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HW-65767 APP-DEL
~~APPENDIX~~

DATE
June 24, 1960

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION
1959

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HW-65767 APP - DEL
APPENDIX

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June 24, 1960

ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION
1959

BENEFITS RESULTING FROM
USE OF COLD WATER FROM THE DEPTHS OF
GRAND COULEE RESERVOIR - 1959

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by:

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

By Authority of *Bm. Den*
CG-nmp-1, 5-31-94
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6-1-94

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ARTIFICIAL COOLING OF THE COLUMBIA RIVER
BY DAM REGULATION
1959

BENEFITS RESULTING FROM
USE OF COLD WATER FROM THE DEPTHS OF
GRAND COULEE RESERVOIR - 1959

I. SUMMARY

As noted in the Unclassified Document an increase in the flow of water from the lower depths of Grand Coulee Reservoir was used to lower the river temperature at HAPO.

A net average daily reduction of over 1.0° C resulted at HAPO. The average for one day varied from 1.7° C to 0.2° C.

Net Production Gain From Bulk Outlet -

Practical Bulk Outlet Temperature established at 93° C for D Area and 92.5° for other areas (SEE TABLE OF CALCULATIONS).

Net Production Gain Increased Tube Power - (SEE TABLE OF CALCULATIONS).

Net Production Gain due to extended tube life -

Td = Average Temperature Decrease - 1.014° C.

Cost of Control -

Grand Coulee Dam Charges = \$ 4,514.30

Other (Estimated) = \$ 5,485.70

TOTAL = \$10,000.00

II. DISCUSSION

During the time before the dam control period Bonneville Power Administration transferred load from Grand Coulee Dam to other dams in order to conserve cold water. We calculate there was more value to HAPO from this transfer than the combined effects of river bed losses and/or any variance in scheduled or base loads.

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III. CALCULATIONS

$$O.S.I. = \text{Tube Power}^{3.3} \times \text{Tube Outlet Temperature}^{8.7}$$

10 Hottest Tubes

$$\text{Rupture Potential} = O.S.I. \times \text{exposure}^5$$

(Research and Engineering Operation reports value in per cent of production is at least 0.55%)

FORMULA FOR BULK OUTLET

$$B.O.V. = \frac{T^{\circ}C \times Q (0.2635)}{1,000} = \text{Theoretical Value of Increased MWD}$$

FORMULA FOR TUBE POWER

$$B.O.V. \times \frac{0^{\circ} + 1.2^{\circ}}{0^{\circ} + 20^{\circ}} = 21\%$$

B.O.V. - Bulk Outlet Value

O.S.I. - Operational Severity Index

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OPERATING LIMITS

1959

<u>DATE</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>
August 7			B	TP			TP	TP
August 8			B	TP			TP	TP
August 9				TP			TP	
August 10								
August 11								
August 12	TP		B	TP	TP		TP	
August 13	TP		B	TP	TP		TP	
August 14	TP		B	TP	TP		TP	
August 15	TP		B	TP	TP		TP	TP
August 16			B	TP	TP		TP	TP
August 17			Down	TP	TP	TP	TP	TP
August 18	TP			TP	TP	TP	TP	TP
August 19	TP				TP	TP	TP	TP
August 20	TP				TP	TP	TP	TP
August 21							TP	TP
August 22	TP			TP			TP	TP
August 23	TP						TP	TP
August 24				TP				TP
August 25								TP
August 26						TP		TP
August 27					TP	TP		TP
August 28					TP	TP		
August 29	TP				TP	TP		TP
August 30	TP				TP	TP		TP
August 31	TP		BO		TP	TP		

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OPERATING LIMITS
(Continued)

1959

<u>DATE</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			B	TP	TP	TP		
September 2			B	TP	TP	TP	TP	
September 3			B	TP	TP	TP	TP	
September 4	TP		B	TP	TP	TP	TP	
September 5	TP		B	TP	TP	TP	TP	
September 6	TP		B	TP	TP	TP	TP	
September 7	TP		B	TP	TP	TP		TP
September 8	TP		B	TP	TP	TP		TP
September 9	TP		B	TP		TP		TP
September 10			B	TP		TP		TP
September 11			B	TP		TP		TP
September 12			B	TP		TP		TP
September 13			B	TP		TP		TP
September 14			B			TP		TP
September 15			B			TP	TP	TP
September 16			B			TP	TP	TP
September 17						TP	TP	TP
September 18						TP	TP	TP
September 19						TP	TP	TP
September 20	TP						TP	TP
September 21	TP						TP	TP
September 22	TP						TP	TP
September 23	TP						TP	TP
September 24	TP		TP	TP			TP	TP
September 25	TP		TP	TP	TP		TP	TP
September 26	TP				TP		TP	TP
September 27	TP			TP			TP	TP
September 28	TP		TP	TP		TP	TP	TP
September 29	TP					TP	TP	TP
September 30	TP			TP		TP		
October 1	TP				TP	TP		
October 2				TP	TP			
October 3				TP	TP			
October 4			B	BO	TP			
October 5			B					

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VALUE OF INCREASED PRODUCTION DUE TO RIVER TEMPERATURE REDUCTION

$$MWD = \frac{T_1 - T_2 Q (0.2635)}{1,000}$$

DATE	T ₁ °C	B		C		KW		KE		D		DR		H		F	
		M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD
		FLOW		FLOW		FLOW		FLOW		FLOW		FLOW		FLOW		FLOW	
10	1.0	83.2		96.2		175.5		174.0		81.1	21.37*	84.1		85.5		85.2	
11	1.4	83.2		96.0		177.5		174.0		81.1	29.92*	84.0		0		85.2	
12	1.4	83.0	<u>30.62</u>	96.3		178.0		174.3	<u>64.30</u>	81.1	29.92*	84.0	<u>30.99</u>	85.5		85.2	<u>31.43</u>
13	1.2	83.0	<u>26.24</u>	96.0		178.0		174.3	<u>55.11</u>	81.1	25.64*	84.0	<u>26.56</u>	85.5		85.2	<u>26.94</u>
14	1.3	83.0	<u>28.43</u>	96.2		178.0		173.7	<u>59.50</u>	81.1	27.78*	84.0	<u>28.77</u>	85.6		85.2	<u>29.19</u>
15	1.4	82.9	<u>30.58</u>	96.3		178.0	<u>65.66</u>	174.0	<u>64.19</u>	81.1	29.92*	83.9	<u>30.05*</u>	85.6		85.5	<u>31.54</u>
16	1.4	83.0		96.2		178.0	<u>65.66</u>	174.0	<u>64.19</u>	81.3	29.99*	83.8	<u>30.91*</u>	85.6		85.6	<u>31.58</u>
17	1.4	82.8		96.4		178.0	<u>65.66</u>	173.5	<u>64.00</u>	81.3	6.99*	83.9	<u>30.95*</u>	85.5	<u>31.54</u>	85.5	<u>31.54</u>
18	1.5	82.9	<u>32.77</u>	96.2		178.0	<u>70.35</u>	174.0	<u>68.84</u>	0		83.8	<u>33.12*</u>	85.5	<u>33.79</u>	85.5	<u>33.79</u>
19	1.6	82.8	<u>34.91</u>	96.0		178.0	<u>75.04</u>	174.0	<u>73.36</u>	0		83.5	<u>35.20*</u>	85.5	<u>36.05</u>	85.5	<u>36.05</u>
20	1.6	82.8	<u>34.91</u>	96.0		178.0	<u>75.05</u>	174.0	<u>73.36</u>	0		83.4	<u>35.20*</u>	85.5	<u>36.05</u>	85.5	<u>36.00</u>
21	1.7	82.8		96.0		178.0	<u>79.74</u>	174.0	<u>77.94</u>	80.9		83.8	<u>37.54*</u>	85.5		85.5	
22	1.2	82.8	<u>26.18</u>	96.0		178.0	<u>56.28</u>	174.0	<u>55.02</u>	80.5		83.7	<u>26.47*</u>	0		0	
23	1.3	82.8	<u>28.36</u>	96.0		178.0	<u>60.97</u>	174.5		80.5		83.5	<u>28.60*</u>	84.1		84.2	
24	1.3	82.8		96.0		178.0	<u>60.97</u>	174.5		81.1		83.4	<u>28.57*</u>	85.3		85.2	
25	1.0	0		96.0		178.0	<u>46.90</u>	0		81.1		83.4	<u>7.47*</u>	85.3		85.4	
26	1.2	0		96.5		178.0	<u>56.28</u>	0		81.1		0		85.8	<u>27.13</u>	85.4	
27	1.1	82.8		96.2		178.0	<u>51.59</u>	170.0		81.1		0		85.3	<u>24.72</u>	85.4	<u>24.72</u>
28	0.8	83.0		96.0		178.0		172.0		81.2		80.8		85.4	<u>18.00</u>	85.4	<u>18.00</u>
29	1.0	82.8	<u>21.82</u>	96.0		178.0	<u>46.90</u>	172.0		81.2		81.5		85.4	<u>22.50</u>	85.4	<u>22.50</u>
30	1.0	82.8	<u>21.82</u>	95.5		178.0	<u>46.90</u>	0		81.0	21.34*	82.0		85.4	<u>22.50</u>	85.4	<u>22.50</u>
31	1.2	82.8	<u>26.18</u>	95.5		178.0		172.0		81.0	25.61*	81.2		85.3	<u>26.97</u>	85.4	<u>27.00</u>
1	1.0	82.7		0		0		170.5		81.0	21.34*	82.3	<u>21.69</u>	85.4	<u>22.50</u>	85.4	<u>22.50</u>
2	1.3	82.5		0		0		174.0	<u>59.60</u>	81.1	27.78*	82.0	<u>28.09</u>	85.4	<u>29.25</u>	86.2	<u>29.53</u>
3	1.3	82.4		0		51.5		174.0	<u>59.60</u>	81.0	27.75*	82.1	<u>28.12</u>	85.5	<u>29.29</u>	86.2	<u>29.53</u>
4	1.0	82.4	<u>21.71</u>	93.5		176.5		174.0	<u>45.85</u>	81.0	21.34*	82.1	<u>21.63</u>	86.6	<u>22.56</u>	86.2	<u>22.71</u>
5	0.9	82.4	<u>19.54</u>	93.8		178.0		174.0	<u>41.26</u>	81.0	19.21*	82.1	<u>19.47</u>	85.6	<u>20.30</u>	86.2	<u>20.44</u>
6	0.9	82.4	<u>19.54</u>	96.8		178.0		174.0	<u>41.26</u>	81.0	19.21*	82.1	<u>19.47</u>	85.5	<u>20.28</u>	86.4	<u>20.49</u>
7	0.9	82.4	<u>19.54</u>	96.4		178.5	<u>42.33</u>	174.0		81.0	19.21*	82.1	<u>19.47</u>	85.5	<u>20.28</u>	86.4	<u>20.49</u>
8	0.8	82.4	<u>17.37</u>	96.8		178.0	<u>37.52</u>	162.0		81.0	17.07*	82.1	<u>17.31</u>	85.6	<u>18.04</u>	86.4	<u>18.21</u>
9	0.8	82.4	<u>17.37</u>	96.6		178.0	<u>37.52</u>	162.0		81.0	17.07*	82.2	<u>17.31</u>	85.6	<u>18.04</u>	86.4	

(Underline) = Tube Power

* (Asterisk) = Bulk Outlet

VALUE OF INCREASED PRODUCTION DUE TO RIVER TEMPERATURE REDUCTION

1959	DATE	T ₁ °C	B		C		KW		KE		D		DR		H		F	
			M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD	M	MWD
			FLOW		FLOW		FLOW		FLOW		FLOW		FLOW		FLOW		FLOW	
Sept.	10	0.7	82.4		96.6		178.0	32.80	170.5		81.0	14.94*	82.2	15.16	85.5	15.77	0	
	11	0.6	0		0		178.0	27.02	172.5		81.0	12.30*	82.2	12.48	85.4	12.96	0	
	12	0.5	82.4		0		178.0	23.45	174.0		81.0	10.67*	82.2	10.83	85.4	11.25	0	
	13	0.5	0		0		178.0	23.45	174.0		81.0	10.67*	82.2	10.83	85.5	11.26	84.9	
	14	0.5	0		0		178.0	23.45	174.0		81.0	10.67*	82.2		85.5	11.26	85.2	
	15	0.6	82.5		94.5		178.0	27.02	174.0	26.41	81.0	12.30*	75.0		85.5	12.98	85.9	
	16	1.0	83.0		95.2		178.0	46.90	174.0	45.85	81.0	21.34*	81.8		85.4	22.50	85.5	
	17	1.7	82.5		96.2		178.0	79.74	174.0	77.84	81.0	8.16*	81.8		85.4	38.25	82.9	
	18	1.4	82.8		96.2		178.0	65.66	174.5	64.37	79.0		82.2		82.4	30.40	82.9	
	19	1.7	82.8		95.0		178.0	79.74	174.5	78.17	80.7		82.2		85.4	38.25	0	
	20	1.6	83.0	34.99	96.0		178.0	75.04	174.5	73.57	81.1		80.5		85.4		85.4	
	21	1.6	82.8	34.91	96.0		178.0	75.04	174.5	73.57	81.1		81.9		0		83.3	
	22	1.1	82.8	24.00	96.5		178.0	51.59	174.5	50.58	81.1		82.1		0		83.3	
	23	0.6	82.8	12.57	96.0		178.0	27.02	174.5	26.49	81.1		82.2		0		83.6	
	24	0.4	82.6	8.71	96.8		178.0	18.76	174.0	18.34	81.1	8.55	82.2	8.66	0		83.3	
	25	0.6	82.5	12.52	96.8		178.0	27.02	174.5	26.49	81.1	12.31	82.2	12.48	84.5		83.6	12.69
	26	0.2	82.5	4.37	96.8		178.0	9.38	174.5	9.20	81.1		82.2		85.6		83.1	4.31
	27	0.4	82.9	8.74	96.6		178.0	18.76	174.5	18.39	81.1		82.2	8.66	85.8		0	
	28	0.6	82.8	12.57	96.4		178.0	27.02	174.5	26.49	81.1	12.31	82.2	12.48	85.8		83.4	
	29	0.6	82.6	12.57	96.5		178.0	27.02	174.5	26.49	81.0		82.1		85.9		83.6	
	30	0.4	82.7	8.72	95.5		178.0		174.5		81.0		82.0	8.64	85.8		83.6	
Oct.	1	0.8	82.6	17.41	95.5				0		81.0		82.7		85.9		83.9	17.69
	2	0.8	82.8		95.3		0		0		81.0	17.07*	80.1	16.89	85.9		83.8	17.67
	3	0.6	82.4		95.2		0		174.5		81.0	12.30*	80.0	12.14	0		83.6	12.69
	4	0.4	82.4		95.2		0		174.5		81.0	8.54*	79.9	8.42*	83.4		83.6	8.81
	5	-	0		95.8		174.5		174.5		81.1		80.0		83.5		83.8	

(Underline) = Tube Power

* (Asterisk) = Bulk Outlet

TOTAL MWD (TP)	680.59	1827.19	1609.63	33.17	402.13	684.67	660.57
MWD x.21	142.92	383.71	338.02	6.97	84.45	143.78	138.72
BO				577.42	338.40		

August 10 to October 4, 1959, inclusive - 646,965

BULK OUTLET - AVERAGE TEMPERATURE °C

1959

SEPTEMBER

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BULK OUTLET TEMPERATURE - °C

1959 - 11:30 P.M.

<u>DATE</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>
August 7	-	-	92.6	90.9	-	88.2	90.4	87.6
August 8	-	-	92.7	90.3	-	89.3	90.5	-
August 9	83.5	83.0	92.3	91.0	85.1	90.4	90.6	-
August 10	87.4	88.2	92.9	90.8	85.6	-	90.6	-
August 11	88.1	88.0	92.7	90.7	85.5	-	90.5	75.7
August 12	88.4	87.8	92.1	90.0	86.3	73.0	90.1	81.7
August 13	88.4	87.8	92.7	90.1	87.0	82.2	90.2	84.1
August 14	88.7	87.8	92.9	90.9	87.8	88.1	90.5	85.7
August 15	89.1	87.9	92.9	91.3	88.0	89.8	91.0	87.0
August 16	89.0	87.9	92.9	91.5	88.5	90.0	90.6	87.8
August 17	89.2	87.6	-	91.5	88.6	89.9	90.5	88.0
August 18	89.9	88.1	-	92.0	89.0	90.1	90.6	88.3
August 19	89.5	88.0	-	91.3	88.3	89.7	90.0	87.9
August 20	89.7	88.3	-	91.1	88.0	90.3	90.0	87.8
August 21	90.2	89.1	71.3	91.8	-	-	90.2	88.1
August 22	89.9	89.3	-	91.5	-	-	90.3	87.9
August 23	91.1	90.0	63.0	92.1	69.8	70.5	90.8	88.5
August 24	-	90.2	76.0	91.8	78.2	80.2	-	88.6
August 25	-	90.2	87.7	-	85.7	86.4	-	88.6
August 26	-	89.9	89.0	-	87.7	90.7	-	88.6
August 27	75.7	90.0	89.6	-	88.0	91.1	63.0	88.6
August 28	86.9	89.8	90.3	64.0	88.2	90.8	83.7	88.1
August 29	87.4	90.0	91.3	76.0	88.7	90.9	-	88.0
August 30	88.2	89.9	92.3	82.5	88.6	90.7	-	88.1
August 31	88.4	-	92.8	88.5	88.3	90.3	-	-
September 1	88.7	-	91.9	91.0	88.2	89.9	81.5	-
September 2	89.2	-	92.4	90.8	88.8	89.8	86.4	-
September 3	89.2	-	92.3	91.1	88.7	89.3	86.4	-
September 4	88.9	-	91.7	90.2	88.2	89.2	86.0	73.0
September 5	89.1	77.0	92.0	90.2	88.5	89.4	86.9	83.4
September 6	89.9	88.0	93.2	91.0	89.3	90.0	87.6	86.6
September 7	90.7	89.8	92.7	90.8	89.6	89.9	-	87.4
September 8	90.6	89.5	92.8	90.5	88.8	89.6	-	87.7
September 9	90.4	89.6	92.8	90.3	-	89.8	-	88.2
September 10	-	-	92.6	90.3	-	89.9	65.7	88.7
September 11	-	-	93.1	91.0	-	90.0	77.8	89.8
September 12	-	-	93.1	91.1	-	90.0	85.0	90.0
September 13	-	-	93.2	91.2	60.0	90.1	86.8	90.2
September 14	-	-	92.6	-	78.6	89.8	87.5	90.0
September 15	74.0	58.0	92.4	-	84.0	89.4	88.3	89.5
September 16	83.0	68.3	93.0	74.5	-	90.6	89.6	90.1

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BULK OUTLET TEMPERATURE - °C
(Continued)

1959 - 11:30 P.M.

<u>DATE</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 17	85.9	79.8	-	79.3	60.0	90.4	90.2	90.2
September 18	88.0	-	-	86.4	-	90.2	90.0	89.8
September 19	88.5	63.0	72.8	89.5	-	90.0	89.9	89.5
September 20	88.8	87.0	81.1	72.7	68.4	-	89.7	89.6
September 21	89.0	87.9	86.7	84.6	80.8	-	89.7	89.9
September 22	89.3	88.5	90.0	88.7	82.9	-	90.0	90.3
September 23	89.6	89.0	91.0	91.0	84.2	-	90.2	90.6
September 24	89.0	87.9	91.2	91.0	87.5	-	90.0	89.8
September 25	88.7	87.3	91.2	90.0	87.8	64.3	89.6	89.4
September 26	88.3	87.0	91.3	90.3	-	76.9	89.4	89.5
September 27	88.1	86.7	91.7	89.8	91.7	89.8	89.0	89.3
September 28	88.2	87.0	92.0	90.0	63.5	89.0	89.1	89.3
September 29	88.9	86.6	92.2	90.2	74.2	89.7	89.2	88.8
September 30	88.7	87.0	92.0	90.2	86.3	89.4	-	-
October 1	88.3	87.0	91.9	90.1	86.3	89.4	-	-

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V. REFERENCES

1. Daily Operating Reports
2. Rough Draft Letter, S. M. Graves, dated June 20, 1960

VI. ACKNOWLEDGMENTS

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