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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

OCTOBER, NOVEMBER, DECEMBER, 1958

Prepared by Members of the
Chemical Effluents Technology Operation

Edited by: W. H. Bierschenk

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION
HANFORD LABORATORIES OPERATION

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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

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INTRODUCTION

The Chemical Effluents Technology Operation performs research to investigate the chemical and physical aspects of environmental contamination resulting from plant effluents or from potential process disasters. This report is primarily concerned with plant assistance research in the field of waste disposal during the quarter October-December, 1958.

The ground-water monitoring data utilized in this report were obtained from well-water samples. These samples are collected routinely by the Regional Monitoring Operation and analyzed by the Radiological Chemical Analysis Operation.

I. INTERPRETATION OF GROUND-WATER MONITORING DATA (W. H. Bierschenk)

Figure 1 shows the probable extent of ground-water contamination. The concentration of radioactive contamination in the ground water is based on the gross beta activity densities averaged for all samples collected from a well during the period October-December, 1958. The boundaries of the contaminated zones shown are fairly indefinite, particularly that for the range of activity between 1.5×10^{-7} and 1.0×10^{-6} $\mu c/cc$. The concentration in wells shown outside of the zones is less than 1.5×10^{-7} $\mu c/cc$. All samples in which the gross beta activity density exceeds 1.0×10^{-4} $\mu c/cc$ are analyzed for Co^{60}, Sr^{90}, and Cs^{137}. Except for two cases discussed below, these isotopes have not been found in the ground water. Laboratory data indicate that the radioactive material in the ground water is chiefly Ru^{106}.

Figure 1 also shows the ground-water contours as of December 1958. The general direction of ground-water movement is normal to the contour lines in the direction of the downward slope.

200-East Area

There are three zones of contaminated ground-water beneath 200-East Area (see Figure 1). The depth to water ranges from about 200 feet below land surface in the northeast part of the area to about 350 feet in the southwest. The principal sources of contamination are the waste effluents disposed to the following three general sites:

(1) 216-BY and 241-B cribs. -- These cribs are no longer in use. Nevertheless, wastes continue to drain from the sediments into the ground-water. (See A, Fig. 1). During this quarter the maximum concentration

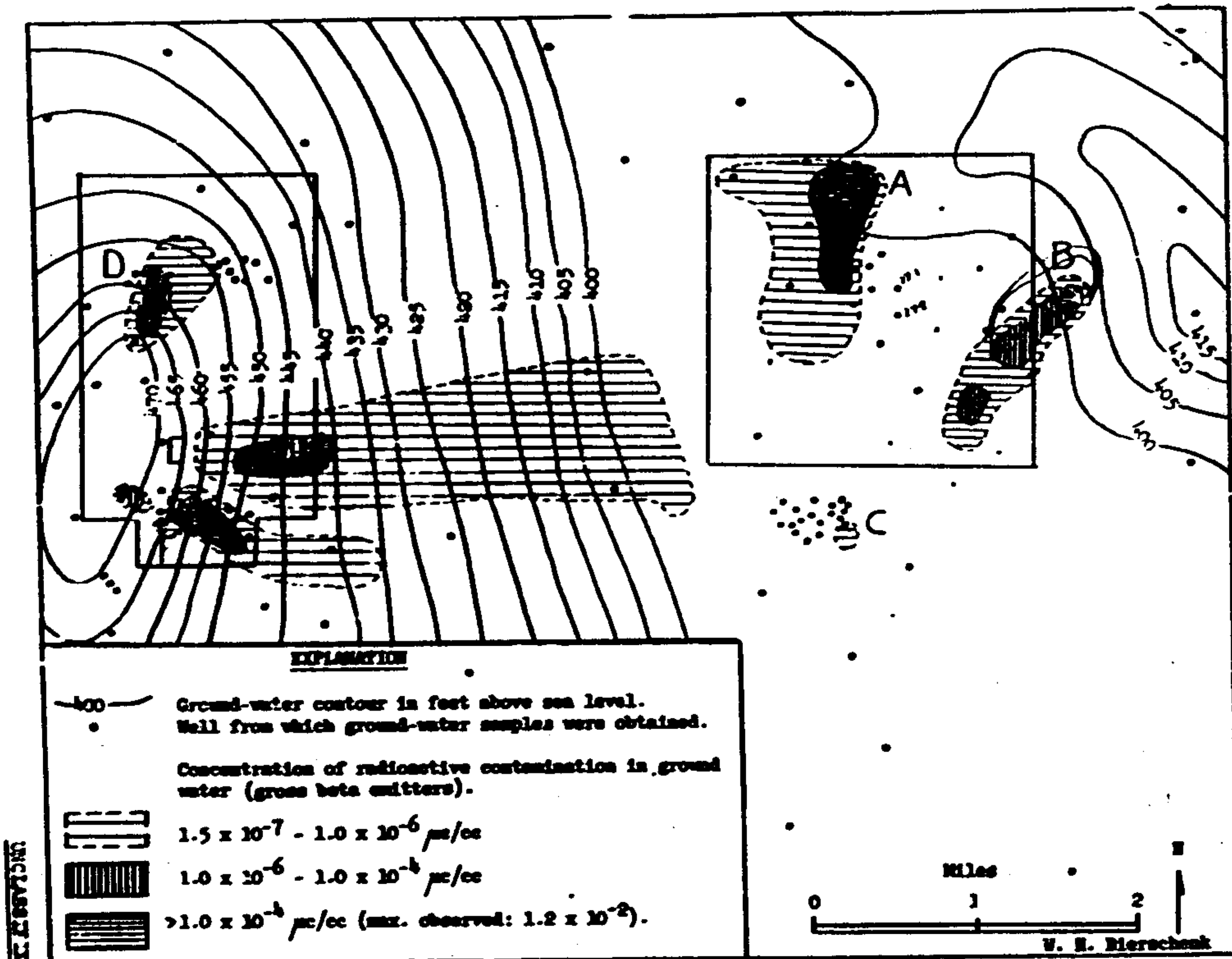

Figure 1. - Map of Separations area showing probable extent of ground-water contamination and contours on the water table, December, 1958.

of gross beta emitters detected was 2.2×10^{-2} µc/cc, reported 10/6/58. The average of six samples from this particular well was 1.2×10^{-2} µc/cc. In general, monitoring wells situated to the east of the crib showed a gradual decrease in concentration during the year, whereas that monitoring well to the southwest increased in concentration. For example, samples from the well about 1,000 feet eastward declined from an average of 2.3×10^{-3} µc/cc in the first quarter of 1958 to an average of 3.2×10^{-4} µc/cc in the last quarter. In contrast, the well about 500 feet southwestward increased from an average of 1.2×10^{-6} µc/cc to 3.3×10^{-4} µc/cc. These changes reflect the general southwestward migration of contaminants and are caused by the gradient imposed by the eastern ground-water mound.

Fission product analyses are made of water samples taken from 11 monitoring wells at this site. In December, 10 wells contained Co^{60} concentrations in excess of 1/10 MPC (4×10^{-5} µc/cc); the maximum being 3.3×10^{-4} µc/cc. Sr^{90} and Cs^{137} concentrations were not found in any wells in excess of their respective analytical sensitivity levels of 7.0×10^{-8} and 7.4×10^{-7} µc/cc.

(2) <u>216-A cribs</u>.-- The 216-A-8 crib was inactivated in May 1958 when the wastes were diverted to the 216-A-24 crib. (See B, Figure 1). As indicated by the following tables, the concentration of gross beta emitters in the ground water underlying the A-8 crib is decreasing, and underlying the A-24 crib it is increasing.

TABLE I. GROSS BETA ACTIVITY DENSITIES IN 216-A-8 WELLS

Well No.	3rd Quarter Average	4th Quarter Average
299-E25-4	4.5×10^{-4} µc/cc	7.0×10^{-5} µc/cc
299-E25-5	1.8×10^{-4} " "	6.2×10^{-5} " "
299-E25-6	4.9×10^{-4} " "	1.3×10^{-4} " "
299-E25-7	[illegible]$.3 \times 10^{-4}$ " "	4.3×10^{-5} " "
299-E25-8	6.0×10^{-4} " "	5.6×10^{-4} " "
299-E25-9	1.2×10^{-5} " "	3.8×10^{-6} " "

TABLE II. GROSS BETA ACTIVITY DENSITIES IN 216-A-24 WELLS

Well No.	3rd Quarter Average	4th Quarter Average
299-E25-10	7.0×10^{-6} µc/cc	3.6×10^{-5} µc/cc
299-E26-2	5.2×10^{-5} " "	3.3×10^{-5} " "
299-E26-3	1.2×10^{-4} " "	2.6×10^{-4} " "
299-E26-4	4.6×10^{-5} " "	8.7×10^{-5} " "
299-E26-5	1.3×10^{-5} " "	6.8×10^{-6} " "

Gamma scintillation probes were made of the wells monitoring the A-8 and A-24 cribs. The wells at each site extend west to east along the axis of the cribs. The A-8 crib wells were probed on 11/11/58 and the results compared to those of 2/19/58. In February, gamma emitters were detected in the westernmost well (299-E25-4) to a depth of 125 feet and in each of the other five wells all the way down to the water table at a depth of about 235 feet. In November, there was no significant change in these findings.

Wells monitoring the A-24 crib were probed on 12/12/58. These monitoring data indicate the presence of gamma emitters in the ground within 20 feet of the surface at all wells. Gamma emitters were detected in the westernmost well (299-E26-5) to a depth of 145 feet and in each of the other three wells all the way down to the water table at a depth of about 240 feet. A recheck of the probe results confirmed the data, and probing of the crib risers further indicated that wastes were in all sections of the crib.

Fission product analyses are made of water samples collected from 12 wells in the area of the 216-A cribs. Co^{60}, Sr^{90}, and Cs^{137} results have all been below the analytical detection limits.

(3) 216-BC cribs and trenches. -- Water samples from wells monitoring the 216-BC site intermittently exceed a gross beta density of 1.5×10^{-7} µc/cc (1). However, when samples were averaged for the quarter, only those from the newly completed well located 15 feet south of the BC-5 crib were greater than this detection limit. In November the average for this well was 5.2×10^{-7} µc/cc. (See C, Figure 1).

200-West Area

In the past, practically all the ground water beneath 200-West Area was contaminated to some degree. At present, however, there appear to be three separate zones. (See Figure 1). The depth to water ranges from about 200 feet below land surface in the western part of the area to about 280 feet in the eastern part.

(1) T-Plant cribs and trenches. -- These facilities are no longer in use, but wastes which continue to drain from the underlying sediments are the source of ground-water contamination. (See D Figure 1). During 1958 the concentration of gross beta emitters in water samples showed an overall decrease. Of the 10 monitoring wells in the vicinity of the T-Plant, nine produced samples that averaged less than 1.5×10^{-7} µc/cc for the last quarter, and the remaining well contained water which contained only 2.5×10^{-7} µc/cc. No contamination has been detected in wells situated further to the north or northeast of these wells. Thus, there apparently has been a contraction of the northeastward extension of the contamination zone during the year. With one exception, all samples from other monitoring wells situated to the west of T-Plant near the tank farms and to the southwest near the Z-facility also showed reductions in concentration. The exception showed a slight increase in average from 3.2×10^{-6} µc/cc for the first quarter to 4.7×10^{-6} µc/cc for the final quarter. There was a 57% average decline in concentration elsewhere. The highest

detectable concentration for the October-December quarter averaged 2.3 x 10^{-5} µc/cc.

The water samples from four critical monitoring wells are analyzed for Sr^{90} and Cs^{137}. No concentrations exceeded the respective analytical sensitivity levels.

(2) Contaminated Zone E (Figure 1) lies beneath U-Plant and probably extends almost three miles eastward. The ground-water contamination is believed to have originated with T-Plant wastes which continue to move with the ground water under influence of the prevailing hydraulic gradient. The average concentration of gross beta emitters in the 216-WR monitoring well decreased from 2.0 x 10^{-5} µc/cc in the first quarter to 1.1 x 10^{-5} µc/cc in the last quarter. In contrast, the concentration in well 699-38-70 (0.5 mile eastward) increased from an average of 1.8 x 10^{-6} to 2.4 x 10^{-6} µc/cc, and in well 699-41-62 (2.7 miles eastward) from 1.2 x 10^{-7} to 2.1 x 10^{-7} µc/cc. These changes suggest that wastes are continuing to move out of the wells beneath 200-West Area and into wells more remote and down the hydraulic gradient. In the future then, concentrations beneath the area as depicted by zones D and E can be expected to decrease whereas slight increases may be expected at places downgradient.

Samples from the 216-WR monitoring well showed no positive indications of Sr^{90} or Cs^{137}.

(3) Redox cribs. -- The 216-S-1, 2 and 7 cribs are responsible for the ground-water contamination beneath Redox. (See F, Figure 1). The 216-S-1 and 2 cribs are no longer in use. Consequently, there has been a general decrease in the gross beta activity densities in ground-water samples from nearby monitoring wells. The decrease in concentration averages about 43% between average values for the first quarter of 1958 and the fourth quarter. The highest average concentration now present is 8.7 x 10^{-4} µc/cc.

Between the first and fourth quarters the average concentration of gross beta emitters underlying the 216-S-7 crib increased from a maximum of 2.0 x 10^{-3} to 1.1 x 10^{-2} µc/cc. The latter figure represents a breakthrough of only about 2% of the wastes being discharged into the crib. Samples from a well located about 1,500 feet southeastward of this crib showed an increase in average concentration from 1.1 x 10^{-6} to 1.8 x 10^{-6} µc/cc, and those from a well about 4,900 feet southeastward showed an increase from 2.0 x 10^{-7} to 8.3 x 10^{-7} µc/cc. The southeastward movement of wastes is therefore apparently confirmed.

Water samples from 11 monitoring wells at these cribs are analyzed for Sr^{90} and Cs^{137}. All samples collected since 4/8/57 from a well 15 feet from the 216-S-1 crib have contained Sr^{90} concentrations exceeding the detection limit. During this quarter the maximum concentration observed was 1.1 x 10^{-6} µc/cc. Positive concentrations were not detected in any of the other wells.

II. PLANT WASTE DISPOSAL PRACTICE

Chemical Processing Department (W. A. Haney)

Storage of high-level wastes. -- The final (sixth) field test simulating loss of Redox high-level waste from a leaking tank was conducted in October. The test employed synthetic waste representative of the unconcentrated waste discharged from the Redox plant. The large amount of precipitate in this solution (ca. 75% by volume) supports previous observations that the quantity of precipitate may be markedly influenced by waste preparation techniques. An insignificant amount (less than 20 gallons) of waste entered the soil before the orifice became plugged by the precipitate. Sparge air at a pressure of 100 psig applied immediately above the orifice failed to dislodge the sludge. The results of all six tests, which used wastes with an appreciable amount of sludge, indicate that a leak through a small opening near the bottom of a tank will tend to be sealed by the sludge, and the rate of loss will be reduced to essentially an immeasurable quantity.

Purex tank-farm hazards appraisal. -- The Purex tank-farm hazards study requested by Chemical Processing Department has been completed and submitted to Radiation Protection Operation for review before issuance. This study evaluates the radiological consequences resulting from the hypothetical release of contaminated vapors from the tank-farm stack at a rate of 25,000 pounds per hour, and the loss of 100,000 gallons of high-level waste to the soil beneath a leaking tank.

Gelling of waste. -- HW-58211, "Status Report -- Disposal of Aluminum Bearing Radioactive Wastes by Gelation," issued November 24, 1958 (2) summarizes pertinent results of work by Chemical Effluents Technology personnel on gel disposal. Recommendations for future work are also presented.

Irradiation Processing Department

Reactor decontamination (W. N. Koop)

Soil column investigations were conducted in support of the program to use Turco 4306-B reagent for decontaminating reactor process tubes. The purpose of these investigations was to evaluate a proposal to dispose of the spent cleaner to an existing 107-trench. Laboratory results showed that trench soil will remove from the spent cleaning solution more than 99.9% of each of the five radioisotopes of concern. Decontamination by the soil was better than previous estimates which were based on caustic precipitation and sintered glass filtration measurements, the improvement being attributed to ion-exchange properties of the soil. Addition of caustic to the spent cleaner was not necessary to achieve this decontamination, but the caustic treatment significantly reduced leaching of rupture debris from the trench soil. Diluting the waste one part cleaning solution to 50 parts reactor coolant will also reduce leaching of rupture debris from the trench. There is evidence that release of treated cleaning solution to a trench will have little or no adverse effect on the future normal use of this facility.

On the basis of these findings, the disposal procedure recommended for the first full reactor cleaning operation is (a) to neutralize the spent cleaning solution with caustic, and (b) to dilute one part of the solution with 50 parts of reactor effluent before release to an existing 107 trench.

Uranium oxidation experiments (R. K. Hilliard).

Correlation of the data obtained from experiments on bare, unirradiated uranium cylinders was accomplished using (a) furnace temperature and (b) original surface area/weight ratio as parameters. Three specimen sizes of 1/8, 1/4, and 1/2-inch diameter were studied at temperatures from 300 to 1450° C. A topical report, HW-58022 (3) is being issued. This study provides information not previously available concerning the oxidation of uranium in air and permits estimates to be made of oxidation rates for any size uranium pieces at temperatures as much as several hundred degrees above the melting point of uranium. It also establishes base-line data for a laboratory investigation of fission product volatilization from heated irradiated uranium.

Fission product volatilization experiments. -- Calculations of reactor disaster consequences require a knowledge of the amounts and types of fission products which would volatilize and be released to the atmosphere in the event of a reactor incident. At present, only scattered data are available regarding fission product release from molten or oxidized uranium fuel elements.

In December, a laboratory investigation was started which was designed to obtain the basic information required for disaster-consequence estimates. Four tests were made using 1/4-inch diameter by 3/4-inch long uranium cylinders irradiated to about 2×10^{14} nvt. The purpose of these tests was to determine the fractions of biologically important radioisotopes volatilized when exposed to air at 1200° C for various periods of time. Particle generation was also investigated. Radiochemical analyses are not complete, but preliminary results indicate that a large fraction of the iodine, tellurium, and xenon is volatilized within 10 minutes. Tests are continuing.

III. LABORATORY EVALUATION OF WASTES (H. L. Brandt, A. E. Reisenauer)

U-Plant Condensate

Laboratory tests were performed to determine the consequences of disposing of unneutralized condensate from the UO_3 plant to a used crib. Soil columns were loaded with radiostrontium from neutralized waste and then leached with unneutralized condensate. As was anticipated from the relationship previously determined between pH and K_d, the acid stream tended to leach adsorbed radiostrontium from the soil. The rate of leaching was not excessive, nearly ten column volumes of leaching solution being charged before the appreciable depletion of radiostrontium on the soil.

Recuplex (CAW) Waste

Further laboratory studies were made of the removal of plutonium from CAW waste by an anion-exchange resin column. These tests indicate more than 95% plutonium removal from at least 200 column volumes of CAW waste by Amberlite IRA 400 resin. These resin columns had a volume of 13.5 - 14 cc and operated at flow rates ranging from 0.11 to 0.34 cm/min. A similar test with Permutit-SK resin resulted in 90% plutonium removal from about 30 column volumes of waste. A single elution test of the Amberlite IRA-400 resin indicated 90% Pu removal with 20 column volumes of 0.35 M nitric acid. The waste contains appreciable quantities of Am^{241} (an alpha emitter) which complicates the analytical problem. None of the americium is retained on the resin.

Purex Tank Condensate

Further soil column tests of tank condensate waste from Purex boiling tanks are in progress to confirm the previously measured capacity of the 216-A-24 crib. The analysis of this crib is complicated by an uncertainty regarding the degree of utilization of the soil volume beneath the crib. It is not clear to what extent all four sections of the structure are being used for waste disposal. Current tests are being made to investigate possible correlations between the Sr^{90} breakthrough curve for this condensate and that of other isotopes such as Cs^{137} and Ru^{106}. This information might provide a better method for predicting the appearance of Sr^{90} in the ground water beneath the crib. The results to date are not encouraging but further tests are in progress to study the relationship between Sr^{90} and Cs^{137} in this waste.

IV. GROUND-WATER HYDROLOGY (W. H. Bierschenk)

200-East Ground-water Mound

Purex cooling water has been discharged to open disposal swamps at a rate that has averaged 8.6 million gallons daily (mgd) for the period December 1957 through December 1958. An average of approximately 4 mgd went to the Gable Mountain swamp and 4.6 mgd to the B-swamp. As a result of this disposal, the water table beneath the Gable Mountain swamp, as measured at well 699-55-50, has risen 3.3 ft to an elevation of 401 ft. The elevation of the water table beneath the B-swamp, as measured at well 699-45-42, has remained essentially the same at an elevation of 412 ft.

In document HW-49728 "The Effect of Ground-Water Mounds on the Purex Operation," it had been estimated that after one year of disposing of a proposed 14 mgd to the Gable Mountain swamp and 6 mgd to the B swamp, the water table would be at elevations of about 405 ft and 412 ft, respectively (4). The estimated and actual conditions are in fairly good agreement considering that operating conditions were not as expected.

At present, contaminated ground water beneath 200-East Area is denied access to the permeable eastward-trending channels adjacent to Gable Mountain. That contamination which is influenced by the southeastward and eastward hydraulic gradient of the ground-water mound (see Fig. 1) will move at very slow rates inasmuch as very shallow gradients in the order of a few tenths of a foot per mile exist in the permeable sediments beneath the area. Average velocities in the order of a few feet per day have been calculated.

200-West Ground-water Mound

During 1958 an average of 4.9 mgd of cooling water went to swamps in the southern part of 200-West Area. This is a decrease of about 0.8 mgd from the 1957 average. The peak of the 200-West mound has consequently declined from an elevation of 474.2 ft to 472.6 ft. Water levels in more distant wells continue to rise, however, in response to continuing recharge of the aquifers. The overall effect is a slight, probably immeasurable, reduction in the average flow rates of 2-3 ft/day off the mound.

The water table beneath the area between 200-West and 200-East is now entirely above an elevation of 399 ft. This represents a rise of 1 to 3 ft in wells situated in this area during the past year. As mentioned above, very shallow hydraulic gradients exist in this area.

Field tests

Hydraulic field tests were completed on four wells. The results of the analyses of drawdown-recovery tests are summarized as follows:

TABLE III. RESULTS OF PUMPING TESTS

Well No.	Aquifer tested	Transmissibility (gpd/ft)	Average Permeability (gpd/ft²)
699-20-20	Glaciofluviatile and Ringold sediments	240,000	1,200
699-33-56	" " " " " "	155,000	1,700
699- 2- 3	Ringold sediments	92,000	575
699-S12-3	" " " " "	1,900	50
699-28-41	Test unsuccessful: pump failure		

To date, 25 pumping tests have been conducted at Hanford. Evaluation of the data so collected, together with estimates obtained from 50 specific capacity tests and from 17 cyclic-fluctuation analyses show that the average field permeability for glaciofluviatile sediments ranges from about 10,000 to 67,000 gpd/ft^2, and for undifferentiated Ringold sediments it ranges from less than 100 to about 600 gpd/ft^2. Inasmuch as under the same hydraulic gradient the rate of flow is proportional to permeability, ground-water velocities up to 100 times greater are possible in glaciofluviatile sediments as compared to the Ringold.

V. WELL DRILLING SUMMARY (D. J. Brown)

Artesian Well & Pump Company

Well	Ft. Drilled	Finished	Total Ft.	To Water	To Basalt
299-E13-20C	596	11/14/58	596	Yes	Yes

Bach Drilling Company

Well	Ft. Drilled	Finished	Total Ft.	To Water	To Basalt
699-24-46	682	10/10/58	682	Yes	Yes
699- 2-33	466	10/ 3/58	466	"	"
699-65-59	201	11/ 5/58	201	"	No
699-17-70	286	10/31/58	286	"	Yes
299-E27-3	360	12/18/58	360	"	"
699-S15-20	172	11/12/58	172	"	"
699-14-40	425	11/22/58	425	"	"

Midland Drilling Company

Well	Ft. Drilled	Finished	Total Ft.	To Water	To Basalt
299-W18-2	280	11/14/58	280	Yes	No
299-W18-5	283	11/10/58	283	"	"
299-W18-3	453	12/29/58	453	"	"
299-W23-72	103	10/ 6/58	103	No	"
299-W18-1	427	12/31/58	427	Yes	"

Drilling crews of the Artesian Well and Pump Company have completed all of their scheduled drilling on the AT (45-1)-1255 drilling contract. In well 699-31-53 remedial action is being taken on the parted 12-inch casing. As this casing was being withdrawn from the hole to expose the 180 feet of well screen, the casing parted leaving a significant portion of it enveloping the screen. In this condition the well does not meet the specifications of the drilling contract and needs to be corrected before the desired hydrological tests can be performed. The contract completion date expired on July 15, 1958.

The Bach Drilling Company has completed approximately 3,500 feet of drilling on the AT (45-1)-1282 contract. There is approximately 500 feet remaining. The scheduled completion date for this contract was December 31, 1958. However, because several wells had to be drilled significantly deeper than anticipated, more time was required for this work.

Drilling crews of the Midland Drilling Company have completed 1,500 feet of drilling on the AT (45111-1406 contract and have 900 feet remaining. They have approximately two months in which to complete this work. Their method of drilling using a coring technique to make hole rather than using a hard-rock bit appears to be slightly faster in the type of formation in which they are working.

VI. REFERENCES

(1) Bierschenk, W. H., Chemical Effluents Technology Waste Disposal Investigations, July-September, 1958. HW-58023-RD, October 30, 1958.

(2) Haney, W. A., Status Report -- Disposal of Aluminum-Bearing Radioactive Wastes by Gelation, HW-58211, November, 1958.

(3) Hilliard, R. K., Oxidation of Uranium at High Temperatures, HW-58022. (Report in preparation)

(4) Bierschenk, W. H., The Effect of Ground-Water Mounds on the Purex Operation, HW-49728, April 18, 1957.

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Drilling crews of the Midland Drilling Company have completed 1,500 feet of drilling on the AT (45-1)-1406 contract and have 900 feet remaining. They have approximately two months in which to complete this work. Their method of drilling using a coring technique to make hole rather than using a hard-rock bit appears to be slightly faster in the type of formation in which they are working.

VI. REFERENCES

(1) Bierschenk, W. H., Chemical Effluents Technology Waste Disposal Investigations, July-September, 1958. HW-58023-RD, October 30, 1958.

(2) Haney, W. A., Status Report -- Disposal of Aluminum-Bearing Radioactive Wastes by Gelation, HW-58211, November, 1958.

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