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Susitna and Chakachamna

Preliminary Decision Document

Environmental-Energy-Cost

AIDEA -08-007-HDR

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The Alaska Energy Authority

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1 Introduction

In 2010, the Alaska State Legislature authorized the Alaska Energy Authority (AEA) to perform Railbelt Large Scale Hydro Planning, Design and Permitting. AEA is preparing a Preliminary Decision Document (PDD) that will compare and contrast two large hydroelectric projects, the Low Watana alternative for Susitna and Chakachamna. This document will lay out the known information and risks of the two projects. HDR Alaska was contracted by AEA to provide input into the environmental, energy and cost sections of the PDD. This report summarizes the results of that effort. The project alternatives reviewed were:

- **Susitna Project, Low Watana Alternative.** This potential project consists of the construction of a large storage reservoir on the Susitna River at the Watana site with a 700-foot-high dam and a four-unit powerhouse with a total capacity of 600 megawatts (MW). This "Low Watana" Alternative is described in detail in *Susitna Hydroelectric Project, Conceptual Alternative Design Report* (HDR Alaska 2009b).
- **Chakachamna Project**. This potential project consists of the inter basin transfer of water from a lake tap near the outlet of Chakachamna Lake through an approximately 11-mile-long tunnel to an underground powerhouse that would discharge to the McArthur River. The project would have a total installed capacity of 300 MW. This alternative is described in detail in the *Pre-Application Document*, *Chakachamna Project* (TDX Power 2009). In an attempt to quantify the effect of different regulation methodologies and environmental flow requirements, three variations of this project were also analyzed.

The Susitna project was recently studied in 2009, and much of the energy, cost, and environmental information in this document is taken verbatim from those reports. The Chakachamna project does not have a similar level of recent study and much of the energy and cost information has been reanalyzed for this report. The locations of the Susitna and Chakachamna projects are depicted on Figure 1 below.

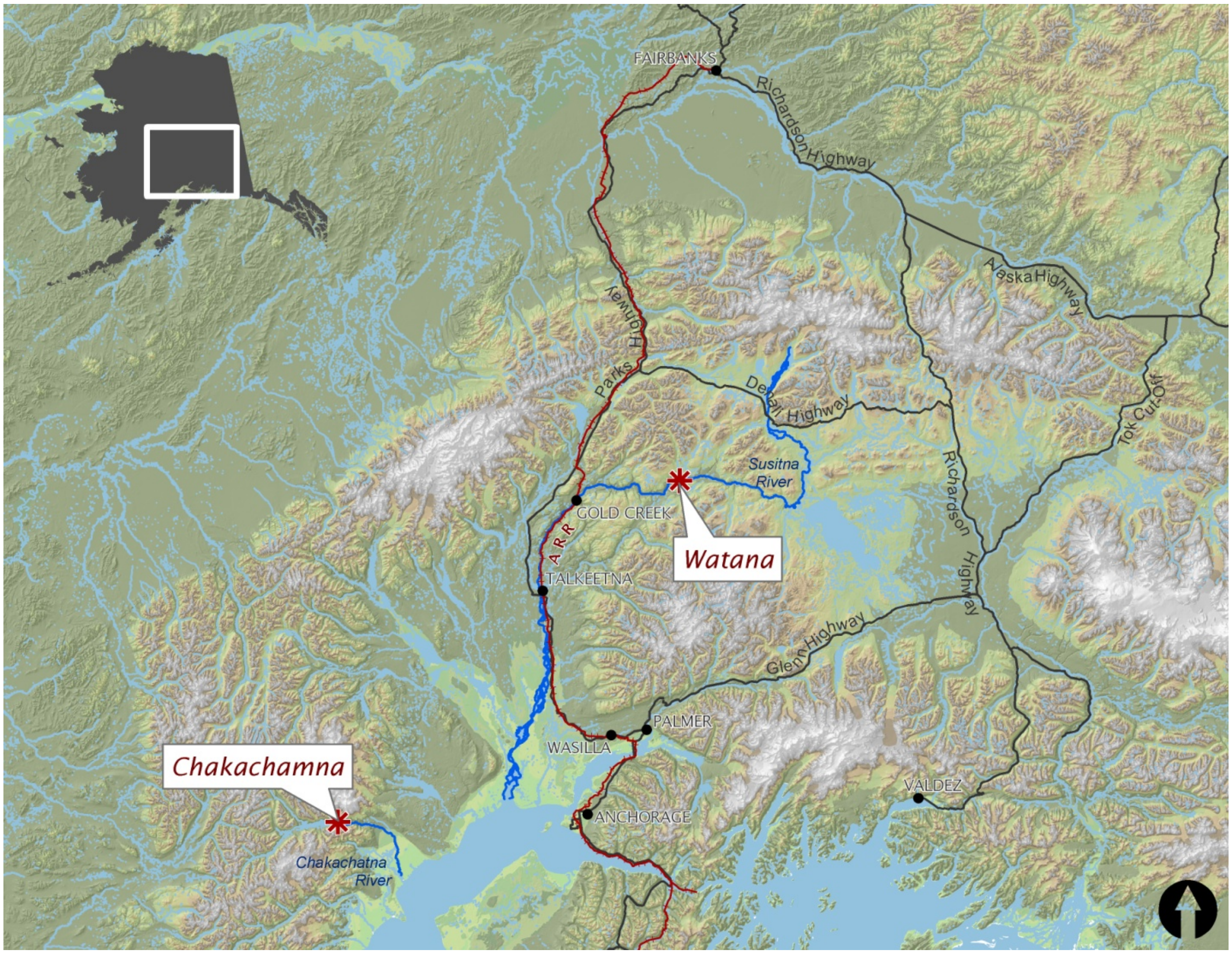

Figure 1. Project Locations

2 Environmental Issues

Development of a hydroelectric project on the Susitna River would face a variety of issues over the design lifetime. The design lifetime for a modern dam is greater than 100 years. The following discussion is not intended to be all inclusive but rather highlight the likely major areas of concern.

2.1 Susitna Environmental Issues

After the Susitna project was discontinued in 1986, a database of 3,573 documents was created. In September 2008, the 87 most relevant documents were scanned into HDR Alaska's files, and of these 18 of the most relevant environmental documents were summarized. A synthesis of the seven most-pertinent documents was completed. Because not all of the documents were summarized, some relevant information has likely been overlooked; however, most information was included in the synthesis.

These documents contain information on potential impacts of the proposed project and mitigation proposals for those impacts. Specifically, the documents deal with fisheries resources, botanical resources, wildlife resources, and cultural resources in the potential project area.

2.1.1 Fisheries Impacts

The fisheries resources have the highest potential to be impacted by the project. Most of the potential impacts would occur in the reservoir and the middle Susitna River downstream of the reservoir. There would be impacts due to changes in water quality, thermal activity, the water's suspended sediment load, reservoir draw-down fluctuations, impoundment zone inundation, flow regime, and lost fish habitat. Not all impacts to fish populations would be negative. For example, an increase in winter water temperatures could lead to the creation of more overwintering habitat and thus greater fish survival; however, the cooler spring water temperatures would slow fish growth.

In the Watana impoundment zone, 40 river miles of the Susitna River would be inundated and transformed into reservoir habitat. An additional 15 miles of four named tributary streams and numerous smaller unnamed tributaries and eight lakes would be inundated. There are nine species of fish occurring in the proposed impoundment zones: Arctic grayling, burbot, Dolly Varden, longnose sucker, round whitefish, humpback whitefish, lake trout, slimy sculpin, and Chinook salmon (Entrix 1985). Of these, Arctic grayling are the most abundant and have the potential to be impacted the most (Woodward-Clyde Consultants 1984). Arctic grayling would lose approximately nine miles of spawning habitat and would not likely populate the impoundment zone (Entrix 1985). River habitat would be transformed into lake/reservoir habitat that may be occupied by a different collection of fish species. Lake drawn down may limit recolonization of species dependent upon these areas for reproduction.

2.1.2 Botanical Impacts

The project area contains 295 vascular plant species, 11 lichen genera, and 7 moss taxa. Low Watana inundation would permanently remove 16,000 acres of vegetation. Most of the vegetation inundated would be spruce forest. An additional 836 acres of vegetation would be permanently removed due to access road construction. In the transmission corridor, effects on vegetation would be minimal due to intermittent placement of control stations, relay buildings, and towers.

There would be limited botanical impacts downstream from the reservoir(s). These involve changes to the vegetation due to a more stable environment. Due to flow regulation there would no longer be major flooding events, which destroy the riparian vegetation; instead, there would be succession of the riparian vegetation and colonization of new floodplains. The increase in winter water temperatures would decrease the amount of ice scouring that occurs, which would result in effects similar to those caused by the decrease in flooding.

Botanical resource mitigation would consist largely of compensation for permanently removed vegetation.

2.1.3 Wildlife Impacts

Within the Susitna River Basin there are 135 bird species, 16 small-mammal species, and 18 large mammal and furbearing species. There are currently no known listed endangered species in the project area. There would be five classes of potential impacts to terrestrial vertebrates:

1. Permanent habitat loss, including flooding of habitat and covering with gravel pads or roads.
2. Temporary habitat loss and habitat alteration resulting from reclaimed and revegetated areas such as borrow pits, temporary right of ways, transmission corridors, and from alteration of climate and hydrology.
3. Barriers, impediments, and hazards to movement.
4. Disturbances associated with project construction and operation.
5. Consequences of increased human access not directly related to project activities.

Impacts on each species would be different based on species abundance and use of the habitat; however, major threats common to most species have been identified. Downstream of the Watana reservoir there may be an increase in preferred moose browse, thus increasing the moose population (Harza Ebasco 1985b). The Susitna development would impact mink and otter in the middle river by increasing the winter turbidities which would reduce the value of the mainstem as sight feeding habitat. Open water in the winter would have a positive effect on mink and otter (Harza Ebasco 1985b). Other impacts to animals downstream of the reservoir would be negligible (Harza Ebasco 1985b).

2.1.4 Cultural Resource Impacts

Within the proposed project area, 297 historic and prehistoric archaeological sites were located. An additional 22 sites were already on file. Sites located within 500 feet of the reservoir's maximum extent may be indirectly impacted due to slumping from shoreline erosion. Indirect impacts may also result from vandalism due to increased access to the sites. The project has the potential to impact 140 sites. None of these sites would occur in the proposed road corridor or transmission lines corridors. The majority of these sites are relatively small prehistoric sites.

Mitigation for the lost cultural resources would mostly occur through data recovery. Preservation would also be used for some sites. Options to consider include construction of protective barriers to minimize erosion, controlled burial, or fencing of the site to restrict access.

Currently, there are a variety of federal, state, and local land use plans that encompass the Susitna Basin.

2.2 Chakachamna Environmental Issues

Based on review of the existing information, field reconnaissance conducted in 2008, and preliminary discussions with agencies, tribes, and other stakeholders, TDX identified 18 potential impact types or information gaps in the PAD to provide an organizational framework for the Chakachamna licensing studies. From this list, key questions or information needs are identified that will require a multi-disciplinary approach to reach an understanding of how the proposed project may affect the areas resource values. Forty nine discreet studies were identified in the PAD to form the basis for determining potential project effects. A majority of these are fisheries based.

2.2.1 Fisheries Impacts

In our analysis we reviewed the eighteen issues identified by TDX, plus additional issues, and have highlighted three that we believe are the most important environmental questions that will determine the project's feasibility.

1. What impacts will lake level fluctuation have on shoal spawning in the lake and fish passage into lake tributaries?
2. How will reduced flows into the Chakachatna River affect fisheries habitat and groundwater input to wetlands in the Trading Bay refuge?
3. Will Chakachatna River sockeye salmon be falsely attracted to the McArthur River powerhouse tailrace?

<u>Lake Level Fluctuations</u> - Chakachamna Lake and the surrounding tributaries support abundant salmon and freshwater fisheries resources. Five significant tributaries and numerous minor drainages empty from the surrounding mountains into Kenibuna and Chakachamna Lakes. Of these, the Chilligan and Igitna Rivers provide significant sockeye salmon (*Oncorhynchus nerka*) spawning habitat. Bechtel estimated 1982 escapements at 38,600 and 2,900 for the Chilligan and Igitna Rivers, respectively (1983). More recent aerial survey data from the Alaska Department of Fish and Game (ADF&G) indicates that numbers may be substantially higher in some years than in others (Johnson and Blanche 2010). The lake tributary streams also provide habitat for Dolly Varden (*Salvelinus malma)* which are ubiquitous in the study area but especially abundant in the Chilligan and Igitna Rivers. Round whitefish (*Prosopium cylindraceum)* are present in Chakachamna Lake and may spawn in tributary streams, but such spawning has not been confirmed.

Studies in 1982 showed large numbers of adult sockeye salmon milling along the north shore of Chakachamna Lake and spawning was suspected but not confirmed. Sockeye are the only salmon species observed in Chakachamna Lake or its tributaries, with the exception of one record of Chinook salmon in 1981. Chakachamna Lake also provides habitat for resident lake trout (*Salvelinus namaycush),* Dolly Varden, and round whitefish. Lake trout probably spend their entire lives in the lake. The size of the lake trout population is unknown. Life histories of lake trout, Dolly Varden, and whitefish have not been investigated in Chakachamna Lake.

Under the proposed operational structure (base case), the lake level would fluctuate approximately 60 feet from the normal maximum pool elevation of 1,142 feet to the normal minimum pool elevation of 1,082 feet. If sockeye salmon spawn along lake shoals, it is likely that their spawning timing would coincide with the maximum pool elevation. The resulting eggs might subsequently be exposed and killed when the lake level drops to the minimum pool elevations in March or April. Similarly, lake trout spawning areas may be affected by the winter lake drawn down.

An additional impact relating to lake drawn down is the potential for down-cutting of the channel between Kenibuna and Chakachamna Lakes and the fluvial fans of lake tributaries such as the Chilligan River. This down-cutting could affect lake levels for Kenibuna and Shamrock lakes, and potentially affect fish passage into the lake tributaries such as the Chilligan and the Igitna Rivers.

Reduced Flows into the Chakachatna River - The proposed operation of the Chakachamna Hydroelectric project involves diverting a portion of the natural flow out of Lake Chakachamna to the powerhouse located in the McArthur River valley. In the base case, the average flow in the Chakachatna River will be reduced by 57 percent to 84 percent from June through November.

The Chakachatna River provides a migration corridor, spawning habitat, and rearing habitat for salmon. The uppermost 14 miles have a uniformly high gradient, and the primary fish value is as a migratory corridor for sockeye salmon and possibly resident species. Salmon spawning is documented within a short reach at the lower end of the Chakachatna River canyon area, within side channels upstream from the Straight Creek confluence and immediately downstream from Straight Creek. Key salmon habitats are associated with upwelling groundwater. These areas also provide rearing habitat and may be important overwintering refugia.

The lower Chakachatna River splits into three branches: Middle River, which flows southeast to Cook Inlet, the Chakachatna River, which flows south and joins the McArthur River near its mouth, and a third braided section called Noaukta Slough which joins the middle part of the McArthur River. At the time of the 1981–1983 studies, the low gradient channels in the lower Chakachatna and Middle Rivers provided significant rearing and feeding habitat for juvenile coho and sockeye salmon, Dolly Varden, pygmy whitefish (*Prosopium coulteri)*, and adult rainbow trout (*Oncorhynchus mykiss)*. Recent environmental reconnaissance (HDR Alaska 2008) indicates that most of the water from the Chakachatna River flows through Noaukta Slough, joining the McArthur River in its middle reaches.

Hydrologic ties to the Chakachatna and McArthur rivers appear important in supporting the lower elevation wetlands north of Noaukta Slough and in the Trading Bay State Game Refuge. Changes in the hydrology could affect floodplains, wetlands, and riparian habitats.

Project operation would substantially alter habitat characteristics of the mainstem Chakachatna River and may affect shallow groundwater regimes, thus impacting fish habitat values within sloughs, side channels, wetlands, and small clear water tributaries that are known to be important to fish.

False Attraction Resulting from Interbasin Water Transfer - Transfer of water from Chakachamna Lake to the upper McArthur River may cause false attraction of adult salmon to the powerhouse tailrace during their spawning migration. The tailrace is proposed to be located approximately 15 miles up the McArthur River from the Noakta Slough (Chakachatna River) confluence. The mixture of Chakachamna Lake water from the tailrace may confuse salmon migration and could prevent or delay the movement of salmon to spawning areas in Chakachamna Lake and its tributaries. The Chilligan River and Igitna River sockeye salmon stocks are the principal stocks dependent upon chemical cues from Chakachamna Lake waters to reach spawning areas in these lake tributary systems. The Chiligan stock is the most numerous salmon stock in the watershed and has been shown to be genetically distinguishable from other Cook Inlet sockeye salmon stocks (Habicht et al. 2007).

From October through April, more than 80% of the water leaving Chakachamna Lake will potentially be diverted through the power tunnel to the McArthur River valley. Critical months for salmon passage into and out of the lake occur between May and September, when 50% to 65% of the lake's discharge will be diverted to the upper McArthur River. It will be difficult to predict if the instream flows proposed for the project will sufficiently provide the chemical signatures to orient migrating salmon to the Chakachatna River and/or to what extent salmon will be falsely attracted to the McArthur River tailrace.

2.2.2 Botanical Impacts

Botanical issues from the Chakachamna project are not explored in this document, but will likely result from construction of roads, transmission lines and barge landing facilities. Further impacts may result from groundwater changes resulting from reduced flows in the Chakachatna River, and their affect on wetlands in the Trading Bay Game Refuge.

2.2.3 Wildlife Impacts

Wildlife impacts from the Chakachamna project are not explored in this document.

2.2.4 Cultural Resources Impacts

Cultural resources impacts from the Chakachamna project are not explored in this document.

3 Preliminary Energy Estimate

3.1 Hydrologic Analysis

Susitna Project. To develop an energy estimate for the Susitna project, a hydrologic record was created by a drainage area proration of daily flow data from United States Geological Survey (USGS) gage 15292000 at Gold Creek. USGS gage 15292000 has a period of record from water years 1950–1996 and 2002–2010.

Chakachamna Project. To develop an energy estimate for the Chakachamna project, a hydrologic record was created using daily flow data from USGS gage 15294500 on the Chakachatna River at the outlet of Lake Chakachamna. USGS gage 15294500 has period of record from water years1959–1972. Using this gage information and rating curves obtained from the USGS, simulated daily inflows into Lake Chakachamna were derived. Figure 2 shows mean monthly inflows and outflows in cubic feet per second (cfs) for Lake Chakachamna for the period of record.

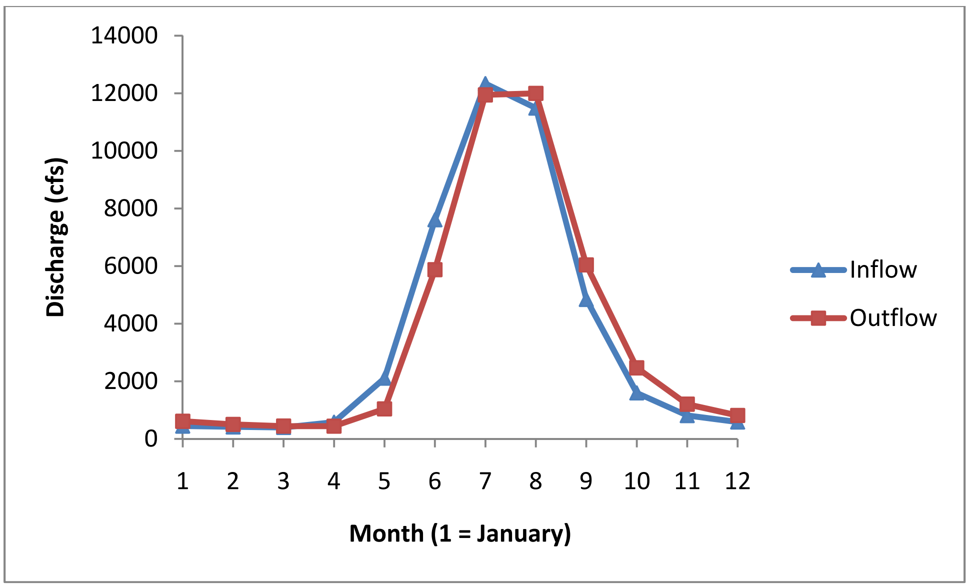

Figure 2. Mean Monthly Outflows and Derived Inflows for Chakachamna Lake, 1959-1972

Table 1 shows the average monthly and annual flow at the Watana site and inflow into Lake Chakachamna for their respective period of records.

Table 1. Average Monthly and Annual Flow

Month	Susitna River at Watana (cfs)	Lake Chakachamna Inflow (cfs)
Jan	1,342	446
Feb	1,162	410
Mar	1,090	401
Apr	1,429	584
May	11,668	2,109
Jun	22,297	7,432
Jul	20,117	12,507
Aug	17,982	11,443
Sep	11,567	4,985
Oct	5,336	1,600
Nov	2,269	814
Dec	1,601	588
Annual	**8,202**	**3,636**

3.2 Evaluation of Average Annual Energy and Firm Winter Capacity

The amount of energy that can be produced from hydroelectric projects is a function of the amount of available water and, in the case of storage projects, how the available water can be regulated (systematically released). In addition to the average annual energy, the firm capacity attainable during winter months is of particular importance. For hydroelectric projects, the firm capacity is almost always lower than the installed generation capacity for a project. For the purposes of this study work, firm capacity is defined as:

> "The amount of power the project can generate on a continuous basis from November 1 through April 30 with 98% reliability."

It should be noted that this is only one manner of regulation. The water can be regulated in a variety of different means in order to achieve other objectives, such as peaking, spinning reserve, or backup capacity.

The average annual energy and winter plant capacity was estimated using HDR Alaska proprietary energy modeling software customized for this particular purpose. Major assumptions used in the modeling efforts are presented below.

3.3 Susitna Model Assumptions and Data Sources

- This potential project consists of the construction of a large storage reservoir on the Susitna River at the Watana site with a 700-foot-high dam and a four-unit powerhouse with a total installed capacity of 600 MW. This "Low Watana" alternative is described in detail in *Susitna Hydroelectric Project, Conceptual Alternative Design Report* (HDR Alaska 2009b).

- Inflow hydrology was based upon USGS gage 15292000 located at Gold Creek on the Susitna River and scaled by a drainage area correction factor for the Watana dam site. Data up to and including water year 2008 was used to allow the results to match the 2009 study.
- Reservoir capacity and area curves were based on information presented in the 1985 Federal Energy Regulatory Commission (FERC) application.
- Tailwater curves were obtained from the 1985 FERC application.
- Operating reservoir levels were obtained from the 1985 FERC application.
- Environmental flow release constraints were as presented in the 1985 FERC application and scaled according to drainage areas for the Watana site.
- Evaporation coefficients were obtained from the 1985 FERC application. Total reservoir evaporation was estimated in the 1985 FERC application to be between one and three inches per month in summer, with negligible evaporation during winter months.
- Equipment performance was based on vendor data obtained in 2008 specifically for the Watana project.
- Headloss estimates were based on the water conveyance design from the 1985 FERC application.
- The reservoir was assumed to start full at the beginning of the simulation and was allowed to fluctuate over the remaining period of the simulation.
- Generation from November 1 to April 30, “winter,” was at a constant capacity level (“block loaded”).
- Generation from May 1 to October 31, “summer,” was to maximize energy with the objective of the reservoir being full on November 1.
- Rule curves for summer target reservoir elevations were developed using a mass balance approach. The ratio of the average monthly inflow volume to the average annual inflow volume during each of the reservoir filling months were used to set target elevations for the reservoir.
- Energy losses of 1.5 percent for un-scheduled outages and 2 percent for transformer losses were applied to the total generation.
- Active storage remained constant over the simulation period. Dead storage in the reservoir was assumed to be sufficient to contain sedimentation loads.
- No ramping rate restrictions were imposed on either reservoir drawdown or downstream flow.

3.4 Chakachamna Model Assumptions and Data Sources

This potential project consists of the inter basin transfer of water from a lake tap near the outlet of Chakachamna Lake through an approximately 10.8-mile-long tunnel to an underground powerhouse that would discharge to the McArthur River. The powerhouse would have a total generating capacity of 300 MW.

The base case for analysis was the project as described in the Pre-Application Document (PAD), Chakachamna Project (TDX Power 2009). Key features are described below.

- A lake outlet weir would be located at the outlet of Chakachamna Lake with an assumed crest elevation of 1142.
- Upstream and downstream fish passage would be provided by an operating plan that would minimize lake fluctuation during the summer to provide passage for adult salmon via the natural river channel. The adult salmon migration period is assumed to be July 15 to October 15.
- A fish passage tunnel would be included to allow downstream passage of juvenile salmon, to allow upstream passage of adult salmon during unusual low water years and to pass environmental flows when the lake level is below the elevation of the lake outlet weir.
- The preliminary environmental flow recommendations suggested for the Chakachatna River in the PAD. Based on the Montana Method (Tennant 1972) these provide environmental flows during the months of April to September of 1094 cfs or lake inflow, whichever was less, and during the months of October through March the minimum environmental flow was assumed to be 365 cfs or lake inflow, whichever was less.
- Outflow hydrology was based upon USGS gage 15294500 located on the Chakachatna River at the outlet of Chakachamna Lake. Only years with a full water year of record were used. Inflow hydrology to lake was determined by adding the volume of the daily change in lake storage to the outflow. Daily change in lake levels was calculated by applying USGS rating curves to the daily outflow record, and the resulting change in storage was calculated using the Chakachamna Lake elevation-capacity curve in the 1983 Bechtel *Chakachamna Hydroelectric Project Interim Feasibility Assessment Report*.
- Tailwater was assumed to be constant at elevation 210.
- Equipment performance was based on representative equipment efficiencies. Headloss estimates were based on the water conveyance design and performance statements provided in the PAD.
- The reservoir was assumed to start full at the beginning of the simulation and was allowed to fluctuate over the remaining period of the simulation.
- Generation from November 1 to April 30, “winter,” was at a constant capacity level (“block loaded”).
- Generation from May 1 to October 31, “summer,” was to maximize energy with the objective of the reservoir being full on November 1 and to provide for fish passage through the natural lake outlet from July 15 to October 15.
- Energy losses of 1.5 percent for un-scheduled outages and 2 percent for transformer losses were applied to the total generation.
- Active storage remained constant over the simulation period. Dead storage in the reservoir was assumed to be sufficient to contain sedimentation loads.
- No ramping rate restrictions were imposed on either reservoir drawdown or downstream flow.

Key input parameters related to energy generation are shown in Table 2 below.

Table 2. Summary of Energy Parameters

	Susitna Low Watana	Chakachamna Base Case
Dam Height (ft)	700	n/a
Gross Head (ft)	557	927
Net Head (Max Flow) (ft)	543	750
Maximum Plant Flow (cfs)	14,500	5,400
Number of Units	4	3
Nameplate Capacity (MW)	600	300
Maximum Pool Elevation (ft)	2014	1142
Minimum Pool Elevation (ft)	1850	1083
Tailwater Elevation (Max Flow) (ft)	1457	210
Usable Storage (acre-ft)	2,704,800	885,000

3.4.1 Environmental Flow

The preliminary environmental flow recommendations suggested for the Chakachatna River in the PAD are based on the Montana Method (Tennant 1972) as presented in the Bechtel report on the project in 1983. The Bechtel report assumed environmental flows during the months of April to September of 1094 cfs or lake inflow, whichever was less. During the months of October through March, the minimum environmental flow was assumed to be 365 cfs or lake inflow, whichever was less. These amounts of discharge are rated as “fair to degrading” flows in the Montana Method. This method was developed for and has primarily been used on rivers in the lower 48 states, which show little similarity to the glacially driven and highly seasonal flows of the Chakachatna River. Winter time flows using this method drop below historic average monthly flows, potentially resulting in freeze-out of spawning beds located outside the main river thalweg or in side channel areas. Summertime flows provided may not be sufficient to attract adult spawners confused by the discharges into the McArthur drainage or to provide for upstream passage through the canyon area located below Chakachamna Lake. Additionally, this environmental flow method does not take into consideration the groundwater hydrology feeding wetlands of the Trading Bay Game Refuge. While it is outside of the scope of this document to complete the environmental flow analysis needed to adequately address all of the environmental issues in the Chakachamna watershed, Table 3 below provides an estimate of environmental flows that may be more likely to be viewed favorably by permitting agencies. It should be noted, however, that these flows have not been reviewed or endorsed by any permitting agencies. Determination of environmental flows for the project will ultimately be the result of a detailed analysis of instream flow data by conducted by a multiagency review team.

Table 3. Estimate of Probable Environmental Flows

Month	Minimum Flow (cfs)	Notes
October	1,250	50% of mean monthly flow: provides water to Noaukta Slough to attract adult coho spawners and protect historic side channel spawning habitats.
November	600	50% of mean monthly flow: provides water to Noaukta Slough to attract adult coho spawners and protect historic side channel spawning habitats.
December	600	75% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
January	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
February	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
March	500	100% of mean monthly flow to protect incubation in Chakachatna/Noaukta Slough spawning beds.
April	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
May	750	75% of mean monthly flow: protects juvenile rearing in Chakachatna/Noaukta Slough areas and provides for outmigration of smolts from lake.
June	2,000	33% of mean monthly flow: provides water for outmigration of smolts from lake and feeds groundwater to Trading Bay Refuge wetlands.
July	4,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.
August	4,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.
September	2,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.

3.4.2 Alternatives Analysis

To evaluate the effect of increased minimum environmental flow requirements in the Chakachatna River and/or the effect of lake level fluctuations, two alternatives to the base case were also evaluated. Environmental issues surrounding project operations generally revolve around three main issues: 1) habitat affected by flows in the bypass reach; 2) upstream and downstream fish passage; and 3) habitat affected by lake level fluctuations.

- **Alternative #1 – Base Case with Probable Environmental Flow.** Alternative 1 is the same as the Base Case except that:

  - Environmental flow requirements are revised as described in Table 3 above.
  - The lake level fluctuations are not restricted.
- **Alternative #2 – Base Case with Probable Environmental Flow & Minimization of Lake Fluctuation**. Alternative 2 is the same as the Base Case except that:
  - Environmental flow requirements are revised as described in Table 3 above.
  - The maximum lake level fluctuation would be 15 feet below the weir outlet.

A comparison of potential environmental impacts resulting from each alternative are presented in Table 4.

Table 4. Comparison of Potential Environmental Impacts Resulting from Chakachamna Lake Hydro Alternatives

Issue	Base Case	Alternative 1	Alternative 2
Lake Level Fluctuation			
• Impacts to shoal spawning areas for sockeye salmon and lake trout	Significant impacts to incubating eggs due to draw down	Significant impacts	Least significant case but impacts may still occur
• Access to inlet streams (Chilligan and Igitna) for sockeye spawners	Not likely to be impacted	Could be impacted due to drawn down	Not likely to be impacted
• Adult salmon passage into lake	Minor to moderate, passage via natural outlet 87% of time	Significant, dependent upon using fish tunnel 91% of the time	Minor to moderate passage via natural outlet 87% of time
• Smolt outmigration from lake	Unknown, smolts 100% dependent on fish passage tunnel	Unknown, smolts 100% dependent on fish passage tunnel	Unknown, smolts 100% dependent on fish passage tunnel
Chakachatna / McArthur Issues			
• False attraction of Chakachamna sockey spawners to the McArthur powerhouse	Likely to occur	Least likely case but may still occur	Least likely case but may still occur
• Noauktna Slough and Chakachatna side channel spawning and rearing habitats	Moderate impacts possible from winter freeze-out	Lower impacts than Base Case	Lower impacts than Base Case
Trading Bay Wildlife Refuge			
• Groundwater fed wetland habitats	Moderate impacts	Lower impacts than Base Case	Lower impacts than Base Case

Under the Base Case and Alternative 1 the lake level would fluctuate approximately 60 feet from the normal maximum pool elevation of 1,142 feet to the normal minimum pool elevation of 1,082 feet. If sockeye salmon spawn along lake shoals, their spawning timing would coincide with the maximum pool elevation. The resulting eggs might subsequently be exposed to freezing temperatures and killed when the lake level drops to the minimum pool elevations in March or April. Similarly, lake trout spawning areas may be affected by the winter lake drawn down.

An additional impact relating to lake drawn down is the potential for down-cutting of the channel between Kenibuna and Chakachamna Lakes and the fluvial fans of lake tributaries such as the Chilligan River. This down-cutting could affect lake levels for Kenibuna and Shamrock lakes, and potentially affect fish passage into importatnt tributaries such as the Chilligan and Ignina Rivers. Portions of Kennibuna Lake and the Igitna River the Neacola River, and upper portions of the Chilligan River all fall within the boundary of the Lake Clark National Park.

Lake level affects adult salmon passage into the lake in Alternative 1, where the natural outlet is not available to spawning adults 91% of the time. In this alternative, fish will be dependant upon using the two mile long fish passage tunnel. There is uncertainty whether fish will be willing to use the tunnel volitionally. In all cases the fish passage tunnel will be required for smolt outmigration.

In Alternative 2, the lake level is minimized to 15 feet below the weir outlet. While this amount of drawdown may exceed natural lake level fluctuation, it is the scenario offering the least impact to lake habitats.

3.5 Model Operation

Daily inflow data was used to determine each alternative's ability to meet a range of winter energy production targets and maximize summer generation. For each day from November through April the flow through the powerhouse was limited to the amount necessary to satisfy a prescribed capacity demand given the available head, environmental flow constraints, and reservoir operational restrictions. During the months of May through September, energy production each day was maximized if the reservoir elevation was above the target rule curve. If the reservoir elevation was below the target rule curve then generation was curtailed. The simulation was repeated at various increasing winter load demands until the maximum firm capacity was determined. The resulting firm capacities and average annual energy estimates are presented in Table 5. Detailed input assumptions and results of these energy analyses are provided in Appendix A of this report.

Table 5. Firm Capacity and Average Annual Energy Estimates

Alternative	98% Winter Capacity (MW)	Average Annual Energy Production (GWh)
Susitna	245	2,600
Chakachamna, Base Case	170	1,300
Chakachamna, Alternative 1	140	1,100
Chakachamna , Alternative 2	30	860

The energy distribution by month for each of the above alternatives is shown in Figure 3 below.

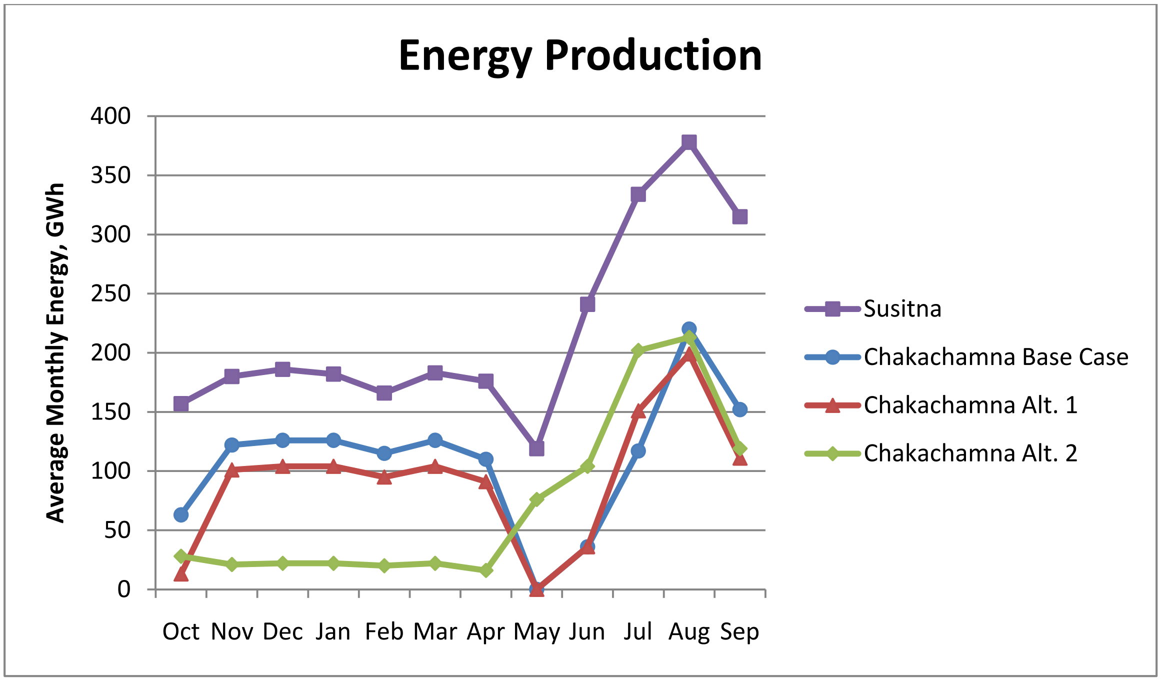

Figure 3. Energy Distribution by Month

As can be seen by these results, the firm winter capacity and average annual energy production estimates can vary significantly based upon the assumed environmental constraints placed upon the project. For Chakachamna, increased environmental flow requirements (Alternatives 1 and 2) reduce the amount of water that is available for generation, thereby lowering the annual energy. Reduced use of reservoir storage greatly limits the amount of energy that can be produced during the winter months (Alternative 2).

For Susitna, environmental flow requirements are met by water being used for energy production passing through the generating units and then being released into the natural stream channel. The effect of changed environmental flows is to change the timing of the energy production but not necessarily the average annual amount of generation.

For Chakachamna, limiting lake fluctuation (Alternative 2) to minimize the affect on upstream spawning will decrease the amount of runoff that can be captured, thereby decreasing the average annual generation. Figure 4 shows the post-project lake elevation by month for the base case and the two alternatives.

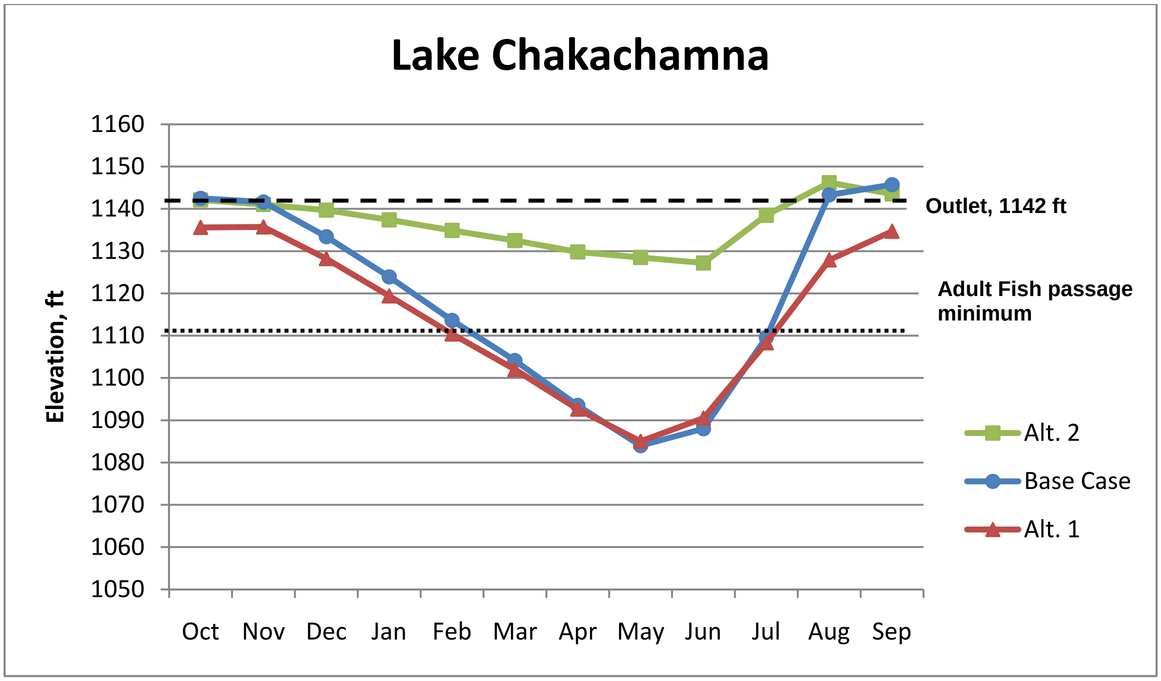

Figure 4. Chakachamna Lake Elevation by Month

Flows in the Chakachatna River during project operation will be comprised of environmental flow releases and spill as shown in Figure 5 Since the powerhouse discharges return to the McArthur River, the net flows in the Chakachatna River are reduced in all cases.

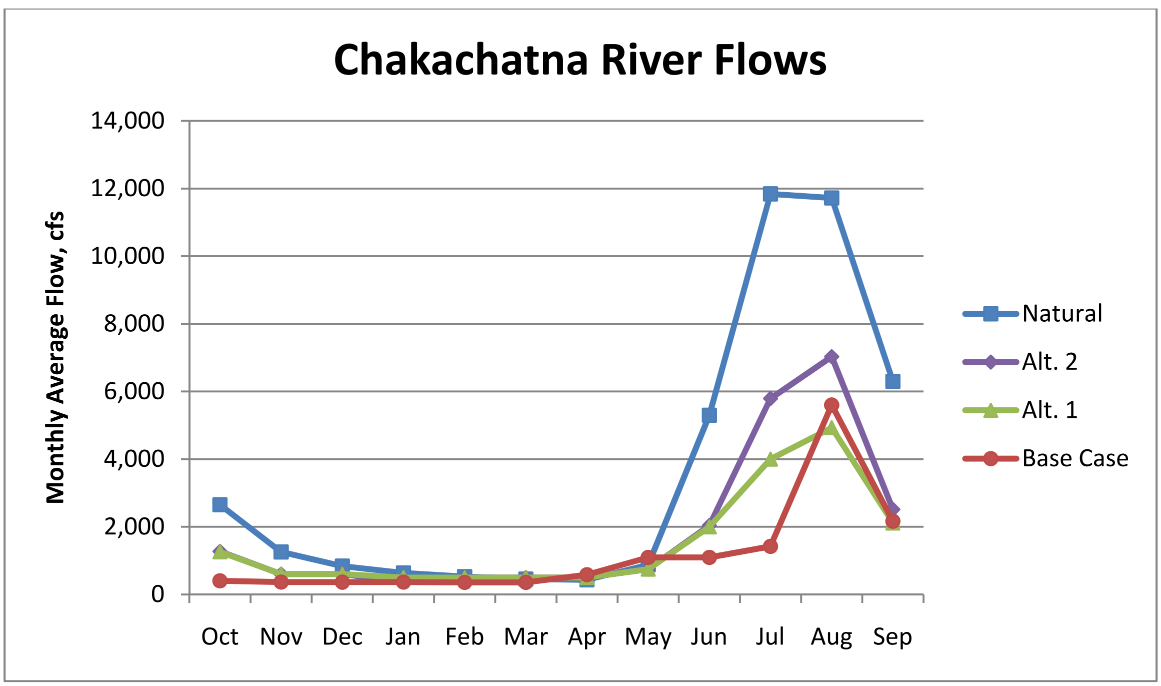

Figure 5. Chakachatna River Flows (Downstream of Lake) by Month

4 Estimates of Probable Project Development Costs

4.1 Susitna Project, Low Watana

4.1.1 Cost Estimate History

In 1982/83, a detailed cost estimate to develop the complete Watana/Devil Canyon project was prepared. In 1985/86, a revised cost estimate to develop a staged Watana/Devil Canyon project was prepared. In March 2009, an estimate for the Low Watana project was prepared, and in November 2009 this estimate was revised for a Low Watana Non-Expandable alternative. The following discussion details the basis for the cost estimates for the Watana projects, the assumptions that were used in creating those estimates, and provides a summary of the projected construction costs. Table 6 provides a chronology.

Table 6. Chronology of Susitna Hydro Cost Estimates

Date	Source	Estimated Construction Cost	Comments
1982/83	Acres. *Susitna Hydroelectric Project Feasibility Report*	$5.0 billion (01/1982 dollars)	Watana/Devil Canyon alternative
1985/86	Harza Ebasco. *Susitna Hydroelectric Project, Draft License Application*	$5.5 billion (1986 dollars)	Staged Watana/Devil Canyon alternative
Nov. 2009	HDR Alaska. *Susitna Hydroelectric Project. Conceptual Alternatives Design Report. Final Draft. (p. 18)*	$4.5 billion (11/2008 dollars)	Low Watana-non expandable alternative. Based on 1982 estimate Quantities from 1982 estimate Unit costs in $2008 Water-to-wire turbine-generator equipment estimates from 2008 budget pricing provided by manufacturers. Transmission Costs of 4.5M/mile (EPS 2009) Road Access from Denali Highway Contingency of 20% of direct construction costs Project licensing, environmental studies, engineering design, and construction management were estimated at 11 percent of direct construction costs including contingency.

4.1.2 Expandability

The Low Watana alternative, as proposed in previous studies, included provisions for eventual expansion of the dam from 700 feet to a height of approximately 885 feet and an increase in powerhouse capacity from 800 MW to 1,200 MW. The most notable of these provisions are the design of the dam cross-section and construction of the powerhouse and water conduits to their ultimate capacity. The non-expandable alternative contains no provisions for future expansion.

For the Low Watana Expandable alternative, the dam cross-section is expanded on the upstream side to provide the opportunity to later raise the dam. This results in additional fill material due to the wider base. The powerhouse, powerhouse equipment, and water conveyance scheme would be built to house six turbine-generator units, but only four would be initially installed.

For the Low Watana Non-expandable alternative, the cross-section is narrower and does not accommodate expansion at a later time. Similarly the powerhouse and water conduit features are sized for only four turbine/generator units.

4.1.3 Quantities

Quantities for the construction cost estimates were based upon detailed estimates developed as part of the 1982 Acres feasibility study for the full sized Watana project and the Devil Canyon project. To estimate the quantities of the smaller Watana alternatives, the full sized Watana quantities were scaled based on the size of the development.

4.1.4 Unit Costs

U.S. Cost, a company specializing in creating cost estimates for large capital infrastructure projects, developed unit prices for the materials detailed in the 1982 estimate in 2008 dollars. For the water-to-wire turbine-generator equipment estimates, budget pricing for the Watana alternative was requested directly from manufacturers. The water-to-wire equipment includes turbines, generators, turbine shutoff valves, and other miscellaneous mechanical and electrical equipment, including installation costs. The equipment costs for other smaller alternatives were developed by scaling the Watana vendor quotes on a per kilowatt basis.

4.1.5 Indirect Costs

A contingency of 20 percent was added to the direct construction costs to reflect level of design and uncertainty in the project. Project licensing, environmental studies and engineering design were estimated at 7 percent of direct construction costs. Construction management was estimated at 4 percent of the direct construction costs and has been included as a separate line item.

4.1.6 Interest During Construction and Financing Costs

Costs associated with interest during construction and project financing are not included in the estimates.

4.1.7 Changes from 1983 Design

The camps, access roads, and transmission lines infrastructure assumptions used in the 1983 configuration have been modified as discussed below.

4.1.7.1 Camps

Reductions were made in the scale of the permanent and construction camps needed to accommodate the workers. These changes were made based on the fact that permanent town facilities would no longer be necessary due to advances in remote project operation. It was also assumed that due to modern construction methods, the number of construction personnel could be reduced. It was assumed that 825 people would need to be housed for the Low Watana alternative. In 1983, it was originally assumed that housing would be provided for 3,000 people plus families. Budget pricing for the construction camp was provided by vendors.

4.1.7.2 Access Roads

Access is assumed to be via the Denali Highway from the north. The route would include the upgrade of 21 miles of the Denali Highway to a construction grade road and the construction of approximately 40 miles of new road to the Watana site. The price per mile of new road has been assumed at $3M/mile which is the current budgetary estimate of the Alaska Department of Transportation and Public Facilities for the road to Bettles and Umiat from the Dalton Highway, which is similar in nature to the road that would be required for a Susitna project. Upgrading of the Denali Highway has been assumed to be $1M/mile, and local site roads have been estimated at $750k/mile.

4.1.7.3 Transmission Lines

A separate study (EPS 2009) investigated the transmission lines and interconnection requirements for the entire Alaska railbelt region as part of the Regional Integrated Resources Plan process. This study estimates that a transmission line from the project site to the substation at Gold Creek would cost approximately $4.5M/mile. Substation costs are estimated at $16M per location. No costs have been assumed to increase or modify the regional transmission grid beyond the Gold Creek substation.

4.1.8 Conclusions

The approach, methodology, and assumptions previously described resulted in the estimated project costs shown in Table 7. Detailed costs are included in Appendix B.

Table 7. Low Watana Project Cost Summary

FERC Line #	Line Item Name	Low Watana ($Millions)
71A	Engineering, Env., and Regulatory (7%)	$ 236
330	Land and Land Rights	$ 121
331	Power Plant Structure Improvements	$ 115
332.1-.4	Reservoir, Dams and Tunnels	$ 1,538
332.5-.9	Waterways	$ 590
333	Waterwheels, Turbines and Generators	$ 297
334	Accessory Electrical Equipment	$ 41
335	Misc Power Plant Equipment	$ 21
336	Roads, Rails and Air Facilities	$ 232
350-390	Transmission Features	$ 224
399	Other Tangible Property	$ 16
63	Main Construction Camp	$ 180
71B	Construction Management, 4%	$ 135
Total Subtotal		**$ 3,746**
Total Contingency		$ 749
Total (Millions of Dollars, rounded)		**$ 4,500**

4.2 Chakachamna Project

4.2.1 Cost Estimate History

In 1982, a detailed cost estimate was prepared for developing the Chakachamna project. In 2008 and 2009, reevaluations of this original estimate were completed with some alternative arrangements. The following discussion details the basis for these previous cost estimates for the Chakachamna project, the assumptions that were used in creating those estimates, and provides a summary of the projected construction costs.

Table 8. Chronology of Previous Chakachamna Hydro Cost Estimates

Date	Source	Total Cost ($ Billion)	Comments
March 1983 (Construction Estimate completed in January 1982).	Bechtel. *Chakachamna Hydroelectric Project Interim Feasibility Assessment Report*. *Section 8-1*	$1.32	Alternative E
July 2009	TDX Power, Inc. *Pre-Application Document (p. 1-3)*	No cost information in PAD	PAD noted following engineering and economic modifications from 1983 Bechtel report: 1. Decreasing diameter of power tunnel to 21 feet. 2. Decreasing installed capacity to 300 MW 3. Decreasing powerhouse hydraulic capacity to 5,400 cfs 4. Eliminating most of the power tunnel's proposed concrete lining through selection of a tunnel boring machine as construction method 5. Reducing number of turbines to three 6. Relocating and redesigning outlet structures to minimize exposure to potential glacial hazards. 7. Shortening the length of new transmission line to 42 miles.
February 2010	Black & Veatch. *Alaska Railbelt Regional Integrated Resources Plan Study. (p. 10-26)*	$1.6, Estimate provided by developer	Includes transmission costs of $58 million.

4.2.2 Quantities

Quantities for the construction cost estimates were based upon estimates developed as part of the 1983 Bechtel report.

4.2.3 Unit Costs

Unit prices for the materials detailed in the Bechtel 1982 estimate were inflated to 2008 dollars so that the project would be comparable to the estimate for the Susitna project. The US Bureau of Reclamation (USBR) publishes construction cost index that encompasses the period of 1982 to 2008. Their composite index is based on a hypothetical project consisting of a concrete dam, earthen dam, powerplant, and transmission system. The increase in the USBR composite index for the period of January 1982 to December 2008 was 211 percent. This index was used to inflate the majority of the unit prices.

For the water-to-wire turbine-generator equipment estimates, the budget pricing developed for the Chakachamna project was developed by scaling the Susitna project vendor quotes on a per kilowatt basis.

For the access roads, the unit prices from the Susitna project were used. For the transmission lines the unit prices from the Susitna project were reduced by 50 percent based on input from EPS.

4.2.4 Indirect Costs

A contingency of 20 percent was added to the direct construction costs to reflect level of design and uncertainty in the project. Project licensing, environmental studies and engineering design were estimated at 7 percent of direct construction costs. Construction management was estimated at 4 percent of the direct construction costs, and has been included as a separate line item.

4.2.5 Interest During Construction and Financing Costs

Costs associated with interest during construction and project financing are not included in the estimates.

4.2.6 Changes from the 1983 Bechtel Design

Modifications to the assumptions used in the 1983 configuration are discussed below.

4.2.6.1 Land and Land Rights

No land and land rights costs were included in the 1982 Bechtel estimate. The estimate included a placeholder until more detailed work could be done on this aspect of the project. To make the cost estimates similar to the Susitna estimate, $75 million was added to the Chakachamna estimate. This value is approximately half of what was assumed for Susitna.

4.2.6.2 Fish Screening

No fish screening costs for the intake were included in the 1982 Bechtel estimate. It was assumed that these would be required. The estimate included a $5 million placeholder until more detailed work could be done on this aspect of the project.

4.2.6.3 Power Tunnel

The 1982 Bechtel estimate assumed construction using a tunnel boring machine and a full concrete lining of the tunnel. The need for a lining is realistic assumption given the unknown nature of the rock and the high water velocities expected in the tunnel. The Bechtel estimate was based upon a 53,400-foot-long, 24-foot-finished diameter tunnel. The estimated quantities indicate that a 1.5-foot-thick lining was assumed.

The current project configuration assumes a 57,000 foot-long, 21-foot finished diameter tunnel. A 1.5-foot-thick lining was assumed to be required.

4.2.6.4 Transmission Lines

The 1982 Bechtel estimate assumed that power transmission lines would extend 82 miles from the project site to Anchorage. For this estimate the length of the power transmission line was reduced from the project site to regional distribution grid at Beluga (50 miles). The current estimate assumes a triple-circuit design with a unit price of $3.9 million per mile (EPS 2010).

4.2.6.5 Camps

No camp costs were included in the 1982 Bechtel estimate. The estimate includes a $90 million placeholder until more detailed work could be done on this aspect of the project. This value is approximately half of the value assumed for the Susitna project.

4.2.7 Conclusions

The approach, methodology and assumptions previously described resulted in the estimated project costs detailed below in Table 9. Detailed costs are included in Appendix C.

Table 9. Chakachamna Cost Summary Table

FERC Line #	Line Item Name	Chakachamna ($Millions)
71A	Engineering, Env., and Regulatory (7%)	$ 151
330	Land and Land Rights	$ 75
331	Power Plant Structure Improvements	$ 105
332.1-.4	Reservoir, Dams and Tunnels	$ 1,147
332.5-.9	Waterways	$ 123
333	Waterwheels, Turbines and Generators	$ 181
334	Accessory Electrical Equipment	$ 20
335	Misc Power Plant Equipment	$ 15
336	Roads, Rails and Air Facilities	$ 172
350-390	Transmission Features	$ 232
399	Other Tangible Property	$ 0
63	Main Construction Camp	$ 90
71B	Construction Management, 4%	$ 86
Total Subtotal		**$ 2,400**
Total Contingency		$ 480
Total (Millions of Dollars, rounded)		**$ 2,880**

5 Summary

The energy and cost results of this report are summarized in Table 10. The primary environmental issues for both projects are fisheries related. The inter basin transfer of water proposed for the Chakachamna project creates a conflict between the probable environmental flows needed to preserve the fishery and the overall project energy production. For Susitna, environmental flow requirements are met by water being used for energy production passing through the generating units and then being released into the natural stream channel. The effect of changed environmental flows is to change the timing of the energy production but not necessarily the average annual amount of generation.

Table 10. Summary

Alternative	Description	Installed Capacity (MW)	98% Winter Capacity (MW)	Average Annual Energy Production (GWh)	Construction Cost ($ Billion)	Alternative
Low Watana	Rockfill Dam on Susitna River	600	245	2,600	$4.5	Low Watana
Chakachamna Base Case	Chakachamna Project as proposed by TDX	300	170	1,300	$2.9	Chakachamna Base Case
Chakachamna Alternative 1	Chakachamna Project with Probable Environment Flows	300	140	1,100	$2.9	Chakachamna Alternative 1
Chakachamna Alternative 2	Chakachamna Project with Probable Environment Flows and restricted lake level fluctuation	300	30	860	$2.9	Chakachamna Alternative 2

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Appendix A:
Chakachamna Energy Analysis Input and Results

Chakachamna - PAD Base Case Energy Generation Estimate

DATA FILE USED: chinflow.QCH

MODEL DESCRIPTION

PIPE #	LENGTH	DIAMETER	MANNING'S n	MINOR LOSSES
1	28500	252	.016	.5
2	28500	252	.016	0
3	1000	282	.02	1

MAX POOL ELEV : 1142
MIN POOL ELEV : 1083
DESIGN FLOW: 5400
GROSS HEAD: 932
NET HEAD @ FULL LOAD: 750.2
NAMEPLATE CAPACITY (MW): 302 @ 1 POWER FACTOR
TARGET FIRM CAPACITY (MW): 170

STATION SERVICE LOSS: 0
TRANSFORMER LOSS: 2
TRANSMISSION LOSS: 0
SCHEDULED DOWN TIME: 1.5

RESERVOIR STAGE /	STORAGE
760	0
810	350000
860	500000
1060	3000000
1160	4500000
1210	5600000

USABLE STORAGE: 885000

SIMULATED PRODUCTION IN MEGAWATT-HOURS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1960	46,992	122,400	126,480	126,480	118,320	126,480	81,240	0	34,632	104,736	225,648	97,272	1,210,680
1961	56,592	122,400	126,480	126,480	114,240	126,480	122,400	0	0	70,248	226,200	199,224	1,290,744
1962	50,496	122,400	126,480	126,480	114,240	126,480	122,400	0	20,808	141,480	226,152	173,472	1,350,888
1963	40,008	122,400	126,480	126,480	114,240	126,480	81,600	0	0	97,200	226,440	184,272	1,245,600
1964	79,872	122,400	126,480	126,480	118,320	126,480	110,160	0	27,768	97,752	226,056	154,920	1,316,688
1965	42,312	122,400	126,480	126,480	114,240	126,480	103,896	0	0	0	204,096	218,928	1,185,312

1966	97,944	122,400	126,480	126,480	114,240	126,480	89,760	0	12,072	104,472	208,560	217,656	1,346,544
1967	90,648	122,400	126,480	126,480	114,240	126,480	108,000	0	48,600	170,928	227,448	196,080	1,457,784
1968	82,872	122,400	126,480	126,480	118,320	126,480	122,400	0	62,472	144,168	226,392	93,384	1,351,848
1969	27,120	122,400	126,480	126,480	114,240	126,480	122,400	0	48,672	170,808	203,664	78,504	1,267,248
1970	126,840	122,400	126,480	126,480	114,240	126,480	122,400	0	20,760	104,880	206,760	77,280	1,275,000
1971	56,304	122,400	126,480	126,480	114,240	126,480	122,400	0	193,920	224,064	227,640	118,824	1,559,232
1972	26,376	122,400	126,480	126,480	118,320	126,480	122,400	0	0	85,032	226,488	170,760	1,251,216
AVERAGE	63,414	122,400	126,480	126,480	115,495	126,480	110,112	0	36,131	116,598	220,119	152,352	1,316,060
AVG CAP	85	170	170	170	170	170	153	0	50	157	296	212	150

TARGET CAPACITY EXCEEDANCE: 98.3%

AVERAGE PLANT FACTOR: 0.50

BEGINNING RESERVOIR ELEVATIONS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1960	1142.0	1141.7	1132.9	1122.9	1112.3	1102.0	1090.6	1083.0	1091.1	1111.0	1142.4	1144.2
1961	1142.0	1141.7	1133.3	1125.0	1116.1	1107.7	1096.8	1084.9	1084.4	1103.0	1143.6	1145.2
1962	1142.0	1141.6	1133.3	1124.2	1114.7	1105.7	1095.3	1085.1	1085.3	1111.3	1145.5	1146.6
1963	1142.0	1141.3	1132.8	1123.0	1112.0	1102.1	1091.0	1082.9	1087.0	1102.4	1144.4	1148.6
1964	1142.0	1141.6	1133.6	1124.9	1114.0	1104.3	1093.3	1082.9	1086.4	1112.0	1141.3	1147.5
1965	1142.0	1141.7	1133.5	1124.3	1113.8	1103.7	1092.7	1082.9	1082.1	1091.8	1135.7	1146.0
1966	1147.1	1141.9	1132.7	1122.5	1112.0	1102.1	1091.4	1082.9	1086.5	1111.0	1138.4	1145.9
1967	1142.9	1141.0	1132.4	1122.8	1112.7	1103.1	1092.2	1083.0	1087.9	1113.9	1149.3	1147.5
1968	1142.0	1141.3	1134.5	1124.6	1114.4	1104.8	1094.5	1084.4	1093.1	1113.5	1146.6	1145.3
1969	1142.0	1141.9	1133.1	1123.6	1113.5	1104.2	1094.2	1083.8	1087.6	1115.9	1144.8	1142.0
1970	1142.0	1141.6	1134.3	1124.9	1114.8	1105.8	1095.9	1086.5	1091.2	1111.0	1138.5	1142.4
1971	1142.0	1141.8	1133.9	1123.6	1113.1	1103.8	1093.7	1085.9	1098.5	1125.3	1147.2	1146.4
1972	1142.0	1141.6	1133.4	1124.0	1114.0	1104.4	1093.9	1083.2	1084.7	1102.4	1144.6	1146.9

TARGET	1142.0	1142.0	1129.0	1120.0	1113.0	1105.0	1100.0	1100.0	1100.0	1111.0	1115.0	1142.0
MIN	1111.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1111.0	1111.0	1111.0
AVG	1142.5	1141.6	1133.4	1123.9	1113.6	1104.1	1093.5	1084.0	1088.1	1109.6	1143.3	1145.7

START POOL ELEV: 1142.0
ENDING POOL ELEV: 1142.0
MIN. POOL ELEV: 1082.1 JUN 1, 1965
STORAGE CHANGE (CFS): 0.0

ADULT FISH PASSAGE VIA LAKE OUTLET
July 15-July 31: 29.0%
Aug 1 - Oct 15: 98.4%

MONTHLY FLOW INFORMATION

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVG
AVG INFLOW	1600	814	588	446	410	401	584	2109	7432	12507	11443	4985	3636
MIF	365	365	363	365	357	358	582	1094	1094	1094	1094	1094	
SPILL	37	0	0	0	0	0	0	0	0	327	4505	1070	
CHAKACHATNA R	402	365	363	365	357	358	582	1094	1094	1421	5599	2164	1189
POWERHOUSE	1409	2520	2546	2574	2543	2637	2404	0	936	2863	5243	3644	2450

THIS SIMULATION USED THE FOLLOWING EQUIPMENT EFFICIENCIES

% CAP	TURBINE	GENERATOR	COMBINED
0	0.0	0.0	0.0
5	0.0	92.0	0.0
10	73.3	92.3	67.6
15	82.8	92.6	76.6
20	89.1	93.0	82.9
25	93.2	94.2	87.8
30	92.2	95.2	87.7
35	90.3	95.8	86.5
40	91.3	96.3	87.9
45	92.4	96.7	89.3
50	93.1	96.9	90.3
55	93.4	97.1	90.7
60	92.6	97.3	90.1
65	91.8	97.4	89.4
70	92.5	97.5	90.2
75	93.2	97.6	91.0
80	93.4	97.7	91.3
85	93.1	97.8	91.0
90	92.1	97.8	90.1
95	91.1	97.8	89.1

100	90.0	97.8	88.0

Chakachamna Alt. 1 Energy Generation Estimate

DATA FILE USED: chinflow.QCH

MODEL DESCRIPTION

PIPE #	LENGTH	DIAMETER	MANNING'S n	MINOR LOSSES
1	28500	252	.016	.5
2	28500	252	.016	0
3	1000	282	.02	1

MAX POOL ELEV : 1142
MIN POOL ELEV : 1083
DESIGN FLOW: 5400
GROSS HEAD: 932
NET HEAD @ FULL LOAD: 750.2
NAMEPLATE CAPACITY (MW): 302 @ 1 POWER FACTOR
TARGET FIRM CAPACITY (MW): 140

STATION SERVICE LOSS: 0
TRANSFORMER LOSS: 2
TRANSMISSION LOSS: 0
SCHEDULED DOWN TIME: 1.5

RESERVOIR

STAGE /	STORAGE
760	0
810	350000
860	500000
1060	3000000
1160	4500000
1210	5600000

USABLE STORAGE: 885000

SIMULATED PRODUCTION IN MEGAWATT-HOURS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1960	50,544	100,800	104,160	104,160	97,440	104,160	92,664	0	13,536	147,672	177,696	7,128	999,960
1961	0	100,800	104,160	104,160	94,080	104,160	100,800	0	0	63,696	222,792	165,120	1,059,768
1962	0	100,800	104,160	104,160	94,080	104,160	100,800	0	20,808	217,584	220,848	85,632	1,153,032
1963	0	100,800	104,160	104,160	94,080	104,160	63,840	0	0	134,184	221,424	173,064	1,099,872
1964	0	100,800	104,160	104,160	97,440	104,160	100,800	0	41,640	147,192	220,896	78,768	1,100,016
1965	0	100,800	104,160	104,160	94,080	104,160	84,984	0	0	0	206,976	216,336	1,015,656

1966	79,680	100,800	104,160	104,160	94,080	104,160	100,800	0	6,648	126,360	184,488	114,432	1,119,768
1967	36,000	100,800	104,160	104,160	94,080	104,160	100,800	0	48,576	218,472	225,840	217,320	1,354,368
1968	7,200	100,800	104,160	104,160	97,440	104,160	100,800	0	103,752	210,720	222,192	64,440	1,219,824
1969	0	100,800	104,160	104,160	94,080	104,160	55,200	0	34,776	218,952	128,136	0	944,424
1970	0	100,800	104,160	104,160	94,080	104,160	100,800	0	31,320	126,072	113,448	0	879,000
1971	0	100,800	104,160	104,160	94,080	104,160	100,800	0	173,160	222,192	226,656	144,408	1,374,576
1972	0	100,800	104,160	104,160	97,440	104,160	84,240	0	0	133,872	221,736	173,088	1,123,656
AVERAGE	13,340	100,800	104,160	104,160	95,114	104,160	91,333	0	36,478	151,305	199,471	110,749	1,111,071
AVG CAP	18	140	140	140	140	140	127	0	51	203	268	154	127

TARGET CAPACITY EXCEEDANCE: 98.3%

AVERAGE PLANT FACTOR: 0.42

BEGINNING RESERVOIR ELEVATIONS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1960	1142.0	1137.2	1129.2	1119.9	1110.5	1101.4	1091.3	1083.0	1092.5	1111.0	1126.2	1129.9
1961	1132.5	1133.6	1125.9	1118.3	1110.6	1103.3	1093.5	1083.8	1084.7	1099.7	1129.2	1136.1
1962	1136.2	1136.6	1129.1	1120.8	1112.5	1104.6	1095.4	1087.4	1089.0	1111.3	1126.6	1130.7
1963	1135.0	1134.5	1126.8	1117.6	1107.9	1099.0	1089.2	1082.9	1088.4	1100.2	1126.8	1138.4
1964	1135.9	1138.9	1131.7	1123.8	1114.1	1105.5	1095.9	1086.6	1091.4	1112.0	1124.4	1134.6
1965	1135.1	1134.9	1127.4	1118.9	1109.6	1100.6	1090.8	1083.0	1083.6	1089.7	1121.7	1132.9
1966	1145.1	1139.1	1130.6	1121.2	1111.8	1103.1	1093.7	1084.5	1089.6	1111.0	1124.3	1129.8
1967	1136.7	1136.3	1128.5	1119.7	1110.7	1102.3	1092.6	1084.4	1090.7	1113.1	1135.9	1145.3
1968	1136.6	1138.9	1132.8	1123.6	1114.7	1106.2	1097.2	1089.3	1099.4	1111.9	1127.7	1135.3
1969	1131.7	1130.4	1122.3	1113.4	1104.5	1096.3	1087.4	1083.1	1088.3	1114.4	1127.2	1127.3
1970	1130.1	1137.6	1131.0	1122.3	1113.4	1105.5	1096.9	1089.7	1095.8	1111.0	1124.5	1129.1
1971	1131.6	1132.7	1125.5	1115.9	1106.6	1098.3	1089.5	1083.8	1097.8	1123.2	1142.2	1144.1
1972	1134.4	1132.9	1125.4	1116.8	1107.9	1099.4	1090.2	1083.0	1085.9	1100.0	1125.7	1137.6

TARGET	1137.0	1142.0	1129.0	1120.0	1113.0	1105.0	1100.0	1100.0	1100.0	1111.0	1125.0	1130.0
MIN	1111.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1083.0	1111.0	1111.0	1111.0
AVG	1135.6	1135.7	1128.2	1119.4	1110.4	1102.0	1092.6	1085.0	1090.5	1108.3	1127.9	1134.7

START POOL ELEV: 1142.0
ENDING POOL ELEV: 1135.6
MIN. POOL ELEV: 1082.9 APR 27, 1963
STORAGE CHANGE (CFS): -10.2

ADULT FISH PASSAGE VIA LAKE OUTLET
July 15-July 31: 3.6%
Aug 1 - Oct 15: 10.2%

MONTHLY FLOW INFORMATION

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVG
AVG INFLOW	1600	814	588	446	410	401	584	2109	7432	12507	11443	4985	3636
MIF	1250	600	600	500	500	500	500	750	2000	4000	4000	2000	
SPILL	11	0	0	0	0	0	0	0	0	1	931	111	
CHAKACHATNA R	1261	600	600	500	500	500	500	750	2000	4001	4931	2111	1532
POWERHOUSE	322	2107	2126	2147	2115	2189	2003	0	943	3738	4851	2769	2117

THIS SIMULATION USED THE FOLLOWING EQUIPMENT EFFICIENCIES

% CAP	TURBINE	GENERATOR	COMBINED
0	0.0	0.0	0.0
5	0.0	92.0	0.0
10	73.3	92.3	67.6
15	82.8	92.6	76.6
20	89.1	93.0	82.9
25	93.2	94.2	87.8
30	92.2	95.2	87.7
35	90.3	95.8	86.5
40	91.3	96.3	87.9
45	92.4	96.7	89.3
50	93.1	96.9	90.3
55	93.4	97.1	90.7
60	92.6	97.3	90.1
65	91.8	97.4	89.4
70	92.5	97.5	90.2
75	93.2	97.6	91.0
80	93.4	97.7	91.3
85	93.1	97.8	91.0
90	92.1	97.8	90.1
95	91.1	97.8	89.1

100	90.0	97.8	88.0

Chakachamna Alt. 2 Energy Generation Estimate

DATA FILE USED: chinflow.QCH

MODEL DESCRIPTION

PIPE #	LENGTH	DIAMETER	MANNING'S n	MINOR LOSSES
1	28500	252	.016	.5
2	28500	252	.016	0
3	1000	282	.02	1

MAX POOL ELEV : 1142
MIN POOL ELEV : 1083
DESIGN FLOW: 5400
GROSS HEAD: 932
NET HEAD @ FULL LOAD: 750.2
NAMEPLATE CAPACITY (MW): 302 @ 1 POWER FACTOR
TARGET FIRM CAPACITY (MW): 30

STATION SERVICE LOSS: 0
TRANSFORMER LOSS: 2
TRANSMISSION LOSS: 0
SCHEDULED DOWN TIME: 1.5

RESERVOIR STAGE /	STORAGE
760	0
810	350000
860	500000
1060	3000000
1160	4500000
1210	5600000

USABLE STORAGE: 885000

SIMULATED PRODUCTION IN MEGAWATT-HOURS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1960	12,864	20,880	21,576	21,576	20,184	21,576	1,392	69,768	128,424	165,912	210,432	52,968	747,552
1961	7,992	20,880	21,576	21,576	19,488	21,576	20,880	39,768	50,232	194,448	225,888	160,416	804,720
1962	15,648	20,880	21,576	21,576	19,488	21,576	20,880	50,064	107,736	225,600	225,384	139,080	889,488
1963	2,304	20,880	21,576	21,576	19,488	21,576	6,264	59,664	21,984	217,992	225,840	156,648	795,792
1964	36,576	20,880	21,576	21,576	20,184	21,576	20,880	67,848	146,616	196,776	225,576	114,600	914,664
1965	6,048	20,880	21,576	21,576	19,488	21,576	16,008	6,936	840	130,920	225,840	218,376	710,064

1966	63,480	20,880	21,576	21,576	19,488	21,576	6,960	57,960	127,032	166,704	225,120	200,280	952,632
1967	69,408	20,880	21,576	21,576	19,488	21,576	7,512	73,536	148,104	225,600	226,920	169,536	1,025,712
1968	39,216	20,880	21,576	21,576	20,184	21,576	20,880	151,728	125,640	224,904	225,792	51,432	945,384
1969	0	20,880	21,576	21,576	19,488	21,576	20,880	61,992	136,416	225,840	125,232	25,080	700,536
1970	86,304	25,152	21,576	21,576	19,488	21,576	20,880	120,624	91,296	194,280	171,960	29,928	824,640
1971	20,736	20,880	21,576	21,576	19,488	21,576	20,880	184,296	215,040	226,416	226,944	76,848	1,076,256
1972	0	20,880	21,576	21,576	20,184	21,576	20,880	39,408	46,944	225,168	226,080	145,536	809,808
AVERAGE	27,737	21,209	21,576	21,576	19,702	21,576	15,783	75,661	103,562	201,582	212,847	118,518	861,327
AVG CAP	37	29	29	29	29	29	22	102	144	271	286	165	98

TARGET CAPACITY EXCEEDANCE: 95.8%

AVERAGE PLANT FACTOR: 0.33

BEGINNING RESERVOIR ELEVATIONS

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1960	1142.0	1141.1	1139.3	1136.4	1133.6	1130.7	1127.3	1126.9	1129.6	1136.5	1146.3	1142.0
1961	1141.0	1141.3	1139.8	1138.7	1137.6	1136.2	1133.1	1130.0	1127.0	1137.0	1148.6	1142.3
1962	1142.0	1141.1	1139.8	1137.9	1136.2	1134.2	1131.8	1130.3	1127.0	1140.8	1146.8	1143.6
1963	1142.0	1141.3	1139.7	1137.1	1133.9	1131.0	1127.9	1126.6	1127.0	1136.9	1146.0	1146.5
1964	1142.0	1141.9	1140.8	1139.3	1136.2	1133.7	1130.7	1128.0	1127.0	1137.7	1144.4	1145.1
1965	1142.0	1141.2	1139.9	1137.9	1135.1	1132.1	1129.1	1127.0	1126.9	1132.9	1147.4	1143.4
1966	1146.4	1141.5	1139.2	1136.2	1133.4	1130.7	1127.9	1126.8	1127.0	1136.5	1144.6	1142.6
1967	1142.0	1139.1	1137.4	1135.1	1132.7	1130.2	1127.2	1127.0	1127.0	1139.9	1149.5	1145.4
1968	1142.0	1141.6	1141.7	1139.0	1136.5	1134.2	1131.8	1130.5	1127.0	1138.0	1147.1	1142.5
1969	1140.9	1139.6	1137.7	1135.3	1133.0	1130.8	1128.7	1127.0	1127.0	1143.3	1144.6	1141.5
1970	1142.0	1141.9	1141.1	1139.0	1136.6	1134.6	1132.7	1132.0	1127.0	1136.7	1143.7	1142.0
1971	1142.0	1141.4	1140.4	1137.3	1134.5	1132.3	1130.1	1131.1	1127.7	1147.6	1145.7	1144.2
1972	1141.6	1140.1	1138.8	1136.6	1134.4	1132.0	1129.6	1127.6	1127.0	1136.6	1146.3	1144.6

TARGET	1142.0	1142.0	1129.0	1120.0	1113.0	1105.0	1097.0	1110.0	1125.0	1137.0	1147.0	1142.0
MIN	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0	1127.0
AVG	1142.1	1141.0	1139.7	1137.4	1134.9	1132.5	1129.8	1128.5	1127.2	1138.5	1146.2	1143.5

START POOL ELEV: 1142.0
ENDING POOL ELEV: 1142.0
MIN. POOL ELEV: 1126.5   APR 16, 1960
STORAGE CHANGE (CFS): -0.1

ADULT FISH PASSAGE VIA LAKE OUTLET
July 15-July 31: 100.0%
Aug 1 - Oct 15: 87.3%

MONTHLY FLOW INFORMATION

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVG
AVG INFLOW	1600	814	588	446	410	401	584	2109	7432	12507	11443	4985	3636
MIF	1250	600	600	500	500	500	500	750	2000	4000	4000	2000	
SPILL	22	0	0	0	0	0	0	0	38	1792	3030	513	
CHAKACHATNA R	1272	600	600	500	500	500	500	750	2038	5792	7030	2513	1900
POWERHOUSE	603	554	549	551	539	554	419	1668	2559	4826	5079	2815	1739

THIS SIMULATION USED THE FOLLOWING EQUIPMENT EFFICIENCIES

% CAP	TURBINE	GENERATOR	COMBINED
0	0.0	0.0	0.0
5	0.0	92.0	0.0
10	73.3	92.3	67.6
15	82.8	92.6	76.6
20	89.1	93.0	82.9
25	93.2	94.2	87.8
30	92.2	95.2	87.7
35	90.3	95.8	86.5
40	91.3	96.3	87.9
45	92.4	96.7	89.3
50	93.1	96.9	90.3
55	93.4	97.1	90.7
60	92.6	97.3	90.1
65	91.8	97.4	89.4
70	92.5	97.5	90.2
75	93.2	97.6	91.0
80	93.4	97.7	91.3
85	93.1	97.8	91.0
90	92.1	97.8	90.1
95	91.1	97.8	89.1

100	90.0	97.8	88.0

Appendix B:
Susitna Construction Cost Estimate

HDR/AEA Susitna Hydroelectric Project
Cost Estimates based on 1982 quantities
By: HDR
By: Leanne Andruszkiewicz, E.I.T.
Checked By: Kellen Roberts, E.I.T.
Date: 10/15/2009
2008 Dollars
Low Watana (Non-Expandable) (4 Turbines)

FERC Line #	Sub Categories		Description	Quantity	Units	2008 Unit Price	Line Price	Total
330			**Land and Land Rights**					
	0.1		Land	1	LS	$ 120,870,000.00	$ 120,870,000	
	0.2		Land Rights				$ -	
	0.3		Misc Charges in Credit Above				$ -	
							$ -	**$ 121,000,000**
							$ -	
331			**Powerplant Structure Improvements**				$ -	
	0.1		Powerhouse				$ -	
	0.11		Powerhouse and Draft Tube				$ -	
		0.111	Excavation				$ -	
			Powerhouse Vault Rock	81,667	CY	$ 90.12	$ 7,360,000	
			Draft Tube Rock	16,800	CY	$ 90.12	$ 1,510,000	
		0.113	Surface Preparation/ Grouting	0			$ -	
			Powerhouse	66,000	SF	$ 3.33	$ 220,000	
			Draft Tube	51,000	SF	$ 3.33	$ 170,000	
			Grout Curtain- Drill holes	29,200	LF	$ 27.63	$ 810,000	
			Grout Curtain- Cement	11,667	CF	$ 81.10	$ 950,000	
		0.114	Concrete and Shot Crete	0			$ -	
			Powerhouse Concrete	21,733	CY	$ 692.87	$ 15,060,000	
			Powerhouse Concrete Overbreak	1,600	CY	$ 447.21	$ 720,000	
			Powerhouse Reinforcing Steel	1,087	TON	$ 2,858.29	$ 3,110,000	
			Powerhouse 4" Shotcrete	27,333	SF	$ 10.14	$ 280,000	
			Draft Tube Concrete	8,000	CY	$ 692.87	$ 5,540,000	
			Draft Tube Concrete Overbreak	1,667	CY	$ 447.21	$ 750,000	
			Draft Tube Reinforcing Steel	660	TON	$ 2,858.29	$ 1,890,000	
			Draft Tube 2" Shotcrete	4,067	SF	$ 5.45	$ 20,000	
		0.115	Support and Anchors	0			$ -	
			Powerhouse Rockbolts 1" @ 25' Hy	647	EA	$ 1,234.86	$ 800,000	
			Powerhouse Rockbolts 1" @ 15'	1,313	EA	$ 735.81	$ 970,000	
			Powerhouse Steel Mesh	29,733	SF	$ 5.81	$ 170,000	
			Powerhouse Steel Support	91	TON	$ 12,671.94	$ 1,160,000	
			Draft Tube Rockbolts 1" @ 25' Hy	100	EA	$ 1,234.86	$ 120,000	
			Draft Tube Rockbolts 1" @ 12'	260	EA	$ 528.34	$ 140,000	
			Draft Tube Rockbolts 1" @ 9'	127	EA	$ 432.12	$ 50,000	
			Draft Tube Steel Mesh	12,600	SF	$ 6.55	$ 80,000	
		0.117	Holes (U/S of Powerhouse)	10,000	LF	$ 51.32	$ 510,000	
			Holes (Powerhouse Crown)	19,000	LF	$ 51.32	$ 980,000	
		0.118	Structural- Misc Steelwork				$ -	
			Powerhouse and Draft Tube- Steel Crane Rails	1	LS	$ 10,276,309.00	$ 10,280,000	
		0.119	Architectural- Powerhouse	1	LS	$ 2,927,898.00	$ 2,930,000	
		0.11c	Mechanical				$ -	
			Draft Tube Gates	4	SETS	$ 427,880.00	$ 1,710,000	
			Draft Tube Gate Guides	4	SETS	$ 202,680.00	$ 810,000	
			Draft Tube Crane	1	LS	$ 1,140,000.00	$ 1,140,000	
	0.12		Access Tunnels and Portals				$ -	
		0.121	Excavation				$ -	
			Main Tunnel	33,500	CY	$ 97.45	$ 3,260,000	
			Transformer Gallery Tunnel	11,833	CY	$ 97.45	$ 1,150,000	
			Grouting Gallery Tunnel	1,267	CY	$ 396.04	$ 500,000	

	Surge Chamber Access Tunnel	4,833	CY	$	145.22	$	700,000
	Penstock Access Tunnel	41,000	CY	$	145.22	$	5,950,000
	Penstock Elbow Access Tunnel	10,000	CY	$	145.22	$	1,450,000
	Access Shaft Tunnel	867	CY	$	145.22	$	130,000
	Connector Tunnel	1,267	CY	$	379.26	$	480,000
	Portals Overburden	4,000	CY	$	17.14	$	70,000
	Portals Rock	2,000	CY	$	49.31	$	100,000
0.123	Surface Preparation					$	-
	Main Tunnel Slab	35,400	SF	$	2.21	$	80,000
	Penstock Access Slab	43,467	SF	$	2.21	$	100,000
	Horizontal Portal	133	SF	$	2.30	$	-
	Inclined Portal	1,400	SF	$	3.33	$	-
0.124	Concrete and Shot Crete					$	-
	Main Portal					$	-
	Concrete Slab	20	CY	$	406.27	$	10,000
	Concrete Walls	380	CY	$	406.27	$	150,000
	Concrete Overbreak	33	CY	$	368.48	$	10,000
	Reinforcing Steel	27	TON	$	2,887.51	$	80,000
	Tunnels					$	-
	Concrete Slab Main Tunnel	1,300	CY	$	503.90	$	660,000
	Concrete Plugs Penstock Elbow ACC	10,000	CY	$	755.86	$	7,560,000
	Concrete Overbreak Main Tunnel 6"	667	CY	$	346.43	$	230,000
	Reinforcing Steel	47	TON	$	2,887.51	$	130,000
	2 " Shotcrete Main Tunnel	13,400	SF	$	5.26	$	70,000
	2 " Shotcrete Transformer Gal	4,733	SF	$	5.26	$	20,000
	2 " Shotcrete Surge Chamber Acc	2,600	SF	$	5.26	$	10,000
	2 " Shotcrete Penstock Access	16,467	SF	$	5.26	$	90,000
	2 " Shotcrete Penstock Elbow Acc	4,733	SF	$	5.26	$	20,000
	2 " Shotcrete Access Shaft	200	SF	$	5.26	$	-
	2 " Shotcrete Grout Gallery	533	SF	$	5.26	$	-
	2 " Shotcrete Connector Tunnel	533	SF	$	5.26	$	-
0.125	Support and Anchors					$	-
	Main Tunnel					$	-
	Rockbolts 1" @12'	800	EA	$	528.34	$	420,000
	Rockbolts 1" @ 9'	167	EA	$	432.12	$	70,000
	Steel Mesh	42,000	SF	$	6.37	$	270,000
	Steel Support	44	TON	$	12,801.49	$	560,000
	Main Tunnel Portal					$	-
	Rockbolts 1" @15'	33	EA	$	735.79	$	20,000
	Transformer Gallery Tunnel					$	-
	Rockbolts 1" @12'	273	EA	$	528.34	$	140,000
	Rockbolts 1" @ 9'	47	EA	$	432.12	$	20,000
	Steel Mesh	15,000	SF	$	5.89	$	90,000
	Steel Support	16	TON	$	12,801.49	$	200,000
	Grouting Gallery Tunnel					$	-
	Rockbolts 3/4" @ 6'	107	EA	$	327.15	$	30,000
	Steel Mesh	107	SF	$	6.37	$	-
	Steel Support	2	TON	$	12,801.49	$	30,000
	Surge Chamber Access Tunnel					$	-
	Rockbolts 1" @12'	153	EA	$	528.34	$	80,000
	Rockbolts 1" @ 9'	33	EA	$	432.12	$	10,000
	Steel Mesh	8,033	SF	$	6.37	$	50,000
	Steel Support	9	TON	$	12,801.49	$	120,000
	Penstock Access Tunnel					$	-
	Rockbolts 1" @12'	953	EA	$	528.34	$	500,000
	Rockbolts 1" @ 9'	160	EA	$	432.12	$	70,000
	Steel Mesh	51,667	SF	$	6.37	$	330,000
	Steel Support	39	TON	$	12,801.49	$	490,000

	Penstock Elbow Access Tunnel					$	-
	Rockbolts 1" @12'	280	EA	$	528.34	$	150,000
	Rockbolts 1" @ 9'	80	EA	$	432.12	$	30,000
	Steel Mesh	15,000	SF	$	6.37	$	100,000
	Steel Support	20	TON	$	12,801.49	$	260,000
	Access Shaft Tunnel					$	-
	Rockbolts 1" @12'	13	EA	$	528.34	$	10,000
	Rockbolts 1" @ 9'	13	EA	$	432.12	$	10,000
	Steel Mesh	620	SF	$	6.37	$	-
	Steel Support	5	TON	$	12,801.49	$	70,000
	Connector Tunnel					$	-
	Rockbolts 3/4" @ 6'	107	EA	$	327.15	$	30,000
	Steel Mesh	107	SF	$	6.37	$	-
	Steel Support	2	TON	$	12,801.49	$	30,000
0.129	Architectural- Main Portal Doors	2	SETS	$	158,371.90	$	320,000
0.12c	Mechanical Ventilation System					$	-
0.13	Access Shaft					$	-
0.131	Excavation Rock	9,133	CY	$	227.67	$	2,080,000
0.133	Surface Preparation Shaft	42,667	SF	$	3.33	$	140,000
0.134	Concrete and Shot Crete					$	-
	Concrete Lining	2,233	CY	$	944.82	$	2,110,000
	Concrete Overbreak 6"	813	CY	$	551.14	$	450,000
0.135	Support and Anchors - Rockbolts 3/4" @ 6'	700	EA	$	327.15	$	230,000
0.138	Structural Misc Steelwork	33	TON	$	7,395.00	$	250,000
0.139	Architectural- control Building					$	-
0.13c	Mechanical Elevators	1	LS	$	2,368,815.00	$	2,370,000
0.14	Fire Protection Head Tank					$	-
0.141	Excavation	767	CY	$	588.80	$	450,000
0.143	Surface Preparation	1,867	SF	$	2.30	$	-
0.144	Concrete & Shotcrete					$	-
	Concrete	167	CY	$	963.72	$	160,000
	Concrete Overbreak 6"	30	CY	$	406.27	$	10,000
	Reinforcing Steel	7	TON	$	2,858.29	$	20,000
0.145	Support and Anchors					$	-
	Rockbolts 1" @12'	17	EA	$	528.34	$	10,000
	Rockbolts 1" @ 9'	7	EA	$	432.12	$	-
	Steel Mesh	800	SF	$	6.30	$	10,000
	Steel Support	2	TON	$	12,671.95	$	30,000
0.148	Misc Steelwork	1	LS	$	73,297.50	$	70,000
0.14c	Mechanical Piping/Valves					$	-
0.15	Bus Tunnels (totals for 3 Bus Tunnels)					$	-
0.151	Excavation					$	-
	Rock Horizontal	1,800	CY	$	213.70	$	380,000
	Rock Inclined	867	CY	$	601.04	$	520,000
0.153	Surface Preparation- Tunnels	4,733	SF	$	3.33	$	20,000
0.154	Concrete and Shotcrete					$	-
	Concrete Slab	233	CY	$	818.84	$	190,000
	Concrete Overbreak 12"	167	CY	$	472.41	$	80,000
	Reinforcing Steel	12	TON	$	2,858.29	$	30,000
	2" Shotcrete	1,467	SF	$	5.26	$	10,000
0.155	Supports and Anchors					$	-
	Rockbolts 1" @ 25'	40	EA	$	1,234.86	$	50,000
	Rockbolts 1" @ 12'	93	EA	$	528.34	$	50,000
	Rockbolts 1" @ 9'	33	EA	$	432.12	$	10,000
	Steel Mesh	4,533	SF	$	6.30	$	30,000
	Steel Support	7	TON	$	12,671.94	$	90,000
0.16	Transformer Gallery Tunnel					$	-

			0.161	Excavation- Rock	17,867	CY	$	87.44	$	1,560,000		
			0.163	Surface Preparation	16,400	SF	$	2.30	$	40,000		
			0.164	Concrete and Shotcrete					$	-		
				Concrete Base Slab	1,600	CY	$	1,228.27	$	1,970,000		
				Concrete Overbreak 12"H/6"V	513	CY	$	377.93	$	190,000		
				Reinforcing Steel	80	TON	$	2,858.29	$	230,000		
			0.165	Support and Anchors					$	-		
				Rockbolts 1" @ 25'	400	EA	$	1,234.86	$	490,000		
				Rockbolts 1" @ 15'	180	EA	$	735.81	$	130,000		
				Steel Mesh	13,800	SF	$	5.81	$	80,000		
				Steel Support	19	TON	$	12,671.94	$	240,000		
			0.167	Drainage Holes	5,533	LF	$	47.95	$	270,000		
		0.17		Cable Shafts					$	-		
			0.171	Excavation Rock	2,267	CY	$	601.04	$	1,360,000		
			0.173	Surface Preparation Shafts	27,600	SF	$	3.33	$	90,000		
			0.174	Concrete and Shotcrete					$	-		
				Concrete Lining	693	CY	$	1,763.66	$	1,220,000		
				Concrete Overbreak 6"	533	CY	$	881.83	$	470,000		
			0.175	Supports and Anchors- Rockbolts 3/4" @ 6'	433	EA	$	327.15	$	140,000		
			0.178	Structural Misc Steelwork	12	TON	$	15,602.00	$	190,000		
			0.179	Architectural- Enclosures	1	LS	$	199,317.00	$	200,000		
			0.17c	Mechanical Hoist	2	EA	$	476,960.00	$	950,000		
		0.18		Dewatering (during Construction)					$	-		
			0.181	Dewatering (Power Facilities)	1	LS	$	1,336,798.50	$	1,340,000		
		0.19		Instrumentation					$	-		
			0.191	Instrumentation	1	LS	$	1,714,813.50	$	1,710,000		
	0.2			Misc Buildings (Control Buildings)	1	LS	$	4,433,085.00	$	4,430,000		
	0.3			Permanent Town	(included in 63.5)							
									$	-	**$**	**115,000,000**
332				**Reservoir, Dams and Waterways**					$	-		
	0.1			Reservoir					$	-		
		0.11		Reservoir Clearing	23,000	ACRE	$	3,005.85	$	69,130,000		
	0.2			Diversion Tunnels /Cofferdams					$	-		
		0.21		Diversion Tunnels /Portals					$	-		
			0.211	Excavation					$	-		
				Upper Tunnel					$	-		
				Rock	221,000	CY	$	92.33	$	20,400,000		
				Lower Tunnel					$	-		
				Rock	208,000	CY	$	92.33	$	19,200,000		
				Excavate Concrete for Plug	700	CY	$	96.92	$	70,000		
				Upstream Upper Portal					$	-		
				Rock Usable (Face Only)	11,200	CY	$	49.16	$	550,000		
				Upstream Lower Portal (Including Most Exc for Upper Portal)					$	-		
				Rock Usable	108,000	CY	$	49.16	$	5,310,000		
				Rock Waste	21,750	CY	$	49.16	$	1,070,000		
				Downstream Portals					$	-		
				Overburden	17,000	CY	$	17.14	$	290,000		
				Rock Usable	120,000	CY	$	49.16	$	5,900,000		
				Rock Waste	28,000	CY	$	49.16	$	1,380,000		
				Emergency Release Chambers					$	-		
				Excavate Concrete for Plugs	1,800	CY	$	101.98	$	180,000		
				Gate Chamber	4,700	CY	$	110.73	$	520,000		
				Access Tunnel to Gate Chamber					$	-		
				Rock	19,100	CY	$	97.15	$	1,860,000		
			0.212	Fill- Temp for Coffer Dam to Construct Upstream Portals	23,000	CY	$	11.66	$	270,000		
			0.213	Surface Preparation \ grouting					$	-		
				Upstream Upper Portal					$	-		
				Horizontal	3,200	SF	$	2.30	$	10,000		

	Inclined	8,600	SF	$ 3.33	$	30,000
	Upstream Lower Portal				$	-
	Horizontal	1,300	SF	$ 2.30	$	-
	Inclined	14,900	SF	$ 3.33	$	50,000
	Downstream Upper Portal				$	-
	Horizontal	6,100	SF	$ 2.30	$	10,000
	Inclined	20,500	SF	$ 3.33	$	70,000
	Downstream Lower Portal				$	-
	Horizontal	600	SF	$ 2.30	$	-
	Inclined	5,600	SF	$ 3.33	$	20,000
	Grout Upper Tunnel Plugs				$	-
	Drill Holes	4,100	LF	$ 26.76	$	110,000
	Cement	820	CF	$ 81.10	$	70,000
	Grout Lower Tunnel Permanent Plugs				$	-
	Drill Holes	2,050	LF	$ 26.76	$	50,000
	Cement	410	CF	$ 81.10	$	30,000
0.214	Concrete and Shotcrete				$	-
	Upper Tunnel				$	-
	Concrete Lining	42,400	CY	$ 566.89	$	24,040,000
	Concrete Lining Overbreak 6"	10,200	CY	$ 314.94	$	3,210,000
	Reinforcing Steel	24	TON	$ 2,887.51	$	70,000
	2" Shotcrete	56,000	SF	$ 5.26	$	290,000
	Lower Tunnel				$	-
	Concrete Lining	37,600	CY	$ 566.89	$	21,320,000
	Concrete Lining for Plug	6,200	CY	$ 428.32	$	2,660,000
	Concrete Lining Overbreak 6"	10,000	CY	$ 314.94	$	3,150,000
	Reinforcing Steel	24	TON	$ 2,887.51	$	70,000
	2" Shotcrete	57,900	SF	$ 5.26	$	300,000
	Upstream Upper Portal				$	-
	Concrete Headwall	3,200	CY	$ 651.93	$	2,090,000
	Concrete Lining	1,300	CY	$ 651.93	$	850,000
	Concrete Slab	750	CY	$ 651.93	$	490,000
	Concrete Piers	800	CY	$ 651.93	$	520,000
	Concrete Overbreak 12" H/6"V	300	CY	$ 472.41	$	140,000
	Reinforcing Steel	400	TON	$ 2,887.51	$	1,160,000
	Upstream Lower Portal				$	-
	Concrete Headwall	4,500	CY	$ 651.93	$	2,930,000
	Concrete Lining	3,000	CY	$ 651.93	$	1,960,000
	Concrete Slab	300	CY	$ 651.93	$	200,000
	Concrete Piers	700	CY	$ 651.93	$	460,000
	Concrete Overbreak 12" H/6"V	350	CY	$ 472.41	$	170,000
	Reinforcing Steel	600	TON	$ 2,887.51	$	1,730,000
	Downstream Upper Portal				$	-
	Concrete Headwall	500	CY	$ 651.93	$	330,000
	Concrete Slab	100	CY	$ 651.93	$	70,000
	Concrete Overbreak 12" H/6"V	100	CY	$ 472.41	$	50,000
	Reinforcing Steel	40	TON	$ 2,887.51	$	120,000
	Downstream Lower Portal				$	-
	Concrete Headwall	2,500	CY	$ 651.93	$	1,630,000
	Concrete Slab	100	CY	$ 651.93	$	70,000
	Concrete Overbreak 12" H/6"V	150	CY	$ 472.41	$	70,000
	Reinforcing Steel	170	TON	$ 2,887.51	$	490,000
	Downstream Flip Bucket				$	-
	Concrete Slab	800	CY	$ 651.93	$	520,000
	Concrete Walls	2,300	CY	$ 651.93	$	1,500,000
	Concrete Invert	1,200	CY	$ 651.93	$	780,000
	Concrete Overbreak 12" H/6"V	410	CY	$ 42.41	$	20,000
	Reinforcing Steel	280	TON	$ 2,887.51	$	810,000

	Downstream Retaining Wall					$	-
	Concrete Slab	200	CY	$	651.93	$	130,000
	Concrete Walls	2,000	CY	$	651.93	$	1,300,000
	Concrete Overbreak 12" H/6"V	110	CY	$	472.41	$	50,000
	Reinforcing Steel	90	TON	$	2,887.51	$	260,000
	Emergency Release Chambers					$	-
	Concrete Plug	15,300	CY	$	755.86	$	11,560,000
	4" Shotcrete	2,790	SF	$	10.13	$	30,000
	Access Tunnel to Gate Chamber					$	-
	2" Shotcrete	12,800	SF	$	5.26	$	70,000
0.215	Supports and Anchors					$	-
	Lower Tunnel					$	-
	Rockbolts 1" @ 12'	3,650	EA	$	528.34	$	1,930,000
	Rockbolts 1" @ 9'	620	EA	$	432.12	$	270,000
	Steel Mesh	217,100	SF	$	6.37	$	1,380,000
	Steel Support	220	TON	$	12,801.49	$	2,820,000
	Upper Tunnel					$	-
	Rockbolts 1" @ 12'	3,530	EA	$	528.34	$	1,870,000
	Rockbolts 1" @ 9'	600	EA	$	432.12	$	260,000
	Steel Mesh	210,200	SF	$	6.37	$	1,340,000
	Steel Support	213	TON	$	12,801.49	$	2,730,000
	Upstream Lower Portal					$	-
	Rockbolts 1" @ 15'	240	EA	$	735.81	$	180,000
	Anchors 1" @ 25'	290	EA	$	1,234.86	$	360,000
	Upstream Upper Portal					$	-
	Rockbolts 1" @ 15'					$	-
	Anchors 1" @ 25'	130	EA	$	735.81	$	100,000
	Downstream Lower Portal					$	-
	Rockbolts 1" @ 15'	200	EA	$	735.81	$	150,000
	Downstream Upper Portal					$	-
	Rockbolts 1" @ 15'	100	EA	$	735.81	$	70,000
	Retaining Wall Anchors 1" @25'	100	EA	$	1,234.86	$	120,000
	Emergency Release Chambers					$	-
	Rockbolts 1" @ 25'	100	EA	$	1,234.86	$	120,000
	Rockbolts 1" @ 15'	125	EA	$	735.77	$	90,000
	Steel Mesh	3,600	SF	$	6.37	$	20,000
	Steel Support	14	TON	$	12,801.49	$	180,000
	Metal to Roof Anchors 3/4" @ 6'	20	EA	$	342.42	$	10,000
	Access Tunnel to Gate Chamber					$	-
	Rockbolts 1" @ 12'	775	EA	$	528.34	$	410,000
	Rockbolts 1" @ 9'	240	EA	$	432.12	$	100,000
	Steel Mesh	39,900	SF	$	6.37	$	250,000
	Steel Support	55	TON	$	12,801.49	$	700,000
0.218	Structural- Misc Steelwork	2,775	SF	$	93.61	$	260,000
0.21c	Mechanical					$	-
	Upstream Lower Gates					$	-
	Gate Equipment	2	EA	$	5,073,120.00	$	10,150,000
	Upstream Upper Gates					$	-
	Gate Equipment	2	EA	$	2,840,080.00	$	5,680,000
	Trashracks	1	LS	$	1,777,500.00	$	1,780,000
	Downstream Lower Outlet					$	-
	Stoplog Guides	1	LS	$	142,200.00	$	140,000
	Stoplogs includes follower	1	LS	$	1,967,100.00	$	1,970,000
	Downstream Upper Outlet					$	-
	Stoplog Guides	1	LS	$	82,950.00	$	80,000
	Low Level Release					$	-
	Slide Gates Include Steel Liner	9	EA	$	3,517,470.00	$	31,660,000
						$	-

	0.22		Upstream Cofferdam						$	-
		0.221	Excavation						$	-
			Overburden Removal		1,000	CY	$	11.56	$	10,000
		0.222	Fill						$	-
			Rock Fill		38,400	CY	$	10.90	$	420,000
			Fine Filter		16,600	CY	$	36.84	$	610,000
			Coarse Filter		15,900	CY	$	30.05	$	480,000
			Rock Shell		196,500	CY	$	10.50	$	2,060,000
			Closure Dike		58,500	CY	$	10.90	$	640,000
			Rip Rap		21,200	CY	$	24.26	$	510,000
		0.223	Cutoff Slurry Wall						$	-
			excavation		4,850	CY	$	4.88	$	20,000
			slurry wall		43,600	SF	$	72.44	$	3,160,000
		0.22d	Dewatering						$	-
			Initial Dewatering		1	LS	$	5,807,685.00	$	5,810,000
			Dewatering Maintenance		1	LS	$	22,377,990.00	$	22,380,000
	0.23		Down Stream Cofferdam						$	-
		0.231	Excavation						$	-
			overburden		5,000	CY	$	11.56	$	60,000
			Rock		500	CY	$	9.91	$	-
			Removal of Cofferdam		14,500	CY	$	13.48	$	200,000
		0.232	Fill						$	-
			Rip Rap		1,800	CY	$	24.26	$	40,000
			Closure Dike		15,200	CY	$	10.90	$	170,000
		0.233	Cutoff Slurry Wall						$	-
			Excavation		1,830	CY	$	4.60	$	10,000
			Slurry Wall		16,500	SF	$	72.44	$	1,200,000
0.3			Main Dam						$	-
	0.31		Main Dam						$	-
		0.311	Excavation						$	-
			Overburden above el. 1470		2,026,000	CY	$	11.53	$	23,360,000
			Overburden below el. 1470		5,320,000	CY	$	11.06	$	58,840,000
			Rock Usable above el. 1470		1,289,000	CY	$	43.03	$	55,470,000
			Rock Usable below el. 1470		478,000	CY	$	43.72	$	20,900,000
			Rock Waste above el. 1470		1,950,000	CY	$	43.03	$	83,910,000
			Rock Waste below el. 1470		869,500	CY	$	50.18	$	43,630,000
		0.312	Fill- Estimated from Attatched Calculations						$	-
			Rip Rap (upstream)		409,000	CY	$	23.30	$	9,530,000
			Gravel (upstream)		6,659,000	CY	$	20.56	$	136,910,000
			Coarse Filter (upstream)		925,759	CY	$	28.86	$	26,720,000
			Fine Filter (upstream)		1,045,588	CY	$	37.91	$	39,640,000
			Core (impervious)		6,300,000	CY	$	25.37	$	159,830,000
			Fine Filter (downstream)		1,171,412	CY	$	37.91	$	44,410,000
			Coarse Filter (downstream)		1,074,241	CY	$	28.86	$	31,000,000
			Shell- Rock and Gravel		2,998,209	CY	$	19.18	$	57,510,000
			Shell- Rock From Other Sources		1,445,000	CY	$	10.09	$	14,580,000
			Cobbles (downstream Face)		530,000	CY	$	16.35	$	8,670,000
			Road Base		12,000	CY	$	34.42	$	410,000
			Frost Protection						$	-
				Process Protection	960,000	CY	$	10.31	$	9,900,000
				Place Protection	960,000	CY	$	3.29	$	3,160,000
				Remove 1' Protect and Waste	93,000	CY	$	7.21	$	670,000
				Scarify Core Surface	193	ACRE	$	858.77	$	170,000
			Filter Fabric						$	-
				Filter Fabric	592,000	SF	$	0.88	$	520,000
		0.313	Surface Prep/ Grouting						$	-
			Surface Preparation						$	-
				Under Core/Filters above el. 1500	1,340,000	SF	$	3.11	$	4,170,000

		Under Core/Filters below el. 1500	490,000	SF	$	3.11	$	1,520,000
		Under Shell above el. 1500	4,149,000	SF	$	2.15	$	8,920,000
		Under Shell below el. 1500	2,067,000	SF	$	2.15	$	4,440,000
		Consolidation Grout					$	-
		Drill Holes	550,000	LF	$	11.91	$	6,550,000
		Cement	550,000	CF	$	67.81	$	37,300,000
		Grout Curtain					$	-
		Drill Holes	372,000	LF	$	26.76	$	9,950,000
		Cement	149,000	CF	$	81.10	$	12,080,000
		Dental Concrete					$	-
		Dental Concrete	68,000	CY	$	365.33	$	24,840,000
	0.317	Drainage					$	-
		Holes	109,000	LF	$	51.32	$	5,590,000
0.32		Grout Galleries/Portals					$	-
	0.321	Excavation					$	-
		Tunnels/ Shafts- Core Area					$	-
		Rock Horizontal	8,100	CY	$	394.80	$	3,200,000
		Rock Inclined	9,000	CY	$	552.93	$	4,980,000
		Rock Vertical	1,600	CY	$	536.19	$	860,000
		Tunnels/ Shafts- Access					$	-
		Rock Horizontal	10,400	CY	$	394.80	$	4,110,000
		Rock Inclined	1,600	CY	$	552.93	$	880,000
		Portals					$	-
		Overburden Rock	2,900	CY	$	17.16	$	50,000
		Rock	800	CY	$	49.16	$	40,000
	0.323	Surface Preparation					$	-
		Portals					$	-
		Horizontal	24	SF	$	2.30	$	-
		Inclined	160	SF	$	3.33	$	-
							$	-
	0.324	Concrete and Shotcrete					$	-
		Tunnels- Core Area					$	-
		Concrete Plugs	800	CY	$	428.32	$	340,000
		Concrete Slab	1,800	CY	$	944.82	$	1,700,000
		Concrete Overbreak 6"	920	CY	$	755.86	$	700,000
		Reinforcing Steel	64	TON	$	2,887.51	$	180,000
		2" Shotcrete	12,000	SF	$	5.26	$	60,000
		Tunnels-Access					$	-
		Concrete Slab	1,280	CY	$	944.82	$	1,210,000
		Concrete Overbreak 6"	640	CY	$	755.86	$	480,000
		Reinforcing Steel	48	TON	$	2,887.51	$	140,000
		2" Shotcrete	4,300	SF	$	5.26	$	20,000
		Shafts					$	-
		2" Shotcrete	4,000	SF	$	5.26	$	20,000
		Portals					$	-
		Concrete	16	CY	$	406.36	$	10,000
		Reinforcing Steel	2	TON	$	2,887.51	$	-
	0.325	Support and Anchors					$	-
		Tunnels- Core Area					$	-
		Rockbolts 3/4" @6'	1,400	EA	$	327.15	$	460,000
		Steel Mesh	2,400	SF	$	5.37	$	10,000
		Steel Support	16	TON	$	12,801.49	$	200,000
		Tunnels- Access					$	-
		Rockbolts 3/4" @6'	960	EA	$	327.15	$	310,000
		Steel Mesh	880	SF	$	5.37	$	-
		Steel Support	16	TON	$	12,801.49	$	200,000
		Shafts					$	-
		Rockbolts 3/4" @6'	280	EA	$	327.15	$	90,000

			Steel Mesh	800	SF	$	5.37	$	-		
			Portals					$	-		
			Rockbolts 1" @15'	24	EA	$	735.81	$	20,000		
		0.329	Architectural Portal Doors					$	-		
			Portal Doors	1	LS	$	33,900.00	$	30,000		
	0.33		Instrumentation					$	-		
		0.331	Instrumentation	1	LS	$	17,315,220.00	$	17,320,000		
0.4			Relict Channel					$	-		
	0.41		Shore Protection					$	-		
		0.411	Excavation					$	-		
			Overburden Stripping 2' thick	2,200	CY	$	11.56	$	30,000		
		0.412	Fill					$	-		
			Dump and Spread					$	-		
			Filter Material - 2' layer	2,200	CY	$	31.93	$	70,000		
			Rock Spalls/ Rip Rap- 3' Ave	3,300	CY	$	9.86	$	30,000		
			Shore Protection					$	-		
			Rip Rap	24,000	CY	$	24.26	$	580,000		
			Waste Rock	24,000	CY	$	22.78	$	550,000		
	0.44		Channel Filter Blanket					$	-		
		0.442	Fill					$	-		
			Coarse Filter	2,900,000	CY	$	33.85	$	98,170,000		
			Fine Filter	2,180,000	CY	$	43.65	$	95,160,000		
			Rip Rap	182,000	CY	$	24.26	$	4,420,000		
		0.443	Surface preparation					$	-		
			Foundation Prep					$	-		
			Clearing and Grubbing	460	ACRE	$	3,963.11	$	1,820,000		
			Excavation	2,236,000	CY	$	15.62	$	34,930,000		
0.5			Outlet Facilities							**$**	**1,537,690,000**
	0.51		Outlet Facilities- (Intake Civil Work Include in Power Intake)	1	LS	$	73,000,000	$	73,000,000		
	0.52		Main (Chute) Spillway (Includes Civil Works for Outlet Facilities)	1	LS	$	182,000,000	$	182,000,000		
	0.53		Emergency Spillway	1	LS	$	164,000,000	$	164,000,000		
0.6			Power Intake (Inc Inlet exec and Inlet Structure Civil Works for Outlet)	1	LS	$	97,000,000	$	97,000,000		
0.7			Surge Chamber	1	LS	$	17,000,000	$	17,000,000		
	0.81		Head Race (Based on Penstock costs	1	LS	$	28,000,000	$	28,000,000		
	0.82		Penstocks	1	LS	$	17,000,000	$	17,000,000		
0.9			Tailrace Works (1 Portal with Combined Tailrace/Diversion Tunnel)	1	LS	$	12,000,000	$	12,000,000		
										$	**590,000,000**
<u>333</u>			**<u>Waterwheels, Turbines and Generators</u>**								
	0.11		Turbines and Governors								
		0.111	Supply								
		0.112	Install								
0.2			Generators and Exciters								
	0.21		Generators and Exciters (Supply and Install)								
		0.211	Generators and Exciters								
0.3			Total Bid From Vendor (includes all equipment in this category)	4	EA	$	74,200,000.00	$	297,000,000	**$**	**297,000,000**
			Average from acquired quotes								
<u>334</u>			**<u>Accessory Electrical Equipment</u>**								
0.1			Connections, Supports and Structures								
	0.11		Structures								
		0.111	Structures (included Below)								
	0.12		Conductors and Insulators								
		0.121	Generator Isolated Phase Bus	1	LS	$	3,792,000.00	$	3,790,000		
		0.122	HV Power Cables and Accessories	1	LS	$	1,540,500.00	$	1,540,000		
		0.123	LV Power Cables and Accessories	1	LS	$	711,000.00	$	710,000		
		0.124	Control Cables and Accessories	1	LS	$	1,303,500.00	$	1,300,000		
		0.125	Grounding System	1	LS	$	177,750.00	$	180,000		

		0.13		Conduits and Fittings							
			0.131	Conduits and Fittings	1 LS	$	474,000.00	$	470,000		
	0.2			Switchgear and Control Equipment							
		0.21		Auxiliary Transformers							
			0.211	Auxiliary Transformers	4 EA	$	83,811	$	340,000		
		0.22		Circuit Breakers Generators				$	-		
			0.221	Circuit Breakers Generators	4 EA	$	1,504,300	$	6,020,000		
		0.23		Surge Protectors and Generator Cubicles		$	-	$	-		
			0.231	Surge Protectors and Generator Cubicles	4 EA	$	50,000.00	$	200,000		
		0.24		Switch boards		$	-	$	-		
			0.241	Switch boards	1 LS	$	924,300.00	$	920,000		
		0.25		Auxiliary Power Equipment		$	-	$	-		
			0.251	Auxiliary Power Equipment	4 EA	$	100,000	$	400,000		
	0.3			Cubicles and Appurtenances				$	-		
		0.31		Control, relay and meter boards				$	-		
			0.311	Control, relay and meter boards	4 EA	$	200,000	$	800,000		
		0.32		Computer Control System		$	-	$	-		
			0.321	Computer Control System		$	-	$	-		
		0.33		Supervisor and Telemeter System		$	-	$	-		
			0.331	Supervisor and Telemeter System		$	-	$	-		
						$	-	$	-		
	0.4			Power Transformers		$	-	$	-		
		0.41		Power Transformers		$	-	$	-		
			0.411	Power Transformers	7 EA	$	2,571,429	$	18,000,000		
						$	-	$	-		
	0.5			Lighting System				$	-		
		0.51		Powerhouse and Transformer Gallery				$	-		
			0.511	Powerhouse and Transformer Gallery	1 LS	$	1,824,900.00	$	1,820,000		
		0.52		Access Tunnels and Roads				$	-		
			0.521	Access Tunnels and Roads	1 LS	$	402,900.00	$	400,000		
								$	-		
	0.6			Misc. Electrical Equipment				$	-		
		0.61		Misc. Electrical Equipment				$	-		
			0.611	Misc. Electrical Equipment	1 LS	$	625,680.00	$	630,000		
								$	-		
	0.7			Surface Accessory Equipment				$	-		
		0.71		34.5 kV and LV Equipment				$	-		
			0.711	Switchboard	1 LS	$	213,300	$	210,000		
			0.712	Cables	1 LS	$	450,300	$	450,000		
			0.713	Aux Transformers	1 LS	$	284,400	$	280,000		
		0.73		Diesel Generator- Standby				$	-		
			0.731	Diesel Generator- Standby	2 EA	$	347,550	$	700,000		
		0.74		Exterior Lighting				$	-		
			0.741	Exterior Lighting	1 LS	$	355,500	$	360,000		
		0.75		Mimic Board- Control Building				$	-		
			0.751	Mimic Board- Control Building	1 LS	$	1,185,000	$	1,190,000		
								$	-	**$**	**41,000,000**
<u>335</u>				**<u>Misc Powerplant Equipment</u>**				$	-		
	0.1			Auxiliary Systems- Underground				$	-		
		0.11		Station Water Systems				$	-		
			0.111	Station Water Systems	1 LS	$	2,488,500.00	$	2,490,000		
		0.12		Fire Protection Systems		$	-	$	-		
			0.121	Fire Protection Systems	1 LS	$	1,422,000.00	$	1,420,000		
		0.13		Compressed Air Systems		$	-	$	-		
			0.131	Compressed Air Systems	1 LS	$	1,777,500.00	$	1,780,000		
		0.14		Oil Handling Systems		$	-	$	-		
			0.141	Oil Handling Systems	1 LS	$	1,185,000.00	$	1,190,000		
		0.15		Drainage & Dewatering		$	-	$	-		

			0.151	Drainage & Dewatering	2	EA	$ 1,738,000	$ 3,480,000	
		0.16		Heating, Ventilation and Cooling System			$ -	$ -	
			0.161	Heating, Ventilation and Cooling System	1	LS	$ 1,777,500.00	$ 1,780,000	
		0.17		Miscellaneous			$ -	$ -	
			0.171	Miscellaneous	1	LS	$ 1,185,000.00	$ 1,190,000	
	0.2			Auxiliary Systems- Surface Facilities			$ -	$ -	
		0.21		Auxiliary Systems- Surface Facilities			$ -	$ -	
			0.211	Auxiliary Systems- Surface Facilities	1	LS	$ 711,000	$ 710,000	
	0.3			Auxiliary Equipment			$ -	$ -	
		0.31		Powerhouse Cranes			$ -	$ -	
			0.311	Powerhouse Cranes	2	EA	$ 1,800,000	$ 3,600,000	
		0.32		Elevators			$ -	$ -	
			0.321	Elevators	2	EA	$ 181,700	$ 360,000	
		0.33		Miscellaneous Cranes and Hoists			$ -	$ -	
			0.331	Miscellaneous Cranes and Hoists	1	LS	$ 505,500	$ 510,000	
		0.34		Machine Shop Equipment			$ -	$ -	
			0.341	Machine Shop Equipment	1	LS	$ 2,022,000	$ 2,020,000	
	0.4			General Station Equipment			$ -	$ -	
	0.5			Communications Equipment	1	LS	$ 106,650.00	$ 110,000	
								$ -	**$ 21,000,000**
336				**Roads, Rails and Air Facilities**				$ -	
	0.1			Roads					
		0.11		Permanent Roads					
				Cost of road upgrades for 23 mi of Denali Highway	23	Mi	$ 1,000,000.00	$ 23,000,000.00	
				Cost of New road to 42 Mi of road to Watana	42	Mi	$ 3,000,000.00	$ 126,000,000.00	
		0.131		Site Roads					
				Construction Roads					
				Site Roads	20	Mile	$ 750,000.00	$ 15,000,000	
				Maintenance	141	MI/YRS	$ 223,092.85	$ 31,500,000	
		0.132		Permanent Roads					
				Permanent Roads	6	Mile	$ 1,287,997.42	$ 7,700,000	
	0.2			Rail					
			0.1	Railhead at Cantwell	1	LS	$ 14,000,000.00	$ 14,000,000	
	0.3			Airstrip					
		0.31		Airstrip					
				Permanent Airstrip	1	LS	$ 13,000,000.00	$ 13,000,000	
				Temporary Airstrip	1	LS	$ 2,000,000.00	$ 2,000,000	
									$ 232,000,000
350-359				**Transmission Plant**	33	MILE	$ 5,700,000.00	$ 188,100,000.00	
					2	EA	$ 18,000,000.00	$ 36,000,000.00	
									$ 224,000,000.00
				General Plant					
389				**Land and Land Rights**					
				Land and Land Rights					
							(incl in 330)		
390				**Structures and Improvements**					
				Structures and Improvements					
							(incl in 331.2)		
391				**Office Furniture and Equipment**					
				Office Furniture and Equipment					
							(incl in 399)		
392				**Transportation Equipment**					
				Transportation Equipment					

Account	Factor	Description	Qty	Unit	Unit Cost	Amount	Total
					(incl in 399)		
393		**Stores Equipment**					
		Stores Equipment					
					(incl in 399)		
394		**Tools Shop and Garage Equipment**					
		Tools Shop and Garage Equipment					
					(incl in 399)		
395		**Laboratory Equipment**					
		Laboratory Equipment					
					(incl in 399)		
396		**Power-Operated Equipment**					
		Power-Operated Equipment					
					(incl in 399)		
397		**Communications Equipment**					
		Communications Equipment					
					(incl in 399)		
398		**Miscellaneous Equipment**					
		Miscellaneous Equipment					
					(incl in 399)		
399		**Other Tangible Property**					
		Other Tangible Property	1	LS	$ 16,000,000	$ 16,000,000	
		Saved Maintenance	1	LS	$ (231,220)	$ (230,000)	
						$ -	**$ 16,000,000**
		Indirect Costs					
61		**Temporary Construction Facilities**					
		Temporary Construction Facilities			(incl in direct costs)		
62		**Construction Equipment**					
		Construction Equipment			(incl in direct costs)		
63		**Main Construction Camp**					
	0.1	Main Construction Camp	1	LS	$ 180,000,000	**$ 180,000,000**	
							$ 180,000,000
64		**Labor Expense**					
		Labor Expense					
65		**Superintendence**					
		Superintendence					
66		**Insurance**					
		Insurance					
68		**Mitigation Fishery, Terrestrial and Recreational)- Not Included**					
69		**Fees**					
		Fees					
Subtotal							
	Contingency (20%)		1	LS	$ 749,200,000.00		**$ 749,000,000**
Subtotal							
71		**Engineering (4%), Environmental (2%), Regulatory(1%)**	1	LS	$ 236,000,000.00		**$ 236,000,000**
71a		**Construction Management (4%)**	1	LS	$ 135,000,000.00		**$ 135,000,000**
72		**Legal Expenses**					
75		**Taxes**					
76		**Administrative & Gen. Expenses**					
77		**Interest**					
80		**Earnings/Expenses During Construction**					
Total Project Cost							**$ 4,495,000,000**
Max Plant Capacity	600						

Appendix C:
Chakachamna Construction Cost Estimate

CHAKACHAMNA HYDROELECTRIC PROJECT
Client: Alaska Power Authority
Site: Chakachamna - Alternative E
Original: November 1982 by Bechtel
NOTE Costs are in 1982 Dollars

					Rounded
71A	Engineering, Env., and Regulatory (7%)	$	151,365,369	$	151,000,000
330	Land and Land Rights	$	75,000,000	$	75,000,000
331	Power Plant Structure Improvements	$	105,394,289	$	105,000,000
332.1-.4	Reservoir, Dams and Tunnels	$	1,147,280,085	$	1,147,000,000
332.5-.9	Waterways	$	123,421,232	$	123,000,000
333	Waterwheels, Turbines and Generators	$	181,170,000	$	181,000,000
334	Accessory Electrical Equipment	$	20,045,000	$	20,000,000
335	Misc Power Plant Equipment	$	15,403,000	$	15,000,000
336	Roads, Rails and Air Facilities	$	172,302,865	$	172,000,000
350-390	Transmission Features	$	232,345,945	$	232,000,000
399	Other Tangible Property	$	-	$	-
63	Main Construction Camp	$	90,000,000	$	90,000,000
71B	Construction Management, 4%	$	86,494,497	$	86,000,000
	Subtotal	$	2,400,222,282	$	2,400,000,000
	Contingency	$	480,044,456	$	480,000,000
	Total	$	2,880,266,739	$	2,880,000,000

CHAKACHAMNA HYDROELECTRIC PROJECT
Client: Alaska Power Authority
Site: Chakachamna - Alternative E
Original: November 1982 by Bechtel
NOTE Costs are in 1982 Dollars

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NO.	DESCRIPTION	Quantity	Unit	Unit Costs	Amount	
	Land & Land Rights	1	LS	75,000,000	75,000,000	prorated to Low Watana total project cost
	POWER PLANT STRUCTURE & IMPROVEMENTS					
	Valve Chamber					
	Excavation and Supports	10,000	CY	580	5,802,500	
	Concrete & Reinforcing Steel	6,520	CY	865	5,640,452	
	Structural Steel & Misc. Metals	52	TON	3,798	197,496	
	Round-Off					
	Underground Powerhouse					
	Dewatering	1	LS	8,651,000	8,651,000	
	Excavation & Supports	58,900	CY	354	20,878,872	
	Drilling-Percus.& Rotary	12,700	LF	57	723,519	
	Concrete & Reinforcing Steel	13,100	CY	1,329	17,413,830	
	Structural Steel & Misc. Metals	300	TON	11,183	3,354,900	
	Architectural	1	LS	2,110,000	2,110,000	
	Round-Off					
	Bus Galleries Between Power-house & Transformer Vaults					
	Excavation & Supports	200	CY	1,741	348,150	
	Concrete	120	Cy	612	73,428	
	Round Off					
	Transformer Gallery & Tunnels					
	Excavation & Supports	11,960	CY	612	7,318,324	
	Concrete & Reinf Steel	830	CY	971	805,598	
	Structural Steel & Misc. Metals	120	TON	8,018	962,160	
	Round Off					
	Valve Chamber & Transformer Gallery-Access Tunnels					
	Excavation & Supports	1,500	CY	528	791,250	
	Concrete	60	CY	612	36,714	
	Round-Off					
	Powerhouse Access Tunnel					

NO.	DESCRIPTION	Qunatity	Unit	Unit Costs	Amount
	Portal Excavation & Protection	56,000	CY	21	1,181,600
	Portal Concrete & Reinf. Steel	1,000	CY	1,203	1,202,700
	Tunnel Excavation & Supports	24,000	CY	633	15,192,000
	Tunnel Concrete	900	CY	612	550,710
	Tunnel Misc. Metals	30	TON	23,210	696,300
	Subsurface Exploration				
	Mobilization	1	LS	3,165,000	3,165,000
	Exploratory Adit	1,000	LF	3,798	3,798,000
	Core drilling	5,000	LF	295	1,477,000
	Helicopter Service	1	LS	1,266,000	1,266,000
	Round Off				
	Cable Way				
	Concrete & Reinf. Steel	1,000	CY	1,477	1,477,000
	Misc. Metals & Cable Support panels	26	TON	10,761	279,786
	Round-Off				
	TOTAL POWER PLANT STRUCTURE & IMPROVEMENTS				
RESERVOIR DAM & WATERWAYS					
	Reservoir				
	Water Level Recording	1	LS	211,000	211,000
	Intake Structure				
	Site exploration				
	Mobilization	1	LS	316,500	316,500
	Core Drilling	5,000	LF	169	844,000
	Helicopter Service	1	LS	316,500	316,500
	Tunnel Excav. & Supports	10,000	CY	1,076	10,761,000
	Tunnel Conc. & Reinf. Steel	90	CY	739	66,465
	Lake-Tap (Final Round)	1	LS	5,275,000	5,275,000
	Place & Remove Temp. Conc	550	CY	1,477	812,350
	Diving Crew	60	DAYS	21,100	1,266,000
	Round-Off				
	Fish Screening	1	LS	5,000,000	5,000,000
	Intake Gate Shaft				
	Excavation & Supports	360	LF	36,925	13,293,000
	Mass Surface Excavation	50,000	CY	63	3,165,000
	Concrete & Reinf. Steel	5,200	CY	1,878	9,765,080
	Misc. Metals, Gates & Hoist	220	TONS	25,742	5,663,240
	Access Road	1	MI	4,220,000	5,275,000
	Round Off				
	Fish Passage Facilities				
	Approach Channel				
	Channel Excavation	1,040,000	CY	24	24,796,720

NO.	DESCRIPTION	Qunatity	Unit	Unit Costs	Amount
	Slope Protection	90,000	CY	59	5,317,200
	Round				
	Upstream Portal				
	Excavation in Rock	64,500	CY	63	4,082,850
	Rock Bolts - Ch, LK, Mesh	1	LS	1,148,895	1,148,895
	Dewatering During Construction	1	LS	105,500	105,500
	Fence	400	LF	95	37,980
	Round				
	Upstream Fish Passage Facility				
	Excavation & Support	16,550	CY	344	5,692,042
	Concrete & Reinf. Steel	5,880	CY	1,601	9,416,761
	Misc. Metal, Gates & Crane	1	LS	3,769,093	3,769,093
	Electrical & Instrumentation.	1	LS	422,000	422,000
	Round Off				
	Downstream Fish Passage Facility				
	Excavation & Support	8,900	CY	403	3,586,789
	Concrete & Reinf. Steel	2,600	CY	1,340	3,483,610
	Misc. Metal, Gates & Crane	1	LS	4,817,130	4,817,130
	Electrical & Instrumentation.	1	LS	211,000	211,000
	Round Off				
	Access Tunnel				
	Excavation & Support	122,500	CY	639	78,317,925
	Concrete & Reinf. Steel	22,800	CY	1,209	27,565,884
	Misc. Metal	1	LS	854,550	854,550
	Electrical - Lighting	1	LS	487,410	487,410
	Round Off				
	Fish Passage Facilities				
	Excavation & Support	6,600	CY	112	738,078
	Concrete & Reinf. Steel	740	CY	1,642	1,214,769
	Misc. Metal, Gate, etc.	1	LS	917,112	917,112
	Round Off				
	Chakachatna River				
	Flow Regulation				
	River Bed Deepening	10,000	CY	20	200,450
	Rip-Rap	1,000	CY	74	73,850
	Access Road	1	LS	633,000	633,000
	Access Tunnel to Fish				
	Passage Facilities				
	Portals Excavation	700	CY	196	137,361
	Tunnel Excavation & Support	3,350	CY	663	2,219,509

NO.	DESCRIPTION		Qunatity	Unit	Unit Costs	Amount	
	Round Off						
	Chakachata Dike and Spillway						
	Excavation and Slope Protection		280,000	CY	62	17,428,600	
	Concrete & Reinf. Steel		1,100	CY	686	754,325	
	Timber Bridge		2,200	SF	317	696,300	
	Dike		250,000	CY	2	395,625	
	Round Off						
	Access Tunnel at Surge Chamber						
	Portal Excavation & Protection		6,000	CY	74	443,100	
	Tunnel Excavation & Supports		14,000	CY	669	9,364,180	
	Tunnel Concrete & reinf. Steel		1,700	CY	886	1,506,540	
	Grouting Contact & Pressure		2,260	CF	122	276,579	
	Watertight Bulkhead & Frame		27	TON	29,118	786,186	
	Round Off						
	Power Tunnel TBM						
	Excavation & Supports		53,400	LF	12,892	688,438,140	25.5' dia excavated, 24' finished
	Concrete		267,000	CY	720	192,109,170	Assume lining approx 1.5' thick
	Grouting		540,000	CF	119	64,262,160	
	Round Off	Remove Exc & Concrete above				(880,547,310)	
		TBM Labor & Equipment	57000	LF	6446.05	367,424,850	Assumes half of cost is labor & equipmer
		Excavation (22.5' dia.)	838968.8	CY	340.9631279	286,057,409	21' finished diameter
		Concrete	216267.5	CY	719.51	155,606,629	Assume lining approx 1.5' thick
	Surge Chamber - Upper						
	Excavation & Supports		27,100	CY	745	20,184,893	
	Concrete & Reinf. Steel		10,000	CY	1,884	18,842,300	
	Earthwork & Fencing_		15,000	CY	57	854,550	
	Round Off						
	Penstock - Horizontal Section						
	Excavation & Supports		12,000	CY	705	8,456,880	
	Concrete & Reinf. Steel		5,100	CY	770	3,927,765	
	Grouting - Contact		2,600	CF	106	274,300	
	Round Off						
	Penstock-Wye Branches to Valve Chamber						
	Excavation & Supports		9,000	CY	1,013	9,115,200	
	Concrete & Reinf. Steel		6,100	CY	1,283	7,825,568	
	Steel Liner		700	TON	10,550	7,385,000	
	Grouting-Contact		7,000	CY	118	827,120	
	Round-Off						
	Penstock Between Valve Chanber & Powerhouse						

NO.	DESCRIPTION		Qunatity	Unit	Unit Costs	Amount
	Excavation & Supports		850	CY	928	789,140
	Concrete & Backfill		500	CY	1,161	580,250
	Round-Off					
	Draft Tube Tunnels					
	Rock Bolts & Grout		15,000	LF	61	917,850
	Concrete & Reinf. Steel		2,975	CY	897	2,667,831
	Round-Off					
	Surge Chamber - Tailrace					
	Excavation & Supports		5,000	CY	1,013	5,064,000
	Tailrace Tunnel & Structures					
	Cofferdam & Dewatering		1	LS	4,220,000	4,220,000
	Portal Excay. & Protecticn		2,000	CY	137	274,300
	Concrete & Reinf. Steel		1,200	CY	1,266	1,519,200
	Walkway Bridge		1	LS	137,150	137,150
	Stoplogs & Hoists		81	TON	17,935	1,452,735
	Tunnel Excav. & Supports		20,000	CY	612	12,238,000
	Plug Excavation		4,000	CY	106	422,000
	Round-Off					
	Tailrace Channel					
	Channel Excavation		80,000	CY	19	1,519,200
	River Training Works					
	River Bed Deepening		50,000	CY	21	1,055,000
	Mech & Elec.		1	LS	12,871,000	12,871,000
	TOTAL RESERVOIR, DAM AND WATERWAYS					
	Turbines & Generators					
	Turbines			EA	17,892,800	
	Generators			EA	12,660,000	
	Round-Off					
		Susitna equalization	366	MW	495,000	181,170,000
	Accessory Electrical Equipnent					
	Equipment		1	LS	20,045,000	20,045,000
	Misc. Power Plant Equipment					
	Crane Bridge		1	EA	1,962,300	1,962,300
	Other Power Plant Equip.		1	LS	13,440,700	13,440,700
	Switchvard Structures					
	Earthworks		15,000	CY	53	791,250

NO.	DESCRIPTION		Qunatity	Unit	Unit Costs	Amount
	Concrete & Reinf. Steel		3,800	CY	1,350	5,131,520
	Struc. Steel & Misc.Meta]s		225	TON	7,385	1,661,625
	Round-Off					
	Switchyard Equipment					
	Transformers 105 MVA		5	EA	2,173,300	10,866,500
	Unit & Line Breakers		7	EA	390,350	2,732,450
	Switches & Lightning Arrestors		30	EA	71,740	2,152,200
	230 KV Cables		18,000	LE	274	4,937,400
	Controls & Metering Equip.		1	LS	5,697,000	5,697,000
	Round Off					
	Comunication and Supervisory Control		1	LS	3,376,000	3,376,000
	TRANSPORTATION FACILITIES					
	Causeway		19,600	CY	169	3,308,480
	Trestle Piles		50	TON	23,843	1,192,150
	Trestle Struct. Steel		110	TON	7,385	812,350
	Trestle Reinf. Conc.		150	CY	1,477	221,550
	Facilities - Allowance		1	LS	4,220,000	4,220,000
	Round-Off					
	Airport					
	Earthwork		54,500	CY	34	1,839,920
	Culverts		1,000	LF	137	137,150
	Subbase & Base		55,000	CY	30	1,624,700
	Building - Allowance		1	LS	633,000	633,000
	Round-Off					
	Access & Construction Roads					
	Mile 0+00 to 18+00					
	Earthwork			CY	14	
	Culverts			Li?	137	
	Bridges			SF	317	
	Subbase & Base			CY	32	
	Guard Rail			LF	53	
	Repair Existing Road			LF	21	
	Snow Fences			LF	74	
	Round-Off					
		Road Upgrade per Susitn	18	MI	1,000,000	18,000,000
	Mile 18+00 to 35+00					
	Earthwork			CY	14	
	Culverts			LF	169	
	Subbase & Base			CY	32	
	Guard Rail			LF	53	

NO.	DESCRIPTION		Qunatity	Unit	Unit Costs	Amount
	Repair Existing Road			LF	21	
	Snow Fences			LF	74	
	Round-Off					
		New Road per Susitna	17	MI	3,000,000	51,000,000
	Mile 35+00 to 39+00					
	Earthwork			CY	18	
	Culverts			LF	169	
	Bridge			SF	317	
	Subbase & Base			CY	32	
	Guard Rail			LF	57	
	Snow Fences			LF	74	
	Round-Off					
		New Road per Susitna	4	MI	3,000,000	12,000,000
	Walkway To Gate Shaft					
	Earthwork		1,200	CY	42	50,640
	Guard Rail		1,000	LF	53	52,750
	Bridge		200	SF	317	63,300
	Riprap		100	CY	74	7,385
	Round-Off					
	Access Road to MacArthur Valley					
	Earthwork		545,000	CY	15	8,049,650
	Culverts		2,400	LF	158	379,800
	Bridge Improvements		9,000	SF	148	1,329,300
	Subbase & Base		105,000	CY	32	3,323,250
	Guard Rail		6,000	LF	53	316,500
	Snow Fences		3,000	LF	74	221,550
	Round-Off					
	Access Road to Tailrace Tunnel					
	Earthwork		56,000	CY	17	945,280
	Culverts		100	LF	169	16,880
	Subbase & Base		2,500	CY	42	105,500
	Guard Rail		600	LF	53	31,650
	Round-Off					
	Access Road to Downstream Power Tunnel					
	Earthwork		215,000	CY	21	4,445,770
	Culverts		800	LF	169	135,040
	Bridge		3,000	SF	317	949,500
	Subbase & Base		10,000	CY	44	443,100
	Guardrail		9,000	LF	68	607,680
	Snowshed & Slide Fall		1,000	LF	1,688	1,688,000
	Round-Off					
	Temporary Construction Roads					

Chakachamna Hydroelectric Project
1982 Bechtel Cost Estimate

NO.	DESCRIPTION		Qunatity	Unit	Unit Costs	Amount	
	Earthwork		61,000	CY	13	772,260	
	Culverts		600	LF	169	101,280	
	Bridge		3,000	SF	317	949,500	
	Guardrail		2,000	LF	53	105,500	
	Round-Off						
	Road Maintenance						
	Summer Season		45	MO	316,500	14,242,500	
	Winter Season		30	MO	1,266,000	37,980,000	
	Round-Off						
	TOTAL ACCESS & CONSTRUCTION ROADS						
	Transmission Line						
	Clear & Grub			MI	474,750		
	Transmission Line			MI	723,730		
	Submarine Cable			MI	1,671,120		
	Round-Off						
		T-Line to Beluga	50	MI	3,900,000	195,000,000	Estimated provided by AEA/EPS
		Construction Camp	1	LS	90,000,000	90,000,000	
	TOTAL SPECIFIC CONSTRUCTION COST AT JANUARY 1982 PRICE LEVELS					2,162,362,417	
	Engineering (4%), Environmental (2%), Regulatory(1%)					151,365,369	
	Construction Management (4%)					86,494,497	
	Contingency	20%				480,044,456	
						2,880,266,739	