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RADIOLOGICAL STATUS
OF THE GROUNDWATER
BENEATH THE HANFORD RESERVATION
JANUARY - DECEMBER 1973

Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

JANUARY 1975

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JANUARY - DECEMBER 1973

by

K. L. Kipp, Jr.
Resources Systems Section

January 1975

On January 19, 1975, research and development programs of the U.S. Atomic Energy Commission (AEC) became part of the newly formed Energy Research and Development Administration (ERDA). In this report, since it refers to work done in 1974, most references are to AEC programs.

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RADIOLOGICAL STATUS OF THE GROUNDWATER
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K. L. Kipp, Jr.

INTRODUCTION

This series of reports has been prepared semi-annually to provide an evaluation of the status of groundwater contamination resulting from disposal of Hanford plant effluents. The present issue covers both the January-June and July-December periods of 1973. The maps of the contamination plumes (and the data tables) are presented for the two semi-annual periods to allow for comparison with previous report periods on the same basis. The data presented in this report were collected during 1973; the previous report in this series was BNWL-1752.⁽¹⁾

Of the wells that have been drilled to the groundwater on and adjacent to the Hanford Reservation, about 310 were used during this report period 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 Areas (Chemical Separations). 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. A description of wells referred to in this report may be found by referring to the Hanford Wells document.⁽²⁾ All sampled wells outside and some of the wells inside the 100, 200, and 300 Areas are shown in Figures 1 through 6.

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:

FIGURE 1. Gross Beta Concentrations January-June 1973

FIGURE 2. Gross Beta Concentrations July-December 1973

FIGURE 3. Tritium (^3H) Concentrations January-June 1973

FIGURE 4. Tritium (^3H) Concentrations July-December 1973

FIGURE 5. Nitrate (NO_3) Concentrations January-June 1973

FIGURE 6. Nitrate (NO_3) Concentrations July-December 1973

- 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 contaminant concentration data for these three source areas 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 as part of the Hanford environmental surveillance program conducted by the Environmental Evaluations Section of Battelle-Northwest.

The radionuclides ruthenium-106 and tritium (^3H), as well as the nitrate ion (NO_3^-), are readily transported by the groundwater and can be detected in groundwater at low concentrations relative to their respective Concentration Guides or drinking water standards. Therefore, these substances are used to trace the movement of contaminated groundwater away from the major disposal sites at the Chemical Separations Facilities (200 Areas). The only other radionuclide detected in the groundwater away from the 200 Areas during this report period was cobalt-60. A gross beta analysis is used to detect ^{106}Ru except for a few selected wells that have gamma scan analyses.

At the 100-N Reactor Area, radioactivity in the groundwater from ground disposal of wastes is predominantly tritium, iodine-131, ruthenium-106, strontium-90 and cobalt-60. At the 300 Laboratory Area, measurable radioactivity in the groundwater from fuel fabrication and laboratory waste disposal to ground is predominantly uranium.

SUMMARY

An evaluation of gross beta and tritium concentrations measured near the surface of the unconfined groundwater during 1973 showed that zones of detectable contamination extended in an easterly to south-easterly direction from 200-E Area (Figures 1 through 4), as has been observed in the past.⁽¹⁾ Measurable tritium and nitrate ion concentrations were found

along the Columbia River in the vicinity of the 100 Areas (Figures 3 through 6). A low groundwater mound showing uranium and nitrate ion continued to be observed in the 300 Area (Figures 5 and 6). The Concentration Guide (CG) of 10 pCi/ml⁽³⁾ for ^{106}Ru was exceeded only within the 200-W Area. Significant concentrations of ^{106}Ru (over 10% of CG) were found only in the 200 Areas. Gross beta activity in the groundwater beneath the 100 Areas was detectable only at the 100-N Area from the effluent discharge to the 1301-N crib.

Due to the recent declassification of tritium concentration data, all tritium average concentrations are now presented in Table 2 for the 200 Areas. Major changes in the tritium plumes include joining of the contaminated zones between Gable Mountain and Gable butte based on data from new wells, and extension of the plume out to the Washington Public Power -WPN-2 construction site (at wells 699-13-1A, -12-1, -11-1, -11-0). Tritium was detected in these wells shortly after pumping for construction water began in 1973.

Nitrate ion concentrations greater than 100% of the Public Health Service (PHS) recommended drinking water standard of 45 ppm⁽⁴⁾ continued to be observed in groundwater samples from a few wells within and in the immediate vicinity of the 100-F, 200 and 300 Areas. However, groundwater from these zones is not consumed by humans or animals. The zone showing nitrate concentrations between 10 and 100% of PHS recommended drinking water standard now includes well 699-S6-E4D southeast of 200 East Area. The extent of the 300 Area nitrate plume to the north has been reduced subsequent to discovery that well 699-S11-E12A was not yielding representative groundwater samples.

Although water samples from several wells with piezometer tubes extending to lower aquifer horizons were obtained and analyzed for tritium and nitrate ion during this report period, most samples had tritium concentrations less than the analytical limit of 1 pCi/ml and nitrate concentrations less than 1.1 mg/l. The exceptions were one isolated high tritium result (well 699-14-E6-Q) and one high nitrate result, (well -36-61-B-P) that were

discounted in view of the subsequent sampling results for those wells. The average nitrate concentration in well 699-59-80B located just south of Gable Butte continued to increase from about 20 mg/l to 37 mg/l during this report period. An explanation of this occurrence has not been found.

EVALUATION OF GROUNDWATER SURVEILLANCE DATA

Radionuclide concentrations in the groundwater beneath Hanford are evaluated in terms of their respective Concentration Guides (CG's)⁽³⁾ while the nitrate concentrations are compared to the PHS recommended drinking water standard.⁽⁴⁾ It is recognized that these guides pertain to drinking water and liquid releases to uncontrolled areas and at present no groundwater from zones having concentrations greater than the standards is used for human or animal consumption. They provide a rapid and meaningful method of evaluating the potential significance of most waterborne materials. The Concentration Guides used in this report are those which apply to uncontrolled areas.⁽³⁾

The concentration zone boundaries shown in Figures 1 through 4 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 in the groundwater outside the lowest contour are below analytical detection levels. Tritium is measurable in the Columbia River from nonplant sources, but any contribution from the 200 Area plume is too low to be distinguished.

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 gross beta, tritium and nitrate. Average data for these substances from the sampled wells in the 200 Area and associated 600 Area wells used in preparation of the figures appear in Tables 1 and 2. The gross beta activity is calculated as ¹⁰⁶Ru since radiochemical analyses have shown that this nuclide accounts

TABLE 1. Average Gross Beta, Tritium, and Nitrate Ion Concentrations in 600 Area Wells Associated with the 200 Areas (Unconfined Aquifer)

Well No.	Gross Beta ⁽¹⁾ (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit		0.08		1.0		0.5
Concentration Guide		--(2)		3000		45
699-S0-7			1.3		6.8	
S0-8	*		27	37	4.8	7.3
699-S3-E12			*	*	2.7	7.5
S3-25			*	*	*	*
S6-E4C-0			*		2.2	
S6-E4-D			*	*	5.4	2.8
S8-19			*	*	1.2	1.0
S12-3			*	*	0.7	0.8
S12-29-0					*	*
S19-11					*	*
1-18			184	190	6.1	3.8
2-3	*		26	44	1.4	7.8
2-33-0			1.2	*	*	*
3-45			*		*	*
8-17	*	*	129	140	23	23
8-25	*	*	265	235	28	
8-32			*	*	1.0	0.5
9-E2		0.20	*	*	*	*
10-E12-0					5.2	11
11-0			57		13	
11-1		*	39	27	15	1
12-1			1.4		12	
13-1A		0.15	92.5	129	15	8.9
13-1B		*	5.1	54	3	6.6
15-15-B	*	*	*	*	8.6	10
15-26	0.11	*	420	400	30	28
17-5	*	*	*	1.4	3.6	5
19-43					2.2	3.3
20-E12-0			*		0.9	*
20-20	0.12	0.12	710		50	
20-39-0			*	*	2.6	1.3
20-82					16	
24-33	*	*	450	430	6.2	5.8
25-70-0					5.2	3.3
26-15	0.25	0.24	1300	1300	52	53
26-89					4.3	
27-8	0.09	*	1000	1000	26	12
28-40-0	*	*	45	40	6.5	8.8
29-78			1.1	*	1.2	2.9
31-53B-0	0.09	*	1.1	*	6.8	8.0
31-65-0			1.4	1.1	4.2	14
32-22	0.23	0.30	1600	1500	62	61
32-43	0.14	0.18	800	700	40	33
32-62-0			*	8.1	*	*

TABLE 1. (contd)

Well No.	Gross Beta (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.08		1.0		0.5	
Concentration Guide			3000		45	
699-32-70	0.16	*	43	49	20	18
32-72-0	*	*	68	75	0.8	*
32-77	*	*	9.4	*	12	9.8
33-56	*	*	*	*	0.7	*
34-39A	0.13	*	1800	1800	22	5.6
34-41	0.27	0.23	2000	2000	66	68
34-42	0.30	0.35	2100	1930	66	74
34-51	*	*	*	*	1.2	1.1
35-9	*	*	45	45	8.8	6.7
35-66	*	*	4.7	2.8	*	*
35-70	0.10	0.10	7700	8100	3.3	2.8
35-78	0.11	*	1.2	1.7	0.8	1.2
36-46-R	*	*	1900	2000	0.8	1.8
36-61-A	*			*		9.5
36-61B-0	*		*		0.7	
37-43-0	*	*	86	93	0.6	*
37-82A-0	*		*	*	18	18
38-70-0	0.24	0.23	90	81	174	154
39-39	*	*	*	*	*	*
39-79-0	*	*	1.1	1.1	2.1	1.1
40-1			*	*	2.1	*
40-33	*	*	*	1.3	*	*
40-62			20	1.4	11	16
41-23	0.08	0.08	850	845	52	51
42-12	*	0.13	200	260	24	30
42-42-0			520	49	13	7.5
43-42	*	*	320	290	0.7	*
43-89			*	*	32	28
44-64-0			*	*	8.8	14
45-42			850	820	2.4	0.6
45-69			*	*	37	40
46-21	0.11	*	1.0	*	3.6	5.1
47-35			*	*	2.9	1.3
47-46			*	*	17	18
47-60			*	*	7.4	8.8
48-71			*	*	3.3	1.6
49-28			*	*	*	*
49-55	*	*	*	*	*	*
49-57	*	1.6	*	115	2.2	127
49-79			*	*	24	15
50-28A			*	*	4.6	4.3
50-30					*	*
50-42-0			*	3.8	*	*
50-53	0.18	0.58	*	1.7	21	84
50-85			*	*	13	11

TABLE 1. (contd)

Well No.	Gross Beta (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.08		1.0		0.5	
Concentration Guide			3000		45	
699-51-63			*	*	1.1	1.6
51-75-0			*	1.5	13	11
53-47			4.2	2.3	*	*
53-55-0			1.6	1.1	*	*
54-42			*	*	3.5	3.7
54-45			*	*	*	*
54-57			*	*	*	*
55-50A			4.8	1.1	3.6	0.6
55-70-0					*	0.9
55-76-0					0.7	0.9
57-83-0					*	*
59-58			5.3	4.0	*	*
59-80B			*		21	37
HAN-6			*	*	3	3.6
HAN-9					2.4	3.4
HAN-19			*	*	1.8	2.8

1. Gross Beta is calculated as ^{106}Ru .
 2. The ^{106}Ru Concentration Guide is not strictly applicable to an unknown mixture of beta emitters. (See text)
- * Indicates that the concentration was less than the analytical limit. No entry indicates no analyses were performed during the 6-month period.

TABLE 2. Average Gross Beta, ^{60}Co , Nitrate, and ^{106}Ru Concentrations in the Unconfined Groundwater Within the 200 Areas

Well No. (299-)	Gross Beta ⁽¹⁾ (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)		Cobalt-60 (pCi/ml)		Ruthenium-106 (pCi/ml)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.08		1		0.5		0.02		0.06	
Concentration Guide	--(2)		3000		45		50		10	
E13-3	*	*								
E16-2	1.5	0.6			24	5.2				
E17-1	0.21	0.11	6500	6000	127	147	0.09	0.06	0.14	0.14
E17-2	0.12	0.13								
E17-4	0.89	0.59					0.18	0.13	0.67	0.44
E17-5	0.36	0.27			245	282	0.04	0.04	0.21	0.23
E17-6	*	0.09								
E17-7	1.2	1.3			278	385	0.13	0.20	2.7	1.5
E17-8	0.10	0.14			186	193				
E17-9	1.2	0.29					<0.03	0.05		0.36
E17-10	0.31	0.27								
E19-1	*	*								
E23-1						24				
E24-2	0.20	0.18			340	422	*	<0.04		0.22
E24-4	*	*	585	810	27	25				
E24-7						31				
E24-9	0.26	0.20			280	198				
E24-10	0.10	0.09	18400	17500	*	1.0				
E24-11	0.09	0.10								
E24-12	0.20	0.24			188	206	*	<0.03	0.23	0.19
E24-13	0.10	*								
E24-14	0.13	*								
E25-1	0.13	0.09								
E25-2	*	*								
E25-5	0.21	0.10								
E25-6	0.17	*	1500	965	40	30	<0.04	<0.03	0.37	0.17
E25-9	*	*								
E25-10	0.12	0.13					*		0.06	0.18
E25-11	2.7	1.4					*		2.9	1.4
E25-12	3.3	1.5			196	233				
E25-13	*	*								
E25-16	0.11	0.09								
E26-1	*	*								
E26-4	0.24	0.14			65	5.5			0.27	0.18
E26-5	0.12	0.12								
E27-1					9.5	11			0.16	
E28-6		*				*				
E28-8	0.38	0.10								
E28-9	0.20	0.20	140	106	196	233	<0.04	<0.03	0.13	0.24
E28-12	0.46	0.11	15	24			*	<0.03	0.30	0.23
E28-13	*	*			160	43		<0.05		
E28-16					332	227			0.38	
E28-17	0.09	0.12								
E28-18	5.1	4.3								
E28-19	3.6	9.9								
E28-20	1.4	5.2								
E32-1	*	0.25			3.2					
E33-7	6.1	5.4					12.4	7.5		
E33-9	1.8	0.94						0.52		
E33-18	0.34	0.30								
E33-23	0.44	0.34	1370	1400	43	28	0.28	0.16		0.24
E33-24	3.9	1.9			263	439	3.6	2.0	1.4	0.83
E33-25	1.6	1.6	1750	108						
E33-26	1.4	1.6			*					
E33-27	4.4				5.9	*				
E34-1										
W6-1	*	*			465	530				
W10-1	*	*		*						
W10-2	<0.10	0.09	5.2	6.3	2133	2082	<0.31	<0.04	0.08	
W10-3	*	*								
W10-4	0.25	0.10					0.08	0.10		
W10-8	*	*				25		<0.05		<0.24
W11-3	*	*			105	96				
W11-12	0.16									
W11-15	0.57	0.31					<0.03	<0.04	0.50	0.34
W11-17	0.14	*			180	158	<0.02	<0.04		0.20
W11-18	*	*					*	<0.33		0.16
W11-20	*	*	167	196	112	90	<0.03	<0.03		
W14-1	0.18	0.19								

TABLE 2. (contd)

Well No. (299-)	Gross Beta (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)		Cobalt-60 (pCi/ml)		Ruthenium-106 (pCi/ml)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
W14-2	1.9	1.6			506	498	0.03	0.04	1.7	1.4
W15-1	*	*								
W15-4	0.09	0.10	4360	3580	267	382	< 0.04			0.18
W15-5	*	*								
W15-6	0.08	*								
W15-7	0.64	0.68			112	110	1.5	2.2	0.13	0.23
W15-8	*	*								
W15-9	*	0.08								
W15-10	0.08	*			0.65					
W15-11	*	*								
W18-1	*	*								
W18-2	*	*								
W18-3	*	*								
W18-4	*	*								
W18-5	*	*	170	93	1.0	*				
W18-7	*	*								
W18-10	*	*								
W18-11	*	*								
W18-12	*	*								
W19-3					31	31				
W19-5	6.2	1.9	262	117	53	44	< 0.04	< 0.03	5.2	2.1
W19-7	*	*								
W21-1						61				
W22-1	14	15			0.8	1.5				
W22-2	0.15	0.13								
W22-13	0.48	0.17	2900	1830	5.1	4.4		0.05	0.29	0.36
W22-19	*	< 0.08			1374	1115	*	< 0.03		0.16
W22-20	0.08	0.14			810	300	*	0.06		0.18
W22-21	3.5	1.1								
W22-22	0.42	0.36	280	445	0.7	0.6				
W22-26	35	25	18700	17500	255	326	0.22	0.17	35	27
W22-38	0.14	0.18								
W23-1	*	*								
W23-2	*	*								
W23-3	*	*								
W23-4	*	*	12350	1600	35	4.2	*			
W23-5	*	*								
W23-7	*	*								
W26-3	0.08	*	1.1	1.5	2.6	3.1	*	0.04		0.20

1. Gross beta is calculated as ^{106}Ru .

2. The ^{106}Ru Concentration Guide is not strictly applicable to an unknown mixture of beta emitters. (See text)

* Indicates that the concentration was less than the analytical limit.
No entry indicates no analyses were performed during the 6-month period.

for a large fraction of the beta radioactivity* in this groundwater zone. The application of the ^{106}Ru Concentration Guide (10 pCi/ml) to the gross beta concentration contour map as has been done in previous reports is not strictly correct. This point becomes more significant with time as ^{106}Ru decay reduces its proportion in the mixture of beta emitters. Application of the Concentration Guide for an unknown mixture of beta emitters (0.03 pCi/ml) is impractical since it is below the routine gross beta detection limit of 0.08 pCi/ml. Efforts are underway to more fully characterize the mixture of gross beta emitters in the groundwater away from the disposal sites which should lead to the derivation of an appropriate Concentration Guide by the procedures specified in AECM 0524.⁽³⁾ Until then the gross beta plume maps will be drawn in terms of ^{106}Ru concentrations rather than percentages of the Concentration Guide for ^{106}Ru . Under the direction of Atlantic Richfield Hanford Company, groundwater samples from beneath some inactive and all of the active disposal sites within the 200 Areas are generally analyzed for gross alpha, ^{60}Co , ^{90}Sr , ^{137}Cs , and ^{106}Ru in addition to gross beta, ^3H and NO_3^- .

Gross Beta Concentrations (Unconfined Aquifer)

Gross beta concentrations are shown in Figures 1 and 2 for zones of 0.1 to 1, 1 to 10 and >10 pCi/ml calculated as ^{106}Ru . The outer boundary of each zone is the down-gradient edge and represents the 0.1, 1, and 10 pCi/ml isopleth, respectively.

It should be kept in mind that these isopleth contours represent averages of the data that were collected over a six-month period. Thus, apparent 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 isopleths are used to illustrate it.

* Not including ^3H , whose low energy beta emission does not contribute to the gross beta activity measured.

A comparison of the isopleths for the six-month periods ending December 1972 and December 1973 indicate only a few minor adjustments. The first detection of gross beta emitters in well 699-49-57 was made during the second half of this period. A reinterpretation of the neck of the plume southeast of 200 East Area was made taking into account the fact that wells 699-37-43 and -36-46-R were not yielding representative groundwater samples. Gross beta activity levels near the front of the 200 East area plume still appear to be declining.

Tritium Concentrations (Unconfined Aquifer)

Tritium concentrations are shown in Figures 3 and 4 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 previously about the average nature of the isopleth contours apply here also.

A comparison of the CG isopleths for the six-month period ending December 1972 and December 1973 indicates that two major changes have occurred. The first reflects the detection of tritium in the water supply wells at the Washington Public Power Supply System's WPN #2 reactor site. The concentration levels were higher than would be expected from the data obtained prior to the start of construction, due in part to the effects of groundwater withdrawal at that site. Although the pumping has accelerated movement of the tritium contamination plume into that area, it is believed that the plume was somewhat closer to the site in 1972 than the corresponding plume maps⁽¹⁾ showed. No radionuclide analyses were performed on samples from these water supply wells (699-11-0, -11-1, -12-1, -13-1A and -13-1B) before heavy groundwater use began. The second change of the contamination pattern reflects results from new sampling structures between Gable Mountain and Gable Butte.

Other minor changes include detection of tritium in well 699-49-57, an increase in tritium concentration in wells 699-35-66 and -2-3, and the discovery that well 699-31-53B was not yielding a representative sample of the groundwater. The concentrations that have been reported for this latter well probably resulted from cross contamination.

Nitrate Ion Concentrations (Unconfined Aquifer)

Nitrate ion concentrations are shown in Figures 5 and 6 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.

A comparison of contamination contours for the six-month periods ending December 1972 and December 1973 indicates that several changes in the 10% of drinking water standard isopleth occurred. The 10% of drinking water standard isopleth now includes well 699-S6-E4-D. However, the 300 Area plume no longer extends as far north as previously depicted because well 699-S11-E12A-0 was identified as a faulty sampling structure. Well 699-49-57 is now included in the plume due to the appearance of nitrate contamination during this period. Minor contour interpretation adjustments immediately south of 200 East Area were made as for the tritium map.

Other Radionuclides (Unconfined Aquifer)

Certain wells in parts of the 600 Area associated with 200 Area disposal operations were also analyzed for ^{60}Co , ^{106}Ru , ^{137}Cs and ^{90}Sr . The only result above the detection limit was a concentration of ^{60}Co of 0.05 pCi/ml in well 699-32-43 and concentrations of ^{106}Ru of 0.08 to 0.14 pCi/ml in wells 699-20-20, -26-15, -32-43.

Table 2 contains the results of gross beta, tritium, nitrate, ^{60}Co , and ^{106}Ru concentration measurements in the (200) Chemical Separations Areas. The ^{106}Ru activity above the Concentration Guide is at inactive disposal sites in the 200 West Area. The entries that show the average ^{106}Ru concentrations greater than the average gross beta concentrations in Table 2 arise from the facts that; 1) at the concentration levels involved the difference between the two values is less than the accuracy of the measurements and 2) for some wells the number of gross beta measurements is much greater than the number of ^{106}Ru measurements, thus invalidating direct comparison of the average values for the period. However, there appear to be four wells in the 200 West Area that show ^{106}Ru concentrations higher than gross beta concentrations. Additional data are required to

interpret this situation. No sites had average ^{60}Co concentrations above the concentration guide (50 pCi/ml).

Detectable concentrations of gross alpha, ^{137}Cs and ^{90}Sr for this report period are listed with disposal site in Table 3. Tables 4 and 5 show the active and cited inactive disposal sites along with associated groundwater sampling wells.

A few changes in concentration levels of gross alpha, ^{137}Cs or ^{90}Sr occurred during 1973. The alpha activity at the 216-S-13 crib, which peaked in the middle of 1973 at 9.2 pCi/ml was due to a uranium concentration of 6 pCi/ml (with a CG of 20 pCi/ml), as has been the case in the past. There is currently a decreasing trend for gross alpha and uranium concentrations at this site. A single analysis at the 241-BY-1 and 2 site showed detectable ^{137}Cs . Strontium-90 concentrations in the groundwater under the 216-S-1 and S-2 cribs continue to decrease. Antimony-125 was detected at the 216-B-50 crib site at 0.43 pCi/ml. (Concentration Guide-100 pCi/ml).

Water Quality Data (Unconfined Aquifer)

Over the past several years, semi-annual samples have been taken from three to six wells for water quality analyses. Table 6 shows the results for 1973. No definite concentration trends are apparent from the historical data.

Analyses of Samples Taken from Lower Aquifer Zones

Water samples from certain horizons below the Hanford Reservation 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 intermittently detectable gross beta or tritium activity have not done so consistently with time.

At present, it is believed that none of the deep aquifers being sampled contain measurable gross beta radioactivity at the points where they

TABLE 3. Detectable Concentrations of Other Radionuclides in the Unconfined Groundwater Under the 200 Areas Listed by Disposal Site

	Site		Average Concentration (pCi/ml)		Analytical Limit	Concentration Guide
			Jan-June 1973	July-Dec 1973		
Gross Alpha ⁽¹⁾					0.02	-- ⁽²⁾
	216-S-13	I ⁽³⁾	3.7 ⁽⁴⁾	2.0 ⁽⁴⁾		
	-S-21	I	0.07 ⁽⁵⁾	0.05 ⁽⁵⁾		
	-A-27	I	0.03	0.02		
¹³⁷ Cs					0.02	20
	216-B-46	I	0.48	0.42		
	241-BY-1,2	I		0.41		
	216-B-50	A	0.08	<0.06		
	216-S-9	I	<0.04	<0.05		
⁹⁰ Sr					0.03	0.3
	216-S-1	I	15	12		
	216-S-2	I	0.1	0.03		
	216-A-36-B	I	0.06	0.04		
	216-A-5	I	0.06	<0.04		
	216-A-10	A	<0.03	0.03		

1. Gross Alpha concentrations are calibrated with a ²³⁹Pu source.
2. The ²³⁹Pu Concentration Guide is not strictly applicable to an unknown mixture of alpha emitters.
3. A denotes active disposal site. I denotes inactive disposal site.
4. Uranium concentrations averaged 3.4 pCi/ml and 2.3 pCi/ml at this site for these periods.
5. Uranium concentrations averaged .06 pCi/ml and .04 pCi/ml at this site for these periods.

TABLE 4. Active Disposal Sites--Crisbs, Ditches, Ponds, Swamps
and Associated Sample Wells

200 East Area
Site Designation

<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-30	299-E25-11, -25-12, -E16-2
 <u>B-Plant</u>	
216-B-3	699-42-42, -42-42, 299-E34-1
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	299-E34-1

TABLE 4. (contd)

<u>200 West Area Site Designation</u>	<u>Associated Sample Wells</u>
216-S-11	699-32-77
216-S-19	699-32-72
216-S-20	299-W22-19, -W22-20
<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-14	299-W19-1
<u>Z-Plant</u>	
216-Z-12	299-W18-1, -W18-2, -W18-4, -W-18-5
216-Z-16	299-W15-10, -W15-11
216-Z-18	299-W18-10, -W18-11

TABLE 4. Active Disposal Sites--Cribs, Ditches, Ponds, Swamps
and Associated Sample Wells

200 East Area
Site Designation

<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-30	299-E25-11, -25-12, -E16-2
 <u>B-Plant</u>	
216-B-3	699-42-42, -42-42, 299-E34-1
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	299-E34-1

TABLE 4. (contd)

<u>200 West Area Site Designation</u>	<u>Associated Sample Wells</u>
216-S-11	699-32-77
216-S-19	699-32-72
216-S-20	299-W22-19, -W22-20
<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-14	299-W19-1
<u>Z-Plant</u>	
216-Z-12	299-W18-1, -W18-2, -W18-4, -W-18-5
216-Z-16	299-W15-10, -W15-11
216-Z-18	299-W18-10, -W18-11

TABLE 5. Selected 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-E26-2, -E26-3, E26-4, E26-5
216-A-27	299-E17-2, -E17-3
216-A-36-B	299-E17-4, -E17-5, -E17-6, -E17-7, -E17-9, -E17-10
<u>B Plant</u>	
216-B-36	299-E33-21
216-B-46	299-E33-4, -E33-23
216-B-49	299-E33-7
241-BX-1,2	299-E33-27
241-BY-1,2	299-E33-9
<u>200 West Area Site Designation</u>	
216-S-1	299-W22-1
216-S-2	299-W22-2
216-S-6	299-W26-3
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
216-S-23	299-W19-5, -W19-6, -W19-7, -W22-38
216-T-26	299-W14-1, -W14-2, -W14-3
216-U-12	299-W22-22
216-Z-7	299-W15-7

TABLE 6. Water Quality

	Sodium (mg/l)		Calcium (mg/l)		Sulphate (mg/l)		pH	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
299-E17-5	37		60		75		7.7	
699-8-17	20		27		53			
-15-26	20		50		60		6.8	
-26-15	20		50		50		6.8	
-32-43	30		40		80		8.4	

are sampled. Tritium concentrations in these same samples were also below the detection limit during this report period with the exception of one anomalous tritium result from well 699-14-E6-Q at 6.1 pCi/ml. Subsequent samples failed to confirm this as a valid concentration at this sample location.

The nitrate concentration in well 699-59-80B south of Gable Butte continued to increase from 20 mg/l to 37 mg/l. The source of this nitrate is unknown at this time. It is possible that this well taps a confined aquifer due to its proximity to Gable Butte.

100 Area and Associated 600 Area Wells

The presence of radioactivity in the groundwater beneath the 100 Areas is due primarily to disposal of low-level liquid wastes to trenches and cribs, although leaks in reactor effluent systems have contributed radioactivity to the groundwater in the past. Table 7 contains the observed average concentrations of gross beta, tritium, and nitrate ion in 100 Area and associated 600 Area wells. Some groundwater samples in the 100-N Area were analyzed for ^{60}Co , ^{90}Sr , ^{106}Ru and ^{131}I . Average measured concentrations of these radionuclides are presented in Table 8.

Gross Beta Concentrations (Unconfined Aquifer)

The estimated extent of detectable gross beta radioactivity (excluding tritium) in the groundwater beneath the 100 Areas and vicinity is shown in Figures 1 and 2. A comparison of data for the 6-month periods ending December 1972 and December 1973 indicates that the average gross beta activity is below the detection level (0.08 pCi/ml) in all areas except 100-N, as was noted in the previous report period. The highest average gross beta concentration (as ^{106}Ru) was measured in well 199-N-6 (1.3 pCi/ml) which is about 750 feet from the 1301-N crib and trench.

Tritium Concentrations (Unconfined Aquifer)

The extent of detectable tritium activity in the groundwater beneath the 100 Areas and vicinity is shown in Figures 3 and 4. Tritium concentrations in the groundwater underneath the 100-N Area decreased significantly

TABLE 7. Average Gross Beta, Tritium and Nitrate Concentrations in 100 Area and Associated 600 Area Wells

Well No.	Gross Beta ⁽¹⁾ (pCi/ml)		Tritium (pCi/ml)		Nitrate (mg/l)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.08		1.0		0.5	
Concentration Guide	(2)		3000		45	
199-84-4	0.09	*	6.4	6.8		2.2
B9-1			2.6	1.9		1.0
D2-5			14	16	54	40
D5-12	0.14	*	11	9	55	36
F5-1			1.2	*	1.4	*
F7-1			3.5			
F8-1			21	19	60	72
H3-1			16	15	17	18
K-11			95	92	*	*
K-20	*		6.6	6.5	0.6	*
N-3	0.40	0.54	57.	140		13
N-4-0	*	*	1950	1060	*	*
N-6		1.3		130		
N-7			850			
N-8-T			120			
N-10-0	0.95	0.10	1300	59		*
N-12			47			
N-13			210			
N-14		0.25		105		10
N-15		0.19		275		8.4
699-59-32					0.7	*
60-32					0.8	*
60-57			2.1	2.2	*	*
60-60			1.7	2.2	0.7	0.7
61-62			2.2	2.4	0.7	<0.6
61-66			*	*	2.8	2.9
62-31					*	*
62-43F					0.7	*
63-25A					0.6	*
63-55			1.3	1.7	0.5	0.6
63-58			2.9	3.2	0.5	*
63-90			*	*	2.3	2.4
64-62			1.0	1.7	0.9	0.8
65-50			1.3	1.4	0.8	*
65-59			2.2	1.6	0.6	0.7
65-72			1.0	2.0	*	*
65-83			2.7	2.0	1.9	2.1
66-23-0					*	*
66-38-0					*	*
66-39					*	*
66-58			2.6	1.8	0.6	0.7
66-64			2.5	*	1.0	1.2
67-51-0			*	*	1.3	0.8
67-98			*	*	2.8	1.9
69-45-0			*	*	*	*
70-68			*	*	1.9	1.8
71-30			*	*	16	17
71-52			4.8	3.8	5.8	2.7
71-77			3.9	*	1.8	1.8
72-73			1.7	*	2.4	2.2
72-88			19	16	*	*
72-92-0			10.8	23	2.6	3.4
72-98			13			
74-44			*	*	*	*
74-48			1.2	1.7	4.2	3.2
77-36			*	*	2	2
77-54			*	*	5.5	4.8
80-43S			*	*	0.73	2.4
81-38			*	*	5.2	
81-58-0			12	8.2	0.5	0.7
83-47-0			*	*	*	*
84-35A-0			1.1	*		
87-55			130	155	10	8.9
89-35			*	*	5.9	5
96-49-0			12	7.7	2.6	2
97-43-0			1.3	8.8	3.1	6
101-48B				*		0.6

1. Gross Beta is calculated as ^{106}Ru .

2. The ^{106}Ru Concentration Guide is not strictly applicable to an unknown mixture of beta emitters. (See text)

* Indicates that the concentration was less than the analytical limit. No entry indicates no analyses were performed during the 6-month period.

TABLE 8. Other Radionuclides Observed in the Groundwater in the Vicinity of the 100 Areas*

	^{60}Co (pCi/ml)		^{90}Sr (pCi/ml)		^{106}Ru (pCi/ml)		^{131}I (pCi/ml)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.02		0.03		0.06		.01	
Concentration Guide	50		0.3		10		0.3	
100-N Area:								
199-N-3	0.16		0.12	0.14	1.2		3.3	0.2
N-4-0	<0.14		<0.04	*	*		<0.16	
N-6	0.13	0.07	*	*	0.54	0.36		
N-7					0.31			
N-8-T	0.08		0.13		3.5		0.6	
N-10-0	0.09		*	<0.05	2.5		0.9	
N-12-0					2.7			
N-13-0					0.36			
N-14	0.25	0.09	*	*	0.88	0.48	0.3	
N-15	0.12	<0.06	*	*	0.32	<0.24		

* Includes results of special sampling study conducted June 1973.

during 1973 as a result of reduced tritium discharges to the 1301-N crib. However, the average concentration observed in the well 699-87-55, a mile from the crib, continued to increase during this period reflecting the discharges of previous years.

Other minor changes in the tritium plume include elimination of detectable tritium under the northern tip of the Reservation based on results from a newly sampled well, and the first detection of tritium in well 699-65-50. It was also determined that well 699-90-45 which locates the end of the tritium plume emanating from the 100-N Area was not a reliable sampling structure. Thus the extent of the 1% of Concentration Guide contour in this area may be somewhat larger than illustrated in Figures 3 and 4.

Nitrate Ion Concentrations (Unconfined Aquifer)

The adjustments to the nitrate plumes in the vicinity of the 100 Areas reflect decreasing concentrations in the neighborhood of well 699-74-60 and the rejection of the observed nitrate concentration in open farm wells as being representative of the aquifer water. The isolated mound in the water table north of Gable Mountain shown in the 1972 map is currently believed to be perched water from former irrigation activity that is not hydraulically connected to the unconfined aquifer under the Reservation. The potential contours shown apply to the water bearing zone below this mound.

The only area with nitrate ion concentrations greater than 100% of drinking water standard is southwest of 100-F Area, probably from Battelle-Northwest research animal wastes. The origin of the other zones of high nitrate ion concentration in the vicinity of the 100 Areas is not certain, but it is believed to be associated with former agricultural sources rather than 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 previous sample periods from 300 Area

and associated 600 Area wells show that the radioactivity is primarily due to uranium, although ^{51}Cr , ^{60}Co , and ^{106}Ru have also been identified on occasion, as mentioned in previous reports. The results of 300 Area well sampling are presented in Table 9. The average gross beta concentration in well 399-3-8 continued to decline through 1973.

The concentration of nitrate ion in some of the groundwater beneath the 300 Area (Table 9) is above the Public Health Service drinking water limit⁽⁴⁾ of 45 ppm. Average fluoride ion concentrations were above drinking water standards (1.5 mg/l) in five 300 Area wells during the first half of 1973 compared to one well in 1972. Only one well in the second half of 1973 had an average fluoride concentration above 1.5 mg/l.

TABLE 9. Analytical Data - 300 Area and Associated 600 Area Wells

Well No.	Gross Beta ⁽¹⁾ (pCi/ml)		Nitrate (mg/l)		Gross Alpha ⁽³⁾ (pCi/ml)		Cr ⁺⁶ (μg/l)		F ⁻ (mg/l)	
	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973	Jan-June 1973	July-Dec 1973
Analytical Limit	0.08		0.5		0.02		3		0.2	
Concentration Guide	(2)		45		(4)		50		1.5	
699-S12-3										
S19-E13	*	*	0.7	0.8	*	*	4.0	*	0.5	0.3
S27-E14			7.3	6.9	*	*	*	3.4	0.3	0.6
S29-E12			11	11	*	*	*	*	0.34	*
S30-E15A			*	*	*	*	*	*	<0.3	*
399-1-1	0.10	<0.09	8.2	2.0	*	*	*	*	1.5	1.0
1-2	*	*	36	53	0.04	0.02	*	*	1.4	0.9
1-3	0.2	0.09	23	25	0.05	0.04	*	*	2.7	4.8
1-4	0.16	*	148	146	0.09	0.05	9.5	10	1.6	0.5
3-1	*	0.1	14	15	0.06	0.02	*	3	1.6	1.2
3-8	0.5	0.3	57	48	0.05	0.04	*	3.8	1.0	0.8
4-1	0.09	*	32	24	0.04	0.03	*	6.0	1.6	0.7
4-7	*	0.17	13	12	0.11	0.11	*	*	2.2	0.9
4-8	*	*	24	28	0.05	0.04	*	*	1.2	0.6
5-1			25	13	*	*	*	*	0.4	0.3
6-1			17	14	0.03	0.02	3.2	3.8	0.4	0.4
8-2			8.0	7.8	*	*	*	*	0.4	0.5
8-3			7.0	2.7	*	*	*	*	0.6	0.4

1. Gross Beta is calculated as ^{106}Ru .

2. The ^{106}Ru Concentration Guide is not strictly applicable to an unknown mixture of beta emitters. (See text)

3. Gross Alpha concentrations are calibrated with a ^{239}Pu source.

4. The ^{239}Pu Concentration Guide is not strictly applicable to an unknown mixture of alpha emitters.

* Indicates that the concentration was less than the analytical limit. No entry indicates no analyses were performed during the 6-month period.

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