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MANAGEMENT OF THE HANFORD WATER TABLE AND
WASTE MANAGEMENT IMPLICATIONS

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MANAGEMENT OF THE HANFORD WATER TABLE AND
WASTE MANAGEMENT IMPLICATIONS

I. INTRODUCTION

Since 1943, the Hanford site has been used for the production of plutonium, first for the Manhattan Project and currently for the Atomic Energy Commission. These operations have resulted in the formation of large quantities of fission products which, because of their radioactivity, require assured isolation from living things. Essentially all of these radionuclides are stored in underground tanks one hundred fifty feet or more above the water table in the 200 Areas near the center of the reservation. A small fraction of the radionuclides, carried in steam condensate and cooling water at very low concentrations, are sorbed directly on the soil above the water table.

Studies have consistently shown that characteristics of the Hanford site, e.g., population density, climate, topography, geology, hydrology, etc., are uniquely favorable for the operation of nuclear reactors and radiochemical reprocessing plants and for the storage of radioactive wastes.

With the phasing out of production activities and the planned diversification of Hanford activities, it becomes logical to consider the location of other compatible industrial activities at Hanford. Before authorizing any proposed new activity, however, its interaction with existing operations (particularly waste storage and waste water disposal) would have to be studied carefully to avoid adverse effect on either activity.

The purpose of this study is to: (1) identify those areas on the Hanford Reservation that should be restricted from unconditional release because of potential hydrological effects on radiochemical waste management and, (2) identify those areas that would have no hydrological restriction.

II. SUMMARY AND CONCLUSIONS

Hydrologically, the Hanford plant facilities lie above and in the path of groundwater flow from the highlands on the west to the Columbia River on the north and east. Most of the groundwater flowing under the reservation flows through highly permeable glacio-fluviatile sands and gravels, although flow is impeded by low permeability silts in some areas in the west and central portions of the Hanford Reservation.

Similarly, the Ringold Formation (semiconsolidated silts, sands, and gravels) impedes groundwater flow in the northeast portion except where ancient river channels were filled with glacial outwash sands and gravels. These ancient river channels trend from northwest to the southeast across the reservation.

Detailed mapping of the regional water table and of the contained trace quantities of tritium and above background concentrations of nitrate ion from the chemical processing plants provided a means for determining the major groundwater flow paths. The discharge of large quantities of cooling water from the radiochemical plants has created a mound of water under the 200 East and 200 West processing areas. Some of the water from the 200 West Area flows north to the Columbia River, while the rest flows southeast and east under the 200 East Area. Water under the 200 East Area flows southeast about five miles and then fans out with one major flow path to the south and another east to northeast toward the river. Data indicate that most of the water released north of 200 East Area flows northward through old buried, sediment-filled river channels to the Columbia River.

Groundwater flow beneath the Hanford site has been simulated by a digital computer model based on available geologic and hydrologic data. This ARHCO sponsored model was built by Battelle Memorial Institute and is known as the Variable Transient Thickness Model, VTT. The model can simulate a new Hanford water table resulting from new stresses on the groundwater system and can predict the new flow paths that should result. Verification and sensitivity analyses of the model are scheduled for completion by the end of FY-1972.

The areas to the north and east of the Columbia River are, in general, hydraulically isolated from the 200 Areas and are thus not treated in this study. West and south of the Columbia River, the areas adjacent to the AEC plants which may be desirable for productive development can be conveniently broken into three areas: an area near the old White Bluffs townsite, an area north of the Hanford townsite, and an area north of the 300 Area. The presence of tritium and nitrate in the groundwater south of the Hanford townsite indicates that this area is an important flow path for waters discharged from the 200 Areas. This area was excluded from use as a water discharge site on the basis of hydraulic considerations.

To determine the sensitivity of the water table in the 200 Areas, due to "hydraulic damming" of major flow paths at the three different locations near the Columbia River, the VTT model was used to simulate the effects. A pond was assumed to exist at each location, causing water table mounds ("hydraulic dams") to occur with an altitude determined at each location on the basis of local topographic relief. Water flow from the pond was assumed to be limited only by local soil conditions and to be additive to present day flow conditions. A new steady-state flow pattern was then simulated. These assumed conditions are recognized to be "worst case" conditions.

In the northeast section of the reservation, a pond was assumed to exist at an altitude of 420 feet above mean sea level* near the White Bluffs townsite. The VTT model indicates that the water table beneath the 200 Areas would not be adversely affected although the water currently flowing north from the Gable Mountain pond would probably be diverted to the south-east. It is likely, based on inferences drawn from known geology and related hydrological characteristics of the aquifer, that detailed study of a specific proposal would show that a pond with a 420 foot water level in the indicated area would be acceptable.

In an area north of the 300 Area, a pond was assumed to have a water-level altitude of 440 feet. The model indicates that such a pond would cause the water table to rise one to three feet beneath the 200 East Area. Further study would probably show

*All altitudes used in this report are referenced to mean sea level.

that this site could be used without affecting the 200 Areas adversely.

In the northwest corner of the Hanford site, west of the 100-B Area, a pond was assumed to be operated with a water-level altitude of 460 feet. The model indicates that such a pond would block groundwater flow paths from parts of the 200 West Area and from Black Rock, Dry Creek and Upper Cold Creek Valleys (west of the reservation). The resulting flow path changes would probably cause a significant rise, 20 to 30 feet, in the water table beneath the 200 West Area. Therefore, it would appear that the northwest corner of the reservation should be restricted from any development that would obstruct discharge of water from the water table to the river.

III. DISCUSSION

A. Background

Hanford is located in an area of relatively low relief in southcentral Washington, Figure 1. Because of the low relief, most of the geologic data on the underlying structure and stratigraphy of the rocks were obtained from wells drilled in the area. ^(1,2,3,4,5,6,7,8) During the past 25 years over 1500 wells were drilled to provide quantitative data for evaluating the chemical and physical properties of the underlying rocks and for measuring the hydrologic characteristics of the various sediments encountered. Figure 2 shows the location of the wells presently used for hydrological measurements.

1. Regional Geology

Three principle rock types underlie the Hanford Reservation. These are: dense, hard basalt (volcanic lava) which forms the bedrock beneath the area; semiconsolidated lake and stream sediments (Ringold Formation) directly overlying the bedrock; and unconsolidated silts, sands and gravels carried into the area by glacial flood waters during the close of the Ice Age. A diagrammatic cross section through a portion of the Hanford Reservation, Figure 3, shows the general stratigraphic position of these main rock types.

Figure 1

HANFORD TOPOGRAPHY

SECTION A-A¹

0 1 2 3
SCALE - MILES

LOCATION MAP

Figure 3
GENERALIZED GEOLOGICAL CROSS SECTION

Deep exploratory drilling has shown the basalt bedrock to be over 10,000 feet thick and comprised of over 100 individual basalt flow units. Sandwiched between many of these flows are extensive deposits of volcanic ash, tuffs, sands, silts and clays. The basalt has been folded into a number of anticlines (up-warped ridges), and synclines (downwarped basins), Figure 3. The most prominent topographic expressions of the anticlines on the reservation are the Rattlesnake Hills along the southwestern boundary, the Umtanum Ridge - Gable Mountain structure through the center of the reservation, and the Saddle Mountains beyond the northern boundary.

Tectonic deformation has been significant in forming the geologic and topographic features of the Pasco Basin within which the Hanford Reservation is located. Largely subsequent to the accumulation of the Columbia River basalts, lateral stresses have produced a series of essentially east-west trending anticlinal ridges and synclinal basins in the region⁽⁸⁾. The basalt flows beneath the reservation dip one to two degrees. The dip is greatly exaggerated in the cross section shown in Figure 3 because the vertical and horizontal scales are different.

The sedimentary rocks of the Ringold Formation, Figure 3, are classified into three distinct lithologic units; a lower clay zone, a middle silt and gravel zone and an upper silt and sand zone. The Ringold Formation was deformed at least in part with the basalt. Well samples and drillers logs indicate that the upper Ringold sediments are missing from all but the extreme western part of the reservation and along the eastern side of the Columbia River from near the old townsite of White Bluffs to the City of Richland. Figure 4 shows the paleotopography of the Ringold Formation as defined above. Two areas in the central part of the reservation lack Ringold sediments, either because they have been completely eroded from above the basalt or perhaps they were never deposited at these sites.

Figure 4

PALEOTOPOGRAPHY OF RINGOLD FORMATION

Directly overlying the Ringold Formation are unconsolidated glaciofluvial silts, sands, and gravels ranging from a few feet to over 300 feet in thickness, Figure 3. These sediments rest unconformably on the Ringold Formation and they may have undergone slight postdepositional deformation. The sediments are heterogeneous, ranging in size from very fine clay to very large boulders (see Table 1), although lenses of well sorted materials have been noted in the drillers logs. The coarse materials are more abundant in the northern and eastern part of the area and as channel deposits in the ancestral river channels of the Columbia River, as defined by the paleotopographic map of the Ringold Formation in Figure 4. The glaciofluvial sediments grade into finer sized materials to the west and south. A certain uniform, fine phase of these sediments is referred to as the Touchet beds of southeastern Washington.

2. Regional Hydrology

Groundwater flow paths drawn perpendicular to the March, 1968, water table contours in Figure 5 indicate that the general direction of groundwater movement is from the highland region west of the reservation toward the Columbia River. The Yakima River recharges the Hanford groundwater system along its reach from Horn Rapids to Richland. Prior to control of the Columbia River by large dams above the Hanford Reservation some river recharge of the system occurred during spring runoff. Columbia River bank storage, during periods of high river stage in the northwestern part of the project, moves inland and discharges eastward down gradient through the buried ancestral river channels filled with glacial outwash sands and gravels, Figure 4. The depth to the water table ranges from one foot to 300 feet below the land surface. Two groundwater mounds have been formed by the discharge of large volumes of cooling water onto the ground surface in natural depressions near the chemical processing plants, Figure 5.

The principal hydrological characteristics of the sediments overlying the basalt have been measured or estimated by a variety of field methods^(10, 11). The results indicate that the

TABLE I

GRAIN-SIZE DEFINITIONS OF SEDIMENTARY MATERIALS AS USED
IN THIS REPORT AND IN COMMON USAGE IN HANFORD GEOLOGIC RESEARCH (9)

Description	mm		(sieve size)		in	
Very fine clay	0.00024	to	0.00049		0.0000096	to 0.000019
Fine clay	.00049	to	.00098		.000019	to .000038
Medium clay	.00098	to	.00195		.000038	to .000077
Coarse clay	.00195	to	.0039		.000077	to .00015
Very fine silt	.0039	to	.0078		.00015	to .00031
Fine silt	.0078	to	.0156		.00031	to .00062
Medium silt	.0156	to	.0313		.00062	to .0013
Coarse silt	.0313	to	.0625		.0013	to .0025
Very fine sand	.0625	to	.125		.0025	to .0049
Fine sand	.125	to	.25		.0049	to .0098
Medium sand	.25	to	.50		.0098	to .0197
Coarse sand	.5	to	1		.0197	to .0394
Very coarse sand	1	to	2		.0394	to .079
Very fine gravel	2	to	4		.079	to .157
Fine gravel	4	to	8		.157	to .315
Medium gravel	8	to	16		.315	to .630
Coarse gravel	16	to	32		.630	to 1.26
Very coarse gravel	32	to	64		1.26	to 2.52
Small cobbles	64	to	128		2.52	to 5.04
Large cobbles	128	to	256		5.04	to 10.08
Small boulders	256	to	512		10.08	to 20.16
Medium boulders	512	to	1024		20.16	to 40.31
Large boulders	1024	to	2048		40.31	to 80.63
Very large boulders	2048	to	4096		80.63	to 161.3

Figure 5
HANFORD WATER TABLE MARCH, 1968

field coefficient of permeability of the glaciofluvial sediments ranges from about 10,000 gpd/sq.ft. to more than 60,000 gpd/sq.ft. The field coefficient of permeability of the Ringold Formation ranges from about 100 to 600 gpd/sq.ft., Table II. These values when used with the observed groundwater gradients suggest that the rate of groundwater movement ranges from a few inches per day to several hundred feet per day throughout the area.

The observed variability in the coefficient of permeability suggests that one quantitative test is insufficient input for a quantitative study of the Hanford groundwater system. Each test is merely an input representative of a small area, less than 0.001 percent, of the total aquifer volume. Fortunately at Hanford, aquifer characteristics at a point (well) have been determined by several different methods which yield similar results. (10,11)

The groundwater beneath the Hanford Reservation moves from some point in an intake area to some point where it eventually is discharged into the Columbia River or into the atmosphere. In the absence of precise data on the Hanford flow system, it is assumed that groundwater movement is in the direction of the hydraulic gradient vector. Therefore, the direction of movement is determined by drawing flow lines perpendicular to groundwater contours, from high to low potentials.

The groundwater contour map, Figure 5, is based on the measured altitude of the water-table surface in a number of wells. A majority of these wells monitor the 200 East and 200 West Area groundwater mounds permitting relatively accurate contouring in these areas. The relatively few data available for those areas lying north of Gable Mountain and immediately northeast of Rattlesnake Hills require interpretation and generalization. Therefore, the contour map of the water table in these areas is known with less certainty as to altitude and detail.

TABLE II
SUMMARY OF AQUIFER PERMEABILITY ⁽¹¹⁾

Avg. Field Permeability (gpd/ft²) Calculated from:

<u>Aquifer Tested</u>	<u>Pumping Tests</u>	<u>Specific Capacity Tests</u>	<u>Tracer Tests</u>	<u>Cyclic Fluctuations</u>	<u>Gradient Method</u>
Glacio- fluviatile	13,000-67,000	10,000-65,000	>63,000	17,000-57,000	---
Glacio- fluviatile and Ringold	900-5,000	1,000-4,000	---	1,600-6,000	---
Ringold (ex- cluding clay zone)	50-600	60-300	---	150-500	100-300

The present pattern of groundwater movement beneath the Hanford Reservation has changed during the 25 years of plant operation, owing to concurrent changes in the shape of the water table as a result of artificial recharge by plant cooling water. The artificially recharged water moves radially northwestward and northeastward from the northern side of the groundwater divide and southeastward to eastward from the southern or inner flank of the divide toward the Columbia River. The natural recharge entering the reservation boundary from the west and southwest is now essentially excluded from the 200 Areas and must pass northward to the Columbia River around the north side of the western groundwater mound or to the south down Lower Cold Creek Valley toward both the Yakima River and the Columbia River. The major groundwater flow paths shown in Figure 5 tend to follow the courses of the ancestral Columbia River channels incised in the Ringold Formation which are filled with more permeable glaciofluvial sediments. Several exceptions do exist, however, as can be seen by comparing the paleotopography map, Figure 4, with the major groundwater flow paths in Figure 5. South of Gable Mountain the water table has risen generally above the Ringold Formation and some of the major flow paths are no longer limited to the ancient river channels.

3. Location and Inventory of Radionuclides in Hanford Sediments

The location and concentration of radionuclides between the ground surface and the water table (in the vadose zone) have been reviewed and previously reported.^(12 13 14 15 16) The Ben-Franklin Dam study concluded that, based on analyses of cable tool drill samples from below important waste storage and low-level liquid disposal sites (Table III), a maximum of 60 curies of long-lived radioisotopes were present in the 25 foot zone directly above the water table (Table IV). Furthermore, the Ben-Franklin Dam study suggests that if all such contamination were leached from the soil and transported to the Columbia River, concentrations of isotopes reaching the river would be several orders of magnitude below permissible drinking water limits.

TABLE III
WASTE FACILITY EXPLORATORY WELLS ⁽¹³⁾

<u>Disposal Site Monitored</u>	<u>Well Number</u>	<u>Depth (feet)</u>
216-BY-1 Crib	299 E33-1A	146
216-BY-3 Crib	299 E33-2A	233
216-BY 2 & 3 Cribs	299 E33-3A	141
216-BY-4 Crib	299 E33-4A	230
216-A-5 Crib	299 E24-1A	320
216-BC-3 Crib	299 E13-3A	338
216-BC-7 Trench	299 E13-7A	100
216-BC-17 Trench	299 E13-14A	94
216-A-24 Crib	299 E26-4A	245
216-A-8 Crib	299 E25-6A	208
216-A-8 Crib	299 E25-5A	85
"B" Swamp	699 43-42	154
Gable Mt. Swamp	699 52-47	41
216-S-1 & 2 Cribs	299 W22-1A	202
216-S-1 & 2 Cribs	299 W22-3A	207
216-S-1 & 2 Cribs	299 W22-1B	206
216-S-1 & 2 Cribs	299 W22-11A	115
216-S-1 & 2 Cribs	299 W22-1C	206
216-S-7 Crib	299 W22-14A	212
216-S-7 Crib	299 W22-13A	212
216-T-28 Crib	299 W14-2A	205
216-S-9 Crib	299 W22-26A	216
216-S-9 Crib	299 W22-27A	215
216-Z-9 Crib	299 W15-83	100
216-Z-9 Crib	299 W15-94	95
216-Z-9 Crib	299 W15-94A	50
216-Z-12 Crib	299 W18-5A	212
216-Z-12 Crib	299 W18-5B	50
P-11 Crib	699 63-25A	50
Background	699 11-45A	100

TABLE IV

ESTIMATED MAXIMUM AMOUNTS OF LONG-LIVED RADIONUCLIDES SUBJECT
TO LEACHING BY A 25-FOOT RISE IN THE WATER TABLE
BENEATH 200-E AREA AND BY A 20-FOOT RISE
BENEATH 200-W AREA⁽¹³⁾

<u>Waste Disposal Site*</u>	<u>Co⁶⁰</u> (Curies)	<u>Sr⁹⁰</u> (Curies)	<u>Cs¹³⁷</u> (Curies)
<u>200-East Area</u>			
216 BY Cribs	15	7.5	15
216 A-5 and 10 Cribs	--	0.7	>0.1
216 BC Cribs	--	7.0	0.5
216 A-8 Crib	--	4.0	1.2
216 A-24 Crib	--	1.7	>0.1
Total	15	20.9	16.7
<u>200-West Area</u>			
216 S-1 & 2 Cribs	--	4	>0.1
216 S-7 Cribs	--	0.4	>0.1
216 S-9 Crib	>0.1	0.8	>0.1
216 T-28 Crib	>0.1	0.6	>0.1
Total	--	5.8	--

* Based on scintillation probe, well-sampling and waste inventory data, the sites which were not investigated as part of this study would not be expected to increase the totals shown appreciably.

The Ben-Franklin Dam would cause the water table to rise, reducing the gradient between the 200 Areas liquid waste discharge locations and the Columbia River. Conversely, if discharge points were unfavorably located, the discharge of unspecified large quantities of liquids on the ground surface could increase the gradient toward the river with a resultant reduction in travel time to the river and a possible increase in quantities of radionuclides leached from the subsurface sediments.

The major trends of the groundwater flow paths, related to the 200 Area waste management program, are indicated by low but detectable quantities of tritium and above normal background concentrations of nitrate ion which probably originate from discharges of low level liquid wastes to ground. The areal extent and flow direction of these "tracers" are determined routinely by analyzing samples of groundwater from monitoring wells. The locations of the monitoring wells are shown in Figure 2. The tritium and nitrate ion distributions are shown in Figures 6 and 7, respectively.

4. Variable Thickness Transient Flow Model

The Variable Thickness Transient (VTT) model is a computer simulation model of the Hanford groundwater flow system.^(17,18,19) A steady-state version of the VTT computer routine solves a partial differential equation that predicts the hydraulic behavior of the Hanford groundwater system. This model approximates a three-dimensional flow system since changes in transmissibility due to changes of saturated thickness are considered. The model has several limitations: (1) a vertical component of flow, if present, is neglected; (2) inflow and outflow surfaces are assumed to penetrate the entire thickness of the system; and, (3) it is assumed that the permeability distribution is constant in the vertical plane. Two years of further study are planned to verify its calculated transmissibility distribution and to ascertain its quantitative accuracy. Caution must be used in applying the results of the model until the verification and sensitivity analyses have been completed.

B. Sensitivity to Changes in the 200 Area Water Table

The sediments above the water table beneath the 200 Areas are essentially dry and have excellent sorption properties for many long-lived fission products. These sediments have been used for over 25 years to confine radionuclides. Significant increases in the groundwater level under the 200 Areas would inundate the dry sediments progressively, thereby reducing the distance between the sorbed radionuclides and the water table. While moderate increases in elevation of the water table could probably be tolerated, data on the distribution of fission and activation products in the sediments underlying the waste disposal sites would be required before any significant increases (more than 20 feet) could be allowed.

At the present time it is believed that the altitude of the water table beneath the 200 Areas has reached a quasi steady-state condition, i.e., the groundwater altitude and the hydraulic gradient is sufficient to transmit the discharged cooling waters away from the recharge areas to the Columbia River. However, significant changes in the river boundary conditions could have a significant effect on the water table beneath the 200 Areas and/or change the groundwater flow paths, river entry points, and groundwater travel times.

C. Simulated Hydrologic Models

To determine the sensitivity of the water table beneath the 200 Areas due to the creation of several water table mounds across the major flow paths, the VTT model was used to simulate the effects due to hydraulic damming at three sites near the right bank of the Columbia River. A seven mile stretch along the Columbia River from the old Hanford townsite southward is a major groundwater flow path from the 200 Areas. Therefore, this area was excluded from further use as a water discharge site on the basis of hydraulic considerations pertinent to the 200 Areas waste management program. The three areas simulated were: an area west of the 100-B Area, an area near the old White Bluffs townsite, and an area north of the 300 Area, Figure 8.

Figure 8

SIMULATED POND SITES

This analysis was limited to simulation of the new water tables which would result from separate operation of the three ground discharge sites and the simultaneous operation of the three sites. A steady-state version of the VTT model was used to obtain a worst case situation for this evaluation. The steady-state simulation consisted of discharging fluid to the ground at a rate sufficient to maintain a constant specified water-table altitude at the discharge site. The March, 1968, Hanford water table was used as a beginning reference datum, Figure 5, for the simulations. The results are presented as a set of two maps for each case evaluated. The first map shows the water table contours (equipotential lines) that result when a water discharge site is added to the 1968 reference datum. The second map shows the amount of rise in the altitude of the water table that would occur.

The results of the model simulation reported here should be regarded as qualitative because the VTT model is still under development awaiting field verification and sensitivity analysis which should be completed in FY-1972. Therefore, the quantitative accuracy of the results cannot be ascertained. However, qualitative significance can be attached to the results from the simulation and used to evaluate the relative sensitivity of the water table beneath the 200 Areas to unspecified large volume discharges at different locations on the Hanford Reservation.

1. Simulated Discharge Area Near the Old White Bluffs Townsite

This discharge site encompasses an area of 16.1 square miles with an assumed water-table altitude of 420 feet. Discharge at this site probably would have a negligible influence, less than a one foot rise, on the water table in the 200 Areas, Figures 9 and 10. This simulation showed that a 40 foot water-table rise would occur beneath and adjacent to the discharge site. The configuration of the simulated water table, Figure 9, would remain similar to the 1968 water table, shown in Figure 5, except beneath and adjacent to the discharge site. The model does indicate, however, that water currently flowing north from the Gable Mountain pond would be diverted

Figure 9
SIMULATED HANFORD WATER TABLE
WITH PROPOSED 420' POND NEAR
OLD WHITE BLUFFS TOWNSITE

LEGEND

Basalt Outcrop Above Water Table

Water-Table Contours in Feet Above Mean Sea Level, 10 Foot Contour Interval, Except as Otherwise Shown

Well in Which Water Level Was Recorded

0 1 2 3 4 5

SCALE: Miles

MODIFIED AFTER BAWL 1907

Figure 10
SIMULATED HANFORD WATER-TABLE
CHANGE WITH PROPOSED 420' POND
NEAR OLD WHITE BLUFFS TOWNSITE

to the southeast. The significance of this diversion, if real, has not been ascertained. It seems likely that the indicated changes could be tolerated.

2. Simulated Discharge North of the 300 Area

This discharge site encompasses an area of 8.2 square miles with an assumed water-table altitude of 440 feet. Discharge at this site probably would have a negligible influence, less than a one foot rise, on the water table in the 200 West Area and a minor influence, a one to three foot rise, on the water table in the 200 East Area, Figures 11 and 12. The simulation showed a maximum water-table rise of 50 feet adjacent to the discharge area. This simulation indicates that the configuration of the water table would remain similar to the 1968 water table except beneath and adjacent to the discharge site. The indicated changes indicate minimal effect on the 200 Areas and could probably be tolerated.

3. Simulated Discharge Area Near 100-B Area

This discharge site encompasses an area of 3.1 square miles with an assumed water-table altitude of 460 feet. Discharge at this site would have a major influence, a 20 to 30 foot rise, on the water table in the 200 West Area and a minor influence, a one to three foot rise, on the water table in the 200 East Area, Figures 13 and 14. This simulation showed that a 60 foot water-table rise would occur beneath and adjacent to the south side of the discharge site. The configuration of the simulated water table, Figure 13, would remain similar to the 1968 water table except beneath and adjacent to the south side of the discharge site.

4. Simulated Simultaneous Discharge at all Three Sites

Simultaneous operation of all three discharge sites at specified water-table altitudes of 420 feet, 440 feet, and 460 feet, respectively, would encompass an area of 27.4 square miles. Simultaneous discharge at these sites would have a major influence, a 25 foot rise, on the

Figure 11
SIMULATED HANFORD WATER TABLE
WITH PROPOSED 440' POND
NEAR 300 AREA

Figure 12

**SIMULATED HANFORD WATER-TABLE
CHANGE WITH PROPOSED 440' POND
NEAR 300 AREA**

LEGEND
 Basalt Outcrop Above Water Table
 Water-Table Change Contour: Interval 10
 Feet, Except as Otherwise Shown
 Well in Which Water Level Was Recorded

0 1 2 3 4 5
 SCALE: Miles

MODIFIED AFTER BNWL 1907

Figure 13
SIMULATED HANFORD WATER TABLE
WITH PROPOSED 460' POND
NEAR 100-B AREA

water table in the 200 West Area and a minor influence, a two to four foot rise on the water table in the 200 East Area, Figures 15 and 16. The simulation showed that a 60 foot maximum water-table rise would occur two to three miles south southwest of the 100-B Area site. The configuration of the simulated water table is shown in Figure 15 and is similar to the 1968 water table except beneath and adjacent to the discharge sites and in the 200 East Area where a well defined southeastward to eastward trough is starting to develop in the water table. A tabulation of the four simulated discharge schemes is given in Table V.

The above mentioned water-table trough is hydrologically significant because it suggests that the groundwater system would be reaching the limit of stress it can contain. The travel times to the river from the 200 Areas, although not determined in this analysis, would probably be in terms of months. Conveyance of additional stresses, such as offsite irrigation or a change in river stage due to construction of a dam, would require a significant change in the distribution of flow paths from the 200 Areas. Such a change would necessitate a reevaluation of the Hanford waste management program. The data indicate, however, that the major influence comes from the 100-B Area site and that the other two sites could probably be developed in conjunction with the postulated additional stresses.

D. Hydrologically Restricted Zones

Based on the above studies, there appear to be two reaches along the river that should be restricted from activities that would discharge large amounts of water onto the ground: viz., one in the locality of the Hanford townsite and one near 100-B Area. The discharge potential near the 100-B Area must be reserved to provide drainage for groundwater resulting from future irrigation of lands to the west of the Hanford Reservation. The discharge area near the Hanford townsite should

Figure 16
SIMULATED HANFORD WATER-TABLE
CHANGE WITH PROPOSED 420', 440'
& 460' PONDS

TABLE V
HYDROLOGIC RESULTS
(Steady-State Version of VTT Model)

	<u>SIZE IN SQUARE MILES</u>	<u>POND ALTITUDE IN FEET</u>	<u>SEEPAGE LOSS IN FEET³/DAY (From BNWL-1507) (18)</u>	<u>WATER TABLE RISE* IN FEET</u>	<u>MAGNITUDE & REGION OF MAXIMUM WATER TABLE RISE IN FEET</u>
Near White Bluffs Townsite	16.1	420	1.2×10^8	200-W, negligible 200-E, negligible	40 Adjacent to Pond
North of 300 Area	8.2	440	7.7×10^6	200-W, negligible 200-E, 1 - 3	50 Adjacent to Pond
Near 100-B Area	3.1	460	8.9×10^7	200-W, 25 - 30 200-E, 2 - 3	60 South of Pond
Simultaneous operation of above ponds	27.4	---	17.8×10^7	200-W, 25 - 30 200-E, 2 - 4	60 South of Pond Near 100-B Area

* Based on an unverified version of the Hanford VTT Groundwater Model.

be reserved because hydraulic considerations based on the distribution of tritium and nitrate in the groundwater at this locality indicate it is a major flow path for subsurface discharge from cribs toward the river.

Two general areas, the White Bluffs and 300 Area sites, are indicated to have a minor influence on the 200 Area water table and therefore could probably be released. Additional geologic and hydrologic studies should be made before approving specific proposals for use of these areas.

On the basis of available geologic and hydrologic data in the White Bluffs and 300 Area sites, it may be possible to define additional area that may be released following some additional study. These areas are indicated on Figure 17. There are no hydrological restrictions associated with the islands of the Columbia River or on land across the Columbia River from AEC production plants.

Figure 17

HYDROLOGICALLY RESTRICTED ZONES

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