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NPL CANDIDATE

Update #

Received SEP 17 87

Facility name: U.S. DOE Hanford 200 Area

Location: Hanford Site

EPA Region: X

Person(s) in charge of the facility: J. J. Keating, Asst. Mgr.
Safety, Environment and Security
509 - 376 - 7334

Name of Reviewer: D. M. Bennett, EPA Region X Date: 8/18/87

General description of the facility:
(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

The 200 Area site contains the 216-A-1, 216-A-2, 216-A-4, 216-A-5, 216-A-6, 216-A-7, 216-A-9, 216-A-11, 216-A-12, 216-A-13, 216-A-14, 216-A-15, 216-A-16, 216-A-17, 216-A-18, 216-A-19, 216-A-20, 216-A-21, 216-A-22, 216-A-23A, 216-A-23B, 216-A-24, 216-A-26A, 216-A-27, 216-A-28, 216-A-31, 216-A-32, 216-A-33, 216-A-34, 216-A-35, 216-A-36A, 216-A-39, 216-A-40, 216-A-41, 216-B-2-1, 216-B-2-2, 216-B-3-1, 216-B-3-2, 216-B-4, 216-B-5, 216-B-6, 216-B-7A&B, 216-B-8, 216-B-9,

Scores: S_M = 69.05 (S_{gw} = 79.59 S_{sw} = 89.09 S_a = 0.00)

S_{FE} = 0.00

S_{DC} = 0.00

FIGURE 1
HRS COVER SHEET

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NPL-UY-2-23

National Priorities List

Superfund hazardous waste site listed under the
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended in 1986

HANFORD 200-AREA (USDOE)
Benton County, Washington

The Hanford 200-Area is in the middle of the 570-square-mile-Hanford Site approximately 20 miles north of the City of Richland, Benton County, Washington. Since 1943, Hanford has been the scene of Federal nuclear activities, primarily production of nuclear materials for national defense.

The U.S. Department of Energy (USDOE) uses the 200-Area for nuclear fuel reprocessing, finishing, and waste management. Over 230 waste disposal locations have been identified in the 200-Area. The disposal locations and plumes of contaminated ground water cover approximately 215 square miles.

An estimated 1 billion cubic yards of solid and dilute liquid wastes comprised of radioactive, mixed and hazardous constituents were disposed of in trenches, ditches, and landfills in the 200-Area. USDOE has detected tritium, iodine-129, uranium, cyanide, and carbon tetrachloride at levels significantly above background in ground water beneath the area. Over 2,500 people obtain drinking water from wells within 3 miles of the 200-Area. Tritium has been detected in Richland's surface water intakes at levels above background. Surface water within 3 miles of the 200-Area provides drinking water to 70,000 people and irrigates over 1,000 acres.

EPA, USDOE, and the Washington Department of Ecology are jointly developing an action plan that will include the work needed to address this area under the Superfund program, as well as other work needed to meet permitting, corrective action, and compliance requirements of Subtitle C of the Resource Conservation and Recovery Act.

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NPL CANDIDATE

Update #

Received: SEP 14 1987

Facility name: U.S. DOE Hanford 200 Area

Location: Hanford Site

EPA Region: X

Person(s) in charge of the facility: J. J. Keating, Asst. Mgr.
Safety, Environment and Security
509 - 376 - 7334

Name of Reviewer: D. M. Bennett, EPA Region X Date: 8/18/87

General description of the facility:
(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

The 200 Area site contains the 216-A-1, 216-A-2, 216-A-4, 216-A-5, 216-A-6, 216-A-7, 216-A-9, 216-A-11, 216-A-12, 216-A-13, 216-A-14, 216-A-15, 216-A-16, 216-A-17, 216-A-18, 216-A-19, 216-A-20, 216-A-21, 216-A-22, 216-A-23A, 216-A-23B, 216-A-24, 216-A-26A, 216-A-27, 216-A-28, 216-A-31, 216-A-32, 216-A-33, 216-A-34, 216-A-35, 216-A-36A, 216-A-39, 216-A-40, 216-A-41, 216-B-2-1, 216-B-2-2, 216-B-3-1, 216-B-3-2, 216-B-4, 216-B-5, 216-B-6, 216-B-7A&B, 216-B-8, 216-B-9,

Scores: S_M = 69.05 (S_{gw} = 79.59 S_{sw} = 89.09 S_a = 0.00)

S_{FE} = 0.00

S_{DC} = 0.00

FIGURE 1
HRS COVER SHEET

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1/12/88
Kathleen Dalkey

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216-B-10A, 216-B-10B, 216-B-11A&B, 216-B-12, 216-B-13, 216-B-14,
216-B-15, 216-B-16, 216-B-17, 216-B-18, 216-B-19, 216-B-20, 216-B-21,
216-B-22, 216-B-23, 216-B-24, 216-B-25, 216-B-26, 216-B-27, 216-B-28,
216-B-29, 216-B-30, 216-B-31, 216-B-31, 216-B-32, 216-B-33, 216-B-34,
216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-40, 216-B-41, 216-B-42,
216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49,
216-B-50, 216-B-51, 216-B-52, 216-B-53A, 216-B-53B, 216-B-54, 216-B-57
216-B-58, 216-B-60, 216-C-1, 216-C-3, 216-C-4, 216-C-5, 216-C-6,
216-C-8, 216-C-10, 218-E-1, 218-E-2, 218-E-2A, 218-E-3, 218-E-4,
218-E-5, 218-E-5A, 218-E-6, 218-E-7, 218-E-8, 218-E-9, 218-E-12A,
218-E-13, 218-E-14, 200 East Burning Pit, 200 East Construction Pit,
216-N-1, 216-N-2, 216-N-3, 216-N-4, 216-N-5, 216-N-6, 216-N-7,
216-S-1&2, 216-S-3, 216-S-4, 216-S-5, 216-S-6, 216-S-7, 216-S-8,
216-S-9, 216-S-11, 216-S-12, 216-S-13, 216-S-14, 216-S-15, 216-S-16P,
216-S-16D, 216-S-17, 216-S-18, 216-S-20, 216-S-21, 216-S-22, 216-S-23,
216-T-2, 216-T-3, 216-T-4-1(D), 216-T-4-1(P), 216-T-4-2(D), 216-T-5,
216-T-5, 216-T-6, 216-T-7, 216-T-8, 216-T-9, 216-T-10, 216-T-11,
216-T-12, 216-T-13, 216-T-14, 216-T-15, 216-T-16, 216-T-17, 216-T-18,
216-T-19, 216-T-20, 216-T-21, 216-T-22, 216-T-23, 216-T-24, 216-T-24,
216-T-25, 216-T-26, 216-T-27, 216-T-28, 216-T-29, 216-T-30, 216-T-31,
216-T-32, 216-T-33, 216-T-34, 216-T-35, 216-T-36, 216-U-1&2, 216-U-2,
216-U-3, 216-U-4, 216-U-4A, 216-U-4B, 216-U-5, 216-U-6, 216-U-7,
216-U-8, 216-U-9, 216-U-11, 216-U-13, 216-U-15, 216-U-15, 216-Z-1A,
216-Z-1(D), 216-Z-1&2, 216-Z-3, 216-Z-4, 216-Z-5, 216-Z-6, 216-Z-7,
216-Z-8, 216-Z-9, 216-Z-10, 216-Z-11, 216-Z-12, 216-Z-16, 216-Z-17,

FIGURE 1 (Continued)
HRS COVER SHEET

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KRD

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216-Z-18, 218-W-1, 218-W-1A, 218-W-2, 218-W-3, 218-W-4A, 218-W-7, 218-W-8, 218-W-9, 218-W-11, Non-Rad Burial Ground, 200-West Burning Pit Z-Plant Burning Pit, 618-10, 618-11, P-11 Crib, 213 J and K Cribs, J. A. Jones No. 1, Original Central Landfill. The above 600 numbered sites were included in the 200 Area because they are located within the defined boundaries of the 200 Area. The ground water and surface water are the routes of major concern. The individual sites listed above are either surface impoundments (i.e., trenches or ditches) or landfills (i.e., land disposal). The 200 Area is located approximately 20 miles north of the City of Richland.

FIGURE 1 (Continued)
HRS COVER SHEET

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HRS Ground Water Route Work Sheet

Site: U.S. DOE Hanford 200 Area 8/18/87

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	45	1	45	45	3.1
If observed release is given a score of 45, proceed to line 4. If observed release is given a score of 0, proceed to line 2.					
2. Route Characteristics					3.2
Depth to Aquifer of Concern	0	2	0	6	
Net Precipitation	0	1	0	3	
Permeability of the Unsaturated Zone	0	1	0	3	
Physical State	0	1	0	3	
Total Route Characteristics Score			0	15	
3. Containment	0	1	0	3	3.3
4. Waste Characteristics					3.4
Chemical					
a. Toxicity/Persistence	18	1	18	18	
Hazardous Waste Quantity	8	1	8	8	
Total Waste Characteristics Score			26	26	
5. Targets					3.5
Ground Water Use	3	3	9	9	
Distance to Nearest Well/ Population Served	30	1	30	40	
Total Targets Score			39	59	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)			45630	57330	
7. Line 6/57330 * 100	Sc(gw)=	79.59			

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HRS Surface Water Route Work Sheet

Site: U.S. DOE Hanford 200 Area 8/18/87

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	45	1	45	45	4.1
If observed release is given a score of 45, proceed to line 4. If observed release is given a score of 0, proceed to line 2.					
2. Route Characteristics					4.2
Facility Slope & Intervening Terrain	0	1	0	3	
1-yr. 24-hr. Rainfall	0	1	0	3	
Distance to Nearest Surface Water	0	2	0	6	
Physical State	0	1	0	3	
Total Route Characteristics Score			0	15	
3. Containment	0	1	0	3	4.3
4. Waste Characteristics					4.4
a. Chemical					
Toxicity/Persistence	18	1	18	18	
Hazardous Waste Quantity	8	1	8	8	
Total Waste Characteristics Score			26	26	
5. Targets					4.5
Surface Water Use	3	3	9	9	
Distance to a Sensitive Environment	0	2	0	6	
Population Served/Distance to Water Intake Downstream	40	1	40	40	
Total Targets Score			49	55	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)		57330	64350		

7. Line 6/64350 * 100 Sc(sw)= 89.09

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HRS Air Route Work Sheet

ROUTE NOT SCORED

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	0	1	0	45	5.1
Date and Location:					
Sampling Protocol:					

If observed release is given a score of 45, proceed to line 2.
If observed release is given a score of 0, the Sa=0. Enter on Line 5.

2. Waste Characteristics					5.2
a. Chemical Reactivity and Incompatibility	0	1	0	3	
Toxicity	0	3	0	9	
Hazardous Waste Quantity	0	1	0	8	
Total Waste Characteristics Score			0	20	
3. Targets					5.3
Population Within 4-Mile Radius	0	1	0	30	
Distance to Sensitive Environment	0	2	0	6	
Land Use	0	1	0	3	
Total Targets Score			0	39	
4. Multiply 1 x 2 x 3			0	35100	

5. Line 4/35100 * 100 Sc(a)= 0.00

1/12/88

	S	S^2
Groundwater Route Score (S_{gw})	79.59	6334.57
Surface Water Route Score (S_{gw})	89.09	7937.03
Air Route Score (S_a)	0.00	0.00
$S_{gw}^2 + S_{sw}^2 + S_a^2$	-	14271.60
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$	-	119.46
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} / 1.73 = S_M =$		69.05

FIGURE 10
WORKSHEET FOR COMPUTING S_M

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DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUMENTATIONS: As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludge"). The source of information should be provided for each entry and should be a bibliographic-type reference, include the location of the document.

FACILITY NAME: U.S. DOE Hanford Site - 200 Area

LOCATION: Hanford Site, Benton County, Washington

DATE SCORED: August 18, 1987

PERSON SCORING: R. D. Stenner, Pacific Northwest Laboratory for DOE

PRIMARY SOURCE(S) OF INFORMATION (e.g., EPA region, state, FIT, etc.):

The information was taken from Department of Energy documents and databases associated with the Hanford site, as well as from other publicly available documents addressing conditions at or in the vicinity of the Hanford Site. Information was also gathered through telephone and personal communications with responsible individuals (such information is referenced accordingly in the package).

FACTORS NOT SCORED DUE TO INSUFFICIENT INFORMATION:

Even though air concentrations of some of the constituents of interest can be detected above background offsite, no air monitoring data was found sufficient for HRS scoring of the Hanford CERCLA sites. These constituents of interest detected above background offsite are present in the routine gaseous effluents from operating facilities at Hanford. Therefore, the air route rating factors were not scored.

COMMENTS OR QUALIFICATIONS:

The Department of Energy has completed a preliminary assessment of the hazardous waste sites located on the Hanford Site. This work served as the primary basis of developing the scores for the aggregate 200 Area Site. These preliminary assessment efforts are documents in the "Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford" volumes and respective addenda which are referenced throughout this package.

QA
1/12/88
Kathe T. Halloy

9113218.0223

GROUND WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected (5 maximum):

An observed release to the ground water from the 200 Area can be verified using several selected constituents. For the purpose of documenting observed release from the 200 Areas, five substances have been selected. These substances are tritium (H-3), iodine-129 (I-129), uranium (U), cyanide (CN^-) and carbon tetrachloride (CCl_4). The Hanford Ground Water Data Base lists carbon tetrachloride as tetrane. Five substances were selected for evidence of observed release due to the variety of chemical processes utilized within the 200 Area. Tritium and I-129 are included as indicators of maximum areal extent of contamination while uranium, cyanide and carbon tetrachloride are included to identify isolated contaminant plumes associated with individual processes. Comparison of background and down gradient concentrations can be illustrated for each of the constituents selected. The following tables present the data for each of the constituents and their background and down gradient concentrations.

200 Area Concentrations for Tritium

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (pCi/L)	Date	Well	Concentration (pCi/L)
2/4/86	6-25-55	-320[a]	3/13/86	6-35-70	1,600,000
			2/4/86	6-37-43	22,000
			3/5/84	481 Bldg Tap	35,400

(a) The negative value means that the concentration is less than detection limit.

200 Area Concentrations for Iodine-129

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (pCi/L)	Date	Well	Concentration (pCi/L)
5/29/86	6-25-55	0.000094	6/6/86	699-32-22	4.89

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200 Area Concentrations for Uranium

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (pCi/L)	Date	Well	Concentration (pCi/L)
2/3/87	6-55-89	1.06	3/11/87	2-W19-3	14,900
			7/22/87	2-W19-9	2748

200 Area Concentrations for Cyanide

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (μg/L)	Date	Well	Concentration (μg/L)
3/25/87	6-51-75	< 10	3/19/87	6-50-53	405

200 Area Concentrations for Carbon Tetrachloride

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (μg/L)	Date	Well	Concentration (μg/L)
3/25/87	6-51-75	< 10	3/16/87	2-w10-4	2000
2/4/87	6-25-55	< 10			

Additional well locations have been identified that contain these constituents, but further evidence of observed release is unnecessary.

Reference 2, page 3.14; Reference 7, pages 92, 144,220, 229, 232, 238, 248, 252, 254, 259; Reference 8, 481 Bldg Tap Water Sample Report; Reference 22; Reference 23; Reference 24; Reference 25; Reference 26; Reference 27

Rationale for attributing the contaminants to the facility:

The rationale for attributing the five substances to the 200 Area requires a brief discussion of each constituent. Tritium and Iodine-129 are fission products that are released as a result of irradiated fuel reprocessing. Both of these constituents are highly mobile in the Hanford environment and are used as indicators of extent of contamination. Localized uranium contamination in the 200 Area is due to the uranium recovery operation performed at U-Plant. Use of ferrocyanide, a complex cyanide compound, to precipitate cesium during uranium recovery operations has also been documented. Carbon tetrachloride was used in a solvent extraction process in the plutonium finishing plant. Spent solvent from the process was subsequently disposed of into adjacent facilities. The concentrations shown in the above tables for down gradient wells are significantly higher than the concentrations shown for the back ground wells.

Reference 2, page 3.18-3.20, Reference 1, page 2.20, 2.22-2.23, 3.10; Reference 21, pages 637-638, 369-370

1/12/88 RCA

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifer(s) of concern:

The aquifer of concern is comprised of the unconfined aquifer and the Rattlesnake Ridge interbed.

In general, the unconfined or water table aquifer is located in the Ringold Formation and glacio fluvial sediments known as the Hanford Formation, as well as some more recent alluvial sediments in areas adjacent to the Columbia River. It is bounded below by either the basalt surface or, in places, the relatively impervious clays and silts of the lower unit of the Ringold Formation. Laterally, the unconfined aquifer is bounded by the anticlinal basalt ridges that ring the basin. The Yakima and Columbia Rivers, however, do not entirely transect these sediments and therefore do not constitute a discontinuity for HRS scoring purposes. The basalt ridges above the water table have a low permeability and act as a barrier to lateral flow of the ground water. The saturated thickness of the unconfined aquifer is greater than 61 m in some areas of the Hanford Site and pinches out along the flanks of the basalt anticlines.

There is a series of confined aquifers in the interflow zones and interbeds between the dense basalt flows that underlie the sediments containing the unconfined aquifer. When postglacial flood waters and the ancestral Columbia River flowed between Gable Mountain and Gable Butte, which are part of the Umtanum-Gable anticline, portions of the Elephant Mountain basalt flows separating the unconfined or confined aquifers were eroded creating "windows" to the lower beds. Later the water table rose to levels exceeding the potentiometric surface of the upper confined aquifer, i.e., the Rattlesnake Ridge aquifer. Thus, these erosional windows provide direct connection between the unconfined and Rattlesnake Ridge aquifers. In this area, the Rattlesnake Ridge interbed begins at 166 feet and ends at 216 feet below ground surface. Well 699-35-70, which has an observed release for tritium, has a first screened depth of 235 feet which is part of the aquifer of concern.

Several other aquifers lie below the Rattlesnake Ridge interbed including the Selah, Cold Creek and Mabton. Borings in the Gable Mountain, Gable Battle area, which support the existence of the erosional windows, do not conclusively demonstrate whether other interbeds besides the Rattlesnake are connected to the unconfined aquifer. Although sampling of the confined aquifers shows that iodine 129 is present at depths of 1,400 feet below ground surface, the data supporting these findings are insufficient to determine whether the iodine is present in the interbeds as a result of migration or as a result of contamination introduced during drilling. Therefore, further study is necessary to determine the degree of interconnection.

Reference 2, page 2.1-2.7; Reference 13, page 3.13, Reference 31; Reference 35

1/12/88 LEB

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Depth(s) from the ground surface to the highest seasonal level of the saturated zone [water table(s)] of the aquifer of concern:

Not applicable.

Depth from the ground surface to the lowest point of waste disposal/storage:

Not applicable.

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Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Not applicable.

Mean annual lake or seasonal evaporation (list months for seasonal):

Not applicable.

Net precipitation (subtract the above figures):

Not applicable.

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Not applicable.

Permeability associated with soil type:

Not applicable.

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

Not applicable.

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3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Not applicable.

Method with highest score:

Not applicable.

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:

The 200 Area is used to process irradiated uranium fuel to recover plutonium. The area is also used to process and store waste generated during fuel processing. Substances associated with the 200 Area activities are:

dibutyl butyl phosphonate	tributyl phosphate
nitric acid	sodium dichromate
kerosene	ammonium carbonate
phosphates	sodium oxalate
sulfuric acid	ferrocyanide
fluoride	sodium silicate
sodium aluminate	sodium nitrite
methyl isobutyl ketone (MIBK)	ferrous sulfamate
aluminum fluoride nitrate	carbon tetrachloride
calcium nitrate	aluminum nitrate
magnesium nitrate	ferric nitrate
H-3	Co-60
Sr-90	Ru-106
Cs-137	Pu-239
Pu-240	uranium

Reference 1, pages 2.15-2.23; Reference 21, pages 213-662. (These pages from Reference 21 are not included in the package. Please consult the referenced document using the list of individual sites listed on the cover sheet of this package for verification of which individual sites contain which substances.) Also, see Table 1.

1/12/88
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Compound with highest score:

Several of the constituents listed above are assigned scores of 18. For example:

Constituent	Toxicity	Persistence	Total Score
Plutonium-239	3	3	18
Plutonium-240	3	3	18
Uranium	3	3	18
Sodium dichromate	3	3	18

Reference 4, pages 794-797 ; Reference 40.

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

The total waste quantity associated with the aggregate 200 Area is at least 935,149,000 cubic yards. Table 1 presents the individual liquid sites that are located within the physical confines of the 200 Area fences and the associated data that were used in creating the aggregate 200 Area Site. Table 2 presents the solid waste sites located within the physical confines of the 200 Area fences and their associated data. Also presented in Table 2 are several individual sites and their associated data that are physically located outside of the 200 Area fences, but located within the defined boundaries of the aggregated 200 Area Site. The total quantity of waste associated with the sites listed in Table 1 and Table 2 is 935,000,000 cubic yards and 149,000 cubic yards, respectively.

References are listed in Tables 1 and 2 by waste site, Reference 37.

Basis of estimating and/or computing waste quantity:

The 200 Area is used to process irradiated uranium fuel for the recovery of plutonium. Additionally the 200 Area is used to process and store waste. There are eight different operational areas within the aggregate 200 Area, PUREX Plant, B Plant, Semiworks and Critical Mass Laboratory, 200 North Area, REDOX Plant, T Plant, Plutonium Finishing Plant (PFP) (formally known as Z Plant). These eight operational areas are individually described below.

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Revised 2/9/88
KCD

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TABLE 1. Basis of Estimating and/or Computing Waste Quantity - 200 Areas

Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area acidic process condensate disposal cribs, 216 series, Nos. A-5, A-15, C-1, C-6, C-10, S-1 & 2, S-7, S-9, S-23 and U-8 (8 areas)	Process condensate waste water containing nitric acid (pH~2), H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1952-1972	2,680,000,000	3,510,000	1, pages B.15 and B.17; 21, pages 219, 220, 235, 236, 401, 402, 409, 410, 465, 466, 475, 476, 479, 480, 505, 506, 597, and 598
200 Area Bismuth Phosphate Plant first cycle waste trenches, 216 series, Nos. B-35 through B-41, T-14 through T-17 and T-21 through T-25 (16 cribs)	First cycle waste contained sodium salts, fluoride, nitrate, sulfate phosphate, aluminate and radionuclides, H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1953-1954	34,100,000	44,600	1, pages B.15 and B.17; 21, pages 353-365, 535-542 and 549-458
200 Area Bismuth Phosphate Second Cycle and 224 Waste Cribs, 216 series, Nos. B-5, B-7A and B, B-8, T-3, T-5, T-6, T-7 and T-32	Second cycle and 224 waste contained sodium salts, fluoride, oxalate, nitrate, sulfate phosphate, ammonium nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1945-1955	299,000,000	391,000	1, pages B.15 and B.17; 21, pages 291, 292, 295, 296, 297, 298, 509, 510, 517-522, 571 and 572

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 North Area basin water ponds and cribs, 216 series, Nos. N-1 through N-7 (7 areas)	Fuel storage basin water containing radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1944-1952	2,870,000,000	3,760,000	21, pages 449-462
200 Area scavenged TBP supernatant waste cribs and trenches, 216 series, Nos. B-14 through B-34, B-42 through B-49, B-51, B-52, T-18 and T-26 (33 areas).	Scavenged TBP waste contained sodium salts, nitrate, sulfate, phosphate, and ferrocyanide and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1953-1958	167,000,000	219,000	1, pages B.15 and B.17; 21, pages 311-352, 367-382, 385, 386, 387, 388, 543, 544, 559, 560
200 Area tributyl phosphate solvent waste cribs, 216 series, Nos. A-2, A-7, A-31, C-4 and U-15 (5 cribs)	Tributyl phosphate solvent wastes contained tributyl phosphate and a paraffin hydrocarbon solvent and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1955-1966	682,000	893	1, pages B.15 and B.17; 21, pages 215, 216, 223, 224, 263, 264, 405, 406, 605 and 606

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area ammonia scrubber and alkaline condensate waste cribs, 216 series, Nos. A-36A, B-12, B-50, S-3, S-12 and S-21 (6 cribs)	Ammonia scrubber and alkaline condensate wastes contained ammonium nitrate (except S-3) and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238. Wastes disposed to 216-S-3 contained sodium salts of dichromate, nitrate, aluminate and hydroxide.	1952-1973	667,000,000	873,000	1, pages B.15 and B.17; 21, pages 273, 274, 307, 308, 383. 384, 483 and 484.
200 Area analytical laboratory liquid waste cribs, 216 series, Nos. A-4, A-21, A-27, B-6, B-10A, T-2 and T-8 (7 cribs)	Laboratory waste contained nitric acid and sulfuric acid (neutralized with NaOH at 'A' cribs) and sodium dichromate. Radionuclides include Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1945-1970	130,000,000	170,000	1, pages B.15 and B.17; 21, pages 217, 218, 247, 248, 259, 260, 293, 294, 301, 302, 507, 508, 523 and 524.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area steam condensate and/or cooling water disposal areas, 216 series, Nos. A-11, A-12, A-32 through A-35, A-40, S-5, S-6, S-16P, S-16D, S-17, T-4-1(D), T-4-1(P), U-9, U-11, Z-1(D), Z-11, T-4-2 (19 areas)	Steam condensate and/or cooling water containing nitrate and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1944-1979	98,600,000,000	129,000,000	1, pages B.15 and B.17; 21, pages 227, 228, 229, 230, 265 through 272, 277, 278, 471, 472, 473, 474, 491, 492, 493, 494, 495, 496, 511, 512, 513, 514, 599, 600, 601, 602, 609, 610, 629, 630, 515, 516.
200 Area Z Plant waste water disposal areas, 216 series, Nos. Z-1A, Z-142, Z-3 and Z-12 (4 areas)	Z Plant waste water contained sodium nitrate, fluoride, and radionuclides Pu-239, Sr-90, Cs-137 and U-138.	1949-1973	499,000,000	653,000	1, page B.17; 21, pages 607, 608, 611, 612, 613, 614, 631 and 632.

Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area plutonium recovery plant waste water cribs, 216-Z-9 and 216-Z-18.	Plutonium recovery plant waste water contains sodium salts, nitrate, sulfate, aluminum fluoride nitrate, aluminum nitrate, magnesium nitrate and calcium nitrate. The waste discharged to the 216-Z-18 also contained carbon tetrachloride, tributyl phosphate and dibutyl butyl phosphorate. Radionuclides include Pu-239 in both cribs and Sr-90, Cs-137, Co-60 and U-238 in 216-Z-9.	1955-1973	7,950,000	10,400	1, page B.17; 21, pages 625, 626, 637 and 639.
200 Area caustic waste areas, 216-T-33, 216-T-36 and 216-Z-8.	Caustic waste water containing sodium hydroxide and radionuclides Pu-239 in all three areas and Sr-90, Cs-137, Co-60 and U-238 in 216-T-33 and 216-T-36.	1955-1969	2,430,000	3,180	1, page B.17; 21, pages 573, 574, 579, 580, 623 and 624.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area chemical sewer areas, 216-B-21, 216-B-2-2 and 216-S-11.	Chemical sewer discharged unknown quantities of chemicals plus radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1945-1965	304,000,000,000	398,000,000	1, pages B.15 and B.17; 21, pages 282, 283, 284, 285, 481 and 482.
200 Area cribs that received 300 Area crib waste, 216 series, Nos. B-53A, B-53B, B-54, T-27, T-34 and T-35 (7 cribs)	300 Area crib waste contained nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1962-1967	31,800,000	41,000	1, pages B.15 and B.17; 21, pages 389-394, 561, 562, 575, 576, 577 and 578.
200 Area A-Tank Farm condensate crib, 216-A-24	A-Tank Farm condensate contained butyl phosphates, paraffin hydrocarbon, ammonium carbonate and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1958-1966	820,000,000	1,020,000	1, page B.15; 21, pages 255 and 256.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area Redox hexone-bearing wastes, 216-S-13 and 216-S-14	Sodium hexone-bearing wastes containing methyl isobutyl ketone and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238. In addition to the above, waste disposed to 216-S-13 contained aqueous sodium nitrate and sodium dichromate.	1951-1972	5,010,000	6,560	1, page B.17; 21, pages 485, 486, 487 and 488.
200 Area, 221-U, 222-U and 224-U liquid wastes disposed to 216-U-142 and 216-U-4A cribs	U Area wastes containing sodium nitrate and sodium phosphate and radionuclides U-238, Sr-90, Cs-137, Co-60 and Pu-239. Crib 216-U-1 & 2 also received sodium sulfate.	1951-1970	160,000,000	209,000	1, page B.17; 21, pages 581, 582, 587 and 588.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area miscellaneous liquid wastes, 216 series, A-1, A-6, A-9, A-13, A-14, A-16, A-17, A-18, A-19, A-20, A-22, A-23A, A-23B, A-26A, A-28, A-39, A-41, B-3-1, B-3-2, B-4, B-9, B-10B, B-11A & B, B-13, B-57, C-3, C-5, C-8, S-4, S-8, S-15, S-18, S-20, S-22, T-9, T-10, T-11, T-12, T-13, T-20, T-28, T-29, T-30, U-3, U-4, U-4B, U-5, U-6, U-7, U-13, Z-4, Z-5, Z-6, Z-10, Z-16, Z-17 (55 areas)	Miscellaneous wastewaters containing nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60, and U-238. In addition, areas 216-A-9. 216-S-4. and 216-T-30 received H-3.	1945-1979	303,000,000,000	397,000,000	1, pages B.15 and B.17; 21, pages 213, 214, 221, 222, 225, 226, 231-234, 237-246, 249-258, 261, 262, 275, 276, 279, 280, 285-290, 299,300, 303-306, 309, 310, 395, 396, 403, 404, 407, 408, 411, 412, 469, 470, 477, 478, 489, 490, 497-500, 503, 504, 525-534, 547, 548, 563-570, 583-586, 589-596, 603, 604, 615-620, 627, 628 and 633-636.
			TOTAL	935,000,000 yd^3	

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TABLE 2. Basis of Estimating and/or Computing Waste Quantity - 200 Areas

Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
200 Area dry waste burial site, 218 series, Nos. E-1, E-2, E-3, E-5, E-6, E-7, E-8, E-12A, W-1, W-2, W-3, W-4A, W-7 and W-8	Dry waste containing radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1944-1968	2,960,000	110,000	1, pages B.15 and B.17; 21, pages 415-418, 421, 422, 425, 426, 429-434, 437, 438, 639, 640, 643-652. 5, Section I NW; and 6.
200 Area regulated equipment burial site, 218 series, Nos. E-2A, E-5A, E-9, E-14, W-1A, W-9 and W-11	Discarded process equipment containing radionuclides SR-90, Pu-239, Cs-137 and U-235.	1944-1964	960,000	36,000	1, pages B.15 and B.17; 21, pages 419, 420, 427, 428, 435, 436, 441, 442, 639, 640, 653, 654, 655 and 565; 5, Sections I NW, I SE; and 6.
200 Area repair and construction waste burial sites 218-E-4 and 218-E-13.	Repair and construction waste containing radionuclides SR-90, Pu-239, Cs-137 and U-238.	1955-1966	58,400	2,200	1, pages B.17; 21, pages 423, 424, 439 and 440; 5, Section I NW.

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Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
200 Area burning pits 200E, 200W, and Z Plant	200E and 200W received construction and office wastes plus paint waste and chemical solvents. Z Plant received office and laboratory waste.	1950-1970	21,500	800	1, pages B.15 and B.17; 21, pages 443, 444, 659, 660, 661 and 662
200 Area nonradioactive repair and construction waste burial sites, construction pit and nonradioactive burial ground	Construction pit received broken concrete and the nonradioactive burial ground received unusable plumbing materials. No radioactive waste was deliberately buried at these sites.	1945-1955	No data	No data	1, pages B.15 and B.17; 21, pages 445, 446 657 and 658.
600 Area dry waste burial sites 618-10 and 618-11	Dry waste containing Sr-90, Pu-239, Cs-137 and U-238	1953-1967	No data	No data	1, page B.21; 21, pages 693-696.
P-11 crib	Waste water containing Pu-239. Site has been exhumed.	1951-1951	No data	No data	1, page B.21; 21, pages 701 and 702.
213 J and K cribs	Drainage from plutonium storage vaults. No Pu-239 had been detected in piping. Cribs exhumed.	1944-1950	No data	No data	1, page B.21; 21, pages 703-704.

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Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
Miscellaneous nonradioactive burial sites, J. A. Jones No. 1 and Original Central Landfill	Miscellaneous nonradioactive wastes. No known chemical disposal.	1973-1979	Unknown quantity.	Unknown quantity.	1, page B.21; 21, pages 705, 706, 711 and 712. 38, pages 1 and 2
			TOTAL	149,000	

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PUREX Plant. The Plutonium URanium EXtraction (PUREX) Plant is the most recently constructed of the irradiated-fuel processing plants. Constructed between April 1953 and October 1955, the PUREX Plant took over fuel-processing operations from the REDuction OXidation (REDOX) Plant. The PUREX Plant was operated from 1956 to 1972; in 1972 it was placed in operational standby mode. Plant operations were resumed in 1983.

At this facility, uranium, plutonium, and neptunium are separated from fission products found in the production reactors' irradiated uranium fuel. The process steps involve fuel-element decladding, uranium metal dissolution, solvent extraction, ion exchange, and product loadout.

Zirconium cladding on fuel elements is removed in an ammonium fluoride-ammonium nitrate (AFAN) solution. Ammonium fluoride reacts with the zirconium, resulting in a soluble zirconium compound. The ammonia and hydrogen evolved during decladding present a potential combustion hazard. Therefore, hydrogen is converted to ammonia by reaction with ammonium nitrate present in the AFAN solution. The dissolver solution is then processed to remove plutonium and uranium that dissolved with the cladding. Gas released from the dissolver is treated to remove iodine in a silver reactor, is acid-adsorbed, and is only then released to the atmosphere. The off-gases are treated with hydrogen peroxide to remove nitrogen oxides before being released to the atmosphere.

Declad fuel elements are dissolved in nitric acid for the solvent extraction processes. An organic solvent is used to separate the uranium, plutonium, and neptunium from associated fission products and from each other. The organic solvent used in a series of extraction and stripping operations is a 30% solution of tributyl phosphate in a normal paraffin hydrocarbon (kerosene) diluent.

The first extraction cycle separates the bulk of the fission products from the plutonium, uranium, and neptunium; the fission products remain in the aqueous phase. The organic phase is sent to the partitioning cycle where the plutonium is partitioned from the uranium and neptunium. The plutonium stream is routed through two additional solvent-extraction cycles for further purification. After purification, the plutonium stream is concentrated.

From 1956 to 1972, the concentrated plutonium nitrate solution was sent to the plutonium finishing operations located in the 200-West Area. When the PUREX Plant resumed operations in 1983, an additional facility was added that produced plutonium oxide from the plutonium nitrate.

The other stream from the partition cycle, which bears the neptunium and uranium, is routed to the final uranium cycle where neptunium is separated. The aqueous neptunium stream is sent to the back-cycle waste system for concentration and recycling to the solvent-extraction column. The uranium stream is routed to a column that strips the uranium from the organic stream with an aqueous nitric acid solution; concentration of the aqueous solution follows. The uranium product, uranyl nitrate hexahydrate (UNH), is then stored in tanks until it is shipped to the UO_3 plant in the 200-West Area.

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A portion of the concentrated neptunium solution from the final uranium cycle is sent to the neptunium recovery and purification cycle. In this cycle, neptunium is separated from the uranium, plutonium, and the remaining fission products in the neptunium stream. This separation is accomplished by a series of extractions and ion-exchange columns. The plutonium and uranium fractions are recycled to the back-cycle waste system and partitioning cycle, respectively.

Supporting process systems include organic solvent decontamination and recovery, nitric acid recovery, and waste concentration and recovery.

B Plant. The B Plant, one of the original fuels-separation facilities, was constructed between August 1943 and February 1945; it was operated until 1952. The plant used the bismuth phosphate process to separate plutonium from irradiated uranium fuel. This process produced a very dilute waste stream that contained the uranium and most of the fission products from the fuel elements. Unlike the PUREX process, the bismuth phosphate process separated plutonium from uranium and fission products by precipitating the plutonium onto a bismuth phosphate carrier.

The uranium fuel elements processed by the bismuth phosphate process were jacketed with aluminum. These jackets were removed in a sodium hydroxide-sodium nitrate ($NaOH$-$NaNO_3$) solution, with the $NaNO_3$ acting as a hydrogen scavenger. Some of the silicon used as a binder in the fuel elements was dissolved during jacket removal. This operation produced sodium silicate, sodium aluminate, and sodium nitrite.

After jacket removal, the fuel elements were dissolved in nitric acid; sulfuric acid was then added to complex the uranium. Complexing of uranium prevented it from being precipitated as uranyl phosphate during later plutonium precipitation. The metal solution was pre-treated with sodium nitrite to oxidize or reduce plutonium to the correct state for precipitation. Bismuth phosphate was then added to the metal solution and the resulting slurry was centrifuged. The solid cake was redissolved in nitric acid for further decontamination of the plutonium.

The decontamination involved several dissolutions and subsequent precipitations of plutonium. Sodium bismuthate and sodium dichromate were used as oxidizing agents, and sodium nitrite or oxalic acid was used as a reducing agent during the plutonium decontamination. The final plutonium precipitate was washed with ammonium nitrate.

The next process involved transferring the plutonium from the bismuth phosphate carrier to a lanthanum fluoride carrier. Hydrofluoric acid was used to acidify the transfer solution and cause lanthanum fluoride to precipitate, carrying the plutonium with it. Potassium hydroxide was used to change the lanthanum precipitate into a soluble compound; then the precipitate was dissolved in nitric acid.

The plutonium was then reduced using ammonium sulphate and precipitated as a peroxide by the addition of hydrogen peroxide. The plutonium peroxide was dissolved into nitric acid. This solution was concentrated to produce the

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final plutonium nitrate product, which was originally shipped off site for conversion to plutonium oxide or plutonium metal.

In 1968, the B Plant was converted to a waste-fractionization plant as part of a program to solidify high-level waste. The B Plant now functions to remove cesium and strontium from PUREX current acid waste and from high-level supernatant liquids, as well as sludges from self-boiling liquid waste.

The solids are removed from the current acid waste and treated for strontium removal, and the liquid is treated with phosphotungstic acid to precipitate the cesium. The supernatant liquid is sent to a series of solvent extraction columns, similar to those used at the PUREX Plant, to remove and purify any remaining strontium. The cesium precipitate is redissolved in sodium hydroxide and treated in ion exchange columns for further purification. Liquid from stored waste is treated the same as current acid waste, except that the solids have already separated in the storage tanks. Sludge from the storage tanks and solids from current acid waste are dissolved in an acid solution and sent to the solvent-extraction columns for strontium removal.

Cesium solutions are converted to cesium chloride by the addition of hydrochloric acid. The liquid is evaporated to yield solid cesium chloride. This solid is encapsulated in Hasteloy cylinders and stored in an underwater storage basin at B Plant.

Strontium is precipitated as strontium fluoride by the addition of sodium fluoride. The strontium fluoride is filtered, dried, and encapsulated in Hasteloy cylinders. These cylinders, like the cesium cylinders, are stored in an underwater storage basin at B Plant.

Semiworks and Critical Mass Laboratory. The Semiworks was built in 1949 as a pilot plant for the REDOX Process; it was later converted to pilot the PUREX process. The Semiworks originally operated from 1952 to 1957. In 1960, the Semiworks was reactivated and equipped for the processing and loadout of fission products; it then operated as both a production and a process demonstration pilot project for converting the B Plant to a waste-partitioning facility. In 1967, the Semiworks was shut down, and it is now being decontaminated and decommissioned. Chemical processes at this facility were similar to those at the REDOX and PUREX plants.

At the Critical Mass Laboratory, research focuses on the criticality safety of plutonium in various forms and combinations with other elements. The resulting data are used to verify analytical methods that predict criticality safety for plutonium in various fuel cycles.

200 North Area. The 200 North Area was built for the ageing of "green" fuel (recently irradiated fuel) to allow for the decay of short lived radionuclides before processing the fuel. Irradiated fuel was stored in water basins while the decay process was proceeding. The area was only used during the first several years of operations, when it was discovered that the required fuel ageing time was much shorter than originally predicted. This discovery allowed the use of the 200 Area to be discontinued in 1952. Several of the sites within the 200 North Area only received waste during the pre-retirement cleaning of the basins actually used to store fuel.

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200-West Area Plants

U Plant. Although the U Plant (constructed between 1943 and 1944) was one of the three original fuels-separation facilities designed to use the bismuth phosphate process, it was never used for that purpose.

Uranium was not recovered by the bismuth phosphate extraction of plutonium from irradiated fuel. However, the later-developed REDOX and PUREX processes recovered the uranium, which still had economic value. Following startup of the REDOX Plant, the U Plant was converted to recover the uranium from stored radioactive waste. From 1952 to 1958, stored waste was transferred to the U Plant for uranium recovery. The resultant sludge was dissolved in nitric acid, and then the uranium was extracted using tributyl phosphate in a normal paraffin diluent. This process left the fission products, sulfate, and phosphate ions in the aqueous acid solution. The uranium was then stripped from the organic solvent with nitric acid. This nitric acid solution was concentrated and sent to the uranium oxide process.

Although the uranium recovery processing is no longer going on, the adjacent uranium oxide plant is still operational. This plant received uranyl nitrate solution from the recovery process and from the REDOX Plant and calcined it to uranium trioxide. The uranium oxide plant now processes the product uranium from the PUREX Plant. Nitric acid is recycled to the PUREX process as a by-product of the calcination process. The uranium trioxide is shipped offsite for use as nuclear fuel.

REDOX Plant. The REDOX process for fuels separation succeeded the bismuth phosphate process and preceded the PUREX process. The REDOX Plant was constructed from May 1950 to August 1951; it operated until it was shut down in July 1967. An analytical laboratory near the facility is still operational. This laboratory supports B-Plant operations and performs research and development in support of waste management and environmental control operations. The laboratory also functions as a backup laboratory to the PUREX and Z-Plant analytical laboratories.

The REDOX Plant used a solvent extraction process to separate uranium and plutonium from fission products and each other. Methyl isobutyl ketone (MIBK) was the organic solvent that was used.

The fuel elements were prepared for nitric acid dissolution using the methods from the bismuth phosphate process. Sodium dichromate was added to the nitric acid solvent to oxidize plutonium to a state suitable for organic extraction.

Aluminum nitrate was added to the acid solution as a salting agent for the first extraction column. This salting agent caused the uranium and plutonium to be preferentially extracted by MIBK, leaving the fission products in the aqueous phase. In a second extraction column, a reducing agent was added to the aqueous phase to reduce the plutonium so that it would be removed from the uranium and extracted into the aqueous phase. The organic uranium solution and the aqueous-plutonium solution were then processed separately

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purified further, and concentrated into their respective products; uranium nitrate hexahydrate (UNH) and plutonium nitrate. The plutonium nitrate was sent to the Z Plant for processing into plutonium oxide or plutonium metal. The UNH was sent to the uranium oxide plant.

The organic solvent was treated for recycling by removing decomposition products and by further decontamination. Aqueous streams were concentrated, then the aluminum nitrate was converted to sodium aluminate by sodium hydroxide before disposal.

T Plant. The T Plant was one of the original bismuth phosphate fuels-separation facilities; it was constructed from June 1943 to October 1944 and operated for the bismuth phosphate process from 1944 to 1956. Since 1956, facilities in the T Plant have been used for decontamination and equipment repair.

Z Plant. Constructed in 1949, the Z Plant was the site of the plutonium laboratory and finishing operations, including the processing of plutonium scrap materials and preparation of plutonium products. The plutonium parts preparation ceased in December 1965. A process known as "recouplex" was operated at the plant from 1955 to 1962 to recover plutonium from scrap and produce a plutonium nitrate solution. The Plutonium Reclamation Facility began operations in 1964 to perform the functions of the recouplex process.

The recouplex process used nitric acid and hydrofluoric acid to dissolve solids and a tributyl phosphate-carbon tetrachloride solvent extraction process for recovery of purified plutonium nitrate solutions. Aluminum nitrate was used to salt the aqueous streams for selective extraction of plutonium and to create complexed fluoride ions as aluminum fluoroxide nitrate to prevent their interference during plutonium extraction. Americium was also recovered in the Plutonium Reprocessing Facility using dibutyl butyl phosphonate (DBBP) in a carbon tetrachloride diluent. The DBBP has subsequently been replaced with tributyl phosphate.

The Plutonium Processing Facility converts plutonium nitrate to plutonium oxide and then to plutonium metal, if metal is the desired product. The plutonium oxide is made by precipitating the plutonium as plutonium oxalate and then calcining the precipitate. To produce metal, the plutonium oxide is first converted to plutonium fluoride. The fluoride is placed in an iron can, which is placed in a magnesium oxide crucible with calcium metal. A reducing charge is applied to the crucible to reduce the plutonium fluoride to plutonium metal, which is then molded into a button. The remaining iron, calcium, and magnesium are dissolved in nitric acid for disposal.

Reference 1, pages 2.15-2.23, Reference 21, pages 449-462.

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5 TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

The aquifer of concern, within three miles of the facility, supplies drinking water at the Fast Flux Test Facility (FFTF). Across the Columbia River, within three miles of the 200 Area defined boundary (disposal sites and contaminant plume), there are 17 wells in the aquifer of concern These wells consist of 14 private wells and 3 community wells. The three wells at FFTF are 294 ft deep, 399 ft deep, and 400 ft deep. These wells are screened at 188 to 281 ft, 221 to 396, and 360 to 390 ft (new deeper well) respectively. The across-river private wells vary in depth and screened intervals. No data was available concerning the depth and screen intervals of the private wells, however it was assumed that these wells were completed into the unconfined aquifer. The across-river community wells are the Eppich Water System, Cypress Gardens School well, and Rio Vista Orchards well. The wells are 88 ft deep, 160 ft deep, and 80 ft deep, respectively. Since these wells are all located in very remote locations, there is no municipal water from alternate unthreatened sources presently available.

Reference 7, pg 178; Reference 8, pg 43; Reference 2, pgs 4.7 and 3.19; Reference 9; Reference 10; Reference 11, Reference 36.

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

The nearest wells drawing water from the aquifer of concern are located at the Fast Flux Test Facility (FFTF) which is located with in the 200 Area plume.

Reference 8; Reference 2, pg. 3.19.

Distance to above well or building:

The water supply wells at the FFTF draws water from the aquifer of concern within the defined boundary of the 200 Area. Sampling of tap water draining from these wells, which are interconnected, have shown contamination. Therefore, the distance to the nearest well is zero feet.

Reference 2, pg 3.19; Reference 8, pg 43 and 481 Bldg Tap Water Sample Report.

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and populations served by each:

The water supply wells at the FFTF supply drinking water for the work force

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at the facility which numbers 2420 people. Assuming that each across-river private well supplies drinking water to 3.8 people per well, 53.2 people are served by these wells. The 3 community wells, the Eppich Water System, the Cypress Garden School well, and the Rio Vista Orchards well serve 12 permanent residents and 8 migrant farm worker residents, 12 permanent residents, and 8 permanent residents, respectively.

Reference 10; Reference 11; Reference 12, pg 3.

Computation of land areas irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

There are no documented wells (within three miles of the site) used for irrigation. All irrigated farm land within 3 miles of the defined boundary of the 200 Area are supplied from either the Columbia River or from the Columbia Basin irrigation project.

Total population served by ground water within a 3-mile radius:

There is a total of 2513.2 (2420 + 53.2 + 40) people served by the aquifer of concern within three miles of the 200 Area's defined boundary. This total includes workers, permanent residents, and migrant farm worker residents.

Reference 12 pg 3; Reference 10, Reference 11.

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SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

Tritium and iodine-129 were used to verify observed release and define the maximum extent of contamination in surface water. Evidence of observed release can be established by comparison of upstream and down stream concentrations of tritium and iodine-129. River bank springs monitoring and localized Columbia River sampling can be used to verify observed release by demonstrating that contaminants are entering the river in this area. The following two tables present upstream and downstream concentrations for iodine-129 and tritium for 1983 (same period as the spring sampling) and 1986.

200 Area Concentrations for Iodine-129

BACKGROUND			DOWN GRADIENT		
Date	Sample Point	Concentration (pCi/L)	Date	Sample Point	Concentration (pCi/L)
1/22/83	27.0 RW	3.3E-6 ± 1.4E-6	10/7/86	312 Intk	1.61E-4 ± 1.45E-5
10/7/86	Prst Rap	1.04E-5 ± 1.29E-6	1/22/83	29.0 RW	6.3E-5 ± 5.0E-6
			Springs		
			9/11/83	27-1 Spg	1.6E-4 ± 2.1E-5
			9/11/83	28-2 Spg	6.2E-2 ± 6.8E-3
			9/11/83	31-5 Spg	3.0E-5 ± 4.0E-6
			9/11/83	32-0 Spg	4.4E-5 ± 2.7E-5

200 Area Concentrations for Tritium

BACKGROUND			DOWN GRADIENT		
Date	Sample Point	Concentration (pCi/L)	Date	Sample Point	Concentration (pCi/L)
Various	Prst Rap	Mean = 119[a]	9/11/83	28.0 RW	60600 ± 761
9/11/83	27.0 RW	107 ± 201	Various	Rich Intk	Mean = 165[a]
			Spring		
			9/11/83	28-2 Spg	110000 ± 995

(a) Comparison of the 75 downstream samples (mean = 165, standard deviation = 160) to the 75 upstream samples (mean = 119, standard deviation = 108) using a one-tailed T-Test, indicated that there is a 95% probability that the downstream sample mean is significantly higher than the upstream. In addition, statistical analyses performed by DOE in 1985 and 1986 of upstream-downstream sampling data showed similar results. It is concluded, therefore, that an observed release of tritium has occurred at least as far downstream as the Richland intake.

Reference 2, Reference 3, page 17, A.5, B.3, C.6-C.7; Reference 23; Reference 25; Reference 28; Reference 30, Reference 39.

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Rationale for attributing the contaminants to the facility:

Tritium and Iodine-129 are products of the fission process that are released as a result of irradiated fuel reprocessing. Thus, both of these constituents are found in certain waste disposed of into the 200 Area. Both of these constituents are highly mobile in the Hanford environment and are used as indicators of extent of contamination. The downgradient samples showed significant increases in contaminant concentrations above those found in the background samples. In addition, spring water contaminated with these elements can be shown to discharge into the river.

Reference 2, pages 3.18-3.20; Reference 1, page 3.10

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:

Not applicable.

Name/description of nearest down slope surface water:

The Columbia River, which originates in the mountains of eastern British Columbia, Canada, flows through the northern edge of the Hanford Site and forms part of the Hanford Site's eastern boundary. The river drains a total area of approximately 70,800 km^2 enroute to the Pacific Ocean. The flow of the Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Site. Priest Rapids Dam is the nearest impoundment upstream of the Site, and McNary Dam is the nearest dam downstream. (The Hanford reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam.) This is the only stretch of the Columbia River within the U.S. that is not impounded by a dam. The width of the river varies from approximately 300 m to about 1000 m. The flow through this stretch of the river is relatively swift, with numerous bends and several islands present throughout the reach. The ground water beneath the site discharges directly into the Columbia River as evidenced by seeps and springs along the Columbia River.

The flow rate of the Columbia River in this region is regulated primarily by Priest Rapids Dam. Hanford reach flows fluctuate significantly because of the relatively small storage capacity and operational practices of the nearby upstream dams. A minimum flow rate of 1,000 cubic meters per second (36,000 cubic feet per second) has been established at Priest Rapids. Typical daily flows range from 1,000 cubic meters per second (36,000 cubic feet per second) to 7,000 cubic meters per second (250,000 cubic feet per second) with peak spring runoff flows of up to 12,600 cubic meters per second (450,000 cubic feet per second) being recorded. Typical annual average flows at Priest Rapids Dam are 3,100 cubic meters per second (110,000 cubic feet per second) to 3,400 cubic meters per second (120,000 cubic feet per second). Monthly mean flows typically peak from April through June and are at the lowest levels from September through October.

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The depth at the deepest part of the measured cross-sections varies approximately from 10 to 40 feet, with an average around 25 feet. Daily fluctuations in depth caused by Priest Rapids regulation can be as much as 10 feet above Vernita and 5 feet at Hanford.

Reference 2, page 2.1; Reference 13, page II.3-13.

Average slope of terrain between facility and above-cited surface water body in percent:

Not applicable.

Is the facility located either totally or partially in surface water?

Not applicable.

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Is the facility completely surrounded by areas of higher elevation?

Not applicable.

1-Year 24-Hour Rainfall in Inches

Not applicable.

Distance to Nearest Down slope Surface Water

Not applicable.

Physical State of Waste

Not applicable.

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Not applicable.

Method with highest score:

Not applicable.

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4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

The 200 Area is used to process irradiated uranium fuel to recover plutonium. The area is also used to process and store waste generated during fuel processing. Substances associated with the 200 Area activities are:

dibutly butyl phosphonate	tributyl phosphate
nitric acid	sodium dichromate
kerosene	ammonium carbonate
butyl phosphates	sodium oxalate
sulfuric acid	ferrocyanide
fluoride	sodium silicate
sodium aluminate	sodium nitrite
methyl isobutyl ketone (MIBK)	ferrous sulfamate
aluminum fluoride nitrate	carbon tetrachloride
calcium nitrate	aluminum nitrate
magnesium nitrate	ferric nitrate
H-3	Co-60
Sr-90	Ru-106
Cs-137	Pu-239
Pu-240	uranium

Reference 1, pgs. 2.15-2.23; Reference 21, pgs.213-662. Also, see Table 1.

Compound with highest score:

Several of the constituents listed above are assigned scores of 18. For example:

Constituent	Toxicity	Persistence
Plutonium-239	3	3
Plutonium-240	3	3
Uranium	3	3
Sodium dichromate	3	3

Reference 4, pgs. 794-797. Reference 40.

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Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

The total waste quantity associated with the aggregate 200 Area is at least 935,149,000 cubic yards. Table 1 presents the individual liquid sites that are located within the physical confines of the 200 Area fences and the associated data that were used in creating the aggregate 200 Area Site. Table 2 presents the solid waste sites located within the physical confines of the 200 Area fences and their associated data. Also presented in Table 2 are several individual sites and their associated data that are physically located outside of the 200 Area fences, but located within the defined boundaries of the aggregated 200 Area Site. The total quantity of waste associated with the sites listed in Table 1 and Table 2 is 935,000,000 cubic yards and 149,000 cubic yards, respectively.

References are listed in Tables 1 and 2 by waste site; Reference 37.

Basis of estimating and/or computing waste quantity:

The ground water seeps into the surface water at springs along the Columbia River; therefore, hazardous waste quantities reported for ground water are also applicable to surface water.

Reference 8, pg 43.

The 200 Area is used to process irradiated uranium fuel for the recovery of plutonium. Additionally the 200 Area is used to process and store waste. In compiling the inventory for the 200 Area, it was assumed that since ground water seeps into the Columbia River the containment associated with the surface water route is considered not to be 0, and all the waste quantities cited were available for migration. There are eight different operational areas within the aggregate 200 Area, PUREX Plant, B Plant, Semiworks and Critical Mass Laboratory, 200 North Area, REDOX Plant, T Plant, Plutonium Finishing Plant (PFP) (formally known as Z Plant). These eight operational areas are individually described below.

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TABLE 1. Basis of Estimating and/or Computing Waste Quantity - 200 Areas

Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area acidic process condensate disposal cribs, 216 series, Nos. A-5, A-15, C-1, C-6, C-10, S-1 & 2, S-7, S-9, S-23 and U-8 (8 areas)	Process condensate waste water containing nitric acid (pH~2), H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1952-1972	2,680,000,000	3,510,000	1, pages B.15 and B.17; 21, pages 219, 220, 235, 236, 401, 402, 409, 410, 465, 466, 475, 476, 479, 480, 505, 506, 597, and 598
200 Area Bismuth Phosphate Plant first cycle waste trenches, 216 series, Nos. B-35 through B-41, T-14 through T-17 and T-21 through T-25 (16 cribs)	First cycle waste contained sodium salts, fluoride, nitrate, sulfate phosphate, aluminate and radionuclides, H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1953-1954	34,100,000	44,600	1, pages B.15 and B.17; 21, pages 353-365, 535-542 and 549-458
200 Area Bismuth Phosphate Second Cycle and 224 Waste Cribs, 216 series, Nos. B-5, B-7A and B, B-8, T-3, T-5, T-6, T-7 and T-32	Second cycle and 224 waste contained sodium salts, fluoride, oxalate, nitrate, sulfate phosphate, ammonium nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1945-1955	299,000,000	391,000	1, pages B.15 and B.17; 21, pages 291, 292, 295, 296, 297, 298, 509, 510, 517-522, 571 and 572

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 North Area basin water ponds and cribs, 216 series, Nos. N-1 through N-7 (7 areas)	Fuel storage basin water containing radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1944-1952	2,870,000,000	3,760,000	1, pages 449-462
200 Area scavenged TBP supernatant waste cribs and trenches, 216 series, Nos. B-14 through B-34, B-42 through B-49, B-51, B-52, T-18 and T-26 (33 areas).	Scavenged TBP waste contained sodium salts, nitrate, sulfate, phosphate, and ferrocyanide and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1953-1958	167,000,000	219,000	1, pages B.15 and B.17; 21, pages 311-352, 367-382, 385, 386, 387, 388, 543, 544, 559, 560
200 Area tributyl phosphate solvent waste cribs, 216 series, Nos. A-2, A-7, A-31, C-4 and U-15 (5 cribs)	Tributyl phosphate solvent wastes contained tributyl phosphate and a paraffin hydrocarbon solvent and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1955-1966	682,000	893	1, pages B.15 and B.17; 21, pages 215, 216, 223, 224, 263, 264, 405, 406, 605 and 606

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area ammonia scrubber and alkaline condensate waste cribs, 216 series, Nos. A-36A, B-12, B-50, S-3, S-12 and S-21 (6 cribs)	Ammonia scrubber and alkaline condensate wastes contained ammonium nitrate (except S-3) and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238. Wastes disposed to 216-S-3 contained sodium salts of dichromate, nitrate, aluminate and hydroxide.	1952-1973	667,000,000	873,000	1, pages B.15 and B.17; 21, pages 273, 274, 307, 308, 383. 384, 483 and 484.
200 Area analytical laboratory liquid waste cribs, 216 series, Nos. A-4, A-21, A-27, B-6, B-10A, T-2 and T-8 (7 cribs)	Laboratory waste contained nitric acid and sulfuric acid (neutralized with NaOH at 'A' cribs) and sodium dichromate. Radionuclides include Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1945-1970	130,000,000	170,000	1, pages B.15 and B.17; 21, pages 217, 218, 247, 248, 259, 260, 293, 294, 301, 302, 507, 508, 523 and 524.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area steam condensate and/or cooling water disposal areas, 216 series, Nos. A-11, A-12, A-32 through A-35, A-40, S-5, S-6, S-16P, S-16D, S-17, T-4-1(D), T-4-1(P), U-9, U-11, Z-1(D), Z-11, T-4-2 (19 areas)	Steam condensate and/or cooling water containing nitrate and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1944-1979	98,600,000,000	129,000,000	1, pages B.15 and B.17; 21, pages 227, 228, 229, 230, 265 through 272, 277, 278, 471, 472, 473, 474, 491, 492, 493, 494, 495, 496, 511, 512, 513, 514, 599, 600, 601, 602, 609, 610, 629, 630, 515, 516.
200 Area Z Plant waste water disposal areas, 216 series, Nos. Z-1A, Z-142, Z-3 and Z-12 (4 areas)	Z Plant waste water contained sodium nitrate, fluoride, and radionuclides Pu-239, Sr-90, Cs-137 and U-138.	1949-1973	499,000,000	653,000	1, page B.17; 21, pages 607, 608, 611, 612, 613, 614, 631 and 632.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area plutonium recovery plant waste water cribs, 216-Z-9 and 216-Z-18.	Plutonium recovery plant waste water contains sodium salts, nitrate, sulfate, aluminum fluoride nitrate, aluminum nitrate, magnesium nitrate and calcium nitrate. The waste discharged to the 216-Z-18 also contained carbon tetrachloride, tributyl phosphate and dibutyl butyl phosphorate. Radionuclides include Pu-239 in both cribs and Sr-90, Cs-137, Co-60 and U-238 in 216-Z-9.	1955-1973	7,950,000	10,400	1, page B.17; 21, pages 625, 626, 637 and 639.
200 Area caustic waste areas, 216-T-33, 216-T-36 and 216-Z-8.	Caustic waste water containing sodium hydroxide and radionuclides Pu-239 in all three areas and Sr-90, Cs-137, Co-60 and U-238 in 216-T-33 and 216-T-36.	1955-1969	2,430,000	3,180	1, page B.17; 21, pages 573, 574, 579, 580, 623 and 624.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area chemical sewer areas, 216-B-21, 216-B-2-2 and 216-S-11.	Chemical sewer discharged unknown quantities of chemicals plus radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1945-1965	304,000,000,000	398,000,000	1, pages B.15 and B.17; 21, pages 282, 283, 284, 285, 481 and 482.
200 Area cribs that received 300 Area crib waste, 216 series, Nos. B-53A, B-53B, B-54, T-27, T-34 and T-35 (7 cribs)	300 Area crib waste contained nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1962-1967	31,800,000	41,000	1, pages B.15 and B.17; 21, pages 389-394, 561, 562, 575, 576, 577 and 578.
200 Area A-Tank Farm condensate crib, 216-A-24	A-Tank Farm condensate contained butyl phosphates, paraffin hydrocarbon, ammonium carbonate and radionuclides H-3, Sr-90, Pu-239, Cs-137, Co-60 and U-238.	1958-1966	820,000,000	1,020,000	1, page B.15; 21, pages 255 and 256.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area Redox hexone-bearing wastes, 216-S-13 and 216-S-14	Sodium hexone-bearing wastes containing methyl isobutyl ketone and radionuclides Sr-90, Pu-239, Cs-137, Co-60 and U-238. In addition to the above, waste disposed to 216-S-13 contained aqueous sodium nitrate and sodium dichromate.	1951-1972	5,010,000	6,560	1, page B.17; 21, pages 485, 486, 487 and 488.
200 Area, 221-U, 222-U and 224-U liquid wastes disposed to 216-U-142 and 216-U-4A cribs	U Area wastes containing sodium nitrate and sodium phosphate and radionuclides U-238, Sr-90, Cs-137, Co-60 and Pu-239. Crib 216-U-1 & 2 also received sodium sulfate.	1951-1970	160,000,000	209,000	1, page B.17; 21, pages 581, 582, 587 and 588.

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Area No. and Name	Waste Types	Years	Estimated Volume (liters)	No. of Cubic Yds	References
200 Area miscellaneous liquid wastes, 216 series, A-1, A-6, A-9, A-13, A-14, A-16, A-17, A-18, A-19, A-20, A-22, A-23A, A-23B, A-26A, A-28, A-39, A-41, B-3-1, B-3-2, B-4, B-9, B-10B, B-11A & B, B-13, B-57, C-3, C-5, C-8, S-4, S-8, S-15, S-18, S-20, S-22, T-9, T-10, T-11, T-12, T-13, T-20, T-28, T-29, T-30, U-3, U-4, U-4B, U-5, U-6, U-7, U-13, Z-4, Z-5, Z-6, Z-10, Z-16, Z-17 (55 areas)	Miscellaneous wastewaters containing nitrate and radionuclides Sr-90, Pu-239, Cs-137, Co-60, and U-238. In addition, areas 216-A-9. 216-S-4. and 216-T-30 received H-3.	1945-1979	303,000,000,000	397,000,000	1, pages B.15 and B.17; 21, pages 213, 214, 221, 222, 225, 226, 231-234, 237-246, 249-258, 261, 262, 275, 276, 279, 280, 285-290, 299,300, 303-306, 309, 310, 395, 396, 403, 404, 407, 408, 411, 412, 469, 470, 477, 478, 489, 490, 497-500, 503, 504, 525-534, 547, 548, 563-570, 583-586, 589-596, 603, 604, 615-620, 627, 628 and 633-636.
			TOTAL	935,000,000 yd^3	

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TABLE 2. Basis of Estimating and/or Computing Waste Quantity - 200 Areas

Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
200 Area dry waste burial site, 218 series, Nos. E-1, E-2, E-3, E-5, E-6, E-7, E-8, E-12A, W-1, W-2, W-3, W-4A, W-7 and W-8	Dry waste containing radionuclides Sr-90, Pu-239, Cs-137 and U-238.	1944-1968	2,960,000	110,000	1, pages B.15 and B.17; 21, pages 415-418, 421, 422, 425, 426, 429-434, 437, 438, 639, 640, 643-652; 5, Section I NW; and 6.
200 Area regulated equipment burial site, 218 series, Nos. E-2A, E-5A, E-9, E-14, W-1A, W-9 and W-11	Discarded process equipment containing radionuclides SR-90, Pu-239, Cs-137 and U-235.	1944-1964	960,000	36,000	1, pages B.15 and B.17; 21, pages 419, 420, 427, 428, 435, 436, 441, 442, 639, 640, 653, 654, 655 and 565; 5, Sections I NW, I SE; and 6.
200 Area repair and construction waste burial sites 218-E-4 and 218-E-13.	Repair and construction waste containing radionuclides SR-90, Pu-239, Cs-137 and U-238.	1955-1966	58,400	2,200	1, pages B.17; 21, pages 423, 424, 439 and 440; 5, Section I NW.

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Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
200 Area burning pits 200E, 200W, and Z Plant	200E and 200W received construction and office wastes plus paint waste and chemical solvents. Z Plant received office and laboratory waste.	1950-1970	21,500	800	1, pages B.15 and B.17; 21, pages 443, 444, 659, 660, 661 and 662
200 Area nonradioactive repair and construction waste burial sites, construction pit and nonradioactive burial ground	Construction pit received broken concrete and the nonradioactive burial ground received unusable plumbing materials. No radioactive waste was deliberately buried at these sites.	1945-1955	No data	No data	1, pages B.15 and B.17; 21, pages 445, 446 657 and 658.
600 Area dry waste burial sites 618-10 and 618-11	Dry waste containing Sr-90, Pu-239, Cs-137 and U-238	1953-1967	No data	No data	1, page B.21; 21, pages 693-696.
P-11 crib	Waste water containing Pu-239. Site has been exhumed.	1951-1951	No data	No data	1, page B.21; 21, pages 701 and 702.
213 J and K cribs	Drainage from plutonium storage vaults. No Pu-239 had been detected in piping. Cribs exhumed.	1944-1950	No data	No data	1, page B.21; 21, pages 703-704.

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Area No. and Name	Waste Types	Years	Estimated Volume (ft^3)	No. of Cubic Yds	References
Miscellaneous nonradioactive burial sites, J. A. Jones No. 1 and Original Central Landfill	Miscellaneous nonradioactive wastes. No known chemical disposal.	1973-1979	Unknown quantity.	Unknown quantity.	1, page B.21; 21, pages 705, 706, 711 and 712; 38, pages 1 and 2
			TOTAL	149,000	

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PUREX Plant. The Plutonium URanium EXtraction (PUREX) Plant is the most recently constructed of the irradiated-fuel processing plants. Constructed between April 1953 and October 1955, the PUREX Plant took over fuel-processing operations from the REDuction OXidation (REDOX) Plant. The PUREX Plant was operated from 1956 to 1972; in 1972 it was placed in operational standby mode. Plant operations were resumed in 1983.

At this facility, uranium, plutonium, and neptunium are separated from fission products found in the production reactors' irradiated uranium fuel. The process steps involve fuel-element decladding, uranium metal dissolution, solvent extraction, ion exchange, and product loadout.

Zirconium cladding on fuel elements is removed in an ammonium fluoride-ammonium nitrate (AFAN) solution. Ammonium fluoride reacts with the zirconium, resulting in a soluble zirconium compound. The ammonia and hydrogen evolved during decladding present a potential combustion hazard. Therefore, hydrogen is converted to ammonia by reaction with ammonium nitrate present in the AFAN solution. The dissolver solution is then processed to remove plutonium and uranium that dissolved with the cladding. Gas released from the dissolver is treated to remove iodine in a silver reactor, is acid-adsorbed, and is only then released to the atmosphere. The off-gases are treated with hydrogen peroxide to remove nitrogen oxides before being released to the atmosphere.

Declad fuel elements are dissolved in nitric acid for the solvent extraction processes. An organic solvent is used to separate the uranium, plutonium, and neptunium from associated fission products and from each other. The organic solvent used in a series of extraction and stripping operations is a 30% solution of tributyl phosphate in a normal paraffin hydrocarbon (kerosene) diluent.

The first extraction cycle separates the bulk of the fission products from the plutonium, uranium, and neptunium; the fission products remain in the aqueous phase. The organic phase is sent to the partitioning cycle where the plutonium is partitioned from the uranium and neptunium. The plutonium stream is routed through two additional solvent-extraction cycles for further purification. After purification, the plutonium stream is concentrated.

From 1956 to 1972, the concentrated plutonium nitrate solution was sent to the plutonium finishing operations located in the 200-West Area. When the PUREX Plant resumed operations in 1983, an additional facility was added that produced plutonium oxide from the plutonium nitrate.

The other stream from the partition cycle, which bears the neptunium and uranium, is routed to the final uranium cycle where neptunium is separated. The aqueous neptunium stream is sent to the back-cycle waste system for concentration and recycling to the solvent-extraction column. The uranium stream is routed to a column that strips the uranium from the organic stream with an aqueous nitric acid solution; concentration of the aqueous solution follows. The uranium product, uranyl nitrate hexahydrate (UNH), is then stored in tanks until it is shipped to the UO_3 plant in the 200-West Area.

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A portion of the concentrated neptunium solution from the final uranium cycle is sent to the neptunium recovery and purification cycle. In this cycle, neptunium is separated from the uranium, plutonium, and the remaining fission products in the neptunium stream. This separation is accomplished by a series of extractions and ion-exchange columns. The plutonium and uranium fractions are recycled to the back-cycle waste system and partitioning cycle, respectively.

Supporting process systems include organic solvent decontamination and recovery, nitric acid recovery, and waste concentration and recovery.

B Plant. The B Plant, one of the original fuels-separation facilities, was constructed between August 1943 and February 1945; it was operated until 1952. The plant used the bismuth phosphate process to separate plutonium from irradiated uranium fuel. This process produced a very dilute waste stream that contained the uranium and most of the fission products from the fuel elements. Unlike the PUREX process, the bismuth phosphate process separated plutonium from uranium and fission products by precipitating the plutonium onto a bismuth phosphate carrier.

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The uranium fuel elements processed by the bismuth phosphate process were jacketed with aluminum. These jackets were removed in a sodium hydroxide-sodium nitrate ($NaOH$-$NaNO_3$) solution, with the $NaNO_3$ acting as a hydrogen scavenger. Some of the silicon used as a binder in the fuel elements was dissolved during jacket removal. This operation produced sodium silicate, sodium aluminate, and sodium nitrite.

After jacket removal, the fuel elements were dissolved in nitric acid; sulfuric acid was then added to complex the uranium. Complexing of uranium prevented it from being precipitated as uranyl phosphate during later plutonium precipitation. The metal solution was pre-treated with sodium nitrite to oxidize or reduce plutonium to the correct state for precipitation. Bismuth phosphate was then added to the metal solution and the resulting slurry was centrifuged. The solid cake was redissolved in nitric acid for further decontamination of the plutonium.

The decontamination involved several dissolutions and subsequent precipitations of plutonium. Sodium bismuthate and sodium dichromate were used as oxidizing agents, and sodium nitrite or oxalic acid was used as a reducing agent during the plutonium decontamination. The final plutonium precipitate was washed with ammonium nitrate.

The next process involved transferring the plutonium from the bismuth phosphate carrier to a lanthanum fluoride carrier. Hydrofluoric acid was used to acidify the transfer solution and cause lanthanum fluoride to precipitate, carrying the plutonium with it. Potassium hydroxide was used to change the lanthanum precipitate into a soluble compound; then the precipitate was dissolved in nitric acid.

The plutonium was then reduced using ammonium sulphate and precipitated as a peroxide by the addition of hydrogen peroxide. The plutonium peroxide was dissolved into nitric acid. This solution was concentrated to produce the

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final plutonium nitrate product, which was originally shipped off site for conversion to plutonium oxide or plutonium metal.

In 1968, the B Plant was converted to a waste-fractionization plant as part of a program to solidify high-level waste. The B Plant now functions to remove cesium and strontium from PUREX current acid waste and from high-level supernatant liquids, as well as sludges from self-boiling liquid waste.

The solids are removed from the current acid waste and treated for strontium removal, and the liquid is treated with phosphotungstic acid to precipitate the cesium. The supernatant liquid is sent to a series of solvent extraction columns, similar to those used at the PUREX Plant, to remove and purify any remaining strontium. The cesium precipitate is redissolved in sodium hydroxide and treated in ion exchange columns for further purification. Liquid from stored waste is treated the same as current acid waste, except that the solids have already separated in the storage tanks. Sludge from the storage tanks and solids from current acid waste are dissolved in an acid solution and sent to the solvent-extraction columns for strontium removal.

Cesium solutions are converted to cesium chloride by the addition of hydrochloric acid. The liquid is evaporated to yield solid cesium chloride. This solid is encapsulated in Hasteloy cylinders and stored in an underwater storage basin at B Plant.

Strontium is precipitated as strontium fluoride by the addition of sodium fluoride. The strontium fluoride is filtered, dried, and encapsulated in Hasteloy cylinders. These cylinders, like the cesium cylinders, are stored in an underwater storage basin at B Plant.

Semiworks and Critical Mass Laboratory. The Semiworks was built in 1949 as a pilot plant for the REDOX Process; it was later converted to pilot the PUREX process. The Semiworks originally operated from 1952 to 1957. In 1960, the Semiworks was reactivated and equipped for the processing and loadout of fission products; it then operated as both a production and a process demonstration pilot project for converting the B Plant to a waste-partitioning facility. In 1967, the Semiworks was shut down, and it is now being decontaminated and decommissioned. Chemical processes at this facility were similar to those at the REDOX and PUREX plants.

At the Critical Mass Laboratory, research focuses on the criticality safety of plutonium in various forms and combinations with other elements. The resulting data are used to verify analytical methods that predict criticality safety for plutonium in various fuel cycles.

200 North Area. The 200 North Area was built for the ageing of "green" fuel (recently irradiated fuel) to allow for the decay of short lived radionuclides before processing the fuel. Irradiated fuel was stored in water basins while the decay process was proceeding. The area was only used during the first several years of operations, when it was discovered that the required fuel ageing time was much shorter than originally predicted. This discovery allowed the use of the 200 Area to be discontinued in 1952. Several of the sites within the 200 North Area only received waste during the pre-retirement cleaning of the basins actually used to store fuel.

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200-West Area Plants

U Plant. Although the U Plant (constructed between 1943 and 1944) was one of the three original fuels-separation facilities designed to use the bismuth phosphate process, it was never used for that purpose.

Uranium was not recovered by the bismuth phosphate extraction of plutonium from irradiated fuel. However, the later-developed REDOX and PUREX processes recovered the uranium, which still had economic value. Following startup of the REDOX Plant, the U Plant was converted to recover the uranium from stored radioactive waste. From 1952 to 1958, stored waste was transferred to the U Plant for uranium recovery. The resultant sludge was dissolved in nitric acid, and then the uranium was extracted using tributyl phosphate in a normal paraffin diluent. This process left the fission products, sulfate, and phosphate ions in the aqueous acid solution. The uranium was then stripped from the organic solvent with nitric acid. This nitric acid solution was concentrated and sent to the uranium oxide process.

Although the uranium recovery processing is no longer going on, the adjacent uranium oxide plant is still operational. This plant received uranyl nitrate solution from the recovery process and from the REDOX Plant and calcined it to uranium trioxide. The uranium oxide plant now processes the product uranium from the PUREX Plant. Nitric acid is recycled to the PUREX process as a by-product of the calcination process. The uranium trioxide is shipped offsite for use as nuclear fuel.

REDOX Plant. The REDOX process for fuels separation succeeded the bismuth phosphate process and preceded the PUREX process. The REDOX Plant was constructed from May 1950 to August 1951; it operated until it was shut down in July 1967. An analytical laboratory near the facility is still operational. This laboratory supports B-Plant operations and performs research and development in support of waste management and environmental control operations. The laboratory also functions as a backup laboratory to the PUREX and Z-Plant analytical laboratories.

The REDOX Plant used a solvent extraction process to separate uranium and plutonium from fission products and each other. Methyl isobutyl ketone (MIBK) was the organic solvent that was used.

The fuel elements were prepared for nitric acid dissolution using the methods from the bismuth phosphate process. Sodium dichromate was added to the nitric acid solvent to oxidize plutonium to a state suitable for organic extraction.

Aluminum nitrate was added to the acid solution as a salting agent for the first extraction column. This salting agent caused the uranium and plutonium to be preferentially extracted by MIBK, leaving the fission products in the aqueous phase. In a second extraction column, a reducing agent was added to the aqueous phase to reduce the plutonium so that it would be removed from the uranium and extracted into the aqueous phase. The organic uranium solution and the aqueous-plutonium solution were then processed separately,

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purified further, and concentrated into their respective products; uranium nitrate hexahydrate (UNH) and plutonium nitrate. The plutonium nitrate was sent to the Z Plant for processing into plutonium oxide or plutonium metal. The UNH was sent to the uranium oxide plant.

The organic solvent was treated for recycling by removing decomposition products and by further decontamination. Aqueous streams were concentrated, then the aluminum nitrate was converted to sodium aluminate by sodium hydroxide before disposal.

T Plant. The T Plant was one of the original bismuth phosphate fuels-separation facilities; it was constructed from June 1943 to October 1944 and operated for the bismuth phosphate process from 1944 to 1956. Since 1956, facilities in the T Plant have been used for decontamination and equipment repair.

Z Plant. Constructed in 1949, the Z Plant was the site of the plutonium laboratory and finishing operations, including the processing of plutonium scrap materials and preparation of plutonium products. The plutonium parts preparation ceased in December 1965. A process known as "recouplex" was operated at the plant from 1955 to 1962 to recover plutonium from scrap and produce a plutonium nitrate solution. The Plutonium Reclamation Facility began operations in 1964 to perform the functions of the recouplex process.

The recouplex process used nitric acid and hydrofluoric acid to dissolve solids and a tributyl phosphate-carbon tetrachloride solvent extraction process for recovery of purified plutonium nitrate solutions. Aluminum nitrate was used to salt the aqueous streams for selective extraction of plutonium and to create complexed fluoride ions as aluminum fluoroxide nitrate to prevent their interference during plutonium extraction. Americium was also recovered in the Plutonium Reprocessing Facility using dibutyl butyl phosphonate (DBBP) in a carbon tetrachloride diluent. The DBBP has subsequently been replaced with tributyl phosphate.

The Plutonium Processing Facility converts plutonium nitrate to plutonium oxide and then to plutonium metal, if metal is the desired product. The plutonium oxide is made by precipitating the plutonium as plutonium oxalate and then calcining the precipitate. To produce metal, the plutonium oxide is first converted to plutonium fluoride. The fluoride is placed in an iron can, which is placed in a magnesium oxide crucible with calcium metal. A reducing charge is applied to the crucible to reduce the plutonium fluoride to plutonium metal, which is then molded into a button. The remaining iron, calcium, and magnesium are dissolved in nitric acid for disposal.

Reference 1, pages 2.15-2.23, Reference 21, pages 449-462.

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5 TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

Surface water within the distance of the furthest point of contamination (i.e., the Richland water intake) is used as a source of drinking water, a source of crop irrigation water, a water source at the Ringold fish hatchery, and for recreation (boating, swimming, and fishing). The surface water within three miles downstream is used for recreation. The City of Richland draws water from the river for their drinking water. The 300 Area also withdraws drinking water from the river. There are river water intakes at Ringold Flats, Taylor Flats, Battelle Farm Operations and the Tri-Cities University Center (TUC) where the water is used to irrigate forage and food crops. Part of the water used to rear steelhead trout at the Ringold hatchery comes from the river. Because this reach of the Columbia River are part of the upstream migration route of several salmon species and steelhead trout, this reach is a popular spot for fishing.

Reference 2, pg. 3.19; Reference 13, pg. II.3-4; Reference 14, pgs. 4.28, 4.10; Reference 15; Reference 16; Reference 17; Reference 18; Reference 32; Reference 33; Reference 34.

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Is there tidal influence?

The site is located upstream of four hydroelectric dams, therefore, no tidal influence is observed in the River at the site.

Reference 2, pg 2.1.

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Not applicable.

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

There is no fresh-water wetland within 1 mile of the defined site boundary.

Reference 15; Reference 16; Reference 17.

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Although there are several sensitive and threatened species that are residents of Hanford Site (for at least part of the year), no endangered species are known to be residents of the site. Two threatened species, the bald eagle and the ferruginous hawk, are residents of the site (for at least part of the year). Because there are no endangered species (state or federal) that reside at the site, there is no critical habitat to be considered in the ranking of the 200 Area Site.

The draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 1, July 1986 listed the Merriam's Shrew as being on the State Endangered Species list. This information was taken from a list published in a preliminary draft of an environmental impact statement, and, since the referenced February 1987 list shows the Merriam's Shrew as only a proposed sensitive species, it is assumed that the previous list taken from the preliminary draft is in error.

Reference 1; Reference 19.

Population Served by Surface Water

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

River water is withdrawn at five locations within 3 miles of the farthest point of downstream contamination (i.e., Richland City Water Intake) which is used for drinking water and irrigation. Four of these five are irrigation intakes which are Ringold Flats, Taylor Flats, Battelle Farm Operations and Tri-Cities University Center (TUC). The fifth intake is the Richland City

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Water Intake which is used for drinking water. The Richland city water system serves a population of 33,578 based on the 1980 census. The Richland city water system also has emergency interties with the City of Kennewick water system and the Hanford 300 Area (which also has an intake from the river located in the 300 Area). The Kennewick population is 34,387 based on 1980 census. The population served by the 300 Area is 3110 Hanford workers. The City of Pasco does not have an emergency intertie with the City of Richland water system. Therefore, the population of Pasco was not considered. The other three intakes are only used for irrigation water.

Reference 2, pg. 3.19; Reference 20; Reference 15; Reference 16; Reference 17; Reference 18; Reference 14, pg. 4.33; Reference 32; Reference 34.

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Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

The acreage of irrigated land at Ringold Flats, Taylor Flats, Battelle Farm Operations and Tri-Cities University Center (TUC) is 330 acres, 270 acres, 168 acres and 160 acres, respectively. Based on the formula of 1.5 people per acre the following calculations are made to determine the population associated with the irrigated land:

Ringold Flats Population	= 330 acres x 1.5 people/acre	= 495 people
Taylor Flats Population	= 270 acres x 1.5 people/acre	= 405 people
TUC Population	= 160 acres x 1.5 people/acre	= 240 people
Battelle Farm Operations	= 168 acres x 1.5 people/acre	= 252 people
	Total Population	= 1392 people

Reference 15; Reference 16; Reference 17; Reference 32; Reference 34.

Total population served:

The sum of the population served by the Richland City drinking water system and the irrigated land population is 69,530. This total does not include the 3110 300-Area workers since they would also be counted in the City of Richland and City of Kennewick numbers. This will avoid double counting of populations.

Name/description of nearest of above water intakes:

The nearest water intake with the largest population would be the Richland City Intake. This intake is used for drinking water.

Reference 28; Reference 12, page 3; Reference 29

Distance to above-cited intakes, measured in stream miles.

Contamination has been observed at the City of Richland intake. All other intakes are within the contaminated portions of the river as defined in the observed release; therefore, the distance is zero.

Reference 15; Reference 16.

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AIR ROUTE

1 OBSERVED RELEASE

Contaminants detected:

Even though air concentrations of some of the constituents of interest can be detected above background offsite, no air monitoring data were found sufficient for HRS scoring of the Hanford CERCLA sites. These constituents of interest detected above background offsite are present in the routine gaseous effluents from operating facilities at Hanford. Therefore, the air route rating factors were not scored.

Date and location of detection of contaminants:

Not applicable.

Methods used to detect the contaminants:

Not applicable.

Rationale for attributing the contaminants to the site:

Not applicable.

2 WASTE CHARACTERISTICS

<u>Reactivity and Incompatibility</u>

Most reactive compound:

Not applicable.

Most incompatible pair of compounds:

Not applicable.

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Toxicity

Most toxic compound:

Not applicable.

Hazardous Waste Quantity

Total quantity of hazardous waste:

Not applicable.

Basis of estimating and/or computing waste quantity:

Not applicable.

3 TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi 0 to 1 mi 0 to 1/2 mi 0 to 1/4 mi

Not applicable.

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Not applicable.

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

Not applicable.

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Distance to critical habitat of an endangered species, if 1 mile or less:

Not applicable.

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Not applicable.

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Not applicable.

Distance to residential area, if 2 miles or less:

Not applicable.

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Not applicable.

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Not applicable.

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 200 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
1	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, Volume 1
2	Environmental Monitoring at Hanford for 1986, PNL-6120
3	Investigation of Ground-Water-Seepage from the Hanford
	Shoreline of the Columbia River, PNL-5289, November 1984
4	Uncontrolled Hazardous Waste Site Ranking System; A Users
	Manual, 40 CFR 300, Appendix A
5	Handbook of 200 Area Waste Sites, Volume I
	1979 Rockwell Hanford Operations, RHO-CD-673
6	Memo to File from BW Mercer on 8-18-87, Solid Waste Volume
	Estimates for Selected 200 Area Burial Grounds
7	Hanford Wells, PNL-5397, February 1985
8	Ground Water Monitoring at Hanford Site, January-December
	1984, PNL-5408
9	Project Inspection, Log Book Project V-749, 400 Area Water
	Systems Improvements Water Well No. 4
10	Washington State Public Supply System Listing
11	Memo to File from BW Mercer on 8-14-87, Drinking Water Wells
	in Franklin County Within 3 Miles of the 200 Area and Within
	3 Miles of the 300 Area Defined Boundary

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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 200 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
12	Hanford Reservation Area Worker Census, BNWL-2298, July 1977
13	Waste Management Operations, Hanford Reservations, ERDA-1538,
	December 1975
14	Draft Environmental Impact Statement, Disposal of Hanford
	Defense High-Level, Transuranic and Tank Waste, DOE/EIS-0113,
	Volume 1
15	U.S.G.S. Map showing 200 Area surroundings
16	U.S.G.S. Maps showing 200 Area surroundings
17	U.S.G.S. Map showing 200 Area surroundings
18	Memo to file from DA Lamar, on 8-18-87, regarding Personal
	Observations of Columbia River Intakes at Taylor Flats and
	Ringold Flats
19	Endangered and Threatened Wildlife and Plants, 50 CFR,
	Part 17, Subpart B, October 86
20	Memo to file from KH Cramer regarding Personal Communications
	with M Gillum concerning Richland City Well Data, August 6,87
21	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, Volume 2 (HISS Database)
22	Hanford Ground Water Database Printouts for Wells of Concern
23	^{129}I, ^{60}Co and ^{106}Ru Measurements on Water Samples From the
	Hanford Project Environs, BNWL-SA-4478, January 1913

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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 200 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
24	Purification of Uranium by IBMK (Hexone) Extraction,
	UST-RD-PM-9-80
25	Determination of Tritium in Water Samples, UST-RD-PM-9-80
26	Volatile Organic Analysis, Method 8240, UST-RD-PM-9-80
27	Cyanide, Method 9010, UST-RD-PM-9-80
28	Drawing H-3-53734 (Showing 300 Area River Intake)
29	Memo to file from WS Weygandt concerning Personal
	Communication with R. B. Hall Regarding the 312 River Water
	Intake for 300 Area, August 13, 1987
30	Database Printouts of Surface Water Sample Points
31	An Assessment of Aquifer Intercommunication in the B Pond -
	Gable Mountain Pond Area of the Hanford Site, RHO-RE-ST-12P
32	Memo to file from WS Weygandt regarding Personal Conversation
	with F Trent concerning TUC irrigation intake, August 12,1987
	including note to file from RD Stenner on October 29, 1987,
	concerning Crops Grown on the TUC 160 Acres
33	Memo to file regarding recreational use of the Columbia River
	from DR Sherwood, August 26, 1987
34	Battelle Farm Operations Drawing, RC-486 and RC-1147
35	Data Compilation: Iodine-129 in Hanford Groundwater,
	WHC-EP-0037

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HRS DOCUMENTATION LOG SHEET

SITE NAME U.S. DOE Hanford 200 Area
CITY Benton County STATE WA
IDENTIFICATION NUMBER

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
36	Letter from RD Stenner to DM Bennett on October 14, 1987,
	regarding ground water contaminant plumes
37	Letter from RD Stenner to DM Bennett regarding liquid waste
	sites and burning pits, October 26, 1987
38	File note from RD Stenner to file on December 2,1987,
	regarding Landfill Operations
39	Environmental Monitoring at Hanford for 1985, PNL-5817
40	Memo to Sandy Crystall, EPA, from Kathleen Galloway,
	MITRE. December 29, 1987.

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REFERENCE 1

Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 1

production reactor still in operation. The reactor is a dual-purpose unit and provides low-pressure steam for the 860 megawatt WNP generating plant nearby. The reactor core's cooling water is recycled after it is passed through a heat exchanger that cools the water and produces the steam used by the WNP generating plant. Fewer than 1,500 people work in this area (Yandon 1977).

The reactor's water treatment plant is an updated version of the treatment systems used at the older reactors. The nonradioactive effluents it treats originate from the secondary side of the cooling-water system. Radioactive waste streams are discharged to cribs. The water from these waste streams eventually discharges to the Columbia River via the ground water. The N Reactor contains some additional alloys and material that were not present in the older reactors. These materials are protected from corrosion and the heat transfer surfaces protected against fouling by suitable water treatment.

2.3.2 200 Areas

In the approximate middle of the Hanford Site, on a plateau about 11 kilometers (7 mi) from the Columbia River, are the two 200 Areas (200-East and 200-West), dedicated to chemical separations and waste management. Irradiated fuel, waste-processing, and waste-storage activities are located in these two areas because they are the most isolated from the Site boundaries and are the farthest from both surface and ground water. The water table in this area is 46 to 91 meters (150 to 300 ft) below the surface.

The 200-Area plateau is a glacial, fluvial gravel bar. A thin surface layer of wind-blown silts and sands covers the well-sorted, coarse sands that comprise the Hanford Formation sediments.

Fewer than 3,000 employees work in the 200 Areas (per shift); slightly more than half are in the 200-West Area (Yandon 1977).

The 200 Areas contain nonradioactive support facilities, including transportation maintenance buildings, service stations, and coal-fired powerhouses (with baghouses for airstream cleanup) for process steam production, steam transmission lines, raw-water treatment plants, water-storage tanks, electrical

Ref. 1.1

maintenance facilities, and subsurface sewage disposal systems. In short, the 200 Areas are almost cities to themselves in that they have most of the utilities necessary to be self supporting.

2.3.2.1 200-East Area Plants

The 200-East Area is a controlled area of approximately 8.4 square kilometers (3.2 sq mi). It is about 10 kilometers (6.2 mi) from the Columbia River and 18 kilometers (11 mi) from the nearest Hanford Site boundary. It is located on a plateau at an elevation of approximately 200 meters (656 ft) above mean sea level (MSL). The surface slopes from southwest to northeast, with a maximum difference in elevation across the Site of about 25 meters (82 ft). Depth to ground water ranges from 47 to 103 meters (155 to 338 ft).

There are no naturally occurring surface-water bodies within the 200-East Area. However, process cooling water and aqueous wastes are discharged to an open ditch that carries the effluents to a large impoundment (B-Pond) located just east of the area. West Lake is a small, natural lake located about 4 kilometers (2.5 mi) north of the area. Gable Mountain Pond, formed as a result of waste-water disposal from the 200 Areas, is about 3 kilometers (1.9 mi) to the north. It will no longer be in use after 1987.

PUREX Plant. The Plutonium URanium EXtraction (PUREX) Plant is the most recently constructed of the irradiated-fuel processing plants. Constructed between April 1953 and October 1955, the PUREX Plant took over fuel-processing operations from the REDuction OXidation (REDOX) Plant. The PUREX Plant was operated from 1956 to 1972; in 1972 it was placed in operational standby mode. Plant operations were resumed in 1983.

At this facility, uranium, plutonium, and neptunium are separated from fission products found in the production reactors' irradiated uranium fuel. The process steps involve fuel-element decladding, uranium metal dissolution, solvent extraction, ion exchange, and product loadout.

Zirconium cladding on fuel elements is removed in an ammonium fluoride-ammonium nitrate (AFAN) solution. Ammonium fluoride reacts with the zirconium, resulting in a soluble zirconium compound. The ammonia and hydrogen evolved during decladding present a potential combustion hazard. Therefore hydrogen is converted to ammonia by reaction with ammonium nitrate

Ref. 1.2

present in the AFAN solution. The dissolver solution is then processed to remove plutonium and uranium that dissolved with the cladding. Gas released from the dissolver is treated to remove iodine in a silver reactor, is acid-adsorbed, and is only then released to the atmosphere. The off-gases are treated with hydrogen peroxide to remove nitrogen oxides before being released to the atmosphere.

Declad fuel elements are dissolved in nitric acid for the solvent extraction processes. An organic solvent is used to separate the uranium, plutonium, and neptunium from associated fission products and from each other. The organic solvent used in a series of extraction and stripping operations is a 30% solution of tributyl phosphate in a normal paraffin hydrocarbon (kerosene) diluent.

The first extraction cycle separates the bulk of the fission products from the plutonium, uranium, and neptunium; the fission products remain in the aqueous phase. The organic phase is sent to the partitioning cycle where the plutonium is partitioned from the uranium and neptunium. The plutonium stream is routed through two additional solvent-extraction cycles for further purification. After purification, the plutonium stream is concentrated. From 1956 to 1972, the concentrated plutonium nitrate solution was sent to the plutonium finishing operations located in the 200-West Area. When the PUREX Plant resumed operations in 1983, an additional facility was added that produced plutonium oxide from the plutonium nitrate.

The other stream from the partition cycle, which bears the neptunium and uranium, is routed to the final uranium cycle where neptunium is separated. The aqueous neptunium stream is sent to the backcycle waste system for concentration and recycling to the solvent-extraction column. The uranium stream is routed to a column that strips the uranium from the organic stream with an aqueous nitric acid solution; concentration of the aqueous solution follows. The uranium product, uranyl nitrate hexahydrate (UNH), is then stored in tanks until it is shipped to the UO_3 plant in the 200-West Area.

A portion of the concentrated neptunium solution from the final uranium cycle is sent to the neptunium recovery and purification cycle. In this

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cycle, neptunium is separated from the uranium, plutonium, and the remaining fission products in the neptunium stream. This separation is accomplished by a series of extractions and ion-exchange columns. The plutonium and uranium fractions are recycled to the backcycle waste system and partitioning cycle, respectively.

Supporting process systems include organic solvent decontamination and recovery, nitric acid recovery, and waste concentration and recovery.

B Plant. The B Plant, one of the original fuels-separation facilities, was constructed between August 1943 and February 1945; it was operated until 1952. The plant used the bismuth phosphate process to separate plutonium from irradiated uranium fuel. This process produced a very dilute waste stream that contained the uranium and most of the fission products from the fuel elements. Unlike the PUREX process, the bismuth phosphate process separated plutonium from uranium and fission products by precipitating the plutonium onto a bismuth phosphate carrier.

The uranium fuel elements processed by the bismuth phosphate process were jacketed with aluminum. These jackets were removed in a sodium hydroxide-sodium nitrate ($NaOH-NaNO_3$) solution, with the $NaNO_3$ acting as a hydrogen scavenger. Some of the silicon used as a binder in the fuel elements was dissolved during jacket removal. This operation produced sodium silicate, sodium aluminate, and sodium nitrite.

After jacket removal, the fuel elements were dissolved in nitric acid; sulfuric acid was then added to complex the uranium. Complexing of uranium prevented it from being precipitated as uranyl phosphate during later plutonium precipitation. The metal solution was pre-treated with sodium nitrite to oxidize or reduce plutonium to the correct state for precipitation. Bismuth phosphate was then added to the metal solution and the resulting slurry was centrifuged. The solid cake was redissolved in nitric acid for further decontamination of the plutonium.

The decontamination involved several dissolutions and subsequent precipitations of plutonium. Sodium bismuthate and sodium dichromate were used as

Ref. 1.4

oxidizing agents, and sodium nitrite or oxalic acid was used as a reducing agent during the plutonium decontamination. The final plutonium precipitate was washed with ammonium nitrate.

The next process involved transferring the plutonium from the bismuth phosphate carrier to a lanthanum fluoride carrier. Hydrofluoric acid was used to acidify the transfer solution and cause lanthanum fluoride to precipitate, carrying the plutonium with it. Potassium hydroxide was used to change the lanthanum precipitate into a soluble compound; then the precipitate was dissolved in nitric acid.

The plutonium was then reduced using ammonium sulphate and precipitated as a peroxide by the addition of hydrogen peroxide. The plutonium peroxide was dissolved into nitric acid. This solution was concentrated to produce the final plutonium nitrate product, which was originally shipped off site for conversion to plutonium oxide or plutonium metal.

In 1968, the B Plant was converted to a waste-fractionization plant as part of a program to solidify high-level waste. The B Plant now functions to remove cesium and strontium from PUREX current acid waste and from high-level supernatant liquids, as well as sludges from self-boiling liquid waste.

The solids are removed from the current acid waste and treated for strontium removal, and the liquid is treated with phosphotungstic acid to precipitate the cesium. The supernatant liquid is sent to a series of solvent extraction columns, similar to those used at the PUREX Plant, to remove and purify any remaining strontium. The cesium precipitate is redissolved in sodium hydroxide and treated in ion exchange columns for further purification. Liquid from stored waste is treated the same as current acid waste, except that the solids have already separated in the storage tanks. Sludge from the storage tanks and solids from current acid waste are dissolved in an acid solution and sent to the solvent-extraction columns for strontium removal.

Cesium solutions are converted to cesium chloride by the addition of hydrochloric acid. The liquid is evaporated to yield solid cesium chloride. This solid is encapsulated in Hasteloy® cylinders and stored in an underwater storage basin at B Plant.

Ref. 1.5

Strontium is precipitated as strontium fluoride by the addition of sodium fluoride. The strontium fluoride is filtered, dried, and encapsulated in Hasteloy® cylinders. These cylinders, like the cesium cylinders, are stored in an underwater storage basin at B Plant.

Semiworks and Critical Mass Laboratory. The Semiworks was built in 1949 as a pilot plant for the REDOX Process; it was later converted to pilot the PUREX process. The Semiworks originally operated from 1952 to 1957. In 1960, the Semiworks was reactivated and equipped for the processing and loadout of fission products; it then operated as both a production and a process demonstration pilot project for converting the B Plant to a waste-partitioning facility. In 1967, the Semiworks was shut down, and it is now being decontaminated and decommissioned. Chemical processes at this facility were similar to those at the REDOX and PUREX plants.

At the Critical Mass Laboratory, research focuses on the criticality safety of plutonium in various forms and combinations with other elements. The resulting data are used to verify analytical methods that predict criticality safety for plutonium in various fuel cycles.

2.3.2.2 200-West Area Plants

The 200-West Area is a controlled area of approximately 8.2 square kilometers (3.2 sq mi); it is about 8 kilometers (5 mi) from the Columbia River and 11 kilometers (6.8 mi) from the nearest Site boundary. In the early 1980s, it was expanded to the west to add land for future burial grounds. There are no naturally occurring surface water bodies within the 200-West Area; however, process cooling water and aqueous waste are discharged to surface impoundments, creating several artificial ponds within or adjacent to the area.

The water table beneath the 200-West Area lies within the Ringold Formation, which has a relatively high permeability. The water table lies at a depth of 55 to 82 meters (180 to 270 ft).

U Plant. Although the U Plant (constructed between 1943 and 1944) was one of the three original fuels-separation facilities designed to use the bismuth phosphate process, it was never used for that purpose.

Ref. 1.6

Uranium was not recovered by the bismuth phosphate extraction of plutonium from irradiated fuel. However, the later-developed REDOX and PUREX processes recovered the uranium, which still had economic value. Following startup of the REDOX Plant, the U Plant was converted to recover the uranium from stored radioactive waste. From 1952 to 1958, stored waste was transferred to the U Plant for uranium recovery. The resultant sludge was dissolved in nitric acid, and then the uranium was extracted using tributyl phosphate in a normal paraffin diluent. This process left the fission products, sulfate, and phosphate ions in the aqueous acid solution. The uranium was then stripped from the organic solvent with nitric acid. This nitric acid solution was concentrated and sent to the uranium oxide process.

Although the uranium recovery processing is no longer going on, the adjacent uranium oxide plant is still operational. This plant received uranyl nitrate solution from the recovery process and from the REDOX Plant and calcined it to uranium trioxide. The uranium oxide plant now processes the product uranium from the PUREX Plant. Nitric acid is recycled to the PUREX process as a by-product of the calcination process. The uranium trioxide is shipped off site for use as nuclear fuel.

REDOX Plant. The REDOX process for fuels separation succeeded the bismuth phosphate process and preceded the PUREX process. The REDOX Plant was constructed from May 1950 to August 1951; it operated until it was shut down in July 1967. An analytical laboratory near the facility is still operational. This laboratory supports B-Plant operations and performs research and development in support of waste management and environmental control operations. The laboratory also functions as a backup laboratory to the PUREX and Z-Plant analytical laboratories.

The REDOX Plant used a solvent extraction process to separate uranium and plutonium from fission products and each other. Methyl isobutyl ketone (MIBK) was the organic solvent that was used.

The fuel elements were prepared for nitric acid dissolution using the methods from the bismuth phosphate process. Sodium dichromate was added to the nitric acid solvent to oxidize plutonium to a state suitable for organic extraction.

Aluminum nitrate was added to the acid solution as a salting agent for the first extraction column. This salting agent caused the uranium and plutonium to be preferentially extracted by MIBK, leaving the fission products in the aqueous phase. In a second extraction column, a reducing agent was added to the aqueous phase to reduce the plutonium so that it would be removed from the uranium and extracted into the aqueous phase. The organic uranium solution and the aqueous-plutonium solution were then processed separately, purified further, and concentrated into their respective products: uranium nitrate hexahydrate (UNH) and plutonium nitrate. The plutonium nitrate was sent to the Z Plant for processing into plutonium oxide or plutonium metal. The UNH was sent to the uranium oxide plant.

The organic solvent was treated for recycling by removing decomposition products and by further decontamination. Aqueous streams were concentrated, then the aluminum nitrate was converted to sodium aluminate by sodium hydroxide before disposal.

T Plant. The T Plant was one of the original bismuth phosphate fuels-separation facilities; it was constructed from June 1943 to October 1944 and operated for the bismuth phosphate process from 1944 to 1956. Since 1956, facilities in the T Plant have been used for decontamination and equipment repair.

Z Plant. Constructed in 1949, the Z Plant was the site of the plutonium laboratory and finishing operations, including the processing of plutonium scrap materials and preparation of plutonium products. The plutonium parts preparation ceased in December 1965. A process known as "recouplex" was operated at the plant from 1955 to 1962 to recover plutonium from scrap and produce a plutonium nitrate solution. The Plutonium Reclamation Facility began operations in 1964 to perform the functions of the recouplex process.

The recouplex process used nitric acid and hydrofluoric acid to dissolve solids and a tributyl phosphate-carbon tetrachloride solvent extraction process for recovery of purified plutonium nitrate solutions. Aluminum nitrate was used to salt the aqueous streams for selective extraction of plutonium and to create complexed fluoride ions as aluminum fluoroxide nitrate to prevent their interference during plutonium extraction. Americium was also

recovered in the Plutonium Reprocessing Facility using dibutyl butyl phosphonate (DBBP) in a carbon tetrachloride diluent. The DBBP has subsequently been replaced with tributyl phosphate.

The Plutonium Processing Facility converts plutonium nitrate to plutonium oxide and then to plutonium metal, if metal is the desired product. The plutonium oxide is made by precipitating the plutonium as plutonium oxalate and then calcining the precipitate. To produce metal, the plutonium oxide is first converted to plutonium fluoride. The fluoride is placed in an iron can, which is placed in a magnesium oxide crucible with calcium metal. A reducing charge is applied to the crucible to reduce the plutonium fluoride to plutonium metal, which is then molded into a button. The remaining iron, calcium, and magnesium are dissolved in nitric acid for disposal.

2.3.3 300 Area

The 300 Area is located about 1.6 kilometers (1 mi) north of the Richland city limits, on the bank of the Columbia River. Roughly rectangular in shape, the area covers about 1.5 square kilometers (370 acres); waste-management facilities have been added just to the north of the 300 Area.

Occupying a relatively flat area on the west bank of the Columbia River, the area has an elevation that is about 15 meters (50 ft) above the average elevation of the adjacent river. The Hanford Site land surface surrounding the 300 Area is devoid of prominent surface features and slopes gently upward to the northwest.

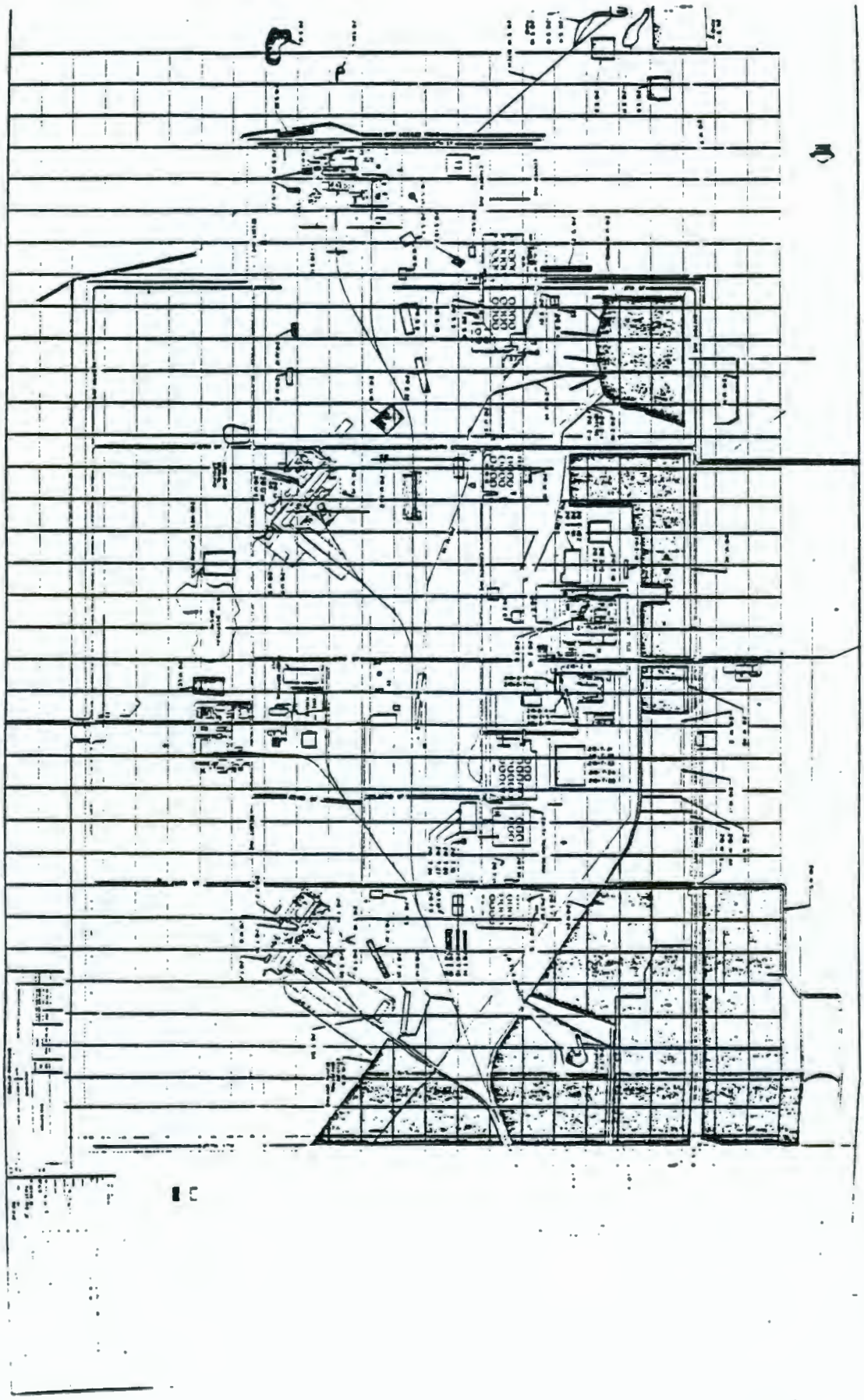
The surface sediments in the 300 Area are largely wind-transported sands and silts. These sediments, which were deposited in dunes up to about 3 meters (9.8 ft) in depth, have been largely stabilized by vegetation. Below this layer lie 20 to 25 meters (66 to 82 ft) of coarse-grained glaciofluvial deposits known as the Pasco Gravels; the permeability of these deposits is very high.

The high porosity and permeability of the sands and gravels that underlie the area allow any precipitation to infiltrate rapidly. Flooding of any

These general categories were used in conjunction with the mHRS/HRS scores to identify the potentially hazardous liquid-effluent disposal sites in the 200 Areas and to complement the mHRS/HRS score by providing site-specific information not otherwise addressed. For example, a waste may have contained complexants that increased contaminant mobility. Although these complexants were not hazardous chemicals (and thus contributed little to the score), they increased the potential hazard of a disposal facility by mobilizing radioactive contaminants. Conversely, factors such as waste volume and distance to or contact with the ground water, as well as many other parameters that influenced the potential hazard of a facility, were taken into account in the scoring but were not considered in categorizing the sites. The mHRS/HRS scores, in combination with waste characteristics, allowed a more comprehensive evaluation of the potential hazard from past waste-disposal practices. The relative potential hazard from each liquid-effluent disposal site will be described on a plant-by-plant basis for the 200-East and 200-West Areas in Section 3.3.

Steam condensate and cooling water are primarily river water with little potential for chemical or radioactive contamination. These liquid effluents made up a large portion of the water used in the 200 Areas. Steam condensate and cooling water were most commonly discharged through unlined ditches to ponds for evaporation or drainage to the ground water. Accidental releases of radioactive and hazardous substances to these facilities have occurred, but represent only a small fraction of the waste volume discharged to these sites. Sites that received steam condensate and cooling water are not considered to represent a priority for Phase II characterization, but for those sites that scored more than 28.5, "further action pending" is recommended.

Process condensate is that water condensed from closed systems that has been in direct contact with radioactive material. Process condensate can be acidic or alkaline and often contains relatively low concentrations of nitrate, ammonia, and possibly volatile organic compounds. It is likely that certain of these process condensates also contain potentially volatile radionuclides. Carbon-14, tritium, iodine-129, ruthenium-106, and other radionuclides could be contained in process condensates. Because of their



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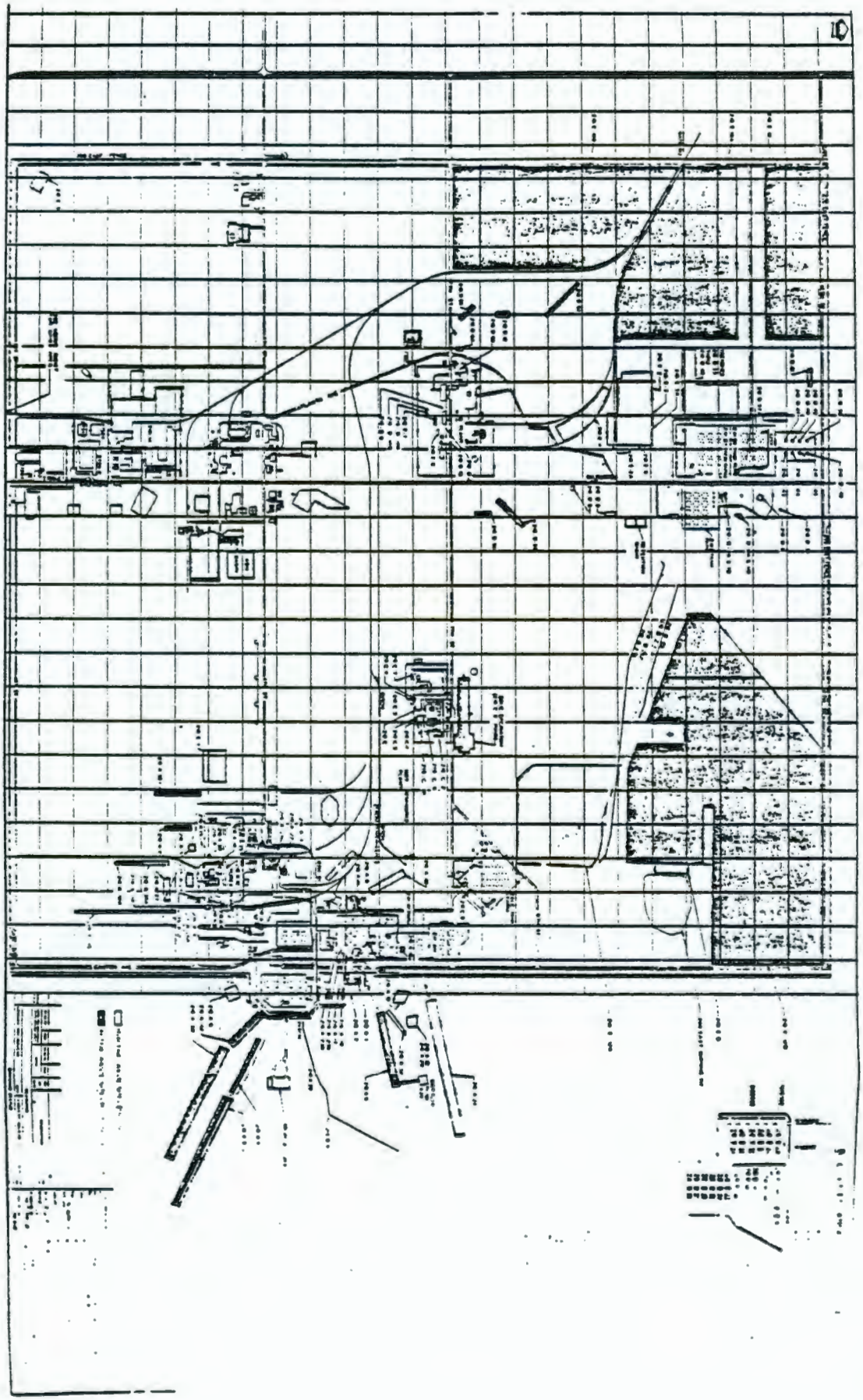

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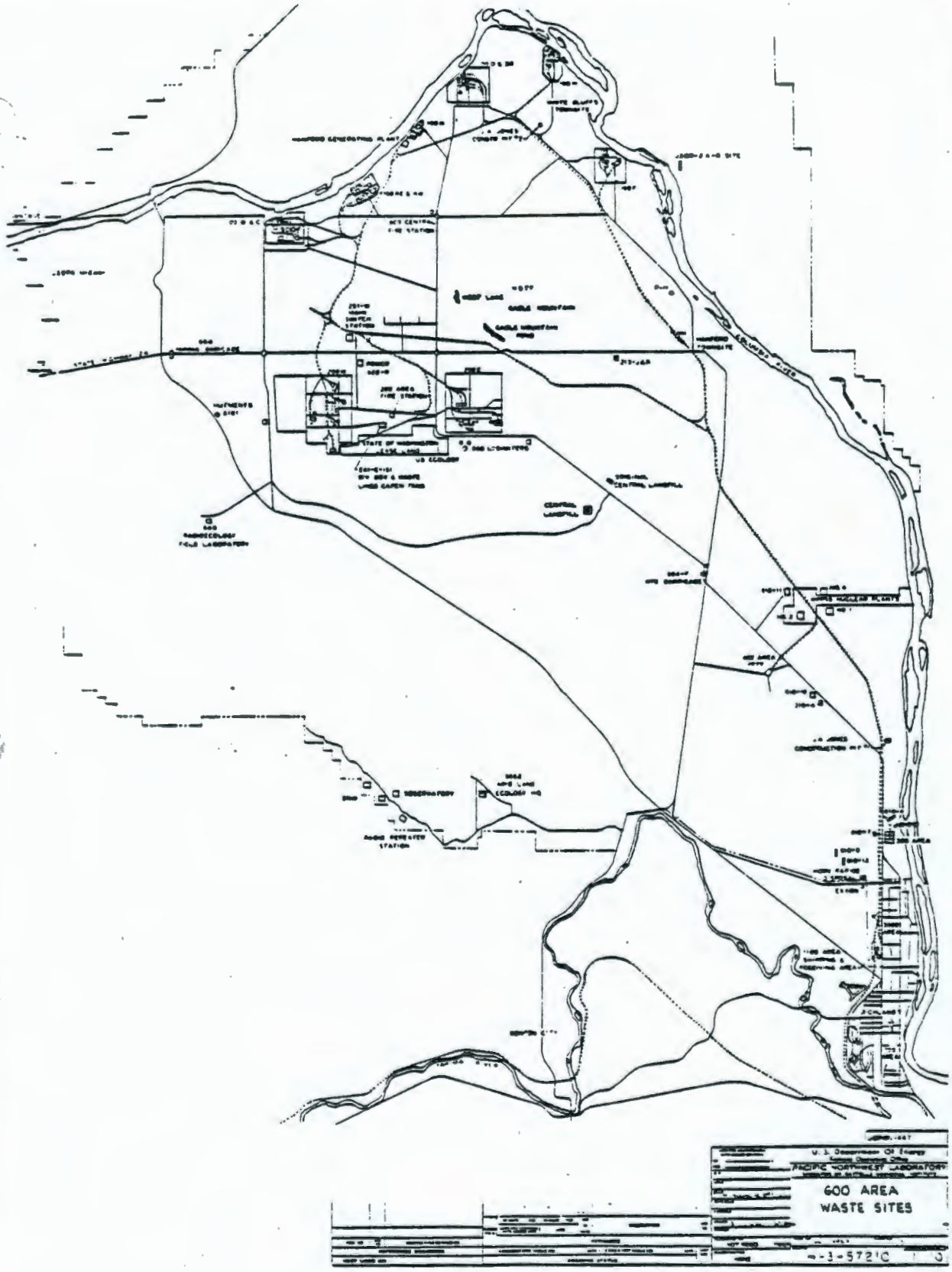

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REFERENCE 2

Environmental Monitoring at Hanford for 1986, PNL-6120

9413218.0296

2.0. BACKGROUND INFORMATION

2.1. DESCRIPTION OF THE HANFORD SITE

K. R. Price, P. J. Mitchell, and M. D. Freshley

The U.S. Department of Energy's Hanford Site is located in a rural region of southeastern Washington and occupies an area of 1,500 km^2. The Site (shown in Figure 2.1) lies about 320 km northeast of Portland, Oregon, 270 km southeast of Seattle, Washington, and 200 km southwest of Spokane, Washington. The Columbia River flows through the northern edge of the Hanford Site and forms part of the eastern boundary. The southern boundary of the Site includes the Rattlesnake Hills, which exceed 1000 m in elevation. Both confined and unconfined aquifers are present beneath the Site. The main geologic units are the Columbia River Basalt Group, the Ringold Formation, and a series of glaciofluvial sediments. The Hanford Project was established in 1943 and was originally designed, built, and operated to produce plutonium for nuclear weapons.

SURFACE CHARACTERISTICS OF THE SITE

The semiarid land on which the Hanford Site is located has a sparse covering of desert shrubs and drought-resistant grasses. The most broadly distributed type of vegetation on the Site is the sagebrush/cheatgrass/bluegrass community. Most abundant of the mammals is the Great Basin pocket mouse. Of the big-game animals, the mule deer is the most abundant, while the cottontail rabbit is the most abundant of the small-game animals. Coyotes are also abundant. The bald eagle is a regular winter visitor to the relatively large areas of uninhabited land comprising the Hanford Site.

The Columbia River, which originates in the mountains of eastern British Columbia, Canada, flows through the northern edge of the Hanford Site and forms part of the Hanford Site's eastern boundary. The river drains a total area of approximately 70,800 km^2 enroute to the Pacific Ocean. The flow of the Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Site. Priest Rapids Dam is the nearest impoundment upstream of the Site, and McNary Dam is the nearest dam downstream. (The Hanford reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam.) This is the only stretch of the Columbia River within the U.S. that is not impounded by a dam. The width of the river varies from approximately 300 m to about 1000 m. The flow through this stretch of the river is relatively swift, with numerous bends and several islands present throughout the reach.

The flow rate of the Columbia River in this region is regulated primarily by Priest Rapids Dam. Hanford reach flows fluctuate significantly because of the relatively small storage capacity and operational practices of the nearby upstream dams. A minimum flow rate of 1,000 cubic meters per second (m^3/s) [36,000 cubic feet per second (cfs)] has been established at Priest Rapids. Typical daily flows range from 1,000 m^3/s (36,000 cfs) to 7,000 m^3/s (250,000 cfs) with peak spring runoff flows of up to 12,600 m^3/s (450,000 cfs) being recorded. Typical annual average flows at Priest Rapids Dam are 3,100 m^3/s (110,000 cfs) to 3,400 m^3/s (120,000 cfs). Monthly mean flows typically peak from April through June and are at the lowest levels from September through October.

The temperature of the Columbia River varies seasonally. Minimum temperatures are observed during January and February while maximum temperatures typically occur during August and September. Monthly temperatures for the river range from approximately 3°C to about 20°C during the course of a year. Water storage management practices at upstream dams and the flow rate of the river dictate, to a large extent, the thermal characteristics of the Columbia River along the Hanford reach.

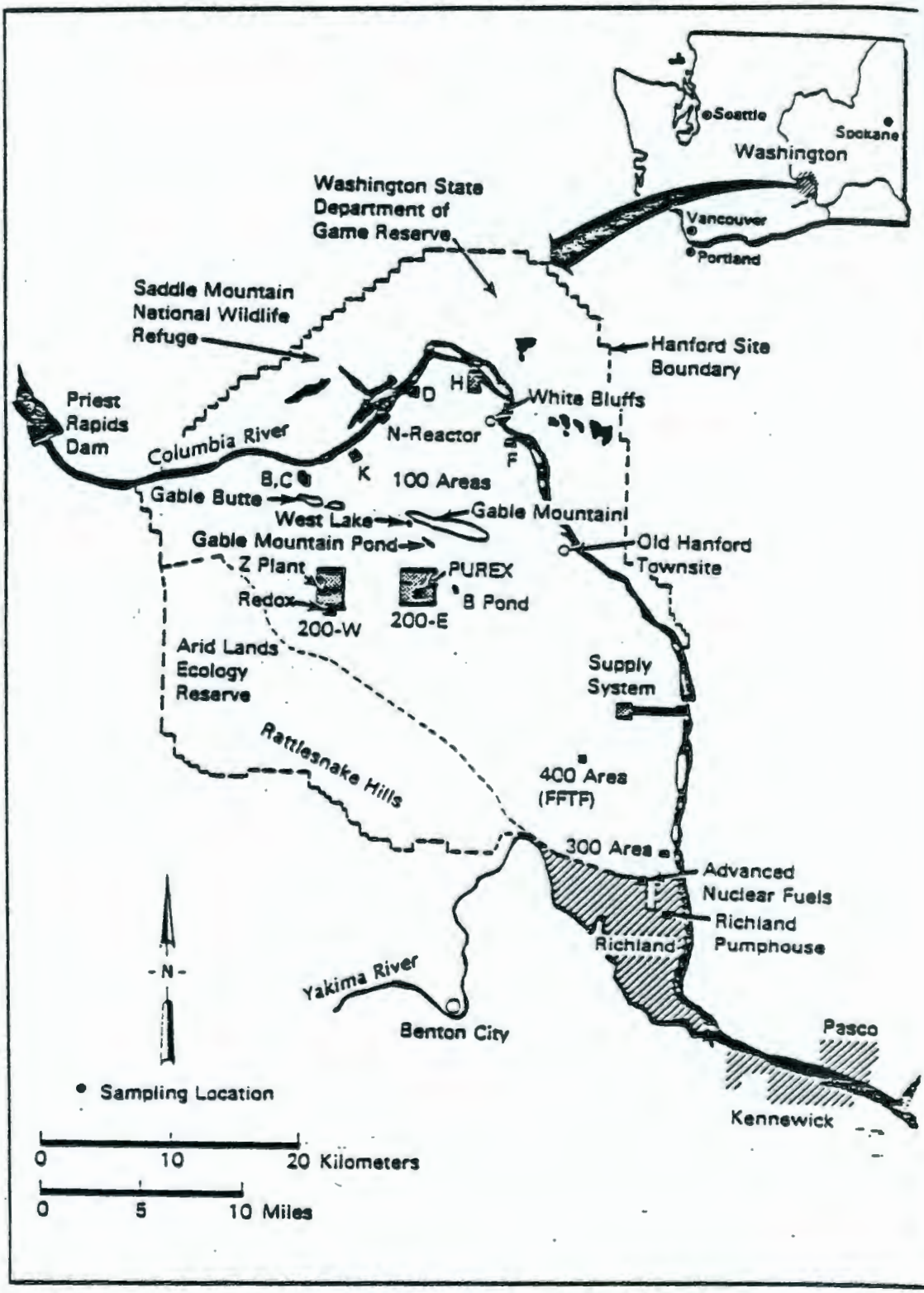

FIGURE 2.1. DOE's Hanford Site

Ref. 2.2

The Columbia River system has been developed extensively for hydroelectric power, flood control, navigation, irrigation, and municipal and industrial water supplies. In addition, the Hanford reach is used for a variety of recreational activities including fishing, hunting, boating, water skiing, and swimming. The State of Washington has classified the stretch of the Columbia River from the Washington-Oregon border to Grand Coulee Dam (which includes the Hanford reach) as Class A and established water quality criteria and water use guidelines for this class designation. Because these criteria do not include specific limits for radionuclides, Environmental Protection Agency (EPA) and State of Washington drinking water limits were used for comparison. Other surface water on the Site consists of West Lake (a small, natural pond) and a number of ditches and artificial ponds created for routine disposal of waste water.

Hanford's climate is dry and mild; the area receives approximately 16 cm of precipitation annually. About 40% of the total precipitation occurs during November, December, and January; only 10% falls in July, August, and September. Approximately 45% of all precipitation from December through February is snow. The average minimum and maximum temperatures in July are 16°C and 32°C. For January, the average temperatures are 3°C and -6°C.

Monthly average wind speeds range from about [illegible] km/h in the summer to 14 km/h in the winter. The prevailing regional winds are from the northwest, with occasional cold-air drainage into valleys and occurrences of strong crosswinds. The region is a typical desert area with frequent strong inversions that occur at night and break during the day, resulting in unstable and turbulent wind conditions.

Land near the Hanford Site is primarily used for agriculture and for livestock grazing. Agricultural lands are found north and east of the Columbia River and south of the Yakima River. These areas contain orchards, vineyards, and fields of alfalfa, wheat, and vegetables. The Hanford Site north of the Columbia River is shared between a state wildlife management area and a federal wildlife refuge. The northeast slope of the Rattlesnake Hills along the southwestern boundary of the Site is designated as the Arid Lands Ecology Reserve (ALE) and is used for ecological research by DOE.

The major population center nearest to the Hanford Site is the Tri-Cities area (Richland, Pasco, and Kennewick), which is situated on the Columbia River downstream from the Site and has a population of approximately 90,000. Approximately 340,000 people live within an 80-km radius of the Hanford Site. This number includes people living in the Tri-Cities, the Yakima area, several small communities, and the surrounding agricultural area. More detail on Site characteristics and activities is available in "The Final Environmental Statement, Waste Management Operations, Hanford Reservation" (ERDA 1975).

SUBSURFACE CHARACTERISTICS OF THE SITE

The DOE operations on the Site have resulted in the production of large volumes of waste water that have historically been discharged to the ground through cribs, ditches, and ponds. These discharges greatly influence the physics and chemistry of the subsurface. Approximately 25 billion liters of liquid effluent in the 200 Areas and 2.6 billion liters of liquid effluent in the 100N Area were disposed to the ground during 1986, including process cooling water and water containing low-level radioactive wastes. The discharge of waste water to the ground at the Hanford Site began in the mid-forties and reached a peak in 1955. After 1955, discharge to cribs declined because of improved treatment of waste streams and the deactivation of various facilities (Graham et al. 1981). Since the restart of the Plutonium and Uranium Extraction (PUREX) Plant and related facilities in late 1983, discharge of PUREX-related effluents has resumed.

Subsurface structures, such as cribs, have primarily been used for the disposal of water containing radioactive wastes, while surface ponds and ditches have primarily been used for the disposal of uncontaminated cooling water (Graham et al. 1981). Sanitary wastes are discharged to the ground via tile fields. The majority of liquid disposal occurred in the Separations Area, which includes the 200-East (200E) and 200-West (200W) Areas (Figure 2.1). Smaller amounts of waste water were disposed in the 100 and 300 Areas. Discharges of waste water to the ground in the 400 Area were minimal.

Geologic and hydrologic properties of the subsurface, including stratigraphy and physical and chemical properties of the host rock, influence the movement of the liquid effluents. The geology and hydrology beneath the Site and the physical nature of liquid effluent movement are described in more detail in the following sections.

Geology

The main geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold Formation, and a series of glaciofluvial sediments informally known as the Hanford formation. A generalized geologic cross section of the Site is shown in Figure 2.2.

The Columbia River Basalt Group is a thick series of basalt flows. The basalts have been warped and folded, producing anticlines that, in some places, crop out at the land surface. The Ringold Formation overlies the basalts except in some localized areas. This formation consists of fluvial and lacustrine sediments and is separated into four lithologic units: basal, lower, middle, and upper. The basal and middle units consist mostly of semiconsolidated gravels and sands whereas the lower and upper units consist mainly of bedded silts and sands. Beneath the 200-West Area, sediments of the upper Ringold Formation have been reworked by the wind and deposited as a silt layer called the Palouse soil. The Hanford formation rests atop the Ringold Formation or Palouse soil. The Hanford formation also rests atop basalts in places where

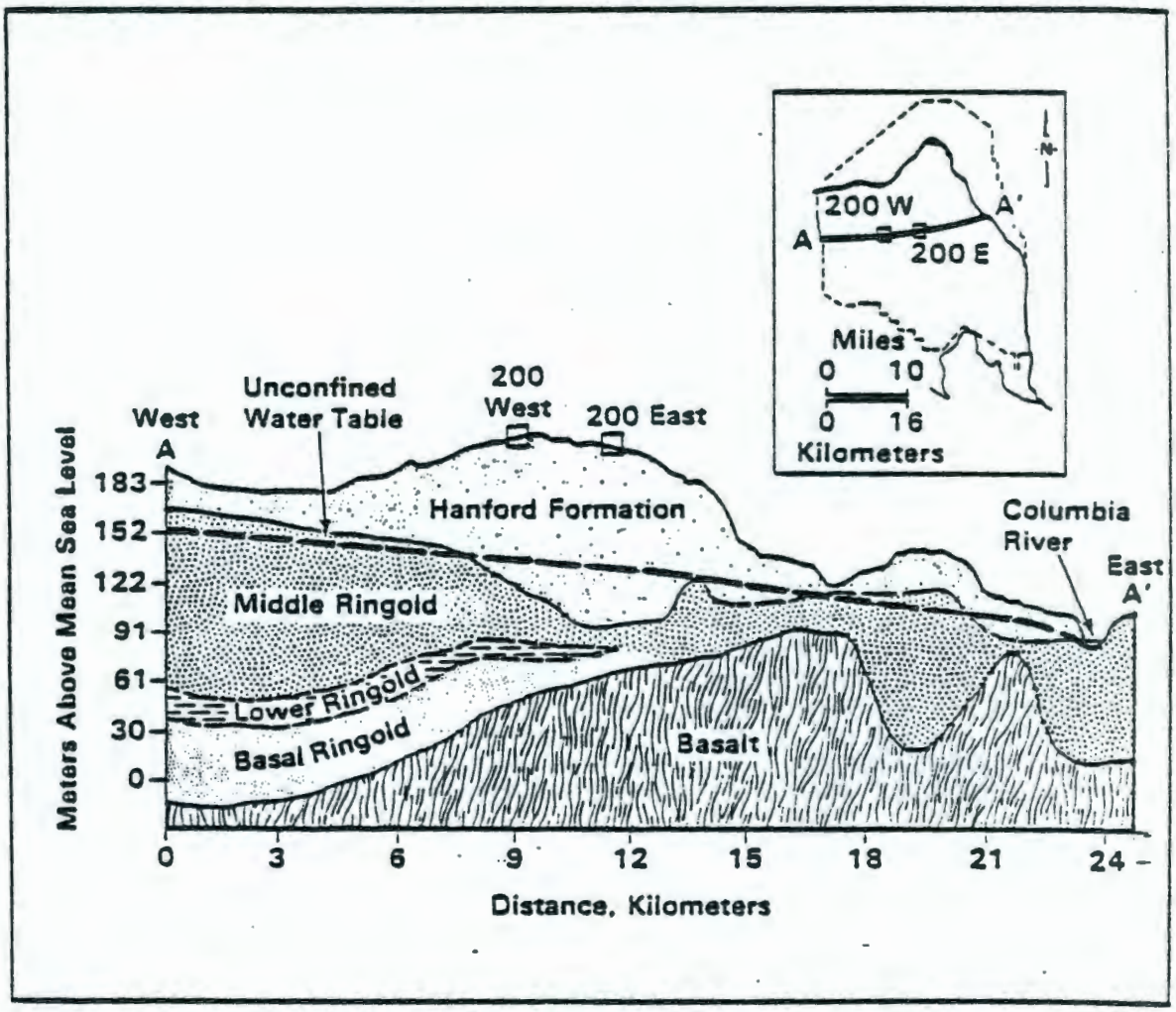

FIGURE 2.2. Geologic Cross Section of theSite (modified from Tallman et al. 1979)

Ref. 2.4

the Ringold formation has been removed. These sediments were deposited by the ancestral Columbia River when it was swollen by glacial meltwater. The glaciofluvial sediments consist primarily of gravels and sands, with some silts (Newcomb, Strand and Frank 1972).

Hydrology

Both confined and unconfined aquifers are present beneath the Hanford Site. The confined aquifers, in which the ground water is under pressure greater than that of the atmosphere, are found primarily within the Columbia River basalts. In general, the unconfined or water-table aquifer is located in the Ringold Formation and glaciofluvial sediments, as well as some more recent alluvial sediments in areas adjacent to the Columbia River (Gephart et al. 1979). This relatively shallow aquifer has been affected by waste-water disposal at Hanford more than the confined aquifers (Graham et al. 1981). Therefore, the unconfined aquifer is the most thoroughly monitored aquifer beneath the Site.

The unconfined aquifer is bounded below by either the basalt surface or, in places, the relatively impervious clays and silts of the lower unit of the Ringold Formation. Laterally, the unconfined aquifer is bounded by the anticlinal basalt ridges that ring the basin and by the Yakima and Columbia rivers. The basalt ridges above the water table have a low permeability and act as a barrier to lateral flow of the ground water (Gephart et al. 1979). The saturated thickness of the unconfined aquifer is greater than 61 m in some areas of the Hanford Site and pinches out along the flanks of the basalt anticlines. The depth from the ground surface to the water table ranges from less than 0.3 m near the Columbia River to over 106 m in the center of the Site. The elevation of the water table above mean sea level for June of 1986 is shown in Figure 2.3.

Recharge to the unconfined aquifer originates from several sources (Graham et al. 1981). Natural recharge occurs from precipitation at higher elevations and runoff from ephemeral streams to the west, such as Cold Creek and Dry Creek. The Yakima River recharges the unconfined aquifer as it flows along the southwest boundary of the Hanford Site. The Columbia River recharges the unconfined aquifer during high stages when river water is transferred to the aquifer along the river bank. The unconfined aquifer receives little, if any, recharge from precipitation directly on the Hanford Site because of a high rate of evapotranspiration under native soil and vegetation conditions. However, present studies, such as those described by Heller, Gee, and Meyers (1985), suggest that precipitation may contribute more recharge to the ground water than was originally thought.

Large scale artificial recharge occurs from offsite agricultural irrigation and liquid-waste disposal in the operating areas at Hanford. Recharge from irrigation in the Cold Creek Valley enters the Hanford Site as ground-water flow across the western boundary. Artificial recharge from waste-water disposal at Hanford occurs principally in the Separations Area. It was estimated that recharge to the ground water from facilities in the Separations Area (including B Pond and Gable Mountain Pond, as well as the various cribs and trenches in the 200W and 200E Areas) adds ten times as great an annual volume of water to the unconfined aquifer as is contributed by natural inflow to the area from precipitation and irrigation waters to the west (Graham et al. 1981).

The operational discharge of water has created ground-water mounds near each of the major waste-water disposal facilities in the Separations Area and in the 100 and 300 Areas (Figure 2.3). These mounds have altered the local flow pattern in the aquifer, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east. Water levels in the unconfined aquifer have changed continuously during Site operations because of variations in the volume of waste water discharged. Consequently, the movement of ground water and its associated constituents has also changed with time.

In addition to the Separations Area, ground-water mounding also occurs in the 100 and 300 Areas. Ground-water mounding in these areas is not as significant as in the Separations Area because of differences in discharge volumes and subsurface geology. However, in the 100 and 300 Areas, water levels are also greatly influenced by river stage.

Liquid Effluent Movement

If significant quantities of liquid effluents are discharged to the ground at the Hanford Site waste disposal facilities, then these effluents would percolate downward through the unsaturated zone to the water table. As

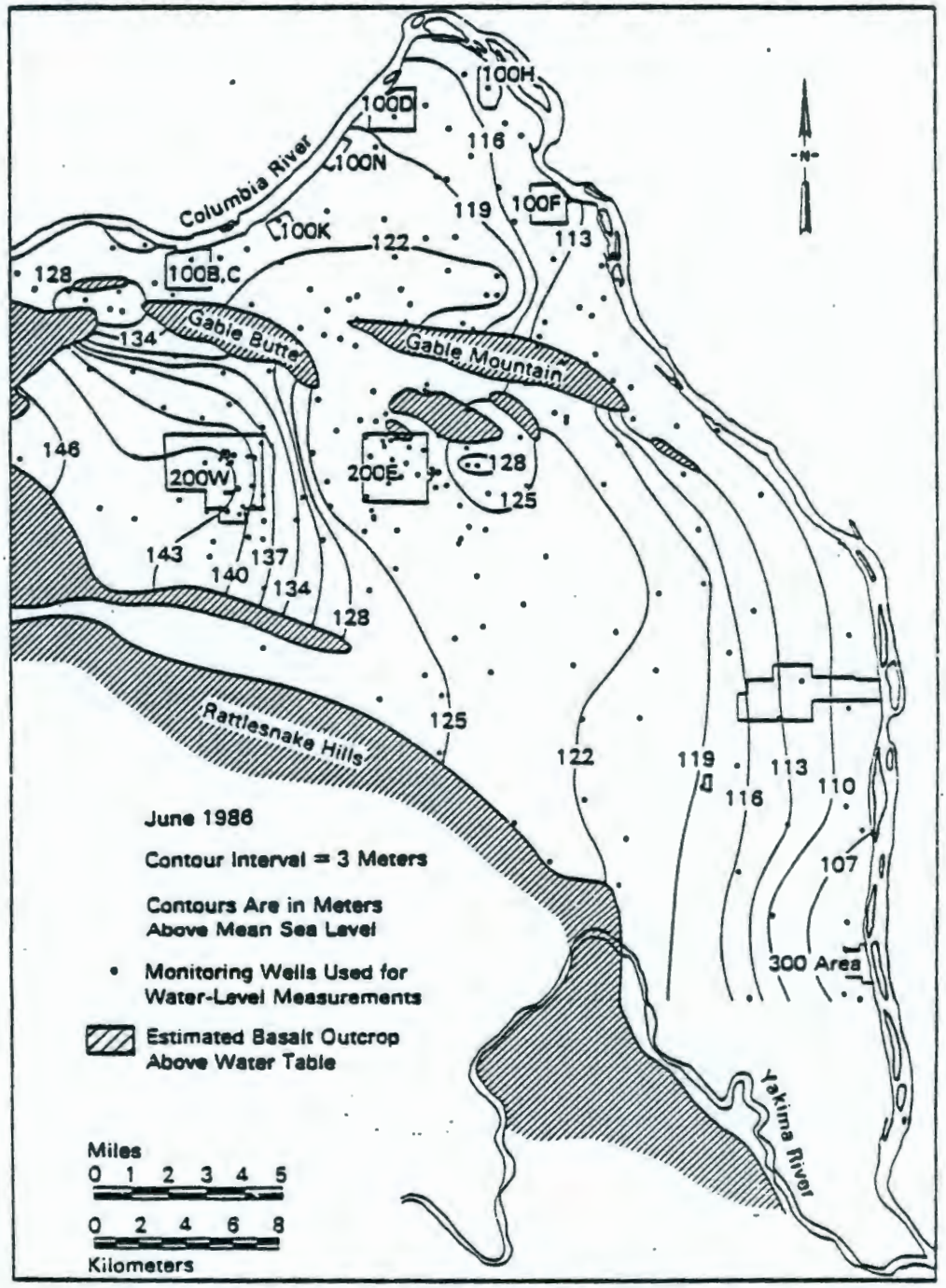

FIGURE 2.3. Water Table Elevations for June 1986 (Schatz and Jensen 1986)

Ref. 2.6

effluents move through the unsaturated zone, adsorption onto soil particles, chemical precipitation, and ion exchange delays the movement of some uncomplexed radionuclides, such as ^{90}Sr, ^{137}Cs, and $^{239,240}Pu$. Other ions, such as nitrate (NO_3), and radionuclides, such as ^{3}H, ^{129}I, and ^{99}Tc, are not retained by the soil as readily. These constituents move through the soil column at varying rates and eventually enter the ground water. Subsequently, the nonattenuated constituents move downgradient in the same direction as and at a rate nearly or often equal to the flow of ground water. As the constituents move with the ground water, radionuclide concentrations are reduced by spreading (dispersion) and radioactive decay.

MAJOR ACTIVITIES

Previously, the Hanford Site housed and operated up to nine production reactors, including eight with once-through cooling by treated river water. Between December 1964 and January 1971, all eight reactors with once-through cooling were deactivated. The N Reactor, which is the production reactor remaining in operation, has a closed primary cooling loop.

Four major DOE operating areas exist at the Hanford Site [i.e., 100, 200, 300, and 400 Areas (Figure 2.1)]. The 100 Areas include facilities for the N Reactor and the eight deactivated production reactors along the Columbia River. The reactor fuel reprocessing plant (PUREX), Plutonium Finishing Plant (Z Plant), and waste-management facilities are on a plateau about 11.3 km from the river, in the 200 Areas. The 300 Area, just north of the city of Richland, contains the reactor fuel manufacturing facilities and research and development laboratories. The Fast Flux Test Facility (FFTF) is located in the 400 Area, approximately 8.8 km northwest of the 300 Area.

Privately owned facilities located within the Hanford Site boundaries include the Washington Public Power Supply System (Supply System) Hanford generating station adjacent to N Reactor, the Supply System power reactor and office buildings, and a low-level radioactive-waste burial site operated by U.S. Ecology. The Advanced Nuclear Fuel Corp. (formerly Exxon) fuel fabrication facility is immediately adjacent to the Hanford Site.

Principal DOE operating contractors at Hanford during 1986 included the following:

Rockwell Hanford Operations (Rockwell) -- responsible for fuel reprocessing, waste management, and Site support services, such as plant security, fire protection, central stores, and electrical power distribution.

Battelle Memorial Institute (BMI) -- responsible for operating PNL for DOE. Pacific Northwest Laboratory activities include research and development in the physical, life, and environmental sciences; chemistry; and advanced methods of nuclear waste management. Pacific Northwest Laboratory is also responsible for environmental monitoring at the Site.

UNC Nuclear Industries (UNC) -- responsible for fabricating N Reactor fuel, operating the N Reactor, and decommissioning formerly used DOE facilities, including deactivated production reactors.

Westinghouse Hanford Company (WHC)-- responsible for operating the Hanford Engineering Development Laboratory (HEDL), including advanced reactor developments and the FFTF test reactor.

Hanford Environmental Health Foundation (HEHF) -- responsible for occupational medicine and environmental health support services.

Operational Highlights

Highlights of operational activities at Hanford during 1986 were

- The N Reactor operated for 182 days, during which time it supplied steam used by the Supply System to generate 860 megawatts of electrical power. Since its startup, the N Reactor has supplied steam for the production of over 65 billion kilowatt-hours of electrical power, which has been supplied to the Bonneville Power Administration grid covering the Pacific Northwest.

- The PUREX Plant fuel reprocessing facility located in the 200E Area completed a third year of operation since restart of operations in 1983. The uranium oxide plant (UO_3 Plant) operated as needed through 1986. The Plutonium Reclamation Facility at Z Plant operated throughout the year as well.

200 Area Background BKG and Down gradient (DG) Wells

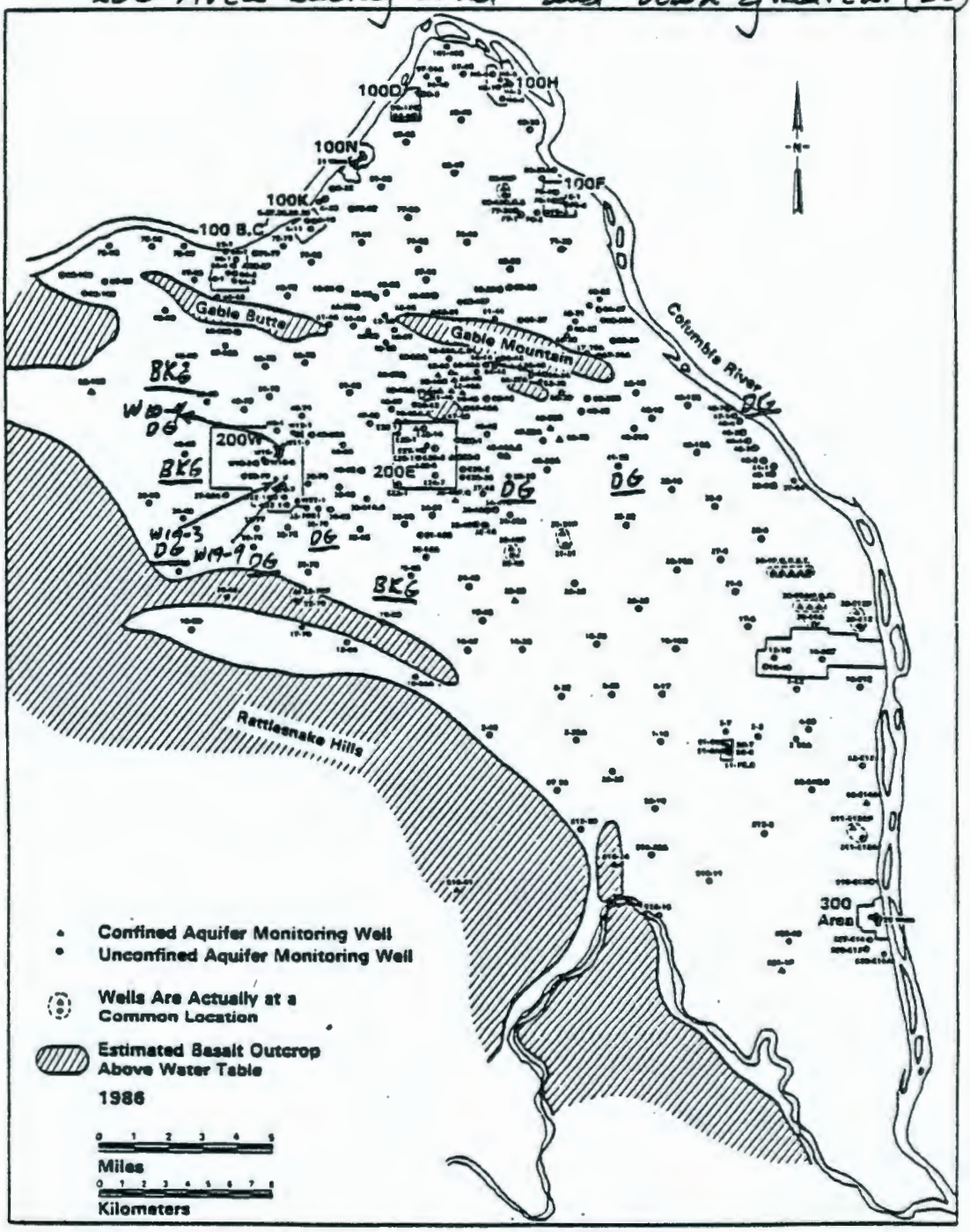

FIGURE 3.10. Location of Ground-Water Monitoring Wells Sampled in 1986 (first digit of well number has been dropped)

collection, in accordance with documented procedures. Further details on analyses are found in Appendix D and in the "Quality Assurance" section.

RADIOLOGICAL MONITORING RESULTS FOR THE UNCONFINED AQUIFER

Ground-water monitoring for certain radiological constituents at the Hanford Site was based on past and/or present waste management practices. Table 3.6 identifies major constituents associated with Site operations. Radiological monitoring results for tritium, gross alpha, gross beta, ^{60}Co, ^{137}Cs, ^{106}Ru, ^{125}Sb, ^{131}I, ^{129}I, uranium (total and isotopic), and strontium isotopes are discussed below. (Nitrate and Cr results are discussed in this section in "Chemical Monitoring Results for the Unconfined Aquifer.")

Past monitoring results have shown that tritium is present in ground water; it also appears to be the most mobile radionuclide at the Site. As a result, tritium reflects the extent of contamination in the ground water from Site operations. Figure 3.12 illustrates the 1986 distribution of average tritium concentrations in the unconfined aquifer, resulting from 40 years of Site operations. Contours of tritium concentrations shown in Figure 3.12 were drawn based on the analysis of ground-water samples collected from monitoring wells. For each well, an average value of up to 12 tritium measurements was used. (The contour level of 5000 pCi/L serves to delineate tritium concentrations above background levels; this contour was not used in previous reports.) A summary of tritium concentrations in wells sampled during 1986 is presented in Appendix A, Table A.12.

Tritium plumes in the 100 Areas are the result of liquid waste disposal during past and present reactor operations. During 1986, tritium concentrations exceeded the DWS (20,000 pCi/L) beneath isolated portions of the 100B, 100F, 100K, and 100N Areas. Tritium distributions beneath the 100B and 100F Areas appeared to have stabilized or diminished slightly from 1985 to 1986. The highest tritium concentration within the 100 Areas was observed in well 1-K-30 (see Figure 3.10 for location). The average tritium concentration in that well increased from 420,000 pCi/L in 1985 to about 640,000 pCi/L in 1986. However, this increase remained within the range of concentrations measured since 1981 (470,000 to 880,000 pCi/L). No other wells within the 100K Area had concentrations in this range, although tritium concentrations above background levels appeared in well 1-K-29 (averaging 27,000 pCi/L) during 1986. Tritium concentrations in wells surrounding the 100N Area remained relatively stable during the past year. The range of average yearly tritium concentrations in the immediate vicinity of the 100N Area liquid disposal facilities was about 30,000 to 110,000 pCi/L. The tritium distribution beneath the 100N Area changed because liquid effluent disposal to the 1301N Liquid Waste Disposal Facility (LWDF) was discontinued and the 1325N LWDF, which is farther from the Columbia River than the 1301N LWDF, was activated. All concentrations observed in the 100 Areas were significantly lower than the DCG (2,000,000 pCi/L) for tritium.

Several tritium plumes emanated from the 200 Areas. The distribution of tritium beneath the 200E and 200W Areas is the result of disposal of liquids used in chemical processing activities. The potential sources of these tritium plumes were identified by comparing data on each of the plumes with data presented in the Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford[a]. This comparison suggested that process condensate liquid wastes from the PUREX Plant (in the 200W Area) and from past operations at the REDOX Plant (in the 200W Area) represent the major sources of tritium. (Process condensate is water that is condensed from closed systems that are in direct contact with radioactive material.) At both the PUREX and REDOX plants, process condensates resulted from the initial dissolution of the nuclear fuel. A widespread plume situated between the 200E Area and the Columbia River (Figure 3.12) is primarily a result of operations at the PUREX Plant during 1956 to 1972. The historical movement of tritium along ground-water flow paths from PUREX to the Columbia River was also observed at individual monitoring wells. The tritium concentration history at well 6-41-23 (Figure 3.13), located midway between

(a) U. S. Department of Energy, 1986, Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Richland, Washington.

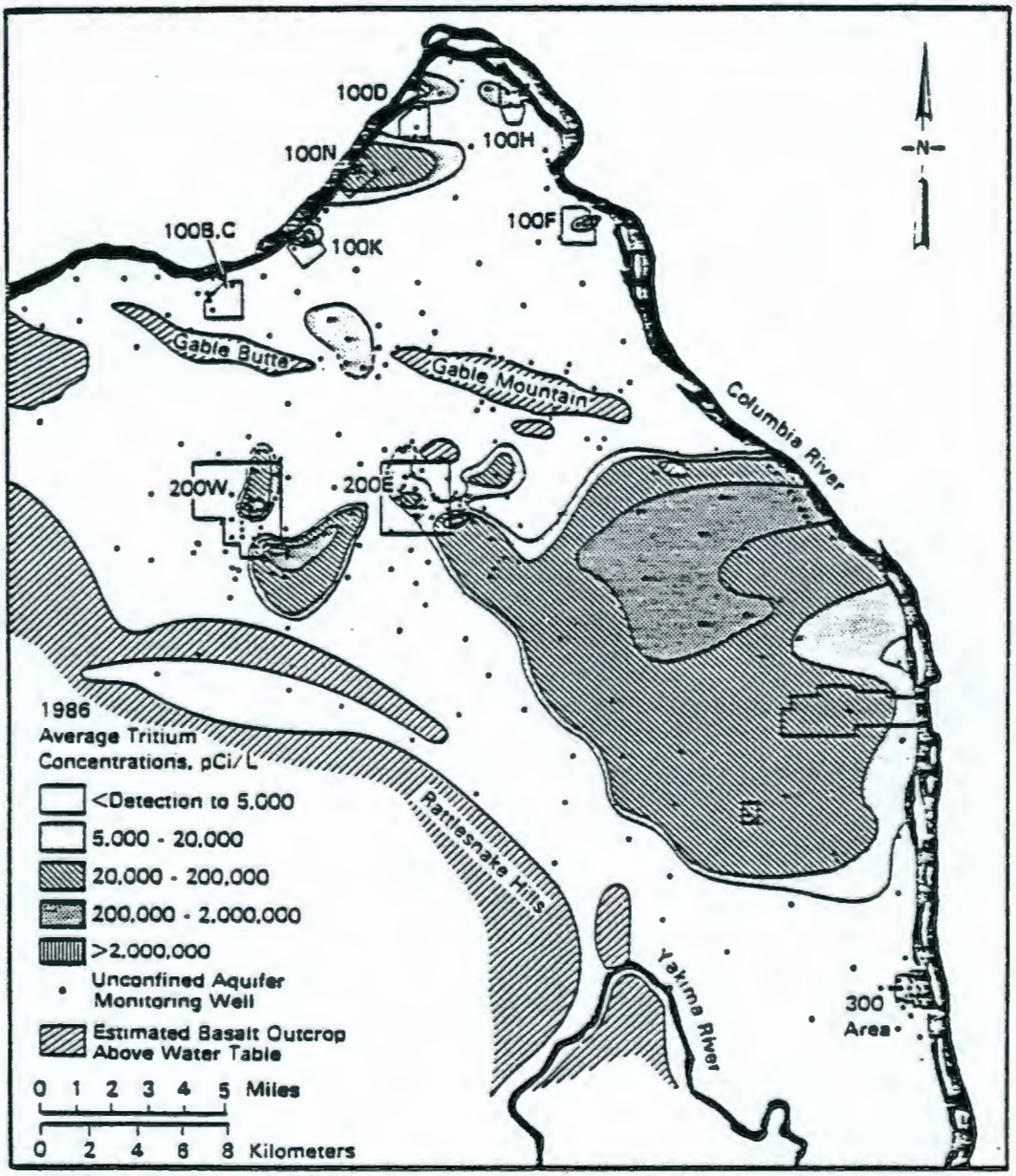

FIGURE 3.12. Tritium Concentrations in Ground Water for 1986

TABLE 3.6. Major Constituents Linked to Site Operation Activities

Facilities Type	Area	Constituents
Reactor Operations	100	Tritium, ^{60}Co, ^{90}Sr, Cr
Irradiated Fuel Processing	200	Tritium, nitrate, ^{137}Cs, ^{129}I
Fuel Fabrication	300	Uranium, Cr

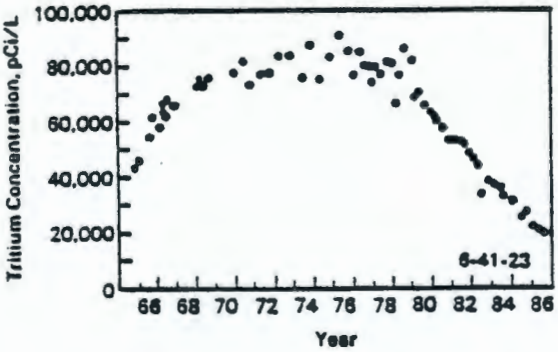

FIGURE 3.13. Tritium Concentrations in Well 6-41-23, 1966 Through 1986

the 200E Area and the Columbia River (Figure 3.10), showed increases (until about 1977) and decreases (from 1977 to the present) in concentrations as tritium flowed past the well. The decrease in concentrations at this well resulted from the discontinuation of PUREX operations in 1972, when ground water with a lower tritium concentration began flowing past the well. Tritium concentration histories at three other locations [wells 6–40–1 and 6–42–2 near the Columbia River (Figure 3.14) and well 6-42–12A located farther inland (Figure 3.15)] also showed increases in tritium during the 1970s. Concentrations have not yet begun to decrease at these wells as shown by their location in the plume (within the contour of 200,000 pCi/L; see Figure 3.12). It is expected that concentrations in these three wells will decrease (as they have in well 6–41–23) when the cleaner ground water reaches the wells. The variations in concentrations at wells 6–40–1 and 6–42–2 can be partially attributed to the mixing of surface water in the aquifer as the Columbia River stage changes.

Recent increases in tritium concentrations were observed close to the 200E Area in wells 6-32-43 and 6-33-42 (located in Figure 3.10). These two wells, which were drilled in 1977, showed decreasing tritium concentrations during the time the PUREX Plant was shut down, and then increasing concentrations in 1985 as a result of increased liquid waste disposal in early 1984 (Figure 3.16). These increased concentrations indicated the presence of a second, smaller area of tritium concentrations that were above 200,000 pCi/L in the region near the PUREX Plant (southeast corner of the 200E Area) (Figure 3.12).

Another major tritium plume, in the southern portion of the 200W Area, emanated from the REDOX Plant, which processed fuel from 1951 until 1967. This plume was less widespread and had higher concentrations than the first plume produced by the PUREX Plant. The lower hydraulic conductivity of the geologic media resulted in slower ground-water flow rates near the 200W Area.

Figure 3.12 shows 1986 tritium concentrations that were above 5000 pCi/L in the northern region of the 200W Area, in the region east of the 200E Area (near B Pond), and between Gable Butte and Gable Mountain. These plumes are the result of past Hanford operations. The waste disposal practices that created these plumes were not identified.

A comparison of the average tritium concentrations in each well for 1986 (Figure 3.12) showed one plume near REDOX at levels above the DCG (2,000,000 pCi/L). Several locations showed tritium concentrations above the DWS (20,000 pCi/L). These locations included 1) isolated portions of the 100B, 100F, 100K and 100N Areas, 2) the 200W Area, and 3) the large plume located between the 200E Area and the Columbia River.

During 1986, samples from ten wells were analyzed for gross alpha activity in the area of the highest tritium concentrations to the south of and along the Columbia River and just south of the midpoint between the 200W and 200E

The per capita dose was calculated to be 0.004 mrem (0.00004 mSv).

RADIOLOGICAL IMPACT FROM PUREX PLANT OPERATIONS

The PUREX Plant restarted operations in November 1983 and continued operations through September 1986. In addition to the dose contributions identified earlier from PUREX Plant operations, other minor dose contributions of interest are discussed here. The greatest percentage of airborne emission from the PUREX Plant in 1986 was 500,000 Ci of ^{85}Kr (see Table G.1, Appendix G). Krypton-85 is an inert gas and is not retained in environmental media or the human body. The dose from inhaling ^{85}Kr is small compared with doses from other radionuclides. Even though the curie quantity of this radionuclide was large, it was a minor contributor to the radiation dose. The average concentration of ^{85}Kr measured in 1986 at the perimeter monitoring stations was 100 pCi/m^3, which was calculated to produce a potential effective dose of 0.002 mrem to an individual who was at that location 100% of the time.

In 1986, there was also 0.003 Ci of $^{239,240}Pu$ in airborne emissions from the PUREX Plant (see Table G.1, Appendix G), compared to 0.01 Ci in 1985. Plutonium-239,240 was also a minor contributor to the dose from 1986 Hanford operations, with a maximum potential effective dose of 0.002 mrem (0.00002 mSv).

RADIOLOGICAL IMPACT ON DRINKING WATER FROM WELLS

During 1986, ground water was used as the source of drinking water for the 400 Area (FFTF), the Yakima Barricade Guardhouse, and the Hanford Patrol Training Academy. Samples were collected from these systems throughout the year in accordance with applicable drinking water regulations. With the exception of tritium concentrations measured in the drinking water at the FFTF, 1986 results were similar to those observed during previous years. Tritium concentrations in the drinking water at the FFTF decreased from an average of 22,000 pCi/L in 1985 to 8,500 pCi/L in 1986 as a result of drilling a new, deeper well for the drinking water source.

The effective dose to a worker at FFTF consuming 250 L of such water during 1986 was estimated to be 0.13 mrem or 3% of the Washington State Drinking Water Standard of 4 mrem/yr. Radionuclide concentrations observed during 1986 were well below applicable drinking water limits in all cases. The monitoring results, nonradiological as well as radiological, from the Hanford Sanitary Water Quality Surveillance Program are discussed in more detail and reported annually by HEHF (Somers 1987).

REFERENCE 3

Investigation of Ground-Water-Seepage from the Hanford Shoreline of the Columbia River, PNL-5289, November 1984

PNL-5289
UC-41, 11

Investigation of Ground-Water Seepage from the Hanford Shoreline of the Columbia River

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November 1984

Prepared for the U.S. Department of Energy
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Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

PNL-5289

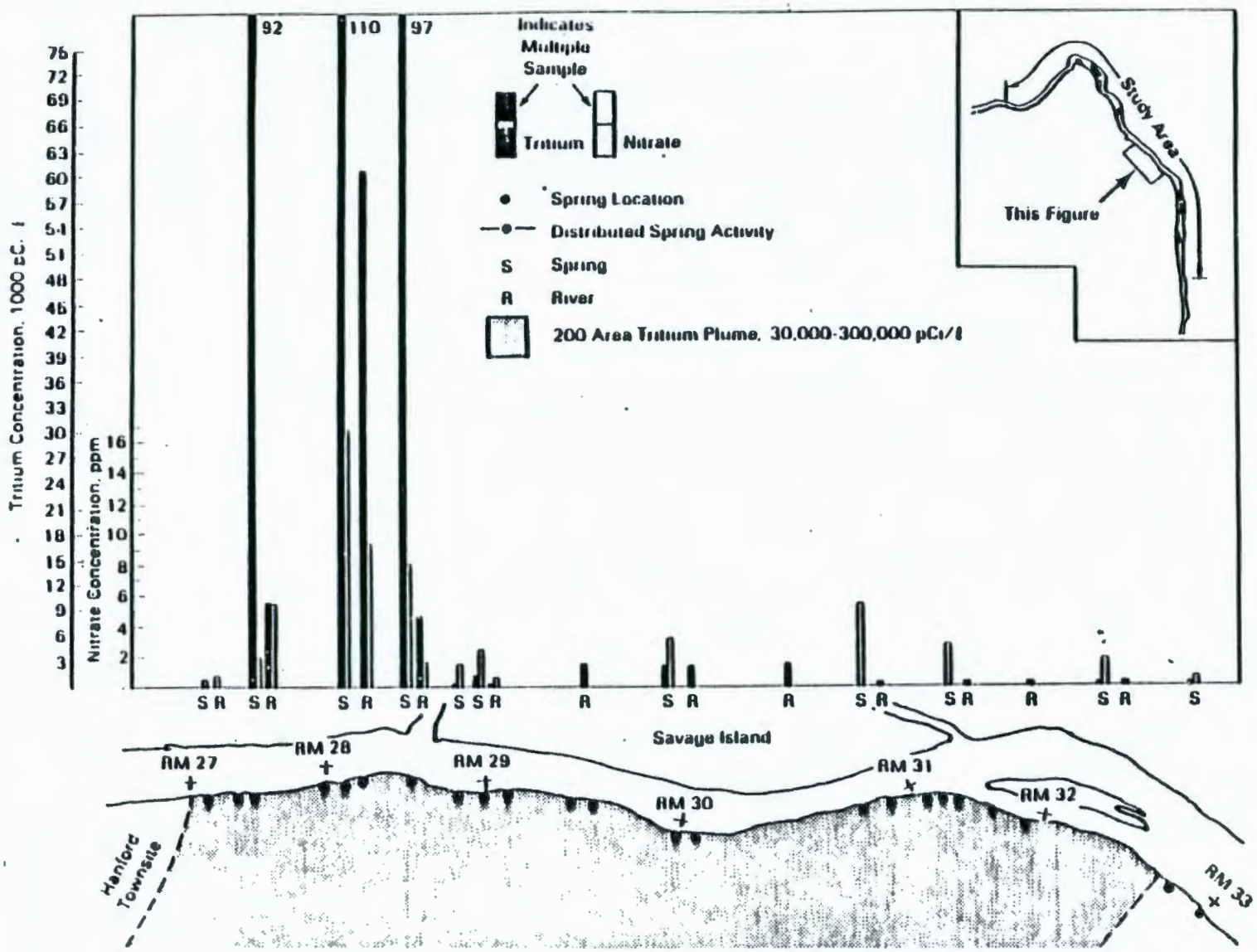

FIGURE 5. Locations and Analytical Results for Spring and River Samples - River Mile 27 through River Mile 33

Ref 3.2

TABLE A.1. Shoreline Inspection Record (Cont'd.)

River Mile Location	Spring Designation	Inspection Date/Time	Description
25.75	25-4	11:47	11.3°C, heavy flow, just DS[b] boat ramp (ferry landing), deep cove in bank, entire cove spring activity, 11.9°C
	25-5	12:00	11.8°C, heavy flow, 50 y DS ferry landing
25.8	25-6	12:05	10.6°C, heavy flow, 6 ft wide stream, 150 y DS ferry landing
26.2	26-1	11:20	10.9°C, heavy flow, springs across inlet at TLD location, 10 ft from river's edge, small cobbles with mud and silt
26.25	26-2	11:40	heavy overall flow/moderate individually, 200 ft wide indentation in bank, flat mud and sand beach capped by boulders, 200 ft DS 26-1
26.6	26-3	12:20	moderate flow, streams trickling down from area of potholes located up the bank, pool 20 ft from river's edge, at foot of trees US[a] from well 48-7
26.8	26-4	12:30	heavy flow, silty beach with cobble lenses, inside wide bay in bank below bluff, emanating from middle cobble lens, 20 ft from river's edge, rivulets extend 20 ft into river
27.0	27-1	11-6-82/8:30 a.m.	12.6°C, heavy flow, broad depressed area forming indentation in bank, flow from 100 y wide area, 100 y DS RM[c] 27
27.25	27-2	9:04	12.7°C, heavy flow, broad dished area, surrounded by numerous potholes, cobble with mud in depressions
27.5	27-3	9:15	12.5°C, heavy flow, broad 100 y wide dished area, broad cobble shoreline, fine silt in areas of springs - 50 y DS 27-3, dished area - 100 DS 27-3 broad shallow depression 100 y US RM 28, several flowing potholes
28	28-1	9:10	12.5°C, moderate flow, continuous 200 y DS
	28-2	9:30	12.3°C, heavy flow, bluff recedes, rocky point in river, DS side of point major flow
28.25	28-3	9:40	12.2°C, large pool 50 ft diameter
28.5	28-4	10:00	12.1°C, large pool DS from point and bend in river, US from narrow beach and bluffs to RM 29 - saturated sand area US from RM 29
29.25	29-1	10:00	13°C, moderate flow, small depressed area and potholes, 150 y wide
29.5	29-2		12.8°C, saturated mud and silt, signs of recent surface flow, buried pipe and timber across hole in bank.
29.75	29-3		12.3°C, saturated mud and silt, no flow on surface
30.0	30-0	10:30	11.7°C, intermittent saturated areas 100 y DS RM 30
	30-1		12.9°C, low flow, narrow shore, 250 y DS RM 30
30.9	30-2		12.0°C, very low flow, 100 y US RM 31, numerous potholes
31.0	31-1		extensive fine mud and silt, signs of recent runoff
31.3	31-2		saturated area, located behind point in back eddy, no trespass sign
31.5	31-3		12.8°C, more sand present, moderate flow
	31-4		12.8°C, low flow, saturated area, in back eddy
31.6	31-5		13.4°C, heavy flow, cobble area separating narrow sandy beaches, opposite US end of Ringold island numerous sandy beaches 200 y US and 1 mile DS, saturated and oozing water, rivulets flowing, 1st layer of silt, 2nd layer coarse sand, 3rd layer silt, hole in sand 13:1, fills rapidly
33.0	33-1	12:30	11.7°, low flow, dry rivulets and saturated beaches, dryer for rest of RM 33, sand more compact

(a) US - Upstream
(b) DS - Downstream
(c) RM - River Mile

TABLE B.1. Strontium-90 Analyses from Columbia River Samples

River Mile Location	Sample ID	Date Collected	Concentration, pCi/ℓ ±2σ
3.0-5.0	B Comp RW[a]	01/22/83	0.55 ± 0.23
5.5-7.5	K Comp RW	12/18/82	0.18 ± 0.02
8.0-9.5	N Comp RW	12/18/82	28 ± 0.47
10.0-12.0	D Comp RW	12/18/82	1.1 ± 0.05
14.0-17.5	H Comp RW	01/22/83	0.50 ± 0.14
18.0-22.0	F Comp RW	01/22/83	0.93 ± 0.15
Upstream Columbia River Concentration (Average 1983)			0.18 ± 0.22
DOE Concentration Guide (USDOE 1981)			300

(a) Comp-RW denotes composite river water sample comprised of aliquots from immediately preceding river sample locations.

TABLE B.2. Iodine-129 Analyses from Spring and Columbia River Samples

River Mile Location	Sample ID	Date Collected	Concentration, pCi/ℓ ±2σ	
27.0	27.0 RW[a]	01/22/83	$3.3\times10^{-6} \pm 1.4\times10^{-6}$	BKG
~~27.0~~	~~27-1 Sp[b]~~	~~09/11/83~~	~~$1.6\times10^{-4} \pm 2.1\times10^{-5}$~~	DG
28.0	28-2 Sp	09/11/83	$6.2\times10^{-2} \pm 6.8\times10^{-3}$	
29.0	29.0 RW	01/22/83	$6.3\times10^{-5} \pm 5.0\times10^{-6}$	
31.75	31-5 Sp	09/11/83	$3.0\times10^{-5} \pm 4.0\times10^{-6}$	
32.5	32-0 Sp	09/11/83	$4.4\times10^{-5} \pm 2.7\times10^{-5}$	
Upstream Columbia River Concentration (1983 Average)			$2.4\times10^{-5} \pm 2.6\times10^{-5}$	
DOE Concentration Guide (USDOE 1981)			60	

(a) RW denotes composite river water sample.
(b) Sp denotes river bank spring sample.

Ref 3.4

TABLE C.1. (contd)

Sample Collection				Analyses			
River Mile[a] Location	Sample ID	Sample Size	Date/Time Collected	^{3}H, pCi/ℓ ±2σ	NO_3, ppm	U, pCi/ℓ ± 2σ	Comments
25.3	25-1 Sp[d]	1ℓ	01-22-83/1550	$3.80\times10^{2} \pm 2.06\times10^{2}$	0.22		7.0°C
25.5	25-3 Sp	1ℓ	01-22-83/0945	$3.10\times10^{2} \pm 2.06\times10^{2}$	0.66		4.9°C
		1ℓ	09-11-83/1300	$5.34\times10^{2} \pm 2.10\times10^{2}$	0.47		17.7°C
25.8	25-4 Sp	1ℓ	01-22-83/1710	$(1.36\times10^{2} \pm 2.11\times10^{2})$[f]	1.11		7.1°C
26.2	26-1 Sp	1ℓ	01-22-83/1015	$3.21\times10^{2} \pm 2.06\times10^{2}$	1.33		4.9°C
		1ℓ	09-11-83/1245	$(8.15\times10^{1} \pm 2.08\times10^{2})$	0.55		21.4°C
27.0	27.0 BKG[b]	1ℓ	09-11-83/1225	$(1.07\times10^{2} \pm 2.01\times10^{2})$	0.09		17.4°C mid river BKG
	27.0 RW[c]	1ℓ	01-22-83/1127	$(-4\times10^{0} \pm 2.10\times10^{2})$	0.75		2 ℓ for 27/29 comp.
		1ℓ	09-11-83/1221	$(1.55\times10^{2} \pm 2.02\times10^{2})$	0.21		2 ℓ for 27/29 comp.
	27-1 Sp	1ℓ	01-22-83/1125	$2.92\times10^{2} \pm 2.05\times10^{2}$	0.58		4.5°C
		1ℓ	09-11-83/1215	$3.69\times10^{2} \pm 2.06\times10^{2}$	0.73		15.1°C
27.5	27.5 RW	1ℓ	01-22-83/1338	$1.05\times10^{4} \pm 3.42\times10^{2}$	5.53		2 ℓ for 27/29 comp. DG
		1ℓ	09-11-83/1200	$2.76\times10^{3} \pm 2.54\times10^{2}$	0.05		2 ℓ for 27/29 comp.
	27-3 Sp	1ℓ	01-22-83/1336	$8.03\times10^{2} \pm 3.16\times10^{2}$	1.99		8.2°C
		1ℓ	09-11-83/1206	$9.17\times10^{4} \pm 9.18\times10^{2}$	3.05		16.7°C
28.0	28.0 RW	1ℓ	01-22-83/1400	$4.88\times10^{4} \pm 6.10\times10^{2}$	9.52		2 ℓ for 27/28 comp.
		1ℓ	09-11-83/1157	$6.06\times10^{4} \pm 7.61\times10^{2}$	1.18		2 ℓ for 27/29 comp.
	28-2 Sp	1ℓ	01-22-83/1400	$7.98\times10^{4} \pm 7.79\times10^{2}$	16.6		11.1°C
		1ℓ	09-11-83/1150	$1.10\times10^{5} \pm 9.95\times10^{2}$	4.65		17.4°C
28.5	28.5 RW	1ℓ	01-22-83/1225	$1.11\times10^{3} \pm 2.22\times10^{2}$			2 ℓ for 27/29 comp.
		1ℓ	09-11-83/1140	$7.92\times10^{3} \pm 3.28\times10^{2}$	2.35		2 ℓ for 27/29 comp.
	28-4 Sp	1ℓ	01-22-83/1425	$2.32\times10^{4} \pm 4.54\times10^{2}$	7.52		5.9°C
		1ℓ	09-11-83/1136	$9.69\times10^{4} \pm 9.40\times10^{2}$	8.2		19.8°C
28.8	28-5 Sp	1ℓ	01-22-83/1517	$4.31\times10^{2} \pm 2.15\times10^{2}$	1.55		new location-middle of beach between Sp 28-4 and RW 29

(a-f) Key found at end of table.

TABLE C.1. (contd)

Sample Collection				Analyses			
River Mile[a] Location	Sample ID	Sample Size	Date/Time Collected	^3H, pCi/ℓ ±2σ	NO_3, ppm	U, pCi/ℓ ± 2σ	Comments
29.0	29.0 RW[c]	1ℓ	01-22-83/1240	$(1.01\times10^2 \pm 2.11\times10^2)$[f]	0.71		
		1ℓ	09-11-83/1119	$4.11\times10^3 \pm 2.75\times10^2$	0.24		2 ℓ for 27/29 comp.
	29-0 Sp[d]	1ℓ	01-22-83/1255	$1.63\times10^3 \pm 2.34\times10^2$	2.65		new location-beach below RM 29
	27/29 comp. RW[e]	10ℓ	01-22-83/1430	$(1.23\times10^4 \pm 3.60\times10^4)$	2.65		2 ℓ for 27/29 comp.
		10ℓ	09-11-83/1221	$1.17\times10^4 \pm 3.74\times10^2$	0.35		
29.5	29.5 RW	1ℓ	09-11-83/1100	$2.56\times10^3 \pm 2.48\times10^2$	<0.02		2.5 ℓ for 29/31 comp.
30.0	30.0 RW	1ℓ	09-11-83/1033	$2.32\times10^3 \pm 2.44\times10^2$	0.15		2.5 ℓ for 29/31 comp.
	30-1 Sp	1ℓ	09-11-83/1025	$2.73\times10^3 \pm 2.52\times10^2$	3.14		20.4°C
30.5	30.5 RW	1ℓ	09-11-83/1012	$2.73\times10^3 \pm 2.51\times10^2$	0.05		2.5 ℓ for 29/31 comp.
31.0	31.0 RW	1ℓ	09-11-83/1009	$9.38\times10^2 \pm 2.20\times10^2$	0.05		2.5 ℓ for 29/31 comp.
	31-1 Sp	1ℓ	09-11-83/1005	$(1.57\times10^2 \pm 2.02\times10^2)$	5.25		15.8°C
	29/31 comp. RW	10ℓ	09-11-83/1100	$2.07\times10^3 \pm 2.39\times10^2$	0.26		
31.5	31.5 RW	1ℓ	09-11-83/0946	$6.86\times10^2 \pm 2.13\times10^2$	0.15		2.5 ℓ for 31/33 comp.
31.75	31-5 Sp	1ℓ	09-11-83/0950	$(1.90\times10^2 \pm 2.02\times10^2)$	2.64		17.4°C
32.0	32.0 RW	1ℓ	09-11-83/0923	$4.69\times10^2 \pm 2.09\times10^2$	0.09		2.5 ℓ for 31/33 comp.
32.5	32.5 RW	1ℓ	09-11-83/0912	$8.06\times10^2 \pm 2.16\times10^2$	0.11		2.5 ℓ for 31/33 comp.
	32-0 Sp	1ℓ	09-11-83/0927	$3.17\times10^2 \pm 2.06\times10^2$	1.78		17.8°C
33.0	33.0 RW	1ℓ	09-11-83/0900	$(1.30\times10^2 \pm 2.04\times10^2)$	0.05		2.5 ℓ for 31/33 comp.
	33-1 Sp	1ℓ	09-11-83/0900	$5.73\times10^2 \pm 2.11\times10^2$	0.75		17.9°C
	31/33 comp. RW	10ℓ	09-11-83/0950	$4.31\times10^2 \pm 2.08\times10^2$	0.15		
37.2	37-1 Sp	1ℓ	12-20-82/1047	$1.19\times10^3 \pm 2.30\times10^2$	5.31		6.7°C
38.25	38-1 Sp	1ℓ	12-20-82/1120	$4.72\times10^2 \pm 2.50\times10^2$	4.65		6.4°C
41.5	41.5 RW	1ℓ	12-20-82/1235		0.62	0.408 ± 0.143	2 ℓ for 41.5/44 comp.; 6.2°C
41.8	41-1 Sp	1ℓ	12-20-82/1235		3.98	9.03 ± 3.16	11.1°C

(a-f) Key found at end of table.

REFERENCE 4

Uncontrolled Hazardous Waste Site Ranking System;

A Users Manual, 40 CFR 300, Appendix A

Physical state refers to the state of the hazardous substances at the time of disposal, except that gases generated by the hazardous substances in a disposal area should be considered in rating this factor. Each of the hazardous substances being evaluated is assigned a value as follows:

Physical state	Assigned value
Solid consolidated or stabilized	0
Solid unconsolidated or unstabilized	1
Powder or fine material	2
Liquid, sludge or gas	3

3.3 Containment

Containment is a measure of the natural or artificial means that have been used to minimize or prevent a contaminant from entering ground water. Examples include liners, leachate collection systems, and sealed containers. In assigning a value to this rating factor (Table 3), consider all ways in which hazardous substances are stored or disposed at the facility. If the facility involves more than one method of storage or disposal, assign the highest from among all applicable values (e.g., if a landfill has a containment value of 1, and, at the same location, a surface impoundment has a value of 2, assign containment a value of 2).

Table 3—Containment Value for Ground Water Route

Assign containment a value of 0-3 (1) All the hazardous substances at the facility are underlain by an essentially non permeable surface (natural or artificial) and adequate leachate collection systems and diversion systems are present or (2) there is no ground water in the vicinity. The value "0" does not indicate no risk. Rather, it indicates a significantly lower relative risk when compared with more serious sites on a national level. Otherwise, evaluate the containment for each of the different means of storage or disposal at the facility, using the following guidance

	As assigned value
A Surface Impoundments	
Diked non-on diversion structure, essentially non permeable liner (natural or artificial) compatible with the waste, and adequate leachate collection system. 1	0
Essentially non permeable compatible liner with no leachate collection system, or inadequate freeboard	1
Potentially unsound non-on diversion structure, or moderately permeable compatible liner	2
Unsound non-on diversion structure, no liner, or incompatible liner	3
B Containers	
Containers sealed and in sound condition, adequate liner, and adequate leachate collection system	0
Containers sealed and in sound condition, no liner or moderately permeable liner	1
Containers leaking, moderately permeable liner	2
Containers leaking and no liner or incompatible liner	3
C Piles	
Piles uncovered and waste stabilized, or piles covered waste unstabilized, and essentially non permeable liner	0
Piles uncovered, waste unstabilized, moderately permeable liner, and leachate collection system	1
Piles uncovered, waste unstabilized moderately permeable liner, and no leachate collection system	2
Piles uncovered, waste unstabilized, and no liner	3
D Lagoons	
Essentially non permeable liner, liner compatible with waste, and adequate leachate collection system	0
Essentially non permeable compatible liner, no leachate collection system, and limited surface precludes ponding	1
Moderately permeable, compatible liner, and limited surface precludes ponding	2
No liner or incompatible liner; moderately permeable compatible liner, limited surface encourages pond by, no run on control	3

3.4 *Waste Characteristics.* In determining a waste characteristics score, evaluate the most hazardous substances at the facility that could migrate (i.e., if scored, containment is not equal to zero) to ground water. Take the substance with the highest score as representative of the potential hazard due to waste characteristics. Note that the substance that may have been observed in the release category can differ from the substance used in rating waste characteristics. Where the total inventory of substances in a facility is known, only those present in amounts greater than the reportable quantity (see CERCLA section 102 for definition) may be evaluated.

Toxicity and Persistence have been combined in the matrix below because of their important relationship. To determine the overall value for this combined factor, evaluate each factor individually as discussed below. Match the individual values assigned with the values in the matrix for the combined rating factor. Evaluate several

of the most hazardous substances at the facility independently and enter only the highest score in the matrix on the work sheet.

Value for toxicity	Value for persistence			
	0	1	2	3
0	0	0	0	0
1	3	6	9	12
2	6	9	12	15
3	9	12	15	18

Persistence of each hazardous substance is evaluated on its biodegradability as follows:

Substance	Assigned value
Easily biodegradable compounds [1]	0
Straight chain hydrocarbons	1
Substituted and other ring compounds	2
Metals, polycyclic compounds and halogenated hydrocarbons	3

More specific information is given in Tables 4 and 5.

Table 4—Waste Characteristics Values for Some Common Chemicals

Chemical/Compound	Toxicity [1]	Persistence [2]	Ignitability [3]	Reactivity [4]
Acetaldehyde	2	0	3	2
Acetic Acid	3	0	2	1
Acetone	2	0	3	0
Aldrin	3	3	1	0
Ammonia, Anhydrous	3	0	1	0
Aniline	3	1	2	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	*0	*0
Chlorobenzene	2	3	3	0
Chloroform	3	3	0	0
Cresol O	3	1	2	0
Cresol M&P	3	1	1	0
Cyclohexane	2	2	3	0
Endrin	3	3	1	0
Ethyl Benzene	2	1	3	0
Formaldehyde	3	0	2	0
Formic Acid	3	0	2	0
Hydrofluoric Acid	3	0	0	0
Isopropyl Ether	3	1	3	1
Lindane	3	3	1	0
Methane	1	1	3	0
Methyl Ethyl Ketone	2	0	3	0
Methyl Parathion in Xylene Solution	3	33	3	2
Naphthalene	3	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	33	1	2
PCB	3	3	33	33
Petroleum, Kerosene (Fuel Oil No. 1)	3	1	2	0
Phenol	3	1	2	0

Table 4—Waste Characteristics Values for Some Common Chemicals—Continued

Chemical/Compound	Toxicity [1]	Persistence [2]	Ignitability [3]	Reactivity [4]
Sulfuric Acid	3	0	0	2
Toluene	2	1	3	0
Trichlorobenzene	2	3	1	0
1,1,1-Trichloroethane	3	2	1	0
Xylene	2	1	3	0

[1] See, N. I., *Dangerous Properties of Industrial Materials*, Van Nostrand Reinhold Co., New York, 6th ed., 1979. The highest rating listed under each chemical is used.

[2] Hill Associates, Inc., *Methodology for Rating the Hazard Potential of Waste Disposal Sites*, May 5, 1980.

[3] National Fire Protection Association, National Fire Codes, Vol 13, No. 49, 1977.

[4] Professional judgment based on information contained in the U.S. Coast Guard CHRIS *Hazardous Chemical Data*, 1978.

[5] Professional judgment based on existing literature.

Table 5—Persistence (Biodegradability) of Some Organic Compounds*

Value = 3 Highly Persistent Compounds	
aldrin	heptachlor
benzopyrene	heptachlor epoxide
benzothiazole	1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin
benzothiophene	hexachlorobenzene
benzyl butyl phthalate	hexachloro-1,3-butadiene
bromochlorobenzene	hexachlorocyclohexane
bromoform butanal	hexachloroethane
bromophenyl phenyl ether	methyl benzothiazole
chlordane	pentachlorophenyl
chlorohydroxy benzophenone	pentachlorophenol
bis chloroisopropyl ether	1,1,2,2-tetrachloroethane
m-chlorotoluene	tetrachlorophenyl
DDE	trimethylbenzothiazole
DDT	trichlorobenzene
dibromobenzene	trichlorophenyl
diethyl phthalate	trichloromethane
1,4-dichlorobenzene	2,4,6-trichlorophenol
dichlorobromomethane	triphenyl phosphate
dieldrin	bromodichloromethane
diethyl phthalate	bromoform
di(2-ethylhexyl)phthalate	carbon tetrachloride
dimethyl phthalate	chloroform
di isobutyl phthalate	chloromethylbromomethane
dimethyl phthalate	dibromodichloromethane
4,6-dinitro-2-aminophenol	tetrachloroethane
dipropyl phthalate	1,1,2-trichloroethane
endrin	
Value = 2 Persistent Compounds	
acenaphthylene	cis 2-ethyl-4-methyl-1,3-dioxolane
alkanes	trans 2-ethyl-4-methyl-1,3-dioxolane
benzo[a]pyrene	glycerol
benzal	2-hydroxybenzaldehyde
benzoic	biphenyline
benzo[a]anthracene	biphenyl
benzo[b]fluoranthene	benzothiazole
chrysene	substituted
dibenzofuran	aromatic ether
1,2-bis chloroethoxy ethane	2-methoxy biphenyl
bis(chloroethyl) methyl ether	methyl biphenyl
chloromethyl ether	methyl stearate

TABLE 6—PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS*—Continued

chloromethyl ethyl ether	methylbromide
2 chloroprene	methylene chloride
dichlorophenol	nitrobenzene
dichlorophenyl ether	nitrobenzene
dihydrazine	1,1,2 trichloroethane
dimethyl sulfoxide	trimethyl trimethylenetrinitrine formal
2,6 dinitrotoluene	

Value—5 Somewhat Persistent Compounds

acetylene dichloride	bromene
boric acid, methyl ester	methyl ester of hypochloric acid
benzene	methane
benzene sulfonic acid	2 methyl 5-ethyl pyridine
butyl benzene	methyl naphthalene
butyl bromide	methyl phthalate
caprolactam	methyl phenyl carbinol
carbon dioxide	methyl thiocyanate
2 cresol	naphthalene
decane	nonane
1,2 dichlorobenzene	octane
1,3 dimethyl benzene	ethyl chloride
1,5 dimethyl naphthalene	pentane
2,4 dimethyl phenol	phenyl benzoate
dioctyl adipate	phthalic anhydride
dodecane	propylbenzene
ethyl benzene	1 propanol
2 ethyl hexane	toluene
2 ethylhexanol	vinyl benzene
heptane	xylene
hexylethyl benzene	

Value—6 Nonpersistent Compounds

acetaldehyde	methyl benzoate
acetic acid	3 methyl butanol
acetone	methyl ethyl ketone
acetophenone	2 methylpropanol
benzoic acid	octadecane
2 butoxyl carbinol	pentadecane
butanone	pentanol
butanone	propanol
ethanol	propylamine
ethylamine	tetradecane
hexadecane	1 tridecanol
methanol	undecane

* Air Association, Inc., *Methodology for Rating the Hazard Potential of Waste Disposal Sites*, May 8, 1986

Toxicity of each hazardous substance being evaluated is given a value using the rating scheme of Sax (Table 6) or the National Fire Protection Association (NFPA) (Table 7) and the following guidance:

Toxicity	Assigned value
Sax level 0 or NFPA level 0	0
Sax level 1 or NFPA level 1	1
Sax level 2 or NFPA level 2	2
Sax level 3 or NFPA level 3 or 4	3

TABLE 8—SAX TOXICITY RATINGS

0—No Toxicity* (None)**

This designation is given to materials which fall into one of the following categories:

(a) Materials which cause no harm under any conditions of normal use

(b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage

1—Slight Toxicity* (Low)**

(a) *Acute local:* Materials which on single exposures lasting seconds, minutes, or hours cause only slight effects on the skin or mucous membranes regardless of the extent of the exposure

(b) *Acute systemic:* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose regardless of the quantity absorbed or the extent of exposure

(c) *Chronic local:* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause only slight and usually reversible harm to the skin or mucous membranes. The extent of exposure may be great or small

(d) *Chronic systemic:* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slightly usually reversible effects on body over days, months, or years. The extent of the exposure may be great or small

In general, those substances classified as having "slight toxicity" produce changes in the human body which are nearly reversible and which will disappear following termination of exposure, either with or without medical treatment

2—Moderate Toxicity* (Moderate)**

(a) *Acute local:* Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter of seconds or moderate exposure for a matter of hours

(b) *Acute systemic:* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and produce moderate effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose.

TABLE 8—SAX TOXICITY RATINGS—Continued

3—Moderate Toxicity* (Mod)**

(c) *Chronic local:* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause moderate harm to the skin or mucous membranes

(d) *Chronic systemic:* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months or years

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are out of such severity as to threaten life or to produce serious physical impairment

5—Severe Toxicity* (High)**

(a) *Acute local:* Materials which on single exposure lasting seconds or minutes cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent physical impairment or disfigurement

(b) *Acute systemic:* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes, or hours, or following ingestion of a single dose.

(c) *Chronic local:* Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or cause permanent impairment, which disfigurement, or irreversible change

(d) *Chronic systemic:* Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months, or years

* Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., New York, New York, 4th edition, 1975.

** Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., New York, New York, 5th edition, 1979.

TABLE 7—NFPA TOXICITY RATINGS*

0 Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material

1 Materials only slightly hazardous to health. It may be desirable to wear self contained breathing apparatus.

2 Materials hazardous to health, but areas may be entered freely with self contained breathing apparatus

3 Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing including self contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed

4 A few whiffs of the gas or vapor could cause death, or the gas vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing which is designed for resistance to heat. For most chemicals having a Health 4 rating the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn

* National Fire Protection Association, *National Fire Codes*, Vol 13, No 49, 1971.

Table 4 presents values for some common compounds.

Hazardous waste quantity includes all hazardous substances at a facility (as received) except that with a containment value of 0. Do not include amounts of contaminated soil or water; in such cases, the amount of contaminating hazardous substance may be estimated.

On occasion, it may be necessary to convert data to a common unit to combine them. In such cases, 1 ton=1 cubic yard=6 drums and for the purposes of converting bulk storage, 1 drum=55 gallons. Assign a value as follows:

Tons in cubic yards	Number of drums	Assigned value
0	0	0
1-10	1-40	1
11-62	41-250	2
63-125	251-500	3
126-250	501-1,000	4
251-625	1,001-2,500	5
626-1,250	2,501-5,000	6
1,251-2,500	5,001-10,000	7
>2,500	>10,000	8

3.6 *Targets. Ground water use* indicates the nature of the use made of ground water drawn from the aquifer of concern within 3 miles of the hazardous substance, including the geographical extent of the measurable concentration in the aquifer. Assign a value using the following guidance:

Ground water use	Assigned value
Unusable (e.g., extremely saline aquifer, extremely low yield, etc.)	0
Commercial, industrial or irrigation and another water source presently available, not used, but feasible	1
Drinking water with municipal water from alternate undiversioned sources presently available (e.g., minimal backup requirements) or commercial, industrial or irrigation with no other water source presently available	2
Drinking water, no municipal water from alternate undiversioned sources presently available	3

Distance to nearest well and population served have been combined in the matrix below to better reflect the important relationship between the distance of a population from hazardous substances and the size of the population served by ground water that might be contaminated by those substances. To determine the overall value for this combined factor, score each individual-

REFERENCE 5

Handbook of 200 Area Waste Sites, Volume I

1979 Rockwell Hanford Operations, RHO-CD-673

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Southeast Quadrant

216-A-2 Crib	I. SE	216-A-33 French Drain	I. SE
216-A-3 Crib	I. SE	216-A-35 French Drain	I. SE
216-A-4 Crib	I. SE	216-A-36A Crib	I. SE
216-A-5 Crib	I. SE	216-A-36B Crib	I. SE
216-A-9 Crib	I. SE	216-A-38 Crib	I. SE
216-A-10 Crib	I. SE	216-A-39 Crib	I. SE
216-A-11 Crib	I. SE	216-A-40 Trench	I. SE
216-A-12 French Drain	I. SE	216-A-41 Crib	I. SE
216-A-13 French Drain	I. SE	216-C-1 Crib	I. SE
216-A-14 French Drain	I. SE	216-C-2 Crib	I. SE
216-A-15 French Drain	I. SE	216-C-3 Crib	I. SE
216-A-16 French Drain	I. SE	216-C-4 Crib	I. SE
216-A-17 French Drain	I. SE	216-C-5 Crib	I. SE
216-A-21 French Drain	I. SE	216-C-6 Crib	I. SE
216-A-22 Crib (Fr. Drain)	I. SE	216-C-7 Crib	I. SE
216-A-23A French Drain	I. SE	216-C-10 Crib	I. SE
216-A-23B French Drain	I. SE	218-E-1 Burial Ground	I. SE
216-A-26A French Drain	I. SE	218-E-13 Burial Ground	I. SE
216-A-26B French Drain	I. SE	218-E-14 Purex Tun. Stor.	I. SE
216-A-27 Crib	I. SE	218-E-15 Purex Tun. Stor.	I. SE
216-A-28 Crib	I. SE		
216-A-31 Crib	I. SE		
216-A-32 Crib	I. SE		

9413218.0520

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-2 Cavern	216-A-2

Location	Service Dates	Status
200 East, SE Quadrant 200 East Area, 260 ft south of 202A Bldg. 900 ft west of Canton Avenue S.W. of the 291-A-1 stack.	1/56-1/63	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39515, W-48278	H-2-56049 H-2-56050	Ground	712 ft
		Water Table	403 ft (1973)
		Site Depth	~~28~~ 27 ft

Source and Description of Waste

2.3×10^5 liters. Organic waste from 202A (Purex). Low-salt, neutral-basic.

Description of Facility

Rock structure, 20 ft x 20 ft bottom surface area.
Deactivated, when the specific retention capacity was reached, by removing a section of effluent pipeline.

Radionuclide Content (calculated from discharge data)

Radionuclide	At time of Discharge	As of 6/30/78
Pu, g	130	1.30×10^2
Beta, Ci	590	< 6.49
^{90}Sr, Ci	2	1.24
^{106}Ru, Ci	150	3.67×10^{-4}
^{137}Cs, Ci	3	1.92
^{60}Co, Ci	1	7.99×10^{-2}
U, kg	78.1	7.81×10^1

Ref. 5.2

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-3 Cavern	216-A-3

Location	Service Dates	Status
200 East, S.E. Quadrant Directly South of 275-EA Bldg. and ~1200 ft west of Canton Ave.	1/56 to 11/67	Active

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-40530; W-48540	H-2-55900 H-2-56049 H-2-56050	Ground	704 ft
		Water Table	404 ft
		Site Depth	16 ft

Source and Description of Waste

2.8×10^6 liters. Silica-Gel regeneration waste from 203-A, the UNH storage pit drainage and the liquid waste from the 203-A Pumphouse.

Description of Facility

Rock filled crib. Area 20 ft x 20 ft bottom dimensions.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	0.20	.20
Beta, Ci	882	< 0.263
^{90}Sr, Ci	0.10	5.82×10^{-2}
^{106}Ru, Ci	350	7.14×10^{-4}
^{137}Cs, Ci	<0.10	$< 6.03 \times 10^{-2}$
^{60}Co, Ci	<0.10	$< 5.50 \times 10^{-3}$
U, kg	1.7×10^3	1.68×10^3

History:

Receives UNH storage pit drainage; the liquid waste from the 203-A Pumphouse and 203-A Bldg enclosure sumps, and the heating coil condensate from the P-1 through P-4 UNH tanks. The discharge of silica gel to this crib was discontinued sometime between 1967 and 1970.

Ref. 5.3

2250.8126146

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-4 Cavern	216-A-4

Location	Service Dates	Status
200 East, S.E. Quadrant 260 ft south of 202-A Bldg. 760 ft west of Canton Ave. 150 ft east of 216-A-2.	12/55-12/58	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39515, W-48158	H-2-56049 H-2-56050	Ground	710 ft
		Water Table	403 ft(1973)
		Site Depth	25 ft

Source and Description of Waste

6.21×10^6 liters. Laboratory cell drainage from the Purex Plant and 291-A-1 stack drainage. Low-salt, neutral-basic.

Description of Facility

Rock structure 20 ft x 20 ft bottom surface area.
Deactivated when the specific retention capacity was reached by blanking the pipeline inlet to the crib.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	140	1.40×10^2
Beta, Ci	864	2.96×10^1
^{90}Sr, Ci	10	5.93
^{106}Ru, Ci	400	2.05×10^{-4}
^{137}Cs, Ci	15	9.19
^{60}Co, Ci	1	6.07×10^{-2}
U, kg	399	3.99×10^2

Ref. 5.4

9413218.0323

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-5 Cavern	216-A-5

Location	Service Dates	Status
200 East, S.E. Quadrant 450 ft south of 202-A Bldg. 1400 ft west of Canton Ave.	12/55-11/61	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39510, W-48750	H-2-55900 H-2-56049 H-2-56050	Ground	710 ft
		Water Table	404 ft (1973)
		Site Depth	32 ft

Source and Description of Waste

1.63 x 10^9 liters. Process condensate from 202-A. Acidic.

Description of Facility

One crib, rock structure, 35 ft x 35 ft bottom surface.
Deactivation: Effluent pipeline to crib was blanked out.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	65	6.50 x 10^1
Beta, Ci	3400	< 1.54 x 10^2
^{90}Sr, Ci	90	5.62 x 10^1
^{106}Ru, Ci	150	5.05 x 10^{-4}
^{137}Cs, Ci	25	1.61 x 10^1
^{60}Co, Ci	110	8.94
U, kg	263	2.63 x 10^2
^{233}U, g	none	

Site Characterization Status

Well No E24-1A was drilled to a depth of 320 ft at the south edge of the 216-A-5 crib in 1966 to determine locations and concentrations of subsurface contamination. Analytical data on core samples from this well show rapidly decreasing ^{137}Cs concentrations from a moderate level of 4.4 x 10^{-3} µCi/g at about 35 ft to a low level of 10^{-5} µCi/g at about 65 ft. The ^{137}Cs values were at or below the detection limit of 10^{-6} µCi/g throughout most of the soil column. The ^{90}Sr concentrations were below the detection limit (3.2 x 10^{-5} µCi/g).

Ref. 5.5

9120818.0524

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	--	216-A-9

Location	Service Dates	Status
200 East, S.E. Quadrant 500 ft west of 241-A Tank Farm 900 ft north of 275-EA Bldg.	3/56-2/58 4/66-10/66 8/69-8/69	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41000, W-48355 to N-41297, W-48652	H-2-55577 H-2-55578 H-2-55579	Ground Water Table Site Depth	694 ft 404 ft(1973) 12 ft

Source and Description of Waste

9.81 x 10^8 liters. Acid fractionater condensate and condenser cooling water from 202-A (3/56-2/58); N Reactor decontamination waste (1966); acid fractionater condensate (1969). Acidic.

Description of Facility

One crib, rock structure, 420 ft x 20 ft bottom area.
Deactivation: Effluent pipeline was blanked north of 202-A-3 Bldg. after replacing 100 ft of effluent pipeline which failed.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	0.5	.50
Beta, Ci	190	<41.8
^{90}Sr, Ci	25	14.9
^{106}Ru, Ci	50	1.70 x 10^{-4}
^{137}Cs, Ci	10	6.17
^{60}Co, Ci	0.14	1.57 x 10^{-2}
U, kg	0.23	0.227

Site Characterization Status

Well E24-3 monitors the southeast end of the 216-A-9 Crib. Waste disposed at this site contained only an estimated 54 Ci of radioactivity. No ground contamination was noted on the 1959 scintillation well log. A small amount of contamination from 30 ft to 100 ft below ground surface is indicated on the 1963 log.

Ref. 5.6

9416218.0325

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	--	216-A-10

Location	Service Dates	Status
200 East, S.E. Quadrant Approximately 270 ft south of the southwest corner of 202-A.	11/61-	Active

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39090, W-48952 to N-39370, W-48952	H-2-55576 H-2-55578 H-2-58131	Ground Water Table Site Depth	714 ft 404 ft(1973) 45 ft

Source and Description of Waste

2.9 x 10^9 liters. Process condensate from 202-A. Acidic.

Description of Facility

Crib, rock-filled. 275 ft x 45 ft bottom dimensions.

Radionuclide Content (calculated from discharge data)

Radionuclides	At Time of Discharge	As of 6/30/78
Pu, g	3.4 x 10^2	343.0
Beta, Ci	8.1 x 10^5	< 720.0
^{90}Sr, Ci	1.5 x 10^2	111.0
^{106}Ru, Ci	7.3 x 10^3	5.49
^{137}Cs, Ci	1.3 x 10^2	106.0
^{60}Co, Ci	1.8 x 10^2	26.7
U, kg	2.0 x 10^2	204.0
^{233}U, g	2.8 x 10^2	277.0

Site Characterization Status

Ground water samples taken from montioring wells near the 216-A-10 crib prior to 1967 show ^{90}Sr concentrations slightly above detection limit (1 x 10^{-8} μCi/cc). However, only small quantities of ^{90}Sr (57 curies) had been disposed to this site. The acidic nature of this waste increases the mobility of ^{90}Sr through the soil column.

Ref. 5.7

9413218.0326

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	--	216-A-11

Location	Service Dates	Status
200 East, S.E. Quadrant Southeast corner of 202-A	1/56-	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39780, W-48050	H-2-55090 H-2-55091 H-2-55095	Ground Water Table Site Depth	708 ft 404 ft(1973) 30 ft

Source and Description of Waste

Volume unknown, steam trap Pit No. 1 drainage from 202-A.
Low-salt, neutral/basic.

Description of Facility

French drain, 30 in. diameter

Radionuclide Content (calculated from discharge data)

<50 Ci Beta

Ref. 5.8

9413218.0527

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	--	216-A-12

Location	Service Dates	Status
200 East, SE Quadrant Center of South side of 202-A, approximately 75 ft from the building.	11/55-	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39780, W-48503	H-2-53014 H-2-55090 H-2-55092	Ground Water Table Site Depth	708 ft 404 ft(1973) 33 ft

Source and Description of Waste

Volume unknown, steam trap Pit No. 3 drainage from 202-A.
Low-salt, neutral/basic.

Description of Facility

French drain, 30 in. diamter.

Radionuclide Content (calculated from discharge data)

<50 Ci total Beta

Ref. 5.9

9413218.0328

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	--	216-A-13

Location	Service Dates	Status
200 East, S.E. Quadrant West end of 202-A Bldg.	1/56-12/62	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39814, W-49010	SK-22568 H-2-55076	Ground Water Table Site Depth	708 ft 403 ft 18 ft

Source and Description of Waste

Volume unknown. Seal water from the air sampler vacuum pumps in the 202-A Bldg. Low-salt, neutral/basic.

Description of Facility

French Drain, 2 ft diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.10

9413218.0529

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	--	216-A-14

Location	Service Dates	Status
200 East, S.E. Quadrant South side of the center of the 202-A Bldg. approximately 75 ft, and 75 ft west of 216-A-12.	~~1/57~~ to present 1.5	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39742, W-48551	H-2-53465 H-2-55090	Ground Water Table Site Depth	708 ft 403 ft 29 ft

Source and Description of Waste

Volume unknown. Vacuum filter and blower pit drainage from the 202-A Bldg. Low-salt, neutral/basic.

Description of Facility

French drain, ~~20~~ 2 in. diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.11

DCSD-8126146

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French drain	--	216-A-15

Location	Service Dates	Status
200 East, S.E. Quadrant Approximately 325 ft South of the center of 202-A	12/55-	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39516, W-48656	H-2-56045-2	Ground	712 ft
		Water Table	404 ft(1973)
		Site Depth	44 ft

Source and Description of Waste

Volume unknown. Drainage from 216-A-10 process condensate sample pit. Acidic.

Description of Facility

French drain, 2 ft diameter.

Radionuclide Content (calculated from discharge data)

<50 Ci total Beta

Ref. 5.12

9413218.0331

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-16 Dry Well	216-A-16

Location	Service Dates	Status
200 East, within the confines of the 241-A Tank Farm	1/56-3/69	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41191, W-47433	H-2-55943 H-2-56521	Ground	686 ft
		Water Table	404 ft(1973)
		Site Depth	17 ft

Source and Description of Waste

Volume unknown. Floor drainage and 296-A-11 stack drainage from the 241-A-431 Bldg.
Low-salt, neutral/basic.

Description of Facility

French drain, 4 ft diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <10 Ci

Ref. 5.13

9413278.0552

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-17 Dry Well	216-A-17

Location	Service Dates	Status
200 East, within the confines of the 241-A Tank Farm.	1/56-3/69	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41181, W-47453	H-2-55943 H-2-56521 H-2-56900	Ground Water Table Site Depth	686 ft 404 ft(1973) 17 ft

Source and Description of Waste

Volume unknown. Floor drainage and 296-A-11 stack drainage from the 241-A-431 Bldg. (overflow).
Low-salt, neutral/basic.

Description of Facility

French drain, 4 ft diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.14

9413218.0333

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-21 Crib	216-A-21

Location	Service Dates	Status
200 East, S.E. Quadrant 200 East Area, 600 ft south of 202-A Bldg. 750 ft west of Canton Ave.	10/57-6/65	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39300, W-48160	H-2-57042 H-2-57032 [illegible]	Ground	711 ft
		Water Table	403 ft (1973)
		Site Depth	19 ft

Source and Description of Waste

7.78×10^7 liters. From 10/57 to 6/58, received sump waste from 293-A Bldg. From 12/58 to 6/65, received 293-A sump waste, Purex Laboratory cell drainage and 291-A-1 stack drainage. Typically low-salt, neutral-basic; waste could have been acidic at times.

Description of Facility

Gravel structure, 60 ft x 16 ft bottom surface area.
Deactivated when the effluent flow rate exceeded the infiltration capacity, by blanking the effluent line to the crib.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	150	150.0
Beta, Ci	2800	225.0
^{90}Sr, Ci	15	10.1
^{106}Ru, Ci	200	6.80×10^{-3}
^{137}Cs, Ci	150	104.0
^{60}Co, Ci	10	1.27
U, kg	195	195.0

Ref. 5.15

9413278.0334

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib (French Drain)	216-A-22 French Drain	216-A-22

Location	Service Dates	Status
200 East, S.E. Quadrant ~400 ft North of the Center of the 202-A Bldg. Near 216-A-28	3/56-12/58	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-40352, W-48560	H-2-54812 H-2-54818 H-2-57617	Ground	708 ft
		Water Table	404 ft
		Site Depth	16 ft

Source and Description of Waste

Volume unknown. Sump waste from the 203-A Bldg. and heating coil condensate from the P-1 through P-4 UNH tanks. Low-salt, neutral/basic.

Description of Facility

French drain, rock filled, 6-ft. diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.16

9413218.0335

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	Same	216-A-23A

Location	Service Dates	Status
200 East, S.E. Quadrant-within the confines of the 241-A Tank Farm	9/57-3/69	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41171, W-47463	H-2-55943 H-2-56521 H-2-56999	Ground Water Table Site Depth	686 ft 404 ft (1973) Not Known

Source and Description of Waste

Volume unknown. Deentrainer tank condensate and back flush from the 241-A-431 Bldg. Low-salt, neutral/basic.

Description of Facility

French drain, 42-in. diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <50 Ci

Ref. 5.17

9413218.0336

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	Same	216-A-23B

Location	Service Dates	Status
200 East, S.E. Quadrant-within the confines of the 241-A Tank Farm.	9/57-3/69	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41171, W-47473	H-2-55943 H-2-56521 H-2-56999	Ground Water Table Site Depth	686 ft 404 ft (1973) NA

Source and Description of Waste

Volume unknown. Deentrainer tank condensate and the back flush from the 241-A-431 Bldg. (overflow). Low-salt, neutral/basic.

Description of Facility

French drain, 42-in. diamter.

Radionuclide Content (calculated from discharge data)

Total Beta: <5 Ci

Ref. 5.18

9413218.0357

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-25 Crib 216-A-26 French Drain	216-A-26A

Location	Service Dates	Status
200 East, S.E. Quadrant ~100 ft south of the center of the 291-A Bldg.	3/59-7/65	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations
N-39550, W-48208	H-2-3325 H-2-55036	Ground 708 ft Water Table 403 ft Site Depth NA

Source and Description of Waste

Volume unknown. Floor drainage from the 291-A fan house. Low-salt, neutral/basic.

Description of Facility

French drain, 3-ft. diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

History: Removed the 216-A-26A French Drain encasement in July, 1965. Reconnected the effluent pipeline to the new 216-A-26B French Drain encasement.

Ref. 5.19

9413218.0358

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-26 French Drain 216-A-26A French Drain	216-A-26B

Location	Service Dates	Status
200 East, S.E.Quadrant 115 ft south of the center of the 202-A Bldg. 15 ft south of 216-A-26A French Drain.	7/65 to present	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
~~N-39535, W-48298~~ * N-39[illegible], W-48[illegible]	H-2-55036 HW-[illegible] pt. [illegible] 2-26 H-2-[illegible]	Ground Water Table Site Depth	708 ft 403 ft Not Known

Source and Description of Waste

Volume unknown. Floor drainage from the 291-A fan house.
Low-salt, neutral/basic.

Description of Facility

French drain, 4 ft. diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.20

9413218.0339

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	--	216-A-27

Location	Service Dates	Status
200 East, S.E. Quadrant. ~700 ft. south of 202-A Bldg. ~800 ft west of Canton Ave.	6/65-7/70	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39100, W-48118 to N-39100, W-48318	H-2-57508 H-2-57509	Ground	719 ft
		Water Table	402 ft
		Site Depth	Not known

Source and Description of Waste

2.3×10^7 liters. Sump waste from 293-A Bldg., the laboratory cell drainage from the 202-A Bldg. and the 291-A-1 stack drainage. Low-salt, neutral/basic.

Description of Facility

Sand filled crib, 200 x 10 ft bottom dimensions.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	97	96.5
Beta, Ci	2.7×10^3	< 159.0
^{90}Sr, Ci	41	33.1
^{106}Ru, Ci	63	6.48×10^{-2}
^{137}Cs, Ci	53	42.9
^{60}Co, Ci	<2.7	< .307
U, kg	68	168.0

Ref. 5.21

9413218.0540

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-28 French Drain	216-A-28

Location	Service Dates	Status
200 East, S.E. Quadrant 500 ft. North of 202-A, 1250 ft. West of Canton Avenue.	12/58-11/67	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-40362, W-48595	H-2-57617	Ground	690 ft
		Water Table	405 ft (1967)
		Site Depth	11 ft

Source and Description of Waste

3×10^4 liters. Waste from 203-A enclosure sumps and heating coil condensate from P-1 through P-4 UNH tanks. Low-salt, neutral/basic.

Description of Facility

One crib, rock structure, 10 ft diameter bottom surface. Deactivation: The effluent pipeline to the crib was blocked north of the 203-A UNH Tank enclosure when the effluent flow rate exceeded the infiltration capacity.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	None	None
Beta, Ci	31	$< 3.12 \times 10^{-2}$
^{90}Sr, Ci	None	None
^{106}Ru, Ci	None	None
^{137}Cs, Ci	None	None
^{60}Co, Ci	None	None
U, kg	632	632.0

Ref. 5.22

9413218.0541

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-32 Crib	216-A-31

Location	Service Dates	Status
200 East, S.E. Quadrant ~500 ft south of the center of the 202-A Bldg.	~~[illegible]~~ 1/65-1-65 7/64-11/66	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39370, W-48290	H-2-57934	Ground	704 ft
		Water Table	404 ft(1973)
		Site Depth	Not known

Source and Description of Waste

1.0×10^4 liters. Organic waste from the 202-A Bldg. Low-salt, neutral/basic.

Description of Facility

Gravel filled crib, 70 ft by 10 ft.
Deactivation: "L" cell nozzles to the 241-A-151 Diversion base which routed the effluent to the crib have been blanked.

Radionuclide Content (calculated from discharge data)

Radionuclide	At time of Discharge	As of 6/30/78
Pu, g	9.0	9.0
Beta, Ci	2.0×10^5	< 246.0
^{90}Sr, Ci	2.0	1.42
^{106}Ru, Ci	9.5×10^4	6.10
^{137}Cs, Ci	150	109.0
^{60}Co, Ci	0.10	1.58×10^{-2}
U, kg	21	20.5

Ref. 5.23

9413218.0392

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib		216-A-32

Location	Service Dates	Status
200 East, S.E. Quadrant 200 East Area. Approximately 300 ft. northeast of 202-A and approximately 700 ft west of Canton Avenue.	1/59-	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-40148, W-47811 to N-40212, W-47782	H-2-55900 H-2-55901 H-2-56000 H-2-57110	Ground	697 ft
		Water Table	404 ft(1973)
		Site Depth	12 ft

Source and Description of Waste

Volume unknown. East crane maintenance facility floor, sink and shower drainage from 202-A.

Description of Facility

Crib, gravel-filled, 70 ft x ~~9~~ ft.
70 ft x 8 FT

Radionuclide Content (calculated from discharge data)

<1 Ci Beta

Ref. 5.24

9113218.0345

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-33 Dry Well	216-A-33

Location	Service Dates	Status
200 East, S.E. Quadrant ~300 ft south of 202-A, ~1100 ft West of Canton Avenue. Near the S.W. corner of 291-A Bldg.	11/56-7/64	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39617, W-48310	H-2-55036	Ground	716 ft
		Water Table	402 ft
		Site Depth	Not known

Source and Description of Waste

Volume unknown. Bearing coolant from the 291-A-1 stack electric exhaust fans.

Description of Facility

French drain, 6-ft diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.25

9113218.0544

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
French Drain	216-A-35 Dry Well	216-A-35

Location	Service Dates	Status
200 East, S.E. Quadrant. 200 East Area, West End of 202-A Bldg. Near 216-A-13	12/63-1/66	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39800, W-49003	H-2-55076	Ground	708 ft
		Water Table	403 ft
		Site Depth	NA

Source and Description of Waste

Volume unknown. Seal cooling water from the air sampler vacuum pumps in the 202-A Bldg. Low-salt, neutral/basic.

Description of Facility

French drain, 6-ft diameter.

Radionuclide Content (calculated from discharge data)

Total Beta: <1 Ci

Ref. 5.26

9413218.0345

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-36 Crib	216-A-36A

Location	Service Dates	Status
200 East, S.E. Quadrant 750 ft. south of 202-A Bldg. 1150 ft West of Canton Ave.	9/65-3/66	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-39000, W-48525 to N-39105, W-48525	H-2-59805 H-2-59129	Ground	710 ft
		Water Table	403 ft(1973)
		Site Depth	25 ft

Source and Description of Waste

1.07×10^6 liters of ammonia scrubber waste from Purex. Low-salt, neutral/basic

Description of Facility

Gravel structure, 100 ft x 11 ft bottom area. Deactivated because of a large discharge of fission products. Concrete dam installed between 216-A-36A and 216-A-36B. Pipeline to 216-A-36 extended into 216-A-36B.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	80	80.0
Beta, Ci	1.5×10^5	< 5280.0
^{90}Sr, Ci	1.8×10^3	1320.0
^{106}Ru, Ci	3×10^3	5.-5
^{137}Cs, Ci	1.5×10^3	1120.0
^{60}Co, Ci	10	1.9[illegible]
U, kg	145	145.0

Ref. 5.27

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-36 Crib	216-A-36B

Location	Service Dates	Status
200 East, S.E. Quadrant ~1200 ft south of the 202-A Bldg.	3/66-1972	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-38500, W-48525 to N-39000, W-48525	H-2-59129 H-2-59805	Ground Water Table Site Depth	719 ft 403 ft NA

Source and Description of Waste

9.4×10^7 liters. Ammonia scrubber waste from the 202-A Bldg. Low-salt, neutral/basic.

Description of Facility

Gravel-filled crib, 500 ft x 11 ft. bottom dimensions. (See 216A-36A)

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	<180	177.0
Beta, Ci	4.8×10^4	< 2050.0
^{90}Sr, Ci	550	455.0
^{106}Ru, Ci	6.5×10^3	45.6
^{137}Cs, Ci	<560	463.0
^{60}Co, Ci	<51	< 18.-
^{238}U, kg	120	119.0
^{233}U, g		25.6

Ref. 5.28

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-38	216-A-38

Location	Service Dates	Status
200 East, S.E. Quadrant ~600 ft Southwest of 202-A Bldg., ~1500 ft north of 1st St.	Never used	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations
N-38971, W-49352 to N-39471, W-49352	H-2-62875	Ground Water Table Site Depth

Source and Description of Waste

Never used.

Description of Facility

Crushed stone-filled, 520 ft x 15 ft bottom dimensions.

Never used.

Radionuclide Content (calculated from discharge data)

Ref. 5.29

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-A-40 Crib	216-A-39

Location	Service Dates	Status
200 East, S.E. Quadrant Directly north of 241-AX Tank Farm along Canton Ave.	6/66	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41860, W-47489 to N-41860, W-47399 N-41930, W-47489 to N-41930, W-47399	H-2-33295	Ground	675 ft
		Water Table	404 ft
		Site Depth	~~Not known~~

Source and Description of Waste

20 liters. Floor drainage from the 241-AX-801-8 Bldg. Low-salt, neutral/basic.

Description of Facility

Crib and two trenches filled with gravel and backfilled. 90 ft x 2 ft bottom dimensions.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Beta, Ci	50	36.4
^{137}Cs, Ci	25	19.0

History:

This site is the result of an unplanned radioactive materials release originating in the 241-AX-801-8 Building.

(See Attachment)

Ref. 5.30

9413218.0349

216-A-39 continued

History:

A Process operator, Maintenance instrument man, and a Radiation Monitor were changing out a valve on the 103AX tank recirculator line when highly radioactive waste liquid pressureized in the line and flowed out onto the floor of the instrument building. Dose rates from the spill were greater than 5 R/hr at a distance of 10 feet from the spill.

A trench approximately 3 feet deep was dug from the door of the 801 Building to the brow of the north hill, then over the hill to the flat ground below where it was extended eastward approximately 90 feet. A hole was cut through the back side of the 801 building and a fire hose was inserted to wash the contamination into the trench. The first trench was covered with soil and a second trench, paralleling the first, was dug to receive a second washing. This trench was also covered. Dose rate residue radiation remains in the floor of the building and in the 2 trenches of 216-A-39.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench	216-A-39 Ditch 216-A-40 Ditch	216-A-40

Location	Service Dates	Status
200 East, S.E. Quadrant ~500 ft West of 241-AX Tank Farm, ~500 ft South of 7th Ave.	1/68-present	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41519, W-48209 to N-41868, W-48404	H-2-61979 H-2-63083 H-2-63084	Ground	683 ft
		Water Table	404 ft
		Site Depth	Not known

Source and Description of Waste

9.5×10^5 liters. Diverted cooling water and steam condensate from the 244AR Vault. This is a rubber bag type diverter trench for the recovery of radioactive cooling water that might become contaminated from equipment failures.

Description of Facility

Open trench, 400 ft x 20 ft. —[illegible]

Radionuclide Content (calculated from discharge data)

Unknown.

Ref. 5.32

9413218.0351

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	--	216-A-41

Location	Service Dates	Status
200 East, S.E. Quadrant Approximately 600 ft west of 241-AX Tank Farm and approximately 600 ft south of 7th Avenue.	1/68- 1974	Out of service

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-41420, W-48082	H-2-61975 ~~H-2-63084~~	Ground	683 ft
		Water Table	405 ft(1973)
		Site Depth	6 ft

Source and Description of Waste

Volume unknown. 296-A-13 Stack Drainage. Potentially slightly acidic.

Description of Facility

Crib, gravel-filled, 10 ft x 10 ft bottom surface.

Radionuclide Content (calculated from discharge data)

<Ci Beta

History

The stack drainage piping from the 296-A-13 stack to the 216-A-41 Crib was removed in 1974. The stack drainage was then rerouted to the ~~Vessel Vent~~ seal pot system of the 244AR Building.

2 filter-vent seal pot.

Ref. 5.33

9413218.0352

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Basic Designation	Number
Crib	216-C Crib	216-C-1

Location	Service Dates	Status
200 East, S.E. Quadrant 250 ft South of 2704-C Bldg. 450 ft South of 7th Street (within the Hot Semiworks comm ex.)	[illegible] ~~[illegible]~~ 1/53-[illegible]	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42069, W-50235	H-2-4137 H-2-[illegible]523	Ground Water Table Site Depth	689 ft 405 ft (1973) 13 ft

Source and Description of Waste

2.34 x 10^7 liters. High-salt waste cold run waste and process condensate from 201-C (semi-works). High-salt neutral/basic.

Description of Facility

One crib, 23 ft x 8 ft bottom surface, concrete structure.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge
Pu, g	8
Beta, Ci	1.[illegible] x 10^4
^{90}Sr, Ci	200
^{106}Ru, Ci	400
^{137}Cs, Ci	<0.10
^{60}Co, Ci	<0.10
U, kg	300

Ref. 5.34

The 218-C-1, C-3, C-4, and C-5 Crib complex along the south fence line of the "Hot Semiworks", 200 East Area, was decontaminated, and the ground surface stabilized against wind erosion and plant root invasion.

The work done was as follows:

- Bladed off four inches of the ground surface and deposited spoil in the cavity above 216-C-1 Crib.
- Covered the ground with a four-inch sand pad.
- Applied ureabor herbicide at the rate of 500 lbs./acre.
- Installed 10 mil plastic sheeting over entire surface. NOTE: The plastic sheet was doubled over the area around the Tank #71 riser.
- Installed 12-inch pad of sand over the plastic.
- The surface stabilized with four inches of pit run gravel.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Dry well.	291-C Dry Well 216-C-2 Dry Well	216-C-2

Location	Service Dates	Status
200 East, S.E. Quadrant Approx. 100 ft southeast of the 291-C Stack. (within the Hot Semi-works complex)	1/53-	Active

Site Coordinates	Reference Drawings	Elevations	
N-42300, W-50000	H-2-4033 H-2-32523	Ground Water Table Site Depth	681 ft 402 ft(1973) 40 ft

Source and Description of Waste

Volume unknown. 291-C stack drainage and the seal water drainage from the stack ventilation filters. Low-salt, neutral/basic.

Description of Facility

Reverse well, 12-in. diameter.

Radionuclide Content (calculated from discharge data)

<1 Ci Beta

Ref. 5.36

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	201-C Leaching Pit	216-C-3

Location	Service Dates	Status
200 East. S.E. Quadrant 400 ft south of 7th Street, 375 ft S.S.E. of 2704-C Bldg. (within the Hot semi-works complex).	1/53-3/54	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42055, W-50390	H-2-4034 H-2-32523	Ground Water Table Site Depth	689 ft 405 ft (1973) 10 ft

Source and Description of Waste

5×10^6 liters. Acid waste from 201-C, 215-C, 271-C.

Description of Facility

One crib, gravel pit structure, 50 ft x 10 ft bottom surface.
Deactivation: Pipeline blanked when the crib reached its specific retention capacity.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge
Pu, g	1
Beta, Ci	200
^{90}Sr, Ci	20
^{106}Ru, Ci	10
^{137}Cs, Ci	<0.10
^{60}Co, Ci	<0.10
U, kg	45
^{233}U, g	none

Ref. 5.37

The 218-C-1, C-3, C-4, and C-5 Crib complex along the south fence line of the "Hot Semiworks", 200 East Area, was decontaminated, and the ground surface stabilized against wind erosion and plant root invasion.

The work done was as follows:

- Bladed off four inches of the ground surface and deposited spoil in the cavity above 216-C-1 Crib.
- Covered the ground with a four-inch sand pad.
- Applied ureabor herbicide at the rate of 500 lbs./acre.
- Installed 10 mil plastic sheeting over entire surface. NOTE: The plastic sheet was doubled over the area around the Tank #71 riser.
- Installed 12-inch pad of sand over the plastic.
- The surface stabilized with four inches of pit run gravel.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib		216-C-4

Location	Service Dates	Status
200 East, S. E. Quadrant 375 ft south of 7th Street, 375 ft S.E. of 2704 Bldg. (within the Hot Semiworks Complex).	7/55-5/65	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42060, W-50430	H-2-4010 H-2-4425 H-2-32523	Ground Water Table Site Depth	689 ft 405 ft(1973) 16 ft

Source and Description of Waste

1.7×10^5 liters. Contaminated organic waste from 276-C. Low-salt, neutral basic.

Description of Facility

One crib, 20 ft x 10 ft bottom surface, gravel structure.
Deactivation: Piping to the crib in 276-C was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge
Pu, g	1
Beta, Ci	120
^{90}Sr, Ci	28
^{106}Ru, Ci	15
^{137}Cs, Ci	<0.10
^{60}Co, Ci	<0.10
U, kg	3.4
^{233}U, g	none

Ref. 5.39

The 218-C-1, C-3, C-4, and C-5 Crib complex along the south fence line of the "Hot Semiworks", 200 East Area, was decontaminated, and the ground surface stabilized against wind erosion and plant root invasion.

The work done was as follows:

- Bladed off four inches of the ground surface and deposited spoil in the cavity above 216-C-1 Crib.
- Covered the ground with a four-inch sand pad.
- Applied ureabor herbicide at the rate of 500 lbs./acre.
- Installed 10 mil plastic sheeting over entire surface. NOTE: The plastic sheet was doubled over the area around the Tank #71 riser.
- Installed 12-inch pad of sand over the plastic.
- The surface stabilized with four inches of pit run gravel.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-C-5	216-C-5

Location	Service Dates	Status
200 East, S.E. Quadrant 450 ft south of 7th Street, 375 ft S.S.W. of the 2704-C Bldg. (within the Hot Semiworks complex).	3/55-6/55	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42030, W-50360	H-2-4010 H-2-4425 H-2-32523	Ground Water Table Site Depth	689 ft 405 ft(1973) 16 ft

Source and Description of Waste

3.79×10^4 liters. High-salt, cold run waste from 201-C (semi-works).

Description of Facility

One crib, ground structure, 10 ft x 10 ft bottom surface. Deactivation: Piping to crib valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge
Pu, g	1
Beta, Ci	94
^{90}Sr, Ci	10
^{106}Ru, Ci	5
^{137}Cs, Ci	<0.10
^{60}Co, Ci	<0.10
U, kg	54

Ref. 5.41

The 218-C-1, C-3, C-4, and C-5 Crib complex along the south fence line of the "Hot Semiworks", 200 East Area, was decontaminated, and the ground surface stabilized against wind erosion and plant root invasion.

The work done was as follows:

- Bladed off four inches of the ground surface and deposited spoil in the cavity above 216-C-1 Crib.
- Covered the ground with a four-inch sand pad.
- Applied ureabor herbicide at the rate of 500 lbs./acre.
- Installed 10 mil plastic sheeting over entire surface. NOTE: The plastic sheet was doubled over the area around the Tank #71 riser.
- Installed 12-inch pad of sand over the plastic.
- The surface stabilized with four inches of pit run gravel.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	241-CX Crib	216-C-6

Location	Service Dates	Status
200 East, S.E. Quadrant 450 ft south of 7th Street, 325 ft south of the 291-C Stack (within the Hot Semiworks Complex).	9/55-9/64	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42015, W-50066	H-2-4425 H-2-35523	Ground Water Table Site Depth	689 ft 405 ft(1973) 16 ft

Source and Description of Waste

5.3×10^5 liters. Process condensate from 201-C; 241-CX vault floor drainage. Acidic.

Description of Facility

One crib, gravel structure, 20 ft x 20 ft bottom surface.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge
Pu, g	<0.10
Beta, Ci	2×10^3
^{90}Sr, Ci	65
^{106}Ru, Ci	25
^{137}Cs, Ci	<0.10
^{60}Co, Ci	<0.10
U, kg	<0.05

Ref. 5.43

INDEX - VOLUME I 200 EAST AREA

Northwest Quadrant

216-B-12 Crib	I. NW	218-E-2 Burial Ground	I. NW
216-B-35 Trench (covered)	I. NW	218-E-2A Burial Ground	I. NW
216-B-36 Trench (covered)	I. NW	218-E-4 Burial Ground	I. NW
216-B-37 Trench (covered)	I. NW	218-E-5 Burial Ground	I. NW
216-B-38 Trench (covered)	I. NW	218-E-5A Burial Ground	I. NW
216-B-39 Trench (covered)	I. NW	218-E-9 Storage Site	I. NW
216-B-40 Trench (covered)	I. NW	218-E-10 Burial Ground	I. NW
216-B-41 Trench (covered)	I. NW	UN-216-E-2 Unplanned Release	I. NW
216-B-42 Trench (covered)	I. NW	UN-216-E-6 Unplanned Release	I. NW
216-B-43 Crib	I. NW	UN-216-E-8 Unplanned Release	I. NW
216-B-44 Crib	I. NW	UN-216-E-13 Unplanned Release	I. NW
216-B-45 Crib	I. NW		
216-B-46 Crib	I. NW		
216-B-47 Crib	I. NW		
216-B-48 Crib	I. NW		
216-B-49 Crib	I. NW		
216-B-50 Crib	I. NW		
216-B-55 Crib	I. NW		
216-B-57 Crib	I. NW		
216-B-60 Crib	I. NW		
216-B-61 Crib	I. NW		
216-B-62 Crib	I. NW		

9413218.0363

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-ER-1,2,and 3 Cribs 216-ER Crib	216-8-12

Location	Service Dates	Status
200 East, N.W. Quadrant 1000 ft Northwest of 221-8	11/52-12/57 11/67-11/73	Deactivated

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42972, W-55000 to N-43133, W-55000	H-2-43027 H-2-43029 H-2-43039 H-2-43046 SK-2-19674	Ground Water Table Site Depth	697 ft 404 ft(1973) 30 ft

Source and Description of Waste

5.2×10^8 liters. Process condensate from Evaporators in 221-U and 224-U Bldgs. 11/52 to 12/57. Construction waste, 5/67 to 11/67. 221-8 Process condesate, 11/67 to 11/73, (neutralized with limestone). Low-salt, neutral/basic.

Description of Facility

Wooden structure. Bottom surface area 160 ft x 50 ft. Three cribs 16 ft square in gravel bed. Crib collapsed (see RL Occurrence Report 73-82). Following discovery of crib collapse, immediate action was taken to deactivate crib and backfill area to grade.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	370	374.0
Beta, Ci	1.1×10^4	<2080.0
^{90}Sr, Ci	<150	< 107.0
^{106}Ru, Ci	310	0.276
^{137}Cs, Ci	1.2×10^3	949.0
^{60}Co, Ci	<1.7	< 0.623
U, kg	2.1×10^4	20,900.0

(See next page)

Atlantic Richfield Hanford Company

RHO-CD-673

DATE AUG 23 1974

TO: [illegible]

B. C. SAUERESSIG

FROM: [illegible]

L. T. BRECKE

REFERENCES:

(1) Radioactive Waste Burial Sites - [illegible], "Burial Disposal Terminating Sites," Atomic Energy Commission Manual - Al Appendix 0513001, [illegible] 1967

(2) ARH-[illegible], "Hanford Architectural and Civil Standards, Adendum [illegible]

3. ARH-223, "Radiation Protection Standards and Controls, Standard No. 1," Personnel Protection Operation, September 16, 1969.

4. Atlantic Richfield Hanford Company Operating Instruction [illegible], "Control Radiation Zones"

I SUMMARY

CONDITIONS FOR DEACTIVATION OF THE 216 - B - 12 Crib

HAVE BEEN SATISFIED AND FUTURE RESPONSIBILITY TRANSFERRED TO TECHNICAL SERVICES

APPROVED: [illegible] APPROVED: [illegible]

[illegible] TECHNICAL SERVICES SECTION DATE MANAGER [illegible] SECTION DATE

II RADIATION ZONE REC'D

1. ORIGIN OF MATERIALS INTRODUCED TO THE SITE

U Plant Condensate

B Plant Condensate

2. HISTORY:

DATE OF INITIAL USE: Nov. 1952 DATE OF FINAL USE: Nov. 1973

Also called the 216 - ER #1, #2, and #3 Crib.
Received the process condensate from the waste evaporators in the 221 - U and 224 - U Bldgs. from November 1952 to December 1957.

Received the process condensate and construction waste from the 221-B Bldg. from May 1967 to November 1973.

3. EST. MAX. OF RADIONUCLIDE AND CURIE INVENTORY

RADIONUCLIDE	a. Du [illegible]	b. Beta	c. Sr90 [illegible] Cs137
CURIES	a. 374 gms 20,[illegible]kgs	b. [illegible] Decayed 2430	c. [illegible] 1200

Decayed < 120

4. RADIATION SURVEY OF THE ZONE

CONDITIONS: (a) ALL ZONE SURFACES TO BE LESS THAN 1 MRAD/HR (b) NO MEASURABLE SURFACE CONTAMINATION

< 100 C/M

Ref. 5.46

[illegible]

DATE:

SURVEY RESULTS			DATE OF SURVEY	REMARKS:
A. RADIATION	< 6	MRAD/HR	7/8/74	
B. CONTAMINATION	< 100	BETA-GAMMA	7/8/74	
	< 100 dm	ALPHA	7/8/74	
C. MOST RECENT GROUND WATER SAMPLE RESULTS	See remarks section.	µc/ml		

D. DRAWINGS (INCLUDING PLOT PLAN, MARKERS, MONITORING WELLS, SIGNS, BARRIERS, COORDINATES, ELEVATION, AND DETAILS OF STEPS TAKEN TO PRECLUDE FUTURE USE):

DRAWINGS NO. 34524, 34525, 43029 FCN's submitted to revise drawings. ATTACHED

III. DEACTIVATION WORK

	DATE		DATE
1. VENT RISERS SEALED OFF BELOW GRADE	4/10/74	3. GROUND STABILIZATION (PREVENTION OF EROSION AND TUMBLEWEED GROWTH)	5/8/74
2. INLET AND TRANSFER LINES DEACTIVATED.	3/14/74	4. OTHER WORK PERFORMED:	

HOW DEACTIVATED:

A cap was cemented on fiberglass fill line and a concrete plug was poured around the line end.

IV. ZONE IDENTIFICATION

	DATE		DATE
1. PERMANENT MARKERS INSTALLED	7/2/74	3. RADIATION ZONE SIGNS INSTALLED SO AS TO BE VISIBLE FROM ALL AVENUES OF APPROACH TO THE ZONE.	5/15/74
2. FENCE OR CHAIN BARRIER INSTALLED IF ZONE IS SUBJECT TO CAVE - IN.	5/15/74		

V. REMARKS

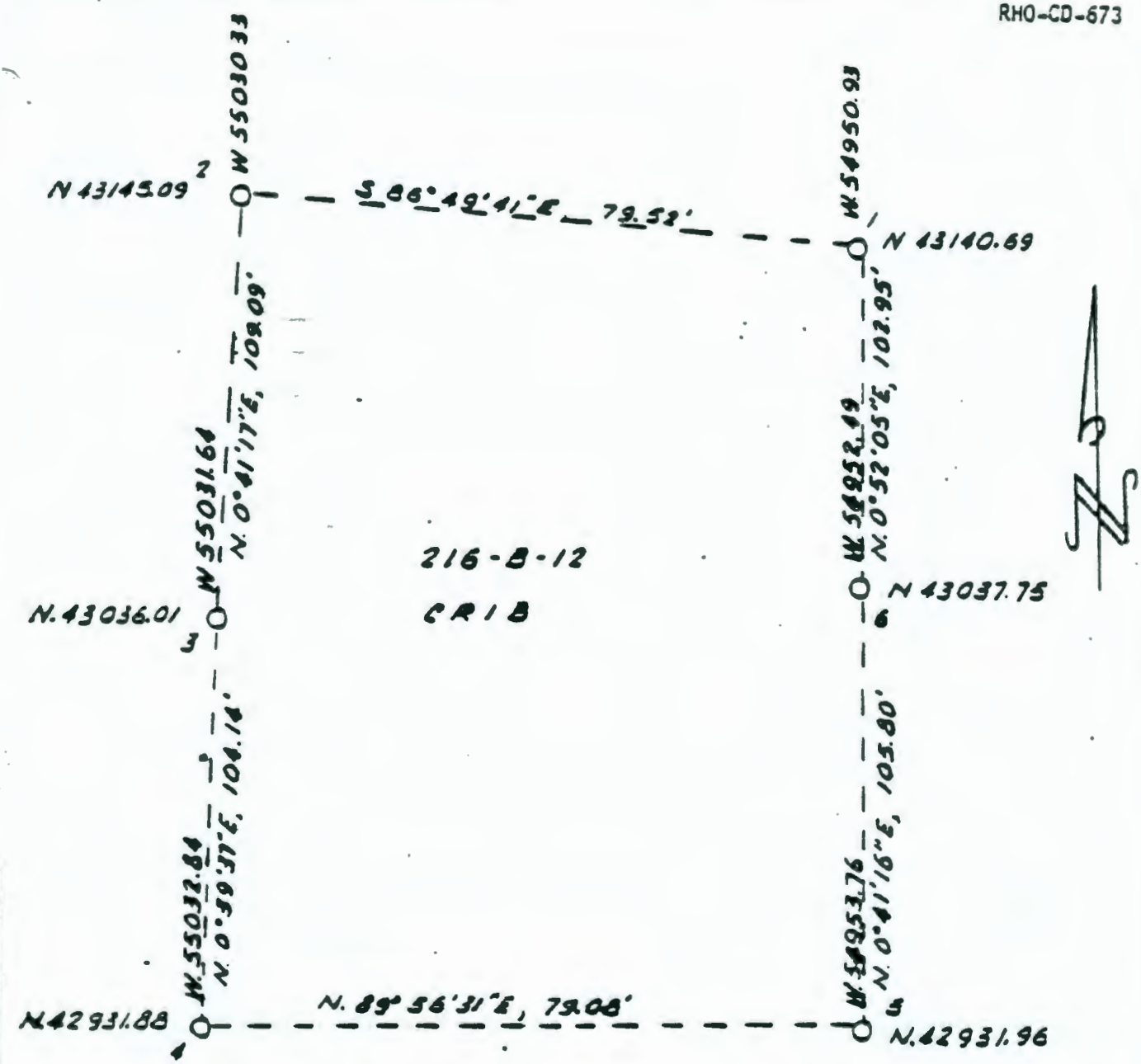
Ground Water Sample for April 1974

Total Beta	270 pico curies/liter
Total Strontium	<.24 pico curies/liter
Cesium	30±30 pico curies/liter

Ref. 5.47

DISTRIBUTION: 1. MANAGER - ORIGINATING SECTION
2. MANAGER - TECHNICAL SERVICES
3. MANAGER - PERSONNEL PROTECTION
4. MANAGER - PROCESS DESIGN ENGINEERING
5. MANAGER - RADIATION MONITORING
EXTRAS

SO-6700-301.2(7-71)
HANFORD, RICHLAND, WASH.



REV. NO.	REV. BY DATE	DRAWING STATUS		APPD. BY DATE	FOR	MICRO F'M'D		
DFTS APPD		DATE	APPD			DATE		
CHECKED			APPD					
DEN	7/17/74		ENGR					
DWG NO. 216-B-12			INDEX NO.					
SCALE NONE	CLASSIFIED BY DATE		CLASSIFICATION NONE					

DWG NO.	REV NO.	DRAWING TITLE OR INDEX NO.
REFERENCE DRAWINGS		

U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE

Vitro
HANFORD ENGINEERING SERVICES
A DIVISION OF VITRO CORPORATION OF AMERICA

AS-BUILT MARKER POSTS
216-B-12 CRIB

DWG NO.	SHEET NO.	SHEETS

CHARLES DRAWING NO. *NONE CLASSIFIED PER (DATE)

Ref. 5.48

SWP
RWP NO

RADIATION SURVEY

SURVEY NUMBER 5740004

TIME JOB STARTED 1300.

TOTAL TIME

RESPIRATORY PROTECTION WORN
N R A C FA

LOCATION 216B 12 crib.

INSTRUMENT(S) USED gm -.

JOB DESCRIPTION Survey of crib -.

LOCATION AND REMARKS	DOSE RATE	NO	NO	DIST	NEUTRON	DIST
area of crib.	<100.					
3 Vent pipes.	<100.					
All vent pipes cut.						
Tf. covered with cribs.						

Gil Bergman Jr

RHO-CD-673

Atlantic Richfield Hanford Company

FACILITIES CHANGE NOTICE

(REF. OPERATING INSTRUCTION 4.3.1.3)

No. 03571

INITIATED BY	ORGANIZATION	PHONE NO.	PLANT NO. (REFERENCE ONLY)
[illegible]	FPI	2-[illegible]	[illegible]

DRAWING(S) AFFECTED	REV. NO.	TITLE, PART, NAME OR DESCRIPTION
H-2-34525	3	CLOSE FILL LINE [illegible] 216-12
H-2-34524	3	CRIB

DESCRIPTION OF CHANGE (BE AS COMPLETE AS POSSIBLE IN DESCRIBING CHANGE) PLANT LOCATION (CELL NOOB, ROOM, AREA, ETC.)

BLDG. NO. 271-B

CUT OFF FILL LINE &
CAP WITH CEMENT FOR
216-B-12 CRIB--FILL LINE.

SAFETY APPROVALS (AS REQUIRED) - INDICATE

NUCLEAR	RADIOLOGICAL	PROCESS	MECHANICAL	FIRE SAFETY	ENGINEERING	PERSONNEL PROTECT.

REVIEW & APPROVAL (AS REQUIRED)

AUTHORIZED BY	DATE	WORK COMPLETED: SIGNATURE AND DATE	CHECK FOR COMPLETENESS: SIGNATURE AND DATE
[illegible]	1-22-74	[illegible] 4-26-74	[illegible]

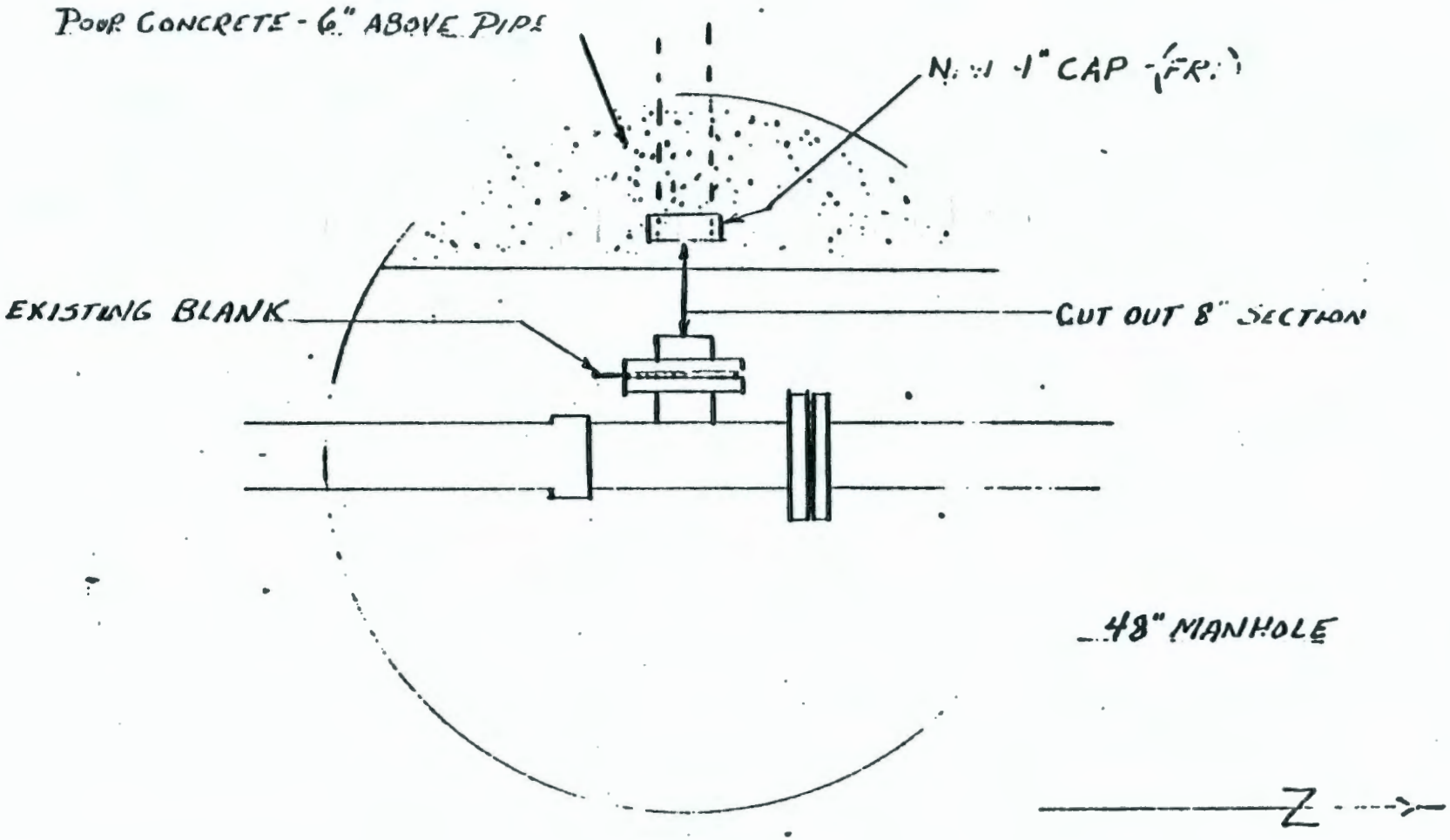
FOR DRAFTING OPERATION	DRAFTSMAN	DATE COMPLETED	REMARKS

BC-6400-037 (8-71)

DISTRIBUTION (AFTER COMPLETION OF WORK)

COPIES 1 AND 2 DRAFTING UNIT; COPY 3 PERFORMER OF WORK; COPY 4 AUTHORIZER'S FILE

Ref. 5.50



PLUG FOR B12 CRIB

W.D.L. - 1/21/

RHO-CD-673

Ref. 5.51

Harold

3-20-78

All of the actions described in the attached letter were completed. I don't know for certain the dates because the job took two years and its been quite some time. If you need more information let me know. I have a folder of surveys, purchase requisitions work orders, plat's by Vitus surveyors, etc. etc.

Dick Purton

9413218.0371

Atlantic Richfield Hanford Company

RHO-CD-673

Date: January 22, 1974

To: A. J. Low

From: R. E. Preston

Subject: 216-B-12 CRIB DEACTIVATION AND TRANSFER OF RESPONSIBILITY

References:

1. Atomic Energy Commission Manual - RL Appendix 0510-1, July 13, 1967, "Radioactive Waste Disposal Guides - Part 1," "Ground Disposal - Terminating Sites"

2. HWS-1000, "Hanford Architectural and Civil Standards," AC-3-20 (June 20, 1960), AC-5-2 (October 19, 1959), and AC-5-40 (August 25, 1960)

3. ARH-220 (unclassified), September 15, 1969, "Radiation Protection Standards and Controls Standard 1," Personnel Protection Operation

4. Atlantic Richfield Hanford Company Operating Instruction 1.6.5.2, "Outdoor Radiation Zones"

The pertinent AEC Manual Chapters, Atlantic Richfield Hanford Company OPG's and Radiation Protection Standards have been reviewed on the layaway of retired radioactive disposal sites. In this letter the steps are shown for the layaway of B-12 crib, the list should be used for an order of performance schedule. Step 2 is the only exception, it must be performed before Step 4, but may be completed before Step 1.

1. The risers (vent and gauge wells) should be cut off below the surface and the risers welded shut or flanges welded on and blanks bolted in place. This work can be performed as soon as the liquid level as measured in the gauge well is at or below the 25-foot level as experienced in operation.

   The test wells (3) are to be left as at present.

The location of these risers and wells is shown on H-2-43029. The gauge well and vent risers are the outside risers in groups of three on each of the three crib sections. The test wells are the center riser in each group.

2. The inlet line has already been blanked off. This was done on November 21, 1973. An FCN has been prepared to show this on drawings H-2-34524 and H-2-34525.

   The line to 8-12 crib should be cut and the line capped with a plastic cap cemented on the pipe and concrete poured around the end of the pipe. This may be done as soon as material is available.

3. The ground stabilization program should probably be put off until April or May to allow for further settling to avoid repetition of the ground stabilization effort.

   The ground stabilization effort should cover an area 60 feet wide, centered on the line running through the test wells. The area should extend 30 feet beyond the outer test wells. This area will be 60 feet wide and 181 feet long, or 10,860 square feet.

   The area should be leveled and smoothed, all vegetation removed and any sharp items removed. Two to three inches of sand should be spread over the area. After this, 10 mil plastic sheet should be laid out and weighted down with soil. A solid soil sterilant such as boric acid-type like Ureabor should be sprinkled evenly on top of the plastic. Ureabor can be ordered through Farmer's Exchange in Kennewick. They do not carry it in stock. The area over the plastic should be covered with 18 inches of sand free from any large rocks. Once the sand is laid and leveled, the area should be covered with two-inch minus gravel to a depth of four to six inches.

4. When the soil stabilization is complete, the crib should be marked off with six monuments built according to Hanford Standard AC-5-40. The monuments should be placed at coordinates: N42964XW55030, N42964XW54970, N43056XW54970, N4305XW55030, N43144XW55030, and N43144XW54970.

A. J. Low
Page 3
January 22, 1974

The brass medallions for these posts can be obtained through the Peterson Pattern Works.

Once the posts are in place, Harold Maxfield will stamp the required numbers on the posts.

5. At this time, a radiation survey should be made of the area. The survey information should be recorded on BD-6700-091.1 (7-71).

6. The normal radiation chain fence with radiation signs on posts should be repaired to good condition if it has been damaged during any of the above work.

7. The information required on BD-6700-091.1 (7-71), "Outdoor Radiation Zone Deactivation and Transfer of Responsibility," should be filled out and routed to mailing list on form.

8. At this time, Technical Services will accept custodianship of the crib.

REP:bl

cc: JD Anderson
RB Bixler
DG Harlow
GL Hanson
AJ Low
LM Knights
RP Knight
JH Mathis
WD Schildknecht
A Smith
RM Smithers
File

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-BX-1 Grave 216-BX-1 Trench 216-B-35 Trench	216-B-35

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-BX Tank Farm, 2650 ft north of B-Plant	2/54-3/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45273, W-53850 to N-45273, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	740 ft 404 ft (1973) 10 ft

Source and Description of Waste

1.06×10^6 liters. First cycle supernatant waste from 221-B. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	1.2	1.2
Beta, Ci	1800	<732.0
^{90}Sr, Ci	240	130.0
^{106}Ru, Ci	230	1.48×10^{-5}
^{137}Cs, Ci	430	246.0
^{60}Co, Ci	0.030	1.27×10^{-3}
U, kg	17	16.7

Potential Hazards

Radioactive weed growth;
Burrowing animals

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-8X-2 Grave 216-8X-2 Trench 216-8-36 Trench	216-8-36

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-8X Tank Farm, 2750 ft north of 8-Plant	3/54-4/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45323, W-53850 to N-45323, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	740 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.94×10^6 liters. First cycle supernatant waste from 221-8. High-salt, neutral/basic.

Description of Facility

Trench, 250 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	0.80	0.80
Beta, Ci	3500	<1390.0
^{90}Sr, Ci	490	269.0
^{106}Ru, Ci	470	3.05×10^{-5}
^{137}Cs, Ci	770	445.0
^{60}Co, Ci	0.070	2.96×10^{-3}
U, kg	16	16.0

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.57

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-BX-3 Grave 216-BX-3 Trench 216-B-37 Trench	216-B-37

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-BX Tank Farm, 2850 ft north of B-Plant	8/54-8/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45413, W-53850 to N-45413, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	663 ft 404 ft(1973) 10 ft

Source and Description of Waste

4.32×10^6 liters. First cycle bottoms waste from the waste evaporator in 242-B. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	2.0	2.0
Beta, Ci	7000	<3440.0
^{90}Sr, Ci	16	8.87
^{106}Ru, Ci	500	3.23×10^{-5}
^{137}Cs, Ci	3100	1780.0
^{60}Co, Ci	1.0	4.22×10^{-2}
U, kg	3.6	3.63

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.58

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-8X-4 Grave 216-8X-4 Trench 216-8-38 Trench	216-8-38

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-8X Tank Farm, 2950 ft north of B-Plant	7/54-8/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45503, W-53850 to N-45503, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	660 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.43×10^6 liters. First cycle supernatant waste from 221-8. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed and trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	1.2	1.20
Beta, Ci	5800	<2610.0
^{90}Sr, Ci	1900	1030.0
^{106}Ru, Ci	560	3.62×10^{-5}
^{137}Cs, Ci	510	292.0
^{60}Co, Ci	<0.06	< 2.53×10^{-3}
U, kg	42	42.4

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.59

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-8X-5 Grave 216-8X-5 Trench 216-8-39 Trench	216-8-39

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-8X Tank Farm, 3050 ft north of B-Plant. East of 218-E-10 Indust. Burial Grounds.	12/53-11/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45593, W-53850 to N-45593, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	650 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.47×10^6 liters. First cycle supernatant waste from 221-B. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed and trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	1.5	1.51
Beta, Ci	1100	<514.0
^{90}Sr, Ci	23	12.5
^{106}Ru, Ci	65	2.69×10^{-6}
^{137}Cs, Ci	450	255.0
^{60}Co, Ci	<0.010	$< 3.92 \times 10^{-2}$
U, kg	5.8	5.80

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.60

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-8X-6 Grave 216-8X-6 Trench 216-8-40 Trench	216-8-40

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-8Y Tank Farm, 3150 ft north of 8-Plant. East of 218-E-10 Indust. Burial Grounds.	4/54-7/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45683, W-53850 to N-45683, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	650 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.64×10^6 liters. First cycle supernatant waste from 221-8. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed and trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/73
Pu, g	1.0	1.0
Beta, Ci	1800	<700.0
^{90}Sr, Ci	280	155.0
^{106}Ru, Ci	240	1.58×10^{-5}
^{137}Cs, Ci	350	203.0
^{60}Co, Ci	<0.020	$< 3.45 \times 10^{-4}$
U, kg	35	35.0

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.61

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-8X-7 Grave 216-8X-7 Trench 216-8-41 Trench	216-8-41

Location	Service Dates	Status
200 East, N. W. Quadrant 250 ft west of 241-8Y Tank Farm, 3250 ft north of B-Plant. East of 218-8-10 Industrial Burial Grounds	11/54-11/54	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45573, W-53850 to N-45573, W-54102	H-2-2431 SK-2-2408	Ground Water Table Site Depth	650 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.44×10^6 liters. First cycle supernatant waste from 221-8. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed and trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	0.30	0.30
Beta, Ci	2100	<1040.0
^{90}Sr, Ci	47	26.1
^{106}Ru, Ci	130	8.47×10^{-5}
^{137}Cs, Ci	890	512.0
^{60}Co, Ci	<0.010	< 4.22×10^{-4}
U, kg	7.5	7.5

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.62

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Trench (covered)	241-BX-8 Grave 216-BX-3 Trench 216-B-42 Trench	216-B-42

Location	Service Dates	Status
200 East, N.W. Quadrant 750 ft west of 241-BX Tank Farm, 2650 ft north of B-Plant, East of 218-E-10 Industrial Burial Grounds.	1/55-2/55	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-45273, W-54152 N-45273, W-54404	H-2-2431 SK-2-2408	Ground Water Table Site Depth	671 ft 404 ft(1973) 10 ft

Source and Description of Waste

1.50×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

Trench, 252 ft x 10 ft bottom surface. Deactivation: Overground pipeline removed and trench backfilled.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	10	10.0
Beta, Ci	5800	<1360.0
^{90}Sr, Ci	1100	625.0
^{106}Ru, Ci	1500	1.93×10^{-4}
^{137}Cs, Ci	96	56.5
^{60}Co, Ci	10	0.482
U, kg	680	680.0

Potential Hazards

Radioactive weed growth;
Burrowing animals

Ref. 5.63

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-8Y-1 Cavern 216-8Y-1 Crib	216-8-43

Location	Service Dates	Status
200 East, N. W. Quadrant 200 ft north of 241-8Y Tank Farm, 450 ft south of 12th St.	11/54-11/54	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46332, W-53355	H-2-2603 H-2-2605	Ground	623 ft
		Water Table	406 ft(1973)
		Site Depth	14 ft

Source and Description of Waste

2.1×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

Crib, 30 ft x 30 ft bottom dimensions, concrete slab roof.
Deactivation: Pipeline to the crib was blanked when the crib reached its specific retention capacity.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	0.5	0.50
Beta, Ci	3500	<1880.0
^{90}Sr, Ci	1400	776.0
^{106}Ru, Ci	50	3.23×10^{-6}
^{137}Cs, Ci	300	173.0
^{60}Co, Ci	1.0	4.22×10^{-2}
U, kg	14	13.6

Site Characterization Status

The 216-8-43 Crib is the first in a series of seven cribs north of the 241-8Y Tank Farm that received U-Plant high-salt, scavenged waste. These cribs were in service from December 1954 to December 1955 and received a total of 3.4×10^7 liters of waste containing 4.1×10^5 gross beta curies.

Ref. 5.64

216-B-43 continued

Site Char. Status

Four wells were drilled in the vicinity of the BY cribs in 1966 to determine the distribution of radionuclides below these cribs. Well E33-2A drilled at the edge of the 216-B-45 Crib showed the highest ^{137}Cs and ^{90}Sr concentrations. Cesium-137 was first detected at 17 ft (approximate crib bottom) at a concentration of 18.4 µCi/g. The ^{137}Cs concentration increases to a maximum of 28.7 µCi/g at 20 ft beneath ground surface then rapidly decreases with depth. Several additional concentration peaks occur at lower depths in the soil column but only on the order of 0.001 to 0.0001 of the peak concentration. Strontium-90 concentrations follow the same general pattern with a maximum of 22 µCi/g at 25 ft. Samples below 75 ft contained less than 2×10^{-3} µCi/g. Data from the other wells showed the same general trend but concentrations were less. It was evident that the quantity of long-lived activity subject to leaching by a moderate rise in the water table is relatively small.

History

The 216-B-43 through 50 cribs are located in a common radiation zone under the hill directly north of the 241-BY Tank Farm. On September 15, 1955 approximately 11,000 gallons of scavenged supernatant radioactive waste overflowed a flush tank and ran over the ground surface near the 216-B-43 Crib. Most of the waste involved was scraped from the ground and pushed into a shallow hole just south and east of the B-43 Crib. It was then covered with 2 feet of clean soil.

Routine radiation surveys in the early 1970's found radioactive Russian thistle to be growing over the old spill site and other ground surfaces within the radiation zone. Remedial action, which reduced the size of the radiation zone by 50 percent, was started in 1975 and completed in November, 1977. It consisted of the following work:

- All crib vent risers were cut and blanked off approximately 18" below ground surface.
- The radioactive buried spill site was removed and all ground surfaces decontaminated by removing radioactive surface soils.
- The ground surface was smoothed off and covered with a 6" sand pad.
- Two test strips of ground surface, 10 ft x 100 ft, over the cribs were treated with a tracer element, lithium chloride, to help in determining the effectiveness of the plastic root barrier against future root penetrations.
- A herbicide, urea borate in dry form, was spread over the radiation zone ground surface at the rate of 500 pounds per acre.

9413218.0584

216-B-43 continued

History

- The surface above and near the cribs was covered with a sheet of 10 mil plastic.
- The plastic was covered with 6" of sand for a padding against puncture by rocks or other sharp objects, then covered by 12" of top soil.
- Monitoring well casings were all extended so as to protrude from 12 to 18 inches above ground level.
- The ground surface was fertilized with 60 pounds of 16-20-0 fertilizer per acre and seeded over the plastic area with 20 lbs. per acre of cheatgrass, and over the remainder of the ground surface of the radiation zone with cheatgrass and Siberian wheatgrass.

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-BY-2 Cavern 216-BY-1 Crib	216-B-44

Location	Service Dates	Status
200 East, N. W. Quadrant 300 ft north of 241-BY Tank Farm, 350 ft south of 12th St.	11/54-3/55	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46417, W-53355	H-2-2603 H -2-2605	Ground Water Table Site Depth	623 ft 406 ft(1973) 14 ft

Source and Description of Waste

5.6×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	15	15.0
Beta, Ci	2.2×10^4	< 4020.0
^{90}Sr, Ci	2900	1620.0
^{106}Ru, Ci	5500	6.53×10^{-4}
^{137}Cs, Ci	700	409.0
^{60}Co, Ci	5.0	0.228
U, kg	5.3	2.27

Site Characterization Status and History

Refer to 216-B-43

Ref. 5.67

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CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-BY-3 Cavern 216-BY-3 Crib	216-B-45

Location	Service Dates	Status
200 East, N. W. Quadrant 400 ft north of 241-BY Tank Farm, 250 ft south of 12th St.	4/55-6/55	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46502, W-53355	H-2-2603 H-2-2605	Ground Water Table Site Depth	623 ft 406 ft(1973) 14 ft

Source and Description of Waste

4.9×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	10	10.0
Beta, Ci	5.3×10^4	< 4880.0
^{90}Sr, Ci	2800	1590.0
^{106}Ru, Ci	1.7×10^4	2.19×10^{-3}
^{137}Cs, Ci	1500	884.0
^{60}Co, Ci	5.0	0.241
U, kg	6.8	6.8

Site Characterization Status and History

Refer to 216-B-43

Ref. 5.68

CONTAMINATED LIQUID DISPOSAL SITES

I. NW

Name/Type of Facility	Past Designation	Number
Crib	216-8Y-4 Cavern 216-8Y-4 Crib	216-8-46

Location	Service Dates	Status
200 East, N. W. Quadrant 500 ft north of 241-8Y Tank Farm, 150 ft south of 12th St.	9/55-12/55	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46587, W-53355	H-2-2603 H-2-2605	Ground	623 ft
		Water Table	406 ft(1973)
		Site Depth	14 ft

Source and Description of Waste

6.7×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	20	20.0
Beta, Ci	1.2×10^5	<1960.0
^{90}Sr, Ci	1500	852.0
^{106}Ru, Ci	2.8×10^4	3.61×10^{-3}
^{137}Cs, Ci	200	118.0
^{60}Co, Ci	5	0.241
U, kg	190	191.0

Site Characterization Status and History

Refer to 216-8-43

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-BY-5 Cavern 216-BY-5 Crib	216-8-47

Location	Service Dates	Status
200 East, N. W. Quadrant 200 ft north of 241-BY Tank Farm, 450 ft south of 12th St.	9/55-9/55	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46332, W-53499	H-2-2603 H-2-2605	Ground Water Table Site Depth	623 ft 406 ft(1973) 14 ft

Source and Description of Waste

3.7×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	5.0	5.0
Beta, Ci	4.5×10^4	<877.0
^{90}Sr, Ci	620	352.0
^{106}Ru, Ci	1.9×10^4	2.45×10^{-3}
^{137}Cs, Ci	150	88.4
^{60}Co, Ci	1.0	4.82×10^{-2}
U, kg	6.8	6.8

Site Characterization Status and History

Refer to 216-8-43

Ref. 5.70

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-BY-6 Cavern 216-BY-6 Crib	216-8-48

Location	Service Dates	Status
200 East, N. W. Quadrant 300 ft north of 241-BY Tank Farm, 350 ft south of 12th St.	11/55-7/57	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46417, W-53499	H-2-2603 H-2-2605	Ground Water Table Site Depth	623 ft 406 ft(1973) 14 ft

Source and Description of Waste

4.1×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	5.0	5.0
Beta, Ci	6.1×10^4	<2010.0
^{90}Sr, Ci	1300	739.0
^{106}Ru, Ci	6800	8.76×10^{-4}
^{137}Cs, Ci	450	265.0
^{60}Co, Ci	1.0	4.82×10^{-2}
U, kg	2.3	2.27

Site Characterization Status and History

Refer to 216-8-43

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-BY-7 Cavern 216-BY-7 Crib	216-8-49

Location	Service Dates	Status
200 East, N. W. Quadrant 400 ft north of 241-BY Tank Farm, 250 ft south of 12th St.	11/55-12/57	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46502, W-53499	H-2-2603 H-2-2605	Ground	623 ft
		Water Table	406 ft(1973)
		Site Depth	14 ft

Source and Description of Waste

6.7×10^6 liters. Scavenged waste from uranium recovery (TBP solvent extraction) process in 221-U. High-salt, neutral/basic.

Description of Facility

One crib, gravel filled, 30 ft x 30 ft bottom surface area, constructed of a concrete slab supported by vertical sections of concrete pipe. Deactivation: The pipeline to the crib was valved out when the specific retention capacity was reached.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	15	15.0
Beta, Ci	1.1×10^5	<3560.0
^{90}Sr, Ci	2700	1530.0
^{106}Ru, Ci	2.4×10^4	3.09×10^{-3}
^{137}Cs, Ci	410	242.0
^{60}Co, Ci	5.0	0.241
U, kg	320	318.0

Site Characterization Status and History

Refer to 216-8-43

CONTAMINATED LIQUID DISPOSAL SITES

I. NW

Name/Type of Facility	Past Designation	Number
Crib	216-8Y-8 Cavern 216-8Y-8 Crib	216-8-50

Location	Service Dates	Status
200 East, N. W. Quadrant ~700 ft north of 241-8Y Tank Farm ~500 ft west of Baltimore Ave.	1/65-1/74	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46502, W-53499	H-2-2603 H-2-2605	Ground Water Table Site Depth	622 ft 404 ft 14 ft

Source and Description of Waste

5.9×10^7 liters. Waste storage tank condensate from the ITS #1 unit in the 241-8Y Tank Farm.

Description of Facility

Crib, concrete slab over pipe, 30 ft x 30 ft bottom dimension.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	$<2.4 \times 10^{-1}$	< 0.239
Beta, Ci	241	< 140.0
^{90}Sr, Ci	<6	< 4.58
^{106}Ru, Ci	11	5.05×10^{-3}
^{137}Cs, Ci	88	67.8
^{60}Co, Ci	$<3.3 \times 10^{-1}$	$< 7.61 \times 10^{-2}$
U, kg	$<2.9 \times 10^{-1}$	< 0.285

Site Characterization Status and History

Refer to 216-8-43 for History

Ref. 5.73

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib		216-B-55

Location	Service Dates	Status
200 East, N.W. Quadrant Approximately 800 ft west of 221-B	9/67-	Active

Site Coordinates	Reference Drawings	Elevations	
N-42497, W-54810 to N-42920, W-55431	H-2-60330 SK-2-19674	Ground Water Table Site Depth	700 ft 400 ft(1973) 6-8 ft

Source and Description of Waste

6.0×10^8 liters as of 12/31/73. Steam condensate from 221-B. Low-salt, neutral/basic.

Description of Facility

Crib, gravel-filled, 750 ft x 10 ft bottom dimension.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	<0.43	< 0.552
Beta, Ci	1.4×10^2	<54.5
^{90}Sr, Ci	$<7.2 \times 10^0$	< 9.53
^{106}Ru, Ci	$<1.4 \times 10^0$	< 0.19
^{137}Cs, Ci	2.0×10^1	27.7
^{60}Co, Ci	$<3.2 \times 10^{-1}$	< 0.262
U, kg	$<3.9 \times 10^0$	< 6.71

Ref. 5.74

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-8-57	216-8-57

Location	Service Dates	Status
200 East, N.W. Quadrant Near the northwest corner of 241-8Y Tank Farm	2/68-6/73	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-46160, W-53775 N-46360, W-53775	H-2-62406	Ground Water Table Site Depth	625 ft 394 ft 10 ft(minimum)

Source and Description of Waste

8.4×10^7 liters (as of 12/31/73). Waste storage tank condensate from the ITS #2 Unit in the 241-8Y Tank Farm.

Description of Facility

Crib, gravel-filled, 200 ft x 15 ft bottom dimension.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/78
Pu, g	$<1.9 \times 10^{-1}$	< 0.187
Beta, Ci	8.4×10^{2}	<580.0
^{90}Sr, Ci	3.2×10^{0}	2.47
^{106}Ru, Ci	8.7×10^{0}	2.23×10^{-2}
^{137}Cs, Ci	3.7×10^{2}	299.0
^{60}Co, Ci	1.4×10^{-1}	< 3.94
U, kg	8.9×10^{-1}	< 0.89

Ref. 5.75

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-8-60 Crib	216-8-60

Location	Service Dates	Status
200 East, N. W. Quadrant The crib is under the floor of the north-east corner of the 225-8 Building.	11/67-11/67	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42573, W-54178 to N-42583, W-54178	H-2-34303	Ground Water Table Site Depth	690 ft 405 ft(1973) 40 ft

Source and Description of Waste

1.89×10^4 liters. Cell cleanout solid and liquid waste from the 24-inch sewer in 221-8. Low-salt, neutral/basic.

Description of Facility

Two cribs, 8-ft diameter caissons, 16-ft long, bottom at depth of 40 ft. Deactivation: Tops of the caissons were grouted with concrete to seal in the waste; the 24-in. sewer was plugged at the west end of 221-8. The site is now (5/75) covered by the 225-8 Encapsulation Facility.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/75
Pu, g	0.080	0.08
Beta, Ci	1600	<19.9
^{137}Cs, Ci	8.0	6.21
U, kg	720	717.0

Ref. 5.76

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-8-61 Crib	216-8-61

Location	Service Dates	Status
200 East, N. W. Quadrant ~500 ft northwest of 241-8Y Tank Farm ~200 ft south of 12th Street	Never used	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-46650, W-54175 to N-46650, W-54350	H-2-34522 H-2-34523	Ground Water Table Site Depth	663 ft 404 ft

Source and Description of Waste

Future use: To receive waste storage tank condensate from ITS #1 Unit in the 241-8Y Tank Farm.

Description of Facility

Gravel-filled, 1750 ft^2 bottom surface area.

Ref. 5.77

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Crib	216-B-62	216-B-62

Location	Service Dates	Status
200 East, N.W. Quadrant Approximately 1500 ft northwest of 221-B	11/73-	Active

Site Coordinates	Reference Drawings	Elevations	
N-43580, W-54995 to N-43934, W-55349	H-2-34524 H-2-34525	Ground Water Table Site Depth	697 ft 404 ft (1973) ~10 ft

Source and Description of Waste

1.9×10^6 liters as of 12/31/73. B Plant process condensate.

Description of Facility

Crib, gravel-filled. 500 ft x 10 ft bottom dimension.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Discharge	As of 6/30/79
Pu, g	8.4×10^{-4}	0.379
Beta, Ci	1.9	<140.0
^{90}Sr, Ci	0.31	19.1
^{106}Ru, Ci	$<1.8 \times 10^{-2}$	< 0.629
^{137}Cs, Ci	0.33	33.9
^{60}Co, Ci	$<8.3 \times 10^{-4}$	<449.0
U, kg	$<1.9 \times 10^{-2}$	< 2.75

Ref. 5.78

CONTAMINATED LIQUID DISPOSAL SITES

I. NW

Name/Type of Facility	Past Designation	Number
Burial Ground	300 East/ Industrial Waste No. 02	218-E-2

Location	Service Dates	Status
200 East, N.W. Quadrant About 2,000 ft north of B-Plant.	1945-1953	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-44827, W-53426 N-44395, W-53426 N-44395, W-53950 N-44827, W-53950	H-2-2479 H-2-55534	Ground Water Table Site Depth	669 ft 404 ft(1973) 15 ft

Source and Description of Waste

Failed equipment and industrial waste (approximately 3.2×10^5 ft^3).

Description of Facility 2.3 acres. Ref: Ltr. - Rockwell 1/09/80 #65421-80-005

Backfilled trenches.
Surface area 2.98×10^5 ft^2.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Burial	As of 9/30/78
U, g	3.0×10^5	3.0×10^5
Pu, g	8.0×10^2	8.0×10^2
Total Beta, Ci	2.5×10^4	1.06×10^3
^{90}Sr, Ci	5.0×10^2	253.0
^{106}Ru, Ci	1.1×10^3	1.12×10^{-5}
^{137}Cs, Ci	5.3×10^2	253.0

NOTE:

A total of ~~seven~~ TEN burial trenches are shown on print # H-2-2479.

An inspection of the burial grounds 2/21/78 disclosed some caving over all trenches, and ground surface contamination on a number of tumbleweeds near the north end of 218-E-9.

Sunken ground surfaces over the centerlines of the various trenches plus the vegetation growth patterns show the true location of the burial trenches in burial grounds E-2, E-5, E-9 to be different than those drawn on print H-2-55534.

See Attachments

Ref. 5.79

Burial Ground : 218-E-2

Extensive research work was done during the year 1979 to determine the locations of all burial trenches within the bounds of the 218-E-5, 218-E-5A, 218-E-2 and 218-E-9 Burial Grounds radiation zone. The work included viewing aerial photographs and construction prints, analyzing plant growth patterns, and the load testing of the ground surface.

Four previously unrecorded sites were identified: (See attached map, Figure A.2, Burial Grounds 218-E-2, E-2A, E-5, E-5A, and E-9)

#1 Site Referred to as the 202-A, L-Cell Burial Package. It consisted of four very large burial boxes. The burial location is shown as a 100 foot by 120 foot rectangular area within the 218-E-5A Burial Ground. The D-2 Column from Purex K Cell was also buried here.

#2 Site Multiple trenches running north and south in Burial Ground 218-E-5. It has been stabilized as a single trench.

#4 Site A long trench (423') running east and west along the north side of 218-E-2 Burial Ground.

#5 Site A long trench (423') parallel and adjacent to Site #4 above.

Burial Ground: 218-E-2

Fiscal year ground surface stabilization work within the 218-E-2 Burial Ground was done over trenches #3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. (See map attachment.) Trenches 5, 6, 7, 10, and 12 were so close together they were treated as a single work area. Trenches 9 and 11 were also treated as a single work area.

The work consisted of load testing the ground surface for subterranean voids by driving over the ground with a 40-ton vehicle, removing vegetation and radioactive contamination from the ground surface, placing 1 foot of fill dirt over the burial trenches and seeding the prepared surfaces with cheatgrass.

Details of Cheatgrass Seeding

- Broadcast seed at rate of 20-25 lbs/acre.
- Cover seed with a drag.
- Cover with wheat straw mulch at the rate of two tons mulch/acre (approximately 60 bales of straw).
- Apply amonium sulphate 21-0-0 fertilizer at the rate of 100 to 200 lbs. per acre.
- Water with water-truck at the rate of 6500 to 7500 gals/acre. Repeat watering after one week.

The ground surfaces between the seeded trenches were stabilized against weather erosion with a three- to six-inch covering of bank run gravel. The gravel covering will be treated with ureabor herbicide at a rate of 500 lbs/acre.

A total of 9,000 yds^3 of dirt was used in the 218-E-5, 5A, 2, and 9 Burial Ground complex for fill material and seed bedding. Three thousand yards of gravel were spread between the trenches.

TABLE 4 218-E-2, 2A, 5, 5A & 9 STATUS

TRENCH NO.	SOIL DEPTH (NO BIOBARRIERS)	REVEGETATION SPECIES
1	1'	To Be Completed FY '80
2	1'	To Be Completed BY '80
3	1'	Cheatgrass
4	1'	Cheatgrass
5, 6, 7, 10, 12	1'	Cheatgrass
8	1'	Cheatgrass
9, 11	1'	Cheatgrass
13	3"-6"	To Be Completed FY '80

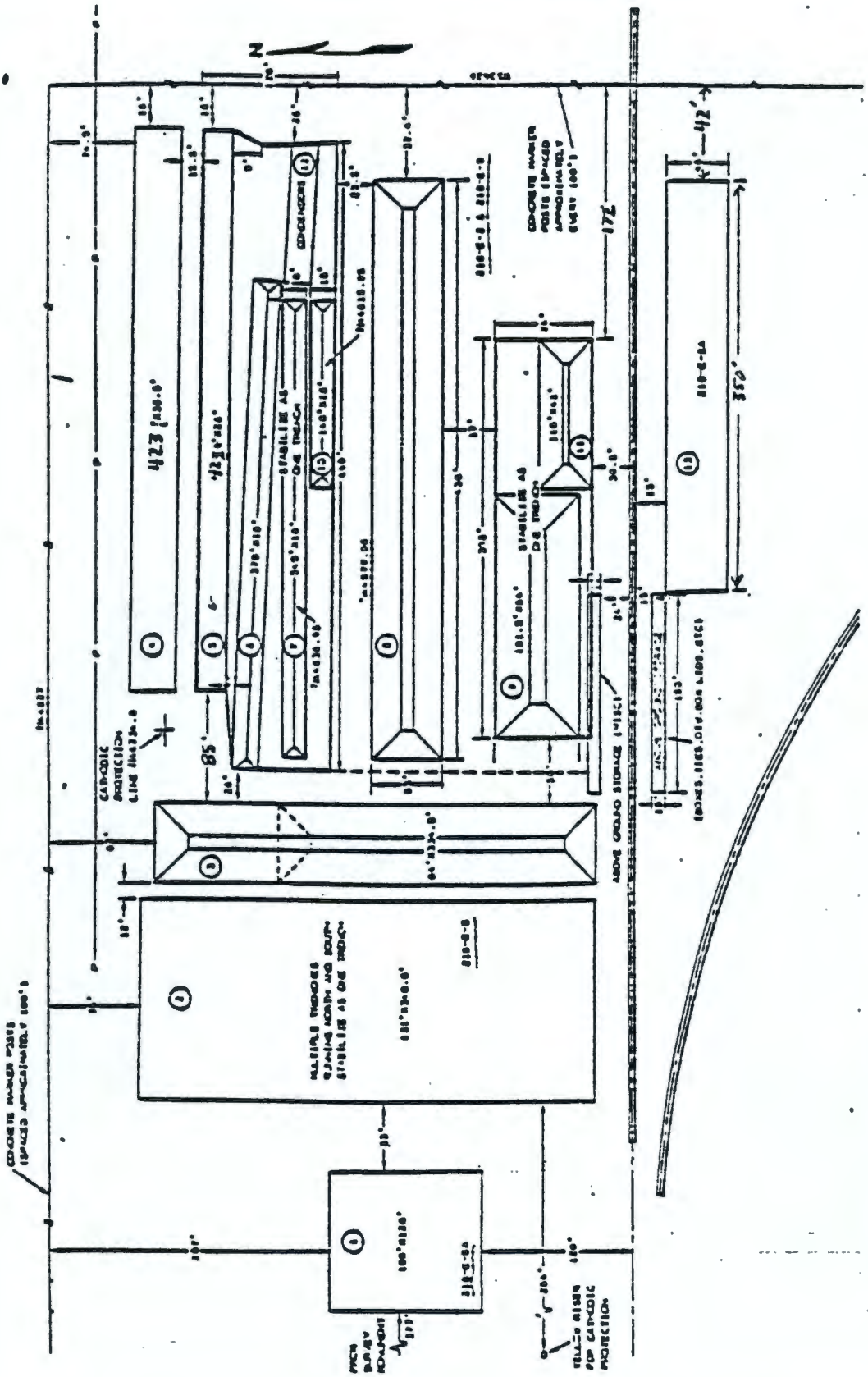

FIGURE A.2: BURIAL GROUNDS 218-E-2, 2A, 5, 5A, AND 9

Reference: H-2-2479

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Storage Site	Regulated Equipment Storage Site No. 02A	218-E-2A

Location	Service Dates	Status
200 East, N. W. Quadrant About 14,00 ft north of B-Plant.	Unknown	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-43827, W-53426 N-44395, W-53426 N-44395, W-54225	H-2-34761 H-2-2479	Ground Water Table Site Depth	681 ft 405 ft(1973) NA

Source and Description of Waste

Regulated equipment.

Description of Facility

Aboveground storage.

Radionuclide Content (calculated from discharge data)

NA

NOTE:

Print H-2-2479 shows the outline of a trench 46 feet wide along the north boundary of 218E-2A (a later designation) Burial Ground or above ground storage site.

Print H-2-55534 also shows this trench at coordinates N-44332, W-53812, N-44332, W-53468; but the trench is improperly drawn on the print. The centerline N-44332 is shown south of a post at N-44327. However, it still falls within the area later designated as the 216-E-2A Burial Ground.

There are no records or ~~burial~~ inventories available at this writing to indicate the 216-E-2A Burial site was ever used as a burial ground. It more properly should be designated as a regulated equipment above ground storage site. ~~The 218-E-2A designation should be dropped.~~

2/21/78 - An inspection of the burial trench in 218-E-2A, south of the railroad track, disclosed a number of sink holes along the center line of the trench, indicating the trench had been dug and used for dry waste burials.

(See Attachment)

Burial Ground: 218-E-2A

During the summer of 1979, a number of loads of dirt were hauled in and dumped over the burial trench in 218-E-2A Burial Ground. This fill material brought the surface of the trench to ground level. Future plans for fiscal year 1980 include stabilization of the ground surface of this trench.

CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

Name/Type of Facility	Past Designation	Number
Burial Ground	200 East/Minor Construction No. 4	218-E-4

Location	Service Dates	Status
200 East, N.W. Quadrant About 1,300 ft north of B-Plant.	2/55-1956	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-43757, W-53575 N-43666, W-53700 N-44175, W-54170 N-44300, W-54150	H-2-31269 H-2-34761	Ground Water Table Site Depth	~681 ft ~404 ft (1973) NA

Source and Description of Waste

Repair and construction wast (approximately 5.6×10^4 ft^3).

Description of Facility

Backfilled trenches, surface area: 1.56×10^5 ft^2.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Burial	As of 9/30/78
U, g	1.0×10^3	1.0×10^3
Pu, g	10	10.
Total Beta, Ci	10	4.67
^{90}Sr, Ci	0.20	0.112
^{106}Ru, Ci	0.43	4.66×10^{-9}
^{137}Cs, Ci	0.21	0.124

NOTE:

The number of trenches is not known.

CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

Name/Type of Facility	Past Designation	Number
Burial Ground	200 East/Industrial Waste No. 05	218-E-5

Location	Service Dates	Status
200 East, N.W. Quadrant About 1,850 ft north of B Plant.	1954, 1955, 1956	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-44827, W-53950	H-2-31269	Ground	671 ft
N-44400, W-53950	H-2-55534	Water Table	404 ft(1973)
N-44400, W-54177	H-2-34761	Site Depth	15 ft
N-44827, W-54177	H-2-2479		

Source and Description of Waste

Failed equipment and industrial waste (approximately 1.1×10^5 ft^3).

Description of Facility 2.3 acres. Ref: Ltr. - Rockwell 1/09/80 #65421-80-005

Backfilled trenches, surface area: 1.02×10^5 ft^2.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Burial	As of 9/30/78
U, g	1.0×10^5	1.2×10^5
Pu, g	6.2×10^2	620.
Total Beta, Ci	7.5×10^3	352.0
^{90}Sr, Ci	1.5×10^2	84.7
^{106}Ru, Ci	3.2×10^2	4.65×10^{-5}
^{137}Cs, Ci	1.6×10^2	93.3

NOTE:

Print H-2-2479 shows the location of ~~one burial~~ trench having been dug in the 218-E-5 Burial Ground.

The locations of the trenches in this burial ground, as indicated by sink holes and weed growth patterns along the length of the trenches, is different than locations shown on Print H-2-55534.

Burial Ground : 218-E-5

Extensive research work was done during the year 1979 to determine the locations of all burial trenches within the bounds of the 218-E-5, 218-E-5A, 218-E-2 and 218-E-9 Burial Grounds radiation zone. The work included viewing aerial photographs and construction prints, analyzing plant growth patterns, and the load testing of the ground surface.

Four previously unrecorded sites were identified: (See attached map, Figure A.2, Burial Grounds 218-E-2, E-2A, E-5, E-5A, and E-9)

#1 Site Referred to as the 202-A, L-Cell Burial Package. It consisted of four very large burial boxes. The burial location is shown as a 100 foot by 120 foot rectangular area within the 218-E-5A Burial Ground. The D-2 Column from Purex K Cell was also buried here.

#2 Site Multiple trenches running north and south in Burial Ground 218-E-5. It has been stabilized as a single trench.

#4 Site A long trench (423') running east and west along the north side of 218-E-2 Burial Ground.

#5 Site A long trench (423') parallel and adjacent to Site #4 above.

Burial Ground: 218-E-5

Fiscal year 1979 ground surface stabilization work within the 218-E-5 Burial Ground was confined to a rectangular area 131 feet by 340.5 feet containing multiple burial trenches running north and south.

The work consited of load testing the ground surface for subterranean voids by driving over the ground with a 40-ton vehicle, marking the site location with steel posts, removing vegetation and radioactive contamination from the ground surface, and establishing a one foot deep soil seed bed over the entire area. Drought resistant grases will be seeded in FY1980.

(See Table 4 Attachment)

TABLE 4 218-E-2, 2A, 5, 5A & 9 STATUS

TRENCH NO.	SOIL DEPTH (NO BIOBARRIERS)	REVEGETATION SPECIES
1	1'	To Be Completed FY '80
2	1'	To Be Completed BY '80
3	1'	Cheatgrass
4	1'	Cheatgrass
5, 6, 7, 10, 12	1'	Cheatgrass
8	1'	Cheatgrass
9, 11	1'	Cheatgrass
13	3"-6"	To Be Completed FY '80

Ref. 5.90

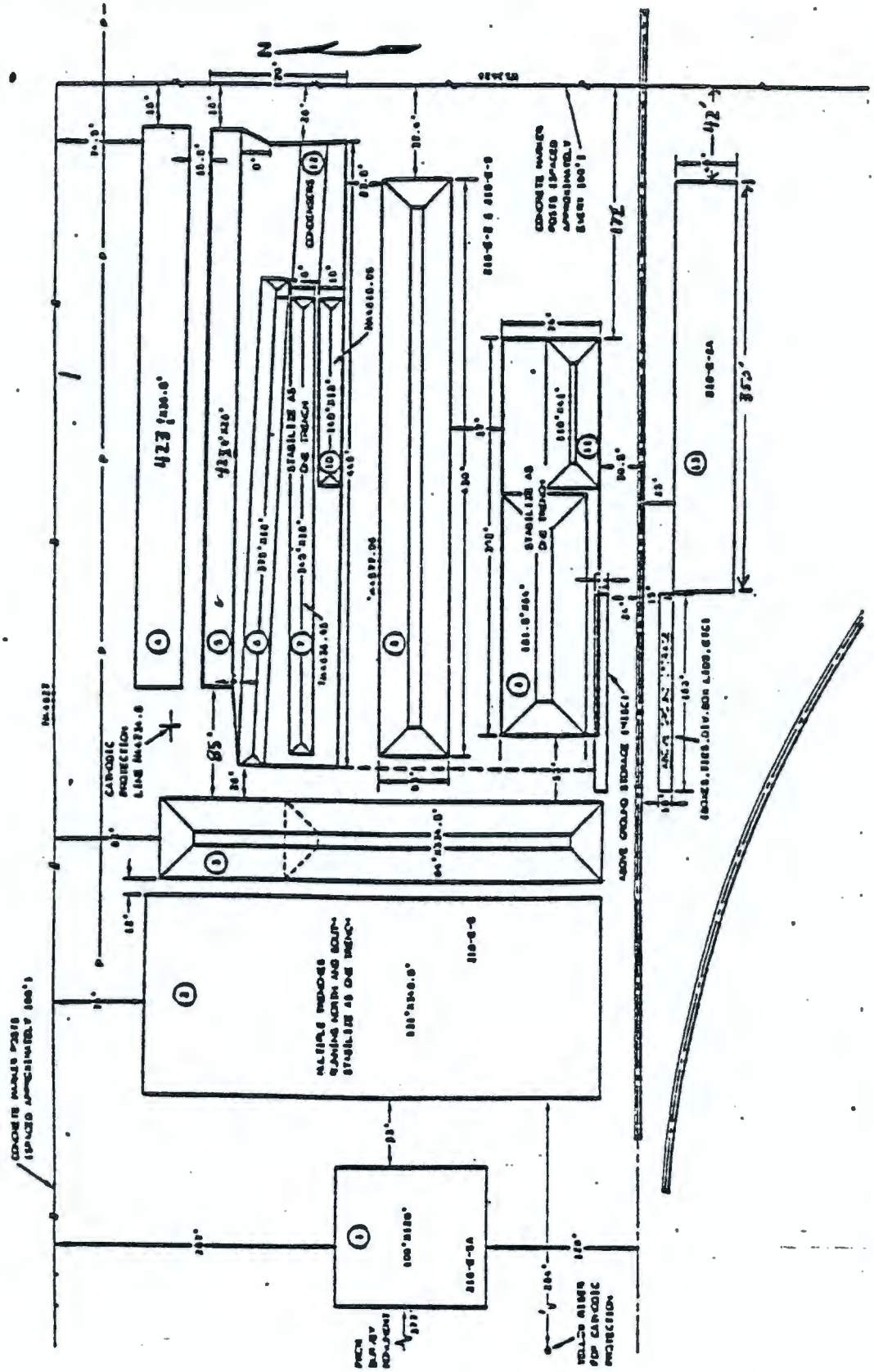

FIGURE A.2: BURIAL GROUNDS 218-E-2, 2A, 5, 5A, AND 9

Reference: H-2-2479

CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

Name/Type of Facility	Past Designation	Number
Burial Ground	200 East/Industrial Waste No. 05A	218-E-5A

Location	Service Dates	Status
200 East, N.W. Quadrant About 1,850 ft north of B Plant adjacent to and west of 218-E-5.	1956-1957-1958-1959	Inactive

Site Coordinates	Reference Drawings	Elevations	
N-44827, W-54177 N-44400, W-54177 N-44400, W-54609 N-44827, W-54609	H-2-55534 H-2-34761	Ground Water Table Site Depth	~671 ft ~404 ft(1973) ~15-25 ft

Source and Description of Waste

Failed equipment and industrial waste (approximately 2.2×10^5 ft).

Description of Facility 3.4 acres. Ref: Ltr. Rockwell 1/09/80 #65421-80-005

Backfilled trenches, surface area: $2.27 \times 10^5 \times ft^2$.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Burial	As of 9/30/78
U, g	1.2×10^5	1.2×10^5
Pu, g	1.4×10^3	1.4×10^3
Total Beta, Ci	1.7×10^4	827.
^{90}Sr, Ci	3.3×10^2	199.0
^{106}Ru, Ci	7.1×10^2	6.59×10^{-4}
^{137}Cs, Ci	3.5×10^2	219.0

NOTE:

Unable to locate any print showing location of burial trenches in this burial ground.

Burial Ground : 218-E-5A

Extensive research work was done during the year 1979 to determine the locations of all burial trenches within the bounds of the 218-E-5, 218-E-5A, 218-E-2 and 218-E-9 Burial Grounds radiation zone. The work included viewing aerial photographs and construction prints, analyzing plant growth patterns, and the load testing of the ground surface.

Four previously unrecorded sites were identified: (See attached map, Figure A.2, Burial Grounds 218-E-2, E-2A, E-5, E-5A, and E-9)

#1 Site Referred to as the 202-A, L-Cell Burial Package. It consisted of four very large burial boxes. The burial location is shown as a 100 foot by 120 foot rectangular area within the 218-E-5A Burial Ground. The D-2 Column from Purex K Cell was also buried here.

#2 Site Multiple trenches running north and south in Burial Ground 218-E-5. It has been stabilized as a single trench.

#4 Site A long trench (423') running east and west along the north side of 218-E-2 Burial Ground.

#5 Site A long trench (423') parallel and adjacent to Site #4 above.

Burial Ground: 218-E-5A continued

Fiscal year 1979 stabilization work within the 218-E-5A Burial Ground was confined to a 100 foot by 120 foot rectangular area above the burial sites of the Purex L-Cell burial package and the "2-D" column from Purex K Cell.

The work consisted of load testing the ground surface for subterranean voids by driving over the ground with a 40-ton vehicle, marking the site location with steel posts, removing vegetation and radioactive contamination from the ground surface, and establishing a one foot deep soil seed bed over the entire area. Drought resistant grasses will be seeded in FY1980.

See Table 4 Attachment

TABLE 4 218-E-2, 2A, 5, 5A & 9 STATUS

TRENCH NO.	SOIL DEPTH (NO BIOBARRIERS)	REVEGETATION SPECIES
1	1'	To Be Completed FY '80
2	1'	To Be Completed BY '80
3	1'	Cheatgrass
4	1'	Cheatgrass
5, 6, 7, 10, 12	1'	Cheatgrass
8	1'	Cheatgrass
9, 11	1'	Cheatgrass
13	3"-6"	To Be Completed FY '80

Ref. 5.95

FROM PUREP EQPT DISPOSAL RECORDS

	11/21/56	1 BOX	IND	#5	South End	11/20/56
*	3/19/56	1 Monorail	West trench	#5	Burial Ground	
*	6/12/56	1 Box	"	"	#5	" "
	6/11/57	1 Box	South end	#5	"	"
	3/21/58	L Cell Package		5A		
	3/24/58	2D Column (K cell)		5A		

~ 10,000 ft³

* THIS PROVES THAT THE 5A BURIAL GROUND WAS USED IN 1956 VICE FIRST USE IN 1958 AS SHOWN BY R. F. ROBERTS DATA.

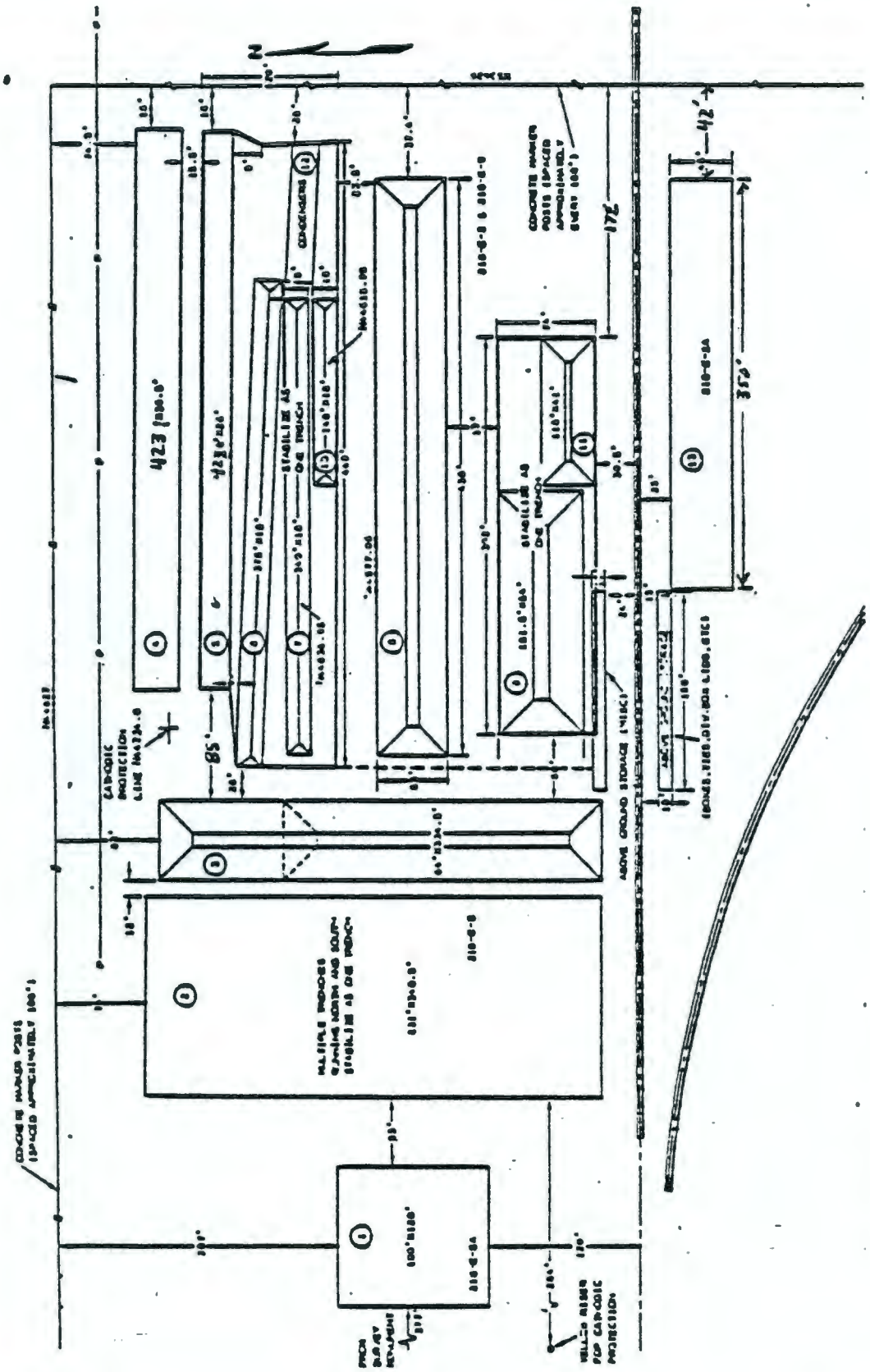

FIGURE A.2: BURIAL GROUNDS 218-E-2, 2A, 5, 5A, AND 9

Reference: H-2-2479

CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

Name/Type of Facility	Last Designation	Number
Storage Site	200 East/Regulated Equipment Storage Site No. 09	218-E-9

Location	Service Dates	Status
200 East, N.W. Quadrant About 2000 ft north of B Plant. East of 218-E-2 Burial Grounds.	1958	INACTIVE

Site Coordinates	Reference Drawings	Elevations	
N-44395, W-53426 N-44827, W-53426 N-44827, W-53516 N-44395, W-53516	H-2-31269	Ground Water Table Site Depth	~669 ft ~404 ft(1973) NA

Source and Description of Waste

Regulated equipment storage.

Description of Facility (See 218-E-2 for acreage)

Above ground storage.

Radionuclide Content (calculated from discharge data)

NA

NOTE:

Burial Ground 218-E-9 appears never to have been a burial ground; but to have been used exclusively as an "Above Ground Storage Site".

The 218-E-9 listed coordinates of N-44395, W-53426; N-44827, W-53426; N-44827, W-53516; and N-44395, W-53516 fall within the boundaries of the east 90 feet of the 218-E-2 Burial Ground.

It is recommended that the designation 218-E-9 be deleted from the burial ground records.

NOTE: Extensive work was done in FY1979 to upgrade 218-E-2 and 218-E-9 Burial Grounds. See 218-E-2 writeup for details.

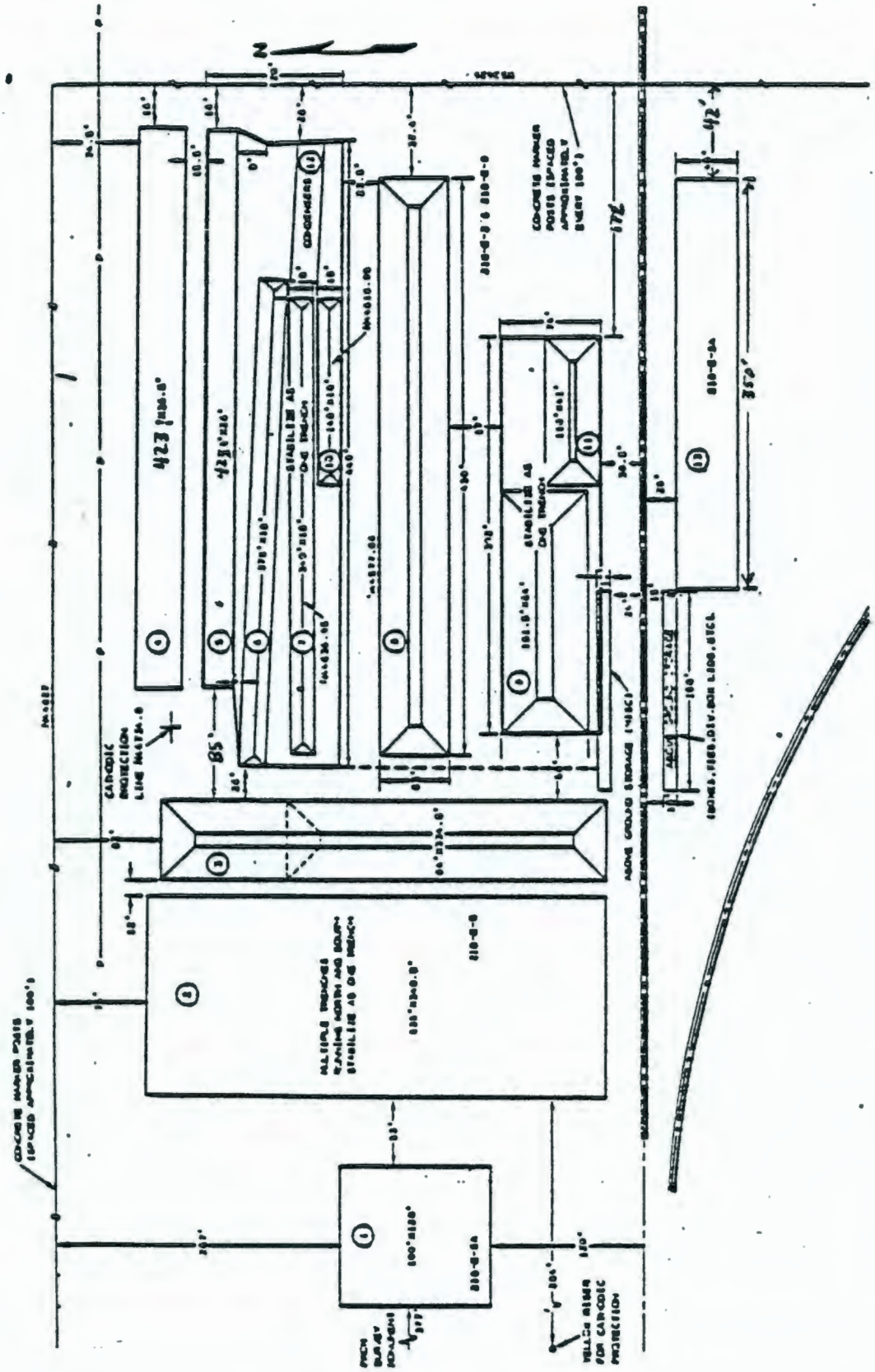

FIGURE A.2: BURIAL GROUNDS 218-E-2, 2A, 5, 5A, AND 9

Reference: H-2-2479

CONTAMINATED SOLIDS STORAGE AND BURIAL SITES

Name/Type of Facility	Past Designation	Number
Burial ground.	200 East/Industrial Waste No. 10	218-E-10

Location	Service Dates	Status
200 East, N.W. Quadrant About 2000 ft north and west of B Plant. Directly west of 218-E-5A.	February 1960	Active

Site Coordinates	Reference Drawings	Elevations	
N-44395, W-55444 N-44464, W-55440	H-2-31269 H-2-55534	Ground Water Table Site Depth	671 ft 404 ft(1973) 15-25 ft

Source and Description of Waste

Failed equipment and industrial waste (approximately 5.4×10^6 ft^3).

Description of Facility

8 trenches running north and south, approx. 400 ft long, surface area: 7.83×10^5 ft^2. Trench #1 is 24' deep, 15 ft wide in the bottom, and 63 ft wide at ground level. All other trenches are 15 ft deep, 16 ft wide in the bottom, and 61 ft wide at ground level.

Radionuclide Content (calculated from discharge data)

Radionuclide	At Time of Burial	As of 9/30/78
U, g	8.0×10^5	8.0×10^5
Pu, g	4.9×10^3	4.9×10^3
Total Beta, Ci	2.4×10^5	4.33×10^5
^{90}Sr, Ci	4.8×10^3	1.02×10^5
^{106}Ru, Ci	1.0×10^4	544.0
^{137}Cs, Ci	5.1×10^3	1.13×10^5
Misc. Radionuclides	1.12×10^3	

Ref. 5.100

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Unplanned Release	241-B-152	UN-216-E-2

Location	Service Dates	Status
200 East, N.W. Quadrant 241-B-152 Diversion Box Southwest corner of 241-B Tank Farm	Spring 1954	Inactive

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-45000, W-53000	H-2-4450 Sheet 7	Ground Water Table Site Depth	625 ft 392 ft (1973) Several trenches

Source and Description of Waste

Description of Facility

An area of approximately 50 ft^2 next to the 241-B-152 Diversion Box was contaminated during work on the diversion box. A portion of the contaminated soil was removed and the remainder covered with several inches of clean soil..

Radionuclide Content (at time of discharge)

Approximately 1 Ci Mixed Fission Products.

Ref. 5.101

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Unplanned Release	241-8X-155 Diversion Box ground contamination	UN-216-E-6

Location	Service Dates	Status
200 East, N.W. Quadrant 241-8X-155 Diversion Box approximately 900 feet south of the 241-8X Tank Farm.	October 1955	

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N=44200, W-53200	H-2-44500 Sheet 7	Ground	625 ft
		Water Table	329 ft(1973)
		Site Depth	Near surface

Source and Description of Waste

Mixed fission product salt waste from B-Plant.

Description of Facility

Ground contamination near 241-8X-155 Diversion box resulting from pressure testing of lines and jumpers in the 155-8X Diversion Box. Approximately 200 ft^2 of surface area was covered with clean soil.

Radionuclide Content (at time of discharge)

Approximately 10 Ci Fission Product.

History:

A spill that occurred during pressure testing of lines and jumpers in the 155-8X Diversion Box caused ground contamination to a maximum dose rate of 22.6 rads/hr at surface. Effected area is approximately ~~200 feet square~~ 200 ft^2. It has been covered with clean soil.

Ref. 5.102

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Unplanned Release	221-8, R-3 line break	UN-216-E-8

Location	Service Dates	Status
200 East, N.W. Quadrant South of 221-8, between the building and 7th Street.	1946	--

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42575, W-53450	H-2-44500 Sheet 7	Ground	686 ft
		Water Table	404 ft(1973)
		Site Depth	NA

Source and Description of Waste

Metal waste from 221-8.

Description of Facility

An area approximately 100 ft x 500 ft long due to waste from a leak in the R-3 line. During subsequent construction activity the major portion of the contaminated soil was removed to the 200-E Dry Waste Burial Ground.

Radionuclide Content (at time of discharge)

<5Ci mixed fission products remain.

Ref. 5.103

CONTAMINATED LIQUID DISPOSAL SITES

Name/Type of Facility	Past Designation	Number
Unplanned Release	221-8, R-13 Line Break Near Utility Pit	UN-216-E-13

Location	Service Dates	Status
200 East, N.W. Quadrant 221-8, R-13 Utility Pit	7/20/72	--

Site Coordinates (Approximate)	Reference Drawings	Elevations	
N-42500, W-53850	H-2-4450 Sheet 7	Ground	700 ft
		Water Table	402 ft(1973)
		Site Depth	NA

Source and Description of Waste

221-8 Process Waste.

Description of Facility

Leak in pipeline from Tank 18-1, 221-8 Bldg. to 154-8X Diversion Box near the R-13 Utility Pit. Radiation measurements in the pit were 15 rad/hr at 2 in.

Radionuclide Content (at time of discharge)

Radionuclide	At Time of Discharge	As of 12/31/73
^{137}Cs, Ci	~15	~14

History:

Excavation of an unencased line (from tank 18-1, 221-8 Building to 154-8X Diversion Box) near the utility pit at R-13 disclosed a process waste leak. Radiation measurements taken at bottom of the pit read 15 rads/hr within two inches of the source.

(See Attachment)

Ref. 5.104

RADIATION OCCURRENCE

	RADIATION OCCURRENCE FACTS	
M. D. Alford	DATE 7/20/72	TIME 0830
	LOCATION 221-B, R-13 Pit	

RADIATION OCCURRENCE TYPE: 3-B	CAUSE CODE: 1-B
Loss of control of contamination from a radiation zone.	Failure of equipment (line or flange leak).

COMPLETE DESCRIPTION AND CAUSE

During a routine survey, high radiation was discovered in the R-13 pit adjacent to the 221-B Canyon Building. Radiation levels of 15 rads/hr existed in the northeast corner of the pit near the bottom (approximately six feet down). It is suspected the contamination had seeped into the pit from the east side where several unencased lines leave the building. The line most likely to have caused the contamination is the 18-1 waste line that goes to the 154 BX diversion box just south of the 221-B Building.

CC:	ACTION TAKEN
GE Backman (2) BJ McMurray (2) GC Oberg FA Perkins RE Smith	The area was zoned off and excavation started to try and locate the leak.
	INVESTIGATED BY: O. L. Mahan/F. A. Perkins — DATE OF INVESTIGATION: 7/20/72

EXPOSED EMPLOYEES

None

Ref. 5.105

REFERENCE 6

Memo to file from BW Mercer on 8-18-87, Solid Waste Volume Estimates for Selected 200 Area Burial Grounds

9413218.0025

Battelle
Pacific Northwest Laboratories

Project Number _____

Internal Distribution

File/LB

Date August 18, 1987

To File

From B. W. Mercer

Subject Solid Waste Volume Estimates for Selected 200 Area Burial Grounds

Supervisory personnel in process operation and radiation monitoring in 200-West Area during the period 1944 to 1968 were interviewed to obtain estimates of the volumes of solid waste disposed to several burial grounds in the 200-West Area. The estimates are as follows:

218-W-1	-	250,000 ft^3
218-W-2	-	290,000 ft^3
218-W-3	-	390,000 ft^3
218-W-4A	-	630,000 ft^3
218-W-1A	-	480,000 ft^3

BWM:DAL:dar

REFERENCE 7

Hanford Wells, PNL-5397, February 1985

RHO FILE 8

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
299 W 6 1 2998 2927R	N 846898 P W 874396	782.53	476	243	8.0	318	230-288	8-57		
299 W 7 51	N 845525 P W 876788		25		6.0			7-84		DESTROYED
299 W 7 52	N 845538 P W 876825		25		6.0			7-84		DESTROYED
299 W 7 53	N 845475 P W 876865		25		6.0			7-84		DESTROYED
299 W10 1 2892R	N 843558 P W 876218	674.86	385	287	8.0	385	198-278	8-47	224-T-4	
299 W10 2 2893R	N 843154 P W 876183	674.33	238	208	4.0	228	201-229	12-51	224-T-18	
299 W10 3 2885R	N 843348 P W 875988	672.66	239	286	8.0	228	194-238	11-51	241-T-15 221-T-15	6 IN. SCREEN 181-234
299 W10 4 2886R	N 843833 P W 875977	678.95	245	284	8.0	236	198-245	11-52	241-T-16	
299 W10 5 2898	N 842669 P W 876489	672.31	248	284	8.0	248	175-228	4-54	241-T-28	
299 W10 6	N 842678 P W 876895		228		6.0			8- 8		
299 W10 7	N 842678 P W 875615		228		6.0			8- 8		
58- 8- 1 299 W10 8 2997 2996R	N 843799 P W 875688	688.33	252	214	6.0		205-251	6-73	2997	SCREEN

RHO FILE 0

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
299 W19 2 2928R	N 036849 P W 073000	694.04	300	232	8.0	240	235-295	0-57		
299 W19 3 2991 2929R	N 037019 P W 074090	695.12	301	225	8.0	244	230-280	9-57		
299 W19 4 2930R	N 039000 P W 071999	715.26	550	255	8.0	350	255-535	2-68		
O		715.52	280	253	1.50		260-280	5-65		
P		715.52	535	256	1.50	464	510-535	6-64		
Q		715.52	481	256	1.50	400	456-481	6-64		
R		715.52	411	256	1.50	348	386-411	6-64		
S			370	256			345-370	0- 0		
299 W19 5 2968R	N 036850 P W 074605	700.00	235	215	6.0	230	205-230	11-68		
299 W19 6 2969R	N 036850 P W 074710	700.00	422	216	6.0	418	380-411	12-68		
299 W19 7 2970R	N 037000 P W 074125	700.00	235	217	6.0	223	200-233	11-68		
299 W19 8	N 038574 P W 073260		585	240	8.0		NONE	6-71		
299 W19 10		700.00	573		3.5	460	NONE	4-76	DH-7	
299 W19 11 2619R	N 037860 P W 074210		250		6.0			4-83		6" SCREEN 220-250 GROUTED

Ref 7.2

WELL DESIGNATION EHA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
499 S1 8F	S 001312 P W 007521	492.50	149					8-71	DH-13	
499 S1 8G	S 001088 P W 007801	540.00	77					8-71	DH-14	
499 S1 8H	S 000692 P W 007880	646.50	1964	155	10.0	1835		8-77	FFTF WELL 03	
499 S0 7 4817	S 000180 P W 007470	540.59	399	162	8.0	399	221-396	3-72	FFTF WELL 2	WATER SUPPLY WELL
499 S0 8 4818	S 000180 P W 007970	546.90	294	150	8.0	294	100-281	3-72	FFTF WELL 1	WATER SUPPLY WELL

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-F PERFORATED DEPTH (FT)	TE CONP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 24 33 4416 4890R	N 023809 P W 033315	524.21	165	124	8.0	159	116-164	8-48	25-35	CEMENT PLUG AT 159FT SAMPLE PUMP
699 24 46 4525	N 023960 P W 045994	591.46	680	189	10.0	680	180-670	10-58		SAMPLE PUMP PLUG AT 230
699 24 95								0- 0	24-133	PROJECT ALE WATER SUPPLY WELL
699 25 E2	N 024700 P E 001600	484.70	135					0-74	1C-SP-25	
699 25 20	N 024586 P W 019731	521.90	992	110	6.0	150		0-81	S-22	
699 25 26	N 024009 P W 025794	515.50	685	DRY	6.0	52		0-81	S-8	
699 25 31	N 025202 P W 050985	511.76	816	110	6.0	680		1-81	S-6	
699 25 55 4415	N 025357 P W 055192	676.55	315	266	8.0	309	260-314	7-48	25-56 USGS-1	CEMENT PLUG AT 309FT SAMPLE PUMP
699 25 70 4452	N 025258 P W 070000	629.56	460	179	8.0	220	175-440	0-48		CEMENT PLUG AT 220FT SAMPLE PUMP
	O	629.82	200	179	1.50		180-200	1-65		REMOVED
	P	629.82	430	179	1.50	437	420-430	5-64		REMOVED
	Q	629.82	390	179	1.50	390	380-390	5-64		REMOVED
	R	629.82	390	179	1.50		320-330	5-64		REMOVED
	S	629.82	272	179	1.50	272	262-272	5-64		REMOVED
699 25 80 4440	N 025080 P W 079512	614.63	336	174	4.0	1210	170-265	11-40	DB-14	DEEPENED 1-79, NX CASING TO 849FT

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 31 65 4495	N 030536 P W 065357	683.09	450	242	8.0	310	240-450	8-57	699-30-65	
	O	683.35	260	242	1.50	260	240-260	4-65		
	P	683.35	430	243	1.50	353	410-430	6-64		
	Q	683.35	390	242	1.50	371	370-390	6-64		
	R	683.35	330	242	1.50	322	310-330	6-64		
699 31 84A	N 031316 P W 083729	625.05	4398		6.0			6-83	DC-16A	
699 31 84B		625.12	1600					12-82	DC-16B	
699 31 84C	N 031290 P W 084238	625.08	3854					10-82	DC-16C	
699 32 18	N 032062 P W 017582	452.64		56	6.0	60		0-80	GOLDER 86	
699 32 22 4794	N 032003 P W 021995	517.55	171	119	6.0	168	111-169	2-71		SAMPLE PUMP
699 32 26	N 031647 P W 026279	520.59	715		6.0			0-80	GOLDER 48	
699 32 31	N 031873 P W 031489	522.08		118	6.0	162		0-80	GOLDER 71A	
699 32 32	N 031860 P W 031504	520.53	780	117	6.0	147		0-80	GOLDER 71	
699 32 42 4777	N 032470 P W 042450	517.42	125	116	6.0	122	110-120	8-68		PLUG AT 122

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 34 89A		643.00	441		8.0		233-353	6-81	RRL-6A	
699 34 89B	N 033507 P W 008816	643.44	4040		3.0			9-81	RRL-6B	
699 35 3	N 035004 P W 003062	486.36	400		6.0			8-80	GOLDER 53	DESTROYED
699 35 9 4419	N 034700 P W 009175	499.83	176	117	8.0	172	110-135	10-50	USGS NO.10 34.7-9.2	SAMPLE PUMP
699 35 16	N 034831 P W 015715	457.83	565	61	6.0	100		0- 0	GOLDER 29	
699 35 19A	N 034728 P W 019074	473.92	556		6.0			8-79	GOLDER 8	
699 35 19B	N 034671 P W 019026	482.00		82	6.0	106		8-79	GOLDER 8A	
699 35 27	N 034673 P W 027437	531.07	1403	159	2.0		NONE	12-73	DB-4	
699 35 28	N 034519 P W 028253	534.36	685	132	6.0	141		8-80	GOLDER 74	
699 35 66 4494	N 034068 P W 065758	725.65	450	288	8.0	307	280-317	6-57		CEMENT PLUG AT 322FT SAMPLE PUMP
699 35 70 4441	N 034523 P W 069988	693.72	325	240	8.0	266	235-320	9-40	34.5-69.5	6" LIN 0-233 SCREEN 233-53,SAMPLE PUMP
699 35 70A 4445 4869R	N 035470 P W 070190	660.65	279	184	8.0	232	180-279	8-50	35.5-70 35-79	CEMENT PLUG AT 232FT SAMPLE PUMP

WELL DESIGNATION EHA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 37 22	N 037437 P W 022864	478.21	117		6.0			8-80	GOLDER 83	
699 37 25	N 037385 P W 024851	501.37	135		6.0			8-80	GOLDER 76	
699 37 36	N 036830 P W 035837	543.97	430		6.0	44		8-80	GOLDER 47	
699 37 43 4480	N 037863 P W 042874	698.17	517	287	8.0	305	316-334	11-55	38-43 37-42	PLUGGED AT 338FT SAMPLE PUMP
	O	698.43	340	287	1.50	340	320-340	12-64		REMOVED
4740	P	698.43	499	284	1.50	500	480-490	5-64		REMOVED
4749	Q	698.43	440	284	1.50	440	420-430	5-64		REMOVED
	R	698.43	390	284	1.50	383	370-380	5-64		REMOVED
699 37 82A 4554	N 037818 P W 081988	636.75	440	163	8.0	175	155-410	10-60		CEMENT PLUG AT 175FT SAMPLE PUMP GROUTED
	O	636.90	200	163	1.50	184	190-200	4-64		REMOVED
4621	P	636.95	400	163	1.50	349	490-400	2-62		REMOVED
4622	Q	636.95	380	162	1.50	362	340-380	2-62		REMOVED
4623	R	636.95	320	162	1.50	311	290-320	2-62		REMOVED
4624	S	636.95	251	159	1.50	242	221-251	2-62		REMOVED
699 37 82B 4555	N 037880 P W 081999	636.87	627	162	8.0	200	163-590	10-60		
	O	636.30	185	162	1.50	296	165-185	10-64		
4685	P	636.32	560		1.50	344	540-560	5-64		
4686	Q	636.30	410		1.50	184	390-410	5-64		
4687	R	636.30	330		1.50	141	310-330	5-64		
4688	S	636.30	250		1.50	414	230-250	5-64		
4688	S	636.30	250		1.50	414	230-250	5-64		
	T	636.32	370		1.50	312	350-370	5-64		REMOVED

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 41 5	N 040620 P W 004942	483.80	273	118	6.0	263		0-80	GOLDER 110	
699 41 10	N 041403 P W 009614	502.03	293		6.0			0-79	GOLDER 5	
699 41 11	N 041053 P W 010640	512.70	430		6.0			0-80	GOLDER 104	
699 41 20	N 041407 P W 019741	485.07	497		6.0			0-80	GOLDER 31	
699 41 23 4430	N 040692 P W 022876	466.50	120	71	8.0	89	65 -115	7-48	40-24	SAMPLE PUMP
699 41 25	N 040642 P W 025001	468.07	105	72	6.0	81		0-80	GOLDER 82	
699 41 31	N 041020 P W 030731	504.63	335	106	6.0	126		0-80	GOLDER 44	
699 41 91	N 041473 P W 091228	652.64	4000		3.9			10-82	RRL-14	4.5 IN. CASING TO 2070
699 42 2 4859	N 042075 P W 001920	433.50	95	76	6.0		74 - 90	0-79		SAMPLE PUMP
699 42 3	N 041990 P W 003225	444.27	420		6.0			0-80	GOLDER 116	
699 42 10	N 041847 P W 009652	495.50	220	130	6.0	222		0-80	GOLDER 112	
699 42 12A 4517	N 042474 P W 011725	514.27	350	141	8.0	180	120-320	12-57	43-11 42-12	PLUG 180.SAMPLE PUMP 6" LINER 101-103

Ref 7.7

WELL DESIGNATION EHA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 47 92	N 047410 P W 091631	807.50	755		6.0	743		10-81	RRL-8	
699 47 80A	N 046705 P W 079816	710.61			6.0			11-83	DC-20A	
1				269	1.75		650-672	12-83		SCREEN
2				259	1.75		503-513	2-84		SCREEN
699 47 80B	N 046910 P W 079835	712.34		312	12.5	1632		9-83	DC-20B	
699 47 80C	N 046706 P W 079919	711.22			12.5			11-83	DC-20C	
1		712.50		310	1.75		3567-3589	1-84		SCREEN
2		712.66		310	1.75		2932-2954	1-84		SCREEN
3		712.84		311	1.75		2757-2779	2-84		SCREEN
4		713.02		312	1.75		2417-2439	2-84		SCREEN
5		713.10		312	1.75		1870-1892	2-84		SCREEN
6		713.34		312	1.75		1619-1629	2-84		SCREEN
699 47 80D	N 046906 P W 080038		1405	300	12.5			1-84	DC-20D	
1		713.14		299	1.75		1386-1400	1-84		SCREEN
699 48 7 4756	N 048470 P W 006547	384.72	54	29	12.0	49	12 - 32	8-43	HD-6W HAN-6	SAMPLE PUMP
699 48 17	N 048470 P W 016616	429.50	83		6.0			4-44	HD-22TH HAN-25	FILLED IN
699 48 18 4850	N 047903 P W 017870	424.90	86	63	6.0	85	60 - 75	3-44	HD-21TH HAN-24	SAMPLE PUMP

Ref 7.8

DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	PERFORATED DEPTH (FT)	COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 50 10	N 049944 P W 010170	389.70	46		48.0			0- 0	HD-5W REP 2 039 HAN-5	FILLED IN
699 50 14	N 049880 P W 013917	392.43	33		12.0			6-43	HANFORD CITY WELL HAN-28	FILLED IN
699 50 28A 4160	N 050000 P W 028350	529.00	260		6.0	260		4-45	BY TELE. EX WELL	PUMPED WELL FILLED IN
699 50 28B 4044	N 050203 P W 027510	537.30	167	145	6.0	161	146-156	8-71	GN-5	SCREEN 146-156 FT. SAMPLE PUMP
699 50 28C	N 050076 P W 028219	534.77	390	DRY	6.0			0-00	GOLDER 20	
699 50 30 4451	N 050299 P W 029033	528.04	300	136	8.0	170	130-221	7-40		PLUG AT 170
699 50 42 4460	N 050206 P W 041909	466.04	125	59	8.0	100	53 - 64	5-55		SAMPLE PUMP PLUG AT 100
O		467.10	90	59	1.50	90	70 - 90	4-65		REMOVED
4666 P		466.04	115	59	1.50	115	110-115	6-77		60 SLOT SCREEN
699 50 45	N 050150 P W 044992	451.41	170		6.0		133-170	5-00		10 SLOT SCREEN
699 50 48 4883	N 049900 P W 047500	550.39	250		6.0		213-250	0-00		20 SLOT SCREEN
699 50 53 4473	N 049840 P W 053267	556.30	185	156	8.0	159	142-159	2-55	50-54	SAMPLE PUMP PLUG AT 159
699 50 85 4497	N 049873 P W 004505	739.35	600	284	8.0	335	285-545	11-57	699-50-84	CEMENT PLUG AT 335FT SAMPLE PUMP
O		739.60	300	285	1.50	301	280-300	4-65		REMOVED
P		739.35	525	292	1.50	525	520-525	0-70		60 SLOT SCREEN
Q		739.60	540	290	1.50	304	520-540	5-64		REMOVED
R		739.60	480	285	1.50	369	460-480	5-64		REMOVED
S		739.60	420		1.50	10	400-420	5-64		REMOVED

WELL DESIGNATION EHA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 55 60B 4835	N 055425 P W 060140	573.60	280	173	24.0	280	230-285	7-44	200ND-5W	14.20.24. IN.CASINGS
699 55 60C		571.92						0- 0		
699 55 63	N 055100 P W 062740	572.00	190	39	14.0	190		5-44	200ND-4W	CASING REMOVED
699 55 65A	N 055100 P W 065300	580.00	136		16.0	136		2-44	200ND-2W	CASING REMOVED
699 55 65B	N 055300 P W 065300	580.00	146	43	16.0	146		4-44	200ND-3W	CASING REMOVED
699 55 65C	N 055100 P W 065300	580.00	146			146		0-44	200ND-6W	CASING REMOVED
699 55 70 4442	N 055326 P W 069955	569.03	205	140	8.0	180	136-202	6-48		CEMENT PLUG 180FT
O		569.30	160	140	1.50	160	150-160	5-65		REMOVED
4625 P		569.03	195	140	1.50	195	190-195	6-77		60 SLOT SCREEN
699 55 76 4533	N 055001 P W 075897	583.24	230	142	8.0	192	141-221	1-59		CEMENT PLUG AT 192FT SAMPLE PUMP
O		583.50	170	142	1.50		150-170	5-65		REMOVED
4671 P		583.50	203	142	1.50	201	183-203	9-63		REMOVED
699 55 89 4453	N 054969 P W 080592	617.43	235	167	8.0	215	160-170	11-48	55-80.5	CEMENT PLUG AT 215FT SAMPLE PUMP
O		617.69	190	165	1.50	191	160-190	4-63		REMOVED
4665 P		617.69	220	165	1.50	220	200-220	9-63		REMOVED

REFERENCE 8

Ground Water Monitoring at Hanford Site,

January-December 1984, PNL-5408

9413210.0439

File Note

Date: 10/29/87

From: RD Stenner RD Stenner

Subject: Prefix number change for FFTF well identification numbers as used in References 7 and 8 of U.S. DOE Hanford 200 Area NPL package

The document in Reference 8 uses the 699 prefix for the FFTF wells which is the general prefix used to indicate general Hanford Site with no attachment to a specifically defined Hanford Area. The document in Reference 7 uses the 499 prefix for the FFTF wells which is the prefix for indicating an assignment specifically to the defined Hanford 400 Area. The wells SO-7 and SO-8 with the 699 prefix in Reference 8 and the SO-7 and SO-8 wells with the 499 prefix in Reference 7 are the same wells.

9413218.0410

RADIOLOGICAL IMPACT

Ground-water transport of radionuclides at the Hanford Site represents a potential pathway for exposure to radiation via water obtained from wells that tap the unconfined aquifer or from the Columbia River into which the unconfined aquifer discharges. The following discussion examines these potential pathways.

UNCONFINED AQUIFER

During 1984, drinking water for the FFTF (wells 699-S0-7 and 699-S0-8), the Yakima Barricade Guardhouse (well 699-49-100C), the Arid Land Ecology (ALE) site (spring and well 699-S18-51), and the Hanford Patrol Firing Range (well 699-S28-E0) was obtained from the unconfined aquifer, or in the case of the spring the confined aquifer. Figures 1 and 4 show the location of these drinking water sources. Untreated water samples were collected quarterly from taps at the various sites. Analyses were conducted to determine the concentrations of gross alpha, ^{60}Co, ^{137}Cs, ^{90}Sr, ^{3}H and gross beta at all the sites, and additionally, ^{106}Ru and ^{22}Na at the FFTF. Calculations were performed by computer model (Napier, Kennedy and Soldat 1980) to determine if the annual dose exceeded the 4 mrem dose equivalent limit established by EPA (U.S. Environmental Protection Agency 1984) and the State of Washington (Washington State Department of Social and Health Services 1978) for drinking water.

Quarterly drinking water samples collected at the Patrol Firing Range, ALE, and the Yakima Barricade were at or below the detection limits for the various constituents listed above. At the FFTF, only tritium appeared at levels well above detection, or State of Washington or Federal EPA screening levels. Tritium concentrations ranged from 24,000 to 35,000 pCi/ℓ, with a mean of 29,000 pCi/ℓ. The annual intake of 250 ℓ of water (based on an occupational consumption of one ℓ/d for 250 d/yr) from this source, at the mean concentration of 29,000 pCi/ℓ, would produce a 50-year committed whole body dose equivalent of 0.46 mrem. This calculated dose equivalent is less than 15% of the Washington State Drinking Water Standard of 4 mrem per year.

Additional monitoring of all DOE drinking water systems at Hanford is conducted by the HEHF. Information on this effort can be obtained from Maas (1985).

COLUMBIA RIVER

Ground water from the unconfined aquifer enters the Columbia River via subsurface flow and springs that emanate from the riverbank, as reported by McCormack and Carlile (1984). The amount of tritium entering the river is calculated, based on the average concentrations of tritium in wells near the river and the flow rate of ground water into the river.

During 1984, tritium concentrations measured in wells at the old Hanford Townsite were in the range of approximately 100,000 to 250,000 pCi/ℓ. The average concentration of tritium entering the river in this area during 1984 was estimated to be 172,000 pCi/ℓ. Except for some small zones around the 100-B, C, 100-K, and 100-N Areas (see Appendix B.2 and Figure 5), ground water from the Hanford Townsite area represents the highest probable tritium concentrations entering the Columbia River.

Despite the fact that tritium enters the Columbia River near the Hanford Townsite, the impact to the river is low. The average annual flow rate from the unconfined aquifer into this section of the river near the Hanford Townsite has been estimated to be approximately 0.085 m^3/sec (3 cfs). This is based on the ground-water Variable Thickness Transient (VTT) model developed for the Hanford Site (Reisenauer 1979). During 1984, the average Columbia River flow rate at Priest Rapids Dam was approximately 3,186 m^3/sec (112,500 cfs) (Price et al. 1985). Ground water entering the Columbia River from the Hanford Site was, therefore, diluted by several orders of magnitude because of the difference between the river and ground-water flow rates. The tritium concentration in the river because of ground water in this area was calculated to be nearly 5 pCi/ℓ. During 1984, the average background tritium concentration in the Columbia River upstream from the site was 130 ± 15 pCi/ℓ, and the average concentration downstream from the site was 170 ± 23 pCi/ℓ (Price et al. 1985). The contribution by ground water compared to background concentrations was not significant.

Ref 8.1

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

05 MAR 84 to 19 NOV 84

WATER SANITARY WATER SAN GRAB UNFILTERED

Samp #: 1220 FFTF 481 BLDG

108/H 3 LIQ

Date Off	Date On	Result +/- 2 Sigma (PCI/L)		Comments
05 MAR 84	05 MAR 84	3.54E+04 +/-	5.93E+02	
01 JUN 84	01 JUN 84	2.64E+04 +/-	5.11E+02	
20 AUG 84	20 AUG 84	2.96E+04 +/-	5.41E+02	
19 NOV 84	19 NOV 84	2.38E+04 +/-	4.84E+02	

Fraction of Results>DL: 4/ 4 Mean: 2.88E+04
Minimum: 2.38E+04 (19 NOV 84) Standard Error of Mean: 5.64E+03
Maximum: 3.54E+04 (05 MAR 84) Standard Deviation: 1.13E+04
Median: 2.64E+04

REFERENCE 9

Project Inspection, Log Book Project V-749,

400 Area Water Systems Improvements Water Well (FFTF Well) No. 4

FILE NOTE

Date: 12/28/87

By: R.D. Stenner RDStenner

Re: Discussion regarding the need for drilling the new deeper drinking water well at FFTF

The new drinking water well (well 499-S1-8C) was drilled to provide a deeper source of drinking water at the FFTF in order to provide drinking water that met the drinking water standards for tritium. The water from this new well is used exclusively except during high water demand periods and during preventative maintenance scheduled outages where the water from the other two wells is mixed in the system to supply the needs of the FFTF. The general percentage of water mix in CY-1986 is as follows: 83.1% from 499-S1-8C, 16.8% from 499-S0-7, and 0.1% from 499-S0-8.

Persons invited to attend:

Meier Associates	Onwigo Drilling	J. A. J.
James Canon Terry Meier Randell Brown	Jerry Bultina Dale Bingham	Bill Swift

W. H. C.

Ken Blair
John Forsberg

(48° and clear)

2/28/85

Drilling of the well was completed on February 27, 1985 to a depth of 400 feet. The casing has been installed to a depth of 360 feet, leaving 40 feet of open hole.

A meeting was held with the contractor, J. A. J., W. H. C., D. O. E. and Meier Associates. In attendance were:

Onwigo Drilling	J. A. J.	W. H. C.
Dale Bingham Jerry Bultina	Bill Swift	John Forsberg

D. O. E.	Meier Associates
John Neath	James Canon Randell Brown

The discussion was on well screening and development. The driller suggested driving casing to the 400 foot depth, and perforating until the desired rate is available, which would also bring an anticipated savings, as perforating would be less expensive than screening.

Meier Associates suggested screening the lower portion of the hole for maximum yield at that depth, as the hole is now open. It was agreed that the driller would install 10 feet of solid casing in the bottom of the hole, 30 feet of screen from depth 390 feet to 360 feet, then test pump the well to find what the G. P. M. would be. If the G. P. M. is not sufficient (200 G. P. M. minimum) perforations will be made at depths determined by the driller and the engineer.

If additional savings are obtained, this money will be spent in the testing and developing of the well.

The driller will discuss the soil analysis and screen design with Mr. Brown, and allowed to order screen as verbally approved by Mr. Brown. No work will be allowed to proceed without the submittal from the contractor on the analysis, screen design, alternatives for developing the well (such as perforating) and testing.

REFERENCE 10

Washington State Public Supply System Listing

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION X
1200 SIXTH AVENUE
SEATTLE, WA 98101

Ref

FACSIMILE REQUEST AND COVER SHEET

PLEASE PRINT IN BLACK INK ONLY

TO
Bob Stenner

Office/Phone
Battelle

Region/Lab

FROM
David Bennett

Phone
399-2103

Office
Superfund

Date
8/6/87

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Equipment	Facsimile number	Verification number
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only info for Townships + Ranges given therefore none in others

PAGE 1 OF 5 PAGES

STATE OF WASHINGTON
PUBLIC WATER SUPPLY SYSTEM LISTING
BENNET

NO. SYSTEM NAME | COUNTY | CLASS
SYSTEM MAILING ADDRESS | CITY, ST ZIP
MANAGER/OWNER NAME | TELEPHONE | ACTUAL | POTEN
BACTI SAMPLING SCHEDULE | JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
POPULATION
SOURCE NO. SOURCE NAME | CATEGORY | TYPE | INTERTIE | DEPTH | CAPACITY | TREATMENT | TWP RNG SEC

34354W EPPICH WATER SYSTEM ? FRANKLIN Class: 4
14480 R-120 MESA, WA 99343 off R-170 x Ringold
ck Mgr: KARL W EPPICH (middle row) (509) 269-4365 4 0
Bacti: once/12 months
Pers: 12 Transitory: 0 0 0 2 0 0 0 0 0 6 0 0
Source: 1 EPPICH WATER SYSTEM WELL 68' 25 NONE. 12N 28E 13J

Z7140N DEPARTMENT OF GAME FRANKLIN Class: 4
1341 RINGOLD RIVER RD. MESA, WA 99343 farm
Mgr: BRUCE D. WALTERS (509) 269-4327 1 0
Bacti: once/12 months
Pers: 2
Source: 1 WELL 740' NONE. 12N 28E 24

172543 CLARK, DUDLEY WATER outside FRANKLIN Class: 4t
11561 RD 170 ? MESA, WA 99343 Auburn Rd (Sect 6 T-11 Range 29)
ck Mgr: CLARK, DUDLEY W (Eltopia area) (509) 269-4711 1 0
Bacti: (m) variable: 0 0 1 0 0 0 0 0 0 0 0 0
Pers: 5 Transitory: 0 0 0 20 20 20 10 0 0 0 0 0
Source: 1 WELL #1 WELL PRI. 250' 8 NONE. 12N 29E 6

293621 COOK, WILLIAM P. FRANKLIN Class: 4
11790 GLADE NORTH RD MESA, WA 99343
✓ Mgr: WILLIAM COOK outside 266-4448 3 0
Bacti: once/12 months
Pers: 12
Source: 1 WM P. COOK WELL PRI. 57' 14 NONE. 12N 29E 12

87625K TESSITORE FARM HOUSING FRANKLIN Class: 4t
STAR RT. BOX 192 ELTOPIA, WA 99330
Mgr: HENRY TESSITORE (509) 297-4313 0 0
Bacti: 0/month
Pers: 0
Source: 1 WELL NONE. 12N 29E 12

18636J HI - POINT ORCHARD ? FRANKLIN Class: 4
STAR RT BOX 194 A MESA, WA 99343 Juniper Rd by 170
ck Mgr: RICK OROZCO (509) 269-4310 2 0 (Davis Lane)
Bacti: once/12 months outside
Pers: 6
Source: 1 WELL #1 WELL PRI. 190' 35 NONE. 12N 29E 15

022[illegible] APEX DOMESTIC WATER ASSOCIATION FRANKLIN Class: 4
960 DAYTON RD ELTOPIA, WA 99330
Mgr: FOREST PUGH (509) 264-4272 5 0
Bacti: once/12 months
Pers: 13
Source: 1 WELL 11[illegible] 10 NONE. 12N [illegible]

[illegible] WATER SYSTEM — FRANKLIN
[illegible] FALLS RD — PASCO, WA 99301
[illegible] ALEN F ROUNDY JR — 547-3723
[illegible]ti: once/12 months
Pers: 14
Source: 1 ROUNDY WATER SYSTEM — WELL PRI. 174' 600 NONE.

Move than 3 miles Falls Rd.

SMITH, ED JR. WATER SYSTEM — FRANKLIN — Class: 4
30 LAURIE LANE, BOX 1023 — PASCO, WA 99301
Mgr: ED SMITH — 545-4836 — 2 — 2
Bacti: once/12 months
Pers: 6
Source: 1 WELL — WELL PRI. 295' 90 NONE.

?

KEPS ACRES ASSOCIATION — FRANKLIN — Class: 2
260 KEPS ROAD — PASCO, WA 99301
Mgr: DARRELL A. ROBSON — (509) 545-6982 — 16 — 0
Bacti: once/ 3 months (a)
Pers: 48
Source: 1 WELL #2 — WELL PRI. 55' 170 NONE. — 10N 31E 32
Source: 2 WELL #3 — WELL PRI. 55' 100 NONE. — 10N 31E 32

? outside

RIO VISTA ORCHARD — FRANKLIN — Class: 4
91 N. COLUMBIA RIVER RD. — PASCO, WA 99301
Mgr: ROBERT D. JONES — 266-4660 — 3 — 0
Bacti: once/12 months
Pers: 8
Source: 1 RIO VISTA ORCHARDS — WELL PRI. 80' NONE. — 11N 29E 12F

? Possible

SYSTEM NAME — COUNTY — CLASS
SYSTEM MAILING ADDRESS — CITY, ST ZIP
MANAGER/OWNER NAME — TELEPHONE — ACTUAL — POTEN
BACTI SAMPLING SCHEDULE — JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
POPULATION
SOURCE NO. SOURCE NAME — CATEGORY TYPE INTERTIE DEPTH CAPACITY TREATMENT — TWP RNG SEC

CYPRESS GARDENS SCHOOL — FRANKLIN — Class: 4 (on sing 3 mi)
RT 1 BOX 672 — PASCO, WA 99301
Mgr: QUINTIN LAUBACH — 266-4663 — 4 — 0
Bacti: once/12 months
Pers: 12
Source: 1 LAUBACH WELL — WELL PRI. 160' 7 NONE. — 11N 29E 30

? Cypress Lane Sections 30

MERRILLS CORNER CAFE — FRANKLIN — Class: 3
TAR ROUTE BOX 183 — ELTOPIA, WA 99330
Bacti: once/ 3 months — 6 — 0
Pers: 20
Source: 1 — WELL 60' 10 NONE. — 11N 29E 1R

out

ANDERSON LABOR CAMP — FRANKLIN — Class: 3

10N/31E-32D01D01			275.00 U	BRIAN	STARKS	TREE FARM ROAD	KENNEWICK WA. 99336	
10N/31E-32L02	4.00		350.00 N	TERRY	SMITH	3029 WEST 2ND AVE.	KENNEWICK WA. 99336	
10N/31E-32L03	4.70	502	290.00 U	HENRY	FORD	90 TREE FARM ROAD	PASCO WA. 99301	
10N/31E-32M01	9.80	889	165.00 N	MIKE	TOBIN	431 MEEKER ROAD	PASCO WA. 99301	
10N/31E-32M02	1.30	459	400.00 N	JOHN	NAUGEN	281 TREE FARM ROAD	PASCO WA. 99301	
10N/31E-32N03	13.00	536	295.00 U	ED	SMITH	30 LAURIE LANE	PASCO WA. 99301	
11N/28E-13E01	7.10		140.00 N	ROBERT	HIGBEE	5550 WEST FIR ROAD	PASCO WA. 99301 WITHIN 3 MI OF 200 AREA BOUNDARY	
11N/28E-36R01	0.10		746.00 N	BOB	BROWN	ROUTE 1 BOX 97	PASCO WA. 99301 WITHIN 3MI OF 200 & 300 ARE BOUNDARY	
11N/29E-01A01	7.90	692	40.00 N	ALVIN	TAYLOR	14020 GLADE NORTH	ELTOPIA WA. 99330	
11N/29E-07M01	0.09	478	590.00 N	STORAGE CO.	PRICE COLD	45 FIR WAY	ELTOPIA WA. 99330 WITHIN 3MI OF 200 AREA BOUNDARY	
11N/29E-12E01	4.60	778	105.00 N	ROBERT	WOOD	FIRCREST ROAD	ELTOPIA WA. 99330	
11N/29E-13C01	1.30	852	30.00 N	ROBERT	DARRINGTON	FIR ROAD	ELTOPIA WA. 99330	
11N/29E-28R01	14.00	853	87.00 U	KEN	McCALL	BLOCK 16 UNIT 144	MATHEWS CORNER WA. 99330	
11N/29E-34D02	1.10		78.00	C	BAYRE	CHERRY DRIVE	MATHEWS CORNER WA. 99330	
11N/29E-34J01	0.10	597	106.00 N		BENSON & RANSOM	1935 EAST SAGEMOOR ROAD	ELTOPIA WA. 99330	
11N/29E-34J01	0.10	597	106.00 N		BENSON & RANSOM	1935 EAST SAGEMOOR ROAD	ELTOPIA WA. 99330	
11N/29E-34K01	6.70	608	160.00 N	JACK	BOYD	ROUTE 1 BOX 982A	PASCO WA. 99301	
11N/30E-02R01	4.70	609	124.00 I	ALLEN	HAILEY	993 BLANTON ROAD	ELTOPIA WA. 99330	
11N/30E-02R01	4.70	609	124.00 I	ALLEN	HAILEY	993 BLANTON ROAD	ELTOPIA WA. 99330	
11N/30E-03L01	7.60	723	105.00 N	H.D.	CHRIESMAN		ELTOPIA WA. 99330	
11N/30E-05N01	50.00	1420	57.00 U		FLANNERY	ELTOPIA WEST ROAD	ELTOPIA WA. 99330	
11N/30E-10B01	5.40	582	115.00 NB	ERNEST	BAKER	50 ELTOPIA DRIVE	ELTOPIA WA. 99330	
11N/30E-11A01	8.60	833	290.00 N	NORM	JACOBSON	700 BLANTON ROAD	ELTOPIA WA. 99330	
11N/30E-14K01	8.30	800	265.00 N	DAVID	TUCK	231 TUCK	ELTOPIA WA. 99330	
11N/30E-15B01	2.10	580	163.00 NB	LARRY	SHELTON	BLK 16 UNIT 99	ELTOPIA WA. 99330	
11N/30E-15C01	7.40	809	94.00 N	OLEN	SCHOCKLEY		ELTOPIA WA. 99330	
11N/30E-16C01	16.00		320.00 NB	HENRY	TERRITORE	STAR ROUTE	ELTOPIA WA. 99330	
11N/30E-17B01	20.00	1422	100.00 N	HENRY	TERRITORE	STAR ROUTE	ELTOPIA WA. 99330	
11N/30E-29C01	1.80	500	220.00	ROBERT	MOREMAN	BLOCK 16 UNIT 132	MATHEWS CORNER WA. 99330	
11N/30E-34H01	19.00	1140	105.00 N	RICHARD	RHOADES	2881 EAST SAGEMOOR ROAD	ELTOPIA WA. 99330	
12N/28E-12K01	0.10	463	450.00 N	CLARENCE	PHIPPS JR.	BLOCK 20 UNIT 162	BASIN CITY WA. 99320 WITHIN 3 MI OF 200 AREA BOUNDARY	
12N/28E-23H01D01	0.10	398	413.00 N	FISHERIES	DEPT. OF	600 EAST MAPLE	BURBANK WA. WITHIN 3MI OF 200 AREA BOUNDARY	
12N/29E-01A01	15.00	1025	313.00 N	RUSSEL	CHASE	BLOCK 19 UNIT 47	BASIN CITY WA. 99343	
12N/29E-11M01	0.09	313	212.00 N	ROGER	DANZ	BLOCK 19 UNIT 95	BASIN CITY WA. 99343	
12N/29E-34K01	0.10	382	971.00 N	C.	RUSSEL	543 GLENWOOD	PASCO WA. 99301	
12N/30E-04D01		1110	290.00 N	RUSSEL	HAWS		BASIN CITY WA. 99343	
12N/30E-04L01	7.60	1090	250.00 N	MARY	BELL	350 BAART ROAD	MESA WA. 99343	
12N/30E-05B01	8.80	750	457.50 N	CHAS L LEE	SO COL BSN T D	402 WEST LEWIS	PASCO WA. 99301	
12N/30E-16L01	14.00	960		KEN	HEINEN	250 IRONWOOD LANE	ELTOPIA WA. 99330	
12N/30E-21G01	11.00	1090	211.00 N	C.R.	HOBBS	370 IRONWOOD LANE	ELTOPIA WA. 99330	
12N/30E-33B01	14.00	1139	374.00 NB	DONALD	DIDIER	444 HOLLY DRIVE	ELTOPIA WA. 99330	
12N/30E-34N01	17.00	970	328.00 NB	GEORGE	O'NEIL		ELTOPIA WA. 99330	
13N/29E-08H01	0.09	448	453.00 N	CURRENT	RESIDENT	ROUTE 1 BOX 175	OTHELLO WA. 99344	
13N/29E-27D01	4.90	843	75.00 N	GEORGE	MATSUMURA	1870 FAIRWAY	BASIN CITY WA. 99343	
13N/29E-28A01	3.50	723	25.00 N	MRS.	SCHROEDER	8471 ROAD	MESA WA. 99343	

Ref 10.4

FRANKLIN COUNTY

9413218.0951

REFERENCE 11

Memo to file from BW Mercer on 8-14-87, Drinking Water Wells in Franklin County Within 3 Miles of the 200 Area and Within 3 Miles of the 300 Area Defined Boundary

9413218.0452

Battelle
Pacific Northwest Laboratories

Project Number _____

Internal Distribution

File/LB

Date August 25, 1987

To File

From B. W. Mercer David Lamar for BWM

Subject Drinking Water Wells in Franklin County within 3 Miles of the 200 Area Defined Boundary and within 3 miles of the 300 Area Defined Boundary

Mr. Clifford L. Bates of the Benton Franklin District Health Department was contacted on the above date for information on the number of drinking water wells within the subject boundaries. Mr. Bates has a map of Franklin County in his office showing the location and nitrate levels of drinking water wells that he is aware of. There may be other wells that have not been reported. The number of wells within 3 miles of the 200 Area defined boundary and within 3 miles of the 300 Area defined boundary are tabulated on the following pages which also give estimates of the number of people served.

BWM:DAL:dar

9413218.0453

Wells within 3 Miles of 200 Area Plume in the Columbia River

Boundary: 1) North edge of T. 12 N. on an east-west line with Klamath Rd.

2) East boundary north-south along Taylor Flats Rd.

3) West boundary - Columbia River

4) South boundary - Sagemoor Rd.

Total No. of wells within this boundary is 17 including private dwellings and community wells(3). Private single dwelling wells = 14.

No. of community wells (from State of Washington Public Water Supply System Listing)

		Permanent People	Migrant Farm Worker Residents	
1.	Eppich Water System	12	8	
2.	Cypress Gardens School	12	0	
3.	Rio Vista Orchards	8	0	
	TOTAL	32	8	= 40 people

assume 3 people to private single dwelling wells = 14 x 3.8 = 53.2 people

TOTAL = 95.2 people

9413218.0454

Wells within 3 Miles of 300 Area Plume

Boundary: 1) North - along Dogwood Rd on line to river

2) East - along Taylor Flats Rd

3) West - along Columbia River

4) South - along Dent Rd and line to river

Total No. of wells within this boundary is 17 including both private single dwelling wells and community wells.

No. of community wells (from State of Washington Public Water Supply System Listing)

		No. People Served
1.	Cypress Gardens School	12
2.	Rio Vista Orchards	8
	TOTAL	20 people

assume 3.8 people at each single dwelling well:

15 wells x 3.8 people/well = 57 people

Total people single + community wells = 77 People

9413218.0455

REFERENCE 12

Hanford Reservation Area Worker Census, BNWL-2298, July 1977

9413218.0456

9413218.0457

BNWL-238
UC-70

Hanford Reservation Area Worker Census

A Research Report for the Rockwell Hanford Operations

by
Keith E. Yandon

July 1977

Prepared for the Energy Research and Development Administration under Contract EY-76-C-06-1830

Battelle
Pacific Northwest Laboratories

Ref 12.1

POOR COPY RECEIVED

TABLE 1. Concentration of Hanford Reservation Workers by Site

Site	Number of Workers	Percent of Total
100	760	5
200 E&W	2,355	16
WPPSS #1,2,&4	2,905	20
FFTF	2,420	16
300	3,110	21
Battelle, et al.	3,345	22
TOTAL	14,895	100

While the worker counts being reported by Reservation employers are usually shown concentrated around a designated site, in reality a substantial portion of these workers are likely to be distributed over the surrounding area. For convenience, however, they are credited to such particular sites as 200 East, 200 West, WPPSS 1, 2, & 4, etc.

Identification of shift workers posed some reporting difficulties since some firms run four shifts while most of the others conduct their operations in three. The 100 Area was a special problem since these workers operate over a wide area. Regardless, all workers have been accounted for in this census although some of the shift counts may be approximate.

DISTRIBUTION OF WORKERS BY RADII AND COMPASS DIRECTION

Figure 2 maps the distribution of Hanford Reservation workers by work shift over intervals of one-mile radii and 16 compass directions centered at the Purex Plant. These same worker distributions are repeated in Figure 3 without the maped Reservation Area as a background. As a tabulating convenience, sector parcel counts have been rounded to units of 5 and 10, but were adjusted to the total count for the separate companies. (Because of confidentiality, worker counts for the separate companies are not being presented here.) For better readability, sector counts within the first two mile radii from the Purex Plant center are presented separately at the bottom of the figure. Table 2 presents work distribution in detail including a cumulative count of workers and percent of total as distance and direction from the Purex Plant center increases.

9413218.0458

REFERENCE 13

Waste Management Operations, Hanford Reservations,

ERDA-1538, December 1975

9413218.0459

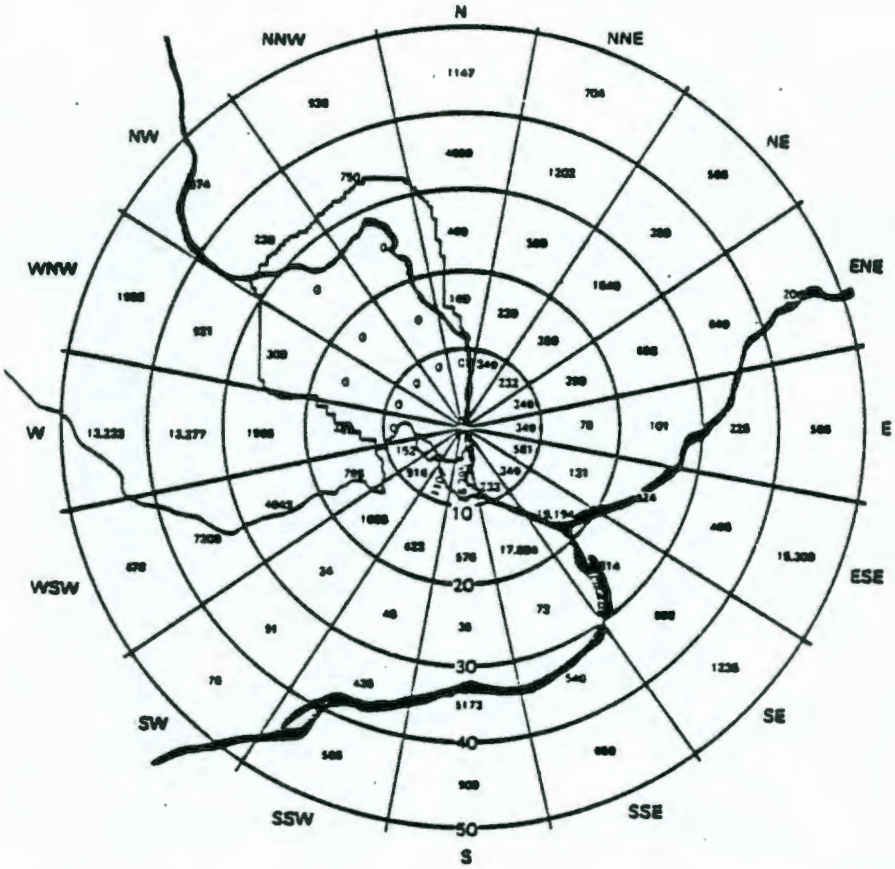

FIGURE II.3-4 ESTIMATED GEOGRAPHIC DISTRIBUTION OF THE 1970 POPULATION (162,000) WITHIN A 50-MILE RADIUS OF THE 300 AREA

The nature and extent of present land use is discussed here on the basis of arcs described from the HMS. Land areas included in a 50-mile radius from the other two site areas are also covered.[3] Figure II.3-5 is an aerial photograph in which the general pattern of agricultural usage is visible as the darker, regular-shaped areas.

Figure II.3-6 shows the Hanford site map with sector markings overlaid. Starting from a line directly north from the HMS, the 0- to 10-mile zone is entirely within the Hanford site boundaries. The area south of the Columbia River is under ERDA control and is a limited access area. Land north of the river is controlled by the Bureau of Sport Fisheries and Wildlife as a game refuge. All of this zone between the 0- and 150-degree radials is limited access area under control of ERDA. Most of the zone between the 150- and 270-degree radials consists of the Arid Lands Ecology (ALE) Reserve, which is also limited access ERDA land under the control of Battelle, Pacific Northwest Laboratories. Between the 270-degree radial and the starting radial, land south of the Columbia River is ERDA-controlled limited access while north of the river the game refuge is again encountered.

Again starting from the 0-degree radial, the 10- to 20-mile zone is a continuation of the game refuge with some areas open for fishing, shotgun and bow hunting during daylight hours. Further north, this zone includes the eastern-most portion of the Wahluke Slope and the Saddle Mountains. Between the Wahluke Branch Canal and the Columbia River, the zone consists of lands in the Columbia Basin Project which are irrigated or are being developed for irrigation. The area west of the river is limited access Hanford site. Leaving the site boundary, the land is mainly unirrigated land used for grazing cattle and sheep. South and west of the Columbia River, in the vicinity of Priest Rapids Dam, is the U.S. Army Yakima Firing Range which is undeveloped, unpopulated land. Northwest of Priest Rapids Dam and Reservoir is the Wahluke Slope portion of the Columbia Basin Project. This area is partially irrigated with the rest (outside the Hanford Reservation) expected to be irrigated in the next 10 years.

Ref. 13.1

9413218.0460

- Trilateration measurements are performed between 17 benchmarks to measure crustal motion. The initial base data were developed 3 years ago, with additional measurements at 6 months, 12 months, and 36 months from that time.

- Tiltmeters are installed at three locations on the Hanford Reservation. These pieces of equipment provide continuous geographic coverage of crustal motion. The output is telemetered to Menlo Park for interpretation.

Figure II.3-9 shows the active earthquake zones in Washington deduced from earthquake activity. East of the Cascades the trends are largely north-south, parallel to the Cascades, and divide the state into separate geographical, structural and tectonic provinces.

In eastern Washington, clearcut relationships of epicenters to specific surface faults or structures capable of faulting are not yet recognized. The suggested low rate of tectonic deformation for more than 10 million years[19] does not indicate any cause for concern. Much of the stress resulting from the continuing low rate of tectonic deformation appears to be dissipated from random epicenters along joints and bedding planes.

On the assumption that an MM-VII quake (magnitude 5.5) were to occur at the northwest end of the Rattlesnake-Wallula fault zone, ground acceleration of 13% g could be expected beneath most of the Hanford Reservation.[31] A design basis of 25% g on the Hanford Reservation thereby allows for an MM-VIII intensity quake (magnitude up to 6.8) for an earthquake epicentered at the same site. No such quake has ever been recorded in eastern Oregon or Washington.

The siting of nuclear facilities over the synclinal troughs assures the maximum distance from all hypothesized faults capable of earthquake generation. If, in addition, the Ringold Formation and Pasco Gravels are compact and undisturbed, the site is certain to pose few problems. An appreciable to high degree of conservatism appears present by acceptance of the MM-VIII quake (magnitude 6.8) and the resulting 25% g acceleration for facility design purposes.

II.3.8 Hydrology[(a)] [RPB, X.18, X.25]

II.3.8.1 Surface Water

The surface water bodies located within the boundaries of the Hanford Reservation consist of the Columbia River, various ditches and ponds in and near the 200 Areas and three ponds located in the 300 Areas (Figure II.3-10). Two ephemeral streams, Cold and Dry Creeks, appear for a short time only after heavy rainfall or snowmelt. The Yakima River borders part of the Reservation's southern boundary.

II.3.8.1.1 Columbia River

The river reach from Priest Rapids Dam (river mile 397) to the head (approximately river mile 351) of the reservoir behind McNary Dam is the last free-flowing reach of the Columbia River within the United States. The main channel is braided around the island reaches, and submerged rock ledges and gravel bars cause repeated pooling and channeling. The riverbed material is mobile, dependent on river velocities; it is typically sand, gravel, and rocks up to 8 inches in diameter. Small fractions of silts and clays are associated with the sands in areas of low velocity deposition, becoming more dominant approaching the upstream face of each river dam.[32,33,34]

The Columbia River in this reach has widely varying flow rates due to regulation by the power producing Priest Rapids Dam just upstream (Figure II.3-11). Flows during the summer, fall and winter vary from a low of 36,000 cubic feet per second (cfs) to as much as 160,000 cfs each day. The long-term annual average flow at Hanford is about 120,000 cfs,[35] but during low flow periods; daily flows average 80,000 to 90,000 cfs. The mean annual flow rate for 1972 at Hanford was 159,500 cfs. In recent years, peak flows during the spring runoff have ranged from 160,000 to 550,000 cfs; the maximum flood peak of record is 693,000 cfs in 1948.

The river width in the Hanford reach varies between 400 and 600 yards depending upon flow rate and position along the river.[36] The depth at the deepest part of the measured cross-sections varies approximately from 10 to 40 feet, with an average around 25 feet. Daily fluctuations in depth caused by Priest Rapids regulation can be as much as 10 feet above Vernita and 5 feet at Hanford. The maximum velocities measured vary from less than 3 feet per second (fps) to over 11 fps, again depending upon the river cross-section and flow rate.

(a) Appendix II.3-D provides a more detailed description of the hydrology of the Hanford Reservation. In 1973 Atlantic Richfield Hanford Company authorized an independent review, recently completed, of the hydrology program.

9413218.0491

REFERENCE 14

Draft Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Waste, DOE/EIS-0113, Volume 1

9413210.0462

Focal mechanism and fault plane solutions of earthquakes within eastern Washington and the central Columbia Plateau indicate that the principal compressional stresses are nearly horizontal and oriented north-south, while the principal tensional stresses are nearly vertical (DOE 1984). This suggests thrust or reverse faulting on east-west striking planes. These principal stress directions are in good agreement with mapped east-west oriented folds and associated thrust or reverse faults (DOE 1984).

Geologic structures of the Pasco Basin are typical of the Yakima Fold Belt subprovince, which is characterized by narrow, linear anticlines and broad synclines (Figure 4.5). These structures generally extend eastward from the western margin toward the center of the Columbia Plateau, where they generally die out (Myers and Price 1979). Most known faults are associated with anticlinal fold axes and probably developed concurrently with folding (Price 1982).

Geologic and geodetic data have been interpreted to suggest that the Columbia Plateau, including the Pasco Basin, was deforming at a low to average rate of strain in the middle to late Miocene and that the rate of deformation has continued into the late Cenozoic (DOE 1984).

Seismic activity and related phenomena such as liquefaction, fault rupture, and subsidence are not believed to be plausible events that might directly release waste, except with continued storage of tanked waste near the end of tank life. A related discussion of the seismicity is included in Appendix R.

4.4 HYDROLOGY

4.4.1 Surface Waters

The Columbia River, which flows through the northern part of the Site and along the eastern boundary, and the Yakima River, which flows along the southern boundary, are the dominant streams in the area. Both streams are important sources of industrial, agricultural and domestic water for the region. The average annual Columbia River flow in the Hanford reach, based on 65 yr of record, is about 3,400 m^3/sec (USGS 1985). Minimum flows of 117 m^3/sec have been recorded. For a period of 57 yr of record, the average annual flow of the Yakima River is about 104 m^3/sec and the monthly maximum and minimum flows of 490 m^3/sec and 4.6 m^3/sec, respectively. Maximum Columbia River floods of historical record occurred in 1894 and 1948, with flows of 21,000 m^3/sec and 19,600 m^3/sec, respectively (DOE 1982a). Floods of this size would inundate part of the 100-F Area but would be of little consequence to the rest of the Site. The likelihood of floods of this magnitude recurring has been reduced by the construction of several flood control/water storage dams upstream of the Site. Normal river elevations within the Site range from 120 m where the river enters the Site near Vernita to 104 m where it leaves the Site near the 300 Area.

The probable maximum flood (the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions reasonably possible in the region) would produce a flow of 40,000 m^3/sec. Flood elevations would be about 129 m at

9413218.0463

Ref. 14.1

Badgers are present in low numbers in the 200 Areas plateau. The coyote is the principal mammalian predator on the Site. Elk are found on the Rattlesnake Hills to the southwest of the 200 Areas. Mule deer are abundant on the western part of the Site. They occasionally use the waste ponds and associated riparian vegetation near the 200 Areas for food and water. Mule deer tagged along the Columbia River have moved as far as 48 km from the Site (Fitzner and Price 1973).

4.6.2 Aquatic Ecology

Aquatic habitats on the Site include the ponds and ditches in or near the 200 Areas, the Columbia River, and two very small streams formed by Rattlesnake Springs and Snively Springs west of the 200 Areas plateau (Figure 4.7). Ponds found in or near the 200 Areas are Gable Mountain Pond, which is undergoing decommissioning, and B Pond, which receives cooling water from the 200-E Area encapsulation facility (Emery and McShane 1980; Meinhardt and Frostenson 1979). The wastewater disposal sites have similar water-quality characteristics, and support similar kinds of algae, rooted plants, and invertebrates; all contain introduced populations of goldfish. West Pond (created by the rise in the water table in the 200 Areas) is very alkaline, has a much lower density and diversity of plants and animals, and has no fish. The ponds and ditches are the only sources of water in the arid environment of the 200 Areas plateau and therefore provide habitat for many birds and mammals. The ditches are generally less productive than the ponds in terms of biomass per unit area of bottom or unit volume of water. Streams formed by Rattlesnake and Snively Springs are quite productive but are remote from the waste sites.

The Columbia River is the largest surface water and supports the most important aquatic ecosystem on the Site (ERDA 1975). Much of the river has been impounded by hydroelectric dams, and the section of river on the Site is the last non-tidal free-flowing reach in the United States. Forty-five species of fish have been identified from the Hanford reach of the river (Gray and Dauble 1977). Several species of economically important salmon and the steelhead trout use the river to migrate to and from upstream spawning and rearing areas. Fall chinook salmon and steelhead trout spawn on the Site. The Hanford site serves as the spawning area for more than one-third of the fall chinook salmon in the mid-Columbia (Watson 1970).

4.6.3 Threatened and Endangered Species

Endangered and threatened plants and animals on the Site, as designated by both the federal and State of Washington agencies, are listed in Table 4.12. There are no endangered or threatened plant species on the Site, although several species are listed as candidates for endangered or threatened status or for classification as "sensitive."

Both the federal and state authorities consider the peregrine falcon to be an endangered species and the bald eagle a threatened species. The state also classifies the white pelican as endangered and the ferruginous hawk and the pygmy rabbit as threatened.

The bald eagle is fairly common along the Hanford reach of the Columbia River during fall and winter, when it feeds on the carcasses of spawned-out salmon (Fitzner et al. 1981).

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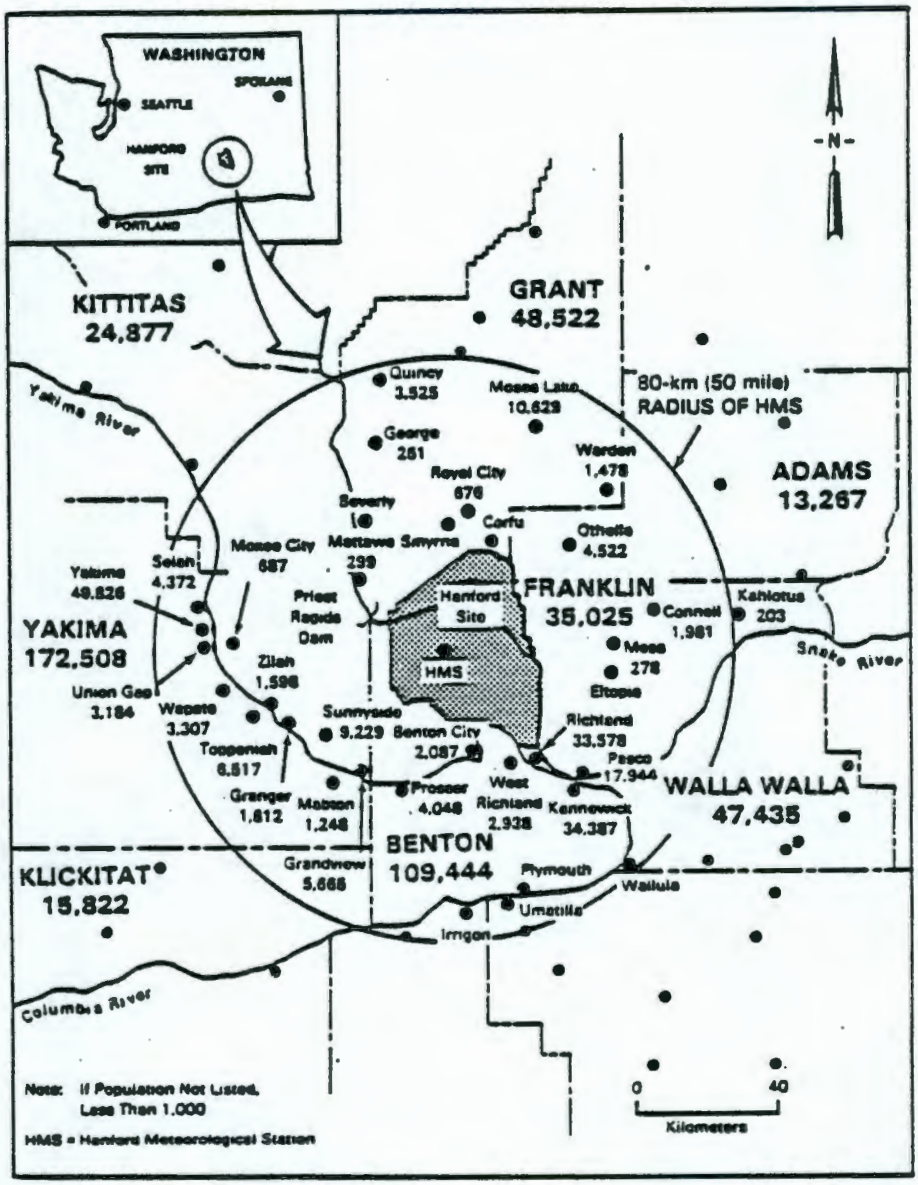

FIGURE 4.11. U.S. Census Populations for 1980 of Cities Within 80 km of the Hanford Meteorology Station (DOE 1982a)

The estimated population of Benton and Franklin Counties from 1981 to 1990 varies from a decline of about 8% to an increase of about 8%, depending on different assumed economic factors. These factors include the restart of construction of WPPSS reactors, possible changes in agricultural growth, or the start of new DOE-related projects (Watson et al. 1984).

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Ref. 14.3

REFERENCE 15, 16 and 17

U.S.G.S. Maps Showing 200 Area Surroundings

Gable Butte, Wash 7.5 Minute Map
Coyote Rapids, Wash 7.5 Minute Map
Locke Island, Wash 7.5 Minute Map
Vernita Bridge, Wash 7.5 Minute Map
Snively Basin, Wash 7.5 Minute Map
Iowa Flats, Wash 7.5 Minute Map
River Island, Wash 7.5 Minute Map
Horn Rapids Dam, Wash 7.5 Minute Map
Richland, Wash 7.5 Minute Map
Wooded Island, Wash 7.5 Minute Map
Columbia Point, Wash 7.5 Minute Map
Hanford, Wash 7.5 Minute Map
Savage Island, Wash 7.5 Minute Map
Basin City, Wash 7.5 Minute Map
Mathews Corner, Wash 7.5 Minute Map

9413218.0946

REFERENCE 18

Memo to file from DA Lamar, on 8-18-87, regarding Personal Observations of Columbia River Intakes at Taylor Flats and Ringold Flats

9413218.0482

Battelle
Pacific Northwest Laboratories

Project Number _____

Internal Distribution

File/LB

Date August 18, 1987

To File

From D. A. Lamar

Subject Personal Observations of Columbia River Intakes at Taylor Flats and Ringold

In observation of the Columbia River, 3 intakes were found in the Taylor Flats region serving as irrigation for crops and forage. In the Ringold Ranch area there are 2 intakes that serve the region as irrigation for crops and forage. At the Ringold Hatchery there was observed one intake that serves for the rearing of steelhead fingerlings.

DAL:dar

REFERENCE 19

Endangered and Threatened Wildlife and Plants, 50 CFR,

Part 17, Subpart B, October 86

9413270.0484

issued under Part 21 of this chapter; and

(2) Identified in the earliest applicable annual report required to be filed by a permittee under Part 21 of this chapter as in a permittee's possession on November 10, 1978, or as the progeny of such a raptor.

(b) This section does not apply to any raptor intentionally returned to the wild.

[48 FR 31607, July 8, 1983]

Subpart B—Lists

SOURCE: 48 FR 34182, July 27, 1983, unless otherwise noted.

§ 17.11 Endangered and threatened wildlife.

(a) The list in this section contains the names of all species of wildlife which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of wildlife treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Common Name," "Scientific Name," and "Vertebrate Population Where Endangered or Threatened" define the species of wildlife within the meaning of the Act. Thus, differently classified geographic populations of the same vertebrate subspecies or species shall be identified by their differing geographic boundaries, even though the other two columns are identical. The term "Entire" means that all populations throughout the present range of a vertebrate species are listed. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Zoological Nomenclature*.

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this title.

(e) The "historic range" indicates the known general distribution of the species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the species, wherever found.

(f)(1) A footnote to the FEDERAL REGISTER publication(s) listing or reclassifying a species is indicated under the column "When listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same FEDERAL REGISTER document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special rules" and "Critical habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The "Special rules" column will also be used to cite the special rules that describe experimental populations and determine if they are essential or nonessential. Separate listing will be made for experimental populations, and the status column will include the following symbols: "XE" for an essential experimental population and "XN" for a nonessential experimental population. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or critical habitat for that par-

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propriate r
through 227
that species.
other rules i
such wildlife
quirements. I
references i
column list a
two Services
species or to
Federal agen
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(g) The list
includes all lo
example, the
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ticular species. However, all other appropriate rules in Parts 17, 217 through 227, and 402 still apply to that species. In addition, there may be other rules in this title that relate to such wildlife, e.g., port-of-entry requirements. It is not intended that the references in the "Special rules" column list all the regulations of the two Services which might apply to the species or to the regulations of other Federal agencies or State or local governments.

(g) The listing of a particular taxon includes all lower taxonomic units. For example, the genus *Hylobates* (gibbons) is listed as Endangered throughout its entire range (China, India, and SE Asia); consequently, all species, subspecies, and populations of that genus are considered listed as Endangered for the purposes of the Act. In 1978 (43 FR 6230–6233) the species *Haliaeetus leucocephalus* (bald eagle) was listed as Threatened in "USA (WA, OR, MN, WI, MI)" rather than its entire population; thus, all individuals of the bald eagle found in those five States are considered listed as Threatened for the purposes of the Act.

(h) The "List of Endangered and Threatened Wildlife" is provided below:

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Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
MAMMALS							
Anoa, lowland	*Bubalus depressicornis* (=*B. anoa depressicornis*).	Indonesia	Entire	E	3	NA	NA
Anoa, mountain	*Bubalus quarlesi* (=*B. anoa quarlesi*)	do	do	E	15	NA	NA
Antelope, giant sable	*Hippotragus niger variani*	Angola	do	E	15	NA	NA
Argali	*Ovis ammon hodgsoni*	China (Tibet, Himalayas)	do	E	15	NA	NA
Armadillo, giant	*Priodontes maximus* (=*giganteus*)	Venezuela and Guyana to Argentina	do	E	15	NA	NA
Armadillo, pink fairy	*Chlamyphorus truncatus*	Argentina	do	E	3	NA	NA
Ass, African wild	*Equus asinus* (=*africanus*)	Somalia, Sudan, Ethiopia	Somalia, Sudan, Ethiopia.	E	3, 22	NA	NA
Ass, Asian wild (=kulan, onager)	*Equus hemionus*	Southwestern and Central Asia	Entire	E	3	NA	NA
Avahi	*Avahi* (=*Lichanotus*) *laniger* (=entire genus).	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Aye-Aye	*Daubentonia madagascariensis*	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Babirusa	*Babyrousa babyrussa*	Indonesia	do	E	15	NA	NA
Baboon, gelada	*Theropithecus gelada*	Ethiopia	do	T	16	NA	17.40(c)
Bandicoot, barred	*Perameles bougainville*	Australia	do	E	4	NA	NA
Bandicoot, desert	*Perameles eremiana*	do	do	E	6	NA	NA
Bandicoot, lesser rabbit	*Macrotis leucura*	do	do	E	4	NA	NA
Bandicoot, pig-footed	*Chaeropus ecaudatus*	do	do	E	4	NA	NA
Bandicoot, rabbit	*Macrotis lagotis*	do	do	E	4	NA	NA
Banteng	*Bos javanicus* (=*banteng*)	Southeast Asia	do	E	3	NA	NA
Bat, Bulmer's fruit (flying fox)	*Aproteles bulmerae*	Papua New Guinea	do	E	139	NA	NA
Bat, bumblebee	*Craseonycteris thonglongyai*	Thailand	do	E	139	NA	NA
Bat, gray	*Myotis grisescens*	Central and Southeastern U.S.A.	do	E	13	NA	NA
Bat, Hawaiian hoary	*Lasiurus cinereus semotus*	U.S.A. (HI)	do	E	2	NA	NA
Bat, Indiana	*Myotis sodalis*	Eastern and Midwestern U.S.A.	do	E	1	17.95(a)	NA
Bat, little Mariana fruit	*Pteropus tokudae*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Bat, Mariana fruit	*Pteropus mariannus mariannus*	Western Pacific Ocean: U.S.A. (Guam, Rota, Tinian, Saipan, Agiguan).	Guam	E	156	NA	NA
Bat, Ozark big-eared	*Plecotus townsendii ingens*	U.S.A. (MO, OK, AR)	Entire	E	65	NA	NA
Bat, Rodrigues fruit (flying fox)	*Pteropus rodricensis*	Indian Ocean: Rodrigues Island	do	E	139	NA	NA
Bat, Singapore roundleaf horseshoe	*Hipposideros ridleyi*	Malaysia	do	E	139	NA	NA
Bat, Virginia big-eared	*Plecotus townsendii virginianus*	U.S.A. (KY, NC, WV, VA)	do	E	65	17.95(a)	NA
Bear, Baluchistan	*Ursus thibetanus gedrosianus*	Iran, Pakistan	do	E	233	NA	NA
Bear, brown	*Ursus arctos pruinosus*	China (Tibet)	Guam	E	15	NA	NA
Bear, brown	*Ursus arctos arctos*	Palearctic	Italy	E	15	NA	NA
Bear, brown or grizzly	*Ursus arctos* (=*U.a. horribilis*)	Holarctic	U.S.A. 48 conterminous States.	T	1, 3, 9	NA	17.40(b)
Bear, brown or grizzly	*Ursus arctos* (=*U.a. nelsoni*)	Holarctic	Mexico	E	3	NA	NA
Beaver	*Castor fiber birulai*	Mongolia	Entire	E	15	NA	NA
Bison, wood	*Bison bison athabascae*	Canada, Northwestern U.S.A.	Canada	E	3	NA	NA
Bobcat	*Felis rufus escuinapae*	Central Mexico	Entire	E	15	NA	NA
Bontebok (antelope)	*Damaliscus dorcas dorcas*	South Africa	do	E	15	NA	NA
Camel, Bactrian	*Camelus bactrianus* (=*ferus*)	Mongolia, China	do	E	15	NA	NA
Caribou, woodland	*Rangifer tarandus caribou*	Canada, U.S.A. (AK, ID, ME, MI, MN, MT, NH, VT, WA, WI).	Canada (that part of S.E. Brit. Col. bounded by the Can.-USA border, Columbia R.,	E	126E, 136E, 143	NA	NA

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Bobcat	*Felis rufus escuinapae*	Central Mexico	Entire	E	15	NA	NA
Bontebok (antelope)	*Damaliscus dorcas dorcas*	South Africa	do	E	15	NA	NA
Camel, Bactrian	*Camelus bactrianus (=ferus)*	Mongolia, China	do	E	15	NA	NA
Caribou, woodland	*Rangifer tarandus caribou*	Canada, U.S.A. (AK, ID, ME, MI, MN, MT, NH, VT, WA, WI).	Canada (that part of S.E. Brit. Col bounded by the Can.-USA border, Columbia R., Kootenay R., Kootenay L., and Kootenai R.), U.S.A. (ID, WA).	E	128E, 136E, 143	NA	NA
Cat, Andean	*Felis jacobita*	Chile, Peru, Bolivia, Argentina	Entire	E	15	NA	NA
Cat, black-footed	*Felis nigripes*	Southern Africa	do	E	15	NA	NA
Cat, flat-headed	*Felis planiceps*	Malaysia, Indonesia	do	E	15	NA	NA
Cat, Iriomote	*Felis (Mayailurus) iriomotensis*	Japan (Iriomote Island, Ryukyu Islands)	do	E	50	NA	NA
Cat, leopard	*Felis bengalensis bengalensis*	India, Southeast Asia	do	E	15	NA	NA
Cat, marbled	*Felis marmorata*	Nepal, Southeast Asia, Indonesia	do	E	15	NA	NA
Cat, Pakistan sand	*Felis margarita scheffeli*	Pakistan	do	E	139	NA	NA
Cat, Temminck's (=golden cat)	*Felis temmincki*	Nepal, China, Southeast Asia, Indonesia (Sumatra).	do	E	15	NA	NA
Cat, tiger	*Felis tigrinus*	Costa Rica to northern Argentina	do	E	5	NA	NA
Chamois, Apennine	*Rupicapra rupicapra ornata*	Italy	do	E	15	NA	NA
Cheetah	*Acinonyx jubatus*	Africa to India	do	E	3, 5	NA	NA
Chimpanzee	*Pan troglodytes*	West and Central Africa	do	T	16	NA	17.40(c)
Chimpanzee, pygmy	*Pan paniscus*	Zaire	do	T	16	NA	17.40(c)
Chinchilla	*Chinchilla brevicaudata boliviana*	Bolivia	do	E	15	NA	NA
Civet, Malabar large-spotted	*Viverra megaspila civettina*	India	do	E	50	NA	NA
Cochito (=Gulf of California harbor porpoise).	*Phocoena sinus*	Mexico (Gulf of California)	do	E	169	NA	NA
Colobus, Preuss's red	*Colobus badius preussi*	Cameroon	do	E	139	NA	NA
Cougar, eastern	*Felis concolor cougar*	Eastern North America	do	E	6	NA	NA
Deer, Bactrian	*Cervus elaphus bactrianus*	U.S.S.R., Afghanistan	do	E	50	NA	NA
Deer, Bawean	*Axis (=Cervus) porcinus kuhli*	Indonesia	do	E	3	NA	NA
Deer, Barbary	*Cervus elaphus barbarus*	Morocco, Tunisia, Algeria	do	E	50	NA	NA
Deer, Cedros Island mule	*Odocoileus hemionus cedrosensis*	Mexico (Cedros Island)	do	E	10	NA	NA
Deer, Columbian white-tailed	*Odocoileus virginianus leucurus*	U.S.A. (WA, OR)	do	E	1	NA	NA
Deer, Corsican red	*Cervus elaphus corsicanus*	Corsica, Sardinia	do	E	50	NA	NA
Deer, Eld's brow-antlered	*Cervus eldi*	India to Southeast Asia	do	E	3	NA	NA
Deer, Formosan sika	*Cervus nippon taiouanus*	Taiwan	do	E	50	NA	NA
Deer, hog	*Axis (=Cervus) porcinus annamiticus*	Thailand, Indochina	do	E	15	NA	NA
Deer, key	*Odocoileus virginianus clavium*	U.S.A. (FL)	do	E	1	NA	NA
Deer, marsh	*Blastocerus dichotomus*	Argentina, Uruguay, Paraguay, Bolivia, Brazil.	do	E	3	NA	NA
Deer, McNeill's	*Cervus elaphus macneilli*	China (Sinkiang, Tibet)	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Deer, musk	*Moschus* spp. (all species)	Central and East Asia	Afghanistan, Bhutan, Burma, China (Tibet, Yunnan), India, Nepal, Pakistan, Sikkim.	E	15	NA	NA
Deer, North China sika	*Cervus nippon mandarinus*	China (Shantung and Chihli Provinces)	Entire	E	50	NA	NA
Deer, pampas	*Ozotoceros bezoarticus*	Brazil, Argentina, Uruguay, Bolivia, Paraguay.	do	E	15	NA	NA
Deer, Persian fallow	*Dama dama mesopotamica*	Iraq, Iran	do	E	3	NA	NA
Deer, Philippine	*Axis* (=*Cervus*) *porcinus calamianensis*	Philippines (Calamian Islands)	do	E	15	NA	NA
Deer, Ryukyu sika	*Cervus nippon keramae*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Deer, Shansi sika	*Cervus nippon grassianus*	China (Shansi Province)	do	E	50	NA	NA
Deer, South China sika	*Cervus nippon kopschi*	Southern China	do	E	50	NA	NA
Deer, swamp (=barasingha)	*Cervus duvaucelli*	India, Nepal	do	E	3	NA	NA
Deer, Yarkand	*Cervus elaphus yarkandensis*	China (Sinkiang)	do	E	50	NA	NA
Dhole (=Asiatic wild dog)	*Cuon alpinus*	U.S.S.R., Korea, China, India, Southeast Asia.	do	E	3	NA	NA
Dibbler	*Antechinus apicalis*	Australia	do	E	4	NA	NA
Dog, African wild	*Lycaon pictus*	Sub-Saharan Africa	do	E	139	NA	NA
Drill	*Papio leucophaeus*	Equatorial West Africa	do	E	16	NA	NA
Dugong	*Dugong dugon*	East Africa to southern Japan, including U.S.A. (Trust Territories).	do	E	4	NA	NA
Duiker, Jentink's	*Cephalophus jentinki*	Sierra Leone, Liberia, Ivory Coast	do	E	50	NA	NA
Eland, Western giant	*Taurotragus derbianus derbianus*	Senegal to Ivory Coast	do	E	50	NA	NA
Elephant, African	*Loxodonta africana*	Africa	do	T	40	NA	17.40(e)
Elephant, Asian	*Elephas maximus*	South-central and Southeast Asia	do	E	15	NA	NA
Ferret, black-footed	*Mustela nigripes*	Western U.S.A., Western Canada	do	E	1, 3	NA	NA
Fox, Northern swift	*Vulpes velox hebes*	U.S.A. (northern plains), Canada	do	E	3	NA	NA
Fox, San Joaquin kit	*Vulpes macrotis mutica*	U.S.A. (CA)	Entire	E	1	NA	NA
Fox, Simien	*Canis* (*Simenia*) *simensis*	Ethiopia	do	E	50	NA	NA
Gazelle, Clark's (=Dibatag)	*Ammodorcas clarkei*	Somalia, Ethiopia	do	E	3	NA	NA
Gazelle, Cuvier's	*Gazella cuvieri*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Mhorr	*Gazella dama mhorr*	Morocco	do	E	3	NA	NA
Gazelle, Moroccan (=Dorcas)	*Gazella dorcas massaesyla*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Rio de Oro Dama	*Gazella dama lozanoi*	Western Sahara	do	E	3	NA	NA
Gazelle, Arabian	*Gazella gazella*	Arabian Peninsula, Palestine, Sinai	do	E	50	NA	NA
Gazelle, sand	*Gazella subgutturosa marica*	Jordan, Arabian Peninsula	do	E	50	NA	NA
Gazelle, Saudi Arabian	*Gazella dorcas saudiya*	Israel, Iraq, Jordan, Syria, Arabian Peninsula.	do	E	50	NA	NA
Gazelle, Pelzeln's	*Gazella dorcas pelzeini*	Somalia	do	E	50	NA	NA
Gazelle, slender-horned (=Rhim)	*Gazella leptoceros*	Sudan, Egypt, Algeria, Libya	do	E	3	NA	NA
Gibbons	*Hylobates* spp. (including *Nomascus*)	China, India, Southeast Asia	do	E	3, 15	NA	NA
Goat, wild (=Chiltan markhor)	*Capra aegagrus* (=*falconeri chiltanensis*)	Southwestern Asia	Chiltan Range of west-central Pakistan.	E	15	NA	NA
Goral	*Nemorhaedus goral*	East Asia	Entire	E	15	NA	NA
Gorilla	*Gorilla gorilla*						

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Goat, wild (=Chilian markhor)	*Capra aegagrus* (=*falconeri chiltanensis*)	Southwestern Asia	Chiltan Range of west-central Pakistan.	E	15	NA	NA
Goral	*Nemorhaedus goral*	East Asia	Entire	E	15	NA	NA
Gorilla	*Gorilla gorilla*	Central and Western Africa	do	E	3	NA	NA
Guadalupe fur seal	*Arctocephalus townsendi*	U.S.A. (Farallon Islands of CA) south to Mexico (Islas Revillagigedo).	do	T	212	NA	227.11
Hare, hispid	*Caprolagus hispidus*	India, Nepal, Bhutan	do	E	15	NA	NA
Hartebeest, Swayne's	*Alcelaphus buselaphus swaynei*	Ethiopia, Somalia	do	E	3, 50	NA	NA
Hartebeest, Tora	*Alcelaphus buselaphus tora*	Ethiopia, Sudan, Egypt	do	E	50	NA	NA
Hog, pygmy	*Sus salvanius*	India, Nepal, Bhutan, Sikkim	do	E	3	NA	NA
Horse, Przewalski's	*Equus przewalskii*	Mongolia, China	do	E	15	NA	NA
Huemul, North Andean	*Hippocamelus antisensis*	Ecuador, Peru, Chile, Bolivia, Argentina	do	E	15	NA	NA
Huemul, South Andean	*Hippocamelus bisulcus*	Chile, Argentina	do	E	15	NA	NA
Hutia, Cabrera's	*Capromys angelcabrerai*	Cuba	do	E	233	NA	NA
Hutia, dwarf	*Capromys nana*	do	do	E	233	NA	NA
Hutia, large-eared	*Capromys auritus*	do	do	E	233	NA	NA
Hutia, little earth	*Capromys sanfelipensis*	do	do	E	233	NA	NA
Hyena, Barbary	*Hyaena hyaena barbara*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Hyena, brown	*Hyaena brunnea*	Southern Africa	do	E	3	NA	NA
Ibex, Pyrenean	*Capra pyrenaica pyrenaica*	Spain	do	E	3	NA	NA
Ibex, Walia	*Capra walie*	Ethiopia	do	E	3	NA	NA
Impala, black-faced	*Aepyceros melampus petersi*	Namibia, Angola	do	E	3	NA	NA
Indri	*Indri indri* (=entire genus)	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Jaguar	*Panthera onca*	U.S.A. (TX, NM, AZ), C. and S. America	Mexico southward	E	6	NA	NA
Jaguarundi	*Felis yagouaroundi cacomitli*	U.S.A. (TX), Mexico	Entire	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi fossata*	Mexico, Nicaragua	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi panamensis*	Nicaragua, Costa Rica, Panama	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi tolteca*	U.S.A. (AZ), Mexico	do	E	15	NA	NA
Kangaroo, eastern gray	*Macropus giganteus* (all subspecies except *tasmaniensis*).	Australia	do	T	7	NA	17.40(a)
Kangaroo, red	*Macropus* (*Megaleia*) *rufus*	do	do	T	7	NA	17.40(a)
Kangaroo, Tasmanian forester	*Macropus giganteus tasmaniensis*	Australia (Tasmania)	do	E	6	NA	NA
Kangaroo, western gray	*Macropus fuliginosus*	Australia	do	T	7	NA	17.40(a)
Kouprey	*Bos sauveli*	Vietnam, Laos, Cambodia, Thailand	do	E	3	NA	NA
Langur, capped	*Presbytis pileata*	India, Burma, Bangladesh	do	E	15	NA	NA
Langur, entellus	*Presbytis entellus*	China (Tibet), India, Pakistan, Kashmir, Sri Lanka, Sikkim, Bangladesh.	do	E	15	NA	NA
Langur, Douc	*Pygathrix nemaeus*	Cambodia, Laos, Vietnam	do	E	3	NA	NA
Langur, Francois'	*Presbytis francoisi*	China (Kwangsi), Indochina	do	E	18	NA	NA
Langur, golden	*Presbytis geei*	India (Assam), Bhutan	do	E	15	NA	NA
Langur, long-tailed	*Presbytis potenziani*	Indonesia	do	T	16	NA	17.40(c)
Langur, Pagi Island	*Nasalis* (*Simias*) *concolor*	do	do	E	3	NA	NA
Langur, purple-faced	*Presbytis senex*	Sri Lanka (=Ceylon)	do	T	16	NA	17.40(c)
Langur, Tonkin snub-nosed	*Pygathrix* (*Rhinopithecus*) *avunculus*	Vietnam	do	T	16	NA	17.40(c)
Lechwe, red	*Kobus leche*	Southern Africa	do	T	3, 15, 106	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Lemurs	Lemuridae (incl. Cheirogaleidae, Lepilemuridae); all members of genera *Lemur, Phaner, Hapalemur, Lepilemur, Microcebus, Allocebus, Cheirogaleus, Varecia.*	Malagasy Republic (=Madagascar)	do	E	3, 15	NA	NA
Leopard	*Panthera pardus*	Africa, Asia	Wherever found, except where it is listed as Threatened as set forth below.	E	3, 6, 114	NA	NA
Do	do	do	In Africa, in the wild, south of, and including, the following countries: Gabon, Congo, Zaire, Uganda, Kenya.	T	3, 6, 114	NA	17.40(i)
Leopard, clouded	*Neofelis nebulosa*	Southeast and south-central Asia, Taiwan	Entire	E	3, 15	NA	NA
Leopard, snow	*Panthera uncia*	Central Asia	do	E	5	NA	NA
Linsang, spotted	*Prionodon pardicolor*	Nepal, Assam, Vietnam, Cambodia, Laos, Burma.	do	E	16	NA	NA
Lion, Asiatic	*Panthera leo persica*	Turkey to India	do	E	3	NA	NA
Loris, lesser slow	*Nycticebus pygmaeus*	Indochina	do	T	16	NA	17.40(c)
Lynx, Spanish	*Felis (=Lynx) pardina*	Spain, Portugal	do	E	3	NA	NA
Macaque, Formosan rock	*Macaca cyclopis*	Taiwan	do	T	16	NA	17.40(c)
Macaque, Japanese	*Macaca fuscata*	Japan (Shikoku, Kyushu and Honshu Islands).	do	T	16	NA	17.40(c)
Macaque, lion-tailed	*Macaca silenus*	India	do	E	3	NA	NA
Macaque, stump-tailed	*Macaca arctoides*	India (Assam) to southern China	do	T	16	NA	17.40(c)
Macaque, Toque	*Macaca sinica*	Sri Lanka (=Ceylon)	do	T	16	NA	17.40(c)
Manatee, Amazonian	*Trichechus inunguis*	South America (Amazon River Basin)	do	E	3	NA	NA
Manatee, West African	*Trichechus senegalensis*	West Coast of Africa from Senegal River to Cuanza River.	do	T	52	NA	NA
Manatee, West Indian (Florida)	*Trichechus manatus*	U.S.A. (southeastern), Caribbean Sea, South America.	do	E	1, 3	17.95(a)	NA
Mandrill	*Papio sphinx*	Equatorial West Africa	do	E	16	NA	NA
Mangabey, Tana River	*Cercocebus galeritus*	Kenya	do	E	3	NA	NA
Mangabey, white-collared	*Cercocebus torquatus*	Senegal to Ghana; Nigeria to Gabon	do	E	16	NA	NA
Margay	*Felis wiedii*	U.S.A. (TX), C. and S. America	Mexico southward	E	5	NA	NA
Markhor, Kabul	*Capra falconeri megaceros*	Afghanistan, Pakistan	Entire	E	15	NA	NA
Markhor, straight-horned	*Capra falconeri jerdoni*	do	do	E	15	NA	NA
Marmoset, buff-headed	*Callithrix flaviceps*	Brazil	do	E	139	NA	NA
Marmoset, buffy tufted-ear	*Callithrix jacchus aurita*	do	do	E	233	NA	NA
Marmoset, cotton-top	*Saguinus oedipus*	Costa Rica to Colombia	do	E	16	NA	NA
Marmoset, Goeldi's	*Callimico goeldii*	Brazil, Colombia, Ecuador, Peru, Bolivia	do	E	3	NA	NA
Marmot, Vancouver Island	*Marmota vancouverensis*	Canada (Vancouver Island)	do	E	139	NA	NA
Marsupial, eastern jerboa	*Antechinomys laniger*	Australia	do	E	4	NA	NA
Marsupial-mouse, large desert	*Sminthopsis psammophila*	do	do				
Marsupial-mouse, long-tailed	*Sminthopsis* [illegible]						

Markhor, Kabul	*Capra falconeri megaceros*	Afghanistan, Pakistan	Entire	E	15	NA	NA
Markhor, straight-horned	*Capra falconeri jerdoni*	do	do	E	15	NA	NA
Marmoset, buff-headed	*Callithrix flaviceps*	Brazil	do	E	139	NA	
Marmoset, buffy tufted-ear	*Callithrix jacchus aurita*	do	do	E	233	NA	NA
Marmoset, cotton-top	*Saguinus oedipus*	Costa Rica to Colombia	do	E	16	NA	NA
Marmoset, Goeldi's	*Callimico goeldi*	Brazil, Colombia, Ecuador, Peru, Bolivia	do	E	3	NA	NA
Marmot, Vancouver Island	*Marmota vancouverensis*	Canada (Vancouver Island)	do	E	139	NA	NA
Marsupial, eastern jerboa	*Antechinomys laniger*	Australia	do	E	4	NA	NA
Marsupial-mouse, large desert	*Sminthopsis psammophila*	do	do	E	4	NA	NA
Marsupial-mouse, long-tailed	*Sminthopsis longicaudata*	do	do	E	4	NA	NA
Marten, Formosan yellow-throated	*Martes flavigula chrysospila*	Taiwan	do	E	3	NA	NA
Monkey, black colobus	*Colobus satanas*	Equatorial Guinea, People's Republic of Congo, Cameroon, Gabon.	do	E	16	NA	NA
Monkey, black howler	*Alouatta pigra*	Mexico, Guatemala, Belize	do	T	16	NA	17.40(c)
Monkey Diana	*Cercopithecus diana*	Coastal West Africa	do	E	16	NA	NA
Monkey, howler	*Alouatta palliata* (=*villosa*)	Mexico to South America	do	E	16	NA	NA
Monkey, L'hoest's	*Cercopithecus lhoesti*	Upper Eastern Congo Basin, Cameroon	do	E	16	NA	NA
Monkey, Preuss' red colobus	*Colobus badius preussi*	Cameroon	do	E	139	NA	NA
Monkey, proboscis	*Nasalis larvatus*	Borneo	do	E	15	NA	NA
Monkey, red-backed squirrel	*Saimiri oerstedii*	Costa Rica, Panama	do	E	3	NA	NA
Monkey, red-bellied	*Cercopithecus erythrogaster*	Western Nigeria	do	E	16	NA	NA
Monkey, red-eared nose-spotted	*Cercopithecus erythrotis*	Nigeria, Cameroon, Fernando Po	do	E	16	NA	NA
Monkey, spider	*Ateles geoffroyi frontatus*	Costa Rica, Nicaragua	do	E	3	NA	NA
Monkey, spider	*Ateles geoffroyi panamensis*	Costa Rica, Panama	do	E	3	NA	NA
Monkey, Tana River red colobus	*Colobus rufomitratus* (=*badius*) *rufomitratus*.	Kenya	do	E	3, 16	NA	NA
Monkey, woolly spider	*Brachyteles arachnoides*	Brazil	do	E	3	NA	NA
Monkey, yellow-tailed woolly	*Lagothrix flavicauda*	Andes of northern Peru	do	E	16	NA	NA
Monkey, Zanzibar red colobus	*Colobus kirki*	Tanzania	do	E	3	NA	NA
Mouse, Alabama beach	*Peromyscus polionotus ammobates*	U.S.A. (AL)	do	E	163	17.95(a)	NA
Mouse, Australian native	*Zyzomys* (=*Notomys*) *pedunculatus*	Australia	do	E	15	NA	NA
Mouse, Australian native	*Notomys aquilo*	do	do	E	15	NA	NA
Mouse, Choctawhatchee beach	*Peromyscus polionotus allophrys*	U.S.A. (FL)	do	E	163	17.95(a)	NA
Mouse, Field's	*Pseudomys fieldi*	Australia	do	E	4	NA	NA
Mouse, Gould's	*Pseudomys gouldii*	do	do	E	6	NA	NA
Mouse, Key Largo cotton	*Peromyscus gossypinus allapaticola*	U.S.A. (FL)	do	E	131E, 160	NA	NA
Mouse, New Holland	*Pseudomys novaehollandiae*	Australia	do	E	4	NA	NA
Mouse, Perdido Key beach	*Peromyscus polionotus trissyllepsis*	U.S.A. (AL, FL)	do	E	163	17.95(a)	NA
Mouse, salt marsh harvest	*Reithrodontomys raviventris*	U.S.A. (CA)	do	E	2	NA	NA
Mouse, Shark Bay	*Pseudomys praeconis*	Australia	do	E	4	NA	NA
Mouse, Shortridge's	*Pseudomys shortridgei*	do	do	E	4	NA	NA
Mouse, Smoky	*Pseudomys fumeus*	do	do	E	4	NA	NA
Mouse, western	*Pseudomys occidentalis*	do	do	E	4	NA	NA
Muntjac, Fea's	*Muntiacus feae*	Northern Thailand, Burma	do	E	50	NA	NA
Native-cat, eastern	*Dasyurus viverrinus*	Australia	do	E	6	NA	NA
Numbat	*Myrmecobius fasciatus*	do	do	E	4, 6	NA	NA
Ocelot	*Felis pardalis*	U.S.A. (AZ, TX) to C. and S. America	do	E	5, 119	NA	NA
Orangutan	*Pongo pygmaeus*	Borneo, Sumatra	do	E	3	NA	NA
Oryx, Arabian	*Oryx leucoryx*	Arabian Peninsula	do	E	3	NA	NA
Otter, Cameroon clawless	*Aonyx* (*Paraonyx*) *congica microdon*	Cameroon, Nigeria	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Otter, giant	*Pteronura brasiliensis*	South America	do	E	3	NA	NA
Otter, long-tailed	*Lutra longicaudis* (incl. *platensis*)	do	do	E	3, 15	NA	NA
Otter, marine	*Lutra felina*	Peru south to Straits of Magellan	do	E	15	NA	NA
Otter, southern river	*Lutra provocax*	Chile, Argentina	do	E	15	NA	NA
Otter, southern sea	*Enhydra lutris nereis*	West coast U.S.A. (WA, OR, CA) south to Mexico (Baja California).	do	T	21	NA	NA
Panda, giant	*Ailuropoda melanoleuca*	People's Republic of China	do	E	139	NA	NA
Pangolin (=scaly anteater)	*Manis temmincki*	Africa	do	E	15	NA	NA
Panther, Florida	*Felis concolor coryi*	U.S.A. (LA and AR east to SC and FL)	do	E	1	NA	NA
Planigale, little	*Planigale ingrami subtilissima* (formerly *P. subtilissima*).	Australia	do	E	4	NA	NA
Planigale, southern	*Planigale tenuirostris*	do	do	E	4	NA	NA
Porcupine, thin-spined	*Chaetomys subspinosus*	Brazil	do	E	3	NA	NA
Possum, Leadbeater's	*Gymnobelideus leadbeateri*	do	do	E	233	NA	NA
Possum, mountain pygmy	*Burramys parvus*	Australia	do	E	4	NA	NA
Possum, scaly-tailed	*Wyulda squamicaudata*	do	do	E	4	NA	NA
Prairie dog, Mexican	*Cynomys mexicanus*	Mexico	do	E	3	NA	NA
Prairie dog, Utah	*Cynomys parvidens*	U.S.A. (UT)	do	T	6, 146	NA	17.40(g)
Pronghorn, peninsular	*Antilocapra americana peninsularis*	Mexico (Baja California)	do	E	10	NA	NA
Pronghorn, Sonoran	*Antilocapra americana sonoriensis*	U.S.A. (AZ), Mexico	do	E	1, 3	NA	NA
Pudu	*Pudu pudu*	Southern South America	do	E	15	NA	NA
Puma, Costa Rican	*Felis concolor costaricensis*	Nicaragua, Panama, Costa Rica	do	E	15	NA	NA
Quokka	*Setonix brachyurus*	Australia	do	E	6	NA	NA
Rabbit, Ryukyu	*Pentalagus furnessi*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Rabbit, volcano	*Romerolagus diazi*	Mexico	do	E	3	NA	NA
Rat, false water	*Xeromys myoides*	Australia	do	E	4	NA	NA
Rat, Fresno kangaroo	*Dipodomys nitratoides exilis*	U.S.A. (CA)	do	E	170	17.95(e)	NA
Rat, Morro Bay kangaroo	*Dipodomys heermanni morroensis*	do	do	E	2	17.95(e)	NA
Rat, stick-nest	*Leporillus conditor*	Australia	do	E	6	NA	NA
Rat-kangaroo, brush-tailed	*Bettongia penicillata*	do	do	E	4	NA	NA
Rat-kangaroo, Gaimard's	*Bettongia gaimardi*	do	do	E	6	NA	NA
Rat-kangaroo, Lesueur's	*Bettongia lesueur*	do	do	E	4	NA	NA
Rat-kangaroo, plain	*Caloprymnus campestris*	do	do	E	4	NA	NA
Rat-kangaroo, Queensland	*Bettongia tropica*	do	do	E	4	NA	NA
Rhinoceros, black	*Diceros bicornis*	Sub-Saharan Africa	do	E	87	NA	NA
Rhinoceros, great Indian	*Rhinoceros unicornis*	India, Nepal	do	E	4	NA	NA
Rhinoceros, Javan	*Rhinoceros sondaicus*	Indonesia, Indochina, Burma, Thailand, Sikkim, Bangladesh, Malaysia.	do	E	3	NA	NA
Rhinoceros, northern white	*Ceratotherium simum cottoni*	Zaire, Sudan, Uganda, Central African Republic.	do	E	3	NA	NA
Rhinoceros, Sumatran	*Dicerorhinus* (=*Didermoceros*) *sumatrensis*.	Bangladesh to Vietnam to Indonesia (Borneo).	do	E	3	NA	NA
Saiga, Mongolian (antelope)	*Saiga tatarica mongolica*	Mongolia	do	E	15	NA	NA
Saki, southern bearded	*Chiropotes satanas satanas*	Brazil	do	E	233	NA	NA
Saki, white-nosed	*Chiropotes albinasus*	do	do	E	3	NA	NA
Seal, Caribbean monk	*Monachus tropicalis*	Caribbean Sea, Gulf of Mexico	do	E	1, 2, 45	NA	NA
Seal, Hawaiian monk	*Monachus schauinslandi*	U.S.A. (HI)	do	E	15	NA	NA
Seal, Mediterranean monk	*Monachus monachus*	Mediterranean, Northwest African Coast and Black Sea.	do	E	3	NA	NA
Seladang (=Gaur)	*Bos gaurus*	Bangladesh, Southeast Asia, India	do	E	3	NA	NA
Serow	*Capricornis sumatraensis*	East Asia, Sumatra	do	E	15	NA	NA
Serval, Barbary	*Felis serval constantina*	Algeria	do				
Sheep, [illegible]	*Ovis vignei vignei*	[illegible]					

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Saki, southern beared	*Chiropotes satanas satanas*	Brazil	do	E	833	NA	NA
Saki, white-nosed	*Chiropotes albinasus*	do	do	E	3	NA	NA
Seal, Caribbean monk	*Monachus tropicalis*	Caribbean Sea, Gulf of Mexico	do	E	1, 2, 45	NA	NA
Seal, Hawaiian monk	*Monachus schauinslandi*	U.S.A. (HI)	do	E	18	NA	NA
Seal, Mediterranean monk	*Monachus monachus*	Mediterranean, Northwest African Coast and Black Sea.	do	E	3	NA	NA
Seladang (=Gaur)	*Bos gaurus*	Bangladesh, Southeast Asia, India.	do	E	3	NA	NA
Serow	*Capricornis sumatraensis*	East Asia, Sumatra	do	E	15	NA	NA
Serval, Barbary	*Felis serval constantina*	Algeria	do	E	3	NA	NA
Shapo	*Ovis vignei vignei*	Kashmir	do	E	15	NA	NA
Shou	*Cervus elaphus wallichi*	Tibet, Bhutan	do	E	3	NA	NA
Shrew, Dismal Swamp southeastern	*Sorex longirostris fisheri*	U.S.A. (VA, NC)	do	T	246	NA	NA
Siamang	*Symphalangus syndactylus*	Malaysia, Indonesia	do	E	15	NA	NA
Sifakas	*Propithecus* spp. (all species)	Malagasy Republic (=Madagascar)	do	E	4	NA	NA
Sloth, Brazilian three-toed	*Bradypus torquatus*	Brazil	do	E	3, 4	NA	NA
Solenodon, Cuban	*Solenodon (Atopogale) cubanus*	Cuba	do	E	3	NA	NA
Solenodon, Haitian	*Solenodon paradoxus*	Dominican Republic, Haiti	do	E	3	NA	NA
Squirrel, Carolina northern flying	*Glaucomys sabrinus coloratus*	U.S.A. (NC, TN)	do	E	189	NA	NA
Squirrel, Delmarva Peninsula fox	*Sciurus niger cinereus*	U.S.A. (Delmarva Peninsula to southeast PA).	Entire, except Sussex Co., DE.	E	1, 151, 168	NA	NA
Do	do	do	U.S.A. (DE—Sussex County).	XN	151	NA	17.84(a)
Squirrel, Virginia northern flying	*Glaucomys sabrinus fuscus*	U.S.A. (VA, WV)	Entire	E	189	NA	NA
Stag, Barbary	*Cervus elaphus barbarus*	Tunisia, Algeria	do	E	3	NA	NA
Stag, Kashmir	*Cervus elaphus hangu*	Kashmir	do	E	3	NA	NA
Suni, Zanzibar	*Neotragus (Nesotragus) moschatus moschatus.*	Zanzibar (and nearby islands)	do	E	50	NA	NA
Tahr, Arabian	*Hemitragus jayakari*	Oman	do	E	50	NA	NA
Tamaraw	*Bubalus mindorensis*	Philippines	do	E	4	NA	NA
Tamarin, golden-rumped (=golden-headed Tamarin; =golden-lion Marmoset).	*Leontopithecus (=Leontideus)* spp. (all species).	Brazil	do	E	3	NA	NA
Tamarin, piled	*Saguinus bicolor*	do	do	E	16	NA	NA
Tamarin, white-footed	*Saguinus leucopus*	Colombia	do	T	16	NA	17.40(c)
Tapir, Asian	*Tapirus indicus*	Burma, Laos, Cambodia, Vietnam, Malaysia, Indonesia, Thailand.	do	E	15	NA	NA
Tapir, Brazilian	*Tapirus terrestris*	Colombia and Venezuela south to Paraguay and Argentina.	do	E	3	NA	NA
Tapir, Central American	*Tapirus bairdii*	Southern Mexico to Colombia and Ecuador.	do	E	3	NA	NA
Tapir, mountain	*Tapirus pinchaque*	Colombia, Ecuador and possibly Peru and Venezuela.	do	E	3	NA	NA
Tarsier, Philippine	*Tarsius syrichta*	Philippines	do	T	16	NA	17.40(c)
Tiger	*Panthera tigris*	Temperate and Tropical Asia	do	E	3, 5	NA	NA
Tiger, Tasmanian (=Thylacine)	*Thylacinus cynocephalus*	Australia	do	E	3	NA	NA
Uakari (all species)	*Cacajao* spp. (all species)	Peru, Brazil, Ecuador, Colombia, Venezuela.	do	E	3	NA	NA
Urial	*Ovis musimon (=orientalis) ophion*	Cyprus	do	E	15	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Vicuna	*Vicugna vicugna*	South America (Andes)	do	E	3	NA	NA
Vole, Amargosa	*Microtus californicus scirpensis*	U.S.A. (CA)	do	E	166	17.95(a)	NA
Wallaby, banded hare	*Lagostrophus fasciatus*	Australia	do	E	4	NA	NA
Wallaby, brindled nail-tailed	*Onychogalea fraenata*	do	do	E	4	NA	NA
Wallaby, crescent nail-tailed	*Onychogalea lunata*	do	do	E	4	NA	NA
Wallaby, Parma	*Macropus parma*	do	do	E	4	NA	NA
Wallaby, Western hare	*Lagorchestes hirsutus*	do	do	E	4	NA	NA
Wallaby, yellow-footed rock	*Petrogale xanthopus*	do	do	E	8	NA	NA
Whale, blue	*Balaenoptera musculus*	Oceanic	do	E	3	NA	NA
Whale, bowhead	*Balaena mysticetus*	Oceanic (north latitudes only)	do	E	3	NA	NA
Whale, finback	*Balaenoptera physalus*	Oceanic	do	E	3	NA	NA
Whale, gray	*Eschrichtius robustus*	North Pacific Ocean: coastal and Bering Sea	do	E	3	NA	NA
Whale, humpback	*Megaptera novaeangliae*	Oceanic	do	E	3	NA	NA
Whale, right	*Balaena glacialis*	do	do	E	3	NA	NA
Whale, Sei	*Balaenoptera borealis*	do	do	E	3	NA	NA
Whale, sperm	*Physeter catodon*	do	do	E	3	NA	NA
Wolf, gray	*Canis lupus*	Holarctic	U.S.A. (48 conterminous States, except MN), Mexico.	E	1, 6, 13, 15, 35	17.95(a)	NA
Do	do	do	U.S.A. (MN)	T	35	17.95(a)	17.40(d)
Wolf, maned	*Chrysocyon brachyurus*	Argentina, Bolivia, Brazil, Paraguay, Uruguay.	Entire	E	4	NA	NA
Wolf, red	*Canis rufus*	U.S.A. (southeastern U.S.A. west to central TX).	do	E	1	NA	NA
Wombat, hairy-nosed (=Barnard's and Queensland hairy-nosed).	*Lasiorhinus krefftii* (formerly *L. barnardi* and *L. gillespiei*).	Australia	do	E	4, 6	NA	NA
Woodrat, Key Largo	*Neotoma floridana smalli*	U.S.A. (FL)	do	E	131E, 160	NA	NA
Yak, wild	*Bos grunniens*	China (Tibet), India	do	E	3	NA	NA
Zebra, Grevy's	*Equus grevyi*	Kenya, Ethiopia, Somalia	do	T	54	NA	NA
Zebra, Hartmann's mountain	*Equus zebra hartmannae*	Namibia, Angola	do	T	54, 111	NA	NA
Zebra, mountain	*Equus zebra zebra*	South Africa	do	E	16, 111	NA	NA
BIRDS							
Akepa, Hawaii (honeycreeper)	*Loxops coccineus coccineus*	U.S.A. (HI)	do	E	2	NA	NA
Akepa, Maui (honeycreeper)	*Loxops coccineus ochraceus*	do	do	E	2	NA	NA
Akiaola, Kauai (honeycreeper)	*Hemignathus procerus*	do	do	E	1	NA	NA
Akiapolaau (honeycreeper)	*Hemignathus munroi* (=*wilsoni*)	do	do	E	1	NA	NA
Albatross, short-tailed	*Diomedea albatrus*	North Pacific Ocean: Japan, U.S.S.R., U.S.A. (AK, CA, HI, OR, WA).	Entire, except U.S.A.	E	3	NA	NA
Blackbird, yellow-shouldered	*Agelaius xanthomus*	U.S.A. (PR)	Entire	E	17	17.95(b)	NA

Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	U.S.A. (AZ), Mexico (Sonora)	do	E	1, 3	NA	NA
Booby, Abbott's	*Sula abbotti*	Indian Ocean: Christmas Island	do	E	15	NA	NA
Bristlebird, western	*Dasyornis brachypterus longirostris*	Australia	do	E	3	NA	NA
Bristlebird, western rufous	*Dasyornis broadbenti litoralis*	do	do	E	15	NA	NA
Broadbill, Guam	*Myiagra freycinet*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Bulbul, Mauritius olivaceous	*Hypsipetes borbonicus olivaceus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Bullfinch, Sao Miguel (finch)	*Pyrrhula pyrrhula murina*	Eastern Atlantic Ocean: Azores	do	E	9	NA	NA
Bushwren, New Zealand	*Xenicus longipes*	New Zealand					
Bustard, great Indian							

Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	A (AZ), Mexico (Sonora)	do	E	1, 3	NA	NA
Booby, Abbott's	*Sula abbotti*	in Ocean: Christmas Island	do	E	15	NA	NA
Bristlebird, western	*Dasyornis brachypterus longirostris*	Australia	do	E	3	NA	NA
Bristlebird, western rufous	*Dasyornis broadbenti litoralis*	do	do	E	15	NA	NA
Broadbill, Guam	*Myiagra freycinet*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Bulbul, Mauritius olivaceous	*Hypsipetes borbonicus olivaceus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Bullfinch, Sao Miguel (finch)	*Pyrrhula pyrrhula murina*	Eastern Atlantic Ocean: Azores	do	E	3	NA	NA
Bushwren, New Zealand	*Xenicus longipes*	New Zealand	do	E	3	NA	NA
Bustard, great Indian	*Choriotis nigriceps*	India, Pakistan	do	E	3	NA	NA
Cahow (=Bermuda Petrel)	*Pterodroma cahow*	North Atlantic Ocean: Bermuda	do	E	3	NA	NA
Condor, Andean	*Vultur gryphus*	Colombia to Chile and Argentina	do	E	4	NA	NA
Condor, California	*Gymnogyps californianus*	U.S.A. (OR, CA), Mexico (Baja California)	do	E	1	17.95(b)	NA
Coot, Hawaiian (=alae keo keo)	*Fulica americana alai*	U.S.A. (HI)	do	E	2	NA	NA
Cotinga, banded	*Cotinga maculata*	Brazil	do	E	15	NA	NA
Cotinga, white-winged	*Xipholena atropurpurea*	do	do	E	15	NA	NA
Crane, black-necked	*Grus nigricollis*	China (Tibet)	do	E	15	NA	NA
Crane, Cuba sandhill	*Grus canadensis nesiotes*	West Indies: Cuba	do	E	15	NA	NA
Crane, hooded	*Grus monacha*	Japan, U.S.S.R	do	E	4	NA	NA
Crane, Japanese	*Grus japonensis*	China, Japan, Korea, U.S.S.R	do	E	3	NA	NA
Crane, Mississippi sandhill	*Grus canadensis pulla*	U.S.A. (MS)	do	E	8	17.95(b)	NA
Crane, Siberian white	*Grus leucogeranus*	U.S.S.R. (Siberia) to India, including Iran and China.	do	E	4	NA	NA
Crane, white-naped	*Grus vipio*	Mongolia	do	E	15	NA	NA
Crane, whooping	*Grus americana*	Canada, U.S.A. (Rocky Mountains east to Carolinas), Mexico.	do	E	1, 3	17.95(b)	NA
Creeper, Hawaii	*Oreomystis (=Loxops) mana*	U.S.A. (HI)	do	E	10	NA	NA
Creeper, Molokai (=kakawahie)	*Paroreomyza (=Oreomystis, =Loxops) flammea.*	do	do	E	2	NA	NA
Creeper, Oahu (=alauwahio)	*Paroreomyza (=Oreomystis, =Loxops) maculata.*	do	do	E	2	NA	NA
Crow, Hawaiian (='alala)	*Corvus hawaiiensis (=tropicus)*	do	do	E	1	NA	NA
Crow, Mariana	*Corvus kubaryi*	Western Pacific Ocean: U.S.A. (Guam, Rota).	do	E	156	NA	NA
Cuckoo-shrike, Mauritius	*Coracina (=Coracina) typica*	Indian Ocean: Mauritius	do	E	3	NA	NA
Cuckoo-shrike, Reunion	*Coracina (=Coracina) newtoni*	Indian Ocean: Reunion	do	E	3	NA	NA
Curassow, razor-billed	*Mitu (=Crax) mitu mitu*	Brazil (Eastern)	do	E	15	NA	NA
Curassow, red-billed	*Crax blumenbachii*	Brazil	do	E	4	NA	NA
Curassow, Trinidad white-headed	*Pipile pipile pipile*	West Indies: Trinidad	do	E	3	NA	NA
Curlew, Eskimo	*Numenius borealis*	Alaska and northern Canada to Argentina	do	E	1, 3	NA	NA
Dove, cloven-feathered	*Drepanoptila holosericea*	Southwest Pacific Ocean: New Caledonia	do	E	3	NA	NA
Dove, Grenada grey-fronted	*Leptotila rufaxilla wellsi*	West Indies: Grenada	do	E	3	NA	NA
Duck, Hawaiian (=koloa)	*Anas wyvilliana*	U.S.A. (HI)	do	E	1	NA	NA
Duck, Laysan	*Anas laysanensis*	do	do	E	1	NA	NA
Duck, pink-headed	*Rhodonessa caryophyllacea*	India	do	E	15	NA	NA
Duck, white-winged wood	*Cairina scutulata*	India, Malaysia, Indonesia, Thailand	do	E	3	NA	NA

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GABLE BUTTE QUADRANGLE
WASHINGTON–BENTON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983. MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°52' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 86 meters east)

There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map

No distinction made between houses, barns, and other buildings

NORTH

SCALE 1:24 000

KILOMETERS
METERS
MILES
FEET

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

WASHINGTON

QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Vernita Bridge
2 Coyote Rapids
3 Locke Island
4 Riverland
5 Hanford
6 Snively Basin
7 Iowa Flats
8 Horn Rapids Dam

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND

Improved Road
Unimproved Road
Trail

Interstate Route U.S. Route State Route

GABLE BUTTE, WASH.

PROVISIONAL EDITION 1986

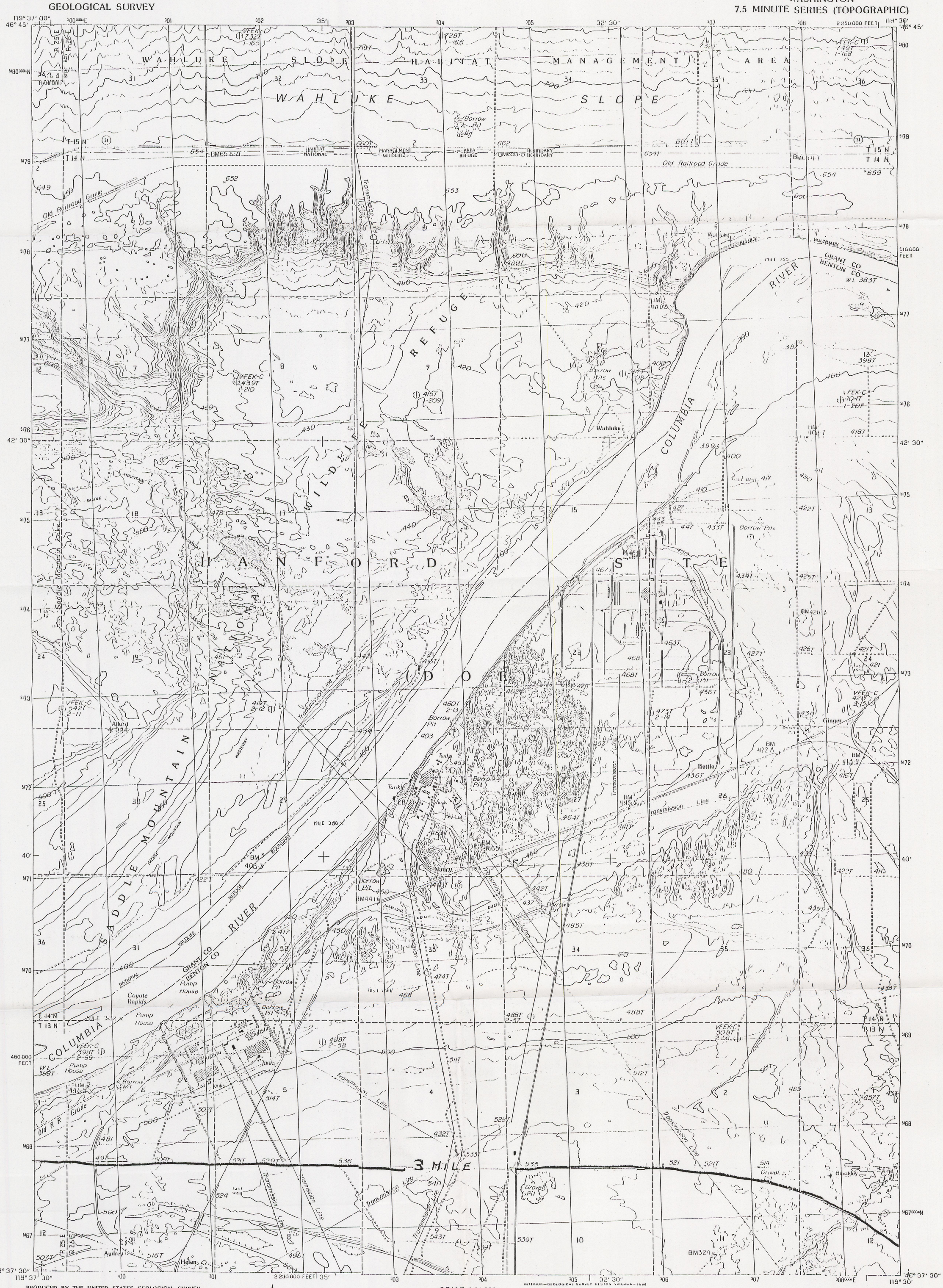
46119-E5-TP-024

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1986

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COYOTE RAPIDS QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°52' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

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No distinction made between houses, barns, and other buildings

NORTH

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

WASHINGTON
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Smyrna
2 Wahatis Peak
3 Corfu
4 Vernita Bridge
5 Locke Island
6 Riverland
7 Gable Butte
8 Hanford

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
Interstate Route U.S. Route State Route

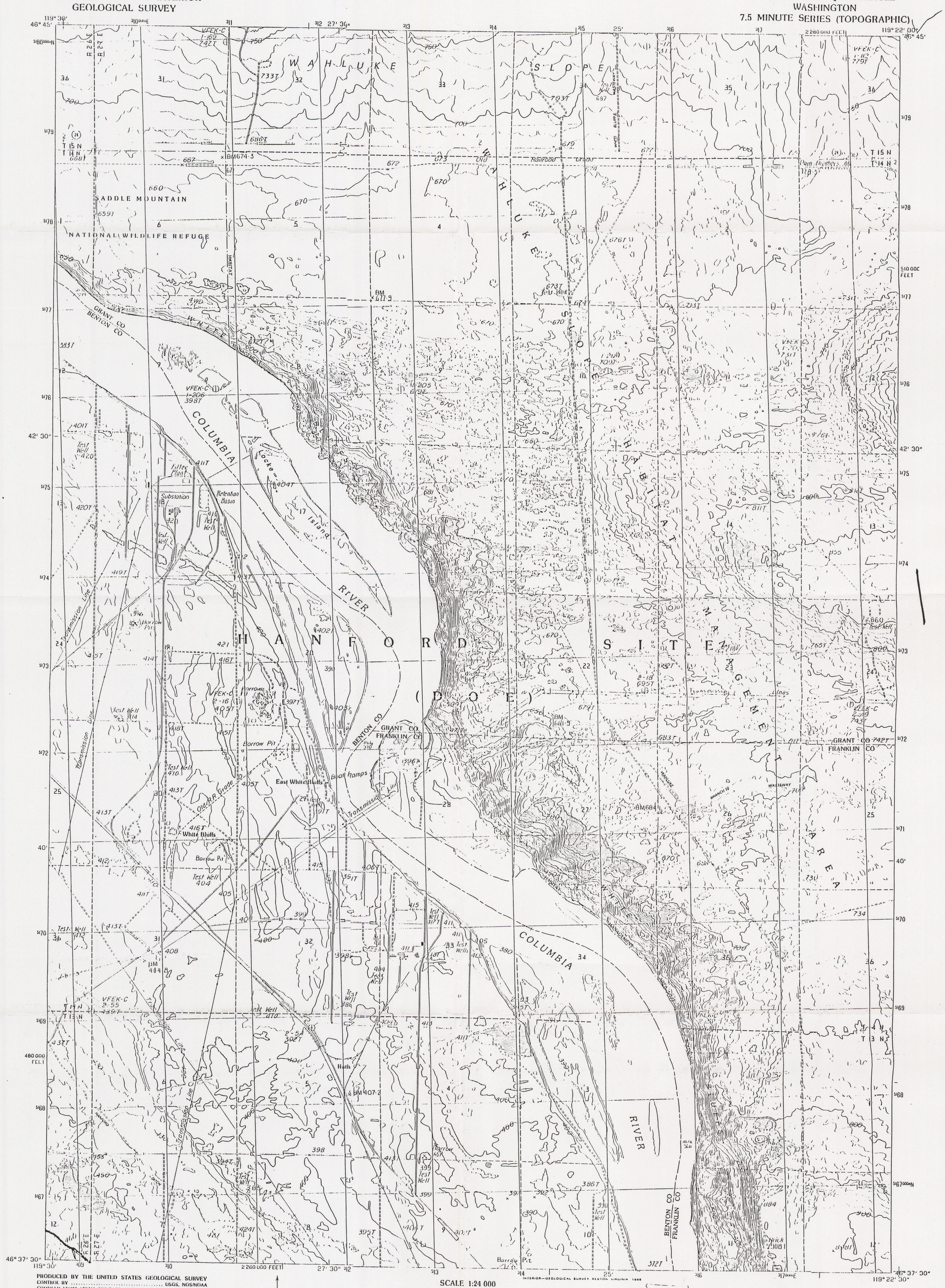
COYOTE RAPIDS, WASH.
PROVISIONAL EDITION 1986

46119-F5-TF-024

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOCKE ISLAND QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)



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CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ... ZONE 11
10,000-FOOT STATE GRID TICKS .... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°46' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 86 meters east)

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No distinction made between houses, barns, and other buildings

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

NORTH

SCALE 1:24 000

KILOMETERS 0 1 2
METERS 0 1000 2000
MILES 0 1 2
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

WASHINGTON
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Wahatis Peak
2 Corfu
3 Taunton
4 Coyote Rapids
5 Hanford NE
6 Gable Butte
7 Hanford
8 Savage Island

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
Interstate Route
U.S. Route
State Route

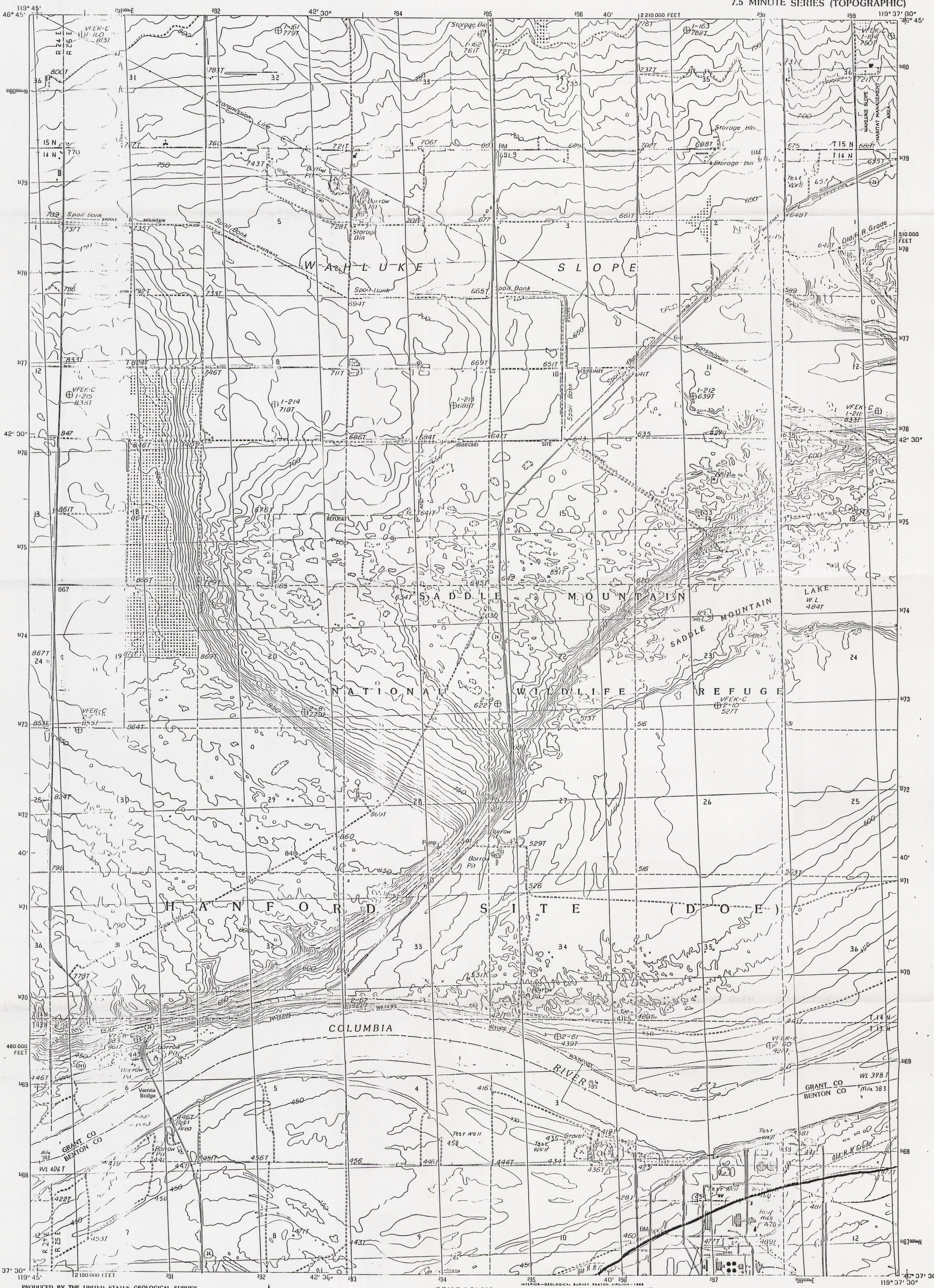
LOCKE ISLAND, WASH.
PROVISIONAL EDITION 1986

46119-F4-TF-024

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

VERNITA BRIDGE QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983. MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°57' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

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No distinction made between houses, barns, and other buildings

NORTH

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 500 0 1000 2000
MILES .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

WASHINGTON

QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Beverly SE
2 Smyrna
3 Wahatis Peak
4 Priest Rapids NE
5 Coyote Rapids
6 Emerson Nipple
7 Riverland
8 Gable Butte

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND

Improved Road
Unimproved Road
Trail
Interstate Route U.S. Route State Route

VERNITA BRIDGE, WASH.

PROVISIONAL EDITION 1986

46119-F6-TF-024

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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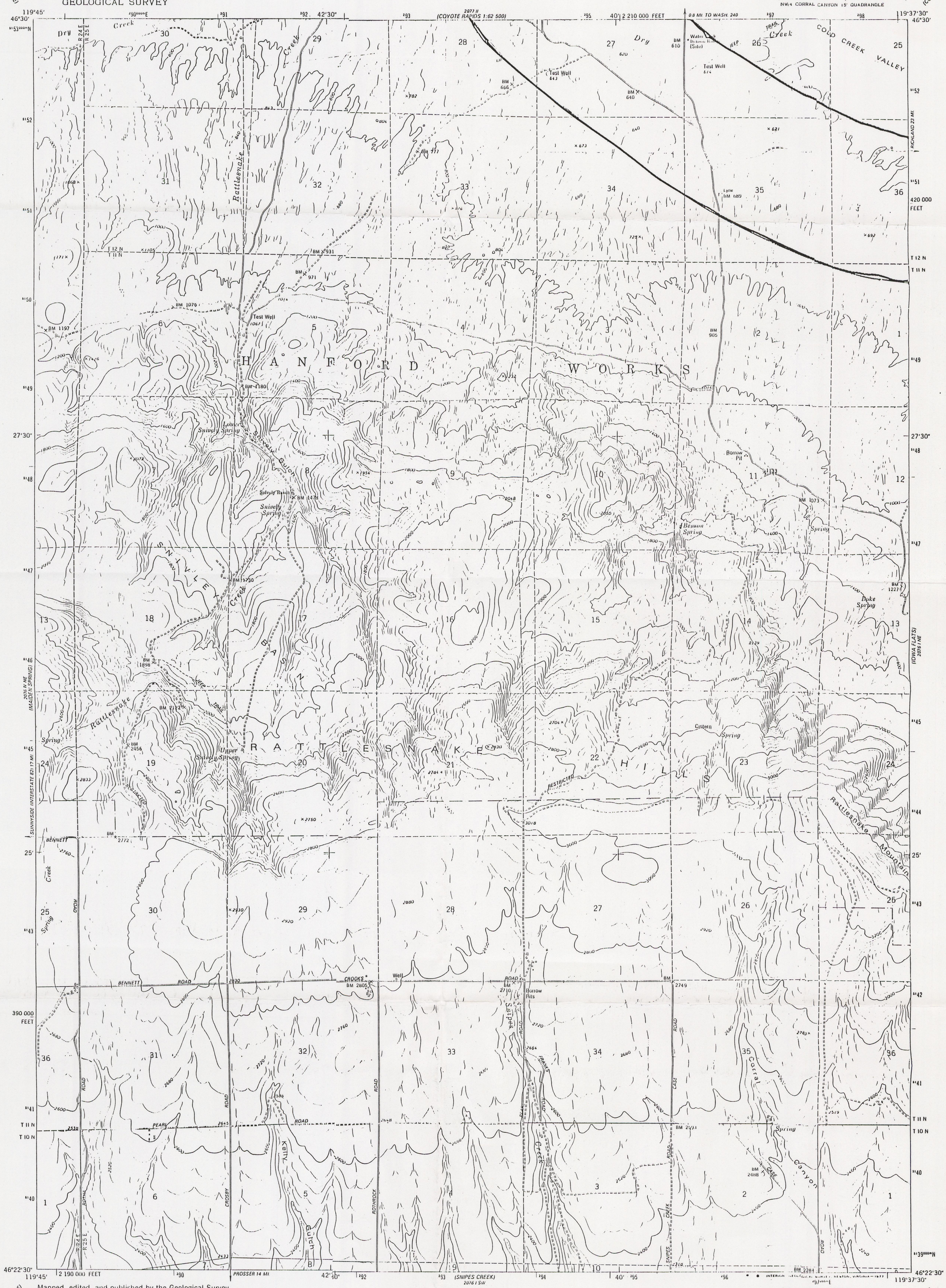
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SNIVELY BASIN QUADRANGLE

WASHINGTON—BENTON CO.

7.5 MINUTE SERIES (TOPOGRAPHIC)

NW/4 CORRAL CANYON 15' QUADRANGLE



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

Certain land lines are omitted because of insufficient data

UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U S Route — State Route

SNIVELY BASIN, WASH.
NW/4 CORRAL CANYON 15' QUADRANGLE
N4622.5—W11937.5/7.5

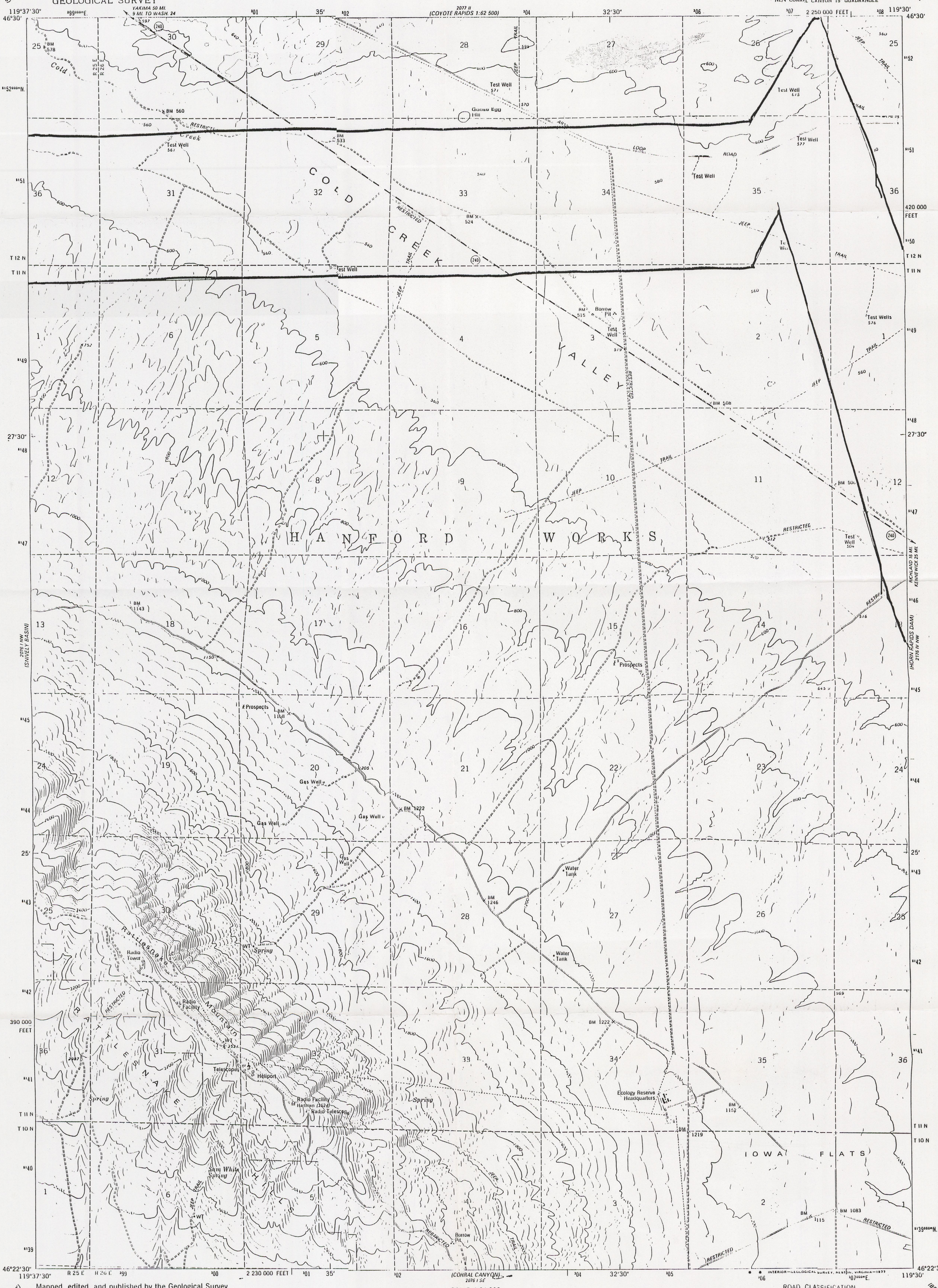
1974

AMS 2076 I NW—SERIES V881

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

IOWA FLATS QUADRANGLE

WASHINGTON—BENTON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 CORRAL CANYON 15' QUADRANGLE



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-metre Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

IOWA FLATS, WASH.
NE/4 CORRAL CANYON 15' QUADRANGLE
N4622.5—W11930/7.5

1974

AMS 2076 I NE—SERIES V891

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

RIVERLAND QUADRANGLE
WASHINGTON – BENTON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000 METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°57' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 87 meters east)

There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map

No distinction made between houses, barns, and other buildings

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

NORTH

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1986

WASHINGTON
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Priest Rapids NE
2 Vernita Bridge
3 Coyote Rapids
4 Emerson Nipple
5 Gable Butte
6 Malden Spring
7 Snively Basin
8 Iowa Flats

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
Interstate Route
U.S. Route
State Route

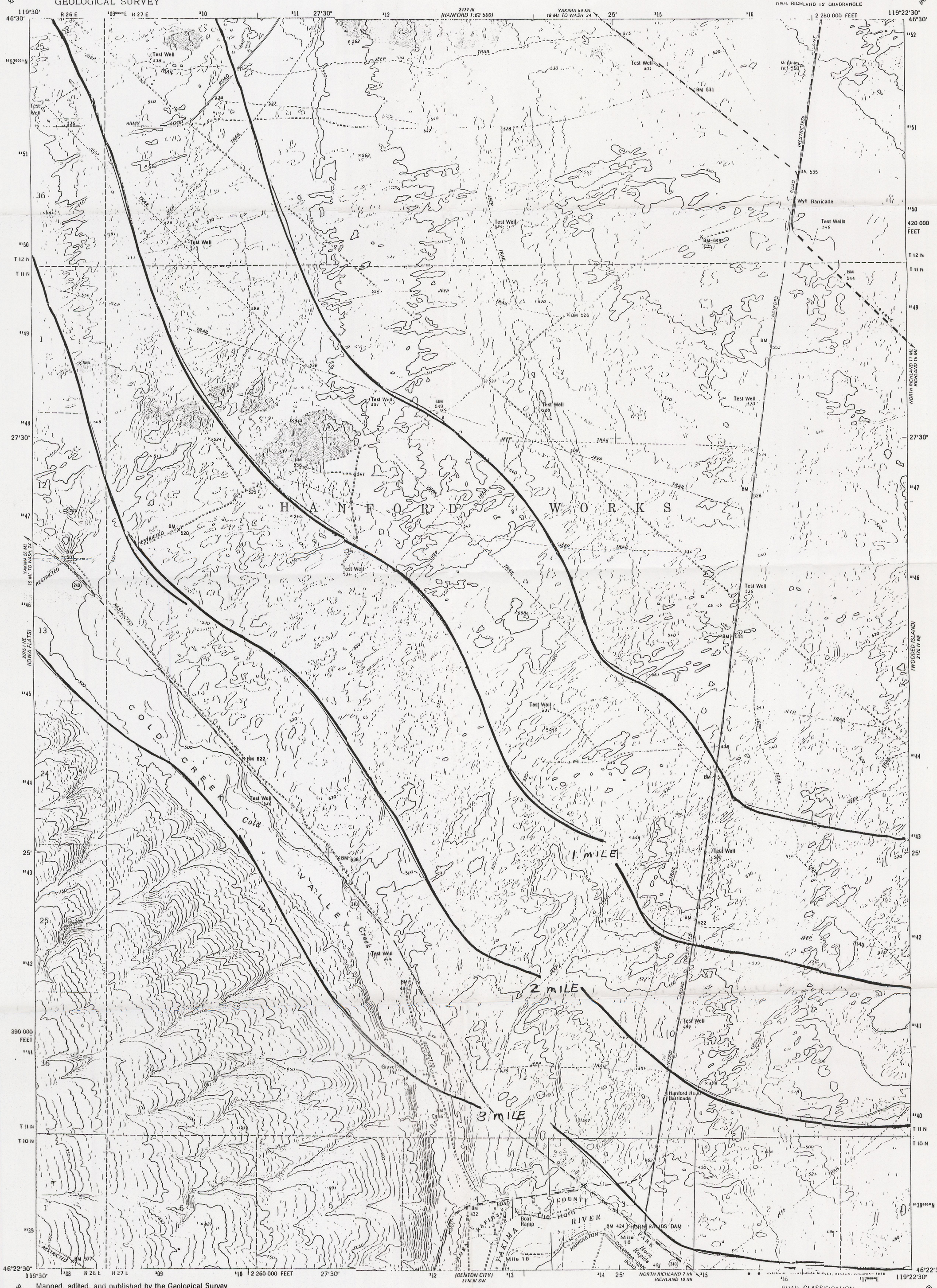
RIVERLAND, WASH.
PROVISIONAL EDITION 1986

46119-E6-TF-024

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HORN RAPIDS DAM QUADRANGLE

WASHINGTON—BENTON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 RICHLAND 15' QUADRANGLE



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974. Map edited 1977

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

Certain land lines are omitted because of insufficient data

GN MN 1°46' 31 MILS 20½° 364 MILS

UTM GRID AND 1977 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

WASHINGTON
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

HORN RAPIDS DAM, WASH.
NW/4 RICHLAND 15' QUADRANGLE
N46 22.5'—W119 22.5'/7.5

1977

AMS 2176 IV NW—SERIES V891

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

RICHLAND QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE/4 RICHLAND 15' QUADRANGLE

Mapped, edited, and published by the Geological Survey

Control by USGS, NOS/NOAA, and USCE

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974. Map edited 1978

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Red tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs.
This information is unchecked

GN MN 1°40' 30 MILS 20½° 364 MILS

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 MILE | 1000 0 1000 2000 3000 4000 5000 6000 7000 FEET | 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

WASHINGTON
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U S Route — State Route

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

RICHLAND, WASH.
SE/4 RICHLAND 15' QUADRANGLE
N4615—W11915/7.5

1978

AMS 2176 IV SE—SERIES V891

2
36122

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WOODED ISLAND QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 RICHLAND 15' QUADRANGLE

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974. Map edited 1978

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

Certain land lines are omitted because of insufficient data

All roads in Hanford Works are restricted

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

WOODED ISLAND, WASH.
NE/4 RICHLAND 15' QUADRANGLE
N4622.5—W11915/7.5

1978

AMS 2176 IV NE—SERIES V891

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COLUMBIA POINT QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 ELTOPIA 15' QUADRANGLE

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1974. Map edited 1978

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

GN MN
1°35' 28 MILS
20° 356 MILS
UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

WASHINGTON
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface	Light-duty road, hard or improved surface
Secondary highway, hard surface	Unimproved road
( ) Interstate Route ( ) U. S. Route	( ) State Route

COLUMBIA POINT, WASH.
SW/4 ELTOPIA 15' QUADRANGLE
N4615—W11907.5/7.5

1978

AMS 2176 I SW—SERIES V891

2
36122

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HANFORD QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)

PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 10
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°46' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 86 meters east)

There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map

No distinction made between houses, barns, and other buildings

All roads on this map are restricted.

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography. 1

NORTH

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

WASHINGTON
QUADRANGLE LOCATION

CONTOUR INTERVAL 10 FEET
CONTOUR ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

1	2	3
4		5
6	7	8

1 Coyote Rapids
2 Locke Island
3 Hanford NE
4 Gable Butte
5 Savage Island
6 Iowa Flats
7 Horn Rapids Dam
8 Wooded Island

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
Interstate Route U.S. Route State Route

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

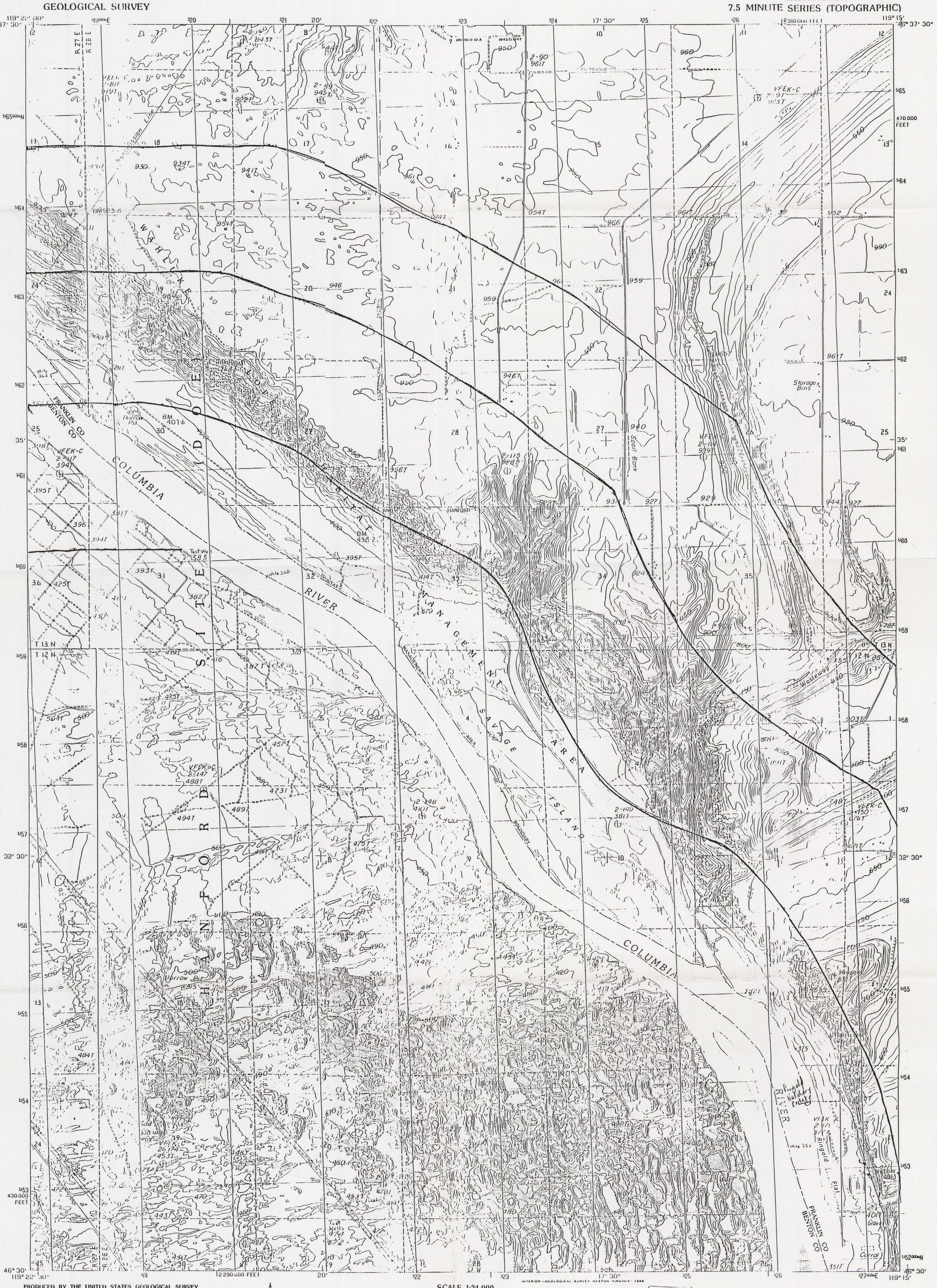
INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1986

HANFORD, WASH.
PROVISIONAL EDITION 1986

46119-E4-TF-024

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SAVAGE ISLAND QUADRANGLE
WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1983 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°41' WEST
1980 MAGNETIC NORTH DECLINATION ..... 20° EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM

To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 86 meters east)

There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map

No distinction made between houses, barns, and other buildings

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography.

NORTH

SCALE 1:24 000

KILOMETERS 1 .5 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 FOOT
OTHER ELEVATIONS SHOWN TO THE NEAREST FOOT

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

WASHINGTON
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Locke Island
2 Hanford NE
3 Eagle Lakes
4 Hanford
5 Basin City
6 Horn Rapids Dam
7 Wooded Island
8 Mathews Corner

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
Interstate Route U.S. Route State Route

SAVAGE ISLAND, WASH.
PROVISIONAL EDITION 1986

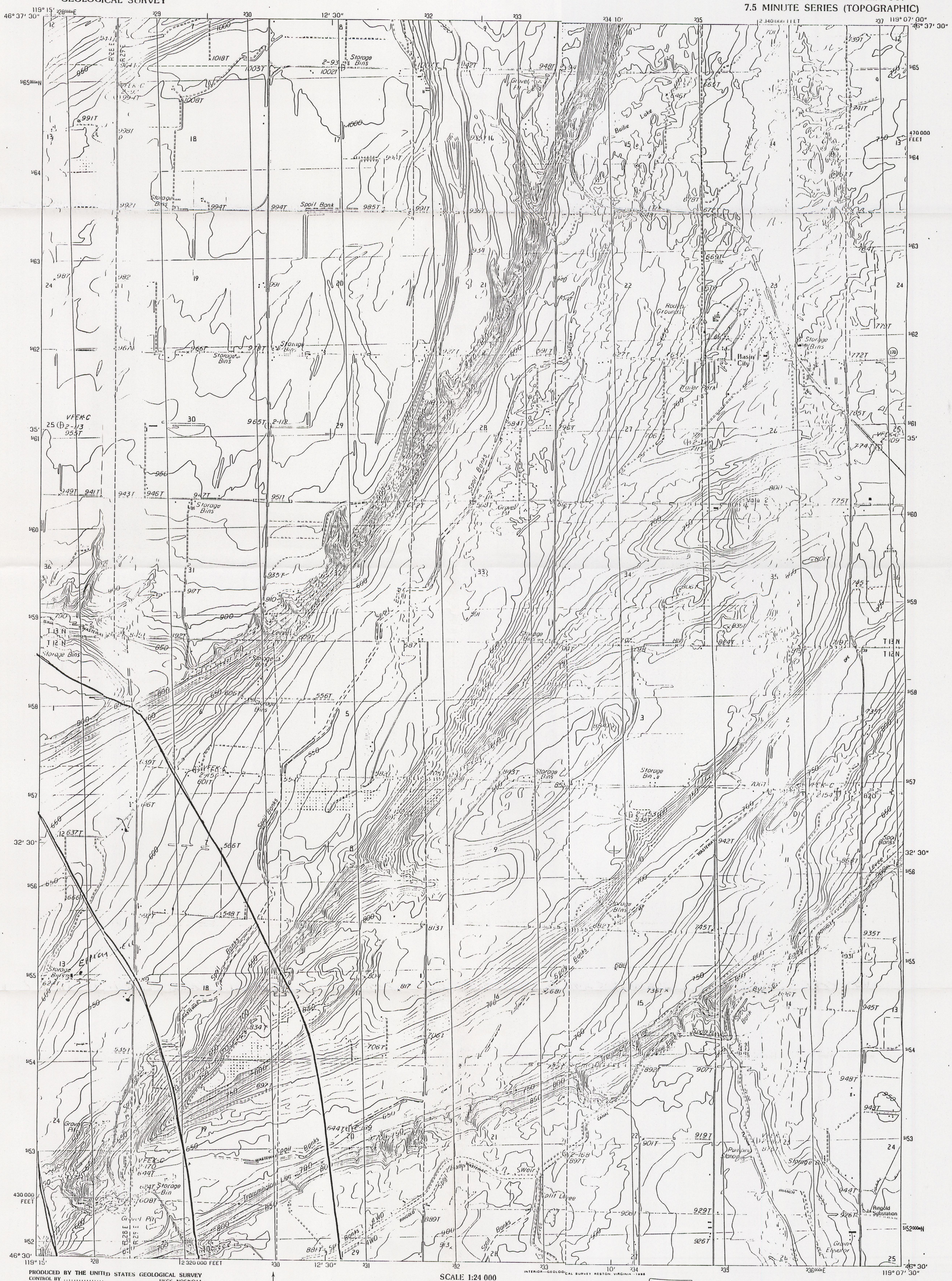
AA119.F3.TE.094

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1986

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BASIN CITY QUADRANGLE
WASHINGTON–FRANKLIN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



PRODUCED BY THE UNITED STATES GEOLOGICAL SURVEY
CONTROL BY ..... USGS, NOS/NOAA
COMPILED FROM AERIAL PHOTOGRAPHS TAKEN 1982
FIELD CHECKED ..... 1982 MAP EDITED 1986
PROJECTION ..... LAMBERT CONFORMAL CONIC
GRID: 1000-METER UNIVERSAL TRANSVERSE MERCATOR ..... ZONE 11
10,000-FOOT STATE GRID TICKS ..... WASHINGTON, SOUTH ZONE
UTM GRID DECLINATION ..... 1°35' WEST
1980 MAGNETIC NORTH DECLINATION ..... 19°30' EAST
VERTICAL DATUM ... NATIONAL GEODETIC VERTICAL DATUM OF 1929
HORIZONTAL DATUM ..... 1927 NORTH AMERICAN DATUM
To place on the predicted North American Datum of 1983, move the projection lines as shown by dashed corner ticks (19 meters north / 85 meters east)
There may be private inholdings within the boundaries of any Federal and State Reservations shown on this map
No distinction made between houses, barns, and other buildings

NORTH

SCALE 1:24 000

KILOMETERS 1 0 1 2
METERS 1000 0 1000 2000
MILES 1 .5 0 1
FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000

CONTOUR INTERVAL 10 FEET

To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

PROVISIONAL MAP
Produced from original manuscript drawings. Information shown as of date of photography. 1

WASHINGTON
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Hanford NE
2 Eagle Lakes
3 Scooteney Reservoir
4 Savage Island
5 Mesa West
6 Wooded Island
7 Mathews Corner
8 Ethola

ADJOINING 7.5' QUADRANGLE NAMES

ROAD LEGEND
Improved Road
Unimproved Road
Trail
( ) Interstate Route [ ] U.S. Route ( ) State Route

BASIN CITY, WASH.
PROVISIONAL EDITION 1986
46119-E2-TF-024

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MATHEWS CORNER QUADRANGLE

WASHINGTON–FRANKLIN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 ELTOPIA 15' QUADRANGLE

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1973. Field checked 1975

Projection and 10,000-foot grid ticks: Washington coordinate system, south zone (Lambert conformal conic)
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs
This information is unchecked

UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
GN — MN — 1°35' 28 MILS — 20½° 364 MILS

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

WASHINGTON
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route

MATHEWS CORNER, WASH.
NW/4 ELTOPIA 15' QUADRANGLE
N4622.5—W11907.5/7.5

1975

AMS 2176 I NW—SERIES V891

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Eagle, bald	*Haliaeetus leucocephalus*	North America south to northern Mexico	U.S.A. (conterminous States, except WA, OR, MN, WI, MI).	E	1, 34	NA	NA
Do	do	do	U.S.A. (WA, OR, MN, WI, MI).	T	34	NA	17.41(a)
Eagle, Greenland white-tailed	*Haliaeetus albicilla groenlandicus*	Greenland and adjacent Atlantic islands	do	E	15	NA	NA
Eagle, harpy	*Harpia harpyja*	Mexico south to Argentina	do	E	15	NA	NA
Eagle, Philippine (=monkey-eating)	*Pithecophaga jefferyi*	Philippines	do	E	3	NA	NA
Eagle, Spanish imperial	*Aquila heliaca adalberti*	Spain, Morocco, Algeria	Entire	E	3	NA	NA
Egret, Chinese	*Egretta eulophotes*	China, Korea	do	E	3	NA	NA
Falcon, American peregrine	*Falco peregrinus anatum*	Nests from central Alaska across north-central Canada to central Mexico, winters south to South America.	do	E	2, 3, 145	17.95(b)	NA
Falcon, Arctic peregrine	*Falco peregrinus tundrius*	Nests from northern Alaska to Greenland; winters south to Central and South America.	do	T	2, 3, 145	NA	NA
Falcon, Eurasian peregrine	*Falco peregrinus peregrinus*	Europe, Eurasia south to Africa and Mid-east.	do	E	15	NA	NA
Falcon, northern aplomado	*Falco femoralis septentrionalis*	U.S.A. (AZ, NM, TX), Mexico, Guatemala	do	E	216	NA	NA
Falcon, peregrine	*Falco peregrinus*	Worldwide, except Antarctica and most Pacific Islands.	Wherever found in wild in the conterminous 48 States.	E(S/A)	145	NA	NA
Finch, Laysan (honeycreeper)	*Telespyza (=Psittirostra) cantans*	U.S.A. (HI)	Entire	E	1	NA	NA
Finch, Nihoa (honeycreeper)	*Telespyza (=Psittirostra) ultima*	do	do	E	1	NA	NA
Flycatcher, Euler's	*Empidonax euleri johnstonei*	West Indies: Grenada	do	E	3	NA	NA
Flycatcher, Seychelles paradise	*Terpsiphone corvina*	Indian Ocean: Seychelles	do	E	3	NA	NA
Flycatcher, Tahiti	*Pomarea nigra*	South Pacific Ocean: Tahiti	do	E	3	NA	NA
Fody, Seychelles (weaver-finch)	*Foudia sechellarum*	Indian Ocean: Seychelles	do	E	3	NA	NA
Frigatebird, Andrew's	*Fregata andrewsi*	East Indian Ocean	do	E	15	NA	NA
Goose, Aleutian Canada	*Branta canadensis leucopareia*	U.S.A. (AK, CA, OR, WA), Japan	do	E	1, 3	NA	NA
Goose, Hawaiian (=nene)	*Nesochen (=Branta) sandvicensis*	U.S.A. (HI)	do	E	1	NA	NA
Goshawk, Christmas Island	*Accipiter fasciatus natalis*	Indian Ocean: Christmas Island	do	E	3	NA	NA
Grackle, slender-billed	*Quiscalus (=Cassidix) palustris*	Mexico	do	E	3	NA	NA
Grasswren, Eyrean (flycatcher)	*Amytornis goyderi*	Australia	do	E	3	NA	NA
Grebe, Atitlan	*Podilymbus gigas*	Guatemala	do	E	3	NA	NA
Greenshank, Nordmann's	*Tringa guttifer*	U.S.S.R., Japan, south to Malaya, Borneo	do	E	15	NA	NA
Guan, horned	*Oreophasis derbianus*	Guatemala, Mexico	do	E	3	NA	NA
Gull, Audouin's	*Larus audouini*	Mediterranean Sea	do	E	3	NA	NA
Gull, relict	*Larus relictus*	India, China	do	E	15	NA	NA
Hawk, Anjouan Island sparrow	*Accipiter francesii pusillus*	Indian Ocean: Comoro Islands	do	E	3	NA	NA
Hawk, Galapagos	*Buteo galapagoensis*	Ecuador (Galapagos Islands)	do	E	3	NA	NA
Hawk, Hawaiian (=io)	*Buteo solitarius*	U.S.A. (HI)	do	E	1	NA	NA
Hermit, hook-billed (hummingbird)	*Glaucis (=Ramphodon) dohrnii*	Brazil	do	E	15	NA	NA
Honeycreeper, crested (='akohekohe)	*Palmeria dolei*	U.S.A. (HI)	do	E	1	NA	NA
Hornbill, helmeted	*Rhinoplax vigil*	Thailand, Malaysia	do	E	15	NA	NA
Honeyeater, helmeted	*Meliphaga cassidix*	Australia	do	E	4	NA	NA
Ibis, Japanese crested	*Nipponia nippon*	China, Japan, U.S.S.R., Korea	do	E	3	NA	NA
Kagu	*Rhynochetos jubatus*	South Pacific Ocean: New Caledonia	do	E	3	NA	NA
Kakapo (=owl-parrot)	*Strigops habroptilus*	New Zealand	do	E	3	NA	NA

Gull, relict	*Larus relictus*	India, China	do	E	10	NA	NA
Hawk, Anjouan Island sparrow	*Accipiter francesii pusillus*	Indian Ocean: Islands	do	E	3	NA	NA
Hawk, Galapagos	*Buteo galapagoensis*	Ecuador (Galapagos Islands)	do	E	3	NA	NA
Hawk, Hawaiian (=Io)	*Buteo solitarius*	U.S.A. (HI)	do	E	1	NA	NA
Hermit, hook-billed (hummingbird)	*Glaucis (=Ramphodon) dohrnii*	Brazil	do	E	15	NA	NA
Honeycreeper, crested (='akohekohe)	*Palmeria dolei*	U.S.A. (HI)	do	E	1	NA	NA
Hornbill, helmeted	*Rhinoplax vigil*	Thailand, Malaysia	do	E	15	NA	NA
Honeyeater, helmeted	*Meliphaga cassidix*	Australia	do	E	4	NA	NA
Ibis, Japanese crested	*Nipponia nippon*	China, Japan, U.S.S.R., Korea	do	E	3	NA	NA
Kagu	*Rhynochetos jubatus*	South Pacific Ocean: New Caledonia	do	E	3	NA	NA
Kakapo (=owl-parrot)	*Strigops habroptilus*	New Zealand	do	E	3	NA	NA
Kestrel, Mauritius	*Falco punctatus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Kestrel, Seychelles	*Falco araea*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Kingfisher, Guam Micronesian	*Halcyon cinnamomina cinnamomina*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Kite, Cuba hook-billed	*Chondrohierax uncinatus wilsonii*	West Indies: Cuba	do	E	3	NA	NA
Kite, Everglade snail	*Rostrhamus sociabilis plumbeus*	U.S.A. (FL), Cuba	Florida	E	1	17.95(b)	NA
Kite, Grenada hook-billed	*Chondrohierax uncinatus mirus*	West Indies: Grenada	Entire	E	3	NA	NA
Kokako (wattlebird)	*Callaeas cinerea*	New Zealand	do	E	3	NA	NA
Macaw, glaucous	*Anodorhynchus glaucus*	Paraguay, Uruguay, Brazil	do	E	15	NA	NA
Macaw, indigo	*Anodorhynchus leari*	Brazil	do	E	15	NA	NA
Macaw, little blue	*Cyanopsitta spixii*	do	do	E	15	NA	NA
Magpie-robin, Seychelles (thrush)	*Copsychus sechellarum*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Malkoha, red-faced (cuckoo)	*Phaenicophaeus pyrrhocephalus*	Sri Lanka (=Ceylon)	do	E	3	NA	NA
Mallard, Mariana	*Anas oustaleti*	West Pacific Ocean: U.S.A. (Guam, Mariana Islands).	do	E	23	NA	NA
Megapode, Micronesian (=La Perouse's)	*Megapodius laperouse*	West Pacific Ocean: U.S.A. (Palau Island, Mariana Islands).	do	E	3	NA	NA
Megapode, Maleo	*Macrocephalon maleo*	Indonesia (Celebes)	do	E	3	NA	NA
Millerbird, Nihoa (old world warbler)	*Acrocephalus familiaris kingi*	U.S.A. (HI)	do	E	1	NA	NA
Monarch, Tinian (old world flycatcher)	*Monarcha takatsukasae*	Western Pacific Ocean: U.S.A. (Mariana Islands).	do	E	3	NA	NA
Moorhen (=gallinule), Hawaiian common	*Gallinula chloropus sandvicensis*	U.S.A. (HI)	do	E	1	NA	NA
Moorhen (=gallinule), Mariana common	*Gallinula chloropus guami*	Western Pacific Ocean: U.S.A. (Guam, Tinian, Saipan, Pagan).	do	E	156	NA	NA
Nightjar (=whip-poor-will), Puerto Rico	*Caprimulgus noctitherus*	U.S.A. (PR)	do	E	6	NA	NA
Nukupu'u (honeycreeper)	*Hemignathus lucidus*	U.S.A. (HI)	do	E	1, 2	NA	NA
'O'o, Kauai (='Ō'o 'A'a) (honeyeater)	*Moho braccatus*	do	do	E	1	NA	NA
Ostrich, Arabian	*Struthio camelus syriacus*	Jordan, Saudi Arabia	do	E	3	NA	NA
Ostrich, West African	*Struthio camelus spatzi*	Spanish Sahara	do	E	3	NA	NA
'O'u (honeycreeper)	*Psittirostra psittacea*	U.S.A. (HI)	do	E	1	NA	NA
Owl, Anjouan scops	*Otus rutilus capnodes*	Indian Ocean: Comoro Island	do	E	3	NA	NA
Owl, giant scops	*Otus gurneyi*	Philippines: Marinduque and Mindanao Island.	do	E	15	NA	NA
Owl, Seychelles	*Otus insularis*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Owlet, Morden's (=Sokoke)	*Otus ireneae*	Kenya	do	E	3	NA	NA
Palila (honeycreeper)	*Loxioides (=Psittirostra) bailleui*	U.S.A. (HI)	do	E	1	17.95(b)	NA
Parakeet, Forbes'	*Cyanoramphus auriceps forbesi*	New Zealand	do	E	3, 15	NA	NA
Parakeet, golden	*Aratinga guarouba*	Brazil	do	E	4	NA	NA
Parakeet, golden-shouldered (=hooded)	*Psephotus chrysopterygius*	Australia	do	E	3	NA	NA
Parakeet, Mauritius	*Psittacula echo*	Indian Ocean: Mauritius	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Parakeet, ochre-marked	*Pyrrhura cruentata*	Brazil	do	E	3	NA	NA
Parakeet, orange-bellied	*Neophema chrysogaster*	Australia	do	E	4	NA	NA
Parakeet, paradise (=beautiful)	*Psephotus pulcherrimus*	do	do	E	4	NA	NA
Parakeet, scarlet-chested (=splendid)	*Neophema splendida*	do	do	E	4	NA	NA
Parakeet, turquoise	*Neophema pulchella*	do	do	E	3	NA	NA
Parrot, Australian	*Geopsittacus occidentalis*	do	do	E	3	NA	NA
Parrot, Bahaman or Cuban	*Amazona leucocephala*	West Indies: Cuba, Bahamas, Caymans	do	E	3, 15	NA	NA
Parrot, ground	*Pezoporus wallicus*	Australia	do	E	6	NA	NA
Parrot, imperial	*Amazona imperialis*	West Indies: Dominica	do	E	3	NA	NA
Parrot, Puerto Rican	*Amazona vittata*	U.S.A. (PR)	do	E	1	NA	NA
Parrot, red-browed	*Amazona rhodocorytha*	Brazil	do	E	3	NA	NA
Parrot, red-capped	*Pionopsitta pileata*	do	do	E	15	NA	NA
Parrot, red-necked	*Amazona arausiaca*	West Indies: Dominica	do	E	50	NA	NA
Parrot, red-spectacled	*Amazona pretrei pretrei*	Brazil, Argentina	do	E	15	NA	NA
Parrot, St. Lucia	*Amazona versicolor*	West Indies: St. Lucia	do	E	3	NA	NA
Parrot, St. Vincent	*Amazona guildingii*	West Indies: St. Vincent	do	E	3	NA	NA
Parrot, thick-billed	*Rhynchopsitta pachyrhyncha*	Mexico, U.S.A. (AZ, NM)	Mexico	E	3	NA	NA
Parrot, vinaceous-breasted	*Amazona vinacea*	Brazil	Entire	E	15	NA	NA
Parrotbill, Maui (honeycreeper)	*Pseudonestor xanthophrys*	U.S.A. (HI)	do	E	1	NA	NA
Pelican, brown	*Pelecanus occidentalis*	U.S.A (Carolinas to TX, CA), West Indies, C. and S. America: Coastal.	Entire, except U.S. Atlantic coast, FL, AL.	E	2, 3, 171	NA	NA
Penguin, Galapagos	*Spheniscus mendiculus*	Ecuador (Galapagos Islands)	Entire	E	3	NA	NA
Petrel, Hawaiian dark-rumped	*Pterodroma phaeopygia sandwichensis*	U.S.A. (HI)	do	E	2, 4, 1	NA	NA
Pheasant, bar-tailed	*Symaticus humiae*	Burma, China	do	E	3	NA	NA
Pheasant, Blyth's tragopan	*Tragopan blythii*	Burma, China, India	do	E	3	NA	NA
Pheasant, brown eared	*Crossoptilon mantchuricum*	China	do	E	3	NA	NA
Pheasant, Cabot's tragopan	*Tragopan caboti*	do	do	E	3	NA	NA
Pheasant, Chinese monal	*Lophophorus lhuysii*	do	do	E	3	NA	NA
Pheasant, Edward's	*Lophura edwardsi*	Vietnam	do	E	3	NA	NA
Pheasant, Elliot's	*Symaticus elliotii*	China	do	E	15	NA	NA
Pheasant, imperial	*Lophura imperialis*	Vietnam	do	E	3	NA	NA
Pheasant, Mikado	*Symaticus mikado*	Taiwan	do	E	3	NA	NA
Pheasant, Palawan peacock	*Polyplectron emphanum*	Philippines	do	E	3	NA	NA
Pheasant, Sclater's monal	*Lophophorus sclateri*	Burma, China, India	do	E	3	NA	NA
Pheasant, Swinhoe's	*Lophura swinhoii*	Taiwan	do	E	3	NA	NA
Pheasant, western tragopan	*Tragopan melanocephalus*	India, Pakistan	do	E	3	NA	NA
Pheasant, white eared	*Crossoptilon crossoptilon*	China (Tibet), India	do	E	4	NA	NA
Pigeon, Azores wood	*Columba palumbus azorica*	East Atlantic Ocean: Azores	do	E	3	NA	NA
Pigeon, Chatham Island	*Hemiphaga novaeseelandiae chathamensis.*	New Zealand	do	E	3	NA	NA
Pigeon, Mindoro zone-tailed	*Ducula mindorensis*	Philippines	do	E	15	NA	NA
Pigeon, Puerto Rican plain	*Columba inornata wetmorei*	U.S.A. (PR)	do	E	2	NA	NA
Piping-guan, black-fronted	*Pipile jacutinga*	Argentina	do	E	15	NA	NA
Pitta, Koch's	*Pitta kochi*	Philippines	do	E	15	NA	NA
Plover, New Zealand shore	*Thinornis novaeseelandiae*	New Zealand	do	E	3	NA	NA
Plover, piping	*Charadrius melodus*	U.S.A. (Great Lakes, northern Great Plains, Atlantic and Gulf coasts, PR VI), Canada, Mexico, etc.	Great Lakes watershed in	E	211	NA	NA

Pigeon, Mindoro zone-tailed	*Ducula mindorensis*	Philippines	do	E	15	NA	NA
Pigeon, Puerto Rican plain	*Columba inornata wetmorei*	U.S.A.	do	E	2	NA	NA
Piping-guan, black-fronted	*Pipile jacutinga*	Argentina	do	E	16	NA	NA
Pitta, Koch's	*Pitta kochi*	Philippines	do	E	15	NA	NA
Plover, New Zealand shore	*Thinornis novaeseelandiae*	New Zealand	do	E	3	NA	NA
Plover, piping	*Charadrius melodus*	U.S.A. (Great Lakes, northern Great Plains, Atlantic and Gulf coasts, PR VI), Canada, Mexico, Bahamas, West Indies.	Great Lakes watershed in States of IL, IN, MI, MN, NY, OH, PA, and WI and Province of Ontario.	E	211	NA	NA
Do	do	do	Entire, except those areas where listed as endangered above.	T	211	NA	NA
Po'ouli (honeycreeper)	*Melamprosops phaeosoma*	U.S.A. (HI)	Entire	E	10	NA	NA
Prairie-chicken, Attwater's greater	*Tympanuchus cupido attwateri*	U.S.A. (TX)	do	E	1	NA	NA
Quail, Merriam's Montezuma	*Cyrtonyx montezumae mearnsi*	Mexico (Vera Cruz)	do	E	15	NA	NA
Quetzel, resplendent	*Pharomachrus mocinno*	Mexico to Panama	do	E	15	NA	NA
Rail, Aukland Island	*Rallus pectoralis muelleri*	New Zealand	do	E	3	NA	NA
Rail, California clapper	*Rallus longirostris obsoletus*	U.S.A. (CA)	do	E	2	NA	NA
Rail, Guam	*Rallus owstoni*	Western Pacific Ocean: U.S.A. (Guam)	do	E	146E, 156	NA	NA
Rail, light-footed clapper	*Rallus longirostris levipes*	U.S.A. (CA), Mexico (Baja California)	do	E	2	NA	NA
Rail, Lord Howe wood	*Tricholimnas sylvestris*	Australia (Lord Howe Island)	do	E	15	NA	NA
Rail, Yuma clapper	*Rallus longirostris yumanensis*	Mexico, U.S.A. (AZ, CA)	do	E	1	NA	NA
Rhea, Darwin's	*Pterocnemia pennata*	Argentina, Bolivia, Peru, Uruguay	do	E	3	NA	NA
Robin, Chatham Island	*Petroica traversi*	New Zealand	do	E	3	NA	NA
Robin, scarlet-breasted (flycatcher)	*Petroica multicolor multicolor*	Australia (Norfolk Island)	do	E	3	NA	NA
Rockfowl, grey-necked	*Picathartes oreas*	Cameroon, Gabon	do	E	3	NA	NA
Rockfowl, white-necked	*Picathartes gymnocephalus*	Africa: Togo to Sierra Leone	do	E	3	NA	NA
Roller, long-tailed ground	*Uratelornis chimaera*	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Scrub-bird, noisy	*Atrichornis clamosus*	Australia	do	E	3	NA	NA
Shama, Cebu black (thrush)	*Copsychus niger cebuensis*	Philippines	do	E	3	NA	NA
Shearwater, Newell's Townsend's (formerly Manx) (=A'o).	*Puffinus auricularis* (formerly *puffinus*) *newelli.*	U.S.A. (HI)	do	T	10	NA	NA
Shrike, San Clemente loggerhead	*Lanius ludovicianus mearnsi*	U.S.A. (CA)	do	E	26	NA	NA
Siskin, red	*Carduelis* (=*Spinus*) *cucullata*	South America	do	E	15	NA	NA
Sparrow, Cape Sable seaside	*Ammodramus* (=*Ammospiza*) *maritimus mirabilis.*	U.S.A. (FL)	do	E	1	17.95(b)	NA
Sparrow, dusky seaside	*Ammodramus* (=*Ammospiza*) *maritimus nigrescens.*	do	do	E	1	17.95(b)	NA
Sparrow, Florida grasshopper	*Ammodramus savannarum floridanus*	do	do	E	239	NA	NA
Sparrow, San Clemente sage	*Amphispiza belli clementeae*	U.S.A. (CA)	do	T	26	NA	NA
Starling, Ponape mountain	*Aplonis pelzeini*	West Pacific Ocean: U.S.A. (Caroline Islands).	do	E	3	NA	NA
Starling, Rothschild's (myna)	*Leucopsar rothschildi*	Indonesia (Bali)	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Stilt, Hawaiian (=Ae'o)	*Himantopus mexicanus* (=*himantopus*) *knudsenl.*	U.S.A. (Hawaii)	do	E	2	NA	NA
Stork, oriental white	*Ciconia ciconia boyciana*	China, Japan, Korea, U.S.S.R.	do	E	3	NA	NA
Stork, wood	*Mycteria americana*	U.S.A., (CA, AZ, TX, to Carolinas), Mexico, Central and South America.	U.S.A. (AL, FL, GA, SC).	E	142	NA	NA
Swiftlet, Mariana gray (=Vanikoro)	*Aerodramus* (=*Collocalia*) *vanikorensis bartschi.*	Western Pacific Ocean: U.S.A. (Guam, Rota, Tinian, Saipan, Agiguan).	Entire	E	156	NA	NA
Teal, Campbell Island flightless	*Anas aucklandica nesiotis*	New Zealand (Campbell Island)	do	E	16	NA	NA
Tern, California least	*Sterna antillarum* (=*albifrons*) *browni*	Mexico, U.S.A. (CA)	do	E	2, 3	NA	NA
Tern, least	*Sterna antillarum*	U.S.A. (Atlantic and Gulf coasts, Miss. R. Basin, CA), Gr. and Lesser Antilles, Bahamas, Mexico; winters C. America, northern S. America.	U.S.A. [AR, CO, IA, IL, IN, KS, KY, LA (Miss. R. and tribs. N of Baton Rouge), MS (Miss. R.), MO, MT, NE, NM, ND, OK, SD, TN, TX (Except within 50 miles of coast)].	E	182	NA	NA
Thrasher, white-breasted	*Ramphocinclus brachyurus*	West Indies: St. Lucia, Martinique	Entire	E	3	NA	NA
Thrush, large Kauai	*Myadestes* (=*Phaeomis*) *myadestinus*	U.S.A. (HI)	do	E	2	NA	NA
Thrush, Molokai (=oloma'o)	*Myadestes* (=*Phaeomis*) *lanaiensis* (=*obscurus*) *rutha.*	do	do	E	2	NA	NA
Thrush, New Zealand (wattlebird)	*Turnagra capensis*	New Zealand	do	E	3	NA	NA
Thrush, small Kauai (=puaiohi)	*Myadestes* (=*Phaeomis*) *palmeri*	U.S.A. (HI)	do	E	1	NA	NA
Tinamou, solitary	*Tinamus solitarius*	Brazil, Paraguay, Argentina	do	E	16	NA	NA
Trembler, Martinique (thrasher)	*Cinclocerthia ruficauda gutturalis*	West Indies: Martinique	do	E	3	NA	NA
Vireo, least Bell's	*Vireo bellii pusillus*	U.S.A. (CA), Mexico	do	E	228	NA	NA
Wanderer, plain (collared-hemipode)	*Pedionomous torquatus*	Australia	do	E	6	NA	NA
Warbler (wood), Bachman's	*Vermivora bachmanii*	U.S.A.(Southeastern), Cuba	do	E	1, 3	NA	NA
Warbler (wood), Barbados yellow	*Dendroica petechia petechia*	West Indies: Barbados	do	E	3	NA	NA
Warbler (wood), Kirtland's	*Dendroica kirtlandii*	U.S.A. (principally MI), Canada, West Indies: Bahama Islands.	do	E	1, 3	NA	NA
Warbler (willow), nightingale reed	*Acrocephalus luscinia*	Western Pacific Ocean	U.S.A. (Mariana Islands).	E	3, 4	NA	NA
Warbler (willow), Rodriques	*Bebrornis rodericanus*	Mauritius (Rodrigues Islands)	Entire	E	3	NA	NA
Warbler (wood), Semper's	*Leucopeza semperi*	West Indies: St. Lucia	do	E	3	NA	NA
Warbler (willow), Seychelles	*Bebrornis sechellensis*	Indian Ocean: Seychelles Island	do	E	3	NA	NA
Whipbird, Western	*Psophodes nigrogularis*	Australia	do	E	3	NA	NA
White-eye, bridled	*Zosterops conspicillata conspicillata*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
White-eye, Norfolk Island	*Zosterops albogularis*	Indian Ocean: Norfolk Islands	do	E	16	NA	NA
White-eye, Ponape greater	*Rukia longirostra* (=*sanfordi*)	West Pacific Ocean: U.S.A. (Caroline Islands).	do	E	3	NA	NA
White-eye, Seychelles	*Zosterops modesta*	Indian Ocean: Seychelles	do	E	3	NA	NA
Woodpecker, imperial	*Campephilus imperialis*	Mexico	do	E	3	NA	NA
Woodpecker, ivory-billed	*Campephilus principalis*	U.S.A. (southcentral and southeastern), Cuba.	do	E	1, 3	NA	NA
Woodpecker, red-cockaded	*Picoides* (=*Dendrocopos*) *borealis*	U.S.A. (southcentral and southeastern)	do	E	2	NA	NA
Woodpecker, Tristam's	*Dryocopus javensis richardsi*	Korea	do	E	3	NA	NA
Wren, Guadeloupe house	*Troglodytes aedon guadeloupensis*	West Indies: Guadeloupe	do	E	3	NA	NA
Wren, St. Lucia house	*Troglodytes aedon mesoleucus*	West Indies: St. Lucia	do	E	3	NA	NA
REPTILES							

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White-eye, Norfolk Island	*Zosterops albogularis*	[illegible]	[illegible]	E	3	NA	NA
White-eye, Ponape greater	*Rukia longirostra* (= *sanfordi*)	Pacific Ocean: U.S.A. (Caroline Is.)	do	E	3	NA	NA
White-eye, Seychelles	*Zosterops modesta*	Indian Ocean: Seychelles	do	E	3	NA	NA
Woodpecker, imperial	*Campephilus imperialis*	Mexico	do	E	3	NA	NA
Woodpecker, ivory-billed	*Campephilus principalis*	U.S.A. (southcentral and southeastern), Cuba.	do	E	1, 3	NA	NA
Woodpecker, red-cockaded	*Picoides* (= *Dendrocopos*) *borealis*	U.S.A. (southcentral and southeastern)	do	E	2	NA	NA
Woodpecker, Tristam's	*Dryocopus javensis richardsi*	Korea	do	E	3	NA	NA
Wren, Guadeloupe house	*Troglodytes aedon guadeloupensis*	West Indies: Guadeloupe	do	E	3	NA	NA
Wren, St. Lucia house	*Troglodytes aedon mesoleucus*	West Indies: St. Lucia	do	E	3	NA	NA
REPTILES							
Alligator, American	*Alligator mississippiensis*	Southeastern U.S.A.	Wherever found in wild except those areas where listed as threatened as set forth below.	E	1, 11, 51, 60, 113, 134, 186	NA	NA
Do	do	do	U.S.A. (certain areas of GA and SC, as set forth in 17.42(a)(1)). 17.42(a)(1)).	T	20, 47, 51, 60, 134, 186	NA	17.42(a)
Do	do	do	U.S.A. (FL, LA and TX); in captivity wherever found.	T(S/A)	11, 47, 51, 60, 113, 134, 186	NA	17.42(a)
Alligator, Chinese	*Alligator sinensis*	China	Entire	E	15	NA	NA
Anole, Culebra Island giant	*Anolis roosevelti*	U.S.A. (PR: Culebra Island)	do	E	25	17.95(c)	NA
Boa, Jamaican	*Epicrates subflavus*	Jamaica	do	E	3	NA	NA
Boa, Mona	*Epicrates monensis monensis*	U.S.A. (PR)	do	T	33	17.95(c)	NA
Boa, Puerto Rico	*Epicrates inornatus*	do	do	E	2	NA	NA
Boa, Round Island [no common name]	*Casarea dussumieri*	Indian Ocean: Mauritius	do	E	86	NA	NA
Boa, Round Island [no common name]	*Bolyeria multocarinata*	do	do	E	86	NA	NA
Boa, Virgin Islands tree	*Epicrates monensis granti*	U.S. and British Virgin Islands	do	E	2, 86	NA	NA
Caiman, Apaporis River	*Caiman crocodilus apaporiensis*	Colombia	do	E	15	NA	NA
Caiman, black	*Melanosuchus niger*	Amazon basin	do	E	15	NA	NA
Caiman, broad-snouted	*Caiman latirostris*	Brazil, Argentina, Paraguay, Uruguay	do	E	15	NA	NA
Caiman, Yacare	*Caiman crocodilus yacare*	Bolivia, Argentina, Peru, Brazil	do	E	3	NA	NA
Chuckwalla, San Esteban Island	*Sauromalus varius*	Mexico	do	E	86	NA	NA
Crocodile, African dwarf	*Osteolaemus tetraspis tetraspis*	West Africa	do	E	15	NA	NA
Crocodile, African slender-snouted	*Crocodylus cataphractus*	Western and central Africa	do	E	8	NA	NA
Crocodile, American	*Crocodylus acutus*	U.S.A. (FL), Mexico, South America, Central America, Caribbean.	do	E	10, 87	17.95(c)	NA
Crocodile, Ceylon mugger	*Crocodylus palustris kimbula*	Sri Lanka	do	E	15	NA	NA
Crocodile, Congo dwarf	*Osteolaemus tetraspis osborni*	Congo River drainage	do	E	15	NA	NA
Crocodile, Cuban	*Crocodylus rhombifer*	Cuba	do	E	3	NA	NA
Crocodile, Morelet's	*Crocodylus moreletii*	Mexico, Belize, Guatemala	do	E	3	NA	NA
Crocodile, mugger	*Crocodylus palustris palustris*	India, Pakistan, Iran, Bangladesh	do	E	15	NA	NA
Crocodile, Nile	*Crocodylus niloticus*	Africa	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Crocodile, Orinoco	*Crocodylus intermedius*	South America: Orinoco River Basin	do	E	3	NA	NA
Crocodile, Philippine	*Crocodylus novaeguineae mindorensis*	Philippine Islands	do	E	15	NA	NA
Crocodile, saltwater (=estuarine)	*Crocodylus porosus*	Southeast Asia, Australia, Papua-New Guinea, Pacific Islands.	Entire, except Papua-New Guinea.	E	87	NA	NA
Crocodile, Siamese	*Crocodylus siamensis*	Southeast Asia, Malay Peninsula	Entire	E	15	NA	NA
Gavial (=gharial)	*Gavialis gangeticus*	Pakistan, Burma, Bangladesh, India, Nepal.	do	E	3, 15	NA	NA
Gecko, day	*Phelsuma edwardnewtoni*	Indian Ocean: Mauritius	do	E	3	NA	NA
Gecko, Monito	*Sphaerodactylus micropithecus*	U.S.A. (PR)	do	E	125	17.95(c)	NA
Gecko, Round Island day	*Phelsuma guentheri*	Indian Ocean: Mauritius	do	E	3	NA	NA
Gecko, Serpent Island	*Cyrtodactylus serpensinsula*	do	do	T	129	NA	NA
Iguana, Acklins ground	*Cyclura nieyi nuchalis*	West Indies: Bahamas	do	T	129	NA	NA
Iguana, Allen's Cay	*Cyclura cychlura inornata*	do	do	T	129	NA	NA
Iguana, Andros Island ground	*Cyclura cychlura cychlura*	do	do	T	129	NA	NA
Iguana, Anegada ground	*Cyclura pinguis*	West Indies: British Virgin Islands (Anegada Island).	do	E	3	NA	NA
Iguana, Barrington land	*Conolophus pallidus*	Ecuador (Galapagos Islands)	do	E	3	NA	NA
Iguana, Cayman Brac ground	*Cyclura nubila caymanensis*	West Indies: Cayman Islands	do	T	129	NA	NA
Iguana, Cuban ground	*Cyclura nubila nubila*	Cuba	Entire (excluding population introduced in Puerto Rico).	T	129	NA	NA
Iguana, Exuma Island	*Cyclura cychlura figginsi*	West Indies: Bahamas	Entire	T	129	NA	NA
Iguana, Fiji banded	*Brachylophus fasciatus*	Pacific: Fiji, Tonga	do	E	88	NA	NA
Iguana, Fiji crested	*Brachylophus vitiensis*	Pacific: Fiji	do	E	88	NA	NA
Iguana, Grand Cayman ground	*Cyclura nubila lewisi*	West Indies: Cayman Islands	do	E	129	NA	NA
Iguana, Jamaican	*Cyclura collei*	West Indies: Jamaica	do	E	129	NA	NA
Iguana, Mayaguana	*Cyclura carinata bartschi*	West Indies: Bahamas	do	T	129	NA	NA
Iguana, Mona ground	*Cyclura stejnegeri*	U.S.A. (PR: Mona Island)	do	T	33	17.95(c)	NA
Iguana, Turks and Caicos	*Cyclura carinata carinata*	West Indies: Turks and Caicos Islands	do	T	129	NA	NA
Iguana, Walling Island ground	*Cyclura nieyi nieyi*	West Indies: Bahamas	do	E	129	NA	NA
Iguana, White Cay ground	*Cyclura nieyi cristata*	do	do	T	129	NA	NA
Lizard, blunt-nosed leopard	*Gambelia (=Crotaphytus) silus*	U.S.A. (CA)	do	E	1	NA	NA
Lizard, Coachella Valley fringe-toed	*Uma inornata*	do	do	T	105	17.95(c)	NA
Lizard, Hierro giant	*Gallotia simonyi simonyi*	Spain (Canary Islands)	do	E	144	NA	NA
Lizard, Ibiza wall	*Podarcis pityusensis*	Spain (Balearic Islands)	do	T	144	NA	NA
Lizard, Island night	*Xantusia (=Klauberina) riversiana*	U.S.A. (CA)	do	T	26	NA	NA
Lizard, St. Croix ground	*Ameiva polops*	U.S.A. (VI)	do	E	24	17.95(c)	NA
Monitor, Bengal	*Varanus bengalensis*	Iran, Iraq, India, Sri Lanka, Malaysia, Afghanistan, Burma, Vietnam, Thailand.	do	E	15	NA	NA
Monitor, desert	*Varanus griseus*	North Africa to Nearest, Caspian Sea through U.S.S.R. to Pakistan, Northwest India.	do	E	15	NA	NA
Monitor, Komodo Island	*Varanus komodoensis*	Indonesia: Rinca, Komodo, Flores.					

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Monitor, desert	*Varanus griseus*	North Africa to Nearest, Caspian Sea through U.S.S.R. to Pakistan, Northwest India.	do	E	15	NA	NA
Monitor, Komodo Island	*Varanus komodoensis*	Indonesia (Komodo, Rintja, Padar, and western Flores Island).	do	E	15	NA	NA
Monitor, yellow	*Varanus flavescens*	West Pakistan through India to Bangladesh.	do	E	15	NA	NA
Python, Indian	*Python molurus molurus*	Sri Lanka and India	do	E	15	NA	NA
Rattlesnake, Aruba Island	*Crotalus unicolor*	Aruba Island (Netherland Antilles)	do	T	129	NA	NA
Rattlesnake, New Mexican ridge-nosed	*Crotalus willardi obscurus*	U.S.A. (NM), Mexico	do	T	43	17.95(c)	NA
Skink, Round Island	*Leiolopisma telfairi*	Indian Ocean: Mauritius	do	T	129	NA	NA
Snake, Atlantic salt marsh	*Nerodia fasciata taeniata*	U.S.A. (FL)	do	T	30	NA	NA
Snake, Concho water	*Nerodia harteri paucimaculata*	U.S.A. (TX)	do	T	241	NA	NA
Snake, eastern indigo	*Drymarchon corais couperi*	U.S.A. (AL, FL, GA, MS, SC)	do	T	32	NA	NA
Snake, San Francisco garter	*Thamnophis sirtalis tetrataenia*	U.S.A. (CA)	do	E	1	NA	NA
Tartaruga	*Podocnemis expansa*	South America: Orinoco and Amazon River basins.	do	E	3	NA	NA
Terrapin, river (=Tuntong)	*Batagur baska*	Malaysia, Bangladesh, Burma, India, Indonesia.	do	E	3	NA	NA
Tomistoma	*Tomistoma schlegelii*	Malaysia, Indonesia	do	E	15	NA	NA
Tortoise, angulated	*Geochelone yniphora*	Malagasy Republic (=Madagascar)	do	E	15	NA	NA
Tortoise, Bolson	*Gopherus flavomarginatus*	Mexico	do	E	46	NA	NA
Tortoise, desert	*Xerobates* (=*Scaptochelys*, =*Gopherus*) *agassizii*.	U.S.A. (UT, AZ, CA, NV); Mexico	Beaver Dam Slope, Utah.	T	103	17.95(c)	NA
Tortoise, Galapagos	*Geochelone elephantopus*	Ecuador (Galapagos Islands)	Entire	E	3	NA	NA
Tortoise, radiated	*Geochelone* (=*Testudo*) *radiata*	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Tracaja	*Podocnemis unifilis*	South America: Orinoco and Amazon River basins.	do	E	3	NA	NA
Tuatara	*Sphenodon punctatus*	New Zealand	do	E	3	NA	NA
Turtle, aquatic box	*Terrapene coahuila*	Mexico	do	E	6	NA	NA
Turtle, black softshell	*Trionyx nigricans*	Bangladesh	do	E	15	NA	NA
Turtle, Burmese peacock	*Morenia ocellata*	Burma	do	E	15	NA	NA
Turtle, Central American river	*Dermatemys mawii*	Mexico, Belize, Guatemala	do	E	129	NA	NA
Turtle, Cuatro Cienegas softshell	*Trionyx ater*	Mexico	do	E	15	NA	NA
Turtle, geometric	*Psammobates geometricus* (=*Geochelone geometrica*).	South Africa	do	E	15	NA	NA
Turtle, green sea	*Chelonia mydas*	Circumglobal in tropical and temperate seas and oceans.	Wherever found except where listed as endangered below.	T	2, 42	NA	17.42(b) and Parts 220 and 227.
Do	do	do	Breeding colony populations in FL and on Pacific coast of Mexico.	E	2, 42	NA	NA
Turtle, hawksbill sea (=carey)	*Eretmochelys imbricata*	Tropical seas	Entire	E	3	17.95(c)	NA
Turtle, Indian sawback	*Kachuga tecta tecta*	India	do	E	15	NA	NA
Turtle, Indian softshell	*Trionyx gangeticus*	Pakistan, India	do	E	15	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Turtle, Kemp's (=Atlantic) Ridley sea	*Lepidochelys kempii*	Tropical and temperate seas in Atlantic Basin.	do	E	4	NA	NA
Turtle, leatherback sea	*Dermochelys coriacea*	Tropical, temperate, and subpolar seas	do	E	3	17.95(c), 226.71	NA
Turtle, loggerhead sea	*Caretta caretta*	Circumglobal in tropical and temperate seas and oceans.	do	T	42	NA	17.42(b) and Parts 220 and 227.
Turtle, Olive (Pacific) Ridley sea	*Lepidochelys olivacea*	Tropical and temperate seas in Pacific Basin.	Wherever found except where listed as endangered below.	T	42	NA	17.42(b) and Parts 220 and 227.
Do	do	do	Breeding colony populations on Pacific coast of Mexico.	E	42	NA	NA
Turtle, peacock softshell	*Trionyx hurum*	India, Bangladesh	Entire	E	15	NA	NA
Turtle, Plymouth red-bellied	*Pseudemys (=Chrysemys) rubriventris bangsi.*	U.S.A. (MA)	do	E	90	17.95(c)	NA
Turtle, short-necked or western swamp	*Pseudemydura umbrina*	Australia	do	E	3	NA	NA
Turtle, spotted pond	*Geoclemys (=Damonia) hamiltonii*	North India, Pakistan	do	E	15	NA	NA
Turtle, three-keeled Asian	*Melanochelys (=Geoemyda, Nicoria) tricarinata.*	Central India to Bangladesh and Burma	do	E	15	NA	NA
Viper, Lar Valley	*Vipera latifii*	Iran	do	E	129	NA	NA
AMPHIBIANS							
Coqui, golden	*Eleutherodactylus jasperi*	U.S.A. (PR)	do	T	29	17.95(d)	NA
Frog, Israel painted	*Discoglossus nigriventer*	Israel	do	E	3	NA	NA
Frog, Panamanian golden	*Atelopus varius zeteki*	Panama	do	E	15	NA	NA
Frog, Stephen Island	*Leiopelma hamiltoni*	New Zealand	do	E	3	NA	NA
Salamander, Chinese giant	*Andrias davidianus davidianus*	Western China	do	E	15	NA	NA
Salamander, desert slender	*Batrachoseps aridus*	U.S.A. (CA)	do	E	6	NA	NA
Salamander, Japanese giant	*Andrias davidianus japonicus*	Japan	do	E	15	NA	NA
Salamander, Red Hills	*Phaeognathus hubrichti*	U.S.A. (AL)	do	T	19	NA	NA
Salamander, San Marcos	*Eurycea nana*	U.S.A. (TX)	do	T	98	17.95(d)	17.43(a)
Salamander, Santa Cruz long-toed	*Ambystoma macrodactylum croceum*	U.S.A. (CA)	do	E	1	NA	NA
Salamander, Texas blind	*Typhlomolge rathbuni*	U.S.A. (TX)	do	E	1	NA	NA
Toad, African viviparous	*Nectophrynoides spp.*	Tanzania, Guinea, Ivory Coast, Cameroon, Liberia, Ethiopia.	do	E	15	NA	NA
Toad, Cameroon	*Bufo superciliaris*	Equatorial Africa	do	E	15	NA	NA
Toad, Houston	*Bufo houstonensis*	U.S.A. (TX)	do	E	2	17.95(d)	NA
Toad, Monte Verde	*Bufo periglenes*	Costa Rica	do	E	15	NA	NA
Toad, Wyoming	*Bufo hemiophrys baxteri*	U.S.A. (WY)	do	E	136	NA	NA
FISHES							
Ala Balik (trout)	*Salmo platycephalus*	Turkey	Entire	E	3	NA	NA
Ayumodoki (loach)	*Hymenophysa (=Botia) curta*	Japan	do	E	3	NA	NA
Blindcat, Mexican (catfish)	*Prietella phreatophila*	Mexico	do	E	3	NA	NA
Bonytongue, Asian	*Scleropages formosus*	Thailand, Indonesia, Malaysia	do	E	[illegible]	[illegible]	[illegible]
Catfish (no common name)	*Pangasius sanitwongsei*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Toad, Wyoming	*Bufo hemiophrys baxteri*	U.S.A. (WY)	do	E	136	NA	NA
Fishes							
Ala Balik (trout)	*Salmo platycephalus*	Turkey	Entire	E	3	NA	NA
Ayumodoki (loach)	*Hymenophysa (=Botia) curta*	Japan	do	E	3	NA	NA
Blindcat, Mexican (catfish)	*Prietella phreatophila*	Mexico	do	E	3	NA	NA
Bonytoungue, Asian	*Scleropages formosus*	Thailand, Indonesia, Malaysia	do	E	15	NA	NA
Catfish (no common name)	*Pangasius sanitwongsei*	Thailand	do	E	3	NA	NA
Catfish, giant	*Pangasianodon gigas*	do	do	E	3	NA	NA
Catfish, Yaqui	*Ictalurus pricei*	U.S.A. (AZ), Mexico	do	T	157	17.95(e)	17.44(g)
Cavefish, Alabama	*Speoplatyrhinus poulsoni*	U.S.A. (AL)	do	T	28	17.95(e)	NA
Cavefish, Ozark	*Amblyopsis rosae*	U.S.A. (AR, MO, OK)	do	T	164	NA	NA
Chub, bonytail	*Gila elegans*	U.S.A. (AZ, CA, CO, NV, UT, WY)	do	E	92	NA	NA
Chub, Borax Lake	*Gila boraxobius*	U.S.A. (OR)	do	E	124	17.95(e)	NA
Chub, Chihuahua	*Gila nigrescens*	U.S.A. (NM), Mexico (Chihuahua)	do	T	132	NA	17.44(g)
Chub, humpback	*Gila cypha*	U.S.A. (AZ, CO, UT, WY)	do	E	1	NA	NA
Chub, Hutton tui	*Gila bicolor ssp*	U.S.A. (OR)	do	T	174	NA	17.44(j)
Chub, Mohave tui	*Gila bicolor mohavensis*	U.S.A. (CA)	do	E	2	NA	NA
Chub, Owens tui	*Gila bicolor snyderi*	do	do	E	195	17.95(e)	NA
Chub, Pahranagat roundtail	*Gila robusta jordani*	U.S.A. (NV)	do	E	2	NA	NA
Chub, slender	*Hybopsis cahni*	U.S.A. (TN, VA)	do	T	28	17.95(e)	17.44(c)
Chub, Sonora	*Gila ditaenia*	U.S.A., (AZ), Mexico	do	T	227	17.95(e)	17.44(c)
Chub, spotfin	*Hybopsis monacha*	U.S.A. (AL, GA, NC, TN, VA)	do	T	28	17.95(e)	17.44(c)
Chub, Yaqui	*Gila purpurea*	U.S.A. (AZ), Mexico	do	E	157	17.95(e)	NA
Cicek (minnow)	*Acanthorutilus handlirschi*	Turkey	do	E	3	NA	NA
Cui-ui	*Chasmistes cujus*	U.S.A. (NV)	do	E	1	NA	NA
Dace, Ash Meadows speckled	*Rhinichthys osculus nevadensis*	do	do	E	117E, 127E, 130	17.95(e)	NA
Dace, desert	*Eremichthys acros*	do	do	T	210	17.95(e)	17.44(m)
Dace, Foskett speckled	*Rhinichthys osculus ssp*	U.S.A. (OR)	do	T	174	NA	17.44(j)
Dace, Kendall Warm Springs	*Rhinichthys osculus thermalis*	U.S.A. (WY)	do	E	2	NA	NA
Dace, Moapa	*Moapa coriacea*	U.S.A. (NV)	do	E	1	NA	NA
Darter, amber	*Percina antesella*	U.S.A. (GA, TN)	do	E	196	17.95(e)	NA
Darter, bayou	*Etheostoma rubrum*	U.S.A. (MS)	do	T	10	NA	17.44(b)
Darter, fountain	*Etheostoma fonticola*	U.S.A. (TX)	do	E	2	17.95(e)	NA
Darter, leopard	*Percina pantherna*	U.S.A. (AR, OK)	do	T	31	17.95(e)	17.44(d)
Darter, Maryland	*Etheostoma sellare*	U.S.A. (MD)	do	E	1	NA	NA
Darter, Niangua	*Etheostoma niangua*	U.S.A. (MO)	do	T	185	17.95(e)	17.44(k)
Darter, Okaloosa	*Etheostoma okaloosae*	U.S.A. (FL)	do	E	6	NA	NA
Darter, slackwater	*Etheostoma boschungi*	U.S.A. (AL, TN)	do	T	28	17.95(e)	17.44(c)
Darter, snail	*Percina tanasi*	U.S.A. (AL, GA, TN)	do	T	12, 150	NA	NA
Darter, watercress	*Etheostoma nuchale*	U.S.A. (AL)	do	E	2	NA	NA
Gambusia, Big Bend	*Gambusia gaigei*	U.S.A. (TX)	do	E	1	NA	NA
Gambusia, Clear Creek	*Gambusia heterochir*	do	do	E	1	NA	NA
Gambusia, Amistad	*Gambusia amistadensis*	do	do	E	93	NA	NA
Gambusia, Pecos	*Gambusia nobilis*	U.S.A. (NM, TX)	do	E	2	NA	NA
Gambusia, San Marcos	*Gambusia georgei*	U.S.A. (TX)	do	E	98	17.95(e)	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Killifish, Pahrump	*Empetrichthys latos*	U.S.A. (NV)	do	E	1	NA	NA
Logperch, Conasauga	*Percina jenkinsi*	U.S.A. (GA, TN)	do	E	196	17.95(e)	NA
Madtom, Scioto	*Noturus trautmani*	U.S.A. (OH)	do	E	10	NA	NA
Madtom, Smoky	*Noturus baileyi*	U.S.A. (TN)	do	E	163	17.95(e)	NA
Madtom, yellowfin	*Noturus flavipinnis*	U.S.A. (GA, TN, VA)	do	T	28	17.95(e)	17.44(c)
Nekogigi (catfish)	*Uncrobagrus ichikawai*	Japan	do	E	3	NA	NA
Pupfish, Ash Meadows Amargosa	*Cyprinodon nevadensis mionectes*	U.S.A. (NV)	do	E	117E, 127E, 130	17.95(e)	NA
Pupfish, Comanche Springs	*Cyprinodon elegans*	U.S.A. (TX)	do	E	1	NA	NA
Pupfish, desert	*Cyprinodon macularius*	U.S.A. (AZ, CA) Mexico	do	E	222	17.95(e)	NA
Pupfish, Devils Hole	*Cyprinodon diabolis*	U.S.A. (NV)	do	E	1	NA	NA
Pupfish, Leon Springs	*Cyprinodon bovinus*	U.S.A. (TX)	do	E	102	17.95(e)	NA
Pupfish, Owens	*Cyprinodon radiosus*	U.S.A. (CA)	do	E	1	NA	NA
Pupfish, Warm Springs	*Cyprinodon nevadensis pectoralis*	U.S.A. (NV)	do	E	2	NA	NA
Shiner, beautiful	*Notropis formosus*	U.S.A. (AZ, NM), Mexico	do	T	157	17.95(e)	17.44(g)
Spikedace	*Meda fulgida*	do	do	T	236	NA	17.44(p)
Spinedace, Big Spring	*Lepidomeda mollispinis pratensis*	U.S.A. (NV)	do	T	173	17.95(e)	17.44(i)
Spinedace, White River	*Lepidomeda albivallis*	do	do	E	203	17.95(e)	NA
Springfish, Hiko White River	*Crenichthys baileyi grandis*	do	do	E	206	17.95(e)	NA
Springfish, Railroad Valley	*Crenichthys nevadae*	do	do	T	224	17.95(e)	17.44(n)
Springfish, White River	*Crenichthys baileyi baileyi*	do	do	E	206	17.95(e)	NA
Squawfish, Colorado	*Ptychocheilus lucius*	U.S.A. (AZ, CA, CO, NM, NV, UT, WY), Mexico.	Entire, except Salt and Verde R. drainages, AZ.	E	1, 193	NA	NA
Do	do	do	Salt and Verde R. drainages, AZ.	XN	193	NA	17.84(b)
Stickleback, unarmored threespine	*Gasterosteus aculeatus williamsoni*	U.S.A. (CA)	Entire	E	2	NA	NA
Sturgeon, shortnose	*Acipenser brevirostrum*	U.S.A. and Canada (Atlantic Coast)	do	E	1	NA	NA
Sucker, June	*Chasmistes liorus*	U.S.A. (UT)	do	E	223	17.95(e)	NA
Sucker, Modoc	*Catostomus microps*	U.S.A. (CA)	do	E	184	17.95(e)	NA
Sucker, Warner	*Catostomus warnerensis*	U.S.A. (OR)	do	T	205	17.95(e)	17.44(l)
Tango, Miyako (Tokyo bitterling)	*Tanakia tanago*	Japan	do	E	3	NA	NA
Temolek, Ikan (minnow)	*Probarbus jullieni*	Thailand, Cambodia, Vietnam, Malaysia, Laos.	do	E	15	NA	NA
Topminnow, Gila	*Poeciliopsis occidentalis*	U.S.A. (AZ, NM), Mexico	do	E	1	NA	NA
Totoaba (seatrout or weakfish)	*Cynoscion macdonaldi*	Mexico (Gulf of California)	do	E	45	NA	NA
Trout, Apache	*Salmo apache*	U.S.A. (AZ)	do	T	1, 8	NA	17.44(a)
Trout, Gila	*Salmo gilae*	U.S.A. (AZ, NM)	do	E	1	NA	NA
Trout, greenback cutthroat	*Salmo clarki stomias*	U.S.A. (CO)	do	T	1, 38	NA	17.44(f)
Trout, Lahontan cutthroat	*Salmo clarki henshawi*	U.S.A. (CA, NV)	do	T	2, 8	NA	17.44(a)
Trout, Little Kern golden	*Salmo aguabonita whitei*	U.S.A. (CA)	do	T	37	17.95(e)	17.44(e)
Trout, Paiute cutthroat	*Salmo clarki seleniris*	do	do	T	1, 8	NA	17.44(a)
Woundfin	*Plagopterus argentissimus*	U.S.A. (AZ, NV, UT)	Entire, except Gila R. drainage, AZ, NM.	E	2, 193	NA	NA
Do	do	do	Gila R. drainage AZ, NM.	XN	193	NA	17.84(b)
SNAILS							
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	U.S.A. (NY)	NA	T	41	NA	NA
Snail, flat-spired three-toothed	*Triodopsis platysayoides*	U.S.A. (WV)	NA	T	41	NA	NA
Snail, Iowa Pleistocene	*Discus macclintocki*	U.S.A. (IA)	NA	E	41	NA	NA
Snail, Manus Island tree	*Papustyla pulcherrima*	Pacific Ocean [illegible]					

Trout, Pahute cutthroat	Salmo clarki ssp.						
Woundfin	*Plagopterus argentissimus*	U.S.A. (AZ, NV, UT)	Entire, except Gila R. drainage, AZ, NM.	E	2, 193	NA	NA
Do	do	do	Gila R. drainage AZ, NM.	XN	193	NA	17.84(b)
Snails							
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	U.S.A. (NY)	NA	T	41	NA	NA
Snail, flat-spired three-toothed	*Triodopsis platysayoides*	U.S.A. (WV)	NA	T	41	NA	NA
Snail, Iowa Pleistocene	*Discus macclintocki*	U.S.A. (IA)	NA	E	41	NA	NA
Snail, Manus Island tree	*Papustyla pulcherrima*	Pacific Ocean: Admiralty Is. (Manus Is.)	NA	E	3	NA	NA
Snail, noonday	*Mesodon clarki nantahala*	U.S.A. (NC)	NA	T	41	NA	NA
Snail, Oahu tree	*Achatinella* spp. (all species)	U.S.A. (HI)	NA	E	108, 112	NA	NA
Snail, painted snake coiled forest	*Anguispira picta*	U.S.A. (TN)	NA	T	41	NA	NA
Snail, Stock Island	*Orthalicus reses* (not incl. *nesodryas*)	U.S.A. (FL)	NA	T	41	NA	NA
Snail, Virginia fringed mountain	*Polygyriscus virginianus*	U.S.A. (VA)	NA	E	41	NA	NA
Clams							
Pearly mussel, Alabama lamp	*Lampsilis virescens*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, Appalachian monkeyface	*Quadrula sparsa*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, birdwing	*Conradilla caelata*	do	NA	E	15	NA	NA
Pearly mussel, Cumberland bean	*Villosa* (=*Micromya*) *trabalis*	U.S.A. (KY, TN)	NA	E	15	NA	NA
Pearly mussel, Cumberland monkeyface	*Quadrula intermedia*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pearly mussel, Curtis'	*Epioblasma* (=*Dysnomia*) *florentina curtisi*	U.S.A. (MO)	NA	E	15	NA	NA
Pearly mussel, dromedary	*Dromus dromas*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, green-blossom	*Epioblasma* (=*Dysnomia*) *torulosa gubernaculum.*	do	NA	E	15	NA	NA
Pearly mussel, Higgins' eye	*Lampsilis higginsi*	U.S.A. (IL, IA, MN, MO, NE, WI)	NA	E	15	NA	NA
Pearly mussel, Nicklin's	*Megalonaias nicklineana*	Mexico	NA	E	15	NA	NA
Pearly mussel, orange-footed	*Plethobasus cooperianus*	U.S.A. (AL, IN, IA, KY, OH, PA, TN)	NA	E	15	NA	NA
Pearly mussel, pale lilliput	*Toxolasma* (=*Carunculina*) *cylindrellus*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, pink mucket	*Lampsilis orbiculata*	U.S.A. (AL, IL, IN, KY, MO, OH, PA, TN, WV).	NA	E	15	NA	NA
Pearly mussel, Tampico	*Cyrtonaias tampicoensis tecomatensis*	Mexico	NA	E	15	NA	NA
Pearly mussel, tubercled-blossom	*Epioblasma* (=*Dysnomia*) *torulosa torulosa.*	U.S.A. (IL, IN, KY, TN, WV)	NA	E	15	NA	NA
Pearly mussel, turgid-blossom	*Epioblasma* (=*Dysnomia*) *turgidula*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, white cat's paw	*Epioblasma* (=*Dysnomia*) *sulcata delicata.*	U.S.A. (IN, MI, OH)	NA	E	15	NA	NA
Pearly mussel, white wartyback	*Plethobasus cicatricosus*	U.S.A. (AL, IN, TN)	NA	E	15	NA	NA
Pearly mussel, yellow-blossom	*Epioblasma* (=*Dysnomia*) *florentina florentina.*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pigtoe, fine-rayed	*Fusconaia cuneolus*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pigtoe, rough	*Pleurobema plenum*	U.S.A. (IN, KY, TN, VA)	NA	E	15	NA	NA
Pigtoe, shiny	*Fusconaia edgariana*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pocketbook, fat	*Potamilus* (=*Proptera*) *capax*	U.S.A. (AR, IN, MO, OH)	NA	E	15	NA	NA
Riffle shell, tan	*Epioblasma walkeri*	U.S.A. (KY, TN, VA)	NA	E	27	NA	NA

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Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Spiny mussel, Tar River	*Elliptio (Canthyria) steinstansana*	U.S.A. (NC)	NA	E	188	NA	NA
CRUSTACEANS							
Amphipod, Hay's Spring	*Stygobromus hayi*	U.S.A. (DC)	NA	E	115	NA	NA
Crayfish, Nashville	*Orconectes shoupi*	U.S.A. (TN)	NA	E	242	NA	NA
Isopod, Madison Cave	*Antrolana lira*	U.S.A. (VA)	NA	T	123	NA	17.46(a)
Isopod, Socorro	*Thermosphaeroma (=Exosphaeroma) thermophilus.*	U.S.A. (NM)	NA	E	36	NA	NA
Shrimp, Kentucky cave	*Palaemonias ganteri*	U.S.A. (KY)	NA	E	136	17.95(h)	NA
INSECTS							
Beetle, delta green ground	*Elaphrus viridis*	U.S.A. (CA)	NA	T	100	17.95(i)	NA
Beetle, valley elderberry longhorn	*Desmocerus californicus dimorphus*	do	NA	T	99	17.95(i)	NA
Butterfly, El Segundo blue	*Euphilotes (=Shijimiaeoides) battoides allyni.*	do	NA	E	14	NA	NA
Butterfly, Lange's metalmark	*Apodemia mormo langei*	do	NA	E	14	NA	NA
Butterfly, lotis blue	*Lycaeides argyrognomon lotis*	do	NA	E	14	NA	NA
Butterfly, mission blue	*Icaricia icarioides missionensis*	do	NA	E	14	NA	NA
Butterfly: Oregon silverspot	*Speyeria zerene hippolyta*	U.S.A. (OR, WA)	NA	T	95	17.95(i)	NA
Butterfly: Palos Verdes blue	*Glaucopsyche lygdamus palosverdesensis.*	U.S.A. (CA)	NA	E	96	17.95(i)	NA
Butterfly, San Bruno elfin	*Callophrys mossii bayensis*	do	NA	E	14	NA	NA
Butterfly, Schaus swallowtail	*Heraclides (=Papilio) aristodemus ponceanus.*	U.S.A. (FL)	NA	E	13,150	NA	NA
Butterfly, Smith's blue	*Euphilotes (=Shijimiaeoides) enoptes smithi.*	U.S.A. (CA)	NA	E	14	NA	NA
Moth, Kern primrose sphinx	*Euproserpinus euterpe*	do	NA	T	91	NA	NA
Naucorid, Ash Meadows	*Ambrysus amargosus*	U.S.A. (NV)	NA	T	181	17.95(i)	NA

EDITORIAL NOTE: For "When listed" citations, see list following; for symbols in "When listed" see below.
#—Indicates FR where species was delisted; relisting of the species is indicated by subsequent number(s).
E—Indicates Emergency rule publication (see FR document for effective dates); subsequent number(s) indicate FR final rule, if applicable under "When listed".

U.S. Fish and W

1—13 FR 4001; Ma
3—15 FR 16047; Oc
3—35 FR 8496; Jun
4—35 FR 18320; De
5—17 FR 6476; Mar
6—38 FR 14678; Ju
7—39 FR 44991; De
8—40 FR 29864; Ju
9—40 FR 31736; Ju
10—40 FR 44151; S
11—40 FR 44418; S
12—40 FR 47506; O
13—41 FR 17740; A
14—41 FR 22044; Ju
15—41 FR 24064; Ju
16—41 FR 45993; O
17—41 FR 51021; N
18—41 FR 51612; N
19—41 FR 53034; De
20—42 FR 2076; Jan
21—42 FR 2968; Jan
22—42 FR 15971; Ma
23—42 FR 25137; Ju
24—42 FR 25545; Ju
25—42 FR 37373; Ju
26—42 FR 40685; Au
27—42 FR 42353; Au
28—42 FR 45528; Se
29—42 FR 58755; No
30—42 FR 60745; No
31—43 FR 3715; Jan
32—43 FR 4028; Jan
33—43 FR 4621; Feb
34—43 FR 6233; Feb
35—43 FR 9612; Mar
36—43 FR 12691; Ma
37—43 FR 15428; Ap
38—43 FR 18345; Ap
40—43 FR 20504; Ma
41—43 FR 28932; Jul
42—43 FR 32808; Jul
43—43 FR 34479; Au
45—44 FR 21289; Ap
46—44 FR 23064; Ap
48—44 FR 29480; Ma
50—44 FR 37126; Jun
51—44 FR 37132; Jun
52—44 FR 42911; Jul
54—44 FR 49220; Au
55—44 FR 54007; Se
60—44 FR 59084; Oc
85—44 FR 69208; No
86—44 FR 70677; De
87—44 FR 75076; De
88—45 FR 18010; Ma
90—45 FR 21833; Ap
91—45 FR 24090; Ap
92—45 FR 27713; Ap
93—45 FR 28722; Ap
94—45 FR 35621; Ma
95—45 FR 44935; Ju
96—45 FR 44939; Ju
97—45 FR 47352; Ju
98—45 FR 47355; Ju
99—45 FR 52803; Au
100—45 FR 52807; Au
102—45 FR 54678; Au

1—32 FR 4001; March 11, 1967.
2—35 FR 16047; October 13, 1970.
3—35 FR 8495; June 2, 1970.
4—35 FR 18320; December 2, 1970.
5—37 FR 6476; March 30, 1972.
6—38 FR 14678; June 4, 1973.
7—39 FR 44991; December 30, 1974.
8—40 FR 29864; July 16, 1975.
9—40 FR 31738; July 28, 1975.
10—40 FR 44151; September 25, 1975.
11—40 FR 44418; September 26, 1975.
12—40 FR 47506; October 9, 1975.
13—41 FR 17740; April 28, 1976.
14—41 FR 22044; June 1, 1976.
15—41 FR 24064; June 14, 1976.
16—41 FR 45993; October 19, 1976.
17—41 FR 51021; November 19, 1976.
18—41 FR 51612; November 23, 1976.
19—41 FR 53034; December 3, 1976.
20—42 FR 2076; January 10, 1977.
21—42 FR 2968; January 14, 1977.
22—42 FR 15971, March 24, 1977.
23—42 FR 28137; June 2, 1977.
24—42 FR 28545; June 3, 1977.
25—42 FR 37373; July 21, 1977.
26—42 FR 40685; August 11, 1977.
27—42 FR 42353; August 23, 1977.
28—42 FR 45528; September 9, 1977.
29—42 FR 58755; November 11, 1977.
30—42 FR 60745; November 29, 1977.
31—43 FR 3715; January 27, 1978.
32—43 FR 4028; January 31, 1978.
33—43 FR 4621; February 3, 1978.
34—43 FR 6233; February 14, 1978.
35—43 FR 9612; March 9, 1978.
36—43 FR 12691; March 27, 1978.
37—43 FR 15429; April 13, 1978.
38—43 FR 16345; April 18, 1978.
40—43 FR 20504; May 12, 1978.
41—43 FR 28932; July 3, 1978.
42—43 FR 32808; July 28, 1978.
43—43 FR 34479; August 4, 1978.
45—44 FR 21289; April 10, 1979.
46—44 FR 23064; April 17, 1979.
48—44 FR 29480; May 21, 1979.
50—44 FR 37126; June 25, 1979.
51—44 FR 37132; June 25, 1979.
52—44 FR 42911; July 20, 1979.
54—44 FR 49220; August 21, 1979.
55—44 FR 54007; September 17, 1979.
60—44 FR 59084; October 12, 1979.
85—44 FR 69208; November 30, 1979.
86—44 FR 70677; December 7, 1979.
87—44 FR 75076; December 18, 1979.
88—45 FR 18010; March 20, 1980.
90—45 FR 21833; April 2, 1980.
91—45 FR 24090; April 8, 1980.
92—45 FR 27713; April 23, 1980.
93—45 FR 28722; April 30, 1980.
94—45 FR 35821; May 28, 1980.
95—45 FR 44935; July 2, 1980.
96—45 FR 44939; July 2, 1980.
97—45 FR 47352; July 14, 1980.
98—45 FR 47355; July 14, 1980.
99—45 FR 52803; August 8, 1980.
100—45 FR 52807; August 8, 1980.
102—45 FR 54678; August 15, 1980.
103—45 FR 55654; August 20, 1980.
105—45 FR 63812; September 25, 1980.
106—45 FR 65132; October 1, 1980.
108—46 FR 3178; January 13, 1981.
111—46 FR 11665; February 10, 1981.
112—46 FR 40025; August 6, 1981.
113—46 FR 40664; August 10, 1981.
114—47 FR 4204; January 28, 1982.
115—47 FR 5425; February 5, 1982.
117—47 FR 19995; May 10, 1982.
119—47 FR 31670; July 21, 1982.
123—47 FR 43701; October 4, 1982.
124—47 FR 43962; October 5, 1982.
125—47 FR 46093; October 15, 1982.
127—48 FR 612; January 5, 1983.
128—48 FR 1726; January 14, 1983.
129—48 FR 28464; June 22, 1983.
130—48 FR 40184; September 2, 1983.
131—48 FR 43043; September 21, 1983.
132—48 FR 46057; October 11, 1983.
134—48 FR 46336; October 12, 1983.
135—48 FR 46341; October 12, 1983.
136—48 FR 49249; October 25, 1983.
137—49 FR 1058; January 9, 1984.
138—49 FR 1994; January 17, 1984.
139—49 FR 2783; January 23, 1984.
142—49 FR 7335; February 28, 1984.
143—49 FR 7394; February 29, 1984.
144—49 FR 7398; February 29, 1984.
145—49 FR 10526; March 20, 1984.
146—49 FR 14356; April 11, 1984.
149—49 FR 22334; May 29, 1984.
150—49 FR 27514; July 5, 1984.
156—49 FR 33885; August 27, 1984.
157—49 FR 34494; August 31, 1984.
159—49 FR 34504; August 31, 1984.
160—49 FR 34510; August 31, 1984.
161—49 FR 35954; September 13, 1984.
163—49 FR 43069; October 26, 1984.
164—49 FR 43969; November 1, 1984.
166—49 FR 45163; November 15, 1984.
168—49 FR 49639; December 21, 1984.
169—50 FR 1056; January 9, 1985.
170—50 FR 4226; January 30, 1985.
171—50 FR 4945; February 4, 1985.
173—50 FR 12302; March 28, 1985.
174—50 FR 12305; March 28, 1985.
181—50 FR 20785; May 20, 1985.
182—50 FR 21792; May 28, 1985.
183—50 FR 23884; June 6, 1985.
184—50 FR 24530; June 11, 1985.
185—50 FR 24653; June 12, 1985.
186—50 FR 25678; June 20, 1985.
188—50 FR 26575; June 27, 1985.
189—50 FR 27002; July 1, 1985.
193—50 FR 30194; July 24, 1985.
195—50 FR 31596; August 5, 1985.
196—50 FR 31603; August 5, 1985.
203—50 FR 37198; September 12, 1985.
205—50 FR 39117; September 27, 1985.
206—50 FR 39123; September 27, 1985.
210—50 FR 50308; December 10, 1985.
211—50 FR 50733; December 11, 1985.
212—50 FR 51252; December 16, 1985.
216—51 FR 6690; February 25, 1986.
222—51 FR 10850; March 31, 1986.

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223—51 FR 10857; March 31, 1986.
224—51 FR 10864; March 31, 1986.
227—51 FR 16047; April 30, 1986.
228—51 FR 16482; May 2, 1986.
233—51 FR 17980; May 16, 1986.
236—51 FR 23781; July 1, 1986.
239—51 FR 27495; July 31, 1986.
241—51 FR 31422; September 3, 1986.
242—51 FR 34412; September 26, 1986.
246—51 FR 34425; September 26, 1986.

[48 FR 34182, July 27, 1983; 48 FR 34961, Aug. 2, 1983, as amended at 48 FR 39943, Sept. 2, 1983; 48 FR 46337, Oct. 12, 1983; 48 FR 52743, Nov. 22, 1983; 49 FR 1058, Jan. 9, 1984; 49 FR 33892, Aug. 27, 1984]

EDITORIAL NOTE: For additional FEDERAL REGISTER citations affecting the table in § 17.11(h), see the listing which follows the table.

EFFECTIVE DATE NOTE: At 51 FR 34412, 34425, Sept. 26, 1986, the table in § 17.11(h) was amended by adding "Shrew, Dismal Swamp southeastern" alphabetically under "Mammals" and adding "Crayfish, Nashville" alphabetically under "Crustaceans", effective October 27, 1986.

§ 17.12 Endangered and threatened plants.

(a) The list in this section contains the names of all species of plants which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of plants treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Scientific name" and "Common name" define the species of plant within the meaning of the Act. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Botanical Nomenclature.*

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this title.

(e) The "Historic range" indicates the known general distribution of the species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the plant species, wherever found.

(f)(1) A footnote to the FEDERAL REGISTER publication(s) listing or reclassifying a species is indicated under the column "When listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same FEDERAL REGISTER document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special rules" and "Critical habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The "Special rules" column will also be used to cite the special rules which describe experimental populations and determine if they are essential or nonessential. Separate listings will be made for experimental populations, and the status column will include the following symbols: "XE" for an essential experimental population and "XN" for a nonessential experimental population. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or critical habitat for that particular species. However, all other appropriate rules in Parts 17, 217 through 227, and 402 still apply to that species. In addition, there may be other rules in this title that relate to

such plants, e.g., port-of-entry requirements. It is not intended that the references in the "Special rules" column list all the regulations of the two Services which might apply to the species or to the regulations of other Federal agencies or State or local governments.

(g) The listing of a particular taxon includes all lower taxonomic units (see § 17.11(g) for examples).

(h) The "List of Endangered and Threatened Plants" is provided below:

Species: Scientific name	Species: Common name	Historic range	Status	When listed	Critical habitat	Special rules
Agavaceae—Agave family:						
Agave arizonica	Arizona agave	U.S.A. (AZ)	E	147	NA	NA
Alismataceae—Water-plantain family:						
Sagittaria fasciculata	Bunched arrowhead	U.S.A. (NC, SC)	E	63	NA	NA
Amaranthaceae—Amaranth family:						
Achyranthes rotundata	None	U.S.A. (HI)	E	220	NA	NA
Annonaceae—Custard-apple family:						
Asimina tetramera	Four-petal pawpaw	U.S.A. (FL)	E	244	NA	NA
Deeringothamnus pulchellus	Beautiful pawpaw	do	E	244	NA	NA
Deeringothamnus rugelii	Rugel's pawpaw	do	E	244	NA	NA
Apiaceae—Parsley family:						
Oxypolis canbyi	Canby's dropwort	U.S.A. (DE, GA, MD, NC, SC).	E	217	NA	NA
Apocynaceae—Dogbane family:						
Cycladenia humilis var. jonesii	Jones cycladenia	U.S.A. (AZ, UT)	T	229	NA	NA
Asteraceae—Aster family:						
Argyroxiphium sandwicense ssp. sandwicense	'Ahinahina (Mauna Kea silversword)	U.S.A. (HI)	E	219	NA	NA
Bidens cuneata	Cuneate bidens	do	E	141	NA	NA
Chrysopsis floridana (=Heterotheca floridana)	Florida golden aster	U.S.A. (FL)	E	232	NA	NA
Dyssodia tephroleuca	Ashy dogweed	U.S.A. (TX)	E	152	NA	NA
Echinacea tennesseensis	Tennessee purple coneflower	U.S.A. (TN)	E	49	NA	NA
Enceliopsis nudicaulis var. corrugata	Ash Meadows sunray	U.S.A. (NV)	T	181	17.96(a)	NA
Erigeron maguirei var. maguirei	Maguire daisy	U.S.A. (UT)	E	202	NA	NA
Erigeron rhizomatus	Rhizome fleabane	U.S.A. (NM)	T	177	NA	NA
Grindelia fraxinopratensis	Ash Meadows gumplant	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Hymenoxys texana	None	U.S.A. (TX)	E	218	NA	NA
Lipochaeta venosa	do	U.S.A. (HI)	E	73	NA	NA
Pityopsis ruthii (=Heterotheca ruthii, =Chrysopsis ruthii)	Ruth's golden aster	U.S.A. (TN)	E	191	NA	NA
Senecio franciscanus	San Francisco Peaks groundsel	U.S.A. (AZ)	T	137	17.96(a)	NA
Solidago shortii	Short's goldenrod	U.S.A. (KY)	E	201	NA	NA
Solidago spithamaea	Blue Ridge goldenrod	U.S.A. (NC, TN)	T	175	NA	NA
Stephanomeria malheurensis	Malheur wire-lettuce	U.S.A. (OR)	E	126	17.96(a)	NA
Townsendia aprica	Last Chance townsendia	U.S.A. (UT)	T	200	NA	NA
Berberidaceae—Barberry family:						
Mahonia sonnei (=Berberis s.)	Truckee barberry	U.S.A. (CA)	E	76	NA	NA
Betulaceae—Birch family:						
Betula uber	Virginia round-leaf birch	U.S.A. (VA)	E	39	NA	NA
Boraginaceae—Borage family:						
Amsinckia grandiflora	Large-flowered fiddleneck	U.S.A. (CA)	E	179	17.96(a)	NA
Brassicaceae—Mustard family:						
Arabis mcdoniana	McDonald's rock-cress	U.S.A. (CA)	E	44	NA	NA
Erysimum capitatum var. angustatum	Contra Costa wallflower	do	E	39	17.96(a)	NA
Thelypodium stenopetalum	Slender-petaled mustard	do	E	158	NA	NA
Buxaceae—Boxwood family:						
Buxus vahii	Vahl's boxwood	U.S.A. (PR)	E	197	NA	NA
Cactaceae—Cactus family:						
Ancistrocactus brevihamatus (=Echinocactus b., Mammillaria b.)						

Berberidaceae—Barberry family:						
Mahonia sonnei (= *Berberis s.*)	Truckee barberry	U.S.A. (VA)	E	39	NA	NA
Betulaceae—Birch family:						
Betula uber	Virginia round-leaf birch					
Boraginaceae—Borage family:						
Amsinckia grandiflora	Large-flowered fiddleneck	U.S.A. (CA)	E	179	17.96(a)	NA
Brassicaceae—Mustard family:						
Arabis modonaldiana	McDonald's rock-cress	U.S.A. (CA)	E	44	NA	NA
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	do	E	39	17.96(a)	NA
Thelypodium stenopetalum	Slender-petaled mustard	do	E	158	NA	NA
Buxaceae—Boxwood family:						
Buxus vahlii	Vahl's boxwood	U.S.A. (PR)	E	197	NA	NA
Cactaceae—Cactus family:						
Ancistrocactus tobuschii (= *Echinocactus t.*, *Mammillaria t.*)	Tobusch fishhook cactus	U.S.A. (TX)	E	80	NA	NA
Cereus eriophorus var. *fragrans*	Fragrant prickly-apple	U.S.A. (FL)	E	208	NA	NA
Cereus robinii	Key tree-cactus	U.S.A. (FL), Cuba	E	153	NA	NA
Coryphantha minima (= *C. nellieae*, *Escobaria n.*, *Mammillaria n.*)	Nellie cory cactus	U.S.A. (TX)	E	81	NA	NA
Coryphantha ramillosa	Bunched cory cactus	U.S.A. (TX), Mexico (Coahuila).	T	77	NA	NA
Coryphantha robbinsorum (= *Cochiseia r.*, *Escobaria r.*)	Cochise pincushion cactus	U.S.A. (AZ), Mexico (Sonora).	T	214	NA	NA
Coryphantha sneedii var. *leei* (= *Escobaria l.*, *Mammillaria l.*)	Lee pincushion cactus	U.S.A. (NM)	T	81	NA	NA
Coryphantha sneedii var. *sneedii* (= *Escobaria s.*, *Mammillaria s.*)	Sneed pincushion cactus	U.S.A. (TX, NM)	E	82	NA	NA
Echinocactus horizonthalonius var. *nicholii*	Nichol's Turk's head cactus	U.S.A. (AZ)	E	71	NA	NA
Echinocereus engelmannii var. *purpureus*	Purple-spined hedgehog cactus	U.S.A. (UT)	E	58	NA	NA
Echinocereus fendleri var. *kuenzleri* (= *E. kuenzleri*, *E. hempelii* of authors, not Fobe).	Kuenzler hedgehog cactus	U.S.A. (NM)	E	70	NA	NA
Echinocereus lloydii (= *E. roetteri* var. *l.*)	Lloyd's hedgehog cactus	U.S.A. (TX)	E	67	NA	NA
Echinocereus reichenbachii var. *albertii* (= *E. melanocentrus*)	Black lace cactus	do	E	68	NA	NA
Echinocereus triglochidiatus var. *arizonicus* (= *E. arizonicus*)	Arizona hedgehog cactus	U.S.A. (AZ)	E	62	NA	NA
Echinocereus triglochidiatus var. *inermis* (= *E. coccineus* var. *i.*, *E. phoeniceus* var. *i.*).	Spineless hedgehog cactus	U.S.A. (CO, UT)	E	83	NA	NA
Echinocereus viridiflorus var. *davisii* (= *E. davisii*)	Davis' green pitaya	U.S.A. (TX)	E	81	NA	NA
Neolloydia mariposensis (= *Echinocactus m.*, *Echinomastus m.*)	Lloyd's Mariposa cactus	U.S.A. (TX), Mexico (Coahuila).	T	77	NA	NA
Pediocactus bradyi (= *Toumeya b.*)	Brady pincushion cactus	U.S.A. (AZ)	E	63	NA	NA
Pediocactus knowltonii (= *P. bradyi* var. *k.* *Toumeya k.*)	Knowlton cactus	U.S.A. (NM, CO)	E	72	NA	NA
Pediocactus peeblesianus var. *peeblesianus* (= *Echinocactus p.*, *Navajoa p.*, *Toumeya p.*, *Utahia p.*).	Peebles Navajo cactus	U.S.A. (AZ)	E	69	NA	NA
Pediocactus sileri (= *Echinocactus s.*, *Utahia s.*)	Siler pincushion cactus	U.S.A. (AZ, UT)	E	64	NA	NA
Sclerocactus glaucus (= *Echinocactus g.*, *E. subglaucus*, *E. whipplei* var. *g.*, *Pediocactus g.*, *S. franklinii*, *S. whipplei* var. *g.*).	Uinta Basin hookless cactus	U.S.A. (CO, UT)	T	59	NA	NA
Sclerocactus mesae-verdae (= *Coloradoa m.*, *Echinocactus m.*, *Pediocactus m.*).	Mesa Verde cactus	U.S.A. (CO, NM)	T	75	NA	NA
Sclerocactus wrightiae (= *Pediocactus w.*)	Wright fishhook cactus	U.S.A. (UT)	E	58	NA	NA
Caryophyllaceae—Pink family:						
Schiedea adamantis	Diamond Head schiedea	U.S.A. (HI)	E	141	NA	NA

Species		Historic range	Status	When listed	Critical habitat	Special rules
Scientific name	Common name					
Chenopodiaceae—Goosefoot family:						
Nitrophila mohavensis	Amargosa niterwort	U.S.A. (CA)	E	181	17.96(a)	NA
Cistaceae—Rockrose family:						
Hudsonia montana	Mountain golden heather	U.S.A. (NC)	T	107	17.96(a)	NA
Crassulaceae—Stonecrop family:						
Dudleya traskiae	Santa Barbara Island liveforever	U.S.A. (CA)	E	39	NA	NA
Cucurbitaceae—Gourd family:						
Tumamoca macdougalii	Tumamoc globe-berry	U.S.A. (AZ), Mexico (Sonora).	E	226	NA	NA
Cupressaceae—Cypress family:						
Fitzroya cupressoides	Chilean false larch (=alerce)	Chile, Argentina	T	79	NA	NA
Cyperaceae—Sedge family:						
Carex specuicola	None	U.S.A. (AZ)	T	176	17.96(a)	NA
Ericaceae—Heath family:						
Arctostaphylos pungens var. *ravenii* (=*A. hooteri* ssp. *ravenii*)	Presidio (=Raven's) manzanita	U.S.A. (CA)	E	85	NA	NA
Rhododendron chapmanii	Chapman rhododendron	U.S.A. (FL)	E	47	NA	NA
Euphorbiaceae—Spurge family:						
Euphorbia (=*Chamaesyce*) *deltoidea* ssp. *deltoidea*	Spurge	U.S.A. (FL)	E	192	NA	NA
Euphorbia (=*Chamaesyce*) *garberi*	None	....do	T	192	NA	NA
Euphorbia skottsbergii var. *kalaeloana*	Ewa Plains 'akoko	U.S.A. (HI)	E	120	NA	NA
Jatropha costaricensis	Costa Rican jatropha	Costa Rica	E	154	NA	NA
Fabaceae—Pea family:						
Amorpha crenulata	Crenulate lead-plant	U.S.A. (FL)	E	192	NA	NA
Astragalus humillimus	Mancos milk-vetch	U.S.A. (CO, NM)	E	187	NA	NA
Astragalus perianus	Rydberg milk-vetch	U.S.A. (UT)	T	39	NA	NA
Astragalus phoenix	Ash Meadows milk-vetch	U.S.A. (NV)	T	181	17.96(a)	NA
Baptisia arachnifera	Hairy rattleweed	U.S.A. (GA)	E	39	NA	NA
Galactia smallii	Small's milkpea	U.S.A. (FL)	E	192	NA	NA
Hoffmannseggia tenella	Slender rush-pea	U.S.A. (TX)	E	209	NA	NA
Lotus dendroideus ssp. *traskiae* (=*L. scoparius* ssp. *t.*)	San Clemente Island broom	U.S.A. (CA)	E	28	NA	NA
Mezoneuron kavaiense	Uhiuhi	U.S.A. (HI)	E	238	NA	NA
Vicia menziesii	Hawaiian vetch	....do	E	39	NA	NA
Frankeniaceae—Frankenia family:						
Frankenia johnstonii	Johnston's frankenia	U.S.A. (TX), Mexico (Nuevo Leon).	E	156	NA	NA
Gentianaceae—Gentian family:						
Centaurium namophilum	Spring-loving centaury	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Goodeniaceae—Goodenia family:						
Scaevola coriacea	Dwarf naupaka	U.S.A. (HI)	E	231	NA	NA
Hydrophyllaceae—Waterleaf family:						
Phacelia argillacea	Clay phacelia	U.S.A. (UT)	E	44	NA	NA
Phacelia formosula	North Park phacelia	U.S.A. (CO)	E	121	NA	NA
Lamiaceae—Mint family:						

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Viola menziesii						
Frankeniaceae—Frankenia family:						
Frankenia johnstonii	Johnst	ienia	U.S.A. (TX), Mexico (Nuevo Leon).	E	166	NA	NA
Gentianaceae—Gentian family:						
Centaurium namophilum	Spring-loving centaury	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Goodeniaceae—Goodenia family:						
Scaevola coriacea	Dwarf naupaka	U.S.A. (HI)	E	231	NA	NA
Hydrophyllaceae—Waterleaf family:						
Phacelia argillacea	Clay phacelia	U.S.A. (UT)	E	44	NA	NA
Phacelia formosula	North Park phacelia	U.S.A. (CO)	E	121	NA	NA
Lamiaceae—Mint family:						
Acanthomintha obovata ssp. duttonii	San Mateo thornmint	U.S.A. (CA)	E	204	NA	NA
Dicerandra cornutissima	Longspurred mint	U.S.A. (FL)	E	207	NA	NA
Dicerandra frutescens	Scrub mint	do	E	207	NA	NA
Dicerandra immaculata	Lakela's mint	do	E	180	NA	NA
Haplostachys haplostachya var. angustifolia	None	U.S.A. (HI)	E	73	NA	NA
Hedeoma apiculatum	McKittrick pennyroyal	U.S.A. (TX, NM)	T	118	17.96(a)	NA
Hedeoma todsenii	Todsen's pennyroyal	U.S.A. (NM)	E	110, 112	17.96(a)	NA
Pogogyne abramsii	San Diego mesa mint	U.S.A. (CA)	E	44	NA	NA
Scutellaria montana	Large-flowered skullcap	U.S.A. (GA,TN)	E	234	NA	NA
Stenogyne angustifolia var. angustifolia	None	U.S.A. (HI)	E	73	NA	NA
Lauraceae—Laurel family:						
Lindera melissifolia	Pondberry	U.S.A. (AL, AR, FL, GA, LA, MO, MS, NC, SC).	E	240	NA	NA
Liliaceae—Lily family:						
Erythronium propullans	Minnesota trout lily	U.S.A. (MN)	E	221	NA	NA
Harperocallis flava	Harper's beauty	U.S.A. (FL)	E	57	NA	NA
Trillium persistens	Persistent trillium	U.S.A. (GA, SC)	E	39	NA	NA
Loasaceae—Loasa family:						
Mentzelia leucophylla	Ash Meadows blazing star	U.S.A. (NV)	T	181	17.96(a)	NA
Malvaceae—Mallow family:						
Abutilon menziesii	Ko'oloa'ula	U.S.A. (HI)	E	243	NA	NA
Callirhoe scabriuscula	Texas poppy-mallow	U.S.A. (TX)	E	109, 112	NA	NA
Hibiscadelphus distans	Kauai hau kuahiwi	U.S.A. (HI)	E	225	NA	NA
Iliamna corei	Peter's Mountain mallow	U.S.A. (VA)	E	230	NA	NA
Kokia cookei	Cooke's kokio	U.S.A. (HI)	E	74	NA	NA
Kokia drynarioides	Koki'o (=hau-hele'ula or Hawaii tree cotton).	do	E	187	17.96(a)	NA
Malacothamnus clementinus	San Clemente Island bush-mallow	U.S.A. (CA)	E	28	NA	NA
Sidalcea pedata	Pedate checker-mallow	do	E	158	NA	NA
Nyctaginaceae—Four-o'clock family:						
Mirabilis macfarlanei	MacFarlane's four-o'clock	U.S.A. (ID, OR)	E	66	NA	NA

Species: Scientific name	Species: Common name	Historic range	Status	When listed	Critical habitat	Special rules
Onagraceae—Evening-primrose family:						
Camissonia benitensis	San Benito evening-primrose	U.S.A. (CA)	T	172	NA	NA
Oenothera avita ssp. *eurekensis*	Eureka Valley evening-primrose	do	E	39	NA	NA
Oenothera deltoides ssp. *howellii*	Antioch Dunes evening-primrose	do	E	39	17.96(a)	NA
Orchidaceae—Orchid family:						
Isotria medeoloides	Small whorled pogonia	U.S.A. (CT, IL, MA, MD, ME, MI, MO, NC, NH, NJ, NY, PA, RI, SC, VA, VT), Canada (Ont.).	E	122	NA	NA
Spiranthes parksii	Navasota ladies'-tresses	U.S.A. (TX)	E	118	NA	NA
Papaveraceae—Poppy family:						
Arctomecon humilis	Dwarf bear-poppy	U.S.A. (UT)	E	78	NA	NA
Pinaceae—Pine family:						
Abies guatemalensis	Guatemalan fir (=pinabete)	Mexico, Guatemala, Honduras, El Salvador.	T	84	NA	NA
Poaceae—Grass family:						
Tuctoria mucronata (=*Orcuttia m.*)	Solano grass	U.S.A. (CA)	E	44	NA	NA
Panicum carteri	Carter's panicgrass	U.S.A. (HI)	E	133	17.96(a)	NA
Swallenia alexandrae	Eureka Dune grass	U.S.A. (CA)	E	39	NA	NA
Zizania texana	Texas wild-rice	U.S.A. (TX)	E	39	17.96(a)	NA
Polygalaceae—Milkwort family:						
Polygala smallii	Tiny polygala	U.S.A. (FL)	E	192	NA	NA
Polygonaceae—Buckwheat family:						
Eriogonum gypsophilum	Gypsum wild-buckwheat	U.S.A. (NM)	T	110, 112	17.96(a)	NA
Eriogonum ovalifolium var. *williamsiae*	Steamboat buckwheat	U.S.A. (NV)	E	237	NA	NA
Eriogonum pelinophilum	Clay-loving wild-buckwheat	U.S.A. (CO)	E	161	17.96(a)	NA
Primulaceae—Primrose family:						
Primula maguire	Maguire primrose	U.S.A. (UT)	T	199	NA	NA
Ranunculaceae—Buttercup family:						
Aconitum noveboracense	Northern wild monkshood	U.S.A. (IA, NY, OH, WI)	T	39	NA	NA
Clematis socialis	Alabama leather flower	U.S.A. (AL)	E	245	NA	NA
Delphinium kinkiense	San Clemente Island larkspur	U.S.A. (CA)	E	29	NA	NA
Rhamnaceae—Buckthorn family:						
Gouania hillebrandii	None	U.S.A. (HI)	E	165	17.96(a)	NA
Rosaceae—Rose family:						
Cowania subintegra	Arizona cliffrose	U.S.A. (AZ)	E	148	NA	NA
Ivesia eremica	Ash Meadows ivesia	U.S.A. (NV)	T	181	17.96(a)	NA
Potentilla robbinsiana	Robbins' cinquefoil	U.S.A. (NH, VT)	E	104	17.96(a)	NA
Rubiaceae—Coffee family:						
Gardenia brighamii	Na'u (Hawaiian gardenia)	U.S.A. (HI)	E	198	NA	NA
Rutaceae—Citrus family:						
Zanthoxylum thomasianum	St. Thomas prickly-ash	U.S.A. (PR, VI)	E	813	NA	NA

9413218.0518

Rosaceae—Rose family:						
Cowania subintegra	Arizona cliffrose	U.S.A. (AZ)	E	148	NA	NA
Ivesia eremica	Ash Meadows ivesia	U.S.A. (NV)	T	181	17.96(e)	NA
Potentilla robbinsiana	Robbins' cinquefoil	U.S.A. (NH, VT)	E	104	17.96(e)	NA
Rubiaceae—Coffee family:						
Gardenia brighamii	Na'u (Hawaiian gardenia)	U.S.A. (HI)	E	198	NA	NA
Rutaceae—Citrus family:						
Zanthoxylum thomasianum	St. Thomas prickly-ash	U.S.A. (PR, VI)	E	213	NA	NA
Santalaceae—Sandalwood family:						
Santalum freycinetianum var. *lanaiense*	Lanai sandalwood or 'Iliahi	U.S.A. (HI)	E	215	NA	NA
Sarraceniaceae—Pitcher plant family:						
Sarracenia oreophila	Green pitcher plant	U.S.A. (AL, GA, TN)	E	56, 59	NA	NA
Saxifragaceae—Saxifrage family:						
Ribes echinellum	Miccosukee gooseberry	U.S.A. (FL, SC)	T	160	NA	NA
Scrophulariaceae—Snapdragon family:						
Castilleja grisea	San Clemente Island indian paintbrush	U.S.A. (CA)	E	26	NA	NA
Cordylanthus maritimus ssp. *maritimus*	Salt marsh bird's-beak	U.S.A. (CA), Mexico (Baja California).	E	44	NA	NA
Cordylanthus palmatus	Palmate-bracted bird's-beak	U.S.A. (CA)	E	235	NA	NA
Pedicularis furbishiae	Furbish lousewort	U.S.A. (ME), Canada (New Brunswick).	E	39	NA	NA
Solanaceae—Nightshade family:						
Goetzea elegans	Beautiful goetzea, matabuey	U.S.A. (PR)	E	176	NA	NA
Styracaceae—Styrax family:						
Styrax texanus	Texas snowbells	U.S.A. (TX)	E	162	NA	NA
Taxaceae—Yew family:						
Torreya taxifolia	Florida torreya	U.S.A. (FL, GA)	E	140	NA	NA

EDITORIAL NOTE: For "When listed" citations, see list following; for symbols in "When listed" see below:

E—Indicates Emergency rule publication (see FR document for effective dates); subsequent number(s) indicate FR final rule, if applicable under "When listed".

9413218.0519

Rosaceae—Rose family:						
Cowania subintegra	Arizona cliffrose	U.S.A. (AZ)	E	148	NA	NA
Ivesia eremica	Ash Meadows Ivesia	U.S.A. (NV)	T	181	17.96(a)	NA
Potentilla robbinsiana	Robbins' cinquefoil	U.S.A. (NH, VT)	E	104	17.96(a)	NA
Rubiaceae—Coffee family:						
Gardenia brighamii	Na'u (Hawaiian gardenia)	U.S.A. (HI)	E	196	NA	NA
Rutaceae—Citrus family:						
Zanthoxylum thomasianum	St. Thomas prickly-ash	U.S.A. (PR, VI)	E	213	NA	NA
Santalaceae—Sandalwood family:						
Santalum freycinetianum var. *lanaiense*	Lanai sandalwood or 'Iliahi	U.S.A. (HI)	E	216	NA	NA
Sarraceniaceae—Pitcher plant family:						
Sarracenia oreophila	Green pitcher plant	U.S.A. (AL, GA, TN)	E	56, 89	NA	NA
Saxifragaceae—Saxifrage family:						
Ribes echinellum	Miccosukee gooseberry	U.S.A. (FL, SC)	T	190	NA	NA
Scrophulariaceae—Snapdragon family:						
Castilleja grisea	San Clemente Island Indian paintbrush	U.S.A. (CA)	E	28	NA	NA
Cordylanthus maritimus ssp. *maritimus*	Salt marsh bird's-beak	U.S.A. (CA), Mexico (Baja California).	E	44	NA	NA
Cordylanthus palmatus	Palmate-bracted bird's-beak	U.S.A. (CA)	E	235	NA	NA
Pedicularis furbishiae	Furbish lousewort	U.S.A. (ME), Canada (New Brunswick).	E	39	NA	NA
Solanaceae—Nightshade family:						
Goetzea elegans	Beautiful goetzea, matabuey	U.S.A. (PR)	E	178	NA	NA
Styracaceae—Styrax family:						
Styrax texana	Texas snowbells	U.S.A. (TX)	E	182	NA	NA
Taxaceae—Yew family:						
Torreya taxifolia	Florida torreya	U.S.A. (FL, GA)	E	140	NA	NA

EDITORIAL NOTE: For "When listed" citations, see list following; for symbols in "When listed" see below.

E—Indicates Emergency rule publication (see FR document for effective dates); subsequent number(s) indicate FR final rule, if applicable under "When listed".

REFERENCE 20

Memo to file from KH Cramer regarding Personal Communication with M Gillum concerning Richland City Well Data, August 6, 1987

9413218.0520

FILE NOTE

Date: 12/23/87

By: R.D. Stenner RD Stenner

Re: Telephone conversation with Michael Gillum, City of Richland, Regarding Kennewick Intertie on the Richland Water System.

The Kennewick intertie on the Richland water system is an intertie that services both ways (i.e., Richland can receive water from Kennewick and Kennewick can receive water from Richland).

The Kennewick system would not have the capacity to service the Richland system as an alternate water supply. Michael said that the Kennewick intertie is only used during problems with the system during peak irrigation demand periods, and that the Kennewick system would not have the capacity to serve the Richland system should something happen to cause the Richland water system to be inoperative.

The 300 Area intertie is a one-way only intertie for the 300 Area to receive water from Richland. The Richland system can not receive water from the 300 Area intertie.

9413218.0521

MEMO: To File

DATE: 8/6/87

FROM: K. H. Cramer

SUBJECT: Personal conversation with Michael Gillum
Regard Richland City Recharge Wells and Water Supply System

There are 14 recharge wells that are within 3 miles of the Hanford Site boundary. These wells have depths that range from 40 to 134 feet. The recharge well system is part of the city's overall water supply system. The recharge wells are designed to be used in conjunction with the Water Supply holding ponds located beside the wells. The recharge well system is used during peak water demand periods and when the Columbia River Water Pump System is down for maintenance. The recharge system operates with water being pumped to the holding ponds from the Columbia River. The water in the ponds then seeps through the soil to the aquifer where it is pumped by the recharge wells to the city's water supply system. The recharge wells are tied into the overall water supply system, which means that the water from the wells is mixed with the Columbia River water and distributed throughout the city.

509 943-9151

MICHAEL GILLUM
Associate Engineer
Utility Administration Division
Water & Waste Utilities Department

505 SWIFT BOULEVARD BOX 150 RICHLAND WASHINGTON 99352

9413218.0522

CITY OF RICHLAND

WATER SYSTEM DATA

A. PRODUCTION

The City of Richland's water supply comes from two major sources:

1. Water Treatment Plant: The Water Treatment Plant uses the "Micro-Floc" process for water treatment (see attached flow diagram). Its present design production capacity is 30 million gallons per day. The plant can be expanded to a maximum production capacity of 45 MGD.

2. Wells: The 18 wells are located in five well fields. The total production capacity of all the wells is 18.2 MGD. The North Richland well field groundwater is recharged artificially through the use of recharge basins (see attachment). The wells are recharged through the months of April to November.

The production capacities can be summarized as follows:

Source	# Wells	Capacity
Columbia Well Field	1	0.8 MGD
Duke Well Field	2	2.0 MGD
North Richland Well Field & D-5	11	11.0 MGD
Wellsian Way Well Field	3	3.0 MGD
Willowbrook Well	1	1.4 MGD
Water Treatment Plant		30.0 MGD
TOTAL	18	48.2 MGD

B. STORAGE

The City of Richland's water system has a water storage capacity of 23.67 million gallons. The major elevated storage, a five and ten million gallon reservoir, is located west of the Yakima River. The other elevated storage consists of five additional reservoirs, with a capacity of 4.47 million gallons and are also located west of the Yakima River, serving the Badger Mountain Area. Water from the remaining reservoirs is pumped into the system by booster pumps.

Storage can be summarized as follows:

Storage		Capacity
Two (2) one-million gallon reservoirs (1182)		2.0 MG
Five million gallon reservoir		5.0 MG
Ten million gallon reservoir		10.0 MG
Water Treatment Plant Clearwell reservoir		2.2 MG
Tapteal I reservoir (reservoir #1)		0.75 MG
Tapteal I reservoir (reservoir #2)		2.6 MG
Tapteal II reservoir (reservoir #1)	Upper Pressure Zone	0.18 MG
Tapteal II reservoir (reservoir #2)	Upper Pressure Zone	0.7 MG
Country Ridge reservoir	Upper Pressure Zone	0.24 MG
TOTAL		23.67 MG

Ref. 20.2

9413218.0523

C. TRANSMISSION

All water transmission lines, 10" or larger, are shown on the utility map of the City of Richland. The major transmission lines are shown on the attached facilities location map.

D. PRESSURE ZONES

The City of Richland has three pressure zones:

1. Richland City core area.
2. Badger Mountain/Meadow Springs area (area west of Yakima River) - Tapteal I pressure zone.
3. Badger Mountain/Meadow Springs area (higher elevations west of Keene Road and portion of Hills West area) - Tapteal II pressure zone.

The Badger Mountain/Meadow Springs area water is pumped from the Richland City core pressure zone to the higher Badger Mountain pressure zone. The booster pump station for this zone is located at the five and ten million gallon reservoirs.

The third pressure zone is supplied by (1) a pumping station off High Meadows Street and currently serves the majority of homes on High Meadows Street, Hillview Drive and all homes west of Orchard Court on Orchard Way and Greenview Drive, and (2) a pumping station on Keene Road at Country Ridge and serves the Country Ridge/Keene Village area.

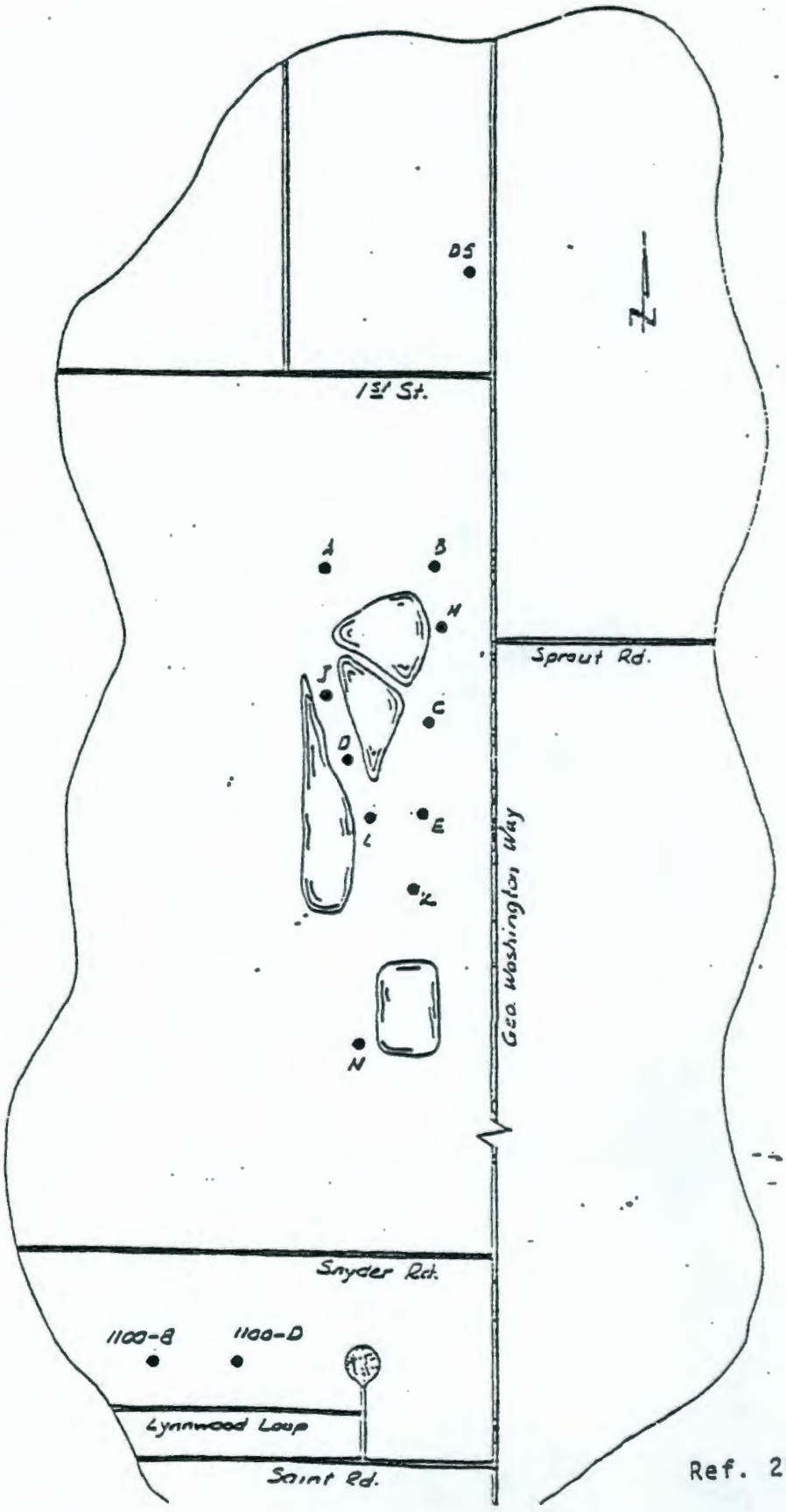
9413218.0524

Attachment

NORTH RICHLAND WELLS

North Richland Well Field

Well #	Depth
3000-A	88'
3000-B	87'
3000-C	64'
3000-D	75.3'
3000-E	61.8'
3000-H	56'
3000-J	71'
3000-K	59'
3000-L	83'
3000-N	40'
3000-DS	134'



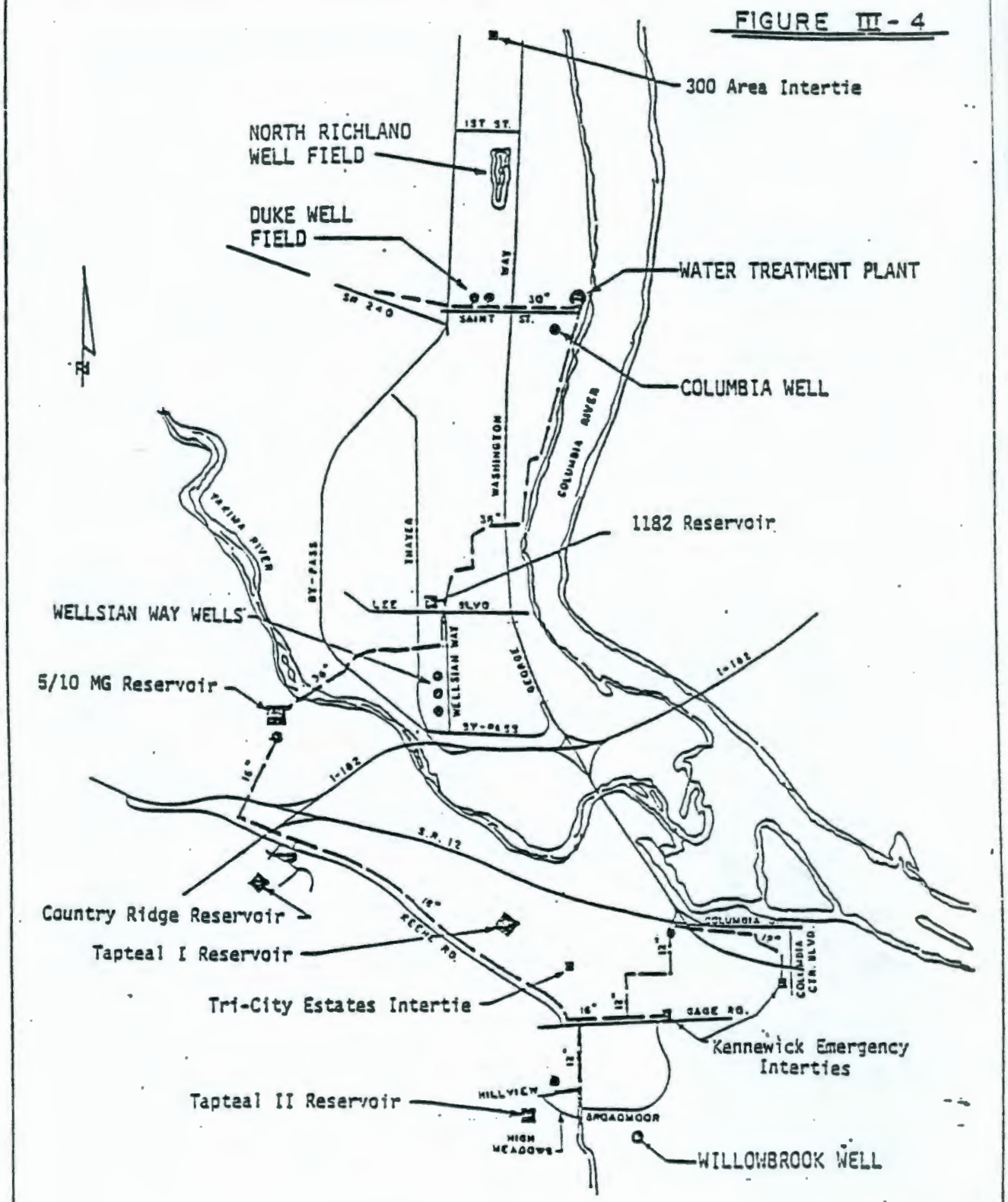
Duke Well Field

Well #	Depth
1100-B	120'
1100-D	86'

Ref. 20.4

9413218.0525

FIGURE III-4

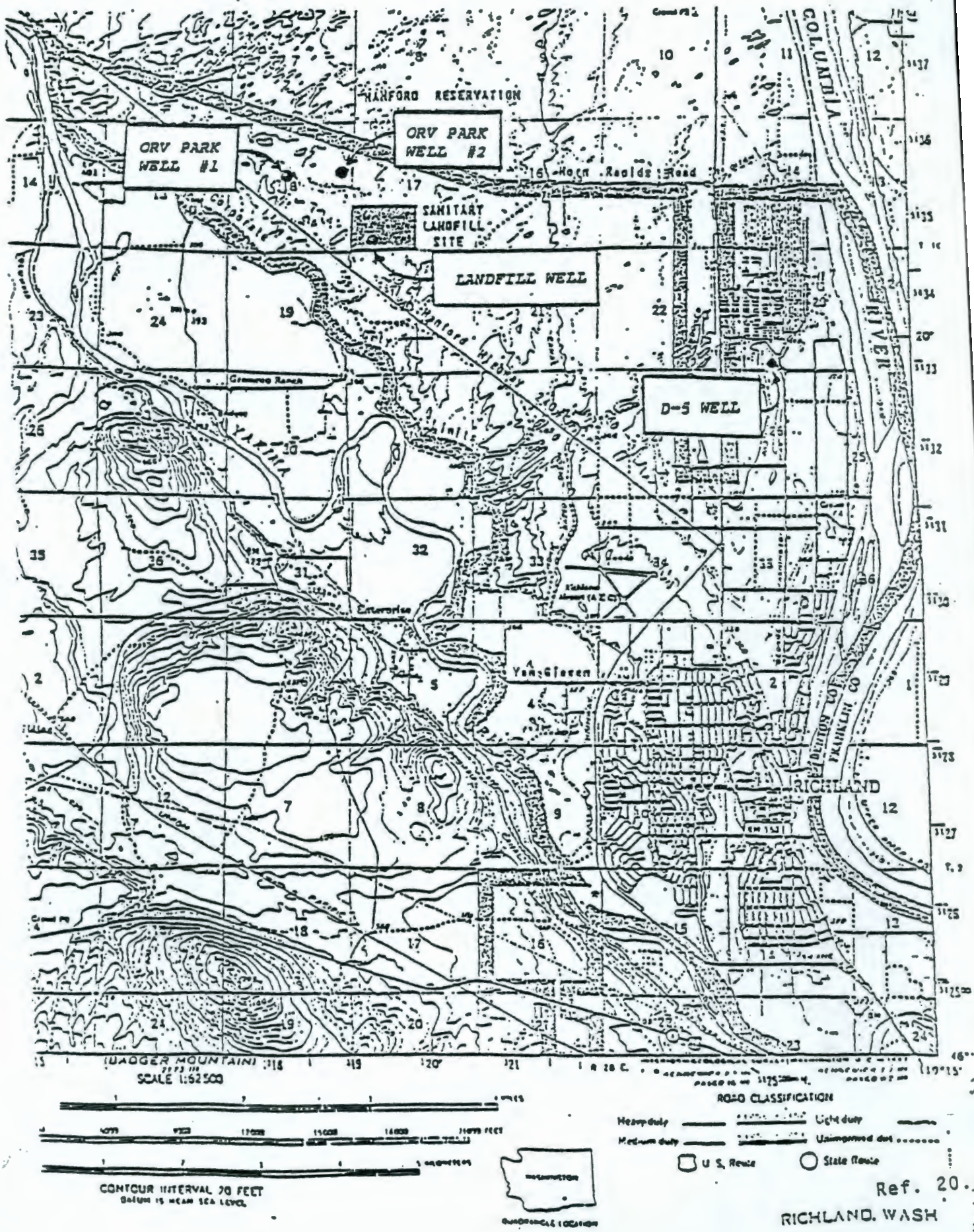


CITY OF RICHLAND

WATER SYSTEM SOURCE and STORAGE FACILITIES LOCATION MAP

Ref. 20.5

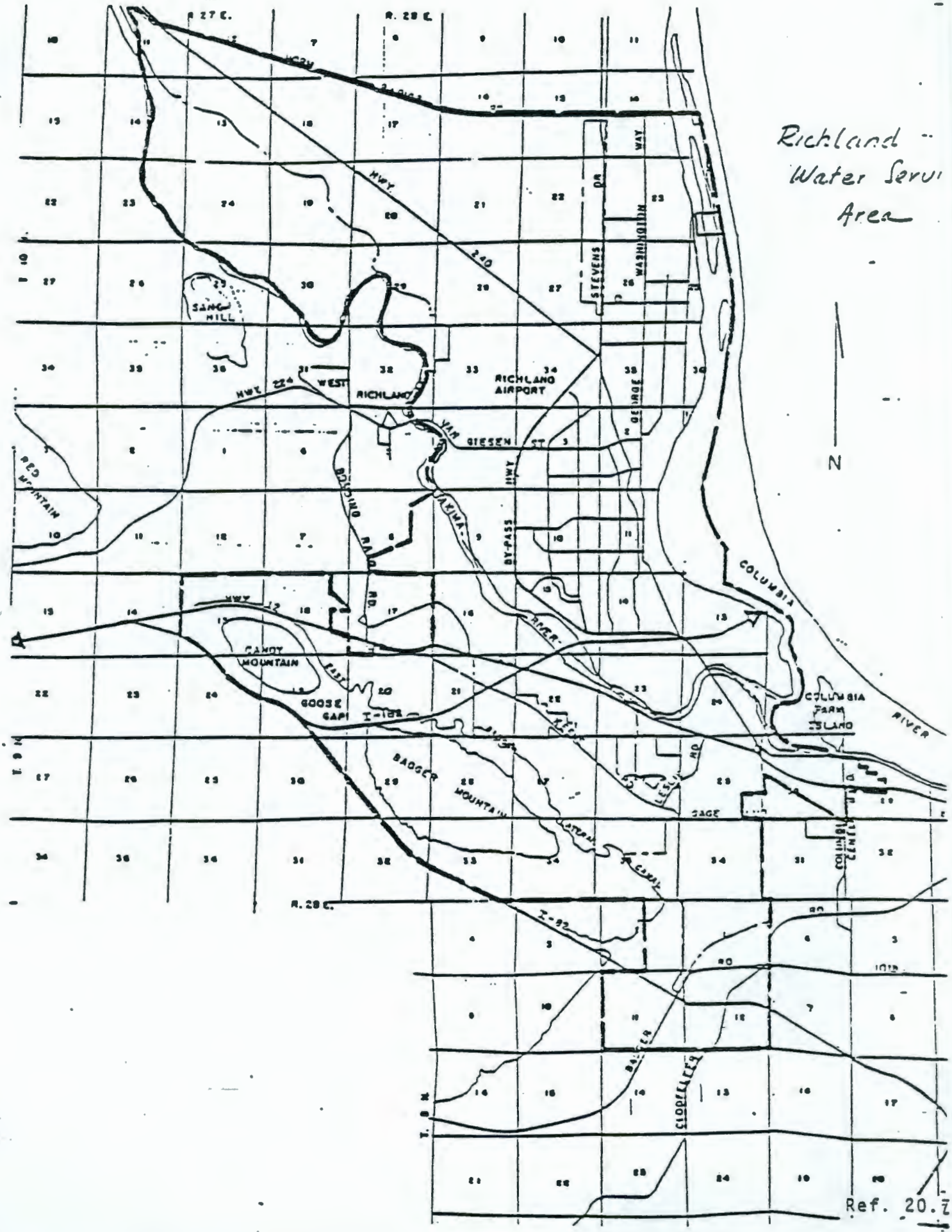
9413218.0526



Ref. 20.6

RICHLAND, WASH

9413218.0527



Richland Water Servi Area

N

Ref. 20.7

9413218.0528

REFERENCE 21

Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 2 (HISS Database)

SITE ID NO.: 216-N-1

ALIAS: 212-N Swamp, 216-N-1 Swamp, 216-N-1 Covered Pond
STATUS: Inactive
DIMENSIONS:
Length: 500 ft
Width: 100 ft
Depth: 3 ft
Diameter: 0 ft

FACILITY: Pond
ELEVATION: 567 ft
WATERTABLE: 162 ft

LOCATION: 200 North
COORDINATES: Head: N53700/W65050 End: N54125/W65475

SITE DESCRIPTION:

Pond, measuring 500 ft. long x 100 ft. wide.

SERVICE DATES: 1944-1952

SERVICE HISTORY:

From 1944 to 1952 the site received the basin overflow from the 212-N building. The site was retired in 1952.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-29-CN
Drawings: H-3-57210

Ref. 21.

SITE ID NO.: 216-N-1

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 946000000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.00000	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.00000
CS-137:	0.00000	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

Although used for radioactive waste disposal, no inventory is available.

These values are decayed through April 1, 1986.

Ref. 21.2

9413218.0531

SITE ID NO.: 216-N-2

ALIAS: 216-N-1 Trench, 216-N-2 Trench
STATUS: Inactive
DIMENSIONS:
Length: 50 ft
Width: 10 ft
Depth: 7 ft
Diameter: 0 ft

FACILITY: Crib
ELEVATION: 578 ft
WATERTABLE: 173 ft

LOCATION: 200 North
COORDINATES: N55485/W65788 (Center of crib)

SITE DESCRIPTION:

Trench, measuring 50 ft. long x 10 ft. wide (bottom dimensions), with a depth of 7 ft.

SERVICE DATES: 1947-1947

SERVICE HISTORY:

From 3/47 to 4/47 the site received the basin water and sludge cleanout when it was drained for special tests. The site was retired in 4/47 and the trench backfilled. The waste type is low activity.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-30-CN
Drawings: H-3-57210

Ref. 21.3

9413218.0532

SITE ID NO.: 216-N-2

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 7570000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.07540	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.31600
CS-137:	0.08560	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

Ref. 21.4

SITE ID NO.: 216-N-3

ALIAS: 212-N-2 Trench, 212-N-3 Trench
STATUS: Inactive
DIMENSIONS:
Length: 50 ft
Width: 20 ft
Depth: 6 ft
Diameter: 0 ft

FACILITY: Crib
ELEVATION: 578 ft
WATERTABLE: 173 ft

LOCATION: 200 North
COORDINATES: N55455/W65838 (Center of crib)

SITE DESCRIPTION:

Trench, with 50 ft. long x 20 ft. wide bottom dimensions, with a depth of 6 ft.

SERVICE DATES: 1952-1952

SERVICE HISTORY:

From 5/52 to 6/52 the site received basin water and sludge cleanout from the 212-N building when the area was shut down. The site was retired in 6/52.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-30-CN
Drawings: H-3-57210

9413218.0534

Ref. 21.5

SITE ID NO.: 216-N-3

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 7570000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.08520	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.35600
CS-137:	0.09600	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

Ref. 21.6

SITE ID NO.: 216-N-4

ALIAS: 212-P Swamp, 216-N-2, 216-N-4 Swamp
STATUS: Inactive
DIMENSIONS:
Length: 500 ft
Width: 200 ft
Depth: 3 ft
Diameter: 0 ft

FACILITY: Pond
ELEVATION: 558 ft
WATERTABLE: 153 ft

LOCATION: 200 North
COORDINATES: Head: N53400/W62600, End: N54300/W62700

SITE DESCRIPTION:

Pond, with 500 ft. x 200 ft. wide bottom dimensions.

SERVICE DATES: 1944-1952

SERVICE HISTORY:

From 9/44 to 6/52 the site received the basin overflow waste from the 212-P Building. The site was retired in 6/52 when the 212-P building was shut down.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-27-CN
Drawings: H-3-57210

9413218.0536

Ref. 21.7

SITE ID NO.: 216-N-4

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 946000000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.07830	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.05710
ZR-95:	0.00000	PU-240:	0.01540
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00152
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.31400
CS-137:	0.08860	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

Ref. 21.8

9413218.0537

SITE ID NO.: 216-N-5

ALIAS: 212-P-Trench, 216-N-5 Trench
STATUS: Inactive
DIMENSIONS:
Length: 80 ft
Width: 15 ft
Depth: 6 ft
Diameter: 0 ft

FACILITY: Crib
ELEVATION: 575 ft
WATERTABLE: 170 ft

LOCATION: 200 North
COORDINATES: N55408/W63130, N55495/W63225 (Diagonally)

SITE DESCRIPTION:

Trench, with dimensions of 80 ft. long x 15 ft. wide x 6 ft. deep.

SERVICE DATES: 1952-1952

SERVICE HISTORY:

From 5/52 to 6/52 the site received the basin water and sludge cleanout from the 212-P Basin during shutdown of the area. The site was retired in 6/52.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-28-CN
Drawings: H-3-57210

9413218.0538

SITE ID NO.: 216-N-5

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 7570000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.08520	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.35600
CS-137:	0.09600	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

Ref. 21.10

SITE ID NO.: 216-N-6

ALIAS: 212-R Swamp, 216-N-6 Swamp
STATUS: Inactive
DIMENSIONS:
Length: 500 ft
Width: 150 ft
Depth: 3 ft
Diameter: 0 ft

FACILITY: Pond
ELEVATION: 557 ft
WATERTABLE: 152 ft

LOCATION: 200 North
COORDINATES: Head: N53600/W60030, End: N54350/W60115

SITE DESCRIPTION:

Pond, with 500 ft. long x 150 ft. wide bottom dimensions.

SERVICE DATES: 1944-1952

SERVICE HISTORY:

From 9/44 to 6/52 the site received the normal overflow from the 212-R Basin. The site was retired in 6/52 when 212-R was shut down.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-26-CN
Drawings: H-3-57210

Ref. 21.11

SITE ID NO.: 216-N-6

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 946000000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.07830	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.05710
ZR-95:	0.00000	PU-240:	0.01320
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00152
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.32800
CS-137:	0.08860	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

Ref. 21.12

9413218.0541

SITE ID NO.: 216-N-7

ALIAS: 212-R Trench, 216-N-7 Trench
STATUS: Inactive
DIMENSIONS:
Length: 80 ft
Width: 15 ft
Depth: 6 ft
Diameter: 0 ft

FACILITY: Crib
ELEVATION: 571 ft
WATERTABLE: 152 ft

LOCATION: 200 North
COORDINATES: N55399/W60505, N55482/W60605 (Diagonally)

SITE DESCRIPTION:

Trench, with dimensions of 80 ft. long x 15 ft. wide x 6 ft. deep.

SERVICE DATES: 1952-1952

SERVICE HISTORY:

From 5/52 to 6/52 the site received the basin water and sludge cleanout waste from 212-R Basin. The site was retired in 6/52 when 212-R was shut down.

REFERENCES:
Documents: ARH-2806, RHO-CD-673, HW-55176
Photographs: 122440-25-CN
Drawings: H-3-57210

9413218.0542

Ref. 21.13

SITE ID NO.: 216-N-7

CHEMICALS DISPOSED

TOTAL VOLUME DISPOSED: 7570000 Liters

No chemicals discharged.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.08520	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.35600
CS-137:	0.09600	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

These values are decayed through April 1, 1986.

9413218.0543

Ref. 21.14

REFERENCE 22

Hanford Ground Water Database Printouts for Wells of Concern

9413218.0544

9413218.0545

Earth Sciences Computer Center

NETPRINT

200

.TMP;9

File $DRA0:[]200.TMP;9 (4121,17,0), last revised on 14-AUG-1987 11:35, is a 26 block sequential file owned by UIC [NETPRINT]. The records are variable length with implied (CR) carriage control. The longest record is 0 bytes.

Job 200 (1159) queued to LPA0 on 14-AUG-1987 11:35 by user NETPRINT, UIC [NETPRINT], under account W8610010 at priority 100, started on printer _LPA0: on 14-AUG-1987 11:35 from queue LPA0.

Digital Equipment Corporation - VAX/VMS Version V4.5

Ref. 22.1

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
6-43-08	3/23/87	1,1,1-T	<	1.0000E+01	H
6-43-08	3/23/87	1,1,2-T	<	1.0000E+01	H
6-43-08	3/23/87	1,1-DIH	<	3.0000E+03	H
6-43-08	3/23/87	1,2-DIH	<	3.0000E+03	H
6-43-08	3/23/87	12-Dcn	<	1.0000E+01	H
6-43-08	3/23/87	123TE	<	1.0000E+01	H
6-43-08	3/23/87	123TE	<	1.0000E+01	H
6-43-08	3/23/87	123TRI	<	1.0000E+01	H
6-43-08	3/23/87	13-Dcn	<	1.0000E+01	H
6-43-08	3/23/87	135TRI	<	1.0000E+01	H
6-43-08	3/23/87	13-Dcn	<	1.0000E+01	H
6-43-08	3/23/87	ACETILE	<	3.0000E+03	H
6-43-08	3/23/87	ACRYLIN	<	3.0000E+03	H
6-43-08	3/23/87	ALKALIN		8.6000E+04	H
6-43-08	3/23/87	ALLYLAL	<	3.0000E+03	H
6-43-08	3/23/87	AMMONIA	<	5.0000E+01	H
6-43-08	3/23/87	BETA		6.6000E+00	H
6-43-08	3/23/87	CHLACET	<	3.0000E+03	H
6-43-08	3/23/87	CHLFORM	<	1.0000E+01	H
6-43-08	3/23/87	CHLORAL	<	3.0000E+03	H
6-43-08	3/23/87	CHLORID		1.9000E+04	H
6-43-08	3/23/87	CHLPRIP	<	3.0000E+03	H
6-43-08	3/23/87	CONDUCT		2.9500E+02	H
6-43-08	3/23/87	CYANIDE	<	3.0000E+03	H
6-43-08	3/23/87	CYANIC IL	<	3.0000E+03	H
6-43-08	3/23/87	CYANIDE	<	3.0000E+03	H
6-43-08	3/23/87	DICPRIP	<	3.0000E+03	H
6-43-08	3/23/87	ETHCAIB	<	3.0000E+03	H
6-43-08	3/23/87	ETHCYAN	<	3.0000E+03	H
6-43-08	3/23/87	ETHOXID	<	3.0000E+03	H
6-43-08	3/23/87	FALDRIN	<	1.5000E+02	H
6-43-08	3/23/87	FANTIIO	<	1.0000E+02	H
6-43-08	3/23/87	FARSEN	<	5.0000E+00	H
6-43-08	3/23/87	FBATIUM		3.8000E+01	H
6-43-08	3/23/87	FBERYLL	<	5.0000E+00	H
6-43-08	3/23/87	FCADMIU	<	2.0000E+00	H
6-43-08	3/23/87	FCALCIU		3.8100E+04	H
6-43-08	3/23/87	FCHROMI	<	1.0000E+01	H
6-43-08	3/23/87	FCOPPER	<	1.0000E+01	H
6-43-08	3/23/87	FIRON	<	5.0000E+01	H
6-43-08	3/23/87	FLEAD	<	5.0000E+00	H
6-43-08	3/23/87	FLUORID	<	5.0000E+02	H
6-43-08	3/23/87	FLUORIDA	<	3.0000E+03	H
6-43-08	3/23/87	FMAGNES		8.7100E+03	H
6-43-08	3/23/87	FMANGAN		1.7000E+01	H
6-43-08	3/23/87	FMERCUR	<	1.0000E-01	H
6-43-08	3/23/87	FNICKEL	<	1.0000E+01	H
6-43-08	3/23/87	FNITRA	<	3.0000E+02	H
6-43-08	3/23/87	FPOTASS		4.3000E+03	H
6-43-08	3/23/87	FSELEN	<	5.0000E+00	H
6-43-08	3/23/87	FSILVER	<	1.0000E+01	H
6-43-08	3/23/87	FSODIUM		1.4200E+04	H
6-43-08	3/23/87	FSTRONT	<	3.0000E+02	H
6-43-08	3/23/87	FVANADI		6.0000E+00	H
6-43-08	3/23/87	FZINC		6.0000E+00	H
6-43-08	3/23/87	GLYCIDY	<	3.0000E+03	H
6-43-08	3/23/87	HEXACHL	<	1.0000E+01	H
6-43-08	3/23/87	HEXCHCP	<	1.0000E+01	H
6-43-08	3/23/87	HYDRAZI	<	3.0000E+03	H

Ref. 22.2

6	3/23/87	ISOBUTY	<	3.0000E+03	H	
6-43-	3/23/87	KERUSEN	<	1.0000E+01	H	
6-43-10	3/23/87	LINALPHA	<	2.2000E-01	H	
6-43-10	3/23/87	M-XYLE	<	1.0000E+01	H	
6-43-10	3/23/87	METHOXE	<	1.0000E+01	H	
6-43-10	3/23/87	METHYCH	<	1.0000E+01	H	
6-43-10	3/23/87	METZINE	<	3.0000E+03	H	
6-43-10	3/23/87	NAPHTHA	<	1.0000E+01	H	
6-43-10	3/23/87	NITRATE		2.3500E+04	H	
6-43-10	3/23/87	OPXYLE	<	1.0000E+01	H	
6-43-10	3/23/87	PARALDE	<	3.0000E+03	H	
6-43-10	3/23/87	PENTCLO	<	1.0000E+01	H	
6-43-10	3/23/87	PERCENE	<	1.0000E+01	H	
6-43-10	3/23/87	PH		7.2000E+00	H	
6-43-10	3/23/87	PH		7.6000E+00	H	
6-43-10	3/23/87	PHENOL	<	1.0000E+01	H	
6-43-10	3/23/87	PHOSPHA	<	1.0000E+03	H	
6-43-10	3/23/87	PROPYLA	<	3.0000E+03	H	
6-43-10	3/23/87	PROPYLB	<	3.0000E+03	H	
6-43-10	3/23/87	RADIUM	<	4.8100E-02	H	
6-43-10	3/23/87	SULFATE		4.0000E+04	H	
6-43-10	3/23/87	TETRAME	<	1.0000E+01	H	BKG Carbon Tetrachloride listed as Tetrane
6-43-10	3/23/87	TETRACL	<	1.0000E+01	H	
6-43-10	3/23/87	TOC	<	5.1000E+02	H	
6-43-10	3/23/87	TOXLOL	<	2.0000E+01	H	
6-43-10	3/23/87	TRICENE	<	1.0000E+01	H	
6-43-10	3/23/87	TRICHLO	<	1.0000E+01	H	
6-51-75	3/25/87	1,1,1-T	<	1.0000E+01	H	
6-51-75	3/25/87	1,1,2-T	<	1.0000E+01	H	
6-51-75	3/25/87	ALKALIN		1.2200E+05	H	
6-51-75	3/25/87	AMMONIU	<	5.0000E+01	H	
6-51-75	3/25/87	BETA		9.6200E+00	H	
6-51-75	3/25/87	CHLFORM	<	1.0000E+01	H	
6-51-75	3/25/87	CHLORID		4.3600E+03	H	
6-51-75	3/25/87	CONDUCT		2.6100E+02	H	
6-51-75	3/25/87	CYANIDE	<	1.0000E+01	H	BKG for Cyanide
6-51-75	3/25/87	FALKIN	<	1.5000E+02	H	
6-51-75	3/25/87	FANTIMO	<	1.0000E+02	H	
6-51-75	3/25/87	FARSENI	<	5.0000E+00	H	
6-51-75	3/25/87	FBARIUM		4.2000E+01	H	
6-51-75	3/25/87	FBENZYLL	<	5.0000E+00	H	
6-51-75	3/25/87	FCADMIU	<	2.0000E+00	H	
6-51-75	3/25/87	FCALCIU		3.4400E+04	H	
6-51-75	3/25/87	FCHROMI	<	1.0000E+01	H	
6-51-75	3/25/87	FCOPPER	<	1.0000E+01	H	
6-51-75	3/25/87	FIRON	<	5.0000E+01	H	
6-51-75	3/25/87	FLEAD	<	5.0000E+00	H	
6-51-75	3/25/87	FLITHIU	<	5.0000E+02	H	
6-51-75	3/25/87	FMAGNES		1.3000E+04	H	
6-51-75	3/25/87	FMANGAN		1.3100E+02	H	
6-51-75	3/25/87	FMERCUR	<	1.0000E-01	H	
6-51-75	3/25/87	FNICKEL	<	1.0000E+01	H	
6-51-75	3/25/87	FOSMIUM	<	3.0000E+02	H	
6-51-75	3/25/87	FPOTASS		3.9400E+03	H	
6-51-75	3/25/87	FSELENI	<	5.0000E+00	H	
6-51-75	3/25/87	FSILVER	<	1.0000E+01	H	
6-51-75	3/25/87	FSODIUM		8.9600E+03	H	
6-51-75	3/25/87	FSTRONT	<	3.0000E+02	H	
6-51-75	3/25/87	FVANADI		1.1000E+01	H	
6-51-75	3/25/87	FZINC	<	5.0000E+00	H	
6-51-75	3/25/87	LINALPHA		3.9500E+00	H	
6-51-75	3/25/87	M-XYLE	<	1.0000E+01	H	
6-51-75	3/25/87	METHOXE	<	1.0000E+01	H	

Ref. 22.3

6-51	3/25/87	NITRATE		1.3100E+03	H
6-51	3/25/87	OPXYLE	<	1.0000E+01	H
6-51-75	3/25/87	PERCENE	<	1.0000E+01	H
6-51-75	3/25/87	PH		7.9000E+00	H
6-51-75	3/25/87	PH		7.7600E+00	H
6-51-75	3/25/87	PHOSPHA	<	1.0000E+03	H
6-51-75	3/25/87	SULFATE		2.8000E+04	H
6-51-75	3/25/87	TETRANE	<	1.0000E+01	H BKG Carbon Tetrachloride listed as Tetrane
6-51-75	3/25/87	TIC		2.0001E+03	H
6-51-75	3/25/87	TOXLOL	<	2.0000E+01	H
6-51-75	3/25/87	TRICENE	<	1.0000E+01	H

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
6-59-53	1/19/87	CYANIDE		4.9500E+02	H DG Cyanide

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
2-419-3	1/11/87	U-GROSS		1.4200E+04	R DG Uranium
2-419-3	1/20/87	U-GROSS		1.3900E+04	R
2-419-3	5/13/87	U-GROSS		1.1900E+04	R

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
2-419-4	1/16/87	TETRANE		2.0000E+03	H DG Carbon tetrachloride listed as Tetrane

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
6-37-70	1/13/86	TRITIUM		1.6000E+06	R DG Tritium
6-37-13	2/24/86	TRITIUM		2.2100E+04	R DG "
~~6-37-7~~	~~2/24/86~~	~~TRITIUM~~		~~1.5400E+06~~	~~R DG Tritium~~

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
6-25-55	2/04/86	1,1,1-T	<	1.0000E+01	H
6-25-55	2/04/86	1,1,2-T	<	1.0000E+01	H
6-25-55	2/04/86	2,4,5TP	<	1.0000E+00	H
6-25-55	2/04/86	2,4-D	<	1.0000E+00	H
6-25-55	2/04/86	ALUMINUM	<	1.5100E+02	H
6-25-55	2/04/86	AMMONIA		1.6400E+02	H
6-25-55	2/04/86	ANTIMONY	<	1.0100E+02	H
6-25-55	2/04/86	AR1016	<	1.0000E+00	H
6-25-55	2/04/86	AR1221	<	1.0000E+00	H
6-25-55	2/04/86	AR1232	<	1.0000E+00	H
6-25-55	2/04/86	AR1242	<	1.0000E+00	H
6-25-55	2/04/86	AR1248	<	1.0000E+00	H
6-25-55	2/04/86	AR1254	<	1.0000E+00	H
6-25-55	2/04/86	AR1260	<	1.0000E+00	H
6-25-55	2/04/86	ARSENIC	<	5.0000E+00	H
6-25-55	2/04/86	BARIUM		3.6100E+01	H
6-25-55	2/04/86	BENZENE	<	1.0000E+01	H
6-25-55	2/04/86	BETA		8.0300E+00	H
6-25-55	2/04/86	CADMIUM	<	2.0100E+00	H

Ref. 22.4

6-25-55	2/04/86	CHLORID		6.0500E+03	H	
6-25-55	2/04/86	CHROMIUM	<	1.0000E+01	H	
6-25-55	2/04/86	CHLIFRM	<	3.0000E+00	H	
6-25-55	2/04/86	CONDUCT		4.2100E+02	H	
6-25-55	2/04/86	COPPER	<	1.0000E+01	H	
6-25-55	2/04/86	DIOXANE	<	5.0000E+02	H	
6-25-55	2/04/86	ENDRIN	<	1.0000E+00	H	
6-25-55	2/04/86	FLUORID		6.5900E+02	H	
6-25-55	2/04/86	FORMALD	<	5.0000E+02	H	
6-25-55	2/04/86	IRON		2.7200E+02	H	
6-25-55	2/04/86	LEADGF	<	5.0000E+00	H	
6-25-55	2/04/86	LDALPHA		2.5000E+00	H	
6-25-55	2/04/86	M-XYLE	<	1.0000E+01	H	
6-25-55	2/04/86	MANGNESE	<	5.0000E+00	H	
6-25-55	2/04/86	MERCURY	<	1.0000E-01	H	
6-25-55	2/04/86	METHLOR	<	1.0000E+00	H	
6-25-55	2/04/86	METHOXE	<	1.0000E+01	H	
6-25-55	2/04/86	NICKEL	<	1.0000E+01	H	
6-25-55	2/04/86	NITRATE		1.3700E+04	H	
6-25-55	2/04/86	NITR-N		3.6000E+01	H	
6-25-55	2/04/86	OPXYLE	<	1.0000E+01	H	
6-25-55	2/04/86	PERCENE	<	1.0000E+01	H	
6-25-55	2/04/86	PH		8.6000E+00	H	
6-25-55	2/04/86	PHOSPHA	<	1.0000E+03	H	
6-25-55	2/04/86	POTASSM		4.6200E+03	H	
6-25-55	2/04/86	PYRIDIN	<	5.0000E+02	H	
6-25-55	2/04/86	RADIUM	<	1.9000E-01	H	
6-25-55	2/04/86	SELENUM	<	5.0000E+00	H	
6-25-55	2/04/86	SILVER	<	1.0000E+01	H	
6-25-55	2/04/86	SODIUM		2.0600E+04	H	
6-25-55	2/04/86	SULFATE		2.8200E+04	H	
6-25-55	2/04/86	TETRANE	<	1.0000E+01	H	BKG Carbon Tetrachloride listed as Tetrane
6-25-55	2/04/86	TOC		2.2500E+03	H	
6-25-55	2/04/86	TOLUENE	<	1.0000E+01	H	
6-25-55	2/04/86	TOX	<	1.5000E-01	H	
6-25-55	2/04/86	TOXAENE	<	1.0000E+00	H	
6-25-55	2/04/86	TOXCENE	<	1.0000E+01	H	
6-25-55	2/04/86	TRITIUM		-3.2000E+02	H	BKG Tritium
6-25-55	2/04/86	VANADIUM		1.7000E+01	H	
6-25-55	2/04/86	a-BHC	<	1.0000E+00	H	
6-25-55	2/04/86	b-BHC	<	1.0000E+00	H	
6-25-55	2/04/86	d-BHC	<	1.0000E+00	H	
6-25-55	2/04/86	g-BHC	<	1.0000E+00	H	

Ref. 22.5

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MMMMMMMMM   ********************************************************************************   MMMMMMMMMM
MMMMMMMMM   ********** Earth Sciences ZVAX Computer Center ***********************************   MMMMMMMMMM
MMMMMMMMM   ********************************************************************************   MMMMMMMMMM
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WATER Remote Users PALMER0383964+VGAD

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M   M  EEEEE  TTTTT  PPPP   RRRR    III   N   N  TTTTT
MM  M  E        T    P   P  R   R    I    NN  N    T
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UUUUUUUUUU  2222222222
UUUUUUUUUU  2222222222

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124		2.3400E+04	6.2400E+03	4/18/86	
124		1.3100E+01	-1.6543E+37	5/07/86	
124		1.3100E+01	-1.6543E+37	7/03/86	
124		8.5100E+03	-1.6543E+37	9/13/86	
124		9.9300E+03	-1.6543E+37	10/06/86	
124		1.4100E+01	-1.6543E+37	11/05/86	
124		5.6300E+03	-1.6543E+37	1/06/87	
124		9.5400E+03	-1.6543E+37	2/11/87	
124		6.0700E+03	-1.6543E+37	3/24/87	
124		7.5500E+03	-1.6543E+37	5/19/87	
124		4.2300E+03	-1.6543E+37	6/01/87	
124		4.2600E+03	-1.6543E+37	7/22/87	
183	U-234	1.3300E+03	4.5300E+01	7/22/87	DG
184	U-235	5.8300E+01	4.5300E+01	7/22/87	DG
185	U-238	1.3600E+03	4.5300E+01	7/22/87	DG

same sample

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U Total = $^{234}U + ^{235}U + ^{238}U$ = 2748 pCi/L

Constituent Codes

^{234}U = 183

^{235}U = 184

^{238}U = 185

Doug - propagation to units for

104

124

183

184

185

(not all pCi/L)

Pam

Ref. 22.7

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NOTE: Remote Jobs:  PHL-HIDSB390::VQ9D

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                                    H  HH  E        T    P      R R      I    N  NN    T
                                    H   H  E        T    P      R  R     I    N   N    T
                                    H   H  EEEEE    T    P      R   R   III   N   N    T

                                                   UU      UU      11
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records are variable length with implied (CR) carriage control.  The longest record is 0 bytes.

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CONSTITUENT CODE	LESS THAN FLAG	ANALYSIS VALUE	COUNTING ERROR	COLLECTION DATE
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BKG in pCi/L Uranium

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constituent Code = 104 U Total

Ref. 22.9

07OCT86

PNL I-129 RESULTS ON WELL WATER SAMPLES COLLECTED SINCE 01JAN85

ANALYSIS NUMBER	USER NUMBER	STARTED yrmoda	ENDED yrmoda	I-129 10**-6 pCi/l	ERROR (%)	COMMENTS
89279	699 101-48B	FY 6	850912	16.1	6.1	#4846 WATER FOR I129 (9/12/85), 699 101-48B, HANFORD
89376	699 101-48B	6	860529	43.9	4.9	#4846 WATER FOR I129 (5/29/86), 699 191-48B, HANFORD
89270	699 25-55	6	850912	49.6	6.1	#4415 WATER FOR I129 (9/12/85), 699 25-55, HANFORD
89377	699 25-55	6	860529	93.5	4.1	#4415 WATER FOR I129 (5/2986), 699 25-35, HANFORD BKG 129 I
89271	699 26-15A	6	850912	2775763.9	7.2	#4518 WATER FOR I129 (9/12/85), 699 26-15A, HANFORD
89272	699 27-08	6	850912	2078439.7	5.7	#4557 WATER FOR I129 (9/12/85), 699 27-08, HANFORD
89341	699 27-08	6	860127	2417553.3	3.7	#4557 WATER FOR I129 (1/27/86), 699 27-08, HANFORD
89273	699 32-22	6	850912	5577959.1	7.1	#4794 WATER FOR I129, (9/12/85), 699 32-22, HANFORD
89379	699 32-22	6	860606	4888290.4	3.7	#4794 WATER FOR I129 (6/6/86), 699 32-22, HANFORD
89342	699 35-09	6	860127	218171.1	3.9	#4419 WATER FOR I129 (1/27/86), 699 35-09, HANFORD
89168	699 35-66	-5	850530	6965857.8	7.3	#4494 WATER FOR I129 (5/30/85), 699 35-66, HANFORD
89167	699 35-70	-5	850530	66934831.4	7.3	#4441 WATER FOR I129 (5/30/85), 699 35-70, HANFORD
89343	699 35-70	6	860127	101823772.4	4.1	#4441 WATER FOR I129 (1/27/86), 699 35-70, HANFORD DG 129 I
89274	699 37-E04	6	850900	22357.8	5.4	#4876 WATER FOR I129 (9/85), 699 37-E04, HANFORD
89301	699 37-E04	6	860107	24354.6	5.6	WATER FOR I129 (1/17/86), 699 37-E04, HANFORD
89171	699 39-39	-5	850530	223.6	88.4	#4791 WATER FOR I129 (5/30/85), 699 39-39, HANFORD
89177	699 39-39	-5	850530	292.4	7.4	RE-RUN #4791 WATER FOR I129 (5/30/85), 699 39-39, HANFORD
89275	699 41-01	6	850910	255174.3	5.4	#4858 WATER FOR I129 (9/10/85), 699 41-01, HANFORD
89302	699 41-1	6	860108	214289.9	5.6	WATER COLLECTED 1/8/86 FOR I-129, 699-41-1, HANFORD
89276	699 41-23	6	850912	2944270.8	7.1	WATER FOR I129, (9/12/85), 699 41-23, HANFORD
89344	699 41-23	6	860127	4720044.4	3.5	#4430 WATER FOR I129 (1/27/86), 699-41-23, HANFORD DG 129 I
89277	699 46-04	6	850910	92918.8	5.4	#4863 WATER FOR I129 (9/10/85), 699 46-04, HANFORD
89303	699 46-04	6	860108	139627.9	5.6	WATER FOR I129 (1/8/86), 699 46-04, HANFORD

Ref. 22.10

07OCT86

PNL I-129 RESULTS ON WELL WATER SAMPLES COLLECTED SINCE 01JAN85

ANALYSIS NUMBER	USER NUMBER	STARTED yrmoda	ENDED yrmoda	I-129 10**-6 pCi/l	ERROR (%)	COMMENTS
89345	699 48-07	6	860127	309.8	4.0	#4756 WATER FOR I129 (1/27/86), 699 48-07, HANFORD DG 129 I
89278	699 50-85 0	6	850912	8.2	6.4	#4497 WATER FOR I129 (9/12/85), 699 50-85 0, HANFORD
89346	699 50-85 0	6	860127	177.5	3.7	#4497 WATER FOR I129 (1/27/86), 699-50-85 0, HANFORD
89156	DB-7/597-812 FT.	5	850425	227.0	9.2	SAMP.#P85-216, DB-7 PUMP ACTUATOR, MABTON, THRU RESIN COLUMN
89157	DB-7/597-812 FT.	5	850425	343.1	9.1	SAMP.#P85-217, DB-7 PUMP ACTUATOR, MABTON, THRU RESIN COLUMN
89151	R299E 17-1	5	850401	22528490.7	6.4	#2328 WATER FOR I129, R299E 17-1, HANFORD
89166	R299E 17-1	5	850530	14500875.9	7.3	#2328 WATER FOR I129 (5/30/85), R299E 17-1, HANFORD
89174	R299E 17-1	5	850621	18614242.4	7.6	SPECIAL SAMPLE FOR I129 (6/21/85), R299E 17-1, HANFORD
89179	R299E 17-1	5	850712	23003503.4	7.2	#2328 WATER FOR I129 (7/12/85), R299E 17-1, HANFORD
89210	R299E 17-1	5	850801	33973544.3	9.3	SPECIAL SAMPLE FOR I129 (8/1/85), R299E 17-1, HANFORD
89216	R299E 17-1	5	850820	26659261.6	7.1	SPECIAL SAMPLES FOR I129 (8/20/85), R299E 17-1, HANFORD
89281	R299E 17-1	6	850924	24400606.8	5.7	#2328 WATER FOR I129 (9/24/85), R299E 17-1, HANFORD
89284	R299E 17-1	5	851112	25183753.5	5.7	#2328 WATER FOR I129 (11/12/85), R299E 17-1, HANFORD
89297	R299E 17-1	6	860102	29366888.3	5.6	WATER COLLECTED 1/2/86 FOR I-129, R299 17-1, HANFORD
89154	R299E 17-9	5	850401	31992971.9	6.4	#2514 WATER FOR I129, R299E 17-9, HANFORD
89165	R299E 17-9	5	850530	20454961.8	7.2	#2514 WATER FOR I129 (5/30/85), R299E 17-9, HANFORD
89175	R299E 17-9	5	850621	27973693.6	7.6	SPECIAL SAMPLE FOR I129 (6/21/85), R299E 17-9, HANFORD
89211	R299E 17-9	5	850801	22808393.5	7.1	SPECIAL SAMPLE FOR I129 (8/1/85), R299E 17-9, HANFORD
89217	R299E 17-9	5	850820	32407331.6	7.2	SPECIAL SAMPLE FOR I129 (8/20/85), R299E 17-9, HANFORD
89282	R299E 17-9	6	850924	30239431.1	5.7	#2514 WATER FOR I129 (9/24/85), R299E 17-9, HANFORD
89285	R299E 17-9	5	851112	26123892.1	5.7	#2514 WATER FOR I129 (11/12/85), R299E 17-9, HANFORD
89298	R299E 17-9	6	860102	31637015.7	5.7	WATER COLLECTED 1/2/86 FOR I-129, R299E 17-9, HANFORD
89169	R299E 24-02	5	850530	10575585.2	7.3	#2329 WATER FOR I129 (5/30/85), R299E 24-02, HANFORD

Ref. 22.11:

REFERENCE 23

<u>^{129}I, ^{60}Co and ^{106}Ru Measurements on Water Samples From the Hanford Project Environs</u>, BNWL-SA-4478, January 1973

N. E. BALLOU

BNWL-SA-4478

^{129}I, ^{60}Co AND ^{106}Ru MEASUREMENTS ON WATER SAMPLES FROM THE HANFORD PROJECT ENVIRONS

January 1973

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

BNWL-SA-4478

^{129}I, ^{60}Co and ^{106}Ru Measurements on Water Samples from the Hanford Project Environs*

F. P. Brauer and H. G. Rieck, Jr.

Battelle
Pacific Northwest Laboratories
P. O. Box 999
Richland, Washington 99352

January, 1973

*This paper is based on work performed under United States Atomic Energy Commission Contract AT(45-1)-1830.

^{129}I, ^{60}Co and ^{106}Ru Measurements on Water Samples from the Hanford Project Environs

F. P. Brauer and H. G.Rieck, Jr.

9413218.0559

ABSTRACT

Groundwater flow and contamination patterns beneath the Hanford project reservation have been studied since the early days of the project. The measurement of radioactive materials at concentrations much below those required for radiation protection are useful for tracing groundwater movement and detection of potential contamination problems before they are apt to occur.

Groundwater samples from a number of wells on or near the Hanford reservation have been analyzed for ^{129}I by neutron activation analysis and for gamma radioactivity by low-level coincidence gamma-ray spectrometry. The major radionuclides in addition to natural radioactivity detected in the underground waters by gamma-ray spectrometry were ^{106}Ru and ^{60}Co. Local river and rain water samples were also analyzed for ^{129}I and long-lived radionuclides.

Special sample collection methods were developed to prevent contamination of the water samples during collection. Anions travel farther than cations in underground water systems since soils are primarily cation exchangers and retain the cations. Anion exchange techniques were used in the field and the laboratory to recover the desired radionuclides. Sample sizes ranged up to several thousand liters.

This paper discusses the sample collection methods, analysis methods, and results obtained. The methods used were found to provide high sensitivity for groundwater studies.

^{129}I, ^{60}Co and ^{106}Ru Measurements on Water Samples from the Hanford Project Environs

F. P. Brauer and H. G. Rieck, Jr.

9413218.0560

INTRODUCTION

Groundwater flow and contamination patterns beneath the Hanford project have been studied since the early days of the project. A large number of wells are available on the Hanford reservation for sampling of the groundwater.[1] Routine surveillance data on the status of groundwater contamination resulting from disposal of Hanford plant effluents are reported periodically.[2] Analyses used for routine surveillance of radioactivity include total-beta and tritium determinations. The analytical methods selected have generally been limited to those required to assure that concentrations of radioactivity in groundwater is safe for human consumption although the groundwater on the Hanford Reservation is not used as potable water supplies.[3]

The measurement of radioactive nuclides at concentrations much below those required for radiation protection are useful for tracing the rate and direction of groundwater movement and detection of possible contamination problems before they reach significant levels. One method for improving the detection sensitivity is by the analysis of larger samples. The usefulness of total-beta measurements on large samples is limited by the natural radioactivity and salt content of the samples. Isotopic concentration of tritium from large water samples is difficult and expensive. Other radiochemical analysis methods are available for the analysis of groundwater tracers and are discussed below.

Since radionuclide retention by soil is primarily a cation absorption process, anionic radionuclides serve as better groundwater tracers. Fission product iodine should serve as a good tracer for following the movement of groundwaters. The only fission product iodine isotope with a sufficiently long half-life for hydrologic studies is ^{129}I. The long (1.6×10^7 year) half-life and low specific activity (370 dpm per micro-

During the period of time since 1962 different well-sampling methods have been employed. Exact sampling conditions were not recorded for most of the pre-1968 well samples. Clean sample containers were supplied by the laboratory prior to collection of some of these samples. Some of the wells were sampled by using a bucket on a rope to lift water to the surface. Repeated sampling was required to obtain several liters of water. The extent to which care was taken to prevent contamination of the pre-1968 samples by the sampling equipment or surface soil is uncertain.

Starting in 1968 the sample collections were conducted by members of the laboratory staff to assure that adequate precautions were taken to prevent contamination of the samples. Thorough flushing of pumps, hoses, pipes, and sample containers was done before sampling. Either new sample containers or used sample containers of known history have been used. Offsite wells were sampled by means of the pumping facilities located at the wells. Most Hanford project wells do not contain pumps and several pumping systems have been employed.

Early 1971 sampling by pumping was done with a submersible pump which was lowered into the well on a 1/4" diameter steel cable. Power to the pump was supplied by an electrical cable and water was delivered to the surface through a 3/4" diameter polyethylene tube. The support-power cable and tubing bundle was washed with demineralized water just outside the well as the unit was being lowered into the well. Normally, the pump was lowered to a point 5 to 10 feet below the static water level. Sampling a well involved pumping for a 30-minute interval to flush the well, then collecting samples in two 13-gallon plastic carboys. After sampling was completed, the system was removed from the well and moved to another location. During the implacement in the well of the pump and tubing bundle it was necessary to drag the whole assembly across the ground surface as the unit was being lowered. Consequently, even with the washing operation being performed, the possibility of surface contamination being introduced into the well could not be ignored.

The problems of possible introduction of surface contamination by installation of the pumping system and of cross contamination

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with a cheesecloth soaked in demineralized water as it was being lowered into the well.

The inner pipe was next implaced inside the outer pipe. The venturi-jet assembly was attached to a 21-foot section of 1" diameter PVC pipe with a combination of steel and PVC plastic fittings. This section was then lowered, with washing, inside the outer pipe. After securely clamping the top end, another 21-foot section was attached with a 1" diameter coupling. PVC cement was used and after a suitable curing time this additional section was lowered. The procedure was continued until the venturi-jet assembly was positioned in the 5-foot section of schedule 40 outer pipe. The section of schedule 40 pipe was required for a positive seal between the inner and outer pipe by the leather packer on the venturi-jet assembly.

A casing adapter was installed at the top of the well. The pressure and suction lines from the adapter were connected to the pump with unions to permit easy attachment and removal of the pump. A steel can was inverted over the well casing to prevent entry of surface contamination.

A well was sampled by the following technique. After the pump was attached to the unions, the system was primed or filled with demineralized water. The pump was then operated for 30 minutes at maximum flow (~10 GPM) until the pump outlet-water cleared. Two 13-gallon plastic carboy samples were then collected. The pump was then disconnected and moved to the next location. A typical pumping installation is shown in Figure 1.

In 5 wells, the casing size is 1-1/2" diameter and would not accommodate the standard submersible pump or venturi-jet assembly. An air-lift pumping system was permanently installed in each well. The air-lift system was assembled by inserting 1/2" diameter into 1" diameter polyethylene tubing. The inner surface of the outer tube was cleaned by pushing a demineralized water soaked cheesecloth plug through the tube ahead of the inner tube. The top end of the system was fitted with a specially fabricated adapter which allows introduction of nitrogen (under pressure) into the annulus between the inner and outer tube. The assembly was lowered into the well to a position where the lower end of the outer tube is

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GAMMA-RAY SPECTROMETRY

Radioactivity in natural water samples generally requires concentration prior to gamma-ray spectrometry measurements. The water samples were concentrated by boiling to reduce the sample volume from as much as 26 liters to less than 0.1 liter. Cleanroom laboratories were used to avoid contamination of the sample with fallout and other environmental radioactivity. New laboratory glassware was used for boiling each sample. The Columbia River samples collected downstream from the reactor areas were processed in separate laboratory facilities to prevent cross contamination of low-level water samples. The residual water and salts remaining after boiling were mounted in plastic containers approximately 0.5-inches thick and 5-inches in diameter for counting. Dowex-1 rather than boiling was used for concentration of radioactive anions from some of the large volume water samples.

The radioactive nuclides concentrated in the water and salts remaining after boiling or absorbed on ion exchange resins were identified and measured by low-level gamma-gamma coincidence spectrometry.[6,7,8,10] Most of the samples were counted with a two-parameter gamma spectrometer consisting of a pair of 6-inch diameter by 5-inch thick NaI(Tl) detectors. The NaI(Tl) detectors each were shielded with NaI light pipes from the radioactivity in the photomultiplier tubes. The detectors were contained in a long plastic anticoincidence shield which reduces both the system background and Compton continuum.[6] The detector system is shown in Figure 4. Figure 5 shows the positions of various radionuclides in the multiplexed two-parameter gamma-ray spectrometer array. Counting times as long as 5000 minutes were used with the lowest activity samples. Computer techniques were used to process the spectral data.[9] Smaller sample sizes and less sensitive spectrometers were used to analyze the samples collected prior to 1966.

Several of the more radioactive samples were also measured with a high-efficiency Ge(Li) spectrometer to confirm the NaI(Tl) results.

and comparator standards during irradiation were estimated by gamma-ray spectrometry using several spectra to obtain half-life information. The low-level, beta-gated, multiple-gamma coincidence spectrometry techniques described in references (6, 13,14,15) were used when required to measure very small amounts of ^{130}I and ^{125}I. A high sensitivity multiple coincidence gamma-ray detector system used for ^{130}I measurements is shown in Figure 7. The backgrounds achieved with this detector operated in several multiple coincidence modes are shown in Figure 8 and tabulated in Table I. ^{130}I decays with the emission of three or four coincident gamma-rays as seen in its decay scheme (Figure 9). ^{130}I spectra recorded with the multiple coincidence gamma-ray spectrometer are shown on Figure 10. Figures 11 and 12 show similar spectra for the ^{135}I and ^{126}I activities frequently also present in an irradiated iodine sample as a result of the fission of trace impurities and the ^{127}I (n,2n)^{126}I reaction. Discrimination against ^{135}I and ^{126}I when counting ^{130}I can be achieved by γ-γ-γ and γ-γ-γ-γ coincidence counting. The components in the time dependent spectra resulting from the measurements on a single sample are calculated using a weighted least squares method.[15] The data handling programs outlined in reference (9) were used for calculation of analytical results and preparation of final data tabulations.

EXPERIMENTS

The radionuclides detected by gamma-ray spectrometry in Hanford reservation groundwaters were ^{60}Co, ^{106}Ru, and the natural radioactive nuclides. Several well-water samples collected close to the Columbia River also contained radionuclides characteristic of Hanford reactor effluent.

The results of several sampling and method studies are listed on Table II for the nuclides ^{60}Co, ^{106}Ru, and ^{129}I. Fractions of rain, river, and well-water samples were analyzed in the laboratory by collection of the radionuclides on Dowex-1 columns and by evaporation. Comparison of the results as shown on Table II confirm that the primary species of ^{60}Co and ^{106}Ru in well-waters are

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are summarized on Table III. The Hanford-area rain-water ^{129}I results clearly show potential for contamination of well waters. Columbia River water collected upstream and downstream from the Hanford project yielded results that are essentially all the same and substantially lower than local rain except for the ^{60}Co in the downstream Columbia River. The ^{60}Co concentration is decreasing since reactor coolant is no longer discharged to the Columbia River. No significant increase was observed in the ^{129}I concentration in the downstream Columbia River water as the result of Hanford activities. The river-water results can be used to establish the maximum radionuclide levels expected in well samples as the result of the entrance of river water into the ground water system.

The background well-water ^{129}I analyses and distilled-water ^{129}I analyses were positive when corrected for our best estimates of the laboratory blank. These results are very close to the detection limit for ^{129}I and may be the result of an unknown analysis artifact or may represent an approximate value for the ^{129}I content of the samples.

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1962-1968 Samples

The ^{129}I concentration values (atoms/liter) observed in water from the wells sampled between 1962 and 1968 have been located on a map of the Hanford Area (Figure 13). When samples from several piezometer tubes in the same well were analyzed, the maximum observed ^{129}I concentration was plotted. Many of the water samples were found to contain much more ^{129}I than was found in the river-water and background-area well-waters. The largest concentrations were observed in water from the 200W and 200E Area wells. ^{129}I concentrations observed in most Hanford project well-waters analyzed were significantly higher than the values observed for the Columbia River.

^{129}I, especially well 699-35-9. This suggests a possible increase in groundwater flow in an easterly direction.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of E. I. Wandling who collected many of the recent samples; H. Tenny, R. S. Strebin, Jr. and J. H. Kaye who modified the ^{129}I analysis procedure to handle large water samples; L. A. Bond, S. C. Simpson, V. B. Saling, L. W. Schock, W. L. Orange, J. E. Fager and past members of the Radiochemical Analysis Section who performed the analyses; and N. E. Ballou, R. E. Brown and D. J. Brown for the helpful discussions and comments.

15. W. L. Nicholson, J. E. Schlosser, F. P. Brauer, "The Quantitative Analysis of Sets of Multicomponent Time Dependent Spectra from Decay of Radionuclides," Nucl. Instr. & Methods 25, 45 (1963).

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TABLE I

BACKGROUND MEASUREMENTS ON SEGMENTED NaI(Tl) DETECTOR

ANTI-COINCIDENCE SHIELD	BETA GATE	NUMBER OF NaI(Tl) SEGMENTS DETECTING AN EVENT			
		1	2	3	4
		COUNT RATES, 0.1-4.0 MeV (CPM)			
NONE	OFF	830	180	23	2.2
NONE	ON	1.0	0.18	0.053	0.005
OFF	OFF	740	125	13	1.5
OFF	ON	0.75	0.16	0.024	0.002
ON	OFF	416	40	3.2	0.54
ON	ON	0.69	0.14	0.018	0.001

TABLE III

SUMMARY OF RAIN, RIVER AND WELL-WATER CONCENTRATIONS, SAMPLES COLLECTED 1962 to 1972

	Concentration Ranges		
	^{129}I (atoms/liter)	^{60}Co (pCi/l)	^{106}Ru (pCi/l)
Hanford Area Rain	$0.02-6 \times 10^{11}$	0.01-0.2	.5-10.
Upstream Columbia River	$1-5 \times 10^{9}$	< .01	.2-.4
Downstream Columbia River	$1-2 \times 10^{9}$	.007-.6	.004-2.
Snake River	$1-2 \times 10^{9}$	≤ .005	.1-.3
Yakima River	$1-2 \times 10^{9}$	< .003	<.4
Artesian Well 699-53-103	$0.6-6 \times 10^{8}$		
Washington, D. C. Well	$2-9 \times 10^{8}$		
Troutdale, Oregon Well	5×10^{8}	< .004	<.3
Thousand Springs, Idaho Well	2×10^{7}	< .0003	<.06
Distilled Laboratory Water	$3-7 \times 10^{7}$	< .007	<.03
Hanford Separations Area Wells	$10^{10}-10^{17}$		100.-2,000,000.
Hanford Reservation Wells near River	$3 \times 10^{8}-10^{12}$	.001-0.3	.001-37.

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DIAGRAM OF JET PUMP INSTALLATION

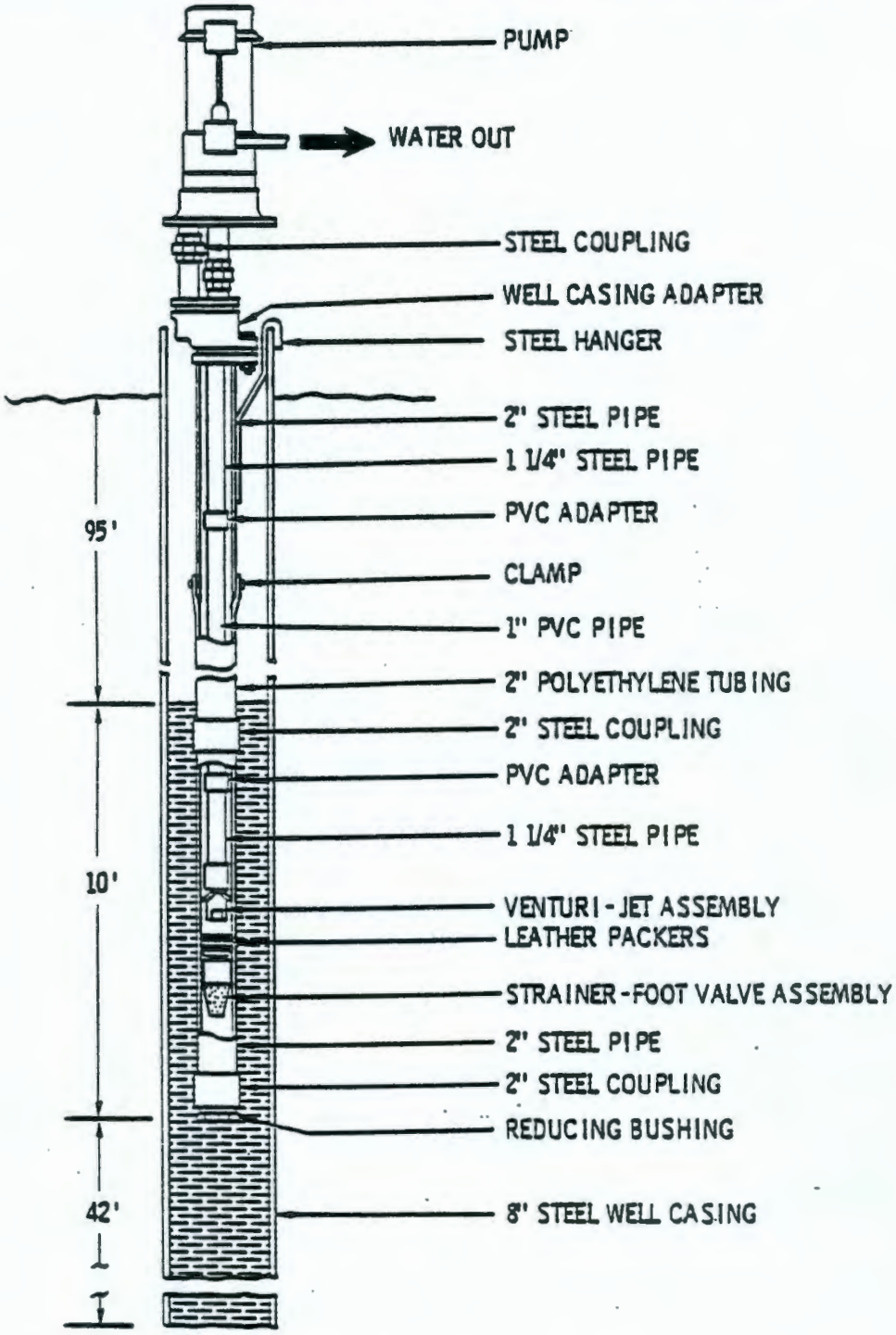

FIGURE 1. DIAGRAM OF JET PUMP INSTALLATION

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DIAGRAM OF ION EXCHANGE FILTER SYSTEM

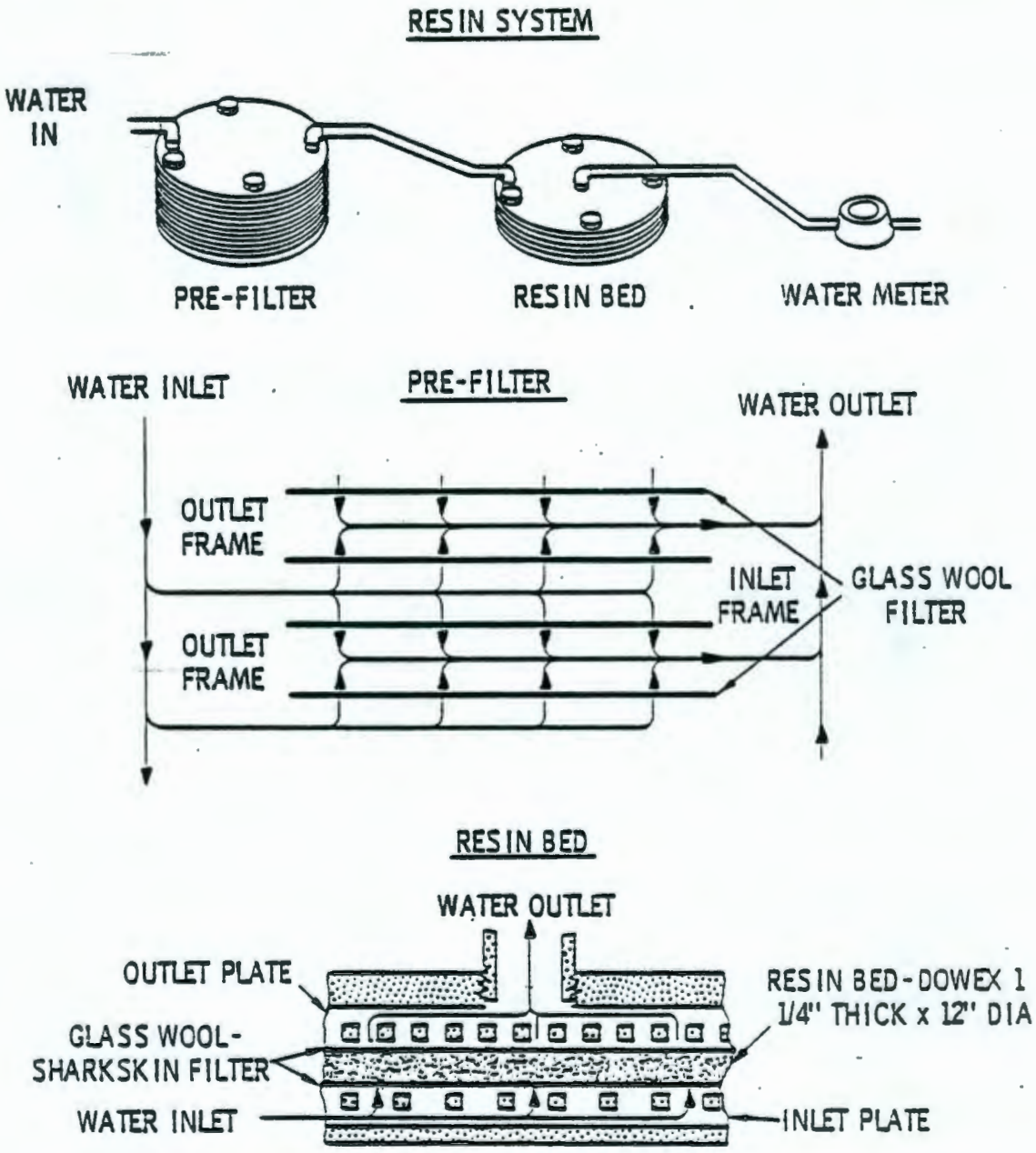

FIGURE 3. DIAGRAM OF ION EXCHANGE FILTER SYSTEM

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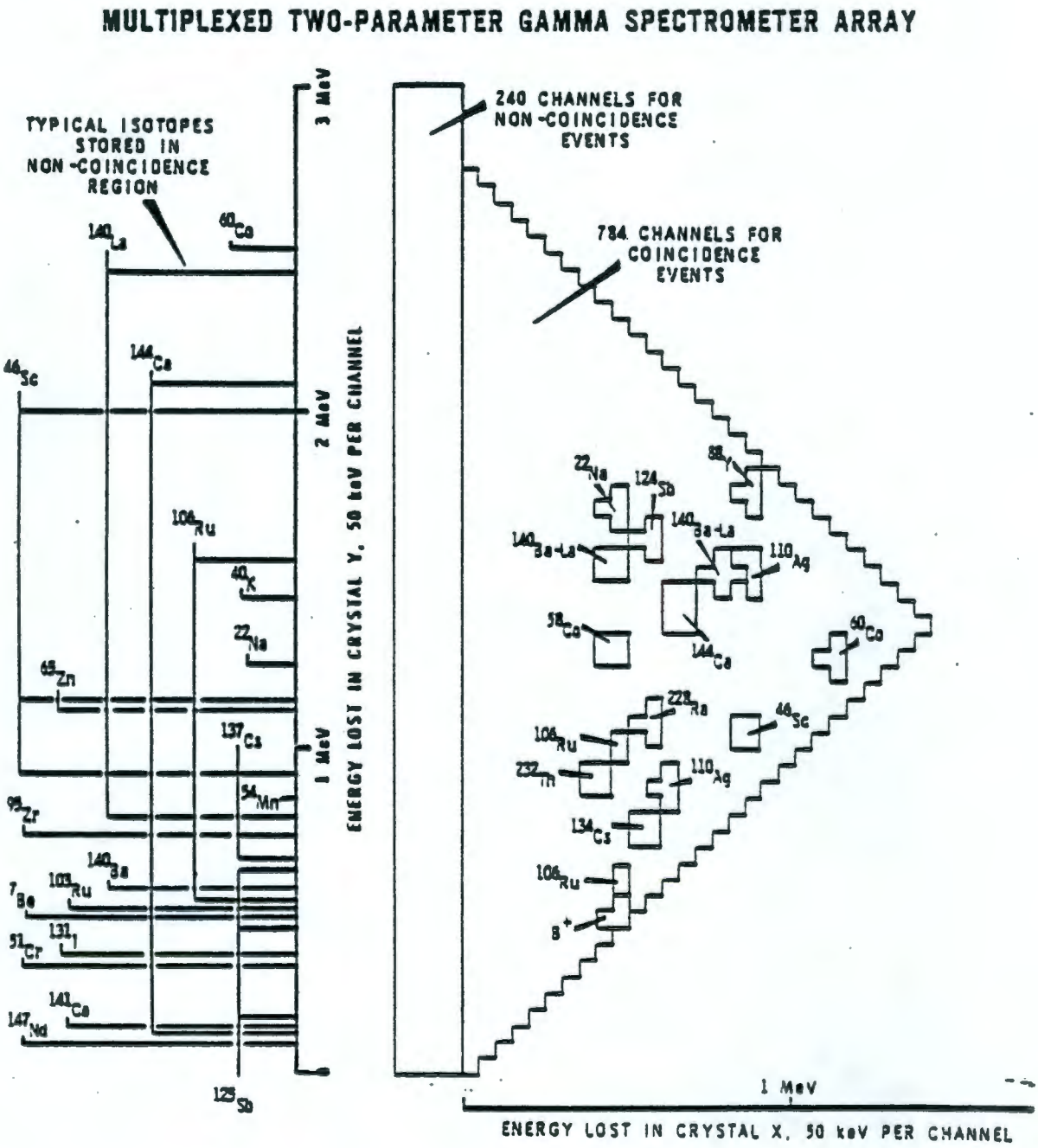

FIGURE 5. DIAGRAM OF TWO-PARAMETER GAMMA-RAY SPECTROMETER DATA ARRAY

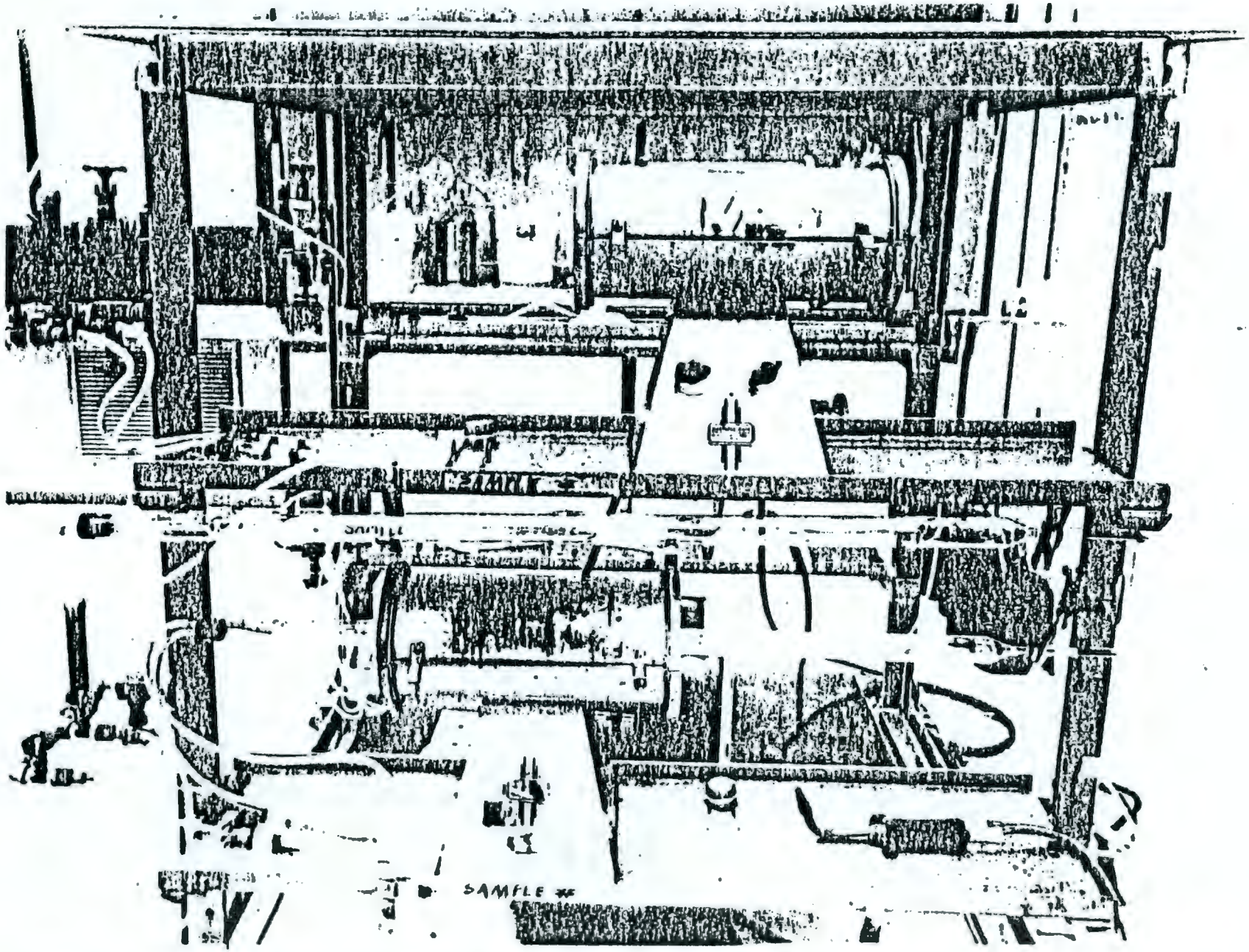

FIGURE 6. COMBUSTION APPARATUS USED FOR SEPARATION OF IODINE FROM RESIN SAMPLE COLLECTORS

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MULTIPLE COINCIDENCE GAMMA-RAY DETECTOR

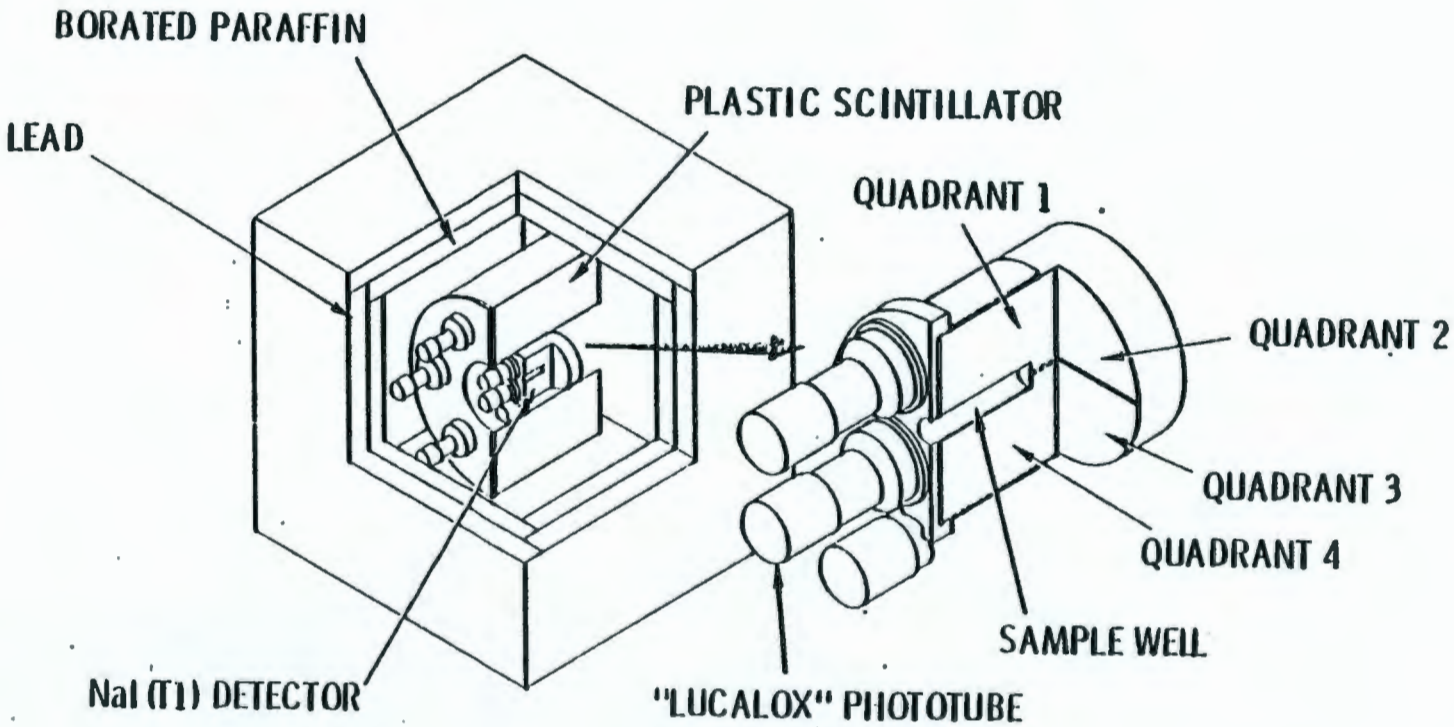

FIGURE 7. - DIAGRAM OF MULTIPLE COINCIDENCE GAMMA-RAY DETECTOR USED FOR COUNTING ^{130}I

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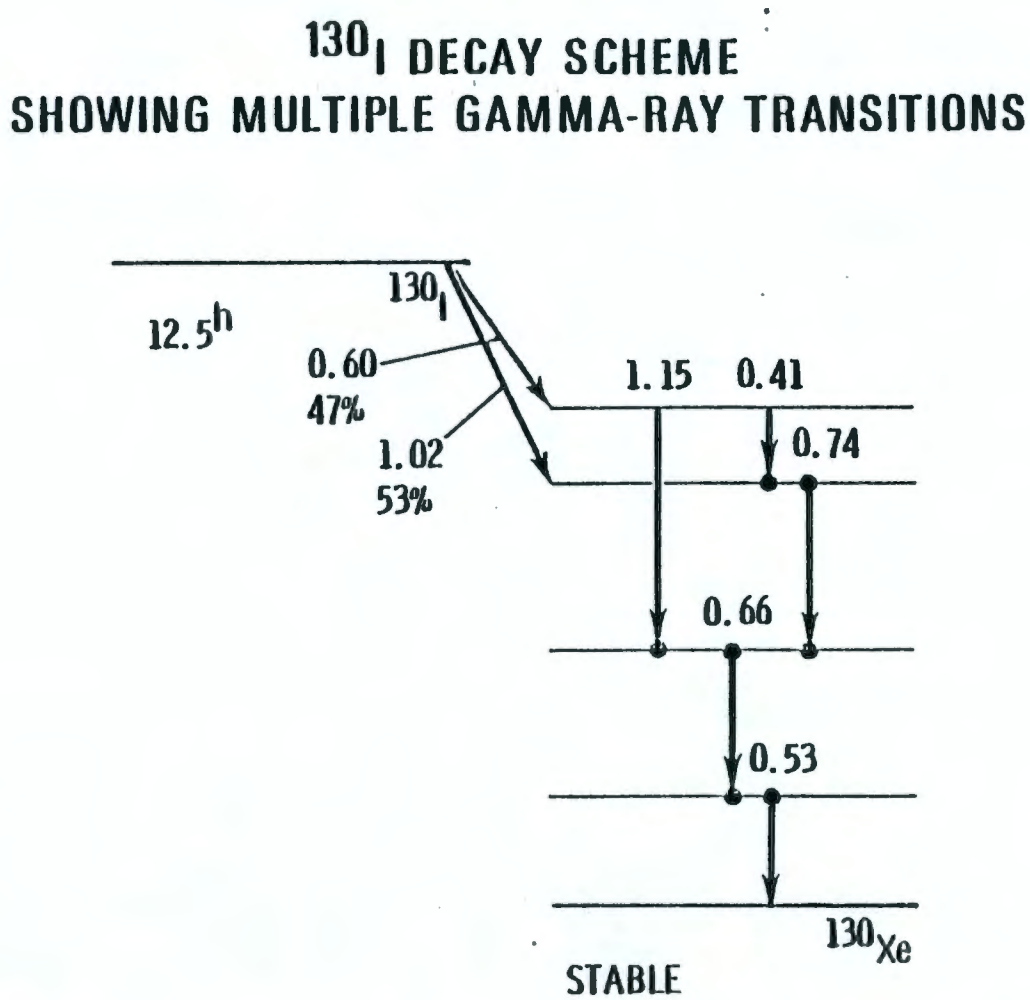

FIGURE 9. ^{130}I DECAY SCHEME SHOWING MULTIPLE GAMMA-RAY TRANSITIONS

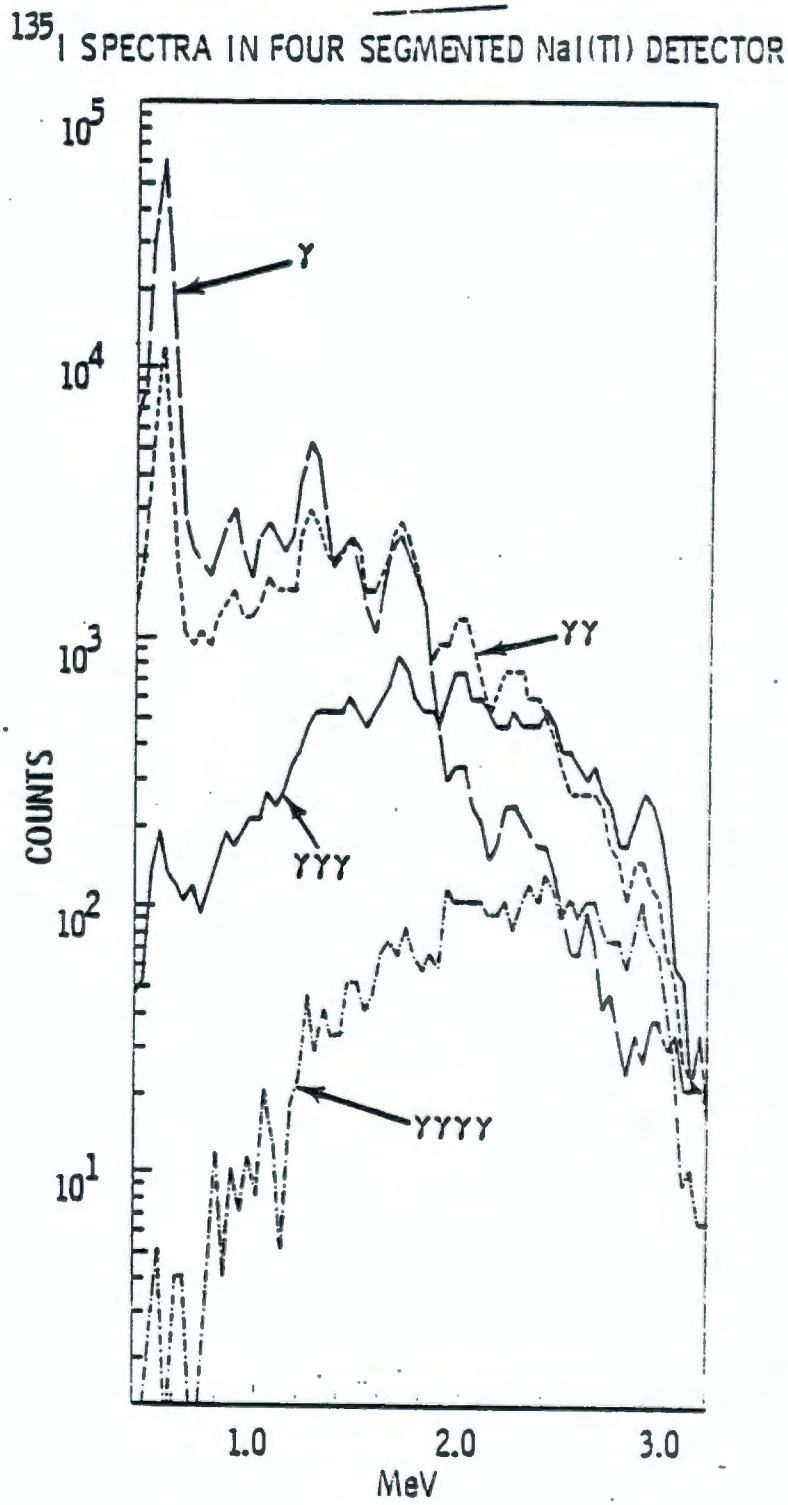

FIGURE 11. ^{135}I SPECTRA IN FOUR-SEGMENTED NaI(Tl) DETECTOR

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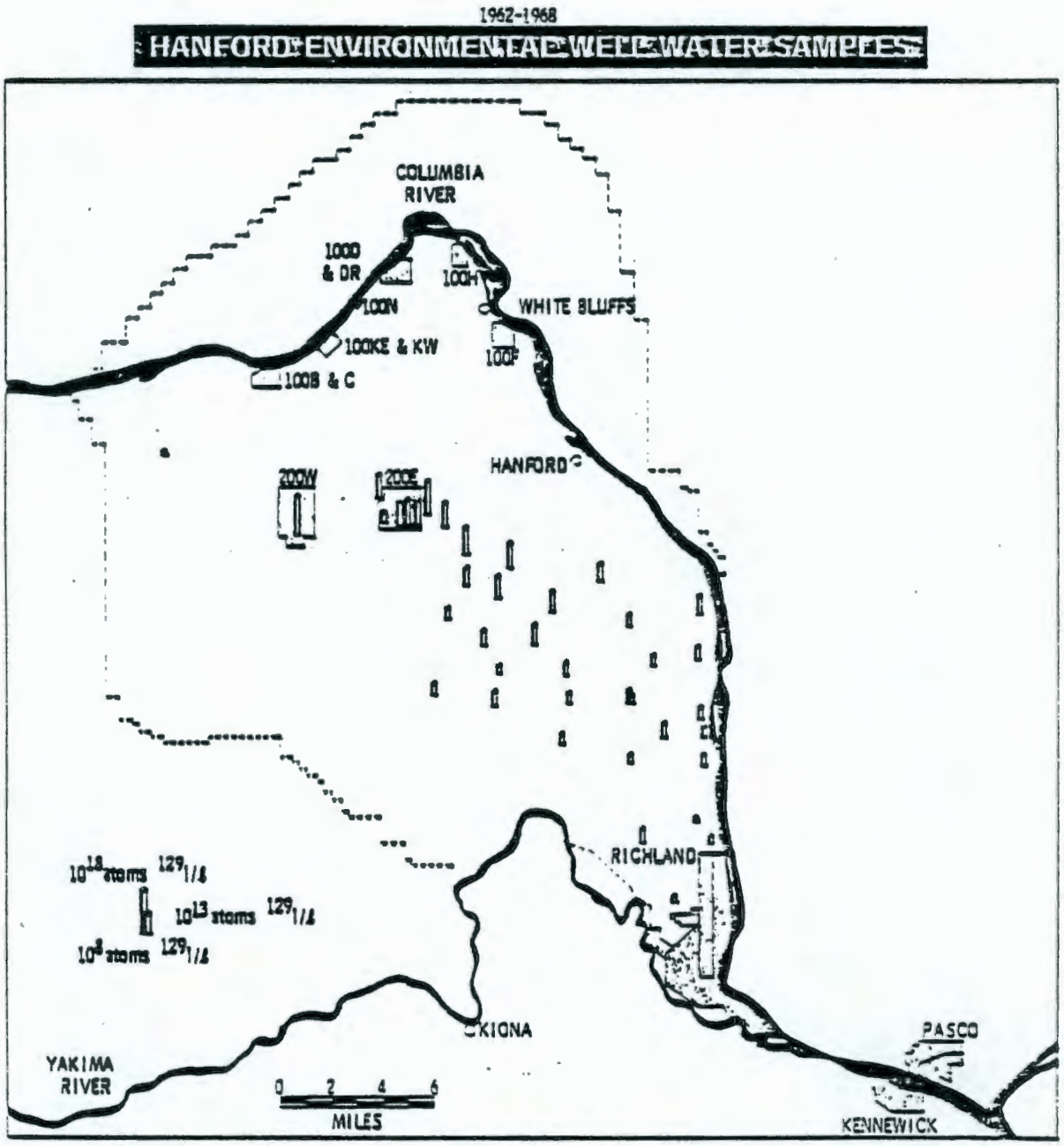

FIGURE 13. ^{129}I IN HANFORD ENVIRONS WELL-WATER SAMPLES 1962-1968

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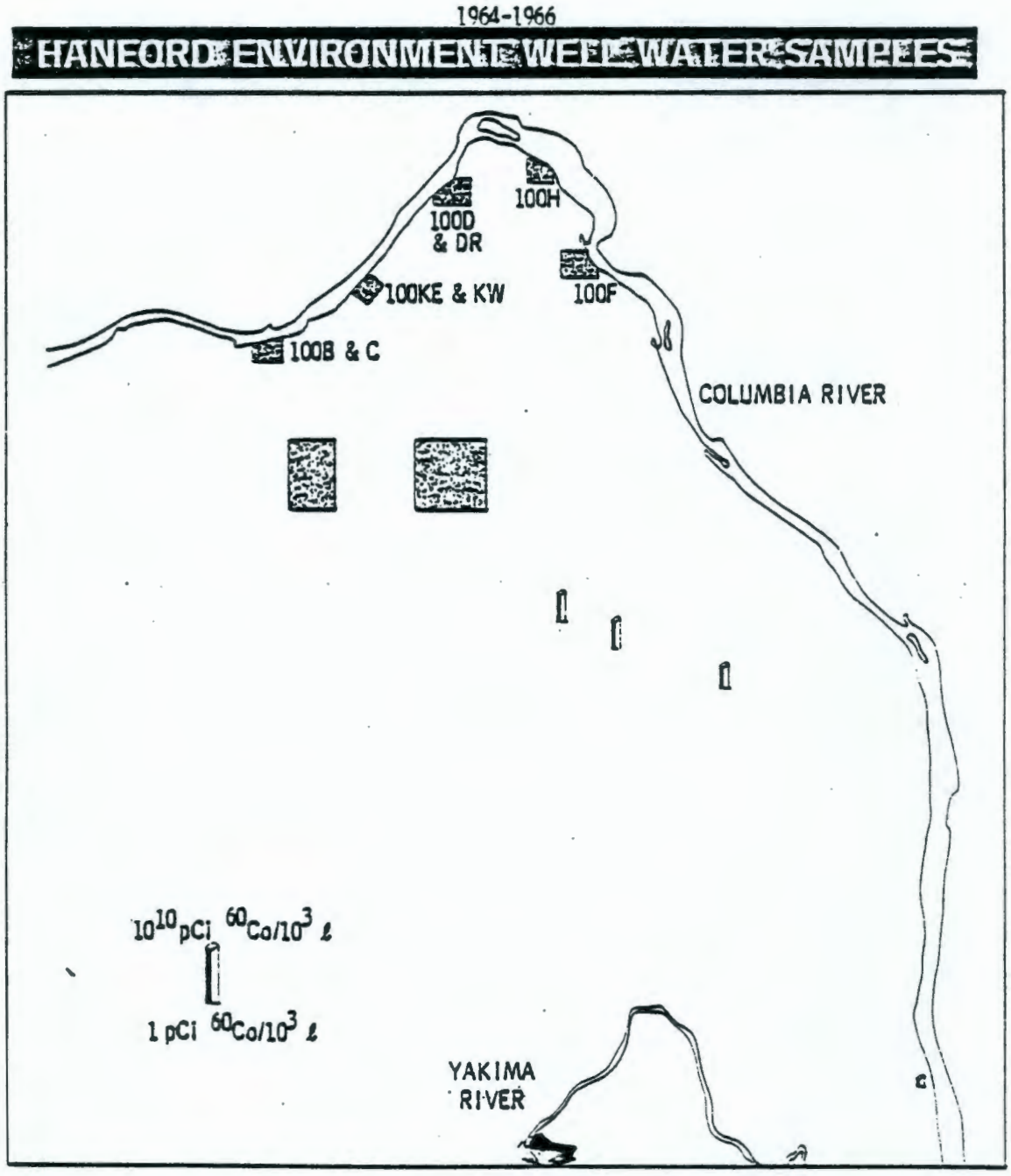

FIGURE 15. ^{60}Co IN HANFORD WELL-WATER SAMPLES 1964-1966

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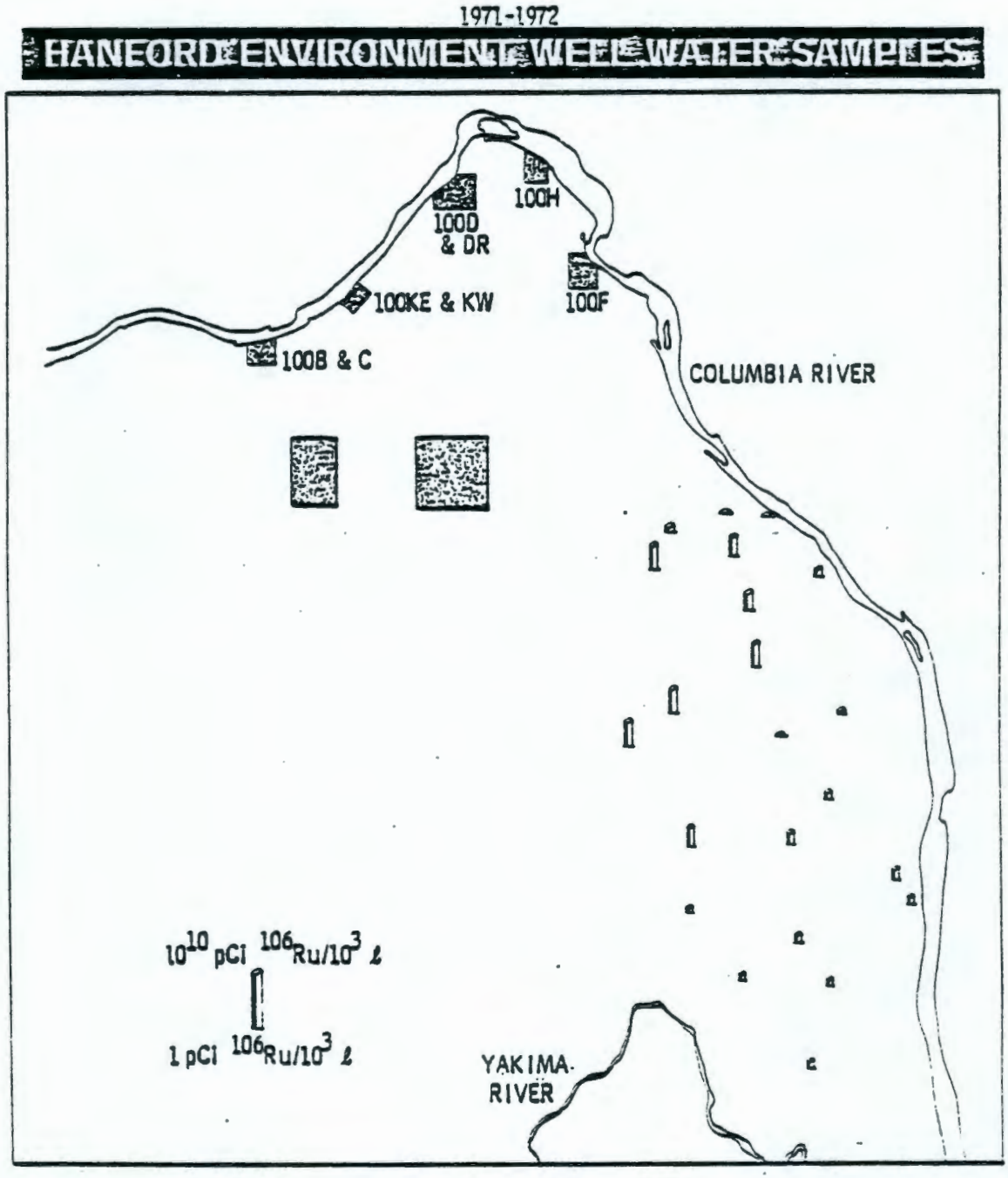

FIGURE 17. ^{106}Ru IN HANFORD WELL-WATER SAMPLES 1971-1972

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Purification of Uranium by IBMK (Hexone) Extraction,

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PURIFICATION OF URANIUM BY IBMK (HEXONE) EXTRACTION

Principles and Limitations

Uranium, as tetrapropylammonium uranyl trinitrate, is extracted from an acidic solution of acid deficient aluminum nitrate and tetrapropylammonium hydroxide with isobutylmethyl ketone (IBMK). Less than 1% of the one-year-cooled fission products are extracted. Most anions, with the exception of tungstate and ferrocyanide in high mole ratios to uranium do not affect the extraction. Americium, curium, and neptunium do not extract to any appreciable extent, whereas plutonium as Pu(VI) will extract. The Uranium is recovered by back extraction into water while evaporating the ketone. Chemical recoveries are determined using standard uranium or U-232 yield monitors.

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Literature References

Booman, G. L., and Rein, J. E., "Uranium," Treatise on Analytical Chemistry, edited by I. M. Kolthoff and P. J. Elving, Part II, Volume 9, Inter-Science Publishers, New York, 1962, pp 1-188.

Maeck, W. J., Booman, G. L., Elliott, M. C., and Rein, J. E., "Separation of Uranium from Diverse Ions," Anal. Chem., Volume 30, 1958, p 1902.

Nietzel, O. A. and de Sesa, M. A., "Spectrophotometric Determination of Uranium with Thiocyanate," Anal. Chem., 29, 1957, p. 756.

Reagents

All reagents are prepared from analytical reagent grade chemicals. Class I D.I. water is used throughout this procedure.

16M HNO_3 - stock reagent.

30% Hydrogen peroxide.

10% Tetrapropylammonium hydroxide.

2M HNO_3 - Pour 125 mL of 16M HNO_3 into D.I. water and dilute to 1 liter.

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Isobutylmethyl ketone - stock reagent. Also called hexone and IBMK.

Ruthenium Dye - 2 grams ruthenium trichloride hydrate dissolved and diluted to 1 liter with D. I. water.

2.8M $Al(NO_3)_3$ Salting Solution, 1M Acid Deficient:

1. Place 1050 grams (2.31 lb) $Al(NO_3)_3 \cdot 9H_2O$ into a 2 liter beaker.

2. Dilute to 900 mL with D. I. Water. Warm until dissolved.

3. Add 67.5 mL of concentrated NH_4OH (ammonium hydroxide) and stir for several minutes until the hydroxide precipitate dissolves.

4. Cool to less than 50 degrees C and dilute approximately to the 1 liter mark with D. I. Water.

5. Remove any uranium contamination by placing the salting solution in a 2 liter separatory funnel, adding about 200 mL of IBMK and shaking manually for 5 minutes. Drain the salting solution back in the 2 liter beaker. Drain the IBMK to a 400 mL beaker containing 25 mL D.I. water.

6. Check the solution for uranium contamination by evaporating the IBMK to dryness. Plate on 1 1/2" dish and count 50 minutes for possible alpha contamination. After reviewing the data, your supervisor will determine whether the salting solution is ready for use or if it is necessary to repeat step 5. A count rate less than ten times the background would indicate further decontamination of the salting solution unnecessary. This is based on a 90% decontamination efficiency.

7. Add 10 mL of tetrapropylammonium hydroxide and stir until dissolution is complete.

<u>Equipment and Materials</u>

8 position stirring unit

1 1/2 or 2 inch magnetic stir bars

beakers: 50, 100 or 250-mL

heat lamp

Two liter beaker and separatory funnel for reagent purification

Procedure

*Refer to procedure 30-BA-SP for Bioassay Samples or 30-ENV-SP for Environmental Samples for the appropriate bioassay or environmental sample preparation procedure.

1. Boil the solution from a sample preparation procedure to near dryness or until solids start forming. If the sample becomes dry or solidified, add 1 mL (or more as necessary) of 2M HNO_3.

2. Add 10 mL of $Al(NO_3)_2$ salting solution for each 1-2 mL of sample. The salts from 100 mL of urine can be dissolved/suspended in about 1 mL of 2M HNO_3. Example: Sample volume is ~3 mL. Use 20 mL of $Al(NO_3)_2$ salting solution.

3. Add 1 mL ruthenium dye and one teflon coated magnetic stirring bar.

   KEY POINT: The ruthenium dye assists in determining phase separation. Ruthenium remains in the aqueous phase (lower layer) and is black in color. The organic (upper layer) phase should be colorless.

4. Add 10 mL of IBMK (hexone) and stir for five minutes on a magnetic stirrer.

5. Remove the beaker from the stirrer and allow the phases to separate.

   KEY POINT: If the phases won't separate within 10 minutes, separation can be achieved by centrifuging.

6. Carefully pour most of the IBMK (upper layer) into a labeled 50 mL beaker. At least 90% of IBMK can be poured off in this way.

   KEY POINT: If <u>any</u> bottom layer goes into the 50 mL beaker, remove it with a pipet and transfer to the original beaker, or recombine the layers and try the separation again.

7. Add a second 10 mL of IBMK and stir for 2-3 minutes.

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Repeat steps 5 and 6, combining with the first IBMK.

8. Place the 50 mL beakers under a heat lamp in the order of increasing sample identification number and fill each beaker to the 40 mL mark with D. I. Water. Evaporate to dryness.

   KEY POINT: 1. Arranging the beakers in order will avoid any error in case the IBMK removes any identification from the beaker.

   2. Water helps to control the temperature. IBMK can boil under heat lamp temperatures. When this happens, the sample will turn yellow in color and dry to a dark residue. Wet-ash with a few mL 16M HNO_3 and a few drops of 30% H_2O_3.

9. Depending on the type of uranium analysis requested on the sample, proceed to one of the following three procedures:

   a) Only Uranium Isotopic is Requested - Proceed to the Electrodeposition Procedure, 30-ED-02.

   b) Only Natural Uranium requested - Proceed to "Fluorometic Determination of Uranium," 20-U-03 or "Determination of Uranium by Kinetic Phosphorescence Analysis", 20-U-05.

L A S T P A G E

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FLUOROMETRIC DETERMINATION OF URANIUM FOLLOWING PURIFICATION

Principles and Limitations

The residue from the Uranium Purification Procedures (20-U-01) or (20-U-02) is dissolved for fluorometric determination of total uranium. The method involves fusion of the sample in a sodium and lithium fluoride flux at 1750°F and measurement of the yellow-green uranium fluorescence using a fluorophotometer. To adjust for interferences and to quantify the sample reading, a known amount of natural uranium is added to a duplicate aliquot and measured similarly. The fluorometric method can be affected by sample matrix interferences such as quenching agents (i.e., iron) and fluorescent agents (i.e. organics).

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Literature References

Booman, G.L. and Rein, J.E., "Uranium", Treatise on Analytical Chemistry, edited by I.M. Kolthoff and P.J. Elving, Part II, Vol. 9, Interscience Publishers, New York, 1962, pp. 1-188.

Reagents

2M HNO_3

Flux for Fluorometric Uranium Determination

1. Add 9.1 g fluorometric grade lithium fluoride to a 1 pound (454g) bottle of fluorometric grade sodium fluoride. Seal the bottle and mix overnight on a rolling mixer.

2. Check the prepared flux by fusing 5 blanks and 5 spikes containing known quantities of uranium and read on a fluorometer prior to use.

3. Spikes should read within 10% of normal values. Blanks are expected to read less than 0.0050.

Equipment and Materials

Beakers, 1-L and 250-mL
Covered metal racks for holding platinum dishes
Platinum dishes

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Pipet - 100 uL, 200 uL
Pipet tips
Pelletizer
Fused-pellet fluorometric equipment

Calculations - Uranium Radiometric Yield

dpc = counting efficiency as disintegration per count

Y = sample yield = (cpm)(dpc)/(dpm uranium added to the spike sample)

Calculations - Uranium Fluorometric

SAM = Sample reading

BL = Blank reading

SP = Spike plus sample reading

SPC = Spike value in micrograms per mL

Y = Radiometric spike yield. Use Y = 1.0 if result is not to be yield corrected

V_T = Total sample volume

V_A = Sample volume analyzed

V_R = Volume of 2M HNO_3 to dissolve residue (step 1). Use 4 mL for DOE bioassay samples, 10 mL for all others.

V = Aliquot of V_R

$$\frac{SAM - BL}{SP - SAM} \times \frac{SPC\ (0.05\ mL)}{Y} \times \frac{V_R}{V} \times \frac{V_T}{V_A} = \text{ug U/sample}$$

This calculation may be used for solid sample by dividing by sample weight in grams.

Section A: Quality Control

1. Quality control checks are to be performed every day that samples are to be analyzed by the fluorometric procedure.

2. Set up the platinum dishes on a covered metal rack, placing 4 low-level dishes and 3 spike dishes in two

separate rows.

KEY POINT: The extra low-level dish is for the blank sample. The spike dishes should be in the front row. The rows are separated to minimize cross-contamination.

3. Add exactly 100 uL (microliters) of QC #1 to a low-level dish and to the spike dish.

4. Repeat Step #3 for QC #2 and QC #3 spikes.

5. Add exactly 50 uL of natural uranium standard to each spike dish.

6. Add 100 uL of 2M HNO_3 to every dish.

7. Place the rack supporting the samples under a heat lamp.

8. Prepare a Fluorometric Analysis Sheet as shown in Procedure #60-23-01 and below:

   Sample vol. 100 uL
   Spike vol. 50 uL
   Spike conc. (value on bottle)
   Fusion time 3 minutes

9. Remove the QC rack from under the heat lamp when the dishes are dry. After the QC samples are measured take the data to your supervisor for evaluation. Go to Section C, Fluorometric Analysis.

Section B: Sample Dissolution and Uranium Radiometric Yield

1. To the residue from a uranium purification procedure, add exactly 10 mL (4 mL for DOE bioassay samples) of 2M HNO_3. Swirl to effect dissolution.

   NOTE: If the results are to be yield-corrected, go to step 2. If not proceed to Section C.

2. Transfer exactly 1 mL to a previously labeled 1.5 inch s.s. planchet and dry under a heat lamp. Go to Section C, Fluorometric Analysis.

3. Count the planchet for 50 minutes with an alpha proportional counter to determine the U-232 tracer yield.

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Section C: Fluorometric Analysis

1. Analyze Hanford DOE and RMI urine samples in duplicate (two spike dishes and two low-level dishes for each sample). Others: one spike, one low-level dish per sample.

2. Set up platinum dishes for the samples on a rack. Place a corresponding spike dish in front of each low-level dish. Add one extra low-level dish for the blank after each set of four samples.

3. Pipet 50 uL of uranium standard containing about 10 micrograms uranium per milliliter into each spike dish.

4. Swirl the sample solutions well and pipet 200 uL (100 uL for ERA samples) into each set of spike and non-spike dishes per sample. Maintain identification by a mapped arrangement.

5. Place the sample rack under a heat lamp and slowly take all dishes to dryness.

6. Prepare to fuse the samples on the fusion wheel as follows:

   a. Turn on the air purifier.
   b. Turn on the burner exhaust fan.
   c. Open the air valve.
   d. Open the gas tank valve several turns.
   e. Light the burners.
   f. Adjust the burners to obtain the desired flame.

7. Place a NaF-LiF flux pellet on each dish.

8. Place the dishes on the fusion wheel in a sample-spike, sample-spike order, and set the timer for three minutes. The fusion temperature is regulated between 1750 and 1780 degrees F. Each sample is fused twice. Retain dish identification by maintaining a consistent order throughout the fusing and reading process.

9. While the samples are fusing, set up the fluorometer as follows:

   a. Open the light shutter, which is kept closed when not measuring samples.

   b. Set the reading at zero on all scales.

   c. Set the #8 position standard to read 5.

KEY POINT: It is necessary to push the middle button on the digital readout if "OL" appears on the display.

d. The #9 position standard should read less than .0025. If it is above .0025, the fluorometer may need service. Consult your supervisor.

e. Recheck the zero.

10. Remove the samples to the metal racks after they have cooled from the second fusion.

11. Prepare the analysis sheet by recording the sample number, volume of sample analyzed, volume of uranium spike used, strength of uranium spike initials of technician, date of analysis and any other comments pertinent to the analysis. See section 60-23 for instructions.

12. Transfer each sample to the platinum dish holder in the fluorometer, close the cover, move sample into position, and record the dial reading on the analysis sheet.

13. After reading the sample, remove the platinum dish from the fluorometer, discard the pellet, and place the platinum dishes in its appropriate "low-level" or "spike" beaker.

14. Add about 200 mL of 16M HNO_3 to each 1 liter beaker containing the platinum dishes. Place on an oscillating hot plate and boil for about 1 hour. Remove and allow to cool. Decant the HNO_3 acid to a cup sink with running water. Rinse with D.I. water liberally and decant to the sink.

KEY POINT: Allow the tap water to run in the sink for at least five minutes to dilute the acid.

15. Repeat step 11.

16. Add about 200 mL of D.I. water to each beaker and place on hot plate again and allow to boil for 30 minutes. Decant D.I. water and rinse twice with D.I. water. Remove as much water as possible and transfer dishes to 250 mL beakers labeled appropriately. The platinum dishes are now ready for re-use.

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Determination of Tritium in Water Samples,

UST-RD-PM-9-80

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DETERMINATION OF TRITIUM IN WATER SAMPLES

Principles and Limitations

Tritium in water is measured by a direct count of the distilled sample using a liquid scintillation spectrometer. After distillation, a sample of 5 milliliters is pipetted into 15 milliliters of scintillator solution. The mixture is transferred to the refrigerated sample changer of the liquid scintillation counter and is allowed to remain there for ~ 24 hours before counting is begun. This waiting period allows temperature equilibrium to be reached and the decay of chemiluminescence within the plastic vials. The counting efficiency of each sample including corrections for quenching, is determined by using the external standard technique. A quench curve is obtained by counting samples with known amounts of tritium and varying amounts of quenching material. The degree of quenching is determined using an external radioactive source and this is correlated with the counting efficiency of the appropriate standard. When a sample is counted, the liquid scintillation counter determines the sample's quench parameter and compares it to the quench curve to obtain the counting efficiency.

Literature Reference

Florkowski and Williams, "Liquid Scintillation Counting of Tritium in Water with Triton Emulsion Systems", Int. J. Applied Radiation Isotope, 19, p. 377, (1968).

Standard Test Method for Tritium in Water, ASTM D2476-81.

United States Testing Company, Inc., Computer Calculation Program REES Manual.

Equipment and Materials

Boiling flask, 500 mL

Condensing column

Heating mantle - six position - currently using one manufactured by Glas-Col Company

Spatula

Beaker (50 mL)

Polyethylene bottle (100 mL)

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Automatic pipet - 5 mL adjustable with disposable tip

Plastic scintillation vials - 25 mL size to fit LSC sample changer

Automatic dispenser - one liter capacity with 1-20 mL dispenser

Reagents

"Dead" water, water which contains little or not tritium.

Hydrochloric Acid, concentrated.

Potassium hydroxide, pellets

Liquid Scintillation cocktail - A. R. Grade - Ready-Solv MP, a solution prepared by Beckman, is currently being used

Calculations

Type DAT to calculate the tritium concentration in water and the total propagated uncertainty. For samples whose results require immediate reporting, the activity concentration and the counting uncertainty may be manually calculated using the equations below:

$$A = K (C - B_c)$$

$$CU = \pm K \times [2] \text{ SQR } (C/T_c + B_c/T_b)$$

where:

A = activity in pCi/L.

K = 1000/(2.22 (E) V (Y)).

CU = two sigma counting uncertainty in pCi/L.

C = gross counts per minute in the tritium region of interest (ROI).

T_c = sample count length in minutes.

B_c = background counts per minute in the tritium ROI.

T_b = background count length in minutes.

1000 = mL per L.

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2.22 = disintegrations per minute per picocurie.

E = counting efficiency using a tritium radionuclide standard.

V = sample volume in mL.

Y = chemical yield.

SQR = square root

Note that the above equation for the counting uncertainty represents only the uncertainty from counting statistics, while the computer program calculates the total propagated uncertainty.

Procedure

1. For samples requesting a tritium analysis, save about 500 mL in a sample container. (The sample may be composited for a month or quarter) Take the same volume of sample and measure accurately when compositing.

2. Transfer 250 mL to a boiling flask. Add 1 to 2 grams of potassium hydroxide (1 to 2 pellets) and a boiling chip. Prepare spikes and blanks in accordance with Table 1 of 30-ENV-SP.

3. The boiling flask and condensers are pre-connected on a six position heating unit. Use a 50 mL beaker for the collection vessel.

   KEY POINT: Be sure that cold water is running through the condenser column from bottom to top.

4. Turn on the heating mantle and set the timer for 35 minutes, adjust the temperature so that the sample is boiling lightly. After the sample has boiled for a little while, check the beaker. If the distillate volume is 10 mL, remove and immediately replace with a poly bottle. This takes about 15 minutes. Collect about 25 mL of the distillate for the analysis. This takes about 20 minutes.

5. When the sample distillation is finished, allow the glassware to cool and drain the remainder of the sample to waste. Clean the equipment for the next sample by rinsing with concentrated HCl, liberal amounts of D.I. water and finally with "dead" water.

6. Write the sample identification number on the cap of the

scintillation counting vial. Transfer 5 mL of the sample plus 15 mL of scintillation solution to the counting vial. For higher level samples add 1 mL of sample and 4 mL of "dead" water. Cap the samples and mix well by shaking vigorously. A blank is made with "dead" water. A spike is made by adding prepared calibrated H-3 spike (vial code EQM) to a vial containing liquid scintillation cocktail.

KEY POINT: Do not prepare samples in the cassette. Spilled scintillation solution can destroy them.

7. Clean the vial with a Kimwipe just before loading it into the cassette. The temperature of the liquid scintillation spectrometer is about 50°F.

8. Load the blank in position one, spike (if any) in position two, followed by the samples.

9. Prepare a Tritium Counting Request Card as described in 60-21-01 and indicate the location of each sample in the cassette. There are 10 positions in each cassette, numbered one through ten. If more than one cassette is used for a batch of samples, the position numbers for samples in the second cassette begin with 11.

<u>Counting times:</u>

Low level water	150 minutes
Enriched tritium	3 x 150 minutes
Fruit	150 minutes
Silica Gel (Air)	150 minutes
Milk	150 minutes
Ground water	100 minutes
Intermediate level	50 minutes

10. Transfer the cassettes with scintillation vials and the request ticket to the counting room for liquid scintillation counting. The cassettes are loaded into the Liquid Scintillation counter and the appropriate program is chosen for counting.

11. The samples are kept in the liquid scintillation counter

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about one day before counting is begun. This provides time for fluorescence and any other excitation to decay.

12. After counting, remove the samples from the liquid scintillation counter and transfer to storage. Submit all data, along with the Liquid Scintillation Request Card, to the data handler.

L A S T P A G E

- -

APPROVED FOR USE R G Sanders 2/6/86

Matthew McLarty 1/31/86

Al Robinson 1/31/86

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REFERENCE 26

Volatile Organic Analysis, Method 8240,

UST-RD-PM-9-80

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Carbon Tetrachloride Analysis

ANALYTICAL GROUP CODE: 730,731

VOLATILE ORGANIC ANALYSIS, METHOD 8240

TAB V

(1) Volatile organic compounds are determined by GC/MS. The compounds are introduced into the GC/MS by a Purge and Trap device according to Method 5030.

(2) The Mass Spectrometer is tuned to meet the Ion Abundance Criteria as outlined in Table 2 of method 8240, by direct injection of 50 ng of Bromoflourobenzene (BFB) followed by software or hardware tuning as may be required. Tuning verification is demonstrated at the beginning of every 12-hour work shift by additional injections of 50 ng of BFB.

(3) Samples with high levels of volatiles, oils, or other compounds that have a high potential for contaminating the system are diluted prior to analysis. It is important to note that this dilution procedure will raise the detection limit of the analytes.

(4) A system blank is run prior to the analysis of any standards.

(5) An initial 5 point calibration for each analyte in the "target" list is made prior to the injection of any samples, blanks, or associated QA/QC samples. Response factors are calculated consistent with 7.1.3 of the method.

Calibration is verified by the analysis of a mid-point calibration standard for every 12-hour shift when samples are to be analyzed. The response factor for each analyte must be within ± 20% of the response factor used for quantitification of sample concentrations.

(6) A minimum of three surrogate compounds, representing a range of Boiling Points, are added to the samples at a level of 50 ug/L as calculated in the initial 5 mL sample. Recovery limits for the selected compounds are monitored. Control limits for recovery data are calculated from the data base that is obtained from sample analysis. The three surrogate compounds are:

1,2-Dichloroethane
Toluene
Bromofluorobenzene

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(7) Until such time that sufficient in-house data is available, U.S. EPA Control Limits are used as available (see Table A).

Samples that exhibit recoveries outside the control limits are re-analyzed a second time. If the recoveries are still outside of the control limits, it is possibly because of matrix effects.

(8) Matrix spike recoveries are determined for the following compounds and concentrations:

Compound	Code	Concentration (ppb)
BENZENE	A62	50
TOLUENE	A66	50
TRICHLOROETHENE	A69	50
CHLOROBENZENE	A78	50
1,1-DICHLOROETHENE	A92	50

(9) A reagent blank is analyzed with each batch of samples. The blank may not contain the compounds listed above at levels exceeding 5 ug/L or 50% of the reported detection limit for that parameter. In the event that this level is exceeded, the appropriate apparatus will be cleaned and blanks will be analyzed until satisfactory results are achieved.

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Approved For Use: [illegible] 6-16-86
Neil H. H. [illegible] 6-16-86

METHOD 8240

GC/MS METHOD FOR VOLATILE ORGANICS

1.0 Scope and Application

1.1 Method 8240 is used to determine volatile organic compounds in a variety of solid waste matrices. This method is applicable to nearly all types of samples, regardless of water content, including groundwater, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments.

1.2 The detection limit of Method 8240 for an individual compound is approximately 1 µg/g (wet weight) in waste samples. For samples containing more than 1 mg/g of total volatile material, the detection limit is proportionately higher.

1.3 Method 8240 is based upon a purge-and-trap, gas chromatographic/mass spectrometric (GC/MS) procedure. This method is restricted to use by or under the supervision of analysts experienced in the use of purge-and-trap systems and gas chromatograph/mass spectrometers and skilled in the interpretation of mass spectra and their use as a quantitative tool.

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2.0 Summary of Method

2.1 The volatile compounds are introduced to the gas chromatograph by direct injection, the Headspace Method (Method 5020), or the Purge-and-Trap Method (Method 5030). Method 5030 should be used for groundwater analysis. The components are separated via the gas chromatograph and detected using a mass spectrometer which is used to provide both qualitative and quantitative information. The chromatographic conditions as well as typical mass spectrometer operating parameters are given.

2.2 If the above sample introduction techniques are not applicable, a portion of the sample can be dispersed in methanol or polyethylene glycol (PEG) to dissolve the volatile organic constituents. A portion of the methanolic or PEG solution is combined with water in a specially designed purging chamber. An inert gas is then bubbled through the solution at ambient temperature and the volatile components are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the volatile components are trapped. After purging is completed, the sorbent column is heated and backflushed with inert gas to desorb the components onto a gas chromatographic column. The gas chromatographic column is heated to elute the components, which are detected with a mass spectrometer.

2.3 An aliquot of each sample must be spiked with an appropriate standard to determine percent recovery and detection limits for that sample.

2.4 Table 1 lists detection limits that can be obtained in wastewaters in the absence of interferences. Detection limits for a typical waste sample would be significantly higher.

TABLE 1. CHROMATOGRAPHIC CONDITIONS AND METHOD DETECTION LIMITS

Parameter	Retention time (min) Column 1[a]	Method detection limit (µg/l)
Chloromethane	2.3	ND
Bromomethane	3.1	ND
Vinyl chloride	3.8	ND
Chloroethane	4.6	ND
Methylene chloride	6.4	2.8
Trichlorofluoromethane	8.3	ND
1,1-Dichloroethene	9.0	2.8
1,1-Dichloroethane	10.1	4.7
trans-1,2-Dichloroethene	10.8	1.6
Chloroform	11.4	1.6
1,2-Dichloroethane	12.1	2.8
1,1,1-Trichloroethane	13.4	3.8
Carbon tetrachloride	13.7	2.8
Bromodichloromethane	14.3	2.2
1,2-Dichloropropane	15.7	6.0
trans-1,3-Dichloropropene	15.9	5.0
Trichloroethene	16.5	1.9
Benzene	17.0	4.4
Dibromochloromethane	17.1	3.1
1,1,2-Trichloroethane	17.2	5.0
cis-1,3-Dichloropropene	17.2	ND
2-Chloroethylvinyl ether	18.6	ND
Bromoform	19.8	4.7
1,1,2,2-Tetrachloroethane	22.1	6.9
Tetrachloroethene	22.2	4.1
Toluene	23.5	6.0
Chlorobenzene	24.6	6.0
Ethyl benzene	26.4	7.2
1,3-Dichlorobenzene	33.9	ND
1,2-Dichlorobenzene	35.0	ND
1,4-Dichlorobenzene	35.4	ND

ND = not determined.

[a]Column conditions: Carbopack B (60/80 mesh) coated with 1% SP-1000 packed in a 6-ft by 2-mm I.D. glass column with helium carrier gas at a flow rate of 30 ml/min. Column temperature is isothermal at 45° C for 3 min, then programmed at 8° C per minute to 220° and held for 15 min.

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3.0 Interferences

3.1 Interferences coextracted from the samples will vary considerably from source to source, depending upon the particular waste or extract being tested. The analytical system, however, should be checked to ensure freedom from interferences under the conditions of the analysis by running method blanks. Method blanks are run by analyzing organic-free water in the normal manner. The use of non-TFE plastic tubing, non-TFE thread sealants, or flow controllers with rubber components in the purging device should be avoided.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride) through the septum seal into the sample during shipment and storage. A field blank prepared from organic-free water and carried through the sampling and handling protocol can serve as a check on such contamination.

3.3 Cross contamination can occur whenever high-level and low-level samples are sequentially analyzed. To reduce cross contamination, the purging device and sample syringe should be rinsed out twice, between samples, with organic-free water. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of organic-free water to check for cross contamination. For samples containing large amounts of water-soluble materials, suspended solids, high boiling compounds, or high organohalide levels, it may be necessary to wash out the purging device with a soap solution, rinse with distilled water, and then dry in a 105° C oven between analyses.

3.4 Low molecular weight impurities in PEG can be volatilized during the purging procedure. Thus, the PEG employed in this method must be purified before use as described in Section 5.2.

4.0 Apparatus and Materials

4.1 Sampling equipment

4.1.1 Vial: 25-ml capacity or larger, equipped with a screw cap (Pierce #13075 or equivalent). Detergent wash, rinse with tap and distilled water, and dry for 1 hr at 105° C before use.

4.1.2 Septum: Teflon-faced silicone (Pierce #12722 or equivalent). Detergent wash, rinse with tap and distilled water and dry at 105° C for 1 hr before use.

4.2 Purge-and-trap device: The purge-and-trap device consists of three separate pieces of equipment: the purging chamber, trap, and the desorber. Several complete devices are now commercially available.

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4.2.1 The purging chamber must be designed to accept 5-ml or 25-ml samples with a water column at least 3 cm deep. The gaseous head space between the water column and the trap must have a total volume of less than 15 ml. The purge gas must pass through the water column as finely divided bubbles with a diameter of less than 3 mm at the origin. The purge gas must be introduced no more than 5 mm from the base of the water column. The purging chamber, illustrated in Figure 1, meets these design criteria.

4.2.2 The trap must be at least 25 cm long and have an inside diameter of at least 2.5 mm. The trap must be packed to contain the following minimum lengths-of-adsorbents: 1.0 cm of methyl-silicone-coated packing (Section 5.3.2), 15 cm of 2,6-diphenylene oxide polymer (Section 5.3.1), and 8 cm of silica gel (Section 5.3.3). The minimum specifications for the trap are illustrated in Figure 2.

4.2.3 The desorber must be capable of rapidly heating the trap to 180° C within 30 sec. The polymer section of the trap should not be heated higher than 180° C and the remaining sections should not exceed 220° C. The desorber design, illustrated in Figure 2, meets these criteria.

4.2.4 The purge-and-trap device may be assembled as a separate unit or be coupled to a gas chromatograph as illustrated in Figures 3 and 4.

4.3 Gas chromatograph/mass spectrometer system

4.3.1 Gas chromatograph: An analytical system complete with a temperature-programmable gas chromatograph and all required accessories including syringes, analytical columns, and gases.

4.3.2 Column: 2-m x 2-mm I.D. stainless steel or glass, packed with 1% SP-1000 on 60/80 mesh Carbopack B or equivalent.

4.3.3 Mass spectrometer: Capable of scanning from 40 to 250 amu every 3 sec or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all the criteria in Table 1 when 50 ng of 4-bromofluorobenzene (BFB) is injected through the GC inlet or introduced in the purge-and-trap mode.

4.3.4 GC/MS interface: Any GC-to-MS interface that gives acceptable calibration points at 50 ng per injection for each compound of interest and achieves acceptable tuning performance criteria (see Section 9) may be used. GC-to-MS interfaces constructed of all glass or glass-lined materials are recommended. Glass can be deactivated by silanizing with dichlorodimethylsilane. The interface must be capable of transporting at least 10 ng of the components of interest from the GC to the MS.

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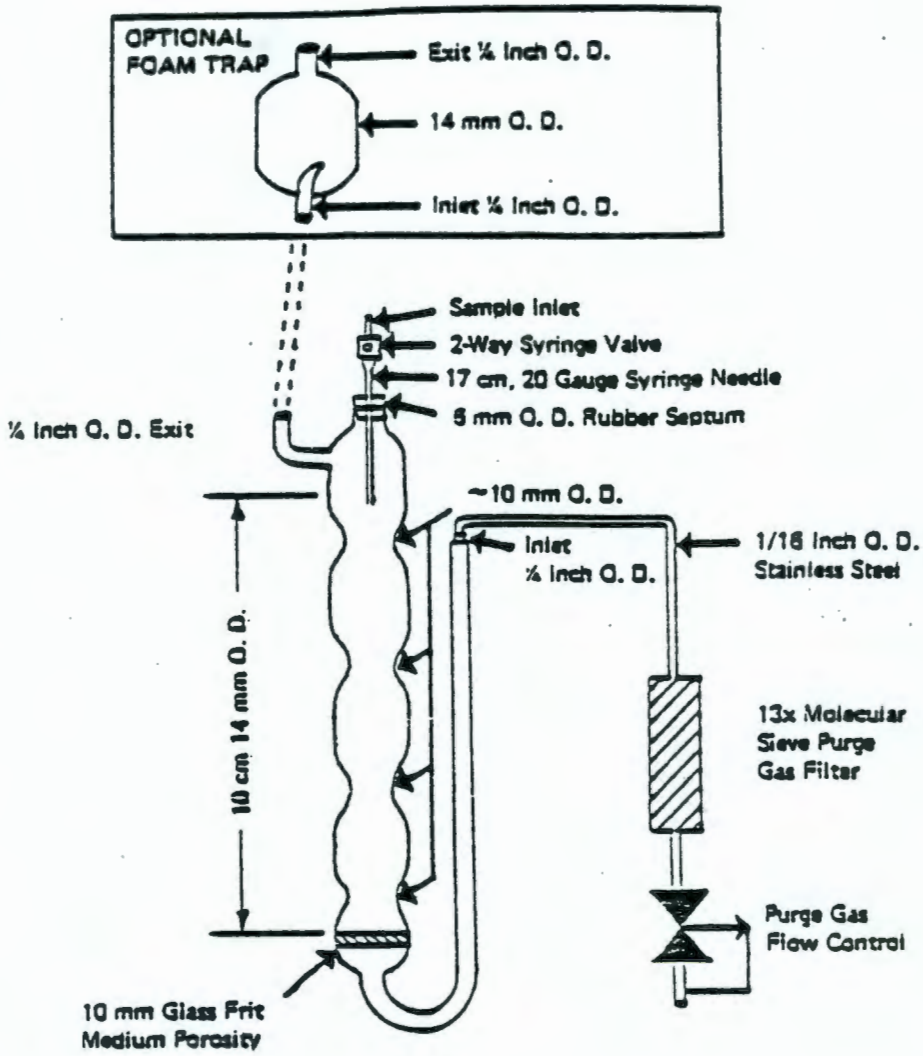

Figure 1. Purging chamber.

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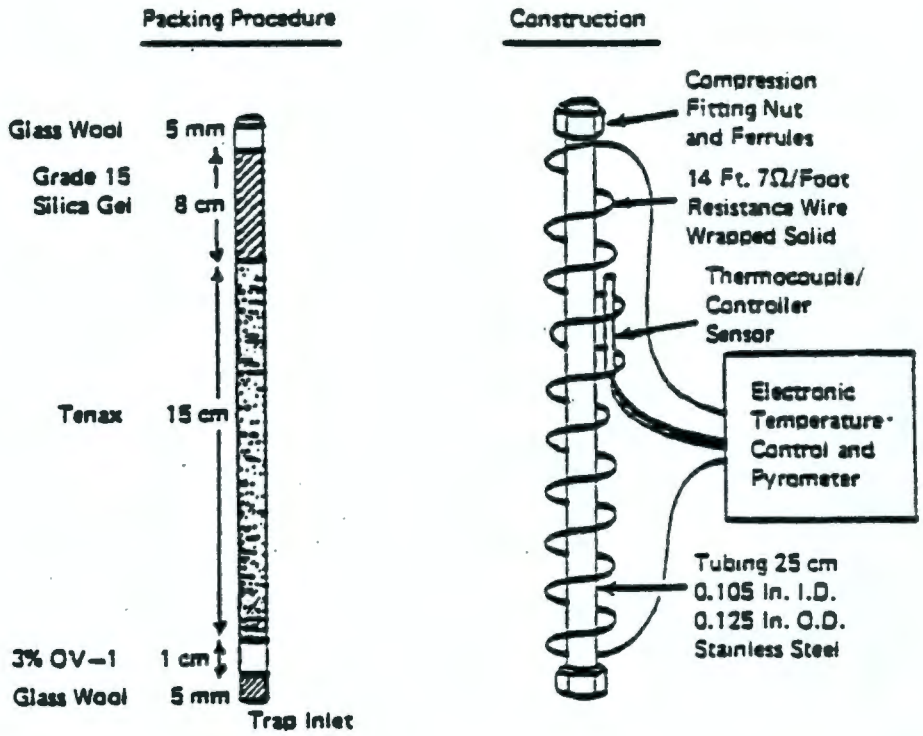

Figure 2. Trap packings and construction to include desorb capability.

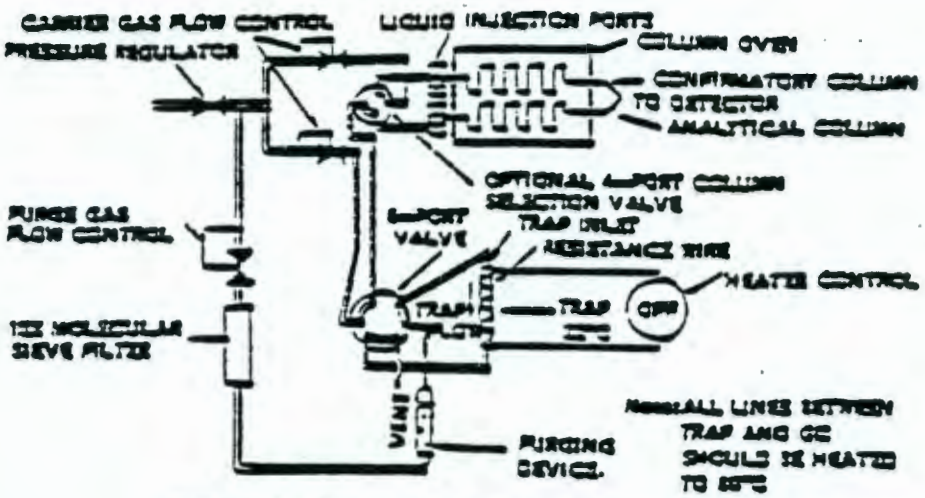

FIGURE 3. Schematic of purge and trap device – purge mode

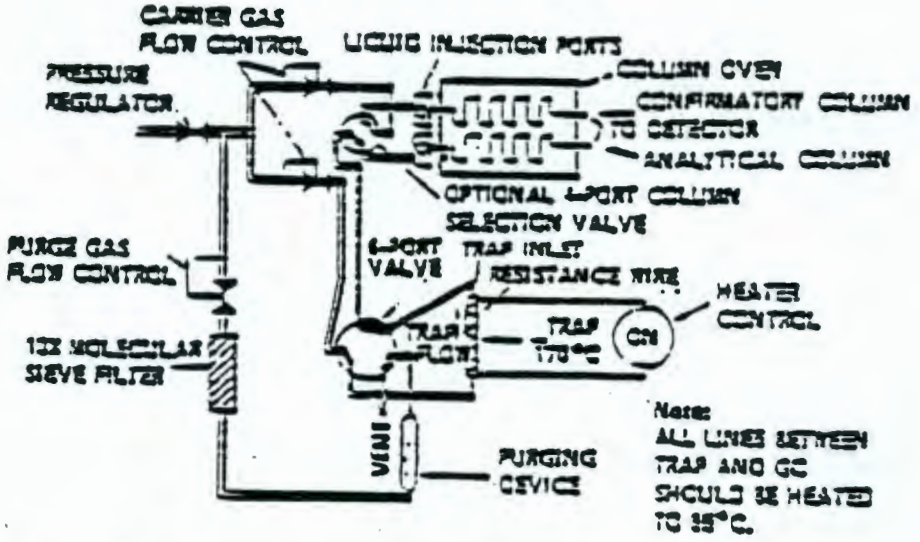

Figure 4. Schematic of purge and trap device - desorb mode

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4.3.5 Data system: A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specific mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). Software must also be available that allows integrating the abundance in any EICP between specified time or scan number limits. Hardware and software must be available to transform the data into a compatible format. These generally consist of a 9-inch, 800-bpi tape drive and the associated software.

4.4 Sample transfer implements: Implements are required to transfer portions of solid, semisolid, and liquid wastes from sample containers to laboratory glassware. The transfer must be accomplished rapidly to avoid loss of volatile components during the transfer step. Liquids may be transferred using a hypodermic syringe with a wide-bore needle or no needle attached. Samples should be introduced into the syringe by (1) removing the plunger from the syringe, (2) pouring the sample into the barrel, and (3) replacing the barrel and inverting the syringe to remove any air trapped in the syringe. Do not draw the sample up into the syringe. Solids may be transferred using a conventional laboratory spatula, spoon, or coring device. A coring device that is suitable for handling some samples can be made by using a glass tubing saw to cut away the closed end of the barrel of a glass hypodermic syringe.

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TABLE 2. BFB KEY ION ABUNDANCE CRITERIA

Mass	Ion abundance criteria
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	Base Peak, 100% Relative Abundance
96	5 to 9% of mass 95
173	less than 2% of mass 174
174	greater than 50% of mass 95
175	5 to 9% of mass 174
176	greater than 95% but less than 100% of mass 174
177	5 to 9% of mass 176

Ref. 26.10

4.5 Syringes: 5-ml and 25-ml glass hypodermic, equipped with 20-gauge needle, at least 15 cm in length.

4.6 Micro syringes: 10-µl, 25-µl, 100-µl, 250-µl, and 1000-µl. These syringes should be equipped with 20-gauge needles having a length sufficient to extend from the sample inlet to within 1 cm of the glass frit in the purging device (see Figure 1). The needle length required will depend upon the dimensions of the purging device employed.

4.7 Centrifuge tubes: 50-ml round-bottom glass centrifuge tubes with Teflon-lined screw caps. The tubes must be marked before use to show an approximate 20-ml graduation.

4.8 Centrifuge: Capable of accommodating 50-ml glass tubes.

4.9 Syringe valve: 2-way, with Luer ends (2 each) (Hamilton #86725 valve equipped with one Hamilton #35033 Luer fitting, or equivalent).

4.10 Syringe: 5-ml, gas-tight with shut-off valve.

4.11 Bottle: 15-ml, screw-cap, Teflon cap liner.

4.12 Balance: Analytical, capable of accurately weighing 0.0001 g.

4.13 Rotary evaporator: equipped with Teflon-coated seals (Buchi Rotavapor R-110, or equivalent).

4.14 Vacuum pump: mechanical, two-stage.

5.0 Reagents

5.1 Reagent water: Reagent water is defined as a water in which an interferent is not observed at the method detection limit of the compounds of interest.

5.1.1 Reagent water may be generated by passing tap water through a carbon filter bed containing about 500 g of activated carbon (Calgon Corp., Filtrasorb-300, or equivalent).

5.1.2 A water purification system (Millipore Super-Q or equivalent) may be used to generate reagent water.

5.1.3 Reagent water may also be prepared by boiling water for 15 min. Subsequently, while maintaining the temperature at 90° C, bubble a contaminant-free inert gas through the water for 1 hr. While still hot, transfer the water to a narrow-mouth screw-cap bottle and seal with a Teflon-lined septum and cap.

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5.1.4 Reagent water may also be purchased under the name "HPLC water" from several manufacturers (Burdick and Jackson, Baker and Waters, Inc.).

5.2 Reagent PEG: Reagent PEG is defined as PEG having a nominal average molecular weight of 400, and in which interferents are not observed at the method detection limit for compounds of interest.

5.2.1 Reagent PEG is prepared by purification of commercial PEG having a nominal average molecular weight of 400. The PEG is placed in a round-bottom flask equipped with a standard taper joint, and the flask is affixed to a rotary evaporator. The flask is immersed in a water bath at 90-100° C and vacuum is maintained at less than 10 mm Hg for at least 1 hr using a two-stage mechanical pump. The vacuum system is equipped with an all-glass trap, which is maintained in a dry ice/methanol bath.

5.2.2 In order to demonstrate that all interfering volatiles have been removed from the PEG, a reagent water/PEG blank must be analyzed.

5.3 Trap materials

5.3.1 2,6-Diphenylene oxide polymer: 60/80-mesh Tenax, chromatographic grade or equivalent.

5.3.2 Methyl silicone packing: 3 percent OV-1 on 60/80 mesh Chromosorb-W or equivalent.

5.3.3 Silica gel, Davison Chemical (35/60 mesh), grade-15 or equivalent.

5.3.4 Prepared trapping columns may be purchased from several chromatography suppliers.

5.4 Methanol: Distilled-in-glass quality or equivalent.

5.5 Calibration standards; stock solutions (2 mg/ml): Stock solutions of calibration standards may be prepared from pure standard materials or purchased as certified solutions. Prepare stock standard solutions of individual compounds in methanol using assayed liquids or gases as appropriate. Because of the toxicity of some of the organohalides, primary dilutions of these materials should be prepared in a hood. A NIOSH/MESA-approved toxic gas respirator should be worn by analysts when handling high concentrations of these materials.

5.5.1 Place about 9.8 ml of methanol in a 10-ml ground-glass-stoppered volumetric flask. Allow the flask to stand, unstoppered, for about 10 min or until all alcohol-wetted surfaces have dried. Weigh the flask to the nearest 0.1 mg.

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5.5.2 Add the assayed reference material as described below.

5.5.2.1 Liquids: Using a 100-µl syringe, immediately add 2 drops of assayed reference material to the flask, then reweigh. The liquid must fall directly into the alcohol without contacting the neck of the flask.

5.5.2.2 Gases: To prepare standards for any compounds that boil below 30° C (e.g., bromomethane, chloroethane, chloromethane, or vinyl chloride), fill a 5-ml valved gas-tight syringe with a reference standard to the 5.0-ml mark. Lower the needle to 5 mm above the methanol meniscus. Slowly introduce the reference standard above the surface of the liquid. The heavy gas rapidly dissolves in the methanol.

5.5.3 Reweigh, dilute to volume, stopper, then mix by gently inverting the flask several times. Calculate the concentration in µg/µl per microliter from the net gain in weight. When compound purity is assayed to be 96% or greater, the weight may be used without correction to calculate the concentration of the stock standard. Commercially prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source.

5.5.4 Transfer the stock standard solution into a Teflon-sealed screw-cap bottle. Store, with minimal headspace, at -10 to -20° C and protect from light.

5.5.5 Prepare fresh standards weekly for gases or for reactive compounds such as 2-chloroethylvinyl ether. All other standards must be replaced after one month, or sooner if comparison with check standards indicates a problem.

5.6 Calibration standards; secondary dilution solutions: Using stock solutions described in Section 5.5, prepare secondary dilution standards in methanol that contain the compounds of interest, either singly or mixed together. The secondary dilution standards should be prepared at concentrations such that the methanol or aqueous PEG calibration solutions prepared as described in Section 6.3.2 will bracket the working range of the analytical system. Secondary dilution standards should be stored with minimal headspace and should be checked frequently for signs of evaporation, especially just prior to preparing calibration standards from them.

5.7 Surrogate standards: Surrogate standards may be added to samples and calibration solutions to assess the effect of the sample matrix on recovery efficiency. The compounds employed for this purpose are 1,2-dibromotetrafluoroethane, bis(perfluoroisopropyl) ketone, fluorobenzene, and m-bromobenzotrifluoride. Prepare methanolic solutions of the surrogate standards using the procedures described in Sections 5.5 and 5.6. The

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concantrations prepared and the amount of solution added to each sample should be those required to give an amount of each surrogate in the purging device that is equal to the amount of each internal standard added, assuming a 100% recovery of the surrogate standards.

5.8 Internal standards: In this method, internal standards are employed during analysis of all samples and during all calibration procedures. The analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Because of these limitations, no internal standard can be suggested that is applicable to all samples. However, for general use, D_4-1,2-dichloroethane, D_6-benzene, and D_5-ethylbenzene are recommended as internal standards covering a wide boiling point range.

5.9 4-Bromofluorobenzene (BFB): BFB is added to the internal standard solution or analyzed alone to permit the mass spectrometer tuning for each GC/MS run to be checked.

5.10 Internal standard solution: Using the procedures described in Sections 5.5 and 5.6, prepare a methanolic solution containing each internal standard at a concentration of 12.5 µg/ml.

5.11 Sodium monohydrogen phosphate: 2.0 µ in distilled water.

5.12 n-Nonane and n-dodecane, 98+% purity.

5.13 N-Hexadecane, distilled-in-glass (Burdick and Jackson, or equivalent).

6.0 Sample Collection, Handling, and Preservation

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Section One of this manual.

6.2 All samples must be stored in Teflon-lined screw cap vials. Sample containers should be filled as completely as possible so as to minimize headspace or void space. Vials containing liquid sample should be stored in an inverted position.

6.3 All samples must be iced or refrigerated from the time of collection to the time of analysis, and should be protected from light.

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7.0 Procedure

7.1 Calibration

7.1.1 Assemble a purge-and-trap device that meets the specifications in Section 4.2 and connect the device to a GC/MS system. Condition the trap overnight at 180° C by backflushing with an inert gas flow of at least 20 ml/min. Prior to use, condition the trap daily for 10 min while backflushing at 180° C.

7.1.2 Operate the gas chromatograph using the conditions described in Section 7.3.5 and operate the mass spectrometer using the conditions described in Section 7.3.2.

7.1.3 Calibration procedure

7.1.3.1 Conduct calibration procedures using a minimum of three concentration levels for each calibration standard. One of the concentration levels should be at a concentration near but above the method detection limit. The remaining two concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the GC/MS system.

7.1.3.2 Prepare the final solutions containing the required concentrations of calibration standards, including surrogate standards, directly in the purging device. To the purging device, add 5.0 ml of reagent water or reagent water/PEG solution. This solution is prepared by taking 4.0 ml of reagent water or reagent PEG and diluting to 100 ml with reagent water. The reagent water/PEG solution is added to the purging device using a 5-ml glass syringe fitted with a 15-cm 20-gauge needle. The needle is inserted through the sample inlet shown in Figure 1. The internal diameter of the 14-gauge needle that forms the sample inlet will permit insertion of a 20-gauge needle. Next, using a 10-µl or 25-µl microsyringe equipped with a long needle (see Section 4.6), take a volume of the secondary dilution solution containing appropriate concentrations of the calibration standards (see Section 5.6). Add the aliquot of calibration solution directly to the reagent water or reagent water/PEG solution in the purging device by inserting the needle through the sample inlet. When discharging the contents of the micro-syringe be sure that the end of the syringe needle is well beneath the surface of the reagent water or water/PEG solution. Similarly, add 20 µl of the internal standard solution (see Section 5.10). Close the 2-way syringe valve at the sample inlet.

7.1.3.3 Carry out the purge and analysis procedure as described in Section 7.3.4. Tabulate the area response of the primary characteristic ion against concentration for each compound

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including the internal standards. Calculate response factors (RF) for each compound as follows:

$$RF = (A_s C_{is})/A_{is} C_s)$$

where:

A_s = Area of the primary characteristic ion for the compound to be measured

A_{is} = Area of the primary characteristic ion of the internal standard

C_{is} = Concentration of the internal standard

C_s = Concentration of the compound to be measured.

The internal standard selected for the calculation of the RF of a compound and subsequent quantification of the compound is generally the internal standard that has a retention time closest to that of the compound. It is assumed that a linear calibration plot will be obtained over the range of concentrations used. If the RF value over the working range is a constant (less than 10% relative standard deviation), the RF can be assumed to be invariant, and the average RF can be used for calculations. Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is}, versus RF.

7.1.3.4 The RF must be verified on each working day. The concentrations selected should be near the midpoint of the working range. The response factors obtained for the calibration standards analyzed immediately before and after a set of samples must be within ±20% of the response factor used for quantification of the sample concentrations.

7.2 Daily GC/MS performance tests

7.2.1 At the beginning of each day that analyses are to be performed, the GC/MS system must be checked to see that acceptable performance criteria are achieved for BFB (see Table 2).

7.2.2 The BFB performance test requires the following instrumental parameters:

Electron Energy:	70 volts (nominal)
Mass Range:	40 to 250 amu
Scan Time:	to give approximately 6 scans per peak but not to exceed 3 sec per scan.

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7.2.3 Bleed BFB vapor into the mass spectrometer and tune the instrument to achieve all the key ion criteria for the mass spectrum of BFB given in Table 1. A solution containing 20 ng of BFB may be injected onto the gas chromatographic column in order to check the key ion criteria.

7.2.4 The peak intensity of D_6-benzene is used to monitor the mass spectrometer sensitivity. The peak intensity for D_6-benzene observed during each sample analysis must be between 0.7 and 1.4 times the D_6-benzene peak intensity observed during the applicable calibration runs. For example, if the peak intensity of D_6-benzene observed during calibration was 355,000 area counts, then each subsequent sample or blank must give a D_6-benzene peak intensity of between 250,000 and 500,000 area counts. If the D_6-benzene peak intensity is outside the specified range, the sample must be reanalyzed. If the peak intensity is again outside the specified range, the analyst must investigate the cause of the variability in sensitivity and correct the problem.

7.3 Sample extraction and analysis

7.3.1 The analytical procedure involves extracting the non-aqueous sample with methanol or polyethylene glycol (PEG) and analyzing a portion of the extract by a purge-and-trap GC/MS procedure. The amount of the extract to be taken for the GC/MS analysis is based on the estimated total volatile content (TVC) of the sample. The TVC is estimated by extracting the sample with n-hexadecane and analyzing the n-hexadecane extract by gas chromatography.

7.3.2 The estimated TVC is based on the total area response relative to that of n-nonane for all components eluting prior to the retention time of n-dodecane. The response factor for n-nonane and the retention time of n-dodecane are determined by analyzing a 2-µl aliquot of an n-hexadecane solution containing 0.20 mg/ml of n-nonane and n-dodecane.

7.3.2.1 The GC analyses are conducted using a flame ionization detector and a 3-m x 2-mm I.D. glass column packed with 10% OV-101 on 100-200 mesh Chromosorb W-HP. The column temperature is programmed from 80° C to 280° C at 8°/min and held at 280° for 10 min.

7.3.2.2 Determine the area response for n-nonane and divide by 0.2 to obtain the area response factor. Record the retention time of n-dodecane.

7.3.2.3 Add 1.0 g of sample to 20 ml of n-hexadecane and 2 ml of 2.0 M Na_2HPO_4 contained in a 50-ml glass centrifuge tube and cap securely with a Teflon-lined screw cap. Shake the mixture vigorously for one minute. If the sample does not disperse

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during the shaking process, sonify the mixture in an ultrasonic bath for 30 min. Allow the mixture to stand until a clear supernatant is obtained. Centrifuge if necessary to facilitate phase separation.

7.3.2.4 Analyze a 2-µl aliquot of the n-hexadecane supernatant using the conditions described in Section 7.3.2.1. Determine the total area response of all components eluting prior to the retention time of n-dodecane and subtract the corresponding area of an n-hexadecane blank. Using the area response factor determined for n-nonane in Section 7.3.2.2, calculate the TVC as follows:

$$TVC = \frac{TAR_{sample} - TAR_{blank}}{\text{n-Nonane Area Response Factor}} \times 20$$

where:

TVC = total volatile content of the sample in mg/g

TAR_{sample} = total area response obtained for the sample

TAR_{blank} = total area response obtained for a blank.

7.3.3 The transfer of an aliquot of the sample for extraction with methanol or PEG should be made as quickly as possible to minimize loss of volatiles from the sample.

7.3.3.1 To a 50-ml glass centrifuge tube with Teflon-lined cap, add 40 ml of reagent methanol or PEG. Weigh the capped centrifuge tube and methanol or PEG on an analytical balance.

7.3.3.2 Using an appropriate implement (see Section 4.4), transfer approximately 2 g of sample to the methanol or PEG in the centrifuge tube in such a fashion that the sample is dissolved in or submerged in the methanol or PEG as quickly as possible. Take care not to touch the sample-transfer implement to the methanol or PEG. Recap the centrifuge tube immediately and weigh on an analytical balance to determine an accurate sample weight.

7.3.3.3 Disperse the sample by vigorous agitation for 1 min. The mixture may be agitated manually or with the aid of a vortex-mixer. If the sample does not disperse during this process, sonify the mixture in an ultrasonic bath for 30 min. Allow the mixture to stand until a clear supernatant is obtained as the sample extract. Centrifuge if necessary to facilitate phase separation.

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7.3.3.4 The sample extract may be stored for future analytical needs. If this is desired, transfer the solution to a 10-ml screw cap vial with Teflon cap liner. Store at -10 to -20° C, and protect from light.

7.3.4 Reagent water, internal standard solution, and the sample extract are added to a purging chamber that is connected to the purge-and-trap device and that has been flushed with helium during a 7-min trap reconditioning step (see Section 7.3.4.4). The additions are made using an appropriately sized syringe equipped with a 15-cm 20-gauge needle. Open the syringe valve of the sample inlet (shown in Figure 1) and insert the needle through the valve.

7.3.4.1 Add 5.0 ml of reagent water or aqueous sample to which 20.0 µl of the internal standard solution has been added (see Section 5.10) to the purging chamber. Insert the needle of the syringe well below the surface of the water for the addition of the internal standard solution. If the sample is aqueous go to Section 7.3.5.

7.3.4.2 Add an aliquot of the sample extract from Section 7.3.3.4. The total quantity of volatile components injected should not exceed approximately 10 µg. If the total volatile content (TVC) of the sample as determined in Section 7.3.1.4 is 1.0 mg/g or less, use a 200-µl aliquot of the sample extract. If the TVC is greater than 1.0 mg/g, use an aliquot of the sample extract that contains approximately 10 µg of total volatile components; the volume (in µl) of the aliquot to be taken can be calculated by dividing 200 by the TVC. If the TVC is greater than 20 mg/g, take a 500-µl aliquot of the sample extract and dilute to 10 ml with PEG. In this case calculate the aliquot volume (in µl) of the undiluted extract to be taken by dividing 4,000 by the TVC. If the TVC is less than 1.0 mg/g and greater sensitivity is desired, use a large purging chamber containing 25 ml of reagent water and use a 1.0-ml aliquot of the sample extract.

7.3.4.3 Close the 2-way syringe valve at the sample inlet.

7.3.5 The sample in the purging chamber is purged with helium to transfer the volatile components to the trap. The trap is then heated to desorb the volatile components which are swept by the helium carrier gas onto the GC column for analysis.

7.3.5.1 Adjust the gas (helium) flow rate to 40 ± 3 ml/min. Set the purging device to purge, and purge the sample for 11.0 ± 0.1 min at ambient temperature.

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7.3.5.2 At the conclusion of the purge time, adjust the device to the desorb mode, and begin the GC/MS analysis and data acquisition using the following GC operating conditions:

Column: 6-ft x 2-mm I.D. glass column of 1% SP-1000 on Carbo-pack B (60-80 mesh).

Temperature: Isothermal at 45° C for 3 min, then increased at 8° C/min to 220° C, and maintained at 220° C for 15 min.

Concurrently, introduce the trapped materials to the GC column by rapidly heating the trap to 180° C while backflushing the trap with helium at a flow rate of 30 ml/min for 4 min. If this rapid heating requirement cannot be met, the GC column must be used as a secondary trap by cooling it to 30° C or lower during the 4-min desorb step and starting the GC program after the desorb step.

7.3.5.3 Return the purge-and-trap device to the purge mode and continue acquiring GC/MS data.

7.3.5.4 Allow the trap to cool for 8 min. Replace the purging chamber with a clean purging chamber. The purging chamber is cleaned after each use by sequential washing with acetone, methanol, detergent solution and distilled water, and then dried at 105° C.

7.3.5.5 Close the syringe valve on the purging chamber after 15 sec to begin gas flow through the trap. Purge the trap at ambient temperature for 4 min. Recondition the trap by heating it to 180° C. Do not allow the trap temperature to exceed 180° C, since the sorption/desorption is adversely affected when the trap is heated to higher temperatures. After heating the trap for approximately 7 min, turn off the trap heater. When cool, the trap is ready for the next sample.

7.3.6 If the response for any ion exceeds the working range of the system, repeat the analysis using a correspondingly smaller aliquot of the sample extract described in Section 7.3.2.3.

7.4 Qualitative identification

7.4.1 Obtain an EICP for the primary characteristic ion and at least two other characteristic ions for each compound when practical. The following criteria must be met to make a qualitative identification.

7.4.1.1 The characteristic ions of each compound of interest must maximize in the same or within one scan of each other.

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7.4.1.2 The retention time must fall within ±30 sec of the retention time of the authentic compound.

7.4.1.3 The relative peak heights of the characteristic ions in the EICP's must fall within ±20% of the relative intensities of these ions in a reference mass spectrum. Reference spectra may be generated from the standards analyzed by the analyst or from a reference library. All reference spectra generated from standards must be obtained from an appropriately tuned mass spectrometer.

7.5 Quantitative determination

7.5.1 When a compound has been identified, the quantification of that compound will be based on the integrated abundance from the EICP of the primary characteristic ion. In general, the primary characteristic ion selected should be a relatively intense ion, as interference-free as possible, and as close as possible in mass to the characteristic ion of the internal standard used. Generally, the base peak of the mass spectrum is used.

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8.0 Quality Control

8.1 Each laboratory that uses this method is required to operate a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and the analysis of spiked samples as a continuing check on performance. The laboratory is required to maintain performance records to define the quality of the data that are generated. Ongoing performance checks must be compared with established performance criteria to determine if the results of analyses are within the accuracy and precision limits expected of the method.

8.1.1 Before performing any analyses, the analyst must demonstrate the ability to generate acceptable accuracy and precision with this method. This ability is established as described in Section 8.2.

8.1.2 The laboratory must spike all samples including check samples with surrogate standards to monitor continuing laboratory performance. This procedure is described in Section 8.4.

8.1.3 Before processing any samples, the analyst should daily demonstrate, through the analysis of an organic-free water method blank, that the entire analytical system is interference-free. The blank samples should be carried through all stages of the sample preparation and measurement steps.

8.2 To establish the ability to generate acceptable accuracy and precision, the analyst must perform the following operations using a representative sample as a check sample.

8.2.1 Analyze four aliquots of the unspiked check sample according to the method in Section 7.3.

8.2.2 For each compound to be measured, select a spike concentration representative of twice the level found in the unspiked check sample or a level equal to 10 times the expected detection limit, whichever is greater. Prepare a spiking solution by dissolving the compounds in methanol at the appropriate levels.

8.2.3 Spike a minimum of four aliquots of the check sample with the spiking solution to achieve the selected spike concentrations. Spike the samples by adding the spiking solution to the PEG used for the extraction. Analyze the spiked aliquots according to the method in Section 7.3.

8.2.4 Calculate the average percent recovery, R, and the standard deviation of the percent recovery, s, for all compounds and surrogate standards. Background corrections must be made before R and s calculations are performed. The average percent recovery must be greater than 20 for all compounds to be measured and greater than 60 for all surrogate compounds. The percent relative standard deviation of the percent recovery, s/R x 100, must be less than 20 for all compounds to be measured and all surrogate compounds.

8.3 The analyst must calculate method performance criteria for each of the surrogate standards.

8.3.1 Calculate upper and lower control limits for method performance for each surrogate standard, using the values for R and s calculated in Section 8.2.4:

Upper Control Limit (UCL) = R + 3s
Lower Control Limit (LCL) = R - 3s

The UCL and LCL can be used to construct control charts that are useful in observing trends in performance.

8.3.2 For each surrogate standard, the laboratory must maintain a record of the R and s values obtained for each surrogate standard in each waste sample analyzed. An accuracy statement should be prepared from these data and updated regularly.

8.4 The laboratory is required to spike all samples with the surrogate standards to monitor spike recoveries. The spiking level used should be that which will give an amount in the purge apparatus that is equal to the amount of the internal standard assuming a 100% recovery of the surrogate standards. If the recovery for any surrogate standard does not fall within the control limits for method performance, the results reported for that sample must be

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qualified as being outside of control limits. The laboratory must monitor the frequency of data so qualified to ensure that it remains at or below 5%. Four surrogate standards, namely 1,2-dibromodifluoroethane, bis(perfluoroisopropyl) ether, fluorobenzene, and m-bromobenzotrifluoride, are recommended for general use to monitor recovery of volatile compounds varying in volatility and polarity.

8.5 Each day, the analyst must demonstrate through the analysis of a process blank that all glassware and reagent interferences are under control.

8.6 It is recommended that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. Field replicates may be analyzed to monitor the precision of the sampling technique. Whenever possible, the laboratory should perform analysis of standard reference materials and participate in relevant performance evaluation studies.

8.7 Standard quality assurance practices should be used with this method. Field replicates should be collected to validate the precision of the sampling technique. Laboratory replicates should be analyzed to validate the precision of the analysis. Fortified samples should be carried through all stages of sample preparation and measurement; they should be analyzed to validate the sensitivity and accuracy of the analysis. If the fortified waste samples do not indicate sufficient sensitivity to detect less than or equal to 1 µg/g of sample, then the sensitivity of the instrument should be increased or the extract subjected to additional cleanup. Detection limits to be used for groundwater samples are indicated in Table 1. Where doubt exists over the identification of a peak on the chromatograph, confirmatory techniques such as mass spectroscopy should be used.

8.8 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations listed in Table 1 were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

8.9 In a single laboratory, using reagent water and wastewaters spiked at or near background levels, the average recoveries presented in Table 3 were obtained. The standard deviation of the measurement in percent recovery is also included in Table 3.

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TABLE 3. ACCURACY AND PRECISION FOR PURGEABLE ORGANICS

Parameter	Reagent Water		Wastewater	
	Average percent recovery	Standard deviation (%)	Average percent recovery	Standard deviation (%)
Benzene	99	9	98	10
Bromodichloromethane	102	12	103	10
Bromoform	104	14	105	16
Bromomethane	100	20	88	23
Carbon tetrachloride	102	16	104	15
Chlorobenzene	100	7	102	9
Chloroethane	97	22	103	31
2-Chloroethyl vinyl ether	101	13	95	17
Chloroform	101	10	101	12
Chloromethane	99	19	99	24
Dibromochloromethane	103	11	104	14
1,1-Dichloroethane	101	10	104	15
1,2-Dichloroethane	100	8	102	10
1,1-Dichloroethene	102	17	99	15
trans-1,2-Dichloroethene	99	12	101	10
1,2-Dichloropropane	102	8	103	12
cis-1,3-Dichloropropene	105	15	102	19
trans-1,3-Dichloropropene	104	11	100	18
Ethyl benzene	100	8	103	10
Methylene chloride	96	16	89	28
1,1,2,2-Tetrachloroethane	102	9	104	14
Tetrachloroethene	101	9	100	11
Toluene	101	9	98	14
1,1,1-Trichloroethane	101	11	102	16
1,1,2-Trichloroethane	101	10	104	15
Trichloroethene	101	9	100	12
Trichlorofluoromethane	103	11	107	19
Vinyl chloride	100	13	98	25

Samples were spiked between 10 and 1000 µg/l.

Ref. 26.24

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REFERENCE 27

Cyanide, Method 9010, UST-RD-PM-9-80

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ANALYTICAL GROUP CODE: C70

CYANIDE, METHOD 9010

TAB XII, B

Detection Limit: ~~30~~ 10 ppb 7-31-86 G.Rao GVC

(1)
Cyanide in aqueous samples is determined by colorimetry using a UV/VIS spectrometer.

(2)
The instrument is set up and calibrated according to the manufacturer's instructions. Calibration standards are prepared in the concentration range of 0 to 120 ppb. The instrument stores the absorbances and generates an internal calibration curve.

(3)
All standards are prepared fresh when samples are to be analyzed. All standards are subjected to the same distillation procedure as the samples. Matrix spike recoveries are determined at a concentration of 100 ppb. Verification standards are prepared at concentrations near 100 ppb. Often EPA QC check samples are used as verification standards.

(4)
Absorbances are determined at a fixed wavelength which is determined whenever a fresh batch of barbituric acid is prepared. A 100 ppb standard is analyzed in the "wavelength scan" mode. In this mode, absorbances for wavelengths between 500 and 600 nm are determined. The peak of the distribution is then chosen as the fixed wavelength for all measurements. The wavelength is typically very close to 578 nm.

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Approved For Use: Govindrao 6-16-86
Neil H. McGee 6-16-86

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METHOD 9010

TOTAL AND AMENABLE CYANIDE

1.0 Scope and Application

1.1 Method 9010 is used to determine the concentration of inorganic cyanide in a waste or leachate. The method detects inorganic cyanides that are present as either simple soluble salts or complex radicals. It is used to determine values for both total cyanide and cyanide amenable to chlorination. Method 9010 does not determine the "reactive" cyanide content of wastes containing iron-cyanide complexes.

2.0 Summary of Method

2.1 The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is then determined colorimetrically.

2.2 In the colorimetric measurement, the cyanide is converted to cyanogen chloride (CNCl) by reaction with chloramine-T at a pH less than 8 without hydrolyzing to the cyanate. After the reaction is complete, color is formed on the addition of pyridine-barbituric acid reagent. The absorbance is read at 570 nm for pyridine-barbituric acid reagent. To obtain colors of comparable intensity, it is essential to have the same salt content in both the sample and the standards.

3.0 Interferences

3.1 Interferences are eliminated or reduced by using the distillation procedure described in Procedure 7.2.3, 7.2.4, and 7.2.5.

3.2 Sulfides adversely affect the colorimetric procedures. Samples that contain hydrogen sulfide, metal sulfides or other compounds that may produce hydrogen sulfide during the distillation should be distilled by the optional procedure described in procedure 7.2.3.

3.3. High results may be obtained for samples that contain nitrate and/or nitrite. During the distillation, nitrate and nitrite will form nitrous acid which will react with some organic compounds to form oximes. These comounds formed will decompose under test conditions to generate HCN. The interference of nitrate and nitrite is eliminated by pretreatment with sulfamic acid.

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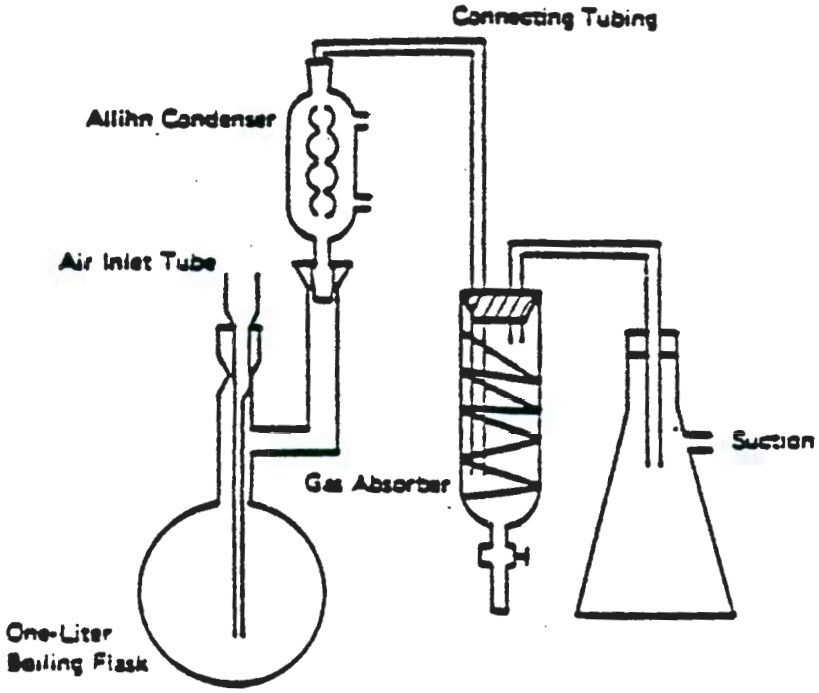

Figure 1. Apparatus for cyanide distillation.

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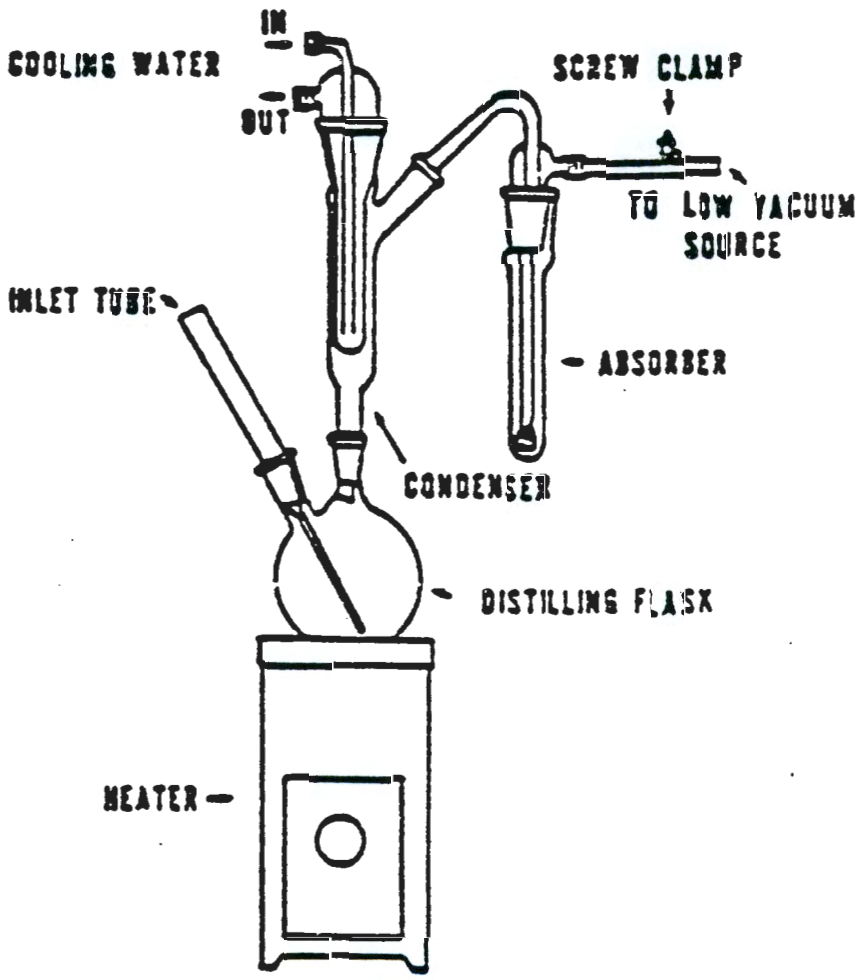

Figure 2. Cyanide distillation apparatus.

Revised 4/8

5.9 Sulfamic acid solution: Dissolve 40 g of sulfamic acid in distilled water. Dilute to 1 liter.

5.10 Calcium Hypochlorite solution: Dissolve 5 g of calcium hypochlorite ($Ca(OCl)_2$) in 100 ml of distilled water.

5.11 Potassium Iodide-starch test paper.

5.12 Reagents for manual colorimetric determination:

5.12.1 Pyridine-Barbituric Acid Reagent: Place 15 g of barbituric acid in a 250 ml volumetric flask and add just enough distilled water to wash the sides of the flask and wet barbituric acid. Add 75 ml of pyridine and mix. Add 15 ml of conc. HCl, mix and cool to room temperature. Dilute to 250 ml with distilled water and mix., This reagent is stable for approximately six months if stored in a cool, dark place.

5.12.2 Chloramine-T solution: Dissolve 1.0 g of white, water soluble Chloramine-T in 100 ml of distilled water and refrigerate until ready to use.

5.13 Reagents for automated colorimetric determination:

5.13.1 Distillation agent: Carefully add 250 ml of 85% phosphoric acid and 50 ml of hypophosphorus acid to 700 ml of distilled water, mix, and dilute to one liter with distilled water.

5.13.2 Sodium dihydrogenphosphate, 1M (phosphate buffer): Dissolve 138 g of $NaH_2PO_4 \cdot H_2O$ in 1 liter of distilled water. Refrigerate this solution.

5.13.3 Chloramine-T: Dissolve 3.0 g of chloramine-T in 500 ml of distilled water.

5.13.4 Pyradine barbituric acid reagent: Refer to (5.12.1).

5.13.5 Sodium hydroxide, 1 N: Dissolve 40 g of NaOH in 500 ml of distilled water.

5.13.6 Stock cyanide solution: Refer to 5.5.

5.13.7 All working standards should contain 2 ml of 1 N NaOH (5.13.5) per 100 ml.

5.13.8 Dilution water and recepticle wash water (NaOH, 0.25 N): Dissolve 10.0 g NaOH in 500 mls of distilled water. Dilute to 1 liter.

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4.0 Apparatus

4.1 Reflux distillation apparatus such as shown in Figure 1 or 2. The boiling flask should be of 1 liter size with inlet tube and provision for condenser. The gas absorber may be a Fisher-Milligan scrubber.

4.2 Spectrophotometer suitable for measurements t 570 nm with a 1.0 cm cell or larger.

4.3 Flow meter, such as Lab Crest with stainless steel float (Fisher 11-164-50).

4.4 Technicon Auto-Analyzer

4.4.1 Sampler

4.4.2 Cyanide manifold. (See Figure 3.)

4.4.3 Proportioning pump.

4.4.4 Colorimeter equipped with a 15 mm flowcell and 570 nm filter.

4.4.5 Recorder.

5.0 Reagents

5.1 Sodium hydroxide solution, 1.25N: Dissolve 50 g of NaOH in distilled water, and dilute to 1 liter with distilled water.

5.2 Bismuth nitrate solution: Dissolve 30.0 grams of $Bi(NO_3)_3$ in 100 mls of distilled water. While stirring, add 250 mls of acetic acid. Stir until dissolved. Dilute to 1 liter with distilled water.

5.3 Sulfuric acid; 18N: Slowly add 500 ml of concentrated H_2SO_4 to 500 ml of distilled water.

5.4 Sodium dihydrogenphosphate, 1 M: Dissolve 138 g of $NaH_2PO_4 \cdot H_2O$ in 1 liter of distilled water. Refrigerate this solution.

5.5 Stock cyanide solution: Dissolve 2.51 g of KCN and 2 g KOH in 900 ml of distilled water. Standardize with 0.0192 N $AgNO_3$. Dilute to appropriate concentration so that 1 ml = 1 mg CN.

5.6 Standard cyanide solution, intermediate: Dilute 100.0 ml of stock (1 ml = 1 mg CN) to 1000 ml with distilled water (1 ml = 100 g).

5.7 Working standard cyanide solution: Prepare fresh daily by diluting 100.0 ml of intermediate cyanide solution to 1000 ml with distilled water and store in a glass stoppered bottle. 1 ml = 10.0 ug CN.

5.8 Magnesium chloride solution: Weigh 510 g of $MgCl_2 \cdot 6H_2O$ into a 1000 ml flask, dissolve and dilute to 1 liter with distilled water.

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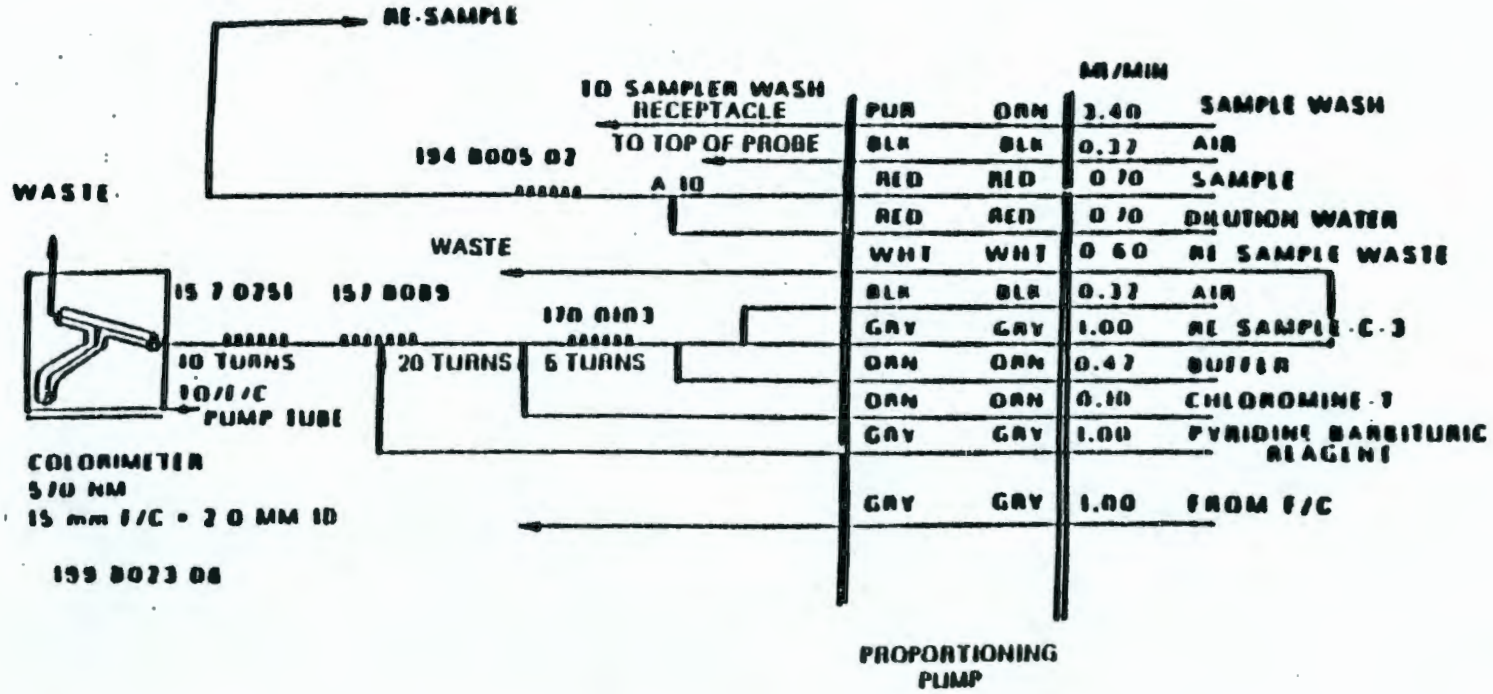

Figure 3. Cyanide manifold AA11.

6.0 Sample Collection, Preservation and Handling

6.1 All samples must have been collected using a sampling plan that addresses the considerations discussed in Section One of this manual.

6.2 Samples should be collected in plastic or glass bottles of 1-liter size or larger. All bottles must be thoroughly cleaned and thoroughly rinsed to remove soluble materials from containers.

6.3 Oxidizing agents such as chlorine decompose most cyanides. To determine whether oxidizing agents are present, test a drop of the sample with potassium iodide-starch test paper; a blue color indicates the need for treatment. Add ascorbic acid a few crystals at a time until a drop of sample produces no color on the indicator paper. Then add an additional 0.6 g of ascorbic acid for each liter of water.

6.4 Samples must be preserved with 2 ml of 10 N sodium hydroxide per liter of sample (pH is greater than or equal to 12) at the time of collection.

6.5 Samples should be refrigerated at 4°C when possible and analyzed as soon as possible.

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7.0 Procedure

7.1 Pretreatment for cyanides amenable to chlorination

7.1.1 Two sample aliquots are required to determine cyanides amenable to chlorination. To one 500 ml aliquot or a volume diluted to 500 ml, add calcium hypochlorite solution (5.10) dropwise while agitating and maintaining the pH between 11 and 12 with sodium hydroxide (5.1).

Caution: The initial reaction product of alkaline chlorination is the very toxic gas cyanogen chloride; therefore, it is recommended that this reaction be performed in a hood. For convenience, the sample may be agitated in a 1 liter beaker be means of a magnetic stirring device.

7.1.2 Test for residual chlorine with KI-starch paper (5.11) and maintain this excess for one hour, continuing agitation. A distinct blue color on the test paper indicates a sufficient chlorine level. If necesssary, add additional hypochlorite solution.

7.1.3 After one hour, add 0.5 g portions of ascorbic acid until KI-starch paper shows no residual chlorine. Add an additional 0.5 g of ascorbic acid to ensure the presence of excess reducing agent.

7.1.4 Test for total cyanide in both the chlorinated and unchlorinated aliquots. (The difference of total cyanide in the chlorinated and unchlorinated aliquots is the cyanide amenable to chlorionation.)

7.2 Distillation Procedure

7.2.1 Place 500 ml of sample, or an aliquot diluted to 500 ml in the 1 liter boiling flask. Pipet 50 ml of sodium hydroxide (5.1) into the absorbing tube. If the apparatus in Figure 1 is used, add distilled water until the spiral is covered. Connect the boiling flask, condenser, absorber and trap in the train. (Figure 1 or 2)

7.2.2 Start a slow stream of air entering the boiling flask by adjusting the vacuum source. Adjust the vacuum so that approximately two bubbles of air per second enters the boiling flask through the air inlet tube.

7.2.3 If samples contain sulfide, add 50 ml of bismuth nitrate solution (5.2) after the air rate is set through the air inlet tube. Mix for 3 minutes prior to addition of H_2SO_4.

7.2.4 If samples contain NO_3 and/or NO_2, add 50 ml of sulfamic acid solution (5.9) after the air rate is set through the air inlet tube. Mix for 3 minutes prior to addition of H_2SO_4.

7.2.5 Slowly add 50 ml 18 N sulfuric acid (5.3) through the air inlet tube. Rinse the tube with distilled water and allow the airflow to mix the flask contents for 3 minutes. Pour 20 ml of magnesium chloride (5.8) into the air inlet and wash down with a stream of water.

7.2.6 Heat the solution to boiling. Reflux for one hour. Turn off heat and continue the airflow for at least 15 minutes. After cooling the boiling flask, disconnect absorber and close off the vacuum source.

7.2.7 Drain the solution from the absorber into a 250 ml volumetric flask. Wash the absorber with distilled water and add the washings to the flask. Dilute to the mark with distilled water.

7.3 Manual spectophotometric determination:

7.3.1 Withdraw 50 ml or less of the solution from the flask and transfer to a 100 ml volumetric flask. If less than 50 ml is taken, dilute to 50 ml with 0.25 N sodium hydroxide solution (5.13.8). Add 15.0 ml of sodium phosphate solution (5.4) and mix.

7.3.2 Add 2 ml of chloramine-T (5.12.2) and mix. See note 1. After 1 to 2 minutes, add 5 ml of pyridine-barbituric acid solution (5.12.1) and mix. Dilute to mark with distilled water and mix again. Allow 8 minutes for color development and then read absorbance at 570 nm in a 1-cm cell within 15 minutes.

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Ref. 27.9

7.4 Standard curve for samples without sulfide

7.4.1 Prepare a series of standards by pipeting suitable volumes of standard solution (5.7) into 250 ml volumetric flasks. To each standard add 50 ml of 1.25 N sodium hydroxide and dilute to 250 ml with distilled water. Prepare as follows:

ML of Working Standard Solution (1 ml = 10 g CN)	Conc. g CN per 250 ml
0	BLANK
1.0	10
2.0	20
5.0	50
10.0	100
15.0	150
20.0	200

7.4.2 It is not imperative that all standards be distilled in the same manner as the samples. It is recommended that at least two standards (a high and a low) be distilled and compared to similar values on the curve to insure that the distillation technique is reliable. If distilled standards do not agree within ± 10% of the undistilled standards, the analyst should find the cause of the apparent error before proceeding.

7.4.3 Prepare a standard curve by plotting absorbance of standard vs. cyanide concentrations.

7.4.4 To check the efficiency of the sample distillation, add an increment of cyanide from either the intermediate standard (5.6) or the working standard (5.7) to 500 ml of sample in insure a level of 20 µg/l. Proceed with the analysis as in Procedure (7.2.1)

7.5 Standard curve for samples with sulfide

7.5.1 It is imperative that all standards be distilled in the same manner as the samples. Standards distilled by this method will give a linear curve, but as the concentration increases, the recovery decreases. It is recommended that at least 3 standards be distilled.

7.5.2 Prepare a standard curve by plotting absorbance of standards vs. cyanide concentrations.

7.6 Calculation: If the colormetric procedure is used, calculate the cyanide, in µg/l, in the original sample as follows:

$$CN,\ \mu g/l = \frac{A \times 1{,}000}{B} \times \frac{50}{C}$$

9413218.0633

where:

A = µg CN read from standard curve
B = ml of original sample for distillation
C = ml taken for colorimetric analysis

7.7 Automated colorimetric determination

7.7.1 Set up the manifold as shown in Figure 3 in a hood or a well ventilated area.

7.7.2 Allow colorimeter and recorder to warm up for 30 minutes. Run a baseline with all reagents, feeding distilled water through the sample line.

7.7.3 Place appropriate standards in the sampler in order of decreasing concentration. Complete loading of sampler tray with unknown samples.

7.7.4 When the baseline becomes steady, begin the analyses.

7.8 Calculation: Prepare standard curve by plotting peak heights of standards against concentration values. Compute concentrations of samples by comparing sample peak heights with standards.

8.0 Quality Control

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occuring.

8.3 Analyze check standards after approximately every 15 samples.

8.4 Run one duplicate sample for every 10 samples. A duplicate sample is a sample brought through the whole sample preparation process.

8.5 Spiked samples or standard referencee materials shall be periodically employed to ensure that correct prcedures are being followed and that all equipment is operating properly.

8.6 The method of standard additions shall be used for the analysis of all samples that suffer from matrix interferences.

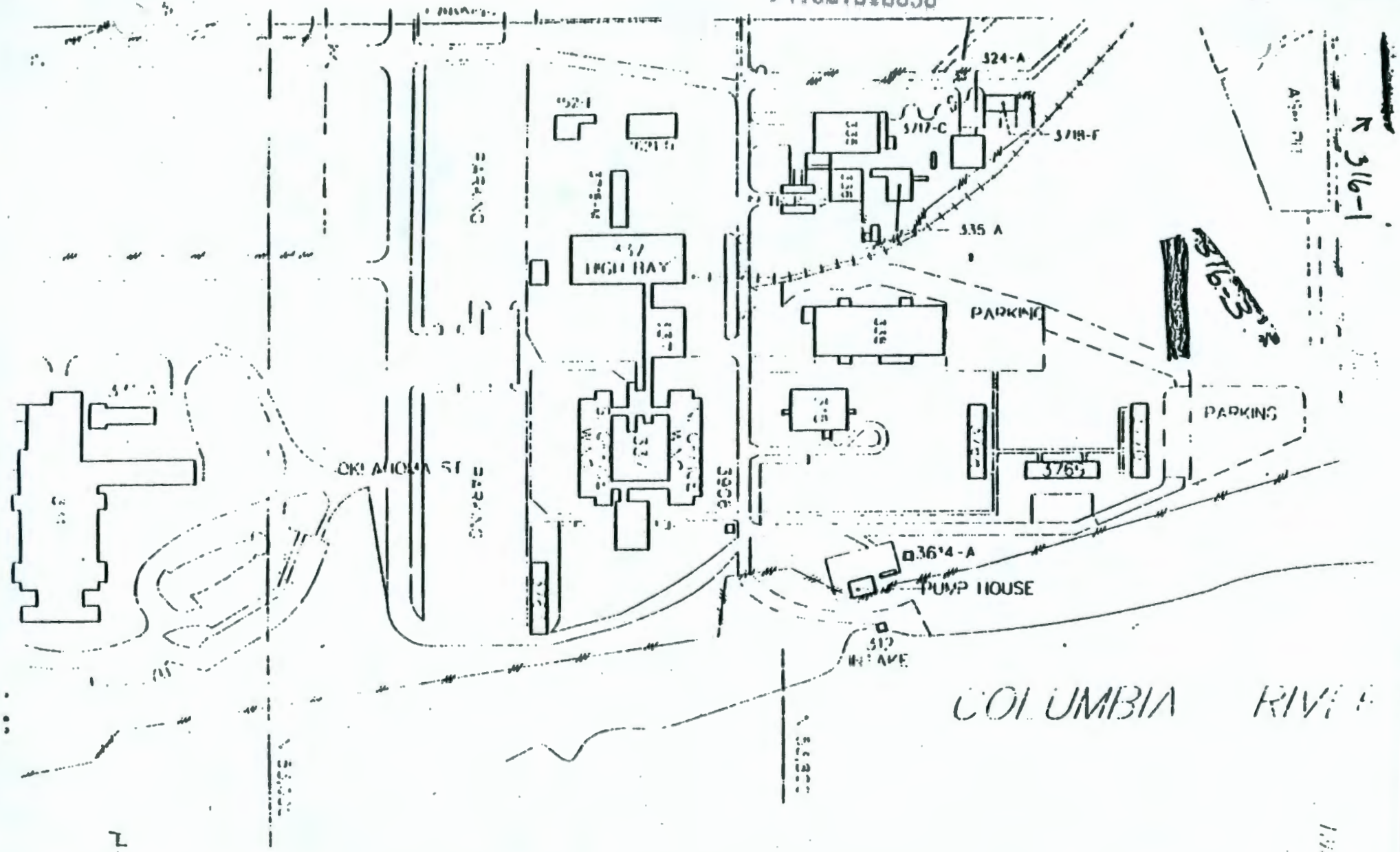
9413218.0634

REFERENCE 28

Drawing H-3-53734 (Showing 300 Area River Intake)

9413218.0635

9413218.0636



Ref. 28.1

REFERENCE 29

Memo to file from WS Weygandt concerning Personal Communication with RB Hall Regarding the 312 River Water Intake for 300 Area, August 13, 1987

9412181.1669

Battelle
Pacific Northwest Laboratories

Project Number _____

Internal Distribution

File/LB

Date August 13, 1987

To File

From W. S. Weygandt WSW

Subject 312 Water Intake

A telephone conversation with R. B. Hall of WHC revealed that the 300 Area gets all of its water from the Columbia River through the 312 intake. The 300 Area is connected to the Richland city water supply, but this is only used during emergencies.

WSW:cs

9413218.0638

Ref. 29.1

REFERENCE 30

Database Printouts of Surface Water Sample Points

9413218.0639

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

21 DEC 82 to 15 MAR 83

WATER RIVER WATER CUMULATIVE UNFILTERED

Samp #: 1265 PRIEST RAPIDS-RIVER

208/LO H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)		Comments
21 DEC 82	23 NOV 82	1.68E+02 +/-	1.40E+01	
18 JAN 83	21 DEC 82	1.20E+02 +/-	1.36E+01	BKG
15 FEB 83	18 JAN 83	1.35E+02 +/-	1.47E+01	
15 MAR 83	15 FEB 83	1.28E+02 +/-	1.41E+01	BKG

Fraction of Results>DL: 4/ 4 Mean: 1.38E+02
Minimum: 1.20E+02 (18 JAN 83) Standard Error of Mean: 2.44E+01
Maximum: 1.68E+02 (21 DEC 82) Standard Deviation: 4.87E+01
Median: 1.28E+02

9413218.0640

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

18 JAN 83 to 20 DEC 83

WATER RIVER WATER CUMULATIVE UNFILTERED

Samp #: 1000 RICHLAND PUMP HOUSE

208/LO H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
18 JAN 83	05 JAN 83	9.07E+01 +/- 1.34E+01	(6)
15 FEB 83	18 JAN 83	1.18E+02 +/- 1.36E+01	
15 MAR 83	15 FEB 83	1.34E+02 +/- 1.40E+01	
12 APR 83	22 MAR 83	1.94E+02 +/- 1.53E+01	
10 MAY 83	12 APR 83	1.49E+02 +/- 2.06E+01	
07 JUN 83	10 MAY 83	1.63E+02 +/- 2.09E+01	
05 JUL 83	07 JUN 83	1.09E+02 +/- 1.74E+01	
~~02 AUG 83~~	~~05 JUL 83~~	~~2.36E+02 +/- 2.07E+01~~	DG
30 AUG 83	02 AUG 83	1.51E+02 +/- 1.49E+01	
27 SEP 83	30 AUG 83	1.55E+02 +/- 1.44E+01	
25 OCT 83	27 SEP 83	1.33E+02 +/- 1.45E+01	
~~22 NOV 83~~	~~25 OCT 83~~	~~3.93E+01 +/- 1.22E+01~~	~~DG~~
20 DEC 83	22 NOV 83	7.81E+01 +/- 1.27E+01	

Fraction of Results>DL: 13/ 13 Mean: 1.35E+02
Minimum: 3.93E+01 (22 NOV 83) Standard Error of Mean: 2.84E+01
Maximum: 2.36E+02 (02 AUG 83) Standard Deviation: 1.02E+02
Median: 1.34E+02

9413218.0641

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

28 JAN 86 to 30 DEC 86

WATER RIVER WATER CUMULATIVE UNFILTERED

Samp #: 1265 PRIEST RAPIDS-RIVER

208/LO H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)		Comments
28 JAN 86	31 DEC 85	1.02E+02 +/-	1.06E+01	
25 FEB 86	28 JAN 86	1.30E+02 +/-	1.11E+01	
~~01 APR 86~~	~~25 FEB 86~~	~~1.05E+02 +/-~~	~~1.03E+01~~	~~BKG~~
29 APR 86	01 APR 86	1.19E+02 +/-	1.10E+01	
03 JUN 86	29 APR 86	9.87E+01 +/-	1.03E+01	
01 JUL 86	03 JUN 86	6.12E+01 +/-	7.07E+00	BKG
~~29 JUL 86~~	~~01 JUL 86~~	~~6.12E+01 +/-~~	~~7.06E+00~~	
02 SEP 86	29 JUL 86	1.06E+02 +/-	8.19E+00	
30 SEP 86	02 SEP 86	8.98E+01 +/-	7.46E+00	
28 OCT 86	30 SEP 86	1.16E+02 +/-	9.04E+00	
02 DEC 86	28 OCT 86	1.04E+02 +/-	8.29E+00	
30 DEC 86	02 DEC 86	8.83E+01 +/-	7.52E+00	

Fraction of Results>DL: 12/ 12 Mean: 9.84E+01
Minimum: 6.12E+01 (01 JUL 86) Standard Error of Mean: 1.24E+01
Maximum: 1.30E+02 (25 FEB 86) Standard Deviation: 4.29E+01
Median: 1.02E+02

9413218.0642

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

28 JAN 86 to 30 DEC 86

WATER RIVER WATER CUMULATIVE UNFILTERED

Samp #: 1000 RICHLAND PUMP HOUSE

208/LO H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)		Comments
28 JAN 86	31 DEC 85	2.09E+02 +/-	1.27E+01	
25 FEB 86	28 JAN 86	2.06E+02 +/-	1.30E+01 DG	(1)
01 APR 86	25 FEB 86	1.10E+02 +/-	1.05E+01	
29 APR 86	01 APR 86	1.28E+02 +/-	1.08E+01	
03 JUN 86	29 APR 86	1.25E+02 +/-	1.09E+01	
01 JUL 86	03 JUN 86	1.38E+02 +/-	8.37E+00	
29 JUL 86	01 JUL 86	1.53E+02 +/-	9.17E+00	
02 SEP 86	29 JUL 86	1.59E+02 +/-	8.29E+00	
30 SEP 86	02 SEP 86	1.54E+02 +/-	8.23E+00	
28 OCT 86	30 SEP 86	1.48E+02 +/-	8.20E+00	
02 DEC 86	28 OCT 86	1.34E+02 +/-	8.48E+00	
30 DEC 86	02 DEC 86	1.26E+02 +/-	8.09E+00	

Fraction of Results>DL: 12/ 12 Mean: 1.49E+02
Minimum: 1.10E+02 (01 APR 86) Standard Error of Mean: 1.80E+01
Maximum: 2.09E+02 (28 JAN 86) Standard Deviation: 6.23E+01
Median: 1.38E+02

9413218.0643

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

21 DEC 82 to 10 MAY 83

WATER RIVER WATER CONT.-RESIN

Samp #: 6394 PRIEST RAPIDS-RIVER

081/I 129

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
21 DEC 82	23 NOV 82	5.20E-06 +/- 8.32E-07	BKG (5)
15 FEB 83	21 DEC 82	2.80E-05 +/- 2.24E-05	
10 MAY 83	15 FEB 83	3.79E-05 +/- 4.09E-06	

Fraction of Results>DL: . 3/ 3 Mean: 2.37E-05
Minimum: 5.20E-06 (21 DEC 82) Standard Error of Mean: 2.36E-05
Maximum: 3.79E-05 (10 MAY 83) Standard Deviation: 4.08E-05
Median: 2.80E-05

9413218.0644

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

15 FEB 83 to 25 OCT 83

WATER RIVER WATER CONT.-RESIN

Samp #: 6384 300 AREA-RIVER

081/I 129

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
15 FEB 83	21 DEC 82	6.80E-05 +/- 4.08E-06	
10 MAY 83	15 FEB 83	3.91E-05 +/- 4.14E-06	
29 JUL 83	10 MAY 83	7.47E-05 +/- 7.62E-06	
25 OCT 83	29 JUL 83	1.20E-04 +/- 1.22E-05	DG

Fraction of Results>DL: 4/ 4 Mean: 7.54E-05
Minimum: 3.91E-05 (10 MAY 83) Standard Error of Mean: 3.94E-05
Maximum: 1.20E-04 (25 OCT 83) Standard Deviation: 7.87E-05
Median: 6.80E-05

9413218.0645

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

25 MAR 86 to 30 DEC 86

WATER RIVER WATER CONT.-RESIN

Samp #: 6394 PRIEST RAPIDS-RIVER

081/I 129

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
25 MAR 86	31 DEC 85	8.10E-06 +/- 8.91E-07	
01 JUL 86	25 MAR 86	8.20E-06 +/- 7.87E-07	
07 OCT 86	01 JUL 86	1.04E-05 +/- 1.29E-06	
30 DEC 86	07 OCT 86	7.60E-06 +/- 9.42E-07	BKG

Fraction of Results>DL: 4/ 4 Mean: 8.58E-06
Minimum: 7.60E-06 (30 DEC 86) Standard Error of Mean: 1.45E-06
Maximum: 1.04E-05 (07 OCT 86) Standard Deviation: 2.90E-06
Median: 8.10E-06

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

25 MAR 86 to 30 DEC 86

WATER RIVER WATER CONT.-RESIN

Samp #: 6384 300 AREA-RIVER

081/I 129

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
25 MAR 86	31 DEC 85	7.93E-05 +/- 7.30E-06	
01 JUL 86	25 MAR 86	8.98E-05 +/- 8.08E-06	
07 OCT 86	01 JUL 86	1.61E-04 +/- 1.45E-05	DG
30 DEC 86	07 OCT 86	7.87E-05 +/- 7.24E-06	

Fraction of Results>DL: 4/ 4 Mean: 1.02E-04
Minimum: 7.87E-05 (30 DEC 86) Standard Error of Mean: 4.03E-05
Maximum: 1.61E-04 (07 OCT 86) Standard Deviation: 8.06E-05
Median: 7.93E-05

9413218.0648

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REI

09 JAN 82 to 28 JUL 87

WATER RIVER WATER CUMULATIVE UNFILTERED
Bemp #1 1265 PRIEST RAPIDS-RIVER

208/LD H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)			Comments
09 JAN 82	02 JAN 81	1.59E+02	+/-	2.00E+01	
22 JAN 82	15 JAN 82	2.41E+02	+/-	1.40E+01	
19 FEB 82	12 FEB 82	3.25E+02	+/-	1.80E+01	
02 MAR 82		1.55E+02	+/-	2.00E+01	
16 MAR 82		3.06E+02	+/-	2.00E+01	
30 MAR 82		3.04E+02	+/-	2.00E+01	
13 APR 82		8.90E+01	+/-	2.00E+01	
27 APR 82	20 APR 82	1.06E+02	+/-	2.00E+01	
11 MAY 82	27 APR 82	1.36E+02	+/-	1.40E+01	
18 MAY 82	11 MAY 82	7.10E+01	+/-	1.80E+01	
08 JUN 82	26 MAY 82	1.25E+02	+/-	1.40E+01	
06 JUL 82	29 JUN 82	1.17E+02	+/-	1.40E+01	
03 AUG 82	13 JUL 82	1.45E+02	+/-	1.40E+01	
31 AUG 82	23 AUG 82	8.60E+01	+/-	1.40E+01	
28 SEP 82	21 SEP 82	7.70E+01	+/-	1.50E+01	
26 OCT 82	28 SEP 82	1.28E+02	+/-	1.20E+01	
23 NOV 82	28 SEP 82	1.21E+02	+/-	1.20E+01	
21 DEC 82	23 NOV 82	1.68E+02	+/-	1.40E+01	
18 JAN 83	21 DEC 82	1.20E+02	+/-	1.36E+01	
15 FEB 83	18 JAN 83	1.35E+02	+/-	1.47E+01	
15 MAR 83	15 FEB 83	1.28E+02	+/-	1.41E+01	
12 APR 83	15 MAR 83	1.23E+02	+/-	1.53E+01	
10 MAY 83	12 APR 83	7.50E+01	+/-	1.58E+01	
07 JUN 83	10 MAY 83	1.20E+02	+/-	1.19E+01	
05 JUL 83	07 JUN 83	6.53E+01	+/-	1.26E+01	
02 AUG 83	05 JUL 83	2.02E+02	+/-	2.15E+01	
30 AUG 83	02 AUG 83	1.44E+02	+/-	2.09E+01	
27 SEP 83	30 AUG 83	7.54E+01	+/-	1.38E+01	
25 OCT 83	27 SEP 83	5.73E+01	+/-	1.36E+01	
22 NOV 83	25 OCT 83	3.95E+01	+/-	1.12E+01	BKG
20 DEC 83	22 NOV 83	5.88E+01	+/-	1.19E+01	
17 JAN 84	20 DEC 83	1.03E+02	+/-	1.10E+01	
14 FEB 84	17 JAN 84	1.11E+02	+/-	1.11E+01	
13 MAR 84	14 FEB 84	1.29E+02	+/-	1.23E+01	
10 APR 84	13 MAR 84	1.66E+02	+/-	9.40E+00	
08 MAY 84	10 APR 84	1.19E+02	+/-	1.07E+01	
05 JUN 84	08 MAY 84	1.37E+02	+/-	1.07E+01	
03 JUL 84	05 JUN 84	1.05E+02	+/-	8.80E+00	
31 JUL 84	03 JUL 84	1.32E+02	+/-	1.00E+01	
28 AUG 84	31 JUL 84	9.40E+01	+/-	9.40E+00	
25 SEP 84	24 AUG 84	1.19E+02	+/-	1.16E+01	
23 OCT 84	25 SEP 84	1.29E+02	+/-	1.22E+01	
20 NOV 84	23 OCT 84	1.13E+02	+/-	1.27E+01	

ENVIRONMENTAL SAMPLE ANALYSIS RESULT RE

09 JAN 82 to 28 JUL 87

Date Off	Date On	Result +/- 2 Sigma (PCI/L)			Comments
18 DEC 84	20 NOV 84	1.90E+02	+/-	1.37E+01	
29 JAN 85	02 JAN 85	1.55E+02	+/-	1.31E+01	(1)
26 FEB 85	29 JAN 85	1.48E+02	+/-	1.19E+01	
02 APR 85	26 FEB 85	1.05E+02	+/-	1.33E+01	
30 APR 85	02 APR 85	6.37E+01	+/-	1.12E+01	
28 MAY 85	30 APR 85	8.48E+01	+/-	1.20E+01	
02 JUL 85	28 MAY 85	8.75E+01	+/-	1.09E+01	
30 JUL 85	02 JUL 85	8.58E+01	+/-	1.09E+01	
03 SEP 85	30 JUL 85	8.88E+01	+/-	1.07E+01	
01 OCT 85	03 SEP 85	1.17E+02	+/-	1.13E+01	
29 OCT 85	01 OCT 85	1.29E+02	+/-	1.09E+01	
03 DEC 85	29 OCT 85	1.32E+02	+/-	1.20E+01	
31 DEC 85	03 DEC 85	1.43E+02	+/-	1.23E+01	
28 JAN 86	31 DEC 85	1.02E+02	+/-	1.06E+01	
25 FEB 86	28 JAN 86	1.30E+02	+/-	1.11E+01	
01 APR 86	25 FEB 86	1.05E+02	+/-	1.03E+01	
29 APR 86	01 APR 86	1.19E+02	+/-	1.10E+01	
03 JUN 86	29 APR 86	9.87E+01	+/-	1.03E+01	
01 JUL 86	03 JUN 86	6.12E+01	+/-	7.07E+00	
29 JUL 86	01 JUL 86	6.12E+01	+/-	7.06E+00	
02 SEP 86	29 JUL 86	1.06E+02	+/-	8.19E+00	
30 SEP 86	02 SEP 86	8.98E+01	+/-	7.46E+00	
28 OCT 86	30 SEP 86	1.16E+02	+/-	9.04E+00	
02 DEC 86	28 OCT 86	1.04E+02	+/-	8.29E+00	
30 DEC 86	02 DEC 86	8.83E+01	+/-	7.52E+00	
03 FEB 87	30 DEC 86	7.62E+01	+/-	9.19E+00	
03 MAR 87	03 FEB 87	6.76E+01	+/-	9.39E+00	
31 MAR 87	03 MAR 87	5.37E+01	+/-	8.83E+00	
28 APR 87	31 MAR 87	1.07E+02	+/-	5.80E+00	
02 JUN 87	28 APR 87	9.40E+01	+/-	6.04E+00	
30 JUN 87	02 JUN 87	7.13E+01	+/-	5.17E+00	
28 JUL 87	30 JUN 87	7.09E+01	+/-	5.26E+00	

Fraction of Results>DL: 75/ 75 Mean: 1.19E+02
Minimum: 3.95E+01 (22 NOV 83) Standard Error of Mean: 1.24E+01
Maximum: 3.25E+02 (19 FEB 82) Standard Deviation: 1.08E+02
Median: 1.13E+02

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REI

09 JAN 82 to 28 JUL 87

WATER
Samp #: 1000

RIVER WATER
RICHLAND PUMP HOUSE

CUMULATIVE

UNFILTERED

208/LO H 3

Date Off	Date On	Result +/- 2 Sigma (PCI/L)			Comments
09 JAN 82	02 JAN 82	2.06E+02	+/-	1.60E+01	
22 JAN 82	15 JAN 82	2.19E+02	+/-	2.00E+01	
05 FEB 82	29 JAN 82	3.57E+02	+/-	1.60E+01	
19 FEB 82	12 FEB 82	6.68E+02	+/-	2.20E+01	
02 MAR 82		2.80E+02	+/-	2.00E+01	
16 MAR 82		3.30E+02	+/-	2.00E+01	
30 MAR 82		2.86E+02	+/-	2.00E+01	
13 APR 82	30 MAR 82	1.78E+02	+/-	2.00E+01	
27 APR 82	20 APR 82	1.57E+02	+/-	2.00E+01	
12 MAY 82		1.34E+02	+/-	2.00E+01	
18 MAY 82	11 MAY 82	1.12E+02	+/-	2.00E+01	
08 JUN 82		1.53E+02	+/-	1.60E+01	
29 JUN 82	12 JUN 82	1.00E+02	+/-	1.40E+01	
03 AUG 82	13 JUL 82	1.54E+02	+/-	1.40E+01	
31 AUG 82	03 AUG 82	1.49E+02	+/-	1.40E+01	
21 SEP 82	31 AUG 82	1.20E+02	+/-	1.50E+01	
26 OCT 82	21 SEP 82	1.51E+02	+/-	1.40E+01	
23 NOV 82	26 OCT 82	2.17E+02	+/-	1.40E+01	
07 DEC 82	23 NOV 82	1.42E+02	+/-	1.40E+01	
18 JAN 83	05 JAN 83	9.07E+01	+/-	1.34E+01	(2)
15 FEB 83	18 JAN 83	1.18E+02	+/-	1.36E+01	
15 MAR 83	15 FEB 83	1.34E+02	+/-	1.40E+01	
12 APR 83	22 MAR 83	1.94E+02	+/-	1.53E+01	
10 MAY 83	12 APR 83	1.49E+02	+/-	2.06E+01	
07 JUN 83	10 MAY 83	1.63E+02	+/-	2.09E+01	
05 JUL 83	07 JUN 83	1.09E+02	+/-	1.74E+01	
02 AUG 83	05 JUL 83	2.36E+02	+/-	2.07E+01	DG
30 AUG 83	02 AUG 83	1.51E+02	+/-	1.49E+01	
27 SEP 83	30 AUG 83	1.55E+02	+/-	1.44E+01	
25 OCT 83	27 SEP 83	1.33E+02	+/-	1.45E+01	2.32 x B
22 NOV 83	25 OCT 83	3.93E+01	+/-	1.22E+01	
20 DEC 83	22 NOV 83	7.81E+01	+/-	1.27E+01	
14 FEB 84	17 JAN 84	1.37E+02	+/-	1.23E+01	
13 MAR 84	14 FEB 84	1.50E+02	+/-	1.25E+01	
10 APR 84	13 MAR 84	2.00E+02	+/-	1.05E+01	
08 MAY 84	10 APR 84	1.56E+02	+/-	1.08E+01	
05 JUN 84	08 MAY 84	1.79E+02	+/-	1.11E+01	
03 JUL 84	05 JUN 84	1.59E+02	+/-	8.30E+00	
31 JUL 84	03 JUL 84	1.34E+02	+/-	1.00E+01	
28 AUG 84	31 JUL 84	1.44E+02	+/-	9.90E+00	
25 SEP 84	28 AUG 84	2.70E+02	+/-	1.39E+01	
23 OCT 84	25 SEP 84	1.76E+02	+/-	1.39E+01	
20 NOV 84	23 OCT 84	1.32E+02	+/-	1.26E+01	
18 DEC 84	20 NOV 84	1.85E+02	+/-	1.28E+01	

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ENVIRONMENTAL SAMPLE ANALYSIS RESULT REF

09 JAN 82 to 28 JUL 87

Date Off	Date On	Result +/- 2 Sigma (PCI/L)			Comments
29 JAN 85	02 JAN 85	1.62E+02	+/-	1.36E+01	(3)
19 FEB 85	29 JAN 85	1.47E+02	+/-	1.16E+01	
02 APR 85	26 FEB 85	1.64E+02	+/-	1.43E+01	
30 APR 85	02 APR 85	1.80E+02	+/-	1.35E+01	2.83X Bkg
28 MAY 85	30 APR 85	9.42E+01	+/-	1.20E+01	
02 JUL 85	28 MAY 85	1.51E+02	+/-	1.24E+01	
30 JUL 85	02 JUL 85	1.72E+02	+/-	1.20E+01	
03 SEP 85	30 JUL 85	1.64E+02	+/-	1.21E+01	
01 OCT 85	03 SEP 85	9.98E+01	+/-	1.11E+01	
29 OCT 85	01 OCT 85	1.07E+02	+/-	1.03E+01	
03 DEC 85	29 OCT 85	1.67E+02	+/-	1.41E+01	
31 DEC 85	03 DEC 85	2.17E+02	+/-	1.33E+01	
28 JAN 86	31 DEC 85	2.09E+02	+/-	1.27E+01	
25 FEB 86	28 JAN 86	2.06E+02	+/-	1.30E+01	(4)
01 APR 86	25 FEB 86	1.10E+02	+/-	1.05E+01	
29 APR 86	01 APR 86	1.28E+02	+/-	1.08E+01	
03 JUN 86	29 APR 86	1.25E+02	+/-	1.09E+01	
01 JUL 86	03 JUN 86	1.38E+02	+/-	8.37E+00	
29 JUL 86	01 JUL 86	1.53E+02	+/-	9.17E+00	
02 SEP 86	29 JUL 86	1.59E+02	+/-	8.29E+00	
30 SEP 86	02 SEP 86	1.54E+02	+/-	8.23E+00	
28 OCT 86	30 SEP 86	1.48E+02	+/-	8.20E+00	
02 DEC 86	28 OCT 86	1.34E+02	+/-	8.48E+00	
30 DEC 86	02 DEC 86	1.26E+02	+/-	8.09E+00	
03 FEB 87	30 DEC 86	1.43E+02	+/-	1.13E+01	
03 MAR 87	03 FEB 87	1.29E+02	+/-	1.02E+01	
31 MAR 87	03 MAR 87	1.27E+02	+/-	9.97E+00	2.36X Bkg.
28 APR 87	31 MAR 87	1.26E+02	+/-	5.59E+00	
02 JUN 87	28 APR 87	6.78E+01	+/-	5.22E+00	
30 JUN 87	02 JUN 87	1.28E+02	+/-	6.08E+00	
28 JUL 87	30 JUN 87	1.31E+02	+/-	6.22E+00	

Fraction of Results>DL: 75/ 75 Mean: 1.65E+02
Minimum: 3.93E+01 (22 NOV 83) Standard Error of Mean: 1.85E+01
Maximum: 6.68E+02 (19 FEB 82) Standard Deviation: 1.60E+02
Median: 1.51E+02

Comments

(1) THE SAMPLE 12/18/84 - 12/26/84 WAS INADVERTANTLY OMI
FROM THE DECEMBER COMPOSITE.
(2) SAMPLES WERE NOT COLLECTED 12/28, 1/4, AND 1/18. TH
ONLY ENOUGH WATER TO RUN ALPHA, BETA, U, AND ENRICHE
THE COMPOSITE 12/28/82 - 1/18/83.
(3) SAMPLE TAKEN 12/18/84 - 12/26/84 WAS INADVERTANTLY O
FROM THE DECEMBER COMPOSITE.
(4) GRAB SAMPLE SUBSTITUTED.

REFERENCE 31

An Assessment of Aquifer Intercommunication in the B Pond - Gable Mountain Pond Area of the Hanford Site, RHO-RE-ST-12P

9413218.0653

RHO-RE-ST-12 P
Distribution Categories
UC-[illegible] and 70

An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site

Date Published March 1984

Michael J Graham
George V Last
Karl R. Fecht
Rockwell Hanford Operations

Prepared for the U.S. Department of Energy
under Contract DE-AC06-77RL01030

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
P.O. Box 800
Richland, Washington 99352

1.0 INTRODUCTION

In 1943, the Manhattan District of the U.S. Army Corps of Engineers chose an unpopulated semiarid region of the Pasco Basin in Washington State as the location for the Hanford Engineering Works. The site (Figure 1) was selected because of the need to isolate the first nuclear plants for national security reasons and to have a large area for isolating nuclear wastes from the public. Today, the Hanford Site is a U.S. Department of Energy (DOE) facility, and Rockwell Hanford Operations (Rockwell), a prime contractor to DOE, is responsible for nuclear waste management at Hanford.

Nuclear waste management at Hanford includes disposing of large volumes of liquid wastes to the ground (via ditches, ponds and underground cribs) and storing highly radioactive solutions in large underground steel lined reinforced concrete tanks. The waste management (disposal and storage) facilities are located near the chemical processing facilities in the Separations Area near the center of the Hanford Site. Normally, the radionuclide concentrations of the waste discharged to the ground average below maximum permissible concentration guidelines; however, occasional, nonroutine, releases of higher concentrations have occurred. As a result of these disposal practices, the unconfined aquifer underlying the Hanford Site has become contaminated (below applicable guidelines) and the water table has increased in elevation.

There is a series of confined aquifers in the interflow zones and interbeds between the dense basalt flows that underlie the sediments containing the unconfined aquifer. When postglacial flood waters and the ancestral Columbia River flowed between Gable Mountain and Gable Butte (Figure 1), portions of the basalt flows separating the unconfined and confined aquifers were eroded. Later the water table rose to levels exceeding the potentiometric surface of the upper confined aquifer, i.e., the Rattlesnake Ridge aquifer. This action created the driving force for the transport of contamination downward to the Rattlesnake Ridge aquifer through these areas of erosion, a phenomenon known as aquifer intercommunication.

9413218.0655

REFERENCE 32

Memo to file from WS Weygandt regarding Personal Conversation with Frank Trent concerning TUC Irrigation Intake, August 12, 1987; including note to file from RD Stenner on October 29, 1987, concerning Crops Grown on the TUC 160 Acres

File Note

Date: 10/29/87

From: RD Stenner RD Stenner

Subject: Crops Grown on the TUC 160 Acres

The 160 Acres that are irrigated by the Tri-Cities University Center are used to grow alfalfa which is used as cattle feed.

9 1 02 18 1987

Battelle
Pacific Northwest Laboratories

INSERT WWB-2-2

Project Number

Internal Distribution

File/LB

Date August 12, 1987

To File

From W. S. Weygandt

Subject Tri-Cities University Center Water Intake

A telephone conversation with Frank Trent, the ground's manager at TUC, revealed that TUC draws water from the Columbia River to irrigate approximately 160 acres. The intake is located directly behind the Center, which is located on Sprout Road.

WSW:cs

9413218.0658

REFERENCE 33

Memo to file regarding recreational use of the Columbia River from DR Sherwood, August 26, 1987

9413218.0659

Battelle
Pacific Northwest Laboratories

Project Number _____

Internal Distribution

KH Cramer
RD Stenner
File/LB

Date August 26, 1987

To IWSS Files

From DR Sherwood DRS

Subject Recreational Use of Hanford Reach

The Hanford Reach of the Columbia River has many recreational uses. Sportsman's access for fishing and waterfowl, big game, and upland bird hunting is provided at several locations. Access points to the Columbia River along the Hanford Reach are located at the old White Bluffs Ferry landing, the Ringold Hatchery, and Leslie Grove Park in Richland. I have fished for steelhead and salmon along the Hanford Reach since 1980.

DRS/mgs

9413218.0660

REFERENCE 34

Battelle Farm Operations Drawing, RC-486 and RC-1147

9413218.0661

File Note

Date: 10/29/87

From: RD Stenner RD Stenner

Subject: Telephone Conversation with Dale Schielke (PNL) Regarding Battelle Farm Operations Acerage

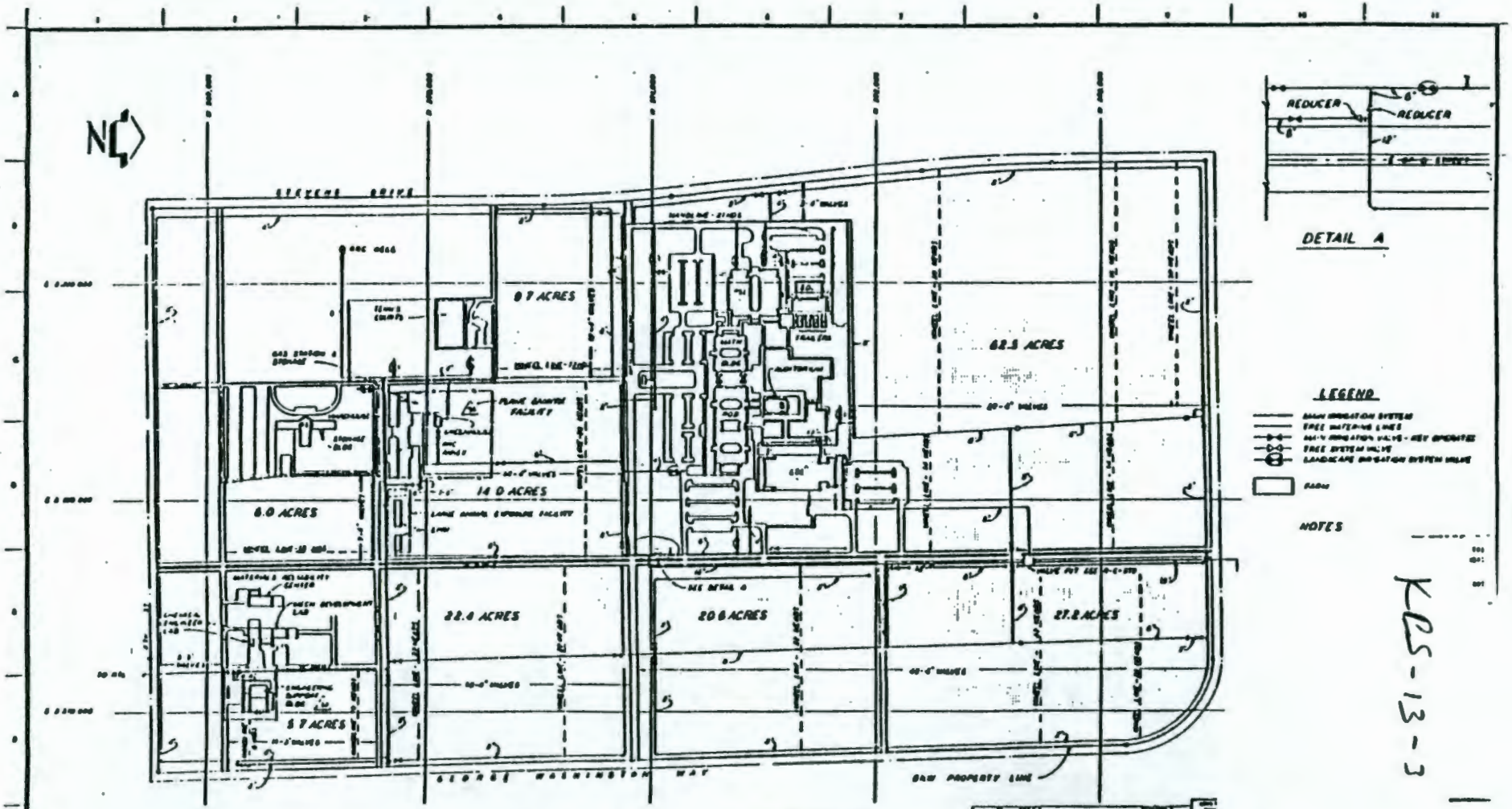
The Battele Farm Operations cover a total of 168.1 acres which are used for growing forage (food crops). The individual plot acrages are as follows:

62.5 acres
27.2 acres
20.6 acres
22.4 acres
5.7 acres
6.0 acres
14.0 acres
9.7 acres

168.1 acres total

9412260062

9413218.0663

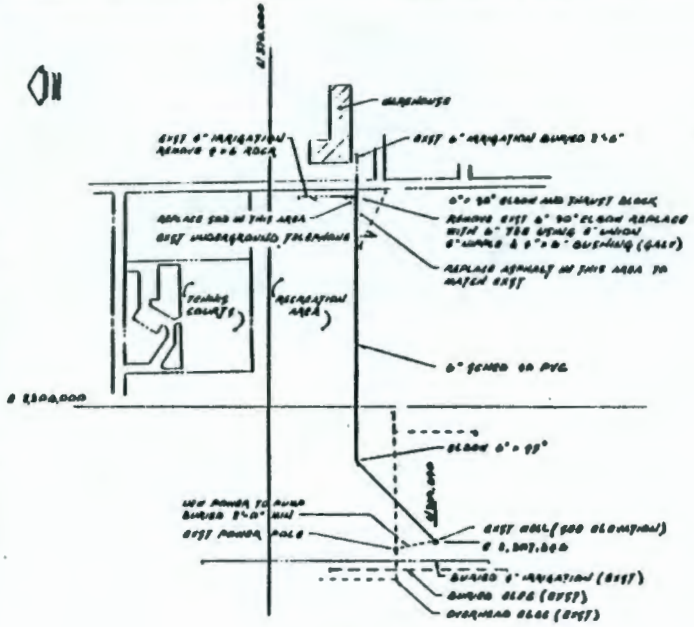


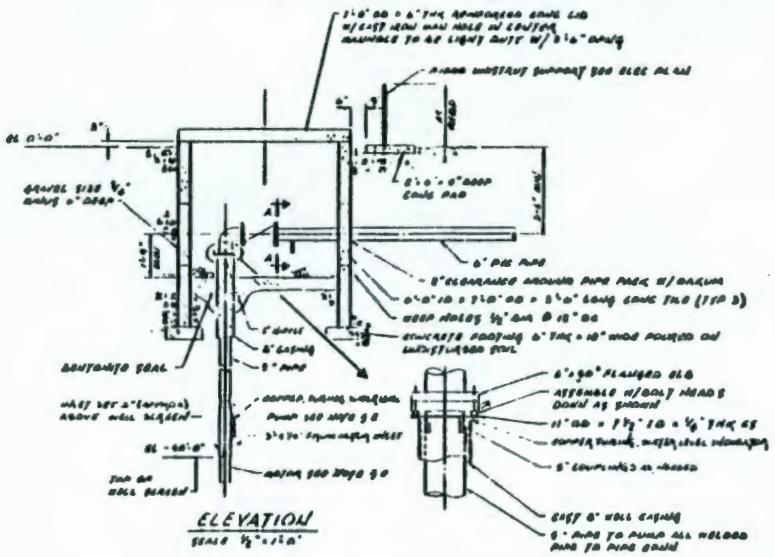
KCS-13-3

FARM OPERATION

R-C-486

9413218.0664



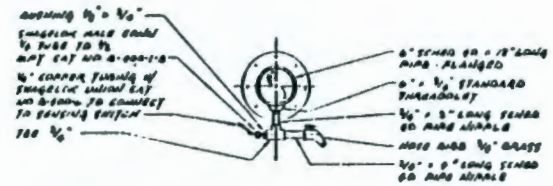


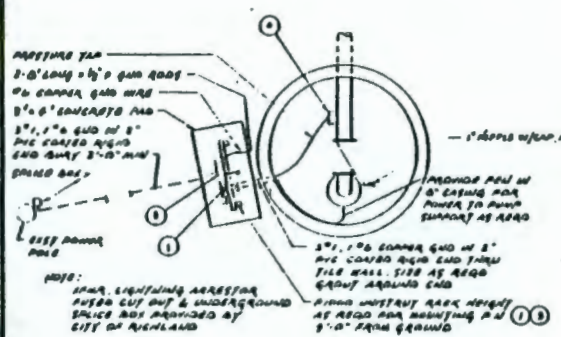
GENERAL NOTES

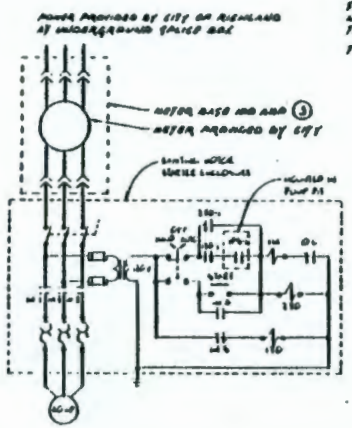
1. ALL WORK TO CONFORM WITH THE MINIMUM LOAD OF THE CITY OF OSCEOLA.
2. ~~INSTALLATION - SEWER PIPE SHALL CONFORM TO ASTM SPECIFICATIONS AND SHALL BE INSTALLED TO MANUFACTURER'S INSTALLATION GUIDE. SHALL BE INSTALLED WITH MINIMUM DEFLECTION.~~
3. ALL EQUIPMENT AND MATERIALS TO BE AS SPECIFIED OR APPROVED EQUAL.
4. AS-BUILT CONSTRUCTION SHALL BE RECORDED ON DRAWINGS AT DEPARTURES FROM PLAN.
5. PIPING
   A. PVC - PVC SEWER PIPE
   B. FITTINGS - AS SHOWN
   C. GATE VALVE - 1000 PSI BRONZE MOUNTED GATE MINIMUM SIZE 6" FLANGED
   D. CHECK VALVE - 1000 PSI BRONZE MOUNTED SWING. CHECK MINIMUM SIZE 2" FLANGED
   E. PUMP - PUMP AND MOTOR CONFIGURATION WITH RPM NOT TO EXCEED 1800 WITH MINIMUM AS MANY POLES. PUMP MUST HAVE NO MINIMUM 1000 GPM AT 0.5 HEAD 5 3/4" OR MIN. 1 1/2 - MOTOR CONFIGURATION TO INCLUDE SHOP DRAWINGS FOR APPROVAL
   F. GASKETS - ALL FLANGED JOINTS SHALL HAVE NEOPRENE GASKETS
6. BACKFILL - FILL CONCRETE - 0" CLEARANCE AT ANY GASKETS
7. BACKFILL BELOW - CONCRETE BACKFILL SHALL BE PROVIDED AND CONTINUED ON THE CONSTRUCTION PLAN AND CONTINUED TO THE UNDERSIDE BELOW AS REQUIRED AS RECOMMENDED WITH PIPE MANUFACTURER'S RECOMMENDATION

ELECTRICAL NOTES

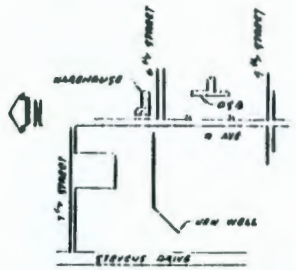
1. ALL ELECTRICAL WORK TO CONFORM TO THE 1981 NATIONAL ELECTRICAL CODE
2. WIRE SHALL BE COPPER SIZE AND MINIMUM WITH 600 VOLT INSULATION AND MEET SPECIFICATIONS. FOUND DETERMINED CONSIDERING INDUCTIVE POWERED INSULATION, RATED AT 90°C DRY WET LOCATION, 30PC 1000
3. CONDUITS AND FITTINGS SHALL BE MADE FROM PVC SCHEDULE 80 SCH
4. CONDUIT SHALL BE SUPPORTED AT MAXIMUM REPEAT OF 5 FEET
5. CONNECTION OF ELECTRICAL SERVICE FOR PUMP SHALL BE COORDINATED WITH THE CITY OF OSCEOLA
6. DISCONNECT AND CONDENSATION MOTOR STARTER SHALL BE LABELED "CONDENSATION WELL PUMP".







QTY	PO	DESCRIPTION
1	1	COMBINATION MAGNETIC MOTOR STARTER, RATED 600 VOLTS, 3 POLE WITH SIZE 3 STARTER, WITH 3 OVERLOAD RELAYS, AND 3 POLE DISCONNECT SWITCH IN A NEMA 12 ENCLOSURE
1	2	SAFETY SWITCH, HEAVY DUTY, CLASS AND WITH, 600 VOLT, 3 POLE, 3 FUSE, IN A NEMA 12 ENCLOSURE
1	3	METER BASE, 4 TERMINAL, 100 AMP, 600 VOLT, IN NEMA COVER AND CIRCUIT ENCLOSURE
1	4	ADJUSTABLE DIFFERENTIAL PRESSURE SWITCH - CLASS 4 ENCLOSURE 0-500 P.S.I. ADJUSTABLE OPERATING RANGE WITH SPLIT ADJUSTMENTS TO SET HIGH AND LOW OPERATING POINTS. ELECTRICAL CONNECT • OPEN ON HIGH RESPONSE, CLOSES ON LOW RESPONSE DP-SP. 600 VOLTS - MERCURY MODEL 600-50-0, RANGE NO. 6.



DRAWER 88

JOP # 1130

R-C-1001	0	IRRIGATION PLAN
R-C-1002	0	IRRIGATION PLAN

REVISED PER FIELD CHECK

AS BUILT

ADDED 6" PVC 90° ELBOW

SHOWN NOT REQD

NONE

GROUNDWATER WELL

RAC SITE PLAN

R-C-1147 | 1 | 1

REFERENCE 35

Data Compilation: Iodine-129 in Hanford Groundwater, WHC-EP-0037

9413218.0665

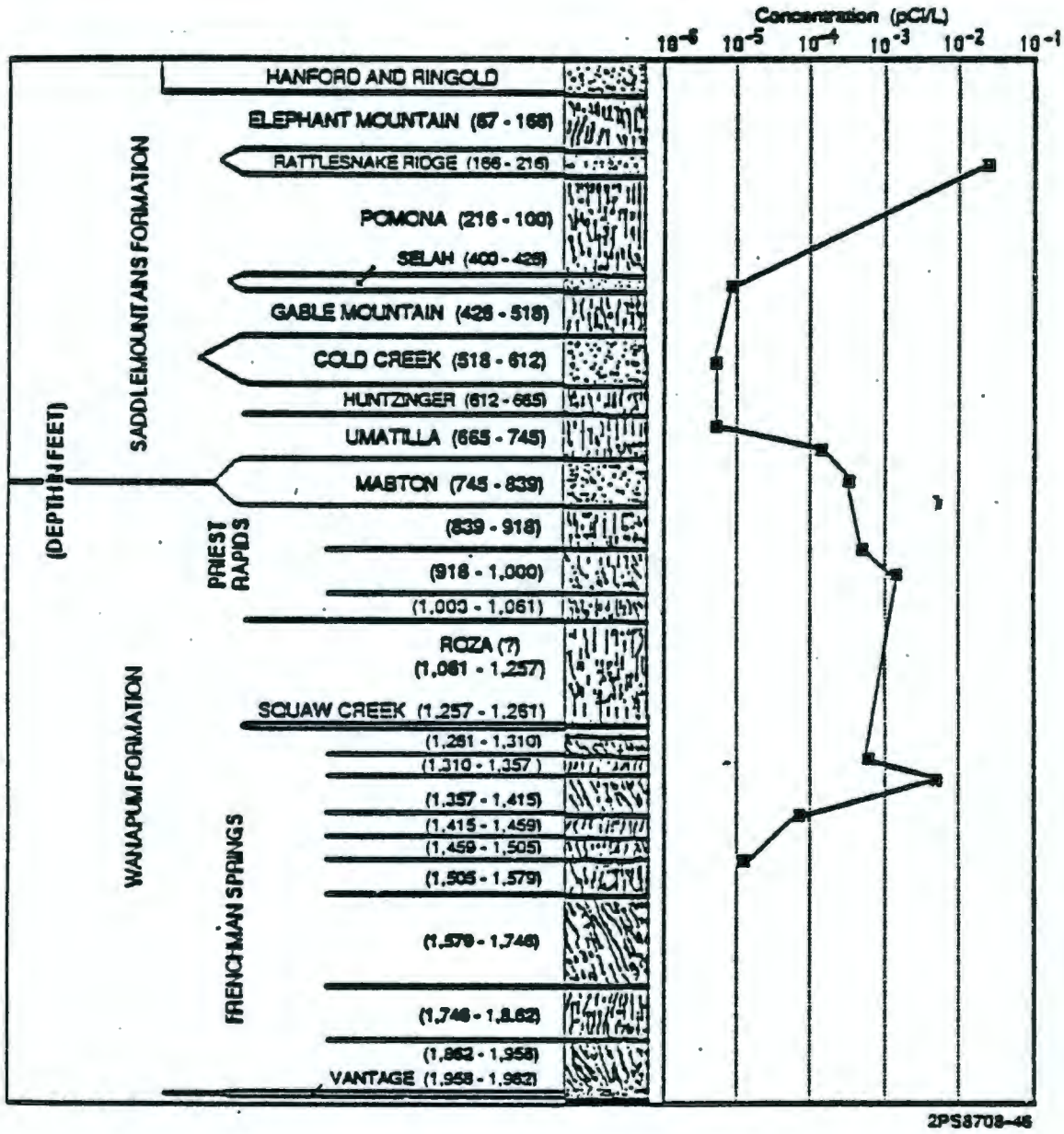


Figure 5-2. Depth Distribution of Iodine-129 in Relation to Relation to DB-15 Stratigraphy.

9413218.0667

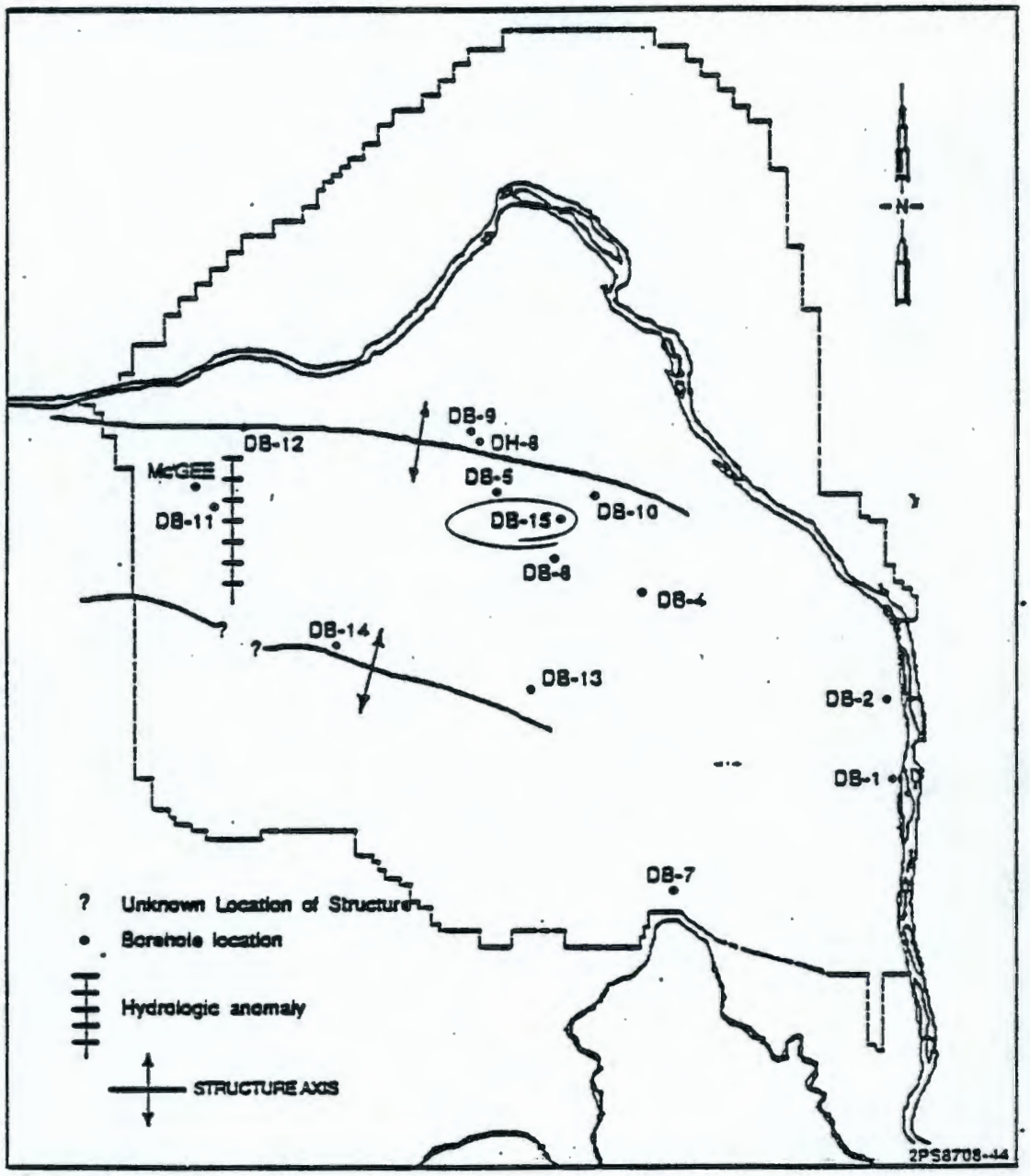


Figure 3-4. Location of "DB" Series Wells.

9413218.0668

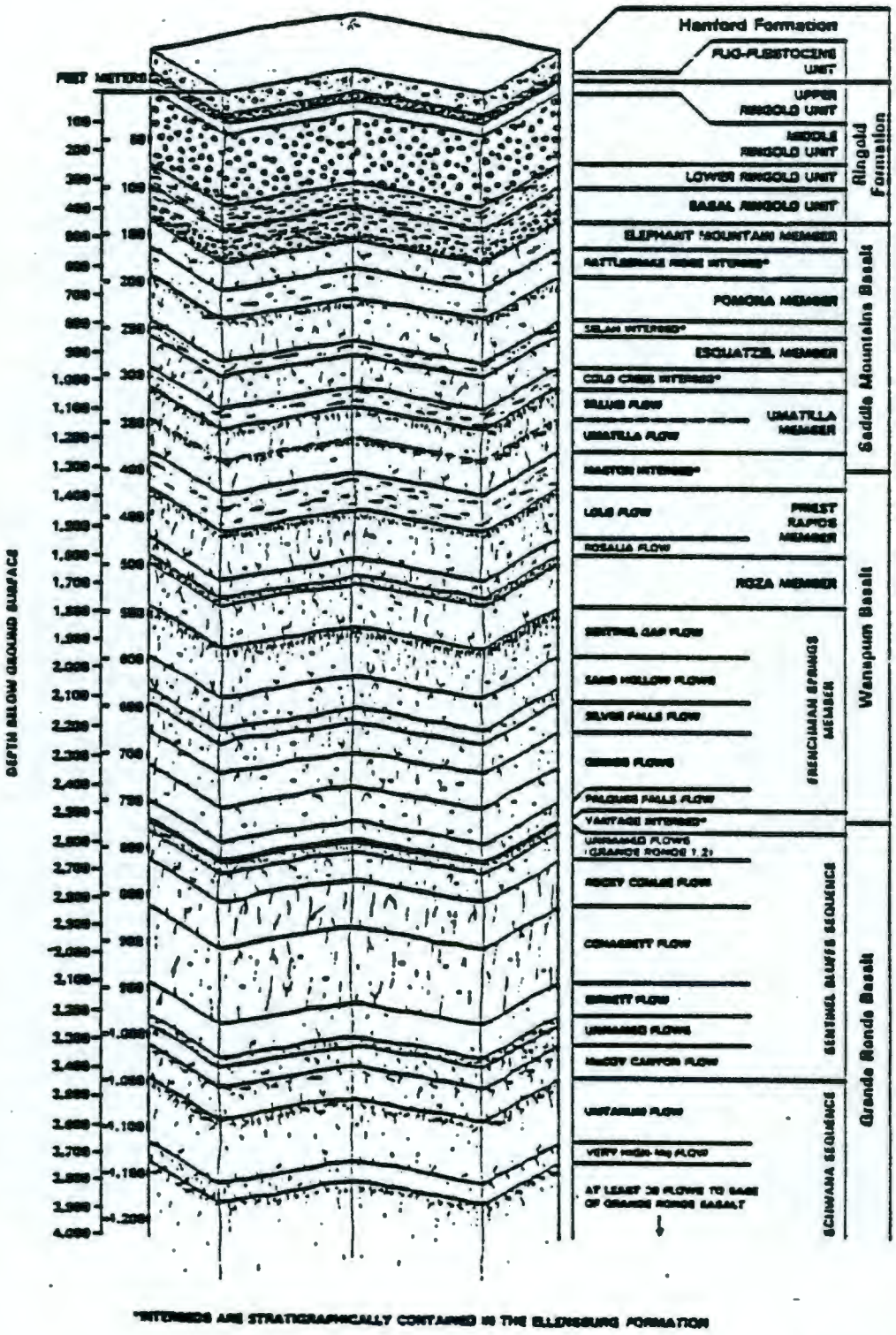


Figure 3-2. Generalized Stratigraphy of the Hanford Site.

REFERENCE 36

Letter From RD Stenner to DM Bennett Regarding Ground Water Contaminant Plumes in the 100 Area, 200 Area and 300 Area, October 14, 1987

Note: Only the 200 Area attachments are included in this package

9413218.0669

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

October 14, 1987

Mr. D. M. Bennett
U.S. Environmental Protection Agency
Region X
Superfund Program
1200 6th Avenue
Seattle, WA 98101

Dear Dave:

Enclosed are the three descriptions of the 100 Area, 200 Area and 300 Area ground water contaminant plumes we discussed on the telephone yesterday. I have included some attached figures and maps to help show the independency of the detected ground water contamination in each of the three aggregate areas.

If there are any questions regarding the descriptions, please contact me at 509-375-2916.

Sincerely,

Bob

R.D. Stenner, Sr. Research Engr.
Earth and Environmental Sciences Center
GEOSCIENCES DEPARTMENT

RDS:th

200 Area Ground Water Contamination

The ground water tritium plume from the 200 Area is a discrete plume determined as the result of several years of ground water monitoring. The attached map shows the extent of the defined plume. As can be seen from the attached map there is considerable distance between the defined aggregate areas and their associated plumes. The seeps discussed as entry points for the contaminated plume to enter the surface water are within the defined plume and no upstream (upstream from the identified seeps) samples of the surface water indicate any influence on the tritium concentrations at the identified seeps. The 200 Area tritium plume enters the river between river mile 27 and river mile 33 as described in the document PNL-5289 (Reference 3).

9413218.0671

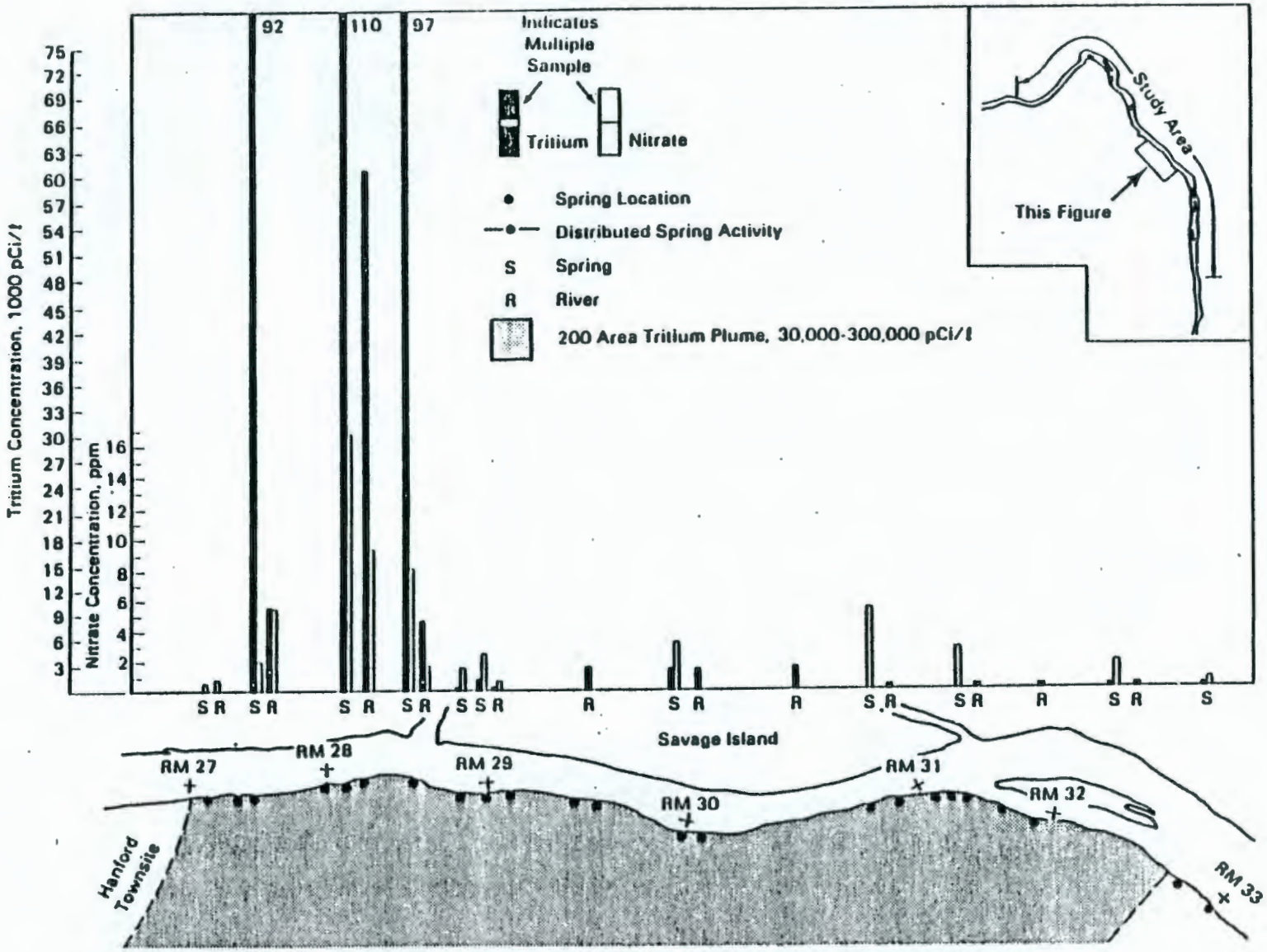


FIGURE 5. Locations and Analytical Results for Spring and River Samples - River Mile 27 through River Mile 33

9413218.0673

REFERENCE 37

Letter From RD Stenner To DM Bennett Regarding Liquid Waste Sites and Burning Pits, October 26, 1987

94132B.067A

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

October 26, 1987

D.M. Bennett
EPA/NPL Coordinator
EPA Superfund Program
U.S. Environmental Protection Agency Region X
1200 Sixth Ave.
Seattle, Washington 98101

9413218.0675

Dear Dave:

Per your telephone request, enclosed are the statements on liquid waste sites and burning pits. It is our understanding that you will incorporate them as references in the appropriate sections of the NPL packages and provide us with a finalized copy of the packages following completion of the MITRE Corp. review.

If there are any questions regarding these statements, please don't hesitate to contact me at 509-375-2916.

Sincerely,

Bob

R.D. Stenner, Senior Research Engineer
Environmental Pathways and Assessment Section
Geosciences Department
Earth and Environmental Sciences Center

RDS:dar

ENCLOSURE

bcc: KH Cramer
MS Hanson
DA Lamar
RM Mangin - DOE/RL
TJ McLaughlin
RG Schreckhise
WB Schulze - DOE/RL
DR Sherwood

100, 200, 300 Area Statement Regarding Liquid Wastes

The general operating procedures for liquid waste sites in the 100, 200 and 300 Areas were such that the waste constituents listed for each site generally entered the process lines and were mixed with each other prior to being disposed of at the site. This process mixing of these waste constituents occurred over the period of site operation.

9413218.0676

Burning Pit Statement

Due to the time period for which the burning pits operated, the nonhazardous combustible waste materials (i.e., paper products, cans, etc.) would have been mixed (i.e., mixed together in the garbage truck or waste container) with the hazardous waste materials (i.e., paints, solvents, etc.) prior to the waste mixture being disposed of at the site.

9413218.0677

REFERENCE 38

File note from RD Stenner to file on December 2, 1987

regarding Landfill Operations

9413218.0678

Date: December 2, 1987

To: File

From: R. D. Stenner RD Stenner

Subject: Operational Assumption for Historical Solid Waste Landfills

In historically operated solid waste landfills where hazardous wastes were suspected the operation of the landfill did not involve any separation of hazardous wastes and nonhazardous wastes prior to disposal in the landfill.

Wastes in these landfills is primarily from Hanford Site maintenance/support activities which could involve hazardous materials originating from the 3000, 1100, 300, 200 or 100 Hanford operational areas.

9413218.0679

MEMORANDUM

DATE: 12/18/87

FROM: R.D. Stenner R.D. Stenner

RE: Addendum to December 2, 1987 Letter Regarding Historic Landfill Operations

The units associated with the December 2, 1987 letter on historic landfill operation assumptions are as follows:

Horn Rapids Landfill (300 Area)
618-10 (200 Area)
618-11 (200 Area)
213-J&K (200 Area)
Central Landfill (200 Area)

REFERENCE 39

Environmental Monitoring at Hanford for 1985

9413218.0681

PNL-5817
UC-41
UC-11

9413218.0682

Environmental Monitoring at Hanford for 1985

K. R. Price, Editor

May 1986

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

PNL-5817

SURFACE-WATER MONITORING

The Columbia River constituted the primary environmental exposure pathway to the public for radioactivity in liquid effluents. Radionuclides in the river have decreased significantly since the shutdown of the plutonium production reactors with single-pass cooling systems and the installation of improved liquid effluent control systems at the N Reactor. However, radionuclides associated with Hanford operations continued to be routinely identified in the river water during 1985.

In addition to the river, four onsite ponds were sampled periodically to determine radionuclide concentrations. These ponds were accessible to migratory water fowl as well as other animals residing on the Site. As a result, a potential biological pathway existed for the removal and dispersal of any contaminants that may have been present in the pond water and sediments.

9413218.0683

COLUMBIA RIVER

The Columbia River is used as a source of drinking water onsite as well as at communities downstream of the Hanford Site. As a result, the Environmental Protection Agency and the State of Washington drinking-water regulations are applicable (Appendix C). In addition, the river is also used extensively for crop irrigation and recreational activities such as fishing, hunting, boating, water skiing, and swimming. In view of this, the river water continued to be closely monitored for radionuclides of potential Hanford origin. Samples taken upstream and downstream of the Site are analyzed for selected radionuclides at frequencies commensurate with their half-lives and their importance as either verifiers of waste containment or indicators of potential environmental impacts. Radionuclides of primary significance in the river are ^{3}H, ^{60}Co, ^{89}Sr, ^{90}Sr, ^{131}I, ^{129}I, ^{137}Cs, $^{239,240}Pu$, and uranium (U).

Sample Collection and Analysis

Samples of Columbia River water were collected throughout 1985 at the upstream and downstream locations shown in Figure 23. The upstream sampler was located approximately mid-stream within Priest Rapids Dam and collected samples as water passed through the dam. Priest Rapids Dam is located approximately 5 miles upstream of the Hanford Site boundary. The downstream samples were collected at the 300 Area and City of Richland water-supply intakes. The 300 Area sampling location was near the southern boundary of the Site and collected water from the intake forebay along the shoreline. The Richland sampler, located about 2 miles downstream of the site boundary, collected water from a point approximately 30 feet into the river from the shoreline.

Two types of samplers were used in most instances: a cumulative system that collected a fixed volume of water at set intervals during each sample period and a specially designed system that continuously collected waterborne radionuclides from the river water on a series of filters and ion-exchange resins. Grab samples were used in a few special cases when routine equipment was inoperable.

The cumulative samplers consisted of a timer-activated solenoid valve that periodically diverted a continuously flowing substream of Columbia River water into a 10 ℓ container. This cycle repeated itself throughout the 1-week sample period such that approximately 30 mℓ of water were collected every 30 minutes. The 10-ℓ sample container was changed every week, and the sample was taken to the laboratory, where the water from a single location was composited over a 4-week period prior to analysis, resulting in a total sample size of approximately 40 ℓ. Tritium, ^{89}Sr, ^{90}Sr and uranium were the radionuclides of interest in the samples collected with the cumulative sampling system.

A special system was used to separate the radionuclides from river water prior to analysis. A large volume of water was required to allow the extremely small concentrations of certain radionuclides in the river water to be detected.

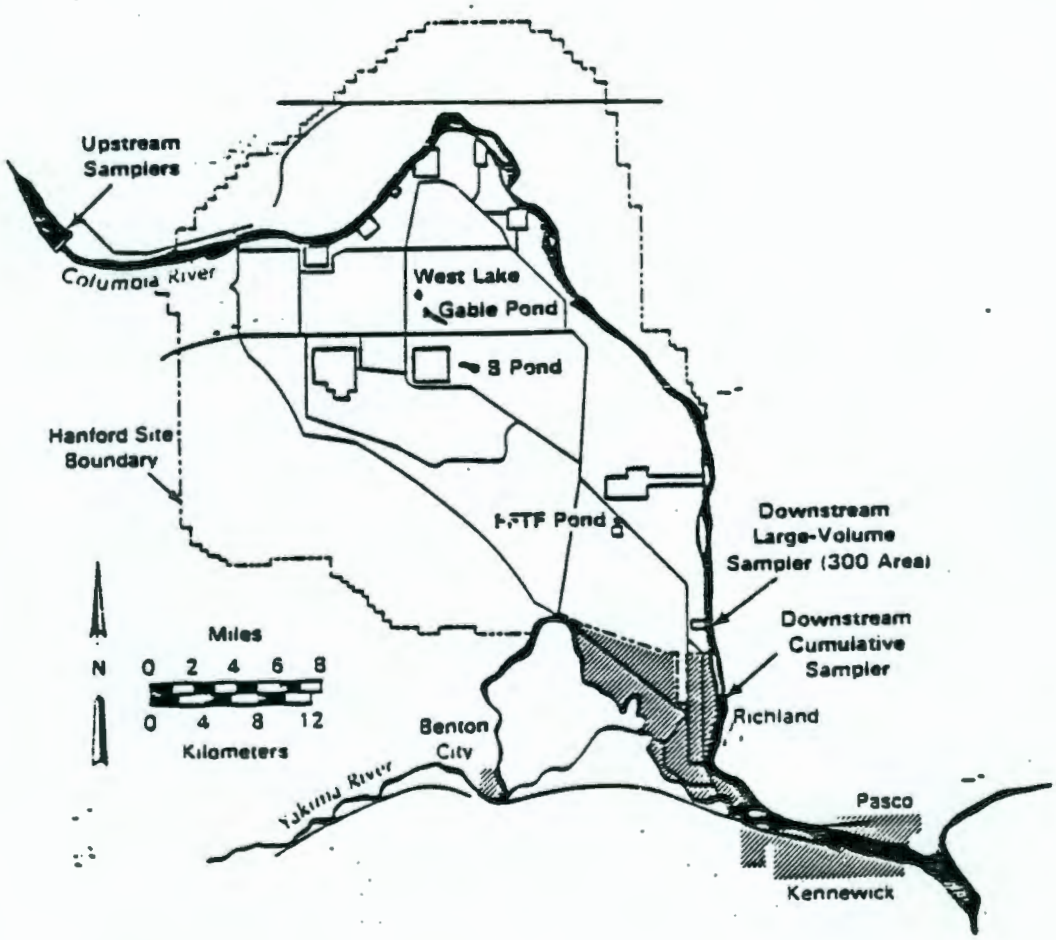


FIGURE 23. Columbia River Water Sampling and Onsite Pond Locations

River water flowed through the collection system at a rate of approximately 50 mℓ/min, resulting in a total volume of about 1000 ℓ sampled during each 2-week sample period. Suspended particulates greater than 0.45 μm in diameter were removed from the water on a series of filters, and soluble radionuclides, except tritium, were collected on a mixed-bed, ion-exchange resin column. The filters and ion-exchange resin were exchanged every 2 weeks and analyzed for gamma-emitting radionuclides. The filters and resin from each location were then composited separately for quarterly analyses of ^{129}I, ^{238}Pu, and $^{239,240}Pu$.

Results

The results of the analysis of Columbia River water samples collected during 1985 are summarized in Tables A.13 and A.14, Appendix A. Significant results are discussed and illustrated below, with comparisons to previous years' results provided as well. Radionuclides consistently observed in measurable quantities in river water during 1985 were ^{3}H, ^{90}Sr, U, ^{129}I, ^{137}Cs, and $^{239,240}Pu$. All of these are reportedly present in effluents from Hanford facilities and exist in worldwide fallout as well. In addition, ^{3}H and U occur naturally in the environment.

Annual average concentrations of tritium measured upstream and downstream of the Hanford

Site during 1985 were 110 pCi/ℓ and 150 pCi/ℓ, respectively. Figure 24 provides a comparison of monthly tritium concentrations observed in river water, showing that concentrations downstream were generally higher than those upstream during the year. Statistical tests indicated that the difference between the downstream and upstream concentrations was significant.[a] Sources of tritium entering the river were effluent releases from N Reactor and ground water entering the river along the Site (see "Effluents, Waste Disposal, and Unusual Occurrences" and "Ground-Water Monitoring"). The concentrations of tritium observed in the river during 1985 were similar to those observed during recent years and were comparable to measurements made on Columbia River water by State of Washington personnel (DSHS 1985). Figure 25 provides a comparison of the annual average concentrations of ^{3}H, ^{90}Sr, and U for the period 1981 through 1985. All observed tritium concentrations were well below the State of Washington and EPA screening level of 20,000 pCi/ℓ for drinking water.

The ^{90}Sr concentrations measured upstream and downstream during 1985 were essentially the same (0.15 pCi/ℓ and 0.16 pCi/ℓ, respectively). Figure 25 shows the annual average ^{90}Sr concentration to be slightly higher at the downstream location, consistent with observations made in past years. However, differences observed since 1981 have been very slight, especially when the uncertainty associated with the averages is considered. Figure 26 presents the monthly ^{90}Sr concentrations observed during the year at both the upstream and downstream locations, demonstrating that downstream concentrations are not consistently higher than the upstream concentrations. Statistical tests also indicated that the difference between upstream

(a) Paired sample comparison, t-test of differences (Snedecor and Cochran 1976).

9413218.0685

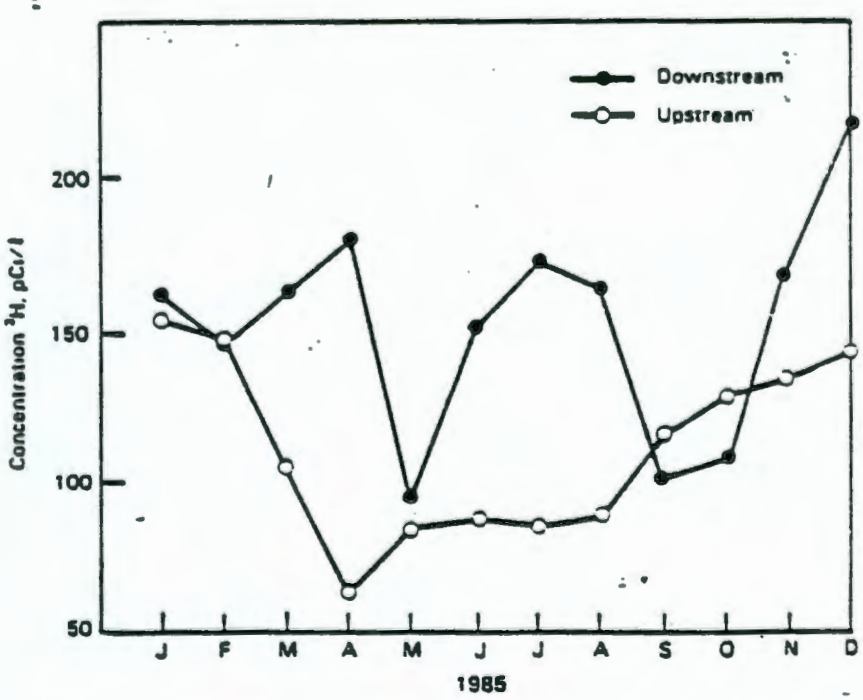


FIGURE 24. Tritium Concentrations Measured in Columbia River Water During 1985

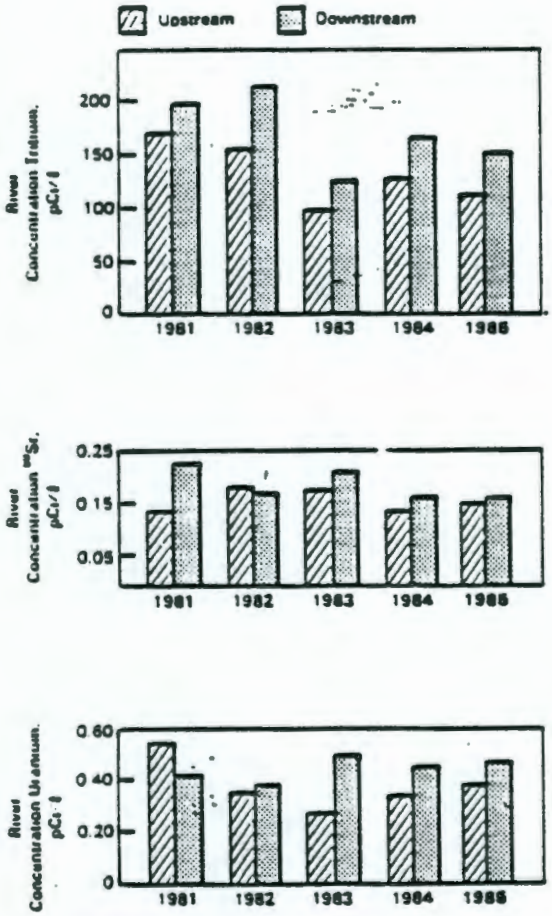


FIGURE 25. Annual Average Tritium, Strontium-90 and Uranium Concentrations Measured in the Columbia River, 1981 to 1985

and downstream concentrations was insignificant. The only known source of ^{90}Sr entering the Columbia River was from the 100N liquid-waste disposal facility, which reportedly discharged 8.7 Ci to the river during 1985. All ^{90}Sr concentrations observed during 1985 in the Columbia River water were well below the State of Washington and EPA screening level of 8 pCi/ℓ for drinking water.

Strontium-89 concentrations in Columbia River water collected upstream and downstream of Hanford were generally below the detection level during 1985. As in past years, average concentrations of ^{89}Sr were essentially the same upstream and downstream of the Site (0.087 pCi/ℓ and 0.100 pCi/ℓ, respectively).

Uranium concentrations in 1985 continued to be slightly higher in samples of Columbia River water collected downstream of Hanford than in those collected upstream, as shown in Figure 25. While the difference in the annual averages upstream versus downstream (0.38 pCi/ℓ and 0.48 pCi/ℓ, respectively) is very slight, monthly values observed during the year were generally higher at the downstream location, as Figure 27 shows. All uranium concentrations observed during 1985 correspond with doses well below the State of Washington and EPA standard of 4 mrem/yr for drinking water. Although there is no direct discharge of uranium to the river, it is known to be a primary constituent of the ground water beneath the 300 Area (see "Ground-Water Monitoring" section) and has been detected at elevated levels in riverbank springs entering the river in this area (McCormack and Carlile 1984).

As in the past several years, ^{129}I concentrations continue to be higher in downstream river water than upstream. The average upstream and downstream concentrations in river water during 1985 were 9 aCi/ℓ and 88 aCi/ℓ, respectively. Iodine-129 in the river is attributable to the flow of ground water, which is known to contain ^{129}I, from the unconfined aquifer into the river (see "Ground-Water Monitoring" section). Figure 28 provides the quarterly ^{129}I results for the upstream and downstream locations and also shows the average quarterly flow rate of the Columbia River for 1985 and the previous 5 years. As the figure shows, the differences observed during 1985 between the upstream and downstream concentrations were similar to the differences observed in past years. The figure also illustrates the influence of the river flow rate on the downstream ^{129}I concentrations, as higher flow rates are associated with reduced concentrations, and vice versa. As has been the case for other radionuclides, the concentrations of ^{129}I observed in the Columbia River water during 1985 were well below those concentrations which would result in doses exceeding the State of Washington and EPA Standard for drinking water, 4 mrem/yr.

9413218.0686

Reference 40

Memo from Kathleen Galloway, MITRE, to Sandy Crystall, EPA
December 29, 1987

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MITRE

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To: Sandy Crystall,
Acting Chief for NPL Operations,
Environmental Protection Agency (EPA)

Date: 29 December 1987

From: Kathleen Galloway, Member of the Technical Staff
The MITRE Corporation

Subject: The Toxicity of Uranium and Plutonium

Copies: B. Myers, S. Parrish

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According to Sax, uranium is a highly toxic element on an acute basis as well as on a radio-toxic basis. For this reason the Agency feels it is appropriate to assign a value of 3 for the toxicity of uranium.

Sax states that the toxicity of plutonium compounds is based first upon the very high radio-toxicity of the plutonium atom. In addition, the permissible levels for plutonium are the lowest for any radioactive element. Therefore, although a method for assigning toxicity values for radio-nuclides is not established, the language in Sax would appear to justify a toxicity value of 3 for plutonium.

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