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Revision 0

RCBRA Stack Air Emissions Deposition Scoping Document



United States
Department of Energy

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ACRONYMS

DOE	U.S. Department of Energy
HEDR	Hanford Environmental Dose Reconstruction
PNNL	Pacific Northwest National Laboratory
RCBRA	River Corridor Baseline Risk Assessment
WDOH	Washington State Department of Health
WIDS	Waste Information Data System

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is required by *Comprehensive Environmental Response, Compensation, and Liability Act* regulations to develop a conceptual understanding of potential contaminant releases from the Hanford Site based on an evaluation of existing data. One potential environmental release pathway is the past Hanford Site facility exhaust stack air emissions of contaminants followed by deposition of the contaminants in the environment (“air deposition”). This pathway has generally been considered to be insignificant for the 100 Areas of the Hanford Site, for reasons explained below. The DOE has decided to complete additional evaluation of the stack air emission pathway in response to comments received while defining data quality objectives for the River Corridor Baseline Risk Assessment (RCBRA) field sampling. This document assembles and evaluates existing information and describes a conceptual site model for air deposition.

2.0 BACKGROUND

Participants in the data quality objectives process for the RCBRA made several comments regarding potential soil contamination from past stack air emissions. Workshop participants requested an evaluation of potential impacts from historical stack emissions from the various process facilities located on the Hanford Site. These comments were made in the context of both selecting areas for RCBRA reference sampling as well as for ensuring that there are no currently unidentified areas of soil contamination due to stack air emissions. The comments emphasized that reference samples should be collected in unimpacted areas (i.e., unimpacted by waste disposal activities or other human activities to the extent practical) and that all waste areas need to be identified.

2.1 PURPOSE AND SCOPE

This report provides historical information regarding Hanford Site stack air emissions and soil sampling study results for the purpose of assessing the potential for areas of contamination from stack air emission deposition in the 100 and 300 Areas. The report also presents previous background surface soil sample locations assessing airborne contaminant deposition on the Hanford Site.

3.0 SOURCES OF STACK AIR EMISSIONS

3.1 NONRADIONUCLIDES

Nonradionuclide contaminant stack emissions from Hanford Site operations were relatively minor and primarily consisted of volatile organic compounds associated with the solvents used in the 200 Area separation processes. None of the 100 Area processes that could have emitted nonradionuclide contaminants produced air emissions at concentrations that would result in a significant accumulation of the nonradionuclides in soil.

Volatile organic stack emissions would have been in a gaseous state and would not have deposited in surface soil. Inorganic stack emissions from the separation plants were minor and primarily consisted of nitrate compound particulates from the inorganic acids used in the separation process. These nitrate compounds generally formed a scale within the stacks that would periodically flake off and fall to the ground in the immediate vicinity of the 200 Area separation plants (Hodges 1989). Other inorganic compounds such as metals were an insignificant component of stack emissions. The nuclear fuel was a very highly processed pure uranium metal that did not contain other inorganic metals. The fuel jacketing material was aluminum from 1945 through 1963 and was zirconium alloy after 1963 when N Reactor began operation. Neither aluminum nor zirconium is a hazardous or toxic metal, and as far as was known both were entirely retained in solution by the jacket dissolution solutions. In addition, zirconium was not used until well after the more robust air emission filtration systems were in place at the 200 Area separation facilities.

3.2 RADIONUCLIDES

Two groups of sources of Hanford Site stack air emissions had the potential to impact the 100 Areas by air deposition. The first source group, the nine production nuclear reactors in the 100 Areas, had stacks to exhaust ventilation air from the working areas of the reactor facilities. These were minor sources of emissions compared to the 200 Area facilities that separated plutonium and uranium from irradiated reactor fuel.

The second source group, where most of the Hanford Site stack air emissions occurred between 1944 and 1972, were the facilities in the 200 Areas that separated plutonium and uranium from irradiated reactor fuel (WDOH 2004a). The major radioactive air releases occurred between 1944 and 1957. The largest releases from these facilities occurred in 1945, before effective collection devices were installed ahead of the stacks to prevent the discharge of volatile and particulate radionuclides. More than half of the entire amount of iodine-131 released during the entire 1944-1972 period was emitted in 5 months during 1945 (Heeb 1994). Water scrubbers and sand filters were installed ahead of the stacks at the 200 Area separation plants in 1948, greatly reducing but not eliminating the air emissions. More advanced technology was installed in 1950 (silver nitrate reactors) specifically to remove iodine-131, further reducing the stack

air emissions. However, the collection devices occasionally failed, resulting in some above-normal releases.

No stack releases from 300 Area operations were reported in Selby and Soldat (1958) or in Heeb (1994). These reports reviewed the historical releases to the atmosphere from Hanford Site operations between 1944 and 1972. The 300 Area primarily supported fuel fabrication processes and research activities and was not expected to contribute to radioactive airborne emissions released on the Hanford Site. The documents that reported soil sampling and monitoring reviewed for this report revealed no indications of contamination related to stack releases in the 300 Area.

3.2.1 Short-Lived Radionuclides

The Hanford Environmental Dose Reconstruction (HEDR) Project, conducted during the 1990s, calculated the Hanford Site radionuclide air release inventory using historical information and computer modeling (Heeb 1994). The HEDR Project was established to estimate the radiation dose to people living near the Hanford Site between 1944 and 1992. The HEDR Project focused on the primary human dose drivers in the stack emissions, which included iodine-131, ruthenium-103, ruthenium-106, strontium-90, plutonium-239/240, and cerium-144 (Heeb 1994). Table 1 summarizes the HEDR calculated air release inventory from the Hanford Site for the principal short-lived radionuclides that contributed the majority of the radiation dose through the air pathways (WDOH 2004a). Table 1 also includes the half-life for each radionuclide and the amount of each radionuclide remaining in 2004. The short-lived radionuclides iodine-131, ruthenium-103, ruthenium-106, and cerium-144 have decayed to negligible amounts since emissions of these radionuclides ended in 1972.

Table 1. Calculated Air Emission Releases of Short-Lived Radionuclides by Hanford Site Operations, 1944-1972.

Radionuclide	Half-Life (days)	Amount Released Through 1972 (Ci)	Calculated Amount Remaining in 2004 (Ci)	Calculated Soil Concentration Remaining in 2004 (pCi/g)
Cerium-144	284	3,800	0.0000000034	0.00000000016
Iodine-131	8	740,000	0	0
Ruthenium-103	39	1,200	0	0
Ruthenium-106	370	390	0.00000014	0.0000000068

3.2.2 Longer lived Radionuclides

Table 2 compares the air emission release inventory calculated for the longer lived radionuclides to the Hanford Site soil background levels (DOE-RL 1996a), decayed to 2004. The range of the calculated soil concentrations due to air emissions reflects the large uncertainty in the calculated values due to uncertainty in air emissions release factors and uncertainty in atmospheric

dispersion (Heeb 1994). Calculations based on the area over which the emissions spread (1,295 km² [500 mi²]; a conservative approximation because the actual emissions covered larger areas) show that dispersion and decay of cesium-137, plutonium-239/240, and strontium-90 would have reduced their remaining soil concentrations to approximately the range of Hanford Site soil background. Iodine-129 is not found in surface soils except in small concentrations near the stacks of the separation plants in the 200 Areas because iodine is very mobile in water and is carried through the soil column to groundwater. Therefore, iodine-129 was not measured in background soil samples.

Table 2. Calculated Air Emission Releases of Long-Lived Radionuclides by Hanford Site Operations, 1944-1972.

Radionuclide	Half-Life (years)	Amount Released Through 1972 (Ci)	Range of Calculated Soil Concentrations Due to Air Emissions Remaining in 2004 (pCi/g)	Range of Hanford Site Soil Background (DOE-RL 1996a) Decayed to 2004 (pCi/g)
Cesium-137	30	42	Zero to 2.28	Zero to 1.30
Iodine-129	16,000,000	1.2	Zero to 0.336	NA
Plutonium-239/240	24,000	1.8	Zero to 0.087	Zero to 0.033
Strontium-90	29	64	Zero to 1.01	0.005 to 0.287

NOTE: Tritium and krypton-85 were also released and have respective half-lives of 12 years and 11 years. These were not included in the table because tritium and krypton-85 would have been released in a gaseous state with no depositional properties.

NA = Not analyzed; not found in Hanford Site soils. Because of high water mobility, iodine would have been dissolved by precipitation and carried to groundwater (DOE-RL 1996b).

3.2.3 Hanford Site Background Radionuclide Concentrations

The Hanford Site Background Study (DOE-RL 1996a) distinguished between surface soils that received radionuclide contamination from anthropogenic sources and subsurface soils unaffected by man-made activities. Surface samples were collected from the top 2.5 cm (1 in.) of soil at 39 Hanford Site localities. The data used were from routine sampling performed by Pacific Northwest National Laboratory (PNNL) and the Washington State Department of Health (WDOH); 149 samples were used in the data set. These samples were considered by PNNL and WDOH to be uncontaminated by Hanford Site operations. Of the hundreds of radionuclides present in fallout from above-ground nuclear bomb testing, only a few are of concern when their half-lives, abundances, and potential threat to human health are evaluated. Those reported in the Hanford Site Background Study (DOE-RL 1996a) were based on a study prepared specifically for the background program and refined through discussions between representatives of the U.S. Environmental Protection Agency, the Washington State Department of Ecology, WDOH, and DOE. The resulting anthropogenic radionuclides suggested for the evaluation of site-wide soil background are cobalt-60, strontium-90, cesium-134, cesium-137, europium-152, plutonium-238, plutonium-239/40,

americium-241, and gross beta. The subset of anthropogenic radionuclides shown to be representative of the vadose-zone compositions for the Hanford Site includes cobalt-60, strontium-90, cesium-137, plutonium-238, plutonium-239/240, and gross beta, which are shown in Table 3. Subsurface samples were used to evaluate the background concentrations of naturally occurring radionuclides (potassium-40, radium-226, thorium-232, uranium-234, uranium-235, and uranium-238) that are pervasive in native materials, especially the basaltic and quartzo-feldspathic components of the Hanford Site vadose zone. The subsurface data were obtained from a random subset of the nonradionuclide soil background reference set, which has been accepted as being representative of vadose zone soils across the Hanford Site (DOE-RL 1996a). The statistical summary from the study is shown in Table 3.

Table 3. Hanford Site Background Vadose Zone Soil Study Statistical Summary.

Radionuclide	Arithmetic Mean (pCi/g)	Standard Deviation (pCi/g)	Upper Confidence Limit ^a at 95% (pCi/g)
Naturally Occurring Radionuclides			
Potassium-40	13.1	2.71	20.0
Radium-226	0.561	0.202	1.12
Thorium-232	0.945	0.260	1.72
Uranium-234	0.793	0.233	1.44
Uranium-235 ^b	0.0515	0.0373	0.252
Uranium-238	0.763	0.216	1.39
Anthropogenic Radionuclides			
Cobalt-60	0.00132	0.00591	0.0122
Strontium-90	0.0806	0.0688	0.364
Cesium-137	0.417	0.338	2.04
Plutonium-238	0.00158	0.00332	0.0128
Plutonium-239/240	0.00935	0.00782	0.00521
Gross beta	19.78	2.40	25.88

NOTE: The summary represents 49 vadose zone samples analyzed for the anthropogenic radionuclides and 149 surface samples for the anthropogenic radionuclides, as reported in DOE-RL (1996a); undecayed from 1996.

^aThe upper confidence limit is based on lognormal distribution.

^bUranium-235 statistics were computed using 47 samples: 17 above and 30 below detection limits. Two data were suspended owing to negative values (DOE-RL 1996a).

4.0 PREVIOUS EVALUATIONS OF AIR DEPOSITION

The Surface Environmental Surveillance Project, now operated by PNNL for the DOE, has conducted environmental monitoring and surveillance on and off the Hanford Site since its creation in 1944-1945. In addition to routine sampling, several special-purpose studies for environmental monitoring have been conducted by Hanford Site scientists.

After separation operations ceased in the 200 Areas in 1972, radionuclide concentrations in Hanford Site environmental samples soon declined until they became indistinguishable from radionuclide analyses of offsite samples (PNL 1995). A 1988 PNNL review of this radionuclide activity in soil samples collected from the Hanford Site and vicinity (Price 1988) concluded that the Hanford-derived radionuclides were difficult to distinguish from global fallout from nuclear bomb testing. A comparison of the concentration ranges from a selection of the routine soil sampling data found in Price (1988) is provided in Table 4. Results for a limited number of locations were reported for sampling events as far back as 1971. The majority of sampling locations with data for comparison had been sampled between 1981 and 1987.

Table 4. Comparison of Undecayed Radionuclide Concentration Ranges in Soil Samples from Hanford Site and Offsite Locations Between 1981 and 1987. (2 Pages)

Sampling Locations ^a		Strontium-90 (pCi/g)	Cesium-137 (pCi/g) ^c	Plutonium-238 (pCi/g) ^d	Plutonium-239/240 (pCi/g) ^e	Uranium (pCi/g) ^f
Offsite Sample Locations ^b	Taylor Flats #2	0.04 – 2.3	0.08 – 2.2	<0.00008-0.001	0.0008 – 0.04	0.44 – 1.3
	Sunnyside	0.05 – 1.6	0.10 – 1.5	<0.0002 -0.001	0.002 – 0.03	0.17 – 0.31
	Walla Walla	0.02 – 0.31	0.07 – 0.28	<0.0002 -0.008	0.0007 – 0.01	0.20 – 0.52
	Moses Lake	0.06 – 0.08	0.13 – 0.24	<0.0002 –0.003	0.002 – 0.02	0.08 – 0.29
Hanford Site Sample Locations	East of 200 West Area gate	0.33 – 2.6	0.59 – 5.7	0.001 – 0.009	0.074 – 0.831	0.39 – 0.73
	Hanford Townsite	0.24 – 1.9	0.91 – 1.1	<0.0007 –0.005	0.006 – 0.02	0.24 – 0.42
	North of 300 Area	0.18 – 0.73	0.42 – 1.2	<0.002 -0.039	0.008 – 0.02	0.50 – 5.4
	Yakima Barricade	0.06 – 0.59	0.08 – 1.1	<0.0007 – 0.002	0.002 – 0.02	0.21 – 0.50

Table 4. Comparison of Undecayed Radionuclide Concentration Ranges in Soil Samples from Hanford Site and Offsite Locations Between 1981 and 1987. (2 Pages)

Sampling Locations ^a		Strontium-90 (pCi/g)	Cesium-137 (pCi/g) ^c	Plutonium-238 (pCi/g) ^d	Plutonium-239/240 (pCi/g) ^e	Uranium (pCi/g) ^f
Hanford Operation Facilities Sample Locations	200 East Area north-central	0.20 – 2.7	9.6 – 28.1	<0.0006 -0.03	0.015 – 0.059	0.23 – 0.66
	0.8 km (0.5 mi) northeast of FFTF	0.04 – 0.52	0.08 – 0.33	<0.00004 - 0.0003	<0.002-0.009	0.23 – 0.49
	2 km (1.25 mi) east of PUREX	0.33 – 0.90	0.69 – 3.0	<0.001 - 0.006	0.009 – 0.03	0.26 – 0.47
	1.6 km (1 mi) east of 100-N Area	0.15 – 0.85	0.54 – 1.1	<0.003 – 0.008	0.007 – 0.03	0.19 – 0.48

^a Routine soil sampling locations at sample depth of 0 to 2.5 cm (0 to 1 in.) (Price 1988). The offsite sample locations are a selection of 4 sites from 19 sites that had monitoring results in the 1980s, and the onsite sample locations were selected from 16 sites that had monitoring results between 1981 and including the year 1987.

^b Walla Walla and Moses Lake data are from 1985 to 1987 and 1986 to 1987, respectively.

^c The highest measured cesium-137 concentration from the routine soil sampling data (Price 1988) for the Hanford Townsite was 1.97 from August 18, 1975; the highest for 200 East Area north-central was 28.6 from June 14, 1977; and the highest for 0.8 km (0.5 mile) east of PUREX was 1.68 from June 14, 1977.

^d The highest measured plutonium-238 concentration the routine soil sampling data (Price 1988) for Taylor Flats #2 was 0.004 from August 6, 1980; the highest for Sunnyside was 0.002 from August 4, 1980; the highest for east of the 200 West Area gate was 0.01 from August 4, 1980; the highest for the Hanford Townsite was 0.006 from August 10, 1976; the highest for the Yakima Barricade was 0.006 from August 5, 1980; and the highest for 0.8 km (0.5 mile) northeast of FFTF was 0.001 from August 10, 1976.

^e The highest measured plutonium-239/240 concentration the routine soil sampling data (Price 1988) for the Hanford Townsite was 0.04 from August 5, 1980, and the highest for 0.8 km (0.5 mile) east of PUREX was 0.165 from June 14, 1977.

^f The highest measured uranium concentration the routine soil sampling data (Price 1988) for Sunnyside was 0.47 from June 14, 1977.

FFTF = Fast Flux Test Facility

PUREX = Plutonium/Uranium Extraction (Plant)

Concentrations of Hanford-derived contaminants could be distinguished only in soil samples obtained near Hanford Site operations facilities (e.g., cesium-137 at 28.1 pCi/g at the north-central part of the 200 East Area) or at known waste sites. One exception is the plutonium-238 concentration of 0.039 pCi/g for the location north of the 300 Area. The sample value was from an event in 1982; subsequent sampling events indicate a decrease in the radionuclide concentrations over time. The 1987 sampling event result reported in Price (1988) for plutonium-238 at the same location was 0.0065 pCi/g. The cesium-137 result of 5.7 pCi/g for the location east of the 200 West Area gate was reported from a 1983 sampling event; the 1987 sampling result for the same location was 1.3 pCi/g. The uranium concentration of 5.4 pCi/g for the location north of the 300 Area was from a 1985 sampling event and is consistent with subsequent sampling events. The sampling events between 1976 and 1984 for the same location yielded radionuclide concentrations in the range of 0.26 to 1.0 pCi/g, which is within the same range as the offsite sample locations. Therefore, the elevated uranium concentrations for that sample location are not likely associated with the 200 Area operations that ceased in 1972. The minimum values in the concentration ranges for numerous Hanford Site locations were higher than the minimum value in the offsite sample locations for the same radionuclide; however, the

higher minimums were still within the radionuclide concentration range of the offsite sample locations.

In 1988, EG&G Energy Measurements (Reiman and Dahlstrom 1990) conducted an aerial radiological survey of the Hanford Site. This survey is part of a continuing program, begun in 1958, “to document the radiological character surrounding specific sites of interest. These sites include nuclear power plants, nuclear waste repositories, and research and development laboratories where radioactive materials may be used.” Figure 1 shows the anthropogenic isoradiation contours overlaid on a topographic map of the Hanford Site. The operations areas, such as the reactors, 200 Areas, US Ecology, Energy Northwest, Fast Flux Test Facility, and 300 Area, appear on this map as having distinctly elevated radionuclide activity. Additional areas of elevated activity are also shown; the more inland of these have been accounted for as known waste sites, such as the ‘Strontium Gardens’ (Waste Information Data System [WIDS] site 100-F-2) 1.6 km (1 mi) southwest of the 100-F Reactor and an area north of Gable Mountain Pond (WIDS sites 216-A-25 and 600-118).

Areas of elevated activity also occur along the river shore, especially in areas of sediment deposition such as the area north of the 100-D Area and the sloughs associated with 100-H, 100-F, and the Hanford Townsite areas. The radionuclides in sediments can be attributed to releases from the reactor effluent pipelines. The more detailed maps of the aerial surveys in Reiman and Dahlstrom (1990) were used in 1993 to help identify river sediment sampling locations (WHC 1993). Table 5 shows some of the results for the sediment samples taken from 0 to 15.24 cm (0 to 6 in.) from the reference areas and the areas identified as elevated by Reiman and Dahlstrom (1990). The slight elevations of radionuclide concentrations from the slough areas are generally where the aerial radiation survey flyover indicated a slight elevation in radionuclide activity. The high degree of sensitivity shown by the aerial survey results, plus a lack of other areas identified by the flyover as having elevated radionuclide activity, supports the conclusion that there are no other, as-yet-unidentified areas of significant radionuclide deposition from old stack releases.

4.1 CONCEPTUAL SITE MODEL – 200 AREA STACK AIR EMISSIONS

The primary stack air emissions associated with the Hanford Site were from the 200 Area separation facilities. When the emissions reached the top of the 61-m (200-ft) exhaust stacks, their dispersion would have been affected by the weather. The stability of the surrounding air, the wind speed and direction, and whether it was raining or snowing influenced the location and magnitude of contaminant deposition (WDOH 2004b). The primary factors in determining where the air emissions may have been deposited are the speed and direction of the wind. On a regional scale, the wind direction on the Hanford Site is generally toward the east.

Figure 1. Hanford Site Topographic Map Showing Distribution of Elevated Radionuclide Levels (Reiman and Dahlstrom 1990).

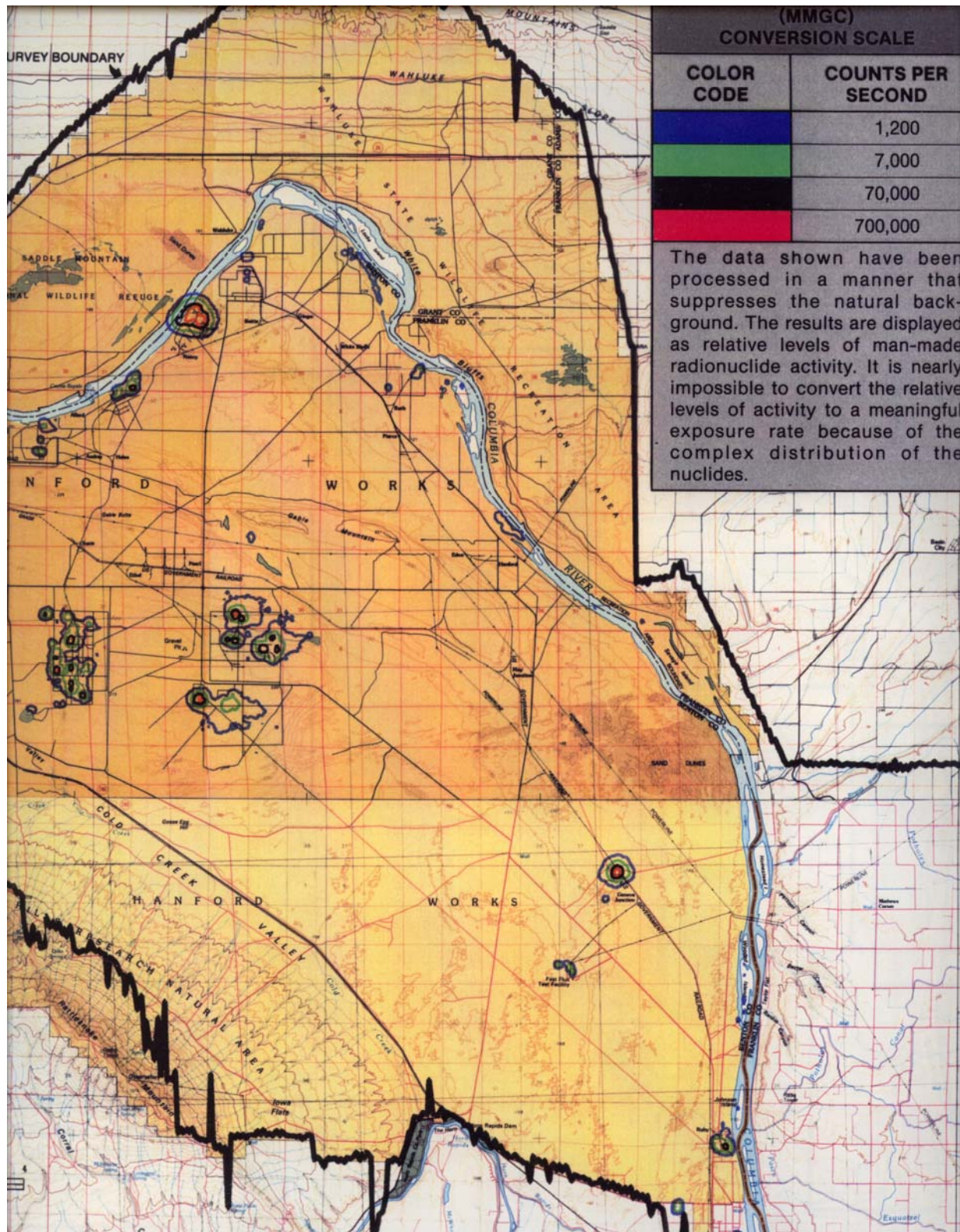


Table 5. Undecayed Sediment Sample Radionuclide Concentrations (pCi/g) from Reiman and Dahlstrom (1990).

Location and Sample Number	Gross Alpha	Gross Beta	Co-60	Cs-137	U-233/234	U-235	U-238
Vernita – Reference B07NF5	8.30 J	16.00	ND	ND	0.85	ND	0.54
Vernita – Reference B07NF7	8.40 J	15.00	ND	ND	1.00	ND	0.58
Vernita – Reference B07NF8	7.50 J	16.00	ND	0.14 J	1.00	ND	0.80
D/H Horn Area B07NH1	7.70 J	14.00	0.10	0.09	0.90	ND	0.98
H Area Slough B07NC0	ND	18.00	0.38	4.60 J	0.79	ND	0.77
H Area Slough B07NC2	27.00 J	20.00	0.09	0.43 J	1.20	ND	1.2
H Area Slough B07NC3	13.00	21.00	ND	0.33 J	1.40	ND	1.20
F Area Slough B07NC4	33.00 J	25.00	ND	0.14 J	1.60	ND	2.00
F Area Slough B07NG9	4.70 J	10.00	0.36	0.83	0.77	ND	0.49
F Area Slough B07NB6	ND	22.00	ND	0.18 J	0.67	ND	0.88
F Area Slough B07NB7	ND	15.00	ND	0.33 J	1.10	ND	0.93
F Area Slough B07NB8	9.80 J	17.00	ND	0.26 J	0.79	ND	0.64
Hanford Townsite Slough B07ND2	ND	16.00	0.056	1.00 J	0.73	0.11 J	0.75
Hanford Townsite Slough B07NC7	9.00 J	19.00	ND	0.074 J	0.60	ND	0.48

J = concentration estimated due to quality control deficiencies

ND = not detected

Based on what is currently known, the wind generally blew toward the southeast during the time periods of maximum emissions from the 200 Area separation plants stacks. However, incidents also occurred when stack air emissions were blown to the north, northeast, and east. Because of the wide variability in climatic conditions, modeling stack heights in relation to the emissions is not expected to provide usable data for identifying “hot spots” of contamination or to confirm areas not expected to have fallout from the stacks.

“Hot spot” is a term used to describe an area where the concentration of contaminants is greater than that found in the surrounding area. Four main factors could have led to the creation of hot spots of air emissions: precipitation, wind patterns, stagnation, and impaction. Because of variations in wind patterns and the ground surface (e.g., hills, valleys), the spread of emissions, even in the downwind direction, may not have been uniform.

- Precipitation - Rain and snow can wash substances from the air and deposit the contamination on vegetation and on the ground. An area where it is raining or snowing could receive greater deposition of contaminants than the areas around it. Over a short period of time this mechanism may have impacted some River Corridor areas more than other factors. However, given the localized variability of Hanford Site wind direction, the length of time

since release, and the low relative precipitation, it is unlikely that any specific River Corridor area would have received greater emission deposition.

- Wind patterns and stagnation - During long-duration emissions, changes in wind direction could have sent the emissions in two or more directions. Lack of wind would have allowed more contamination to deposit in one area, possibly creating a hot spot. These types of hot spots have been identified only in the immediate areas surrounding the 200 Area separation facilities (Hodges 1989, Selby and Soldat 1958).
- Impaction occurs when the air emission plume meets the side of a hill or mountain. Contamination tends to be deposited in greater amounts where the wind carries a plume to the side of a hill or mountain than in other areas at the same elevation. Deposition by impaction apparently accounted for localized areas of greater radioactivity on the Wahluke Slope found after emissions incidents during the 1950s (Selby and Soldat 1958), but radioactive decay and dispersion have caused any anomalies to disappear in the 40 plus years since the area was impacted, as noted in the conclusions of *A Review of Historical Data on the Radionuclide Content of Soil Samples Collected from the Hanford Site and Vicinity* (Price 1988).

4.2 RIVER CORRIDOR AREAS THAT RECEIVED STACK AIR EMISSIONS

Historical surface contamination contour maps included in the *Summary of Environmental Contamination Incidents at Hanford 1952-1957* (Selby and Soldat 1958) show that the 100-B/C and 100-K Areas likely received more air emissions from the 200 Area separation plants than other areas of the River Corridor. However, the air emission particulate frequencies at a distance from the stacks were considerably lower than those in the immediate vicinity of the 200 Area stacks at the time of deposition (Selby and Soldat 1958). Tables 1 and 2 show that, except for the known hot spots in the immediate vicinity of the 200 Area stacks and other waste sites, radionuclide dispersion and decay would have reduced any residual concentrations to the approximate range of Hanford Site background.

In 1955 about 0.8 Ci of radioactive material was released through the 105-H Reactor stack, affecting an estimated 18 km² (7 mi²) to the south of the 105-H Reactor building (Selby and Soldat 1958). Surveys with radiological instruments determined the extent of contamination, measuring the number of radioactive particles per 9.3 m² (100 ft²). Surveys ranged from 20 particles per 9.3 m² (100 ft²) near the stack to 3 particles downwind at the reactor area fence. Average soil concentrations resulting from the spread of 0.8 Ci of radioactive material (mainly uranium isotopes) over 18 km² (7 mi²) would have been 2.8 pCi/g, which is indistinguishable from the variability of total uranium background of 3.08 +/- 0.62 pCi/g as estimated in Selby and Soldat (1958).

There are historical indications that the hillside of the Wahluke Slope (north of the Columbia River, across from the reactors) received more contamination from stack emissions than other River Corridor areas through impaction deposition (WDOH 2004b). Additional historical

documentation (Turner and Healy 1947; GE 1948, 1957, 1958) generally indicates that Hanford Site areas northeast, east, and southeast of the 200 Area separations plants were impacted by air deposition more than onsite areas west of the 200 Areas and more than offsite areas. In spite of these deposition patterns, onsite and offsite soil sampling (PNL 1995, PNNL 2002) has revealed no statistical differences in soil radionuclide concentrations from several Hanford areas and offsite areas. The average concentration for soil samples taken in different areas of the Hanford Site and from distant communities in 2001 are compared to Hanford Site background in Table 6. The concentrations of cesium-137, plutonium-239/240, and strontium-90 are somewhat higher in the 200/600 Areas because of the inclusion of samples taken in the vicinity of former operations facilities. However, there is no statistical difference between the samples taken from the different areas and Hanford Site background (PNL 1995, PNNL 2002)

Table 6. Comparison of Surface Soil Average Concentrations of Radionuclides from Several Sources (PNNL 2002) to the Average Hanford Site Background Soil Concentration.

Soil Sample Description	Cesium-137 (pCi/g) ^a	Plutonium-239/240 (pCi/g) ^a	Strontium-90 (pCi/g) ^a
ERDF	0.21 ± 0.034	0.018 ± 0.012	ND
100-B/C Area	0.22 ± 0.035	0.015 ± 0.012	ND
100-H Area	0.55 ± 0.11	ND	ND
100-F Area	0.21 ± 0.036	0.019 ± 0.013	0.39 ± 0.2
100-N Area	0.39 ± 0.36	0.031 ± 0.04	0.48 ± 0.42
200/600 Areas	1.5 ± 4.0	0.13 ± 0.4	0.55 ± 1.3
300/400 Areas	0.05 ± 0.08	0.041 ± 0.06	ND
Distant communities	0.15 ± 0.32	0.0055 ± 0.012	0.052 ± 0.11
Hanford Site background ^b	0.417 ± 0.338	0.00935 ± 0.00782	0.0806 ± 0.0688

^a ±2 standard deviations

^bHanford Site background analyses (DOE-RL 1996a) have been decayed to the same date as the PNNL samples (2001).

ERDF = Environmental Restoration Disposal Facility

ND = not detected

4.3 RIVER CORRIDOR RADIOLOGICAL SURVEY INFORMATION

Ground surface surveys, roadway surface surveys, site-wide aerial surveys, and soil and biota sampling activities have not identified any River Corridor areas with radiological contamination attributable to Hanford Site air emissions. These historical surveys and sampling events (Hanson 1960, Johnson 1991, Napier et al. 2004, Perkins 1988, Poston et al. 1995, Price and Kinnison 1982, Reiman and Dahlstrom 1990, Winship 1991) have often identified surface and subsurface contaminated areas associated with known solid and liquid waste sites, liquid releases from these waste sites, and to a lesser degree windblown contamination from nearby waste sites. These areas have been appropriately accounted for and have been given WIDS waste site identifiers.

The WIDS database documents waste sites, including new waste sites resulting from spills on releases to the environment from other established waste sites such as trenches, cribs, and ponds. From the time of the initial reactor operations in 1944, radiological control programs were in place to monitor and prevent releases. In general, potential releases from soil sources were contained upon identification. Placement of additional soil cover, a gravel surface, or pneumatically sprayed concrete created a barrier that prevented wind from suspending the contamination and prevented migration far from the source location. Spills were open to the wind action for very limited time intervals before they were stabilized or immobilized. The locations and remedial actions for such releases are documented in WIDS. Some releases in the 200 Area resulted in airborne releases that traveled a significant distance (e.g., from 200 West Area burial grounds to the 200 East Area fenceline). There is no documentation that airborne releases from such 200 Area surface sources traveled as far as the 100 Area reactors.

Recent radiological surveys and soils sampling have shown that areas along the River Corridor that may have received air emissions have soil concentrations that are not statistically different from other onsite or offsite soil sampling sites (PNNL 2002), as shown in Table 7. The current data indicate that radionuclides in soils at previously impacted areas have decayed and attenuated so that soil concentrations are indistinguishable from surrounding unimpacted or less impacted areas. Sampling locations on and off the Hanford Site are shown in the annual *Hanford Site Environmental Report* by PNNL.

Table 7. 2001 Soil Radionuclide Concentrations^a in Remediation Areas (PNNL 2002).

Site	Strontium-90 (pCi/g)	Cesium-137 (pCi/g)	Cobalt-60 (pCi/g)	Plutonium-239/40 (pCi/g)	Uranium-238 (pCi/g)
100-B/C	Not detected	0.22 ± 0.035	Not detected	0.015 ± 0.012	0.23 ± 0.062
100-H	Not detected	0.38 ± 0.072	Not detected	Not detected	0.15 ± 0.044
100-H	Not detected	0.55 ± 0.11	Not detected	Not detected	0.16 ± 0.048
100-F	Not detected	0.21 ± 0.036	Not detected	0.013 ± 0.011	0.18 ± 0.05
100-F	0.39 ± 0.2	0.077 ± 0.018	Not detected	0.019 ± 0.013	0.19 ± 0.051
100-N	Not detected	0.032 ± 0.013	0.021 ± 0.019	Not detected	0.31 ± 0.074
100-N	Not detected	0.41 ± 0.066	0.068 ± 0.055	Not detected	0.14 ± 0.042
100-N	0.34 ± 0.2	0.038 ± 0.01	0.033 ± 0.007	Not detected	0.19 ± 0.051
100-N	Not detected	0.049 ± 0.013	0.017 ± 0.008	Not detected	0.23 ± 0.06
Distant Community	0.052 ± 0.11	0.15 ± 0.32	Not reported	0.0055 ± 0.012	0.13 ± 0.11

^a +/- 2 Standard deviations

4.4 RECENT VEGETATION AND SOIL STUDIES ON AND OFF THE HANFORD SITE

In 1995 Pacific Northwest Laboratory conducted a thorough study of recent (1983 through 1993) terrestrial vegetation and soil samples on and around the Hanford Site (PNL 1995). The Pacific Northwest Laboratory study found that, with the possible exception of areas in the immediate vicinity of waste sites and in the immediate vicinity of the separation plants, onsite measurements were comparable to offsite measurements and in some cases less than offsite measurements. The study indicated that all of the onsite and offsite measurements were essentially at background levels and that any potential difference between onsite and offsite measurements was likely masked from historical nuclear bomb testing fallout. Subsequent annual Hanford Site environmental reports have continued to accumulate terrestrial vegetation and soil data showing that onsite and offsite radionuclide concentrations are representative of background (PNNL 2002).

5.0 CONCLUSIONS

Identification of Additional Waste Sites: There is no evidence that waste sites should exist in the River Corridor area as a result of historical air emission deposition. Any previous areas of elevated contamination existing in the River Corridor area as a result of historic stack emission deposition would have decayed or attenuated to negligible levels over the past 40 plus years since the majority of the air emissions occurred. Aerial radiation surveys of the Hanford Site and widespread sampling over many years support the conclusion.

Radiological Emissions: Recent Hanford Site radiological surveys and recent onsite and offsite vegetation and soil studies have not identified any areas of elevated contamination caused by historical air emissions. The primary air emissions were associated with releases of short-lived radionuclides more than 40 years ago. These short-lived radionuclides have decayed to negligible levels since their release. The longer lived radionuclides in the air emission releases are masked by long-lived radionuclides in worldwide fallout from nuclear bomb testing. Dispersion and decay of past releases of radionuclides has made onsite and offsite environmental concentrations indistinguishable from natural and anthropogenic (fallout) background.

Nonradionuclide Emissions: Evaluation of known air emissions and evaluation of the nonradionuclides contained in Hanford Site processes shows that deposition of hazardous or toxic materials from air emissions have been negligible. Air emissions of nonradionuclide materials were not generated or released in the 100 or 300 Areas except from sources such as burning of trash and exhaust of laboratory fumes that would have resulted in minor and localized releases. Separation plants in the 200 Areas did not emit hazardous or toxic nonradionuclides that would have been deposited on Hanford Site soils.

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