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WHC-EP-0100

Properties and Environmental Impact of Ammonia Scrubber Discharge Waste to the 216-A-36B Crib

Prepared for the U.S. Department of Energy
Assistant Secretary for Defense Programs

Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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Staff, Environmental Technology Section

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EXECUTIVE SUMMARY

Review of process flowsheets for potentially reportable waste components was conducted at the Hanford Site. The review indicated the ammonia scrubber distillate (ASD) likely contained reportable quantities of the Class C toxin ammonium hydroxide (NH_4OH). Sampling and analysis of the ASD waste stream confirmed that reportable levels of NH_4OH were present. The Plutonium-Uranium Extraction (PUREX) processes that generated the waste to the 216-A-36B Crib were discontinued. The responsible regulatory agencies were notified on August 31, 1987.

This report provides characterization data for evaluating the effect on the environment of the discharge of the ASD waste stream. Data provided include the concentration and quantity of NH_4OH discharged per hour during the maximum five hours of discharge. The total quantity of NH_4OH discharged for 29 h headend cycles and the estimated total quantities of NH_4OH and NH_4F discharged from 1966 to 1971 and 1983 to 1987 are provided. Numbers and dates of decladding cycles, volumes of discharges, and frequency of discharge are provided and combined with the NH_4OH discharge quantity per cycle to develop the total NH_4OH discharge values. Inorganic and organic waste parameter values are provided for two sampling dates. Average ammonium fluoride (NH_4F) concentration of 10 hourly samplings of the 10 h decladding cycle are provided.

Crib and groundwater data provided for 216-A-36B Crib include the following:

- Crib constructional data
- Crib and groundwater monitoring well locations
- Crib disposal history including the crib radioactive waste inventory
- Levels of radioactive constituents in the groundwater
- Levels of nonradioactive constituents in the groundwater
- Stratigraphy of soils beneath the crib.

An environmental impact analysis was performed to determine the effects of the ASD waste streams discharged to the 216-A-36B crib. Vadose zone and groundwater transport models were used to predict waste component transport as a function of waste composition, ammonia volatilization, ammonium sorption, ammonium biological conversion to nitrite and nitrate, hydrologic parameters, and time. The environmental effects at the future crib control zone and Columbia river were evaluated by comparing the concentrations of waste components with environmental regulations.

The amount of ammonium hydroxide in the ASD waste stream exceeded the Comprehensive Environmental Response, Compensation and Liablity Act (CERCLA) reportable quantity of 1,000 lb/d by a factor of about four. The peak concentrations of ammonium hydroxide discharged exceeded Washington State Department of Ecology dangerous waste threshold concentration of 1% (Class C toxic substance), resulting in the waste stream being classified as a dangerous waste. Due to the biological conversion of ammonia to nitrite and nitrate, the nitrite and nitrate concentration in groundwater is predicted to be 320 ppm at the crib boundary. This value exceeds the drinking water standard of 45 ppm by a factor of about seven. All 344 decladding events are assumed to have approximately the same chemical discharges. No other waste component exceeded CERCLA reportable levels, Washington State Department of Ecology limits, or groundwater drinking water standards. The single waste component of environmental concern was groundwater nitrate.

The effect of leaching the 216-A-36B Crib with ammonia-free water at the discharge rate used for the ASD waste stream was also evaluated. The nitrate concentration was predicted to remain essentially constant at the operational nitrate level for the initial 75 d and slowly drop to background levels in the following 3 d. The elevated nitrate concentrations are due to leaching the estimated 81,000 kg of nitrate (or nitrate equivalents of NH_4^+ and NO_2^-) that remained in the vadose zone when ASD ceased.

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CONTENTS

Introduction 1

Data 3
Ammonia Scrubber Distillate Source and Chemical Properties 3
Dangerous Waste Designation Evaluation 3

Impact of the Ammonia Scrubber Waste Discharge 18
Environmental Impact Analysis Approach 18
Impacts from Discharge to the 216-A-36B Crib 22
Leaching of Sorbed Species from Soil Column 25

References 27

Appendix 28

Figures:
1. Location of the 216-A-36B Crib and Associated Wells 10
2. Stratigraphy Beneath the 216-A-36B Crib 11

Tables:
1. Ammonia Scrubber Distillate Waste Stream Chemical Parameters 4
2. Estimated Quantity of NH_4OH and NH_4F Discharged to 216-A-36B Crib 5
3. PUREX Decladding Event Dates from 1983 through 1987 6
4. Waste Inventory for the 216-A-36B Crib 12
5. 1983 Average Concentrations of Radiological Parameters for Plutonium Uranium Extraction Ammonia Scrubber Waste Effluent and Groundwater Near the 216-A-36B Crib from 1983 through 1987 13
6. Groundwater Parameters Measured in Wells 299-E17-5 and 299-E17-9 17
7. Groundwater Travel Times 21
8. Predicted Nitrate Concentrations in the Groundwater Resulting from Discharge of Ammonium to the 216-A-36B Crib 23
9. Ammonia Scrubber Discharge Waste Species of Interest 24

INTRODUCTION

Even though the Hanford Site has spent a great deal of effort characterizing waste prior to June 1987, since then the Hanford Site has accelerated its program to characterize the nonradiological components in liquid effluent streams. Process flow sheets for the Plutonium-Uranium Reduction Extraction (PUREX) Plant were reviewed to identify components that may exceed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reportable quantities or Washington State Department of Ecology (WDOE) dangerous waste criteria. This review indicated that the ammonia scrubber distillate (ASD) waste discharged to the 216-A-36B (A-36B) Crib potentially contains reportable quantities of ammonium hydroxide. Sampling and analyzing ASD confirmed that reportable levels of NH_4OH were present in the ASD waste stream. The PUREX processes that generated the waste to the A-36B Crib were terminated. The WDOE and the U.S. Environmental Protection Agency (EPA) were notified and given followup information on August 31, 1987.

This document provides characterization data required to evaluate the environmental effects of ASD waste stream disposal. Vadose zone and groundwater transport models are used for estimating the environmental effects of the ASD on the environment. These models predict waste component transport as a function of waste composition, NH_4^+ biological conversion to NO_2^- and NO_3^-, soil sorption of NH_4^+, NH_3 volatilization, and time. Data from the ASD characterization were used with laboratory-measured NH_4^+ conversion parameters, laboratory-measured sorption parameters, derived volatilization parameters, unsaturated flow, and groundwater-transport parameters as input to the vadose zone and groundwater transport models to estimate the environmental effects of the ASD waste stream. Environmental effects were assessed at the crib boundary, at the future control zone boundary (2 km from the crib) (DOE 1986), and in the Columbia River.

When an evaluator considers the data described, he should also consider the assumptions implicit in models used to estimate the effects of the ASD waste stream discharged to the 216-A-36B crib. The Pacific Northwest Laboratory (PNL) analyzed these effects. A report of the methods, assumptions, and findings used to analyze the ASD waste stream's environmental effects is being prepared; but we anticipate that it will be published slightly later than this report. The impact analysis in this report summarizes the PNL report. The PNL environmental analysis used worst-case parameters, so that the environmental effects of the ASD waste stream represent a worst-case analysis.

To grasp a balanced understanding of the environmental effects reported of the ASD waste stream, we recommend the evaluator read both reports.

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DATA

AMMONIA SCRUBBER DISTILLATE SOURCE AND CHEMICAL PROPERTIES

The ammonia scrubber distillate waste stream is generated in the PUREX Plant. The discharge is composed of two primary sources: one is from the dissolvers where Zircaloy® fuel cladding is dissolved (decladding); and a second stream from the treatment of the cladding removal waste solution. Offgases from the decladding and waste treatment operations pass through four parallel ammonia scrubbers. Spent ammonia scrub water is collected in a catch tank and transferred to a second catch tank where it is combined with three other minor ammonia-bearing waste streams. The combined waste stream is transferred to a concentrator where NH_3 is distilled and the concentrated radionuclide bottoms are periodically sent to a double-shell underground storage tank. The overhead condensate from the concentrator was discharged to the 216-A-36B Crib as the ASD-waste stream.

The discharge of ammonium hydroxide (NH_4OH) was variable during a typical 29 h headend cycle. The NH_4OH discharge reaches a maximum value within 2 h of the start of the decladding operation of about 26,000 ppm (10,000 g-mol/h) at a pH of 11.5 and decreases to about 1,200 ppm (250 g-mol/h) after the initial 10 h of the headend cycle and essentially remains constant through the remainder of the cycle. Discharge NH_4OH values for each hour of the subsequent 4 h were 25,000 ppm (9,700 g-mol/h), 20,000 ppm (7,600 g-mol/h), 15,000 ppm (6,000 g-mol/h), and 12,800 ppm (4,800 g-mol/h). Flow rate during the decladding cycle was 1.31 x 10^4 L/h. The total quantity of NH_4OH discharged per headend cycle was about 3,800 lb (49,000 g-mol).

Concentration data for waste components other than NH_4OH and F^- are provided in table 1. Concentrations of all components except fluoride are based on the analysis of two samples that were collected near the beginning of the fuel decladding cycle. Fluoride is based on 10 hourly grab samplings of the ASD stream during a 10 h decladding period and averages 8.3 ppm with a range of 0.77 to 33 ppm.

Table 2 estimates the quantity of NH_4OH and NH_4F that has been discharged to the A-36B Crib since its initial operation in 1966. Table 3 lists the dates of the 344 decladding events that have occurred since November 1983. The average frequency of discharge is about 87 discharges per year from 1983 to 1987. The discharge frequency from 1983 - 1986 was 110 discharges per year with 17 discharges in 1987.

DANGEROUS WASTE DESIGNATION EVALUATION

A complete dangerous waste designation evaluation was applied to the ASD waste stream, using WAC 173-303-080 to WAC 173-303-104 criteria (WDOE 1987). Waste designation evaluation documentation for the ASD waste stream is provided in the appendix. The ASD waste is designated as a

Table 1. Ammonia Scrubber Distillate Waste Stream Chemical Parameters.

Sampling date	August 23, 1985	May 8, 1987
Aluminum	<1.5 E+02	<1.5 E+02
Antimony	<1.0 E+02	<1.0 E+02
Barium	<6.0 E+00	<6.0 E+00
Beryllium	<5.0 E+00	<5.0 E+00
Cadmium	<2.0 E+00	<2.0 E+00
Calcium	7.4 E+01	9.8 E+01
Chromium	1.3 E+01	<1.0 E+01
Copper	<1.0 E+01	<1.0 E+01
Iron	<5.0 E+01	<5.0 E+01
Lead	<3.0 E+01	<5.0 E+00
Magnesium	2.1 E+01	<5.0 E+01
Manganese	<5.0 E+00	<5.0 E+00
Mercury	<1.0 E-01	<1.0 E-01
Nickel	1.1 E+01	<1.0 E+01
Potassium	<1.0 E+02	<1.0 E+02
Silver	<1.0 E+01	<1.0 E+01
Sodium	5.3 E+02	<1.0 E+02
Strontium	<3.0 E+02	<3.0 E+02
Uranium	2.7 E-01	2,17 E-03
Vanadium	<5.0 E+00	<5.0 E+00
Zinc	5.3 E+01	7.7 E+01
Chloride	3.9 E+02	5.8 E+02
Cyanide	<1.0 E+01	<1.0 E+01
Nitrate	7.0 E+02	<5.0 E+02
Phosphate	<1.0 E+03	<1.0 E+03
Sulfide	HTE	<1.0 E+03
Sulfate	<5.0 E+02	<5.0 E+02
Benzyl alcohol	1.2 E+01	<1.0 E+01
pH	9.74	8.90
Temperature (°C)	31.0	29.6
Alpha Activity (pCi/L)	1.3 E+00	3.1 E+00
Beta Activity (pCi/L)	1.4 E+05	1.4 E+04
Total Organic Carbon (ppb)	9.6 E+03	<5.5 E+02
Total Organic Halide (ppb)	<1.0 E+02	<2.0 E+01

NOTE: Analyte concentrations are in parts per billion. Result notations include measurements made after holding times were exceeded (HTE), and measurements that have not been received from the laboratory (NA).

PST88-3093-1

Table 2. Estimated Quantity of NH_4OH and NH_4F Discharged to 216-A-36B Crib.

Year	Decladding events	Volume (L)	NH_4OH (g)	NH_4F (g)
1966 - 1972	1,367	9.4×10^7	3.78×10^8	4.79×10^5
1983 - 1985	233	13.3×10^7	4.02×10^8	4.92×10^5
1986	94	5.66×10^7	1.62×10^8	1.98×10^5
1987	17	2.48×10^7	0.293×10^8	0.358×10^5
Total 1983 - 1987	344	21.5×10^7	5.93×10^8	1.20×10^6

PST88-3093-2

Table 3. Plutonium Uranium Extraction Decladding Events Dates from 1983 through 1987. (sheet 1 of 3)

JANUARY					FEBRUARY					MARCH					APRIL				
1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987
	1/1/84	1/18/85	1/9/86			2/20/84	2/3/85	2/6/86			3/2/84	3/5/85	3/7/86	3/31/87		4/6/84	4/1/85	4/1/86	4/27/87
	1/4/84	1/4/85	1/7/86			2/23/84	2/4/85	2/11/86			3/4/84	3/7/85	3/7/86	3/21/87		4/8/84	4/3/85	4/3/86	
	1/6/84	1/5/85	1/13/86			2/26/84	2/10/85	2/10/86			3/5/84	3/11/85	3/9/86			4/10/84	4/5/85	4/7/86	
	1/7/84	1/7/85	1/17/86			2/26/84	2/11/85	2/12/86			3/8/84	3/11/85	3/11/86			4/13/84	4/7/85	4/8/86	
	1/9/84	1/8/85	1/19/86			2/29/84	2/13/85	2/14/86			3/9/84	3/14/85	3/12/86			4/14/84	4/8/85	4/9/86	
	1/12/84	1/17/85	1/29/86				2/15/85	2/16/86			3/11/84	3/16/85	3/14/86			4/17/84	4/10/85	4/10/86	
	1/14/84	1/19/85					2/16/85	2/17/86			3/12/84	3/17/85	3/15/86			4/19/84	4/11/85	4/12/86	
	1/19/84	1/21/85					2/23/85	2/23/86			3/14/84	3/19/85	3/16/86			4/20/84	4/13/85	4/13/86	
	1/20/84	1/26/85					2/24/85	2/24/86			3/18/84	3/21/85	3/18/86			4/24/84	4/14/85	4/14/86	
	1/21/84	1/22/85					2/25/85	2/25/86			3/18/84	3/23/85	3/21/86			4/26/84	4/20/85	4/19/86	
		1/27/85						2/28/86			3/21/84	3/24/85	3/22/86			4/27/84	4/19/85	4/20/86	
		1/29/85									3/29/84	3/26/85	3/23/86				4/23/85	4/22/86	
												3/28/85	3/25/86				4/24/85	4/25/86	
												3/29/85	3/26/86				4/29/85		
												3/31/85	3/27/86				4/30/85		
													3/28/86						
													3/29/86						
													3/30/86						
													3/31/86						

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Table 3. Plutonium Uranium Extraction Decladding Events Dates from 1983 through 1987. (sheet 2 of 3)

MAY					JUNE					JULY					AUGUST				
1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987
	5/3/84	5/20/85	5/16/86			6/1/84	6/9/85	6/2/86	6/22/87		7/2/84	7/2/85	7/6/86	7/5/87		8/8/84	8/1/85	8/1/86	8/2/87
	5/5/84	5/23/85	5/17/86			6/4/84	6/11/85	6/3/86			7/4/84	7/4/85	7/7/86	7/16/87		8/11/84	8/3/85	8/2/86	8/4/87
	5/10/84	5/25/85	5/20/86			6/8/84	6/16/85	6/5/86			7/5/84	7/6/85	7/8/86	7/17/87		8/13/84	8/5/85	8/2/86	8/9/87
	5/17/84	5/25/85	5/21/86			6/9/84	6/19/85	6/10/86			7/8/84	7/8/85	7/14/86	7/29/87		8/14/84	8/7/85	8/4/86	8/20/87
	5/18/84	5/27/85	5/22/86			6/19/84	6/30/85	6/22/86			7/10/84	7/10/85	7/15/86			8/15/84	8/8/85	8/6/86/	8/23/87
	5/20/84	5/28/85	5/23/86			6/22/84		6/25/86			7/11/84	7/12/85	7/17/86			8/18/84	8/11/85	8/7/86	8/25/87
	5/21/84	5/28/85	5/24/86			6/24/84					7/13/84	7/17/85	7/18/86			8/19/84	8/15/85	8/8/86	8/27/87
	5/26/84	5/30/85	5/26/86			6/26/84					7/22/84	7/18/85	7/19/86			8/24/84	8/17/85	8/9/86	8/30/87
	5/28/84		5/28/86			6/29/84					7/24/84	7/20/85	7/20/86			8/23/84	8/18/85	8/10/86	
			5/29/86			6/30/84					7/22/84	7/23/85	7/22/86			8/26/84	8/25/85	8/13/86	
			5/31/86								7/25/84	7/27/85	7/23/86			8/27/84	8/24/85	8/15/86	
											7/27/84	7/28/85	7/25/86			8/28/84	8/25/85		
											7/28/84	7/31/85	7/28/86			8/29/84	8/29/85		
											7/31/84		7/29/86			8/31/84	8/30/85		
											7/31/84		7/30/86						
													7/31/86						

PSTDD-3093 3

Table 3. Plutonium Uranium Extraction Decladding Events Dates from 1983 through 1987. (sheet 3 of 3)

SEPTEMBER					OCTOBER					NOVEMBER					DECEMBER				
1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987	1983	1984	1985	1986	1987
	9/1/84	9/1/85		9/6/87			10/11/85			11/13/83	11/2/84	11/1/85			12/21/83	12/3/84	12/3/85		
	9/3/84	9/3/85					10/13/85			11/16/83	11/15/84	11/2/85			12/13/83	12/7/84	12/5/85		
	9/14/84	9/4/85					10/17/85			11/19/83	11/16/84	11/4/85			12/25/83	12/8/84			
	9/15/84	9/6/85					10/21/85				11/30/84	11/6/85			12/28/83	12/17/84			
	9/19/84	9/7/85					10/26/85					11/6/85			12/31/83	12/19/84			
	9/20/84						10/27/85					11/13/85				12/24/84			
	9/22/84						10/29/85					11/15/85				12/25/84			
												11/20/85				12/28/84			
												11/24/85				12/31/84			
												11/27/85							
												11/29/85							
												11/30/85							

PST88-3093-3

dangerous waste (DW, WT02) for 5 h during its 29 h discharge cycle. The DW designation is based on its derived equivalent concentration (%) value of 0.0028 for the maximum hour of NH_4OH discharge. The equivalent concentration (%) decreases to less than the 0.001 dangerous waste limit after 5 h of decladding operation. During the subsequent 4 h after the initial hour of maximum NH_4OH discharge, the equivalent concentration (%) values decrease to 0.0027, 0.0022, 0.0017, and 0.0014, respectively. The total volume of ASD waste solution during the 5 h above the 0.001 equivalent concentration (%) value, is 6.6×10^4 L. In addition the CERCLA reportable quantity (RQ) for NH_4OH (Class C toxic substance) of 1,000 lb/d is exceeded by the 3,800 lb/d discharged.

216-A-36B Crib

The 216-A-36B Crib (A-36B) (fig. 1) is located approximately 1,400 ft (370 m) south of the 202-A (PUREX) building. The bottom of the crib is 500 ft (152 m) long and varies in width from 7 ft for the first 25 ft (8 m) to 11 ft (3.7 m) for the last 475 ft (144 m). The bottom of the crib is 24 ft (7.3 m) below grade. The original distribution system consisted of a perforated 6-in. (15-cm) diameter H-8 pipe placed on 3 ft (1.0 m) of gravel and covered with 3 ft (1.0 m) of gravel. The excavation was backfilled with original soil. Stratigraphy beneath the A-36B Crib is provided in figure 2.

In March 1966, the A-36B Crib was divided into A and B sections because the A section of the crib received a high radionuclide inventory during its initial 5 mo of operation. The headend A section of the crib was physically isolated from the B section of the crib by pumping grout through two 2 in. (5 cm) wells into the gravel layer of the crib. Waste was directed to the B section of the crib by inserting a 4 in. (10 cm) diameter stainless-steel distribution line into the original distribution line. The new distribution line was top perforated beyond the A section.

Associated structures include a liquid-level monitoring riser and a vent riser. The liquid-level monitoring riser extends to the crib bottom and is perforated at the lower end to permit liquid depth monitoring. The vent riser is at the end of the distributor pipe and contains an internal, 8 in. (20 cm) diameter tube filter at the top of the riser.

A-36B Crib History

The A-36B Crib was placed in service in March 1966 and received ammonia scrubber waste from PUREX. Wastes were discharged to the A-36B Crib from 1966 to 1972. Ammonia scrubber waste discharges were resumed in 1983 with the startup of PUREX and continued until August 1987 when it was confirmed that the waste stream contained reportable quantities of NH_4OH. Table 4 lists the radioactive waste inventory for the A-36B Crib. Table 5 lists the average concentrations of radiological parameters for the PUREX ASD waste effluent and groundwater near the A-36B Cribfor the years 1983 to 1987.

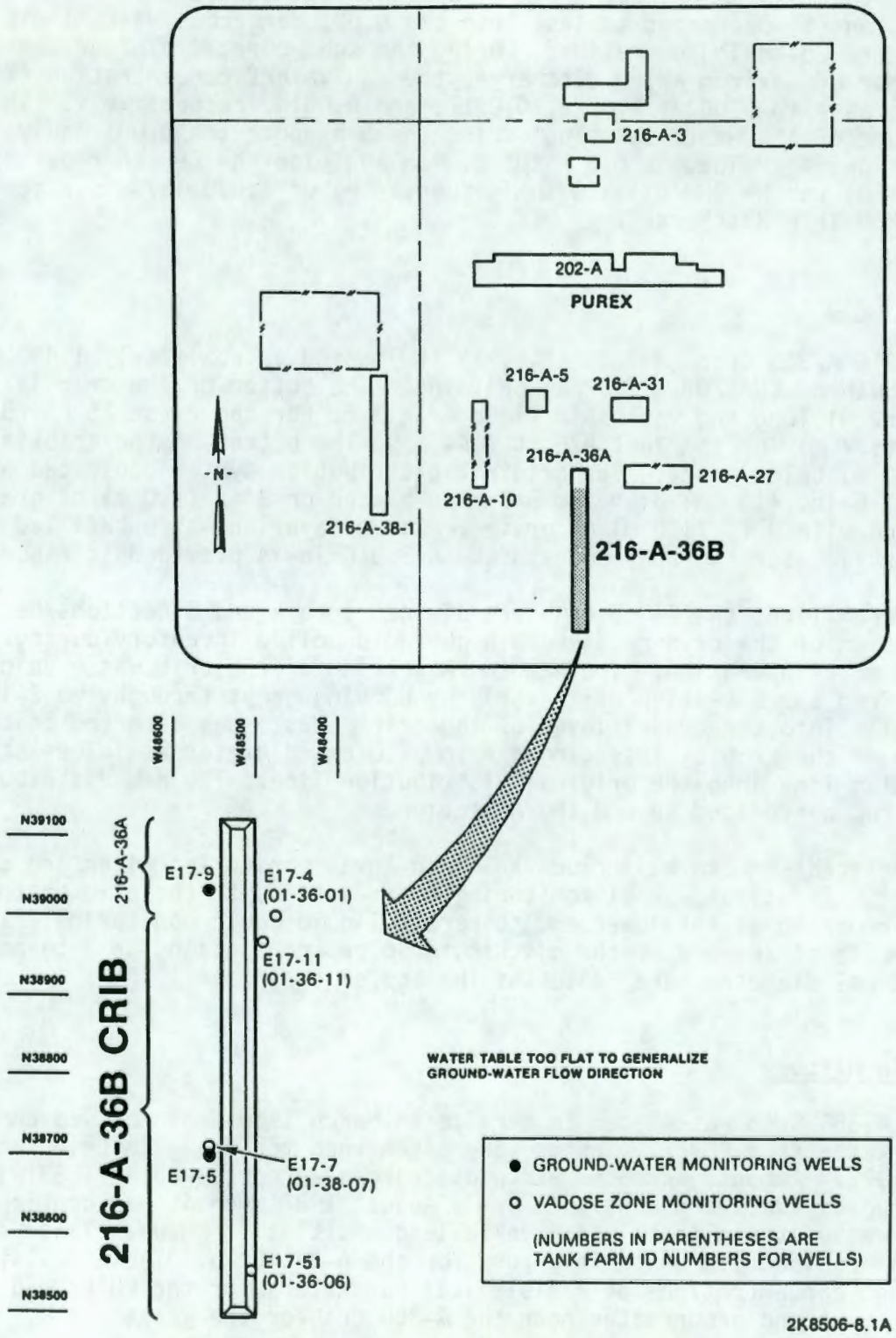

Figure 1. Location of the 216-A-36B Crib and Associated Wells.

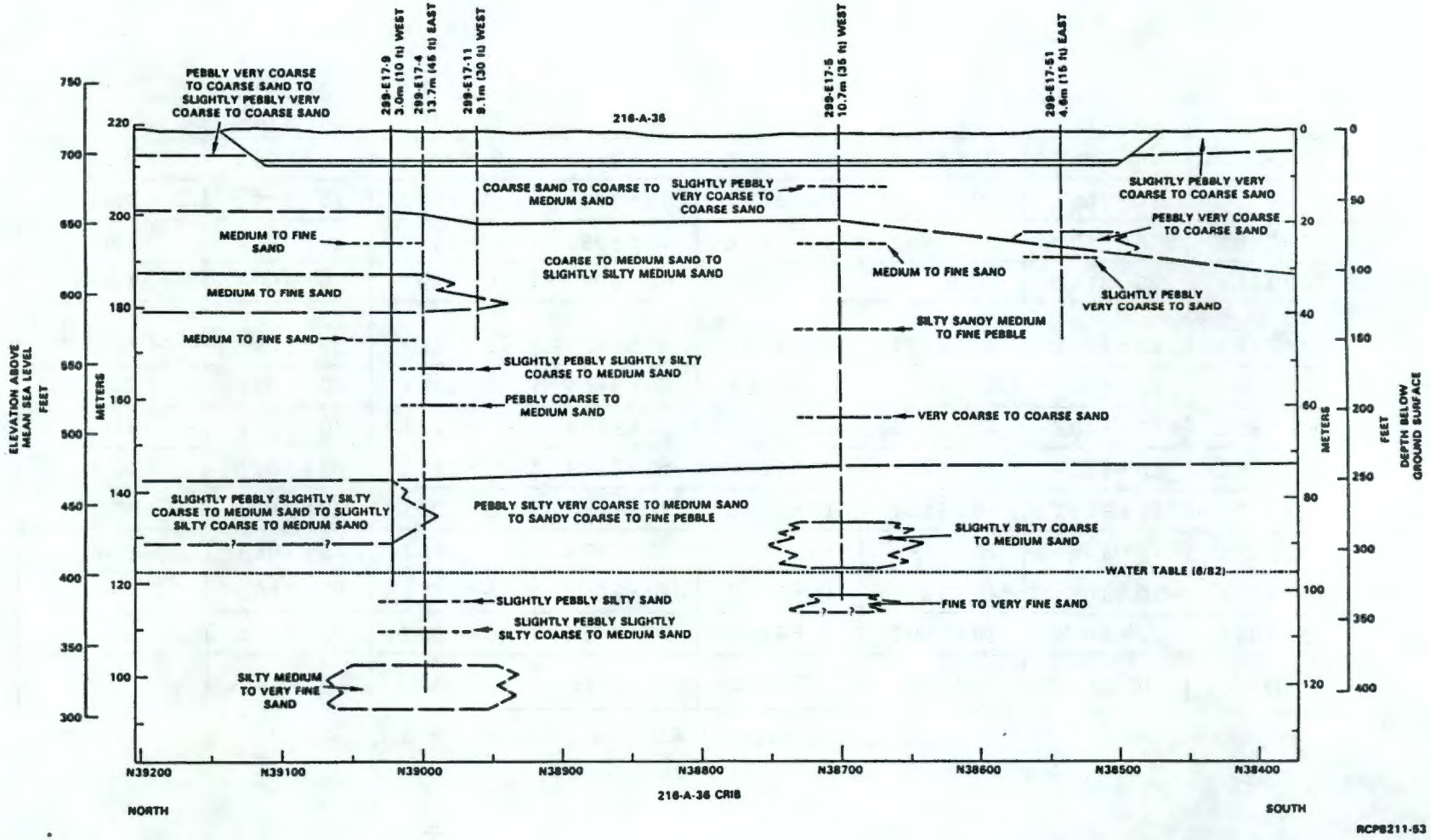

Figure 2. Stratigraphy Beneath the 216-A-36B Crib.

Table 4. Waste Inventory for the 216-A-36B Crib.

Date	Volume (L)	Pu (g)	Beta (Ci)	^{90}Sr (Ci)	^{106}Ru (Ci)	^{137}Cs (Ci)	^{238}U (kg)
1966	4.19 E + 06	7.00 E + 01	4.20 E + 03	6.00 E + 01	2.00 E + 02	5.80 E + 01	5.00 E + 01
1967	4.94 E + 06	1.39 E + 01	5.00 E + 03	2.50 E + 01	7.00 E + 01	1.50 E + 01	1.03 E + 01
1968	1.26 E + 07	1.94 E + 01	9.28 E + 02	1.40 E + 01	1.61 E + 02	1.48 E + 01	1.83 E + 01
1969	1.78 E + 07	7.20 E + 00	1.79 E + 03	9.91 E + 01	4.54 E + 02	1.10 E + 02	1.00 E + 01
1970	9.00 E + 06	3.58 E + 00	1.13 E + 04	2.29 E + 02	1.67 E + 03	1.31 E + 02	2.62 E + 01
1971	2.27 E + 07	<1.49 E + 01	7.01 E + 03	<2.11 E + 01	3.28 E + 03	7.01 E + 01	2.09 E + 00
1972	2.28 E + 07	4.81 E + 01	3.28 E + 03	9.84 E + 01	7.73 E + 02	1.65 E + 02	1.95 E + 00
Total Decayed To 1981	9.40 E + 07	1.77 E + 02	<1.72 E + 03	4.08 E + 02	4.07 E + 00	4.27 E + 02	1.19 E + 02
1983	1.00 E + 07	3.68 E + 01	1.88 E − 01	2.28 E − 02	a	6.59 E − 02	4.13 E + 01
1984	4.78 E + 07	2.21 E + 01	1.54 E + 01	3.53 E − 02	7.08 E + 00	4.05 E − 01	<3.81 E − 01
1985	7.54 E + 07	2.66 E − 01	4.68 E + 01	2.42 E + 00	2.54 E + 01	7.49 E − 01	--
1986	5.66 E + 07	3.50 E − 02	4.77 E + 01	2.11 E − 01	2.38 E + 00	3.48 E − 01	--
1987	2.82 E + 07	2.37 E − 03	7.87 E − 01	2.49 E − 02	4.30 E − 01	9.32 E − 02	--

[a]Values not available.

PST88-3093-4

Table 5. Average Concentrations of Radiological Parameters for Plutonium-Uranium Extraction Ammonia Scrubber Waste Effluent and Groundwater Near the 216-A-36B Crib from 1983 through 1987. (sheet 1 of 3)

1983		Total alpha (pCi/mL)	Total beta (pCi/mL)	^{3}H (pCi/mL)	^{90}Sr (pCi/mL)	^{137}Cs (pCi/mL)	^{106}Ru (pCi/mL)	^{60}Co (pCi/mL)	U (pCi/mL)	NO_3 (as nitrate) (mg/L)
Waste stream										
PUREX (ASD)		1.61 E+00	1.88 E+01	5.63 E+02	2.28 E+00	6.59 E+00	NA[a]	NA[a]	1.38 E+00	NA[a]
Wells										
299-E17-5	Max	1.14 E-01	1.63 E-01	5.70 E+02	8.23 E-02	1.42 E-02	4.28 E-02	1.08 E-02	[a]	40
	Ave	1.39 E-02	4.59 E-02	5.01 E+02	1.04 E-02	3.91 E-03	1.36 E-02	2.47 E-03	7.69 E-03	25
	Min	1.54 E-03	9.99 E-03	3.81 E+02	0.00 E+00[c]	0.00 E+00	0.00 E-00[c]	0.00 E+00[c]	[a]	19
299-E17-9	Max	[a]	8.47 E-02	1.06 E+04	1.08 E-02	2.08 E-02	2.35 E-02	1.02 E-02	[a]	145
	Ave	1.19 E-03	4.09 E-02	7.02 E+03	4.24 E-03	5.43 E-03	4.97 E-03	2.8 E-03	NA[a]	106
	Min	a	1.57 E-02	3.27 E+03	4.06 E-04	0.00 E+00[c]	0.00 E+00[c]	0.00 E+00[c]	[a]	12

1984		Total alpha (pCi/mL)	Total beta (pCi/mL)	Tritium (pCi/mL)	Nitrate (mg/L)	^{90}Sr (pCi/mL)	^{137}Cs (pCi/mL)	^{60}Co (pCi/mL)	^{106}Ru (pCi/mL)	Uranium (pCi/mL)
Waste stream										
PUREX (ASD)	Ave	<9.00 E-02	3.00 E+02	5.00 E+03	1.62 E+01	7.00 E-01	8.00 E+00	NA[a]	2.00 E+02	BDL[b]
Wells										
2E 17 5	Max	1.03 E-02	9.93 E-02	2.49 E+03	7.92 E+01	1.00 E-02	6.26 E-03	7.82 E-03	6.42 E-02	1.15 E-02
	Ave	4.45 E-03	5.95 E-02	1.06 E+03	4.47 E+01	3.31 E-03	1.35 E-03	1.75 E-03	1.97 E-02	5.15 E-03
	Min	0.00 E-01[c]	1.58 E-02	5.17 E+02	3.03 E+01	0.00 E-01[c]	0.00 E-01[c]	0.00 E-01[c]	0.00 E-01[c]	1.26 E-03
2E 17 9	Max	NA[a]	7.67 E-02	3.87 E+03	9.52 E+01	2.50 E-02	8.54 E-03	2.84 E-02	9.96 E-02	NA[a]
	Ave	[a]	4.05 E-02	3.03 E+03	7.33 E+01	6.75 E-03	1.98 E-03	6.51 E-03	2.69 E-02	a
	Min	a	1.58 E-02	2.53 E+03	6.25 E+01	6.37 E-01	0.00 E-01[c]	0.00 E-01[c]	0.00 E-01[c]	a

[a]Blank spaces denote values are not available.

PST88-3093-S

Table 5. Average Concentrations of Radiological Parameters for Plutonium-Uranium Extraction Ammonia Scrubber Waste Effluent and Groundwater Near the 216-A-36B Crib from 1983 through 1987. (sheet 2 of 3)

1985		Total alpha (pCi/mL)	Total beta (pCi/mL)	^{3}H (pCi/mL)	^{90}Sr (pCi/mL)	^{137}Cs (pCi/mL)	^{106}Ru (pCi/mL)	^{60}Co (pCi/mL)	U (pCi/mL)	NO_3 (as nitrate) (mg/L)
Waste stream										
PUREX (ASD)	Ave	<4 E+02	6 E+05	3 E+06	NA[a]	3 E+04	1 E+04	NA	3 E+05	NN[d]
Wells										
2-E17-5	Max	1.20 E+01	6.60 E+01	2.71 E+06	1.16 E+02	5.14 E+00	7.67 E+00	7.89 E+00	4.79 E+01	2.26 E+01
	Ave	8.29 E+00	3.28 E+01	2.03 E+06	9.18 E+01	3.14 E+00	−4.65 E−01	2.11 E+00	−5.24 E+00	1.17 E+01
	Min	5.56 E+00	2.21 E+01	1.31 E+06	6.46 E+01	2.32 E+00	−1.41 E+01	−1.82 E+00	−8.01 E+01	6.53 E+00
2-E17-9	Max	6.08 E+00	3.60 E+01	5.56 E+06	1.72 E+02	4.71 E+00	7.12 E+00	7.11 E+00	7.12 E+01	5.91 E+00
	Ave	3.54 E+00	2.71 E+01	4.68 E+06	1.40 E+02	4.17 E+00	−4.87 E−02	1.96 E+00	1.32 E+01	5.24 E+00
	Min	2.15 E+00	2.20 E+01	3.82 E+06	1.08 E+02	3.30 E+00	−9.25 E+00	−7.09 E+00	−2.98 E+01	4.56 E+00

1986		Alpha (pCi/L)	Beta (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	^{60}Co (pCi/L)	^{106}Ru (pCi/L)	Uranium (pCi/L)
Waste stream										
PUREX (ASD)	Ave	<3.71 E+02	8.44 E+05	2.42 E+06	NA[a]	3.72 E+03	6.14 E+03	NA[a]	4 E+05	NN[d]
Wells										
299-E17-05	Max	1.44 E+01	7.09 E+01	5.06 E+06	1.19 E+02	3.58 E+00	7.70 E+00	8.03 E+00	4.42 E+01	9.71 E+00
	Ave	9.18 E+00	3.37 E+01	3.88 E+06	9.90 E+01	2.84 E+00	5.55 E−01	1.51 E+00	5.48 E+00	6.60 E+00
	Min	5.79 E+00	2.29 E+01	2.69 E+06	8.68 E+01	2.33 E+00	−1.35 E+01	−4.13 E+00	−3.67 E+01	4.30 E+00
299-E17-09	Max	5.20 E+00	2.54 E+01	6.62 E+06	2.07 E+02	5.01 E+00	1.20 E+01	5.09 E+00	4.43 E+01	NA
	Ave	3.90 E+00	2.10 E+01	5.84 E+06	1.38 E+02	3.67 E+00	9.24 E−01	−1.90 E−01	1.31 E+01	NN[d]
	Min	3.19 E+00	1.75 E+01	3.55 E+06	9.38 E+01	1.95 E+00	−8.31 E+00	−1.13 E+01	−2.20 E+01	NA

PST88-3093-5

Table 5. Average Concentrations of Radiological Parameters for Plutonium-Uranium Extraction Ammonia Scrubber Waste Effluent and Groundwater Near the 216-A-36B Crib from 1983 through 1987. (sheet 3 of 3)

1987		Alpha (pCi/L)	Beta (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	^{60}Co (pCi/L)	^{106}Ru (pCi/L)	Uranium (pCi/L)
Wells										
2-E17-5	Max	8.87 E+00	6.13 E+02	5.39 E+06	1.07 E+02	3.27 E+00	7.94 E+00	6.03 E+01	5.57 E+02	1.05 E+01
	Ave	6.68 E+00	1.75 E+02	4.42 E+06	9.78 E+01	2.78 E+00	9.65 E−01	1.22 E+01	9.28 E+01	8.16 E+00
	Min	5.83 E+00	4.65 E+01	4.09 E+06	7.52 E+01	2.52 E+00	−5.99 E+00	−9.11 E+00	−5.431	5.89 E+00
2-E17-9	Max	4.16 E+00	3.40 E+01	6.29 E+06	1.70 E+02	3.43 E+00	8.55 E+00	5.61 E+00	1.12 E+02	4.29 E+00
	Ave	3.26 E+00	2.32 E+01	5.53 E+06	1.54 E+02	3.33 E+00	−1.49 E+00	−1.53 E+00	1.91 E+01	3.61 E+00
	Min	2.10 E+00	1.42 E+01	4.93 E+06	1.37 E+02	3.28 E+00	−1.59 E+01	−1.07 E+01	−5.42 E+01	2.64 E+00

[a]NA = No analysis for this constituent.
[b]BDL = Below detectable limit.
[c]Negative analytical values appear as zeroes.
[d]N = Analyses not necessary (as determined from inventory, effluent history, or gross alpha/beta analyses).

PST88-3093-5

A-36B Crib Monitoring

The crib is monitored by two groundwater wells and four vadose zone wells (figure 1). Groundwater wells 299-E17-5 and 299-E17-9 contain pumps and are part of the Hanford Site groundwater monitoring network. The groundwater wells are monitored monthly for radionuclides, pH, and nitrates. Beginning in March 1987, the wells have been monitored quarterly for hazardous waste parameters. Total gamma logs of vadose zone wells 299-E17-4, 299-E17-7. 299-E17-11, and 299-E17-51 are taken quarterly to evaluate the transport of radionuclides toward groundwater. Table 5 lists groundwater concentrations of radiological parameters. Table 6 lists concentrations of nonradiological parameters for the groundwater near the A-36B Crib.

Table 6. Groundwater Parameters Measured in Wells 299-E17-5 and 299-E17-9 (299-E17-9 Monitoring the 216-A-36B Crib).

Well	Date	Ammonia (ppm)	Fluoride (ppm)	Nitrate (ppm)	pH	TOC (ppm)	Chloride (ppm)	Conductivity (µmho/cm)
299-E17-5	March 4, 1987	<0.050	<0.500	99.8	7.85	0.516	6.87	452
	April 9, 1987	<0.050	<0.500	89.5	7.62	0.763	6.83	435
	July 20, 1987	0.064	0.675	118.0	7.77	0.531	6.22	422
	October 10, 1987	<0.050	<0.500	261.0	NA[a]	NA	NA	NA
299-E17-9	March 4, 1987	<0.050	<0.500	171.0	7.63	0.414	8.31	639
	April 14, 1987	<0.050	<0.500	153.0	7.50	0.455	6.87	728
	July 20, 1987	<0.050	0.812	128.0	7.54	0.466	6.95	477
	October 10, 1987	<0.050	<0.500	123.0	NA	NA	NA	NA

[a]NA = Not received from the laboratory at the time the report was prepared.

PST88-3093-6

IMPACT OF THE AMMONIA SCRUBBER WASTE DISCHARGE*

ENVIRONMENTAL IMPACT ANALYSIS APPROACH

After reporting the August 31, 1987 ASD discharge, the effects of ASD discharge to the 216-A-36B Crib were analyzed. Two discharge scenarios were evaluated. The first considers the effects from predicted normal PUREX operations (122 decladding operations per year) and the second considers past PUREX operations (87 decladding operations per year). These effects were measured according to regulations. The following approach was taken for this analysis.

- The chemistry of the waste was compared to regulations to identifying specific chemicals, which are present in sufficient quantity to be classified a dangerous waste.
- The amount of ammonia gas that volatilizes from the liquid waste was determined.
- Adsorption and desorption were studied to determine the retardation factors (R) for ammonium in the sediment.
- The rate of conversion of ammonium to nitrite and nitrate by biological processes in the local sediments and groundwater were determined.
- The transport of the waste contaminants through the vadose zone and into the aquifer was modeled and the resulting ground concentrations determined.
- The results of the analysis were then compared to the regulations to determine which contaminants exceeded the regulatory limits.

Model Input Discharge Characteristics

Ammonium discharges to these cribs result primarily from the decladding operations of spent fuel at the headend of the PUREX process. During the decladding operation, spent fuel is boiled in a solution of ammonium fluoride/ammonium nitrate to remove the Zircaloy• cladding.

Ammonia is discharged from the dissolver, reaching a peak concentration within 2 h of each decladding operation. The peak number of moles discharged in any one hour is about 10,000 g-moles. These amounts fall off rapidly after the 7 h decladding operation. Following decladding, the decladding solution is jetted to the coating receiver tank, and a metathesis solution is introduced (in metathesis, flourides introduced during decladding are removed to allow for solvent extraction of Pu and U). During metathesis, significantly smaller amounts of ammonia (3% of previous amount) are discharged so that the total discharge per decladding operation is 49,000 g-moles.

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*Impact analysis performed by the Pacific Northwest Laboratory.

Although the decladding operation from one dissolver may overlap the metathesis of another, the theoretical time period for each decladding operation is 29 h.

Ammonia is scrubbed from the overheads of the dissolver with water to form NH_4OH. The scrub solution is concentrated, and the overheads from the concentrator are discharged to the A-36B Crib. The rate of discharge is 13,100 L/h during decladding reduced to about 7,500 L/h between decladding operations. Ammonium discharge concentrations vary significantly, by the rate at which ammonia is exhausted from the dissolvers.

Volatilization of Ammonia

To determine the maximum amount of ammonia that could volatilize from the effluent to the crib, the crib was modeled by assuming the crib's distribution pipe represented a line source of ammonium hydroxide solution. Treating the soil surface as a plane, the rate of ammonia volatilization and subsequent diffusing to the surface were calculated.

The concentration of ammonium hydroxide used for this analysis was 24,000 ppm or 0.7*M*, at a flow rate of 13,100 L/h to the crib, which is a typical peak concentration observed during the early stages of decladding. The partial pressure of ammonia gas over a solution of ammonium hydroxide is approximately proportional to the ammonium concentration. A value of 0.05 atm/*m* at 50 °C (Perry 1963), the temperature at which the waste enters the crib, was used to determine the partial pressure of ammonia in the soil gas. Assuming a soil void fraction of 35% and a diffusion coefficient for ammonia in air of 0.2 cm^2/s (Welty et al. 1976), the effective diffusivity is about 0.08 cm^2/s. Using these parameters, one calculates a maximum release to the atmosphere of about 24 lb/d of ammonia. This release rate represents a small fraction of the total ammonia discharged per day; ammonia volatilization was not included in the transport modeling analyses.

Ammonium Adsorption/Desorption Studies

Several laboratory tests were performed to determine the degree to which ammonium is sorbed by the sediments beneath the crib. These tests used a waste similar to that of the actual waste stream. The ammonium concentration was varied from about 21 ppm ammonium to 3,400 ppm ammonium to determine the distribution coefficient (K_d). The K_d increases from 1.3 to 11.8 mL/g as the ammonium concentration drops from 3,400 to 21 ppm. The K_d calculated from the column test ranged from 0 to 7 mL/g. Because column determinations are more representative than batch measurements, the column values were used for the subsequent transport modeling. The range of K_d from 0 to 7 mL/g results in a range for retardation factors from 1 to 31.

Biological Conversion of Ammonium

The conversion of ammonium (NH_4^+) to nitrite (NO_2^-) and nitrate (NO_3^-) following the release of ammoniated waters to the cribs during PUREX operations is important because of the high mobility of NO_2^- and NO_3^-, as well as their known toxicities to human and aquatic life. The process whereby NH_4^+ is oxidized to NH_2^- and NH_3^- is referred to as nitrification. Nitrification takes place in virtually all soils and aquatic environments where ammonium is present and environmental conditions are favorable. The overall process of nitrification is shown in equations (1) and (2).

$$NH_4^+ + 3/2\ O_2 \xrightarrow{6e} NO_2^- + H_2O + 2H^+ \quad (1)$$

$$NO_2^- + 1/2\ O_2 \xrightarrow{2e} NO_3^- \quad (2)$$

Nitrification is mainly, if not exclusively, a biological process carried out by bacteria comprising the family *Nitrobacteriaceae*. The genera within this family are divided into two groups depending on whether they oxidize NH_4^+ to NO_2^- or oxidize NO_2^- to NO_3^-. Although the family is comprised of eight genera, most studies have been limited to two genera, the *Nitrosomonas*, which carry out reaction 1, and *Nitrobacter*, which carry out reaction 2. Nitrifying bacteria are chemoautotrophs; that is, they oxidize NO_4^+ or NO_2^- to derive energy for metabolic functions and utilize CO_2 as a carbon source.

This study determined if sufficient populations of the required bacteria exist in the soil and groundwater near the 216-A-36B Crib to convert ammonium to nitrite/nitrate. Rate constants for the two conversion reactions in local soils and groundwater were also measured. Rate constants for ammonia conversion were determined for two different groundwater samples and one soil sample.

Population densities of nitrifiers were determined using the most probable number (MPN) method of Schmidt and Belser (1982). Based on the results of these determinations for local soils and groundwater, the nitrified population density was sufficient for ammonia oxidation to take place if environmental conditions are conducive.

Oxidation of ammonia to nitrite was observed in the soil experiments, but the sequential oxidation of nitrite to nitrate was not observed. The calculated rate constant for nitrite production in the soils was 0.577/d (the rate constant is analogous to the rate constant (λ) in the radioactive decay equation, $N = N_0e^{-\lambda t}$). Conversion of ammonium was also observed in the groundwater experiments. However, the high concentrations of nitrate in the groundwater samples used for this work masked any increase in nitrate concentration that may have resulted from oxidation of nitrite to nitrate. Therefore, the rate constant for nitrite oxidation could not be calculated.

The rate constants observed for oxidation of ammonium to nitrite in the groundwater were 0.3712/d and 0.316/d. The lower rate constant of 0.316/d was used for the subsequent analyses. A value of 0.024/d (Misra. et al 1974) was the rate constant used for conversion of nitrite to nitrate. Because no oxidation of nitrite to nitrate was observed in the local soils, the analyses only accounted for conversion of ammonium to nitrite using 0.577/d for the rate constant.

Transport of Waste Contaminants in the Unsaturated and Saturated Zones

The 216-A-36B Crib is located in the southeast corner of the 200 East Area. Liquid effluents discharged to the crib infiltrate through the vadose zone to the water table. The effluent then migrates in the unconfined aquifer toward the Columbia River.

Travel time of the effluent through the vadose zone to the aquifer was calculated. The resulting value was 0.208 yr. Groundwater travel times through the unconfined aquifer were determined with a model of the aquifer based on the Variable Thickness Transient (VTT) code (Cearlock et al. 1975; Kipp et al. 1972; Reisenauer 1979a, b, c). Groundwater streamlines and the resulting travel times from the cribs to a 100-ft crib boundary, to 2 km downstream (DOE 1986) and to the Columbia River were determined (table 7).

Table 7. Groundwater Travel Times (years).

Crib	100-ft Crib Boundary	2 Km Boundary	Columbia River
216-A-36B Crib	0.023	1.7	48

The TRANSS code (Simmons et al. 1986) was used to model the transport of contaminants through the soil profile and into the groundwater. The ammonium was treated as a known quantity or inventory. The transformation of ammonium to nitrate was assumed not to affect the properties of the quantity transported.

A unit hydraulic study of the soil profile beneath the crib indicates that the specific flux of water is about 2.7 cm/h. The same calculations indicate that the volumetric water content is about 0.33. A dispersion coefficient of 54.1 cm^2/h was used.

The crib received pulses of NH_4^+ at about 3 d intervals in a constant liquid stream. Three days is small compared to the time scale of the migration (years), so an assumption was made that the soil profile received a constant input of NH_4^+. Because the profile receives a nearly constant supply of NH_4^+, further assumptions were that no more NH_4^+ could be adsorbed; therefore, the NH_4^+ was not retarded, and the NO_2^- was also not retarded.

The simulation was long enough to assure steady state results. The model predicts that the NH_4^+ has been totally converted to NO_2^- by a depth of 40 m. The concentration of NO_2^- arriving at the water table was 100% of the NH_4OH concentration discharged.

We wanted to know what species arrived at a 2 km distance from the crib. A 2 km pathline with a pore water velocity of 14 cm/h and a porosity of 0.33 was modeled. A steady influx of NH_4^+ with a unit concentration was introduced into the groundwater system. No retardation was applied. A dispersion coefficient of 54.0 cm^2 was used. All of the NH_4^+ had been converted to NO_3^- at the 2-km boundary. This analysis indicates that if the rate constants for decay are appropriate for the saturated zone, then no matter how much NH_4^+ reaches the water table, all of it will be converted to NO_3^- by a distance of 2 km.

In both the unsaturated and saturated zones, the conversion process is so rapid that retardation in the unsaturated zone has little effect. Because no ammonium reaches the groundwater, no retardation of the groundwater was assumed. Consequently, the most meaningful modeling with combined saturated and unsaturated flow will be with no retardation.

Table 8 summarizes the concentrations of reportable quantities in the groundwater and in the Columbia River resulting from the different cases. These concentrations express the total nitrate in the groundwater, because analyzing the ammonia transformation indicates that most of the quantity in the groundwater is rapidly converted to nitrate.

Concentrations of nitrate observed in wells at the facility boundary range from 92 to 240 mg/L.

EFFECTS OF DISCHARGE TO THE 216-A-36B CRIB

This section analyzes the environmental effects (or potential effects) resulting from disposal of the waste stream. The effects are determined at two locations: (1) at the boundary of the future control zone and (2) at the Columbia River.

The future control zone is an area 64 km wide (north to south) by 13 km long (east to west) that encompasses the 200 East and West Separations Areas. When institutional control is lost at the Hanford Site, markers placed along the boundary of the control zone will serve as an early warning of radioactive disposal sites within the zone (DOE 1986). The closest down-gradient boundary of the control zone is approximately 2 km from the A-36B Crib.

Table 8. Predicted Nitrate Concentrations in the Groundwater Resulting from Discharge of Ammonium to the 216-A-36B Crib.

Location		216-A-36B normal operations (mg/L)	216-A-36B past operations (mg/L)
R-1	Facility boundary	430	320
	2 km	430	320
	River[b]	3 E-04	1.7 E-04
R-31	Facility boundary	430	320
	2 km	430	320
	River	3 E-04	1.7 E-04

[a]Average from FY 1984 through FY 1987.
[b]Concentration in the river.

The predicted concentrations of contaminants in both the aquifer and the river are compared to both regulatory limits and toxicological thresholds. Environmental effects at the future control zone boundary from disposing of the ASD stream in the 216-A-36B Crib were predicted for two cases: (1) predicted normal operations at PUREX (122 decladding operations/yr) and (2) past operations (87 decladding operations/yr).

During both the normal and past operations scenarios, about 3,800 lb of ammonium hydroxide is discharged to the crib during the 29 h decladding operation. Theoretically, a maximum of 25 lb of ammonia gas from this 3,800 lb of ammonium hydroxide vaporizes and is released to the atmosphere from the crib. Discharged ammonium hydroxide substantially exceeds the CERCLA reportable quantity of 1,000 lb/d, but the release of ammonia from the crib to the air is under the limit of 100 lb/d. The peak concentrations of ammonium hydroxide discharged to the crib exceed the 1-wt% limit set for class C toxins by the State of Washington (WAC 173-303), which classifies the waste stream as a dangerous waste. The 430 ppm of nitrate in the aquifer predicted for the case of normal operations at PUREX exceeds the drinking water limit by about one order of magnitude. For past operations, the predicted concentration of nitrate in the aquifer is about seven times higher (320 ppm) than the drinking water standard. Because the existing nitrate standard is based on nitrogen content, whether the ammonia is fully oxidized to nitrate or only partially oxidized to nitrite is irrelevant from a regulatory viewpoint (i.e., the standard is exceeded by the same factor for either nitrate or nitrite).

Only the concentration of nitrate (from ammonium conversion) in the aquifer was determined because the previously described analysis indicates

that all of the ammonium was eventually converted to nitrate. The aquifer concentrations of other waste stream constituents can be predicted by assuming that the constituents move at the rate of the infiltrating water (i.e., have K_d values of zero) and taking the ratio of their input concentrations to those of the ammonia. The dilution factor between the concentration observed in the waste stream and that predicted in the aquifer is about seven (i.e., the predicted aquifer concentration is about one-seventh the waste stream concentration).

The other waste species of interest, their concentrations in the ASD stream, and predicted aquifer concentrations can be found in table 9. These concentrations (except for fluoride) are based on the analysis of one ASD sample taken on August 23, 1985. The fluoride concentration was based on hourly analyses of the ASD stream over the first 10 h of a decladding operation. The value in table 9 is the average of these 10 analyses diluted into the 3 d ASD discharge volume assumed for normal operations (122 decladding operations/yr); the peak concentration observed for fluoride was about 32 ppm in the ASD.

Table 9. Ammonia Scrubber Discharge Waste Species of Interest.

Waste species	ASD concentration (ppb)	Aquifer concentration (ppb)
Chromium	13	2
Benzyl alcohol	12	2
Zinc	53	7
Chloride	390	50
Fluoride: normal operation	1,200	160

The drinking water limit for fluoride is 2,000 ppb so that the predicted fluoride concentration is well below the drinking limit for the worst scenario. Even through fluoride concentrations periodically exceed drinking water limits during a decladding operation, the limit is never approached in the groundwater. The drinking water limits for chromium, zinc (secondary limit), and chloride (secondary limit) are 50 ppb, 5,000 ppb, and 250,000 ppb, respectively. These constituents are at least two orders of magnitude below their respective limits, except for chromium, which is a factor of 25 below standards.

If the chromium and the fluoride exist in the waste stream as ammonium chromate (a class C toxic substance) and ammonium fluoride (a class B toxic substance) their peak concentrations would be 46 ppb and 62,000 ppb, respectively. The WAC 173-303 limit for a class C toxin is 1 wt% and 0.1 wt% for a class B toxin. Neither limit is exceeded; the ammonium hydroxide concentration causes the waste to be regulated as a dangerous waste.

Chromium alone has a reportable quantity limit identified according to the CERCLA, which is 1 lb/d. At the listed concentration about 4 x 10^{-4} lb would be released in a 24 h period, well below the limit.

Therefore, based on this analysis, the only constituents of concern in the waste stream are the ammonium hydroxide and its subsequent conversion product, nitrate.

As seen in table 8, the high dilution factor from the river results in predicted maximum river concentrations that are far below any regulatory concern.

LEACHING OF SORBED SPECIES FROM SOIL COLUMN

The effect of a clean water leach of the same discharge rate (13,100 L/h) to the A-36B Crib after equilibrium concentrations in the soil column are reached was also modeled. This scenario was evaluated for the past operations case. Nitrate concentrations in the aquifer at the crib boundary begin to drop within about 75 d. Concentrations at the future control zone boundary start to drop within about 650 d. Within 730 d, the nitrate concentration falls below the drinking water limit at the future control zone (DOE 1986). The concentrations do not decrease sooner because of an estimated 31,000 kg of converted nitrates in the soil column when the discharge was discontinued.

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APPENDIX

WASTE DESIGNATION FORM

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Disposal Request Number_____ Date_____

Material_____ Physical state_____
Density_____
Composition_____ pH_____
_____ flash point_____
_____ Total waste quantity (kg)_____
_____ Containers_____
_____ Waste Status_____
_____ RQ (kg)_____ Reportable?___

WASTE DESCRIPTION AND CHARACTERISTICS

Discarded Chemical Product? ☐ yes ☐ no Designation:_____

Dangerous Waste Source? ☐ yes ☐ no Designation:_____

Toxic?_____ E.C.____ ☐ EHW WT01 (EC >.01)
_____ ☐ DW WT02 (EC ≥.001)
_____ ☐ no (EC <.001 , no applic data)
_____

Persistent? ☐ yes ☐ no ☐ EHW WP01 (HH >1%)
☐ DW WP02 (HH >.01%)
☐ EHW WP03 (PAH >1%)

Carcinogenic? ☐ yes ☐ no (IARC only) ☐ EHW WC01 (positive >1%)
☐ DW WC02 (positive >.01%, susp. >1%)

Ignitable? ☐ yes ☐ no ☐ DW D001 (fp <140 F)
☐ flammable (fp <100 F)
☐ combustible (fp 100-200 F)
☐ oxidizer

Corrosive? ☐ yes ☐ no ☐ DW D002 (pH ≤2 or ≥12.5)

Reactive? ☐ yes ☐ no ☐ DW D003

EP Toxic? ☐ yes ☐ no Designation:_____

* *

Waste Class:_____ Waste Numbers:_____

US DOT Proper Shipping Name_____
Hazard Class_____
ID #_____
Labels_____ Package reference_____

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Number of Copies

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