Summary Profiles of Hanford Effluent Release Data

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Executive Summary

Hanford publishes extensive estimates of their offsite releases of various chemical and radiological species annually. In this report we examine using these estimates to develop additional insight into how effectively such releases of hazardous materials are being controlled at Hanford. Historical estimates of airborne and surface water releases of selected contaminants are compared with estimates of the overall Site inventory of those contaminants and with the corresponding release limits and background levels. These comparisons are also examined over a five-year period (1993 to 1997) to determine how these releases have changed during that time.

Most of the waste management and environmental restoration activities under way at Hanford are intended to provide final, permanent disposition of the Site's inventory of hazardous materials, with the ultimate objective of ensuring that risks to the public and the environment are controlled to an acceptable level. An important consideration during the conduct of these activities is protecting the public and the environment while accomplishing the longer-term objectives. The amounts of hazardous materials that are being released to the air or surface water while waste management and environmental activities are being conducted is one important measure of their overall effectiveness.

The comparisons described in this report indicate that measures to control the release of the selected contaminants from the Hanford Site are, and have been, very effective. The amounts of these materials released to surface water and air are very small compared with background and regulatory limits and smaller still considering the inventories under management. Comparisons of annual releases ranged from slightly over background to five orders of magnitude below background levels (e.g., $1/10,000^{\text{th}}$ of background levels), and up to 14 orders of magnitude less than estimates of Site inventories. Annual releases for these contaminants ranged from three to ten orders of magnitude less than regulatory limits. In addition, release of the selected contaminants generally decreased over the five-year period examined.

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Contents

Executive Summary	iii
Acknowledgments	v
Introduction	1
Key Comparisons	2
Summary	3
Effluent Release, Environmental Measurements, and Site Inventory Data	5
References	23

Figures

1 Release to Surface Water Comparison	6
2 Release to Air Comparison	6
3 Effluent Releases Versus Site Inventory Estimates	7
4 Effluent Releases Versus Background Values	8
5 Effluent Releases Versus Regulatory Limits	9
6a Release to Surface Water Versus Site Inventory Estimates	10
6b Release to Air Versus Site Inventory Estimates	10
7a Release to Surface Water Versus Background Values	11
7b Release to Air Versus Background Values	11
8a Release to Surface Water Versus Regulatory Limits	12
8b Release to Air Versus Regulatory Limits	12

Tables

1 Hanford Summary Data for 1997	13
2 Hanford Summary Data for 1996	14
3 Hanford Summary Data for 1995	15
4 Hanford Summary Data for 1994	16
5 Hanford Summary Data for 1993	17
6 1997 Hanford Effluent Comparison Calculations	18
7 1996 Hanford Effluent Comparison Calculations	19
8 1995 Hanford Effluent Comparison Calculations	20
9 1994 Hanford Effluent Comparison Calculations	21
10 1993 Hanford Effluent Comparison Calculations	22

Introduction

Extensive information is published annually by each Department of Energy (DOE) Site providing both measurements and estimates of offsite releases of various chemical and radiological species. These releases typically occur as a result of continuing Site mission operations or as a consequence of waste management or environmental operations intended to permanently limit releases from the Site to acceptable levels. The release information published typically addresses whether such releases are within relevant regulatory limits; i.e., whether DOE is "in compliance."

The purpose of this study is to complement annual effluent release information published for Hanford with additional comparisons that put these measured and estimated releases into a broader perspective. Examining effluent releases provides insight into the level of hazard associated with waste management and environmental restoration activities being conducted to permanently reduce the hazards associated with the radionuclide and chemical contaminants onsite. The objective of these longer-term waste management and environmental restoration activities is to dispose of or control onsite contamination in a manner that permanently limits offsite releases to an acceptable level. Current release data indicate how well we are doing in the short term while we pursue these long-term objectives.

This report considers annual release information for Hanford for the years 1993 to 1997. The most recent information published for Hanford is the *Hanford Site 1996 Environmental Report* (Dirkes and Hanf 1997). Equivalent information for 1993 through 1995 was published in previous annual reports. Effluent release information for 1997, which is considered preliminary until published in the next annual report, was included to allow evaluation of effluent release trends for the most recent five-year period.

The comparisons described here for Hanford are illustrative of the type of higher-level assessments of effluent releases that can be made to put the hazards associated with current operations into perspective. Rather than considering all contaminants of concern individually, as is the case for typical annual effluent release data, aggregate or summary representations of these detailed data are developed to provide a more easily understandable indication of the overall effect of current Site operations. Assessing how such release indicators vary year to year, as different amounts of contamination are actively processed or managed, provides additional assurance that these activities are being conducted in a manner that does not pose an interim hazard as permanent hazard reduction goals are pursued.

Key Comparisons

The primary offsite releases of concern at Hanford are airborne releases at the Site boundary and effluent releases to the Columbia River. This summary compares the measured and estimated releases of key contaminants of concern with both the approximate inventory of these contaminants onsite as an indicator of the degree to which they are controlled and with appropriate regulatory limits. In addition, where possible, current releases are compared with the levels of these contaminants that would be experienced even if there were no releases from the Hanford Site (i.e., background levels). Comparing releases with background levels provides additional insight on the relative significance of current releases from Hanford.

Each of these comparisons (effluents-to-inventory, effluents-to-regulatory limits, effluents-to-background) is evaluated for each year from 1993 through 1997. Considering how these effluent comparisons have varied with time allows evaluation of any trends that may be occurring in effluent releases.

The effluent comparisons herein are intended to provide perspective about the relative magnitudes of releases rather than detail their absolute values. These comparisons are primarily concerned with order-of-magnitude (factors of 10, 100, 1000, etc.) differences between contaminant inventories, releases, and release limits. In addition, for this preliminary evaluation, only radionuclide releases are evaluated because the relevant release data are more readily available. The simplifying assumptions described herein to calculate various contaminant inventories, releases, or release limits are made to facilitate such comparisons rather than to generate precise estimates of the various factors, and the results shown here should be interpreted accordingly.

Summary

Figures 1 and 2 illustrate these key comparisons for estimated or calculated air and surface water releases of various contaminants at Hanford from 1993 through 1997. These air and surface-water releases are compared with total inventory estimates, with allowable releases based on regulatory limits, and with typical background levels for each year. Each of these comparisons for each year is represented by a bar showing the variation across a variety of contaminants for that comparison. This convention applies to Figures 3 through 5 as well.

Figure 1 provides summary data for surface water effluent releases to the Columbia River during the most recent five-year period for which data are available. The most recent (1997) comparisons indicate that surface-water releases of contaminants (i.e., releases to the Columbia River) are controlled to 6 to 9 orders of magnitude less than the estimated Site inventory for that year. Similarly, the surface-water releases for the selected contaminants are 4 to 10 orders of magnitude less than regulatory limits and 3 to 5 orders of magnitude less than background levels away from the Hanford Site. The figure also indicates that there has been a gradual decline in these releases over the five-year period, and that the variation in these comparisons across contaminants is decreasing. Estimates of the public health risk associated with these surface water releases indicate that the probability of these effluent releases causing an incremental incidence of cancer ranging from 10^{-9} to 10^{-11} .

Figure 2 shows similar data for airborne releases of contaminants from Hanford facilities. Air releases are controlled to 4 to 12 orders of magnitude less than the Site inventory for these contaminants as of 1997. Releases to the air pathway at Hanford are higher than typical ambient levels for these contaminants (1 to 2 orders of magnitude) but are 5 to 8 orders of magnitude lower than relevant regulatory constraints. Figure 2 also indicates that there has been a gradual decline in these airborne releases over the five-year period. Estimates of the public health risk associated with these airborne releases indicate that the probability of their causing an incremental incidence of cancer ranges from 10^{-9} to 10^{-12} .

Figures 1 and 2 appear to indicate that, despite the variety of waste management and environmental restoration activities under way at Hanford during these five years, surface-water and airborne effluent releases have been successfully managed. Both surface water and airborne releases are many orders of magnitude lower than corresponding regulatory limits and have generally been declining relative to such limits.

The data used to develop the comparisons illustrated in Figures 1 and 2 are discussed in the next section. In addition, Figures 3–8 present the data illustrated in Figures 1 and 2 in more detail and in a variety of formats. Figures 3 through 5 show the annual representation of the each of the three key comparisons (release to inventory, release to background concentration, release to regulatory limit) individually to facilitate assessment of how these comparisons have varied between 1993 through 1997. Figures 1 through 5 illustrate the variation in these comparisons across a variety of contaminants. Figures 6 through 8 provide the contaminant-specific information for each of the five years.

The key assumptions for these comparisons are described in more detail below. However, a few general comments are pertinent for interpreting the results. The "inventory" estimates shown for the various contaminants typically represent a summation of the estimated inventories for the major Site sources of each of seven selected contaminants rather than a comprehensive estimate of total Site inventory for these contaminants. Therefore, the inventory data on the figure should be interpreted as meaning that there is *at least* the indicated inventory onsite. Since the significant information is that releases are many, many orders of magnitude lower than what is present, this approximation provides a conservative indication of the degree of management or control of the contaminant being achieved by current operations or practices.

Similarly, the "regulatory limit" information shown for each contaminant represents the most restrictive of the potentially relevant regulatory constraints appropriate for airborne or surface-water releases. Again, this provides a conservative indication of how currently estimated or calculated releases compare with potentially allowable releases.

Effluent Release, Environmental Measurements, and Site Inventory Data

The source data used to develop the comparisons shown in Figures 1 through 8 can be found in Tables 1 through 5; the calculated results shown in the figures are found in Tables 6 through 10. The contaminants listed on these tables were selected from among those for which effluent release data were reported in the Hanford Site annual environmental reports for the most recent five-year period (1993 through 1997). They were selected as representative of the contaminants of major interest. The effluent release values reported on these are from those five annual reports. Total releases were reported in the documents and corresponding concentrations were calculated as described on the tables. The limiting concentration for releases to surface water or to the air pathway shown on the table are based on Ambient Surface Water Quality (ASWQ) standards or Air Quality Standards and/or Derived Concentration Guideline (DCGs) for water or air, respectively. Where both values are given, the more restrictive was selected. While these are not regulatory limits in the strictest sense (other constraints may apply for specific contaminants or releases), they provide a reasonable context for assessing the relative magnitude of effluent releases.

The release, inventory, regulatory limit, and background concentration data shown in Tables 1–5 were developed from both Hanford-specific reports and DOE complex-wide reports. The sources of these data are listed in the tables.

Also shown in Tables 1–5 are “unit risk factors” developed for use in the Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS). These provide a way to approximate the public health hazard associated with the various offsite release estimates. These factors relate the incremental cancer risk for the various contaminants for each pathway (surface water or airborne release) to the corresponding release concentration. Although using these factors will not suffice for estimating the risk associated with any specific release scenario (a risk assessment is required), they do provide a reasonable basis for approximating typical risk levels.

The data in Tables 6–10 were used to develop the comparisons shown in Figures 1 through 8. Comparison of total annual releases to Site inventory for each pathway (surface water or airborne) were developed by calculating the fraction of the release for each contaminants and its estimated inventory. Similarly, each estimated release was compared with its corresponding appropriate regulatory concentration limit or background concentration by calculating the appropriate fraction.

Figure 1. Release to Surface Water Comparison
Figure 2. Release to Air Comparison

Figure 3. Effluent Releases Versus Site Inventory Estimates

Figure 4. Effluent Releases Versus Background Values

Figure 5. Effluent Releases Versus Regulatory Limits

Figure 6a. Release to Surface Water Versus Site Inventory Estimates
Figure 6b. Release to Air Versus Site Inventory Estimates

Figure 7a. Release to Surface Water Versus Background Values
Figure 7b. Release to Air Versus Background Values

Figure 8a. Release to Surface Water Versus Regulatory Limits

Figure 8b. Release to Air Versus Regulatory Limits

Table 1. Hanford Summary Data for 1997

Airborne Release Data												Surface Water (Columbia River) Release Data				
Contaminants	Site inventory ^(a)	Total annual release ^(b)	Effluent concentration measured at site perimeter ^(b)	Concentration limit ^(c)	Background concentration ^(d)	Unit risk factor ^(e)	Total annual release ^(b)	Estimated effluent release concentration ^(b)	Concentration limit ^(c)	Background concentration ^(d)	Unit risk factor ^(e)					
	pCi	pCi	pCi/m ³	pCi/m ³	pCi/m ³	R/(Ci/m ³)	pCi	pCi/L	pCi/L	pCi/L	R/(Ci/mL)					
⁹⁰ Sr	9.12E+19	5.99E+08	2.13E-05	9.00E+00	5.42E-06	1.36E-05	1.30E+11	8.61E-04	8.00E+00	9.74E-02	2.65E+09					
²³⁸ Pu	2.60E+17	2.96E+06	1.66E-07	3.00E-02	-1.53E-07	6.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.41E+11					
^{239/240} Pu	5.33E+17	1.22E+08	4.50E-07	2.00E-02	0.00E+00	6.09E-03	0.00E+00	0.00E+00	0.00E+00	1.31E-04	1.57E+11					
³ H	5.67E+16	3.05E+13	6.40E-01	1.00E+05	9.10E-01	3.17E-08	1.30E+11	8.61E-04	2.00E+04	3.03E+01	1.68E+11					
¹²⁹ I	6.67E+12	1.40E+09	1.58E-06	7.00E+01	5.61E-07	6.82E+05	0.00E+00	0.00E+00	1.00E+00	8.40E-06	3.19E+10					
¹³⁷ Cs	1.02E+20	9.70E+08	7.80E-05	4.00E+02	2.03E-04	4.68E-06	0.00E+00	0.00E+00	2.00E+04	7.30E-01	4.30E-01					
⁶⁰ Co	5.98E+17	8.30E+02	2.34E-04	8.00E+01	3.86E-04	1.57E-05	0.00E+00	0.00E+00	1.00E+02	3.70E-01	7.80E-01					

(a) Inventory for each contaminant estimated from data extracted from the following documents:

Integrated Database Report-1997: U.S. Nuclear Fuel and Radioactive Waste Inventories (DOE 1997)

Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1996 (Hagel 1997)

Hanford Site Existing Irradiated Fuel Storage Facilities Description (Willis 1995)

WHC SAR for PFP (Shapley 1995).

These documents describe the inventory from major facilities or operations possessing significant inventory of the contaminants of interest. However, because these documents do not describe all contaminant sources at Hanford, total Site inventory of the contaminants of interest will be as shown or greater.

(b) Effluent release data for airborne and surface water (Columbia River) were extracted from the draft *Hanford Site 1997 Environmental Report* (Dirkes and Hanf 1998).

(c) Concentration limit for airborne is the Derived Concentration Guideline or Air Quality Standard, whichever is more restrictive. Concentration limit for surface water is represented by the Washington State Ambient Surface Water Quality Standards (ASWQ) or Derived Concentration Guidelines, whichever is more restrictive. These values are as reported in the draft *Hanford Site 1997 Environmental Report* (Dirkes and Hanf 1998).

(d) Background concentration for air is represented by measured concentration data for at a distant community, as reported in the draft *Hanford Site 1997 Environmental Report* (Dirkes and Hanf 1998). Background concentration for surface water is represented by measured concentration for the radionuclide upstream from the Hanford Site, as reported in Dirkes and Hanf (1998).

(e) Unit Risk Factors developed for use in Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS).

(f) Effluent concentration for airborne is the value measured at the Site perimeter as reported in the draft *Hanford Site 1997 Environmental Report* (Dirkes and Hanf 1998); the value for surface water is calculated using the average river flow rate data. The value for 1997 is 4787m³/s or 1.51E+14 liters per year.

Table 2. Hanford Summary Data for 1996

Contaminants	Site inventory ^(a) pCi	Airborne Release Data					Surface Water (Columbia River) Release Data				
		Total annual release ^(b) pCi	Effluent concentration measured at site perimeter ^(c) pCi/m ³	Concentration limit ^(d) pCi/m ³	Background concentration ^(e) pCi/m ³	Unit risk factor ^(f) R/(Ci/m ³)	Total annual release ^(b) pCi	Estimated effluent release concentration ^(e) pCi/L	Concentration limit ^(d) pCi/L	Background concentration ^(e) pCi/L	Unit risk factor ^(f) R/(Ci/ml)
⁹⁰ Sr	9.12E+19	4.71E+08	1.38E-05	9.00E+00	5.42E-06	1.36E-05	1.20E+11	8.46E-04	8.00E+00	8.65E-02	2.65E+09
²³⁸ Pu	2.60E+17	4.96E+06	6.70E-08	3.00E-02	-1.53E-07	6.01E-03	4.00E+07	2.82E-07	0.00E+00	0.00E+00	1.41E+11
^{239/240} Pu	5.32E+17	2.54E+08	4.50E-07	2.00E-02	2.20E-07	6.09E-03	0.00E+00	0.00E+00	1.50E+01	9.20E-05	1.57E+11
³ H	5.59E+16	7.10E+12	6.00E-01	1.00E+05	4.70E-01	3.17E-08	1.30E+11	9.16E-04	2.00E+04	3.26E+01	1.68E+11
¹²⁹ I	6.67E+12	3.90E+09	1.58E-06	7.00E+01	7.50E-08	6.82E+05	0.00E+00	0.00E+00	1.00E+00	1.88E-05	3.19E+10
¹³⁷ Cs	1.02E+20	6.10E+08	6.10E-05	4.00E+02	2.60E-04	4.68E-06	3.80E+09	2.68E-05	2.00E+02	4.30E-01	4.30E-01
⁶⁰ Co	5.84E+17	5.11E+05	1.13E-04	8.00E+01	4.40E-04	1.57E-05	2.30E+09	1.62E-05	1.00E+02	7.80E-01	7.80E-01

(a) Inventory for each contaminant estimated from data extracted from the following documents:

Integrated Database Report-1996: U.S. Nuclear Fuel and Radioactive Waste Inventories (DOE 1996);

Summary of Radioactive Solid Waste received in the 200 Areas During Calendar Year 1996 (Hagel 1997);

Hanford Site Existing Irradiated Fuel Storage Facilities Description (Willis 1995);

and WHC SAR for PFP (Shapley 1995).

These documents describe the inventory from major facilities or operations possessing significant inventory of the contaminants of interest. However, because these documents do not describe all contaminant sources at Hanford, total Site inventory of the contaminants of interest will be as shown or greater.

(b) Effluent release data for air and Columbia River were extracted from *Hanford Site 1996 Environmental Report* (Dirkes and Hanf 1997).

(c) Effluent concentration for airborne is the value measured at the Site perimeter as reported in *Hanford Site 1996 Environmental Report* (Dirkes and Hanf 1997); the concentration for the effluent release to surface water is calculated from the release total as reported in Dirkes and Hanf (1997) and the total river volume in liters. River volume is calculated from the average river flow rate data reported in Dirkes and Hanf (1997). These are 4500 m³/sec or 1.41E+14 liters per year.

(d) Concentration limit for air is represented by Derived Concentration Guidelines (DCGs) or Air Quality Standards, whichever is more restrictive, as given in *Hanford Site 1996 Environmental Report* (Dirkes and Hanf 1997). Concentration limit for surface water is represented by the Washington State Ambient Surface Water Quality Standards (ASWQ) or Derived Concentration Guidelines, whichever is more restrictive.

(e) Background concentration for air is represented by measured concentration data for at a distant community, as reported in Dirkes and Hanf (1997). Background concentration for surface water is represented by measured concentration for the radionuclide upstream from the Hanford Site, as reported in *Dirkes and Hanf (1997)*.

(f) Unit Risk Factors developed for use in Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS).

Table 3. Hanford Summary Data for 1995

Contaminants	Site inventory ^(a)	Airborne Release Data					Surface Water (Columbia River) Release Data				
		Total annual release ^(b)	Effluent concentration measured at site perimeter ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)	Total annual release ^(b)	Estimated effluent release concentration ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)
	pCi	pCi	pCi/m ³	pCi/m ³	pCi/m ³	R/(Ci/m ³)	pCi	pCi/L	pCi/L	pCi/L	R/(Ci/ml)
⁹⁰ Sr	9.31E+19	2.44E+08	-1.00E-07	9.00E+00	-3.00E-07	1.36E-05	2.10E+11	2.08E-03	1.00E+03	9.17E-02	2.65E+09
²³⁸ Pu	1.88E+17	5.59E+06	1.48E-07	3.00E-02	4.90E-08	6.01E-03	0	0.00E+00	4.00E+01	0.00E+00	1.41E+11
^{239/240} Pu	5.30E+17	1.27E+08	9.60E-07	2.00E-02	1.23E-06	6.09E-03	4.30E+05	4.25E-09	6.00E+01	1.09E-04	1.57E+11
³ H	3.79E+16	6.67E+12	2.51E-06	1.00E+05	1.19E-06	3.17E-08	1.50E+11	1.48E-03	2.00E+06	3.62E+01	1.68E+11
¹²⁹ I	6.67E+12	8.90E+09	1.58E-06	7.00E+01	5.30E-08	6.82E+05	0	0.00E+00	5.00E+02	4.14E-06	3.19E+10
¹³⁷ Cs	1.04E+20	6.56E+08	8.10E-05	4.00E+02	1.23E-04	4.68E-06	2.10E+09	2.08E-05	3.00E+03	0.00E+00	4.30E-01
⁶⁰ Co	7.48E+15	9.20E+06	0.00E+00	8.00E+01	0.00E+00	1.57E-05	1.10E+08	1.09E-06	5.00E+03	0.00E+00	7.80E-01

(a) Inventory for each contaminant estimated from data extracted from the following documents:

Integrated Database Report-1995: U.S. Nuclear Fuel and Radioactive Waste Inventories (DOE 1996);

Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1995 (Anderson and Hagel 1996);

Hanford Site Existing Irradiated Fuel Storage Facilities Description (Willis 1995);

and WHC SAR for PFP (Shapley 1995).

These documents describe the inventory from major facilities or operations possessing significant inventory of the contaminants of interest. However, because these documents do not describe all contaminant sources at Hanford, total Site inventory of the contaminants of interest will be as shown or greater.

(b) Effluent release data for airborne and surface water (Columbia River) were extracted from *Hanford Site 1995 Environmental Report* (Dirkes and Hanf 1996).

(c) Effluent concentration for airborne release is the value measured at the Site perimeter as reported in *Hanford Site 1995 Environmental Report* (Dirkes and Hanf 1996); the concentration for the effluent release to surface water is calculated from the release total as reported by Dirkes and Hanf and the total river volume in liters. River volume is calculated from the average daily river flow rate data for 1995 reported in the same document. River flow rate 3206 m³/sec or 1.01E+14 liters/year.

(d) Concentration limit for airborne release is the Derived Concentration Guideline or Air Quality Standards, whichever is more restrictive, as reported in *Hanford Site 1995 Environmental Report* (Dirkes and Hanf 1996). Concentration limit represented by the Washington State Ambient Surface Water Quality Standards (ASWQ) or Derived Concentration Guidelines, whichever is more restrictive.

(e) Background concentration for air is represented by measured concentration data for at a distant community, as reported in *Hanford Site 1995 Environmental Report* (Dirkes and Hanf 1996). Background concentration in surface water is represented by measured concentration for the radionuclide upstream from the Hanford Site, as reported in Dirkes and Hanf (1996).

(f) Unit Risk Factors developed for use in Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS).

Table 4. Hanford Summary Data for 1994

Contami- nants	Site Inventory ^(a)	Airborne Release Data					Surface-water (Columbia R.) Release Data				
		Total annual release ^(b)	Effluent concentration measured at site perimeter ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)	Total annual release ^(b)	Estimated effluent release con- centration ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)
	pCi	pCi	pCi/m ³	pCi/m ³	pCi/m ³	R/(Ci/m ³)	pCi	pCi/L	pCi/L	pCi/L	R/(Ci/mL)
⁹⁰ Sr	9.52E+19	2.03E+08	3.00E-06	9.00E+00	9.00E-05	1.36E-05	1.10E+11	1.30E-03	1.00E+03	1.07E-01	2.65E+09
²³⁸ Pu	2.45E+17	1.63E+07	1.01E-06	3.00E-02	8.79E-07	6.01E-03	1.40E+04	1.66E-10	4.00E+01	0.00E+00	1.41E+11
^{239/240} Pu	4.10E+17	4.36E+08	6.80E-07	2.00E-02	-7.00E-08	6.09E-03	2.50E+05	2.97E-09	3.00E+01	1.26E-04	1.57E+11
³ H	3.79E+16	1.17E+13	7.70E-01	1.00E+05	8.30E-01	3.17E-08	2.70E+11	3.20E-03	2.00E+06	4.04E+01	1.68E+11
¹²⁹ I	6.67E+12	1.40E+10	1.57E-06	7.00E+01	7.90E-08	6.82E+05	0.00E+00	0.00E+00	5.00E+02	1.02E-04	3.19E+10
¹³⁷ Cs	1.07E+20	6.74E+08	1.07E-04	4.00E+02	2.10E-04	4.68E-06	1.50E+07	1.78E-07	3.00E+03	0.00E+00	4.30E-01
⁶⁰ Co	1.19E+16	6.39E+06	0.00E+00	8.00E+01	0.00E+00	1.57E-05	1.10E+08	1.30E-06	5.00E+03	0.00E+00	7.80E-01

(a) Inventory for each contaminant estimated from data extracted from the following documents:

Integrated Database Report-1994: U.S. Nuclear Fuel and Radioactive Waste Inventories (DOE 1995);

Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1994 (Anderson and Hagel 1995);

Hanford Site Existing Irradiated Fuel Storage Facilities Description (Willis 1995);

and WHC SAR for PFP (Shapley 1995).

These documents describe the inventory from major facilities or operations possessing significant inventory of the contaminants of interest. However, because these documents do not describe all contaminant sources at Hanford, total Site inventory of the contaminants of interest will be as shown or greater.

(b) Effluent release data for airborne and surface water (Columbia River) were extracted from *Hanford Site 1994 Environmental Report* (Dirkes and Hanf 1995).

(c) Effluent concentration for airborne is the value measured at the Site perimeter reported in *Hanford Site 1994 Environmental Report* (Dirkes and Hanf 1995); the concentration for effluent releases to surface water are calculated using the average river flow rate for 1994. The average is calculated from daily flow measurements and converted into liters. Average flow rate is 2674m³/s for a total of 8.43E+13 liters per year.

(d) Concentration limit is the Derived Concentration Guideline or the Clean Air Standards or Washington State Ambient Surface Water Quality Standards, as appropriate, whichever is the more restrictive, reported in *Hanford Site 1994 Environmental Report* (Dirkes and Hanf 1995).

(e) Background concentration for air is represented by measured concentration data at a distant community as reported in *Hanford Site 1994 Environmental Report* (Dirkes and Hanf 1995). Background concentration represented by measured concentration for the contaminant upstream from the Hanford Site also reported in Dirkes and Hanf (1995).

(f) Unit Risk Factors developed for use in Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS).

Table 5. Hanford Summary Data for 1993

Contaminants	Site inventory ^(a)	Airborne Release Data					Surface Water (Columbia River) Release Data				
		Total annual release ^(b)	Effluent concentration measured at site perimeter ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)	Total annual release ^(b)	Estimated effluent release concentration ^(c)	Concentration limit ^(d)	Background concentration ^(e)	Unit risk factor ^(f)
	pCi	pCi	pCi/m ³	pCi/m ³	pCi/m ³	R/(Ci/m ³)	pCi	pCi/L	pCi/L	pCi/L	R/(Ci/ml)
⁹⁰ Sr	1.00E+20	3.67E+08	2.52E-06	5.00E+01	-7.14E-06	1.36E-05	1.10E+11	1.35E-03	8.00E+00	1.10E-01	2.65E+09
²³⁸ Pu	2.61E+17	4.20E+06	2.75E-07	3.00E-02	-2.02E-07	6.01E-03	0.00E+00	0.00E+00	4.00E+01	0.00E+00	1.41E+11
^{239,240} Pu	5.29E+17	5.79E+08	5.21E-05	2.00E-02	1.46E-06	6.09E-03	1.40E+05	1.72E-09	3.00E+01	2.30E-04	1.57E+11
³ H	3.79E+16	2.31E+13	1.31E+00	0.00E+00	1.3446	3.17E-08	3.80E+11	4.67E-03	2.00E+04	4.20E+01	1.68E+11
¹²⁹ I	6.64E+12	4.80E+09	1.57E-06	7.00E+01	7.22E-07	6.82E+05	0.00E+00	0.00E+00	1.00E+00	6.00E-06	3.19E+10
¹³⁷ Cs	1.03E+20	1.90E+09	1.35E-04	4.00E+02	4.76E-05	4.68E-06	4.40E+08	5.41E-06	3.00E+03	0.00E+00	4.30E-01
⁶⁰ Co	2.54E+16	5.21E+06	0.0E+00	0.00E+00	0.00E+00	1.57E-05	3.60E+09	4.42E-05	8.00E+01	0.00E+00	7.80E-01

(a) Inventory for each contaminant estimated from data extracted from the following documents:

Integrated Database Report-1993: U.S. Nuclear Fuel and Radioactive Waste Inventories (DOE 1994),

Summary of Radioactive Solid Waste received in the 200 Areas During Calendar Year 1993 (Anderson and Hagel 1994);

Hanford Site Existing Irradiated Fuel Storage Facilities Description (Willis 1995);

and WHC SAR for PFP (Shapley 1995).

These documents describe the inventory from major facilities or operations possessing significant inventory of the contaminants of interest. However, because these documents do not describe all contaminant sources at Hanford, total Site inventory of the contaminants of interest will be as shown or greater.

(b) Effluent release data for airborne and surface water (Columbia River) were extracted from *Hanford Site 1993 Environmental Report* (Dirkes and Hanf 1994).

(c) Effluent concentration for airborne is the value measured at the Site perimeter as reported in *Hanford Site 1993 Environmental Report* (Dirkes and Hanf 1994); the effluent concentrations in surface water are calculated from release totals and the average river flow rate. The river flow rate is converted to liters for the calculations. Average flow rate is 2581 m³/s for a total volume of 8.14E+13 liters.

(d) Concentration limit is the Derived Concentration Guideline or Air Quality Standards, whichever is more restrictive, as reported in *Hanford Site 1993 Environmental Report* (Dirkes and Hanf 1994). Concentration limit represented by the Washington State Ambient Surface Water Quality Standards (ASWQ) or Derived Concentration Guidelines, whichever is more restrictive.

(e) Background concentration for air is represented by measured concentration data at a distant community, as reported in *Hanford Site 1993 Environmental Report* (Dirkes and Hanf 1994). Background concentration is represented by measured concentration for the radionuclide upstream from the Hanford Site, as reported in the same document.

(f) Unit Risk Factors developed for use in Hanford Risk Assessment-Environmental Impact Statement (HRA-EIS).

Table 6. 1997 Hanford Effluent Comparison Calculations for Figures (data from Table 1)

Contaminant	Surface Water Comparisons			Airborne Comparisons		
	Release versus inventory	Release versus background ^(a)	Release versus regulatory limit ^(b)	Release versus inventory	Release versus Background ^(c)	Release versus Regulatory Limit ^(d)
⁹⁰ Sr	1.43E-09	8.84E-03	1.08E-04	6.57E-12	3.93E+00	2.37E-06
²³⁸ Pu	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	1.14E-11	-1.08E+00 ^(f)	5.53E-06
^{238/240} Pu	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	2.28E-10	0.00E+00	2.25E-05
³ H	2.29E-06	2.84E-05	4.30E-10	5.38E-04	7.03E-01	6.40E-06
¹²⁹ I	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	2.10E-04	2.82E+00	2.26E-08
¹³⁷ Cs	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	9.49E-12	3.84E-01	1.95E-07
⁶⁰ Co	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	1.39E-15	6.06E-01	2.93E-06

(a) Amount of contaminant released to the Columbia River is divided by the amount of contaminant arriving from upstream of Hanford, as calculated by multiplying the measured upstream or background concentrations by the estimated volume of the river flow for 1997.

(b) Amount of contaminant released is divided by the amount allowed by regulation, as calculated by multiplying the more limiting of ASWQ standards or DCGs by the estimated volume of river flow for 1997.

(c, d) Amount of contaminant released is divided by the amounts estimated present for a distant community (background) and the amounts that would be present if the concentration were at the regulatory limit. Amounts of contaminant corresponding to background and regulatory limits were calculated from an equivalent air volume and the corresponding background or regulatory limit concentration.

(e) Surface water releases are 0 for ²³⁸Pu, ^{239,240}Pu, ¹²⁹I, ¹³⁷Cs, and ⁶⁰Co as per the draft Hanford Site Environmental Report for Calendar Year 1997 (Dirkes and Hanf 1998). The values given were "ND," not detected. There is no concentration guide for ^{239,240}Pu for surface water. ^{239,240}Pu, ¹²⁹I, ¹³⁷Cs, and ⁶⁰Co were measured in the Columbia River upstream of Hanford.

(f) Negative values occur when the reported data are given as negative values.

Table 7. 1996 Hanford Effluent Comparison Calculations for Figures (data from Table 2)

Contaminant	Surface Water Comparisons			Airborne Comparisons		
	Release versus inventory	Release versus background ^(a)	Release versus regulatory limit ^(b)	Release versus inventory	Release versus background ^(c)	Release versus regulatory limit ^(d)
⁹⁰ Sr	1.32E-09	9.78E-03	1.06E-04	5.17E-12	2.55E+00	1.54E-06
²³⁸ Pu	1.54E-10	0.00E+00 ^(e)	0.00E+00 ^(e)	1.91E-11	-4.38E-01 ^(f)	2.23E-06
^{239,240} Pu	0.00E+00 ⁵	0.00E+00 ^(e)	0.00E+00 ^(e)	4.77E-10	2.05E+00	2.25E-05
³ H	2.33E-06	2.81E-05	4.58E-08	1.27E-04	1.28E+00	6.00E-06
¹²⁹ I	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	5.85E-04	2.11E+01	2.26E-08
¹³⁷ Cs	3.72E-11	6.23E-05	1.34E-07	5.97E-12	2.35E-01	1.53E-07
⁶⁰ Co	3.94E-09	2.08E-05	1.62E-07	8.74E-13	2.58E-01	1.42E-06

(a) Amount of contaminant released to the Columbia River is divided by the amount of contaminant arriving from upstream of Hanford, as calculated by multiplying the measured upstream or background concentrations by the estimated volume of the river flow for 1996.

(b) Amount of contaminant released is divided by the amount allowed by regulation, as calculated by multiplying the more limiting of ASWQ standards or DCGs by the estimated volume of river flow for 1996.

(c,d) Amount of contaminant released is divided by the amounts estimated for a distant community (background) and the amounts that would be present if the concentration were at the regulatory limit. Amounts of contaminant corresponding to background and regulatory limits were calculated from an equivalent air volume and the corresponding background or regulatory limit concentration.

(e) Surface water releases are 0 for ^{239,240}Pu and ¹²⁹I, as per *Hanford Site Environmental Report for 1996* (Dirkes and Hanf 1997). The values given were "ND," not detected. There is no concentration guide for ^{239,240}Pu and ¹²⁹I were measured in the Columbia River upstream of Hanford.

(f) Negative values occur when the reported data are given as negative values.

Table 8. 1995 Hanford Effluent Comparison Calculations for Figures (data from Table 3)

Contaminant	Surface Water Comparisons			Airborne Comparisons		
	Release versus inventory	Release versus background ^(a)	Release versus regulatory limit ^(b)	Release versus inventory	Release versus background ^(c)	Release versus regulatory limit ^(d)
⁹⁰ Sr	2.26E-09	2.27E-02	2.60E-04	2.62E-12	-3.33E-01 ^(f)	1.11E-08
²³⁸ Pu	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	2.98E-11	3.02E+00	4.93E-06
^{239,240} Pu	8.11E-13	3.92E-05	2.84E-10	2.39E-10	7.80E-01	4.80E-05
³ H	3.96E-06	4.10E-05	7.42E-08	1.76E-04	2.11E+00	2.51E-11
¹²⁹ I	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00	1.33E-03	2.98E+01	2.26E-08
¹³⁷ Cs	2.01E-11	0.00E+00 ^(e)	1.04E-07	6.29E-12	6.57E-01	2.03E-07
⁶⁰ Co	1.47E-08	0.00E+00 ^(e)	7.75E-09	1.23E-09	0.00E+00 ^(e)	0.00E+00 ^(e)

(a) Amount of contaminant released to the Columbia River is divided by the amount of contaminant arriving from upstream of Hanford, as calculated by multiplying the measured upstream or background concentrations by the estimated volume of the river flow for 1995.

(b) Amount of contaminant released is divided by the amount allowed by regulation, as calculated by multiplying the more limiting of ASWQ standards or DCGs by the estimated volume of river flow for 1995.

(c,d) Amount of contaminant released is divided by the amounts estimated for a distant community (background) and the amounts that would be present if the concentration were at the regulatory limit. Amounts of contaminant corresponding to background and regulatory limits were calculated from an equivalent air volume and the corresponding background or regulatory limit concentration.

(e) Surface water releases are 0 for ²³⁸Pu and ¹²⁹I, as per *Hanford Site Environmental Report for 1995* (Dirkes and Hanf 1996). The values given were "ND," not detected. There is no concentration guide for ^{239,240}Pu for surface water. ^{239,240}Pu and ¹²⁹I were measured in the Columbia River upstream of Hanford.

(f) Negative values occur when the reported data are given as negative values.

(g) Data indicate that ¹³⁷Cs and ⁶⁰Co were released to surface water, but the surface water background levels were 0. ⁶⁰Co was also absent from background air measurements in *Hanford Site Environmental Report for 1995* (Dirkes and Hanf 1996).

Table 9. 1994 Hanford Effluent Comparison Calculations for Figures (data from Table 4)

Contaminant	Surface Water Comparisons			Airborne Comparisons		
	Release versus inventory	Release versus background ^(a)	Release versus regulatory limit ^(b)	Release versus inventory	Release versus background ^(c)	Release versus regulatory limit ^(d)
⁹⁰ Sr	1.16E-09	1.22E-02	1.63E-04	2.13E-12	3.33E-02	3.33E-07
²³⁸ Pu	5.72E-14	0.00E+00 ^(e)	4.15E-12	6.65E-11	1.15E+00	3.37E-05
^{239,240} Pu	6.09E-13	2.35E-05	9.88E-11	1.06E-09	-9.71E+00 ^(f)	3.40E-05
³ H	7.13E-06	7.93E-05	1.60E-07	3.09E-04	9.28E-01	7.70E-06
¹²⁹ I	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	2.10E-03	1.99E+01	2.24E-08
¹³⁷ Cs	1.41E-13	0.00E+00 ^(e)	5.93E-11	6.33E-12	5.10E-01	2.68E-07
⁶⁰ Co	9.23E-09	0.00E+00 ^(e)	2.61E-10	5.36E-10	0.00E+00 ^(e)	0.00E+00 ^(e)

(a) Amount of contaminant released to the Columbia River is divided by the amount of contaminant arriving from upstream of Hanford, as calculated by multiplying the measured upstream or background concentrations by the estimated volume of the river flow for 1994.

(b) Amount of contaminant released is divided by the amount allowed by regulation, as calculated by multiplying the more limiting of ASWQ standards or DCGs by the estimated volume of river flow for 1994.

(c,d) Amount of contaminant released is divided by the amounts estimated for a distant community (background) and the amounts that would be present if the concentration were at the regulatory limit. Amounts of contaminant corresponding to background and regulatory limits were calculated from an equivalent air volume and the corresponding background or regulatory limit concentration.

(e) Surface water releases are 0 for ¹²⁹I, from *Hanford Site Environmental Report for 1994* (Dirkes and Hanf 1995). The values given were "ND," not detected. ¹²⁹I was measured in the Columbia River upstream of Hanford. ²³⁸Pu, ¹³⁷Cs, and ⁶⁰Co were released to surface water, but the values in the surface water background were zero. ⁶⁰Co was also absent from background and perimeter air measurements reported in *Hanford Site Environmental Report for 1994* (Dirkes and Hanf 1995).

(f) Negative values occur when the reported data are given as negative values.

Table 10. 1993 Hanford Effluent Comparison Calculations for Figures (data from Table 5)

Contaminant	Surface Water Comparisons			Airborne Comparisons		
	Release versus inventory	Release versus background ^(a)	Release versus regulatory limit ^(b)	Release versus inventory	Release versus background ^(c)	Release versus regulatory limit ^(d)
⁹⁰ Sr	1.10E-09	1.23E-02	1.69E-04	3.66E-12	-3.53E-01	5.04E-08
²³⁸ Pu	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00	1.61E-11	-1.36E+00 ^(f)	9.17E-06
^{239,240} Pu	2.64E-13	7.48E-06	5.73E-11	1.09E-09	3.57E+01	2.60E-03
³ H	1.00E-05	1.11E-04	2.33E-07	6.10E-04	9.71E-01	1.31E-05
¹²⁹ I	0.00E+00 ^(e)	0.00E+00 ^(e)	0.00E+00 ^(e)	7.23E-04	2.18E+00	2.25E-08
¹³⁷ Cs	4.26E-12	0.00E+00 ^(e)	1.80E-09	1.84E-11	2.84E+00	3.38E-07
⁶⁰ Co	1.42E-07	0.00E+00 ^(e)	5.53E-07	2.05E-10	0.00E+00 ^(e)	0.00E+00 ^(e)

(a) Amount of contaminant released to the Columbia River is divided by the amount of contaminant arriving from upstream of Hanford, as calculated by multiplying the measured upstream or background concentrations by the estimated volume of the river flow for 1997.

(b) Amount of contaminant released is divided by the amount allowed by regulation, as calculated by multiplying the more limiting of ASWQ standards or DCGs by the estimated volume of river flow for 1997.

(c,d) Amount of contaminant released is divided by the amounts estimated for a distant community (background) and the amounts that would be present if the concentration were at the regulatory limit. Amounts of contaminant corresponding to background and regulatory limits were calculated from an equivalent air volume and the corresponding background or regulatory limit concentration.

(e) Surface water releases are 0 for ²³⁸Pu and ¹²⁹I, as reported in *Hanford Site Environmental Report for 1993* (Dirkes and Hanf 1994). The values given were "ND," not detected. ¹²⁹I was measured in the Columbia River upstream of Hanford. ¹³⁷Cs and ⁶⁰Co were released to surface water, but the values in the surface water background were 0. ⁶⁰Co was also absent from background and perimeter air measurements, as per *Hanford Site Environmental Report for 1993* (Dirkes and Hanf 1994).

(f) Negative values occur when the reported data are given as negative values.

References

- Anderson JD and DL Hagel. 1996. *Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1995*. WHC-EP-0125-8, Westinghouse Hanford Company, Richland, Washington.
- Anderson JD and DL Hagel. 1995. *Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1994*. WHC-EP-0125-7, Westinghouse Hanford Company, Richland, Washington.
- Anderson JD and DL Hagel. 1994. *Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1993*. WHC-EP-0125-6, Westinghouse Hanford Company, Richland, Washington.
- Dirkes RL and RW Hanf. 1998. *Hanford Site Environmental Report for Calendar Year 1997* (draft). PNNL-11795, Pacific Northwest National Laboratory, Richland Washington
- Dirkes RL and RW Hanf. 1997. *Hanford Site Environmental Report for Calendar Year 1996*. PNNL-11472, Pacific Northwest National Laboratory, Richland Washington
- Dirkes RL and RW Hanf. 1996. *Hanford Site Environmental Report for Calendar Year 1995*. PNNL-11139, Pacific Northwest National Laboratory, Richland Washington
- Dirkes RL and RW Hanf. 1995. *Hanford Site Environmental Report for Calendar Year 1994*. PNNL-10574, Pacific Northwest National Laboratory, Richland Washington
- Dirkes RL and RW Hanf. 1994. *Hanford Site Environmental Report for Calendar Year 1993*. PNNL-9823, Pacific Northwest National Laboratory, Richland Washington
- Hagel DL. 1997. *Summary of Radioactive Solid Waste Received in the 200 Areas During Calendar Year 1996*. HNF-EP-0125-9, Rust Federal Services of Hanford, Inc, Richland, Washington.
- Shapley JE. 1995. *Plutonium Finishing Plant Final Safety Analysis Report*. WHC-SD-CP-SAR-021 Rev 0, Westinghouse Hanford Company, Richland, Washington.
- United States Department of Energy. 1997. *Integrated Database Report-1996: U.S. Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-006 Rev 13, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

United States Department of Energy. 1996. *Integrated Database Report-1995: U.S. Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-006 Rev 11, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

United States Department of Energy. 1995. *Integrated Database Report-1994: U.S. Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-006 Rev 10, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

United States Department of Energy. 1994. *Integrated Database Report-1993: U.S. Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-006 Rev 9, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Willis WL. 1995. *Hanford Site Existing Irradiated Fuel Storage Facilities Description*. WHC-SD-SNF-TI-002 Rev 0, Westinghouse Hanford Company, Richland, Washington.

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