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**A PRELIMINARY REPORT CONCERNING
THE DEVELOPMENT OF AN UNDERGROUND
WATER SUPPLY
RDS-14**

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**A Review of Reference Material and Previous
Work Including Recommendations for This Program**

by

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A study of the geology of the Hanford-White Bluffs area has shown that it consists of terrace deposits of sand and gravel covering a consolidated sandstone known as the Ringold formation. Beneath the Ringold are successive layers of basalt interbedded with volcanic ash, sand and other materials. In the past the Columbia River has cut channels through the area which extended downward into the Ringold formation. The old channels have been filled and upgraded to the present land surface in repeated flooding of the river over a long period of time.

The elevation of the upper Ringold shows considerable change with evidence to indicate that portions of the Ringold were deposited in successive layers and at different times. Intermixed with the Ringold and the sand and gravels of the terrace deposits are layers of volcanic ash, clay and other fine soils. There are stratified layers of the Ringold formation which are almost impervious to water movement in either a horizontal or vertical direction.

There is evidence to indicate the presence of basin like structures lined with a low permeability soil formation. These basins are filled with ground water creating what are known as "perched" water bodies elevated above the true water table. (See Log of Well 4, 100-K Test Borings.) Perched water bodies would account for finding ground water at several different elevations in this generally sandy soil. A terrace deposit such as this would normally have a uniform high permeability for water and a uniform distribution of the ground water table with respect to its elevation and gradient.

It is assumed in the reference works that the source of the ground water is the river and that the aquifers are recharged during flood periods.

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Throughout the area the water table elevation is consistently above the river at all stages indicating that if the ground water source is the river the point of entry must be some distance upstream. The possibility that natural drainage from the higher ground could be the source is not accepted because of the limited rainfall in the area.

The perched or confined water bodies, if they exist, would drain very slowly. In the past these natural cisterns may have retained between successive floodings, quantities of water in an amount sufficient for domestic well purposes. It is known that the old Hanford irrigation canal had an important effect in maintaining the water elevation in the old wells. A high capacity well drawing its supply from a perched water body would undoubtedly fail under continuous pumping. (See quote from reference document GEH-15045 concerning perched water.)

The ground waters are constantly draining from the area and during periods of low water on the river the water table is steadily dropping. The evidence available tends to show that the aquifer (or aquifers) are limited in extent by subsurface barriers and are recharged abundantly only during periods of high water on the river. With a lowering of the river stages the recharging is greatly reduced.

Flowing springs along the river bank near the old Hanford substation have been assumed to be a continuous natural drain from the area. It has been noted that the springs are issuing from a clay formation about ten feet above the low river level at this point. It would appear that the clay formation forms an impervious barrier which limits the river recharging effect in this area. The clay bank also forms in effect a dam along the river bank which restricts ground water movement out of the area to a few low points such as this.

An examination of the records of approximately 400 wells located in the Hanford and White Bluffs area shows only three wells which have developed 1000

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gpm, the maximum being 1400 gpm. The majority of the wells of record developed less than 500 gpm. All of the wells received their water from the Ringold and terrace formations above the basalt. It would be reasonable to assume therefore that in order to obtain a firm supply of 3000 gpm from the same aquifers, three to five wells would be required at each location. The wells would have to be separated by a few hundred feet at least. The resultant water gathering system would lack the virtue of simplicity and reliability, and such an arrangement in each area would be very costly.

The probability is almost nonexistent of developing one well in the Ringold region in any given area which would consistently produce 3000 gpm. The chances of developing a combined flow from two fully developed wells of 3000 gpm are about 50%. The probability that four wells would be required is very good.

For the eight areas (B, BC, KE, KW, D, DR, H and F) 32 wells with a combined flow of 24,000 gpm would be required. The aquifer must therefore be capable of supplying 34,560,000 gallons per day. The reliability of the aquifer supplying the wells would have to be such that the wells could maintain this required output for several weeks after the initial emergency period had passed.

Under the assumed very abnormal flood conditions the river may revert to the old channels through the area. In such an event the old channels would probably be scoured out to some unknown depth. A probable result of such an occurrence would be the partial or complete destruction of the ground water aquifers supplying the wells.

The non-uniform rise and fall of the water table with changes in river elevation, show that the ground water supply is dependent upon a modified bank charging effect. If a period of emergency, such as that for which the well system is being planned, should occur during the low water period of the fall and winter months, there is a very good possibility that the well system would

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fail prematurely for lack of water. This possibility exists notwithstanding the fact that during the initial phase the area would be submerged.

If dependence were to be placed upon wells drawing water from the Ringold, consideration would have to be given to improving the reliability of the aquifers. At present the situation is somewhat analogous to that of a leaky basin resting upon a basalt shelf along the river. On the upstream side there is a porous section that the water can flow into during periods of high water. On the downstream side the basin drains through a relatively narrow channel parallel to the northeast face of Gable Mountain. (See reference documents by Jenkins, 1922, and Piper, 1944.) It might be possible, using the technique of the buried dyke, to create an impervious barrier which would restrain the natural drainage of the area. This method has been used by the Corps of Engineers to construct dykes in the Kennewick, Washington, area. Continuous recharging of the aquifer by pumping might also be done.

The foregoing discussion has been confined to an evaluation of the reliability of ground water aquifers, located in the Ringold formation and terrace deposits above the basalt. The conclusion is reached that the Ringold supply is not reliable. An alternate possibility does exist, that of drilling a deep well 1500 to 2000 feet in depth, the object being to tap an artesian water stratum estimated to lie some 600 feet into the basalt in an interbed known as the Ellensburg formation. The water source for such a deep well would be independent of surface condition and within its specific yield could be depended upon to perform reliably for the time period required.

There is considerable evidence to indicate that this artesian stratum is present. At the nearby McGee wells, which tap this artesian stratum, the water flowed out of the casing under its own head. Flow rates have been measured at up to 1000 gpm and from an average depth of 1000 feet, at casing head

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elevations of 800 to 1100 feet above sea level. (See USGS Report by Hart, January 1952.)

In addition to the calculated risk inherent in drilling any well, there are other risk factors in this program which have become apparent. The problem of maintaining the integrity of surface structures looms large. Assuming that it is nevertheless desirable to construct a well in order to provide information for future guidance, the information presently available would dictate that it should be constructed in the following manner:

1. The well should be drilled to a depth of 1500 to 2000 feet.
2. The well should be so designed that it can be used as a producing well if successful.
3. Incorporated into the design should be greater structural strength than usual in the region near the surface.
4. The developmental and exploratory aspects of the well should be stressed in order to obtain a maximum amount of geological information.
5. The first well should be constructed in the 100-C Area for the geology of this region is such that the greatest possibility of success lies in this area.
6. No attempt should be made to proceed with similar work in other areas until the results achieved in 100-C can be evaluated.

The information assembled covering previous work in this area is quite extensive and is presently in the writer's possession. A bibliography and pertinent quotations from the references are included in this report. The final cost of this well program, if it is ever fully consummated, will be great. An order of magnitude cost figure for the first well is \$100,000. This figure does not include equipment or surface structures of any kind.

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Alternate methods of supplying water have suggested themselves. Such methods could be made equally or more reliable than wells. The cost would be greater than the cost of one well in each area but might be comparable to a fully developed well field. Maintaining the integrity of surface structures, as previously mentioned, will be a major problem in any program which may be undertaken. Work to date has not reached a point where this problem can be evaluated.

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QUOTES FROM REFERENCE DOCUMENTS

The DuPont Company in 1943 rejected a well system for process water supply in the 100 Areas because of "the lack of a continuous contact between the water bearing sands and the river". Reference report by H. W. Beacock, 12-12-51, to File, concerning the water plant studies, RDA-DC-6.

From USSS Report "Aquifer Evaluation Test in 100-K Area" by Strand and Hart, October 1952, page 9 - "Daily measurements of water table had established that a slow decline was occurring in the altitude of the water table - apparently as a drainage toward a lowering stage of the Columbia River." (The pump tests were run September/October 1952 when the river was dropping.)

From Page 10 - "The Ringold conglomerate aquifer is composed of an unusual mixture of coarse and fine materials that make necessary care in the design and construction of wells to permit extraction of large quantities of water without too much entrained sand. Possibly sand traps will be necessary in water lines leading from wells drawing large amounts of water from the conglomerate."

From Page 6 - "The horizontal bedding and zoning impedes to some extent the vertical movement of ground water."

GEH-20490 - Water Supply Hanford Barracks by A. M. Piper, 1944 - "Concurrently with the rising stage of the river the body of ground water in the terrace deposit presumably will receive the greater part of its yearly replenishment. In wells along the river the ground water level will rise substantially in pace with the river stage and will subsequently recede with the river. In the principal ground-water artery, however, replenishment will have different effects. Until the river stage overtops the remnants of the concealed Ringold terrace, seepage from the river cannot reach that artery within the area; thus, early replenishment by the river would reach the area from some upstream source and would take place gradually. The ensuing natural depletion would also be gradual, owing to the travel time of water passing to the remote discharge area downstream. Thus in this artery ground water tables may not rise as high as the river stage but probably will remain substantially above river stage after the peak run-off has passed."

GEH-20490 - "The impermeable Ringold formation constitutes an essentially water-tight floor beneath the permeable terrace deposit; the form of that floor is critical with respect to the movement of ground water into the area to replenish that withdrawn from wells."

From GEH-15045

See Section of Perched Water, Page 82-85, Quote from Page 84, 3rd Paragraph - "In terms of materials in the central part (200 Areas) of the Richland area, neither extensive nor numerous bodies of perched water are likely to exist or to accumulate in the highly permeable terrace deposits owing to infiltration of waste water. On the other hand, in the underlying Ringold formation, in which even the beds of coarsest average grain size so commonly have a matrix of fine sand and silt or of silt and clay, and whose average permeability is

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low, perched bodies may be more numerous and extensive than have been observed, but passed by unwittingly in drilling the test wells. For example, in well 34 - 51.5 no saturated materials were recognized above the water table by ordinary drilling methods, but the drive-core sampler recovered very damp clay from 285 to 286 feet below land surface and moist silty gravel below that. This moist zone begins about 59 feet above the regional water table--much too high to be within the capillary fringe of that table. It is not impossible that the zone is the feather edge of a perched water body derived from the infiltration sump in the 200-E Area, about 14,000 feet to the northeast."

From GEN-15045

From Page 9 - "Spring at west end of Table Mountain at 400' elevation establishes water table in this area."

From Page 67, 3rd Paragraph, reference to river fixing ground water level - "...with rising stage in the rivers, particularly the Columbia River, 'bank storage' takes place and ground water movement from the interior (if any) is checked: With falling stage and especially at low stage, ground water discharge takes place, as at the perennial springs along the right bank of the Columbia River near White Bluffs and somewhat below Hanford." See also Page 73, 74 and 75.

From Page 68, 4th Paragraph - "On the average, presumably the Ringold formation is only slightly permeable to water but has a fairly high capacity to retain water against the force of gravity (specific retention); both these characteristics are determined by its very poor assortment of particles--in other words, by the prevalence of fine sand, silt, or clay throughout nearly all its beds, even the coarsest. Thus, the permeability of a "gravel" bed commonly is that of its fine-grained matrix. In very minor part, a few beds of gravel and sand are sufficiently clean that permeability doubtless is moderately large and specific retention low; on the other hand, some beds of silty clay or clay no doubt are sensibly impermeable under hydraulic gradients of ordinary magnitude. Other beds, of both fine and coarse textures, are sensibly impermeable because original void spaces have been filled by cementing materials, such as calcium carbonate or silica. The permeability of the Ringold formation in the mass doubtless is but a fraction of that of the overlying terrace deposits; by inference, it is little if any greater than that of the underlying Yakima basalt."

From USGS Report - Preliminary Report on the Aquifer Evaluation Test in 100-K Area, by Strand and Hart, October 1952

From Page 3 - "As far as is known to the writers in the whole synclinal area along the Columbia River east of Priest Rapids no wells have penetrated the basalt far enough to test for artesian water the zones beneath the Ellensburg interbeds. That is the zone which supplies flowing artesian water in the Cold Creek Valley farther southwest."

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Notes from Logs, Test Borings in 100-K, RDA-DC-6 - See report by F. E. Shadel, 4-22-52, HDC-2564.

- Well #1 Ground Elevation - 405.7
First water @ 23' not enough to drill with stronger flow @ 35'
Good flow @ 43' - stands at 22' from surface
63' to 70' - good water bearing stratum
Below 85' - very little water, can bail out
Ringold - sand and silt and ash at 104' to bottom @ 107'
- Well #2 Ground elevation - 467
Bottom at 40' - dry hole
Sand and binder from 20'
- Well #3 Ground elevation - 496.4 Dry hole 34' to 36' Fine basalt gravel
Water runs through as fast as it is put in. Will not drill and you cannot bail. Will not hold water or top soil mud. Large amount of mud runs out into formation. Well bottom at 36 1/2'.
- Well #4 Ground elevation - 407.8
Caving gravel at 23'
Water filled hole during night to 22' below surface
Finished: filling to 40'. Water ran into hole from upper level.
At first very little water. Later a lot of water.
- Well #5 Ground elevation - 458.5 Dry hole Water run in for bailing in larger quantity. Ran out before bailer could be placed in hole. Sand and gravel throughout.
- Well #6 Ground elevation - 476.7 Dry hole Sand-gravel and boulders
Bailing water runs out bottom at 40'.
- Well #7 Ground elevation - 404.0 Gravel, sand and silt
Water at 25' raised to 22' overnight - small quantity
Old 6" diameter well 1/2 mile west of this location, 102' deep, shows water elevation of 22' below surface, bottom at 33' due to caving
- Well #8 Ground elevation - 456.6 Dry hole Gravel, sand and boulders
Bottom at 40'
- Well #9 Ground elevation - 463.6 Dry hole Gravel, sand and boulders
Bailing water runs out bottom at 40' Bad caving

Rock and Boulder Data (Most wells report extensive caving, blocking tools, casing essential to progress.)

- Well #4 "Have rock along side of pipe and every time I drive pipe I put a wrinkle in the pipe. Rock rolls in under pipe and causes my tools to hang up. Drills as if I am in this rock and boulder about 100 yards (?) north of rig. Date 3-3-52 Depth of well 27' Driller Row
- Well #2 Large Boulders at 10' to 15'
- Well #5 Large Boulders at 10' to 25'
- Well #6 Large Boulders at 5' to 15' and 35' to 40'
- Well #8 Large Boulders at 5' to 23'
- Well #9 Large Boulders at 5' to 25'

Wells #2, 3, 5, 6, 8 and 9 were not drilled deep enough to tap the water table then established @ 303' above sea level. The data on these wells are included here to illustrate typical drilling conditions.

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HDC-2564 - Test Borings in 100-K Area, RDA-DC-6, by F. H. Shadel, dated April 22, 1952

Abstract of the Report on the Geology and Resources of the Prosser Quadrangles, by H. E. Culver, State of Washington Department of Conservation and Development, dated January 12, 1926

USGS Report - Tests of Artesian Wells in the Cold Creek Area of State of Washington, by Don H. Hart, dated January 1952

USGS Report - "Preliminary Report on the Aquifer Evaluation Test in the 100-K Area", by J. R. Strand and D. H. Hart, October 1952

Report to File, by H. W. Heacock, dated December 12, 1951, concerning the Ranney Report and possible application to the 100 Area water plant. Ranney Report dated 1943

Document GEH-15045 - USGS Report - Geologic and Hydrologic Features of the Richland Area, Washington, Interim Report #1, dated July 1949, by G. G. Parker and A. M. Piper

Calkins, Frank Cathcart - Geology and Water Resources of a Portion of East-Central Washington, U.S. Geological Survey, Water-Supply Paper 118: 56 pp (1905)

Jenkins, Olaf Pitt - Underground Water Supply of the Region about White Bluffs and Hanford, Washington, Washington Geological Survey, Bulletin 26: 41, map (1922)

Geology and Water Resources of a Portion of Yakima County, Washington, by George Otis Smith, USGS, dated 1901, from Olympia, Paper #55

USGS W-P.7 - Geologic and Hydrologic Features of the Richland Area, by G. G. Parker and A. M. Piper, July 1949

GEH-20,490 - Adequacy of the Public Water Supplies in the Hanford Barracks and Richland Village Areas of the Hanford Engineer Works, Project 9536, Hanford Washington. By Arther M. Piper, District Geologist, US Geological Survey, Portland, Oregon, May 1949.

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