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# Environmental Status of the Hanford Site for CY-1977

by
J. R. Houston
P. J. Blumer

June 1978

Pacific Northwest Laboratory
Richland, Washington 99352
Operated for the
U.S. Department of Energy
by

Battelle
Memorial Institute

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## SUMMARY

Environmental data collected during 1977 showed continued compliance of Hanford operations with all applicable state and federal regulations. Included in the environmental data collected were measurements of external radiation, and radionuclide analyses of air samples, Columbia River water, wildlife, soil, vegetation, and surface waste waters. In addition, all roadways, railways, and active as well as retired burial grounds were surveyed periodically to detect any abnormal levels of radioactivity. Highlights of the environmental status of the Hanford Site for 1977 follow:

- Average airborne concentrations of particulate beta- and alpha-emitting radionuclides observed at onsite, perimeter, and distant locations were statistically identical. This implies that there was no distinguishable impact from Hanford operations. However, the concentrations of $^{137}Cs$ and $^{90}Sr$ observed in the 200 East and 200 West Areas' air-filter composites were slightly higher than the $^{137}Cs$ and $^{90}Sr$ concentrations observed elsewhere. These maximum concentrations were less than 1% of the most restrictive Manual Chapter 0524 concentration guides.
- The Hanford operation's contributions to radionuclides in Columbia River water were small. Throughout 1977, $^{60}Co$ and $^{129}I$ were the only radionuclides observed at higher concentrations downstream than upstream. The presence of these radionuclides was attributed to routine low-level releases at N-Reactor and resident $^{60}Co$ in river sediments. The maximum levels of all radionuclides were less than 1% of the most restrictive Manual Chapter 0524 concentration guides.
- Radionuclide concentrations in samples collected from open waters on the Hanford Site during 1977 were, in general, within their expected range of variation and were similar to levels observed in past years. With the exception of naturally occurring West Lake, the sampled ponds, swamps, and ditches received low-level waste from Hanford facilities.

Wildlife (i.e., game birds, deer, rabbits, and mice) were sampled on the Hanford Site. All wildlife, with the exception of waterfowl from along the Columbia River and dry land game birds from the 100 Areas, showed measurable levels of radionuclides related to Hanford operations. The potential total-body dose to an individual consuming about 1 lb (500 g) of duck meat or about 50 lb (23 kg) of deer meat containing the maximum amounts of radionuclides observed in 1977 samples would be 3.4 mrem for the duck meat and 1 mrem for the deer meat.

- Average radionuclide concentrations in soil at onsite locations were similar to those of offsite locations, except for $^{137}Cs$ and $^{239-240}Pu$. The unusual plutonium concentrations in soil were noted at two widely spaced locations. Only one finding of an unusual concentration of $^{239-240}Pu$ in soil was supported by evidence of a high concentration of $^{239-240}Pu$ in a vegetation sample. These samples were from the plot east of the 200 West Area. The maximum concentration of $^{137}Cs$ in soil observed at the 200 ENC site (sampled for the first time in 1977 - see Figure 2) was supported by an accompanying high result for the vegetation sample and was attributed to Hanford operations. All other radionuclides observed in soil and vegetation were attributed to worldwide fallout.
- External radiation dose rates measured at perimeter and at distant locations were indistinguishable, implying that there was no detectable Hanford impact offsite. However, several onsite locations (primarily near the 200 and 100-N Areas) showed dose rates in excess of natural background levels; these dose rates were attributed to Hanford operations.
- External radiation dose rates measured at several locations along the Columbia River islands and the shoreline were higher than those measured at other locations. Residual quantities of $^{60}Co$ associated with sediment from past operation of once-through-cooled production reactors were responsible for these higher doses. The maximum observed dose rate has been declining each year and is now about 0.01 mrem/hr more than the approximately 0.008 mrem/hr due to background radiation.

- Surveys of Hanford Site roadways, railways, and waste-disposal sites disclosed no serious problems.

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# INTRODUCTION

The environmental surveillance and evaluation program, conducted by the Pacific Northwest Laboratory under contract to the U.S. Department of Energy, provides measurement and interpretation of the Hanford operations' radiological impact on its environs, both onsite and offsite. In compliance with applicable state and federal regulations, the radiation exposure that is attributable to Hanford operations is evaluated. Contributions to environmental radioactivity from nuclear detonations in the atmosphere and from natural sources are also evaluated and compared with the radiological impact attributable to Hanford operations.

The program is designed to evaluate all significant potential pathways. The most important potential pathways are those resulting in direct exposure of the public and those in which environmental reconcentration is likely to occur. Summaries and interpretations of the data are published in a series of annual reports which include surface environmental data from locations within the reservation boundaries. The previous report in this series is numbered BNWL-2246 and is for 1976.[1] The present report describes each major monitoring activity and evaluates data collected during 1977. Environmental data for offsite locations are published for a more general audience in the report series, "Environmental Surveillance at Hanford . . ." The latest is numbered PNL-2614 and is for 1977.[2] Ground-water data and evaluations are presented in the series, "Radiological Status of the Ground Water Beneath the Hanford Project for . . ." The latest is numbered PNL-2624 and is for 1977.[3]

## ATMOSPHERIC MONITORING

During 1977, air samples were taken at the onsite, perimeter, and distant locations shown in Figures 1 and 2. (Detailed maps showing specific locations of the sampling stations around the operating areas are contained in the Appendix.) Each air sampler draws air at a flow rate of 1.5 $ft^3$/min (2.5 $m^3$/hr) through a particulate filter (Hollingsworth and Vose Company, HV-70) and a 2-in.-long (5.5 cm) by 1.5-in.-diameter (4.4 cm) charcoal cartridge (Nuclear Consulting Services, NUSORB KITEG 1016). Both of these sampling media have been tested at a collection efficiency of greater than 99%. The particulate filters were collected biweekly, and after a wait of 7 days to allow the short-lived radon and thoron daughters to decay, they were analyzed for gross beta and alpha activity. Once a month the filters were grouped according to geographical location and analyzed by gamma spectrometry. On a quarterly frequency, the filters from each geographical location were dissolved and analyzed for $^{90}Sr$ and plutonium.

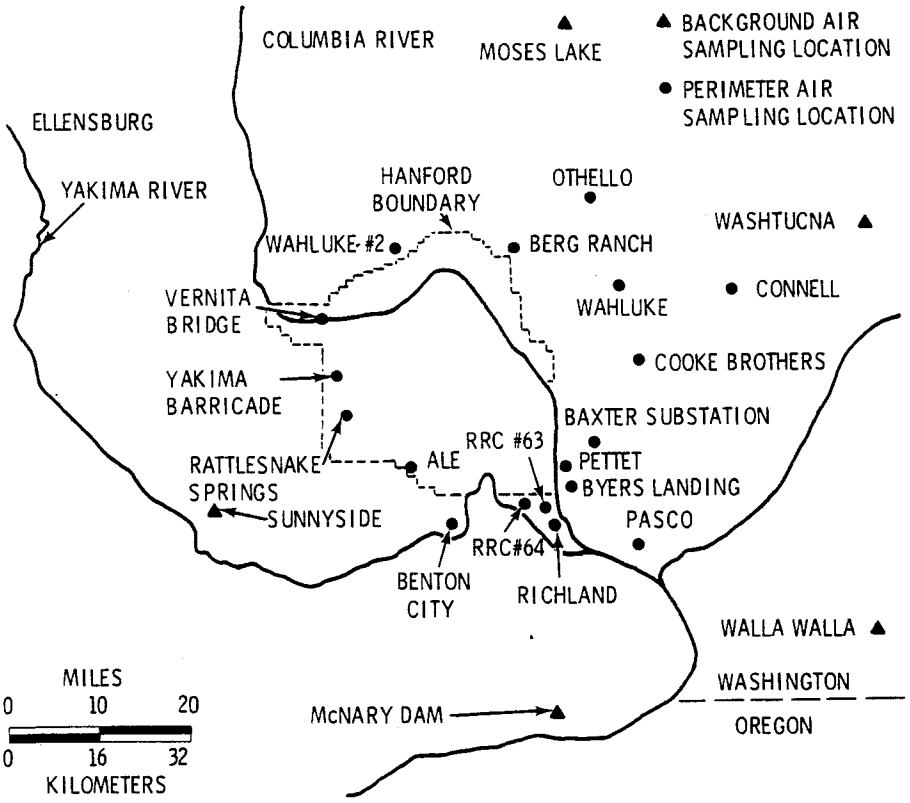



FIGURE 1. Hanford Environmental Air-Sampling Locations During 1977

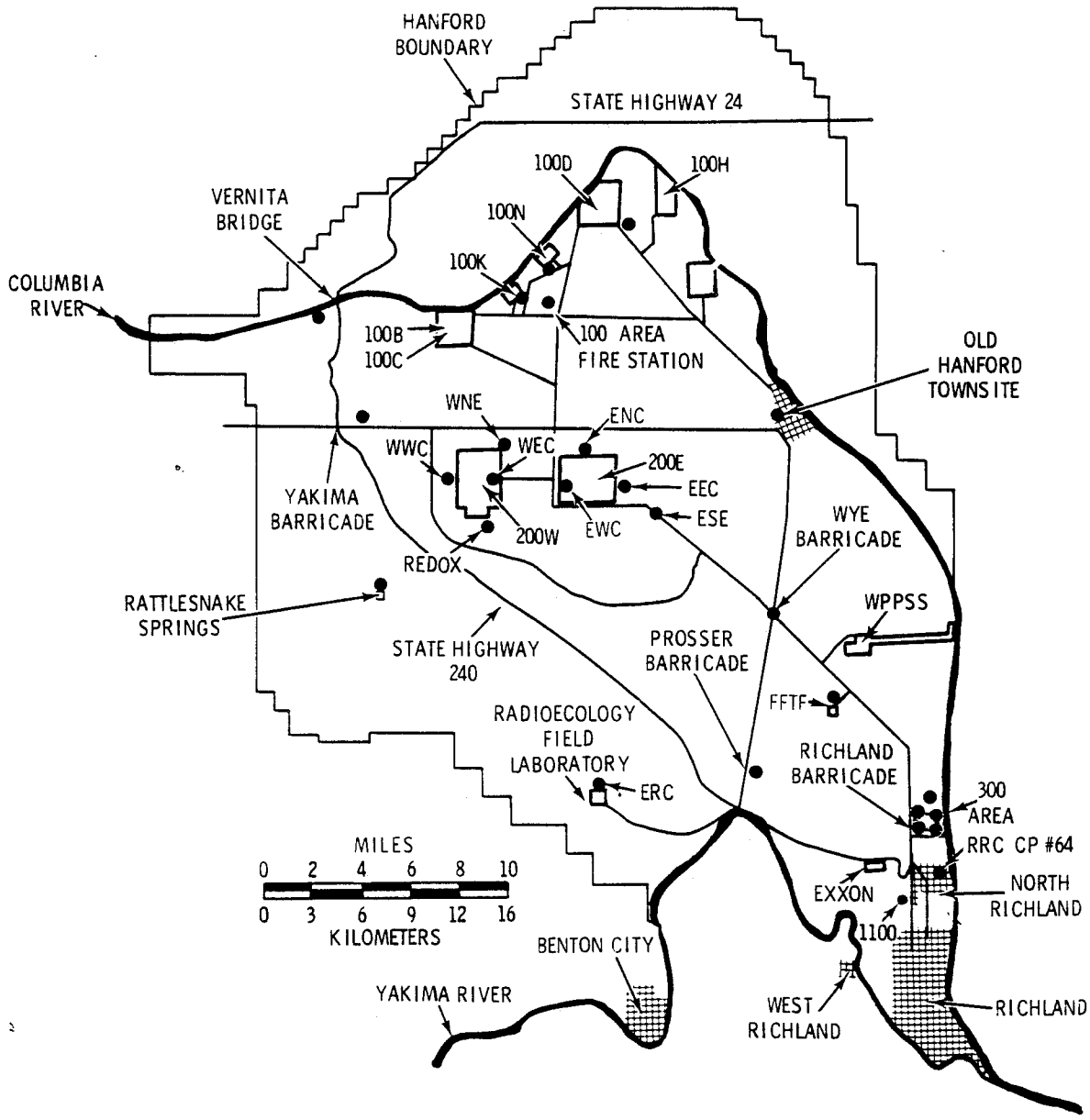



FIGURE 2. Onsite and North Richland Air-Sampling Locations During 1977

At a few selected locations, transparent cartridges 10 in. (25 cm) in length by 2 in. (5 cm) in diameter and containing indicating silica gel were used to collect water vapor in air during biweekly sampling periods. These cartridges were analyzed for tritium (HTO). The samples were collected by passing a portion of the air, which was drawn through the particulate filter and charcoal cartridge at a rate of 0.21 $ft^3$/hr (100 $cm^3$/min), through the silica gel. Listed in Table 1 are all of the air-sampling locations, the sample media collected and analyzed, and the composite groups in which the samples were placed.

## GROSS ALPHA, GROSS BETA, AND $^{131}I$ ACTIVITY

Shown in Figure 3 are the annual patterns of gross beta-emitter activity for the years 1973-1977. Concentrations of beta-emitting radionuclides at eastern quadrant stations (usually downwind from Hanford) were compared with concentrations at onsite and distant stations. The distant stations

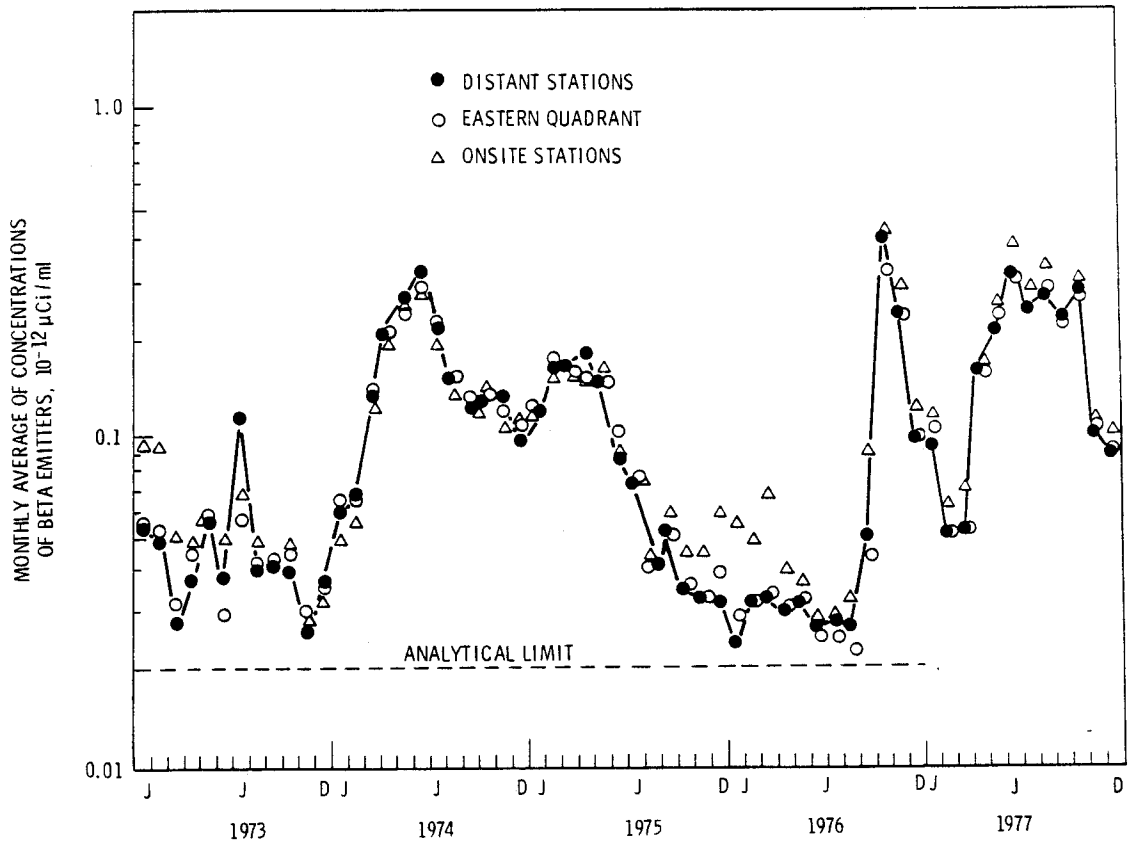



FIGURE 3. Monthly Average Gross Beta-Emitter Activity in the Atmosphere

# TABLE 1. Hanford Air-Sampling Network for 1977

| Location | Frequency[a] Charcoal | Silica Gel | Composite Group: Onsite Area Comp 1 | 2E | 2W | 3 | Inner Quadrant NE | E | SE | SW | NW | Outer Quadrant NE | SE | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Onsite** | | | | | | | | | | | | | | |
| 200 ENC | M (NRA) | | | * | | | | | | | | | | |
| 200 ESE | BW | BW | | * | | | | | | | | | | |
| 200 EWC | M (NRA) | | | * | | | | | | | | | | |
| 200 EEC | M (NRA) | | | * | | | | | | | | | | |
| 200 WEC | M (NRA) | | | | * | | | | | | | | | |
| Redox | M (NRA) | | | | * | | | | | | | | | |
| 200 WWC | M (NRA) | | | | * | | | | | | | | | |
| 200 WNE | M (NRA) | | | | * | | | | | | | | | |
| 3705 Bldg. | M (NRA) | | | | | * | | | | | | | | |
| ACRMS[b] | M (NRA) | | | | | * | | | | | | | | |
| 300 Pond | M (NRA) | | | | | * | | | | | | | | |
| 300 SW Gate | BW | | | | | * | | | | | | | | |
| 300 South Gate | M (NRA) | | | | | * | | | | | | | | |
| Prosser Barr. | M (NRA) | | | | | | | | | * | | | | |
| 100K | M (NRA) | | * | | | | | | | | | | | |
| 100-N | M (NRA) | | * | | | | | | | | | | | |
| 100-D | BW | BW | * | | | | | | | | | | | |
| 100-F | M (NRA) | | * | | | | | | | | | | | |
| 100 Fire Stn. | M (NRA) | | * | | | | | | | | | | | |
| Hanford | M (NRA) | | | | | | | * | | | | | | |
| FFTF[c] | BW | | | | | | | * | | | | | | |
| Wye Barr. | M (NRA) | | | | | | | * | | | | | | |
| **Perimeter** | | | | | | | | | | | | | | |
| Pasco | M (NRA) | | | | | | | | * | | | | | |
| Richland | BW | BW | | | | | | | * | | | | | |
| Benton City | BW | | | | | | | | | * | | | | |
| Vernita | M (NRA) | | | | | | | | | | * | | | |
| Berg Ranch | M (NRA) | | | | | | * | | | | | | | |
| Rattlesnake Springs | M (NRA) | | | | | | | | | * | | | | |
| ERC[d] | M (NRA) | | | | | | | | | * | | | | |
| Yakima Barr. | M (NRA) | | | | | | | | | | * | | | |
| Wahluke #2 | M (NRA) | | | | | | | | | | * | | | |
| Wahluke Wm. | M (NRA) | | | | | | * | | | | | | | |
| Cooke Bros. | M (NRA) | | | | | | * | | | | | | | |
| Baxter Sub. | BW | BW | | | | | | | * | | | | | |
| Byers Landing | BW | | | | | | | | * | | | | | |
| Pettett | BW | | | | | | | | * | | | | | |
| Othello | M (NRA) | | | | | | * | | | | | | | |
| Connell | M (NRA) | | | | | | * | | | | | | | |
| C.P. #63 | M (NRA) | | | | | | | | | | | | | |
| C.P. #64 | M (NRA) | | | | | | | | | | | | | |
| **Distant** | | | | | | | | | | | | | | |
| Walla Walla | M (NRA) | | | | | | | | | | | | * | |
| McNary | M (NRA) | | | | | | | | | | | | * | |
| Sunnyside | BW | | | | | | | | | | | | | * |
| Moses Lake | M (NRA) | | | | | | | | | | | * | | |
| Washtucna | M (NRA) | | | | | | | | | | | * | | |

[a] Frequency of sample collection: BW-biweekly, M-monthly. All analyses by United States Testing except NRA (not routinely analyzed).

[b] Automatic Columbia River Monitoring Station.

[c] Fast-Flux Test Facility

[d] Emergency Relocation Center

are sufficiently remote from Hanford operations that observed radionuclide concentrations can be assumed to be due to natural causes or to worldwide fallout. During 1977, the maximum concentrations of airborne beta-emitting radionuclides were observed during the summer months. This finding was attributed to residual fission products from past atmospheric nuclear tests re-entering the trophosphere. This increase in airborne radioactivity masked the airborne concentrations of fission products recorded following the Chinese nuclear test on September 17, 1977, when only slight increases over the ambient levels were noted.

Average concentrations of gross beta emitters (shown in Figure 3) for onsite locations, primarily around the 200 Areas, were higher than those at perimeter and distant locations. These higher concentrations were attributed to $^{137}Cs$, which was released in these areas.

Shown in Table 2 are the results of gross beta, gross alpha, and $^{131}I$ analyses for all of the sampling locations. The average beta-emitter concentrations during 1977 at perimeter and distant stations were $0.19 \times 10^{-12}$ $\mu Ci/ml$ and $0.18 \times 10^{-12}$ $\mu Ci/ml$, respectively, indicating no statistical difference between perimeter and distant locations. The average beta-emitter concentrations for onsite locations were slightly higher than those for perimeter and distant locations ($0.20 \times 10^{-12}$ $\mu Ci/ml$). Analysis for gross alpha-emitter concentrations in the atmosphere during 1977 was performed on filters obtained from 9 of the 26 onsite sampling stations, and 4 of the 13 perimeter sampling stations. The results were similar at all locations, averaging $0.001 \times 10^{-12}$ $\mu Ci/ml$. These results were attributed to naturally occurring radionuclides in the air.

During 1977, biweekly analysis for $^{131}I$ concentrations in the atmosphere was performed for three of the onsite and four of the perimeter sampling stations; samplers at all other stations were analyzed monthly. Although charcoal cartridges were located at all onsite, perimeter, and distant sampling stations, the majority were not analyzed. Instead, the cartridges were available to provide samples for analysis if there had been any indication that iodine was present in the atmosphere. No air concentrations of $^{131}I$ in excess of the detection limit were noted during 1977.

# TABLE 2. Radioactivity in Air During 1977

| | Concentration in Units of $10^{-12}$ µCi/ml[a] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gross Beta | | | | Gross Alpha[b] | | | | $^{131}I$ | | | |
| Location | No. of Samples | Max. | Min. | Average | No. of Samples | Max. | Min. | Average | No. of Samples | Max. | Min. | Average |
| **Onsite Stations** | | | | | | | | | | | | |
| 100K | 26 | 0.45 | 0.04 | 0.20±0.25 | | | | | | | | |
| 100N - WPPSS | 21 | 0.35 | 0.04 | 0.19±0.20 | | | | | | | | |
| 100D | 25 | 0.40 | 0.04 | 0.18±0.22 | | | | | 25 | * | * | * |
| 100F | 9 | 0.38 | 0.04 | 0.12±0.21 | | | | | | | | |
| 100 Area Fire Station | 26 | 0.46 | 0.04 | 0.21±0.26 | | | | | | | | |
| Hanford | 26 | 0.45 | 0.04 | 0.21±0.24 | | | | | | | | |
| 200 ENC | 26 | 0.47 | 0.02 | 0.19±0.25 | 25 | 0.011 | 0.0004 | 0.001±0.004 | | | | |
| 200 ESE | 25 | 0.48 | 0.04 | 0.20±0.27 | 26 | 0.003 | * | 0.001±0.002 | 26 | * | * | * |
| 200 EEC | 26 | 1.5 | 0.05 | 0.24±0.56 | 26 | 0.003 | * | 0.002±0.001 | | | | |
| 200 EWC | 25 | 0.51 | 0.04 | 0.21±0.27 | | | | | | | | |
| 200 WNE | 25 | 0.41 | 0.06 | 0.21±0.23 | | | | | | | | |
| 200 WEC | 25 | 0.41 | 0.05 | 0.20±0.21 | 25 | 0.003 | * | 0.001±0.001 | | | | |
| 200 WWC | 24 | 0.78 | 0.01 | 0.26±0.40 | | | | | | | | |
| Redox | 25 | 0.47 | 0.04 | 0.21±0.25 | 24 | 0.004 | * | 0.001±0.002 | | | | |
| FFTF[c] | 18 | 0.38 | 0.09 | 0.23±0.20 | 18 | 0.002 | 0.0009 | 0.001±0.001 | 15 | * | * | * |
| Wye Barricade | 26 | 0.38 | 0.03 | 0.18±0.21 | 26 | 0.005 | * | 0.001±0.002 | | | | |
| 300 Pond | 25 | 0.79 | 0.03 | 0.21±0.33 | | | | | | | | |
| 300 SW Gate | 26 | 0.44 | 0.04 | 0.19±0.23 | | | | | 26 | * | * | * |
| 300 South Gate | 26 | 0.43 | 0.03 | 0.20±0.24 | 26 | 0.002 | 0.0006 | 0.002±0.001 | | | | |
| 3705 Bldg. | 26 | 0.47 | 0.03 | 0.21±0.25 | | | | | | | | |
| ACRMS[d] | 26 | 0.38 | 0.03 | 0.18±0.21 | | | | | | | | |
| Prosser Barricade | 25 | 0.41 | 0.03 | 0.20±0.24 | 26 | 0.004 | * | 0.001±0.002 | | | | |
| | | | | 0.20 | | | | 0.001 | | | | |
| **Perimeter Stations** | | | | | | | | | | | | |
| Rattlesnake Springs | 21 | 0.42 | 0.03 | 0.19±0.23 | | | | | | | | |
| ALE Lab. | 26 | 0.57 | 0.03 | 0.21±0.29 | | | | | | | | |
| Benton City | 23 | 0.59 | 0.03 | 0.14±0.24 | 25 | 0.004 | * | <0.001 | 22 | * | * | * |
| Yakima Barricade | 24 | 0.61 | 0.03 | 0.21±0.27 | | | | | | | | |
| Vernita | 26 | 0.54 | 0.02 | 0.21±0.27 | | | | | | | | |
| Wahluke #2 | 25 | 0.42 | 0.03 | 0.21±0.25 | | | | | | | | |
| Othello | 23 | 0.35 | 0.02 | 0.13±0.16 | | | | | | | | |
| Connell | 26 | 0.49 | 0.04 | 0.22±0.27 | | | | | | | | |
| Berg Ranch | 26 | 0.51 | 0.03 | 0.22±0.26 | 26 | 0.005 | 0.0007 | 0.002±0.002 | | | | |
| Wahluke Watermaster | 26 | 0.40 | 0.03 | 0.19±0.23 | | | | | | | | |
| Cooke Bros. | 24 | 0.31 | 0.03 | 0.15±0.19 | | | | | | | | |
| Richland | 25 | 0.42 | 0.03 | 0.19±0.24 | 25 | 0.002 | 0.0007 | 0.001±0.001 | 24 | * | * | * |
| Pasco | 24 | 0.37 | 0.03 | 0.18±0.19 | | | | | | | | |
| Byers Landing | 25 | 0.41 | 0.04 | 0.19±0.23 | 25 | 0.004 | 0.0006 | 0.002±0.001 | 24 | * | * | * |
| Baxter Substation | 24 | 0.47 | 0.02 | 0.18±0.25 | | | | | 25 | * | * | * |
| Pettett Farm | 18 | 0.37 | 0.08 | 0.21±0.17 | | | | | 17 | * | * | * |
| RRC CP #63 | 24 | 0.37 | 0.03 | 0.17±0.20 | 24 | 0.004 | 0.0005 | 0.001±0.002 | | | | |
| RRC CP #64 | 22 | 0.43 | 0.03 | 0.18±0.22 | | | | | | | | |
| | | | | 0.19 | | | | 0.001 | | | | |
| **Distant Stations** | | | | | | | | | | | | |
| Walla Walla | 24 | 0.47 | 0.03 | 0.21±0.25 | | | | | | | | |
| McNary | 26 | 0.50 | 0.01 | 0.19±0.25 | | | | | | | | |
| Moses Lake | 24 | 0.35 | 0.03 | 0.16±0.20 | | | | | | | | |
| Washtucna | 26 | 0.47 | 0.02 | 0.18±0.25 | | | | | | | | |
| Sunnyside | 22 | 0.36 | 0.05 | 0.17±0.19 | | | | | 14 | * | * | * |
| | | | | 0.18 | | | | | | | | |
| Detection Limit[e] | | 0.005 | | | | 0.003 | | | | 0.002 | | |
| Concentration Guide:[f] | | 100 | | | | 0.02 | | | | 100 | | |

* Less than the detection limit.

[a] $10^{-12}$ µCi/ml = 1 pCi/m$^3$. Average ± two standard deviations is shown if all analyses were positive. Otherwise, a less-than- detectable value was calculated from all results, assuming that all less-than-detectable results were equal to the detection limit for the analysis.

[b] Gross alpha activity does not include any significant contribution due to naturally-occurring radon and short-lived daughters in the air. The filters are held 7 days before analysis to allow radioactive decay of these radionuclides.

[c] Fast-Flux Test Facility.

[d] Automatic Columbia River Monitoring Station.

[e] The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

[f] Manual Chapter 0524 standards only apply to concentrations of radioactivity in excess of that due to naturally occurring or fallout radioactivity.

## HTO CONCENTRATIONS

Airborne tritiated water vapor (HTO) was sampled at two onsite and two perimeter locations during 1977. The biweekly results are shown in Figure 4. Since there were no apparent geographical patterns, the observed concentrations were attributed to worldwide fallout. The approximate average air concentration of $5 \times 10^{-12}$ µCi/ml during 1977 was less than 0.003% of the most restrictive Manual Chapter 0524 concentration guide for HTO in air.

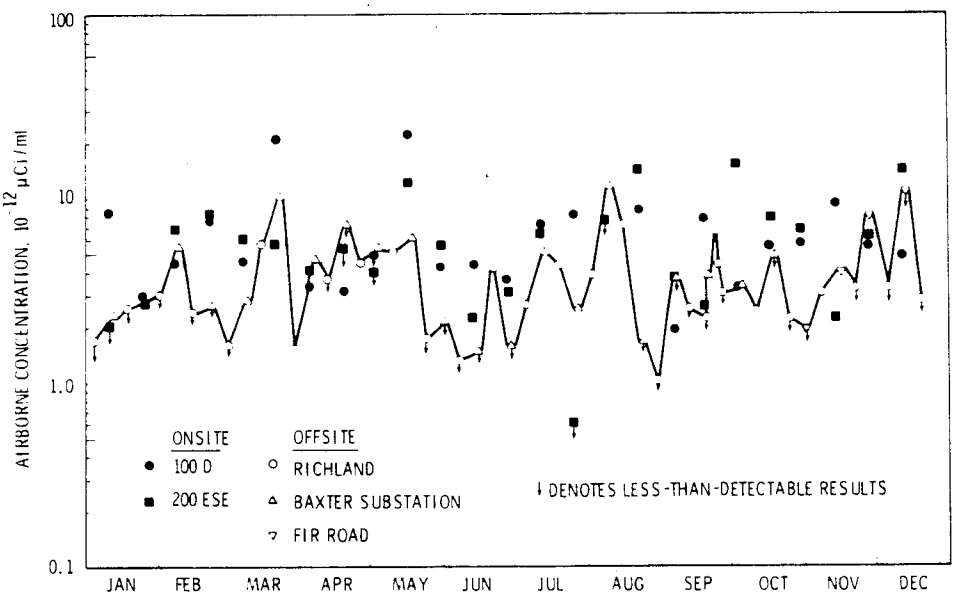



FIGURE 4. Tritiated Water Vapor Concentrations During 1977

## SPECIFIC RADIONUCLIDE CONCENTRATIONS

Figure 5 shows the results of specific radionuclide analyses of each of the 12 filter composite groups shown in Table 1. The analyses were done on a monthly and quarterly basis. All radionuclides shown, except for plutonium, are fission or activation products that resulted from worldwide fallout and, possibly, from Hanford operations. A comparison of the concentrations observed at onsite stations with those observed at perimeter or distant stations revealed the portion of each radionuclide concentration attributable to Hanford.

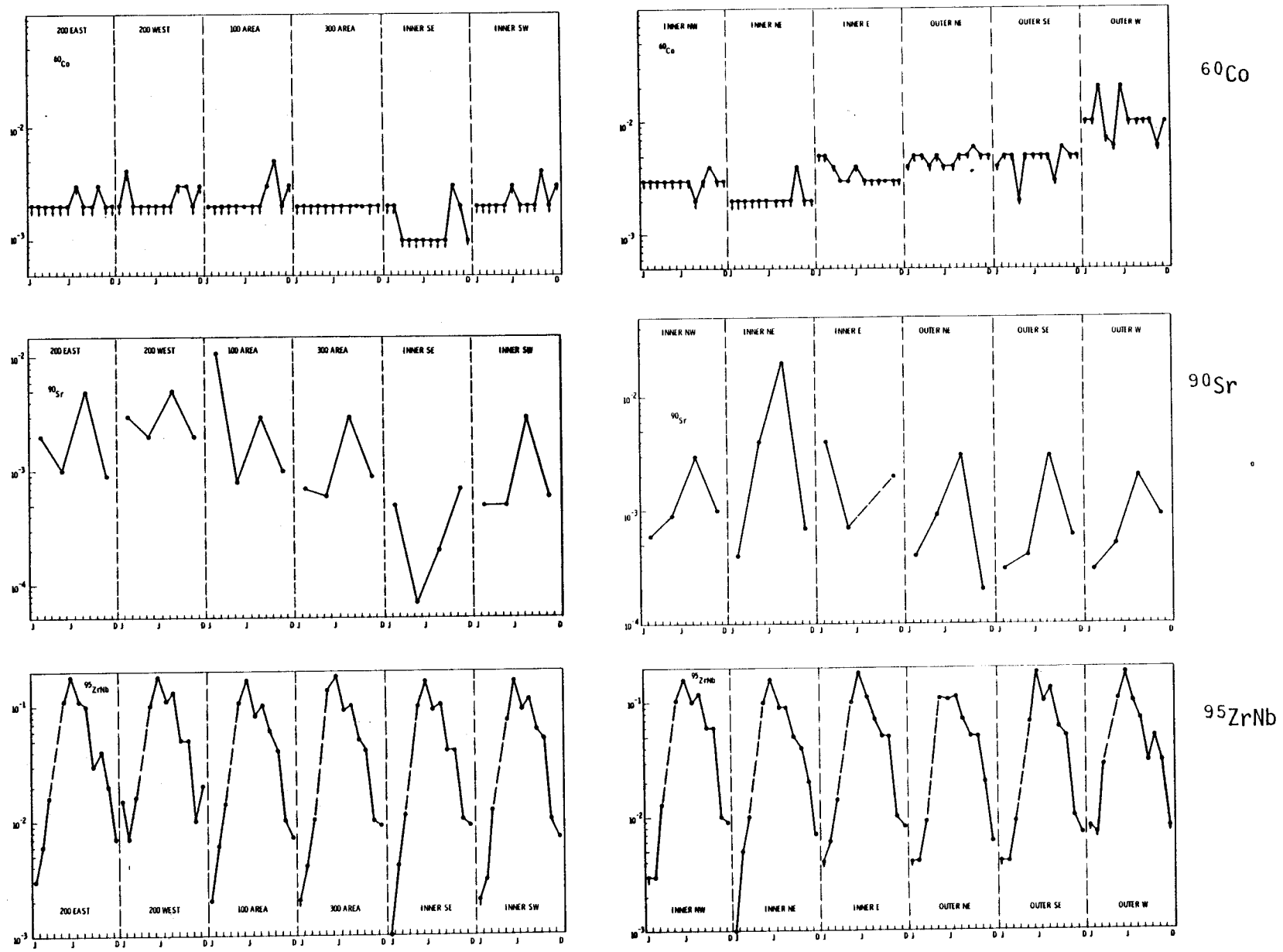



FIGURE 5. Radionuclide Concentrations in Air by Composite Group During 1977 (Arrow denotes less-than-detectable result.)

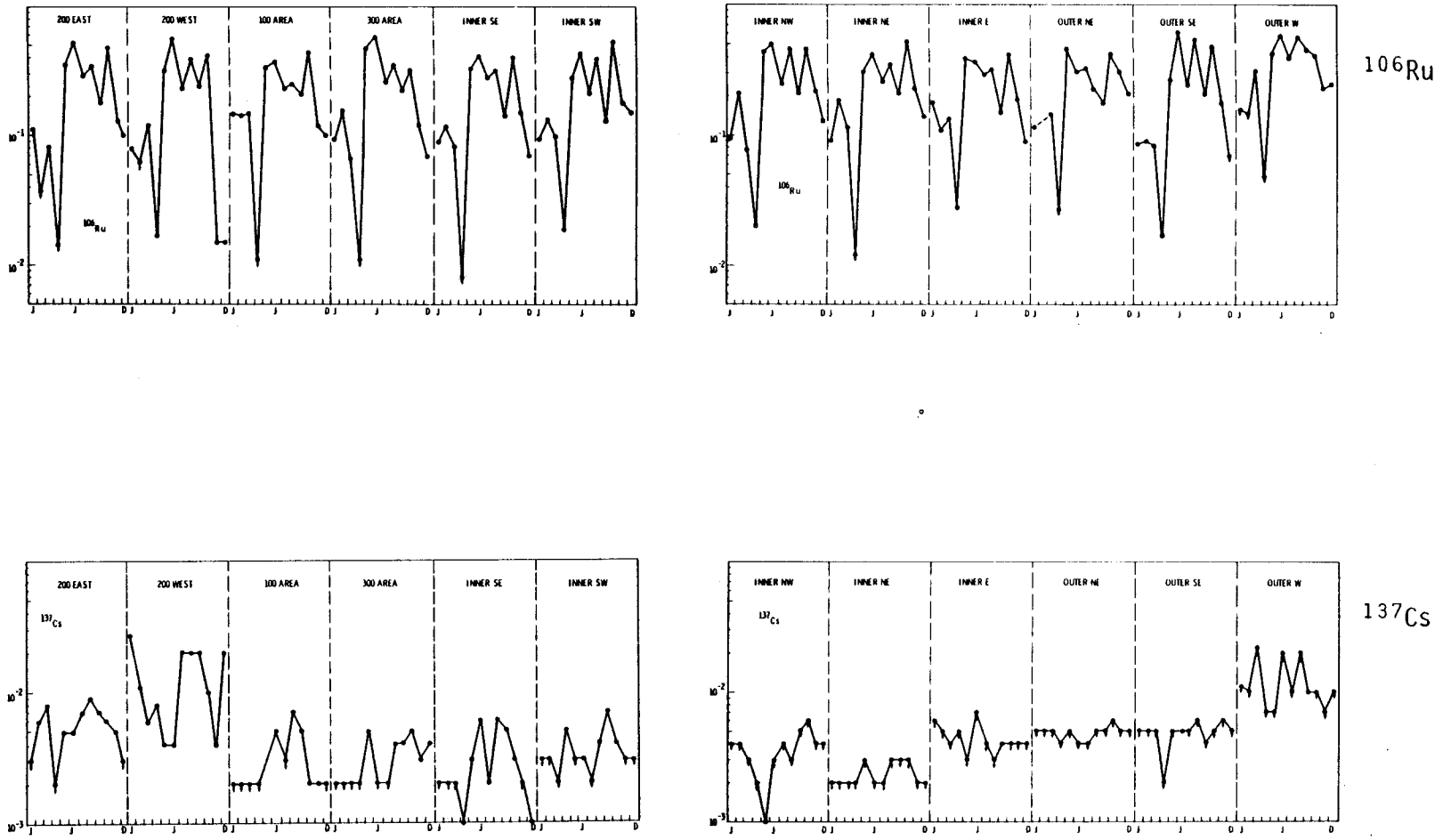
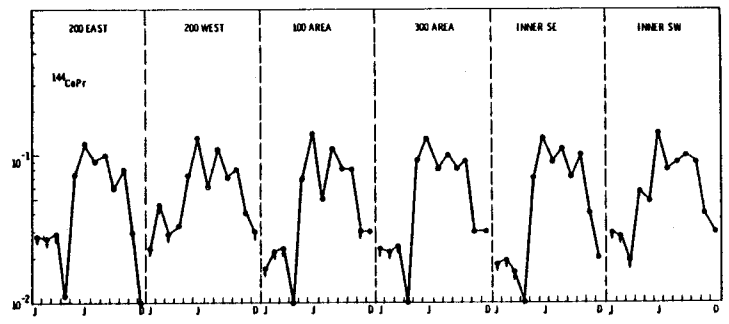
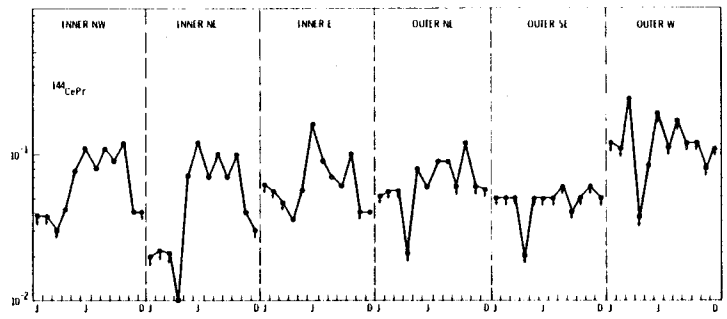
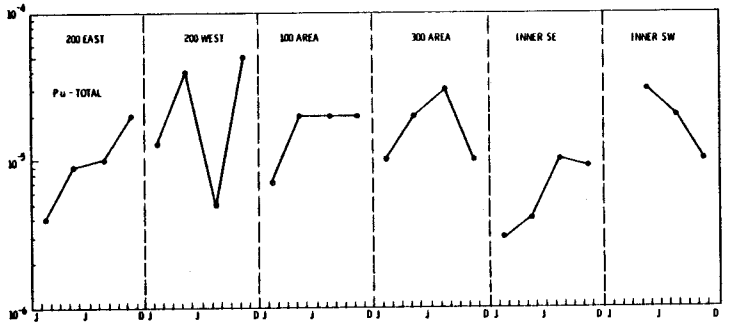


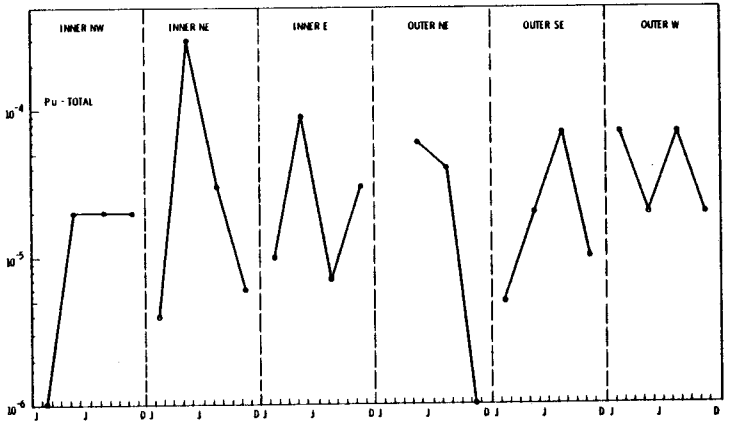

FIGURE 5. Radionuclide Concentrations in Air by Composite Group During 1977 (Arrow denotes less-than-detectable result.)




144CePr




Pu

FIGURE 5. Radionuclide Concentrations in Air by Composite Group During 1977 (Arrow denotes less-than-detectable result.)

The annual pattern of concentrations of the various radionuclides was generally similar for each composite group. Concentrations of $^{90}Sr$, $^{95}Zr$-Nb, $^{106}Ru$, and $^{144}Ce$-Pr all increased sharply in the spring of the year and were attributed to fission products of recent nuclear tests, which were re-entering the troposphere. Hanford operations in the 200 Areas were responsible for the slightly higher concentrations of $^{137}Cs$ observed in the 200 East and 200 West filter composites, as compared with recent concentrations in other areas.

Radionuclide concentrations at perimeter and distant sampling stations were similar, implying no distinguishable offsite impact from Hanford operations, even though $^{137}Cs$ was observed at higher concentrations onsite, around the 200 Areas. In Table 3, the maximum observed concentration for each radionuclide in any composite group is compared with the Manual Chapter 0524 concentration guide. In all cases, the observed values are a small fraction of the values in the guides.

TABLE 3. Maximum Concentrations of Selected Radionuclides in Air During 1977

| | Concentration in Units of $10^{-12}$ $\mu Ci/ml$[a] | | |
|---|---|---|---|
| Radionuclide | Maximum Observed | Concentration Guide[b] | Maximum Composite Group Location |
| $^{60}Co$ | 0.02 | 300 | Outer W |
| $^{90}Sr$ | 0.02 | 30 | Inner NE |
| $^{95}ZrNb$ | 0.18 | 3,000 | 200-W |
| $^{106}Ru$ | 0.61 | 200 | Outer SE |
| $^{137}Cs$ | 0.03 | 500 | 200-W |
| $^{144}CePr$ | 0.25 | 200 | Outer W |
| Pu-Total | $3 \times 10^{-4}$ | 0.06[c] | Inner NE |

[a] $10^{-12}$ $\mu Ci/ml = 1$ $pCi/m^3$.

[b] Most restrictive Manual Chapter 0524 concentration guide for uncontrolled areas.

[c] Concentration guide for $^{239}Pu$.

## COLUMBIA RIVER MONITORING

Columbia River water was sampled upstream (at Priest Rapids Dam, Vernita Bridge, and the 100-B Area) and downstream (at the Hanford powerline, the 300 Area forebay, and the Richland pumping dock) for radiological, chemical, physical, and/or biological analyses. The majority of the information on Columbia River sampling has been presented and evaluated in the 1977 environmental surveillance report.[2] Discussed here is more specific information regarding the sample collection and analysis procedures.

Analyses for $^{3}H$, U, and $^{90}Sr$ in Columbia River water were done on integrated water samples obtained at the 100-B Area and in Richland. Samples were collected weekly, but composited and analyzed monthly. Gamma-emitting radionuclides were measured every 2 weeks on both the filters and the resin column from the filter-resin samplers at Priest Rapids Dam and the 300 Area forebay.[4] Iodine-129 was measured every 4 weeks on an aliquot of the monthly composite of the resin, using neutron activation analysis.[5] On a quarterly frequency, a specific analysis for total plutonium was done on a composite of the biweekly filter and resin samples. Summaries of the data resulting from these analyses were presented in the environmental surveillance report.[2]

In Figure 6, concentrations of soluble radionuclides collected from the resin at Priest Rapids Dam are compared with those from the 300 Area forebay. The $^{40}K$ is a naturally occurring radionuclide, whereas the other radionuclides result from fallout from past atmospheric nuclear detonations and, at the downstream location, from Hanford operations. Within the variability observed in the measurements, the only obvious Hanford contributions were those for $^{60}Co$ and $^{129}I$. The $^{60}Co$ concentrations were due to routine low-level releases from N-Reactor throughout the year and residual $^{60}Co$ in river sediments. The $^{129}I$ concentrations were also attributable to routine low-level releases from N-Reactor.[6]

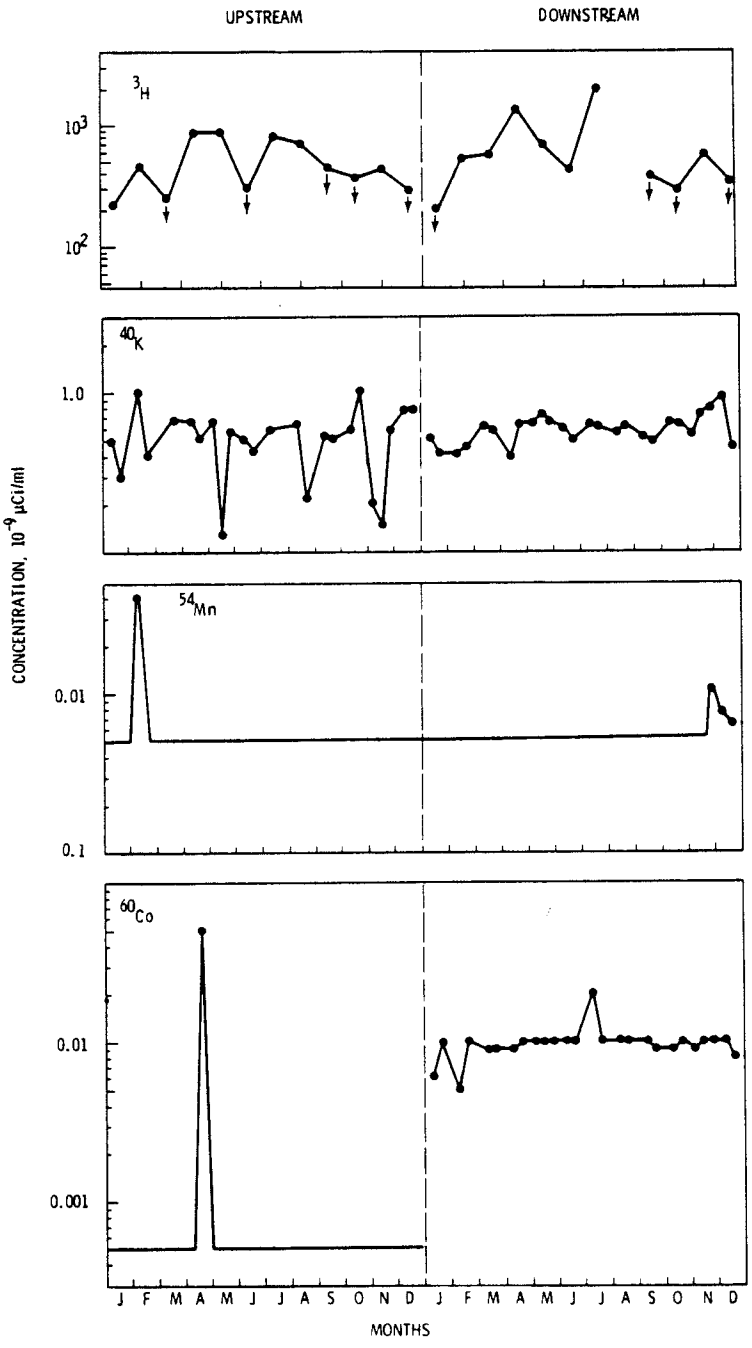



FIGURE 6. Radionuclide Concentrations in Columbia River Water During 1977

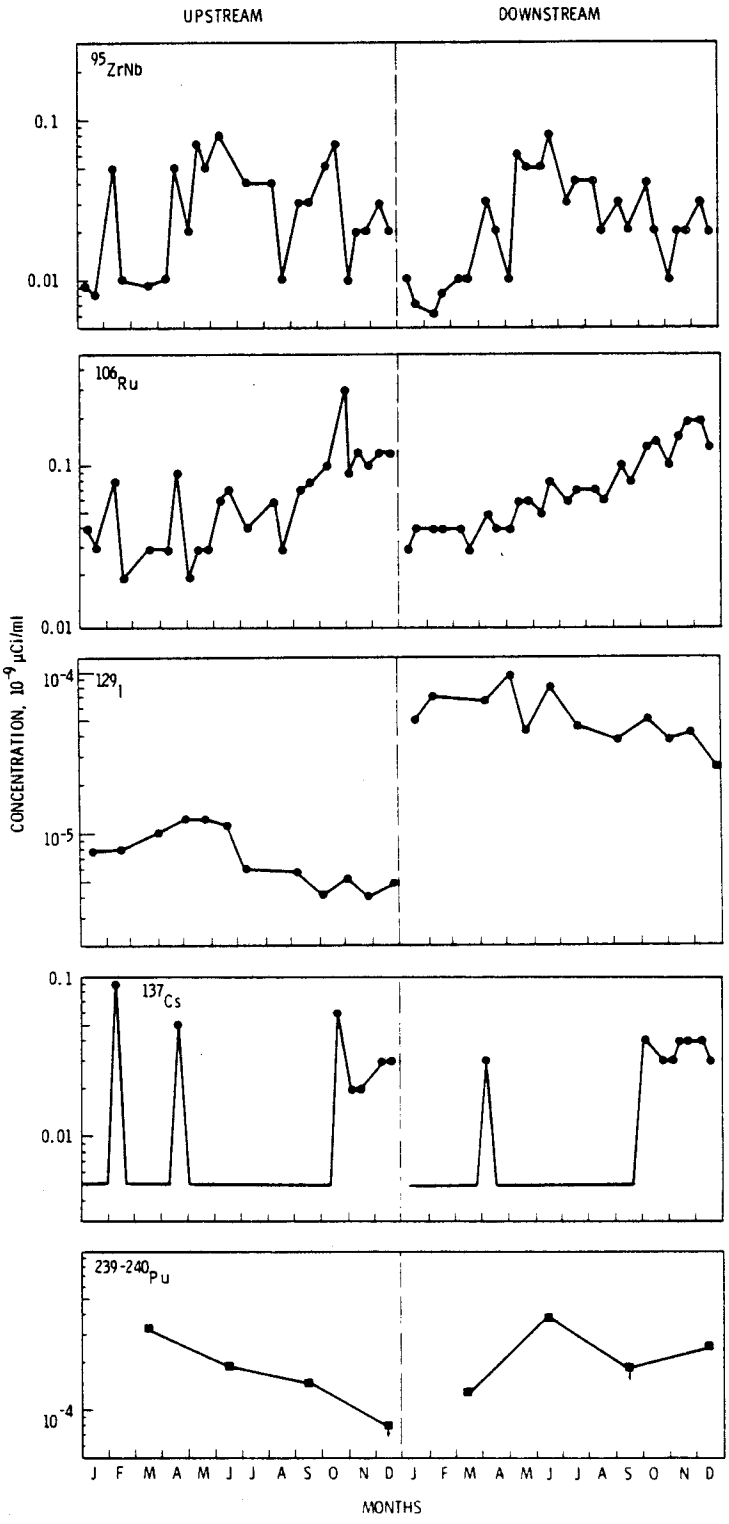



FIGURE 6. Radionuclide Concentrations in Columbia River Water During 1977 (Arrow denotes less-than-detectable result.)

## DITCHES, PONDS, AND TRENCHES

Surface water that has accumulated on the Hanford Site as a result of the disposal of process water was sampled routinely in 1977. Grab samples were collected and analyzed for gross beta and gross alpha activity, and for gamma-emitting radionuclides. In some instances, specific analyses for $^{90}Sr$, uranium, and plutonium were done. The locations of the major ditches, ponds, and trenches sampled on the Hanford Site during 1977 are shown in Figure 7.

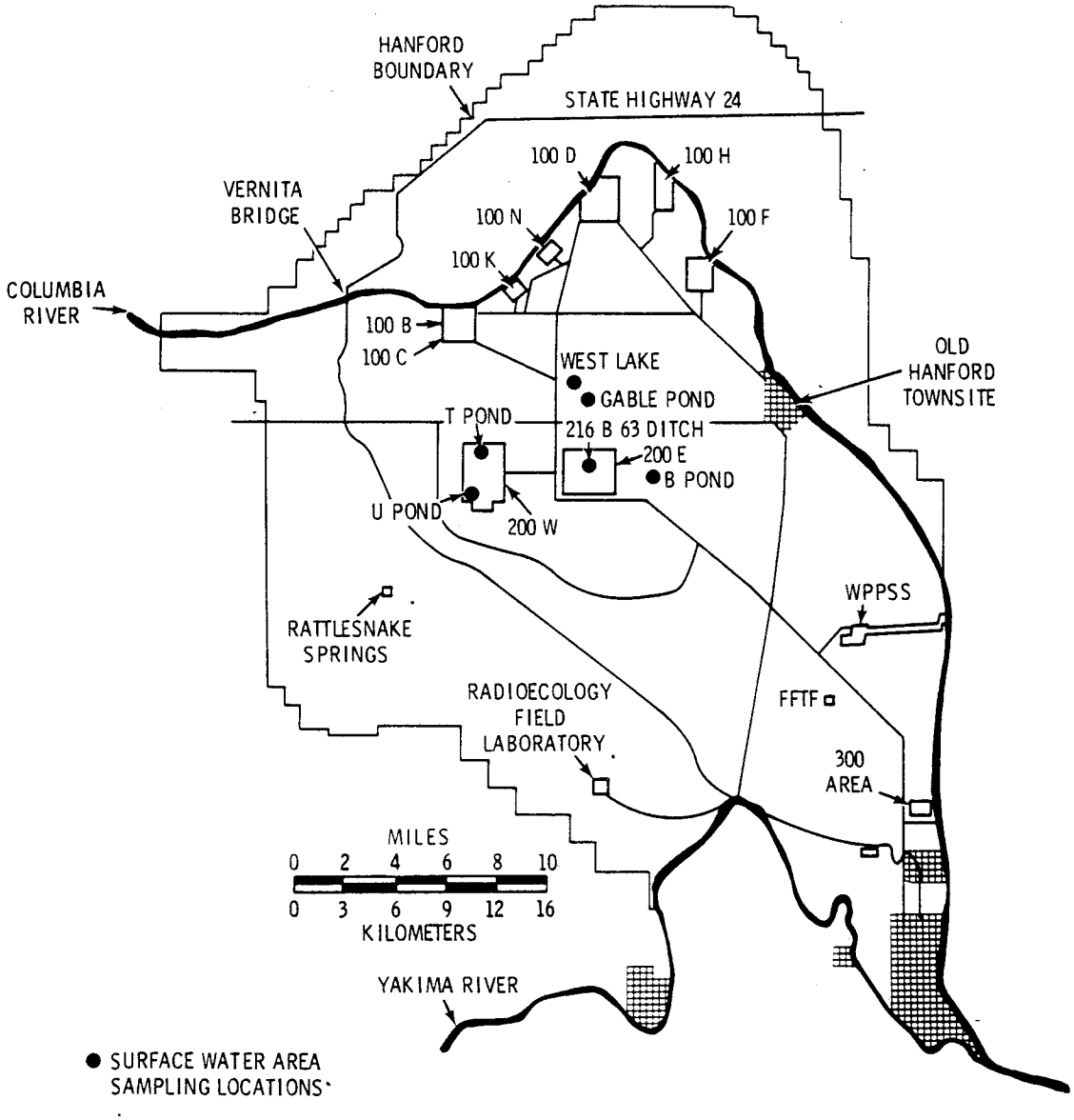



FIGURE 7. Surface Water Areas Sampled During 1977

The results of the analyses for gross beta and gross alpha activity and for $^{90}Sr$ for all 200 Area and vicinity surface waters are shown in Figures 8 through 10. West Lake, a naturally occurring water-table intersection pond, which also serves as a natural basin for a relatively large watershed area, generally had the highest levels of gross beta and gross alpha activity. No waste water is discharged directly into West Lake. A possible cause of the relatively high concentrations of radionuclides in this water body is the concentrating effect of continual evaporation of water from the pond. The radionuclides that have accumulated in the pond are uranium and $^{90}Sr$. Uranium (accounting for the gross alpha activity) may have been eroding from the soil during the entire history of West Lake's existence, and the presence of $^{90}Sr$ is probably due to worldwide fallout in rainwater. By contrast, the waste discharged to the other ponds has been diluted with river water containing relatively low concentrations of $^{90}Sr$ and uranium.

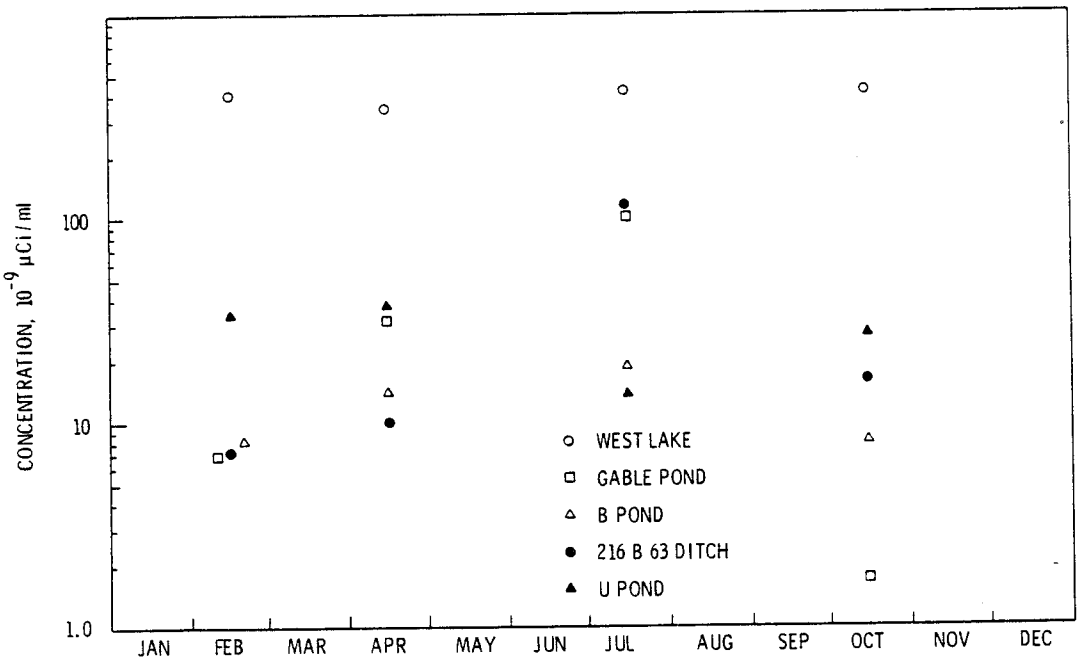



FIGURE 8. Gross Beta-Emitter Activities Observed in 200 Area Ponds During 1977

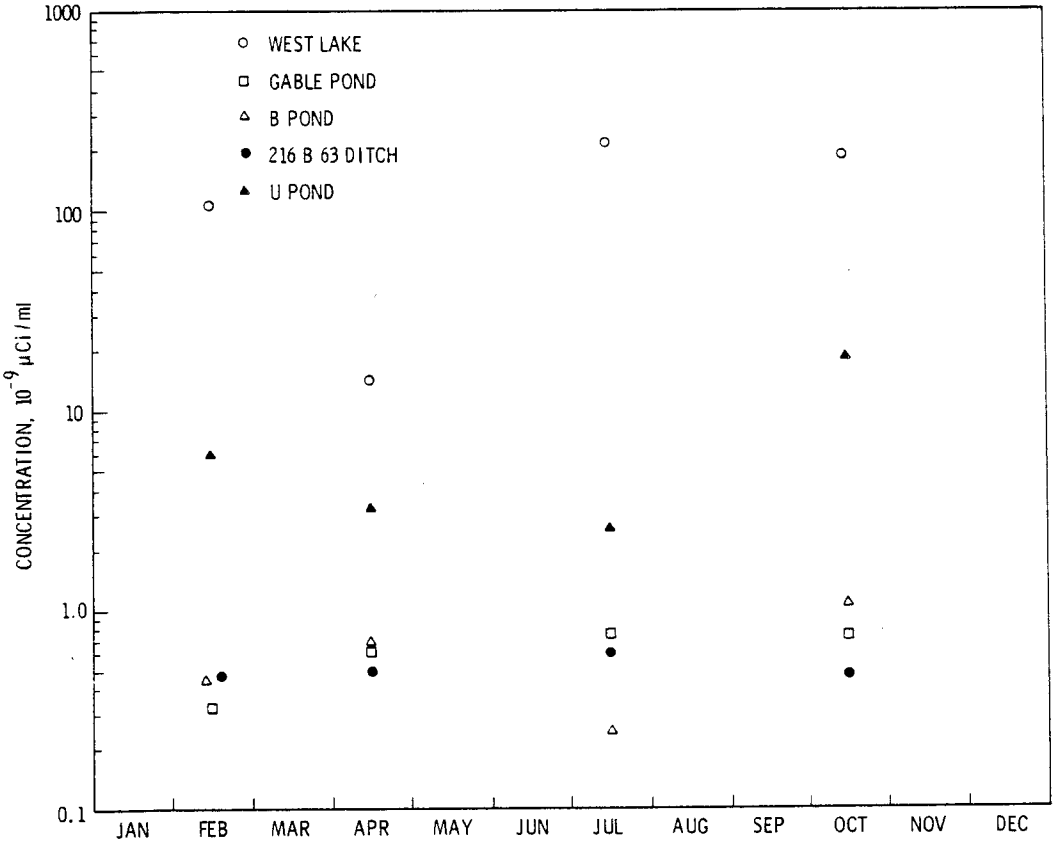



FIGURE 9. Gross Alpha-Emitter Activities Observed in 200 Area Ponds During 1977

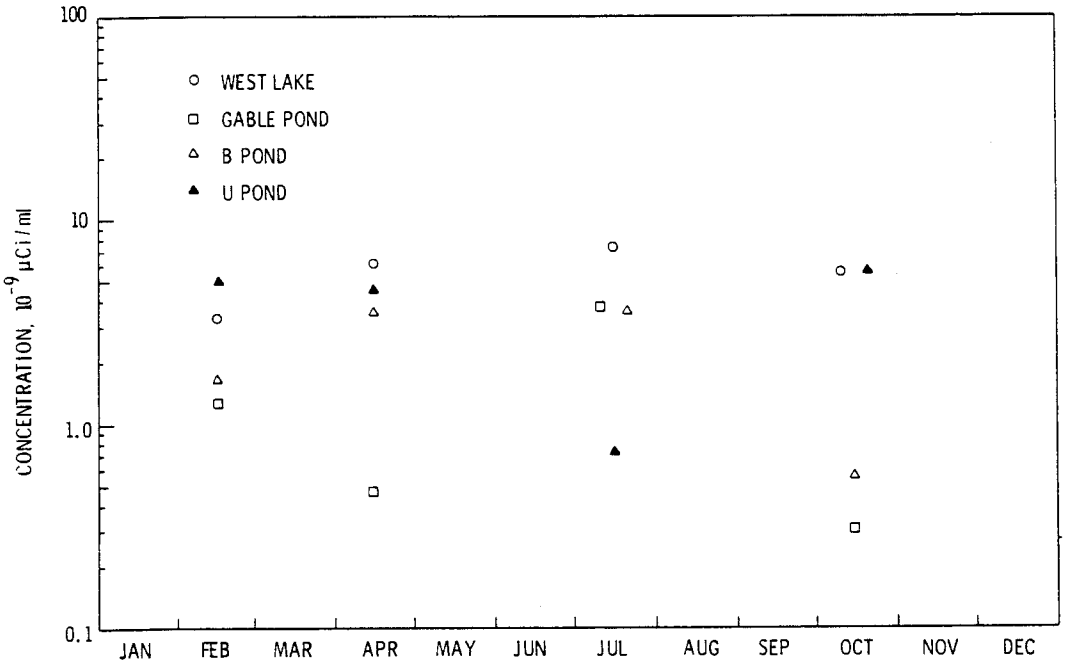



FIGURE 10. Strontium-90 Concentrations Observed in 200 Area Ponds During 1977

Presented in Table 4 is a summary of replicate sampling from U Pond during June of 1977. These samples were collected, from a rowboat, at 10 locations in U Pond. Average concentrations of $5 \times 10^{-9}$ µCi/ml, $2.5 \times 10^{-9}$ µCi/ml, and $1.5 \times 10^{-9}$ µCi/ml for $^{90}Sr$, U, and $^{239}Pu$, respectively, were observed. By contrast, the Columbia River concentrations of these nuclides were approximately $0.3 \times 10^{-9}$ µCi/ml, $0.6 \times 10^{-9}$ µCi/ml, and $<0.0002 \times 10^{-9}$ µCi/ml, respectively.(2)

The results of gamma spectroscopy and $^{90}Sr$ analyses of pond-water samples are shown in Table 5. Cesium-137 was detected in Gable Pond, B Pond, and U Pond, and $^{90}Sr$ was detected in all pond samples that were analyzed. Except for some sporadic $^{95}Zr$-Nb concentrations at Gable Pond and U Pond, all other radionuclides, if present, were at less-than-detectable concentrations.

TABLE 4. U Pond Replicate Sampling During 1977

| | Concentration in Units of $10^{-12}$ µCi/ml(a) | | | | |
|---|---|---|---|---|---|
| Sample # | Alpha | Beta | $^{90}Sr$ | U | $^{239}Pu$ |
| 1 | 7.1 ± 1.5 | 45 ± 5.4 | 5.5 ± 0.10 | 3.1 ± 0.5 | 3.9 ± 0.63 |
| 2 | 6.2 ± 1.1 | 41 ± 5.4 | 7.3 ± 0.12 | 2.6 ± 0.5 | 1.7 ± 0.35 |
| 3 | 3.7 ± 0.89 | 56 ± 6.4 | 5.4 ± 0.10 | 2.0 ± 0.5 | 2.2 ± 0.48 |
| 4 | 4.7 ± 0.70 | 38 ± 5.3 | 5.0 ± 0.10 | 2.2 ± 0.5 | 2.0 ± 0.46 |
| 5 | 6.1 ± 1.4 | 41 ± 5.4 | 3.6 ± 0.10 | 2.5 ± 0.5 | 0.58 ± 0.06 |
| 6 | 9.5 ± 1.7 | 25 ± 4.2 | 3.0 ± 0.10 | 1.7 ± 0.5 | 1.3 ± 0.13 |
| 7 | 4.3 ± 0.93 | 35 ± 4.9 | 3.5 ± 0.10 | 2.7 ± 0.5 | 0.19 ± 0.02 |
| 8 | 3.6 ± 0.88 | 45 ± 5.4 | 4.7 ± 0.10 | 2.3 ± 0.5 | 1.7 ± 0.44 |
| 9 | 4.8 ± 0.99 | 37 ± 5.1 | 6.0 ± 0.10 | 2.9 ± 0.5 | 0.86 ± 0.10 |
| 10 | 2.5 ± 0.75 | 38 ± 5.3 | 5.5 ± 0.10 | 2.6 ± 0.5 | 0.70 ± 0.07 |
| Average(b) | 5.3 ± 4.1 | 40 ± 16 | 5.0 ± 2.6 | 2.5 ± 0.8 | 1.5 ± 2.1 |

(a) $10^{-12}$ µCi/ml = 1 pCi/ℓ

(b) Average ± two standard deviations shown.

TABLE 5. Radionuclide Concentrations in Surface Water Samples During 1977

| Location | Date | Concentration in Units of $10^{-9}$ µCi/ml[a,b] | | | | | |
|---|---|---|---|---|---|---|---|
| | | $^{51}Cr$ | $^{60}Co$ | $^{65}Zr$ | $^{90}Sr$ | $^{95}ZrNb$ | $^{137}Cs$ |
| West Lake | 2/16 | * | * | * | 3.3 ± 0.3 | * | * |
| | 4/25 | * | * | * | 6.1 ± 0.3 | * | * |
| | 7/18 | * | * | * | 7.3 ± 0.3 | * | * |
| | 10/10 | * | * | * | 5.5 ± 0.3 | * | * |
| Gable Pond | 2/16 | * | * | * | 1.2 ± 0.1 | * | * |
| | 4/25 | * | * | * | 0.46 ± 0.1 | 2.4 ± 1.2 | 20 ± 2.1 |
| | 7/18 | * | * | * | 3.7 ± 0.1 | * | 7.2 ± 2.2 |
| | 10/10 | * | * | * | 0.30 ± 0.1 | * | * |
| B Pond | 2/16 | * | * | * | 1.6 ± 0.1 | * | 2.5 ± 2.1 |
| | 4/25 | * | * | * | 3.4 ± 0.1 | * | 2.3 ± 2.1 |
| | 7/18 | * | * | * | 3.4 ± 0.1 | * | 6.7 ± 2.2 |
| | 10/10 | * | * | * | 0.53 ± 0.1 | * | 2.4 ± 2.2 |
| 216-B-63 Ditch | 2/16 | * | * | * | | * | * |
| | 4/25 | * | * | * | | * | * |
| | 7/18 | * | * | * | | * | * |
| | 10/10 | * | * | * | | * | * |
| U Pond | 2/16 | * | * | * | 4.9 ± 0.2 | * | 14 ± 2.1 |
| | 4/25 | * | * | * | 4.4 ± 0.1 | 1.4 ± 1.2 | 15 ± 2.1 |
| | 7/18 | * | * | * | 0.71 ± 0.1 | * | 6.4 ± 2.2 |
| | 10/10 | * | * | * | 5.4 ± 0.1 | 5.0 ± 1.3 | 16 ± 2.3 |
| T Pond[c] | 2/16 | | | | | | |
| | 4/25 | | | | | | |
| | 7/18 | | | | | | |
| | 10/10 | | | | | | |
| Detection Limit:[d] | | 69 | 4.5 | 8.5 | 0.005 | 4.0 | 7.0 |

* Less than detection limit.

(a) $10^{-9}$ µCi/ml = 1 pCi/ℓ.

(b) A blank indicates that no analysis was made.

(c) T Pond was dry on all sampling dates.

(d) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

## WILDLIFE

The Hanford site serves as a refuge for migratory and resident waterfowl, dry-land game birds, and a variety of mammals. All of these animals have access to swamps, ponds, and trenches on the site that receive low-level radioactive wastes. Ingestion of the waste-water or contaminated vegetation may result in measurable quantities of radionuclides being incorporated in the animals' tissues.

Selected wildlife were collected throughout the Hanford environs as an indicator of radionuclide availability and potential transfer through the food chain. Although the Hanford Site south of the Columbia River is not open to public hunting, several of its wildlife species are game animals and, as such, are potentially subject to being taken by hunters during the time they spend offsite.

### RADIONUCLIDE CONCENTRATIONS IN GAME BIRDS

Gamma spectroscopy and $^{90}Sr$ analyses were performed on 1-lb (500-g) samples of muscle tissue taken from game birds collected during 1977. Results of these analyses are shown in Table 6. The ducks were collected from each of the larger trenches or ponds on the Hanford Site and along the Columbia River. Only the three radionuclides shown were detected in the samples, and $^{137}Cs$ and $^{90}Sr$ were the only artificially produced radionuclides detected. The $^{90}Sr$ was attributed to worldwide fallout, since concentrations in both onsite and Columbia River waterfowl were similar. Cesium-137, however, was attributed primarily to Hanford operations; the concentrations measured were similar to those observed in previous years, with some downward trend indicated.

Livers from waterfowl taken at the 300 Area pond, U Pond, and West Lake were analyzed for uranium and for plutonium to determine the availability of these radionuclides. The results of these analyses are shown in Table 7. While there is some indication of measurable concentrations of plutonium and uranium in the duck livers, it is unlikely that the livers would be eaten by hunters. Even if they were ingested, the intake of radionuclides would be inconsequential.

## TABLE 6. Radionuclide Concentrations in Game Bird Muscle Samples During 1977

| | | | Concentration in Units of $10^{-6}$ µCi/g, Wet Weight[a,b] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $^{40}K$ | | | $^{90}Sr$ | | | $^{137}Cs$ | | |
| Location | Species | No. of Samples | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| 300 Pond | Ducks | 3 | 6.2 | 2.4 | 3.8 | 0.01 | * | <0.007 | * | * | * |
| U Pond | Ducks | 3 | 350 | * | <120 | 0.01 | * | <0.006 | 70 | 45 | 56 |
| Gable Pond | Ducks | 4 | 3.7 | * | < 3.3 | 0.01 | * | <0.009 | 120 | 36 | 83 |
| West Lake | Ducks | 3 | 4.3 | * | < 3.6 | 0.05 | * | <0.02 | 120 | 1.6 | 60 |
| B Pond | Ducks | 3 | 4.0 | * | < 5.3 | 0.02 | * | <0.01 | 110 | 3.2 | 37 |
| Columbia River | Ducks | 18 | 2.7 | * | < 3.7 | 0.09 | * | <0.01 | * | * | * |
| Columbia River | Geese | 10 | 3.2 | 1.9 | < 2.5 | | | | * | * | * |
| 100 Areas | Pheasants | 7 | 3.4 | * | < 4.4 | 0.01 | * | <0.006 | * | * | * |
| 100 Areas | Quail | 9 | * | * | * | 0.05 | * | <0.02 | * | * | * |
| 200 Areas | Chukar | 2 | * | * | * | * | * | * | 4.2 | 1.8 | 3.0 |
| Detection Limit:[c] | | | | 4.0 | | | 0.008 | | | 0.2 | |

*

(a) $10^{-6}$ µCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

## TABLE 7. Average Concentrations of Selected Radionuclides in Waterfowl Liver Samples During 1977

| | | Concentration in Units of $10^{-6}$ µCi/g, Wet Weight[a,b] | | | | | |
|---|---|---|---|---|---|---|---|
| | | U | | | Total Pu | | |
| Location | No. of Samples | Max. | Min. | Average | Max. | Min. | Average |
| 300 Pond | 3 | 0.08 | * | <0.04 | 0.17 | * | <0.06 |
| U Pond | 2 | | | | 0.02 | 0.003 | 0.01 |
| West Lake | 1 | | | * | | | |
| Detection Limit:[c] | | | 0.05 | | | 0.003 | |

* Less than detection limit.

(a) $10^{-6}$ µCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

Table 8 contains the results of analytical measurements, classified according to the variety of duck. Only those radionuclides that exceeded the detection limit are shown. During 1977, the highest observed concentrations of $^{137}Cs$ were found in a Barrow's Golden Eye and an American Golden Eye. Other varieties of duck had similar maximum concentrations.

Assuming that an individual consumed 1-lb (500-g) of meat from the duck containing the highest levels of $^{137}Cs$ observed during 1977 ($120 \times 10^{-6}$ μCi/g), that individual would incur 50-yr internal dose commitments of 3.4 mrem to the total body and 3.8 mrem to the bone. The majority of these doses would be received during the first year following ingestion.

TABLE 8. Radionuclide Concentrations in Waterfowl Muscle Samples During 1977

| | | Concentrations in Units of $10^{-6}$ μCi/g, Wet Weight[a,b] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{40}K$ | | | $^{90}Sr$ | | | $^{137}Cs$ | | |
| Duck Variety | No. of Samples | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| Mallard | 10 | 350 | * | <38 | 0.01 | * | <0.007 | 70 | * | <27 |
| American Golden Eye | 1 | | | * | | | 0.01 | | | 120 |
| Gadwall | 2 | * | * | * | 0.02 | * | <0.01 | 110 | 3.2 | 59 |
| Barrow's Golden Eye | 3 | * | * | * | 0.05 | * | <0.02 | 120 | 57 | 95 |
| Detection Limit:[c] | | | 4.0 | | | 0.008 | | | 0.2 | |

* Less than detection limit.

(a) $10^{-6}$ μCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

## RADIONUCLIDE CONCENTRATIONS IN DEER

Muscle, liver, and bone samples were obtained from road-killed deer on the Hanford Site, and analyzed for radionuclide content. Naturally occurring $^{40}K$ was observed, as expected, in deer-muscle samples.

Generally, the radionuclide concentrations seen in muscle tissue (shown in Table 9) were comparable to the concentrations in the 1976 samples. Plutonium-239 was detected in one liver sample and $^{90}Sr$ was measured in bone samples. Since the $^{90}Sr$ concentrations observed in the Hanford deer were similar to concentrations observed in deer taken in the past from other parts of the country, these concentrations were attributed to worldwide fallout. The $^{137}Cs$ concentration observed in one of the muscle samples is probably attributable to Hanford operations because of the availability of $^{137}Cs$ on the Hanford Site at Gable Pond. Assuming a person ingested 50 lb (22.7 kg) of deer meat containing the observed concentration of $0.73 \times 10^{-6}$ μCi/g of $^{137}Cs$, a 50-year dose commitment of 1 mrem to the total body and 1.3 mrem to the bone would be incurred.

TABLE 9. Radionuclide Concentrations in Deer Tissues During 1977

| | | | Concentration in Units of $10^{-6}$ μCi/g, Wet Weight[a,b] | | | | |
|---|---|---|---|---|---|---|---|
| Location | Date | Tissue | $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239}Pu$ |
| Rt 2S Mile 5 | 1/24 | Muscle | 2.0 | * | * | * | |
| | | Liver | | | | | 0.01 |
| | | Bone | | | 0.03 | | |
| 100-D Area | 3/18 | Muscle | * | 0.29 | | 0.73 | |
| 100-H Area | 12/30 | Muscle | 2.0 | * | * | * | |
| | | Liver | | | | | * |
| | | Bone | | | 0.88 | | |
| Detection Limit:[c] | | | 1.5 | | 0.001 | 0.2 | 0.0004 |

* Less than detection limit.

(a) $10^{-6}$ μCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

## RADIONUCLIDE CONCENTRATIONS IN MICE AND RABBITS

Mice and rabbits, collected around sources of drinking water or potential sources of salt on the Hanford Site were analyzed for selected radionuclides. The results, shown in Tables 10 and 11, indicate that the potential for transport of radionuclides away from waste sites by mammals exists.

## TABLE 10. Radionuclide Concentrations in Rabbit Tissues During 1977

| Location | Date | Tissue | Concentrations in Units of $10^{-6}$ µCi/g, Wet Weight[a,b] $^{40}K$ | $^{60}Co$ | $^{90}Sr$ | $^{137}Cs$ | $^{239}Pu$ |
|---|---|---|---|---|---|---|---|
| Rt 2S Mile 5 | 5/12 | Muscle | 2.7 | * | | * | |
| | | Bone | | | 0.84 | | |
| | | Liver | | | | | * |
| 200 B-C | 5/20 | Muscle | * | * | | 0.46 | |
| | | Bone | | | 170 | | |
| | | Liver | | | | | 0.01 |
| 200 B-C | 11/10 | Muscle | * | * | | * | |
| | | Bone | | | 27 | | |
| | | Liver | | | | | 0.0002 |
| 200 B-C | 11/10 | Muscle | * | * | | * | |
| | | Bone | | | 24 | | |
| | | Liver | | | | | 0.002 |
| Detection Limit:[c] | | | 2.7 | 0.1 | 0.001 | 0.2 | 0.0004 |

* Less than detection limit.

(a) $10^{-6}$ µCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

## TABLE 11. Radionuclide Concentrations in Mice During 1977

| Location | Species[c] | Date | Concentration in Units of $10^{-6}$ µCi/g, Wet Weight[a,b] $^{40}K$ | $^{54}Mn$ | $^{60}Co$ | $^{65}Zn$ | $^{90}Sr$ | $^{134}Cs$ | $^{137}Cs$ | $^{144}Ce$ | U | Total Pu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 Area | PM | 3/04 | * | * | 0.59 | * | 0.19 | * | * | * | 4.2 | |
| U Plant | PM | 3/04 | * | * | * | * | 4.4 | * | * | * | * | 0.008 |
| B Pond | PM | 3/11 | * | * | * | * | 6.6 | * | * | * | | |
| Gable Pond | Mus M | 3/11 | * | * | * | * | 0.47 | * | * | * | | |
| West Lake | PM | 3/18 | * | * | * | * | 0.10 | * | * | * | 0.03 | |
| 100-N | PM | 3/18 | * | 900 | 2100 | 66 | 300 | 470 | 3400 | 180 | | |
| 141-F | PM | 3/18 | * | * | * | * | 0.88 | * | * | * | 0.02 | |
| T Pond | PM | 3/25 | * | * | 0.48 | * | 1.5 | * | 31 | * | | |
| Redox | PP | 3/25 | * | * | * | * | 2.8 | * | 11 | * | | |
| BC Crib | PP | 4/29 | * | * | * | * | 12 | * | * | * | | |
| U Pond | PM | 7/08 | * | * | * | * | 1.1 | * | 26 | * | | 0.29 |
| T Pond | PM | 7/08 | * | * | * | * | 8.2 | * | 27 | * | * | |
| 300 Pond | PP | 9/23 | * | * | * | * | 0.13 | * | * | * | | |
| BC Crib | PM | 9/30 | * | * | * | * | 0.05 | * | * | * | | * |
| B Pond | PM | 10/14 | * | * | * | * | 1.6 | * | 0.80 | * | | |
| Detection Limit:[d] | | | 10 | 8 | 0.6 | 1.4 | 0.005 | 0.7 | 0.7 | 5 | 0.02 | 0.001 |

* Less than detection limit.

(a) $10^{-6}$ µCi/g = 1 pCi/g.

(b) A blank indicates that no analysis was made.

(c) PM - Peromyscus Maniculatus (Deer Mouse)
PP - Perognothus Parvus (Great Basin Pocket Mouse)
Mus M - Mus Musculus (House Mouse)

(d) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

All of the rabbit samples were collected around the 200 B-C crib area, and the radionuclide concentrations measured in the rabbit tissue in 1977 were similar to those measured in recent years. A mouse collected from the vicinity of the 100-N area showed radionuclide concentrations orders of magnitude above specimens collected from other Hanford locations. These high concentrations in mice have been observed for many years at this sampling location. This was most likely a result of ingestion of water from the 100-N trench.

## SOIL AND VEGETATION

Surface-soil vegetation samples were collected during June 1977 from the 21 locations shown in Figure 11. Exact locations around operating areas are shown in the Appendix. Each soil sample was a composite of five plugs from an area of approximately 93 $ft^2$ (10 $m^2$). Each plug was approximately 1 in. (2.5 cm) in depth by 4 in. (10 cm) in diameter. The vegetation samples were collected in the immediate vicinity of each soil-sample plot. They consisted of perennial vegetation, primarily the new growth from rabbit brush plants (chrysothamnus species), and annual grasses. Both sets of samples were analyzed for gamma-emitting radionuclides using a lithium-drifted germanium detector, and for plutonium nuclides and $^{90}Sr$ by chemical separation and specific analysis. Americium-241 analysis of soil samples was performed for the first time in 1977.

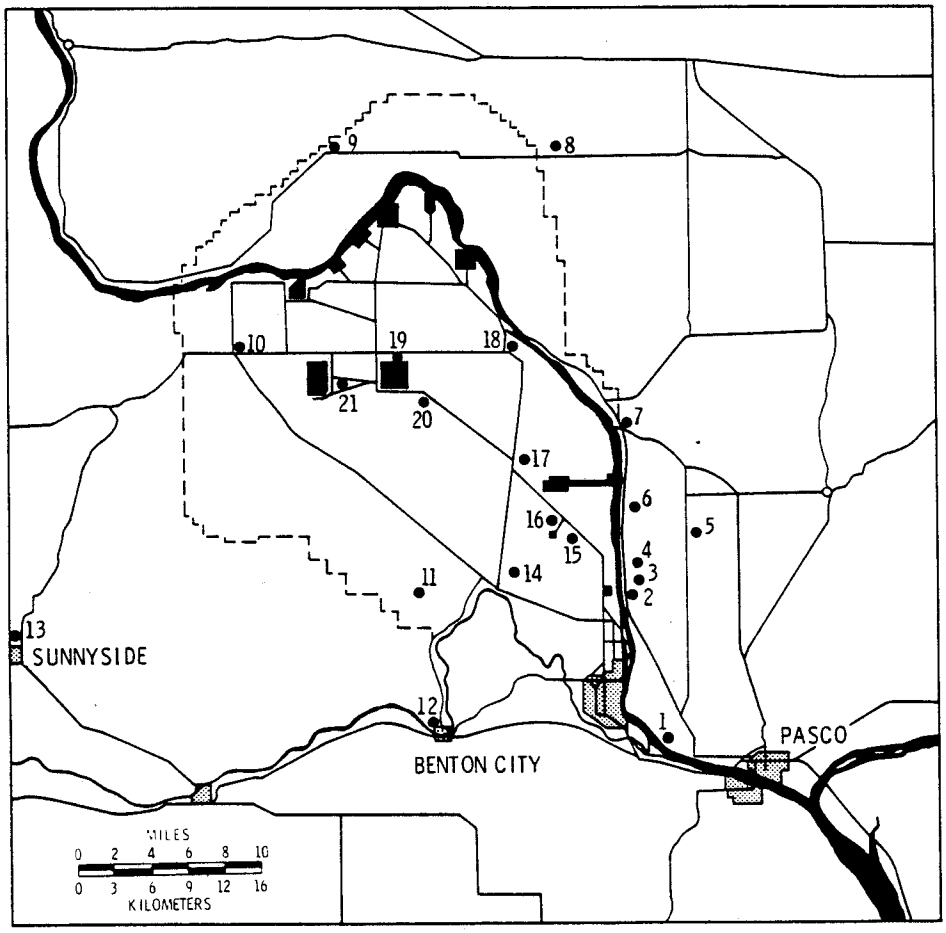



FIGURE 11. Soil and Vegetation Sampling Locations During 1977

Soil sample analyses for both onsite and offsite locations are shown in Table 12. With the exception of $^{137}Cs$ and $^{239-240}Pu$, all onsite soil concentrations were similar to offsite concentrations, indicating no Hanford contribution. The maximum $^{137}Cs$ soil-sample result of $2.9 \times 10^{-5}$ μCi/g was observed at the 200 ENC site, which was sampled for the first time in 1977. The average $^{137}Cs$ concentrations for the other onsite locations were higher than concentrations for the offsite locations, which indicated that the Hanford contribution was roughly equivalent to world-wide fallout. The maximum $^{239-240}Pu$ soil-sample result of $0.17 \times 10^{-6}$ μCi/g occurred onsite at two widely spaced locations: northeast of the

TABLE 12. Concentrations of Artificially Produced Radionuclides in Soil Samples During 1977

| Sample Location | Map Location | Concentration in Units of $10^{-6}$ μCi/g, Dry Weight[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{60}Co$ | $^{90}Sr$ | $^{95}ZrNb$ | $^{134}Cs$ | $^{137}Cs$ | $^{144}Ce$ | $^{238}Pu$ | $^{239-240}Pu$ | $^{241}Am$ |
| Onsite | | | | | | | | | | |
| Waluke #2 | 9 | 0.04 | 0.02 | 0.23 | 0.03 | 0.18 | 0.35 | * | 0.003 | 0.09 |
| Yakima Barricade | 10 | * | 0.01 | 0.06 | 0.06 | 0.62 | 0.36 | 0.004 | 0.008 | * |
| ALE Field Lab. | 11 | * | 0.08 | 0.08 | 0.06 | 0.97 | 0.33 | * | 0.017 | * |
| Prosser Barricade | 14 | * | 0.11 | 0.06 | 0.04 | 0.82 | 0.26 | * | 0.014 | * |
| NE of FFTF | 15 | * | 0.02 | 0.10 | 0.05 | 1.7 | 0.33 | * | 0.17 | * |
| SE of FFTF | 16 | * | 0.13 | * | 0.04 | 0.52 | 0.21 | 0.008 | 0.009 | 0.07 |
| Wye Barricade | 17 | * | 0.14 | 0.07 | * | 0.60 | 0.39 | 0.006 | 0.009 | * |
| Hanford Townsite | 18 | 0.05 | 0.03 | 0.05 | 0.03 | 0.77 | 0.39 | * | 0.019 | * |
| 200 ENC | 19 | 0.04 | 0.002 | 0.14 | 0.04 | 29 | 1.1 | 0.009 | 0.024 | 0.09 |
| 200 East Hill | 20 | * | 0.06 | 0.24 | * | 0.57 | 0.41 | 0.003 | 0.006 | * |
| East of 200 W Area | 21 | 0.05 | 0.15 | 0.05 | 0.04 | 0.97 | 0.31 | 0.009 | 0.17 | * |
| Average | | <0.04 | 0.064 | <0.10 | <0.04 | 3.3 | 0.40 | <0.005 | 0.041 | <0.074 |
| Offsite | | | | | | | | | | |
| Harris Farm | 1 | * | 0.02 | 0.15 | * | 0.17 | 0.37 | 0.003 | 0.004 | * |
| Byers Landing | 2 | 0.04 | 0.17 | 0.06 | 0.03 | 0.42 | 0.28 | * | 0.006 | 0.10 |
| Sagemoor Farm | 3 | 0.04 | 0.01 | 0.06 | 0.04 | 0.07 | 0.21 | * | 0.002 | * |
| Pettett Farm | 4 | * | * | 0.10 | * | 0.29 | 0.47 | 0.003 | 0.020 | * |
| Baxter Substation | 5 | * | 0.03 | * | * | 0.19 | * | * | 0.003 | * |
| West End of Fir Road | 6 | * | 0.15 | 0.11 | 0.04 | 0.40 | 0.40 | * | 0.006 | * |
| Ringold | 7 | * | * | 0.05 | * | 0.21 | 0.31 | 0.003 | 0.005 | * |
| Berg Ranch | 8 | * | * | 0.20 | * | 1.4 | 0.47 | 0.004 | 0.067 | * |
| Benton City | 12 | * | 0.03 | 0.12 | * | 0.46 | 0.23 | * | 0.008 | * |
| Sunnyside | 13 | * | 0.03 | 0.04 | 0.04 | 0.14 | 0.28 | 0.001 | 0.004 | * |
| Average | | <0.03 | 0.05 | <0.09 | <0.03 | 0.37 | <0.32 | <0.003 | 0.013 | <0.073 |
| Detection Limit:[b] | | 0.03 | 0.003 | 0.05 | 0.03 | 0.05 | 0.13 | 0.003 | 0.004 | 0.07 |

* Less than the detection limit.

[a] $10^{-6}$ μCi/g = 1 pCi/g.

[b] The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

Fast-Flux Test Facility (FFTF) and east of the 200 West Area. The results of sample analyses for the other onsite sample locations in the vicinity of the FFTF and the 200 West Area did not support the two maximum values observed. The average of the remaining onsite sample results was statistically the same as the offsite sample results, which indicated that the two high values may have been spurious and that the $^{239-240}Pu$ soil concentrations were attributable to worldwide fallout. In general, the results showed no geographic pattern and were the same as, or slightly lower than, results from recent years.

Results of analysis of vegetation samples from onsite and offsite locations were not directly comparable, since identical vegetation was not readily available at all sampling sites. Rabbit brush was available and was sampled at all onsite sampling locations. The results of the analyses of these samples are shown in Table 13. The maximum $^{137}Cs$ result was observed at the 200 ENC site, corroborating the maximum soil sample result

TABLE 13. Concentrations of Artificially Produced Radionuclides in Vegetation Samples During 1977.

| Sample Location | Map Location | Concentration in Units of $10^{-6}$ µCi/g, Dry Weight[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $^{60}Co$ | $^{90}Sr$ | $^{95}ZrNb$ | $^{137}Cs$ | $^{141}Ce$ | $^{144}Ce$ | $^{238}Pu$ | $^{239-240}Pu$ |
| Onsite | | | | | | | | | |
| Waluke #2 | 9 | * | 0.02 | 2.3 | * | * | 0.8 | * | 0.001 |
| Yakima Barricade | 10 | * | 0.01 | 3.3 | 0.16 | 0.41 | 1.9 | 0.01 | 0.004 |
| ALE Field Lab. | 11 | * | 0.16 | 3.6 | 0.24 | 0.34 | 2.0 | 0.01 | 0.02 |
| Prosser Barricade | 14 | * | 0.72 | 9.8 | 1.0 | 0.71 | 4.5 | 0.005 | 0.006 |
| NE of FFTF | 15 | 0.13 | 0.09 | 2.9 | 0.39 | * | 1.4 | 0.016 | 0.005 |
| SE of FFTF | 16 | * | 0.18 | 2.9 | 0.24 | 0.38 | 2.0 | * | * |
| Wye Barricade | 17 | * | 0.03 | 3.1 | 0.23 | 0.34 | 1.6 | 0.007 | 0.003 |
| Hanford Townsite | 18 | * | 0.13 | 4.3 | 0.21 | 0.65 | 2.8 | * | * |
| 200 ENC | 19 | 0.24 | 0.45 | 4.3 | 5.6 | 0.54 | 2.3 | 0.02 | 0.02 |
| 200 East Hill | 20 | * | 0.22 | 4.7 | 0.42 | 0.55 | 2.6 | 0.007 | 0.004 |
| East of 200 W Area | 21 | 0.58 | 0.09 | 3.8 | 0.68 | 0.54 | 2.1 | 0.002 | 0.02 |
| Average | | <0.16 | 0.19 | 4.1 | <0.85 | <0.46 | 2.2 | <0.008 | <0.008 |
| Detection Limit[b] | | 0.1 | 0.01 | 0.5 | 0.15 | 0.27 | 0.7 | 0.005 | 0.005 |

* Less than detection limit.

(a) $10^{-6}$ µCi/g = 1 pCi/g.

(b) The detection limit is the average of the individual detection limits for the less-than-detectable results in each sample group.

observed at that location. All other sample results showed no particular geographical pattern, and except for the $^{137}Cs$ result at the 200 ENC site, the radionuclides observed were attributed to worldwide fallout.

Probability plots of onsite results for $^{90}Sr$, $^{137}Cs$, and $^{239-240}Pu$ in soil and vegetation samples are shown in Figures 12 through 14. Probability plotting produces a straight-line plot when the data are log normally distributed. A change in the slope of the line can indicate two data distributions: one due to worldwide fallout and the other due to some other source. Analysis of the plots indicated that probably only one data distribution existed for each nuclide, but there were isolated high values in the cases of $^{137}Cs$ and $^{239-240}Pu$. The $^{137}Cs$ maximum values were discussed previously. The maximum $^{239-240}Pu$ results for soil and vegetation coincided only at a location east of 200 West Area (map location 21 in Figure 11) and it is possible that they were due to Hanford operations.

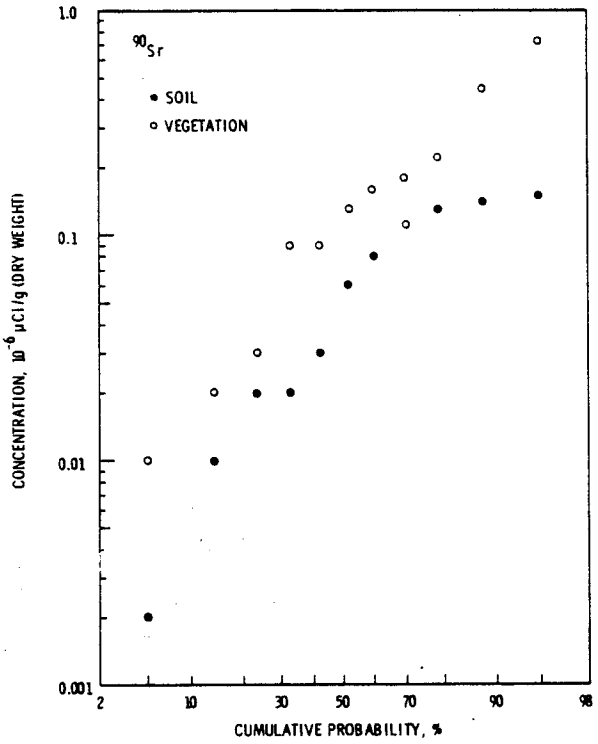



FIGURE 12. Log-Normal Probability Plot of $^{90}Sr$ in Soil and Vegetation

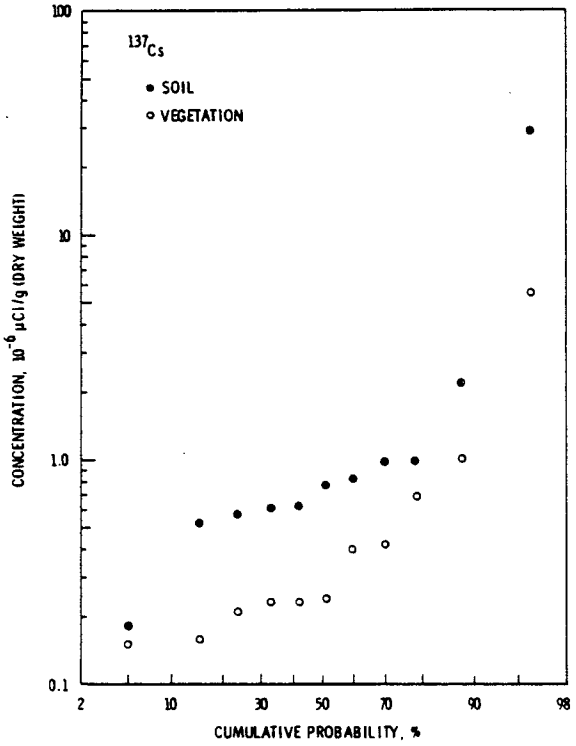



FIGURE 13. Log-Normal Probability Plot of $^{137}Cs$ in Soil and Vegetation

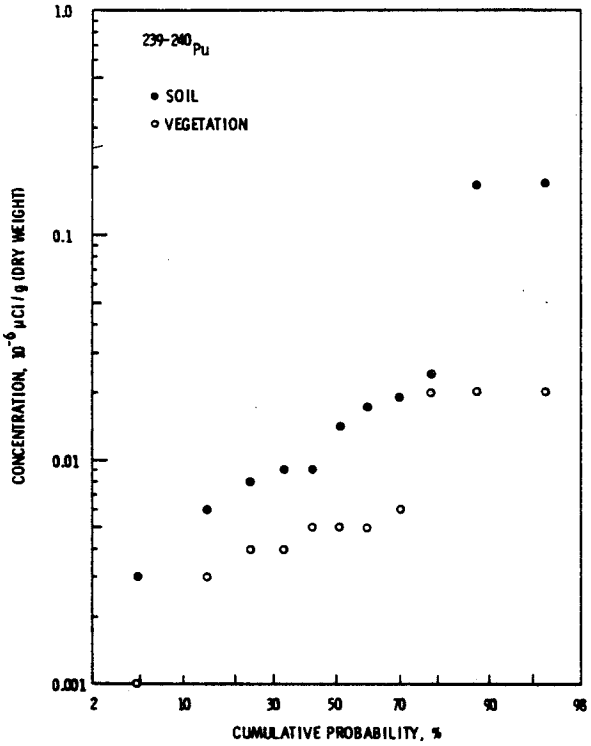



FIGURE 14. Log-Normal Probability Plot of $^{239-240}Pu$ in Soil and Vegetation

## EXTERNAL RADIATION

Thermoluminescent dosimeters (TLDs) were used to measure the external dose at several onsite, perimeter, and distant locations, as shown in Figure 15. Detailed maps showing the locations of TLDs around each operating area are included in the Appendix. In general, the onsite dosimeters were located on the perimeter of each operating area. The dosimeters consisted of $CaF_2$:Mn chips (Harshaw TLD-400) encased in an opaque plastic capsule, and lined with 0.01 in. (0.025 cm) of tantalum and 0.002 in. (0.005 cm) of lead to flatten the low-energy response.[7] The dosimeters were mounted approximately 1 m above ground-level and changed monthly.

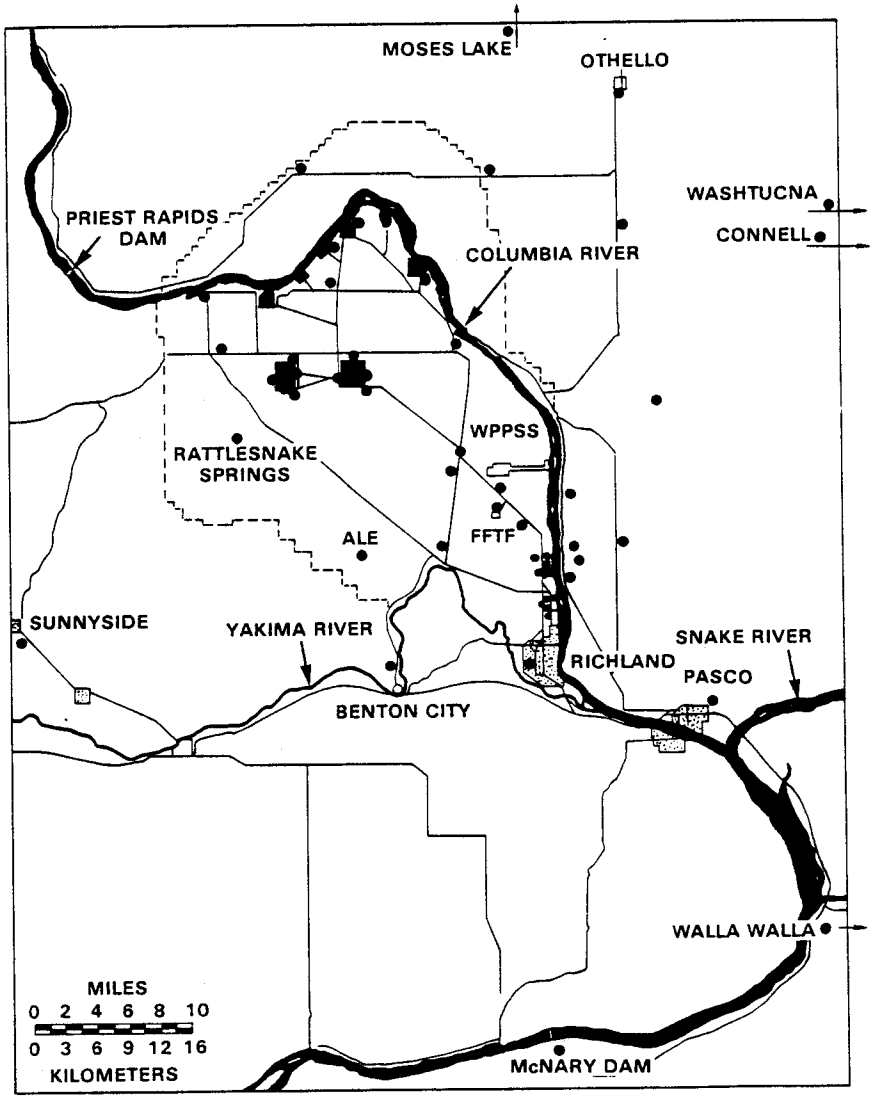



FIGURE 15. TLD External Dose Measurement Locations During 1977

Shown in Table 14 are the results of the dose measurements made during 1977. Variability in the measured dose from the different locations was expected, primarily because of spatial differences in the amount of natural radioactivity in the soil. The external dose measured at any location is affected by several parameters, including the height of the dosimeter above ground-level, its elevation above sea-level, the amount of natural and worldwide fallout radionuclides, and the presence of any radionuclides of Hanford origin.

A log-normal probability plot of the annual average dose rate for two groups of dosimeters is shown in Figure 16. The two groups represent onsite and offsite stations. Dose rates from both groups produced straight-

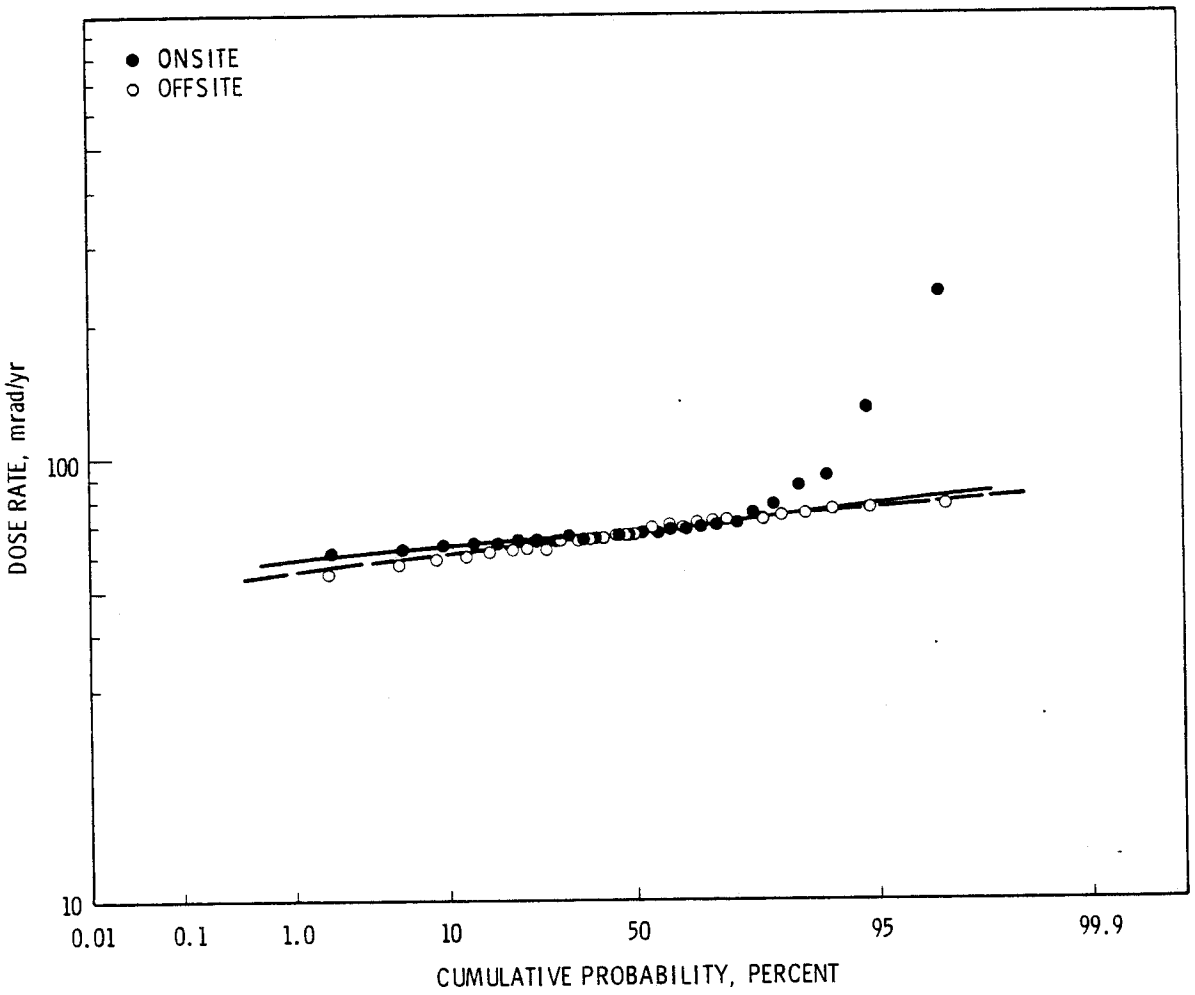



FIGURE 16. Log-Normal Probability Plot of TLD External Dose Measurements

## TABLE 14. Results of TLD Measurements During 1977

| Location | No. of Measurements | Dose (mrad/yr) Maximum | Minimum | Average |
|---|---|---|---|---|
| **Onsite** | | | | |
| 200 ENC | 13 | 288 | 164 | 239 ± 73 |
| 200 EWC | 13 | 77 | 51 | 63 ± 15 |
| 200 ESE | 13 | 77 | 51 | 67 ± 13 |
| 200 EEC | 13 | 110 | 73 | 91 ± 24 |
| 200 WEC | 13 | 88 | 51 | 69 ± 19 |
| 200 WNE | 13 | 80 | 51 | 64 ± 18 |
| Redox | 13 | 91 | 66 | 75 ± 17 |
| 200 WWC | 13 | 168 | 95 | 130 ± 45 |
| 100-K | 13 | 69 | 47 | 61 ± 12 |
| WPPSS-100N | 13 | 106 | 69 | 87 ± 28 |
| 100-D | 12 | 84 | 62 | 69 ± 13 |
| 100 Area Fire Station | 13 | 80 | 51 | 65 ± 18 |
| 100-F | 4 | 69 | 66 | 67 ± 3.7 |
| 3705 Bldg. | 13 | 77 | 47 | 64 ± 18 |
| ACRMS[a] | 13 | 84 | 51 | 68 ± 21 |
| 300 Pond | 13 | 91 | 62 | 78 ± 19 |
| 300 SW Gate | 13 | 80 | 55 | 68 ± 17 |
| 300 South Gate | 13 | 77 | 51 | 66 ± 17 |
| 331 Bldg. | 12 | 80 | 51 | 66 ± 17 |
| Rt 10 Mile 1.6 | 12 | 77 | 51 | 65 ± 17 |
| Hanford | 12 | 77 | 51 | 62 ± 15 |
| Wye Barricade | 13 | 84 | 51 | 65 ± 18 |
| FFTF Site[b] | 13 | 80 | 55 | 69 ± 16 |
| FFTF North | 13 | 84 | 55 | 71 ± 19 |
| FFTF Southeast | 13 | 77 | 51 | 66 ± 17 |
| Prosser Barricade | 13 | 95 | 55 | 70 ± 21 |
| | Average ± two standard deviations | | | 78 ± 20 |
| **Perimeter** | | | | |
| Rattlesnake | 11 | 88 | 55 | 68 ± 10 |
| ALE | 13 | 80 | 58 | 72 ± 14 |
| Benton City | 12 | 66 | 40 | 55 ± 14 |
| Yakima Barricade | 13 | 84 | 58 | 72 ± 15 |
| Vernita | 13 | 91 | 58 | 76 ± 18 |
| Wahluke #2 | 13 | 88 | 62 | 75 ± 18 |
| Othello | 12 | 66 | 47 | 57 ± 10 |
| Connell | 13 | 73 | 55 | 61 ± 13 |
| Berg Ranch | 13 | 95 | 62 | 78 ± 22 |
| Wahluke Watermaster | 12 | 77 | 55 | 69 ± 16 |
| Cooke Bros. | 13 | 80 | 47 | 65 ± 18 |
| Richland | 13 | 77 | 47 | 59 ± 18 |
| Pasco | 13 | 91 | 47 | 66 ± 24 |
| Byers Landing | 13 | 95 | 58 | 77 ± 20 |
| Baxter Substation | 11 | 80 | 51 | 67 ± 17 |
| Pettett | 8 | 69 | 47 | 60 ± 13 |
| Fir Road | 9 | 73 | 55 | 66 ± 12 |
| Sagemoor | 9 | 77 | 58 | 70 ± 12 |
| RRC CP #63 | 13 | 84 | 51 | 67 ± 18 |
| RRC CP #64 | 12 | 77 | 47 | 62 ± 16 |
| RRC CP #65 | 12 | 88 | 58 | 71 ± 18 |
| RRC CP #66 | 12 | 88 | 55 | 73 ± 19 |
| RRC CP #67 | 12 | 84 | 55 | 70 ± 17 |
| | Average ± two standard deviations | | | 68 ± 16 |
| **Distant** | | | | |
| Walla Walla | 12 | 88 | 58 | 74 ± 14 |
| McNary | 12 | 88 | 58 | 73 ± 17 |
| Moses Lake | 12 | 69 | 55 | 62 ± 10 |
| Washtucna | 13 | 77 | 58 | 65 ± 12 |
| Sunnyside | 13 | 73 | 51 | 62 ± 14 |
| | Average ± two standard deviations | | | 67 ± 13 |

[a] Automatic Columbia River Monitoring Station.
[b] Fast-Flux Test Facility.

line plots, although several higher dose rates were measured onsite, as expected, primarily around the 200 Areas. The straight-line plot for the offsite stations (perimeter and distant locations) indicated that contributions from Hanford operations measured at perimeter stations were indiscernable from the contributions of the background dose rate at distant locations.

From the data in Table 14, the external background dose rate from natural radioactivity received by the population in the Hanford environs can be estimated. The average annual dose measured at perimeter stations was about 68 mrem (1 mrem equals 1 mrad in this case). An additional 6 mrem must be added to account for the neutron component of cosmic radiation[8] and an additional 25 mrem must be added to account for the dose received from internal radionuclides in the human body, primarily $^{40}K$.[9] The annual average background dose from all sources in the Hanford environs is thus about 100 mrem.

Environmental dosimeters wers submerged in the Columbia River at the four locations indicated in Figure 17: at Coyote Rapids, below the 100-N Area, at the Hanford powerline crossing, and at the Richland pumphouse. The doses measured by these TLD's, shown in Table 15, were similar to those obtained in previous years and indicated that a swimmer immersed in the Columbia River at Richland would be subject to a dose rate of approximately 0.004 mrad/hr. By comparison, the dose rate on land is approximately 0.008 mrad/hr.

Past analyses of sediment samples collected along the Columbia River have revealed the presence of a few long-lived radionuclides, primarily $^{60}Co$, which was attributable to the past operation of once-through-cooled production reactors.[10] The activity occurred in sediments along the river's islands, shoreline, and slough areas. It gradually decreased downstream from the historical production reactors and became undetectable below North Richland. The maximum exposure rate measured in 1974 was 0.014 mR/hr, which should have decayed to about 0.010 mR/hr by 1977.

Summarized in Table 16 are the data from the TLDs that were placed at 10 locations along the Columbia River shoreline and at three of the larger islands during 1976. These locations are shown in Figure 18. The

wide variation in dose rates among the locations was due to different concentrations of $^{60}Co$ in the sediment. The variation between the maximum and minimum dose rate observed at each location was caused by changes in the river's flow rate. These changes tended to shield the $^{60}Co$ in the sediment.

The maximum external dose rate observed for 1977, 150 mrad/yr, is approximately equal to the decay-corrected dose rate from the $^{60}Co$ (~90 mrad/yr) plus that from natural background (~70 mrad/yr).

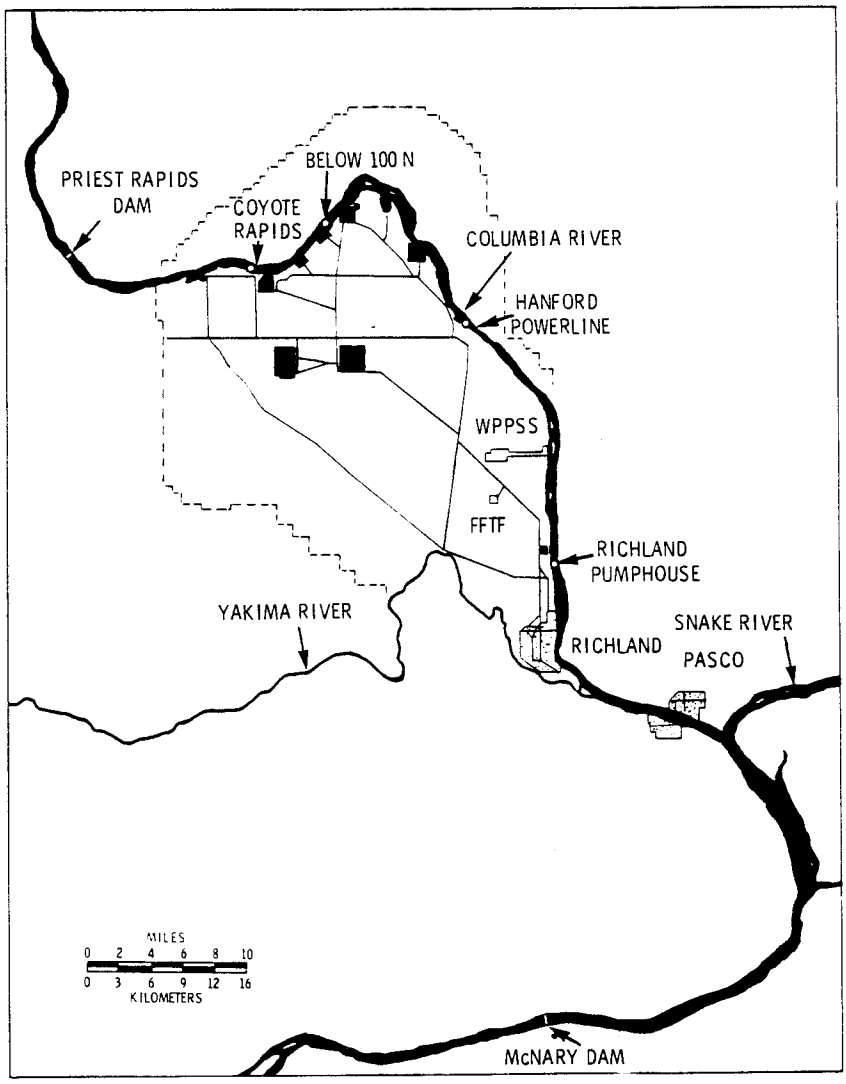



FIGURE 17. Locations of Immersion Dose Measurements in the Columbia River During 1977

TABLE 15. Columbia River Immersion Dose Rates

| Location | No. of Measurements | Dose Rate (mrad/yr) Maximum | Minimum | Average |
|---|---|---|---|---|
| Coyote Rapids | 12 | 69 | 33 | 44 ± 23 |
| Below 100-N | 10 | 139 | 51 | 85 ± 49 |
| Hanford Powerline | 9 | 58 | 37 | 49 ± 14 |
| Richland Pumphouse | 13 | 40 | 22 | 33 ± 11 |
| | | | Average | 53 ± 24 |

TABLE 16. Dose Rate Measurements Along the Columbia River Islands and Shoreline During 1977

| Location | No. of Measurements | Dose Rate (mrad/yr) Maximum | Minimum | Average |
|---|---|---|---|---|
| 100-K | 12 | 88 | 62 | 74 ± 16 |
| 100-D | 12 | 77 | 58 | 67 ± 13 |
| Locke Island | 12 | 99 | 69 | 83 ± 15 |
| White Bluffs | 12 | 88 | 66 | 79 ± 14 |
| 100-F | 12 | 84 | 62 | 75 ± 14 |
| Hanford Ferry Landing | 11 | 91 | 66 | 80 ± 15 |
| Hanford RR Track | 11 | 150 | 117 | 134 ± 23 |
| Ringold Island | 12 | 91 | 69 | 80 ± 14 |
| Powerline Crossing | 12 | 106 | 77 | 92 ± 17 |
| Wooded Island | 11 | 95 | 69 | 84 ± 15 |
| | | | Average | 85 ± 16 |

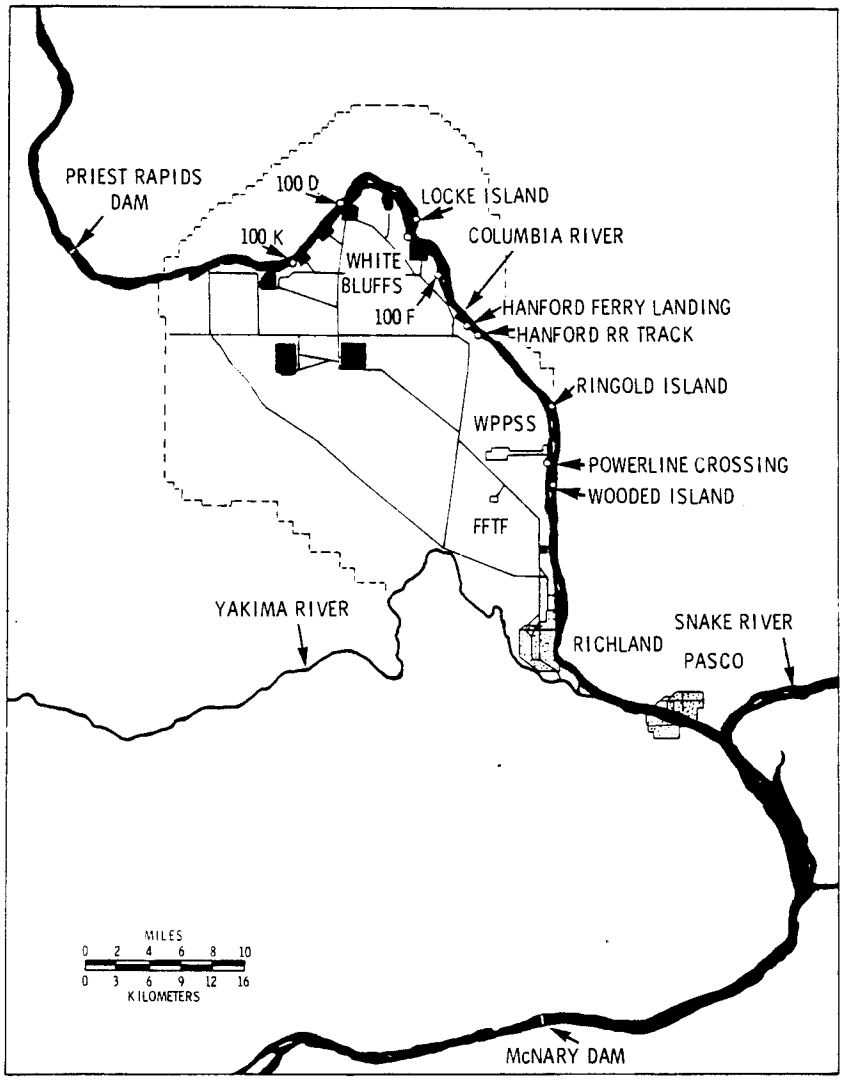



FIGURE 18. Locations of External Dose Measurements Along the Columbia River During 1977

## RADIATION SURVEYS

The Hanford environmental surveillance program includes routine surveillance of roads, railways, and waste-disposal sites to detect any abnormal levels of radioactivity. Aerial surveys of large land areas are also conducted.

### HANFORD ROADS SURVEY

The roads on the Hanford Site were routinely surveyed with a bioplastic scintillation detector attached to the front end of a truck and positioned about 2 ft (0.6 m) above the road surface. This road monitor has been described in BNWL-62.[11] The survey frequency ranged from biweekly to quarterly, depending on the road usage and the potential for contamination. Most of the roads on the site were surveyed monthly. During 1977, no conditions that required corrective action were detected.

### RAILROAD SURVEY

All Hanford railroad tracks outside of the operating area fences were surveyed semiannually. The survey was conducted using the previously described road survey detector attached to a railroad maintenance car.

Several areas that required corrective action were found in 1977. An area along the railroad tracks just north of the 300 area exclusion fence was found to be contaminated with uranium. The historic railroad car wash pit area west of highway 240 towards the midway electrical distribution substation, and a spur near the Susie Railroad junction were found to be in need of corrective action. These findings were reported to the responsible contractor.

### WASTE-DISPOSAL SITES

Active, inactive, and retired waste-disposal sites were surveyed and inspected for general physical condition during 1977. The sites were generally in good condition, except for the housekeeping problem of vegetation growing inside the waste sites. Unusual radiation levels and conditions, if any, were noted during each survey and reported to the responsible contractor representatives for corrective action.

## AERIAL SURVEYS

Aerial surveys can be used to detect contamination that is spread over a large land area. These surveys were conducted at an altitude of 500 ft (150 m), using a 3-in. by 5-in. (7.5-cm by 13-cm) NaI(Tl) scintillation crystal detector. During August of 1977, three flight patterns were flown:

- along the perimeter of the Hanford Site
- along the Columbia River from Vernita Bridge to Plymouth
- parallel to the perimeter of the Hanford Site, but 15 to 20 air-miles outside the perimeter.

No significant differences from previous surveys were observed.

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# APPENDIX

## SPECIFIC SAMPLING LOCATIONS AROUND HANFORD FACILITIES

100-K

100-N

100-D and 100-DR

100-H

100-F

200-W

200-E

300 Area

3000 Area

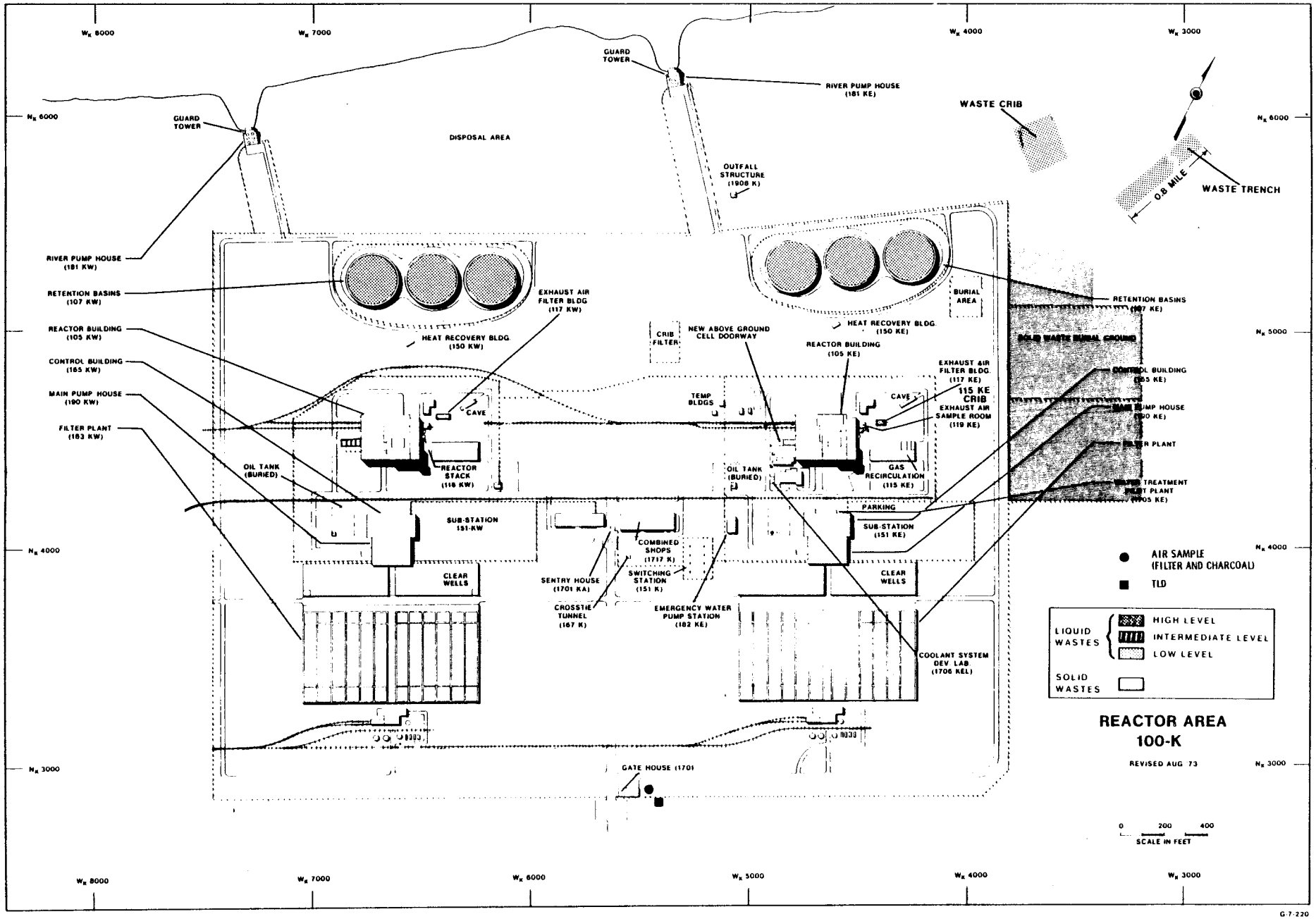


FIGURE A.1. Sampling Locations in the 100-K Reactor Area

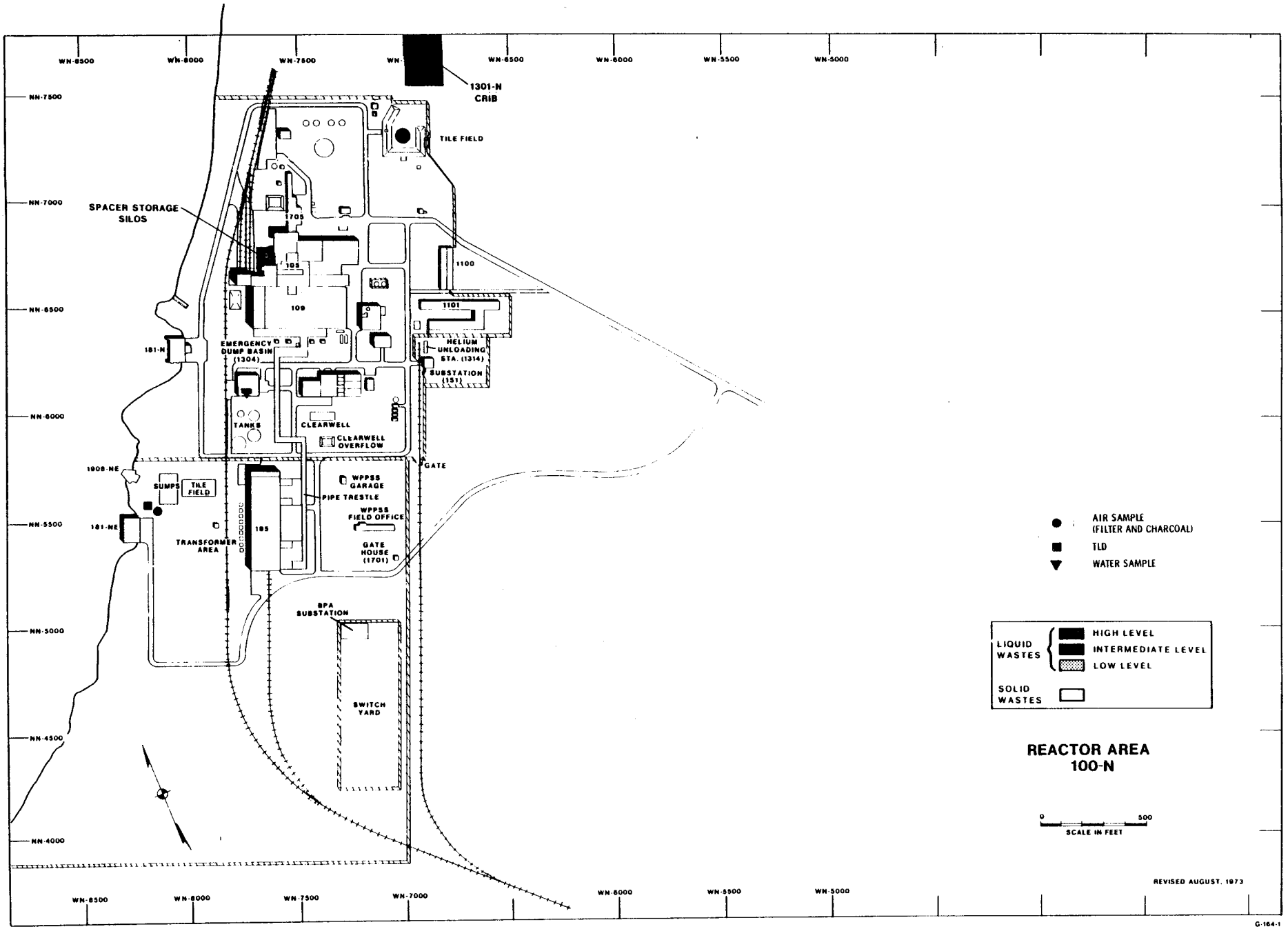


FIGURE A.2. Sampling Locations in the 100-N Reactor Area

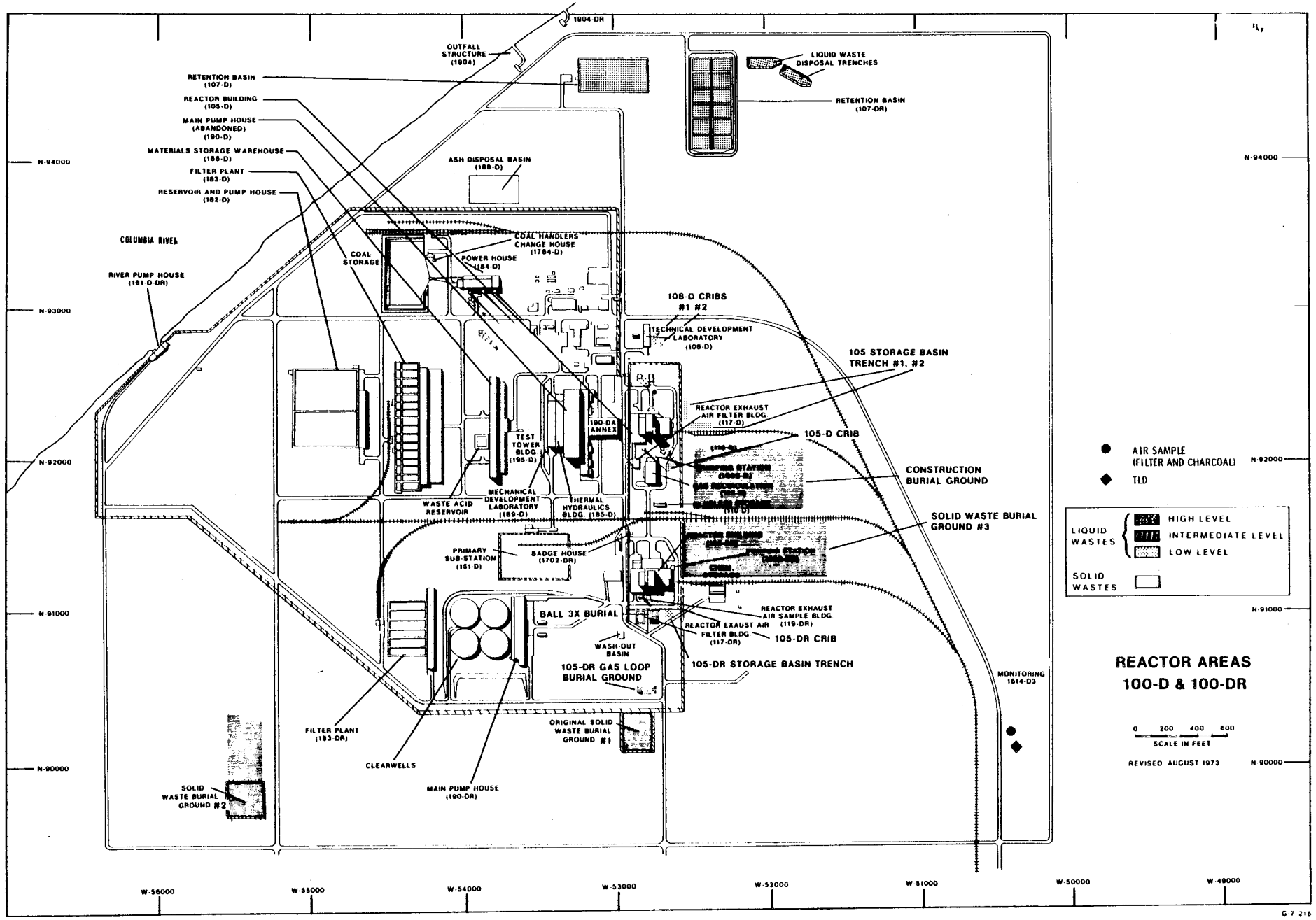


FIGURE A.3. Sampling Locations in the 100-D and 100-DR Reactor Areas

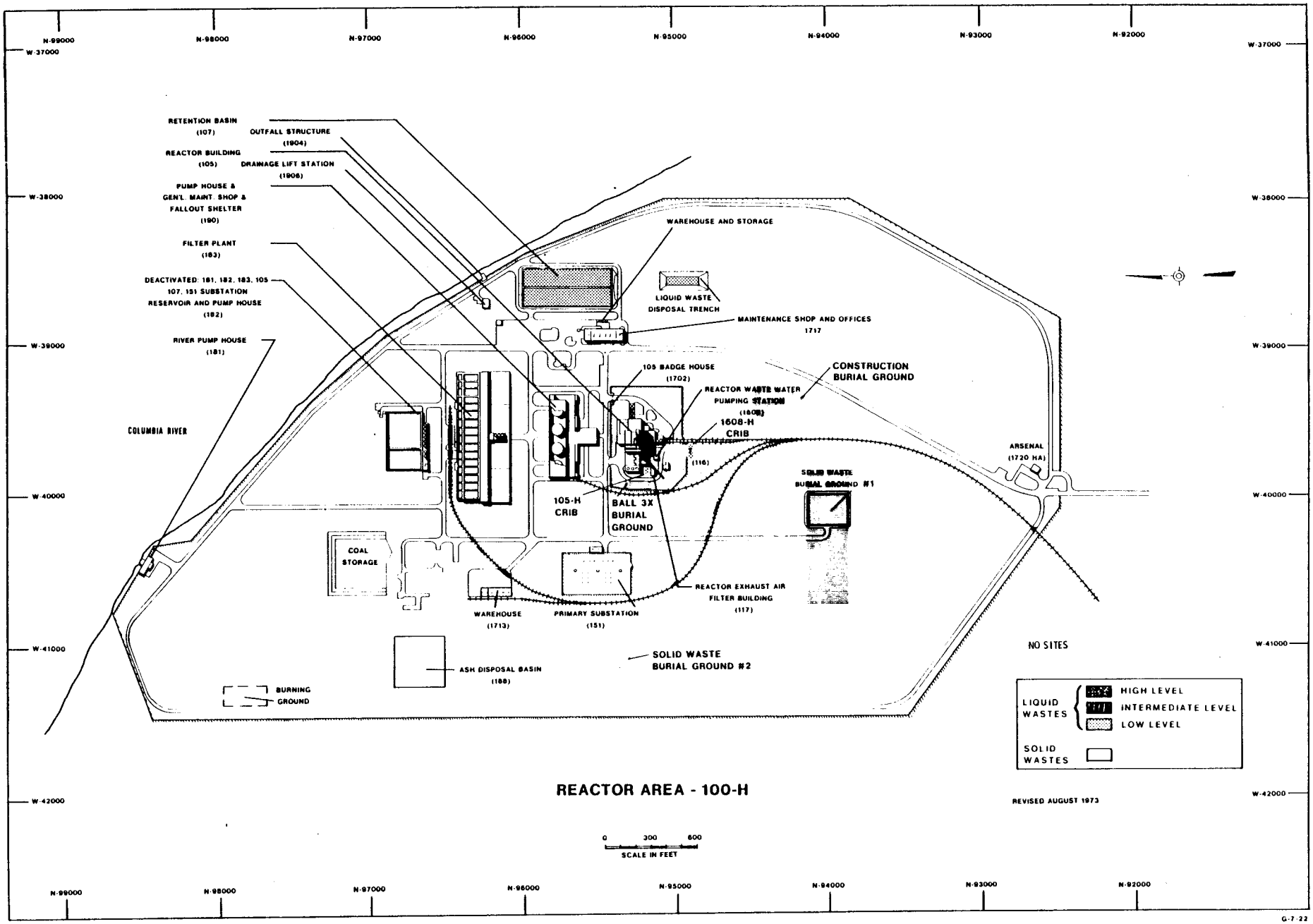


FIGURE A.4. Sampling Locations in the 100-H Reactor Area

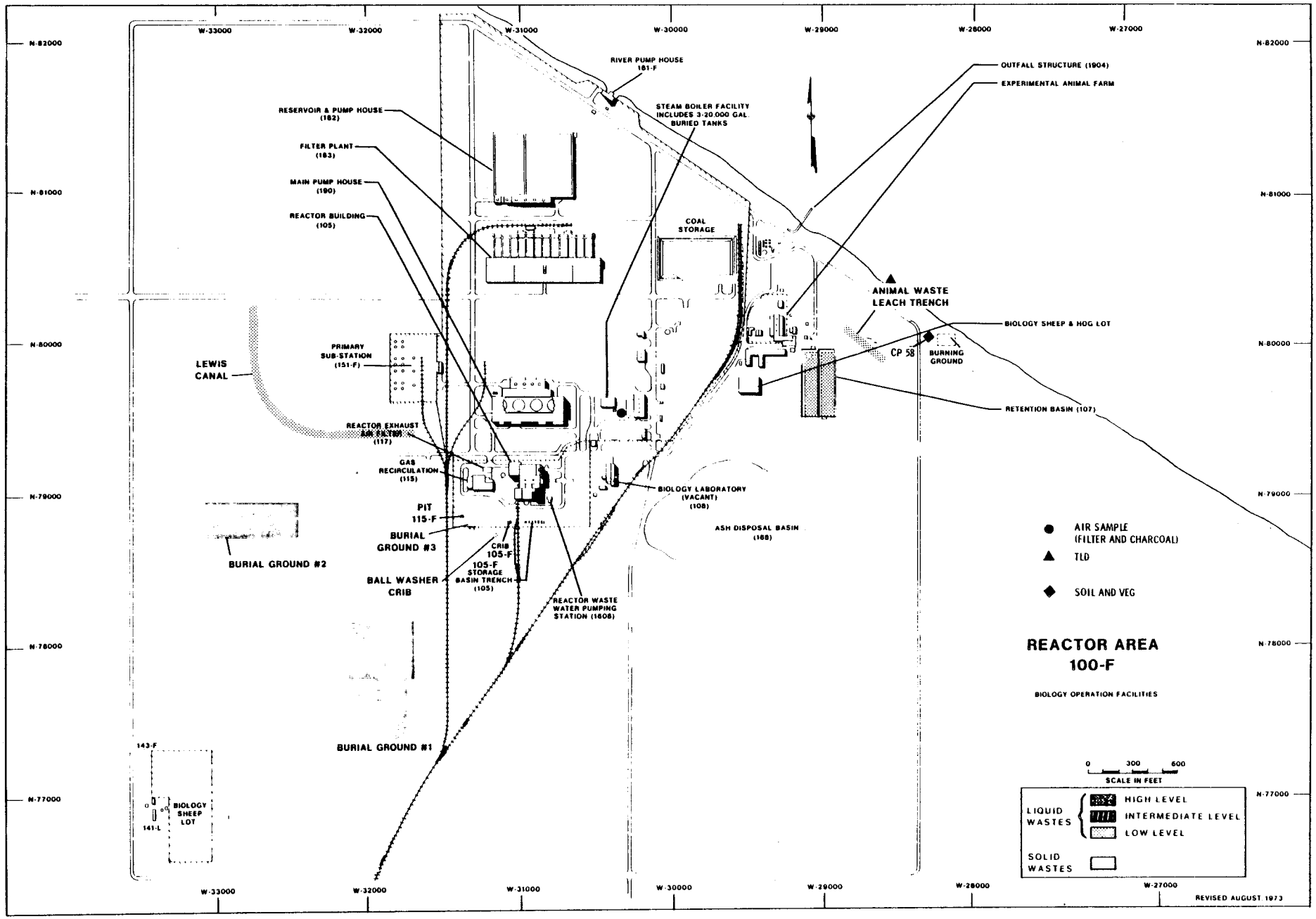


FIGURE A.5. Sampling Locations in the 100-F Reactor Area

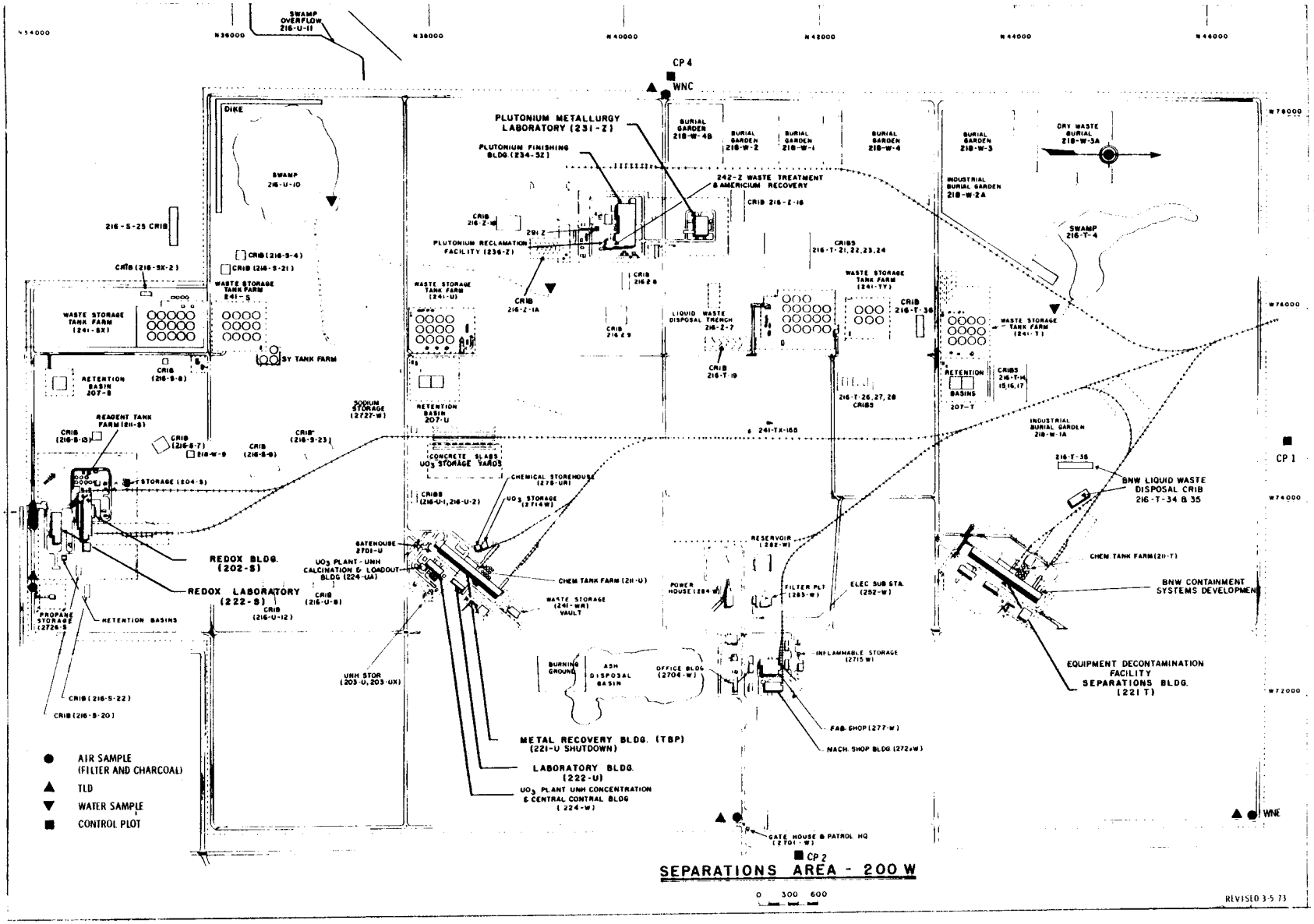


FIGURE A.6. Sampling Locations in the 200-W Separations Area

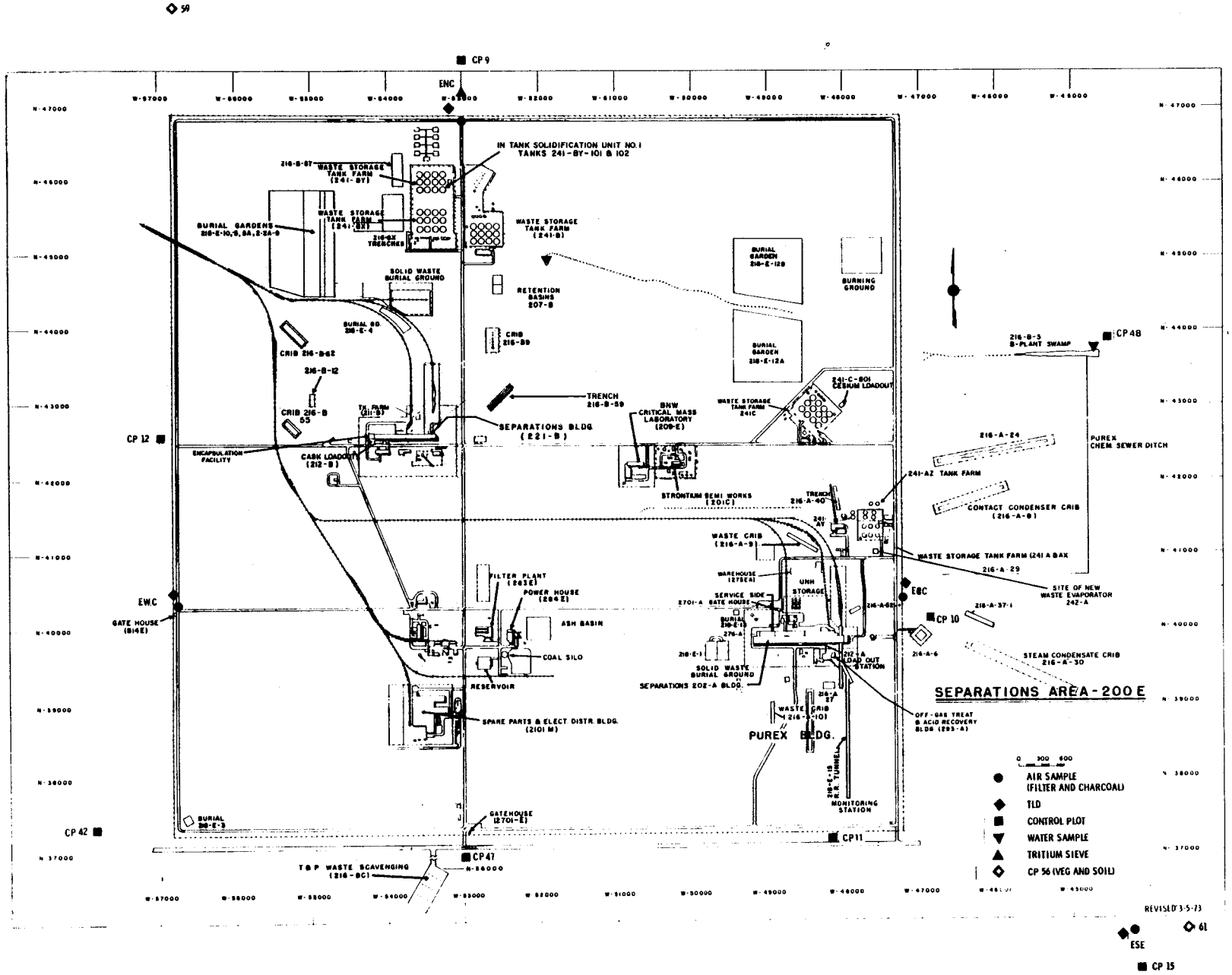


FIGURE A.7. Sampling Locations in the 200-E Separations Area

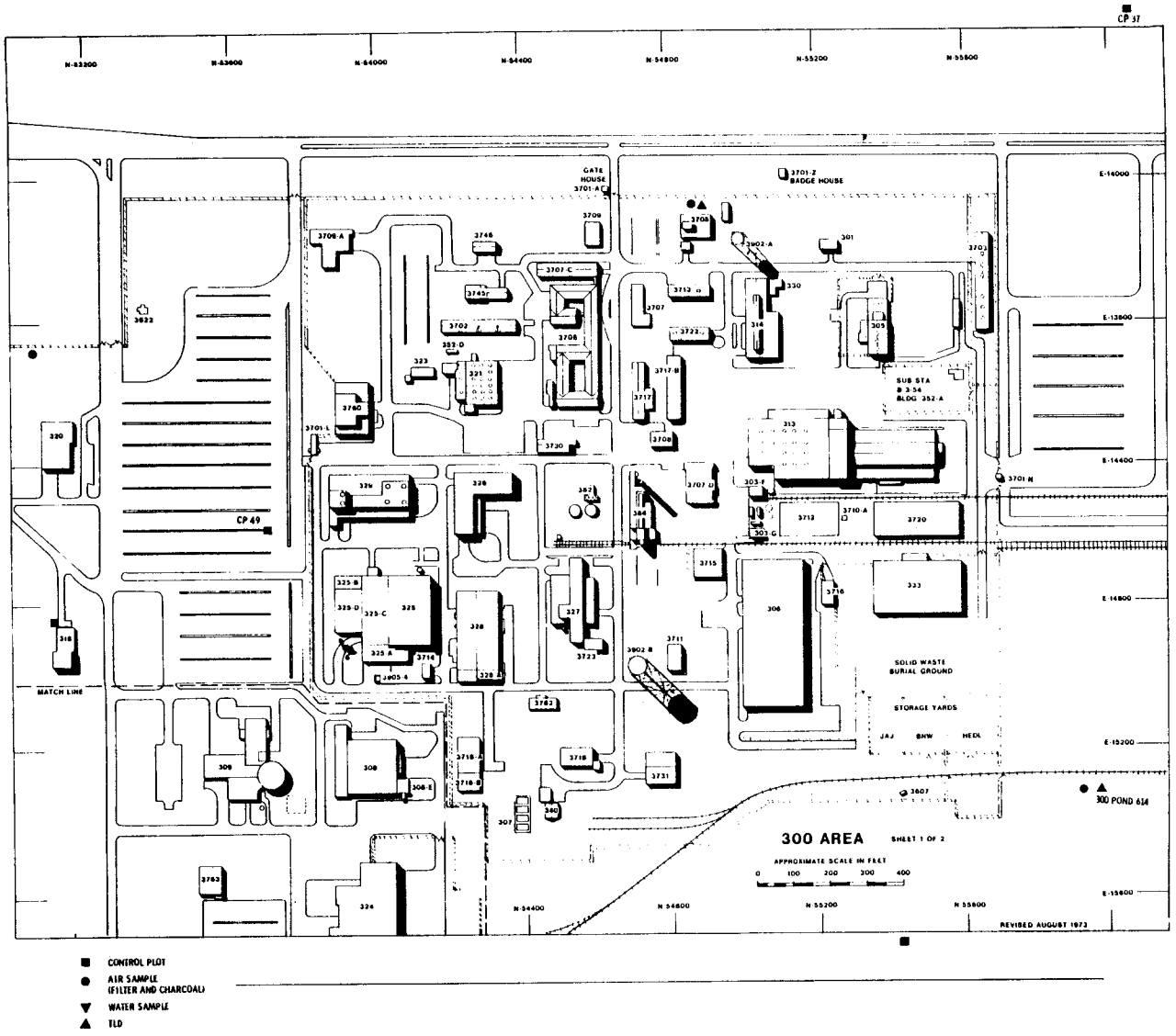


FIGURE A.8(a). Sampling Locations in the 300 Area

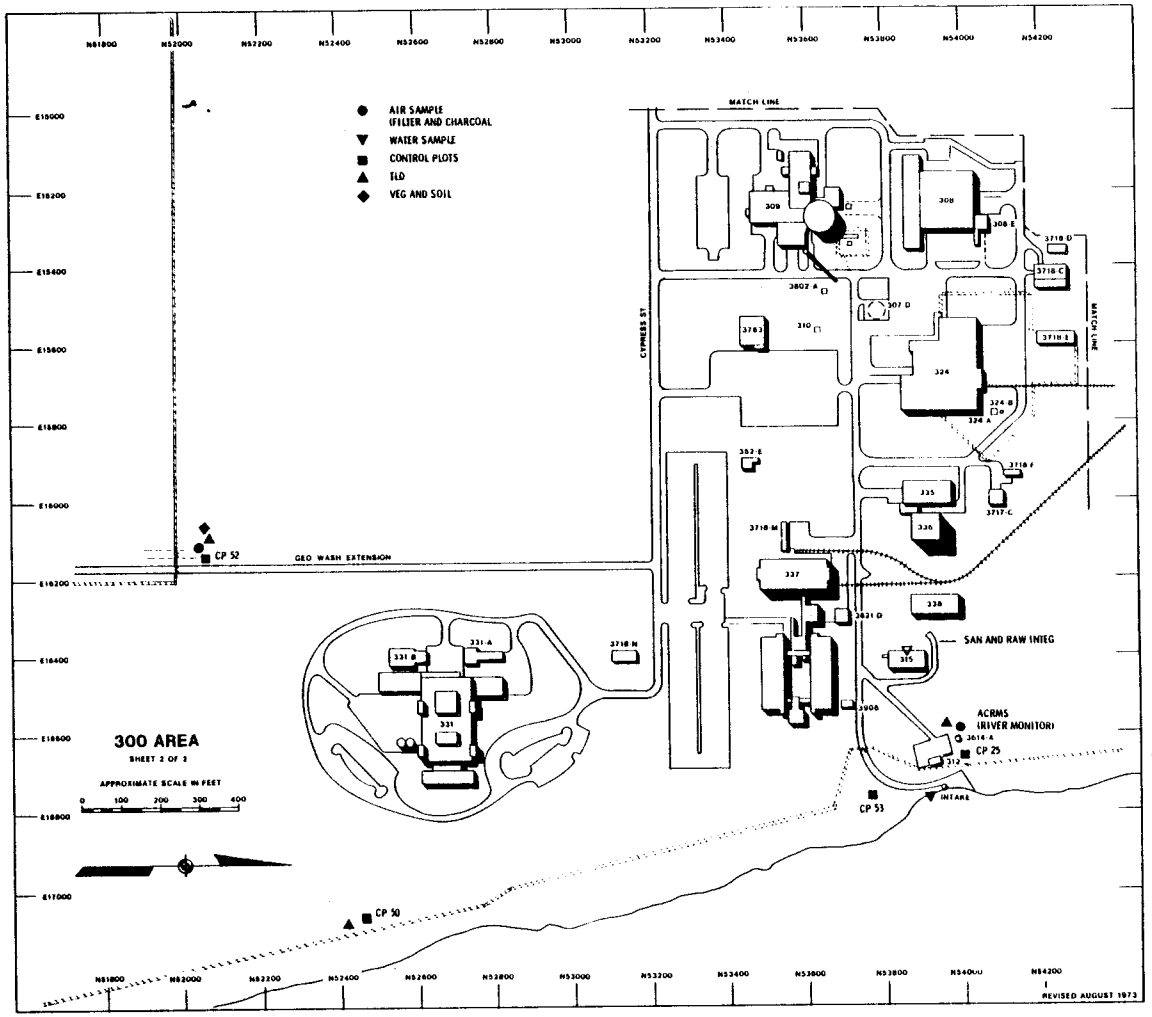


FIGURE A.8(b). Sampling Locations in the 300 Area (Con't)

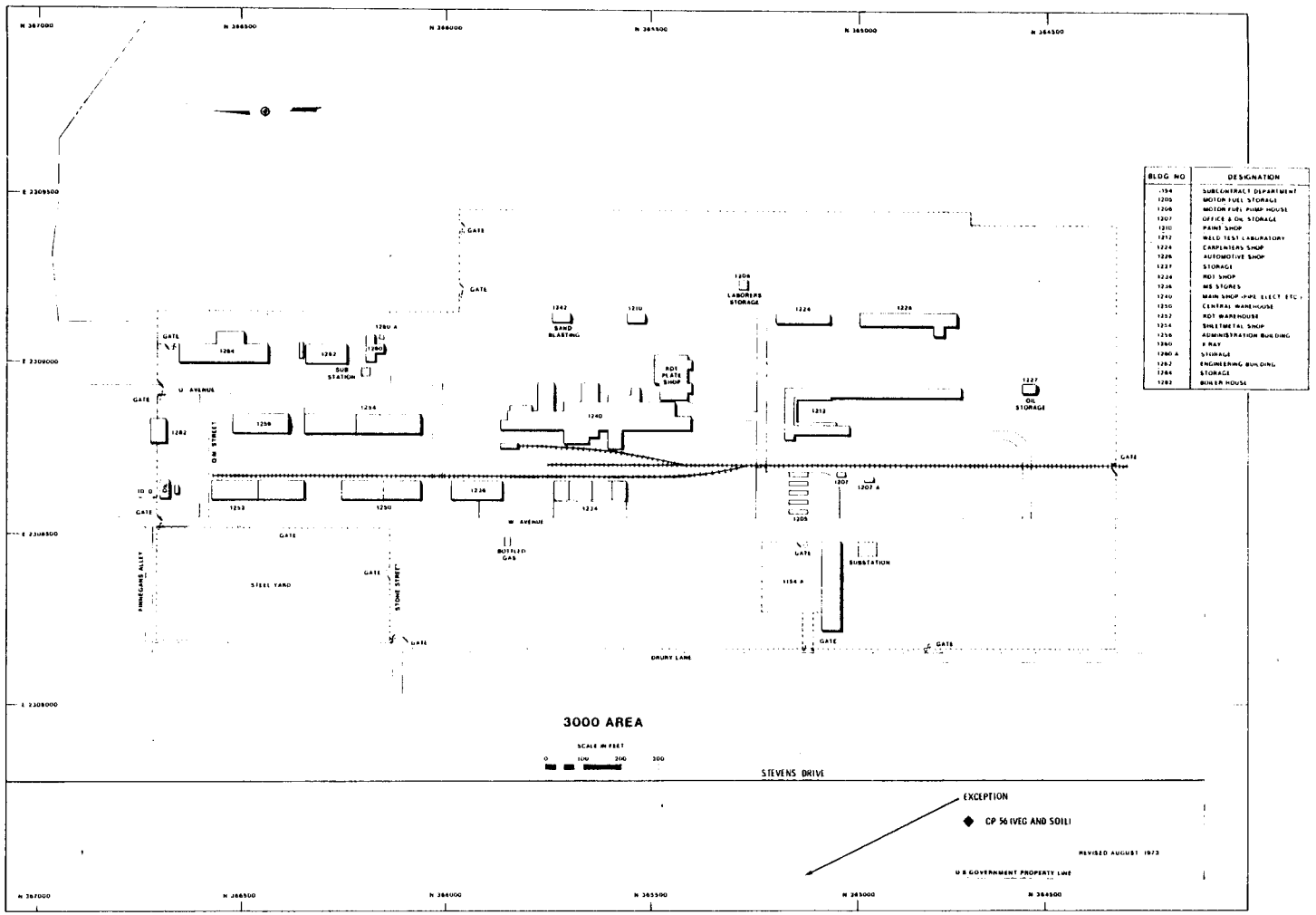


FIGURE A.9. Sampling Locations in the 3000 Area

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