**A Status Report for
Rockwell Hanford Operations**

**PUREX Environmental
Radiological Surveillance—
Preoperational and Operational
Support Program Conducted by
Pacific Northwest Laboratory**

**M. J. Sula
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October 1983

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PUREX ENVIRONMENTAL RADIOLOGICAL
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Richland, Washington 99352

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SUMMARY

This report describes the radiological environmental sampling program that is being conducted at the U.S Department of Energy's (DOE) Hanford Site in support of resumed operation of the PUREX fuel processing plant. The report also summarizes preoperational radiological environmental data collected to date. The activities described herein are part of the ongoing Hanford Environmental Surveillance Program, operated by the Pacific Northwest Laboratory (PNL) for the DOE. This report has been written for the Rockwell Hanford Operations Energy Systems Group for their use in preparing the preoperational radiological status report for PUREX operation.

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PUREX ENVIRONMENTAL RADIOLOGICAL SURVEILLANCE--
PREOPERATIONAL AND OPERATIONAL SUPPORT PROGRAM
CONDUCTED BY PACIFIC NORTHWEST LABORATORY

INTRODUCTION

A continuing radiological environmental surveillance program has been conducted for the Department of Energy (DOE) Hanford Site in Washington State for the past 40 years. The surveillance program provides for the monitoring and assessment of radiological environmental impacts of all DOE operations conducted on the site, including the PUREX fuel processing facility operated by Rockwell Hanford Operations (RHO), a prime DOE contractor. The PUREX facility was constructed in the mid-1950's to process irradiated reactor fuel and recover plutonium, neptunium, and uranium. The PUREX facility was initially operated from 1956 to 1972 at which time it was placed in a standby mode. DOE is planning to restart PUREX plant operations in late 1983 and in conjunction with the restart activities, RHO is preparing a PUREX preoperational radiological status report.

This document was written for RHO's use in preparation of the PUREX preoperational radiological status report. Included in this document is a description of the Hanford radiological environmental sampling program as it will be conducted in consideration of PUREX operation. Also included are summaries of environmental radiological measurements performed through the Hanford radiological environmental sampling program describing pre-PUREX restart environmental radiological conditions in the Hanford environs.

THE HANFORD ENVIRONMENTAL SURVEILLANCE PROGRAM

A continuing radiological environmental surveillance program has been conducted for the Hanford Site since the 1940's. This program, referred to as the Hanford Environmental Surveillance Program, is conducted by PNL which is operated by Battelle Memorial Institute, for DOE.

The Hanford Environmental Surveillance Program has the following objectives:

- Assess dose impacts to the uncontrolled public from site operations.
- Verify in-plant controls for the containment of radioactive materials within controlled areas.
- Monitor to determine buildup of long-lived radionuclides in uncontrolled areas.
- Provide reassurance to the public that the program is capable of adequately assessing impacts and identifying noteworthy changes in the radiological status of the environment.
- Provide for the measurement of environmental media following an unplanned release of radioactive material from an onsite facility.

The program consists primarily of collecting and analyzing samples of various environmental media for radionuclides associated with DOE operations on the Hanford Site. The design of the environmental sampling program, i.e., the selection of media sampled, sampling locations, and specific analyses performed, is based on a number of considerations including historical data and experience, radionuclide transport and dose pathway analysis, local climatology, demography, and the nature and status of nuclear operations onsite.

Radiological impacts both in terms of environmental radioactivity levels and offsite dose equivalents are reported annually in two summary reports. A bibliography of these reports extending from 1968 to 1982 is provided in the appendix.

ANTICIPATED RADIOLOGICAL ENVIRONMENTAL CONDITIONS

Nuclear fuel processing was performed at Hanford's PUREX facility from 1956 to 1972. Effluent monitoring and environmental sampling data collected during at period provide the basis for the present PUREX environmental sampling program described in the next section.

Table 1 summarizes quantities of radionuclides released to the atmosphere from the PUREX plant during 1972, the most recent year of operation. The table also includes estimated maximum discharges following resumption of processing activities. In terms of radioactivity, ^{85}Kr and tritium represent the principal routine atmospheric discharges from the PUREX facility. Air-borne radioactivity releases from the UO_3 plant are much lower as shown in Table 2.

Table 3 provides the 1972 and the estimated future maximum discharge of radioactivity in liquids to cribs and ponds -- the primary radionuclide being tritium. A small fraction of the discharged tritium will eventually reach the Columbia River with an estimated travel time to the river of about 20 years (Eddy and Wilbur 1981).

Predicted radiation dose commitments from the routine atmospheric releases in Table 1 are shown in Table 4 for both a maximum individual and the general population. Dose impacts resulting from future routine PUREX emissions are expected to approximately double the current overall calculated dose impacts due to Hanford Site operations (Sula et al. 1983). Calculated doses from future routine operations of the UO_3 plant are much lower than those calculated for PUREX (DOE 1982).

Environmental measurements performed during the initial PUREX operating campaign have been documented in a series of annual and special reports (See Appendix A). Analyses of environmental samples show that during the last few years of PUREX operations, radionuclides in samples collected from offsite locations were generally not distinguishable from worldwide fallout levels. The occasional observation of low levels of radioiodine in milk and air samples as well as ^{90}Sr and ^{137}Cs in locally produced foodstuffs were possibly

TABLE 1. Radioactivity Content of Annual Airborne Effluents from the PUREX Plant^(a)

Radionuclide	1972 Actual ^(b)	Projected ^(c)	
	Annual Release, Ci	Annual Release, Ci	Concentration at Site Boundary, pCi/m ³
Total Alpha	4.3×10^{-3}	6.3×10^{-3}	8.8×10^{-7}
Total Beta	5.9×10^{-1}	4.6×10^{-1}	6.4×10^{-5}
¹²⁹ I	1.4×10^{-1}	4.0×10^{-2}	5.6×10^{-6}
¹³¹ I	2.1×10^{-1}	2.9×10^{-1}	4.1×10^{-5}
⁸⁵ Kr	4.1×10^5	1.3×10^6	1.8×10^{-2}
³ H	1.0×10^3	2.2×10^3	3.1×10^{-1}
¹⁴ C	7.0×10^{-1}	6.9×10^0	9.7×10^{-4}

(a) Taken from DOE (1982).

(b) Based on processing of 1013 MTU of fuel, including 525 MTU of 3.5% ²⁴⁰Pu.

(c) Based on processing of 2100 MTU/yr of 12% ²⁴⁰Pu, 180-day cooled fuel, 20% of which is spike fuel.

TABLE 2. Radioactivity Content of Annual Effluents from the UO₃ Plant^(a)

Radionuclides	Radioactivity, Ci	
	1972 Actual ^(b)	Projected (2100 MTU/yr) ^(c)
Total Alpha	9×10^{-5}	9×10^{-8}
Total Beta	6×10^{-3}	6×10^{-5}

(a) Taken from DOE (1982)

(b) Based on processing 1013 MTU of fuel including 525 MTU of 3.5% ²⁴⁰Pu.

(c) Based on processing of 2100 MTU/yr of 12% ²⁴⁰Pu, 180-day cooled fuel, 20% of which is spike fuel.

TABLE 3. Annual Radioactive Waste Discharges from the PUREX Plant to Cribbs and Ponds^(a)

Radionuclides	1972 Actual ^(b) Annual Release, Ci	Projected ^(c) Annual Release, Ci
Discharges to Cribbs		
²³⁹ Pu	4.3×10^0	2.7×10^{-1}
²³⁸ U	1.4×10^{-3}	1.4×10^{-3}
³ H	7.0×10^3	3.4×10^4
⁹⁰ Sr	1.5×10^2	6.0×10^0
¹³⁷ Cs	1.7×10^2	1.8×10^0
¹⁰⁶ Ru	8.1×10^2	2.4×10^0
⁶⁰ Co	1.9×10^1	8.4×10^{-2}
Discharges to Ponds		
²³⁹ Pu	4.4×10^{-1}	2.7×10^{-1}
²³⁸ U	1.9×10^{-2}	2.0×10^{-2}
³ H	Not Analyzed	6.1×10^1
⁹⁰ Sr	3.0×10^{-1}	4.3×10^{-1}
¹³⁷ Cs	1.8×10^0	1.0×10^0
¹⁰⁶ Ru	4.9×10^0	1.1×10^0
⁶⁰ Co	1.0×10^0	5.7×10^{-1}

(a) From OOE (1982)

(b) 1972 emissions are based on processing a total of 1013 MTU of fuel including about 525 MTU of 3.5% ²⁴⁰Pu.

(c) Projected emissions are based on processing 2100 MTU of 12% ²⁴⁰Pu irradiated fuel, 20% of which is spike fuel.

the result of PUREX releases. Nevertheless, the elevated results were usually only slightly above expected background levels and were for short durations and could therefore not be positively linked to any Hanford source.

Because of the relatively small expected contribution of most radionuclides to current environmental background levels, only ⁸⁵Kr in air and

TABLE 4. Radiation Dose Impacts from Expected Routine Releases from the PUREX Plant (a)

Organ	Maximum Individual, mrem 1-yr Release/70-yr Accumulation	Population, man-rem 1-yr Release/70-yr Accumulation
Total Body	0.02	2.1
Bone	0.05	5.3
Lung	0.02	2.2
Thyroid	0.06	6.4
GI-LLI	0.02	1.7

(a) Taken from Table D.17, DOE (1982), assuming 2100 MTU/yr processing rate.

^{129}I in milk are expected to be observed routinely at increased levels in the offsite environment following PUREX restart. Based on samples collected during 1982, current atmospheric ^{85}Kr concentrations in the local environs are approximately 20 pCi/m³. Using the estimated upper limit for the routine operational release of ^{85}Kr of 1.3×10^6 Ci annually (Table 1), ^{85}Kr concentrations may be expected to increase approximately an order of magnitude on an annual average basis at downwind site perimeter locations.

Iodine-129 concentrations measured in milk samples collected during PUREX operations in 1967 and 1971 (Brauer et al. 1973) were observed to be nearly two orders of magnitude higher than in samples collected in 1978, 6 years following PUREX shutdown. Future ^{129}I releases are expected to be similar to those during past operations.

Tritium and ^{14}C may also be observed at increased levels in air samples collected near operating facilities; however, in offsite locations these radionuclides most likely will not be distinguishable on a regular basis from background levels.

Increased concentrations of other radionuclides (^{90}Sr , ^{137}Cs , ^{239}Pu , and U) are generally not expected to be routinely detectable relative to fallout levels in any sample of environmental media collected offsite.

PUREX ENVIRONMENTAL RADIOLOGICAL SAMPLING PROGRAM

The following sections summarize those aspects of the Hanford environmental sampling program that will be applied to PUREX activities. The program involves the sampling and radioanalysis of air, soil, vegetation, foodstuffs, wildlife, and water and the measurement of direct radiation exposure at selected locations in the Hanford environs. Although, these media have historically been sampled in conjunction with the Hanford Environmental Surveillance Program, several additions have been made in consideration of the potential radiological impacts associated with PUREX operations. Sampling methods, schedules, and locations herein, may be modified in the future to best meet the program's objectives. Radioanalytical procedures are described in the 1982 annual environmental surveillance at Hanford report (Sula et al. 1983)

AIR SAMPLING

Ambient air samples are collected and analyzed for gross radioactivity and specific radionuclides to verify radioactive material containment measures, provide information regarding radionuclide concentrations in areas of public access and to maintain a general 360° coverage in locations near the site boundary in the event of an unanticipated atmospheric release of radioactive material.

Airborne particulate and radioiodine sampling is accomplished through the operation of both onsite and offsite sampling networks involving a total of 48 continuously operating samplers. (Shown in Figures 1 and 3). Water vapor (^3H) and gaseous samples (^{85}Kr , ^{14}C) are collected at locations shown in Figures 2 and 3.

The onsite samplers are located relatively close to the 200 Areas to maximize the capability to detect any radioactivity associated with PUREX airborne effluents. Samples are analyzed for indicator radionuclides, characteristic of potential PUREX sources. The offsite samplers are positioned near the site boundary and near local population centers, with

FIGURE 1. Airborne Particulate and Radioiodine Sampling Locations

FIGURE 2. Airborne Tritium, Carbon-14, and Krypton-85 Sampling Locations

LOCATION →	SUNNYSIDE	MOSES LAKE	WASHTUCNA	WALLA WALLA	McNARY
MEDIA					
AIRBORNE PARTICULATE	•	•	•	•	•
RADIOIODINE	•	•	•	•	•
CARBON-14	•				
TRITIUM (HTO)	•	•			
KRYPTON-85	•				
SOIL	•	•			
VEGETATION	•	•			
DOSE RATE	•	•	•	•	•

FIGURE 3. Background Sampling Locations

emphasis in the predominant downwind directions. Samples are analyzed for radionuclides of primary importance with respect to potential dose impacts as well as for radionuclides of perceived importance by the public. Air samples collected at distant locations (Figure 3) provide information on background concentrations of radionuclides in the site environs.

The combined onsite and perimeter samplers provide continuous coverage in all compass sectors around the 200 Areas in the event of a sudden and unanticipated increase in the discharge of radionuclides to the atmosphere from PUREX facilities. The angular separation between air samplers is generally less than 30°. Table 5 summarizes the air sample collection and analysis schedule.

TABLE 5. Atmospheric Radionuclide Sampling

Radionuclide	Physical Form	Collection Method	Analysis Frequency	Minimum Detectable Concentration, pCi/m ³
³ H (Tritium)	Water vapor	Silica gel	Monthly	300 ^(a)
¹⁴ C	Carbon dioxide	Soda lime	Bimonthly	1
⁸⁵ Kr	Gas	Compressed air	Monthly	10
⁹⁰ Sr	Particulate	Glass fiber filter	Quarterly	0.006
¹³¹ I	Molecular and organic vapor	TEDA, KI impregnated activated charcoal	Biweekly	0.01
¹³⁷ Cs	Particulate	Glass fiber filter	Monthly	0.005
Uranium	Particulate	Glass fiber filter	Quarterly	0.001
^{239,240} Pu	Particulate	Glass fiber filter	Quarterly	0.0001
Total beta	Particulate	Glass fiber filter	Biweekly	0.01
Total alpha	Particulate	Glass fiber filter	Biweekly	0.001

(a) Given in pCi/l of atmospheric water

Particulates

Airborne particulates are collected by drawing air at a flow rate of 2.6 m³/h through a 5-cm diameter high-efficiency particulate filter mounted facing horizontally about 3 ft above the ground surface. The filters are removed and replaced every 2 weeks. Each biweekly filter is analyzed for gross beta activity after a 7-day holding period during which short-lived radioactivity including naturally occurring radon and thoron daughters, decay. Selected filters are also analyzed for long-lived total alpha activity.

After analysis for gross radioactivity, the individual filters are composited into 21 geographical groups, shown within dotted lines in Figures 1 and 3. The composited filters are then analyzed for ¹³⁷Cs and other gamma-emitting radionuclides on a monthly frequency (i.e., filters from two biweekly sampling periods are combined) and on a quarterly frequency for ⁹⁰Sr, uranium, and ²³⁹Pu. Results reported for specific radionuclide analysis of air particulate samples thus represent averaged concentrations for the composite area based on the individual samples collected at specific locations within the composite area.

Radioiodines

Radioiodines are collected using a cartridge containing activated charcoal placed downstream of the particulate filter. Cartridges from 20 of the locations are exchanged every 2 weeks and analyzed for ¹³¹I. At the other radioiodine sampling locations, the charcoal cartridges are exchanged monthly to maintain fresh absorption media, but are not analyzed unless ¹³¹I is identified at a routinely analyzed sampling location or if there is any indication of an onsite release that could result in detectable concentrations.

Tritium

The airborne tritium collection unit consists of a cartridge containing silica gel through which a stream of filtered air is passed at a flow rate of 0.015 m³/h. Water vapor in the sample stream is trapped in the silica gel cartridge, which is exchanged and analyzed for tritium on a monthly frequency.

Carbon-14

Carbon-14 as CO_2 is sampled continuously by drawing a stream of filtered air at $0.03 \text{ m}^3/\text{h}$ through a bed of soda lime. Cartridges containing the soda lime are removed for analysis at 2-month intervals.

Krypton-85

Krypton-85 is sampled by intermittently collecting filtered ambient air into a pressure cylinder. Approximately 700 cm^3 of air are pumped into the cylinder at 1-hour intervals such that about 0.5 m^3 are accumulated during the 1-month sample period.

FOODSTUFFS

Locally produced foodstuffs are collected from several locations near the site perimeter (Figure 4) to determine radionuclide concentrations in foods produced in the Hanford area. Foodstuffs collected include: milk, leafy vegetables, apples, cherries, grapes, wheat, alfalfa, beef, chickens, and eggs. The foodstuffs sampling schedule is summarized in Table 6. The samples, which are collected fresh in season as available, are analyzed for radionuclides potentially associated with PUREX effluents of primary importance from a food pathway radiological impact standpoint. Samples collected from the Moses Lake and Sunnyside areas serve as controls.

WILDLIFE SAMPLING

Wildlife sampling is performed onsite to provide information concerning the continued containment of radioactive materials within waste management areas, and to determine the potential for offsite biotransport of radionuclides. Wildlife samples are collected at onsite locations with the highest potential for uptake of radionuclides. For edible game that could wander offsite (deer, waterfowl), the samples also provide an indication of the maximum concentrations of Hanford radionuclides in local game potentially available for consumption by a member of the public. The wildlife sampling program described here is part of the overall routine environmental surveillance program conducted at Hanford. The samples will be sensitive to PUREX-related

FIGURE 4. Foodstuffs Sampling Areas

radionuclides as well as to other potential onsite sources; however, the sampling program is not source specific, i.e., special supplementary sampling would be necessary if an unusual condition was detected. Wildlife sampled onsite include waterfowl, game birds, deer, and rabbits.

Waterfowl (mallard ducks) are collected annually during hunting season from Gable Mountain Pond, B Pond, and U Pond. These ponds serve as discharge

TABLE 6. Foodstuffs Sampling Schedule

Foodstuff	Locations ^(a)	Frequency	Analyses
Milk	Sagemoor, Sunnyside	BW	^{131}I , ^{137}Cs
	Other areas	M	^{131}I , ^{137}Cs
	All locations	M Q SA	H Sr I
Leafy Vegetable	All locations	A	^{90}Sr , ^{137}Cs
Apple	Sagemoor, Cold Creek, Sunnyside	A	^3H , ^{90}Sr , ^{137}Cs
Cherries	Sagemoor, Sunnyside	A	^3H , ^{90}Sr , ^{137}Cs
Grapes	Sagemoor, Cold Creek, Sunnyside	A	^3H , ^{90}Sr , ^{137}Cs
Wheat	All locations	A	^{90}Sr , ^{137}Cs
Alfalfa	All locations	A	^{90}Sr , ^{137}Cs
Beef	Sagemoor, Riverview, Benton City, Sunnyside	SA	^{90}Sr , ^{137}Cs
Chickens	Sagemoor, Sunnyside	SA	^{90}Sr , ^{137}Cs
Eggs	Sagemoor, Sunnyside	SA	^{90}Sr , ^{137}Cs

(a) Refer to map, Figure 5.

points for cooling water and condensates from PUREX facilities. All three ponds have been in use at Hanford for a number of years and contain radio-nuclides, primarily in their sediments, attributable to past operations.

Waterfowl sampling is performed to determine if there is any change in radionuclide availability in the ponds to waterfowl. Twenty mallard samples are collected annually from Gable Mountain Pond and four samples are collected annually from B Pond and from U Pond.

Pheasants and rabbits are collected annually from south of the 200-East and 200-West Areas as shown in Figure 5. Rabbit samples are collected in April with four jack rabbits retrieved from each of the two sample areas. The muscle tissue from each rabbit is analyzed for ^{137}Cs and other gamma-emitting radionuclides by gamma spectroscopy, and the bone and liver are analyzed for ^{90}Sr and $^{239,240}\text{Pu}$ respectively. Three pheasants (quail or chukar if pheasants are not available) are collected from each area in October. Muscle tissue is analyzed for ^{137}Cs .

Deer forage over a relatively large area and serve as accumulators of radionuclides present in vegetation. The primary source of deer samples are from accidental roadkills onsite. On the average, about six deer samples per year are obtained in this manner. To supplement the road-kill samples, two deer are collected annually during hunting season in the vicinities of Gable Mountain Pond and B Pond located just north and east of the 200-E Area (Figure 5). Of the several facilities used for discharging water containing low levels of radionuclides from PUREX facilities, these ponds provide the most attractive foraging environment for deer. Deer tagging studies have shown that a number of Hanford deer spend much of their time in close proximity to the ponds, (Eberhardt, Hansen, and Cadwell 1982). Muscle tissue is analyzed for ^{137}Cs and liver for $^{239,240}\text{Pu}$.

SOIL SAMPLING

Soil sampling is performed to determine if there is a gradual build-up of long-lived radionuclides in the environment as a result of PUREX activities. Samples are collected annually from locations both onsite and near the site perimeter as shown in Figures 3 and 6. Samples are collected predominantly in the prevalent downwind direction from PUREX as well as between PUREX and other onsite facilities. Control samples are collected near Sunnyside and Moses Lake.

FIGURE 5. Wildlife Sampling Areas in the Vicinity of the 200 Areas

A soil sample consists of a composite of five cylindrical "plugs" of surface soil approximately 2.5 cm deep and 10 cm in diameter obtained within a 100-m² area at the sampling site. The composites are mixed and dried and large stones and debris removed. Aliquots are taken from the mixture and analyzed for long-lived radionuclides of primary interest with respect to PUREX operations. These include: ⁹⁰Sr, ¹³⁷Cs, ^{239,240}Pu, U, and in several samples ²⁴¹Am.

FIGURE 6. Soil and Vegetation Sampling Locations

VEGETATION SAMPLING

Samples of new growth from naturally growing perennial vegetation are collected and composited at each soil sampling location. These samples may consist of sagebrush, rabbitbrush, or a mixture of the two depending on their relative abundance at the sampling location. Because only new growth of

perennial vegetation is collected, the samples provide an indication of radionuclides deposited on or incorporated in the plant during the recent growing season. Vegetation samples are analyzed for the following radionuclides of principle interest with respect to PUREX operations: ^{90}Sr , ^{137}Cs , $^{239,240}\text{Pu}$, and U.

ENVIRONMENTAL DOSE RATE MEASUREMENTS

Monthly integrated penetrating radiation doses are measured at the 48 air sample locations in the Hanford environs (see Figures 1 and 3). Measurements are made using thermoluminescent dosimeters consisting of three $\text{CaF}_2\text{:Mn}$ thermoluminescent chips in a cylindrical capsule. The opaque capsule incorporates a lead/tantalum filter to provide uniform dose response characteristics for penetrating radiation above 70 keV. The dosimeters are calibrated using a ^{137}Cs gamma source, and results are expressed in dose equivalent units.

COLUMBIA RIVER SAMPLING

Since 1943, liquids containing radioactive contaminants have been discharged to ground disposal facilities including ponds, ditches, trenches, and cribs within controlled areas in the 200 Areas. These liquids percolate laterally and downward through the 150 to 300 feet of silts and gravel underlying the ground-water table. As the water moves through the sedimentary earth materials, contaminants in the water are removed to a large extent by a number of physical and chemical interactions with the soil. The ground water eventually re-enters the surface environment where the ground-table intersects the Columbia River east of the 200 Areas. The travel time between discharge and re-entry is estimated to be about 20 years (Eddy and Wilbur 1981). The presence of radionuclides in the ground water is monitored through an extensive network of wells located throughout the Hanford Site as described elsewhere in this document. The Columbia River is also sampled on a continuous basis through the routine Hanford Environmental Surveillance Program.

The primary radionuclide of interest with respect to liquid discharges to the ground during future PUREX operations is tritium, which is incorporated chemically in water molecules and thus moves with the ground water. The tritium concentration is reduced principally by radioactive decay and

hydrodynamic dispersion. The Columbia River sampling program, conducted in consideration of past operations involving liquid discharges to the ground in the 200 Area, includes analysis for tritium as well as for several other radionuclides associated with liquids discharged from PUREX operations. These liquids have been observed during past studies to exhibit some mobility in ground-water systems. This sampling program is described in detail by Sula et al. (1983) and will be continued in consideration of future PUREX activities, although it will be a number of years before liquids discharged to the ground will reach the river.

SUMMARY OF PREOPERATIONAL ENVIRONMENTAL RADIONUCLIDE CONCENTRATIONS

Environmental radionuclide concentrations and dose rate levels have been measured in the Hanford environs on a routine basis since 1943 as part of a comprehensive radiological environmental surveillance program maintained by the DOE. Results of the program have been reported in publicly available documents since 1948^(a). Thus, an extensive data base of environmental radioactivity data for the Hanford region exists.

Current environmental radiological conditions (i.e., pre-PUREX restart levels) in the Hanford area are discussed in this section. The reported environmental radiological conditions generally represent those observed during 1982. Trend data is provided for specific environmental parameters, where appropriate, to demonstrate temporal variability in recent years. It is planned to update in a subsequent report the information in this section using data from samplers collected prior to PUREX restart during 1983.

Because environmental parameters reported herein will be used as a base line for comparison with observed conditions following PUREX restart, due consideration should be given to the temporal variability of the parameter and of possible offsite contributions such as worldwide fallout to environmental radionuclides in the Hanford area.

The primary reason for the changes in environmental radioactivity levels in recent years has been the introduction of radioactivity into the environment through the atmospheric detonation of nuclear explosives. Although atmospheric fallout products may be observed in all environmental

(a) From 1948 to 1958, quarterly environmental summary reports were prepared. From 1959 to the present, the reports have been issued annually. The most recently issued report is titled Environmental Surveillance at Hanford for CY 1982 (Sula et al. 1983). Appendix A contains a bibliography of annual environmental surveillance reports from 1968 to 1983.

media, airborne radionuclide concentrations are particularly sensitive to this source.

Because several countries have continued atmospheric testing, there is no assurance that environmental radionuclide concentrations presented in this report will continue to represent valid base-line environmental radionuclide concentrations during the planned PUREX operating campaign.

AIRBORNE RADIONUCLIDE CONCENTRATIONS

Airborne radionuclide concentrations in the Hanford area for 1982 are summarized in Table 7. In recent years airborne radionuclide concentrations have been uniform with respect to sampling location, and the summary information provided in Table 7 is based on consideration of measured air concentrations at sampling locations near the site boundary, in nearby communities and at locations distant from the site. The information in Table 7 is discussed in more detail below.

Tritium

A comparison of average concentrations for the different sampling locations (Figure 7) based on 1982 data is provided in Figure 8. As shown in the figure, there appears to be no relationship between atmospheric tritium levels and location in the Hanford area. Average tritium concentrations in atmospheric water vapor at offsite sampling locations as of 1982 averaged 240 pCi/l within a 95% confidence interval of 190-290 pCi/l. The temporal variability exhibited by tritium in atmospheric water vapor over the past 2 years is shown in Figure 9, which gives the average concentration at offsite locations during 1981 and 1982.

Carbon-14

Sampling for carbon-14 as CO_2 was begun in March 1983 at the locations shown in Figure 7. Although analysis of the initial samples has begun, no results have been received to date.

FIGURE 7. PUREX Preoperational Sampling Locations for Airborne Tritium, Carbon-14, and Krypton-85

Krypton-85

Krypton-85 sampling was initiated in September 1982 at several locations shown in Figure 7. The limited amount of data obtained to date indicate concentrations are uniform in the Hanford environs at about 19 pCi/m^3 within a 95% confidence interval of 17 to 21 pCi/m^3 . Currently observed levels are thus attributed to worldwide atmospheric nuclear testing.

TABLE 7. Airborne Radionuclides Concentrations
In the Hanford Environs, 1982

Radionuclide	Physical Form	Concentration, pCi/m ³ (except as shown)	
		95% Confidence Interval	Mean
³ H	Water vapor	190 to 290 pCi/l water	240 pCi/l of water
¹⁴ C	CO ₂	NA ^(a)	NA
⁸⁵ Kr	Gas	(1.7 to 2.1) X 10 ¹	1.9 X 10 ¹
⁹⁰ Sr	Particulate	(0.6 to 1.6) X 10 ⁻⁴	1 X 10 ⁻⁴
¹³¹ I	Molecular & organic vapor	(Not identified, <0.01 pCi/m ³)	
¹³⁷ Cs	Particulate	(0.2 to 1.3) X 10 ⁻³	8 X 10 ⁻⁴
Uranium	Particulate	NA	NA
^{239,240} Pu	Particulate	(1.0 to 3.0) X 10 ⁻⁵	2 X 10 ⁻⁵
Total alpha	Particulate	(0.9 to 1.1) X 10 ⁻³	1 X 10 ⁻³
Total beta	Particulate	0.028 to 0.032	3 X 10 ⁻²

(a) Data not available at this time, but will be reported in the final PUREX preoperational report.

Strontium-90

Strontium-90 concentrations have been measured in airborne particulates as part of the routine environmental surveillance program at Hanford since 1977. Figure 10 shows quarterly ⁹⁰Sr concentrations averaged for all offsite composite samples from 1978 to 1982. A foreign atmospheric nuclear test was conducted in October 1980, and the figure illustrates the effect of the test on ⁹⁰Sr concentrations in ambient air. As of 1982, concentrations have decreased to the lowest levels observed since atmospheric nuclear testing peaked in the 1960's. However, considering the current low environmental concentrations, background levels can be expected to exhibit dramatic

FIGURE 8. Atmospheric Tritium (HTO) Concentrations, 1982

FIGURE 9. Tritium Concentration in Water Vapor at Offsite Locations

FIGURE 10. Airborne Strontium-90 Concentrations, 1978 to 1982

increases following any future atmospheric testing. The average ^{90}Sr concentration observed in ambient air at offsite locations during 1982 was $1 \times 10^{-4} \text{ pCi/m}^3$ within a 95% confidence interval of $(0.6 \text{ to } 1.6) \times 10^{-4} \text{ pCi/m}^3$. A comparison (Figure 11) of annual average concentrations for composite groups located as shown in Figure 12 during 1982 does not indicate geographical variability or significant contributions from onsite sources.

Because of the generally decreasing trend observed for ^{90}Sr over the past several years, concentrations in ambient air are expected to continue to decrease if no further atmospheric testing is conducted. Concentrations are currently near the sampling program's minimum detection level with positive ^{90}Sr concentrations identified in only half of the samples collected during 1982.

Iodine-131

Sampling for ^{131}I in air has been performed at a number of locations in the Hanford environs since 1959; however, there have been no positive identifications of atmospheric ^{131}I in samples since the weeks immediately following a foreign atmospheric nuclear test in 1978. The minimum detectable concentration for ^{131}I in air is 0.01 pCi/m^3 .

Cesium-137

Cesium-137 concentrations have been measured in airborne particulates on a monthly basis by the environmental surveillance program since 1969. Although atmospheric ^{137}Cs concentrations vary moderately on a month-to-month and year-to-year basis as shown in Figures 13 and 14, current concentrations at different locations in the area, both onsite and offsite, (Figure 12) are fairly uniform, as shown in Figure 15. Concentrations during 1982 at offsite locations averaged $7.5 \times 10^{-4} \text{ pCi/m}^3$ within a 95% confidence interval of $(0.2 \text{ to } 1.3) \times 10^{-3} \text{ pCi/m}^3$.

Cesium-137 was positively identified in about 25% of the samples collected during 1982. Concentrations are currently near the program's minimum detectable concentration, with about 25% of all samples yielding a positive ^{137}Cs identification during 1982. Concentrations are expected to

FIGURE 11. Strontium-90 in Airborne Particulate Samples, 1982

FIGURE 12. PUREX Preoperational Sampling Locations for Airborne Particulate Composite Groups

decline further in future years unless atmospheric nuclear testing is conducted. Figure 13 demonstrates the effects of an atmospheric nuclear test conducted in October 1980 on ^{137}Cs concentrations in air during 1981.

Uranium

The analysis of selected composited air samples for natural uranium was begun on a quarterly frequency in January 1983. Results have been

FIGURE 13. Average Monthly Airborne Cesium-137 Concentrations at Offsite Sampling Locations, 1981 to 1982

FIGURE 14. Average Annual Airborne Cesium-137 Concentrations at Offsite Locations, 1978 to 1982

received for the initial sampling period with concentrations ranging from 0.02 to 0.1 pCi/m³ over all sampling locations.

Plutonium-239

The analysis of airborne particulate samples for plutonium has been performed as part of the routine environmental surveillance program since 1971. Prior to 1981 the samples were analyzed for total plutonium using radiochemical separation followed by nuclear track counting. Beginning in 1981 alpha spectrometry was used to determine the ^{239,240}Pu component.

Results of the quarterly analysis of airborne particulate composite samples averaged over all offsite locations for 1981 and 1982 are shown in Figure 16. Higher concentrations existed during the first half of 1981 as a

ONSITE LOCATIONS

100 AREA

300 AREA

400 AREA

INNER EASTERN

OFFSITE LOCATIONS

INNER NORTHEAST

INNER SOUTHEAST

INNER SOUTHWEST

INNER NORTHWEST

OUTER NORTHEAST

OUTER SOUTHEAST

OUTER WESTERN

FIGURE 15. Cesium-137 in Airborne Particulate Samples, 1982

FIGURE 16. Average Airborne Plutonium-239, 240 Concentrations at Offsite Sampling Locations, 1981 to 1982

result of fallout from a foreign atmospheric nuclear test in 1980.

The homogeneity of plutonium concentrations in airborne particulates among the various composite groups during 1982 is demonstrated in Figure 17. Concentrations during 1982 at offsite locations averaged 2.0×10^{-5} pCi/m³ within a 95% confidence interval of $(1.0 \text{ to } 3.0) \times 10^{-5}$ pCi/m³.

Alpha and Beta Particulate Radioactivity

Results of long-lived gross beta and gross alpha radioactivity measurements of airborne particulate samples during 1982 at locations shown in Figure 18 are summarized in Figures 19 and 20. The figures demonstrate the uniformity of airborne radioactivity levels in the Hanford environs but perhaps indicates that concentrations in the immediate vicinity of operating areas

FIGURE 17. Plutonium-239,240 Concentrations in Airborne Particulates, 1982

FIGURE 18. PUREX Preoperational Sampling Locations for Airborne Particulates and Radioiodines

may be slightly higher than at other locations. Nevertheless, the differences noted in Figure 19 are small compared to those observed in recent years due to variations in airborne radionuclides associated with atmospheric nuclear testing as demonstrated in Figure 21 for the period 1978-1982.

Gross beta long-lived radioactivity in ambient air in the Hanford environs during 1982 averaged over all offsite sampling locations was 0.03 pCi/m^3 within a 95% confidence interval of 0.028 to 0.032 pCi/m^3 . Long-lived gross alpha radioactivity levels during 1982 were 0.001 pCi/m^3

ONSITE LOCATIONS

200 ESE
100 K
100 N
100 D
100 A
HANFORD
WYE BARRICADE
400 E
400 S
ACRMS
300 S

OFFSITE LOCATIONS

PROSSER BARRICADE
BENTON CITY
ALE
RATTLESNAKE SPRINGS
YAKIMA BARR.
VERNITA BARR.
WAHLUKE-2
BERG RANCH
OTHELLO
WAHLUKE
CONNELL
COOKE
FIR ROAD
PETTETT
BYERS
PASCO
RICHLAND
1100
RRC
McNARY
WALLA WALLA
WASHTUCNA
MOSES LAKE
SUNNYSIDE

FIGURE 19. Gross Beta Radioactivity in Airborne Particulate Samples, 1982

FIGURE 20. Gross Alpha Radioactivity in Airborne Particulate Samples, 1982

FIGURE 21. Monthly Average Gross Beta Radioactivity in Airborne Particulate Samples, 1978 to 1982

within a 95% confidence interval of $(0.9 \text{ to } 1.1) \times 10^{-3} \text{ pCi/m}^3$.

FOODSTUFFS

Radionuclide concentrations in foodstuff samples collected during 1982 are summarized in Table 8. The following sections discuss the data presented in the table and provide additional details regarding current radionuclide concentrations in local foodstuffs.

TABLE 8. Range of Radionuclide Concentrations in Various Foodstuffs in the Hanford Environs, 1982.

Foodstuff	Radionuclide Concentrations, pCi/g wet weight (except as noted)				
	⁹⁰ Sr	¹³⁷ Cs	³ H, pCi/l	¹²⁹ I	¹³¹ I
Milk, pCi/l	<0.5-2.0	<10-20	<300-500	(0.6 to 4.8) × 10 ⁻³	<0.5
Leafy Vegetables	<0.002-0.02	<0.02-0.1			
Cherries	<0.002-0.002	<0.02	<300-500		
Apples	<0.002-0.004	<0.02	<300-500		
Grapes	<0.002-0.005	<0.02	<300-500		
Wheat	<0.002-0.02	<0.02			
Alfalfa	<0.002-0.2	<0.03-0.2			
Beef	<0.002	<0.02-0.03			
Chicken	<0.002-0.01	<0.02			
Eggs	<0.002-0.01				

Milk

Iodine-131 has not been detected in milk samples collected in the Hanford environs since late in 1980 when concentrations up to 2 pCi/l were observed within a few weeks following an atmospheric nuclear test conducted in China. The current minimum detectable concentration for ^{131}I in milk is 0.01 pCi/l.

The routine analysis of milk for ^{129}I was begun on a semiannual frequency in August 1982. Iodine-129 concentrations in milk samples collected in 1982 ranged from 6.9×10^{-4} to 4.8×10^{-3} pCi/l.

Strontium-90 concentrations in milk samples have been fairly uniform both geographically and with respect to time as shown in Figures 22 and 23. The mean ^{90}Sr concentration in milk samples collected during 1982 was 1.4 pCi/l.

Cesium-137 has been infrequently detected in milk samples in recent years with positive identifications occurring in only about 10% of samples collected during 1982. Cesium-137 concentrations in 1982 ranged from less than the detection level (~ 10 pCi/l) to 20 pCi/l with no apparent differences among sample locations.

The analysis of milk samples for tritium was initiated in January 1983 and, to date, tritium has been positively identified in fewer than half of the samples collected (minimum detectable concentration ~ 300 pCi/l). In all samples with detectable tritium, concentrations have been low and near the minimum detectable level.

Leafy Vegetables

Strontium-90 concentrations were observed to be fairly uniform among the different sampling locations as shown in Figure 24. As indicated in the figure, currently observed ^{90}Sr concentrations are very low and near the minimum detection level of 0.002 pCi/g.

Cesium-137 was identified in fewer than half of the samples collected in 1982 with observed concentrations ranging from below detection level (~ 0.02 pCi/g) to 0.1 pCi/g. No differences in ^{137}Cs concentrations in

FIGURE 22. Strontium-90 Concentrations in Milk, 1982

leafy vegetables at the different sampling locations are apparent from data collected in recent years.

Fruit

Cesium-137 concentrations in fruit (cherries, grapes, and apples) have generally been below detection levels (~ 0.02 pCi/g wet weight) in recent years. Strontium-90 was consistently observed only in cherries. For all fruit samples in which ^{90}Sr was observed, concentrations were very low, near minimum detectable concentrations (~ 0.002 pCi/g wet weight).

The analysis of water obtained from fruit samples for tritium was initiated in 1982. Tritium was detectable in about two thirds of all samples (minimum detectable concentration ~ 300 pCi/l) with observed concentration

FIGURE 23. Strontium-90 Concentrations in Milk, 1981 to 1982

FIGURE 24. Strontium-90 in Leafy Vegetables Collected in the Hanford Environs, 1982

ranging only up to 500 pCi/l. There were no apparent differences in concentrations either for different fruit types or for different sampling locations.

Wheat and Alfalfa

Wheat and alfalfa sampling was begun on an annual basis in 1982. The samples collected are field dried and analyzed on a wet weight basis. Cesium-137 was detected in fewer than half of the samples with concentrations ranging from less than detectable to 0.01 pCi/g for wheat and 0.2 pCi/g for alfalfa. Strontium-90 was observed in all wheat and alfalfa samples. In contrast to other media sampled, differences in concentration were apparent

FIGURE 25. Mean Strontium-90 Concentrations in Wheat Collected in the Hanford Environs, 1982

for different sampling locations as shown Figures 25 and 26. Results of samples to be collected during 1983 will help in determining the nature of the observed variability; however, it is likely that the variability is the result of the differences in moisture content of the collected samples. In the future, samples will be dried in the laboratory and concentrations determined on a dry weight basis.

Beef

Strontium-90 and ¹³⁷Cs have been only occasionally identified in beef samples collected in recent years. When the radionuclides have been observed, they were at very low levels, near the minimum detectable concentration for the analytical procedure employed.

FIGURE 26. Mean Strontium-90 Concentrations in Alfalfa Collected in the Hanford Environs, 1982

Chicken and Eggs

The collection of chickens and eggs in the Sagemoor and Sunnyside Areas (Figure 5) for radionuclide analysis was begun in 1982. Samples are collected semiannually and analyzed for ⁹⁰Sr and ¹³⁷Cs. Radionuclide concentration data for 1982 are summarized in Table 8. In all samples, radionuclide concentrations are very low, near the minimum detectable concentration for the analytical technique. The occurrence of identifiable concentrations in the samples is attributed to worldwide fallout.

WILDLIFE

Wildlife sampled onsite include waterfowl, gamebirds, deer and rabbits.

Waterfowl

Many different types of waterfowl have been collected from the 200 Area ponds in past years including ducks, geese and coots. Ducks represent the most important species and, over the past five years, have included:

<u>Puddle Ducks</u>	<u>Diving Ducks</u>
Mallard	Goldeneye
Teal	Ruddy Duck
Widgeon	Bufflehead
Gadwall	
Pintail	
Shoveler	

Nearly 60% of the ducks collected were mallards. Mallard ducks are the most important waterfowl from a surveillance standpoint because they are abundant and sought after by hunters.

Figures 27 and 28 show the distribution of data for ^{137}Cs in muscle tissue of ducks collected primarily between September and March over the past five years. Results of analyses performed on ducks collected from the Columbia River are presented for comparative purposes. Values range over five orders of magnitude making it difficult to compare central tendencies such as the mean or median. However, the median value for all types of ducks collected at all ponds apparently has not changed appreciably over the past five years (or even ten years). The value is about 2 pCi/g which means that about half of the time duck specimens had muscle tissue concentrations of ^{137}Cs greater than 2 pCi/g. On the other hand, only one duck collected in the past 10 years (1980) from the Columbia River contained a muscle concentration of >0.5 pCi/g. Nearly all mallards collected from 200 Area ponds contain detectable levels of ^{137}Cs in muscle tissue, whereas, only 30% collected from the Columbia River are above detection limits. The highest values for 200 Area ponds (1981) were from two Ruddy Duck samples. Usually only a gamma scan analysis for ^{137}Cs is conducted, but ^{90}Sr in muscle and Pu in liver were determined in 1978. No strontium was detected in any duck sampled, and a

FIGURE 27. Range of Cesium-137 Concentrations in Muscle Tissue of Ducks Collected at All 200 Area Ponds for Past 5 Years ($\bar{X}_g$ = Median)

FIGURE 28. Range of Cesium-137 Concentrations in Muscle Tissue of Mallard Ducks and All Other Ducks Collected at 200 Area Ponds from 1978 to 1982 ($\bar{X}_g$ = Median)

teal collected at U Pond contained a liver concentration of total plutonium of 0.11 ± 0.01 pCi/g (wet).

Gamebirds

Upland game birds have been collected routinely from the 200 Area since 1980. Table 9 lists all data currently available.

The number of samples is small and the data cannot be compared to the 100 Area where game birds are also collected because both areas have contamination sources. The pheasant with 40 pCi/g represents the largest cesium concentration of any game bird sampled at Hanford.

Deer

The routine surveillance program utilizes deer accidentally killed on Hanford roads. A special study was conducted in 1981 to determine if roadkill samples were sufficiently representative of Hanford deer to continue the use of roadkilled animals. The current sampling program calls for supplementing the roadkill samples with additional samples collected from the 200 Area.

Table 10 summarizes the last five years of roadkill data and compares it to the special study results.

Results do not show a relationship between levels of ^{90}Sr in bone and ^{137}Cs in muscle. This illustrates the differences in tissue retention times between the two nuclides. Strontium retention in bone is known to be much longer than cesium retention in muscle. The maximum concentrations of ^{90}Sr in bone (65 pCi/g), and ^{137}Cs in muscle (0.94 pCi/g) occurred in special study animals collected from the 200 Area. Maximum liver concentrations of $^{239,240}\text{Pu}$ (.07 pCi/g) were the same for both types of samples. The detection level of ^{137}Cs was lower for special study samples than the routine samples. Thus, no special study control samples were less than the detection level.

Rabbits

A few jack rabbits (hares) and cottontail rabbits have been collected from the 200 Area over the past five years. Table 11 summarizes results and compares the 200 Area with the 300 Area to provide some perspective.

TABLE 9. ^{137}Cs in Muscle from Gamebirds
Collected from the 200 Area

Area	Species	Collection Date	^{137}Cs , pCi/g wet Result $\pm$ 2 std. dev.
200 W	Pheasant	Oct. 1982	40 $\pm$ 0.19
	Pheasant	Nov. 1981	<DL
200 E	Pheasant	Oct. 1982	1.5 $\pm$ 0.04
	Chukar	Oct. 1981	<DL
	Chukar	Oct. 1981	0.14 $\pm$ 0.06
	Chukar	Oct. 1981	<DL
	Quail	Oct. 1980	0.13 $\pm$ 0.02

TABLE 10. Strontium, Cesium, and Plutonium
in Hanford Deer Samples

Radionuclide and Tissue	Range of Concentration, pCi/g	Number of Samples		
		Routine Program Roadkills (1978-82)	Special Study (1981) ^(a)	
			200 Area	Control
^{90}Sr , Bone	<DL to 0.10	4	1	0
	0.11 to 1.0	14	1	4
	1.1 to 10.0	5	5	1
	>10.1	3	5	0
^{137}Cs , Muscle	<DL to 0.01	19	0	5
	0.011 to 0.10	6	9	0
	>0.11	2	3	0
$^{239,240}\text{Pu}$, Liver	<DL	8	9	5
	>DL	14	9	5

(a) 200 Area deer determined to spend >50% of time within 2 km of
200 Area (Eberhardt, Hanson, and Cadwell 1982).

TABLE 11. Strontium and Cesium in Rabbits
Collected During 1978 to 1982

¹³⁷ Cs, Muscle	Total Samples	Number of Results			
		<DL	DL to 0.1	0.1 to 1.0	>1.0
200 Area	20	3	6	8	3
300 Area	14	12	0	2	0
⁹⁰ Sr, Bone					
200 Area	20	0	1	2	17
300 Area	14	0	0	12	2

Note that only 2 rabbits out of 14 collected from the 300 Area showed detectable levels of ¹³⁷Cs in muscle tissue, whereas, 17 of 20 rabbits collected from the 200 Area showed detectable levels. The percentage of rabbits with elevated levels of ⁹⁰Sr in bone also is greater for the 200 Area. As with the deer data, there is no obvious relationship between the concentrations of the two nuclides because of the differences in tissue retention times. Extreme variability is noteworthy in the 200 Area data, i.e., ¹³⁷Cs ranged between <DL (≈ 0.07) to 19 pCi/g (wet).

SOIL AND VEGETATION

Ten onsite locations and ten offsite locations have been routinely sampled for the past five years. The locations are:

<u>Onsite</u>	<u>Offsite</u>
East of 200-W Gate	Wahluke Slope
200 ENC	Berg Ranch
200-E Hill	Ringold
Hanford Townsite	Fir Road
Wye Barricade	Taylor Flats
Yakima Barricade	Sagemoor Farms
North of FFTF	Byers Landing
South of FFTF	Riverview
Prosser Barricade	Benton City
ALE Field Labs	Sunnyside

Figure 29 shows the range of soil concentrations of radionuclides and the median value for each onsite location for the past five years. The data are compared with a single value representing all offsite locations. Surface soil at some of the 200 Area sites appears to contain elevated levels of radioactive materials compared to offsite locations. Note that the bars on the charts are not error estimates but rather the range of maximum and minimum results. Similar data for offsite locations are provided in Figure 30 to show the variability to be expected from results influenced primarily by worldwide fallout. Figure 31 plots the same data set to show the variability of the median values for all offsite and all onsite locations with time. Due to the large variability in the data, it is difficult to conclude if there is a time dependent trend in the data over the past five years. It should be noted that the data for uranium in soil reflect "extractable" uranium and not total uranium (typically 40% of total).

A special study was conducted in 1980 wherein various kinds of surface soil samples were collected from onsite and offsite locations and analyzed for ^{241}Am (Price et al. 1981). Results were somewhat tempered by the very low levels of ^{241}Am (<0.10 pCi/g dry) detected and by the fact that statistically significant differences depended on the type of statistical analysis used. In general, the average concentration of ^{241}Am in surface (0 to 1.0 cm) was greater than the corresponding subsurface layer (1 to 2.5 cm). Also, the average concentration of ^{241}Am in some kinds of surface (0 to 1.0 cm) and subsurface (1 to 2.5 cm) samples collected onsite near the PUREX plant was greater than comparable samples collected offsite 60-km upwind of Hanford. The median value for these onsite surface soil samples (0 to 1.0 cm) was 0.035 pCi of ^{241}Am /g dry. Routine sampling and analyses for ^{241}Am was initiated at selected locations in 1982. Results are summarized in Table 12.

Samples of perennial vegetation are collected at the same sites listed previously for soil. Figure 32 shows the range of vegetation concentrations of radionuclides and the median value for each onsite location for the past five years. The data are compared with single value representing all offsite locations. Again, some onsite locations near the 200 Area show evidence of elevated levels of radioactive materials compared to offsite locations.

FIGURE 29. Range of Concentrations of Radionuclides in Soil at Onsite Sampling Locations, 1978 to 1982

FIGURE 30. Range of Concentrations of Radionuclides in Soil at Offsite Sampling Locations, 1978 to 1982

FIGURE 31. Median Concentrations of Radionuclides in Soil Samples for the Years of 1978 to 1982

TABLE 12. ^{241}Am Concentrations in Soil Samples Collected in 1982

Location	^{241}Am Concentration, pCi/g dry
200 ENC	(<0.03)
1.25 Mi E Purex	(<0.03)
200-E Hill	0.059 ± 0.026
2 Mi S Purex	(<0.03)
SW BC Crib	(<0.03)
E 200-W Gate	0.053 ± 0.033
2 Mi S 200 W	0.031 ± 0.025
Rattlesnake Springs	0.047 ± 0.033
Hanford Townsite	(<0.04)
Wye Barricade	0.030 ± 0.026
Sagemoor Farms	0.042 ± 0.029
Sunnyside	(<0.03)

Similar data for offsite locations are shown in Figure 33. The variability is attributable to worldwide fallout. Figure 34 illustrates the variability among median values of offsite and onsite locations with time. The levels of ^{90}Sr and ^{137}Cs may show a decreasing trend due to generally lower levels of worldwide fallout in recent years. However, uranium values show a similar trend that would not be expected to reflect worldwide fallout.

A special study was conducted in 1980 on the ^{14}C content of sagebrush samples collected at offsite and onsite locations. Results noted an approximate fourfold increase in ^{14}C detected in sagebrush wood collected onsite near the PUREX plant compared to offsite samples. Samples from offsite locations, representing wood produced at the time the PUREX facility was operating (1956 to 1972) averaged 8 pCi of ^{14}C /g carbon. Onsite samples averaged about 30 pCi of ^{14}C /g carbon for the same time period.

Routine sampling and analysis for ^{241}Am was initiated at selected locations in 1982. Results are summarized in Table 13.

FIGURE 32. Range of Concentrations of Radionuclides in Vegetation at Onsite Sampling Locations, 1978 to 1982

FIGURE 33. Range of Concentrations of Radionuclides in Vegetation at Offsite Sampling Locations, 1978 to 1982

FIGURE 34. Median Concentration of Radionuclides in Vegetation Samples for the Years 1978 to 1982

TABLE 13. ^{241}Am Concentrations in Vegetation Samples Collected in 1982

Location	^{241}Am Concentration, pCi/g dry
200 ENC	$<0.020 \pm 0.026$
1.25 Mi E Purex	$<0.032 \pm 0.023$
200-E Hill	$<0.010 \pm 0.030$
2 Mi S Purex	$<0.022 \pm 0.025$
SW BC Crib	$<0.022 \pm 0.018$
E 200-W Gate	$<0.002 \pm 0.029$
2 Mi S 200 W	$<0.015 \pm 0.024$
Rattlesnake Springs	$<0.002 \pm 0.022$
Hanford Townsite	$<0.012 \pm 0.002$
Wye Barricade	$<0.031 \pm 0.030$
Sagemoor Farms	$<0.002 \pm 0.026$
Sunnyside	$<0.010 \pm 0.024$

ENVIRONMENTAL DOSE RATES

Planned operations of PUREX are not expected to have any impact on environmental dose rate levels outside of the immediate vicinity of its associated processing and waste management facilities. Nevertheless, an external dose rate monitoring program operated at Hanford since 1973 that will be continued through the upcoming PUREX operating campaign will provide external dose rate data at a number of monitoring locations onsite and offsite.

Unlike most other environmental radiological parameters measured in the Hanford environs, dose rate levels are not geographically homogeneous. The environmental dosimeter is sensitive to naturally occurring radiations of both terrestrial and cosmic origin as well as to worldwide fallout in addition to any Hanford-related radionuclides or radiation fields.

The variability of the annual average dose rates in the Hanford region for 1982 including several onsite locations is illustrated in Figure 35. Because this variability is present among distant as well as among near site and onsite locations, it is not associated with Hanford operations.

LOCATION

ONSITE

200 ESE
100 FIRE STATION
300 S GATE
FFTF NORTH
HANFORD
WYE BARRICADE

PERIMETER

PROSSER BARRICADE
BENTON CITY
ALE
RATTLESNAKE SPRINGS
YAKIMA BARRICADE
VERNITA BRIDGE
WAHLUKE-2
BERG RANCH
OTHELLO
WAHLUKE WATERMASTER
CONNELL
COOKE BROS.
FIR ROAD
PETTETT
SAGEMORE
BYERS LANDING
PASCO
RICHLAND
1100 AREA
RRC #64

DISTANT

McNARY
WALLA WALLA
WASHTUCNA
MOSES LAKE
SUNNYSIDE

FIGURE 35. Penetrating Radiation Dose Rates, 1982

FIGURE 36. Annual Average Measured Penetrating Radiation Dose Rates in the Hanford Environs

Temporal variations in environmental dose rates also occur as shown in Figure 36, which shows the annual average dose rates from 1978 to 1982 at distant locations.

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APPENDIX A

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