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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

January, February, March, 1960

Prepared by members of the

Chemical Effluents Technology Operation

Edited by: W. A. Haney

May 19, 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

January, February, March, 1960

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CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

January, February, March, 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 January, February, March, 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

Every quarter samples of ground water from six to eight selected wells are obtained and given special analytical processing to determine precisely which radioisotopes are included in the routine "gross beta" determinations. Wells are selected on the basis of radioisotope concentration, proximity to disposal facilities, and location with respect to the path of contaminated ground-water movement. Thus, samples are taken from outlying wells containing relatively low concentrations of radioisotopes as well as from monitoring wells immediately adjacent to disposal facilities. Samples are analyzed for about ten radioisotopes which are the longer-lived, predominant radionuclides in separation wastes, and those likely to appear in the ground-water. Analytical results (Table I) of samples collected during the period covered by this report were in agreement with previous results that showed essentially all of the radioactive material reported on routine analyses as "gross beta" activity to consist of ruthenium -106 and its daughter, rhodium -106.

TABLE I

RADIOISOTOPIC ANALYSES OF SPECIAL MONITORING--WELL SAMPLES

Concentrations in units of μc/cc

Isotope	(1) * 699-34-39A	(2) 699-50-53	(3) 299W 22-13	(4) 299W-22-14	(5) 299W-22-5	(6) 299W-15-4	(7) 299E-25-4
Total Alpha	$<1.8\times10^{-7}$	$<5.5\times10^{-7}$	$<2.3\times10^{-7}$	$\leq5.1\times10^{-7}$	$<2.2\times10^{-7}$	$<2.2\times10^{-7}$	$<2.6\times10^{-7}$
Gross Beta	5.6×10^{-6}	7.1×10^{-5}	1.2×10^{-3}	1.5×10^{-2}	1.4×10^{-4}	1.4×10^{-5}	1.9×10^{-5}
Rare Earths+Y	$3.7\times10^{-8}\pm 1.6\times10^{-8}$	$<7.2\times10^{-8}$	$7.0\times10^{-8}\pm 5.7\times10^{-8}$	1.9×10^{-7}	$<7.2\times10^{-8}$	$<7.8\times10^{-8}$	$<7.2\times10^{-8}$
Ru^{106}	$4.6\times10^{-6}\pm 2.3\times10^{-6}$	6.3×10^{-5}	1.4×10^{-3}	1.7×10^{-2}	1.4×10^{-4}	1.4x10-5	1.9×10^{-5}
Cs^{137}	$<3.0\times10^{-8}$	$<2.1\times10^{-8}$	$<4.4\times10^{-8}$	$<4.8\times10^{-8}$	$<4.0\times10^{-8}$	$<4.3\times10^{-8}$	$<3.1\times10^{-8}$
Ce^{144}	$7.9\times10^{-8}\pm 7.5\times10^{-8}$	$<7.2\times10^{-8}$	$<1.3\times10^{-7}$	$<6.4\times10^{-8}$	$<9.1\times10^{-8}$	$<8.8\times10^{-8}$	$<7.2\times10^{-8}$
Pm^{147}	$<8.1\times10^{-8}$	$<1.3\times10^{-7}$	$<2.0\times10^{-7}$	$\leq3.0\times10^{-7}$	$<1.1\times10^{-7}$	$<1.5\times10^{-7}$	$<1.2\times10^{-7}$
Sr^{90}	$<5.8\times10^{-8}$	$<5.1\times10^{-8}$	$<5.6\times10^{-8}$	$<5.3\times10^{-8}$	1.5×10^{-8}	$<5.9\times10^{-8}$	$<4.9\times10^{-8}$
Sb^{125}	$<4.6\times10^{-7}$	$<6.1\times10^{-7}$	$<6.2\times10^{-7}$	$<9.0\times10^{-7}$	$<5.2\times10^{-7}$	$<6.6\times10^{-7}$	$<5.2\times10^{-7}$
Zr^{95}-Nb^{95}	$<3.9\times10^{-7}$	$<5.7\times10^{-7}$	$<3.5\times10^{-7}$	$<2.6\times10^{-7}$	$<3.0\times10^{-7}$	$<4.8\times10^{-7}$	$<2.5\times10^{-7}$
Co^{60}	$<5.8\times10^{-7}$	1.1×10^{-5}	$<3.6\times10^{-7}$	$<6.2\times10^{-7}$	$<4.0\times10^{-7}$	$<9.4\times10^{-8}$	$5.3\times10^{-8}\pm 4.9\times10^{-8}$
Te^{127}	$<3.9\times10^{-8}$	$<3.6\times10^{-8}$	$<7.4\times10^{-8}$	1.5×10^{-7}	$5.1\times10^{-8}\pm 4.3\times10^{-8}$	$<8.4\times10^{-8}$	$<4.5\times10^{-8}$

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

The special sample of ground water from well 299W-22-5, located 185 feet east of the abandoned 216-S-1 & 2 cribs, contained Sr^{90} at a concentration of 1.5×10^{-8} μc/cc. This is the first positive indication of Sr^{90} in this well. The appearance at this location is not unexpected since it is routinely detected in well 299W-22-2 at the crib site.

The concentrations of Co^{60} in two wells monitoring sites in 200 East Area are in close agreement with past routine analytical results of samples from these wells.

200 East Area

Figure 1 is a map of the 200 Area showing the extent of detectable ground-water contamination during the period January-March, 1960. No appreciable changes in the areal extent of the various contamination zones were evident during this quarter.

(1) 216-BY and 241-B Cribs

Wells monitoring the 216-BY scavenged waste cribs (Site A, Figure 1) have continued to decrease in radioactive material content while wells to the south and southeast have shown increases in concentrations of radioisotopes. Of the seven wells at this location containing average concentrations of radioisotopes greater than 1×10^{-3} μc/cc, only two are at the crib site. The remaining five are located from 500 to 1000 feet south and southeast of the disposal facility. The progressively more prominent southeastward movement of contaminants noted from north to south on the map is in good agreement with existing ground-water contour data. The localized south and southeastward movement of wastes at Site A indicates that even this far north the 200 West Area ground-water mound exerts a slightly greater influence on waste movement than does the 200 East Area ground-water mound.

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

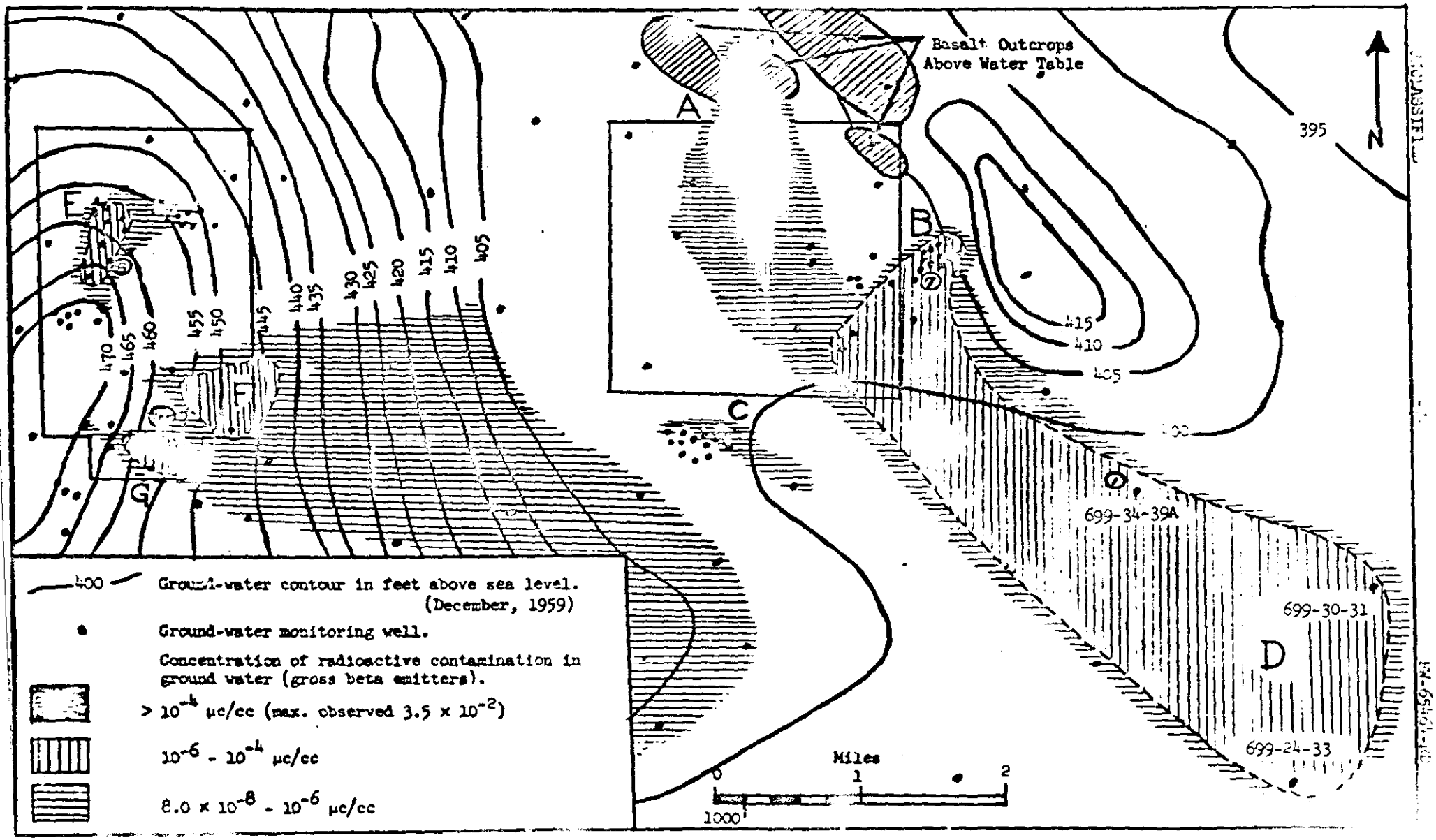

FIGURE 1 -- Map of Separat[illegible] Probable Extent of Ground-Water Contamination, March, 1960

1.6 x 10^{-4} μc/cc in well 299E-33-3. This well also contained the maximum average gross beta-emitter concentration during this quarter, 5.1 x 10^{-3} μc/cc.

(2) 216-A Cribs

The reduced cribbing of Purex tank farm condensates continues to be reflected in ground-water samples obtained from monitoring wells at Site B. Samples from only two of the thirteen wells in the vicinity of the condensate cribs now contain concentrations of radioisotopes exceeding 10^{-4} μcβ/cc. One year ago twelve of the thirteen wells contained concentrations of radioactive material exceeding 10^{-4} μcβ/cc. The maximum average gross-beta emitter concentration this quarter was 1.6 x 10^{-4} μc/cc in well 299E-25-8. No radiocesium or radiostrontium has ever been detected in wells at Site B.

(3) 216-BC Cribs and Trenches

There has been no significant change in the contaminated ground-water zone at Site C. Gross beta emitter concentrations were detected in the same wells at about the same low concentrations as noted the previous quarter. All of the wells showing positive results monitor disposal facilities in the northern section of this site. The maximum concentration detected this quarter was 3.6 x 10^{-7} μcβ/cc in well 299E-13-2. No long lived radioisotopes have ever been detected in wells monitoring these disposal facilities.

(4) Contaminated ground water southeast of 200 East Area

No appreciable changes in radioisotope concentrations were evident in wells monitoring the ground-water shown as Site D, Figure 1, during this quarter. Maximum concentrations of radioactive material, averaging 9.3 x 10^{-6} μcβ/cc, were detected in samples from well 699-34-39A. Concentrations in the two more distant wells, 699-31-30 and 699-24-33, averaged 5.9 x 10^{-6} μcβ/cc and 2.3 x 10^{-6} μcβ/cc respectively for an increase of about

10% over the previous quarter's averages. Wells to the south and southeast of Site D have as yet shown no evidence of waste migration, although above normal concentrations of nitrate ion are detected routinely.

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 CONCENTRATIONS OF GROSS BETA ACTIVITY IN 200 WEST AREA WELLS

Site	Well No.	Concentration (μcβ/cc) Jan.-March, 1960	Oct.-Dec., 1959
E	299W-15-4	1.6×10^{-5}	2.3×10^{-5}
F	299W-19-2	6.0×10^{-6}	1.1×10^{-5}
G	299W-22-14	3.5×10^{-2}	4.7×10^{-2}

The wells in Table II contained the highest concentrations of radioisotopes at their respective sites for at least the past twelve months.

Strontium-90 continues to be detected in well 299W-22-2 monitoring the abandoned Redox 216-S-1 and 2 cribs. The average concentration this quarter was 8.4×10^{-7} μc Sr^{90}/cc which is just slightly less than the average concentration over the previous quarter. The persistent appearance of Sr^{90} at fairly constant concentration in well W22-2, and the failure to detect strontium in nearby wells indicate possible well stagnation. Reperforation and bailing of W22-2 will be undertaken in April, 1960.

II. Plant Waste Disposal Practice

Chemical Processing Department (W. A. Haney)

Chemical Effluents Technology's recommendations regarding the need for waste storage tank leak detection methods and comments on the "caisson-laterals" method for detecting leaks were forwarded to the Chemical Processing Department. Based on a limited knowledge of the spreading of wastes in soils, the caisson-laterals system was recommended as the desirable leak detection method for the 241-A Tank Farm. However, the caisson-laterals method appears to have no measurable advantage over a system of well-points or shallow wells drilled around the circumference of a tank for detecting leaks in the 241-S Farm where considerably more lateral waste spread would be likely. Additional theoretical and field studies are planned to obtain more factual data relative to the spread of waste from a leaking storage tank.

Irradiation Processing Department (W. N. Koop)

NPR Decontamination Wastes

Laboratory investigations were continued on the scavenging of radionuclides from mixtures of prospective NPR cleaning solutions. The decontamination procedure currently favored for the NPR primary coolant loop consists of either a two or three step circulation of chemical cleaning-solutions with intermediate rinses; an alkaline permanganate solution will probably be used as one step. In the mixture of spent solutions, scavenging results from adsorption of radionuclides by the reduction product, MnO_2, of the permanganate ion. The radioactive materials concentrated in the relatively small sludge volume might be buried or stored in a tank. Decontaminated supernatant liquid could either be released directly to the environs or, if necessary, undergo additional treatment prior to release.

Laboratory studies were undertaken to determine the efficiency of candidate NPR cleaning solutions in scavenging fifteen radioisotopes of concern in reactor effluent. Decontamination factors obtained in tests employing "spiked" simulated cleaning solutions are presented in Table III.

TABLE III

SCAVENGING DECONTAMINATION FACTORS FOR RADIOISOTOPES IN PROSPECTIVE NPR CLEANING SOLUTIONS

Radioisotope	Decontamination Factor* Solution A	Solution B
Fe^{59}	4,000-30,000	3,000-9,000
Ca^{45}	2,000-11,000	1,000-3,000
Sr^{85}	500-1,500	2,000-4,000
Zr^{95}-Nb^{95}	1,000-3,000	700-1,000
Ba^{133}	700-1,500	700-1,500
Ce^{144}	1,000-2,000	1,000-3,000
Zn^{65}	400-1,100	150-200
Co^{60}	2,000-5,000	2-5
I^{131}	1,000-2,000	0.9-1.0
Sb^{124}	1.9-2.0	2.0-2.9
Ru^{106}	1.9-2.0	1.1-1.2
Cs^{137}	1.1-1.5	1.0-1.1
Ag^{110}	1.0-1.4	1.1-1.3
Cr^{51}	1.0-1.1	1.0-1.1
P^{32}	1.0-1.1	1.0-1.1

*Decontamination factor = $\frac{\text{initial concentration in solution}}{\text{concentration in supernatant liquid}}$

Solution A: equal volumes of water, alkaline permanganate and Wyandotte 1112.

Solution B: equal volumes of "peroxide-carbonate", alkaline permanganate and Wyandotte 1112.

The results in Table III indicate effective scavenging of the first seven isotopes from both solutions while the last six isotopes were not removed to any significant degree. Cobalt-60 and iodine-131 were exceptions

in that both were effectively scavenged from Solution A, but not from Solution B. Additional work is planned to investigate the apparent reduction in removal of these two radioisotopes due to the addition of the peroxide-carbonate solution.

Failure to obtain high decontamination factors for the last six radionuclides listed does not preclude utilizing this ready-made waste treatment step. The necessity for an additional treatment step will be dictated by the concentrations of both scavenged and unscavenged isotopes remaining in the supernatant liquid.

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

Experiments with uranium irradiated to low levels were conducted in the high-level fission product release facility to obtain base line data. It was found that the stainless steel equipment retained a significant fraction of the volatilized fission products even after being exposed to severe decontamination efforts. The furnace and off-gas train were modified by replacing all metal parts exposed to volatilized fission products with fused silica and Pyrex. The off-gas train will consist of two liquid-caustic scrubbers, a cold trap, a Millipore filter, two charcoal traps, a CWS "Absolute" filter, and a tail-gas caustic scrubber installed in the order listed. Equipment for direct counting of the charcoal traps for Xe^{133} was modified to assure a counting error from other fission products of less than one percent for any one individual measurement.

Experiments at 900, 1180, and 1450° C were performed to determine qualitatively the reactions of Zircaloy with aluminum-clad uranium. The specimens were held at temperature for about 25 minutes in an atmosphere of 50% helium, 50% carbon dioxide. Insignificant diffusion was observed at 900 and 1180° C, but at 1450° C the Zircaloy boat and the aluminum-clad uranium

specimen had completely inter-diffused. In an additional test at 1450° C for five minutes and in the same atmosphere, inter-diffusion was also complete.

Document HW-62604, "Fission Product Release by the High Temperature Uranium-Steam Reaction", authored by A. J. Scott, was issued.

Particulate Deposition in Sampling Lines (L. C. Schwendiman, A. K. Postma)

The degree to which particulate sampling results are invalidated due to the sampling line has been under study during the reporting period. It is necessary at present to draw samples from ducts and stacks through relatively long sampling lines due to radiation from the duct, the mechanical problems in placing continuous strip filter samples very near to the duct, and difficult access to the best sampling point due to height of stacks.

Many variables have been found to influence the deposition of particles within delivery lines. The important variables are particle size, duct diameter, and fluid velocity. A correlation was developed which relates these and other variables and permits reasonable estimates of deposition due to turbulence. The practical significance of the results is evident when the length of sampling line is calculated within which 50% of the particles will be lost to the wall through turbulent deposition. In Figure 2 is plotted this length as a function of Reynold's Number $(\frac{DV\rho}{\mu})$, and cfm for 4 μ particles with a density of 4 in a one-inch pipe.

A practical test of these relations showed that in a 1-inch pipe 72 feet long 86% of the entering 4 μ particles was retained on the pipe wall when 8 and 13 cfm of air flowed through the pipe. Developed relations predicted that 92% retention should have resulted.

Although sub-micron particles are often the principal constituents in exhaust effluents, off-standard conditions may produce appreciable quantities

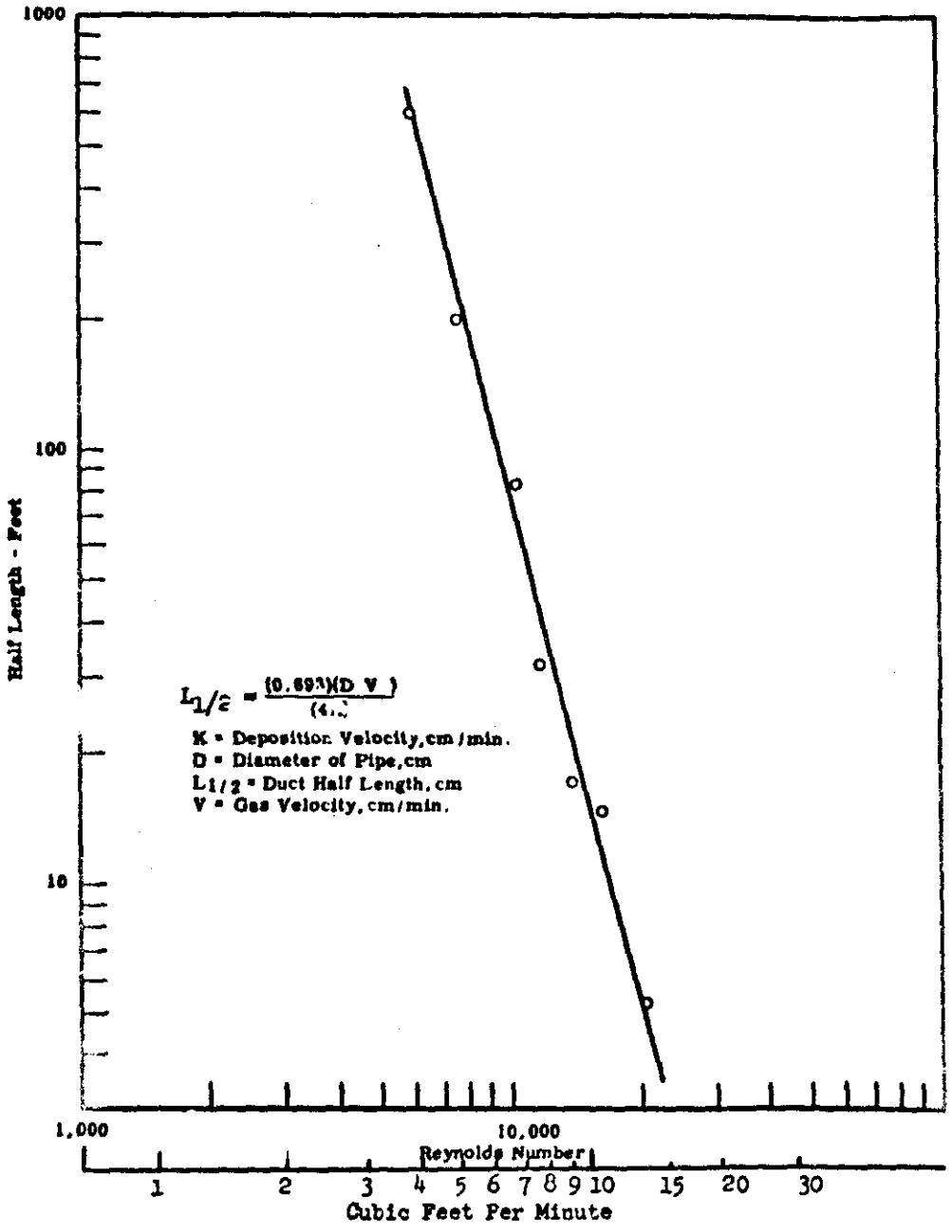

FIGURE 2

DUCT HALF-LENGTH FOR 4μ ZINC SULFIDE PARTICLES IN ONE INCH ALUMINUM PIPE

of larger particles which will be significantly retained on the walls. The particle sizes for which present sampling lines are of limited value will be determined.

III. Ground-Water Hydrology (D. J. Brown)

The elevation of several monitoring well casings was resurveyed and found to be in error. Two of these wells, 699-30-31 and 699-24-33, were reported to be in error by approximately seven feet. These two wells are located southeast of the 200 East Area where an anomalous extension of the 200 East mound on the ground-water contour map resulted from the erroneous elevations. Correcting the casing elevations changed the measured ground-water elevation in these two wells and eliminated the apparent extension of the ground-water mound into this region.

A new water-table contour map was constructed from recent data obtained from a representative pattern of wells over the Hanford plant area. No significant changes were observed in the general contour pattern other than those resulting from seasonal changes in stream flow and those reflecting the above changes in basic well-casing elevations.

IV. Well Drilling Summary (D. J. Brown)

Bach Drilling Company

Completed Wells	Feet Drilled	Date Completed	Total Feet	To Water	To Basalt
699-44-64	0	1-27-60	452	Yes	Yes
699-36-61B	173	2-4-60	468	Yes	Yes
299-W19-4	170	2-15-60	550	Yes	Yes
299-E17-3	402	3-17-60	402	Yes	No

Wells Under Construction

699-32-62	400
299-E17-2	250

Two additional monitoring wells were added to well drilling project CAH-848, contract number AT(45-1)-1467, at the request of the Project Engineering Operation of the Chemical Processing Department. This project now calls for the construction of eighteen wells, with a total footage of 4,400 feet. The work on this contract is being done by the Bach Drilling Company of Coulee City, Washington.

Drilling crews of the Bach Drilling Company completed four wells this quarter. The cumulative footage drilled is now 4,150 feet. They have slightly less than 250 feet of drilling remaining on their contract. The completion date for this project is April 27, 1960.

Invitations to bid on the FY-1960 well drilling project were sent out by the AEC to prospective bidders. This work is scheduled to begin by June 1 and to be completed during CY-1960.