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AEC RESEARCH AND DEVELOPMENT REPORT

HANFORD TECHNICAL RECORD RADIOACTIVE CONTAMINATION IN THE HANFORD ENVIRONS

FOR THE PERIOD
JULY, AUGUST, SEPTEMBER

1957
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M. W. McCONIGA, J. M. SELBY and J. K. SOLDAT

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RADIOACTIVE CONTAMINATION IN THE HANFORD ENVIRONS

FOR THE PERIOD

JULY, AUGUST, SEPTEMBER

1957

By

M. W. McConiga, J. M. Selby
and

J. K. Soldat

Regional Monitoring
Radiation Protection Operation

February 24, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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SECTION I: RADIOACTIVE CONTAMINATION IN EFFLUENT GASES

Total average I^{131} emission from A-plant and S-plant stacks this quarter was 1.0 curie per day, compared to 0.8 curie per day during the previous quarter. Approximately 60 per cent of the I^{131} was emitted from A-plant stack this quarter. Ruthenium emission from the S-plant stack again averaged less than 0.01 curie per day.

C^{14} measurements were generally comparable to previous measurements. The S^{35} emission rates from 100-C and 100-F Areas increased by factors of 5 and 16, respectively, this quarter. Total average tritium oxide emission from all reactor area stacks combined was 1.9 curies per day this quarter, about 50 per cent of last quarter's unusually high value.

No significant changes were noted in the alpha particle emitters from reactor stack gases this quarter. Filterable gross beta emitters and the concentrations of radioactive particles both increased by factors of about 10 this quarter at 100-B reactor stack. This represents a reversal of the decreasing trend noted since October, 1956.

SECTION II: RADIOACTIVE CONTAMINATION ON VEGETATION

Application of gamma energy analysis techniques to vegetation analyses was made during July. Results of vegetation measurements are now reported for six isotopes or groups of isotopes instead of for radio-iodine and non-volatile beta emitters as in the past. Correlations between old and new methods were favorable for gross activity less I^{131} . Gamma spectrometry gave results one to three times those obtained by the previous wet-chemistry radio-iodine analysis, when performed on duplicate samples.

Quarterly averages for radio-iodine deposition on vegetation were less than $1.5 \times 10^{-6} \mu\text{c/gm}$ at all locations, except those close to the separations areas. The latter had average values of $2.7 \times 10^{-6} \mu\text{c/gm}$ this quarter. Average values for "fission products less I^{131} " were $(2 \text{ to } 4) \times 10^{-5} \mu\text{c/gm}$ at all off-project locations. On-project vegetation averaged $(6 \text{ to } 11) \times 10^{-5} \mu\text{c/gm}$ for this group of isotopes. The radio-iodine deposition patterns for July, August and September are illustrated in Appendix B.

SECTION III: RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE

The average dosage rates in the Tri-City Area increased by a factor of two over the previous quarter. At 300 Area, average values remained at the levels observed last quarter. The concentration of radioactive particles and the radio-iodine activity density in the atmosphere decreased in the vicinity of the project, while a five-fold increase in radioactive particle concentration was noted at Boise, Idaho.

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SECTION IV: RADIOACTIVE CONTAMINATION IN HANFORD WASTES

Gross beta activity in reactor cooling water discharged to the Columbia River averaged 1.5×10^4 curies per day this quarter compared to 3.4×10^4 curies per day last quarter. This decrease follows the normal seasonal pattern. A summary of activity in liquid wastes discharged to open swamps and ditches is tabulated. Results of ground surveys on project and in nearby residential areas are illustrated in Appendix B.

Ground surveys of Richland in August revealed six particles in 80,000 square feet surveyed. The particle concentration around the Purex stack increased significantly during the quarter.

SECTION V: RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER AND RELATED WATERS

The beta emitter activity densities of Columbia River water during the quarter were generally the same as last quarter. Mud activity levels generally increased this quarter. Activity levels of the Snake and Yakima Rivers remained at background concentrations.

SECTION VI: RADIOACTIVE CONTAMINATION IN DRINKING WATER

The average flow for the third quarter was 9.3×10^5 gps, compared to 1.7×10^6 gps during the second quarter. During the third quarter, Pasco Filter Plant samples showed increased beta emitter activities all through the treatment process, due partly to the decreased dilution of reactor effluents at lower flow. Water leaving the plant averaged 3.0×10^{-6} $\mu\text{c/cc}$, about 60 per cent higher than last quarter.

MPC fractions, based on the continuous occupational limit related to the gastrointestinal tract, were calculated from analyses of samples from Pasco and 100-F Area.

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INTRODUCTION

This document summarizes the results obtained from monitoring the Hanford environs for radioactive contamination during the period July, August, September, 1957. Samples were collected by Regional Monitoring forces according to procedures previously outlined in documents of this series.⁽¹⁾ These samples were analyzed by Radiological Chemical Analysis forces according to procedures and techniques described in a previously published laboratory manual.⁽²⁾

Counting rates obtained from these analyses were corrected for geometry, backscatter, air-window absorption, source size, self-absorption, chemical yield, and collection efficiency by Radiological Chemical Analysis forces using factors described in previous reports.^(3, 4, 5) Additional corrections for decay were applied to those samples in which significant amounts of short half-life beta particle emitters were found. The findings obtained from analyzing the direct samples were supplemented with readings obtained from portable and fixed instrumentation.

The results obtained from the described efforts are presented in Sections I through VI. These sections discuss the amounts of active material discharged from plant facilities and their effect on the contamination of vegetation, air, soil, and water.

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SECTION I

RADIOACTIVE CONTAMINATION IN EFFLUENT GASES

Radioactive contaminants in the separations and reactor area effluent gases released to the Hanford environs were sampled at the stacks and the stack breechings. Daily filter and scrubber samples from the separations areas were analyzed for I^{131} , $Ru^{103-106}$, and filterable total beta activity. Semi-weekly filter samples and monthly tritium oxide and C^{14} - S^{35} samples were taken from the reactor area stacks. The results obtained are discussed below and summarized in Tables I through V in Appendix A.

SEPARATIONS AREAS

Slight changes in the I^{131} emission rates from the A-plant (Purex) stack this quarter were within the range of fluctuations normally observed at this facility. Average daily emission of filterable gross beta emitters increased slightly over values noted in the second quarter.⁽¹⁰⁾ The present quarter average of 0.01 curie per day is still within the expected range of values (Table I).

An increase in the average daily emission rate of I^{131} from the S-plant (Redox) stack was noted this quarter. Average value last quarter was 0.13 curie per day; average during the present quarterly reporting period was 0.41 curie per day (Table II). These values are still below the average for the first quarter of 1957 (0.86 curie per day). Average ruthenium emission rates from the S-plant stack were below the detection limit again this quarter. Maximum measurement was 0.04 curie per day, compared to a maximum of 0.21 curie per day last quarter.

Changes in concentrations of filterable radioactive materials discharged from the U-plant stack this quarter were insignificant when compared with previous fluctuations.

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REACTOR AREAS

Tritium oxide emission rates from three reactor areas decreased significantly this quarter. Total average emission from the eight reactor areas combined was 1.9 curies per day this quarter, compared to 3.9 curies per day last quarter. Maximum measurement was 1.4 curie per day at 100-C Area in July. Values obtained from 100-DR stack gases returned to normal this quarter after the unusually low measurements obtained last quarter.

No significant changes in C^{14} emission rates were noted this quarter. Average values were near the detection limit and only scattered positive measurements were obtained. The maximum C^{14} value occurred at 100-C Area in July when 3.3×10^{-2} curie per day was emitted. Daily average S^{35} emission increased by factors of 1.6, 5.0, and >16 at 100-B, 100-C, and 100-F Areas, respectively, this quarter. Quarterly average value at 100-F Area was 9.6×10^{-3} curie per day this quarter, compared to $<6 \times 10^{-4}$ curie per day last quarter. The maximum measurement was 1.6×10^{-2} curie per day at 100-F Area in August (Table IV).

The average activity density of alpha particle emitters discharged from the reactor stacks was below the detection limit of 6×10^{-8} curie per day again this quarter. Maximum value this quarter was 1.1×10^{-7} curie per day at 100-KW Area; last quarter's maximum was 2.4×10^{-7} curie per day at 100-KE Area.

Gross beta particle emitter activity density and the concentration of radioactive particles increased by factors of 7 and 12, respectively, at 100-B Area this quarter. These increases represent a reversal of a decreasing trend noted at this area since October, 1956. Decreases were noted at 100-D and 100-H Areas this quarter.

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300 AREA - 327 BUILDING

Weekly filter and scrubber samples collected from the plenum of the 327 Building stack were analyzed for gross beta particle emitters. The average emission rate of 4.0×10^{-3} curie per day this quarter was weighted by one unusually high value of 5.2×10^{-2} curie per day obtained over the period August 27 to September 3, 1957. Without this one high measurement, this quarter's average would have been 3×10^{-4} curie per day. Last quarter's average value was $<5 \times 10^{-5}$ curie per day.

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SECTION II

RADIOACTIVE CONTAMINATION ON VEGETATION

The routine determination of the radioactive contamination on vegetation in the environs was made by gamma spectrometric analysis⁽⁶⁾ for the first time this quarter. Measurements were made for Zr^{95} - Nb^{95} , Ru^{103} - Ru^{106} , I^{131} , Ba^{140} - La^{140} , and Ce^{141} - Ce^{144} - Pr^{144} on 100 composite samples collected from the project and about 160 composite samples collected from off-project locations in Washington and Oregon. Duplicate samples were also collected from some locations for analysis of I^{131} and non-volatile beta emitters by wet-chemistry analysis. Analysis for alpha particle emitters on vegetation was made on 25-gram samples of vegetation collected from selected locations in and near the project. The results of these vegetation measurements are summarized in Tables VI and VII in Appendix A.

Starting in July, 1957, ten 150-gram vegetation samples were collected from each of 25 "zones" (Figure 1 in Appendix B). The samples were composited in the laboratory into one 150-gram sample per zone, placed into 9-ounce jars, and counted on a 3 in. x 3 in. NaI crystal connected to a 100-channel gamma spectrometer. Isotopic concentrations calculated from these gamma counting rates were summarized by combining the results of the 25 zones into six groups (Table VI).

<u>Group</u>	<u>Zones</u>
Separations Areas	A, B, C, and D
Project	E, F, G, H, and J
Wahluke Slope	O and P
Residential Areas	I, K, L, M, N, and Q
Eastern Washington	R, S, T, and U
So. Central Washington and Northern Oregon	V, W, X, and Y

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Thirty-one pairs of duplicate samples were taken to test the reproducibility of the compositing and gamma counting method. The ratio of duplicate results ranged from 0.5 to 2.7 for I^{131} analysis, with an average of 1.2. This ratio was 0.79 to 1.4 for "summation of fission products less I^{131} " (F.P. - I^{131}), with an average of 1.1. This latter term (F.P. - I^{131}) includes the following isotopes as measured by the gamma spectrometry method - Zr^{95} - Nb^{95} , Ru^{103} - Ru^{106} , Ba^{140} - La^{140} , and Ce^{141} - Ce^{144} - Pr^{144} . Additional duplicate samples were taken to compare the results of wet-chemistry analysis for I^{131} and "non-volatile beta emitters" with the results of gamma spectroscopy measurements for I^{131} and "F.P. - I^{131} ".

Comparison of I^{131} measurements this quarter revealed that gamma spectroscopy results averaged 1.6 times as high as wet-chemistry measurements. Previous investigation had indicated this ratio could be as high as 3.0.⁽⁷⁾

Gamma spectroscopy measurements for "F.P. - I^{131} " compared favorably with the wet-chemistry "non-volatile beta emitter" results on duplicate samples. The average ratio for the results of these two types of measurements for over 200 pairs of samples this quarter was 1.1.

Average I^{131} and "F.P. - I^{131} " activity density on vegetation decreased this quarter at all locations sampled. Last quarter's⁽¹⁰⁾ high average values reflected the deposition of bomb fallout during June. Figures 2 through 5 illustrate the patterns of I^{131} activity density on vegetation during July, August, and September, 1957. Figure 2 shows results obtained in July by wet-chemistry methods for radio-iodine; and Figure 3 illustrates the pattern obtained in July by gamma spectroscopy measurements for I^{131} .

The data in Figure 2 indicates higher results than that in Figure 3 because of the multiplying factor of 3.0 used in calculating wet-chemistry results since the first quarter of 1957.⁽⁹⁾ As discussed previously, this factor was closer to 1.6 during the present quarter.

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Average alpha emitter activity density on vegetation this quarter increased by a factor of two at locations near the separations areas. These data represent a return to the increasing trend noted from October, 1956, to March, 1957. (8 and 9) No significant changes were noted in alpha activity on vegetation sampled from nearby residential areas this quarter.


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SECTION III

RADIOACTIVE CONTAMINATION IN THE ATMOSPHERE

The magnitude and extent of airborne contamination in the Hanford environs were determined from analyses of filter and scrubber samples and from data recorded in the operation of Victoreen Integrators, H. M. Chambers, and Detachable Ionization Chambers. The results obtained by each of these monitoring methods are summarized in Tables VIII through X in Appendix A.

The quarterly average dosage rates in the vicinity of 300 Area were comparable to those occurring last quarter.⁽¹⁰⁾ The quarterly average in the Tri-City Area was twice as high as that in the 300 Area and Vicinity. The Benton City integrator was back in operation this quarter, and a reading of 0.5 mrad per day was observed. The 100 Area and Vicinity readings increased by a factor of two this quarter.

The average alpha particle emitter activity density in the atmosphere was above the detection limit of 2×10^{-15} $\mu\text{c/cc}$ at six scattered locations. In each case, one extremely high sample occurred during the quarter. If these high samples were omitted, the average of the other samples would have been below the detection limit.

Filterable beta particle emitters and radioactive particle concentrations in the atmosphere decreased on the project and in the Tri-City Area; however, a five-fold increase in radioactive particle concentrations was noted at Boise, Idaho. During August, a monthly average of 1.8 particles/ m^3 was obtained at Boise, Idaho. This unusually high value was due to fallout of bomb debris from continental tests.

The quarterly average radio-iodine activity density in the atmosphere decreased to one-half of the values noted last quarter (Table X). This decrease was principally due to a decrease in bomb fallout. At one 200 East location, the quarterly average increased by a factor of two because of one high weekly value of 3×10^{-12} $\mu\text{c/cc}$. This maximum was obtained during the week of July 29 to August 5, co-incident with the high emission rate of 4.2 curies of I^{131} per day from the A-plant stack on July 25, 1957.

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SECTION IV

RADIOACTIVE CONTAMINATION IN HANFORD WASTES

The magnitude and extent of radioactive contamination in Hanford wastes were determined from the results of over 2700 measurements. Solid and liquid samples obtained from open waste areas were analyzed radiochemically for gross alpha and beta particle emitters. Specific isotopic analyses were also performed for certain other contaminants. These measurements were supplemented with data obtained from portable instrument surveys at various locations on the plant.

100 AREA WASTES

Radioactive contamination discharged to the Columbia River from the reactor areas was determined by analyzing samples collected daily from the outlets of the effluent water retention basins and correcting the results for decay. A summary of the activity of beta particle emitters discharged to the river per unit of time, not corrected for periods of reactor outage (when no samples were taken) is given in Table XI in Appendix A.

The average total beta activity in cooling water discharged to the river from all reactors decreased from 3.4×10^4 curies per day last quarter⁽¹⁰⁾ to 1.5×10^4 curies per day during the current quarter. This decrease follows the normal seasonal pattern.

The activity density of I^{131} in waste discharged to the Columbia River from the Biology Farm at 100-F Area was measured by analyzing composite samples collected from the sump in the waste discharge line. An average of 100 $\mu\text{c}/\text{day}$ was discharged to the river during the quarter.

200 AREA WASTES

The results of liquid and solid samples collected from waste sources in the separations areas are summarized in Tables XII and XIII in Appendix A. The beta activity density in the T-swamp and the U-swamp has been steadily

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decreasing during the last few quarters, while the U-swamp has shown a steady increase in alpha activity density over the last few quarters. The alpha activity density increased by a factor of three at the U-ditch inlet, by a factor of ten at the 234-5 ditch, and a factor of 20 at the 231 ditch. The alpha activity density in the laundry ditch returned to its normal value following the ten-fold increase last quarter. The alpha and beta activity densities in the remaining locations were within the range of fluctuations expected.

Portable instrument surveys using GM and CP meters were performed at the perimeter of all open waste zones in the separations areas. Counting rates obtained over mud and water at the B-ditch and B-swamp in 200 East Area this quarter ranged from background to 300 c/m above background. These readings were slightly lower than those noted last quarter. Counting rates observed at the T-swamp and T-ditch generally decreased throughout the quarter as these waste zones gradually dried up. Maximum readings were 15,000 c/m over the ditch in September and 30,000 c/m over the swamp in July. Laundry ditch readings continued to range from background to a few thousand c/m. Maximum readings were again obtained at the U-swamp inlet, where dosage rates up to 50 mrad/hr were found during the quarter.

300 AREA WASTES

Radioactive contamination in waste water entering the 300 Area North pond was measured in bi-weekly composite samples collected by Fuels Preparation Department personnel (Table XIV). Decreases in both uranium and gross beta activity density were noted in this waste stream during the quarter. This is the second consecutive quarter that the beta activity has decreased.

ENVIRONS - GROUND CONTAMINATION

Six radioactive particles were detected when portable instrument surveys of 80,000 square feet were performed in Richland during August. The maximum surface reading obtained on these particles was 15,000 c/m.

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Surveys of ground adjacent to the project roadways and inside of areas revealed 0 to 2 particles per 1000 square feet, except in the vicinity of 100-B Area, 200 West Area, and downwind from 200 West Area. A concentration of 0 to 4 particles per 1000 square feet surveyed at 100-B Area, was higher than the average project reading, as a result of the basin dry-out in 100-B area during April. Depositions of 5 particles per 1000 square feet near 200 West Area and 10 particles per 1000 square feet downwind of 200 West Area were found after a stack flush at Redox in August.

Surveys of 400 square foot plots around Redox during the quarter disclosed an average deposition of 6 particles per plot. This is comparable to the concentration found during the last quarter. The maximum concentration found during the quarter was 52 particles per plot. Particle deposition around Purex increased during the quarter with a maximum of 68 particles found in one plot during September. The average concentration of 90 plots surveyed during the quarter was 2 particles per plot, compared to an average of 0.2 particle per plot during the last quarter.

Figure 6 (Appendix B) illustrates the ground contamination pattern found during August.

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SECTION V

RADIOACTIVE CONTAMINATION IN THE COLUMBIA RIVER
AND RELATED WATERS

Approximately 500 samples of water were collected from the Columbia, Yakima, and Snake Rivers to determine the concentration of their radioactive contaminants. Alpha particle emitters averaged below the reporting limit of $5 \times 10^{-9} \mu\text{c/cc}$ for all river locations sampled this quarter.

The average beta particle emitter activity densities of the Columbia River water (Table XV) were generally similar to those of last quarter.⁽¹⁰⁾

The monthly one-liter samples collected from the Columbia River below McNary Dam revealed gross beta activity densities up to $6 \times 10^{-7} \mu\text{c/cc}$, about 20 per cent lower than those of last quarter.⁽¹⁰⁾ The maximum value, $6 \times 10^{-7} \mu\text{c/cc}$, occurred at Maryhill Ferry early in July.

Thirteen water samples collected from the south bank of the Columbia River at the Hanford Ferry Landing were analyzed for the activity density of I^{131} . Average and maximum results for this quarter were 4.5×10^{-8} and $1.2 \times 10^{-7} \mu\text{c/cc}$, respectively, compared to 5.0×10^{-8} and $1.8 \times 10^{-7} \mu\text{c/cc}$, respectively, in the previous quarter.

Approximately 200 river mud samples were collected from the Columbia River and nearby tributaries for measurement of gross alpha and beta particle emitters. All alpha particle emitter concentrations were below the reporting limit of $3 \times 10^{-6} \mu\text{c/gm}$.

The activity density of beta particle emitters in Columbia River mud increased this quarter at most locations. River mud samples collected within the project ranged from $6 \times 10^{-5} \mu\text{c/gm}$ to a maximum of $5 \times 10^{-4} \mu\text{c/gm}$ obtained at Hanford. Off-project mud samples collected from the Columbia, Snake, and Yakima Rivers ranged from $1.3 \times 10^{-5} \mu\text{c/gm}$ to $2 \times 10^{-4} \mu\text{c/gm}$.

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More than 150 samples of raw water were collected from the 183 and 283 Buildings in the reactor and separations areas for gross alpha and beta analysis (Table XVI). The activity density from gross alpha emitters was below the detection limit for all samples.

The raw water samples represent water prior to purification for drinking; the activity density of beta particle emitters in raw water this quarter was generally the same as that of the previous quarter, except for positive values at 183-B and 183-C, which may be caused by 107 basin seepage into the 181 intakes. Seepage has been proven by temperature and sampling surveys. The average for 183-F has more than doubled over last quarter from high values of the last two months of the quarter. These, too, may be the result of basin leakage. The highest activity density of $4.6 \times 10^{-5} \mu\text{c/cc}$ was found at 183-H Building on September 11, 1957.

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SECTION VI

RADIOACTIVE CONTAMINATION IN DRINKING WATER

The results of 611 samples of drinking water analyzed for gross alpha and beta particle emitters are presented in Table XVII in Appendix A. Drinking water derived from the Columbia River was slightly higher in beta emitter activity densities than that of last quarter.⁽¹⁰⁾ The beta emitter activity density of drinking water at the White Bluffs Fire Hall has decreased to one-half of its previous value.

Columbia River flow averaged 9.3×10^5 gps compared with 1.7×10^6 gps in the second quarter of 1957.

Fractions of continuous occupational MPC's for the gastrointestinal tract were calculated from isotopic analyses of raw water. A summary of the results, not including the unaccounted fraction, is presented below:

<u>Month</u>	<u>Pasco</u>
July	0.3 per cent of MPC _{GI}
August	0.3 per cent of MPC _{GI}
September	0.6 per cent of MPC _{GI}

The increases in MPC follow the period of decreasing river flow after the middle of June.

The results of 90 samples analyzed for alpha emitters and uranium are compared in Table XVIII. There were no significant changes in these figures from previous measurements.

The results of samples collected from successive stages of the water treatment process of the Pasco Filter Plant are shown in Table XIX. All of the values for beta particle emitters were higher, reflecting the decrease in flow and lesser dilution of the Columbia River during the third quarter.

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APPENDIX A

Tables I through XIX


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TABLE I
IODINE-131 AND FILTERABLE BETA PARTICLE EMITTERS
DISCHARGED FROM THE A-PLANT STACK
JULY, AUGUST, SEPTEMBER
1957

<u>Month</u>	<u>Units of Curies Per Day</u>		<u>Units of Curies Per Day</u>	
	<u>I-131</u>		<u>Filterable Total Beta</u>	
	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>
July	1.9	0.70	0.020	0.013
August	4.6	1.0	0.017	0.011
September	0.2	0.09	0.035	0.007
Quarter	4.6	0.64	0.035	0.010
Last Quarter	2.5	0.69	0.056	0.008

TABLE II
IODINE-131 AND RUTHENIUM DISCHARGED
FROM THE S-PLANT STACK
JULY, AUGUST, SEPTEMBER
1957

<u>Month</u>	<u>Units of Curies Per Day</u>		<u>Units of Curies Per Day</u>	
	<u>I-131</u>		<u>Ruthenium</u>	
	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>
July	1.4	0.31	0.03	<0.01
August	2.1	0.57	0.04	<0.01
September	1.6	0.32	0.02	<0.01
Quarter	2.1	0.41	0.04	<0.01
Last Quarter	2.5	0.13	0.21	<0.01

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TABLE III
RADIOACTIVE PARTICULATE MATERIALS DISCHARGED
FROM THE U-PLANT STACK
JULY, AUGUST, SEPTEMBER

<u>Month</u>	<u>1957</u>					
	<u>Alpha Particle</u> <u>Emitters</u>		<u>Beta Particle</u> <u>Emitters</u>		<u>Radioactive</u> <u>Particle</u> <u>Concentrations</u>	
	<u>Units of 10^{-8}</u> <u>curie/day</u>		<u>Units of 10^{-5}</u> <u>curie/day</u>		<u>Units of 10^4</u> <u>Particles/day</u>	
	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>
July	2.4	0.6	0.05	0.04	2.6	0.6
August	3.2	0.7	0.06	0.03	1.3	0.2
September	4.0	1.7	0.33	0.20	1.0	0.2
Quarter	3.2	1.0	0.15	0.09	2.6	0.3
Last Quarter	0.6	0.3	0.13	0.05	7.7	0.9

TABLE IV
QUARTERLY SUMMARY OF
TRITIUM OXIDE, CARBON-14, SULFUR-35
DISCHARGED FROM REACTOR STACKS
JULY, AUGUST, SEPTEMBER

<u>Stack</u>	<u>Tritium Oxide</u>		<u>Carbon-14</u>		<u>Sulfur-35</u>	
	<u>Units of curie/day</u>		<u>Units of 10^{-3} curie/day</u>		<u>Units of 10^{-4} curie/day</u>	
	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>
100-B	0.3	0.2	7.9	<6	52	18
100-C	1.4	0.3	33	13	70	30
100-KW	0.5	0.2	9.4	<6	<6	<6
100-KE	0.6	0.1	7.4	<6	11	<6
100-D	0.9	0.7	6.7	<6	<6	<6
100-DR	0.3	0.2	18	<6	12	<6
100-H	0.3	0.1	7.4	<6	<6	<6
100-F	0.2	0.1	26	13	160	96

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TABLE V
QUARTERLY SUMMARY OF
RADIOACTIVE PARTICULATE MATERIALS DISCHARGED
FROM THE REACTOR STACKS
JULY, AUGUST, SEPTEMBER
1957

Stack	Alpha Particle Emitters		Beta Particle Emitters		Radioactive Particle Concentrations	
	Units of 10^{-7} curie/day		Units of 10^{-5} curie/day		Units of 10^5 Particles/day	
	Maximum	Average	Maximum	Average	Maximum	Average
100-B	0.6	<0.6	28	4.4	21	2.4
100-C	<0.6	<0.6	89	7.9	25	3.5
100-KW	1.1	<0.6	21	9.3	0.9	0.1
100-KE	<0.6	<0.6	79	10	23	1.8
100-D	<0.6	<0.6	20	3.7	0.9	0.1
100-DR	0.7	<0.6	8.6	3.7	7.8	0.6
100-H	0.9	<0.6	17	4.9	5.7	0.2
100-F	0.8	<0.6	53	3.4	28	2.8

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TABLE VI

SUMMARY OF VEGETATION MEASUREMENTS
JULY, AUGUST, SEPTEMBER
1957

<u>Locations</u>	<u>Units of $10^{-6} \mu\text{c/gm}$</u>					
	<u>Zr-95</u> <u>Nb-95</u>	<u>Ru-103</u> <u>Ru-106</u>	<u>I-131</u>	<u>Ba-140</u> <u>La-140</u>	<u>Ce-141</u> <u>Ce-144</u>	<u>Fission Products</u> <u>Less I-131</u>
Separations Areas	29	8.3	2.7	9.0	56	110
Project	22	5.2	<1.5	7.7	33	68
Wahluke Slope	20	5.1	<1.5	8.4	30	64
Residential Areas	9.4	2.3	<1.5	4.0	16	31
Eastern Washington	11	2.8	<1.5	4.9	23	37
So. Central Washington and No. Oregon	6.0	<2.0	<1.5	2.8	6.7	16

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TABLE VII
RADIOACTIVE CONTAMINATION FROM ALPHA
PARTICLE EMITTERS ON VEGETATION
JULY, AUGUST, SEPTEMBER
1957

Units of $10^{-7} \mu\text{c/gm}$

<u>Location</u>	<u>July</u> <u>Average</u>	<u>August</u> <u>Average</u>	<u>September</u> <u>Average</u>	<u>Quarter</u> <u>Maximum</u>	<u>Average</u>
<u>Near Separations Areas</u>					
200 West Gate	7.8	57	17	57	27
Meteorology Tower	1.1	1.7	2.7	2.7	1.9
Batch Plant	1.0	8.2	6.4	10	5.2
Rt. 4S, Mi. 4	1.9	6.2	6.2	8.0	4.8
Rt. 4S, Mi. 6	0.4	2.7	3.0	3.5	2.0
<u>Residential Areas</u>					
Pasco	0.3	0.3	0.3	0.4	0.3
Benton City	<0.3	0.4	0.3	0.6	0.3

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TABLE VIII

AVERAGE DOSE RATES MEASURED BY IONIZATION CHAMBERS

JULY, AUGUST, SEPTEMBER

1957

<u>Location</u>	<u>Units of mrad per day</u>			
	<u>Integrations and HM Chambers</u>		<u>Detachable Chambers</u>	
	<u>Quarterly Average</u>	<u>Average Last Quarter</u>	<u>Quarterly Average</u>	<u>Average Last Quarter</u>
100 Areas and Vicinity	5.8	2.7	0.8	1.2
200 Areas and Vicinity	4.0	5.8	0.8	1.3
300 - 3000 Areas and Vicinity	0.8	0.6	0.9	1.1
Benton City	0.5	---	---	---
Tri-City Area	1.5	0.6	0.7	---

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TABLE IX

RADIOACTIVE PARTICULATE MATERIALS FILTERED FROM AIR
JULY, AUGUST, SEPTEMBER

<u>Location</u>	<u>1957</u>		<u>1957</u>	
	Beta Particle Emitters		Concentration of Radioactive Particles	
	Units of 10^{-14}	$\mu\text{c/cc}$	Units of 10^{-3}	Particles/ m^3
	<u>Quarterly Average</u>	<u>Average Last Quarter</u>	<u>Quarterly Average</u>	<u>Average Last Quarter</u>
100 Areas and Vicinity	31	70	18	56
200 Areas and Vicinity	44	92	27	52
300 - 3000 Areas and Vicinity	34	77	15	39
Benton City	43	85	13	26
Tri-City Area	18	35	16	53
Seattle, Washington	--	--	14	30
Spokane, Washington	--	--	19	57
Walla Walla, Washington	--	--	27	88
Yakima, Washington	--	--	18	73
Boise, Idaho	--	--	600	160
Lewiston, Idaho	--	--	24	80
Great Falls, Montana	--	--	41	58
Meacham, Oregon	--	--	7	11
Klamath Falls, Oregon	--	--	30	88

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TABLE X

CONCENTRATIONS OF IODINE DETECTED BY AIR SCRUBBERS
JULY, AUGUST, SEPTEMBER
1957

Units of 10^{-12} $\mu\text{c/cc}$

<u>Location</u>	<u>July</u>	<u>August</u>	<u>September</u>	<u>Qtrly. Avg.</u>	<u>Wkly. Max.</u>	<u>Avg. Last Qtr.</u>
100 Areas and Vicinity	<0.1	0.1	< 0.1	0.1	0.4	0.3
200 Areas and Vicinity	0.3	0.4	0.3	0.3	3.0	0.6
300 Areas and Vicinity	0.1	0.2	0.1	0.1	0.3	0.2
Benton City	<0.1	0.2	0.1	0.1	0.3	0.2
Tri-City Area	0.1	0.1	0.1	0.1	0.4	0.3

TABLE XI

BETA PARTICLE EMITTERS DISCHARGED TO RIVER
IN REACTOR EFFLUENT WATER
JULY, AUGUST, SEPTEMBER

1957

Units of 10^3 $\mu\text{c/sec}$

<u>Location</u>	<u>No. Samples</u>	<u>July</u>		<u>August</u>		<u>September</u>		<u>Quarterly</u>	
		<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>
100-B	52	40	5	30	16	25	18	40	13
100-C	36	49	24	64	32	260	50	260	35
100-KW	54	53	34	61	35	55	33	61	34
100-KE	52	54	36	34	13	40	26	54	25
100-D	59	30	23	31	14	22	11	31	16
100-DR	59	44	14	30	11	26	18	44	14
100-H	61	140	17	26	17	34	22	140	19
100-F	56	24	16	24	16	30	20	30	17

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TABLE XII

RADIOACTIVE CONTAMINATION IN 200 AREA WASTE SYSTEMS

JULY, AUGUST, SEPTEMBER

1957

Liquid Samples

Location	Alpha Particle Emitters			Beta Particle Emitters		
	Units of $10^{-8} \mu\text{c/cc}$			Unit of $10^{-7} \mu\text{c/cc}$		
	Maximum	Average	Average Last Quarter	Maximum	Average	Average Last Quarter
T-Ditch	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
T-Swamp	<0.5	<0.5	<0.5	<5.0	<5.0	11.
Laundry Ditch	6.7	1.3	9.3	21.	<5.0	<5.0
U-Ditch Inlet	24.	2.2	0.8	<5.0	<5.0	<5.0
231 Ditch	1160.	46.	2.9	19.	<5.0	<5.0
234-5 Ditch	46.	11.	0.8	<5.0	<5.0	<5.0
U-Swamp	380.	79.	58.	60.	14.	20.
B-Ditch	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
B-Swamp	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
Purex	4.7	<0.5	<0.5	<5.0	<5.0	<5.0
222-S Swamp	77.	18.	15.	<5.0	<5.0	<5.0
Redox Swamp	14.	2.3	3.9	60.	12.	22.

Solid Samples

	Units of $10^{-6} \mu\text{c/gm}$			Units of $10^{-5} \mu\text{c/gm}$		
	Maximum	Average	Average Last Quarter	Maximum	Average	Average Last Quarter
T-Ditch	10.	5.1	8.7	1950.	940.	1910.
Laundry Ditch	15.	9.9	9.5	320.	100.	19.
234-5 Ditch	11400.	1360.	420.	5.0	3.1	4.1
B-Swamp	7.7	1.3	1.6	19.	5.8	5.5
Purex	3690.	970.	770.	31.	5.8	6.2
222-S Swamp	280.	160.	150.	170.	81.	86.
Redox Swamp	4010.	970.	800.	15800.	3190.	4980.

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TABLE XIII

RADIOACTIVE CONTAMINATION IN 200 AREA WASTE SYSTEMS
JULY, AUGUST, SEPTEMBER
1957

Liquid Samples

<u>Location</u>	<u>Uranium</u> <u>Units of $10^{-9} \mu\text{c/cc}$</u>		<u>Average Last Quarter</u>
	<u>Maximum</u>	<u>Average</u>	
U-Swamp	19800	1340	640
Laundry Ditch	58	10	88
U-Ditch	24	2.6	4.6
222-S Swamp	710	130	100

Solid Samples

	<u>Units of $10^{-6} \mu\text{c/gm}$</u>		<u>Average Last Quarter</u>
	<u>Maximum</u>	<u>Average</u>	
Laundry Ditch	16	8	8.3
222-S Swamp	130	68	70

TABLE XIV

RADIOACTIVE CONTAMINATION IN 300 AREA POND INLET
JULY, AUGUST, SEPTEMBER
1957

Units of $10^{-7} \mu\text{c/cc}$

<u>Liquid Samples</u>	<u>Maximum</u>	<u>Average</u>	<u>Average Last Quarter</u>
Beta Particle Emitters	160	27	5.6
Alpha Particle Emitters	<1.7	<1.3	<1.3
Uranium	9.4	4.7	7.1
Plutonium	<1.5	<1.2	<1.2

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TABLE XV
CONCENTRATIONS OF BETA PARTICLE EMITTERS IN RIVER WATER
JULY, AUGUST, SEPTEMBER

<u>Location</u>	<u>1957</u>				
	<u>Units of $10^{-8} \mu\text{c/cc}$</u>				
	<u>July</u>	<u>August</u>	<u>September</u>	<u>Quarter</u>	<u>Average</u>
	<u>Average</u>	<u>Average</u>	<u>Average</u>	<u>Average</u>	<u>Last</u>
					<u>Quarter</u>
<u>Columbia River</u>					
Will's Ranch	<5	<5	<5	<5	<5
181-B	<5	<5	<5	<5	<5
181-C	<5	<5	<5	<5	<5
181-KW	35	140	480	220	270
181-KE	30	48	970	350	310
181-D	570	600	1500	890	1630
181-H	1390	1100	1680	1390	1570
Below 100-H	910	1510	2800	1740	2290
181-F	1000	1250	2010	1420	2200
Below 100-F	1480	1860	3880	2410	1520
Hanford	1620	2180	3530	2440	1490
300 Area	770	750	1370	960	940
Byer's Landing	320	590	970	630	520
Richland	680	560	1250	830	660
<u>Kennewick Highlands</u>					
Pumping Station	280	430	590	430	460
Pasco Bridge (Kennewick side)	300	440	540	430	370
Pasco Bridge (Pasco side)	370	460	550	460	440
Pasco Filter Plant					
Pumping Station	360	1090	790	750	400
Sacajawea Park	250	250	300	270	310
Below McNary Dam	33	45	60	46	69
Paterson	45	45	62	51	68
<u>Snake River</u>					
Mouth	<5	<5	<5	<5	<5
<u>Yakima River</u>					
Prosser	20	<5	5	9	<5
Shore	<5	<5	<5	<5	<5
Horn	6	<5	<5	<5	<5

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TABLE XVI

CONCENTRATIONS OF BETA PARTICLE EMITTERS IN RAW WATER
RIVER EXPORT LINE
JULY, AUGUST, SEPTEMBER
1957

Units of $10^{-8} \mu\text{c/cc}$

<u>Location</u>	<u>July Average</u>	<u>August Average</u>	<u>September Average</u>	<u>Quarter Average</u>	<u>Average Last Quarter</u>
183-B	5	<5	15	8	<5
183-C	13	6	11	10	<5
183-KW	38	140	530	240	260
183-KE	42	160	940	380	260
183-D	170	670	1480	770	890
183-DR	230	640	1910	930	860
183-H	710	1100	2910	1570	1330
183-F	520	1640	2520	1560	680
283-East	24	12	14	16	41
283-West	10	9	56	25	12

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TABLE XVII
CONCENTRATIONS OF ALPHA AND BETA PARTICLE EMITTERS
IN WATER SUPPLIES
JULY, AUGUST, SEPTEMBER
1957

<u>Location</u>	<u>No. Samples</u>	<u>Alpha Particle Emitters</u>		<u>Beta Particle Emitters</u>	
		<u>Units of 10^{-9} Max.</u>	<u>$\mu\text{c/cc}$ Avg.</u>	<u>Units of 10^{-8} Max.</u>	<u>$\mu\text{c/cc}$ Avg.</u>
Mattawa Chev. Station	13	<5	<5	<5	<5
Midway and Vicinity	21	<5	<5	<5	<5
100-B Area	13	<5	<5	26	10
100-C Area	13	<5	<5	30	10
100-K Area	24	<5	<5	980	280
100-D Area	12	<5	<5	1650	370
100-DR Area	12	<5	<5	830	310
100-H Area	12	<5	<5	450	230
100-F Area	12	72	6	1030	570
White Bluffs' Fire Hall	14	<5	<5	17	8
PSN-21	4	7	6	<5	<5
B-Y Well	3	<5	<5	<5	<5
251 Building	13	<5	<5	110	26
200 East Area	37	<5	<5	21	6
200 West Area	52	<5	<5	30	10
300 Area, 3000 Area (San)	24	<5	<5	<5	<5
Byer's Landing Pump Station	12	<5	<5	7	<5
Larson Farm	12	6	<5	<5	<5
Richland	25	<5	<5	<5	<5
Prosser	13	<5	<5	<5	<5
Benton City	39	17	8	6	<5
Headgate Well	12	<5	<5	<5	<5
Enterprise	13	<5	<5	<5	<5
Kennewick	100	<5	<5	480	180
Pasco	51	<5	<5	660	200
Sacajawea	12	11	8	<5	<5
McNary	24	<5	<5	<5	<5
Paterson Store	14	<5	<5	<5	<5

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TABLE XVIII
CONCENTRATIONS OF ALPHA PARTICLE EMITTERS
IN DRINKING WATER
JULY, AUGUST, SEPTEMBER
1957

<u>Location</u>	<u>No. Samples</u>	<u>Alpha Particle Emitters</u>		<u>No. Samples</u>	<u>Uranium</u>	
		<u>Units of 10⁻⁹ μc/cc</u>			<u>Units of 10⁻⁹ μc/cc</u>	
		<u>Max.</u>	<u>Avg.</u>		<u>Max.</u>	<u>Avg.</u>
Columbia Field (San)	12	<5	<5	12	2	1
B-Y Well	3	<5	<5	3	3	3
PSN-21	4	7	6	4	8	7
Lee Blvd. (San)	12	6	<5	12	4	3
Benton City Store	12	17	11	12	11	9
Benton City Water Company	13	15	12	13	15	10
Sacajawea	13	11	8	12	13	9
Paterson Store	13	<5	<5	12	3	1

TABLE XIX
CONCENTRATIONS OF BETA PARTICLE EMITTERS
AT THE PASCO FILTER PLANT
JULY, AUGUST, SEPTEMBER
1957

<u>Type Sample</u>	<u>No. Samples</u>	<u>Maximum</u>	<u>Average</u>
Water Entering Plant From River	40	$1.3 \times 10^{-5} \mu\text{c/cc}$	$5.5 \times 10^{-6} \mu\text{c/cc}$
Filter Bed Material	12	$1.7 \times 10^{-3} \mu\text{c/gm}$	$4.3 \times 10^{-4} \mu\text{c/gm}$
Backwash Activity (Soluble)	9	$8.4 \times 10^{-6} \mu\text{c/cc}$	$3.3 \times 10^{-6} \mu\text{c/cc}$
Backwash Activity (Insoluble)	10	$5.5 \times 10^{-1} \mu\text{c/gm}$	$2.7 \times 10^{-1} \mu\text{c/gm}$
Foam From Filter Beds	1	$2.1 \times 10^{-2} \mu\text{c/gm}$	$1.4 \times 10^{-2} \mu\text{c/gm}$
Water Leaving Plant	38	$6.6 \times 10^{-6} \mu\text{c/cc}$	$3.0 \times 10^{-6} \mu\text{c/cc}$

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APPENDIX B

Figures 1 through 6

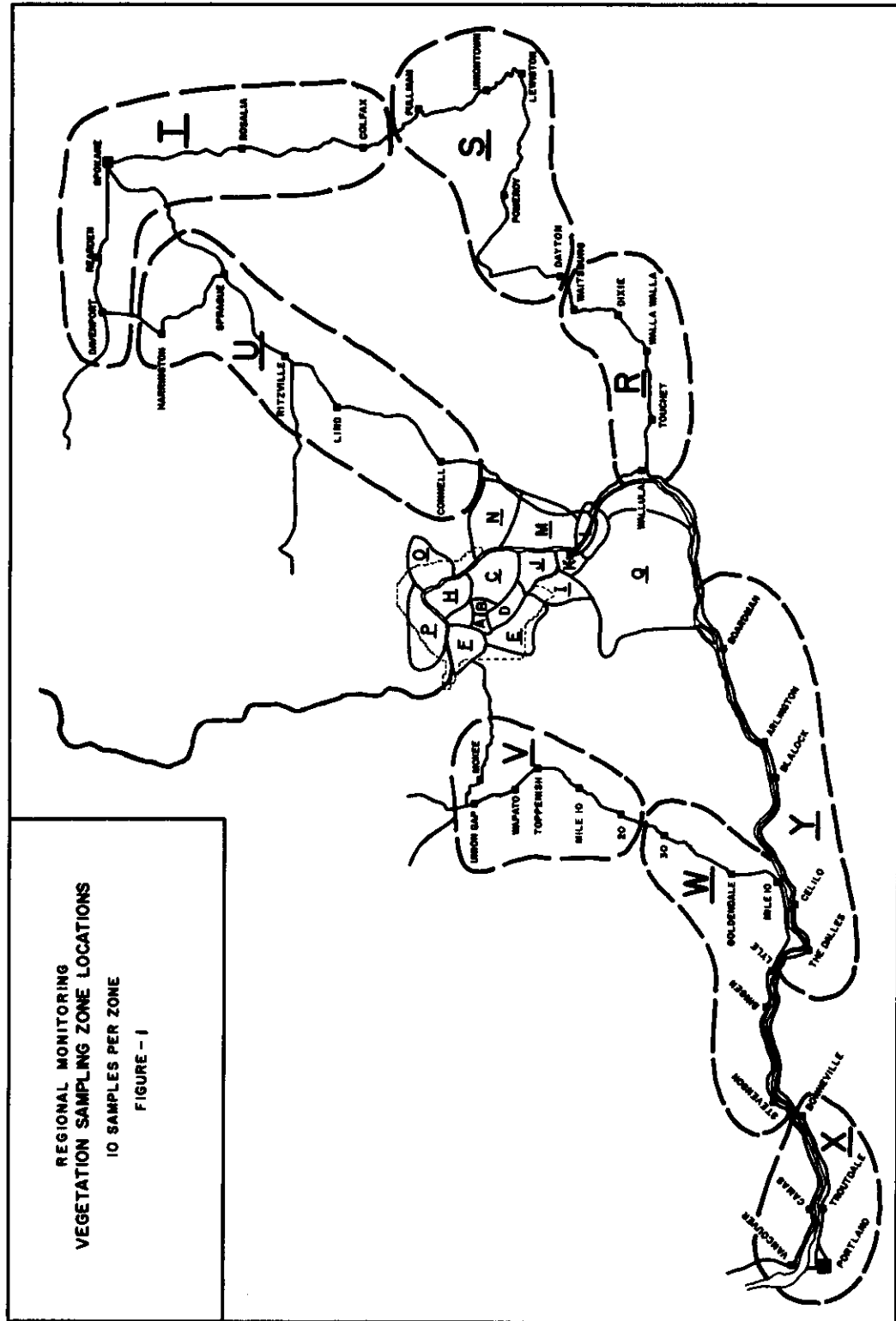
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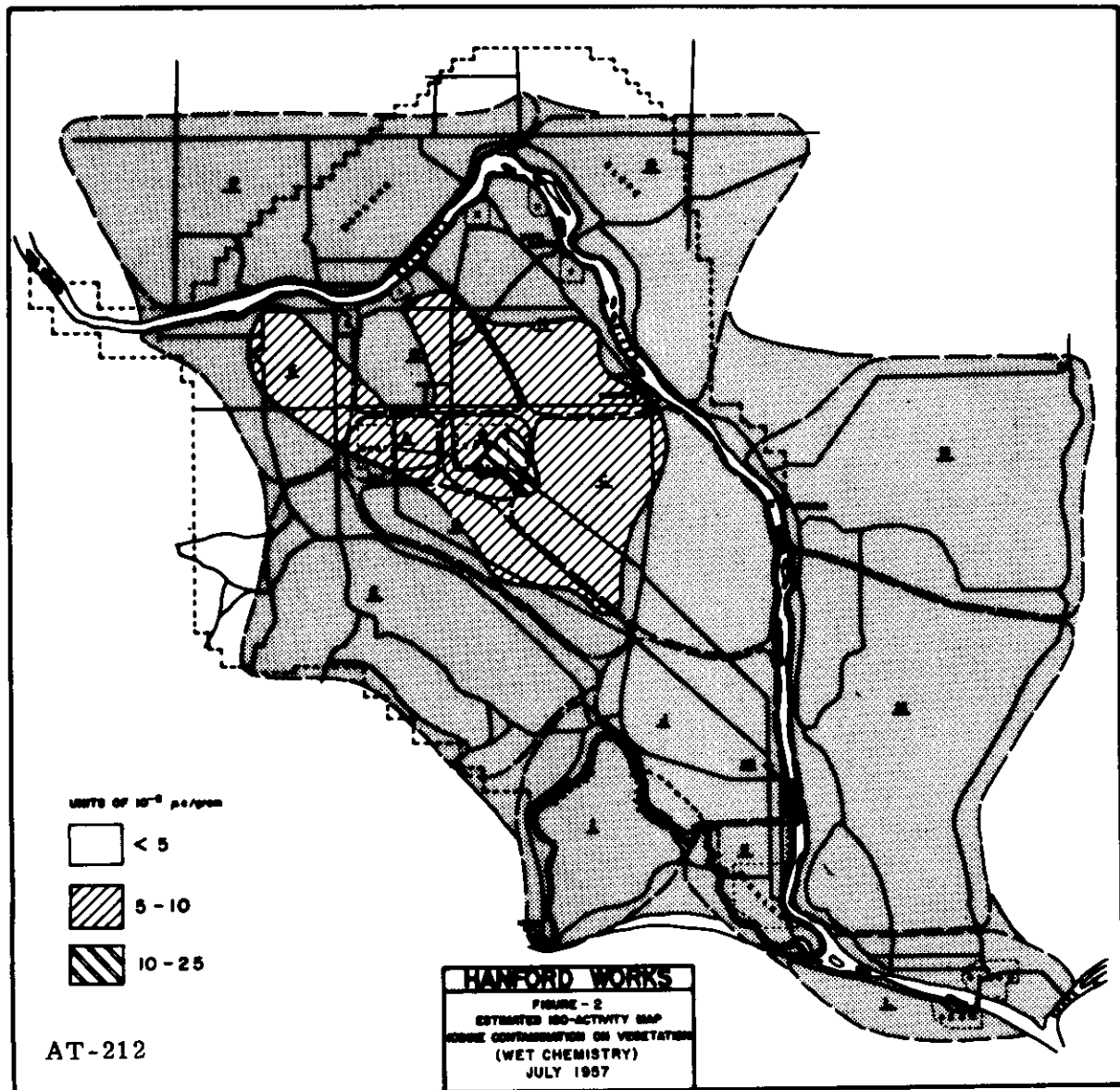
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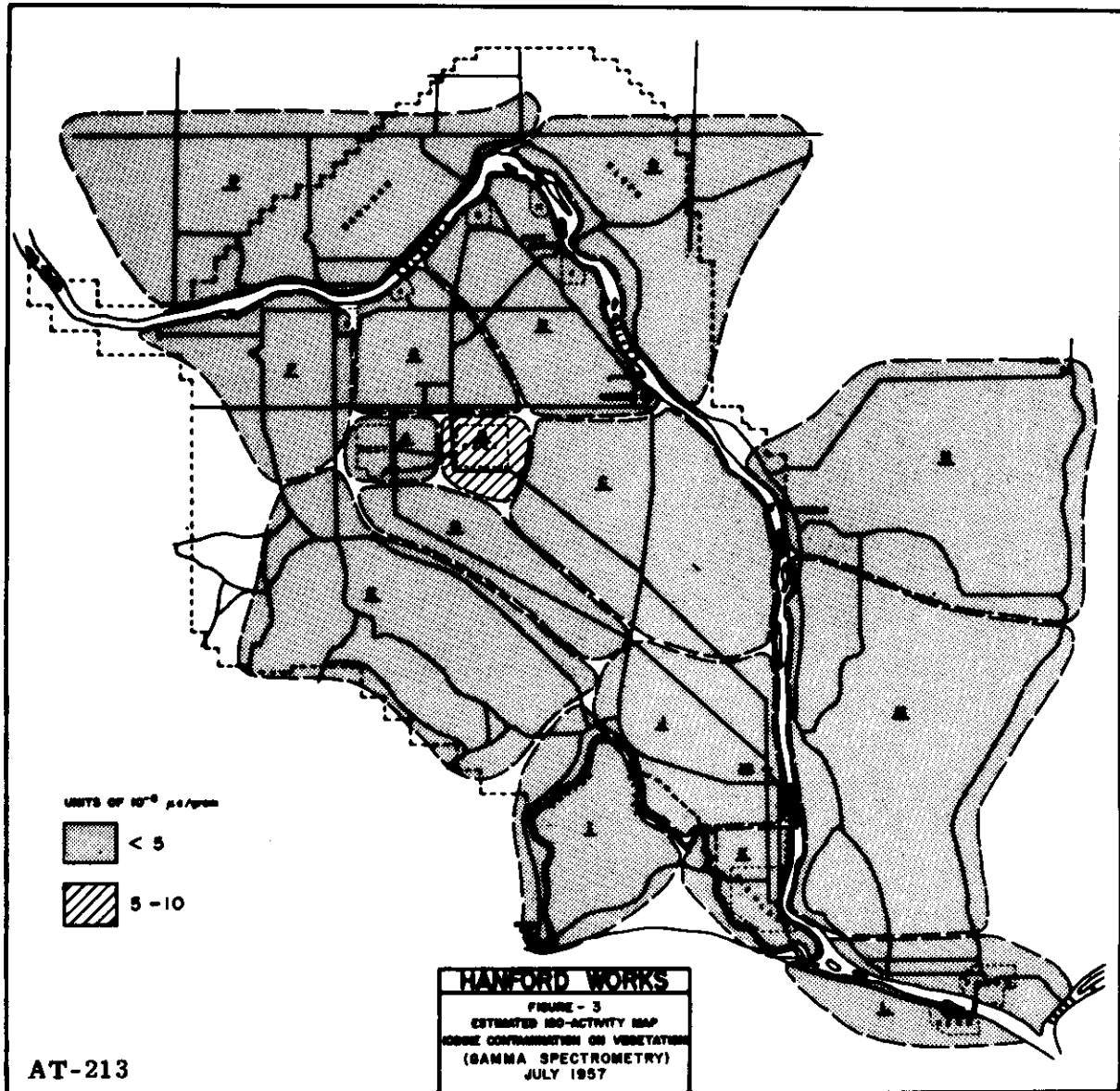
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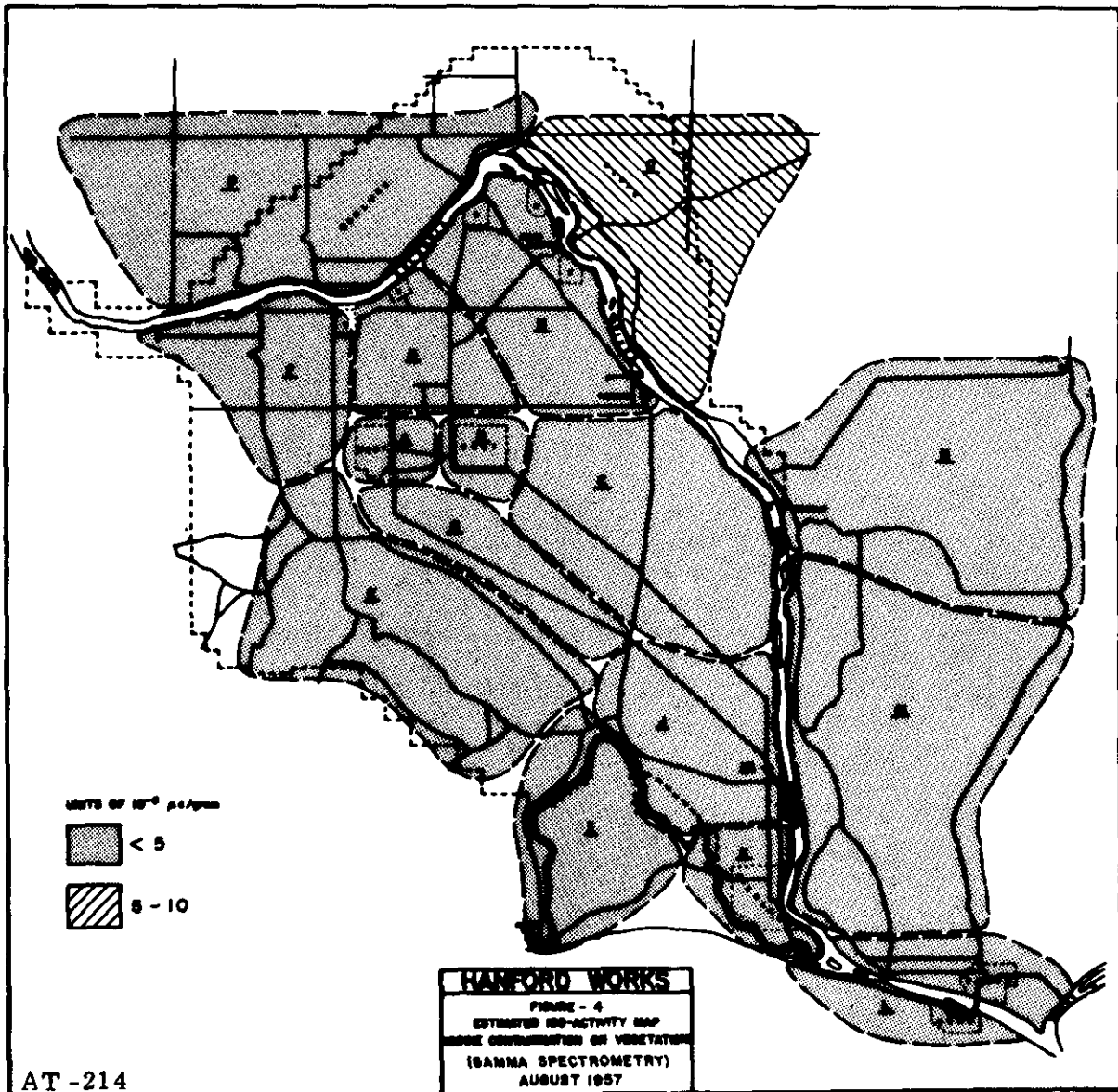
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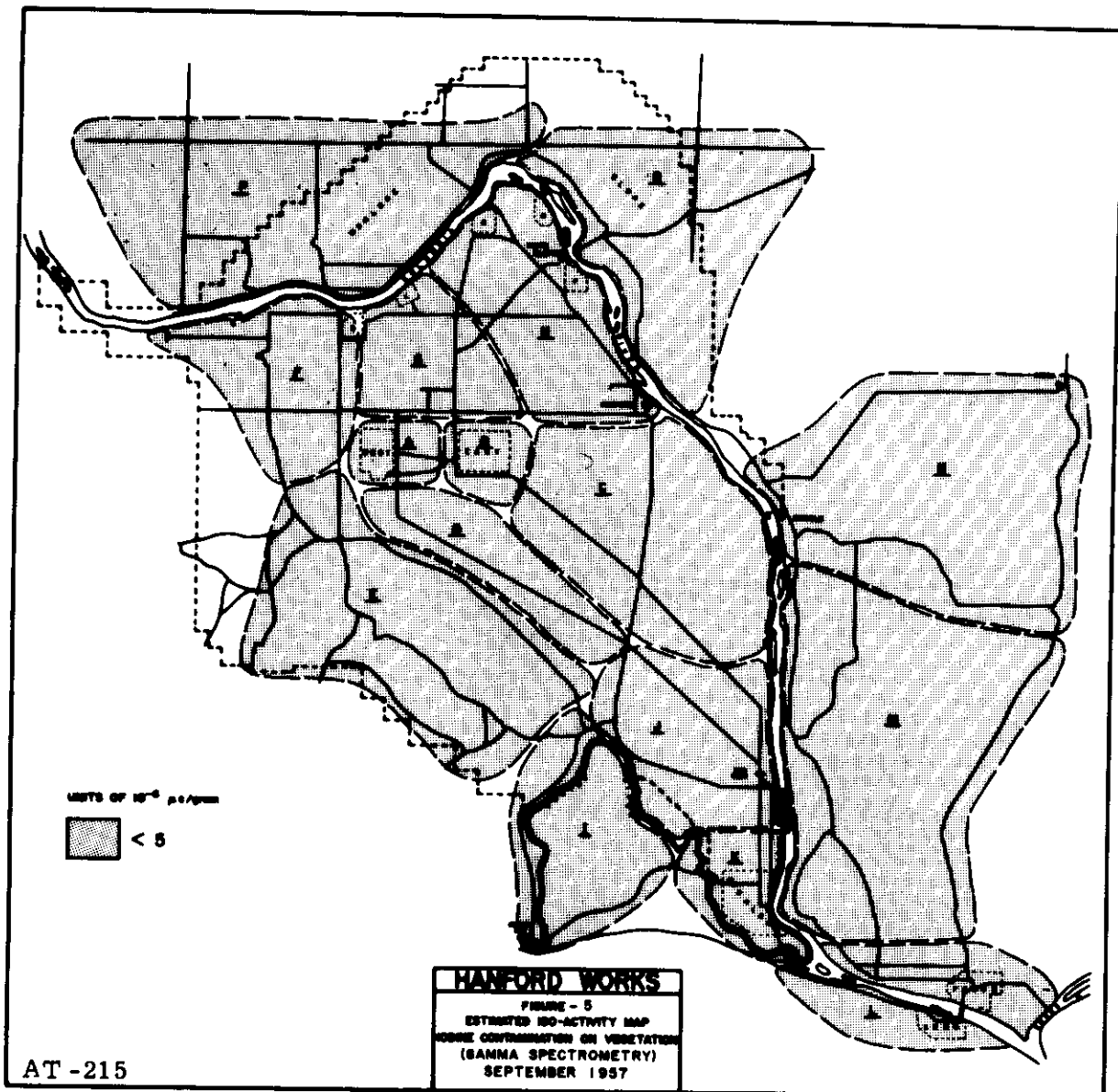
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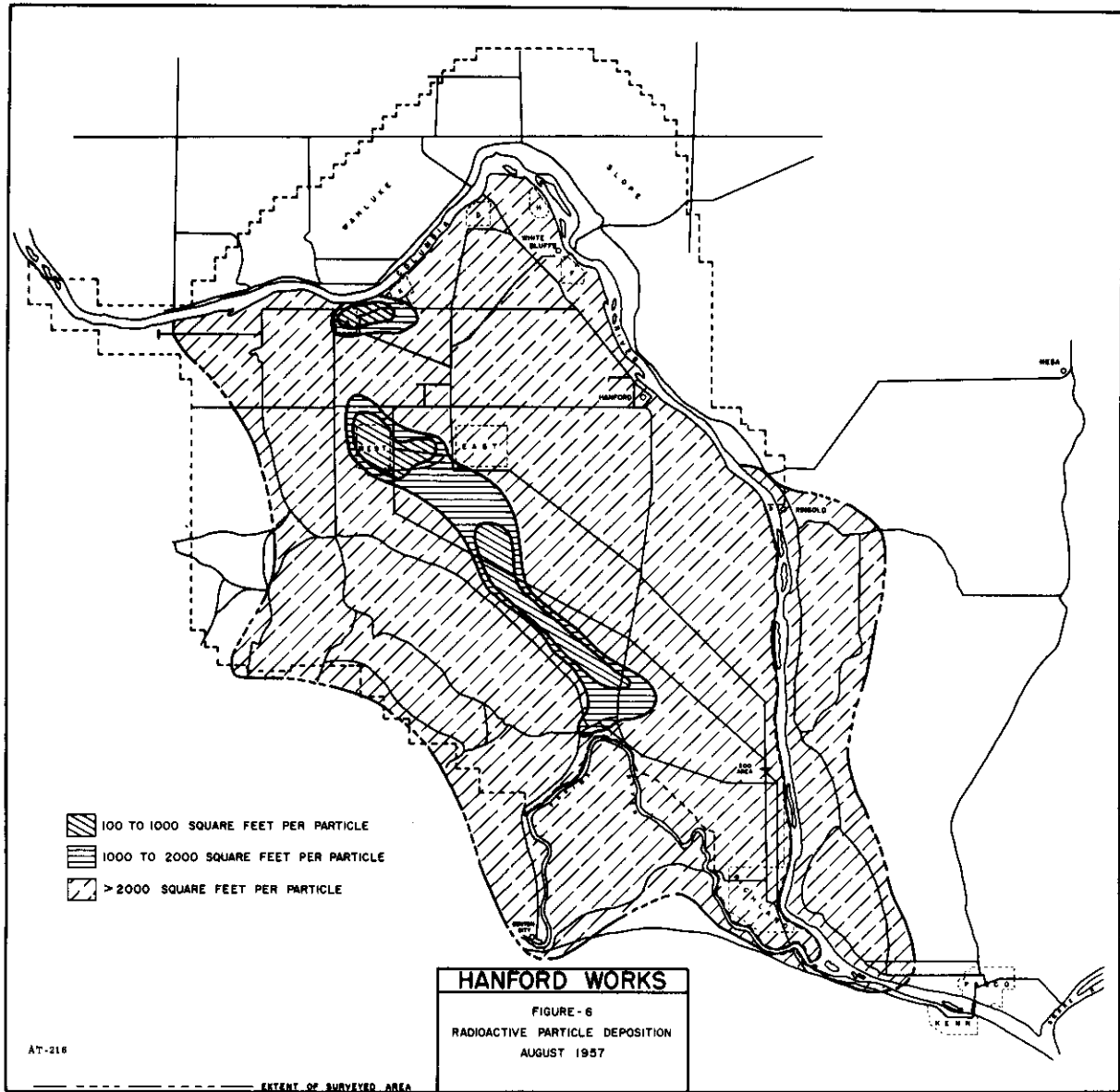


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42	ANP Project Office, Convair, Fort Worth

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133	Sandia Corporation, Livermore
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