LEVEL 1 AND 2 REPORT

DEVELOPMENT AND SCREENING OF POTENTIALLY EFFECTIVE AND FEASIBLE ALTERNATIVES TO ACHIEVE THE BASIN PLAN OBJECTIVE FOR WATER TEMPERATURE AND PROTECT COLD FRESHWATER HABITAT BENEFICIAL USE ALONG THE NORTH FORK FEATHER RIVER

Photo taken looking upstream in Belden Reservoir during a special test on July 22, 2006 showing visual evidence of cold water plunging. The floating debris line marked the convergence of dense cold water, released through the low level outlet at Canyon Dam, with lighter ambient warm water layer on the surface. Measurements revealed that the lighter warm water layer had reversed direction and moved upstream while the cold water plunged and moved along the reservoir bottom. The cold water plume ultimately reached Belden Dam and was released back to the North Fork Feather River through the low level outlet.

W A T E R   R E S O U R C E   E N G I N E E R S

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TO ACHIEVE THE BASIN PLAN OBJECTIVE FOR WATER TEMPERATURE AND
PROTECT COLD FRESHWATER HABITAT BENEFICIAL USE ALONG THE
NORTH FORK FEATHER RIVER

Prepared For

State Water Resources Control Board

October 2007

Prepared By

Stetson Engineers, Inc.

STETSON
ENGINEERS INC.

TABLE OF CONTENTS **PAGE**

APPENDICES

LIST OF TABLES — PAGE

LIST OF FIGURES PAGE

LIST OF FIGURES (CONTINUED) PAGE

LIST OF ABBREVIATIONS/ACRONYMS

af	Acre-foot or acre-feet
afa	Acre-feet per annum
Basin Plan	Water Quality Control Plan for the Central Valley Region
BSP	Black steel pipe
CDFG	California Department of Fish and Game
Central Valley Regional Board	Regional Water Quality Control Board, Central Valley Region
CEQA	California Environmental Quality Act
cfs	Cubic feet per second
CWA	Federal Clean Water Act
cy	Cubic yard
DSOD	Division of Safety of Dams
DWR	California Department of Water Resources
East Branch	East Branch North Fork Feather River
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FERC No. 2105	Upper North Fork Feather River Project
FERC No. 1962	Rock Creek – Cresta Project
FERC No. 619	Bucks Creek Project
FERC No. 2107	Poe Project
fps	Feet per second
ft	Feet or Foot
HDPE	High-density polyethylene
IIHR	Iowa Institute of Hydraulic Research
KWh	Kilowatt-hour
LF	Linear feet
Licensing Group	Upper North Fork Feather River Project Collaborative Licensing Group
MW	Megawatts
NEPA	National Environmental Policy Act
NFFR	North Fork Feather River
NGVD 1929	National Geodetic Vertical Datum of 1929
No.	Number
NOP	Notice of Preparation
NSR	North State Resources, Inc.
O&M	Operation and Maintenance
Partial Settlement	Upper North Fork Feather River Project Relicensing Settlement Agreement, 2004

PG&E	Pacific Gas and Electric Company
PH	Powerhouse
PM&E	Protection, mitigation, and enhancement
RCB	Reinforced concrete box
RCP	Reinforced concrete pipe
sq ft	Square feet
State Water Board	State Water Resources Control Board
Stetson	Stetson Engineers, Inc.
SNTEMP	Stream Network Temperature Model
UNFFR	Upper North Fork Feather River
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
x-section	Cross-section
°C	Degrees Celsius
°F	Degrees Fahrenheit
#	Number

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EXECUTIVE SUMMARY

Pacific Gas and Electric Company (PG&E) has submitted an application to the Federal Energy Regulatory Commission for relicensing of the Upper North Fork Feather River Project (FERC Project #2105). Prior to issuance of a new federal license, PG&E must obtain Clean Water Act (CWA) section 401 water quality certification that the project will be in compliance with specified provisions of the CWA (33 U.S.C.§ 1341), including State water quality standards as contained in the applicable water quality control plan. Portions of the North Fork Feather River (NFFR) do not meet the water quality objective for temperature as set forth in the Water Quality Control Plan for the Central Valley Region (Basin Plan). The State Water Resources Control Board has determined that elevated water temperatures are impairing the cold freshwater habitat beneficial use of the NFFR, and has cited hydromodification and flow regulation as potential sources of the impairment (State Water Board Resolution No. 2006-0079). Water quality certification of the project is subject to the California Environmental Quality Act (CEQA), and an Environmental Impact Report (EIR) with CEQA alternatives that include water temperature reduction proposals will be prepared to meet this requirement.

Consistent with requirements of CEQA, alternatives to be evaluated in the EIR should be reasonable, feasible and implementable. This Level 1 and 2 Report documents initial progress on the development and screening of a wide range of potentially feasible alternatives for seasonal cooling of water temperature along the NFFR. Each of the "water temperature reduction alternatives" considered consists of a combination of measures, such as modifications to hydropower facilities or operations, which collectively reduce mean daily water temperatures during the summer to 20°C along the approximate 50 river miles of the NFFR, from Lake Almanor's Canyon Dam to the discharge from the Poe Powerhouse afterbay at Big Bend into Lake Oroville.

ES.1 THREE-PHASED APPROACH

CEQA guidelines require that the State Water Board base its findings concerning alternatives and project approval on "substantial evidence." With this in mind, a systematic, three-phased approach to the development and screening of water temperature reduction measures has been developed. The three-phased approach provides transparency and a logical elimination of those less effective or less reasonable measures, allowing the more realistic solutions to remain as potential comprehensive watershed alternatives. This Level 1 and 2 Report documents the first two phases of the three-phased approach used to develop a reasonable range of feasible water temperature reduction alternatives for achieving the water temperature objective and protection of the cold freshwater habitat beneficial use of the NFFR. A subsequent report will document the refined Level 3 analysis and final screening of water temperature alternatives suitable for analysis in the EIR prepared for the CEQA process. Figure ES-1 illustrates the three-phased approach as a flow diagram and presents the results of Level 1 and Level 2 screening.

To facilitate the development and analysis of water temperature reduction alternatives that could address the temperature objectives established by the Basin Plan, a numerical value for the water temperature objective was deemed necessary (water temperature objective target or "temperature target"). In setting the temperature target value, it was recognized that it must be feasibly attainable through physical or operational modifications of the UNFFR Project, since the alternatives being developed are intended for support of the State Water Board's 401 certification decision for relicensing of the FERC No. 2105 Project. Accordingly, for purposes of developing and screening water temperature reduction alternatives in this Level 1 and 2 Report, *a numerical value of 20°C maximum mean daily NFFR-wide was set as the water temperature objective target*.[1,2] This initial numerical value could be modified in the subsequent Level 3 effort if, at that time, a different and more appropriate temperature target is determined to be feasibly attainable through modification or re-operation of the UNFFR Project.

Level 1 casts a "wide net" that captures most all of the possible water temperature reduction alternatives and then subjects these possible alternatives to the following coarse screening criteria:

- Effectiveness and reliability – Is there a reasonable potential that the alternative can effectively and reliably achieve the preliminary temperature target or, is the effectiveness and reliability of the alternative overly speculative?

- Technological feasibility and constructability – Can the alternative be implemented with currently available technology and construction methods?

- Logistics – Can the alternative be implemented when considering current legal obligations, regulatory permitting requirements, public safety needs, right-of-way and access needs, and other real world logistical constraints?

- Reasonability[3] – Are there clearly more reasonable or superior alternatives available based on the other criteria? Is implementation of the alternative remote or highly speculative?

The set of alternative measures passing Level 1 screening represents a reasonable range of potentially effective and feasible water temperature reduction alternative measures that are carried forward to Level 2.

Level 2 screens-out (eliminates) those water temperature reduction alternatives passing Level 1 screening that, after closer examination, are ineffective, infeasible, or are clearly inferior to other alternatives. In Level 2 the alternatives are analyzed using the best resource information currently available. Water temperature reduction alternatives are modified or refined based on

[1] This water temperature objective target was set only for purposes of developing and screening alternatives, and should not be construed as the numeric temperature requirement necessary to achieve compliance with the Basin Plan. The State Water Board will determine the appropriate numeric temperature requirement in its 401 certification decision.

[2] The basis for this temperature target is explained in Chapter 3.

[3] An EIR need not consider an alternative whose effect cannot be reasonably ascertained and whose implementation is remote and speculative (CEQA Guidelines, § 15126, subd. (d)).

the analysis, and rough engineering designs and cost estimates are developed. The alternatives are subjected to the same screening criteria used in Level 1, plus the following additional criteria:

- Substantial Further Study - Is there sufficient information currently available or can it be readily developed in order to evaluate the potential effectiveness and feasibility of the alternative, or is substantial further investigation or study required?

- Environmental challenges – Are there obvious environmental consequences or problems associated with the alternative that would pose a major challenge to overcome?

- Economic feasibility – Can the alternative be implemented at a reasonable cost, including capital, O&M, and considering energy replacement costs?

The resulting Level 2 alternatives represent *the set of potentially effective and feasible water temperature reduction alternatives* that are advanced to Level 3. A separate report will be prepared to document the Level 3 water temperature reduction alternatives analysis and screening efforts.

Prior to completing the Level 3 analysis and screening, additional detailed modeling, engineering design, and cost estimate work will be completed. This work will involve application of new water quality models and the newly modified existing hydrologic and temperature models in a detailed technical analysis. During Level 3 screening, these data and models will be used to carefully analyze the effectiveness, sustainability, and reliability of the water temperature reduction alternatives that advanced from Level 2. The temperature reduction alternatives may be further modified or refined based on the analysis, particularly if a new water temperature target is developed. The water temperature reduction alternatives verified to be effective, sustainable, and reliable will be designed to a feasibility-level of detail. The alternatives will then be screened based on the same screening criteria used in Level 1 and 2. The resulting set of water temperature reduction alternatives passing the Level 3 screening will represent *the set of effective and feasible water temperature reduction alternatives*. These water temperature reduction alternatives will be carried forward into the EIR as elements of the CEQA alternatives, where they may be augmented and/or modified to address potentially significant environmental impacts identified through the CEQA process.

ES.2 FRAMEWORK

The complexity of the NFFR system hydrology and thermal regime and the large number of potential water temperature reduction measures under consideration (41 measures) demands that a systematic approach be followed to develop and screen potential water temperature reduction alternatives[4]. Recognizing this need, a "framework concept" was formulated that approaches the problem of reducing water temperatures along the entire NFFR by developing solutions on a reach-by-reach scale. Solutions identified in each reach become available as interchangeable

[4] Refer to Appendix C for presentation of potential water temperature reduction measures. These potential water temperature reduction measures were derived from those described in PG&E's 24 Alternatives Report (PG&E, 2005b) as well as others developed by the State Water Board team. These measures mainly consist of physical and operational changes to existing UNFFR Project facilities, but changes to other PG&E-owned and non-PG&E-owned facilities in the NFFR basin are considered as well. Watershed management actions that may potentially reduce temperature are also included.

measures that can be combined as necessary to create a comprehensive water temperature reduction alternative for the NFFR. The framework provides alternatives that focus on reducing the temperature of water delivered to and discharged from Belden Reservoir, then builds from this point by adding measures as necessary to satisfy the temperature needs in all reaches of the NFFR. Water temperature reduction at Belden Reservoir is central to achieving temperature reduction in the downstream reaches and, the cooler the water available for discharge from Belden Reservoir, the less the water needs to be cooled downstream to meet the target. Use of the framework concept allows for the formulation, analysis, and evaluation of a full range of alternative ways to reduce the temperature of water in Belden Reservoir and combines additional cooling along individual or multiple downstream reaches, as necessary for comprehensive watershed solutions.

Because the temperature of water discharged from Belden Reservoir drives the amount of cooling required in the downstream reaches, an analysis was performed to determine, over a range of starting water temperatures in Belden Reservoir, the additional cooling that would be needed to achieve the temperature target in all downstream reaches. The month of July 2002 was used as the analysis period[5] in the framework to estimate NFFR water temperature profiles for a range of starting water temperatures in Belden Reservoir. The profiles were estimated based on July 2002 meteorological conditions, observed temperature changes in the Belden and Rock Creek Reservoirs during the July 2003 Caribou special test for the infusion of cold water, and use of stream temperature modeling of the Belden, Rock Creek, Cresta, and Poe Reaches. Results of the modeling work formed the basis for the formulation of six categories of water temperature reduction alternatives as shown in Table ES.1. The categories are differentiated by the amount of temperature reduction provided at Belden Reservoir. A higher numbered category means that more temperature reduction is required in reaches downstream.

ES.3 FINAL LEVEL 2 WATER TEMPERATURE REDUCTION ALTERNATIVES

Through the Level 1 and Level 2 water temperature reduction alternatives development and screening process, the set of comprehensive, potentially feasible water temperature reduction alternatives was generated. The set of potentially feasible water temperature reduction alternatives, including variations of the alternatives, are summarized in Table ES-2. The following 16 alternatives and alternative variations remain and will advance to Level 3 for further refinement, analysis, and screening.

- ***Alternative Category 2 –*** one alternative (Alternative 2c) with one variation for the Poe Reach. No water temperature reduction measures are needed for the Belden, Rock Creek, and Cresta Reaches. This Category has *one alternative variation* (i.e., 1 × 1 = 1).

- ***Alternative Category 3 –*** one alternative (Alternative 3) with one variation for each of the Belden, Cresta, and Poe Reaches. No water temperature reduction measures are needed for the Rock Creek Reach. This Category has *one alternative variation* (i.e., 1 × 1 × 1 × 1 = 1).

[5] Data from July 2002 represents the most adverse conditions for achieving the temperature target, as compared to all months during PG&E's summer 2002 – 2004 monitoring period. Any water temperature reduction alternative that could achieve the target during July 2002 could likely do so during the summer months of any wet, normal, and most dry years. The thermal regime of the NFFR during PG&E's summer 2002 – 2004 monitoring period and, in particular, during July 2002 is explained in Chapter 2.

- ***Alternative Category 4*** **–** three alternatives (Alternatives 4a, 4b, and 4c) with one variation for the Belden Reach, one variation for the Rock Creek Reach, two variations for the Cresta Reach, and one variation for the Poe Reach, totaling *6 alternative variations* (i.e., 3 × 1 × 1 × 2 × 1 = 6).

- ***Alternative Category 5*** **–** two alternatives (Alternatives 5a and 5b) with one variation for the Belden Reach, one variation for the Rock Creek Reach, two variations for the Cresta Reach, and two variations for the Poe Reach, totaling *8 alternative variations* (i.e., 2 × 1 × 1 × 2 × 2 = 8).

These water temperature reduction alternatives were developed using the best available data and analytical tools generated through years of effort, including:

- PG&E's temperature modeling results for 33-years of the hydrologic record (Bechtel Corporation and Thomas R. Payne and Associates 2006);

- PG&E's physical-prototype hydraulic modeling results for the Prattville Intake thermal curtain (IIHR 2004);

- PG&E's 2002-2004 temperature monitoring data reports (PG&E 2003; PG&E 2004; PG&E 2005a);

- PG&E's 2006 NFFR special testing data (Stetson and PG&E 2007); and

- Stream water temperature modeling analysis and water temperature mixing analysis (refer to Chapter 3).

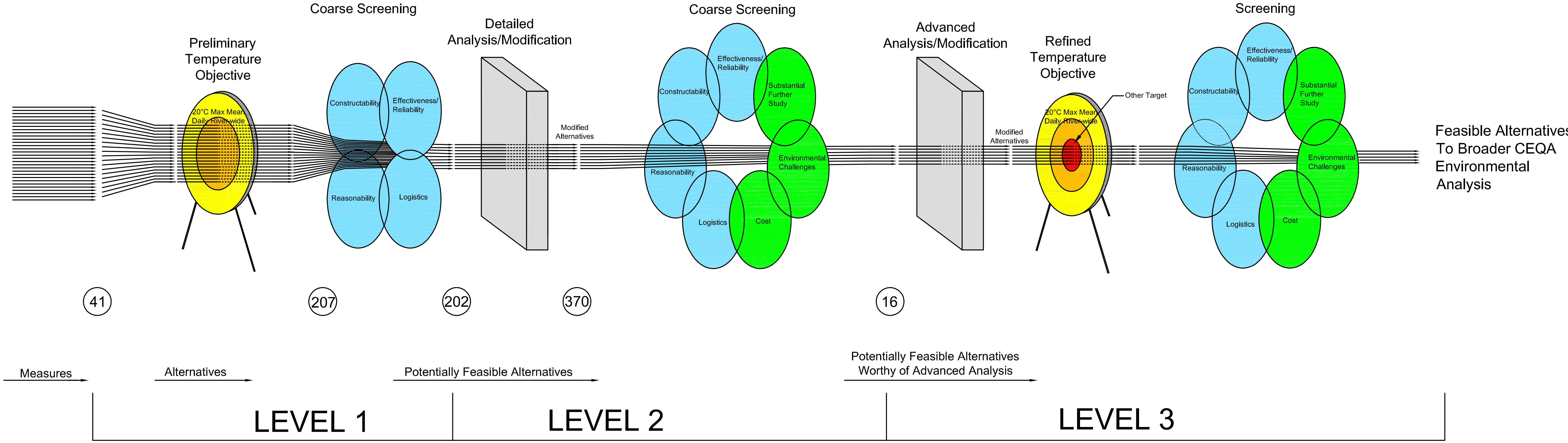
Particularly noteworthy is PG&E's 2006 NFFR special test which demonstrated cold water plunging and stratification in Butt Valley and Belden Reservoirs, suggesting that new measures for cooling may be effective, sustainable, and reliable, including:

- Reduced rate of withdrawal from the Prattville Intake for thermal selection;

- Re-operation of the Caribou Powerhouses through preferential or exclusive use of Caribou Powerhouse No. 1 or strict extended peaking procedures; and

- Enhanced submerged flow of cool water along the bottom of Butt Valley and Belden Reservoirs.

Further analysis is proposed in future Level 3 to verify the effectiveness, sustainability, reliability, and feasibility of the water temperature reduction alternatives to be carried forward from Level 2. New water quality models of Butt Valley Reservoir and Belden Reservoir have been developed and existing models of Lake Almanor have been improved. These models will enable engineers to simulate water temperatures in the lakes, reservoirs and flowing reaches of the NFFR and test the effectiveness, sustainability, and long-term reliability of the alternatives at reducing water temperatures. More detailed engineering design and cost estimating work will examine the feasibility and costs associated with the alternatives, including initial capital cost, recurring annual cost, and foregone power cost. All of this further work will be documented in the Level 3 report, which will set forth the water temperature alternatives to be carried forward into the EIR for broader environmental analysis.



F:\DATA\2125\CAD\Alternative Flow Diagram Rev .5.dwg

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Figure ES-1

Upper North Fork Feather River: Alternatives Development and Evaluation Process Flow Diagram and Resulting Number of Alternatives in Level 1 & 2

Table ES-1 Summary of Alternative Categories and Requirements

<table>
<tr><th colspan="2">Alternative Category</th><th>Belden Reach</th><th>Rock Creek Reach</th><th>Cresta Reach</th><th>Poe Reach</th></tr>
<tr><td rowspan="2">1</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">Reduce inflow temperature at Belden Forebay to 12.5°C</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td rowspan="2">2</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">Reduce inflow temperature at Belden Forebay to 14.5°C</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>No</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td rowspan="2">3</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">Reduce inflow temperature at Belden Forebay to 16.0°C</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>No (except for lower Belden reach)</td><td>No</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="2">4</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">Reduce inflow temperature at Belden Forebay to 18.0°C</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>No (except for lower Belden reach)</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="2">5</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">Reduce inflow temperature at Belden Forebay to 19.5°C</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="2">6</td><td>Cold Water from Lake Almanor/Butt Valley Reservoir</td><td colspan="4">No</td></tr>
<tr><td>Additional Cold Water Needed?</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
</table>

Table ES-2 *Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR*

(Green highlighted measures remain as final Level 2 Alternatives and will advance to Level 3; Bright green highlighted measures represent variations for cooling downstream reaches)

<table>
<tr><th rowspan="2">Alternative Category</th><th colspan="2">Alternative</th><th colspan="4">Variations for Cooling Downstream Reaches</th></tr>
<tr><th>Alt.</th><th>Measures in reducing source water temperature to Belden Forebay</th><th>Additional measures for Belden Reach</th><th>Additional measures for Rock Creek Reach</th><th>Additional measures for Cresta Reach</th><th>Additional measures for Poe Reach</th></tr>
<tr><td>1. Reduce the temperature in Belden Forebay to 12.5 °C.
(eliminated)</td><td>1</td><td>• Install Prattville thermal curtain with levee removed
• ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~
• Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td rowspan="3">2. Reduce the temperature in Belden Forebay to 14.5 °C.

(1 variation)</td><td>2a</td><td>• Install Prattville thermal curtain with levee removed
• ~~Convey Butt Valley PH discharges **to 2,000 cfs** to Butt Valley Reservoir near Caribou Intake~~</td><td rowspan="3">No</td><td rowspan="3">No</td><td rowspan="3">No</td><td>• Increase shading along Poe Reach</td></tr>
<tr><td>2b</td><td>• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~</td><td>• Increase Poe Dam release to 360 cfs</td></tr>
<tr><td>2c</td><td>• Decrease Prattville Intake release to 500 cfs to cause cold water selective withdrawal
• Extend the existing deeper channel of Butt Valley Reservoir by dredging
• Use Caribou #1 exclusively with reduced release to cause cold water selective withdrawal from Butt Valley Reservoir
• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs</td><td>• Construct outlet/pipeline from the Poe Adit and release to 180 cfs of cooler water to the Poe Reach</td></tr>
<tr><td rowspan="2">3. Reduce the temperature in Belden Forebay to 16.0 °C.

(1 variation)</td><td rowspan="2">3</td><td rowspan="2">• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• Increase Canyon Dam release to 250 cfs (and decrease Prattville Intake release commensurately)</td><td rowspan="2">• Convey warm water to 100 cfs from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline

Note: This measure is designed to protect the lower Belden Reach</td><td rowspan="2">No</td><td>• Increase Cresta Dam release to 390 cfs</td><td rowspan="2">• Increase Poe Dam release to 300 cfs
• Construct outlet/pipeline from the Poe Adit and release to 400 cfs the cooler water to the Poe Reach</td></tr>
<tr><td>• Increase Grizzly Creek release to 50 cfs</td></tr>
</table>

Note: All alternatives will have no affect on Lake Almanor water levels except Alternative 2c which would result in higher than historical lake levels due to significant flow reduction at the Prattville Intake.

Table ES-2 Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR
(Continued)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	**Measures in reducing source water temperature to Belden Forebay**	**Additional measures for Belden Reach**	**Additional measures for Rock Creek Reach**	**Additional measures for Cresta Reach**	**Additional measures for Poe Reach**
4. Reduce the temperature in Belden Forebay to 18.0 °C. (6 variations)	**4a**	• Install Prattville thermal curtain • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir	• Convey warm water **to 100 cfs** from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	• ~~Construct Yellow Cr/ Belden PH bifurcation or,~~ Convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Construct low level outlet at Rock Creek Dam • Dredge a submerged channel in Rock Creek Reservoir	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by pipeline • Construct low level outlet at Cresta Dam	• Increase Poe Dam release **to 400 cfs** • Construct outlet/pipeline from the Poe Adit and release **to 450 cfs** of cooler water to the Poe Reach
				• Bypass Yellow Creek flows **to 60 cfs** around Rock Creek Reservoir by diversion/pipeline	• Bypass cold Bucks Creek PH flows **to 95 cfs** around Cresta Reservoir by diversion/pipeline	
	4b	• Install Prattville thermal curtain • Use Caribou #1 preferentially over Caribou #2		• Increase Rock Creek Dam release **to 400 cfs**	• Increase Cresta Dam release **to 500 cfs**	
					• Increase Grizzly Creek releases **to 80 cfs**	
	4c	• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs (and decrease Prattville Intake release commensurately) • Use Caribou #1 preferentially over Caribou #2		• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	• Construct **200 cfs capacity** water chiller at Poe Dam
5. Reduce the temperature in Belden Forebay to 19.5 °C. (8 variations)	**5a**	• Use Caribou #1 preferentially over Caribou #2 • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Convey cold Seneca Reach flows **to 250 cfs** to Belden Reservoir for plunging by diversion/pipeline • Install a thermal curtain near Belden PH Intake • Convey warm water **to 100 cfs** from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• ~~Construct Yellow Cr/ Belden PH bifurcation or,~~ Convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Convey lower Belden Reach flows **to 140 cfs** to Rock Creek Reservoir for plunging • Dredge a submerged channel in Rock Creek Reservoir • Construct low level outlet at Rock Creek Dam	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by diversion/pipeline • Dredge a submerged channel in Cresta Reservoir • Construct low level outlet at Cresta Dam	• Increase Poe Dam release • Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach
	5b	• Install thermal curtain near Caribou Intake in Butt Valley Reservoir • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)			• Bypass cold Bucks Creek PH flows **to 110 cfs** around Cresta Reservoir by pipeline	
			• Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water **to 100 cfs** from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass Yellow Creek/Chips Creek flows **to 80 cfs** around Rock Creek Reservoir by diversion/pipeline	• Increase Cresta Dam release **to 700 cfs**	• Construct **200 cfs capacity** water chiller at Poe Dam
	5c	• ~~Convey Butt Valley PH discharges to 2,000 cfs by pipeline to Butt Valley Res. near the Caribou Intake~~ • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)		• Increase Rock Creek Dam release **to 600 cfs**	• Increase Grizzly Creek releases **to 100 cfs**	
				• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	

Table ES-2 Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR
(Continued)

<table>
<tr><th rowspan="2">Alternative Category</th><th colspan="2">Alternative</th><th colspan="4">Variations for Cooling Downstream Reaches</th></tr>
<tr><th>Alt.</th><th>Measures in reducing source water temperature to Belden Forebay</th><th>Additional measures for Belden Reach</th><th>Additional measures for Rock Creek Reach</th><th>Additional measures for Cresta Reach</th><th>Additional measures for Poe Reach</th></tr>
<tr><td rowspan="3">6. Reduce temperatures in all downstream reaches.
(eliminated)</td><td>6a</td><td rowspan="3">No</td><td>• Repair/modify Canyon Dam low level outlet and increase release to 250 cfs
• Convey cold Seneca Reach flows to Belden Reservoir for plunging by diversion/pipeline
• Increase Belden Dam/Oak Flat PH release to 250 cfs
• Convey warm water to 100 cfs in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline</td><td>• Bypass lower Belden Reach flows to 250 cfs around Rock Creek Reservoir by diversion/pipeline

Note: Must be combined with bypassing Seneca flows around Belden Reservoir.</td><td>• Bypass lower Rock Creek Reach flows to 250 cfs around Cresta Reservoir by diversion/pipeline

Note: Must be combined with bypassing Seneca flows around Belden Reservoir.</td><td>• Bypass lower Cresta Reach flows to 250 cfs around Poe Reservoir by diversion/ pipeline

Note: Must be combined with bypassing Seneca flows around Belden Reservoir.</td></tr>
<tr><td>6b</td><td>• Increase Canyon Dam low level outlet release to 90 cfs or higher
• Operate Caribou PHs in strict peaking mode with several hours shut down
• Convey warm water to 100 cfs in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline</td><td>• Construct 150 cfs capacity water chiller at Rock Creek Dam</td><td>• Construct 175 cfs capacity water chiller at Cresta Dam</td><td>• Construct 200 cfs capacity water chiller at Poe Dam</td></tr>
<tr><td>6c</td><td>• ~~Convey cold water from Lake Oroville to below Belden Dam~~</td><td>• ~~Convey cold water from Lake Oroville to below Rock Creek Dam~~</td><td>• ~~Convey cold water from Lake Oroville to below Cresta Dam~~</td><td>• ~~Convey cold Lake Oroville to below Poe D.~~</td></tr>
</table>

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Level 1 and 2 Report is to document the development and screening of *potentially* feasible water temperature reduction alternatives for seasonal cooling of water temperatures along the North Fork Feather River (NFFR) to achieve the water quality objective and protect the designated cold freshwater habitat beneficial use[6]. A subsequent Level 3 Report will expand on the water temperature reduction alternatives passing Level 2 screening, and will document the development of *confirmed* feasible water temperature reduction alternatives that could be incorporated into California Environmental Quality Act (CEQA) alternatives[7] and carried forward in the CEQA process. The State Water Resources Control Board (State Water Board) will use this report and the subsequent Level 3 Report to support, in part, its actions regarding issuance of Clean Water Act (CWA) section 401 water quality certification and adoption of an adequate CEQA Environmental Impact Report (EIR) for the certification. The geographic extent of the water temperature reduction alternatives covers the NFFR and its tributaries from Lake Almanor to the point of discharge to Lake Oroville. Most of the water temperature reduction alternatives under consideration are located along the mainstem NFFR.

Portions of the NFFR do not meet the water quality standards for water temperature as set forth in the Water Quality Control Plan for the Central Valley Region (Basin Plan; California Regional Water Quality Control Board, Central Valley Region 2004, amended 2006). The State Water Board has determined that elevated water temperatures are impairing the cold freshwater habitat beneficial use of the NFFR, as designated in the Basin Plan. On October 25, 2006, in accordance with CWA Section 303(d), the State Water Board approved placement of the NFFR (below Lake Almanor) on the list of water quality limited segments (State Water Board Resolution No. 2006-0079). The State Water Board cited water temperature as a pollutant that is causing impairment to the cold freshwater habitat beneficial use, and specified hydromodification and flow regulation as potential sources of the impairment. On November 30, 2006, the U.S. EPA approved this 303(d) listing (U.S. EPA's 2004-2006 Clean Water Act Section 303(d) List of Water Quality Impaired Segments for California).

PG&E's hydroelectric facilities are known to contribute to warming of water in the NFFR. These facilities, including a series of dams and reservoirs, powerhouses, and diverted stream reaches, prolong the hydraulic residence time, modify the thermal structure of the river, and alter the magnitude and timing of stream flows. These variations from natural hydrologic conditions alter the heat exchange characteristics of the river and contribute to warming that impairs cold freshwater habitat beneficial use, particularly during the summer.

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[6] A *water temperature measure* is defined as a physical or operational modification implemented at a specific location that is intended to reduce water temperature. A *water temperature reduction alternative* is defined as a combination of individual water temperature measures that act collectively to reduce water temperature, achieve the water quality objective, and protect the designated cold freshwater habitat beneficial use along the NFFR.

[7] Water temperature reduction alternatives are differentiated from comprehensive CEQA alternatives in the sense that water temperature reduction alternatives address only water temperature concerns. Comprehensive CEQA alternatives include water temperature reduction alternatives plus additional measures to address other environmental resource concerns.

PG&E submitted an application to the Federal Energy Regulatory Commission (FERC) for a new federal license for its Upper North Fork Feather River Project (UNFFR Project; FERC No. 2105). Prior to issuance of the new FERC license, CWA water quality certification must be obtained (18 C.F.R. §4.34, subd. (b)(5)(i)). Section 401 of the CWA (33 U.S.C. § 1341) requires certification that the Project will be in compliance with specified provisions of the CWA, including state water quality standards contained in the applicable Basin Plan (401 certification) and provides that the conditions of certification become conditions of the new federal license. The State Water Board is responsible for certifying hydroelectric projects in California (Wat. Code, § 13160; Cal. Code Regs., tit. 23, § 3855, subd. (b)), including the UNFFR Project.

The State Water Board's issuance of 401 certification is a discretionary action subject to compliance with CEQA. Because of project complexity, the level of controversy surrounding unresolved temperature issues on the UNFFR Project, and the likelihood of significant impacts, the State Water Board as the CEQA lead agency, made the decision to prepare an EIR. Consistent with CEQA, the EIR must evaluate a reasonable range of alternatives (CEQA Guidelines, § 15126, subd. (d)). The development of potentially feasible water temperature reduction alternatives documented in this report finishes an important initial stage toward defining comprehensive CEQA alternatives that could be analyzed in the EIR.

1.2 BACKGROUND

In deciding whether to issue 401 certification, the State Water Board will determine whether the UNFFR Project achieves the water quality objectives for affected water bodies and adequately protects the beneficial uses, as designated in the Basin Plan. The Basin Plan designates beneficial uses, including cold freshwater habitat, hydropower generation[8] and others, for two discrete water bodies associated with the UNFFR Project, Lake Almanor and the NFFR[9]. The Basin Plan provides numeric and narrative objectives for water temperatures in the NFFR. The numeric objective states: "At no time or place shall the temperature be increased more that 5° Fahrenheit (°F) above the natural receiving water temperature." The narrative objective states: "The natural receiving waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses." In order to meet this narrative temperature objective, a numeric requirement must be developed on a case-by-case basis that affords adequate protection to the designated beneficial uses for the specific water body.

The State Water Board's assessment of temperature conditions, for purposes of CWA section 303(d) determination of impairment to cold freshwater habitat beneficial uses, was based on values established in the Water Quality Control Policy for Developing California's CWA Section 303(d) List (State Water Board Resolution No. 2004-0063). In listing the NFFR for temperature impairment the State Water Board used the following water quality evaluation criteria:

- 7-day mean water temperature 17.0°C

[8] The Basin Plan defines cold freshwater habitat as uses of water that support coldwater ecosystems that may include, but are not limited to, preservation and enhancement of aquatic habitats, vegetation, fish, and wildlife, including invertebrates. Hydropower generation is defined as uses of water for hydroelectric power generation.
[9] Additional information concerning the Basin Plan and designated beneficial uses for these two water bodies and their tributaries is available at the following web site: http://www.waterboards.ca.gov/centralvalley/.

- Maximum weekly water temperature 19.6°C

- Maximum annual average water temperature 21.0°C

In determining the appropriate numeric temperature requirement as part of the 401 certification process, the State Water Board is not necessarily bound to follow the same criteria that it used in the 303(d) listing process, but the State Water Board will consider all of the information that supported development of the guidelines used during the 303(d) listing process, together with any other reliable information.

Achievement of water quality objectives depends on applying them to controllable water quality factors. The Basin Plan defines controllable water quality factors as those actions, conditions or circumstances resulting from human activities that may influence water quality, that are subject to the authority of the State or Regional Water Board, and that may reasonably be controlled. Accordingly, in deciding whether to issue 401 certification, the State Water Board will also consider feasible modifications to the UNFFR Project to address controllable factors contributing to seasonal warming of the NFFR. There may be feasible and effective temperature reduction methods other than modifications to the UNFFR Project available to PG&E to address controllable factors contributing to warming of the NFFR. These other methods may involve physical or operational modifications to PG&E's other hydroelectric projects in the NFFR watershed, and some of these may have lesser adverse environmental impacts than measures within the UNFFR Project. Accordingly, consistent with the CEQA requirement that alternatives be considered that would eliminate or reduce adverse environmental impacts (CEQA Guidelines, § 15126.6, subd. (c)), development of temperature reduction methods other than feasible modifications to the UNFFR Project is also covered in this report.

Impacts of the UNFFR Project on downstream water temperatures have been recognized since 1980 when PG&E, along with the CDFG, began fishery and water temperature studies of the NFFR in connection with the relicensing of the Rock Creek–Cresta Project (FERC No. 1962). In that relicensing effort, a settlement agreement (Rock Creek–Cresta Relicensing Settlement Agreement, 2000) stipulated that additional studies be conducted to determine the feasibility of modifying UNFFR Project facilities, operations, or other measures to achieve desired water temperatures in the NFFR. Conditions of the settlement agreement and the recent FERC License No. 1962 (FERC 2001) establish goals for restoring water temperatures of 20°C or lower through the Rock Creek and Cresta Reaches of the NFFR to protect the cold freshwater habitat beneficial use.

FERC prepared a Final Environmental Impact Statement (EIS) for the relicensing of the UNFFR Project (FERC, 2005) pursuant to NEPA. The document evaluated the effects of continued Project operations in accordance with environmental measures presented in a partial settlement agreement, Project 2105 Relicensing Settlement Agreement (Partial Settlement; 2004) signed by various stakeholders in the Project 2105 Collaborative Licensing Group (Licensing Group). Although State Water Board staff provided guidance to the Licensing Group, the State Water Board was not a party to the Partial Settlement. The Licensing Group negotiated agreements on many Project-related resource issues, but it was unable to achieve consensus on matters related to water temperature, shoreline erosion, and wetlands. Thus, the Partial Settlement identifies several unresolved issues which fall within the jurisdictional mandates of the State Water Board, including water temperature. State Water Board staff have determined that the Final EIS is not adequate to support the 401 certification process because it does not address all water quality impacts and other resource issues, and does not fully satisfy the requirements of CEQA. In fact, FERC selectively requested additional comments on the final EIS analysis of potential measures to provide colder water to the NFFR. Due to project complexity and the level of controversy surrounding the FERC relicensing efforts, the State Water Board has determined that an EIR is required to comply with CEQA and to fully disclose measures necessary for a 401 certification.

1.3 DESCRIPTION OF THE UNFFR PROJECT

For purposes of CEQA, the proposed project can be defined as the operation of the existing UNFFR Project as presented in PG&E's Application for License of the UNFFR Project (PG&E 2002) plus the protection, mitigation, and enhancement (PM&E) measures proposed for the UNFFR Project, as described in the Partial Settlement. The following section provides a brief overview of the UNFFR Project facilities, the operational configuration, and the changes to the existing UNFFR Project as proposed in the Partial Settlement.

The facilities of the UNFFR Project include three dams that impound water from the NFFR and Butt Creek, five powerhouses (PH), and three stream bypass reaches. Figures 1-1a and 1-1b show the locations and relationships of dams, impounded reservoirs, and bypass reaches associated with the UNFFR Project. Generation and transmission facilities are shown on these figures, as well as the recreational facilities located near the reservoirs and bypass reaches. The UNFFR Project also includes numerous roads and administrative facilities to support hydroelectric operation and maintenance activities.

UNFFR Project reservoirs include Lake Almanor (1,142,251 acre-feet), Butt Valley Reservoir (49,897 acre-feet), and Belden Forebay (2,477 acre-feet). Generation capacity is provided by Butt Valley PH (41 MW), Caribou No. 1 PH (75 MW), Caribou No. 2 PH (120 MW), Oak Flat PH (1.3 MW), and Belden PH (125 MW). Project dams at the three reservoirs regulate bypass flows released to the diverted reaches of the NFFR, including the Seneca Reach (below Canyon Dam) and Belden Reach (below Belden Forebay Dam). Butt Valley Dam, with no stream outlet structure, contributes minor leakage to lower Butt Creek in conjunction with a series of springs downstream of Butt Valley Dam.

Facilities of the UNFFR Project are operated in an integrated manner. Operation of the UNFFR Project is coordinated with other PG&E facilities in the NFFR watershed, including the upstream Hamilton Branch Project (unlicensed) and the downstream Rock Creek– Cresta (FERC No. 1962), Bucks Creek (FERC No. 619), and Poe (FERC No. 2107) Projects. Downstream of these hydroelectric projects, the waters of the NFFR flow into Lake Oroville, a feature of the FERC No. 2100 Project operated by the California Department of Water Resources, then into the Feather River, and ultimately into the Sacramento River system.

Under existing conditions, water levels in Lake Almanor, Butt Valley Reservoir, and Belden Forebay are controlled by License No. 2105 streamflow requirements and the operational decisions made by PG&E for power generation. Lake Almanor is managed to ensure that the lake level does not exceed the full-pool elevation of 4,504 feet in USGS Datum[10] to avoid spill at Canyon Dam. Typically, outflows from Canyon Dam and the Prattville Intake are controlled in the spring to allow the lake to refill with snowmelt, though in dry years the lake may not

[10] USGS Datum (NGVD 1929) = PG&E Datum + 10.2 feet.

completely fill. During the summer, the lake is managed for power generation and recreational opportunities. The Canyon Dam intake tower is designed to selectively draw from either the lower water column or higher in the lake strata, allowing some control over the temperature of flow releases[11]. The Canyon Dam outlet structure has a maximum capacity of 2,100 cfs, but is generally operated to release only the required minimum instream flows to the Seneca bypass reach (Seneca Reach) of the NFFR. Although current minimum flow releases are established at 35 cfs, the Partial Settlement provides for a revised and variable flow release schedule that will be evaluated in the EIR.

Butt Valley Reservoir is operated to meet power system needs, while also providing recreational opportunities, including fishing, swimming, boating, and shoreline camping. Flow enters the reservoir from the upper reach of Butt Creek and from Lake Almanor through the Prattville diversion tunnel to the Butt Valley PH. Butt Valley Dam has no outlet structure for releasing water to the bypass reach of lower Butt Creek. Currently, there is no minimum instream flow requirement for Butt Creek, and all flow entering the reservoir is diverted through the Caribou PH No. 1 and No. 2 Intakes. A 1997 seismic retrofit of Butt Valley Dam altered the natural drainage course of Benner Creek, a tributary to Butt Creek located immediately below Butt Valley Dam, converting it from a perennial to an intermittent stream. Lower Butt Creek receives limited leakage from the bottom of the dam, and the operation of Caribou PH No. 1 (1,100 cfs capacity) and Caribou PH No. 2 (1,500 cfs capacity) prevent spill at the dam. The water surface elevation of Butt Valley Reservoir fluctuates by about 10 to 15 feet below the maximum water surface elevation of 4,142 feet (USGS datum) on an annual basis.

Belden Forebay functions as a regulating facility, buffering the effects of discharges from the Caribou PHs prior to intake of flows through the Belden tunnel or discharge through the Oak Flat PH at the toe of Belden Dam, to the Belden bypass reach (Belden Reach). Because it is a regulating impoundment, the operational parameters provide for daily surface-level fluctuations of up to 10 feet. These fluctuations may limit the type and quality of recreational opportunities at Belden Forebay. The Oak Flat PH, an integral part of Belden Dam, has a maximum capacity of 140 cfs and currently serves as the release structure for minimum flows to the Belden Reach. Minimum flow requirements for the Belden Reach are currently set at 60 cfs during fall and winter, with flow increases to 140 cfs during the spring and summer fishing season. Data indicate that summer water temperatures in the Belden Reach often exceed the thresholds protective of cold freshwater habitat. The Partial Settlement provides a revised flow release schedule, but does not include measures that fully address seasonal water temperature concerns.

In addition to the power generation beneficial use, the UNFFR Project facilities provide a range of recreational uses, including contact and non-contact water-based recreation. Lake Almanor and Butt Valley Reservoir offer a variety of recreational facilities, including campgrounds, marinas, and day-use areas. The Partial Settlement includes PM&E measures for recreation facilities at the reservoirs and along the NFFR that have been recommended for inclusion in a new license for the UNFFR Project.

[11] The Canyon Dam intake tower has three low level outlets gates – Gate #1, Gate #3, and Gate #5 – all located at elevation 4432 ft, about 72 ft below the maximum lake level elevation of 4504 ft USGS datum. These three low level gates are damaged or are in poor condition due to corrosion and long-term hydrostatic loading on the gates and gate-stems. PG&E inspections revealed the poor condition of the gate-stems, gate connections, and bolts. In August-October 2005 PG&E did repair work on Gate #5 and rehabilitated the gate and gate-stem connection. Gate #5 is the only low level gate that is currently operable, but its operation is limited and it can reliably and safely release up to only about 73 cfs.

1.4 OVERVIEW OF APPROACH TO THE DEVELOPMENT AND SCREENING OF POTENTIALLY FEASIBLE WATER TEMPERATURE REDUCTION ALTERNATIVES

This Level 1 and 2 Report documents the first two phases of a three-phased approach to the development of a reasonable range of feasible alternatives for achieving the water temperature objective and protection of the cold freshwater habitat beneficial use of the NFFR. Figure 1-2 presents the three-phased approach as a flow diagram.

To facilitate the analysis needed to develop alternatives that could address the temperature objectives established by the Basin Plan, a numerical value for the water temperature objective was deemed necessary (water temperature objective target or "temperature target"). In setting the temperature target value, it was recognized that it must be feasibly attainable through physical or operational modifications of the UNFFR Project, since the alternatives being developed are intended for support of the State Water Board's 401 certification decision for relicensing of the FERC No. 2105 Project. Accordingly, for purposes of developing and screening water temperature reduction alternatives in this Level 1 and 2 Report, *a numerical value of 20°C maximum mean daily NFFR-wide was set as the water temperature objective target*.[12,13] This initial numerical value could be modified in the subsequent Level 3 effort if, at that time, a different and more appropriate temperature target is determined to be feasibly attainable through modification or re-operation of the UNFFR Project.

Level 1 casts a "wide net" that captures most all of the possible water temperature reduction alternatives and then subjects these possible alternatives to the following coarse screening criteria:

- Effectiveness and reliability – Is there a reasonable potential that the alternative can effectively and reliably achieve the preliminary temperature target or, is the effectiveness and reliability of the alternative overly speculative?

- Technological feasibility and constructability – Can the alternative be implemented with currently available technology and construction methods?

- Logistics – Can the alternative be implemented when considering current legal obligations, regulatory permitting requirements, public safety needs, right-of-way and access needs, and other real world logistical constraints?

- Reasonability[14] – Are there clearly more reasonable or superior alternatives available based on the other criteria? Is implementation of the alternative remote or highly speculative?

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[12] This water temperature objective target was set only for purposes of developing and screening alternatives, and should not be construed as the numeric temperature requirement necessary to achieve compliance with the Basin Plan. The State Water Board will determine the appropriate numeric temperature requirement in its 401 certification decision.

[13] The basis for this temperature target is further explained in Chapter 3.

[14] An EIR need not consider an alternative whose effect cannot be reasonably ascertained and whose implementation is remote and speculative (CEQA Guidelines, § 15126, subd. (d)).

The set of alternative measures passing Level 1 screening represents a reasonable range of potentially effective and feasible water temperature reduction alternative measures that are carried forward to Level 2.

Level 2 screens-out (eliminates) those water temperature reduction alternatives passing Level 1 screening that, after closer examination, are ineffective, infeasible, or are clearly inferior to other alternatives. In Level 2 the alternatives are analyzed using the best resource information currently available. Water temperature reduction alternatives are modified or refined based on the analysis, and rough engineering designs and cost estimates are developed. The alternatives are subjected to the same screening criteria used in Level 1, plus the following additional criteria:

- Substantial Further Study - Is there sufficient information currently available or can it be readily developed in order to evaluate the potential effectiveness and feasibility of the alternative, or is substantial further investigation or study required?

- Environmental challenges – Are there obvious environmental consequences or problems associated with the alternative that would pose a major challenge to overcome?

- Economic feasibility – Can the alternative be implemented at a reasonable cost, including capital, O&M, and considering energy replacement costs?

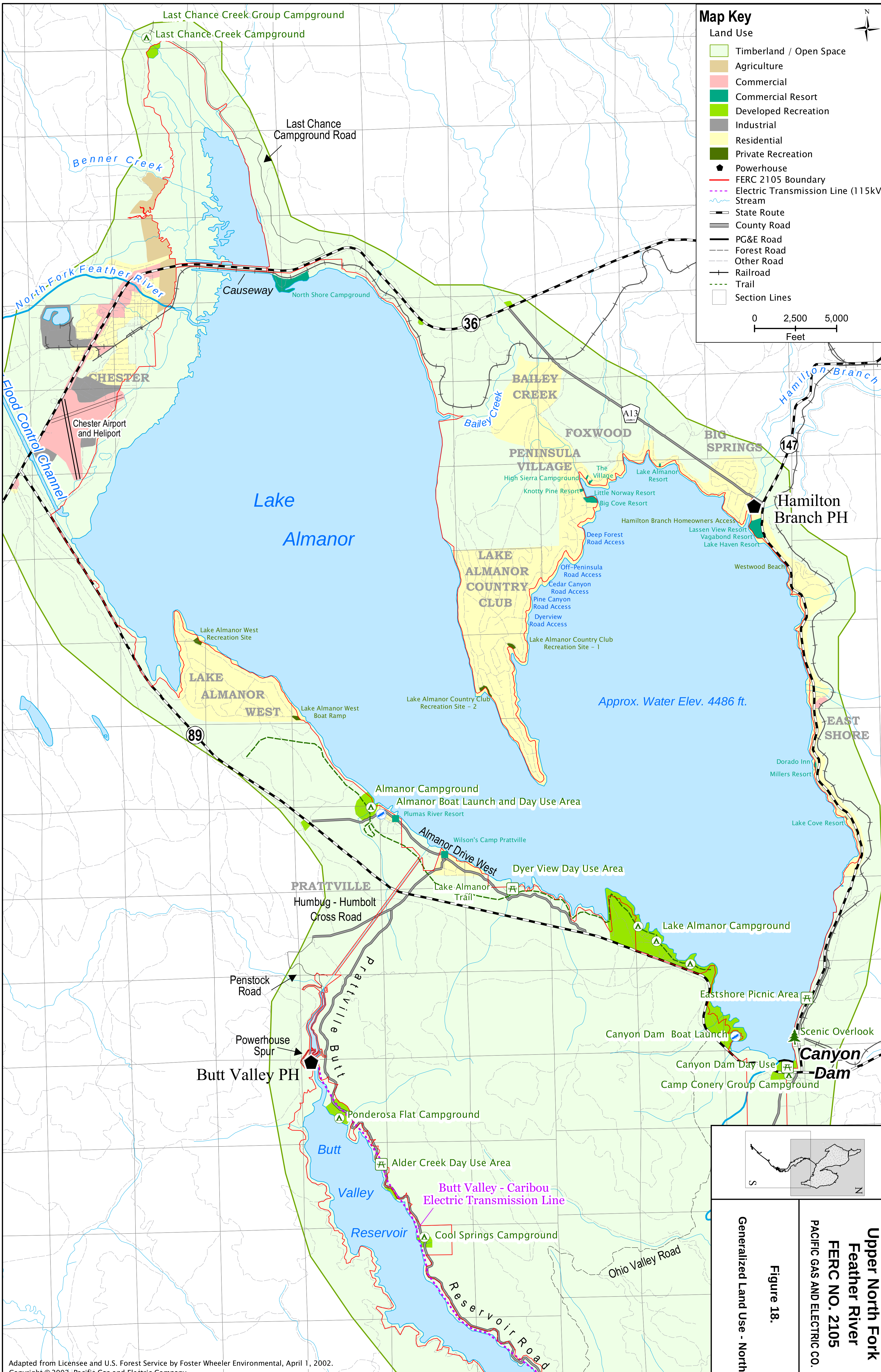
The resulting Level 2 alternatives represent *the set of potentially effective and feasible water temperature reduction alternatives* that are advanced to Level 3. (A separate report will be prepared to document the Level 3 water temperature reduction alternatives analysis and screening efforts.)

Prior to completing the Level 3 analysis and screening, additional detailed modeling, engineering design, and cost estimate work will be completed. This work will involve application of the newly developed water quality models and the newly modified existing hydrologic and temperature models in a detailed technical analysis. During Level 3 screening, these data and models will be used to carefully analyze the effectiveness, sustainability, and reliability of the water temperature reduction alternatives that advanced from Level 2. The temperature reduction alternatives may be further modified or refined based on the analysis, particularly if a new water temperature target is developed. The water temperature reduction alternatives verified to be effective, sustainable, and reliable will be designed to a feasibility-level of detail. The alternatives will then be screened based on the same screening criteria used in Level 1 and 2. The resulting set of water temperature reduction alternatives passing the Level 3 screening will represent *the set of effective and feasible water temperature reduction alternatives*. These water temperature reduction alternatives will be carried forward into the EIR as elements of the CEQA alternatives, where they may be augmented and/or modified to address potentially significant environmental impacts identified through the CEQA process.

1.5 OFF-SITE WATER TEMPERATURE MITIGATION

The County of Plumas has requested that the State Water Board analyze the "Watershed Restoration and Improvement Alternative (Watershed Alternative)" in the EIR for 401 certification.[15] The Watershed Alternative proposes "off-site mitigation" in the East Branch watershed in-lieu of achieving the water temperature objective and protecting cold freshwater habitat beneficial use in the NFFR through physical or operational modifications of the UNFFR Project. The State Water Board may consider the merits of this or other off-site compensatory mitigation in the future if all reasonable on-site temperature reduction alternatives are found to be infeasible, ineffective or unreasonable. However, in terms of quantifiable water temperature benefits in the NFFR, the Watershed Alternative provides no demonstration of effectiveness; therefore, it is not considered further in this Level 1 and 2 Report.

[15] The Plumas County letter of request (October 17, 2005) and a description of the Watershed Alternative are provided in Appendix D.



Upper North Fork Feather River
FERC NO. 2105
PACIFIC GAS AND ELECTRIC CO.

Figure 18.
Generalized Land Use - North

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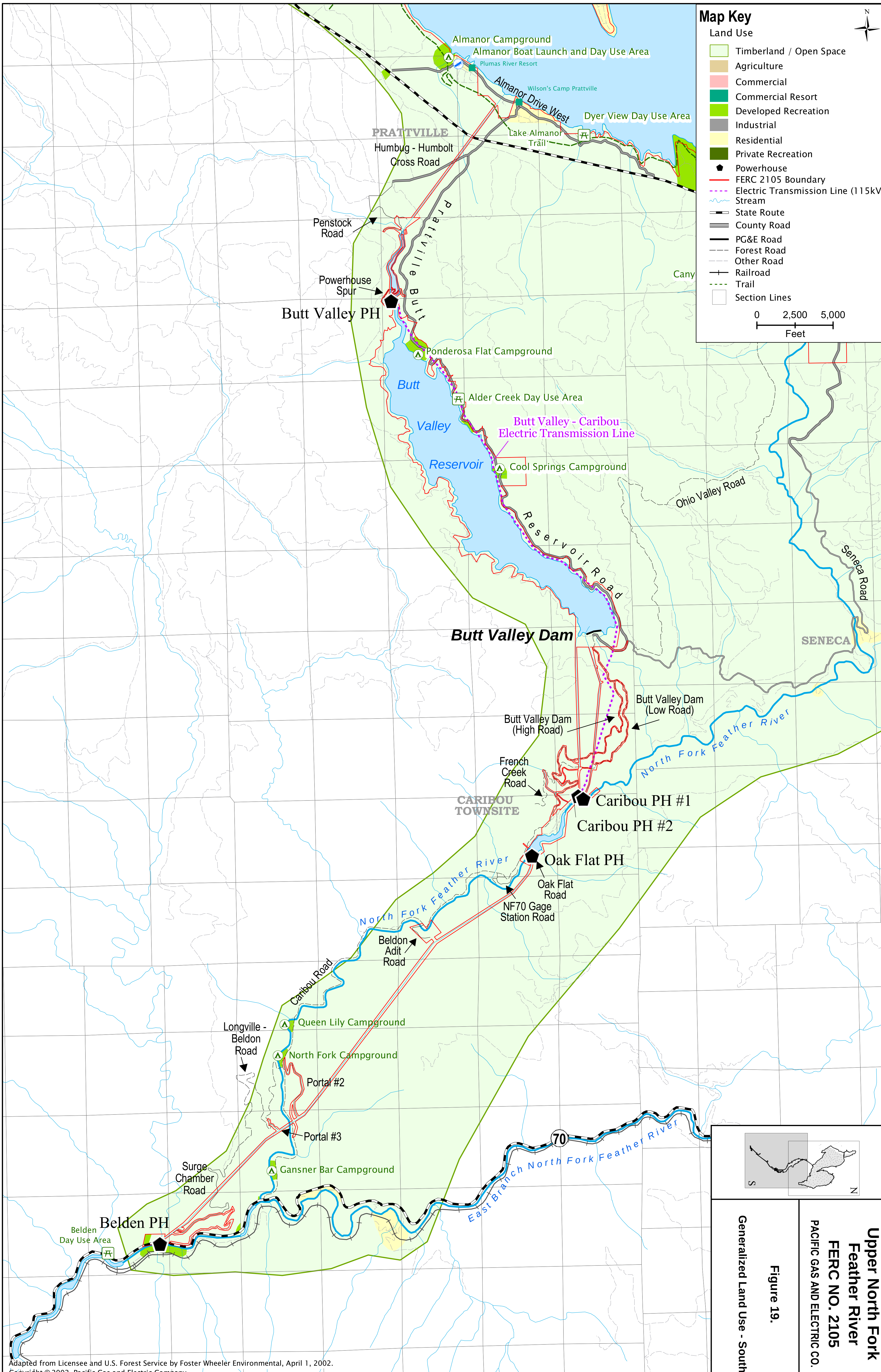

Upper North Fork Feather River
FERC NO. 2105
PACIFIC GAS AND ELECTRIC CO.

Figure 19.
Generalized Land Use - South

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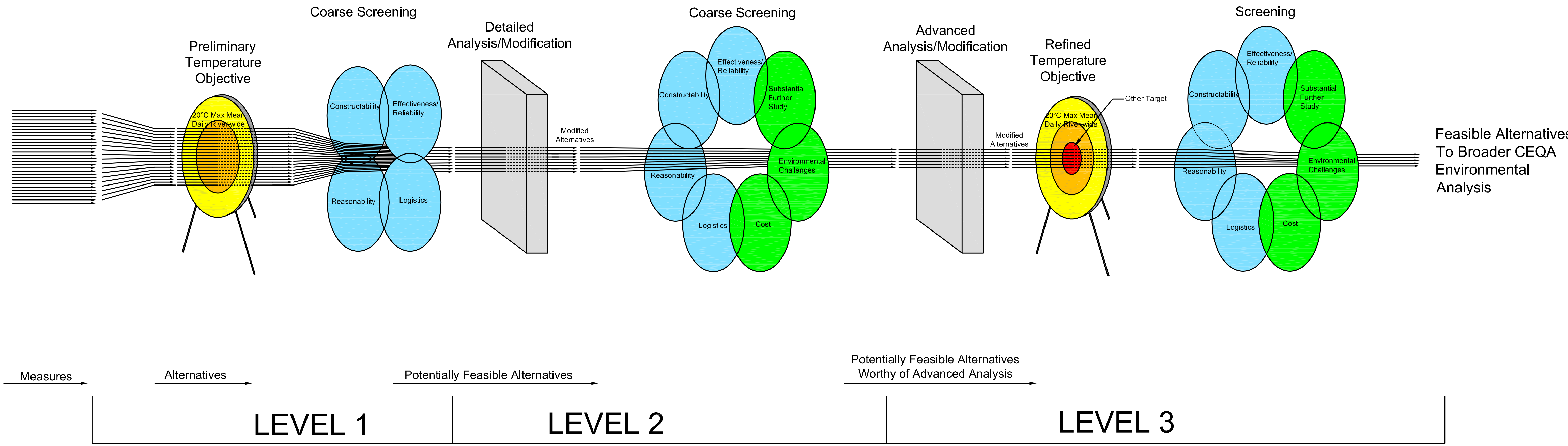


F:\DATA\2125\CAD\Alternative Flow Diagram Rev 4.dwg

STETSON ENGINEERS INC.

Figure 1-2

Upper North Fork Feather River: Alternatives Development and Evaluation Process Flow Diagram

2.0 THE SUMMER THERMAL REGIME OF THE NORTH FORK FEATHER RIVER AND THE RESPONSE TO THE INFUSION OF COLD WATER

This chapter characterizes the summer thermal regime of the NFFR and describes its response to the infusion of cold water. Infusion of cold water from some source will be necessary to achieve the Basin Plan temperature objective and protect the cold freshwater habitat beneficial use designated for the NFFR. The analysis and observations presented in this chapter are based on historical temperature data and recent data produced by PG&E through its special project re-operation and temperature testing and various NFFR monitoring efforts.

As discussed in Chapter 1, for purposes of this report a 20°C maximum mean daily water temperature throughout the NFFR is used as the water temperature objective target necessary for protection of cold freshwater habitat. Use of 20°C as the temperature target is consistent with the Rock Creek–Cresta Settlement Agreement and articles of FERC License No. 1962, which establish goals for restoring mean daily water temperatures of 20°C or lower in the Rock Creek and Cresta Reaches of the NFFR to protect the cold freshwater habitat beneficial use. Outside the summer months of most water years, water temperatures in the NFFR achieve the Basin Plan objective and are cool enough to protect cold freshwater habitat. But typically during the summer months, water temperatures below Belden Dam and downstream on the NFFR are warmer than 20°C.

2.1 GENERAL DESCRIPTION OF THE SUMMER THERMAL REGIME

The warming effects resulting from the PG&E hydroelectric facilities are first seen within the UNFFR Project at the upper end of the NFFR system and thermal effects intensify as flow passes through operations downstream. During the summer season, the upper layer of Lake Almanor warms to over 21°C. Water warmed in Lake Almanor is currently delivered to the NFFR through two pathways: (1) directly, by release at Canyon Dam to the NFFR and (2) indirectly, routed through Butt Valley Reservoir where it is further warmed before passing through the Caribou powerhouses to the NFFR. The water delivered to the NFFR through these two pathways is conveyed downstream and ultimately flows into Lake Oroville. As flow moves downstream, only about 10 percent of the water remains in the natural river channel; about 90 percent of the NFFR flow is diverted off-river and is conveyed downstream in large pipes or tunnels and run through an articulated system of powerhouses. The NFFR powerhouses discharge to four small regulating reservoirs; Belden, Rock Creek, Cresta, and Poe, where water is further warmed (Table 2-1 summarizes the physical characteristics of the NFFR reservoirs). Accretion flows from tributary sources enter the river as it courses downstream. The accretion flows are generally cool except for summer contributions from the East Branch, the largest tributary, which typically warms to greater than 20°C. Reservoir storage and the significant reduction in streamflow along diverted reaches increase heat exchange with the atmosphere which warms the water flowing in the river. Summer water temperatures in the NFFR from the Belden Reach below Belden Dam and downstream along every diverted reach to Lake Oroville are typically warmer than 20°C.

2.2 DETAILED DESCRIPTION OF THE SUMMER THERMAL REGIME BASED ON HISTORICAL MONITORING BY PG&E

Warming of the NFFR under current hydroelectric project operations is evident in data from an ongoing comprehensive water temperature monitoring program conducted by PG&E during summer months. The results of the 2002, 2003, and 2004 summer monitoring program are presented in Appendix A. The water temperature monitoring program for these years consisted of continuous stream flow and water temperature measurements at numerous stations along the NFFR. These monitoring stations are shown in Figure 2-1 and listed in Appendix A. In addition, PG&E performed temperature profile monitoring at all reservoirs along the lower NFFR in 1985. These data provide additional information on the thermal structures of the reservoirs and the availability of cold water at depth in each impoundment.

2.2.1 Summer Thermal Regime, 2002 – 2004

Water years 2002, 2003, and 2004 for the North Fork Feather River watershed were classified, in hydrologic terms, as "dry", "normal", and "normal" hydrologic years, respectively. The NFFR water temperature monitoring program results are summarized in Tables 2-2a and 2-2b (see also Appendix A). The number of days and calculated percentage of time that water temperatures exceeded the 20°C mean daily threshold are summarized in Tables 2-3a and 2-3b (see also Appendix B).

As shown in Table 2-3a, mean daily water temperatures in July and August exceeded the 20°C temperature target at all monitoring sites along the Belden, Rock Creek, Cresta, and Poe Reaches. The mean daily water temperature in the Belden Reach below Belden Dam (NF5) exceeded 20°C 100 percent of the time in August 2002 and 2004, with maximum mean daily water temperatures of 21.2°C in August 2002 and 21.8°C in August 2004 (Table 2-2a). High water temperatures in Belden Dam releases to the NFFR resulted from warm water discharges from the Caribou PHs (the primary source of water to Belden Reservoir). Caribou No. 2 PH had a mean daily discharge water temperature exceeding 20°C 100 percent of the time in both August 2002 and 2004 (Table 2-3b) and maximum mean daily discharge water temperatures of 23.7°C in August 2002 and 22.7°C in August 2004 (Table 2-2b). High discharge temperatures at the Caribou PHs resulted from high water temperature in the Butt Valley PH discharge (the primary source of water to Butt Valley Reservoir). Butt Valley PH discharges exceeded 20°C 100 percent of the time (Table 2-3b) and had a maximum mean daily discharge water temperature of 21.9°C in August 2002 and 21.8°C in August 2004 (Table 2-2b).

Table 2-3a shows that the mean daily water temperature in the Belden Reach above Belden PH (NF8) was significantly higher than other monitoring sites in the reach (Table 2-2a). This can be attributed to the warming effect of accretion flows from the East Branch, which had maximum mean daily water temperatures of 25.5°C, 26.4°C, and 24.8°C in 2002, 2003, and 2004, respectively (see Table A-1 in Appendix A).

2.2.2 Severe Summer Thermal Regime, July 2002

Water temperatures recorded during the month of July 2002 reflect the lowest flows, most extreme heat-inducing atmospheric conditions and, consequently, the warmest water temperatures of the 2002 – 2004 summer monitoring period. A longitudinal temperature profile along the NFFR was developed based on the “worst case scenario” conditions represented by July 2002 measurements. Mass balance mixing and SNTEMP modeling was used to enhance the detail of the profile where tributary stream inflows significantly influenced river temperatures (Figure 2-2). The observations below describe river segments where temperatures exceeded the water temperature target in the NFFR and bring to light the causal factors of temperature target exceedences.

a. The Seneca Reach met the temperature target, generally exhibiting temperatures lower than 17ºC. Inflow from Butt Creek had a cooling effect, but there was still considerable warming of about 4ºC along the Seneca Reach as water traveled from Canyon Dam downstream to Belden Reservoir. This warming, however, was not a major causal factor of downstream target exceedences because Seneca flows represented a small proportion of the total inflow into Belden Reservoir (see next).

b. The obvious jump in the temperature profile between the downstream end of the Seneca Reach and the beginning of the Belden Reach (below Belden Dam) reflects the warming of Belden Reservoir caused by releases from the Caribou PHs. These releases dominated the temperature of Belden Reservoir and, ultimately, the temperatures of releases from Belden Dam and beyond. In July 2002, Caribou PH releases contributed an average daily flow of about 617 cfs or 89% of the total inflow into Belden Reservoir while the Seneca Reach contributed an average daily flow of only about 75.9 cfs or 11% of the total inflow.

c. The Belden Reach above the East Branch generally met the temperature target, but exceedences were frequent. Inflow from the East Branch (EB1 average temperature was 23.8ºC; average flow was 80 cfs) had a considerable warming effect on the NFFR of about 1.5ºC. This warming further contributed to downstream temperature target exceedences. Discounting the effects of the East Branch, the Belden Reach otherwise exhibited little atmospheric warming, limited to about 0.4ºC.

d. Compared to the jump in the temperature profile at Belden Reservoir, there was little change in the profile across Rock Creek Reservoir. This may be explained by the fact that Belden Reservoir was the dominant source for both the Belden Reach and Rock Creek Reservoir (delivered through Belden PH). Additionally, the effects of cold water inflow from Yellow Creek/Chips Creek moderated temperatures in Rock Creek Reservoir. In July 2002, Belden PH releases contributed an average daily flow of about 518 cfs or 63 % of the total inflow into Rock Creek Reservoir, while the Yellow Creek/Chips Creek contributed an average daily flow of only about 82.6 cfs or 10 % of the total inflow, and Belden Reach contributed an average daily flow of only about 227.5 cfs or 27 % of the total inflow.

e. The Rock Creek Reach consistently exceeded the temperature target. Inflow from Bucks Creek and Bucks Creek PH had a considerable cooling effect of about 1ºC. This cooling was sufficient to mask the atmospheric warming of about 0.5ºC, but it was not sufficient to prevent downstream temperature target exceedences.

f. Similar to Rock Creek Reservoir, there was little change in the temperature profile across Cresta Reservoir. This may be explained by the fact that Rock Creek Reservoir was the dominant source for both the Rock Creek Reach and Cresta Reservoir (delivered through

Rock Creek PH). In July 2002, Rock Creek PH releases contributed an average daily flow of about 756 cfs or 70 % of the total inflow into Cresta Reservoir while the Rock Creek Reach contributed an average daily flow of only about 324.2 cfs or 30 % of the total inflow.

g. The Cresta Reach consistently exceeded the temperature target. Inflow from Grizzly Creek averaged 24 cfs or 9 % of the total flow in the Cresta Reach, and had a very small cooling effect of about 0.1ºC (GR1 average temperature was 19.3ºC). This cooling was not sufficient to mask the atmospheric warming of about 0.5ºC, nor prevent downstream temperature target exceedences.

h. Similar to Rock Creek and Cresta Reservoirs, there was little change in the temperature profile across Poe Reservoir. This may be explained by the fact that Cresta Reservoir was the dominant source for both the Cresta Reach and Poe Reservoir (delivered through Cresta PH). In July 2002, Cresta PH releases contributed an average daily flow of about 820 cfs or 76 % of the total inflow into Poe Reservoir while the Cresta Reach contributed an average daily flow of only about 265 cfs or 24 % of the total inflow.

i. The Poe Reach consistently exceeded the temperature target. There was no significant source of cool surface inflow to the Poe Reach; considerable warming of about 2 to 3ºC occurred as flow traveled from the Poe Dam downstream to the Poe PH. During July 2002, the maximum mean daily temperature was 24.7ºC and the average mean daily temperature was 23.7ºC.

j. The maximum mean daily temperatures in July 2002 were higher than the average mean daily temperatures along the entire NFFR as follows: about 0.7ºC higher on Seneca Reach, 1.7ºC higher on Belden Reach, 1.2ºC higher on Rock Creek Reach, 1.0ºC higher on Cresta Reach, and 1.0ºC higher on Poe Reach.

2.2.3 Reservoir Water Temperature Profiles

Historical temperature profile data from monitoring conducted at Belden, Rock Creek, Cresta, and Poe Reservoirs was examined to assess the potential for thermal stratification and the availability of cooler waters at depth. In 1985, as part of the cold water feasibility study for the Rock Creek-Cresta Project (Woodward-Clyde Consultants 1986), PG&E performed temperature monitoring of all reservoirs along the NFFR. The monitoring results are illustrated in Figures 2-3 – 2-6 and summarized by reservoir below:

a. The June 21, 1985 temperature profiles in Belden Reservoir indicated a relatively well-developed thermal structure, including a relatively well mixed epilimnetic layer with surface water temperature at about 22ºC and a cold hypolimnion with bottom water temperature at about 11ºC (Figure 2-3a). This may have resulted from cold water left over from the winter-spring period since increased fish-flow releases from the low level outlet at Oak Flat PH were not made until late June. Because there was considerably less cold water entering the reservoir over the summer (the only source of cold water entering the reservoir would have been from the Seneca Reach, which would have been about 65 cfs – 75 cfs with a water temperature of about 15 – 16ºC in July), there was a weakening trend in the thermal stratification as the summer months progressed (Figures 2-3b and 2-3c).

b. The temperature profiles in Rock Creek Reservoir showed a very weak thermal structure (Figure 2-4). Overall temperature differences between the top and bottom of the reservoir were less than 2ºC. Yellow Creek and Chips Creek are the cold water sources to the reservoir. Flows from these two creeks in July are approximately 60 - 90 cfs and 25 - 40 cfs, respectively.

c. The temperature profiles in Cresta Reservoir (Figure 2-5) and Poe Reservoir (Figure 2-6) indicated that the two reservoirs were well mixed vertically. There were no cold water sources to these two reservoirs during the summer of 1985.

d. The weak stratification in Belden Reservoir and Rock Creek Reservoir could be affected by selective ON/OFF peaking operations of Caribou PHs and Belden PH, respectively. Cold water from the Seneca Reach generally mixes with warm water discharges from Caribou PHs during on-peak hours; and, during off-peak hours when it doesn't mix, the cold water will plunge to the bottom of Belden Reservoir. This phenomenon is demonstrated in Figure 2-7 which shows that the release water temperature from the low-level outlet at Oak Flat PH during Caribou PH off-peak hours is about 1ºC cooler than during on-peak hours (Note: diurnal air temperature cycle would be a very minor contributing factor to the variation of water temperature at NF5 because the water is released from the reservoir bottom). Similarly, cold water from Yellow Creek probably mixes with warm water discharges from Belden PH during on-peak hours and partially mixes with warm water from the Belden Reach. The release temperature at Rock Creek Dam shows a trend similar to Belden Dam release temperature with respect to on-peak and off-peak operations (Figure 2-8).

2.3 THERMAL RESPONSE TO THE INFUSION OF COLD WATER

The infusion of cold water from an appropriate source will likely be necessary to achieve the temperature objective target of 20^{o}C for protection of the cold freshwater habitat beneficial use along the NFFR. To assess the thermal response of the river to the infusion of cold water, PG&E carried out special tests in 2003 and 2006. The tests consisted of modifying the operations of certain NFFR hydroelectric project facilities to infuse cold water into the river, coupled with monitoring of flow and temperature at strategic points along the river to measure the thermal response. The test results yielded important information that will be used in the development of water temperature reduction measures and alternatives that may be considered as possible solutions to the NFFR temperature concerns.

2.3.1 July 2003 Caribou PH Special Test

In July 2003, PG&E conducted a special short duration test of Caribou PH intake operations. The primary purpose of the special test was to investigate the effectiveness of preferential use of Caribou PH No. 1 over Caribou PH No. 2, as a measure to reduce temperatures in Belden Reservoir and downstream. But, the special test also provided the unique opportunity to observe and track the thermal response of the greater NFFR system to the introduction of cold water from the upstream source as might occur under an actual temperature reduction scheme.

The special test was carried out in three parts: Part 1 covered the six day period, 7/12-7/17/03, and involved almost exclusive use of Caribou PH No. 2; Part 2 covered the eight day period, 7/18-7/25/03, and involved almost exclusive use of Caribou PH No. 1; and Part 3 covered the five day period, 7/26-7/30/03, and involved use of both Caribou PHs No. 1 and No. 2 simultaneously, as is often PG&E's operating practice. Throughout the special test PG&E continued with the comprehensive water temperature and streamflow monitoring program (Table 2-4 and Figure 2-9), the results are summarized below:

a. During Part 1 Caribou PH No. 2 was operated preferentially, flows ranged from about 1,076 to 1,270 cfs. The day 1 temperature of discharge to Belden Reservoir was 20.1ºC, and increased to 21.0ºC on day 6. Caribou PH No. 1 flows ranged from 0 to 66 cfs.

b. During Part 2 Caribou PH No. 1 was operated preferentially, flows ranged from about 564 to 997 cfs. The day 1 temperature of discharge to Belden Reservoir was 16.4ºC, and increased steadily to 18.4ºC by day 8 as the cold water pool in Butt Valley Reservoir was depleted. Caribou PH No. 2 flows ranged from 0 to 67 cfs.

c. The initial drop of 4.6ºC during the transition from Caribou PH No. 2 operation to Caribou PH No. 1 operation was the largest difference measured between Parts 1 and 2. As Part 2 of the special test progressed, the temperature in the discharge to Belden Reservoir increased.

d. During the initial three days of Part 2, in response to cooler inflow from Caribou PH No. 1, Belden Reservoir (BD1) temperature dropped to a minimum of 17.3ºC on day 3 (a drop of 3ºC from the last day of part 1). Thereafter, Belden Reservoir temperature steadily rose; suggesting a response to increasing temperature in the Caribou PH No. 1 discharge with depletion of the cold water pool in Butt Valley Reservoir.

e. Temperatures in the NFFR below Belden Dam (NF5) showed a trend similar to that measured in Belden Reservoir; that is, an initial drop followed by a steady rise during Part 2. In response to cooler inflow from Caribou PH No. 1, which caused Belden Reservoir temperature to drop, the NFFR below Belden Dam temperatures dropped to a minimum of 17.1ºC on day 3 (a drop of 2.5ºC from the last day of Part 1). Thereafter, temperatures in the NFFR below Belden Dam steadily rose; again, presumably, partially in response to increasing temperature in the Caribou PH No. 1 discharge which caused a rise in Belden Forebay Reservoir.

f. Farther downstream the temperatures followed a similar trend, but the reduction effect of selectively using Caribou PH No. 1 dampened and diminished.
   i) Temperatures in the NFFR above the East Branch (NF7) dropped to a minimum of 18.5ºC on day 3 (a drop of 1ºC from the last day of Part 1), and thereafter steadily rose.
   ii) Temperatures in the NFFR above Yellow Creek (but below East Branch; NF8) showed no discernible effect from the Part 2 test, probably due to the masking effect of warmer water from the East Branch.
   iii) Temperatures in the NFFR below Rock Creek Dam (NF9) dropped to a minimum of 19.1ºC on day 3 (a drop of 1.1ºC from the last day of Part 1), and thereafter steadily rose.
   iv) Temperatures in the NFFR below Cresta Dam (NF14) dropped to a minimum of 19.6ºC on day 3 (a drop of 0.3ºC from the last day of Part 1), and thereafter rose.

v) Temperatures in the NFFR below Poe Dam dropped to a minimum of 20ºC on day 3 (a drop of 0.3ºC from the last day of Part 1), and thereafter rose.

g. The special test data also indicated possible thermal stratification and the availability of cooler water at depth in Belden Reservoir. Comparison of temperature measured at Belden Reservoir (BD1; temperature probe is at a depth of 20-30 ft, reflecting temperatures near the surface) and NFFR below Belden Dam (NF5; reflecting temperatures released from Oak Flat PH which release water at a depth of 90-100 ft) indicated possible stratification when temperatures in Belden Reservoir (as measured at BD1) were higher than 19ºC. Oak Flat PH release temperatures were about 1 – 2ºC lower than Belden Reservoir temperatures when the reservoir temperatures were higher than 19ºC. The difference was less than 1ºC when reservoir temperatures were lower than 19ºC (Figure 2-10). During Part 2, as there were no significant water temperature differences between Caribou PH No.1 discharges and Seneca Reach flows, Oak Flat PH release temperatures were close to Belden Reservoir temperatures.

h. The special test data also show that temperatures at NFFR below Rock Creek Dam were higher than estimated temperatures in Rock Creek Reservoir, indicating that warming occurred in Rock Creek Reservoir[16]. This warming was estimated at about 1°C when Rock Creek Reservoir was lower than about 19 ºC (which occurred when the Belden Reservoir temperature was about 18ºC or lower). The warming ceased when the Rock Creek Reservoir and Belden Forebay were both about 19.5ºC or higher (Figure 2-11). Total warming from Belden Reservoir Dam to Rock Creek Reservoir was influenced by two factors; one was the warming along the lower Belden Reach due primarily to the East Branch, and the other was the warming within Rock Creek Reservoir. Total warming was about 2°C during the Caribou PH special test when the Belden Reservoir temperature was about 17.5 -18.0°C. This total warming resulted in minimal water temperature reduction along the Cresta and Poe Reaches during the July 2003 Caribou PH special test.

2.3.2 Summer 2006 Special Test

Further special testing of the thermal response of the river to project re-operation and the infusion of cold water was conducted during the summer of 2006[17]. The summer 2006 special test was designed to fill additional water temperature data needs determined after careful examination of the available historical data. Specifically, the objectives of the summer 2006 special testing were:

- To further assess the thermal response of the river to the infusion of cool water, and to evaluate, through actual operation and field measurement, the effectiveness of certain water temperature reduction measures; and,

[16] Since temperature measurements were not taken in Rock Creek Reservoir, the reservoir temperature was estimated by mass balance mixing calculations using flow and temperature data from the four reservoir inflow sources; Yellow Creek above Belden Powerhouse (YC1), Belden Powerhouse (BD2), NFFR above Yellow Creek (NF8), and Chips Creek (CHIP1).

[17] Refer to 2006 North Fork Feather River Special Testing Data Report (Stetson and PG&E 2007) for detailed information on the Summer 2006 Special Test.

- To provide data to support development of new or enhancement of existing computer simulation models of water temperature for evaluating water temperature reduction measures.

2.3.2.1 Description of the Special Test

This special test actually consisted of six separate special tests. All tests were conducted during summer 2006. Following are descriptions of the tests:

- **Special Tests 1, 2 and 4 - Increased Canyon Dam Release Test with Restricted Peaking Operations for Caribou PH No. 2**
  The purpose of these special tests was to better understand the effects of increased release of cold water from the Canyon Dam low level outlets on the thermal structure at Belden Reservoir under conditions that avoided disturbance and mixing with warm Caribou PH discharges. Additionally, these special tests were designed to (1) evaluate Belden Reservoir thermocline development and sustainability as the cold water density current moved through the reservoir, (2) monitor the water temperature of Belden Dam releases through Oak Flat PH, and (3) characterize the thermal responses in the downstream reaches of the NFFR (e.g., Rock Creek, Cresta, and Poe reaches).[18] Special Test 1 released cold water at 90 cfs; Special Test 2 released cold water at 250 cfs; and Special Test 4 released cold water at 600 cfs.

  The design of these special tests was based on the hypothesis that denser cold water released from the Canyon Dam low level outlet, if undisturbed by Caribou PH discharge turbulence, would plunge as a density current into the bottom of Belden Reservoir during the Caribou PH No. 2 off-peaking hours. The plunged water would then move along the bottom of the reservoir toward Belden Dam, partially mixing with the ambient reservoir water along the way. During Caribou PH No. 2 on-peaking hours, the cold water from the Canyon Dam low level outlet would completely mix with warmer water discharged from Caribou PH No. 2.

- **Special Test 3 - Extended Off-Peaking Hours Test for Caribou PH No. 2 Concurrent with Increased Canyon Dam Release at 250 cfs**
  The purpose of this special test was to better understand the influence that the duration of peaking operations at the Caribou PH No. 2 may have on the thermal structure of Belden Reservoir and the water temperature of Oak Flat PH releases. This special test was designed to assess whether extending off-peaking hours (3 additional hours off) of the Caribou PH No. 2 would cause a greater volume of cold water released from the Canyon Dam low level outlet to plunge to the bottom of Belden Reservoir, thereby strengthening the thermocline and enlarging the pool of cold water available for release from Oak Flat PH.

- **Special Test 5 - Caribou Special Test with Reduced Butt Valley PH Flows**
  Data collected by PG&E during testing conducted August 1-5, 1994, suggested that decreasing the rate of Butt Valley PH discharge to below 800 cfs by reducing approach velocities at the Prattville Intake would, in effect, selectively withdraw water from the

[18] Another element of Special Test 4, Yellow Creek flow bifurcation from Belden PH discharges, was deferred due the long lead time that would have been needed to design and obtain the required regulatory permits for the instream bifurcation structure.

Lake Almanor hypolimnion and reduce the discharge water temperature.[19] The purpose of Special Test 5 was to better understand the relationship between the rate and water temperature (and the associated dissolved oxygen level) of the Butt Valley PH discharge. This special test was also intended to help evaluate whether the cold water released from the Butt Valley PH (through a reduction in discharge rate) would plunge and travel the 5-miles through Butt Valley Reservoir to become available for withdrawal at the Caribou PH No. 1 Intake. This special test was designed to include collection of physical water quality data (temperature, dissolved oxygen and velocity) to better characterize hydraulic conditions within the reservoir with changes in water delivery temperature.

- **Special Test 6 - Increased Grizzly Creek Release Test**
  The purpose of Special Test 6 was to better understand the effect that increasing the Grizzly Creek release rate may have on reducing warming along the creek to its confluence with the NFFR and, in addition, the resulting potential temperature reduction benefits available to the Cresta Reach. Historical flow releases from the Grizzly Forebay Dam low level outlet during the summer have been about 6 cfs. PG&E conducted water temperature monitoring along Grizzly Creek in the summer of 2002 at three locations: above Grizzly Forebay, below Grizzly Forebay, and near the mouth of Grizzly Creek. The measured mean daily flow near the mouth of Grizzly Creek in July and August 2002 ranged from 15 cfs to 28 cfs, which indicated a flow accretion of about 10 – 20 cfs. The measured water temperature below Grizzly Forebay in July and August 2002 ranged from 12°C to 15°C at the release rate of 6 cfs. The measured average warming in July and August 2002 from Grizzly Forebay to the mouth of Grizzly Creek was about 5.0°C. If increased release from Grizzly Forebay could shorten the travel time and thereby effectively reduce warming along the creek, water arriving at the confluence of Grizzly Creek with the NFFR should be significantly cold than the Cresta Reservoir releases to the NFFR. Thus, increasing Grizzly Creek releases should effectively reduce water temperatures along the Cresta Reach for some distance downstream.

In conjunction with the special tests, monitoring was carried out in compliance with Condition 4C of FERC License No. 1962 for the Rock-Creek-Cresta Project. The monitoring covered from Lake Almanor downstream to the Cresta PH and provided data to enhance understanding of the thermal responses of the entire NFFR system to cold water infusion during the special tests, changing reservoir operations, and meteorological conditions. Additional data was gathered from April through October as follows:

- Continuous monitoring of stream flow and water temperature at selected stations;

- Continuous monitoring of reservoir stage and water temperature at about 5 foot depth intervals in Lake Almanor, Butt Valley, Belden, and Rock Creek Reservoirs, as well as periodic water temperature profile monitoring at more refined intervals;

- Continuous monitoring of local meteorological conditions using PG&E's existing meteorology stations at Prattville Intake and Rock Creek Dam.

2.3.2.2 Observations from the Special Test

Following are summaries of the major findings of the special tests.

[19] Source: Figure 7 in North Fork Feather River Study Data and Informational Report on Water Temperature Monitoring and Additional Reasonable Water Temperature Control Measures, PG&E, Amended September 2005.

- Special Tests 1 - 4 verified that the cold water plunge process will occur in Belden Reservoir during the Caribou PH No. 2 “off-peaking” hours, and the cold water will then move along the bottom to Belden Dam for release, partially mixing with ambient reservoir water along the way. Figure 2-13 shows the plunge test results observed at Belden Reservoir on July 22, 2006 (see Figure 2-12 for Belden Reservoir water temperature monitoring sites and transect x-section locations).

  During July 22 monitoring, Caribou PH No. 1 was operating while Caribou PH No. 2 was totally shutdown. Under this re-operation test, cold water from Caribou PH No. 1 mixed with cold Seneca reach flows (about 14.0°C) and plunged into the bottom of Belden Reservoir. This plunging process is demonstrated in Figure 2-13. At transect X1, located about 500 ft upstream of data buoy BDR1 and approximately 700 ft below Caribou PH No. 2, the water temperature profile was uniform at about 14.2°C. Farther downstream at transect X2, located about 150 ft upstream of data buoy BDR1, stratified behavior was first observed in the water temperature profile. Field velocity profiles measured on July 22 during this stratified behavior showed higher velocity measurements near the reservoir bottom, indicating that the cold water plunged and moved along the reservoir bottom. In addition, slow reversal in surface water movement near the cold water plunging location (between transect X2 and transect X3) during the July 22 testing was observed and video recorded.

- Special Tests 1 – 4 demonstrated that entrainment and mixing of the ambient warm water of Belden Reservoir into the denser, cold inflowing water stream occurs both in the region of the plunge and after the cold inflow has assumed the form of a density current. Field test results have shown that the entrainment and mixing of ambient warm water into the cold inflowing current occurs mainly in the upstream portion of Belden Reservoir. As shown in Figure 2-13, bottom water temperature increased from about 14.3°C at transect X2 to about 16.3°C at transect X6. Downstream of transect X6, little warming was observed in the reservoir bottom water temperature. This indicates that entrainment and mixing of ambient warm surface water mainly occurred between transects X2 and transect X6. This suggests that conveying the cold Seneca flows directly to a location between transect X5 and transect X6 would help reduce the amount of warm water entrainment and mixing, and thereby preserve the cold water benefits of lower temperatures in releases from Belden Dam.

- During Special Tests 1 – 4, a thermally stratified condition was created in Belden Reservoir and the release water temperature at Belden Dam was relatively low compared to the warm surface water temperature. Figure 2-14 presents mean daily water temperatures at different depths in Belden Reservoir near Belden Dam (BDR2). Before the special tests, relatively weak stratification existed with water temperature decreasing linearly from water surface to bottom. During the special tests, the stratification was greatly strengthened, with an apparent hypolimnion layer below the 50 ft depth. After completion of the special tests, the defined stratification gradually returned back to the generally mixed condition observed before the special tests. It is important to note that, the Belden PH Intake did not access the cold water pool; instead, it withdrew warm water from the surface of the reservoir. The Belden PH discharge is the primary source of water to the downstream Rock Creek, Cresta, and Poe Reaches. This suggests that to reduce water temperatures in the downstream reaches, a measure that would cause the Belden PH Intake to draw from the deeper cold water pool would be effective.

- During the Special Tests 1 – 4, little stratification was observed in Rock Creek Reservoir (Figure 2-15). A longitudinal warming of 0.5 - 1.0°C through Rock Creek Reservoir was observed.

- Special Test 5 verified that decreasing the rate of Butt Valley PH discharge to below 800 cfs would selectively withdraw cold water from the Lake Almanor hypolimnion and lower discharge water temperatures to Butt Valley Reservoir. During this special test, the Butt Valley PH discharge was reduced from about 1,800 cfs to about 500 cfs, and measured water temperatures decreased from about 16.5°C to 12.5°C-13.0°C (Figure 2-16).

- Special Test 5 demonstrated that the cold water from Butt Valley PH (through a reduction in discharge rate to about 500 cfs) would plunge at a location near the Butt Valley Reservoir entrance. Figure 2-18 shows water temperature profiles collected from the upper portion of Butt Valley Reservoir during Special Test 5 (see Figure 2-17 for Butt Valley Reservoir water temperature monitoring sites and transect x-section locations). Water temperature profiles at transects X1 and X2 were generally uniform. Water temperature profiles at transects X3 and X4 showed relatively strong stratification, indicating that the cold water plunged at a location upstream of transect X3. Field observation indicated that the plunging location actually occurred immediately upstream of transect X3, where the wind-induced surface turbulence showed an interfacial line with the colder plunging water.

- During the Special Test 5, field efforts to trace the cold water plume in Butt Valley Reservoir were conducted. The intent was to capture and document the mixing process by measuring temperature and dissolved oxygen profiles at various points along the pathway of the cold water plume. A deeper channel was identified along the west side of the reservoir entrance above the Boat Ramp, but measurements could not locate the course of a distinct channel downstream of the Boat Ramp.

- Temperature stratification measurements in Butt Valley Reservoir indicated that the cold water that plunged moved primarily along the deeper channel with little entrainment or mixing with warm surface water. However, the mixing with warm surface water was relatively high from the Boat Ramp area, where the deeper channel began to disappear, to Cool Springs. This suggests that extending the deeper channel along the reservoir bottom toward the Caribou Intake structures may help reduce mixing with warm surface water during the movement of cold water along the reservoir bottom.

- Special Test 6 demonstrated that increasing the Grizzly Creek release rate would significantly reduce warming along the creek. During Special Test 6, increasing flow from 6 cfs to 20-50 cfs reduced the rate of warming in Grizzly Creek by about 2°C – 2.5°C. The cooler water contributions from Grizzly Creek to the NFFR reduced water temperature slightly in the Cresta Reach. It would be expected that higher releases to Grizzly Creek would further reduce warming along the creek and further reduce water temperatures in the Cresta Reach.

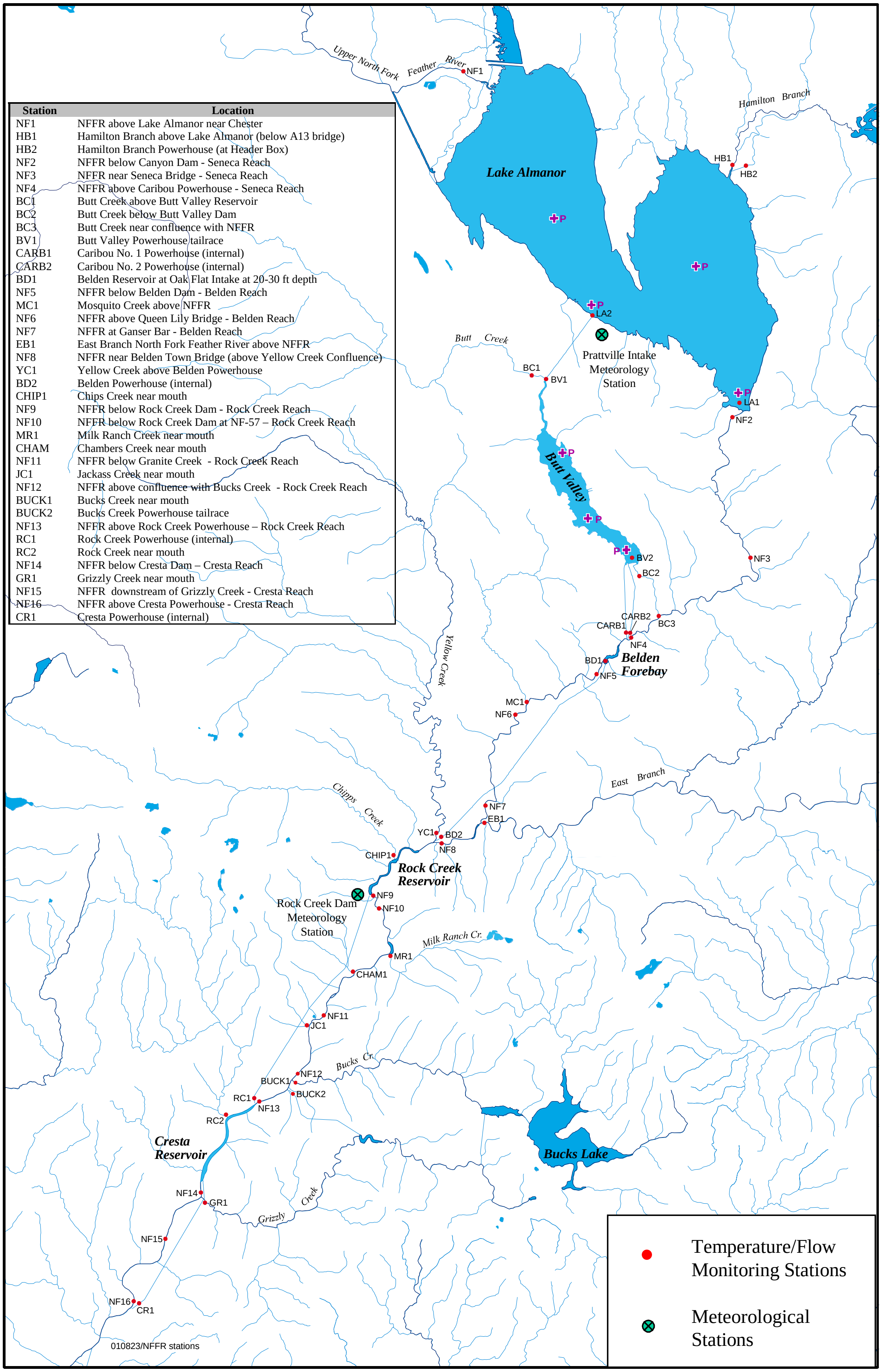
Table 2-1 Physical Characteristics of Reservoirs along the NFFR

Reservoir	Normal Maximum Water Surface Elevation (ft, USGS Datum)	Storage Capacity (acre-ft)	Surface Area at Maximum Water Surface Elevation (acres)	Average Depth (ft)	Maximum Depth (ft)	Hydraulic Residence Time [3] (days)
Lake Almanor	4,504	1,142,251	27,000	42	100	265
Butt Valley Reservoir	4,142	49,897	1,600	31	60	10
Belden Reservoir	2,985	2,477	42	59	105	0.5
Rock Creek Reservoir [1]	2,216	4,400	118	37	100	0.7
Cresta Reservoir [2]	1,681	4,140	95	44	100	0.5
Poe Reservoir	1,391	1,203	53	23	45	0.2

Notes:

1) *Rock Creek Reservoir's original capacity of 4,400 acre-ft has been reduced more than 50% by sedimentation that occurred in the 1980s.*
2) *The original capacity of Cresta Reservoir (4,140 acre-ft) has also been decreased by sedimentation.*
3) *Hydraulic residence time was estimated based on the powerhouse discharge capacity plus dam release.*

Figure 2-1 NFFR Stream Temperature Monitoring Locations



Station	Location
NF1	NFFR above Lake Almanor near Chester
HB1	Hamilton Branch above Lake Almanor (below A13 bridge)
HB2	Hamilton Branch Powerhouse (at Header Box)
NF2	NFFR below Canyon Dam - Seneca Reach
NF3	NFFR near Seneca Bridge - Seneca Reach
NF4	NFFR above Caribou Powerhouse - Seneca Reach
BC1	Butt Creek above Butt Valley Reservoir
BC2	Butt Creek below Butt Valley Dam
BC3	Butt Creek near confluence with NFFR
BV1	Butt Valley Powerhouse tailrace
CARB1	Caribou No. 1 Powerhouse (internal)
CARB2	Caribou No. 2 Powerhouse (internal)
BD1	Belden Reservoir at Oak Flat Intake at 20-30 ft depth
NF5	NFFR below Belden Dam - Belden Reach
MC1	Mosquito Creek above NFFR
NF6	NFFR above Queen Lily Bridge - Belden Reach
NF7	NFFR at Ganser Bar - Belden Reach
EB1	East Branch North Fork Feather River above NFFR
NF8	NFFR near Belden Town Bridge (above Yellow Creek Confluence)
YC1	Yellow Creek above Belden Powerhouse
BD2	Belden Powerhouse (internal)
CHIP1	Chips Creek near mouth
NF9	NFFR below Rock Creek Dam - Rock Creek Reach
NF10	NFFR below Rock Creek Dam at NF-57 – Rock Creek Reach
MR1	Milk Ranch Creek near mouth
CHAM	Chambers Creek near mouth
NF11	NFFR below Granite Creek - Rock Creek Reach
JC1	Jackass Creek near mouth
NF12	NFFR above confluence with Bucks Creek - Rock Creek Reach
BUCK1	Bucks Creek near mouth
BUCK2	Bucks Creek Powerhouse tailrace
NF13	NFFR above Rock Creek Powerhouse – Rock Creek Reach
RC1	Rock Creek Powerhouse (internal)
RC2	Rock Creek near mouth
NF14	NFFR below Cresta Dam – Cresta Reach
GR1	Grizzly Creek near mouth
NF15	NFFR downstream of Grizzly Creek - Cresta Reach
NF16	NFFR above Cresta Powerhouse - Cresta Reach
CR1	Cresta Powerhouse (internal)

Table 2-2a Summary of 2002 - 2004 Mean Daily Water Temperatures along the NFFR Reaches (°C)

Station	Month	2002			2003			2004		
		Max	min	mean	max	min	mean	max	min	mean
Belden Reach										
NF5	June	18.9	15.9	17.4	18.2	14.1	16.8	19.1	15.2	17.0
	July	**21.1**	17.8	19.4	**20.8**	17.1	18.5	**21.6**	18.7	20.3
	Aug	**21.2**	20.2	20.7	**20.5**	18.4	19.8	**21.8**	20.8	21.4
	Sep	**20.9**	16.8	18.8	**20.5**	17.6	19.0	**20.8**	17.1	18.8
NF6	June	19.0	15.7	17.1	17.9	14.3	16.6	18.8	15.1	16.9
	July	**21.1**	18.1	19.5	**20.6**	17.3	18.5	**21.2**	18.5	20.0
	Aug	**21.1**	19.6	20.3	**20.3**	18.0	19.3	**21.4**	20.2	20.8
	Sep	**20.9**	19.3	18.0	19.9	16.7	17.9	**20.2**	16.1	17.7
NF7	June	19.3	16.2	17.5	18.4	14.9	16.9	19.0	14.7	17.1
	July	**21.3**	18.5	19.7	**20.9**	17.3	18.9	**21.2**	18.5	20.0
	Aug	**21.1**	19.1	20.1	**20.5**	17.9	19.3	**21.3**	19.9	20.5
	Sep	**20.5**	16.1	17.6	20.0	16.3	17.6	19.9	15.4	17.4
NF8	June	**21.2**	17.1	19.4	**20.5**	16.5	18.7	**20.8**	15.5	18.9
	July	**22.9**	20.4	21.4	**22.9**	18.8	21.0	**22.9**	20.2	21.5
	Aug	**22.3**	19.5	20.7	**22.0**	19.2	20.4	**22.0**	20.1	21.0
	Sep	**21.0**	16.1	18.0	**21.1**	16.4	18.2	**20.2**	15.1	17.6
Rock Creek Reach										
NF10	June	**20.7**	20.1	20.3	19.1	14.9	17.6	19.9	14.1	17.7
	July	**22.5**	20.0	21.3	**22.1**	18.1	19.9	**21.9**	19.5	20.9
	Aug	**22.1**	20.5	21.2	**21.6**	19.9	20.4	**21.9**	20.6	21.3
	Sep	**21.2**	17.6	19.1	**20.7**	17.3	18.8	**20.6**	16.6	18.5
NF11	June	**20.9**	16.0	18.6	19.3	14.1	17.1	20.1	14.3	17.8
	July	**22.8**	20.2	21.5	**22.6**	17.9	20.2	**22.2**	19.7	21.1
	Aug	**22.5**	19.8	21.0	**21.7**	19.6	20.3	**21.9**	20.3	21.1
	Sep	**21.0**	17.3	18.8	**20.9**	17.0	18.6	**20.4**	16.3	18.3
NF12	June	**21.0**	15.9	18.6	19.3	14.2	17.2	**20.2**	14.4	17.9
	July	**22.9**	20.2	21.6	**22.7**	17.8	20.3	**22.3**	19.8	21.2
	Aug	**22.6**	19.7	21.0	**21.8**	19.6	20.3	**22.0**	20.4	21.2
	Sep	**21.1**	17.2	18.8	**21.0**	16.8	18.6	**20.5**	16.3	18.3
NF13	June	**21.0**	15.8	18.6	17.9	13.3	15.7	19.3	13.3	16.5
	July	**22.8**	19.4	20.7	**23.0**	15.4	18.7	**21.1**	18.6	19.5
	Aug	**21.8**	17.6	19.3	**22.0**	16.3	18.4	19.0	17.3	18.1
	Sep	18.1	15.0	16.3	17.1	14.2	15.6	19.2	15.7	17.2
Cresta Reach										
NF14	June	**20.8**	16.7	18.4	18.5	14.1	16.9	19.8	14.0	17.2
	July	**22.2**	20.3	21.2	**22.2**	17.4	19.6	**21.6**	19.4	20.7
	Aug	**21.9**	19.6	20.7	**21.8**	19.2	20.0	**21.3**	20.0	20.6
	Sep	**20.5**	17.1	18.5	**20.1**	16.8	18.2	20.0	16.5	18.3
NF15	June	**20.9**	16.2	18.4	18.6	14.0	16.9	19.7	14.3	17.3
	July	**22.1**	20.4	21.3	**22.4**	17.3	19.8	**21.7**	19.4	20.7
	Aug	**22.0**	19.5	20.6	**21.9**	19.3	20.0	**21.3**	19.9	20.6
	Sep	**20.5**	16.9	18.4	**20.3**	16.7	18.2	19.9	16.3	18.1
NF16	June	**21.2**	16.4	18.7	18.9	14.4	17.2	20.0	14.7	17.6
	July	**22.6**	20.9	21.7	**22.7**	17.7	20.1	**22.1**	19.7	21.1
	Aug	**22.4**	19.6	20.9	**22.1**	19.5	20.2	**21.6**	20.2	20.9
	Sep	**20.7**	17.1	18.5	**20.6**	16.5	18.3	**20.2**	16.5	18.3

Table 2-2a Summary of 2002 - 2004 Mean Daily Water Temperatures along the NFFR Reaches (°C) (Continued)

Station		Month	2002			2003			2004		
			Max	**min**	**mean**	**Max**	**min**	**mean**	**max**	**min**	**mean**
Poe Reach											
	NF17	June	**21.0**	16.7	18.7	18.7	14.1	17.0	**20.0**	14.5	17.5
		July	**22.5**	20.7	21.6	**22.5**	17.6	19.9	**21.9**	19.7	21.0
		Aug	**22.3**	20.1	21.0	**22.2**	19.5	20.3	**21.5**	20.2	20.9
		Sep	**20.7**	17.5	18.8	**20.2**	17.0	18.4	**20.3**	18.4	19.6
	NF18	June	**23.2**	17.8	21.0	**21.0**	17.6	19.7	**22.4**	17.5	20.1
		July	**24.7**	22.9	23.7	**24.5**	19.6	22.1	**24.4**	21.4	22.9
		Aug	**24.1**	20.9	22.3	**23.5**	20.5	21.5	**22.9**	21.1	22.1
		Sep	**22.1**	18.6	19.6	**21.9**	17.0	19.2	**21.2**	18.7	20.2

Notes:

1) *All values are mean daily water temperatures computed from hourly temperature measurements. Monthly statistics represent the maximum, minimum, and mean daily water temperatures based on the hourly temperature measurements. For example, the maximum June temperature represents the maximum mean daily temperature measured in June.*
2) *Refer to Figure 2-1 for station locations.*
3) *NF17: NFFR below Poe Dam.*
4) *NF18: NFFR above Poe PH.*

Table 2-2b Summary of 2002 - 2004 Mean Daily Water Temperatures at the NFFR Powerhouse Discharges (°C)

Powerhouse	Month	2002			2003			2004		
		Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
Butt Valley PH	June	16.1	14.8	15.5	16.3	11.7	14.1	18.7	14.7	17.4
	July	**21.7**	17.8	20.2	19.1	15.4	17.4	**21.3**	18.4	19.7
	Aug	**21.9**	20.4	21.2	**20.4**	19.3	19.8	**21.8**	20.2	21.1
	Sep	**21.3**	17.9	19.3	**20.6**	17.8	18.9	**20.3**	16.8	18.6
Caribou #1 PH	June	13.3	12.3	12.7	11.2	10.9	11.0	18.0	16.4	17.2
	July	**21.0**	16.3	19.3	19.1	16.4	18.1	**21.1**	18.0	19.9
	Aug	**21.9**	21.2	21.4	20.0	17.5	19.5	**21.7**	20.8	21.2
	Sep	**21.3**	18.2	19.7	**20.1**	18.0	19.1	**20.8**	16.8	19.1
Caribou #2 PH	June	**21.5**	17.4	19.3	19.3	16.7	18.2	**21.0**	17.7	19.6
	July	**24.0**	21.9	23.2	**23.4**	18.4	20.4	**22.7**	21.0	22.0
	Aug	**23.7**	21.5	22.5	**21.9**	21.0	21.4	**22.7**	21.4	22.1
	Sep	**22.1**	18.3	19.9	**21.8**	19.2	20.2	**21.4**	17.4	19.4
Belden PH	June	18.7	17.7	18.0	19.2	15.6	18.1	20.0	16.6	18.8
	July	**22.5**	19.0	21.2	**21.7**	17.4	19.3	**22.0**	19.4	20.9
	Aug	**22.6**	21.4	21.8	**21.1**	20.3	20.7	**22.2**	21.1	21.7
	Sep	**21.7**	18.3	19.8	**21.1**	18.2	19.5	**21.1**	17.3	19.2
Rock Creek PH	June	**20.1**	16.1	18.1	19.6	14.8	17.7	20.1	14.3	17.8
	July	**22.6**	19.6	21.3	**22.3**	18.5	20.1	**22.3**	19.8	21.3
	Aug	**22.6**	21.0	21.7	**22.0**	20.4	20.9	**22.5**	21.4	21.9
	Sep	**21.7**	18.4	19.8	**21.2**	18.1	19.5	**21.4**	17.4	19.7
Cresta PH	June	**20.8**	16.3	18.5	18.5	13.9	16.8	19.8	13.8	17.1
	July	**22.5**	20.4	21.4	**22.3**	17.4	19.7	**21.5**	19.4	20.7
	Aug	**22.5**	20.1	21.0	**22.0**	19.5	20.2	**21.2**	20.1	20.7
	Sep	**20.7**	17.3	18.7	**20.1**	17.0	18.3	**20.1**	16.7	18.5

Table 2-3a Summary of 2002 - 2004 Mean Daily Water Temperature Comparison with the 20°C Level along the NFFR Reaches

Station	Month	2002			2003			2004		
		Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C
Belden Reach										
NF5	June	0	30	0%	0	30	0%	0	30	0%
	July	7	31	**23%**	4	31	**13%**	18	31	**58%**
	Aug	31	31	**100%**	10	31	**32%**	31	31	**100%**
	Sep	6	30	**20%**	6	30	**20%**	4	30	**13%**
NF6	June	0	30	0%	0	30	0%	0	30	0%
	July	7	31	**23%**	4	31	**13%**	17	31	**55%**
	Aug	23	31	**74%**	1	31	**3%**	31	31	**100%**
	Sep	2	30	**7%**	0	30	0%	1	30	**3%**
NF7	June	0	30	0%	0	30	0%	0	30	0%
	July	13	31	**42%**	4	31	**13%**	19	31	**61%**
	Aug	18	31	**58%**	2	31	**6%**	28	31	**90%**
	Sep	2	30	**7%**	1	30	**3%**	0	30	0%
NF8	June	8	30	**27%**	4	30	**13%**	10	30	**33%**
	July	31	31	**100%**	22	31	**71%**	31	31	**100%**
	Aug	23	31	**74%**	23	31	**74%**	31	31	**100%**
	Sep	3	30	**10%**	6	30	**20%**	1	30	**3%**
Rock Creek Reach										
NF10	June	5	5	**100%**	0	30	0%	0	30	0%
	July	29	31	**94%**	13	31	**42%**	26	31	**84%**
	Aug	31	31	**100%**	27	31	**87%**	31	31	**100%**
	Sep	5	30	**17%**	6	30	**20%**	2	30	**7%**
NF11	June	6	30	**20%**	0	30	0%	3	30	**10%**
	July	31	31	**100%**	20	31	**65%**	28	31	**90%**
	Aug	29	31	**94%**	22	31	**71%**	31	31	**100%**
	Sep	4	30	**13%**	6	30	**20%**	2	30	**7%**
NF12	June	6	30	**20%**	0	30	0%	4	30	**13%**
	July	31	31	**100%**	20	31	**65%**	29	31	**94%**
	Aug	28	31	**90%**	21	31	**68%**	31	31	**100%**
	Sep	4	30	**13%**	6	30	**20%**	2	30	**7%**
NF13	June	6	30	**20%**	0	30	0%	0	30	0%
	July	26	31	**84%**	4	31	**13%**	6	31	**19%**
	Aug	10	31	**32%**	7	31	**23%**	0	31	0%
	Sep	0	30	0%	0	30	0%	0	30	0%
Cresta Reach										
NF14	June	4	30	**13%**	0	30	0%	0	30	0%
	July	31	31	**100%**	10	31	**32%**	24	31	**77%**
	Aug	27	31	**87%**	11	31	**35%**	30	31	**97%**
	Sep	4	30	**13%**	2	30	**7%**	0	30	0%
NF15	June	5	30	**17%**	0	30	0%	0	30	0%
	July	31	31	**100%**	14	31	**45%**	24	31	**77%**
	Aug	26	30	**84%**	12	31	**39%**	29	31	**94%**
	Sep	4	30	**13%**	4	30	**13%**	0	30	0%
NF16	June	6	30	**20%**	0	30	0%	1	30	**3%**
	July	31	31	**100%**	17	31	**55%**	28	31	**90%**
	Aug	28	31	**90%**	14	31	**45%**	31	31	**100%**
	Sep	4	30	**13%**	5	30	**17%**	2	30	**7%**

Table 2-3a Summary of 2002 - 2004 Mean Daily Water Temperature Comparison with the 20°C Level along the NFFR Reaches (Continued)

Station	Month	2002			2003			2004		
		Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C
Poe Reach										
NF17	June	5	30	**17%**	0	30	0%	1	30	**3%**
	July	31	31	**100%**	15	31	**48%**	29	31	**94%**
	Aug	31	31	**100%**	19	31	**61%**	31	31	**100%**
	Sep	4	27	**15%**	5	30	**17%**	2	15	**13%**
NF18	June	24	30	**80%**	12	30	**40%**	15	30	**50%**
	July	31	31	**100%**	28	31	**90%**	31	31	**100%**
	Aug	31	31	**100%**	31	31	**100%**	31	31	**100%**
	Sep	4	26	**15%**	7	30	**23%**	9	15	**60%**

Notes:

1) *Refer to Figure 2-1 for station locations*
2) *NF17: NFFR below Poe Dam.*
3) *NF18: NFFR above Poe PH.*

Table 2-3b Summary of 2002 - 2004 Mean Daily Water Temperature Comparison with the 20°C Level at the NFFR Powerhouse Discharges

Powerhouse	Month	2002			2003			2004		
		Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C	Days Greater than 20°C	Total Data Days	Percent Greater than 20°C
Butt Valley PH	June	0	4	0%	0	28	0%	0	22	0%
	July	20	29	**69%**	0	31	0%	13	31	**42%**
	Aug	31	31	**100%**	9	31	**29%**	31	31	**100%**
	Sep	5	30	**17%**	5	27	**19%**	3	30	**10%**
Caribou #1 PH	June	0	5	0%	0	2	0%	0	2	0%
	July	10	29	**34%**	0	14	0%	15	31	**48%**
	Aug	31	31	**100%**	0	31	0%	31	31	**100%**
	Sep	8	31	**27%**	4	25	**16%**	6	21	**29%**
Caribou #2 PH	June	8	30	**27%**	0	30	0%	14	30	**47%**
	July	28	28	**100%**	13	24	**54%**	26	26	**100%**
	Aug	31	31	**100%**	31	31	**100%**	31	31	**100%**
	Sep	13	30	**43%**	14	30	**47%**	13	30	**43%**
Belden PH	June	0	7	0%	0	30	0%	0	20	0%
	July	25	29	**86%**	9	31	**29%**	26	31	**84%**
	Aug	31	31	**100%**	31	31	**100%**	31	31	**100%**
	Sep	NA	NA	NA	10	30	**33%**	10	30	**33%**
Rock Creek PH	June	1	30	**3%**	0	30	0%	3	30	**10%**
	July	29	31	**94%**	17	31	**55%**	29	31	**94%**
	Aug	31	31	**100%**	31	31	**100%**	31	31	**100%**
	Sep	11	30	**37%**	10	30	**33%**	18	30	**60%**
Cresta PH	June	5	30	**17%**	0	30	0%	0	30	0%
	July	30	30	**100%**	13	31	**42%**	24	31	**77%**
	Aug	31	31	**100%**	16	31	**52%**	31	31	**100%**
	Sep	5	30	**17%**	2	30	**7%**	2	30	**7%**

Table 2-4 Summary of Observed Mean Daily Water Temperatures during July 2003 Caribou Special Test

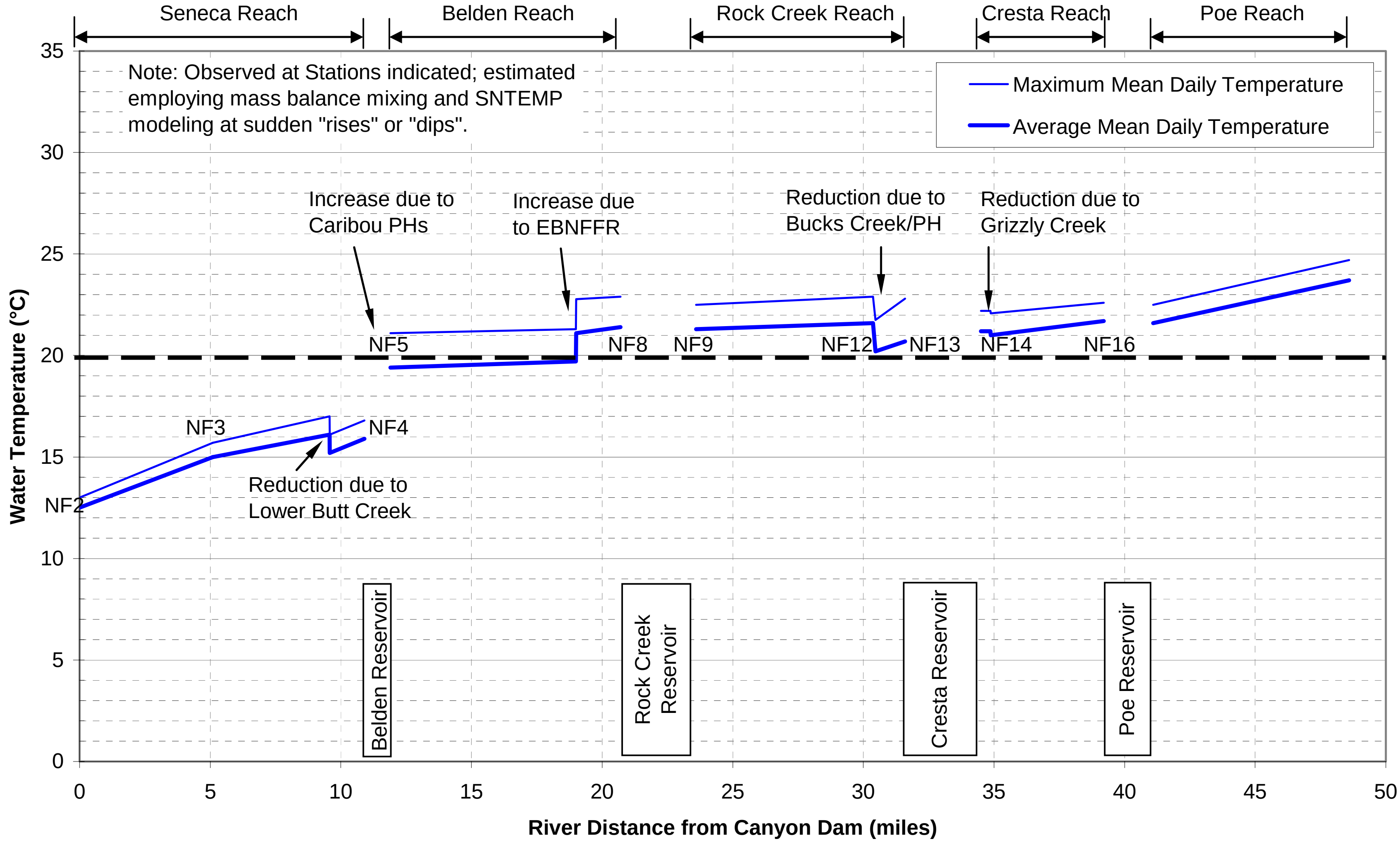
Date	Caribou No. 1 Temperature (°C)	Caribou No. 1 Flow (cfs)	Caribou No. 2 Temperature (°C)	Caribou No. 2 Flow (cfs)	Resultant Caribou Blend * (°C)	Belden Forebay (BD1) (°C)	NFFR below Belden Dam (NF5) (°C)	NFFR above EBNFFR (NF7) (°C)	EBNFFR above NFFR (EB1) (°C)	NFFR above Belden PH (NF8) (°C)	Remarks
07/12/03	---	9	20.1	1076	20.1	19.7	18.8	18.9	22.5	20.8	Part 1
07/13/03	---	7	20.0	1172	20.0	19.8	19.0	18.9	22.4	20.7	Part 1
07/14/03	---	0	20.2	1214	20.2	19.8	19.2	19.1	22.3	20.7	Part 1
07/15/03	---	14	20.5	1270	20.5	20.1	19.4	19.3	22.5	20.9	Part 1
07/16/03	---	57	20.6	1191	20.6	20.2	19.4	19.4	22.7	21.1	Part 1
07/17/03	---	66	21.0	1250	21.0	20.3	19.6	19.5	22.8	21.1	Part 1
07/18/03	16.4	893	---	67	16.4	19.1	18.3	19.1	23.2	21.3	Part 2
07/19/03	16.8	940	---	21	16.8	17.5	17.2	18.6	23.8	21.2	Part 2
07/20/03	17.0	994	---	12	17.0	17.3	17.1	18.5	24.4	21.4	Part 2
07/21/03	17.5	996	---	0	17.5	17.6	17.2	18.8	25.4	22.0	Part 2
07/22/03	17.8	996	---	0	17.8	17.8	17.4	19.0	25.8	22.1	Part 2
07/23/03	18.0	997	---	9	18.0	18.1	17.6	19.0	26.4	22.3	Part 2
07/24/03	18.4	992	---	3	18.4	18.4	17.8	19.0	25.8	22.0	Part 2
07/25/03	18.4	564	---	3	18.4	19.8	18.1	19.0	25.1	21.8	Part 2
07/26/03	18.4	628	23.0	897	21.1	20.9	18.5	19.1	24.7	21.6	Part 3
07/27/03	18.8	495	23.0	1001	21.6	21.3	19.4	19.6	24.5	21.7	Part 3
07/28/03	19.1	495	23.0	842	21.5	21.4	20.0	20.4	24.9	22.4	Part 3
07/29/03	19.0	552	23.4	904	21.7	21.5	20.1	20.6	25.4	22.9	Part 3
07/30/03	19.1	460	23.2	874	21.8	21.7	20.5	20.7	25.6	23.0	Part 3

** Based on mass balance calculations.*

Table 2-4 Summary of Observed Water Temperatures during July 2003 Caribou Special Test (Continued)

Date	Belden PH Temperature (°C)	Belden PH Flow (cfs)	NFFR below Rock Creek Dam (NF9) (°C)	NFFR Above Bucks Creek (NF12) (°C)	NFFR above Rock Creek PH (NF13) (°C)	NFFR below Cresta Dam (NF14) (°C)	NFFR above Cresta PH (NF16) (°C)	NFFR below Poe Dam (°C)	NFFR above Poe PH (°C)	Remarks
07/12/03	19.6	984	19.8	20.1	18.2	19.4	19.8	19.6	21.8	Part 1
07/13/03	19.8	1086	19.9	20.2	18.2	19.5	20.0	19.9	21.9	Part 1
07/14/03	19.8	1172	19.8	20.0	18.1	19.6	19.9	19.9	21.9	Part 1
07/15/03	20.1	1140	20.1	20.3	18.3	19.7	20.1	19.9	22.0	Part 1
07/16/03	20.2	1221	20.2	20.5	18.4	19.9	20.2	20.2	22.1	Part 1
07/17/03	20.3	1199	20.2	20.5	18.4	19.9	20.3	20.3	22.1	Part 1
07/18/03	19.5	900	20.4	20.7	18.5	20.0	20.4	20.3	22.3	Part 2
07/19/03	17.8	913	19.7	21.1	18.8	20.2	20.8	20.5	22.7	Part 2
07/20/03	17.4	903	19.1	21.0	18.7	19.6	20.6	20.2	22.7	Part 2
07/21/03	17.6	957	19.3	21.3	19.0	19.6	20.9	20.0	23.4	Part 2
07/22/03	17.9	962	19.6	21.5	19.2	19.8	21.0	20.1	23.6	Part 2
07/23/03	18.2	944	19.9	21.7	19.3	20.1	21.2	20.4	23.9	Part 2
07/24/03	18.4	932	19.8	21.4	19.1	20.1	21.2	20.5	23.6	Part 2
07/25/03	19.5	1352	19.9	21.1	18.8	19.9	21.0	20.3	23.3	Part 2
07/26/03	20.8	1441	20.7	21.1	18.8	20.1	20.5	20.4	23.1	Part 3
07/27/03	21.3	1323	21.2	21.2	19.8	20.6	21.0	20.8	22.8	Part 3
07/28/03	21.4	1318	21.5	21.8	20.5	21.4	21.7	21.4	23.2	Part 3
07/29/03	21.5	1413	21.7	22.4	22.3	21.7	22.2	22.0	23.9	Part 3
07/30/03	21.7	1361	22.0	22.7	23.0	22.1	22.7	22.4	24.5	Part 3

Figure 2-2 Observed and Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Observed Average Mean Daily Temperature at BD1 (Belden Forebay) = 21.5°C)



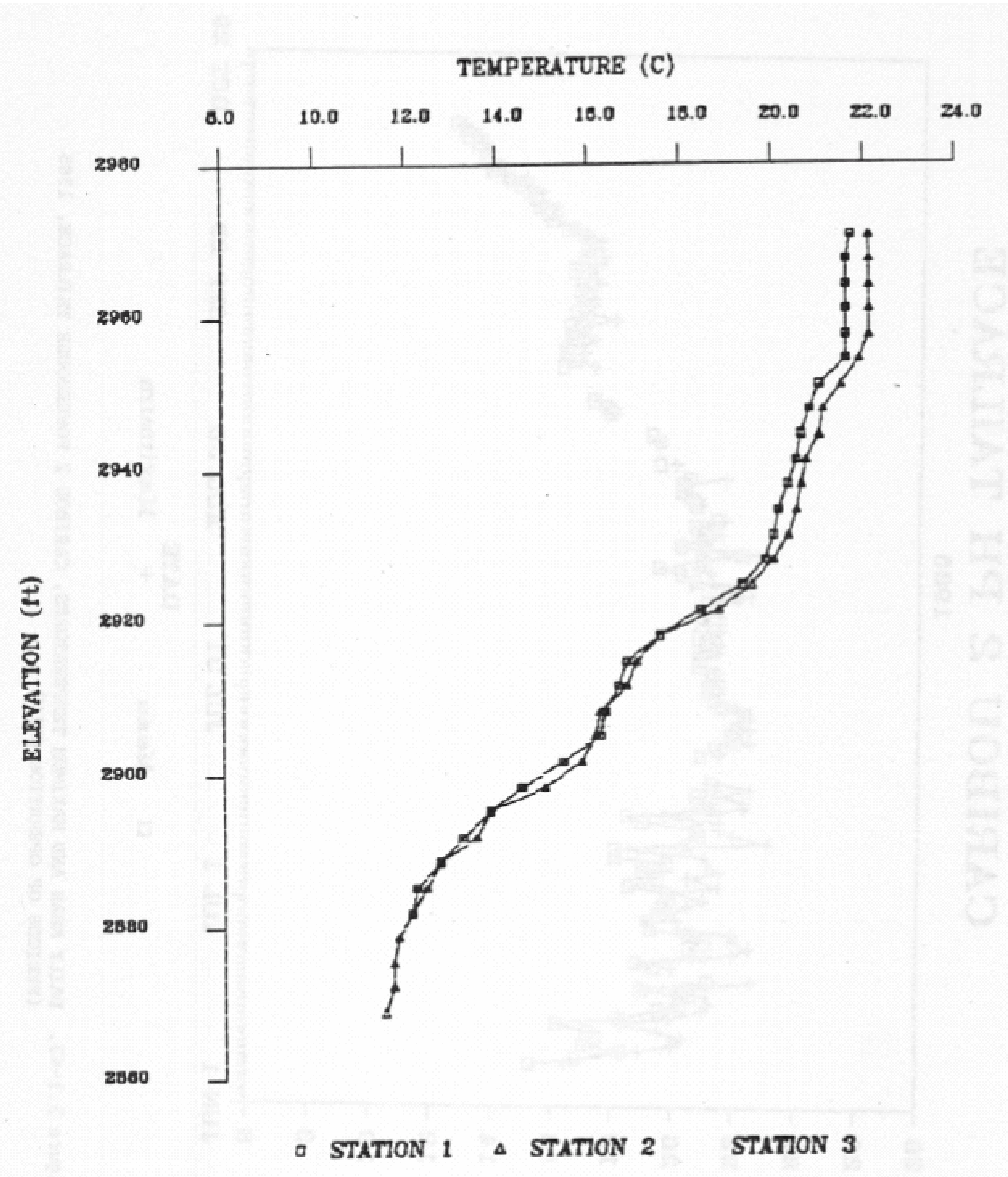


Figure 2-3a Belden Reservoir Temperature Profiles, June 21, 1985
(Source: Woodward-Clyde Consultants, 1986)

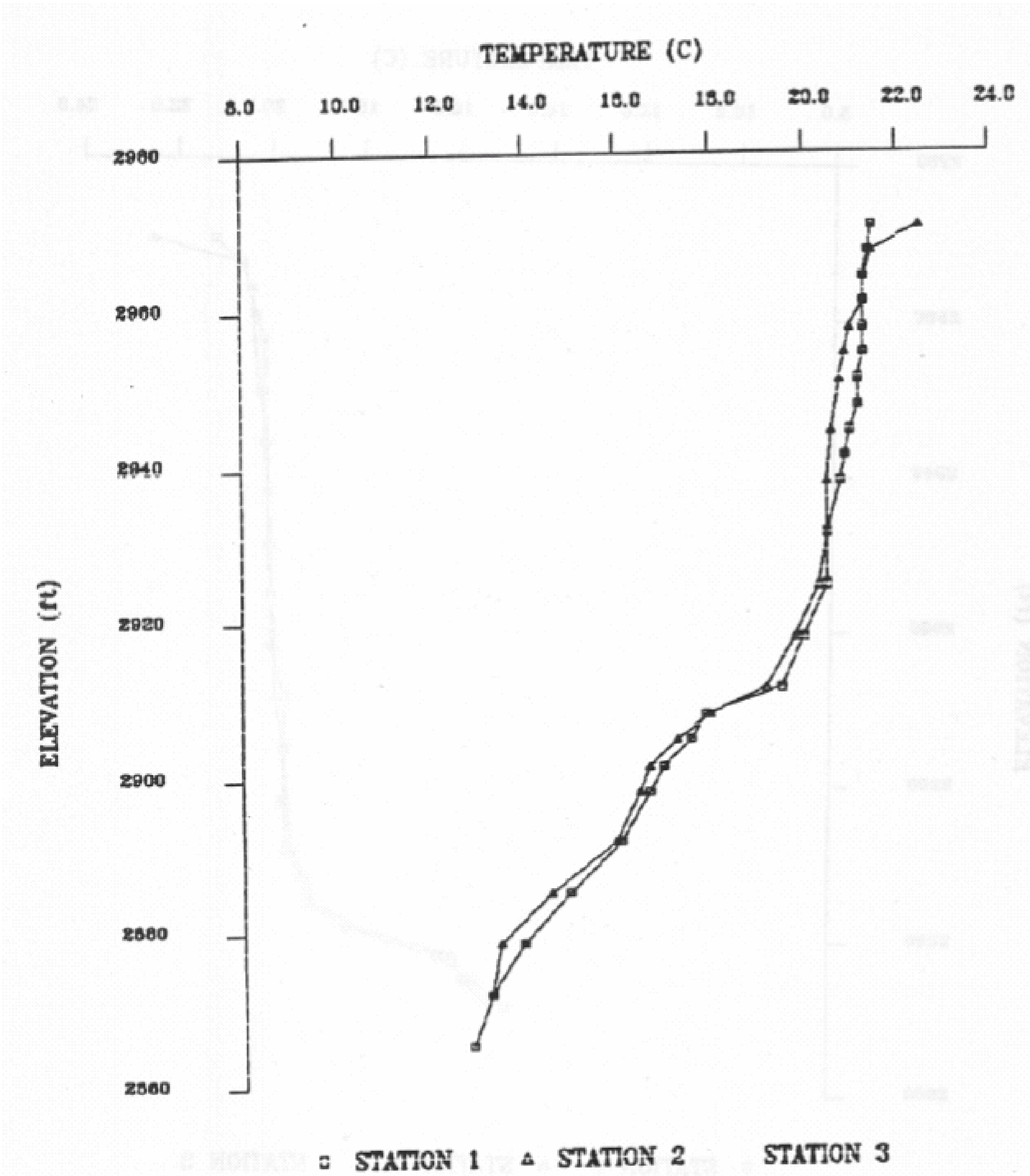


Figure 2-3b Belden Reservoir Temperature Profiles, July 12, 1985
(Source: Woodward-Clyde Consultants, 1986)

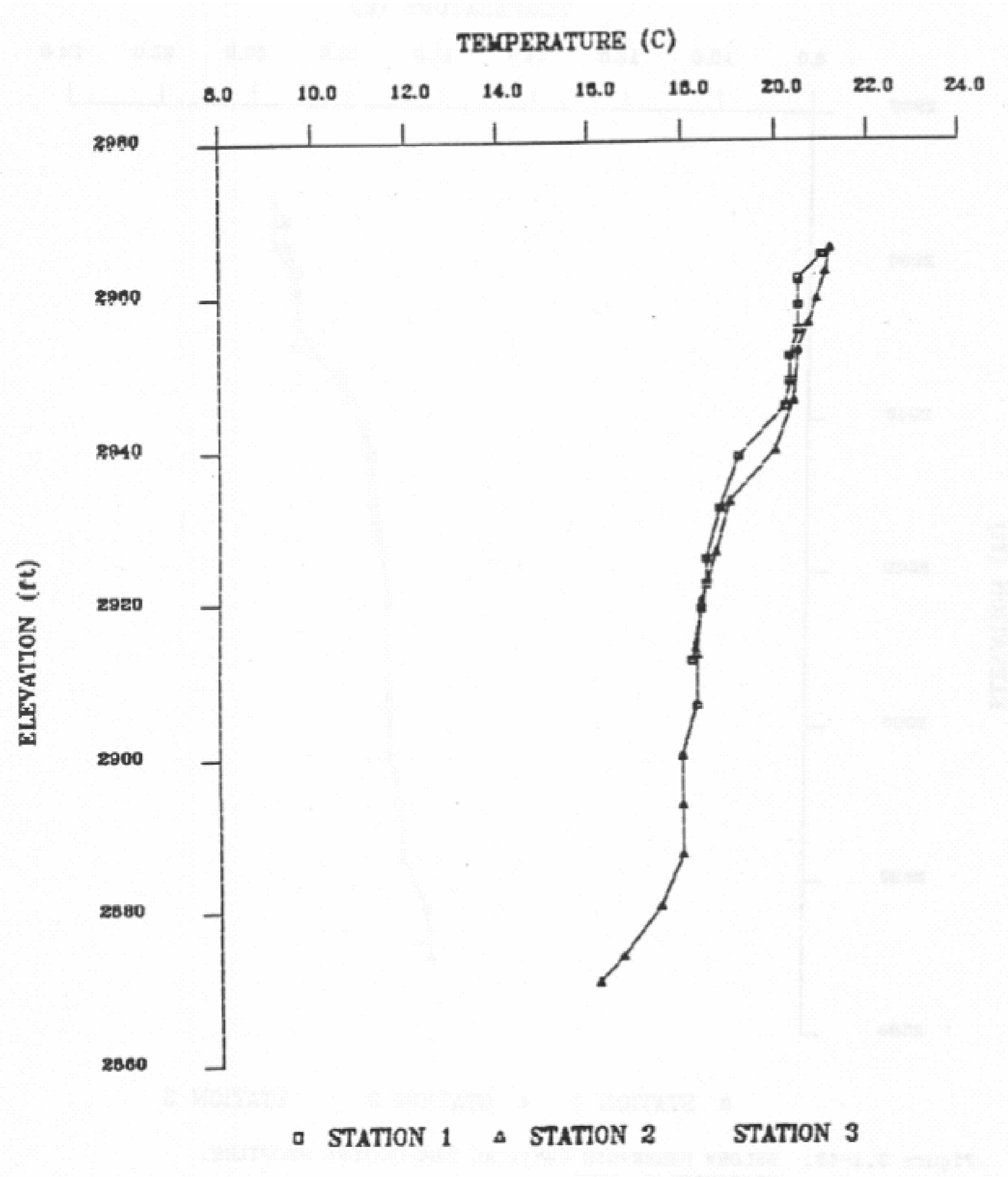


Figure 2-3c Belden Reservoir Temperature Profiles, August 20, 1985
(Source: Woodward-Clyde Consultants, 1986)

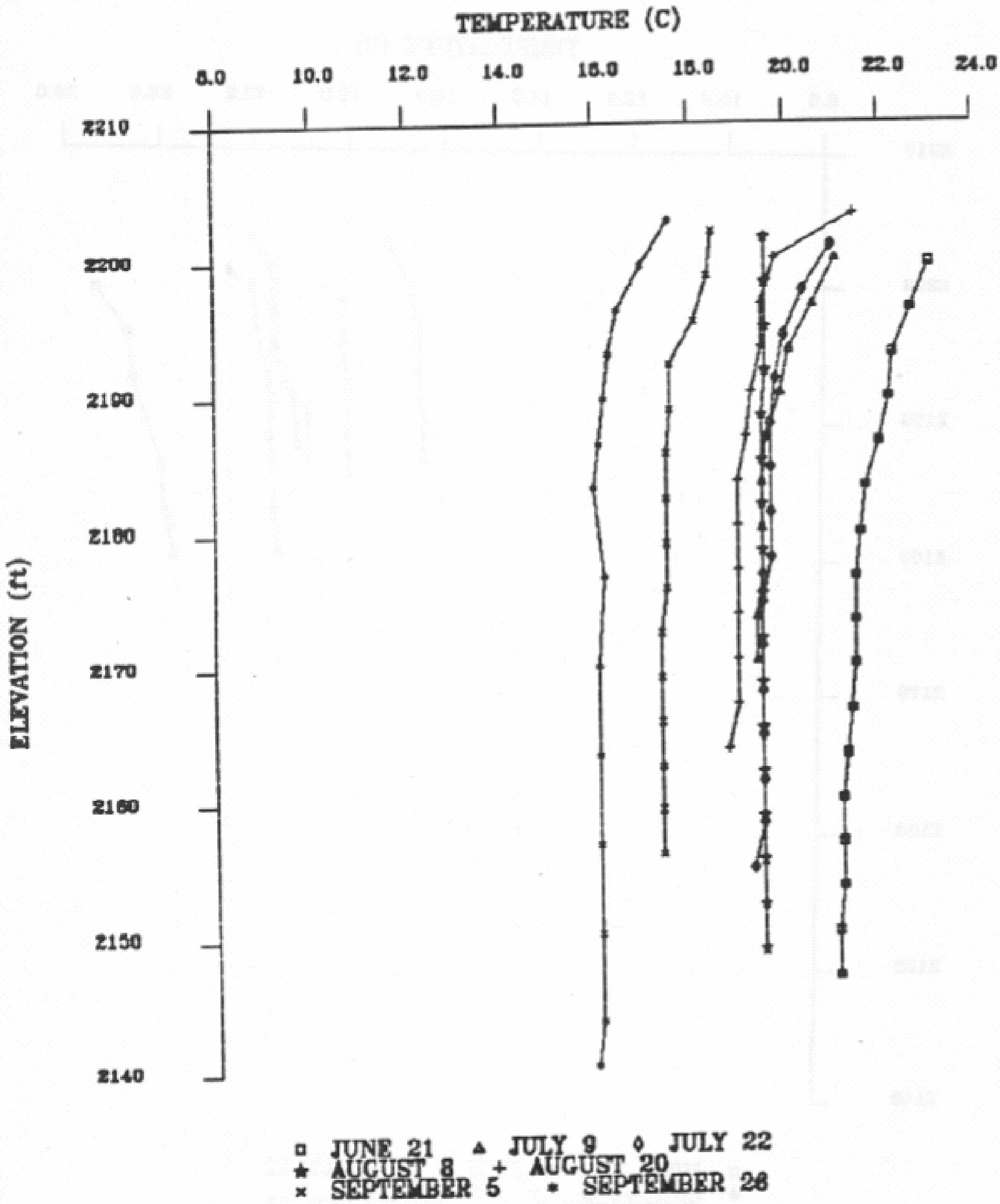


Figure 2-4 Rock Creek Reservoir Temperature Profiles near Rock Creek Dam, 1985 (Source: Woodward-Clyde Consultants, 1986)

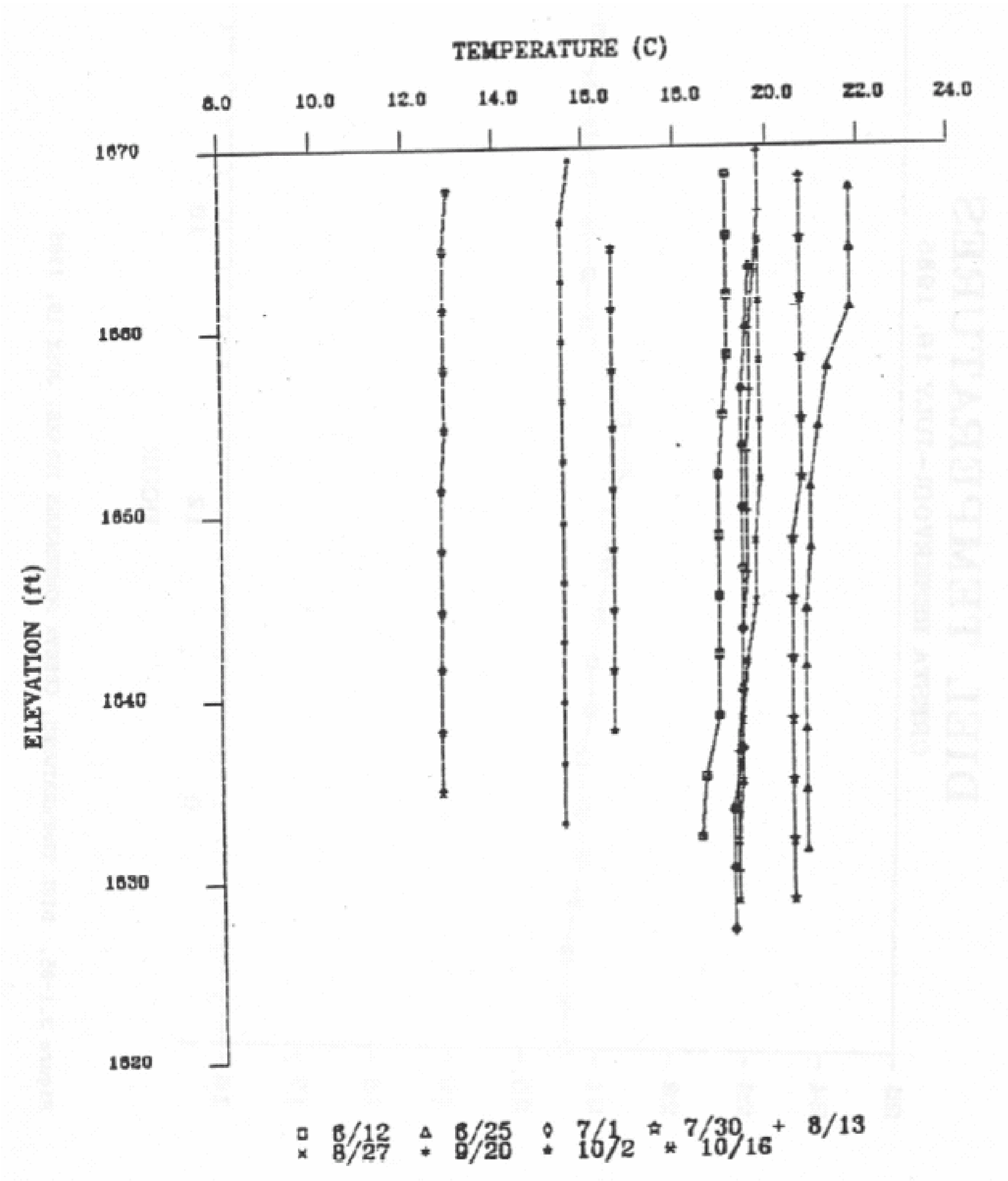


Figure 2-5 Cresta Reservoir Temperature Profiles near Cresta Dam, 1985
(Source: Woodward-Clyde Consultants, 1986)

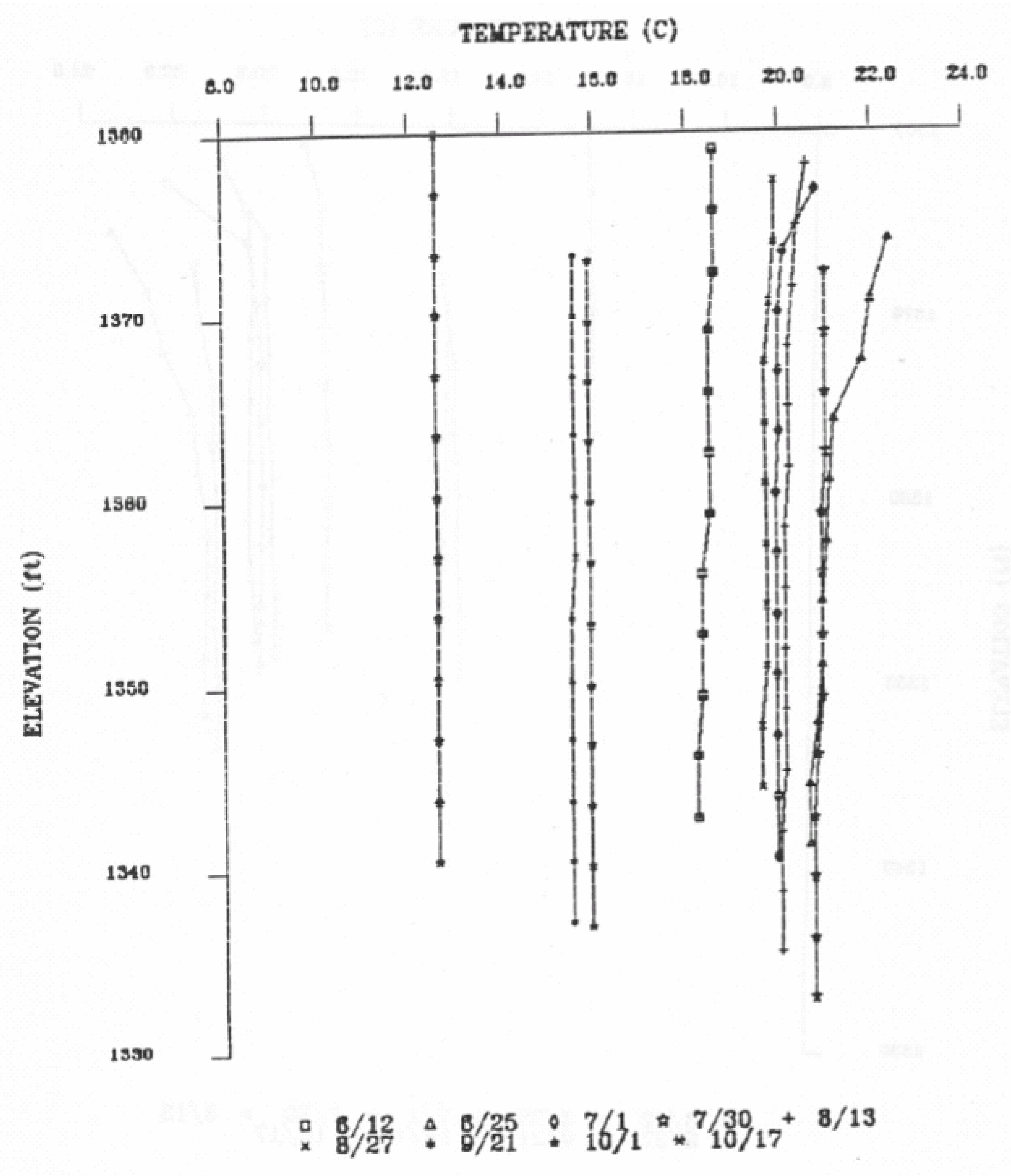


Figure 2-6 Poe Reservoir Temperature Profiles near Poe Dam, 1985
(Source: Woodward-Clyde Consultants, 1986)

Figure 2-7 Hourly Inflows to Belden Reservoir on 7/21 - 7/ 31, 2002

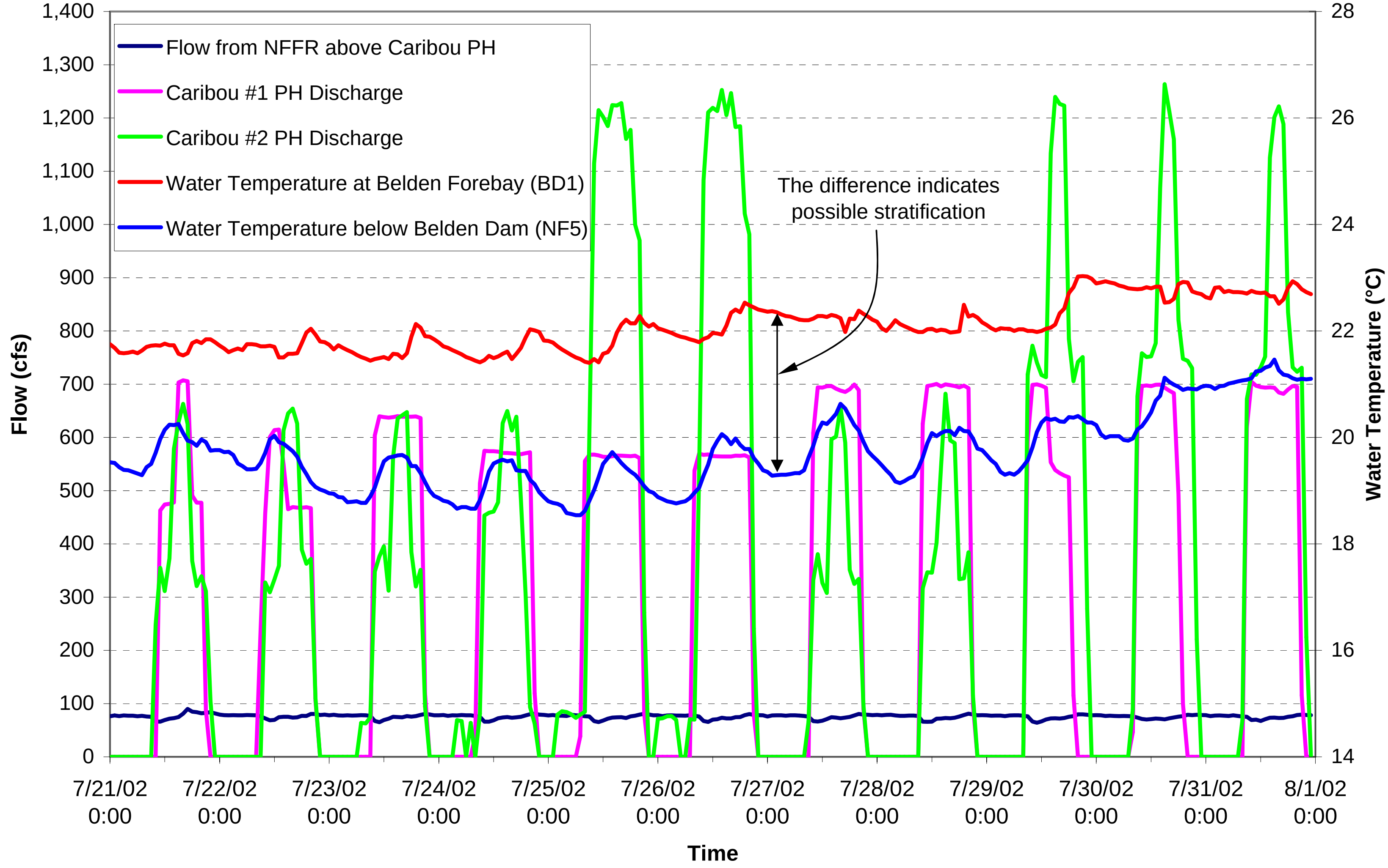


Figure 2-8 Hourly Inflows to Rock Creek Reservoir on 7/21 - 7/ 31, 2002

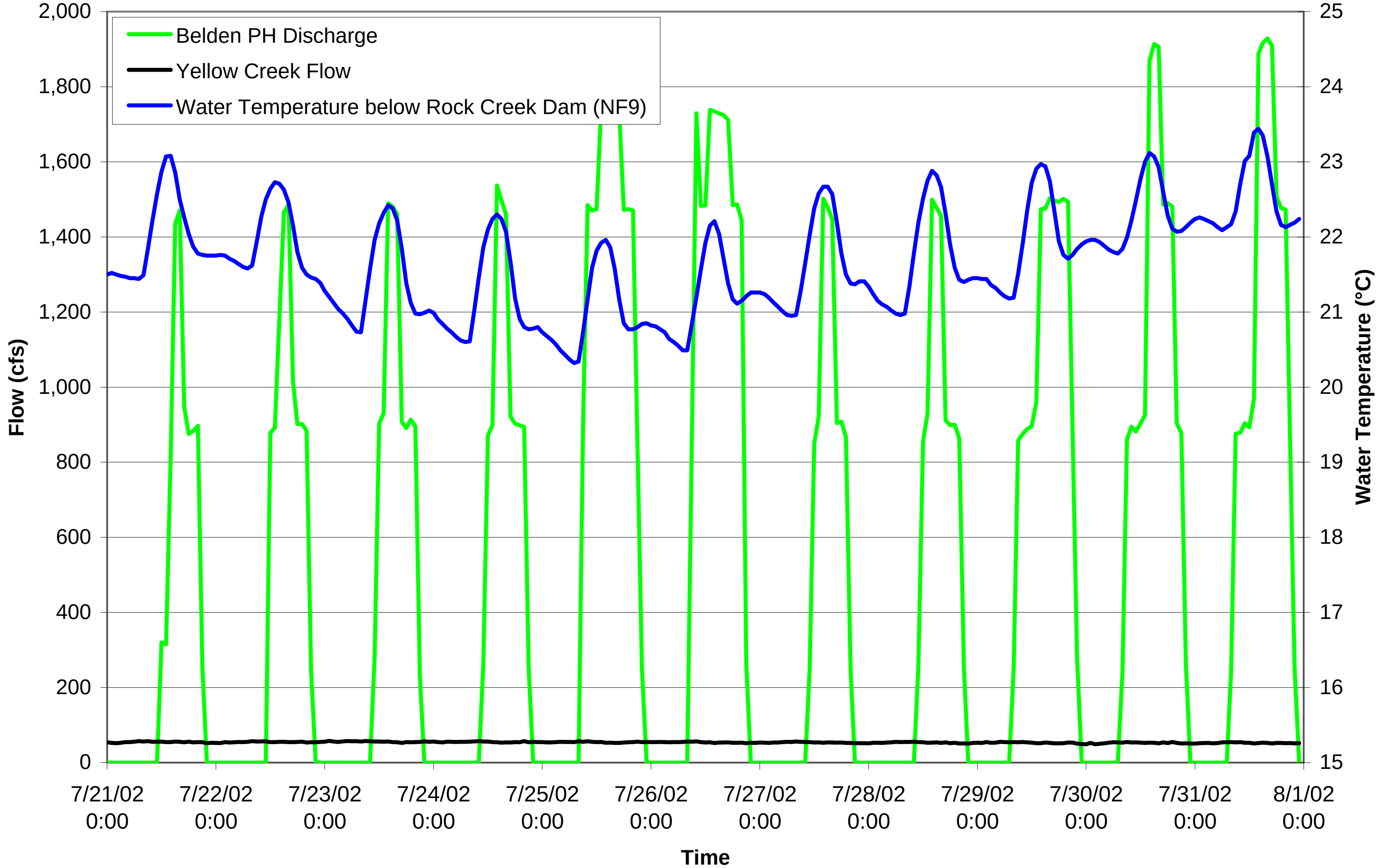


Figure 2-9 Observed Mean Daily Temperatures along NFFR during July 2003 Caribou Special Test

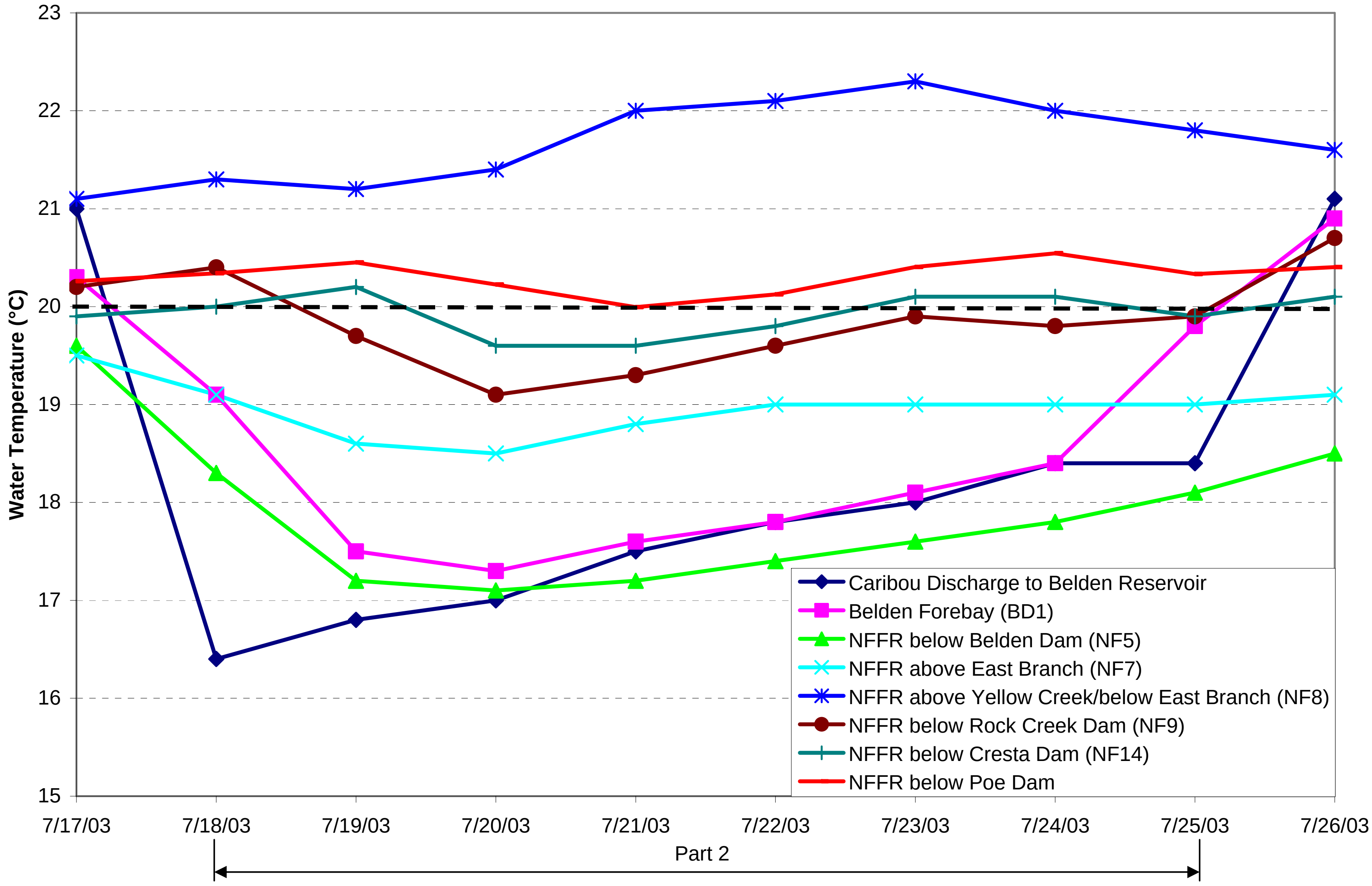


Figure 2-10 Observed Mean Daily Temperatures Indicating Possible Belden Reservoir Stratification during July 2003 Caribou Special Test

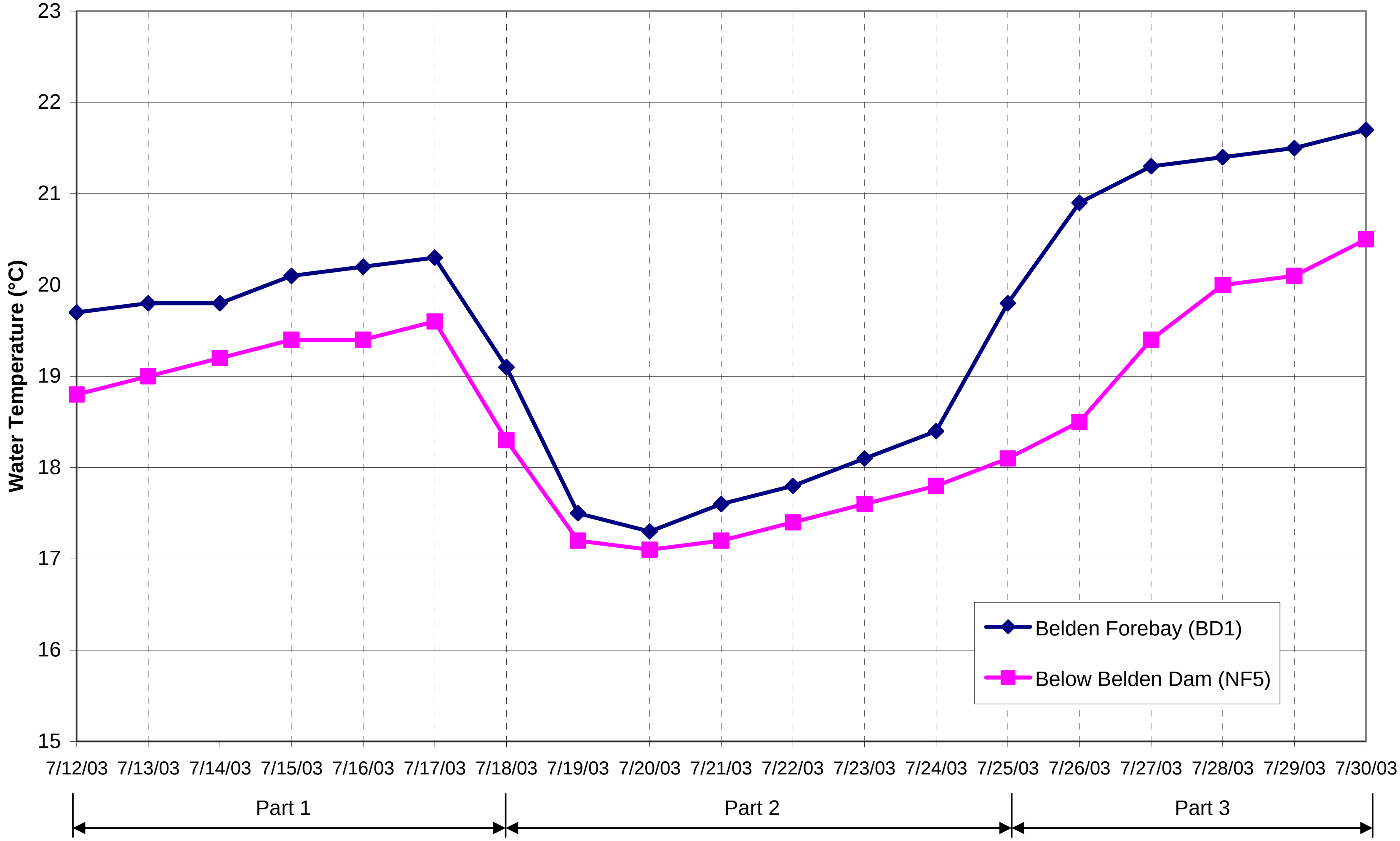


Figure 2-11 Observed Mean Daily Temperatures Indicating Possible Rock Creek Reservoir Warming during July 2003 Caribou Special Test

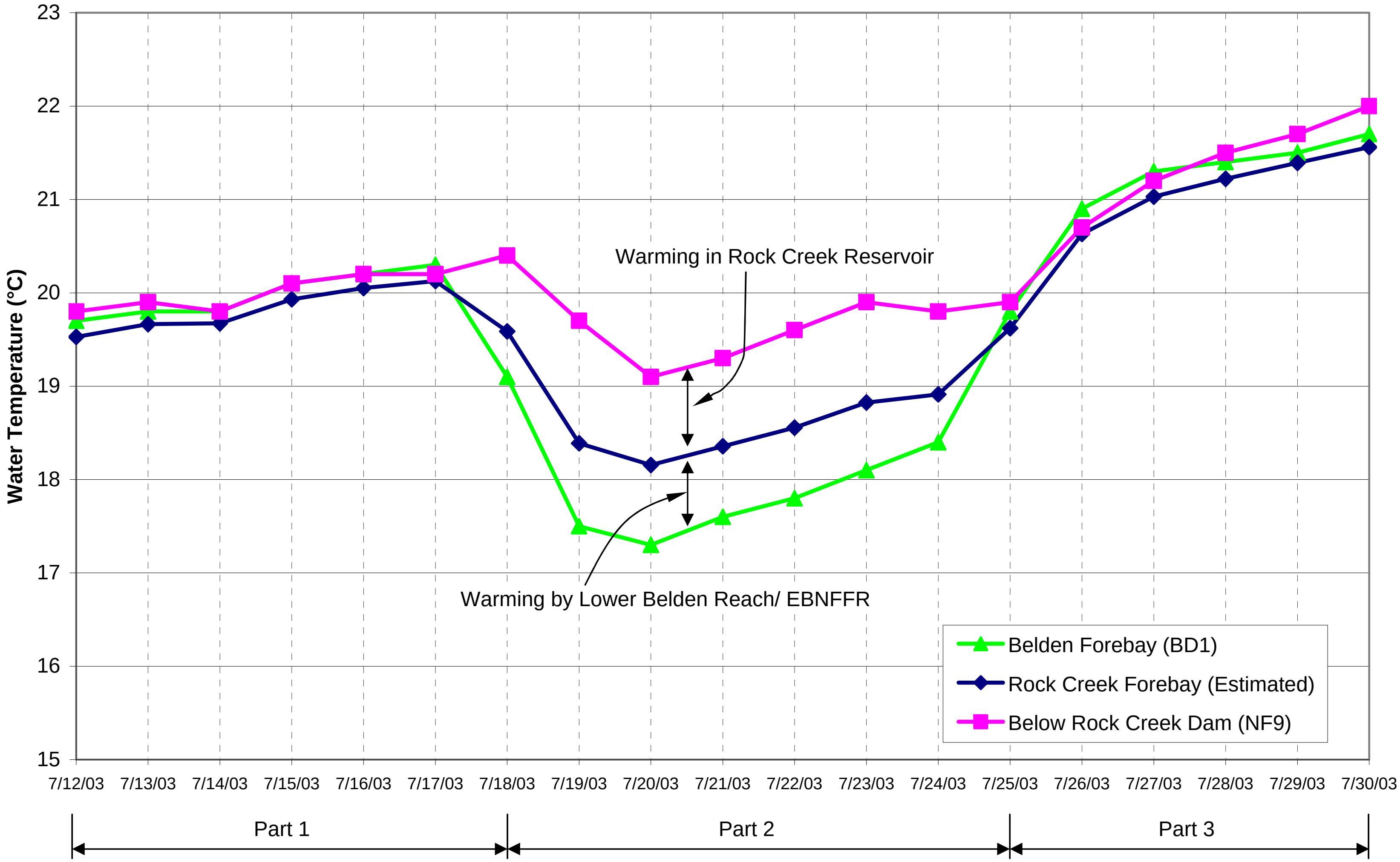


Figure 2-12 Belden Reservoir Water Temperature Profile Monitoring Sites and Current Velocity Transects during Summer 2006 Special Test

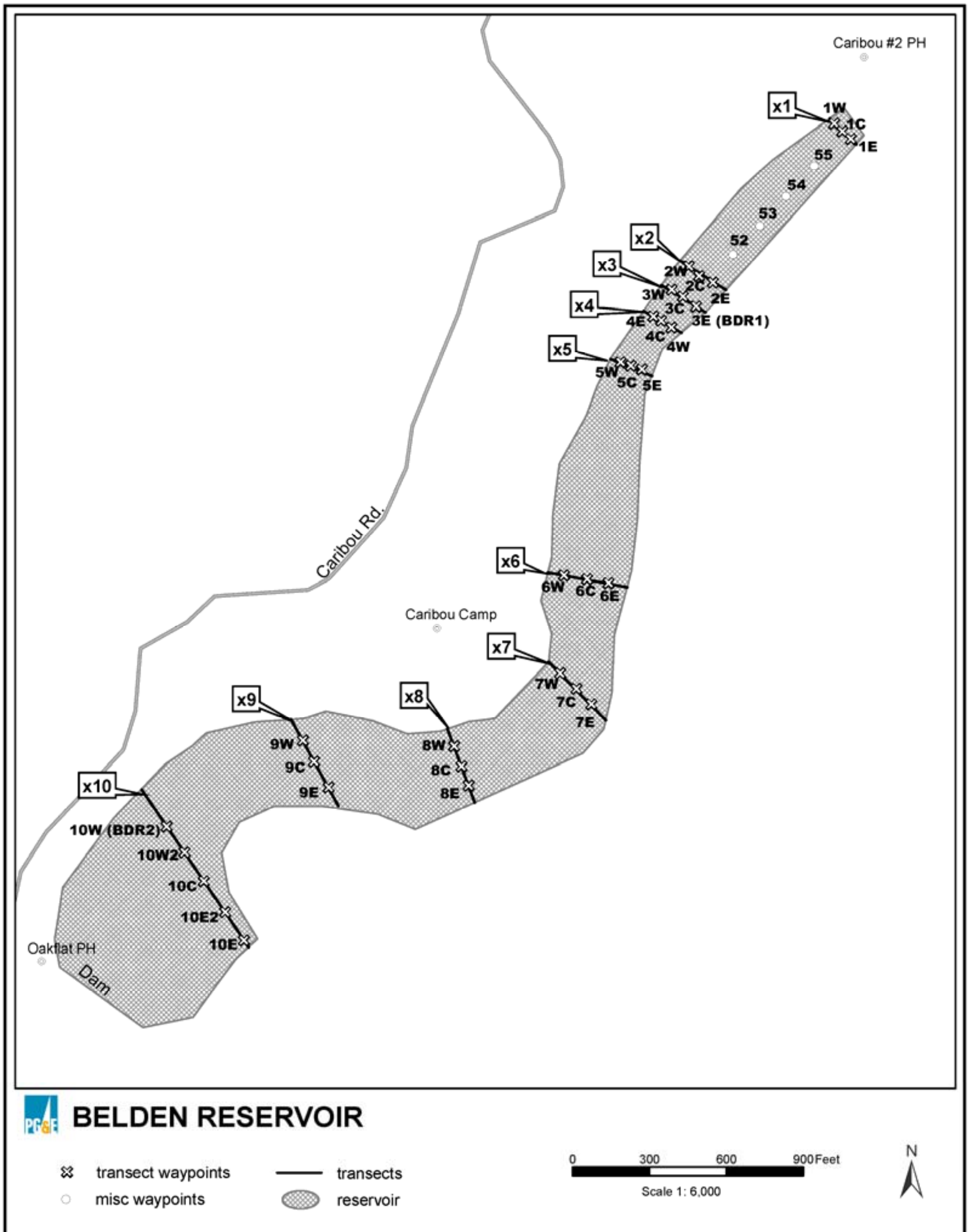


Figure 2-13 Belden Reservoir Temperature Profiles along the Centerline of the Upper Portion of the Reservoir during Summer 2006 Special Test (Caribou #2 was shutdown; Caribou #1 was operating at 527 cfs)

July 22, 2006, 11:00 am

(Refer to Figure 2-12 for monitoring locations)

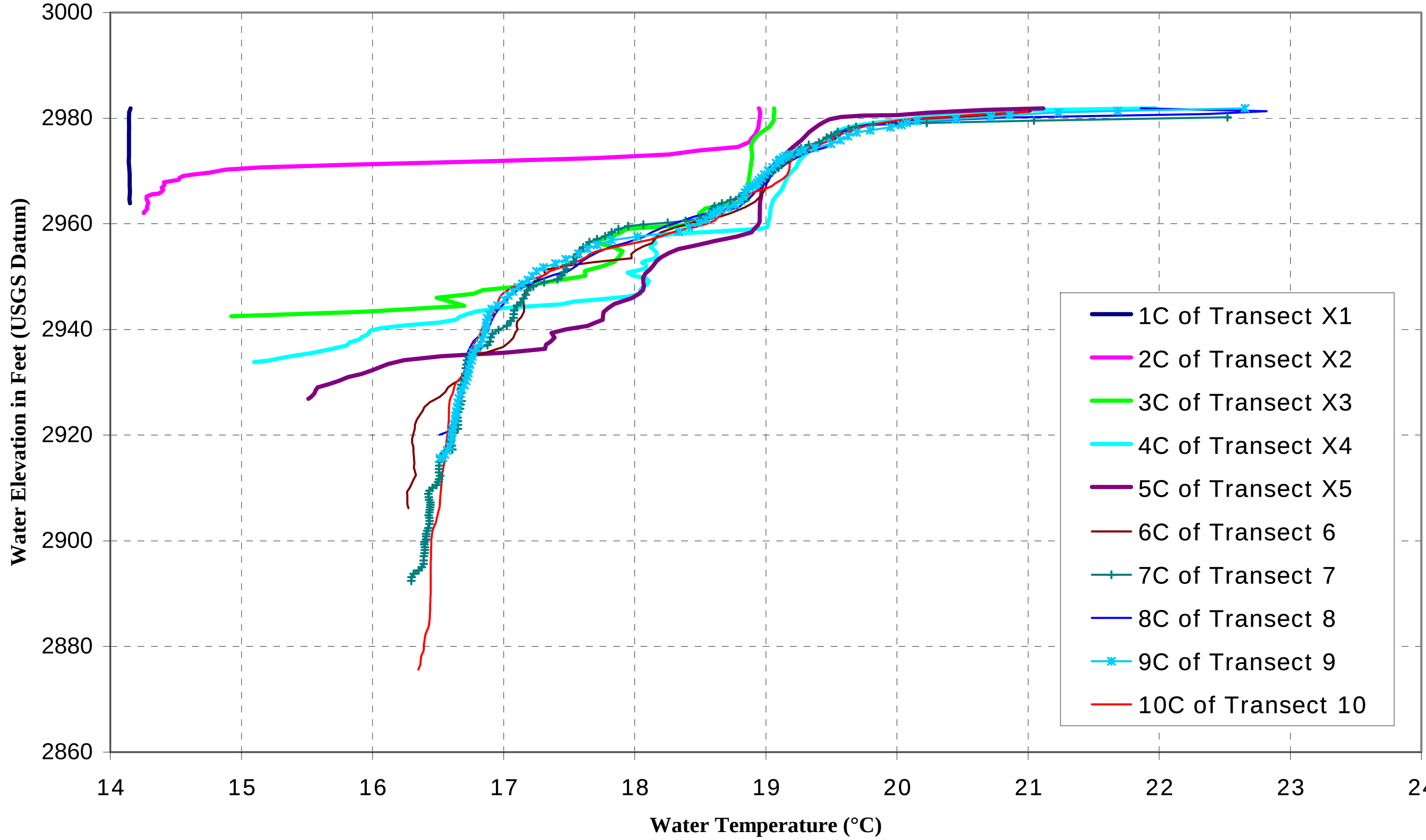


Figure 2-14 Observed Mean Daily Water Temperatures at Various Strata of Belden Reservoir near Dam (BDR2) during Summer 2006 Special Test
(Refer to Figure 2-12 for monitoring location BDR2)

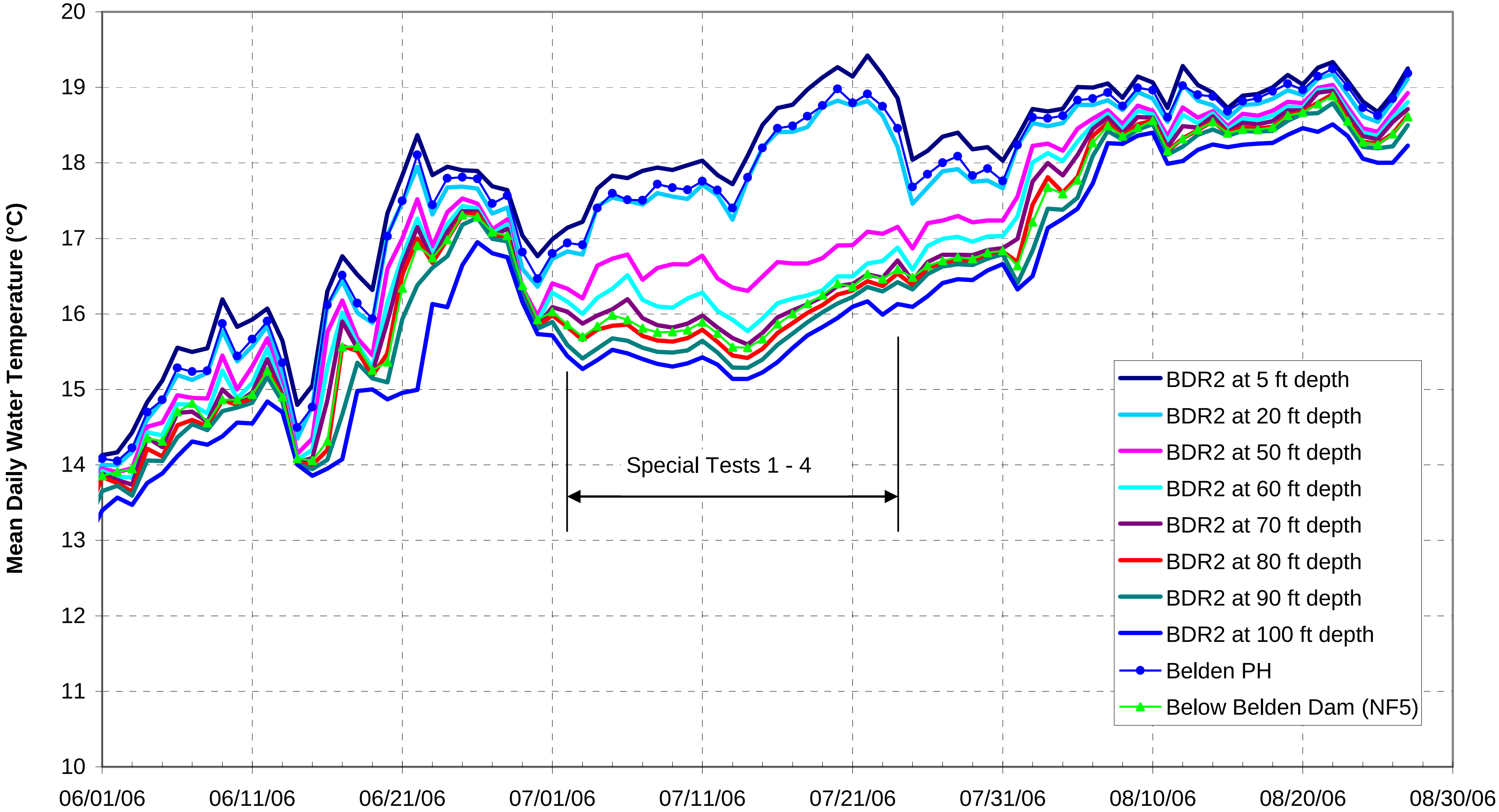


Figure 2-15 Observed Temperature Profiles of Rock Creek Reservoir near Dam during Summer 2006 Special Test

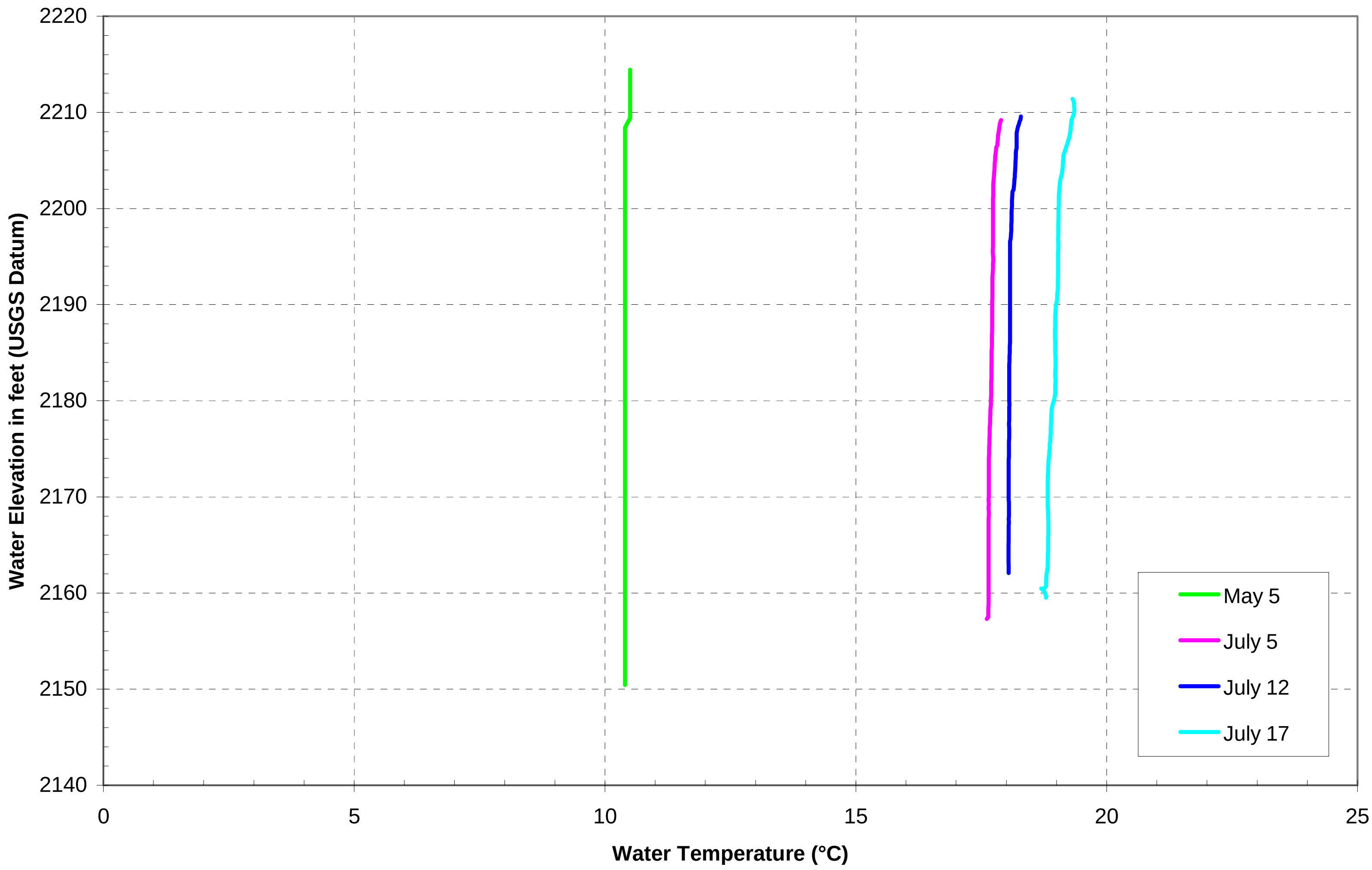


Figure 2-16 Observed Butt Valley PH Mean Daily Discharges and Discharge Water Temperatures during Summer 2006 Special Test

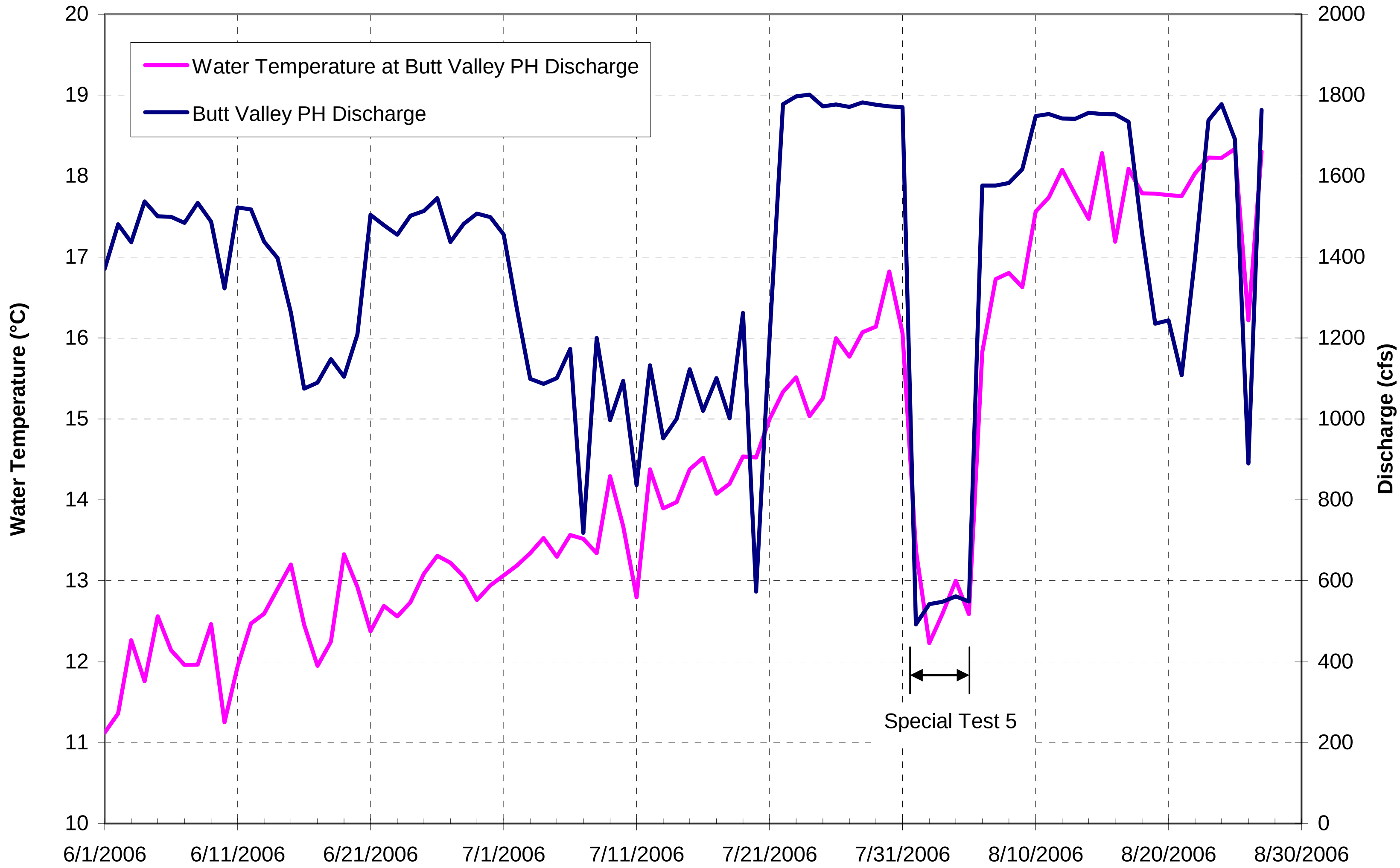


Figure 2-17 Butt Valley Reservoir Temperature Profile Monitoring Sites and Current Velocity Transects during Summer 2006 Special Test

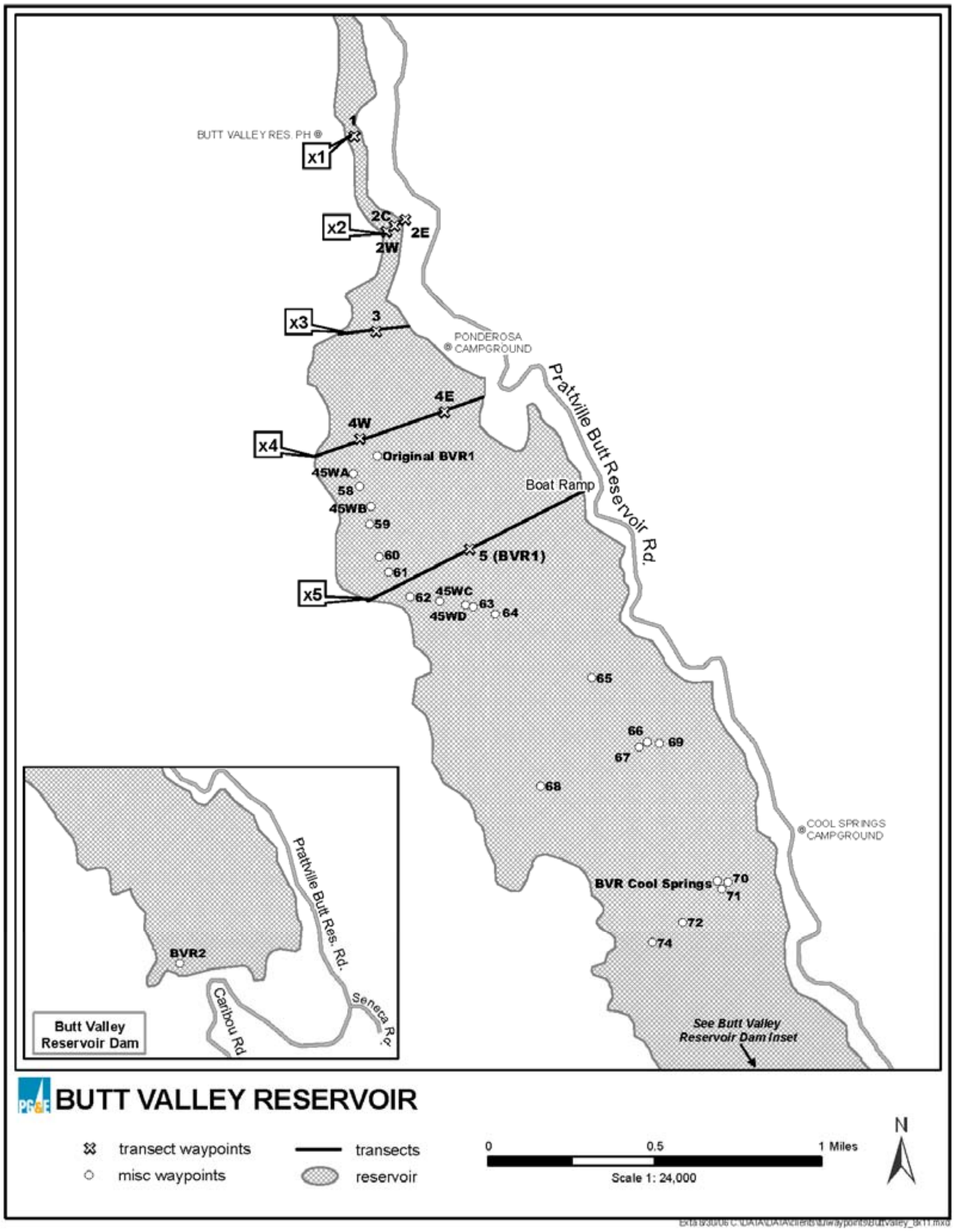
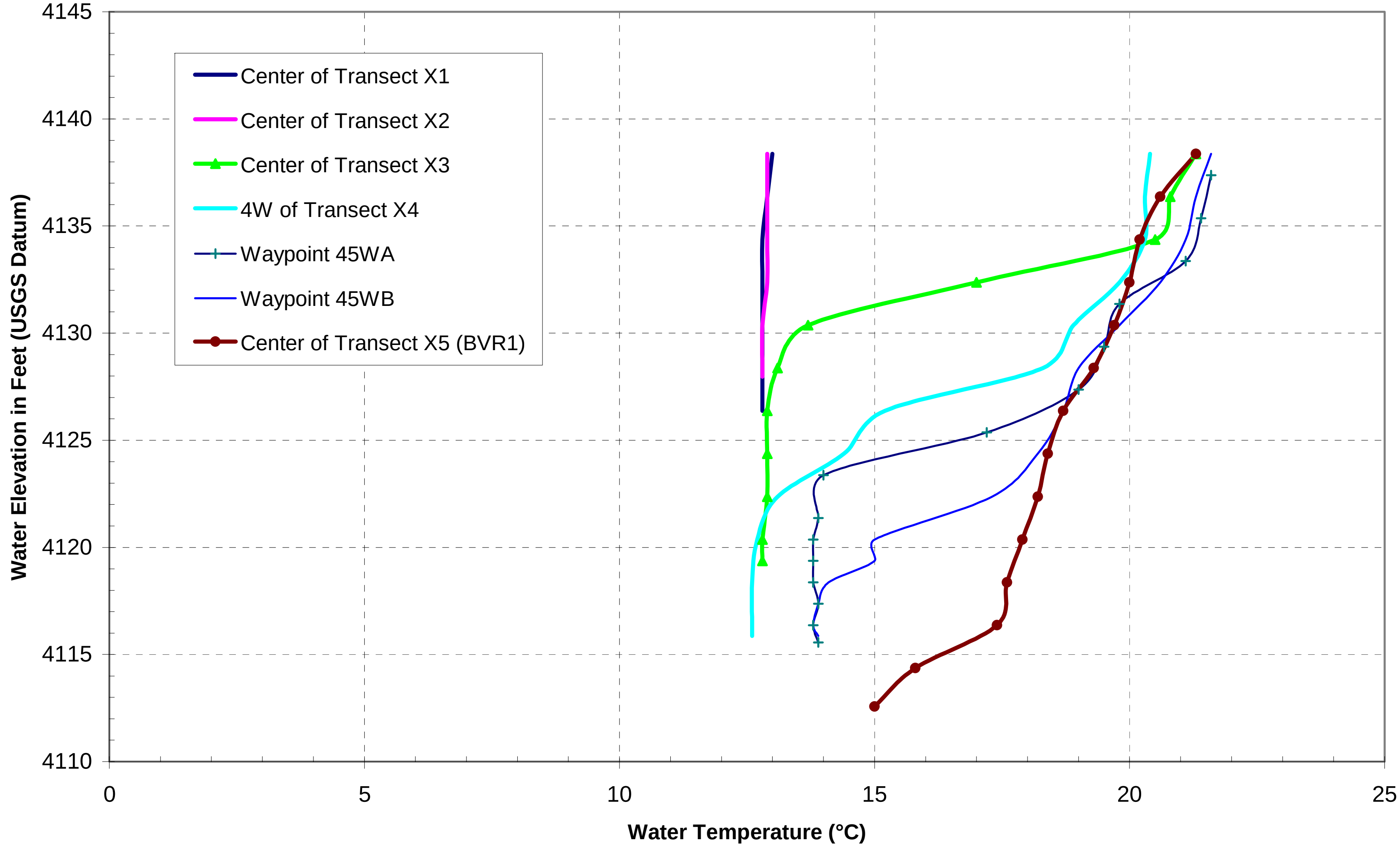


Figure 2-18 Observed Water Temperature Profiles along the Upper Portion of Butt Valley Reservoir August 3, 2006

(Refer to Figure 2-17 for monitoring locations)



3.0 FRAMEWORK FOR DEVELOPING AND SCREENING WATER TEMPERATURE REDUCTION ALTERNATIVES

Consistent with preparing an EIR, the CEQA alternative development process requires that alternatives evaluated in the EIR should be reasonable, feasible and implementable. The complexity of the NFFR system hydrology and thermal regime and the large number of potential water temperature reduction measures under consideration demands that a systematic approach be followed to develop and screen potential water temperature reduction alternatives (refer to Appendix C for presentation of potential water temperature reduction measures). This chapter describes the framework used for such an approach and introduces the resulting categories of potential water temperature reduction alternatives initially considered by the State Water Board in the Level 1 evaluation.

A temperature value of 20ºC *maximum* mean daily[20] was used as the water temperature target in the framework for developing Level 1 water temperature reduction alternatives. Using this screening target assured that 20ºC mean daily temperature would be accomplished on all days comprising the analysis period. Use of an *average* mean daily temperature of 20ºC as the target was considered, but this would have meant that in some days 20ºC mean daily temperature could be exceeded (provided that such exceedences were offset by days with mean daily temperatures less than 20ºC). Using a 20ºC *maximum* mean daily as the temperature target offers greater assurance that the water temperature reduction alternatives would be protective of cold freshwater habitat under all ambient conditions at specified locations within the NFFR. Further, 20ºC *maximum* mean daily is consistent with the target temperature required in the Rock Creek and Cresta Reaches under the Rock Creek – Cresta Relicensing Settlement Agreement.[21] As discussed in section 1.4, use of 20ºC *maximum* mean daily as the temperature target assumes that 20ºC is feasibly attainable through modifications to the UNFFR Project. This temperature target may be modified following Level 3 screening if, after advanced analysis, a different and more appropriate temperature target is identified as feasibly attainable through modification or re-operation of the UNFFR Project.

The month of July 2002 was used as the analysis period[22] in the framework. Data from this month represents the most adverse conditions for achieving the temperature target, as compared to all months during PG&E's summer 2002 – 2004 monitoring period. Any water temperature reduction alternative that could achieve the target during July 2002 could likely do so during the summer months of any wet, normal, and most dry years.[23]

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[20] It is important to distinguish between two terms that are used in this report; *maximum* mean daily temperature and *average* mean daily temperature. Mean daily temperature is defined as the computed mean value for a given calendar day based on the 24 hourly temperature measurements. In a month, there are 30 or 31 mean daily temperature values. The *maximum* mean daily temperature for a month is the highest of the 30 or 31 mean daily temperature values, and the *average* mean daily temperature is the computed average of the 30 or 31 mean daily temperatures values.

[21] The Rock Creek – Cresta Relicensing Settlement Agreement states: "In order to reasonably protect cold freshwater habitat, Licensee shall maintain mean daily water temperatures of 20 degrees Celsius or less in the Rock Creek and Cresta Reaches, to the extent that Licensee can reasonably control such temperatures".

[22] The thermal regime of the NFFR during PG&E's summer 2002 – 2004 monitoring period and, in particular, during July 2002 is explained in Chapter 2.

[23] Using the long-term meteorological data synthesized by PG&E for the Prattville Intake station from 1948 to 2001 and the observed meteorological data from 2002 to 2004, it is estimated that July 2002 meteorological conditions were more heat inducing than the 5% exceedance condition.

3.1 FRAMEWORK

The "framework concept" approaches the problem of reducing water temperatures along the entire NFFR by developing solutions on a reach-by-reach scale. Solutions identified in each reach become available as interchangeable measures that can be combined as necessary, constituting a comprehensive water temperature reduction alternative for the NFFR. The framework provides alternatives that focus on reducing the temperature of water delivered to and discharged from Belden Reservoir, then builds from this point by adding measures as necessary to satisfy the temperature needs in all reaches of the NFFR. Because most of the water delivered to the downstream reaches is dispatched from Belden Reservoir, it follows that temperature reduction at Belden Reservoir is central to temperature reduction in the downstream reaches. Other factors influence downstream NFFR temperatures, including warming due to inflows from the East Branch and atmospheric effects. Nonetheless, the cooler the water available for discharge from Belden Reservoir, the less the water needs to be cooled downstream to meet the target. Conversely, the warmer the water discharged from Belden Reservoir is, the more the water needs to be cooled downstream to meet the target. The framework provides alternatives that further reduce the temperature, as needed to achieve the temperature target along each of the four downstream reaches. Use of the framework concept allows for the formulation, analysis, and evaluation of a full range of alternative ways to reduce the temperature of water in Belden Reservoir combined with additional cooling along the downstream reaches. Since water temperature reduction at Belden Reservoir is central to temperature reduction in the downstream reaches, the framework defines and differentiates alternatives primarily by the amount and method of temperature reduction achieved at Belden Reservoir.

Because the temperature of water discharged from Belden Reservoir drives the amount of cooling required in the downstream reaches, an analysis was performed to determine, over a range of starting water temperatures in Belden Reservoir, the additional cooling that would be needed to achieve the temperature target in all downstream reaches. July 2002 water temperature profiles for the NFFR were estimated for a range of starting water temperatures in Belden Reservoir. The profiles were estimated based on July 2002 meteorological conditions, observed temperature changes in the Belden and Rock Creek Reservoirs, and use of temperature modeling of the Belden, Rock Creek, Cresta, and Poe Reaches, as described below:

a. PG&E developed SNTEMP models for all the NFFR reaches (i.e., Seneca, Belden, Rock Creek, Cresta, and Poe Reaches). The SNTEMP models were used to estimate the July 2002 water temperature profiles for a range of starting temperatures in Belden Reservoir.

   July 2002 meteorological data collected at the Prattville Intake station were used in the SNTEMP models for the Belden Reach, and data collected at the Rock Creek Dam meteorological station were used for the Rock Creek and Cresta Reaches. PG&E did not collect data at the Poe station in 2002, but did collect data in 1999, 2000, and 2003. Poe station humidity, solar radiation, and wind speed for July 2002 were estimated by averaging the data for July 1999, 2000, and 2003 – these were all normal water years. Poe station air temperature for July 2002 was estimated based on the July 2002 and 2003 air temperatures at the Rock Creek Dam station and the July 2003 air temperature at Poe station according to the following equation:

$$\text{Temperature}_{\text{Poe 2002}} = \text{Temperature}_{\text{RC 2002}} + (\text{Temperature}_{\text{Poe 2003}} - \text{Temperature}_{\text{RC 2003}})$$

Measured and calculated meteorology data used in the SNTEMP models is summarized in Table 3-1.

The SNTEMP models were run for one single time period, July 2002, using observed average mean daily flows and water temperatures. The results of the model runs were compared against the observed July 2002 average mean daily temperatures at stations along the NFFR (Table 3-2). The errors were in the range of -0.3ºC to +0.2ºC. For purposes of this effort, errors in this range were considered acceptable by Stetson and the State Water Board and the SNTEMP models were considered tested and verified.

b. Using the verified SNTEMP models, July 2002 average mean daily temperature profiles of the NFFR were estimated for a range of starting temperatures in Belden Reservoir. Flow and temperature inputs into the models consisted of observed July 2002 average mean daily flows and temperatures at the powerhouses and tributaries. Flow releases from dams that were input into the models were as follows:

    i) Belden Dam releases to Belden Reach were those given in the Partial Settlement, for Dry year conditions;

    ii) Rock Creek Dam releases to the Rock Creek Reach and Cresta Dam releases to the Cresta Reach were those given in the 2000 Relicensing Settlement Agreement for Rock Creek-Cresta, First 5-year Dry year conditions;

    iii) Poe Dam releases to the Poe Reach were those given in the 2005 Draft 4(e) Conditions, Dry year conditions for Poe (Figure 3-1).

c. The temperature profiles incorporate the following assumptions based on previously described observations from the July 2003 Caribou special test (Section 2.3.1):

    i) Temperatures below Belden Dam were assumed 1.0ºC lower than Belden Forebay when the forebay temperature was 19.5ºC; 0.5ºC lower when the forebay temperature was 18.5ºC; and no difference when the forebay temperature was 17.5ºC or lower;

    ii) Temperatures in the lower (farther downstream) part of Rock Creek Reservoir were assumed 0.6ºC warmer than the upper part when the Belden Forebay temperature was 18.5ºC; 1.0ºC warmer when the forebay temperature was 17.5ºC; and no difference when the forebay temperature was 19.5ºC or higher.

d. Temperature profiles for July 2002 maximum mean daily temperature were estimated by first increasing the July 2002 average mean daily temperatures at the starting points of respective reaches by the same amounts of difference that were observed during the July 2002 monitoring. Then the profiles for the rest of the reaches were estimated using the SNTEMP models. The estimated average mean daily/maximum daily temperatures for specified Belden Reservoir temperatures are shown in Figures 3-2a – 3-2g and a summary of average mean daily temperatures for the range of specified Belden Reservoir temperatures is shown in Figure 3-3).

e. The temperature profiles show the following:

i) When the Belden Forebay temperature is 12.5ºC or lower, the target (average and maximum mean daily) is achieved along all reaches of the NFFR without the need for additional temperature reduction below Belden Reservoir (Figure 3-2g);

ii) When the Belden Forebay temperature is 14.5ºC the target (average and maximum mean daily) is achieved along all reaches of the NFFR without the need for additional temperature reduction below Belden Reservoir (Figure 3-2f), except for

- the lower portion of the Belden Reach below East Branch where the maximum mean daily temperature may exceed the target by up to 0.6ºC; and,
- the lower portion of the Poe Reach where the maximum mean daily temperature may exceed the target by up to 0.8ºC.

iii) When the Belden Forebay temperature is 15.5ºC the target (average and maximum mean daily) is achieved along all reaches of the NFFR without the need for additional temperature reduction below Belden Reservoir (Figure 3-2e), except for

- the portion of the Belden Reach below the East Branch where the maximum mean daily temperature may exceed the target by about 1.0ºC;
- the lower portion of the Cresta Reach where the maximum mean daily temperature may exceed the target by about 0.4ºC; and,
- the lower portion of the Poe Reach where both the average mean daily and maximum mean daily temperatures may exceed the target.

iv) When the Belden Forebay temperature is 16.5ºC the target (average mean daily) is achieved along all reaches of the NFFR without the need for additional temperature reduction below Belden Reservoir (Figure 3-2d), except for

- the portion of the Belden Reach below the East Branch where the average mean daily temperature may exceed the target slightly and the maximum mean daily temperature may exceed the target by about 1.4°C;
- the Rock Creek Reach where the maximum mean daily temperature may exceed the target by up to 0.5ºC;
- the Cresta Reach where the maximum mean daily temperature may exceed the target by up to 0.7ºC; and,
- the Poe Reach where both the maximum mean daily and average mean daily temperatures may exceed the target throughout the reach.

v) When the Belden Forebay temperature is either 17.5ºC or 18.5ºC the target (average mean daily and maximum mean daily) is generally achieved only along the upper Belden Reach above the East Branch – although a Belden Forebay temperature of 18.0ºC would assure that the maximum mean daily temperature meets the target. In all reaches of the NFFR below the East Branch, the target is generally exceeded. (Figured 3-2b and 3-2c).

vi) When the Belden Forebay temperature is 19.5ºC the target temperature (average mean daily) is achieved only along the upper Belden Reach above the East Branch

- the maximum mean daily temperature exceeds the target. Below the East Branch the target is generally exceeded. (Figure 3-2a).

vii) Reducing the Belden Forebay temperature from 19.5ºC to 17.5ºC has little benefit to downstream reaches (except that this causes the upper Belden Reach to meet the maximum mean daily target; Figure 3-3) because when the Belden Forebay temperature is reduced (1) warming in Rock Creek Reservoir occurs and (2) diminished stratification occurs in Belden Reservoir.

viii) Reducing the Belden Forebay temperature by 1ºC from a starting temperature of 17.5ºC results in the following reductions in average mean daily temperatures downstream (Figure 3-3):
- Belden Reach above the East Branch, 0.8ºC;
- Rock Creek Reach above Bucks Creek/Buck PH, 0.6ºC;
- Cresta Reach above Cresta PH, 0.5ºC; and,
- Poe Reach above Poe PH, 0.4ºC.

f. The SNTEMP models for July 2002 were further used to estimate the release temperatures at each dam that would be required to achieve the target (average mean daily and maximum mean daily) for the respective downstream reaches (Figure 3-4a). The average/maximum mean daily July 2002 release temperatures required to achieve the temperature target are:

i) Belden Dam to Belden Reach, 13.0ºC/14.7ºC (If the lower portion of the Belden Reach is sacrificed, then the required release temperature from Belden Dam is raised by 5ºC to 18.0ºC/19.7 ºC (Figure 3-4b).);

ii) Rock Creek Dam to Rock Creek Reach, 17.8ºC/19.0 ºC;

iii) Cresta Dam to Cresta Reach, 17.3ºC/18.3 ºC; and,

iv) Poe Dam to Poe Reach, 16.4ºC/17.4 ºC.

g. The following uncertainties exist in the above analysis. More detailed analysis using mathematical models is needed to address these uncertainties.

i) In the analysis, temperatures below Belden Dam were assumed 1.0ºC lower than Belden Forebay when the forebay temperature was 19.5ºC; 0.5ºC lower when the forebay temperature was 18.5ºC; and no difference when the forebay temperature was 17.5ºC or lower. These assumptions were solely based on observations during the July 2003 Caribou special test. Further detailed analysis is needed since the extent of Belden Reservoir stratification would depend on peaking operations and discharge rates of the Caribou powerhouses and the rate of cool water inflow from Seneca Reach.

ii) In the analysis, temperatures in the lower part of Rock Creek Reservoir (near the dam) were assumed 0.6ºC warmer than the upper part when the Belden Forebay temperature was 18.5ºC; 1.0ºC warmer when the forebay temperature was 17.5ºC or lower; and no difference when the forebay temperature was 19.5ºC or higher. In fact it would be expected that the warming at Rock Creek Reservoir would be more pronounced when the inflow water temperature was lower than 17.5ºC.

3.2 WATER TEMPERATURE REDUCTION ALTERNATIVE CATEGORIES

Results of the above-described modeling work formed the basis for the formulation of six categories of water temperature reduction alternatives (Table 3-3). The categories are differentiated by the amount of temperature reduction at Belden Reservoir. A higher numbered category means that more temperature reduction is required in reaches downstream. The water temperature reduction alternative categories are described below:

a. **Water Temperature Reduction Alternative Category 1:** Reduce the temperature in Belden Forebay to 12.5ºC. This category includes alternatives consisting of measures that would significantly reduce the temperatures of the source waters to the Belden Forebay without the need for additional temperature reduction below the dam. Measures in this category are included in Appendix C under the headings "Measures Above or at Lake Almanor" and "Measures At Butt Valley Reservoir".

b. **Water Temperature Reduction Alternative Category 2:** Reduce the temperature in Belden Forebay to 14.5ºC combined with additional temperature reduction along the Poe Reach. This category includes measures that would also significantly reduce the temperatures of the source waters to the Belden Forebay (but not as much as Category 1) combined with measures that would reduce temperatures along the lower portion of the Poe Reach – no additional measures would be necessarily needed for the Belden, Rock Creek and Cresta Reaches, although measures along these reaches that would also reduce temperatures along the Poe Reach would also work. Measures in this category are included in Appendix C under the headings "Above or at Lake Almanor" and "At Butt Valley" combined with other headings, particularly "Measures Along Poe Reach".

c. **Water Temperature Reduction Alternative Category 3:** Reduce the temperature in Belden Forebay to 16.0ºC combined with additional temperature reduction along the lower Belden, Cresta, and Poe Reaches. This category includes measures that would also significantly reduce the temperatures of the source waters to the Belden Forebay (but not as much as Category 2) combined with measures that would reduce temperatures along the lower Belden Reach and the lower portions of the Cresta and Poe Reaches – no additional measures would be necessarily needed for the upper Belden and Rock Creek Reaches. Measures in this category are included in Appendix C under the headings "Above or at Lake Almanor" and "At Butt Valley" combined with other headings, particularly "Along Poe Reach" and "Along Cresta Reach".

d. **Water Temperature Reduction Alternative Category 4:** Reduce the temperature in Belden Forebay to 18.0ºC combined with additional temperature reduction along the lower Belden, Rock Creek, Cresta, and Poe Reaches. This category includes measures that would moderately reduce the temperatures of the source waters to the Belden Forebay combined with measures that would reduce temperatures along the lower Belden, Rock Creek, Cresta, and Poe Reaches. No additional measures would necessarily be needed for the upper Belden Reach. Measures in this category are included in Appendix C under the headings "Above or at Lake Almanor" and "At Butt Valley" combined with other headings for downstream reaches.

e. **Water Temperature Reduction Alternative Category 5:** Reduce the temperature in Belden Forebay to 19.5ºC combined with additional temperature reduction along all downstream reaches. This category includes measures that would slightly reduce the temperatures of the source waters to the Belden Forebay combined with measures that would reduce temperatures along all downstream reaches. Measures in this category are included in Appendix C under the headings "Above or at Lake Almanor" and "At Butt Valley" combined with other headings for all downstream reaches.

f. **Water Temperature Reduction Alternative Category 6:** Reduce temperatures in all downstream reaches. This category includes measures that would focus on temperature reduction in the downstream reaches, and does not necessarily require measures at Lake Almanor and Butt Valley Reservoir. However, absent measures at Lake Almanor and Butt Valley, temperature reduction in the downstream reaches would be very difficult and costly. Measures in this category are included in Appendix C under the headings "Along Belden Reach", "Along Rock Creek Reach", "Along Cresta Reach", and "Along Poe Reach."

Table 3-1 Meteorology Data in July 2002

	Prattville Intake Station	Rock Creek Dam Station	Poe Station
Mean Air Temperature (°C)	20.6	26.0	25.8
Mean Relative Humidity (%)	45	34	52
Mean Solar Radiation (watts/s)	286	279	278
Mean Wind Speed (mph)	1.10	3.01	1.61

Note: Meteorology data for the Prattville Intake and Rock Creek Dam stations were observed; meteorology data for the Poe station were estimated.

Table 3-2 SNTEMP Model Verification Results Using July 2002 Data

River Reach	Calibration Station	Observed Mean Temperature (°C)	Simulated Mean Temperature (°C)	Difference (°C)
Seneca Reach	Seneca Bridge (NF3)	15.0	14.8	-0.2
	Above Caribou PH (NF4)	15.9	15.7	-0.2
Belden Reach	Above Queen Lily (NF6)	19.5	19.5	0.0
	Gansner Bar (NF7)	19.7	19.6	-0.1
	Above Belden PH (NF8)	21.4	21.4	0.0
Rock Creek Reach	Above Granite Creek (NF11)	21.5	21.6	0.1
	Above Bucks Creek (NF12)	21.6	21.8	0.2
	Above Rock Ck PH (NF13)	20.7	20.5	-0.2
Cresta Reach	Below Grizzly Ck. (NF15)	21.3	21.0	-0.3
	Above Cresta PH (NF16)	21.7	21.6	-0.1
Poe Reach	Above Poe PH	23.7	23.5	-0.2

Table 3-3 Summary of Alternative Categories and Requirements

Alternative Category		Belden Reach	Rock Creek Reach	Cresta Reach	Poe Reach
1	Cold Water from Lake Almanor/Butt Valley Reservoir	Reduce inflow temperature at Belden Forebay to 12.5°C			
	Additional Cold Water Needed?	No	No	No	No
2	Cold Water from Lake Almanor/Butt Valley Reservoir	Reduce inflow temperature at Belden Forebay to 14.5°C			
	Additional Cold Water Needed?	No	No	No	Yes
3	Cold Water from Lake Almanor/Butt Valley Reservoir	Reduce inflow temperature at Belden Forebay to 16.0°C			
	Additional Cold Water Needed?	No (except for lower Belden reach)	No	Yes	Yes
4	Cold Water from Lake Almanor/Butt Valley Reservoir	Reduce inflow temperature at Belden Forebay to 18.0°C			
	Additional Cold Water Needed?	No (except for lower Belden reach)	Yes	Yes	Yes
5	Cold Water from Lake Almanor/Butt Valley Reservoir	Reduce inflow temperature at Belden Forebay to 19.5°C			
	Additional Cold Water Needed?	Yes	Yes	Yes	Yes
6	Cold Water from Lake Almanor/Butt Valley Reservoir	No			
	Additional Cold Water Needed?	Yes	Yes	Yes	Yes

Figure 3-1 Hydrology and Temperature Data Used as Inputs in the SNTEMP Modeling Analysis

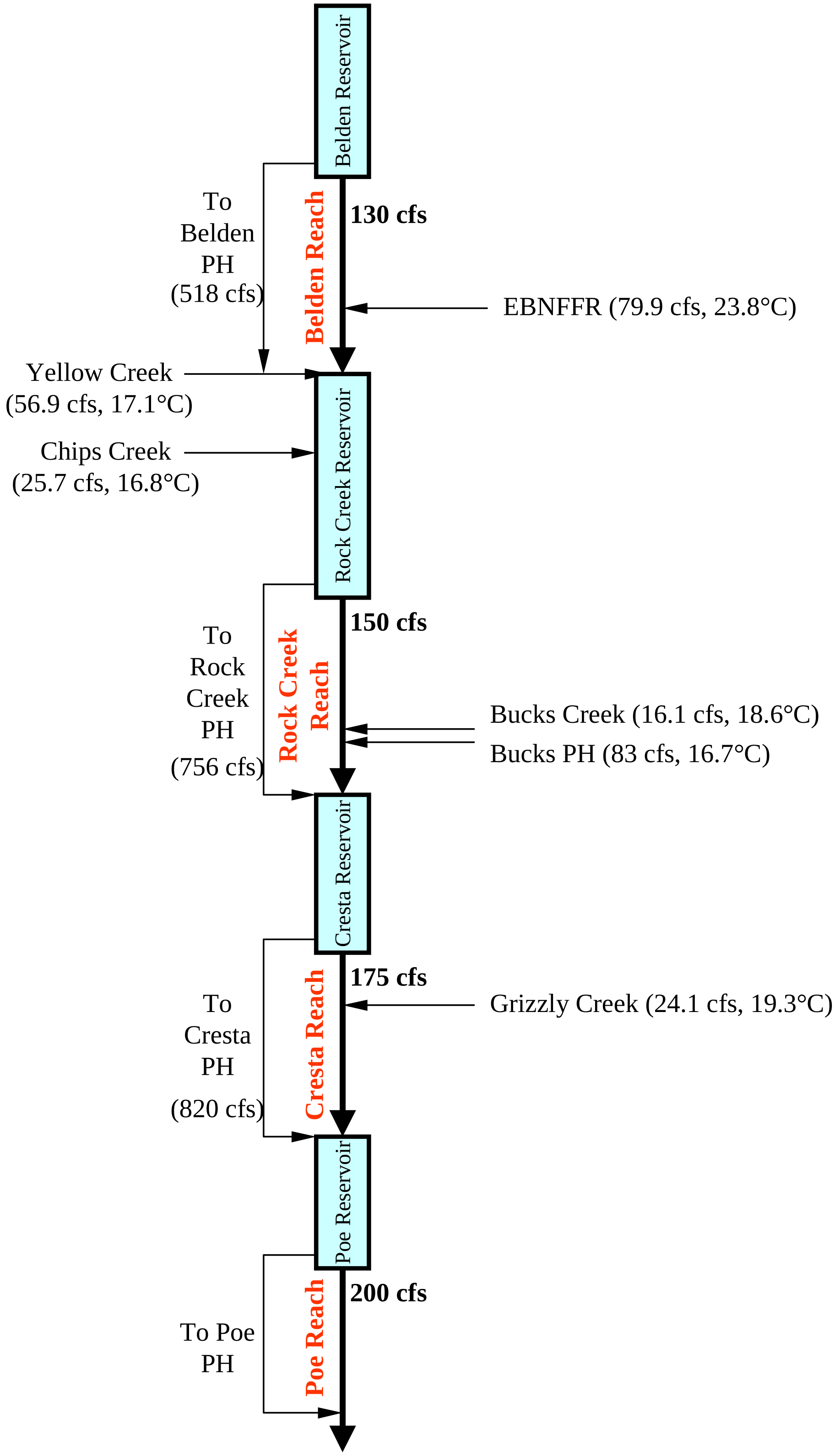


Figure 3-2a Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 19.5°C)

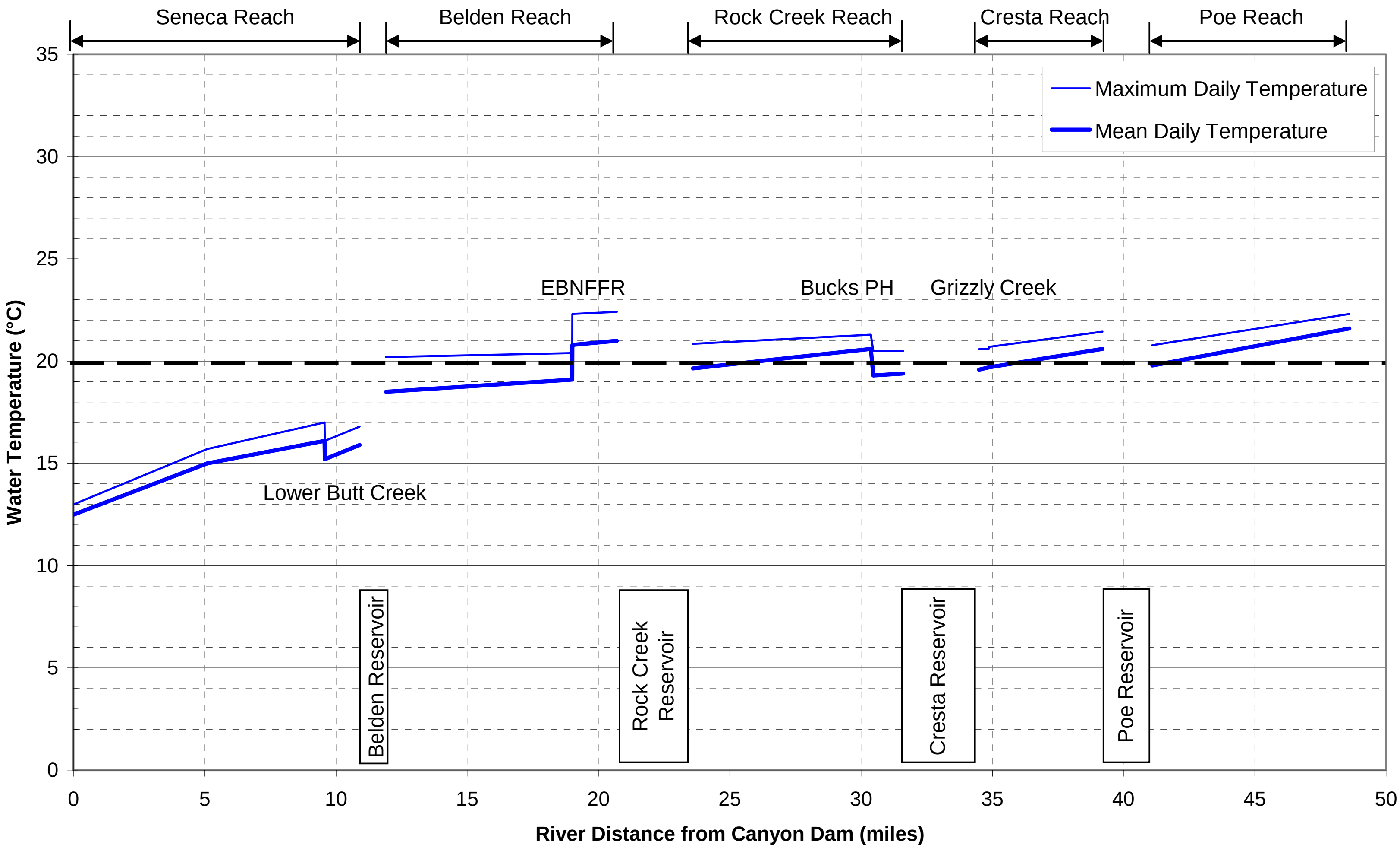


Figure 3-2b Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 18.5°C)

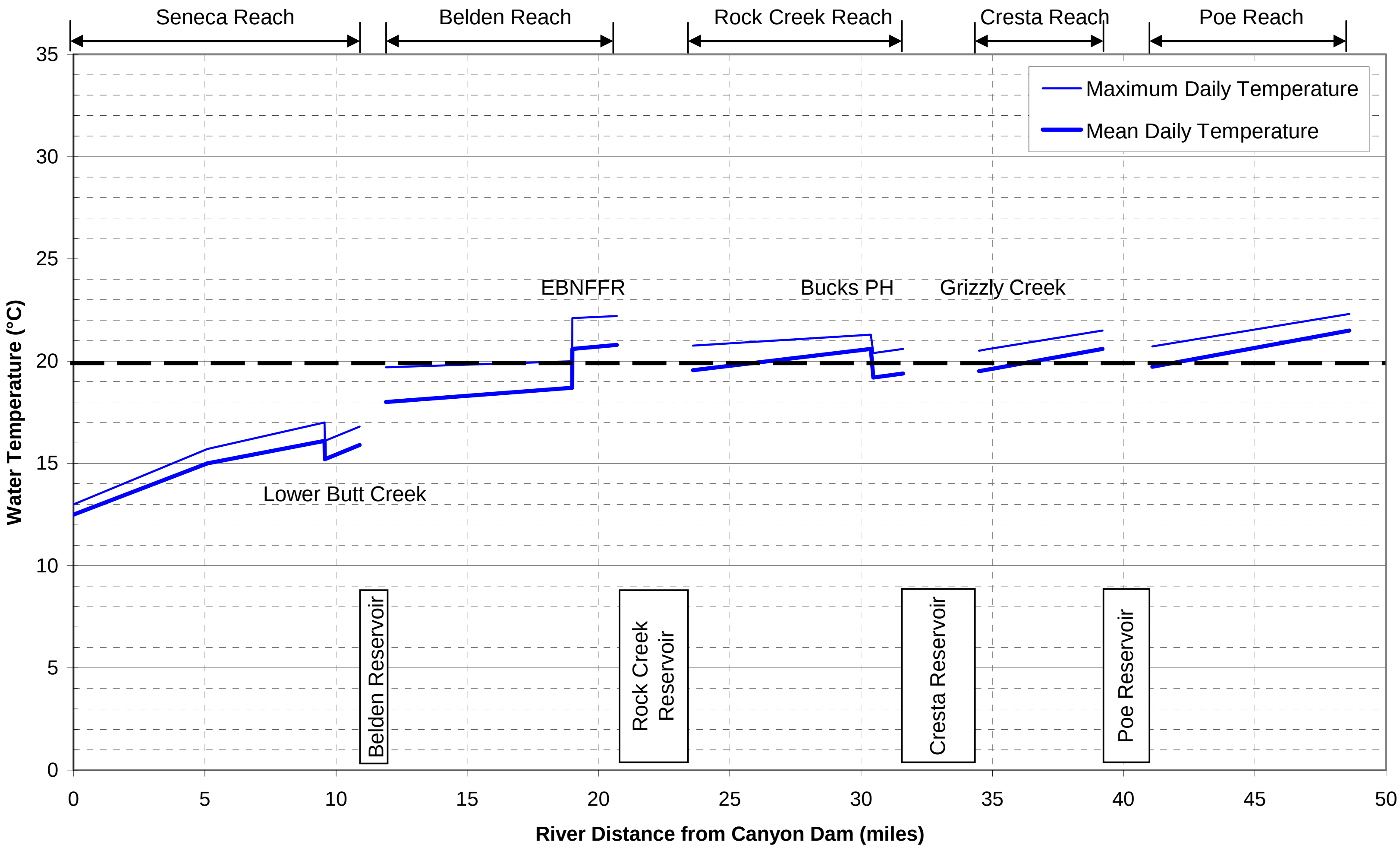


Figure 3-2c Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 17.5°C)

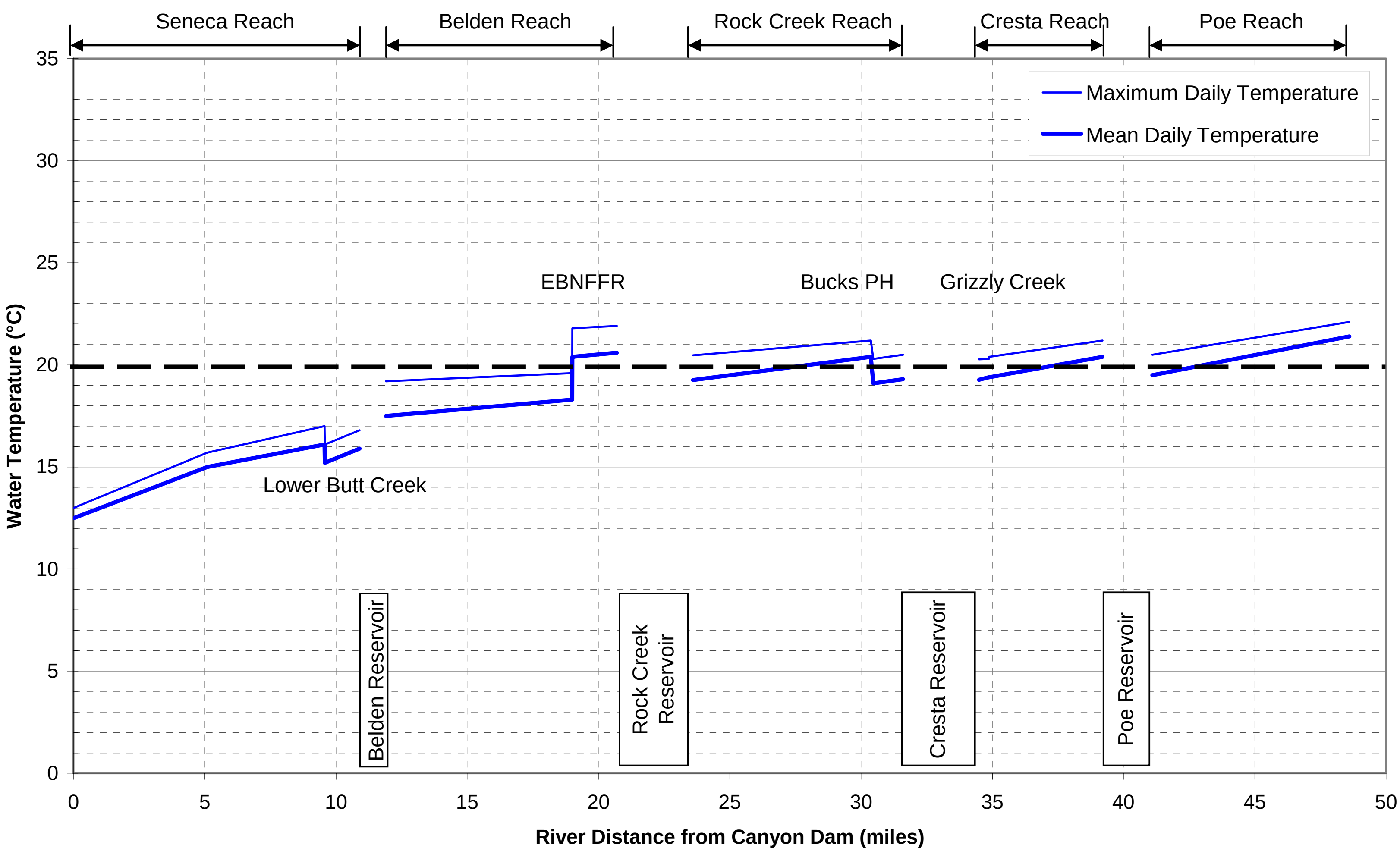


Figure 3-2d Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 16.5°C)

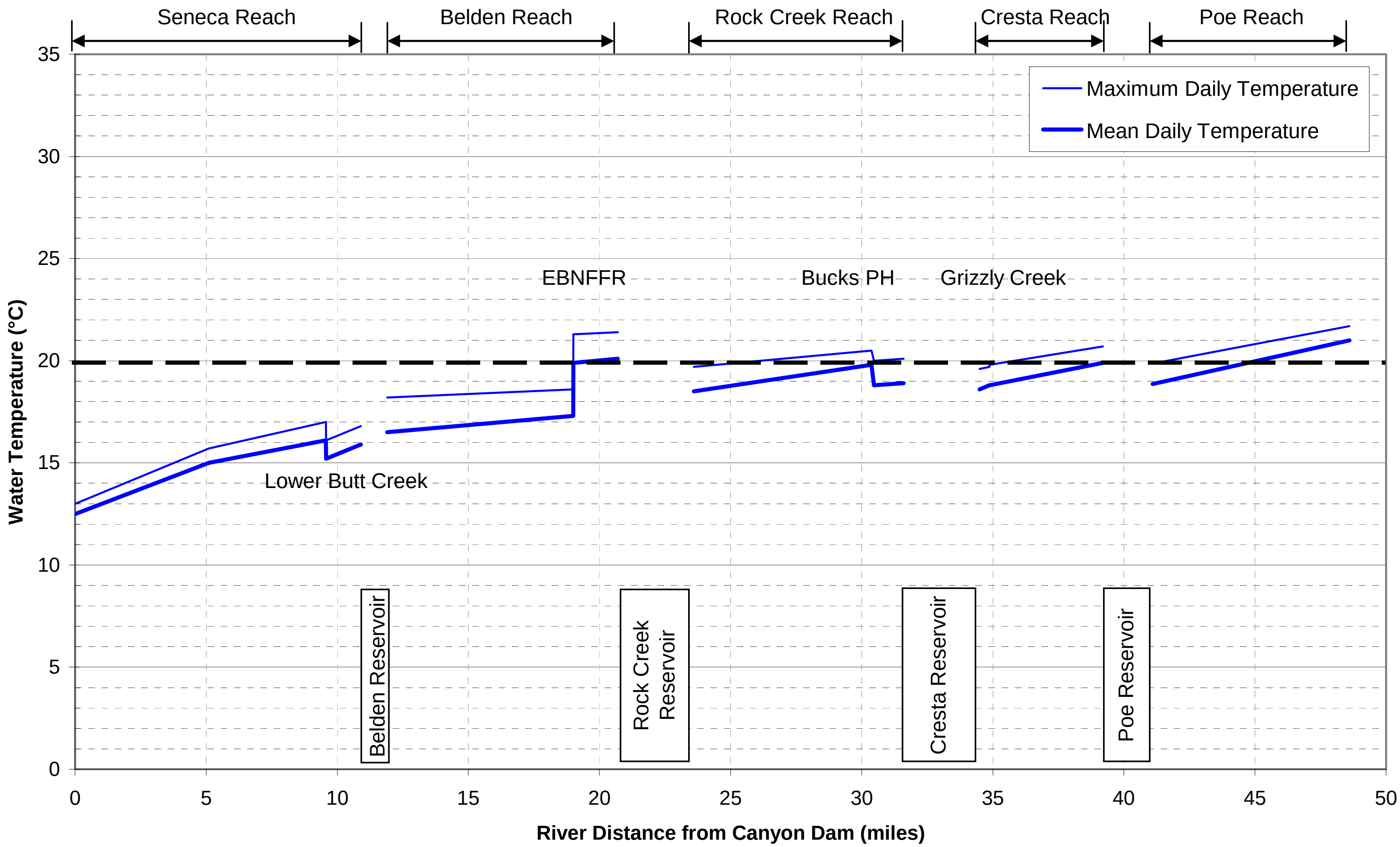


Figure 3-2e Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 15.5°C)

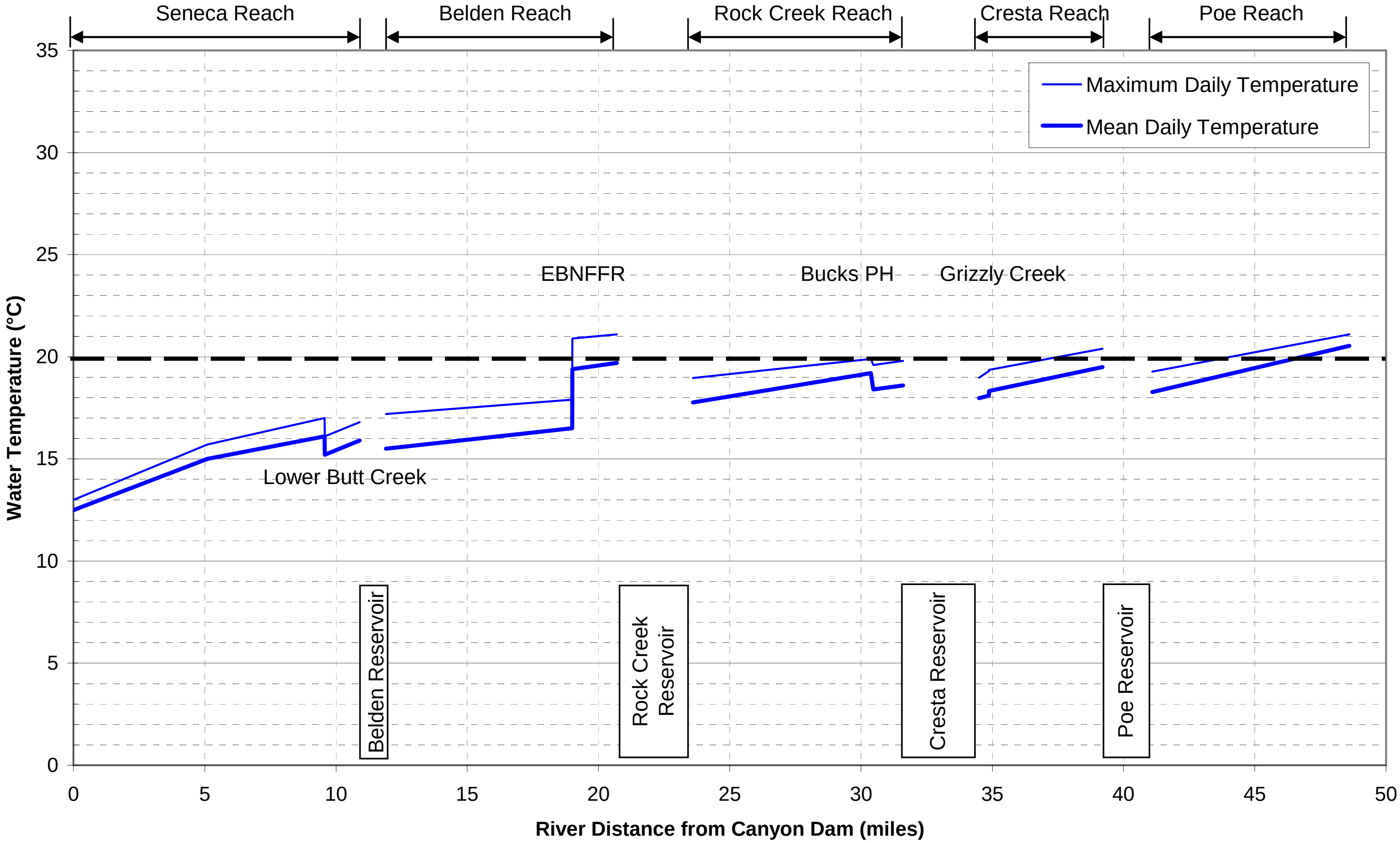


Figure 3-2f Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 14.5°C)

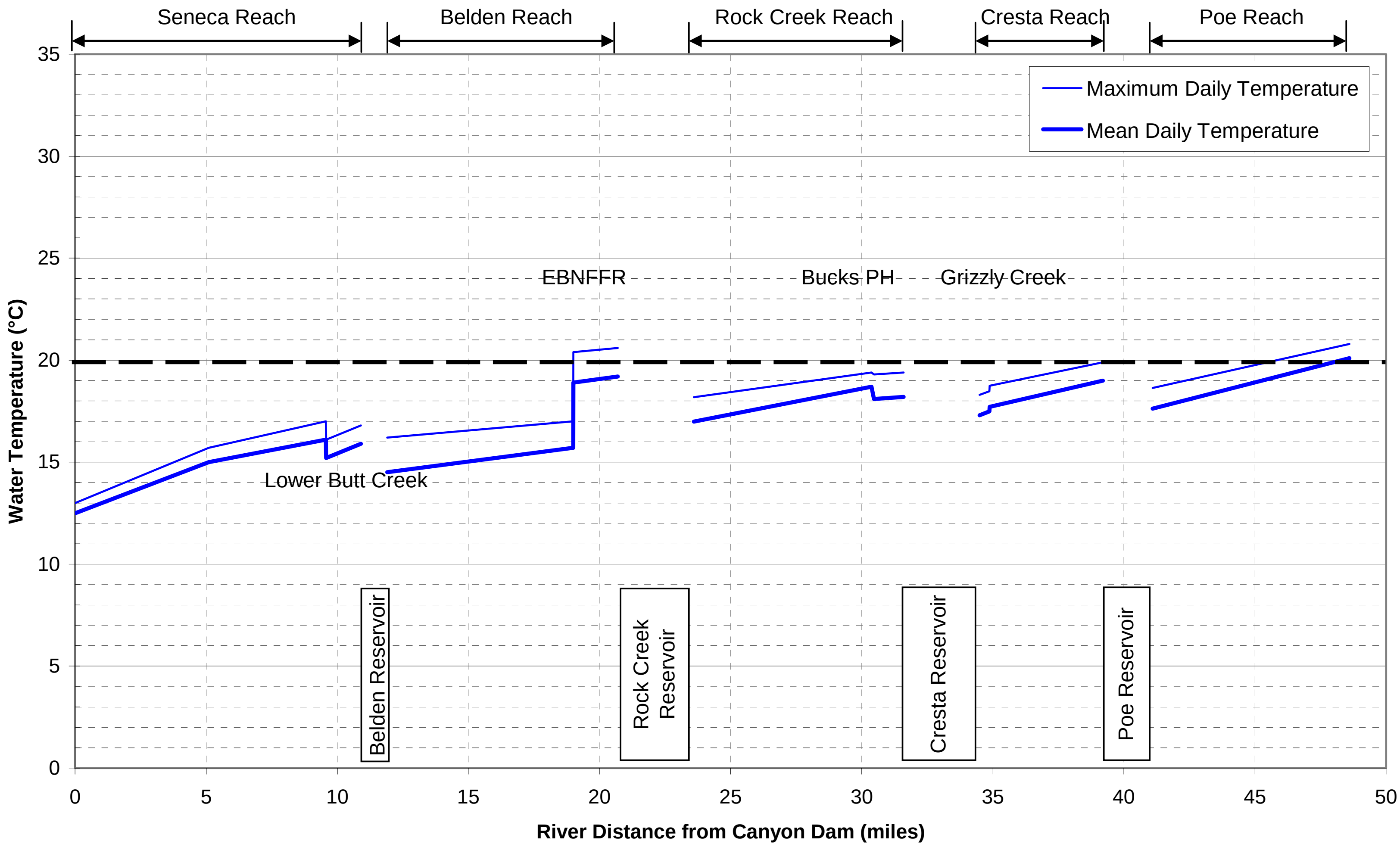


Figure 3-2g Estimated July 2002 (Dry Year) Water Temperature Profile along NFFR (Assuming Average Mean Daily Temperature at Belden Forebay = 12.5°C)

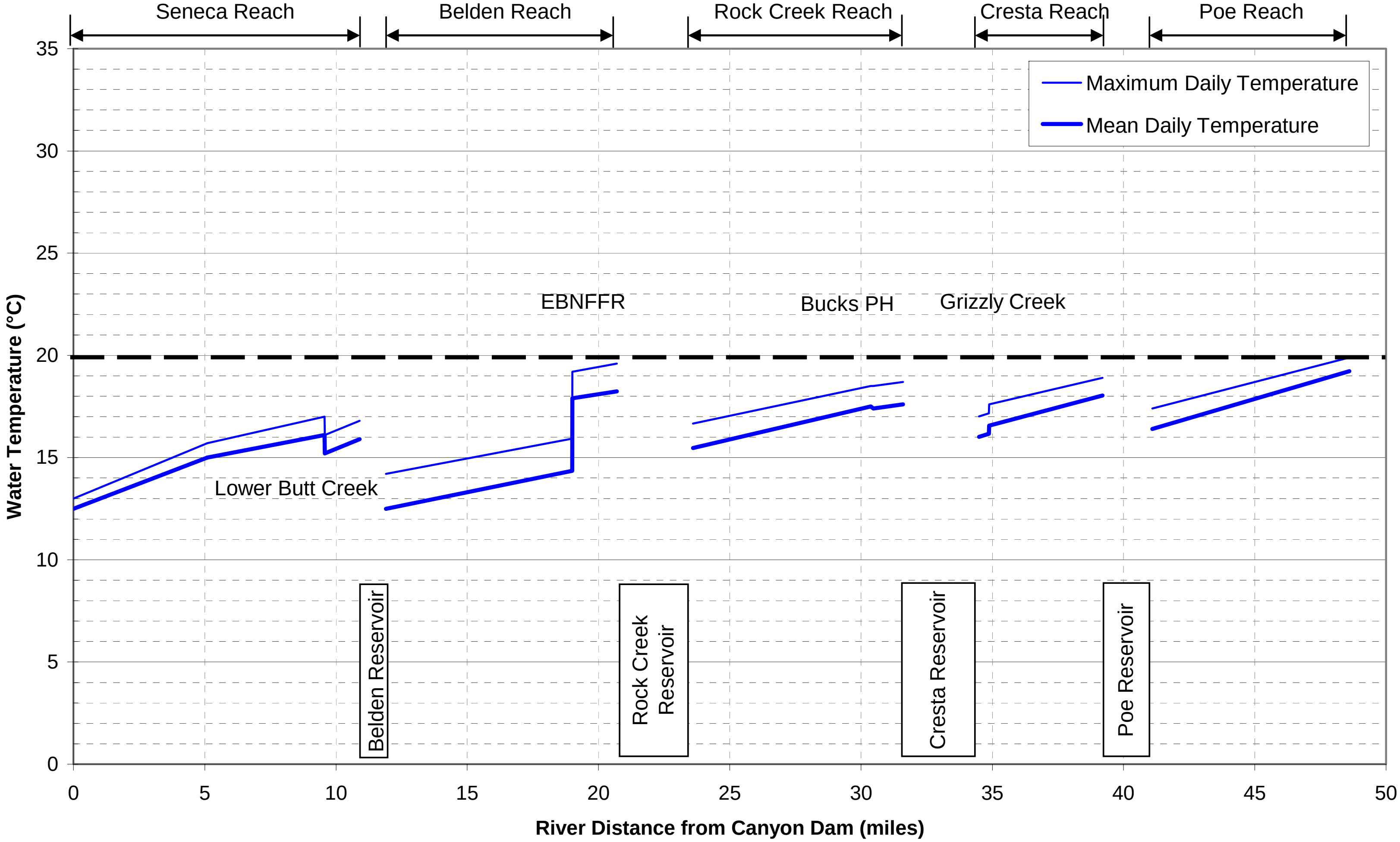


Figure 3-3 Estimated July 2002 (Dry Year) Water Temperature Profiles along NFFR for a Range of Inflow Temperatures at Belden Forebay

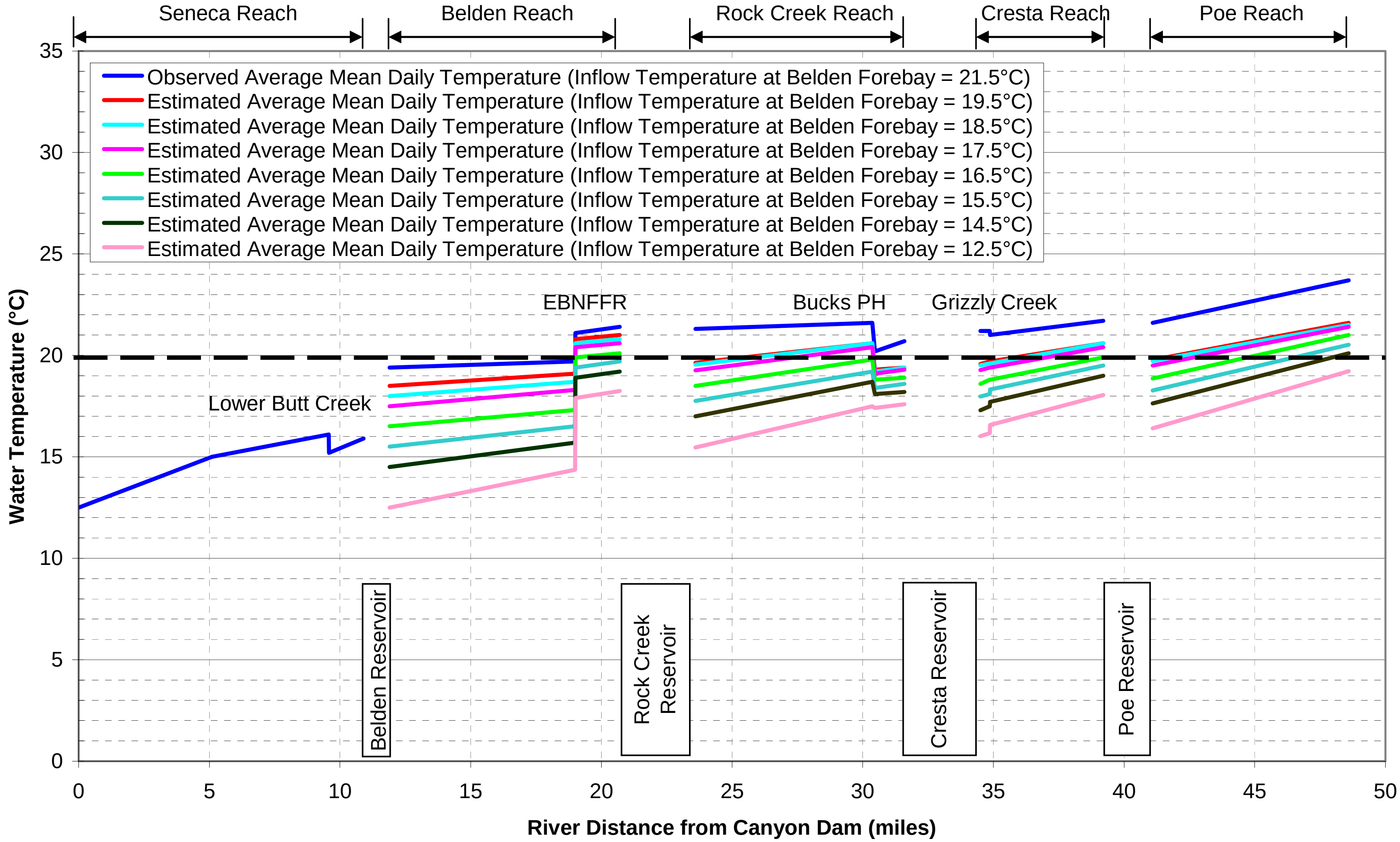


Figure 3-4a July 2002 (Dry Year) Water Temperature Profile along NFFR Required to Achieve Target

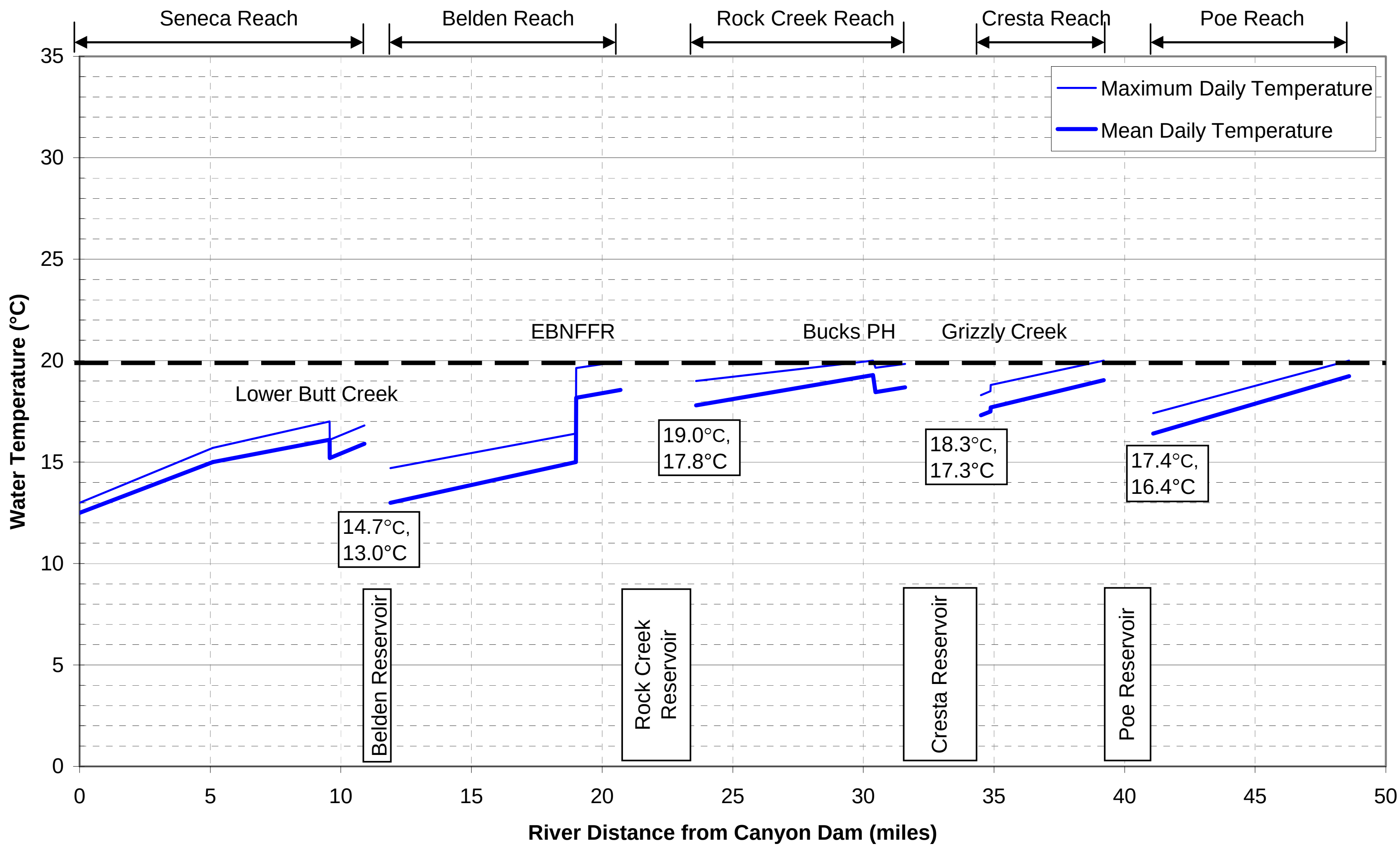
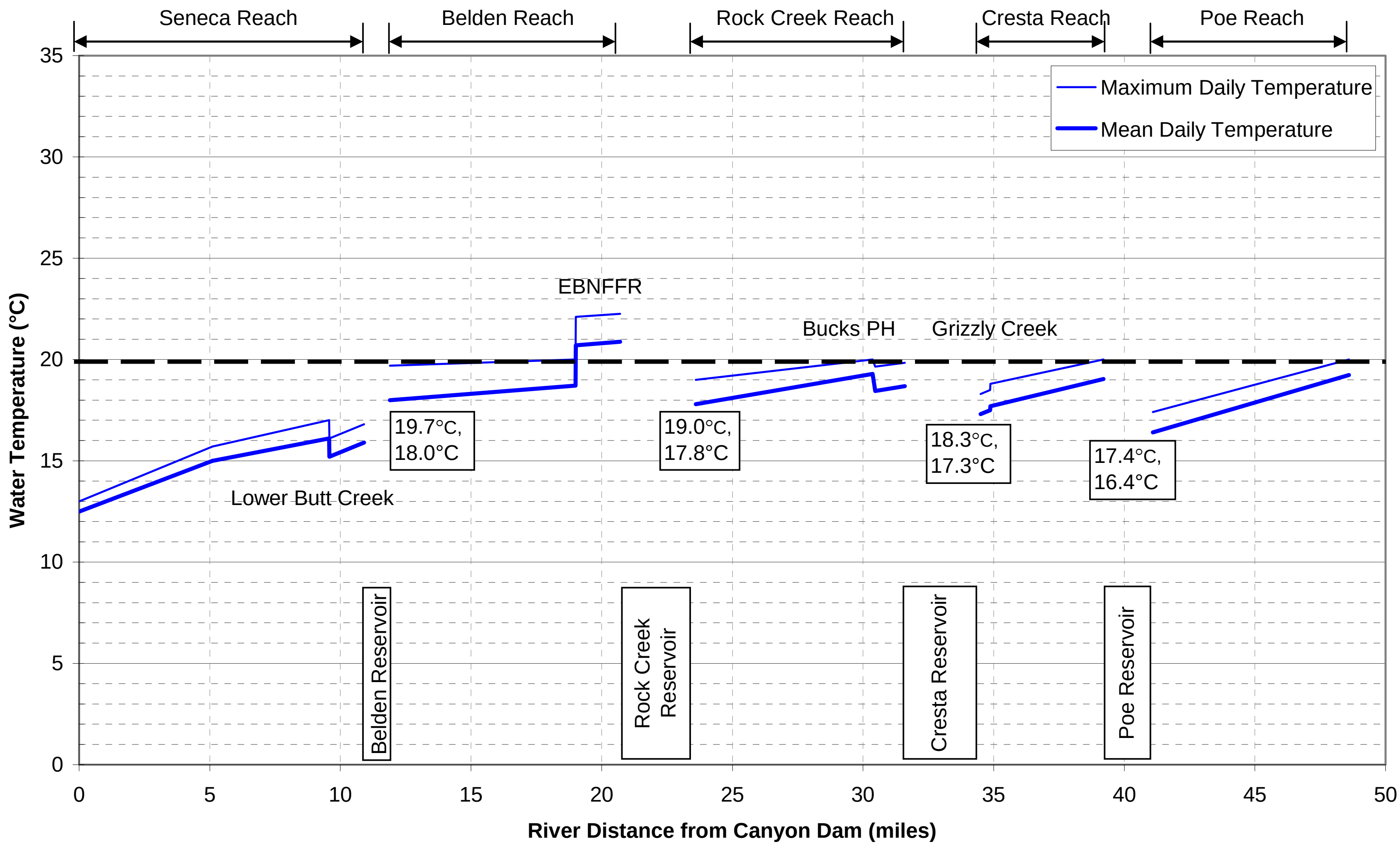


Figure 3-4b July 2002 (Dry Year) Water Temperature Profile along NFFR Required to Achieve Target with Sacrifice of Lower Belden Reach below East Branch NFFR Confluence



4.0 LEVEL 1 WATER TEMPERATURE REDUCTION ALTERNATIVES FORMULATION AND SCREENING

This chapter describes the formulation and screening of Level 1 water temperature reduction alternatives. These alternatives represent a reasonable range of *potentially effective and feasible* alternatives to achieving the temperature target. The framework described in Chapter 3 was followed in formulating the alternatives. The water temperature reduction alternatives consist of temperature reduction measures selected and assembled from those 41 measures passing the preliminary evaluation in Appendix C: Potential Effective and Feasible Measures for Reducing Temperature along the North Fork Feather River. Not all of the 41 measures passing the preliminary evaluation were selected for inclusion in the alternatives. Certain measures were excluded[24] because there were other, equally or more effective measures available that were clearly superior.

The effectiveness of each alternative in reducing temperatures and achieving the 20^{o}C maximum mean daily temperature target on the NFFR was analyzed using the information and tools summarized below:

- PG&E's *Temperature Modeling Results for 33-years of the Hydrologic Record* (Bechtel Corporation and Thomas R. Payne and Associates 2006);
- PG&E's *Physical-prototype Hydraulic Modeling Results for the Prattville Intake Thermal Curtain* (IIHR 2004);
- PG&E's *2002-2004 Temperature Monitoring Data Reports* (PG&E 2003; PG&E 2004; PG&E 2005a);
- PG&E's *2006 NFFR Special Testing Data Report* (Stetson and PG&E 2007);
- Stream water temperature modeling analysis (refer to Chapter 3); and
- Water temperature mixing analysis.

4.1 FORMULATION OF INITIAL LEVEL 1 WATER TEMPERATURE REDUCTION ALTERNATIVES

Initial Level 1 water temperature reduction alternatives were formulated by category in accordance with the framework described in Chapter 3. The alternative categories are differentiated by the amount of temperature reduction at Belden Reservoir. Within a particular category, alternatives are differentiated by the method of temperature reduction at Belden Reservoir. An alternative may have multiple variations with respect to the selection of measure(s) for temperature reduction in downstream reaches. The initial Level 1 water temperature reduction alternatives are described below (summarized in Table 4-1):

[24] Measures from Appendix C that passed the preliminary evaluation but were excluded from the Level 1 alternatives include measures 4e, 7, 12, 13 and 15.

4.1.1 Water Temperature Reduction Alternative Category 1: Reduce the temperature in Belden Forebay to 12.5ºC

This category includes a combination of measures that would significantly reduce the temperatures of the source waters to the Belden Forebay without the need for additional temperature reduction below the forebay. There is only one alternative in this category.

Alternative 1: Reduce the temperature in Belden Forebay to 12.5ºC by installing a thermal curtain at Prattville Intake, pumping collected spring flows to the Intake, and conveying Butt Valley PH discharges by pipeline to Butt Valley Reservoir near Caribou PH Intake. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake with the submerged levee removed by dredging.
- Construct an expansive, high-capacity wellfield that would pump directly from the basalt aquifer discharging to Big Springs/northeastern Lake Almanor. The pumped cold water is conveyed by pipeline laid along the lakebed and connected for direct discharge into the Prattville Intake.
- Construct about five miles of pipeline laid along the bed of Butt Valley Reservoir for conveying Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake.

Remarks:

- o An estimated 215 cfs of pumped groundwater (8°C) is needed under the normal operating discharge of 1,600 cfs at Butt Valley PH. There would be no power generation loss at this operating level.
- o Little information is available on the hydrogeology and development potential of the basalt aquifer at Lake Almanor. Extensive field investigation would be required to evaluate the feasibility of this alternative.

4.1.2 Water Temperature Reduction Alternative Category 2: Reduce the temperature in Belden Forebay to 14.5ºC combined with additional temperature reduction along the Poe Reach

This category includes a combination of measures that would significantly reduce the temperatures of the source waters to the Belden Forebay (but not as much as Category 1) combined with measures that would reduce temperatures along the lower portion of the Poe Reach – no additional measures would be necessary for the Belden, Rock Creek and Cresta Reaches. This category has three alternatives.

Alternative 2a: Reduce the temperature in Belden Forebay to 14.5ºC by installing a thermal curtain at Prattville Intake and conveying Butt Valley PH discharges by pipeline to Butt Valley Reservoir near Caribou PH Intake, with one additional temperature reduction measure for the Poe Reach. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake with the submerged levee removed by dredging.

- Construct about five miles of pipeline laid along the bed of Butt Valley Reservoir for conveying Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake.

- Increase shading along the Poe Reach from the existing 22% level to the 50% level through planting of vegetation; or, alternatively, increase Poe Dam releases, or release cool water to the lower Poe Reach from the Poe Adit.

Remarks:

- There would be no power generation loss under this alternative if the Poe Reach temperature reduction measure is increased shading. There would be power generation loss if the Poe Reach temperature reduction measure is increased Poe Dam releases or cooler water release from the Poe Adit.

Alternative 2b: Reduce the temperature in Belden Forebay to 14.5ºC by installing a thermal curtain at Prattville Intake and a thermal curtain near Caribou PH Intake in Butt Valley Reservoir and pumping collected spring flows to the Prattville Intake, with one additional temperature reduction measure for the Poe Reach. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake with the submerged levee removed by dredging.

- Install a thermal curtain near the Caribou PH Intakes in Butt Valley Reservoir.

- Construct an expansive, high-capacity wellfield that would pump directly from the basalt aquifer discharging to Big Springs/northeastern Lake Almanor. The pumped cold water is conveyed by pipeline laid along the lakebed and connected for direct discharge into the Prattville Intake.

- Increase shading along the Poe Reach from the existing 22% level to the 50% level through planting of vegetation; or, alternatively, increase Poe Dam releases, or release cool water to the lower Poe Reach from the Poe Adit.

Remarks:

- Assuming the warming in Butt Valley Reservoir is 2°C, an estimated 215 cfs of pumped groundwater (8°C) is needed under the normal operating discharge of 1,600 cfs at Butt Valley PH.

- There would be no power generation loss under this alternative if the Poe Reach temperature reduction measure is increased shading. There would be power generation loss if the Poe Reach temperature reduction measure is increased Poe Dam releases or cooler water release from the Poe Adit.

- Little information is available on the hydrogeology and development potential of the basalt aquifer at Lake Almanor. Extensive field investigation would be required to evaluate the feasibility of this alternative.

Alternative 2c: Reduce the temperature in Belden Forebay to 14.5ºC by significantly decreasing release of water from Lake Almanor to Butt Valley Reservoir through reduced withdrawal from the Prattville Intake and increased release from Canyon Dam, with one additional temperature reduction measure for the Poe Reach. This alternative includes the following measures:

- Decrease release from the Prattville Intake significantly to cause selective cold water withdrawal.
- Dredge and extend the existing deep channel along the bottom of Butt Valley Reservoir to the Caribou No. 1 Intake.
- Use Caribou PH No.1 exclusively with reduced release to cause selective cold water withdrawal.
- Increase Canyon Dam release to 600 cfs from the low level outlet.
- Increase shading along the Poe Reach from the existing 22% level to the 50% level through planting of vegetation; or, alternatively, increase Poe Dam releases, or release cool water to the lower Poe Reach from the Poe Adit.

Remarks:

- There would be significant power generation loss under this alternative due to reduced withdrawal from the Prattville Intake and increased release from Canyon Dam. This could be partially off-set by discharging Canyon Dam releases through a new hydropower plant constructed at the dam.
- Reducing the withdrawal from the Prattville Intake would result in higher Lake Almanor water levels than those that occurred historically during the summer. Higher releases than occurred historically during the fall may be required to meet obligations for water delivery downstream.

4.1.3 Water Temperature Reduction Alternative Category 3: Reduce the temperature in Belden Forebay to 16.0ºC combined with additional temperature reduction measures along the lower Belden, Cresta, and Poe Reaches.

This category includes a combination of measures that would significantly reduce the temperatures of the source waters to the Belden Forebay (but not as much as Category 2) combined with measures that would reduce temperatures along the lower Belden Reach and the lower portions of the Cresta and Poe Reaches – no additional measures would be necessary for the upper Belden and Rock Creek Reaches. There is one alternative under this category.

Alternative 3: Reduce the temperature in Belden Forebay to 16.0ºC by installing a thermal curtain at Prattville Intake and a thermal curtain at Butt Valley Reservoir near Caribou PH

Intake and increasing Canyon Dam release as needed, with additional temperature reduction measures for the lower Belden, Cresta and Poe Reaches. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake with the submerged levee removed by dredging.
- Install a thermal curtain near Caribou PH Intake in Butt Valley Reservoir.
- Increase Canyon Dam low-level outlet release as needed and reduce withdrawal through the Prattville Intake commensurately.
- Convey warm water discharges from the East Branch directly into upper Rock Creek Reservoir.
- Increase Cresta Dam releases or, alternatively, increase release of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek.
- Increase Poe Dam releases and release cooler water to the lower Poe Reach from the Poe Adit.

Remarks:

- There would be power generation loss at the Butt Valley PH and Caribou PH due to reduced releases.
- There would be power generation loss at the Cresta PH if the Cresta Reach temperature measure is increased Cresta Dam release.
- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.
- There would be power generation loss at the Poe PH due to increased Poe Dam release and cooler water release from the Poe Adit.

4.1.4 Water Temperature Reduction Alternative Category 4: Reduce the temperature in Belden Forebay to 18.0ºC combined with additional temperature reduction measures along the lower Belden, Rock Creek, Cresta, and Poe Reaches.

This category includes a combination of measures that would moderately reduce the temperatures of the source waters to the Belden Forebay combined with measures that would reduce temperatures along the lower Belden, Rock Creek, Cresta, and Poe Reaches. No additional measures would be necessary for the upper Belden Reach. This category has three alternatives.

Alternative 4a: Reduce the temperature in Belden Forebay to 18.0ºC by installing a thermal curtain at Prattville Intake and a thermal curtain at Butt Valley Reservoir near Caribou PH Intake, with additional temperature reduction measures along the lower Belden, Rock Creek, Cresta, and Poe Reaches. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake.
- Install a thermal curtain at Butt Valley Reservoir near the Caribou PH Intakes.

- Convey warm water discharges from the East Branch directly into upper Rock Creek Reservoir.

- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, increase Rock Creek Dam release; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.

- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Buck Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach. Or, alternatively, increase Cresta Dam release; or alternatively, increase release (to about 130 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.

- Increase Poe Dam release and release cool water to the lower Poe Reach from the Poe Adit; or, alternatively, construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- There would be power generation loss at the Rock Creek PH if the Rock Creek Reach temperature measure is increased Rock Creek Dam release.
- There would be power generation loss at the Cresta PH if the Cresta Reach temperature measure is increased Cresta Dam release.
- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.
- There would be power generation loss at the Poe PH if the Poe Reach temperature reduction measure is increased Poe Dam release and cooler water release from the Poe Adit.

Alternative 4b: This alternative is similar to 4a, except that the measure of installing a thermal curtain at Butt Valley Reservoir near Caribou PH Intake is replaced by preferential use of Caribou PH No.1. This alternative includes the following measures:

- Install a thermal curtain at the Prattville Intake.

- Use Caribou PH No. 1 preferentially over operation of Caribou PH No. 2.

- Convey warm water discharges from the East Branch directly to into upper Rock Creek Reservoir.

- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, increase Rock Creek Dam release; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.

- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Buck Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach. Or, alternatively, increase Cresta Dam release; or alternatively, increase release (to about 130 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.

- Increase Poe Dam release and release cool water to the lower Poe Reach from the Poe Adit; or, alternatively, construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- There would be power generation loss at the Caribou PH complex due to lower turbine efficiency of Caribou PH No.1 relative to Caribou PH No.2. This could be mitigated by constructing a “crossover” conduit connecting Caribou PH No.1 to Caribou PH No.2.

- There would be power generation loss at the Rock Creek PH if the Rock Creek Reach temperature measure is increased Rock Creek Dam release.

- There would be power generation loss at the Cresta PH if the Cresta Reach temperature measure is increased Cresta Dam release.

- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.

- There would be power generation loss at the Poe PH if the Poe Reach temperature reduction measure is increased Poe Dam release and cooler water release from the Poe Adit.

Alternative 4c: This alternative is similar to 4b except that the measure of installing a thermal curtain at the Prattville Intake is replaced by increasing Canyon Dan release. This alternative includes the following measures:

- Increase Canyon Dam low-level outlet release to about 600 cfs and reduce withdrawal through the Prattville Intake commensurately.

- Use Caribou PH No. 1 preferentially over operation of Caribou PH No. 2.

- Convey warm water discharges from the East Branch directly into upper Rock Creek Reservoir.

- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, increase Rock Creek Dam release; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.

- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Bucks Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach. Or, alternatively, increase Cresta Dam release; or alternatively, increase release (to about 130 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.

- Increase Poe Dam release and release cool water to the lower Poe Reach from the Poe Adit; or, alternatively, construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- There would be power generation loss at the Butt Valley PH and Caribou PH due to reduced releases.

- There would be further power generation loss at the Caribou PH complex due to lower turbine efficiency of Caribou PH No.1 relative to Caribou PH No.2. This could be mitigated by constructing a "crossover" conduit connecting Caribou PH No.1 to Caribou PH No.2.

- There would be power generation loss at the Rock Creek PH if the Rock Creek Reach temperature measure is increased Rock Creek Dam release.

- There would be power generation loss at the Cresta PH if the Cresta Reach temperature measure if increased Cresta Dam release.

- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release to Grizzly Creek.

- There would be power generation loss at the Poe PH if the Poe Reach temperature reduction measure is increased Poe Dam release and cooler water release from the Poe Adit.

4.1.5 Water Temperature Reduction Alternative Category 5: Reduce the temperature in Belden Forebay to 19.5ºC combined with additional temperature reduction measures along all downstream reaches

This category includes a combination of measures that would slightly reduce the temperatures of the source waters to the Belden Forebay combined with measures that would reduce temperatures along all downstream reaches. This category has three alternatives.

Alternative 5a: Reduce the temperature in Belden Forebay to 19.5ºC by preferential use of Caribou PH No.1 plus any needed increased releases from Canyon Dam, and additional temperature reduction measures along all downstream Reaches. This alternative includes the following measures:

- Use Caribou PH No. 1 preferentially over operation of Caribou PH No. 2.
- Increase Canyon Dam low-level outlet release to about 250 cfs or higher and reduce withdrawal through the Prattville Intake commensurately.
- Convey cold water from Seneca Reach directly to Belden Reservoir at an appropriate plunging location and install a thermal curtain near Belden PH Intake; or, alternatively, operate Caribou PHs in strict peaking mode with several hours shut down completely in order for cold water from Seneca Reach to submerge.
- Convey warm water discharges from the East Branch NFFR directly into upper Rock Creek Reservoir.
- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; convey lower Belden Reach flows to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek/Chips Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.
- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Buck Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach; and, dredge a submerged channel in Cresta Reservoir. Or, alternatively, increase release (to about 150 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.
- Construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- There would be power generation loss at the Butt Valley PH and Caribou PH due to reduced releases.

- There would be further power generation loss at the Caribou PH complex due to lower turbine efficiency of Caribou PH No.1 relative to Caribou PH No.2. This could be mitigated by constructing a "crossover" conduit connecting Caribou PH No.1 to Caribou PH No.2.

- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.

Alternative 5b: This alternative is similar to 5a, except that the measure of preferential use of Caribou PH No. 1 is replaced by installing a thermal curtain near Caribou PH Intake. This alternative includes the following measures:

- Install a thermal curtain at Butt Valley Reservoir near Caribou PH Intake.

- Increase Canyon Dam low-level outlet release to about 250 cfs or higher and reduce withdrawal through the Prattville Intake commensurately.

- Convey cold water from Seneca Reach directly to Belden Reservoir at an appropriate plunging location and install a thermal curtain near Belden PH Intake; or, alternatively, operate Caribou PHs in strict peaking mode with several hours shut down completely in order for cold water from Seneca Reach to submerge.

- Convey warm water discharges from the East Branch directly into upper Rock Creek Reservoir.

- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; convey lower Belden Reach flows to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek/Chips Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.

- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Buck Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach; and, dredge a submerged channel in Cresta Reservoir. Or, alternatively, increase release (to about 150 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.

- Construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- o There would be power generation loss at the Butt Valley PH and Caribou PH due to reduced releases.

- o There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.

<u>**Alternative 5c:** This alternative is similar to 5a, except that the measure of preferential use of Caribou PH No. 1 is replaced by conveying Butt Valley PH discharges by pipeline to Butt Valley Reservoir near Caribou PH Intakes. This alternative includes the following measures:</u>

- Construct about five miles of pipeline laid along the bed of Butt Valley Reservoir for conveying Butt Valley PH discharges to Butt Valley Reservoir near Caribou PH Intake.

- Increase Canyon Dam low-level outlet release to about 250 cfs or higher and reduce withdrawal through the Prattville Intake commensurately.

- Convey cold water from Seneca Reach directly to Belden Reservoir at an appropriate plunging location and install a thermal curtain near Belden PH Intake; or, alternatively, operate Caribou PHs in strict peaking mode with several hours shut down completely in order for cold water from Seneca Reach to submerge.

- Convey warm water discharges from the East Branch directly into upper Rock Creek Reservoir.

- Construct a bifurcation berm/wall/partition starting along Yellow Creek extending into Rock Creek Reservoir to separate Yellow Creek flows from Belden PH discharges and Belden Reach flows to prevent mixing, allowing cooler Yellow Creek flows to submerge in Rock Creek Reservoir for release to the Rock Creek Reach, or convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging; convey lower Belden Reach flows to Rock Creek Reservoir for plunging; dredge a submerged channel in Rock Creek Reservoir; and, construct a low level outlet at Rock Creek Dam. Or, alternatively, construct a bypass pipeline to convey cold Yellow Creek/Chips Creek flows around Rock Creek Reservoir to the Rock Creek Reach; or alternatively, construct a mechanical cooling tower/chiller at Rock Creek Dam.

- Construct a low level outlet at Cresta Dam and construct a pipeline to convey all or a portion of the cold Buck Creek PH discharges directly into Cresta Reservoir to avoid mixing with Rock Creek PH discharges, allowing the cold Buck Creek PH flows to submerge in Cresta Reservoir for release to the Cresta Reach; and, dredge a submerged channel in Cresta Reservoir. Or, alternatively, increase release (to about 150 cfs) of cold water to the Cresta Reach from Grizzly Forebay/Grizzly Creek; or alternatively, construct a mechanical cooling tower/chiller at Cresta Dam.

- Construct a mechanical cooling tower/chiller at Poe Dam.

Remarks:

- o There would be power generation loss at the Butt Valley PH and Caribou PH due to reduced releases.

- There would be power generation loss at the Bucks Creek PH if the Cresta Reach temperature reduction measure is increased release from Grizzly Forebay/Grizzly Creek.

4.1.6 Water Temperature Reduction Alternative Category 6: Reduce temperatures in all downstream reaches

This category includes a combination of measures that would focus on temperature reduction in the downstream reaches, and does not necessarily require measures at Lake Almanor and Butt Valley Reservoir. This category has three alternatives.

<u>**Alternative 6a:** Reduce temperatures in all downstream reaches by increasing Canyon Dam cold water release from the low level outlet and bypassing this cold water to all downstream reaches. This alternative includes the following measures:</u>

- Increase Canyon Dam release to 250 cfs from the low level outlet.
- Construct a pipeline to convey cold Seneca Reach flows to Belden Reservoir for plunging or around Belden Reservoir to the Belden Reach and convey warm water discharges from the East Branch NFFR directly into upper Rock Creek Reservoir.
- Construct a bypass pipeline to convey cold Belden Reach flows (originating from Seneca Reach) from upstream of the East Branch and around Rock Creek Reservoir to the Rock Creek Reach.
- Construct a bypass pipeline to convey cold Rock Creek Reach flows (originating from Seneca Reach) around Cresta Reservoir to the Cresta Reach.
- Construct a bypass pipeline to convey cold Cresta Reach flows (originating from Seneca Reach) around Cresta Reservoir to the Poe Reach.

Remarks:

- There would be power generation loss at the Butt Valley PH and Caribou PHs due to reduced releases.

<u>**Alternative 6b:** Reduce temperatures in all downstream reaches (except for the Belden Reach) by constructing a mechanical cooling tower/chiller at each dam. This alternative includes the following measures:</u>

- Increase Canyon Dam low-level outlet release to 90 cfs or higher and reduce withdrawal through the Prattville Intake commensurately.
- Operate Caribou PHs in strict peaking mode with several hours shut down completely in order for cold water from Seneca Reach to submerge.
- Construct a mechanical cooling tower/chiller at Rock Creek Dam.
- Construct a mechanical cooling tower/chiller at Cresta Dam.

- Construct a mechanical cooling tower/chiller at Poe Dam.

Alternative 6c: Reduce temperatures in all downstream reaches by discharging cold water to the reaches from a delivery system that conveys cold water pumped from Lake Oroville.

- Construct a water delivery system that draws cold water from depth at Lake Oroville and delivers it to a discharge point below each NFFR dam starting upstream at Belden Dam and infusing to the Belden, Rock Creek, Cresta and Poe reaches.

Table 4-1 Initial Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR

<table>
<tr><th rowspan="2">Alternative Category</th><th colspan="2">Alternative</th><th colspan="4">Variations for Cooling Downstream Reaches</th></tr>
<tr><th>Alt.</th><th>Measures in reducing source water temperature to Belden Forebay</th><th>Additional measures for Belden Reach</th><th>Additional measures for Rock Creek Reach</th><th>Additional measures for Cresta Reach</th><th>Additional measures for Poe Reach</th></tr>
<tr><td>1. Reduce the temperature in Belden Forebay to 12.5 ºC.

(1 variation)</td><td>1</td><td>• Install Prattville thermal curtain with levee removed
• Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake
• Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td rowspan="3">2. Reduce the temperature in Belden Forebay to 14.5 ºC.

(9 variations)</td><td>2a</td><td>• Install Prattville thermal curtain with levee removed
• Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake</td><td rowspan="3">No</td><td rowspan="3">No</td><td rowspan="3">No</td><td>• Increase shading along Poe Reach</td></tr>
<tr><td>2b</td><td>• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake</td><td>• Increase Poe Dam release</td></tr>
<tr><td>2c</td><td>• Decrease Prattville Intake release to cause cold water selective withdrawal
• Extend the existing deeper channel of Butt Valley Reservoir by dredging
• Use Caribou #1 exclusively with reduced release to cause cold water selective withdrawal
• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs</td><td>• Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach</td></tr>
<tr><td rowspan="2">3. Reduce the temperature in Belden Forebay to 16.0 ºC.

(2 variations)</td><td rowspan="2">3</td><td rowspan="2">• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• Increase Canyon Dam release as needed (and decrease Prattville Intake release commensurately)</td><td rowspan="2">• Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline

Note: This measure is designed to protect the lower Belden Reach.</td><td rowspan="2">No</td><td>• Increase Cresta Dam release</td><td rowspan="2">• Increase Poe Dam release
• Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach</td></tr>
<tr><td>• Increase Grizzly Creek Release</td></tr>
</table>

Note: To explain how the number of variations is determined, take Alternative Category 2 as an example: Alternative Category 2 has three alternatives (2a, 2b, and 2c) and three variations for the Poe Reach, totaling 9 alternatives with variations (i.e., 3 × 3 = 9).

Table 4-1 Initial Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (Cont'd)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	**Measures in reducing source water temperature to Belden Forebay**	**Additional measures for Belden Reach**	**Additional measures for Rock Creek Reach**	**Additional measures for Cresta Reach**	**Additional measures for Poe Reach**
4. Reduce the temperature in Belden Forebay to 18.0 ºC. **(120 variations)**	**4a**	• Install Prattville thermal curtain • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir	• Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	• Construct Yellow Creek/ Belden PH bifurcation or, convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging • Construct low level outlet at Rock Creek Dam • Dredge a submerged channel in Rock Creek Reservoir	• Convey cold Bucks Creek PH flows to Cresta Reservoir for plunging by pipeline • Construct low level outlet at Cresta Dam	• Increase Poe Dam release • Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach
				• Bypass Yellow Creek flows around Rock Creek Reservoir by diversion/pipeline	• Bypass cold Bucks Creek PH flows around Cresta Reservoir by diversion/pipeline	
	4b	• Install Prattville thermal curtain • Use Caribou #1 preferentially over Caribou #2		• Increase Rock Creek Dam release	• Increase Cresta Dam release	
					• Increase Grizzly Creek releases to about 130 cfs	
	4c	• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs (and decrease Prattville Intake release commensurately) • Use Caribou #1 preferentially		• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	• Construct water chiller at Poe Dam
5. Reduce the temperature in Belden Forebay to 19.5 ºC. **(72 variations)**	**5a**	• Use Caribou #1 preferentially over Caribou #2 • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Convey cold Seneca Reach flows to Belden Reservoir for plunging by diversion/pipeline • Install a thermal curtain near Belden PH Intake • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct Yellow Creek/ Belden PH bifurcation or, convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging • Convey lower Belden Reach flows to Rock Creek Reservoir for plunging • Dredge a submerged channel in Rock Creek Reservoir • Construct low level outlet at Rock Creek Dam	• Convey cold Bucks Creek PH flows to Cresta Reservoir for plunging by diversion/pipeline • Dredge a submerged channel in Cresta Reservoir • Construct low level outlet at Cresta Dam	• Construct water chiller at Poe Dam
					• Bypass cold Bucks Creek PH flows around Cresta Reservoir by pipeline	
	5b	• Install thermal curtain near Caribou Intake in Butt Valley Reservoir • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass Yellow Creek/Chips Creek flows around Rock Creek Reservoir by diversion/pipeline	• Increase Grizzly Creek releases to about 150 cfs	
	5c	• Convey Butt Valley PH discharges by pipeline to Butt Valley Reservoir near the Caribou Intake • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)		• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	

Table 4-1 Initial Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (Cont'd)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	Measures in reducing source water temperature to Belden Forebay	Additional measures for Belden Reach	Additional measures for Rock Creek Reach	Additional measures for Cresta Reach	Additional measures for Poe Reach
6. Reduce temperatures in all downstream reaches. **(3 variations)**	**6a**	No	• Repair/modify Canyon Dam low level outlet and increase release to 250 cfs • Convey cold Seneca Reach flows to Belden Reservoir for plunging or around Belden Reservoir by diversion/pipeline • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass lower Belden Reach flows around Rock Creek Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Rock Creek Reach flows around Cresta Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Cresta Reach flows around Poe Reservoir by diversion/ pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.
	6b		• Increase Canyon Dam low level outlet release to 90 cfs or higher • Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	• Construct water chiller at Poe Dam
	6c		• Convey cold water from Lake Oroville to below Belden Dam	• Convey cold water from Lake Oroville to below Rock Creek Dam	• Convey cold water from Lake Oroville to below Cresta Dam	• Convey cold Lake Oroville to below Poe D.

Notes:
1) Water temperature reduction Alternative 6a is created by combining the measures in the first row. Accordingly, Alternative 6a has only one alternative and variation.
2) Water temperature reduction Alternative 6b is created by combining the measures in the second row. Accordingly, Alternative 6b has only one alternative and variation.
3) Water temperature reduction Alternative 6c is created by combining the measures in the third row. Accordingly, Alternative 6c has only one alternative and variation.

4.2 Screening of Initial Level 1 Water Temperature Reduction Alternatives and Final Level 1 Water Temperature Reduction Alternatives

As shown on Table 4-1, more than 200 alternative variations were available for consideration at the onset of the Level 1 evaluation. The State Water Board recognized that the wide array of choices offered in Level 1 would inhibit the ability to fully develop a reasonable range of CEQA alternatives. To focus efforts of the alternative development process on the most promising variations, the initial Level 1 water temperature reduction alternatives were subjected to the following coarse screening criteria:

- Effectiveness and reliability – Is there a reasonable potential that the alternative can effectively and reliably achieve the preliminary temperature target or, is the effectiveness and reliability of the alternative overly speculative?

- Technological feasibility and constructability – Can the alternative be implemented with currently available technology and construction methods?

- Logistics – Can the alternative be implemented when considering current legal obligations, regulatory permitting requirements, public safety needs, right-of-way and access needs, and other real world logistical constraints?

- Reasonability[25] – Are there clearly more reasonable or superior alternatives available based on the other criteria? Is implementation of the alternative remote or highly speculative?

The initial screening resulted in the elimination of certain alternatives. Justifications are described below:

<u>Elimination of Alternative Category 1 (Alternative 1) and Alternative 2b</u>
Alternative 1 and Alternative 2b rely on the substantial temperature reduction at the Butt Valley PH discharge by constructing an expansive, high-capacity wellfield that would pump cold water directly from the basalt aquifer discharging to Big Springs/northeastern Lake Almanor. This measure would, in theory, effectively reduce Butt Valley PH discharge temperature as required in Alternative 1. The hydrologic budget analysis of Lake Almanor suggests that Big Springs and related cold springs discharge up to 400 cfs into the lake on average; however, very little detailed information is available on the hydrogeology and developmental potential of the basalt aquifer supplying this cold water discharge. Extensive field investigation would be required to evaluate the feasibility and reliability of this alternative. Accordingly, this measure was eliminated based on the reasonability criterion because its effectiveness and implementation are remote and speculative. Consequently, Alternatives 1 and 2b, which rely on this wellfield measure, were eliminated.

<u>Elimination of Alternative 6c</u>
Alternative 6c relies on temperature reduction in the downstream reaches without drawing any cold water from Lake Almanor. Instead, this alternative cools the NFFR

[25] An EIR need not consider an alternative whose effect cannot be reasonably ascertained and whose implementation is remote and speculative (CEQA Guidelines, § 15126, subd. (d)).

reaches downstream of Belden Dam by constructing an expensive water delivery system that pumps cold water drawing from depth at Lake Oroville and delivers it to discharge points below each dam. This measure would, in theory, effectively reduce water temperature in each reach as required. However, the real world logistical considerations of withdrawing cold water from FERC Project 2100 could cause this measure to be dismissed. This measure would be extremely costly, in terms of construction cost and energy cost for pumping. Accordingly, this alternative was eliminated based on the reasonability criterion because there are clearly superior and more reasonable alternatives available and its implementation is remote.

The final Level 1 alternatives are summarized in Table 4-2. These alternatives are advanced for further analyses and evaluation in the Level 2 water temperature reduction alternatives screening process, detailed in Chapter 5. The "Alternative Development and Evaluation Process Flow Diagram", updated to reflect the results of Level 1 screening, is presented in Figure 4-1.

Table 4-2 Final Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR

(Level 1 screening eliminations identified by “strikeout”)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	Measures in reducing source water temperature to Belden Forebay	Additional measures for Belden Reach	Additional measures for Rock Creek Reach	Additional measures for Cresta Reach	Additional measures for Poe Reach
1. Reduce the temperature in Belden Forebay to 12.5 °C.	1	• Install Prattville thermal curtain with levee removed • ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~ • Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake	No	No	No	No
2. Reduce the temperature in Belden Forebay to 14.5 °C. **(6 variations)**	2a	• Install Prattville thermal curtain with levee removed • Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake	No	No	No	• Increase shading along Poe Reach
	2b	• Install Prattville thermal curtain with levee removed • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir • ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~				• Increase Poe Dam release
	2c	• Decrease Prattville Intake release to cause cold water selective withdrawal • Extend the existing deeper channel of Butt Valley Reservoir by dredging • Use Caribou #1 exclusively with reduced release to cause cold water selective withdrawal • Repair/modify Canyon Dam low level outlet and increase release to 600 cfs				• Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach
3. Reduce the temperature in Belden Forebay to 16.0 °C. **(2 variations)**	3	• Install Prattville thermal curtain with levee removed • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir • Increase Canyon Dam release as needed (and decrease Prattville Intake release commensurately)	• Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	No	• Increase Cresta Dam release • Increase Grizzly Creek Release	• Increase Poe Dam release • Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach

Note: To explain how the number of variations is determined, take Alternative Category 2 as an example: Alternative Category 2 has two alternatives (2a and 2c) and three variations for the Poe Reach, totaling 6 alternatives with variations (i.e., 2 × 3 = 6).

Table 4-2 Final Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR(Cont'd)

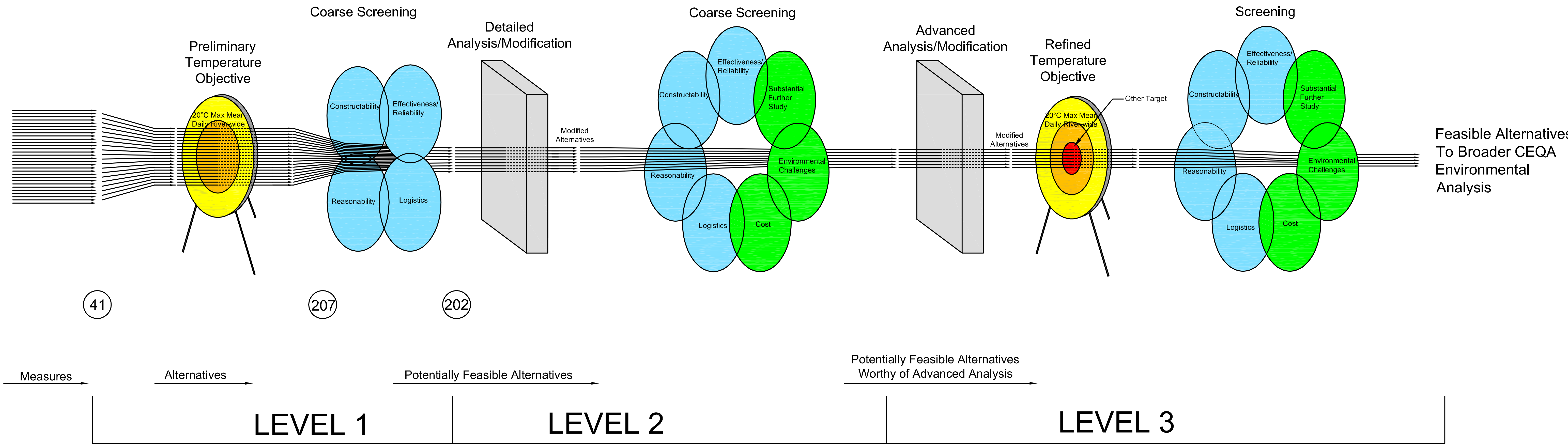
Alternative Category	Alternative: Alt.	Alternative: Measures in reducing source water temperature to Belden Forebay	Variations for Cooling Downstream Reaches: Additional measures for Belden Reach	Variations for Cooling Downstream Reaches: Additional measures for Rock Creek Reach	Variations for Cooling Downstream Reaches: Additional measures for Cresta Reach	Variations for Cooling Downstream Reaches: Additional measures for Poe Reach
4. Reduce the temperature in Belden Forebay to 18.0 ºC. **(120 variations)**	**4a**	• Install Prattville thermal curtain • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir	• Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	• Construct Yellow Creek/ Belden PH bifurcation or, convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging • Construct low level outlet at Rock Creek Dam • Dredge a submerged channel in Rock Creek Reservoir	• Convey cold Bucks Creek PH flows to Cresta Reservoir for plunging by pipeline • Construct low level outlet at Cresta Dam	• Increase Poe Dam release • Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach
				• Bypass Yellow Creek flows around Rock Creek Reservoir by diversion/pipeline	• Bypass cold Bucks Creek PH flows around Cresta Reservoir by diversion/pipeline	
	4b	• Install Prattville thermal curtain • Use Caribou #1 preferentially over Caribou #2		• Increase Rock Creek Dam release	• Increase Cresta Dam release	
					• Increase Grizzly Creek releases to about 130 cfs	
	4c	• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs (and decrease Prattville Intake release commensurately) • Use Caribou #1 preferentially		• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	• Construct water chiller at Poe Dam
5. Reduce the temperature in Belden Forebay to 19.5 ºC. **(72 variations)**	**5a**	• Use Caribou #1 preferentially over Caribou #2 • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Convey cold Seneca Reach flows to Belden Reservoir for plunging by diversion/pipeline • Install a thermal curtain near Belden PH Intake • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct Yellow Creek/ Belden PH bifurcation or, convey Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging • Convey lower Belden Reach flows to Rock Creek Reservoir for plunging • Dredge a submerged channel in Rock Creek Reservoir • Construct low level outlet at Rock Creek Dam	• Convey cold Bucks Creek PH flows to Cresta Reservoir for plunging by diversion/pipeline • Dredge a submerged channel in Cresta Reservoir • Construct low level outlet at Cresta Dam	• Construct water chiller at Poe Dam
					• Bypass cold Bucks Creek PH flows around Cresta Reservoir by pipeline	
	5b	• Install thermal curtain near Caribou Intake in Butt Valley Reservoir • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass Yellow Creek/Chips Creek flows around Rock Creek Reservoir by diversion/pipeline	• Increase Grizzly Creek releases to about 150 cfs	
	5c	• Convey Butt Valley PH discharges by pipeline to Butt Valley Reservoir near the Caribou Intake • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)		• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	

Table 4-2 Final Level 1 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (Cont'd)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	Measures in reducing source water temperature to Belden Forebay	Additional measures for Belden Reach	Additional measures for Rock Creek Reach	Additional measures for Cresta Reach	Additional measures for Poe Reach
6. Reduce temperatures in all downstream reaches. (2 variations)	6a	No	• Repair/modify Canyon Dam low level outlet and increase release to 250 cfs • Convey cold Seneca Reach flows to Belden Reservoir for plunging or around Belden Reservoir by diversion/pipeline • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass lower Belden Reach flows around Rock Creek Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Rock Creek Reach flows around Cresta Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Cresta Reach flows around Poe Reservoir by diversion/ pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.
	6b		• Increase Canyon Dam low level outlet release to 90 cfs or higher • Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct water chiller at Rock Creek Dam	• Construct water chiller at Cresta Dam	• Construct water chiller at Poe Dam
	~~6c~~		• ~~Convey cold water from Lake Oroville to below Belden Dam~~	• ~~Convey cold water from Lake Oroville to below Rock Creek Dam~~	• ~~Convey cold water from Lake Oroville to below Cresta Dam~~	• ~~Convey cold Lake Oroville to below Poe D.~~

Notes:

1) Water temperature reduction Alternative 6a is created by combining the measures in the first row. Accordingly, Alternative 6a has only one alternative and variation.
2) Water temperature reduction Alternative 6b is created by combining the measures in the second row. Accordingly, Alternative 6b has only one alternative and variation.



F:\DATA\2125\CAD\Alternative Flow Diagram Rev 5.dwg

STETSON ENGINEERS INC.

Figure 4-1

Upper North Fork Feather River: Alternatives Development and Evaluation Process Flow Diagram and Resulting Number of Alternatives in Level 1

5.0 LEVEL 2 ANALYSIS OF WATER TEMPERATURE REDUCTION ALTERNATIVES

This chapter describes the Level 2 analysis of water temperature reduction alternatives that passed Level 1 screening (as summarized in Chapter 4, Table 4-2). The analysis included further study of effectiveness in reducing water temperatures and achieving the temperature target along the NFFR, refinement of the alternatives, and preparation of rough design layouts, cost estimates and operational requirements. Based on this information, the initial Level 2 water temperature reduction alternatives were then screened by applying the same criteria used in Level 1 (refer to Section 4.2, p. 4-17) plus the following additional criteria:

- Substantial Further Study - Is there sufficient information currently available or can it be readily developed in order to evaluate the potential effectiveness and

- feasibility of the alternative, or is substantial further investigation or study required?

- Environmental challenges – Are there obvious environmental consequences or problems associated with the alternative that would pose a major challenge to overcome?

- Economic feasibility – Can the alternative be implemented at a reasonable cost, including capital, O&M, and considering energy replacement costs?

The resulting water temperature reduction alternatives passing Level 2 screening represent *the set of potentially effective and feasible* alternatives to achieving the temperature target and are recommended for final detailed technical analysis in Level 3.

5.1 INITIAL LEVEL 2 WATER TEMPERATURE REDUCTION ALTERNATIVES -- DESIGN LAYOUTS, OPERATIONAL REQUIREMENTS, COST ESTIMATES, AND EFFECTIVENESS

Descriptions for the initial Level 2 water temperature reduction alternatives generally follow those provided in Chapter 4 (refer to section 4.1; Table 4-2), with some refinements based on more detailed modeling analysis of effectiveness in reducing water temperatures in Level 2. The refinements offer several new variations, focusing primarily on changes in hydroelectric facility operations. These new variations increased the number of alternatives from 202 to 370, and are shown in bold font in Table 5-1[26]. This formatting is carried forward in subsequent tables.

Illustrative layouts for selected alternatives are presented in Figures 5-1 through 5-7. Each figure also includes a table summarizing the estimated cost of the alternative and a graph showing the resulting water temperature profile along the NFFR. Because it was not practical to prepare figures for all the alternatives and possible variations listed in Table 5-1 (370 variations), figures were prepared only for selected alternatives covering a range of alternatives and variations. These figures illustrate how water temperature measures have been combined to create

[26] As a result of refinement of the alternatives, flow-related measures were added for the Rock Creek, Cresta, and Poe downstream reaches, creating additional variations for the Category 5 alternatives (not previously explored in Level 1).

comprehensive water temperature reduction alternatives to decrease water temperature and meet the temperature target of 20°C mean daily along the entire NFFR.

The following alternatives with variations were available at the beginning of the Level 2 evaluation (i.e., initial Level 2 water temperature reduction alternatives).

- Alternative Category 2 – two alternatives (Alternatives 2a & 2c) with three variations for the Poe Reach, totaling 6 alternative variations (i.e., 2 × 3 = 6).
- Alternative Category 3 – one alternative (Alternative 3) with one variation for the Belden Reach, two variations for the Cresta Reach, and one variation for the Poe Reach, totaling 2 alternative variations (i.e., 1 × 1 × 2 × 1 = 2).
- Alternative Category 4 – three alternatives (Alternatives 4a, 4b, and 4c) with one variation for the Belden Reach, four variations for the Rock Creek Reach, five variations for the Cresta Reach, and two variations for the Poe Reach, totaling 120 alternative variations (i.e., 3 × 1 × 4 × 5 × 2 = 120).
- Alternative Category 5 – three alternatives (Alternatives 5a, 5b & 5c) with two variations for the Belden Reach, four variations for the Rock Creek Reach, five variations for the Cresta Reach, and two variations for the Poe Reach, totaling 240 alternative variations (i.e., 3 × 2 × 4 × 5 × 2 = 240).
- Alternative Category 6 – two alternatives (Alternatives 6a & 6b), 2 variations[27].

Cost tables for all initial Level 2 water temperature reduction alternatives are presented by category in Tables 5-2a through 5-2e. The cost estimates derive from the design layouts and detailed descriptions of the individual water temperature reduction measures that comprise the water temperature reduction alternatives. These descriptions include narratives, rough engineering designs and cost estimates, key design or construction uncertainties, and discussions (refer to Appendix E for detailed information about engineering designs and cost estimates for these individual water temperature reduction measures). The effectiveness of each alternative in reducing temperatures and achieving the temperature target was analyzed following the same method used in Level 1, with the addition in Level 2 of detailed stream water temperature modeling and water temperature mixing analysis (refer to Chapter 3).

[27] See the notes under Alternative Category 6 of Table 5-1.

Table 5-1 Initial Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR

(Note: **bold** denotes refinement to final Level 1 alternative)

<table>
<tr><th rowspan="2">Alternative Category</th><th colspan="2">Alternative</th><th colspan="4">Variations for Cooling Downstream Reaches</th></tr>
<tr><th>Alt.</th><th>Measures in reducing source water temperature to Belden Forebay</th><th>Additional measures for Belden Reach</th><th>Additional measures for Rock Creek Reach</th><th>Additional measures for Cresta Reach</th><th>Additional measures for Poe Reach</th></tr>
<tr><td rowspan="3">2. Reduce the temperature in Belden Forebay to 14.5 ºC.

(6 variations)</td><td rowspan="2">2a</td><td rowspan="2">• Install Prattville thermal curtain with levee removed
• Convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intake</td><td rowspan="3">No</td><td rowspan="3">No</td><td rowspan="3">No</td><td>• Increase shading along Poe Reach</td></tr>
<tr><td>• Increase Poe Dam release to 360 cfs</td></tr>
<tr><td>2c</td><td>• Decrease Prattville Intake release to 500 cfs to cause cold water selective withdrawal
• Extend the existing deeper channel of Butt Valley Reservoir by dredging
• Use Caribou #1 exclusively with reduced release to cause cold water selective withdrawal from Butt Valley Reservoir
• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs</td><td>• Construct outlet/pipeline from the Poe Adit and release to 180 cfs of cooler water to the Poe Reach</td></tr>
<tr><td rowspan="2">3. Reduce the temperature in Belden Forebay to 16.0 ºC.

(2 variations)</td><td rowspan="2">3</td><td rowspan="2">• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• Increase Canyon Dam release to 250 cfs (and decrease Prattville Intake release commensurately)</td><td rowspan="2">• Convey warm water to 100 cfs from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline

Note: This measure is designed to protect the lower Belden Reach.</td><td rowspan="2">No</td><td>• Increase Cresta Dam release to 390 cfs</td><td rowspan="2">• Increase Poe Dam release to 300 cfs
• Construct outlet/pipeline from the Poe Adit and release to 400 cfs the cooler water to the Poe Reach</td></tr>
<tr><td>• Increase Grizzly Creek release to 50 cfs</td></tr>
</table>

Note: All alternatives will have no affect on Lake Almanor water levels except Alternative 2c which, due to significant flow reduction at the Prattville Intake, would result in higher summer lake levels than those that occurred historically.

Table 5-1 Initial Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (continued)

(Note: **bold** denotes refinement to final Level 1 alternative)

Alternative Category	**Alternative**		**Variations for Cooling Downstream Reaches**			
	Alt.	**Measures in reducing source water temperature to Belden Forebay**	**Additional measures for Belden Reach**	**Additional measures for Rock Creek Reach**	**Additional measures for Cresta Reach**	**Additional measures for Poe Reach**
4. Reduce the temperature in Belden Forebay to 18.0 ºC. **(120 variations)**	**4a**	• Install Prattville thermal curtain • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir	• Convey warm water **to 100 cfs** from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	• Construct Yellow Cr/ Belden PH bifurcation or, convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Construct low level outlet at Rock Creek Dam • Dredge a submerged channel in Rock Creek Reservoir	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by pipeline • Construct low level outlet at Cresta Dam	• Increase Poe Dam release **to 400 cfs** • Construct outlet/pipeline from the Poe Adit and release **to 450 cfs** of cooler water to the Poe Reach
				• Bypass Yellow Creek flows **to 60 cfs** around Rock Creek Reservoir by diversion/pipeline	• Bypass cold Bucks Creek PH flows **to 95 cfs** around Cresta Reservoir by diversion/pipeline	
	4b	• Install Prattville thermal curtain • Use Caribou #1 preferentially over Caribou #2		• Increase Rock Creek Dam release **to 400 cfs**	• Increase Cresta Dam release **to 500 cfs**	
					• Increase Grizzly Creek releases to **80 cfs**	
	4c	• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs (and decrease Prattville Intake release commensurately) • Use Caribou #1 preferentially over Caribou #2		• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	• Construct **200 cfs capacity** water chiller at Poe Dam
5. Reduce the temperature in Belden Forebay to 19.5 ºC. **(240 variations)**	**5a**	• Use Caribou #1 preferentially over Caribou #2 • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Convey cold Seneca Reach flows **to 250 cfs** to Belden Reservoir for plunging by diversion/pipeline • Install a thermal curtain near Belden PH Intake • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct Yellow Cr/ Belden PH bifurcation or, convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Convey lower Belden Reach flows **to 140 cfs** to Rock Creek Reservoir for plunging • Dredge a submerged channel in Rock Creek Reservoir • Construct low level outlet at Rock Creek Dam	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by diversion/pipeline • Dredge a submerged channel in Cresta Reservoir • Construct low level outlet at Cresta Dam	• **Increase Poe Dam release** • **Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach**
	5b	• Install thermal curtain near Caribou Intake in Butt Valley Reservoir • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)			• Bypass cold Bucks Creek PH flows **to 110 cfs** around Cresta Reservoir by pipeline	
			• Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water **to 100 cfs** from East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass Yellow Creek/Chips Creek flows **to 80 cfs** around Rock Creek Reservoir by diversion/pipeline	• **Increase Cresta Dam release to 700 cfs**	
	5c	• Convey Butt Valley PH discharges **to 2,000 cfs** by pipeline to Butt Valley Res. near the Caribou Intake • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)		• **Increase Rock Creek Dam release to 600 cfs**	• Increase Grizzly Creek releases to **100 cfs**	• Construct **200 cfs capacity** water chiller at Poe Dam
				• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	

Table 5-1 Initial Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (continued)

(Note: **bold** denotes refinement to final Level 1 alternative)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	Measures in reducing source water temperature to Belden Forebay	Additional measures for Belden Reach	Additional measures for Rock Creek Reach	Additional measures for Cresta Reach	Additional measures for Poe Reach
6. Reduce temperatures in all downstream reaches. **(2 variations)**	**6a**	No	• Repair/modify Canyon Dam low level outlet and increase release to 250 cfs • Convey cold Seneca Reach flows to Belden Reservoir for plunging by diversion/pipeline • **Increase Belden Dam/Oak Flat PH release to 250 cfs** • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass lower Belden Reach flows **to 250 cfs** around Rock Creek Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Rock Creek Reach flows **to 250 cfs** around Cresta Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Cresta Reach flows **to 250 cfs** around Poe Reservoir by diversion/ pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.
	6b		• Increase Canyon Dam low level outlet release to 90 cfs or higher • Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	• Construct **200 cfs capacity** water chiller at Poe Dam

Notes:

1) Water temperature reduction alternative 6a is created by combining the measures in the first row. Accordingly, Alternative 6a has only one alternative and variation.
2) Water temperature reduction alternative 6b is created by combining the measures in the second row. Accordingly, Alternative 6b has only one alternative and variation.

Table 5-2a Summary of Cost Estimates for Alternative Category 2

Alt.	Measures	Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh $\times 10^6$/ year	$/year	
Measures in Reducing Source Water Temperature to Belden Forebay										
2a	Install Prattville thermal curtain and remove submerged levees	8,068,000	2,824,000	2,723,000	13,615,000	529,000	136,000	0.00	0	665,000
	Construct bypass pipeline to convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intakes	101,560,000	35,546,000	34,277,000	171,383,000	6,661,000	428,000	7.29	474,000	7,563,000
	Subtotal	**109,628,000**	**38,370,000**	**37,000,000**	**184,998,000**	**7,190,000**	**564,000**	**7.29**	**474,000**	**8,228,000**
2c	Decrease Prattville Intake Release to 500 cfs to cause cold water selective withdrawal	0	0	0	0	0	0	0.00	0	0
	Extend the Existing Bottom Channel of Butt Valley Reservoir to near Caribou #1 Intake by Dredging	11,876,000	4,157,000	4,008,000	20,041,000	779,000	200,000	0.00	0	979,000
	Operate Caribou #1 PH Exclusively	0	0	0	0	0	0	10.88	707,000	707,000
	Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 600 cfs	12,000,000	4,200,000	4,050,000	20,250,000	787,000	101,000	79.17	5,146,000	6,034,000
	Subtotal	**23,876,000**	**8,357,000**	**8,058,000**	**40,291,000**	**1,566,000**	**301,000**	**90.05**	**5,853,000**	**7,720,000**
Additional Measures for Poe Reach										
(1)	Increase shading along Poe Reach *									
(2)	Increase Poe Dam release to 360 cfs	0	0	0	0	0	0	7.72	502,000	502,000
(3)	Construct outlet/pipeline from Poe Adit to release cool water to 180 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	8.69	565,000	775,000

Note: A water temperature reduction alternative is created by combining any numbered “measure” in reducing source water temperature to Belden Forebay together with one “additional measure” provided for each downstream reach.

* Cost was not estimated.

Table 5-2b Summary of Cost Estimates for Alternative Category 3

Alt.	Measures	Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh $\times 10^6$/ year	$/year	
Measures in Reducing Source Water Temperature to Belden Forebay										
3	Install Prattville thermal curtain and remove submerged levees	8,068,000	2,824,000	2,723,000	13,615,000	529,000	136,000	0.00	0	665,000
	Install Caribou Intake thermal curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39	1,715,000	2,160,000
	Subtotal	**19,445,000**	**6,806,000**	**6,563,000**	**32,814,000**	**1,276,000**	**278,000**	**26.39**	**1,715,000**	**3,269,000**
Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Additional Measures for Cresta Reach										
(1)	Increase Cresta Dam release to 390 cfs	0	0	0	0	0	0	6.29	409,000	409,000
(2)	Increase Grizzly Creek release to 50 cfs	0	0	0	0	0	0	9.81	638,000	638,000
Additional Measures for Poe Reach										
(1)	Increase Poe Dam release to 300 cfs	0	0	0	0	0	0	4.83	314,000	314,000
	Construct outlet/pipeline from Poe Adit to release cool water to 400 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	19.31	1,255,000	1,465,000
	Subtotal	**2,998,000**	**1,049,000**	**1,012,000**	**5,059,000**	**197,000**	**13,000**	**24.14**	**1,569,000**	**1,779,000**

Note: A water temperature reduction alternative is created by combining any numbered “measure” in reducing source water temperature to Belden Forebay together with one “additional measure” provided for each downstream reach.

Table 5-2c Summary of Cost Estimates for Alternative Category 4

Alt.	Measures	Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh $\times 10^6$/ year	$/year	
Measures in Reducing Source Water Temperature to Belden Forebay										
4a	Install Prattville thermal curtain	5,948,000	2,082,000	2,008,000	10,038,000	390,000	100,000	0.00	0	490,000
4a	Install Caribou Intake thermal curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
4a	**Subtotal**	**11,325,000**	**3,964,000**	**3,823,000**	**19,112,000**	**743,000**	**191,000**	**0.00**	**0**	**934,000**
4b	Install Prattville thermal curtain	5,948,000	2,082,000	2,008,000	10,038,000	390,000	100,000	0.00	0	490,000
4b	Operate Caribou #1 PH preferentially	0	0	0	0	0	0	13.91	904,000	904,000
4b	**Subtotal**	**5,948,000**	**2,082,000**	**2,008,000**	**10,038,000**	**390,000**	**100,000**	**13.91**	**904,000**	**1,394,000**
4c	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 600 cfs	12,000,000	4,200,000	4,050,000	20,250,000	787,000	101,000	79.17	5,146,000	6,034,000
4c	Operate Caribou #1 PH preferentially	0	0	0	0	0	0	11.32	736,000	736,000
4c	**Subtotal**	**12,000,000**	**4,200,000**	**4,050,000**	**20,250,000**	**787,000**	**101,000**	**90.49**	**5,882,000**	**6,770,000**
Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Additional Measures for Rock Creek Reach										
(1)	Convey Yellow Creek flows to 60 cfs to Rock Creek Reservoir for plunging									
(1)	Dredge a submerged channel in Rock Creek Reservoir									
(1)	Construct low-level outlet at Rock Creek Dam									
(1)	**Subtotal ***	**13,516,000**	**4,731,000**	**4,562,000**	**22,809,000**	**886,000**	**57,000**	**0.00**	**0**	**943,000**
(2)	Construct bypass pipeline to convey Yellow Creek flows to 60 cfs around Rock Creek Reservoir	12,576,000	4,402,000	4,245,000	21,223,000	825,000	53,000	0.00	0	878,000
(3)	Increase Rock Creek Dam release to 400 cfs	0	0	0	0	0	0	14.46	940,000	940,000
(4)	Construct 150 cfs capacity water chiller near Rock Creek Dam	3,401,000	1,190,000	1,148,000	5,739,000	223,000	172,000	5.05	328,000	723,000

* Cost was estimated for combined measure.

Table 5-2c Summary of Cost Estimates for Alternative Category 4 (Continued)

		Capital Cost ($)				Annual Cost ($/year)				
								Foregone Power Generation Loss		
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	KWh ×10^6/ year	$/year	Total
Additional Measures for Cresta Reach										
(1)	Construct bypass pipeline to convey Bucks Creek PH flows to 140 cfs to Cresta Reservoir for plunging									
	Construct low-level outlet at Cresta Dam									
	Subtotal *	**14,597,000**	**5,109,000**	**4,927,000**	**24,633,000**	**957,000**	**62,000**	**0.00**	**0**	**1,019,000**
(2)	Construct bypass pipeline to convey Bucks Creek PH flows to 95 cfs around Cresta Reservoir	17,770,000	6,220,000	5,998,000	29,988,000	1,165,000	75,000	0.00	0	1,240,000
(3)	Increase Cresta Dam release to 500 cfs	0	0	0	0	0	0	9.50	618,000	618,000
(4)	Increase Grizzly Creek release to 80 cfs	0	0	0	0	0	0	16.50	1,073,000	1,073,000
(5)	Construct 175 cfs capacity water chiller near Cresta Dam	6,039,000	2,114,000	2,038,000	10,191,000	396,000	306,000	9.09	591,000	1,293,000
Additional Measures for Poe Reach										
(1)	Increase Poe Dam release to 400 cfs	0	0	0	0	0	0	9.66	628,000	628,000
	Construct outlet/pipeline from Poe Adit to release cool water to 450 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	21.72	1,412,000	1,622,000
	Subtotal	**2,998,000**	**1,049,000**	**1,012,000**	**5,059,000**	**197,000**	**13,000**	**31.38**	**2,040,000**	**2,250,000**
(2)	Construct 200 cfs capacity water chiller near Poe Dam	8,285,000	2,900,000	2,796,000	13,981,000	543,000	419,000	13.12	853,000	1,815,000

Note: A water temperature reduction alternative is created by combining any numbered "measure" in reducing source water temperature to Belden Forebay together with one "additional measure" provided for each downstream reach.

* Cost was estimated for combined measure.

Table 5-2d Summary of Cost Estimates for Alternative Category 5

Alt.	Measures	Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh ×10^6/ Year	$/year	
Measures in Reducing Source Water Temperature to Belden Forebay										
5a	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39	1,715,000	2,160,000
	Operate Caribou #1 PH preferentially	0	0	0	0	0	0	14.31	930,000	930,000
	Subtotal	**6,000,000**	**2,100,000**	**2,025,000**	**10,125,000**	**394,000**	**51,000**	**40.70**	**2,645,000**	**3,090,000**
5b	Install Caribou Intake thermal curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39	1,715,000	2,160,000
	Subtotal	**11,377,000**	**3,982,000**	**3,840,000**	**19,199,000**	**747,000**	**142,000**	**26.39**	**1,715,000**	**2,604,000**
5c	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39	1,715,000	2,160,000
	Construct bypass pipeline to convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intakes	101,560,000	35,546,000	34,277,000	171,383,000	6,661,000	428,000	7.29	474,000	7,563,000
	Subtotal	**107,560,000**	**37,646,000**	**36,302,000**	**181,508,000**	**7,055,000**	**479,000**	**33.68**	**2,189,000**	**9,723,000**
Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey Seneca Reach flows to 250 cfs to Belden Reservoir for plunging	9,486,000	3,320,000	3,202,000	16,008,000	622,000	40,000	0.00	0	662,000
	Install Belden PH Intake thermal curtain	3,371,000	1,180,000	1,138,000	5,689,000	221,000	57,000	0.00	0	278,000
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
	Subtotal	**16,905,000**	**5,917,000**	**5,706,000**	**28,528,000**	**1,108,000**	**114,000**	**0.00**	**0**	**1,222,000**
(2)	Operate Caribou PHs in strict peaking mode with several hours shutdown	0	0	0	0	0	0	0.00	0	0
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
	Subtotal	**4,048,000**	**1,417,000**	**1,366,000**	**6,831,000**	**265,000**	**17,000**	**0.00**	**0**	**282,000**

Table 5-2d Summary of Cost Estimates for Alternative Category 5 (Continued)

		Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh $\times 10^6$/ Year	Foregone Power Generation Loss: $/year	Total
Additional Measures for Rock Creek Reach										
(1)	Convey Yellow Creek flows to 60 cfs to Rock Creek Reservoir for plunging									
	Convey lower Belden Reach flows to 140 cfs to Rock Creek Reservoir for plunging									
	Dredge a submerged channel in Rock Creek Reservoir									
	Construct low-level outlet at Rock Creek Dam									
	Subtotal *	**18,309,000**	**6,408,000**	**6,179,000**	**30,896,000**	**1,201,000**	**77,000**	**0.00**	**0**	**1,278,000**
(2)	Construct bypass pipeline to convey Yellow Creek/ Chips Creek flows to 80 cfs around Rock Creek Reservoir	15,652,000	5,478,000	5,283,000	26,413,000	1,027,000	66,000	0.00	0	1,093,000
(3)	Increase Rock Creek Dam release to 600 cfs	0	0	0	0	0	0	26.03	1,692,000	1,692,000
(4)	Construct 150 cfs capacity water chiller near Rock Creek Dam	4,171,000	1,460,000	1,408,000	7,039,000	274,000	211,000	7.07	460,000	945,000
Additional Measures for Cresta Reach										
(1)	Construct bypass pipeline to convey Bucks Creek PH flows to 140 cfs to Cresta Reservoir for plunging									
	Dredge a submerged channel in Cresta Reservoir									
	Construct low-level outlet at Cresta Dam									
	Subtotal *	**21,913,000**	**7,670,000**	**7,396,000**	**36,979,000**	**1,437,000**	**92,000**	**0.00**	**0**	**1,529,000**
(2)	Construct bypass pipeline to convey Bucks Creek PH flows to 110 cfs around Cresta Reservoir	17,770,000	6,220,000	5,998,000	29,988,000	1,165,000	75,000	0.00	0	1,240,000
(3)	Increase Cresta Dam release to 700 cfs	0	0	0	0	0	0	15.35	998,000	998,000
(4)	Increase Grizzly Creek release to 100 cfs	0	0	0	0	0	0	20.96	1,362,000	1,362,000
(5)	Construct 175 cfs capacity water chiller near Cresta Dam	6,809,000	2,383,000	2,298,000	11,490,000	447,000	345,000	11.10	722,000	1,514,000
Additional Measures for Poe Reach										
(1)	Increase Poe Dam release									
	Construct outlet/pipeline from Poe Adit to release cool water									
	Subtotal **									
(2)	Construct 200 cfs capacity water chiller near Poe Dam	9,055,000	3,169,000	3,056,000	15,280,000	594,000	458,000	15.14	984,000	2,036,000

Note: A water temperature reduction alternative is created by combining any numbered "measure" in reducing source water temperature to Belden Forebay together with one "additional measure" provided for each downstream reach. * Cost was estimated for combined measure. ** Cost was not estimated. Further analysis to determine design/operational parameters is required.

Table 5-2e Summary of Cost Estimates for Alternative Category 6

Alt.	Measures	Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh $\times 10^6$/ year	$/year	
Measures in Reducing Source Water Temperature to Belden Forebay										
6a	None									
6b	None									
Additional Measures for Belden Reach										
(1)	Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 250 cfs	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39	1,715,000	2,160,000
	Construct Bypass Pipeline to Convey Seneca Reach Flows (250 cfs) to Belden Reservoir for Plunging and increase Belden Dam release to 250 cfs	9,486,000	3,320,000	3,202,000	16,008,000	622,000	40,000	9.26	602,000	1,264,000
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
	Subtotal	**19,534,000**	**6,837,000**	**6,593,000**	**32,964,000**	**1,281,000**	**108,000**	**35.65**	**2,317,000**	**3,706,000**
(2)	Increase Canyon Dam Low-Level Outlet Release to the Required Minimum Flow 90 cfs	0	0	0	0	0	0	0.00	0	0
	Operate Caribou PHs in Strict Peaking Mode with Several Hours Shutdown	0	0	0	0	0	0	0.00	0	0
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
	Subtotal	**4,048,000**	**1,417,000**	**1,366,000**	**6,831,000**	**265,000**	**17,000**	**0.00**	**0**	**282,000**
Additional Measures for Rock Creek Reach										
(1)	Construct Bypass Pipeline to Convey Lower Belden Reach Flows to 250 cfs around Rock Creek Reservoir	15,242,000	5,335,000	5,144,000	25,721,000	1,000,000	64,000	5.78	376,000	1,440,000
(2)	Construct 150 cfs capacity water chiller near Rock Creek Dam	6,096,000	2,134,000	2,058,000	10,288,000	400,000	309,000	12.11	787,000	1,496,000

Table 5-2e Summary of Cost Estimates for Alternative Category 6 (Continued)

		Capital Cost ($)				Annual Cost ($/year)				
		Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
								KWh $\times 10^6$/ year	$/year	
Additional Measures for Cresta Reach										
(1)	Construct Bypass Pipeline to Convey Lower Rock Creek Reach Flows to 250 cfs around Cresta Reservoir	16,299,000	5,705,000	5,501,000	27,505,000	1,069,000	69,000	2.19	142,000	1,280,000
(2)	Construct 175 cfs capacity water chiller near Cresta Dam	8,349,000	2,922,000	2,818,000	14,089,000	548,000	423,000	15.14	984,000	1,955,000
Additional Measures for Poe Reach										
(1)	Construct Bypass Pipeline to Convey Lower Cresta Reach Flows to 250 cfs around Poe Reservoir	13,066,000	4,573,000	4,410,000	22,049,000	857,000	55,000	2.41	157,000	1,069,000
(2)	Construct 200 cfs capacity water chiller near Poe Dam	11,750,000	4,113,000	3,966,000	19,829,000	771,000	595,000	22.21	1,444,000	2,810,000

Notes:

1) Water temperature reduction alternative 6a is created by combining the first numbered “measure” in reducing source water temperature to Belden Forebay together with the first numbered “additional measure” provided for each downstream reach.
2) Water temperature reduction alternative 6b is created by combining the second numbered “measure” in reducing source water temperature to Belden Forebay together with the second numbered “additional measure” provided for each downstream reach.

5.2 SCREENING OF INITIAL LEVEL 2 WATER TEMPERATURE REDUCTION ALTERNATIVES AND FINAL LEVEL 2 WATER TEMPERATURE REDUCTION ALTERNATIVES

Due to the large number of alternative variations at the completion of the Level 1 effort plus the addition of flow-related measures as choices for the Rock Creek, Cresta, and Poe reaches, the State Water Board identified the need to enhance the screening process for the initial Level 2 water temperature reduction alternatives. The following coarse screening criteria were applied to these water temperature reduction alternatives:

- Effectiveness and reliability – Is there a reasonable potential that the alternative can effectively and reliably achieve the preliminary temperature target or, is the effectiveness and reliability of the alternative overly speculative?
- Technological feasibility and constructability – Can the alternative be implemented with currently available technology and construction methods?
- Logistics – Can the alternative be implemented when considering current legal obligations, regulatory permitting requirements, public safety needs, right-of-way and access needs, and other real world logistical constraints?
- Reasonability[28] – Are there clearly more reasonable or superior alternatives available based on the other criteria? Is implementation of the alternative remote or highly speculative?

plus,

- Substantial Further Study -- Is there sufficient information available or can it be readily developed in order to evaluate the potential effectiveness and feasibility of the alternative, or is substantial further investigation or study required?
- Environmental challenges – Are there obvious environmental consequences or problems associated with the alternative that would pose a major challenge to overcome?
- Economic feasibility – Can the alternative be implemented at a reasonable cost, including capital, O&M, and considering energy replacement costs?

Through the Level 2 screening, the application of these criteria reduced the number of variations available and resulted in the elimination of certain alternatives or measures. The process of eliminating alternatives/measures incorporated a grading system where values were assigned under each of the screening criterion to identify how well a particular alternative/measure met the criteria. Four grades were used in Level 2 screening: Fail, 1 (nearly fails), 2 (minor concerns), or 3 (meets the criterion). One “fail” or consistent low grades across the criteria were grounds for elimination of the alternative/measure. Operational modification measures were not graded for the technological feasibility/ constructability criterion. Tables 5-3a through 5-3e summarize justifications for the elimination of certain initial Level 2 water temperature reduction alternatives and other individual additional water temperature reduction measures considered for downstream reaches. The following discussion provides the rational for the elimination of certain alternatives/measures.

[28] An EIR need not consider an alternative whose effect cannot be reasonably ascertained and whose implementation is remote and speculative (CEQA Guidelines, § 15126, subd. (d)).

Elimination of Alternatives/Measures

Alternative 2a fails the technological feasibility/constructability, reasonability, and economic feasibility criteria. This alternative consists of the measure of conveying Butt Valley PH discharge (2,000 cfs) through Butt Valley Reservoir by submerged pipeline to an endpoint near the Caribou Intakes, which requires placing seven, 72-inch diameter pipelines, 5-miles long along the bottom of Butt Valley Reservoir and requires designing and installing an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting. The measure also requires connecting three 13' x 9.5' conduits to the Butt Valley PH turbine discharge pipes which are inside of the powerhouse structure. The constructability of this alternative is highly uncertain. Construction would be difficult and the capital cost is estimated to be very high (over $100 million). In addition, there is another alternative in Alternative Category 2, Alternative 2c, that has considerably less uncertainty and is more reasonable than Alternative 2a. Consequently, Alternative 2a was eliminated.

Alternative 5c, like Alternative 2a, also includes construction of a submerged pipeline along the bottom of Butt Valley Reservoir. Following the same reasoning for Alternative 2a, Alternative 5c fails the technological feasibility/constructability, reasonability, and the economic feasibility criteria. Consequently, Alternative 5c was eliminated.

Alternative 6a fails the technological feasibility/constructability criterion. This alternative requires the construction of bypass pipelines around Rock Creek Reservoir, Cresta Reservoir, and Poe Reservoir. Bypassing Rock Creek Reservoir requires: 1) attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek; 2) burying a 66-inch Reinforced Concrete Pipe near the channel along the north bank of the NFFR just upstream of the confluence with Yellow Creek; and 3) connecting 155 LF of 66-inch Black Steel Pipe to the steep rock face at the dam. Bypassing Cresta Reservoir requires: 1) attaching a 66-inch HDPE pipe to the existing 7'-8 3/8" I.D. sluice pipe underwater at the toe of Cresta Dam; 2) connecting a 66-inch black steel pipe to the concrete face of Rock Creek PH without affecting the existing discharge of the PH; 3) placing a 66-inch, 2-mile long HDPE along the bottom of Cresta Reservoir. Bypassing Poe Reservoir requires: 1) connecting a 66-inch black steel pipe to the concrete face of Cresta PH without affecting the existing discharge of the PH; 2) placing a 66-inch, one-mile long HDPE along the bottom of Poe Reservoir; and 3) attaching a 66-inch HDPE pipe to the existing 66-inch outlet pipe underwater at the toe of the dam. The constructability of this alternative is highly uncertain, and construction would be difficult and the capital cost is estimated to be very high (over $100 million). Consequently, Alternative 6a was eliminated.

Alternative 6b fails the logistics criterion. This alternative requires installing multiple large capacity water chillers near each of Rock Creek, Cresta, and Poe Dams. The chillers should be located above the 100-year floodplain to avoid significant safety hazards: Siting the chillers in suitable locations outside of the flood hazard area would require further investigation. The chillers would be large and unsightly, which could aesthetically degrade the scenic river corridor. The chillers could produce fog creating a safety hazard. Consequently, Alternative 6b was eliminated.

Table 5-3a Screening of Alternative/ Measures under Alternative Category 2

(Level 2 screening eliminations identified in red; Four grades used in Level 2 screening: Fail, 1 (nearly fails), 2 (minor concerns), or 3 (meets the criterion); One failure or consistent low grades are grounds for elimination; Operational modification measures not graded for the technological feasibility/ constructability criterion)

Alt.	Measures	Economics			Screening Criteria						Evaluation Result
		Amortized Capital and Annual O&M ($/year)	**Energy Replacement Cost ($/year)**	**Total Annual Cost ($/year)**	**Effectiveness and Reliability**	**Technological Feasibility/ Constructability**	**Logistics**	**Reasonability**	**Substantial Further Study**	**Environ. Challenges**	
	Measures in Reducing Source Water Temperature to Belden Forebay										
2a	Install Prattville thermal curtain and remove submerged levees	665,000	0	665,000							
	~~Construct bypass pipeline to convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intakes~~	7,089,000	474,000	7,563,000		Fail		Fail			Eliminate [a]
	Subtotal	**7,754,000**	**474,000**	**8,228,000**							
2b	Install Prattville Intake thermal curtain and remove submerged levees										
	Install Caribou Intake thermal Curtain										
	~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~										
2c	Decrease Prattville Intake Release to 500 cfs to cause cold water selective withdrawal	0	0 *	0	3		3	3	3	3	
	Extend the Existing Bottom Channel of Butt Valley Reservoir to near Caribou #1 Intake by Dredging	979,000	0	979,000	2	2	2 (reg. permitting)	2	2	1 (dredging effects)	
	Operate Caribou #1 PH Exclusively	0	707,000	707,000	3		3	3	3	3	
	Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 600 cfs	888,000	5,146,000 **	6,034,000	3	3	3	3	3	3	
	Subtotal	**1,867,000**	**5,853,000**	**7,720,000**							
	Additional Measures for Poe Reach										
(1)	Increase shading along Poe Reach					Fail					Eliminate [b]
(2)	Increase Poe Dam release to 360 cfs	0	502,000	**502,000**	3		3	3	3	3	
(3)	Construct outlet/pipeline from Poe Adit to release cool water to 180 cfs	210,000	565,000	775,000				Fail			Eliminate [c]

* No foregone power generation loss was assumed for the measure of reduced Prattville Intake release since the water would still be stored in Lake Almanor for power generation at a later time. It is acknowledged that power prices are higher during the peak demand summer season than other non-peak demand seasons and, as such, PG&E would incur added cost to purchase the summer replacement power based on the seasonal price differential.

** Foregone power generation loss due to increased Canyon Dam releases could be partially offset by discharging the releases through a new hydropower plant constructed at the dam.

a) See the justification for elimination of Alternative 2a in Section 5.2.

b) The measure of increased shading along Poe Reach fails the technological feasibility/constructability criterion. Existing shading along the Poe Reach is low (about 20%) because the channel bed is mainly rock and not suitable for growing trees.

c) This measure fails the reasonability criterion since there is another measure, the increased Poe Dam release measure, that is clearly superior and more reasonable.

Table 5-3b Screening of Alternative/ Measures under Alternative Category 3

(Level 2 screening eliminations identified in red. Four grades used in Level 2 screening: Fail, 1 (nearly fails), 2 (minor concerns), or 3 (meets the criterion); One failure or consistent low grades are grounds for elimination; Operational modification measures not graded for the technological feasibility/ constructability criterion)

Alt.	Measures	Economics			Screening Criteria						Evaluation Result
		Amortized Capital and Annual O&M ($/year)	**Energy Replacement Cost ($/year)**	**Total Annual Cost ($/year)**	**Effectiveness and Reliability**	**Technological Feasibility/ Constructability**	**Logistics**	**Reasonability**	**Substantial Further Study**	**Environ. Challenges**	
	Measures in Reducing Source Water Temperature to Belden Forebay										
	Install Prattville thermal curtain and remove submerged levees	665,000	0	665,000	3	3	2	3	1 (cultural resources)	2 (levee removal)	
3	Install Caribou Intake thermal curtain	444,000	0	444,000	3	3	3	3	2 (curtain location)	3	
	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs	445,000	1,715,000	2,160,000	3	3	3	3	3	3	
	Subtotal	**1,554,000**	**1,715,000**	**3,269,000**							
	Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	**282,000**	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Additional Measures for Cresta Reach										
(1)	Increase Cresta Dam release to 390 cfs	0	409,000	**409,000**	3		3	3	3	3	
~~(2)~~	Increase Grizzly Creek release to 50 cfs	0	638,000	638,000				Fail			Eliminated [a]
	Additional Measures for Poe Reach										
	Increase Poe Dam release to 300 cfs	0	314,000	314,000	3		3	3	3	3	
(1)	Construct outlet/pipeline from Poe Adit to release cool water to 400 cfs	210,000	1,255,000	1,465,000	3	2	3	3	2 (Poe Adit capacity)	3	
	Subtotal	**210,000**	**1,569,000**	**1,779,000**							

a) This measure fails the reasonability criterion since there is another measure, the increased Cresta Dam release measure, that is more reasonable than this measure. Also, this measure may fail the logistics criterion because increasing Grizzly Creek release affects operations of Bucks Creek PH which is owned by the City of Santa Clara.

Table 5-3c Screening of Alternative/ Measures under Alternative Category 4

(Level 2 screening eliminations identified in red. Four grades used in Level 2 screening: Fail, 1 (nearly fails), 2 (minor concerns), or 3 (meets the criterion); One failure or consistent low grades are grounds for elimination; Operational modification measures not graded for the technological feasibility/ constructability criterion)

Alt.	Measures	Economics			Screening Criteria						Evaluation Result
		Amortized Capital and Annual O&M ($/year)	Energy Replacement Cost ($/year)	Total Annual Cost ($/year)	Effectiveness and Reliability	Technological Feasibility/ Constructability	Logistics	Reasonability	Substantial Further Study	Environ. Challenges	
	Measures in Reducing Source Water Temperature to Belden Forebay										
4a	Install Prattville thermal curtain	490,000	0	490,000	3	3	3	3	3	3	
	Install Caribou Intake thermal curtain	444,000	0	444,000	3	3	3	3	2 (curtain location)	3	
	Subtotal	**934,000**	**0**	**934,000**							
4b	Install Prattville thermal curtain	490,000	0	490,000	3	3	3	3	3	3	
	Operate Caribou #1 PH preferentially	0	904,000	904,000	3		3	3	3	3	
	Subtotal	**490,000**	**904,000**	**1,394,000**							
4c	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 600 cfs	888,000	5,146,000	6,034,000	3	3	3	3	3	3	
	Operate Caribou #1 PH preferentially	0	736,000	736,000	3		3	3	3	3	
	Subtotal	**888,000**	**5,882,000**	**6,770,000**							
	Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	**282,000**	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Additional Measures for Rock Creek Reach										
(1)	~~Construct Yellow Cr/ Belden PH bifurcation or~~, Convey Yellow Creek flows to 60 cfs by pipeline to Rock Creek Reservoir for plunging				Fail	Fail			Fail		Eliminated [a]
	Dredge a submerged channel in Rock Creek Reservoir										
	Construct low-level outlet at Rock Creek Dam										
	Subtotal	**943,000**	**0**	**943,000**							
(2)	Construct bypass pipeline to convey Yellow Creek flows to 60 cfs around Rock Creek Reservoir	878,000	0	878,000		Fail		Fail		Fail	Eliminated [b]
(3)	Increase Rock Creek Dam release to 400 cfs	0	940,000	**940,000**	3		3	3	3	3	
(4)	Construct 150 cfs capacity water chiller near Rock Creek Dam	395,000	328,000	723,000				Fail			Eliminated [c]

Table 5-3c Screening of Alternative/ Measures under Alternative Category 4 (Continued)

		Economics			Screening Criteria						
		Amortized Capital and Annual O&M ($/year)	**Energy Replacement Cost ($/year)**	**Total Annual Cost ($/year)**	**Effectiveness and Reliability**	**Technological Feasibility/ Constructability**	**Logistics**	**Reasonability**	**Substantial Further Study**	**Environ. Challenges**	**Evaluation Result**
	Additional Measures for Cresta Reach										
~~(1)~~	Construct bypass pipeline to convey Bucks Creek PH flows to 140 cfs to Cresta Reservoir for plunging				Fail	Fail			Fail		Eliminated [d]
	Construct low-level outlet at Cresta Dam										
	Subtotal	**1,019,000**	**0**	**1,019,000**							
~~(2)~~	Construct bypass pipeline to convey Bucks Creek PH flows to 95 cfs around Cresta Reservoir	1,240,000	0	1,240,000		Fail		Fail	Fail		Eliminated [e]
(3)	Increase Cresta Dam release to 500 cfs	0	618,000	**618,000**	3		3	3	3	3	
(4)	Increase Grizzly Creek release to 80 cfs	0	1,073,000	**1,073,000**	3		3	3	2 (fish study)	2 (effects on fish)	
~~(5)~~	Construct 175 cfs capacity water chiller near Cresta Dam	702,000	591,000	1,293,000				Fail			Eliminated [f]
	Additional Measures for Poe Reach										
(1)	Increase Poe Dam release to 400 cfs	0	628,000	628,000	2		3	3	3	3	
	Construct outlet/pipeline from Poe Adit to release cool water to 450 cfs	210,000	1,412,000	1,622,000	2	2	3	3	2 (Poe Adit capacity)	3	
	Subtotal	**210,000**	**2,040,000**	**2,250,000**							
~~(2)~~	Construct 200 cfs capacity water chiller near Poe Dam	962,000	853,000	1,815,000	3	2	2 (reg. permit-ting)	1	1 (chiller siting)	1 (air, aesthetic, floodplain)	Eliminated [g]

a) This measure fails the effectiveness and reliability criterion. The measure was designed mainly based on the 2006 special test result in Butt Valley Reservoir demonstrating that the plunged cold water mainly moved in the submerged channel along the bottom in the upper portion of the reservoir with minimal mixing with warm surface water. Further study is required to evaluate the effectiveness and reliability of applying this measure to Rock Creek Reservoir because Rock Creek Reservoir is relatively shallow, has higher flow velocities and, hence, greater mixing potential than Butt Valley Reservoir. This measure also fails the technological feasibility/constructability criterion because it requires setting a 54-inch HDPE along the bottom of upper Rock Creek Reservoir which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study. This measure also requires dredging a submerged channel along the bottom of lower Rock Creek Reservoir which could be difficult and costly since it may require removing large boulders. In addition, the dredged conveyance channel at the bottom of Rock Creek Reservoir will likely fill with sediment and require repeated dredging. Directing Yellow Creek flows around Rock Creek Reservoir poses substantial environmental challenges due to potential effects on fish and regulatory permitting hurdles.
The measure of conveying Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging is easier and more reliable than the measure of constructing a Yellow Creek/ Belden PH bifurcation.

b) This measure fails the technological feasibility/constructability criterion. This measure requires attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek, which could make the existing structure unstable. This measure also requires connecting 155 LF of 42-inch Black Steel Pipe to the steep rock face at the dam, which could be difficult and costly. This measure also fails the reasonability criterion because the increased Rock Creek Dam release measure is clearly superior to this measure. Directing Yellow Creek flows poses substantial environmental challenges due to potential effects on fish and regulatory permitting hurdles.

c) Constructing a water chiller near Rock Creek Dam fails the reasonability criterion because there is another measure, the increased Rock Cree Dam release measure, that is clearly superior.

d) Similar to the justifications in a) above, this measure fails the effectiveness and reliability criterion and requires further study because Cresta Reservoir is relatively shallow. This measure also fails the technological feasibility/constructability criterion. This measure requires setting a 54-inch HDPE along the bottom of upper Cresta Reservoir, which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study.

e) This measure fails the technological feasibility/constructability criterion. This measure requires setting a 48-inch HDPE along the bottom of Cresta Reservoir, which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study. This measure also requires tying into the existing submerged 92-inch sluice pipe underwater at the toe of Cresta Dam, which could be difficult and costly due to underwater construction. This measure also fails the reasonability criterion because either the increased Cresta Dam release measure or the increased Grizzly Creek release measure is clearly superior to this measure.

f) Constructing a water chiller near Cresta Dam fails the reasonability criterion because either the increased Cresta Dam release measure or the increased Grizzly Creek release measure is clearly superior to constructing a water chiller near Cresta Dam.

g) Constructing a water chiller near Poe Dam is relatively unreasonable compared with the increased Poe Dam/ Poe Adit release measure. Siting the chiller above the 100-year floodplain near Poe Dam requires substantial further study. The chiller may have significant negative impacts on air quality, aesthetic quality, and floodplain.

Table 5-3d Screening of Alternative/ Measures under Alternative Category 5

(Level 2 screening eliminations identified in red. Four grades used in Level 2 screening: Fail, 1 (nearly fails), 2 (minor concerns), or 3 (meets the criterion); One failure or consistent low grades are grounds for elimination; Operational modification measures not graded for the technological feasibility/ constructability criterion)

Alt.	Measures	Economics			Screening Criteria						Evaluation Result
		Amortized Capital and Annual O&M ($/year)	**Energy Replacement Cost ($/year)**	**Total Annual Cost ($/year)**	**Effectiveness and Reliability**	**Technological Feasibility/ Constructability**	**Logistics**	**Reasonability**	**Substantial Further Study**	**Environ. Challenges**	
	Measures in Reducing Source Water Temperature to Belden Forebay										
5a	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	445,000	1,715,000	2,160,000	3	3	3	3	3	3	
	Operate Caribou #1 PH preferentially	0	930,000	930,000	3		3	3	3	3	
	Subtotal	**445,000**	**2,645,000**	**3,090,000**							
5b	Install Caribou Intake thermal curtain	444,000	0	444,000	3	3	3	3	2 (curtain location)	3	
	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	445,000	1,715,000	2,160,000	3	3	3	3	3	3	
	Subtotal	**889,000**	**1,715,000**	**2,604,000**							
5c	Modify Canyon Dam low-level outlet to increase Canyon Dam release to 250 cfs or higher	445,000	1,715,000	2,160,000	3	3	3	3	3	3	
	~~Construct bypass pipeline to convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intakes~~	7,089,000	474,000	7,563,000		Fail		Fail		Fail	Eliminated [a]
	Subtotal	**7,534,000**	**2,189,000**	**9,723,000**							
	Additional Measures for Belden Reach										
(1)	Construct bypass pipeline to convey Seneca Reach flows to 250 cfs to Belden Reservoir for plunging	662,000	0	662,000				Fail			Eliminated [b]
	Install Belden PH Intake thermal curtain	278,000	0	278,000	3	3	3	3	2 (curtain location)	3	
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	282,000	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Subtotal	**1,222,000**	**0**	**1,222,000**							
(2)	Operate Caribou PHs in strict peaking mode with several hours shutdown	0	0	0	3		3	3	3	3	
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	282,000	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Subtotal	**282,000**	**0**	**282,000**							

Table 5-3d Screening of Alternative/ Measures under Alternative Category 5 (Continued)

		Amortized Capital and Annual O&M ($/year)	Energy Replacement Cost ($/year)	Total Annual Cost ($/year)	Screening Criteria: Effectiveness and Reliability	Technological Feasibility/ Constructability	Logistics	Reasonability	Substantial Further Study	Environ. Challenges	Evaluation Result
	Additional Measures for Rock Creek Reach										
(1)	~~Construct Yellow Cr/ Belden PH bifurcation or,~~ Convey Yellow Creek flows to 60 cfs by pipeline to Rock Creek Reservoir for plunging				Fail	Fail			Fail	Fail	Eliminated [c]
	Convey lower Belden Reach flows to 140 cfs to Rock Creek Reservoir for plunging										
	Dredge a submerged channel in Rock Creek Reservoir										
	Construct low-level outlet at Rock Creek Dam										
	Subtotal	**1,278,000**	**0**	**1,278,000**							
(2)	Construct bypass pipeline to convey Yellow Creek/ Chips Creek flows to 80 cfs around Rock Creek Reservoir	1,093,000	0	1,093,000		Fail				Fail	Eliminated [d]
(3)	Increase Rock Creek Dam release to 600 cfs	0	1,692,000	**1,692,000**	2		3	3	3	3	
(4)	Construct 150 cfs capacity water chiller near Rock Creek Dam	485,000	460,000	945,000	3	2	2 (reg. permit-ting)	1	1 (chiller siting)	1 (air, aesthetic, floodplain)	Eliminated [e]
	Additional Measures for Cresta Reach										
(1)	Construct bypass pipeline to convey Bucks Creek PH flows to 140 cfs to Cresta Reservoir for plunging				Fail	Fail			Fail		Eliminated [f]
	Dredge a submerged channel in Cresta Reservoir										
	Construct low-level outlet at Cresta Dam										
	Subtotal	**1,529,000**	**0**	**1,529,000**							
(2)	Construct bypass pipeline to convey Bucks Creek PH flows to 110 cfs around Cresta Reservoir	1,240,000	0	1,240,000		Fail		Fail	Fail		Eliminated [g]
(3)	Increase Cresta Dam release to 700 cfs	0	998,000	**998,000**	2		3	3	3	3	
(4)	Increase Grizzly Creek release to 100 cfs	0	1,362,000	**1,362,000**	3		3	3	2 (fish study)	2 (effects on fish	
(5)	Construct 175 cfs capacity water chiller near Cresta Dam	792,000	722,000	1,514,000				Fail			Eliminated [h]
	Additional Measures for Poe Reach										
(1)	Increase Poe Dam release				1		3	3	3	3	
	Construct outlet/pipeline from Poe Adit to release cool water				1	2	3	3	2 (Poe Adit capacity)	3	
	Subtotal **										
(2)	Construct 200 cfs capacity water chiller near Poe Dam	1,052,000	984,000	**2,036,000**	3	2	2 (reg. permit-ting)	2 *	1 (chiller siting)	1 (air, aesthetic, floodplain)	

Notes for Table 5-3d:

a) See the justifications for elimination of Alternative 5c in Section 5.2.
b) This measure fails the reasonability criterion because there is another measure, the Caribou PHs ON/OFF peaking operations measure, that is clearly superior to this measure.
c) This measure fails the effectiveness and reliability criterion. The measure was designed mainly based on the 2006 special test result in Butt Valley Reservoir demonstrating that the plunged cold water mainly moved in the submerged channel along the bottom in the upper portion of the reservoir with minimal mixing with warm surface water. Further study is required to evaluate the effectiveness and reliability of applying this measure to Rock Creek Reservoir because Rock Creek Reservoir is relatively shallow, has higher flow velocities and, hence, greater mixing potential than Butt Valley Reservoir. This measure also fails the technological feasibility/constructability criterion because it requires setting a 78-inch HDPE along the bottom of upper Rock Creek Reservoir which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study. This measure also requires dredging a submerged channel along the bottom of lower Rock Creek Reservoir which could be difficult and costly since it may require removing large boulders. In addition, the dredged conveyance channel at the bottom of Rock Creek Reservoir will likely fill with sediment and require repeated dredging. Directing Yellow Creek/Chips Creek flows into Rock Creek Reservoir poses substantial environmental challenges due to potential effects on fish and regulatory permitting hurdles.

The measure of conveying Yellow Creek flows by pipeline to Rock Creek Reservoir for plunging is easier and more reliable than the measure of constructing a Yellow Creek/ Belden PH bifurcation.

d) This measure fails the technological feasibility/constructability criterion. This measure requires attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek, which could make the existing structure unstable. This measure also requires connecting 155 LF of 42-inch Black Steel Pipe to the steep rock face at the dam, which could be difficult and costly. Directing Yellow Creek/Chips Creek flows around Rock Creek Reservoir poses substantial environmental challenges due to potential effects on fish and regulatory permitting hurdles.
e) Constructing a water chiller near Rock Creek Dam is relatively unreasonable compared with the increased Rock Creek Dam release measure. Siting the chiller above the 100-year floodplain near the dam requires substantial further study. The chiller may have significant negative impacts on air quality, aesthetic quality, and floodplain.
f) Similar to the justifications in c) above, this measure fails the effectiveness and reliability criterion and requires further study because Cresta Reservoir is relatively shallow. This measure also fails the technological feasibility/constructability criterion. This measure requires setting a 54-inch HDPE along the bottom of upper Cresta Reservoir, which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study.
g) This measure fails the technological feasibility/constructability criterion. This measure requires setting a 48-inch HDPE along the bottom of Cresta Reservoir, which could be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires substantial further study. This measure also requires tying into the existing submerged 92-inch sluice pipe underwater at the toe of Cresta Dam, which could be difficult and costly due to underwater construction. This measure also fails the reasonability criterion because the increased Grizzly Creek release measure is clearly superior to this measure.
h) Constructing a water chiller near Cresta Dam fails the reasonability criterion because the increased Grizzly Creek release measure is clearly superior to constructing a water chiller near Cresta Dam.

* Poe chiller graded “1” in Alternative Category 4 because there was another superior measure for reducing Poe Reach water temperature. Here, Poe chiller graded “2” because there is no other superior measure.

** Cost was not estimated. Further analysis to determine design/operational parameters is required.

Table 5-3e Screening of Alternative/ Measures under Alternative Category 6

(Level 2 screening eliminations identified in red)

Alt.	Measures	Economics			Screening Criteria						Evaluation Result
		Amortized Capital and Annual O&M ($/year)	Energy Replacement Cost ($/year)	Total Annual Cost ($/year)	Effective-ness and Reliability	Technological Feasibility/ Constructability	Logistics	Reasonability	Substantial Further Study	Environ. Challenges	
	Measures in Reducing Source Water Temperature to Belden Forebay										
6a	None										
6b	None										
	Additional Measures for Belden Reach										
(1)	Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 250 cfs	445,000	1,715,000	2,160,000	3		3	3	3	3	
	Construct Bypass Pipeline to Convey Seneca Reach Flows (250 cfs) to Belden Reservoir for Plunging and increase Belden Dam release to 250 cfs	662,000	602,000	1,264,000				Fail			
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	282,000	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Subtotal	**1,389,000**	**2,317,000**	**3,706,000**							
(2)	Increase Canyon Dam Low-Level Outlet Release to the Required Minimum Flow 90 cfs	0	0	0	3		3	3	3	3	
	Operate Caribou PHs in Strict Peaking Mode with Several Hours Shutdown	0	0	0	3		3	3	3	3	
	Construct bypass pipeline to convey warm water to 100 cfs from EBNFFR into upper Rock Creek Reservoir	282,000	0	282,000	3	2 (construction along river)	2 (reg. permit-ting)	3	2 (pipeline alignment)	2 (construct-ion effects)	
	Subtotal	**282,000**	**0**	**282,000**							
	Additional Measures for Rock Creek Reach										
(1)	Construct Bypass Pipeline to Convey Lower Belden Reach Flows to 250 cfs around Rock Creek Reservoir	1,064,000	376,000	1,440,000		Fail					Eliminated [a]
(2)	Construct 150 cfs capacity water chiller near Rock Creek Dam	709,000	787,000	1,496,000			Fail				Eliminated [b]
	Additional Measures for Cresta Reach										
(1)	Construct Bypass Pipeline to Convey Lower Rock Creek Reach Flows to 250 cfs around Cresta Reservoir	1,138,000	142,000	1,280,000		Fail					Eliminated [a]
(2)	Construct 175 cfs capacity water chiller near Cresta Dam	971,000	984,000	1,955,000			Fail				Eliminated [b]
	Additional Measures for Poe Reach										
(1)	Construct Bypass Pipeline to Convey Lower Cresta Reach Flows to 250 cfs around Poe Reservoir	912,000	157,000	1,069,000		Fail					Eliminated [a]
(2)	Construct 200 cfs capacity water chiller near Poe Dam	1,366,000	1,444,000	2,810,000			Fail				Eliminated [b]

a) See the justifications for elimination of Alternative 6a in Section 5.2.
b) See the justifications for elimination of Alternative 6b in Section 5.2.

Final Level 2 Water Temperature Reduction Alternatives

The resulting final Level 2 water temperature reduction alternatives are summarized in Table 5-4. Consistent with the framework described in Chapter 3 and discussions in Section 4.1 of Chapter 4, Table 5-4 shows alternative categories, alternatives, and variations for cooling downstream reaches. The shaded cells represent alternatives/measures advanced to Level 3 (green); or eliminated (gray). The alternative categories are differentiated by the amount of temperature reduction at Belden Reservoir. Within a particular category, alternatives are differentiated by the method of temperature reduction at Belden Reservoir. An alternative may have multiple variations with respect to the method of temperature reduction in downstream reaches. The following alternatives with variations remain and will advance to Level 3 for further refinement, analysis, and screening.

- Alternative Category 2 – one alternative (Alternative 2c) with one variation for the Poe Reach. No water temperature reduction measures are needed for the Belden, Rock Creek, and Cresta Reaches. This Category has one alternative variation (i.e., 1 × 1 = 1).

- Alternative Category 3 – one alternative (Alternative 3) with one variation for each of the Belden, Cresta, and Poe Reaches. No water temperature reduction measures are needed for the Rock Creek Reach. This Category has one alternative variation (i.e., 1 × 1 × 1 × 1 = 1).

- Alternative Category 4 – three alternatives (Alternatives 4a, 4b, and 4c) with one variation for the Belden Reach, one variation for the Rock Creek Reach, two variations for the Cresta Reach, and one variation for the Poe Reach, totaling 6 alternative variations (i.e., 3 × 1 × 1 × 2 × 1 = 6).

- Alternative Category 5 – two alternatives (Alternatives 5a and 5b) with one variation for the Belden Reach, one variation for the Rock Creek Reach, two variations for the Cresta Reach, and two variations for the Poe Reach, totaling 8 alternative variations (i.e., 2 × 1 × 1 × 2 × 2 = 8).

These water temperature reduction alternatives are recommended for further analysis and evaluation in Level 3. The "Alternatives Development and Evaluation Process Flow Diagram", updated to reflect the results of Level 2 screening, is presented in Figure 5-8.

Table 5-4 Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR

(Green highlighted measures remain as final Level 2 Alternatives and will advance to Level 3; Bright green highlighted measures represent variations for cooling downstream reaches)

<table>
<tr><th rowspan="2">Alternative Category</th><th colspan="2">Alternative</th><th colspan="4">Variations for Cooling Downstream Reaches</th></tr>
<tr><th>Alt.</th><th>Measures in reducing source water temperature to Belden Forebay</th><th>Additional measures for Belden Reach</th><th>Additional measures for Rock Creek Reach</th><th>Additional measures for Cresta Reach</th><th>Additional measures for Poe Reach</th></tr>
<tr><td>1. Reduce the temperature in Belden Forebay to 12.5 °C.
(eliminated)</td><td>1</td><td>• Install Prattville thermal curtain with levee removed
• ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~
• Convey Butt Valley PH discharges to Butt Valley Reservoir near Caribou Intake</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td rowspan="3">2. Reduce the temperature in Belden Forebay to 14.5 °C.

(1 variation)</td><td>2a</td><td>• Install Prattville thermal curtain with levee removed
• ~~Convey Butt Valley PH discharges to 2,000 cfs to Butt Valley Reservoir near Caribou Intake~~</td><td rowspan="3">No</td><td rowspan="3">No</td><td rowspan="3">No</td><td>• Increase shading along Poe Reach</td></tr>
<tr><td>2b</td><td>• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• ~~Collect and convey cold spring water (215 cfs, 8°C) to Prattville Intake~~</td><td>• Increase Poe Dam release to 360 cfs</td></tr>
<tr><td>2c</td><td>• Decrease Prattville Intake release to 500 cfs to cause cold water selective withdrawal
• Extend the existing deeper channel of Butt Valley Reservoir by dredging
• Use Caribou #1 exclusively with reduced release to cause cold water selective withdrawal
• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs</td><td>• Construct outlet/pipeline from the Poe Adit and release to 180 cfs the cooler water to the Poe Reach</td></tr>
<tr><td rowspan="2">3. Reduce the temperature in Belden Forebay to 16.0 °C.

(1 variation)</td><td rowspan="2">3</td><td rowspan="2">• Install Prattville thermal curtain with levee removed
• Install a thermal curtain near Caribou Intake in Butt Valley Reservoir
• Increase Canyon Dam release to 250 cfs (and decrease Prattville Intake release commensurately)</td><td rowspan="2">• Convey warm water to 100 cfs in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline

Note: This measure is designed to protect the lower Belden Reach</td><td rowspan="2">No</td><td>• Increase Cresta Dam release to 390 cfs</td><td rowspan="2">• Increase Poe Dam release to 300 cfs
• Construct outlet/pipeline from the Poe Adit and release to 400 cfs the cooler water to the Poe Reach</td></tr>
<tr><td>• Increase Grizzly Creek release to 50 cfs</td></tr>
</table>

Note: All alternatives will have no affect on Lake Almanor water levels except Alternative 2c which would result in higher than historical lake levels due to significant flow reduction at the Prattville Intake.

Table 5-4 Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (Continued)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	Measures in reducing source water temperature to Belden Forebay	Additional measures for Belden Reach	Additional measures for Rock Creek Reach	Additional measures for Cresta Reach	Additional measures for Poe Reach
4. Reduce the temperature in Belden Forebay to 18.0 °C. **(6 variations)**	**4a**	• Install Prattville thermal curtain • Install a thermal curtain near Caribou Intake in Butt Valley Reservoir	• Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline Note: This measure is designed to protect the lower Belden Reach.	• ~~Construct Yellow Cr/ Belden PH bifurcation or,~~ Convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Construct low level outlet at Rock Creek Dam • Dredge a submerged channel in Rock Creek Reservoir • Bypass Yellow Creek flows **to 60 cfs** around Rock Creek Reservoir by diversion/pipeline	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by pipeline • Construct low level outlet at Cresta Dam • Bypass cold Bucks Creek PH flows **to 95 cfs** around Cresta Reservoir by diversion/pipeline	• Increase Poe Dam release **to 400 cfs** • Construct outlet/pipeline from the Poe Adit and release **to 450 cfs** the cooler water to the Poe Reach
	4b	• Install Prattville thermal curtain • Use Caribou #1 preferentially over Caribou #2		• Increase Rock Creek Dam release **to 400 cfs**	• Increase Cresta Dam release **to 500 cfs** • Increase Grizzly Creek releases to **80 cfs**	
	4c	• Repair/modify Canyon Dam low level outlet and increase release to 600 cfs (and decrease Prattville Intake release commensurately) • Use Caribou #1 preferentially over Caribou #2		• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	• Construct **200 cfs capacity** water chiller at Poe Dam
5. Reduce the temperature in Belden Forebay to 19.5 °C. **(8 variations)**	**5a**	• Use Caribou #1 preferentially over Caribou #2 • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Convey cold Seneca Reach flows **to 250 cfs** to Belden Reservoir for plunging by diversion/pipeline • Install a thermal curtain near Belden PH Intake • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• ~~Construct Yellow Cr/ Belden PH bifurcation or,~~ Convey Yellow Creek flows **to 60 cfs** by pipeline to Rock Creek Reservoir for plunging • Convey lower Belden Reach flows **to 140 cfs** to Rock Creek Reservoir for plunging • Dredge a submerged channel in Rock Creek Reservoir • Construct low level outlet at Rock Creek Dam	• Convey cold Bucks Creek PH flows **to 140 cfs** to Cresta Reservoir for plunging by diversion/pipeline • Dredge a submerged channel in Cresta Reservoir • Construct low level outlet at Cresta Dam	• Increase Poe Dam release • Construct outlet/pipeline from the Poe Adit and release the cooler water to the Poe Reach
	5b	• Install thermal curtain near Caribou Intake in Butt Valley Reservoir • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)	• Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass Yellow Creek/Chips Creek flows **to 80 cfs** around Rock Creek Reservoir by diversion/pipeline	• Bypass cold Bucks Creek PH flows **to 110 cfs** around Cresta Reservoir by pipeline • Increase Cresta Dam release to **700 cfs**	• Construct **200 cfs capacity** water chiller at Poe Dam
	5c	• ~~Convey Butt Valley PH discharges **to 2,000 cfs** by pipeline to Butt Valley Res. near the Caribou Intake~~ • Repair/modify Canyon Dam low level outlet and increase release to 250 cfs or higher (and decrease Prattville Intake release commensurately)		• Increase Rock Creek Dam release **to 600 cfs** • Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Increase Grizzly Creek releases **to 100 cfs** • Construct **175 cfs capacity** water chiller at Cresta Dam	

Table 5-4 Final Level 2 Alternatives to Achieve the 20°C Objective Target for Water Temperature along the NFFR (Continued)

Alternative Category	Alternative		Variations for Cooling Downstream Reaches			
	Alt.	**Measures in reducing source water temperature to Belden Forebay**	**Additional measures for Belden Reach**	**Additional measures for Rock Creek Reach**	**Additional measures for Cresta Reach**	**Additional measures for Poe Reach**
6. Reduce temperatures in all downstream reaches. **(eliminated)**	**6a**	No	• Repair/modify Canyon Dam low level outlet and increase release to 250 cfs • Convey cold Seneca Reach flows to Belden Reservoir for plunging by diversion/pipeline • **Increase Belden Dam/Oak Flat PH release to 250 cfs** • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Bypass lower Belden Reach flows **to 250 cfs** around Rock Creek Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Rock Creek Reach flows **to 250 cfs** around Cresta Reservoir by diversion/pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.	• Bypass lower Cresta Reach flows **to 250 cfs** around Poe Reservoir by diversion/ pipeline Note: Must be combined with bypassing Seneca flows around Belden Reservoir.
	6b		• Increase Canyon Dam low level outlet release to 90 cfs or higher • Operate Caribou PHs in strict peaking mode with several hours shut down • Convey warm water **to 100 cfs** in East Branch NFFR to Rock Creek Reservoir by diversion/pipeline	• Construct **150 cfs capacity** water chiller at Rock Creek Dam	• Construct **175 cfs capacity** water chiller at Cresta Dam	• Construct **200 cfs capacity** water chiller at Poe Dam
	6c		~~• Convey cold water from Lake Oroville to below Belden Dam~~	~~• Convey cold water from Lake Oroville to below Rock Creek Dam~~	~~• Convey cold water from Lake Oroville to below Cresta Dam~~	~~• Convey cold Lake Oroville to below Poe D.~~

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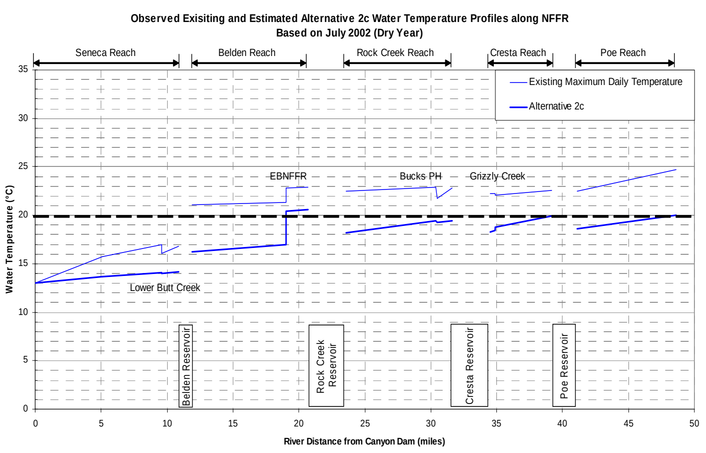

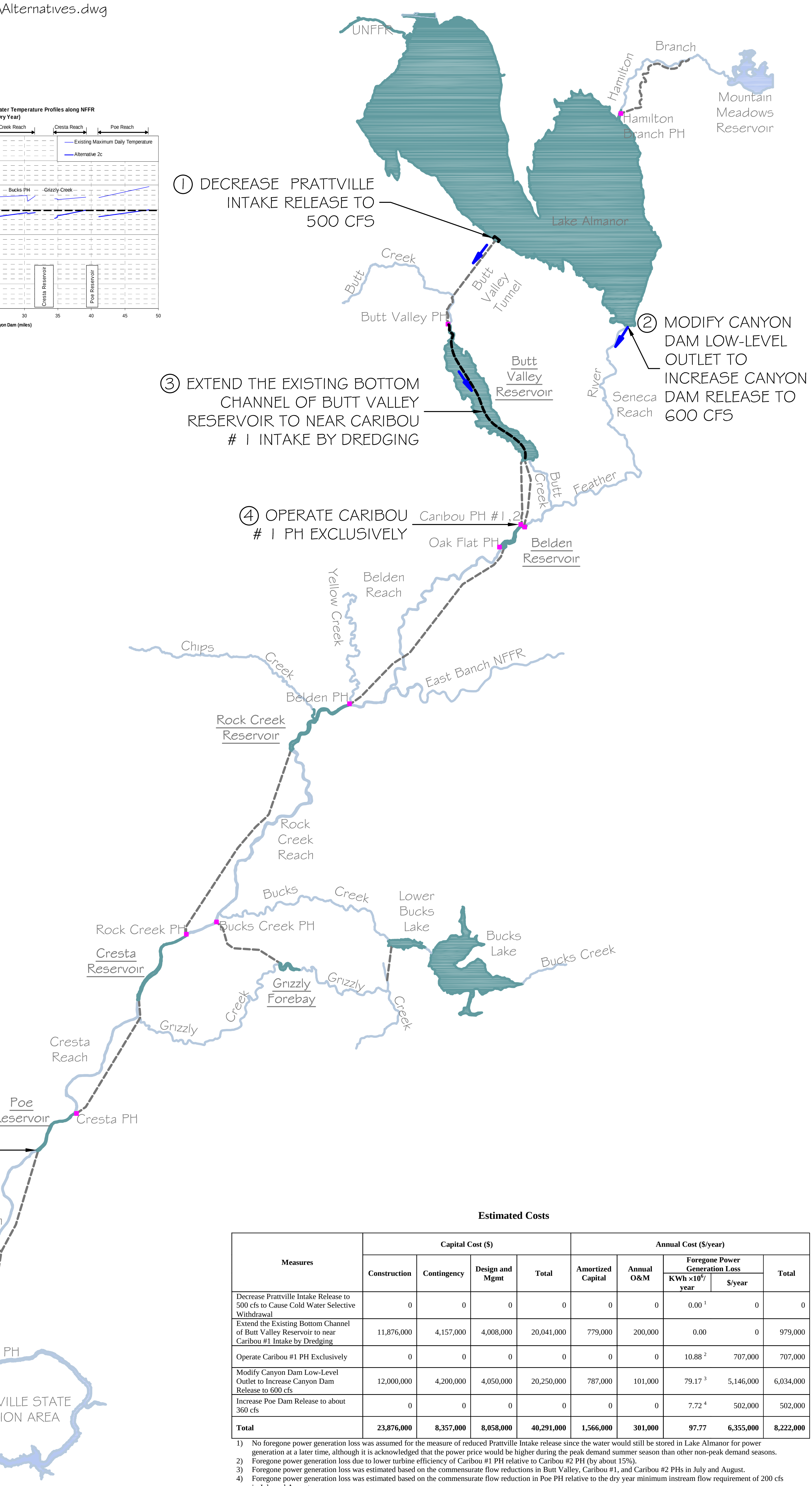

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh ×10^6/year	Foregone Power Generation Loss: $/year	Total
Decrease Prattville Intake Release to 500 cfs to Cause Cold Water Selective Withdrawal	0	0	0	0	0	0	0.00 [1]	0	0
Extend the Existing Bottom Channel of Butt Valley Reservoir to near Caribou #1 Intake by Dredging	11,876,000	4,157,000	4,008,000	20,041,000	779,000	200,000	0.00	0	979,000
Operate Caribou #1 PH Exclusively	0	0	0	0	0	0	10.88 [2]	707,000	707,000
Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 600 cfs	12,000,000	4,200,000	4,050,000	20,250,000	787,000	101,000	79.17 [3]	5,146,000	6,034,000
Increase Poe Dam Release to about 360 cfs	0	0	0	0	0	0	7.72 [4]	502,000	502,000
Total	**23,876,000**	**8,357,000**	**8,058,000**	**40,291,000**	**1,566,000**	**301,000**	**97.77**	**6,355,000**	**8,222,000**

1) No foregone power generation loss was assumed for the measure of reduced Prattville Intake release since the water would still be stored in Lake Almanor for power generation at a later time, although it is acknowledged that the power price would be higher during the peak demand summer season than other non-peak demand seasons.
2) Foregone power generation loss due to lower turbine efficiency of Caribou #1 PH relative to Caribou #2 PH (by about 15%).
3) Foregone power generation loss was estimated based on the commensurate flow reductions in Butt Valley, Caribou #1, and Caribou #2 PHs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH relative to the dry year minimum instream flow requirement of 200 cfs in July and August.

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FIGURE 5-1

ALTERNATIVE 2C

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE I IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N W E S

SCALE (MILES)
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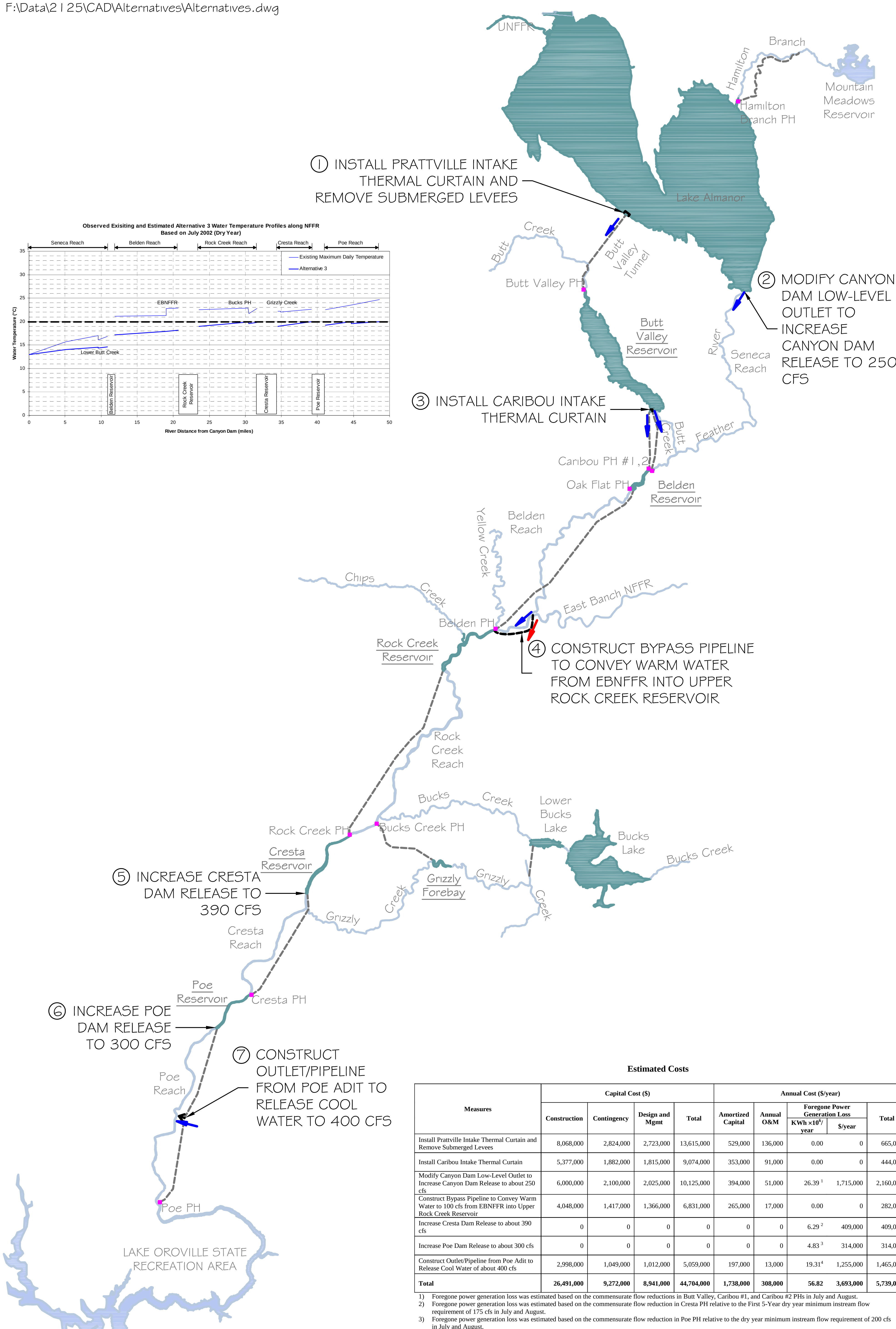

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh ×10[6]/ year	Foregone Power Generation Loss: $/year	Total
Install Prattville Intake Thermal Curtain and Remove Submerged Levees	8,068,000	2,824,000	2,723,000	13,615,000	529,000	136,000	0.00	0	665,000
Install Caribou Intake Thermal Curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to about 250 cfs	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39 [1]	1,715,000	2,160,000
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Cresta Dam Release to about 390 cfs	0	0	0	0	0	0	6.29 [2]	409,000	409,000
Increase Poe Dam Release to about 300 cfs	0	0	0	0	0	0	4.83 [3]	314,000	314,000
Construct Outlet/Pipeline from Poe Adit to Release Cool Water of about 400 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	19.31[4]	1,255,000	1,465,000
Total	**26,491,000**	**9,272,000**	**8,941,000**	**44,704,000**	**1,738,000**	**308,000**	**56.82**	**3,693,000**	**5,739,000**

1) Foregone power generation loss was estimated based on the commensurate flow reductions in Butt Valley, Caribou #1, and Caribou #2 PHs in July and August.
2) Foregone power generation loss was estimated based on the commensurate flow reduction in Cresta PH relative to the First 5-Year dry year minimum instream flow requirement of 175 cfs in July and August.
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH relative to the dry year minimum instream flow requirement of 200 cfs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH in July and August.

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FIGURE 5-2

ALTERNATIVE 3

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE 1 IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N S E W

SCALE (MILES)
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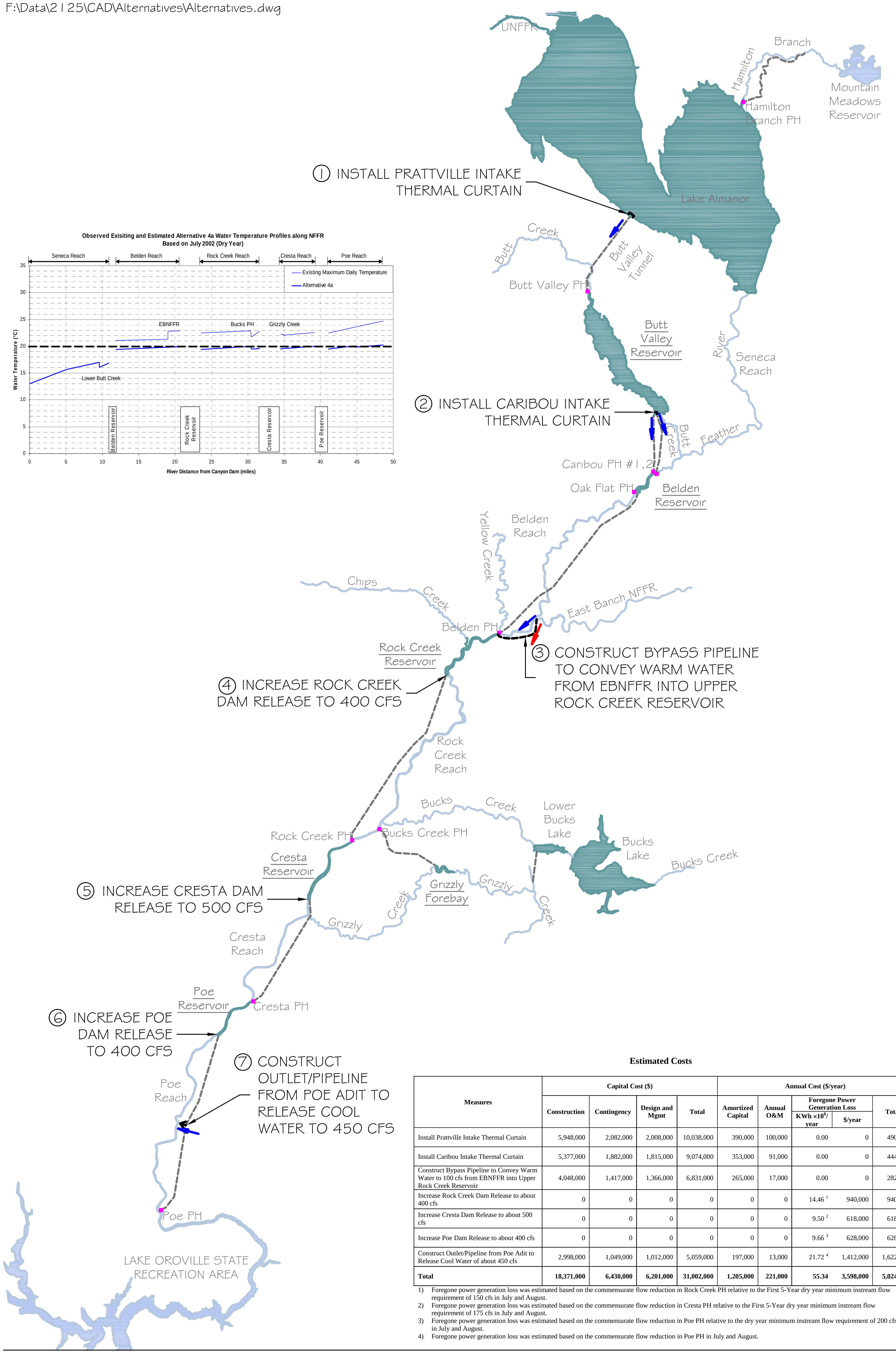

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss		Total
							KWh $\times 10^6$/ year	$/year	
Install Prattville Intake Thermal Curtain	5,948,000	2,082,000	2,008,000	10,038,000	390,000	100,000	0.00	0	490,000
Install Caribou Intake Thermal Curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Rock Creek Dam Release to about 400 cfs	0	0	0	0	0	0	14.46 [1]	940,000	940,000
Increase Cresta Dam Release to about 500 cfs	0	0	0	0	0	0	9.50 [2]	618,000	618,000
Increase Poe Dam Release to about 400 cfs	0	0	0	0	0	0	9.66 [3]	628,000	628,000
Construct Outlet/Pipeline from Poe Adit to Release Cool Water of about 450 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	21.72 [4]	1,412,000	1,622,000
Total	**18,371,000**	**6,430,000**	**6,201,000**	**31,002,000**	**1,205,000**	**221,000**	**55.34**	**3,598,000**	**5,024,000**

1) Foregone power generation loss was estimated based on the commensurate flow reduction in Rock Creek PH relative to the First 5-Year dry year minimum instream flow requirement of 150 cfs in July and August.
2) Foregone power generation loss was estimated based on the commensurate flow reduction in Cresta PH relative to the First 5-Year dry year minimum instream flow requirement of 175 cfs in July and August.
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH relative to the dry year minimum instream flow requirement of 200 cfs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH in July and August.

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FIGURE 5-3

ALTERNATIVE 4A

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE I IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N W E S

SCALE (MILES)
0 1.5 3

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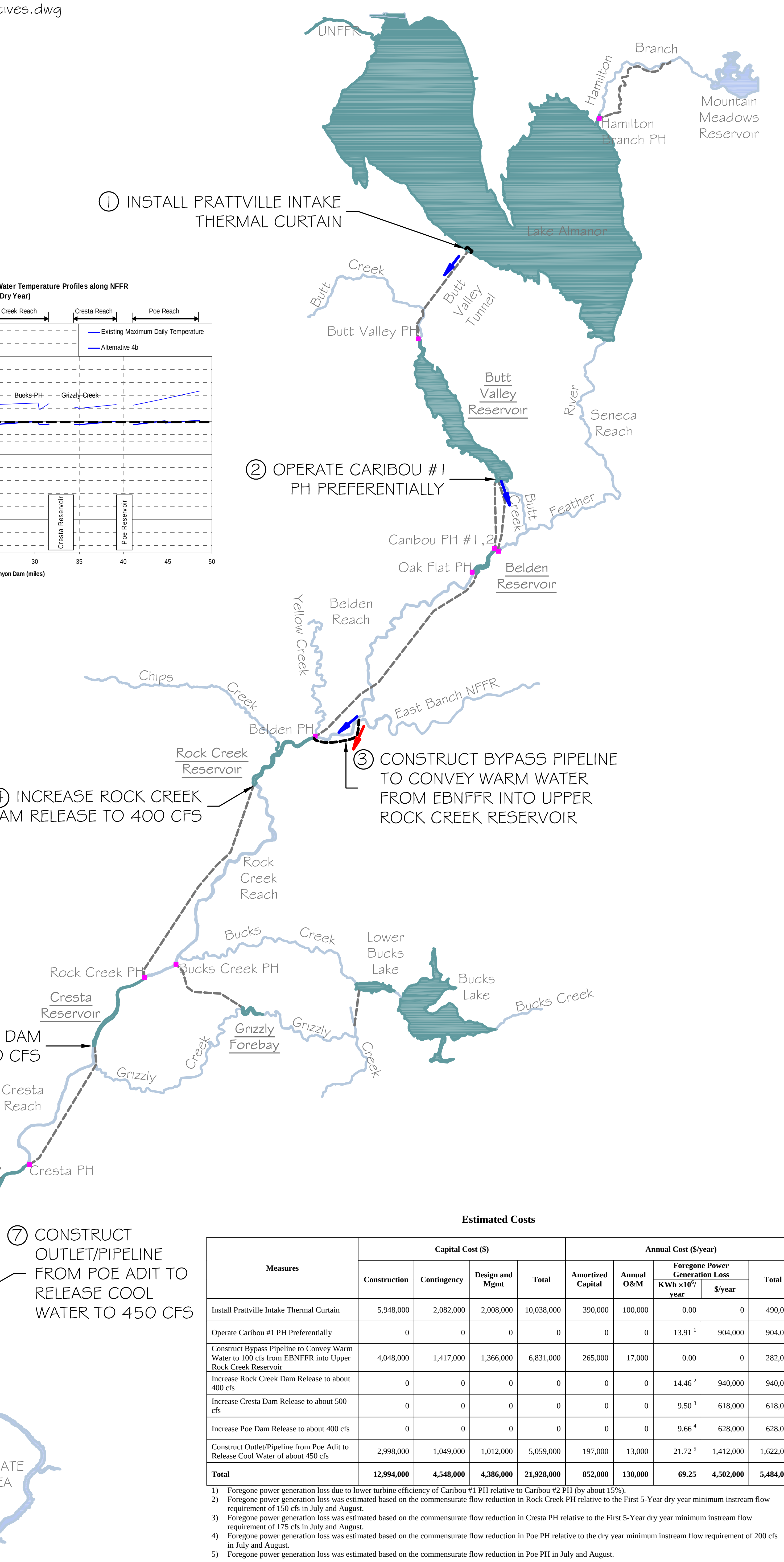

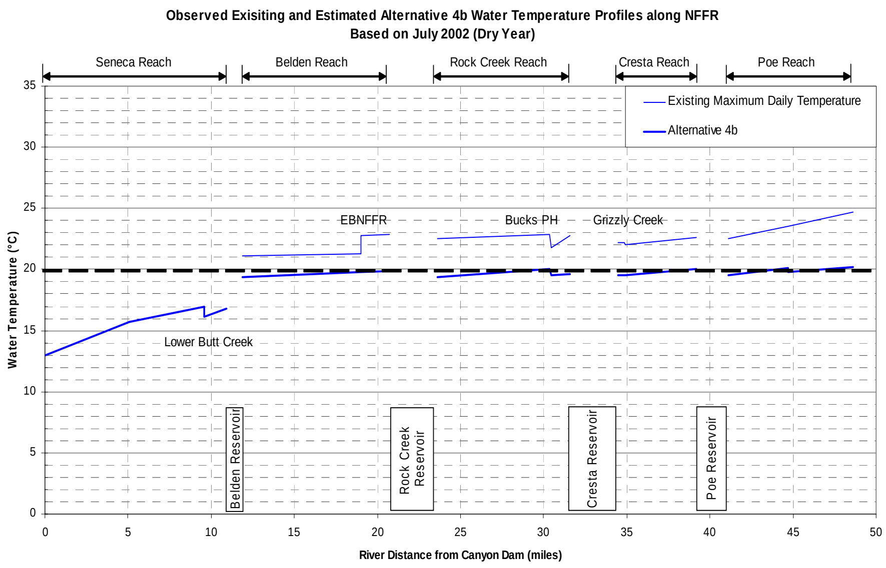

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh $\times 10^6$/year	Foregone Power Generation Loss: $/year	Total
Install Prattville Intake Thermal Curtain	5,948,000	2,082,000	2,008,000	10,038,000	390,000	100,000	0.00	0	490,000
Operate Caribou #1 PH Preferentially	0	0	0	0	0	0	13.91 [1]	904,000	904,000
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Rock Creek Dam Release to about 400 cfs	0	0	0	0	0	0	14.46 [2]	940,000	940,000
Increase Cresta Dam Release to about 500 cfs	0	0	0	0	0	0	9.50 [3]	618,000	618,000
Increase Poe Dam Release to about 400 cfs	0	0	0	0	0	0	9.66 [4]	628,000	628,000
Construct Outlet/Pipeline from Poe Adit to Release Cool Water of about 450 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	21.72 [5]	1,412,000	1,622,000
Total	**12,994,000**	**4,548,000**	**4,386,000**	**21,928,000**	**852,000**	**130,000**	**69.25**	**4,502,000**	**5,484,000**

1) Foregone power generation loss due to lower turbine efficiency of Caribou #1 PH relative to Caribou #2 PH (by about 15%).
2) Foregone power generation loss was estimated based on the commensurate flow reduction in Rock Creek PH relative to the First 5-Year dry year minimum instream flow requirement of 150 cfs in July and August.
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Cresta PH relative to the First 5-Year dry year minimum instream flow requirement of 175 cfs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH relative to the dry year minimum instream flow requirement of 200 cfs in July and August.
5) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH in July and August.

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FIGURE 5-4

ALTERNATIVE 4B

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE I IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N W E S

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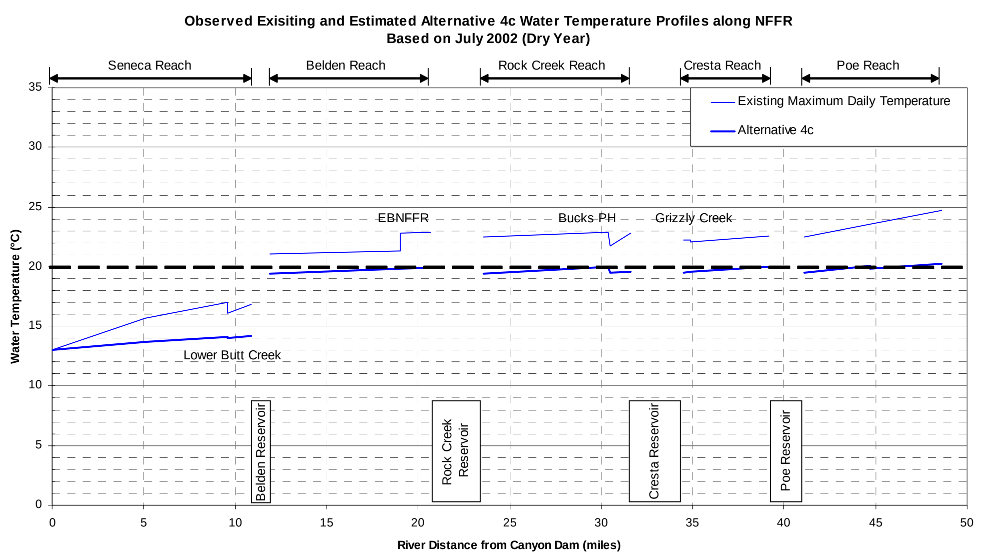

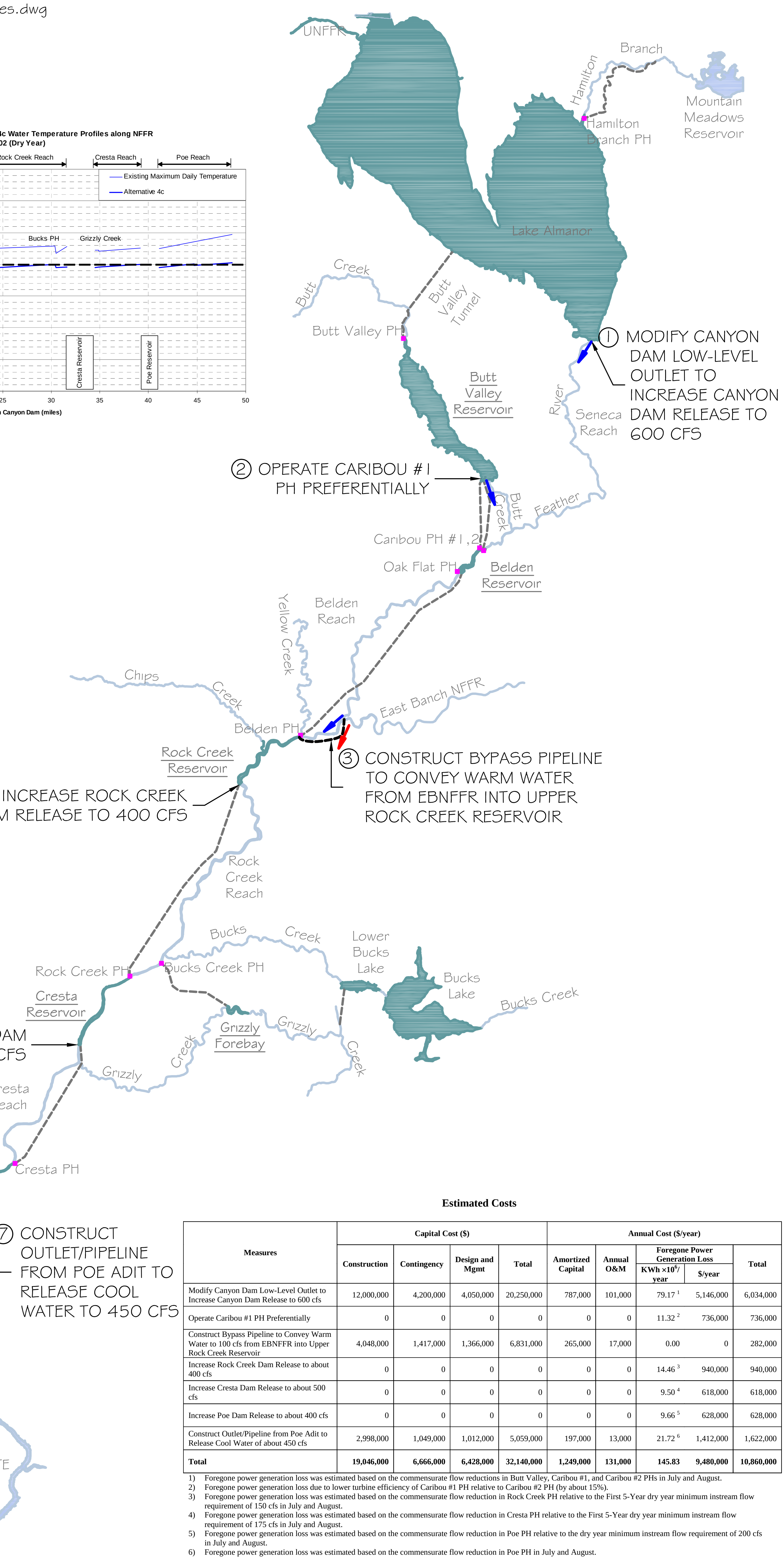

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh $\times 10^6$/year	Foregone Power Generation Loss: $/year	Total
Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 600 cfs	12,000,000	4,200,000	4,050,000	20,250,000	787,000	101,000	79.17 [1]	5,146,000	6,034,000
Operate Caribou #1 PH Preferentially	0	0	0	0	0	0	11.32 [2]	736,000	736,000
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Rock Creek Dam Release to about 400 cfs	0	0	0	0	0	0	14.46 [3]	940,000	940,000
Increase Cresta Dam Release to about 500 cfs	0	0	0	0	0	0	9.50 [4]	618,000	618,000
Increase Poe Dam Release to about 400 cfs	0	0	0	0	0	0	9.66 [5]	628,000	628,000
Construct Outlet/Pipeline from Poe Adit to Release Cool Water of about 450 cfs	2,998,000	1,049,000	1,012,000	5,059,000	197,000	13,000	21.72 [6]	1,412,000	1,622,000
Total	**19,046,000**	**6,666,000**	**6,428,000**	**32,140,000**	**1,249,000**	**131,000**	**145.83**	**9,480,000**	**10,860,000**

1) Foregone power generation loss was estimated based on the commensurate flow reductions in Butt Valley, Caribou #1, and Caribou #2 PHs in July and August.
2) Foregone power generation loss due to lower turbine efficiency of Caribou #1 PH relative to Caribou #2 PH (by about 15%).
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Rock Creek PH relative to the First 5-Year dry year minimum instream flow requirement of 150 cfs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Cresta PH relative to the First 5-Year dry year minimum instream flow requirement of 175 cfs in July and August.
5) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH relative to the dry year minimum instream flow requirement of 200 cfs in July and August.
6) Foregone power generation loss was estimated based on the commensurate flow reduction in Poe PH in July and August.

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FIGURE 5-5

ALTERNATIVE 4C

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE I IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N W E S

SCALE (MILES) 0 1.5 3

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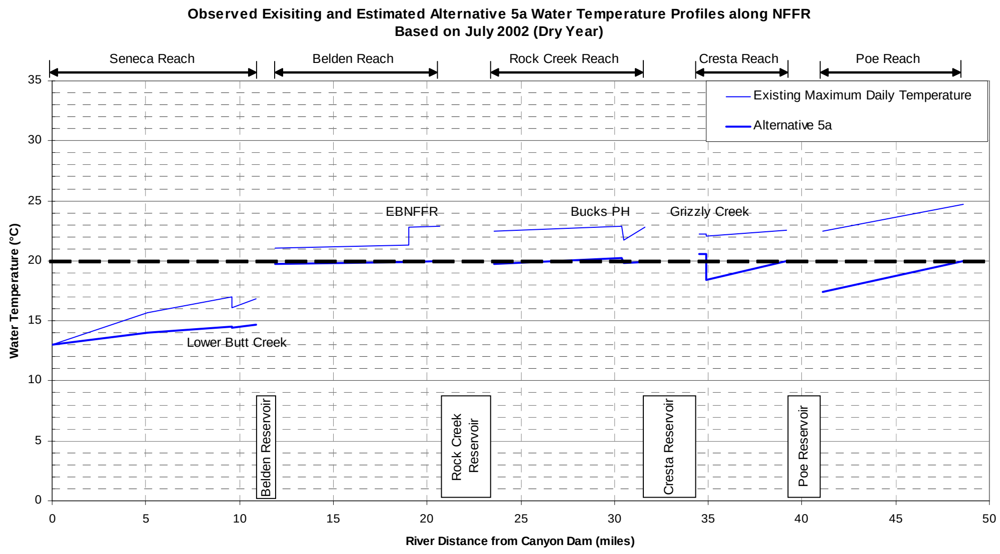

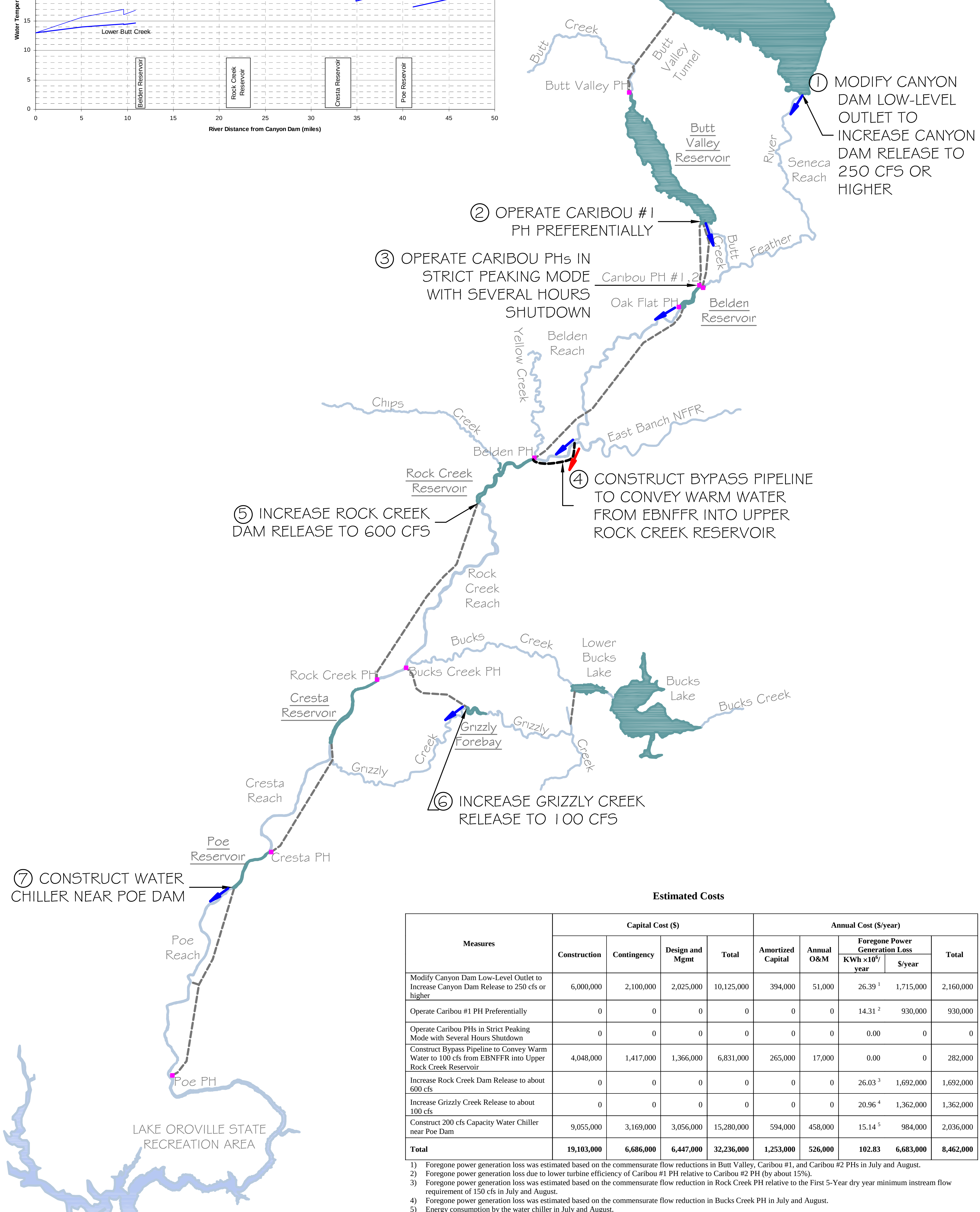

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh ×10⁶/year	Foregone Power Generation Loss: $/year	Total
Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 250 cfs or higher	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39 [1]	1,715,000	2,160,000
Operate Caribou #1 PH Preferentially	0	0	0	0	0	0	14.31 [2]	930,000	930,000
Operate Caribou PHs in Strict Peaking Mode with Several Hours Shutdown	0	0	0	0	0	0	0.00	0	0
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Rock Creek Dam Release to about 600 cfs	0	0	0	0	0	0	26.03 [3]	1,692,000	1,692,000
Increase Grizzly Creek Release to about 100 cfs	0	0	0	0	0	0	20.96 [4]	1,362,000	1,362,000
Construct 200 cfs Capacity Water Chiller near Poe Dam	9,055,000	3,169,000	3,056,000	15,280,000	594,000	458,000	15.14 [5]	984,000	2,036,000
Total	**19,103,000**	**6,686,000**	**6,447,000**	**32,236,000**	**1,253,000**	**526,000**	**102.83**	**6,683,000**	**8,462,000**

1) Foregone power generation loss was estimated based on the commensurate flow reductions in Butt Valley, Caribou #1, and Caribou #2 PHs in July and August.
2) Foregone power generation loss due to lower turbine efficiency of Caribou #1 PH relative to Caribou #2 PH (by about 15%).
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Rock Creek PH relative to the First 5-Year dry year minimum instream flow requirement of 150 cfs in July and August.
4) Foregone power generation loss was estimated based on the commensurate flow reduction in Bucks Creek PH in July and August.
5) Energy consumption by the water chiller in July and August.

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FIGURE 5-6

ALTERNATIVE 5A

LEGEND
- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:
1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE 1 IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

SCALE (MILES) 0 1.5 3

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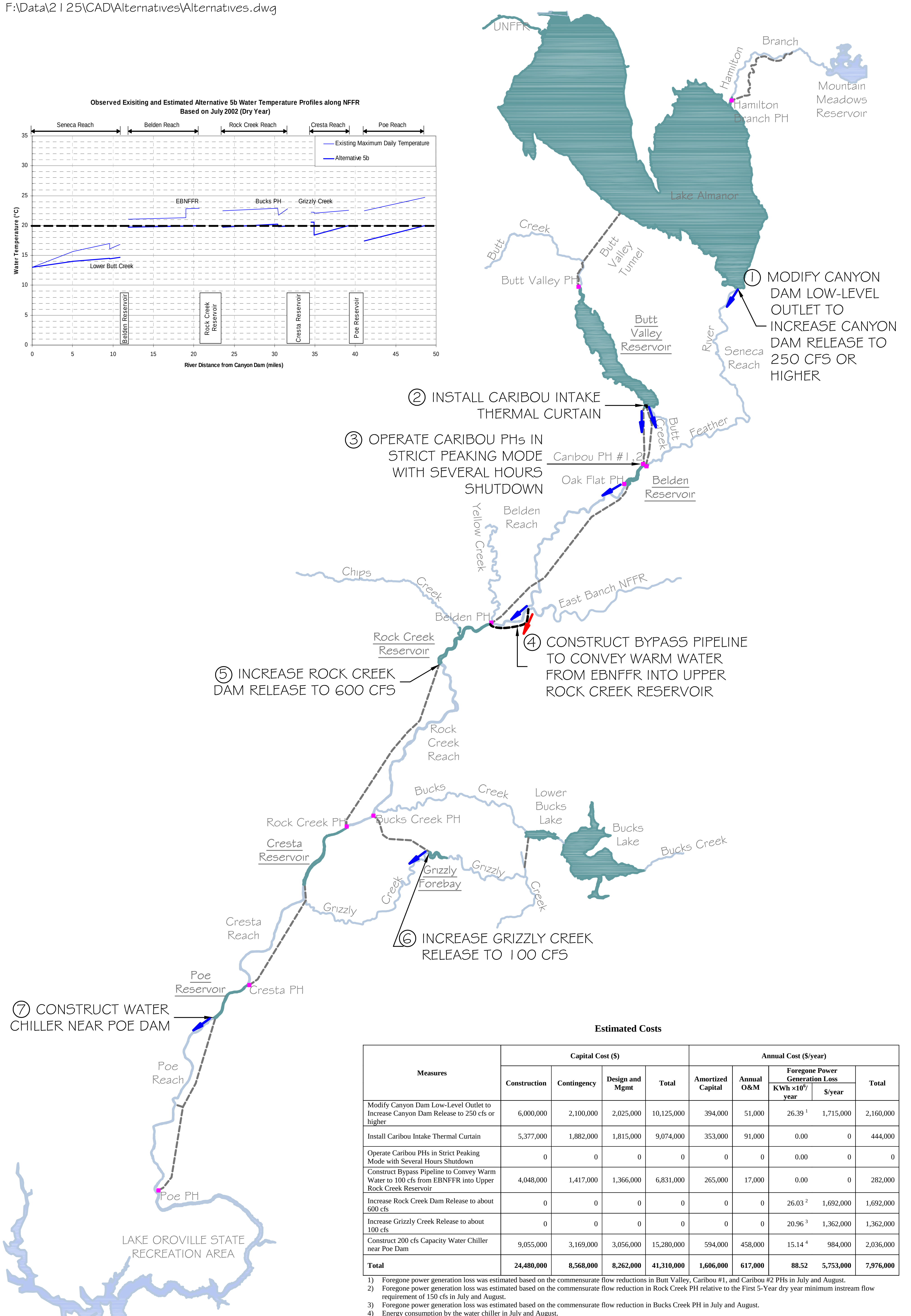

Estimated Costs

Measures	Capital Cost ($)				Annual Cost ($/year)				
	Construction	Contingency	Design and Mgmt	Total	Amortized Capital	Annual O&M	Foregone Power Generation Loss: KWh ×10^6/ year	Foregone Power Generation Loss: $/year	Total
Modify Canyon Dam Low-Level Outlet to Increase Canyon Dam Release to 250 cfs or higher	6,000,000	2,100,000	2,025,000	10,125,000	394,000	51,000	26.39 [1]	1,715,000	2,160,000
Install Caribou Intake Thermal Curtain	5,377,000	1,882,000	1,815,000	9,074,000	353,000	91,000	0.00	0	444,000
Operate Caribou PHs in Strict Peaking Mode with Several Hours Shutdown	0	0	0	0	0	0	0.00	0	0
Construct Bypass Pipeline to Convey Warm Water to 100 cfs from EBNFFR into Upper Rock Creek Reservoir	4,048,000	1,417,000	1,366,000	6,831,000	265,000	17,000	0.00	0	282,000
Increase Rock Creek Dam Release to about 600 cfs	0	0	0	0	0	0	26.03 [2]	1,692,000	1,692,000
Increase Grizzly Creek Release to about 100 cfs	0	0	0	0	0	0	20.96 [3]	1,362,000	1,362,000
Construct 200 cfs Capacity Water Chiller near Poe Dam	9,055,000	3,169,000	3,056,000	15,280,000	594,000	458,000	15.14 [4]	984,000	2,036,000
Total	**24,480,000**	**8,568,000**	**8,262,000**	**41,310,000**	**1,606,000**	**617,000**	**88.52**	**5,753,000**	**7,976,000**

1) Foregone power generation loss was estimated based on the commensurate flow reductions in Butt Valley, Caribou #1, and Caribou #2 PHs in July and August.
2) Foregone power generation loss was estimated based on the commensurate flow reduction in Rock Creek PH relative to the First 5-Year dry year minimum instream flow requirement of 150 cfs in July and August.
3) Foregone power generation loss was estimated based on the commensurate flow reduction in Bucks Creek PH in July and August.
4) Energy consumption by the water chiller in July and August.

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FIGURE 5-7

ALTERNATIVE 5B

LEGEND

- COOL WATER INFUSION
- WARM WATER
- STREAM
- POWERHOUSE CONDUIT
- POWERHOUSE (PH)
- NEW OR MODIFIED FACILITY

NOTES:

1. SOURCE: USGS 7.5 MINUTE QUADRANGLE MAPS (PROJECTION: STATE PLANE NAD83 CALIFORNIA ZONE 1 IN FEET)
2. UNFFR: UPPER NORTH FORK FEATHER RIVER

N W E S

SCALE (MILES) 0 1.5 3

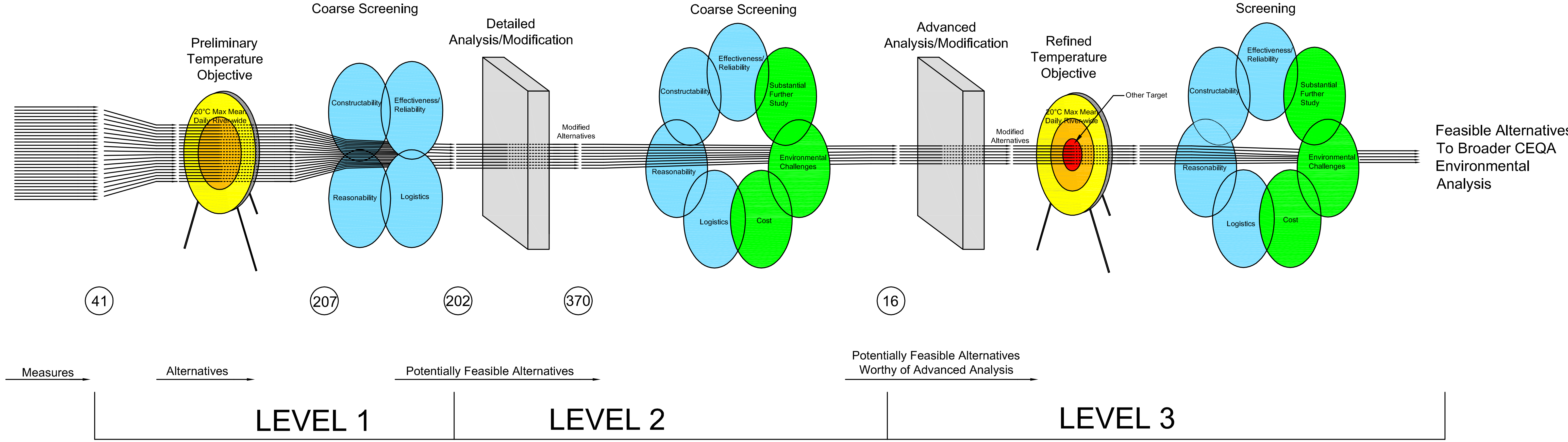

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Figure 5-8

Upper North Fork Feather River: Alternatives Development and Evaluation Process Flow Diagram and Resulting Number of Alternatives in Level 1 & 2

6.0 PROPOSED APPROACH FOR LEVEL 3 ANALYSIS OF WATER TEMPERATURE REDUCTION ALTERNATIVES

This chapter describes the proposed approach for Level 3 analysis and further screening of water temperature reduction alternatives that pass Level 2 (as summarized in Table 5-4 of Chapter 5). The 16 resulting water temperature reduction alternatives that pass Level 2 represent *the set of potentially effective and feasible* alternatives to achieving the temperature target. These water temperature reduction alternatives were formulated using the results of existing modeling studies conducted primarily by PG&E with some enhancements by Stetson. The purpose of Level 3 analysis will be to verify the effectiveness, sustainability, and long-term reliability of those water temperature reduction alternatives that pass Level 2. The water temperature reduction alternatives that pass Level 2 will be analyzed through detailed modeling using newly developed and improved water quality models, to modify or refine the alternatives where necessary, and to screen the alternatives to arrive at a *set of effective and feasible* water temperature reduction alternatives that are suitable for broader environmental analysis in the EIR.

Following are the major steps in the proposed approach for the Level 3 analysis:

- Identify the feasible "UNFFR Project-only" water temperature reduction alternative and develop the associated water temperature profile along the NFFR;

- Verify the effectiveness, sustainability, and long-term reliability of the water temperature reduction alternatives that pass Level 2 through detailed modeling using newly developed and improved water quality models, and modify or refine the water temperature reduction alternatives as necessary to meet the temperature target;

- Prepare feasibility-level engineering designs and associated costs, including capital, O&M, and foregone energy replacement, for the water temperature reduction alternatives verified to be effective, sustainable, and reliable;

- Screen the water temperature reduction alternatives determined to be effective, sustainable, reliable, and feasible, and select those that are most suitable for CEQA analysis; and

- Prepare the Level 3 Report.

6.1 IDENTIFY THE FEASIBLE "UNFFR PROJECT-ONLY" WATER TEMPERATURE REDUCTION ALTERNATIVE AND DEVELOP THE ASSOCIATED WATER TEMPERATURE PROFILE ALONG THE NFFR

In deciding whether to issue 401 certification for the UNFFR Project, the State Water Board will consider feasible modifications to the UNFFR Project (i.e., the UNFFR Project-only alternative) to address controllable factors within project boundaries that are contributing to seasonal warming of the NFFR. Alternatives 2c and 3 in Table 5-4 of Chapter 5, excluding the measures outside the FERC Project 2105 boundary, are two examples of UNFFR Project-only water temperature reduction alternatives. The water temperature profile along the NFFR that is associated with such feasible modifications will define the temperature target for all the water temperature reduction alternatives. In Level 1 and 2, the temperature target used was 20°C maximum mean daily water temperature along the NFFR. This target may be modified based on the results of Level 3 analysis of the UNFFR Project-only alternative.

Detailed modeling using the newly developed and improved water quality models will be carried out to determine the water temperature profile along the NFFR that is associated with the UNFFR Project-only alternative. The modeling work will consider the following flow releases as baseline conditions:

- Canyon Dam releases to the Seneca Reach are those agreed to in the Partial Settlement for the UNFFR Project except flows used for the measures of "increased Canyon Dam releases";
- Belden Dam releases to the Belden Reach are those given in the Partial Settlement for the UNFFR Project;
- Rock Creek Dam releases to the Rock Creek Reach are those given in the 2000 Relicensing Settlement Agreement for the Rock Creek-Cresta Project;
- Cresta Dam releases to the Cresta Reach are those given in the 2000 Relicensing Settlement Agreement for the Rock Creek-Cresta Project; and,
- Poe Dam releases to the Poe Reach are those given in the USFS's final 4(e) conditions for the Poe Project.

6.2 VERIFY THE EFFECTIVENESS, SUSTAINABILITY, AND LONG-TERM RELIABILITY OF WATER TEMPERATURE REDUCTION ALTERNATIVES THAT PASS LEVEL 2 THROUGH DETAILED MODELING USING NEWLY DEVELOPED AND IMPROVED WATER QUALITY MODELS, AND MODIFY OR REFINE THE WATER TEMPERATURE REDUCTION ALTERNATIVES AS NECESSARY TO MEET THE TEMPERATURE TARGET

Level 3 analysis is needed to verify the effectiveness, sustainability, and reliability for the water temperature reduction alternatives that pass Level 2 in meeting the NFFR temperature target. The water temperature reduction alternatives that pass Level 2 were formulated using the results of existing modeling studies conducted primarily by PG&E with some enhancements by Stetson. The effectiveness, sustainability, and long-term reliability of these alternatives have not been verified. For example, Alternative 3 in Table 5-4 shows that three measures are needed to reduce Belden Reservoir water temperature to 16.0°C plus one additional measure is needed for each of the Belden and Cresta Reaches, and two additional measures are needed for the Poe Reach to meet the temperature target for the river. More detailed modeling studies using long-term hydrology and meteorology data are needed to verify whether the three measures can indeed effectively, sustainably, and reliably reduce the Belden Reservoir water temperature to 16.0°C. If not, the measure of increasing Canyon Dam low-level outlet release to 250 cfs could be modified to allow a higher release rate and/or the measures for the Cresta Dam and Poe Dam/Poe Adit releases could be refined. Conversely, if modeling studies show that the three measures can reduce Belden Reservoir water temperature to less than 16.0°C, the measures for the Cresta Dam and Poe Dam/Poe Adit releases could also be refined.

Table 6-1 summarizes all models that will be used in Level 3 to analyze water temperature profiles along the NFFR, and Figure 6-1 shows how these models are related. For example, outflow and temperature at Canyon Dam derived from output of the Lake Almanor model will be input to the Seneca Reach SNTEMP model. Outflow and temperature at the Butt Valley PH derived from output of the Lake Almanor model will be input to the Butt Valley Reservoir CE-QUAL-W2 model. The outflows and temperatures at the Caribou #1 and #2 PHs derived from output of the Butt Valley Reservoir CE-QUAL-W2 model, and outflow and temperature derived from output of the Seneca Reach SNTEMP model will be either fully mixed at Belden Reservoir or input to the Belden Reservoir CE-QUAL-W2 model, depending on the water temperature reduction alternatives for evaluation[29]. Outflow and temperature at the Belden PH derived from output of the Belden Reservoir model will define the discharge water temperature at the Belden PH and will be input to the Rock Creek Reservoir SNTEMP model. Outflow and temperature at the Belden Dam derived from output of the Belden Reservoir model will be input to the Belden Reach SNTEMP model. Water temperature profiles along the Rock Creek, Cresta, and Poe Reaches will be computed using SNTEMP models for these reaches. Water temperature calculations for Cresta and Poe Reservoirs will be conducted using the complete mixing method of analysis[30] which will be performed outside of the modeling work.

In PG&E's modeling studies for the historical 33 years (1970 – 2002), Rock Creek Reservoir was assumed to be completely mixed and warming in the reservoir was not accounted for. However, about 0.5°C – 1.0°C warming from the upstream to downstream of Rock Creek Reservoir was observed during the July 2003 Caribou special test and again during the 2006 special test. Not accounting for the warming would underestimate water temperatures in the Rock Creek Reach and downstream reaches. A new Rock Creek Reservoir SNTEMP model currently being constructed by Stetson from a previous model developed by PG&E[31] will be used to account for warming through the reservoir. Rock Creek Reservoir is relatively long, shallow, narrow, and similar, in terms of thermal behavior, to a river. The previous Rock Creek Reservoir SNTEMP model has been well calibrated by PG&E using the July 2003 Caribou special test data.

It is worth noting that two models for Lake Almanor are included in Table 6-1 and Figure 6-1. The existing Lake Almanor MITEMP model was developed by Bechtel for simulating Lake Almanor water temperature profiles and discharge water temperatures at Butt Valley PH and Canyon Dam. The Lake Almanor CE-QUAL-W2 model was initially developed by Jones & Stokes, and recently improved by Stetson, for simulating the impacts of cold water withdrawal on the distribution of appropriate temperature and dissolved oxygen concentrations, providing suitable cold freshwater habitat in the lake. The two models may need to be used conjunctively for Lake Almanor water temperature simulations since both models have unique limitations in

[29] For the Alternatives 2c, 3, 4a, 4b, and 4c in Table 5-4 of Chapter 5, stratification in Belden Reservoir, if any, is expected to be weak because all inflow sources to Belden Reservoir are cool and water temperature differences between the sources are small. So, Belden Dam release and Belden PH discharge water temperatures can be determined using the complete mixing method by mixing all inflows and inflow temperatures to Belden Reservoir. For the Alternatives 5a and 5b in Table 5-4, stratification in Belden Reservoir is expected. The Belden Reservoir CE-QUAL-W2 model will be used to evaluate the sustainability of routing cold water through the stratified reservoir by balancing inflows relative to outflows.

[30] Historical observations show that water temperatures in the Cresta and Poe Reservoirs are generally well mixed.

[31] The new Rock Creek Reservoir SNTEMP model was originally developed by PG&E as an extension to the existing Belden Reach SNTEMP model which used meteorological data at the Prattville Intake station. Stetson will separate the Rock Creek Reservoir SNTEMP model from the Belden Reach SNTEMP model because Rock Creek Reservoir and Belden Reach are two different water bodies and it makes more sense for the Rock Creek Reservoir SNTEMP model to use meteorological data at the Rock Creek Dam station, rather than the Prattville Intake station. Stetson will also test the new Rock Creek Reservoir SNTEMP model using the 2006 special testing data.

simulating the withdrawal water temperatures at the Prattville Intake[32]. The most significant limitation of the Lake Almanor MITEMP model is that a minimum outflow of 700 cfs was prescribed in the model code for discharges at the Butt Valley PH and Canyon Dam. Specifically, the model automatically uses 700 cfs to compute withdrawal water temperatures, even if discharges are less than 700 cfs. The model code was modified and recompiled by Bechtel to remove this minimum flow setting at the request of Stetson in April 2006. However, the reliability of the so-modified Lake Almanor MITEMP model has not been verified, particularly at low discharges that are less than 700 cfs. The modified MITEMP model will be verified by running the model for the calibration year 2000 and for the special testing year 2006, then comparing the model output with observed data. This testing will verify the reliability of the modified MITEMP model at low discharge conditions because both years had a period with flow discharges at the Prattville Intake less than 700 cfs. The Lake Almanor MITEMP and CE-QUAL-W2 models will be used conjunctively based on the outcome of the testing.

A comprehensive work plan for Level 3 water temperature reduction alternative analysis will be prepared prior to conducting detailed water temperature modeling. The Level 3 process will be consistent with that described for screening of Level 1 and 2, but will include more rigorous modeling, design work, and analysis. The modeling approach, model simulation scenarios, approach in determining an appropriate long-term modeling analysis period, approach in synthesizing long-term hydrological and meteorological data for model inputs, and approach in determining typical "normal", "warm', and "cool" weather conditions will be described in the comprehensive work plan.

6.3 PREPARE FEASIBILITY-LEVEL ENGINEERING DESIGNS AND ASSOCIATED COSTS, INCLUDING CAPITAL, O&M, AND FOREGONE ENERGY REPLACEMENT, FOR THE WATER TEMPERATURE REDUCTION ALTERNATIVES VERIFIED TO BE EFFECTIVE, SUSTAINABLE, AND RELIABLE.

Feasibility-level engineering designs and cost estimates, including capital, O&M, and foregone energy replacement, for the water temperature reduction alternatives verified to be effective, sustainable, and reliable will be prepared. The design layouts and cost estimate results of Level 3 will be presented in a format similar to Level 2.

6.4 SCREEN WATER TEMPERATURE REDUCTION ALTERNATIVES DETERMINED TO BE EFFECTIVE, SUSTAINABLE, RELIABLE, AND SELECT ALTERNATIVES TO BE CARRIED FORWARD FOR CEQA ANALYSIS.

The water temperatures reduction alternatives that are verified to be effective, sustainable, and reliable will become initial Level 3 water temperature reduction alternatives. These initial Level 3 water temperature reduction alternatives will be screened based on the similar screening criteria used in Level 2, although the economic criterion may be refined by the State Water Board. The resulting set of water temperature reduction alternatives passing the Level 3 screening will represent *the set of effective and feasible alternatives*. These water temperature reduction alternatives will be carried forward into the EIR where they will be augmented and/or

[32] The Lake Almanor CE-QUAL-W2 model is not reliable for simulating the hydraulic effects of removing the submerged levees near the intake, while the Lake Almanor MITEMP model is not reliable for simulating discharge water temperatures at the Butt Valley PH at low discharges. Both conditions were included in the water temperature reduction alternatives that pass Level 2 and will need to be evaluated in Level 3.

modified to address potentially significant environmental impacts identified through the CEQA process.

6.5 PREPARE LEVEL 3 REPORT

A report documenting Level 3 analysis of water temperature reduction alternatives will be prepared upon completion of the above analyses and feasibility-level designs and costs. It is anticipated the Level 3 Report will include the following sections and appendices:

- Introduction
- Summary of Level 1 and 2 Analysis of Water Temperature Reduction Alternatives
- Analysis of Effectiveness, Sustainability, and Reliability of the Water Temperature Reduction Alternatives That Pass Level 2
- Initial Level 3 Water Temperature Reduction Alternatives Verified to Be Effective, Sustainable, and Reliable – Design Layouts, Operational Requirements, Cost Estimates, and Effectiveness
- Screening of Initial Level 3 Water Temperature Reduction Alternatives and Resulting Final Level 3 Water Temperature Reduction Alternatives
- Recommendation of Water Temperature Reduction Alternatives for CEQA Analysis
- Appendix A: Water Temperature Profiles along the NFFR for Water Temperature Reduction Alternatives Over a Range of Meteorological Conditions
- Appendix B: Feasibility-Level Engineering Designs and Cost Estimates for the Water Temperature Reduction Alternatives Verified to Be Effective, Sustainable, and Reliable
- Appendix C: Documentation of the Development of New and Improved Water Quality Models: Lake Almanor, Butt Valley Reservoir, and Belden Reservoir CE-QUAL-W2 Models

Table 6-1 Proposed NFFR Water Temperature Models for Level 3 Analysis

Models	Notes
Existing Lake Almanor MITEMP model	The Lake Almanor MITEMP model was developed by Bechtel in 2002. The model code was originally set at a minimum outflow of 700 cfs for discharges at Canyon Dam and the Butt Valley PH. The model code was modified and recompiled by Bechtel to remove this minimum flow setting at the request of Stetson in April 2006. The Lake Almanor MITEMP model simulates water temperature only.
Improved Lake Almanor CE-QUAL-W2 model	The Lake Almanor CE-QUAL-W2 model was developed by Jones & Stokes in 2004. The original model did not accurately capture the relationship between discharge rate (particularly at low discharge rates) and discharge water temperatures at the Butt Valley PH. The model was improved by Stetson to capture this relationship. The Lake Almanor CE-QUAL-W2 will be used to simulate water temperature and dissolved oxygen.
New Butt Valley Reservoir CE-QUAL-W2 model	The new CE-QUAL-W2 model was developed by Stetson. It will be used to simulate both water temperature and dissolved oxygen.
New Belden Reservoir CE-QUAL-W2 model	The new CE-QUAL-W2 model was developed by Stetson. It will be used to simulate water temperature.
Existing Seneca Reach SNTEMP model	The existing Seneca Reach SNTEMP model was developed by Thomas R. Payne and Associates (received from PG&E in July 2005). It will be used to simulate the water temperature profile along the Seneca Reach.
Existing Belden Reach SNTEMP model	The existing Belden Reach SNTEMP model was developed by Thomas R. Payne and Associates (received from PG&E in July 2005). It will be used to simulate the water temperature profile along the Belden Reach.
New Rock Creek Reservoir SNTEMP model	The new Rock Creek Reservoir SNTEMP model is being derived by Stetson from a previous model developed by PG&E. This model will be used to simulate warming from the upstream to downstream ends of Rock Creek Reservoir.
Existing Rock Creek Reach SNTEMP model	The existing Rock Creek Reach SNTEMP model was developed by Thomas R. Payne and Associates (received from PG&E in July 2005). It will be used to simulate the water temperature profile along the Rock Creek Reach.
Existing Cresta Reach SNTEMP model	The existing Cresta Reach SNTEMP model was developed by Thomas R. Payne and Associates (received from PG&E in July 2005). It will be used to simulate the water temperature profile along the Cresta Reach.
Existing Poe Reach SNTEMP model	The existing Poe Reach SNTEMP model was developed by PG&E. It will be used to simulate the water temperature profile along the Poe Reach (received from PG&E in July 2005).

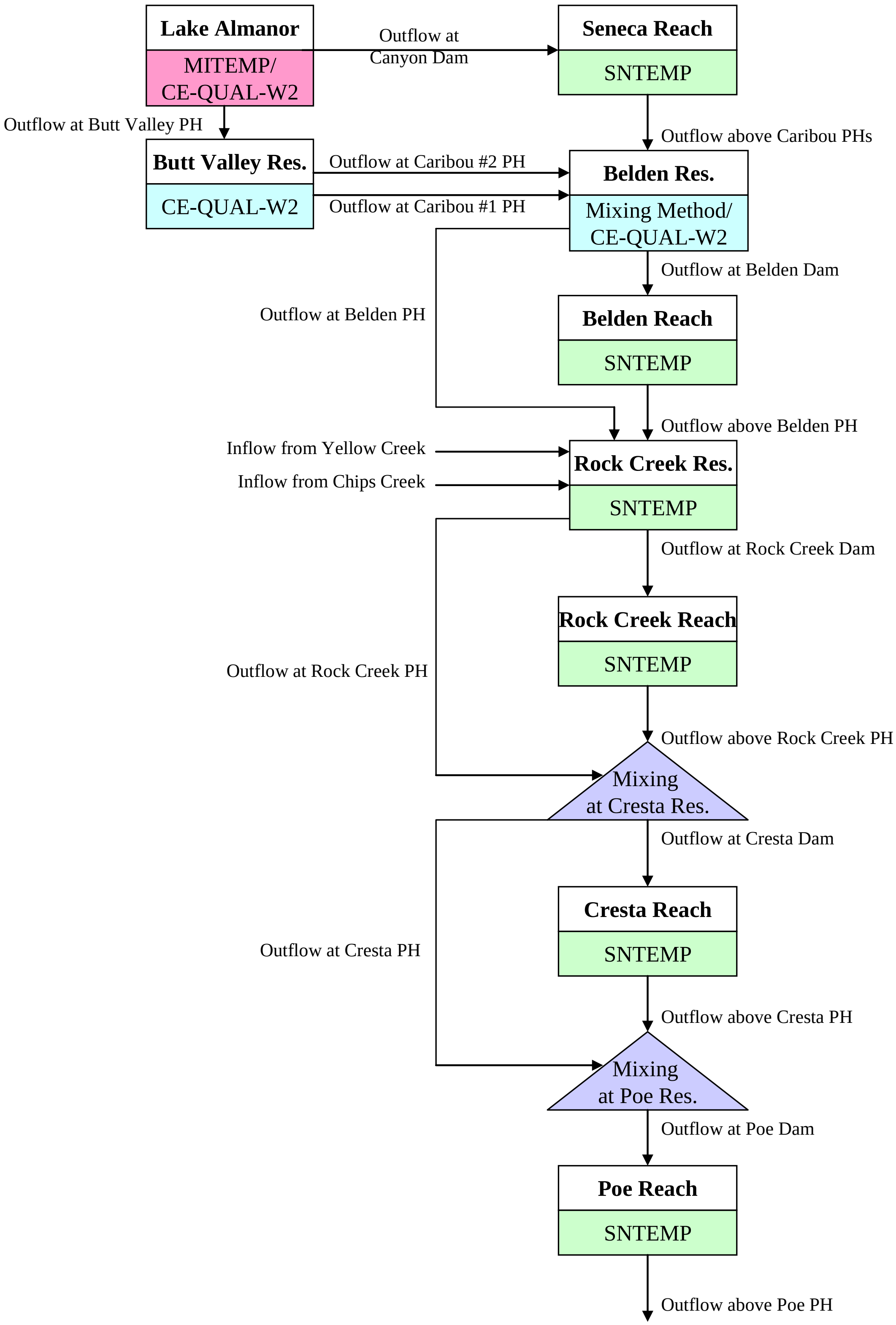

Figure 6-1 Proposed Water Temperature Models and Model Relationships

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