

# Planning of Large-Scale Pumped Hydroelectric Energy Storage in Colorado

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## *Introduction*

Large-scale energy storage is essential for successful integration of wind and solar renewable power generation and maintaining reliable transmission grid operations. At present, pumped hydro provides the only means for efficient and economic large-scale storage of electric energy. Large-scale or utility-scale pumped hydroelectric energy storage (PHES) plants have installed capacities ranging from < 500 MW to >2,000 MW. Their quick response in generating peaking power is useful to prevent blackouts. In Colorado, a number of potential PHES sites with installed capacities up to 630 MW have been identified in a study published by Jonah G. Levine, University of Colorado (2007):

[www.colorado.edu/engineering/energystorage/files/MSThesis\\_JGLEvine\\_final.pdf](http://www.colorado.edu/engineering/energystorage/files/MSThesis_JGLEvine_final.pdf)

This paper describes the sites that are currently being considered for potential development in Gunnison County as part of the proposed Central Colorado Project (CCP): United States Patent No. US 7,866,919 B2 ( Jan. 11, 2011): [www.ueblacker.us](http://www.ueblacker.us)

The sites are known by the following names: Rocky Point, Union Park, Park Cone, Cebolla Creek, and Soap Mesa. Their locations together with conceptual layouts of the facilities and preliminary estimates of revenues and construction costs are described in the following section.

## *Project Description*

- Rocky Point PHES (1,000 MW+)  
This project is of special interest since much of the information required for obtaining a FERC permit has already been prepared and included in the license application for the proposed 1,000 MW+ Rocky Point Pumped Storage Project (FERC Project No. 7802, Natural Energy Resources Company, July 1987). The following Executive Summary (Exhibit 1) describes the project and its history through the end of 1989.

The use of Taylor Park Reservoir as lower pool may not be feasible unless substantial improvements are made to the existing Taylor Park Dam because of safety issues. Major concerns are possible earthquakes and floods which could affect the stability of the 74 year- old embankment dam and its foundation. In addition, there are unresolved issues with the Colorado Roadless Rule: [www.dnr.state.co.us/roadlessrule](http://www.dnr.state.co.us/roadlessrule)

The attached estimate of probable revenues and construction costs (Table 1) does not include the costs for remedial work to improve the stability of Taylor Park Dam and shows that the 1,000 MW+ PHES operation, as originally planned, could be constructed in 5 years for approximately \$1.4 billion.

- Rocky Point PHES (2,000 MW+)

A reconnaissance level study was completed to evaluate the feasibility of enlarging the originally proposed Rocky Point PHES project to 2,000 MW+ and operating the facility without using Taylor Park Reservoir. This evaluation produced the attached location map and elevation view (Figures 1 and 2) illustrating the conceptual arrangement of various project components such as forebays, afterbay, underground powerhouse, pressure shafts, pressure tunnels, surge tanks, and tail-raise tunnels. The proposed 15,000 acre-ft. afterbay reservoir is located near and above the inlet to Taylor Park Reservoir, approximately 2.75 miles from the north forebay area at Rocky Point, keeping the distance to head (D/H) ratio well below 10.

The locations and dimensions of access roads, access tunnels as well as the dimensions of pressure shafts, surge tanks, pressure and tailrace tunnels, and the size of the powerhouse cavern for this enlarged facility, and any other proposed facilities as described below, are presently unknown and will depend on the capacity and number of pump-turbine units to be installed. The attached estimate of probable revenues and construction costs (Table 2) is considered to be conservative and firmly shows the economic viability of the project. The estimate includes all relevant technical data used in preparing the financial analysis. The analysis shows that the proposed 2,000 MW+ Rocky Point Project can be constructed in 5 years for approximately \$ 3.3 billion.

- Union Park PHES (1,500 MW +) and Park Cone PHES (1,000 MW+)

These sites are located near Union Park and Taylor Park Reservoir (Figure 3). The estimates of probable revenues and construction costs for the proposed Union Park PHES and Park Cone PHES are shown in Table 3 and 4. These estimates show that the proposed projects can be constructed in five years for approximately \$2.0 billion and \$1.65 billion respectively.

- Cebolla Creek PHES (1,500 MW+) and Soap Mesa PHES (6,000 MW+)

The sites of these proposed facilities are located near Blue Mesa Reservoir (Figures 4, 5, 6, 7, and 8). They have been selected for consideration of alternatives in case issues with the Colorado Roadless Rule and safety concerns with Taylor Park Dam cannot be resolved or cause delays in proceeding with the development of the proposed Rocky Point, Union Park, and Park Cone projects. Preliminary estimates of probable revenues and construction costs for these facilities have been prepared and summarized in Tables 5, 6, 7, and 8. These estimates show that the proposed facilities for Cebolla Creek and Soap Mesa (Site 1, 2, and 3) can be constructed in five years for approximately \$2.06 billion, \$3.23 billion, \$1.75 billion, and \$2.96 billion respectively.

As pointed out previously, the locations and dimensions of access roads, access tunnels as well as the dimensions of pressure shafts, surge tanks, pressure and tailrace tunnels, and the size of the powerhouse cavern for any of the proposed facilities are presently unknown and will depend on the capacity and number of pump-turbine units to be installed. It is believed that the revenue and construction cost estimates are conservative and confirm the economic viability of the evaluated project alternatives.

*Conclusions and Recommendations*

*Acknowledgements*

*References*

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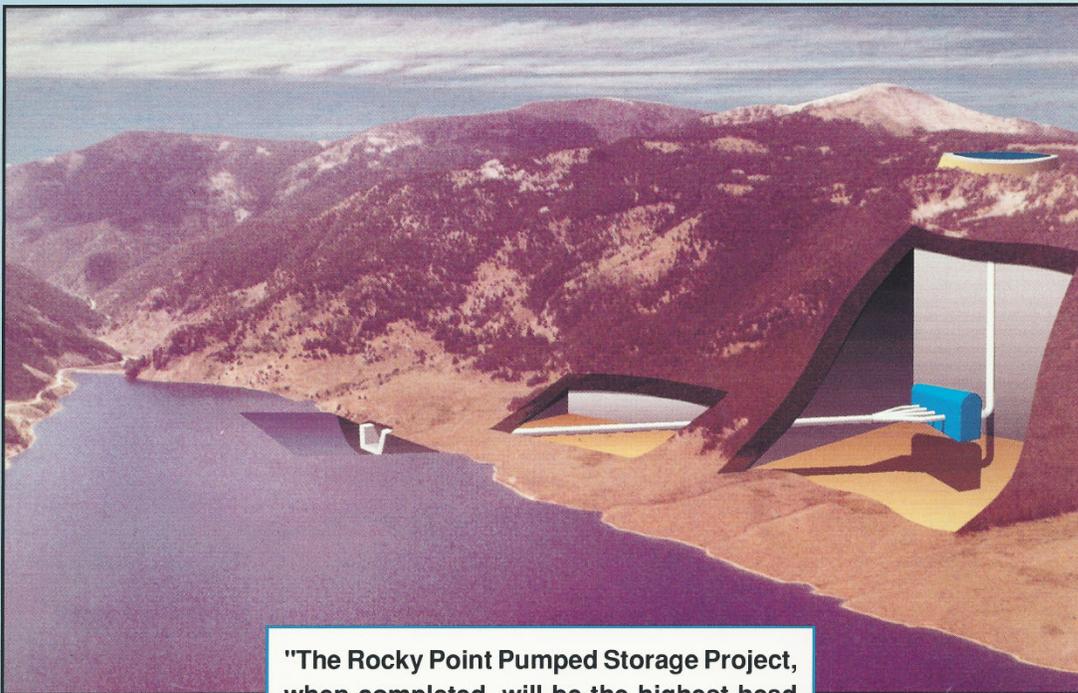
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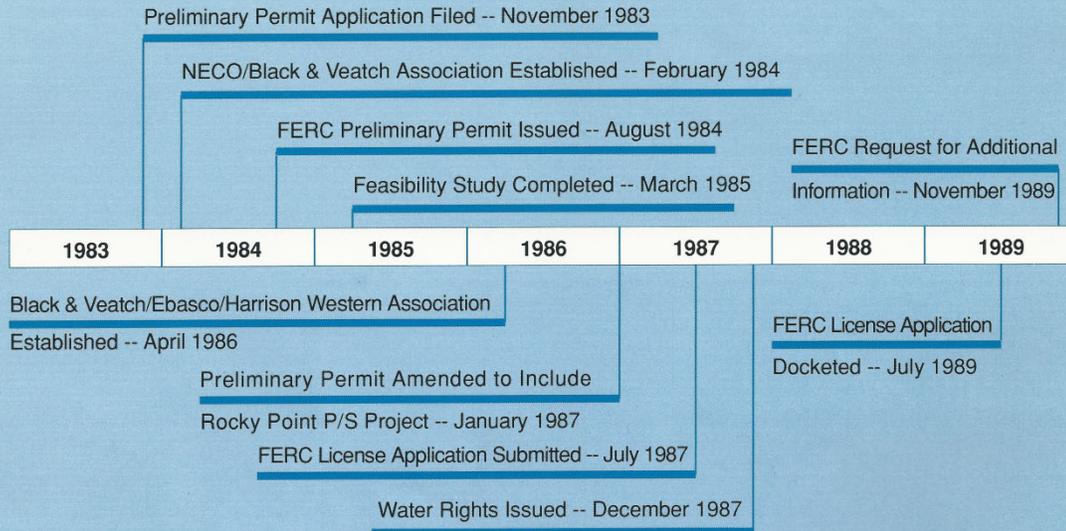
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## **ROCKY POINT PUMPED STORAGE PROJECT EXECUTIVE SUMMARY**



**"The Rocky Point Pumped Storage Project, when completed, will be the highest head pumped storage facility in North America. The 1,000 MW project is being developed near Gunnison, Colorado. The project will use the US Bureau of Reclamation's existing Taylor Park Reservoir as the lower reservoir and the proposed Rocky Point Reservoir as the upper reservoir. This Executive Summary describes the project and its history through the end of 1989."**

**CHRONOLOGICAL HISTORY**



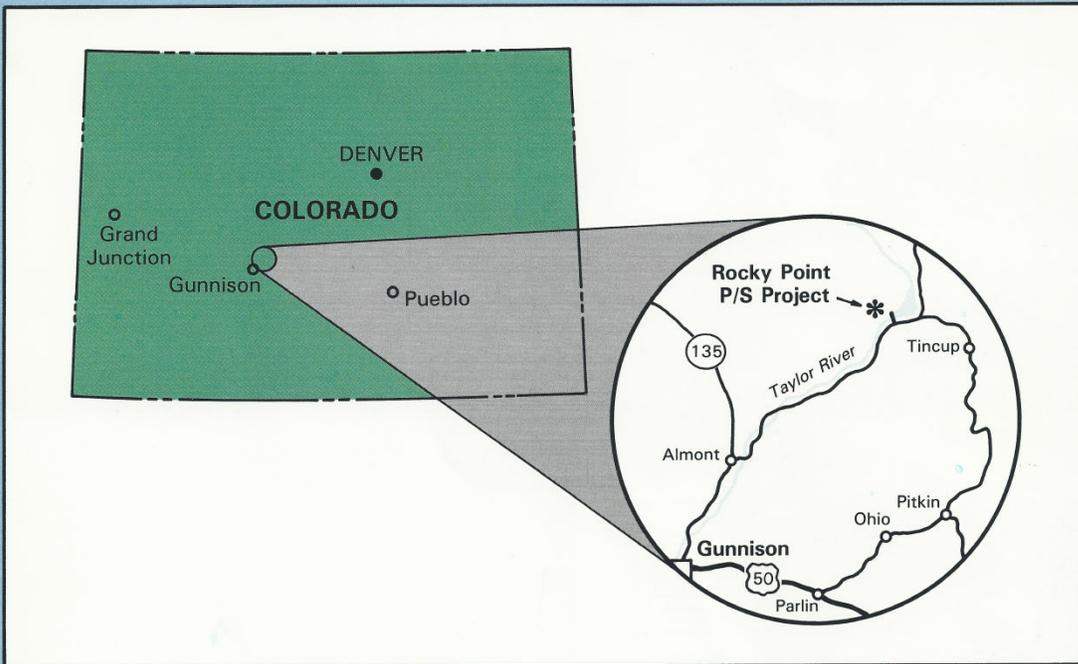
**PROJECT PARTICIPANTS**

Natural Energy Resources Company Palmer Lake, Colorado	Licensee
Black & Veatch, Engineers-Architects Kansas City, Missouri	Engineering Licensing Environmental Studies
Ebasco Services Incorporated Denver, Colorado	Engineering Licensing Environmental Studies
Harrison Western International Denver, Colorado	Geotechnical Field Investigations
Chadbourne & Parke Washington, D.C.	Attorneys

**PROJECT DEVELOPMENT TEAM**

Licensee	Natural Energy Resources Company
Engineers/Constructors	Black & Veatch, Engineers-Architects Ebasco Services Incorporated Harrison Western International
Equipment Supply	Unnamed
Financing	Unnamed
Operator	Unnamed

**PROJECT DESCRIPTION**



**Location**

**Taylor Park Reservoir**

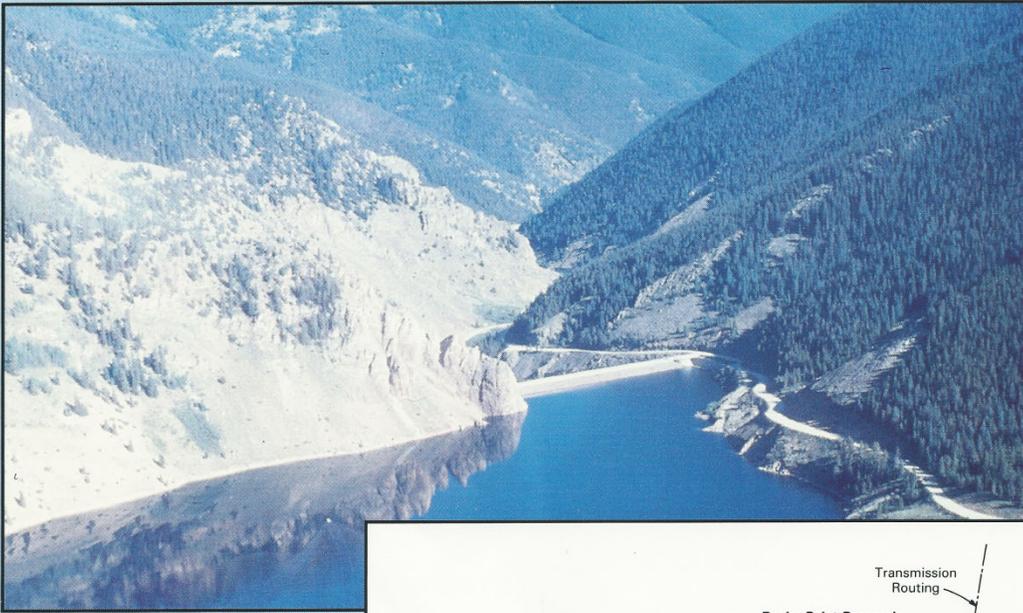
The lower reservoir for the Rocky Point Pumped Storage Project is the existing Taylor Park Reservoir which is created by Taylor Park Dam located approximately 30 miles northeast of Gunnison, Colorado, on the Taylor River. Taylor Park Dam was completed in 1937 and is owned and operated by the US Bureau of Reclamation.

<i>Reservoir Capacity</i>	<i>106,200 acre-feet</i>
<i>Area at Full Pool</i>	<i>2,040 acres @ El.9330</i>

**Rocky Point Reservoir**

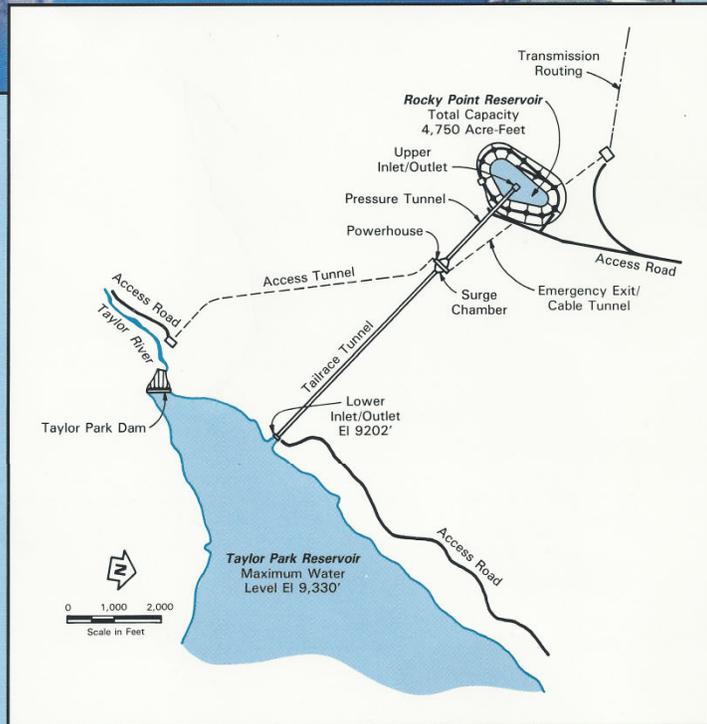
The upper Rocky Point Reservoir will be located in the plateau area between Matchless Mountain and Rocky Point, approximately 2,300 feet above and 9,500 feet west of Taylor Park Reservoir.

<i>Embankment</i>	<i>Asphalt-faced rockfill</i>
<i>Reservoir Capacity</i>	<i>4,750 acre-feet</i>
<i>Area at Full Pool</i>	<i>50 acres @ El.11,658</i>
<i>Surface Fluctuation</i>	<i>100 feet</i>



**Taylor Park Inlet/Outlet Works**

A new concrete inlet/outlet structure will be constructed on the west side of Taylor Park Reservoir. Flow will be screened by four steel trashracks supported from the concrete side retaining walls and three intermediate piers.



**Waterways**

A 17.5 ft. diameter by 5,000 ft. long steel-lined pressure tunnel will convey the water from the upper reservoir inlet/outlet structure to the headrace manifold. The 23 ft. diameter by 6,000 ft. long concrete tailrace will connect the lower reservoir inlet/outlet structure and powerhouse.

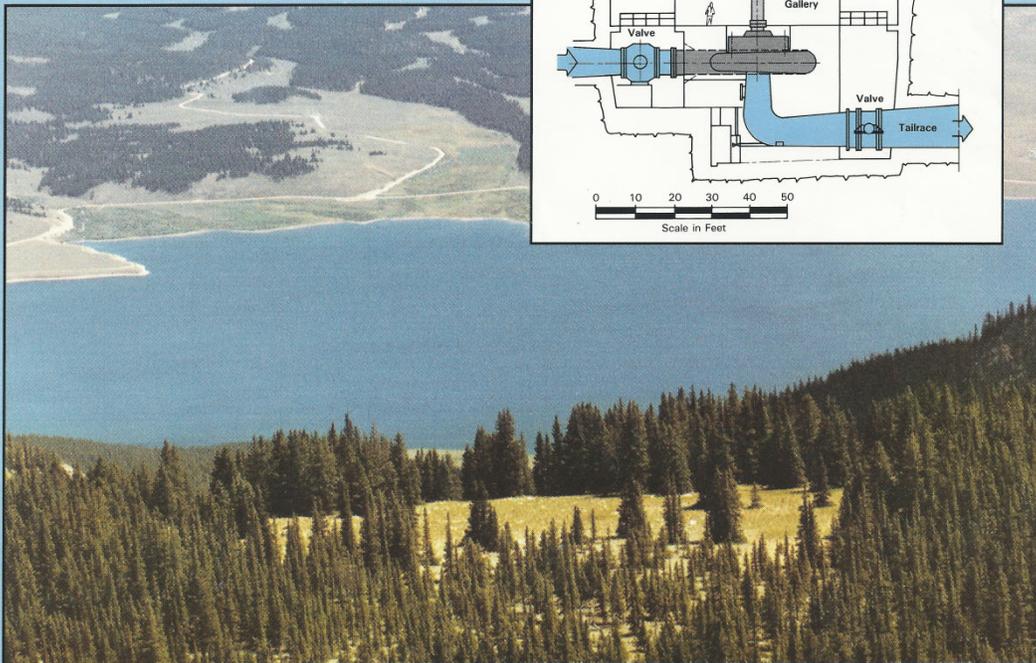
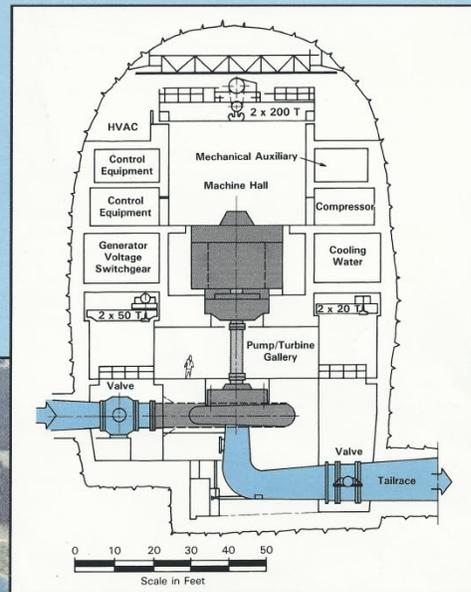
**Turbine Generators**

Four vertical, single stage, Francis reversible pump/turbine-motor generator units will be provided for pumping and generation. The range of expected performance at minimum head is as follows.

Turbine (Generating) Net Head, feet	2,200
Turbine Output, MW	257
Flow, cfs	1,526
Pump (Pumping) Net Head, feet	2,260
Pump Input, MW	285
Flow, cfs	1,350

**Powerhouse**

The powerhouse cavern will be located within granitic rock approximately 6,000 feet from the Taylor Park inlet/outlet structure. The powerhouse cavern will be sized to accommodate four 250 MW reversible pump/turbines directly coupled to motor generators. The cavern will have an interior space of the following approximate dimensions: width 82 feet, height 150 feet, and length 455 feet.





**Transmission**

The 26.7 mile transmission corridor serving the project will run southwest of Taylor Park Reservoir to intersect the existing transmission corridors near Gunnison. These corridors give access to transmission lines and generating stations north and south of the project. From the Four Corners area, combinations of federal and utility transmission facilities provide access to the Phoenix and Southern California power markets.

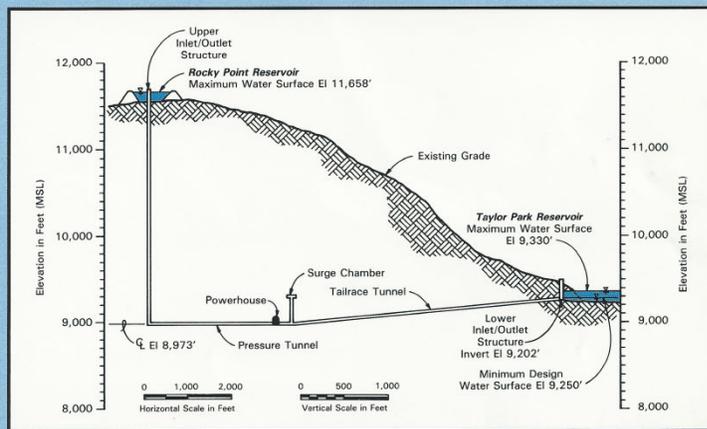
**SUMMARY OF PROJECT COSTS\***

Electromechanical Equipment	154.4
Powerhouse	69.1
Water Conduits	187.5
Upper Reservoir	46.1
Miscellaneous Facilities	32.1
Transmission	50.8
<b>Total Construction Costs</b>	<b>540.0</b>
Indirect Costs	81.0
Allowances for Contingencies	124.2
<b>Total Cost (January 1990 Dollars)</b>	<b>745.2</b>
Escalation (4%)	93.7
AFDC (7.5%)	111.5
<b>Total Capital Costs (1995 Dollars)</b>	<b>950.4</b>

\*All Values in Million Dollars.

**PROJECT FEASIBILITY**

An initial Feasibility Study found the Rocky Point project to be economically and financially feasible in the Rocky Mountain region market. In a larger power market the value of the project would be enhanced. The high head of the site and the close proximity of the lower and upper reservoir are attractive physical site features. The high head reduces the size and cost of the pump/turbine motor-generator equipment and civil structures. The low ratio of the horizontal distance between the reservoirs and the head (L/H) represents a highly economic pumped storage water conduit system. These advantageous site conditions contribute to the project being the lowest cost per kilowatt project available.



**FERC LICENSING STATUS**

LICENSING SCHEDULE			
	1990	1991	1992
NECO Responds to FERC's Information Request	→		
FERC Issues Public Notice	→		
FERC Prepares EIS		→ DEIS FEIS	
FERC Issues License			→
USFS, USBR, & BLM Issue Special Use Permits			→

During the past several years, the Rocky Point Pumped Storage Project has overcome the following licensing challenges.

- Successfully resolved initial agency concerns about impacts to bighorn sheep.
- Successfully resolved potential jurisdictional conflicts among four federal agencies by having FERC act as the lead federal agency and having the US Forest Service, US Bureau of Reclamation, and US Bureau of Land Management become cooperating agencies.
- Successfully secured water rights to store and use 4,000 acre-feet of water.
- Identified several feasible transmission line corridors in conjunction with the key federal agencies and Gunnison County.

During the resolution of these licensing challenges, the Project participants have established good working relationships with the various federal, state, and local agencies reviewing the project. These relationships will continue to benefit the project as we move toward attaining the FERC License. FERC recently docketed the hydropower license application for processing and the FERC staff has thoroughly reviewed the application. Public notice of the application will be issued in the next year. Upon resolution of agency and public comments, the FERC will decide whether an Environmental Impact Statement or a Finding of No Significant Impact is appropriate for the project. Upon completion of either environmental review document, FERC will issue the license for the project.

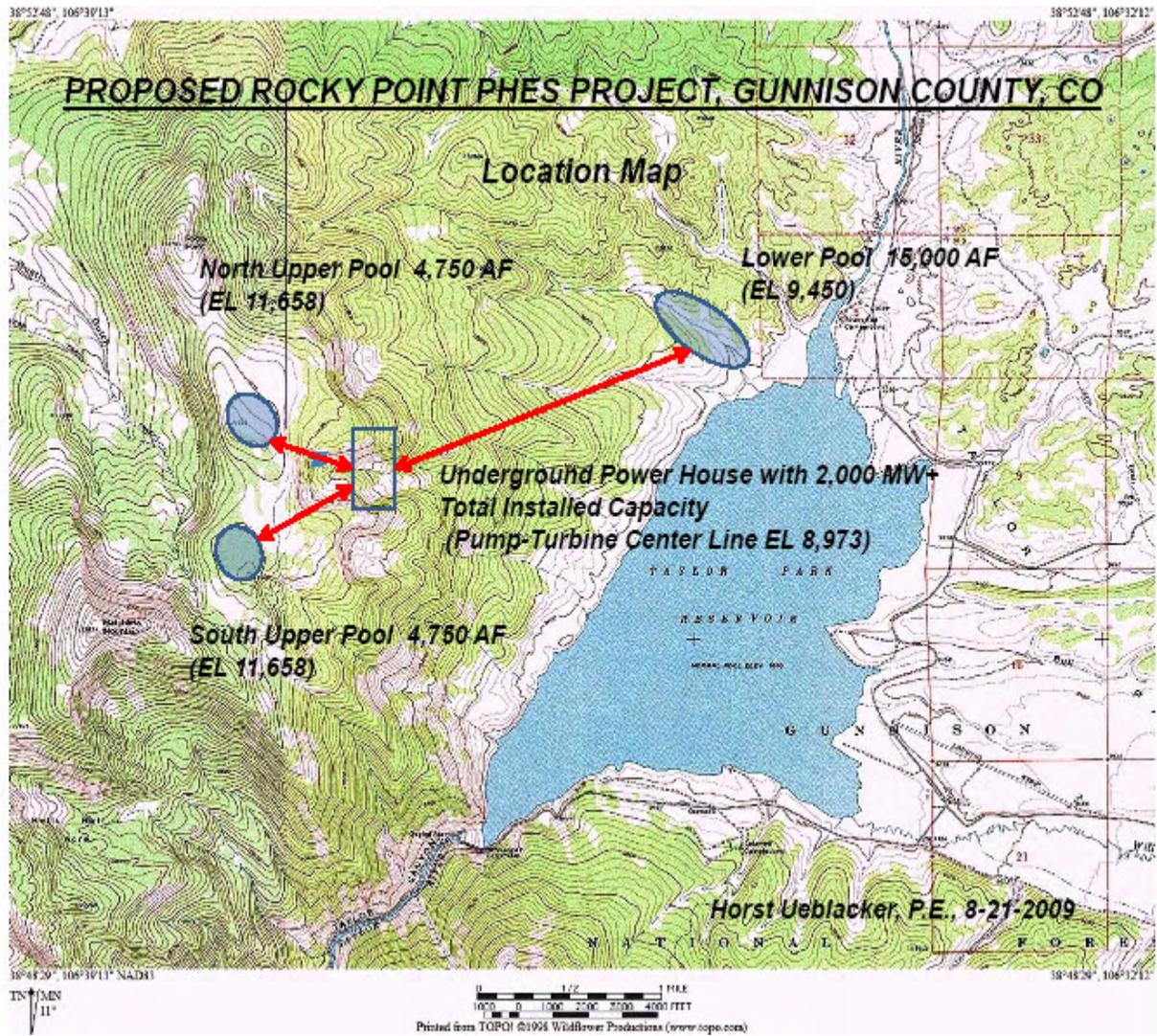
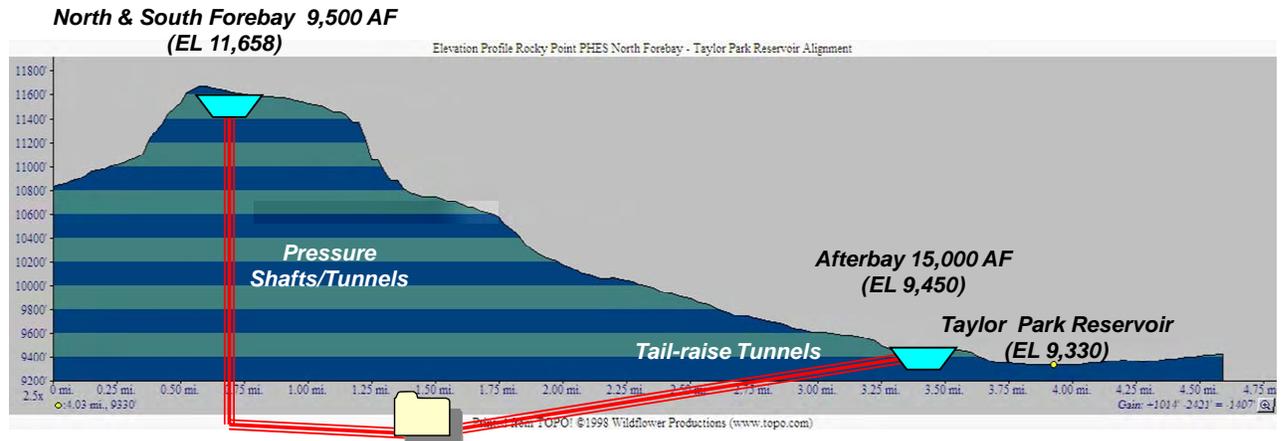


Figure 1.

Location map with conceptual layout of proposed Rocky Point 2,000 MW+ PHES.

**PROPOSED ROCKY POINT PHES PROJECT, GUNNISON COUNTY, CO**

***Elevation View***



**Underground Power House with 2,000 MW+ Total Installed Capacity  
(Pump-Turbine Center Line EL 8,973)**

**Horst Ueblacker P.E., August 24, 2009**

Figure 2.

Elevation view with conceptual layout of proposed Rocky Point 2,000 MW+ PHES.



Figure 3.

Location map of proposed PHES sites near Taylor Park and Union Park Reservoirs.

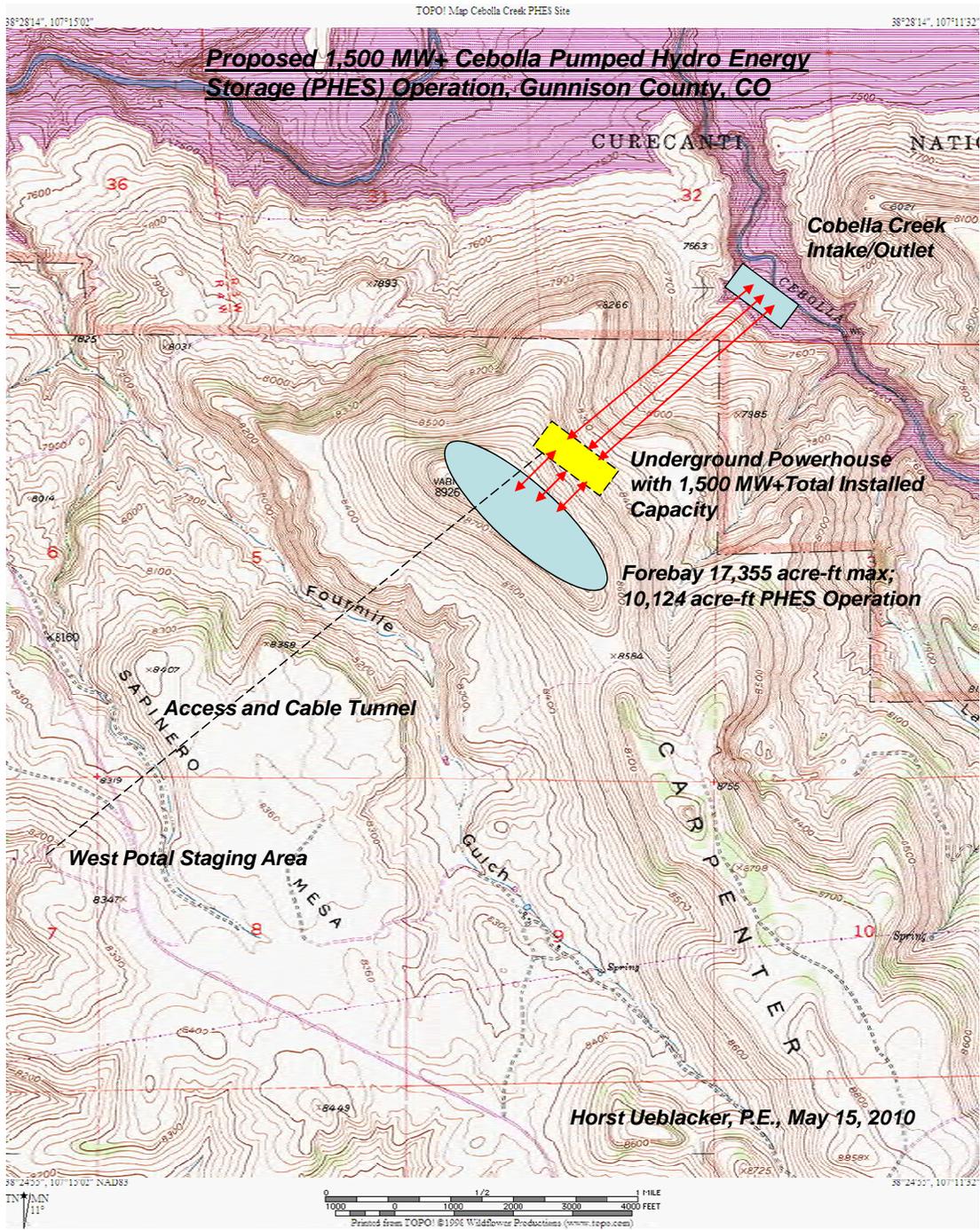
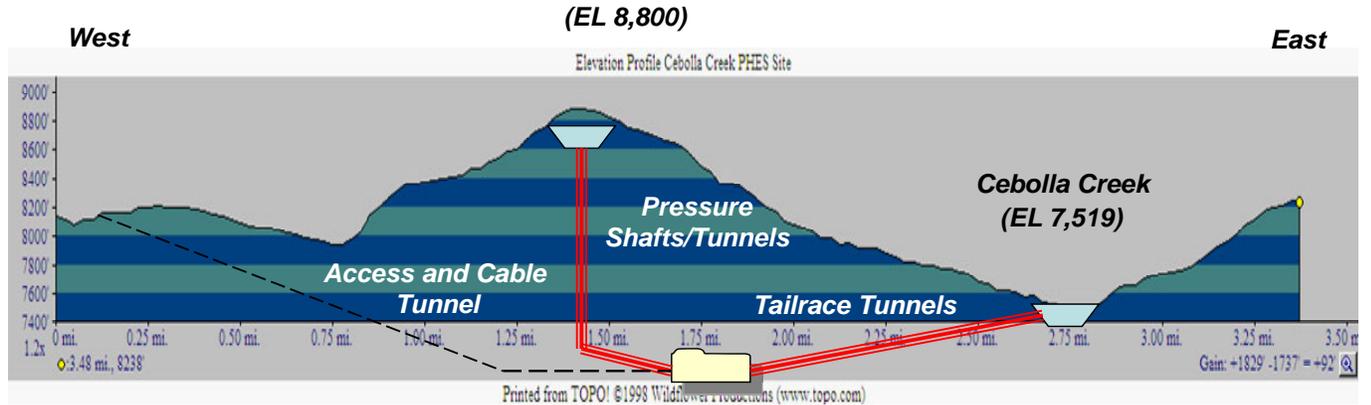


Figure 4.

Location map with conceptual layout of proposed Cebolla Creek 1,500 MW+ PHEs.

**PROPOSED CEBOLLA CREEK PHES PROJECT, GUNNISON COUNTY, CO**

**Forebay Volume 17,355 acre-ft max; 10,124 acre-ft PHES Operation**



**Underground Power House with 1,500 MW+ Total Installed Capacity  
(Pump-Turbine Center Line EL 7,200)**

**Horst Ueblacker, P.E., May 15, 2010**

Figure 5.

Elevation view with conceptual layout of proposed Cebolla Creek 1,500 MW+ PHES.

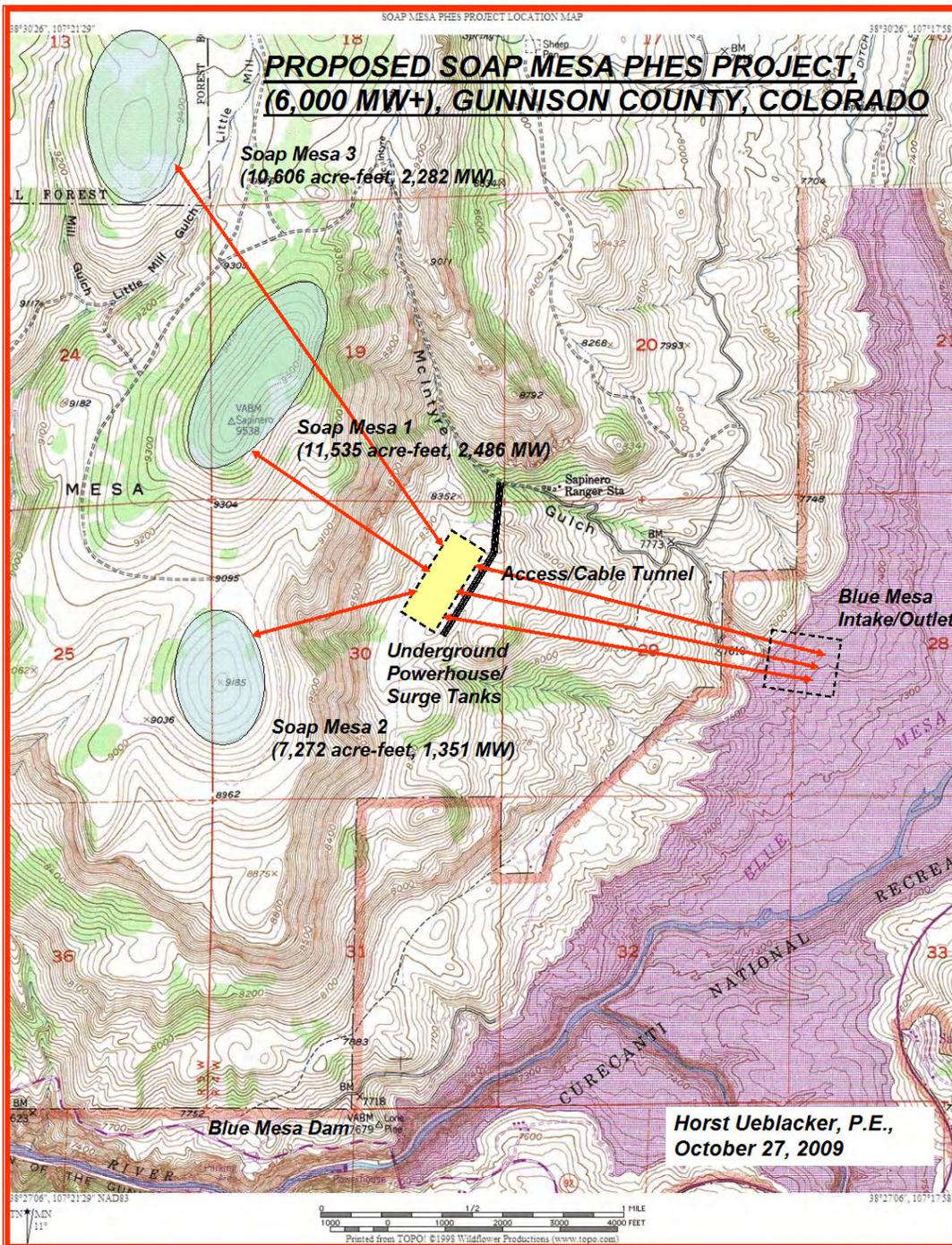


Figure 6.

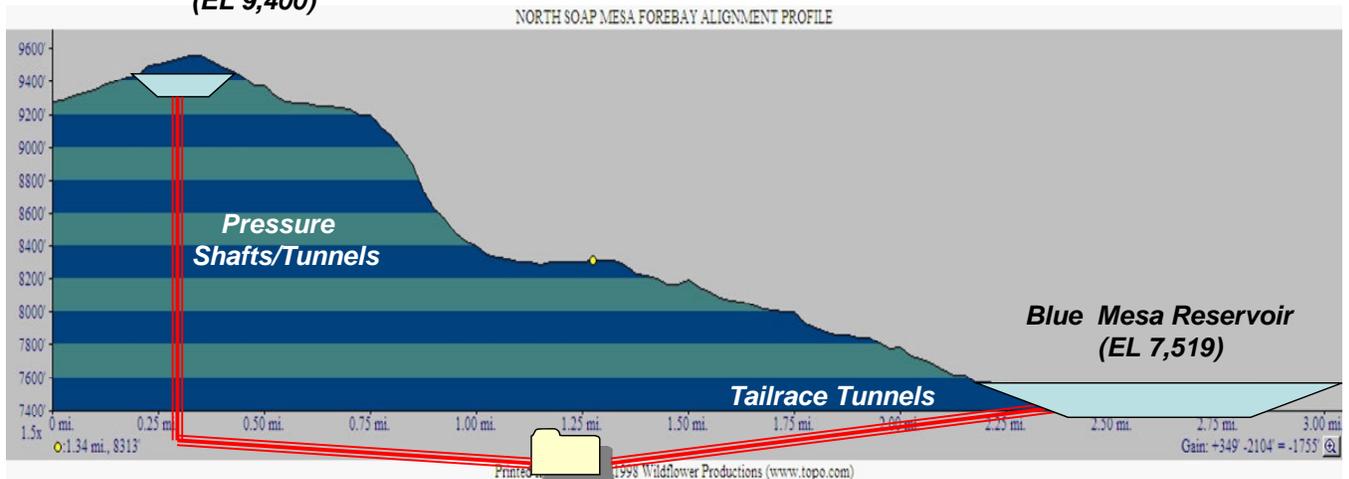
Site map with conceptual layout of proposed Soap Mesa 6,000 MW+ complex.

PHES

**PROPOSED 'SOAP MESA 1' PHES PROJECT, GUNNISON COUNTY, CO**

***Elevation View***

**Soap Mesa 1 Forebay 11,535 AF  
(EL 9,400)**



**Underground Power House with 2,486 MW Max. Installed Capacity  
(Pump-Turbine Center Line EL 7,200)**

**Horst Ueblacker, P.E., October 15, 2009**

Figure 7.

Elevation view with conceptual layout of proposed Soap Mesa (1) 2,486 MW PHES.

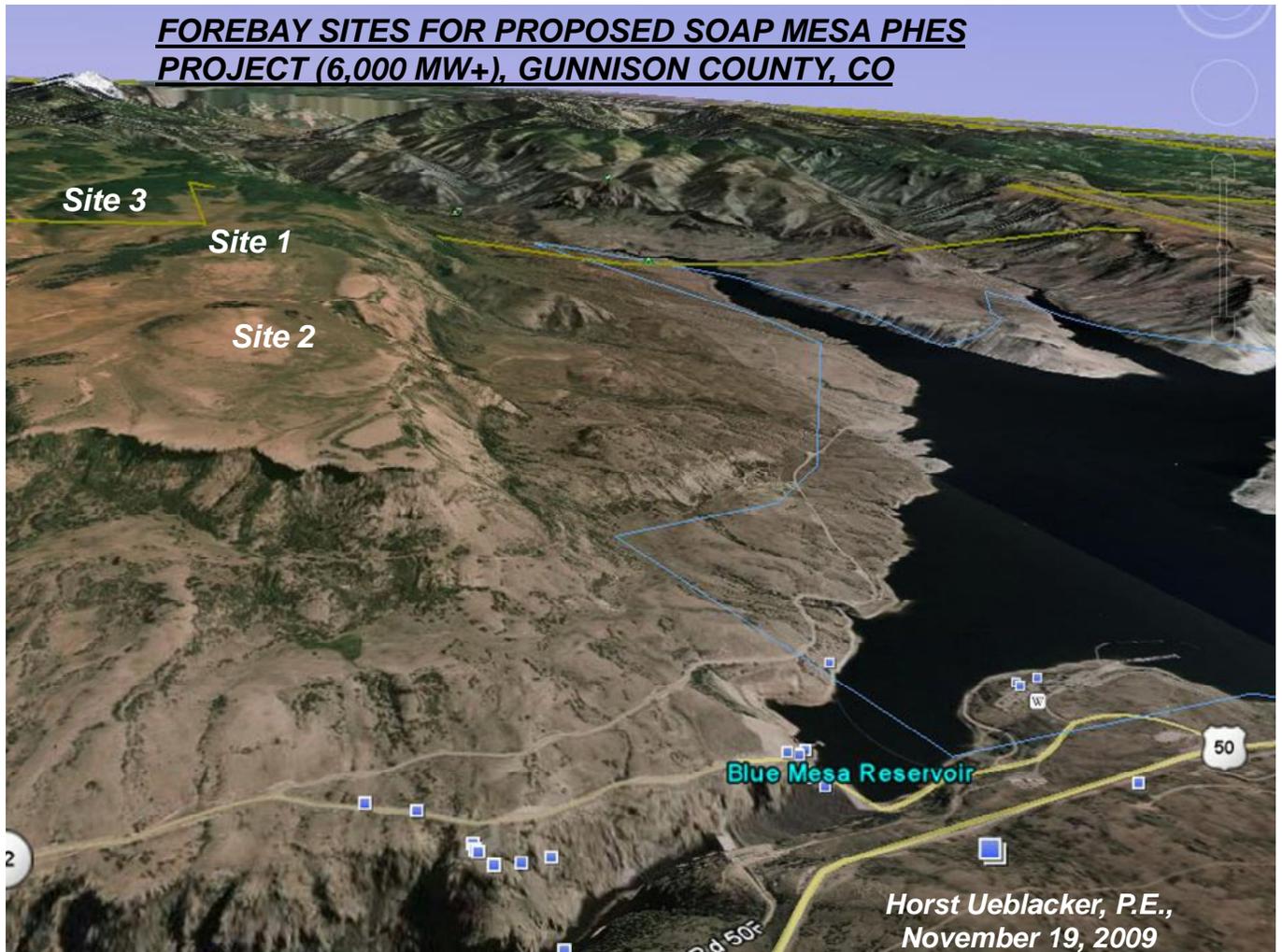


Figure 8.

Google Earth image showing the location of forebay sites for proposed 6,000 MW+ PHES complex.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED 1,000MW+ ROCKY POINT PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblacker, P. E., January 14, 2011**

**TABLE 1**

<b>Power and Capacity</b>		
Head	709.57 Meters	
Limiting Forebay Volume	4,980,256.25 M <sup>3</sup>	
Maximum Forebay Volume	4,750.00 acre feet	
Res.Surface Area @ El.11,658'	50.00 Acres	
Flow Rate Min	138.34 M <sup>3</sup> /S	
Flow Rate Max	172.93 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	866.68 MW	
Power Max	1,083.35 MW	
Energy	8,666.79 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$386,717	
Annual Revenue	\$140,765,120	
Avoided Natural Gas Cost	\$88,726,288	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b> \$140,765,119.91 Counted Annual Revenue		
<b>Cost Breakdown by %</b>		
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$28,859,709
Power Station Structures and Improvements	9%	\$122,956,789
Reservoirs, Dams, Waterways, and Access Roads	22%	\$311,901,301
Reversible Pump Turbines and Valve Governors	9%	\$129,868,689
Generator Motors and Static Starting Equipment	6%	\$90,186,590
Accessory Electrical Power and Plant Substation Equipment	10%	\$143,240,354
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$381,910,144
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>		<b>TOTAL \$1,408,353,782</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$1,408,353,782	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$229,491,408	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time</b> 13 years		
Life Time Net Present Value	\$29,010,295,794	100 year plant lifetime
Interest Rate	6.50%	
O & M	\$7,041,769 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 1.

Preliminary estimate of probable revenues and construction costs for proposed 1,000 MW+ Rocky Point PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED 2,000 MW+  
ROCKY POINT PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Uebliacker, P. E., December 5, 2009**

**TABLE 2**

<b>Power and Capacity</b>		
Head	818.39 Meters	
Limiting Forebay Volume	9,960,512.50 M <sup>3</sup>	
Maximum Forebay Volume	9,500.00 acre feet	
Res.Surface Area @ El.11,658'	88.00 Acres	
Flow Rate Min	276.68 M <sup>3</sup> /S	
Flow Rate Max	345.85 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,999.17 MW	
Power Max	2,498.96 MW	
Energy	19,991.71 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$892,042	
Annual Revenue	\$324,703,230	
Avoided Natural Gas Cost	\$204,665,136	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b> <span style="float:right">\$324,703,230.26 Counted Annual Revenue</span>		
<b>Cost Breakdown by %</b>		
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$66,570,757
Power Station Structures and Improvements	9%	\$283,624,711
Reservoirs, Dams, Waterways, and Access Roads	22%	\$719,463,459
Reversible Pump Turbines and Valve Governors	9%	\$299,568,407
Generator Motors and Static Starting Equipment	6%	\$208,033,616
Accessory Electrical Power and Plant Substation Equipment	10%	\$330,412,858
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$880,953,020
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$3,248,652,952</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$3,248,652,952	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at</b> <b>\$0.00</b>
Annual Rev	\$529,368,366	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time</b> <span style="float:right">13 years</span>		
Life Time Net Present Value	\$66,918,116,940 100 year plant lifetime	
Interest Rate	6.50%	
O & M	\$16,243,265 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 2.

Preliminary estimate of probable revenues and construction costs for proposed 2,000 MW+ Rocky Point PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED 1,500 MW+ UNION PARK PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblicker, P. E., January 14, 2011**

**TABLE 3**

<b>Power and Capacity</b>		
Head	240.58 Meters	
Limiting Forebay Volume	20,969,500.00 M <sup>3</sup>	
Maximum Forebay Volume	20,000.00 acre feet	
Res.Surface Area @ El.11,658'	5,020.00 Acres	
Flow Rate Min	582.49 M <sup>3</sup> /S	
Flow Rate Max	728.11 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,237.24 MW	
Power Max	1,546.55 MW	
Energy	12,372.42 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$552,065	
Annual Revenue	\$200,951,597	
Avoided Natural Gas Cost	\$126,662,694	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b> \$200,951,597.10 Counted Annual Revenue		
<b>Cost Breakdown by %</b>		
	%	
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$41,199,159
Power Station Structures and Improvements	9%	\$175,529,017
Reservoirs, Dams, Waterways, and Access Roads	22%	\$445,259,910
Reversible Pump Turbines and Valve Governors	9%	\$185,396,215
Generator Motors and Static Starting Equipment	6%	\$128,747,372
Accessory Electrical Power and Plant Substation Equipment	10%	\$204,485,159
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$545,202,203
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$2,010,518,955</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$2,010,518,955	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$327,614,291	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time</b> 13 years		
Life Time Net Present Value	\$41,414,132,108	100 year plant lifetime
Interest Rate	6.50%	
O & M	\$10,052,595 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 3.

Preliminary estimate of probable revenues and construction costs for proposed 1,500 MW+ Union Park PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED 1,000MW+ PARK CONE PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblacker, P. E., January 14, 2011**

**TABLE 4**

<b>Power and Capacity</b>		
Head	580.64 Meters	
Limiting Forebay Volume	7,129,630.00 M <sup>3</sup>	
Maximum Forebay Volume	6,800.00 acre feet	
Res.Surface Area @ El.11,658'	100.00 Acres	
Flow Rate Min	198.05 M <sup>3</sup> /S	
Flow Rate Max	247.56 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,015.28 MW	
Power Max	1,269.10 MW	
Energy	10,152.80 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$453,024	
Annual Revenue	\$164,900,741	
Avoided Natural Gas Cost	\$103,939,319	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b>	<b>\$164,900,740.75</b>	<b>Counted Annual Revenue</b>
<b>Cost Breakdown by %</b>		
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$33,808,001
Power Station Structures and Improvements	9%	\$144,038,989
Reservoirs, Dams, Waterways, and Access Roads	22%	\$365,379,972
Reversible Pump Turbines and Valve Governors	9%	\$152,136,005
Generator Motors and Static Starting Equipment	6%	\$105,650,004
Accessory Electrical Power and Plant Substation Equipment	10%	\$167,800,379
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$447,392,548
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$1,649,830,455</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$1,649,830,455	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$268,840,059	Revenue based on Min storage time and buying vs. selling data
<b>Payback Time</b>	<b>13 years</b>	
Life Time Net Present Value	\$33,984,407,991	100 year plant lifetime
Interest Rate	6.50%	
O & M	\$8,249,152 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 4.

Preliminary estimate of probable revenues and construction costs for proposed 1,000MW+ Park Cone PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED 1,500 MW+  
CEBOLLA CREEK PHES OPERATION, Horst Ueblacker, P. E., May 15, 2010**

**TABLE 5**

<b>Power and Capacity</b>			
Head	487.68 Meters		
Adjusted Forebay Volume	10,614,173.68 M <sup>3</sup>		
Forebay Volume	12,487,263.15 M <sup>3</sup>		10,123.97 Acre-Feet
Res.Surface Area	50.40 Acres		
Flow Rate Min	294.84 M <sup>3</sup> /S		
Flow Rate Max	368.55 M <sup>3</sup> /S		
Storage Time Min	8.00 hours		
Storage Time Max	10.00 hours		
Power Min	1,269.49 MW		
Power Max	1,586.87 MW		
Energy	12,694.93 MWh/day	** Assumes 15% of forebay volume is unused	
<b>Revenue</b>			
Cycle Value	\$566,455		
Annual Revenue	\$206,189,624		
Avoided Natural Gas Cost	\$129,964,298		
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>		
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>		
<b>Total</b> \$206,189,623.95 Counted Annual Revenue			
<b>Cost Breakdown by %</b>			
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits		2%	\$42,273,061
Reservoirs, Dams, Waterways, and Access Roads		22%	\$456,866,105
Reversible Pump Turbines and Valve Governors		9%	\$190,228,774
Generator Motors and Static Starting Equipment		6%	\$132,103,315
Accessory Electrical Power and Plant Substation Equipment		10%	\$209,815,292
Engineering, Administrative, and Legal Services		14%	\$398,860,413
Subsurface Exploration, Design, and Construction		27%	\$559,413,505
OTHER:			\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>		<b>TOTAL</b>	<b>\$2,062,925,367</b>
<b>Payback Period and Life Cycle</b>			
overnight cost	\$2,062,925,367 Cost based on Max Cost of shortest storage duration & itemized cost entries.		
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at</b>	<b>\$0.00</b>
Annual Rev	\$336,153,922 Revenue based on Min storage time and buying vs.selling data		
<b>Payback Time</b> 13 years			
Life Time Net Present Value	\$42,493,637,518 100 year plant lifetime		
Interest Rate	6.50%		
O & M	\$10,314,627 per year		
Construction Time	5 years		
Annual % increase in Cost	1.00%		

Table 5.

Preliminary estimate of probable revenues and construction costs for proposed 1,500 MW+ Cebolla Creek PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR SOAP MESA 1 2,486 MW PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblacker, P. E., December 4, 2009**

**TABLE 6**

<b>Power and Capacity</b>		
Head	670.56 Meters	
Limiting Forebay Volume	12,094,381.58 M <sup>3</sup>	
Maximum Forebay Volume	11,535.82 acre feet	
Res.Surface Area @ El.9,400'	129.00 Acres	
Flow Rate Min	335.96 M <sup>3</sup> /S	
Flow Rate Max	419.94 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,988.98 MW	
Power Max	2,486.22 MW	
Energy	19,889.80 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$887,494	
Annual Revenue	\$323,047,944	
Avoided Natural Gas Cost	\$203,621,785	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total \$323,047,944.18 Counted Annual Revenue</b>		
<b>Cost Breakdown by %</b>		
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$66,231,390
Power Station Structures and Improvements	9%	\$282,178,837
Reservoirs, Dams, Waterways, and Access Roads	22%	\$715,795,747
Reversible Pump Turbines and Valve Governors	9%	\$298,041,255
Generator Motors and Static Starting Equipment	6%	\$206,973,094
Accessory Electrical Power and Plant Substation Equipment	10%	\$328,728,465
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$876,462,060
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$3,232,091,830</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$3,232,091,830	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$526,669,729	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time 13 years</b>		
Life Time Net Present Value	\$66,576,978,889	100 year plant lifetime
Interest Rate	6.50%	
O & M	\$16,160,459 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 6.

Preliminary estimate of probable revenues and construction costs for proposed Soap Mesa -1 2,486 MW PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED SOAP MESA-2 1,351 MW PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblacker, P. E., October 25, 2009** **TABLE 7**

<b>Power and Capacity</b>		
Head	578.12 Meters	
Limiting Forebay Volume	7,624,875.79 M <sup>3</sup>	
Maximum Forebay Volume	7,272.73 acre feet	
Res.Surface Area @ El.9,400'	80.80 Acres	
Flow Rate Min	211.80 M <sup>3</sup> /S	
Flow Rate Max	264.75 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,081.08 MW	
Power Max	1,351.36 MW	
Energy	10,810.85 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$482,386	
Annual Revenue	\$175,588,650	
Avoided NG Cost	\$110,676,062	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b>	<b>\$175,588,649.66</b>	<b>Counted Annual Revenue</b>
<b>Cost Breakdown by %</b>		
	%	
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$35,999,240
Power Station Structures and Improvements	9%	\$153,374,760
Reservoirs, Dams, Waterways, and Access Roads	22%	\$389,061,781
Reversible Pump Turbines and Valve Governors	9%	\$161,996,578
Generator Motors and Static Starting Equipment	6%	\$112,497,624
Accessory Electrical Power and Plant Substation Equipment	10%	\$178,676,226
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$476,389,937
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$1,756,762,890</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$1,756,762,890	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$286,264,712	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time</b>	<b>13 years</b>	
Life Time Net Present Value	\$36,187,080,066 100 year plant lifetime	
Interest Rate	6.50%	
O & M	\$8,783,814 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 7.

Preliminary estimate of probable revenues and construction costs for proposed Soap Mesa-2 1,351 MW PHES operation.

**PRELIMINARY ESTIMATE OF PROBABLE REVENUES AND CONSTRUCTION COSTS FOR PROPOSED SOAP MESA- 3 2,282 MW PUMPED HYDRO ENERGY STORAGE (PHES) OPERATION, Horst Ueblacker, P. E., December 5, 2009**

**TABLE 8**

<b>Power and Capacity</b>		
Head	669.56 Meters	
Limiting Forebay Volume	11,119,610.53 M <sup>3</sup>	
Maximum Forebay Volume	10,606.06 acre feet	
Res.Surface Area @ El.9,400'	117.05 Acres	
Flow Rate Min	308.88 M <sup>3</sup> /S	
Flow Rate Max	386.10 M <sup>3</sup> /S	
Storage Time Min	8.00 hours	
Storage Time Max	10.00 hours	
Power Min	1,825.95 MW	
Power Max	2,282.43 MW	
Energy	18,259.47 MWh/day	** Assumes 15% of forebay volume is unused
<b>Revenue</b>		
Cycle Value	\$814,748	
Annual Revenue	\$296,568,314	
Avoided NG Cost	\$186,931,292	
<b>Renewable Energy Credits</b>	<b>\$0.00 per MWh</b>	
<b>Total REC Credits</b>	<b>\$0.00 annual REC value</b>	
<b>Total</b>	<b>\$296,568,314.04</b>	<b>Counted Annual Revenue</b>
<b>Cost Breakdown by %</b>		
Purchase of Private Land & Mining Claims, Environmental Impact Statements and Federal Permits	2%	\$60,802,528
Power Station Structures and Improvements	9%	\$259,049,170
Reservoirs, Dams, Waterways, and Access Roads	22%	\$657,123,321
Reversible Pump Turbines and Valve Governors	9%	\$273,611,376
Generator Motors and Static Starting Equipment	6%	\$190,007,900
Accessory Electrical Power and Plant Substation Equipment	10%	\$301,783,214
Engineering, Administrative, and Legal Services	14%	\$398,860,413
Subsurface Exploration, Design, and Construction	27%	\$804,620,120
OTHER:		\$0
<b>Cost Estimate Based on Needed Facilities and other Costs</b>	<b>TOTAL</b>	<b>\$2,967,163,364</b>
<b>Payback Period and Life Cycle</b>		
overnight cost	\$2,967,163,364	Cost based on Max Cost of shortest storage duration & itemized cost entries.
<b>Do REC's Have Market Value?</b>	<b>yes yes or no</b>	<b>REC valued at \$0.00</b>
Annual Rev	\$483,499,606	Revenue based on Min storage time and buying vs.selling data
<b>Payback Time</b>	<b>13 years</b>	
Life Time Net Present Value	\$61,119,789,612	100 year plant lifetime
Interest Rate	6.50%	
O & M	\$14,835,817 per year	
Construction Time	5 years	
Annual % increase in Cost	1.00%	

Table 8.

Preliminary estimate of probable revenues and construction costs for proposed Soap Mesa-3 2,282 MW PHES operation.