Appendix E

Rough Designs and Cost Estimates for Water Temperature Measures

ROUGH DESIGNS AND COST ESTIMATES FOR WATER TEMPERATURE MEASURES

The purpose of this report is to describe the methods, assumptions, and resulting rough designs and cost estimates for measures to reduce water temperature along the NFFR. The measures covered include those comprising the initial Level 2 water temperature alternatives. These rough designs and cost estimates form the basis for the design layouts and cost estimates for the water temperature alternatives presented in Chapter 5 which were used to support Level 2 screening. They should be considered preliminary and subject to change based on further detailed analysis and design. They were prepared to a level rigor and detail deemed appropriate for project planning and for purposes of this Level 1 and 2 Report.

The rough designs and cost estimates relied heavily on information provided by PG&E. This information included the following:

- Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River/ Pipe Yellow Creek Water Alternative (PG&E 2005c)
- Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River/ Mechanical Water Chillers Alternative (PG&E 2005d)
- Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River/ Mechanical Cooling Tower Alternative (PG&E 2005e)
- Prattville Intake Modifications Phase 3 Feasibility Study, Final Report (Black and Veatch 2004a)
- Prattville Intake Modifications Closeout Status Memorandum (Black and Veatch 2004b)
- North Fork Feather River Yellow Creek Diversion Cooling Water Pipeline Feasibility Study, Summary Report (Black and Veatch 2005a)
- Poe Tunnel Adit Feasibility Study/ Pre-Feasibility Level Sizing and Cost Estimate Summary Memorandum (Black and Veatch 2005b)
- Flow Improvement Modifications/ Plan & Sections/ Canyon Dam Intake Tower (Black and Veatch 2007)
- Miscellaneous design drawings of NFFR hydropower facilities provided by PG&E

DESIGN METHODOLOGY AND ASSUMPTIONS

- Site Selection for Facilities and Conduit Alignments

  Sites for facilities and conduit alignments were selected with the objective to simplify construction and minimize construction cost. USGS 7.5 minute topographical maps, aerial photos and other information provided by PG&E were examined during the site/alignment selection process.

  Sites for diversions and conduit alignments were selected to produce maximum head in order to reduce conduit size and construction costs.

- Conduit Materials

  Conduit materials were as chosen based on the lowest cost material that would offer the best performance for a given application. In general, high density polyethylene (HDPE) was used for underwater conduit applications; black steel pipe (BSP) was used where flexibility was required due to site conditions with the potential for land movement; and reinforced concrete pipe (RCP) was used where site conditions would allow because of its low cost and long life.

- Diversion Structures

  Inflatable rubber dams were used for stream diversions because their capability to deflate and allow for pass-through of flow, sediment, debris, and fish passage addressed concerns about establishing permanent instream barriers.

- Dredging

  Dredging of the reservoir bottom using a dredging rig was required for excavating submerged channels and for preparing reservoir bottoms for setting and anchoring conduits. The dredging material was assumed to be soft, unconsolidated lake sediments. This assumption may need to be modified if Level 3 investigations reveal that the reservoirs along the NFFR have sediments mainly consisting of rocks that are markedly different.

- Modifications or Connections to Existing Hydropower Structures

  Several modifications or connections to existing hydropower structure were included in various measures, as follows:
  - Three 13' x 9.5' reinforced concrete boxes were attached to the face of the Butt Valley PH discharge outlet and carry flow 1,150 feet to the proposed regulating pond.
  - A concrete regulating basin was attached to the face of Bucks Creek PH discharge to regulate the bypass flows and overflow into the North Fork Feather River.
  - Gates #1 and #5 of the three low-level outlet gates at Canyon Dam Intake Tower were modified by connecting two pre-fabricated steel bulkheads with built-in slide gates to the existing outlets to enable controllable releases up to 600 cfs.
  - Several submerged pipes were connected to existing outlets of dams.

  The feasibility of these modifications and connections will require further investigation.

- Thermal Curtains

  The fixed U-shaped "long upper curtain" at Prattville Intake designed by Black and Veatch (2004a) was used as the main basis for the designs of the Caribou Intake and Belden PH Intake thermal curtains.

The fixed Γ-shaped upper curtain was selected for the Caribou Intake and Belden PH Intake thermal curtains to allow free flows to the spillways at Butt Valley Dam and Belden Dam.

- Water Chillers

  The following criteria were used for selecting appropriate sites for chillers:
  1) Close to upper end of the reach or near the dam;
  2) Warm reservoir water could be conveyed to the chillers by gravity and the chilled water could be returned by gravity back to the reach just below each dam;
  3) Adequate open land space above the estimated flood plain;
  4) No open land space along the Cresta reach was found to be available for deployment of multiple chillers; therefore, a constructed deck was proposed.

- Other Design Features

  A submerged diffuser was proposed for all cold water plunging discharge outlets. The diffuser was designed to distribute the discharge in a larger cross sectional area for the purpose of reducing discharge velocity, turbulence and, hence, mixing.

ROUGH COST ESTIMATE METHODOLOGY AND ASSUMPTIONS

Rough cost estimates considered capital cost, annual operation and maintenance (O&M) cost, and annual foregone power generation loss.

Capital cost estimates were developed based on unit costs given in Means 2007, budgetary quotes from vendors, and cost derived from Black & Veatch estimates and Stetson databases. A 35% add-on for contingency/unlisted items and a 25% add-on for design and project management costs were used in the capital cost estimates.

To allow for comparison of costs across water temperature alternatives, capital costs were amortized and converted to an equivalent annual cost based on an interest rate of 3% and useful lives that varied depending on the capital component. New facilities, such as thermal curtains[1], diversion dams, bypass pipelines, constructed or modified low-level outlets, dredged channels, and water chillers, were assumed to have a useful life of 50 years.

Annual O&M costs were estimated to be a percentage of capital costs. The breakdown of percentages is listed in the following table:

[1] The Hypalon fabric used for thermal curtain applications, is a reinforced flexible geomembrane, a synthetic rubber product manufactured into plies that are combined over a reinforcing polyester scrim fabric. It has a demonstrated long life in harsh environments such as industrial wastes, sewage lagoons, and reservoir linings. It resists flexural cracking and abrasion as well as damaging effects of weather and heat.

Percentages Used in Annual O&M Cost Estimates

Facility	O&M Percentage of Capital Cost
Thermal Curtain	1.00%
Bypass Pipeline	0.25%
Low-Level Outlet	0.50%
Dredged Channel	1.00%
Water Chiller	3.00%

PG&E is a net importer of power, so any forgone power generation resulting from any particular measure must be replaced by purchased power from an outside supplier. Annual foregone power generation loss was estimated based on the potential commensurate flow reduction and/or turbine efficiency reduction in each respective powerhouse resulting from a particular measure[2], static head of the powerhouse, and normal operating efficiency of the powerhouse turbines. The unit purchase price of $0.065/KWh was used in the foregone power generation estimates. The following table lists static heads and turbine efficiencies that were used in the foregone power generation loss estimates.

Powerhouse Static Head and Turbine Efficiency Used in Foregone Power Generation Loss Estimates

Powerhouse	Static Head (ft)	Turbine Efficiency
Butt Valley PH	362	80.6%
Caribou #1 PH	1,151	69.1%
Caribou #2 PH	1,150	84.2%
Belden PH	770	79.6%
Rock Creek PH	535	85.9%
Cresta PH	290	80.1%
Poe PH	488	78.6%
Bucks Creek PH	2,558	78.1%

[2] The measure of reduced Butt Valley PH discharges was assumed to have no power generation loss 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 summer demand season compared to other non-peak seasons. The measure of increased Grizzly Creek release was assumed to result in a commensurate decrease in the Cresta Dam release (or commensurate increase in Cresta PH discharge) since the minimum instream flow is required at the location just below Grizzly Creek confluence with the NFFR. Note that in addition to the minimum instream flow requirement at the location below Grizzly Creek confluence with the NFFR, Cresta Dam has a minimum release requirement of 100 cfs.

Measure Name: Prattville Intake Thermal Curtain and Dredging

Applicable Alternative Category(s): 2a, 2b, 3, 4a, 4b (Note: Dredging excluded in Alternatives 4a and 4b)

Description of Measure: Install a U-shaped "long upper curtain" at Prattville Intake (referred to as curtain #4 in Black and Veatch, 2004a) and dredge the lake bottom to remove levees near the intake area to enhance cool water flow into the intake. The purpose of the thermal curtain is to create a barrier that prevents the flow of warm surface water into the intake. Warm water is retained behind the curtain while cool water is drawn into the intake from the lake bottom through the open area under the curtain.

Description of Operations: This measure does not affect operations. Implement normal operations at Prattville Intake and Butt Valley PH.

Detailed Description of Facilities Improvements and Design Criteria:
To be effective, the curtain must be designed such that the velocities in the open area under the curtain are relatively low, in the range of 0.10 - 0.25 fps. This objective is achieved with a Hypalon fabric curtain approximately 2,570 ft long by 50 ft deep (total area = 108,000 sq ft) extending about 900 ft offshore from the high shoreline. The curtain is "fixed," meaning that as the lake level fluctuates the level of the lower lip of the curtain, which is set about 5 ft above the lake bottom, remains constant with respect to the lake bottom. In this way, the total open area under the curtain is maintained at the required 5,280 sq ft. Galvanized steel bin-type walls extend about 300 ft offshore from the shoreline and connect to the curtain endpoints. To enhance cool water inflow into the intake, submerged levees that impede cool water flow are removed by dredging about 23,000 cy of lake bottom material comprising the levees.

List of Figures:
- General location map of Prattville Intake thermal curtain
- Plan view of Prattville Intake thermal curtain site layout
- Elevation views of Prattville Intake thermal curtain

Discussion:

Black and Veatch prepared reports documenting the design and estimated cost for the thermal curtain at the Prattville Intake (Black and Veatch, 2004a, 2004b). Stetson evaluated the design and estimated cost documented in the Black and Veatch reports.

Evaluation of Black and Veatch design

The design size and layout of the fixed U-shaped "long upper curtain" at Prattville Intake in the Black and Veatch 2004 reports were based on results of physical prototype hydraulic model testing at the Iowa Institute of Hydraulic Research (IIHR, 2003). IIHR evaluated six thermal curtains of different sizes and layouts and conducted physical prototype model tests to compare and select the most effective and viable thermal curtain.

The most effective thermal curtain configuration was determined to be U-shaped, 900-feet x 770-feet x 900-feet (i.e., curtain #4). The most effective elevation of the curtain bottom was determined to be 4,455 ft (USGS datum). According to IIHR (2004), with the U-shaped long upper curtain in place and with the dredging of submerged levees at the Prattville Intake area, the Butt Valley PH discharge water temperature could be reduced by about 5.8°C and 5.2°C during July and August respectively at its normal operating discharge of 1,600 cfs. Dredging alone provides about 1.4°C and 1.6°C water temperature reduction at the Butt Valley PH during July and August respectively at its normal operating discharge of 1,600 cfs. IIHR also evaluated the effectiveness of installing a submerged hooded pipeline at the existing Prattville Intake to cause colder water to enter the intake. The thermal curtain measure was determined to be more effective.

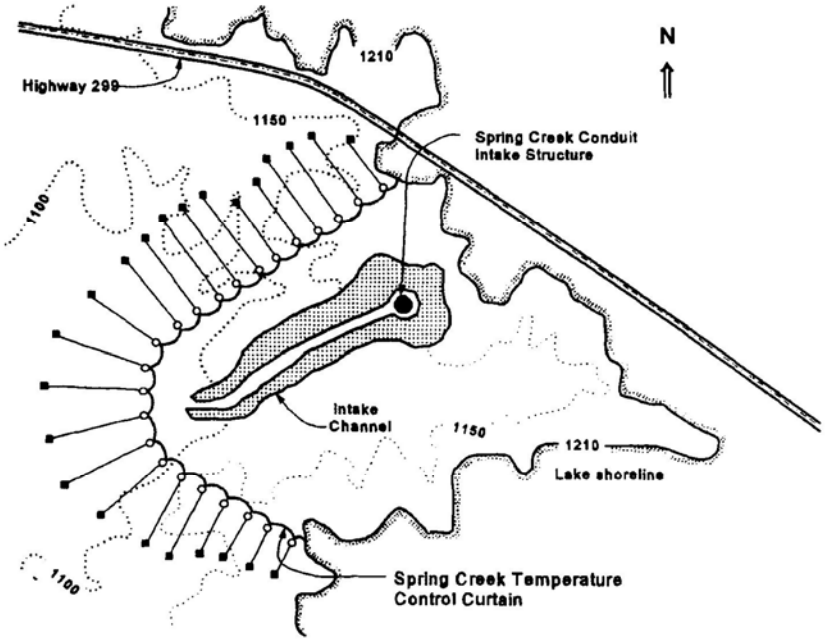
Stetson concludes that the basis of designing the fixed U-shaped "long upper curtain" at Prattville Intake for controlling the temperature of water entering the intake is technically-sound and acceptable.

Evaluation of Black and Veatch cost estimate

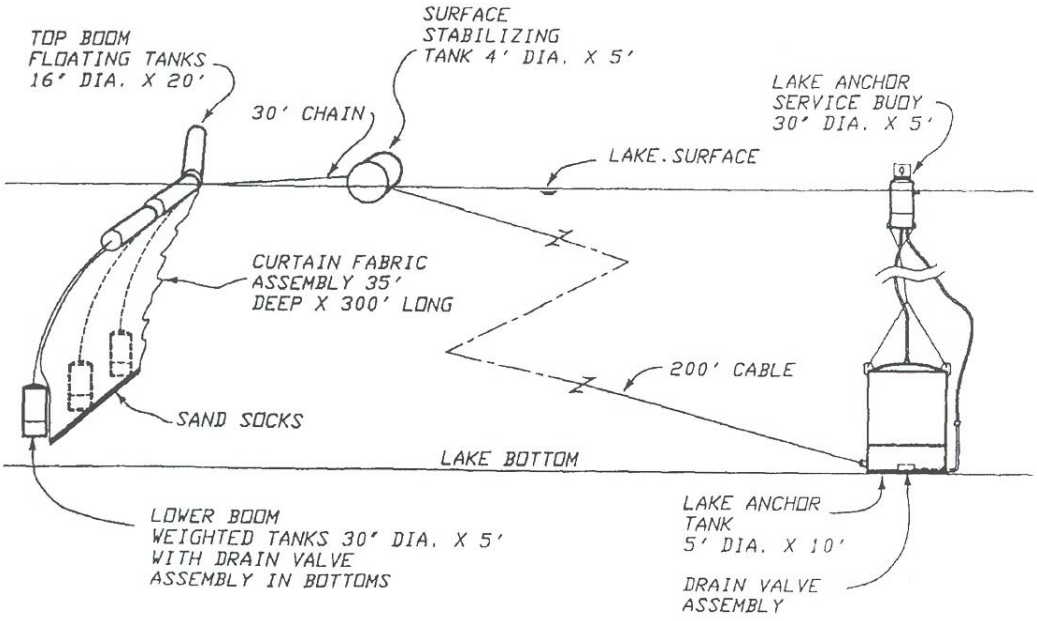
Initially, Black and Veatch estimated the cost of the "long upper curtain" (2,570 ft) and dredging at $8.3 million (2004a). After meeting with PG&E staff and discussing the report and design assumptions, Black and Veatch modified the design to strengthen the curtain against large wave forces and revised the estimated cost to about $17.8 million (2004b). The revision to the estimated cost was due to the modified design, changes in disposal site for the dredging material and other dredging-related costs, changes to costs for scuba diving for installation, prolonging of the construction schedule, and an increase in contingency from 25% to 35%.

At first glance, the Black and Veatch estimated cost for the Prattville thermal curtain appears to differ markedly from the actual cost of a thermal curtain of similar length installed by the Bureau of Reclamation. This difference was investigated as a way of evaluating the reasonableness of the Black and Veatch cost estimate.

In 1993, Reclamation installed thermal curtains at Whiskeytown and Lewiston Lakes in connection with the Whiskeytown Spring Creek Tunnel Intake and the Carr Powerplant tailrace. A report prepared by Tracy Vermeyen of Reclamation describing the nature of the work can be found at the following web address: http://www.usbr.gov/pmts/hydraulics_lab/tvermeyen/asce95m/index.html. The Spring Creek Tunnel Intake thermal curtain is a 100 ft deep, 2,400 ft long surface-suspended curtain which encloses the Spring Creek Tunnel intake. The curtain is surface-suspended, meaning that when the reservoir level drops the elevation of the bottom of the curtain also drops (see the following figure). In addition, the ends of curtain are anchored to shore so that when the water level drops the curtain gathers along the exposed reservoir shoreline. Installation took 4 months to complete at a cost of $1.8 million in contractor labor and materials.



Location map of the Spring Creek Tunnel intake curtain, Whiskeytown Reservoir, California (not to scale).



- Elevation view of a typical temperature control curtain and its structural components.

Plan and Elevation Views of Reclamation's Thermal Curtain at Spring Creek Tunnel Intake (Source: Bureau of Reclamation 1997)

Mr. Greg O'Haver, former Reclamation employee in charge of construction of the Whiskeytown thermal curtain project, and Ms. Tracy Vermeyen, Reclamation project engineer for the hydraulic study, were contacted to discuss the Spring Creek Tunnel

Intake thermal curtain. These discussions aided in understanding the reasons for the cost difference between the two thermal curtains.

In general terms, the primary difference between the two thermal curtains has to do with the design intent. The Spring Creek Tunnel Intake thermal curtain was designed to be temporary structure with a target useful life of 10 years. The Prattville thermal curtain, on the other hand, has been designed to be a permanent structure. While the basic functions of the two curtains are the same, the design of the permanent structure provides for a stronger and more robust curtain. This is demonstrated by the use of stainless steel for various components as well a heavier duty metal for other components.

Further specific differences between the thermal curtains follow:

- Thermal curtain design

The length of the Prattville thermal curtain is 2,570 feet compared to 2,400 feet for the Spring Creek Tunnel Intake thermal curtain. The Spring Creek Tunnel Intake thermal curtain used the same material (Hypalon fabric) as the Prattville thermal curtain.

The Prattville thermal curtain employs a fixed curtain design while the Spring Creek Tunnel Intake thermal curtain employs a surface-suspended curtain design. The fixed curtain design was selected so that when the water surface of the lake drops the opening under the curtain will remain the same and preserve the hydraulics necessary for effective cool water flow to the intake. The fixed curtain is more costly due to the added cost to anchor the system to the bottom of reservoir, which requires scuba divers and additional anchoring features.

- Strengthening for Wave Forces

At Prattville there was concern for the forces on the curtain system from wave action. This resulted in increased material costs for the cables, chains, and fasteners as well as the amount of concrete needed for the anchoring system.

- Bin Walls

The Prattville thermal curtain has galvanized steel bin walls to prevent damage to the curtain that may arise from wind, debris, and vandalism when the reservoir level declines and exposes the curtain along the shoreline. At the Spring Creek Tunnel Intake the curtain tore at the shoreline, was vandalized, and was buried by sand preventing it from floating when the lake level rose. The Black and Veatch design for the Prattville thermal curtain calls for a bin wall extending from the high water shoreline to 50-150 ft beyond the low water shoreline, where a vertical trolly system is proposed. This system allows the top of the curtain to slide up and down as the water surface varies preventing stresses in the curtain. It also prevents the curtain from being exposed and buried in the sand and discourages vandalism. This system also eliminates the periodic maintenance that would be needed to free the curtain buried by sand.

- Dredging

The Prattville thermal curtain design calls for dredging of submerged levees on the lake bottom near the intake, which was not included in the Spring Creek Tunnel Intake thermal curtain. The hydraulic study prepared by the Iowa Institute of Hydraulic Research (IIHR, 2003) based on a physical prototype hydraulic model and referenced in the Black and Vetch report (2004a) found that the levees must be removed in order to allow cool water to be drawn to the intake.

- Scuba Diving

The cost for divers to install various components of the Prattville thermal curtain is anticipated to be substantially higher than the cost incurred at the Spring Creek Tunnel Intake thermal curtain. This higher cost is due to the added complexity of the fixed curtain's anchoring system.

- Concrete

At Prattville additional concrete is needed to anchor the curtain. The cost of concrete world-wide has increased substantially since 1993 when the Spring Creek Tunnel Intake thermal curtain was installed.

The revised Black and Veatch report (2004b) placed the total capital construction, design, and other pre-construction costs of the Prattville thermal curtain at approximately $17.8 million. In order to compare the costs of Prattville and Spring Creek Tunnel Intake thermal curtains certain itemized costs for components that were not included in the Spring Creek Tunnel Intake thermal curtain construction cost were deducted from the Prattville total cost. The costs included dredging, bin walls, and other cost items. The remaining common Prattville thermal curtain costs were adjusted to 1993 dollars to be comparable to the Spring Creek Tunnel Intake thermal curtain costs. This comparative cost analysis is summarized in the following table.

The General Requirements section (mobilization, supervision, temporary facilities and utilities, safety, and miscellaneous) for the Prattville thermal curtain accounts for slightly more than $1 million, far less than it likely accounted for on the Spring Creek Tunnel Intake thermal curtain. The primary factor driving this cost for Prattville is the overall cost since this figure is estimated based on the scale of the project and the overall total project cost.

While the comparable costs in 1993 dollars are different they are of similar magnitude. It appears that the Prattville thermal curtain is more costly due to increased complexity and numerous other factors that differentiate it from the Spring Creek Tunnel Intake thermal curtain. Absent detailed examination of the Black and Veatch design and cost (2004a, 2004b), the Prattville thermal curtain and cost estimate, while conservative, appears to be reasonable and acceptable for use in this Level 2 analysis.

Comparison of Spring Creek Tunnel Intake and Prattville Intake Thermal Curtain Costs

Item	Spring Creek Tunnel	Prattville
Published Cost	$1,800,000	$17,800,000
Non-Construction Costs	$0	-$7,500, 000 [1]
Dredging	$0	-$2,120,000 [2]
Bin Walls	$0	-$1,260,000 [3]
Scuba Diving	$0	-$640,000 [4]
Wave Force Cost	$0	-$1,270,000 [5]
General Requirements	$270,000 [6]	-$1,000,000 [7]
Prattville comparable to Spring Creek Tunnel costs	$1,530,000	$4,010,000
1993 Dollars	$1,530,000	$2,980,000 [8]
Difference		$1,450,000

Notes:

1. Prattville costs from Black & Veatch report (2004b) that are not construction related total $7.5 million.
2. Total of sections 02240 and 02300 from Black & Veatch report (2004a) and rounded, not including cost of rock for bin walls (~$120,000).
3. Sum of bin walls item in section 05100 from Black & Veatch report (2004a) and rounded. Includes cost of bin wall rock ($120,000) from 02300 as well as line item cost for diving of $150,000.
4. Sum of subcontract for divers items in section 02480 from Black & Veatch report (2004a) and rounded.
5. This figure resulted from the difference between the concrete and metals sections of the B&V report (2004a) (without wave force consideration) and Black & Veatch report (2004b) (with wave force consideration).
6. General requirements were assumed to be 15% of the total project cost and rounded.
7. Sum of general requirements items in Division 1 from Black & Veatch report (2004a) and rounded.
8. Adjusts the total project costs to 1993 dollars based on ENR Construction Cost Index change (1993 = ~72% of 2004). This was done by reviewing the Construction Cost index from the Engineering New Record (ENR) for the first week of June 1993 (value = 5260.23) and the first week of December 2004 (value = 7206.30) and decreasing the Prattville estimate by the percent change in the index (1993 = ~72% of 2004).

Based on the Prattville thermal curtain length of 2,570 feet and the 2004 cost of $4.01 million, the unit cost of a thermal curtain is approximately $1,560 per linear foot for construction only items. To adjust this cost to 2007 dollars, the percent change in the ENR Construction Cost Index was used. The previously stated ENR value of 7306.30 for the first week of December 2004 was used and the most recent available value of 7864.70 for April 23, 2007 was used. The value for 2007 is approximately 7.6% greater than the December 2004 value. The resulting 2007 unit cost is $1,700 per lineal foot. This unit value can be used for approximating the cost of curtains at other sites constructed in a manner similar to the Spring Creek Tunnel Intake thermal curtain.

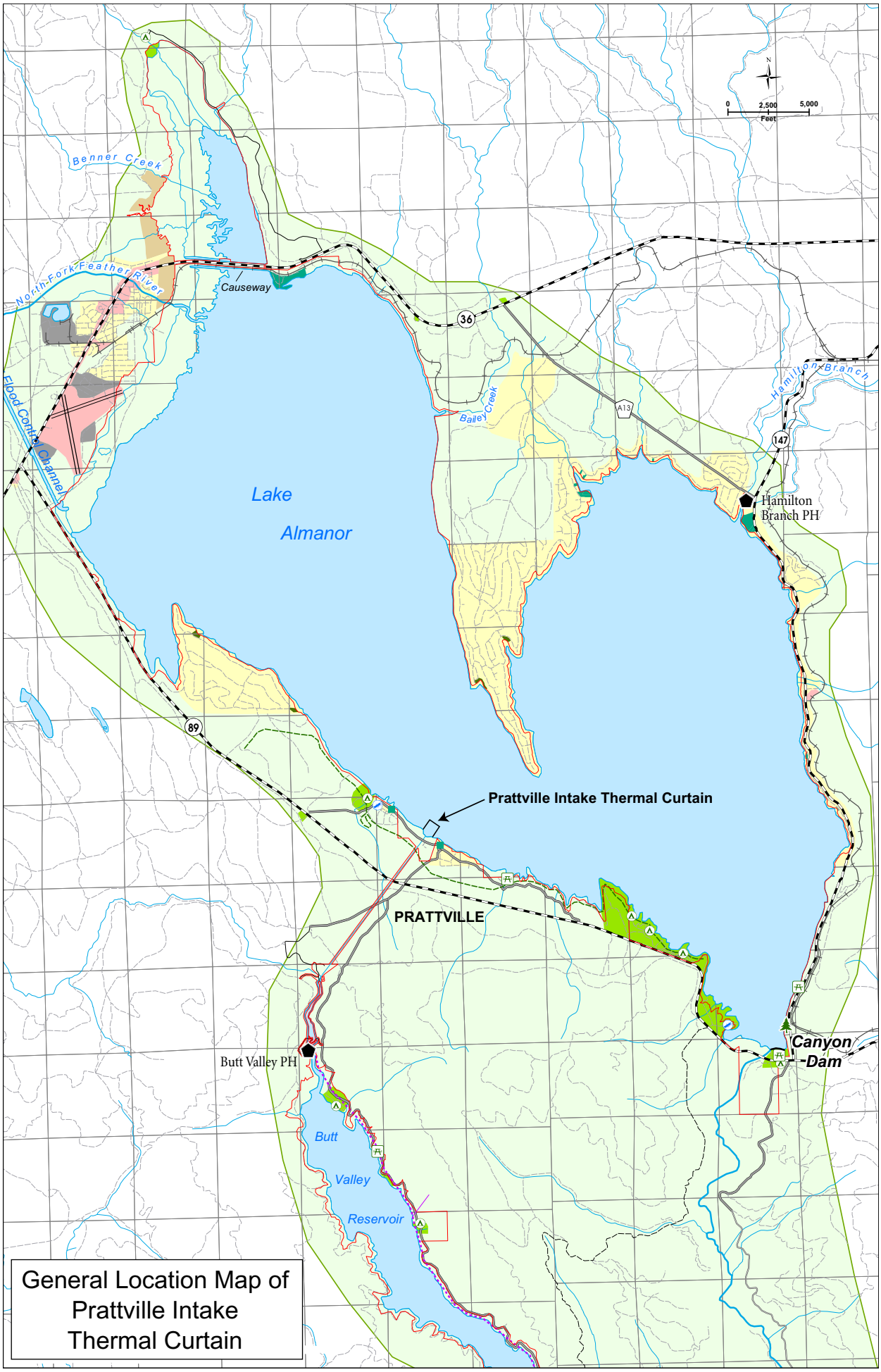
Black and Veatch Opinion of Cost of Prattville Intake Thermal Curtain #4 (2004b)

CSI Div. / Sect.	DESCRIPTION	Quantity	Unit	Unit Cost	Labor: Crew Code	Labor: M-H per Unit	Labor: Man Hours	Labor: Duration Days	Labor: Avg. Wage Rate	Labor Cost	Material: Unit Cost	Material: Material Cost	Equipment: Code	Equipment: No.	Equipment: Avg. Cost ($/hr)	Equipment: Equipment Cost	Sub-contract	Other	Total Cost	Remarks
1	General Requirements																			
	Mobilization	1	LS	95,515				0.0		0.00		0.00				0.00		95,515	95,515	
	Supervision	1	LS	349,638				0.0		0.00		0.00				0.00		349,638	349,638	
	Temporary construction facilities	1	LS	139,855				0.0		0.00		0.00				0.00		139,855	139,855	
	Temporary utilities	1	LS	104,892				0.0		0.00		0.00				0.00		104,892	104,892	
	Safety	1	LS	174,819				0.0		0.00		0.00				0.00		174,819	174,819	
	Miscellaneous	1	LS	139,855				0.0		0.00		0.00				0.00		139,855	139,855	
	Subtotal Mobilization									0		0				0.00	0	1,004,575	1,004,575	
2	Site Work																			
02240	Dewatering																			
	1 Decant Basin (Excavation And Restoration)	300	CY	16	H	0.246	74	0.6	58.77	4,336.86		0.00	6	4	35.53	349.57			4,686	Excavation & Demo Conc. Basin
	1 Decant Basin (Concrete)	182	CY	249	E	1.499	273	2.3	58.77	16,041.41	112.00	20,390.22	8	2	47.66	867.38	0	8,000	45,299	Other Is Filters for Fines
02300	Earthwork																			
	1 Dredge disposal area prep	1	LS	15,000	A	0.000	0	0.0	55.00	0.00	0.00	0.00				0.00		15,000	15,000	
	1 Dredge Disposal Area Restoration	1	LS	20,000	A	0.000	0	0.0	55.00	0.00	0.00	0.00				0.00		20,000	20,000	
	1 Silt curtains	76,000	SF	1.27	C	0.004	269	11.2	48.33	12,996.00	0.89	67,640.00	3	1	96.65	8,662.91		7,300	96,599	
	1 Dredging	22,750	CY	60	A	0.448	10,200	63.8	55.00	561,000.00	0.00	0.00	1	1	294.12	375,000.20	79,000	360,900	1,375,900	Other is special mob/demob
	1 Crane	1	LS	155,373.81	B	2,040	2,040	63.8	52.00	106,080.00	0.00	0.00	3	1	96.65	49,293.81		0	155,374	Fourth Additional Crane
	2 Bin wall backfill (rock)	3,750	CY	31	A	0.000	0	0.0	55.00	0.00	31.00	116,250.00				0.00		0	116,250	
	1 Skinner Flat - Machine Loading & Hauling 5 Miles	22,750	CY	13.69	H	0.274	6,234	194.8	47.75	297,649.63		0.00	6	4	35.53	13,840.32			311,490	
	1 Skinner Flat - Level Site	22,750	CY	4.17	C	0.082	1,866	77.7	48.33	90,165.83		0.00	7	2	46.00	4,767.39			94,933	
02480	Marine Work																			
	3 Work boat	1	EA	150,000	F	0.000	0	0.0	51.75	0.00	150,000.00	150,000.00			0.00	0.00		0	150,000	
	Subcontract For Divers																			
	Curtain Anchors																			
	3 Windward Main Anchors	1	LS	271,397	E	0.000	0	0.0	56.00	0.00	0.00	0.00				0.00	271,397	0	271,397	Was $210K Divers For 53.7 MD
	3 Leeward Main Anchors	1	LS	155,251	E	0.000	0	0.0	56.00	0.00	0.00	0.00				0.00	155,251	0	155,251	Adj. for 39.7 MD $210K Divers
	Bin Walls																			
	3 Water Installation, Including Fill	1	LS	150,000	A	0	0	0.0	55.00	0.00		0.00	1	1	335.81	0.00	150,000	0	150,000	Subcontract for Diving
	Curtain Wall																			
	3 Hypalon Curtain (60 mils)	1	LS	210,000	G	0.000	0	0.0	49.20	0.00	0.00	0.00				0.00	210,000		210,000	Subcontract for Diving
	Subtotal Site Construction						20,955			1,088,270		354,280				452,782	865,648	411,200	3,172,180	
3	Concrete																			
03400	Precast Concrete																			
	Curtain Anchors																			
	4 Windward Main Anchors	1,244	CY	250	E	1.786	2,221	69.4	56.00	124,400.00	150.00	186,600.00				0.00	0	0	311,000	Caissons
	4 Leeward Main Anchors	711	CY	250	E	1.786	1,270	39.7	56.00	71,100.00	150.00	106,650.00				0.00	0	0	177,750	Caissons
	4 Chain Anchors For Bottom Of Curtain	1,444	CY	250	E	1.786	2,579	80.6	56.00	144,400.00	150.00	216,600.00				0.00		0	361,000	Caissons
	Subtotal Concrete						6,070			339,900		509,850				0	0	0	849,750	
5	Metals																			
05050	Basic Materials & Methods																			
	Curtain Anchors																			
	4 Windward Main Anchor Frame	33,600	LBS	2.40	B	0.012	388	12.1	52.00	20,160.26	1.80	60,480.00				0.00		0	80,640	
	4 Leeward Anchor Frames	24,000	LBS	2.40	B	0.012	277	8.7	52.00	14,400.19	1.80	43,200.00				0.00		0	57,600	
	4 Chain Anchors (For BOC) Frames	65,000	LBS	1.80	B	0.012	750	23.4	52.00	38,999.99	1.20	78,000.00				0.00		0	117,000	
	4 Miscellaneous	23,800	LBS	3.20	B	0.015	366	11.4	52.00	19,040.01	2.40	57,120.00				0.00		0	76,160	
05100	Structural Metal Framing																			
	Bin Walls																			
	2 east and west walls	8,400	sf	29	A	0.060	502	7.9	55.00	27,636.00	24.00	201,600.00	1	1	192.58	12,095.56		0	241,332	
	2 Water Installation, Including Fill	1	LS	373,975	A	3,856	3,856	60.3	55.00	212,100.00		0.00	1	1	335.81	161,874.52	0	0	373,975	
	4 Curtain cables (Galv.)																			
	4 Windward Main Anch. To Stabilizing Buoy, 1-1/4" Dia.	5,250	ft	15.63	D	0.070	368	5.7	52.88	19,431.56	11.90	62,475.00	3	0	96.65	138.97		0	82,046	

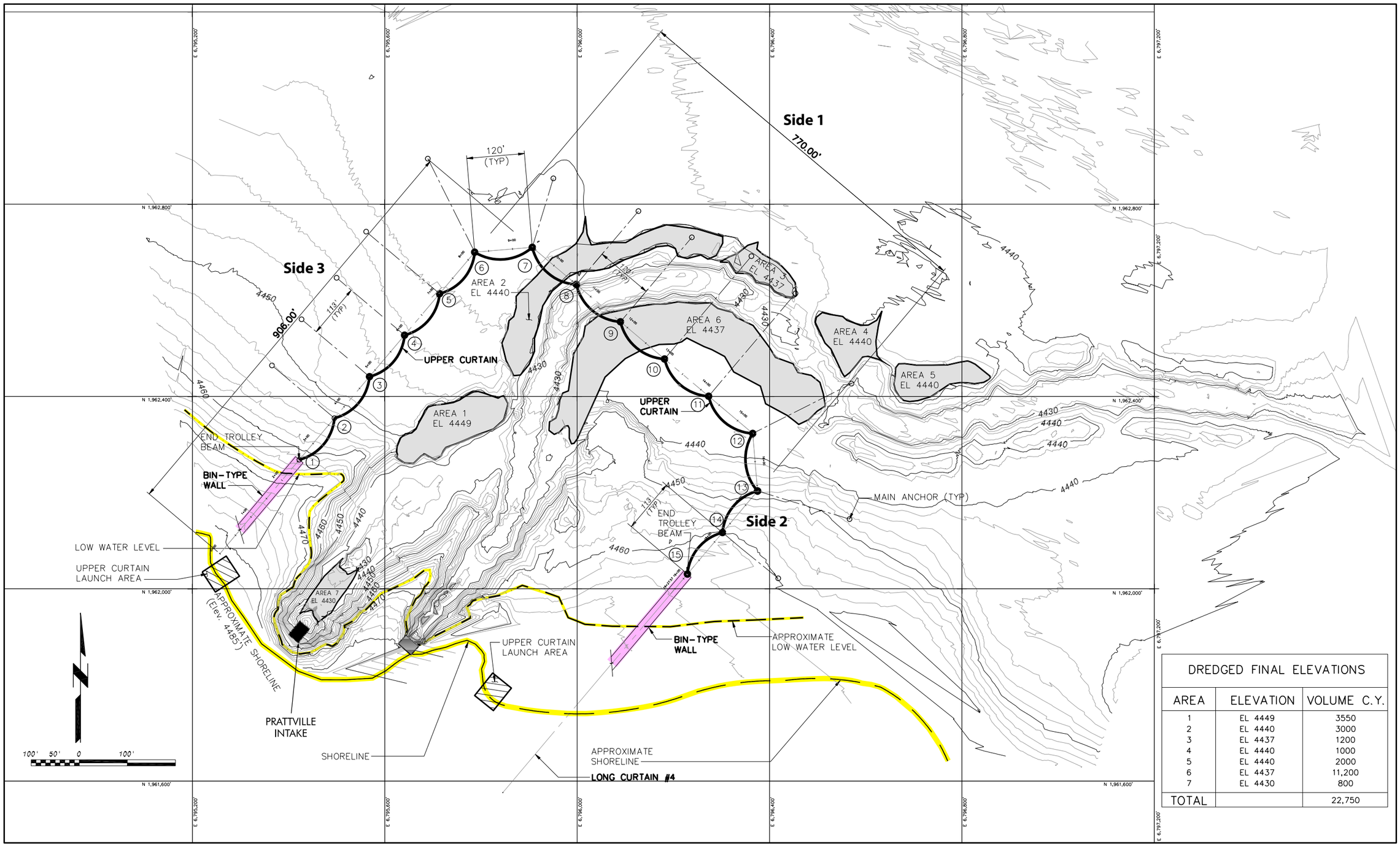
Black and Veatch Opinion of Cost of Prattville Intake Thermal Curtain #4 (2004b)
(Continued)

					Labor						Material		Equipment							
CSI Div. / Sect.	DESCRIPTION	Quantity	Unit	Unit Cost	Crew Code	M-H per Unit	Man Hours	Duration Days	Avg. Wage Rate	Labor Cost	Unit Cost	Material Cost	Code	No.	Avg. Cost ($/hr)	Equipment Cost	Sub-contract	Other	Total Cost	Remarks
	4 Leeward Main Anch. To Stabilizing Buoy, 1-1/8" Dia.	4,200	ft	12.78	D	0.056	235	3.7	52.88	12,436.20	9.80	41,160.00	3	0	96.65	88.94		0	53,685	
	4 Windward Main Anch. To Bottom Tanks, 7/8" Dia.	4,200	ft	8.31	D	0.033	139	2.2	52.88	7,328.48	6.55	27,510.00	3	0	96.65	52.41		0	34,891	
	4 Leeward Main Anch. To Bottom Tanks, 1" Dia.	3,150	ft	10.40	D	0.046	145	2.3	52.88	7,661.59	7.95	25,042.50	3	0	96.65	54.80		0	32,759	
	Curtain chains (1" Extra Strength Galv.)																			
	4 Windward Stabilizing Buoy To Top Tanks	1,050	ft	29.61	D	0.154	162	2.5	52.88	8,557.49	21.41	22,480.50	3	0	96.65	53.30		0	31,091	
	4 Leeward Stabilizing Buoy To Top Tanks	1,050	ft	29.61	D	0.154	162	2.5	52.88	8,557.49	21.41	22,480.50	3	0	96.65	53.30		0	31,091	
	4 Between Top Tanks	390	ft	29.61	D	0.154	60	0.9	52.88	3,178.50	21.41	8,349.90	3	0	96.65	19.80		0	11,548	
	4 Between Bottom Tanks	195	ft	29.61	D	0.154	30	0.5	52.88	1,589.25	21.41	4,174.95	3	0	96.65	9.90		0	5,774	
	4 Anchors To Bottom Tanks	1,950	ft	29.61	D	0.154	301	4.7	52.88	15,892.49	21.41	41,749.50	3	0	96.65	98.05		0	57,740	
	4 Ropes (3/4" Polyester)																			
	4 Top Of Curtain	1,750	ft	2.16	D	0.017	30	0.5	52.88	1,573.03	1.25	2,187.50	3	0	96.65	11.25		0	3,772	
	4 Bottom Of Curtain	1,750	ft	2.16	D	0.017	30	0.5	52.88	1,573.03	1.25	2,187.50	3	0	96.65	11.25		0	3,772	
	Floatable Tanks																			
	4 Top Of Curtain - 15' Long	132	LS	3,186	D	0.000	0	0.0	52.88	0.00	3,186	420,495.54	3		96.65	0.00		0	420,496	
	4 Bottom Of Curtain - 30' Long	66	LS	5,734	D	0.000	0	0.0	52.88	0.00	5,734	378,445.98	3		96.65	0.00		0	378,446	
	Stabilizing buoys																			
	4 Windward Stabilizing Buoys	21	ea	3,290	D	0.000	0	0.0	52.88	0.00	3,136.00	65,856.00	3		96.65	0.00		3,231	69,087	
	4 Leeward Stabilizing Buoys	21	ea	3,290	D	0.000	0	0.0	52.88	0.00	3,136.00	65,856.00	3		96.65	0.00		3,231	69,087	
	2 Trolley Beams At Ends Of Bin Wall	2	ea	17,320	D	6.998	14	0.2	52.88	740.00	13,800.00	27,600.00	1	1	742.85	1,299.55	5,000	0	34,640	
	2 Duct Pipe At Ends of Bin Wall	2	ea	4,420	D	6.998	14	0.2	52.88	740.00	900.00	1,800.00	1	1	742.85	1,299.55	5,000	0	8,840	
	Subtotal Metals						7,828			421,596		1,660,251				177,161	10,000	6,462	2,275,470	
8	Doors																			
089xx	4 Curtain Wall																			
	Hypalon Or XR-5 Curtain (60 mils)	108,000	SF	6.24	G	0.046	5,020	62.7	49.20	246,960.19	2.15	232,200.00	5	4	96.75	194,250.02		1,000	674,410	
	Subtotal Doors						5,020			246,960		232,200				194,250	0	1,000	674,410	
10	Specialties																			
	4 Cable Break Warning Buoys - foam	84	EA	100.00	F	0.000	0	0.0	51.75	0.00	100.00	8,400.00			0.00	0.00		0	8,400	
	4 Marine Warning And Signs Around Curtain	1	LS	12,560.00	F	0.000	0	0.0	51.75	0.00	12,560.00	12,560.00			0.00	0.00		0	12,560	
	Subtotal Specialties						0			0		20,960				0	0	0	20,960	
16	Electrical																			
	4 Off Shore Temporary Floating Lighting	1	LS	36,381				0.0		0.00		0.00			0.00	0.00	36,381		36,381	Subcontract Furnish and Install
	1 On Shore Temporary Lighting	1	LS	29,191				0.0		0.00		0.00			0.00	0.00	29,191		29,191	Subcontract Furnish and Install
	Subtotal Electrical						0			0		0				0	65,572	0	65,572	
17	Instrumentation																			
	4 Trash rack blockage warning system	1	EA	5,000	F	0.000	0	0.0	51.75	0.00	0.00	0.00	4	2	81.29	5,000.00		0	5,000	
	Subtotal Instrumentation						0	0		0		0				5,000	0	0	5,000	
	Construction Subtotal (Direct Costs)						39,872			2,096,725		2,777,542				829,193	941,220	1,423,236	**8,067,916**	

Indirect Costs			
Sales Tax	8%	of purchased materials	222,203
Overhead and Profit	20%	of construction cost + general requirements	1,613,583
Bonds and Insurance	4%	of construction cost + general requirements + sales tax + overhead and profit	396,148
Escalation	8%	of construction cost	645,433
Contingency	35%	of construction cost + general conditions + sales tax + overhead and profit + bonds and insurance + escalation	3,830,849
Construction Subtotal Indirects			**6,708,217**
Total Construction (directs and Indirects)			**14,776,133**
Permits			50,000
Design	10%	of construction cost	1,477,613
Construction Management	10%	of construction cost	1,477,613
Total			**17,781,359**



General Location Map of Prattville Intake Thermal Curtain

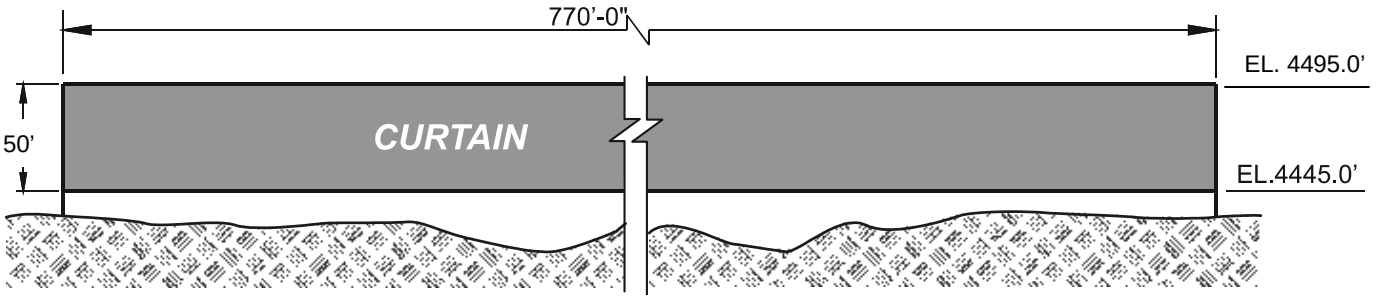


DREDGED FINAL ELEVATIONS		
AREA	ELEVATION	VOLUME C.Y.
1	EL 4449	3550
2	EL 4440	3000
3	EL 4437	1200
4	EL 4440	1000
5	EL 4440	2000
6	EL 4437	11,200
7	EL 4430	800
TOTAL		22,750

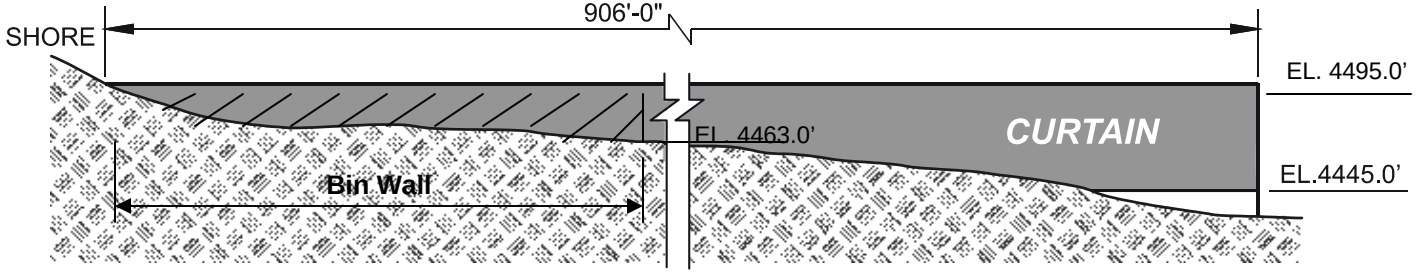
ELEVATIONS ARE PG&E DATUM

HORIZONTAL DATUM IS BASED ON THE CALIFORNIA STATE PLANE COORDINATE SYSTEM, ZONE 1 (NAD 1983)

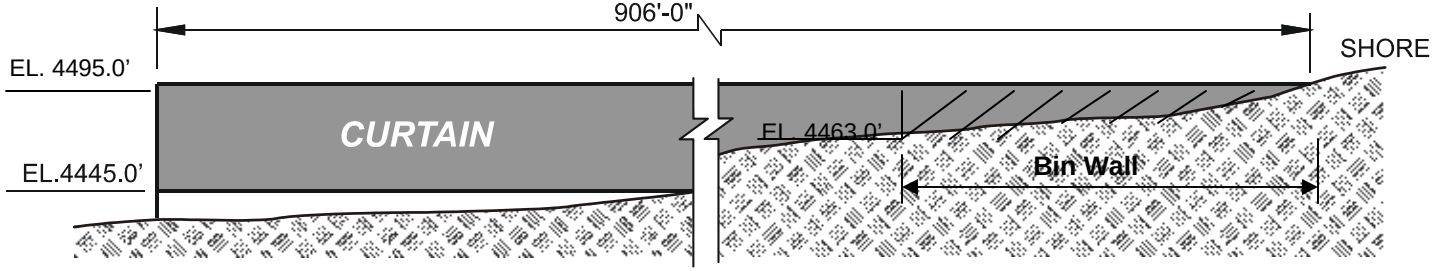
Plan View of Prattville Intake Thermal Curtain Site Layout



SIDE 1



SIDE 2



SIDE 3

Note: Bin walls extend from the shoreline to where the bottom of the lake is at el. 4463 ft (PG&E datum)

Elevation Views of Prattville Intake Thermal Curtain (Curtain #4)

(Adapted from Figure 7-8 of IIHR, 2004)

Measure Name: Caribou Intake Thermal Curtain

Applicable Alternative Category(s): 2b, 3, 4a

Description of Measure: Install a fixed Γ-shaped "long upper curtain" near the Caribou Intakes. The purpose of the thermal curtain is to create a barrier that prevents the flow of warm surface water into the intake. Warm water is retained behind the curtain while cool water is drawn from the lake bottom into the intake through the open area under the curtain. The Γ-shaped curtain does not affect flow to the spillway at Butt Valley Dam.

Description of Operations: This measure does not affect operations. Implement normal operations at Caribou Intakes and Caribou PHs.

Detailed Description of Facilities Improvements and Design Criteria:
To be effective, the curtain must be designed such that the velocities in the open area under the curtain are relatively low, in the range of 0.10 - 0.25 fps. This objective is achieved with a Hypalon fabric curtain approximately 1,960 ft long by 42 ft deep (total area = 63,000 sq ft) extending about 980 ft offshore from the high shoreline. The curtain is "fixed," meaning that as the reservoir level fluctuates the level of the lower lip of the curtain, which is set about 10 ft above the reservoir bottom, remains constant with respect to the reservoir bottom. In this way, the total open area under the curtain is maintained at the required 5,930 sq ft. Galvanized steel bin-type walls extend about 200 ft offshore from the shoreline and connect to the curtain endpoints.

List of Figures:
- General location map of Caribou Intake thermal curtain
- Plan view of Caribou Intake thermal curtain site layout
- Elevation views of Caribou Intake thermal curtain

Key Design or Construction Uncertainties Requiring Further Study:
- The Caribou Intake thermal curtain design is conceptual, particularly the curtain location and curtain depth. Further analysis is needed to develop details for the design and operation of the curtain, including physical prototype hydraulic testing and/or mathematical hydrodynamic modeling.

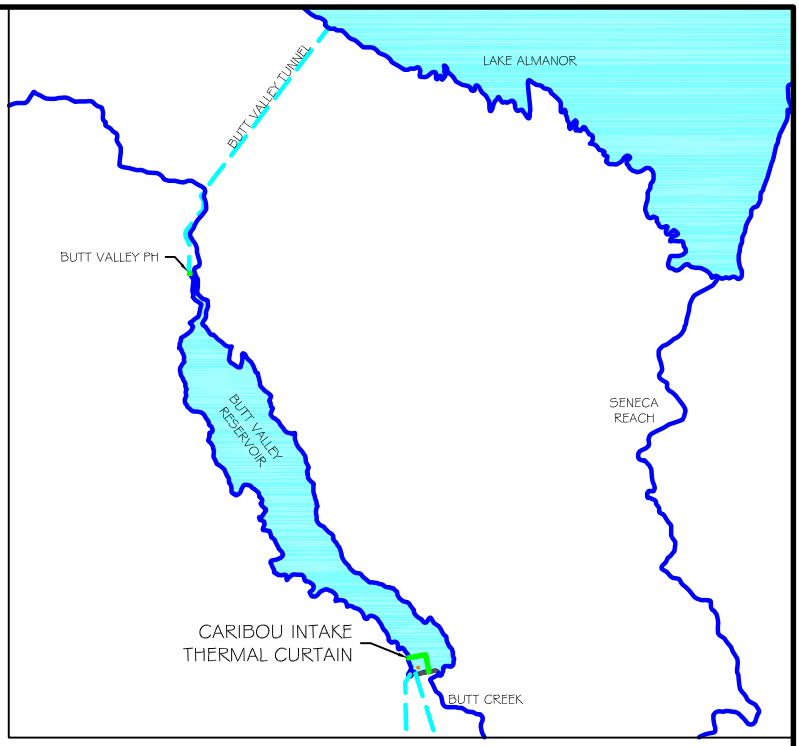
Discussion:
Butt Valley Reservoir has a storage capacity of 49,897 acre-feet. Water surface elevations fluctuate by about 10 to 15 feet from the maximum water surface elevation of 4,142 feet (USGS datum) on an annual basis. The reservoir serves as the afterbay to Butt Valley PH and the forebay for the Caribou No.1 and No. 2 PHs. Some additional flow enters Butt Valley Reservoir through Butt Creek and possibly through seepage. Water is delivered to the two Caribou powerhouses through two separate intake structures near Butt Valley Dam and there are no low-level outlets constructed at the dam. The Caribou No. 1 Intake is located at an invert elevation of 4,077 feet (USGS datum) in Butt Valley Reservoir and delivers up to 1,100 cfs to the Caribou #1 PH. The Caribou No. 2 Intake is located in a shallow cove area with an entrance elevation of 4,110 feet (USGS datum)

and normally delivers up to 1,460 cfs to the Caribou No. 2 PH. Both Caribou No. 1 and No. 2 PHs discharge to Belden Reservoir located in the NFFR approximately 10 river miles downstream of Canyon Dam Outlet. Caribou No. 2 PH is a preferred generating PH because it has higher turbine efficiency than Caribou No. 1 PH by about 15%.

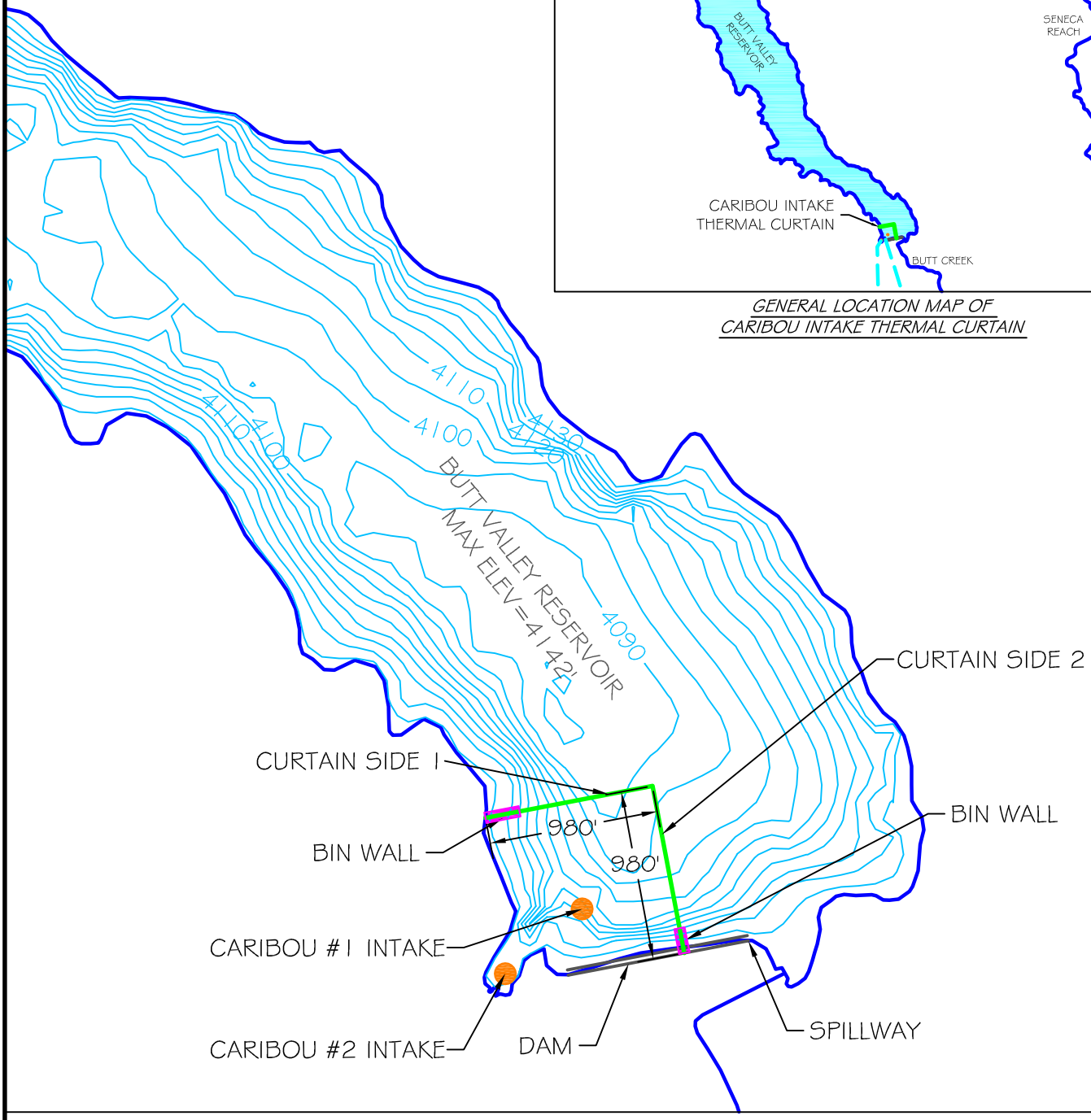
Historical water temperature measurements indicated that Caribou No. 1 Intake mainly draws cold hypolimnion water while Caribou No. 2 Intake mainly draws warm surface water. To cause Caribou No. 2 Intake to draw cold hypolimnion water, installing a thermal curtain is necessary. Bin-type walls would be constructed at the two ends of the curtain from the high water line to about 30 ft beyond the low water level to reduce localized damage to the curtain arising from water level fluctuations of the reservoir. When the water elevation is drawn down a significant amount of the curtain would be exposed making the curtain vulnerable to damage from vandalism, wind, and debris. At Whiskeytown the curtain tore at these locations, was vandalized, and was buried by sand preventing it from floating when the water rose. Similar to Black and Veatch's design for the Prattville Intake thermal curtain, a trolly system is proposed at the end of the bin walls. This system allows the top of the curtain to slide up and down as the water surface varies preventing stresses in the curtain. It prevents the curtain from being exposed and buried in the sand and discourages vandalism. This system also eliminates the periodic maintenance that may be necessary to free the curtain buried by sand and prevented from floating.

Cost Estimate of Caribou Intake Thermal Curtain

Item	Quantity	Unit	Unit Cost	Cost	Source
Basic Thermal Curtain System	1,960	LF	1,700	$3,332,000	Unit cost derived from Prattville Intake thermal curtain evaluation.
Bin Walls	1	LS	1,356,000	$1,356,000	Black &Veatch, 2004 index to 2007 by 7.6% increase
Scuba Diving	1	LS	689,000	$689,000	Black &Veatch, 2004 index to 2007 by 7.6% increase
Total				**$5,377,000**	



GENERAL LOCATION MAP OF CARIBOU INTAKE THERMAL CURTAIN



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PLAN VIEW OF CARIBOU INTAKE THERMAL CURTAIN SITE LAYOUT

SCALE (FEET)

0 450 900 1800

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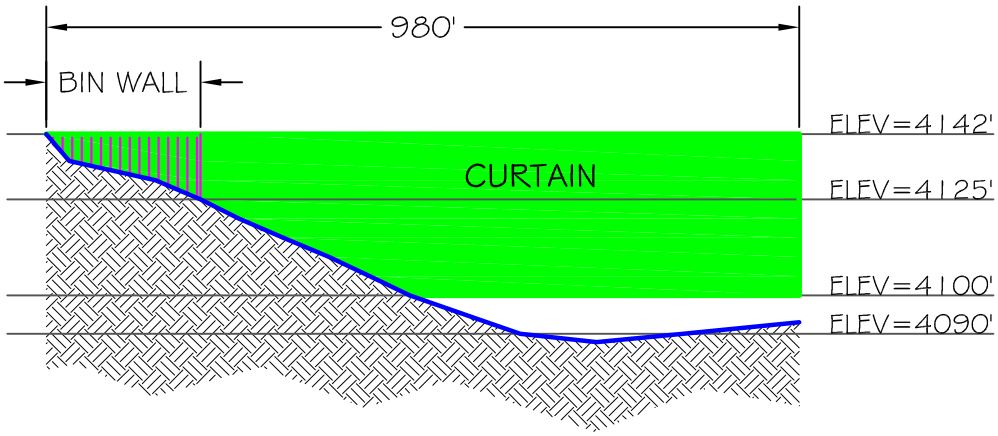
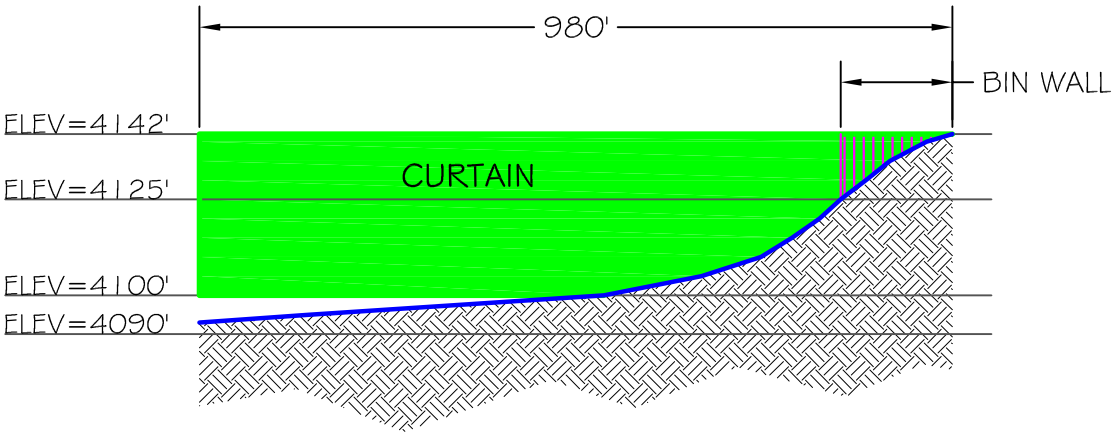


SIDE 1



SIDE 2

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ELEVATION VIEW OF CARIBOU INTAKE
THERMAL CURTAIN

F:\DATA\2125\CAD\Figures\Butt Valley Thermal Curtain.dwg ElevView

Measure Name: Belden PH Intake Thermal Curtain

Applicable Alternative Category(s): 5; additional measure for Belden Reach

Description of Measure: Install a fixed Γ-shaped "upper curtain" at the Belden PH Intake. The purpose of the thermal curtain is to allow the Belden PH Intake to draw cool water from the lower strata of Belden Reservoir to Belden PH for the purpose of reducing water temperatures in the downstream Rock Creek, Cresta, and Poe reaches, while maintaining sufficient cold water release to the Belden Reach from the low-level outlet of Belden Dam. The Γ-shaped curtain does not affect flow to the spillway at Belden Dam.

Description of Operations: This measure does not affect operations. Implement normal operations at Belden PH Intake and Belden PH.

Detailed Description of Facilities Improvements and Design Criteria:
To be effective, the curtain must be designed such that the velocities in the open area under the curtain are relatively low, in the range of 0.10 - 0.25 fps. This objective is achieved with a Hypalon fabric curtain approximately 780 ft long by 55 ft deep (total area = 36,710 sq ft) extending about 400 ft offshore from the high shoreline. The curtain is "fixed," meaning that as the reservoir level fluctuates the level of the lower lip of the curtain, which is set about 50 ft above the reservoir bottom, remains constant with respect to the reservoir bottom. In this way, the total open area under the curtain is maintained at the required 23,040 sq ft. Galvanized steel bin-type walls extend about 35-80 ft offshore from the shoreline and connect to the curtain endpoints.

List of Figures:
- General location map of Belden PH Intake thermal curtain
- Plan view of Belden PH Intake thermal curtain site layout
- Elevation views of Belden PH Intake thermal curtain

Key Design or Construction Uncertainties Requiring Further Study:
- The Belden PH Intake thermal curtain design is conceptual, particularly the curtain location and curtain depth. Further analysis is required to develop details for the design and operation of the curtain. In particular further analysis to evaluate the sustainability of routing cold water through the reservoir by balancing inflows relative to outflows will be required. Belden Reservoir outflows include (1) the instream flow released to the NFFR below Belden Dam, and (2) the power generation flow drawn through the Belden intake structure for delivery to Belden PH. The ability to sustain a thermally stratified condition created by the cold water plunging and routing through Belden Reservoir will be evaluated using modeling techniques.

Discussion:
Belden Reservoir has a maximum water surface elevation of 2,985 feet (USGS datum) and a theoretical usable storage capacity of 2,477 acre-feet. Under normal operations, the water surface elevation fluctuates between 2,960 and 2,973 feet, depending on power

operations. The average hydraulic residence time in Belden Reservoir is estimated at approximately 0.5 to 1.0 days. The principal sources of inflow to this small reservoir are the Caribou No. 1 and No. 2 PHs. Additional inflow is received from the Seneca Reach of the NFFR. The Belden PH Intake structure is located near the downstream end of the reservoir with an invert elevation at 2,942 ft (USGS datum). The intake can release up to 2,610 cfs to Belden PH which is located on Yellow Creek, immediately upstream of the confluence of Yellow Creek with the NFFR. Instream flow releases from the Belden Reservoir to the NFFR immediately downstream of the Belden Dam were made from the dam's low-level outlet at el. 2,877 ft (USGS datum) to Oak Flat PH.

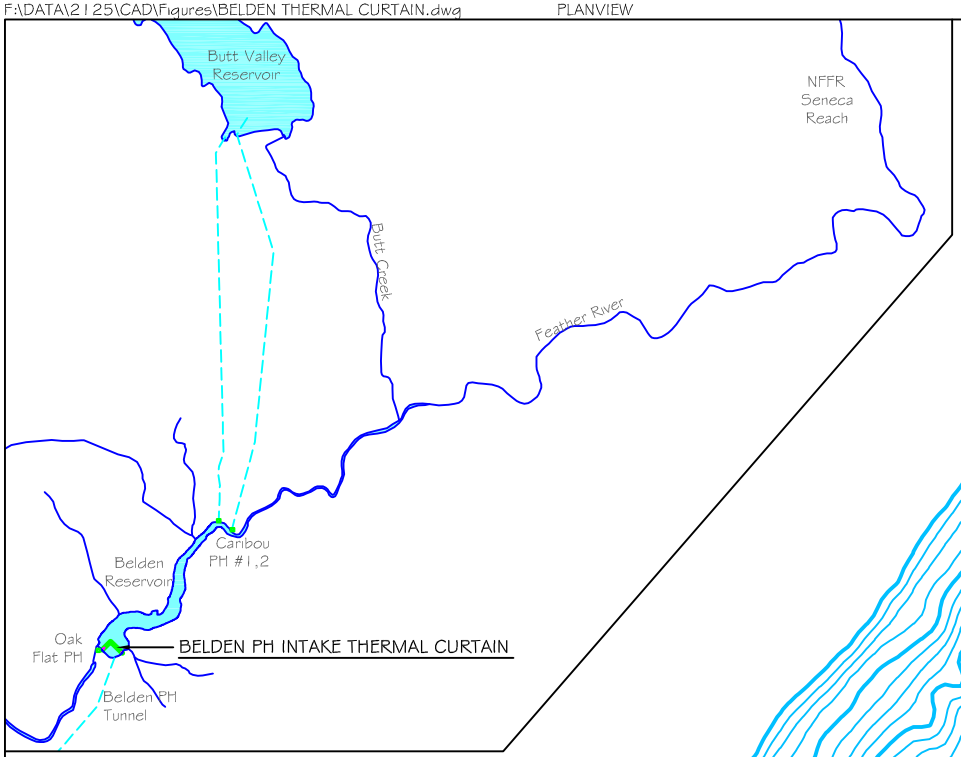
Historical water temperature measurements indicate that the low-level outlet draws cool bottom water of the reservoir and the Belden PH Intake draws warm surface water of the reservoir. That the Belden PH Intake draws warm surface water of the reservoir was clearly demonstrated in the 2006 special test (Stetson and PG&E 2007) that the Belden PH Intake did not access the cold water pool even though there was a strong reservoir stratification created during the test: 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. A measure that would cause the Belden PH Intake to draw from the deeper cold water pool would be an effective way to reduce water temperatures in the downstream reaches.

To reduce localized damage to the curtain arising from large water level fluctuations of the reservoir, bin-type walls would be constructed at the two ends of the curtain from the high water line to about 20 ft beyond the low water line. When the water elevation is drawn down a significant amount of the curtain would be exposed making the curtain vulnerable to damage from vandalism, wind, and debris. At Whiskeytown the curtain tore at these locations, was vandalized, and was buried by sand preventing it from floating when the water rose. Similar to Black and Veatch's design for the Prattville Intake thermal curtain, a trolly system is proposed at the end of the bin walls. This system allows the top of the curtain to slide up and down as the water surface varies preventing stresses in the curtain. It prevents the curtain from being exposed and buried in the sand and discourages vandalism. This system also eliminates the periodic maintenance that may be necessary to free the curtain buried by sand and prevented from floating.

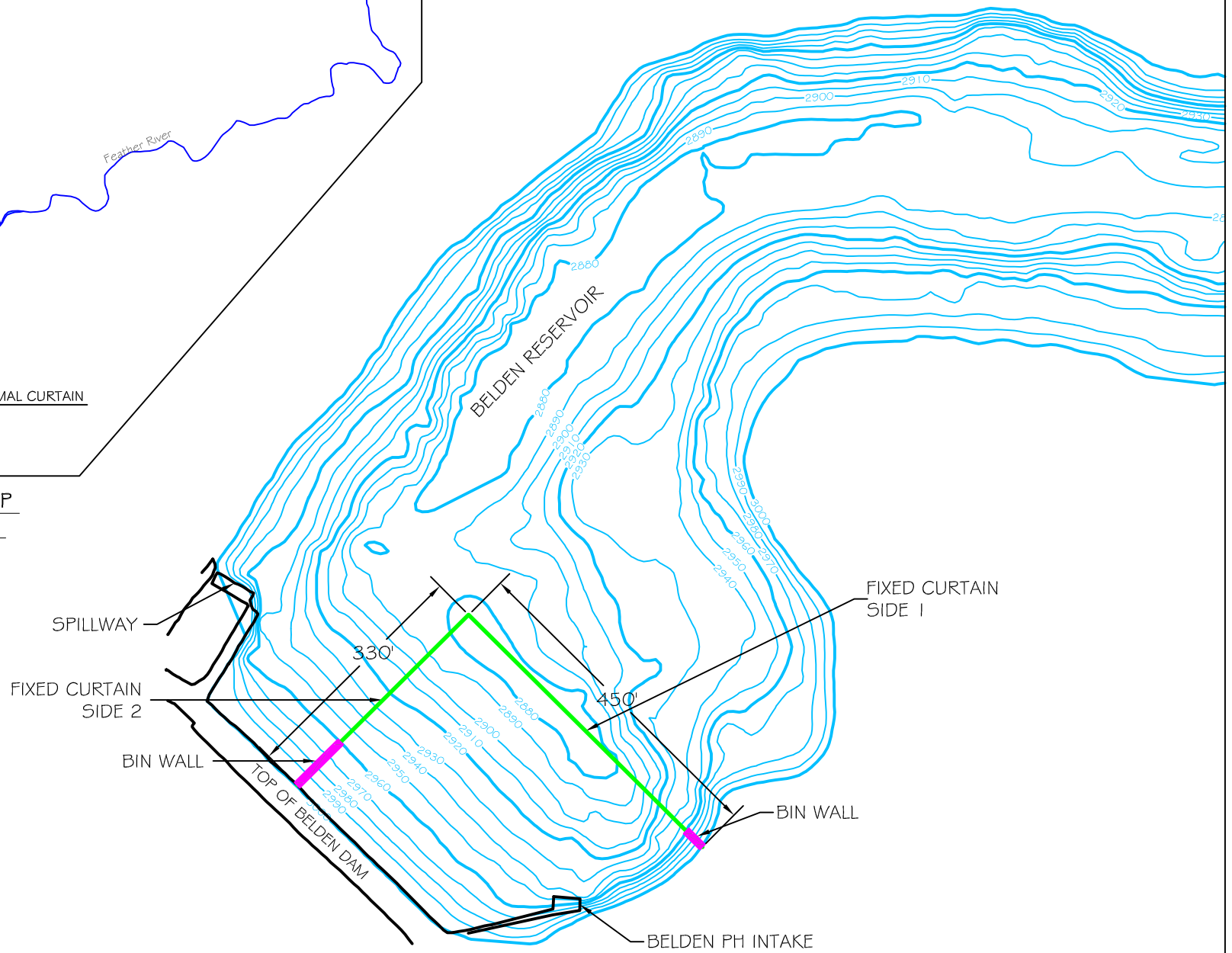
Cost Estimate of Belden PH Intake Thermal Curtain

Item	Quantity	Unit	Unit Cost	Cost	Source
Basic Thermal Curtain System	780	LF	1,700	$1,326,000	Unit cost derived from Prattville Intake thermal curtain evaluation.
Bin Walls	1	LS	1,356,000	$1,356,000	Black &Veatch, 2004 index to 2007 by 7.6% increase
Scuba Diving	1	LS	689,000	$689,000	Black &Veatch, 2004 index to 2007 by 7.6% increase
Total				**$3,371,000**	

F:\DATA\2125\CAD\Figures\BELDEN THERMAL CURTAIN.dwg PLANVIEW



GENERAL LOCATION MAP OF BELDEN PH INTAKE THERMAL CURTAIN



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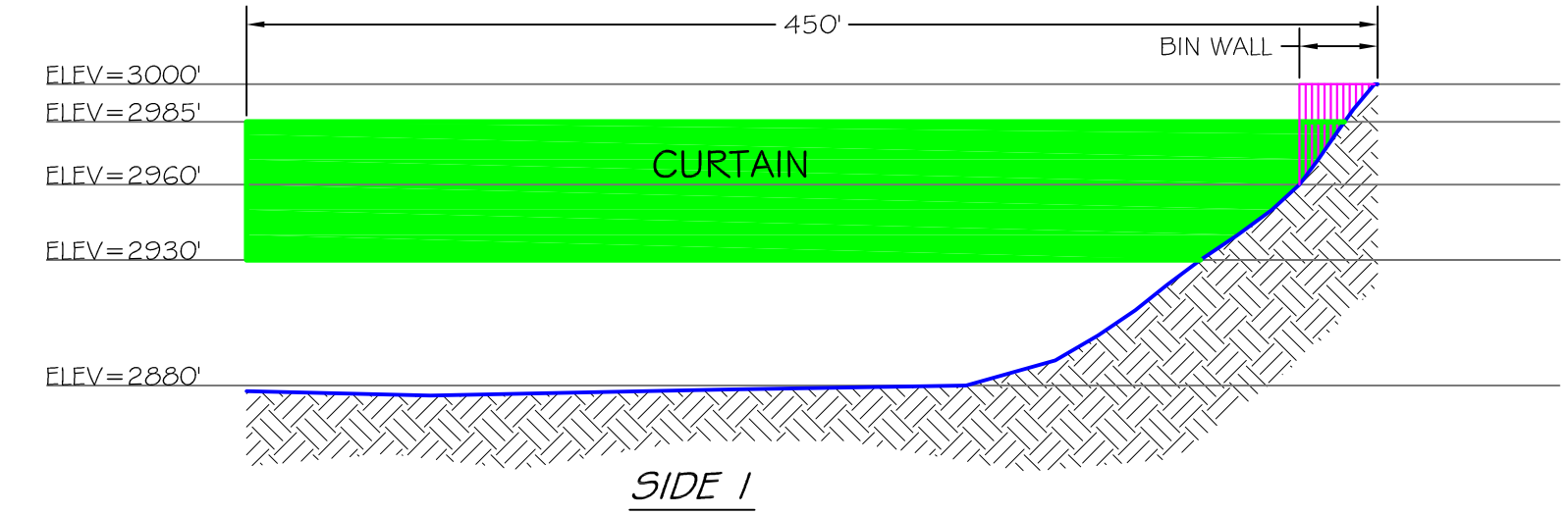
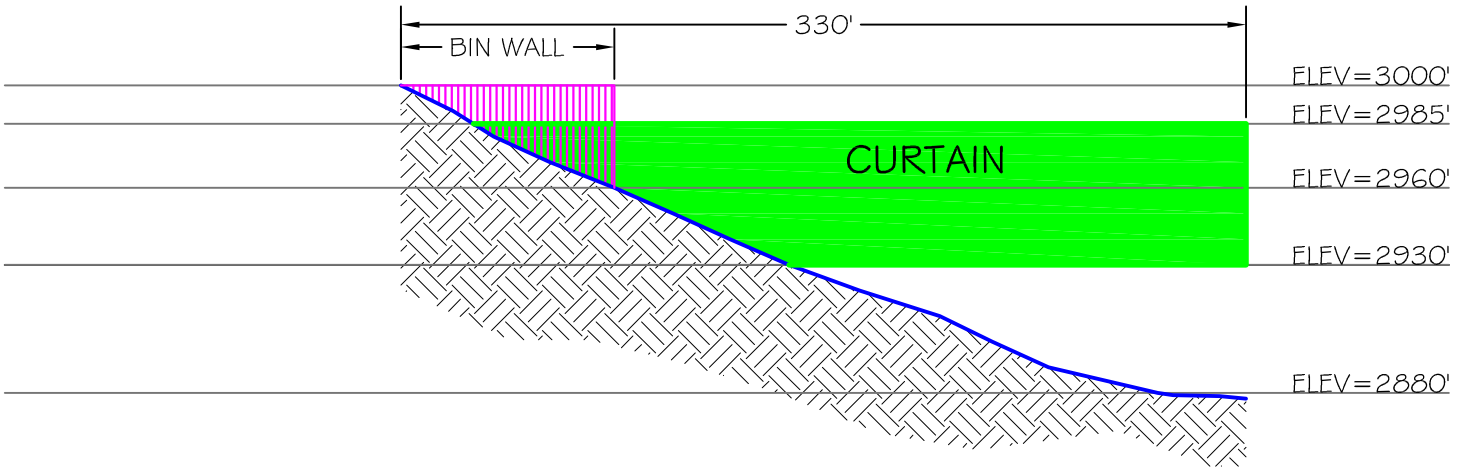
PLAN VIEW OF BELDEN PH INTAKE THERMAL CURTAIN

SCALE (FEET)

0 100 200 400



SIDE 1



SIDE 2

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ELEVATION VIEW OF BELDEN PH THERMAL CURTAIN

SCALE (FEET)

0 75 150

Measure Name: Modify/Repair Canyon Dam Low-Level Outlet and Increase Release

Applicable Alternative Category(s): 2c, 3, 4c, 5a, 5b, 5c, 6a

Description of Measure: Modify/repair the Canyon Dam low-level outlet and increase cool water release from the low-level outlet as needed during the summer. At present, the low-level outlet can safely release up to only 73 cfs. The purpose of this measure is to increase the cool water release from the hypolimnion of Lake Almanor to the NFFR.

Description of Operations: Depending upon the alternative, the release rate of the Canyon Dam low-level outlet ranges from about 90 cfs to 600 cfs. The maximum allowable discharge to avoid potential adverse impacts arising from velocity and scour to aquatic habitat along the Seneca Reach is estimated at about 700 cfs [3]. Increasing Canyon Dam release would require decreasing Prattville Intake release commensurately to avoid lake level fluctuation or changes from the operating rules agreed to in the Partial Settlement Agreement.

High release from the Canyon Dam low-level outlet would cause hydropower generation loss. The feasibility of hydropower generation to recover the foregone power by constructing a powerhouse below Canyon Dam will be investigated further in Level 3.

Detailed Description of Facilities Improvements and Design Criteria:
Modify and repair two (Gates #1 and #5) of the three low level outlets by connecting two pre-fabricated steel bulkheads with built-in slide gates to the existing outlets to enable controllable releases up to 600 cfs. Modifying and repairing Gate #1 only can release up to about 340 cfs.

List of Figures:

- Location map of Canyon Dam
- Flow Improvement Modifications/ Plan & Sections/ Canyon Dam Intake Tower

Key Design or Construction Uncertainties Requiring Further Study:

- There are concerns about vibrations during high discharges which require further study.

[3] At 700 cfs, the river stage is approximately at bankfull in the lower half of the Seneca reach near the Seneca Resort and China Bar areas. Flows exceeding about 700 cfs result in over bank flows in this reach (PG&E 2002), which would, therefore, be avoided. Flows between 600 and 700 cfs begin to mobilize spawning gravel and flows greater than 700 cfs can result in significant movement of streambed materials in the Seneca reach (PG&E 2002). Since most trout spawning and egg incubation is completed by July (PG&E 2002), any minor movement of gravel at flows as high as 700 cfs would not disturb fish nests. Habitat area for adult trout increases with flow to near a maximum between 300 and 800 cfs, but it gradually decreases for rearing juvenile trout from a maximum habitat area at about 50 cfs to about 70% of the maximum at 700 cfs (PG&E 2002). However, juvenile trout rearing habitat provided at a flow of 700 cfs would result in about 80% of that provided by the FERC-recommended minimum stream flows during the same season (13,000 ft^2/1000 ft vs. 16,000 ft^2/1000 ft) (PG&E 2002). Although some variable decrease in juvenile rearing habitat area could occur during periods when river temperature management would be needed, it is not likely to limit trout production (Source: Keith. Marine, Fisheries Scientist, NSR, June 8, 2007). This estimate of the maximum allowable discharge will be re-examined in Level 3.

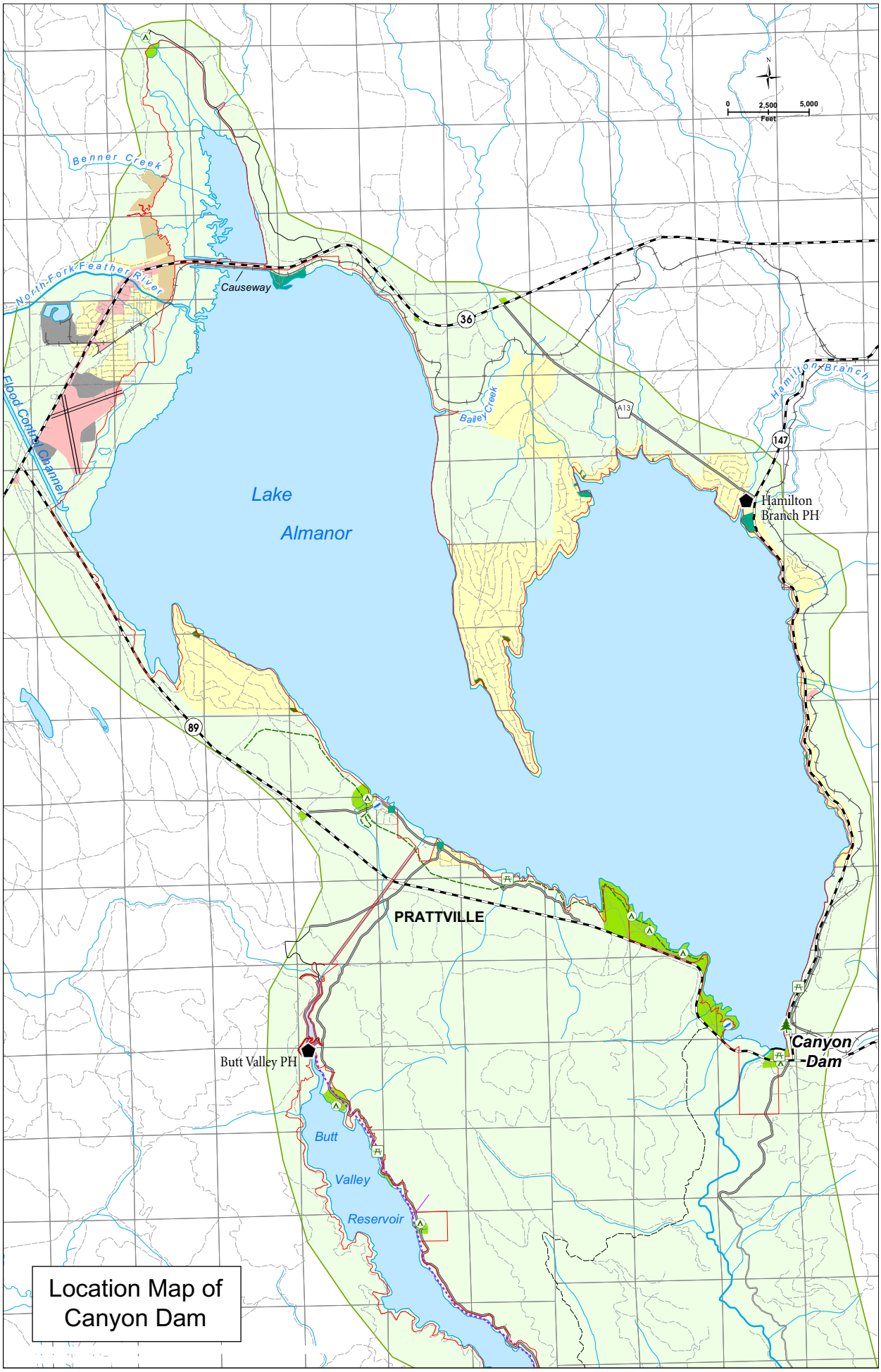
- The design used the normal maximum water surface elevation of Lake Almanor as the basis for providing up to 600 cfs flows when all low-level gates and valves are opened. Actual flows through each gate or valve needs to be determined using field data and shop testing prior to installation.
- The required number of gages and valves depend on the required release rate from the low-level outlet which will be studied further in Level 3.

Discussion:
The Canyon Dam Intake Tower has three low level outlets gates – Gates #1, #3, #5 – all are set at elevation 4432 ft, about 72 ft below the maximum lake level elevation of 4504 ft USGS datum[4]. 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 bad gate-stems, gate connections, and bolts. In August-October 2005 did repair work on Gate #5 and rehabilitated the gate and gate-stem connection at a cost of about $860,000. 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.

The needed modification and repair work to Gates #1 and #5 is depicted in preliminary design drawings prepared by Black and Veatch. PG&E estimates the cost to complete the work at about $10 million per gate, for a total cost for both gates of about $20 million. This estimate is based in large part on actual costs incurred in the repair of Gate #5.

To comply with FERC requirements, PG&E is currently investigating the need for additional modifications and repairs to the overall Canyon Dam Outlet Tower and Tunnel Works to address concerns about vibrations during high discharges and outlet capacity limitations. It may be possible to incorporate the modification and repair work to Gates #1 and #5 described herein into this overall workplan.

[4] There are two additional gates that are set even lower, Gates #2 and #4, at el. 4410. But these two gates are buried under about 20 ft of sediment and are considered unrepairable and permanently inoperable.



Location Map of Canyon Dam

Intentionally Not Shown:

Figure of Flow Improvement Modifications/Plan and Sections/Canyon Dam Intake Tower

Measure Name: Convey Butt Valley PH Discharge through Butt Valley Reservoir by a Submerged (Dredged) Channel to an Endpoint near the Caribou Intakes

Applicable Alternative Category(s): 2c

Description of Measure: Dredge to enlarge the existing channel that is submerged along the bottom of Butt Valley Reservoir and extend it to an endpoint near the Caribou Intakes. The purpose of this measure is to reduce warming caused by mixing of cool Butt Valley PH discharge during its transport through Butt Valley Reservoir. The 2006 NFFR special test conducted by PG&E in Butt Valley Reservoir revealed the existence of a submerged channel along the bottom in the upper portion of the reservoir. During the special test, the cool discharge from Butt Valley PH was observed plunging to the reservoir bottom and moving mainly in the submerged channel along the bottom in the upper portion of the reservoir with minimal mixing with warm surface water of Butt Valley Reservoir. The submerged channel is shown in an aerial photo taken in 1997 when the reservoir was drawn down to enable work on the dam.

During the special test, some cool water was found to be flowing outside of the submerged channel, implying that the capacity of the channel was insufficient to convey the 500 cfs cool water discharge. In addition, the submerged channel was found to fade out and end about 6,600 ft downstream of the Butt Valley PH near Transect 5 as shown in attached figures. Downstream of this end point, the cool water was found to mix with warmer water in the reservoir which reduced the cool water inflow to the Caribou Intakes.

Description of Operations:
To draw cool water from the hypolimnion of Lake Almanor for transport to Butt Valley Reservoir, reduce Butt Valley PH discharges to about 500 cfs. This would necessitate commensurate reductions in the discharges for the Caribou PHs.

Detailed Description of Facilities Improvements and Design Criteria:
It is proposed that the existing bottom channel of Butt Valley Reservoir be extended along the lake bed by dredging to convey cold water releases from Butt Valley PH to the downstream section of the reservoir, near the Caribou Intakes. The cold water will flow in the dredged channel along the lake bed as a negatively-buoyant, density driven current.

During the 2006 NFFR special test when 500 cfs of cool water was discharged from Butt Valley PH the average velocity of the current observed flowing in the submerged channel was of 0.4 ft/s. To fully contain and convey the 500 cfs in the channel with minimal mixing, the dimensions of the channel need to be as given in the table below. Dredging is required to enlarge the existing channel and extend it a distance of approximately 16,800 ft to an endpoint near the Caribou Intakes. At this extended endpoint, the cool water could be drawn with minimal mixing into the Caribou #1 Intake.

Dimension	Value
Side slopes	3H:1V
Bottom width	60 ft
Top width	132 ft
Depth	12 ft [1]
Cross sectional area	1,152 ft

1) Based on the thickness of the cool water layer observed during the special test.

List of Figures:

- Butt Valley Reservoir Dredged Channel Alignment for Cold Water Deliver
- Historical Arial Photo Showing the Existing Channel in the Upper Portion of Butt Valley Reservoir

Key Design or Construction Uncertainties Requiring Further Study:

- The submerged tree trunks on the reservoir bed may make construction of the dredged channel difficult.
- The dredged conveyance channel at the bottom of Butt Valley Reservoir may slowly fill with sediment over time requiring future repeated dredging.

Discussion:

The required submerged channel dimensions and 16,800 ft extension to a new endpoint near the Caribou Intakes is estimated based on the best information available. The dimensions, extension distance and endpoint may be refined based on further analysis using physical prototype hydraulic modeling and/or mathematical hydrodynamic modeling. In particular, further analysis may reveal that the channel need extend only about 8,000 feet to an endpoint near the middle of the reservoir.

COST ESTIMATE FOR BUTT VALLEY RESERVOIR DIVERSION BY DREDGING A SUBMERGED CHANNEL					
ITEM	**QUANTITY**	**UNIT**	**UNIT COST**	**COST ($)**	**Source**
Mobilization/Demobilization of Equipment					
Mobilization/demobilization	1	LS	250,000	250,000	Based on actual CPEN Lake O'Neil project, CA - cost estimate for hydraulic dredging. See Note 1
Site Establishment					
Site Establishment	1	LS	15,000	15,000	Nominal cost
Dredging					
Dredge channel using barge mounted clamshell and dump in fill site or stockpile on bank	774,400	CY	13.04	10,101,270	Means, 2007 adj to Redding CA
Fill and Grade Camp Site Extension					
Spreading of dredged material using 300HP dozer, 300' haul, no compaction	387,200	CY	3.76	1,456,270	Means, 2007 adj to Redding CA
Camp Site Rehabilitation					
Hydro or air seeding, turf mix, with mulch and fertilizer	697	SF x 1,000	43.48	30,300	Means, 2007 adj to Redding CA
Resurface gravel road, 12' wide and apx 1000' long	12,000	SF	1.93	23,160	Means, 2007 adj to Redding CA
TOTAL				**$11,876,000**	

Notes:
Costs of geologic/geotechnical survey not included
Regional index = 108.7 for Redding
Mobilization of dredging equipment for CPEN Lake O'Neil project, CA quoted by Perry & Shaw Inc at $175,500. Approx $75,000 contingency included for remote location, road conditions etc.
No additional dewatering of dredged materials necessary if using a clamshell dredge and dumping onto transport barge.
Assume no rock to be excavated. Dredge to remove deposited sediment from remnant channel
Assume dredged material is suitable for fill and land reclamation and no imported material required.
Assume 1/2 of dredged material can be placed on fill site directly from barge. Area to be rehabilitated calculated assuming 15' thick fill layer
Water quality controls (silt curtains, etc) are not included
Landscaping and construction of camp facilities not included
CPEN: Camp Pendleton, CA

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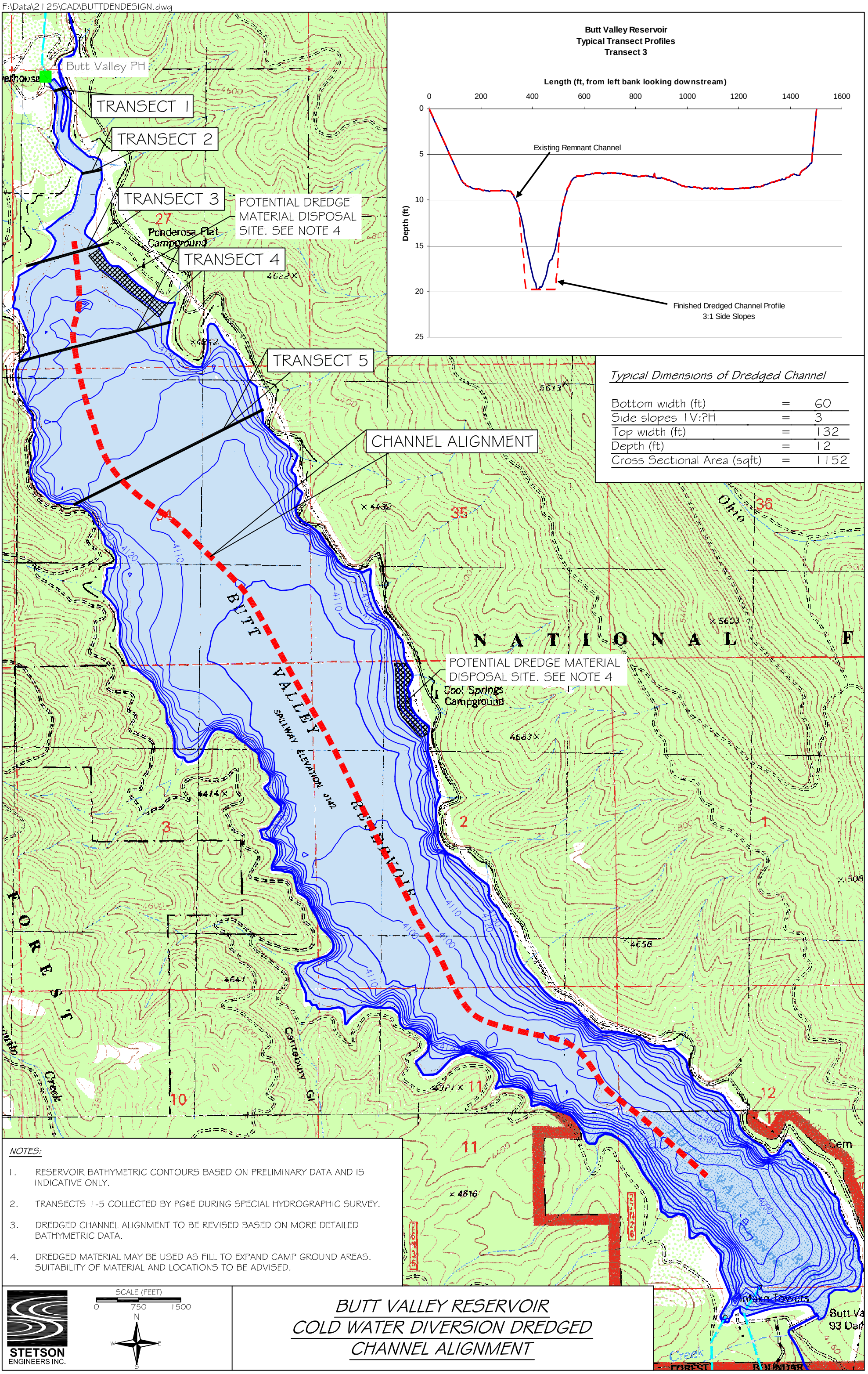

Butt Valley Reservoir
Typical Transect Profiles
Transect 3

Typical Dimensions of Dredged Channel

Bottom width (ft)	=	60
Side slopes 1V:?H	=	3
Top width (ft)	=	132
Depth (ft)	=	12
Cross Sectional Area (sqft)	=	1152

NOTES:

1. RESERVOIR BATHYMETRIC CONTOURS BASED ON PRELIMINARY DATA AND IS INDICATIVE ONLY.
2. TRANSECTS 1-5 COLLECTED BY PG&E DURING SPECIAL HYDROGRAPHIC SURVEY.
3. DREDGED CHANNEL ALIGNMENT TO BE REVISED BASED ON MORE DETAILED BATHYMETRIC DATA.
4. DREDGED MATERIAL MAY BE USED AS FILL TO EXPAND CAMP GROUND AREAS. SUITABILITY OF MATERIAL AND LOCATIONS TO BE ADVISED.

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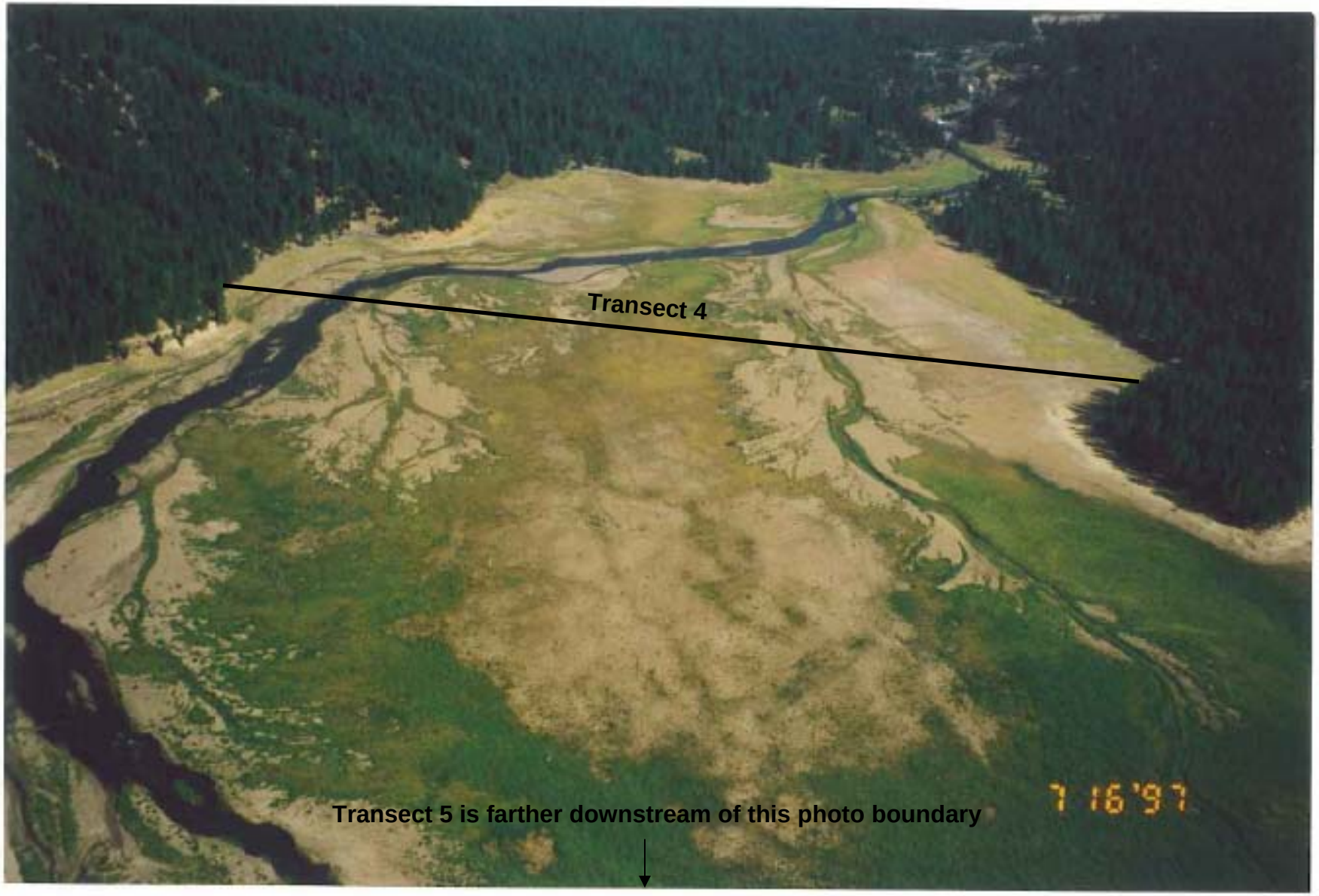
BUTT VALLEY RESERVOIR COLD WATER DIVERSION DREDGED CHANNEL ALIGNMENT



Historical Arial Photo showing the Existing Channel in the Upper Portion of Butt Valley Reservoir

Measure Name: Convey Butt Valley PH Discharge through Butt Valley Reservoir by Submerged Pipeline to an Endpoint near the Caribou Intakes

Applicable Alternative Category(s): 2a, 5c

Description of Measure: Construct an approximately five mile long submerged pipeline to convey Butt Valley PH discharge through Butt Valley Reservoir for submerged discharge near the Caribou Intakes. The purpose of this measure is to eliminate warming caused by mixing of cool Butt Valley PH discharge during its transport through Butt Valley Reservoir.

Description of Operations: This measure does not affect PH operations.

Detailed Description of Facilities Improvements and Design Criteria:
Discharge from Butt Valley PH is conveyed about 1,150 feet to a small regulating pond in three, side-by-side, 13' x 9.5' reinforced concrete box (RCB) conduits. Near the upstream end, about 100 cfs is released from one of the conduits to the existing discharge channel to maintain wetted conditions in the channel for aquatic habitat. From the regulating pond water is conveyed through seven, side-by-side, 72-inch HDPE pipes set and anchored on the reservoir bottom. The higher water level in the regulating pond (el. 4,170 ft in USGS datum) relative to the reservoir (normal maximum water level at 4,142 ft in USGS datum) forces the water through the pipes. The pipes extend about 5-miles to a submerged outlet near the Caribou Intakes. A fixed thermal curtain place in front of the Caribou Intakes causes cool water discharged from the outlet to be drawn to the intakes.

List of Figures:
- Plan view: Butt Valley PH to Caribou Intakes
- Profile: Butt Valley PH to Caribou Intakes

Key Design or Construction Uncertainties Requiring Further Study:
- Setting seven, 72-inch HDPE pipes along the bottom of Butt Valley Reservoir will 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 further study.
- Connecting three, side-by-side, 13' x 9.5' reinforced concrete boxes to the turbine discharge pipes of Butt Valley PH requires further study.

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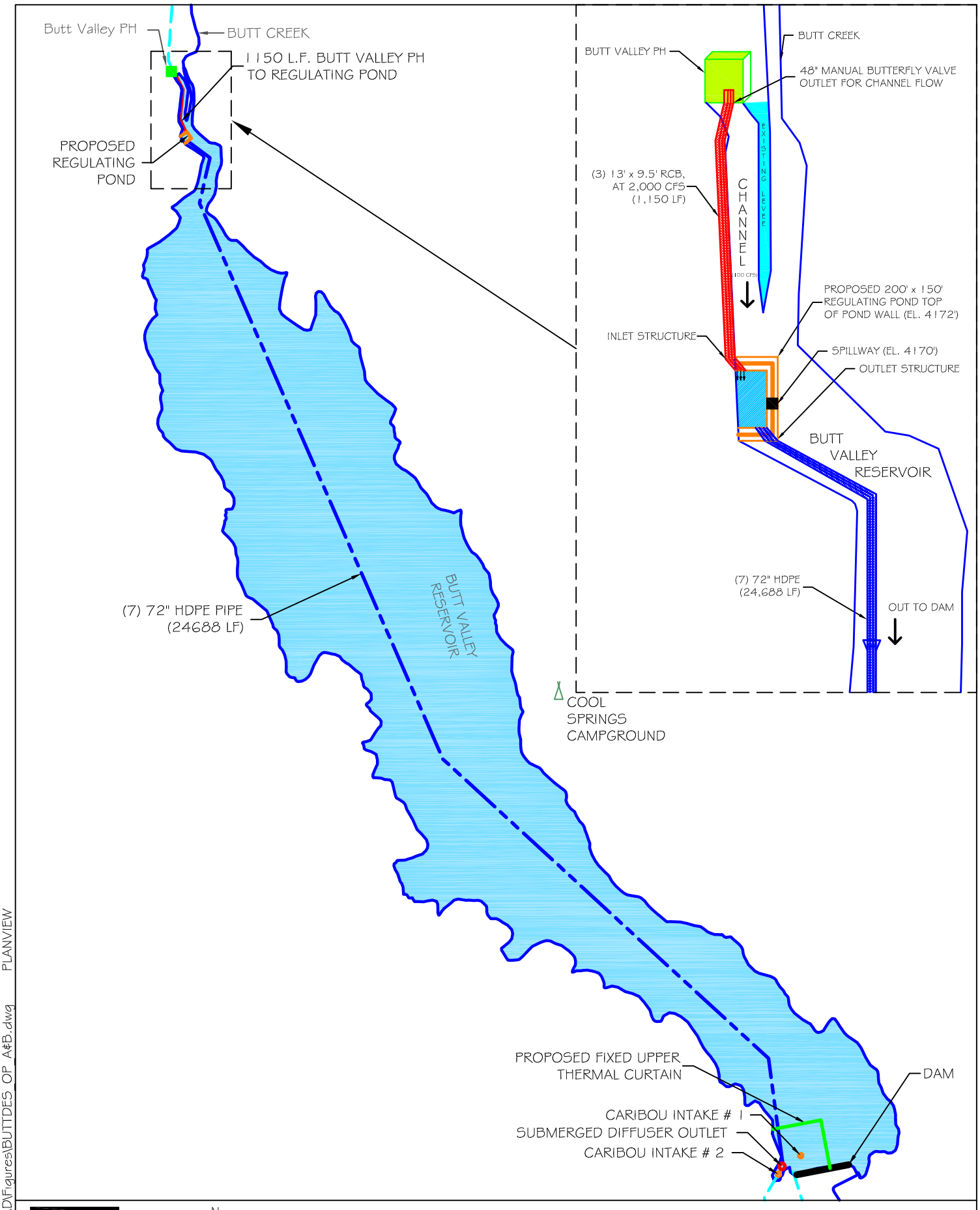
Discussion:
The location of the pipeline endpoint near the Caribou Intakes is estimated based on the best information available, and it may be refined based on further analysis using physical prototype hydraulic modeling and/or mathematical hydrodynamic modeling. In particular, further analysis may reveal that the pipeline need extend only about 8,000 feet to an endpoint near the middle of the reservoir.

COST ESTIMATE FOR BUTT VALLEY PH TO CARIBOU INTAKES 2,000 CFS				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
Bypass Conduit from Butt Valley PH to Proposed Detention Basin				
Triple, 13' x 9.5' Reinforced Concrete Box	1150	LF	2,115	2,432,250
Tie in Structure at Powerhouse	1	LS	15,000	$15,000
48-inch hydraulic operated butterfly valve for in channel low flow	1	LS	47,000	$47,000
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	9583	CY	12	$114,996
Backfill, 6" layers, roller compaction operator walking	23000	CY	44	$1,006,940
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	23000	CY	3	$69,690
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	7283	SY	120	$877,165
1/2 CY bucket wheel mounted front end loader, min haul	32583	CY	16	$517,744
Hauling, 20 mile round trip, 0.4 loads/ hr (Added 15% for Expansion)	15430	CY	27	$410,438
Sediment and Erosion Control (Silt Fence)	1150	LF	5	$5,819
		Sub total		**$5,497,000**
Detention Basin				
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	46602	CY	3	$141,204
Backfill, 6" layers, roller compaction operator walking	46602	CY	44	$2,040,236
Concrete bottom for detention basin	550	CY	1,800	$990,000
1/2 CY bucket wheel mounted front end loader, min haul	53592	CY	16	$851,577
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	53592	CY	27	$1,425,547
Outlet Structure	1	LS	50,000	$50,000
Inlet Structure	1	LS	100,000	$100,000
Hydroseeding	3600	SY	1	$3,600
Sediment and Erosion Control (Silt Fence)	500	LF	5	$2,530
		Sub total		**$5,605,000**
(7) 72" HDPE from Proposed Detention Basin to Plunging				
72-inch HDPE (Length Mult by 7)	172816	LF	425	$73,446,800
HDPE Pipe Placement, concrete weight collars / "Float Flood" method, Mechanical Crane, barge mounted	1	LS	4,400,000	$4,400,000
Underwater pipe laying preparation of reservoir bottom	1	LS	9,077,000	$9,077,000
Diffuser Outlet Structure	1	LS	50,000	$50,000
Attach 72" HDPE to diffuser structure and install pad / rock cover	1	LS	150,000	$150,000
Upper Thermal Curtain around both	1	LS	3,101,500	$3,101,500

Caribou Intakes				
		Sub total		**$90,225,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (1)	1	LS	600	$600
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger / Crane, barge mounted and all loading equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		**$233,000**
				$101,560,000



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BUTT VALLEY RESERVOIR
TO CARIBOU INTAKES PLUNGING

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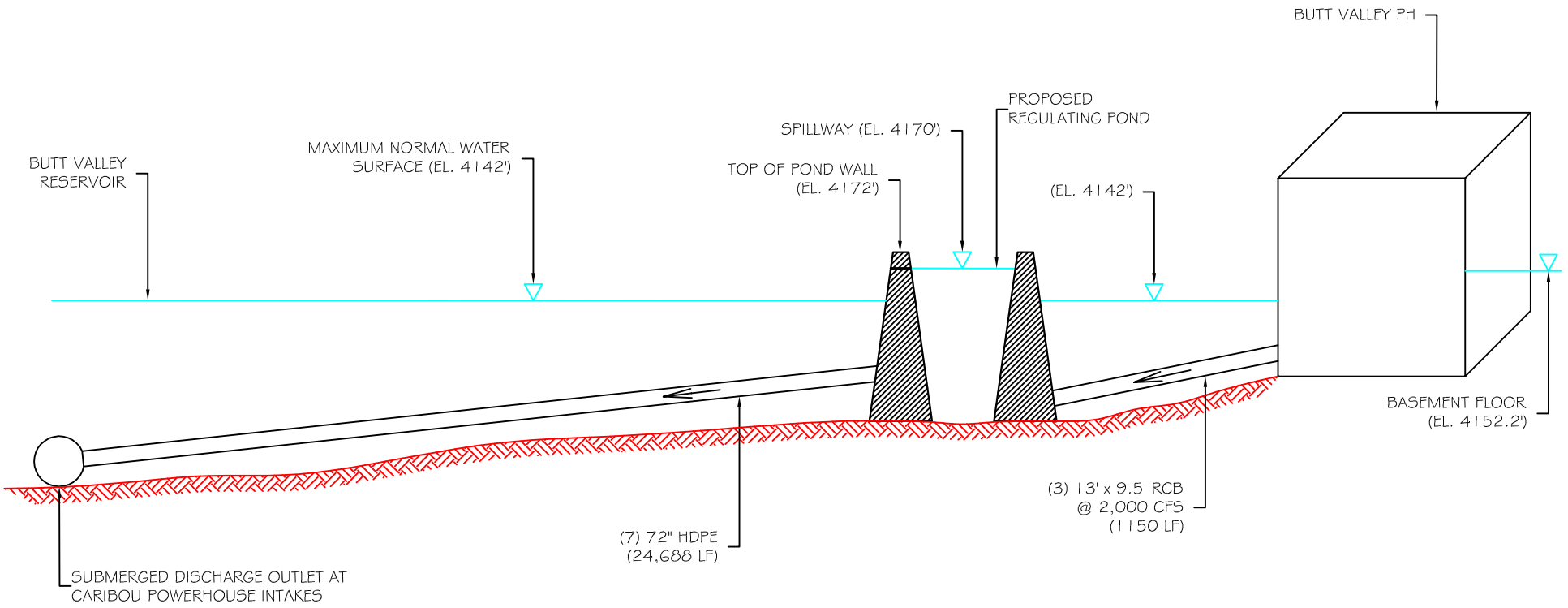

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BUTT VALLEY POWERHOUSE TO CARIBOU INTAKES

Measure Name: Divert Cool Seneca Reach Flows into a Submerged Pipeline to Discharge at an Appropriate Plunging Point in Belden Reservoir

Applicable Alternative Category(s): 5, 6; additional measure for Belden Reach

Description of Measure: Construct an approximately 1,900 ft long pipeline to convey cool Seneca Reach flows directly to a plunging location in Belden Reservoir, bypassing discharges from Caribou PHs No. 1 and 2. The purpose of this measure is to avoid mixing cool Seneca flows with warmer discharges from the Caribou PHs during operational hours and minimize mixing with warmer ambient waters near the surface of Belden Reservoir. Field observations in Belden Reservoir during the 2006 NFFR special test and preliminary reservoir hydrodynamic modeling by Stetson identified a plunging location downstream of which further mixing during transport along the bottom of the reservoir is minimal.

Description of Operations: This measure has no affect on PH operations. Operate the diversion system to convey about 250 cfs through the pipeline and spill the remaining flow over the dam. The diversion rate is supplied by the increased release measure from Canyon Dam low-level outlet. The flow accretion along the Seneca Reach, including inflows from lower Butt Creek, would maintain flows for aquatic habitat in the stream over the short distance between the diversion dam and the Caribou No. 1 discharge.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 7-foot high inflatable/deflatable rubber diversion dam at the lower end of Seneca Reach just upstream of Caribou PH No. 1. Except during summer, the rubber dam would remain in the deflated position. Construct an approximately 1,900 ft long pipeline to convey cool Seneca Reach flows captured behind the dam to a plunging location in Belden Reservoir.

The pipeline starts at the diversion dam and extends about 1,900 ft to a submerged diffuser at the bottom of Belden Reservoir. The first segment of the pipeline is about 400 feet long and consists of 72-inch reinforced concrete pipe (RCP) trenched into the river bank and covered with riprap. The second segment is about 180 feet long and consists of 72-inch Black Steel Pipe (BSP) which is connected to the face of Caribou PH #1, delivering flows to the northwest bank of the NFFR just upstream of Caribou PH #2. The third segment is about 360 ft long and consists of 72-inch RCP which is trenched along the toe of the north bank of the NFFR and protected with riprap. The fourth segment is about 400 feet and consists of 72-inch RCP which is buried along the shoulder of Caribou Road. The fifth and last segment is about 580 feet long and consists of 72-inch HPDE pipe that enters Belden Reservoir and is set on and anchored to the bottom of the reservoir for the remaining 580 feet. A submerged diffuser outlet is placed at the end of the pipeline to distribute the discharge in a larger cross sectional area for the purpose of reducing discharge velocity, turbulence, and mixing potential.

List of Figures:

- Plan view: NFFR / Lower Seneca Reach to Belden Reservoir Plunging.
- Profile: NFFR / Lower Seneca Reach to Belden Reservoir Plunging Outlet.

Key Design or Construction Uncertainties Requiring Further Study:

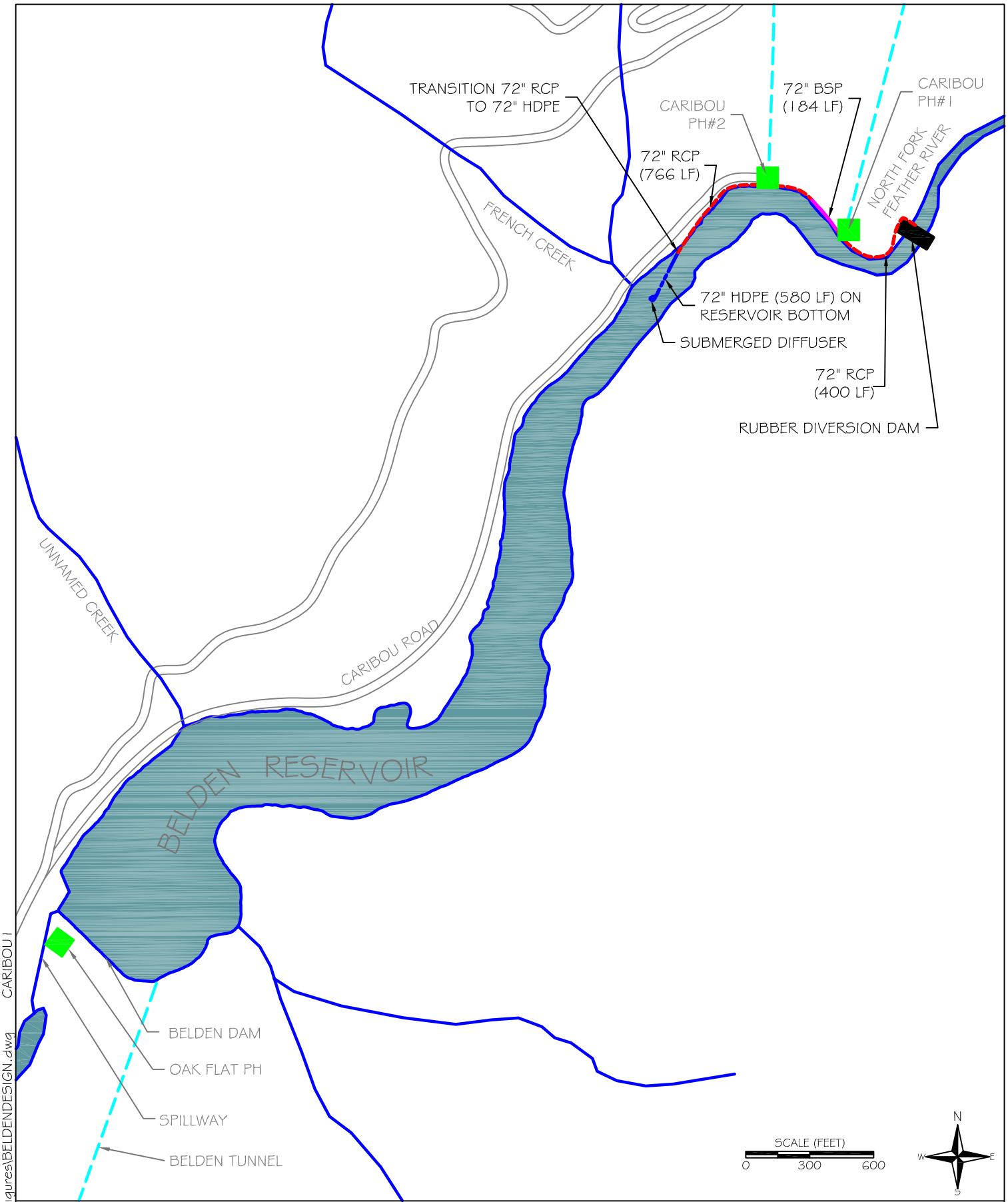
- Setting a 72-inch HDPE along the bottom of Belden Reservoir will be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires further study.
- Placing and connecting a 72-inch reinforced concrete or black steel pipe to the faces of both powerhouses will require blasting and difficult construction, which could be hazardous due to unstable slopes and recent landslides.
- Pipeline construction beside Caribou Road will require blasting, jack hammering work due to the existing conditions being steep rock cliffs near the powerhouses, which could be hazardous due to unstable slopes and recent landslides.

Discussion:

The design and cost estimate for this measure is based on a flow rate of 250 cfs. The flow rate may be refined based on further analysis using mathematical hydrodynamic modeling which could affect the design.

COST ESTIMATE FOR BYPASSING COOL SENECA REACH FLOWS TO 250 CFS FOR PLUNGING				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE AT CARIBOU PHS				
7' high and 39' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$1,940,000	$1,940,000
		Sub Total NF Feather River Dam		**$1,940,000**
60" RCP from Rubber Dam to Caribou PH #1				
60-inch Reinforced Concrete Pipe, Class 3	400	LF	279	$111,600
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	800	SY	120	$96,352
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	1363	CY	26	$34,934
Backfill, 6" layers, roller compaction operator walking	237	CY	44	$10,376
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	766	CY	3	$2,321
Pipe bedding, crushed rock, 1/2" to 3/4"	529	CY	48	$25,540
1/2 CY bucket wheel mounted front end loader, min haul	1090	CY	16	$17,320
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	1090	CY	27	$28,994
Sediment and Erosion Control (Silt Fence)	400	LF	5	$2,024
		Sub total		**$329,000**
60" Black Steel Pipe along Concrete Face of Caribou PH #1				
60" black steel pipe	184	LF	572	$105,248
Drill concrete anchor bolts	184	LF	29	$5,268
Install concrete anchor bolts	184	LF	25	$4,659
Drill & Blast restricted areas	109	CY	214	$23,326
1/2 CY bucket wheel mounted front end loader, min haul	125	CY	16	$1,986
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	125	CY	27	$3,325
Anchor rings	4	EACH	800	$3,200
Precast Storm Drain Manhole, 6' I.D., 8' Deep	2	EACH	4,300	$8,600
		Sub total		**$156,000**
60" RCP from Concrete Face of Caribou PH #1 to N Fork Feather River / Toe of Caribou Road				
60-inch Reinforced Concrete Pipe, Class 3	366	LF	279	$102,114
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	682	CY	3	$2,066
Backfill, 6" layers, roller compaction operator walking	198	CY	44	$8,668
Pipe bedding, crushed rock, 1/2" to 3/4"	484	CY	48	$23,368
Remove (load) small boulders (under 1/2 CY)	347	CY	17	$6,062
Replace (load) small boulders (under 1/2 CY)	347	CY	17	$6,062
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	597	CY	26	$15,301
Drill & Blast in restricted areas	596	CY	214	$127,544
1/2 CY bucket wheel mounted front end loader, min haul	998	CY	16	$15,858
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	998	CY	27	$26,547
Precast Storm Drain Manhole, 6' I.D., 8' Deep	1	EACH	4,300	$4,300
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	407	SY	120	$49,019
Sediment and Erosion Control (Silt Fence)	366	LF	5	$1,852

		Sub total		**$389,000**
60" RCP from Toe of Caribou Road to 400 feet Downstream				
60-inch Reinforced Concrete Pipe, Class 3	400	LF	279	$111,600
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	8000	SF	39	$312,000
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	938	CY	3	$2,842
Backfill, 6" layers, roller compaction operator walking	409	CY	44	$17,906
Pipe bedding, crushed rock, 1/2" to 3/4"	529	CY	48	$25,540
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	771	CY	26	$19,761
Drill & Blast in restricted areas	770	CY	214	$164,780
1/2 CY bucket wheel mounted front end loader, min haul	1090	CY	16	$17,320
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	1090	CY	27	$28,994
Precast Storm Drain Manhole, 6' I.D., 8' Deep	1	EACH	4,300	$4,300
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	569	SY	120	$68,530
Sediment and Erosion Control (Silt Fence)	400	LF	5	$2,024
Traffic Control	1	LS	10,000	$10,000
		Sub total		**$786,000**
60" HDPE from Toe of Caribou Road to underwater tie in at dam				
60-inch HDPE	4521	LF	354	$1,600,434
HDPE Pipe Placement, concrete weight collars / "Float Flood" method, Mechanical Crane, barge mounted	1	LS	961,000	$961,000
Underwater pipe laying preparation of reservoir bottom	1	LS	$2,925,000	$2,925,000
Attach to existing plugged inlet structure	1	LS	20,000	$20,000
60-inch hydraulic operated butterfly valve	1	LS	60,000	$60,000
48-inch hydraulic operated butterfly valve	1	LS	47,000	$47,000
Attach hydraulic valve controls to existing sluice gate controls	1	LS	40,000	$40,000
		Sub total		**$5,653,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (1)	1	LS	600	$600
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger / Crane, barge mounted and all loading equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		**$233,000**
			TOTAL	**$9,486,000**



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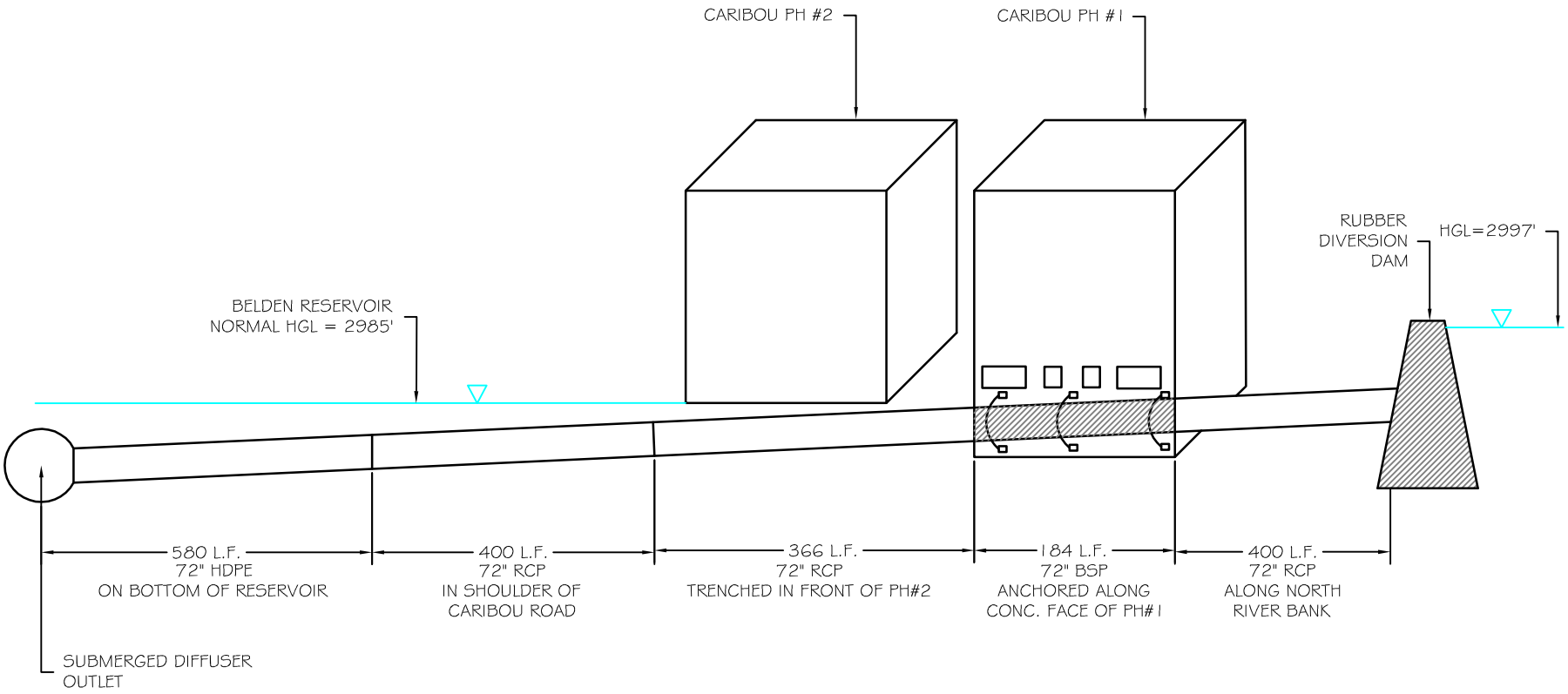
NFFR / LOWER SENECA REACH TO BELDEN RESERVOIR PLUNGING

NFFR / LOWER SENECA REACH TO BELDEN RESERVOIR PLUNGING OUTLET



Measure Name: Divert Cool Seneca Reach Flows and Convey by Pipeline to Discharge below Belden Dam

Applicable Alternative Category(s): 6a; additional measure for Belden Reach

Description of Measure: Construct an approximately 1.1 mile long pipeline to convey cool Seneca Reach flows to below Belden Dam, bypassing Belden Reservoir. The purpose of this measure is to avoid mixing cool Seneca flows with warmer discharges from the Caribou PHs during operational hours and minimize mixing with warmer ambient waters near the surface of Belden Reservoir.

Description of Operations: This measure has no affect on PH operations. Operate the diversion system to convey about 250 cfs through the pipeline and spill the remaining flow over the dam. The diversion rate is supplied by the increased release measure from Canyon Dam low-level outlet. The flow accretion along the Seneca Reach, including inflows from lower Butt Creek, would maintain flows for aquatic habitat in the short reach to the Caribou No. 1 discharge.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 7-foot high inflatable/deflatable rubber diversion dam at the lower end of Seneca Reach just upstream of Caribou PH No. 1. Except during summer, the rubber dam would remain in the deflated position. Construct an approximately 1.1 mile long pipeline to convey cool Seneca Reach flows captured behind the dam to connect to the existing Oak Flat PH outlet structure for discharge below Belden Dam.

The pipeline starts at the diversion dam and extends about 1.1 mile to a submerged diffuser at the bottom of Belden Reservoir. The first segment of the pipeline is about 400 feet long and consists of 60-inch reinforced concrete pipe (RCP) buried into the river bank and covered with riprap. The second segment is about 180 feet long and consists of 60-inch Black Steel Pipe (BSP) which is connected to the concrete face of Caribou PH #1, delivering flows to the northwest bank of the NFFR just upstream of Caribou PH #2. The third segment is about 360 ft long and consists of 60-inch RCP which is buried along the toe of the north bank of the NFFR and protected with riprap. The fourth segment is about 400 feet and consists of 60-inch RCP which is buried along the shoulder of Caribou Road.

The fifth and last segment is about 4,520 feet long and consists of 60-inch HPDE pipe that enters Belden Reservoir and is set on and anchored to the bottom of the reservoir. The end of the pipe connects to the existing outlet structure which conveys the flow through a 150-inch conduit to the Oak Flat PH. Because the capacity of the Oak Flat PH turbine is 150 cfs, a 100 cfs outlet from the 150-inch conduit is needed to discharge the flow in excess of the turbine capacity to the Belden Reach. Alternatively, PG&E may choose to increase the capacity of the turbine by 100 cfs.

List of Figures:

- Plan view: Lower Seneca Reach Bypass to Belden Dam Outlet
- Profile: Lower Seneca Reach Bypass

Key Design or Construction Uncertainties Requiring Further Study:

- Setting a 60-inch HDPE along the bottom of Belden Reservoir will 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 further study.
- Attaching the end of the 60-inch HDPE pipe to the existing submerged intake and 150-inch outlet pipe will be difficult and costly due to construction underwater.
- Placing and connecting a 60-inch reinforced concrete or black steel pipe to the faces of both powerhouses will require blasting and difficult construction, which could be hazardous due to unstable slopes and recent landslides.
- Pipeline construction beside Caribou Road will require blasting, jack hammering work due to the existing conditions being steep rock cliffs near the powerhouses, which could be hazardous due to unstable slopes and recent landslides.

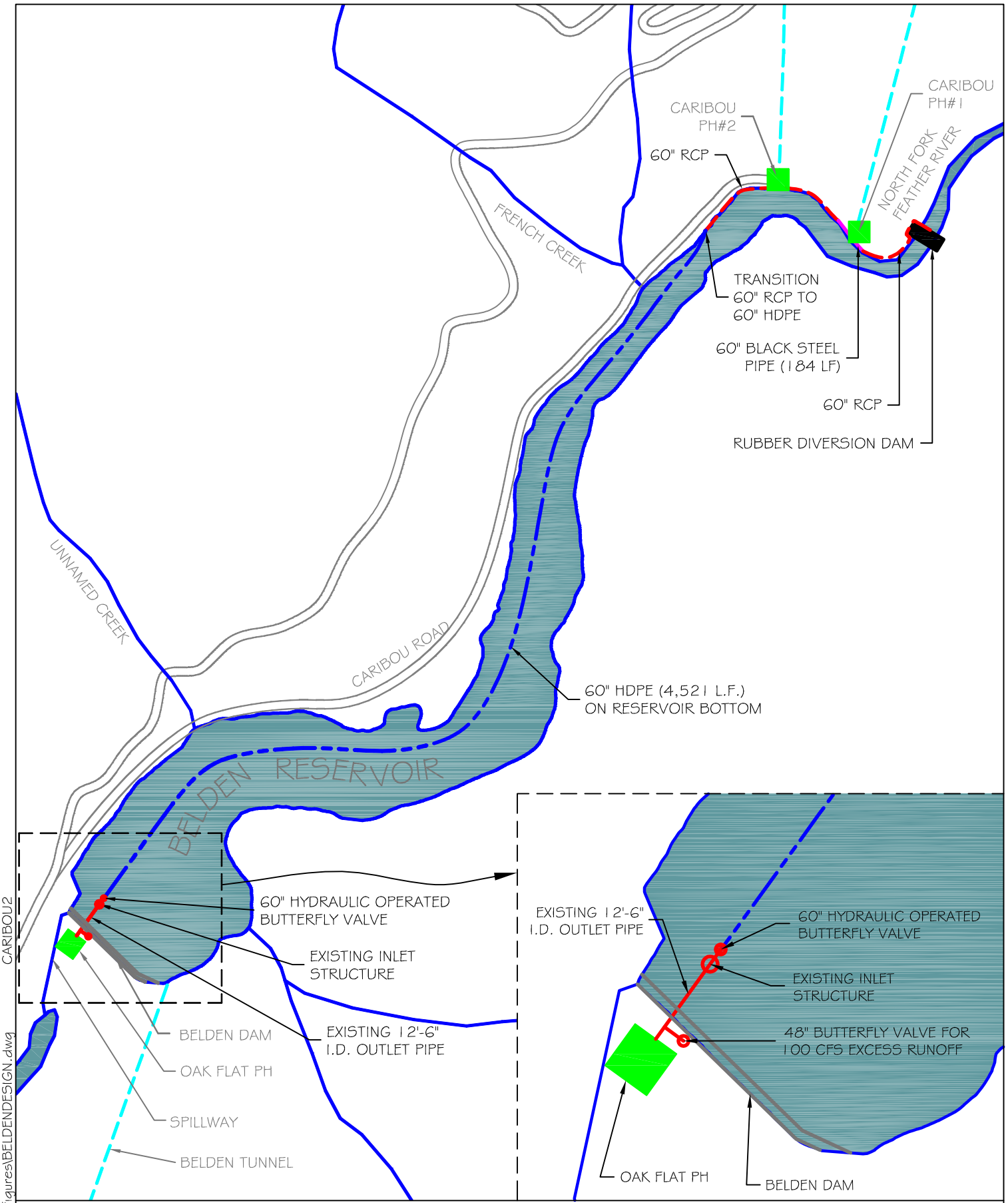
Discussion:

The 60-inch HDPE pipe was not placed along Caribou Road because the elevation gained near the dam would not allow the system to have gravity flow at the design flow rate of 250 cfs.

COST ESTIMATE FOR BYPASSING COOL SENECA REACH FLOWS TO 250 CFS TO BELOW BELDEN DAM				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE AT CARIBOU PHS				
7' high and 39' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$1,940,000	$1,940,000
		Sub Total NF Feather River Dam		$1,940,000
60" RCP from Rubber Dam to Caribou PH #1				
60-inch Reinforced Concrete Pipe, Class 3	400	LF	279	$111,600
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	800	SY	120	$96,352
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	1363	CY	26	$34,934
Backfill, 6" layers, roller compaction operator walking	237	CY	44	$10,376
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	766	CY	3	$2,321
Pipe bedding, crushed rock, 1/2" to 3/4"	529	CY	48	$25,540
1/2 CY bucket wheel mounted front end loader, min haul	1090	CY	16	$17,320

Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	1090	CY	27	$28,994
Sediment and Erosion Control (Silt Fence)	400	LF	5	$2,024
		Sub total		$329,000
60" Black Steel Pipe along Concrete Face of Caribou PH #1				
60" black steel pipe	184	LF	572	$105,248
Drill concrete anchor bolts	184	LF	29	$5,268
Install concrete anchor bolts	184	LF	25	$4,659
Drill & Blast restricted areas	109	CY	214	$23,326
1/2 CY bucket wheel mounted front end loader, min haul	125	CY	16	$1,986
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	125	CY	27	$3,325
Anchor rings	4	EACH	800	$3,200
Precast Storm Drain Manhole, 6' I.D., 8' Deep	2	EACH	4,300	$8,600
		Sub total		$156,000
60" RCP from Concrete Face of Caribou PH #1 to N Fork Feather River / Toe of Caribou Road				
60-inch Reinforced Concrete Pipe, Class 3	366	LF	279	$102,114
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	682	CY	3	$2,066
Backfill, 6" layers, roller compaction operator walking	198	CY	44	$8,668
Pipe bedding, crushed rock, 1/2" to 3/4"	484	**CY**	48	**$23,368**
Remove (load) small boulders (under 1/2 CY)	347	**CY**	17	$6,062
Replace (load) small boulders (under 1/2 CY)	347	CY	17	$6,062
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	597	CY	26	$15,301
Drill & Blast in restricted areas	596	CY	214	$127,544
1/2 CY bucket wheel mounted front end loader, min haul	998	CY	$16	$15,858
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	998	CY	27	$26,547
Precast Storm Drain Manhole, 6' I.D., 8' Deep	1	EACH	4,300	$4,300
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	407	SY	120	$49,019
Sediment and Erosion Control (Silt Fence)	366	LF	5	$1,852
		Sub total		**$389,000**
60" RCP from Toe of Caribou Road to 400 feet Downstream				
60-inch Reinforced Concrete Pipe, Class 3	400	LF	279	$111,600
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	8000	SF	39	$312,000
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	938	CY	3	$2,842
Backfill, 6" layers, roller compaction operator walking	409	CY	44	$17,906
Pipe bedding, crushed rock, 1/2" to 3/4"	529	CY	48	$25,540
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	771	CY	26	$19,761
Drill & Blast in restricted areas	770	CY	214	$164,780
1/2 CY bucket wheel mounted front end loader, min haul	1090	CY	16	$17,320
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	1090	CY	27	$28,994
Precast Storm Drain Manhole, 6' I.D., 8' Deep	1	EACH	4,300	$4,300

Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	569	**SY**	120	**$68,530**
Sediment and Erosion Control (Silt Fence)	400	LF	5	2,024
Traffic Control	1	LS	**10,000**	**$10,000**
		Sub total		$786,000
60" HDPE from Toe of Caribou Road to underwater tie in at dam				
60-inch HDPE	**4521**	**LF**	**354**	**$1,600,434**
HDPE Pipe Placement, concrete weight collars / "Float Flood" method, Mechanical Crane, barge mounted	**1**	**LS**	**961,000**	**$961,000**
Mechanical Dredging, barge mounted, clamshell, hopper dumped	69622	CY	$14	$960,784
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	94000	**SF**	**39**	**$3,666,000**
Furnish and place topsoil, truck dumped, screened, 4" deep	2089	**SY**	4	$8,105
Fine grading with seeding inc lime, fertilizer & seed w/ equip.	188000	SF	6	$1,214,480
Attach to existing plugged inlet structure	1	LS	20,000	$20,000
60-inch hydraulic operated butterfly valve	1	LS	60,000	$60,000
Attach hydraulic valve controls to existing sluice gate controls	1	LS	40,000	$40,000
		Sub total		$8,531,000
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	**LS**	6,000	**$6,000**
25 ton truck mounted hydraulic crane (2)	1	**LS**	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (1)	1	LS	600	$600
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger / Crane, barge mounted and all loading equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		$233,000
			TOTAL	**$12,364,000**



CARIBOU2

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LOWER SENECA REACH BYPASS TO BELDEN DAM OUTLET

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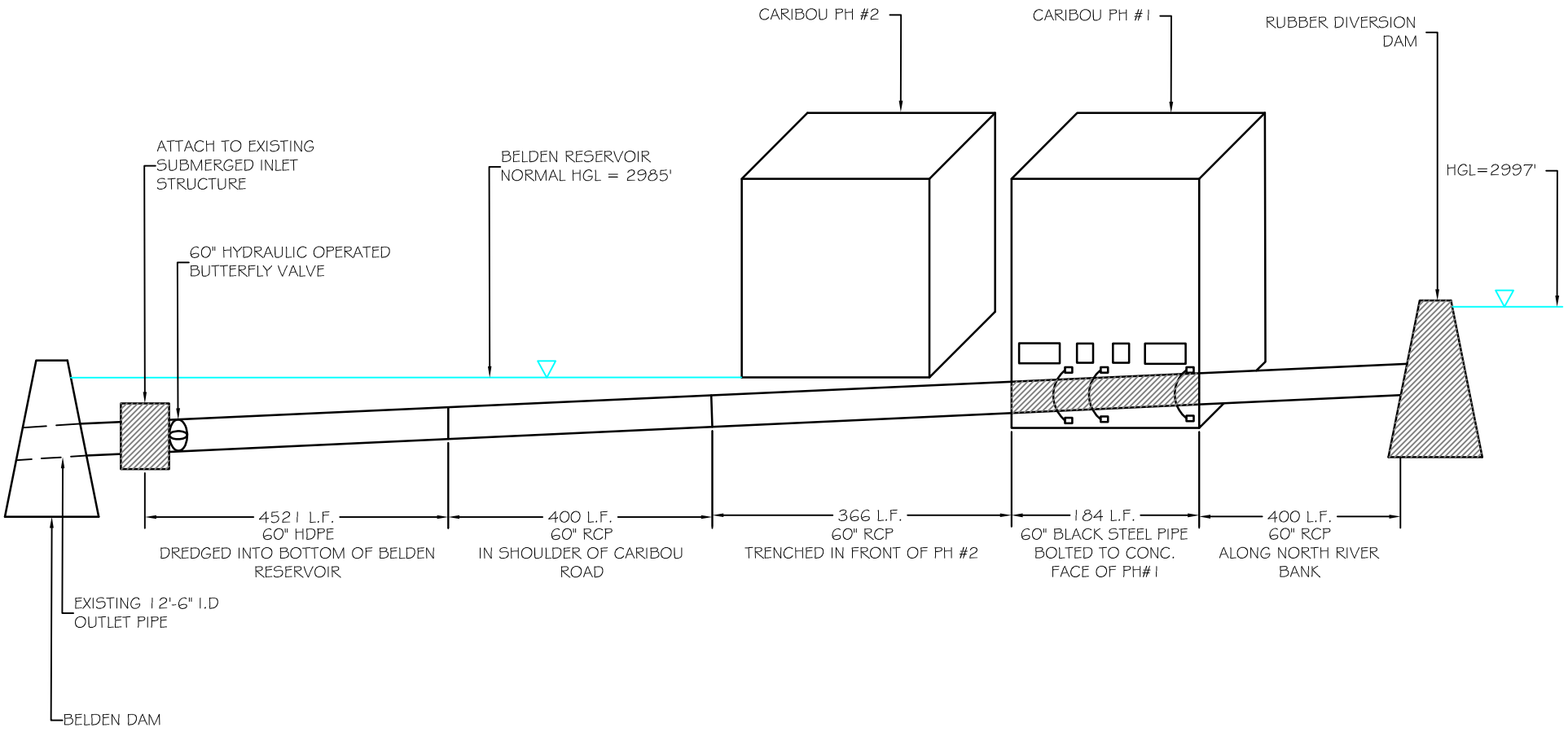
CARIBOU PH'S #1 & 2 BYPASS TO BELDEN DAM (250 C.F.S)



Measure Name: Divert Warm Water from East Branch NFFR into a Pipeline to Discharge into Upper Rock Creek Reservoir

Applicable Alternative Category(s): 3, 4, 5a, 6a; additional measure for Belden Reach

Description of Measure: Construct about 1.8-mile long pipeline to convey warm water from East Branch NFFR to discharge into upper Rock Creek Reservoir. The purpose of this measure is to protect the lower Belden Reach from the warming effects of East Branch NFFR inflows.

Description of Operations: This measure does not affect PH operations. According to PG&E's flow measurements in summer 2002-2004, flows in East Branch NFFR during July and August ranged from 45 cfs to 150 cfs, and were less than 100 cfs most of time. A diversion rate of 100 cfs from the East Branch NFFR was used as design flow for this measure. Spill 10 cfs over the rubber dam to maintain instream flow for aquatic habitat in the remaining short reach of the East Branch to the NFFR.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 3-foot high inflatable/deflatable rubber diversion dam at the lower end of the East Branch NFFR about 300 feet upstream from the NFFR confluence. Except during summer, the rubber dam would remain in the deflated position. Construct an approximately 1.8 mile long, 48-inch RCP pipeline to convey the warm water flows captured behind the dam to discharge into Rock Creek Reservoir. The pipeline discharges through a manually operated butterfly valve to the NFFR just upstream of the Yellow Creek confluence.

Flows in the NFFR above the East Branch during July and August exhibited an average temperature of about 22.5 °C (ranging from 19.9 °C to 26.4 °C), ranged from 45 cfs to 150 cfs, and were less than 100 cfs most of time. These flows would maintain aquatic habitat along the lower Belden Reach.

List of Figures:
- Plan view: East Branch Feather River to Rock Creek Reservoir
- Profile: East Branch to Rock Creek Reservoir

Key Design or Construction Uncertainties Requiring Further Study:
- Construction of the 48-inch reinforced concrete pipe close to the channel along the south bank of the NFFR will be difficult and costly due to boulders and water in the channel.

Discussion:
This measure is slightly different when it is incorporated into alternatives in Alternative Categories 5 and 6. In these alternatives, warm water conveyed from the East Branch NFFR is discharged farther upstream of the Yellow Creek confluence in order to better integrate with the diversion and conveyance of cool lower Belden flows for plunging or bypassing Rock Creek Reservoir.

COST ESTIMATE FOR CONVEYING EAST BRANCH NFFR FLOWS TO UPPER ROCK CREEK RESERVOIR				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
RUBBER DAM AND INTAKE				
3' high and 66' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$1,400,000	$1,400,000
		Sub Total		**$1,400,000**
Access Road (1000-foot Access Road from Howells Road)				
Sediment and Erosion Control (Silt Fence)	955	LF	5	$4,829
Clearing (including Trees), Dozer 300 HP	2334	SY	6	$13,957
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	706	CY	13	$9,501
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	706	CY	38	$27,133
Concrete for Retaining Wall Footings	39	CY	1,900	$73,530
Steel Galv. Retaining Wall Posts, 8-Foot	14	EACH	84	$1,191
Treated Wood for Retaining Wall	28483	BF	12	$336,636
Fill, 1/2 to 3/4" Crushed Rock	686	CY	47	$32,376
Fill, Road Surface Gravel	221	CY	36	$8,010
		Sub Total		**$507,000**
48" Pipe From Dam to Howells Road				
48-inch Reinforced Concrete Pipe	2700	LF	104	$281,232
1/2 CY bucket wheel mounted front end loader, min haul	4140	CY	16	$65,785
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	4140	CY	27	$110,124
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	2943	CY	3	$8,917
Pipe bedding, crushed rock, 1/2" to 3/4"	2343	CY	48	$113,120
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	4200	CY	12	$50,400
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	80	SY	120	$9,635
Precast Storm Drain Manhole, 4' I.D., 8' Deep	2	EACH	1,900	$3,800
		Sub Total		**$643,000**
48" Pipe in Howells Road				
48-inch Reinforced Concrete Pipe	6104	LF	104	$635,793
Sawcut Asphalt, 4" Thick	8400	LF	2	$19,572
Pavement Removal, Bituminous Roads 4" to 6"	3733	SF	8	$28,968
Pavement Replacement Over Trench, 4" Thick	3733	SF	35	$131,626
1/2 CY bucket wheel mounted front end loader, min haul	5665	CY	16	$90,017
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	5665	CY	27	$150,689
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	4578	CY	3	$13,871
Pipe bedding, crushed rock, 1/2" to 3/4"	3645	CY	48	$175,981

Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	6533	CY	12	$78,396
Precast Storm Drain Manhole, 4' I.D., 8' Deep	6	EACH	1,900	$11,400
Traffic Control	1	EACH	10,000	$10,000
		Sub Total		**$1,346,000**
48" Pipe from Howells Road to Outlet				
48-inch Reinforced Concrete Pipe	260	LF	104	$27,082
1/2 CY bucket wheel mounted front end loader, min haul	150	CY	16	$2,384
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	150	CY	27	$3,990
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	163	CY	3	$494
Pipe bedding, crushed rock, 1/2" to 3/4"	130	CY	48	$6,276
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	233	CY	12	$2,796
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	156	SY	120	$18,789
48-inch hydraulic operated butterfly valve	1	LS	47,000	$47,000
Concrete Outlet Structure	10	CY	1,900	$19,000
Grouted Riprap Slope Protection for Outlet Structure	75	SY	120	$9,000
		Sub Total		**$137,000**
Mobilization				
Dozer, above 150 HP (2)	1	LS	2,400	$2,400
Excavator, 1-1.5 CY Diesel Hyd. Mobilization	1	EACH	4,800	$4,800
Loader (2)	1	LS	2,400	$2,400
Paver Mobilization	1	LS	1,200	$1,200
Grout pumper (1)	1	LS	600	$600
Dump truck, 26 tons (4)	1	LS	2,400	$2,400
Grader, 30,000 lbs (1)	1	LS	1,200	$1,200
		Sub Total		**$15,000**
			TOTAL	**$4,048,000**

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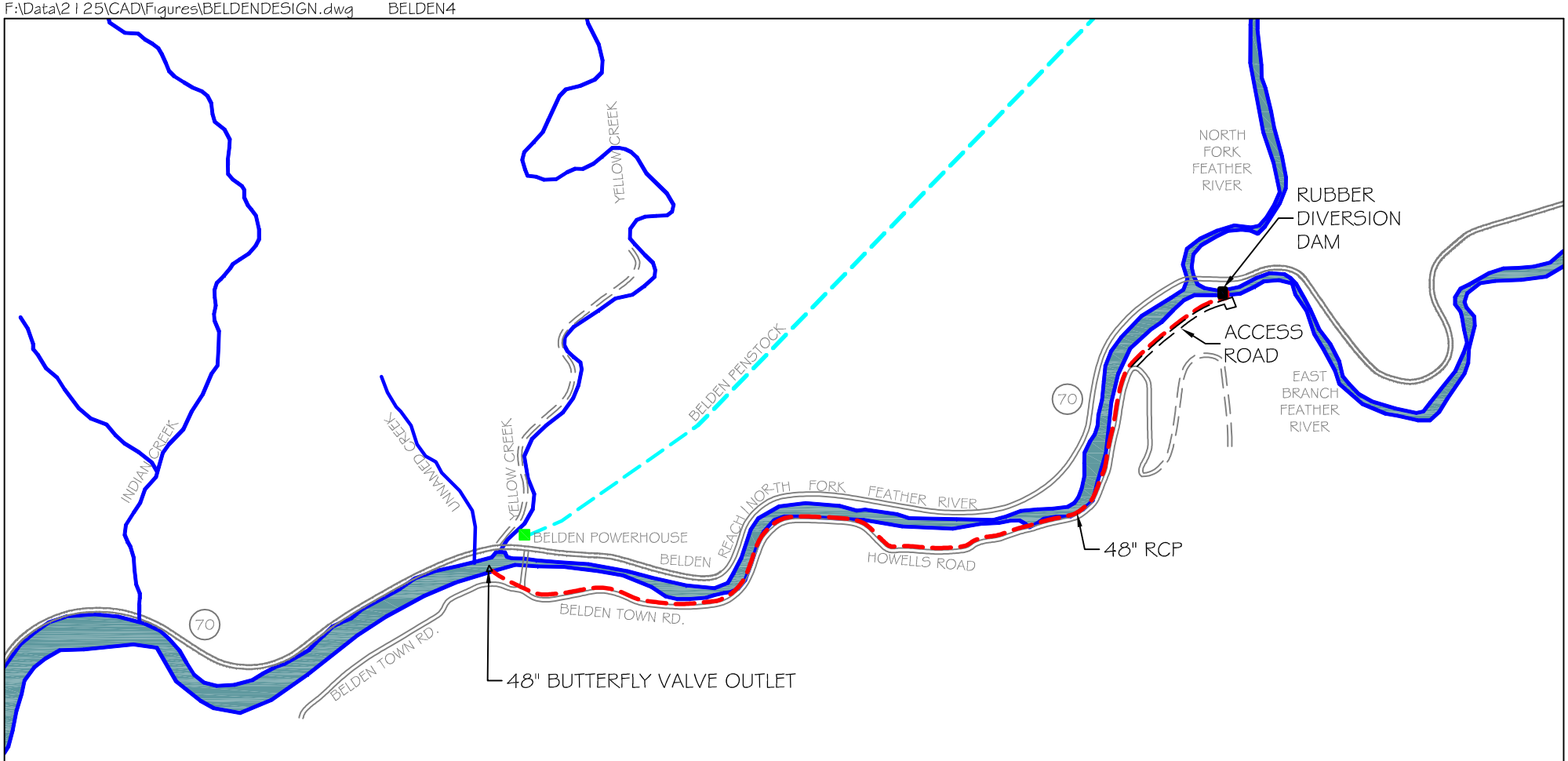

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EAST BRANCH FEATHER RIVER TO ROCK CREEK RESERVOIR

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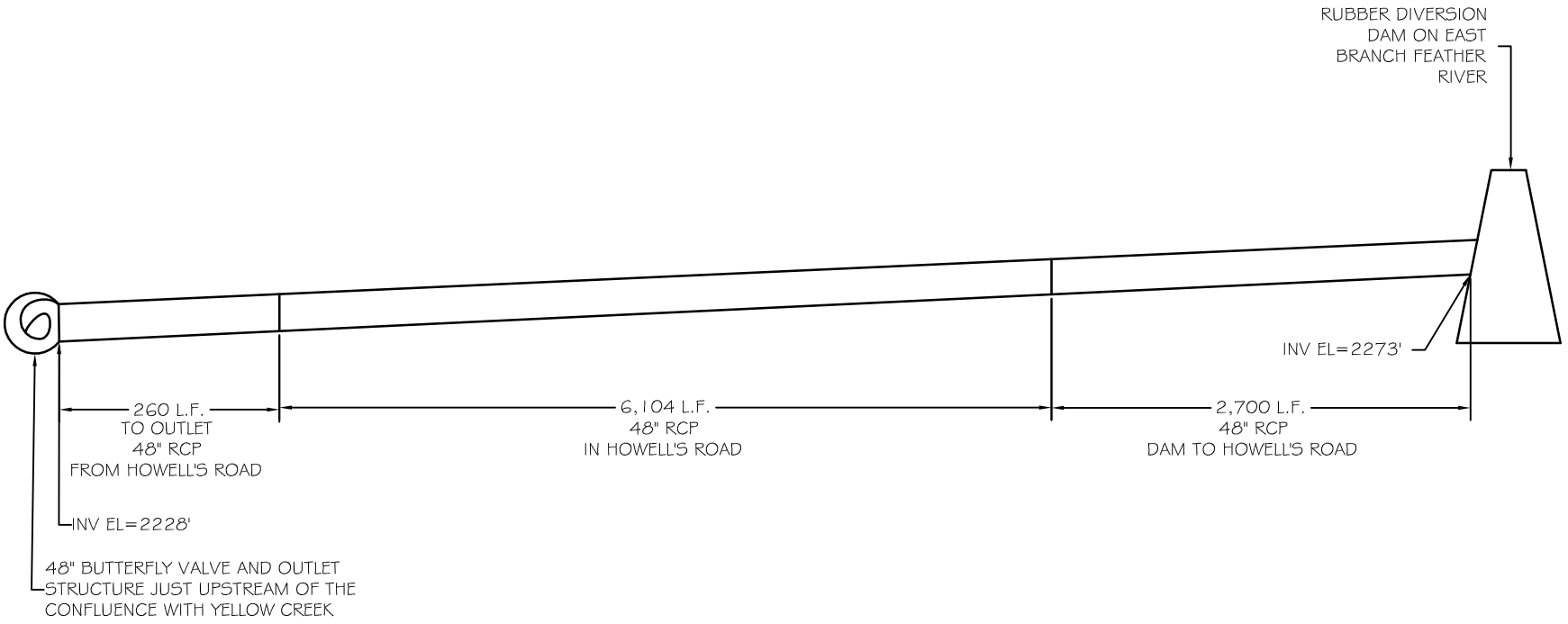
EAST BRANCH TO ROCK CREEK RESERVOIR



Measure Name: Divert Cool Yellow Creek Flow and Convey by Conduit to an Appropriate Plunging Location and Dredge a Submerged Channel in Rock Creek Reservoir

Applicable Alternative Category(s): 5a; additional measure for Rock Creek Reach

Description of Measure: Construct a conduit to convey cool Yellow Creek flows directly to a plunging location in Rock Creek Reservoir, bypassing the Belden PH discharge. The purpose of this measure is to avoid mixing cool Yellow Creek flows with warmer discharges from the Belden PH during operating hours and minimize mixing with warmer ambient waters near the surface of Rock Creek Reservoir. Field observations in Rock Creek Reservoir during the 2006 NFFR special test conducted by PG&E indicate very little thermal stratification in Rock Creek Reservoir suggesting that dredging a channel along the bottom is required to facilitate the transport of cool water through the reservoir.

Description of Operations: This measure does not affect PH operations. At the Yellow Creek dam, divert 60 cfs of cool Yellow Creek flows and spill about 10 cfs to maintain flows for aquatic habitat in the stream over the short distance between the diversion dam and the NFFR/Belden PH confluence.

Detailed Description of Facilities Improvements and Design Criteria:
Construct an inflatable/deflatable 3-foot high rubber diversion dam on Yellow Creek about 1,400 feet upstream of the Belden PH. Except during summer, the rubber dam remains in the deflated position.

The Yellow Creek diversion dam directs 60 cfs through a 54-inch Reinforced Concrete Pipe (RCP) constructed along the bank approximately 1,400 feet to where the pipe transitions into 54-inch HDPE near the NFFR/Yellow Creek confluence. The flow is then conveyed about 7,100 feet through the 54-inch HDPE anchored to the reservoir bottom to a submerged discharge point near the confluence with Chips Creek. A submerged diffuser outlet is installed at the end of the pipeline to distribute the discharge in a larger cross sectional area for the purpose of reducing discharge velocity, turbulence, and mixing potential. Dredge a submerged channel down from the submerged discharge outlet a distance of about 7,000 feet along the bottom of the reservoir to a point near the low level outlet at Rock Creek Dam.

List of Figures:
- Plan view: Yellow Creek to Rock Creek Reservoir
- Profile: Yellow Creek to Rock Creek Reservoir Plunging

Key Design or Construction Uncertainties Requiring Further Study:
- Dredging the reservoir bottom may require removing large boulders which could be difficult and costly.
- The dredged conveyance channel at the bottom of Rock Creek Reservoir will likely fill with sediment and will require repeated dredging.

- The effectiveness of cold water transport by a dredged channel in Rock Creek Reservoir requires further study.
- Setting a 54-inch HDPE along the bottom of Rock Creek Reservoir will 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 further study.

Discussion: None

COST ESTIMATE FOR YELLOW CREEK BYPASS TO PLUNGING				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
YELLOW CREEK RUBBER DAM AND INTAKE				
3' high and 40' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$850,000	$850,000
		Sub Total Yellow Creek Dam		**$850,000**

Access Road (710-feet along west bank of Yellow Creek)				
Sediment and Erosion Control (Silt Fence)	740	LF	$5	$3,744
Clearing (including Trees), Dozer 300 HP	1809	SY	$6	$10,819
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	547	CY	$13	$7,365
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	547	CY	$38	$21,033
Concrete for Retaining Wall Footings	30	CY	$1,900	$57,000
Steel Galv. Retaining Wall Posts, 8-Foot	11	EACH	$84	$923
Treated Wood for Retaining Wall	22080	BF	$12	$260,958
Fill, 1/2 to 3/4" Crushed Rock	532	CY	$47	$25,098
Fill, Road Surface Gravel	171	CY	$36	$6,209
24" CMP, corrugated 14 ga.	20	LF	$50	$1,009
Triple span, 1 lane bridge over Yellow Creek	1	LS	$344,000	$344,000
		Sub total access road		**$738,000**
54" Pipe From Rubber Dam to Confluence of Yellow Creek and NF Feather River				
54-inch Reinforced Concrete Pipe, Class 3	1370	LF	$230	$315,100
1/2 CY bucket wheel mounted front end loader, min haul	2566	CY	$16	$40,774
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	2566	CY	$27	$68,256
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	1541	CY	$3	$4,669
Pipe bedding, crushed rock, 1/2" to 3/4"	1541	CY	$48	$74,399
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	2231	CY	$12	$26,772

Precast Storm Drain Manhole, 4' I.D., 8' Deep	4	EACH	$1,900	$7,600
Concrete Encasement Under Hwy 70	43	CY	$1,125	$48,370
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	100	SY	$120	$12,044
Sawcut Asphalt, 4" Thick	122	LF	$2	$284
Pavement Removal, Bituminous Roads 4" to 6"	396	SF	$8	$3,073
Pavement Replacement Over Trench, 4" Thick	396	SF	$35	$13,963
Traffic Control	1	EACH	$5,000	$5,000
		Sub total 54" RCP		**$620,000**
54-Inch HDPE From Confluence of Yellow Creek and NFFR to Chips Creek (With Dredging to Dam)				
54-inch HDPE	2640	LF	$271	$715,440
HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	$1,700,000	$1,700,000
Mechanical Dredging, barge mounted, clamshell, hopper dumped	130256	CY	$13	$1,667,277
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	117200	SF	$39	$4,570,800
Furnish and place topsoil, truck dumped, screened, 4" deep	39067	SY	$4	$151,580
Fine grading with seeding inc lime, fertilizer & seed w/ equip.	351600	SF	$6	$2,271,336
Concrete Outlet Diffuser Structure, Structure Pad and Rock Cover	1	LS	$15,000	$15,000
		Sub total 54" HDPE		**$11,091,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	$3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	$9,600	$9,600
Loader (2)	1	LS	$2,400	$2,400
Paver Mobilization	1	LS	$1,200	$1,200
Grout pumper (1)	1	LS	$600	$600
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	$200,000	$200,000
		Sub total Mob / Demob		**$217,000**
			TOTAL	**$13,516,000**

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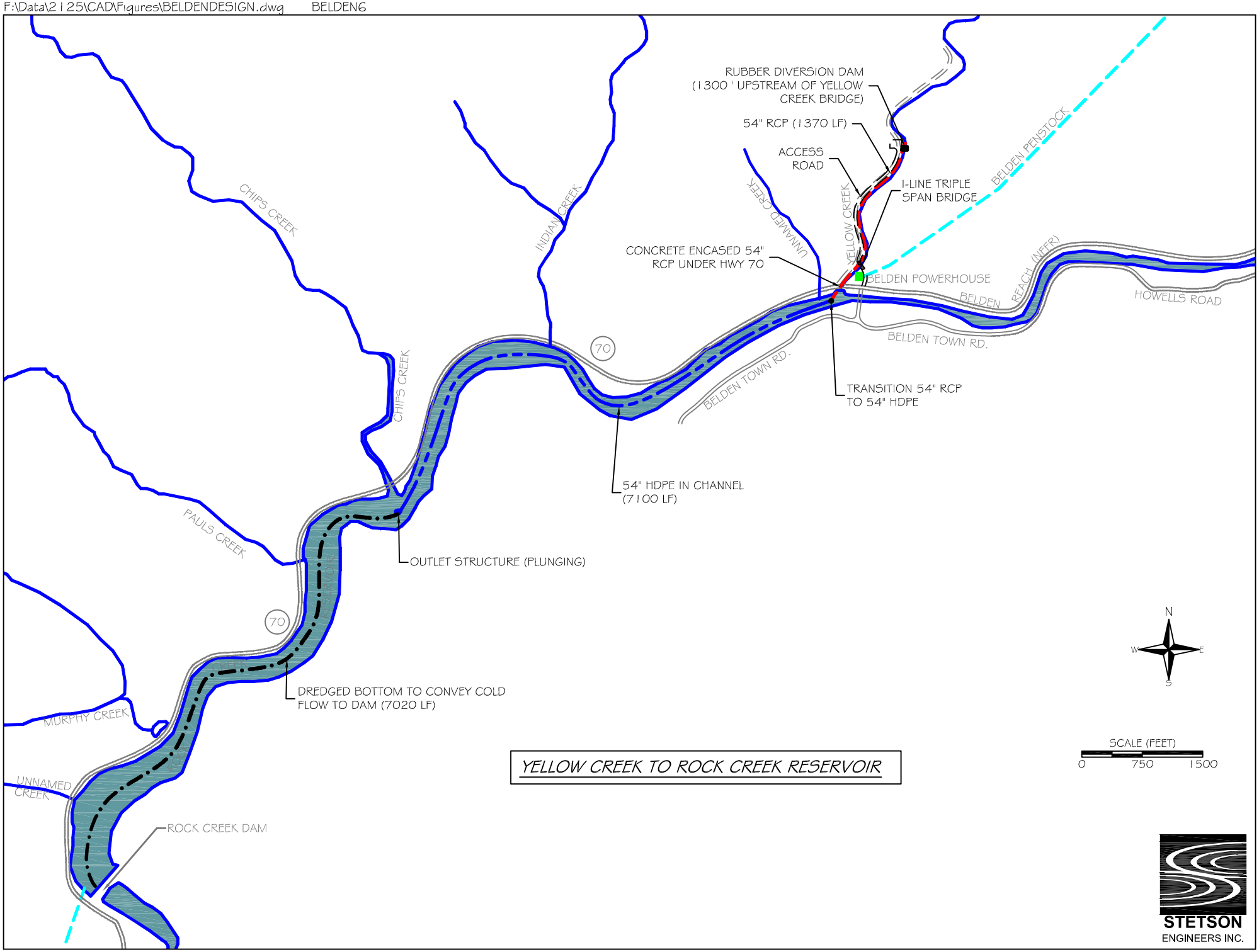

YELLOW CREEK TO ROCK CREEK RESERVOIR

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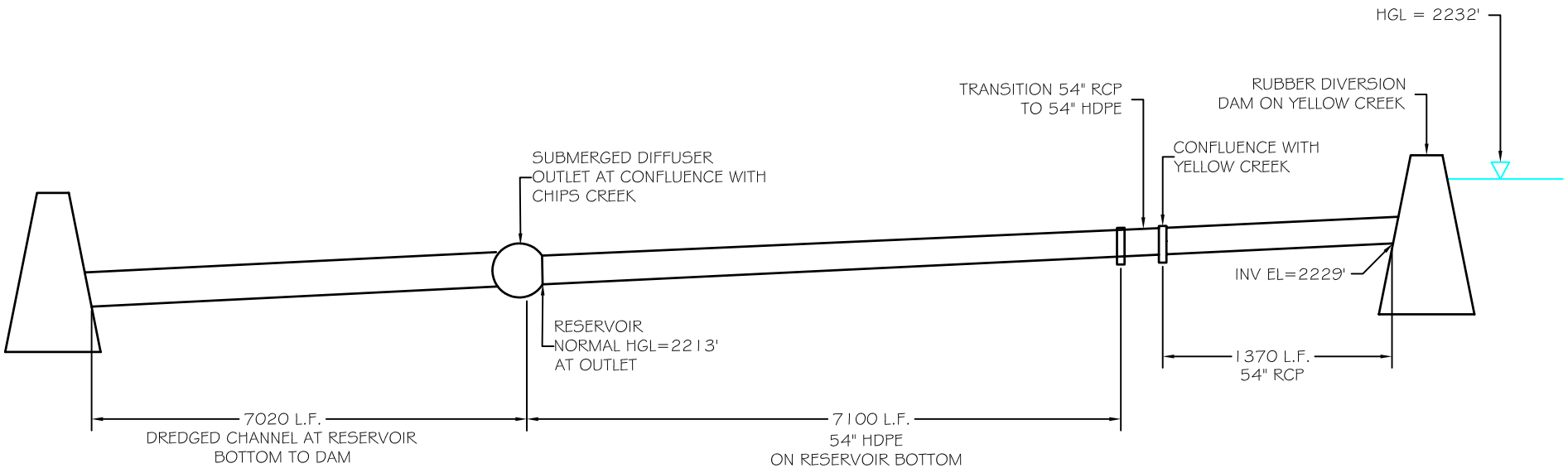
YELLOW CREEK TO ROCK CREEK RESERVOIR PLUNGING



Measure Name: Divert Cool Yellow Creek Flows into a Pipeline to Discharge below Rock Creek Dam

Applicable Alternative Category(s): 4, 5; additional measure for Rock Creek Reach

Description of Measure: Construct about 3-mile long pipeline to convey cool Yellow Creek flows to below Rock Creek Dam directly, bypassing Rock Creek Reservoir. The purpose of this measure is to avoid mixing cool Yellow Creek flows with warmer discharges from the Belden PH during operational hours and minimize mixing of Yellow Creek flows with warmer ambient waters near the surface of Rock Creek Reservoir.

Description of Operations: This measure does not affect PH operations. According to PG&E's flow measurements in summer 2002-2004, Yellow Creek discharges during July and August ranged from about 50 cfs to 100 cfs, with most of time less than 70 cfs. Operate the Yellow Creek diversion system to divert and convey about 60 cfs while spilling about 10 cfs over the diversion dam to maintain flows for aquatic habitat in the short reach to the Yellow Creek/Belden PH confluence.

Detailed Description of Facilities Improvements and Design Criteria:
Construct an inflatable/deflatable rubber diversions dam on Yellow Creek. Construct the 3-foot high rubber dam about 1,400 feet upstream of the Belden PH. Except during summer, the rubber dam will remain in the deflated position.

The Yellow Creek diversion dam directs 60 cfs through a 42-inch Reinforced Concrete Pipe (RCP) conduit. The RCP is buried under a newly constructed access road that extends to Highway 70. Downstream of Yellow Creek the pipe is buried along shoulder of Highway 70 for approximately 6,900 feet to the confluence of Chips Creek.

The Yellow Creek flow is conveyed in 42-inch Black Steel Pipe (BSP) over Chips Creek which is attached to the Chips Creek Bridge and transitions back into 42-inch RCP for a distance of 7,893 feet to the top of Rock Creek Dam. The conduit then transitions back to 42-inch BSP and is connected with rock anchors to the steep rock face on the southwest side of the dam for 155 feet to discharge through a manually operated butterfly valve to the Rock Creek Reach.

The design and costs associated with the Yellow Creek temporary access road as well as the connected steel pipe and stair tower down to the toe of Rock Creek Dam were derived from the 2005 Black and Veatch Summary Report (North Fork Feather River Yellow Creek Diversion Cooling Water Pipeline Feasibility Report, 2005).

List of Figures:
- Plan view: Yellow Creek Diversion to Rock Creek Dam
- Profile: Yellow Creek Diversion to Rock Creek Dam Outlet

Key Design or Construction Uncertainties Requiring Further Study:

- Attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek could make the existing structure unstable and will require further study.
- Connecting 155 LF of 42-inch Black Steel Pipe to the steep rock face at the dam requires further study.

Discussion: None

COST ESTIMATE FOR YELLOW CREEK BYPASS TO ROCK CREEK DAM				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
YELLOW CREEK RUBBER DAM AND INTAKE				
3' high and 40' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$850,000	$850,000
		Sub Total Yellow Creek Dam		**$850,000**
Access Road (710-feet along west bank of Yellow Creek)				
Sediment and Erosion Control (Silt Fence)	740	LF	$5	$3,744
Clearing (including Trees), Dozer 300 HP	1809	SY	$6	$10,819
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	547	CY	$13	$7,365
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	547	CY	$38	$21,033
Concrete for Retaining Wall Footings	30	CY	$1,900	$58,139
Steel Galv. Retaining Wall Posts, 8-Foot	11	EACH	$80	$923
Treated Wood for Retaining Wall	22080	BF	$12	$260,958
Fill, 1/2 to 3/4" Crushed Rock	532	CY	$47	$25,098
Fill, Road Surface Gravel	171	CY	$36	$6,209
24" CMP, corrugated 14 ga.	20	LF	$50	$1,009
Triple span, 1 lane bridge over Yellow Creek	1	LS	$340,000	$340,000
		Sub total access road + bridge		**$735,000**
42" Pipe From Yellow Creek Dam to south side of Hwy 70 at confluence with NFFR				
42-inch Reinforced Concrete Pipe, Class 3	1400	LF	$132	$184,800
1/2 CY bucket wheel mounted front end loader, min haul	3354	CY	$16	$53,295
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	3354	CY	$27	$89,216
Backfill, 6" layers, roller compaction operator walking	1167	CY	$44	$51,091

Pipe bedding, crushed rock, 1/2" to 3/4"	1685	CY	$48	$81,352
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	4083	CY	$12	$48,996
Precast Storm Drain Manhole, 5' I.D., 8' Deep	4	EACH	$3,000	$11,176
Concrete Encasement Under Hwy 70	65	CY	$1,100	$73,118
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	100	SY	$120	$12,044
Sawcut Asphalt, 4" Thick	122	LF	$2	$284
Pavement Removal, Bituminous Roads 4" to 6"	396	SF	$8	$3,073
Pavement Replacement Over Trench, 4" Thick	396	SF	$35	$13,963
Traffic Control	1	EACH	$5,000	$5,000
		Sub total		**$627,000**
42" Pipe From south side of Hwy 70 at confluence with NFFR to Chips Creek				
Clearing, medium	1	ACRE	$1,400	$1,400
42-inch Reinforced Concrete Pipe, Class 3	6913	LF	$132	$912,516
1/2 CY bucket wheel mounted front end loader, min haul	16562	CY	$16	$263,170
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	16562	CY	$27	$440,549
Backfill, 6" layers, roller compaction operator walking	5761	CY	$44	$252,217
Pipe bedding, crushed rock, 1/2" to 3/4"	8319	CY	$48	$401,641
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	20163	CY	$12	$241,956
Remove Gravel shoulder	1874	SY	$7	$12,481
Replace Gravel shoulder	625	CY	$48	$30,175
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	9471	SY	$120	$1,140,687
Sediment and Erosion Control (Silt Fence)	6913	LF	$5	$34,980
Remove and reset existing corrugated metal guard rail (includes all guard rail on 70)	12940	LF	$35	$449,277
Precast Storm Drain Manhole, 5' I.D., 8' Deep	20	EACH	$3,000	$60,000
Traffic control, signage (includes traffic cont. down to dam)	1	LS	$30,000	$30,000
Traffic control, 2 signals (includes traffic cont. down to dam)	1	LS	$380,000	$380,000
		Sub total		**$4,651,000**
Chips Creek at Hwy 70 to top of Rock Creek Dam				
Clearing, medium	1	ACRE	$1,400	$1,400
42-inch Reinforced Concrete Pipe, Class 3	7893	LF	$132	$1,041,876
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	28576	CY	$12	$342,912
1/2 CY bucket wheel mounted front end loader, min haul	24289	CY	$16	$385,952
Backfill, 6" layers, roller compaction operator walking	7455	CY	$44	$326,380
Pipe bedding, crushed rock, 1/2" to 3/4"	11421	CY	$48	$551,406
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	24289	CY	$27	$646,087
Precast Storm Drain Manhole, 6' I.D., 8' Deep	34	EACH	$4,000	$136,000
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	11690	SY	$120	$1,407,944

Remove Gravel shoulder	2140	SY	$7	$14,252
Replace Gravel shoulder	713	CY	$48	$34,424
Sediment and Erosion Control (Silt Fence)	7893	LF	$5	$39,939
		Sub Total		**$4,929,000**

Top of Rock Creek Dam to Outlet				
42" black steel pipe	155	LF	$354	$54,870
Rock excavation, drill and blast	11	CY	$128	$1,412
Drill rock anchor bolts	494	LF	$29	$14,143
Install rock anchor bolts	480	LF	$25	$12,154
Anchor rings	5	EACH	$800	$4,000
Stair tower (Down to base of dam)	1	LS	$224,000	224,000
42-inch hydraulic operated butterfly valve	1	LS	40,000	$40,000
		Sub total		**$351,000**

Indian Creek Crossing				
Cast in place 10.5'W x 1.5'H x 16'L Reinforced Concrete Box Culvert	8	CY	$2,770	$22,160
Cast in place culvert transitions to 42" pipe	3	CY	$2,770	$8,310
Structural excavation	84	CY	$46	$3,864
1/2 CY bucket wheel mounted front end loader, min haul	97	CY	$16	$1,541
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	97	CY	$27	$2,580
Backfill and roller compaction operator walking	9	CY	$44	$394
Remove Gravel shoulder	6	SY	$7	$40
Replace Gravel shoulder	2	CY	$48	$97
Bedding, crushed rock, 1/2" to 3/4"	7	CY	$49	$345
Clearing	1	LS	$500	$500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	28	SY	$120	$3,372
		Sub total		**$43,000**

Various Small Culverts (3) Upstream of Chips Creek				
Cast in place 10.5'W x 1.5'H x 6'L Reinforced Concrete Box Culverts	9	CY	$2,770	$24,930
Cast in place culvert transitions to pipe	9	CY	$2,770	$24,930
Structural excavation	148	CY	$46	$6,808
1/2 CY bucket wheel mounted front end loader, min haul	170	CY	$16	$2,701
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	170	CY	$27	$4,522
Backfill and roller compaction operator walking	16	CY	$44	$700
Remove Gravel shoulder	11.5	SY	$7	$77
Replace Gravel shoulder	4	CY	$48	$193
Bedding, crushed rock, 1/2" to 3/4"	12	CY	$49	$591
Clearing	1	LS	$1,500	$1,500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY	47.8	SY	$120	$5,757

Pieces, 18" Thick				
		Sub total		**$73,000**

Chips Creek Crossing				
42" black steel pipe	130	LF	$354	$46,020
Concrete pier footing, piers, pier caps and abutments	19	CY	$1,800	$33,558
Pier and abutment excavation	18	CY	$46	$828
Structural steel	12	TONS	$3,200	$38,400
Structural steel, pier supports	3	TONS	$4,300	$12,900
Steel, anchor rings	5	EACH	$800	$4,000
Sediment and Erosion Control (Silt Fence)	130	LF	$5	$658
Clearing	1	LS	$500	$500
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	43	CY	$12	$516
Backfill, 6" layers, roller compaction operator walking	18	CY	$44	$788
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	18	SY	$120	$2,168
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	38	CY	$27	$1,011
Remove Gravel shoulder	3	SY	$7	$20
Replace Gravel shoulder	1	CY	$48	$48
Bedding, crushed rock, 1/2" to 3/4"	17	CY	$48	$821
		Sub total		**$142,000**

Paul's and Murphy's Creek Crossing (downstream of Chips Creek)				
Cast in place 13'W x 1.5'H x 9'L Reinforced Concrete Box Culverts	11	CY	$2,770	$30,470
Cast in place culvert transitions to pipe	7	CY	$2,770	$19,390
Structural excavation	149	CY	$46	$6,854
1/2 CY bucket wheel mounted front end loader, min haul	171	CY	$16	$2,717
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	171	CY	$27	$4,549
Backfill and roller compaction operator walking	15	CY	$44	$657
Remove Gravel shoulder	9	SY	$7	$60
Replace Gravel shoulder	3	CY	$48	$145
Bedding, crushed rock, 1/2" to 3/4"	12	CY	$48	$579
Clearing	1	LS	$1,000	$1,000
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	39	SY	$120	$4,697
		Sub total		**$71,000**

Various Small Culverts (2) Downstream of Chips Creek				
Cast in place 13'W x 1.5'H x 6'L Reinforced Concrete Box Culverts	7.4	CY	$2,770	$20,498
Cast in place culvert transitions to pipe	7.4	CY	$2,770	$20,498
Structural excavation	122	CY	$46	$5,612
1/2 CY bucket wheel mounted front end loader, min haul	140	CY	$16	$2,225

Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	140	CY	$27	$3,724
Backfill and roller compaction operator walking	13	CY	$44	$569
Remove Gravel shoulder	8	SY	$7	$53
Replace Gravel shoulder	3	CY	$48	$145
Bedding, crushed rock, 1/2" to 3/4"	10	CY	$49	$493
Clearing	1	LS	$1,500	$1,500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	32	SY	$120	$3,854
		Sub total		**$59,000**
Mobilization / Demobilization				
Dozer, above 150 HP (3)	1	LS	$3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	$9,600	$9,600
Loader (2)	1	LS	$2,400	$2,400
Dump truck, 26 tons (10)	1	LS	$6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	$2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	$700	$700
Grader, 30,000 lbs (2)	1	LS	$2,400	$2,400
Grout pumper (1)	1	LS	$600	$600
Water truck, 6000 gal (2)	1	LS	$1,200	$1,200
Wash & Screen (1)	1	LS	$7,200	$7,200
		Sub total		**$36,000**
		Total		**$12,567,000**

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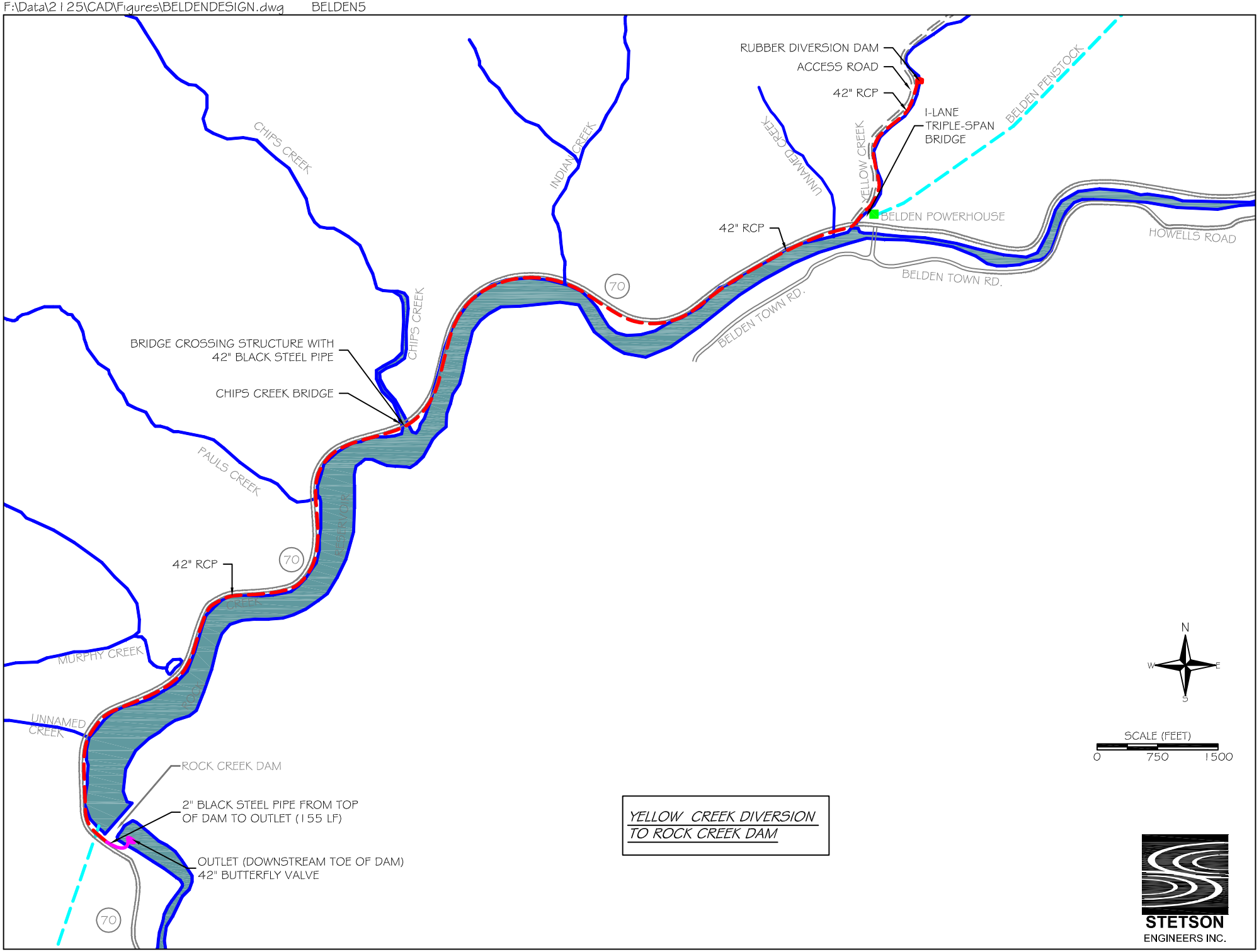

YELLOW CREEK DIVERSION TO ROCK CREEK DAM

STETSON ENGINEERS INC.

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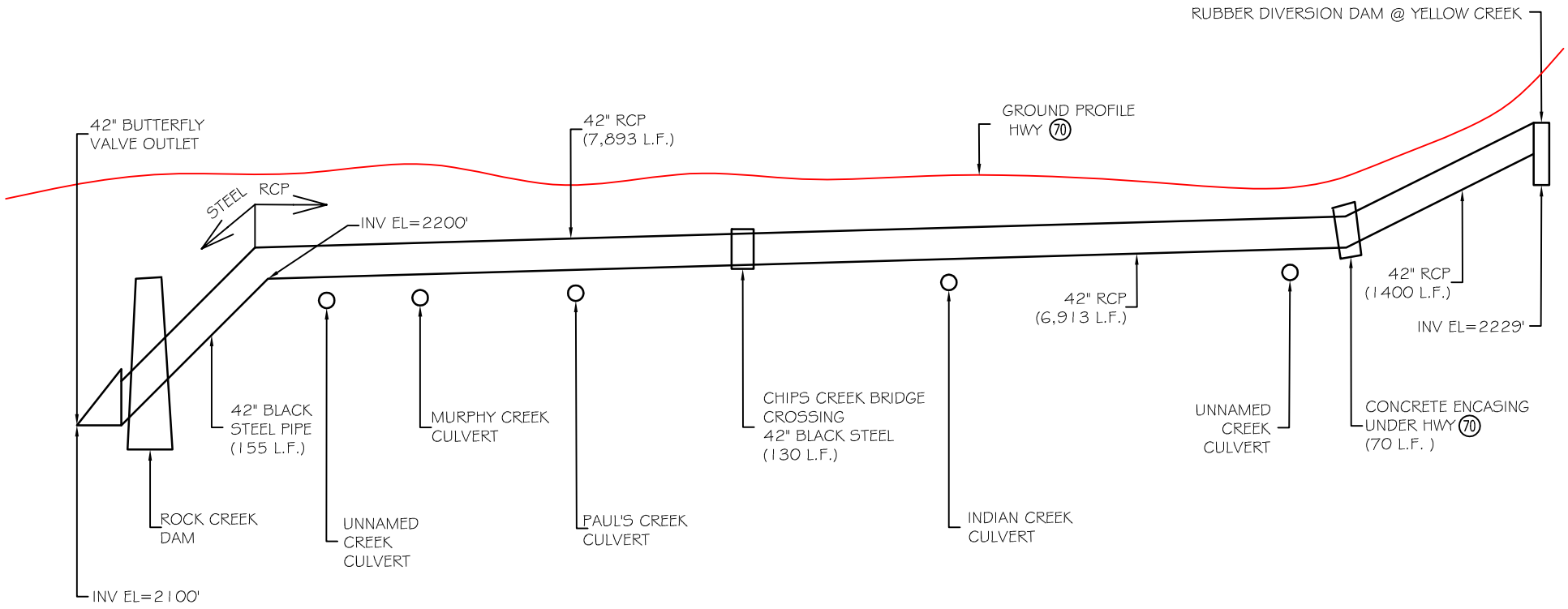
YELLOW CREEK DIVERSION TO ROCK CREEK DAM OUTLET



Measure Name: Divert Cool Yellow Creek and Chips Creek Flows into a Pipeline to Discharge below Rock Creek Dam

Applicable Alternative Category(s): 4, 5; additional measure for Rock Creek Reach

Description of Measure: Construct about 3-mile long pipeline to convey cool Yellow Creek and Chips Creek flows to below Rock Creek Dam directly, bypassing Rock Creek Reservoir. The purpose of this measure is to avoid mixing cool Yellow Creek flows with warmer discharges from the Belden PH during operational hours and minimize mixing of Yellow Creek and Chips Creek flows with warmer ambient waters near the surface of Rock Creek Reservoir.

Description of Operations: This measure does not affect PH operations. According to PG&E's flow measurements in summer 2002-2004, Yellow Creek discharges during July and August ranged from about 50 cfs to 100 cfs, with most of time less than 70 cfs. Chips Creek discharges during July and August ranged from about 15 cfs to 50 cfs, with most of time less than 30 cfs. Operate the Yellow Creek diversion system to divert and convey about 60 cfs while spilling about 10 cfs over the diversion dam to maintain flows for aquatic habitat in the short reach to the Yellow Creek/Belden PH confluence. Operate the Chips Creek diversion system to divert and convey about 20 cfs while spilling about 3 cfs over the diversion dam to maintain flows for aquatic habitat in the short reach to Rock Creek Reservoir.

Detailed Description of Facilities Improvements and Design Criteria:
Construct two inflatable/deflatable rubber diversions dams; one on Yellow Creek and another on Chips Creek. On Yellow Creek, construct a 3-foot high rubber about 1,400 feet upstream of the Belden PH. On Chips Creek construct a 3-foot high rubber about 740 feet upstream of Highway 70 above Rock Creek Reservoir. Except during summer, the rubber dams remain in the deflated position.

The Yellow Creek diversion dam directs 60 cfs through a 54-inch Reinforced Concrete Pipe (RCP) conduit. The RCP is buried under a newly constructed access road that extends to Highway 70. Downstream of Yellow Creek the pipe is buried along shoulder of Highway 70 for approximately 6,900 feet to the confluence of Chips Creek.

The Chips Creek diversion dam directs 20 cfs through a 18-inch RCP which is buried for a distance of about 740 feet along the east bank of Chips Creek. The Yellow Creek and Chips Creek RCPs join at a tie-in structure at Highway 70. The combined 80 cfs is conveyed in 60-inch Black Steel Pipe (BSP) that is attached to the Chips Creek Bridge over Chips Creek and transitions back into 60-inch RCP for a distance of 7,893 feet to the top of Rock Creek Dam. The conduit then transitions back to 60-inch BSP and is connected with rock anchors to the steep rock face on the southwest side of the dam for 155 feet to discharge through a manually operated butterfly valve to the Rock Creek Reach.

The design and costs associated with the Yellow Creek temporary access road as well as the bolted steel pipe and stair tower down to the toe of Rock Creek Dam were derived from the 2005 Black and Veatch Summary Report (North Fork Feather River Yellow Creek Diversion Cooling Water Pipeline Feasibility Report, 2005)

List of Figures:

- Plan view: Yellow and Chips Creek Diversion to Rock Creek Dam
- Profile: Yellow and Chips Creek Diversion to Rock Creek Dam

Key Design or Construction Uncertainties Requiring Further Study:

- Attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek could make the existing structure unstable and will require further study.
- Connecting 155 LF of 60-inch Black Steel Pipe to the steep rock face at the dam requires further study.

Discussion: None

COST ESTIMATE FOR YELLOW CREEK/ CHIPS CREEK BYPASS TO ROCK CREEK DAM				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
YELLOW CREEK RUBBER DAM AND INTAKE				
3' high and 40' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$850,000	$850,000
		Sub Total Yellow Creek Dam		**$850,000**
Access Road (710-feet along west bank of Yellow Creek)				
Sediment and Erosion Control (Silt Fence)	740	LF	$5	$3,744
Clearing (including Trees), Dozer 300 HP	1809	SY	$6	$10,819
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	547	CY	$13	$7,365
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	547	CY	$38	$21,033
Concrete for Retaining Wall Footings	30	CY	$1,900	$58,139
Steel Galv. Retaining Wall Posts, 8-Foot	11	EACH	$80	$923
Treated Wood for Retaining Wall	22080	BF	$12	$260,958
Fill, 1/2 to 3/4" Crushed Rock	532	CY	$47	$25,098
Fill, Road Surface Gravel	171	CY	$36	$6,209
24" CMP, corrugated 14 ga.	20	LF	$50	$1,009
Triple span, 1 lane bridge over Yellow Creek	1	LS	$340,000	$340,000
		Sub total access road + bridge		**$735,000**
54" Pipe From Yellow Creek Dam to south side of Hwy 70 at confluence with NFFR				
54-inch Reinforced Concrete Pipe, Class 3	1400	LF	$230	$322,000
1/2 CY bucket wheel mounted front end loader, min haul	3354	CY	$16	$53,295
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	3354	CY	$27	$89,216
Backfill, 6" layers, roller compaction operator walking	1167	CY	$44	$51,091
Pipe bedding, crushed rock, 1/2" to 3/4"	1685	CY	$48	$81,352
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	4083	CY	$12	$48,996
Precast Storm Drain Manhole, 5' I.D., 8' Deep	4	EACH	$3,000	$11,176
Concrete Encasement Under Hwy 70	65	CY	$1,100	$73,118
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	100	SY	$120	$12,044
Sawcut Asphalt, 4" Thick	122	LF	$2	$284
Pavement Removal, Bituminous Roads 4" to 6"	396	SF	$8	$3,073
Pavement Replacement Over Trench, 4" Thick	396	SF	$35	$13,963
Traffic Control	1	EACH	$5,000	$5,000
		Sub total		**$765,000**

54" Pipe From south side of Hwy 70 at confluence with NFFR to tie in at Chips Creek				
Clearing, medium	1	ACRE	$1,400	$1,400
54-inch Reinforced Concrete Pipe, Class 3	6913	LF	$230	$1,589,990
1/2 CY bucket wheel mounted front end loader, min haul	16562	CY	$16	$263,170
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	16562	CY	$27	$440,549
Backfill, 6" layers, roller compaction operator walking	5761	CY	$44	$252,217
Pipe bedding, crushed rock, 1/2" to 3/4"	8319	CY	$48	$401,641
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	20163	CY	$12	$241,956
Remove Gravel shoulder	1874	SY	$7	$12,481
Replace Gravel shoulder	625	CY	$48	$30,175
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	9471	SY	$120	$1,140,687
Sediment and Erosion Control (Silt Fence)	6913	LF	$5	$34,980
Remove and reset existing corrugated metal guard rail (includes all guard rail on 70)	12940	LF	$35	$449,277
Precast Storm Drain Manhole, 5' I.D., 8' Deep	20	EACH	$3,000	$60,000
Traffic control, signage (includes traffic cont. down to dam)	1	LS	$30,000	$30,000
Traffic control, 2 signals (includes traffic cont. down to dam)	1	LS	$380,000	$380,000
		Sub total		**$5,329,000**
CHIPS CREEK RUBBER DAM AND INTAKE				
3' high and 40' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$850,000	$850,000
		Sub Total Chips Creek Dam		**$850,000**
Chips Creek Dam to tie in at Hwy 70				
18-inch Reinforced Concrete Pipe, Class 3	740	LF	$37	$27,698
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	925	CY	$12	$11,100
1/2 CY bucket wheel mounted front end loader, min haul	638	CY	$16	$10,138
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	638	CY	$27	$16,971
Pipe bedding, crushed rock, 1/2" to 3/4"	420	CY	$48	$20,278
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	790	CY	$3	$2,394
Precast Storm Drain Manhole, 5' I.D., 8' Deep	2	EACH	$3,000	$6,000
Excavate and load on truck, bank measure. Bucket drag line 3/4 CY, sand & gravel	397	CY	$4	$1,632
Temporary road, gravel fill, no surfacing, 6" gravel depth (10' wide)	794	SY	$11	$8,790
Hand grade select gravel, including compaction, 6" deep (10' wide)	794	SY	$3	$2,453
Concrete Encasement Under Hwy 70	39	CY	$1,100	$43,871
Sawcut Asphalt, 4" Thick	80	LF	$2	$186
Pavement Removal, Bituminous Roads 4" to 6"	240	SF	$8	$1,862
Pavement Replacement Over Trench, 4" Thick	240	SF	$35	$8,462
Traffic Control	1	EACH	$5,000	$5,000

Tie in structure, 18" and 54" RCP in, 60" RCP out	1	LS	$5,000	$5,000
		Sub Total		**$172,000**
Tie in at Hwy 70 to top of Rock Creek Dam				
Clearing, medium	1	ACRE	$1,400	$1,400
60-inch Reinforced Concrete Pipe, Class 3	7893	LF	$279	$2,200,963
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	28576	CY	$12	$342,912
1/2 CY bucket wheel mounted front end loader, min haul	24289	CY	$16	$385,952
Backfill, 6" layers, roller compaction operator walking	7455	CY	$44	$326,380
Pipe bedding, crushed rock, 1/2" to 3/4"	11421	CY	$48	$551,406
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	24289	CY	$27	$646,087
Precast Storm Drain Manhole, 6' I.D., 8' Deep	34	EACH	$4,000	$136,000
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	11690	SY	$120	$1,407,944
Remove Gravel shoulder	2140	SY	$7	$14,252
Replace Gravel shoulder	713	CY	$48	$34,424
Sediment and Erosion Control (Silt Fence)	7893	LF	$5	$39,939
		Sub Total		**$6,088,000**

Top of Rock Creek Dam to Outlet				
60" black steel pipe	155	LF	$572	$88,660
Rock excavation, drill and blast	11	CY	$128	$1,412
Drill rock anchor bolts	494	LF	$29	$14,143
Install rock anchor bolts	480	LF	$25	$12,154
Anchor rings	5	EACH	$800	$4,000
Stair tower (Down to base of dam)	1	LS	$224,000	224,000
66-inch hydraulic operated butterfly valve	1	LS	$66,000	$66,000
		Sub total		**$410,000**

Indian Creek Crossing				
Cast in place 10.5'W x 1.5'H x 16'L Reinforced Concrete Box Culvert	8	CY	$2,770	$22,160
Cast in place culvert transitions to 54" pipe	3	CY	$2,770	$8,310
Structural excavation	84	CY	$46	$3,864
1/2 CY bucket wheel mounted front end loader, min haul	97	CY	$16	$1,541
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	97	CY	$27	$2,580
Backfill and roller compaction operator walking	9	CY	$44	$394
Remove Gravel shoulder	6	SY	$7	$40
Replace Gravel shoulder	2	CY	$48	$97
Bedding, crushed rock, 1/2" to 3/4"	7	CY	$49	$345
Clearing	1	LS	$500	$500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	28	SY	$120	$3,372
		Sub total		**$43,000**

Various Small Culverts (3) Upstream of Chips Tie-In				
Cast in place 10.5'W x 1.5'H x 6'L Reinforced Concrete Box Culverts	9	CY	$2,770	$24,930
Cast in place culvert transitions to pipe	9	CY	$2,770	$24,930
Structural excavation	148	CY	$46	$6,808
1/2 CY bucket wheel mounted front end loader, min haul	170	CY	$16	$2,701
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	170	CY	$27	$4,522
Backfill and roller compaction operator walking	16	CY	$44	$700
Remove Gravel shoulder	11.5	SY	$7	$77
Replace Gravel shoulder	4	CY	$48	$193
Bedding, crushed rock, 1/2" to 3/4"	12	CY	$49	$591
Clearing	1	LS	$1,500	$1,500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	47.8	SY	$120	$5,757
		Sub total		**$73,000**

Chips Creek Crossing				
60" black steel pipe	130	LF	$572	$74,360
Concrete pier footing, piers, pier caps and abutments	19	CY	$1,800	$33,558
Pier and abutment excavation	18	CY	$46	$828
Structural steel	12	TONS	$3,200	$38,400
Structural steel, pier supports	3	TONS	$4,300	$12,900
Steel, anchor rings	5	EACH	$800	$4,000
Sediment and Erosion Control (Silt Fence)	130	LF	$5	$658
Clearing	1	LS	$500	$500
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	43	CY	$12	$516
Backfill, 6" layers, roller compaction operator walking	18	CY	$44	$788
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	18	SY	$120	$2,168
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	38	CY	$27	$1,011
Remove Gravel shoulder	3	SY	$7	$20
Replace Gravel shoulder	1	CY	$48	$48
Bedding, crushed rock, 1/2" to 3/4"	17	CY	$48	$821
		Sub total		**$171,000**

Paul's and Murphy's Creek Crossing (downstream of Chips Creek Tie-In)				
Cast in place 13'W x 1.5'H x 9'L Reinforced Concrete Box Culverts	11	CY	$2,770	$30,470
Cast in place culvert transitions to pipe	7	CY	$2,770	$19,390
Structural excavation	149	CY	$46	$6,854
1/2 CY bucket wheel mounted front end loader, min haul	171	CY	$16	$2,717
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	171	CY	$27	$4,549
Backfill and roller compaction operator walking	15	CY	$44	$657
Remove Gravel shoulder	9	SY	$7	$60
Replace Gravel shoulder	3	CY	$48	$145
Bedding, crushed rock, 1/2" to 3/4"	12	CY	$48	$579

Clearing	1	LS	$1,000	$1,000
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	39	SY	$120	$4,697
		Sub total		**$71,000**

Various Small Culverts (2) Downstream of Chips Tie-In				
Cast in place 13'W x 1.5'H x 6'L Reinforced Concrete Box Culverts	7.4	CY	$2,770	$20,498
Cast in place culvert transitions to pipe	7.4	CY	$2,770	$20,498
Structural excavation	122	CY	$46	$5,612
1/2 CY bucket wheel mounted front end loader, min haul	140	CY	$16	$2,225
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	140	CY	$27	$3,724
Backfill and roller compaction operator walking	13	CY	$44	$569
Remove Gravel shoulder	8	SY	$7	$53
Replace Gravel shoulder	3	CY	$48	$145
Bedding, crushed rock, 1/2" to 3/4"	10	CY	$49	$493
Clearing	1	LS	$1,500	$1,500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	32	SY	$120	$3,854
		Sub total		**$59,000**
Mobilization / Demobilization				
Dozer, above 150 HP (3)	1	LS	$3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	$9,600	$9,600
Loader (2)	1	LS	$2,400	$2,400
Dump truck, 26 tons (10)	1	LS	$6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	$2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	$700	$700
Grader, 30,000 lbs (2)	1	LS	$2,400	$2,400
Grout pumper (1)	1	LS	$600	$600
Water truck, 6000 gal (2)	1	LS	$1,200	$1,200
Wash & Screen (1)	1	LS	$7,200	$7,200
		Sub total		**$36,000**
		Total		**$15,652,000**

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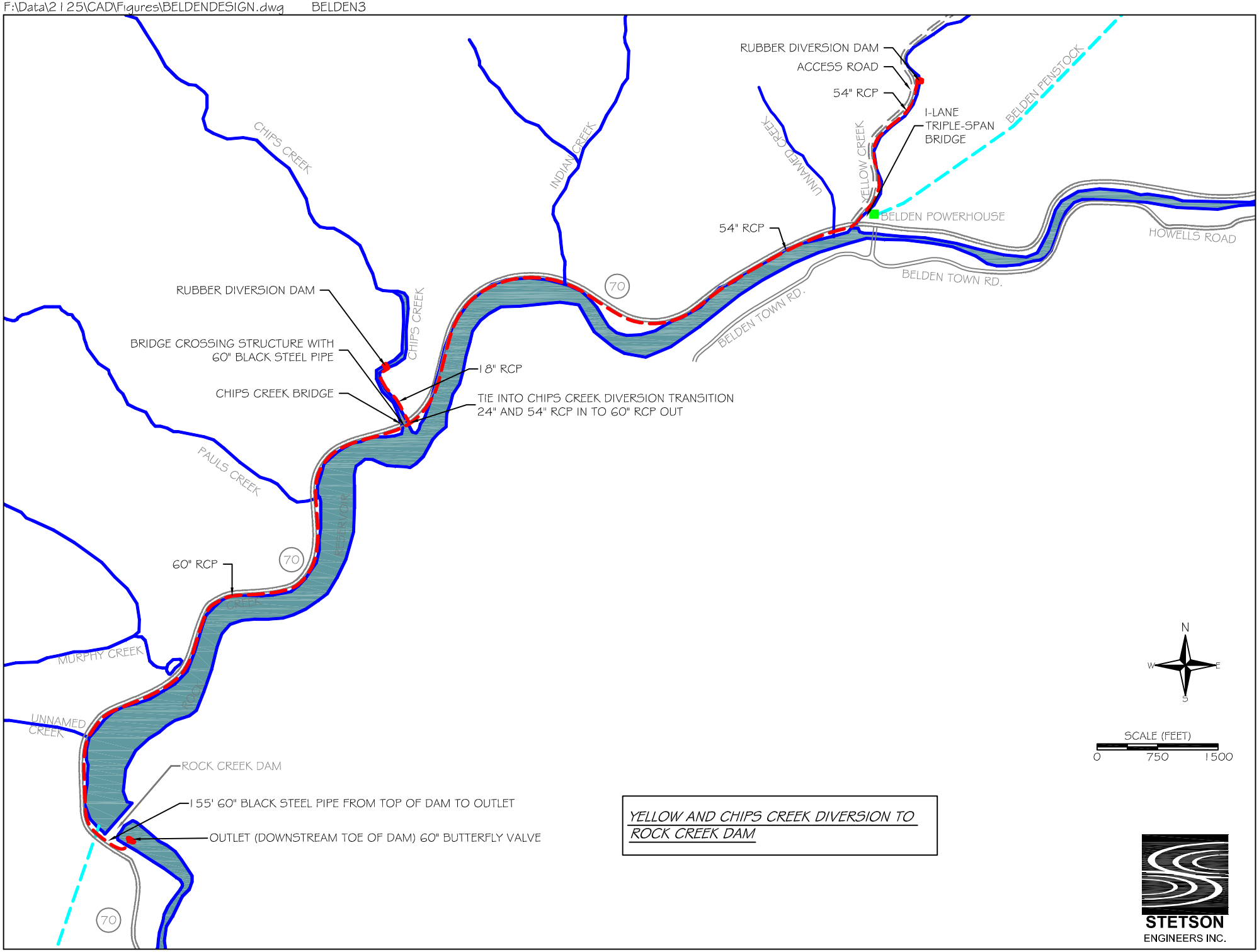

YELLOW AND CHIPS CREEK DIVERSION TO ROCK CREEK DAM

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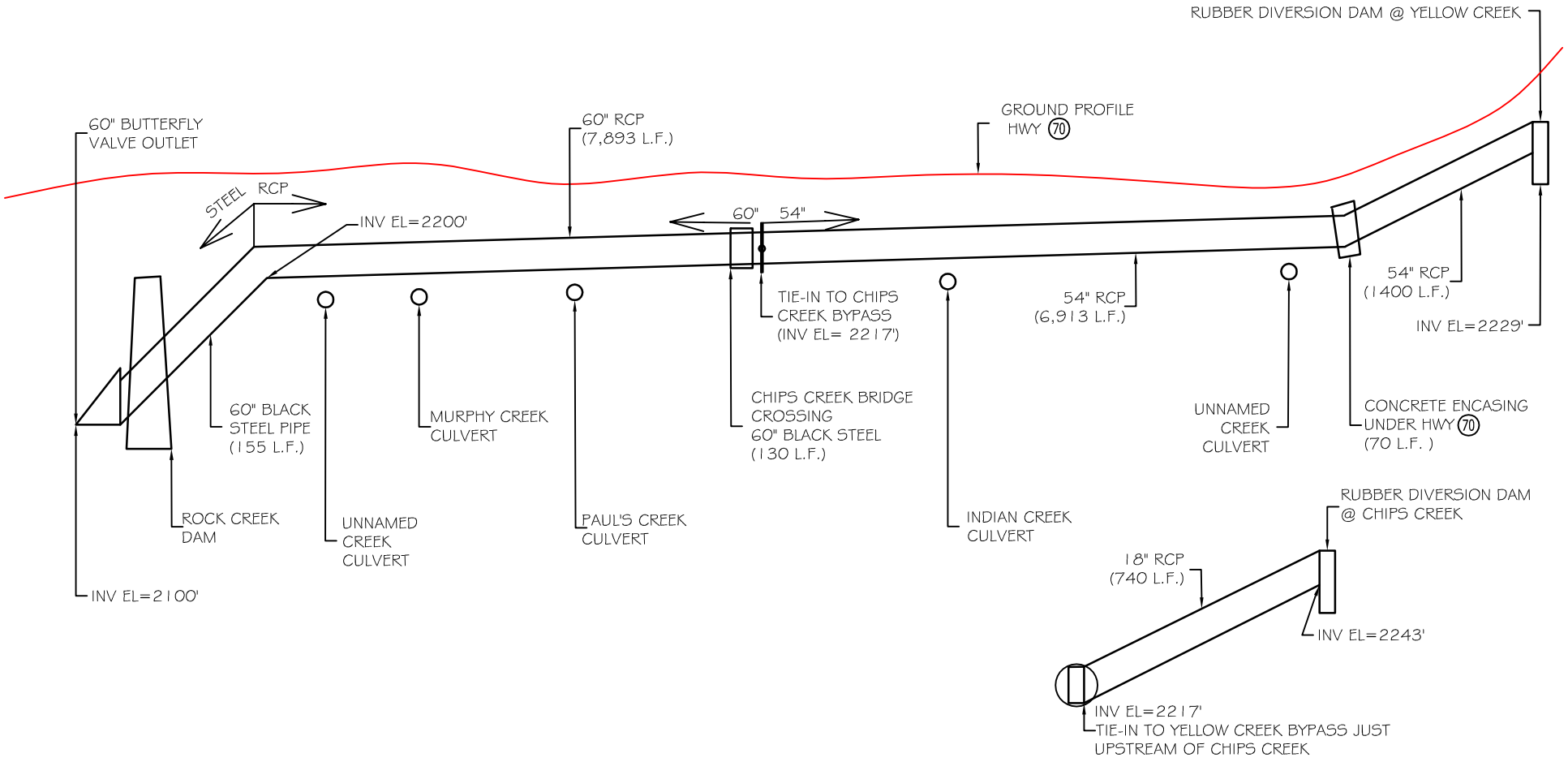
YELLOW AND CHIPS DIVERSION TO ROCK CREEK DAM



Measure Name: Divert Cool Lower Belden Reach and Yellow Creek Flows and Convey by Conduits to an Appropriate Plunging Location and Dredge a Submerged Channel in Rock Creek Reservoir

Applicable Alternative Category(s): 5a; additional measure for Rock Creek Reach

Description of Measure: Construct conduits to convey cool lower Belden Reach and Yellow Creek flows directly to a plunging location in Rock Creek Reservoir, bypassing the Belden PH discharge. The purpose of this measure is to avoid mixing cool lower Belden Reach and Yellow Creek flows with warmer discharges from the Belden PH during operating hours and minimize mixing with warmer ambient waters near the surface of Rock Creek Reservoir. Field observations in Rock Creek Reservoir during the 2006 NFFR special test conducted by PG&E indicate very little thermal stratification in Rock Creek Reservoir suggesting that dredging a channel along the bottom is required to facilitate the transport of cool water through the reservoir.

Description of Operations: This measure does not affect PH operations. At the lower Belden Reach dam, divert 140 cfs of cool lower Belden Reach flows and spill the remaining flow over the dam. The flow accretion along the Belden Reach, including inflows from East Branch NFFR, would maintain flows for aquatic habitat in the stream over the short distance between the diversion dam and the Yellow Creek/Belden PH confluence. At the Yellow Creek dam, divert 60 cfs of cool Yellow Creek flows and spill about 10 cfs to maintain flows for aquatic habitat in the stream over the short distance between the diversion dam and the NFFR/Belden PH confluence.

Detailed Description of Facilities Improvements and Design Criteria:
Construct two inflatable/deflatable rubber diversions dams; one on lower Belden Reach and another on Yellow Creek. On lower Belden Reach construct a 3-foot high rubber about 2,220 feet upstream of the Yellow Creek confluence and the Belden PH. On Yellow Creek, construct a 3-foot high rubber about 1,400 feet upstream of the Belden PH. Except during summer, the rubber dams remain in the deflated position.

The lower Belden Reach diversion dam directs 140 cfs through a 6’ x 3’ Reinforced Concrete Box (RCB) that is constructed in the NFFR channel. The Yellow Creek diversion dam directs 60 cfs through a 36-inch Reinforced Concrete Pipe (RCP) constructed along the bank. Near the NFFR/Yellow Creek confluence, the RCB and RCP join at a tie-in structure. The combined 200 cfs is conveyed about 7,100 feet through a 78-inch HDPE anchored to the bottom of the reservoir to a submerged discharge point near the confluence with Chips Creek. A submerged diffuser outlet is installed at the end of the pipeline to distribute the discharge in a larger cross sectional area for the purpose of reducing discharge velocity, turbulence, and mixing potential. Dredge a submerged channel a distance of about 7,000 feet along the bottom of the reservoir to a point near the low level outlet at Rock Creek Dam.

List of Figures:

- Plan view: Yellow Creek and Lower Belden Reach (NFFR) to Rock Creek Reservoir Plunging
- Profile: Yellow Creek / Belden Reach (NFFR) to Rock Creek Reservoir Plunging

Key Design or Construction Uncertainties Requiring Further Study:

- Dredging the reservoir bottom may require removing large boulders which could be difficult and costly.
- The dredged conveyance channel at the bottom of Rock Creek Reservoir will likely fill with sediment and will require repeated dredging.
- The effectiveness of cold water transport by a dredged channel in Rock Creek Reservoir requires further study.
- Setting a 78-inch HDPE along the bottom of Rock Creek Reservoir will 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 further study.
- Installing a 6’ x 3’ reinforced concrete box culvert inside the channel along the north bank of the NFFR will be difficult and costly due to boulders and water in the channel.

Discussion:

The location of the lower Belden Reach dam assumes that the measure to divert and convey warm East Branch NFFR flows to upper Rock Creek Reservoir is implemented. If it is not implemented, then the lower Belden Reach diversion dam needs to be located above the confluence of East Branch NFFR.

COST ESTIMATE FOR LOWER BELDEN REACH / YELLOW CREEK BYPASS TO PLUNGING				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
YELLOW CREEK RUBBER DAM AND INTAKE				
3' high and 71' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$1,510,000	$1,510,000
		Sub Total Yellow Creek Dam		**$1,510,000**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE				
Mobilization				
Mobilization	1	LS	$9,700	$9,700
Site Clearing and Excavation				
Site Clearing	1	LS	$1,200	$1,200
Excavation Inside Channel	150	CY	$24	$3,532
Rubber Diversion Dam				
Concrete for Foundation	50	CY	$1,200	$60,000
Anchor Bolts	1	LS	$1,200	$1,200
Rubber Dam with Controls (3-foot diameter)	1	LS	$259,000	$259,000
Installation of Rubber Dam and Controls	1	LS	$24,000	$24,000
Installation Advisor for Rubber Dam and Controls	1	LS	$12,000	$12,000
Turnout Structure				
Excavation	300	CY	$24	$7,065
Concrete	40	CY	$1,800	$72,000
6'W X 3'H Canal Control Gate	1	LS	$5,000	$5,000
Handrail	1	LS	$600	$600
8-inch Diameter Vent Pipe, HDPE	1	LS	$400	$400
Access Hatch	1	LS	$600	$600
Precast Concrete Steps	1	LS	$600	$600
Trash Rack	1	LS	$5,900	$5,900
Cleanup and Demobilization				
Cleanup and Demobilization	1	LS	$9,700	$9,700
		Sub Total NF Feather River Dam		**$472,000**
Access Road (710-feet along west bank of Yellow Creek)				

Sediment and Erosion Control (Silt Fence)	740	LF	$5	$3,744
Clearing (including Trees), Dozer 300 HP	1809	SY	$6	$10,819
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	547	CY	$13	$7,365
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	547	CY	$38	$21,033
Concrete for Retaining Wall Footings	30	CY	$1,900	$57,000
Steel Galv. Retaining Wall Posts, 8-Foot	11	EACH	$84	$923
Treated Wood for Retaining Wall	22080	BF	$12	$260,958
Fill, 1/2 to 3/4" Crushed Rock	532	CY	$47	$25,098
Fill, Road Surface Gravel	171	CY	$36	$6,209
24" CMP, corrugated 14 ga.	20	LF	$50	$1,009
Triple span, 1 lane bridge over Yellow Creek	1	LS	$344,000	$344,000
		Sub total access road		**$738,000**
36" Pipe From Dam to Tie In at Confluence of Yellow Creek and NF Feather River				
36-inch Reinforced Concrete Pipe, Class 3	1370	LF	$104	$142,699
1/2 CY bucket wheel mounted front end loader, min haul	2566	CY	$16	$40,774
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	2566	CY	$27	$68,256
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	1541	CY	$3	$4,669
Pipe bedding, crushed rock, 1/2" to 3/4"	1541	CY	$48	$74,399
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	2231	CY	$12	$26,772
Precast Storm Drain Manhole, 4' I.D., 8' Deep	4	EACH	$1,900	$7,600
Concrete Encasement Under Hwy 70	43	CY	$1,125	$48,370
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	100	SY	$120	$12,044
Tie in Structure (36"RCP & 6'x3' RCB in / 78" HDPE out)	1	LS	$6,000	$6,000
Sawcut Asphalt, 4" Thick	122	LF	$2	$284
Pavement Removal, Bituminous Roads 4" to 6"	396	SF	$8	$3,073
Pavement Replacement Over Trench, 4" Thick	396	SF	$35	$13,963
Traffic Control	1	EACH	$5,000	$5,000
		Sub total 36" pipe		**$454,000**
6' x 3' RCB From NF Feather River Dam to Tie In				
6' x 3' Reinforced Concrete Box	2222	LF	$347	$771,478
1/2 CY bucket wheel mounted front end loader, min haul	3408	CY	$16	$54,153
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	3408	CY	$27	$90,653
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	2963	CY	$26	$75,942
		Sub total 6' x 3' RCB		**$992,000**
78-Inch HDPE From Tie In to Chips Creek (With Dredging to Dam)				

78-Inch HDPE From Tie In to Chips Creek	7100	LF	$500	$3,550,000
HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	$1,700,000	$1,700,000
Mechanical Dredging, barge mounted, clamshell, hopper dumped	130256	CY	$13	$1,667,277
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	117200	SF	$39	$4,570,800
Furnish and place topsoil, truck dumped, screened, 4" deep	39067	SY	$4	$151,580
Fine grading with seeding inc lime, fertilizer & seed w/ equip.	351600	SF	$6	$2,271,336
Concrete Outlet Diffuser Structure, Structure Pad and Rock Cover	1	LS	$15,000	$15,000
		Sub total 7' x 4' RCB		**$13,926,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	$3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	$9,600	$9,600
Loader (2)	1	LS	$2,400	$2,400
Paver Mobilization	1	LS	$1,200	$1,200
Grout pumper (1)	1	LS	$600	$600
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	$200,000	$200,000
		Sub total Mob / Demob		**$217,000**
			TOTAL	**$18,309,000**

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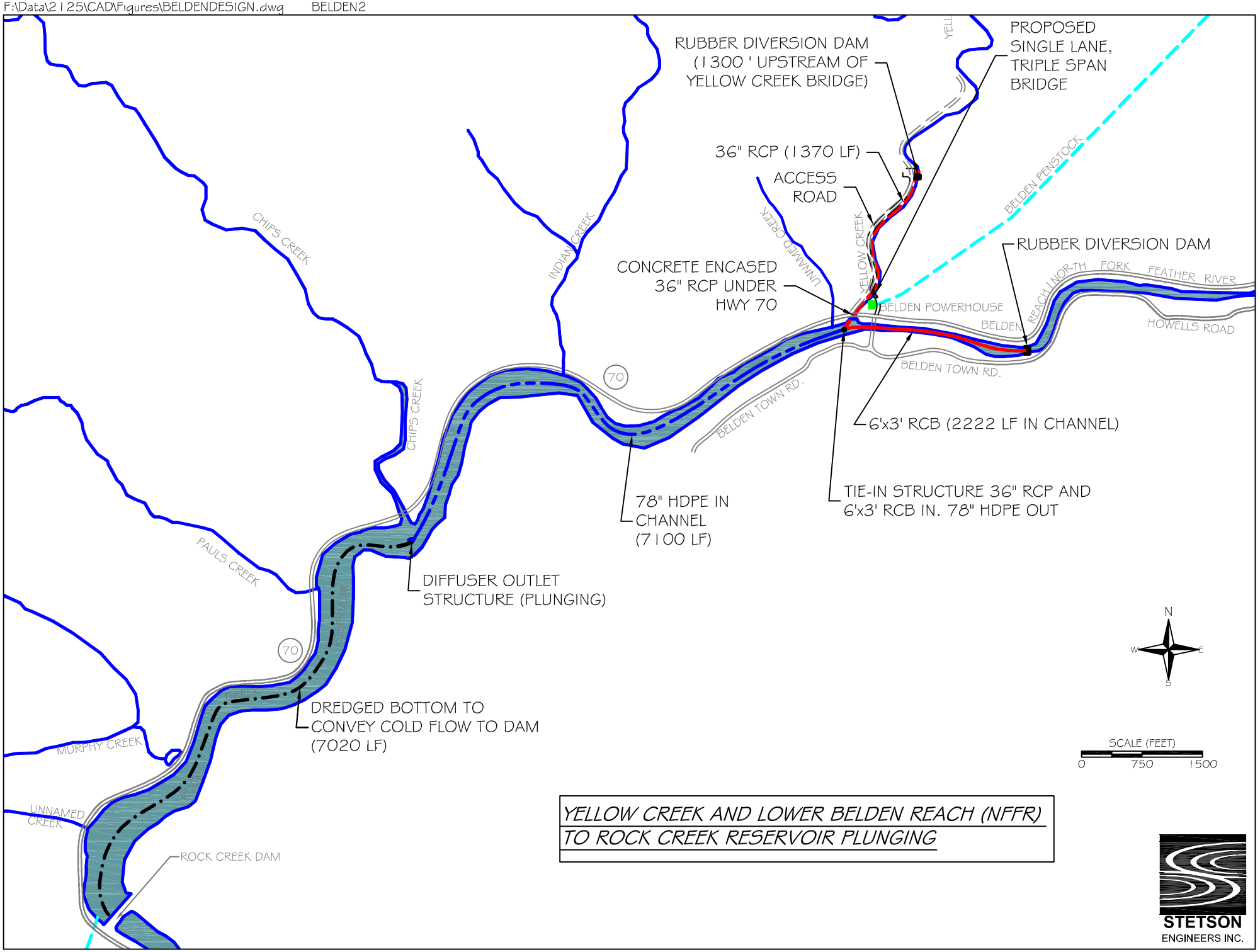

YELLOW CREEK AND LOWER BELDEN REACH (NFFR)
TO ROCK CREEK RESERVOIR PLUNGING

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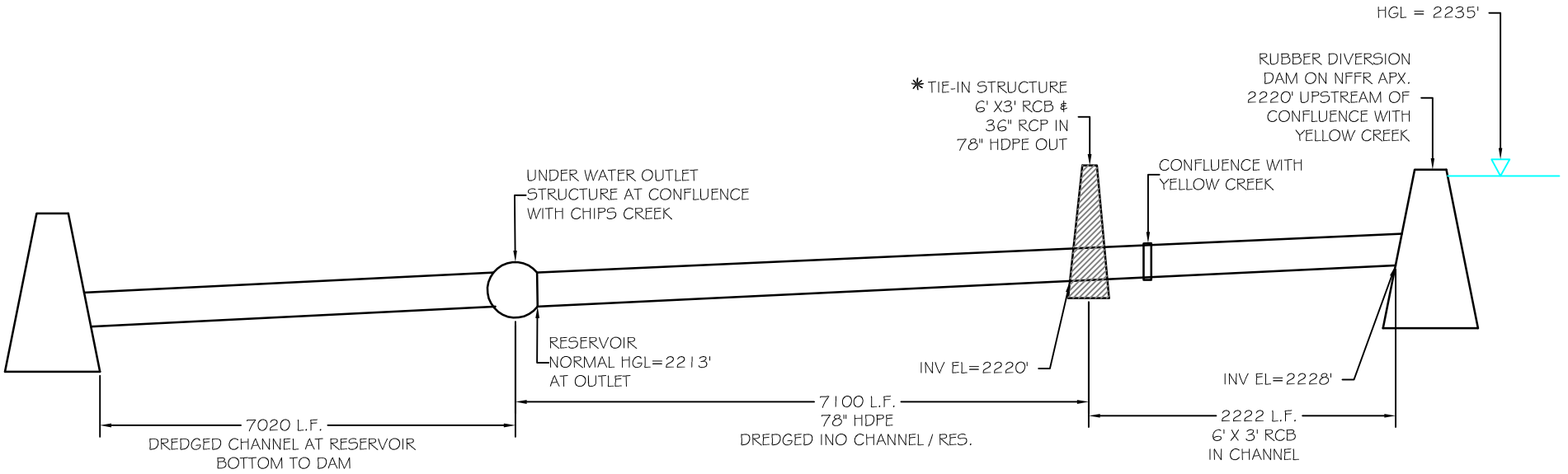
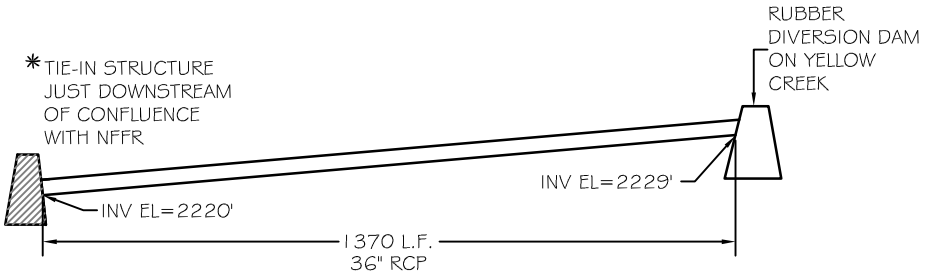
YELLOW CREEK / BELDEN REACH (NFFR) TO ROCK CREEK RESERVOIR PLUNGING





Measure Name: Divert Cool Lower Belden Reach Flows into a Pipeline to Discharge below Rock Creek Dam

Applicable Alternative Category(s): 6a

Description of Measure: Construct about 3-mile long pipeline to convey cool lower Belden Reach flows to discharge below Rock Creek Dam directly, bypassing Rock Creek Reservoir. The purpose of this measure is to avoid mixing cool lower Belden Reach flows with warmer discharges from the Belden PH during operational hours and avoid mixing with warmer ambient waters near the surface of Rock Creek Reservoir.

Description of Operations: This measure does not affect PH operations. Operate the diversion system to convey about 250 cfs through the pipeline and spill the remaining flow over the dam. The diversion rate is supplied by the increased release measure from Belden Dam. The flow accretion along the Belden Reach, including inflows from East Branch NFFR, would maintain flows for aquatic habitat in the short reach from the diversion dam to the Yellow Creek/Belden PH confluence.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 3-foot high inflatable/deflatable rubber diversion dam at the lower end of the Belden Reach just upstream of the Yellow Creek/Belden PH confluence. Except during summer, the rubber dam would remain in the deflated position. Construct an approximately 3 mile long pipeline to convey the cool Seneca Reach flows captured behind the dam to discharge below Rock Creek Dam.

The pipeline starts at the diversion dam and extends about 3 miles to below Rock Creek Dam. The first segment of the pipeline consists of about 500-feet of 66-inch reinforced concrete pipe (RCP) buried into the river bank and covered with riprap. Downstream of the Yellow Creek/Belden PH confluence, the pipe is buried along the shoulder of Highway 70 for approximately 14,650 feet along the north bank of the NFFR, crossing over various existing culverts to the top of Rock Creek Dam. The pipe then transitions to 66-inch Black Steel Pipe (BSP) and is bolted with rock anchors to the steep rock face on the southwest side of the dam for 155 feet to discharges through a manually operated butterfly value into the Rock Creek Reach.

List of Figures:
- Plan view: Belden Reach (NFFR) to Rock Creek Dam
- Profile: Belden Reach (NFFR) Diversion to Rock Creek Dam
- Detail: Belden Reach (NFFR), Pipe Bridge Detail at Chips Creek
- Detail: Belden Reach (NFFR), Pipeline and Culvert Details

Key Design or Construction Uncertainties Requiring Further Study:
- Attaching a bridge crossing structure and steel pipeline to the existing Highway 70 bridge over Chips Creek could make the existing structure unstable and will require further study.

- 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 will be difficult and costly due to boulders and water in the channel.
- Connecting 155 LF of 66-inch Black Steel Pipe to the steep rock face at the dam requires further study.

Discussion:
The location of the lower Belden Reach dam assumes that the measure to divert and convey warm East Branch NFFR flows into upper Rock Creek Reservoir is implemented. If it is not implemented, then the lower Belden Reach diversion dam needs to be located above the confluence of East Branch NFFR.

COST ESTIMATE FOR LOWER BELDEN REACH BYPASS TO ROCK CREEK DAM				
OPTION A 250 CFS				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE			**(Rounded)**	
3' high and 71' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$1,510,000	$1,510,000
		Sub Total		**$1,510,000**
66" Pipe From Dam to north bank of NF Feather River,				
66-inch Reinforced Concrete Pipe, Class 3	500	LF	309	$154,500
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	1811	CY	26	$46,416
1/2 CY bucket wheel mounted front end loader, min haul	2083	CY	16	$33,099
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	2083	CY	27	$55,408
Pipe bedding, crushed rock, 1/2" to 3/4"	723	CY	48	$34,906
Backfill, 6" layers, roller compaction operator walking	472	CY	44	$20,664
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	16	SY	120	$1,927
Sediment and Erosion Control (Silt Fence)	500	LF	5	$2,530
Precast Storm Drain Manhole, 6' I.D., 8' Deep	1	EACH	4,300	$4,300
		Sub Total		**$354,000**
66" Pipe from north bank of NF Feather River to SW side of Rock Creek Dam				
66-inch Reinforced Concrete Pipe, Class 3	14654	LF	309	$4,528,086
Clearing, medium	2	ACRE	1,400	$2,800
Backfill, 6" layers, roller compaction operator walking	13593	CY	44	$595,102
Pipe bedding, crushed rock, 1/2" to 3/4"	20826	CY	48	$1,005,479
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	52108	CY	12	$625,296
1/2 CY bucket wheel mounted front end loader, min haul	44292	CY	16	$703,800

Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	44292	CY	27	$1,178,167
Precast Storm Drain Manhole, 6' I.D., 8' Deep	54	EACH	4,300	$232,200
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	21318	SY	120	$2,567,540
Remove Gravel shoulder	3969	SY	7	$26,434
Sediment and Erosion Control (Silt Fence)	14393	LF	5	$72,829
Remove and reset existing corrugated metal guard rail	12940	LF	35	$449,277
Traffic control, signage	1	LS	30,000	$30,000
Traffic control, 2 signals	1	LS	380,000	$380,000
		Sub total		**$12,397,000**
Chips Creek Crossing				
66" black steel pipe	130	LF	629	$81,770
Concrete pier footing, piers, pier caps and abutments	19	CY	1,800	$34,200
Pier and abutment excavation	18	CY	46	$828
Structural steel	12	TONS	3,200	$38,400
Structural steel, pier supports	3	TONS	4,300	$12,900
Steel, anchor rings	5	EACH	800	$4,000
Sediment and Erosion Control (Silt Fence)	130	LF	5	$658
Clearing	1	LS	500	$500
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	43	CY	12	$516
Backfill, 6" layers, roller compaction operator walking	11	CY	44	$482
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	18	SY	120	$2,168
1/2 CY bucket wheel mounted front end loader, min haul	38	CY	16	$604
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	38	CY	27	$1,011
Shoulder repair, crushed rock, 1/2" to 3/4"	1	CY	48	$48
Bedding, crushed rock, 1/2" to 3/4"	17	CY	48	$821
		Sub total		**$179,000**
Paul's and Murphy's Creek Crossing				
Cast in place 15'W x 1.5'H x 9'L Reinforced Concrete Box Culverts	12	CY	2,800	$33,600
Cast in place culvert transitions to pipe	11	CY	2,800	$30,800
Structural excavation	53	CY	46	$2,438
1/2 CY bucket wheel mounted front end loader, min haul	53	CY	16	$842
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	61	CY	27	$1,623
Backfill and roller compaction operator walking	17	CY	44	$744
Shoulder repair, crushed rock, 1/2" to 3/4"	2	CY	48	$97
Bedding, crushed rock, 1/2" to 3/4"	15	CY	48	$724
Clearing	1	LS	1,000	$1,000
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	18	SY	120	$2,168
		Sub total		**$74,000**

Indian Creek Crossing				
Cast in place 15'W x 1.5'H x 16'L Reinforced Concrete Box Culvert	10	CY	2,800	$28,000
Cast in place culvert transitions to pipe	5	CY	2,800	$14,000
Structural excavation	37	CY	46	$1,702
1/2 CY bucket wheel mounted front end loader, min haul	43	CY	16	$683
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	43	CY	27	$1,144
Backfill and roller compaction operator walking	14	CY	44	$613
Shoulder repair, crushed rock, 1/2" to 3/4"	1	CY	48	$48
Bedding, crushed rock, 1/2" to 3/4"	13	CY	49	$641
Clearing	1	LS	500	$500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	18	SY	120	$2,168
		Sub total		**$50,000**
Various Small Culverts (5)				
Cast in place 15'W x 1.5'H x 6'L Reinforced Concrete Box Culverts	20	CY	2,800	$56,000
Cast in place culvert transitions to pipe	25	CY	2,800	$70,000
Structural excavation	109	CY	46	$5,014
1/2 CY bucket wheel mounted front end loader, min haul	125	CY	16	$1,986
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	125	CY	27	$3,325
Backfill and roller compaction operator walking	32	CY	44	$1,401
Shoulder repair, crushed rock, 1/2" to 3/4"	5	CY	48	$241
Bedding, crushed rock, 1/2" to 3/4"	27	CY	49	$1,331
Clearing	1	LS	2,500	$2,500
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	34	SY	120	$4,095
		Sub total		**$146,000**
Top of Rock Creek Dam to Outlet				
66-inch Reinforced Concrete Pipe, Class 3	139	LF	309	$42,951
66" black steel pipe	155	LF	629	$97,495
Backfill, 6" layers, roller compaction operator walking	131	CY	44	$5,735
Pipe bedding, crushed rock, 1/2" to 3/4"	201	CY	48	$9,704
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	503	CY	12	$6,036
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	460	CY	27	$12,236
Rock excavation, drill and blast	11	CY	128	$1,412
Drill rock anchor bolts	494	LF	29	$14,143
Install rock anchor bolts	480	LF	25	$12,154
Anchor rings	5	EACH	805	$4,025
Stair tower (Down to base of dam)	1	LS	224,000	224,000
66-inch hydraulic operated butterfly valve	1	LS	66,000	$66,000
		Sub total		**$496,000**

Mobilization / Demobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grader, 30,000 lbs (2)	1	LS	2,400	$2,400
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (2)	1	LS	1,200	$1,200
Wash & Screen (1)	1	LS	7,000	$7,000
		Sub total		**$36,000**
			(Rounded)	**$15,242,000**

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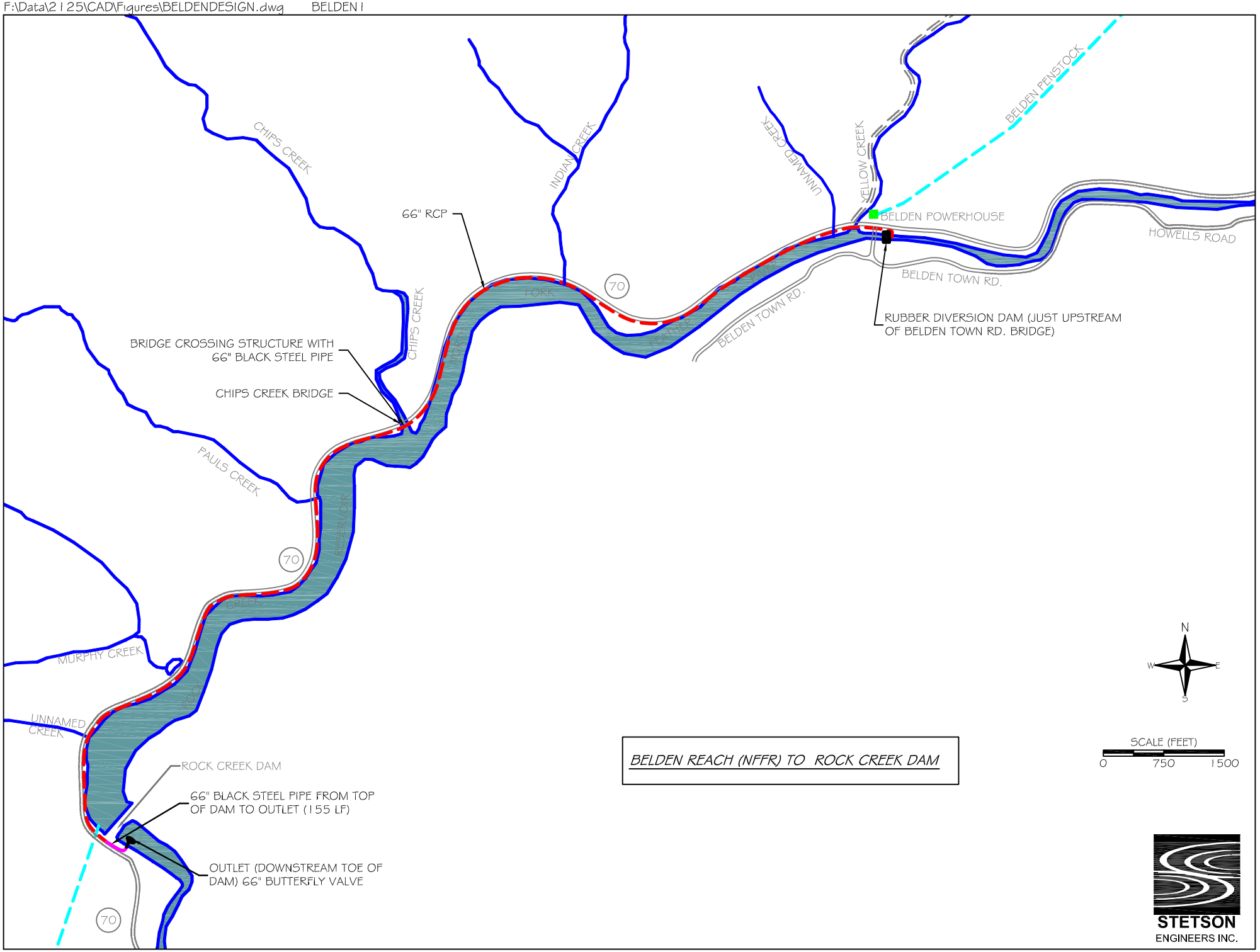

BELDEN REACH (NFFR) TO ROCK CREEK DAM

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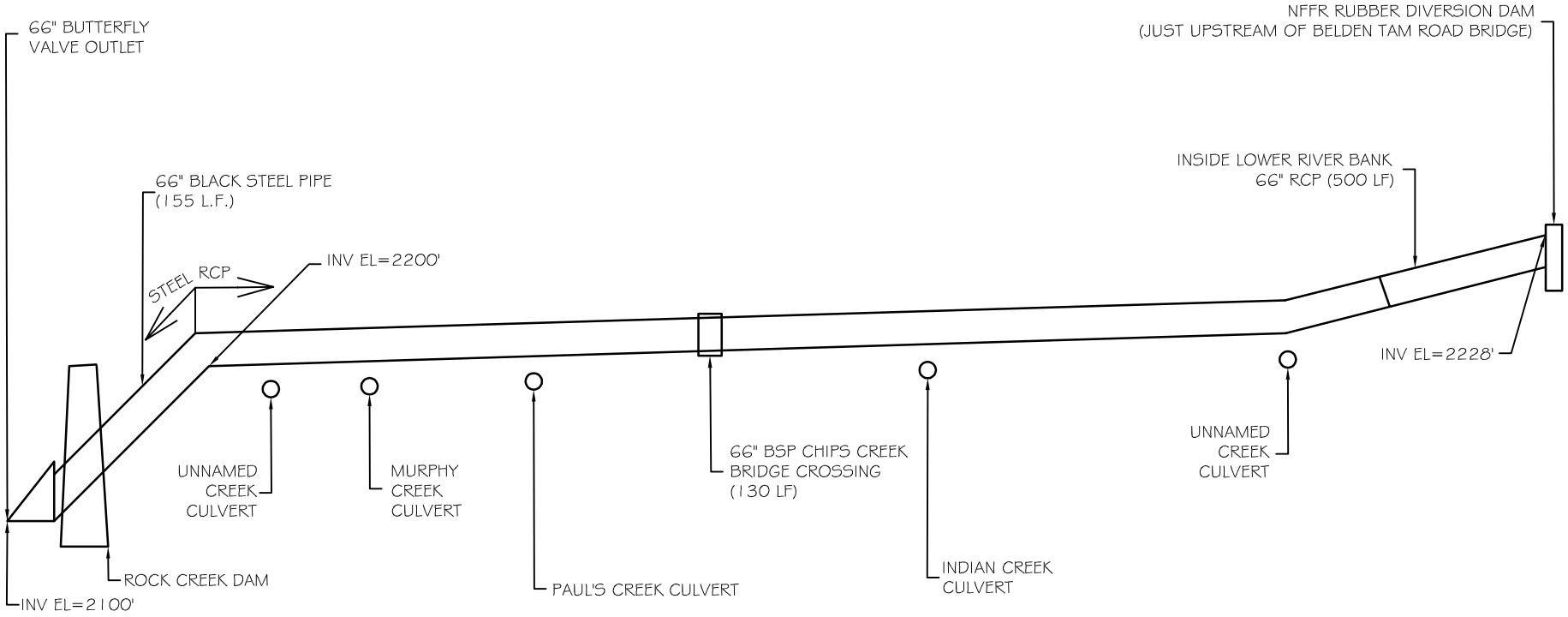
BELDEN REACH (NFFR) DIVERSION TO ROCK CREEK DAM



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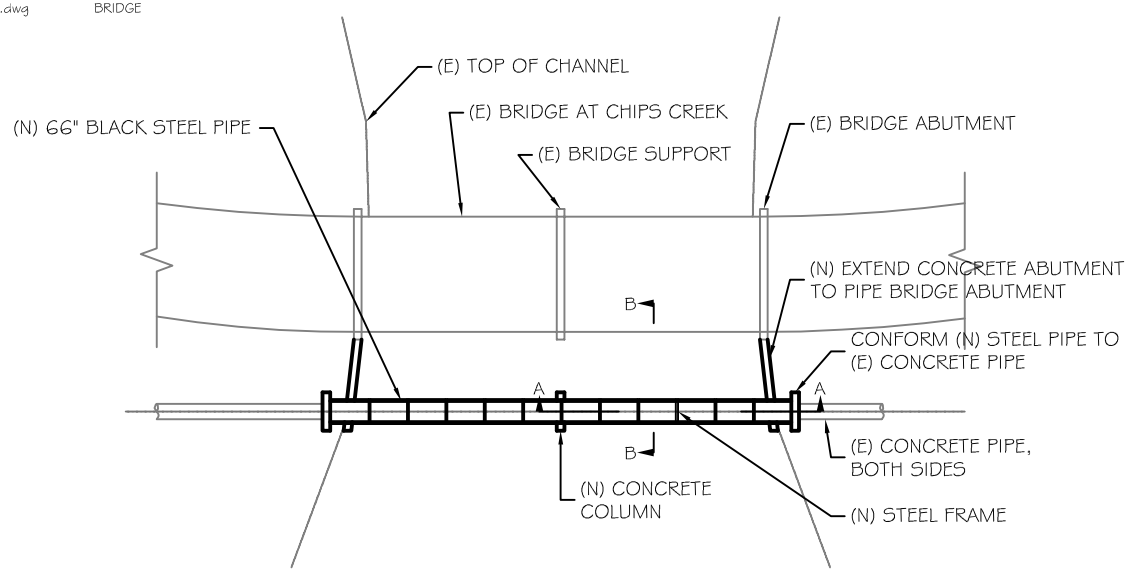
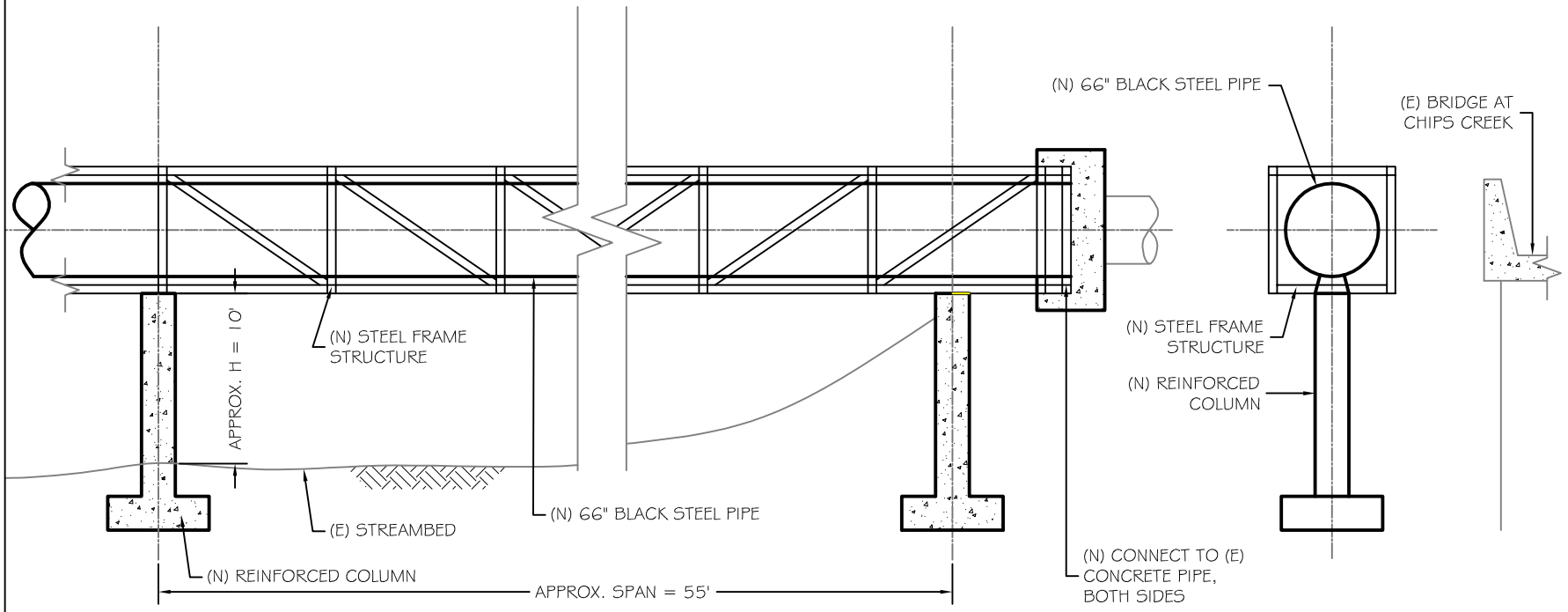
BELDEN REAH (NFFR)
PIPE BRIDGE DETAIL AT CHIPS CREEK

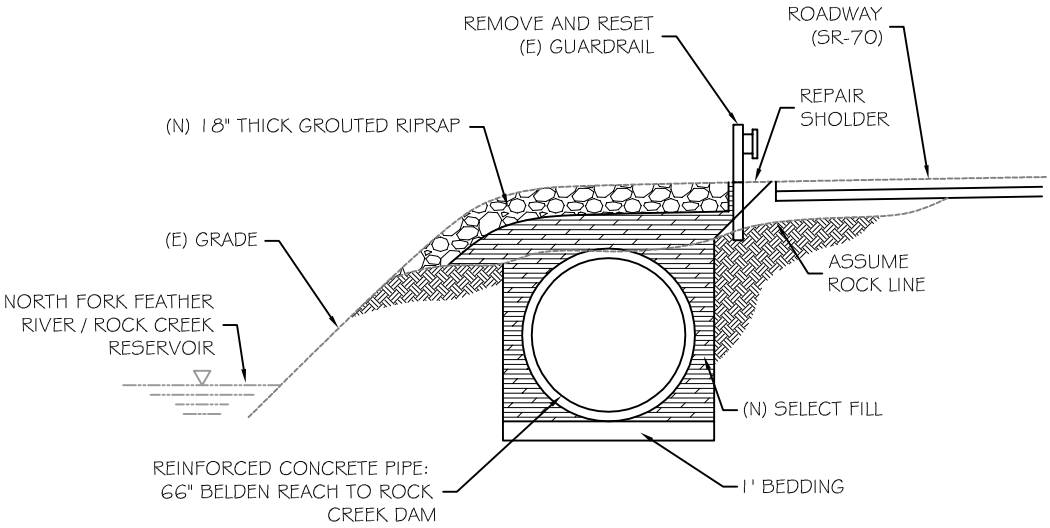


PLAN VIEW AT CHIPS CREEK

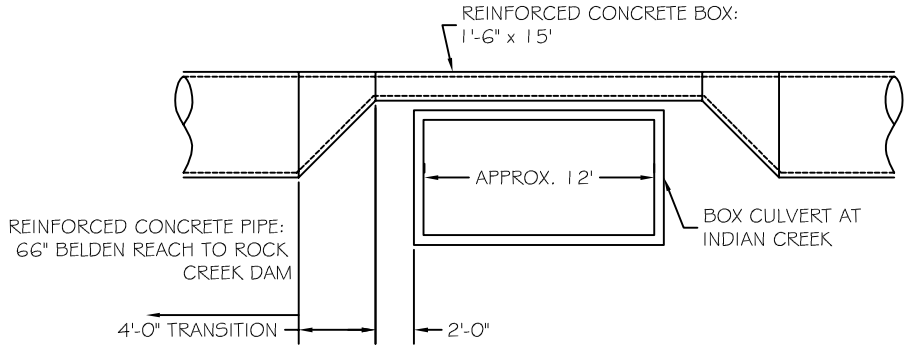


SECTION A-A

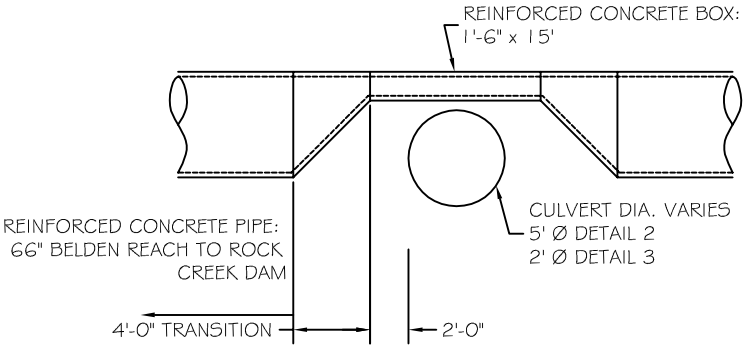
SECTION B-B



TYPICAL PIPELINE SECTION



DETAIL 1



DETAIL 2 & 3

PIPE

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BELDEN REACH (NFFR)
PIPELINE AND CULVERT DETAILS

Measure Name: Convey Cool Bucks Creek PH Flows by a Submerged Pipeline to Discharge at an Appropriate Plunging Location and Dredge a Submerged Channel in Cresta Reservoir

Applicable Alternative Category(s): 4, 5; additional measure for Cresta Reach

Description of Measure: Construct a approximately 2.4-mile long pipeline to convey cool Buck Creek PH flows to an appropriate plunging location in Cresta Reservoir. The purpose of this measure is to avoid mixing with warmer ambient waters of Cresta Reservoir.

Description of Operations: This measure does not affect PH operations. According to PG&E's flow measurements in summer 2002-2004, Bucks Creek PH discharges during July and August ranged from 0 to 260 cfs. The cool water flow needed to reduce water temperatures below Cresta Dam is estimated at about 140 cfs. The design flow rate is 140 cfs, and Bucks Creek PH discharges exceeding 140 are released to the NFFR.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a concrete regulating basin at the outlet of Bucks Creek PH. The regulating basin functions to regulate the powerhouse discharge between the NFFR and the proposed bypass pipeline. The regulating basin has an outlet consisting of a large gate valve connected to a 54-inch RCP bypass pipeline. The regulating basin also has a spillway to control the water level in the basin while releasing PH discharges exceeding the bypass flows to the NFFR.

The 54-inch RCP bypass pipeline extends from the regulating basin outlet structure to discharge below Cresta Dam. The first segment of the RCP extends about 10,050 ft and is buried under a new access road constructed along the south bank of the NFFR. In the second segment the pipeline transitions to 54-inch HDPE and enters Cresta Reservoir. The HDPE is set and anchored along the bottom of Cresta Reservoir for a distance of about 3,000 ft to an appropriate plunging location at the reservoir bottom. A submerged diffuser outlet is placed at the end of the pipeline to distribute the discharge in a larger cross sectional area for the purpose of reducing discharge velocity, turbulence, and mixing potential.

List of Figures:
- Plan view: Bucks Creek PH to Cresta Reservoir Plunging
- Profile: Bucks Creek PH to Cresta Reservoir Plunging Outlet
- Detail: Regulating Basin Detail at Bucks Creek PH

Key Design or Construction Uncertainties Requiring Further Study:
- Siting and designing the regulating basin above the floodplain of the NFFR to avoid flood damage requires further study.
- Setting a 54-inch HDPE along the bottom of Cresta Reservoir will 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 further study.

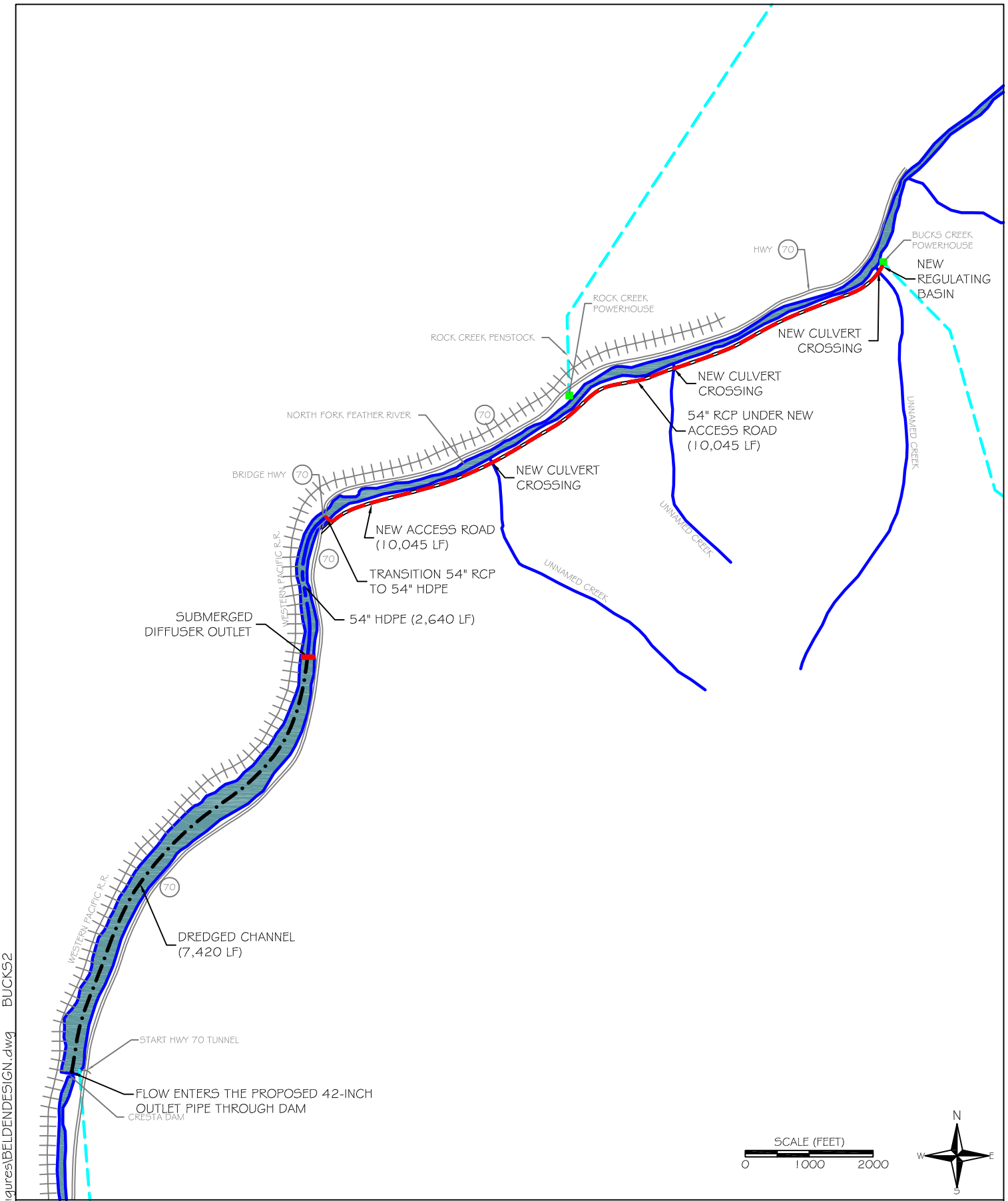
- Microtunneling a 42-inch diameter outlet tunnel through the toe of Cresta Dam will be difficult, costly and time consuming due to the thickness of the concrete at the toe of the dam.
- Dredging the reservoir bottom may require removing large boulders which could be difficult and costly.
- The dredged conveyance channel at the bottom of Cresta Reservoir will likely fill with sediment and will require repeated dredging.
- The effectiveness of cold water transport by a dredged channel in Cresta Reservoir requires further study.

Discussion:

The required cool water flow of 140 cfs from Bucks Creek PH was estimated based on the assumption that the mixing ratio of ambient warm water is 50%.

COST ESTIMATE FOR BUCKS CREEK PH TO CRESTA RESERVOIR PLUNGING				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
Access Road (10,045-feet along south bank of NFFR)				
Sediment and Erosion Control (Silt Fence)	10045	LF	$5	$50,817
Clearing (including Trees), Dozer 300 HP	24556	SY	$6	$146,862
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	7425	CY	$13	$99,976
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	7425	CY	$38	$285,507
Concrete for Retaining Wall Footings	407	CY	$1,900	$773,300
Concrete for Culvert Headwall Structures (6)	16	CY	$1,900	$30,400
Steel Galv. Retaining Wall Posts, 8-Foot	152	EACH	$84	$12,760
Treated Wood for Retaining Wall	299721	BF	$12	$3,542,332
Fill, 1/2 to 3/4" Crushed Rock	7222	CY	$47	$340,707
Fill, Road Surface Gravel	2321	CY	$36	$84,281
24" CMP, corrugated 14 ga.	60	LF	$50	$3,027
		Sub total access road		**$5,370,000**
54" RCP from Bucks Creek Powerhouse to Cresta Reservoir / N Fork Feather River at Hwy 70 Bridge				
Cast in-Place Concrete Inlet / Outlet Structure at Powerhouse	101	CY	$2,800	$282,800
Transition structure, 6' x 3' RCB to 54" RCP	1	LS	$7,000	$7,000
6'W X 3'H Canal Control Gate	1	LS	$6,000	$6,000
54-inch Reinforced Concrete Pipe, Class 3	10045	LF	$226	$3,103,905
Clearing, medium	5	ACRE	$1,400	$7,000
Backfill, 6" layers, roller compaction operator walking	27003	CY	$44	$1,182,191
Pipe bedding, crushed rock, 1/2" to 3/4"	11154	CY	$48	$538,515
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	41616	CY	$12	$499,392
1/2 CY bucket wheel mounted front end loader, min haul	21568	CY	$16	$342,716
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	21568	CY	$27	$573,709
Precast Storm Drain Manhole, 6' I.D., 8' Deep	12	EACH	$4,300	$51,600
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	33	SY	$120	$3,975
Sediment and Erosion Control (Silt Fence)	10045	LF	$5	$50,828
Traffic control, signage	1	LS	$29,000	$29,000
Traffic control, 2 signals	1	LS	$100,000	$100,000
		Sub total		**$6,779,000**
54" HDPE from Hwy 70 Bridge to Tie-In at Toe of Dam				
54-inch HDPE	2640	LF	$271	$715,440

HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	$450,000	$450,000
Mechanical Dredging, barge mounted, clamshell, hopper dumped	120720	CY	$14	$1,665,936
Cofferdam, 15-22' Deep, 2 lines of braces, 10" H max	108640	SF	$39	$4,236,960
Furnish and place topsoil, truck dumped, screened, 4" deep	36213	SY	$4	$140,506
Fine grading with seeding inc lime, fertilizer & seed w/ equip.	325920	SF	$6	$2,105,443
Underwater Diffuser Outlet	1	LS	$15,000	$15,000
Microtunneling 42-inch diameter hole in concrete dam under adverse conditions	70	LF	$1,260	$88,200
42" black steel water supply pipe w/ 1/2" walls	100	LF	$426	$42,600
Drill rock anchor bolts	100	LF	29	$2,863
Install rock anchor bolts	100	LF	25	$2,532
Anchor rings	4	EACH	805	$3,220
42" butterfly valve (manually operated)	1	EACH	$39,000	$39,000
Diffuser Outlet Structure	1	LS	$20,000	$20,000
		Sub total		**$9,528,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	$3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	$9,600	$9,600
Loader (2)	1	LS	$2,400	$2,400
Dump truck, 26 tons (10)	1	LS	$6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	$2,000	$2,000
Grout pumper (1)	1	LS	$600	$600
Grader, 30,000 lbs (1)	1	LS	2,400	$2,400
Crawler Type Drill, 4" (1)	1	LS	700	$700
Water truck, 6000 gal (2)	1	LS	$1,200	$1,200
Wash & Screen (1)	1	LS	$7,200	$7,200
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	$200,000	$200,000
		Sub total Mob / Demob		**$236,000**
			TOTAL	**$21,913,000**



BUCKS CREEK PH TO CRESTA RESERVOIR PLUNGING

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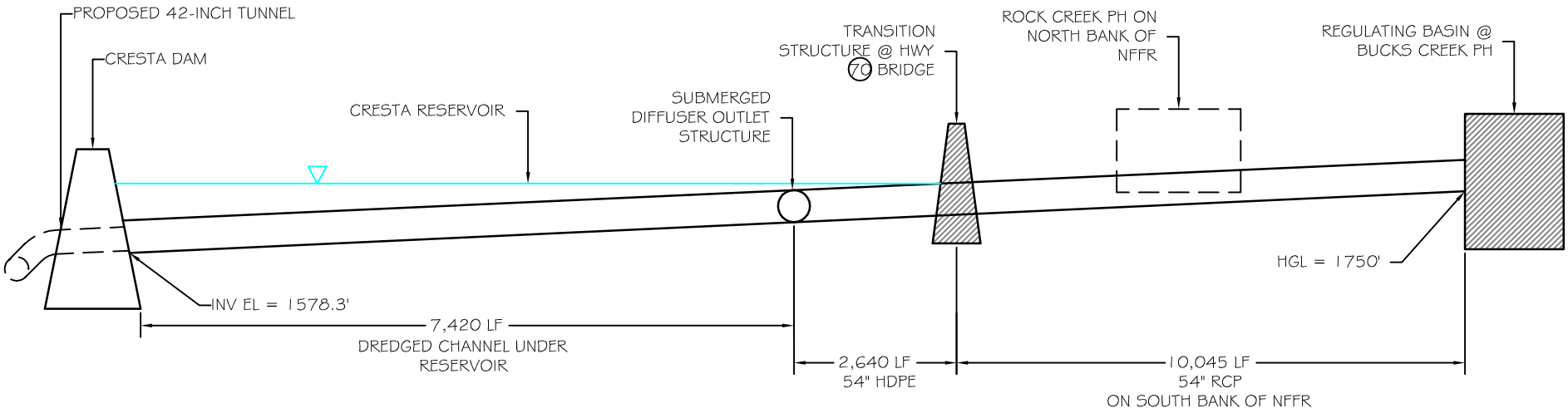
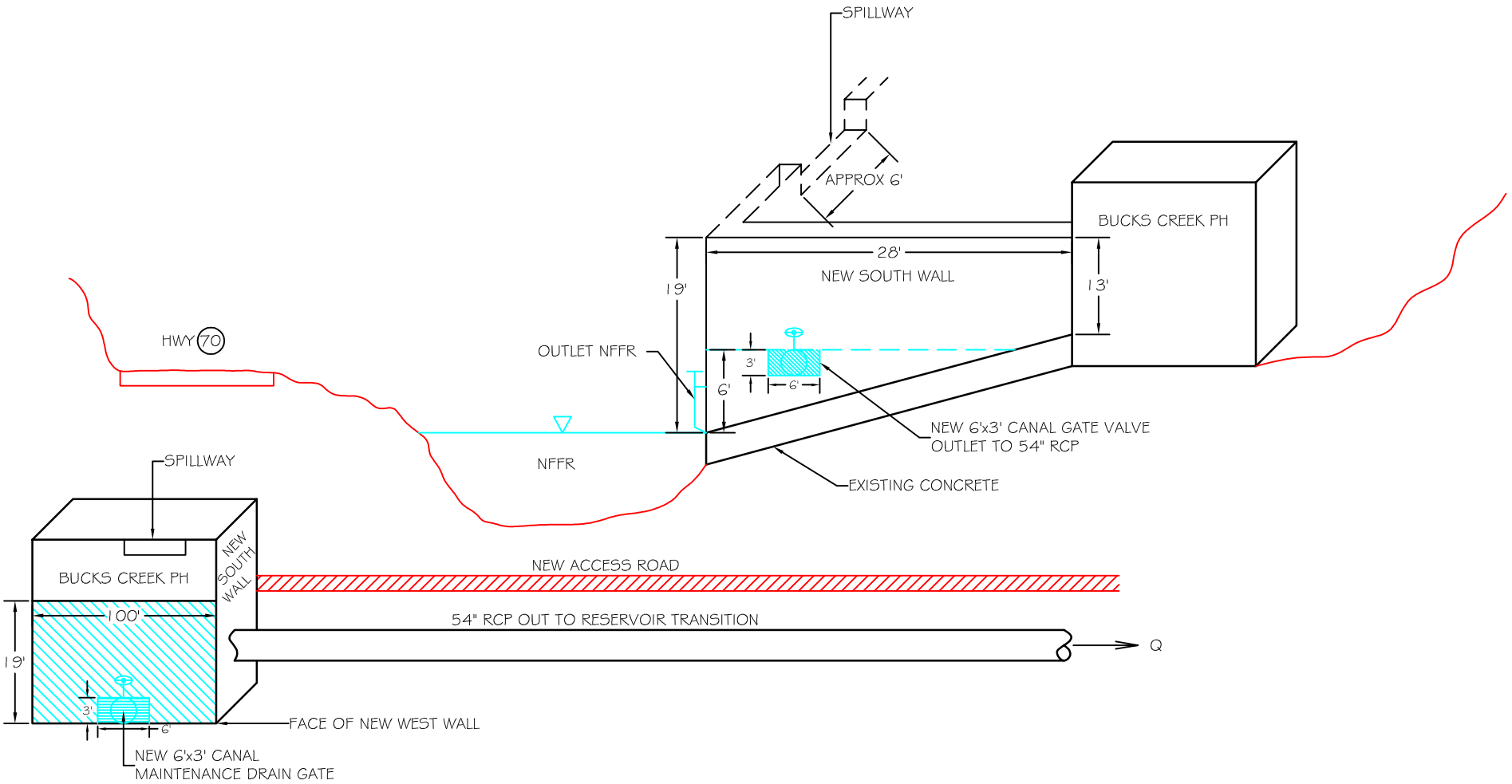
BUCKS CREEK PH TO CRESTA RESERVOIR PLUNGING OUTLET



REGULATING BASIN DETAIL AT BUCKS CREEK PH



Measure Name: Convey Cool Bucks Creek PH Flows by Pipeline to Discharge below Cresta Dam

Applicable Alternative Category(s): 4, 5; additional measure for Cresta Reach

Description of Measure: Construct about 4-mile long pipeline to convey cool Buck Creek PH flows to discharge below Cresta Dam, bypassing Cresta Reservoir. The purpose of this measure is to avoid mixing with warmer ambient waters of Cresta Reservoir.

Description of Operations: This measure does not affect PH operations. According to PG&E's flow measurements in summer 2002-2004, Bucks Creek PH discharges during July and August ranged from 0 to 260 cfs. The cool water flow needed to reduce water temperatures below Cresta Dam is estimated at about 95 cfs and 110 cfs for alternative categories 4 and 5 respectively. The design flow rate is 110 cfs, and Bucks Creek PH discharges exceeding 110 are released to the NFFR.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a concrete regulating basin at the outlet of Bucks Creek PH. The regulating basin functions to regulate the powerhouse discharge between the NFFR and the proposed bypass pipeline. The regulating basin has an outlet consisting of a large gate valve connected to a 48-inch RCP bypass pipeline. The regulating basin also has a spillway to control the water level in the basin while releasing PH discharges exceeding the bypass flows to the NFFR.

The 48-inch RCP bypass pipeline extends from the regulating basin outlet structure to discharge below Cresta Dam. The first segment of the RCP extends about 10,050 ft and is buried under a new access road constructed along the south bank of the NFFR. In the second segment the pipeline transitions to 48-inch HDPE and enters Cresta Reservoir. The HDPE is set and anchored along the bottom of Cresta Reservoir for a distance of 10,050 ft to the dam. The HDPE connects to one of three submerged 92-inch sluice pipes that pass through and discharge below the dam.

List of Figures:
- Plan view: Bucks Creek PH to Cresta Dam
- Profile: Bucks Creek PH to Cresta Dam Outlet
- Detail: Regulating Basin Detail at Bucks Creek PH

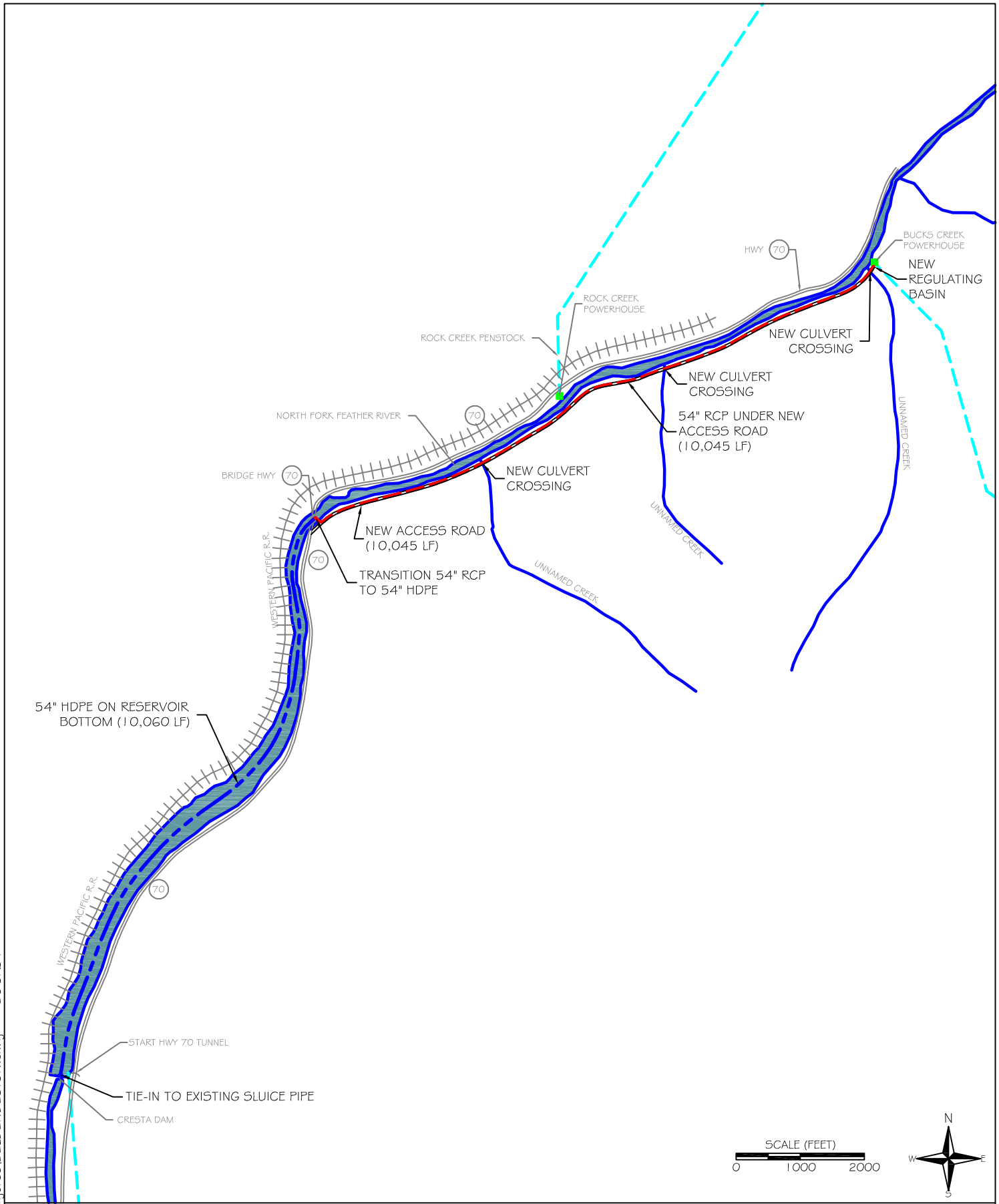
Key Design or Construction Uncertainties Requiring Further Study:
- Siting and designing the regulating basin above the floodplain of the NFFR to avoid flood damages requires further study.
- Setting a 48-inch HDPE along the bottom of Cresta Reservoir will be difficult and costly. Design and installation of an anchoring system adequate to withstand the potential forces on the pipe arising from flow momentum and land shifting requires further study.

- Tying into the existing submerged 92-inch sluice pipe underwater at the toe of the dam will be difficult and costly due to underwater construction.

Discussion:
The design flow rate of 110 cfs is based on the estimated flow rate required to reduce water temperatures below Cresta Dam for alternative category 5. Alternative category 4 has lower flow rate requirement and thus requires smaller size of pipeline.

COST ESTIMATE FOR BUCKS CREEK PH TO CRESTA DAM				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
Access Road (10,045-feet along south bank of NFFR)				
Sediment and Erosion Control (Silt Fence)	10045	LF	$5	$50,817
Clearing (including Trees), Dozer 300 HP	24556	SY	$6	$146,862
Excavation, Road and Retaining Wall Footings, 1CY Truck Mounted Hydr.	7425	CY	$13	$99,976
Hauling, 12 CY Dump Truck, 20-mile RT, 0.4 Loads / Hour	7425	CY	$38	$285,507
Concrete for Retaining Wall Footings	407	CY	$1,900	$773,300
Concrete for Culvert Headwall Structures (6)	16	CY	$1,900	$30,400
Steel Galv. Retaining Wall Posts, 8-Foot	152	EACH	$84	$12,760
Treated Wood for Retaining Wall	299721	BF	$12	$3,542,332
Fill, 1/2 to 3/4" Crushed Rock	7222	CY	$47	$340,707
Fill, Road Surface Gravel	2321	CY	$36	$84,281
24" CMP, corrugated 14 ga.	60	LF	$50	$3,027
		Sub total access road		**$5,370,000**
48" RCP from Bucks Creek Powerhouse to Cresta Reservoir / N Fork Feather River at Hwy 70 Bridge				
Cast in-Place Concrete Inlet / Outlet Structure at Powerhouse	101	CY	2,800	$282,800
Transition structure, 6' x 3' RCB to 54" RCP	1	LS	$7,000	$7,000
6'W X 3'H Canal Control Gate	1	LS	$6,000	$6,000
48-inch Reinforced Concrete Pipe, Class 3	10045	LF	173	$1,737,785
Clearing, medium	5	ACRE	1,400	$7,000
Backfill, 6" layers, roller compaction operator walking	27003	CY	44	$1,182,191
Pipe bedding, crushed rock, 1/2" to 3/4"	11154	CY	48	$538,515
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	41616	CY	12	$499,392
1/2 CY bucket wheel mounted front end loader, min haul	21568	CY	16	$342,716
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	21568	CY	27	$573,709
Precast Storm Drain Manhole, 6' I.D., 8' Deep	12	EACH	4,300	$51,600
Grouted Riprap Slope Protection, 3/8 to 1/4 CY	33	SY	120	$3,975

Pieces, 18" Thick				
Sediment and Erosion Control (Silt Fence)	10045	LF	5	$50,828
Traffic control, signage	1	LS	29,000	$29,000
Traffic control, 2 signals	1	LS	100,000	$100,000
		Sub total		**$5,413,000**
48" HDPE from Hwy 70 Bridge to Tie-In at Toe of Dam				
48-inch HDPE	10060	LF	214	$2,152,840
HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	1,300,000	$1,300,000
Underwater pipe laying preparation of reservoir bottom	1	LS	$3,087,000	$3,087,000
Remove existing metal trash rack at toe of dam (apx 100' underwater)	1	LS	50,000	$50,000
Concrete transition structure, 48" HDPE to 7.7'-dia sluice pipe	1	LS	12,000	$12,000
Attach48" HDPE to transition structure and sluice pipe (apx 100' underwater)	1	LS	150,000	$150,000
		Sub total		**$6,752,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (1)	1	LS	1,200	$1,200
Grader, 30,000 lbs (1)	1	LS	2,400	$2,400
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		**$235,000**
			TOTAL	**$17,770,000**



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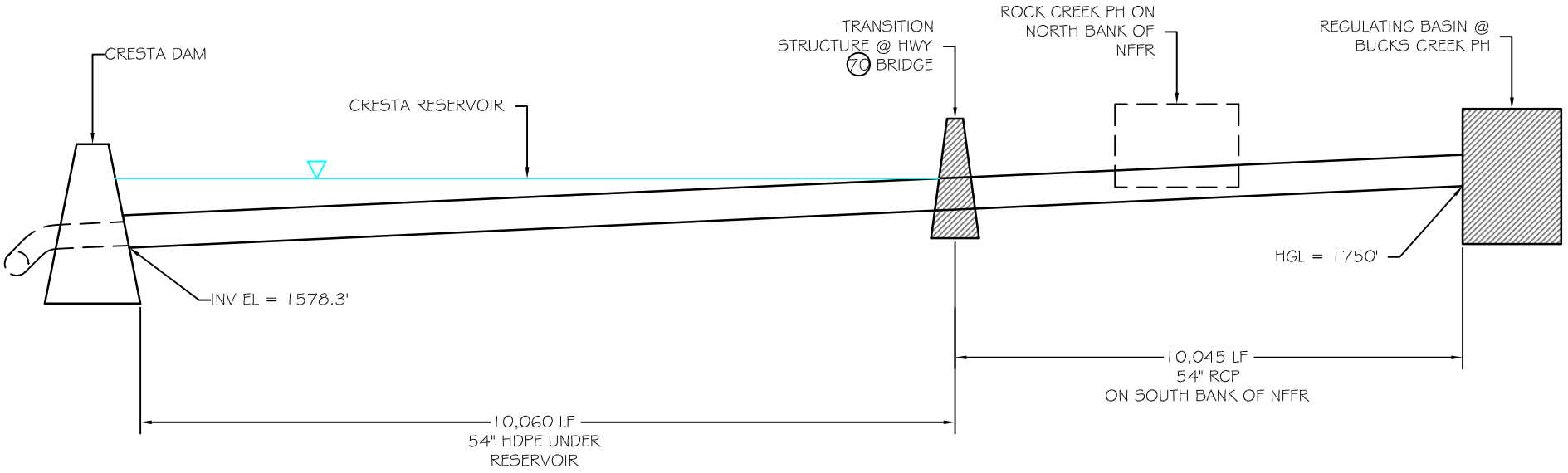
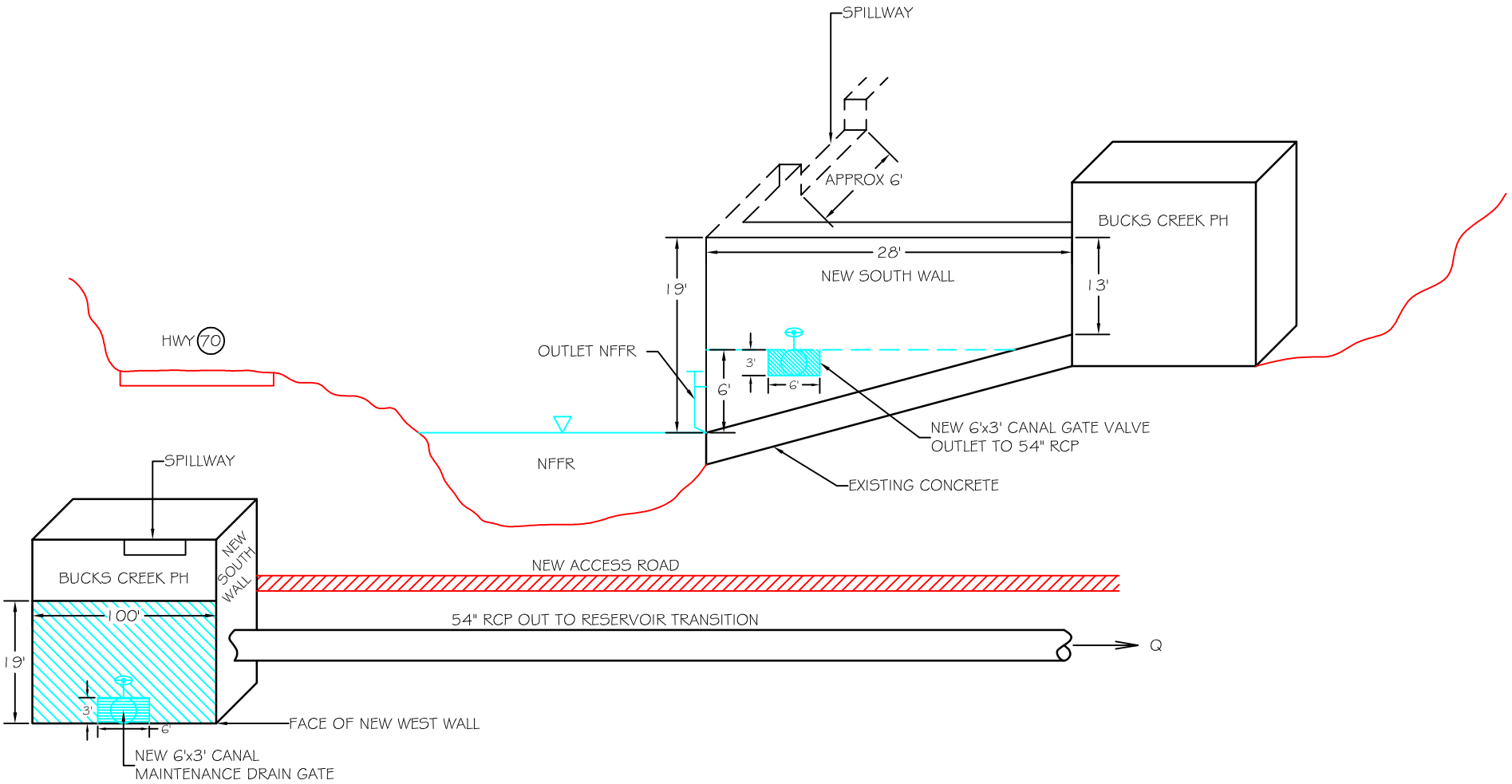
BUCKS CREEK PH TO CRESTA DAM

BUCKS CREEK PH TO CRESTA DAM OUTLET



REGULATING BASIN DETAIL AT BUCKS CREEK PH



Measure Name: Divert Cool Lower Rock Creek Reach Flows into a Pipeline to Discharge Below Cresta Dam

Applicable Alternative Category(s): 6a; additional measure for Cresta Reach

Description of Measure: Construct about 3-mile long pipeline to convey cool lower Rock Creek Reach flows to below Cresta Dam directly, bypassing Cresta Reservoir. The purpose of this measure is to avoid mixing cooler Rock Creek Reach flows with warmer ambient waters of Cresta Reservoir. This measure must be combined with the measure bypassing cold Seneca Reach flows around Belden Reservoir and the measure bypassing lower Belden Reach flows around Rock Creek Reservoir.

Description of Operations: This measure does not affect PH operations. Operate the diversion system to divert and convey about 250 cfs through the pipeline and spill the remaining flow over the diversion dam. The diversion rate is supplied by the increased release measure from Rock Creek Dam. The flow accretion from Bucks Creek and Bucks Creek PH inflows would maintain flows for aquatic habitat in the short reach from the diversion dam to the Rock Creek PH discharge.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 6-foot high rubber inflatable/deflatable rubber diversion dam on the NFFR about 150 feet upstream of the Rock Creek PH. Except during summer, the rubber dam remains in the deflated position.

The diversion dam directs 250 cfs through a 3-mile long pipeline to convey cool lower Rock Creek Reach flows to below Cresta Dam, bypassing Cresta Reservoir. The first segment consists of 66-inch RCP that extends about 150 ft to the Rock Creek PH. The pipe then transitions into a 66-inch Black Steel Pipe (BSP) which is connected to the face of Rock Creek PH and extends about 160 feet to the north bank of the NFFR just downstream of Rock Creek PH. The pipe material then transitions back into 66-inch RCP where it is buried along the shoulder of Highway 70 for approximately 4,155 feet. The pipe then enters Cresta Reservoir and where it transitions to 66-inch HDPE. The HDPE pipe is set and anchored to the reservoir bottom for the last 10,060 feet to Cresta Dam. The end of the 66-inch HDPE connects to one of the three existing submerged 92-inch sluice pipes (currently abandoned) at the toe of the dam which discharges below Cresta Dam.

List of Figures:
- Plan view: North Fork Feather River (NFFR), Lower Rock Creek Reach Bypass
- Profile: Lower Rock Creek Reach Bypass to Cresta Dam and Details

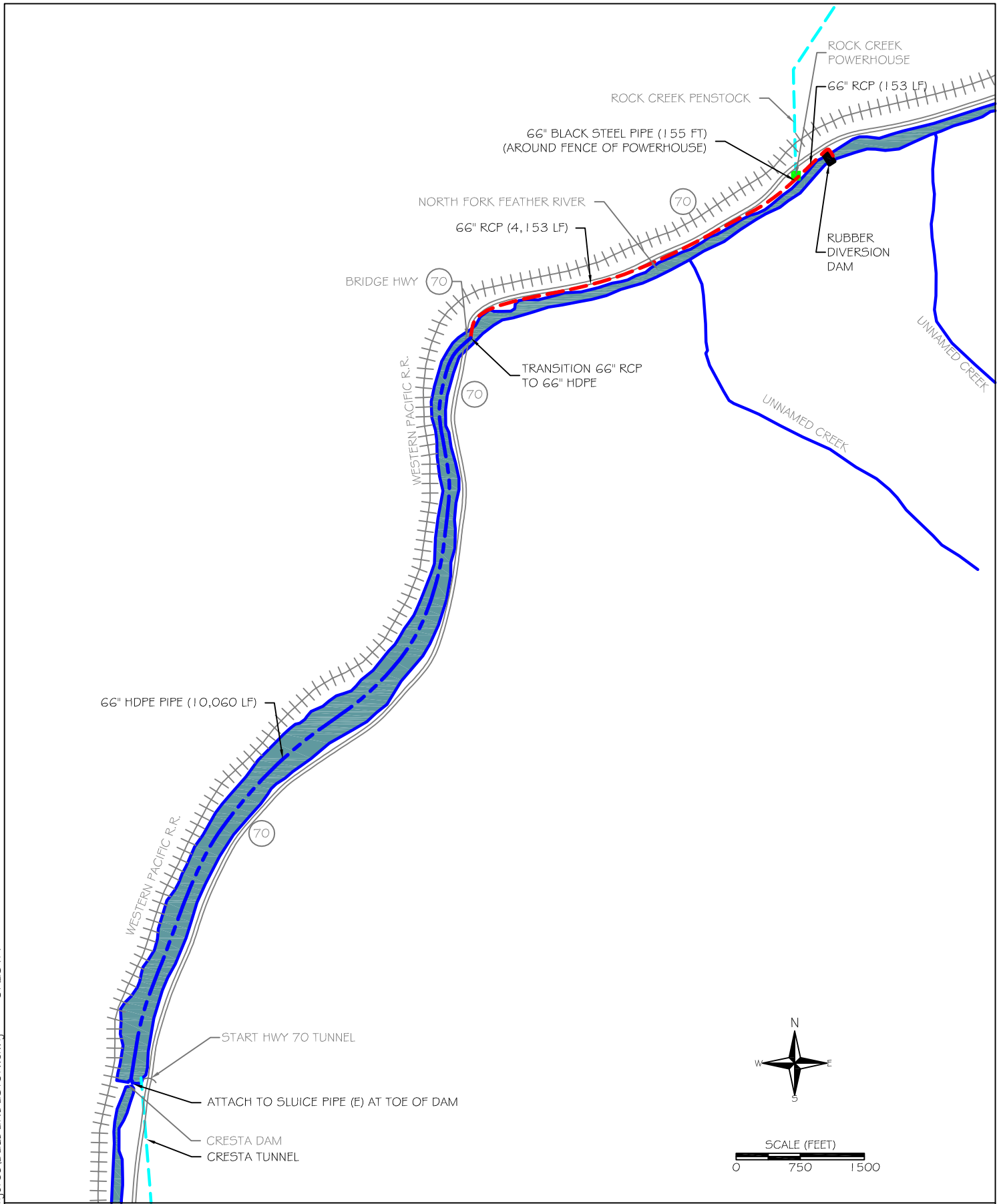
Key Design or Construction Uncertainties Requiring Further Study:
- Attaching to the existing 7’-8 3/8” I.D. sluice pipe underwater at the toe of Cresta Dam will be difficult and costly due to underwater construction.
- Connecting a 66-inch black steel pipe to the face of the powerhouse and anchoring it against the flow forces of the NFFR requires further study.

- Setting a 66-inch HDPE along the bottom of Cresta Reservoir will 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 further study.

Discussion: None

COST ESTIMATE FOR LOWER ROCK CREEK REACH BYPASS TO CRESTA DAM				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE AT ROCK CREEK PH				
6' high and 78' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$3,320,000	$3,320,000
		Sub Total NF Feather River Dam		**$3,320,000**
66" RCP from Rubber Dam to Concrete Face of Rock Creek Powerhouse				
66-inch Reinforced Concrete Pipe, Class 3	153	LF	309	$47,277
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	1374	SY	120	$165,485
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	204	CY	26	$5,229
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	51	CY	3	$155
Pipe bedding, crushed rock, 1/2" to 3/4"	51	CY	48	$2,462
1/2 CY bucket wheel mounted front end loader, min haul	235	CY	16	$3,734
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	235	CY	27	$6,251
Sediment and Erosion Control (Silt Fence)	153	LF	5	$774
		Sub total		**$231,000**
66" Black Steel Pipe along Concrete Face of Rock Creek Powerhouse				
66" black steel pipe	155	LF	629	$97,495
Drill concrete anchor bolts	155	LF	29	$4,438
Install concrete anchor bolts	155	LF	25	$3,925
Anchor rings	8	EACH	800	$6,400
Precast Storm Drain Manhole, 6' I.D., 8' Deep	2	EACH	4,300	$8,600
		Sub total		**$121,000**
66" RCP from Concrete Face of Rock Creek Powerhouse to Cresta Reservoir / N Fork Feather River at Hwy 70 Bridge				
66-inch Reinforced Concrete Pipe, Class 3	4153	LF	309	$1,283,277
Clearing, medium	1	ACRE	1,400	$1,400
Backfill, 6" layers, roller compaction operator walking	3922	CY	44	$171,705

Pipe bedding, crushed rock, 1/2" to 3/4"	6009	CY	48	$290,115
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	15035	CY	12	$180,420
1/2 CY bucket wheel mounted front end loader, min haul	12780	CY	16	$203,074
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	12780	CY	27	$339,948
Precast Storm Drain Manhole, 6' I.D., 8' Deep	14	EACH	4,300	$60,200
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	6137	SY	120	$739,140
Remove Gravel shoulder	1126	SY	7	$7,499
Replace Gravel shoulder	375	CY	48	$18,105
Shoulder Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	375	CY	3	$1,136
Sediment and Erosion Control (Silt Fence)	4153	LF	5	$21,014
Remove and reset existing corrugated metal guard rail	4153	LF	35	$144,192
Traffic control, signage	1	LS	29,000	$29,000
Traffic control, 2 signals	1	LS	382,000	$382,000
		Sub total		**$3,872,000**
66" HDPE from Hwy 70 Bridge to Tie-In at Toe of Dam				
66-inch HDPE	10060	LF	390	$3,923,400
HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	1,300,000	$1,300,000
Underwater pipe laying preparation of reservoir bottom	1	LS	3,087,000	$3,087,000
Remove existing metal trash rack at toe of dam (apx 100' underwater)	1	LS	50,000	$50,000
Concrete transition structure, 66" HDPE to 7.7'-dia sluice pipe	1	LS	12,000	$12,000
Attach 66" HDPE to transition structure and sluice pipe (apx 100' underwater)	1	LS	150,000	$150,000
		Sub total		**$8,522,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (2)	1	LS	1,200	$1,200
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		**$233,000**
			TOTAL	**$16,299,000**



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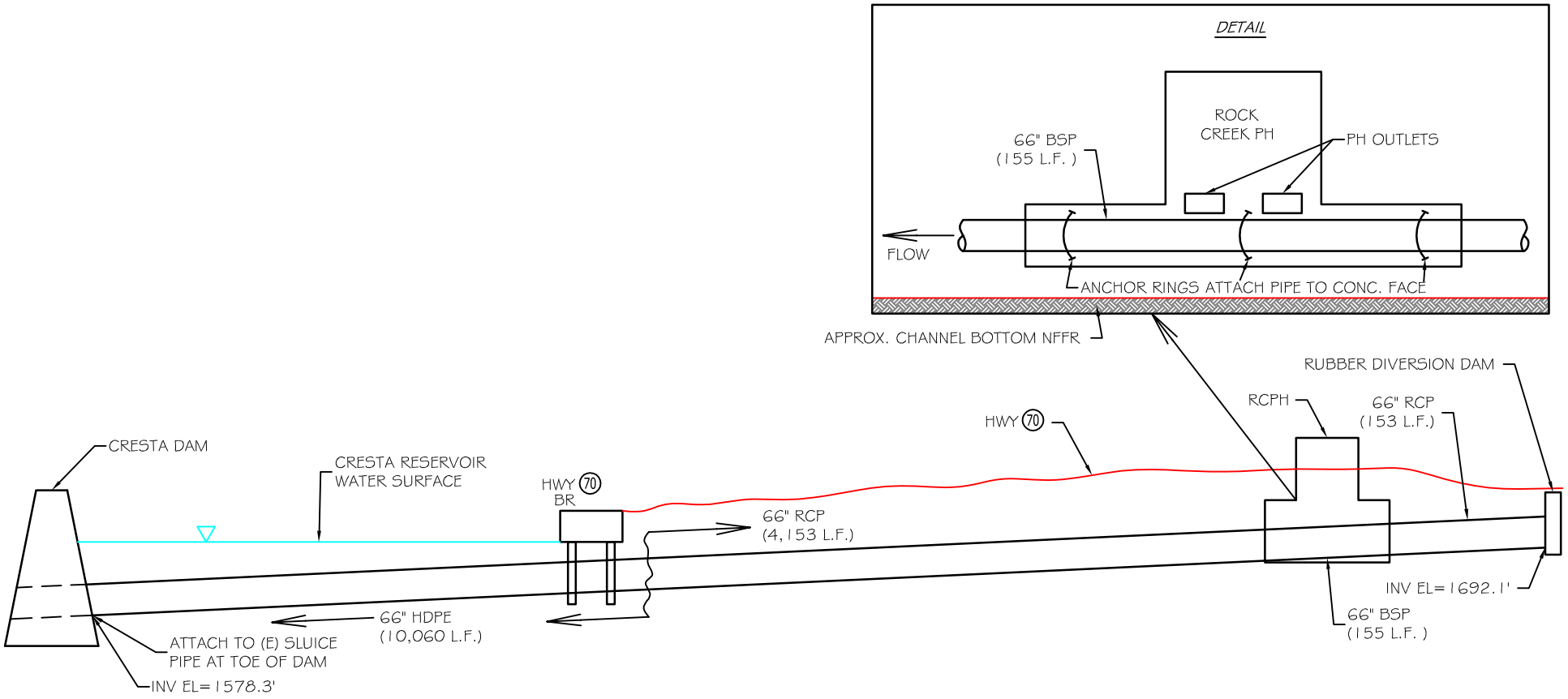
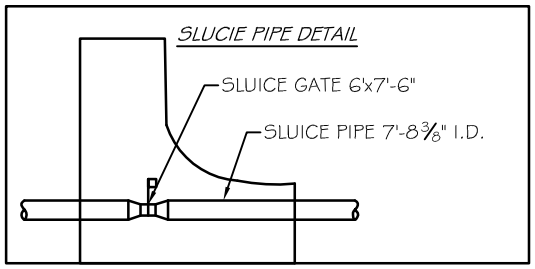
NORTH FORK FEATHER RIVER (NFFR)
LOWER ROCK CREEK REACH BYPASS TO CRESTA DAM

LOWER ROCK CREEK REACH BYPASS TO CRESTA DAM





Measure Name: Convey Cool Water from Poe Adit to Poe Reach

Applicable Alternative Category(s): 2, 3, 4; additional measure for Poe Reach

Description of Measure: Construct an approximately 2/3-mile long pipeline to deliver cool water from the Poe Adit to the middle of Poe Reach. The purpose of this measure is to reduce water temperature in the lower Poe Reach.

Description of Operations: This measure does not affect PH operations. Convey 150 cfs from the Poe Adit to the middle of Poe Reach.

Detailed Description of Facilities Improvements and Design Criteria:
The delivery pipeline extends from the Poe Tunnel near Bardee's Bar, through the Poe Adit (the existing horizontal access tunnel leading to the Poe Tunnel) to the middle of the Poe Reach.

Flow is collected from the Poe Tunnel, which is an existing underground 17-feet diameter tunnel that delivers water from Poe Reservoir to Poe PH. The Poe Tunnel is accessed through the Poe Adit. The existing butterfly value and tunnel access hole inside the adit is enlarged from 18 to 42-inches and attached to a 42-inch Black Steel Pipe (BSP) buried under the floor of the adit, carrying flow approximately 960 feet outside the adit. The 42-inch BSP is then jack and bored under the railroad tracks and buried under the existing gravel access road the remaining 2,000 feet to Poe Reach, discharging through a manually operated butterfly valve into the Poe Reach just downstream of Bardee's Bar Road Bridge.

Selected portions of the pipe alignment, design and costs were taken from the Black and Veatch Report (Prefeasibility Level Sizing and Cost Estimate Summary Memorandum, 2005).

List of Figures:
- Plan view: North Fork Feather River (NFFR) Poe Adit Pipeline.
- Profile: Poe Adit to NFFR at Poe Reach.

Key Design or Construction Uncertainties Requiring Further Study:
- It will be difficult and costly to microtunnel through Poe Tunnel from within Poe Adit due to tunneling through concrete in a confined space.
- The unstable spoils pile / hillside under proposed pipe alignment is dangerous requires further study of its stability.

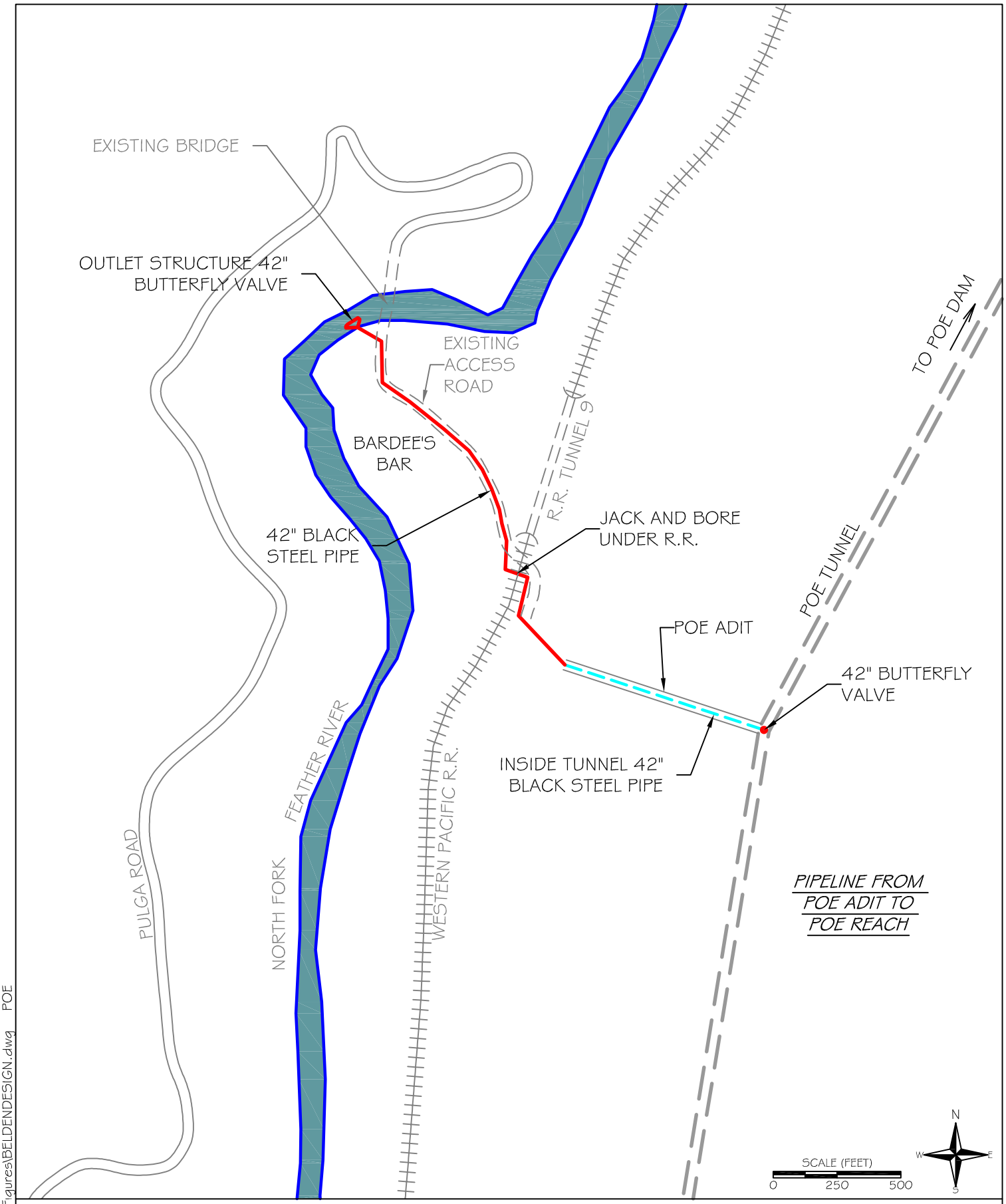
Discussion:
This design used diverted flow of 150 cfs from Poe Adit. However, the required discharge for each alternative category differs.

COST ESTIMATE FOR POE ADIT

ITEM	QUANITY	UNIT	UNIT COST	COST
INSIDE ADIT				
Microtunneling, increase existing 18" bore to 42" (cost for 24" to 48") hole in tunnel under adverse conditions	20	LF	$1,260	$25,200
Spoils handling inside tunnel				
1/2 CY bucket wheel mounted front end loader, min haul	3	CY	$16	$48
Hauling, 20 mile round trip, 0.4 loads/ hr	4	CY	$27	$106
Tunnel ventilation, duct, 48", 20ga., spun on site	1000	LF	$21	$21,480
Fan, 48" dia, 125 HP, inc. starter	1	EACH	$29,000	$29,000
Mob / demob of microtunneling equipment (maximum)	1	EACH	$510,000	$510,000
Pipe inside tunnel				
42" black steel water supply pipe w/ 1/2" walls	960	LF	$426	$408,960
Excavation by hand 2-6' deep in heavy soil inc tamping	1271	CY	$94	$118,839
Pipe bedding, crushed rock, 1/2" to 3/4"	929	CY	$48	$44,852
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	929	CY	$3	$2,815
1/2 CY bucket wheel mounted front end loader, min haul	1271	CY	$16	$20,196
Hauling, 20 mile round trip, 0.4 loads/ hr	1271	CY	$27	$33,809
42" butterfly valve (manually operated)	1	EACH	$39,000	$39,000
90 degree 42" elbow	2	EACH	$19,000	$38,000
INSIDE ADIT				**$1,292,000**

ITEM	QUANITY	UNIT		COST
OUTSIDE ADIT				
Pipe outside gravel road				
42" black steel water supply pipe w/ 1/2" walls	402	LF	$426	$171,252
1/2 CY bucket wheel mounted front end loader, min haul	532	CY	$16	$8,453
Hauling, 20 mile round trip, 0.4 loads/ hr	532	CY	$27	$14,151
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	389	CY	$3	$1,179
Pipe bedding, crushed rock, 1/2" to 3/4"	389	CY	$48	$18,781
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Rock, drill & blast	532	CY	$138	$73,613
45 degree bend, 42"	3	EACH	$10,000	$30,000
90 degree 42" elbow	1	EACH	$19,000	$19,000
Pipe in gravel road				
42" black steel water supply pipe w/ 1/2" walls	1614	LF	$426	$687,564

Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	2137	CY	$12	$25,644
Pipe bedding, crushed rock, 1/2" to 3/4"	1562	CY	$48	$75,413
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	1562	CY	$3	$4,733
1/2 CY bucket wheel mounted front end loader, min haul	2137	CY	$16	$33,957
Hauling, 20 mile round trip, 0.4 loads/ hr	2137	CY	$27	$56,844
22.5 degree bend, 42"	1	EACH	$10,000	$10,000
45 degree bend, 42"	4	EACH	$10,000	$40,000
90 degree 42" elbow	1	EACH	$19,000	$19,000
Resurface gravel road, 12' wide and apx 1614' long	19368	SF	$2	$37,380
Under Railroad				
42" black steel water supply pipe w/ 1/2" walls	33	LF	$426	$14,058
Horizontal boring, railroad work, 42" dia.	33	LF	$580	$19,140
Jacking pits inc. mob. / demob., maximum	1	EACH	$22,000	$22,000
1/2 CY bucket wheel mounted front end loader, min haul	29	CY	$16	$461
Hauling, 20 mile round trip, 0.4 loads/ hr	29	CY	$27	$771
Pipe bedding, crushed rock, 1/2" to 3/4"	17	CY	$48	$821
Outlet				
Concrete Outlet Structure	1	LS	$30,000	$30,000
42" butterfly valve (manually operated)	1	EACH	$40,000	$40,000
All sections				
Site clean up & repairs	1	EACH	$172,000	$172,000
Signage & traffic control	1	EACH	$34,000	$34,000
Silt fence	4660	LF	$5	$21,483
Site Demolition Work	1	EACH	$2,900	$2,900
General Equipment Mobilization	1	EACH	$21,000	$21,000
OUTSIDE ADIT				**$1,706,000**
COMPLETE BYPASS			**(Rounded)**	**$2,998,000**



POE ADIT PIPELINE

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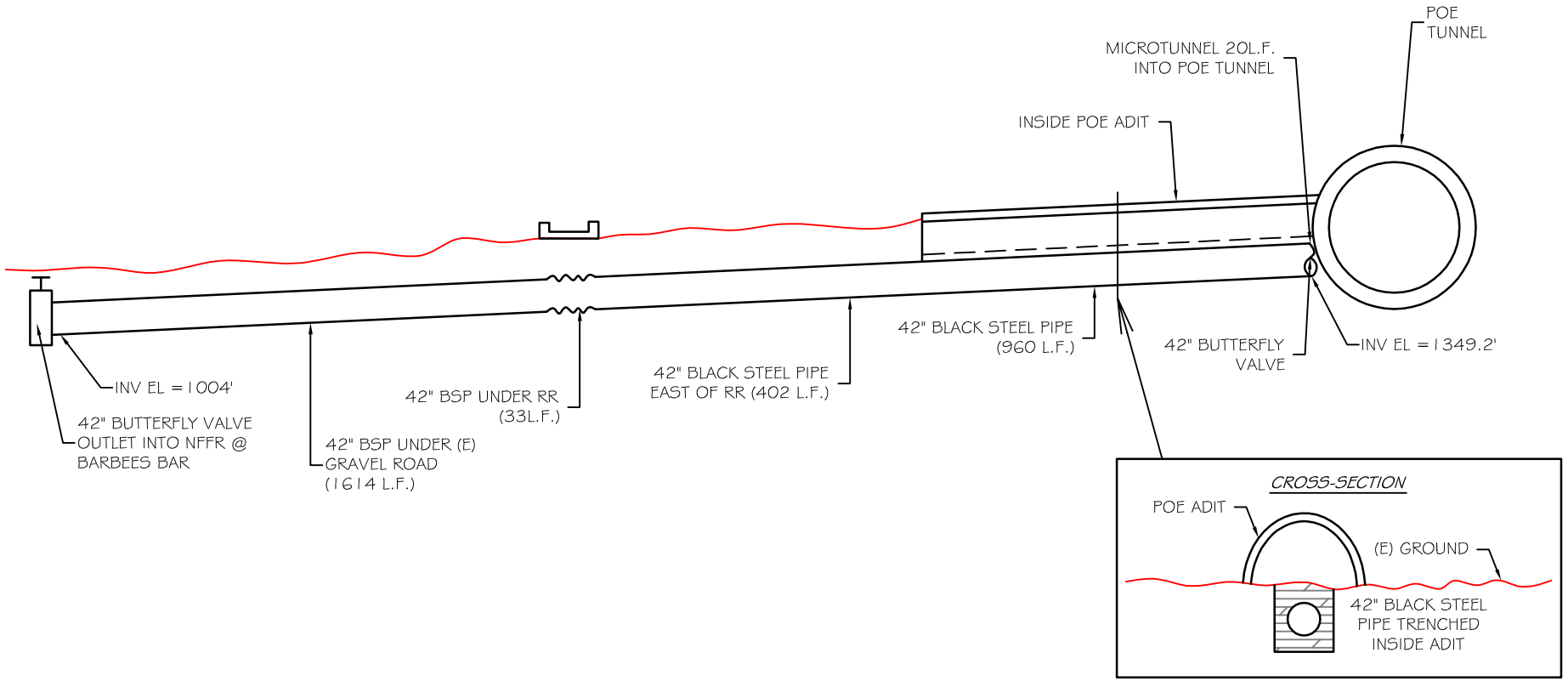
POE ADIT TO NFFR AT POE REACH



Measure Name: Divert Lower Cresta Reach Flows and Convey by Submerged Pipeline to Discharge below Poe Dam

Applicable Alternative Category(s): 6a; additional measure for Poe Reach

Description of Measure: Construct about 3-mile long pipeline to convey cold lower Cresta Reach flows to below Poe Dam directly, bypassing Poe Reservoir. The purpose of this measure is to avoid mixing cool Cresta Reach flows with warmer ambient waters of Poe Reservoir. This measure must be combined with the measure bypassing cold Seneca Reach flows around Belden Reservoir, the measure bypassing lower Belden Reach flows around Rock Creek Reservoir, and the measure bypassing lower Rock Creek flows around Cresta Reservoir.

Description of Operations: This measure does not affect PH operations. Operate the diversion system to divert 250 cfs of lower Cresta Reach flows to below Poe Dam and spill the remaining flow over the diversion dam. The diversion rate is supplied by the increased release measure from Cresta Dam. The flow accretion from Grizzly Creek inflows would maintain flows for aquatic habitat in the short reach from the diversion dam to the Cresta PH discharge.

Detailed Description of Facilities Improvements and Design Criteria:
Construct a 7-foot high inflatable/deflatable rubber diversion dam at the lower end of Cresta Reach just upstream of the Cresta PH. Except during summer, the rubber dam would remain in the deflated position. Construct an approximately 3 mile long pipeline to convey cool Cresta Reach flows captured behind the dam to connect to the existing outlet structure for discharge below Poe Dam.

The pipeline starts at the diversion dam and extends about 3 mile to connect to the existing outlet at the bottom of Belden Reservoir. The first segment of the pipeline consists of about 170-feet of 66-inch RCP. The second segment transitions into about 280 feet of 66-inch black steel pipe (BSP) which is connected to the face of Cresta PH and extending to the southeast bank of the NFFR just downstream of Cresta PH. The pipe material then transitions back into 66-inch RCP where it is buried underneath a small existing access road along the southeast bank of the NFFR for approximately 934 feet. The pipe then transitions to 66-inch HDPE and is set anchored to the bottom of Poe Reservoir for the remaining 8,394 feet down to the toe of the dam. The 66-inch HDPE is connected to the existing 66-inche diameter outlet which discharges below Poe Dam.

List of Figures:
- Plan view: Lower Cresta Reach Bypass to Poe Dam.
- Profile: NFFR Lower Cresta Reach Bypass to Poe Dam

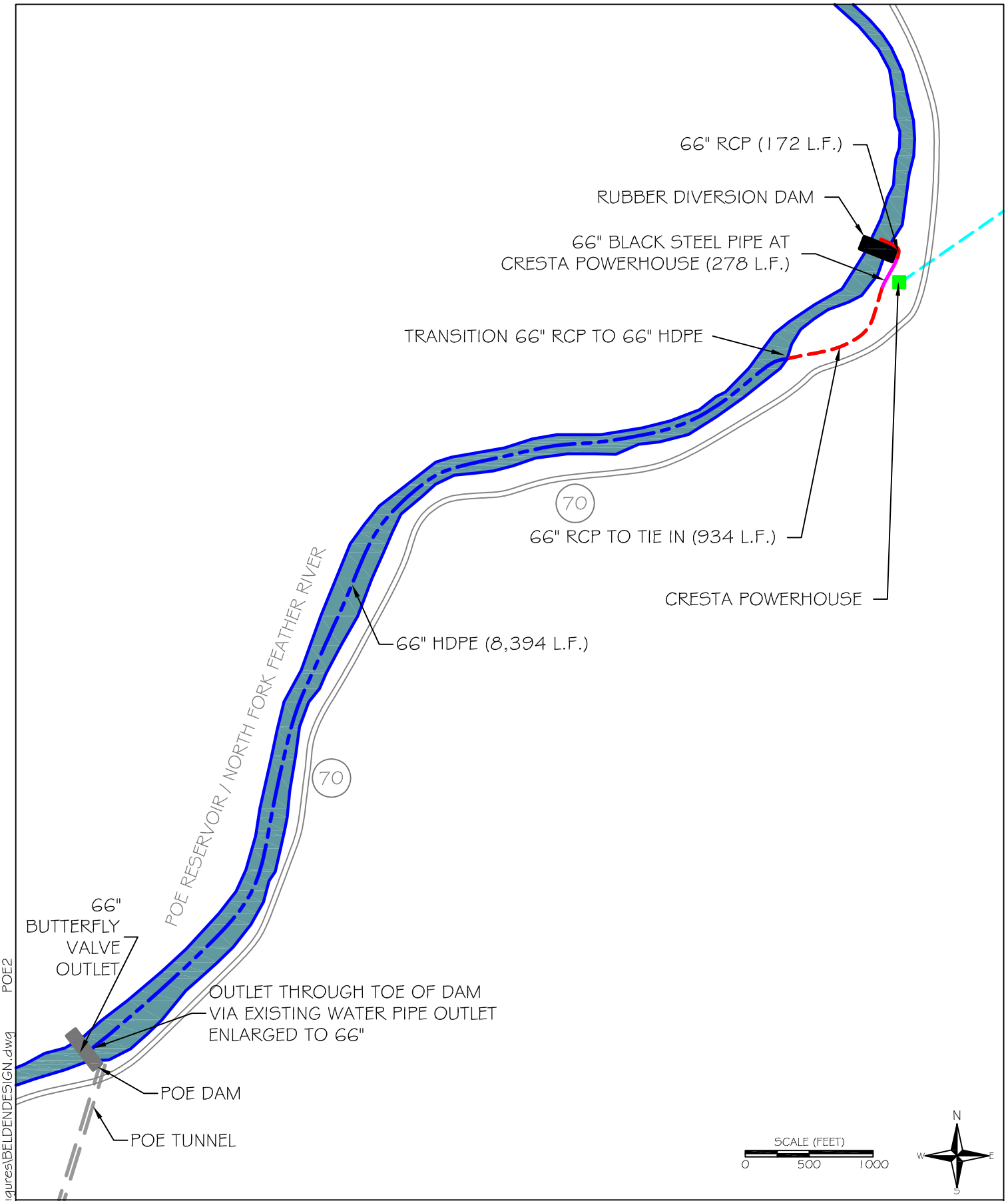
Key Design or Construction Uncertainties Requiring Further Study:

- Connecting a 66-inch black steel pipe to the face the powerhouse will be difficult and costly to anchor against the flow forces of the NFFR and the powerhouse outlet.
- Setting a 66-inch HDPE along the bottom of Cresta Reservoir will 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 further study.
- Attaching to the existing 66-inch outlet pipe at the toe of the dam will be difficult and costly due to underwater construction.

Discussion: None

COST ESTIMATE FOR LOWER CRESTA REACH BYPASS TO POE DAM OUTLET				
ITEM	**QUANITY**	**UNIT**	**UNIT COST**	**COST**
N FORK FEATHER RIVER RUBBER DAM AND INTAKE AT CRESTA PH				
7' high and 84' wide inflatable rubber dam including: mobilization, site prep, foundation, turnout structure and all necessary materials and construction.	1	LS	$4,170,000	$4,170,000
		Sub Total NF Feather River Dam		**$4,170,000**
66" RCP from Rubber Dam to Concrete Along Face of Cresta Powerhouse				
66-inch Reinforced Concrete Pipe, Class 3	172	LF	309	$53,148
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	354	SY	120	$42,636
Excavator, Clamshell, 1/2 CY, wet plus addit. Equip	650	CY	26	$16,660
Backfill, 6" layers, roller compaction operator walking	108	CY	44	$4,728
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	357	CY	3	$1,082
Pipe bedding, crushed rock, 1/2" to 3/4"	249	CY	48	$12,022
1/2 CY bucket wheel mounted front end loader, min haul	529	CY	16	$8,406
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	529	CY	27	$14,071
Sediment and Erosion Control (Silt Fence)	172	LF	5	$870
		Sub total		**$154,000**
66" Black Steel Pipe along Concrete Face of Cresta Powerhouse				
66" black steel pipe	278	LF	629	$174,862
Drill concrete anchor bolts	278	LF	29	$7,959
Install concrete anchor bolts	278	LF	25	$7,039
Anchor rings	8	EACH	800	$6,400
Precast Storm Drain Manhole, 6' I.D., 8' Deep	2	EACH	4,300	$8,600
		Sub total		**$205,000**
66" RCP from Concrete Face of Cresta Powerhouse to N Fork Feather River / Poe Reservoir				
66-inch Reinforced Concrete Pipe, Class 3	934	LF	309	$288,606
Clearing, medium	0.5	ACRE	1,400	$700
Compaction, walk behind vibrating plate, 18" wide, 6" lifts, 4 passes	1939	CY	3	$5,875
Backfill, 6" layers, roller compaction operator walking	588	CY	44	$25,743
Pipe bedding, crushed rock, 1/2" to 3/4"	1351	CY	48	$65,226
Excavation, truck mounted, 6-10' deep, 1 CY excavator, Hydraulic Jack hammer	3528	CY	12	$42,336
1/2 CY bucket wheel mounted front end loader, min haul	2874	CY	16	$45,668
Hauling, 20 mile round trip, 0.4 loads/ hr (Add 15% for Expansion)	2874	CY	27	$76,448
Precast Storm Drain Manhole, 6' I.D., 8' Deep	3	EACH	4,300	$12,900
Grouted Riprap Slope Protection, 3/8 to 1/4 CY Pieces, 18" Thick	1920	SY	120	$231,245

Sediment and Erosion Control (Silt Fence)	934	LF	5	$4,726
Remove and reset existing corrugated metal guard rail	934	LF	35	$32,428
Traffic control, signage	1	LS	29,000	$29,000
Traffic control, 2 signals	1	LS	51,000	$51,000
		Sub total		**$912,000**
66" HDPE from Poe Rseervoir near Cresta PH to Tie-In at Toe of Dam				
66-inch HDPE	8394	LF	390	$3,273,660
HDPE Pipe Placement, S-lay method with stinger, Mechanical Crane, barge mounted	1	LS	1,300,000	$1,300,000
Underwater pipe laying preparation of reservoir bottom	1	LS	2,490,000	$2,490,000
Microtunneling, increase existing 36" fish water bore in dam to 66"	50	LF	2,000	$100,000
Concrete transition structure, 66" HDPE to 66-dia fish water pipe	1	LS	12,000	$12,000
Attach 66" HDPE to transition structure and expanded fish water pipe (apx 35' underwater)	1	LS	150,000	$150,000
66-inch hydraulic operated butterfly valve	1	LS	66,000	$66,000
		Sub total		**$7,392,000**
Mobilization				
Dozer, above 150 HP (3)	1	LS	3,600	$3,600
Excavator, 1-1.5 CY Diesel Hyd. (2)	1	LS	9,600	$9,600
Loader (2)	1	LS	2,400	$2,400
Dump truck, 26 tons (10)	1	LS	6,000	$6,000
25 ton truck mounted hydraulic crane (2)	1	LS	2,000	$2,000
Crawler Type Drill, 4" (1)	1	LS	700	$700
Grout pumper (1)	1	LS	600	$600
Water truck, 6000 gal (2)	1	LS	1,200	$1,200
Wash & Screen (1)	1	LS	7,200	$7,200
Mechanical Dredger, Crane and stinger, barge mounted and all equipment	1	LS	200,000	$200,000
		Sub total Mob / Demob		**$233,000**
			TOTAL	**$13,066,000**



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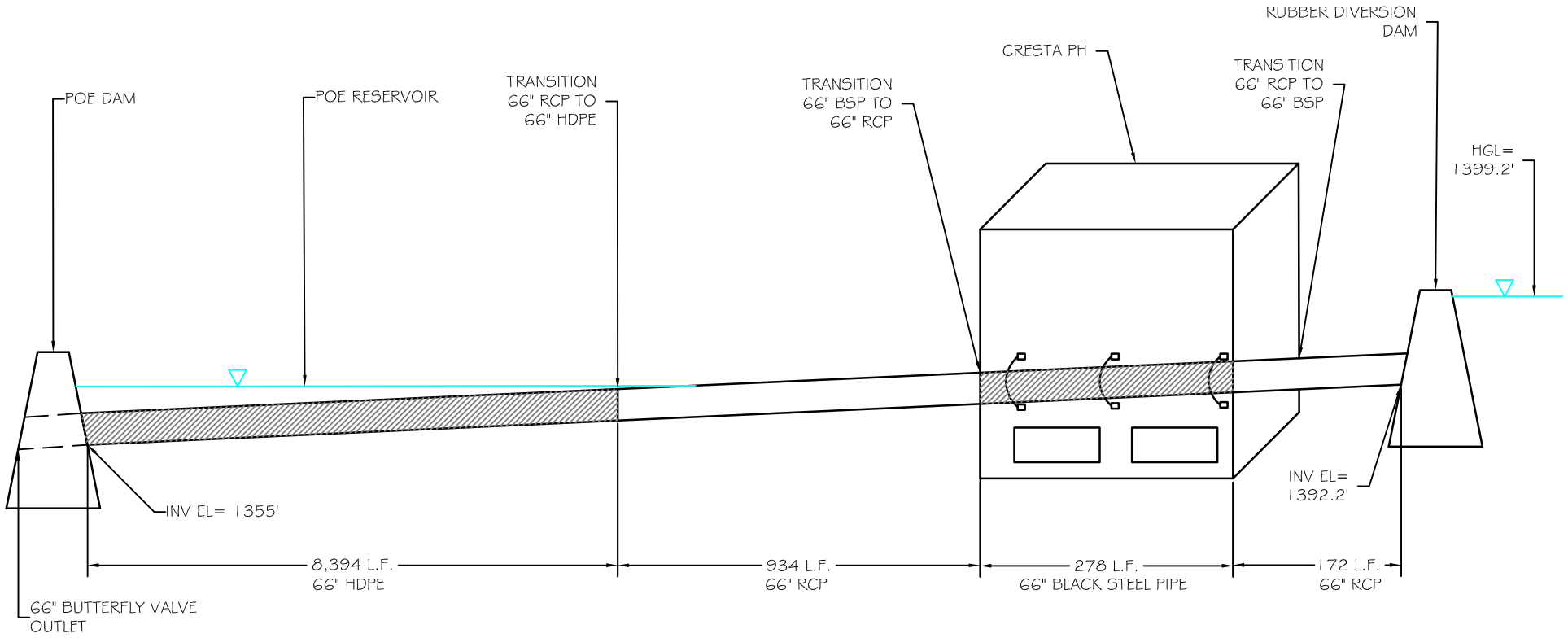
LOWER CRESTA REACH BYPASS TO POE DAM

NFFR, LOWER CRESTA REACH BYPASS TO POE DAM



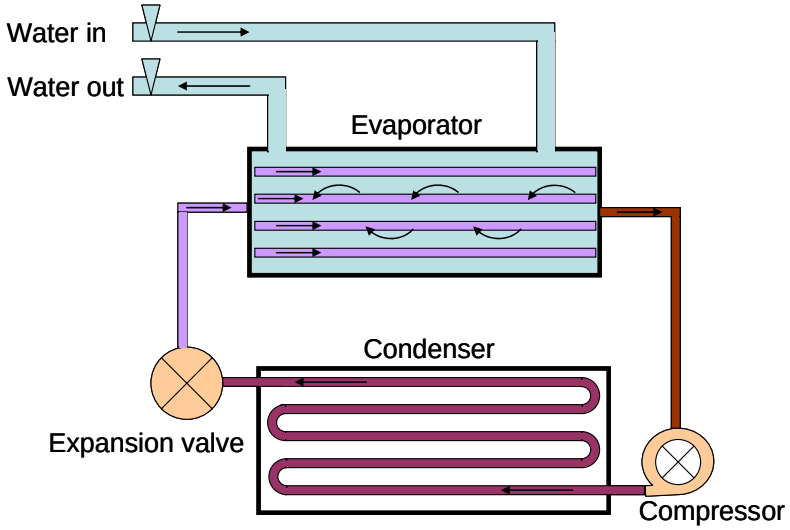
ENLARGE EXISTING 3'-DIA X 40' LONG
TO 66" I.D. EX. WATER PIPE THROUGH
DAM AND ATTACH 66" HDPE

Measure Name: Construct Mechanical Water Chillers near Rock Creek, Cresta, and Poe Dams

Applicable Alternative Category(s): 4, 5, 6

Description of Measure: Construct a mechanical water chiller to cool reservoir water and deliver it back to the reach just below the Rock Creek, Cresta, and Poe Dams. The purpose of this measure is to reduce the water temperature of flows below the dams.

A water chiller is a machine that removes heat from water by employing a vapor-compression or absorption-refrigeration cycle. Chillers typically made as complete packaged closed-loop systems, including the evaporator, compressor, condenser, and expansion valve (see the following figure). Warm water entering the chiller inlet is cooled by a coil-confined refrigerant and the chilled water is discharged from the chiller outlet. The heat energy taken out of the warm water by the refrigerant is released to the environment through an air- or water-cooled condenser.



Conceptual process flowchart of mechanical water chillers

The cycle begins in the evaporator where a liquid refrigerant flows over the evaporator tube bundle and evaporates, absorbing heat from the chilled water circulating through the bundle. The refrigerant vapor is drawn out of the evaporator by the compressor. The compressor then "pumps" the refrigerant vapor to the condenser raising its pressure and temperature. The refrigerant condenses on or in the condenser tubes, giving up its heat to the cooling air (or water). The high pressure liquid refrigerant from the condenser then passes through the expansion device that reduces the refrigerant pressure and temperature as it enters the evaporator. The refrigerant again flows over the chilled water coils absorbing more heat and completing the cycle.

Description of Operations: This measure does not affect PH operations. Operate the chiller system to divert 150 cfs from Rock Creek Reservoir, 175 cfs from Cresta

Reservoir, and 200 cfs from Poe Reservoir and convey the water to each of the respective chillers. Return the chilled water back to the NFFR right below each dam.

Detailed Description of Facilities Improvements and Design Criteria:
Specifications considered in chiller selection include the ability to handle large flow rate, cooling capacity, and cooling type. Flow requirements in July of a dry year for Rock Creek, Cresta, and Poe Reaches are estimated at 150, 175, and 200 cfs, respectively (see the following table). Depending upon the alternative categories considered, the estimated required temperature reductions range from 3.5°C to 5.0°C. Accordingly, the total heat reduction is estimated at 17,600 – 33,600 tons[5]. Chillers that are typically available on the market have a maximum capacity of about 1,500 tons. Multiple parallel air-cooled chillers are selected for this design.

Cooling Scenarios and Land Size Requirements

	Total Cooling Energy (tons)	Number of Chillers	Estimated Land Size in W x L (ft^2)
Rock Creek Reach (150 cfs)			
from 22.5°C --> 19.0°C	17,700	12	103x66
from 21.0°C --> 19.0°C	10,100	7	
from 20.5°C --> 19.0°C	7,600	5	
Cresta Reach (175 cfs)			
from 22.0°C --> 18.3°C	22,300	15	89x93
from 21.0°C --> 18.3°C	16,400	11	
from 20.5°C --> 18.3°C	13,500	9	
Poe Reach (200 cfs)			
from 22.5°C --> 17.4°C	33,700	22	110x120
from 21.0°C --> 17.4°C	23,600	15	
from 20.5°C --> 17.4°C	20,300	13	

In order to avoid pumping cost, it is important to identify a suitable location below each dam to deploy chillers so that warm reservoir water can be conveyed to the chillers by gravity and the chilled water can be delivered back to the reach right below each dam by gravity. The following criteria were also used for site selection in addition to gravity flow:

4) Close to upper end of the reach;
5) Large enough open land space; otherwise a constructed deck is needed;
6) Above 100-yr flood plain;

The selected locations that meet the above criteria for the Rock Creek, Cresta, and Poe reaches are shown in Figures 1a-1c. Because there is no available land space along the Cresta reach for deployment of multiple chillers, a constructed a deck is proposed.

Example chiller layouts, based on the July 2002 water temperature and meteorological conditions (most conservative; requires the most chillers), are shown in Figures 2a-2c. Water is diverted to chillers via a reinforced concrete pipe (RCP) from the low level outlets of the dams (Figures 1a-1c and Figures 3a-3c). The cooled water is then released

[5] Ton is an energy unit here. Ton = BTU/hr ÷ 12,000; BTU/hr = gallons per hour × 8.33 × ΔT (°F)

back by way of another RCP to the upper end of each reach, i.e., just below the reservoir dam.

List of Figures:

- Figures 1a – 1c: Plan view of chiller locations and piping:
- Figures 2a – 2c: Plan view of example chiller layouts and piping
- Figures 3a – 3c: Profile of chiller designs

Key Design or Construction Uncertainties Requiring Further Study:

- Siting and design of the chiller for a confirmed location above the 100-year floodplain to avoid flood damages while being able to deliver the chilled water back to the NFFR right below each dam by gravity requires further study.
- The design was mainly based on the vendor's quote which requires further verification.

Discussion:

A mechanical cooling tower was also considered to cool reservoir water. However, preliminary analysis indicates that a mechanical cooling tower is not feasible to cool waters in Rock Creek, Cresta, and Poe Reservoirs to below 20°C because the ambient wet bulb temperatures at the sites are already close to 20°C (or 68°F) in July and August based on the meteorological data observed at Rock Creek Dam station and Poe Dam station by PG&E. Theoretically, the ambient wet bulb temperature must be lower than target temperature by at least 5°F (or about 3°C) to make a mechanical cooling tower feasible. (Note: Wet bulb temperature is the temperature indicated by a moistened thermometer bulb exposed to the air flow. The evaporation of water from the thermometer has a cooling effect, so the wet bulb temperature is always lower than the dry bulb temperature (i.e., temperature measured by a normal thermometer) except when there is 100% relative humidity.)

Cost Estimates of Each Installation of Chillers

	Cost of Chillers				Cost of Construction ($)	Total Installation Cost ($)	Annual Energy Consumption		
	Number of Chillers	Unit Chiller Cost ($) [1]	Unit Startup Fee ($) [1]	Subtotal ($)			Unit Power Demand at Full load (kW) [1]	Running Time Period (days/year)	Energy Consumption (KWh $\times 10^6$/year)
Rock Creek Reach									
from 22.5°C --> 19.0°C	12			4,620,000		6,096,000			12.11
from 21.0°C --> 19.0°C	7	382,000	3,000	2,695,000	1,476,000 [2]	4,171,000	678.4	62	7.07
from 20.5°C --> 19.0°C	5			1,925,000		3,401,000			5.05
Cresta Reach									
from 22.0°C --> 18.3°C	15			5,775,000		8,349,000			15.14
from 21.0°C --> 18.3°C	11	382,000	3,000	4,235,000	2,574,000 [3]	6,809,000	678.4	62	11.1
from 20.5°C --> 18.3°C	9			3,465,000		6,039,000			9.09
Poe Reach									
from 22.5°C --> 17.4°C	22			8,470,000		11,750,000			22.21
from 21.0°C --> 17.4°C	15	382,000	3,000	5,775,000	3,280,000 [4]	9,055,000	678.4	62	15.14
from 20.5°C --> 17.4°C	13			5,005,000		8,285,000			13.12

1) From vendor's quote, see attached.
2) Includes two 48-inch, 900 ft long reinforced concrete pipes and installation.
3) Includes two 48-inch, 350 ft long reinforced concrete pipes and installation and constructed deck for chiller deployment.
4) Includes two 48-inch, 2,000 ft long reinforced concrete pipes and installation

Figure 1a. Plan view of chiller location on Rock Creek Reach; Pipe size = 4 ft; flow rate = 150 cfs

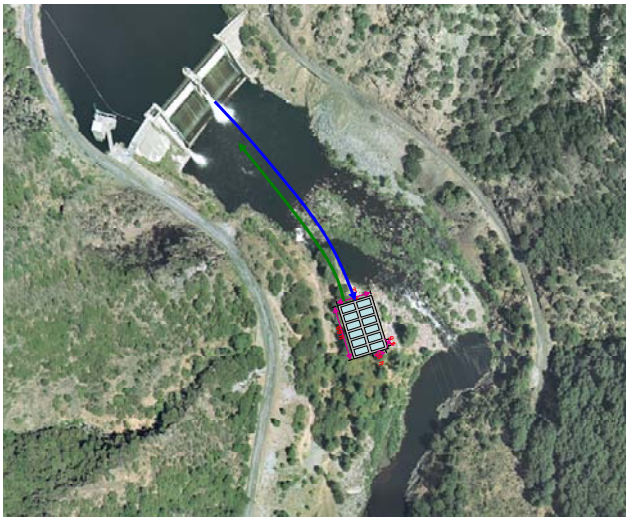


Figure 1b. Plan view of chiller location on Cresta Reach; Pipe size = 4 ft; flow rate = 175 cfs

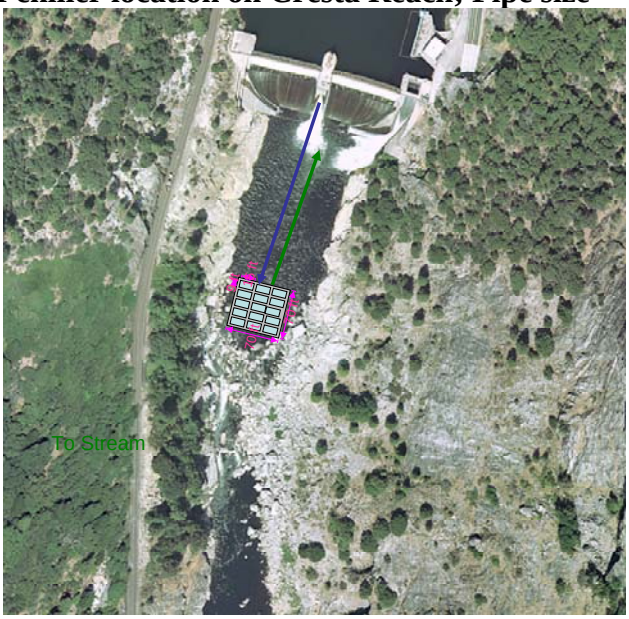


Figure 1c. Plan view of chiller location on Poe Reach; Pipe size = 4 ft; flow rate = 200 cfs

Figure 2a Example chiller layout and piping on Rock Creek Reach (Not to Scale)

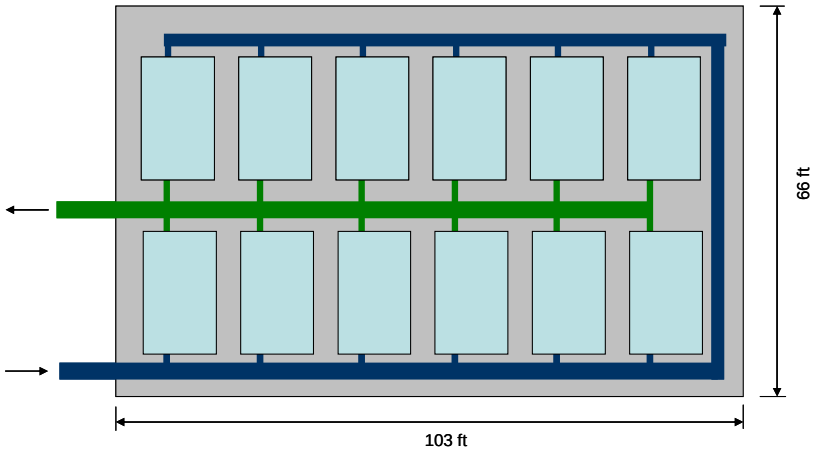


Figure 2b Example chiller layout and piping on Cresta Reach (Not to Scale)

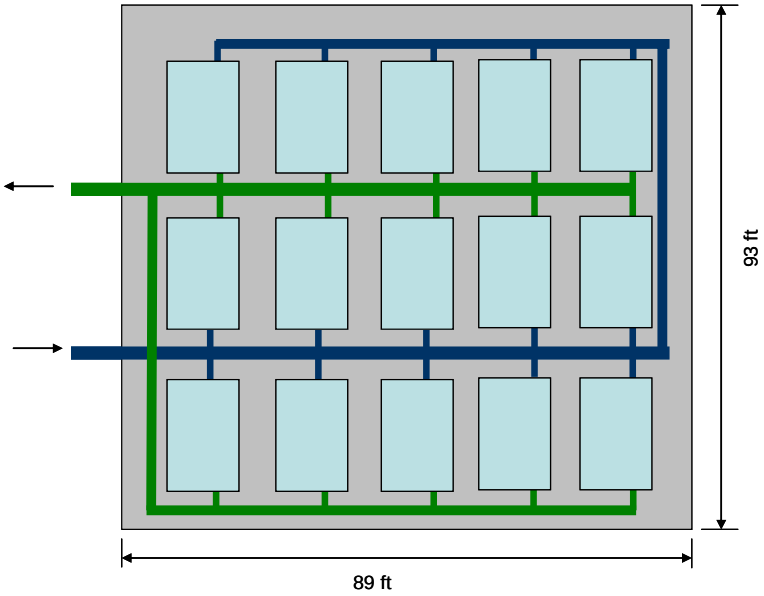


Figure 2c Example chiller layout and piping on Poe Reach (Not to Scale)

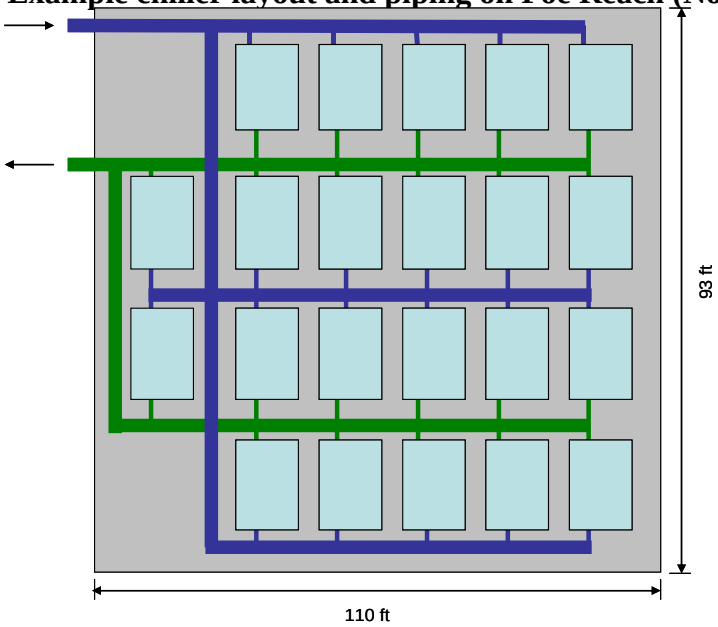


Figure 3a Profile of chiller design on Rock Creek Reach; Chillers are on river bank (Not to Scale).

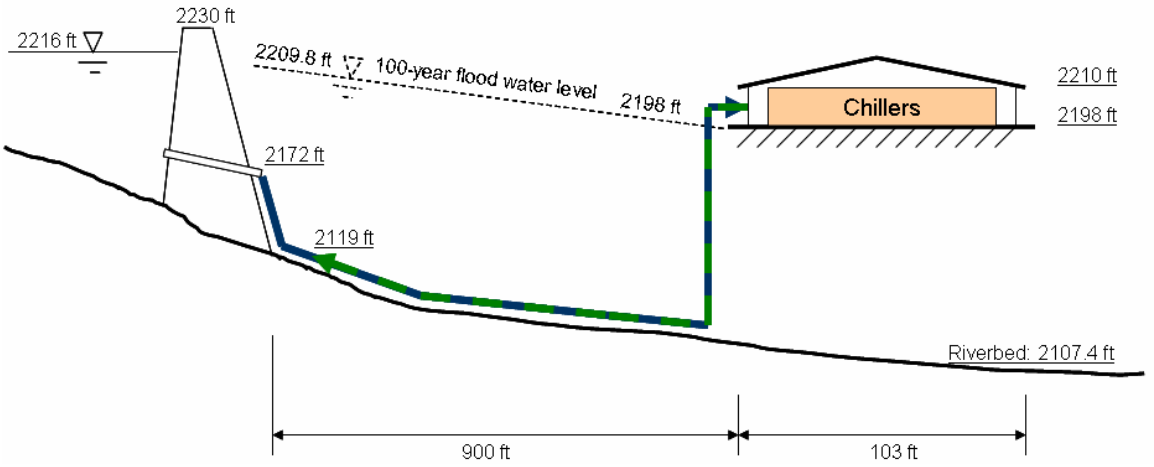


Figure 3b Profile of chiller design on Cresta Reach; Chillers are on a constructed deck (Not to Scale).

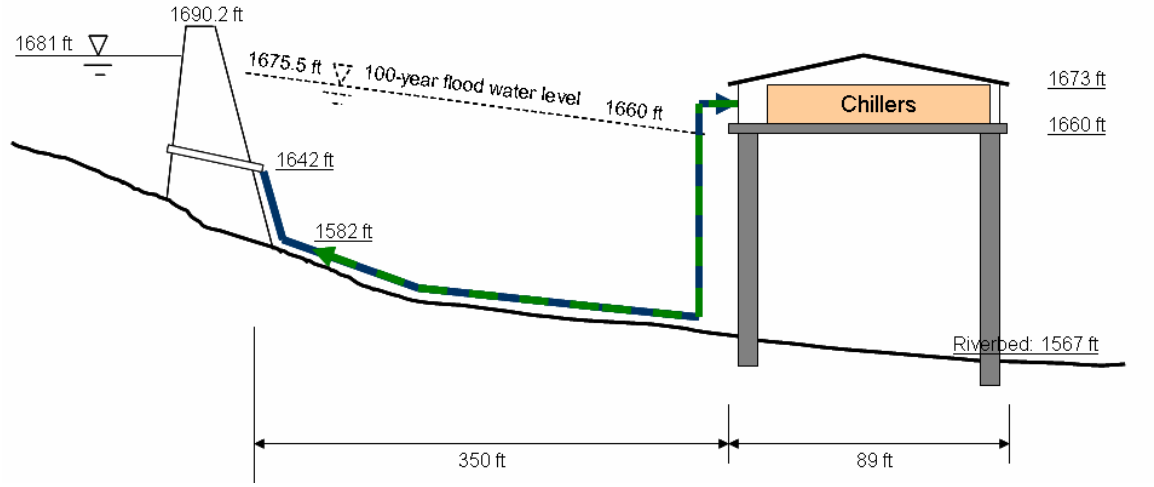
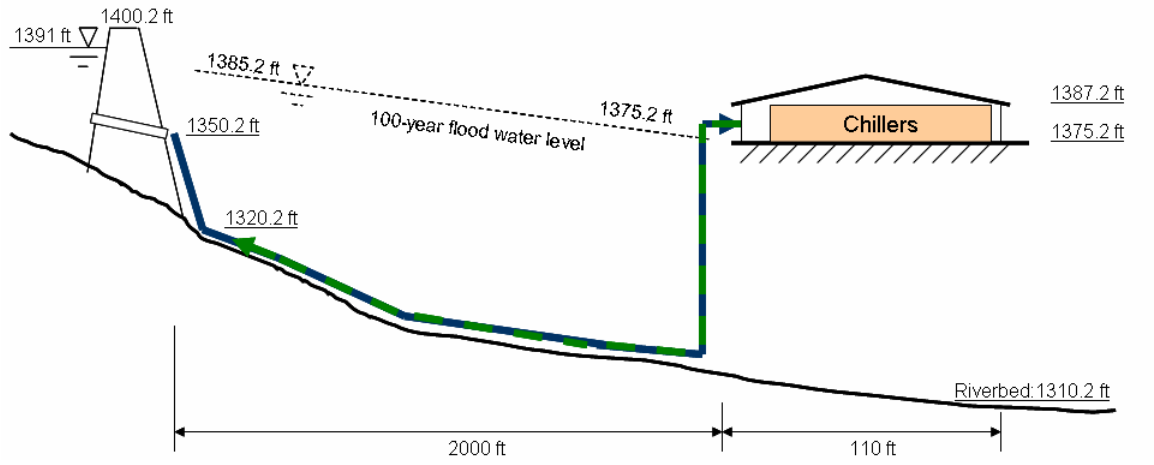


Figure 3c Profile of chiller design on Poe Reach; Chillers are on river bank (Not to Scale).



DB Sales HVAC
Manufacturers Representatives

To:	Xiaoqing Zeng	**Date:**	March 9, 2006
Company:	Stetson Engineering, Inc.	**Page:**	1 of 4
Fax No.:	(415) 457-1638	**Subject:**	Fish Habitat Project, Water Chillers

In accordance with our understanding of the above subject project, we are pleased to quote on the following quality equipment.

Enclosed are preliminary selections on the Dunham-Bush Series "WCOX" Water Cooled Chillers for your review.

The enclosed file contains the print out for the model WCOX-160-QQ=R-134A.

The unit capacity is 1581.6 tons at 678 KW. (would use 1000 HP motor).

Selection is based on 72°F entering and 66°F leaving. If they have a condition of 77°F to 66°F the load would change from 22,440 tons to 41,140 tons, which of course the units could not handle. The units would have to be sized for the 41,140 tons which means you would go from 14 or 15 units to 32 units.

Due to he highflow rates both the condenser and evaporator will be one pass (opposite end connections).

The pricing does not include the remote starter/disconnect, start-up, compressor or motor extended warranty.

Start-Up would be $3,000 net per unit, does not include travel. Would suggest adding hot gas bypass and analog output board for head pressure control.

The second file attachment is strictly for envelope dimensions. The drawings "WC0X-160" shows two pass vessels. This quote is for single pass vessels of which I do not have a drawing of.

A job of this magnitude has to have detailed plans and specifications therefore the pricing is subject to change after a review has been made on same.

Budget Pricing:
Model #WCOX160-Q .....$ 381,700 ea.

Price includes the following options.

a. Evaporator Insulation
b. Hot Gas Bypass
c. Analong Output Board for Head Pressure Control

Should you have any questions, please feel free to give me a call.
Sincerely,

Gilbert Cruz
Gc0309.06b

Quoted prices are firm for 30 days of this proposal. Quotations are subject to acceptance by the manufacturer and subject to terms and conditions of sale.

11582 Markon Drive Garden Grove, CA 92841
(714) 897-1036 • fax (714) 894-7586
E-mail: DBSalesCA@aol.com
WWW.DBSALES.NET

DUNHAM-BUSH®

APPLICATIONS RATING
Dunham-Bush

WCOX160 clr:2pW5Q cnd:2pP5Q std. Q

Conditions of Service

Hertz	60	Unit efficiency (EER)	28.0
Percent of full load	100%	Unit efficiency (kW/Ton)	0.429
Capacity (Tons)	1,581.6	NPLV	0.460
Unit power (kW)	678.4	Refrigerant	R-134a

Compressor(s): 3216

Notes

- Not submitted to ARI for certification under standard-550/590.

Evaporator

Fluid	Water	Pressure drop (psi/ft w.g.)	3.1/7.1
Entering fluid temp. (°F)	72.0	Pass arrangement	1
Leaving fluid temp. (°F)	66.0	Tube velocity (ft/s)	5.6
Fluid flow rate (gal/min)	6,333.1	Fluid freezing point (°F)	32.0
Fouling factor (hr·ft·°F/Btu)	0.00010		

Model(s): W5Q

Condenser

Fluid	Water	Pressure drop (psi/ft w.g.)	2.1/4.9
Entering fluid temp. (°F)	85.0	Pass arrangement	1
Leaving fluid temp. (°F)	94.0	Tube velocity (ft/s)	4.1
Fluid flow rate (gal/min)	4,744.9	Fluid freezing point (°F)	32.0
Fouling factor (hr·ft·°F/Btu)	0.00025		

Model(s): P5Q

NPLV Points

% Full load	Tons	kW	kW/Ton	Cond. EFT	Type
100%	1,581.6	678.4	0.429	85.0	Actual
75%	1,186.2	504.7	0.425	75.0	Actual
50%	790.8	395.5	0.500	65.0	Actual
25%	395.4	272.3	0.689	65.0	Actual

Part Load Points

% Full load	Tons	kW	kW/Ton	Cond. EFT	Type
100%	1,581.6	678.4	0.429	85.0	Actual
75%	1,186.2	504.7	0.425	75.0	Actual
50%	790.8	395.5	0.500	65.0	Actual
25%	395.4	272.3	0.689	65.0	Actual

PERFORMANCE SUMMARY • CH-1

DUNHAM-BUSH®

Untitled

Standard Equipment

Unit
- All units are painted with an acrylic air dried enamel
- Micro computer control cabinet mounted
- Positive displacement open-drive oil pump
- Lights for: Control power on, Compressor enabled, General alarm light
- Operating charge of refrigerant and oil

Cooler
- Flooded type shell and tube
- Cleanable and removable integral finned copper tubes
- Victaulic water connections
- Removable heads
- Single pressure relief device 1.25" FPT
- Vent and drain plugs for each head
- Diffuser and baffle plates
- Oil recovery system
- ASME coded on the refrigerant side, section 8, Div. One "Unfired Pressure Vessels"

Compressor
- D/B rotary helical axial compressor
- Slide valve control infinitely variable to as low a 10%
- Load/Unload solenoid valves
- Motor mount for positive alignment
- Thrust and journal bearings
- Rotors machined from AISI 1141 bar stock
- Cast iron housing
- Shaft seal and seal oil cooler
- Positive pressure lubrication system
- Gear type open drive oil pump
- Replaceable core oil filter
- Suction check valve

External Oil Separator & Reservoir
- ASME coded, Section 8, Division one
- Thermostatically controlled immersion heaters

Condenser
- Cleanable shell and tube type
- Cleanable and replaceable integral finned copper tubes
- Victaulic water connection
- Removable heads
- Vent and drain plugs for each head
- Sized for full pumpdown capacity
- Dual pressure relief devices 1" FPT
- ASME codeded on the refrigerant side, Section 8, Division one "Unfired Pressure Vessels"

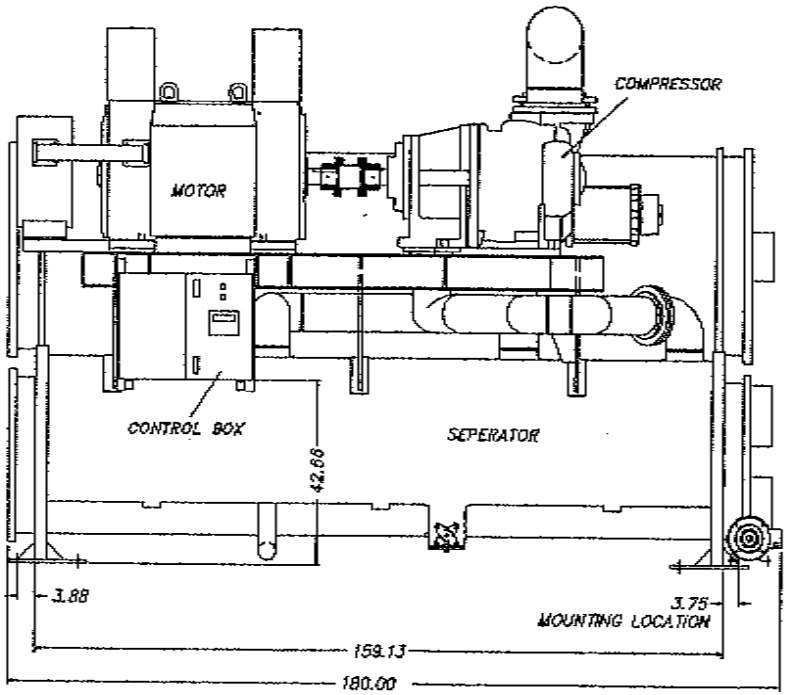
Controls
- Microcomputer control direct digital type, 2 line, 80 character with push button keyboard, menu driven software, LCD display

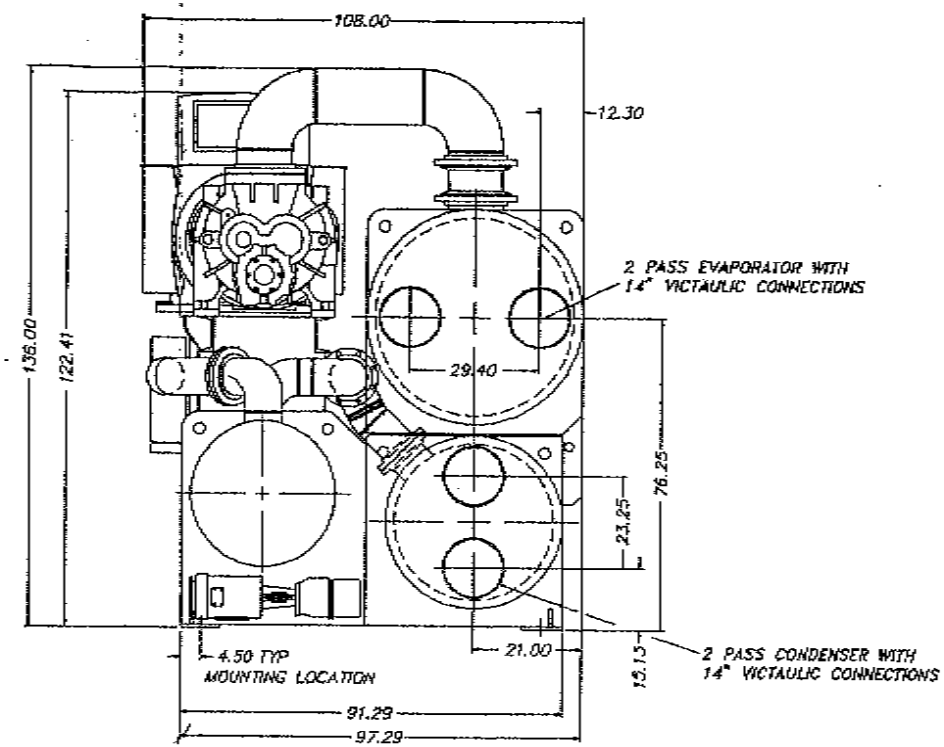
Control inputs
- Leaving water temperature
- Cooler refrigerant pressure
- Condenser refrigerant pressure
- Oil pressure
- Compressor amp draw
- Compressor elapsed time
- Percent slide valve loading
- Reservoir oil temperature
- Seal oil temperature
- Water temperature reset valve
- Demand limit reset valve
- Compressor starter status
- Oil pump starter status
- Water flow switch status
- External start/stop command status

Refrigerant Controls
- Finite refrigerant motorized valve
- Liquid refrigerant level sensor for cooler
- Compressor load, unload solenoid valves

Control Function
- Low refrigerant suction pressure
- High refrigerant discharge pressure
- Low oil temperature
- Freeze protection
- High reservoir oil temperature
- High seal oil temperature
- Compressor starter failure
- Oil pump starter failure
- Compressor run error
- Power loss
- Chilled water flow loss
- Sensor error
- Compressor over current
- Anti-recycle
- Retains the latest eight alarm conditions with time of failure in alarm history

Unit Conformances
- ASME Section 8 for unfired vessel construction
- ASME Standard 31.5 Refrig. Piping
- ASHRAE 90A, 1980
- NEC, NEMA, ANSI/ASHRAE 15
- Rated in accordance with ARI 550/590-98
- Rated in accordance with ARI Standard-550/590-98.





WCOX-160

2 PASS EVAPORATOR, RH CONNECTION SHOWN
2 PASS CONDENSER, RH CONNECTION SHOWN

WEIGHTS:

SHIPPING - 57,000 LBS
OPERATING - 65,000 LBS

* ALL DIMENSIONS ARE IN INCHES
* ALL DIMENSIONS ARE PRELIMINARY

DUNHAM-BUSH, INC.
COMPRESSOR(ED) PRODUCTS DIV. HARRISONBURG,VA 22801 USA

SIMILAR TO 018722RDP2	APP.	DATE
TITLE: DWG-OUTLINE WCOX		
INITIAL USAGE WCOX-160		
DRAWN BY: NWH	DATE: 3 4-97	WCOX-160
	SHEET 1 OF 1 SHEETS	

DO NOT SCALE THIS DRAWING