	2002	July	25.5	21.6	23.3	31
Near surface NO	2002	Aug	24.8	21.4	22.7	31
(BV2-S)	2002	Sept	23.0	18.3	20.1	30
Butt Valley Res.	2002	June	12.1	9.2	10.4	30
at Caribou Intake	2002	July	18.7	11.7	15.0	31
Near bottom NO	2002	Aug	21.0	18.4	20.0	31
(BV2-B)	2002	Sept	20.8	18.2	19.3	30
Butt Creek above	2002	June	18.3	8.5	13.9	30
Butt Valley	2002	July	18.9	10.3	14.7	31
Reservoir NO	2002	Aug	17.7	8.9	13.1	31
(BC1)	2002	Sept	15.3	7.6	11.1	30
Butt Creek below	2002	June	11.1	10.2	10.6	30
Butt Valley	2002	July	11.2	10.5	10.7	31
Reservoir NO	2002	Aug	11.2	10.4	10.7	31
(BC2)	2002	Sept	11.1	10.2	10.5	30
Butt Creek at	2002	June	13.3	9.6	11.5	30
Mouth	2002	July	13.9	11.1	12.4	31
(BC3)	2002	Aug	14.0	10.8	12.4	31
	2002	Sept	13.6	10.5	12.0	30
Caribou No. 1	2002	June	14.9	10.6	12.7	5
Powerhouse	2002	July	21.3	11.8	19.3	29
[corrected]	2002	Aug	22.2	18.9	21.4	31
(CARB1)	2002	Sept	21.6	18.0	19.7	30
Caribou No. 2	2002	June	22.4	14.7	19.3	30
Powerhouse	2002	July	24.7	19.8	23.2	28
[corrected]	2002	Aug	24.0	21.3	22.5	31
(CARB2A)	2002	Sept	22.6	18.1	19.9	30
Belden Reservoir	2002	June	21.8	17.8	19.5	30
At Intake	2002	July	23.0	19.0	21.5	31
(BD1)	2002	Aug	22.9	21.2	21.9	31
	2002	Sept	21.9	18.5	19.8	30
NFFR below	2002	June	19.3	15.6	17.4	30
Belden Dam	2002	July	21.4	17.7	19.4	31
(NF5)	2002	Aug	21.5	19.9	20.7	31
	2002	Sept	21.3	15.8	18.8	30

24 stations exceed

~~criteria = ≥21.0°C~~
~~N.F.~~
~~34 stations total)~~
~~34 daily~~
~~x 4~~
~~136 total~~
~~max temp measurements~~
~~23 annual max. temps are in exceedance~~

Middle Fork
4 measurements
1 station
1/4 exceed

Appendix A (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Data Days
Mosquito Creek	2002	June	15.6	10.5	13.0	30
At mouth	2002	July	16.7	12.9	14.7	31
(MC1)	2002	Aug	16.4	12.0	13.9	31
	2002	Sept	14.7	10.8	12.2	30
NFFR near	2002	June	21.3	14.7	17.1	30
Queen Lily	2002	July	22.9	16.8	19.5	31
Campground	2002	Aug	22.9	18.6	20.3	31
(NF6)	2002	Sept	22.6	14.4	18.0	30
NFFR near	2002	June	22.5	14.3	17.5	30
Gansner Bar	2002	July	24.0	16.3	19.7	31
(NF7)	2002	Aug	23.8	17.3	20.1	31
	2002	Sept	23.0	13.9	17.6	30
East Branch	2002	June	25.1	15.8	20.8	30
NFFR at mouth	2002	July	26.5	20.5	23.8	31
(EB1)	2002	Aug	25.4	18.5	21.8	31
	2002	Sept	22.7	15.5	18.2	30
NFFR at Belden	2002	June	23.9	15.1	19.4	30
Town Bridge	2002	July	25.2	18.2	21.4	31
(NF8)	2002	Aug	24.7	17.2	20.7	31
	2002	Sept	23.2	14.8	18.0	30
Belden	2002	June	18.8	17.3	18.0	7
Powerhouse	2002	July	22.8	18.7	21.2	29
(BD2)	2002	Aug	22.8	21.2	21.8	31
	2002	Sept	21.9	18.2	19.8	30
Yellow Creek	2002	June	18.9	10.8	15.0	30
Near mouth	2002	July	20.1	14.6	17.1	31
(YC1)	2002	Aug	19.2	12.7	15.6	31
	2002	Sept	16.5	11.0	13.1	30
Chips Creek	2002	June	19.4	8.9	13.6	30
Near mouth	2002	July	21.0	13.3	16.8	31
(CHIP)	2002	Aug	20.6	12.4	15.9	31
	2002	Sept	18.6	10.8	13.7	30
NFFR below Rock	---	---	---	---	---	---
Creek Dam	---	---	---	---	---	---
(NF9)	---	---	---	---	---	---
	---	---	---	---	---	---
NFFR at NF-57	2002	June	22.4	18.8	20.3	5
Insitu Recorder	2002	July	23.4	19.2	21.3	31
(NF10)	2002	Aug	23.3	19.9	21.2	31
	2002	Sept	21.9	17.3	19.1	30

Appendix A (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Data Days
Milk Ranch Creek	2002	June	18.8	8.6	14.0	30
Near mouth	2002	July	20.4	12.5	16.4	31
(MR1)	2002	Aug	19.6	11.2	15.0	31
	2002	Sept	17.0	9.6	12.7	30
Chambers Creek	2002	June	19.6	6.9	13.7	30
Near mouth	2002	July	21.4	12.8	16.9	31
(CHAM)	2002	Aug	21.0	11.2	15.7	31
	2002	Sept	18.9	9.7	13.8	30
NFFR near Tobin	2002	June	22.8	14.0	18.6	30
blw Granite Crk	2002	July	24.3	18.2	21.5	31
(NF11)	2002	Aug	23.9	17.8	21.0	31
	2002	Sept	22.3	16.2	18.8	30
Jackass Creek	2002	June	19.8	7.3	14.1	30
Near mouth	2002	July	21.2	12.8	17.0	31
(JKC1)	2002	Aug	20.3	11.8	15.9	31
	2002	Sept	18.4	10.5	14.2	30
NFFR abv Bucks	2002	June	22.4	13.7	18.6	30
Creek	2002	July	24.0	18.4	21.6	31
(NF12)	2002	Aug	23.6	17.7	21.0	31
	2002	Sept	22.0	16.1	18.8	30
Bucks Creek	2002	June	21.7	9.7	16.0	30
Near Mouth	2002	July	23.5	13.9	18.6	31
(BUCK1)	2002	Aug	21.9	12.1	16.9	31
	2002	Sept	19.2	10.1	14.0	30
Bucks Creek	2002	June	19.9	12.2	15.6	27
Powerhouse	2002	July	20.0	15.2	16.7	26
(BUCK2)	2002	Aug	18.3	13.2	14.3	21
	2002	Sept	15.2	12.4	13.0	30
NFFR abv Rock	2002	June	22.7	14.0	18.6	30
Creek Powerhouse	2002	July	24.1	17.5	20.7	31
(NF13)	2002	Aug	23.0	16.1	19.3	31
	2002	Sept	20.9	14.2	16.3	30
Rock Creek	2002	June	20.3	15.5	18.1	30
Powerhouse	2002	July	22.8	19.3	21.3	31
(RC1)	2002	Aug	22.8	20.2	21.7	31
	2002	Sept	22.0	18.1	19.8	31

Appendix A (Continued)

Station	Year	Month	Daily Temperatures[1] max	Min	mean	Data Days
Rock Creek	2002	June	18.8	10.3	14.8	30
Near mouth	2002	July	20.7	15.5	18.1	31
(RC2)	2002	Aug	20.3	14.6	17.1	31
	2002	Sept	18.0	13.0	14.8	30
NFFR abv Grizzly	2002	June	21.8	15.7	18.4	30
Creek	2002	July	22.8	19.8	21.2	31
(NF14)	2002	Aug	22.2	18.9	20.7	31
	2002	Sept	21.3	17.0	18.5	30
Grizzly Creek	2002	June	20.4	11.0	15.9	30
Near mouth	2002	July	22.7	15.9	19.3	31
(GR1)	2002	Aug	22.3	14.9	18.0	31
	2002	Sept	19.2	12.7	15.0	30
NFFR at NF-56	2002	June	22.6	15.0	18.4	30
blw Grizzly Crk	2002	July	23.5	19.1	21.3	31
(NF15)	2002	Aug	23.2	18.2	20.6	30
	2002	Sept	21.9	16.5	18.4	30
NFFR abv Cresta	2002	June	22.9	14.8	18.7	30
Powerhouse	2002	July	23.9	19.1	21.7	31
(NF16)	2002	Aug	23.6	18.1	20.9	31
	2002	Sept	21.9	16.3	18.5	30
Cresta	2002	June	21.1	15.9	18.5	30
Powerhouse	2002	July	22.8	20.0	21.4	30
(~~CR1~~)	2002	Aug	22.8	19.3	21.0	31
	2002	Sept	21.2	17.1	18.7	30
Middle Fork	2002	June	22.9	14.0	18.2	30
Feather River	2002	July	25.3	19.1	21.9	31
At Milsap Bar	2002	Aug	24.4	17.3	20.3	31
(MB1)	2002	Sept	21.4	15.1	17.3	26

Only middle Fork site

1. Values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average temperatures. For example, the maximum June temperature represents the maximum hourly average temperature measured in June.

APPENDIX B

REVISED WATER TEMPERATURE MODELING FOR THE ROCK CREEK-CRESTA HYDROELECTRIC PROJECT - FERC PROJECT NO. 1962

FS # 2702 + 2375

470

From: <Risler.Palma@epamail.epa.gov>
To: <dgoding@waterboards.ca.gov>
Date: 8/31/05 2:03PM
Subject: North Fork Feather

Here's the report (See attached file: 2002_Report_final.doc)

The Figures are pages 3-100 up to 3-117
The only monitoring locations relevant to the main channel of the North Fork Feather are labeled NF1 - NF16. There was no NF - 9 during this year.

My visual inspection of the graphs show the following

0/120 days (using daily average as a surrogate for hourly) for stations NF1, NF2, NF3 and NF4

NF5, NF6, NF7 are close calls if you make assumptions regarding the relationship of the daily average temperature to hourly

NF8 27/120 days >21
NF 10 36/120 days > 21
NF 11 36/120 days >21
NF 12
NF 13 ???
NF14,15 and 16 31-42/120 days >21

1 hit in 1 yr = violation of 21°C

I will also fax some graphs - Palma

Palma Risler
U.S. EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105

415/972-3451
FAX - 415/947-3537

~~hourly max~~
The warmest wk. of the year shall not exceed the criteria.

NF8

Meets listing percentage exceedence

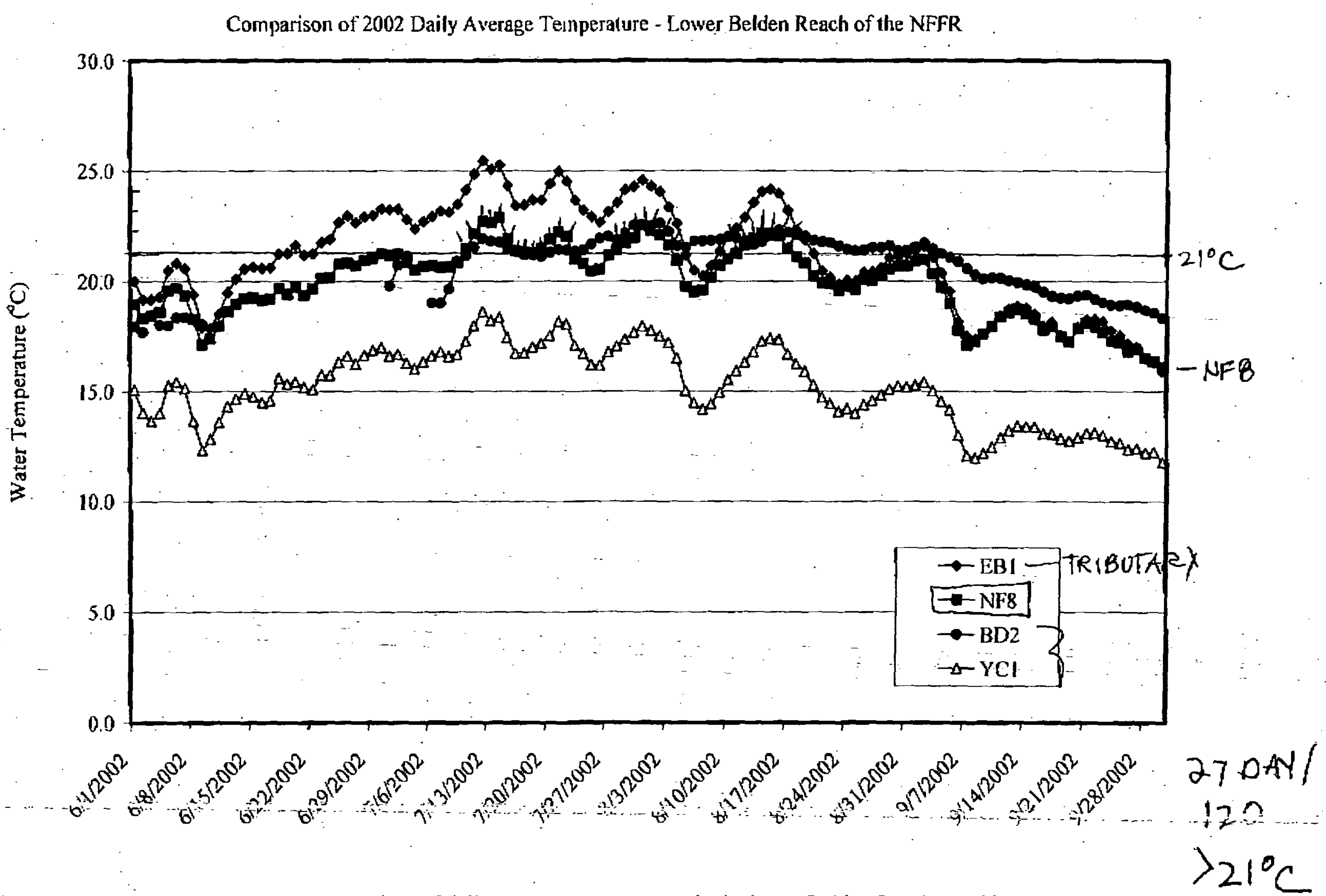

Figure 3-18. Comparison of daily average temperatures in the lower Belden Reach – 2002

NF10
NF11

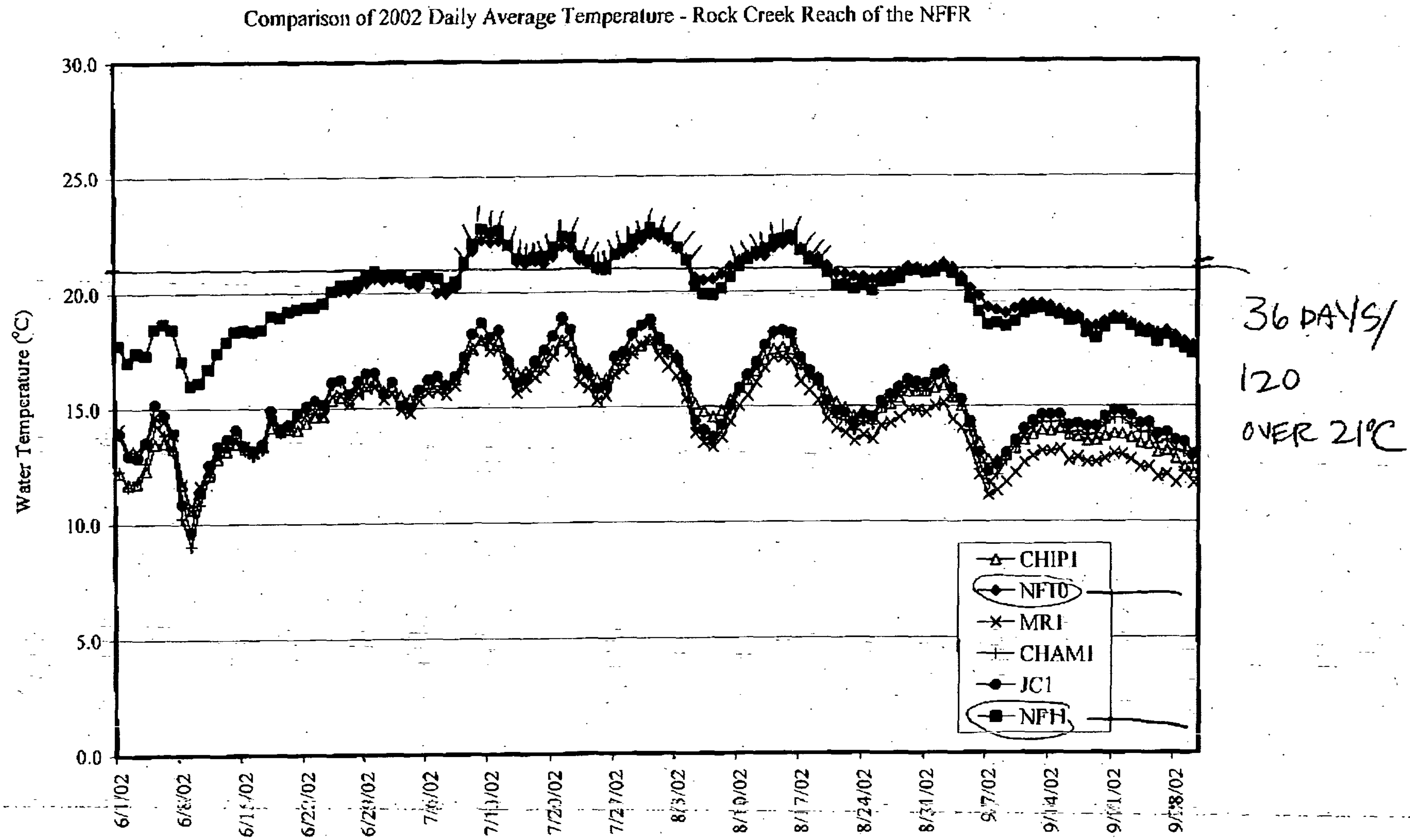

Figure 3-19. Comparison of daily average temperatures from stations in the upper Rock Creek Reach – 2002

copy 2 of 2

Rock Creek – Cresta Project

FERC Project No. 1962

Water Temperature Monitoring of 2002

~~Data Report~~

FERC License Condition No. 4C

~~Draft~~ Final May 21 ~~April 27~~, 2003

Prepared By:

Pacific Gas and Electric Company

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ROCK CREEK-CRESTA COMPLIANCE MONITORING REPORT -- 2002

1 INTRODUCTION

1.1 BACKGROUND

NFFR water temperatures in the Rock Creek and Cresta reaches reflect a combination of conditions derived from several sources including; the upper North Feather River (Federal Energy Regulatory Commission [FERC] Project 2105), flows from the unregulated East Branch of NFFR, small tributary contributions, releases from Bucks Creek Project (FERC Project 619), and flow within Project bypass reaches. The temperature of water from Project 2105 is primarily determined by conditions at the non-selective Prattville Intake in Lake Almanor. Pursuant to the Rock Creek – Cresta Relicensing Settlement Agreement (Settlement Agreement), the Ecological Resource Committee (ERC) and Forest Service (FS) have agreed to a post-license monitoring and modeling study to determine if structural modification of the Prattville Intake is feasible, and if these modifications can sustain water deliveries such that daily average temperatures in the Rock Creek and Cresta reaches would be maintained below 20°C. Pursuant to FERC Condition 4C of the Project License (issued October 24, 2001), temperature monitoring is required during the summer months to determine if and to what extent the 20°C temperature level can be met with reasonable control measures.

The Rock Creek-Cresta Hydroelectric Project License No.1962 required the Licensee to file a water temperature monitoring plan with FERC, which described the implementation (including a schedule for implementation) of the water temperature monitoring program described in Condition No. 4C of the new Project License. The Rock Creek-Cresta water temperature monitoring plan was prepared in consultation with the Rock Creek - Cresta ERC and the FS and was implemented in June 2002.

The objective of the water temperature monitoring program is to:

1. Document summer water temperatures and flows in the Rock Creek and Cresta reaches as well as in upstream areas tributary to the Project.
2. Install and monitor continuous temperatures at two telemetry stations installed at two flow gaging stations in the Rock Creek and Cresta reaches.
3. Determine if mean daily water temperatures of 20°C or less can be met in the Rock Creek and Cresta reaches to the extent that Licensee can reasonably control such temperatures, particularly if a modified Prattville Intake is implemented.
4. Develop and verify a temperature model that predicts, with reasonable accuracy, the temperature profile of the river based on data from two telemetered temperature stations.

This report documents the results and subsequent analysis of the 2002 monitoring program.

1.2 PROJECT SETTING

The Licensee's North Fork Feather River Projects (FERC 2105 and FERC 1962) are located on the North Fork Feather River (NFFR) watershed in northeastern California (see Figure 1-1). The Project is located in Plumas County, approximately 90 miles northeast of Oroville, California, and encompasses approximately 30 river-miles of the upper NFFR.

The NFFR is part of the greater Sacramento River watershed and drains a large portion of the eastern Sierra-Cascade geomorphic area in California. The NFFR watershed extends from its headwater area originating on the southeastern slope of Mount Lassen to Lake Oroville, traversing lands in Lassen, Plumas, and Butte counties. The main stem of the Feather River is formed downstream of Lake Oroville; the North, Middle, and South forks of the Feather River are impounded behind Oroville Dam which was completed in 1967.

The monitoring program involved collecting data from facilities associated with the Licensee's Upper North Fork Feather River Project (FERC 2105) and Rock Creek-Cresta Project (FERC 1962). Both projects are part of a major hydroelectric generation network that utilizes the water resources of the NFFR and its tributaries for hydroelectric power generation. Downstream of these Projects is the Poe Project (FERC 2107) operated by the Licensee, and the Oroville Project (FERC 2100) owned by the State of California Department of Water Resources (DWR). Delivering water to the NFFR upstream of Licensee's Rock Creek Powerhouse is the Licensee's Bucks Creek Project (FERC 619).

Figure 1-1. Regional location of study area.

2 STUDY DESIGN

2.1 MONITORING PROGRAM

2.1.1 Monitoring Network

A first year of compliance water resource monitoring was initiated in May 2002, and continued through September 2002. The monitoring program consisted of monitoring continuous water temperature and continuous stream flow data from selected locations. All monitoring activities were conducted by staff or contract personnel from the Licensee's Technical and Ecological Services, Land and Water Quality Unit.

A map of the system (Figure 2-1) depicts monitoring stations in relation to the major Project features such as powerhouses, reservoirs and bypass reaches. Station identification, location, monitoring activity and the rationale for selection is shown in Table 2-1. Results of the 2002 water resource monitoring effort are discussed in Section 3.

Table 2-1

Upper NFFR Water Quality Sampling Locations

Station ID	Alternate Station Identification	Station Location	Monitoring Activity [1]
NF1	----	NFFR above Chester, CA.	F, TR
HB1	----	Hamilton Branch of NFFR at HWY bridge	TR,
NF-83	----	Hamilton Branch Powerhouse	F
HB2	----	Hamilton Branch Powerhouse – canal head-works	TR
LA1-S	----	Lake Almanor near Canyon Dam - Epilimnion	TR - buoy
LA1-B	----	Lake Almanor near Canyon Dam - Hypolimnion	TR - buoy
LA – P1	----	Lake Almanor near Canyon Dam – near intake	IS-P
LA – P2	----	Lake Almanor - Offshore of Prattville Intake (LA2)	IS-P
LA – P3	----	Lake Almanor – middle of Eastern lobe (LA8)	IS-P
LA – P4	----	Lake Almanor – middle of Western lobe (LA6)	IS-P
LA-MET	----	Meteorological station on Prattville Intake	M
NF-1	11-399000	Lake Almanor near Prattville	Lake storage
NF2	----	NFFR below Canyon Dam	TR,
NF-2	11-399500	NFFR below Canyon Dam	F
NF3	----	NFFR at Seneca	TR
NF4	NF-47 (PG&E)	NFFR above Caribou No.1 Powerhouse	TR F
BV1		Butt Valley Powerhouse Tailrace	TR,
NF-71	11-400600	Butt Valley Powerhouse	F
BV2_S	----	BVR near Caribou No.1 Intake - Epilimnion	TR - buoy
BV2_B	----	BVR near Caribou No.1 Intake - Hypolimnion	TR - buoy
BV-P1	----	BVR at Caribou No. 1 Intake	IS-P
BV-P2	----	BVR near Cool Springs Campground	IS-P
BV-P3	----	BVR near boat ramp	IS-P
BV-P4A	----	BVR near Caribou No.2 intake channel	IS-P (special)
BV-P4B	----	BVR at mouth of Caribou No.2 intake channel	IS-P (special)
NF-8	11-401050	Butt Valley Reservoir near Caribou (at dam)	Lake storage
CARB1	----	Caribou No. 1 Powerhouse tailrace	TR
NF-63	11-401110	Caribou No. 1 Powerhouse	F
CARB2	----	Caribou No. 2 Powerhouse tailrace	TR
CARB2B	----	Caribou No. 2 Intake channel bottom at structure	TR
NF-263	11-401109	Caribou No. 2 Powerhouse	F
BC1	----	Butt Creek upstream of Butt Valley Reservoir	TR
NF-4	11-400500	Butt Creek below ABC tunnel, near BVR	F
BC2	----	Butt Creek downstream of Butt Valley Reservoir	TR
BC3	----	Butt Creek near confluence with NFFR	TR, F
BD1	----	Belden Reservoir at powerhouse intake	TR
NF-67	11-403050	Belden Reservoir	Lake storage
NF-103	----	Oak Flat Powerhouse	F
NF5	---	NFFR below Belden Dam	TR
NF-70	11-401112	NFFR below Belden Dam	F
MC1	----	Mosquito Creek near mouth	TR, F
NF6	----	NFFR near Queen Lily Campground	TR

Table 2-1 Continued

Station ID	Alternate Station Identification	Station Location	Monitoring Activity [1]
NF7	----	NFFR near Gansner Bar	TR
EB1	----	East Branch of NFFR above confluence	TR
NF-51	11403000	East Branch of NFFR above confluence	F
NF8	----	NFFR at Belden Town Bridge	TR
BD2	----	Belden Powerhouse tailrace	TR
NF-74	11-403050	Belden Powerhouse	F
YC1	----	Yellow Creek near mouth	TR, F
RCK-MET	----	Meteorological station on Rock Creek Dam	M
CHIP	----	Chips Creek near mouth	TR, S
NF9	----	NFFR below Rock Creek Dam	TR
NF10	----	NFFR below Rock Creek Dam at NF-57	TR
NF-57	11-403200	NFFR downstream of Rock Creek Dam	F
MR1	----	Milk Ranch Creek near mouth	TR, F
CHAM	----	Chambers Creek near mouth	TR, S
NF11	----	NFFR below Granite Creek	TR
JC1	----	Jackass Creek near mouth	TR
NF12	----	NFFR above confluence with Bucks Creek	TR
BUCK1	11-403700	Bucks Creek near mouth	TR, F
NF-20	----	Bucks Creek Powerhouse	F
BUCK2	----	Bucks Creek Powerhouse tailrace	TR
NF13	----	NFFR above Rock Creek Powerhouse	TR
RC1	11-403800	Rock Creek Powerhouse (internal)	TR
NF-64	----	Rock Creek Powerhouse	F
RC2	----	Rock Creek near mouth	TR, S
NF14	----	NFFR below Cresta Dam	TR
GR1	----	Grizzly Creek near mouth	TR, F
NF15	----	NFFR downstream of Grizzly Creek	TR
NF-56	11-404330	NFFR downstream of Grizzly Creek	F
NF16	----	NFFR upstream of Cresta Powerhouse	TR
CR1	----	Cresta Powerhouse(internal)	TR
NF-62	11-404360	Cresta Powerhouse	F
MB1	----	Middle Fork Feather River at Milsap Bar	TR

~~1.2~~2.2 METHODOLOGY

2.2.1 Flow Monitoring

Stream flow was monitored throughout the Project area in 2002 at a seven stations (NF1, NF4, BC3, YC1, MR1, BUCK1, and GR1). Flow data were also obtained from permanent stream flow gages and from powerhouses associated with the Project through Pacific Gas and Electric Company's Hydroelectric Department. Flow monitoring station locations are shown on Figure 2-1 and are described in Table 2-1.

Each of the temporary flow monitoring stations consisted of a Campbell CR510 digital recorder, associated Druck 5 psi pressure transducer and a stage pin. The stage pins and pressure transducer were placed in-stream, while the digital recorders were located on the stream bank in locked enclosures. The digital recorders were set to record instantaneous readings every 15 minutes, and stored this data as hourly average transducer values. All data were stored in non-volatile memory. During routine site visits, stream stage was recorded, and stored hourly average transducer data were downloaded to computer.

A simple linear regression was used to define the relationship between transducer readings and the associated stream stage measurements at each station. Average hourly transducer readings were then converted into average hourly stream stage readings using the resultant regression equation. The conversion to a stage value based on a fixed reference (stage pin) facilitated year to year comparison of flow measurements and allowed for correction for error associated with transducer drift.

Stream flow measurements were made at each station during routine site visits at transects located near each gaging station. Measurements were made using U. S. Geological Survey (USGS) approved stream flow measurement techniques (Buchanan 1980). All measurements were made using a Price AA-type flow meter, and 5-foot top-setting wading rod. The errors associated with measurements made in the river were estimated at 10 to 15% due to the large substrate and abundant amount of vegetation in the channel. Measurements made in the tributary creeks had an estimated error of 8 to 10%. The primary objective of the routine flow measurements was to cover the range of observed flows in order to develop a stage-flow rating equation.

The relationship of stream stage to stream flow (stage-flow rating) was developed using flow measurements and the associated stage pin readings collected during routine site visits. The resultant stage-flow rating was used to convert average hourly stage readings into average hourly flow. The rating is only applicable to flow within the defined range of stage, and is also subject to changes in the hydraulic control. All instrumentation-installed *in situ* was removed during months when seasonal high flows could damage the equipment.

Daily flow at four tributary streams (Mosquito, Chambers, Chips, and Rock creeks) was estimated based on periodic flow measurements. A linear decay between measurements was assumed to generate a daily flow estimate. A staff gage (stage pins) was installed at each of these stations to periodically measure stream stage. A total of at least four measurements were made at each station between June and September.

~~1.1.2~~2.2.2 Meteorological Monitoring

Local meteorology was monitored to provide input to the stream temperature model. Two temporary stations were placed in the Project area. One station was located on the Prattville Intake at Lake Almanor; another was located on Rock Creek Dam (Figure 2-1). These stations effectively represent conditions in the upper and middle portion of the Project. Parameters that were measured included; average wind speed and direction, air temperature, relative humidity, and solar radiation. These parameters were monitored continuously using a Campbell Scientific Model CR10 data logger. Data were collected at 1-second intervals and reduced to hourly average readings.

~~1.1.3~~2.2.3 Temperature Monitoring

The temperature-monitoring program used recorders from three different manufactures to monitor temperature during the 2002 effort. The bulk of the data loggers deployed in the system were Vemco Minilog 12T recorders. These units recorded continuous temperature data as instantaneous readings taken at 20-minute intervals, these data are then converted into hourly average temperatures. Campbell Scientific Model CR510 recorders were used at seven stations to monitor temperature. These recorders were also used to record continuous stream stage (flow) at the same locations (Table 2-1). The CR510 loggers recorded continuous temperature data as hourly averages based on readings taken at 15-minute intervals. A final type of recorder deployed during the monitoring program was the Omnidata Model DP112. These units were placed at six locations; these recorders were used exclusively on Project powerhouses (Caribou No. 1, No. 2, Belden, Rock Creek, and Cresta). The tailrace characteristics of these facilities dictated that the temperature sensors be installed internally in the powerhouse. The DP112 loggers recorded continuous temperature data as hourly averages based on readings taken at 5-minute intervals.

Stream temperature sensors were typically deployed in well-mixed areas with elevated velocity and turbulent flow to ensure representative measurements. In general, continuous monitoring of temperature was conducted from June through September 2002.

During the period June through September 2002, vertical profiles were collected from 4 locations on Lake Almanor and from three locations on Butt Valley Reservoir to determine the magnitude and seasonal development of thermal gradients. Profiles were defined using 1-meter vertical spacing from the surface to the bottom.

In addition to the synoptic profiles collected at the three Project reservoirs, vertical temperatures in Lake Almanor and Butt Valley were continuously monitored from June through September 2002. Temperatures were monitored at a single station near the dam in each reservoir (Figure 2-1). A thermistor array consisting of Vemco Model Minilog 12T recorders positioned at two depths, near the surface (1.0 meters below surface) and near the bottom (2 meters above bottom to resting on bottom depending on lake elevation), was placed at each location. The thermistor array was suspended from a buoy so that each recorder was maintained at a fixed depth below the surface.

To verify the operation and accuracy of the temperature recorders, the units were calibrated using an American Society for Testing and Materials (ASTM) reference thermometer, both prior to and following removal from the *in situ* deployment. Typical instrument error is between 0.1 and 0.2°C.

Temperature records from instruments placed internally or in the tailrace of the various Project powerhouses were corrected to reflect periods of powerhouse operation. This process was done on an hourly basis by comparing powerhouse load records with temperature recorder data. This processed helped eliminate periods when there was little or no flow through the powerhouse and temperatures reflected stagnate conditions.

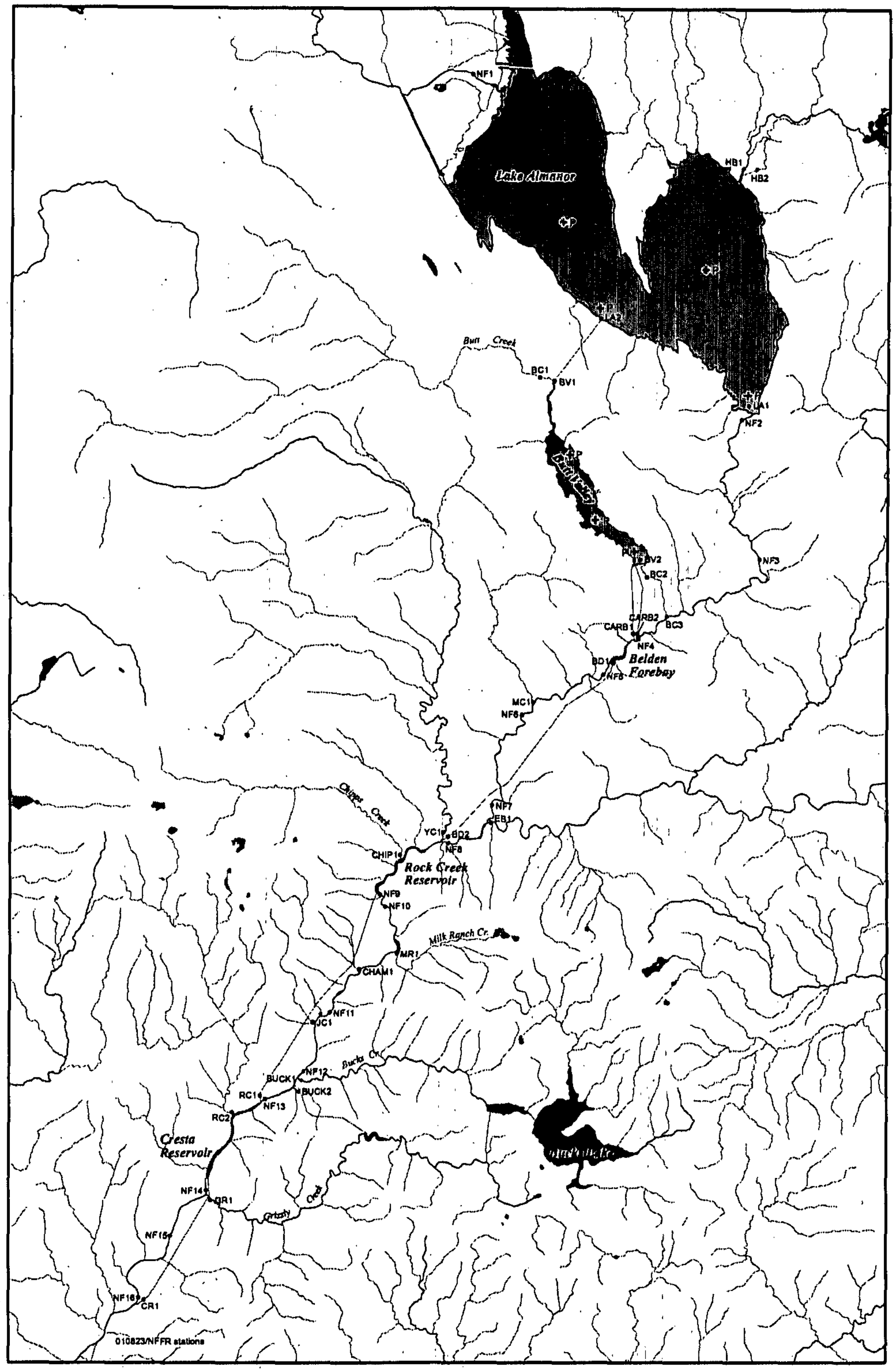

Figure 2-1. Map of station locations used during the 2002 monitoring program.

3 MONITORING RESULTS - 2002

3.1 HYDROLOGY AND METEROLOGY

3.1.1 Streamflow and Reservoir Operation

The Licensee's Upper NFFR Project encompasses the water resources and aquatic habitats of the upper NFFR drainage basin (from Lake Almanor to the NFFR confluence with Yellow Creek [headwaters of Rock Creek Reservoir]). The majority of flow entering the Project originates from water first stored in Lake Almanor. Water is then passed downstream through a series of powerhouses and associated forebays. The Licensee's Rock Creek- Cresta Project encompasses the water resources of the middle portion of the NFFR basin, extending from the confluence of Yellow Creek to the headwaters of Poe Reservoir.

In addition to the permanent flow monitoring stations, the Licensee installed a series of temporary flow monitoring gages. These gages provided supplemental information in support of the temperature modeling effort. Table 3-1 summarizes streamflow data from these temporary flow-monitoring stations.

Table 3-1

Summary of 2002 stream flow monitoring at permanent and temporary stations.

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
NFFR near	2002	June	397	214	298	---	30
Chester (NF1)	2002	July	212	139	175	---	31
[Estimated]	2002	Aug	136	112	120	---	31
	2002	Sept	111	97	104	---	30
Hamilton Branch	2002	June	85.5	69.7	76.8	---	30
at A13 Bridge	2002	July	95.0	67.7	76.8	---	31
(HB1)	2002	Aug	78.0	75.8	76.5	---	31
[Estimated]	2002	Sept	76.2	61.0	71.7	---	30
Hamilton Branch	2002	June	38	32	34	100%	30
Powerhouse	2002	July	35	0	23	69%	21
(NF-83)	2002	Aug	92	11	79	97%	30
[Corrected]	2002	Sept	79	35	72	100%	30
NFFR below	2002	June	36.5	36.5	36.5	---	30
Canyon Dam	2002	July	36.9	36.1	36.5	---	31
(NF-2)	2002	Aug	36.1	35.2	35.8	---	31
[Permanent]	2002	Sept	35.2	34.7	34.9	---	30
NFFR above	2002	June	83.2	77.6	80.1	---	30
Caribou PH	2002	July	77.3	74.9	75.9	---	31
(NF4)	2002	Aug	75.4	73.3	74.2	---	31
[Temporary]	2002	Sept	73.5	71.2	72.7	---	30
Butt Valley	2002	June	1084	0	115	6.5%	4
Powerhouse	2002	July	1283	0	746	49%	29
[Corrected]	2002	Aug	1439	159	984	63%	31
(NF-71)	2002	Sept	1615	504	1436	90%	30
Butt Creek at ABC	2002	June	71.8	48.3	56.2	---	30
Tunnel (NF-4)	2002	July	47.6	43.6	45.6	---	31
[Permanent]	2002	Aug	43.8	42.1	42.9	---	31
	2002	Sept	42.4	40.9	41.6	---	30
Butt Creek at	2002	June	14.2	14.0	14.1	---	30
Mouth	2002	July	14.2	13.7	13.9	---	31
(BC3)	2002	Aug	14.3	14.1	14.2	---	31
[Temporary]	2002	Sept	14.6	14.1	14.3	---	30
Caribou No. 1	2002	June	325	0	21	4%	5
Powerhouse	2002	July	564	0	285	47%	29
(NF-63)	2002	Aug	744	129	516	67%	31
[Corrected]	2002	Sept	716	247	503	72%	30

Table 3-1 (Continued)

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
Caribou No. 2	2002	June	722	108	245	98%	30
Powerhouse	2002	July	735	0	332	90%	28
(NF-263)	2002	Aug	719	33	484	100%	31
	2002	Sept	1070	245	912	100%	30
Oak Flat	2002	June	0	116	105	---	29
Powerhouse	2002	July	0	116	64.5	---	19
(NF-103)	2002	Aug	111	116	114	---	31
	2002	Sept	0	114	49.2	---	26
NFFR below	2002	June	145	143	144	---	30
Belden Dam	2002	July	144	142	143	---	31
(NF-70)	2002	Aug	144	142	143	---	31
[Permanent]	2002	Sept	143	62	69	---	30
Mosquito Creek	2002	June	7.5	5.1	6.2	---	30
At mouth	2002	July	5.1	4.2	4.6	---	31
(MC1)	2002	Aug	4.1	4.0	4.1	---	31
[Estimate]	2002	Sept	4.2	4.1	4.1	---	30
East Branch	2002	June	334	117	187	---	30
NFFR near NFFR	2002	July	118	51.4	79.9	---	31
(NF-51)	2002	Aug	60.9	45.0	52.5	---	31
[Permanent]	2002	Sept	62.0	48.8	55.9	---	30
Belden	2002	June	830	0	121	12%	7
Powerhouse	2002	July	1216	0	518	48%	29
(NF-74)	2002	Aug	1504	241	1001	73%	31
	2002	Sept	1513	677	1108	91%	30
Yellow Creek	2002	June	117	64.5	81.5	---	30
Near mouth	2002	July	63.6	52.4	56.9	---	31
(YC1)	2002	Aug	53.7	50.8	52.2	---	31
[Temporary]	2002	Sept	54.0	48.8	51.3	---	30
Chips Creek	2002	June	107	33.8	64.3	---	30
Near mouth	2002	July	33.3	18.2	25.7	---	31
(CHIP)	2002	Aug	17.7	14.4	15.5	---	31
[Estimate]	2002	Sept	14.3	12.4	13.3	---	30
NFFR below	2002	June	1133	170	267	---	30
Rock Creek Dam	2002	July	774	150	216	---	31
(NF-57)	2002	Aug	553	191	209	---	31
[Permanent]	2002	Sept	650	196	229	---	30

Table 3-1 (Continued)

Station	Year	Month	Daily Average Flow [1] max	min	mean	Powerhouse Operation [2]	Data Days
Milk Ranch Creek	2002	June	9.8	6.4	8.2	---	30
Near mouth	2002	July	6.2	4.1	5.0	---	31
(MR1)	2002	Aug	4.2	3.4	3.7	---	31
[Temporary]	2002	Sept	3.5	3.2	3.3	---	30
Chambers Creek	2002	June	46.9	9.9	25.2	---	30
Near mouth	2002	July	9.7	4.6	4.1	---	31
(CHAM)	2002	Aug	4.4	3.0	3.5	---	31
[Estimate]	2002	Sept	3.0	2.5	2.7	---	30
Bucks Creek	2002	June	24.1	19.0	21.7	---	30
Near Mouth	2002	July	18.8	13.8	16.1	---	31
(BUCK1)	2002	Aug	13.7	10.7	12.1	---	31
[Temporary]	2002	Sept	13.5	10.2	12.2	---	30
Bucks Creek	2002	June	51	5	19	29%	27
Powerhouse	2002	July	194	1	83	36%	26
(NF-20)	2002	Aug	228	0	113	44%	21
	2002	Sept	237	109	171	92%	30
Rock Creek	2002	June	1342	204	479	98%	90
Powerhouse	2002	July	1358	97	756	100%	31
(NF-64)	2002	Aug	1596	184	1095	100%	31
	2002	Sept	1744	422	1466	100%	30
Rock Creek	2002	June	44.5	8.9	21.6	---	30
Near mouth	2002	July	8.7	3.0	5.8	---	31
(RC2)	2002	Aug	2.8	2.1	2.3	---	31
[Estimate]	2002	Sept	2.1	1.7	1.9	---	30
Grizzly Creek	2002	June	38.8	28.9	33.6	---	30
Near mouth	2002	July	28.4	20.0	24.1	---	31
(GR1)	2002	Aug	20.2	15.1	17.5	---	31
[Temporary]	2002	Sept	16.9	12.9	14.6	---	30
NFFR below	2002	June	1109	271	321	---	30
Grizzly Creek	2002	July	805	235	265	---	31
(NF-56)	2002	Aug	568	236	260	---	31
[Permanent]	2002	Sept	667	240	262	---	30
Cresta	2002	June	1576	243	600	66%	30
Powerhouse	2002	July	1457	12	820	55%	30
(NF-62)	2002	Aug	1698	216	1135	63%	31
	2002	Sept	1898	544	1658	82%	30

1. Daily values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average flows.

2. Percent powerhouse operation is based on hourly generation data.

~~1.1.1.1~~3.1.1.1 Lake Almanor and tributaries

The major tributaries feeding into Lake Almanor are the NFFR at Chester with an historic average annual flow of approximately 335 cfs, the Hamilton Branch with an historic average flow of 190 cfs, and a number of minor tributaries including Benner, Last Chance, and Bailey creeks.

Flow in the NFFR upstream of Lake Almanor (which provides an estimated 50 percent of the annual inflow to Lake Almanor) is derived from headwaters that originate on the slopes of Mount Lassen. During the 2002 monitoring program, flow in the NFFR upstream of Lake Almanor was measured at a temporary stream gage (NF1) located upstream of the city of Chester, CA. Mean daily flow at this station for the period June-September 2002 ranged from 97 to 397 cfs, averaging 174 cfs. Figure 3.1 compares daily average flow from the NFFR with other stations tributary to Lake Almanor.

Flow in the Hamilton Branch (which provides 20 to 25 percent of the annual inflow to Lake Almanor), originates from the Licensee's Mountain Meadows Project (to be amended to the Application for New License, FERC License 2105). During the 2002 monitoring program, flow in the Hamilton Branch was measured upstream of Lake Almanor at a temporary stream gage (HB1). This station is located near the confluence with Lake Almanor, and is downstream of a series of small diversion facilities that diverts flow into a canal that supplies the Licensee's Hamilton Branch Powerhouse. During the June-September 2002 monitoring period, estimated mean daily flows in the Hamilton Branch upstream of Lake Almanor ranged from 61 to 95 cfs, with an average flow of 75 cfs. Figure 3.1 compares daily average flow from the Hamilton Branch with other stations tributary to Lake Almanor.

The second location monitoring flow in the Hamilton Branch system as inflow to Lake Almanor is the Licensee's Hamilton Branch Powerhouse (NF-83). This facility is located near the mouth of the Hamilton Branch River and discharges directly into Lake Almanor (Figure 2-1). During the June-September 2002 monitoring period, mean daily flows at the Hamilton Branch Powerhouse averaged 52 cfs and ranged from 0 to 92 cfs. Figure 3.1 compares daily average flow from Hamilton Branch Powerhouse with other stations tributary to Lake Almanor.

Lake Almanor is the primary storage reservoir for the Upper NFFR Project; it is located about 90 miles upstream of the city of Oroville. Lake Almanor was created by the construction of a hydraulic fill dam now referred to as Canyon Dam. Canyon Dam was completed in various phases between 1913 and 1927. Lake Almanor has a normal maximum water surface elevation of 4,504 ft (USGS datum) and a storage capacity of 1,142,00 acre-ft. The average residence time in Lake Almanor is approximately 291 days. Major lake outlets include the Canyon Dam Intake, which releases water to the NFFR downstream of Lake Almanor (Seneca Reach), and the Prattville Intake that diverts water to Butt Valley Reservoir through Butt Valley Powerhouse. Figure 3-2 presents daily average reservoir storage for Lake Almanor for the June through September 2002 monitoring period.

Releases from the Prattville Intake to Butt Valley Reservoir represent the greatest portion of water released from Lake Almanor. The maximum flow through the intake is 2,200 cfs. The Prattville Intake is a high-Froude number structure; as a result, water is drawn from the entire water column regardless of thermal stratification conditions. The tunnel invert is situated at the bottom of a narrow steep-sided trough that connects the relatively shallow intake channel with the deeper areas of the reservoir. The invert of the Prattville Intake is located at 4,420 ft. (USGS datum). However, access to the deeper areas of Lake Almanor is restricted by the shallow approach channel that has a base elevation of 4,432 ft (USGS datum). As a result, the water withdrawn by the Prattville Intake is primarily from the warmer layers in the lake.

~~1.1.1.2~~3.1.1.2 Butt Valley Reservoir and tributaries

The main source of inflow to Butt Valley Reservoir is the discharge from Butt Valley Powerhouse (NF-71), which draws water from Lake Almanor through the Prattville Intake. During the June-September 2002 monitoring period, mean daily flows in Butt Valley Powerhouse averaged 820 cfs and ranged from 0 to 1,615 cfs. Figure 3-3 compares daily average flow through Butt Valley Powerhouse with those from the other powerhouses associated with the Upper NFFR Project.

Butt Creek is the only significant natural tributary entering Butt Valley Reservoir. During the June-September 2002 monitoring period, mean daily flows in Butt Creek (NF-4) ranged from 40.9 to 71.8 cfs, with an average flow of 46.6 cfs.

On an annual basis, the Butt Valley Reservoir water surface elevations fluctuate by about 10 to 15 feet from the maximum water surface elevation of 4,142 ft. (USGS datum). Under normal operating conditions, daily changes in elevation are typically less than 1 foot. The retention time for water traveling through the reservoir is 14 to 32 days depending on operating conditions. Figure 3-4 presents average daily storage for Butt Valley Reservoir for the June through September 20002 monitoring period.

The primary outflow from the Butt Valley Reservoir is through the intakes for Caribou No. 1 and No. 2 powerhouses. The Caribou No. 1 Intake has a capacity of about 1,100 cfs and is located in the deepest area of Butt Valley Reservoir near the dam. The Caribou No. 1 Intake tunnel invert elevation is at 4,077 ft. (USGS datum). The actual Caribou No. 1 Intake structure is located in a small depression zone. Recent bathymetric surveys (April 1996), indicated that the main approach channel has an elevation of 4,095 ft. (USGS datum). Caribou No. 2 Intake has a larger capacity (1,460 cfs), and is located in a shallow channel with an entrance elevation (channel invert) of 4,110 ft. (USGS datum). Because of the higher invert elevation, the Caribou No. 2 Intake withdraws warmer surface water from the reservoir.

No controlled minimum release is made from Butt Valley Dam to the Butt Creek channel downstream of the reservoir. The reservoir rarely spills due to the large combined outflow capability of Caribou No. 1 and No. 2 powerhouses (2,560 cfs). The Licensee has monitored leakage flows in Butt Creek below Butt Valley Dam since 1997 to ensure that leakage flows were not reduced after seismic restoration work on the dam was completed in 1997. The average annual leakage flow is about 0.07 cfs (32 gallons per minute [GPM]). Flow conditions in Butt Creek below Butt Valley Dam will be discussed in the following Section.

~~1.1.1.3~~3.1.1.3 Seneca Reach of the NFFR and tributaries

The Seneca bypass reach (Seneca Reach) consists of a 10.8-mile section of the NFFR extending from Canyon Dam to Caribou No.1 Powerhouse. A seasonally constant minimum of 35 cfs is released from Canyon Dam to the NFFR in accordance with Article 26 of FERC License 2105. Flows are measured by the Licensee in cooperation with the USGS at a permanent gaging station (NF-2) located approximately 0.5 mile downstream of the release structure. During the June-September 2002 monitoring period, mean daily flows in NFFR below Canyon Dam (NF-2) ranged from 34.7 to 36.9 cfs, and averaged 35.9 cfs.

Butt Creek enters the NFFR approximately 1.25 miles upstream of Belden Forebay. Butt Creek is the largest of the NFFR tributaries in the Seneca Reach. There are no minimum flow requirements for Butt Creek below Butt Valley Reservoir. Flows in Butt Creek downstream of Butt Valley Dam consist primarily of spring flow accretion, supplemented with leakage from the Butt Valley Dam, and tributary inflow from Benner Creek. During the June-September 2002 monitoring period, mean daily flows in Butt Creek near its confluence with the NFFR (BC3) ranged from 13.7 to 14.6 cfs, with an average flow of 14.1 cfs.

The monitoring station located on the NFFR above Caribou Powerhouse (NF4) is also the site of a discontinued permanent gage (NF-47). This station captures the total flow entering Belden Forebay from the Seneca Reach. During the June-September 2002 monitoring period, mean daily flows in NFFR above Caribou Powerhouse from 71.2 to 83.2 cfs, and averaged 75.7 cfs.

The total mean daily tributary and lateral accretion flows were calculated for the entire Seneca Reach. For the June through September 2002 period tributary flows ranged from 36.0 to 46.7 cfs, and averaged 39.8 cfs. The measured range of accretion (36.0 to 46.7 cfs) constitutes a 103 to 133 percent dilution effect under the existing 35 cfs in-stream release from Canyon Dam.

~~1.1.1.4~~3.1.1.4 Belden Forebay and Caribou Powerhouse complex

Belden Reservoir is located on the NFFR approximately 10.8 miles downstream of Canyon Dam. Belden Forebay forms the afterbay for the Caribou Powerhouses, and is the forebay for Belden Powerhouse. The forebay was created by a rock-filled dam in 1958 and has a maximum water surface elevation of 2,985 ft. (USGS datum) and a usable storage capacity of 2,477 acre-ft. Under normal operation, the water surface elevation fluctuates between 2,960 ft. and 2,973 ft. depending on power operations. Lake Almanor and Butt Valley Reservoir control the majority of upstream run-off; as a result, spill events at Belden Dam are rare. Belden Forebay has no storage capability and therefore the operation of the Caribou Powerhouses is closely coordinated with the operation of

Belden Powerhouse as well as Licensee's other downstream powerhouses. The average residence time in Belden Reservoir is estimated at approximately 0.5 to 1.0 days.

The majority of flow entering Belden Forebay originates from Butt Valley Reservoir and is discharged through the Caribou No. 1 and No. 2 powerhouses. These powerhouses have average annual flow rates of 615 and 674 cfs, respectively (Pacific Gas and Electric Company 1999). Additional inflow is received from the Seneca Reach of the NFFR; the average annual inflow from this source is approximately 120 cfs. Caribou No. 1 was completed in 1921 and Caribou No. 2 was completed in 1958. Depending on water availability and power requirements, one or both powerhouses may be used. The generating units at Caribou No. 2 are more efficient than those at Caribou No. 1, and their operation is favored.

During the June-September 2002 monitoring period, mean daily flows at Caribou No.1 Powerhouse (NF-63) ranged from 0 to 744 cfs, and averaged 331 cfs. Flow through the Caribou No. 2 Powerhouse (NF-263) during 2002 ranged from 0 to 1,070 cfs, and averaged 493 cfs. Figure 3-3 compares daily average flow through the Caribou No.1 and No.2 powerhouses with those from the other powerhouses associated with the Upper NFFR Project.

The primary outflow from Belden Forebay is through an intake structure located on the left bank (looking downstream) near Belden Dam. This intake provides flows of up to

2,610 cfs to Belden Powerhouse, which is located on Yellow Creek immediately upstream of the confluence of Yellow Creek with the NFFR. Water released from Belden Powerhouse enters the NFFR at its confluence with Yellow Creek; this flow enters the Licensee's Rock Creek Reservoir immediately downstream. During the June-September 2002 monitoring period, mean daily flow at Belden Powerhouse (NF-74) ranged from 0 to 1,513 cfs, and averaged 687 cfs. Figure 3-3 compares daily average flow through Belden Powerhouse with those from the other powerhouses associated with the Upper NFFR Project.

~~1.1.1.5~~3.1.1.5 Belden Reach of the NFFR and tributaries

The Belden bypass reach (Belden Reach) is a 9.3-mile section of the NFFR extending from Belden Dam to the confluence of the NFFR and Yellow Creek. Prior to July 1985, releases from Belden Forebay to the NFFR immediately downstream of the Belden Dam were made from a low-level release in the dam or its upper spillway gates. Oak Flat Powerhouse was completed in 1985 and operates on the instream flow release made at the base of Belden Forebay Dam. To accommodate the two flow rates the turbine has a high flow and a low flow runner. These runners are changed in the spring and fall. This change-out takes a few days and during this time the instream flow is met by releasing water through the pressure release valve at the end of the outlet pipe so that a continuous release is maintained. During the June-September 2002 monitoring period, mean daily flows through Oak Flat Powerhouse (NF-103) ranged from 0 to 116 cfs, and averaged 83 cfs.

Under the terms of FERC License 2105 and the California Department of Fish and Game (CDFG) agreement, the Licensee releases a minimum of 140 cfs from the last Saturday in April to Labor Day and 60 cfs during the rest of the year to the NFFR downstream of Belden Dam for the maintenance of fish life in the Belden Reach of the NFFR. The instream flow releases from Belden Dam are measured at a compliance stream gage located approximately 0.5 mile downstream of the Belden Dam-Oak Flat Powerhouse complex. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Belden Dam (NF-70) ranged from 62.1 to 145 cfs, and averaged 125 cfs.

Mosquito Creek is the largest tributary to the NFFR between Belden Forebay and the NFFR confluence with the East Branch NFFR (EBNFFR). Flows in Mosquito Creek typically range from 2 to 10 cfs during the period June through September (Pacific Gas and Electric Company 1987). Flows in Mosquito Creek were estimated based on periodic flow measurements and regression comparison to monitored flows in Yellow Creek. Based on this estimation, mean daily flows during the June-September 2002 monitoring period ranged from 4.0 to 7.5 cfs, and averaged 4.8 cfs.

The EBNFFR is a large unregulated tributary of the NFFR with an average annual flow of 1,031 cfs (Pacific Gas and Electric Company 1999). The EBNFFR and the NFFR merge approximately 1.75 miles upstream of the confluence with Yellow Creek. Winter and spring flows in the EBNFFR are sufficient under most conditions to allow the Licensee to operate the Upper NFFR Project such that water is stored in Lake Almanor until required by the downstream production facilities. During the June-September 2002 monitoring period, mean daily flows in EBNFFR ranged from 45.0 to 334 cfs, with an average of 93.7 cfs.

Yellow Creek is one of the larger tributary streams contributing to the NFFR downstream of the confluence with the EBNFFR. Typical flows in Yellow Creek range from 40 to 170 cfs during the June through September period (Pacific Gas and Electric Company 1986a, 1987). Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Flow during June through September 2002 ranged from 48.8 to 117 cfs, averaging 60.5 cfs.

~~1.1.1.6~~3.1.1.6 Rock Creek Reach of the NFFR and tributaries

Rock Creek Reservoir is located on the NFFR approximately 3.0 miles downstream of Belden Powerhouse. Rock Creek Reservoir forms the afterbay for Belden Powerhouse, and is the forebay for Rock Creek Powerhouse. The forebay was created by a concrete dam in 1950 and has a maximum water surface elevation of 2,216.2 ft. (USGS datum). Rock Creek Reservoir's original operating capacity of 4,400 acre-feet at 2,216.2 ft. has been significantly reduced (greater than 50%) by sediment accumulation.

Chips Creek is a major tributary of the NFFR, discharging directly into Rock Creek Reservoir. Flows in Chips Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 12.4 to 107 cfs, and averaged 29.7 cfs.

The Rock Creek bypass reach (Rock Creek Reach) is an 8.4-mile section of the NFFR extending from Rock Creek Dam to the tailrace of Rock Creek Powerhouse. Under the terms of the FERC License (Dated October 24, 2001), the Licensee released a minimum of 220 cfs in June, and 180 cfs from July through November in 2002. A more detailed discussion of the minimum release requirements is contained in Appendix A of the FERC License.

The instream flow releases from Rock Creek Dam to the Rock Creek Reach of the NFFR are measured at a permanent stream gage located approximately 1.5 miles downstream of the dam. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Rock Creek Dam (NF-57) ranged from 150 to 1,133 cfs, and averaged 230 cfs.

Milk Ranch Creek is one of several tributaries to the Rock Creek Reach of the NFFR. Flows in Milk Ranch Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 3.2 to 9.8 cfs, and averaged 5.0 cfs.

Chambers Creek is another of the streams tributary to the Rock Creek Reach of the NFFR. Flows in Chambers Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 2.5 to 46.9 cfs, and averaged 9.6 cfs.

Flows in Bucks Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flow in Bucks Creek originates from Lower Bucks Reservoir. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 10.2 to 24.1 cfs, and averaged 15.5 cfs.

The source of flow to Bucks Powerhouse is Grizzly Forebay, which receives diversion flow from Bucks Lake and Lower Bucks Lake. Bucks Powerhouse has a maximum capacity of 340 cfs; flows are released to the NFFR immediately upstream of Rock Creek Powerhouse. During the June-September 2002 monitoring period, mean daily flow at Bucks Powerhouse ranged from 0 to 237 cfs, and averaged 97 cfs (Figure 3-5).

The primary outflow from Rock Creek Reservoir is through an intake structure located on the right bank (looking downstream) near Rock Creek Dam. This intake provides flows of up to 3,560 cfs to Rock Creek Powerhouse, which is located on the NFFR upstream Cresta Reservoir. During the June-September 2002 monitoring period, mean daily flow at Rock Creek Powerhouse ranged from 97 to 1,744 cfs, and averaged 949 cfs. Figure 3-5 compares daily average flow through Rock Creek Powerhouse with those from the other powerhouses associated with the Rock Creek-Cresta Project.

Rock Creek is the last major tributary stream to the Rock Creek section of the NFFR; flows enter the NFFR at the upper end of Cresta Reservoir. Flows in Rock Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 1.7 to 44.5 cfs, and averaged 7.9 cfs.

~~1.1.1.7~~3.1.1.7 Cresta Reach of the NFFR and tributaries

Cresta Reservoir is located on the NFFR immediately downstream of Rock Creek Powerhouse, and acts as the afterbay for this facility. Cresta Reservoir forms the afterbay for Rock Creek Powerhouse, and is the forebay for Cresta Powerhouse. The forebay was created by a concrete dam in 1949 and has a maximum water surface elevation of 1,681.20 ft (USGS datum). The original capacity of 4,410 acre-feet has been significantly reduced by accumulated sediments.

Rock Creek flows enter the NFFR at the upper end of Cresta Reservoir. Flows in Rock Creek were estimated based on periodic flow measurements and an assumed constant rate of hydrologic decay. Based on these data, mean daily flows during the June-September 2002 monitoring period ranged from 1.7 to 44.5 cfs, and averaged 7.9 cfs.

The Cresta bypass reach (Cresta Reach) is a 4.9-mile section of the NFFR extending from Cresta Dam to the tailrace of Cresta Powerhouse. Under the terms of the FERC License (Dated October 24, 2001), the Licensee released a minimum of 240 cfs in June, and 220 cfs from July through November 2002. A more detailed discussion of the minimum release requirements is contained in Appendix A of the FERC License.

Flows in Grizzly Creek were monitored using a temporary flow monitoring gage installed near the mouth. Flows were calculated based on hourly average stage data, and a rating developed using periodic flow measurements. Mean daily flows during the June-September 2002 monitoring period ranged from 12.9 to 38.8 cfs, and averaged 22.4 cfs.

The instream flow releases from Cresta Dam to the Cresta Reach of the NFFR are measured at a permanent stream gage located approximately 2.8 miles downstream of the dam, and 2.4 miles downstream of Grizzly Creek. During the June-September 2002 monitoring period, mean daily flows in the NFFR below Rock Creek Dam (NF-56) ranged from 235 to 1,109 cfs, and averaged 277 cfs.

The primary outflow from Cresta Reservoir is through an intake structure located on the left bank (looking downstream) near Cresta Dam. This intake provides flows of up to 3,700 cfs to Cresta Powerhouse, which is located on the NFFR upstream Poe Reservoir. During the June-September 2002 monitoring period, mean daily flow at Cresta

Powerhouse ranged from 12 to 1,898 cfs, and averaged 1,053 cfs. Figure 3-5 compares daily average flow through Cresta Powerhouse with those from the other powerhouses associated with the Rock Creek-Cresta Project.

~~1.1.2~~3.1.2 Meteorology

3.1.2.1 2002 Regional Precipitation

Mean annual precipitation in the upper NFFR watersheds ranges from a low of 20 inches (in eastern portions of the EBNFFR watershed), to a high of 90 inches in the northwestern part of the watershed near Mount Lassen (California Data Exchange Center [CDEC] 2001). Most of the precipitation in the basin occurs from October through May, with maximum storm intensities occurring December through March. Winter precipitation at higher elevations usually occurs as snow, although warm winter storms can produce rain up to the 10,000-ft level. The typical April 1 snow accumulations range from 2 inches of water at an elevation of 5,800 ft, to 32 inches of water at 6,700 ft. (CDEC 2001). Larger snow accumulations occur on Mount Lassen, with an average April 1 snow-water-equivalent of 78 inches. The mean annual precipitation within the Project area ranges from about 30 to 40 inches (CDEC 2002). Table 3-2 summarizes precipitation data from the available stations in the Project vicinity.

Table 3-2

Summary of Precipitation Data from Meteorological Stations in the Upper NFFR Project Vicinity.

Station	YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Annual Total
		Water Year* (inches)												
Chester	2002	1.94	4.43	2.45	1.4	2.17	3.15	2.02	1.67	0	0	0	0	19.23
4,525 ft.	% of Normal	97%	119%	47%	23%	41%	78%	93%	114%	0%	0%	0%	0%	60%
	Average	2.01	3.73	5.24	6.00	5.24	4.02	2.18	1.46	0.93	0.23	0.28	0.60	31.92
Canyon Dam	2002	1.1	5.19	8.2	3.84	2.6	3.54	1.25	1.14	0.02	0	0	0	26.88
4,560 ft.	% of Normal	48%	117%	126%	51%	41%	69%	45%	69%	3%	0%	0%	0%	70%
	Average	2.28	4.44	6.49	7.58	6.30	5.11	2.76	1.65	0.78	0.18	0.29	0.58	38.44
Greenville	2002	1.41	8.28	10.87	3.92	2.39	4.44	1.52	0.98	0	0	0	0	33.81
RS	% of Normal	55%	155%	174%	54%	38%	83%	57%	63%	0%	0%	0%	0%	86%
3,570 ft.	Average	2.55	5.35	6.26	7.22	6.26	5.35	2.68	1.55	0.78	0.26	0.36	0.78	39.40
Caribou PH	2002	1.18	6.53	7.39	5.23	2.51	3.88	1.84	0.95	0.12	0.1	0	0	29.73
2,986 ft.	% of Normal	50%	141%	107%	65%	36%	71%	60%	56%	15%	91%	0%	0%	73%
	Average	2.34	4.62	6.92	7.99	6.88	5.50	3.06	1.71	0.79	0.11	0.20	0.55	40.67

* Water year is period October 1 through September 31

Table 3-2 Continued.

Snow Survey Data from the Greater NFFR Watershed Area

Station	Elevation (ft. USGS)	2002 April 1 Water Equivalents (inches)	Average April 1 Water Equivalents (inches)
Lower Lassen Peak	8,250	79.1	79.8
Mount Dyer 1	7,100	26.6	25.3
Mount Dyer 2	6,050	17.8	16.1
Harkness Flat	6,200	29.8	28.5
Mount Stover	5,600	12.7	16.0
Feather River Meadows	5,400	24.9	22.6
Warner Creek	5,100	17.9	14.9
Humbug Summit 2	4,850	13.4	16.1
Chester Flat	4,600	3.6	6.5

The data from the four stations presented in Table 3-2 broadly define conditions in the upstream watersheds and immediate Project area. Total precipitation during the 2002 water year (October 2001 to September 2002) averaged 72 % of normal (4 stations).

~~1.1.1.2~~3.1.2.2 2002 Monitoring at Prattville Intake and Rock Creek Dam

Two temporary meteorological stations were installed in the Project vicinity during the 2002 monitoring period. One station was located at the Prattville Intake on Lake Almanor; another station was located on Rock Creek Dam. Data from these stations were used as input to the SNTEMP model for calibration and validation. The data collected at these meteorological stations in 2002 are summarized in Table 3-3.

Table 3-3

Summary of 2002 Meteorological Data from Project Area

Prattville Intake Station

Station	Units	Year	Month	Daily Average [1] Max	Min	Mean	Data Days
Air Temperature	(°C)	2002	June	20.0	9.5	16.6	30
		2002	July	25.0	18.1	20.6	31
		2002	Aug	23.4	13.3	18.6	31
		2002	Sept	20.1	9.3	15.3	30
Relative Humidity	(%)	2002	June	66	37	49	30
		2002	July	70	29	45	31
		2002	Aug	53	27	41	31
		2002	Sept	73	31	43	30
Solar Radiation	(watts/S)	2002	June	337	211	305	30
		2002	July	326	163	286	31
		2002	Aug	287	181	244	31
		2002	Sept	220	122	184	30
Wind Speed	(mph)	2002	June	4.83	0.94	1.44	30
		2002	July	1.21	0.93	1.10	31
		2002	Aug	2.88	0.99	1.20	31
		2002	Sept	3.46	0.83	1.21	30

Rock Creek Dam Station

Station	Units	Year	Month	Daily Average [1] Max	Min	Mean	Data Days
Air Temperature	(°C)	2002	June	25.0	16.5	22.0	30
		2002	July	30.1	23.6	26.0	31
		2002	Aug	29.0	18.7	23.8	31
		2002	Sept	25.9	14.5	20.8	30
Relative Humidity	(%)	2002	June	55	21	38	30
		2002	July	47	23	34	31
		2002	Aug	42	20	31	31
		2002	Sept	62	22	32	30
Solar Radiation	(watts/S)	2002	June	312	238	290	30
		2002	July	302	209	279	31
		2002	Aug	276	223	248	31
		2002	Sept	228	62	193	30
Wind Speed	(mph)	2002	June	3.99	2.34	3.26	30
		2002	July	3.84	2.17	3.01	31
		2002	Aug	3.52	2.40	3.11	31
		2002	Sept	4.31	2.57	3.15	30

1: Base on hourly average data.

~~1.2~~3.2 WATER TEMPERATURE

3.2.1 2002 Monitoring

As discussed in Section 2.2.3, water temperatures were continuously monitored during the summer of 2002. Due to the voluminous nature of this data, the information presented in the following section will summarize the data collected during the monitoring effort. Appendix A presents a summary of hourly average data.

For consistency with the temperature level specified for the Licensee's Rock Creek Cresta Project (FERC 1962) (Pacific Gas and Electric Company 2000b), daily average data are used throughout this document unless otherwise specified. Table 3-4 summarizes the daily average water temperature data collected during the 2002 program.

Table 3-4
Summary of Daily Average Water Temperatures from UNFFR – 2002

Station	Year	Month	Daily Temperatures [1] max	min	mean	Daily Range [2] max	min	mean	Data Days
NFFR at Chester (NF1)	2002	June	15.4	9.6	12.7	7.5	3.6	6.6	30
	2002	July	16.8	14.7	15.7	7.6	3.9	6.4	31
	2002	Aug	16.1	12.8	14.2	6.7	4.2	5.7	31
	2002	Sept	14.0	9.8	11.5	5.4	2.8	4.4	30
Hamilton Branch at Road bridge (HB1)	2002	June	12.4	10.1	11.8	5.6	3.6	5.1	30
	2002	July	12.6	11.5	12.0	5.4	3.7	4.9	31
	2002	Aug	12.7	11.0	11.8	7.1	3.9	4.5	31
	2002	Sept	11.7	9.3	10.4	4.1	2.0	3.6	30
Hamilton Branch Powerhouse (HB2)	2002	June	13.4	10.9	12.6	7.9	5.0	7.3	30
	2002	July	14.0	12.4	13.3	8.0	5.3	7.3	21
	2002	Aug	19.1	16.1	17.5	5.2	3.4	4.4	30
	2002	Sept	17.0	9.5	14.4	5.1	2.2	3.8	30
Lake Almanor at Canyon Dam near surface (LA1-S)	2002	June	22.5	16.9	19.7	4.1	0.7	1.6	30
	2002	July	25.3	21.7	23.6	2.3	0.7	1.3	31
	2002	Aug	25.4	21.8	23.1	1.6	0.5	1.0	31
	2002	Sept	22.5	18.1	20.0	1.6	0.3	1.0	30
Lake Almanor at Canyon Dam near bottom (LA1-B)	2002	June	9.3	8.2	8.9	0.6	0.1	0.2	30
	2002	July	10.4	9.3	9.9	0.6	0.2	0.3	31
	2002	Aug	11.2	10.5	10.8	0.7	0.3	0.4	31
	2002	Sept	11.4	11.1	11.3	0.4	0.1	0.3	30
NFFR below Canyon Dam (NF2)	2002	June	11.9	10.6	11.3	2.5	0.5	1.0	30
	2002	July	13.0	11.8	12.5	1.6	0.5	0.8	31
	2002	Aug	13.4	12.9	13.3	1.0	0.3	0.6	31
	2002	Sept	14.1	13.3	13.7	1.7	0.5	1.0	30
NFFR at Seneca Bridge (NF3)	2002	June	14.7	11.8	13.5	4.6	3.2	4.2	30
	2002	July	15.7	14.2	15.0	4.7	3.0	3.9	31
	2002	Aug	15.6	13.5	14.5	4.0	2.9	3.3	31
	2002	Sept	14.6	12.2	13.4	3.0	1.4	2.5	30
NFFR above Caribou PH (NF4)	2002	June	15.6	12.3	14.3	4.3	2.0	3.7	30
	2002	July	16.8	15.0	15.9	4.1	2.0	3.3	31
	2002	Aug	16.3	13.9	15.0	3.7	2.3	3.0	31
	2002	Sept	15.0	12.1	13.4	3.0	1.1	2.3	30
Butt Valley Powerhouse [Corrected] (BV1)	2002	June	16.1	14.8	15.5	8.4	1.4	3.4	4
	2002	July	21.7	17.8	20.2	5.3	1.2	3.1	29
	2002	Aug	21.9	20.4	21.2	3.1	0.3	0.8	31
	2002	Sept	21.3	17.9	19.3	1.3	0.3	0.6	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Daily Range [2] max	min	mean	Data Days
Butt Valley Res.	2002	June	22.1	18.3	20.1	2.9	.5	1.2	30
at Caribou Intake	2002	July	24.4	22.1	23.3	2.0	0.6	1.1	31
Near surface	2002	Aug	24.0	21.7	22.7	1.9	0.5	0.9	31
(BV2-S)	2002	Sept	22.2	18.4	20.1	1.6	0.3	0.8	30
Butt Valley Res.	2002	June	11.9	9.4	10.4	0.8	0.2	0.5	30
at Caribou Intake	2002	July	18.5	11.9	15.0	1.6	0.4	0.8	31
Near bottom	2002	Aug	20.8	18.7	20.0	0.7	0.1	0.5	31
(BV2-B)	2002	Sept	20.6	18.2	19.3	0.5	0.1	0.2	30
Butt Creek above	2002	June	15.1	11.6	13.9	7.5	5.1	6.5	30
Butt Valley	2002	July	16.0	13.7	14.7	7.1	4.7	6.0	31
Reservoir	2002	Aug	14.8	11.9	13.1	6.2	4.2	5.4	31
(BC1)	2002	Sept	13.1	9.5	11.1	5.0	2.5	4.1	30
Butt Creek below	2002	June	10.7	10.4	10.6	0.7	0.4	0.6	30
Butt Valley	2002	July	10.8	10.6	10.7	0.6	0.4	0.5	31
Reservoir	2002	Aug	10.8	10.5	10.7	0.7	0.5	0.6	31
(BC2)	2002	Sept	10.7	10.4	10.5	0.6	0.3	0.5	30
Butt Creek at	2002	June	12.1	10.6	11.5	2.6	1.5	2.2	30
Mouth	2002	July	12.8	11.9	12.4	2.3	1.4	2.0	31
(BC3)	2002	Aug	12.9	11.7	12.4	2.4	1.7	1.9	31
	2002	Sept	12.6	11.3	12.0	2.0	0.9	1.6	30
Caribou No. 1	2002	June	13.3	12.3	12.7	1.9	0.1	1.0	5
Powerhouse	2002	July	21.0	16.3	19.3	4.3	0.6	1.3	29
[corrected]	2002	Aug	21.9	21.2	21.4	2.6	0.2	0.9	31
(CARB1)	2002	Sept	21.3	18.2	19.7	0.9	0.3	0.2	30
Caribou No. 2	2002	June	21.5	17.4	19.3	4.1	0.6	1.5	30
Powerhouse	2002	July	24.0	21.9	23.2	2.7	0.6	1.1	28
[corrected]	2002	Aug	23.7	21.5	22.5	1.2	0.3	0.7	31
(CARB2A)	2002	Sept	22.1	18.3	19.9	1.1	0.3	0.6	30
Belden Reservoir	2002	June	21.5	18.1	19.5	1.5	0.3	0.6	30
At Intake	2002	July	22.8	19.3	21.5	1.9	0.2	0.7	31
(BD1)	2002	Aug	22.6	21.4	21.9	0.9	0.3	0.5	31
	2002	Sept	21.7	18.4	19.8	0.6	0.2	0.3	30
NFFR below	2002	June	18.9	15.9	17.4	1.4	0.3	0.6	30
Belden Dam	2002	July	21.1	17.8	19.4	1.3	0.3	0.8	31
(NF5)	2002	Aug	21.2	20.2	20.7	0.7	0.2	0.5	31
	2002	Sept	20.9	16.8	18.8	2.8	0.4	0.5	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Daily Range [2] max	min	mean	Data Days
Mosquito Creek	2002	June	14.4	11.4	13.0	2.3	1.4	2.0	30
At mouth	2002	July	15.6	13.8	14.7	2.4	1.4	2.0	31
(MC1)	2002	Aug	15.3	12.9	13.9	2.2	1.5	1.8	31
	2002	Sept	13.7	11.3	12.2	1.7	1.0	1.5	30
NFFR near	2002	June	19.0	15.7	17.1	3.9	2.5	3.4	30
Queen Lily	2002	July	21.1	18.1	19.5	4.2	2.6	3.3	31
Campground	2002	Aug	21.1	19.6	20.3	3.5	2.2	2.8	31
(NF6)	2002	Sept	20.9	19.3	18.0	4.7	2.4	3.5	30
NFFR near	2002	June	19.3	16.2	17.5	5.6	3.6	5.0	30
Gansner Bar	2002	July	21.3	18.5	19.7	6.0	3.5	4.9	31
(NF7)	2002	Aug	21.1	19.1	20.1	5.4	3.4	4.3	31
	2002	Sept	20.5	16.1	17.6	5.5	2.6	4.2	30
East Branch	2002	June	22.3	17.8	20.8	4.6	2.5	3.9	30
NFFR at mouth	2002	July	25.5	22.4	23.8	4.0	1.8	2.9	31
(EB1)	2002	Aug	24.3	19.9	21.8	3.4	1.9	2.5	31
	2002	Sept	21.6	15.9	18.2	2.8	1.1	2.0	30
NFFR at Belden	2002	June	21.2	17.1	19.4	5.2	4.2	4.7	30
Town Bridge	2002	July	22.9	20.4	21.4	5.3	3.5	4.6	31
(NF8)	2002	Aug	22.3	19.5	20.7	5.2	3.9	4.5	31
	2002	Sept	21.0	16.1	18.0	4.4	2.2	3.4	30
Belden	2002	June	18.7	17.7	18.0	1.0	0.4	0.7	7
Powerhouse	2002	July	22.5	19.0	21.2	1.9	0.1	0.6	29
(BD2)	2002	Aug	22.6	21.4	21.8	1.0	0.1	0.4	31
	2002	Sept	21.7	18.3	19.8	0.6	0.2	0.3	30
Yellow Creek	2002	June	17.0	12.3	15.0	3.8	1.9	3.2	30
Near mouth	2002	July	18.6	16.0	17.1	3.5	2.0	2.9	31
(YC1)	2002	Aug	17.7	14.0	15.6	3.1	2.0	2.9	31
	2002	Sept	15.4	11.8	13.1	2.2	0.8	1.7	30
Chips Creek	2002	June	16.2	10.6	13.6	5.4	3.2	4.6	30
Near mouth	2002	July	17.9	15.4	16.8	5.8	3.7	4.9	31
(CHIP)	2002	Aug	17.7	14.5	15.9	5.6	4.0	4.7	31
	2002	Sept	15.9	12.1	13.7	4.8	1.8	4.0	30
NFFR below Rock	---	---	---	---	---	---	---	---	---
Creek Dam	---	---	---	---	---	---	---	---	---
(NF9)	---	---	---	---	---	---	---	---	---
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NFFR at NF-57	2002	June	20.7	20.1	20.3	3.7	1.4	3.0	5
Insitu Recorder	2002	July	22.5	20.0	21.3	2.5	0.6	1.7	31
(NF10)	2002	Aug	22.1	20.5	21.2	2.0	1.1	1.4	31
	2002	Sept	21.2	17.6	19.1	1.4	0.3	1.0	30

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Daily Range [2] max	min	mean	Data Days
Milk Ranch Creek	2002	June	16.0	10.6	14.0	5.3	3.0	4.7	30
Near mouth	2002	July	17.9	14.8	16.4	5.5	3.2	4.5	31
(MR1)	2002	Aug	17.2	13.3	15.0	4.8	3.1	3.9	31
	2002	Sept	18.1	11.1	12.7	3.5	1.5	2.7	30
Chambers Creek	2002	June	16.5	9.0	13.7	6.3	3.1	5.0	30
Near mouth	2002	July	18.8	14.9	16.9	5.9	3.4	4.9	31
(CHAM)	2002	Aug	18.1	13.9	15.7	5.7	3.5	4.7	31
	2002	Sept	16.3	11.6	13.8	5.1	1.8	4.1	30
NFFR near Tobin	2002	June	20.9	16.0	18.6	5.1	3.0	3.9	30
Blw Granite Crk	2002	July	22.8	20.2	21.5	4.3	2.6	3.5	31
(NF11)	2002	Aug	22.5	19.8	21.0	4.1	2.7	3.2	31
	2002	Sept	21.0	17.3	18.8	3.5	1.5	2.7	30
Jackass Creek	2002	June	16.5	9.6	14.1	6.4	4.2	5.4	30
Near mouth	2002	July	18.9	15.0	17.0	6.1	3.2	4.6	31
(JKC1)	2002	Aug	18.3	13.7	15.9	4.5	2.9	3.7	31
	2002	Sept	16.5	12.2	14.2	3.9	1.4	3.1	30
NFFR abv Bucks	2002	June	21.0	15.9	18.6	5.2	2.7	3.6	30
Creek	2002	July	22.9	20.2	21.6	3.8	2.2	2.9	31
(NF12)	2002	Aug	22.6	19.7	21.0	3.6	2.4	2.8	31
	2002	Sept	21.1	17.2	18.8	3.7	1.3	2.5	30
Bucks Creek	2002	June	18.1	12.4	16.0	7.0	4.1	6.0	30
Near Mouth	2002	July	20.4	16.8	18.6	7.2	3.9	5.7	31
(BUCK1)	2002	Aug	19.3	14.8	16.9	6.2	3.5	4.8	31
	2002	Sept	17.1	12.0	14.0	4.6	1.6	3.5	30
Bucks Creek	2002	June	18.6	13.2	15.6	2.9	0.0	1.4	27
Powerhouse	2002	July	18.9	15.6	16.7	3.6	0.3	1.1	26
(BUCK2)	2002	Aug	15.5	13.5	14.3	4.5	0.3	1.5	21
	2002	Sept	13.7	12.6	13.0	2.3	0.2	0.6	30
NFFR abv Rock	2002	June	21.0	15.8	18.6	4.6	2.0	3.1	30
Creek Powerhouse	2002	July	22.8	19.4	20.7	4.6	1.9	3.3	31
(NF13)	2002	Aug	21.8	17.6	19.3	5.3	1.9	3.7	31
	2002	Sept	18.1	15.0	16.3	4.5	1.7	2.9	30
Rock Creek	2002	June	20.1	16.1	18.1	1.8	0.2	0.9	30
Powerhouse	2002	July	22.6	19.6	21.3	1.4	0.2	0.8	31
(RC1)	2002	Aug	22.6	21.0	21.7	1.5	0.3	0.9	31
	2002	Sept	21.7	18.4	19.8	1.4	0.4	0.8	31

Table 3-4 (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Daily Range [2] max	min	mean	Data Days
Rock Creek	2002	June	17.6	11.4	14.8	3.6	1.4	2.3	30
Near mouth	2002	July	19.7	16.5	18.1	2.7	1.47	2.1	31
(RC2)	2002	Aug	19.3	15.6	17.1	2.3	1.3	1.8	31
	2002	Sept	17.1	13.7	14.8	1.9	0.4	1.3	30
NFFR abv Grizzly	2002	June	20.8	16.7	18.4	1.5	0.7	1.1	30
Creek	2002	July	22.2	20.3	21.2	1.6	0.5	1.0	31
(NF14)	2002	Aug	21.9	19.6	20.7	1.6	0.5	1.1	31
	2002	Sept	20.5	17.1	18.5	1.3	0.3	0.8	30
Grizzly Creek	2002	June	18.3	12.7	15.9	4.0	2.7	3.6	30
Near mouth	2002	July	20.8	17.8	19.3	4.4	2.7	3.6	31
(GR1)	2002	Aug	20.5	16.4	18.0	3.8	2.6	3.1	31
	2002	Sept	17.8	13.5	15.0	2.9	0.8	2.1	30
NFFR at NF-56	2002	June	20.9	16.2	18.4	3.2	1.0	2.6	30
blw Grizzly Crk	2002	July	22.1	20.4	21.3	3.2	1.8	2.5	31
(NF15)	2002	Aug	22.0	19.5	20.6	3.1	1.0	2.3	30
	2002	Sept	20.5	16.9	18.4	2.6	0.9	3.1	30
NFFR abv Cresta	2002	June	21.2	16.4	18.7	3.5	2.1	3.1	30
Powerhouse	2002	July	22.6	20.9	21.7	3.7	2.1	2.8	31
(NF16)	2002	Aug	22.4	19.6	20.9	3.1	1.6	2.4	31
	2002	Sept	20.7	17.1	18.5	3.0	1.0	2.1	30
Cresta	2002	June	20.8	16.3	18.5	1.7	0.1	0.7	30
Powerhouse	2002	July	22.5	20.4	21.4	1.3	0.1	0.8	30
(CR1)	2002	Aug	22.5	20.1	21.0	1.8	0.4	1.1	31
	2002	Sept	20.7	17.3	18.7	1.6	0.3	0.6	30
Middle Fork	2002	June	21.1	15.2	18.2	3.3	1.4	2.5	30
Feather River	2002	July	23.3	20.5	21.9	3.7	2.0	3.0	31
At Milsap Bar	2002	Aug	22.9	18.6	20.3	3.0	2.1	2.6	31
(MB1)	2002	Sept	19.9	16.2	17.3	2.6	1.6	2.2	26

1. Daily values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average temperatures. For example, the maximum June temperature represents the maximum daily average measured in June. See Appendix A for a summary of hourly data.
2. Daily range is calculated based on the daily maximum temperature minus the daily minimum temperature. Monthly statistics are based on these daily range values.

~~1.1.1.1~~3.2.1.1 Lake Almanor and Tributaries

Summer water temperatures in the NFFR upstream of Lake Almanor (near Chester) (NF1) were monitored in 2002 by the Licensee. This station was located in the NFFR upstream of the town of Chester and about 1 mile downstream of the Army Corp. of Engineers flood diversion dam. During the 2002 program, daily average temperatures at station NF1a ranged from 9.6 to 16.8°C, and averaged 13.5°C. The diel fluctuation in temperature ranged from 2.8 to 7.6°C, and averaged 5.8°C in 2002.

Under the Rock Creek-Cresta Relicensing Settlement Agreement (Pacific Gas and Electric Company 2000b), a daily average water temperature of 20°C or less is specified as the desired water temperature level. As part of the license, to the extent that can reasonably be controlled the Licensee shall try to maintain conditions at or below this temperature level. For this reason, a comparison to this level was made at applicable locations. At station NF1, daily average temperatures did not exceed 20°C during the 2002 June through September period. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.1°C on July 11, 2002 (Appendix A). Table 3-5 compares daily average temperatures from each station with the 20°C level. Figure 3-6 compares the daily average temperature from the NFFR with other stations tributary to Lake Almanor.

Table 3-5

Summary of daily average temperature comparison with the 20°C level.

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
NFFR at	2002	June	0	30	0%
Chester	2002	July	0	31	0%
(NF1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Hamilton	2002	June	0	30	0%
Branch at	2002	July	0	31	0%
Road bridge	2002	Aug	0	31	0%
(HB1)	2002	Sept	0	30	0%
Hamilton	2002	June	0	30	0%
Branch	2002	July	0	31	0%
Powerhouse	2002	Aug	0	31	0%
(HB2)	2002	Sept	0	30	0%
Lake Almanor	2002	June	13	30	43%
at Canyon Dam	2002	July	31	31	100%
near surface	2002	Aug	31	31	100%
(LA1-S)	2002	Sept	12	30	40%
Lake Almanor	2002	June	0	30	0%
at Canyon Dam	2002	July	0	31	0%
near bottom	2002	Aug	0	31	0%
(LA1-B)	2002	Sept	0	30	0%
NFFR below	2002	June	0	30	0%
Canyon Dam	2002	July	0	31	0%
(NF2)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR at	2002	June	0	30	0%
Seneca Bridge	2002	July	0	31	0%
(NF3)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR above	2002	June	0	30	0%
Caribou PH	2002	July	0	31	0%
(NF4)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Butt Valley	2002	June	0	4	0%
Powerhouse	2002	July	20	29	69%
[Corrected]	2002	Aug	31	31	100%
(BV1)	2002	Sept	5	30	17%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Butt Valley Res.	2002	June	16		53%
at Caribou Intake	2002	July	31		100%
Near surface	2002	Aug	31		100%
(BV2-S)	2002	Sept	14		47%
Butt Valley Res.	2002	June	0		0%
at Caribou Intake	2002	July	0		0%
Near bottom	2002	Aug	15		48%
(BV2-B)	2002	Sept	8		27%
Butt Creek above	2002	June	0	30	0%
Butt Valley	2002	July	0	31	0%
Reservoir	2002	Aug	0	31	0%
(BC1)	2002	Sept	0	30	0%
Butt Creek below	2002	June	0	30	0%
Butt Valley	2002	July	0	31	0%
Reservoir	2002	Aug	0	31	0%
(BC2)	2002	Sept	0	30	0%
Butt Creek at	2002	June	0	30	0%
Mouth	2002	July	0	31	0%
(BC3)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Caribou No. 1	2002	June	0	5	0%
Powerhouse	2002	July	10	29	34%
[corrected]	2002	Aug	31	31	100%
(CARB1)	2002	Sept	8	31	27%
Caribou No. 2	2002	June	8	30	27%
Powerhouse	2002	July	28	28	100%
[corrected]	2002	Aug	31	31	100%
(CARB2A)	2002	Sept	13	30	43%
Belden Reservoir	2002	June	89	30	30%
At Intake	2002	July	28	31	90%
(BD1)	2002	Aug	31	31	100%
	2002	Sept	12	30	40%
NFFR below	2002	June	0	30	0%
Belden Dam	2002	July	7	31	23%
(NF5)	2002	Aug	31	31	100%
	2002	Sept	6	30	20%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Mosquito Creek	2002	June	0	30	0%
At mouth	2002	July	0	31	0%
(MC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR near	2002	June	0	30	0%
Queen Lily	2002	July	7	31	23%
Campground	2002	Aug	23	31	74%
(NF6)	2002	Sept	2	30	7%
NFFR near	2002	June	0	30	0%
Gansner Bar	2002	July	13	31	42%
(NF7)	2002	Aug	18	31	58%
	2002	Sept	2	30	7%
East Branch	2002	June	21	30	70%
NFFR at mouth	2002	July	31	31	100%
(EB1)	2002	Aug	29	31	94%
	2002	Sept	4	30	13%
NFFR at Belden	2002	June	8	30	27%
Town Bridge	2002	July	31	31	100%
(NF8)	2002	Aug	23	31	74%
	2002	Sept	3	30	10%
Belden	2002	June	0	7	0%
Powerhouse	2002	July	25	29	86%
(BD2)	2002	Aug	31	31	100%
	2002	Sept			
Yellow Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(YC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Chips Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(Chip1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR at NF-57	2002	June	5	5	100%
Below Rock Crk	2002	July	29	31	94%
Dam (NF10)	2002	Aug	31	31	100%
	2002	Sept	5	30	17%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Milk Ranch Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(MR1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Chambers Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(Cham1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR near Tobin	2002	June	6	30	20%
Blw Granite Crk	2002	July	31	31	100%
(NF11)	2002	Aug	29	31	94%
	2002	Sept	4	30	13%
Jackass Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(JC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR abv Bucks	2002	June	6	30	20%
Creek	2002	July	31	31	100%
(NF12)	2002	Aug	28	31	90%
	2002	Sept	4	30	13%
Bucks Creek	2002	June	0	30	0%
Near Mouth	2002	July	2	31	6%
(BC1)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
Bucks Creek	2002	June	0	27	0%
Powerhouse	2002	July	0	26	0%
(BC2)	2002	Aug	0	21	0%
	2002	Sept	0	30	0%
NFFR abv Rock	2002	June	6	30	20%
Creek Powerhouse	2002	July	26	31	84%
(NF13)	2002	Aug	10	31	32%
	2002	Sept	0	30	0%
Rock Creek	2002	June	1	30	3%
Powerhouse	2002	July	29	31	94%
(RC1)	2002	Aug	31	31	100%
	2002	Sept	11	30	37%

Table 3-5 (Continued)

Station	Year	Month	Days Greater 20°C	Total Data Days	Percent Exceedance
Rock Creek	2002	June	0	30	0%
Near mouth	2002	July	0	31	0%
(RC2)	2002	Aug	0	31	0%
	2002	Sept	0	30	0%
NFFR abv Grizzly	2002	June	4	30	13%
Creek	2002	July	31	31	100%
(NF14)	2002	Aug	27	31	87%
	2002	Sept	4	30	13%
Grizzly Creek	2002	June	0	30	0%
Near mouth	2002	July	8	31	26%
(GC1)	2002	Aug	3	31	10%
	2002	Sept	0	30	0%
NFFR at NF-56	2002	June	5	30	17%
blw Grizzly Crk	2002	July	31	31	100%
(NF15)	2002	Aug	26	30	84%
	2002	Sept	4	30	13%
NFFR abv Cresta	2002	June	6	30	20%
Powerhouse	2002	July	31	31	100%
(NF16)	2002	Aug	28	31	90%
	2002	Sept	4	30	13%
Cresta	2002	June	5	30	17%
Powerhouse	2002	July	30	30	100%
(Cresta1)	2002	Aug	31	31	100%
	2002	Sept	5	30	17%
Middle Fork	2002	June	6	30	20%
Feather River	2002	July	31	31	100%
At Milsap Bar	2002	Aug	16	31	52%
(MB1)	2002	Sept	0	26	0%

Water temperatures in the Hamilton Branch of the NFFR (Hamilton Branch) are primarily a function of conditions in Mountain Meadows Reservoir and the significant accretion that occurs along its entire length. Temperatures in the Hamilton Branch tend to be less variable and slightly cooler than those measured in the NFFR upstream of Lake Almanor (NF1). The Hamilton Branch station (HB1) was located in the river below the Peninsula Road Bridge; this station was positioned to be upstream of any backwater effect associated with Lake Almanor. During the 2002 program, daily average temperatures at station HB1 ranged from 9.3 to 12.7°C, and averaged 11.5°C. The diel fluctuation in temperature ranged from 2.0 to 7.1°C, and averaged 4.5°C in 2002. Figure 3-6 compares the daily average temperature from HB1 with other stations tributary to Lake Almanor. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 17.1°C on August 1, 2002 (Appendix A). At station HB1, daily average temperatures did not exceed 20°C during the June-September 2002 period (Table 3-5).

Water temperatures associated with flow through Hamilton Branch Powerhouse are a function of conditions in Mountain Meadows Reservoir. The Hamilton Branch Powerhouse station (HB2) was located in the diversion canal immediately upstream of the head-works control structure. The powerhouse discharges directly into Lake Almanor from an elevated tailrace. During the 2002 program, daily average temperatures at station HB2 ranged from 9.5 to 19.1°C, and averaged 14.5°C. The diel fluctuation in temperature ranged from 2.2 to 8.0°C, and averaged 5.7°C in 2002. Figure 3-6 compares the daily average temperature from HB2 with other stations tributary to Lake Almanor.

The higher temperature values observed in the late part of the summer (August-September) were associated with higher instream releases from Mountain Meadows Reservoir. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.6°C on August 2, 2002 (Appendix A). Daily average temperatures did not exceed 20°C during the June-September 2002 period.

As discussed earlier, Lake Almanor is the primary storage reservoir on the NFFR. Lake Almanor has a very large surface area with relatively moderate depths. Resource monitoring indicates that near the Canyon Dam and Prattville intakes, Lake Almanor undergoes thermal stratification (CDFG 1988; DWR 1999; Pacific Gas and Electric Company 1982, 1984, 1986a, 1987, 2002). Thermal gradients typically begin to develop relatively early in Lake Almanor (April-May). During June, the development of temperature stratification is well underway. By July, a fully developed thermal structure is present, including a well-developed epilimnion, thermocline, and hypolimnion. The stratification is persistent throughout the summer, with the epilimnion growing downward throughout the period and with turnover usually occurring in during the period between late September and October.

The general pattern of temperature stratification near the Canyon Dam Intake was continuously measured by a submerged array of digital recorders deployed in 2002. The temperature recorders were set up on a cable attached to a buoy. As a result, the top sensor remained approximately 0.5 meters below the surface, while the bottom sensor was typically 0 to 2 meters off of the bottom depending on lake elevation. Data from 2002 indicated that mean daily temperatures at the lake surface (epilimnion) ranged from 16.9 to 25.4°C during the June through September period. Mean daily temperatures near the bottom (hypolimnion) ranged from 8.2 to 11.4°C during the same period. Figure 3-7 compares mean daily temperatures from the epilimnion and hypolimnion for 2002.

Summer temperature profiles in Lake Almanor show that a warm upper layer (epilimnion) extends to a depth of about 9 meters and that a colder bottom layer (hypolimnion) typically exists below a depth of 12 meters. The seasonal characteristics of the Lake Almanor thermocline were defined using monthly vertical profiles. Figure 3-8 compares monthly profiles from Lake Almanor near the Canyon Dam Intake (LA-P1) for the period June through September 2002.

Vertical temperature profiles were measured at four locations, covering the main body and two longitudinal axes of Lake Almanor. Figure 3-9 compares monthly profiles from each of the four profile stations. This figure illustrates the longitudinal thermal structure present in Lake Almanor in 2002. As illustrated by these figures, temperature profiles indicate that colder water is present only in stations located in the deeper portions of the lake, particularly near Canyon Dam (Pacific Gas and Electric Company 2002).

~~1.1.1.2~~3.2.1.2 Butt Valley Reservoir and tributaries

Butt Valley Reservoir is a long, narrow water body of moderate depth. The deepest areas of the reservoir occur near the dam. Water temperature in Butt Valley Reservoir is essentially driven by conditions in Lake Almanor and the physical configuration of the Prattville Intake. The operations of Butt Valley Powerhouse and the Caribou No. 1 and No. 2 powerhouses are the primary controlling influences on the water resources leaving Butt Valley Reservoir. Under typical conditions, only a limited volume of cold water is available in Butt Valley Reservoir during the summer. Contributions from Butt Creek are seasonally variable, but typically remain a relatively small portion of the total inflow to the reservoir. The thermal structure of Butt Valley Reservoir is driven largely by the physical configuration of the reservoir and the location and operation of the two Caribou intakes.

Although perennial flow is present in Butt Creek upstream of Butt Valley Reservoir, the primary source of flow into the reservoir is through Butt Valley Powerhouse. Temperatures in the tailrace are representative of temperatures withdrawn from the Prattville Intake in Lake Almanor (Pacific Gas and Electric Company 1986a). The Butt Valley Powerhouse station (BV1) was located in the tailrace estuary downstream of the powerhouse. The tailrace discharges directly into the original Butt Creek channel, however, depending on lake elevation this area can exhibit flow characteristics ranging from riverine to lakersturne. During the 2002 program, daily average temperatures at station BV1 ranged from 14.8 to 21.9°C, and averaged 19.1°C. The diel fluctuation in temperature ranged from 0.3 to 8.4°C, and averaged 2.2°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.6°C on August 1, 2002 (Appendix A). The daily average temperatures at station BV1 exceeded 20°C on 56 of 94 operational days (60%) during the 2002 June through September period. Figure 3-10 compares daily average temperatures from BV1 with other station tributary to Butt Valley Reservoir.

Temperatures in Butt Creek (BC1) were monitored upstream of the backwater effect from Butt Valley Reservoir during the 2002 period. During the 2002 program, daily average temperatures at station BC1 ranged from 9.5 to 16.0°C, and averaged 13.2°C. The diel fluctuation in temperature ranged from 2.5 to 7.5°C, and averaged 5.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 18.9°C on July 11, 2002 (Appendix A). The daily average temperatures at station BC1 did not exceed 20°C during the 2002 June through September period (Table 3-5).

A moderately pronounced thermal gradient does develop in Butt Valley Reservoir in the late spring and early summer. However, as a result of the relatively short retention time, and depending on the frequency of usage of the Caribou No. 1 Intake (located in the deeper portion of the lake), the limited cold water volume can be consumed in a few weeks. In general, an identifiable thermocline was present in June and persisted through July. By early August, a well-defined epilimnion was no longer present (Pacific Gas and Electric Company 2002).

The seasonal characteristics of the Butt Valley Reservoir thermocline in 2002 were defined using monthly vertical profiles. Figure 3-11 compares monthly profiles from the Butt Valley Reservoir near Caribou No. 1 Intake (BV-P1) for the period June through September 2002. As indicated by this data Butt Valley Reservoir was essentially isothermal by August 2002.

Vertical temperature profiles were measured at three locations (BV-P1, BV-P2, BV-P3), covering the longitudinal axis of Butt Valley Reservoir. Profiles measured from June through September 2002 indicated little difference in thermal structure along the longitude of the reservoir. Figure 3-12 illustrates the longitudinal thermal structure present in Butt Valley Reservoir in 2002 by comparing monthly temperature profiles from the three profile stations located in the reservoir. As illustrated by these figures the general thermal structure is well established in the upper portion of the reservoir. The data also indicate that the only area with cool water is located near the dam.

The development of temperature stratification near the Caribou No. 1 Intake was measured continuously by a submerged array of digital recorders deployed in 2002. The temperature recorders were set up on a cable attached to a buoy. As a result, the top sensor remained approximately 0.5 meters below the surface, while the bottom sensor was typically 0.5 to 5 meters off of the bottom. Mean daily temperatures recorded in the epilimnion (BV2-S) of Butt Valley Reservoir near the Caribou No. 1 Intake averaged 21.5°C, and ranged from 18.3 to 24.4°C for the period June through September in 2002. Mean daily temperatures from the hypolimnion (BV2-B) ranged from 9.4 to 20.8°C, with an average of 16.2°C during the same period (Table 3-4). Figure 3-13 compares mean daily temperatures from the epilimnion and hypolimnion of Butt Valley Reservoir for 2002. As indicated by the data in this figure, the reservoir became isothermal (less than 2°C difference between top and bottom recorders) by late August.

To further evaluate the withdrawal characteristics of the Caribou No. 2 Intake channel, a series of special profiles were made at two locations near the mouth of the channel. These profiles were taken in July, August, and October. The results of this investigation are presented in Section 3.2.2.2.

~~1.1.1.3~~3.2.1.3 Seneca Reach of NFFR

Water temperature in the NFFR below Canyon Dam is largely determined by the level at which water is released from the lake through the Canyon Dam Intake tower. At present, the Licensee preferentially utilizes the lower gates as the source of fishwater releases. The lower gates in combination with the upper gates the upper gates are used during periods that require high flow releases. During the 2002 monitoring program, the lower gates were used throughout the study period.

Water temperatures in the NFFR downstream of Canyon Dam (NF2) were monitored approximately 0.25 miles downstream of the release structure during the 2002 monitoring effort. This station represents the initial conditions in the Seneca Reach and corresponded with the location of the permanent flow monitoring station (NF-2). During the 2002 program, daily average temperatures at station NF2 ranged from 10.6 to 14.1°C, and averaged 12.7°C. The diel fluctuation in temperature ranged from 0.3 to 2.5 °C, and averaged 0.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 14.8°C on September 29, 2002 (Appendix A). The daily average temperatures at station NF2 did not exceed 20°C during the June through September 2002 (Table 3-5).

Water temperatures in the NFFR at Seneca (NF3) were monitored approximately 60 meters downstream of the Seneca Road Bridge during the 2002 monitoring effort. This station represents conditions present in the middle of the Seneca Reach. During the 2002 program, daily average temperatures at station NF3 ranged from 11.8 to 15.7°C, and averaged 14.1°C. The diel fluctuation in temperature ranged from 1.4 to 4.7°C, and averaged 3.4°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 17.4°C on July 11, 2002 (Appendix A). The daily average temperatures at station NF3 did not exceed 20°C during the June through September 2002 period (Table 3-5).

Water temperatures were monitored in the NFFR approximately 0.5 miles upstream of Caribou Powerhouse (NF4) during the 2002 monitoring effort. This station represents conditions present at the end of the Seneca Reach. During the 2002 program, daily average temperatures at station NF4 ranged from 12.1 to 16.8 °C, and averaged 14.6°C. The diel fluctuation in temperature ranged from 1.1 to 4.3°C, and averaged 3.1°C in

2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 18.4°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF4 did not exceed 20°C during the 2002 June through September period (Table 3-5).

The magnitude of temperature changes occurring in the Seneca Reach depends on several factors including which release gates are used, the magnitude of the release flow, the magnitude of tributary inflows, physical characteristics of the stream channel, and meteorological conditions. To compare the relative change in temperature occurring through the entire bypass reach, the daily average from NF2 was compared with NF4. The daily average temperatures at NF4 (upstream of Caribou Powerhouse) averaged 1.9°C warmer in 2002, than at NF2 (below Canyon Dam) for the June through September period. These values represent the average heating occurring through the entire Seneca Reach and calculate to a 0.2°C per mile increase in temperature for 2002. Figure 3-14 compares the daily average temperatures at the three stations located in the Seneca Reach in 2002.

~~1.1.1.4~~3.2.1.4 Lower Butt Creek

As discussed previously, there is no release from Butt Valley Reservoir to the lower Butt Creek channel. As a result, flows in lower Butt Creek are derived from various sources of tributary and accretion inflows. Water temperature was measured at two locations in Butt Creek downstream of Butt Valley Dam.

The first station in lower Butt Creek was located approximately 0.3 mile below the dam (BC2). This station captured inflow from Benner Creek, leakage flows from Butt Valley Dam, and the spring inflow that arises in the Butt Creek channel downstream of the Benner Creek confluence. During the 2002 program, daily average temperatures at station BC2 ranged from 10.4 to 10.8°C, and averaged 10.6°C. The diel temperature fluctuation ranged from 0.3 to 0.7°C, and averaged 0.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 11.2°C on August 1, 2002 (Appendix A). The daily average temperatures at station BC2 did not exceed 20°C during the June through September period 2002 (Table 3-5).

The second station in lower Butt Creek was located near the mouth (BC3). This station was about 100 meters above the confluence with the NFFR. This station defines the quality of inflow to the NFFR from the largest tributary in the Seneca Reach. During the 2002 program, daily average temperatures at station BC3 ranged from 10.6 to 12.9°C, and averaged 12.1°C. The diel fluctuation in temperature ranged from 0.9 to 2.6°C, and averaged 1.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 14.0°C August 14, 2002 (Appendix A). The daily average temperatures at station BC3 did not exceed 20°C during the June through September period in either 2002 (Table 3-5). Figure 3-15 compares the daily average temperatures from the two stations in lower Butt Creek in 2002.

~~1.1.1.5~~3.2.1.5 Belden Forebay and Caribou Powerhouse complex

Water temperature in Belden Forebay is primarily the result of the combined flows from Caribou No. 1 and No. 2 Powerhouses. Other inflows to Belden Forebay originate from the Seneca Reach of the NFFR. All three-inflow sources enter through the same channel in the upper portion of Belden Forebay.

Water temperatures at Caribou No.1 Powerhouse (CARB1) were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CARB1 ranged from 12.3 to 21.9°C, and averaged 18.3°C. The diel fluctuation in temperature ranged from 0.1 to 4.3°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.2°C on August 17, 2002 (Appendix A). The daily average temperatures at station CARB1 exceeded 20°C on 49 of 95 operational days (52%) during the 2002 June through September period (Table 3-5).

Water temperatures at Caribou No. 2 Powerhouse (CARB2) were monitored direct from the penstock at the main valve house. This location was chosen due to the configuration of the tailrace at this facility, which is submerged by Belden Forebay. Water temperature data were processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CARB2 ranged from 17.4 to 24.0°C, and averaged 21.2°C. The diel fluctuation in temperature ranged from 0.3 to 4.1°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.7°C on July 29, 2002 (Appendix A). The daily average temperatures at station CARB2 exceeded 20°C on 80 of 119 operating days (67%) during the 2002.

Water temperature was monitored in Belden Forebay near the Belden Powerhouse Intake at a fixed depth. During the 2002 program, daily average temperatures at station BD1 ranged from 18.1 to 22.8°C, and averaged 20.7°C. The diel fluctuation in temperature ranged from 0.2 to 1.9°C, and averaged 0.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.0°C on July 29, 2002 (Appendix A). The daily average temperatures at station BD1 exceeded 20°C on 80 of 122 days (66%) during the 2002.

Evaluation of water temperatures measured at BD1 and NF5 from 2000, 2001, 2002 indicate that a thermal gradient exists in Belden Forebay. Due to the short retention time in the forebay, this thermal gradient is likely the result of operational conditions within the system (inflow from both Caribou powerhouses, Belden Powerhouse outflow, and forebay water level fluctuations), and not ambient meteorological conditions. The 2002 data indicates that the difference between BD1 and NF5 temperatures during the June through September period ranged from 0.6 to 3.0°C, and averaged 1.6°C. In all cases, BD1 was warmer than NF5. This data indicates that to some degree cool water and warm water are segregating as flows come into the forebay. This segregation is contined downstream as the cooler water from the forebay is released to the Belden Reach through Oak-flat Powerhouse, and the warmer water is transported to Rock Creek Reservoir via Belden Powerhouse.

As discussed, temperatures at Belden Powerhouse (BD2) are essentially the same as those measured in Belden Forebay at BD1 and primarily reflect the temperature of Butt Valley Reservoir water as released by the Caribou powerhouses, with some minor modification due to mixing and heat exchange in Belden Forebay. Water temperatures at Belden Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station BD2 ranged from 17.7 to 22.6 °C, and averaged 20.2°C. The diel fluctuation in temperature ranged from 0.2 to 1.9°C, and averaged 0.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 29, 2002 (Appendix A). The daily average temperatures at station BD2 exceeded 20°C on 68 of 97 operational days (70%) during the 2002 June through September period. Figure 3-16 compares the daily average temperatures at the four stations associated with the Caribou Powerhouse-Belden Forebay complex in 2002.

~~1.1.1.6~~3.2.1.6 Belden Reach of the NFFR and tributaries

Water temperatures were recorded in the NFFR downstream of Belden Dam (NF5) throughout the 2002 sampling seasons. This station represents initial conditions in the Belden Reach and corresponds with the location of the permanent flow monitoring station (NF-70). During the 2002 program, daily average temperatures at station NF5 ranged from 15.9 to 21.2°C, and averaged 19.1°C. The diel fluctuation in temperature ranged from 0.2 to 2.8°C, and averaged 0.7°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.5°C August 1, 2002 (Appendix A). The daily average temperatures at station NF5 exceeded 20°C on 44 of 122 days (36%) during the 2002 June through September period.

Water temperatures were recorded in Mosquito Creek near its confluence with the NFFR (MC1). Temperatures were comparatively cool with a relatively stable flow regime suggesting a strong groundwater supply during non-runoff periods. Mosquito Creek provides a cooling influence in the Belden Reach. During the 2002 program, daily average temperatures at station MC1 ranged from 11.3 to 15.6°C, and averaged 13.5°C. The diel fluctuation in temperature ranged from 1.0 to 2.4°C, and averaged 1.8°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 16.7°C July 21, 2002 (Appendix A). The daily average temperatures at station MC1 did not exceed 20°C during the 2002 June through September period (Table 3-5).

The station located near the Queen Lily Campground (NF6) represents conditions in the middle section of the Belden Reach and defines conditions downstream of the largest tributary in the reach. During the 2002 program, daily average temperatures at station NF6 ranged from 15.7 to 21.1°C, and averaged 18.7°C. The diel fluctuation in temperature ranged from 2.2 to 4.7°C, and averaged 3.2°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.9°C on August 1, 2002 (Appendix A). The daily average temperatures at station NF6 exceeded 20°C on 32 of 122 days (26%) during the 2002 June through September period.

Station NF7 represents conditions in the NFFR at the end of the upper Belden Reach. This station is also upstream of the confluence with the EBNFFR. During the 2002 program, daily average temperatures at station NF7 ranged from 16.1 to 21.3°C, and averaged 18.8°C. The diel fluctuation in temperature ranged from 2.6 to 6.0°C, and averaged 4.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.0°C July 14, 2002 (Appendix A). The daily average temperatures at station NF7 exceeded 20°C on 33 of 122 days (27%) during the 2002 June through September period.

The total change in daily average temperature in the upper Belden Reach was measured as the difference between the NFFR at the confluence with the EBNFFR (NF7) and below Belden Dam (NF5). The change in temperature between stations NF5 and NF7 was evaluated for the period June-September. The total daily average temperature at NF7 averaged 0.3°C cooler in 2002 than at NF5. These values calculate to a 0.05°C per mile decrease in temperature in the upper Belden Reach. Figure 3-17 compares the daily average temperatures at the four stations located in the upper Belden Reach in 2002.

The temperature station in the NFFR immediately upstream of Yellow Creek (NF8), was located immediately upstream of the Belden Town bridge. This station is approximately 1.75 miles downstream of the confluence of the EBNFFR with the NFFR. Temperatures at this location were warmer than those measured in the NFFR upstream of the EBNFFR (NF7), but cooler than in the EBNFFR. This station represents conditions in the NFFR at the end of the Belden bypass reach. During the 2002 program, daily average temperatures at station NF8 ranged from 16.1 to 22.9°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 2.2 to 5.3°C, and averaged 4.3°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 25.2°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF8 exceeded 20°C on 65 of 122 days (53%) during the 2002 June through September period.

The daily average change in temperature in the NFFR between the NFFR at the confluence with the EBNFFR (NF7) and Belden Town Bridge (NF8) was evaluated for the period June-September. The daily average temperatures at NF8 in 2002 averaged 1.1°C warmer than at NF7. These values calculate to a 0.6 per mile increase in temperature in this section of the NFFR. This increase is attributable to conditions that exist in the EBNFFR.

Temperatures were recorded in the EBNFFR upstream of the confluence with the NFFR (EB1) during the 2002 sampling season. During the 2002 program, daily average temperatures at station EB1 ranged from 15.9 to 25.5°C, and averaged 21.1°C. The diel fluctuation in temperature ranged from 1.1 to 4.6°C, and averaged 2.8°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 26.5°C on July 14, 2002 (Appendix A). This was the highest daily average temperature recorder during the 2002 monitoring program. The daily average temperatures at station EB1 exceeded 20°C on 85 of 122 days (70 %) during the 2002 June through September period.

Temperatures were monitored in Yellow Creek (YC1) 0.5 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions at the mouth of Yellow Creek upstream of the confluence with the NFFR. During the 2002 program, daily average temperatures at station YC1 ranged from 11.8 to 18.6°C, and averaged 15.2°C. The diel fluctuation in temperature ranged from 0.8 to 3.8°C, and averaged 2.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.1°C on July 14, 2002 (Appendix A). The daily average temperatures at station YC1 did not exceed 20°C during the June through September period in 2002 (Table 3-5). Figure 3-18 compares the daily average temperatures from several stations in the lower Belden Reach.

Temperatures were monitored in Chips Creek (CHIP) 0.2 mile upstream of its confluence with the NFFR (Rock Creek Reservoir) during the 2002 sampling season. Chips Creek discharges directly into Rock Creek Reservoir. During the 2002 program, daily average temperatures at station CHIP ranged from 10.6 to 17.9°C, and averaged 15.0°C (Figure 3-20). The diel fluctuation in temperature ranged from 1.8 to 5.8°C, and averaged 4.6°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.0°C on July 14, 2002 (Appendix A). The daily average temperatures at station CHIP did not exceed 20°C during the June through September period in 2002 (Table 3-5).

~~1.1.1.7~~3.2.1.7 Rock Creek Reach of the NFFR and tributaries

The first temperature station in the NFFR downstream of Rock Creek Dam (NF9) is located immediately below the dam. This station was not installed in 2002; the station located downstream at the NF-57 gage is representative of conditions at this site.

The temperature station in the NFFR downstream of Rock Creek Dam (NF10) was located near the NF-57 gaging station. This station is approximately 1.5 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF10 ranged from 17.6 to 22.5°C, and averaged 20.5°C. The diel fluctuation in temperature ranged from 0.3 to 3.7°C, and averaged 1.5°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.4°C on July 31, 2002 (Appendix A). The daily average temperatures at station NF10 exceeded 20°C on 70 of 97 days (72%) during the 2002 June through September period. Figure 3-19 compares the 2002 daily average temperatures from NF10 with four other river stations located in the Rock Creek Reach.

A telemetry system was installed at the NF-57 gage station to enable real-time monitoring of temperatures in the Rock Creek Reach. The performance of this station was compared with the *in situ* recorder is presented in Section 3.2.2.4.

Temperatures were monitored in Milk Ranch Creek (MR1) 0.25 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions at the mouth upstream of the influence from the NFFR. During the 2002 program, daily average temperatures at station MR1 ranged from 10.6 to 17.9 °C, and averaged 14.5°C. The diel fluctuation in temperature ranged from 1.5 to 5.5°C, and averaged 4.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.4°C on July 21, 2002 (Appendix A). The daily average temperatures at station MR1 did not exceed 20°C during the June through September period in 2002 (Table 3-5). Figure 3-20 compares 2002 daily average temperatures from MR1 with other stations tributary to the NFFR in the Rock Creek Reach.

Temperatures were monitored in Chambers Creek (CHAM) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions near the mouth upstream of any influence from the NFFR. During the 2002 program, daily average temperatures at station CHAM ranged from 9.0 to 18.8°C, and averaged 15.0°C. The diel fluctuation in temperature ranged from 1.8 to 6.3°C, and averaged 4.7°C in 2002. Figure 3-20 compares 2002 daily average temperatures from CHAM with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.4°C on July 21, 2002 (Appendix A). The daily average temperatures at station CHAM did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The station located on the NFFR below Granite Creek (NF11) represents conditions in the middle section of the Rock Creek Reach and defines conditions downstream of several tributaries. During the 2002 program, daily average temperatures at station NF11 ranged from 16.0 to 22.8°C, and averaged 20.0°C. The diel fluctuation in temperature ranged from 1.5 to 5.1°C, and averaged 3.3°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from NF11 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.3°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF11 exceeded 20°C on 70 of 122 days (57%) during the 2002 June through September period.

Temperatures were monitored in Jackass Creek (JKC1) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. This station represents conditions near the mouth upstream of any influence from the NFFR. During the 2002 program, daily average temperatures at station JKC1 ranged from 9.6 to 18.9°C, and averaged 15.3°C. The diel fluctuation in temperature ranged from 1.4 to 6.4°C, and averaged 4.2°C in 2002. Figure 3-20 compares 2002 daily average temperatures from JKC1 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 21.2°C on July 21, 2002 (Appendix A). The daily average temperatures at station JKC1 did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The NFFR station located upstream of the Bucks Creek confluence (NF12) represents conditions at the end of the Rock Creek Reach and defines conditions prior to inflow from Bucks Creek and Bucks Creek Powerhouse. During the 2002 program, daily average temperatures at station NF12 ranged from 15.9 to 22.9°C, and averaged 20.0°C. Figure 3-19 compares the 2002 daily average temperatures from NF12 with four other river stations located in the Rock Creek Reach. The diel fluctuation in temperature ranged from 1.3 to 5.2°C, and averaged 3.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.0°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF12 exceeded 20°C on 69 of 122 days (57%) during the 2002 June through September period.

Temperatures were monitored in Bucks Creek (BUCK1) 0.10 miles upstream of its confluence with the NFFR during the 2002 sampling season. During the 2002 program, daily average temperatures at station BUCK1 ranged from 12.0 to 20.4°C, and averaged 16.4°C. The diel fluctuation in temperature ranged from 1.6 to 7.2°C, and averaged 5.0°C in 2002. Figure 3-20 compares 2002 daily average temperatures from BUCK1 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.5°C on July 11, 2002 (Appendix A). The daily average temperatures at station BUCK1 exceeded 20°C on 2 days (2%) during the 122 day June through September period in 2002 (Table 3-5).

Temperatures at Bucks Powerhouse (BUCK2) are essentially the same as those present in Lower Bucks Creek Reservoir. Water temperatures at Bucks Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station BUCK2 ranged from 12.6 to 18.9°C, and averaged 14.9°C. The diel fluctuation in temperature ranged from 0.0 to 4.5°C, and averaged 1.2°C in 2002. Figure 3-20 compares 2002 daily average temperatures from BUCK2 with other stations tributary to the NFFR in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.0°C on July 1, 2002 (Appendix A). The daily average temperatures at station BUCK2 did not exceed 20°C during the 2002 June through September period.

The NFFR station located upstream of Rock Creek Powerhouse (NF13) represents conditions at the end of the Rock Creek Reach and defines conditions prior in receiving diversion flow from Rock Creek Powerhouse. During the 2002 program, daily average temperatures at station NF13 ranged from 15.0 to 22.8°C, and averaged 18.7°C. The diel fluctuation in temperature ranged from 1.7 to 5.3°C, and averaged 3.2°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from NF13 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 24.1°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF13 exceeded 20°C on 42 of 122 days (34%) during the 2002 June through September period.

The daily average change in temperature in the Rock Creek Reach (NFFR between Rock Creek Dam [NF10] and above Rock Creek Powerhouse [NF13]) was evaluated for the period June 26 through September. The daily average temperature at NF13 averaged 1.7°C cooler in 2002 than NF10. This value calculates to a cooling trend of approximately 0.2°C per mile in this section of the Rock Creek Reach. This change is largely due to the contribution from Bucks Creek and Bucks Creek Powerhouse.

Temperatures at Rock Creek Powerhouse (RC1) are essentially the same as those present in Rock Creek Reservoir. Water temperatures at Rock Creek Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station RC1 ranged from 16.1 to 22.6°C, and averaged 20.2°C. The diel fluctuation in temperature ranged from 0.2 to 1.8°C, and averaged 0.9°C in 2002. Figure 3-19 compares the 2002 daily average temperatures from RC2 with four other river stations located in the Rock Creek Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 31, 2002 (Appendix A). The daily average temperatures at station RC1 exceeded 20°C on 72 of 122 operational days (59%) during the 2002 June through September period.

~~1.1.1.8~~3.2.1.8 Cresta Reach of the NFFR and tributaries

Temperatures were monitored in Rock Creek (RC2) 0.2 mile upstream of its confluence with the NFFR during the 2002 sampling season. Rock Creek discharges directly into Cresta Reservoir approximately 0.75 miles downstream of Rock Creek Powerhouse. During the 2002 program, daily average temperatures at station RC2 ranged from 11.4 to

19.7°C, and averaged 16.2°C (Figure 3-22). The diel fluctuation in temperature ranged from 0.4 to 3.6°C, and averaged 1.9°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 20.7°C on July 31, 2002 (Appendix A). The daily average temperatures at station RC2 did not exceed 20°C during the June through September period in 2002 (Table 3-5).

The first temperature station in the NFFR downstream of Cresta Dam (NF14) was located upstream of the confluence with Grizzly Creek. This station is approximately 0.4 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF14 ranged from 16.2 to 22.2°C, and averaged 19.7°C. The diel fluctuation in temperature ranged from 0.3 to 1.6°C, and averaged 1.0°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 15, 2002 (Appendix A). The daily average temperatures at station NF14 exceeded 20°C on 66 of 122 days (54%) during the 2002 June through September period. Figure 3-21 compares the 2002 daily average temperatures at NF14 with three other river stations located in the Cresta Reach.

Temperatures were monitored in Grizzly Creek (GR1) 0.5 mile upstream of its confluence with the NFFR during the 2002 sampling season. During the 2002 program, daily average temperatures at station GR1 ranged from 12.7 to 20.8°C, and averaged 17.1°C. The diel fluctuation in temperature ranged from 0.8 to 4.4°C, and averaged 3.1°C in 2002. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.7°C on July 14, 2002 (Appendix A). The daily average temperatures at station GR1 exceeded 20°C on 11 of 122 days (9%) during the June through September period in 2002 (Table 3-5). Figure 3-22 compares daily average temperatures from GR1 with another station tributary to the NFFR in the Cresta Reach in 2002.

The temperature station in the NFFR downstream of Grizzly Creek (NF15) was located near the NF-56 gaging station. This station is approximately 2.5 miles downstream of the dam. During the 2002 program, daily average temperatures at station NF15 ranged from 16.2 to 22.1°C, and averaged 19.7°C. The diel fluctuation in temperature ranged from 0.9 to 3.2°C, and averaged 2.4°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at NF15 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.5°C on July 15, 2002 (Appendix A). The daily average temperatures at station NF15 exceeded 20°C on 66 of 122 days (54%) during the 2002 June through September period.

A telemetry system was installed at the NF-56 gage station to enable real-time monitoring of temperatures in the Cresta Reach. The performance of this station was compared with the in-situ recorder is presented in Section 3.2.2.4.

The NFFR station located upstream of Cresta Powerhouse (NF16) represents conditions at the end of the Cresta Reach and defines conditions prior in receiving diversion flow from Cresta Powerhouse. During the 2002 program, daily average temperatures at station NF16 ranged from 16.4 to 22.6°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 1.0 to 3.7°C, and averaged 2.6°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at NF16 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 23.9°C on July 14, 2002 (Appendix A). The daily average temperatures at station NF16 exceeded 20°C on 69 of 122 days (57%) during the 2002 June through September period.

The daily average change in temperature in the Cresta Reach (NFFR between Cresta Dam [NF14] and above Cresta Powerhouse [NF16]) was evaluated for the period June-September. The daily average temperature at NF16 averaged 0.2°C warmer in 2002 than NF14. This value calculates to a warming trend of less than 0.05°C per mile in this section of the Cresta Reach.

Temperatures at Cresta Powerhouse (CR1) are essentially the same as those present in Cresta Reservoir. Water temperatures at Cresta Powerhouse were monitored at an internal location due to the configuration of the tailrace at this facility. Water temperature data were then processed to remove data from periods when the powerhouse was not operating and water within the penstock was static and no discharge to the NFFR was being made. During the 2002 program, daily average temperatures at station CR1 ranged from 16.3 to 22.5°C, and averaged 19.9°C. The diel fluctuation in temperature ranged from 0.1 to 1.8°C, and averaged 0.8°C in 2002. Figure 3-21 compares the 2002 daily average temperatures at CR1 with three other river stations located in the Cresta Reach. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 22.8°C on July 15, 2002 (Appendix A). The daily average temperatures at station CR1 exceeded 20°C on 71 of 121 operational days (59%) during the 2002 June through September period.

~~1.1.1.9~~3.2.1.9 Middle Fork Feather River

The Licensee collected temperature data in 2002 from a station in the Middle Fork of the Feather River (at Milsap Bar). This data were collected in order to compare temperature conditions in the NFFR with those in the lower portion of the unregulated MFFR. During the 2002 program, daily average temperatures from the Middle Fork of the Feather River at Milsap Bar (MB1) ranged from 15.2 to 23.3°C, and averaged 19.4°C. The diel fluctuation in temperature ranged from 1.4 to 3.7°C, and averaged 2.6°C in 2002. Figure 3-23 compares the 2002 daily average temperatures at MB1 with river stations located in the Rock Creek and Cresta reaches of the NFFR. The maximum hourly average temperature recorded at this station during the 2002 monitoring program was 25.3°C on July 14, 2002 (Appendix A). The daily average temperatures at station MB1 exceeded 20°C on 53 of 118 days (45%) during the 2002 June through September period.

As indicated in Figure 3-23, temperatures in the NFFR were similar in value and trend to measured temperatures in the Middle Fork at Milsap Bar through late August. From late August through September NFFR temperatures were similar in value and trend to those observed in the East Branch NFFR. Temperatures in the East Branch NFFR (unregulated) were warmer than those in the Middle Fork during the entire monitoring period. All stations exceeded the 20°C level from late June through early September 2002.

~~1.1.2~~3.2.2 Special Investigations

This section presents the results of various special field tests and data analyses conducted on the 2002 data. These tests and evaluations were conducted in response to specific requests by the ERC or implemented by the Licensee to improve monitoring methods.

~~1.1.1.1~~3.2.2.1 Evaluation of Sensor Placement in Caribou No. 2 Intake

In order to verify the accuracy of temperatures recorded by the sensor installed in the Caribou No.2 Penstock (CARB2A), a backup recorder was placed at the bottom of the Caribou No.2 Intake channel (CARB2B). Data from both stations were compared for the period June through September. In order to facilitate data comparison, both were processed to correct for powerhouse operation. Both data sets were compared with data from the near surface recorder located in Butt Valley Reservoir (BV2-S). Figure 3-24 compares daily average temperatures from these three stations associated with Caribou No. 2 Intake.

The recorder on the bottom of the intake channel (CARB2B) had a daily mean temperature that ranged from 0.4°C warmer to 1.1°C cooler than the penstock recorder. In general, the channel recorder temperatures were consistently lower than both the penstock recorder (CARB2A) and the near surface recorder placed in Butt Valley Reservoir (BV2-S). In addition, the channel recorder did not follow the temporal pattern of temperature as defined by the reservoir surface recorder.

This variability was probably related to the physical characteristics of the channel and the ultimate placement of the recorder. The recorder was placed at a fixed depth (on or near bottom) on the north side of the intake structure. Depending on lake elevation, and powerhouse flow this area can be exposed to backwater conditions of various magnitude. However, the data indicate that the two recorders agree relatively well and during periods of consistent powerhouse operation there was little temperature differential. For the June through September period, the average difference between the penstock recorder and the channel recorder was ±0.4°C. This is within the realm of combined recorder error.

Based on this information and data presented in Section 3.2.2.2, data from the penstock recorder are considered superior to the channel recorder as long as the flow-through-system that connects the sensor to the penstock remains functional. There were no problems with this system in 2002.

~~1.1.1.2~~3.2.2.2 Butt Valley Reservoir Thermal Structure near Caribou No.2 Intake Channel

In an attempt to further define the withdrawal dynamics associated with the Caribou No.2 Intake, the Licensee collected data from two special profile stations located near the mouth of the intake channel. The first location (BV-P4A) was located in Butt Valley Reservoir approximately 50 meters from the mouth of the intake channel. Profiles were collected from this location in June, July, August, and October. The second profile station (BV-P4B) was located in Butt Valley Reservoir at the mouth of the intake channel. Profiles were collected only in August and October from this location. Since October conditions were strongly isothermal, only profiles from June through August were used as part of this evaluation. Figure 3-25 compares monthly temperature data from the special profile stations with those from BV-P1. As indicated by the data presented in Figure 3-25, the thermal structure associated with the Caribou No. 2 Intake channel is essentially identical to that observed at BV-P1.

All profiles were collected between 0900 and 1030. As a result, the elevated near surface temperatures associated with warm afternoon conditions were not captured. Conditions in the Caribou No. 2 penstock and to a lesser degree the intake channel are also influenced by the magnitude and consistency of flow through Caribou No. 2 Powerhouse. At the time the June profile was collected, the Caribou No. 2 Powerhouse was not operating. Caribou No. 2 Powerhouse had been operational for approximately one hour at the time of the July profile, and for four hours at the time of the August profiling effort. Table 3-6 compares data from special profile stations with temperature data from the

Table 3-6

Summary of profile data from select stations in Butt Valley Reservoir.

Profile Date	Profile Time	Profile Temperatures						Caribou No.2 Release Hourly Average (hour)		Powerhouse Operation
		BV-P1		BV-P4A		BV-P4B		Penstock	Channel	
		Average[1]	Average[2]	Average[1]	Average[2]	Average[1]	Average[2]	CARB2A	CARB2B	
6/26/2002	9:30	20.9	21.6	20.9	21.6	---	---	21.6 (0700)	21.6 (0700)	Caribou No.2 not operating at time of profile.
7/9/2002	10:02	22.3	22.8	22.5	22.8	---	---	22.8 (1100)	22.4 (1100)	Caribou No.2 running for ~one hour before profile.
8/21/2002	10:18	22.0	22.0	22.0	22.0	22.0	22.0	22.0 (1100)	21.7 (1100)	Caribou No.2 running for ~four hours before profile.

1. Profile temperatures averaged from surface to 4,110 ft elevation (USG datum).
2. Profile temperatures averaged from surface to 4,115 ft elevation (USG datum).

4,110 ft. is the bottom elevation of the intake channel entrance.

CARB2 and CARB2B data recorders. As indicated by this data, the agreement between the synoptic profiles and data from CARB2 located in the penstock is very good during periods of powerhouse operation. The data also indicates that the effective withdrawal depth associated with the Caribou No. 2 Intake is from the surface to 4,115 ft (USGS datum).

~~1.1.1.3~~3.2.2.3 Performance of telemetry stations

Real-time temperature (telemetry) systems were installed in the gaging stations located at NF-56 and NF-57. Temperatures were measured at 30-minute intervals and stored locally on a data logger as well as being transmitted through SCADA to the Rock Creek and Caribou Powerhouse Switching Centers. The temperature data were processed for the daily average value, mid-night to mid-night, and if temperature levels exceeded 20°C on two consecutive days, a signal alerted operators and the temperature condition was reported to ERC and FS personal. An appropriate course of action was then developed in order to try and maintain daily average temperatures below 20°C at NF-56 and/or NF-57.

In order to evaluate the performance of the two telemetry station sensors, data from the in-situ recorders installed at the telemetry location were used to document performance. Figure 3-28A compares daily average temperatures from station NF-56. The evaluation of telemetry data from the NF-56 station indicated that the average difference was 0.10°C, with a maximum absolute difference of 0.21°C. This level of discrepancy is well within the margin of combined instrument error. Figure 3-28B compares daily average temperatures from station NF-57. The evaluation of data from the NF-57 station indicated that the average difference was 0.12°C, with a maximum absolute difference of 0.69°C. This drift at NF 57 was observed during one of the periodic performance tests. Periodic performance tests were conducted at each station using known temperature bath data on April 15, May 16 and October 28 of 2002. Test results indicated all telemetered remote temperature unit were within the specified accuracy (less than 0.1°C) at all times, except NF 57, which showed a drift of 0.72°C in the October 28 test.

Another stipulation of the FERC 4C Condition was that, "Temperatures at NF57 and at NF56 are to be monitored and telemetered, from June 1 through October 31, for the term of the Project License". If temperatures from the telemetered stations demonstrate that mean daily water temperatures regularly exceed 20°C in October, the entire monitoring program will be expanded to include October". This stipulation was incorporated into the monitoring program presented in the Water Temperature Monitoring Plan.

The telemetered stations were continuously operated through October 2002. Daily average temperatures at NF-56 ranged from 11.3–16.0°C, and from 11.4–16.4°C at NF-57 during October 2002.

~~1.1.3~~3.2.3 Evaluation of Controllable and Non-controllable Conditions

This section will discuss tests conducted to determine the effect of various controllable mitigation options that may have the potential to reduce water temperatures below the 20°C level. As part of the 4C requirements, the Licensee was to determine the effect controllable factors (flow releases, intake configuration, release locations) would have on temperature control in the project area, as well as the effect of non-controllable factors (e.g. solar radiation, lack of shading, tributary inflow, powerhouse return flow).

~~1.1.1.1~~3.2.3.1 Temperature mitigation testing at Caribou complex powerhouses

Butt Valley Reservoir is a long, narrow water body of moderate depth. The reservoir receives inflows from Butt Creek and Butt Valley Powerhouse. Butt Valley Powerhouse has an annual average flow of 1,600 cfs and represents more than 95% of the total inflow to the reservoir. Butt Creek is the largest of the natural inflow sources, with summer flows ranging from 40-56 cfs (Table 3-1). Exclusive of spill events, outflow from Butt Valley Reservoir is through the Caribou No. 1 and Caribou No. 2 powerhouses. Caribou No.1 has a capacity of 1,100 cfs and is older and less efficient unit than Caribou No. 2, which has a flow capacity of 1,400 cfs. Because of this difference in efficiency and operational reliability, Caribou No. 2 is the Licensee's preferred operational unit.

Caribou No. 2 Intake is located in a shallow cove; as a result water withdrawals are restricted to the upper layers of Butt Valley Reservoir by the cove's entrance elevation of 4,110 ft. (USGS datum). Caribou No.1 is located in the deepest portion of the reservoir and can access water from the surface to 4,095 ft. (USGS datum). Several years of data (1985-1986, 2000-2002) have shown that cooler water is present in the deeper portion of the reservoir (Section 3.2.1.2 for 2002 data). The expectation that this cold water could be used to mitigate temperatures in the Rock Creek and Cresta reaches has been suggested in the past and was revisited by the ERC as a possible method of achieving the 20°C temperature level in the NFFR downstream.

The thermal characteristics of Butt Valley Reservoir must be identified before determining the mitigating effect of alternate operational regimes at the Caribou Powerhouse complex. Figure 3-26 displays mean daily temperatures from the three stations associated with conditions in Butt Valley Reservoir for the period June 1 through September 30, 2002. Average daily flow at Caribou No.1 and Caribou No. 2 are included to illustrate the effect of operation on temperature. As indicated by this figure, cooler water was present in the hypolimnion of the reservoir and persisted through June 2002. As part of the normal operational regime, Caribou No.1 had not been significantly utilized prior to July. As soon as use of Caribou No.1 was begun (July 3, 2002) there was a noticeable upward shift in the temperature of the hypolimnion. The upward trend continued as Caribou No.1 was operated for the remainder of the summer. By late August, the reservoir was essentially isothermal. These same thermal characteristics are observed in the monthly synoptic profiles previously presented in Figure 3-11.

The thermal regime present in Butt Valley Reservoir develops in a relatively simple manner. In general, the areas in Butt Valley Reservoir with depths greater than 30 feet are isolated from the effects of short wave solar radiation and surface turbulence. As warmer ambient conditions develop, the cold water present in the deeper portions of the reservoir is preserved. The warmer upper layers of the reservoir are actively maintained as inflows from Butt Valley Powerhouse are matched to outflows from Caribou No.2.

Under the current operational regime, Caribou No. 1 is typically not used until late June or early July. As a result the pool of cool water is left untapped until this period. As soon as Caribou No.1 begins operating, this volume of cool water is rapidly depleted (Figure 3-26). The influence of any cold water inflows from Butt Creek are negated through mixing with inflows from Butt Valley Powerhouse or with the warmer surface layers in the shallow upper reaches of Butt Valley Reservoir. As the volume of stored cool water is released through Caribou No.1, temperatures in the hypolimnion rapidly warm to temperatures that are similar to those observed entering the reservoir through Butt Valley Powerhouse (BV1) (Figure 3-26). This pattern has been observed during previous monitoring efforts in 2000-2001 (Pacific Gas and Electric Company, 2002).

As discussed, the operation of Caribou No. 1 can provide some mitigating effect on downstream temperatures for as long as the pool of cool water is present. By examining the access of each intake structure to Butt Valley Reservoir, the volume of water available exclusively to the Caribou No.1 Intake can be determined. The Caribou No. 2 Intake is located in a shallow cove with an entrance elevation of 4,110 feet (USGS datum). The Caribou No. 1 Intake is in the deeper portion of the reservoir, data from a 1996 bathymetric survey indicates that the intake has access to water from the surface to 4,095 feet (USGS datum). The storage-capacity rating for Butt Valley Reservoir indicates a total volume of 7,837 ac-feet at an elevation of 4,110 feet (USGS) and 598 ac-feet at 4,095 ft (USGS). The difference between these two values (7,239 acre-ft) is the volume of water available to Caribou No.1 that is not available to Caribou No.2. Depending on thermal conditions in the reservoir, some or all of this 7,000 acre-feet comprises the pool of cool water accessed by Caribou No. 1. At a maximum withdrawal rate of 1,100 cfs through Caribou No.1, this volume would last about 80 hours, or 3.3 days. A subsequent reduction in withdrawal rate would extend the period of time the cool water was available, but would also reduce the effective change in downstream temperatures. It can therefore be concluded that preferential operation of Caribou No.1 can only provide a short period of temperature mitigation. When the pool of cool water is depleted there is no temperature benefits associated with operating Caribou No.1 over Caribou No. 2.

To define and quantify the effect that preferential use of Caribou No. 1 has on temperatures in the lower NFFR, the Licensee conducted a special short duration operational test in July 2002. This test was conducted from July 3 through July 7, 2002. During this period Caribou No. 1 was operated preferentially over Caribou No. 2. On three days during this period Caribou No.2 was not operated at all. Because the pool of cool water in Butt Valley Reservoir had not been utilized up to this point, this test represents a best-case scenario with regard to the mitigating effect of using Caribou No. 1 preferentially over Caribou No. 2. Figure 3-27 compares daily average temperatures from the Caribou powerhouse complex, with NFFR stations in the Rock Creek-Cresta reach during this test. Table 3-7 summarizes the data presented in Figure 3-27.

Table 3-7

Summary of temperature data from Caribou complex operational test.

Date	Caribou No. 2 Temperature (°C)	Caribou No. 2 Flow (cfs)	Caribou No.1 Temperature (°C)	Caribou No.1 Flow (cfs)	Resultant Caribou Complex * (°C)	Upper Belden Forebay [BD1] (°C)	NFFR below Rock Creek Dam [NF10] (°C)	NFFR below Forebay [NF13] (°C)	Remarks
6/30/2002	21.4	150	---	---	21.4	21.5	20.9	20.8	Pre-test, no Caribou No.1 flow
7/1/2002	22.2	230	---	---	22.2	21.8	20.7	20.9	Pre-test, no Caribou No.1 flow
7/2/2002	22.0	251	---	3	21.7	22.2	20.8	20.9	Pre-test, no Caribou No.1 flow
7/3/2002	---	---	16.3	203	16.3	21.8	20.7	20.8	Test period
7/4/2002	---	---	16.3	138	16.3	21.0	20.5	20.8	Test period
7/5/2002	---	---	16.4	117	16.4	20.1	20.6	20.8	Test period
7/6/2002	21.8	228	17.3	460	18.8	19.5	20.7	20.7	Test period
7/7/2002	22.2	198	17.3	436	18.8	19.3	20.6	20.7	Test period
7/8/2002	22.5	443	18.1	284	20.8	19.9	20.2	20.8	Post-test, normal operation
7/9/2002	23.2	625	18.4	425	21.3	21.1	20.4	20.3	Post-test, normal operation
7/10/2002	23.0	1,091	18.7	672	21.3	21.5	21.3	20.5	Post-test, normal operation

- Based on mass balance calculations.

Table 3-7

(Continued)

Date	Belden Powerhouse		Belden Reach (Nf5)		Belden Reach				Remarks
	Temperature (°C)	Flow (cfs)	Temperature (°C)	Flow (cfs)	[NF6] (°C)	[NF7] (°C)	[NF8] (°C)	[EB1] (°C)	
6/30/2002	---	0	18.9	144	19.0	19.3	21.2	23.3	Pre-test, no Caribou No.1 flow
7/1/2002	19.8	87	19.1	144	19.0	19.1	21.2	23.3	Pre-test, no Caribou No.1 flow
7/2/2002	20.7	187	19.3	144	19.2	19.3	21.2	23.3	Pre-test, no Caribou No.1 flow
7/3/2002	21.1	58	19.2	143	19.0	19.1	20.8	22.8	Test period
7/4/2002	---	0	18.7	144	18.7	18.8	20.5	22.4	Test period
7/5/2002	---	0	18.3	144	18.5	18.8	20.7	22.7	Test period
7/6/2002	19.0	558	17.9	143	18.2	18.7	20.7	22.9	Test period
7/7/2002	19.0	500	17.8	144	18.1	18.5	20.6	23.2	Test period
7/8/2002	19.6	641	17.9	144	18.1	18.5	20.6	23.1	Post-test, normal operation
7/9/2002	20.9	783	18.1	144	18.3	18.7	20.8	23.5	Post-test, normal operation
7/10/2002	21.2	1216	18.9	144	19.1	19.5	21.5	24.1	Post-test, normal operation

As indicated, in Table 3-7, release temperatures from the Caribou powerhouse complex were approximately 22.0°C before the test began. Once Caribou No. 1 came into full utilization and Caribou No. 2 flows were decreased, release temperatures dropped to approximately 16.3°C. This drop of 5.7°C represents the maximum change in temperature measured at the Caribou complex release, temperatures increased in a progressive manner as contributions from Caribou No. 2 increased following the shut down period.

The observed rate of change in release temperatures at Caribou No. 1 supports the previous discussion. At the beginning of the test, Caribou No. 1 release temperatures measured 16.3°C. At the end of the five day test period, Caribou No.1 release temperatures had risen to 17.3°C, and were 18.7°C by July 10 (eight days after use of Caribou No. 1 began). Caribou No. 1 release temperatures exceeded 20°C, on July 19, 2002; 16 days after the start of Caribou No. 1 utilization, at an average daily flow of 295 cfs.

As discussed in Section 3.2.1.5, a thermal gradient exist in Belden Forebay that is probably the result of operational influences on the system. This gradient, results in cooler water being released to the Belden Reach through Oak-flat Powerhouse and warmer water diverted through Belden Powerhouse. The BD1 monitoring station represents temperatures in the upper layers of the forebay that are passed through Belden Powerhouse. The NF5 station represents temperatures in the lower layers of the forebay, as well as initial temperatures in the Belden Reach. To evaluate the effect of operational changes on temperature each transport pathway will be discussed separately.

During the test, temperatures in the upper portion of Belden Forebay (BD1) showed a gradual reduction through the test period. The maximum decrease in temperature was 2.9°C, which was recorded on the last day of the test period (July 7, 2002). This slow rate of change in the forebay temperature was related to the relatively low rate of inflow (117-203 cfs) and outflow in Belden Forebay. During full load conditions, the retention time in Belden Forebay is less than 12 hours. However, at the flows present during the test, the estimated forebay retention time was about one week (at an average flow of 160 cfs). The longer retention time combined and the presence of pre-test warm water in the Belden Forebay contributed to the slow rate of temperature change as measured at BD1 compared to the Caribou complex release temperatures.

During the test, temperatures in the lower portion of Belden Forebay (NF5) also showed a gradual reduction through the test period. However, because of the thermal gradient in the forebay, the maximum change was much less than that seen in the upper layers. The maximum decrease in temperature was 1.4°C, and was also recorded on the last day of the test period (July 7, 2002). For most of the test period, outflow from the Forebay was comprised entirely of instream releases to the Belden Reach through Oak-flat Powerhouse. The monitoring station at the end of the upper Belden Reach (NF7), is located upstream of the confluence with the East Branch of the NFFR. The maximum decrease in temperature at this station was 0.8°C, and was also recorded on the last day of the test period (July 7, 2002). The last station in the Belden Reach (NF8) is located upstream of the confluence with Yellow Creek. Temperatures at this station reflect the influence of the warmer EBNFFR inflows. As a result of the EBNFFR inflows the temperature reduction in the Belden Reach was further moderated to 0.6°C.

The stations below Rock Creek Dam and Cresta Dam (NF10 and NF14, respectively), were used to detect any effect from the Caribou test. It was assumed that these stations would be the least affected by tributary inflow and ambient conditions. Temperatures at the beginning of the Rock Creek Reach (NF10) showed a maximum decrease of 0.6°C the day after the test ended (July 8, 2002). On the following day (July 9, 2002), the station located below Cresta Dam (NF14) measured a similar maximum decrease of 0.6°C. Temperatures at NF10 and NF14 exceeded 20°C during the entire test period. The results of this test were influenced by the high flow released for whitewater test on July 7, 2002.

It is acknowledged that the 2002 preferential use test was conducted under less than ideal circumstances. Flow through Caribou No.1 was much less than would be expected through Caribou No.2 under normal operations. There was little or no flow through Belden Powerhouse during the test; as a result residence time in the forebay was increased. Finally, a high flow whitewater test was begun in the Rock Creek/Cresta reach on the last day of the preferential use test. This coincidental timing significantly altered the rate of travel through the system and undoubtedly affected the test results in the Rock Creek and Cresta reaches.

In summary, the 2020 preferential use of Caribou No. 1 over Caribou No. 2 produced the following results:

•Routing flows only through Caribou No. 1 produced a 5.7°C decrease in release temperature at the Caribou Powerhouse complex. Caribou No.1 temperatures rapidly increased following the start of withdrawals from the pool of cool water.

•The test produced a 3°C decrease in temperature in the upper layers of Belden Forebay (BD1), and yielded a decrease of 1.4°C in the lower layers of the Forebay (NF5).

• The test yielded a 0.8°C decrease in temperatures at the end of the upper Belden bypass reach (NF7), decrease was further moderated to 0.6°C at NF8 after mixing with the East Branch NFFR.

• The test yielded a 0.6°C decrease in temperatures in the Rock Creek and Cresta bypass reaches at NF10 and NF14 stations

• The reserve of cool water is limited in Butt Valley Reservoir, and operation of Caribou No. 1 in preference over Caribou No. 2 can at best provide only temporary periods (several days) of mitigation.

~~1.1.1.2~~3.2.3.2 Effect of Outlet Use at Cresta Dam on NFFR Water Temperature

The minimum instream flows to the NFFR are released from two sources at Cresta Dam. The primary release is made from the in-stream flow release valves, which are positioned approximately 30 ft. below normal water surface. These valves release a minimum of 150 cfs and self adjusts for changes in reservoir level. The radial gates are the second source of release flow; these gates withdraw water from the top 20 ft. of the reservoir. The radial gates are not self-adjusting and are therefore typically used in conjunction with the instream release valves.

A daily log is kept documenting the total release flow, as well as the flow originating from each outlet. During the June through September 2002 monitoring period, the instream release valve provided 26 to 61 percent of the total release flow. Flow from the radial gate provided 39 to 74 percent of the total flow.

Due to a short retention time, Cresta Reservoir does not undergo thermal stratification. Consequently, no difference in temperature was expected with respect to outlet used. To test this assumption, temperature data from monitoring stations at NF14 and RC1 were used to evaluate the temperature effect associated with differential use of the two Cresta Dam release outlets. A long term evaluation was not possible since both gates were used equally throughout the period to generate the total flow. However, an eight day period (June 28 through July 5) was evaluated during which preferential use of the outlets was alternated. For the period June 28 through July 1 the instream valve averaged 35% of the total release. For the period July 2 through July 5 the instream valve averaged 59% of the total release.

Based on this evaluation, there was no measurable change in the difference between downstream (NF14) and upstream (RC1) temperatures during periods when either gate provided the majority of release flow. For the two day period June 30-July 1, the radial gate provided 66% of the total flow and the mean daily average temperature at NF14 was 20.9°C. For the two day period July 2-3, the instream release valves provided 60% of the total flow and the mean daily average temperature at NF14 was 20.8°C. As a result of this evaluation there appears to be no benefit derived from preferential use of either release outlet.

~~1.1.1.3~~3.2.3.3 Effect of inflow from Bucks Lake system on water temperatures in the NFFR

The Bucks Lake system delivers relatively cool water to the end on the Rock Creek Reach. Two temperature evaluations were performed on data from stations located upstream and downstream of inflows from the Bucks system. The first evaluation focused on inflow from Bucks Creek and Bucks Powerhouse. The second evaluation focused on inflow from Grizzly Creek. Data used for these evaluations is summarized in Table 3-8.

The Bucks Lake system is comprised of Bucks Lake, Lower Bucks Lake, Grizzly Powerhouse, Grizzly Forebay, and Bucks Powerhouse. Bucks Lake is the main storage reservoir and delivers relatively cool water to Lower Bucks Lake through a low level outlet. Water is then diverted from Lower Bucks Lake to Grizzly Forebay through Grizzly powerhouse. A minimum release of 3 cfs (in summer time) is made to Bucks Creek downstream of Lower Bucks Dam; this flow subsequently discharges into the NFFR approximately 1.3 miles upstream of Rock Creek Powerhouse. Flow from Grizzly Powerhouse immediately enters Grizzly Forebay, which provides generation storage for Bucks Powerhouse. Bucks Powerhouse discharges directly to the NFFR approximately 1.0 mile upstream of Rock Creek Powerhouse and 0.3 mile downstream of the mouth of Bucks Creek. A minimum release of 4 cfs (in summer time) is made to Grizzly Creek downstream of Grizzly Forebay Dam; this flow subsequently discharges into the NFFR approximately 0.75 mile downstream of Cresta Dam.

Table 3-8

Temperature data associated with inflows from Bucks Lake system.

A. Daily average temperature and flow data near Bucks Powerhouse.

Date	NF12	BUCK1		BUCK2		NF13	ROCK1		ROCK2	NF14
	(°C)	(°C)	(cfs)	(°C)	(cfs)	(°C)	(°C)	(cfs)	(°C)	(°C)
8/14/2002	22.3	19.3	16.1	14.3	188.6	19.4	21.9	1045	18.6	21.5
8/15/2002	22.4	19.3	16.0	14.2	216.2	19.0	22.2	1043	18.8	21.2
8/16/2002	22.4	19.2	15.9	13.9	214.8	19.0	22.4	1021	19.0	21.2
8/17/2002	21.8	18.0	15.8	14.0	135.4	19.5	22.4	1022	18.5	21.2
8/18/2002	21.3	17.5	15.8	13.5	227.7	17.6	22.0	1021	18.0	20.7
8/19/2002	21.2	17.0	15.7	----	0.0	20.7	21.9	1059	17.7	20.5
8/20/2002	20.7	16.0	15.4	----	0.6	20.6	21.5	1009	17.1	21.0
8/21/2002	20.2	15.4	15.2	----	0.0	20.0	21.3	1217	16.5	20.8
8/22/2002	20.1	15.2	15.2	----	0.5	19.9	21.4	1290	16.2	20.5
8/23/2002	20.0	14.8	15.0	----	1.7	19.7	21.2	1205	15.8	20.4

Table 3-8 (Continue)

B. Daily average temperature and flow data near Grizzly Creek.

Date	Daily Average Temperatures			
	NF14	GC1	NF15	Delta-T
8/6/2002	19.8	16.8	19.7	-0.1
8/7/2002	19.6	16.5	19.5	-0.2
8/8/2002	19.7	16.6	19.6	-0.2
8/9/2002	20.1	17.2	20.0	-0.1
8/10/2002	20.3	17.8	20.3	0.0
8/11/2002	20.5	18.3	20.6	0.0
8/12/2002	20.6	18.8	20.7	0.1
8/13/2002	20.8	19.5	21.0	0.2
8/14/2002	21.5	19.9	21.5	0.1
8/15/2002	21.2	20.1	21.4	0.2
8/16/2002	21.2	20.2	21.4	0.2

The Bucks Creek-Bucks Powerhouse (Bucks system) evaluation used temperatures from NF12, NF13, RC1, and NF14 to determine the effect of inflows from Bucks Creek (BUCK1) and Bucks Powerhouse (BUCK2). Bucks Powerhouse was operated on a peaking-type regime during the June through September period. This is done largely to maintain lake levels in Bucks Lake through the summer period in support of recreational concerns and property owner issues.

In order to compare periods with relatively similar ambient meteorological influences, a ten-day test period was selected which included five days of consistent Bucks powerhouse operation and five days of no powerhouse operation.

The test period illustrating the effect of powerhouse operations was from August 14 -18, 2002. During this five day period the average temperature at station NF-12 (upstream of Bucks system inflows) was 22.1°C. The average five day temperature at Bucks Creek was 18.7°C, and the average Bucks Powerhouse temperature was 14.0°C. The resultant temperature in the NFFR downstream of the Bucks system inflows (NF13) was 18.9°C. This represents an average decrease in temperature of 3.1°C; temperatures were also reduced below the 20°C level. Inflow temperatures from Rock Creek Powerhouse averaged 22.2°C during this same five day period. The absolute effect of Bucks system inflows on the NFFR was measured at station NF14. This station is below Cresta Dam and represents resulting temperatures following the mixing of Rock Creek (RC2), Rock Creek Powerhouse (RC1), and the NFFR end of the Rock Creek Reach (NF13) in Cresta

Reservoir. Temperatures at NF14 during the five day period averaged 21.1°C, or 1.0°C cooler than the Rock Creek powerhouse inflow.

The test period illustrating the effect of no powerhouse operations was from August 19 - 23. During this five day period the average temperature at station NF-12 (upstream of Buck Creek and Bucks Powerhouse) was 20.4°C. The average five day temperature at Bucks Creek was 15.7°C. The resultant temperature in the NFFR downstream of the Bucks Creek inflow (NF13) was 20.2°C. This represents an average decrease in temperature of 0.2°C. Inflow temperatures from Rock Creek Powerhouse averaged 21.5°C during the same five day period. Temperatures at NF14 during this five day period averaged 20.7°C, or 0.8°C cooler than the Rock Creek powerhouse inflow.

Results of this evaluation indicate that operation of Bucks Powerhouse can significantly reduce temperatures in the NFFR immediately upstream of Rock Creek Powerhouse. However, due to the large volume of inflow from Rock Creek Powerhouse at temperatures similar to those measured in the NFFR upstream of inflows from the Bucks system, there appears to be no measurable effect downstream of Rock Creek Powerhouse. This is true as long as Rock Creek Powerhouse is operating.

The Grizzly Creek evaluation used temperatures from NF14, and NF15 to determine the effect of inflows from Grizzly Creek (GR1). In order to compare periods with relatively similar ambient meteorological influences, an eleven-day test period was selected which included a wide range of Grizzly Creek inflow temperatures. The test period chosen was August 6-16, 2002. During this period, Grizzly Creek temperatures ranged from 16.2 to 20.5°C. Flows in Grizzly Creek ranged from 16.1 to 20.2 cfs.

Temperatures in the NFFR upstream of the Grizzly Creek confluence (NF14) for this period ranged from 19.6 to 21.5°C. Temperatures in the NFFR downstream of the Grizzly Creek confluence (NF15) for this period ranged from 19.5 to 21.5°C. In general, there was no difference in average temperatures between NF15 and NF14. The absolute difference ranged from 0.2°C cooler to 0.2°C warmer. As indicated by this data, during the summer period when creek flows are low, inflows from Grizzly Creek do not mitigate temperatures in the NFFR.

~~1.1.1.4~~3.2.3.4 Water Temperature Model Evaluation

3.2.3.4.1 Existing Model Evaluation

In 1986 Woodward-Clyde Consultants (WCC) developed temperature models of the Rock Creek Reach and Cresta Reach of the NFFR using the SNTEMP (Stream Network Temperature Model). Both models were developed using data from 1985. As part of the most recent Rock Creek-Cresta Hydroelectric Project relicensing effort (FERC 1962), the 1986 SNTMP temperature models were revised and updated. As part of the updating process, data collected in 2002 was incorporated into the exiting models to strengthen model calibration. The results of this modeling analysis are presented in: Revised Water Temperature Modeling for the Rock Creek-Cresta Hydroelectric Project - FERC Project No. 1962 (TRPA, 2003). This document is included as Appendix B.

Both of the revised models were then used to evaluate a matrix (gaming) of alternative flow scenarios. The calibration and validation of both models was based on two years (1985 and 2002) of hydrologic and meteorologic data, while the 2002 weather conditions was used in scenario gaming.

The original Rock Creek Reach water temperature model was fine-tuned by the addition of tributaries influences not incorporated in the structure of the original model. The 2002 data was merged into the 1985 dataset and the calibration recalibrated. This was followed by scenario gaming of varied flow releases using the 2002 June-September meteorologic data. The original Cresta Reach temperature model structure and calibration was validated using the 2002 data and retained unchanged. Flow release gaming of the Cresta model also used 2002 ambient conditions. Table 3-9 summarizes the quality control statistics for each model.

~~1.1.1.1.2~~3.2.3.4.2 Scenario Simulation

Based upon precipitation within the North Fork Feather River watershed, the year 2002 was classified as a normal hydrologic year. Both reach models were used to predict river temperatures resulting from the gaming of multiple release scenarios under the 2002 hydrologic year conditions. Results of the scenario gaming were then compared to the existing release conditions to evaluate the influence of controllable factors (such as higher instream flow release) relative to uncontrollable factors (meteorological condition s and initial water temperatures).

Table 3-9

Summary of Model Quality Control Statistics

A. Rock Creek Reach (Re-calibration)

North Fork Feather River downstream of Granite Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9932	0.07	0.13	0.64	0.01	122

North Fork Feather River upstream of Bucks Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9901	0.01	0.17	0.71	0.01	122

North Fork Feather River upstream of Rock Creek Powerhouse

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9834	-0.22	0.24	0.95	0.02	122

B. Cresta Reach (Validation 2002 data)

North Fork Feather River downstream of Grizzly Cr confluence

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9988	-0.12	0.05	-0.26	0.00	122

North Fork Feather River upstream of Cresta Powerhouse

Correlation Coefficient	Mean Error	Prob. Error	Max. Error	Bias Error	Day
0.9889	0.08	0.17	-0.67	0.02	122

TRP, 2003

License conditions issued in ~~October,~~October 2001, specified that release flows in each reach be increased to a new level for evaluation at intervals of every five qualified years (a total of three ~~3~~ five-year periods are specified in the license). Release flows were tied to water year type (normal/wet, dry, critical dry) and changed seasonally. Temperature conditions resulting from the increased release flows would then be monitored during each five-year time period. Using the 2002 hydrologic and meteorologic data, flow releases for the "normal/wet" condition from the first, second, and third 5-year periods were modeled. Table 3-10 defines the monthly flow release scenarios used in this modeling effort.

Results of gaming the three alternative flow release scenarios varied for the two river reaches during the four summer months simulated. Table 3-11 presents the results of model simulation under normal/wet conditions. Table 3-11 compares mean monthly water temperature at selected nodes within each reach for each month and release flow. Under the normal/wet condition, model predictions for the Rock Creek Reach suggest that higher instream flow releases produce incrementally higher average water temperature at the end of the reach. This is largely the result of higher release flows over-riding the cooling benefit from colder tributaries and inflows from Bucks Powerhouse. Some reduction in temperature is seen with higher flows closer to the dam. Under the normal/wet condition, model predictions for the Cresta Reach suggest that higher instream flow releases produce incrementally lower water temperature with distance from the dam. Higher releases flows benefit the Cresta Reach largely because of the lack of cooling tributary inflows. Overall, the net temperature change (higher or

Table 3-10

Summary of Release Flows used during Scenario Gaming

A: Rock Creek Reach - Normal/Wet Water Year

Monitoring Year	Flow Release from Rock Creek Dam			
	June	July	August	September
Years 1-5	220	180	180	180
Years 6-10	260	260	260	260
Years 11-15	3940	390	390	390

B: Cresta Reach - Normal/Wet Water Year

Monitoring Year	Flow Release from Cresta Dam			
	June	July	August	September
Years 1-5	240	220	220	220
Years 6-10	325	325	325	325
Years 11-15	440	440	440	440

Table 3-11

Predicted Monthly Average Stream Temperature at Selected Release Flows.

A. Rock Creek Reach

Location on NFFR	Miles below Rock Cr Dam	June			July		
		220 cfs	260 cfs	390 cfs	180 cfs	260 cfs	390 cfs
Rock Creek Dam	**0.00**	18.4	18.4	18.4	21.3	21.3	21.3
Above Milk Ranch Creek	**2.06**	18.8	18.8	18.7	21.7	21.6	21.5
Below Milk Ranch Creek	**2.11**	18.7	18.6	18.6	21.5	21.5	21.5
Above ~~Cummings~~ Chambers Creek	**2.98**	18.8	18.8	18.7	21.7	21.6	21.6
Below ~~Cummings~~ Chambers Creek	**3.04**	18.3	18.4	18.4	21.5	21.5	21.5
Below Granite Creek	**4.10**	18.5	18.5	18.5	21.6	21.6	21.6
Above Bucks Creek	**6.71**	18.4	18.5	18.6	21.7	21.7	21.6
Below Bucks Creek	**6.77**	18.3	18.3	18.4	21.4	21.5	21.5
Above Bucks Cr Powerhouse	**6.96**	18.3	18.3	18.5	21.4	21.5	21.5
Below Bucks Cr Powerhouse	**7.02**	18.1	18.1	18.3	20.2	20.2	20.8
Above Rock Cr Powerhouse	**7.95**	18.2	18.3	18.4	20.3	20.6	20.9

Location on NFFR	Miles below Rock Cr Dam	August			September		
		180 cfs	260 cfs	390 cfs	180 cfs	260 cfs	390 cfs
Rock Creek Dam	**0.00**	21.2	21.2	21.2	19.1	19.1	19.1
Above Milk Ranch Creek	**2.06**	21.3	21.3	21.3	19.1	19.1	19.1
Below Milk Ranch Creek	**2.11**	21.2	21.2	21.2	18.9	19.0	19.1
Above ~~Cummings~~ Chambers Creek	**2.98**	21.2	21.3	21.3	18.9	19.0	19.1
Below ~~Cummings~~ Chambers Creek	**3.04**	21.1	21.2	21.2	18.9	19.0	19.1
Below Granite Creek	**4.10**	21.2	21.2	21.3	18.8	19.0	19.1
Above Bucks Creek	**6.71**	21.1	21.2	21.3	18.7	18.9	19.1
Below Bucks Creek	**6.77**	20.8	21.0	21.2	18.4	18.7	18.9
Above Bucks Cr Powerhouse	**6.96**	20.8	21.0	21.2	18.4	18.7	18.9
Below Bucks Cr Powerhouse	**7.02**	18.8	18.8	19.8	15.9	15.9	17.2
Above Rock Cr Powerhouse	**7.95**	18.9	19.4	19.9	16.0	16.6	17.2

Table 3-11

(Continued)

B. Cresta Reach

Location on NFFR	Miles below Cresta Dam	June			July		
		240 cfs	**325 cfs**	**440 cfs**	**220 cfs**	**325 cfs**	**440 cfs**
Cresta Dam	**0**	18.4	18.4	18.4	21.2	21.2	21.2
Above Grizzly Cr	**0.37**	18.5	18.5	18.5	21.3	21.2	21.2
Below Grizzly Cr	**0.38**	18.2	18.2	18.3	21.1	21.1	21.1
Middle Cresta reach	**2.24**	18.6	18.5	18.5	21.4	21.4	21.4
Above Cresta Powerhouse	**4.72**	19.0	18.9	18.9	21.9	21.7	21.7
Location on NFFR	Miles below Cresta Dam	**August**			**September**		
		220 cfs	**325 cfs**	**440 cfs**	**220 cfs**	**325 cfs**	**440 cfs**
Cresta Dam	**0**	20.7	20.7	20.7	18.5	18.5	18.5
Above Grizzly Cr	**0.37**	20.7	20.7	20.7	18.5	18.5	18.5
Below Grizzly Cr	**0.38**	20.5	20.6	20.6	18.3	18.4	18.4
Middle Cresta reach	**2.24**	20.7	20.7	20.7	18.4	18.4	18.5
Above Cresta Powerhouse	**4.72**	20.9	20.9	20.9	18.4	18.5	18.5

lower) for the various in-stream flow releases was small. A complete presentation of the water temperature model simulation is presented in Appendix B.

Based upon model predictions, controllable factors (flow releases) are over-ridden by non-controllable physical factors (e.g. solar radiation, lack of shading, tributary inflow, starting water temperatures released from the dam). Water temperatures in the NFFR in Rock Creek and Cresta study reaches were frequently above temperature thresholds (18-20°C) for salmonids and other cold water aquatic organisms, primarily due to initial (starting) water temperatures at the release point.

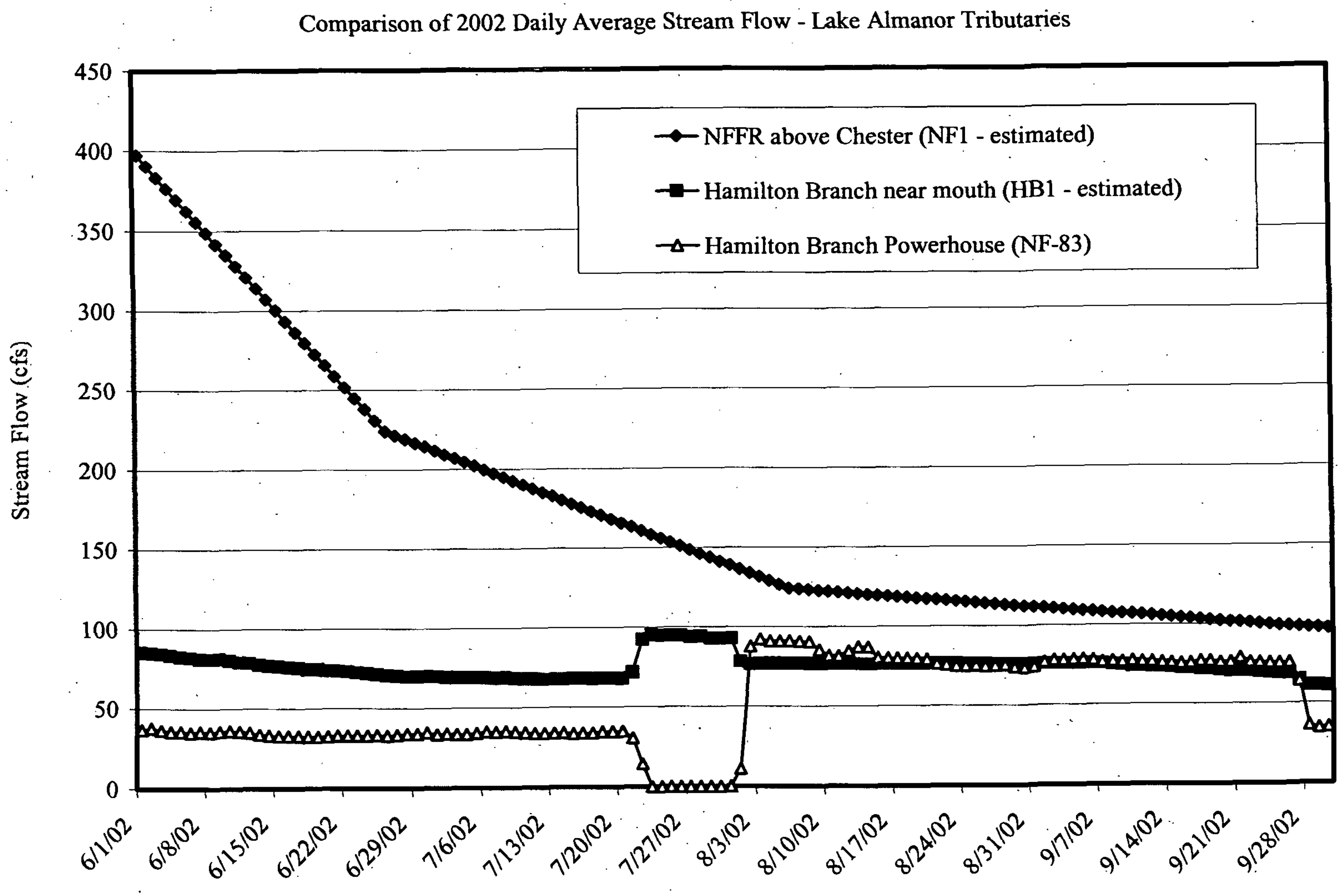


Figure 3-1. Comparison of daily average flow at stations tributary to Lake Almanor – 2002

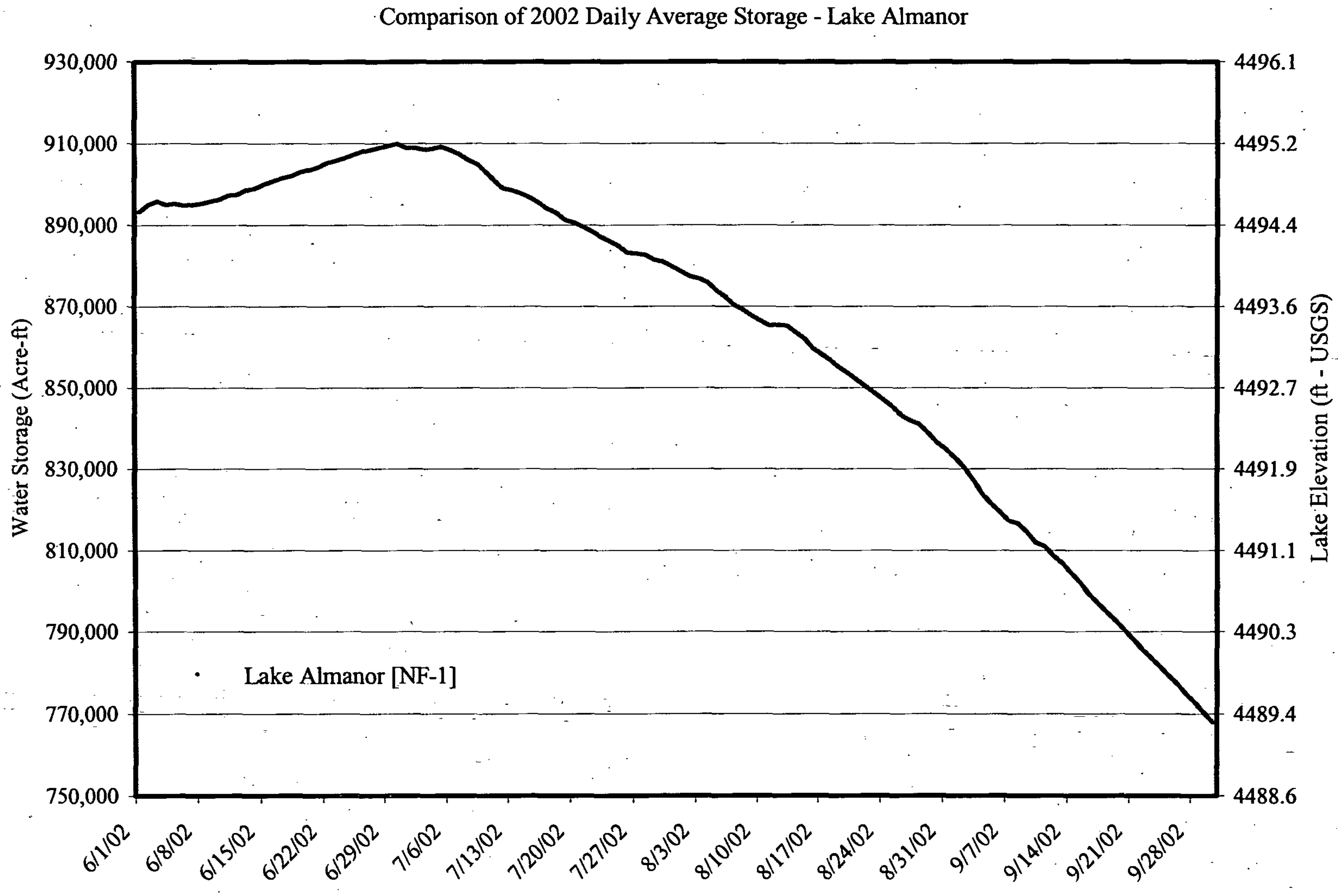
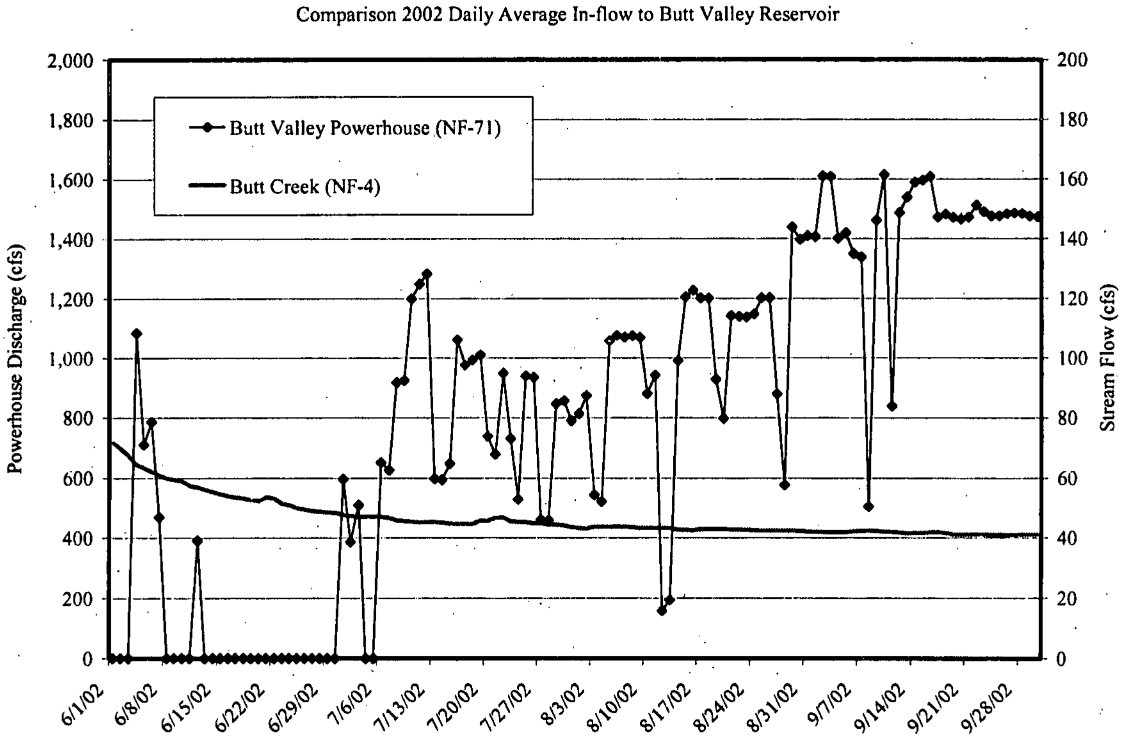
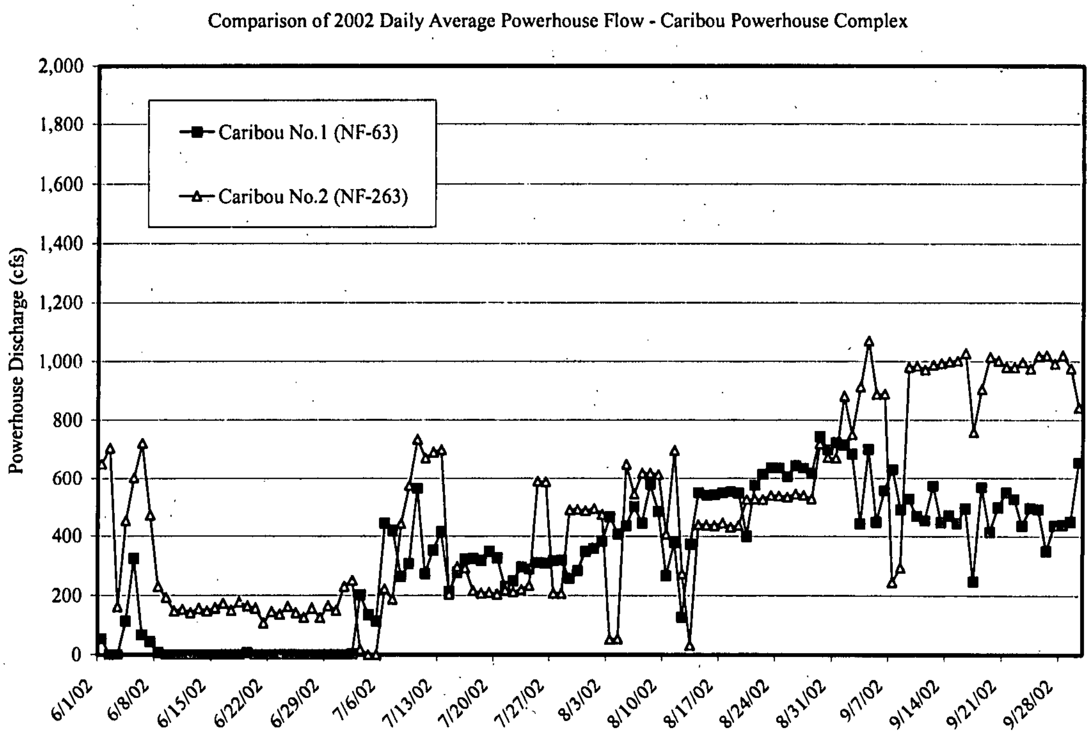


Figure 3-2. Lake Almanor average daily storage and elevation – 2002

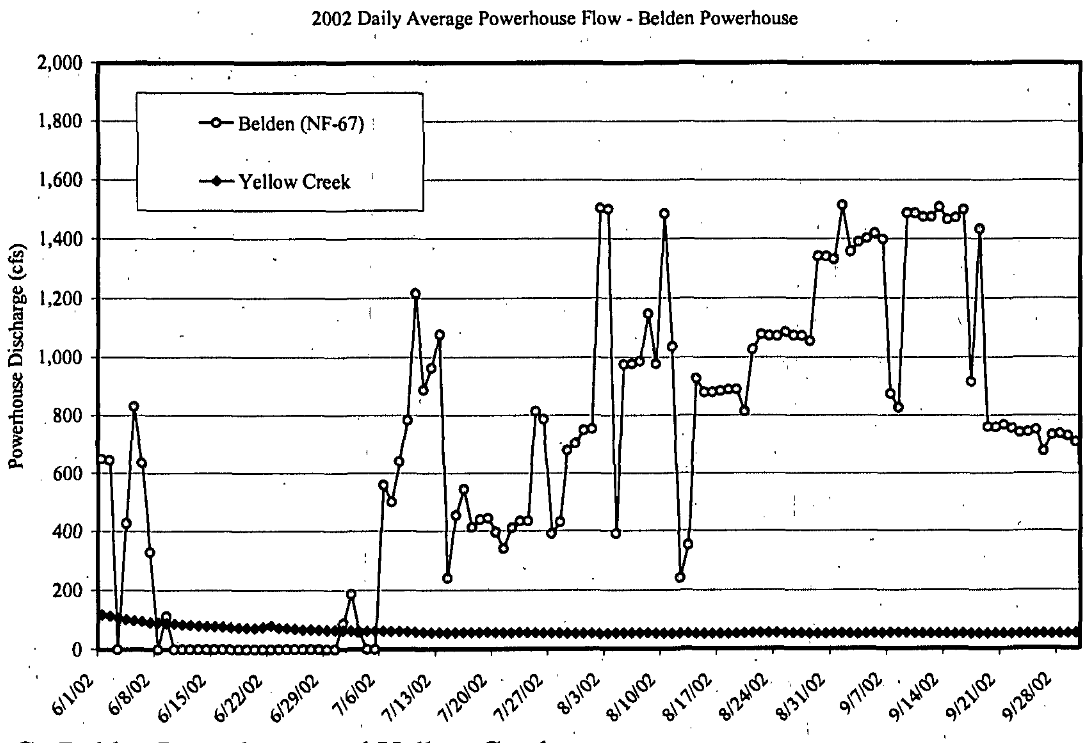


A. Butt Valley Powerhouse and Butt Creek



B. Caribou No.1 and Caribou No.2 powerhouses

Figure 3-3. Comparison of daily average flow from select stations in the upper NFFR Project – 2002



C. Belden Powerhouse and Yellow Creek

Figure 3-3 (continued).

Comparison of daily average flow from select stations in the upper NFFR Project – 2002

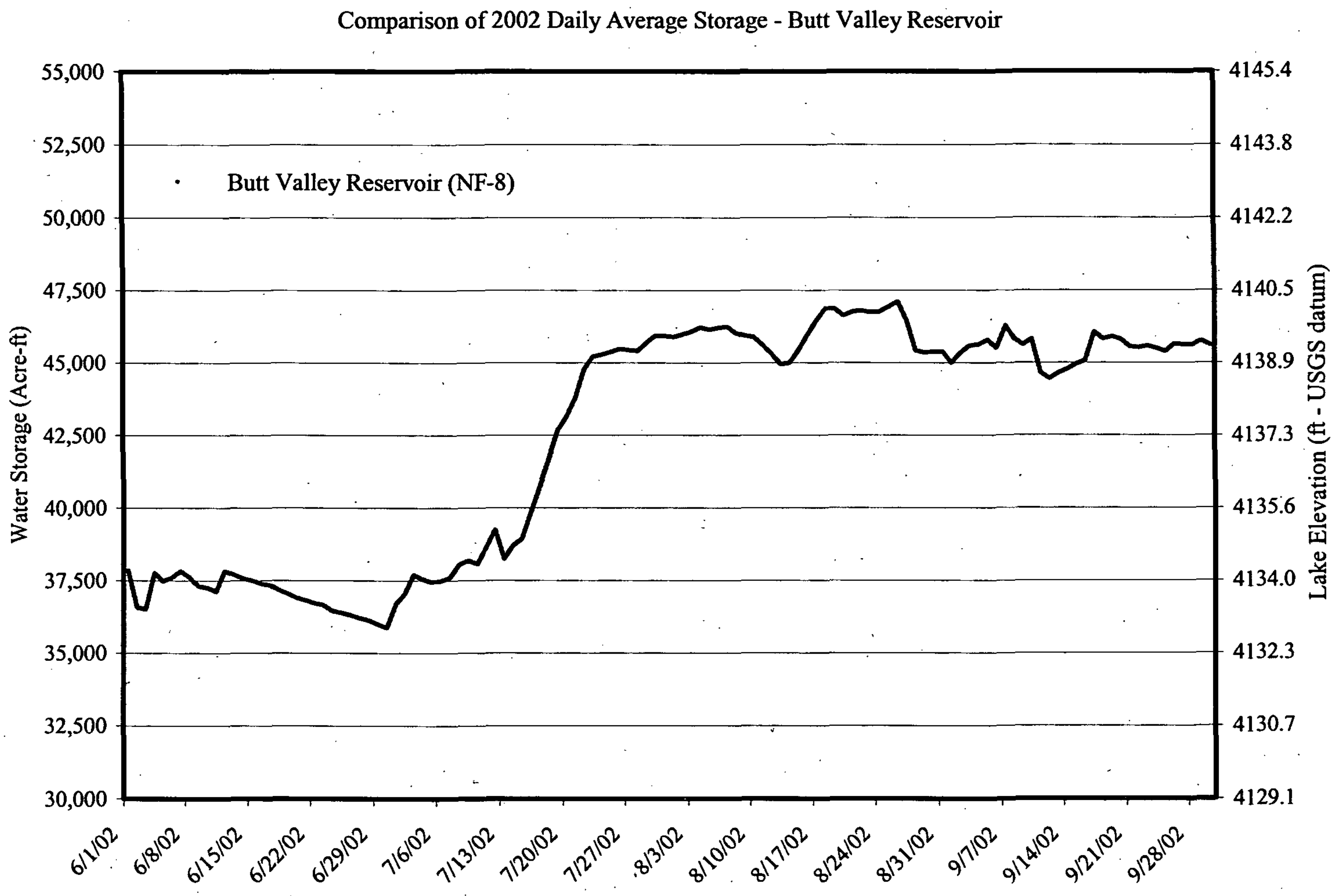


Figure 3-4. Daily Average Storage in Butt Valley Reservoir – 2002

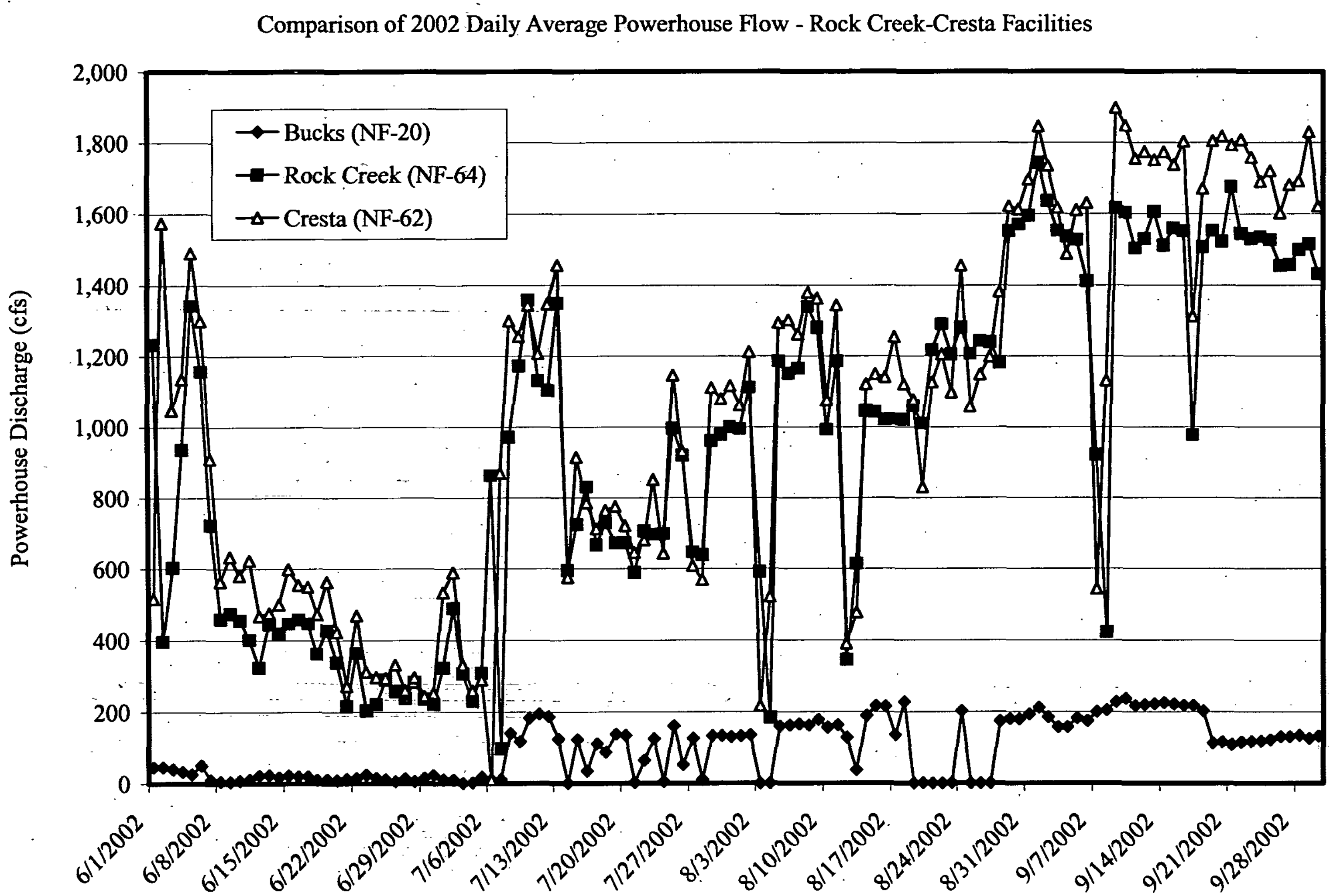


Figure 3-5. Comparison of daily average flow at Rock Creek-Cresta Project powerhouses – 2002

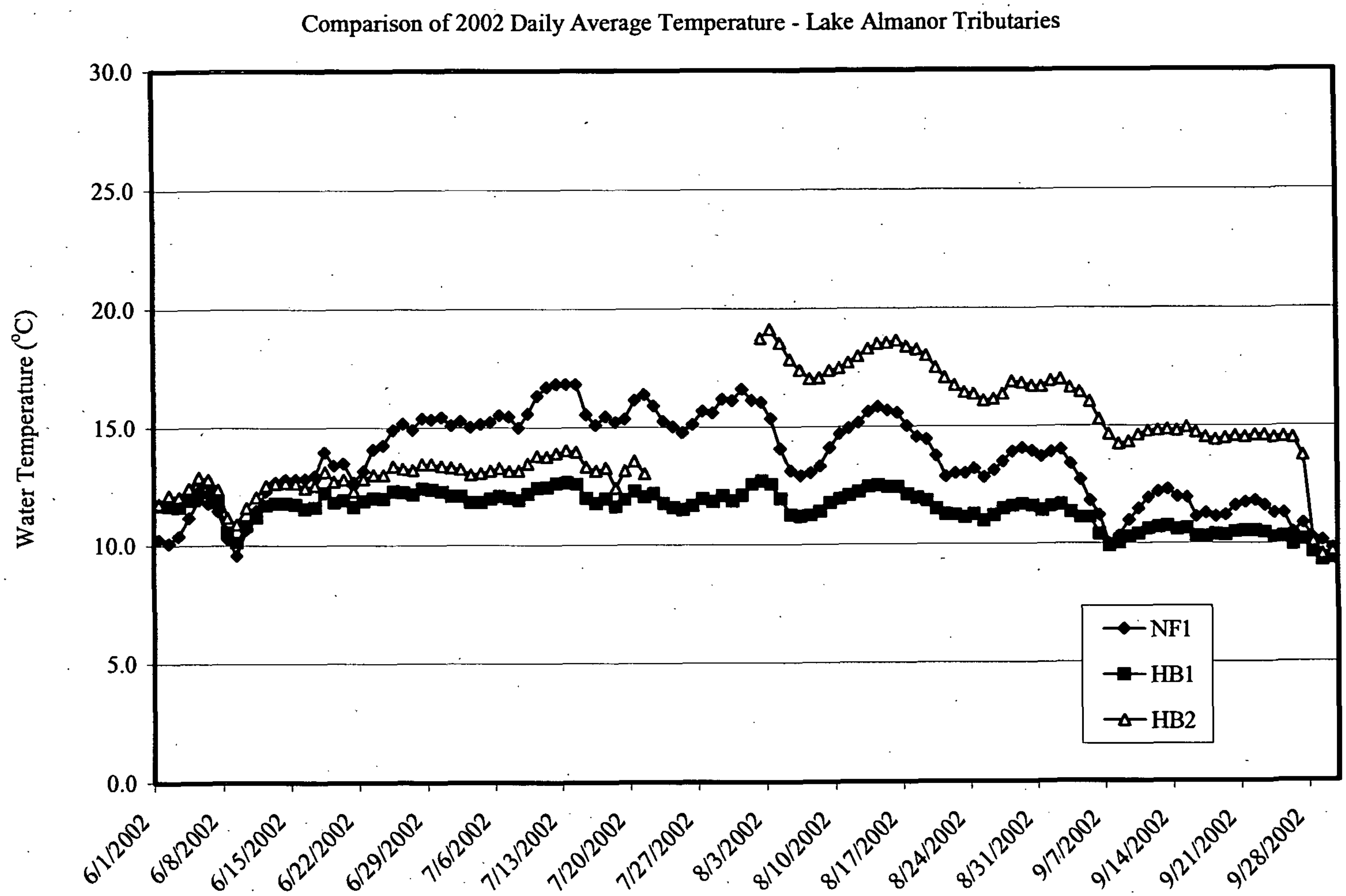


Figure 3-6. Comparison of daily average temperature at stations tributary to Lake Almanor – 2002

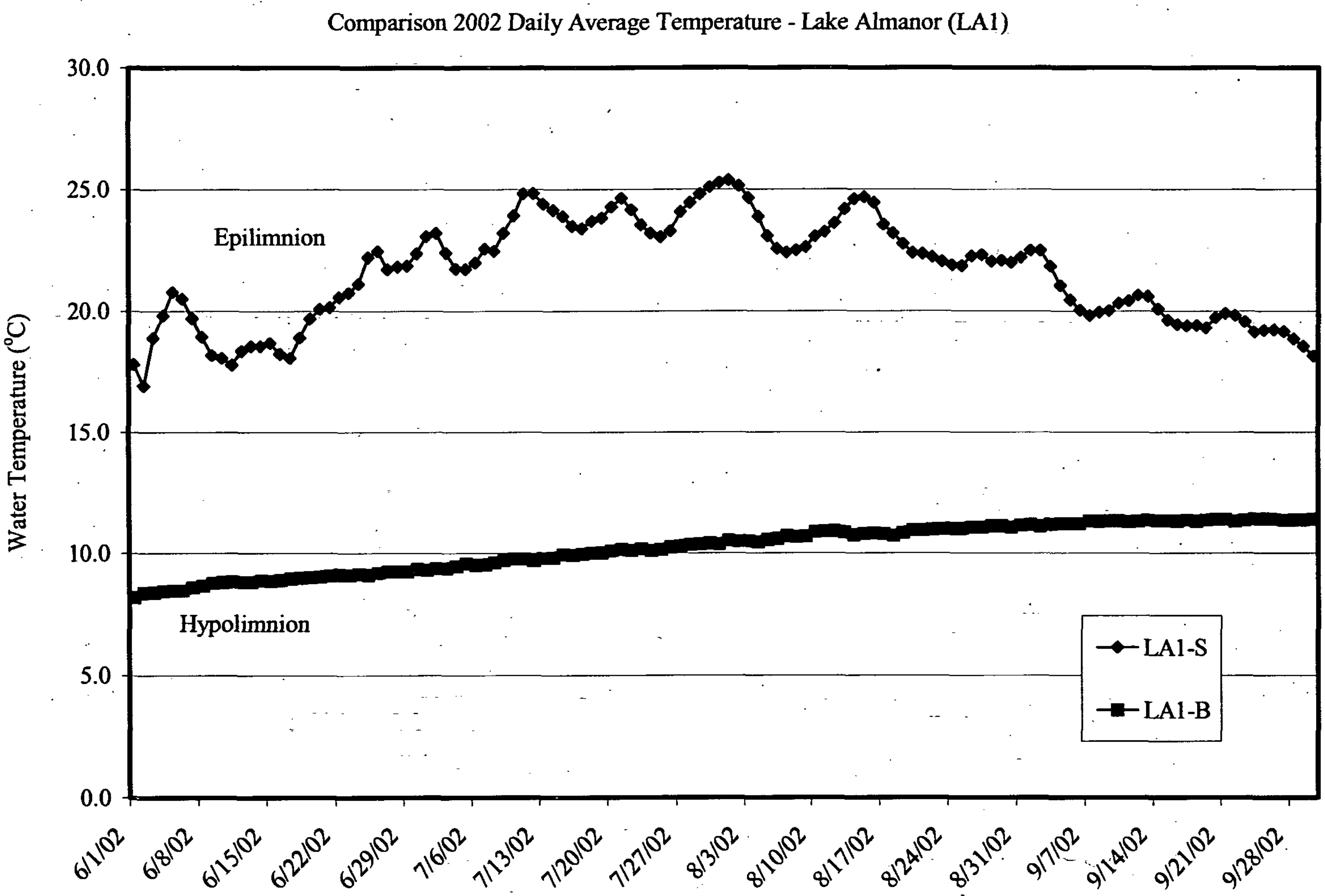


Figure 3-7. Comparison of mean daily temperatures from two depths in Lake Almanor near the Canyon Dam Intake – 2002

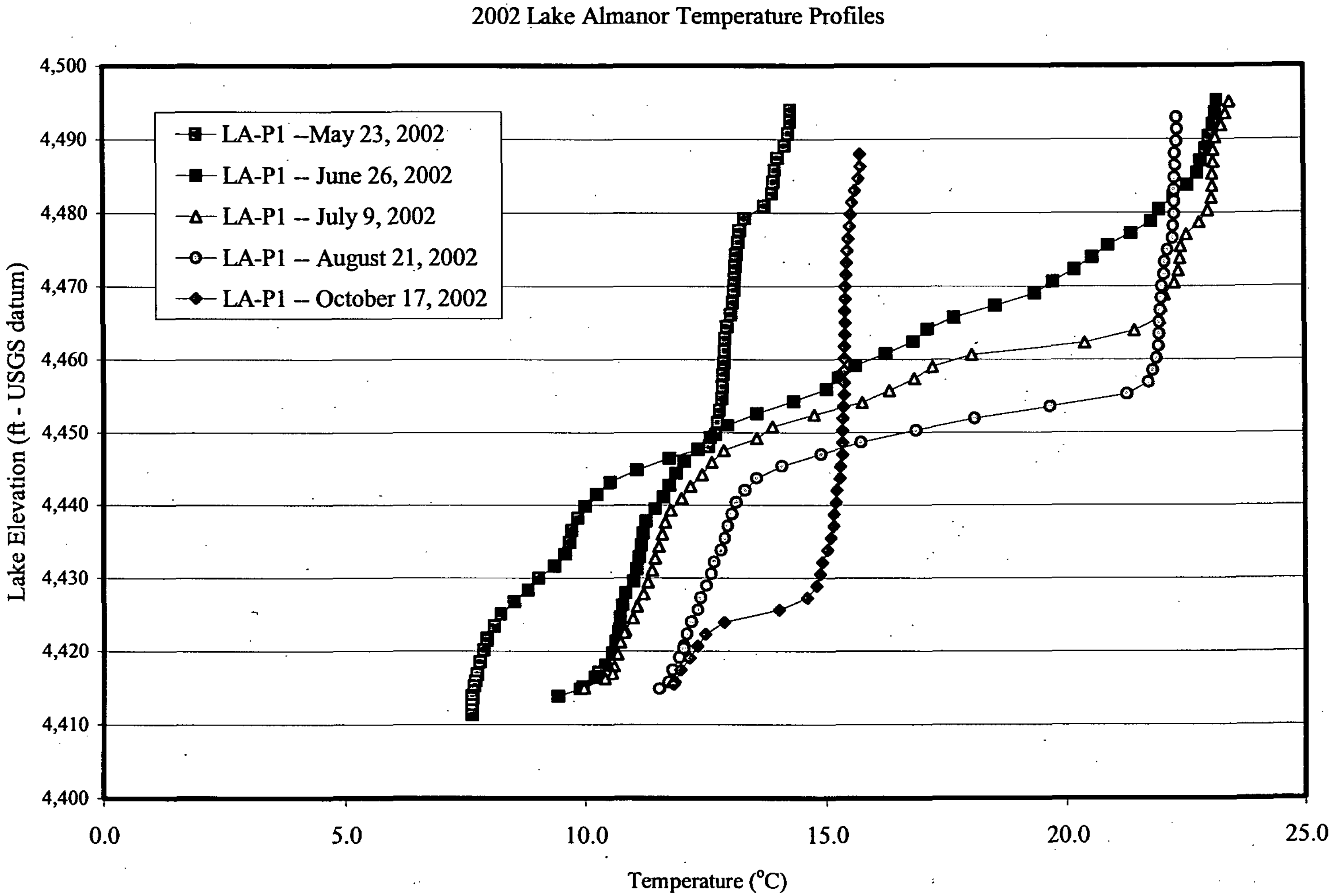
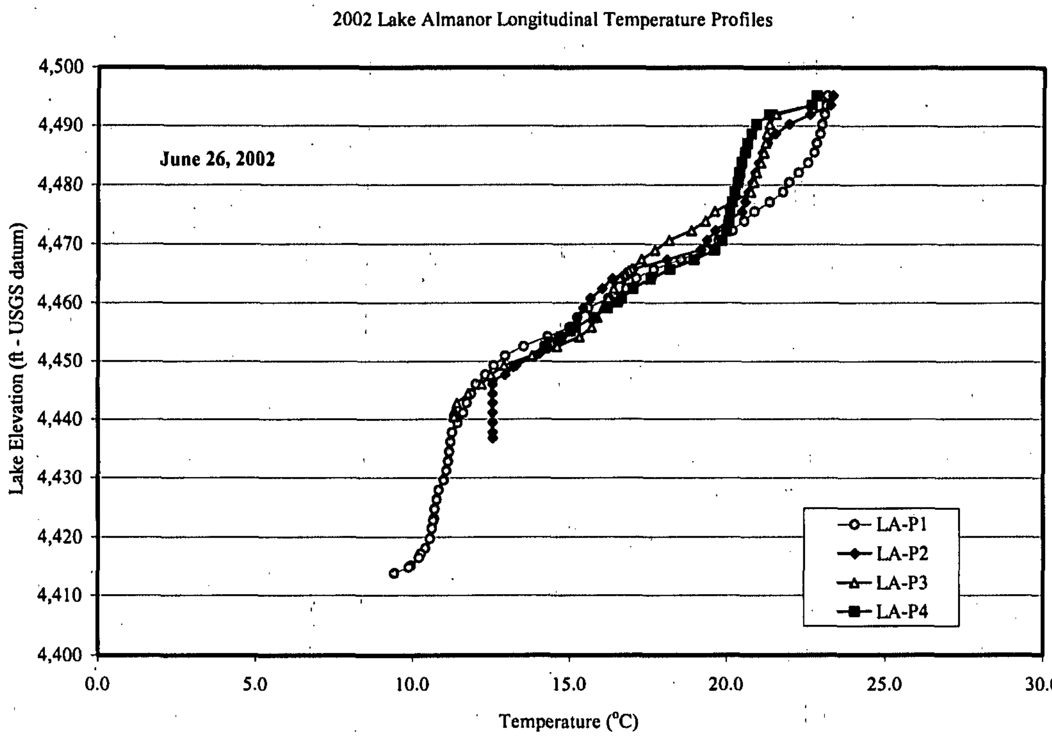
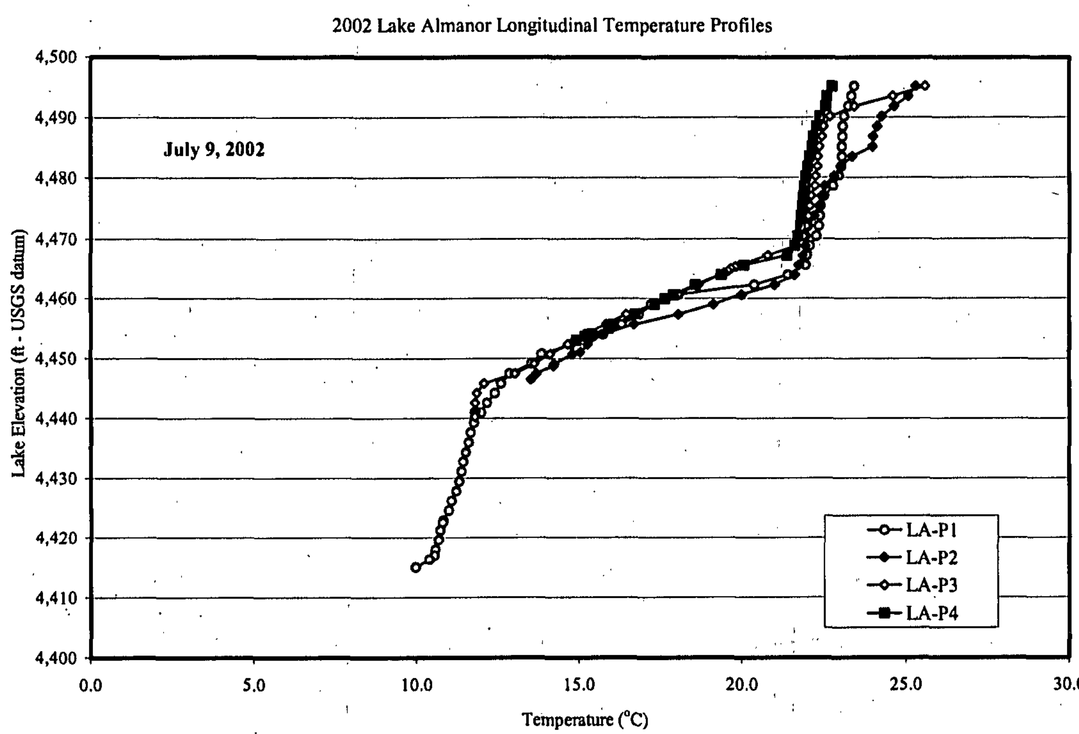


Figure 3-8. Comparison of monthly profiles from Lake Almanor (LA1) for the period June through September 2002

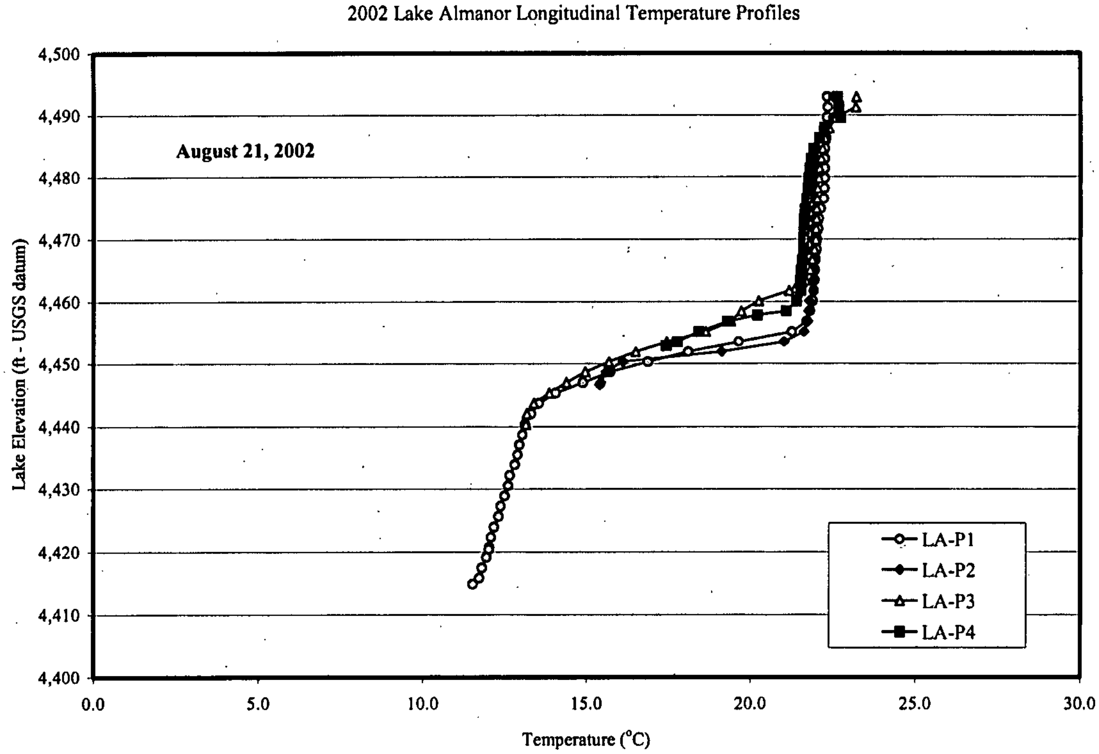


A. June 26, 2002 – Lake Almanor Profiles

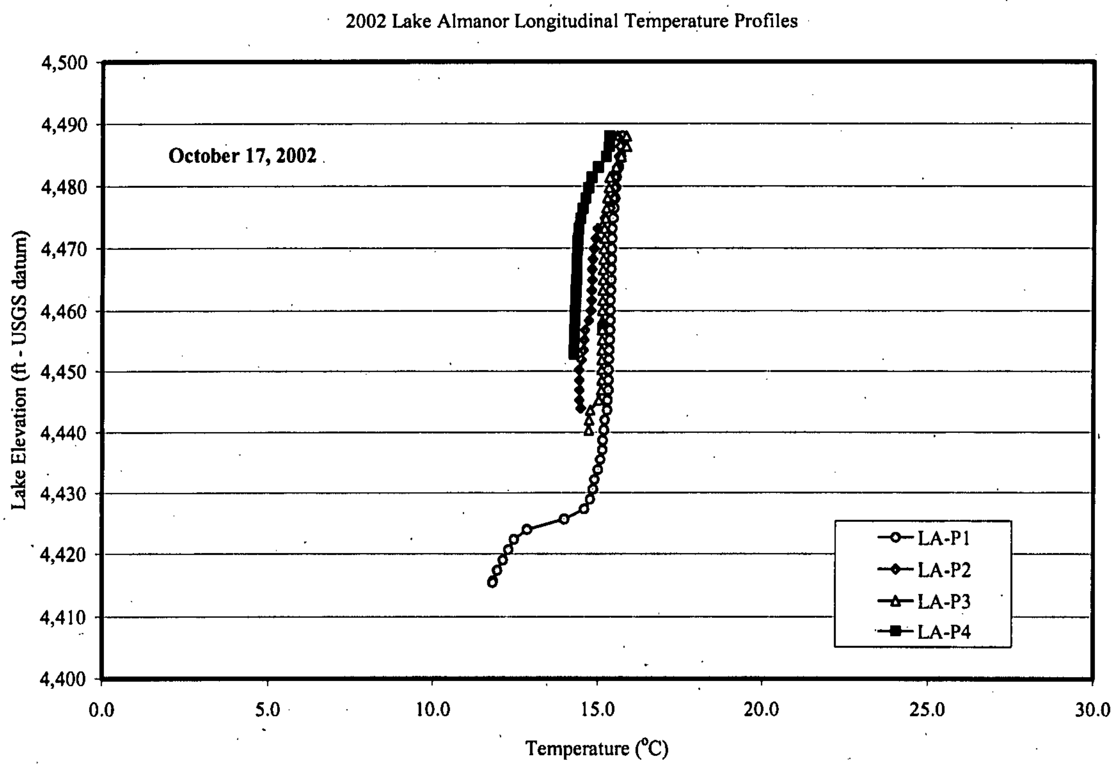


B. July 9, 2002 – Lake Almanor Profiles

Figure 3-9. Longitudinal thermal structure at four profile stations in Lake Almanor – 2002



C. August 21, 2002 – Lake Almanor Profiles



D. October 17, 2002 – Lake Almanor Profiles

Figure 3-9 (continued).

Longitudinal thermal structure at four profile stations in Lake Almanor – 2002

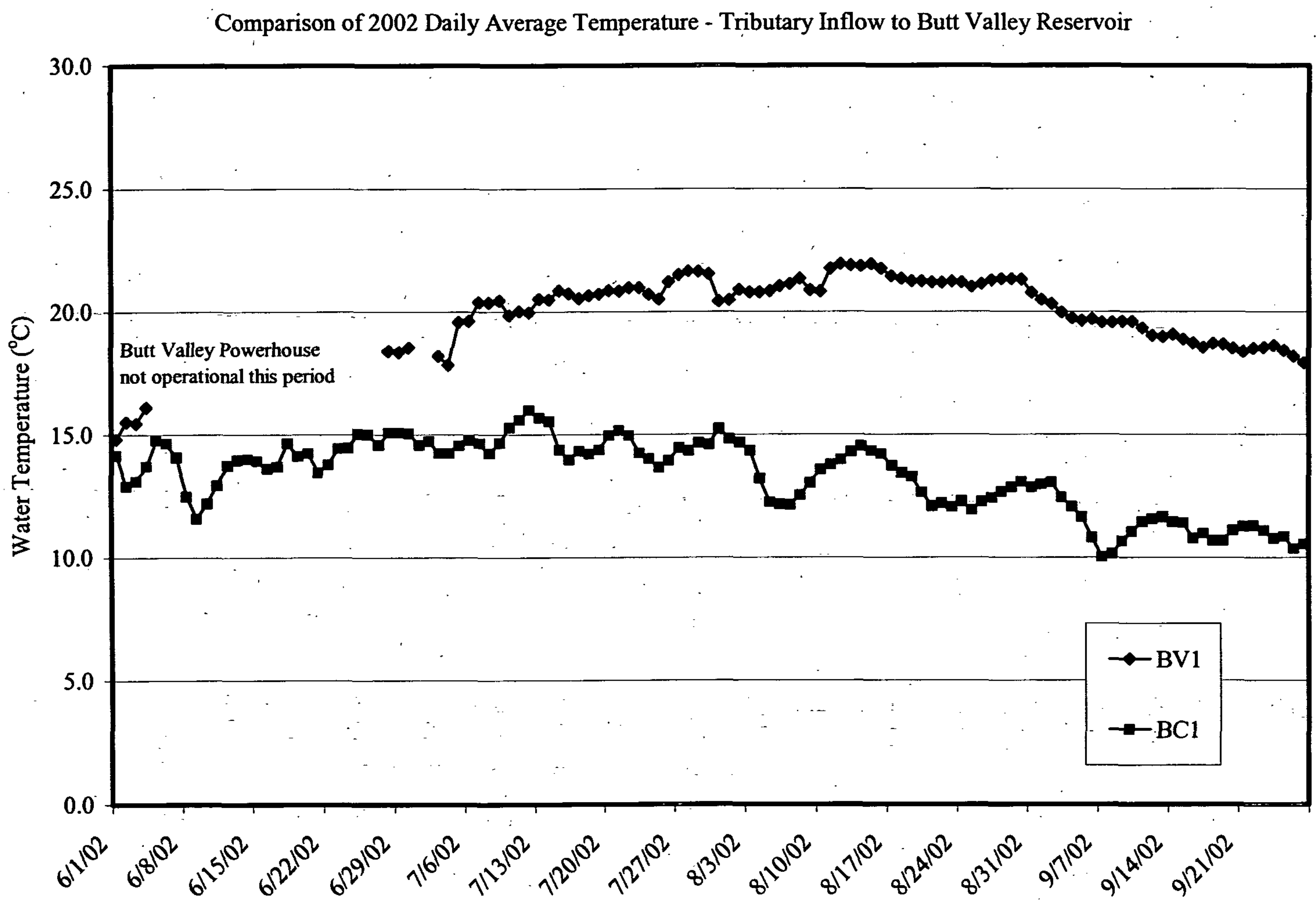


Figure 3-10. Comparison of daily average temperature at stations tributary to Butt Valley Reservoir – 2002

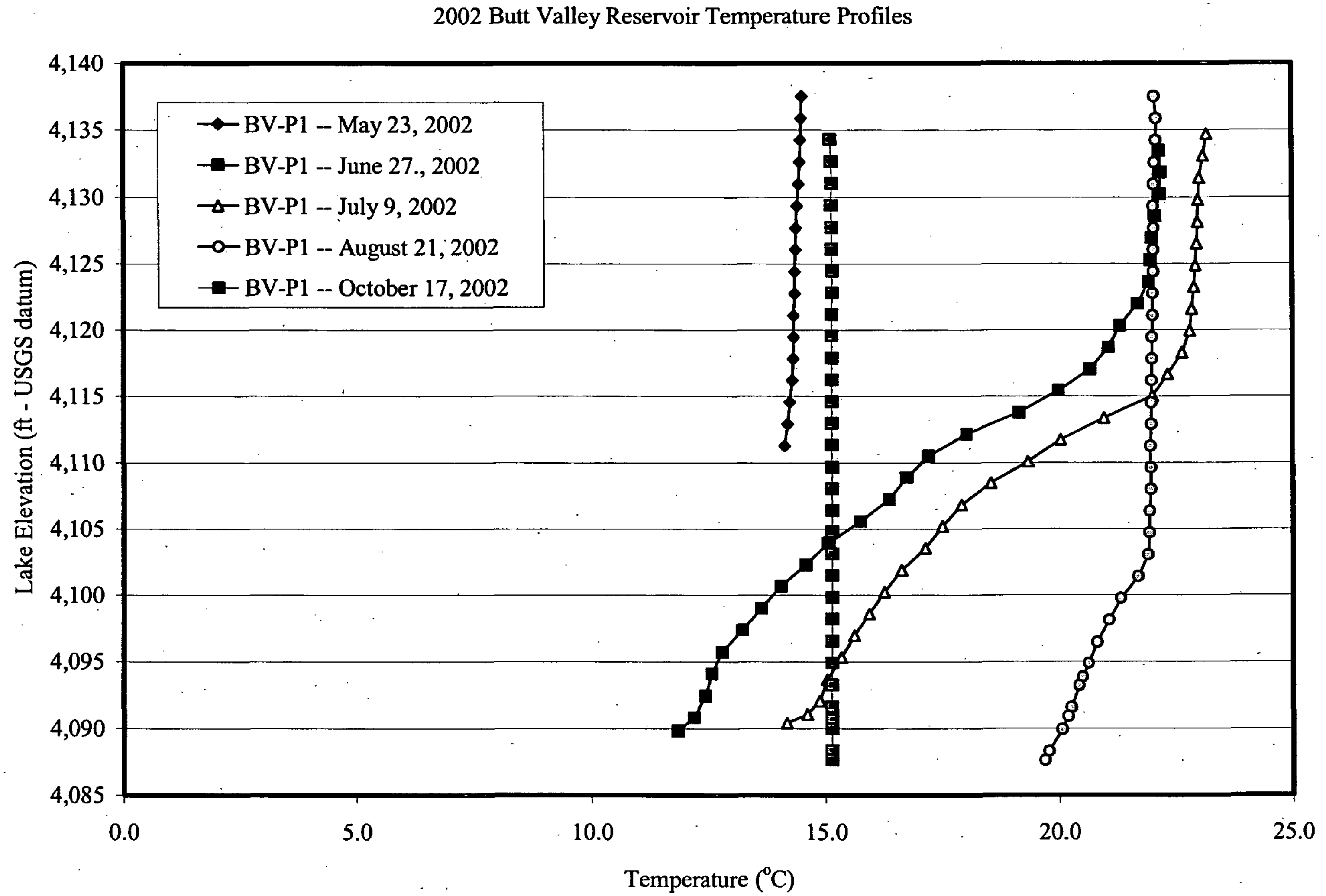
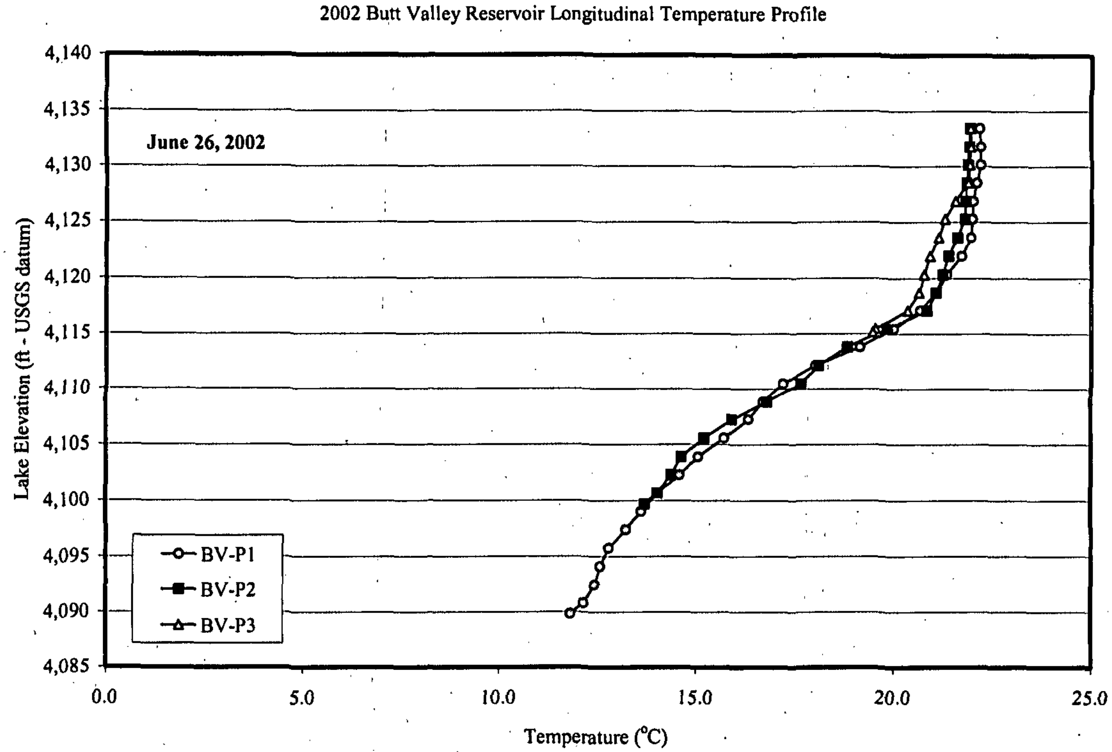
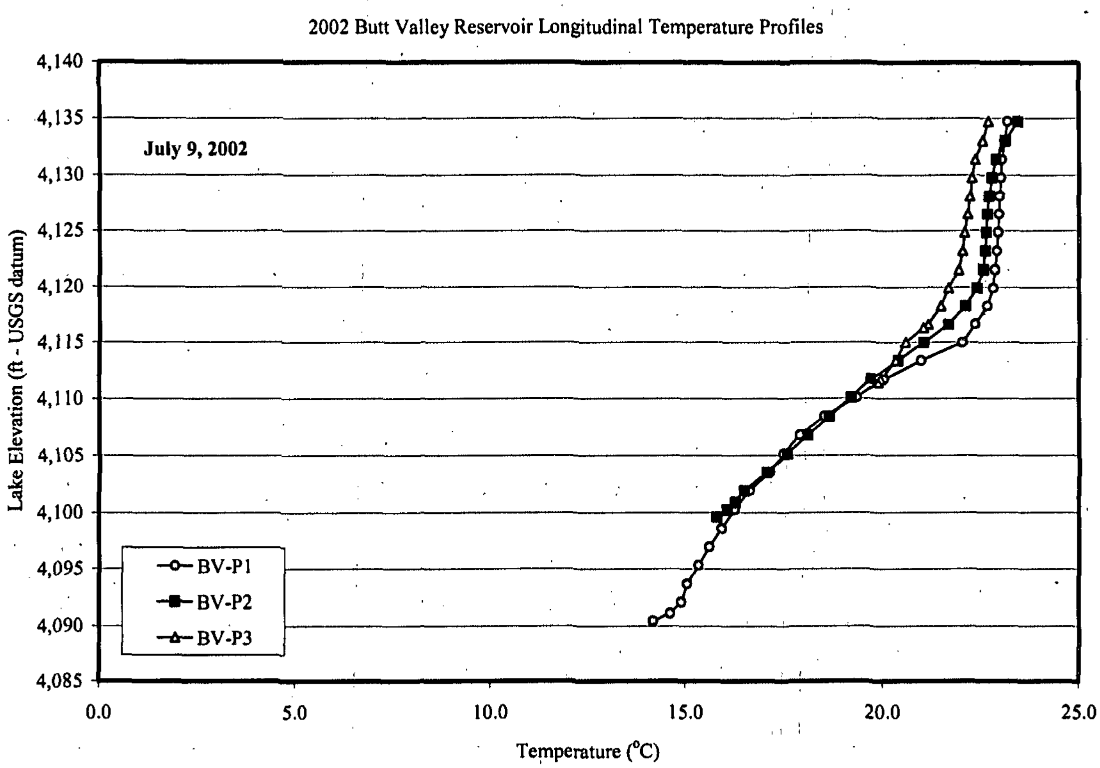


Figure 3-11. Comparison of monthly profiles from Butt Valley Reservoir (BV2-A) for the period June through September 2002

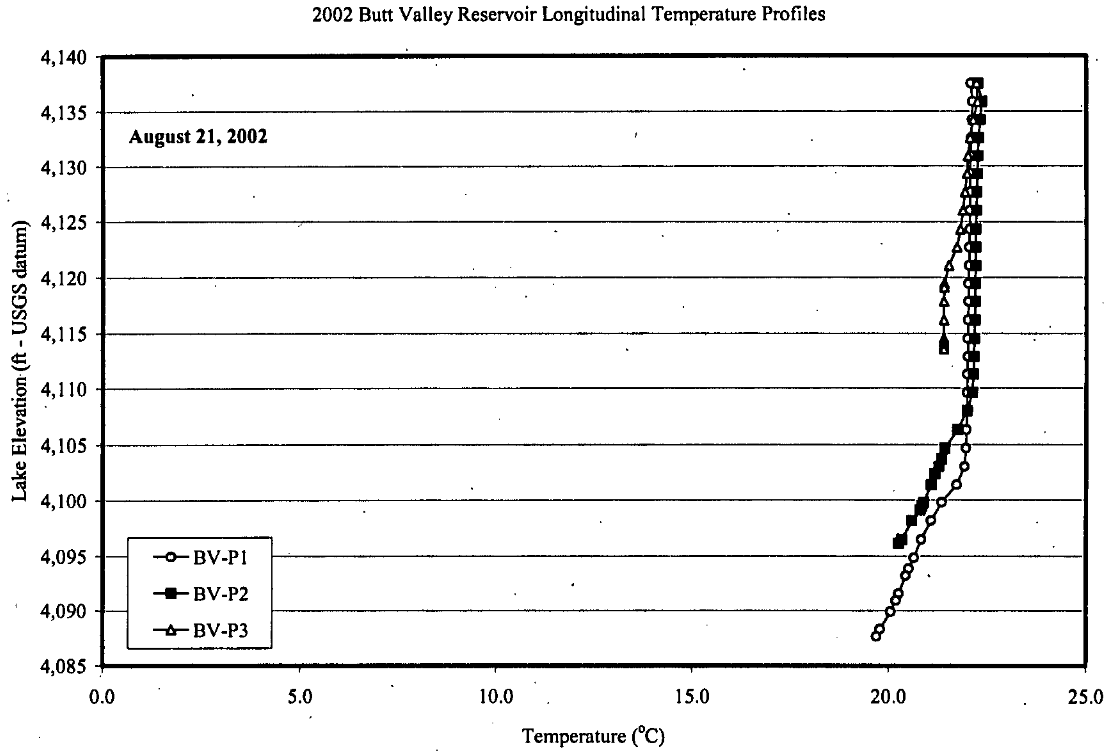


A. June 26, 2002 – Butt Valley Reservoir Profiles

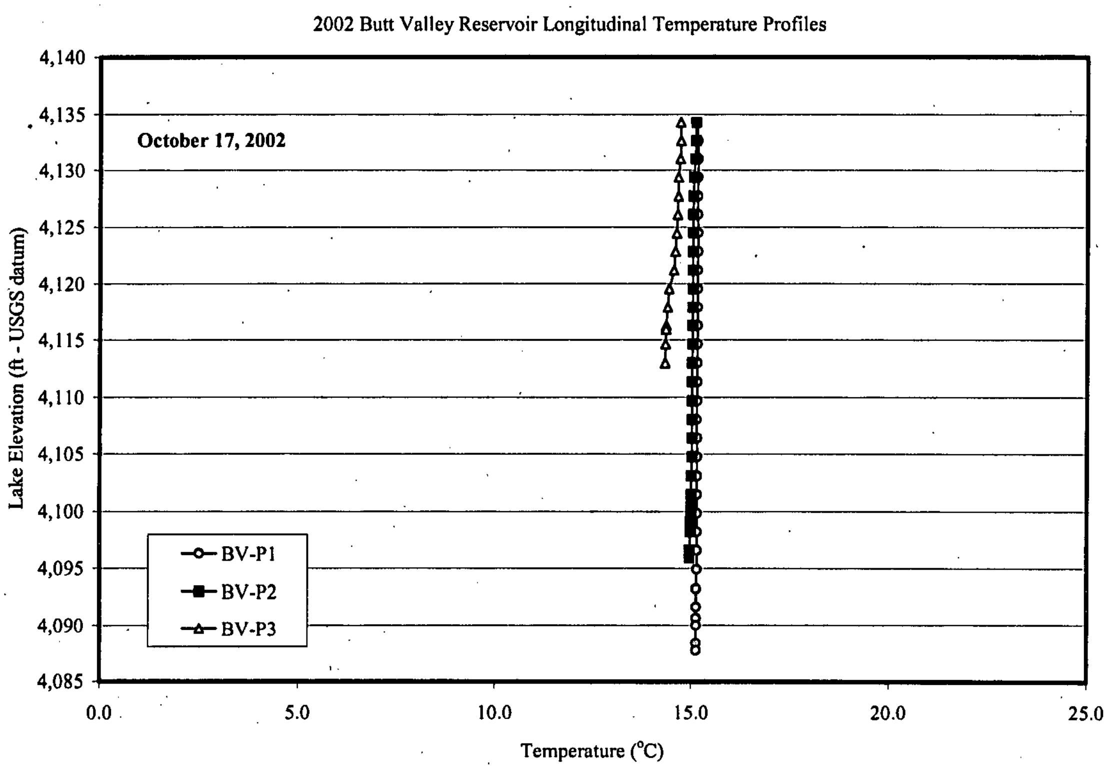


B. July 9, 2002 – Butt Valley Reservoir Profiles

Figure 3-12. Longitudinal thermal structure at three stations in Butt Valley Reservoir – 2002



C. August 21, 2002 – Butt Valley Reservoir Profiles



D. October 17, 2002 – Butt Valley Reservoir Profiles

Figure 3-12 (continued).

Longitudinal thermal structure at three stations in Butt Valley Reservoir – 2002

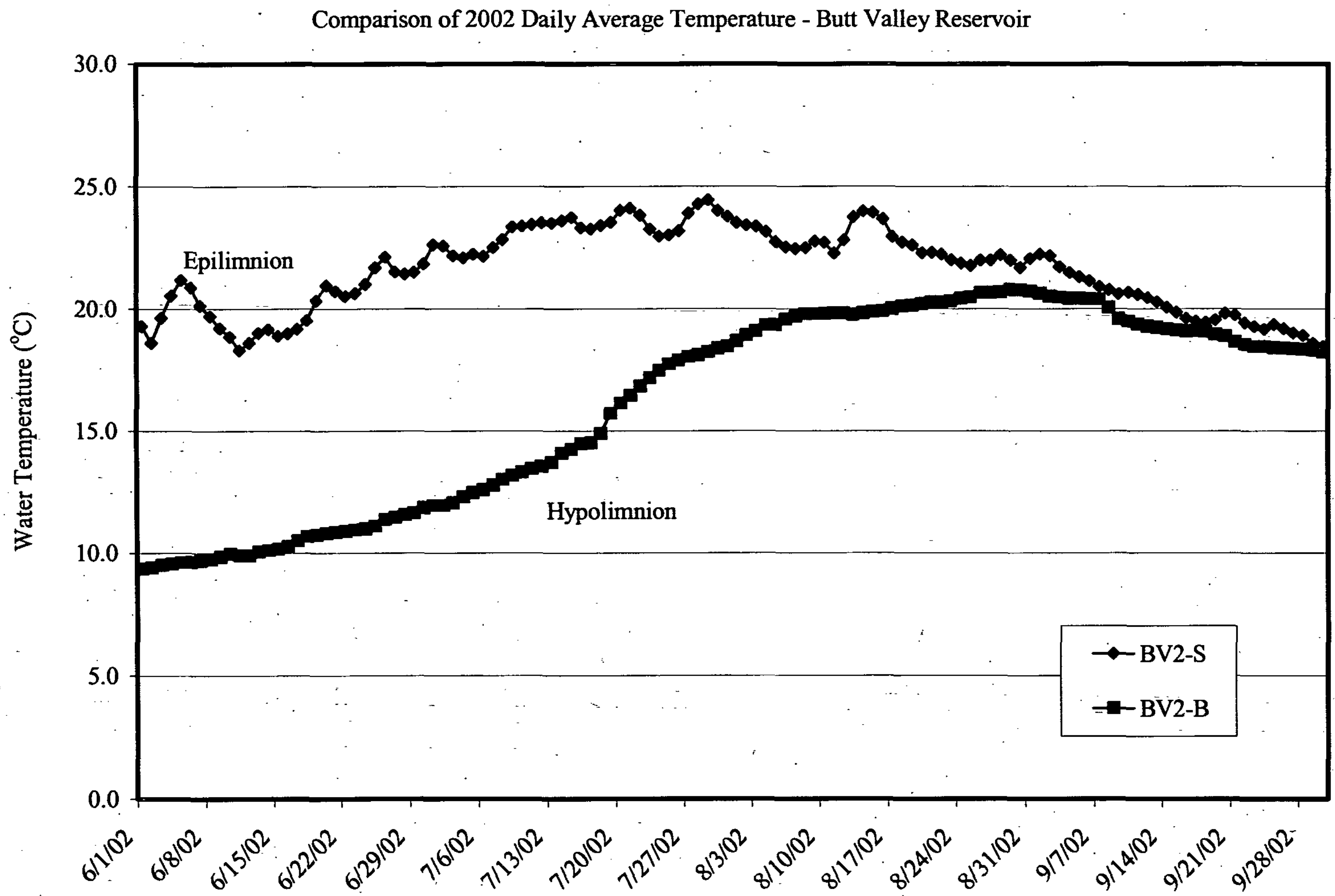


Figure 3-13. Comparison of mean daily temperatures from two depths in Butt Valley Reservoir near Caribou No. 1 Intake – 2002

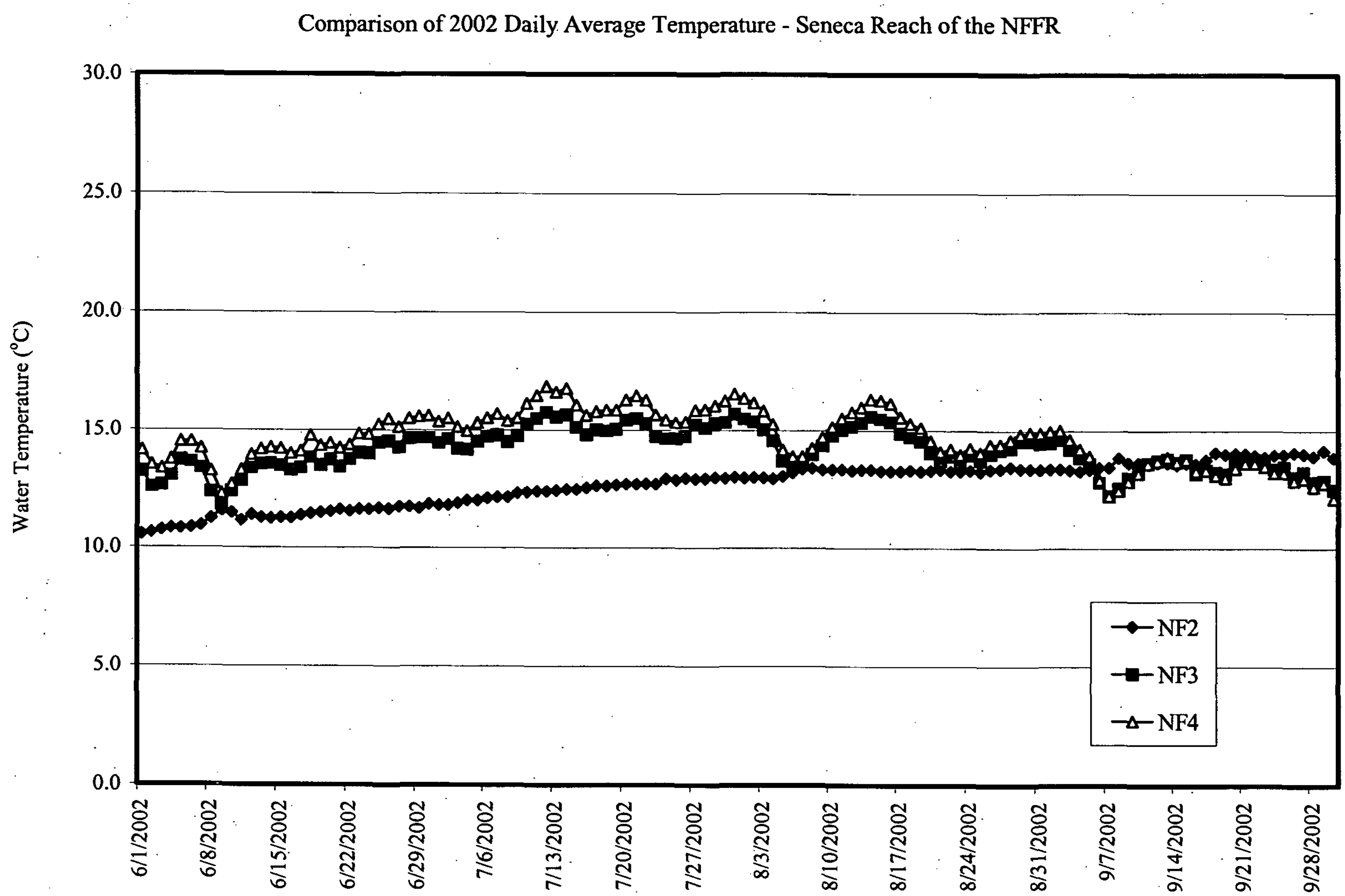


Figure 3-14. Comparison of daily average temperatures in the Seneca Reach – 2002

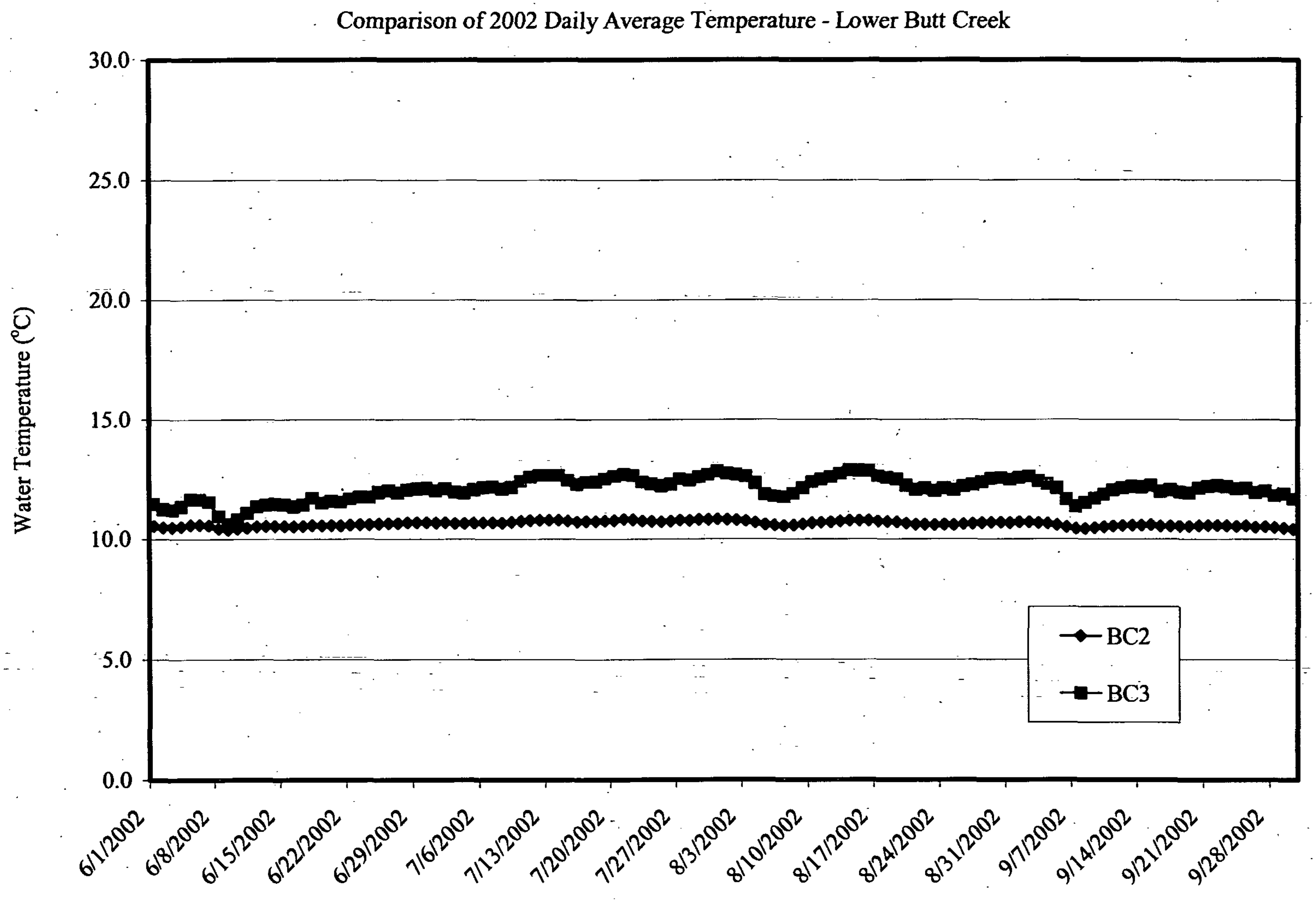


Figure 3-15. Comparison of daily average temperatures in lower Butt Creek – 2002

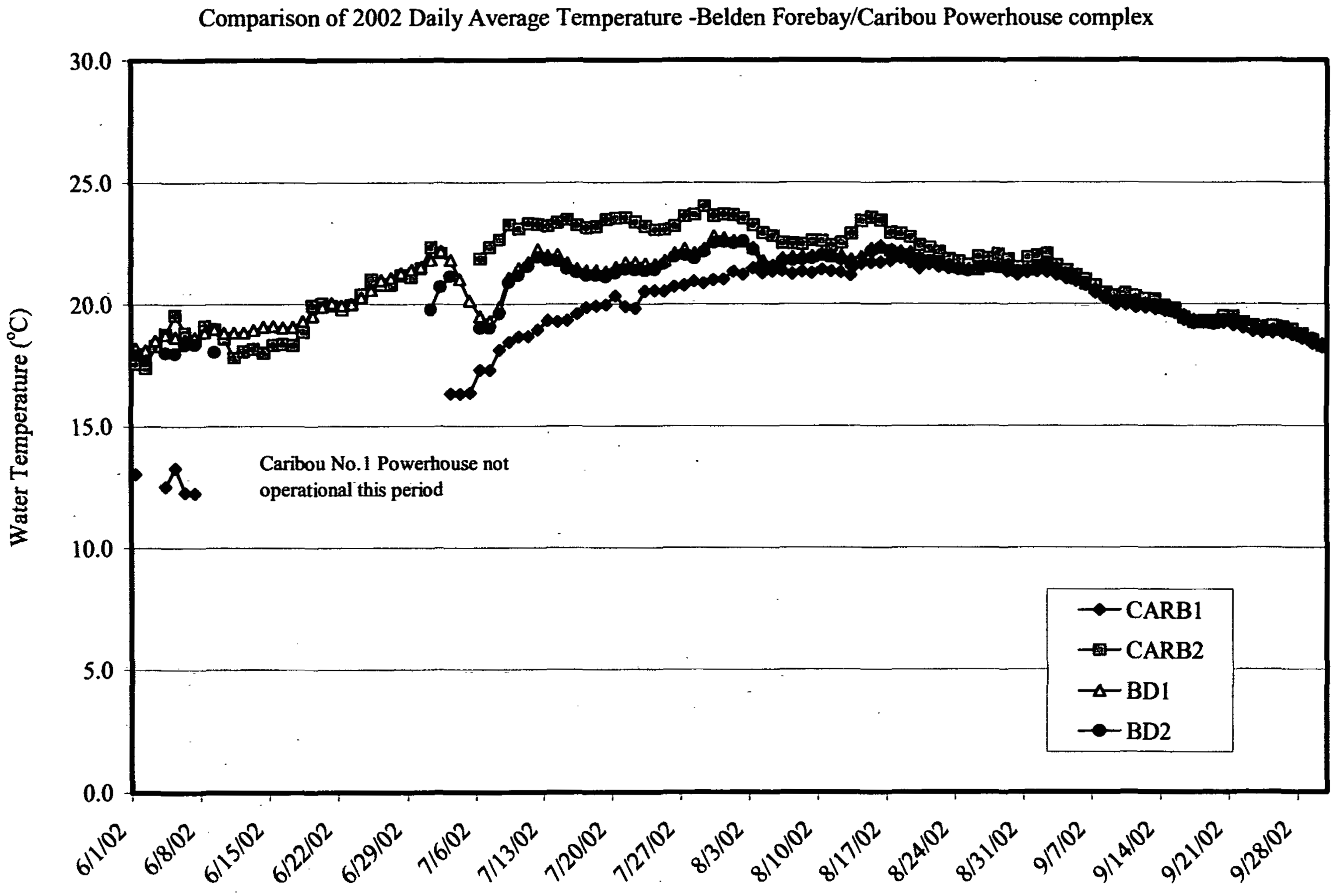


Figure 3-16. Comparison of daily average temperatures from the Caribou Powerhouse/Belden Forebay complex – 2002

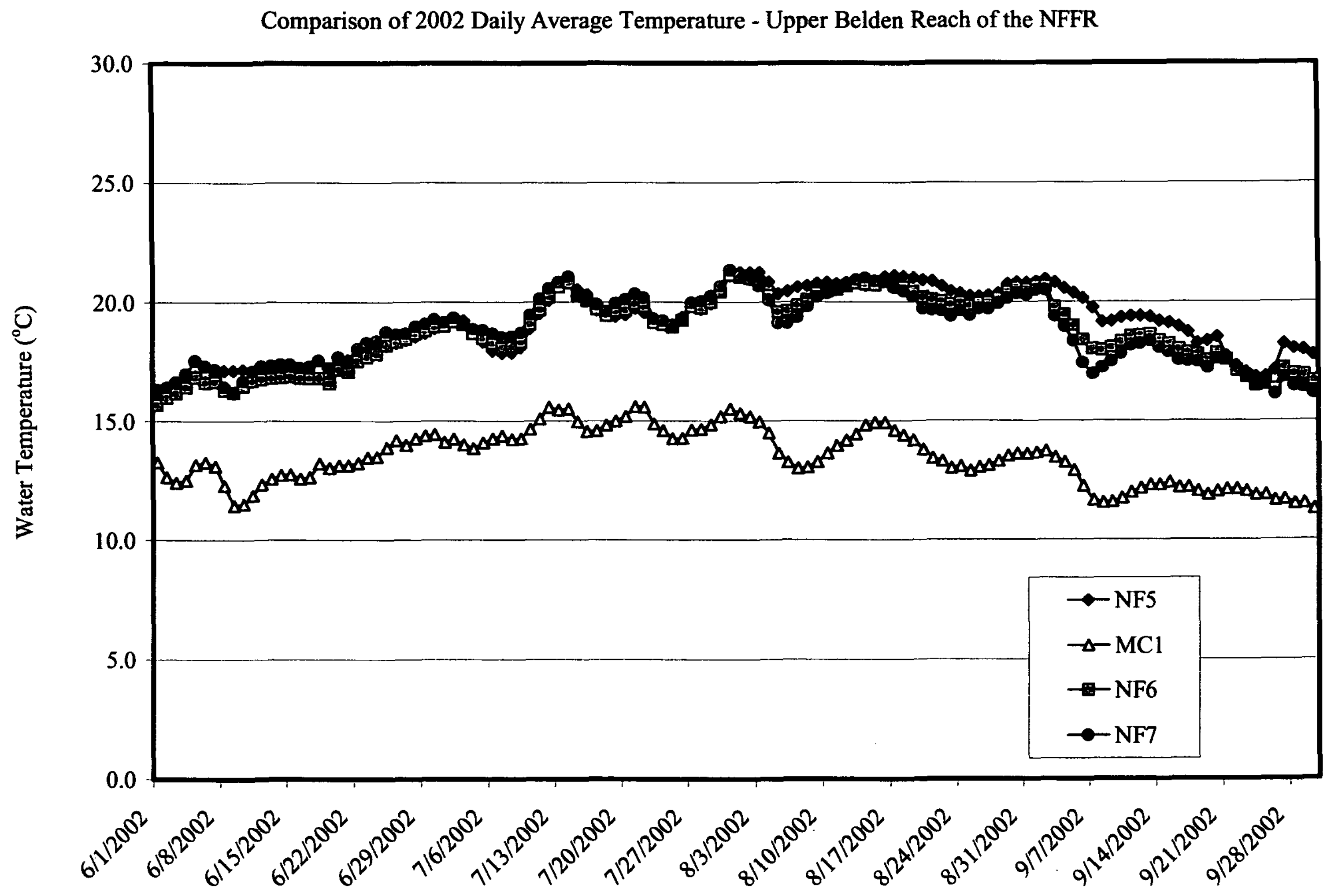


Figure 3-17. Comparison of daily average temperatures in the upper Belden Reach – 2002

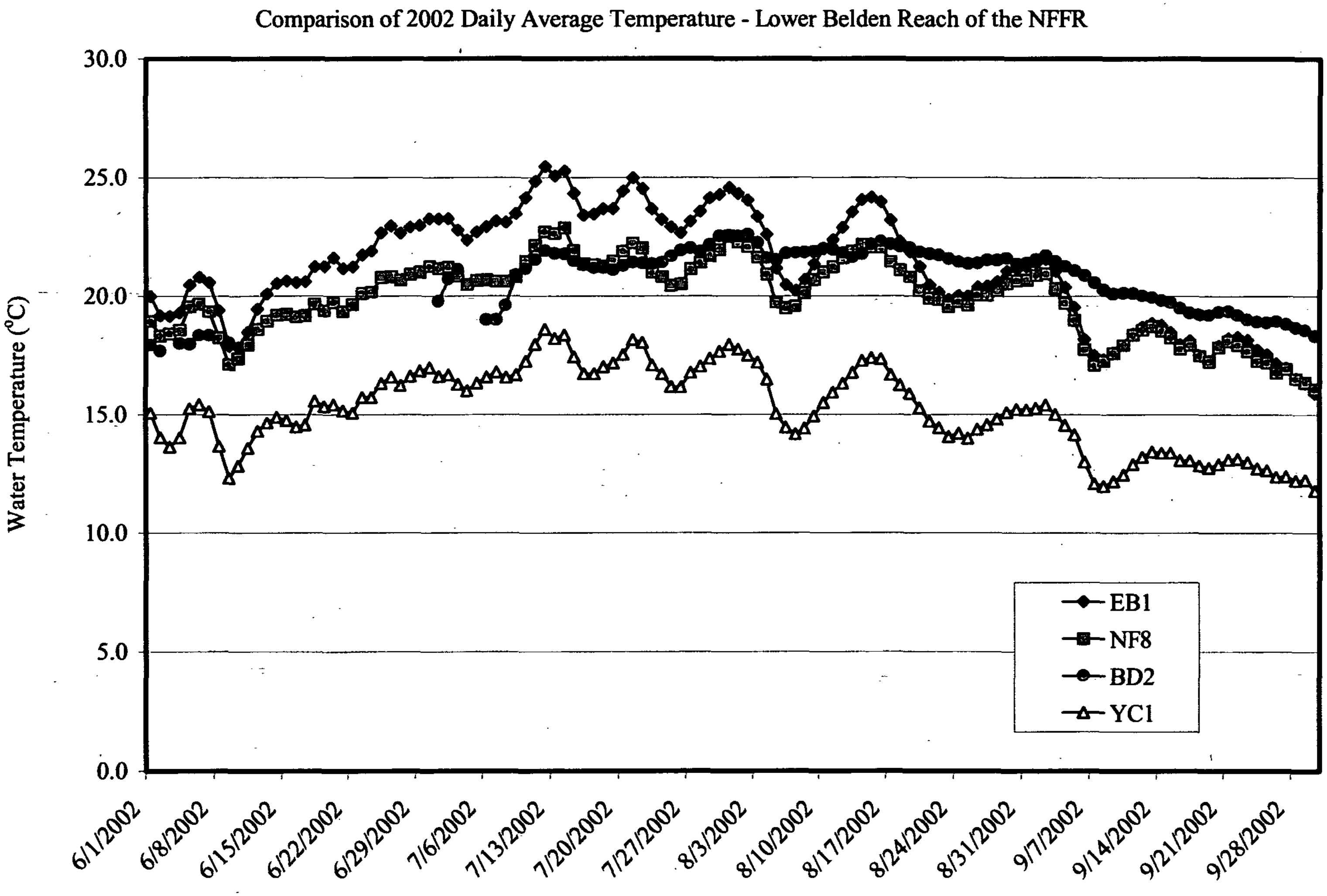


Figure 3-18. Comparison of daily average temperatures in the lower Belden Reach – 2002

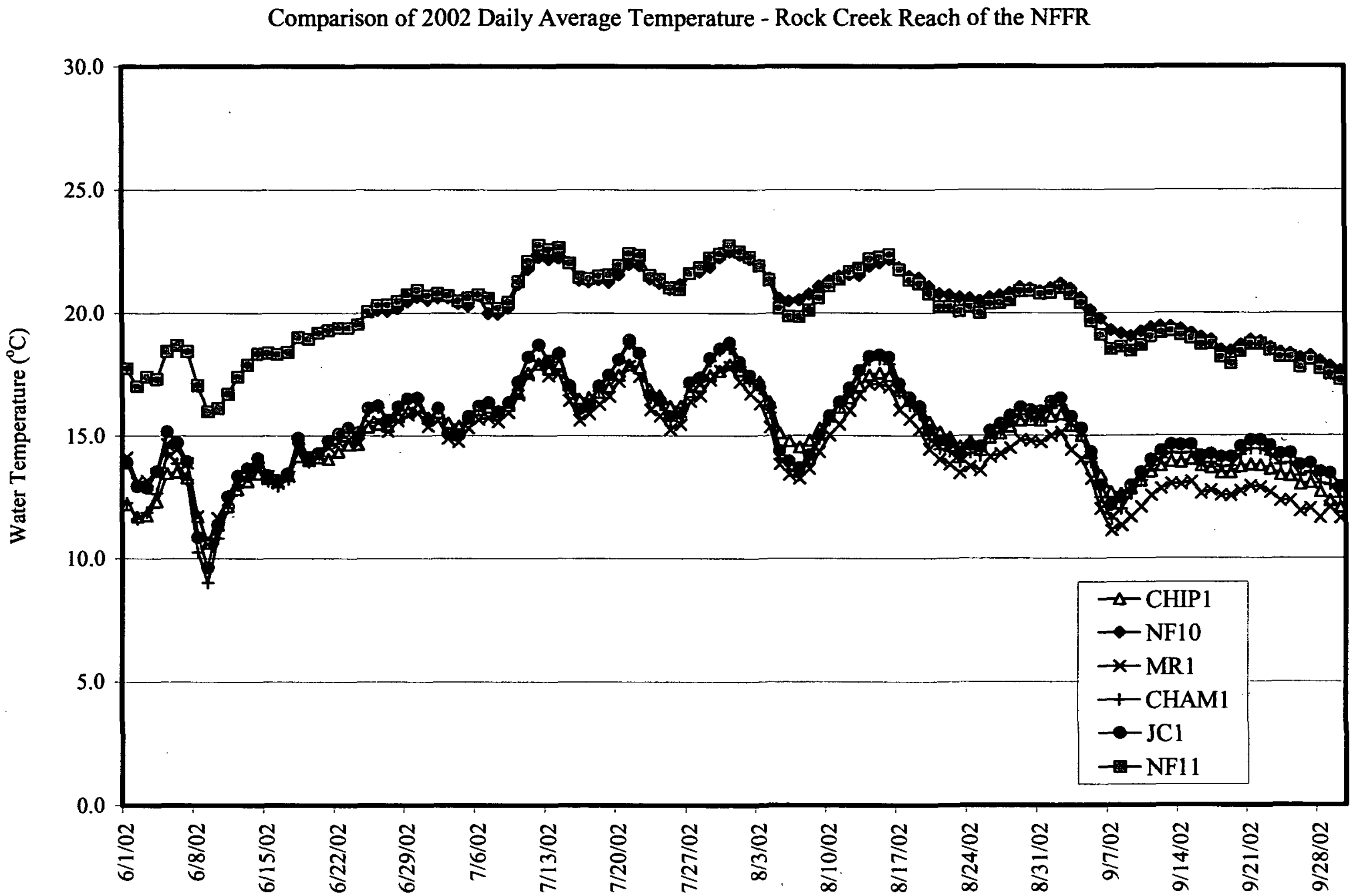


Figure 3-19. Comparison of daily average temperatures from stations in the upper Rock Creek Reach – 2002

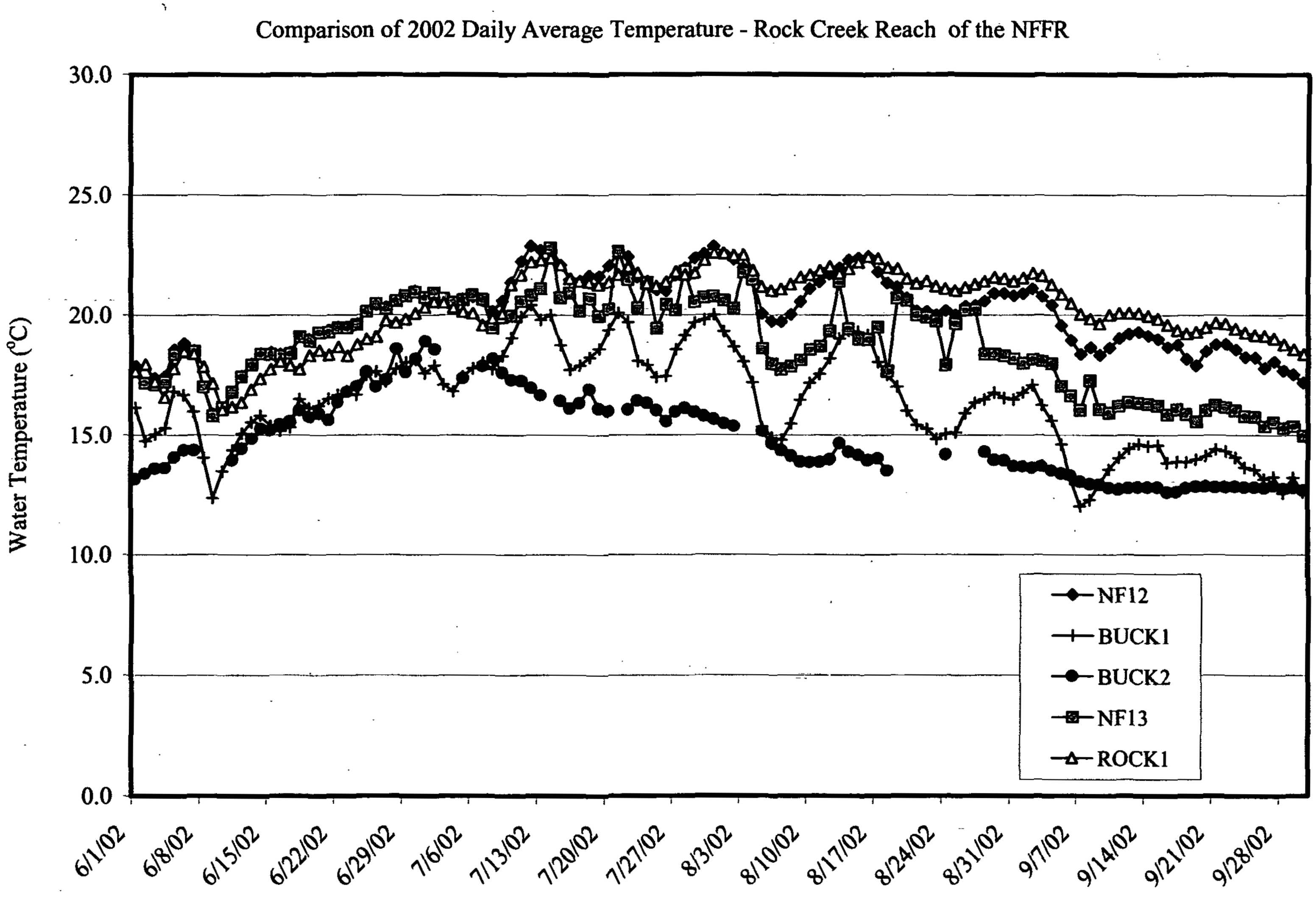


Figure 3-20. Comparison of daily average temperatures from stations in the lower Rock Creek Reach – 2002

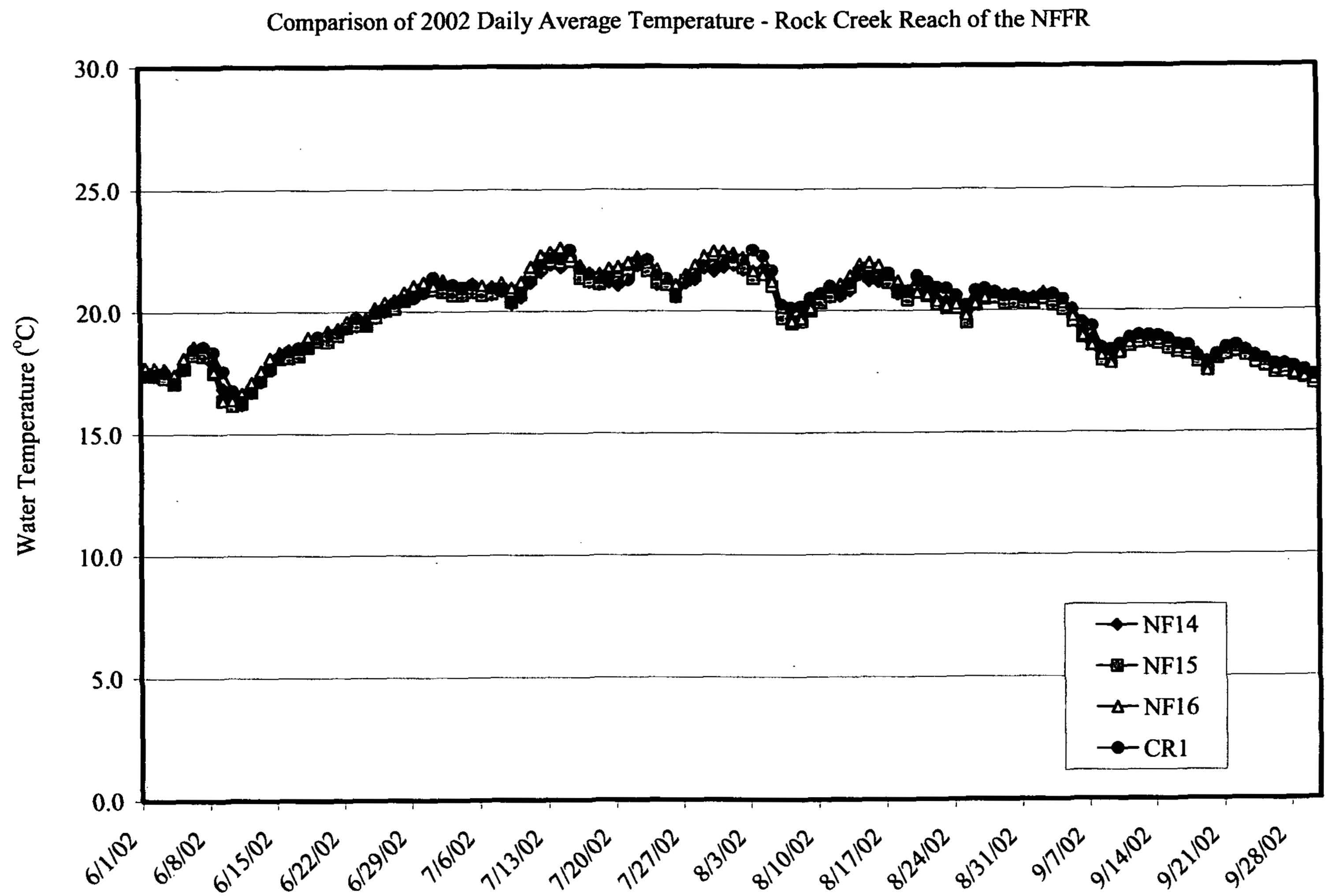


Figure 3-21. Comparison of daily average temperatures from river stations in the Cresta Reach – 2002

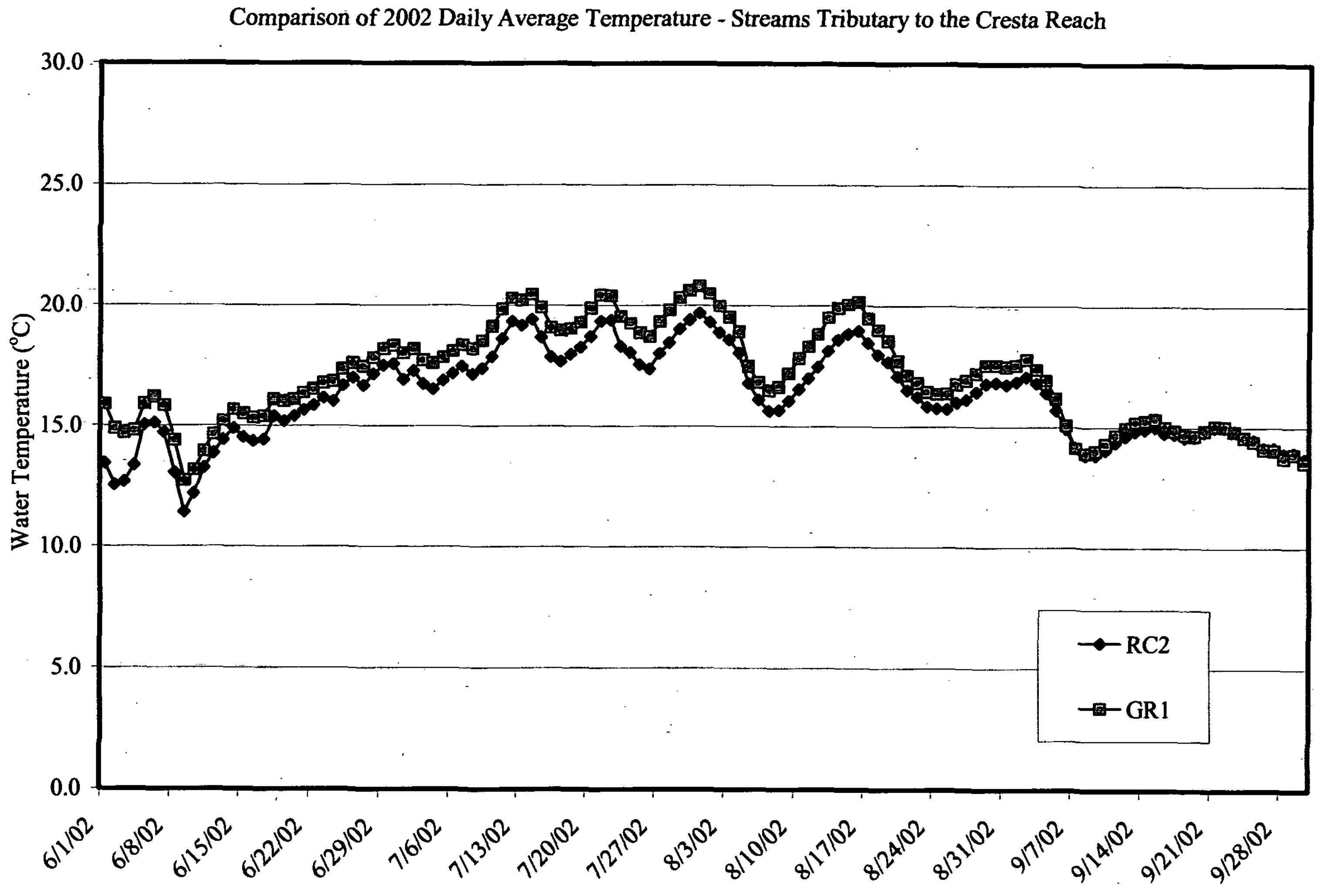


Figure 3-22. Comparison of daily average temperatures in streams tributary to the Cresta Reach – 2002

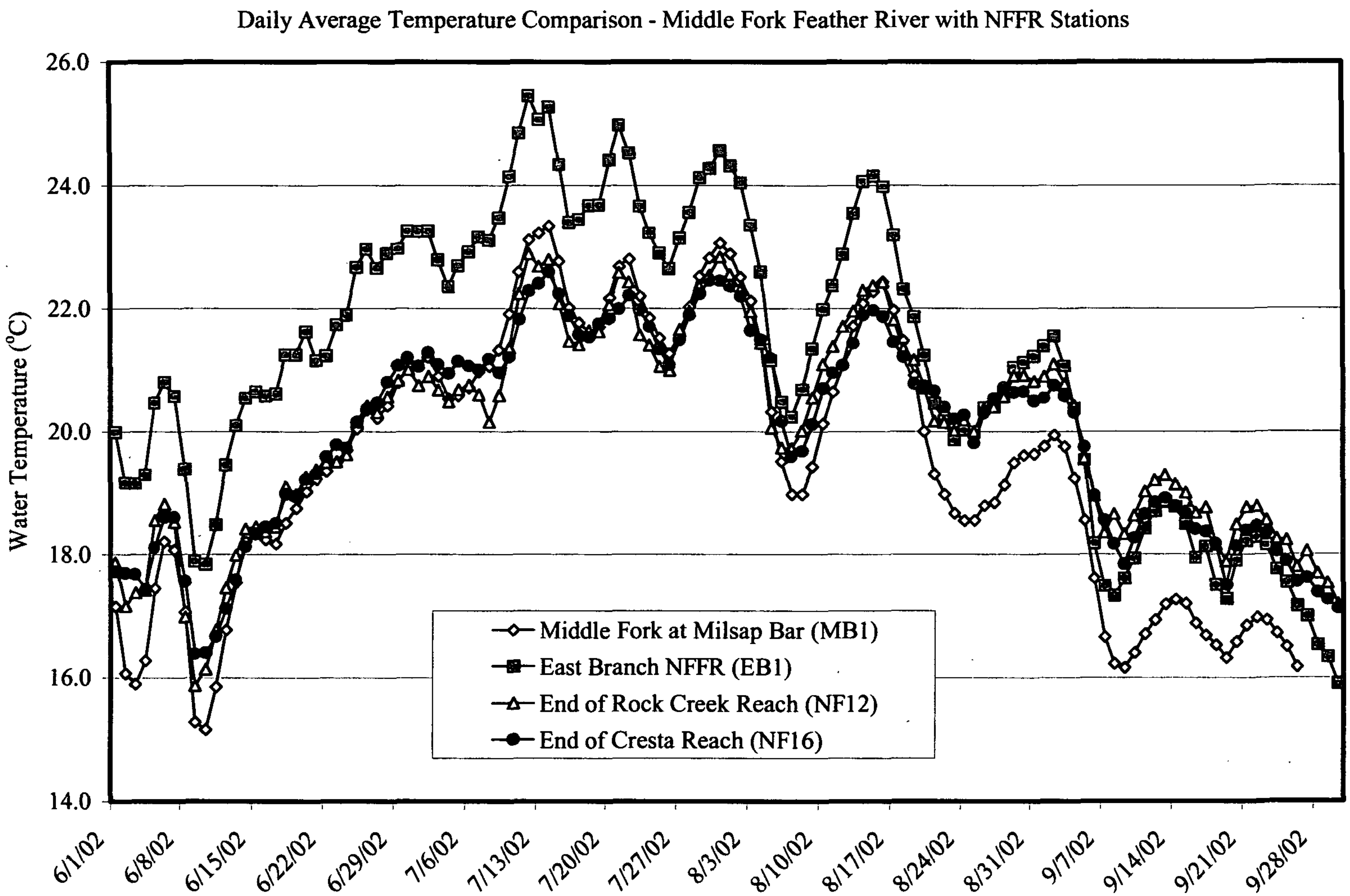


Figure 3-23. Comparison of daily average temperatures from MFFR at Milsap Bar with selected NFFR stations - 2002

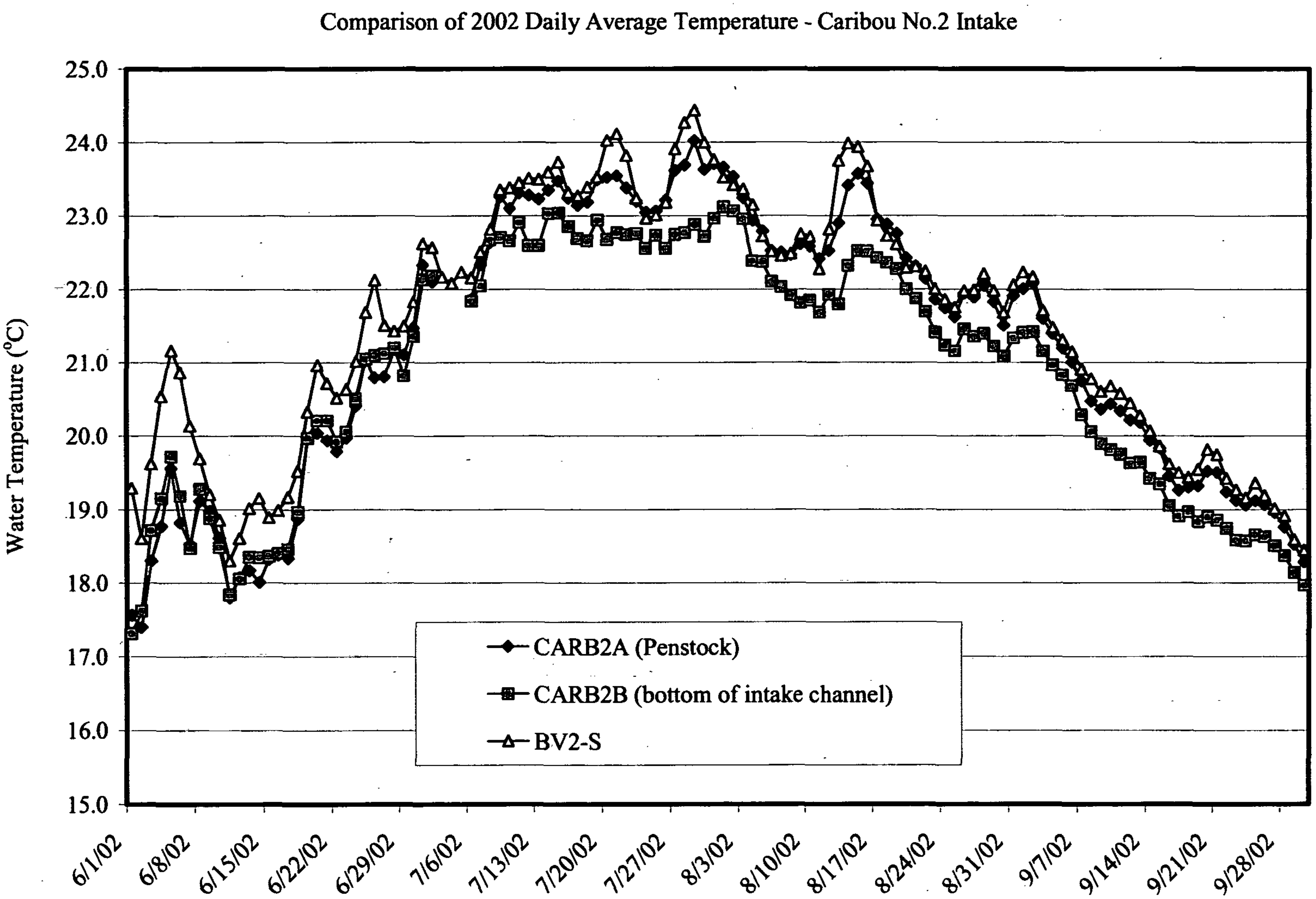
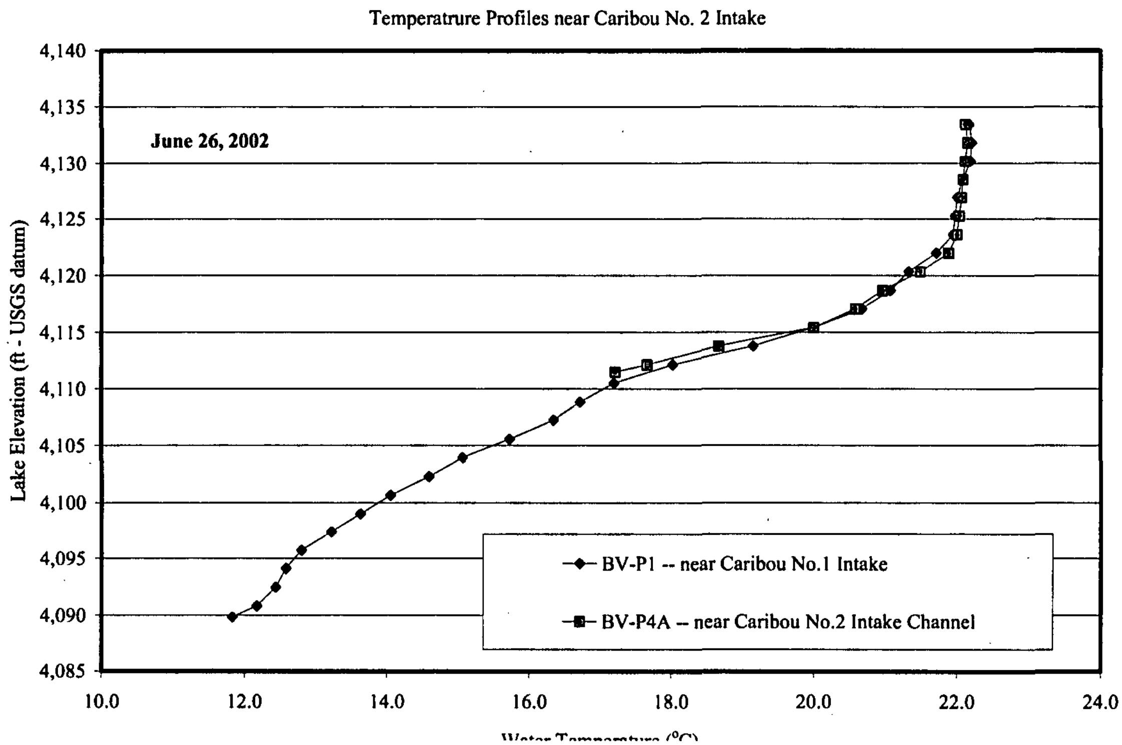
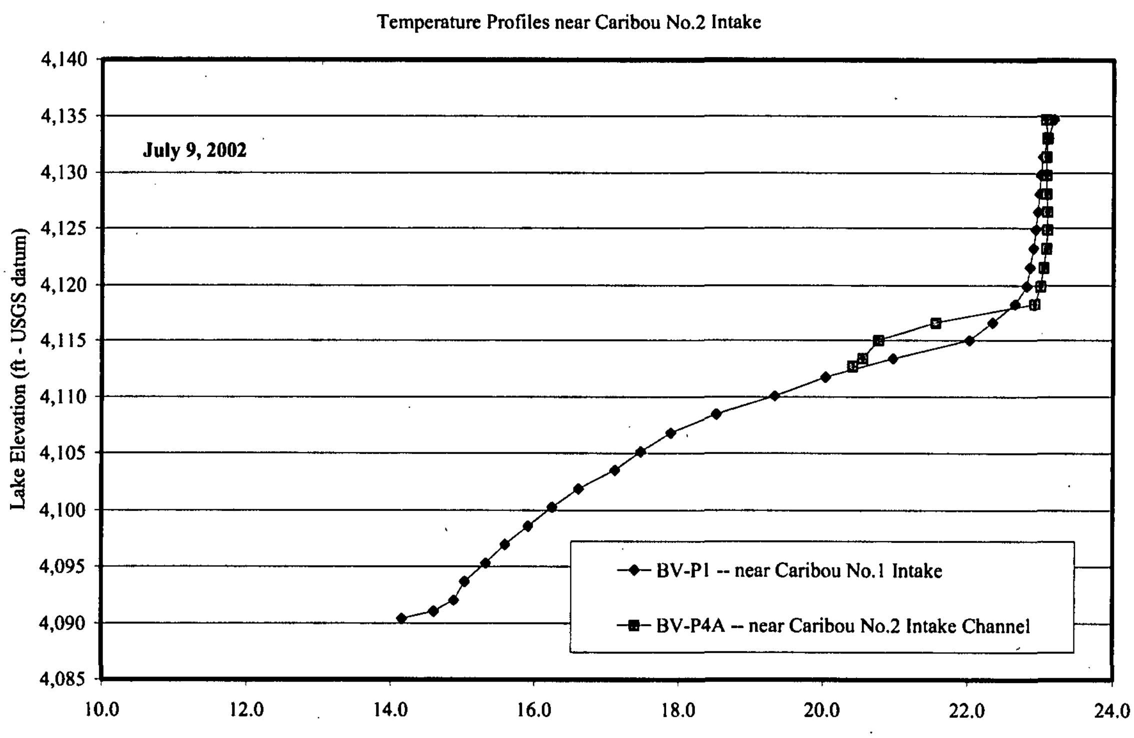


Figure 3-24. Comparison of daily average temperatures from three stations associated with the Caribou No.2 intake – 2002

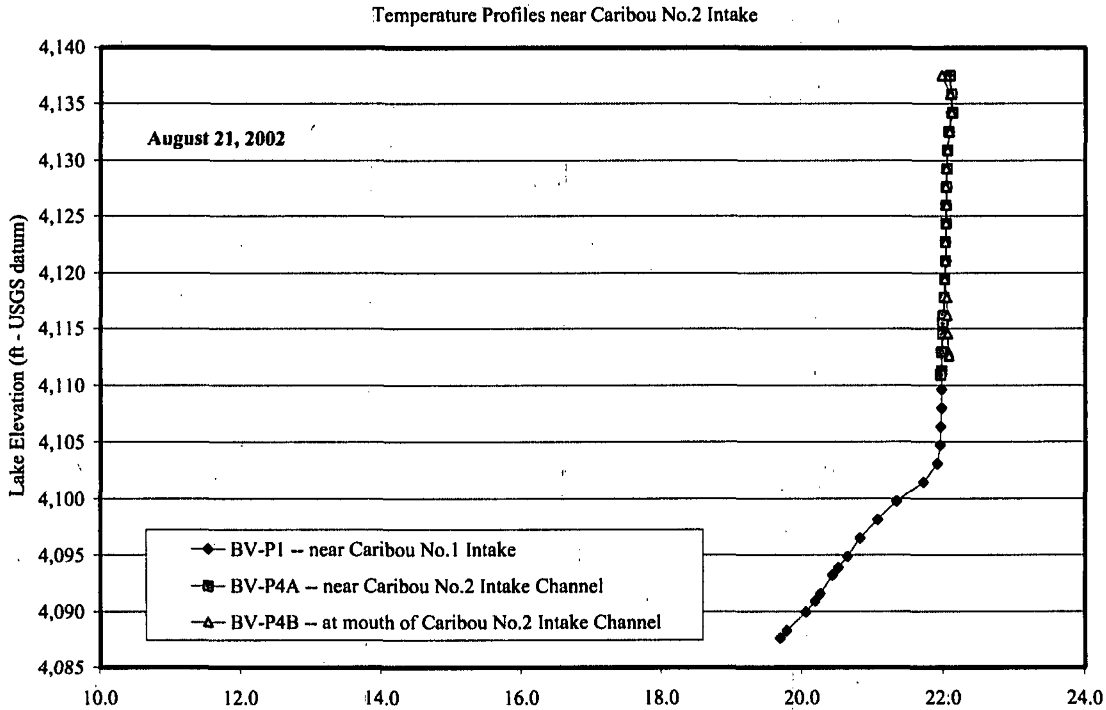


A. June 26, 2002 – Butt Valley Reservoir

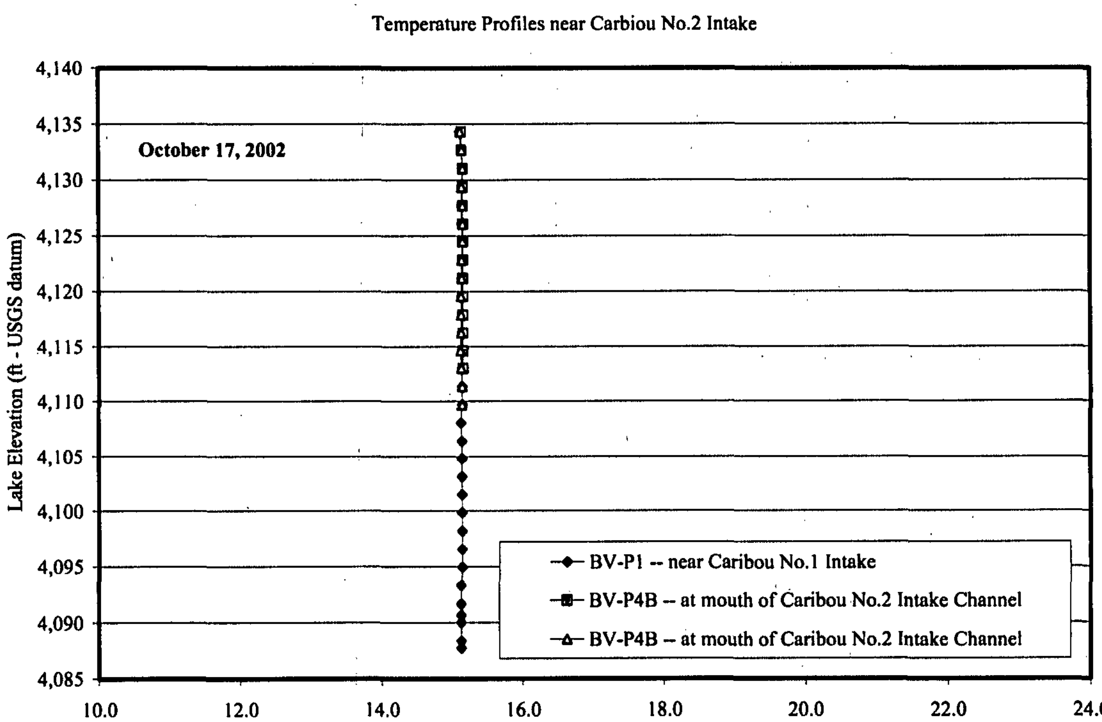


B. July 9, 2002 – Butt Valley Reservoir

Figure 3-25. Profile data from three stations near Caribou No.2 intake – 2002



C. August 21, 2002 – Butt Valley Reservoir Profiles



D. October 17, 2002 – Butt Valley Reservoir Profiles

Figure 3-25 (continued). Profile data from three stations near Caribou No. 2 Intake – 2002

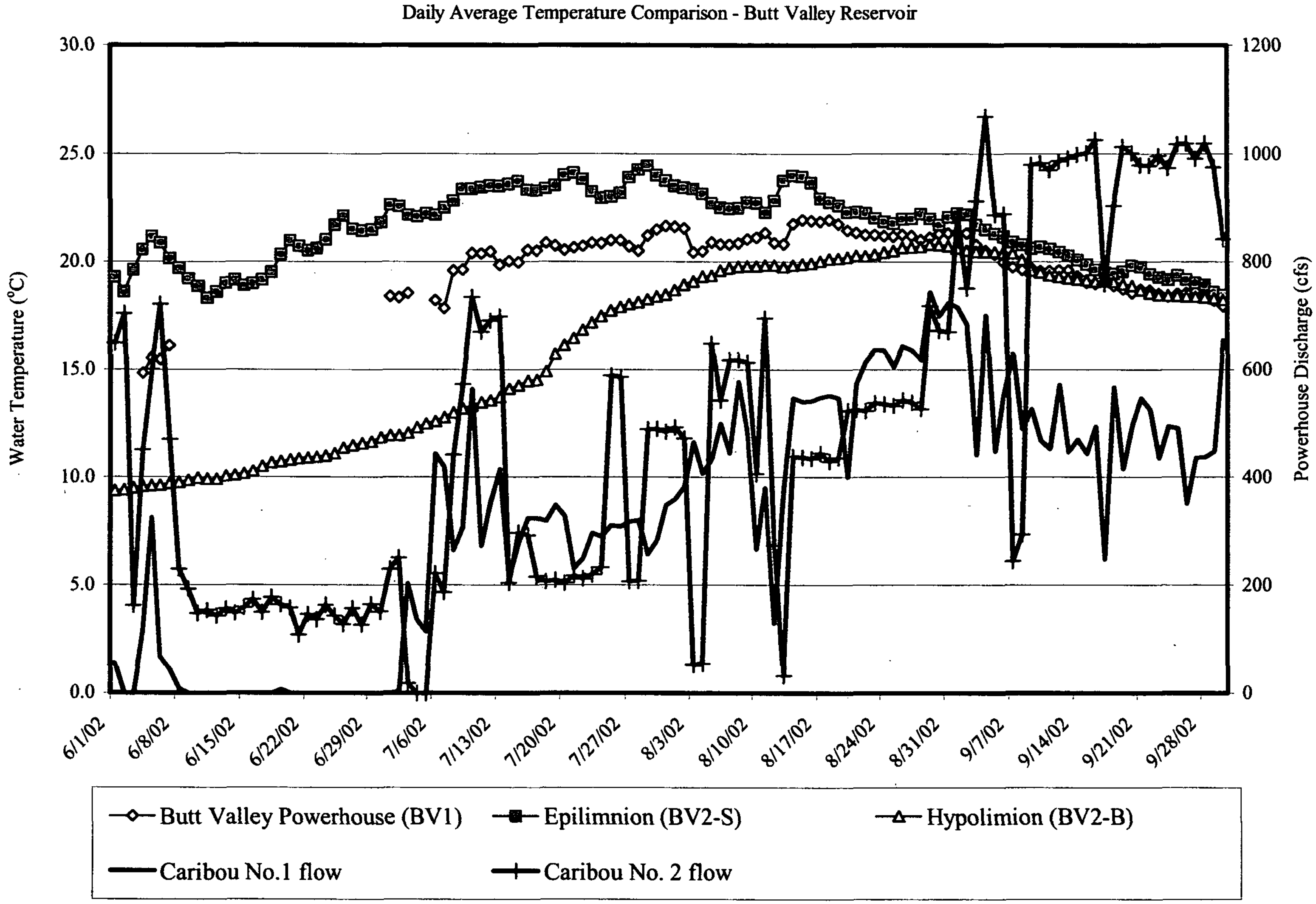


Figure 3-26. Comparison of daily average temperatures from three stations in Butt Valley Reservoir – 2002.

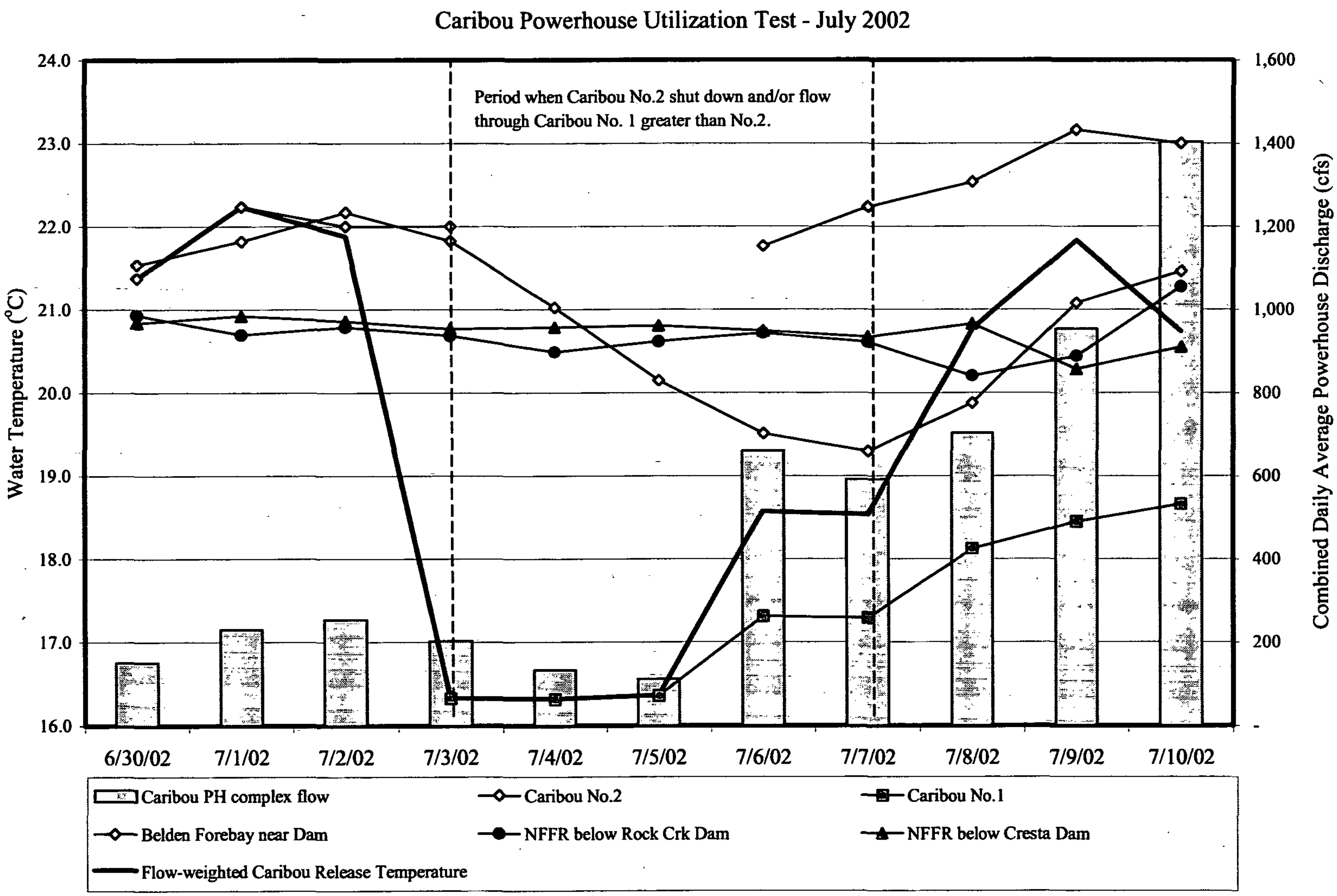
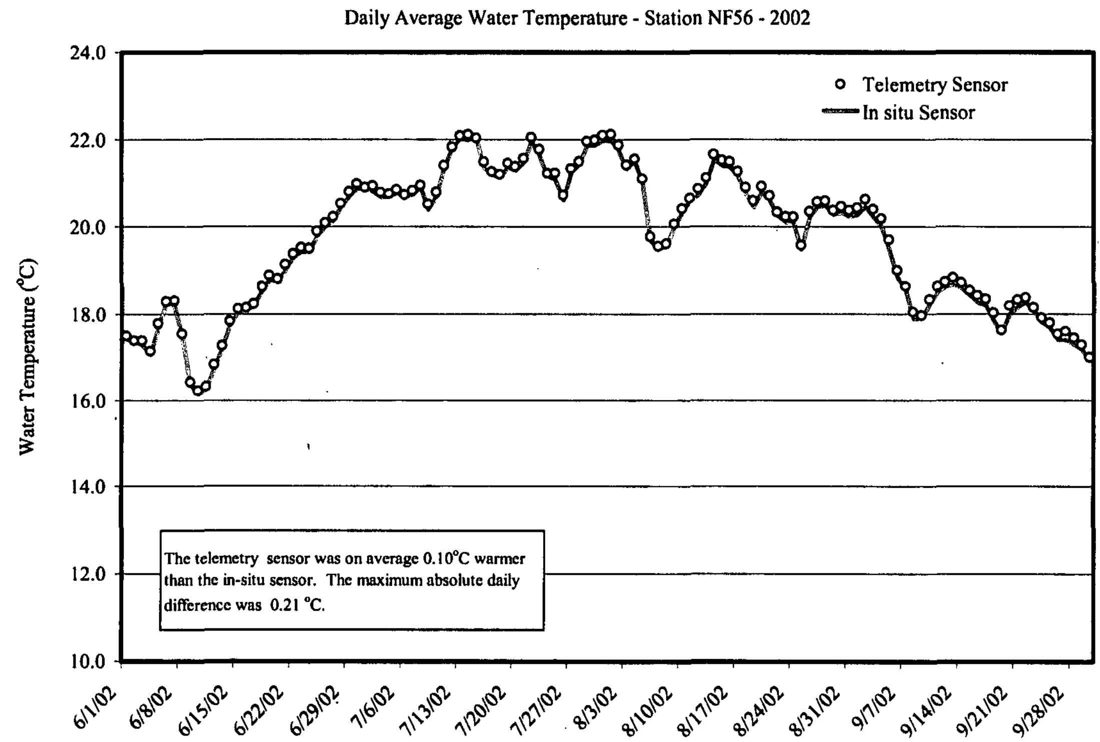
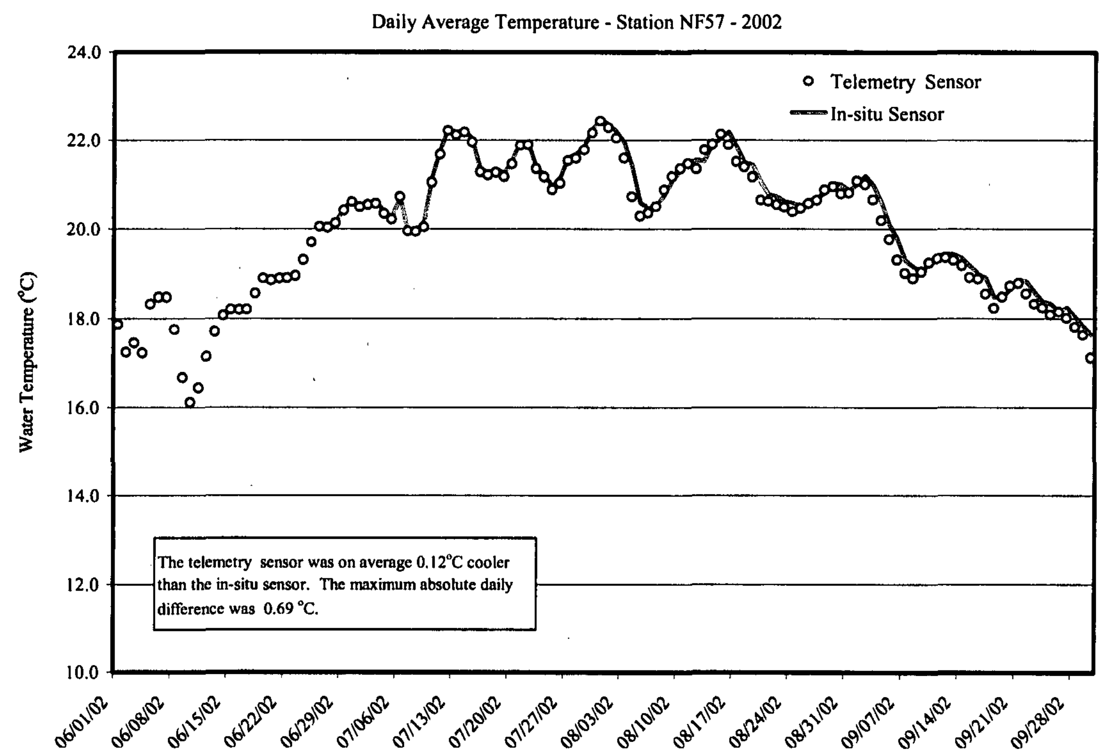


Figure 3-27. Comparison of daily average temperatures from select stations during Caribou complex flow test – 2002.



A. Station NF-56.



B. Station NF-57.

Figure 3-28. Comparison of daily average temperatures from telemetry sensors with insitu recorders – 2002.

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APPENDIX A

SUMMARY OF DAILY MAXIMUM, MINIMUM, AND MEAN WATER TEMPERATRURE

Appendix A

Summary of Hourly Average Water Temperatures Data - UNFFR 2002

Station	Year	Month	Hourly Temperatures[1] max	min	mean	Data Days
NFFR at Chester (NF1)	2002	June	19.0	6.4	12.7	30
	2002	July	20.1	11.3	15.7	31
	2002	Aug	19.1	9.8	14.2	31
	2002	Sept	16.5	7.5	11.5	30
Hamilton Branch at Road bridge (HB1)	2002	June	15.3	8.1	11.8	30
	2002	July	15.4	9.0	12.0	31
	2002	Aug	17.1	8.8	11.8	31
	2002	Sept	13.8	8.1	10.4	30
Hamilton Branch Powerhouse (HB2)	2002	June	17.8	7.9	12.6	30
	2002	July	18.3	9.7	13.3	21
	2002	Aug	21.6	14.3	17.5	30
	2002	Sept	19.6	8.2	14.4	30
Lake Almanor at Canyon Dam near surface (LA1-S)	2002	June	23.5	14.6	19.7	30
	2002	July	25.9	21.1	23.6	31
	2002	Aug	26.0	21.4	23.1	31
	2002	Sept	23.2	18.0	20.0	30
Lake Almanor at Canyon Dam near bottom (LA1-B)	2002	June	9.5	8.1	8.9	30
	2002	July	10.7	9.2	9.9	31
	2002	Aug	11.4	10.2	10.8	31
	2002	Sept	11.6	10.9	11.3	30
NFFR below Canyon Dam (NF2)	2002	June	13.0	9.8	11.3	30
	2002	July	13.9	11.3	12.5	31
	2002	Aug	14.0	12.5	13.3	31
	2002	Sept	14.8	12.6	13.7	30
NFFR at Seneca Bridge (NF3)	2002	June	16.6	9.6	13.5	30
	2002	July	17.4	11.9	15.0	31
	2002	Aug	17.0	11.5	14.5	31
	2002	Sept	15.7	10.6	13.4	30
NFFR above Caribou PH (NF4)	2002	June	17.6	10.4	14.3	30
	2002	July	18.4	13.1	15.9	31
	2002	Aug	17.9	12.1	15.0	31
	2002	Sept	16.3	10.8	13.4	30
Butt Valley Powerhouse [Corrected] (BV1)	2002	June	16.9	7.9	15.5	4
	2002	July	22.4	14.3	20.2	29
	2002	Aug	22.6	18.4	21.2	31
	2002	Sept	21.6	18.1	19.3	30

Appendix A (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Data Days
Butt Valley Res.	2002	June	22.7	17.3	20.1	30
at Caribou Intake	2002	July	25.5	21.6	23.3	31
Near surface	2002	Aug	24.8	21.4	22.7	31
(BV2-S)	2002	Sept	23.0	18.3	20.1	30
Butt Valley Res.	2002	June	12.1	9.2	10.4	30
at Caribou Intake	2002	July	18.7	11.7	15.0	31
Near bottom	2002	Aug	21.0	18.4	20.0	31
(BV2-B)	2002	Sept	20.8	18.2	19.3	30
Butt Creek above	2002	June	18.3	8.5	13.9	30
Butt Valley	2002	July	18.9	10.3	14.7	31
Reservoir	2002	Aug	17.7	8.9	13.1	31
(BC1)	2002	Sept	15.3	7.6	11.1	30
Butt Creek below	2002	June	11.1	10.2	10.6	30
Butt Valley	2002	July	11.2	10.5	10.7	31
Reservoir	2002	Aug	11.2	10.4	10.7	31
(BC2)	2002	Sept	11.1	10.2	10.5	30
Butt Creek at	2002	June	13.3	9.6	11.5	30
Mouth	2002	July	13.9	11.1	12.4	31
(BC3)	2002	Aug	14.0	10.8	12.4	31
	2002	Sept	13.6	10.5	12.0	30
Caribou No. 1	2002	June	14.9	10.6	12.7	5
Powerhouse	2002	July	21.3	11.8	19.3	29
[corrected]	2002	Aug	22.2	18.9	21.4	31
(CARB1)	2002	Sept	21.6	18.0	19.7	30
Caribou No. 2	2002	June	22.4	14.7	19.3	30
Powerhouse	2002	July	24.7	19.8	23.2	28
[corrected]	2002	Aug	24.0	21.3	22.5	31
(CARB2A)	2002	Sept	22.6	18.1	19.9	30
Belden Reservoir	2002	June	21.8	17.8	19.5	30
At Intake	2002	July	23.0	19.0	21.5	31
(BD1)	2002	Aug	22.9	21.2	21.9	31
	2002	Sept	21.9	18.5	19.8	30
NFFR below	2002	June	19.3	15.6	17.4	30
Belden Dam	2002	July	21.4	17.7	19.4	31
(NF5)	2002	Aug	21.5	19.9	20.7	31
	2002	Sept	21.3	15.8	18.8	30

Appendix A (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Data Days
Mosquito Creek At mouth (MC1)	2002	June	15.6	10.5	13.0	30
	2002	July	16.7	12.9	14.7	31
	2002	Aug	16.4	12.0	13.9	31
	2002	Sept	14.7	10.8	12.2	30
NFFR near Queen Lily Campground (NF6)	2002	June	21.3	14.7	17.1	30
	2002	July	22.9	16.8	19.5	31
	2002	Aug	[redacted]	18.6	20.3	31
	2002	Sept	22.6	14.4	18.0	30
NFFR near Gansner Bar (NF7)	2002	June	22.5	14.3	17.5	30
	2002	July	[redacted]	16.3	19.7	31
	2002	Aug	23.8	17.3	20.1	31
	2002	Sept	23.0	13.9	17.6	30
East Branch NFFR at mouth (EB1)	2002	June	25.1	15.8	20.8	30
	2002	July	26.5	20.5	23.8	31
	2002	Aug	25.4	18.5	21.8	31
	2002	Sept	22.7	15.5	18.2	30
NFFR at Belden Town Bridge (NF8)	2002	June	23.9	15.1	19.4	30
	2002	July	[redacted]	18.2	21.4	31
	2002	Aug	24.7	17.2	20.7	31
	2002	Sept	23.2	14.8	18.0	30
Belden Powerhouse (BD2)	2002	June	18.8	17.3	18.0	7
	2002	July	22.8	18.7	21.2	29
	2002	Aug	22.8	21.2	21.8	31
	2002	Sept	21.9	18.2	19.8	30
Yellow Creek Near mouth (YC1)	2002	June	18.9	10.8	15.0	30
	2002	July	20.1	14.6	17.1	31
	2002	Aug	19.2	12.7	15.6	31
	2002	Sept	16.5	11.0	13.1	30
Chips Creek Near mouth (CHIP)	2002	June	19.4	8.9	13.6	30
	2002	July	21.0	13.3	16.8	31
	2002	Aug	20.6	12.4	15.9	31
	2002	Sept	18.6	10.8	13.7	30
NFFR below Rock Creek Dam (NF9)	---	---	---	---	---	---
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NFFR at NF-57 Insitu Recorder (NF10)	2002	June	22.4	18.8	20.3	5
	2002	July	[redacted]	19.2	21.3	31
	2002	Aug	23.3	19.9	21.2	31
	2002	Sept	21.9	17.3	19.1	30

Appendix A (Continued)

Station	Year	Month	Daily Temperatures [1] max	Min	mean	Data Days
Milk Ranch Creek	2002	June	18.8	8.6	14.0	30
Near mouth	2002	July	20.4	12.5	16.4	31
(MR1)	2002	Aug	19.6	11.2	15.0	31
	2002	Sept	17.0	9.6	12.7	30
Chambers Creek	2002	June	19.6	6.9	13.7	30
Near mouth	2002	July	21.4	12.8	16.9	31
(CHAM)	2002	Aug	21.0	11.2	15.7	31
	2002	Sept	18.9	9.7	13.8	30
NFFR near Tobin	2002	June	22.8	14.0	18.6	30
blw Granite Crk	2002	July	[redacted]	18.2	21.5	31
(NF11)	2002	Aug	23.9	17.8	21.0	31
	2002	Sept	22.3	16.2	18.8	30
Jackass Creek	2002	June	19.8	7.3	14.1	30
Near mouth	2002	July	21.2	12.8	17.0	31
(JKC1)	2002	Aug	20.3	11.8	15.9	31
	2002	Sept	18.4	10.5	14.2	30
NFFR abv Bucks	2002	June	22.4	13.7	18.6	30
Creek	2002	July	[redacted]	18.4	21.6	31
(NF12)	2002	Aug	23.6	17.7	21.0	31
	2002	Sept	22.0	16.1	18.8	30
Bucks Creek	2002	June	21.7	9.7	16.0	30
Near Mouth	2002	July	23.5	13.9	18.6	31
(BUCK1)	2002	Aug	21.9	12.1	16.9	31
	2002	Sept	19.2	10.1	14.0	30
Bucks Creek	2002	June	19.9	12.2	15.6	27
Powerhouse	2002	July	20.0	15.2	16.7	26
(BUCK2)	2002	Aug	18.3	13.2	14.3	21
	2002	Sept	15.2	12.4	13.0	30
NFFR abv Rock	2002	June	22.7	14.0	18.6	30
Creek Powerhouse	2002	July	[redacted]	17.5	20.7	31
(NF13)	2002	Aug	23.0	16.1	19.3	31
	2002	Sept	20.9	14.2	16.3	30
Rock Creek	2002	June	20.3	15.5	18.1	30
Powerhouse	2002	July	22.8	19.3	21.3	31
(RC1)	2002	Aug	22.8	20.2	21.7	31
	2002	Sept	22.0	18.1	19.8	31

Appendix A (Continued)

			Daily Temperatures [1]			Data
Station	Year	Month	max	Min	mean	Days
Rock Creek	2002	June	18.8	10.3	14.8	30
Near mouth	2002	July	20.7	15.5	18.1	31
(RC2)	2002	Aug	20.3	14.6	17.1	31
	2002	Sept	18.0	13.0	14.8	30
NFFR abv Grizzly	2002	June	21.8	15.7	18.4	30
Creek '	2002	July	22.8	19.8	21.2	31
(NF14)	2002	Aug	22.2	18.9	20.7	31
	2002	Sept	21.3	17.0	18.5	30
Grizzly Creek	2002	June	20.4	11.0	15.9	30
Near mouth	2002	July	22.7	15.9	19.3	31
(GR1)	2002	Aug	22.3	14.9	18.0	31
	2002	Sept	19.2	12.7	15.0	30
NFFR at NF-56	2002	June	22.6	15.0	18.4	30
blw Grizzly Crk	2002	July	23.5	19.1	21.3	31
(NF15)	2002	Aug	23.2	18.2	20.6	30
	2002	Sept	21.9	16.5	18.4	30
NFFR abv Cresta	2002	June	22.9	14.8	18.7	30
Powerhouse	2002	July	23.9	19.1	21.7	31
(NF16)	2002	Aug	23.6	18.1	20.9	31
	2002	Sept	21.9	16.3	18.5	30
Cresta	2002	June	21.1	15.9	18.5	30
Powerhouse	2002	July	22.8	20.0	21.4	30
(CR1)	2002	Aug	22.8	19.3	21.0	31
	2002	Sept	21.2	17.1	18.7	30
Middle Fork	2002	June	22.9	14.0	18.2	30
Feather River	2002	July	25.3	19.1	21.9	31
At Milsap Bar	2002	Aug	24.4	17.3	20.3	31
(MB1)	2002	Sept	21.4	15.1	17.3	26

1. Values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average temperatures. For example, the maximum June temperature represents the maximum hourly average temperature measured in June.

APPENDIX B

REVISED WATER TEMPERATURE MODELING FOR THE ROCK CREEK-CRESTA HYDROELECTRIC PROJECT - FERC PROJECT NO. 1962