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WATER PLANT MODIFICATIONS FOR
INCREASED PRODUCTION
AT B, C, D, DR, F, AND H REACTORS

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WATER PLANT MODIFICATIONS FOR
INCREASED PRODUCTION
AT B, C, D, DR, F, AND H REACTORS

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WATER PLANT MODIFICATIONS
FOR INCREASED PRODUCTION AT
B, C, D, DR, F, AND H REACTORS

I. INTRODUCTION

A. Purpose

The purpose of this report is a) to define the extent of modifications necessary to increase capacities of the 100-B, C, D, DR, F, and H water plants for reactor flows of 90,000, 95,000, 105,000 and 115,000 GPM, and b) to provide supporting data for budget studies for increased production.

B. Background

As part of the combined IPD study on means and economics of providing major production increases at the six older reactors, the Water Plant and Utilities Engineering Operation was assigned the task of determining the water plant modifications necessary to support various increased process flow rates. Since a decision was made early in the study program to limit consideration to a single fixed bulk outlet temperature, any increase in existing reactor production must be obtained by increased coolant flow rates, improved time operated efficiency, or increased conversion ratio. Only increased coolant flow rates affect the water plant facilities directly.

At present, CG-558 flows have been exceeded at B, D, DR, F, and H Reactors, with a maximum of over 85,000 GPM at F and H. Minor additional flow increases at all six reactors are programmed for the next two years, but such increases will be limited by the available capacities of the filter plants, 181, 183, and 190 Building pumps, or size of outside lines.

This report is a companion to the report (1) by the Reactor Modification Design Operation which describes the modifications required from the 105 Building Valve Pits to the 107 Basins for the same study cases covered in this document. Budget planning for the increased production program was derived from the combined studies.

C. Scope of Study

The scope of the study is limited to capacity increases of the water plants from the river pump houses to the valve pits of the 105 Buildings and to the effluent systems from the 107 basins to the river. Inter-area temperature effects of the increased process flow are also included in this study. A flow of 85,000 GPM is considered as the base case or present flow for B, D, DR, F, and H Areas and 95,000 GPM for C Area.

The study includes the modifications necessary for flows of 90,000, 95,000, 105,000, and 115,000 GPM at B, D, DR, F, and H and for flows of 100,000, 105,000, and 115,000 GPM at C Area. The study cases considered in this report are defined in Table 1, page 5.

(1) HW-63351 (SECRET), "Increased Production Study, B, D, DR, F, H, and C Reactors", by N. F. Fifer and F. J. Kempf, dated April 18, 1960.

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TABLE 1
STUDY CASES
(All Pressures in PSI)

CASE	FLOW - GPM	OVERBORE	ΔP TUBE	ΔP FITTINGS	BACK PRESSURE	TORP	190 PUMP DISCHARGE PRESSURE	T.D.H.	NEW PUMPS OPERATING	NUMBER PUMPS OPERATING	FLOW PER PUMP - GPM	MOTOR INPUT H.P. PER PUMP
I-A	90,000	No	-	-	-	560	620	605	0 <i>9 Drives</i>	8	11,250	5100
II-A	95,000	No	390	130	-	520	580	565	1	8	11,900	5000
II-Z	95,000	Yes	380	130	-	510	580	565	0	7	13,550	5750
II-C	100,000	No	-	-	-	405	465	460	1	10	10,000	3660
III-A	105,000	No	525	175	-	700	750	725	3	10	10,500	5700
III-B	105,000	No	300	150	-	450	530	505	0	7	15,000	5740
III-Z	105,000	Yes	300	150	-	450	530	505	0	7	15,000	5740
III-C	105,000	No	-	-	-	390	455	450	1	10	10,500	3660
IV-A	115,000	No	410	190	-	600	655	630	3	10	11,500	5450
IV-B	115,000	No	335	180	-	515	580	555	2	9	12,800	5350
✓ IV-Z	115,000	Yes	225	180	-	405	495	470	0	7	16,400	5750
IV-C	115,000	No	-	-	-	380	455	450	2	11	10,500	3660
IV-A ₁	115,000	No	410	190	35	635	690	665	3	10	11,500	5750
IV-B ₁	115,000	No	335	180	35	550	615	590	2	9	12,800	5650
IV-Z ₁	115,000	Yes	190	180	35	405	495	470	0	7	16,400	5750
IV-C ₁	115,000	No	-	-	35	380	455	450	2	11	10,500	3660

II. BASIC ASSUMPTIONS

1. The existing 190 drive motors are suitable for operation at 5750 input horsepower and 0.95 leading power factor, as per Specification HWS-7003 and BPF-8831.
2. The 190 pump gears are also adequate for this motor horsepower, based on the designer's calculations and observations during a recent inspection by the vendor's design engineer (2).
3. One pump in each of the 181, 183, and 190 Buildings would be a spare unit. ←
4. An overall average filter rate of 7.2 GPM per square foot of filter area can be obtained in all areas, based on filter tests conducted at D Area in 1959 (3).
5. The two 181-C pumps currently being installed on Project CG-841 will be in place and operating.
6. The 181-D pump, for which funds are included in the FY1961 - IPD Equipment Budget, will be installed.
7. Funds for a fourth 30 MVA transformer at 151-B and 151-D, required because of general load increases not associated with a specific project, will be included in the FY1961 - CE&UO Equipment Budget.
8. Project CGI-889 for re-routing of B effluent through the 107-C West Basin will have been completed.

III. SUMMARY AND CONCLUSIONS

The Case I-A interim flow of 90,000 GPM can be achieved in B, D, F, and H Areas by adding one new pump in the 181-H, 183-B, and 183-D Buildings and one new filter in F Area. No new outside lines would be required.

The Case II flows of 95,000 GPM can be accomplished in the five oldest reactor areas by adding new pumps at 181 and 183 Buildings, new filters at F and DR Areas, and new outside lines in the D/DR Area. For the Case II-Z flow the present 190 motors and pumps with new impellers designed for greater flow and lower discharge pressure would be adequate for the new flow at all 190 Buildings. One additional 190 pumping unit for each reactor would be required for the Case II-A.

The Case III and IV flows would require considerably more water plant modifications for all six old reactors. New outside lines from 181 to 183 and from 183 to 190 Buildings as well as new pumps in 181 and 183 and additional filters would be required. At B, D, F, and H the new lines from 183 would tie-in to the header downstream from the 190 storage tanks and the present 190 tanks would normally be bypassed. A small storage tank would be installed on each end of the 190 Building roof to provide a back-up for the increased suction pressure for the 190 Annex pumps during the critical time of the decay period in the event of a power failure. At 190-DR a 600 HP booster pump would be added ahead of each of the 190-DR pumps. These booster pumps would be installed in the existing suction lines and would be a vertical drive type with a flywheel.

- (2) E. D. Heter, Letter to R. T. Jaske, "Report of Inspection of 4500 HP Gears", dated March 22, 1960.
- (3) R. W. Pitman - Personal Communication.

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III. SUMMARY AND CONCLUSIONS (Continued)

Additional transformer capacity would also be required at the pumping facilities in order to furnish the electrical power for the new pumps added in flow Cases II, III, and IV.

At this time it is assumed that new 190 pumps would be required to replace the existing pumps at B, D, DR, F, and H to obtain the Case III or Case IV flows, with the exception of Case IV-A. For flow Cases III-B, III-Z, IV-Z, and IV-Z₁ no new pumping units would be required. For Cases III-A, IV-A, and IV-A₁ the present pumps would not need to be replaced with new pumps; only the impellers would need to be changed. For Case IV-B, and IV-B₁ two additional pumping units would be required.

At 190-C the Case II-C or III-C flow would require one additional 3,500 HP pumping unit. Two additional units would be required to obtain the Case IV-C or IV-C₁ flow at C Area.

Effluent and outfall line capacities would be adequate for the range of flows considered with a few exceptions in B and D Areas. For Case III flows, an additional ring plate to raise the height of the 107-C tanks would be required. For Case IV flows, a cross-tie line between the two existing 60 inch effluent lines from the 107-C tanks to 1904-C would be required, plus an additional line between the DR Junction Box and 1904-DR. Effluent spill over the 1904 flumes will occur at somewhat lower flood flows, but should be tolerable for all cases considered.

Temperature increments in inlet water to be expected as a result of increased reactor flow should not be limiting but would have some effect on the economic gain. An annual mean temperature increment of $< 1^{\circ} \text{C}$ (a maximum increment of 2°C) in F Area would be expected over the base case; less in other areas.

A new transmission line would be required from Midway to 100-B Area for Case II-A, III-A, and all Case IV flows. A transformer larger than the 30 MVA transformer, funds for which have been included in budget planning, would be required at 151-D for Cases III-A, IV-A, and IV-A₁. The increased cost of this larger transformer is included in the estimate.

The project cost estimates for the complete water plant modification work are as follows:

	<u>B, D, F, AND DR</u>	<u>H *</u>	<u>C</u>
CASE I-A	\$ 680,000	\$ 110,000	
CASE II-A	10,750,000	1,650,000	
CASE II-Z	5,900,000	800,000	
CASE III-A	25,525,000	5,000,000	
CASE III-B	14,400,000	2,225,000	
CASE III-Z	14,400,000	2,225,000	
CASE IV-A AND IV-A ₁	25,925,000	4,800,000	
CASE IV-B AND IV-B ₁	25,150,000	4,450,000	
CASE IV-Z AND IV-Z ₁	✓ 18,850,000	2,600,000	
CASE II-C			\$ 530,000
CASE III-C			1,230,000
CASE IV-C AND IV-C ₁			2,360,000 ✓

* The H Area costs are shown separate from B, D, DR, and F Areas since the flow case best suited for H Area from a reactor modification standpoint is not necessarily the same as that for B, D, DR, and F Areas.

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IV. DISCUSSION

A. Water Plant

The additional pumps and outside lines required to produce sufficient water at 181 and 183 for the four flow cases have been determined from system curves produced from actual tests on the existing facilities (4)(5), combined with calculated friction losses in new lines to produce new system curves for the modified facilities. The river pump house curves are based on a low water level of 36,000 cfs.

Increased flows through the reactor, without a corresponding increase in friction loss, can be accomplished by either overboring the tube channels and installing larger tubes or by changing the size of the fuel elements. The cases considered in this study include the various reactor flows for both an overboring program and a non-overboring program and are defined in Table 1. Overboring is not currently being considered for C or H Reactors.

1. Case I-A

Case I-A is an interim flow case that could be achieved at B, D, F, and H Reactors for a minimum of capital expenditure in the water plants, but does not provide a spare unit at all of the water plant facilities for all periods of the year. At DR this interim flow is expected to be about 85,000 GPM instead of the 90,000 GPM at the other four reactors. To achieve a 90,000 GPM flow at DR would require considerable changes in the 183-DR effluent system and piping to 190-DR as well as an additional filter.

The Case I-A flows will require a reduction in top of riser pressure at B, D, F, and H Reactors to about 560 PSI for an eight pump operation and about 510 PSI for a seven pump operation. A flow of 85,000 GPM at DR will require a TORP of 545 PSI for an eight pump operation and 495 PSI for a seven pump operation.

The minimum modifications necessary for the Case I-A flows are given in Appendix A.

2. 181 Building to 190 Annex Building - Cases II, III, and IV

The pumping capacity from the 181 Building to the 190 Annex Building can be accomplished for the Case II flow of 95,000 GPM in B and H Areas by adding new pumps and motors in the existing 181 and 183 Buildings. F Area would require one new filter as well as additional pumps in the 181 and 183 Buildings. At D/DR Areas new outside lines, new filters, and additional pumps at 183 would be required. Additional filtering capacity can be achieved by adding more filters to the existing bank of filters. Additional flocculators and settling basins would not be required since the present settling basins have adequate volume for the required retention time for even Case IV flows. The water plant system for Case II would operate much the same as at present. The 183 pumps would pump water into the 190 storage tanks.

(4) HW-58580 (SECRET), "Existing Reactor Water Plant Study B, C, D, DR, F, and H Reactors Interim Report", D. F. Watson, dated January 19, 1959.

(5) HW-60816 (SECRET), "190-C Pumping Capacity", D. F. Watson, dated June 22, 1959.

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2. 181 Building to 190 Annex Building - Cases II, III, and IV (Continued)

The Case III and IV flows would require new outside lines as well as new pumps and additional filters. The Case IV flows would require an extension to the 181-D Building of one 16 foot bay to house the additional pumps. At B, D, F, and H the two new 36 inch lines from the 183 Building would tie into each end of the 36 inch header downstream from the 190 storage tanks. Check valves would be installed in the lines between the tanks and downstream header. These check valves would normally be closed and the storage tanks would be bypassed. If the normal source of water were lost, the check valves would open and the 190 storage tank water would be available as it is now. By bypassing the 190 tanks, it is expected that a NPSH of 25 to 30 PSI could be attained at the 190 Annex pumps.

In order to maintain this new NPSH in the event of a power failure, two 10,000 gallon storage tanks would be mounted on the roof of the 190 tank room building and be tied into the 36 inch header. New columns and other structural modifications would be required for each tank. The storage tanks would supply water at the required pressure for the first several critical seconds.

At 190-DR, 600 HP vertical type booster pumps would be installed in the 24 inch suction lines ahead of the Annex pumps. The pumps would be in the basement of the Annex Building and the motor and flywheel would be above the operating floor. The flywheels would be of a size to match the decay curve of the Annex pumps. The pumps would develop a TDH of about 50 pounds at a flow of 16,400 GPM per pump. With this added booster pump pressure the DR Annex pumps could supply water to the DR Reactor at the same TORP as the other four reactors.

Additional transformer capacity would be required at all 181 Buildings, all 183 Buildings except H, and the 190-DR Building for this increased production program. The present 3,000/4,000 KVA transformers, which are not equipped with fans and therefore rated at 3,000 KVA, would be replaced with 3,750/5,000 KVA transformer equipped with fans at part of the locations requiring more capacity. The replaced transformers would be moved to the remaining locations and paralleled with existing transformers to meet the increased load requirements. After the completion of these changes, all 181 and 183 Buildings would be able to operate in the event one transformer or one 13.8 KV line were lost.

The modifications required for the Case II, III, and IV flows are given for each area in Appendix A.

3. 190 Annex Building - Cases II-A, II-Z, III-A, III-B, III-Z, IV-A, IV-B, IV-Z, IV-A₁, IV-B₁, and IV-Z₁

The number of pumps required at the 190 Annex Building for Case II to Case IV flows depends on the TORP at the reactors. For a given flow, the horsepower per pump is approximately proportional to the TORP. The present 190 Annex pump motors are limited to 5,750 input horsepower at 0.95 leading power factor. In order to continue to use these existing motors in the increased production program, each pumping unit motor must still be limited to 5,750 input horsepower. Additional pumping units must then be added when the input horsepower per motor would exceed 5,750.

3. 190 Annex Building - Cases II-A, II-Z, III-A, III-B, III-Z, IV-Z, IV-B, IV-Z, IV-A₁, IV-B₁, and IV-Z₁ (Continued)

With the overboring program the TORP can be made low enough so that the required flows could be achieved with seven pumps operating within the limiting horsepower per pump. Except for Case III-B, all of the non-overboring cases would require a TORP higher than that which seven pumps can produce with the existing motors. From one to three additional "4,500 HP" pumping units complete with drives would be required for these cases.

For a given flow the electrical operating costs for the 190 pumps are also proportional to the TORP. Figure 1 shows the incremental annual electrical and water treatment costs for the twelve different flow cases for the B, D, DR, F, and H Areas. The non-overboring cases would cost up to approximately \$1,000,000 more per year than the overboring cases for the Case III and IV flows.

Two additional new "4,500 HP" pumping units could be installed in the present 190-B, D, DR, and F pump rooms by removing two existing steam turbine pumps and constructing new bases. The third unit would have to be housed in an addition to the Annex Building. Three units could be installed at 190-H pump room by removing four existing steam turbine pumps. The 18 inch discharge lines from these new units at B, D, DR, and F would be installed in the two old tunnels from 190 pump room to the 105 valve pit. One new 18 inch line could be added to the tunnels without too much difficulty. Two new lines in one tunnel, however would require considerable modifications to the pipe supports. At H Area the abandoned 24 inch lines could be used by extending them to the 105-H valve pit.

At this time it is estimated that for the Case II flows the present pumps could be used. New impellers might be necessary and have been included in the estimate. For all Case III and IV flows with the exception of Case IV-A and IV-A₁ it is assumed that the present pumps would be replaced with new pumps since the present pump housings would probably not accommodate the larger impellers required for the greater flows. The TDH and discharge per pump for the Case IV-A and IV-A₁ are probably within the reach of the present pumps with new impellers.

The modifications and number of pumps necessary to obtain the various Case II, III, and IV flows at the 190 Annex Buildings are shown in Appendix A.

4. 190-C Building - Cases II-C, III-C, IV-C, and IV-C₁

Since overboring is not currently being considered at 105-C, no great reduction in TORP is expected with planned reactor modifications. Additional flow would have to be accomplished by adding more complete pumping units on the existing spare bases plus additional 3,750 KVA transformers. The modifications necessary to obtain the various flow cases are shown in Appendix A.

5. 190 Process Pump Flywheel Capacity

For this report, emergency process water supply was studied for adequacy of flywheel capacity during the initial few seconds following complete loss of primary (BPA) power to all pumps. Flywheel energy must supply sufficient water to the reactor to prevent significant boiling in process tubes, rear-

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FIGURE 1

INCREMENTAL ANNUAL ELECTRICAL & WATER TREATMENT COSTS
B, D, DR, F & H AREAS

5. 190 Process Pump Flywheel Capacity (Continued)

face piping, or downcomers, until the reactor heat generation decays to the point where other power sources can provide an adequate water supply. In practice, boiling in the cross-over piping and downcomers is of most concern during this period. Normally the secondary source would be the 190 steam pumps, however in the unlikely event of concurrent loss of steam and electrical supply, the source would be the high tanks, followed by the export water system. The adequacy of these sources has been studied and is being reported (6)(7) by others.

Figure 2 shows the critical cooling period immediately following the loss of electric power. The distance between the "Flow Decay" and the "Flow Required" curves is a measure of the instantaneous deficit of coolant flow required to maintain the initial bulk outlet temperature and is related to the size of the bulk temperature surge. As the heat generation decreases, so does the bulk temperature. Note that the "Flow Required" curves have two distinct parts, the first covering the lag-time between actual loss of pump power and effective reactor shutdown. This lag-time is primarily determined by the rod drop time (to a lesser degree by the time delay in relay operation) and is obviously a major factor in determining the size of the temperature surge. The relatively minor increase in flow decay rate and temperature surge compared to current operating conditions as a result of using the increased pump horsepower is evident. Table II shows the calculated maximum temperature surge following BPA failure for various operating conditions.

TABLE II

BULK TEMPERATURE INCREASE FOLLOWING BPA POWER LOSSB, D, DR, F, and H Reactors

	<u>te = 1.0 sec.</u>		<u>te = 2.0 sec.</u>		<u>te = 2.5 sec.</u>		<u>te = 3.0 sec.</u>	
<u>CASE</u>	<u>T_i</u>	<u>T₀</u>	<u>T₀ ← Probable → T₀</u>		<u>Range</u>		<u>T₀</u>	
Design	2	1.3	2.5		3.2		3.9	
	20	1.0	2.1		2.5		3.1	
Existing	2	1.5	2.8		3.5		4.3	
	20	1.2	2.3		2.8		3.4	
I-A	2	1.5	2.9		3.7		4.4	
	20	1.2	2.4		3.0		3.5	
Maximum HP cases (II-Z, III-A, B, Z, IV-A, B, Z)	2	1.8	3.5		4.3		5.3	
	20	1.4	2.8		3.5		4.1	

- NOTES: 1) Based on 95° C B.O.T., no change in existing 190 pump flywheels.
 2) Values are not corrected for fluid inertia.
 3) Details of calculations are given in Appendix A.

(6) HW-62861 (SECRET), "Adequacy of the Old Reactor Backup Cooling Systems", S. S. Jones, dated December 1, 1959.

(7) HW-63526 (SECRET), "FY1962 P&AC Budget, Coolant Backup, Old Reactors and KER", W. J. Tupper and D. F. Watson, dated January 15, 1960.

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FIGURE 2
190 FLOW DECAY
VS
REACTOR HEAT DECAY

5. 190 Process Pump Flywheel Capacity (Continued)

A comparison of various temperatures is shown below. The maximum temperature transient calculated for the expected time delay is less than the 15°C calculated for potential transients from other causes than loss of BPA power (8). The maximum surge calculated could cause the bulk temperature

T- $^{\circ}\text{C}$

102.5 Equivalent of 2 PSI overpressure in top of downcomer (recommended maximum)

101.5 Possible temperature surge with study cases with maximum expected variation of B.O.T.

99.5 Maximum temperature surge calculated over normal B.O.T. with study cases; also normal saturation temperature

98.5 Maximum temperature surge calculated over normal B.O.T. with existing operating conditions

95 Proposed B.O.T.

to exceed momentarily the saturation temperature in the cross-over pipe and top of downcomer, when superimposed on a random bulk temperature fluctuation of $\pm 2^{\circ}\text{C}$. As described in reference (9) and later documents, a bulk temperature higher than the saturation temperature could cause instability and pressure cycling. The limited test data available, however, do not confirm these calculated temperature transients (10). The temperature record following a recent unscheduled BPA trip in H Area indicated no transient at all (although the instrumentation characteristics may have masked it).

In view of the lack of confirming test data and the comparative size of the temperature surge increment due to the increased production levels, no cost for increasing flywheel capacity to eliminate this increment has been included in the study cost estimate. Actually, the size of the calculated increment is within the accuracy of either calculation or of measurement. For reference however, a cost estimate has been obtained for adding the approximately 10 per cent inertia to the existing flywheels to provide the same decay characteristic as at present. The estimated project cost is \$5,000 per flywheel or \$200,000 for the five reactors concerned. This is considered as a contingency item pending further trip-out test data.

B. Effluent System1. System Capacities - 107 Basins to River

This study is concerned with effluent system capacities only from the 107 basins to the river, since the portions from the 105 Buildings to the basins have been studied and reported separately (8). The basic assumption was made that no changes in the existing effluent systems would be made other

(8) HW-63487 (SECRET), "Piping Changes for Increased Production at B, D, DR, F, C, and H Reactors", G. H. Bauer, et al., dated January 22, 1960.

(9) HW-51325 (SECRET), "Preliminary Analysis of Bulk Outlet Temperature", S. S. Jones, dated May 8, 1957.

(10) S. S. Jones - Private Communication.

1. System Capacities - 107 Basins to River (Continued)

than as indicated by this study, except in B Area. A project for re-routing B effluent into 107-C West Basin and back to 1904-B has been authorized and capacity calculations have been based on its completion. Where dual lines from the 107 Basins to 1904 exist (DR and H), the further assumption was made of **using both lines during normal operation.**

With a few exceptions, the existing effluent systems will have adequate capacities for process flows up to 115,000 GPM. For all Case IV flows at DR, an additional line between the DR Junction Box and 1904-DR would be required to prevent excessive spill into 1904-D and over the 1904-D flume at high river flows. For Case III-C, additional wall height would be needed at the 107-C tanks to prevent over-topping, and for Case IV-C, a cross-tie line between the existing 60 inch lines from the 107-C tanks to 1904-C.

Capacities of the outfall lines into the river have been considered in terms of the amount of effluent discharged via the overflow flumes from the 1905 structures during high river flows. The potential problem is primarily increased effluent uptake at downstream reactors as a result of discharge along the shoreline. The critical location is 1904-H, where flume spill now occurs at river flows in excess of about 350,000 cfs and would occur at about 275,000 cfs with Case IV flows. The worst case at this location would be at a river flow of about 450,000 cfs, when the 1904 structure is partially submerged. Even for this case, however, the resulting effluent concentration at 181-F would be less than the annual mean. River flows above which spill over the flumes may be expected with process flows of 115,000 GPM are:

1904-B	550,000 cfs	(10 year frequency)
1904-C	> 900,000 cfs	(> 100 year frequency)
1904-D	350,000 cfs	(1-2 year frequency)
1904-DR	> 900,000 cfs	(> 100 year frequency)
1904-H	275,000 cfs	(Annually - average duration 6 weeks)
1904-F	350,000 cfs	(1-2 year frequency)

Water velocities would increase proportionately with flow to a maximum of 17 fps (in the D outfall lines) at Case IV flows, and generally 10 to 15 fps. These higher velocities would cause somewhat more rapid deterioration of concrete structures and possibly the steel lines, but the resulting increased maintenance cost cannot now be realistically predicted. Evidence of damage to date has been almost completely due to thermal expansion which would not be affected.

2. Temperature Increases in Process Water

An inevitable result of increased process flows is increased pickup of upstream reactor effluent in reactor area raw water. Available data indicate that the increase which occurs persists through the water plant to the reactor inlet except in the coldest months. Unfortunately, the diffusion of effluent in the river is such a complex phenomenon that extrapolation of plant data to operating conditions other than those for which data was obtained must be of questionable accuracy. For calculation, results of several special sampling programs performed at intermediate flows have been used, and adjusted as indicated by routine plant temperature data and raw water analyses. Details are shown in Appendix B.

Calculated values of the temperature increases of raw water at each reactor for varying nominal process flows are shown in Figure 3, based on all reactors operating, a river flow of 100,000 cfs, an inlet temperature at 20° C, and a bulk outlet temperature of 95° C. All values should be reliable to within ± 50 per cent. A flow of 100,000 cfs is close to the mean annual flow and also the probable mean during the most critical temperature period (middle of August to the middle of September). For lower river flows and larger reactor bulk temperature increases, the plotted values would be higher, but lack of available data prevents reliable prediction. As noted above, pickup from flume overflow during flood periods should not cause the values shown in Figure 3 to be exceeded.

C. Electrical Utilities Capacity

Increased 230 KV transmission line and transformer capacity would be required to support the increased electrical power demand of some of the study cases. A study of the increased loads and equipment capacities has been made by F. J. Mollerus (11).

Criteria used in determining adequacy of equipment were as follows:

- a. Total area electrical loads include those already forecast through Fiscal Year 1964 (12) plus the increases resulting from the various study cases.
- b. Total capacity will be required for operation of all water plant pumps, even though the study cases are based on maintaining a spare unit at each location. This provision has been included on the basis of past experience with hot weather operation.
- c. 100 per cent loading on existing 230/13.8 KV transformers is 29 MVA. (31.25 KVA absolute top rating)
- d. A conductor temperature of 80° C in the 230 KV transmission lines from Midway is permissible at average voltage (with an ambient temperature of 25° C). This is slightly less conservative than the present Electrical Utility Operation rating, but agrees with advice from Schenectady.

(11) Letter, F. J. Mollerus to R. T. Jaske, "Expansion Program - Major Electrical Equipment Requirements", dated March 7, 1960.

(12) HW-59962 REV. (SECRET), "IPD Five-Year Power Forecast - FY 1960 Through 1964", V. G. Blanchette, dated December 9, 1959.

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Transformers

Overloading of four 250/13.8 KV transformers in 100-D Area up to 111 per cent would occur with Cases III-A, IV-A, and IV-A₁ under the stated conditions. Since installation of a fifth transformer in this area would be difficult because of space limitations, and since the fourth transformer is not yet ordered, a larger capacity in this transformer should be provided if the study cases in questions are adopted. A nominal 50 MVA instead of 30 MVA would be required. The estimated increase in project cost for the larger capacity transformer is \$225,000 and is included in Appendix D.

All other areas should have sufficient transformer capacity to handle all study case loads, with four at 100-B and two at 100-F and H.

Transmission Lines

Existing 230 KV transmission lines have adequate capacity as rated for all study cases as long as all three feeder lines from Midway are in service. (See sketch below) When No. 3 line is open, however, for maintenance or under possible emergency conditions, an overload could exist on No. 1 line between Midway and 100-B with all reactors operating under Case III-A and all Case IV flows. Opening of lines No. 1 or No. 2 is less of a problem since line No. 3 is of heavier conductors. Although other study cases would be marginal, proper

scheduling of line opening with reactor operation should avoid the necessity for additional replacement.

Replacement of the existing (Egret size) conductors with the next heavier size (Drake) would therefore be required on No. 1 line from Midway to 100-B. The estimated project cost of \$1,500,000 is included in Appendix D.

V. ACKNOWLEDGMENTS

The authors wish to express their appreciation to D. F. Watson for providing plant test data and capacity calculations previously accumulated by Reactor Modification Design Operation, to F. J. Mollerus and C. F. Quackenbush, Principal Engineers, FEO, for technical guidance, to V. G. Blanchette for providing detailed electrical requirements, and to J. C. Baudendistel, M. P. Johnson, and A. McDonald, Water Plant and Utilities Engineering Operation, for providing and interpreting additional plant operating and test data.

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APPENDIX A

MODIFICATIONS TO WATER PLANTS

The water plant modifications for the various Case I, II, III, and IV flows considered in the Increased Production Study and which form the basis for the Budget Study estimates are shown below. The modifications shown for each flow case are the total work required for that case.

1. Case I-A

- (1) 183-B - Add one 700 HP pump and motor.
- (2) 183-D - Add one 700 HP pump and motor.
- (3) 183-F - Add one filter.
- (4) 181-H - Add one 600 HP pump and motor.

2. Case II, III, and IV - 181 Building to 190 Annex Building

a. 100-B Area

(1) 181-B/C Building

The 181-B/C will be considered as one unit since the C side supplies water to B via the cross-tie line. The modifications in the 181 Building for the three flow cases are shown on SK-1-3916, sheets 1 and 2, pages 43 and 44.

Case II

- (a) Add one new 600 HP pump and motor on the B side.

Case III

- (a) Add two new 600 HP pumps and motors, and replace two existing 450 HP export pumps with 600 HP pumps and motors on the B side.
- (b) Replace three existing 450 HP pumps with 900 HP pumps and motors on the C side.
- (c) Add two 3,000/4,000 KVA transformers (from 181-F).
- (d) Add one new 13.8 KV line from 151-B Substation to 181-B.
- (e) Restrung two existing No. 2/0 13.8 KV line with No. 3/0 wire.

Case IV

- (a) Add two new 600 HP pumps and motors and replace two existing 450 HP export pumps with 600 HP pumps and motors on the B side.
- (b) Replace five 450 HP pumps with 900 HP pumps and motors and the one 450 HP export pump with a 600 HP pump and motor on the C side.
- (c) Add two 3,000/4,000 KVA transformers (from F Area).
- (d) Add one new 13.8 KV line from 151-B Substation to 181-B.
- (e) Restrung two existing No. 2/0 13.8 KV lines with No. 3/0 wire.
- (f) Add 42 inch line from 181 to 183-B Building.

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(2) 183-B Building

The modifications proposed for the 183-B Pump Room are shown on SK-1-3951, page 45.

Case II

- (a) Add two new 700 HP pumps and motors. This work requires two new foundations and minor structural modifications to the building to provide adequate space for the two new units.
- (b) Add two 3,000/4,000 KV transformers (from 183-D).

Case III

- (a) Add two new 700 HP pumps and motors.
- (b) Add one filter.
- (c) Add two 3,000/4,000 KVA transformers (from 183-D).
- (d) Add 36 inch and 42 inch lines from the 183-B Building to 36 inch header downstream from 190 storage tanks as shown on SK-1-3950, page 42.

Case IV

- (a) Case III modifications plus one additional filter.
- (b) Replace the 18 inch discharge piping with 24 inch pipe and valve on the existing six pumps.
- (c) Replace the 24 inch gate valves and cone valves in the head house with 36 inch valves.

(3) 190-B Tank Room

Case III and IV

- (a) Install two 10,000 gallon storage tanks on roof of 190 Tank Room and tie-in to the 36 inch header.

(4) 183-C Building

Case IV Only

- (a) Add one 450 HP process water pump and motor in the pump room.

b. 100-D/DR Area

(1) 181-D/DR Building

The 181-D/DR will be considered as one unit since the modifications proposed effect both areas. The modifications at 181 are shown on SK-1-4076, page 47.

Case II

- (a) Replace the existing 450 HP export pump with a 600 HP pump and motor.
- (b) Replace the 36 inch header with a 42 inch header.
- (c) Remove the 30 inch header and tie-in the export pump and steam turbine pumps to the new 42 inch header.
- (d) Add a 60 inch line from the new 42 inch header at 181-D to the vicinity of 183-D, then a 48 inch line to 183-D and a 48 inch line to 183-DR as shown on SK-1-4078, page 46.
- (e) Tie-in 30 inch export line to 60 inch lines as shown on SK-1-4078.
- (f) Add a new 13.8 KV line from 151 Substation to 181-D.

Case III

- (a) Case II modifications plus one additional 900 HP pump and motor.
- (b) Add one 3,000/4,000 KVA transformer (from F Area).

Case IV

- (a) Case II modifications plus three additional 900 HP pumps and motors.
- (b) Add one 3,750/5,000 KVA transformer.
- (c) Add one 16 foot bay extension to the 181 Building.
- (d) Replace the No. 2/0 wire on the two existing 13.8 KV lines from the 151 Substation with No. 3/0 wire or larger.

(2) 183-D Building

The modifications for 183-D are shown on SK-1-4077, page 48.

Case II

- (a) Add two 700 HP pumps and motors. This modification involves removing one high-tank steam turbine pump, relocating the 6,000 GPM electric high-tank pump to the position vacated by the steam turbine pump, and adding one new 700 HP pump in the position vacated by the electric high-tank pump. It also involves some minor structural modifications to the building to provide adequate space for the second new pump.
- (b) Replace the 18 inch discharge piping on the six existing pumps with 24 inch pipe and valves.
- (c) Replace the 24 inch gate valves and cone valves in the head house with 36 inch valves.
- (d) Replace two 3,000 KVA transformer with new 3,750/5,000 transformers.

Case III

- (a) Case II modifications except delete item (b).
- (b) Add one filter.
- (c) Add 36 inch and 42 inch lines from the 183-D Building to 36 inch header downstream from the 190 storage tanks as shown on SK-1-4078, page 46.

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Case IV

- (a) Case III modifications plus one additional filter.
- (b) Replace the 18 inch discharge piping with 24 inch pipe and valves.

(3) 190-D Tank Room

Cases III and IV

- (a) Add two 10,000 gallon storage tanks on roof of 190 Tank Room and tie-in to the 36 inch header.

(4) 183-DR Building

Case II

- (a) Alter distribution flume to the settling basins to increase influent capacity.
- (b) Add one 200 HP back wash pump and appropriate building addition.
- (c) Add two 48 inch lines from the effluent flume to the 36 inch header in the 190-DR Building as shown on SK-1-4078, page 46.
- (d) Add two filters.
- (e) Change 24 inch gate valves and cone valves in head house to 36 inch valves.

Case III

- (a) Case II modifications except add four filters instead of two filters.

Case IV

- (a) Case III modifications except add five filters instead of four.

(5) 190-DR Building

Cases III and IV

- (a) Add 600 HP booster pumps ahead of 190-DR Annex pumps.
- (b) Add two 3,000/4,000 KVA transformers.

c. 100-F Area

(1) 181-F Building

The modifications proposed for 181-F are shown on SK-1-3907, page 50.

Case II

- (a) Add two 450 HP pumps and motors.
- (b) Replace two 3,000 KVA transformers with new 3,750/5,000 KVA transformers.

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Case III

- (a) Case II modifications.
- (b) Add 48 inch line from 181-F to 183-F as shown on SK-1-3949, page 49.

Case IV

- (a) Add three 450 HP pumps and motors.
- (b) Replace two 3,000 KVA transformers with new 3,750/5,000 KVA transformers.
- (c) Add 48 inch line from 181-F to 183-F.

(2) 183-F Building

The modifications required at 183-F are shown on SK-1-3947, page 51.

Case II

- (a) Add two 700 HP pumps and motors.
- (b) Replace two 3,000 KVA transformers with new 3,750/5,000 KVA transformers.
- (c) Add one filter.

Case III

- (a) Case II modifications except add three filters instead of one.
- (b) Replace 24 inch gate valves and cone valve in the head house with 36 inch valves.
- (c) Add 36 inch and 42 inch lines from the 183-F Building to 36 inch header downstream from 190-F storage tanks as shown on SK-1-3949, page 49.

Case IV

- (a) Case III modifications except add four filters instead of three.
- (b) Replace 18 inch discharge piping with 24 inch pipe and valves on the six existing pumps.

(3) 190-F Tank Room

Cases III and IV

- (a) Add two 10,000 gallon storage tanks on roof of 190 Tank Room and tie-in to the 36 inch header.

d. 100-H Area

(1) 181-H Building

The modifications proposed for 181-H are shown on SK-1-3909, page 53.

Case II

- (a) Remove one steam turbine.
- (b) Add three 600 HP pumps and motors.
- (c) Add one 3,000 KVA transformer (from F Area).

Case III

- (a) Remove one steam turbine.
- (b) Add two 600 HP pumps and motors.
- (c) Add 42 inch line from 181-H to 183-H as shown on SK-1-3952, page 52.
- (d) Add one 3,000 KVA transformer (from F Area).

Case IV

- (a) Case III modifications.
- (b) Add 42 inch line from 181-H to 183-H.

(2) 183-H Building

The modifications required for 183-H are shown on SK-1-3948, page 54.

Case II

- (a) Add one 700 HP pump and motor.

Case III

- (a) Add one 700 HP pump and motor.
- (b) Replace 18 inch discharge piping with 24 inch pipe and valves on the six existing pumps.
- (c) Replace the 24 inch gate valves and cone valves in the head house with 36 inch valves.
- (d) Add two 36 inch lines from 190 Building to 36 inch header downstream from the 190 storage tanks as shown on SK-1-3952, page 52.
- (e) Replace filter media in eight filters.

Case IV

- (a) Case III modifications.
- (b) Add one additional 700 HP pump and motor.
- (c) Replace filter media in eight additional filters.

(3) 190-H Tank RoomCases III and IV

- (a) Add two 10,000 gallon storage tanks on roof of 190 Tank Room and tie-in to the 36 inch header.

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3. 190 Annex Buildings - Cases II-A, II-Z, III-A, III-B, III-Z, IV-A, IV-B, IV-Z, IV-A₁, IV-B₁, and IV-Z₁

a. 190-B, D, and F Buildings

Case II-A

- (a) Install new impellers in the 190 pumps.
- (b) Remove one steam turbine pump in the 190 Pump Room and add one "4,500 HP" pump and drive.
- (c) Add one 18 inch line to 105 valve pit.

Case II-Z

- (a) Install new impellers in the 190 pumps.

Case III-A

- (a) Replace existing 190 Annex pumps with new pumps.
- (b) Remove two steam turbine pumps in the 190 Pump Room and add two "4,500 HP" drives and pumps.
- (c) Add 190 Annex Building addition and one "4,500 HP" pump and drive.
- (d) Add three 18 inch lines to 105 valve pit.

Cases IV-A and IV-A₁

Same as III-A except install new impellers in the existing 190 pumps.

Cases III-B, III-Z, IV-Z, and IV-Z₁

- (a) Replace existing 190 Annex pumps with new pumps.

Cases IV-B and IV-B₁

- (a) Replace existing 190 Annex pumps with new pumps.
- (b) Remove two steam turbine pumps in the 190 Pump Room and add two "4,500 HP" pumps and drives.
- (c) Add two 18 inch lines to 105 valve pit.

b. 190-DR Building

Case II-A

- (a) Install new impellers in the 190 pumps.
- (b) Remove one steam turbine pump in the 190 Pump Room and add one "4,500 HP" pump and drive.
- (c) Add one 18 inch line to 105 valve pit.

Case II-Z

- (a) Install new impellers in 190 pumps.

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Case III-A

- (a) Replace existing 190 Annex pumps with new pumps.
- (b) Remove two steam turbine pumps in 190 Pump Room and add two "4,500 HP" pumps and drives and two 600 HP booster pumps.
- (c) Add 190 Annex addition and one "4,500 HP" pump and drive and one 600 HP booster pump.
- (d) Add three 18 inch lines to 105 valve pit.
- (e) Add one 3,000/4,000 KVA transformer.

Cases IV-A and IV-A₁

Same as Case III-A except install new impellers in existing 190 Annex pumps.

Cases III-B, III-Z, IV-Z, and IV-Z₁

- (a) Replace 190 Annex pumps with new pumps.
- (b) Add one 3,000/4,000 KVA transformer.

Case IV-B

- (a) Replace 190 Annex pumps with new pumps.
- (b) Remove two steam turbine pumps in 190 Pump Room and add two "4,500 HP" pumps and drives and two 600 HP booster pumps.
- (c) Add two 18 inch lines to 105 valve pit.
- (d) Add one 3,000/4,000 KVA transformer.

c. 190-H Building

Case II-A

- (a) Install new impellers in the 190 pumps.
- (b) Remove one steam turbine pump in the 190 Pump Room and add one "4,500 HP" pump and drive.
- (c) Extend abandoned 24 inch line in old tunnel to 105 valve pit.

Case II-Z

- (a) Install new impellers in the 190 Annex pumps.

Case III-A

- (a) Replace existing 190 Annex pumps with new pumps.
- (b) Remove four steam turbine pumps in the 190-H Pump Room and add three complete "4,500 HP" pumps and drives.
- (c) Extend the two abandoned 24 inch lines in the old tunnel to the 105-H valve pit.

Cases IV-A and IV-A₁

Same as Case III-A except install new impellers in existing 190 pumps.

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Cases III-B, III-Z, IV-Z, and IV-Z₁

- (a) Replace existing 190 Annex pumps with new pumps.

Cases IV-B and IV-B₁

- (a) Replace existing 190 Annex pumps with new pumps.
- (b) Remove two steam turbine pumps in the 190 Pump Room and add two "4,500 HP" pumps and drives.
- (c) Extend the two abandoned 24 inch lines in the old tunnel to the 105 valve pit.

4. 190-C Building - Cases II-C, III-C, IV-C, and IV-C₁

Cases II-C and III-C

- (a) Add one 3,500 HP pump and drive.
- (b) Add one 3,750 KVA transformer.

Cases IV-C and IV-C₁

- (a) Add two 3,500 HP pumps and drives.
- (b) Add two 3,750 KVA transformers.

5. 107 to 190₄

Cases IV-A, IV-A₁, IV-B, IV-B₁, IV-Z, IV-Z₁

- (a) Add 48 inch line between 190₄-DR and Junction Box.

Case III-C

- (a) Add two feet height to top of 107-C Basins.

Case IV-C

- (a) Add two feet height to top of 107-C Basins.
- (b) Add 48 inch cross-tie line between existing 60 inch lines from 107-C Basins.

APPENDIX B

FLYWHEEL DECAY AND SHUTDOWN FLOW CALCULATIONS

Flow Required

Heat generation in a given reactor after shutdown is a function of initial power level (P_o) and time (t). This may be expressed as:

$$q_{\text{generated}} = f(P_o, t)$$

$$\text{and for a given initial power level, } q_g = P_o \cdot f(t) = \rho C_p Q_o (T_o - T_i)_o \cdot f(t)$$

where Q_o = initial reactor coolant flow rate

T_o = bulk outlet temperature

T_i = inlet temperature

The heat removed at time (t),

$$q_r = \rho C_p Q_t (T_o - T_i)_t = U A (T_r - T_w)_t$$

where U = overall mean heat transfer coefficient from tubes and fuel elements

A = overall area coefficient for tubes and fuel elements

T_r = overall mean film temperature coefficient for tubes and fuel elements

T_w = mean coolant temperature

For the heat decay period after shutdown,

$$\text{if } q_g = q_r$$

$$\text{and } (\Delta T)_t = (\Delta T)_o \text{ (stable bulk outlet temperature)}$$

$$\text{then } Q_t = Q_o \cdot f(t)$$

Over an extended time interval and wide range of flow, the ratio Q_t/Q_o is a function of a number of other variables, but over the limited range of flows (80 to 100 per cent) and short time interval considered here, the approximations above are valid. Therefore, neglecting any changes in the physical properties of the coolants, a single heat decay curve of Q_t/Q_o vs. t may be drawn, irrespective of Q_o , T_o , T_i , and P_o .

When plotting the heat decay curve, the decay function $f(t)$ originates at some time after the actual time of power loss as determined by the time of effective reactor shutdown t_e .

$$t = t_{\text{eff.}} + t_e$$

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Flow Required (Continued)

The value of t_e varies somewhat from reactor to reactor, but is currently between 2 and 3 seconds based on limited tests. It is subject to change in the future by VCR and relay modifications to as low as one second with air-accelerated rods. Otherwise a value between 2 and 2-1/2 seconds should represent future conditions at B, D, DR, F, and H for a BPA trip.

Heat decay curves used were prepared by S. S. Jones for use in HW-56814 RD. The normalized values of Q/Q_0 vs. t as shown in Figure 2, page 13 of this report, with t_e varying from 1 to 3 seconds, are:

<u>$t_{eff.}$</u>	<u>Q/Q_0</u>
0	1.000
1	0.948
2	0.883
3	0.820
4	0.760
5	0.695
6	0.643
7	0.593

Flow Available

The general formula for flow decay from a pump is

$$Q_t/Q_0 = \frac{1}{1 + \beta t}$$

where β is the decay constant equal to the ratio of initial pump power requirement to initial kinetic energy in pump, flywheel, and fluid (13).

If fluid inertia is neglected,

$$\beta = \frac{(P_0 Q_0 + e L_0) g}{I_w \omega_0 e}$$

Where P_0 = initial TDH

Q_0 = initial pump flow

e = pump efficiency

L_0 = friction losses in pump and bearings

I_w = inertia of flywheel shaft and motor in weight units

ω_0 = initial pump speed

(13) HW-62846 (UNCLASSIFIED), "Hydraulic System Flow Decay Relations During Loss of External Power", W. J. Love, dated February 11, 1960.

Flow Available (Continued)

For this study, the following values were used (14):

$$e = 0.82 \text{ (average for existing pumps for 80-100\% rated flow)}$$

$$L_0 = 7.74 \times 10^4 \text{ lb./feet/second}$$

$$I_w = 5.744 \times 10^5 \text{ lb./feet}^2$$

$$\omega_0 = 75.4 \text{ radians/second (720 RPM)}$$

Since an upper limit was set on pump motor horsepower, the maximum β for any of the study cases could be calculated. Fluid kinetic energy was calculated for existing and study cases. It ranged from 2 to 8 per cent of the flywheel energy and was therefore neglected, introducing a small safety factor in the subsequent calculations. Love (13) treated the case of multiple parallel pumps in a recirculating system. Comparison of values showed that treating the pumps individually gave less conservative values for Q/Q_0 .

Test data from recent tripout tests at D, F, and H has not been fully evaluated as yet. Comparison of partial data on measured pump speed decay with that calculated by the method above indicates that there is an initial loss of flywheel energy during the first second, after which the decay follows that calculated. The data can also be correlated by the formula $Q/Q_0 = \frac{1}{1+(\beta t)^n}$ where n is an

empirical constant, but the physical significance of this form is not known.

Calculations for the maximum horsepower case (e.g. Case IV-Z) were as follows:

$$\text{Maximum Pump HP} = 5,750 \times 0.95 = \frac{P_0 Q_0}{550 \times 0.83}$$

$$P_0 Q_0 = 2.47 \times 10^5 \text{ ft. - lb./second}$$

$$\beta = \frac{[2.47 \times 10^5 + (7.74 \times 10^4)(0.82)](32.2)}{(5.744 \times 10^5)(75.4)^2(0.82)} = 0.0304$$

t	βt	$\frac{1}{1+\beta t} = Q/Q_0$
0	0	1.000
1	0.0304	0.971
2	0.0608	0.943
3	0.0912	0.916
4	0.1216	0.892
5	0.1520	0.868
6	0.1824	0.846

These values are plotted in Figure 2, page 13. Similar calculations were made for the other cases, although only the values for the Existing and maximum HP Cases are plotted.

(14) HW-41856 (SECRET), "Transient Water Flow Curves for B and C Piles Following Completion of Projects CG-558 and CG-600", D. L. Condotta, dated March 5, 1956.

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Determination of Maximum Outlet Temperature

Some heat accumulation probably occurs in the reactor during the temperature transient, with the effect of lowering and broadening the transient. Insufficient data is available for the calculation, therefore the method shown here has been used even though it should exaggerate the actual temperature surge.

If it is assumed that the heat generated at any time t during the decay period is instantaneously removed by the coolant, then

$$q_g = q_r$$

$$\text{and } \frac{(\Delta T)_t}{(\Delta T)_0} = \frac{(q_g)_t / (q_g)_0}{Q_t / Q_0} = \frac{f(t)}{Q_t / Q_0} = \frac{\text{Flow Required}}{\text{Flow Available}}$$

For any flow decay condition, the maximum outlet temperature will occur at the time that the ratio of values of the two curves is a maximum. With the heat decay shown, this is about $(t_e + 0.2)$ seconds for every flow case. Then,

$$(\Delta T)_{\text{max.}} = \frac{(Q/Q_0)_{\text{req.}}}{(Q/Q_0)_{\text{avail.}}} \times (\Delta T)_0$$

$$\text{and } (\Delta T_o)_{\text{max.}} = (\Delta T)_{\text{max.}} + T_i - 95$$

This gives the maximum change in tube outlet temperature. As discussed in HW-52793 (15), mixing of the hottest water in the crossheaders and risers with water passing through the reactor at a different time lowers the maximum temperature. Values of 0.5 to 0.6 have been applied to the maximum tube outlet temperature increase for various flows. Calculations for the maximum horsepower case are:

CASE IV-Z @ $(t_e + 0.2)$

t_e	T_i	(Q/Q_0) Req.	(Q/Q_0) Avail.	(ΔT) Max.	(ΔT_o) Max.
1.0	20°	0.996	0.965	96.0	1.8
1.0	200°	0.996	0.965	77.4	1.4
2.0	20°	0.996	0.937	98.8	3.5
2.0	200°	0.996	0.937	79.6	2.8
2.5	20°	0.996	0.924	100.2	4.3
2.5	200°	0.996	0.924	80.8	3.5
3.0	20°	0.996	0.911	101.8	5.3
3.0	200°	0.996	0.911	81.9	4.1

Similar calculations as carried out for the Design, Existing, I-A, and maximum HP Cases are shown in Table II on page 12.

Increase in Flywheel Capacity

The increase in flywheel inertia required to lower the temperature surge for the maximum horsepower case to that for existing conditions was calculated as follows (on page 32):

(15) HW-52793 (SECRET), "Reactor Bulk Outlet Temperature Limits", S. S. Jones, dated March 6, 1958.

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Increase in Flywheel Capacity (Continued)

$$\beta_1 = 0.0304$$

$$\beta_2 = 0.0274$$

$$I_{w2} = \frac{\beta_1}{\beta_2} \times I_{w1} = \frac{0.0304}{0.0274} \times 5.744 \times 10^5$$
$$= 6.376 \times 10^5 \text{ lb. - ft.}^2$$

$$I_w = 6.376 \times 10^5 - 5.744 \times 10^5 = 6.32 \times 10^4 \text{ lb.- ft.}^2 \text{ or about}$$

10% increase

Method of addition - side plates welded and bolted each side

$$I_w = \frac{WD^2}{8}, \text{ so for same } D,$$

$$\frac{\Delta W}{W} = \frac{\Delta I_w}{I_w}$$

$$t = \frac{4W}{\pi D^2 \rho}$$

$$\frac{\Delta t}{t} = \frac{\Delta W}{W} = \frac{\Delta I_w}{I_w}$$

$$\Delta t = 0.11 \times 11" = 1.2" \text{ total} = 5/8" \text{ plate each side}$$

Flywheel capacity for the 190-DR booster pumps proposed for Case III and IV flows was calculated in the same manner.

APPENDIX C

EFFLUENT DILUTION - INCREASED REACTOR FLOW

A special effluent sampling program performed in 1957 indicated the following dilution factors for $Q_R = 60,000$ cfs, $Q_K = 155,000$ GPM, $Q_C = 83,000$ GPM, $Q_{others} = 71,000$ GPM, where dilution factor F equals the fraction of an effluent stream in a downstream intake.

<u>EFFLUENT</u>	<u>INLET</u>	<u>F</u>	<u>F FOR COMPLETE DILUTION</u>
B/C	KE/KW	0.004	0.007
B/C	D/DR	0.01	0.007
KE/KW	D/DR	0.03	0.014
KE/KW	H	0.014	0.014
D/DR	H	0.002	0.006
D/DR	F	0.005	0.006
H	F	0.005	0.003

The sum of upstream reactor effects may be expressed as a concentration parameter.

$$C_I = \sum (F_i \cdot C_0)$$

where C_I = concentration in raw water intake

C_0 = concentration in effluent stream

and if C_0 is constant for all reactors (in the case of temperature this would mean the same bulk outlet temperature)

$$C_I = C_0 \cdot \sum F_i$$

These factors include a hidden process flow and river flow relationship, so that the extrapolation to different operating conditions in accordance with other diffusion phenomena is made:

$$F' = F \cdot \left(\frac{Q_r}{Q_r'} \right)^n \cdot \frac{Q_I'}{Q_I} \cdot \frac{Q_0'}{Q_0}$$

with a limit for complete dilution

$$F_0' = \frac{Q_0'}{Q_r}$$

Subsequent comparisons of these test data with raw water temperatures, radioactivity, and chemical analyses have shown that for extrapolation to other river flows, for the plant distances at least, the relationship should be

$$F' = F \cdot \frac{Q_R}{Q_R'} \cdot \frac{Q_I'}{Q_I} \cdot \frac{Q_0'}{Q_0}$$

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APPENDIX C (Continued)

For river flow rates of 60,000 to 100,000 cfs, essentially uniform dilution is indicated at the second reactor downstream in each case except at F Area, where the total ΣF appears low by a factor of 50 per cent. The original factor F_{K-D} also appears to have been in error, a value of 0.2 instead of 0.3 giving more consistent results. Insufficient data is available to permit corrections for extreme low flows, although one correlation indicates a lower ΔT than would be predicted using the formula on page 33. An upper limit of three times the values calculated for 100,000 cfs is probable.

Table III has been calculated using these relationships, and process flows as defined in this study, with a total K Reactor flow of 376,000 GPM. For the increase in raw water temperature, the sum of the dilution factors at a reactor inlet for all upstream reactors is multiplied by the effluent temperature rise above the base river temperature.

$$(T_I - T_R) = (T_O - T_R) \cdot \Sigma F$$

Figure 3 on page 17 was prepared in this manner.

Dilution of flume overflow was calculated as follows. The rate of diffusion is proportional to the mean velocity, which for the in-shore section of the river at 300,000 cfs (just below H Area) is about 1/2 the mean river velocity at 60,000 cfs. Since lateral diffusion can occur only in one direction from the shore,

$$F_{\text{shore}} = 2 \times 2 \times F_L = 4F_L$$

The flow rate of the spill was determined by trial and error, balancing head loss for the portion of the flow through the outfall lines against height in the flume using the broad-crested weir formula. A sample calculation for 1904-H, a river flow of 300,000 cfs, and a process flow of 115,000 is given:

River Elevation -	383.5 feet
1904 Elevation -	+ 4.0 (Trial)
	<u>387.5</u>

Flume Invert -	<u>387.0</u>
Water Height in Flume -	0.5 feet

For $h = 0.5$, $p = 1.0$, $L = 20$, $Q_{\text{flume}} = 20$ cfs

$$Q_{\text{pipe}} = \frac{115,000 \times 1.04 \times 1.10}{450} - 20 = 273 \text{ cfs}$$

For $Q_p = 273$ cfs, $\frac{u^2}{2g} = 0.81$, $\Delta h = 4.0$ feet (Check)

TABLE III
DILUTION FACTORS

(100,000 cfs: 36,000 cfs)

CASE	F _O '-B/C		B/C-K		F _O '-K		K-D		F _O '-D		D-H		H-F	
Existing	0.004	0.011	0.003	0.009	0.008	0.022	0.017	0.048	0.004	0.011	0.002	0.005	0.004	0.012
I	0.004	0.012	0.003	0.010	0.008	0.023	0.018	0.051	0.004	0.011	0.002	0.005	0.004	0.013
II	0.004	0.012	0.003	0.010	0.008	0.023	0.019	0.054	0.004	0.012	0.002	0.006	0.005	0.015
III	0.005	0.013	0.004	0.011	0.008	0.023	0.021	0.059	0.005	0.013	0.003	0.008	0.006	0.018
IV	0.005	0.014	0.004	0.012	0.008	0.023	0.023	0.065	0.005	0.014	0.003	0.009	0.008	0.022

F _K		F _D		F _H		F _F	
0.003	0.009	0.021	0.059	0.014	0.038	0.030	0.084
0.003	0.010	0.022	0.063	0.014	0.040	0.030	0.088
0.003	0.010	0.023	0.066	0.014	0.041	0.032	0.093
0.004	0.011	0.026	0.072	0.016	0.044	0.036	0.10
0.004	0.012	0.028	0.079	0.016	0.046	0.039	0.11

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APPENDIX C (Continued)

Using this method, the following table was prepared. At a river flow of 450,000 cfs, the river is higher than the flume invert. In this event, it is assumed all effluent would discharge over the flume; the effluent concentration at F Area would be less for any higher river flow.

<u>QR</u>	<u>ELEVATION</u>	<u>QS</u>	<u>FS</u>	<u>QP</u>	<u>FP</u>	<u>Fother</u>	<u>ΣF (at 181-F)</u>
100,000	374.5	0	-	293	0.012	0.027	0.039
270,000	382.5	0	-	293	0.004	0.010	0.014
300,000	383.5	20	0.030	273	0.004	0.009	0.015
350,000	385.5	70	0.026	223	0.003	0.008	0.017
400,000	387.0	118	0.023	175	0.003	0.007	0.018
450,000	388.5	293	0.020	0	-	0.007	0.027

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APPENDIX D

COST ESTIMATE - WATER PLANT MODIFICATIONS 100-B, D, DR, F, AND H AREAS

(COST IN THOUSANDS OF DOLLARS)

	CASE I-A <u>B,D,F,DR</u>	CASE I-A <u>H</u>	CASE II-A <u>B,D,F,DR</u>	CASE II-A <u>H</u>	CASE II-Z <u>B,D,F,DR</u>	CASE II-Z <u>H</u>
<u>181 Building</u>						
Structural		5	30	20	30	20
Equip. & Piping		45	390	160	390	160
Electrical		10	125	50	125	50
<u>183 Building</u>						
Structural	50		155	10	155	10
Equip. & Piping	100		465	60	465	60
Filters	175		525	10	525	10
Electrical	40		235	15	235	15
Backwash Pump & Bldg.			50		50	
<u>190 Building</u>						
Mod. of Exist. Bldg.						
Equip. & Piping			240	70	240	70
Electrical			0	0	0	0
<u>New Equipment</u>						
Structural			215	55		
Equip. & Piping			1,130	285		
Electrical			330	85		
<u>Outside Lines</u>			655	0	655	0
<u>Instrumentation</u>			95	10	95	10
Sub Total	365	60	4,640	830	2,965	405
Const. Overhead	90	15	1,160	210	745	100
Direct Const. Cost	455	75	5,800	1,040	3,710	505
Construction Engineering	10	2	200	40	130	20
Contingency	100	16	1,740	300	1,110	150
Escalation	25	4	345	60	215	30
General Overhead	25	3	325	60	205	25
Management Service	20	3	260	50	165	20
Design	45	7	580	100	365	50
PROJECT COST	680	110	9,250	1,650	5,900	800
<u>Other Projects</u>						
New Transmission Line			1,500			
Larger Transformer						
TOTAL PROJECT COST	680	110	10,750	1,650	5,900	800

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APPENDIX D (Continued)

COST ESTIMATE - WATER PLANT MODIFICATIONS 100-B, D, DR, F, AND H AREAS

(COST IN THOUSANDS OF DOLLARS)

	CASE III-A B,D,F,DR	CASE III-A H	CASES III-B & III-Z B,D,F,DR	CASES III-B & III-Z H
<u>181 Building</u>				
Structural	45	20	45	20
Equipment & Piping	625	125	625	125
Electrical	205	45	205	45
<u>183 Building</u>				
Structural	155	10	155	10
Equipment & Piping	385	145	385	145
Filters	1,575	45	1,575	45
Electrical	235	15	235	15
Backwash Pump & Bldg.	50		50	
<u>190 Building</u>				
<u>Mod. of Exist. Bldg.</u>				
Equip. & Piping	2,175	465	2,175	465
Electrical	130	0	130	0
<u>New Equipment</u>				
Structural	615	145	0	0
Equip. & Piping	3,110	1,000	0	0
Electrical	985	245	0	0
<u>Outside Lines</u>	1,415	225	1,415	225
<u>Instrumentation</u>	210	20	210	20
Sub Total	11,915	2,505	7,205	1,115
Construction Overhead	2,980	630	1,800	280
Direct Const. Cost	14,895	3,135	9,005	1,395
Construction Engineering	530	110	320	50
Contingency	4,480	920	2,720	420
Escalation	895	195	550	85
General Overhead	830	180	500	75
Management Service	680	145	405	60
Design	1,490	315	900	140
PROJECT COST	23,800	5,000	14,400	2,225
<u>Other Projects</u>				
New Transmission Line	1,500			
Larger Transformer	225			
TOTAL PROJECT COST	25,525	5,000	14,400	2,225

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APPENDIX D (Continued)

COST ESTIMATE - WATER PLANT MODIFICATIONS 100-B, D, DR, F, AND H AREAS (COST IN THOUSANDS OF DOLLARS)

	CASES IV-A & IV-A ₁ <u>B,D,F,DR</u>	CASES IV-A & IV-A ₁ <u>H</u>	CASES IV-B & IV-B ₁ <u>B,D,F,DR</u>	CASES IV-B & IV-B ₁ <u>H</u>	CASES IV-Z & IV-Z ₁ <u>B,D,F,DR</u>	CASES IV-Z & IV-Z ₁ <u>H</u>
<u>181 Building</u>						
Structural	170	20	170	20	170	20
Equip. & Piping	800	165	800	165	800	165
Electrical	250	50	250	50	250	50
<u>183 Building</u>						
Structural	155	10	155	10	155	10
Equip. & Piping	645	205	645	205	645	205
Filters	2,275	75	2,275	75	2,275	75
Electrical	235	25	235	25	235	25
Backwash Pump & Bldg.	50	0	50	0	50	0
<u>190 Building</u>						
Mod. of Exist. Bldg.						
Equip. & Piping	885	185	2,175	505	2,175	505
Electrical	130	0	130	0	130	0
<u>New Equipment</u>						
Structural	615	145	435	85	0	0
Equip. & Piping	3,110	1,000	2,030	660	0	0
Electrical	985	245	660	165	0	0
<u>Outside Lines</u>	1,625	225	1,625	225	1,625	225
<u>Instrumentation</u>	200	50	200	50	200	50
Sub Total	12,130	2,400	11,835	2,240	8,710	1,330
Construction Overhead	3,040	600	2,960	560	2,180	335
Direct Const. Cost	15,170	3,000	14,795	2,800	10,890	1,665
Construction Engineering	530	110	530	100	380	60
Contingency	4,550	900	4,450	840	3,260	500
Escalation	900	180	890	160	650	80
General Overhead	850	170	830	140	600	70
Management Service	680	140	675	130	500	65
Design	1,520	300	1,480	280	1,070	160
PROJECT COST	24,200	4,800	23,650	4,450	17,350	2,600
<u>Other Projects</u>						
New Transmission Line	1,500	0	1,500	0	1,500	0
Larger Transformer	225	0	0	0	0	0
TOTAL PROJECT COST	25,925	4,800	25,150	4,450	18,850	2,600

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APPENDIX D (Continued)

COST ESTIMATE - WATER PLANT MODIFICATIONS
100-C AREA

(COST IN THOUSANDS OF DOLLARS)

	<u>CASE II-C</u>	<u>CASE III-C</u>	<u>CASES IV-C AND IV-C₁</u>
<u>181 Building</u>			
Structural		15	25
Equip. & Piping		185	355
Electrical		75	70
<u>183 Building</u>			
Structural		0	5
Equip. & Piping		20	60
Electrical		0	10
<u>190 Building</u>			
Equip. & Piping	225	225	450
Electrical	60	60	110
<u>Outside Lines</u>			
(107 to 1904)	0	25	65
<u>Instrumentation</u>	0	10	30
Sub Total	285	615	1,180
Construction Overhead	70	155	295
Direct Const. Cost	<u>355</u>	<u>770</u>	<u>1,475</u>
Construction Engineering	15	30	50
Contingency	85	230	440
Escalation	20	45	90
General Overhead	15	45	80
Management Service	15	35	75
Design	<u>25</u>	<u>75</u>	<u>150</u>
TOTAL PROJECT COST	530	1,230	2,360

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APPENDIX D (Continued)

SUMMARY OF ESTIMATED PROJECT COST
WATER PLANT AND REACTOR MODIFICATIONS
FOR INCREASED PRODUCTION B, C, D, DR, F, AND H AREAS

(COST IN THOUSANDS OF DOLLARS)

	<u>B, D, F, AND DR</u>	<u>H</u>	<u>C</u>
Case I-A	28,330	7,310	
Case II-A	38,400	8,850	
Case II-Z	41,550	8,000 *	
Case III-A	53,475	12,700	
Case III-B	42,220	9,875	
Case III-Z	50,100	9,875 *	
Case IV-A	54,145	12,450	
Case IV-B	55,380	12,900	
Case IV-Z	<u>54,950</u>	10,250 *	
Case IV-A ₁	56,645	13,250	
Case IV-B ₁	57,880	13,700	
Case IV-Z ₁	57,450	11,050 *	
Case II-C			6,130
Case III-C			6,830
Case IV-C			8,035
Case IV-C ₁			8,960

* Overboring is not being considered for 105-H. The TORP for the Z Cases at H will be achieved by a change in the size of the fuel element.

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QTY.

FT.
NO.

DESCRIPTION

HW 64458
PAGE 42 10,000 GALLON STORAGE TANK
ON ROOF OF BLDG. 190 B NEW LINES
AS SHOWN

190C

105C

CHECK PRINT

NOT FOR CONSTRUCTION

I
ESII
AS SHOWN
AS SHOWNV
AS SHOWN
AS SHOWN

UNCLASSIFIED

M-1901-B SMT. 2, 1548	OUTSIDE LINES & UNDERGROUND WATER
DWG. NO.	DRAWING TITLE
REF No.	REFERENCE DRAWINGS
NEXT USED ON	

No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION NONE		CLASSIFIED BY <i>A. C. Hitting</i> DATE 1/2/60			
DWG. NO.	SHEET NO.	SHEETS	REV. NO.		
SK-1-3950					
SCALE: NONE		APPROVALS			
DRAWN J. E. KINUM DATE 12-22-59		BY	FOR	DATE	
CHECKED DATE					
ISSUED DATE					
DES. ENG. UNIT					
INST. NO. 10089F					
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
I.P.D. DRAFTING					
100 B & C AREA PIPE LINE MODIFICATION					
INCREASED PRODUCTION					
BLDG. NO. 100 B & C AREA		INDEX NUMBER 0302			
DWG. NO. SK-1-3950		SMT. NO. SHEETS			

1st issue
2-8-60

CASE - II (BLDG 181-B)
ADD 600 H.P. PUMP IN #19 & 20" LINE & V

CASE - III (BLDG 181-B)
ADD 600 H.P. PUMPS IN #8 & 19 & 20" LINES & V
CHANGE EXPORT PUMPS IN #7 & 18 TO 600

VALVE

181-B)

VALVES.

HP & LINES TO 20"

UNCLASSIFIED

H-1-26061	181-B & C PUMP ARRANGEMENT & PIPING.
DWG. NO.	DRAWING TITLE
REF. No.	REFERENCE DRAWINGS
NEXT USED ON	

QTY. PT. NO. DESCRIPTION

UNCLASSIFIED

HW 64458
PAGE 43

CHECK PRINT

NOT FOR CONSTRUCTION

No.	DESCRIPTION	REV. BY	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION		CLASSIFIED BY			
NONE		J.E. Hestings			
		DATE 1/4/60			
DWG. NO.	SHEET NO.	SHEETS	REV. NO.		
SK-I-3916	2	2	-		
SCALE: NONE		APPROVALS			
DRAWN J.E. KINUM		DATE 11-12-59	BY J.R. Hestings	FOR	DATE 1-12-60
CHECKED		DATE			
ISSUED		DATE			
DES. ENG.		UNIT			
INST. NO.		10089 F			
PROJECT NO.					

U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC

I.P.D. DRAFTING

181-B - BUILDING MODIFICATION
INCREASED PRODUCTION

BLDG. NO.	INDEX NUMBER	SHT. NO.	SHEETS
181-B		2	2
DWG. NO.	SK-I-3916		

1st page
2-8-60

A

B

CASE-II (181-C)
NO CHANGES

C

900 H.P. PUMPS

CASE-III (181-C)
REPLACE 3, 7 & #12 WITH 900

D

900 H.P. PUMPS

CASE-IV (181-C)
REPLACE 3, 5, 7, 9, & 12 WITH
REPLACE #14 WITH 600 H.P. P

E

UNCLASSIFIED

QTY.

FT.
NO.

DESCRIPTION

HW 64458
PAGE 44

CHECK PRINT

NOT FOR CONSTRUCTION

No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE

REVISIONS

CLASSIFICATION

NONE

CLASSIFIED BY

J.E. Hittinger
DATE 1/4/60DWG.
NO.

SK-I-3916

SHEET NO.

SHEETS

REV. NO.

1 2 -

SCALE: NONE

APPROVALS

BY	FOR	DATE

DRAWN J.E. KINUM DATE 11-16-59

CHECKED DATE

ISSUED DATE

DES. ENG. UNIT

INST. NO. 10089F

PROJECT NO.

U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC

I. P. D. DRAFTING

181 B&C BUILDING MODIFICATION
INCREASED PRODUCTION

H-1-26016 181 B&C PUMP ARRANGEMENT & PIPING

DWG. NO. DRAWING TITLE

No. REFERENCE DRAWINGS

NEXT USED ON

BLDG. NO. 181-C

INDEX
NUMBER

DWG. NO. SK-I-3916

SHT. NO. 1 2

SHEET NO. 1 2

4

5

6

7

1st issue
2-8-60

UNCLASSIFIED

QTY.

PT.
NO.

DESCRIPTION

HW 64458
PAGE 45 **CHECK PRINT**

NOT FOR CONSTRUCTION

No.	DESCRIPTION	REV. BY	DATE	APP'D BY	FOR	DATE
REVISIONS						
CLASSIFICATION		CLASSIFIED BY				
NONE		J.L. Hartung				
		DATE 1/4/60				
DWG. NO.	S K-I-3951		SHEET NO.	SHEETS	REV. NO.	
SCALE: NONE		APPROVALS				
DRAWN J.E. KINUM DATE 12-30-59		BY	FOR	DATE		
CHECKED		DATE				
ISSUED		DATE				
DES. ENG.		UNIT				
INST. NO. 10089F						
PROJECT NO.						
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC						
I. P. D. DRAFTING						
183-B BUILDING MODIFICATION FOR INCREASED PRODUCTION						
BLDG. NO. 183-B		INDEX NUMBER				
DWG. NO. S K-I-3951		SHEET NO.		SHEETS		

SK-I-26015	183-B PUMP ROOM PLAN EQUIP. ARRANGEMENT
DWG. NO.	DRAWING TITLE
No.	REFERENCE DRAWINGS
NEXT USED ON	

UNCLASSIFIED

1st issue
2-8-60

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QTY.	FT. NO.	DESCRIPTION

HW 64458
PAGE 40

No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION		CLASSIFIED BY R.H. Bonnell DATE 2-16-60			
NONE					
DWG. NO.	SK-1-4078		SHEET NO.	SHEETS	REV. NO.
SCALE:	NONE		APPROVALS		
DRAWN	DATE 2-16-60	BY	FOR	DATE	
CHECKED	DATE				
ISSUED	DATE				
DES. ENG.	UNIT				
INST. NO.	10089 F				
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
I.P.D. DRAFTING					
SITE PLAN AREA MODIFICATION INCREASED PRODUCTION					
REACTOR PLANT MODIFICATION					
BLDG. NO.	100-D AREA		INDEX NUMBER		
DWG. NO.	SK-1-4078		SHT. NO.	SHEETS	

SK-1-3917	SITE PLAN MODIFICATION
DWG. NO.	DRAWING TITLE
REF. NO.	REFERENCE DRAWINGS
NEXT USED ON	

1st issue
4-4-60

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FT.
NO.

DESCRIPTION

HW 64458
PAGE 47 WITH 600 H.P. PUMP
HEADER IE TO 183 BLDGS.
H 600 H.P. PUMP
HEADER 17 WITH 600 H.P. PUMP
O BUILDING
42" HEADER

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No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION			CLASSIFIED BY		
NONE			R.H. Sonenwill DATE 2-16-60		
DWG. NO.		SHEET NO.		SHEETS	REV. NO.
SK-1-4076		-		-	-
SCALE: NONE		APPROVALS			
DRAWN <i>R. Bell</i>		DATE 2-19-60	BY <i>J. A. Brubaker</i>	FOR <i>W. H. G. G.</i>	DATE 3-31-60
CHECKED		DATE			
ISSUED		DATE			
DES. ENG.		UNIT			
INST. NO. - 10089 E					
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
I.P.D. DRAFTING					
181-D PUMP HOUSE MOD. FOR INCREASED PRODUCTION					
REACTOR PLANT MODIFICATION					
DWG. NO.		INDEX NUMBER			
181-D-DR		8400			
DWG. NO.		SK-1-4076		DWG. NO.	SHEETS

H-1-26375	181-D PUMP ROOM STRENGTHENING FLOOR
DWG. NO.	DRAWING TITLE
REF. No.	REFERENCE DRAWINGS
NEXT USED ON	

FIELD

1st issue
4-4-60

CASE II & IV

1. CHANGE 18" DISCHARGE PIPING TO 24" FOR PROCESS PUMP
2. ADD 700 H.P. PUMP IN #7.
3. REMOVE #3 STEAM TURBINE.
4. MOVE ELECTRIC 6000 GPM HI TANK PUMP TO SPACE VACATED BY #3 STEAM TURBINE.
5. INSTALL 700 HP PUMP (#8) IN SPACE VACATED BY ELECTRIC 6000 GPM HI-TANK PUMP.

CASE III

SAME AS CASE II & IV EXCEPT DELETE ITEM 1.

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DESCRIPTION

HW 64458
PAGE 49 NEW LINE
CASE III & IVNEW FILTER
CASE III

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CASE II
NO NEW LINES
ADD 2 NEW FILTERSCASE III
NEW LINES AS SHOWN
ADD 3 NEW FILTERSCASE IV
NEW LINES AS SHOWN
ADD 4 NEW FILTERS.0 GALLON STORAGE TANK
OOF OF BLDG. 190-F

M1901-F SHT 2 & 5		OUTSIDE & UNDERGROUND WATER-100F
REF. No.	DWG. NO.	DRAWING TITLE
		REFERENCE DRAWINGS
NEXT USED ON		

No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE		
REVISIONS							
CLASSIFICATION NONE		CLASSIFIED BY <i>J.P.D. Drafting</i> DATE 1/4/60					
DWG. NO.	SK-I-3949		SHEET NO.	SHEETS	REV. NO.		
SCALE: NONE		APPROVALS					
DRAWN J.E. KINUM DATE 12-21-59		BY	FOR	DATE			
CHECKED DATE		<i>J.P.D. Drafting</i>	<i>REVIEWED</i>	1-12-60			
ISSUED DATE							
DES. ENG. UNIT							
INST. NO. 10089F							
PROJECT NO.							
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC							
J. P. D. DRAFTING							
100-F PIPE LINE MODIFICATION INCREASED PRODUCTION							
BLDG. NO. 100F AREA		INDEX NUMBER					
DWG. NO. SK-I-3949				SHT. NO.	SHEETS		

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1st floor
2-8-60

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ADD 450 HP PUMPS IN 3 & 17

ADD 450 HP PUMPS IN 3 & 17

ADD 450 HP PUMPS IN #2, #

UN

AND 48 LINE

4" 17 AND 48 LINE

CLASSIFIED

4		5		6		7	
QTY.	FT. NO.	DESCRIPTION					
HW 64458 PAGE 50							
CHECK PRINT NOT FOR CONSTRUCTION							
No.		DESCRIPTION		REV. BY	DATE	APP'D BY	FOR DATE
REVISIONS							
CLASSIFICATION		NONE		CLASSIFIED BY <i>L. C. Spelling</i> DATE 1/4/60			
DWG. NO.		5K-1-3907		SHEET NO.	SHEETS	REV. NO.	
SCALE: NONE		APPROVALS					
DRAWN J.E. KINUM DATE 11-5-59		BY		FOR	DATE		
CHECKED DATE		T. B. Brinkman		W. BRUD	11-6-59		
ISSUED DATE							
DES. ENG. UNIT							
INST. NO. 10089F							
PROJECT NO.							
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC J. P. D. DRAFTING							
181-F BUILDING MODIFICATION INCREASED PRODUCTION							
1 H-1-26725		181-F PUMP ROOM EQUIP. ARRANGEMENT.		BLDG. NO. 181-F		INDEX NUMBER 2600	
DWG. NO.		DRAWING TITLE		DWG. NO.		SHEET NO.	
No.		REFERENCE DRAWINGS		5K-1-3907		SHEETS	
NEXT USED ON							

11-12-59 2-8-60

CASE - II

REWORK FLOOR PLAN BY MOVING V
 REVAMP STAIRS & ADD DE
 ADD - 700 HP 15,000 GPM PUMPS IN #

CASE - III

REWORK FLOOR PLAN AS IN CASE
 ADD - 700 HP 15,000 GPM PUMPS IN #
 ADD - 42" LINE TO 190 BLDG.

CASE - IV

REWORK FLOOR PLAN AS IN CASE
 ADD - 700 HP 15,000 GPM PUMPS IN #
 ADD - 42" LINE TO 190 BLDG.
 CHANGE 18" DISCHARGE LINES TO 24"

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QTY.

PT.
NO.

DESCRIPTION

HW 64458
PAGE 51 WALL 3 FT.
DRAINAGE DITCH
74\"/>E-I
74\"/>E-I
74\"/>

CHECK PRINT

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H-1-26728	183F PUMP ROOM PLAN EQUIP. ARRANGEMENT
DWG. NO.	DRAWING TITLE
REF. NO.	REFERENCE DRAWINGS
NEXT USED ON	

NO.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION		CLASSIFIED BY			
NONE		H.O. Helling			
		DATE 1/4/60			
DWG. NO.	5K-1-3947	SHEET NO.	SHEETS	REV. NO.	
SCALE:		APPROVALS			
DRAWN J.E. KINUM DATE 12-9-59		BY	FOR	DATE	
CHECKED DATE		P.O. Amherman	W.P. LUGG	1-12-60	
ISSUED DATE					
DES. ENG. UNIT					
INST. NO. 10089F					
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION					
HANFORD ATOMIC PRODUCTS OPERATION					
GENERAL ELECTRIC					
I.P.D. DRAFTING					
183-F BUILDING MODIFICATION					
INCREASED PRODUCTION					
BLDG. NO.	183-F	INDEX NUMBER		SHT. NO.	SHEETS
DWG. NO.	5K-1-3947				1

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2-8-60

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PT.
NO.

DESCRIPTION

HW 64458
PAGE 52

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CASE-II

NO NEW LINES

CASE III

NEW LINES AS SHOWN

CASE IV

NEW LINES AS SHOWN

NEW 36" LINE
CASE III & IV

M-1901-H SHT 1,2,4	OUTSIDE UNDERGROUND WATER 100 H
DWG. NO.	DRAWING TITLE
REF. NO.	REFERENCE DRAWINGS
NEXT USED ON	

No.	DESCRIPTION	REV. BY	DATE	APP'D BY	FOR	DATE
REVISIONS						
CLASSIFICATION		CLASSIFIED BY				
NONE		S.C. Hittinger				
		DATE 1/4/60				
DWG. NO.	S K-I-3952		SHEET NO.	SHEETS	REV. NO.	
SCALE: NONE		APPROVALS				
DRAWN J.E. KINUM DATE 1-4-60		BY	FOR	DATE		
CHECKED DATE		S.B. Burman	WPA280	1-12-60		
ISSUED DATE						
DES. ENG. UNIT						
INST. NO. 10089 F						
PROJECT NO.						
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC						
I. P. D. DRAFTING						
100-H PIPELINE MODIFICATION INCREASED PRODUCTION						
BLDG. NO.	100-H AREA		INDEX NUMBER			
DWG. NO.	S K-I-3952		SHT. NO.	SHEETS		

6

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2-8-65

7

DESCRIPTION

HW 64458
PAGE 53

NINE FROM 13
14 AND NEW 20 LINES

NE FROM #13
2 20" LINES
13 H. & 2 VALVES.

CHECK PRINT

NOT FOR CONSTRUCTION

LINE FROM #13
LAND 29' LINES.
H& 2 VALVES

1	P-4781	181-H PUMP ROOM EQUIP. ARRANGEMENT
REF.	DWG. NO.	DRAWING TITLE
No.	REFERENCE DRAWINGS	
NEXT USED ON		

No.	DESCRIPTION	REV. BY	APP'D BY	FOR	DATE
REVISIONS		DATE			
CLASSIFICATION NONE			CLASSIFIED BY <i>S.C. Hastings</i> DATE <i>1/4/60</i>		
DWG. NO.	5K-1-3909	SHEET NO.	SHEETS	REV. NO.	
SCALE: NONE		APPROVALS			
DRAWN J.E. KINUM DATE 11-9-59		BY	FOR	DATE	
CHECKED DATE		<i>F.B. Anderson</i>	<i>W.P. Ueber</i>	<i>1-12-60</i>	
ISSUED DATE					
DES. ENG. UNIT					
INST. NO. 10089F					
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
I. P. D. DRAFTING					
181-H BUILDING MODIFICATION INCREASED PRODUCTION					
BLOG. NO.	181-H	INDEX NUMBER			
DWG. NO.	5K-1-3909	SHT. NO.		SHEETS	

6 1st issue 2-8-60

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QTY.

PT.
NO.

DESCRIPTION

HW 64458
PAGE 54

CHECK PRINT

NOT FOR CONSTRUCTION

ACCESS PUMPS #1 THRU #6

PUMPS #1 THRU #6

VIEW A-A

P-4785	183H PUMP ROOM PLAN EQUIP. ARRANGEMENT
DWG. NO.	DRAWING TITLE
No.	REFERENCE DRAWINGS
NEXT USED ON	

No.	DESCRIPTION	REV. BY DATE	APP'D BY	FOR	DATE
REVISIONS					
CLASSIFICATION NONE		CLASSIFIED BY <i>J.C. Letting</i> DATE 1/4/60			
DWG. NO.	SK-1-3948	SHEET NO.	SHEETS	REV. NO.	
SCALE: NONE		APPROVALS			
DRAWN J.E. KINUM DATE 12-18-59		BY	FOR	DATE	
CHECKED		DATE			
ISSUED		DATE			
DES. ENG.		UNIT			
INST. NO.		10089F			
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
I.P.D. DRAFTING					
183-H BUILDING MODIFICATION INCREASED PRODUCTION					
BLDG. NO.	183-H	INDEX NUMBER		SHT. NO.	SHEETS
DWG. NO.	SK-1-3948				

1st revision
8-8-60

DATE

FILMED

7/18/94

END