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# RADIOLOGICAL STATUS OF THE GROUND WATER BENEATH THE HANFORD PROJECT JULY-DECEMBER 1969

By

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# RADIOLOGICAL STATUS OF THE GROUNDWATER BENEATH THE HANFORD PROJECT JULY-DECEMBER, 1969

D. H. Denham

## INTRODUCTION

This report is prepared semiannually to provide an evaluation of the status of groundwater contamination resulting from disposal of plant effluents. The data presented in this report were collected during the last six months of 1969; the previous report in this series was BNWL-1233[1].

Of the wells that have been drilled to groundwater on the Hanford project, about 250 are used for the routine surveillance of radionuclide movement through the sediments both above and below the regional water table. Approximately one-third of the surveillance wells are located at disposal sites situated on the interior plateau 12 to 15 miles up-gradient from the nearest domestic water supply. These wells are used to determine when a disposal facility is to be retired. All other surveillance wells are sampled to determine the status of contaminants within the general groundwater flow network. The locations of wells referred to in this report may be found by referring to the Hanford Wells document[2].

It is assumed that $^{106}Ru$, $^{3}H$, and the nitrate ion ($NO_3^-$) move at essentially the same rate as groundwater. In addition, they can be detected in groundwater at low concentrations relative to their respective drinking water standards. Therefore, $^{106}Ru$, $^{3}H$, and $NO_3^-$ are used to trace the groundwater flow paths away from the major chemical processing disposal sites. Nitrate ion measurements also reflect changes in water quality attributable to the concentrations of salts in the wastes. All groundwater samples were analyzed by the Technical Analysis Section, Battelle-Northwest.


## SUMMARY

An evaluation of $^{106}Ru$ and $^{3}H$ concentrations measured in the unconfined groundwater during the last half of 1969 shows that the zones of detectable contamination extend in a southeasterly direction from 200-E Area (Figures 1 and 2) as observed in the past(1). The few locations from which average groundwater concentrations exceeded the Concentration Guide (CG) for $^{106}Ru$ were all within either the 200-E or 200-W Areas. Water from only one well located outside of the 200 Area fences (#699-35-70) indicated a $^{3}H$ concentration greater than the CG. The highest average concentration of $^{51}Cr$ measured in unconfined groundwater within or near the 100 Areas (Well 199B-5-1) was less than 10% of the CG for $^{51}Cr$ (2000 pCi/ml)(3). Concentrations of uranium, the principal radionuclide observed in 300 Area groundwater, averaged less than 0.5 pCi/ml (<3% CG).

Although water from several wells with piezometers was sampled and analyzed during this report period, no total beta concentrations were detected in any confined groundwater aquifers.

Water samples showing detectable $^3H$ concentrations in confined groundwater zones were from wells 699-24-1-S, -28-40-P, -28-40-Q, and -36-46-Q.

Nitrate ion concentrations greater than 10% of the Public Health Service recommended drinking water limit of 45 ppm(4) were observed in most groundwater samples from wells surrounding the 200 Areas. Water from a number of wells showed $NO_3^-$ concentrations greater than 45 ppm, especially around the disposal sites and the 300 Area. However, groundwater from these zones is not consumed by humans or animals.

## EVALUATION OF GROUNDWATER SURVEILLANCE DATA

Radionuclide concentrations in the groundwater beneath Hanford are evaluated in terms of their respective CG's, while the $NO_3^-$ concentrations are compared to the PHS drinking water standard. It is recognized that these guides are intended only for drinking water, and at present no groundwater from the contaminated zones (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 water-borne materials. The CG's used in this report are those which apply to individuals of the general public(3).

The groundwater contamination pattern beneath Hanford can be divided logically into three zones, based on the kinds and and quantities of waste disposed to ground at each area:

200 Area (chemical processing areas) and associated 600 Area wells

100 Area (production reactor areas) and associated 600 Area wells

300 Area (fuel fabrication and laboratory area) wells.

Groundwater concentration data for these three zones are presented in this report.

Data from all wells for which average total beta, $^{3}H$, or $NO_3^-$ concentrations were above the respective analytical limits are tabulated in this report. All 100 Area and associated 600 Area wells routinely sampled are listed in Table 4 along with the concentration data for those wells showing detectable activity. In addition, the average concentration data for both halves of calendar year 1969 are shown in Tables 2, 3, and 4 for rapid comparison of the respective trends. 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 are present are analyzed for total beta, $^{3}H$, and $NO_3^-$. The total beta activity is calculated as $^{106}Ru$, since radiochemical analyses have shown that this nuclide accounts for a large fraction of the radioactivity* in this groundwater zone. Groundwater samples from beneath some inactive and all of the active crib sites (Table 1) are analyzed for total alpha, $^{60}Co$, $^{90}Sr$, and $^{137}Cs$, in addition to total beta, $^{3}H$, and $NO_3^-$.

*TABLE 1. Active Disposal Sites--Cribs, Ditches, Ponds, Swamps*

| 200 East Area | | 200 West Area | |
|---|---|---|---|
| Site Designation | | Site Designation | |
| Purex | B Plant | Redox | U Plant |
| 216-A-3 | 216-B-2 | 216-S-6 | 216-U-4A,B |
| 216-A-6 | 216-B-3 | 216-S-11 | 216-U-10 |
| 216-A-8 | 216-B-10B | 216-S-16 | 216-U-12 |
| 216-A-10 | 216-B-12 | 216-S-19 | 216-U-14 |
| 216-A-25 | 216-B-50 | 216-S-21 | |
| 216-A-27 | 216-B-55 | 216-S-23 | Z Plant |
| 216-A-29 | 216-B-57 | T Plant | |
| 216-A-30 | 216-B-59 | 216-T-4 | 216-Z-11 |
| 216-A-36B | | 216-T-19 | 216-Z-12 |
| | | 216-T-35 | 216-Z-16 |
| | | 216-T-36 | 216-Z-18 |

No detectable (>0.03 pCi/ml) concentrations of $^{137}Cs$ were observed in groundwater samples collected from the 200 Area disposal sites during the last half of 1969. Groundwater near only one crib site (216-A-36B) indicated an average $^{90}Sr$ concentration (0.05 pCi/ml) above the detection limit (0.03 pCi/ml) during the last half of 1969. Low but detectable alpha concentrations were observed beneath the 216-T-32 crib (0.034

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

*TABLE 2. Average Total Beta, Tritium, and Nitrate Ion ($NO_3^-$) Concentrations in 600 Area Wells*

| Well No. (699-) | Total Beta[a] (pCi/ml) July-Dec'69 | Total Beta[a] (pCi/ml) Jan-Jun'69 | Tritium (pCi/ml) July-Dec'69 | Tritium (pCi/ml) Jan-Jun'69 | $NO_3^-$ (ppm) July-Dec'69 | $NO_3^-$ (ppm) Jan-Jun'69 |
|---|---|---|---|---|---|---|
| Analytical Limits[b] | 0.16 | | 1 | | 1 | |
| S6-E4C | - | - | - | - | 4 | - |
| S8-19 | - | - | - | - | 1 | 3 |
| 1-18 | - | - | 82 | 70 | 3 | - |
| 2-3 | - | - | 3.1 | 1.5 | - | 2 |
| 8-17 | - | - | 24 | 14 | 15 | 12 |
| 14-38 | - | - | - | - | 1 | 4 |
| 15-26 | 0.50 | 0.68 | 530 | 300 | 30 | 16 |
| 17-5 | - | - | - | - | 2 | 2 |
| 20-20 | 0.35 | 0.58 | 740 | 750 | 31 | 76 |
| 20-39 | - | - | - | - | 2 | 3 |
| 24-1-T | - | - | - | - | 1 | - |
| 24-33 | - | - | 380 | 530 | 3 | 4 |
| 24-46 | - | - | - | - | 7 | 6 |
| 26-15 | 1.2 | 1.8 | 1500 | 1500 | 37 | 34 |
| 27-8 | - | - | 720 | 580 | - | - |
| 28-40 | - | - | 25 | 56 | 10 | 16 |
| 29-78 | - | - | NA[c] | 1.4 | 2 | 1 |
| 31-31 | 0.96 | 1.4 | 2000 | 1800 | 23 | 65 |
| 31-53B | - | - | - | - | 4 | NA |
| 32-42 | - | - | 430 | 990 | - | - |
| 32-43 | 0.64 | 0.90 | 610 | 750 | 17 | 29 |
| 32-70 | - | - | 28 | 28 | 23 | 16 |
| 32-72 | - | - | 51 | 45 | - | - |
| 32-77 | - | - | NA | - | 14 | 16 |
| 33-42 | - | - | 1200 | 1200 | - | - |
| 34-39A | 0.58 | 0.72 | 1900 | 2100 | 18 | 22 |
| 34-51 | - | - | - | - | 7 | 3 |
| 34-88 | - | - | 1.7 | - | 3 | 2 |
| 35-9 | - | - | 4.1 | 3.7 | NA | 6 |
| 35-70 | 0.32 | 0.36 | 5100 | 4700 | 2 | 6 |
| 35-78 | - | - | 1.7 | 1.5 | 1 | 3 |
| 36-46-R | 0.52 | 0.75 | 2100 | 2200 | - | - |
| 37-43 | - | - | 650 | 740 | 1 | - |
| 37-82A | - | - | 1.4 | - | 2 | - |
| 38-65 | - | - | 1.4 | 1.9 | 25 | 25 |
| 38-70 | 0.79 | 0.23 | 190 | 220 | 120 | 150 |

*TABLE 2. (cont'd)*

| Well No. (699-) | Total Beta (pCi/ml) July-Dec'69 | Total Beta (pCi/ml) Jan-Jun'69 | Tritium (pCi/ml) July-Dec'69 | Tritium (pCi/ml) Jan-Jun'69 | $NO_3^-$ (ppm) July-Dec'69 | $NO_3^-$ (ppm) Jan-Jun'69 |
|---|---|---|---|---|---|---|
| 39-79 | - | - | 2.0 | 2.0 | 1 | 4 |
| 40-62 | - | - | NA | - | 2 | NA |
| 41-23 | 0.53 | 0.67 | 750 | 750 | 25 | 37 |
| 42-12 | - | - | 79 | 64 | 12 | 12 |
| 42-42 | - | - | 100 | 81 | 16 | 95 |
| 45-42 | - | - | 940 | 870 | 9 | 4 |
| 45-69 | - | - | - | - | 26 | 38 |
| 46-21 | - | - | - | - | 3 | 3 |
| 47-35 | - | - | - | - | 1 | 2 |
| 47-46 | - | - | NA | - | 3 | 3 |
| 47-60 | - | - | NA | - | 3 | 1 |
| 48-71 | - | - | NA | - | 3 | 2 |
| 49-57 | - | - | 1.6 | 1.1 | 1 | - |
| 49-79 | - | - | - | - | 32 | 49 |
| 50-28 | - | - | - | - | 3 | 3 |
| 50-53 | 1.0 | 1.2 | 7.2 | 1.1 | 120 | 60 |
| 50-85 | - | - | NA | - | 10 | 20 |
| 51-63 | - | - | - | - | 2 | 5 |
| 51-75 | - | - | NA | - | 19 | 4 |
| 52-47 | - | - | 11 | 7.5 | - | - |
| 53-55 | - | - | 2.0 | 2.2 | - | - |
| 55-50 | - | - | 5.2 | 2.2 | 5 | 7 |
| 61-66 | - | - | - | - | 3 | 4 |

(a) *Calculated as $^{106}Ru$.*
(b) *A (-) indicates that the concentration was less than the analytical limit.*
(c) *No analyses were performed during six-month period.*

pCi/ml) and the 216-S-21 crib (0.083 pCi/ml). The highest average total beta concentrations beneath active disposal sites were observed at the 216-A-36B crib (45 pCi/ml) in 200 East Area and at the 216-T-35 crib (17 pCi/ml) in 200 West Area. (An average total beta concentration of 3600 pCi/ml was observed beneath the retired 216-S-9 crib.)

## 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 $^{106}Ru$ (10 pCi/ml)[3]. The outer boundary of each zone is the down-gradient edge and represents 2%, 10%, and 100% CG, respectively. The lowest level shown (2% CG) corresponds to a total beta concentration of 0.2 pCi/ml.

A comparison of contamination contours for the six-month periods ending June 1969 and December 1969, indicates that the major flow path from 200-East Area is to the west of Wells 699-32-42 and -33-42, contrary to that shown in previous reports. The inner contour (10% CG) southeast of the 200-East Area has decreased in area.

## 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 0.03%, 1%, 10%, and 100% CG, respectively.

A comparison of concentration contours for the six-month period ending December 1969 indicates that the following changes have occurred since the previous report period ending June 1969: East Area--The outermost contour (0.03% CG) no longer includes Wells 699-50-42, -54-57, and -60-60; and the 1 to 10% contour has shifted eastward to exclude well 699-28-40. West Area--The outer boundary (0.03% CG) has expanded to include Wells 699-34-88 and -37-82A.

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 or in the river.

## Contamination in Confined Groundwater

Samples taken in past years from wells penetrating specific aquifers have indicated that some radioactive wastes may be entering confined aquifers beneath the Hanford project. The extent to which such wastes appear in confined or semi-confined aquifers is difficult to evaluate because of the limited number of points at which these aquifers can be sampled with the present well system.

*TABLE 3. Average Total Beta and $^{60}Co$ Concentrations in Unconfined Groundwater Within the 200 Areas*

| Well No. (299-) | Total Beta[(a)] (pCi/ml) July-Dec '69 | Total Beta[(a)] (pCi/ml) Jan-June '69 | $^{60}Co$ (pCi/ml) July-Dec '69 | $^{60}Co$ (pCi/ml) Jan-June '69 |
|---|---|---|---|---|
| Analytical Limits[(b)] | 0.16 | | 0.2 | |
| E17-1 | 2.2 | 3.9 | 0.30 | 0.31 |
| E17-2 | 2.0 | 2.4 | - | 0.43 |
| E17-3 | 2.4[(c)] | 6.1[(c)] | NA[(d)] | NA |
| E17-4 | 45[(c)] | NA | 0.46 | 0.55 |
| E17-5 | 45 | 50 | 0.95 | 0.64 |
| E17-7 | 42 | 37 | 0.85 | 0.57 |
| E24-2 | 5.2 | 5.7 | NA | NA |
| E24-5 | 0.45 | 0.32 | - | - |
| E24-9 | 6.4 | 7.8 | 0.28 | 0.44 |
| E25-3 | 1.1 | 0.2 | NA | NA |
| E25-5 | 0.19 | 0.29 | - | - |
| E33-23 | 1.7 | 1.4 | NA | NA |
| W6-1 | 0.26 | 0.19 | NA | NA |
| W10-2 | 0.19 | 0.38 | - | - |
| W10-4 | 0.22 | 0.25 | - | - |
| W11-17 | 17 | 20 | - | - |
| W11-18 | 4.2 | 7.4 | - | - |
| W15-4 | 5.4 | 2.3 | NA | NA |
| W15-7 | 26 | 71 | 9.5 | 14 |
| W19-5 | 37 | 0.5 | - | - |
| W21-1 | 0.9 | 1.8 | NA | NA |
| W22-4 | 0.25 | 0.27 | NA | NA |
| W22-22 | 6.9 | 7.2 | NA | NA |
| W22-25 | 570 | 7900 | 1.3 | 3.0 |
| W22-26 | 3600 | 9400 | 1.6 | 4.0 |
| W22-37 | 0.26 | 0.24 | - | - |
| W26-2 | 1.2 | 1.1 | NA | NA |

(a) *Calculated as $^{106}Ru$.*
(b) *A (-) indicates that the concentration was less than the analytical limit.*
(c) *Single analysis during six-month period.*
(d) *No analyses were performed during six-month period.*

Water samples from specific aquifers are obtained from either vertically separated tubes (piezometers) contained within a single well or from piezometer tubes drilled as separate wells. There is no certainty that the vertical separation of piezometer tubes if infallible; and, in fact Eliason[5] has shown that interaquifer transfer within a well does occur.

Total beta concentrations in samples taken at various depths (in some instances from confined aquifers) below the water table were all at or below the detection limit (<2% CG for $^{106}Ru$) for the last six months of 1969. The maximum six-month average $^{3}H$ concentration in well water from a confined aquifer was 2.5 pCi/ml (<0.1% of the CG for $^{3}H$) in well 699-24-1-S in a zone 260 feet below the water table. In the past the maximum $^{3}H$ concentrations in confined groundwater zones were reported from wells 699-31-31-R or 699-42-42-P. However, a recent study[5] indicates that interaquifer transfer occurs within these wells; hence, concentrations reported in the past probably represented the unconfined rather than the confined aquifer.

## Groundwater Quality

The disposal of liquid wastes to the ground has caused measurable changes in groundwater quality adjacent to and down-gradient from the disposal sites. Water quality is directly affected by the concentrations of salts in the wastes and indirectly by the degradation of soil minerals by the wastes. The average concentrations of $NO_3^-$ in the groundwater, primarily from the disposal of wastes in the 200 Areas, are given in Table 2.

The extent of $NO_3^-$ contamination in the groundwater beneath the Hanford project is shown in Figure 3. Analyses of much of the Hanford project groundwater indicate detectable $NO_3^-$ concentrations, probably as a result of previous farming and the use of fertilizers in addition to the disposal of wastes in the 200 Areas. However, only those wells having average $NO_3^-$ concentrations above 1 ppm are included within the contamination zones since these are most probably from waste disposal in the 200 Areas. Although water from a number of wells in the contaminated area shows $NO_3^-$ concentrations above the Public Health Service recommended drinking water limit of 45 ppm[4], no water from these particular wells is consumed by humans or animals or is used for irrigation.

## 100 AREA AND ASSOCIATED 600 AREA WELLS

The presence of radioactivity in the groundwater beneath the 100 Areas is due to leaks in reactor effluent systems and to disposal of wastes to trenches. Well water samples, collected from within and near the 100 Areas, were analyzed for total beta, $^{51}Cr$, and $Cr^{+6}$. In addition, wells located in 100-N Area were analyzed for $^{3}H$.

The estimated extent of detectable total beta radioactivity in groundwater beneath the 100 Areas is shown as a short-dashed line in Figure 1. Three contaminated zones can be distinguished: 100-K-100-N, 100-B, and 100-D, with the radioactivity level decreasing in that order. Radionuclide concentrations in groundwater at 100-B have dropped significantly as a result of the shutdown of C Reactor in the spring. As far as total beta activity is concerned, these zones were well defined. However, inconsistent data were obtained from the $^{51}Cr$ and $Cr^{+6}$ analyses, so these are not shown in the accompanying figures or in Table 4. The concentration of $^{51}Cr$, the only gamma-emitting radionuclide detectable by routine methods, was found to be approximately an order of magnitude larger that the total beta (calculated as $^{106}Ru$) concentration. An estimate of the maximum average $^{51}Cr$ concentration for the last half of 1969 in 100 Area groundwater is 50 pCi/ml (Well 199-K-20). The $^{3}H$ concentration observed in the two N Area wells (199-N-3-0 and -N-8-U) ranged between 500 and 1000 pCi/ml, typical of the concentrations observed in the past.

*TABLE 4. Total Beta Concentrations in Unconfined Groundwater (100 Area and Associated 600 Area Wells)*

| Well No. | Units of pCi[a]/ml: July-Dec. 1969 Avg. Conc. | July-Dec. 1969 Max. Conc. | July-Dec. 1969 Conc. In Latest Sample | Jan-June 1969 Avg. Conc. |
|---|---|---|---|---|
| Analytical Limit[b] | 0.16 | | | |
| 199B-3-2 | 0.92 | 1.5 | 0.43 | 3.6 |
| 199B-4-4 | 0.57 | 1.5 | 0.16 | 4.9 |
| 199B-5-1 | 0.32 | 0.84 | - | 6.9 |
| 199D-5-12 | 0.18 | 0.35 | 0.35 | 0.23 |
| 199K-20 | 4.6 | 5.8 | 3.4 | 5.5 |
| 199N-3-0 | 1.0 | 1.8 | 1.4 | 0.44 |
| 699-71-84 | 0.24 | 0.57 | - | 1.7 |
| 699-86-60 | 0.18 | 0.22 | - | 0.37 |

*The average total beta concentration was below the analytical limit for each of the following wells:*

| | | |
|---|---|---|
| 199B-9-1 | 699-65-83 | 699-74-60 |
| 199D-2-5 | 699-67-86 | 699-78-62 |
| 199K-11 | 699-70-68 | 699-81-58 |
| 199K-25 | 699-71-77 | 699-96-49 |
| 199N-8-U | 699-72-73 | |

(a) *Calculated as* $^{106}Ru$.
(b) *A (-) indicates that the concentration was less than the analytical limit.*

## 300 AREA WELLS

The presence of radioactive and nonradioactive contaminants in groundwater beneath the 300 Area arises from the disposal of wastes to two process ponds located north and east of the

300 Area. Results of samples collected from 300 Area wells show that the radioactivity is primarily due to uranium, although $^{51}Cr$, $^{60}Co$, and $^{106}Ru$ have also been identified.

The concentration of $NO_3^-$ in much of the groundwater beneath the 300 Area (Table 5) is above the Public Health Service drinking water limit[4] of 45 ppm. However, sampling of the river adjacent to the disposal sites has shown measurable increases in $NO_3^-$ concentrations only at seepage locations along the riverbank.

*TABLE 5. Analytical Data - 300 Area and Associated 600 Area Wells, July-Dec, 1969 Averages*

| Well No. (399-) | Alpha, pCi/ml | Beta, pCi/ml | $NO_3^-$ ppm | $Cr^{+6}$ ppb | $F^-$ ppm |
|---|---|---|---|---|---|
| Analytical Limit[a] | 0.01 | 0.16 | 1 | 2 | 0.2 |
| 1-1 | 0.28 | 0.46 | 73 | 16 | 1.1 |
| 1-2 | 0.16 | 0.24 | 65 | 41[b] | 1.0 |
| 1-3 | 0.41 | 0.30 | 85 | 64[b] | 1.3 |
| 1-4 | 0.29 | 0.30 | 48 | 11[b] | 1.0 |
| 3-1 | 0.14 | 0.22 | 70 | 9 | 0.8 |
| 4-1 | 0.38 | 0.37 | 37 | 10[b] | 1.9 |
| 4-7 | 0.33 | 0.23 | 64 | - | 0.9[b] |
| 5-1 | 0.05 | - | 13 | - | NA[c] |
| 6-1 | 0.03 | - | 14 | 12[b] | NA |
| 8-1 | 0.12 | - | 9 | - | NA |
| 8-2 | 0.02[b] | - | 7[b] | - | NA |
| 8-3 | 0.06 | - | 19 | 13 | NA |
| 699-S27-E14 | 0.05 | - | 10 | 4.4 | NA |

*(a) A (-) indicates that the concentration was less than the analytical limit.*
*(b) Single analysis during six-month period.*
*(c) NA - No analyses during six-month period.*

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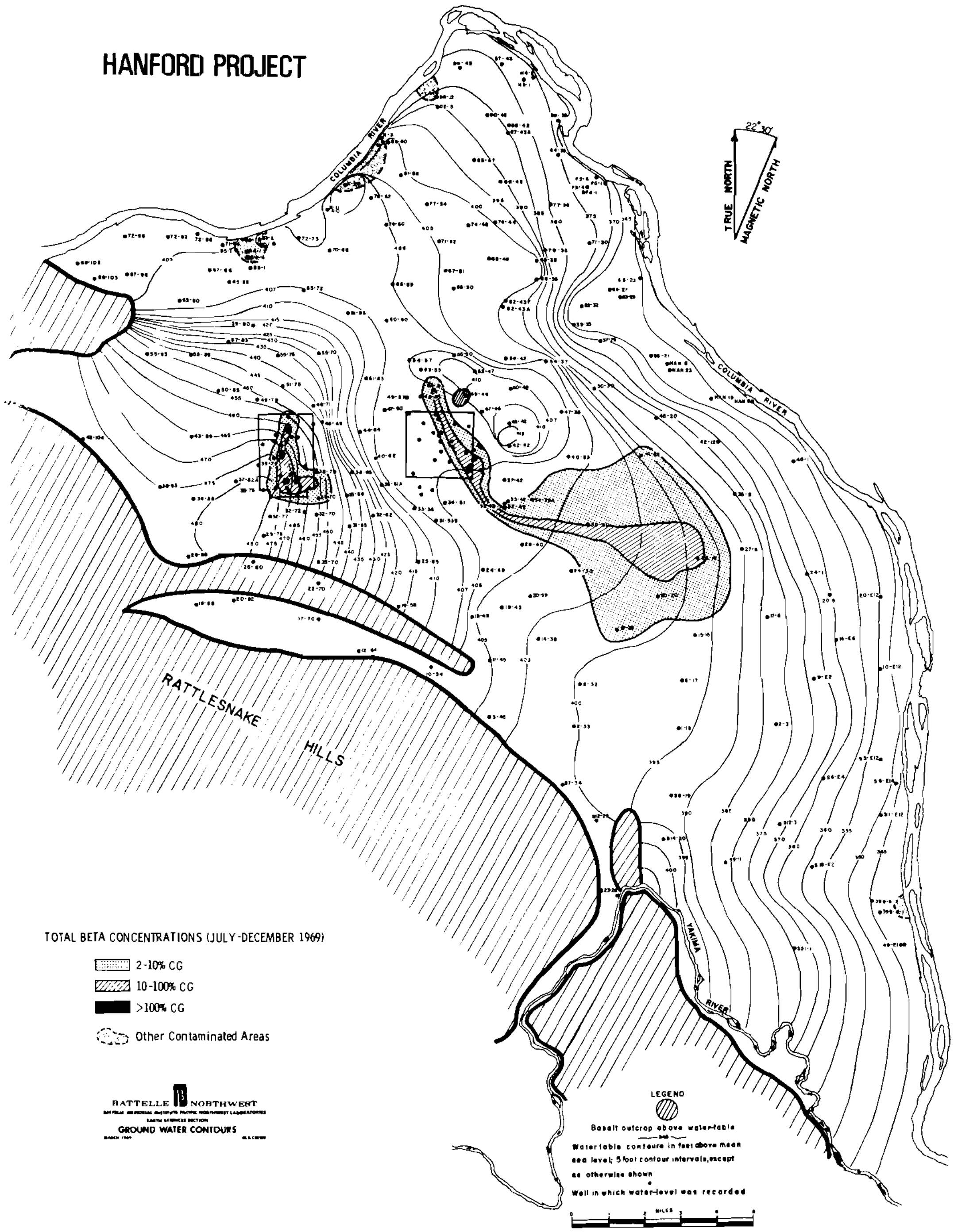
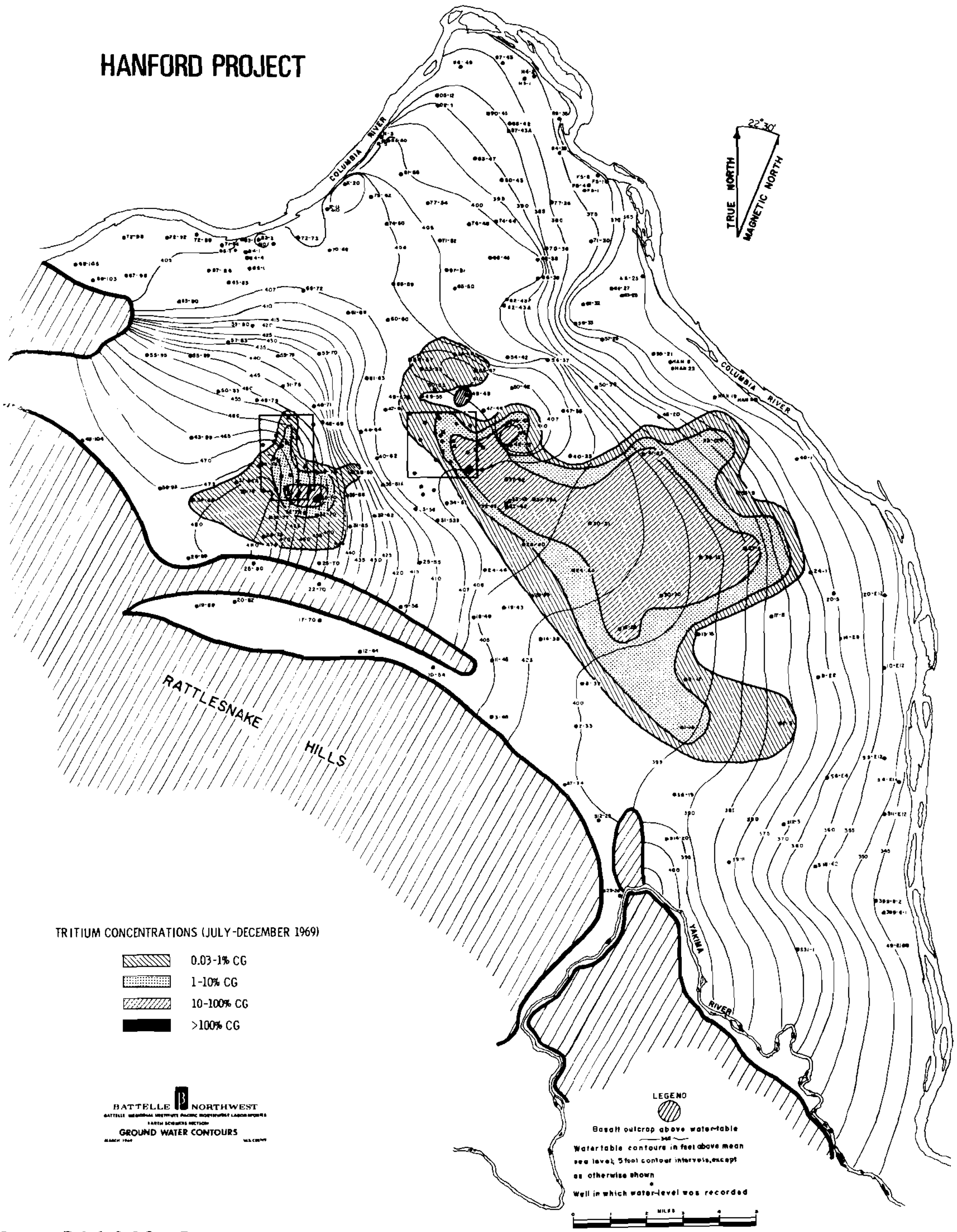



*Neg 701882-2*

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




*Neg 701882-3*

*<u>FIGURE 2.</u> Tritium Concentrations Beneath the Hanford Project Expressed as Percent of $^{3}H$ Concentration Guide (3000 pCi/ml)*

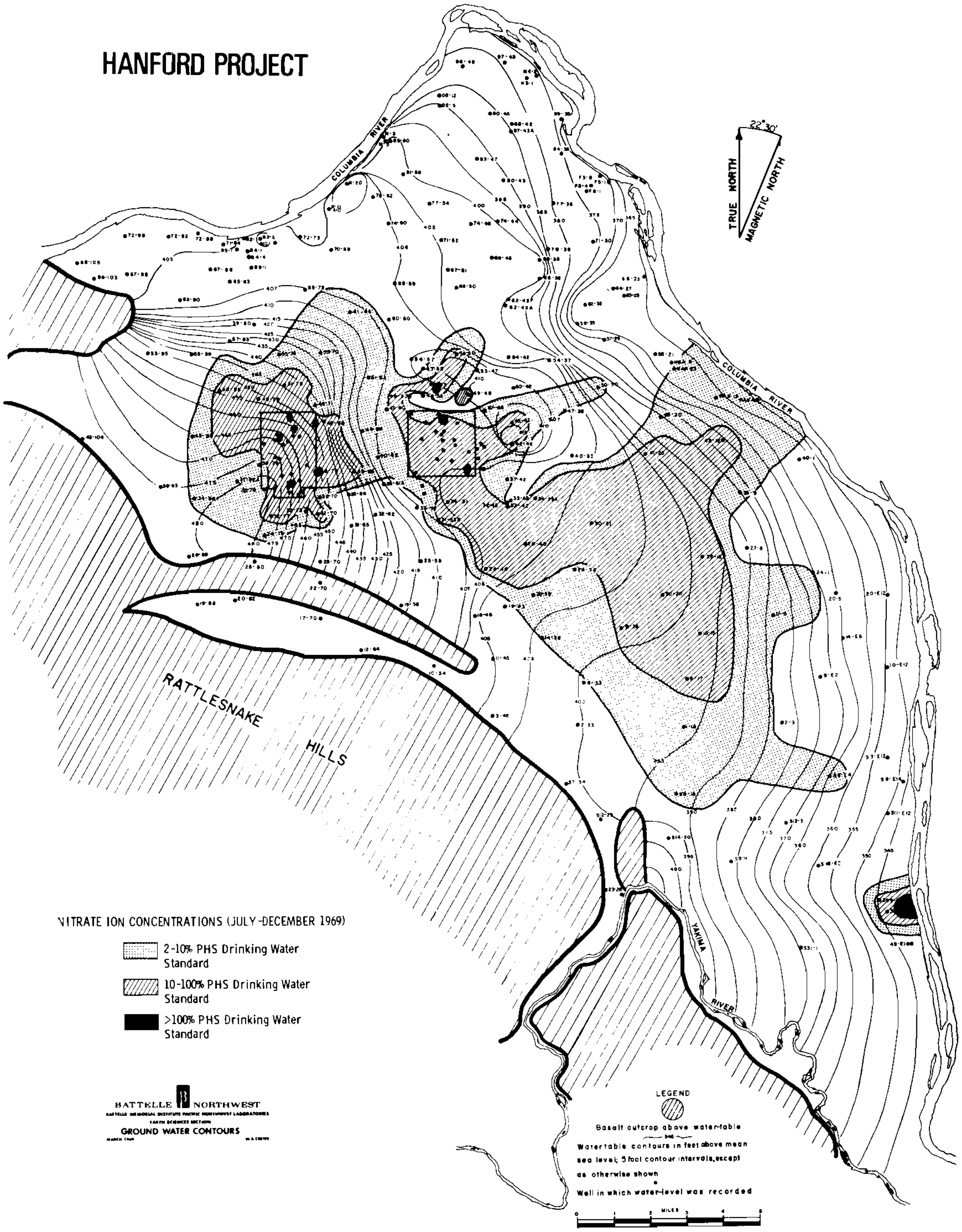



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*FIGURE 3. Nitrate Ion Concentrations Beneath the Hanford Project Expressed as Percent of Public Health Service Drinking Water Limit (45 ppm)*

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