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ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

TASK 6 - DESIGN DEVELOPMENT

SUBTASK 6.01 - CLOSEOUT REPORT REVIEW OF PREVIOUS STUDIES AND REPORTS

FEBRUARY 1981



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#### 1 - INTRODUCTION

#### 1.1 - Background

The development of hydropower in the Susitna Basin has been under study for the past 30 years. The objective of Subtask 6.01, as stated in the February 1980 Plan of Study for the Susitna Project is to "Assemble and review all available engineering data, siting, and economic studies relating to the Susitna hydropower development and alternative potential sites". Alternative potential sites have been assumed to include only sites in the Susitna River Basin upstream from Gold Creek. For study purposes, this area is referred to as the Upper Susitna River Basin.

Other sites and developments both on the lower Susitna and other rivers are included in Subtask 6.33 - Hydroelectric Generation Resources. Collection of geotechnical and hydrological data is dealt with separately in Subtask 5.01 - Data Collection and Review and Subtask 3.01 - Review of Available Material.

# 1.2 - Report Contents

This report contains a brief review of the previous studies pertaining to hydroelectric development in the Upper Susitna River Basin and sumarizes the significant findings.

Section 2 contains a summary of the report and Section 3 outlines the discussion and conclusions. Section 4 outlines the scope of work associated with Subtask 6.01. A chronological review of the previous studies is dealt with in Section 5. Section 6 outlines the civil, hydrological, geotechnical, environmental, hydropower and planning parameters associated with each of the previously identified sites. Cost comparison between alternatives is given in Section 7.

#### 2 - SUMMARY

#### 2.1 - Previous Studies

The major engineering studies conducted during the past 30 years are briefly discussed below:

- A 1953 study by the US Bureau of Reclamation (USBR) (11) identified a total of 10 sites in the Susitna Basin upstream from Gold Creek. Preliminary schemes of development including dam types and heights were presented for seven of the sites. Based on these studies the USBR proposed that the ultimate development consist of dams at Olson, Devil Canyon, Watana, Vee and Denali with a total installed capacity of 1010 MW.
- The first stage of this USBR proposal was the subject of the 1961 follow-up study (10) of the Devil Canyon Project. In this study designs for the Devil Canyon Dam and the Denali Dam were developed. Devil Canyon was to have an installed capacity of 580 MW and Denali was to be used for flow regulation purposes only.
- In 1974 the Alaska Power Administration, Department of Interior, issued a report on the status of the Devil Canyon Project (1). This involved an update of information in the 1961 USBR study and included some minor design changes.
- A report issued by Kaiser Engineers (4) in 1974 suggested the construction of a dam approximately five miles upstream from the Devil Canyon site known as Susitna I (or High Devil Canyon) as an alternative to the Devil Canyon Project. Unlike Devil Canyon, this site has the advantage that sufficient storage is available for utilization of the maximum power potential without an additional upstream reservoir. Ultimately this scheme called for three other dams to be constructed for full basin development.
- To date, the Interim and Supplemental Feasibility Studies by the Corps of Engineers (7,8) issued in 1975 and 1979 respectively represent the most extensive studies on development of hydropower on the Upper Susitna river. Several different schemes involving six dam sites were considered. A scheme including dams at Watana and Devil Canyon was selected as being the most economical development as well as the best from an environmental viewpoint. It was shown that the Benefit Cost Ratio for this scheme was 1.4 using alternative coal-fired energy to assess project benefits (1979 value).

The above studies identified a total of eleven sites upstream from Gold Creek (see Figure 2.1). Figure 2.2 illustrates the river profile, indicates heights and shows which site would be eliminated by development at other sites.

Other studies that have been conducted have dealt more specifically with environmental issues and geotechnical investigations.

<sup>(1)</sup> Indicates the reference number.

#### 2.2 - Design Parameters

The design parameters associated with the various developments are discussed in Section 6. Tables 2.1 to 2.6 summarize the civil, hydrological, mechanical and hydropower parameters contained in the previous studies. Table 2.7 summarizes the environmental data pertaining to various reaches of the Upper Susitna River.

#### 2.3 - Cost Comparisons

The most extensive cost information for alternative developments is contained in the 1975 Corps of Engineers Interim Feasibility Report. The unit prices used were based on bid prices from the Pacific Northwest and Canada. They were adjusted to reflect 1975 prices, Alaska labor rates, and additional transportation costs to the sites. Cost data extracted from the Corps of Engineers 1975 report is given in Appendix C.

For purposes of this report these costs as well as cost information from other reports were escalated to 1980 price levels using the Handy-Whitman Index. Table 2.8 lists updated total costs as well as capacity and energy costs.

#### 2.4 - Conclusions

The following major items were identified in this review of previous studies:

- The level of detail on the potential development at each site varies significantly. Standardization of this information and some upgrading of information pertaining to the less intensively studied sites would facilitate a more formal and convincing site selection study.
- The Devil Canyon and Watana sites appear to be the most economic combination.
   The Devil Canyon site requires upstream regulation for economic power generation.
- The Kaiser plan proposed a dam located in the vicinity of Devil Creek (High Devil Canyon). It provides both a high head and storage and consideration should be given to studying it in more detail.
- The economics of the project as proposed by the Corps of Engineers is very dependent on the assumed rate of retirement of existing plants and, to a lesser degree, on the rate of load growth. The validity of their assumptions with respect to these aspects should therefore be carefully reviewed in any further studies.

TABLE 2.1: CIVIL DESIGN PARAMETERS

Site (Pool El.)	Dam Type	Height (ft)	Length (ft)	Length Height	Reservoir Area (acres)	Gross Storage 10 <sup>6</sup> Ac-ft	Low Spillway Leve Type Outl
Gold Creek	Earthfill	135	4,900	36			
01san (920)	Concrete Gravity	50	400	7		.01	Overflow section of dam
Olson (1020)	Concrete Gravity	145					
Devil Canyon (1450)	75 US Corps Thin Arch Alternative Thrust Block Earthfill	635 110 200	1,370 155 950	2 1.4 4.2	7,550	1.1	Chute & flip bucket Yes
	79 US Corps Gravity & Alternative Earthfill	650 . 200	1,590 720	2.4 3.6	7,550 	1.1	Center section of dam Yes
High Devil Canyon (1750)	Concrete-faced Rockfill	810	3,050	3.8	24,200	4.7	Channel cut into south abutment
Devil Creek	Concrete	350 Max		744 TO			
Low Watana (1905)	Earthfill	515	1,650	3.2		2.5	Channel cut in saddle discharging to Tsusena Creek
Mid Watana (2050)	Earthfill	660	2,600	3.9		5.2	H II H
High Watana (2200)	Earthfill	810	3,450	4.3	43,000	9.4	H H H
Susitna III							20 M
Vee (2300)	Earthfill	455			***	3.4	
Vee (2350)	Earthfill			<b></b>			age long.
Maclaren (2395)	Earthfill with Concrete	100	2,300	23		0.2	
Denali (2535)	Earthfill	260		<b></b>	<b></b>	3.9	19' Dia. Glory Hole & conduit
Denali (2552)	Earthfill	219*	2,050	9.4	51,000	5.4	through embankment 
Denali (2590)	Earthfill	205*	1,900	9.3	<b></b>	5.7	
Butte Creek		100	500	5		, <del></del>	
Tyone	Earthfill with Concrete	35	500	14		=~	

<sup>\*</sup>Discrepancy probably due to better information in the 1961 study (Denali - 2552) than in the 1953 study (Denali - 2590)

Site (Pool El.)	Mean Annual In-Flow	Min. Avg. Monthly In-	Max. Avg. Monthly In-	Spillway Design	Reservoir S	Reservoir Storage	
0.001 2.1.7	(Ac-ft/year) (cfs)	Flow (March)* (cfs)	flow (June)* (cfs)	flood (cfs)	Total (Ac-ft)	Usable (Ac-ft)	Data Sources (Ref. No.)
Gold Creek	6,965,000 (9620)	710	50,580	-		-	
Dlson (920/1020)	6,815,000** (9410)	690	49,600	<u>.</u>	6,600	NIL	USBR (11)
Devil Canyon (1450)	6,682,000** (9230)	660	47,800	228,000	1,050,000	790,000	U.S. Corps (7)
ligh D.C. (1750)	6,617,000** (9,140)	650	47,600		4,730,000	3,930,000	U.S. Corps (7)
Devil Creek	6,487,000** (8,960)	640	46,600	- -	-	-	
latana (1905)	5,893,000** (8,160)	570	42,800	· _	2,480,000	2,310,000	U.S. Corps (7)
Vatana (2050)	5,893,000 (8,160)	570	42,800	<del>-</del>	5,300,000	4,575,000	U.S. Corps (7)
/atana (2200)	5,893,000 (8,160)	570	42,000	165,000	9,425,000	8,125,000	U.S. Corps (7)
iusitna III	4,590,000** (6,350)	440	35,300	_	-	~	-
ee (2300)	4,481,000 (6,190)	430	34,630	-	1,000,000	820,000	U.S. Corps (7)
aclaren	3,150,000*** (4,360)	<b>70</b>	18,000	-	210,000	158,000	USBR (11)
enali (2535)	2,386,000*** (3,290)	55	14,110	-	4,250,000	3,770,000	U.S. Corps (7)
enali (2552)	2,386,000* (3,290)	55	14,110	<del>-</del>	5,400,000	5,300,000	USBR (10)
enali (2590)	2,386,000 (3,290)	55	14,110	-	6,700,000	5,700,000	USBR (11)

Folk which which will be the same with the best with the same with the s

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#### TABLE 2.2: (Continued)

Site (Pool El.)	Mean Annual In-Flow (Ac-ft/year) (cfs)	Min. Avg. Monthly In- Flow (March)* (cfs)	Max. Avg. Monthly In- Flow (June)* (cfs)	Spillway Design Flood (cfs)	Reservoir St Total (Ac-ft)	orage Usable (Ac-ft)	Data Sources (Ref. No.)
Butte Creek	2,064,000 (2,850)	55	12,200	-	-	-	<u>-</u> .
Tyone (2385)	222,000 (300)	Proration no	ot appropriate	-	700,000	700,000	USBR (11)

#### NOTES

The mean annual, minimum and maximum average monthly inflows were calculated as part of subtask 6.01 by prorating available streamflow records

Unregulated
Inflows prorated from gaged flow at Gold Creek using drainage basin area ratios.
Inflows prorated from gaged flow at Denali using drainage basin area ratios. \*\*

\*\*\*

TABLE 2.3: DEVIL CANYON PROJECT - MECHANICAL EQUIPMENT

		USBR March 1961 (10)	Alaska Power Administration May 1974(1)	Corps of Engineers 1979(8)
1.	GENERAL			
	Capacity Total Head Powerhouse type Number of units	580 MW 530 ft surface 8	600 MW 550 ft underground 4	776 MW 520 ft underground 4
2.	HYDRAULIC CONDITIONS Headwater level			
	- maximum	EL 1455 EL 1450 EL 1275	EL 1455 EL 1275	EL 1455 EL 1450 EL 1275
	- maximum	EL 897 EL 875 EL 870	EL 924 - EL 878	EL 924 - EL 878
	Gross Head - maximum	585 ft 405 ft	577 ft 351 ft	577 ft 351 ft
	Net Head - maximum rated minimum	570 ft 530 ft 395 ft	550 ft	520 ft
3.	TURBINES Type	vertical Francis	vertical Francis	vertical Francis
	Rated power (each)	100,000 hp	205,000 hp	265,000 hp (best gate)
	Rated net head Centerline distributor Submergence (minimum)	530 ft EL 881 - 11 ft	550 ft EL 867 11 ft	520 ft EL 867 11 ft
4.	Type	vertical synchronous 72.5 MW	vertical synchronous 150 MW	vertical synchoronous 194 MW
5.	POWERHOUSE CRANES		, , , , , , , , , , , , , , , , , , ,	
٠.	Type	overh	ead travelling	bridge 2
	Number Capacity (each) Span	350 tons -	235 tons 68 ft	425 72 ft
6.	PENSTOCK VALVES Number Type Diameter Head to centerline	eight butterfly 11.5 ft 355 ft	none	none - - -
7.	INTAKE CATES Number Type	2 fixed wheel	4 bonnet ed	4 bonneted
	Width Height Head to centerline Hoist	26 ft (approx) 26 ft (approx) 210 feet hydraulic	fixed wheel	fixed wheel 18 18 588 ft. hydraulic
8.	INTAKE BULKHEAD GATES	none	· <u>-</u>	3 sets of slots with several sets of stoplogs to premit water to be drawn from various elevations.

# TABLE 2.3: (Continued)

	USBR March 1961 (10)	Alaska Power Administration May 1974(1)	Corps of Engineers 1979(8)
TRASHRACKS Number Configuration	2 sloping, semi- circular	2 vertical, semi-vertical	2 vertical, semi-circular
DRAFT TUBE GATES Number of openings per turbine	3 bulkhead 5 ton gantry crane (outside	2 bulkhead powerhouse e) crane	2 bulkhead powerhouse crane
Number of openings Sill beam	Nane - -	2 E1 850	E1 850
SPILLWAY CREST GATES Number Type Width Height Hoist	2 radial - 64 ft. wire rope	none - - - -	2 radial 64 ft (approx) 42.5 ft wire rope
LOW LEVEL OUTLETS (Main Gates) Number Type	none -	6 vertical fixed wheel	4 bonnetted slide
Width Height Head to centerline Hoist	- -	70	7.5 11 ft 380 ft hydraulic
LOW LEVEL OUTLETS (Emergency Gates) Number Type	none -	none ~	4 as per main gate
LOW LEVEL DUTLET TRASHRACKS	none	none	none
OUTLET VALVES  Number  Type  Diameter  Head to centerline	1 hallow jet 66 575 ft	1 jet flow - -	none - -
Type	gate	ring follower gate	-
Head to centerline	66 in. 575 ft.	-	-
OUTLET VALVE TRASHRACKS Number of sets Configuration	1 vertical semi-circular	1 vertical semi-circular	none -
DIVERSION CLOSURE GATES Number	2 vertical	vertical	1 set wheeled bulkhead 26 ft 36 ft approx 18 ft approx 594
	Number Configuration  DRAFI TUBE GATES Number of openings per turbine. Type of gate. Handling  TAILRACE TUNNEL STOPLOGS Number of openings. Sill beam Stoplog handling.  SPILLWAY CREST GATES Number Type Width Height Hoist  LOW LEVEL OUTLETS (Main Gates) Number Type Width Height Head to centerline Hoist.  LOW LEVEL OUTLETS (Emergency Gates) Number Type  LOW LEVEL OUTLET TRASHRACKS  OUTLET VALVES Number Type  Diameter Head to centerline.  OUTLET VALVE CLOSURE GATE Type  Size Head to centerline.  OUTLET VALVE TRASHRACKS Number of sets Configuration.  DIVERSION CLOSURE GATES Number Type Width. Height Head to centerline:	TRASHRACKS Number	USBR March

#### TABLE 2.4: WATANA PROJECT - MECHANICAL EQUIPMENT

		Corps of
1.	GENERAL	Engineers 1979(8)
	Total Capacity	. 792 MW . 580
	Powerhouse type	<ul> <li>underground</li> </ul>
	Number of units	. 3
2.	HYDRAULIC CONDITIONS	
	Headwater level: - maximum	. EL 2190
	- normal	• EL 2185
	- minimum	
	- normal	• EL 1465
	- maximum	
	- minimum	
3.	TURBINES	
	Туре	. vertical Francis
	Rated power (each)	. 362,000 hp (best
	Rated net head	gate) • 580 ft.
	Centerline distributor	. 1460 . 5 ft.
,		. ) (
4.	GENERATORS	,
	TypeRater power	. vertical synchronous . 264 MW
5.	POWERHOUSE CRANES	
	Туре	<ul><li>overhead travelling bridge</li></ul>
	Number	
	Span	. 72 ft
6.	PENSTOCK VALVES	• None
7.	INTAKE GATES	
	Number	<b>3</b> ·
	Type b	connetted fixed wheel
	Width Height	18 ft. 18 ft.
	Head to centerline	730 ft. hydraulic
8.	INTAKE BULKHEAD GATES	
9.	TRASHRACKS	
/•		
	Number Configuration	2 vertical semi-
10.	DRAFT TUBE GATES	circular
	Number of Openings per turbine	2
	Type of Gate	bulkhead overhead travelling
		case

# TABLE 2.4: (Continued)

		Corps of Engineers	
11.	TAILRACE TUNNEL STOPLOGS		
	Number of openings	1 El 1405	
12.	SPILLWAY CREST GATES		
	Number Type Width Height Head to sill Hoist	3 radial 55 ft. 45 ft. 44 ft. wire rope	
13.	SPILLWAY STOPLOGS		
	Number of sets of guides	3 1 EL 2147 55 ft. 46 ft.	
14.	OUTLETS (Main Gate)	High <u>Level</u>	Low Level
	Number Type Width Height Head to centerline Hoist	2 radial 10 ft 14 ft 250 ft hydraulic	2 radial 10 ft 14 ft 490 ft hydraulic
15.	OUTLETS (Emergency Gate)		
	Number Type  Width Height. Head to centerline Hoist	2 bonnetted b slide gate s 10 ft 14 ft 250 ft hydraulic	2 onnetted lide gate 10 ft 14 ft 490 ft hydraulic
16.	<u>OUTLET TRASHRACKS</u>		
	Number of sets	2 flat, slig sloping	htly
17.	DIVERSION CLOSURE GATES		
	Number Type Width Height Head to centerline	1 set wheeled bul 30 ft 38 ft 239 ft	(approx)
18.	DIVERSION PLUG SLIDE GATES		
	Type	10	5 ft ft
	- for control after closure	255 730 hydrau	ft

#### TABLE 2.5: DEVIL CANYON PROJECT - DENALI DAM - MECHANICAL EQUIPMENT

OUTLET WORKS CONTROL GATES	USBR March 1961(10)
Number Type Width Height Head to Centerline Hoist	3 radial 10 12 210 ft hydraulic
OUTLET WORKS EMERGENCY GATES	
Number Type	3 bonnetted slide gates
Width	10 16 208 ft hydraulic

TABLE 2.6: HYDROPOWER PARAMETERS

Site/Scheme (Pool El. ft.)	Approx Max Head (ft)	Installed Capacity (MW)	Dependable Capacity (MW)	Average Annual Energy (x10 kWh)	Firm Energy (x10 kWh)	% of River Potential*	Remarks
Gold Creek	1 <del>9</del> 0	260			1.139	17%	Referred to as Gold Site by the Federal Power Commission(3)
Olson (920)	45						
Olson (1020)	145		187	<b>U.</b> 915	0.821	13%	With U/S Regulation
Devil Canyon(1450)	570		206	1.489	0.900	2 1%	
ligh D.C. (1750)	720	700	600	3, 346	2.628	47%	
Devil Creek							
Low Watana (1905)	425	420	252	1.550	1.104	22%	
1id Watana (2050)	570	500	457	2,601	1.997	36%	
ligh Watana (2200)	720	792	686	3, 346	3.004	47%	
Susitna III	600	445		1	1.840	28%	Data obtained from Kaiser(4)
Vee (2300)	375		300	1.450	1.310	20%	With U/S Regulation
/ee (2350)	425						r.
Maclaren					•,		
Denali (2535)			NO P	OWER GENERATION		· · · · · · · · · · · · · · · · · · ·	
Butte Creek							
Tyone							
Devil Canyon (1450) Denali (2535)	570		575	3, 300	2,500	46%	
Devil Canyon (1450) .ow Watana (1905)	995		730	4.485	3.200	62%	
Devil Canyon (1450) Mid Watana (2050)	1,140	~	1,062	5.630	4.650	78%	
Devil Canyon (1450) High Watana (2200)	1,290	1,568	1,404	6.850	<b>6.</b> 150	95%	

TABLE 2.6: (Continued)

Site/Scheme (Pool El. ft.)	Approx. Max Head (ft)	Installed Capacity (MW)	Dependable Capacity (MW)	Average Annual Energy (x10' kWh)	Firm Engrgy (x10° kWh)	% of River Potential*	Remarks
Devil Canyon (1450) High Watana (2200) Denali (2535)	1290		1,552	6.911	6.800	96%	
Susitna I Susitna II Susitna III	1455	1,308		6.309		88%	Data obtained from Kaiser(4)
Devil Canyon (1450) Low Watana (1905) Vee (2300) Denali (2535)	1370		1,427	6.881	6.252	96%	USBR four dam proposal (10)
Olson (1018) High Devil Canyon (1750) Vee (2300) Denali (2535)	1238		1,347	6.511	5,900	91%	Kaiser four dam proposa (4)
Devil Canyon Watana Vee Denali Olson				7.181*	6,552	100%	

#### NOTES:

All data obtained from US Corps 1975 Study (7) unless otherwise indicated.

<sup>\*</sup> Percent of Average Annual Energy with Devil Canyon, Watana, Vee, Denali; Olson assumed to be 100%

# IABLE 2.7: UPPER SUSITNA ENVIRONMENTAL DATA BASE FOR INPUT INTO THE SELECTION OF DEVELOPMENT SITES (Includes only information that varies between reaches)

			•			
	Talkeetna to Devil Canyon (Reach A)	Devil Canyon to Watana (Reach B)	Watana to Vee (Reach C)	Vee to Maclaren (Reach D)	Maclaren to Denali (Reach E)	Upstream from Denali (Reach F)
Biological:					-	
fisheries	- Resident & migratory salmon - Provides salmon access to Portage Creek and Indian River	- No anadromous fish	- Inundation of part of Deadman & Kosina Creek	- Inundation of part of Oshetna and Tyone River		
Wildlife	- Moose habitat in river valley downstream of Portage Creek	Nelchina Caribou herd - Summer range north of Susitna River - Summer & winter range south of Susitna River - Migration in the area of Fog Creek	Caribou  - Calving area south of Susitna River in the area of Kosina Creek  - Migration in the Jay Creek area  - Ranges as stated for Reach B	<ul> <li>Inundation of posible moose winter range</li> <li>Medium waterfowl density</li> <li>Caribou migration in the area of Oshetna River</li> </ul>	- Brown Grizzly bear denning adjacent to reservoir area - Good moose habitat - Medium water- fowl density	- Waterfowl nesting area - Good moose habitat - Medium waterfowl density
Vegetation	- Mainly upland or lowland spruce- hardwood forest	<u>-</u> ·	- Moose habitat Watana Creek	<u>-</u>	- Fragile moist & alpine tundra	- Fragile moist & al- pine tundra
Social:						
Aesthetic	<del>-</del>	~ Unique Devil Canyon	· <u>-</u>	- Moderately unique Vee Canyon	-	-
Recreation	-	~ White water kayaking Class IV Devil Canyon	<del>-</del>	<del>-</del>	-	-
Access	- Access road would open up minimal area of wilderness	- Access road would open up moderate area of wilderness	- Access road would open up moderate area of wilderness	- Access road would open up large areas of wilder- ness presently inaccessible	- Access road would open up large areas of wilderness presently inaccessible	- Reservoir could have access from the Denali Highway, therefore impact on wilderness area minimal

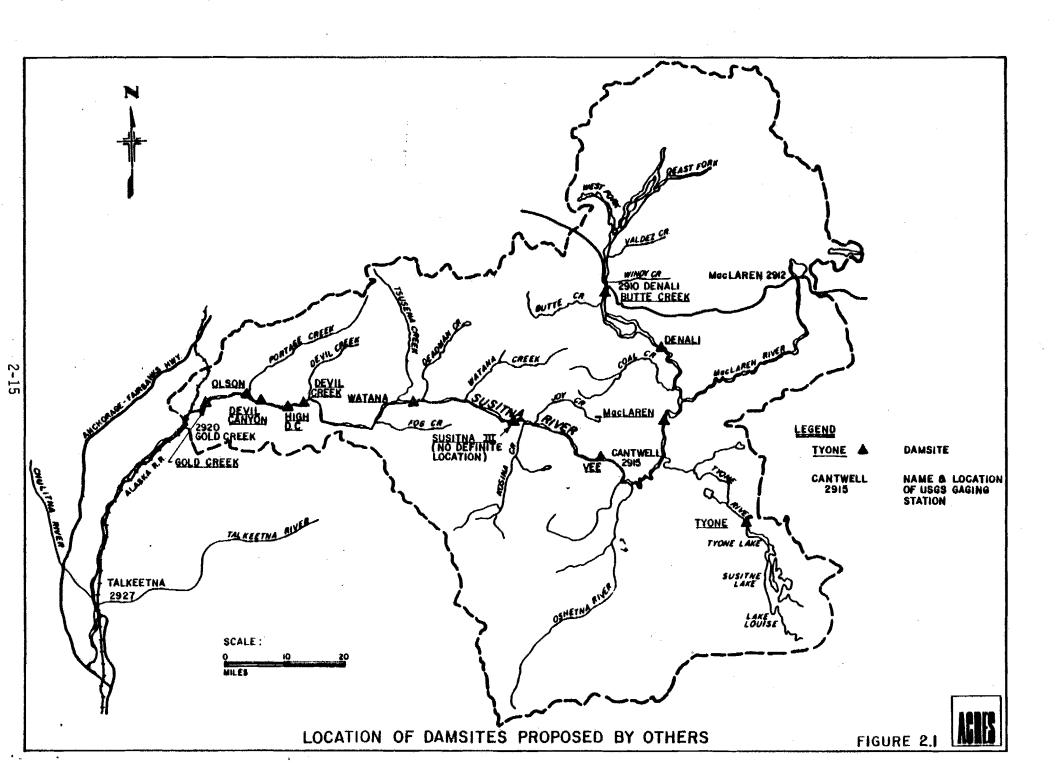
#### TABLE 2.8: COST COMPARISON

	Estimated Cost (1) (\$ x 10°)	Year of Estimate	Escalation Factor (Whitman Index)	1980 Cost (\$x10 <sup>6</sup> )	Dependable Capacity (MW)	Cost \$/kW	Avg. Annual Energy (10 <sup>6</sup> kWh)	Cost/Avg. Energy Cost Cost (9) (\$/1000 kWh	Notes
Gold Creek	338	1968	550/210	885	260 (4)	3,404	1,139 (5)	117	(3)(6)
Olson (920)	-	-	-	-	-	. <del>-</del>	-	-	-
Olson (1020)	380	1975	550/377	554	187	2,964	<del>9</del> 15	91	*(3)(6)
Devil Canyon Arch (1450)	714 432 463	1975 1975 1975	550/377 550/377 550/377	1,042 630 675	206 695 206	5,056 906 3,277	1,489 3,340 1,489	105 28 68	*(2) *(3)(6) with H. Watan *(8)
Devil Canyon Gravity (1450)	535 535 823	1975 1975 1978	550/377 550/377 550/495	780 780 914	206 695 695	3,286 1,122 1,315	1,489 3,340 3,340	79 35 41	*(7) *(7)(6)(3) (3)(6) with H. Watana
High Devil Canyon (1750	1,266 1,015	1975 1975	550/377 550/377	1,846 1,481	600 600	3,078 2,470	3,346 3,346	83 67	*(2) *(8)
Devil Creek	-	-	-	-	-		. <del>-</del>	_	-
Low Watana (1905)	668 420	1975 1975	550/377 550/377	975 613	25 2 25 2	3,868 2,431	1,550 1,550	94 59	*(2) *(3)
Mid Watana (2050)	877 628	1975 1975	550/377 550/377	1,279 916	457 457	2,800 2,004	2,601 2,601	74 53	*(2) *(3)
High Watana (2200)	1,088 837 1,765	1975 1975 1978	550/377 550/377 550/495	1,587 1,221 1,961	686 686 686	2,313 1,780 2,859	3,346 3,346 3,346	71 55 88	*(2) *(3) *(2) Revised Estimate
Susitna III					<del></del>			<del></del> -	-
/ee (2300)	477	1975	550/377	696	300	2,320	1,450	72	*(3)(6)
/ee (2350)	527	1975	550/377	769					*(3)
faclaren	<del>-</del>	-	-	-	-	-	-	-	-
Denali (2335)	340	1975	550/377	496	None		None		*(3)
Denali (2552)	134	1960	550/170	433	None		None		
Denali (2590)	80	1953	550/122	331	None -		None		
utte Creek		-	-	-	-	-	-	-	<b>-</b> .
yone		-	-	_	_	-	-	_	,

Firm energy With U/S Regulation

Estimated in same base year therefore best for comparison purposes Generally includes contingencies but not IDC Constructed first (i.e. includes main access road and transmission line) Subsequent development Installed capacity

<sup>(7) 1978</sup> cost adjusted back to 1975 using relative costs of Arch Dam and Gravity Dam, Page B-9, Corps 1979 Report (7) and escalted to 1980 costs
(8) Constructed first but excludes common costs of transmission lines and roads (\$251,000,000 - 1975 \$'s)
(9) Based on annual cost equal to 15% of Capital Cost.



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# 3 - SCOPE

The publications listed in the Bibliography of this report were reviewed. Discussions were held with the engineering staff of the Corps of Engineers in Alaska. Data was collected from the reports and from material such as working files and drawings obtained from the Corps. The type of information obtained ranges from detailed layouts to merely an identification of a potential site. Table 3.1 lists what data is available in terms of engineering layouts, topographic mapping, geotechnical field drilling, and air photos. The available engineering layouts are included in Appendix A.

# TABLE 3.1: CORPS OF ENGINEERS - EVALUATION OF ALTERNATIVES (Reproduced from (7))

	<u>VF</u>	ALTERNATIVES (Repro-	duced from (/))	
. •	REAN Y	PLAN B	FLAR C	PLAN D
	MITHORT COMPILION	NATIONAL ECONOMIC DEVELOPMENT (NEO) ENVIRONMENTAL QUALITY (EQ) PLANS	NAXIH'N FOVER DEVELOPMENT PLAN	PREVIOUSLY RECOMMENDED PLAN
	Conventional Coal Thermal Plant	Devil Canyon-Watana Dama	Devil Camyon-Waters-Denalt Dame	USBR Four-Dam System
A. PLAN DESCRIPTION	Non-federal financing of a 300-mm coal- fired generating plant at Healy and a 1,200-mm coal-fired plant at Beluga. The plants would have 35-year service lives. Project would include costs for coal mining and separate Healy-to- Fairbanks and Beluga-to-Anchorage trans- mission systems.	Foderal financing of the total system to include a thin-arch dam and underground powerplant at the Devil Canyon site, and an earthfill dam and underground powerplant at the Matana site. Both projects would provide at-site power generation. Matana would provide the seasonal storage for the system. Plan would also include transmission system between projects and to the Anchorage and Fairbanks load centers.	This plan is basically the same as the Plan B, but with the addition of the Denail Project would have no at-site power generation and would be used only for low flow augmentation of the two downstream Projects.	This is the system proposed by the Bureau of Reclamation in its 1952 report on hydropower resources of the Upper Sustans River Basin. Federal financing of the total system to include a thin-arch dam and powerplant at the Uevil Canyon site, a low head earth-fill dam and powerplant at the Watana site, an earthfill dam and powerplant at the Vec site, and a flow augmentation reservoir at the Demail site. Plan would also include transmission system between projects and to the two load centers.
i. Dam Heights	No Dams	1. Devil Canyon - 635 feet p. 2. Matana - 810 feet	1. Devil Canyon - 635 feet 2. Watana - BiO feet 3. Denali - 260 feet	l. Devil Canyon - 635 feet b 2. Watana - 515 feet 3. Vee - 455 feet 4. Denali - 250 feet
2. Dependable Capacity	1,500,000 kllowatts	1,394,000 kilowatts	1,552,000 killowatts	1,404,000 kilowatts
B. SIGNIFICANT IMPACTS	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)	(Included in Relationship to Four Accounts)
C. PLAN EVALUATION			·	
1. Contribution to Planning Objective a. Firm Annual Energy b. Average Annual Energy c. Percent of Basin Potential d. System Dependability	6.800,000,000 kilomati-hours 6.910,000,000 kilomati-hours Not Applicable No grid Intertie of major lead centers. Reduced dependability.	6,100,000,000 kilowatt-hours 6,910,000,000 kilowatt-hours 965 Provides grid intertie of mejor load centers.	6,800,000,000 kilowatt-hours 6,910,000,000 kilowatt-hours 962 Provides grid intertie of major load centers.	6,350,000,000 kilowatt-hours 6,880,000,000 kilowatt-hours 95% Provides grid intertie of major load centers.
2. Relationship to Four Accounts a. National Economic Development (MED) MET MED BENEFITS BENEFIT-TO-COST RATIO b. Environmental Quality (EQ) Acreage inundated or Destroyed Drawdown Zone Acreage Stream Mileage Inundated or Degraded Whitewater Mileage Inundated	0 1,0 20,000 0 110-120	\$33,856,000 1.3 50,550 13,000 B2 9	\$29,611,000 1.3 104,550 45,000 116 9	\$16,795,000 1.2 84,950 45,000 138
Major Ecosystems, Acreage inundated or Destroyed Important Hoose Habitat Important Carlbou Habitat Important Haterfowl Habitat (number of pothole lakes) Archaeological Zones Prec'luded from Post-Construction Studies	18.000 2.000 2.000 acres Unquantified area has very Migh	4,000 0 0	4,000 52,000 400 6G	10,000 52,000 400 85
Prehistoric Sites Inundated or	potential 0	D	D.	1
Destroyed Historic Sites Inundated or	0	1	4	4
Destroyed c. Social Hell-Being (SWB) Energy Resources Conserved in Toos per Year		5,850,000	5,850,000	\$,830,000
d. Regional Development (RD) Cost of Power in Hills/Kwhr 3. Plan Response to Associated Evaluation	26.4 - 11.4	21,1	21.0	24. J
Criteria a. Acceptability	This plan is the worst frux the stand- point of conservation of nonrenewable resources. It has large adverse (Q effects in that it requires strip- mining of 20,000 acres of important wildlife habitat, it degrades water quality by chemical inputs and suspende sediments, and it degrades air quality by inputs of particulates and chemical pollutants. Its NED performance is acceptable. It provides no flood control or recreational opportunity.	Supported by consensus of most publics,	Preater adverse EQ effects than in recommended plan. Ranks second to the recommended plan in the NED account. Journal of the recommended plan in the NED account, Journal of the recommended plan firm power of hydro development plans. Mould provide flood control and recreation potential.	Beneficial impacts in NED, SMB, and RD accounts. Has good potential for stage development of hydro projects and is plan favored by Alaska Power Administration. Ranks low in the EQ account in comparison to other alternatives. Would provide flood control and recreation potential.

TABLE 3.1: (continued)

	PLAM A	FLAN B	PLAN C	PLAK D
	ATTHORE COMPLETON	HATIONAL ECONOMIC DEVELOPMENT (NED)	HARTHUM POWER DEVELOPMENT PLAN	PREVIOUSLY RECOMMENDED PLAN
·	Conventional Coal Thermal Plant	Devil Canyon-Waters Dams	Devil Canyon-Watana-Denail Dama	USBR Four-Dom System
C. PLAN EVALUATION (Cont.)	•			
<ol> <li>Plan Response to Associated Evaluation Criteria (Cant.)</li> </ol>				
b. Certainty ·	This appears to be an implementable plan which could be pursued to west energy needs for the near and long range future. It is the most flexible plan in terms of incremental development and operation potentials.	Foundation conditions appear adequate for construction of both projects.  Transmission system is within the means of present terhnology. Least floxible of alternatives to changes in projected power demand.	Sems avaluation as for Plan B except for atorage Control project at Denall site. Additional explorational required before this attucture could be recommended. Hore itextitle than Plan B.	Same avaluation on for Plan C except for the power project at the Ves este Additional exploration of abutent seteral required before this descould be recommended for the structur height estated above. Host firstble of hydro alternatives.
c. Completeness	Could match the energy output of any plans evaluated herein as long as fuel source is available.	Provides adequate power to satisfy projected demand growth until mid-1990's bittle potential for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to eatisfy projected demand growth until mid-1990's Little Potontial for expansion. Demand beyond the project capability will have to be met by other development.	Provides adequate power to satisfy projected demand growth until mid-1990' Little potential for expension. Demand beyond the project capability will have to be met by other devalopment.
d. Effoctivenedes	Could be expanded indufinituly to limits of fuel.	Would develop 96 percent of basin development potential.	Davidos grantest firm power - equal to Pien & in everage annual power.	Would develop 95 percent of beein development patential.
D. IMPLEMENTATION RESPONSIBILITY		•		
l, Financial Responsibility	Private and/or semi-public antities coordinated with Federal and State tegulatory agencies.	Federal Government with power merketed through the Alaska Power Administration.	Federal Covernment with power worketed through the Aleske Power Administration,	Federal Government with power marketed through the Alaska Power Administration.
2. Recreation Sponsorshitp	None	State of Alaska	State of Aleska	State of Aleska
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#### 4 - PREVIOUS STUDIES

The earliest studies were undertaken by the Corps of Engineers in 1950 and identified several potential sites for hydroelectric power development in the Susitna River Basin as part of a reconnaissance level survey of Cook Inlet and tributaries. A second study; the Bureau of Reclamation "Reconnaissance Study on the Potential Development of Water Resources in Alaska" was completed in January 1952.

Subsequently, the feasibility of hydropower development of the Susitna River has been the subject of several more detailed studies. The most significant of these were conducted by the following agencies (or company):

- U.S. Bureau of Reclamation (11) 1953
- U.S. Bureau of Reclamation (10) 1961
- Alaska Power Administration (1) 1974
- Kaiser Engineers (4) 1974
- U.S. Corps of Engineers (7) 1975
- U.S. Corps of Engineers (8) 1979

The above studies are discussed in more detail in the following sections.

#### 4.1 - U.S. Bureau of Reclamation - 1953

This represented the first major study and was completed in 1953. The following ten sites were identified above the railroad crossing at Gold Creek (see also Figure 2.1):

- Gold Creek
- 01son
- Devil Canyon
- Devil Creek
- Watana
- Vee
- Maclaren
- Denali
- Butte Creek
- Tyone (on the Tyone river)

An additional 15 dam sites were identified within the remainder of the Susitna Basin downstream of the Gold Creek railroad crossing.

The sites at Butte Creek, Devil Creek, and Gold Creek were eliminated from detailed study on the basis of field reconnaissance. The other sites were included in desk studies involving the development of conceptual engineering layouts and costs. Selection of the development plan was based on maximizing energy output for the least cost. This plan included the development of the following sites:

```
01sen:
                     Max. pool elev. = 920 ft.
                                                        Installed capacity = 50MW
  Devil Caynon:
                                       = 1.417 \text{ ft.}
                                                                             = 390MW
  Watana:
                                       = 1,900 ft.
                                                                             = 310MW
   Vee:
                                       = 2.330 \text{ ft.}
                                                                             = 260MW
   Denali:
                                       = 2,590 ft.
                                                        No power generation
                                                             facilities
```

The first stage of development involved a dam at Devil Canyon with an initial installation of 195 MW of generating capacity. To meet subsequent increases in demand the dam at Denali would be built. This would provide sufficient regulation to allow doubling the capacity at Devil Canyon to 390 MW. The sequence of construction for the remaining developments would depend on future load growth.

It should be emphasized that this USBR study was very preliminary in nature. At the time of the study, limited mapping and geotechnical information as well as only two or three years of hydrological records were available.

#### 4.2 - U.S. Bureau of Reclamation - 1961

In 1961 a more detailed feasibility study dealing specifically with the Devil Canyon-Denali development was completed. It recommended a five-stage construction scheme be used to match the load growth curve. The first stage would consist of a 635 ft high arch dam constructed at Devil Canyon. Initially, 3 units totaling 217.5 MW were to be installed. The second stage involved building an earthfill dam without a power house at Denali to increase the dependable energy at Devil Canyon. Stages 3 and 4 each involved adding two units and stage 5 one unit, to the Devil Canyon powerhouse, leading to a total installed capacity of 580 MW.

The increase in installed capacity over the value derived in the previous study resulted from the greater level of detail to which the development at Devil Canyon was studied. The full pool elevation of the Devil Canyon Reservoir was increased by 33 ft to 1,450 feet. The larger period of streamflow data (10 year vs 2 years) allowed a more accurate determination of the mean annual flow which was 12 percent higher than the previous estimate. The proposed development was also sized for a lower plant factor.

# 4.3 - Alaska Power Administration - 1974

The status of the Devil Canyon Project was reviewed in a report which was essentially an update of the USBR 1961 report. One major change from the 1961 report on Devil Canyon Dam was the change from a single curvature arch to a double curvature thin arch dam. Revised load forecasts as well as revised cost estimates and schedules were included in this report.

#### 4.4 - Kaiser Engineers - 1974

This study suggested an alternative to the USBR scheme of development. It was proposed that the initial development consist of a single dam known as Susitna I\* located at at site approximately 5 miles upstream from the USBR Devil Canyon site. A 810 ft high rockfill dam at this site with a pool elevation of 1750 ft

\*Note: Subsequently this name has been changed to High Devil Canyon.

would provide sufficient storage for 600 MW of dependable capacity without an additional upstream reservoir. Because of the perception that foundation conditions at Denali are questionable, this scheme was preferred to the USBR Devil Canyon-Denali scheme.

Kaiser suggested the ultimate development would incorporate Susitna II located downstream at approximately the same location as to the USBR Olson Site, and Susitna III located at the upstream end of the Susitna I reservoir. The exact location of the Susitna III site was not identified but it was determined that a head of 600 feet could be obtained. Information developed for the Susitna II and III site was limited to an estimate of the energy potential. The report also mentioned that the future addition of Denali, if foundation conditions proved to be adequate, would increase the energy generation potential of the other three sites.

#### 4.5 - U.S. Corps of Engineers - 1975

The most comprehensive study of the hydroelectric potential of the Upper Susitna Basin was completed in 1975 by the Corps of Engineers. In this study several schemes of development were considered including combinations of dams of various heights at the following sites:

- 01sen;
- Devil Canyon;
- High Devil Canyon (Susitna I from the Kaiser Plan);
- Watana:
- Vee; and
- Denali

A total of 23 alternative developments were identified and evaluated using a "scoping type" economic analysis. The results are shown in Table 4.1. Alternatives were selected for final evaluation based on "maximizing net benefits consistant with engineering judgement". The more promising of these alternatives are listed in Table 4.2 together with their respective firm annual energy, dependable capacity values, and comments relating to further study.

The four most promising alternatives for meeting the future power needs of the Railbelt Area were selected for futher studies. These were:

- Coal (considered to be the "without" Susitna condition or the base case);
- Devil Canyon (1450) Watana (2200);
- Devil Canyon (1450) Watana (2200) Denali (2535); and
- Devil Canyon (1450) Watana (1905) Vee (2300) Denali (2535)

Note: The numbers in brackets refer to the maximum pool elevation in feet.

Each of these alternatives were evaluated using the following four criteria (See Appendix B for a more detailed definition of the terms):

- Technical Criteria;
- National economic development (NED);
- Environmental quality criteria (EQ); and
- Social well-being and regional development

Table 3.1 gives a summary comparison of the four alternatives in terms of the above criteria.

The scheme finally selected by the U.S. Corps was the Devil Canyon (1450) – Watana (2200) option. It maximized the National Economic Development and also minimized environmental effects. The scheme involved the first stage construction of an earthfill dam at the Watana site with a height of 810 feet. Three 264 MW units would be installed giving a total capacity of 792 MW. The second stage involved a 635 high thin arch dam at Devil Canyon and would be constructed to meet future local growth. The Devil Canyon site would have an installed capacity of 776 MW. Firm annual energy was estimated as 3.0 x  $10^9$  kW-hr for Watana and 3.2 x  $10^9$  kW-hr for Devil Canyon. The benefit-cost ratio for the total development was computed as 1.3 with power benefits based on the cost of the coal alternative.

## 4.6 - U.S. Corps of Engineers - 1979

In 1977 the Office Management and Budget (OMB) questioned the economic justification of the project. Concerns expressed were that the cost estimates for Watana were not based on any geotechnical investigations. Also the construction schedule required higher construction rates than had ever been achieved. These concerns, as well as several other comments, were addressed in 1979 in a "Supplementary Feasibility Report". Highlights of this later study include:

- At the Devil Canyon site, a concrete gravity dam was analyzed as an alternative to the thin arch dam. This was done to provide a more conservative basis for economic evaluation in the event that subsequent more detailed field data collection and engineering design studies proved an arch dam to be technically infeasible.
- Results of additional geotechnical exploration at the Watana site performed in 1978 were incorporated. As a result, the Watana dam was changed from earthfill to rockfill.
- The total construction period for both dams was increased to more accurately reflect historical construction rates.
- New cost estimates were developed and the economic analyses redone. The revised benefit-cost ratio was found to have increased to 1.4 because the value of power, as assessed by the coal thermal alternative, had increased more in the five year period than the construction costs.
- Sensitivity analyses were carried out to determine the effect of different rates of local growth on the economics of the proposed scheme. These revealed that the local growth rate would have to fall below 0.8 percent annually before project costs exceed benefits. This lack of sensitivity was due in-part to a large number of fossil-fuel plants which were specified to have planned retirements close to the proposed on-line dates for the Susitna development and should therefore be interpreted with caution.

TABLE 4.1: CORPS OF ENGINEERS - "SCOPING ECONOMIC ANALYSIS"

System of Development	Total Average Annual Costs	lotal Average Annual Benefits	Net Benefit
	(\$1000)	(\$1000)	(\$1000)
Devil Canyon, Denali, Vee (2300), Watana (1905)	102,491	109,461	6 <b>,97</b> 0
evil Canyon, Denali, Vee (2350), Watana (1905)	104,445	112,407	7,962
evil carryon, condit, top (2550), and and (1505)	.0.,	112,107	.,,,,,,
ligh Devil Canyon, Olson, Denali, Vee (2300)	139,984	113,654	-26,330
	·	·	
evil Canyon, Watana (2200), Denali	110 <b>,</b> 091	133,188	23,097
evil Canyon, Watana (2050), Denali	99,094	118,615	19,521
Pevil Canyon, Watana (1905), Denali	88,150	98,727	10 <b>,</b> 577
Devil Canyon, Watana (2250)	104,336	126,262	21,926
evil Canyon, Watana (2200)	96,600	126,188	29,588
evil Canyon, Watana (2050)	85,604	103,193	17,589
evil Canyon, Watana (1905)	74,660	78,222	3,562
revii canyon, nacana (1707)	74,000	,0,222	3,702
Matana (2250), Devil Canyon	106,379	127,147	20,768
Matana (2200), Devil Canyon	101,776 3/	126,523	24,747
Vatana (2050), Devil Canyon	86,834 -	102,547	15,713
atana (1905), Devil Canyon	72,034	77,168	5,134
	(0.454	47.050	. 707
Devil Canyon, Denali	69,651	63,858	- 5,793
Devil Canyon	51,561	29,644	-21,917
CATT COULD	, , , , , , , , , , , , , , , , , , ,	22,044	,>17
ligh Devil Canyon	90,651	67,397	-23,254
-	70.044		5 047
Vatana (2200)	78,046	73,029	- 5,017
latana (2050)	63,104	54,741	- 8,363
latana (1905)	48,304	31,574	-16 <b>,</b> 730

Number in parenthesis represents the normal maximum pool elevation of the project.
 Project staging in sequence as shown and each project was assumed to have a five-year construction time.
 Six-year Watana construction and IDC based on annual expenditures would have resulted in an Annual Cost of \$103,920,000.

TABLE 4.2: CORPS OF ENGINEERS - DATA PERTAINING TO PROMISING SUSITNA DEVELOPMENTS

, 	Firm Annugl Energy x 10 kWh	Dependable Capacity-MW	CORPS OF ENGINEERS COMMENTS
Devil Canyon (1450)	0.9	206	Not economic by itself
High Devil Canyon (1750)	2.6	600	Not economic by itself
High Watana (2200)	3.0	686	Economic, however, same environmental impact as project twice its size
Devil Canyon (1450) - Denali (25	55) 2.5	575	Not economically feasible
Devil Canyon (1450) - High Watana (2200)	6.1	1,404	Economic - should be studied further
Devil Canyon (1450) - High Watana (2200) - Denali (2535)	6.8	1,552	Economic – environmental affects greater than Devil Canyon – Watana – should be studied further
High Devil Canyon (1750) - Olson (1018)- Vee (2300) - Denali (2	5 <b>.</b> 9 535)	1,347	Develops less than basin potential - Not economically justified

#### 5 - DESIGN PARAMETERS

#### 5.1 - <u>General</u>

For each of the twelve sites identified in the basin (Figure 2.1), information has been gathered and tabulated. At several sites various heights have been studied, although, not always to the same degree of detail. At other sites, such as the Susitna III site, very little information is available. Table 5.1 summarizes available topographic, engineering layout, subsurface investigation and air photo information for each site and the source of such information.

In the sections that follow, some of the more pertinent parameters associated with the various sites are discussed in more detail.

#### 5.2 - Civil Engineering Parameters

Preliminary engineering layouts are available for the following dam alternatives:

Site	Max. Pool Elevation	Dam Type
Devil Canyon	1417	Concrete Arch
Devil Canyon	1450	Concrete Thin Arch
Devil Canyon	1450	Concrete Gravity
High Devil Canyon (Susitna I)	1750	Concrete Faced Rock- fill
Watana	2200	Earthfill
Watana	2185	Rockfill
Vee	2300	Earthfill
Denali	2535	Earthfill
Denali	2552	Earthfill

Copies of these drawings are included in Appendix A.

For other levels of development, and dams at the other seven sites, information is limited to descriptions in the text of the reports.

Civil detailed design parameters such as dam type, height, length, length-to-height ratio, reservoir area, gross storage, spillway type and provision for a low level outlet are listed in Table 2.1. A brief description of the more important aspects associated with dams at each site follows:

#### (a) Gold Creek

A 135 feet high earthfill dam constructed at this site would cause water to back-up to the Olson site. A spillway and power plant could be constructed on either abutment.

Diversion of the Chulitna River (by two tunnels) and of the Indian River into the reservoir would considerably increase the energy generating potential of this site.

# (b) <u>01son</u>

A concrete gravity dam at the Olson site would raise the water level 50 feet without encroaching on the tailwater level at the High Devil Canyon site. The spillway could be a gated overflow section in the center of the dam.

#### (c) Devil Caynon

At the Devil Canyon site, three dam designs have been proposed. Each of these designs has a maximum pool elevation of 1450 feet with a dam height of approximately 650 feet. These designs each consist of a main concrete section and an earthfill embankment 200 feet high and 950 feet long at the south end of the main dam.

As proposed by the USBR (10) in 1961, the main concrete section is a single curvature arch dam. The Devil Canyon Project Status Report, prepared by the Alaska Power Administration (1) in 1974 included an updated design of the dam using a double curvature thin arch section. This design was also utilized by the Corps in their 1975 Interim Feasibility Study (7). In the 1979 report, the Corps (8) substituted a concrete gravity section as it was considered less sensitive to foundation conditions and led to a more conservative (higher) cost estimate. It was pointed out that further geotechnical investigations would be required to firm up the feasibility of an arch dam.

The USBR design includes a tunnel spillway through the north abutment. The thin arch dam design has a chute-type spillway with a flip bucket located on the south canyon wall. For the gravity dam option the spillway is incorporated in the center of the dam.

# (d) High Devil Canyon (Susitna I)

A 810 foot high concrete-faced rock fill dam was proposed for the High Devil Canyon site. The crest elevation was set at 1755 feet giving a maximum pool elevation of 1,750 feet. Upstream and downstream slopes of the rockfill dam were 1.4 and 1.3 to 1 respectively. On preliminary examination it appears that these slopes may be too steep for this type of dam in the area; particularly because of the high seismicity.

The spillway is located on the south abutment. It is a channel type and incorporates a series of steps excavated in the rock to form a cascade.

## (e) <u>Devil Creek</u>

Located just below the mouth of Devil Creek, the Devil Creek site appears sutiable for the Construction of a low dam. The maximum height would be limited to 350 feet by the right abutment. No layouts are available for this site.

#### (f) Watana

Rockfill dams of various heights have been proposed at the Watana site. The most recent Watana Dam design presented in the Corps of Engineers 1979 report is a rockfill dam with a crest elevation of 2,195 feet and a maximum water pool elevation of 2,185 feet. This is essentially the same dam as proposed in 1975 (7) which has a maximum pool elevation of 2,200 feet. The discrepancy was due to corrections in topography made during field investigations. The dam is 810 feet high and incorporates a sloping impervious core.

A saddle spillway is provided across the right abutment discharging into the Tsusena Creek. Twin diversion tunnels are also located in the right abutment. These tunnels would be converted to a high and low level outlets before completion of the project. The powerhouse is located underground below the left abutment.

#### (g) Susitna III

The Susitna III site is defined by the H.J. Kaiser Company (4) as a point above the headwaters of the High Devil Canyon (Susitna I) reservoir where a head of 600 feet could be obtained. There is no engineering information available at this site.

#### (h) <u>Vee</u>

At the Vee site, any structure higher than 250 feet requires a saddle dam. Above height 480 feet water starts to spill into the Copper River Basin to the south. The USBR originally proposed a gravity-arch concrete structure with a crest elevation of 2,340 feet. Further work by the USBR, and the Corps of Engineers which included some site investigation, resulted in an earthfill dam being selected with a height of 410 feet and a maximum pool elevation of 2,300 feet. No reference has been found detailing the rationale for this design. A geotechnical investigation report (12) for the Vee Canyon site refers to a tunnel type spillway; however, this is not shown on the available plan.

#### (i) Maclaren

In the initial USBR studies, a concrete dam with a height of not more than 100 feet flanked by earth embankments was considered. The concrete river section incorporated an overflow spillway. No engineering layouts are available.

#### (j) Denali

The primary purpose of the Denali reservoir was considered to be the provision of storage for regulating releases to downstream power facilities. As the mode of operation for this type of reservoir involves no downstream water release for several months each year, it was not considered feasible to install a powerhouse at this site. A 260 foot high earthfill dam was proposed. The spillway is a 19 foot diameter Glory Hole type with the outlet conduit passing through the embankment.

# (k) Butte Creek

A dam at the Butte Creek site was considered by the USBR. A field reconnaissance led to the rejection of this site in favor of the Denali site which was found to have better foundation conditions. No engineering layouts are available.

#### 5.3 - Hydrology

The following USGS gaging stations have been operated by the USGS:

USGS Gaging Stations	Period of Record
Gold Creek	1949 - present
Vee	1961 - 1972
Denali	1957 - present
Maclaren	1958 - present
Talkeetna	1964 - present

Obviously, the earlier studies were based on very limited flow records. In particular, the initial USBR studies had at most, two years of record. Extended flow estimates were obtained by correlation with long term rainfall records at Talkeetna.

The most comprehensive study in which hydrological parameters are given for the various site is the 1975 Corps of Engineers report. Monthly flow data for the Devil Canyon and Watana sites were generally prorated from the Gold Creek using factors based on drainage basin areas. Flood estimates were derived both from frequency analyses of recorded flood flows and by utilizing the SSARR computer model to develop Probable Maximum Flood values. Table 2.2 lists pertinent hydrological parameters such as annual and monthly flow rates, spillway design floods and reservoir volumes for each of the sites.

Detailed hydrological information is contained in Subtask 3.01 - Review of Available Material.

#### 5.4 - Geotechnical

Geotechnical investigations at the sites have ranged from aerial reconnaissance to drilling programs at Watana, Devil Canyon, Vee and Denali. A preliminary assessment of the seismicity of the area indicated tht the maximum credible earthquake for all sites is a 8.5 Richter magnitude located at a distance of approximately 40 miles. Available geological and geotechnical information is discussed in the 1980 Interim Report Task 5 - Geotechnical Explorations. However, for the sake of completeness, a brief review of geotechnical aspects pertaining to each site is included in this report.

#### (a) Gold Creek

Available information is very limited. It is known that a very deep cut-off wall of the order of 70 feet will be required and that construction material suitable for the earthfill dam may be difficult to obtain.

#### (b) 01son

Available information is very limited. The abutments appear to be a sound graywacke formation.

#### (c) Devil Canyon

Exploration performed by the Bureau of Reclamation in 1957 consisted of 22 borings, 19 trenches and test pits and geologic mapping. The Corps of Engineers did a limited amount of additional seismic work in 1979. The significant aspects resulting from these investigations include:

- About 35 feet of alluvium overlying bedrock in the channel;
- The abutments will require extensive dental work;
- The foundation will require grouting;
- Shear zones exist in both abutments;
- A buried stream channel or shear zone exists near the saddle dam location (to the south of the main dam);
- The maximum Credible Earthquake was estimated to be 8.5 Richter magnitude at 40 miles or 7.0 at 10 miles;
- Materials for a concrete dam are available in sufficent quantity but the aggregate shows marginal freeze-thaw resistance; and
- Sporadic permafrost may exist in the left (south) abutment.

#### (d) <u>Watana</u>

Exploration of Watana has taken place as follows:

<u>Date</u>	Agency	Scope
1950 - 1953 1974 1975	Bureau of Reclamation USGS Corps of Engineers	Reconnaissance Reconnaissance and mapping Reconnaissance
1975	Dames and Moore (under contract to the Corps of Engineers)	Right abutment seismic
1978	Corps of Engineers	28 borings, 27 test pits. 18 auger holes
1978	Shannon & Wilson (under contract to the Corps of Engineers)	Seismic

The significant aspects resulting from these investigations include:

- Overburden thickness varies from 40 to 80 feet in the valley bottom and 10 feet to 20 feet on the abutments.
- The river channel alluvium thickness varies from 40 feet to 80.
- It is suspected that a buried stream channel incorporating an aquifer under artesian pressure occurs near the spillway location.
- It is suspected that a slide block exists on the right abutment.
- The "Finger Buster" and "Fins" are pronounced shear zones located just downstream and upstream of the dam on the right abutment.
- Relatively deep permafrost occurs in the left abutment.
- Sufficient borrow material is available. Although engineering properties of the fine-grained materials are not well defined they are known to be very sensitive to water content.
- Once the reservoir is filled the "warm" permafrost which occurs in the banks may will thaw and may cause local slumping.
- Linear features located approximately 2.5 miles to the west and 5 miles to the southeast of the site have been identified and tentatively named the "Susitna Fault" and the "Talkeetna Thrust".

#### (e) Susitna III

The location of this site has not been firmly fixed and therefore no geotechnical information is available.

#### (f) Vee

Investigations consisting of thirteen borings and 16 dozen trenches were performed by the USR during 1960 - 1962.

- Deposits in the river bottom are estimated to be 125 feet deep.
- A buried streambed is located at the site of the saddle dam and could be as deep as the present Susitna River channel.
- Considerable amounts of talus and weathered rock must be removed from abutment areas to expose good quality rock.
- Permafrost is present at the saddle dam location.

#### (g) <u>Maclaren</u>

Bedrock outcrops indicate a potential site. The presence of deep alluvium, particularly on the left bank, was reported by the Corps of Engineers.

#### (h) Denali

In 1958 - 1959 the USBR performed investigations consisting of five borings and 14 test pits. Significant features include:

- Deep permafrost occurs in both abutments;
- Pervious sand and gravel occurs in the right abutment;
- Low density, potentially liquifiable, fine grained sands occur in the river bottom;
- Layers of compressible silt are found in both abutments;
- Maximum Credible Earthquake is estimated as a Richter Scale of 8.5 at 40 miles:
- A deep cutoff excavation and extensive foundation treatment will be required; and
- Impervious materials may be difficult to obtain.

#### (i) Butte Creek

Limited information is available. Glacial silts occur on the right abutment and will require removal for dam construction.

#### (j) <u>Tyone</u>

No information available.

#### 5.5 - Mechanical

Preliminary project layouts showing the major mechanical equipment were developed in the recent studies by the Corp of Engineers, and also to a lesser extent in the studies by the Alaska Power Administration and the USBR.

The major mechanical equipment is summarized in Tables 2.3, 2.4 and 2.5 and a brief description of the arrangements is presented below.

#### (a) Devil Canyon

The underground power house has four 194 MW units with Francis turbines (rated head - 520 ft). Access to the powerhouse is by a 550 ft. vertical shaft. The units have bonnetted fixed wheel intake gates located in a separate gallery upstream of the powerhouse cavern. Two penstocks are provided and the intake has three stoplog slots with provision to place stoplogs at various elevations to permit water to be taken from different levels.

The spillway has radial crest gates and bonnetted slide type low level outlet gates. Wheeled bulkhead gates are provided for closure in the single diversion tunnel.

#### (b) Watana

The underground powerhouse has three 264 MW units with Francis turbines (rated head - 580 ft). The units have bonnetted fixed wheel intake gates located in a separate gallery upstream of the powerhouse cavern. Two penstocks are provided, one supplying water to two units, the other for the third unit.

The spillway has radial crest gates. A high and low level outlet each with two radial control gates and two bonnetted slide type emergency gates are incorporated in the spillway. The outlets are provided at two levels to reduce the operating head on the control gate.

Wheeled bulkhead gates are provided for diversion closure. Two slide gates are also provided in a temporary plug in one of the diversion tunnels. These are used for final closure of the second diversion tunnel.

#### (c) Denali Dam

Denali Dam, described in the USBR March 1961 report, has a morning glory type spillway with no gates, as well as a single outlet works tunnel with radial control gates and vertical lift emergency gates.

#### 5.6 - Hydropower

Table 2.6 lists available hydropower parameters for each of the sites as well as the parameters for the multi-site schemes developed by the Corps of Engineers in 1975. As hydroelectric potential at a given site is not only dependent upon the site characteristics but also upon the degree of upstream regulation, the hydropower parameters are related to specific schemes of development.

#### 5.7 - Environmental

The majority of baseline environmental information for the Upper Susitna River was acquired from U.S. Corps of Engineers Environmental Impact Statement Report (9) and the Jones and Jones (5) March 1975 Report.

To facilitate synthesis and presentation of the environmental information in this report the river is divided into 6 study reaches starting with reach A at the downstream end and finishing with reach F located upstream of Denali (Figure 2.2). Within each of these reaches the environmental aspects can be assumed to be constant for the general level of study at this stage. Major environmental features for each of these reaches are tabulated in Table 2.7 and are summarized below.

#### (a) Reach A - Talkeetna To Devil Canyon

Under existing conditions, salmon mirgrate as far as Devil Canyon, utilizing Portage Creek and Indian River for spawning (Figure 2.1). The development of any dam downstream of Devil Canyon would thus result in a direct loss of salmon habitat. It can therefore be anticipated that approval for such schemes would be extremely difficult to acquire.

#### (b) Reach B - Devil Canyon to Watana

The concerns associated with development in this section of the river relate mainly to the inundation of Devil Canyon which is considered a unique scenic and white water reach of the river, and dam safety aspects associated with the occurrence of major geological faults. In addition, the Nelchina caribou heard has a general migration crossing in the area of Fog Creek (Figure 2.1).

#### (c) Reach C - Watana to Vee

There are concerns which relate to the loss of some moose habitat in the Watana Creek area and the inundation of sections of Deadman and Kosina Creeks.

Other aspects include the effect on caribou crossing in the Jay Creek area, and the potential for extensive reservoir shoreline erosion and dam safety because of the possibility of geological faults.

#### (d) Reach D - Vee to Maclaren

Inundation of moose winter range, waterfowl breeding areas, the scenic Vee Canyon and the downstream portions of the Oshetna and Tyone Rivers are all potential environmental impacts associated with this reach of the river. In addition, caribou crossing occurs in the area of the Oshetna River. The area surrounding this section of the river is relatively inaccessable and development would open large areas to hunters.

#### (e) Reach E - Maclaren to Denali

Environmentally, this area appears to be more sensitive than Reaches B and C. Inundation could affect grizzly bear denning areas, moose habitat, waterfowl breeding areas and moist alpine tundra vegetation. Improved access would open wilderness areas to hunters.

#### (f) Reach F - Upstream of Denali

This area is similiar to Reach E with the exception of grizzly bear denning areas. Human access to this area would not impact to the same extent as in Section D and F, however due to the proximity to the Denali highway, the inflow of people could be greater.

In an attempt to put the above information in perspective, the reaches were ranked relative to each other in terms of biological, social and physical impact potential. This is summarized in Table 5.2.

#### 5.8 - Generation Planning

A substantial portion of each of the previous studies has been devoted to generation planning studies and the consideration of how the Susitna development would fit into the total electrical system. The initial USBR report showed that Susitna power would be required to meet load growth in the 1960's. As the Susitna project was delayed, fossil fuel plants were built to meet the demand.

In 1970 the Corps of Engineers showed the need for Watana in 1994 followed by Devil Canyon in 1998. Figures 5.1 and 5.2 demonstrate how the proposed development was to fit into the total system subject to medium and low load growth rates.

As can been seen from these figures, the retirement of the existing plants has a pronounced effect on the timing of introducing Susitna power. By assuming the relatively rapid retirement rates shown, the U.S. Corps found that for load growth rates as low as 0.8 percent annually, the Susitna development would still be economical. Preliminary sensitivity calculations as part of Subtask 6.01 indicate that without any planned retirement of existing plants, admittedly an extreme case, the benefit-cost ratio for the low range growth curve would reduce to 0.75 as opposed to 1.4 with the planned retirement shown.

TABLE 5.1: DATA AVAILABLE FOR ALTERNATIVE HYDROELECTRIC DEVELOPMENT SCHEMES

SITE (Pool El.)	TOPOGRAPHIC MAPPING**	ENGINEERING LAYOUTS (Date)	SUBSURFACE INVESTIGATION	AIR PHOTOS
Gald Creek				
Olson (920) Olson (1020)		N - COE (1975)	-	
Devil Canyon (1417/ 1450)	Y - COE*	Y - USBR (1961) Y - APAd (1974) Y - COE (1975)	Y - USBR	1:30,000 B&W
High Devil Canyon (1750)		Y - COE (1979)* Y - Ka (1974) N - COE (1975)		1:30,000 B&W
Devil Creek		,	~~	1:30,000 B&W
Low Watana (1905) Mid Watana (2050) High Watana (2185/ 2200)	Y - COE* Y - COE* Y - COE*	N - COE (1975) N - COE (1975) Y - COE (1975) Y - COE (1979)*	Y - COE	1:30,000 B&W
Susitna III		<del></del>		
Yee (2300) Yee (2350)	N - COE N - COE	Y - COE (1975) N - COE (1975)	Y - USBR	***
Maclaren	. ==			
Denali (2535) Denali (2552) Denali (2590)	 	Y - COE (1975) Y - USBR (1961)	Y - USBR	
Butte Creek	···		<del></del> .	<del></del>
Tyone		·		

No information available
This information may be available, but could not be traced.
Information obtained
Alaska Power Administration
Corps of Engineers
United States Bureau of Reclamation

Y: APAd: COE: USBR:

Ka: Kaiser Engineers

Reproducible drawings Other than USGS 1 inch to the mile with 50 or 100 ft contours.

TABLE 5.2: ENVIRONMENTAL RANKING OF SITES

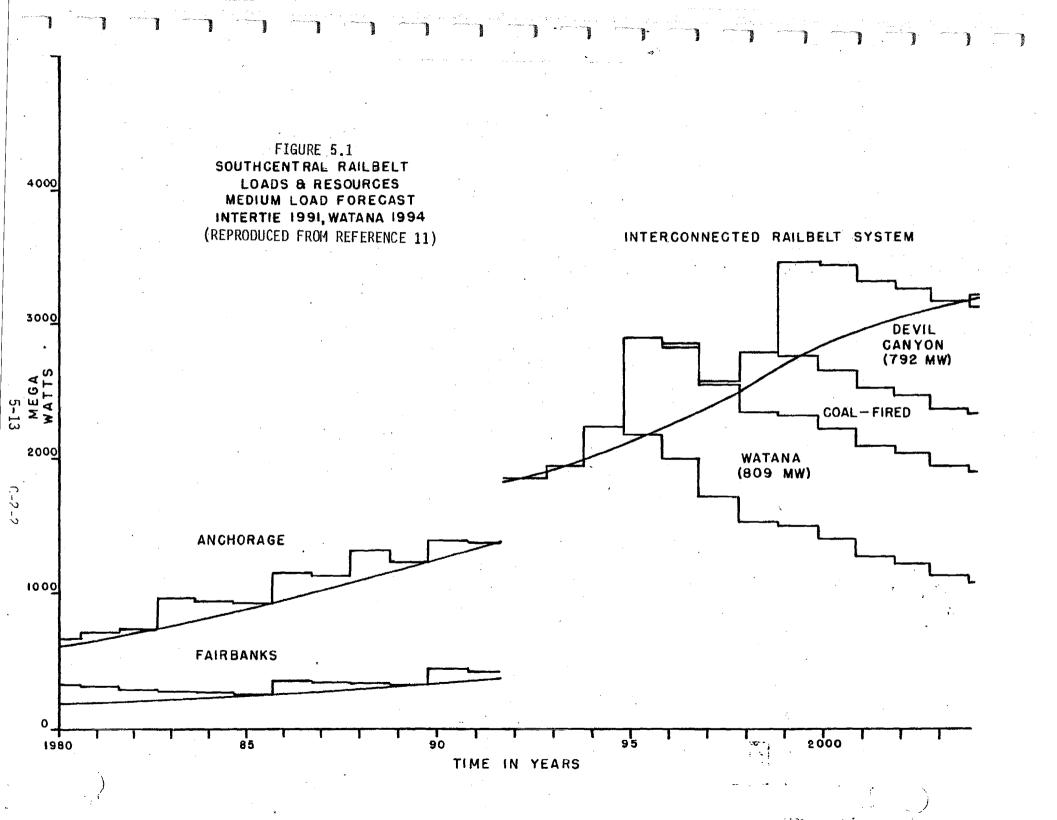
River Section	Type of Develop.	Bio Fish	logical <u>Wildlife</u>	Soci Local	al Reg.	Institutional	Overall
Gold Creek	a b	М	М	М	L	<b>X</b>	м-н
Olson (Susitna II)	a b	М	М	М	· , L	X	М-Н
Devil Canyon	a b	L	L	M-H	M-H	М	M-L
Devil Canyon (Susitna I)	a b	L	М	M-H	М-Н	М	M.
Devil Creek	a b	L	М	M–H	М	<b>M</b> .	М .
Watana	a b	L	М~Н ,	M-H	L-M	М	М
Susitna III	a b	L-M	M-H	M-H	м-н	м–Н	М-Н
Vee	a b	L-M	M–H	М	MH	М-Н	M-H
McLaren	a b	L-M	M-H	М	L-M	М-Н	М
Denali	a	L	M-H	М	М	M-H	М
Butte Creek	a	L	M–H	L-M	L-M	М	М
Tyone	a	L	M-H	L-M	Н	M-H	M-H

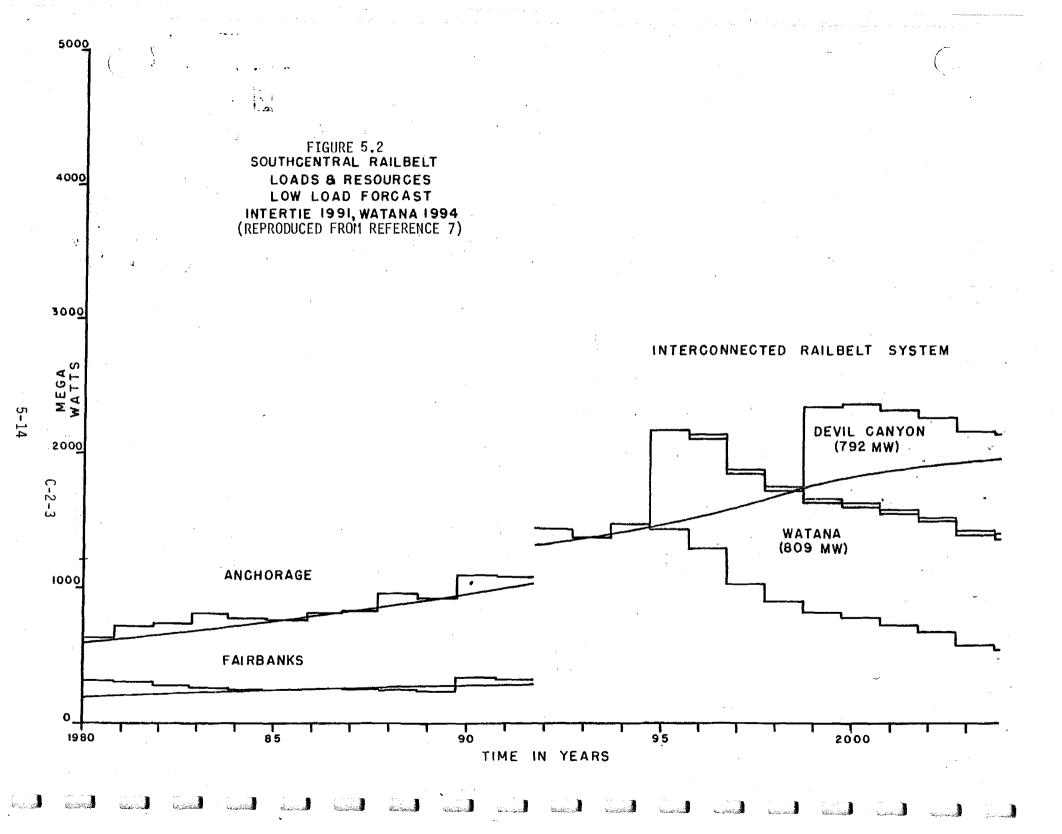
Type of development: a) independent development b) development with upstream regulation

Type of impact:

H: Potential for High Impact X: Potentially Unacceptable

L: Potential for Low Impact
M: Potential for Moderate Impact





#### 6 - CONSTRUCTION COST INFORMATION

#### 6.1 - Available Data

The cost of development at a particular site is dependent on whether that site is the first to be developed in the basin or whether it constitutes a second or third stage of development. The initial development is usually burdened with the major proportion of the access and transmission costs and with higher flood diversion costs. For this reason the available cost data is referred to as being applicable to either an initial or a subsequent stage of development.

The most recent cost estimates for development of the Susitna were performed in October 1978 by the Corps of Engineers (8). Detailed engineering type estimates were developed for the Watana (2200) and the Devil Canyon Concrete Gravity (1450) alternative only.

More comprehensive cost information is incorporated in the 1975 Corps of Engineers report (7). This includes detailed quantities and unit costs for the Watana (2200) and Devil Canyon thin arch dam (1450) alternatives constructed in that order. Also included are summaries of cost estimates performed on a similar basis for the following developments:

- Olson (1020) subsequent stage.
- Devil Canyon (1450) initial stage.
- High Devil Canyon (1702) initial stage.
- Low Watana (1905) initial stage.
- Low Watana (1905) subsequent stage.
- Mid Watana (2050) initial stage.
- Mid Watana (2050) subsequent stage.
- High Watana (2200) subsequent stage.
- Vee (2300) subsequent stage.
- Vee (2350) subsequent stage.
- Denali (2535) subsequent stage.

Except for Olson these costs are given as summary costs for individual accounts such as Lands and Damages, Reservoir, Dams, Power-Plant, Roads and Bridges, Recreational Facilities, Buildings, Grounds and Utilities, Permanent Operating Equipment, Engineering and Design, and Supervision and Administration.

Since the 1975 data incorporates the most complete set of alternatives, this information is included in Appendix C. For information the detailed cost estimate sheets and construction schedules from the 1979 COE report are also included in Appendix D.

Some limited cost information is available for developments at other sites. It is based on relatively crude estimates performed between 1953 and 1968 and is not included in this report.

#### 6.2 - Basis of Cost Estimates

Both the 1975 and 1978 Corps of Engineers estimates used unit prices derived from bid prices of other major hydroelectric projects in the Pacific Northwest and Canada. These bid prices were adjusted to reflect the following:

- Current price levels;
- Alaska labor costs; and
- Transportation costs for material and equipment to the site.

### 6.3 - Preliminary Ranking of Sites

All estimates have been brought to a 1980 basis using the Handy-Whitman Index. Table 2.8 lists the costs for the various alternative developments as well as the years of the original estimate. It also includes costs per kilowatt and costs per kilowatt hour. This data is briefly summarized below. The sites have been ranked in ascending order of energy costs. The capital cost estimates include allowances for contingencies, engineering and design, and supervision and administration. They also include the main access road and major transmission facilities to transport the power to Anchorage and Fairbanks.

Rank	Dam Site (Maximum pool elevation)	Capital Cost (\$ x 10 <sup>6</sup> )	Cost (\$) per kW Dependable Capacity	Cost (\$)/1000 kWh Energy*
1	High Watana (2200)	1587	2300	57
2	Miď Watana (2050)	1279	2800	59
3	High Devil Canyon (1750)	1846	3100	66
4	Low Watana (1905)	975	3900	75
5	Devil Canyon (1450)	1042	5000	84

The ranking of dams for subsequent development stage (i.e. including the cost of the main access road and major transmission facilities) is as follows:

1	Devil Canyon (1450)	630	900	22
2	Mid Watana (2050)	916	2000	42
3	High Watana (2200)	1221	1800	44
4	Low Watana (1905)	613	2400	47
5	Vee (2300)	696	2300	58

<sup>\*</sup>Based on an assumed annual cost factor of 12 percent of Capital Cost.

The above results should be regarded merely as a ranking of currently proposed developments and not necessarily as being indicative of the most economic schemes to meet future load demands. To accomplish the latter requires additional studies aimed at assessing the best methods of staging development to meet a range of possible future load forecasts. Such a study should also incorporate a review of the potential at sites for which currently very little information is available and should incorporate the environmental impacts associated with the various developments.

The 1979 COE study involved a more detailed assessment of the capital costs associated with the Watana-Devil Canyon dam scheme. As indicated the Devil Canyon costs were based on a concrete ground dam. These estimates were updated to 1980 levels and are listed below:

Dam Site (Maximum pool elevation)	Capital Cost _(\$ x 106)
High Watana (2200)	1590
Transmission Facilities	371
Devil Canyon (1450)	914
Total	2875

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# APPENDIX A PROJECT LAYOUTS

# APPENDIX A

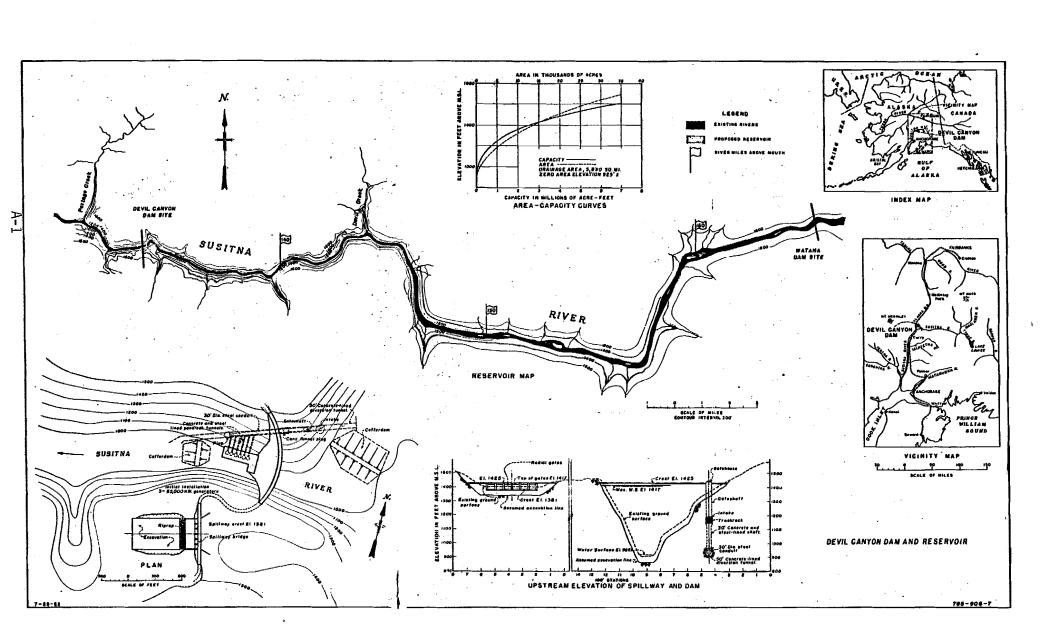
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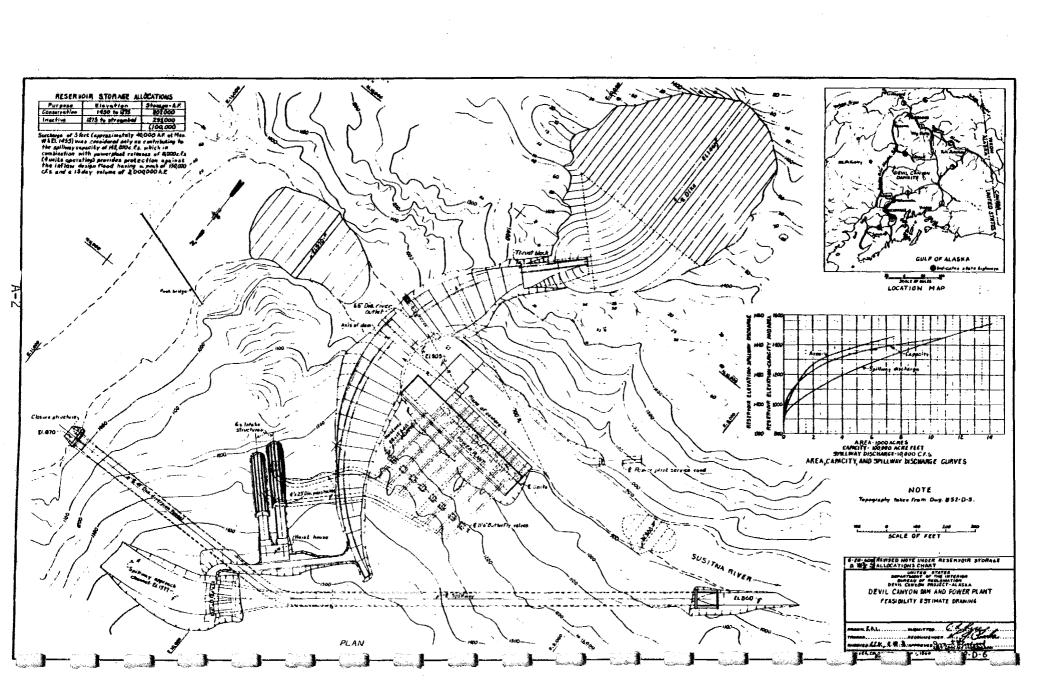
Author		<u>Title</u>	<u>P age</u>
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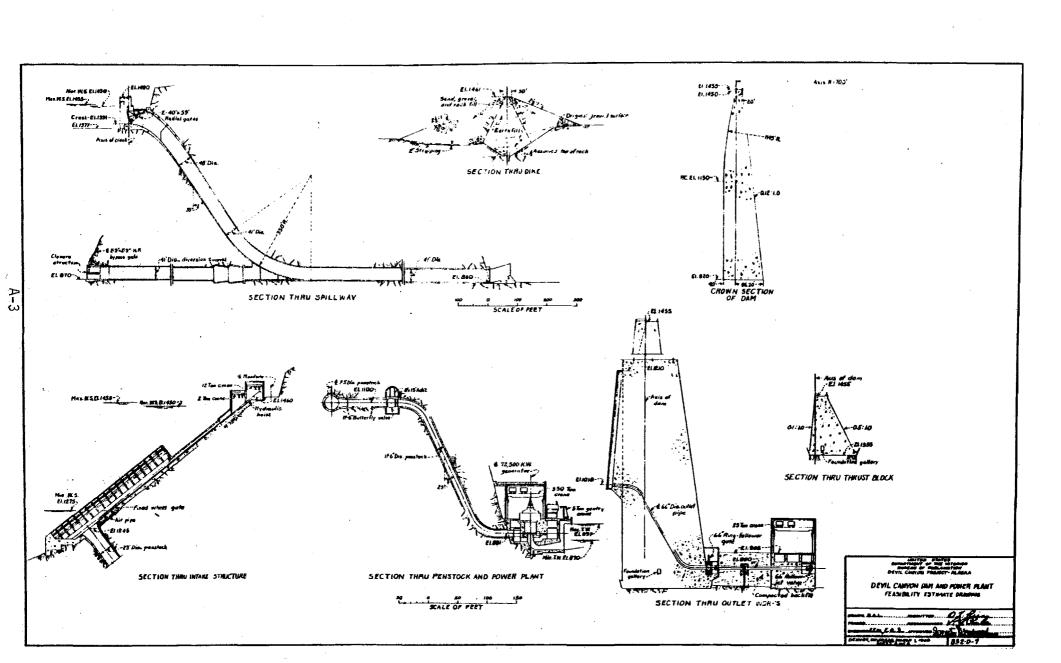
# APPENDIX A

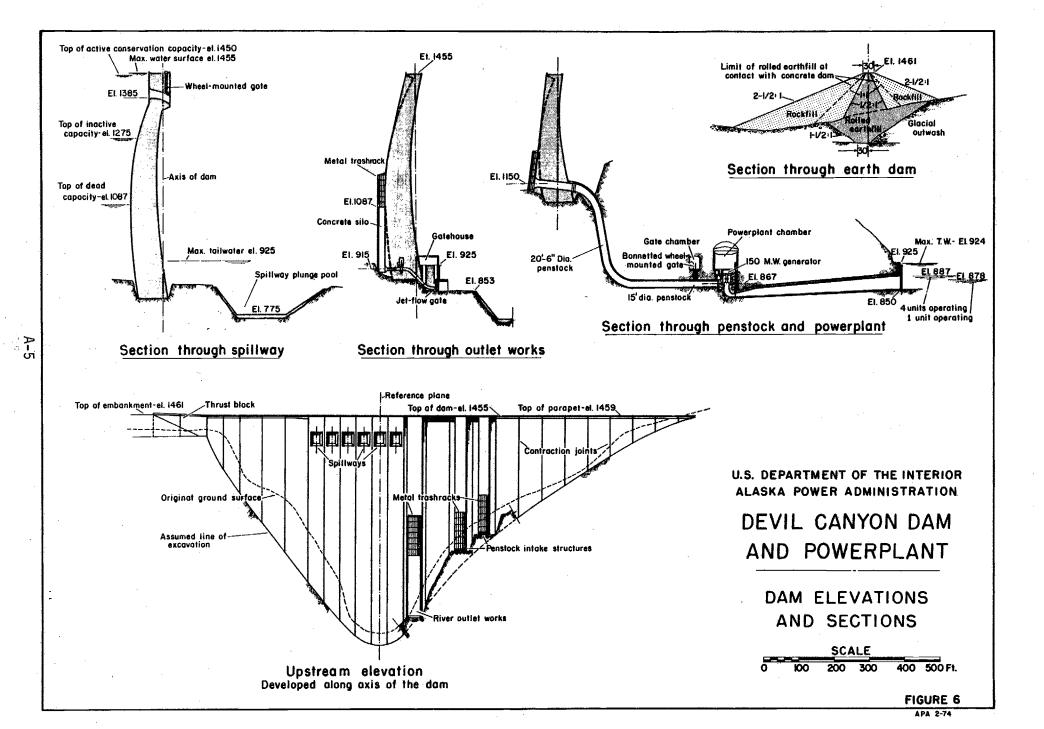
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APAdmin (1974)	Denali Dam - Plan and Sections	A-24
COE (1975)	Denali - Site Plan	A-25







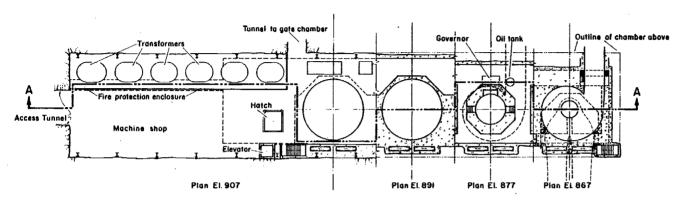


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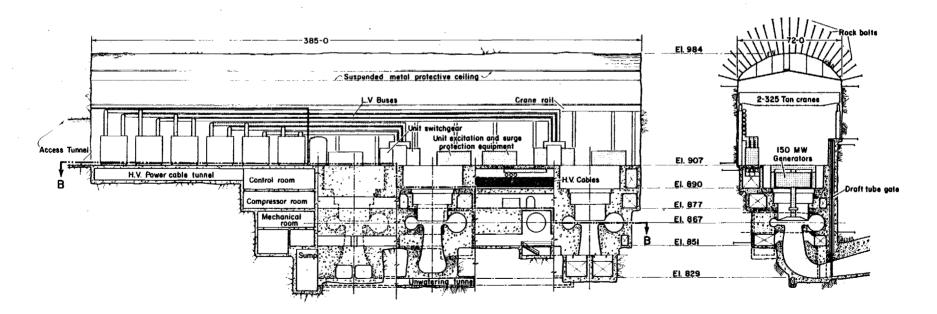
DEVIL CANYON DAM AND POWERPLANT

POWERPLANT
PLAN AND SECTIONS





General plan
Section B-B

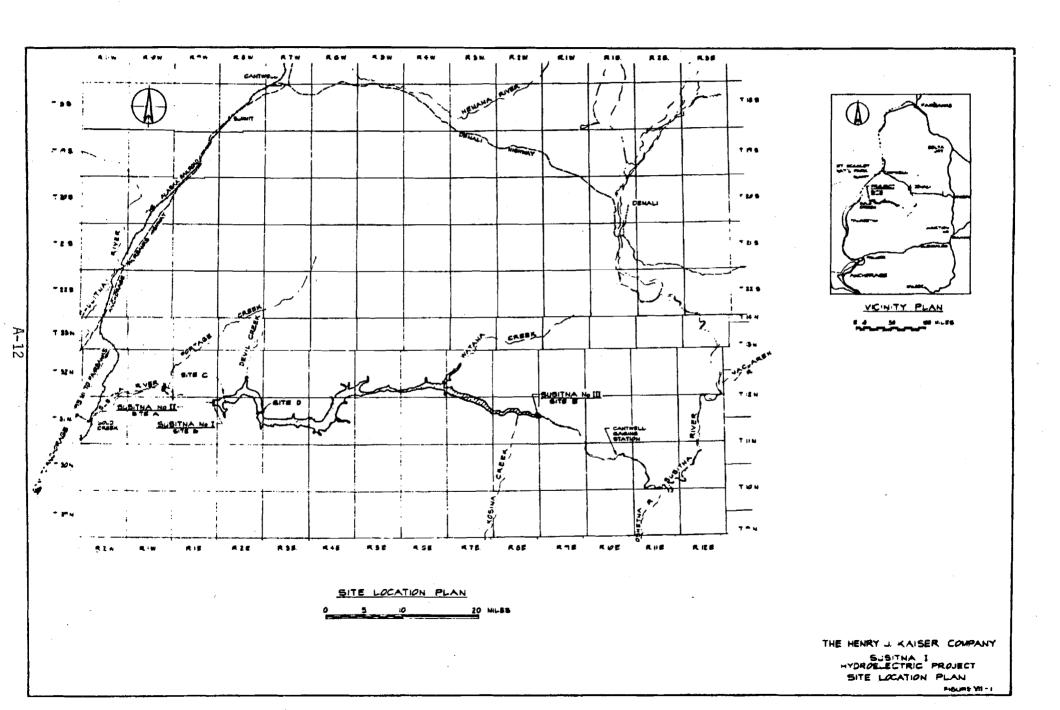


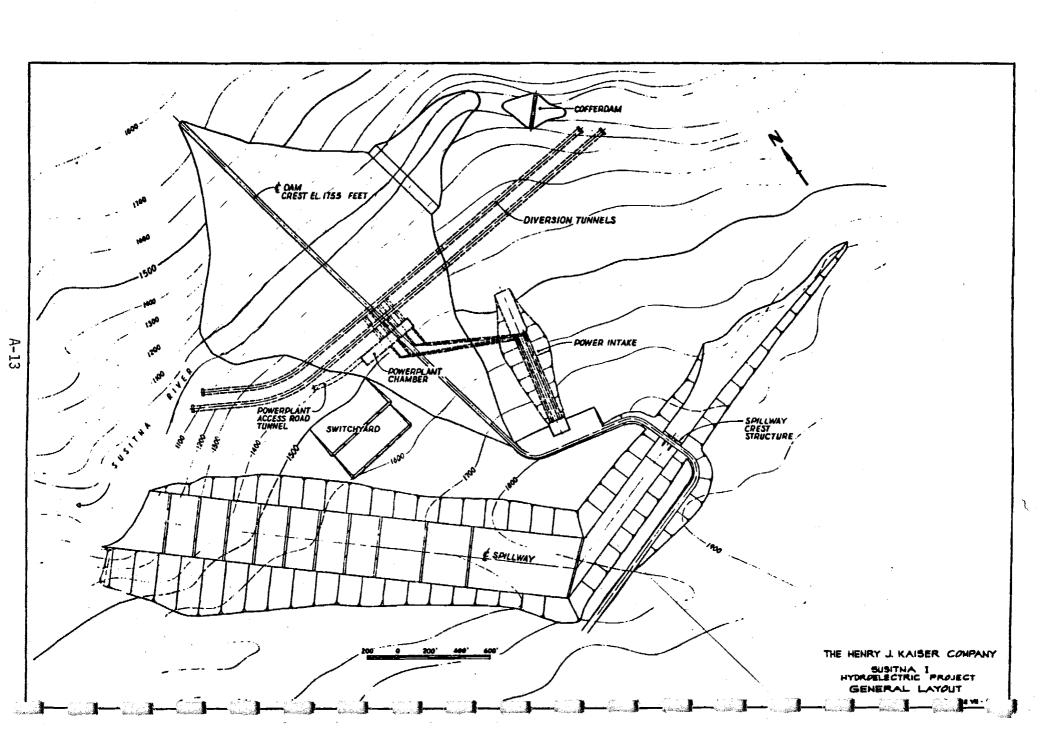
Longitudinal section
Section A-A

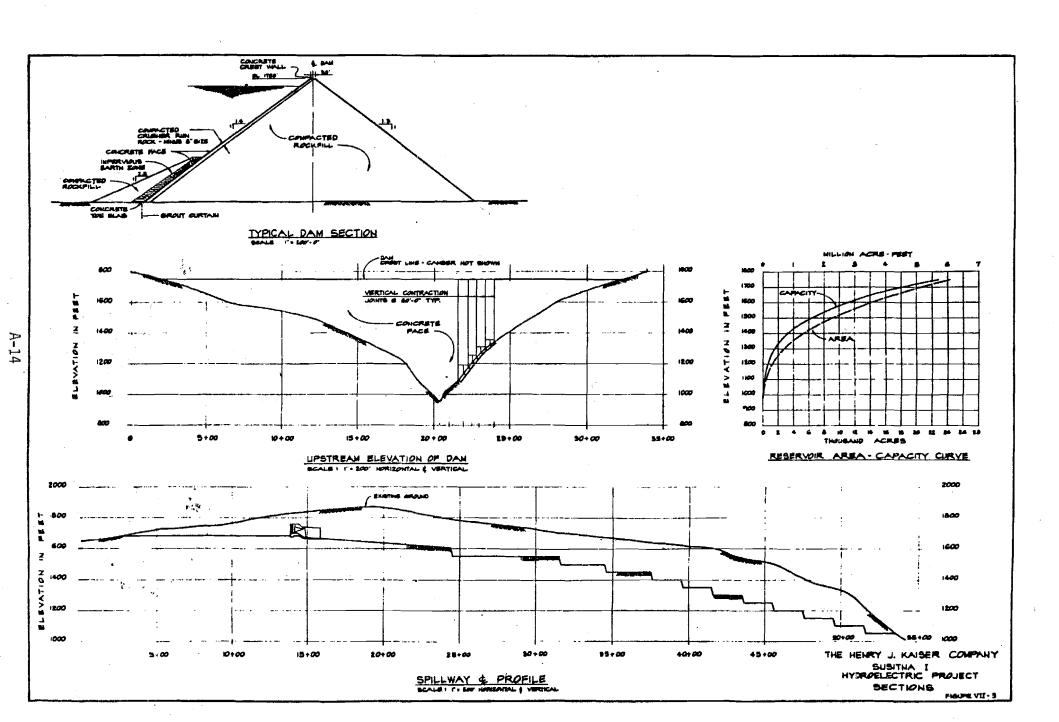
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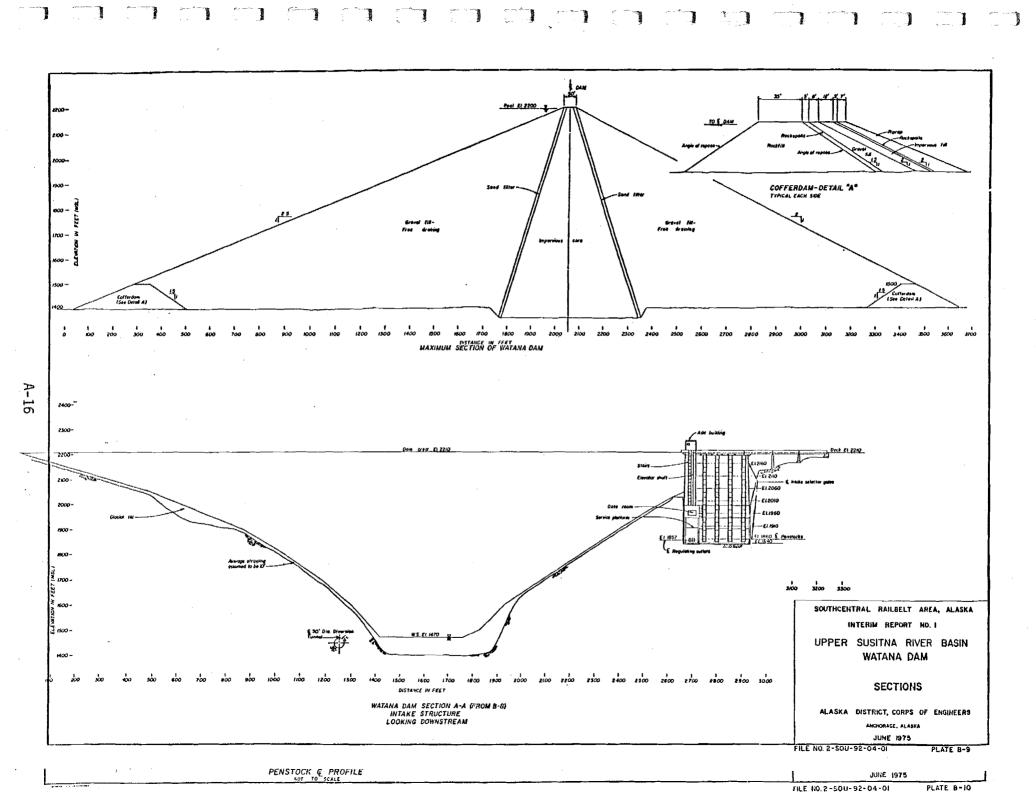
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PLATE 8-7

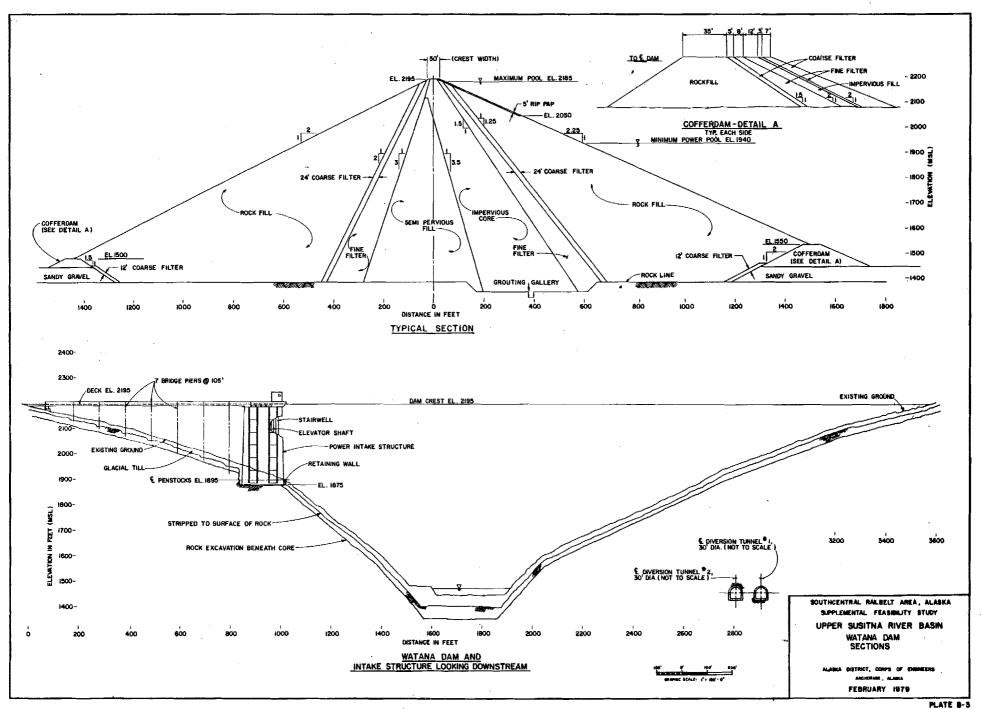


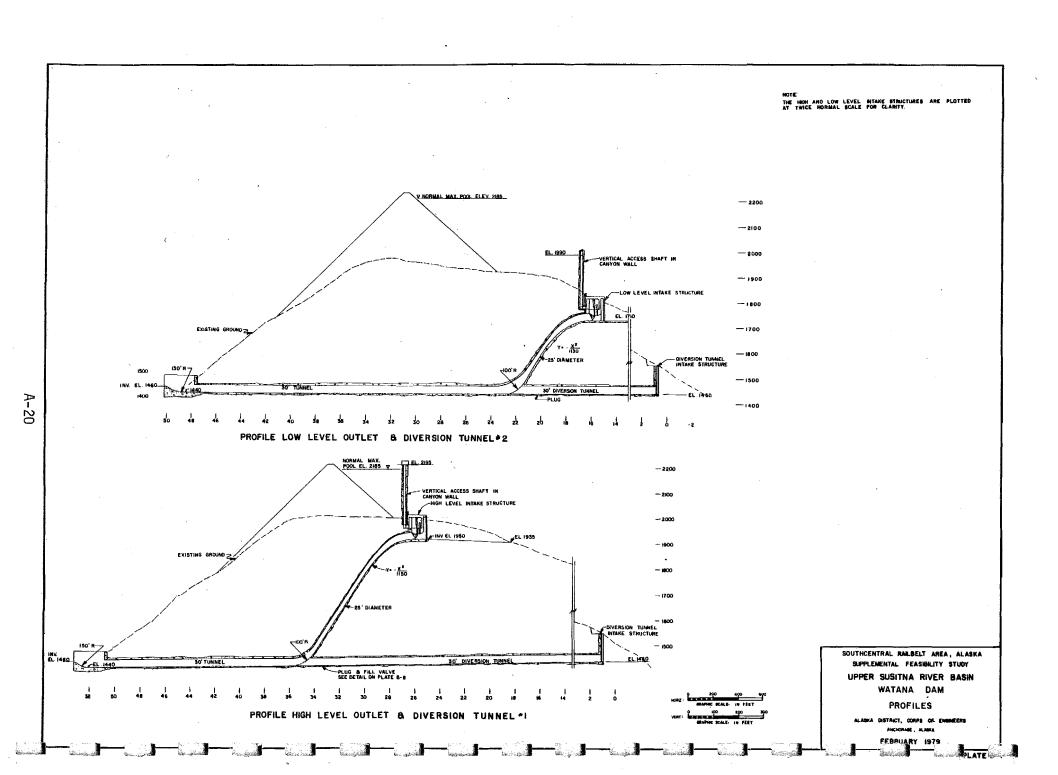


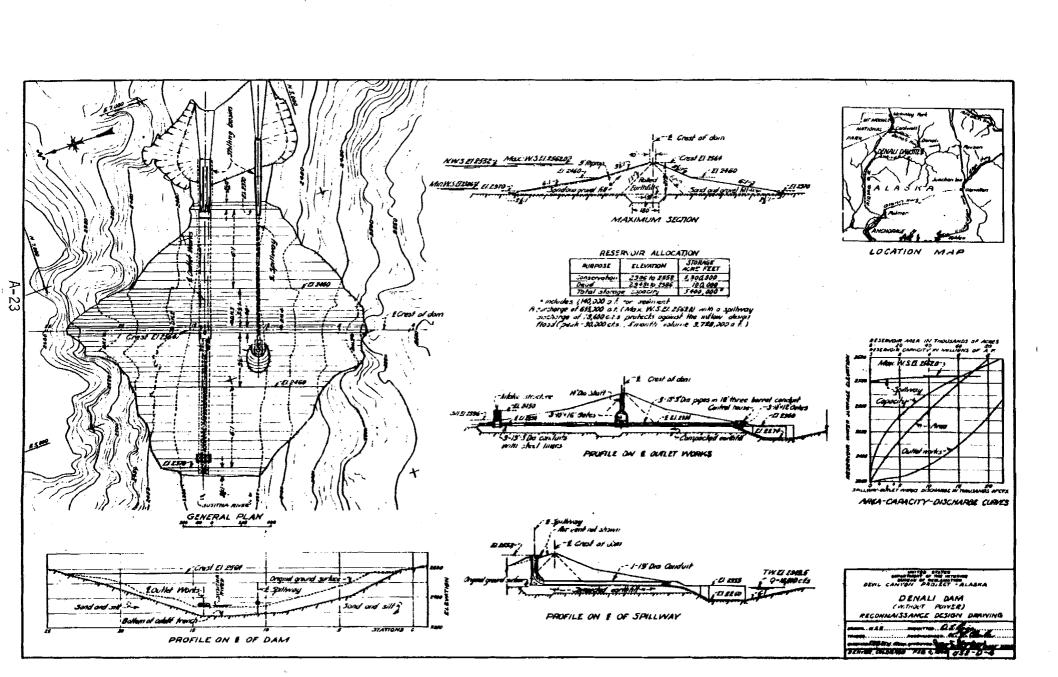


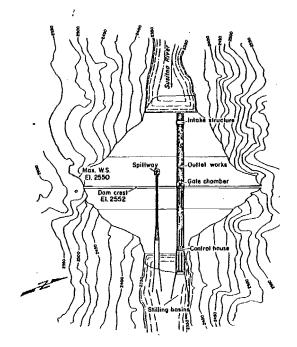


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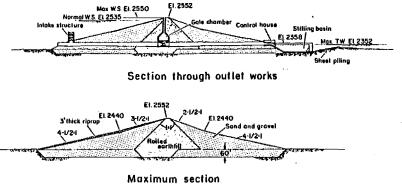


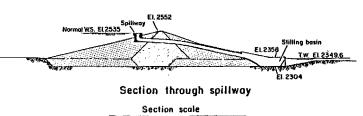






General damsite plan
Scale

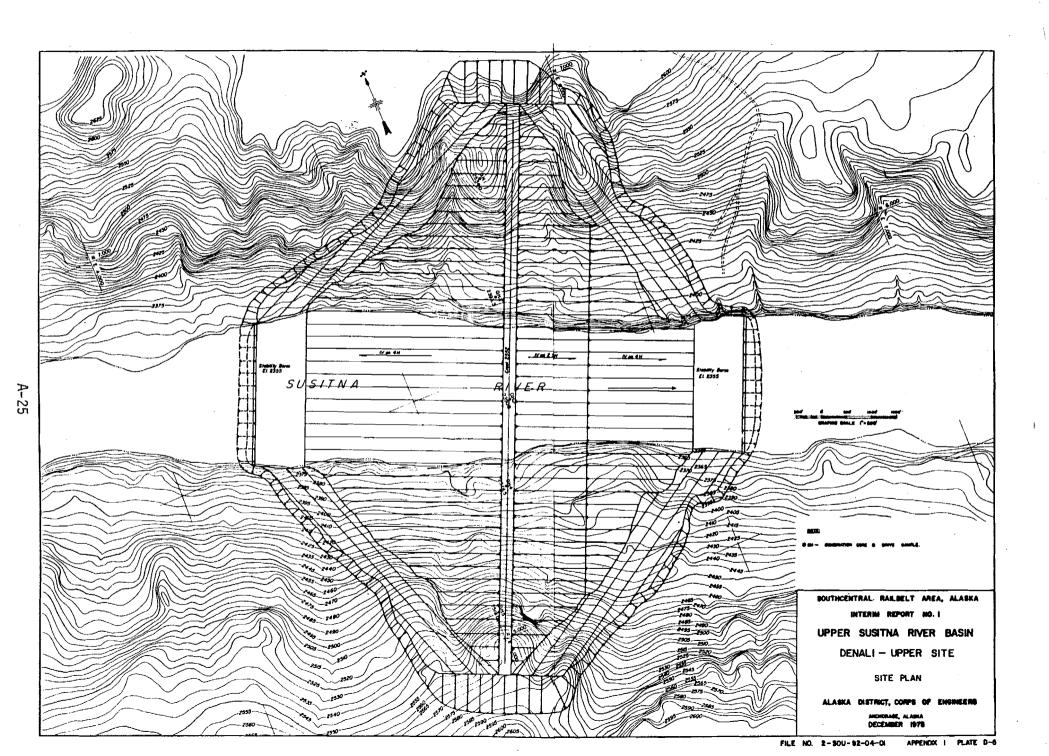




U.S. DEPARTMENT OF THE INTERIOR ALASKA POWER ADMINISTRATION

**DENALI DAM** 

PLAN & SECTIONS



## APPENDIX B

CORPS OF ENGINEERS (7)
CRITERIA FOR EVALUATION OF ALTERNATIVES

#### EVALUATION OF ALTERNATIVES

Selection of the best plan from among the alternatives involves evaluation of their comparative performance in meeting the study objectives as measured against a set of evaluation criteria.

These criteria derive from law, regulations, and policies governing water resource planning and development. The following criteria were adopted for evaluating the alternatives.

#### Technical Criteria:

The growth in electrical power demand will be as projected by the Alaska Power Administration.

That power generation development, from any source or sources, will proceed to satisfy the projected needs.

A plan to be considered for initial development must be technically feasible.

National Economic Development Criteria:

Tangible benefits must exceed project economic costs.

Each separable unit of work or purpose must provide benefits at least equal to its cost.

The scope of the work is such as to provide the maximum net benefits.

The benefits and costs are expressed in comparable quantitative economic terms to the fullest extent possible. Annual costs are based on a 100-year amortization period, an interest rate of 6-1/8 percent, and January 1975 price levels. The annual charges include interest; amortization; and operation, maintenance, and replacement costs.

Power benefits are based on the costs of providing the energy output of any plan by conventional coal-fired thermal generation.

Lovironmental Quality Criteria:

Conservation of esthetics, natural values, and other desirable environmental effects or features.

The use of a systematic approach to insure integration of the natural and social sciences and environmental design arts in planning and utilization.

The application of overall system assessment of operational effects as well as consideration of the local project area.

the study and development of recommended alternative courser of action to any proposal which involved conflicts concerning uses of available resources.

Ivaluation of the environmental impacts of any proposed action, including effects which cannot be avoided, alternatives to proposed actions, the relationship of local short-term uses and of long-term productivity, and a determination of any irreversible and irretrievable resource commitment.

Avoidance of detrimental environmental effects, but where these are unavoidable, the inclusion of practicable mitigating features.

Social Well-Being and Regional Development Considerations:

In addition to the basic planning criteria, consideration was given to:

The possibility of enhancing or creating recreational values for the public;

The effects, both locally and regionally, on such items as income, employment, population, and business;

The effects on educational and cultural opportunities;

The conservation of nonrenewable resources.

## APPENDIX C

CORPS OF ENGINEERS 1975
INTERIM FEASIBILITY REPORT (7)
COST DATA

#### WATANA DAM AND RESERVOIR 2200 FEET NORMAL POOL ELEVATION (FIRST-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST (\$1,000)
01 03	LANDS AND DAMAGES RESERVOIR		16,392 9,180
04	DAMS		479,775
	Main Dam Spillway Outlet Works Power Intake	194,172 57,665 44,544 123,298	4/3,//3
07	Construction Facilities	60,096	420 220
07	POWERPLANT	C7 000	439,238
	Powerhouse	67,229	4
	Turbines and Generators	50,649	
	Accessory Electrical and Powerplant Equipment	11,121	
	Tailrace	47,287	
	Switchyard	15,717	
	Transmission Facilities	219,600	
	Construction Facilities	27,635	
08	ROADS AND BRIDGES	27,000	48,875
14	RECREATIONAL FACILITIES		39
19	BUILDINGS, GROUNDS, AND UTIL	ITIES	3,565
20	PERMANENT OPERATING EQUIPMEN	VT	1,800
30	ENGINEERING AND DESIGN	•	39,638
31	SUPERVISION AND ADMINISTRATE	ION	49,498
	TOTAL PROJECT COST		1,088,000

Table B-1 / Appendix I B-20

1

#### DEVIL CANYON DAM AND RESERVOIR 1450 FEET NORMAL POOL ELEVATION (SECOND-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST (\$1,000)
01 <b>03</b>	LANDS RESERVOIRS		1,444 3,456
03	DAMS		219,543
04	Main Dam	140,971	2131373
	Spillway	19,792	
	Power Intakes	42,136	
	Auxiliary Dam	3,897	•
	Construction Facilities	12,747	•
07	POWERPLANT	,	147,977
	Powerhouse	42,702	
	Turbines and Generators	57,808	
	Accessory Electrical and	_	
	Powerplant Equipment	10,475	
	Tailrace	13,921	
•	Switchyard	19,518	
	Construction Facilities	3,553	
80	ROADS AND BRIDGES		8,528
14	RECREATIONAL FACILITIES		512
19	BUILDINGS, GROUNDS, AND UTIL		2,519
20	PERMANENT OPERATING EQUIPMEN	T	1,800
30	ENGINEERING AND DESIGN		26,962
31	SUPERVISION AND ADMINISTRATI	ON	19,259
	TOTAL PROJECT COST		432,000

Table B-2 Appendix I B-21

### WATANA DAM AND RESERVOIR 2200 FEET NORMAL POOL ELEVATION (SECOND-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST (\$1,000)
01 03 04	LANDS AND DAMAGES RESERVOIR DAMS		16,392 9,180 479,775
04	Main Dam Spillway Outlet Works Power Intake Construction Facilities	194,172 57,665 44,544 123,298 60,096	4733773
07	POWERPLANT  Powerhouse  Turbines and Generators  Accessory Electrical and	67,229 50,649	232,305
	Powerplant Equipment Tailrace Switchyard Transmission Facilities	11,121 47,287 15,717 12,667	
08 14 19	Construction Facilities ROADS AND BRIDGES RECREATIONAL FACILITIES BUILDINGS, GROUNDS, AND UTIL	27,635 .ITIES	26,137 39 3,565
20 30 31	PERMANENT OPERATING EQUIPMENT ENGINEERING AND DESIGN SUPERVISION AND ADMINISTRATI	<b>1T</b>	1,800 30,142 37,665
	TOTAL PROJECT COST		837,000

Table B-3 Appendix I B-22

#### DEVIL CANYON DAM AND RESERVOIR 1450 FEET NORMAL POOL ELEVATION (FIRST-ADDED)

ACCOUNT NO.	ITEM		FEATURE COST (\$1,000)
01	LANDS		1,444
03	RESERVOIRS		3,456
04	DAMS	340 073	236,728
	Main Dam	140,971	
	Spillway	19,792	
	Power Intakes	42,136	
	Auxiliary Dam	3,897	
07	Construction Facilities	29,932	250 700
07	POWERPLANT	40 702	359,700
	Powerhouse	42,702	
	Turbines and Generators	57,808	
	Accessory Electrical and	10 475	
	Powerplant Equipment Tailrace	10,475 13,921	
		19,518	
	Switchyard Transmission Facilities	206,933	
	Construction Facilities	8,343	
00	ROADS AND BRIDGES	0,343	31,266
08 14	RECREATIONAL FACILITIES		51,200
19	BUILDINGS, GROUNDS, AND UTIL	TTIFS	2,519
20	PERMANENT OPERATING EQUIPMEN		1,800
30	ENGINEERING AND DESIGN	•	44,648
31	SUPERVISION AND ADMINISTRATION	กพ	31,927
J.	Co. Englosed find fibrialized little	<b>-</b>	01,521
	TOTAL PROJECT COST		714,000

Table B-4 Appendix I B-23

#### DETAILED COST ESTIMATE

#### WATANA DAM AND RESERVOIR ELEVATION 2200

#### JANUARY 1975 PRICE LEVEL

#### (FIRST-ADDED)

Cost	•				
Account				Unit	Total
Number	Description or Item	Unit	Quant	Cost	Cost
				(\$)	(\$1,000)
	•		÷		
01	LANDS AND DAMAGES				
	Reservoir				
	Public domain	AC	18,600	323.00	(6,008)
	Private land	AC	30,000	317.00	9,510
	Site and other	ΛC	1,080	500.00	540
	Access road	AC	. 780	615.00	480
	Transmission facilities				
	Public domain	AC	4,400	300.00	(1,320)
	Private land	ΛC	3,795	620.00	2,352
	Recreation	AC	90	500.00	45
	Subtotal				20,255
	Contingencies 20%				4,051
	Government administrative	costs			880
					370
•	TOTAL LANDS AND DAMAGES				(25,186)
	Construction cost				16,392
	Economic cost				(8,794)
					(0,7547
03	RESERVOIR				
	Clearing	AC	5,100	1,500.00	7,650
	Contingencies 20%		-	•	1,530
	TOTAL, RESERVOIR				9,180
04	DAMS				
04.1	MAIN DAM				
	Mobilization and				
	preparatory work	LS			23,000
	Clearing	ΛC	860	1,500.00	1,290
	Foundation preparation	SY	105,000	10.00	1,050
	Excavation		,		~,~~
	Foundation	CY	1,800,000	3.50	6,300
	Borrow and quarry areas	LS	_,,		3,000
	Embankment				5,000
	Gravel fill	CY	39,200,000	1.65	64,680
	Sand filter	CY	1,100,000	8.00	8,800
	Second filter	CY	1,000,000	4.00	4,000
	Impervious core	CY	9,250,000	3.75	34,688
	Riprap	CY	280,000	10.00	2,800
	Select drain	CY	1,800,000	4.00	7,200
Table			_,,	7.00	7,200
Table	υ-υ υ-υ				

#### WATANA DAM AND RESERVOIR

Cost				11-1-6	Total
Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Cost (\$1,000)
04	DAMS				
04.1	MAIN DAM (Cont'd) Drilling and grouting	LF	145,000	18.75	2,719
	Drainage system Right abutment scepage	LS			283
	control	LS			2,000
	Subtotal			,	161,810
	Contingencies 20%				32,362
	TOTAL, MAIN DAM				194,172
04.2	SPILLWAY				
	Clearing and stripping	AC	150	1,500.00	<b>22</b> 5
	Foundation preparation	CY	8,500	16.00	136
	Excavation	CY	10,530,000	3.00	31,590
	Concrete	-	27 22	50.00	
	Mass	CY	97,000	50.00	4,850
	Structura1	CY	15,100	325.00	4,908
	Cement	Cwt	240,000	4.00	960
	Reinforcing steel	Lbs	1,510,000	. 60	906
	Anchor bars	Lbs	37,000	1.25	46
	Drilling and grouting	LF	6,200	21.50	133
	Drainage system	LS			250
	Tainter gates (3),			•	
	complete	LS			3,250
	Stoplogs (1 set)	LS			300
	Electrical and				
	mechanical work	LS			500
	Subtotal				48,054
	Contingencies 20%				9,611
	TOTAL, SPILLWAY		r		57,665
04.3	OUTLET WORKS				
	Intake structure	•			
	Excavation rock	CY	41,000	15.00	615
	Foundation preparation	SY	8,000	10.00	80
	Concrete		•		
	Mass	CY	20,400	50.00	1,020
	Structural	CY	18,500	325.00	6,013
	Cement	Cwt	82,000	4.00	328
	Reinforcing steel	Lbs		.60	1,833
			•		-,~~

#### WATANA DAM AND RESERVOIR

Cost					_
Account Number	Description or Item	Unit	Quant	Unit Cost	Total Cost
MINIOCI	bescription of frem	OHILL	Quant	(\$)	(\$1,000)
04 04.3	DAMS OUTLET WORKS (Cont'd)				
04.5	Electrical and				
	mechanical work	LS			100
	Gate bonnets	EA	4	133,000.00	532
	Gate frames	EA	4	130,000.00	520
	Cates (slide)	EA	4	285,000.00	1,140
•	Trash racks	EA	4	96,000.00	384
	Tainter gates	EA	4	395,000.00	1,580
	Excavation				_
	Tunnels	CY	95,300	125.00	11,913
	Concrete	CY	21,700	300.00	6,510
	Cement	Cwt	100,000	4.00	400
	Reinforcing steel	Lbs	4,790,000	.60	2,874
•	Elevator	LS LS	1		200
	Stairs Steel sets & lagging	Lbs	240 000	1.00	100
	Rock bolts	EA	349,000 3,700	170.00	349 629
	NOCK DOILS	140	3,700	170,000	029
	Subtotal				37,120
	Contingencies 20%				7,424
	TOTAL, OUTLET WORKS				44,544
04.4	POWER INTAKE WORKS		•		
	Intake structure				
	Excavation	CY	222,000	15.00	3,330
	Foundation preparation	SY	3,700	10.00	37
	Mass concrete	CY	39,500	50.00	1,975
	Structural concrete	CY	69,200	325.00	22,490
	Cement	Cwt	376,000	4.00	1,504
	Restecl	Lbs	4,839,000	.60	2,904
	Emb. metal	Lbs	35,000	3.00	105
	Trash rack	LS	1		2,000
	Stairs	LS	1		75
	Elevator Bulkhead gates	LS LS	1		200
	Stoplogs	LS	1 1		1,500
	Electrical and	0	1		1,500
	mechanical work	LS	1	•	1,600
	Truck crane	ĹS	ī		225
	Bridge	LS	ī		2,500
	Trash boom	LS	1		300
	Tunnel excavation	CY	79,000	125.00	9,875

#### WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
04	DAMS			<b></b> ,	
04.4	POWER INTAKE WORKS (Cont'	a١			
	Concrete	CY	16,650	300.00	4,995
	Cement	Cwt	84,000	4.00	336
	Resteel	Lbs	3,745,000	.60	2,247
	Steel liner		21,000,000	2.00	42,000
	Bonnetted gates	LS	,,		900
	Electrical and				
	mechanical work	LS			150
	Subtotal				102,748
	Contingencies 20%				20,550
	TOTAL POWER INTAKE WORKS				123,298
	TOTAL DAMS				419,679
07 07.1	POWERPLANT POWERHOUSE				
	Mobilization and	TC	1		2 500
	preparatory work	LS CY	1 202,000	110.00	3,500
	Excavation, rock Concrete	CY	57,600	325.00	22,220 18,720
	Cement	Cwt	261,000	4.00	1,044
	Reinforcing steel	Lbs	5,228,000	.60	3,137
	Architectural features	LS	3,220,030		1,000
	Elevator	LS -			200
	Mechanical and				
	electrical work	LS			3,300
	Structural steel	Lbs	1,250,000	1.50	1,875
	Miscellaneous metalwork Draft tube bulkhead	Lbs	150,000	3.00	450
	gates	LS			380
	Rock holts	EA	563	170.00	96
	Steel sets	Lbs	102,000	1.00	102
	Subtotal Contingencies 20%				56,024 11,205
	one angunace son				11,200
	TOTAL, POWERHOUSE				67,229

#### WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
07 07. 2	POWERPLANT (Cont <sup>†</sup> d) TURBINES AND GENERATORS Turbines Governors Generators	LS LS LS			20,608 765 20,834
	Subtotal Contingencies 20%				42,207 8,442
	TOTAL, TURBINES AND GENERAT	ors			50,649
07.3	ACCESSORY ELECTRICAL EQUIP Accessory Electrical Equipment Contingencies 20%	MENT LS			4,065 813
	TOTAL, ACCESSORY ELECTRICAL	. EQUIPME	NT		4,878
07.4	MISCELLANEOUS POWERPLANT E	EQUIPMENT			
	Equipment Contingencies	LS			5,202 1,041
	TOTAL, MISCELLANEOUS POWERE	PLÁNT EQU	IPMENT		6,243
07.5	TAILRACE Excavation, tailrace tunnel		223,000	125.00	27,875
	Concrete, tailrace tunnel lining Cement Reinforcing steel Rock bolts Steel sets	CY Cwt Lbs 5, EA	21,000 104,000 202,000 3,400 115,000	300.00 4.00 .60 170.00	6,300 416 3,122 578 1,115
	Subtotal Contingencies 20%			·	39,406 7,181
	TOTAL, TAILRACE				47,287
07.6	SWITCHYARD Transformers Insulated cables	LS LS			5,826 1,030

#### WATANA DAM AND RESERVOIR

Cost Account				Unit	Total
Number	Description or Item	Unit	Quant	Cost (\$)	Cost (\$1,000)
07	POWERPLANT			. ,.	
07.6	SWITCHYARD (Cont'd) Switchyard	LS			6,241
	Subtotal Contingencies 20%				13,097 2,620
				1	
	TOTAL, SWITCHYARD				15,717
07.8	TRANSMISSION FACILITIES				
	Transmission Facilities Contingencies 20%	LS			183,000 36,600
	TOTAL, TRANSITISSION FACILIT	IES .	,		219,600
	TOTAL, POWERPLANT				411,603
08	ROADS AND BRIDGES Permanent Access Road - 27 (Highway No. 3 to Devil Ca				
	Clearing	AC	135	1,500.00	203
	Excavation	CY	210,000	6.20	1,302
	Embankment	CY	885,000	2.00	1,770
	Riprap	CY	2,700	30.00	81
	Road surfacing (crushed)	CY	216,000	12.00	2,592
	Bridges	LS	1		10,000
	Culverts and guardrail Permanent Access Road - 37	LS mile	:s		3,000
	(Devil Canyon to Watana)		105	1 500 00	20.2
	Clearing Excavation	AC CY	195 360,000	1,500.00 6.20	293
	Embankment	CY	1,244,000	2.00	2,232 2,488
	Riprap	CY	3,800	30.00	114
	Road surfacing (crushed)	CY	304,000	12.00	3,648
	Bridges	LS			3,700
	Culverts and guardrail	LS	1		1,585
	Permanent on-site roads Power plant access			•	·
	tunnel	LS	1		5,096
	Power plant access road	LS	1		1,515
	Dam crest road	LS	1		80

TABLE B-5 --DETAILED COST ESTIMATE--Continued
WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
				, , , ,	.,-,,
08	ROADS AND BRIDGES (Cont'd)		,		200
	Spillway access road Switch yard access road	LS LS	1		380 200
·	Road to operating	20	<b>±</b>		200
	facility	LS	1.		200
	Power intake structure		_		
	access road	LS	1		250
	Subtotal				40,729
-	Contingencies 20%				8,146
	TOTAL, ROADS AND BRIDGES		•		48,875
14	RECREATION FACILITIES				
•	Site D				x*
	Camp units (tent camp)	EA	10	1,800.00	18
•	Vault toilets	EA	2	2,000.00	4
	Subtotal		•		22
	Contingencies 15%			•	3
	Total Site D				25
	Site E				
	Trail system	MI	12	1,000.00	12
	Contingencies 15%	•			2
	Total Site E				14
	TOTAL, RECREATION FACILITY	IES			39
19	BUILDINGS, GROUNDS, AND U	TILITIES			
	Living quarters and				
	0&M facilities	LS			1,631
	Visitor facilities	LS			100
	Visitor building Parking area	SF	12,000	3.00	100
	Boat ramp	LS	12,000	3.00	36 200
	Vault toilets	EA	2	2,000.00	4
	Runway facility	LS	1	2,000	1,000
	Subtotal				2,971
	Contingencies 20%				594
	TOTAL, BUILDINGS, GROUNDS,	, AND UT	ILITIES		3,565

#### WATANA DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
20	PERMANENT OPERATING EQUIPM Operating Equipment				·
	and Facilities Contingencies 20%	LS	1		1,500 300
	TOTAL, PERMANENT OPERATING	EQUIE	PMENT		1,800
50	CONSTRUCTION FACILITIES Diversion tunnels		•		
	Excavation	CY	281,000	115.00	32,315
	Concrete	CY	48,750	275.00	13,407
	Cemont	Cwt	244,000	4.00	•
			•		976
	Resteel		11,544,000	. 60	6,927
	Steel sets and lagging	Lbs	1,404,000	1.00	1,404
	Rock bolts	EA	7,800	170.00	1,326
	Diversion outlet works				
	Excavation	CY	14,000	15.00	210
	Concrete	CY	7,500	325.00	2,438
	Cement	Cwt	30,000	4.00	120
	Resteel	Lbs	1,500,000	. 60	900
	Anchors	LS	1		500
	Diversion inlet works				
	Excavation	CY	43,000	15.00	645
	Concrete	CY	16,500	325.00	5,363
	Cement .	Cwt	58,000	4.00	232
	Resteel	Lbs	2,475,000	.60	1,485
	Gate frames and gates	LS	1		861
	Diversion tunnel plug	LS	ī		3,000
	Care of water	LS	1		
	Cale or water	20	<b>.</b>		1,000
	Subtotal				70 100
					73,109
	Contingencies 20%				14,622
	TOTAL, CONSTRUCTION FACILI	TIES			87,731
	TOTAL CONSTRUCTION COST				998,864
30	ENGINEERING AND DESIGN			•	39,638
31	SUPERVISION AND ADMINISTRA	TION			49,498
	TOTAL PROJECT COST WATANA DAM AND RESERVOIR ELEVATION 2200 (First-Added)				L,088,000

#### DETAILED COST ESTIMATE

#### DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450

#### JANUARY 1975 PRICE LEVEL

#### (SECOND-ADDED)

	,				
Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
01	LANDS AND DAMAGES				
	Reservoir				
	Public domain	AC	8,350	300.00	(2,505)
	Private land	AC	850	300.00	255
	Site and other	AC	250	600.00	1.50
	Recreation	AC	740	600.00	440
	Subtotal				3,350
	Contingencies 20%			* /	670
	Government administrative	cost			430
	TOTAL, LANDS AND DAMAGES				(4,450)
	Construction cost				1,444
	Economic cost				(3,006)
03	RESERVOIR				
	Clearing	ΛC	1,920	1,500.00	2,880
	Contingencies 20%				576
	TOTAL, RESERVOIR		·		3,456
04	DAMS				
04.1	MAIN DAM	•			
	Mobilization and				
	preparatory work Prevention of water	LS			24,300
	pollution	LS			500
	Scaling of canyon walls Excavation	CY	21,000	75.00	1,575
	Exploratory tunnels	CY	3,500	190.00	665
•	Dam	CY	327,000	15.00	4,905
	Foundation treatment	CY	3,000	60.00	180
	Drilling line holes for				
	rock excavation	LF	34,000	4.60	156
	Drilling and grouting	LF	64,000	22.00	1,408
	Drainage holes	LF	29,570	15.30	452
	Concrete				_
	Dam	CY	994,000	50.00	49,700
	Thrust block	CY	25,600	60.00	1,536
7.13	Foundation treatment	CY	3,000	125.00	<b>3</b> 75
Table Append B-32	ix I				

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

	•				
Cost Account Number	Description or Item	Unit	Quant	Unit Cost	Total Cost
	•			(\$)	(\$1,000)
04	DAMS				
04.1	MAIN DAM (Cont'd)				
<b></b>	Foundation, mass	CY	15,250	50.00	763
	Structural	CY	10,240	325.00	3,328
	Cooling concrete	LS	10,240	323.00	2,000
	Contraction joint and				2,000
u.	cooling system				
	grouting	LS			1,135
	Cement	Cwt	3,779,000	4.00	15,116
	Pozzolan	Cwt	922,000	3.00	2,766
	Reinforcing steel	Lbs	1,200,000	.60	720
	Gates		, .	,	
	Slide gates, frames,				
	guides, and operators	EA	4	345,000.00	1,380
	Miscellaneous			•	,,,
	High strength steel				
	strands	Lhs	290,000	2.00	580
	larthquake anchorages	LS			500
	Gantry crane	LS			385
		Lbs	39,000	1.00	39
	Elevators	LS			280
	Stairways	Lbs	105,500	5.20	549
	Instrumentation	LS			115
	Rock bolts	LF	50,000	10.70	535
	Chain-link fence	LF	1,535	15.00	23
	Electrical and	7.0			
	mechanical work Miscellaneous metalwork	LS	170 000	2 00	1,000
	Miscellaneous metalwork	LS.	170,000	3.00	510
	Subtotal				117 /7/
	Contingencies 20%				117,476
	conclude to Low		•		23,495
	TOTAL, MAIN DAM				140,971
04.2	SPILLWAY				
	Excavation, all classes	CY	239,000	15.00	3,585
	Foundation preparation	SY	7,520	10.00	75
	Drilling and grouting	LF	8,000	25.00	200
	Anchor bars	LF	48,000	1.25	60
	Drainage system	LS	1	_ <b></b> ,	500
	Concrete				
	Mass	CY	37,000	50.00	1,850
	Structural	CY	12,000	325.00	3,900
	Cement	Cwt	152,000	4.00	608

TABLE B-6 --DETAILED COST ESTIMATE--Continued
DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
04	DAMS				•
04.2	SPILLWAY (Cont'd)		•		
ı	Reinforcing steel Tainter gates and	Lbs	1,191,000	.60	715
	hoists, complete	EA	2	2,000,000.00	4,000
	Stoplogs, complete Miscellaneous	Set	1		500
	Electrical and				
	mechanical work	LS			500
	Subtotal			•	16,493
	Contingencies 20%				3,299
	TOTAL, SPILLWAY				19,792
04.4	POWER INTAKE WORKS		•		
	Excavation	CV.	7 200	15.00	100
	Open cut	CY CY	7,200 34,400	15.00	108
	Tunnels Concrete	CI	34,400	125.00	4,300
	Mass	CY	7,300	55.00	402
	Structural and backfill	CY	10,430	325.00	3,390
	Cement	Cwt	74,000	4.00	296
•	Reinforcing steel	Lbs	1,070,000	.60	642
	Penstocks	Lbs	8,175,000	2.00	16,350
	Bonnetted gates and		.,,		20,500
	controls	EA	5	1,375,000.00	6,875
	Stoplogs, complete	LS		•	914
	Trashracks	Lbs	1,224,000	1.50	1,836
	Subtotal				35,113
	Contingencies 20%	•			7,023
	TOTAL, POWER INTAKE WORKS				42,136
04.5	AUXILIARY DAM (EARTH FILL)	)		•	
	Excavation  Dam foundation	CY	110,000	3.50	385
	Foundation preparation	LS	1	٥٠.٠	40
	Dam embankment	CY	760,000	2.25	1,710
	Drilling and grouting	LF	8,800	46.60	410
	Concrete	CY	5,400	120.00	648

#### DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
04 04.5	DAMS AUXILIARY DAM (EARTH FILL) Coment	Cont	'd) 13,500	4.00	54
	Subtotal Contingencies 20%				3,247 650
	TOTAL, AUXILIARY DAM				3,897
•	TOTAL, DAMS				206,796
07	POWERPLANT POWERHOUSE Mobilization and preparatory work Excavation, rock Concrete Coment Reinforcing steel Architectural features Elevator Mechanical and electrical work Structural steel Miscellaneous metalwork Subtotal Contingencies 20% TOTAL, POWERHOUSE	LS CY CWt Lbs LS LS Lbs Lbs	1 120,000 20,000 100,000 4,600,000	110.00 325.00 4.00 .60	5,000 13,200 6,500 400 2,760 1,000 75 4,400 1,800 450 35,585 7,117
07.2	TURBINES AND GENERATORS Turbines Governors Generators Subtotal Contingencies 20%	LS LS			22,575 2,546 23,052 48,173 9,635
	TOTAL, TURBINES AND GENERAL	CORS		Append B-35	

#### DEVIL CANYON DAM AND RESERVOIR

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
07 07.3	POWERPLANT  ACCESSORY ELECTRICAL EQUIT  Accessory Electrical  Equipment  Contingencies 20%	PMENT LS			6,600
	TOTAL, ACCESSORY ELECTRICAL	L EQUI	PMENT		1,320 7,920
07.4	MISCELLANEOUS POWERPLANT I	EQUIPM	ENT		
	Equipment Contingencies 20%	LS		· · · · · · · · · · · · · · · · · · ·	2,129 426
	TOTAL, MISCELLANEOUS POWER	PALNT	EQUIPMENT		2,555
07.5	TAILRACE Excavation tunnel Concrete Coment Rosteel Draft tube bulkhead	CY CY Cwt Lbs	37,000 13,800 69,000 3,163,000	125.00 300.00 4.00 .60	4,625 4,140 276 1,898
	gates Draft tube stoplogs	LS LS	1		378 284
	Subtotal Contingencies 20%				11,601 2,320
	TOTAL, TAILRACE				13,921
07.6	SWITCHYARD Transformers Insulated cables Switchyard	LS LS LS			5,967 1,372 8,926
	Subtotal Contingencies 20%				16,265 3,253
	TOTAL, SWITCHYARD TOTAL, POWERPLANT				19,518 144,424
08	ROADS AND BRIDGES On-site road Clearing and earthwork Paving	Mile Mile		200,000.00 72,000.00	460 166

#### DEVIL CANYON DAM AND RESERVOIR

Cost Account				Unit	Total
Number	Description or Item	Unit	Quant	Cost (\$)	Cost (\$1,000)
08	ROADS AND BRIDGES (Cont'd)				
	Culverts Tunnel Road to operating	lf Lf	850 2,100	39.00 2,975.00	33 6,248
•	facility	Mile	2	100,000.00	200
	Subtotal Contingencies 20%				7,107 1,421
	TOTAL, ROADS AND BRIDGES				8,528
14	RECREATION FACILITIES Site A	,			
,	(Boat access only) Boat dock	EA	1	25,000.00	25
	Camping units	EA	10	1,800.00	18
	Two-vault toilets	EA	. 2	2,000.00	4
	Subtotal Contingencies 15% Total Site A				47 7 54
			·	,	
	Site B	Mile	0.5	100 000 00	50
	Access road Overnight camps	EA	50	100,000.00 2,500.00	50 125
	Comfort stations	EA	2	35,000.00	70
	Power	LS	_	25,000.00	25
	Sewerage	LS		50,000.00	50
	Subtotal				320
	Contingencies 15%				48
	Total Site B				368
	Site C Trailhead picnic area			. 100 000 00	22
	access road Picnic units w/parking	Mile EA	0.2 12	100,000.00	20 24
	Trail system	Mile	30	1,000.00	30
	Two-vault toilets	EA	2	2,000.00	4
	Subtotal				78
	Contingencies 15%				12
	Total Site C				90
	TOTAL, RECREATION FACILITI	ES			512

TABLE B-6 --DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR

Cost					
Account	Decembrica on Item	11-1+	Quant	Unit	Total
Number	Description or Item	Unit	Quant	Cost (\$)	Cost (\$1,000)
			•	(4)	(41,000)
19	BUILDINGS, GROUNDS, AND U	TILITIE	ES		
	Living quarters and				
	O&M facilities	LS.		•	1,700
	Visitor facilities				
	Visitor building	LS			200
	Parking area	SF	15,000	3.00	45
	Boat ramp	LS			150
	Vault toilets	EA	2	2,000.00	4
	Subtotal				2,099
	Contingencies 20%				420
,	:				420
	TOTAL, BUILDINGS, GROUNDS	, AND U	TILITIES		2,519
20	PERMANENT OPERATING EQUIPM	MENT			,
	Operating Equipment				
	and Facilities	LS	1		1,500
	Contingencies 20%				300
	TOTAL, PERMANENT OPERATING	G EQUIP	MENT		1,800
					·
50	CONSTRUCTION FACILITIES				
	Coffer dams .				
	Sheet pile	Ton	1,024	1,000.00	1,024
	Earthfill	CY	38,000	5.00	190
	Diversion works				
	Tunnel				
	Excavation	CY	32,000	115.00	3,680
	Concrete	CY	5,750	275.00	1,582
	Cement	Cwt	29,000	4.00	116
	Resteel	Lbs	1,323,000	.60	794
	Steel sets	Lbs	157,000	1.25	197
	Rock bolts	EA	1,150	170.00	196
	Diversion intake structure Rock excavation	CY	6 000	15 00	100
	Structural concrete	CY	6,800	.15.00	102
	Cament	Cwt	3,800 150,000	325.00	1,235
	Rosteel	Lbs	750,000	4.00 .60	60 450
	Gates and frames	LS	750,000	.00	450 860
	Diversion outlet structur		T	•	000
	Rock excavation	CY	6,800	15.00	102
	Concrete	CY	3,800	325.00	1,235
	Cement	Cwt	15,000	4.00	60
	5	~ <b>~</b>	20,000	7.00	60

# TABLE B-6 --DETAILED COST ESTIMATE--Continued DEVIL CANYON DAM AND RESERVOIR

Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
50	CONSTRUCTION FACILITIES ( Restect Anchors Care of water	Cont'd) Lbs LS LS	750,000 1 1	.60	450 250 1,000
	Subtotal Contingencies 20%	ι			13,583 2,717
	TOTAL, CONSTRUCTION FACIL	ITIES	•		16,300
	TOTAL, CONSTRUCTION COST				385,779
30	ENGINEERING AND DESIGN				26,962
31	SUPERVISION AND ADMINISTR	ATION			19,259
	TOTAL PROJECT COST DEVIL CANYON DAM AND RESE ELEVATION 1450 (SECOND-ADDED)	RVOIR			432,000

# SUMMARY COST ESTIMATES--OTHER PROJECTS STUDIED JANUARY 1975 PRICE LEVEL (Costs in \$1,000)

	PROJECT FULL POOL ELEV. (Ft., m.s.l.) CONST. SEQUENCE (Added)	DENAL I 2535 (Second)	YEE 2300 (Second)	VEE 2350 (Second)	HIGH D.C. 1750 (First)	WATANA 1905 (First)	WATANA 1905 (Second)	WATANA 2050 (First)	WATANA 2050 (Second)
ACCOUNT NO.	PROJECT FEATURE			•					4
01 02	LANDS AND DAMAGES RELOCATIONS	7,000 13,000	2,550	3,495	8,400	4,381	4,381	12,050	12,050
03 04	RESERVOIR DAM	4,800 237,017	3,165 203,170	5,160 225,500	7,650 574,900	5,100 165,058	5,100 165,058	7,920 287,229	7,920 287,229
07 08	POWERPLANT ROADS AND BRIDGES	1,500	143,788 19,968	159,600 20,748	450,478 34,511	313,076 47,587	106,143 24,849	360,721 48,231	153,788 25,493
14 19	RECREATIONAL FACILITIES' BUILDINGS, GROUNDS, AND UTILITIES	39 3,565	39 3,565	39 3,565	512 3,565	39 3,565	39 3,565	39 3,565	39 3,565
20 ′ <b>3</b> 0-31	PERMANENT OPERATING EQUIPMENT ENGINEERING AND DESIGN -	1,800	1,800	1,800	1.800	1,800	1,800	1,800	1,800
50	SUPERVISION AND ADMINISTRATION CONSTRUCTION FACILITIES	36,279 35,000	48,855 50,100	53,093 54,000	104,184 80,000	62,638 64,756	44,309 64,756	79,419 76,026	60,090 76,026
	TOTAL PROJECT COST	340,000	477,000	527 000	1,266,000	668,000	420,000	877,000	628,000

#### APPENDIX D

CORPS OF ENGINEERS 1979
SUPPLEMENTARY FEASIBILITY REPORT (8)
COST DATA AND SCHEDULE

# TABLE B-1--DETAILED COST ESTIMATE WATANA DAM AND RESERVOIR ELEVATION 2185 OCTOBER 1978 PRICE LEVEL (FIRST-ADDED)

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
01	LANDS AND DAMAGES Reservoir Public domain Private land Site and other Access road Transmission facilities Recreation Mining claims	AC AC AC AC AC AC EA	2,560 99,170 1,080 780 3,965 90	195.00 186.00 185.00 186.00 965.00 222.00 8,000.00	500 18,446 200 145 3,826 20 32
•	Subtotal Contingencies 20% Government administrative	costs			23,169 4,634 880
	TOTAL LANDS AND DAMAGES Construction cost Economic cost				(28,683) 28,000 ( 500)
03	RESERVOIR Mob and Prep Clearing Contingencies 20%	LS AC	1 5,100	800.00	204 4,080 857
	TOTAL, RESERVOIR			**	5,000
04 04.1	DAMS MAIN DAM Excavation common Left abutment Right abutment River channel	CY CY CY	1,466,000 1,292,000 1,547,000	5.00 5.00 5.00	7,330 6,460 7,735
•	Rock Excavation Left abutment Right abutment River channel Drainage system Foundation preparation Drilling-grouting	CY CY CY LF SY	616,000 428,000 198,000 135,000 114,000 145,000	18.00 18.00 18.00 35.00 35.00 50.00	11,088 7,704 3,564 4,725 3,990 7,250
	Care of water and pumping Mobilization and Prepa-	ĻS	1	•	2,000
•	tory work Instrumentation Clearing grubbing	LS LS - AC	111	3,500.00	19,000 960 389

Cost Account			•	Unit	Total
Number .	Description or Item	Unit	Quant .	Cost (\$)	Cost (\$1,000)
04	DAMS		• ;.	· •	•
04.1	MAIN DAM (Cont'd) Embankment			•	
	Semi Pervious				•
	From stockpile	CY	1,335,000	3.50	4,673
	From req. excavation	CY	4,743,000	1.00-	4,743
	Impervious				
	From req. excavation	CY	3,342,000	1.00	3,342
	From borrow	CY	4,031,000	4.00	16,124
•	Rock		•		•
	From abutments				
	*Req.cexcavation	CY	1,123,000	.75	842
•	Stockpile	CY	420,000	3.25	1,365
•	From Spillway Req. exca	.CY	13,693,000	.75	10,270
	From roads (stockpile)	CA .	2,348,000	3.25	7,631
	From grout gallery	CY	36,000	.75	27
	From stockpile misc.	CY	800,000	3.25	2,600
•	From borrow	CY	17,876,000	9.00	160,884
	Filters from borrow	CY	7,822,000	8.00	65,576
	Riprap	CY	223,000	22.00	4,906
	Grout gallery				•
•	Excavation	CY	26,700	75.00	2,003
•	Concrete (roof-sides)	CY	19,000	375.00	7,125
	Cement	Cwt	87,000	8.00	696
	Reinforcement	LB	6,793,000	.55	3,736
•	Concrete floor steps,		:		
	landings, etc	CY	2,750	500.00	1,375
-	Ventilation				375
	Access tunnel from		•	,	•
	Powerhouse			700.00	
•	Excavation rock	CY	10,768	190.00	2,046
•	Concrete	CY	6,528	600.00	3,917
•	Cement	Cwt	26,109	8.00	209
	Resteel	LB	2,164,000	.55	1,190
	Subtotal				387,850
	Contingencies 15%			•	58,178
•	contingencies 15%	•			20,170
	TOTAL, MAIN DAM			•	446,000
04.2	SPILLWAY		•		
-	Clearing & stripping	AC	158	2,500.00	· 395
		SY	33,700	50.00	1,685
	Excavation		• .		•
•	Common -	CY	10,568,000	2.00	21,136

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
04 04.2	DAMS SPILLWAY Rock	СҮ	10,533,000	8.00	84,264
	Concrete Mass Structural Lining Cement Reinforcement Drill & grout for	CY CY CY Cwt Lb	16,900 9,750 15,600 182,500 1,123,000	100.00 500.00 450.00 8.00 .55	1,690 4,875 7,020 1,460 618
	anchors	LF	17,200	20.00	344
	Tainter gates 1200000# gate hoists Stoplogs (400000#) Spillway bridges	EA LS	3 1, 1	250,000.00	3,750 600
	(55'L by 26'W) (3EA) Drainage Mob-Prep	LS LS LS	] ]. .]		500 2,000 6,517
	Subtotal Contingencies 15%				136,854 20,528
	TOTAL, SPILLWAY	-	•		157,000
04.3	OUTLET WORKS Excavation			•	
•	Common Rock Tunnel 25 Ø	CY CY	35,700 115,400	15.00 50.00	536 5,770
	45° slope Vertical Horizontal Concrete	CY CY	29,400 1,880 4,250	190.00 140.00 125.00	5,586 263 531
	Lining 45° slope Rebar Vertical Rebar Horizontal	CY LB CY LB CY	6,000 322,000 350 14,100 820	600.00 .55 500.00 .55 .300.00	3,600 177 175 8 246
	Rebar Structural Rebar Rockbolts In vertical face	LB CY LB	33,100 9,600 900,000	.55 600.00 .55	18 5,760 495
	Drill & grout bolts (92,200 LB)	LF	21,400	20.00	428

Cost					
Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,00)
04	DAMS		•	•	
04.3	OUTLET WORKS 45° Slope Horizontal	LF LF -	4,800 4,400 496,000	20.00 20.00 3.00	96 88 1,488
	Tainter gates (4) Slide gates (4) Trashracks (2) Cement	LB LB Cwt	2,200,000 64,800 110,700	3.00 2.00 8.00	6,600 130 886
	Elevators (50-ton) Mob and Prep work	LS	2 25 1	50,000.00	500 <b>*</b> 1,700
-	Subtotal Contingencies 20%		•		35,081 7,016
•	TOTAL, OUTLET WORKS		•	•	42,000
04.4	POWER INTAKE WORKS Mob and Prep Work	LS	. 1		9,700
	Intake structure Excavation (rock)	CY SY	222,000 3,700	30.00 50.00	6,66C
	Foundation preparation Mass concrete	CY-	39,500	100.00	3,950
	Structural concrete Cement Resteel	CY Cwt LB	102,900 555,600 9,372,000	500.00 8.00 .55	51,450 4,445 5,155
	Emb. metal Trash rack	LB LB	35,000 938,000	4.50 2.00	158 1,876
	Stairs Elevator	LS LS	1	2.00	100 300 7 720
٠.	Bulkhead gates Stoplogs   Electrical and	LB LB	3,860,000 1,594,000	2.00 2.00	7,720 3,188
•	mechanical work Truck crañe	LS LS	. 1		2,250 300
	Bridge <sub>-</sub> Trash boom	LS LS	. 1	•	3,500 425
	Tunnel excavation Concrete	CY	95,100 35,200	175.00 350.00	16,643 <b>1</b> 2,320
<i>,</i>	Cement Resteel Steel liner	Cwt LB LB	140,800 483,000 24,350,000	8.00 .55 2.70	1,126 266 65,745
	Bornetted gates	EA LS		,800,000.00	5,400 500

Cost Account Number	Description or Item	Urit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
04 04.4	DAMS POWER INTAKE WORKS (Cont Electrical and	'd)			٠
	mechanical work	LS	1		500 <sub>.</sub>
	Subtotal Contingencies 20%				203,862 40,772
•	TOTAL, POWER INTAKE WORKS		•		245,000
	TOTAL DAMS				890,000
. 07	POWERPLANT		•		•
07.1	POWERHOUSE  Mob and prep work  Rock excavation, tunnel	LS s,	. 1		3,000
• ·	P.H. chamber, trans- former chamber, etc Concrete Cement	CY CY Cwt	202,000 57,600 261,000	75.00 500.00 8.00	15,150 28,800 2,038
	Reinforcement Architectural features Elevators	LB LS LS	6,912,000	.55	3,802 1,500 600
	Mechancial and electrical work	LS	1 250 000	2 00	5,000
	Structural steel Misc. Metalwork Draft tube bulkhead	LB LB	1,250,000 150,000	2.00 4.50	2,500 <b>675</b>
	gates - guides Rock bolts Steel sets 600 ton bridge crane	LS - LF LB LS	'8,445. 102,000 1	30.00	750 253 204 1,000 "
	30 ton bridge crane Airshaft (transformer chamber) 3' DIA 880'	LS LS	. 1		250 900
	Subtotal Contingencies 20%	. 20	. •		66,472 13,294
	TOTAL, POWERHOUSE	•	•		80,000

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
07 07.2	POWERPLANT (Cont'd) TURBINES AND GENERATORS Turbines Governors Generators	LS LS LS	] ] ]	(*)	18,900 814 21,600
	Subtotal Contingencies 15%				41,314 6,197
<b>-</b>	TOTAL, TURBINES AND GENERA	TORU	•		48,000
07.3	ACCESSORY ELECTRICAL EQUIPMENT Equipment Contingencies 15%	PMENT LS	1 .		3,532 530
	TOTAL, ACCESSORY ELECTRICAL	L EQUIPME	INT	•	4,000
07.4	MISCELLANEOUS POWERPLANT Miscellaneous Powerplant Equipment Contingencies 15%		1		1,716 257
	TOTAL, MISCELLANEOUS POWER	PLANT EQU	IPMENT	·	2,000
07.5	TAILRACE Mob and Prep Work Tunnel excavation Concrete lining Cement Reinforcement Rock bolts Steel sets	LF	233,000 28,200 112,800 5,202,000 51,000 ,115,000	85.00 250.00 8.00 .55 20.00 1.50	2,400 19,805 7,050 902 2,861 1,020 1,673
•	Outlet Portal Excavation rock Concrete Cement Reinforcement Stoplogs-steel	CY CY Cwt LB LB	2,500 450 1,800 207,000 737,100	75.00 500.00 8.00 .55 1.50	188 225 14 114 1,106
	Tailrace channel Excavation rock Concrete Cement Reinforcement Anchor bars #9	CY. CY Cwt LB LF	176,300 4,425 17,700 177,000 5,700	50.00 300.00 8.00 .55 15.00	8,815 1,328 142 97 86

#### TABLE B-1--DETAILED COST ESTIMATE--Continued

Cost Account Number	Description or Item Unit	Quant	Unit Cost (\$)	Tota! Cost (\$1,000)
07 07.5	POWERPLANT (Cont'd) TAILRACE (Cont'd) Cofferdam LS	. 1		2,000
	Subtotal Contingencies 20%			49,826 9,965
	TOTAL, TAILRACE	. •		60,000
07.6	SWITCHYARD Transformers LS Insulated cables LS Earthwork LS	· 1 1 1		5,434 2,832 1,300
	Subtotal Contingencies 20%			9,566 1,913
	TOTAL, SWITCHYARD		•	11,000
07.7	TRANSMISSION FACILITIES Transmission facilities LS Contingencies 20%	1		255,000 51,000
•	TOTAL, TRANSMISSION FACILITIES	<del></del> .*		306,000
	TOTAL, POWERPLANT		٠.	511,000
08	ROADS AND BRIDGES  Permanent Access Road - 27 miles (Highway No. 3 to Devil Canyon)		3 500 00	
	Clearing and grubbing AC Excavation	135	1,500.00	203
• •	Rock CY Common CY Embankment CY Riprap CY Road surfacing (crushed) CY Bridges LS Culverts and guardrail LS Permanent Access Road - 37 miles	200,000 60,000 890,000 2,700 216,000	20.00 3.00 3.50 30.00 15.00	4,000 180 3,115 81 3,240 15,000 1,250
	(Devil Canyon to Watana) Clearing AC Excavation	195	1,500.00	293
	Rock CY Common CY	300,000 90,000	20.00 3.00	6,000 270

### TABLE B-1--DETAILLD COS: ESTIMATE--Continued

Cost Account Number	Description or Item	Urit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
08	ROADS AND BRIDGES (Cont'd) Embankment Riprap Road surfacing (crushed) Bridges Culverts and guardrail Permanent on-site roads Power plant access	CY CY CY LS LS	1,244,000 3,800 304,000 1	3.50 30.00 15.00	4,354 114 4,560 5,000 2,250
	tunnel Power plant access road Dam crest road Mob and prep Spillway access road Switchyard access road Road to operating	LS LS LS LS LS LS	1 1 1 1 1		15,459 1,971 125 3,500 560 300
	facility	LS	1		300
	Power intake structure access road Airstrip access road	LS LS	1	•	375 650
	Subtotal Contingencies 20%				73,150 14,630
	TOTAL, ROAD AND BRIDGES				33,000
14	RECREATION FACILITIES Site D Camp units (tent camp) Vault toilets	EA EA	10 2	3,000.00 3,000.00	30 6
	Subtotal Contingencies 20% Total Site D				36 7 43
	Site E Trail system Contingencies 20% Total Site E	MI	12	15,000.00	180 36 216
	TOTAL, RECREATION FACILITIE	ES:	•		1,000
19	BUILDINGS, GROUND, AND UTILL Living quarters and O&M facilities	LITIES LS	1		2,500

### TABLE B-1--DETAILED COST ESTIMATE--Continued

Cost					
Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
19	BUILDINGS, GROUNDS, AND U	TILITIES	(Cont'd)	•	
	Visitor facilities Visitor building Parking area Boat ramp Vault toilets Runway facility	LS SF LS EA LS	12,000 1 2 1	3.00	100 36 200 6 250
••	Subtotal Contingencies 20%		•	. •	3,192 638
	TOTAL, BUILDINGS, GROUNDS	, AND UT	ILITIES		4,000
20	PERMANENT OPERATING EQUIP Operating Equipment	MENT		,	
	and Facilities Contingencies 20%	LS	1		2,500 500
	TOTAL, PERMANENT OPERATIN	G EQUIPM	ENT		3,000
50	CONSTRUCTION FACILITIES Diversion tunnels D.S. Bulkhead	LS	1		75
•	Excavation Common Rock Tunnel 33 H.S.	CY. CY CY	37,700 173,600 336,200	15.00 50.00 90.00	566 8,680 30,258
	Concrete Lining Reinforcement Structural Reinforcement	CY LB CY LB	58,350 3,155,000 9,150 1,045,000	275.00 .55 500.00 .55	16,046 1,735 4,575 575
	<ul> <li>Rock bolts</li> <li>Vertical face</li> <li>Tunnel roof</li> <li>Bulkheads</li> </ul>	LF LF LS	24,900 40,000 1	20.00	498 800 900
•	Cement Plug tunnels Care of water Mob and prep work	Cwt LS LS LS	386,700 1 1 1	8.00	3,094 1,352 1,250 3,500
	Subtotal Contingencies 20%	,	÷.		73,924 14,785
	TOTAL, CONSTRUCTION FACIL	ITIES			89,000
	•	-			

### TABLE B-1--DETAILED COS! ESTIMATE--Continued

Cost Account Number	Description or Item	Unit	Quant	Unit Cost (\$)	Total Cost (\$1,000)
TOTAL CONS	TRUCTION COST				1,619,000
ENGINEERIN	G AND DESIGN 4%	•			65,000
SUPERVISIO	N AND ADMINISTRATION 5%				81,000
TOTAL PROJ WATANA DAM ELEVATION (First-Add	AND RESERVOIR 2135	• • •			1,765,000

TABLE B-2--DETAILED COST ESTIMATE

#### DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450, GRAVITY DAM

### OCTOBER 1978 PRICE LEVEL (SECOND-ADDED)

Cost			•		
Account Number	Description or Item	Unit	Quantity .	Unit Cost (\$)	Total Cost (\$1,000)
	•	•		(4)	
01	LAND AND DAMAGES	· · · · · · · · · · · · · · · · · ·			
	Reservoir Public Domain			•	(0)
:	State & Private Land	•			14,160
	Mining Claim				. 8
	Subtotal				14,168
	Contingencies 20%	•			2,834
	Government Administrative C	ost	•	•	558
	TOTAL, LAND AND DAMAGES	*	•		18,000
•	Construction Cost			• •	18,000
	Economic Cost				18,000
03	RESERVOIR				
	Mob-Prep Work		<u>-</u> .		77
	Clearing	AC	1,920	800.00	1,536
,	Subtotal	· , ·	•		1,613
	Contingencies 20%	•			323
•	TOTAL, RESERVOIR	•			2,000
04	DAMS		•	•	•
04.1	MAIN DAM			•	
•	Excavation Rock	CY	476,400	20.00	9,528
•	Excavation common	CY	89,400	5.00	447
	Exterior mass concrete	CY	256,100	80.00	20,488
~	Interior mass concrete	CY	2,138,000	75.00	160,350
	Structural concrete (dam structure)	CY	8,883	475.00	4,219
	Concrete (spillway)	CY	18,600	450.00	8,370
	Post cooling	LS	. ]		8,000
	Instrumentation .	LS	ĺ		900
	Pier & spillway rebar	Lb	3,255,000	.55	1,790
•	Taintor gates	EΑ		500,000.00	3,000
	Bridges	LS	1		700
	Prevention or water			•	
	pollution	LS	3		1,000

TABLE B-2--DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450, GRAVITY DAM

Cost	•				_
Account	·			Unit	To:
Number	Description or Item	Unit	Quantity	Çost	Cos d
				(\$)	(\$1,000
04	DAMS		٠,		
04.1	MAIN DAM (Cont'd)				
04.1		LS	1		1,000
	Scaling canyon walls	LS	. ,	•	1,000;
•	Stoplog, complete	LS.	1		1,000 750
•	Gantry crane	LS.	1		600 <b>=</b>
	Elevator	LS	1 3	•	686
-	Stairways		. 1		
	l:ock bolts	LS		,	1,500
	Electrical and	10	· •	•	1 500
	mechancial work	LS .	י דרים	4.50	1,500
* -	Miscellaneous metalwork	Lb.	2,500	4.50	11
	Foundation treatment	LF	400,000	5.56	2,224
	Drilling and grouting	LF	70,000		3,500
	Drilling drainage holes	LF	52,500	35.00	1,838
	Concrete for parapet	~V	0.050	500.00	
-	and overhang	CY	3,352	500.00	1,676
	Resteel	Lb	4,296,115	.55	2,363
•	Slide gates, frames,			3 200 000 00	. 5 400
	guides and operators	Sets		1,350,000.00	5,400
	Chain link fence	LF	1,845	20.00	37
	Resteel for sluce conduits	Lb	891,560	. 55	490
	Exploratory tunnels	CV	2 500	500.00	1 400
	(excavation)	CY	3,500	400.00	1,400
•	Rock bolts	LF	50,000	20.00	1,000
	Contraction joint & cooling				0.760
•	system grouting	LS	7 442 222	. 0.00	2,750
•	Cement	Cwt	7,441,000	8.00	59,528
	Mob and Prep	LS		•	15,400
	Subtata 1				222 445
•	Subtotal			•	323,445
	Contingencies 20%				64,689 388,000
	TOTAL, MAIN DAM				300,000
04.4	POWER INTAKE WORKS			•	
04.4	Mob and Prep	LS	1		4,496
	Excavation		,		1,120
	Open cut	CY	7,200	75.00	· 540
	Tunnels	CY	34,400	175.00	6,020
	Concrete	· ·	34,700	175.00	0,020
	Mass	CY	7,300	100.00	730
	Structural and backfill	CY	10,430	500.00	5,215
	Cement	Cwt	74,000	8.00	592
	Reinforcing steel	Lb	2,478,000	.55	1,363
	Penstocks	Lb	9,582,270	2.25	21,560
	t chatocha	te.	293069610	2.20	21,300
	,			A. Contract of the contract of	

Cook					•
Cost Account Number	Description or Item	Unit	Quantity	Unit Cost (\$)	Total Cost (\$1,000)
04 04.4	DAMS POWER INTAKE WORKS (Cont'd) Bonnetted gates and			•	
	controls Stoplogs, (936000#) Trashracks (421,000# each) Intake selector gate tower	EA LS EA	4 1 2	1,800,000.00	7,200 1,875 1,263
	Excavation rock Concrete structural Cement Reinforcement	CY CY Cwt Lb	7,400 47,100 188,400 7,065,000	500.00 8.00 .55	370 23,550 1,507 3,886
	Selector gates (1,500,000#)	EA	4	3,375,000.00	13,500
	Subtotal Contingencies 20% TOTAL, POWER INTAKE WORKS				94,417 18,883 113,000
04.5	AUXILIARY DAM (EARTH FILL AN Mob and Prep Excavation	D CONCRETE	E)		312
	Dam foundation Foundation prepareation Dam embankment Drilling and grouting	CY SY CY LF	100,000 2,100 835,000 8,800	6.00 50.00 6.00 60.00	600 105 5,010 528
•			•		
•	Subtotal Contingencies 20% TOTAL, AUXILIARY DAM	··			6,555 1,311 8,000
	TOTAL, DAMS				509,000
07 07.1	POWERPLANT POWERHOUSE Mob and Prep work Excavation, rock Concrete Cement Reinforcing steel Architectural features	LS CY CY Cwt Lbs LS	208,400 22,000 88,000 5,400,000	75.00 500.00 8.00 .55	2,000 15,630 11,000 704 2,970 1,500

Cost Account	Daniel Tri		0 11	Unit	Total
Number	Description or Item	Unit	Quantity	Cost (\$)	Cost (\$1,000
07 07.1	POWERPLANT POWERHOUSE (Cont'd) Elevator	LS	. 1	(4)	200
	Mechancial and			•,	
	electrical work Structural steel	LS Lb	1,200,000	2.25	4,812
	Miscellaneous metalwork	Lb	150,000	. 4.50	675
	Subtotal - Contingencies 20% TOTAL, POWERHOUSE				42,191 8,438 51,000
07.2	TURBINES AND GENERATORS		÷ ,		
	Turbines Governors Generators	LS LS LS	1 1 1	•	20,250 1,053 22,950
	Subtotal Contingencies 15% TOTAL, TURBINES AND GENERATO	)RS			44,253 6,638 51,000
07.3	ACCESSORY ELECTRICAL EQUIPM	IENT			
	Accessory Electrical Equipment	LS	1 .		2,512
	Contingencies 15% TOTAL, ACCESSORY ELECTRICAL		ī	•	377 3,000
07.4	MISCELLANEOUS POWERPLANT EQ	UIPMENT	•	•	
,	Miscellaneous Powerplant	•	7		3 700
	Equipment Contingencies 15%	LS			1,798 270
:	TOTAL, MISCELLANEOUS POWERPL	ANT EQUIP	PMENT	•	2,000
07.5	TAILRACE		· _		
	Mob and Prep Excavation tunnel	LS CY	1 74,500	85.00	766 6,333
	Concrete	CY	17,500	300.00	5,250
*	Cement	Cwt	70,200	8.00	562
	Resteel Draft tube bulkhead	Lb.	3,029,000	. 55	1,666
	gate and guides	LS	1		700
•	Tailrace tunnel stoplogs (370,000#)	LS	1		. 800
	Subtotal			,	16,077
	Contingencies 20% TOTAL, TAILRACE				3,215 19,000
		• •			*

TABLE B-2--DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450, GRAVITY DAM

Cost Account Number	Description or Item	Unit ·	Quantity	Unit Cost (\$)	Total Cost (\$1,000)
07 07.6	POWERPLANT SWITCHYARD Transformers Insulated cables Excavation Rock Common	LS LS CY CY	36,000 75,000	20.00 5.00	6,545 3,312 720 375
٠	Embankment	CY	470,000	4.00	1,880
	Subtotal Contingencies 20% TOTAL, SWITCHYARD				12,832 2,566 15,000
	TOTAL, POWERPLANT			·•.	141,000
.08	ROADS AND BRIDGES Mob and Prep On-site road	LS	1		400
	Clearing and earthwork Paving Culverts Powerhouse and tailrace	Mile Mile LF	2.3 2.3 850	300,000.00 110,000.00 100.00	690 253 85
	access Road to operating facility Portals	LS Mile EA	2 2	125,000.00 500,000.00	6,000 250 1,000
:	Subtotal Contingencies 20% TOTAL, ROADS AND BRIDGES	·			8,678 1,736 10,000
14	RECREATION FACILITIES Site A				
٠.	(Boat access only) Boat dock Camping units Two-vault toilets	EA EA	1 10 2	40,000.00 3,000.00 3,000.00	40 30 6
	Subtotal Contingencies 20% Total Site A	2.42.82			76 15 91
	Site B Access road Overnight camps	Mile EA	0.5 50	150,000.00	75 200

Cost Account Number	Description or Item	Unit	Quantity	Unit Cost (\$)	Total Cost (\$1,000)
14	RECREATION FACILITIES Site B (Cont'd) Comfort stations Power Sewage	EA LS LS	2 1 1	60,000.00	120 40 75
	Subtotal Contingencies 20% Total Site B	· <del>-</del> .	~	•.	510 102 612
• •	Site C Trailhead picnic area access road Picnic units w/parking Trail system Two-vault toilets	Mile EA Mile EA	.2 12 30 2	150,000.00 3,000.00 15,000.00 3,000.00	30 36 450 6
	Subtotal Contingencies 20% Total Site C			·	522 104 626
	TOTAL, RECREATION FACILITIE	S			1,000
19	BUILDINGS, GROUND, AND UTIL Living quarters and 0&M facilities	ITIES LS	1	•	2,500
·	Visitor facilities Visitor buildings Parking Area Boat ramp Vault toilets	LS LS LS EA	1 1 2	3,000.00	300 70 220 6
	Subtotal Contingencies 20% TOTAL, BUILDINGS, GROUNDS,	AND UTILITIE	:S		3,496 699 4,000
20	PERMANENT OPERATING EQUIPME Operating Equipment and facilities Contingencies 20% TOTAL, PERMANENT OPERATING	LS	1		2,200 440 3,000

TABLE B-2--DETAILED COST ESTIMATE--Continued

DEVIL CANYON DAM AND RESERVOIR, ELEVATION 1450, GRAVITY DAM

Description or Item	Ųnit	Quantity	Unit Cost (\$)	Total Cost (\$1,000
CONSTRUCTION FACILITIES				1.1
· · · · · · · · · · · · · · · · · · ·	LS	1		1,885
		-		1,536
		38,000	15.00	570
		1		3,500
	r2			600
	<b>.</b>	25 700	100 00	2 570
•				3,570
				2,760 294
•				860
				. 471
				345
	EA.	. 1,130	300.00	343
	CV.	noi r	600.00	660
				35
				103
		.07,000		. 100
	CY	104.000	30.00	3,120
				1,900
				122
			.55	209
•	Lb		1.50	1,440
		•	•	-
Concrete	CY	1,600	300.00	480
Cement	Cwt	6,400	8.00	51
Reinforcement	Lb	80,000	.55	44
Diversion Outlet Structure	•		•	
Excavation Rock		274,000	50.00	13,700
Concrete .				550
Cement				•
				61
	ГР	100,000	1.50	150
	***		<b>500</b> 00	
				450
				29
Reinforcement	LD '	45,000	.55	25
Subtotal Contingencies 20% TOTAL, CONSTRUCTION FACILITIE	ES	•	· ·	39,555 7,911 47,000
	CONSTRUCTION FACILITIES Mob and Prep work Coffer dams Sheet pile Earth fill Pumping Remove Coffer dams Diversion workds Tunnel excavation Concrete Cement Reinforcement Steel sets Rock bolts Tunnel Plug Concrete Cement Reinforcement Diversion Intake Structure Excavation rock Concrete structural Cement Reinforcement Bulkhead Approach Channel Lining Concrete Cement Reinforcement Diversion Outlet Structure Excavation Rock Concrete Cement Reinforcement Stoplogs Outlet Channel Lining Concrete Cement Reinforcement Stoplogs Outlet Channel Lining Concrete Cement Reinforcement Stoplogs Outlet Channel Lining Concrete Cement Reinforcement	CONSTRUCTION FACILITIES  Mob and Prep work  Coffer dams  Sheet pile  Earth fill  Pumping  Remove Coffer dams  Diversion workds  Tunnel excavation  Concrete  Cement  Reinforcement  Steel sets  Rock bolts  Tunnel Plug  Concrete  Cement  Cement  Reinforcement  Diversion Intake Structure  Excavation rock  Cy  Concrete structural  Cy  Cement  Reinforcement  Bulkhead  Approach Channel Lining  Concrete  Cement  Reinforcement  Diversion Outlet Structure  Excavation Rock  Cy  Concrete  Cy  Cement  Cwt  Reinforcement  Lb  Diversion Outlet Structure  Excavation Rock  Cy  Concrete  Cy  Cement  Cwt  Reinforcement  Lb  Diversion Outlet Structure  Excavation Rock  Cy  Concrete  Cy  Concrete  Cy  Cement  Cwt  Reinforcement  Lb  Stoplogs  Outlet Channel Lining  Concrete  Cy  Cement  Cwt  Reinforcement  Lb  Stoplogs  Cy  Cwt  Reinforcement  Lb  Subtotal	CONSTRUCTION FACILITIES  Mob and Prep work LS 1  Coffer dams Sheet pile Ton 1,024 Earth fill CY 38,000 Pumping LS 1 Remove Coffer dams LS 1 Diversion workds Tunnel excavation CY 35,700 Concrete CY 9,200 Cement Cwt 36,800 Reinforcement Lb 1,564,000 Steel sets Lb 157,000 Rock bolts EA 1,150 Tunnel Plug Concrete CY 1,000 Cement Cwt 4,400 Reinforcement Lb 187,000 Diversion Intake Structure Excavation rock CY 104,000 Concrete structural CY 3,800 Cement Cwt 15,200 Reinforcement Lb 380,000 Approach Channel Lining Concrete CY 1,600 Corete CY 1,600 Approach Channel Lining Concrete CY 1,600 Cement Cwt 6,400 Reinforcement Lb 80,000 Diversion Outlet Structure Excavation Rock CY 274,000 Cement Cwt 4,400 Reinforcement Lb 110,000 Stoplogs Lb 110,000 Outlet Channel Lining Concrete CY 1,100 Cement Cwt 4,400 Reinforcement Lb 110,000 Stoplogs Lb 100,000 Outlet Channel Lining Concrete CY 2,000 Cement Cwt 3,600 Reinforcement Lb 110,000 Stoplogs Lb 100,000 Outlet Channel Lining Concrete CY 900 Cement Cwt 3,600 Reinforcement Lb 45,000	CONSTRUCTION FACILITIES  Mob and Prep work  Coffer dams  Sheet pile Farth fill CY Farth fill CONCRETE CY Farth fill CY Farth fill CY Farth fill CY Farth fill CONCRETE

Cost Account Number	Description or Item Unit	Quantity	Unit Cost (\$)	Total Cost (\$1,000)
	TOTAL, CONSTRUCTION COST			735,000
30	ENGINEERING AND DESIGN 7%			51,000
31	SUPERVISION AND ADMINISTRATION 5%			37,000
	TOTAL PROJECT COST DEVIL CANYON DAM AND RESERVOIR ELEVATION 1450, GRAVITY DAM (SECOND-ADDED)		• •	823,000

		CALE	HOE	YAL	979	Ç	LEND	ERY	19	<u> </u>	CAL	ENDE.	A YR	<u>1887</u>	لسلب	CALE	NDER	Yn.	1984	CA	LEND	ER.Y	(1	100	CAL	ENDE	A YR	1984	عــــــــــــــــــــــــــــــــــــــ	ALL	DER	Y8 15	45	CA	LEND	ER.	1410	٤٤	CAL	END	ER Y				
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LASOS & DAVAGES	<del>   </del>	Ш	Ш	111	#	: 11	111	#	Ш		$\pm$	$^{\dagger\dagger}$	++	$\mathbf{H}$	++	$^{\dagger}$		$^{\dagger\dagger}$		1	$\dagger \dagger$	111	+	11.	++		+++	T	111	117	at I	est, de	131	۲,,	lel l	Hy.	$\chi$ .1.		- 12 - 14 - 14 - 14	,,,,			- 71	7	+
		Ш	Ш	Ш	$\prod$	Ш	Ш	$\prod$	Ш	11	П	Ш	$\Box$	$\Box$	$\Box$	$\prod$	Ш	Ш		Ш	$\Pi$	Ш	$\blacksquare$	11:	Ш	Щ	Щ	П	П	Ш	$\prod$	Ш	П	$\Box$	Щ	П	1		T	11	41	Ш			Ш
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		Ш	Ш	111	$\Pi$	Ш	Ш	Ŧ	П	111	П	Ш	11	$\Pi$		П	Щ	П	-11-	Ш	П	Ш	$\Pi$	114	Ш	П	Ш	$\Pi$	1	Ш	$\blacksquare$	Ш	$\top$	1	Ш	Ш	却	Щ	ш	#	#	Ш	$\dashv$		
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04.3 OUTLET WORKS			Ш	444	44				╟╫	111	11.	╂╂╂	44	Ш	Li-l	Н	H	1-1-1	444		11-	Ш	44	11+	Ш	$\mathbf{H}$	Ш	$\Pi$		Ш	$\mathbf{H}$	Ш	П	$\Pi$	Ш	$\Box$		1	Ш	11	П	П	$\mp$	Ш	
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SHILL POWER INTAKE		Ш	Ш	Ш	П	П	Ш	1	Ш	П	$\Pi$	Ш	#	Ш	71	П	Ш	Ш	$\top$	$\Box$	П	Ш	$\Pi$	$\Pi$	П	П	П	П		Ш	11	Ш		11	Ш	П	Ш		ш	#	Ш	Ш	1:	Ш	
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77.1 Powernoose		Ш	Ш	111	$\perp$	ш	Ш	Ш			11	Ш	1	Ш	-1	Ш		ш	11:		Ш	Ш	$\perp$		Ш	1		Ш	11.	Ш	ፗ		止		Ш	廿		1:	ш	11	Ш		111	Τİ	+
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7.2 TURBINES & GENERATORS			Ш	Ш	11	#	111	11	11		11	丗	世	tП	*	Ш	止	ш			$\Box$				Ħ	11	11	Ш	*	$\Box$	$\Box$	Ш	H	+1-	Ш	$\pm$	$^{\rm tt}$	1:	Ш	11	111	Tit.		Ġ.	
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		Ш	Ш	Ш	П	П	Ш	11	Ш		П	Ш	I	Ш		$\Pi$		Ш	Ш	$\Box$		Ш	71		Ш	$\mathbf{T}$				Ш	$\blacksquare$	Ш	П:	$\perp$	Ш	11			ш	11	П				-
TT.4 MISC POKER PLANT EQUIP																																													
77.5		吐	Ш	111	11	:Ш	<u> </u>	#	Ш	Ш	Ш	Ш	址	Ш		Ш	吐	Ш							Ш	廿	Ш	11	++	111	11	Ht	11:	11	111	11	111	++	itt	++	Hi	7	de la Sa	ridida.	- Marie
77.5 TAIL SAGE		Н	╂╂┫	++4	+	Ш	+++	44-	Н	<del> -i- </del>	++	╂╂┪	-1-1-	HH		+	Н⊹	╂╂┨	11-	++	+H	╟╂		-	Н		H	#	11	111	4	Н	H	11-	Н	$\Pi$	H	1	Ш	#	Ш	-11		41	1
777		Ш		Ш	11.	:11	Ш	11	Ш		$\pm$	$\Pi$	11	111		$\mathbf{H}$		111			Ш	$\Box$	11			11		$\Box$	1	Ш	11		111	11		++	111	1	†#†	++	11:	Н	+	ΠŤ	+
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