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SUPPORTING STUDIES OF THE EFFECTS ON HANFORD
OF A DAM AT COLUMBIA RIVER MILE 345

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PROPOSED EXPLORATION PROGRAM
SUPPORTING STUDIES OF THE EFFECTS ON HANFORD
OF A DAM AT COLUMBIA RIVER MILE 348

By

R. T. Jaske

June 30, 1959

IRRADIATION PROCESSING DEPARTMENT
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC COMPANY
RICHLAND, WASHINGTON

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PROPOSED STUDY PROGRAM OF THE EFFECTS ON
HANFORD OF A DAM AT COLUMBIA RIVER MILE 348

I. INTRODUCTION

At the request (1) of Hanford Operations Office, Atomic Energy Commission, a study was made of the effects on the Hanford Facilities of a navigation and power dam at Columbia River mile 348, about five miles upstream of the 300 Area. The original study (1) was based on a nominal slack-water pool elevation of 395 to 400 feet at the dam location. A supplemental study (2) evaluated the effects on plant facilities of a dam at the same location but with slack-water pool elevation of 385 feet.

As a result of further exchanges of information and correspondence (3,4) the General Electric Company was requested to furnish a study program and details of the supporting exploration and test work which will be used as a basis for a comprehensive report of the effects on Hanford of the proposed dam. A report of the results of this program would be expected by the AEC within a period of 30 months from the official start of the program. It has been stated (3) that, even after completion of what now may be considered a reasonable sub-terranean exploration program, the assurance cannot be made that conclusive data would be developed.

Because of the request by AEC for an interim report, the program would be reported in two parts. Initially are grouped those activities which could reasonably be accomplished within a period of from 16 to 20 months, at which time an interim data report would be prepared summarizing progress to date and making any appropriate recommendations regarding additional scope of work or revisions to the time schedule. Thereafter the work would involve a continued effort to complete what is now considered a reasonable sub-terranean exploration program supplemented by further engineering work related to preparation of the final report. Should significant amounts of radioisotopes be discovered in soil zones to be inundated by the rising water table, or in locations expected to drain into such zones, it is likely that a more extensive program beyond that presently planned for the 30 month period would be required to provide a firm capital estimate.

It is not planned to relate this program to the Chemical Processing Department Seven Year Waste Program. Action considered in the seven year waste program will result in an increase in the depth of the soil column and thus provide an even more favorable situation in regard to control of the radioisotopes in the ground than exists today. In contrast to this, the back waters of the dam would have the opposite effect; in this case, the water table would be raised inundating part of the soil column above the present water table. The initial phase of the study program would be to investigate the deposition of radioisotopes in the soil zones that may be inundated by this rising water table. These findings would be the basic facts required to calculate or predict the effect of a dam on Chemical Processing ground disposal operations. It appears appropriate that all charges for this study program be assigned to the investigation of the effects of the dam.

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II. ABSTRACT OF PROGRAM

A. Work During Interim Report Period

Work would be started upon official notice by the AEC. An interim data report would be forwarded in from 16 to 20 months. Where contracts with outside parties are required it is assumed this period would start with the signing of the contractual instruments.

Financing of the proposed work would be arranged by the AEC. Based on informal discussions, the Commission would issue an appropriate directive to the General Manager, HAPO, authorizing the entire program without the necessity of preparation by HAPO of a project proposal.

1. River Studies (5)

The investigation would be aimed toward determination of the possible effects of reservoir conditions on the reactor effluent discharge. This work would be carried out in a 1/300 scaled river model, modified to represent the river with the reservoir at a nominal 385 ft. elevation and with flows varying from the expected minimum flow of 25,000 cfs to higher values. Specific studies would be directed toward estimation of effluent stratification and recirculation correlated as a function of river flow, and with various combinations of plants operating or in stand-by. Remedial works would be modeled and results optimized to permit balance of capital and operating considerations in the final study report. The effects of variation in the pool elevations would also be considered with the other variables.

It is assumed that the necessary river model, previously recommended, will be available for the program. Should this model not be available there would be a delay of results since there is no alternative to use of a scale model for this study. The estimate (See Page 12) also includes funds for detailed study of river reaches requiring additional examination.

2. Ground Water Effects in Reactor Areas

The deposits, forming the structural base for important reactor structures which would be subjected to a permanent rise in water table, consist of very pervious sand, gravel and cobbles roughly 75 feet in depth, over-lying the Ringold formation. Because of the moderate looseness of the strata, with an average in place density of 38 percent, there is concern that dynamic disturbances of newly saturated materials might cause some settlement of structures founded on this deposit.

To investigate these conditions the following detailed steps would be taken:

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- a. Determine in-place unit weight of the natural deposit and or fill. At least six test shafts sunk to a depth of 30 feet are required to establish statistical confidence.
- b. Perform laboratory tests on representative samples obtained to determine curves for ranges of density and graduation.
- c. Perform loading tests on both dry and saturated deposits, to correlate unit weight and volume change as a function of unit loading.
- d. Determine by a series of seismometer tests, using measurements in the field, the reaction of the basic strata to impulse loading in both the dry and saturated condition.
- e. Conduct other static loading or physical tests as required by field conditions.

3. Ground Water Effects on Underground Separations Wastes

Because it is necessary to inventory the present waste in relation to the affected zones, the initial work would consist of a series of exploratory wells at crib and waste trench sites. A program total of from 35 to 50 wells located at 13 sites is projected for this activity. Approximately 20 analyses per well for gross beta, Cs 137, Sr 90 (or total Sr), Ru and possibly several other isotopes would be conducted. The resulting data would be used as a basis for determining the extent to which confidence can be placed in the program planning. Specific sites to be investigated include 216-S-1 & 2 cribs, 216 BY cribs, 216-BC trenches, 216-BC Cribs, 216-BX and 216 TX trenches, the 216-H-8 crib, and other locations associated with waste disposal.

4. Interim Data Report

At the conclusion of 16 to 20 months work a data report of technical findings would be forwarded to the AEC.

B. Work Following Interim Report Period

1. River Studies

While this portion would be substantially complete in from 16 to 20 months it is expected that detailed analysis of specific remedial measures would be required. Additional 1/10C models of critical areas would be constructed as appropriate to confirm indications obtained in the generalized model. The 100-D, H and F Areas are of particular concern. The balance of time remaining would be used for analysis and firming of capital estimates as appropriate.

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2. Ground Water Effects on Reactor Areas

No test work is planned following the interim report unless the interim results indicate further testing is desirable. The scope of this latter activity would probably include repetition of the initial type of tests at additional locations.

3. Ground Water Effects on Separations Wastes Stored Underground

Based on what now seems a reasonable exploration program totaling from 35 to 50 wells in 13 sites, the balance not completed previous to the interim report would be completed. If no significant contamination were found in the soil zones to be affected by the dam, the final analysis and completion of the data could be expected 30 months after authorization of the program. However should significant contamination or potential contamination be discovered, the program would be adjusted as necessary to define the degree of the over-all problem. Further definition of scope and additional funds might be required at that time.

4. Report of Findings

Engineering studies to provide an integrated report with capital estimates would be concluded during the final months of the presently planned test program. Should the need for additional information develop, the report would serve as a basis for a preliminary capital evaluation. Capital estimates provided would be firm to the extent that time and data obtained in the test program permit.

III. DISCUSSION:

A. River Studies

The discharge of hot water effluent, contaminated to some extent by the radioactive solutes, into the Columbia River at Hanford presents serious problems both from the point of view of Hanford and from the point of view of those who utilize the natural resources of the Columbia River for navigation, power, irrigation, fishing, and recreation. It is not surprising, therefore, that a proposed change in the regimen of the river at Hanford by the creation of reservoir conditions would require considerable examination.

At the present time some of the effluent from each plant enters intakes of downstream plants, thereby slightly raising the temperatures of the intake water at low river flows. This reduces the effectiveness of the cooling system. It is possible, though unlikely, for the heated effluent to travel upstream as a density current and enter the intake of the plant from whence it originated. The question immediately arises as to whether or not the existing undesirable features would be made still worse by the creation of a reservoir.

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A categorical answer cannot be given because of the complex nature of rivers and reservoirs and because of the lack of precise methods of predicting their behavior. The only acceptable engineering procedure existing today for solving river control problems is the use of hydraulic models. The theory of models, (6) and the laws of similitude, (7) and the techniques of modelling (8) have been developed over several decades. Within the known limits of application, models are extremely useful tools.

Every model must be built and tested according to a particular model law. In the case of river models, as in the case of most open channel models, the primary agents affecting the flow pattern are gravity and inertia forces. Under these circumstances the Froude Law, which states that the ratio of the gravity to inertia forces in the model must be the same as in the prototype, is used. This is achieved if the ratios of the discharges in model and prototype vary as the $5/2$ power of the linear scale ratio. However, in doing so certain other laws are violated. In particular, the effects of viscosity are ignored. Despite this shortcoming, it has been demonstrated repeatedly that river models on a sufficiently large scale give reliable answers.

B. Ground Water Effects On Reactor Areas

The effect of saturation upon the foundation performance of important structures is a vital issue, particularly with respect to settlements which might develop when this newly saturated ground is subjected to dynamic disturbances.

It has been concluded that in the 100-F and 100-H Areas, the construction of the proposed dam would have the affect of producing a rise in the ground water table. The extent of this rise would be a function not only of the dam, but also of the ground water table presently developing due to discharge of substantial quantities of natural effluents to ground at other locations in the Hanford Areas not associated with the reactors. The rise to be anticipated could be sufficient to cause the inundation of the lower portions of some backfill areas around important structures with resulting settlements and damage to utilities embedded in the backfill and structures founded on the backfill. Further, the anticipated ground water table rise might produce uplift pressures against the bottom slab of deep pits and storage basins for which these structures were not designed. Under static conditions, the rise in the ground water table would probably not cause damage to structures founded on the undisturbed ground. Dynamic considerations, yet to be determined, (for example, earthquakes) might yield other recommendations.

The deposit which would be subjected to a permanent rise in elevation of ground-water table consists of very pervious sand, gravel and cobbles. This deposit is roughly 75 feet deep over-lying the Ringold formation which consists of silts, sands and clays, generally firm, which in turn overlies bedrock at substantial depth in the area in question. The surficial deposit of pervious sand, gravel and cobbles, was deposited during a period of glaciation by exceedingly large flood discharges released by the breaching of ice dams upstream.

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Four in-place density tests made by the Corps of Engineers in May, 1958, indicate that "the deposit is in a moderately loose condition, with an average relative density of 38 percent" (9). It should be recognized that it is exceedingly difficult to measure the relative density in a deposit such as this. If this average value is a true measure of the relative density, then there may be some cause for concern that dynamic disturbances of newly saturated material might cause some settlement of structures founded on this deposit. The areas of man-made fill placed around the principal structures are apparently so relatively loose that settlements have already developed of structures found on these loose materials due to saturation of the fill. Dynamic effects are expected to cause further settlements of the structures founded on loose saturated fill. A rise in ground-water table will increase the depth of saturated fill and thus result in an increase in the settlements.

Before a final capital estimate can be prepared the unknown factors relative to dynamic disturbance of the subsoil must be resolved. The proposed series of tests in the program abstract is recommended as the minimum program to insure a proper treatment to safeguard continuity of operation of plant structures.

C. Ground Water Effects on Separations Wastes Underground

The first step in determining the effects of the dam on the possible contaminated waste movement would be to develop knowledge about the contamination levels in soil zones which may be effected by the back-water.

We have no exact knowledge of the distribution of radioisotopes in the soil column beneath ground disposal facilities, nor has the practice of ground disposal at Hanford been dependent or based on having such an exact knowledge. Radioactive liquid waste disposal practices in the 200 Areas are based on preventing excessive contamination of the regional ground water, and waste management is accomplished by monitoring the ground water rather than the vadose zone. Therefore, evaluating the effect of a rise in the ground water on waste disposal facilities and future operations would require the accumulation and appraisal of data which are not now available. Also, the obtaining of these data would require using exploratory methods which heretofore have not been extensively employed at Hanford, and accordingly results cannot be reliably forecast. The methods of investigation recommended in the program are designed to evaluate the types, concentrations, and distribution of radioisotopes in the soil zones of interest. This is in essence an attempt to make a "radioisotope inventory" of these zones.

Although the contamination status of the soil zone that might be flooded is of immediate concern, such a study would be incomplete without an attempt to identify contamination patterns in sediments

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above this region. Past experience in the 200 Areas has shown that wetted soils beneath waste disposal sites will drain for a considerable period of time after the facility has been removed from service. The drainage of liquid is accompanied by the migration of radioisotopes down the soil column. The extent of drainage and migration will be dependent upon the type of soil and waste, the cation saturation status of the soil, the retentivity of specific radioisotopes and other factors.

In general, the relative position of a specified radioisotope in the soil column is indicative of its migration potential, those near the top of the column having the lower migration potential and those near the bottom having the higher migration potential. Therefore, the present location of specific radioisotopes is of definite interest and should be determined as part of the exploratory program.

Major changes in ground-water level and minor fluctuations in the contours of the regional ground-water table under the 200 Areas have been experienced in the past primarily due to large-volume cooling water disposals (10) and fluctuations in these volumes. A dam at river mile 348 would increase the general level of the ground-water over any level which would otherwise exist at the time. It is probable, however, that future plant modifications such as relocation of swamps, changes in cooling water discharges, or large volume pumping from the ground water would result in local fluctuations of the ground-water table around intermediate levels.

A rise in the water table would result in a loss of some of the effective ion-exchange capacity of soils now available for waste disposal use. Based on a knowledge (11,12) of exchange capacities and thicknesses of the available soil columns near the 200 Areas, it is estimated that these losses in some cases, could be as much as 20 percent of the total cation exchange capacity of the soil column. More frequent replacement of disposal facilities would be required because of this effect.

The following schedule is proposed for drilling and sampling exploratory wells, for analyzing samples and for evaluating results. Such a schedule is tentative and is based on preliminary information. A reasonable degree of flexibility with regard to the number and depth of wells at each site, sampling frequency and radioisotope analysis is assumed and should be provided for in executing such an exploratory program. For example, it is conceivable and expected that some of the wells could fail to reveal the presence of isotopes at the greater depths of interest. It would be of no benefit to perform radioisotopic analyses of samples that showed no beta activity. The exercise of such flexibility, however, should be minimized by the judicious application of available geological, well-probe and disposal data prior to specifying drilling locations, and by the proper selection of samples to be analyzed.

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PROPOSED PHASE I PROGRAM SCHEDULE --CHRONOLOGICAL ORDER

	<u>Facility</u>	<u>Estimated Number of Wells</u>	<u>Feet of* Drilling</u>	<u>Number of** Analyses</u>
1.	216-S-1 & 2 Cribs	3	650	60
2.	216-BY Cribs	8	1,880	160
3.	216-BC Trenches	5	1,750	100
4.	216-B-C Cribs	4	1,360	80
5.	216-A-8 Crib	4	1,140	80
6.	216-BX Trenches	4	1,040	80
7.	241-TX Trenches	3	630	60
8.	216-TY-1 Crib	2	450	40
9.	216-S-7 Crib	3	630	60
10.	216-Z-3 Crib	3	720	60
11.	216-Z-9 Crib	2	480	40
12.	216-Z-24 Crib	4	1,140	80
13.	P-11 Crib	<u>2</u>	<u>70</u>	<u>40</u>
	TOTALS	47	11,940	940

*Basis of each well being drilled ten feet into ground-water zone.

**Nominal 20 analyses per well. Each analysis will include gross beta, Cs 137, Sr 90 (or total Sr), Ru and possibly several other isotopes.

Completion dates for the exploration of individual sites have not been specified. Predictions of this type are difficult considering the many uncertainties in drilling through contaminated soil.

The 216-S-1 & 2 cribs and 216-BY cribs are recommended as the initial sites for investigation because many data have already been accumulated on these facilities. These cribs have received appreciable activity and have been out of service for a significant period of time (ca. 3 years). These are also the only two sites which now have critical radioisotopes present in the ground water under them, Sr₉₀ at the S-1 and 2 cribs and Co₆₀ at the BY cribsite, and consequently are the ones most likely to show positive evidence of radioisotopes in the soil zone of interest. The order of preference following these two facilities is based on either total activity discharged, location of the site, type of waste discharged, or a combination of these considerations.

If no significant ground contamination is indicated by the exploratory program, cost of the further program to evaluate the results and determine the scope and cost of a plan to contain the wastes can be considered as part of this program cost. In this event, the study can be expected to be completed in 30 months.

The reason, however, for conducting an initial exploratory program is to determine the distribution of radioisotopes in the soils beneath the disposal sites and as a basic starting point in evaluating the program. Until significant data are available from an

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initial exploratory program, no meaningful estimates on either study time or money requirements for completing the entire program can be made. It is proposed to schedule the program work such that within 16-20 months after starting the exploratory program sufficient basic facts will have been developed to allow a realistic appraisal of any further program costs and the timing.

Should significant concentrations of radioisotopes be indicated from the initial evaluation of the sample results, a more comprehensive program of evaluation should be initiated to run concurrent with the continuing exploratory program. Any funds expended on this more comprehensive evaluation program would be an additional program cost beyond the \$525,000 estimated for the exploratory study on separations waste. It is desirable that the authorizing directive permit this flexibility.

This program to study the effects of a dam at mile 348 is not directly related to the Chemical Processing Department's Seven Year Waste Program. Actions considered in the Seven Year Waste Program will result in an increase in the depth of the soil column and thus provide an even more favorable situation in regard to control of the radioisotopes in the ground than exists today. In contrast to this, the backwaters of the dam would have the opposite effect; in this case, the water table would be raised inundating part of the soil column above the present water table.

Initially the study program would investigate the disposition of radioisotopes in soil zones that may be inundated by this rising water table. These findings would provide a means to calculate or predict the effects of a dam upon CPD ground disposal operations. It appears appropriate that all charges for this study program be assigned to the investigation of the effects of the dam.

D. Other Studies

In the two previous studies (1, 2) forwarded to the AEC insufficient time existed to permit exhaustive examination of effects on Fuel Preparation, Hanford Laboratories, or other related activities. It is intended during the course of the study program to supplement the scope of the references (1, 2) to the extent necessary to develop the best possible capital estimate.

E. Program Costs

The following breakdown of program costs is presented to supplement the technical program outlined in Section 2.

IV. ACKNOWLEDGEMENT

The author is appreciative of the assistance given by C. R. Anderson Chemical Processing Department, and D. W. Pearce, Hanford Laboratories Operation, who furnished portions of the material used in this report and who assisted the writer in the final editing.

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A. Engineering and Analysis

1.	Analysis and Correlation	\$30,000	
2.	Preparation of report and capital estimate	<u>15,000</u>	
3.	Sub-Total	45,000	
4.	Contingency	<u>9,000</u>	
5.	Sub-Total - Engineering		<u>54,000</u>

B. River Studies

6.	Alterations to River Model	25,000	
7.	Technician's labor on tests	20,000	
8.	2 - 1/100 detailed models	<u>15,000</u>	
9.	Sub-Total	60,000	
10.	Contingency*	<u>177,000</u>	
11.	Sub-Total - River studies		<u>237,000</u>

C. Ground Water Effects on Reactor Foundations

12.	In-place density measurements	25,000	
13.	Lab. tests & correlation	12,000	
14.	Seismometer testing	<u>30,000</u>	
15.	Sub Total	67,000	
16.	Contingency	<u>13,000</u>	
17.	Sub-Total - Reactor Foundations		<u>80,000</u>

D. Ground Water - Separations Wastes

18.	Drilling - 12,000 ft. @ \$17/ft.	200,000	
19.	Sampling and analysis	45,000	
20.	Loss of Contaminated Equipment	40,000	
21.	Consultation & Personnel	<u>100,000</u>	
22.	Sub-Total	385,000	
23.	Contingencies for additional Drilling, sampling, etc.**	<u>140,000</u>	
24.	Sub-Total - Separations Waste		<u>525,000</u>

E. Program Estimate

25.	TOTAL - PROGRAM	<u>\$896,000</u>
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* Line 10 contains funds for a generalized model of the Columbia River between 100-A and 100-B required to study stratification and recirculation. Should this model be available as part of other plant engineering activity, this contingency can be reduced to 20% of Line 9.

** Line 23 contains additional funds for drilling, more sampling and analyses, equipment, added manpower, and other factors necessary to assure continued execution of the program.

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