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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

APRIL, MAY, JUNE, 1960

Prepared by members of the

Chemical Effluents Technology Operation

Edited by: W.A. Haney

September 22, 1960

Chemical Research and Development Operation
Hanford Laboratories Operation

Hanford Atomic Products Operation
Richland, Washington

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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS
April, May, June, 1960

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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS APRIL, MAY, JUNE, 1960

INTRODUCTION

The Chemical Effluents Technology Operation performs research to investigate the chemical and physical aspects of environmental contamination resulting from the disposal of plant effluents or from potential process incidents. This report is primarily concerned with plant assistance research in the field of waste disposal during the quarter April, May, June, 1960.

Ground-water monitoring data utilized in this report were obtained from samples collected routinely by the Environmental Monitoring Operation and analyzed by the Radiological Chemical Analysis Operation.

I. INTERPRETATION OF GROUND-WATER MONITORING DATA (W.A. Haney)

Special Monitoring Well Samples

During the period covered by this report large volume samples from seven selected wells were obtained and given special analytical processing to further detail the radioisotopes which are included in routine "gross beta" determinations. Wells were selected on the basis of changes in radioisotope concentrations, proximity to disposal facilities of interest, and location with respect to contaminated ground-water movement. Samples were analyzed for the predominant longer-lived isotopes of interest in separations wastes. The analytical results presented in Table I are in agreement with the results of previously collected samples from these and other wells which continue to show that essentially all of the gross-beta activity consists of ruthenium-106 and its daughter, rhodium-106.

The positive Co^{60} concentration noted in well 299E-28-2, located about

TABLE I

RADIOISOTOPIC ANALYSES OF SPECIAL MONITORING-WELL SAMPLES
(Concentrations in units of μc/cc)

Isotope	Well (1)* 299E-28-2	(2) 299E-17-2	(3) 299E-13-4	(4) 299W-14-1	(5)** 699-1-18	(6)** 699-39-80B	(7) 699-31-30
Total Alpha	$<1.4 \times 10^{-7}$	$<1.5 \times 10^{-7}$	$<1.8 \times 10^{-7}$	$<1.3 \times 10^{-7}$	$<1.5 \times 10^{-7}$	$<2.2 \times 10^{-7}$	$<1.9 \times 10^{-7}$
Gross Beta	5.1×10^{-6}	1.4×10^{-5}	3.4×10^{-7}	3.2×10^{-7}	7.1×10^{-8} ±2.0×10^{-8}	1.6×10^{-7} ±5.1×10^{-8}	3.8×10^{-7}
Rare Earths + Y	$<6.1 \times 10^{-8}$	$<2.5 \times 10^{-8}$	$<6.0 \times 10^{-8}$	$<3.2 \times 10^{-8}$	$<3.0 \times 10^{-8}$	$<2.7 \times 10^{-8}$	$<2.6 \times 10^{-8}$
Ru^{106}	4.8×10^{-6}	1.5×10^{-5}	3.6×10^{-7}	3.0×10^{-7}	1.3×10^{-7} ±2.5×10^{-8}	1.5×10^{-7}	3.2×10^{-7}
Cs^{137}	$<2.4 \times 10^{-8}$	4.9×10^{-8}	$<1.0 \times 10^{-8}$	$<2.3 \times 10^{-8}$	$<2.5 \times 10^{-8}$	$<2.2 \times 10^{-8}$	$<3.1 \times 10^{-8}$
Ce^{144}	$<6.1 \times 10^{-8}$	$<2.5 \times 10^{-8}$	$<6.0 \times 10^{-8}$	$<3.2 \times 10^{-8}$	$<3.0 \times 10^{-8}$	$<2.7 \times 10^{-8}$	$<2.6 \times 10^{-8}$
Pm^{147}	$<9.1 \times 10^{-8}$	$<3.7 \times 10^{-8}$	$<9.0 \times 10^{-8}$	$<4.9 \times 10^{-8}$	$<4.4 \times 10^{-8}$	$<3.1 \times 10^{-8}$	$<4.1 \times 10^{-8}$
Total Sr	$<2.0 \times 10^{-8}$	$<1.3 \times 10^{-8}$	$<1.8 \times 10^{-8}$	$<1.4 \times 10^{-8}$	$<2.3 \times 10^{-8}$	$<1.5 \times 10^{-8}$	$<1.5 \times 10^{-8}$
Sb^{125}	$<1.2 \times 10^{-7}$	$<4.8 \times 10^{-8}$	$<3.6 \times 10^{-8}$	$<4.6 \times 10^{-8}$	$<2.9 \times 10^{-8}$	$<4.2 \times 10^{-8}$	$<1.1 \times 10^{-7}$
Zr^{95}-Nb^{95}	$<5.2 \times 10^{-7}$	$<5.9 \times 10^{-7}$	$<4.0 \times 10^{-7}$	$<3.2 \times 10^{-7}$	$<2.6 \times 10^{-7}$	$<3.0 \times 10^{-7}$	$<5.8 \times 10^{-7}$
Co^{60}	6.4×10^{-7}	$<1.4 \times 10^{-7}$	$<1.3 \times 10^{-7}$	$<1.2 \times 10^{-7}$	$<1.4 \times 10^{-7}$	$<1.5 \times 10^{-7}$	$<1.3 \times 10^{-7}$
Te^{127}	$<1.3 \times 10^{-8}$	$<1.2 \times 10^{-8}$	$<3.4 \times 10^{-8}$	$<2.2 \times 10^{-8}$	$<4.6 \times 10^{-8}$	$<8.4 \times 10^{-9}$	$<7.7 \times 10^{-9}$

* These numbers refer to the approximate well locations as indicated by the encircled numbers on Figure 1.

** These two wells are outside the area shown on Figure 1.

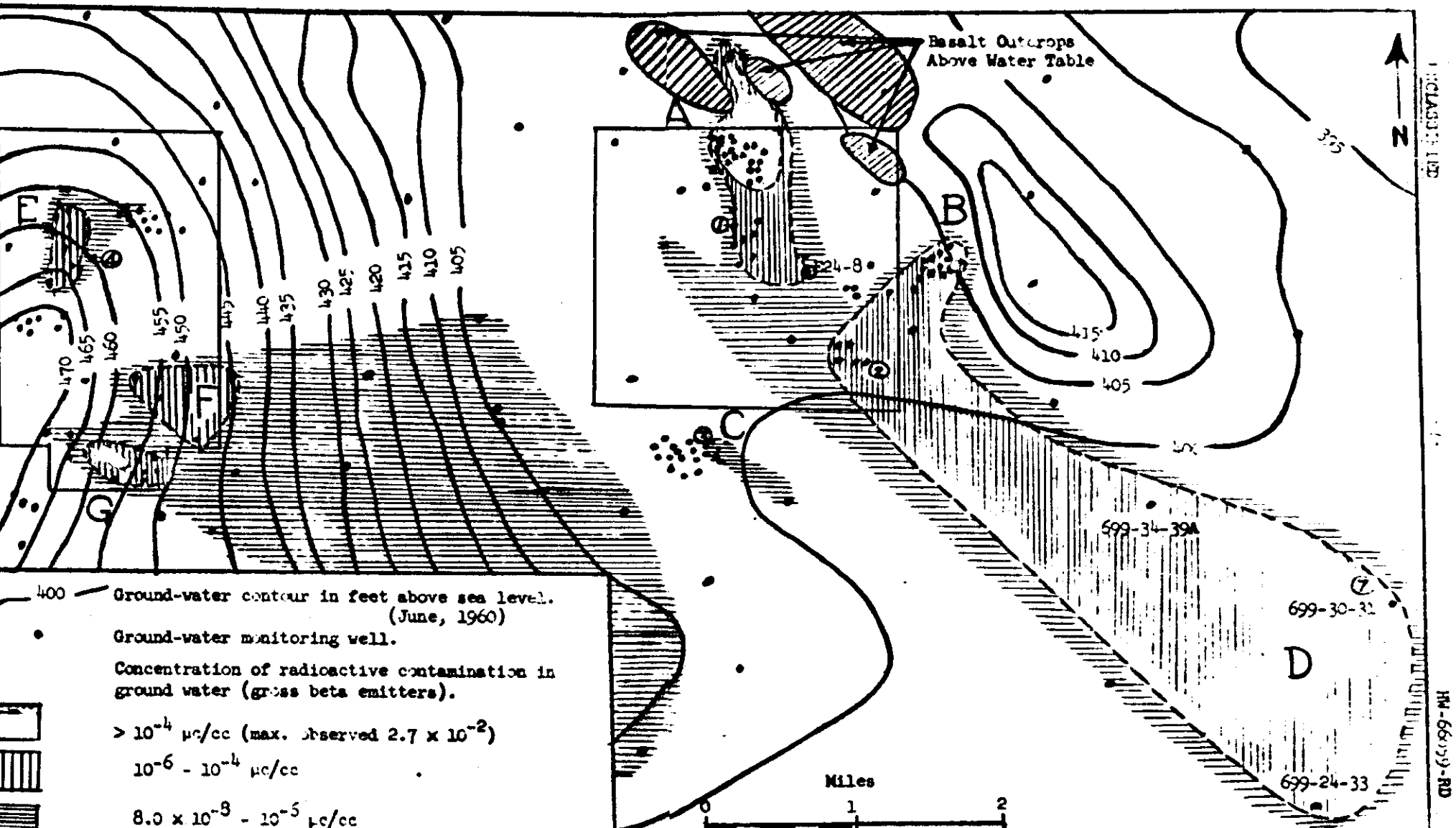
one-half mile south of the abandoned 216-BY scavenged waste cribs, is in agreement with the results previously noted in a depth sample from this well.

The quite low but positive Cs^{137} results noted for well 299E-17-2 is the first indication of Cs^{137} in the ground water at this location. The most likely source is the Purex 216-A-5 process condensate crib located several hundred feet northwest of the monitoring well. It is unlikely that the concentration of Cs^{137} in the ground water under this crib will exceed the recommended ground-water limit of 2×10^{-5} μc Cs^{137}/cc (0.1 MPC_w) since the concentration in the crib influent is usually about 3×10^{-6} μc/cc.

200 East Area

Figure 1 is a map of the 200 Areas showing the extent of detectable ground-water contamination during the period April-June, 1960. Only minor changes, as subsequently described, in the areal extent of the various contamination zones were evident during this quarter.

A general decreasing trend in the concentration of radioisotopes in 200 Area monitoring wells has been noted during the past year, and particularly so during the current quarter. This trend has been most noticeable in wells near active and abandoned cribsites. Decreasing concentrations are due in major part to the decay of radionuclides already in the ground water. Decreased drainage of the many crib facilities which were abandoned between 1955 and 1957 may also contribute to this reduction. Certainly if the volumetric drainage rate has not decreased significantly, the concentration of the principal radioisotope (Ru^{106}) draining into the ground-water table has decreased by about an order of magnitude through radioactive decay. Quite appreciable reductions in the quantities of radioactive


Basalt Outcrops
Above Water Table
N
A
B
C
D
E
F
G
699-24-8
699-34-39A
699-30-32
699-24-33
405
410
415
420
425
430
435
440
445
450
455
460
465
470
400 — Ground-water contour in feet above sea level. (June, 1960)
Ground-water monitoring well.
Concentration of radioactive contamination in ground water (gross beta emitters).
> 10^-4 μc/cc (max. observed 2.7 x 10^-2)
10^-6 - 10^-4 μc/cc
8.0 x 10^-8 - 10^-5 μc/cc
Miles
0
1
2

materials disposed to active cribsites over the past year have undoubtedly contributed significantly to this downward trend.

(1) 216-BY and 241-B Cribs

The most noticeable change in ground-water contamination patterns during the past three months occurred at Site A, Figure 1. The predominant direction of movement of wastes from under the 216-BY and B-Plant cribs has shifted from the south to the southeast. Recent sample results from the B24-8 well (Figure 1) show that the gross beta activity has increased by a factor of 10 over the past three months. Small but noticeable decreases in the concentration of beta-emitters in the north-south line of wells along the western edge of the contamination zone at site A also attest to the easterly shift of the ground water at this location. A slight lowering of the ground water elevation under the B-Swamp, resulting in an increase in the influence of the 200 West Area ground-water mound on these wastes, probably accounts for the eastward movement of the ground water at Site A. Subsequent movement of these ground-water contaminants should follow much the same path as have Purex wastes, toward site D.

There has been no detectable movement of contaminants to the north beyond well 299-50-53 which is the most northerly well in the contamination zone at Site A. No radiocesium or radiostrontium was detected in wells at Site A during this quarter; however, several of the wells contain Co^{60} in positive concentrations. The maximum Co^{60} concentration detected this quarter was 2.0×10^{-5} μc/cc in well 699-50-53. Well 299E-33-12 contained the maximum gross beta emitter concentration at Site A this quarter,

1.4×10^{-3} μc/cc.

(2) 216-A Cribs and Contaminated Ground Water Southeast of 200 East Area

Radioactive contaminants in the ground water under Purex waste disposal facilities and contaminants which have moved from this area to the southeast are shown as Sites B and D respectively on Figure 1. The reduced cribbing of Purex tank farm condensates continues to be reflected in analytical results of samples obtained from wells monitoring the 216-A-8 and 216-A-24 cribs. Beta-emitter concentrations this quarter averaged only one-half of the concentration for the first quarter of CY-1960, and only one of the thirteen wells monitoring these facilities, 299E-25-8, contained a concentration greater than 10^{-4} μcβ/cc (1.5×10^{-4} μc/cc).

The predominant southeastward movement of ground water under the Purex process condensate crib, 216-A-5, was confirmed by analyses of samples from two wells recently drilled several hundred feet southeast of this disposal facility. Both of these wells showed concentrations of radioisotopes measurably greater than the concentration detected in a well immediately adjacent to but on the west side of the crib.

No detectable change in the concentration of radioisotopes in ground water at Site D was evident during this quarter. The initial rapid increase of activity in wells at this location with the subsequent leveling off at a fairly constant concentration indicates that an equilibrium has been established for present ground-water flow and Purex waste disposal conditions. Wells to the south and east of Site D continue to show less than detectable concentrations of radioisotopes.

(3) 216-BC Cribs and Trenches

Only minor changes were evident in the contaminated ground-water pattern at Site C this quarter. Detectable concentrations of beta-emitters were found in wells monitoring the six scavenged waste cribs at this location. The maximum average concentration this quarter was 3.5×10^{-7} μcβ/cc; no long-lived radioisotopes were present in concentrations exceeding routine detection limits.

200 West Area

Three major areas of ground-water contamination in 200 West Area are shown on Figure 1 as Sites E, F and G. There were no significant changes in the areal extent of contaminated ground water in 200 West Area this quarter.

Maximum gross beta-emitter concentrations for the three sites in 200 West Area this quarter, together with maximum concentration averages for the previous quarter, are presented in the following table.

TABLE II

MAXIMUM AVERAGE CONCENTRATIONS OF GROSS BETA ACTIVITY IN 200 WEST AREA WELLS

Site	Well No.	Concentration (μcβ/cc) April-June, 1960	Jan.-March, 1960
E	299W-15-4	1.1×10^{-5}	1.6×10^{-5}
F	299W-19-2	1.8×10^{-6}	6.0×10^{-6}
G	299W-22-14	2.7×10^{-2}	3.5×10^{-2}

The wells in Table II contained the highest concentrations of radioisotopes at their respective sites for at least the past fifteen months. Strontium-90 continues to be detected in well 299W-22-2 monitoring

the abandoned Redox 216-S-1 and 2 cribs. The maximum concentration detected this quarter was 9.7×10^{-6} μc/cc which is about a factor of ten greater than the previous quarter's maximum. This well was partially bailed and reperforated in April, 1960 since nearly constant Sr^{90} concentrations indicated that the well may have become stagnant. Samples taken immediately after reworking the well showed gross beta and Sr^{90} concentrations greater by an order of magnitude than those previously observed. These higher concentrations persisted in subsequent samples taken in May and June.

Uranium was detected in well 299W-19-3 monitoring the 216-U-1 and 2 cribs at a concentration of 1.5×10^{-6} μc/cc. This is about 10% of the recommended maximum concentration in ground water. These cribs now receive small batches of miscellaneous waste from the 224-U Building.

II. PLANT WASTE DISPOSAL PRACTICE

Chemical Processing Department (W.A. Haney)

Locations were chosen for sinking six well points, each to a depth of about seventy feet, in the vicinity of the 241-106-TY underground storage tank. Gamma probing of these shafts is expected to assist in defining the pattern formed by wastes that leaked from the 106-TY tank. Such basic data should be useful in evaluating the effectiveness of a shallow well system for detecting a leak in an active, underground, waste storage tank.

It was recommended to the Chemical Processing Department that well 299E-27-3 not be used as a source of water for the proposed Purex Tank Farm emergency water supply project (CAC-881). Fine sediments at this location may result in low water yields and pumping problems which will reduce the reliability of the emergency system. It was recommended that

a well drilled approximately 900 feet north of the Purex surface condenser installation would be in a location having favorable aquifer characteristics and outside the presently contaminated ground-water zone.

Irradiation Processing Department (W.H. Koop)

NPR Decontamination Wastes

Laboratory investigations were continued on the scavenging that results from mixing spent cleaning solutions used in multi-step procedures for decontaminating the NPR primary loop. One of the cleaners is an alkaline-permanganate solution which, after mixing with other cleaning solution wastes, results in the removal of many of the radionuclides by the scavenging action of the precipitated manganese dioxide. As previously reported (HW-65464-RD), certain of the cleaner ingredients appear to inhibit scavenging of radiocobalt. The peroxide-carbonate-EDTA solution used as the initial agent in a three step decontamination procedure appears to retard radiocobalt scavenging. Also, some two step decontamination procedures used an ammonium citrate-EDTA solution for the second step which results in poor cobalt removal. Scavenging experiments were conducted in which each of the cleaner ingredients was omitted. The results indicated that while EDTA is partly responsible, both the peroxide and the citrate ingredients contributed to the poor cobalt removal. In contrast, the scavenging of radiozinc is not affected by the presence of these agents. It is probably that strong complexing and oxidizing agents may inhibit scavenging due to the formation of highly stable cobalt (III) complexes.

Fission Product Release Experiments (R.K. Hilliard, D.L. Reid)

All stainless steel parts of the high-level experimental equipment in

the 292-T Building were replaced with quartz and Pyrex to facilitate recovery of evolved fission products.

Ten oxidation measurements were made under identical conditions of time, temperature and air flow rate. In an air atmosphere at 1215°C furnace temperature for 24 minutes, the 11.5 gram irradiated and unirradiated uranium specimens averaged 68% oxidized with a standard deviation of 3.3%. Four of these specimens had been irradiated up to a level of about 2.4×10^{17} nvt. The average percent oxidation of the irradiated specimens was 67% with a 4.3% standard deviation. This shows that irradiation up to 10^{17} nvt does not significantly affect the oxidation rate. Reproducibility of oxidation rates is important since it indicates that constant experimental conditions were maintained between tests. Also, previous work showed that release of volatile fission products is proportional to the extent of oxidation.

Five fission product release experiments were made: two at 2.4×10^{14} nvt, two at 3.5×10^{16} nvt, and one at 2.4×10^{17} nvt. Table III presents the percentage release data for eight isotopes.

TABLE III

EFFECT OF IRRADIATION ON THE RELEASE OF FISSION PRODUCTS

Isotope	Percent Released From Uranium Specimens*		
	2.4×10^{14} nvt	3.5×10^{16} nvt	2.4×10^{17} nvt
I^{131}	71	76	85
Te^{132}	58	64	62
Xe^{133}	80	93	93
Sr	0.2	0.2	--
Cs	17	28	31
Ru^{103}	0.1	0.1	0.05
Ba^{140}	0.3	0.1	--
Zr^{95}	0.03	0.02	--

*Experimental conditions: furnace temperature, 1215°C; time, 24 minutes; air atmosphere.

The tentative conclusions to be drawn from these results is that iodine, tellurium, xenon and cesium are released to a greater extent from uranium irradiated to high levels. The release of strontium, barium, ruthenium and zirconium appears to be independent of irradiation levels, at least up to a value of 2.4×10^{17} nvt.

Two tests were made to determine the retention efficiencies of "absolute" filters and charcoal beds for airborne fission products released from uranium heated in air. The filters were Cambridge model ID-1000, and the charcoal bed was one inch thick; both were at ambient temperature. The superficial gas velocity through the filters and charcoal bed was about 5 ft/min. The average iodine concentration in the off-gas was about 10^{-6} ppm. Table IV lists the retention efficiencies observed.

TABLE IV

FILTER EFFICIENCIES FOR REMOVING AIRBORNE FISSION PRODUCTS RELEASED FROM HEATED URANIUM

	Percent Of Isotope (Entering Each Stage) Retained	
Retained On	I^{131}	Te^{132}
First Filter	30	99.4
Second Filter	14	92
Charcoal Bed	70	50

Document HW-64573, "Observations on a Zircaloy-Uranium-Aluminum system at High Temperatures", was issued May 27, 1960.

III. GROUND-WATER HYDROLOGY (D.J. Brown)

A new water-table contour map was constructed from data obtained from a representative pattern of wells drilled over the Hanford plant area. No significant changes were observed in the general contour pattern other

than those resulting from seasonal changes in the level of the Columbia River.

The present method of monitoring the water in an aquifer is by sampling the contents of a perforated well which fully penetrates the aquifer. Such monitoring wells, being perforated throughout their length beneath the water table, form low resistance flow paths for water movement between zones having different potential heads. Thus, a monitoring well drilled through several zones having different potential heads will have water entering the well in the zone of greatest potential and leaving the well from the lower-head zones. Such cross flow in a well would prevent entry of water in the zones of lower potential. It is estimated that a head difference of only a few thousandths of an inch would prevent entry of water into a well from a low-head zone having typical Hanford hydrologic characteristics. It is impossible, therefore, to monitor the water in some zones of the ground-water aquifer by analyzing well samples. Methods are now being studied for identifying these zones that cannot be sampled by means of a completely penetrating, perforated well. One method will be to measure the potential head at different depths in several of the wells on the FY-1960 well drilling project as they are being constructed.

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

Company	Completed Wells	Feet Drilled	Date Completed	Total Feet	To Water	To Basalt
Bach Drilling Co.	699-32-62	101	4-6-60	501	Yes	No
Bach Drilling Co.	299-E17-2	156	4-7-60	406	Yes	No
Hatch Drilling Co.	699-15-15	147				
Hatch Drilling Co.	299-W22-22	31				

The HLO FY-1959 well drilling project, CAH-848, was completed by the Bach Drilling Company of Coulee City, Washington, April 27, 1960. Eighteen wells were drilled on this project with a combined footage of 4,400 feet.

Invitations to bid on the FY-1960 well drilling project, CAH-885, were distributed by the AEC, but only one bid was received and this was 79% higher than the fair cost estimate. This bid was rejected by the AEC. Several revisions were then made in the original contract and new bid packages were prepared and distributed to drilling companies. This time five companies responded with bids. The low bidder was the Hatch Drilling Company of Half Moon Bay, California. Their bid was $77,430. The fair cost estimate was $90,000.

Notice to proceed with the work was issued by the AEC on May 11, 1960. The drilling was scheduled to start May 20th. The Hatch drilling crews actually started drilling June 22, 1960 approximately 34 days behind schedule. They have completed approximately 178 feet of drilling this quarter.