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EXISTING REACTOR WATER PLANT STUDY
B, C, D, DR, F AND H REACTORS
INTERIM REPORT

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EXISTING REACTOR WATER PLANT STUDY
B, C, D, DR, F AND H REACTORS

INTERIM REPORT

January 19, 1959

D. F. Watson
Reactor Modification Design
IRRADIATION PROCESSING DEPARTMENT

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EXISTING REACTOR WATER PLANT STUDY
B, C, D, DR, F AND H REACTORS

INTERIM REPORT

I. INTRODUCTION

The five year forecast⁽¹⁾ for operation of the HAPO reactors calls for the achievement of increased process water flows in B, C, D, DR, F and H reactors. The Process Design Operation has initiated a study in support of this forecast whose objectives are: to determine present water plant and effluent system flow capabilities; to provide basic data for determining the ultimate economic optimum flow capability of these plants; and to provide a basis for scope and development work preliminary to the initiation of any required project action. The present I&E slug program has pointed up the need for such a study of increased flows in order to take advantage of the lower system resistance of the I&E slugs. Initial studies have indicated that considerable development work and testing is required in order to determine the most economical method of achieving increased process water flows. For this reason, CGI-815 "Increased Water Capacity, 100-B, C, D, DR, F and H" was initiated. This project was intended to provide funds for necessary testing, scope drawing preparation, and preliminary estimates of reactor water plant and effluent system modifications. Since the proposed project was not approved by the AEC, these studies have proceeded with available R&D funds and are necessarily somewhat limited in magnitude.

This interim report presents the information on the first goal of the study, namely the present capabilities of the existing water plant systems and equipment. The reactor study program has been reported separately in HW-57737.⁽²⁾ Conditions which may be encountered in the reactor such as corrosion and temperature limits which could limit the ultimate optimum water plant expansion are not reflected in the data presented herein.

Information developed by this study was also used for related work such as determining the optimum rib height of the proposed zirconium alloy process tubes, based on estimated project costs (HW-57547)⁽³⁾; and for obtaining cost information for use in preparation of the five year program costs (HW-57091)⁽⁴⁾.

II. SUMMARY

Preliminary surveys of all the areas indicate that expenditures will be required to provide year around flows over 76,000 gpm in B, D, DR and F areas, over 80,000 gpm in H area and over 94,000 gpm in C area. The major restrictions to flow increases in the water plants are:

- (1) HW-55404, "Anticipated Reactor Operating Conditions for Use in Proposal HAPO 5-year Program Document", R. L. Dickeman, 3-19-58.
- (2) HW-57737, "Increased Power Level Study Program", E. R. Rudock, 10-16-58.
- (3) HW-57547, "Existing Reactor Modification Program Costs", D. F. Watson, 9-24-58.
- (4) HW-57091, "Project Costs for Five-Year Existing and Reactor Program", A. B. Carson, H. W. Heacock, 8-12-58.

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B-C Area - 190 C pump motors, 181 B-C pump capacity, electric distribution, 183-C filter effluent piping.

D-DR Area - 181-D-DR pump capacity, 183-D-DR crosstie, D-effluent system.

F Area - 183 Filter capacity, 105 downcomer capacity

H Area - 181 pump capacity, electric distribution

III. DISCUSSION

For the purposes of determining maximum flows through the water systems, the following assumptions were made:

1. Reactor hydraulic resistance has been reduced by the I&E slug and the zirconium alloy process tube programs.
2. River elevations will not exceed those encountered during the 1948 flood, and river flows will not fall below the 36,000 cfs limit set in the authorization for the Priest Rapids dam.
3. Present cavitation problems in the 190 Bldg. and 183 Bldg. pumps will be resolved so pumps will operate at design capacity.
4. One spare full capacity pump will be provided at all pumping locations.
5. Export water will not exceed 15,000 gpm, and will be supplied by 100-BC or 100 D-DR exclusively.
6. Clearwells operated at the recommended CG-558 levels except at DR where a lower clearwell would reduce the suction head available for the reactor pumps.
7. No filters used exclusively for sanitary water.
8. No relaxation of existing water quality standards.

A. Program

The program for this study is necessarily long range, and encompasses study efforts of other operations such as R&EO who are developing new filter media configurations and water treatment methods. The R&D efforts of Process Design have been directed towards determining the scope of the study program and in making preliminary investigations of water plant components.

If adequate funding is made available, the following programs will be initiated.

1. Continue field testing to determine existing flow limits in all the water plants.
2. Determine the most economical solution to flow restrictions for various flow increments.
3. Install strain gages on the 190 to 105 piping to determine if high velocities and vibration is producing excessive stress.
4. Review adequacy of 190 steam back up pumps and emergency facilities at projected flow and power levels.
5. Determine the most feasible and economical means of providing increased electrical power capacities in existing distribution systems.
6. Initiate model studies at hydraulic laboratories to determine if existing 181 Bldg. and 183 Bldg. suction wells will limit pump capacities and determine corrective action if required.

B. STUDY PROGRESS

To determine the modifications necessary to provide increased flows, it is first necessary to determine the existing capacity under the worst conditions. That is, 181 river pump capacity is lowest at low river flows, and 183 filter plant capacity is lowest when the river is high but turbid.

System friction data are determined by field test where possible. Existing test data such as pump ATP's are utilized if the data are consistent with system test results. The system capacity data are then used to pin point the sections requiring modification.

Flow configuration and hence capacity of pump suction chambers cannot be determined analytically. It is planned to initiate a program of model testing at one of the colleges to investigate the effects of adding pumps at existing pump houses. The program would be similar to that being carried out in connection with the "K" water plant expansion.

100-B, C Areas

Dual areas must be considered as a whole because generally one is dependent upon the other either electrically or hydraulically. The B-C crosstie line, while not complete, will be considered to be complete for the purposes of this study. A project is being initiated by B-C power operation to install two additional pumps in 181-C. This remedial step is one of the first that would be recommended by this study. However, since this project is still in the scoping stage, the study will proceed as though the project was not being considered.

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B Area

Table No. 1 points up the limitations to flow increases in this area. The filter plant is the main restriction to flow increase, but this will be relieved by the B-C crosstie provided 105-C flows are not increased over present flows. There would be little point to adding to the 183-B filter plant when potential excess capacity exists at 183-C. If C plant could supply the water, the B-C crosstie will provide all additional B area needs to a reactor flow of 94,000 GPM.

181-B Building

The 181-B pumps will produce all the water the existing 183-B filter plant can handle. See 181-B-183-B system curve Figure 1. In any case, there is no room for additional pumps on the "B" side of the 181-B-C pump house.

183-B Building

The 183-B filters and pumps are similar to those in D and F areas. A detailed discussion of the filters is included in the D section of this report. The 183-B to 190-B system capacity is shown on Figure 2. There appears to be no limit at this location at least within the capacity of the 190 pumps with aluminum tubes.

190-B Building

The 190 pumps are performing at near design loads. There are still some problems regarding the service life of the pumps, but for the purpose of this study it is assumed that any pump changes made in this connection will not lower the existing pump capacities. Figure 3 indicates the 190-B capacity for several reactor conditions. These capacities are based on cone valves wide open.

B-Effluent

The effluent system has but one immediate limit according to system calculations. The downcomer is limited to approximately 89,000 GPM by the configuration of the top tray and downcomer framing. Current tests on a model of the "F" downcomer at Washington State College are expected to reveal means of increasing this flow.

C Area

Table 2 indicates the maximum capacities of water plant components in this area. The first and main restriction is the 181 pump capacity. Fortunately there is room on the C side of the 181 B-C pump house for two additional pumps. Considerable electrical modifications will be required to provide the necessary switchgear and transformer capacity at 181-B-C for these pumps. One solution being considered by Electrical Design and B-C operations is: replace the

existing 2500 KVA transformers at 181 with 3000 KVA units installed at 182-B, uprate all transformers by installing fans, and replace older switch gear units. This solution appears to be favorable since the switchgear and fans are presently in CG-558 excess.

181-C Building

Existing capacity and capacity if 2 additional pumps are added is shown on Figure 4, 181-C to 183-C system curve. Present operation is with 11 pumps, which provides marginal spare capacity. The three 48 inch lines from 181-C to 183-C are adequate for substantial increases in flow.

183-C Building

The 183-C filter plant present limit is approximately 116,000 gpm. This limit is imposed by the flow restriction of the filter discharge piping and controls. If all 12 filters were revised to provide full potential capacity, as much as 160,000 gpm gross could be realized.

C Clearwells

The system capacity from 183-C to the clearwells* is shown on Figure 5. Normal operation is with five pumps which provides backwash water in addition to the process water. During the spring of the year as much as 5,000 gpm of the five pump output could be required for backwash. Under this condition, six pump operation would be required for a reactor demand of over 105,000 gpm. In the event that reactor demand is increased to 110,000 gpm, space and switch gear is available for an additional pump.

190-C Building

The 190-C to 105-C system capacity is shown on Figure 6. The main limit to flow increases at this facility is a motor winding temperature limit which restricts pump motor horsepower to 3500. This restriction was thoroughly studied in HW-56041.** The motor overheats at the slightest overload due to the marginal capacity of the air cooler. By providing dual water supply to the cooler inlet and excess voltage, the limit was stretched from 92,000 gpm to 94,000 gpm.

There is little point to rewinding the existing motors with high temperature insulation, because this limit is followed closely by wiring and transformer capacities, and transmitting capacity of the fluid couplings. Any major flow increase must be achieved by pump addition. The added pump, however, must be provided with a larger motor and adequate drive connections, for as can be seen from Figure 6, the same limitations are soon reached if the 10th existing pump is placed in service.

*Equivalent to the 190 tanks in B, D, F and H

**Load Limitations 3500 HP process drive motors, 100-C area, F. J. Mollerus, 5-13-58.

C Effluent

The effluent system was recently modified by the addition of new lines between the diversion box and the 107 basins. By using both downcomers, the first limit to be reached is approximately 160,000 GPM.

100-D, DR Areas

D Areas

Table 3 points up the limitations to flow increases in this area. Generally, the 181 pumps are providing design flows, however little excess capacity exists for year around flow increases. Room is available in the 181-D, DR pump house for two additional pumps and necessary switch gear if the small export pump is replaced.

181-D Building

As can be seen from Figure 7, addition of one pump for nine pump operation will add only 6000 gpm to the system. System modifications will be required to utilize the full capacity of an additional pump.

183-D Building

The 183-D filter plant capacity is likewise indicated table 3. This capacity is based on operating the clearwell at 13 ft. with a minimum filter run of five hours. As can be seen from Figure 8, during very bad water conditions the optimum run may be less than five hours. However, with 16 filters, one backwash pump and one operator, more frequent backwashing is not too practical. Figure 9 is a family of curves similar to Figure 8 and can be used to determine the optimum filter run for any water condition. Filter clog rates are not a straight line function as shown, and control valve lag does not permit flows to start at the hydraulic limit, but the curves approximate conditions at high filter flows. Figures 10 and 11 indicate filter losses due to backwash and out of service for various filter runs.

The 183-D to 190-D system is shown on Figure 12. The system losses in this area are greater than in B or F due to the extra length imposed by the 186 building. The 183 to 190 pump capacity shown on Table 3 is based upon five pump operation with existing 18 inch pump discharge piping. As can be seen from Figure 12, six pump operation will add only 7,000 gpm to the system, but all pumps will be operating at design level. One pump can be added in the 183 pump room to provide a spare under six pump operation, but there will be marginal working area around the pump and additional cooling will be required in the pump room. Room is available for the additional switch gear, but fans must be installed on the 183 transformers to provide the required additional capacity.

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183-D to 183-DR Crosstie

183-D to 183-DR Make-up capacity is presently limited by the restriction of the 12-inch distribution lines in 183-DR, and by the back wash pump capacity (assuming one backwash pump is held as spare). With present I&E slug loadings, as much as 20,000 gpm could be required as DR make-up during turbid water conditions. 3000 gpm (average) additional water would be required from 183-D for DR backwash. This backwash water could be supplied from the process pumps by connecting the existing 16 inch process water line lateral to the DR backwash system; but as can be seen from Figure 12, six pump operation would be required at 183-D if 105-D flows are increased over existing flows. With the 12" lines replaced at 183-DR, two backwash pumps in operation and DR backwash water supplied from process flows, the maximum I&E capacity at 105-DR could be supplied. (Except during very turbid water conditions at which time the flow might be 2,000 gpm less.)

190-D Building

The 190-D to 105-D capacity is the same as that for 105-B, and is shown on Figure 13. As can be seen, the drive gear capacity appears to offer no limitation until zirconium tube flows are reached.

D Effluent

The effluent system has two immediate limits according to system calculations. The downcomer is limited to approximately 89,000 GPM as at B area, and the No. 2 junction box will become pressurized at approximately 79,000 GPM. The condition at the junction box can be alleviated by installing a steel jumper section through the box.

DR Area

Table 4 illustrates the dependency DR has upon D area for year around flows over 62,000 gpm. The 181-DR pump capacity can supply all the needs of the DR filter plant, but as in the B-C areas, there is no need to add filter plants if excess capacity exists at D area. While this excess is not large, it should supply DR needs for aluminum tubes provided D area maintains equal flow with DR.

181-DR Building

Any flow in excess of 82,000 gpm at 105-DR will require a filter plant addition as well as system modifications between 181-D-DR and 183-DR. This system is shown on Figure 14. It is immediately apparent that the addition of a pump will add little to the system capacity, unless friction losses can be decreased.

183-DR Building

183-DR filter plant consists of but 10 filters. The capacity of these filters is relatively fixed by system elevations which prevent increasing the available head across the filters. Some increase could be acquired with complete modification of filter effluent piping, but it is believed a cost study will show a filter addition to be more desirable.

183-DR Clearwells

Flow from the 183-DR filter plant to the 190-DR clearwells is by gravity (See Figure 15) If present clearwell levels are maintained (16' - 3"), flows in excess of 80,000 gpm will spill into the sewer over an overflow weir at 183-DR. If the 190 clearwells are lowered six inches, the flow capacity will be increased to 100,000 gpm.

190-DR Building

The 190-DR to 105-DR capacity is shown on Figure 16 for several reactor conditions. As in D area the flow limit is the heavy walled aluminum tubes. Little increase beyond 82,000 will be possible at DR unless the system friction is reduced by installation of zirconium alloy tubes.

DR Effluent

Dowcomer tray configuration limits flow to approximately 86,000 GPM/downcomer. No other limits occur in the system to 111,000 GPM.

F Area

Table 5 shows the limitation to flow increases in F area. The main water plant restriction is the capacity of the filter plant. Some increase can be obtained by lowering the clearwell to increase the head on the filters, but since F has a shallow clearwell this reduces the suction head available for the 183 pumps and limits their output.

181-F Building

Figure 17 indicates the system curve from 181-F to 183-F. The static head from the river to 183 is low at this area, therefore it should be possible to operate the pumps slightly beyond their design capacity to provide all aluminum tube needs with existing pumps. The existing pumps were re-bowled during CG-558 to provide 10,000 gpm at 150 ft. head. This capacity is currently being provided by loading the 450 HP motors to 478 HP. No serious heating problem has been encountered, or is expected at the required flows.

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183-F Building

The capacity of the 12 filters at F area could be increased by lowering the clearwells. However the effect of the lower suction on the pump capacity and on pump cavitation is uncertain. Tests are planned to clarify this point. In any case, the capacity required to meet the possible demand of aluminum tubes and I&E slugs cannot be met with only 12 filters. An alternate solution to building additional filters would be to import filtered water from H area via the existing export line. This alternate is being studied by P&TEO for "F" Operations. The feasibility of this method will, of course, depend on the total cost versus a new filter, and upon a management decision regarding removal of the export system as an emergency back-up for H and F areas.

The capacity of the 183-F to 190-F system is shown on Figure 18. This system is similar to B area, and offers no restriction up to the capacity of the 190 pumps with aluminum tubes.

190-F Building

Figure 19 indicates the system capabilities from 190-F to 105-F. This system is similar to B&D since the piping, reactors and components are alike. As in the other systems, it appears the next large increase will be with zirconium alloy tubes.

F Effluent

The 105-F Downcomer differs from B and D areas in that the inlet is from the side and the cross section of the downcomer is slightly smaller. Tests of a model at Holbrook Hydraulic Laboratory at Washington State College indicates that the maximum possible flow is approximately 85,000 GPM. To avoid excessive pressures in the downcomer, however, the Laboratory recommends a maximum flow of 77,500 GPM (cold measure). The existing downcomer differs from the model in that holes have been cut in the top tray. These holes may account for the fact that slightly higher flows than those recommended can be achieved without any apparent difficulty. The test program at the Laboratory has been extended to determine what structural modifications can be made to increase the capacity of the F downcomer.

To prevent shore line discharge of effluent at high river levels, stop logs must be placed in the 1904 Bldg. spillway exit. Five feet of stop logs will be required to prevent flow out the spillway at 78,000 GPM with the river at the 1948 flood level.

H Area

181-H Building

Table 6 reveals the system capacities of the H water plant. The only immediate limit is the 181 river pump capacity. Figure 20 shows that the installation of one additional pump will supply H needs to the capacity of the existing 190 pumps. Unfortunately,

however, the existing 151-H transformer bank is loaded to capacity. That is, one bank may still be out of service without causing a reactor outage. One bank will not assume the total load if one pump is added at 181 Building.

If water is supplied to F area during the period of high turbidity the power situation is further aggravated by the addition of that pump. Providing additional transformer capacity would be the ideal long range solution to the power problem. This could be circumvented, however, by installing controls to trip out the extra pumps in the event of a transformer failure, and operate the reactor at reduced level until the trouble was corrected.

183-H Building

The 183-H filter plant is more than adequate with 16 filters, and can supply reactor demands if zirconium alloy tubes are used.

The 183-H pump system shown on Figure 21 is comparatively low so that the limit on these pumps is one of providing adequate suction head at the capacity to which the pumps could be extended. No capacity problem should be experienced here until zirconium tube flows are reached. This will require six pump operation or addition of one pump for spare.

190-H Building

The 190-H to 105-H pump system, Figure 22 is similar to B, D, and F areas. The limiting capacity of the pump drives will not be reached until zirconium tubes are installed.

H Effluent

Flow through each downcomer is limited to approximately 87,000 gpm by the configuration of the cascades.

Stop logs will be required at the spillway river to prevent shoreline discharge at higher reactor flows when the river is at the 1948 flood stage.

IV. ACKNOWLEDGEMENTS

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E. R. Rudock provided the reactor system curves for the reactors.

E. L. Etheridge provided the calculated friction and capacity data for C area water plants and effluent.

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F. J. Kempf assisted in conducting tests and in calculating flow data.

D. E. Sebade provided the calculated friction and capacity data for the effluent systems.

Personnel of the Construction Engineering Operation advised on necessary electrical requirements for pump additions.

D. F. Watson

Reactor Modification Design
FACILITIES ENGINEERING OPERATION

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100-B
WATER PLANT FLOW CAPACITIES

Table No. 1

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (Not applicable to present flows)
181 Building	105,000	105,000	87,000	7 Pumps to process, 2 pumps to 182, 1 pump spare
182 Raw Water Requirements	20,000	20,000	5,000	
Raw Water Available for Filtering	85,000	85,000	82,000	
Net Filter Flow (Less Backwash)	83,000	81,000	80,000	
Actual Net Filter Capacity	98,000	81,000	85,000	Capacity based on lowering clearwell to 13 ft. 10 hr. filter runs for good water, 5 hour filter runs for bad water.
Process Water From C	1,000	8,000	None	
Non Process Filtered Water	5,000	5,000	5,000	
Process Water Available to 190	79,000	84,000	75,000	
Pump Capacity 183-B to 190-B	89,000	89,000	75,000	Based on 5 pumps
190-B Pump Capacity	84,500	84,500	75,000	7 Pump operation - Al. tubes - I&E slugs

*As of 11-12-58, clearwell at 15.8 ft. export water by D area.

100-C Area
WATER PLANT FLOW CAPACITIES

Table No. 2

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (Not applicable to present flows)
181 Building	105,000	115,000	102,000	11 pump operation. Elect. emergency pump as spare (marginal spare)
182 Raw Water	None	None	None	
183 Raw Water	105,000	115,000	102,000	
Net Filter Flow (Less Backwash)	103,000	110,000	99,700	
Actual Net Filter Capacity	116,000	113,000	116,000	Based on existing filter discharge piping and controls.
Non Process Filtered Water	8,000	8,000	5,700	
Process water to 183-B	1,000	8,000	None	
183-C Pump Capacity	110,000	110,000	110,000	5 pump operation - backwash water is supplied from this output.
Water available to 190	94,000	94,000	94,000	
190-C Pump Capacity	94,000	94,000	94,000	3540 motor horsepower limit 9 pump operation

*As of 11-12-58,

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100-D Area
WATER PLANT FLOW CAPACITIES

Table No. 3

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (not applicable to present flows)
181 Building	117,000	112,000	109,900	8 pump operation. One pump held as spare. Purex pump to 182
182 Raw Water Requirements	20,000	From DR & Export Pumps	16,600	Assumed total raw water including export load is 20,000 GPM. This is supplied in part by the Purex pump.
Net Filter Flow (less backwash)	94,800	106,800	91,200	Good water requires 2.3% or less of thru-put for backwash. Bad water (5 hr. runs) requires 4.7% for backwash.
Actual Net Filter Capacity	131,000	108,000	113,200	Actual capacity is based upon lowering clearwell to 13 ft. 10 hour runs for good water, 5 hour runs for bad water.
Non process Filtered Water	5,000	5,000	4,860	Includes sanitary water requirements
DR backwash	1,800	3,000	1,630	
Process water available to DR	6,500	18,400**	5,960	
Present DR Make-up Line Capacity	11,800	11,800	11,800	Make up line carries DR backwash and process make-up. Capacity based upon one pump, with one pump spare.
Water Available to 190-D	81,500	90,000	78,700	
183 Pump Capacity 5 pumps	83,000	83,000	83,000	Based on 5 pumps
190 Pump Capacity 1&E slugs	84,500	84,500	78,700	7 pump operation - Al. tubes

*as of 10-17-58, clearwell at 15.8 ft.

**based on equal dist. to D and DR

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100-DR Area
WATER PLANT FLOW CAPACITIES

Table No. 4

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (Not applicable to present flows)
181-DR Building 5 Pumps	76,000	78,000	70,900	
182 Raw Water		15,000		One DR pump is used for export during bad water since 183-DR capacity does not equal pump capacity.
Raw Water Available for Filters	76,000	63,000	70,900	
Net Filter Flow	76,000	63,000	70,900	
Actual Filter Capacity	75,000	62,000	75,000	
Process Water from 183-D	6,500	8,800	5,960	4000 gpm additional process water is available if spare backwash pump is used.
Water Available to 190	81,500	70,800	76,800	
Gravity Flow Capacity 183 to 190 Clearwells	100,000	100,000	80,000	Based upon clearwell level of 15'-9". A level of 16'-3" will reduce capacity to 80,000 gpm
190 Pump Capacity (I&E Slugs)	82,000	82,000	75,000	7 pump operation - All tubes - I&E Slugs

*as of 10-17-58.

100-F Area
WATER PLANT FLOW CAPACITIES

Table No. 5

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (not applicable to present flows)
181 Building	96,000	100,000	84,700	9 pump operation - 1 spare
182 Building Raw Water Requirements	5,000	5,000	3,000	
Raw Water Available for Filtering	91,000	95,000	81,700	
Net Filter Flow (less backwash)	89,000	90,500	79,700	
Actual Net Filter Capacity	90,800	80,000	85,000	Based on lowering clearwell 2 ft. 5 hour runs for bad water, 10 hour runs for good water.
Non Process Filtered Water	3,000	3,000	1,900	
Process Water Available to 190	86,800	77,000	77,800	
183 Pump Capacity	89,000	89,000	77,800	
190-F Pump Capacity	84,500	84,500	77,800	7 pump operation, al. tubes, I&E slugs

*as of 11-23-58

100-H Area
WATER PLANT FLOW CAPACITIES

Table No. 6

	Low River Good Water	High River Bad Water	Present* Flows	Remarks (Not applicable to present flows)
181 Building	89,000	95,000	85,200	8 pump operation + Elect. Emergency as spare
182 Raw Water	5,000	5,000	2,500	
Raw Water Available for Filtering	84,000	90,000	82,700	
Net Filter Flow (less backwash)	82,000	85,700	80,800	
Actual Net Filter Capacity	131,000	108,000	113,200	Capacity based upon lowering clearwell 3 ft., 5 hour runs for bad water, 10 hour runs for good water.
Non Process Filtered Water	3,000	3,000	1,800	
Process Water Available to 190	79,000	82,700	79,000	
183-H Pump Capacity 5 Pumps	90,000	90,000	79,000	
190 Pump Capacity	84,500	84,500	79,000	7 pumps, I&E slugs, al. tubes

*as of 11-26-58

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16-22 10 X 10 TO THE CM. 359 14
16-22 10 X 10 TO THE CM. 359 14

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FIGURE NO. 1
181-B to 183-B

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FIGURE NO. 2
 183-B to 190-B

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FIGURE NO. 3
190-B to 105-B

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FIGURE NO. 4
181-C to 183-C

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NOTE: 1. Pump curves from ATP data
2. System curve at low river static head - 110 ft.

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FIGURE NO. 5
183-C to 190-C Clearwell

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183-D FILTER CAPACITY
Clearwell at 15.8 Ft.

EXAMPLE: If 5 Hour Filter Run, Average Flow is

$$\frac{8600 + 4800}{2} = 6700 \text{ GPM}$$

$$\text{Net Flow is } 6700 - 9.6\% \text{ Loss} = 6120 \text{ GPM}$$

Figure No. 8

DETERMINATION OF OPTIMUM FILTER RUN

EXAMPLE: Assume plant is operating on a 8 Hr. filter run. At the end of 7 $\frac{3}{4}$ Hrs, filter flow has dropped to 4000 GPM. This point falls between curves D and E. A corresponding point on the optimum curve indicates filter run should be 4 $\frac{1}{4}$ Hrs. This run will produce a NET filter capacity of 6600 GPM. Rather than the 5600 GPM produced with the 8 Hour run.

Figure No. 9

FILTER RUN - HOURS

FILTER FLOW GPM X 1000

Figure No. 10

BACKWASH AND OUT OF SERVICE LOSSES

Assume: 15 Minute backwash schedule
2½ minutes for valving
12½ minutes for backwashing
8000 GPM backwash flow
Out of service time is included in filter run
Time correction for backwash flow = $\frac{8}{7}$

Then,

$$\text{Out of service loss} = \frac{15 \text{ Min.}}{\text{Filter run min.}}$$

$$\text{Backwash loss} = \frac{12.5 \text{ Min.} \times \frac{8}{7}}{\text{Filter Run Min.}} = \frac{14.3}{\text{Filter Run}}$$

Filter Run Hours	Filter Run Minutes	Out of Service Loss	Backwash Loss	$X \div Y$	XY	Total Loss %
1	60	.25	.238	.488	.0596	42.84
2	120	.125	.119	.244	.01487	22.91
4	240	.0625	.0595	.1220	.00372	11.97
6	360	.04165	.0397	.08135	.00165	7.97
8	480	.03125	.0298	.06105	.00093	6.01
10	600	.025	.0238	.0488	.000596	4.82

Total Loss = (Out of Service $\div$ Backwash) - (Out of Service times X Backwash)

Backwash losses are subtracted from actual water filtered. See Below:

Let F = total filter capacity
F₁ = filter capacity less out of service
F₂ = filter capacity less backwash
X = out of service loss
Y = backwash loss
Z = total loss

Then, F₁ = (1-X) F
F₂ = (1-Y) F₁

or F₂ = (1-Y)(1-X)F = F (1 - Y - X $\div$ XY)

or Z = (Y $\div$ X - XY)

FILTER LOSSES

Figure No. 11

FIGURE NO.12
183-D to 190-D

FIGURE NO. 13
190-D to 105-D

FIGURE NO. 14
181-DR to 183-DR

Note: Normal Available head is 1 foot.
Flow is through 4-48" lines
Flow based on longest run

FIGURE NO. 16
190-DR to 105-DR

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FIGURE NO. 17
181-F to 183-F

- Note:
1. - Maximum pump efficiency
 2. Pump curves from ATP Data
 3. System Curve at Low River - Static Head = 65.5 Ft.

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1642 10-A-10 TO THE CM 359 14

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FIGURE NO. 18
183-F to 190-F

Maximum Pump Efficiency
Pump Curves from ATP Data
System Curve Static Head = 47'

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Figure No.19
190-F to 105-F

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FIGURE NO. 20
181-H to 183-H

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Figure No. 21
183-H to 190-H

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Figure No.22
190-H to 105-H

Legend: ▨ Maximum pump efficiency
 ✕ Maximum gear capacity
 (1) Solid slug system al. to 1831 EFT

2	I&S* system al. tubes	1736 EFT
3	I&S* system zr. tubes	1831 EFT

*1.445 O.D., 0.310 I.D.

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FLOW - GPM IN THOUSANDS	70
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90

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END

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