HW-73707 APP1-CH

June 15, 1962

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ARTIFICIAL COOLING OF THE COLUMBLA
RIVER BY DAM REGULATION
1961

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June 15, 1962

ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION
1961

BENEFITS RESULTING FROM USE
OF COLD WATER FROM THE DEPTHS
OF GRAND COULEE RESERVOIR - 1961

By

Harry A. Kramer
Facilities Engineering Operation
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HANFORD ATOMIC PRODUCTS OPERATION
Richland, Washington

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ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION
1961

BENEFITS RESULTING FROM USE
OF COLD WATER FROM THE DEPTHS
OF GRAND COULEE RESERVOIR - 1961

I. SUMMARY

An increase in the flow of water from the lower depths of Grand Coulee was used to lower river temperatures at HAPO.

A net average daily reduction of over 1.7° C resulted at HAPO. The peak reduction was over 4.0° C.

Net production gain from temperature change: (13,350 MWD)

Cost of Control:

Grand Coulee Charges (Estimated)	\$37,000
Other	<u>3,500</u>
Total	\$40,500

II. DISCUSSION (Basic calculations by J. P. Corley)

In our calculations we used these selection rules

1. B. L. T. = 93.5° C at B, D, F, H
95.0° C at C, DR, KE, KW
2. $(T_o + \Delta T) > \text{B. L. T.}$

$$\Delta_1(\text{MWD}) = \frac{(T_o + \Delta T - \text{BLT})}{T_o - T_i} \times \text{PL}$$

$$\Delta_2(\text{MWD}) = (0.006)(\text{BLT} - T_o)\text{PL}$$

$$\Delta(\text{MWD})_T = \Delta(\text{MWD})_1 + \Delta(\text{MWD})_2$$

$$(T_o + \Delta T) < \text{BLT and } T_o > 85^\circ \text{ C}$$

$$\Delta(\text{MWD})_T = (0.006)(\Delta T)(\text{PL})$$

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3. If $T_o < 85^\circ \text{ C}$, $\Delta(\text{MWD}) = 0$
4. Correct for fraction of day to shutdown by multiplying
 $\frac{\text{Hours}}{24} \times \Delta(\text{MWD})$ for previous day
5. If $T_o > 85^\circ \text{ C}$ on day of startup, allow 12 hours until
 $T_o > 85^\circ \text{ C}$ is reached
6. Average value of $0.6\% \times \Delta T \times \text{PL}$ (Reference 2)

Symbols:

- (-) Operational Severity Index gain only
- (75.0) Bulk gain from entire ΔT
- 0.2
(78.3/1.3) Corresponding fractions for separate gains
- $6/24 \times 1$ Fraction of day until shutdown

We have made four separate calculations of benefits:

A. In this calculation, we use as normal generation base the projected normal generation by Grand Coulee actually generated for the period immediately before our control. The increased production would be 20,670 MWD or *del* at an approximate average value of *del*.

B. We used in this calculation the normal generation as reported by Bonneville for Grand Coulee and a calculated saving in cfs for the use of flash boards. The increased production would be 17,080 MWD or *del*.

C. For the third calculation we used the normal generation for Grand Coulee as reported by Bonneville but made a correction for two items.

1. Warm weather extended several weeks longer than normal and our cold water from the depths of Coulee was warmer than anticipated for about one week. While it was necessary to maintain the cooling program, the results were not as favorable as anticipated and this part of the savings was deducted.

2. During September, we were uncertain how much credit should be allowed for reduction of spill due to flash boards, therefore not credit was calculated for this item.

Savings 15,260 MWD.

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D. We have never been able to determine how much the temperature peaks "average out" as the flow passes one storage reservoir to another. We do not know that our instrumentation is always exactly representative of the average condition although we persistently check and double check. The worst conditions we have ever checked have shown resultant peak delta T between Grand Coulee and HAPO to be near 80 percent of measured amounts. We can assume that our actual savings should be more than 87-1/2 percent of the amount calculated from actual measured amounts. 87-1/2 percent of _____ or 11,445 MWD.

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LIMITING CONDITION

<u>Date</u>	<u>Area</u>							
	<u>B</u>	<u>C</u>	<u>D</u>	<u>DR</u>	<u>F</u>	<u>H</u>	<u>KE</u>	<u>KW</u>
July 22	BO	G		AL		BO	NE	BO
July 23	BO	BO		AL	NE	BO	BO	BO
July 24		BO		AL	NE	BO	G	BO
July 25		BO		AL	NE	BO	BO	BO
July 26		BO	NE	AL	G	BO	BO	BO
July 27		BO	BO			BO	BO	BO
July 28		BO	BO			BO	BO	
July 29		BO	BO			BO	BO	BO
July 30	NE	BO	BO	NE		BO	BO	BO
July 31	NE	BO	BO	G		BO		BO
August 1	NE		BO	G	NE	BO		BO
August 2	G		BO	G	NE	BO	NE	BO
August 3	BO		BO	AL	NE		NE	BO
August 4	BO	NE	BO	G	NE		BO	BO
August 5	BO	NE	BO	G	NE		BO	BO
August 6	BO	NE		G	NE		BO	BO
August 7	BO	BO		AL	NE		BO	BO
August 8	BO	BO		AL	NE	NE		BO
August 9	BO	BO			NE	NE		BO
August 10	BO	BO	NE		NE	BO	NE	BO
August 11	BO	G	NE	NE	NE	BO	BO	BO
August 12	BO	BO	BO	NE	BO	BO	BO	BO
August 13	BO	BO	BO	NE	BO	BO	BO	BO
August 14		NE	BO		BO	BO	BO	
August 15		NE	BO		BO		BO	
August 16	NE	BO	BO	NE	BO	NE	BO	
August 17		BO	BO	NE	BO	NE	BO	NE
August 18		BO		G	BO	NE	BO	NE
August 19	NE			G	BO	BO	BO	NE
August 20	NE		NE	G	BO	BO	BO	NE
August 21			BO	G	BO	BO	BO	NE
August 22			BO	G	HC	BO	BO	BO
August 23	NE		BO			BO	BO	BO
August 24								
August 25	NE	NE	NE	NE		BO	BO	
August 26	NE	NE	BO	NE	NE	BO	BO	
August 27	BO	NE	BO	NE	NE	BO	BO	NE
August 28		NE	BO	NE	BO	BO	BO	NE
August 29		BO		NE	BO	BO	BO	NE
August 30	NE			NE	BO			NE
August 31	NE	NE			BO			NE

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LIMITING CONDITION

<u>Date</u>	<u>Area</u>							
	<u>B</u>	<u>C</u>	<u>D</u>	<u>DR</u>	<u>F</u>	<u>H</u>	<u>KE</u>	<u>KW</u>
September 1	NE	NE	NE		BO	NE	NE	NE
September 2	BO	NE	NE	NE	BO		NE	NE
September 3	BO	BO		NE	BO	NE		BO
September 4	BO	BO		NE	BO	NE	NE	BO
September 5	BO	BO	NE			BO	NE	BO
September 6	BO	BO	NE		NE		NE	BO
September 7	BO	BO	NE		NE	NE	NE	BO
September 8		BO			BO	NE	BO	BO
September 9		BO			BO	BO	BO	BO
September 10		BO	NE		BO		BO	BO
September 11		BO	NE	TP	BO		BO	BO
September 12		BO	NE	TP			BO	BO
September 13		BO	BO	BO			BO	BO
September 14	NE	BO	BO	BO	NE		BO	BO
September 15	NE	NE		BO		NE	BO	BO
September 16	BO			BO	NE	NE	BO	BO
September 17	BO			BO	NE	BO		BO
September 18	BO		NE		BO	BO		TP
September 19	BO		NE				NE	
September 20	BO		BO	NE			NE	
September 21	BO	NE		NE	NE	NE	NE	NE
September 22	BO	NE		G	NE	NE	BO	
September 23	BO	NE	NE	BO	BO	BO	BO	NE
September 24		NE	NE	BO	BO			NE
September 25		NE		BO	BO			NE
September 26		G	NE				NE	BO
September 27		BO	NE				NE	BO
September 28	NE	BO	NE	NE	NE	NE	BO	BO
September 29	NE	BO	BO	NE	NE	NE	BO	BO
September 30	NE	BO		NE	BO		BO	BO
October 1	TP	BO		NE	BO	NE	BO	BO
October 2		BO			BO	NE	BO	BO
October 3		BO	NE			BO	BO	BO
October 4		N	BO	NE		BO	BO	BO
October 5		N	BO	NE	NE		BO	BO
October 6	NE	BO	AL			NE	BO	BO
October 7	NE	BO	AL			NE	BO	BO
October 8	NE	BO	AL	NE	NE	BO	BO	BO
October 9	NE	BO	AL	NE	NE	BO	BO	BO
October 10		BO			BO	BO	BO	BO

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LIMITING CONDITION

<u>Date</u>	<u>Area</u>							
	<u>B</u>	<u>C</u>	<u>D</u>	<u>DR</u>	<u>F</u>	<u>H</u>	<u>KE</u>	<u>KW</u>
October 11		BO			BO	BO	BO	BO
October 12	NE			NE	BO	BO	BO	BO
October 13	NE		NE	NE	BO	BO	BO	BO
October 14	G		NE	NE	BO		BO	BO
October 15	G	NE	AL		BO	NE	BO	BO
October 16	G	NE	AL		BO	NE		BO
October 17		NE	AL	NE	BO	BO		BO
October 18		NE	BO	NE	BO	BC		BO
October 19	NE	NE	BO	NE	BO	BC	NE	BO
October 20	NE	NE	BO		BO	BO	NE	BO
October 21	NE	NE	BO		BO	BO	NE	BC
October 22	G	NE	BO	NE	BO	BO	NE	
October 23	G		BO		BO		G	
October 24			BO			NE	G	
October 25		NE		NE		NE	G	
October 26	NE			NE	NE	BO	G	NE
October 27	NE	NE	NE		NE	BO		NE
October 28	G	NE	NE	NE	BO			NE
October 29	G	NE	NE	NE		NE		NE
October 30	G	NE	NE	NE		BO		NE
October 31	G	BO	AL	TP		BO	NE	BO
November 1		NE	AL	TP	NE		NE	BO
November 2		NE	AL	TP	NE	NE	NE	BO
November 3		NE	AL	TP	G	NE	NE	TP
November 4		G		TP	G	NE	NE	TP
November 5		G		TP	BO	BO	BO	TP
November 6	NE	G		TP	BO		TP	TP
November 7	NE	G		NE	TP	BO	TP	TP
November 8	NE		NE	TP	BO	NE	G	TP
November 9	NE		NE	TP	BO	BO	HC	TP
November 10	TP		NE	TP	BO	BO	HC	TP

Nomenclature:

TP	Tube Power
BO	Bulk Outlet
AL	Administrative Limit
HC	Heat Cycle
G	Graphite
NE	Nonequilibrium

CALCULATION "A" CALCULATION "A"

HAPO Date	Coulee Date	AT	B	C	D	DR	F	H	KE	KW
7-22-61	7-18-61	0.1	72.4	-				-	2	2
7-23-61	7-19-61	0.1	-	-			-	-	2	2
7-24-61	7-20-61	0.1	2/3-	-			-	-	2	2
7-25-61	7-21-61	0.2		74.6			-	72.4	4	4
7-26-61	7-22-61	0.2		-	1/2-		-	-	4	4
7-27-61	7-23-61	0.1		-	-		-	-	2	2
7-28-61	7-24-61	0.1		-	-		-	-	2	2
7-29-61	7-25-61	0.3		-	-0.2		-	-	7	7
7-30-61	7-26-61	1.9		-0.5	-0.1		-0.2	-0.2	79	83
7-31-61	7-27-61	4.1	-0.8	74.4/1.4	-0.1		71.8/1.7	41	40	195
8-1-61	7-28-61	4.4	-0.5	74.1/3.7	-0.2		71.8	93	40	203
8-2-61	7-28-61	4.4	72.0/3.9	6/24 x ↑	-0.1		-0.6	92	0	197
8-3-61	7-29-61	5.1	-0.6		-0.2		-0.4	95	46	237
8-4-61	7-30-61	4.4	72.0/3.8		-0.4		71.9/4.0	0	205	206
8-5-61	7-31-61	4.0	-0.3		-0.1		-0.8	0	173	175
8-6-61	8-1-61	3.7	72.2/4.8		-0.3		-0.5	0	167	174
8-7-61	8-2-61	3.7	-0.1		-0.3		-0.2	0	174	176
8-8-61	8-2-61	3.7	72.4/4.3		71.6/4.3		74.7/3.5	65	176	176
8-9-61	8-3-61	3.8	-0.7	-	19/24 x ↑		-3.0	46	0	181
8-10-61	8-4-61	4.4	72.4/3.3	-3.0			-0.1	98 1/2	79	208
8-11-61	8-5-61	4.4	-0.3	72.1/0.7			-0.3	96	214	210
8-12-61	8-6-61	4.3	-0.2	74.3/3.2			-0.5	91	198	200
8-13-61	8-7-61	3.7	72.1/4.1	74.7			-0.6	76	154	173
8-14-61	8-9-61	2.6	-0.1	74.9			-0.5	52	108	22
			72.5/3.6	74.5			71.3/2.1			
			-0.3	70						
			72.2/2.3	70						

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ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION

1961

BENEFITS RESULTING FROM USE
OF COLD WATER FROM THE DEPTHS
OF GRAND COULEE RESERVOIR - 1961

I. SUMMARY

An increase in the flow of water from the lower depths of Grand Coulee was used to lower river temperatures at HAPO.

A net average daily reduction of over 1.7° C resulted at HAPO. The peak reduction was over 4.0° C.

Net production gain from temperature change: *100,000 MWD*
(13,350 MWD)

Cost of Control:

Grand Coulee Charges (Estimated)	\$37,000
Other	<u>3,500</u>
Total	\$40,500

II. DISCUSSION (Basic calculations by J. P. Corley)

In our calculations we used these selection rules

1. B. L. T. = 93.5° C at B, D, F, H
95.0° C at C, DR, KE, KW

2. $\frac{1}{2}(T_o + \Delta T) > \text{B. L. T.}$

$$\Delta_1(\text{MWD}) = \frac{(T_o + \Delta T - \text{BLT})}{T_o - T_i} \times \text{PL}$$

$$\Delta_2(\text{MWD}) = (0.006)(\text{BLT} - T_o)\text{PL}$$

$$\Delta(\text{MWD})_T = \Delta(\text{MWD})_1 + \Delta(\text{MWD})_2$$

$$(T_o + \Delta T) < \text{BLT and } T_o > 85^\circ \text{ C}$$

$$\Delta(\text{MWD})_T = (0.006)(\Delta T)(\text{PL})$$

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						CALCULATION	
<u>HAPO Date</u>	<u>Coulee Date</u>	<u>ΔT</u>	<u>B</u>	<u>C</u>	<u>D</u>		
8-15-61	8-10-61	3.6	0	-	41	71.6	84
				-0.4		-0.1	93
8-16-61	8-11-61	4.1	0	73.8/3.7	104	72.3/4.0	
				-0.2		-0.1	75
8-17-61	8-12-61	3.3	0	74.2/3.1	85	72.5/3.2	
				-0.1		4/24 x ↑	12
8-18-61	8-12-61	3.3	0	74.0/3.2	87		
8-19-61	8-13-61	3.1	0	8/24 x ↑	29		0
8-20-61	8-14-61	3.0	-1.4 69.8/1.6	51	0	8/24 x -	10
8-21-61	8-14-61	3.0	9/24 x ↑	19	0	-0.2	64
						70.6/2.8	
8-22-61	8-16-61	3.3	0		0	-0.1	75
						70.6/3.2	
8-23-61	8-17-61	3.1	0		0	-0.3	68
						70.5/2.8	
8-24-61	8-18-61	3.3	-	30	0	2/3 x ↑	55
						1/3 -	
8-25-61	8-19-61	3.0	-0.9 71.3/2.1	58	0	-	29
8-26-61	8-20-61	2.3	-0.5 72.2/1.8	47	0	-0.6	45
						72.1/1.7	
8-27-61	8-21-61	2.6	72.4	60	-	-0.3	56
						72.2/2.3	
8-28-61	8-22-61	1.6	9/24 x ↑	22	-	-0.3	33
						71.9/1.3	
8-29-61	8-23-61	3.0	0	-0.2 73.6/2.8	77	6/24 x ↑	8
8-30-61	8-24-61	2.8	0		0		0
8-31-61	8-25-61	3.2	-	31	0		0
9-1-61	8-26-61	3.1	-2.3 71.3/0.8	42	-		0
9-2-61	8-27-61	3.2	-1.3 72.3/1.9	57	-1.9 73.1/1.3	-1.8 70.9/1.4	50

"A" (contd.)

DR		F		H		KE		KW	
	0	-0.1 72.6/3.5	84	9/24 x ↑	19	-0.6 73.4/3.0	161		0
	0	72.8	96		0	-0.4 73.8/3.7	190		0
	0	-0.1 72.8/3.2	76	-2.8 68.9/0.5	39	-0.7 74.1/2.6	142		0
-	30	72.6	78	-1.0 70.4/2.3	62	-0.4 73.9/2.9	150	-	69
-	28	71.8	74	70.7	70	-0.3 73.6/2.8	144	-2.4 71.8/0.7	85
-	28	71.0	71	-0.1 69.4/2.9	67	-0.3 73.1/2.7	139	-0.7 73.3/2.3	128
-	28	70.7	71	-0.3 69.4/2.7	64	-0.4 72.9/2.6	136	-0.3 73.4/2.7	140
-	32	-0.2 70.5/3.1	76	-0.4 69.1/2.9	70	-0.2 72.8/3.1	155	-0.2 73.2/3.1	156
19/24 x ↑	25	17/24 x ↑	54	-0.5 69.2/2.6	64	-0.6 72.6/2.5	135	-0.4 73.2/2.7	141
	0		0	-1.0 70.2/2.3	61	-1.4 72.7/1.9	123	1/2 x "	70
	0		0	-0.6 70.9/2.4	60	-1.3 73.1/1.7	111		0
-	22		0	?	60	-0.9 73.8/1.4	77		0
-	25	-	25	-0.4 70.9/2.2	54	-0.2 74.0/2.4	121		0
-	15	-0.7 71.0/0.9	28	-0.2 70.9/1.4	34	-0.2 74.1/1.4	72		0
-	28	72.1	70	-0.5 70.5/2.5	62	-0.3 74.0/2.7	139	-	61
-	27	72.7	65	13/24 x ↑	34	8/24 x ↑	46	-	59
1/2 x ↑	13	-0.3 72.9/2.9	71		0		0	-3.0 72.0/0.2	74
	0	-0.2 73.5/2.9	70	-	29		0	-2.3 73.1/0.8	90
	0	72.7	76	3/24 x ↑	4	-	63	-1.6 73.9/1.6	114

						<u>CALCULATION</u>	
<u>HAPO Date</u>	<u>Coulee Date</u>	<u>ΔT</u>	<u>B</u>	<u>C</u>	<u>D</u>		
9-3-61	8-27-61	3.2	-0.3 73.1/2.9	70	-0.1 74.7/3.1	83	6/24 x ↑ 12
9-4-61	8-29-61	3.0	-0.3 73.0/2.7	66	74.7	79	0
9-5-61	8-30-61	3.0	-0.7 73.0/2.3	61	-0.1 75.2/2.9	77	0
9-3-61	8-31-61	2.5	-0.4 73.2/2.1	53	75.3	66	- 24
9-7-61	9-1-61	1.8	-0.4 73.9/1.4	37	-0.1 75.8/1.7	45	-0.9 71.6/0.9 30
9-8-61	9-2-61	2.0	22/24 x ↑	34	75.3	53	18/24 x ↑ 23
9-9-61	9-3-61	1.5		0	75.1	40	0
9-10-61	9-4-61	1.3		0	74.8	34	1/4 x - 3
9-11-61	9-5-61	1.0		0	-0.2 74.8/0.8	23	- 9
9-12-61	9-6-61	1.1		0	75.2	29	- 11
9-13-61	9-7-61	1.0		0	75.3	26	-0.2 73.0/0.8 20
9-14-61	9-8-61	1.1		0	75.7	29	-0.1 73.2/1.0 24
9-15-61	9-9-61	1.1	-	11	7/24 x ↑ 17/24-	17	11/24 x ↑ 11
9-16-61	9-9-61	1.1	-0.3 73.5/0.8	22	19/24-	10	0
9-17-61	9-10-61	1.3	-0.1 73.3/1.2	29		0	0
9-18-61	9-11-61	0.7	-0.4 73.4/0.3	11		0	9/24- 2
9-19-61	9-12-61	0.6	-0.2 73.3/0.4	11		0	- 6
9-20-61	9-13-61	0.5	-	5		0	- 5
9-21-61	9-14-61	0.6	-0.3 74.4/0.3	10		0	17/24 x ↑ 4

"A" (contd.)

DR		F		H		KE		KW	
-	31	72.9	75		0	12/24 x ↑	31	-1.2 74.2/2.0	124
-	29	73.3	70	-1.7 70.5/1.3	45		0	-1.0 74.2/2.0	121
19/24 x ↑	23	9/24 x ↑	26	-1.2 70.9/1.8	53		0	-1.0 75.0/2.0	120
	0		0	14/24 x ↑	31	-	52	-0.5 75.3/2.0	109
	0	-	18		0	-	39	-0.5 75.7/1.3	75
	0	-0.2 72.7/1.8	44		0	-0.5 75.2/1.5	84	-0.2 75.6/1.8	93
	0	73.0	35	-0.4 73.0/1.1	28	-0.3 75.1/1.2	66	-0.2 75.4/1.3	68
	0	72.8	31	8/24 x ↑	9	-0.2 75.0/1.1	58	-0.2 75.1/1.1	58
	0	-0.1 73.1/0.9	22		0	-0.2 75.4/0.8	43	-0.4 75.3/0.6	38
-	11	10/24 x ↑	9		0	-1.0 74.8/0.1	27	-0.4 75.3/0.7	43
-0.7 74.1/0.3	14		0		0	-0.6 75.3/0.9	33	-0.5 75.3/0.5	36
-0.4 74.4/0.7	20		0		0	-0.8 75.2/0.3	33	-0.7 75.4/0.4	35
-0.3 73.7/0.8	21		0		0	-0.4 75.4/0.7	43	-0.3 75.4/0.8	46
-0.6 73.6/0.5	17		0	-	10	-0.3 75.5/0.8	46	-0.4 75.4/0.7	43
-0.7 73.4/0.6	21	-0.5 72.2/0.8	24	-0.3 71.1/1.0	26	15/24 x ↑	29	-0.4 75.5/0.9	52
16/24 x ↑	14	-0.4 73.1/0.3	11	-	7		0	-	16
	0	12/24 x ↑	6	21/24 x ↑	6	8/24-	4	23/24 x ↑	15
	0		0		0	-	11		0
-	6		0		0	-	13		0

DECLASSIFIED

[REDACTED]

<u>HAPO Date</u>	<u>Coulee Date</u>	<u>ΔT</u>	<u>B</u>	<u>C</u>	<u>D</u>			
9-22-61	9-15-61	0.7	-0.4 74.3/0.3	11	—	8	0	
9-23-61	9-16-61	0.5	74.5	12	—	6	0	
9-24-61	9-17-61	0.4	18/24 x ↑	9	—	5	—	4
9-25-61	9-19-61	0.3		0	—	4	5/24 x ↑	1
9-26-61	9-20-61	0.3		0	—	4		0
9-27-61	9-21-61	0.3		0	—	4	—	3
9-28-61	9-22-61	0.1		0	—	1	—	1
9-29-61	9-23-61	0.1	—	1	—	1	—	1
9-30-61	9-24-61	0.1	—	1	—	1		0
10-1-61	9-25-61	0.1	—	1	77.3	3		0
10-2-61	9-26-61	0.1	16/24—	1	—	1		0
10-3-61	9-27-61	0.1		0	—	1		0
10-4-61	9-28-61	0.1		0	76.9	3		0
10-5-61	9-29-61	0.1		0	76.9	3		0
10-6-61	9-30-61	0.1		0	—	1	—	1
10-7-61	10-1-61	0.1	—	1	—	1	—	1
10-8-61	10-2-61	0.1	—	1	78.1	3	—	1
10-9-61	10-3-61	0.1	—	1	78.3	3	—	1
10-10-61	10-4-61	0.1		0	78.6	3	—	1
10-11-61	10-5-61	0.1		0	78.5	3		0
10-12-61	10-6-61	0.1		0	20/24 x ↑	3		0
10-13-61	10-7-61	0.1	—	1		0	—	1
10-14-61	10-8-61	0.1	—	1		0	—	1
10-15-61	10-9-61	0.1	—	1		0	—	1
10-16-61	10-10-61	0.1	—	1		0	—	1
10-17-61	10-11-61	0.1		0		0	—	1
10-18-61	10-12-61	0.1		0	—	1	—	1
10-19-61	10-13-61	0.1		0	—	1	—	1
10-20-61	10-14-61	0.1	—	1	—	1	—	1
10-21-61	10-15-61	0.1	—	1	—	1	—	1
10-22-61	10-16-61	0.1	—	1	—	1	—	1

For first quarter, FY 1962

Gross Benefit = 20,670

"A" (contd.)

DR	F	H	KE	KW
-	-	-	-0.6	18
-0.2	-0.2	-	76.0/0.1	0
75.4/0.3	73.7/0.3	9	-0.4	14
-0.3	73.6	9	75.8/0.1	9
74.5/0.1	74.6	6/24 x ↑	15/24 x ↑	0
7/24 x ↑	14/24 x ↑	7	-	0
0	0	4	-	7
6/21-	11/24-	0	-	2
-	-	1	-	2
-	-	1	-	2
-	74.5	1	-	2
-	74.4	2	-	2
-	13/24 x ↑	2	-	2
0	0	1	-	2
0	0	1	-	2
18/24-	0	0	-	2
-	0	0	-	2
-	0	0	-	2
-	75.5	1	-	2
-	-	2	-	2
-	75.6	1	-	2
-	-	2	-	2
-	74.7	1	-	2
-	74.8	2	-	2
-	-	1	-	2
-	-	1	-	2
-	76.5	1	-	2
-	76.0	2	-	2
-	-	1	-	2
21/24-	76.4	2	-	2
-	76.5	2	-	2

DECLASSIFIED
WITH DELETIONS

CALCULATION

HAPO Date	ΔT	B	C	D	DR
7-22-61	0.1	72.4	2	0	
7-23-61	0.1	—	1	0	
7-24-61	0.1	2/3—	1	0	
7-25-61	0.1		74.6	0	
7-26-61	0.2		—	1	
7-27-61	0.2		—	1	
7-28-61	0.1		—	1	
7-29-61	0.3		—	4	
			—0.5	72.4/0.1	4
7-30-61	1.7		74.4/1.4	—0.1	38
		—0.8	—0.4	72.1/1.8	
7-31-61	3.8	71.3/3.3	78	—0.2	86
		—0.5	74.1/3.7	72.0/3.9	
8-1-61	4.2	72.0/3.9	90	—0.1	95
		—0.6	1/4 x ↑	72.4/4.3	
8-2-61	4.4	72.0/3.9	94	—0.2	100
		—0.3		72.2/4.2	
8-3-61	4.7	72.2/4.8	105	—0.4	105
		—0.1		71.6/4.7	
8-4-61	3.7	72.4/4.3	85	—0.1	86
		—0.7		—0.3	
8-5-61	3.3	72.4/3.3	68	71.9/3.7	73
		—0.3	—8.0		
8-6-61	3.2	72.2/3.4	71	72.1/0.7	53
		—0.2	—0.5	3/4 x ↑	
8-7-61	3.3	72.7/3.5	74	81	0
		—0.3	—1.0	76	0
8-8-61	3.3	72.2/3.4	73	73.7/2.7	
		—0.3	—0.5	81	0
8-9-61	3.3	72.1/3.3	71	74.3/3.3	
		—0.3	74.7	105	0
8-10-61	3.9	72.1/4.1	87	—0.3	
		—0.2	74.3/4.1	106	40
8-11-61	4.1	72.0/4.2	93	—1.5	
		—0.2	74.7	70.8/2.8	74
8-12-61	4.0	72.1/4.1	90	—1.4	
		—0.1	74.9	71.2/2.3	51
8-13-61	2.8	72.5/3.6	63	—0.5	
		—0.3	74.5	72.4/2.1	40
8-14-61	2.0	72.2/2.3	42		

"B,C,D"

Handwritten: Δ (mud) - Pro-12.2.1

	F		H		KE		KW	
0		0	-	1	-	2	-	2
0	-	1	-	1	-	2	-	2
0	-	1	-	1	-	2	-	2
0	-	2	72.4	2	-	2	-	2
0	-	2	-	2	-	4	-	4
0	-	2	-	2	-	4	-	4
0		0	-	1	-	2	-	2
0		0	-	3	-	7	-	7
0		0	-0.2	36	-0.5	70	-0.4	74
			71.8/1.7		74.6/1.4		74.7/1.5	
0		0	71.8	86	1/2 x ↑	37	-0.2	180
							74.8/3.9	
0		0	-0.6	87		0	-0.5	193
			71.8/3.8				74.6/3.9	
0		0	-0.4	95	1/2	46	-0.7	197
			71.9/4.0		-		74.5/3.7	
0		0		0	-1.7	189	-0.5	218
					73.4/2.4		74.8/4.6	
0		0		0	-0.2	175	-0.4	173
					74.9/4.2		74.7/4.0	
0		0		0	-0.8	142	-0.8	144
					74.6/3.2		74.9/3.2	
0		0		0	-0.5	144	-0.3	150
					74.6/6.2		74.8/3.4	
0		0		0	-0.2	155	-0.2	157
					74.7/3.5		74.8/3.5	
0		0		0	9/21 x ↑	58	-0.2	157
							74.8/3.5	
0		0	-3.0	40		0	-0.2	157
			68.8/0.8				74.9/3.6	
0		0	-0.1	87	1/2 { -2.0	70	-0.3	184
			71.5/4.3		72.8/2.4		74.8/4.1	
0		40	-0.3	92	74.4	199	-0.2	196
			71.0/4.1				74.8/4.2	
36	-2.4	60	-0.5	85	-0.4	184	-0.3	184
	70.1/1.9		71.1/3.8		74.6/3.9		74.6/3.9	
0	-0.1	65	-0.6	57	-1.0	116	-0.3	130
	72.4/3.6		71.1/3.1		73.8/2.7		74.8/3.4	
0		46	-0.5	39	-0.7	81	3/24 ↑	17
	72.5		71.3/2.1		73.7/1.9			

DECLASSIFIED

DECLASSIFIED

-15-

CALCULATION "B"

HAPO Date	ΔT	B		C		D		DR
8-15-61	2.5		0	-	25	71.6	53	
8-16-61	3.1		0	-0.4 73.8/3.7	77	- 0.1 72.3/4.0	70	
8-17-61	2.7		0	-0.2 74.2/3.1	64	- 0.1 72.5/3.2	57	
8-18-61	2.7		0	-0.1 74.0/3.2	66	4/24 x $\uparrow$	7	-
8-19-61	2.5		0	8/24 $\uparrow$	23		0	-
8-20-61	2.1	-1.4 69.8/1.6	41		0	1/3 x $\uparrow$	8	-
8-21-61	2.3	9/24 x 5.1	13		0	-0.2 70.6/2.8	49	-
8-22-61	2.0		0		0	-0.1 70.6/3.2	42	-
8-23-61	2.5		0		0	-0.3 70.5/2.8	55	19/24 x
8-24-61	2.5	-	23		0	2/3 x $\uparrow$ 1/3-	42	
8-25-61	2.4	-0.9 71.3/2.1	44		0	-	22	
8-26-61	1.9	-0.5 72.2/1.8	39		0	-0.6 72.4/1.7	37	-
8-27-61	1.8	72.4	42	-	20	-0.3 72.2/2.3	39	-
8-28-61	2.3	9/24 $\uparrow$	32	-	27	-0.3 71.9/1.3	45	-
8-29-61	2.6		0	-0.2 73.6/2.8	67	6/24 $\uparrow$	5	-
8-30-61	2.8		0		0		0	-
8-31-61	3.4	-	32		0		0	1/2 x $\uparrow$
9-1-61	3.3	-2.3 71.3/0.8	45	-	36		0	
9-2-61	3.4	-1.3 72.3/1.9	60	-1.9 73.1/1.3	59	-	33	
9-3-61	3.0	-0.3 73.1/2.9	65	-0.1 74.7/3.1	77	6/24 x $\uparrow$	7	-

C,D" (contd.)

	F		H		KE		KW	
0	-0.1 72.6/3.5	58	9/24 x ↑	13	-0.6 73.4/3.0	112		0
0	72.8	72		0	-0.4 73.8/3.7	143		0
0	-0.1 72.8/3.2	57	-2.8 68.9/0.5	29	-0.7 74.1/2.6	107		0
22	72.6	59	-1.0 70.4/2.3	47	-0.4 73.9/2.9	114		52
22	71.8	60	70.7	56	-0.3 73.6/2.8	116	-0.7 73.3/2.3	103
22	71.0	57	-0.1 69.4/2.9	53	-0.3 73.1/2.7	111	-0.7 73.3/2.3	102
21	70.7	54	-0.3 69.4/2.7	49	-0.4 72.9/2.6	107	-0.3 73.4/0.7	107
19	-0.2 70.5/3.1	46	-0.4 69.1/2.8	42	-0.2 72.8/3.1	94	-0.2 73.2/3.1	95
20	17/24 x ↑	44	-1.0 70.2/2.3	52	-0.6 72.6/2.5	109	-0.4 73.2/2.7	114
0		0	-1.0 70.2/2.3	46	-1.4 72.7/1.9	93	1/2 x ↑	54
0		0	-0.6 70.9/2.4	45	-1.3 73.1/1.7	85		0
18		0	?	50	-0.9 73.8/1.14	64		0
17	-	17	-0.4 70.9/2.2	37	-0.2 74.0/2.4	84		0
22	-0.7 71.0/0.9	40	-0.2 70.9/1.4	49	-0.2 74.1/1.4	103		0
24	72.1	61	-0.5 70.5/2.5	54	-0.3 74.0/2.7	120	-	53
27		65	13/24 x ↑	34	8/24 ↑	46	-	59
14	-0.3 72.9/2.9	75		0		0	-3.0 72.0/0.2	78
0	-0.2 73.5/2.9	74	-	31		0	-2.3 73.1/0.8	95
0	72.7	81	3/24 x ↑	4	-	67	-1.6 73.9/1.6	121
29	72.9	70		0	12/24 x ↑	29	-1.2 74.2/2.0	116

CALCULATION

<u>HAPO Date</u>	<u>ΔT</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>I</u>
9-4-61	3.0	-0.3 73.0/2.7	66 74.7	79 0	-
9-5-61	2.7	-0.7 73.0/2.3	55 -0.1 75.2/2.9	69 0	19/24
9-6-61	2.3	-0.4 73.2/2.1	49 75.3	61 -	22
9-7-61	2.2	-0.4 73.2/2.1	45 -0.1 75.8	55 -0.9 71.6/0.9	37
9-8-61	2.6	22/24 x ↑	44 75.3	69 18/24 x ↑	30
9-9-61	2.1		0 75.1	56 0	
9-10-61	2.0		0 74.8	51 1/4 x-	5
9-11-61	0.8		0 -0.2 74.8/0.8	18 -	7
9-12-61	0.7		0 75.2	19 -	7
9-13-61	0.8		0 75.3	21 -0.2 73.0/0.8	16 -0.1 74.1/0
9-14-61	0.6		0 75.7	16 -0.1 73.3/1.0	13 -0.1 74.4/0
9-15-61	0.6	-	6 7/24 x ↑ 17/24-	9 11/24 x ↑	6 -0.1 73.7/0
9-16-61	0.6	-0.3 73.5/0.8	12 19/24-	6 0	-0.1 73.6/0
9-17-61	1.1	-0.1 73.3/1.2	25 0	0 0	-0.1 73.4/0
9-18-61	0.3	-0.4 73.4/0.3	5 0	9/24 x ↑	1 16/24
9-19-61	0.3	-0.2 73.3/0.4	6 0	- 3	
9-20-61	-0.1	-	-1 0	- -1	
9-21-61	-0.1	-0.3 74.4/0.3	-2 0	17/24 x ↑	-1 -
9-22-61	-0.4	-0.4 74.3/0.3	-6 -	-5 0	
9-23-61	-0.4	74.5	-10 -	-5 0	-0.1 75.4/0

"B, C, D" (contd.)

OR	F		H		KE		KW	
	29	73.3	70	-1.7 70.5/1.3	45	0	-1.0 74.2/2.0	121
	21	9/24 ↑	23	-1.2 70.9/1.8	48	0	-1.0 75.0/2.0	108
	0		0	14/24 x ↑	29	-	-0.5 75.3/2.0	100
	0	-	22		0	-	-0.5 75.7/1.3	92
	0	-0.2 72.7/1.8	57		0	-0.5 75.2/1.5	-0.2 75.6/1.8	121
	0	73.0	49	-0.4 73.0/1.1	39	-0.3 75.1/1.2	-0.2 75.4/1.3	95
	0	72.8	47	8/24 x ↑	14	-0.2 75.0/1.14	-0.2 75.1/1.1	87
	0	-0.1 73.1/0.9	18		0	-0.2 75.4/0.8	-0.4 75.3/0.6	30
	7	10/24 x ↑	6		0	-1.0 74.8/0.1	-0.4 75.3/0.7	28
3	11		0		0	-0.6 75.3/0.4	-0.5 75.3/0.5	29
7	11		0		0	-0.8 75.2/0.3	-0.7 75.4/0.4	19
8	12		0		0	-0.4 75.4/0.7	-0.3 75.4/0.8	25
5	9		0	-	6	-0.3 75.5/0.8	-0.4 75.4/0.7	24
6	18	-0.5 72.2/0.8	20	-0.3 71./1.0	22	15/24 x ↑	-0.4 75.5/0.9	44
x ↑	6	-0.4 73.1/0.3	5	-	3		-	7
	0	12/24 x ↑	3	21/24 x ↑	3	8/24 -	2	23/24 x *
	0		0		0	-	-2	0
	-1		0		0	-	-2	0
	-4		-4		-4	-0.6 76.0/0.1	-10	0
3	-7	-0.2 73.7/0.3	-7	-	-4	-0.4 75.8/0.1	-11	-6

DECLASSIFIED

DECLASSIFIED

WITH DELETIONS

-17-

CALCULATION "B"

<u>HAPO Date</u>	<u>ΔT</u>	<u>B</u>		<u>C</u>		<u>D</u>		<u>DR</u>
9-24-61	-0.4	18/24 x ↑	-9	—	-5	—	-4	— 0.3 74.5/0.1
9-25-61	-0.5		0	—	-7	5/24 x ↑	-2	—
9-26-61	-0.6		0	—	-8		0	7/24 x ↑
9-27-61	-0.7		0	—	-9	—	-7	
9-28-61	-0.7		0	—	-7	—	-7	6/24—
9-29-61	-0.5	—	-5	—	-5	—	-5	—
9-30-61	-0.5	—	-5	—	-5		0	—
10-1-61	-0.5	—	-5	77.3	-15		0	—
10-2-61	-0.5	16/24	-5	—	-5		0	
10-3-61	-0.4		0		-4		0	
10-4-61	-0.2		0	76.9	-6		0	
10-5-61	-0.1		0	76.9	-3		0	
10-6-61	-0.2		0	—	-2	—	-2	18/24
10-7-61	-0.2	—	-2	—	-2	—	-2	
10-8-61	-0.1	—	-1	78.1	-3	—	-1	
10-9-61	-0.1	—	-1	78.3	-1	—	-1	—
10-10-61	Zero	—	0	78.6	0	—	0	—

Saving through 8-20-61
10,248 Mw

Saving through August
13,431 Mw

Saving through September
3658 Mw

Use only 50% 1829 Mw

Total
@ 87-1/2% (averaging)

Saving Use BPA Data
17,089

Basic Data Calculation A Calculation B, C, D ΔT BPA Data/ ΔT HAPO Data

C,D" (contd.)

	F	H	KE	KW				
-5	73.6	-9	6/24 x ↑	-1	15/24	-9	-	-8
-5	74.6	-12		0		0	-	-12
-2	14/24	-8		0		0	-	-14
0		0		0		-16	-	-16
0	11/24-	0		0		-5	-	-5
-5	-	-5		0		-10	-	-10
-5	-	-5		0		-10	-	-10
-5	74.5	-10		0		-10	-	-10
0	74.4	-10		-5		-10	-	-10
0	13/24 x ↑	-4		-4		-8	-	-8
0		0		-2		-4	-	-4
-3		0		0		-2	-	-2
-2		0		0		-4	-	-4
0		0		-2		-4	-	-4
0		0		-1		-2	-	-2
-1	-	-1		-1		-2	-	-2
0	-	0		0		0	-	0

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WITH DELETIONS

IV. REFERENCES

1. Daily Operating Reports
2. S. M. Graves letter, February 10, 1961
- 3 Bureau of Reclamation daily reports
4. Memo from G. W. Owsley, January 30, 1961

V. ACKNOWLEDGEMENTS

We are indebted to the following:

John P. Corley

Stanley Graves

Dale DeNeal

IPD Power Managers

Reactor Engineers in each area

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HW-73707, *del*

SAMPLE CALCULATIONS

On August 19, 1961, the calculated temperature reduction at HAPO was 3.1° C (water released from Grand Coulee on August 13, 1961).

For August 19, 1961, the Daily Operating Report shows the following reactor data:

	<u>B</u>	<u>C</u>	<u>D</u>	<u>DR</u>	<u>F</u>	<u>H</u>	<u>KE</u>	<u>KW</u>
Power Level, Mw	1550	0	0	1510	1705	1595	3610	3525
Inlet Temp., °C	21.8	-	-	21.3	21.8	22.8	21.1	20.8
Outlet Temp., °C	82.0	-	-	86.6	93.6	93.5	94.7	92.6
Shutdown Time		0730	-					

B

$$T_o = 82 < 85^{\circ} \text{ C}$$

Entry: 0

C

No data available for day prior to shutdown. Prorate previous day's benefits.

$$\Delta(\text{MWD})_T = \left(\frac{8}{24} \right) (87) = 29$$

Entry: $\frac{8}{24} \times 1$ 29

D

Reactor down all day

Entry: 0

DR

$$T_o + \Delta T = 86.6 + 3.1 = 89.7$$

$$\text{BLT} = 95.0^{\circ} \text{ C}$$

$$\Delta(\text{MWD})_T = (0.006)(3.1)(1510) = 28$$

Entry: - 28

F

$$T_o + \Delta T = 93.6^{\circ} \text{ C}$$

$$\text{BLT} = 93.5^{\circ} \text{ C}$$

$$\Delta(\text{MWD})_T = \left(\frac{3.1}{93.6 - 21.8} \right) (1705) = \left(\frac{3.1}{71.8} \right) (1705) = 74$$

Entry: 71.8 74

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H

$$T_o = 93.5^\circ \text{ C} \quad \text{BLT} = 93.5^\circ \text{ C}$$

$$\Delta(\text{MWD})_T = \left(\frac{3.1}{93.5 - 22.8} \right) (1595) = \left(\frac{3.1}{70.7} \right) (1595) = 70$$

Entry: 70.7 70

KE

$$T_o + \Delta T = 94.7 + 3.1 = 97.8^\circ \text{ C} \quad \text{BLT} = 95.0^\circ \text{ C}$$

$$\Delta(\text{MWD})_1 = \left(\frac{97.8 - 95.0}{94.7 - 21.1} \right) (3610) = \left(\frac{2.8}{73.6} \right) (3610) = 137$$

$$\Delta(\text{MWD})_2 = (0.006)(3.1 - 2.8)(3610) = 7$$

$$\Delta(\text{MWD})_T = 144$$

Entry: $\frac{-0.3}{73.6/2.8}$ 144

KW

$$T_o + \Delta T = 92.6 + 3.1 = 95.7^\circ \text{ C} \quad \text{BLT} = 95^\circ \text{ C}$$

$$\Delta(\text{MWD})_1 = \left(\frac{95.7 - 95.0}{92.6 - 20.8} \right) (3525) = \left(\frac{0.7}{71.8} \right) (3525) = 34$$

$$\Delta(\text{MWD})_2 = (0.006)(3.1 - 0.7)(3525) = 51$$

$$\Delta(\text{MWD})_T = 85$$

Entry: $\frac{-2.4}{71.8/0.7}$ 85

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DATE

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5 / 31 / 94

END