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GEOLOGY UNDERLYING HANFORD REACTOR AREAS

Donald J. Brown[1/]

INTRODUCTION

A comprehensive study is being made to extend and refine the conceptual understanding of the geology underlying the Hanford Project and the region immediately surrounding it. An understanding of the detailed geology in this region is important for proper interpretation of ground-water monitoring information, for selecting and evaluating waste disposal sites, and for estimating earthquake and earthquake-damage potential. This study makes use of data obtained largely from the construction of wells and from observations of exposed geologic formations. More recently results from the limited application of geophysical techniques have been utilized.

Certain regions and geologic horizons of the Hanford Project are being studied first because of their more immediate interest (1,2,3,4,5). A general over-all report will combine and incorporate the reports covering these selected regions and problem areas. This paper is an interim report summarizing the latest concepts of the geology underlying the Hanford Reactor Areas. Its basic purpose is to provide working maps and information on the geologic structure and stratigraphy beneath the reactor areas as well as to describe the general influence of the geology on ground-water movement. These kinds of information are needed to provide a foundation upon which to base the data now being assembled for the first inland disposal crib for NPR, the emergency water supply facilities for the 100 Areas, and for ground-water temperature studies.

[1/] General Electric Company, Richland, Washington. Work performed under Contract No. AT(45-1)-1350 for the U. S Atomic Energy Commission.

SUMMARY

There are three distinct geologic units beneath the reactor areas: The Columbia River Basalt, the Ringold Formation, and the Glaciofluviatile sediments. The Columbia River Basalt series forms the bedrock beneath the reactor areas and is generally compact, hard, and dense. The surface of the basalt series reflects the structure of the flows and is only locally modified by erosion. The Ringold Formation overlies and is largely conformable to the basalt. This formation is an extensive lacustrine and fluviatile deposit of sand, silt, gravel and clay. The three members of the Ringold Formation distinguishable elsewhere on the Hanford Project are not readily differentiated beneath the reactor areas. Unconformably overlying the Ringold Formation to a maximum depth of 170 feet is a sedimentary deposit of fluviatile and glaciofluviatile outwash sands and gravels. This unit is referred to at Hanford as Glaciofluviatile sediments. The coarse materials of this deposit which are more abundant in the northwestern section of the project, grade into finer materials to the east and south.

The structure of the materials underlying the reactor areas reflects the deformation which has been going on essentially continuously for the last several million years. The lower beds of the Ringold Formation exhibit the greatest degree of conformity with the basalt with successively higher beds showing less and less deformation. Contours of the basalt surface and the Ringold surface reflect this orogeny in that the topographic highs on the basalt surface lie in the same position as the highs on the Ringold Surface.

The contour of the water table in the region underlying the reactor areas reflects strongly the contact between the Ringold Formation and the Glaciofluviatile

sediments. The most rapid ground-water movement rates were noted in glaciofluviatile-filled channels incised in the Ringold sediments.

STRATIGRAPHY

Columbia River Basalt

The name Columbia River Basalt is applied to the vast series of basaltic lava flows and related rocks that cover a great part of southern Washington, eastern Oregon, and parts of Idaho, Nevada, and California. These lavas, which came to the ground surface through many fissures in the earth's crust, were accompanied by the discharge of little or no fragmental material as they welled up to flood the lower ground with successive horizontal sheets (5). The Columbia River Basalt series forms the bedrock in the region about the reactor areas. Generally the surface of the series reflects the structure of the series, only locally modified by erosion.

In the western portion of the region where reactor areas are located, near the 100-B and 100-K sites, the first one hundred feet of basalt are essentially continuous with no apparent interbeds. To the east, however, near the 100-H and 100-F sites, there are numerous interbeds within the upper portion of the basalt series. In this general region basalt flows originating to the west evidently interfinger with other basalt flows originating to the east, in what probably was then the lowest part of the Pasco Basin and the Columbia River course. The interbedded materials are predominantly sand, gravel, clay, and volcanic ash. Some of the interbeds can probably be correlated with the Ellensburg Formation in central Washington, of Pliocene age. Some of the well cuttings from the surface of the basalt show it to be quite

vesicular to scoriaceous, caused by the emission of gases during cooling, while other samples are compact, hard and dense. All samples of the basalt obtained from depths of more than about ten feet beneath the surface of the top flow were strikingly hard, dense, dark gray in color, fine textured, but similar in composition to surface samples.

Ringold Formation

Directly overlying the basalt bedrock is an extensive lacustrine and fluviatile deposit of sand, silt, gravel and clay known as the Ringold Formation. These sediments were deposited in a shallow lake formed in Pleistocene time when the Columbia River was at least temporarily and locally impounded by the uplift of the Horse Heaven Hills. The sediments originally deposited were up to 1200 feet thick.

Over much of the Hanford Project three members of the Ringold Formation are distinguishable; the lower blue clay, the middle conglomerate, and the upper sandy silt. Beneath the reactor areas, however, these three members are not as distinct from each other as elsewhere and can not be readily differentiated. In the north western region of the project the Ringold Formation is dominantly coarse material, such as sands and gravels; farther to the east it grades into sand and coarse silt, and on the eastern margin it is mostly silt and coarse clay (see Table I).

Extensive portions of the middle member of the Ringold Formation contain sands and gravels thoroughly cemented with calcium carbonate which makes them highly resistant to erosion. The most pronounced area where this occurs is in the Columbia River channel near 100-K Area. Erosion of less competent material downstream from a middle Ringold outcrop in the stream bed created what is known as Coyote Rapids.

TABLE I

GRAIN-SIZE DEFINITIONS OF SEDIMENTARY MATERIALS AS USED IN THIS REPORT AND IN COMMON USAGE IN HANFORD GEOLOGIC RESEARCH (6)

(sieve size)

Description	mm			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

The upper portion of the Ringold is probably absent beneath the reactor areas because of erosion. The best exposure of this member is in the White Bluffs on the eastern shore of the Columbia River.

Glaciofluviatile Sediments

At the close of the last Ice Age, probably about 10 000 years ago, the Columbia River was swollen with glacial meltwater and loaded with sediments brought down from farther north by the ice sheet Much of this sedimentary load was dropped by the river in the Pasco Basin probably as the result of a decrease in the velocity of the stream as it spread out in the broad Pasco Basin above Wallula Gap. In the region about the reactor areas these materials consist of sand, gravel and boulders, although some lenses of fine, well-sorted materials have been observed in road cuts and excavations. The coarse materials are more abundant in the northwestern section of the project and grade into finer materials to the east and south. On the Hanford Project these sediments are referred to as Glaciofluviatile sediments although they consist of both fluviatile and glaciofluviatile outwash sands and gravels.

Many huge icebergs moved down the Columbia River from the disintegrating ice mass during the time this material was being deposited. Some of these icebergs evidently grounded in the region south of the 100-K and 100-D areas forming the hummocky mound-like appearance or "kame and kettle" topography of the material in that area. This topography is typical of that formed in front of melting glaciers. Some areas also exist where the wind has reworked the finer outwash material forming sand dunes and well sorted beds of sandy silt.

The fluviatile and glaciofluviatile deposits which were laid down on top of the erosion surface of the Ringold Formation in this locale are up to 170 feet thick.

STRUCTURE

Tectonic deformation was significant in forming the geologic and topographic features of the Pasco Basin (8). Largely subsequent to the accumulation of the Columbia River Basalts lateral stresses produced a series of essentially east-west trending asymmetrical anticline ridges and synclinal troughs in the region. The reactor areas are located north of the Gable Mountain-Gable Butte Anticline and south of the Saddle Mountain Anticline A host of smaller, subsidiary anticlinal ridges and synclinal troughs lie beneath the reactor areas and between these two main anticlinal ridges. Figure 1 is a contour map of the basalt surface underlying the region about the reactor areas. All of the relief features shown on this map resulted primarily from folding of the basalt flows with essentially no erosion. The extent to which this folding has taken place can be readily seen on this map. Some synclinal troughs are several hundred feet below sea level while others are several hundred feet above sea level The anticlinal ridges are similarly displaced in elevation. Some ridges are buried beneath several hundred feet of unconsolidated sediments while others extend above the level of the regional plain to form projections such as Gable Butte and Gable Mountain.

The data for this basalt contour map were obtained mainly from an airborne magnetometer survey made by the United States Geological Survey in 1960. These results were correlated with the data from seven wells which were drilled to the basalt bedrock in this region.

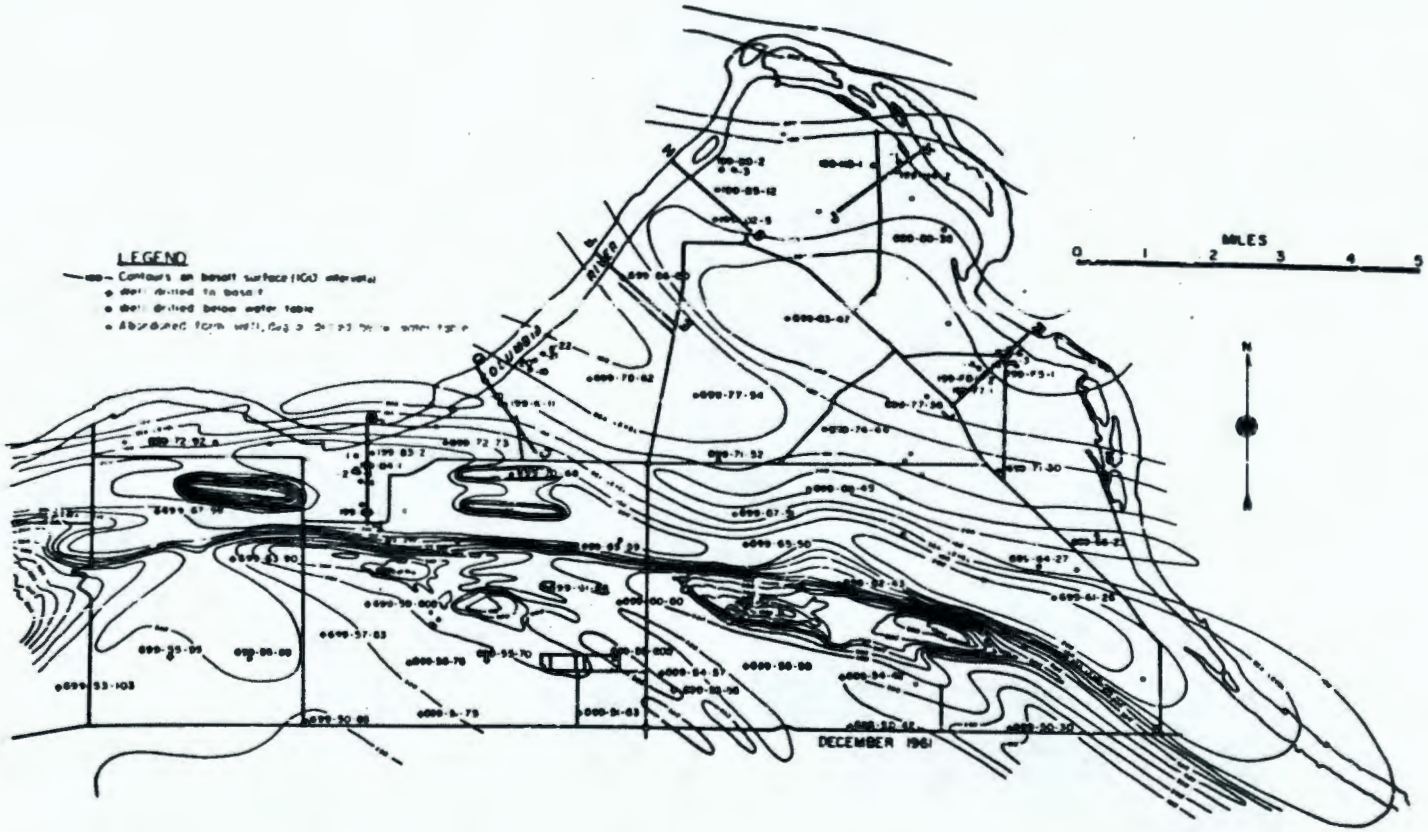

FIGURE 1

Contour Map of Basalt Surface Underlying the Hanford Reactor Areas

Figure 2 is a contour map of the surface of the Ringold Formation. The contour pattern suggests that the Ringold surface was eroded at one time by the Columbia River. Two main channels are shown on this map: One, at point marked A southwest of the 100-B Area, trends to the southeast along the south side of Gable Butte; another channel is shown incised into the Ringold Formation sediments between the 100-B and 100-K Areas. This second channel continues to the southeast where it forks; one fork, marked B on this map, continues along the north flank of Gable Mountain while the other fork, marked C, swings northeastward toward the 100-F Area.

A comparison of the differences in elevation between the top of the basalt bedrock and the surface of the Ringold Formation reveals that in places the Ringold sediments are approximately 600 feet thick. The present concept of the Ringold Formation is that it was deposited during folding of the basalt; hence, the lower beds exhibit maximum deformation and general conformability with the basalt while the successively higher beds show less and less deformation. Some of the topographically higher areas shown on this surface coincide with the highs on the basalt contour map. This may be coincidental or it may reflect the structural control these deformed units had on the movement of the Columbia River in this region.

The structure of the materials underlying the reactor areas reflect the deformation which has been going on essentially continuously for the last several million years. Several geologic cross sections were constructed to show the general structure of the rocks beneath the reactor areas; these cross sections are shown in Figures 3 through 8. As mentioned previously, the Ringold is deformed with the basalt, but it should be kept in mind when viewing these cross sections that the vertical exaggeration distorts out of proportion the dip of the beds in relation to the actual

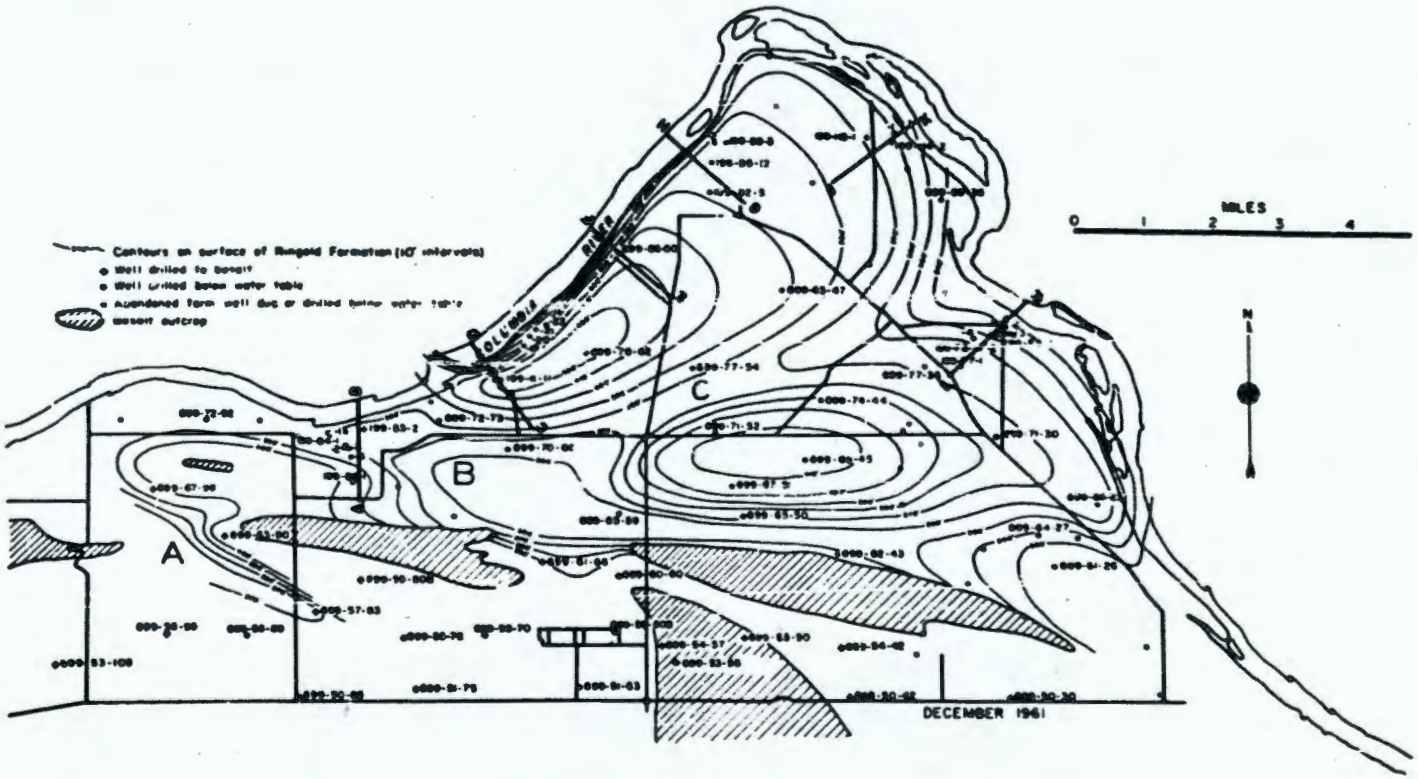

FIGURE 2

Contour Map of the Surface of the Ringold Formation Underlying Region of the Hanford Reactor Areas

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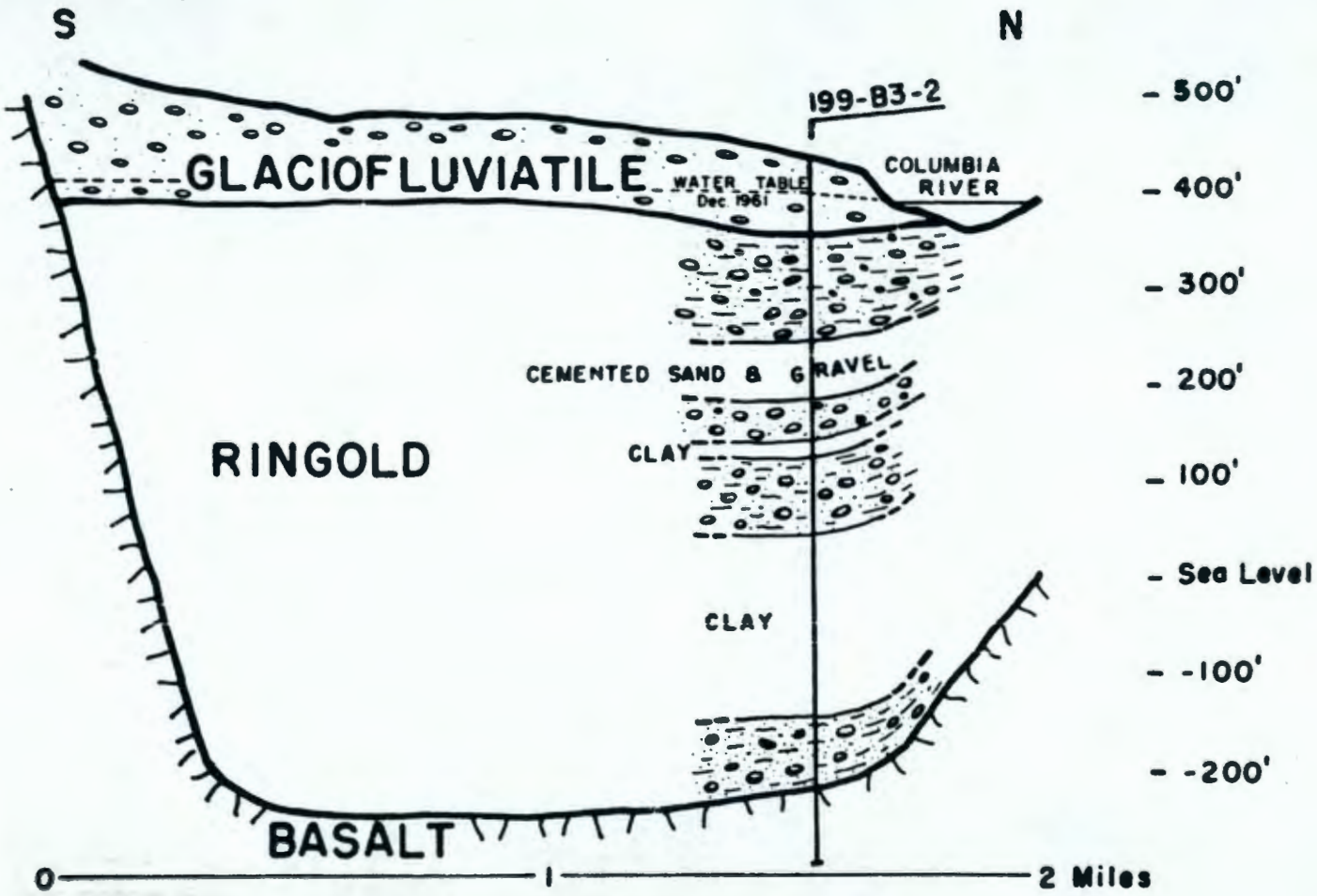

FIGURE 3

Geologic Cross Section A-B (100-B Area)

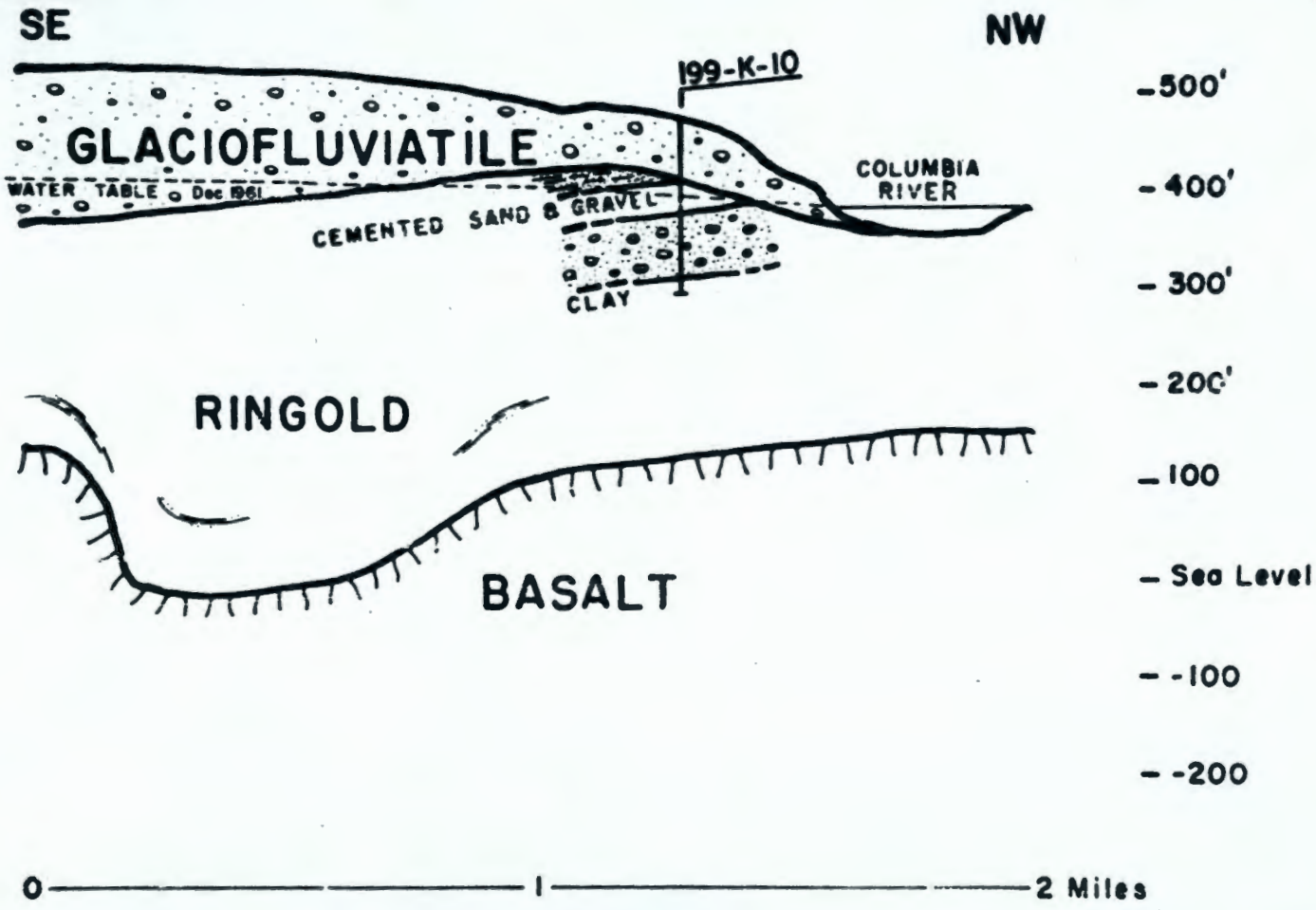

FIGURE 4

Geologic Cross Section C-D (100-K Area)

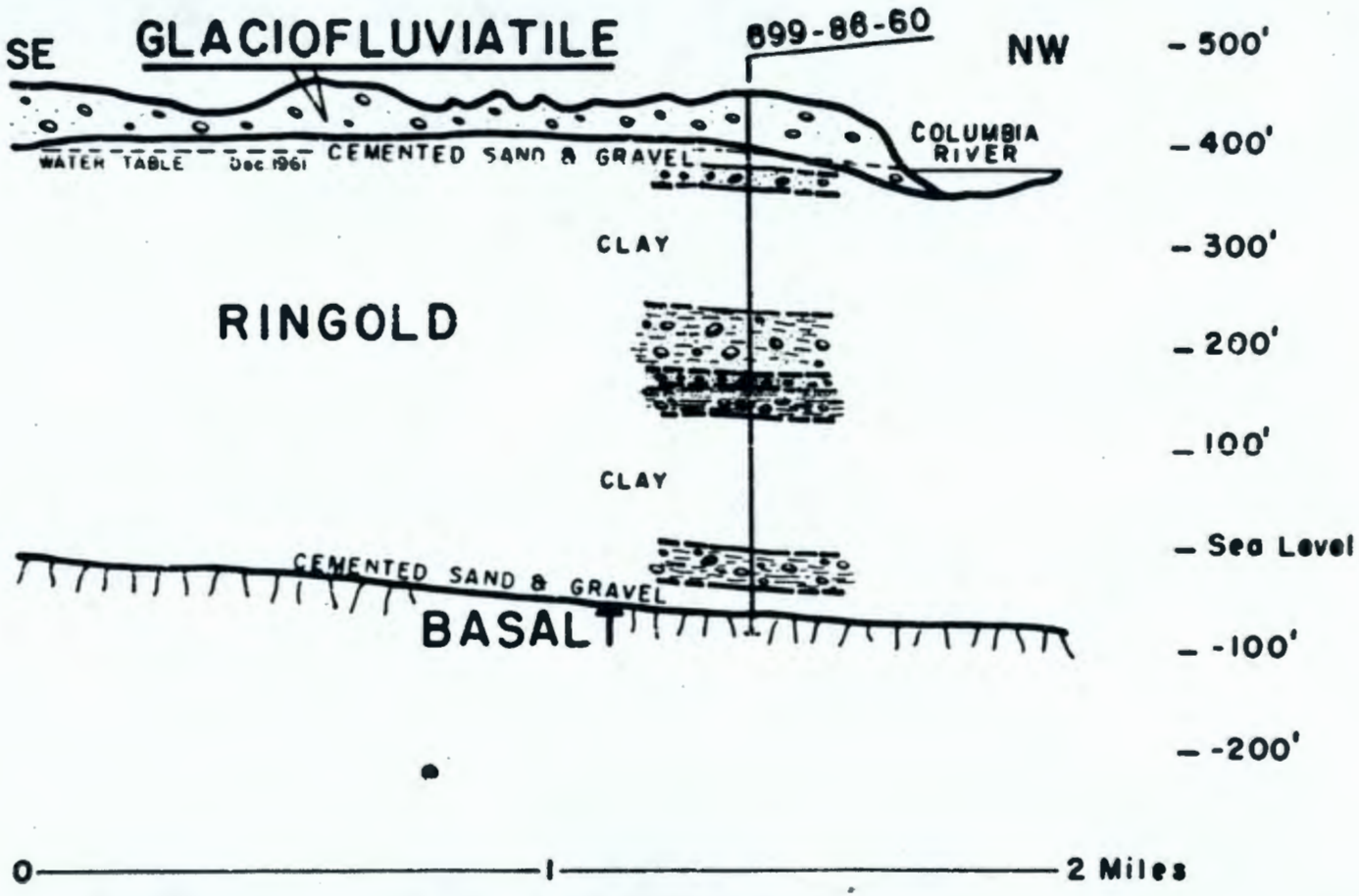

FIGURE 5

Geologic Cross Section E-F (100-N Area)

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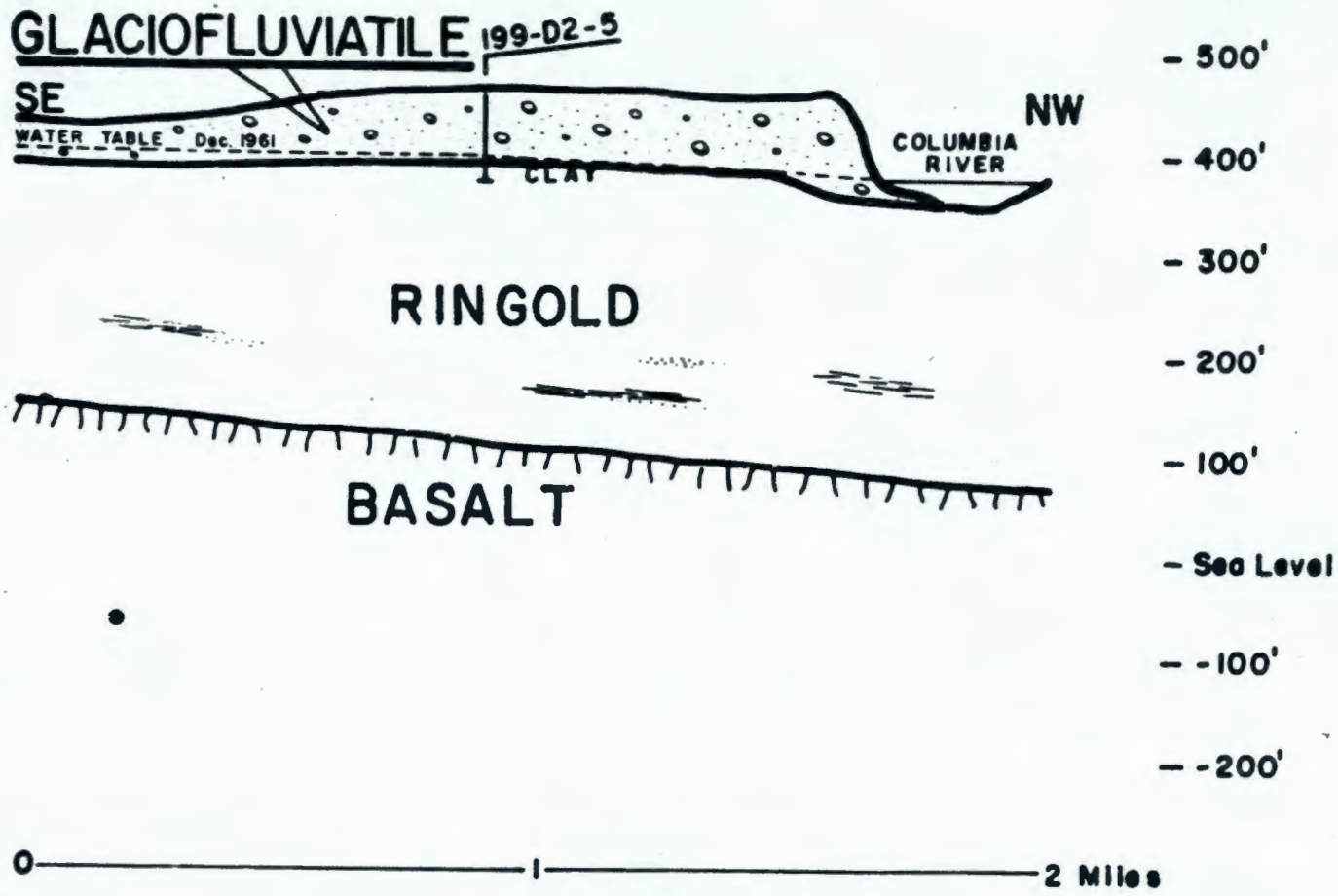

FIGURE 6
Geologic Cross Section G-H (100-D Area)

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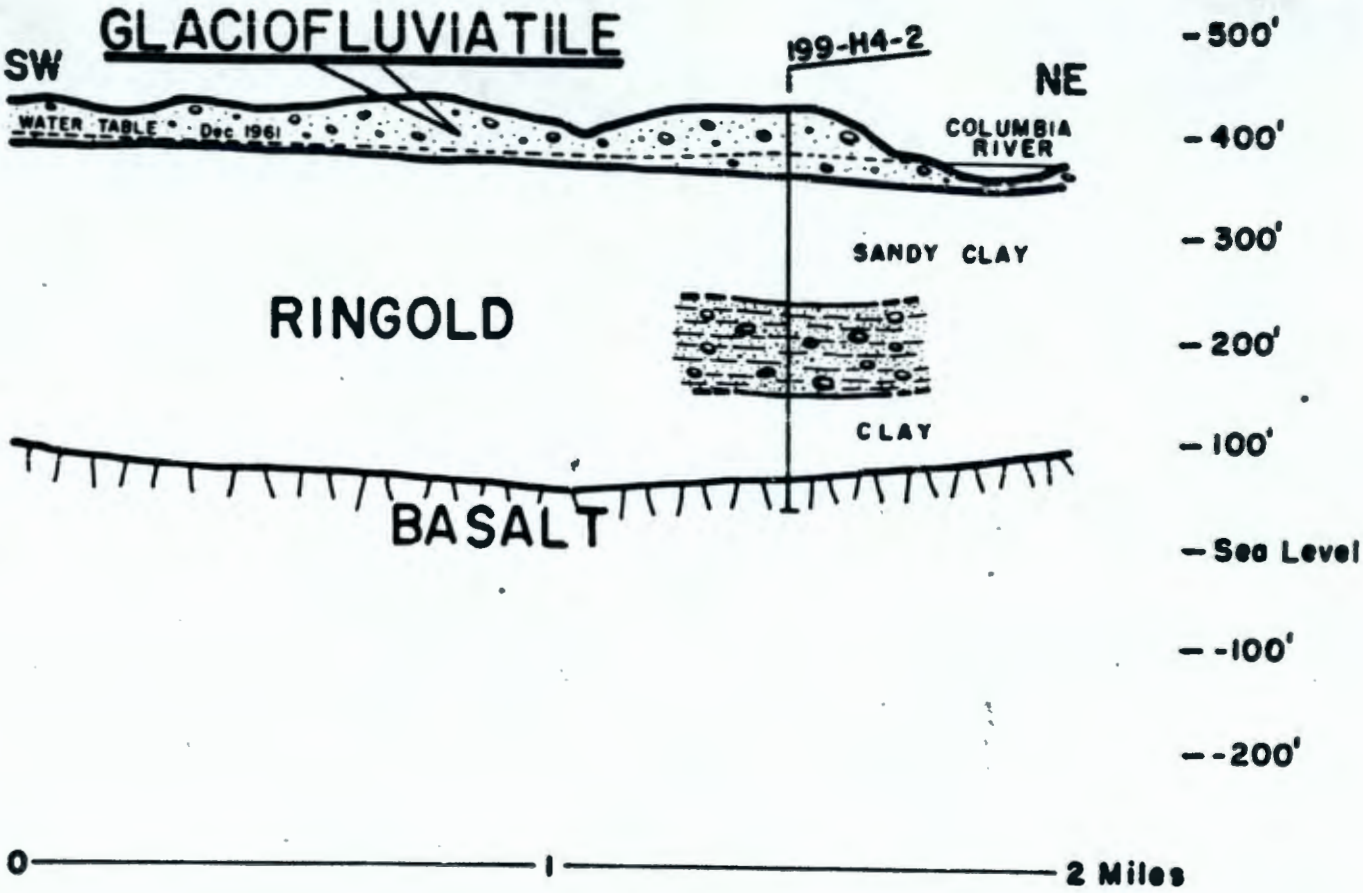

FIGURE 7
Geologic Cross Section J-K (100-H Area)

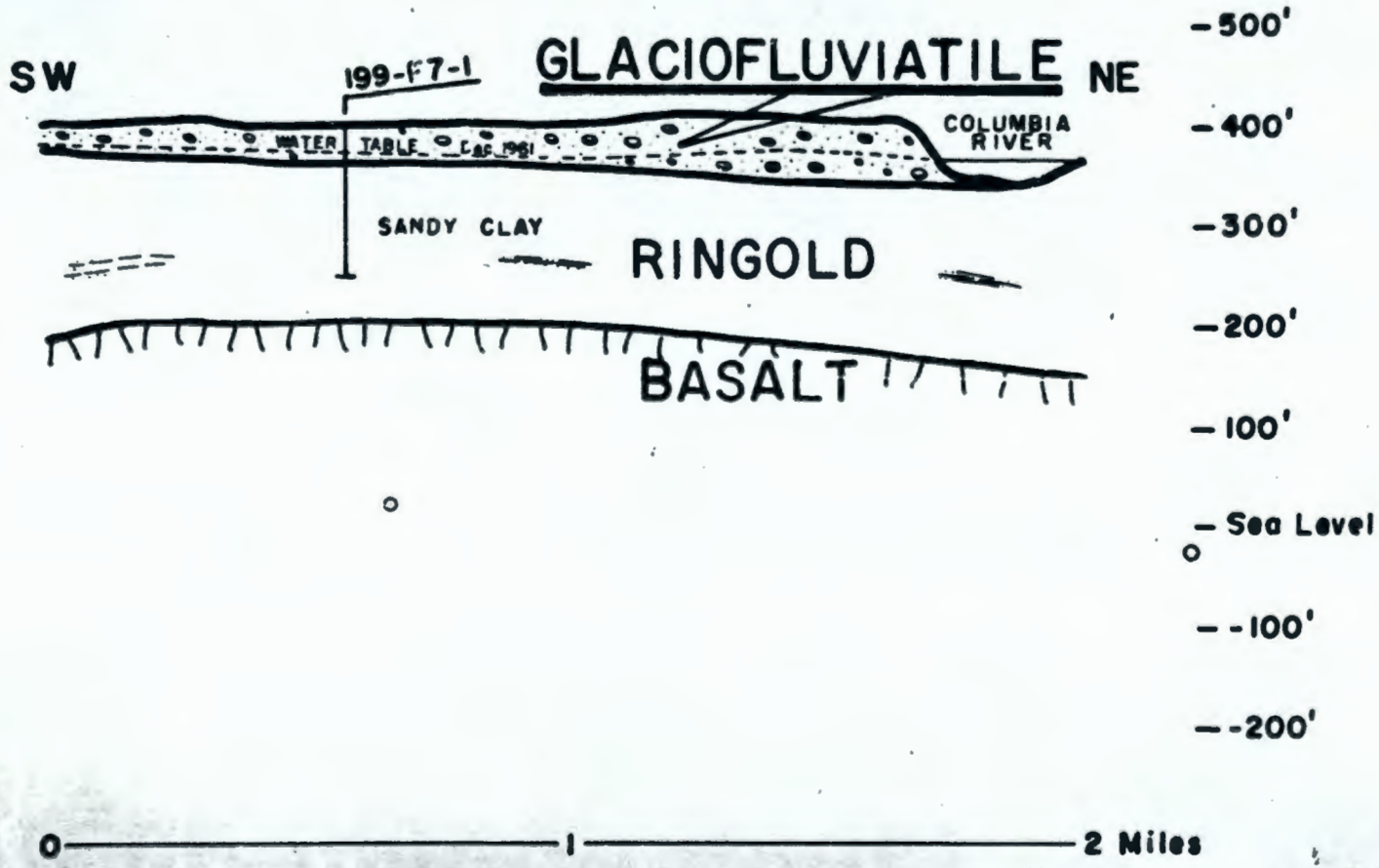

FIGURE 8

Geologic Cross Section L-M (100-F Area)

conditions existing in the field. The structure shown in these cross sections is based on the concept that the Ringold sediments are conformable to the basalt. The contour maps reflect this orogeny in that the topographic highs shown on the basalt map lie in the same position as some of the highs shown on the contour map of the Ringold surface. This particular fact is quite significant, especially when considering the effect of geology on the movement of ground water. The Ringold beds being folded and differentially eroded impose more complex solutions to ground-water problems than would similar horizontal beds.

GROUND WATER

The water table beneath the reactor areas lies at an average depth of 100 feet and represents the upper boundary of the unconfined ground-water zone in this region. Figure 9 is a contour map of the water table beneath the reactor areas for the month of December, 1961. This map shows the general ground-water contour pattern beneath the reactor areas, except for seasonal fluctuations which occur adjacent to the Columbia River in the late spring. The recharge of the ground water is normally from the highland areas to the south and southwest (9). A small amount of recharge comes from the retention basins and cribs located within the 100-Areas. These areas show up conspicuously on the contour map as isolated ground-water mounds along the river. Because of the limited number of observation wells in the 100-D Area (cross section G-K), no ground-water mound can be differentiated in this region; however, one is believed to exist there.

The permeability of the basalt flows normal to their surfaces is generally very low, particularly compared to the lateral permeability of the interflow zones. The

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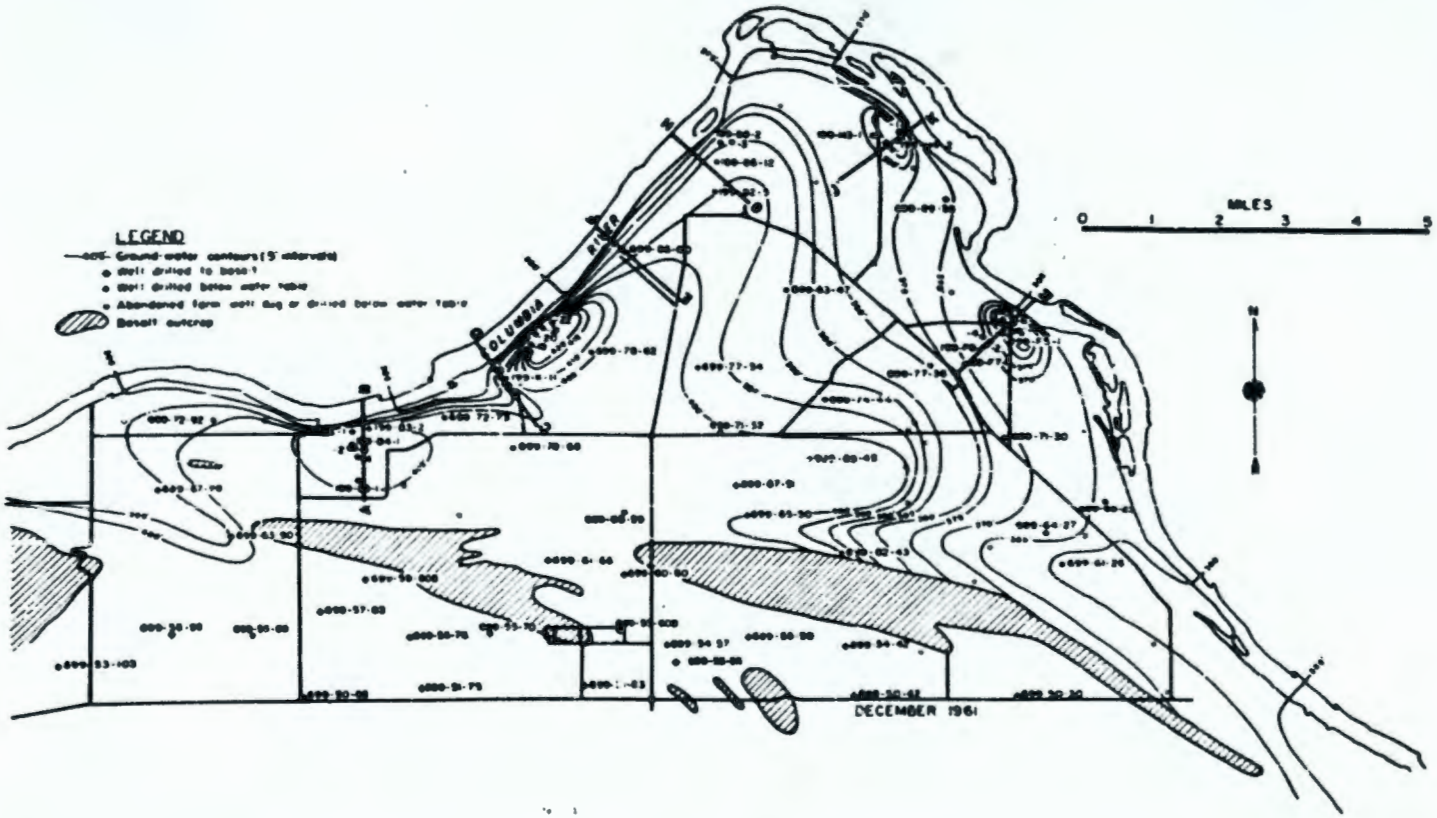

FIGURE 9

Ground Water Contour Map of the Water Table Underlying the Region of the Hanford Reactor Areas

ground waters within the basalt series are, therefore, quite separate and distinct from those in the post-basalt sediments. The material which makes up the Ringold Formation directly overlying the basalt is either so fine-grained or so poorly sorted that it has a relatively low permeability; generally this ranges from 10 to 1,000 gpd/ft^2. The Glaciofluviatile sediments are coarse-grained and generally highly permeable. Permeabilities range from 10,000 to 50,000 gpd/ft^2, or from 10 to as much as 5,000 times those of the Ringold Formation sediments. Permeability being a vector quantity may have significantly different values for each direction measured. The values given above are three-dimensional averages calculated from pumping tests made at selected field sites (9). It should be kept in mind that there are interbeds within each of these sedimentary deposits which vary significantly in permeability with the average values stated above. The average field permeability of the sediments directly beneath the 100-F, 100-H, 100-D, 100-N, and 100-K Areas is probably near 500 gpd/ft^2 and beneath the 100-B Area, 1,000 gpd/ft^2.

The contour map of the water table reflects strongly the contact between the Ringold Formation and the Glaciofluviatile sediments. Tracer tests have shown the ground water to be moving at relatively high velocities through glaciofluviatile sediments deposited in channels cut into the Ringold Formation. Several of these ancient river channels are known to exist in the region of the reactor areas. The general locations of the channels are inferred where the ground-water contours are concave inland away from the river. The most prominent channel is located just north of Gable Mountain.

At the present time many of the variables which affect the movement of ground water beneath the Hanford Project are unknown. Many of the plant problems relating

to ground-water movement, however, can be solved with our present knowledge. Work is continuing to define further these unknown variables.

REFERENCES

1. Brown, D. J. Subsurface Geology of the Hanford Separations Areas, HW-61780. October 1, 1959.

2. Brown, D. J. An Eolian Deposit Beneath 200-West Area, HW-67549. December 6, 1960.

3. Brown, R. E. The Surface of the Ringold Formation Beneath the Hanford Works Area, HW-62530. March 17, 1960.

4. Brown, R. E. and D. J. Brown. The Ringold Formation and its Relationships to Other Formations, HW-SA-2319. November, 1961.

5. Brown, R. E. and D. J. Brown. Surface of the Basalt Bedrock Beneath the Hanford Works, HW-57935. November 13, 1958.

6. National Research Council. "Report of the Subcommittee on Sediment Terminology." Trans. Am. Geophysical Union, Vol. 28, No. 6. December, 1947.

7. Newcomb, R. C., and J. R. Strand. Geology and Ground-Water Characteristics of the Hanford Reservation of the A. E. C., Washington, USGS-W-P-8. December, 1953.

8. McConiga, M. W. Deformation of the Ringold Formation, HW-36373. April, 1955.

9 Bierschenk, W. H. Aquifer Characteristics and Ground-Water Movement at Hanford, HW-60601. June 9, 1959.