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AEC Research and Development Report

RADIOLOGICAL STATUS
OF THE GROUNDWATER
BENEATH THE HANFORD PROJECT
JANUARY-JUNE 1971

APRIL 1972

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BENEATH THE HANFORD PROJECT
JANUARY-JUNE 1971

By

K. L. Kipp, Jr.

Water Resources Systems Section

April 1972

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PACIFIC NORTHWEST LABORATORIES
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RADIOLOGICAL STATUS OF THE GROUNDWATER
BENEATH THE HANFORD PROJECT
JANUARY-JUNE 1971

K. L. Kipp, Jr.

INTRODUCTION

This report is prepared semiannually to provide an evaluation of the status of groundwater contamination resulting from disposal of Hanford plant effluents. The data presented in this report were collected during the first six months of 1971; the previous report in this series was BNWL-1613.⁽¹⁾

Of the wells that have been drilled to groundwater on the Hanford project, about 300 are used for the routine surveillance of radionuclide movement through the sediments below the regional water table. Approximately one-third of the surveillance wells are located at disposal sites situated in or near the 200 separations areas about 10 miles up-gradient from the nearest domestic water supply. Many of these wells are used to determine when a disposal facility is to be retired. Almost all other surveillance wells are sampled to determine the status of contaminants within the groundwater system. With the exception of wells drilled since 1968, the locations of wells referred to in this report may be found by referring to the Hanford Wells document.⁽²⁾ Most of the wells outside and some of the wells inside the 100, 200 and 300 areas are shown in Figures 1, 2 and 3.

The radionuclides ^{106}Ru and ^3H and the nitrate ion (NO_3^-) are readily transported by the groundwater and can be detected in groundwater at low concentrations relative to their respective drinking water standards. Therefore, ^{106}Ru , ^3H and NO_3^- are used to trace the movement of contaminated groundwater away from the major disposal sites.

The groundwater contamination pattern beneath Hanford at the present time can be divided into three source zones, based on the kinds and quantities of wastes disposed to ground at each location:

- 200 Areas (chemical processing areas) and associated 600 Area wells
- 100 Areas (production reactor areas) and associated 600 Area wells
- 300 Area (fuel fabrication and laboratory area) and associated 600 Area wells.

Groundwater concentration data for these three source zones are presented in this report. All groundwater samples reported here were taken by the Radiation Monitoring Section and were analyzed by the Technical Analysis Section of Battelle-Northwest as part of the Hanford environmental surveillance program conducted by the Environmental Evaluations Section.

SUMMARY

An evaluation of $^{106}\text{Ru-Rh}$ and ^3H concentrations measured near the surface of the unconfined groundwater during the first half of 1971 showed that zones of detectable contamination extended in an easterly to southeasterly direction from 200-E Area (Figures 1 and 2), as has been observed in the past.⁽¹⁾ Measurable ^3H and NO_3^- concentrations were found along the Columbia River in the vicinity of the 100 Areas (Figures 2 and 3). A low groundwater mound showing uranium and nitrate ion continued to be observed in the 300 Area (Figure 3). The few locations for which average groundwater concentrations exceeded the Concentration Guide (CG) for $^{106}\text{Ru-Rh}$ were all within either 200-E or 200-W Areas with the exception of Well 299-E26-7 which monitors the 216-A-24 crib. Total beta activity concentrations in the groundwater beneath the 100 areas were detectable only at 100-N Area, as a result of continued discharges to the 100-N trench. Concentrations of ^3H greater than the Concentration Guide were found in Wells 699-35-70 (outside the southeast corner of 200-W Area) and 299-E-26-7 (east of the 200-E Area).

FIGURE 1. Total Beta Concentrations Beneath the Hanford Project Expressed as Percent of $^{106}\text{Ru-Rh}$ Concentration Guide (10 pCi/ml)

FIGURE 2. Tritium Concentrations Beneath the Hanford Project Expressed as Percent of ^3H Concentration Guide (3000 pCi/ml)

FIGURE 3. Nitrate Ion Concentrations Beneath the Hanford Project Expressed as Percent of Public Health Service Drinking Water Standard (45 ppm)

Nitrate ion concentrations greater than 10 percent of the Public Health Service (PHS) recommended drinking water standard of 45 ppm⁽⁴⁾ were observed in most groundwater samples from wells within and surrounding the 200 and 300 Areas. However, groundwater from these zones is not consumed by humans or animals. For the first time, extensive routine nitrate measurements were made within and surrounding the 100 Areas. These measurements showed large zones north of Gable Mountain in which nitrate concentrations were greater than 10% of the PHS recommended drinking water standard.

There are no major changes in other isopleth contours since the previous report period (July-December 1970). The minor adjustments which have been made are mostly due to results from newly sampled wells.

Although water samples from several wells with piezometer tubes extending to deep aquifers were obtained and analyzed during this report period, all such samples had gross beta concentrations less than the analytical limit (0.16 pCi/ml).

EVALUATION OF GROUNDWATER SURVEILLANCE DATA

Radionuclide concentrations in the groundwater beneath Hanford are evaluated in terms of their respective Concentration Guides (CG's), while the NO_3^- concentrations are compared to the PHS recommended drinking water standard.⁽⁴⁾ It is recognized that these guides are intended only for drinking water, and at present no groundwater from zones having concentrations >10 percent of the employed standards (Figures 1-3) is used for human or animal consumption. However, they do provide a rapid, meaningful method of evaluating the potential significance of most waterborne materials. The Concentration Guides used in this report are those which apply to individuals of the general public.⁽³⁾

Data from those 200 Area and associated 600 Area wells for which average total beta, ^3H or NO_3^- concentrations were above the respective

analytical limits during the report period appear in Tables 1 and 2. All 100 Area and associated 600 Area wells routinely sampled are listed in Table 3 along with the concentration data for those wells showing detectable activity. In addition, the average concentration data for the second half of 1970 and the first half of 1971 are shown in Tables 1, 2, and 3 for rapid comparison of the respective trends. The analytical data for wells within or near the 300 Area appear in Table 4. A number of other wells, particularly those immediately adjacent to the outermost down-gradient contours shown in the accompanying figures, were sampled and analyzed on a routine schedule. However, because the results were below the respective analytical limits, no data were tabulated.

200 AREA AND ASSOCIATED 600 AREA WELLS

Groundwater samples collected from wells within and near the zone in which 200 Area effluents have been detected are analyzed for total beta, ^3H and NO_3^- . The total beta activity is calculated as $^{106}\text{Ru-Rh}$, since radio-chemical analyses have shown that this nuclide accounts for a large fraction (~80 percent) of the radioactivity* in this groundwater zone. In a joint program with ARHCO, groundwater samples from beneath some inactive and all of the active disposal sites are generally analyzed for total alpha, ^{60}Co , ^{90}Sr , and ^{137}Cs , in addition to total beta, ^3H and NO_3^- .

Tables 5 and 6 show the active and cited inactive disposal sites during this report period along with associated wells that were sampled.

Cesium-137 concentrations were detected in the 200 East Area groundwater near the 216-B-46, 216-B-49 and 216-B-50 crib sites (only the 216-B-50 site was active during this period) and the 216-B-36 trench. Average concentrations were 0.72, 0.07, 0.70 and 0.10 pCi/ml at the respective sites. Cesium-137 average concentrations of less than 0.28 pCi/ml were measured at wells monitoring crib site 216-S-23 in 200 West Area. The detection

* Not including ^3H , whose low energy beta emission does not contribute to the total beta activity measured. Other beta-gamma emitters which have been identified in the groundwater away from the disposal sites include ^{99}Tc , U, ^{60}Co , ^{51}Cr and ^{155}Eu .

TABLE 1. Average Total Beta, Tritium, and Nitrate Ion (NO_3^-) Concentrations in 600 Area Wells Associated with the 200 Area

Well No. (699-)	Total Beta (pCi/ml) ^(a)		Tritium (pCi/ml)		NO_3^- (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(b)						
Limit	0.16		1.0		0.5	
S3-E12	NA ^(c)	NA	-	-	1.7	2.2
S6-E4CO	NA	NA	-	NA	0.8	<1.3
S6-E14	NA	NA	NA	NA	1.0	1.1
S8-19	NA	NA	3.0	NA	-	<2.2
S11-E12-0	NA	NA	-	NA	2.8	<0.6
S12-3	NA	NA	3.8	NA	-	1.3
1-18	NA	NA	147	120	<0.6	<1.6
2-3	NA	-	13	6.9	3.3	11
2-33-0	NA	NA	NA	NA	<0.7	<0.6
8-17	NA	NA	63	42	19	24
8-25	NA	NA	350	NA	26	NA
8-32	NA	NA	-	-	<1.0	1.3
9E-2	NA	NA	-	-	0.75	<0.75
10E-12-0	NA	NA	NA	NA	12	NA
14E-6T	NA	NA	NA	-	2.2	<0.8
14-38-0	NA	NA	1.1	3.4	4.0	6.0
15-15-0	-	-	1.0	7.9	7.7	8.5
15-26	0.27	0.37	520	530	29	33
17-5	NA	NA	-	NA	<2.2	<2.2
19-43	NA	NA	NA	NA	1.5	<0.8
20-E12-0	NA	NA	-	NA	<0.54	NA
20-20	<0.22	0.26	690	700	44	32
20-39-0	NA	NA	1.2	-	7.8	7.1
24-1-T	NA	NA	-	-	-	1.6
24-33	<0.20	0.21	445	510	3.0	4.6
24-46	NA	NA	-	NA	3.9	<3.2
25-55	NA	NA	NA	NA	1.7	<2.6
25-70-0	NA	NA	-	1.4	2.1	2.2
26-15	0.63	0.86	NA	1400	48	46
26-89	NA	NA	NA	NA	0.7	<0.7
27-8	-	<0.18	925	800	12	14
28-40	-	-	60	76	10	9.9
28-52	NA	NA	NA	NA	<0.65	<1.1
29-78	NA	NA	1.3	1.1	1.8	1.5
31-31-0	0.53	0.38	1900	1800	27	14
31-53B-0	-	-	-	NA	5.5	4.2
31-65-0	NA	NA	-	-	1.0	<0.5
32-22	0.46	NA	1700	NA	56	NA
32-43	0.49	0.46	800	690	30	25

TABLE 1. (contd)

Well No. (699-)	Total Beta (pCi/ml) ^(a)		Tritium (pCi/ml)		NO ₃ ⁻ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(b) Limit	0.16		1.0		0.5	
32-62-0	-	-	800	690	0.8	<0.6
32-70	-	NA	33	30	25	22
32-72	-	NA	72	62	-	<0.8
32-77	NA	NA	1.2	-	13	13
33-56	-	NA	2.2	NA	<0.85	NA
34-39A	0.28	<0.25	2000	2000	15	24
34-41	1.1	NA	2600	NA	66	NA
34-42	1.3	NA	2633	NA	69	NA
34-51	NA	NA	-	NA	3.1	4.0
34-88	NA	NA	-	<7.7	2.6	4.9
35-9	-	-	17.5	12	3.8	5.6
35-66	-	NA	<1.1	-	<0.7	<0.7
35-70	-	0.31	6933	6600	1.6	4.8
35-78	-	-	7.7	2	<1.0	1.3
36-46-R	0.2	<0.27	2300	2200	1.4	1.2
36-61B-0	-	-	-	-	-	<0.6
36-71B-P	NA	NA	-	5.9	<0.8	1.2
36-93-0	NA	NA	-	-	<0.8	0.7
37-43-0	-	NA	103	120	<3.2	<0.52
37-82A-0	NA	NA	-	<1.6	3.9	<0.88
38-65-0	-	NA	6.5	5.3	32	34
38-70-0	1.2	1.6	157	160	123	144
39-39	0.23	NA	-	NA	-	NA
39-79	-	NA	1.9	NA	<1.5	NA
40-1	NA	NA	1.3	NA	-	NA
40-33	-	NA	1.2	NA	-	NA
40-62	NA	NA	-	NA	13	NA
41-23	0.27	0.36	780	770	48	47
42-12	-	NA	155	140	18	17
42-42-0	NA	NA	590	930	73	41
44-64	NA	NA	6.9	4.3	12	17
45-42	NA	NA	940	1000	2.2	5.5
45-69	NA	NA	-	-	30	32
46-21	NA	NA	<3.3	-	3.2	3.3
47-35	NA	NA	-	-	1.9	2.5
47-46	NA	NA	-	-	20	19
47-60	NA	NA	<2.6	-	4.5	7.2
48-71	NA	NA	-	-	1.3	-
49-55	-	NA	-	NA	<0.7	NA
49-57	NA	NA	1.9	1.6	1.5	1.6
49-79	NA	NA	4.5	-	35	38
50-28	-	-	-	-	4.5	4.2

TABLE 1. (contd)

Well No. (699-)	Total Beta (pCi/ml) ^(a)		Tritium (pCi/ml)		NO ₃ ⁻ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(b) Limit	0.16		1.0		0.5	
50-42-0	NA	NA	2.6	NA	-	NA
50-53	1.51	1.4	4.7	2.1	171	210
50-85	NA	NA	NA	NA	11	8.7
51-63	NA	NA	-	NA	1.5	<1.3
53-47	NA	NA	3.3	3.0	-	-
53-55-0	NA	NA	1.6	1.8	-	-
54-37	NA	NA	NA	NA	4.7	NA
54-42	NA	NA	-	NA	2.4	3.8
54-57	NA	NA	-	NA	<0.7	NA
55-21	NA	NA	NA	NA	-	NA
55-50A	NA	NA	2.1	2.5	-	-
55-70-0	NA	NA	NA	NA	<0.8	<0.6
55-76-0	NA	NA	NA	NA	<0.8	NA
55-89	NA	NA	NA	NA	<0.8	NA
55-95	NA	NA	NA	NA	<2.2	NA
57-83	NA	NA	NA	NA	<0.8	NA
59-80B	NA	NA	NA	NA	4.3	NA
HAN-6	NA	NA	NA	NA	2.4	NA
HAN-9	NA	NA	NA	NA	2.8	2.1
HAN-19	NA	NA	-	-	-	<1.1

a. Calculated as ¹⁰⁶Ru-Rh

b. A (-) indicates that the concentration was less than the analytical limit.

c. NA - no analyses were performed during six-month period.

TABLE 2. Average Total Beta ⁶⁰Co and Nitrate Concentrations in Unconfined Groundwater within the 200 Areas

Part A: Wells Near Active Crib Sites

Well No. (299-)	Total Beta (pCi/ml) ^(a)		⁶⁰ Co (pCi/ml)		NO ₃ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical Limit	0.16		0.03		0.5	
E16-2	1.6	0.63	NA ^(c)	NA	3.3	<4.6
E17-1	1.1	1.3	0.22	0.21	90	NA
E17-4	3.1	5.0	0.33	0.33	NA	NA
E17-5	9.5	23	0.58	0.94	320	425
E17-6	<0.17	-(b)	-	-	NA	NA
E17-7	6.2	9.3	0.46	0.40	290	NA
E17-9	9.8	15	-	NA	NA	NA
E17-10	2.6	48	NA	NA	NA	NA
E24-2	1.6	2.7	0.14	0.14	240	435
E24-10	0.37	0.39	NA	NA	-	<1.5
E25-5	0.94	1.1	NA	NA	NA	<38
E25-6	0.56	0.53	-	NA	30	NA
E25-7	-	-	NA	NA	43	36
E25-9	-	NA	NA	NA	NA	NA
E25-11	1.2	0.82	NA	NA	NA	4.8
E25-12	1.0	0.95	NA	NA	NA	NA
E28-9	0.26	<0.18	-	-	305	550
E28-12	<0.27	<0.18	-	-	110	NA
E28-13	-	-	-	<0.46	NA	112
E28-16	0.36	0.64	-	<0.42	380	515
E28-17	-	-	NA	NA	NA	NA
E33-7	8.1	8.3	10.8	7.0	NA	NA
E33-23	1.3	1.2	-	NA	<5.2	48
E33-24	11.5	14	6.2	7.7	NA	NA
W15-4	1.1	2.6	NA	NA	120	74
W15-10	-	-	NA	NA	NA	NA
W15-11	-	-	NA	NA	NA	NA
W18-1	<0.20	-	NA	NA	NA	NA
W18-2	-	<0.21	NA	NA	NA	NA
W18-4	-	-	NA	NA	NA	NA
W18-5	-	<0.17	NA	NA	-	-
W18-10	<0.35	-	NA	NA	NA	NA
W18-11	0.85	<0.17	NA	NA	NA	NA
W19-5	120	68	-	-	80	20
W19-7	-	-	-	-	NA	NA
W22-22	0.9	1.4	NA	NA	<0.8	1.2
W22-38	<0.31	-	-	-	NA	NA
W26-3	0.39	0.68	-	-	3.9	NA

TABLE 2. (contd)

Part B: Wells Near Inactive Crib Sites with Average Total Beta
Concentrations Greater than 10% CG (1 pCi/ml)

Well No. (299-)	Total Beta (pCi/ml) ^(a)		⁶⁰ Co (pCi/ml)		NO ₃ ⁻ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical Limit	0.16		0.03		0.5	
E24-9	1.1	2.6	NA	NA	210	275
E24-12	1.1	NA	-	NA	190	NA
E26-7	25.3	-	NA	NA	-	<9.1
E28-18	1.1	NA	NA	NA	NA	NA
E28-19	9.5	NA	NA	NA	NA	NA
E33-1	10	NA	6.8	NA	NA	NA
E33-5	11	NA	3.8	NA	NA	NA
E33-9	7.3	NA	NA	NA	NA	NA
E33-13	8.8	NA	7.8	NA	NA	NA
E33-18	1.1	NA	NA	NA	NA	NA
E33-25	4.3	NA	NA	NA	584	415
E33-26	3.4	NA	NA	NA	NA	NA
E33-27	21.8	NA	NA	NA	-	NA
W11-15	6.5	9.1	0.31	<0.36	NA	NA
W11-17	2.1	3.8	0.39	NA	410	490
W11-21	8.6	12	0.93	0.92	565	NA
W14-2	16	26	0.48	NA	640	NA
W15-7	4.4	6.2	3.3	NA	44	34
W22-1	54	42	NA	NA	NA	NA
W22-13	3.7	NA	NA	NA	NA	NA
W22-21	26	29	NA	NA	-	NA
W22-25	13	24	<0.04	0.05	NA	NA
W22-26	298	548	0.36	0.43	197	200
W22-27	6.3	20	NA	NA	NA	NA

a. Calculated as ¹⁰⁶Ru-Rh.

b. A (-) indicates that the concentration was less than the analytical limit.

c. NA - no analyses were performed during six-month period.

TABLE 3. Average Total Beta, Tritium, and Nitrate Concentrations in 100 Area and Associated 600 Area Wells

Well No.	Total Beta (pCi/ml) ^(a)		Tritium (pCi/ml)		NO ₃ ⁻ (ppm)	
	Jan-	July-	Jan-	July-	Jan-	July-
	June '71	Dec '70	June '71	Dec '70	June '71	Dec '70
Analytical ^(b) Limit	0.16		1.0		0.5	
199-B3-1	-	-	NA ^(c)	NA	NA	NA
B3-2	<0.19	<0.21	NA	NA	NA	NA
B4-4	-	-	7.3	NA	0.6	NA
B9-1	NA	NA	2.8	NA	NA	NA
D2-5	NA	NA	3.9	NA	4.8	NA
D5-12	<0.18	-	7.9	10.0	23	NA
F5-1	NA	NA	1.1	NA	-	NA
F7-1	NA	NA	1.8	NA	NA	NA
F8-1	NA	NA	18.5	NA	64	NA
H3-1	NA	NA	19.5	NA	12	NA
K-11	NA	NA	120	NA	-	NA
K-20	-	NA	11.4	110	1.2	NA
N-3-0	0.51	1.1	50	58	1.5	NA
N-4-0	<0.29	-	314	705	1.8	NA
N-10-0	2.2	3.3	69	88	6.2	NA
699-59-33	NA	NA	NA	NA	<0.6	NA
60-60	NA	NA	-	NA	1	1
61-66	NA	NA	-	NA	2	3
62-32	NA	NA	-	NA	6.6	NA
62-43F	NA	NA	NA	NA	<1.2	NA
63-25	NA	NA	NA	NA	-	NA
63-90	NA	NA	NA	NA	4.5	NA
65-50	NA	NA	NA	NA	0.8	0.8
65-59	NA	NA	1.1	NA	1.6	NA
65-72	NA	NA	1.9	NA	-	-
65-83	NA	NA	2.1	NA	1.4	NA
66-23-0	NA	NA	NA	NA	-	NA
66-38	NA	NA	NA	NA	1.3	NA
66-103	NA	NA	-	NA	-	NA
67-51	NA	NA	-	2.8	2.6	NA
67-86	NA	NA	4	NA	2.2	NA
67-98	NA	NA	1.2	NA	2.2	NA
68-105	NA	NA	-	NA	-	NA
69-38	NA	NA	NA	NA	-	NA
69-45-0	NA	NA	<1.2	-	-	NA
70-68	NA	NA	2.7	3.1	4.2	NA
71-30	NA	NA	-	NA	23	NA
71-52	NA	NA	6.4	NA	6.6	NA
71-77	NA	NA	3.0	NA	3.2	NA
71-84	NA	NA	6.5	NA	2.6	NA

TABLE 3. (contd)

Well No.	Total Beta (pCi/ml) ^(a)		Tritium (pCi/ml)		NO ₃ ⁻ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(b) Limit	0.16		1.0		0.5	
699-72-73	NA	NA	6.5	6.9	5.4	NA
72-88	NA	NA	19	NA	-	NA
72-92	NA	NA	32	NA	3.4	NA
72-98	NA	NA	17	NA	-	NA
74-44	NA	NA	-	NA	-	NA
74-48	NA	NA	1.4	NA	4.6	NA
77-36	NA	NA	-	-	145	NA
77-54	NA	NA	-	-	7.2	NA
78-62	NA	NA	-	NA	11	NA
80-435	NA	NA	-	1.4	0.6	NA
81-58	NA	NA	-	NA	1.4	NA
83-470	NA	NA	-	26	-	NA
84-35	NA	NA	1.2	NA	16	NA
86-60	<0.31	NA	170	340	5.8	NA
87-42	NA	NA	1.1	NA	2.0	NA
87-55	NA	NA	30	NA	6.1	NA
89-35	NA	NA	-	-	NA	NA
90-45	NA	NA	61	75	-	NA
96-490	NA	NA	10	9.8	3.3	NA
97-43	NA	NA	11	28	2.7	NA

a. Calculated as ¹⁰⁶Ru-Rh

b. A (-) indicates that the concentration was less than the analytical limit.

c. NA - not analyzed.

TABLE 4. Analytical Data - 300 Area and Associated 600 Area Wells

Well No.	Beta (pCi/ml) ^(c)		NO ₃ ⁻ (ppm)		Alpha (pCi/ml) ^(d)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(a) Limit	0.16		0.5		0.02	
699-S27-E14	NA ^(b)	NA	9.4	<8.4	-	<0.035
399-1-1	<0.18	0.22	33	39	0.09	0.02
1-2	-	0.25	56	20	0.09	0.52
1-3	-	0.52	79	48	0.18	0.38
1-4	-	<0.35	39	15	0.04	0.18
3-1	-	0.63	45	92	0.08	0.51
3-8	7.5	0.29	55	23	0.07	0.29
4-1	-	0.36	25	40	0.11	0.14
4-7	-	1.0	44	73	0.07	0.36
5-1	NA	NA	16	15	-	0.03
6-1	NA	NA	12	14	-	0.04
8-2	NA	NA	5.5	6.6	-	-
8-3	NA	-	8.9	9.6	-	0.17

Well No.	Cr ⁺⁶ (ppb)		F ⁻ (ppm)	
	Jan- June '71	July- Dec '70	Jan- June '71	July- Dec '70
Analytical ^(a) Limit	2		0.2	
699-S27-E14	4.0	2.0	0.23	0.6
399-1-1	4.9	3.4	1.3	1.9
1-2	4.9	2.6	1.3	1.4
1-3	7.1	12	2.2	2.1
1-4	<2.8	3.2	1.0	2.2
3-1	5.2	19	1.3	4.2
3-8	3.3	NA	1.6	2.2
4-1	<4.5	4.5	1.1	3.6
4-7	5.7	4.8	0.83	5.4
5-1	<5.0	2.2	0.25	1.7
6-1	5.5	5.6	0.25	1.7
8-2	<3	2.6	0.3	1.5
8-3	<3.6	3.3	0.3	2

a. A (-) indicates that the concentration was less than the analytical limit.

b. NA - not analyzed.

c. Calculated as ¹⁰⁶Ru-Rh

d. Concentrations calibrated for ²³⁹Pu

TABLE 5

Active Disposal Sites--Cribs, Ditches, Ponds, Swamps

200 East Area	
<u>Site Designation</u>	
<u>Purex</u>	<u>Associated Sample Wells</u>
216-A-8	299-E25-4, -E25-5, -E25-6, -E25-7, -E25-9
216-A-10	299-E17-1, -E24-2,
216-A-25	699-53-47, -55-50
216-A-29	- - - -
216-A-30	299-E25-11, -E25-12, -E16-2
216-A-36B	299-E17-4, -E17-5, -E17-6, -E17-7, -E17-9, -E17-10
<u>B-Plant</u>	
216-B-2	- - - -
216-B-3	- - - -
216-B-10-B	299-E28-17
216-B-12	299-E28-9, -E28-16
216-B-50	299-E33-7, -E33-23
216-B-55	299-E28-12, -E28-13
216-B-57	299-E33-24
216-B-63	- - - -
200 West Area	
<u>Site Designation</u>	<u>Associated Sample Wells</u>
<u>Redox</u>	
216-S-6	299-W26-3
216-S-11	699-32-77
216-S-16	- - - -
216-S-19	699-32-72
216-S-23	299-W19-5, -W19-6, -W19-7, -W22-38
216-S-24	- - - -
<u>T-Plant</u>	
216-T-4	699-49-79
216-T-19	299-W15-4
<u>U-Plant</u>	
216-U-10	699-35-78
216-U-12	299-W22-22
216-U-14	- - - -
<u>Z-Plant</u>	
216-Z-11	- - - -
216-Z-12	299-W18-1, -W18-2, -W18-4, -W18-5
216-Z-16	299-W15-10, -W15-11
216-Z-18	299-W18-10, -W18-11

TABLE 6

Cited Inactive Disposal Sites

<u>200 East Area Site Designation</u>	<u>Associated Sample Wells</u>
<u>Purex</u>	
216-A-5	299-E24-10
216-A-24	299-E26-4, -E26-7
216-A-27	299-E17-2, -E17-3
<u>B-Plant</u>	
216-B-36	299-E33-21
216-B-46	299-E33-23
216-B-49	299-E33-7, -E33-23
<u>200 West Area Site Designation</u>	<u>Associated Sample Wells</u>
216-S-1	299-W22-1
216-S-2	299-W22-2
216-S-9	299-W22-25, -W22-26, -W22-27
216-S-13	299-W22-21
216-S-20	299-W22-19, -W22-20
216-S-21	299-W23-4

limit for ^{137}Cs is 0.03 pCi/ml and the Concentration Guide is 20 pCi/ml. These results were consistent with values from the previous reporting period.

^{90}Sr concentrations averaged 0.077, 0.034, 25, and 0.31 pCi/ml in the groundwater near the 216-A-36B, 216-A-10, 216-S-1, and 216-S-2 crib sites respectively during the first half of 1971. This represents an increase in average concentration of from 35% at 216-S-1 to 150% at 216-S-2 (both inactive sites) over the previous reporting period, except for the 216-A-10 crib site which showed about a 15% decrease. Analysis of the groundwater at the 216-A-5 crib site (inactive) showed an average concentration of ^{90}Sr of 0.051 pCi/ml. The detection limit for ^{90}Sr is 0.03 pCi/ml and the CG is 0.3 pCi/ml.

Total alpha concentrations averaged 0.036, 1.03, and 0.06 pCi/ml in the groundwater near the 216-A-27, 216-S-13, and 216-S-21 crib sites respectively during the first half of 1971. The detection limit for alpha is 0.02 pCi/ml calibrated for ^{239}Pu . Average concentrations near 216-B10-B and 216-S-20 dropped below the detection limit. The only significant increase was about 65% at the 216-S-13 site and was due entirely to uranium (with a CG of 20 pCi/ml), as has been the case in the past.⁽¹⁾

The highest average total beta concentrations beneath active disposal sites in the 200 East Area were observed at the 216-B-57 crib (12 pCi/ml). The 216-A-36B crib which previously had the highest total beta concentrations has dropped to second highest with a 9.8 pCi/ml average. In the 200 West Area, the 216-S-23 crib had the highest average total beta (120 pCi/ml) for an active disposal site in the first half of 1971 as in all of 1970.

The highest average total beta concentrations measured near inactive disposal sites in the 200 East Area were at the 216-A-24 crib (25 pCi/ml) just outside the East fence. In the 200 West Area, the 216-S-9 crib area monitoring wells had the highest average total beta concentration (300 pCi/ml). This is an increase from below detection limit at the 216-A-24 crib site, but a decrease of 45% at the 216-S-9 site.

Total Beta Concentrations (Unconfined Aquifer)

Total beta concentrations are shown in Figure 1 for zones of 2 to 10%, 10 to 100%, and >100% of the CG for $^{106}\text{Ru-Rh}$ (10 pCi/ml).⁽³⁾ The outer boundary of each zone is the down-gradient edge and represents the 2%, 10%, and 100% CG isopleth, respectively. The lowest level shown (2% CG) corresponds to a total beta concentration of 0.2 pCi/ml.

It should be kept in mind that these isopleth contours represent averages of the data that were collected over a six month period. Thus short-term fluctuations, both increases and decreases, are effectively filtered out in this pictorial representation. Furthermore, much of the topography of the concentration isopleth surface does not appear when only three or four CG isopleths are used to illustrate it.

A comparison of the CG isopleths for the six-month periods ending December 1970 and June 1971 indicates that there is an apparent southwest extension of the 2% isopleth from the 200 West Area. Although not shown in the previous map, this area has been within the 2 to 10% CG zone since January - June 1970. There have been no significant changes in the outer boundary of the plume from the 200 East Area except for a shift in the 2% CG boundary to the north, the appearance of a small zone in the 10 to 100% CG zone near Well 699-33-42, and the appearance of a new zone of greater than 100% CG $^{106}\text{Ru-Rh}$ just outside the east boundary fence of 200 East Area (216-A-24 crib). The first two changes are based on measurements taken from newly sampled wells (699-39-39, 699-34-41, and 699-34-42). The last change is indicated by samples from Well 299-E26-7 which was dry during the last half of the July - December 1970 period.

Tritium Concentrations (Unconfined Aquifer)

Tritium concentrations are shown in Figure 2 for zones of 0.03 to 1%, 1 to 10%, 10 to 100%, and >100% of the CG (3000 pCi/ml).⁽³⁾ The outer boundary of each zone is the down-gradient edge and represents the 0.03%, 1%, 10%, and 100% CG isopleth, respectively. Comments made above about the average nature of the isopleth contours apply here also.

A comparison of the CG isopleths for the six-month periods ending December 1970 and June 1971 indicates that several changes have occurred. The 0.03% CG isopleth now includes Well 699-49-79 to the northwest of 200 West Area. North of the 200 East Area the ^3H distribution around the small basalt outcrop has been treated as in the previous report,⁽¹⁾ even though two wells (699-49-55 and 699-47-46 within the isopleth) did not indicate detectable ^3H during this report period. For a discussion of the region between 200 East and the 100 Areas to the north see "100 Areas and Associated 600 Area Wells" section below. Well 699-46-21 is now contained in the 0.03 to 1% CG zone for ^3H . The 0.03% CG contour has been extended toward Well 699-40-1 to reflect increased but intermittent activity detected in that well. The remainder of the 200 East Area ^3H plume advanced slightly in the southeastward direction.

The concentration zone boundaries shown in Figures 1 and 2 should not be interpreted as indicating that no radioactivity is present in the groundwater beyond these outer boundaries. It is probable that some radionuclides do in fact reach the river, but because of dilution and decay, the concentrations are too low to be measured by current techniques in the groundwater outside the lowest contour. Tritium is measurable in the Columbia River from nonplant sources, but any contribution from the 200 Area plume is too low to be distinguished.

Nitrate Ion (NO_3^-) Concentrations (Unconfined Aquifer)

Nitrate ion (NO_3^-) concentrations are shown in Figure 3 for zones of 10 to 100% and >100% of the U.S. Public Health Service drinking water standard, 45 ppm.⁽⁴⁾ The outer boundary of each zone is the down-gradient edge and represents 10% and 100% of the drinking water standard, respectively. The 2 to 10% concentration isopleth is not shown in this report. It has been found that nitrate concentrations in this range are readily subject to misinterpretations as related to specific plant sources because of previous use of fertilizers for cultivation and occasional organic detritus in the wells.

A comparison of contamination contours for the six-month periods ending December 1970 and June 1971 indicates that a few changes in the 10% drinking

water standard isopleth occurred. In the region of the 200 West Area, Well 699-32-70 is included within the 10% isopleth (inadvertently omitted from the previous map). The zone of greater than 100% of the drinking water standard in the 200 West Area has been enlarged, due to results from analyzing samples from additional wells for nitrate ion. The southeast corner of 200 East Area is now included in the 10% zone. There are new areas of greater than 100% of the drinking water standard at Well 699-42-42, as well as at newly sampled Wells 699-34-41 and 699-34-42. Well 699-14-38 is no longer included within the 10% zone. It was included in the previous map due to one sample which showed a very high NO_3^- concentration. Investigation of the sample concentration histories of Wells 699-31-53B and 699-34-51 has shown that the 10% contour in their area should be drawn as indicated. The average concentration in 699-34-51 is 3.1 ppm which is somewhat below the 10% of drinking water standard isopleth.

The 100% isopleth projection in the southwest direction from the area in the middle of the 200 East plume shown on the previous map has been removed due to lack of sample wells to confirm its presence.

Analyses of Samples Taken from Deep Aquifers

Water samples from specific depths below the Hanford Reservation's regional water table are obtained from either vertically separated tubes (piezometers) contained within a single well or from piezometer tubes drilled as separate wells. Those few wells which have shown detectable beta activity have not done so consistently with time. A few wells have exhibited detectable ^3H concentrations rather consistently; however, there is no certainty that the vertical separation of piezometer tubes is infallible and in fact, Eliason⁽⁵⁾ has shown that interaquifer transfer within a well can occur.

At present, it is believed that none of the deep aquifers being sampled contain any beta radioactivity at the points where they are sampled. Total beta concentrations in samples taken at various depths below the water table were all at or below the detection limit ($<2\%$ CG for $^{106}\text{Ru-Rh}$) for the first six months of 1971. Tritium concentrations in

these same samples were all below the detection limit except for one sample collected from 699-20-E12P in a zone 350 feet below the water table. The ^3H concentration in this sample was 1.4 pCi/ml compared to less than 0.47 pCi/ml for July - December 1970.

100 AREA AND ASSOCIATED 600 AREA WELLS

The presence of radioactivity in the groundwater beneath the 100 Areas is due primarily to disposal of wastes to trenches and cribs, although leaks in reactor effluent systems have contributed radioactivity to the groundwater in the past. Some well water samples, collected from within the 100 Areas, were analyzed for ^{51}Cr in addition to total beta, tritium and nitrate ion.

Total Beta Concentrations (Unconfined Aquifer)

The estimated extent of detectable total beta radioactivity (excluding tritium) in the groundwater beneath the 100 Areas and vicinity is shown in Figure 1. A comparison of data for the six month periods ending December 1970 and June 1971 indicates that the total beta activity is below the detection level (0.16 pCi/ml) in all areas except 100-N, as was noted in the previous report period. The highest average total beta concentration was measured in Well 199-N-10-0 (2.2 pCi/ml).

Tritium Concentrations (Unconfined Aquifer)

The extent of detectable tritium activity in the groundwater beneath the 100 Areas and vicinity is shown in Figure 2. The number of wells sampled for tritium and analyzed in the 100 Areas and vicinity was increased during this report period to improve the delineation of tritium contamination. This radionuclide has probably been distributed in the groundwater beneath the 100 Areas and vicinity to the extent shown in Figure 2 for several years. Based on analyses of groundwater flowpaths prior to recent reactor shutdowns, it appears that the tritium contamination in this region originated from waste disposal in the 100 Areas. In the western portion around Wells 699-72-92, 699-72-98, and 699-72-88, there is a local zone of tritium concentration that just barely peaks above the 1% CG level. A more accurate definition of the

main 1 to 10% CG zone in the 100 Areas indicates that it is actually in three zones as shown in Figure 2. There is one small zone in the 10 to 100% CG range at Well 199-N-4-0(314 pCi/ml). However, the average concentration of tritium in this well decreased 50% since the July - December 1970 period.

The interzone area between the 100 and 200 Area effluent plumes was more thoroughly analyzed during this report period and it is believed that the two zones of tritium contamination are not connected at this time. This conclusion is based on average concentrations in the four wells that lie in the interzonal area.

Nitrate Concentrations (Unconfined Aquifer)

Routine analysis for nitrate was begun in early 1971 in a number of additional wells to evaluate the distribution of NO_3^- (nitrate ion) in 100 and associated 600 Area wells; Figure 3 shows the indicated distribution. There are three definite zones of 10 to 100% nitrate concentration relative to the Public Health Service drinking water standard. However the zones in the 100K Area and the 100N Area are connected by a region of average nitrate contamination of less than 10% of drinking water standard. The only area greater than 100% of drinking water standard is southwest of 100F Area, probably from the Battelle-Northwest Animal Research Area wastes.

The origin of the other high zones of nitrate concentration in the vicinity of the 100 Areas is not known, but it is not believed to be associated with Hanford Plant operations.

300 AREA AND ASSOCIATED 600 AREA WELLS

The presence of radioactive and nonradioactive contaminants in the groundwater beneath the 300 Area arises primarily from the disposal of low-level fuel processing wastes to two process ponds located northeast and east of the 300 Area. Results of samples collected from 300 Area and associated 600 Area Wells show that the radioactivity is primarily due to uranium, although ^{51}Cr , ^{60}Co , and $^{106}\text{Ru-Rh}$ have also been identified on occasion as mentioned in previous reports. The relatively high total beta concentration in Well 399-3-8 is due to a previously reported leakage of waste solutions from a line (since repaired) to the 340 Laboratory waste handling facilities.

The concentration of NO_3^- in much of the groundwater beneath the 300 Area (Table 4) is above the Public Health Service drinking water limit⁽⁴⁾ of 45 ppm. There has been a significant increase in the average nitrate concentration in Wells 399-1-2, 399-1-3, and 399-1-4 adjacent to the northeast process pond (see Table 4).

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